Working Document to

Working Group on International Pelagic Surveys (WGIPS)
20 – 24 January 2025
and
Working Group on Widely Distributed Stocks (WGWIDE)
28 August – 4 September 2024

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) in April - May 2024

Post-cruise meeting on Teams, 18-20 June 2024

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Introduction

In April-May 2024, four research vessels and one hired commercial vessel participated in the International ecosystem survey in the Nordic Seas (IESNS); R/V Dana, Denmark (joint EU survey by Denmark, Germany, Ireland, The Netherlands and Sweden), R/V Jákup Sverri, Faroe Islands, R/V Árni Friðriksson, Iceland, R/V G.O. Sars, Norway and M/S Resolute, United Kingdom (UK). The aim of the survey was to cover the whole distribution area of the Norwegian Spring-spawning herring with the objective of estimating the total abundance of the herring stock, in addition to collect data on plankton and hydrographical conditions in the area. The survey was initiated by the Faroes, Iceland, Norway and Russia in 1995. Since 1997 the EU has also participated (except 2002 and 2003) and from 2004 onwards the survey has been more integrated into an ecosystem survey.

This report represents analyses of data from this international survey in 2024 that are stored in the PGNAPES database and the ICES acoustic database and supported by national survey reports from some survey participants (Dana: Cruise Report R/V Dana Cruise 03/2024, Árni Friðriksson: A6-2024 Cruise Report, Bjarnason, 2024, Jákup Sverri, cruise report 2416, (IESNS_2024_JakupSverri_CruiseReport.docx) and IESNS-UK 2024 Survey Report).

In July 2024, about one month after the post-cruise meeting, the IESNS survey group was informed by our colleagues at PINRO that the Russian Research vessel Vilnyus had covered the Barents Sea during April 16 to May 6, 2024. The results from this survey are presented in an appendix to this report.

Material and methods

Coordination of the survey was done during the WGIPS meeting in January 2024 and by correspondence. Planning of the acoustic transects, hydrographic stations and plankton stations were carried out by using the survey planner function in the r-package Rstox version 1.11 (see https://www.hi.no/en/hi/forskning/projects/stox). The survey planner function generates the survey plan (transect lines) in a cartesian coordinate system and transforms the positions to the geographical coordinate system (longitude, latitude) using the azimuthal equal distance projection, which ensures that distances, and also equal coverage, if the method used is designed with this prerequisite, are preserved in the transformation. Figure 1 shows the planned acoustic transects and hydrographic and plankton stations in each stratum. Only parallel transects were used this year, however, because the transects follow great circles they appear bended in a Mercator projection. The participating vessels together with their effective survey periods are listed in the table below:

Vessel	Institute	Survey period
Dana	DTU Aqua - National Institute of Natural Resources, Denmark	29/04-27/05
G.O. Sars	Institute of Marine Research, Bergen, Norway	23/04-21/05
Jákup Sverri	Faroe Marine Research Institute, Faroe Islands	24/04-02/05
Árni Friðriksson	Marine and Freshwater Research Institute, Iceland	04/05-21/05
Resolute	CEFAS, United Kingdom	24/04-06/05

Figure 2 shows the cruise tracks and strata, Figure 3 the hydrographic and WPII plankton stations and, Figure 4 Macroplankton trawl and Multinet stations and Figure 5 the pelagic trawl stations. Survey effort by each vessel is detailed in Table 1. Daily contacts were maintained between the vessels during the course of the survey, primarily through electronic mail. The temporal progression of the survey is shown in Figure 6.

The weather conditions were good during the survey, and the acoustic data collection was not negatively affected by weather, however, a few pre-planned CTD and WP2 stations had to be cancelled due to rough sea. The survey was based on scientific echosounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote *et al.*, 1987) prior to the survey. Salient acoustic settings are summarized in the text table below.

Acoustic instruments and settings for the primary frequency (boldface).

	Dana	G. O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
Echo sounder	Simrad EK60	Simrad EK80	Simrad EK80	Simrad EK80	Simrad EK80
Frequency (kHz)	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 70, 120, 200	18,**38**, 70, 120, 200, 333	**38**,200
Primary transducer	ES38BP	ES 38-7	ES38-7	ES38-7	ES38-7
Transducer installation	Towed body	Drop keel	Drop keel	Drop keel	Hull-mounted
Transducer depth (m)	2-5	8.5	6.9	6-9	6
Upper integration limit (m)	10	15	12	15	10
Absorption coeff. (dB/km)	10.4	10.1	10.6	10.5	10.1
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	2.425	3.06	2.425
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	18	21.9	18
2-way beam angle (dB)	-20.5	-20.7	-20.3	-20.4	-20.7

	Dana	G. O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.35	26.19	27.05	26.93	26.51
s_A correction (dB)	-0.55	-0.07	0.01	-0.05	-0.04
3 dB beam width (dg)					
alongship:	6.94	6.39	6.44	6.52	6.36
athw. ship:	6.98	6.38	6.52	6.53	6.49
Maximum range (m)	500	500	500	750	500
Post processing software	LSSS	LSSS	LSSS	LSSS	Echoview

All participants except UK used the same post-processing software (LSSS). The UK data were, however, scrutinized using Echoview. Scrutinization was carried out according to an agreement at the PGNAPES scrutinizing workshop in Bergen in February 2009 (ICES 2009), and “Notes from acoustic Scrutinizing workshop in relation to the IESNS”, Reykjavík 3.-5. March 2015 (Annex 4 in ICES 2015). Generally, acoustic recordings were scrutinized on daily basis and species identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms. All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls, plankton nets and hydrographic equipment are as follows:

	Dana	**G.O. Sars**	**Arni Friðriksson**	**Jákup Sverri**	**Resolute**
Trawl dimensions					
Circumference (m)		**496**	**832**	**832**	**972**
Vertical opening (m)	**20-30**	**25-30**	**20–35**	**30-40**	**30-50**
Mesh size in codend (mm)	**18**	**24**	**20**	**45**	**20**
Typical towing speed (kn)	**3.5-4.5**	**3.0–4.5**	**3.1–5.0**	**3.5–4.5**	**3.5-5**
Plankton sampling					
Sampling net	**WP2**	**WP2**	**WP2**	**WP2**	**WP2**
Standard sampling depth (m)	**200**	**200**	**200**	**200**	**200**
Hydrographic sampling					
CTD unit	**SBE911**	**SBE911**	**SBE911**	**SBE911**	**SAIV SD208**
Standard sampling depth (m)	**1000**	**1000**	**1000**	**1000**	**500**

Catches from trawl hauls were sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. A subsample of herring, blue whiting and mackerel were sexed, aged, and measured for length and weight, and their maturity status was estimated using established methods. An additional sample of fish was measured for length. For the Norwegian, Icelandic and Faroese vessel, a smaller subsample of stomachs was sampled for further analyses on land. As part of ongoing stock identity research, herring genetic samples were collected. Salient biological sampling protocols for trawl catches are listed in the table below.

	Species	Dana	G.O. Sars	Arni Friðriksson	Jákup Sverri	Resolute
Length measurements	Herring	200-300	100	200	100-150	100
	Blue whiting	200-300	100	50	100-150	100
	Mackerel	100-200	100	50	100-150	100
	Other fish sp.	50	30	30	30-100	30
Weighed, sexed and maturity determination	Herring	50	25-100	50	100-150*	50
	Blue whiting	50	25-100	50	100-150*	50
	Mackerel	50	25-100	50	100-150*	50
	Other fish sp.	0	0	0	30-100*	0
Otoliths/scales collected	Herring	50	25-30	50	25-50	50
	Blue whiting	50	25-30	50	25-50	50
	Mackerel	0	25-30	50	25-50	50
	Other fish sp.	0	0	0	0	0
Stomach sampling	Herring	0	10	10	5	0
	Blue whiting	0	10	10	5	0
	Mackerel	0	10	10	5	0
	Other fish sp.	0	0	0	0	0
Genetic samples	Herring	50	25-30	50	30	50

* Only fish that are aged are being sexed and maturity determined.

Acoustic data were analysed using the StoX software package (version 3.6.2) which has been used for many years now for WGIPS coordinated surveys. A description of StoX can be found in Johnsen et al. (2019) and here: https://www.hi.no/en/hi/forskning/projects/stox. Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). This method requires pre-defined strata, and the survey area was therefore split into 5 strata with pre-defined acoustic transects. Within each stratum, parallel transects with equal distances were used. The distance between transects was based on available survey time, and the starting point of the first transect in each stratum was randomized. This approach allows for robust statistical analyses of uncertainty of the acoustic estimates. The strata and transects used in StoX are shown in Figure 2. Generally, and in accordance with most WGIPS coordinated surveys, all trawl stations within a given stratum with catches of the target species (either blue whiting or herring) were assigned to all transects within the stratum, and the length distributions were weighted equally within the stratum.

The following target strength (TS)-to-fish length (L) relationships were used:

Blue whiting: TS = 20.0 log(L) – 65.2 dB (ICES 2012)

Herring: TS = 20.0 log(L) – 71.9 dB (Foote et al. 1987)

The target strength for herring is the traditionally one used while this target strength for blue whiting was first applied in 2012 (ICES 2012).

The hydrographical and plankton stations by survey are shown in Figure 3. Hydrographical were collected data using a SBE 911 CTD. Maximum sampling depth was 1000 m.

Zooplankton was sampled by WP2 nets on all vessels, according to the standard procedure for the surveys. Mesh sizes were 180 or 200 µm. The net was hauled vertically from 200 m to the surface or from the bottom whenever bottom depth was less than 200 m. Samples were split in two and one half was preserved in formalin while the other half was dried and weighed (Resolute did not collect samples in formalin, just dry weight). The samples for dry weight were size fractionated before drying by sieving the samples through 2000 µm and 1000 µm sieves, giving the size fractions 180/200 – 1000 µm, 1000 – 2000 µm, and > 2000 µm. Data are presented as total mg dry weight per m2. For the zooplankton distribution map, all stations are presented. Interpolation was carried out using Bratseth's Successive Correction Method (Bratseth, 1986). This method was designed specifically for marine data, and it uses bottom depth to calculate the similarity among the interpolation points. More specifically, it uses objective analysis with a Gaussian correlation function where the effective distance between the observations and the nodes of the interpolation grids is defined based on the difference in bottom depths, as follows:

$$r^2 = r_x^2 + r_y^2 + \left(\lambda \frac{H_a - H_o}{H_a + H_o}\right)^2$$

where r_x and r_y is the geographic distance in the zonal and meridional directions, and H_a and H_o are the bottom depths at the analysis and observation points, respectively (Skagseth and Mork, 2012). The analysis was done using an R script based on a MATLAB routine developed by Kjell Arne Mork (Mork et al. 2014). For the time series, stations in the Norwegian Sea delimited to east of 14°W and west of 20°E have been included. Estimates of the statistical distribution of the zooplankton biomass indices is done by simple bootstrapping by re-sampling with replacement.

Results and Discussion

Hydrography

The temperature distributions in the ocean, averaged over selected depth intervals; 0-50 m, 50-200 m, and 200-500 m, are shown in Figures 7a-c. The temperatures in the surface layer (0-50 m) ranged from below 0°C in the Greenland Sea to 9-10°C in the southern part of the

Norwegian Sea (Figure 7a). The Arctic front was encountered south of 65°N east of Iceland extending eastwards towards about 2°W where it turned north-eastwards to 65°N and then almost straight northwards. The front sharpened and had a more eastern location with depths. Further to west at about 8°W, another front runs northward to Jan Mayen, the Jan Mayen Front, that was most distinct in the upper 200 m. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures about 5 °C to south of the Bear Island at 74°N in the surface layer.

Relative to the long-term mean, from 1995 to 2021, the temperature anomalies at 0-50 m had fragmented patterns with several areas below and above the mean (Figure 7a). At 50-200 m depth, the patterns were also fragmented, but the Norwegian Sea was, in general, dominated by areas colder than the long-term mean and particular in the central and southern part (Figure 7b). At 200-500 m depth, the patterns were less fragmented and nearly the whole Norwegian Sea was colder than the long-term mean (Figure 7c).

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters. This water largely derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the southwestern Norwegian Sea where its waters subduct under the Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is in the last four decades a similar layer has been observed all over the Norwegian Sea. Also, in periods this layer has been less well-defined.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. The NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward. The western branch of the NWAC reaches the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge. It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front, that separates the warm North Atlantic waters from the cold Arctic waters, is correlated with the large-scale distribution of the atmospheric sea level pressure. The local air-sea heat flux in addition influence the upper layer and it is found that it can explain about half of the year-to-year variability of the ocean heat content in the Norwegian Sea.

Zooplankton

The zooplankton biomass (g dry weight m^{-2}) distribution in the upper 200 m in 2024 is shown in Figure 8. Sampling stations were evenly spread over the area, covering Atlantic water, Arctic water, and the Arctic frontal zone. Spots with higher zooplankton biomass were found spread over the entire investigated area. One such spot was located north of the Faroe Islands, another north of Lofoten (Norway), and smaller spots were found in the basins. The biomass was however evenly distributed between water masses and larger geographical areas.

Figure 9a) shows new sub-areas that have been developed in the ICES group WGINOR, based on bottom-topography, water-mass distribution, and geographical variations in annual primary production. It is the first time these sub-areas have been used in the IESNS post-cruise report, and the sub-areas are designed so that they can be merged into larger sub-areas when the time series are presented, if desired. The two westernmost sub-areas were not fully covered with stations, and some stations were located outside the sub-areas.

Figure 9b) shows the zooplankton time series indices for the six sub-areas. The highest average biomass in 2024 was found in the Lofoten Basin, East, with 9467 mg dry weight m^{-2}. The lowest biomass was found in the Iceland Sea with 5095 mg dry weight m^{-2}. All sub-areas showed a decrease or no change from the level in 2023. The zooplankton biomass indices for the Norwegian Sea and adjacent areas in May have been estimated since 1995. All sub-areas had a high biomass period until mid-2000, and a lower period thereafter. The long-term decrease has been most pronounced in the Iceland Sea and the western part of the Norwegian Basin. The low-biomass period after 2010 has been relatively stable, but with interannual variations. The average biomass in this lower period has also been relatively similar for the entire investigated area, varying between 8661 and 7501 mg dry weight m^{-2} for the different sub-areas.

