Working Document to

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Preliminary cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS)
28th June – 2nd August 2024

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1 Executive summary

The International Ecosystem Summer Survey in the Nordic Seas (IESSNS) was performed within approximately 5 weeks from June 28th to August 2nd in 2024 using five vessels from Norway (2), Iceland (1), Faroe Islands (1) and Denmark (1). The main objective is to provide annual age-segregated abundance index with start in 2010, with an uncertainty estimate, for northeast Atlantic mackerel (*Scomber scombrus*) using a standardised pelagic swept area trawl method. Another aim is to construct abundance indices for blue whiting (*Micromesistius poutassou*) and for Norwegian spring-spawning herring (NSSH) (*Clupea harengus*). This is obtained by utilizing standardized acoustic methods to estimate their abundance in combination with biological trawling on acoustic registrations. The time series for blue whiting and NSSH now consists of nine years (2016-2024).

The total swept-area mackerel index in 2024 was 2.5 million tonnes in biomass and 5.6 billion in numbers, a decrease of 42% for biomass and 48% for abundance compared to 2023. In 2024, most abundant year-classes were from 2020 (age 4) and 2019 (age 5), respectively. The internal consistency between cohorts improved overall compared to last year and ranged from good to strong for all ages. Mackerel of age 1, 2 and to some extent age 3 are not completely recruited to the survey, because the main nursery area was further south than the surveyed area. All the surveyed mackerel were in the Norwegian Sea. However, compared with previous years, the mackerel appears to have retracted to the central and southern Norwegian Sea in 2024: i) the western border retracted from west coast of Iceland to the East coast of Iceland (from 25° to 10° W); ii) the northern boundary of mackerel retracted from latitude 78 °N in 2023 to latitude 72 °N in 2024.

Norwegian spring-spawning herring (NSSH) was predominantly recorded in the northern Norwegian Sea and in the Jan Mayen zone. The total biomass index of Norwegian spring-spawning herring measured during IESSNS 2024 was 3.78 million tonnes, 24% lower than in 2023. A reduction of 11% was recorded in the abundance for adult fish age 4+. The 2016 year-class (8-year-olds) dominated in the stock and contributed 56% to the total biomass. Other year classes are much weaker with less than 10% compared to the 2016-year class. The zero-boundary of the distribution of the mature part of NSSH was reached in all directions, except for the northwestern area between Jan Mayen and Greenland. The herring was mainly observed in the upper surface layer as relatively small schools.

Blue whiting was distributed in parts of the survey area dominated by warm Atlantic waters and had a continuous distribution from the southern boundary of the survey area (60° N) to Bear Island (74.30° N). The total biomass index of blue whiting was very similar in 2024 (1.96 mill ton) compared to 2023 (1.98 million ton). Estimated stock abundance (ages 1+) was 17.7 billion in 2024 compared to 20.8 billion in 2023 (15% decrease). Ages 4 and 3 respectively, dominated the estimate in 2024 as they contributed to 26% and 21% (abundance) and 36% and 27% (biomass), respectively. Interestingly, 0-group contributed with 24% in abundance in 2024.

Other fish species were also monitored such as lumpfish (*Cyclopterus lumpus*), capelin (*Mallotus villosus*), polar cod (*Boreogadus saida*), and Atlantic salmon (*Salmo salar*). A separate coverage of capelin in the Jan Mayen zone will be included in the final version of the report.

Satellite measurements of sea surface temperature (SST) in the central areas in the Northeast Atlantic in July 2024 were slightly warmer than the long-term average for July 1990-2009. The northern regions of the Nordic Seas were slightly warmer than the average, while the East Greenland Current was cooler than the long-term average. The SST in the Irminger Sea was similar to the long-term average, and slightly colder in the Iceland Basin. Overall, the temperatures were cooler in 2024 compared to 2023 and more similar to the long-term average.

The zooplankton biomass varied between areas with a patchy distribution throughout the area, with high concentration north of Iceland and north of Faroes Island. In the Norwegian Sea areas, vast regions had biomass values below 10 g/m^2, with an average value around 7 g/m^2, which is lower than last year.

Systematic observations of marine mammals using two separate platforms were conducted onboard M/V "Eros" from Norway, R/V "Jákup Sverri" from Faroe Islands and R/V "Arni Fridriksson" from Iceland, during IESSNS 2024 as part of the North Atlantic Sighting Survey.

2 Introduction

During approximately five weeks of survey in 2024 (28th of June to 2nd of August), five vessels; the M/V "Eros" and M/V "Vendla" from Norway, "Jákup Sverri" operating from Faroe Islands, the R/V "Árni Friðriksson" from Iceland and M/V "Ceton" operating in the North Sea by Danish scientists, participated in the International Ecosystem Summer Survey in the Nordic Seas (IESSNS).

The major aim of the coordinated IESSNS was to collect data on abundance, distribution, migration, and ecology of Northeast Atlantic (NEA) mackerel (*Scomber scombrus*) during its summer feeding migration phase in the Nordic Seas and surrounding coastal and offshore waters. The resulting abundance index will be used in the stock assessment of NEA mackerel at the annual meeting of ICES working group of widely distributed stocks (WGWIDE). The IESSNS mackerel index goes back to 2010. Since 2016, systematic acoustic abundance estimation of both Norwegian spring-spawning herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) have also been conducted. This is considered as potential input for stock assessment since the time series are sufficiently long. Furthermore, the IESSNS is a pelagic ecosystem survey collecting data on physical oceanography, plankton, and other fish species such as lumpfish, capelin, polar cod, and Atlantic salmon. In 2024 systematic whale observations applying two separate platforms were conducted by Norway (Eros), Iceland (Árni Friðriksson) and Faroe Islands (Jákup Sverri). Opportunistic whale observations have also been recorded from Norway (Vendla). The wide geographical coverage, standardization of methods, sampling on many trophic levels and international cooperation around this survey facilitates research on the pelagic ecosystem in the Nordic Seas, see e.g. Nøttestad et al. (2016), Jansen et al. (2016), Bachiller et al. (2018), Olafsdottir et al. (2019), Nikolioudakis et al. (2019), Løviknes et al. (2021), dos Santos Schmidt et al. (2024), and Ono et al. (2024).

The methods have evolved over time since the survey was initiated by Norway in the Norwegian Sea in the beginning of the 1990s. The main elements of international standardization were conducted in 2010. Minor improvements have been implemented since 2010. Faroe Islands and Iceland have participated in the joint mackerel-ecosystem survey since 2009. Greenland since 2013 and Denmark from 2018. Greenland did not participate in 2021, 2023, and 2024 but participated with their new research vessel R/V "Tarajoq" back in 2022.

The North Sea was included in the survey area for the seventh time in 2024, following the recommendations of WGWIDE. This was done by scientists from DTU Aqua, Denmark. The commercial fishing vessels "Ceton S205" was used. No problems applying the IESSNS methods were encountered. Area coverage, however, was restricted to the northern part of the North Sea at water depths deeper than 50 m (see Appendix 1 for comparison of the 2018 - 2024 results).

3 Material and methods

Coordination of the IESSNS 2024 was done during the WGIPS 2024 hybrid meeting at the Faroe Marine Research Institute (Havstovan) in Torshavn, Faroe Island in January 2024, and by correspondence in December 2023 and during spring and summer 2024. The participating vessels together with their effective survey periods are listed in Table 1.

Overall, the weather conditions were calmer and less windy in the east compared to the west for the two Norwegian vessels, but nevertheless providing good survey progress as well as favourable conditions for the acoustic recordings and pelagic trawling onboard both Vendla in the east and Eros in the west. It was sometimes challenging for the systematic marine mammal observations onboard Eros, due to windy conditions and fog during part of the survey, operating in the western and northwestern part of the Norwegian Sea. The Icelandic vessel experienced in general calm weather for duration of the survey with 12 hours of survey delay due to rough weather and two WP2-net stations were not sampled due to high winds. For the Faroese vessel, the survey was not hampered by weather; however, the systematic marine mammal observations were hampered during the first half of the survey. The chartered vessel Ceton had moderate to bad weather conditions throughout the survey.

The northwestern boundary of the mackerel distribution in the western part of the Norwegian Sea (dynamic stratum 9) was reduced compared to the number predetermined fixed stations planned prior to survey start. Same occurred with the eastern border of dynamic stratum 7, from Bear Island to the coast of Finnmark. Area of strata 5 (west of Iceland) and 6 (south of Iceland) was reduced to reflect number of sampled surface trawl stations. In those two strata 42% of planned surface trawl stations was not sampled as no mackerel was present in the area.

During the IESSNS, the special designed pelagic trawl, Multpelt 832, has been applied by all participating vessels since 2012. This trawl is a product of cooperation between participating institutes in designing and constructing a standardized sampling trawl for the IESSNS. The work was led by trawl gear scientist John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway (Valdemarsen et al. 2014). The design of the trawl was finalized during meetings of fishing gear experts and skippers at meetings in January and May 2011. Further discussions on modifications in standardization between the rigging and operation of Multpelt 832 was done during a trawl expert meeting in Copenhagen 17-18 August 2012, in parallel with the post-cruise meeting for the joint ecosystem survey, and then at the WKNAMMM workshop and tank experiments on a prototype (1:32) of the Multpelt 832 pelagic trawl, conducted as a sequence of trials in Hirtshals, Denmark from 26 to 28 February 2013 (ICES 2013a). The swept area methodology was presented and discussed during the WGISDAA workshop in Dublin, Ireland in May 2013 (ICES 2013b). The standardization and quantification of catchability from the Multpelt 832 pelagic trawl was further discussed during the mackerel benchmark in Copenhagen in February 2014. Recommendations and requests coming out of the mackerel benchmark in February 2014, were considered and implemented during the IESSNS survey in July-August 2014 and in the surveys thereafter. Furthermore, recommendations and requests resulting from the mackerel benchmark in January-February 2017 (ICES 2017), were carefully considered and implemented during the IESSNS survey in July-August 2017. In 2018, the Faroese and Icelandic vessels employed new, redesigned cod-ends with the capacity to hold 50 tonnes. This was done to avoid the cod-end from bursting during hauling of large catches as occurred at three stations in the 2017 IESSNS. During the last few years with significantly reduced spatial distribution, densities and abundance of NEA mackerel, such issues have not been present to any extent during the pelagic swept-area trawling.

Table 1. Survey effort by each of the five vessels during the IESSNS 2024. The number of predetermined ("fixed") trawl stations being part of the swept-area stations for mackerel in the IESSNS are shown after the total number of trawl stations.

Vessel	Effective survey	Length of cruise	Total trawl stations/	CTD stations	Plankton stations

	period	track (nmi)	Fixed stations		
Árni Friðriksson	1/7-2/8	5917	53/43	43	41
Jákup Sverri	28/6-12/7	2466	39/34	34	34
Ceton	5-13/7	1850	34/35	34	-
Vendla	2/7-30/7	5212	85/66	66	66
Eros	3/7-30/7	5022	76/62	62	62
Total	28/6-2/8	14239	287/240	239	203

3.1 Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 1. Eros, Vendla, Árni Friðriksson and Jákup Sverri were all equipped with a SEABIRD CTD sensor and Árni Friðriksson and Jákup Sverri moreover also had a water rosette. Ceton used a Seabird SeaCat offline CTD. The CTD-sensors were used for recording temperature, salinity, and pressure (depth) from the surface down to 500 m, except 750 m on the Icelandic vessel, or to the bottom when at shallower depths.

Zooplankton was sampled with a WP2-net on 4 vessels, excluding Ceton which operates in the North Sea. Mesh sizes were 180 µm (Eros and Vendla) and 200 µm (Árni Friðriksson and Jákup Sverri). The net was hauled vertically from a depth of 200 m (or bottom depth at shallower stations) to the surface at a speed of 0.5 m/s. All samples were split in two, one half preserved for species identification and enumeration, and the other half dried and weighed. The zooplankton was sorted into three size categories (µm), > 2000, 1000–2000, 180/200–1000, on the Norwegian and Faroese vessels; and two size fractions (µm), > 1000 and 200–1000, on the Icelandic vessel. Detailed description of the zooplankton and CTD sampling is provided in the survey manual (ICES 2014a).

Two planned WP2-plankton samples were not taken due to bad weather. The number of stations taken by the different vessels is provided in Table 1.

3.2 Trawl sampling

All vessels used the standardized Multpelt 832 pelagic trawl (ICES 2013a; Valdemarsen et al. 2014; Nøttestad et al. 2016) for trawling, both for fixed surface stations and for trawling at greater depths to confirm acoustic registrations and to target blue whiting registrations identified by echograms. Standardization of trawl deployment was emphasised during the survey as in previous years (ICES 2013a; ICES 2014b; ICES 2017). Sensors on the trawl doors, headrope and ground rope of the Multpelt 832 trawl recorded data, and allowed live monitoring, of effective trawl width (actually door spread) and trawl depth. The properties of the Multpelt 832 trawl and rigging on each vessel is reported in Table 2.