The reasons for the changes in zooplankton biomass are not obvious. It is worth noting that the period with lower zooplankton biomass coincides with higher-than-average heat content in the Norwegian Sea (ICES, 2020) and reduced inflow of Arctic water into the southwestern Norwegian Sea (Kristiansen et al., 2019; Skagseth et al., 2022). Timing effects, such as match/mismatch with the phytoplankton bloom, can also affect the zooplankton abundance. The high biomass of pelagic fish feeding on zooplankton has been suggested to be one of the main causes for the reduction in zooplankton biomass. However, carnivorous zooplankton and not pelagic fish may be the main predators of zooplankton in the Norwegian Sea (Skjoldal et al., 2004), and we do not have good data on the development of the carnivorous zooplankton stocks.

Norwegian spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2024. The zero-line was believed to be reached for adult NSS herring in all areas. It is recommended that the results from IESNS 2024 can be used for assessment purpose. The herring distribution (Figure 10) was more northeasterly this year compared to last year. It is a commonly observed pattern that the older fish are distributed in the west while the younger fish are found closer to the nursery areas in the Barents Sea (Figure 11).

Eight-year-old herring (2016-year class) was the most abundant year class both in terms of numbers (34%) and biomass (41%) on basis of the StoX bootstrap estimates for the Norwegian Sea (Table 2). The point estimate of abundance of the 2016 year-class decreased by 37% compared to last year's estimate (Figure 12). Uncertainty estimates for number at age based on bootstrapping within StoX are shown in Figure 13 and Table 2. The relative standard error (CV) is 23% for the total biomass and 25% for the total numbers estimate. The relative standard error for the dominating age group (2016 year-class) is 25% (Figure 13) while there is a typical pattern of higher values for the youngest and oldest age classes.

The total estimate of herring in the Norwegian Sea from the 2024 survey was 17.7 billion in number and the biomass was 3.8 million tonnes. The biomass estimate is about 7% lower than the 2023 survey estimate and the estimated number of individuals is about 7% higher than in 2023. The biomass estimate decreased significantly from 2009 to 2012 and has since then been rather stable with similar confidence intervals (Figure 14), but the trend has been downwards the last three years and the lowest abundance occurred in 2024.

Since 2015 an increased awareness has been raised around the age reading of herring. It appeared that the age distributions from the different participants some years showed differences and the older specimens appear to have uncertain ages. An age-reading workshop was held in Bergen 17.-19. April 2023 (WKARNSSH2, ICES 2023). This workshop was based on otoliths and scales collected in 2021 and subsequently exchanged between the participating countries. The conclusion from the workshop was that the agreement in age reading were at an acceptable level (ICES 2023), although there were some differences between readings of scales and otoliths particularly for older individuals. No issues directly related to age reading were identified and the guidelines were therefore not updated. The workshop also concluded that stock mixing is a minor issue when it comes to age reading.

With respect to age-reading, the comparison between the nations, in this year's survey, show that there were some differences within strata (Figure 15), particularly, in stratum 1 and 2. This could at least partly be explained by spatial differences in sampling between vessels within strata since we do not expect a uniform distribution of age classes. However, some vessels have a clear peak in abundance for age 8 while others have a high abundance of 7-year-olds, which could indicate differences in age reading among nations.

Recently, concerns have been raised by the survey groups for the International ecosystem surveys in the Nordic Seas (IESNS and IESSNS) on mixing issues between Norwegian spring-spawning herring and other herring stocks (e.g. Icelandic summer-spawning, Faroese autumn-spawning, Norwegian summer-spawning and North Sea type autumn-spawning herring) occurring in some of the fringe regions in the Norwegian Sea. Until now, fixed cut lines have been used by the survey group to exclude herring of presumed other types than NSS herring, however this simple procedure is thought to introduce some contamination of the stock indices of the targeted NSS herring. WGIPS noted in their 2019 report that the separation of different herring stock components is an issue in several of the surveys coordinated in WGIPS and the needs for development of standardized stock splitting methods was also noted in the WKSIDAC (ICES 2017) and WGIPS ever since as well as WKSIDAC2 and WKSIDAC3. Genetic samples of herring are therefore now collected routinely in the survey (Figure 5).

Blue whiting

Boostrap estimates of abundance, biomass, mean length and mean weight of blue whiting during IESNS 2024 are shown in Table 3. The estimated biomass was 779 thousand tons (CV=0.13) which is a 19% decrease from last year’s estimate, and slightly below the average from the period 2008-2023. The estimated total abundance was 7 869 million (CV=0.14) which is a 38% decrease from last year’s estimate. The stock is dominated by 1-4 years old blue whiting. Uncertainty estimates for numbers at age based on bootstrapping with StoX are shown in Figure 18 and Table 3.

The spatial distribution of blue whiting in 2023 is shown in Figure 16. As usual, most of the fish was registered in the eastern part of the Norwegian Sea. The largest fish was found in the northern part of the of the survey area (Figure 17). Comparison of the size and age distributions of blue whiting by stratum and country are shown in Figure 19 and 20, and they seem to be in fairly good agreement.

Mackerel

Trawl catches of mackerel are shown in Figure 21. Mackerel was present in the southern and eastern part of the Norwegian Sea in the beginning of May. The spatial distribution of catches in 2024 extended north to 68°N which is further north than what was observed last year and in 2022. No further quantitative information can be drawn from these data as this survey is not designed to monitor mackerel.

General recommendations and comments

Recommendation	Addressed to
1. Continue the methodological research in distinguishing between herring and blue whiting in the interpretation of echograms.	WGIPS
2. Implement logging of sonar data to measure the amount of herring in the surface blind zone	WGIPS
3. Conduct genetic sampling of all aged herring (even if the actual analysis will only be realised in a few years time from now at least the samples will be there to produce a retrospective split)	WGIPS

Next year's post-cruise meeting

We will aim for next meeting in 17-19 June 2025. The final decision will be made at the next WGIPS meeting.

Concluding remarks

- The sea temperature in 2024 was generally below the long-term mean (1995-2021) in the Norwegian Sea.
- The 2024 indices of zooplankton biomass in the Norwegian Sea and adjoining waters showed a decrease or no change from the level in 2023 in all sub-areas
- The total biomass estimate of NSSH in herring in the Norwegian Sea was 3.8 million tonnes, which is an 7% decrease from the 2023 survey estimate. The estimate of total number of NSSH was 17.7 billion, which is 7% higher than in the 2023 survey. The survey followed the pre-planned protocol and the survey group recommends using the abundance estimates in the analytical assessment.
- The 2016 year class of NSSH dominated in the survey indices both in numbers (34%) and biomass (41%). The abundance of the 2016 year-class decreased by 37% compared to last year's estimate.
- The biomass of blue whiting measured in the 2022 survey decreased by 19% from last year's survey and 38% in terms of numbers. The stock is dominated by the 2020 to 2023 year classes.

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in May - June 2024.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Ctd stations	Aged fish (HER)	Length fish (HER)	Plankton stations
Dana	01/5-21/5	2594	29	38	535	620	35
Jákup Sverri	24/4-2/5	1100	16	17	405	1060	17
Árni Fridriksson	4/5-21/5	2500	14	31	340	1385	27
G.O. Sars	23/4-21/5	4346	34	54	558	1497	54
Resolute	24/4-06/5	1214	13	20	330	661	209

Table 2. IESNS 2024 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring. The estimates are mean of 1000 bootstrap replicates in Stox.

Length (cm)	Age in years (year class) 1 2023	2 2022	3 2021	4 2020	5 2019	6 2018	7 2017	8 2016	9 2015	10 2014	11 2013	12 2012	13 2011	14 2010	15 2009	16 2008	17 2007	18 2006	20 2004	Unknown	Number (10^6)	Biomass (10^6 kg)	Mean weight (g)
13-14	13.3																				13.3	0.2	14.0
14-15	20.7																			2.4	23.2	0.4	18.0
15-16																				3.2	54.7	1.3	25.3
16-17		110.3																		2.8	113.1	3.5	33.7
17-18		88.8																		1.0	89.8	3.4	36.8
18-19		57.2	35.5																		92.7	4.1	43.9
19-20		74.6	35.0																	2.0	111.6	5.5	49.7
20-21		128.8	131.4																	1.0	261.2	16.0	61.5
21-22		73.5	329.1																		402.6	29.2	72.6
22-23		127.4	412.6																		540.0	45.2	83.4
23-24		72.3	464.8																		537.1	51.5	95.8
24-25			369.8																		369.8	39.0	105.0
25-26		31.1	278.8	27.0	6.1																343.0	41.5	120.7
26-27			213.8	278.0	6.9		2.6														501.2	68.3	135.2
27-28		31.0	334.7	408.2	39.0																812.8	124.5	151.3
28-29			92.0	386.9	74.9	39.3	20.2	11.3		5.2											629.9	104.7	165.2
29-30			20.8	247.5	119.3	91.2	75.5	52.5	10.7	17.4											634.9	115.6	180.9
30-31				263.7	96.6	178.5	75.3	31.5	24.3	37.3	36.6	12.0		6.7							762.4	153.2	200.4
31-32				249.3	47.9	216.8	79.7	60.3	17.9	54.0	23.4		3.5								752.9	166.3	219.9
32-33				140.2	170.1	548.3	590.0	811.6	13.1	79.8	39.2	11.3	3.2		2.9						2 409.7	571.9	236.7
33-34					23.4	243.7	897.4	2764.7	60.4	35.5	3.4										4 028.4	1018.9	251.4
34-35				6.9		27.1	244.3	1876.5	101.6	121.7	97.0										2 475.2	676.5	271.2
35-36						6.3	49.3	325.1	92.6	160.0	171.3	27.4	16.3	2.4	1.8						852.6	250.1	292.4
36-37						2.0	16.5	45.5	31.3	101.6	165.6	21.0	38.3	50.2	10.7	4.8					487.5	153.2	314.9
37-38							6.0		17.7	9.9	33.7	21.0	45.3	47.6	62.7	6.6		16.1	12.0		278.4	92.6	335.2
38-39										8.4	4.4	6.9	5.7	17.0	19.0	15.6	5.2				82.2	28.5	350.3
39-40												3.1	11.1		6.3						20.8	7.4	355.5
TSN(mill)	34.0	846.5	2718.3	2007.8	584.1	1353.3	2056.7	5978.9	369.5	631.0	574.5	102.9	123.5	123.9	103.4	27.0	5.2	16.1	12.0	12.6	17 681.1		
cv (TSN)	1.00	0.73	0.51	0.40	0.30	0.27	0.25	0.25	0.32	0.28	0.35	0.44	0.38	0.55	0.49	0.67	1.21	0.97	1.45	1.44	0.25		
TSB(1000 t)	0.6	52.2	287.2	357.9	116.3	307.8	508.7	1 541.2	101.5	171.6	163.2	30.8	39.0	39.9	34.4	9.1	1.7	5.2	4.0	0.4	3 772.5		
cv (TSB)	1.01	0.63	0.50	0.40	0.29	0.27	0.26	0.26	0.33	0.28	0.37	0.46	0.38	0.57	0.49	0.66	1.21	0.95	1.44	2.48	0.24		
Mean length(cm)	13.6	20.4	23.9	28.6	29.6	31.3	32.5	33.3	33.8	33.7	34.6	35.1	36.4	36.4	37.1	37.5	38.0	37.0	37.0	16.3			
Mean weight(g)	16.2	68.7	109.1	178.5	191.7	222.9	245.0	256.1	275.9	272.9	284.3	300.9	318.9	321.7	337.5	336.7	327.9	330.4	338.5	70.4			

Table 3. IESNS 2024 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of blue whiting. The estimates are mean of 1000 bootstrap replicates in Stox.

Length (cm)	Age in years (year class) 1 2023	2 2022	3 2021	4 2020	5 2019	6 2018	7 2017	8 2016	9 2015	10 2014	Unknown	Number (10^6)	Biomass (10^6 kg)	Mean weight (g)
16-17	11.7										0.4	12.0	0.3	24.3
17-18	18.7										0.7	19.4	0.5	29.5
18-19	164.7	5.1										169.9	5.8	34.4
19-20	580.0	3.7										583.7	23.7	40.7
20-21	953.5	16.6										970.0	45.5	47.2
21-22	498.2	25.9										524.2	27.5	52.7
22-23	98.8	32.8	27.9									159.5	10.1	64.3
23-24		233.7	39.2	12.3								285.3	21.6	75.7
24-25		257.5	330.7	55.6	3.1							646.9	55.6	86.2
25-26		271.9	482.4	212.8	40.8	6.8						1 014.8	98.9	98.0
26-27		110.9	456.7	398.2	76.1	3.8						1 045.7	115.6	111.1
27-28		7.8	222.0	468.8	124.6	15.2			6.9			845.3	105.8	125.4
28-29		3.1	75.4	325.8	116.8	5.2	1.6	3.6	4.4			536.0	75.2	139.3
29-30			28.4	157.7	75.3	45.7	11.1	4.2				322.4	49.8	154.3
30-31			12.8	88.4	66.8	47.5	26.1	28.8				270.4	46.8	173.5
31-32			4.9	23.7	55.8	26.7	19.1	8.8	5.5	5.4		149.8	27.9	186.4
32-33				12.7	32.0	26.6	20.2	29.2	26.1	10.6		157.3	31.9	205.4
33-34					14.9	36.9	30.7	18.2		14.5		115.2	25.6	223.9
34-35			4.6		3.1	10.9					0.4	19.0	4.6	240.8
35-36					1.7	8.7	1.5			3.8	0.1	15.8	4.1	261.6
36-37											1.1	1.1		
37-38						1.8			1.6			3.4	1.0	290.4
38-39														
39-40									1.9			1.9	0.8	418.0
TSN(mill)	2326	969	1685	1756	611	236	110	93	46	34	3	7 868.8		
cv (TSN)	0.28	0.20	0.19	0.16	0.23	0.24	0.28	0.32	0.42	0.62	1.41	0.14		
TSB(1000 t)	106.9	83.8	178.0	221.2	89.9	43.9	21.2	18.0	8.5	7.0	0.1	778.6		
cv (TSB)	0.28	0.19	0.19	0.16	0.23	0.25	0.28	0.32	0.41	0.61	4.02	0.13		
Mean length(cm)	19.9	24.0	25.6	27.2	28.6	30.7	31.3	31.3	31.6	32.5	32.9			
Mean weight(g)	46	87	107	128	151	189	193	196	195	206	74			

Figures

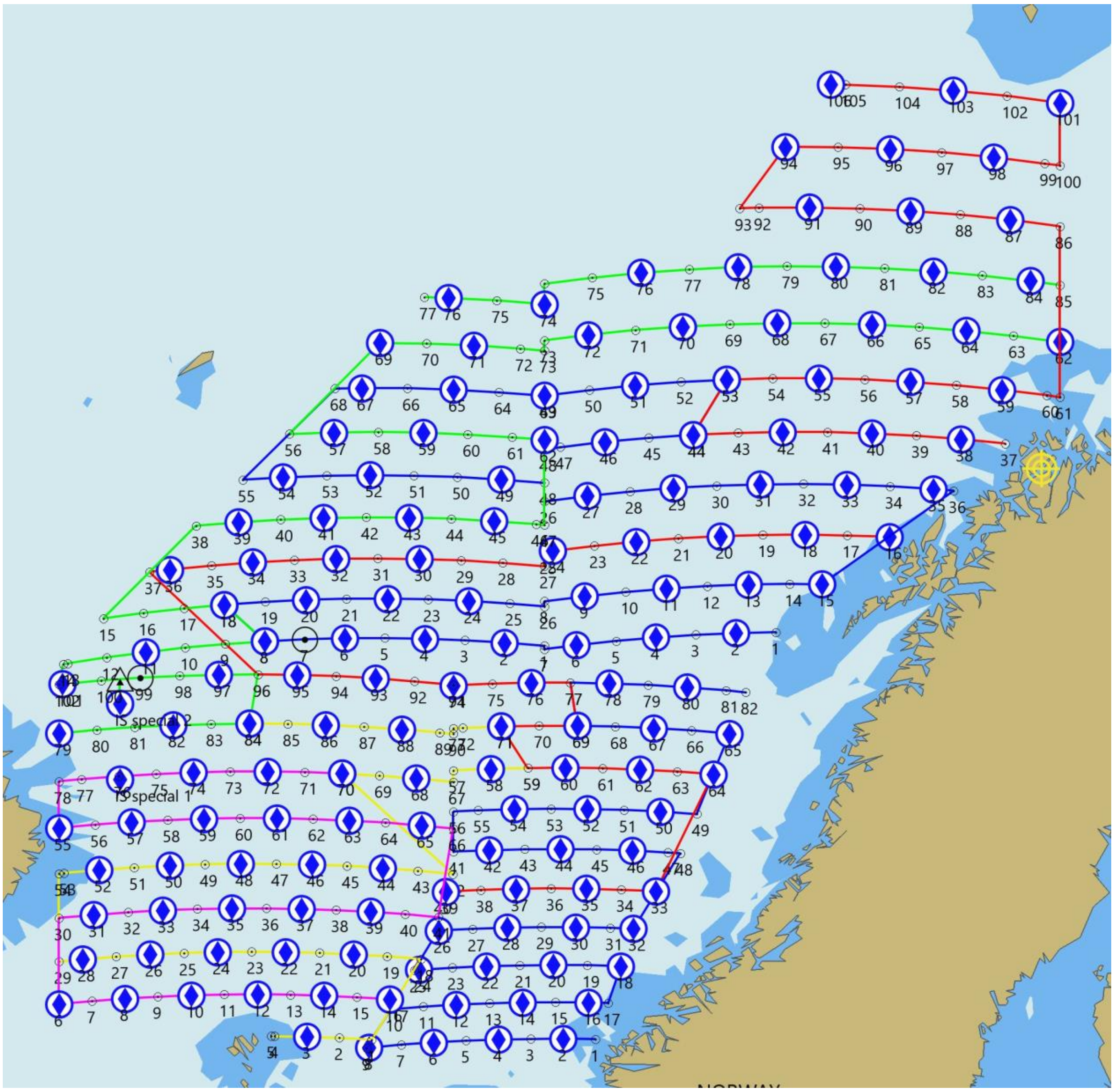


Figure 1. The pre-planned strata and transects for the IESNS survey in 2024 (red: EU, dark blue: Norway, yellow: Faroes Islands, violet: UK, green: Iceland). Hydrographic stations and plankton stations are shown as blue circles with diamonds. All the transects have numbered waypoints for each 30 nautical mile and at the ends**.**

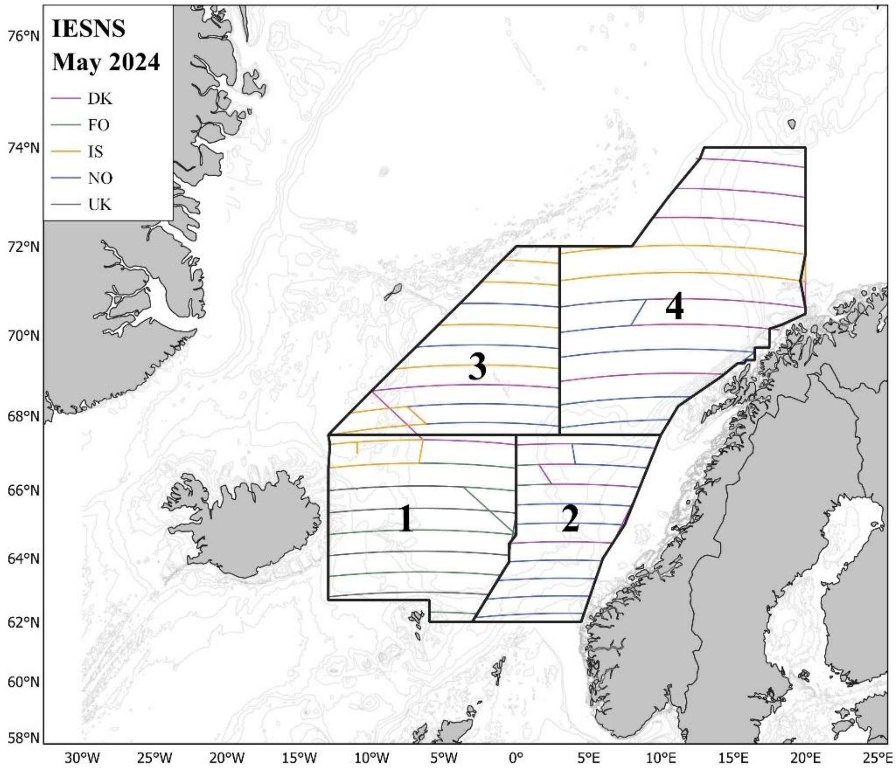


Figure 2. Cruise tracks and strata (with numbers) for the IESNS survey in May 2024.

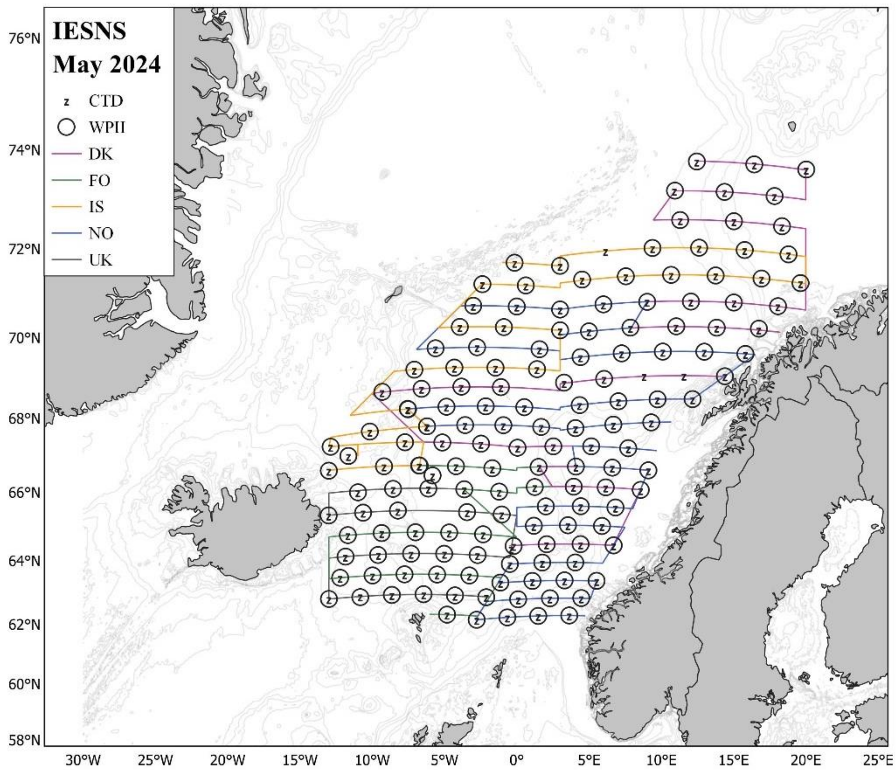


Figure 3. IESNS survey in May 2024: location of hydrographic and WPII plankton stations.

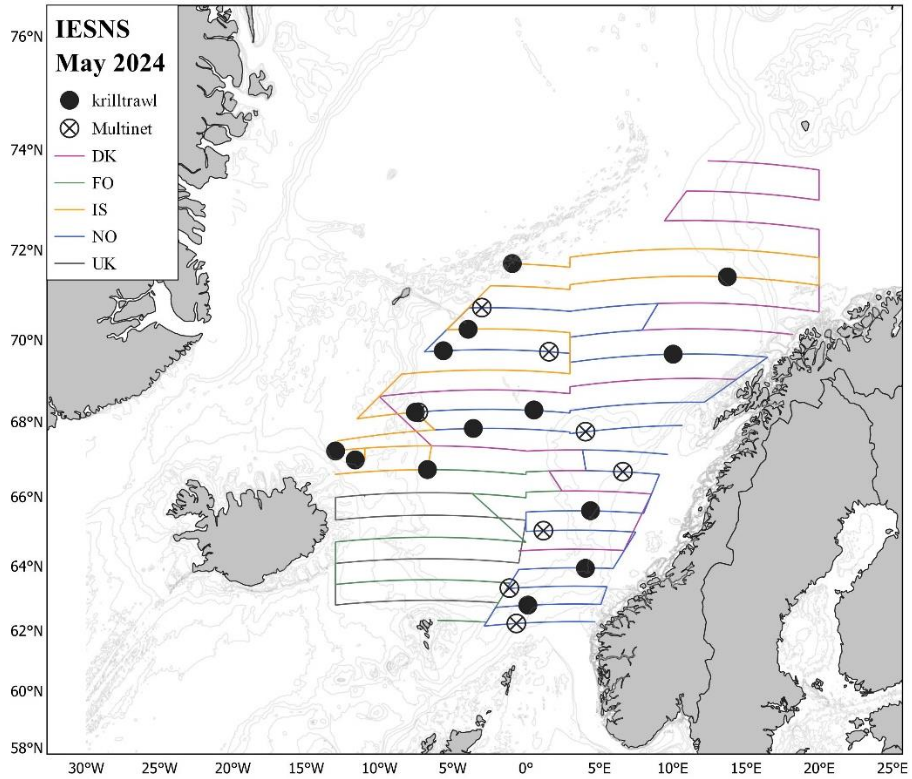


Figure 4. IESNS survey in May 2024: location of Macroplankton/Krill trawl and Multinet stations.

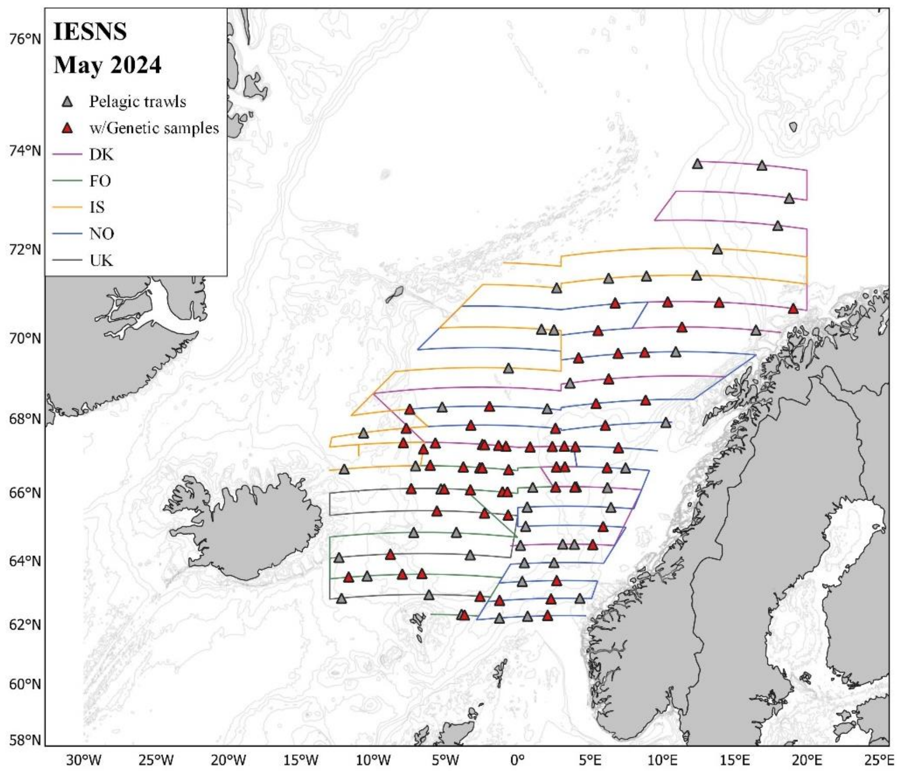


Figure 5. IESNS survey in May 2024: cruise tracks and location of pelagic trawl stations. Stations where genetic herring samples were taken are red.