Trawl catch was sorted to the highest taxonomical level possible, usually to species level for fish, and total weight per species was recorded. The processing of trawl catch varied between nations. The Norwegian vessels sorted the whole catch to species but the Faroese vessel sub-sampled the catch before sorting if catches were more than 500 kg. Sub-sample size ranged from 60 kg (if it was clean catch of either herring or mackerel) to 200 kg (if it was a mixture of herring and mackerel); however, other species were mostly sorted out of the full catch. On the Icelandic vessel, the whole catch was sorted to species for all species.

The biological sampling protocol for trawl catch varied between nations in number of specimens sampled per station (Table 3).

Results from the survey expansion southward into the North Sea are analyzed separately from the traditional survey grounds north of latitude 60°N as per stipulations from the 2017 mackerel benchmark meeting (ICES 2017). However, data collected with the IESSNS methodology from the Skagerrak and the northern and western part of the North Sea are now available for seven years (2018-2024).

Table 2. Trawl settings and operation details during the international mackerel survey in the Nordic Seas from 28th June to 2nd August 2024. The column for influence indicates observed differences between vessels likely to influence performance. Influence is categorized as 0 (no influence) and + (some influence).

Properties	**Árni Friðriksson**	**Vendla**	**Ceton**	**Jákup Sverri**	**Eros**	**Influence**
Trawl producer	Ísfell new trawl in 2023	Egersund Trawl AS	Egersund Trawl AS	Vónin (2024)	Egersund Trawl AS	0
Warp in front of doors	Dynex-34 mm	Dynex -34 mm	Dynex	Dynex – 38 mm	Dynex-34 mm	+
Warp length during towing	350	350	315-350	350 (350-380)	350	0
Difference in warp length port/starb. (m)	11-19	2-10	5-10	0-10	5-10	0
Weight at the lower wing ends (kg)	2×400	2×400	2×400	2×400	2×400	0
Setback (m)	6	6	6	6	6	+
Type of trawl door	Hampidjan Polyice Jupiter	Seaflex 7.5 m^2 adjustable hatches	Thybron type 15	Twister	Seaflex 7.5 m^2 adjustable hatches	0
Weight of trawl door (kg)	2200	1700	1970	1650	1700	+
Area trawl door (m^2)	7	7.5 with 25% hatches (effective 6.5)	7	4.5	7 with 50% hatches (effective 6.5)	+
Towing speed (knots) mean (min-max)	5.2 (4.6-5.7)	4.5 (3.9-5.4)	4.9 (4.1-5.5)	4.4 3.64-5.3)	4.6 (4.1-5.4)	+
Trawl height (m) mean (min-max)	31 (25-41)	32.7 (28.2-42.5)	28.9 (24.9-34.2)	36.4 (30-46)	26.4 (24.1-29.4)	+
Door distance (m) mean (min-max)	114 (97 - 120)	115.8 (109.2-1234.4)	121.0 (109.7-126.1)	116.5 (110-130)	134.8 (124.3-142.3)	+
Trawl width (m)*	66.0	63.8	68.0	63.9	72.8	+
Turn radius (degrees)	5	5-12 SB turn	5-10	5 BB/SB turn	5-8 SB turn	+
Fish lock front of cod-end	Yes	Yes	Yes	Yes	Yes	+
Trawl door depth (port, starboard, m) (min-max)	8-24, 6-30	6-22, 8-23	7-20, 6-18	4-20, 4-22	6-18, 8-20	+
Headline depth (m)	0	0	0	0	0	+
Float arrangements on the headline	Kite + 1 buoy on each wingtip	Kite with fender buoy +2 buoys on each wingtip	Kite with fender buoy + 2 buoys on each wingtip	Kite with + 1 buoy and kite on each wingtip	Kite + 2 buoy on each wingtips	+
Weighing of catch	All weighed	All weighted	All weighed	All weighed	All weighted	+

* calculated from door distance (Table 6)

Table 3. Protocol of biological sampling during the IESSNS 2024. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Iceland	Norway	Denmark
Length measurements	Mackerel	200/100*	150	100	≥ 125
	Herring	200/100*	200	100	75
	Blue whiting	200/100*	100	100	75
	Lumpfish	all	all	all	all
	Salmon	All (1)	all	all	-
	Capelin	-	100	25-30	
	Other fish sp.	20-50	50	25	As appropriate
Weight, sex and maturity determination	Mackerel	15-25	50	25	***
	Herring	25-50	50	25	0
	Blue whiting	15-50	50	25	0
	Lumpfish	0-6	1^	25	0
	Salmon	All (1)	0	25	0
	Capelin	-	50		
	Other fish sp.	0-20	0	0	0
Otoliths/scales collected	Mackerel	15-25	25	25	***
	Herring	25-50	25	25	0
	Blue whiting	15-50	50	25	0
	Lumpfish	0	8^	0	0
	Salmon	-	0	0	0
	Capelin		50		
	Other fish sp.	0	0	0	0
Fat content	Mackerel	0	10	0	0
	Herring	0	10	0	0
	Blue whiting	0	10	0	0
Stomach sampling	Mackerel	5	10	10	0
	Herring	5	10	10	0
	Blue whiting	5	10	10	0
	Other fish sp.	0	0	10	0
Tissue for genotyping	Mackerel	0	0	0	0
	Herring	5-30	50**	25	0

*Length measurements / weighed individuals

**Sampled at eight stations but not stations with herring present.

*** Up to one fish per cm-group < 25 cm, two fish 25 – 30 cm and three fish > 30 cm from each station was weighed and aged.

^All live lumpfish were tagged and released, only otoliths taken from fish which were dead when brought aboard.

This year's survey was quite well synchronized in time and was conducted over a relatively short period (36 days), similar to previous years, given the large spatial coverage of around 2.2 million km^2 (Figure 1). This was in line with recommendations put forward in 2016, that the survey period should be around four weeks with mid-point around 20th of July. The main argument for this time-period was to make the IESSNS survey as synoptic as possible in space and time, and at the same time be able to finalize data and report for inclusion in the assessment for the same year.

Underwater camera observations during trawling

Onboard M/V "Vendla" a stereo camera system (Mohn Technology AS) was be used to collect image data from the first part of the cruise and include daytime hauls (~ 20, 30 min hauls). The camera system were positioned in the last part of the trawl, attached slightly ahead of the extension. The objective of this activity is to evaluate the feasibility for fish sizing and counting during the pelagic trawling.

3.3 Marine mammals

Systematic observations of marine mammals using two separate platforms were conducted onboard M/V “Eros” from Norway, R/V “Jákup Sverri” from Faroe Islands and R/V “Arni Fridriksson” from Iceland, during IESSNS 2024. Furthermore, opportunistic observations of marine mammals were conducted by scientific personnel and crew members from the bridge between 1st -31st July 2024 onboard M/V “Vendla”.

The overall coverage from the systematic marine mammal observations during IESSNS 2024 are given in the following link https://nass.nammco.org/2024/

3.4 Acoustics

Multifrequency echosounder

The acoustic equipment onboard Vendla and Eros were calibrated 1st of July 2024 for 18, 38, 70, 120 and 200 kHz. Árni Friðriksson was calibrated 4th of May 2024 for frequencies 18, 38, 70, 120 and 200 kHz. Jákup Sverri was calibrated on 20th February 2024 for 18, 38, 120, 200 and 333 kHz. Ceton did not conduct any acoustic data collection because no calibrated equipment was available, and acoustics are done in the same area and period of the year during the ICES coordinated North Sea herring acoustic survey (HERAS). All the other vessels used standard hydro-acoustic calibration procedure for each operating frequency (Foote 1987). CTD measurements were taken in order to get the correct sound velocity as input to the echosounder calibration settings.

Acoustic recordings were scrutinized to herring and blue whiting on daily basis using the post-processing software (LSSS, see Table 4 for details of the acoustic settings by vessel). Species were 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.

To estimate the abundance from the allocated NASC-values the following target strengths (TS) relationships were used.

Blue whiting: TS = 20 log(L) – 65.2 dB (rev. acc. ICES CM 2012/SSGESST:01)
Herring: TS = 20 log(L) – 71.9 dB (Foote, 1987)

Table 4. Acoustic instruments and settings for the primary frequency (38 kHz) during IESSNS 2024.

	R/V Árni Friðriksson	M/V Vendla	R/V Jákup Sverri	M/V Eros
Echo sounder	Simrad EK80	Simrad EK60	Simrad EK80	Simrad EK80
Frequency (kHz)	18, **38**, 70, 120, 200	18, **38**, 70, 120, 200	18, **38**, 70, 120, 200, 333	18, **38**, 70, 120, 200, 333
Primary transducer	ES38-7	ES38B	ES38-7	ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Drop keel
Transducer depth (m)	9.6	8	6-9	6
Upper integration limit (m)	15	15	12	15
Absorption coeff. (dB/km)	10.5	9.9	10.5	9.3
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	3.06	2.43
Transmitter power (W)	2000	2000	2000	2000
Angle sensitivity (dB)	18	23.0	21.9	23.0
2-way beam angle (dB)	-20.30	-20.70	-20.7	-20.7
TS Transducer gain (dB)	27.06	26.93	26.93	25.49
s_A correction (dB)	-0.02	-0.65	-0.05	-0.69
3 dB beam width alongship:	6.43	7.01	6.52	6.74
3 dB beam width athw. ship:	6.43	7.01	6.53	6.66
Maximum range (m)	750	500	500	500
Post processing software	LSSS v.2.16.0	LSSS 2.16.0	LSSS 2.16.0	LSSS 2.16.0

M/V Ceton: No acoustic data collection because other survey in the same area in June/July (HERAS).

Multibeam sonar

Both M/V Eros and M/V Vendla were equipped with the Simrad fisheries sonar. Medium frequency CS90 sonar (frequency range: 70-90 kHz) on M/V Eros and low frequency ST90 sonar (frequency range: 14-24 kHz) on M/V Vendla with a scientific output incorporated which allow the storing of the beam data for post-processing. Acoustic multibeam sonar data was stored continuously onboard Eros and Vendla for the entire survey.

Cruise tracks

The five participating vessels followed predetermined survey lines with predetermined surface trawl stations (Figure 1). Calculations of the mackerel index are based on swept area approach with the survey area split into 10 strata, of which 6 are permanent (1, 2, 3, 7, 10 and 13) and four dynamic (4, 5, 6 and 9) (Figure 2). Distance between predetermined surface trawl stations is constant within stratum but variable between strata and ranged from 40 to 70 nmi. The survey design using different strata is done to allow the calculation of abundance indices with uncertainty estimates, both overall and from each stratum in the software program StoX (see Salthaug et al. 2017). Temporal survey progression by vessel along the cruise tracks in June-August 2024 is shown in Figure 3. The cruising speed was between 10-11 knots if the weather permitted, otherwise the cruising speed was adapted to the weather situation.