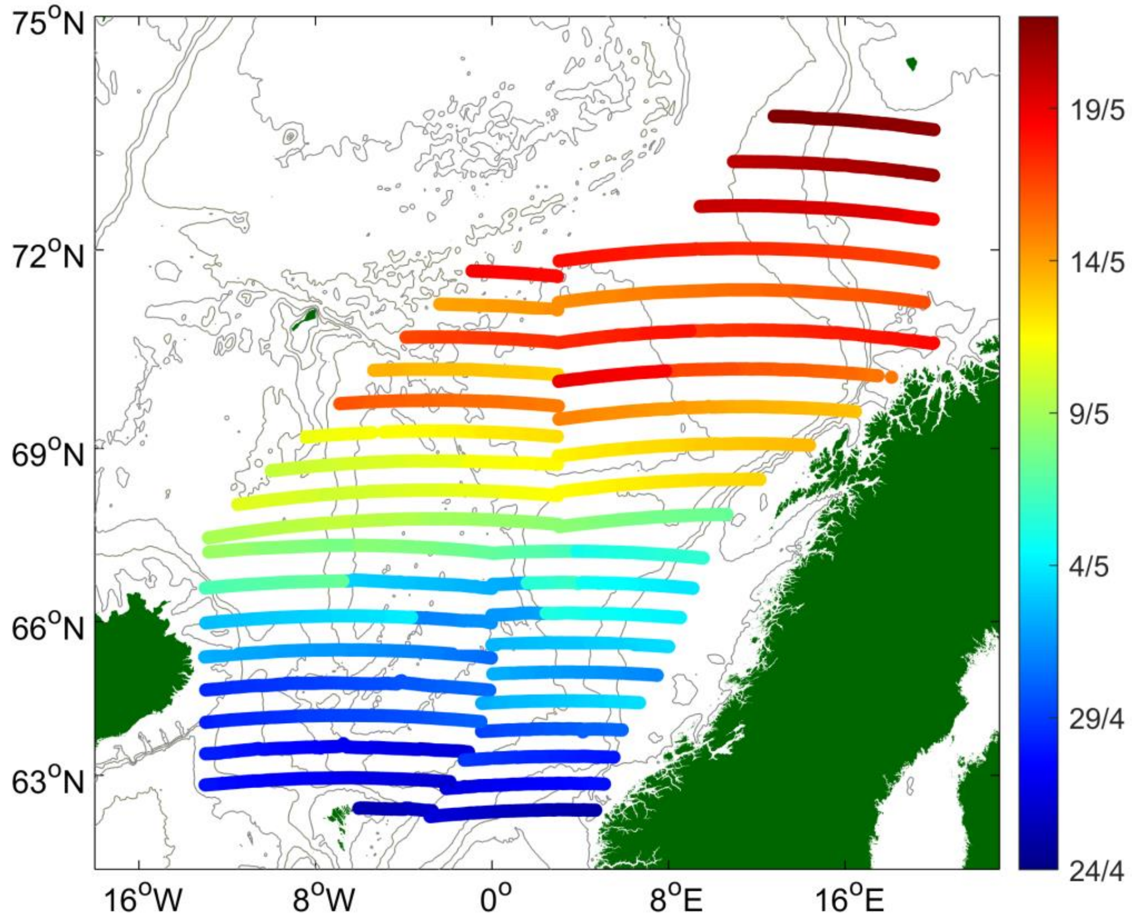


Figure 6. Temporal progression IESNS in April-May 2024.

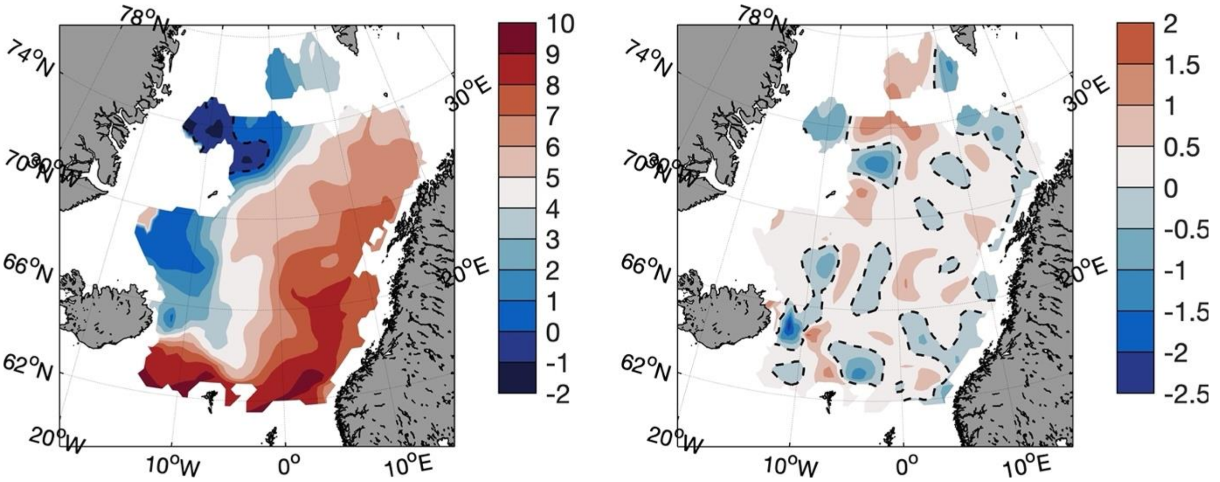


Figure 7a. Temperature (left) and temperature anomaly (right) averaged over 0-50 m depth in May 2024. Anomaly is relative to the 1995-2021 mean.

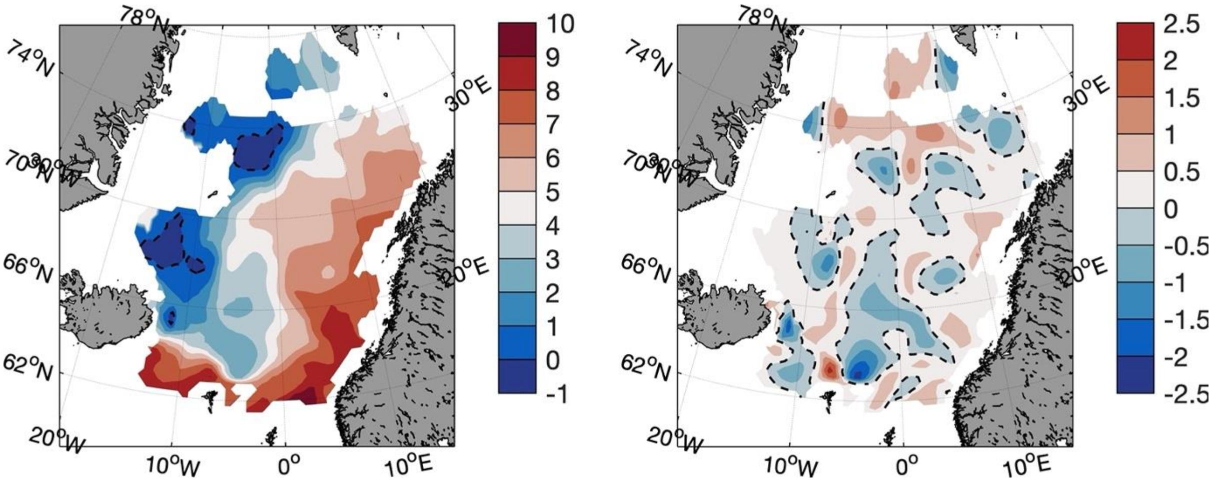


Figure 7b. Same as above but averaged over 50-200 m depth.

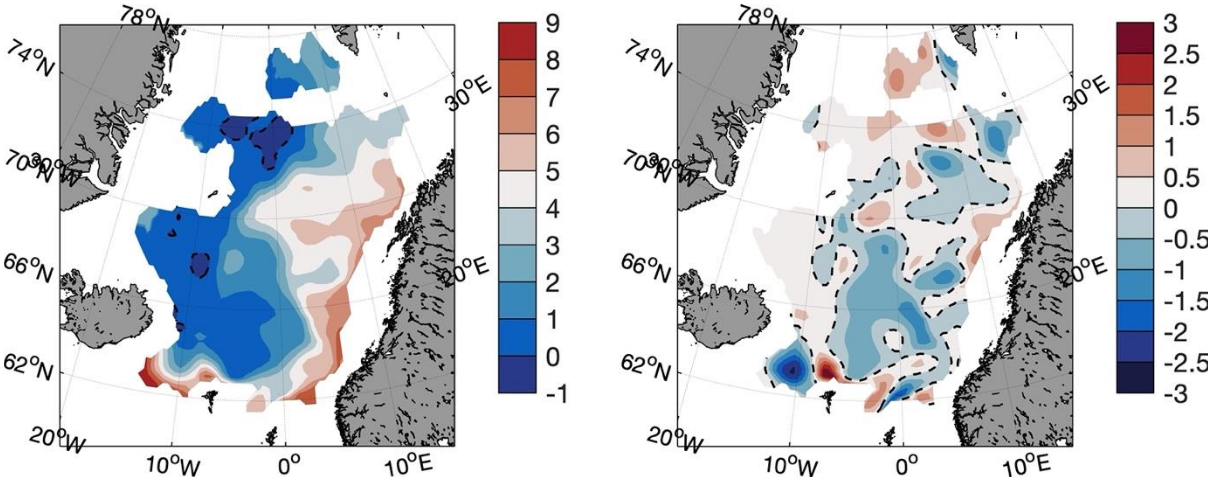


Figure 7c. Same as above but averaged over 200-500 m depth.

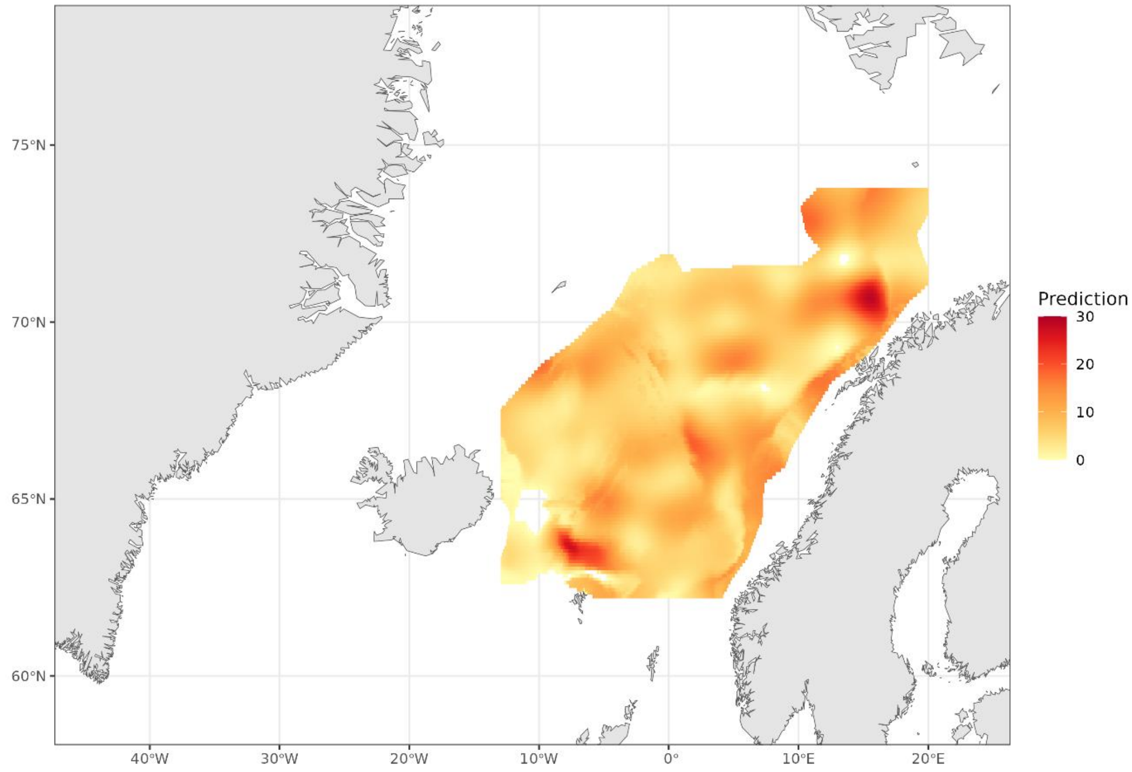
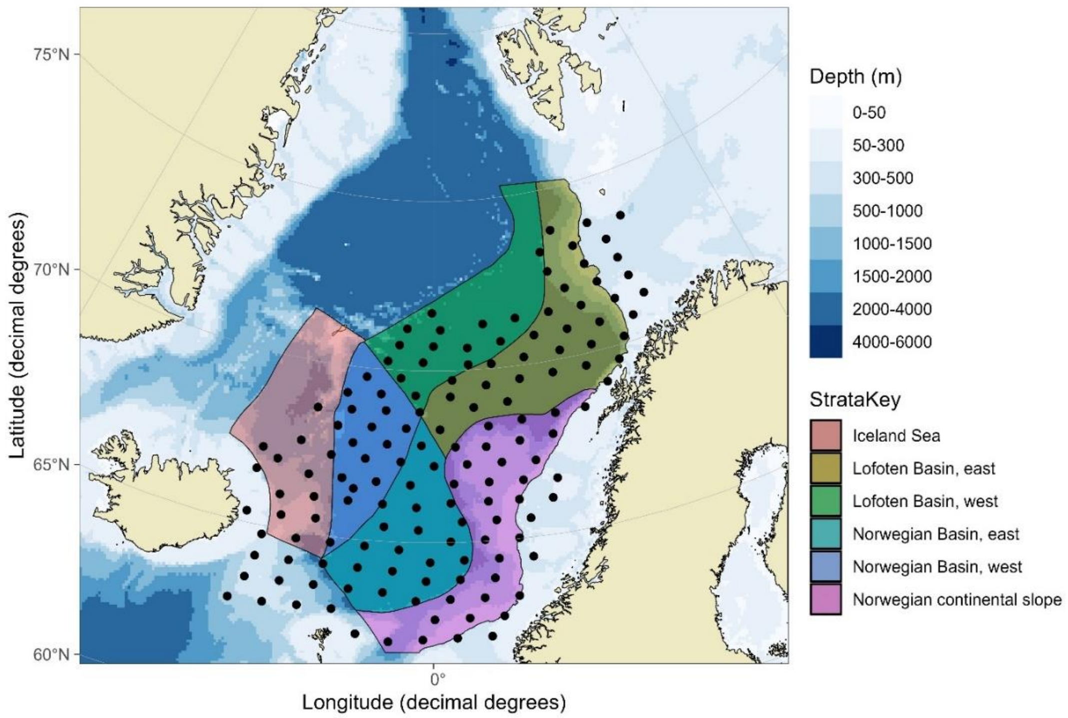