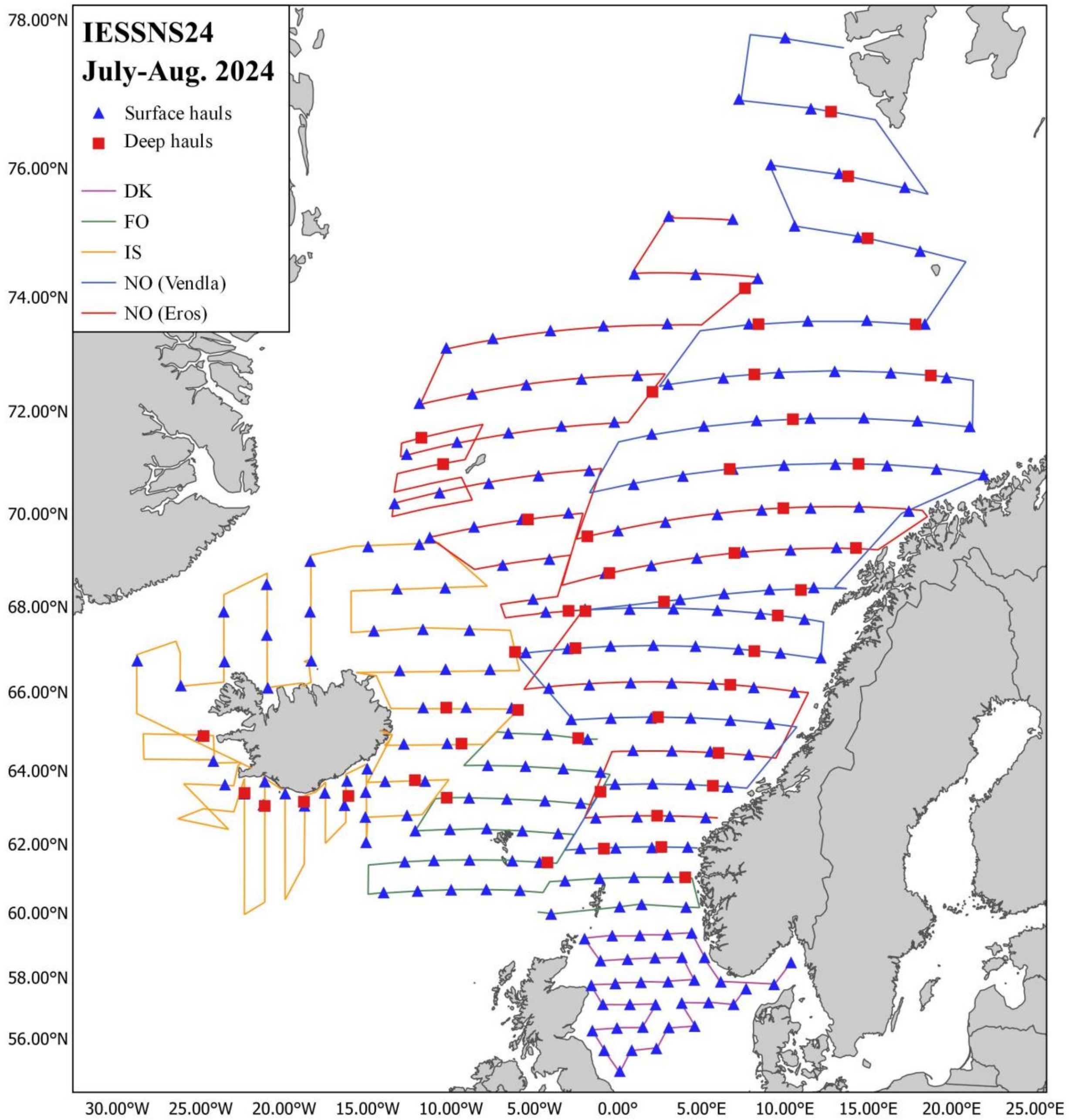


Figure 1 a. Fixed predetermined trawl stations and additional deep hauls included in the IESSNS from June 28th to August 2nd 2024. At each station a 30 min surface trawl haul was performed.

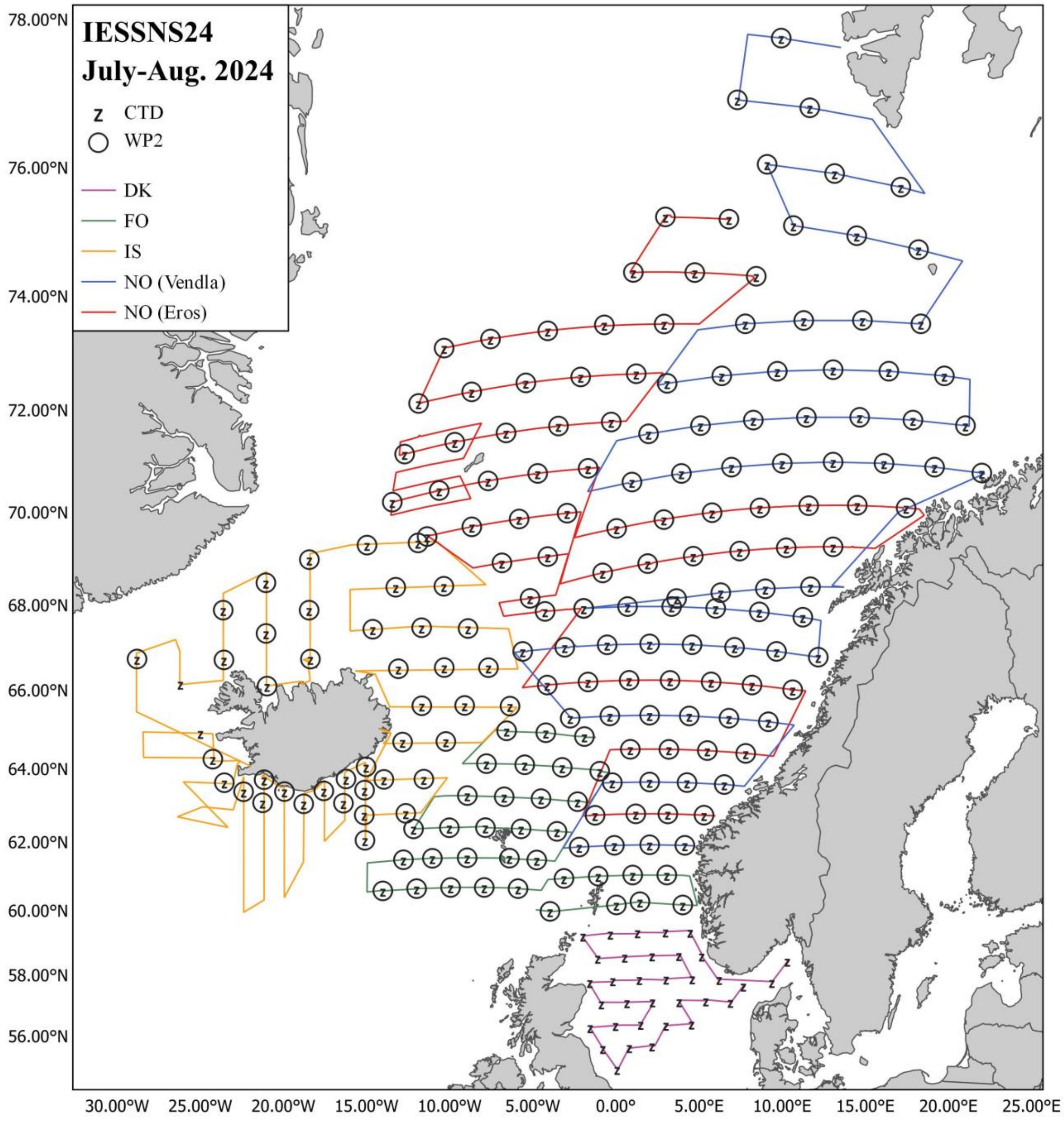


Figure 1 b. Fixed predetermined hydrographic stations (CTD and WP2) included in the IESSNS from June 28th to August 2nd 2024. CTD station (0-500 m, and 0-750m for Iceland) and WP2 plankton net samples (0-200 m depth).

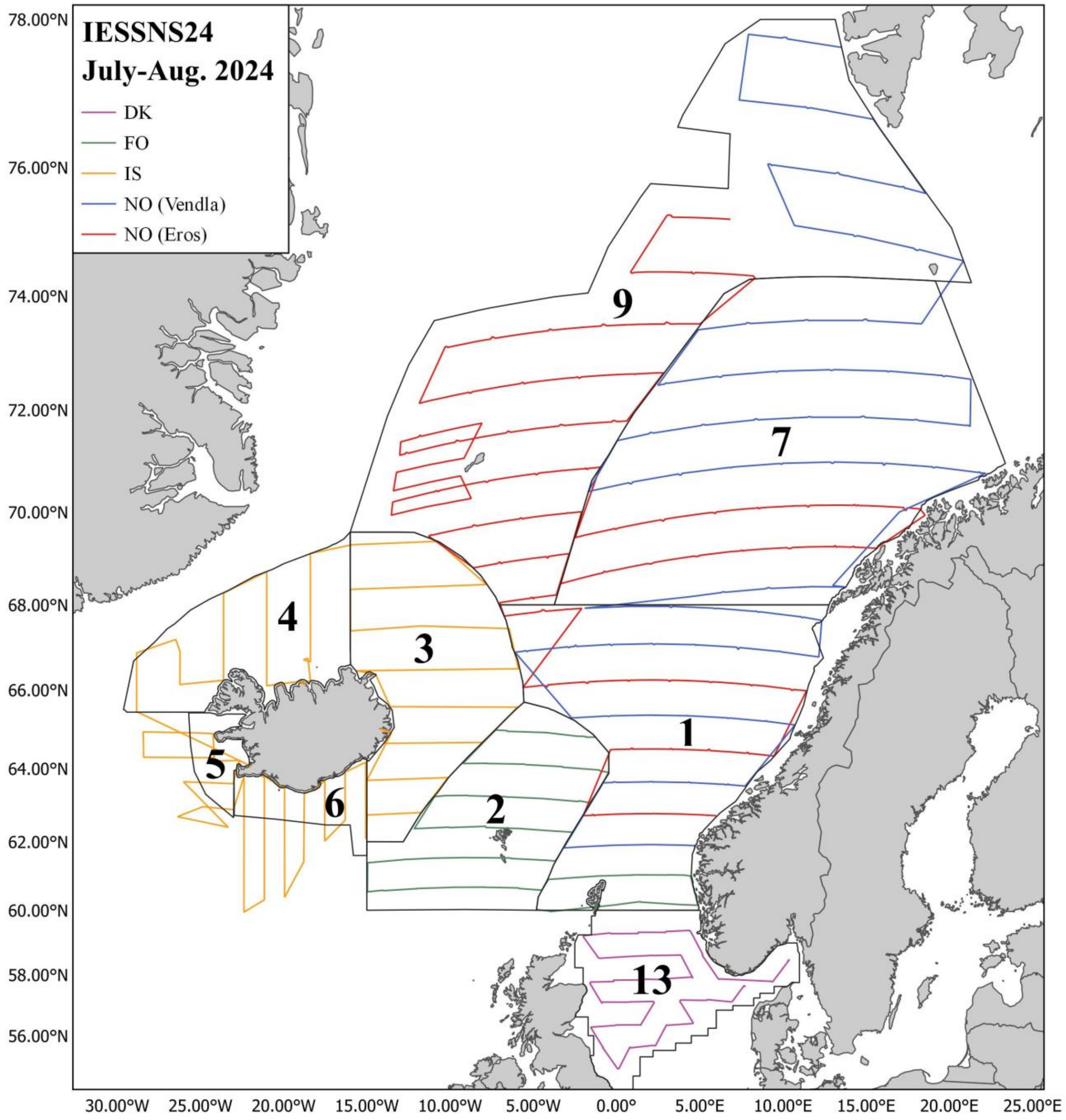


Figure 2. Permanent and dynamic strata used in StoX for IESSNS 2024. The survey area is split into 10 strata, of which 6 are permanent (1, 2, 3, 7, 10 and 13) and four dynamic (4, 5, 6 and 9). The former stratum 8 (along the Norwegian coast) was merged into adjacent strata 1 and 7. Stratum 10 (northern Greenland waters) and 11 (southern Greenland waters) were not surveyed in 2024 and are not displayed. The former stratum 12 (offshore south of Iceland) is not used any longer, since the southern boundaries of strata 5 and 6 have been converted to dynamic boundaries. For original strata boundaries see WGIPS manual (ICES 2014a). In 2023, stratum 2 was split in two strata, 2 and 14, as two predetermined surface trawl stations were not sampled on the western end of the 2nd transect from the south, see Figure 1a. Due to large variability in mackerel density within in stratum 2, the area around the skipped predetermined stations was defined as a separated stratum to reflect the mackerel density in the area. This was done to prevent inflation on mackerel abundance in the stratum 2 due to under sampling in a low-density part of stratum 2.

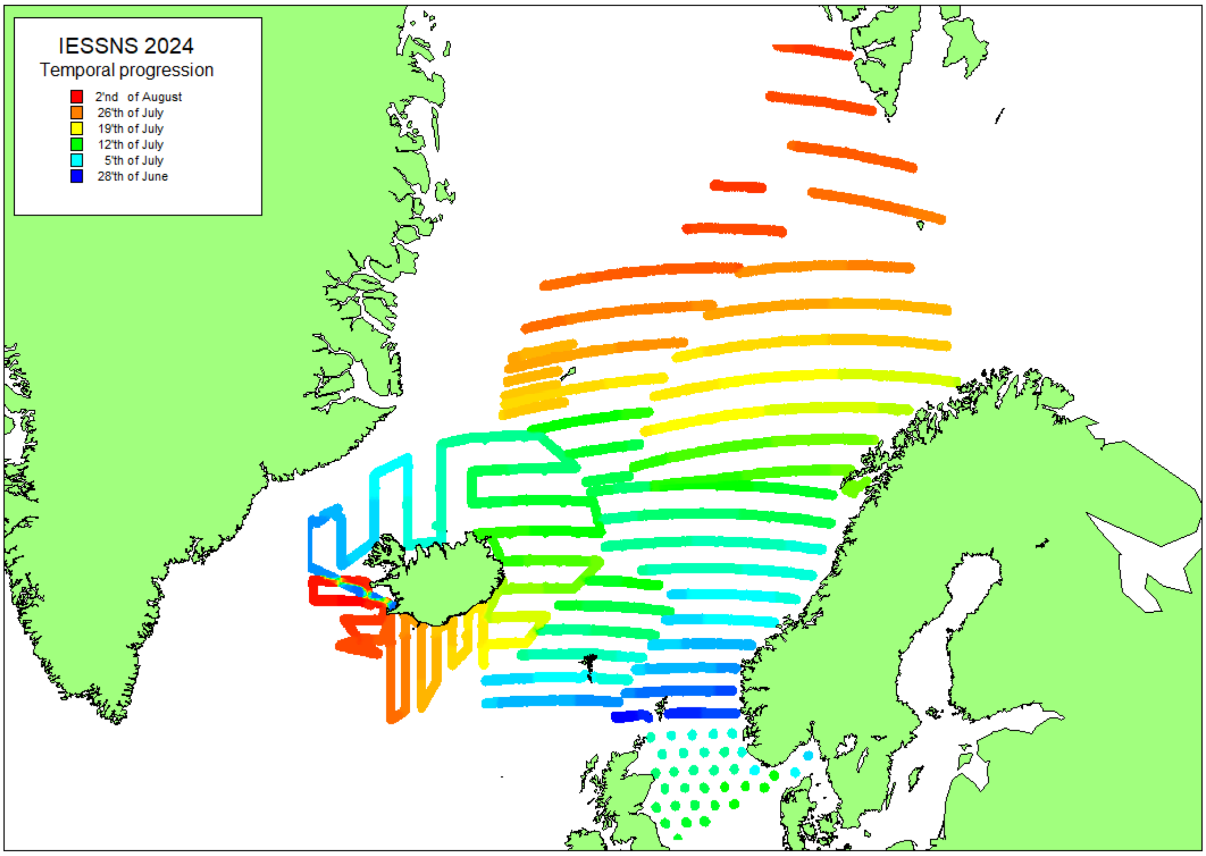


Figure 3. Temporal survey progression by vessel along the cruise tracks during IESSNS 2024: Blue represents effective survey start (28th of June) progressing to red representing a five-week span (survey ended 2nd of August). As Ceton did not submit acoustics, they have been represented by station positions.

3.5 StoX

The recorded acoustic and biological data were analysed using the StoX software package which has been used for some years now for WGIPS coordinated surveys. A description of StoX can be found in Johnsen et al. (2019) and here: www.imr.no/forskning/prosjekter/stox. Mackerel swept-area abundance index, excluding the North Sea, was calculated using StoX version 4.0.0. Also herring and blue whiting acoustic abundance indices were calculated using StoX version 4.0.0.

3.6 Swept area index and biomass estimation

This year the input data for the swept area calculations were taken from the ICES database. Up until 2020 the input data were extracted from the PGNAPES database.

The swept area age segregated index is calculated separately for each stratum. Stratum 7 and 9 were modified from the original design (Figure 2), as was reached the zero line with no mackerel in the pre-defined trawl stations. Northwest border of starta 9 and Southeast border of starta 7 were modified accordingly as show in Appendix 2. Half distance of the station separation in the strata (i. e. 60 nmi) was used to trace the new border from the last trawl station done in the transect. Individual stratum estimates are added together to get the total estimate for the whole survey area which is approximately defined by the area between 60°N and 77°N and 40°W and 20°E in 2024. An additional run is made, including the North Sea. The density of mackerel on a trawl station is calculated by dividing the total number caught by the assumed area swept by the trawl. The area swept is calculated by multiplying the towed distance by the horizontal opening of the trawl. The horizontal opening of the trawl is vessel specific, and the average value across all hauls is calculated based on door spread (Table 5 and Table 6). An estimate of total number of mackerel in a stratum is obtained by taking the average density based on the trawl stations in the stratum and multiplying this with the area of the stratum.

Table 5. Descriptive statistics for trawl door spread, vertical trawl opening and tow speed for each vessel during IESSNS 2024 at predetermined surface trawl stations. Number of trawl stations used in calculations is also reported. Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (details in Table 6).

	Jákup Sverri	RV Árni Friðriksson	Eros	Vendla	Ceton
Trawl doors horizontal spread (m)					
Number of stations	34	35	61	55	34
Mean	116.5	114	135	115	121.0
max	130	120	142	123	126.1
min	110	97	124	109	109.7
st. dev.	4.2	5.8	3.4	2.3	4.2
Vertical trawl opening (m)					
Number of stations	34	43	61	55	34
Mean	36.4	31	26	32	28.9
max	46	25	29	42	34.6
min	30	41	24	28	24.9
st. dev.	3.9	3.5	1.2	2.7	2.3
Horizontal trawl opening (m)					
Mean	63.9	66.0	72.8	63.8	68.0
Speed (over ground, nmi)					
Number of stations	34	35	61	55	34
Mean	4.4	5.2	4.6	4.5	4.9
max	5.3	5.7	5.3	5.4	5.5
min	3.6	4.6	4.1	3.9	4.1
st. dev.	0.4	0.2	0.2	0.3	0.3

Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (Table 6). The estimates in the formulae were based on flume tank simulations in 2013 (Hirtshals, Denmark) where formulas were developed from the horizontal trawl opening as a function of door spread, for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 × Door spread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 × Door spread (m) + 20.094

Table 6. Horizontal trawl opening as a function of trawl door spread and towing speed. Relationship based on simulations of horizontal opening of the Multpelt 832 trawl towed at 4.5 and 5 knots, representing the speed range in the 2014 survey, for various door spread. See text for details. In 2017, the towing speed range was extended from 5.0 to 5.2, in 2020 the door spread was extended to 122 m and in 2022 the towing speed range was extended down to 4.3 knots and up to 5.5 knots. The door spread was furthermore extended to 135 m in 2023. See also Appendix 3.

	Towing speed (knots)												
Door spread(m)	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5	5.1	5.2	5.3	5.4	5.5
100	56.5	56.9	57.2	57.7	58.2	58.7	59.2	59.7	60.2	60.7	61.2	61.7	62.2
101	56.9	57.3	57.6	58.1	58.6	59.1	59.6	60.1	60.6	61.1	61.5	62.0	62.5
102	57.3	57.7	58.1	58.6	59.0	59.5	60.0	60.5	60.9	61.4	61.9	62.4	62.9
103	57.7	58.1	58.5	59.0	59.5	59.9	60.4	60.9	61.3	61.8	62.3	62.8	63.2
104	58.1	58.5	59.0	59.4	59.9	60.3	60.8	61.3	61.7	62.2	62.7	63.1	63.6
105	58.6	59.0	59.4	59.9	60.3	60.8	61.2	61.7	62.1	62.6	63.0	63.5	63.9
106	59.0	59.4	59.8	60.3	60.7	61.2	61.6	62.1	62.5	62.9	63.4	63.8	64.3
107	59.5	59.9	60.3	60.7	61.2	61.6	62.0	62.5	62.9	63.3	63.8	64.2	64.6
108	59.9	60.3	60.7	61.1	61.6	62.0	62.4	62.9	63.3	63.7	64.1	64.6	65.0
109	60.4	60.8	61.2	61.6	62.0	62.4	62.8	63.2	63.7	64.1	64.5	64.9	65.3
110	60.9	61.2	61.6	62.0	62.4	62.8	63.2	63.6	64.1	64.5	64.9	65.3	65.6
111	61.3	61.7	62.0	62.4	62.8	63.2	63.6	64.0	64.4	64.8	65.2	65.6	66.0
112	61.8	62.1	62.5	62.9	63.3	63.7	64.0	64.4	64.8	65.2	65.6	66.0	66.3
113	62.2	62.6	62.9	63.3	63.7	64.1	64.4	64.8	65.2	65.6	66.0	66.3	66.7
114	62.7	63.0	63.4	63.7	64.1	64.5	64.9	65.2	65.6	66.0	66.3	66.7	67.0
115	63.1	63.5	63.8	64.2	64.5	64.9	65.3	65.6	66.0	66.3	66.7	67.0	67.3
116	63.6	63.9	64.3	64.6	65.0	65.3	65.7	66.0	66.4	66.7	67.0	67.4	67.7
117	64.0	64.4	64.7	65.0	65.4	65.7	66.1	66.4	66.8	67.1	67.4	67.7	68.0
118	64.5	64.8	65.1	65.5	65.8	66.1	66.5	66.8	67.2	67.5	67.8	68.1	68.4
119	64.9	65.3	65.6	65.9	66.2	66.6	66.9	67.2	67.6	67.9	68.1	68.4	68.7
120	65.4	65.7	66.0	66.3	66.6	67.0	67.3	67.6	67.9	68.2	68.5	68.8	69.1
121	65.8	66.1	66.5	66.8	67.1	67.4	67.7	68.0	68.3	68.6	68.9	69.1	69.4
122	66.3	66.6	66.9	67.2	67.5	67.8	68.1	68.4	68.7	69.0	69.2	69.5	69.8
123	66.7	67.0	67.3	67.6	67.9	68.2	68.5	68.8	69.1	69.3	69.6	69.9	70.1
124	67.2	67.5	67.8	68.0	68.3	68.6	68.9	69.2	69.5	69.7	70.0	70.2	70.4
125	67.6	67.9	68.2	68.5	68.8	69.0	69.3	69.6	69.8	70.1	70.3	70.6	70.8
126	68.1	68.4	68.7	68.9	69.2	69.5	69.7	70.0	70.2	70.5	70.7	70.9	71.1
127	68.6	68.8	69.1	69.4	69.6	69.9	70.1	70.4	70.6	70.9	71.1	71.3	71.5
128	69.0	69.3	69.5	69.8	70.0	70.3	70.5	70.8	71.0	71.2	71.4	71.6	71.8
129	69.5	69.7	70.0	70.2	70.5	70.7	71.0	71.2	71.4	71.6	71.8	72.0	72.1
130	69.9	70.2	70.4	70.7	70.9	71.1	71.4	71.6	71.8	72.0	72.2	72.3	72.5
131	70.4	70.6	70.9	71.1	71.3	71.6	71.8	72.0	72.2	72.3	72.5	72.7	72.8
132	70.8	71.1	71.3	71.5	71.8	72.0	72.2	72.4	72.5	72.7	72.9	73.0	73.1
133	71.3	71.5	71.7	72.0	72.2	72.4	72.6	72.7	72.9	73.1	73.2	73.3	73.4
134	71.7	71.9	72.2	72.4	72.6	72.8	72.9	73.1	73.3	73.4	73.5	73.6	73.7
135	72.1	72.4	72.6	72.8	73.0	73.1	73.3	73.5	73.6	73.7	73.8	73.9	74.0

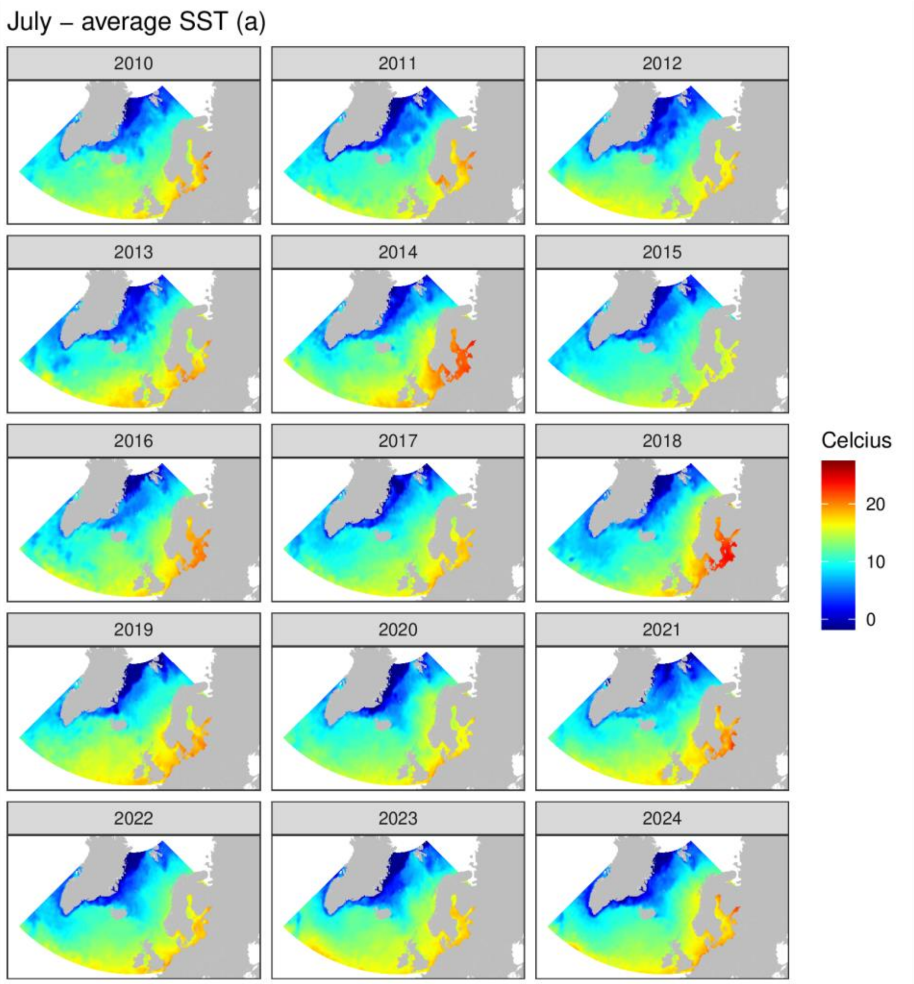
4 Results and discussion

4.1 Hydrography

Satellite measurements (NOAA OISST) of sea surface temperature (SST) in the central areas in the Northeast Atlantic in July 2024 were slightly warmer than the long-term average for July 1990-2009 based on SST plots (Figure 4a) and SST anomaly plots (Figure 4b). The northern regions of the Nordic Seas were slightly warmer than the average while the East Greenland Current was cooler than the long-term average. The SST in the Irminger Sea was similar to the average, and the Iceland Basin, slightly colder. Comparing with 2023, a less warmer an more similar to the long term average was observed in 2024.