Figure 8. Distribution of zooplankton biomass (g dry weight m^{-2}) in the upper 200 m in May, IESNS survey 2024.

a)



b)

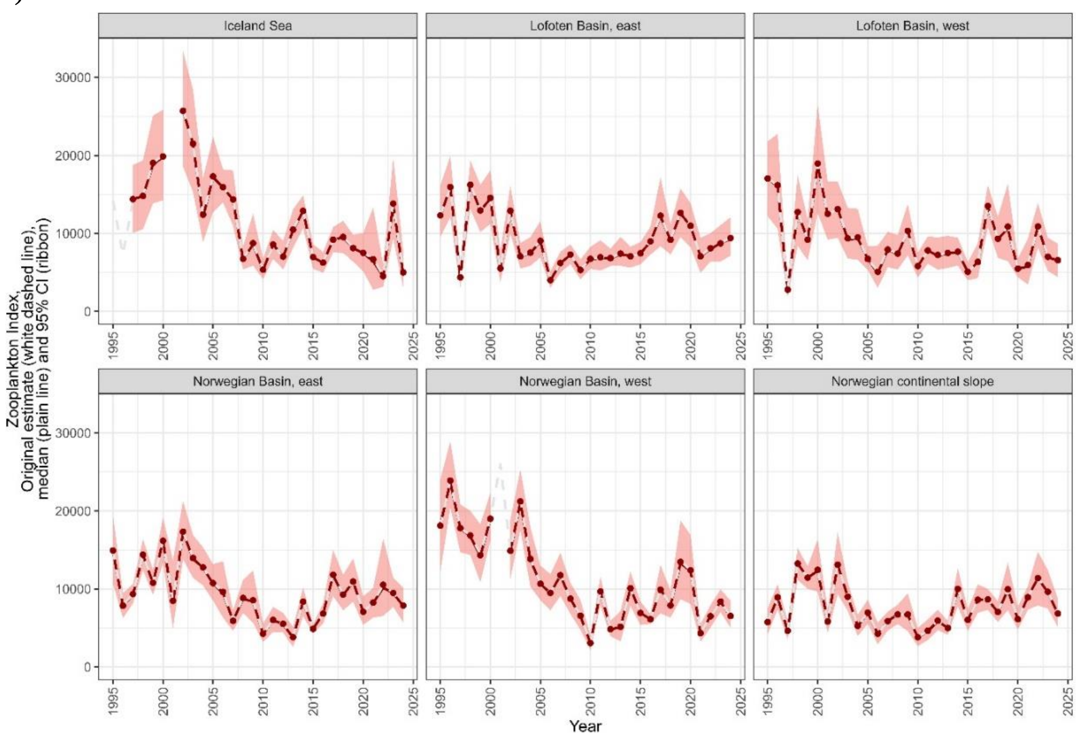
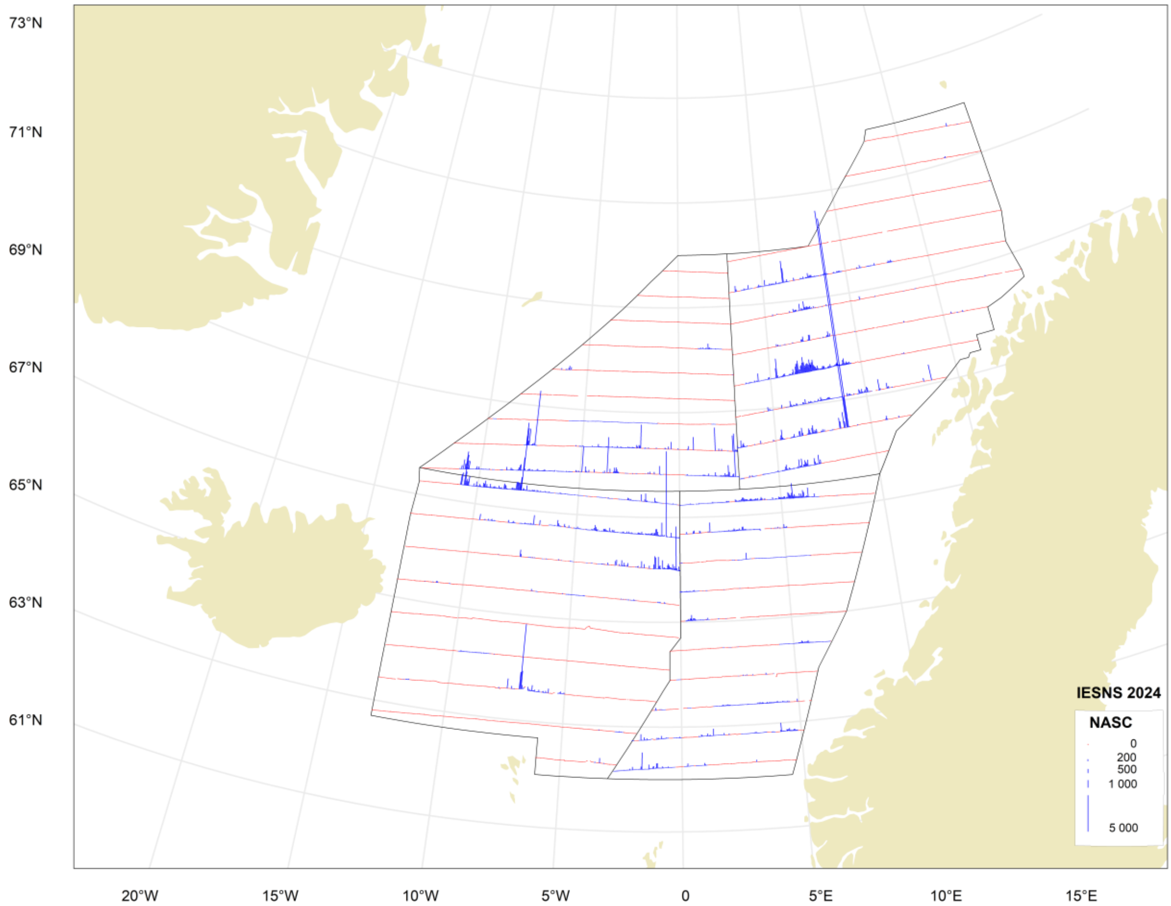


Figure 9 a) shows the sub-areas, and b) the indices of zooplankton biomass (mg dry weight m^{-2}) sampled by WP2 in May from 1995-2024.

(a)


73°N
71°N
69°N
67°N
65°N
63°N
61°N
20°W
15°W
10°W
5°W
0
5°E
10°E
15°E
IESNS 2024
NASC
0
200
500
1 000
5 000

(b)

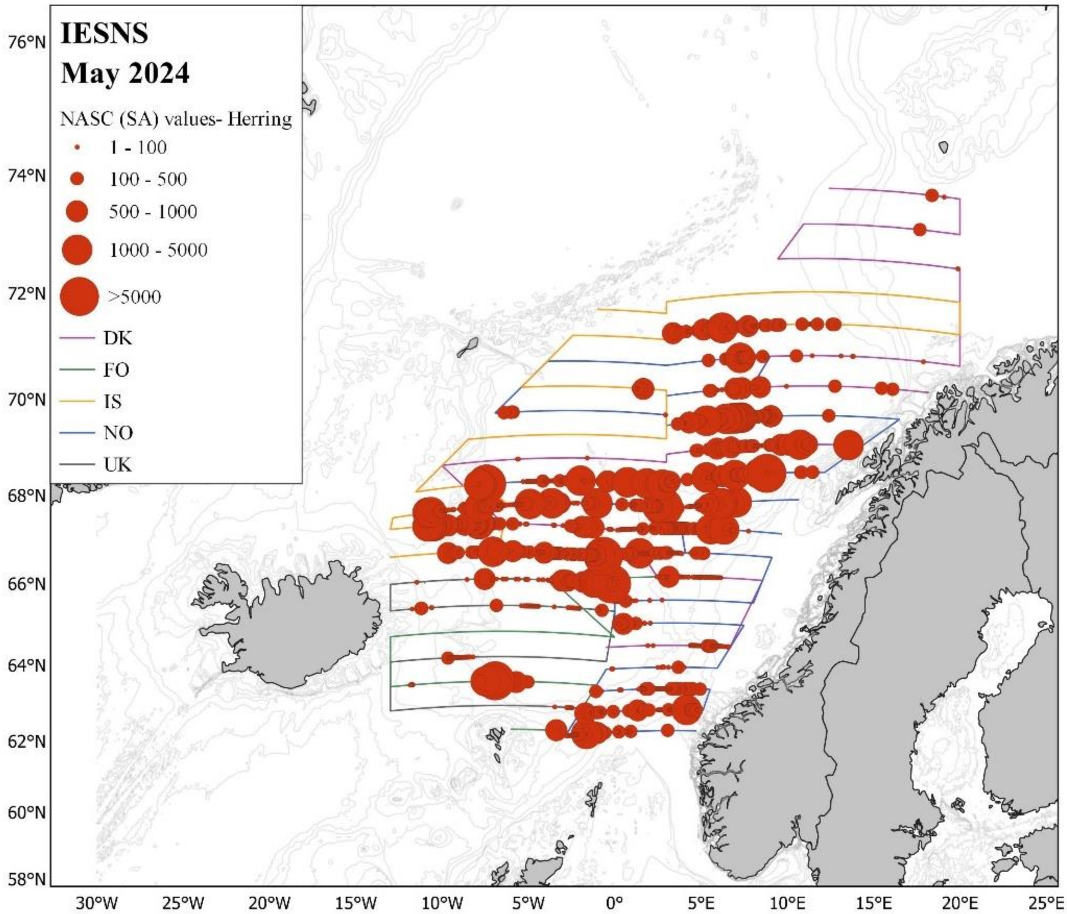


Figure 10. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2024 in terms of NASC values (m^2/nm^2) averaged for every 1 nautical mile. The NASC values are represented as both bars (a) and bubbles (b).

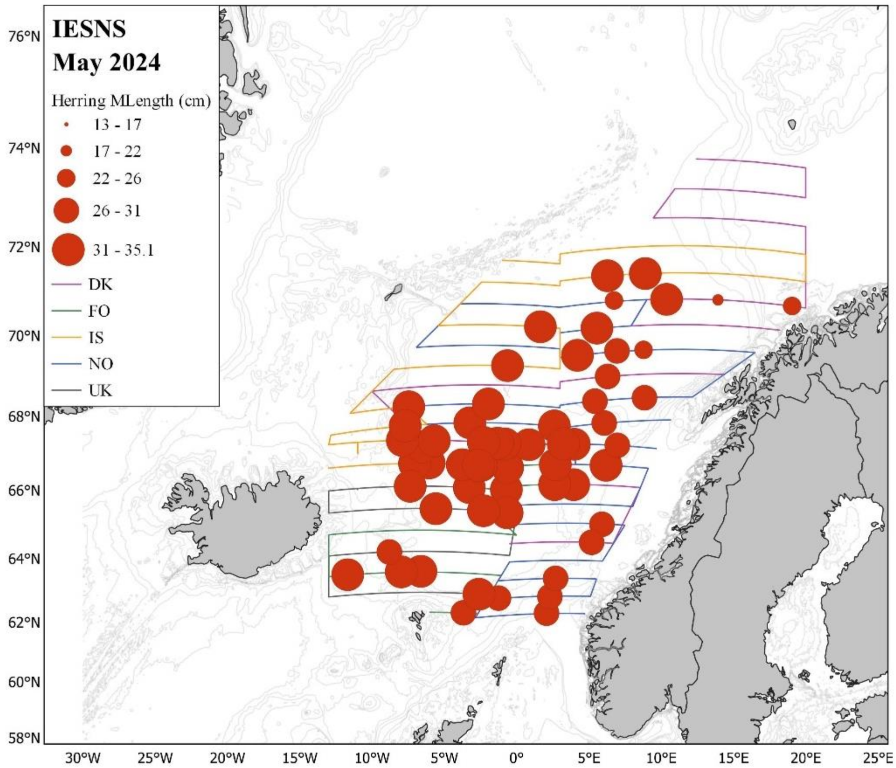


Figure 11. Mean length of Norwegian spring-spawning herring in all hauls in IESNS 2024.

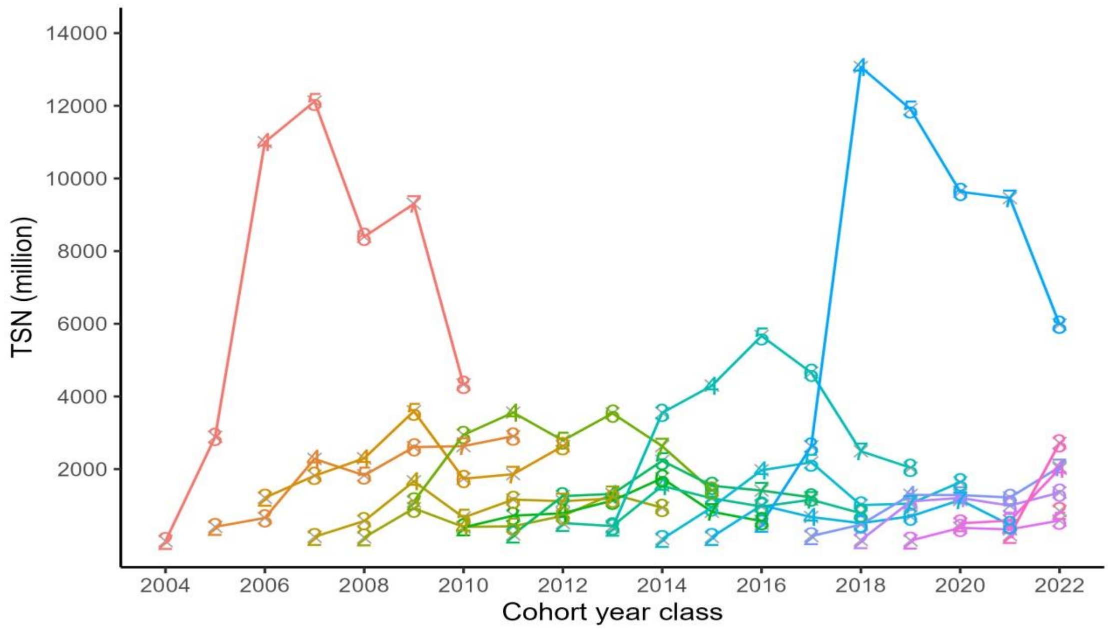


Figure 12. Tracking of the Total Stock Number at age (TSN, in billions) of Norwegian spring-spawning herring for each cohort since 2004 from age 2 to age 8. From 2008, stock is estimated using the StoX software. Prior to 2008, stock was estimated using BEAM.

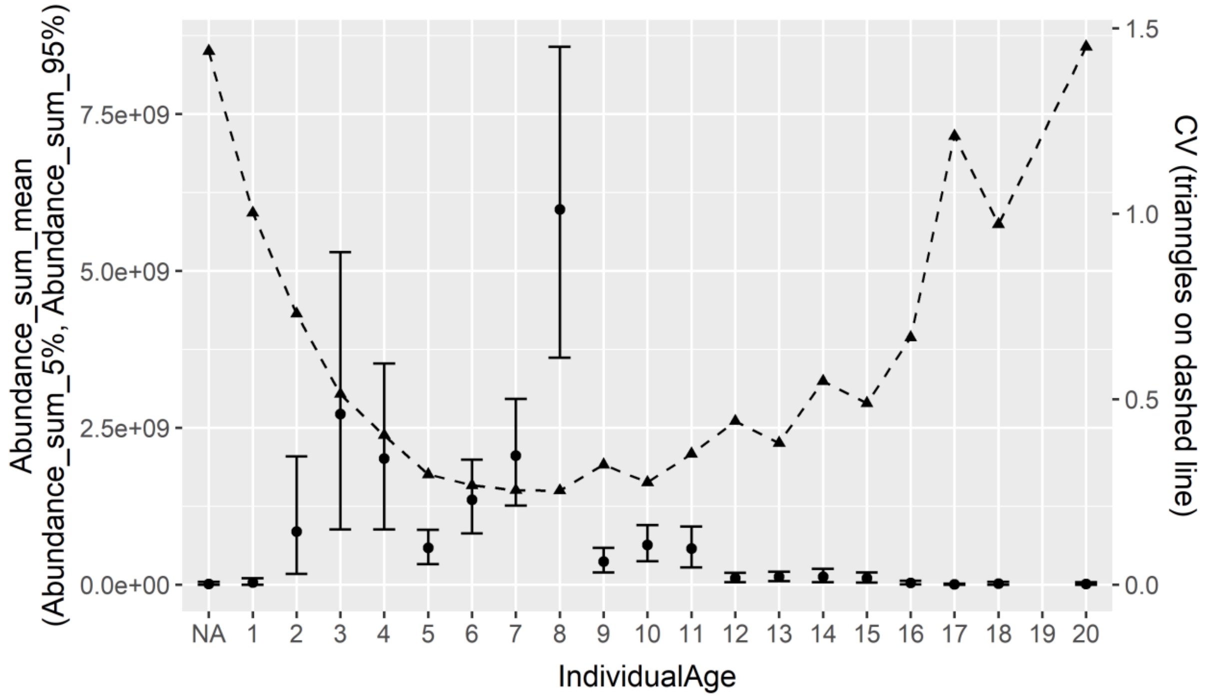


Figure 13. IESNS 2024. Norwegian spring-spawning herring in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

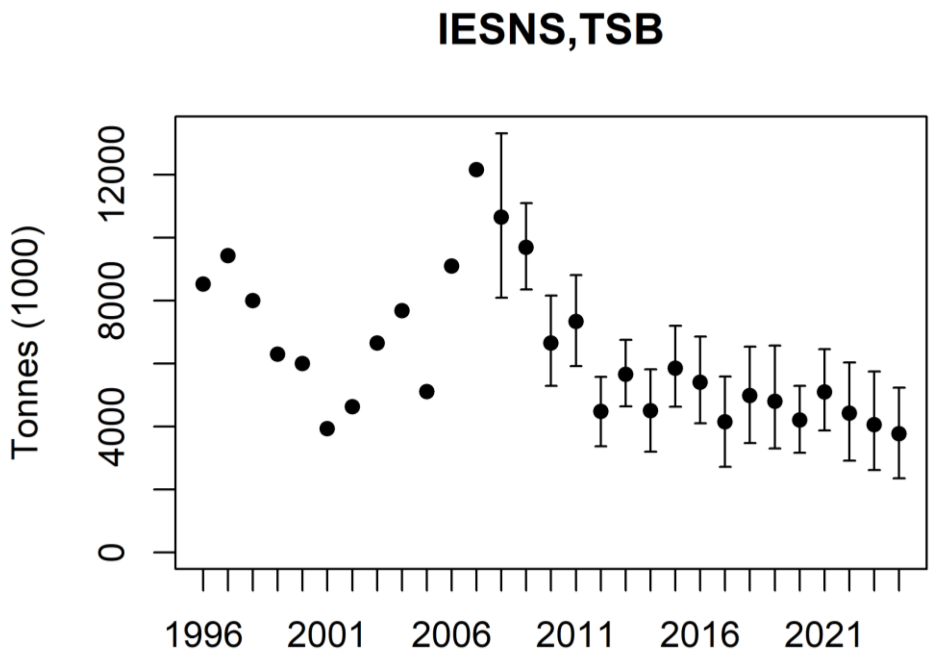


Figure 14. Biomass estimates of Norwegian-spring spawning herring in the IESNS survey (Barents Sea, east of 20°E, is excluded) from 1996 to 2024 as estimated using BEAM (1996-2007; calculated on basis of rectangles) and as estimated with the software StoX (2008-2024; bootstrap means with 90% confidence interval; calculated on basis of standard stratified transect design).

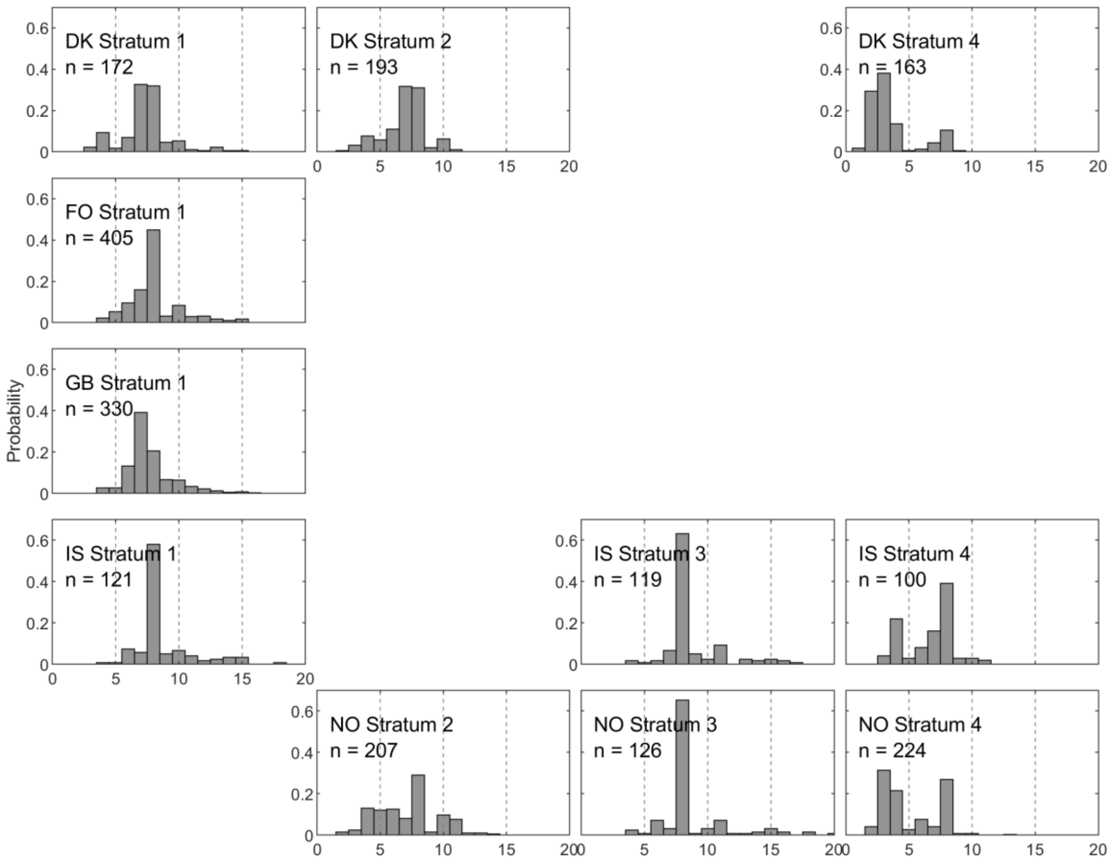
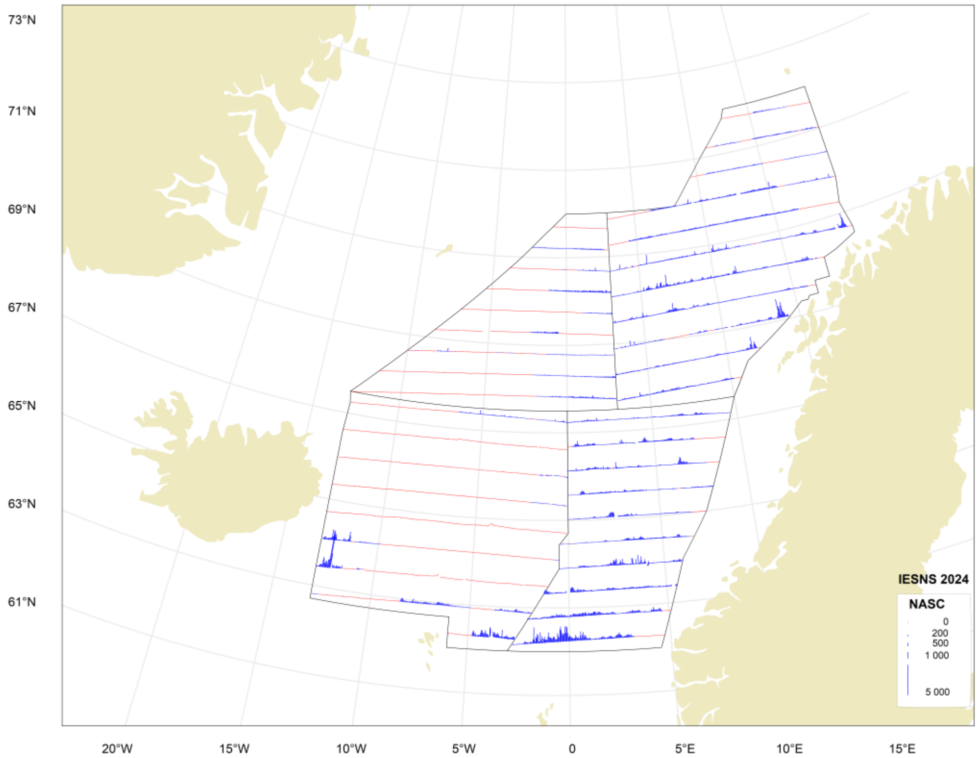


Figure 15. Comparison of the age distributions of herring by stratum and country in IESNS 2024. The strata are shown in Figure 2.

(a)



b)

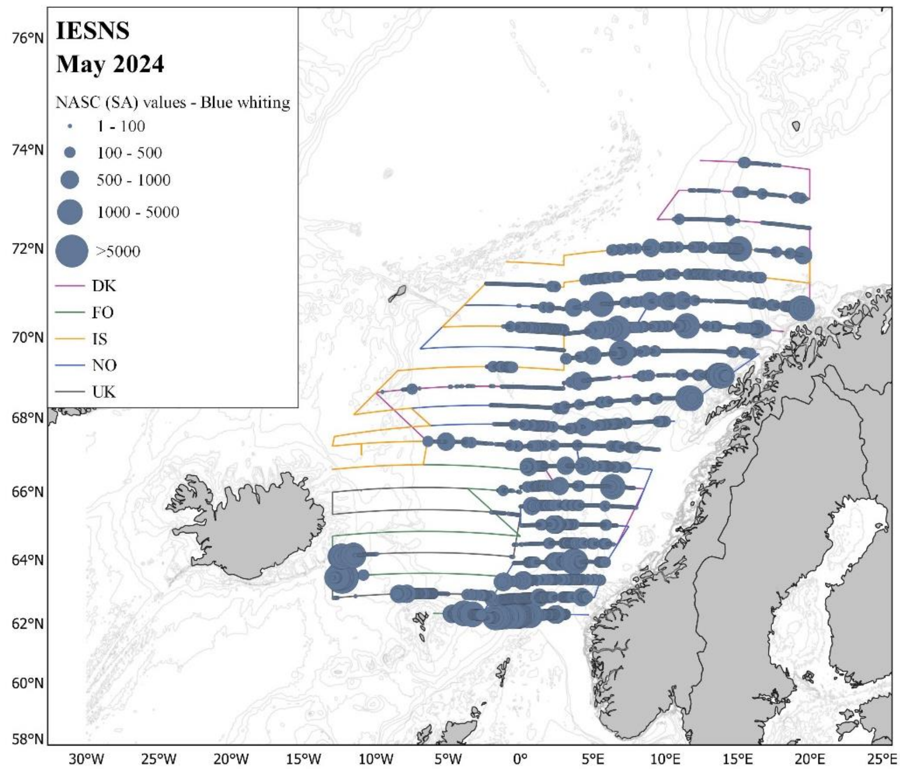


Figure 16. Distribution of blue whiting as measured during the IESNS survey in May 2024 in terms of NASC values (m²/nm²) (a) averaged for every 1 nautical mile. The NASC values are represented as both bars (a) and bubbles (b).