It should be mentioned that the NOAA SST are sensitive to the weather conditions (i.e. wind and cloudiness) prior to and during the observations and do therefore not necessarily reflect the oceanographic condition of the water masses in the areas, as seen when comparing detailed *in situ* features of SSTs between years (Figures 4a,b-5). However, since the anomaly is based on the average for the whole month of July, it should give representative results of the surface temperature.

The temperature distribution at 10, 50, 100, and 400 m depths is shown in Figure 5. At 10 m depth, the temperatures ranged from less than 1°C in the Greenland Sea to 15°C in the North Sea. At all depths there is a clear signal from the cold East Icelandic Current which carries cold and fresh water into the central and south-eastern part of the Norwegian Sea. Along the Norwegian Shelf and in the southernmost areas, the water masses are dominated by warmer waters of Atlantic origin. The CTD measurements at 10 m depths showed that the 8°C isotherm around Jan Mayen was closely aligned to the Jan-Mayen Ridge.



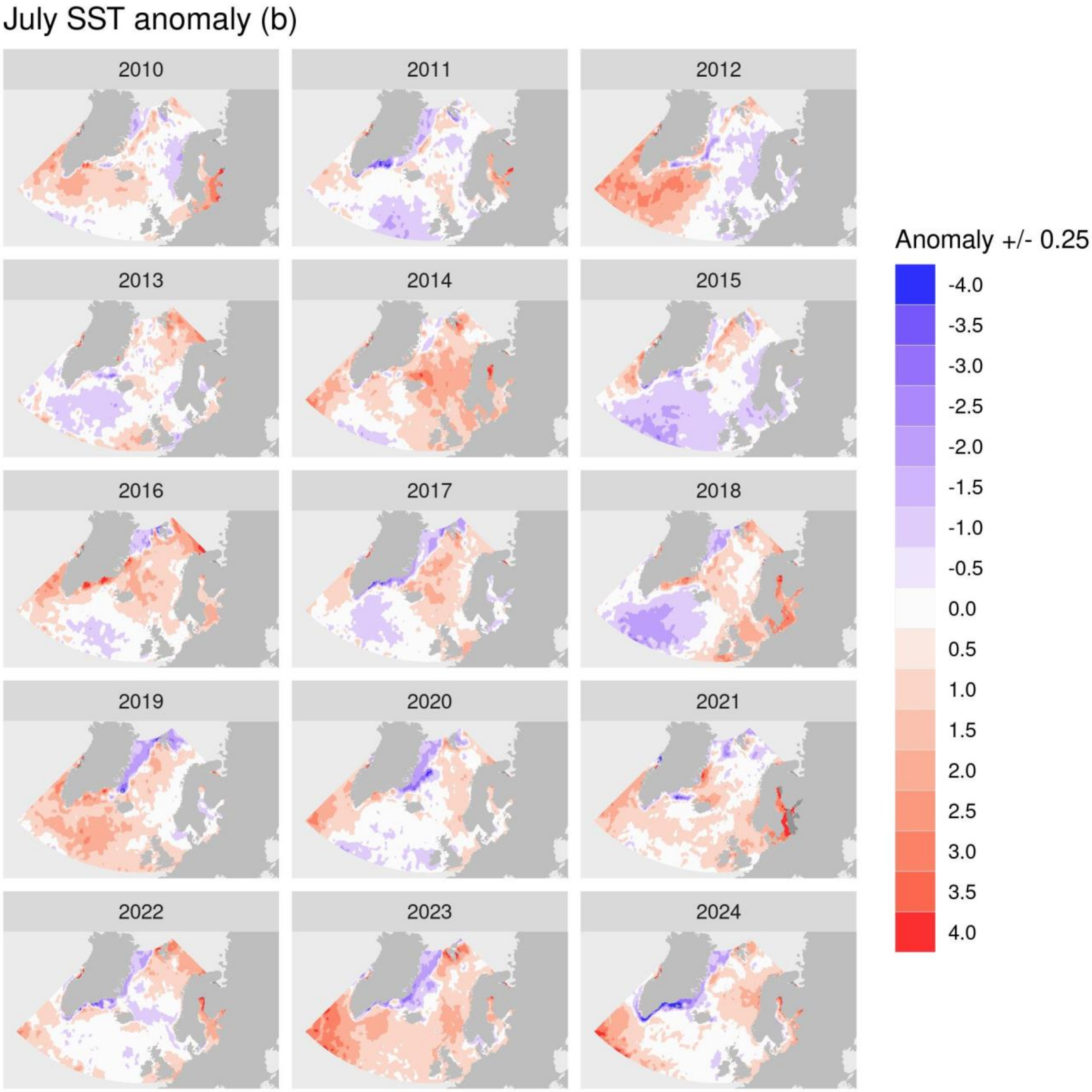


Figure 4. Annual sea surface temperature (a; top panel) and its anomaly (b; lower panel; -4 to +4°C) in Northeast Atlantic for the month of July from 2010 to 2024 showing warm and cold conditions in comparison to the average for July 1990-2009. Based on monthly averages of daily Optimum Interpolation Sea Surface Temperature (Ver. 2.1 NOAA OISST, AVHRR-only, Banzon et al. 2016, https://www.ncei.noaa.gov/products/optimum-interpolation-sst).

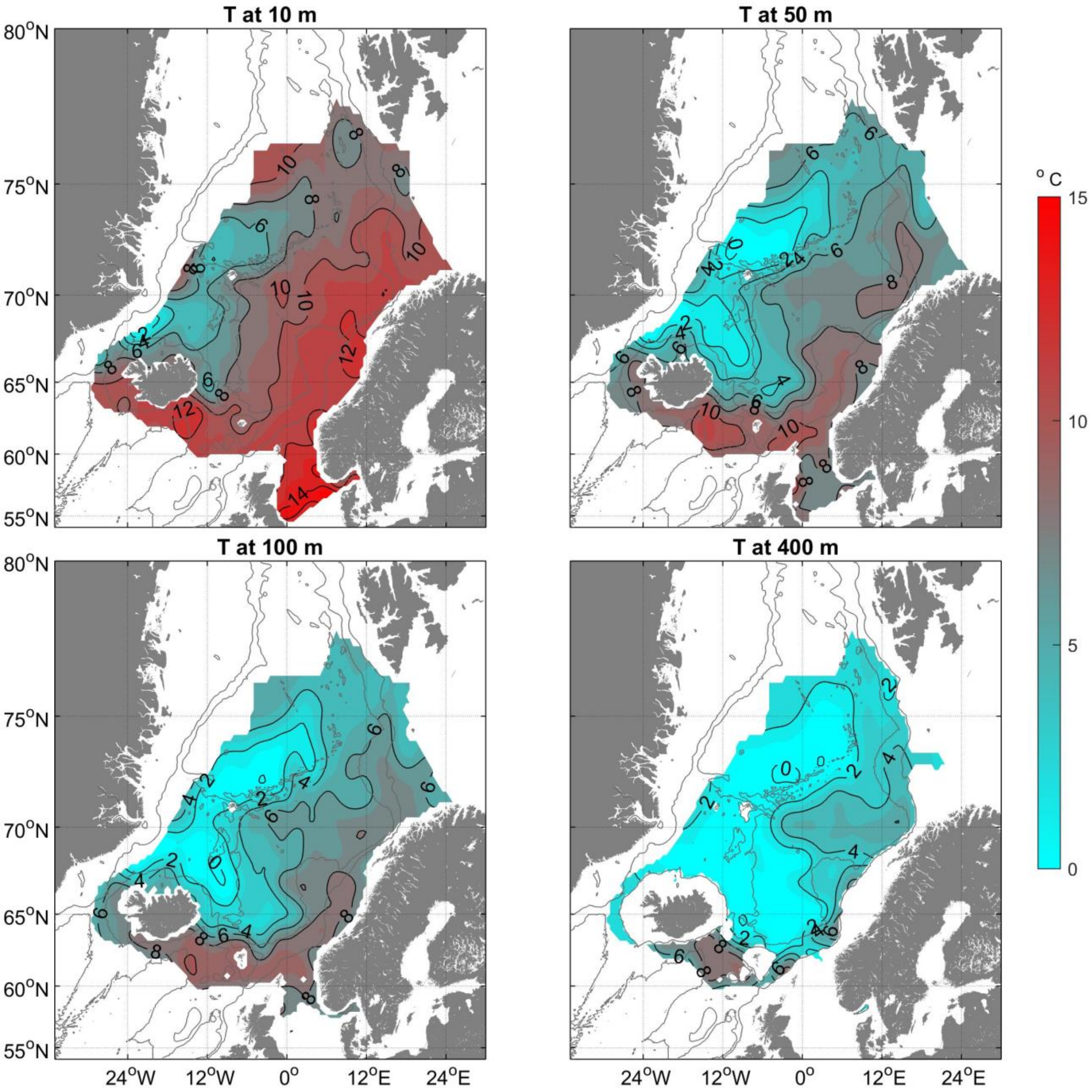


Figure 5. Interpolated temperature (°C) at 10, 50, 100 and 400 m depth in Nordic Seas and the North Sea in July 2024. 500 m and 2000 m depth contours are shown in light grey.

4.2 Zooplankton

The zooplankton biomass varied between areas with a patchy distribution throughout the area, with high concentrations north of Iceland and north of Faroes Island (Figure 6). In the Norwegian Sea areas, vast regions had biomass values below 10 g/m^2, with an the average value around 7 g/m^2, which is lower than last year (Figure 7).

The time-series of zooplankton biomass was averaged by three subareas: Greenland region (not covered since 2023), Iceland region, and the Norwegian Sea region (Figure 7; see definitions in legend). In the Icelandic region and the Norwegian Sea the level was lower than in 2023. The biomass index in the Norwegian Sea in 2024 was comparable to 2017-2018 (Figure 7). The lower variability over time in the Norwegian Sea might in part be explained by the more homogeneous oceanographic conditions in the area defined as Norwegian Sea.

These plankton indices should be treated with some caution as it is only a snapshot of the standing stock biomass, not of the actual production in the area, which complicates spatio-temporal comparisons.

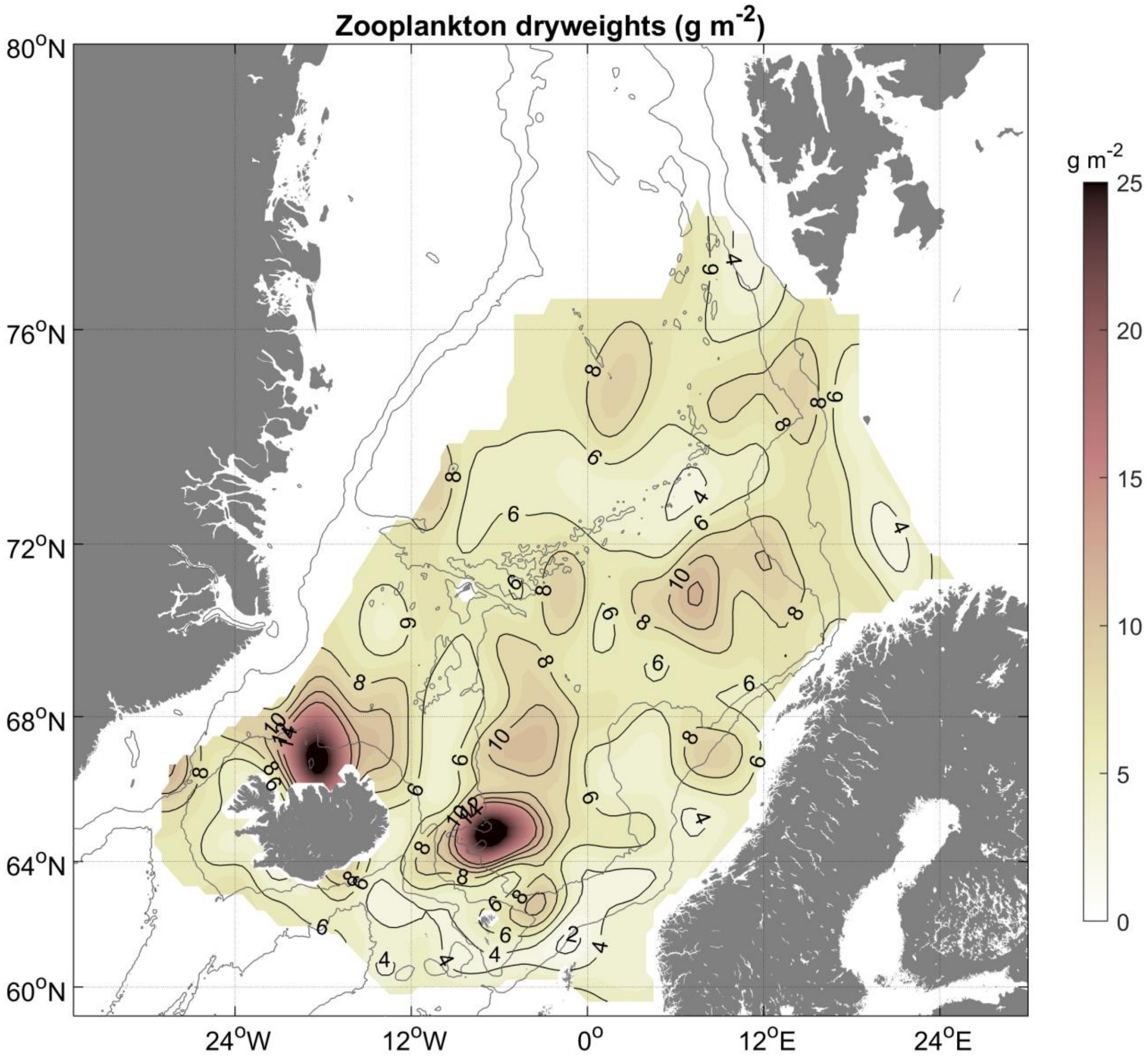


Figure 6. Interpolated zooplankton biomass (g dw/m², 0-200 m) in Nordic Seas in July-August 2024. 500 m and 2000 m depth contours are shown in light grey.

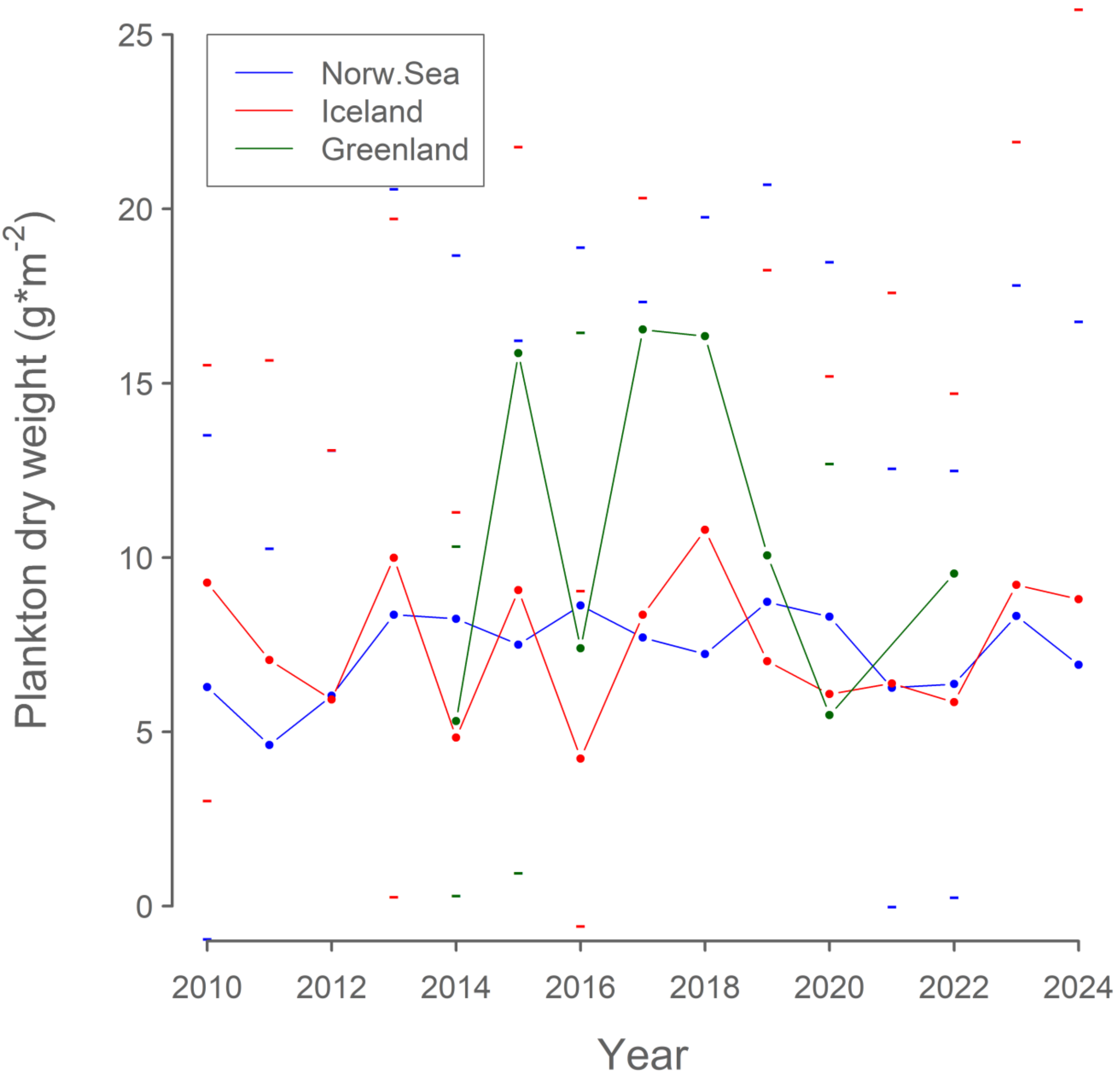


Figure 7. Zooplankton biomass indices (g dw/m², 0-200 m). Time-series (2010-2024) of mean zooplankton biomass for three subareas within the survey range: Norwegian Sea (between 14°W-17°E & north of 61°N), Icelandic waters (14°W-30°W) and Greenlandic waters (2014-2022, west of 30°W).

4.3 Mackerel

The total swept-area mackerel index in 2024 was 2.5 million tonnes in biomass and 5.6 billion in numbers, a decrease of 42% for biomass and 48% for abundance compared to 2023. The survey coverage area (excl. the North Sea, 0.28 million km²) was 2.23 million km² in 2024, which is 6% smaller compared to 2023. The survey area reduction was in the northern part of the Norwegian Sea due to lack of mackerel presence. The zero-line was reached for the survey area (survey southern boundary is latitude 60° N). One high catch, (10.3 tonnes) was caught in 2024, increased the uncertainty of the biomass index in 2024 to CV = 0.21 compared to CV = 0.12 in 2023.

All the surveyed mackerel were located in the Norwegian Sea (Figure 8). However, compared with previous years, the mackerel appears to have retracted in 2024: i) the western border retracted from west coast of Iceland to the East coast of Iceland (from 25° to 10° W); ii) the northern boundary of mackerel retracted from latitude 78° N in 2023 to latitude 72° N in 2024 (Figure 9 – 10). Furthermore, the highest mackerel density was located in the southwestern part of the Norwegian Sea compared to a more easterly and northeasterly distribution in 2023.

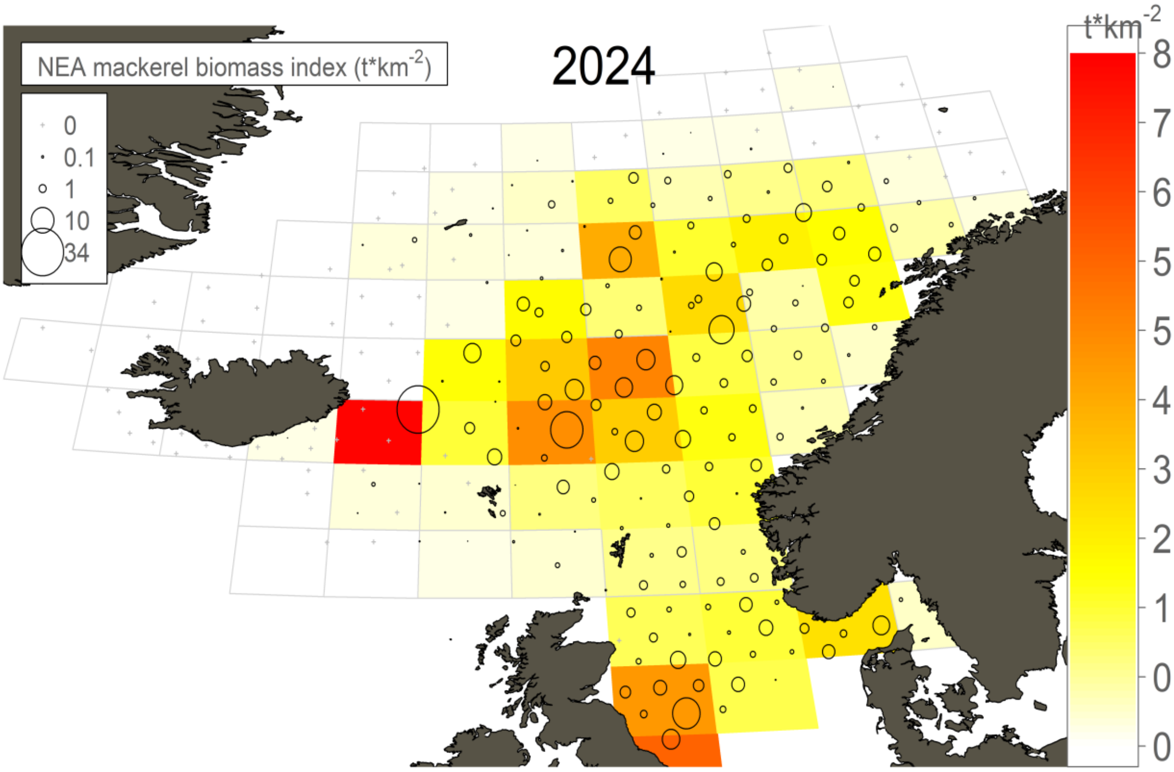


Figure 8. Mackerel catch rates by Multpelt 832 pelagic trawl haul at predetermined surface trawl stations (circle areas represent catch rates in kg/km^2) overlaid on mean catch rates per standardized rectangles (2° lat. x 4° lon.) in Nordic Seas in July-August 2024.