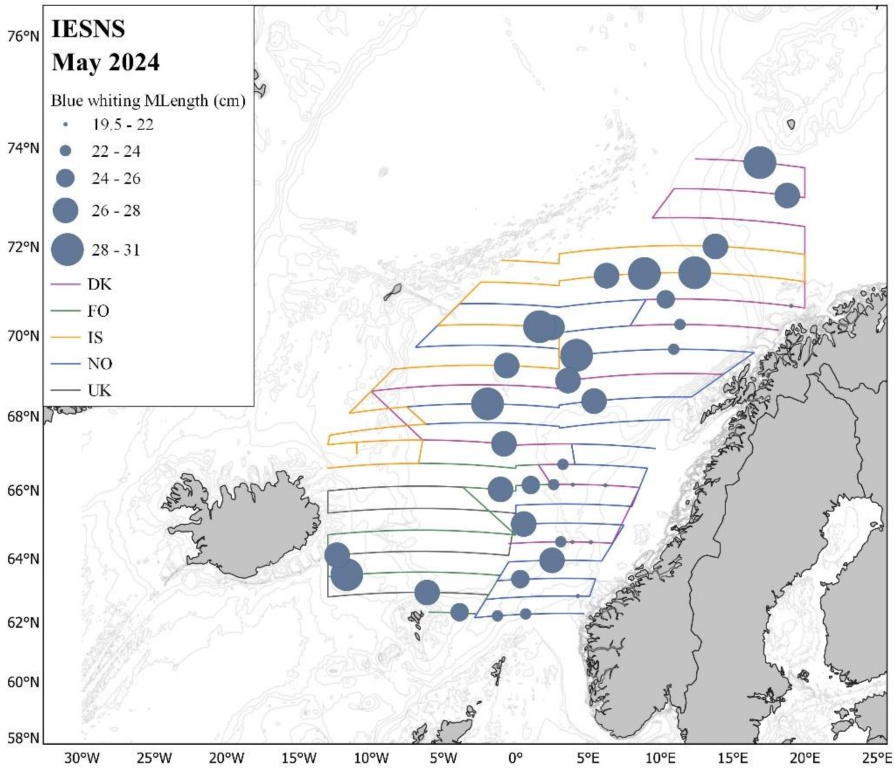


Figure 17. Mean length of blue whiting in all hauls in IESNS 2024. The strata are shown.

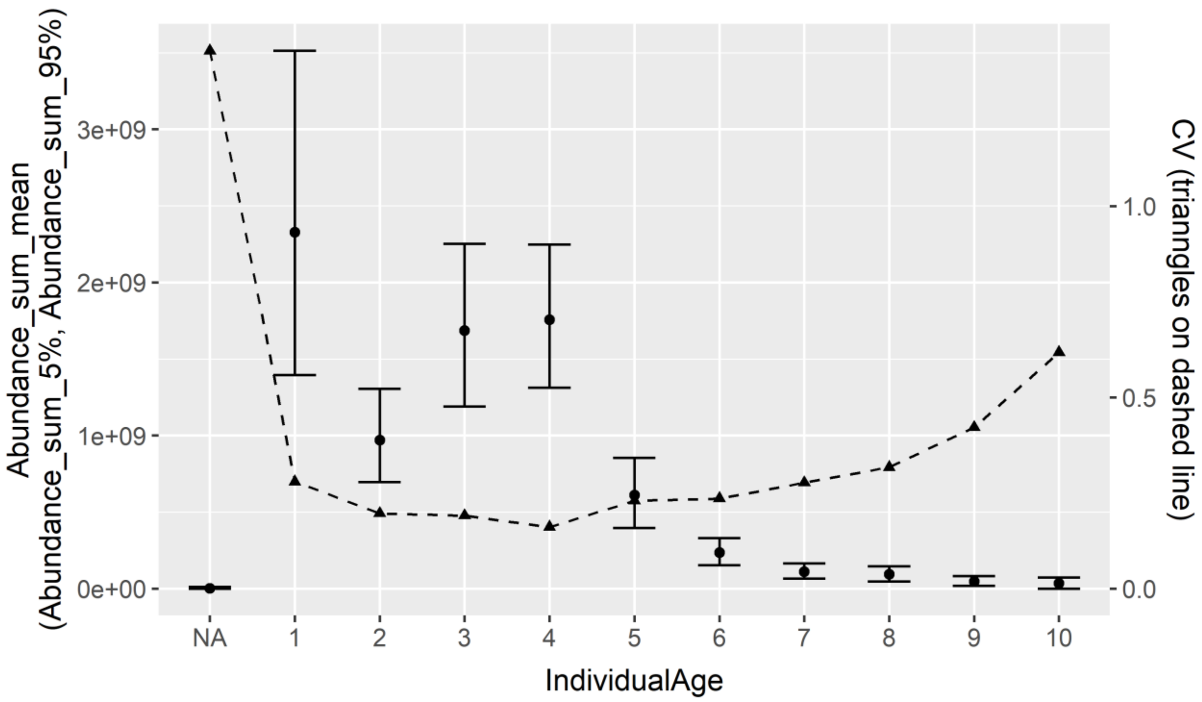


Figure 18. IESNS 2024. Blue whiting in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

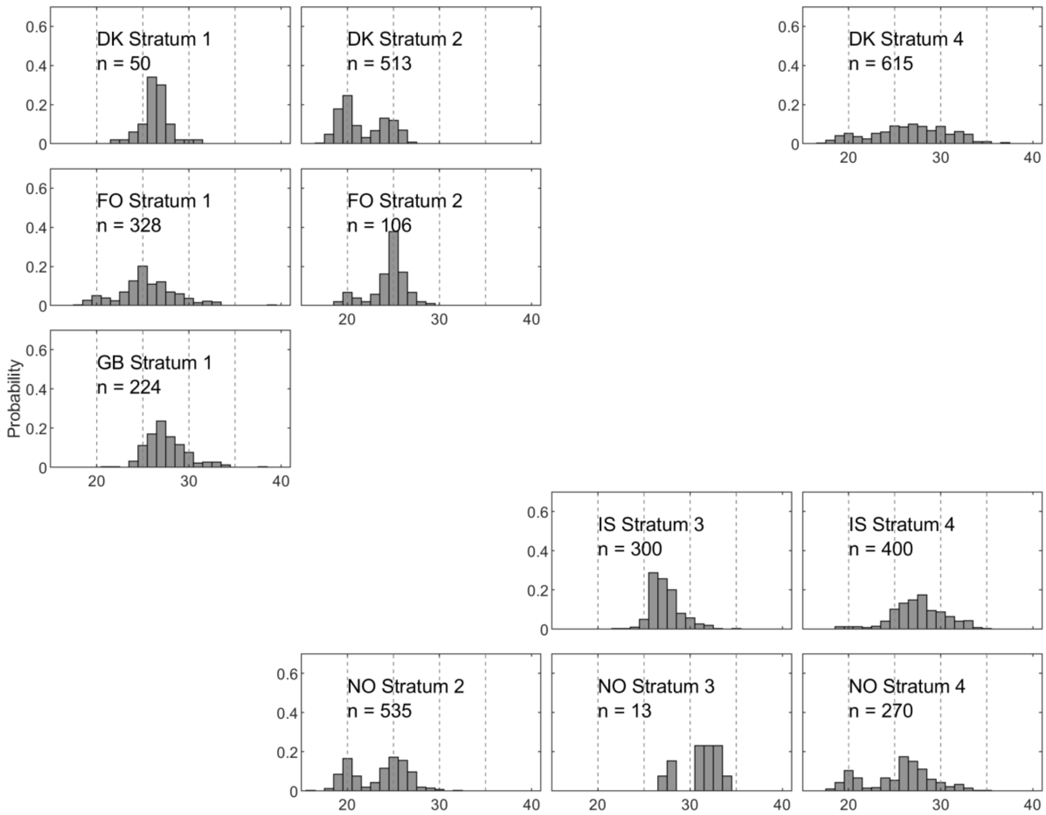


Figure 19. Comparison of the length distributions of blue whiting by stratum and country in IESNS 2024. The strata are shown in Figure 2.

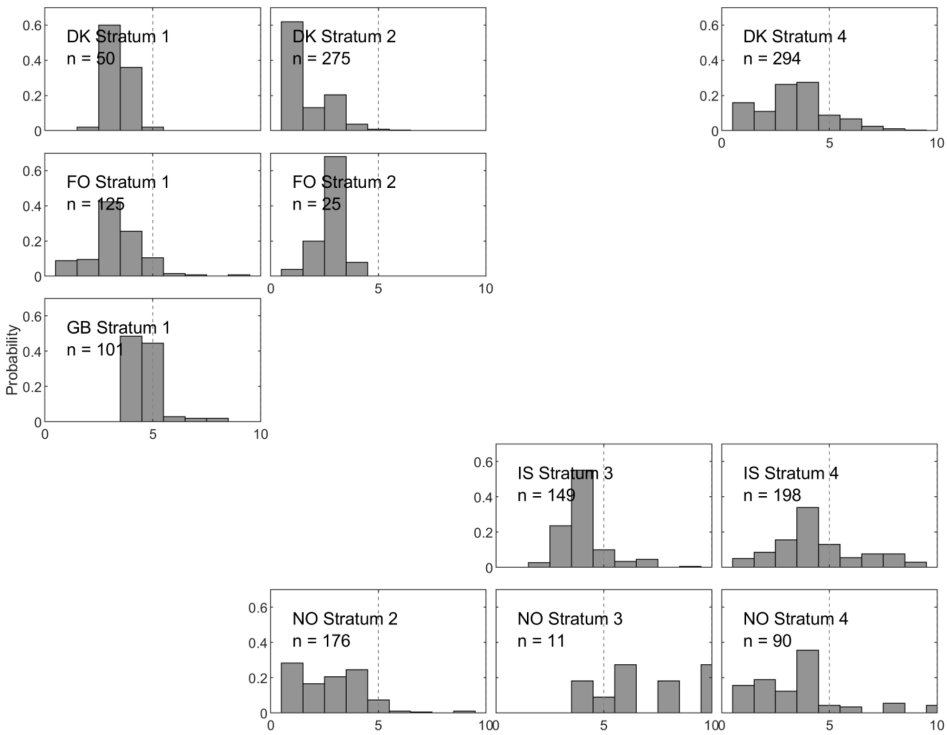


Figure 20. Comparison of the age distributions of blue whiting by stratum and country in IESNS 2024. The strata are shown in Figure 2.

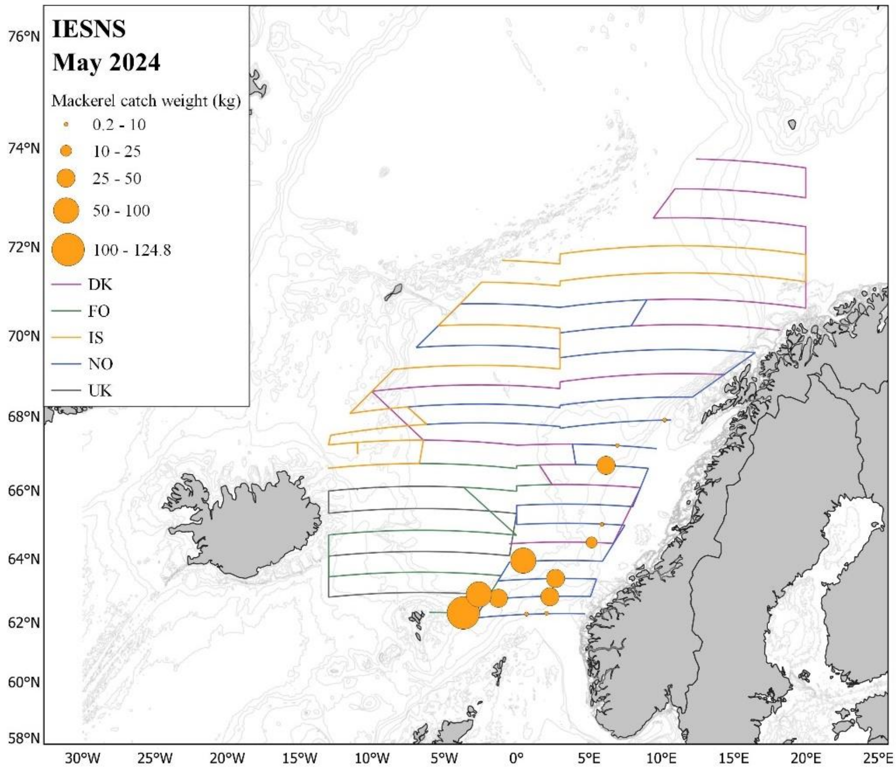


Figure 21. Pelagic trawl catches of mackerel in IESNS 2024.

Acoustic survey in the Barents Sea in April-May 2024 with RV Vilnyus

Maxim Rybakov (cruise leader) and Sergey Kharlin (acoustician)
PINRO, Murmansk, Russia

During April 16 to May 6, 2024, an acoustic trawl survey was carried out by RV Vilnyus in the Barents Sea. The data from this survey was delivered after the IESNS post-cruise meeting and the results are therefore presented as an appendix to the IESNS 2024 report. The acoustic, biological and hydrographic data are now uploaded to the PGNAPES database.

The properties of the sampling trawl used are presented in Table A1 and the survey effort in table A2. Acoustic data were analysed using the StoX software package (version 4.0.0) at IMR in Bergen.