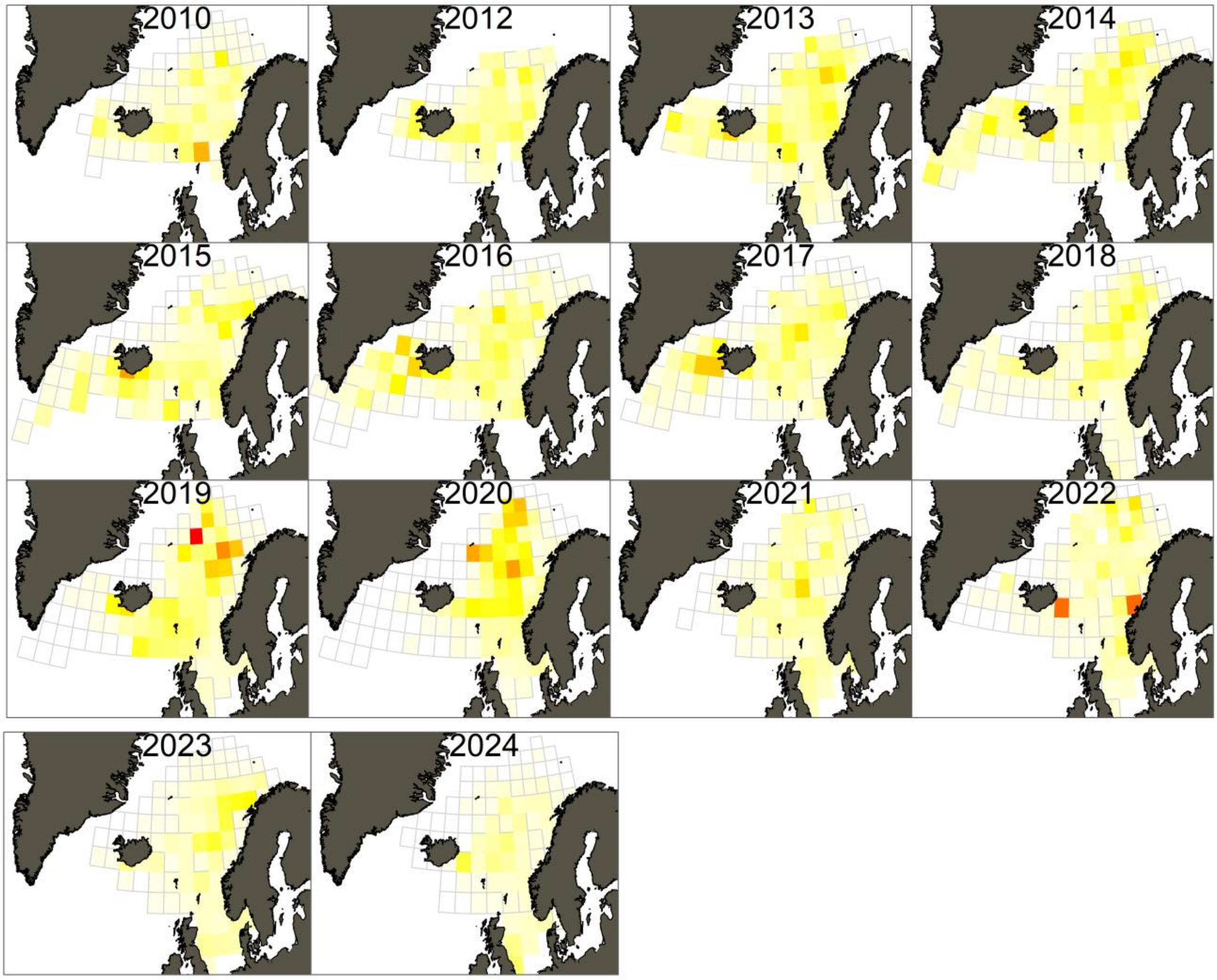


Figure 9. Annual distribution of mackerel proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations in Nordic Seas in June-August 2010-2024. Colour scale goes from white (= 0) to red (= maximum value for the highest year).

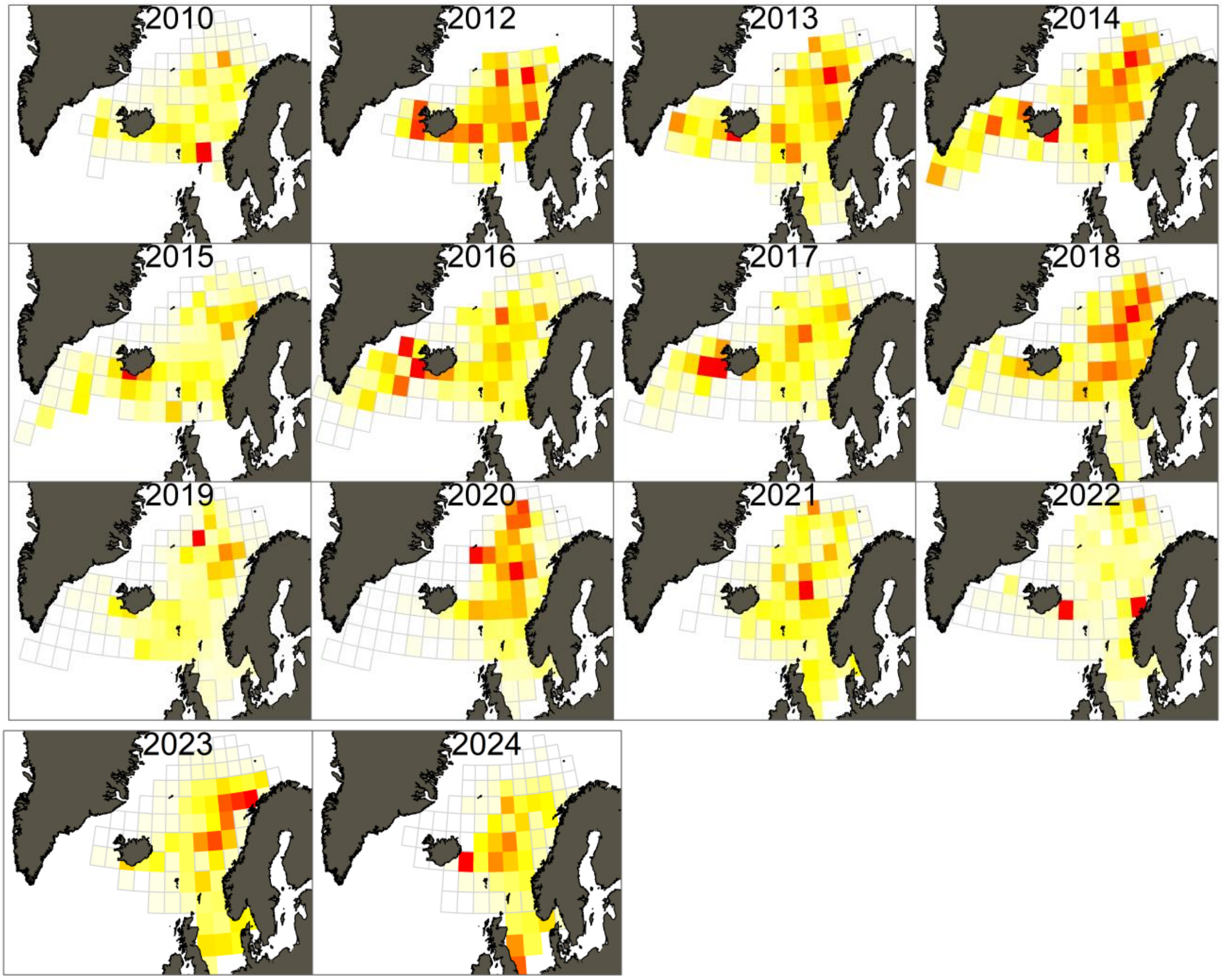


Figure 10. Annual distribution of mackerel proxied by the relative distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations stations in Nordic Seas in June-August 2010-2024. Colour scale goes from white (= 0) to red (= maximum value for the given year).

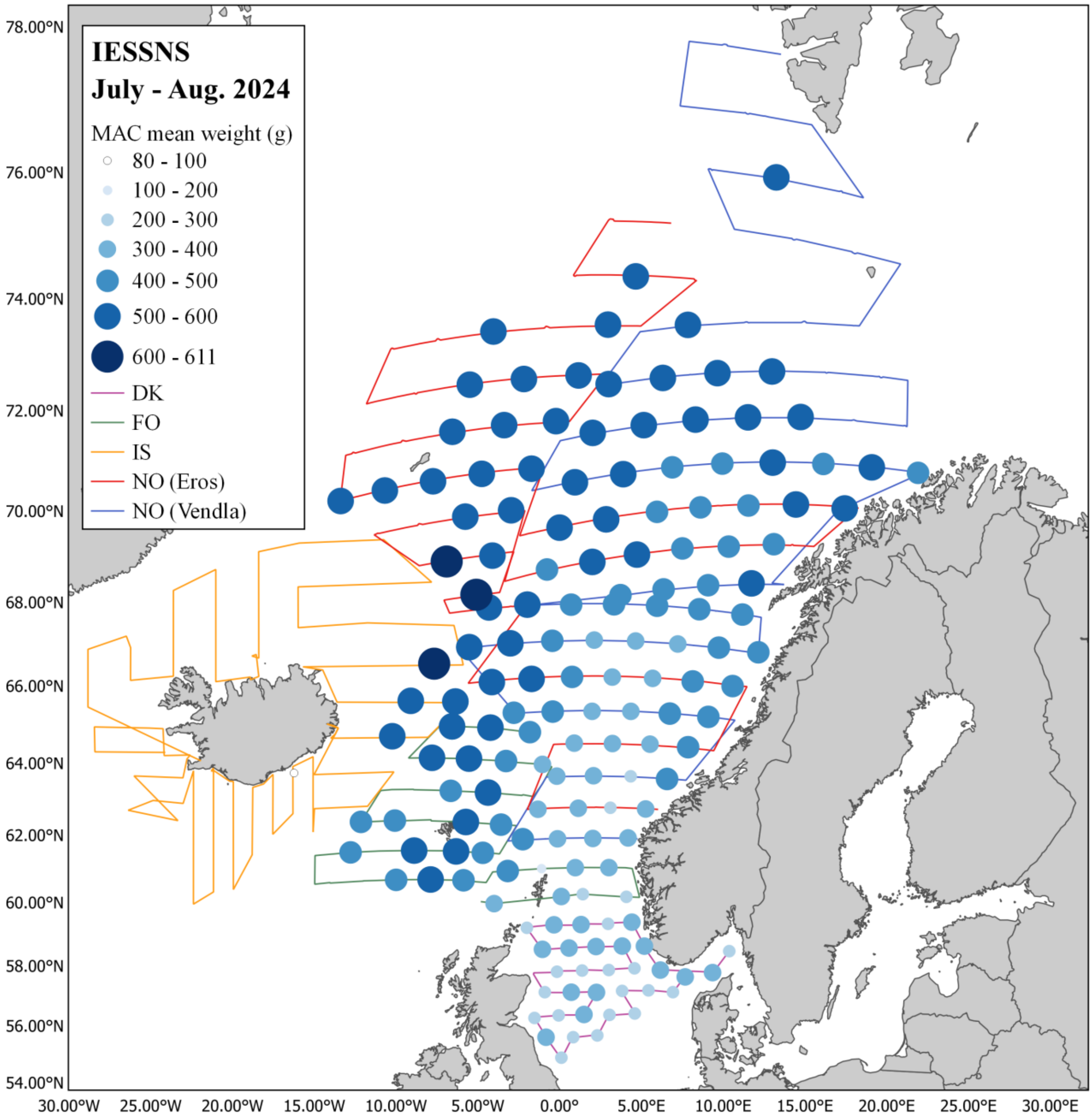


Figure 11. Average weight of mackerel at predetermined surface trawl stations during IESSNS 2024.

The mackerel weight varied between 52 to 874 g with an average of 462 g. The length of mackerel caught in the pelagic trawl hauls onboard the five vessels varied from 18.5 to 44.5 cm, with an average of 37 cm. In total we measured 10282 mackerel. Mackerel size distribution followed the same overall pattern as previous years with increasing size from the central Norwegian Sea and the North Sea towards the westward and northward distribution boundaries (Figure 11). The spatial distribution and overlap between the major pelagic fish species (mackerel, herring, and blue whiting) in 2024 according to surface trawl catches is shown in Figure 12. In 2024 there is a significantly lower overlapping between Mackerel and NSS herring compared with previous years. Similar to previous years, herring presence and density are highest in frontal areas and mackerel in areas dominated by warm Atlantic waters.