Cruise tracks and pelagic trawl stations are shown in Figure A1. Only the eastern part of the Barents Sea was covered and the area covered was therefore smaller than normal in this survey. It should however be noted that juvenile herring normally is most abundant in the eastern part of the Barents Sea. A total of 28 pelagic trawl hauls were carried out of which 24 had catch of herring and 15 of these had more than 10 sampled individuals. This level of sampling is regarded as good compared to earlier years, as juvenile herring in the Barents Sea can be difficult to catch. Hydrographic stations and plankton stations are shown in Figure A2. Figure A3 shows the spatial distribution of herring in the survey area in terms of nautical back-scattering coefficients. Dense concentrations of herring were observed in a small part of all acoustic transects at around 70-71°N. Abundance estimates of herring by age and length are shown in Table A3. Age 2 is by far the most abundant age group and the abundance of age 2 in 2024 is almost twice as high as the abundance of the strong 2016 year class as two year olds in the 2018 survey in the Barents Sea. Since only the eastern part of the Barents Sea was covered the estimate is most likely an underestimate.

The time series of age 2 herring from the acoustic survey in the Barents Sea in April-June is currently used in the stock assessment of Norwegian spring-spawning herring. The estimate of age 2 from this survey in 2024 provides valuable information to the assessment.

Table A1. Acoustic survey in the Barents Sea in April-May 2024. Sampling trawl properties.

Vilnyus	
Circumference (m)	500
Vertical opening (m)	50
Mesh size in codend (mm)	16
Typical towing speed (kn)	3,0-3,9

Appendix

Table A2. Acoustic survey in the Barents Sea in April-May 2024. Survey effort.

Vessel	Effective survey period	Length of cruise track (nm) *	Trawl stations	CTD stations	Aged fish	Length-measured fish
Vilnyus	16/04–06/05	2031	28	60	1771	14872

Table A3. Acoustic survey in the Barents Sea in April-May 2024. Estimates of abundance (millions) by age and length, and mean length (cm) of Norwegian spring-spawning herring. The estimates are mean of 1000 bootstrap replicates in Stox.

	Age in years (year class)					Number
Length	1	2	3	4	5	
(cm)	2023	2022	2021	2020	2019	(10^6)
7-8	54.9					54.9
8-9	165.7	56.1				165.7
9-10	224.4	111.3				280.5
10-11	222.6	864.2				333.9
11-12	288.1	2508.9				1152.3
12-13	147.6	5471.4				2656.5
13-14		9198.5				5471.4
14-15		7569.0				9198.5
15-16		3962.2	61.5			7630.6
16-17		2140.4	236.5	59.1		4257.9
17-18		307.3	566.5			2706.8
18-19			1045.1			1352.4
19-20			726.9			726.9
20-21			1002.3			1002.3
21-22			277.5	110.8	55.3	443.7
22-23			51.7	103.4		155.1
23-24				91.7		91.7
24-25				91.7		91.7
TSN(10^6)	1103.2	32189.4	3968.1	456.7	55.3	37772.7
cv (TSN)	0.74	0.65	0.68	0.75	0.83	0.64
Mean length(cm)	9.7	14.3	18.6	21.3	21.0	

Appendix

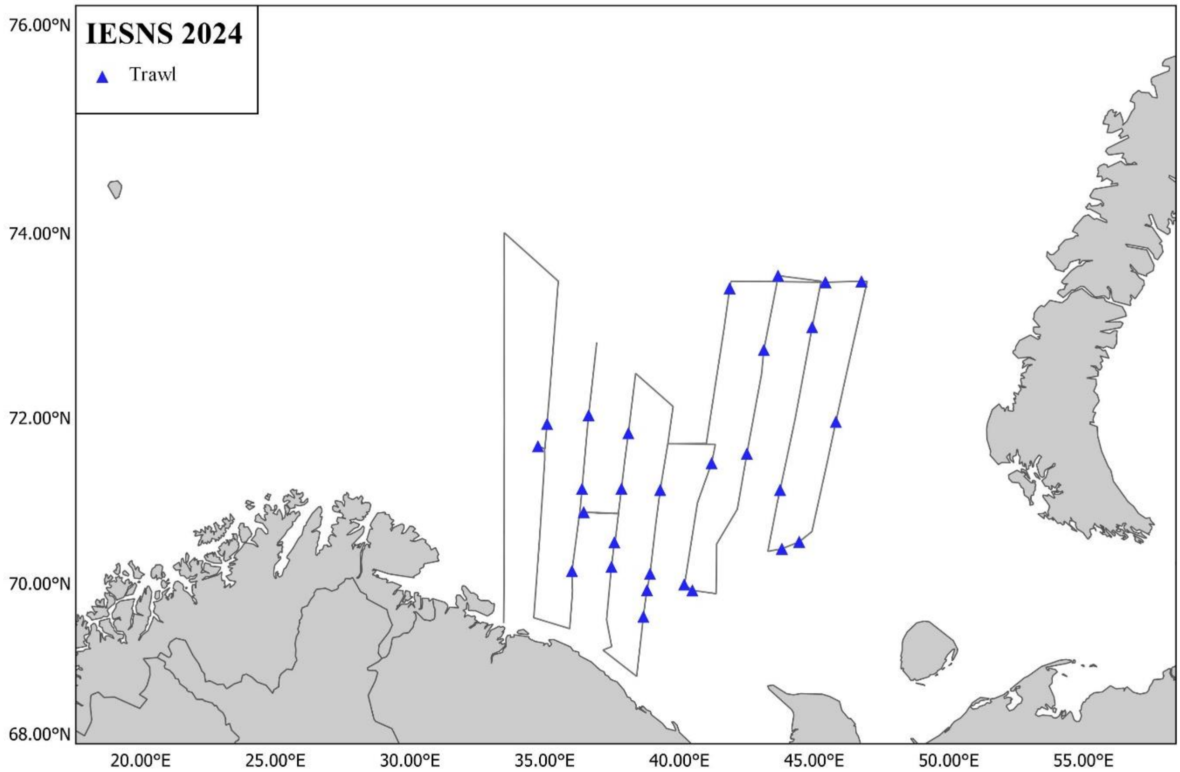


Figure A1. Acoustic survey in the Barents Sea in April-May 2024. Cruise track and pelagic trawl stations.

a)

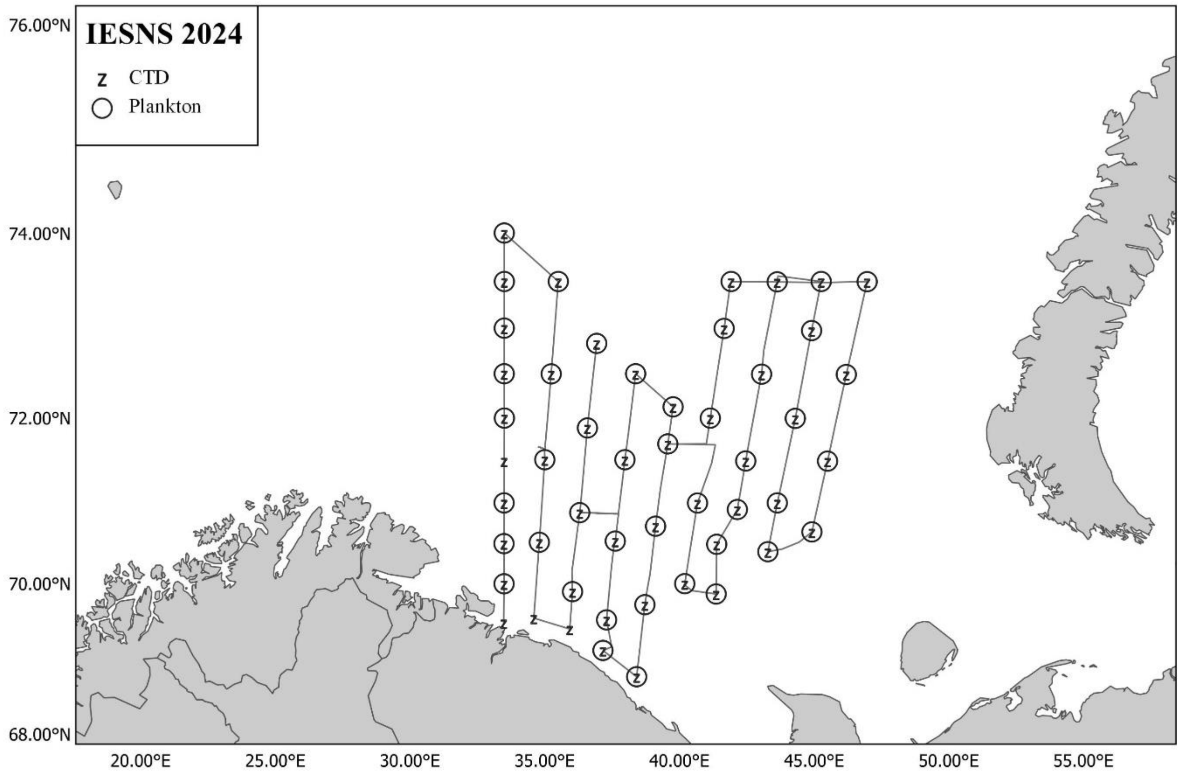
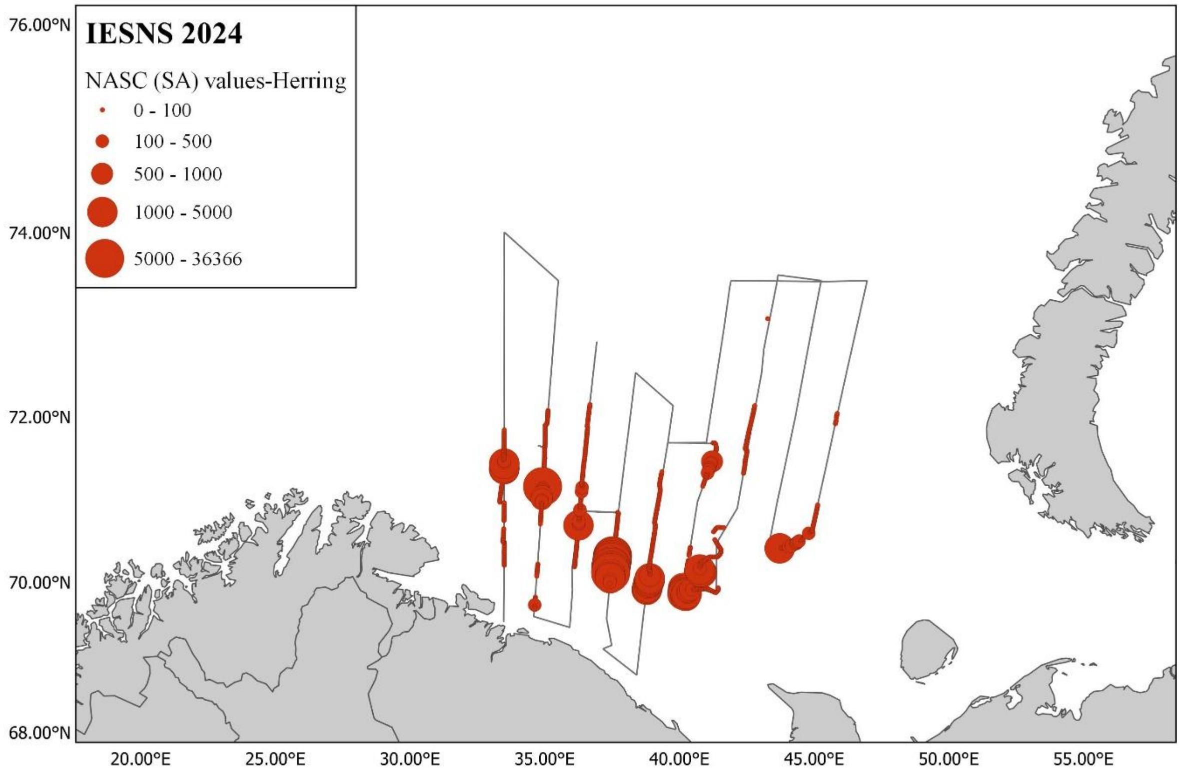


Figure A2. Acoustic survey in the Barents Sea in April-May 2024. Hydrographic stations and plankton stations.

Appendix

a)



b)

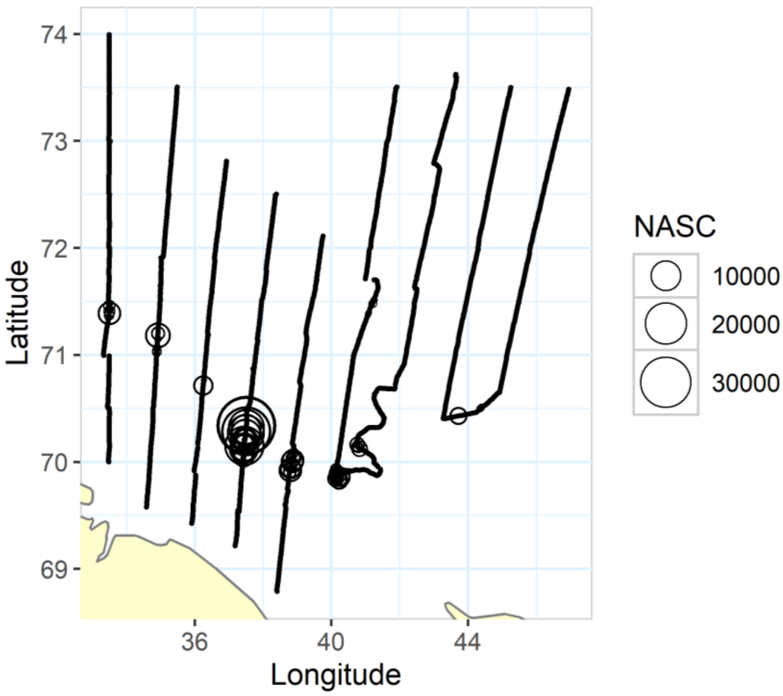


Figure A3. Acoustic survey in the Barents Sea in April-May 2024. Distribution of Norwegian spring-spawning herring in terms of NASC values (m2/nm2) averaged for every 1 nautical mile. The NASC values are presented with two different bubble types and scales (Figure a and b).