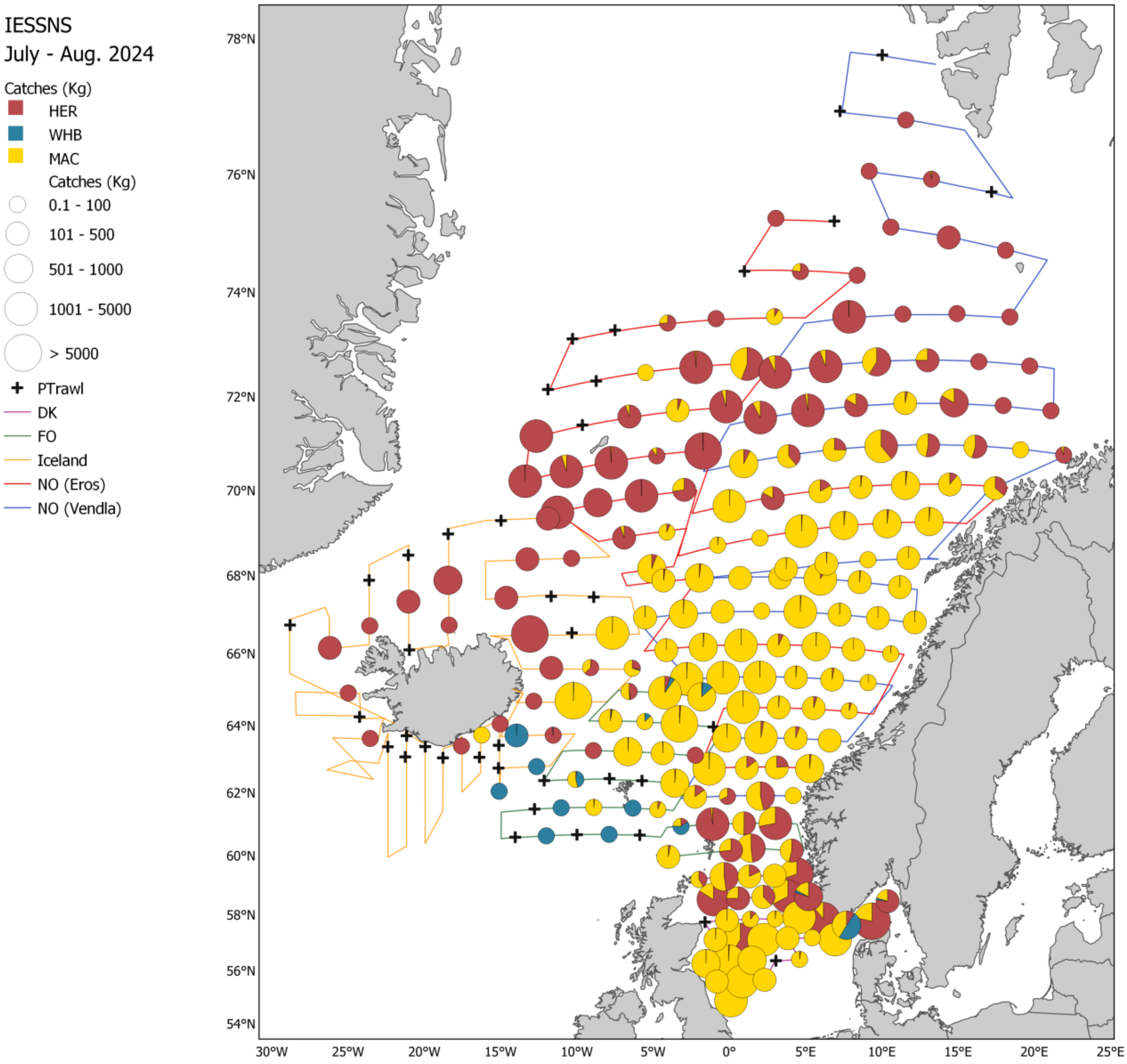


Figure 12. Distribution and spatial overlap between mackerel, herring, and blue whiting, at all surface trawl stations during IESSNS 2024. Vessel tracks are shown as continuous lines and predetermined surface trawl stations with no catch of the three species is displayed as +.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass from the 2024 IESSNS were based on abundance of mackerel per stratum (see strata definition in Figure 2) and calculated in StoX version 4.0.0. Mackerel abundance index in 2024 was 48% lower than in 2023, and 70% lower index than the average for the last 5 years (Table 7; Figure 13) and the biomass index was 42% lower than in 2023, and 69% lower than the average for the last 5 years (Table 9; Figure 13). Mackerel estimates of abundance, biomass and mean weight by age and length are displayed in Table 10. There is no pattern in changing size-at-age between years (Table 8). In 2024, the largest year-classes were from year 2020 (age 4) and 2019 (age 5), respectively (Figure 14). The 2020-year class contributed 14% of the total biomass and 15% of the total abundance. The 2019-year class contributed 12% of biomass and 13% of abundance. The same two year classes were also the most abundant once in 2023. Mackerel of age 1, 2 and to some extent also age 3 are not completely recruited to the survey (Figure 16), because the main part of the nursery area was further south than the survey area. Therefore, information on recruitment is uncertain. Variance in age index estimation is provided in Figure 15.

The overall internal consistency improved compared to last year and is good to strong for all ages with r ranging from 0.68 to 0.89 (Figure 17). Adding of the 2024 data to the time series improved the weakest link in the internal consistency, between ages 5-6, from 0.56 to 0.71. Currently the weakest internal consistency is between ages 10-11 with r value of 0.68.

Mackerel index calculations from the catch in the North Sea (Figure 2) were excluded from the index calculations presented in the current chapter to facilitate comparison to previous years and because the 2017 mackerel benchmark stipulated that trawl stations south of latitude 60° N should be excluded from index calculations (ICES 2017). Results from the mackerel index calculations for the North Sea are presented in Appendix 1.

The indices used for NEA mackerel stock assessment in WGWIDE are the number-at-age indices for age 3 to 11 year (Table 7).

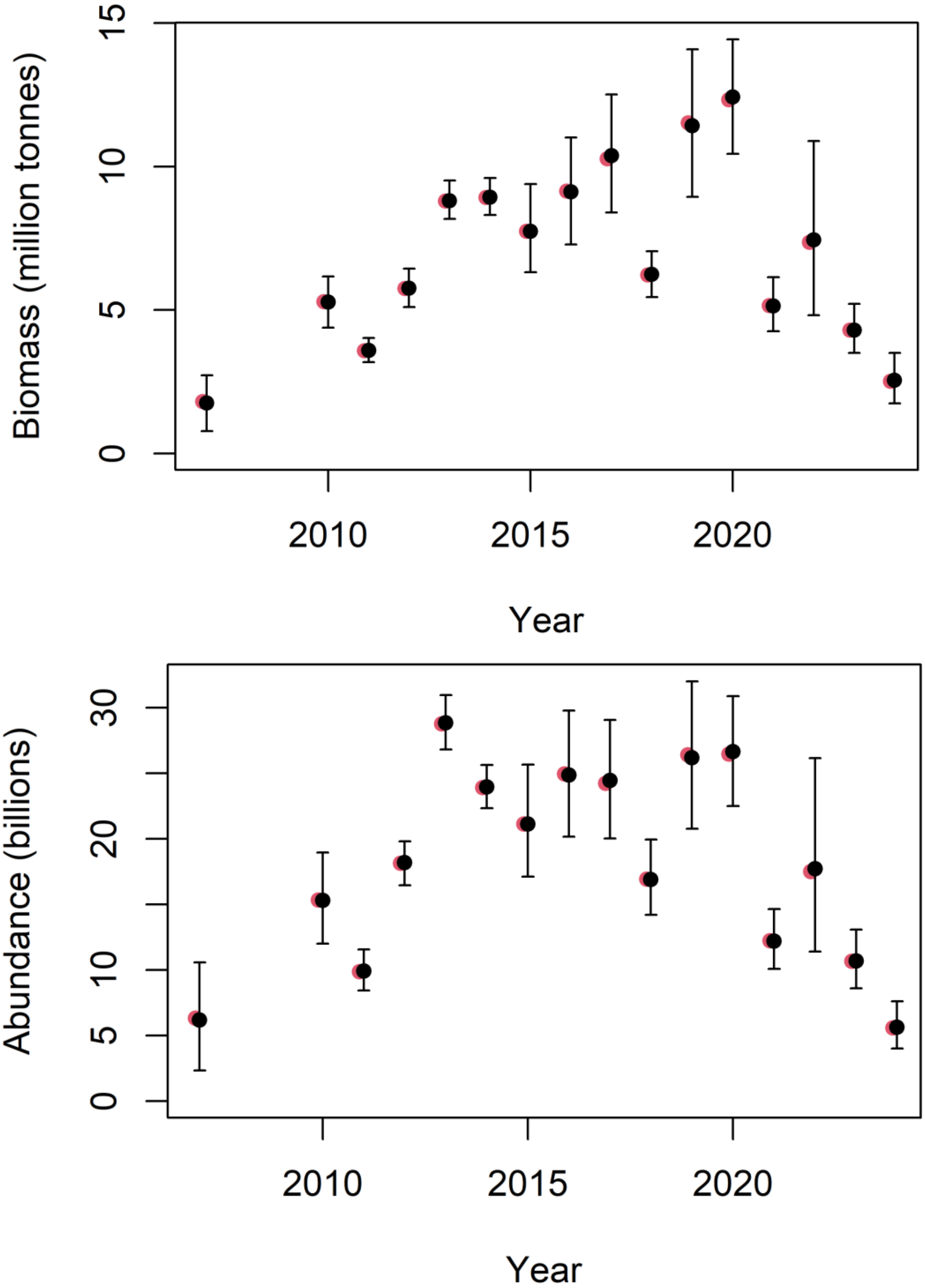


Figure 13. Estimated total stock biomass (upper panel) and total stock numbers (lower panel) of mackerel from StoX for the years 2007 and from 2010 to 2024. The red dots are baseline estimates, the black dots are mean of 1000 bootstrap replicates while the error bars represent 90% confidence intervals based on the bootstrap. Note, in 2011 the northern part of the Norwegian was not surveyed, hence the index for that year is not representative of mackerel stock size. See IESSNS 2011 cruise report for details.

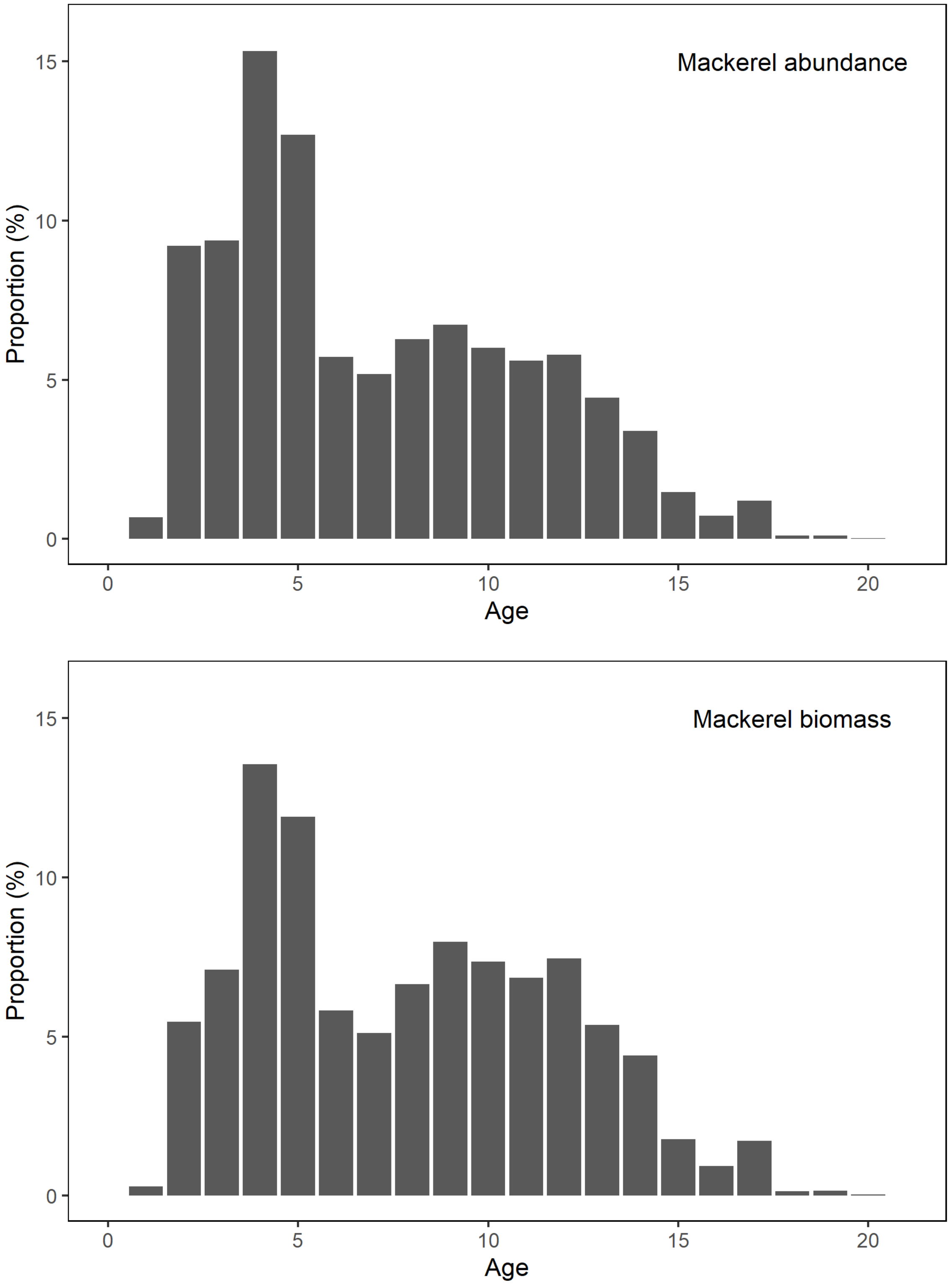


Figure 14. Mackerel age distribution in numbers (%) and in biomass (%) from IESSNS 2024.

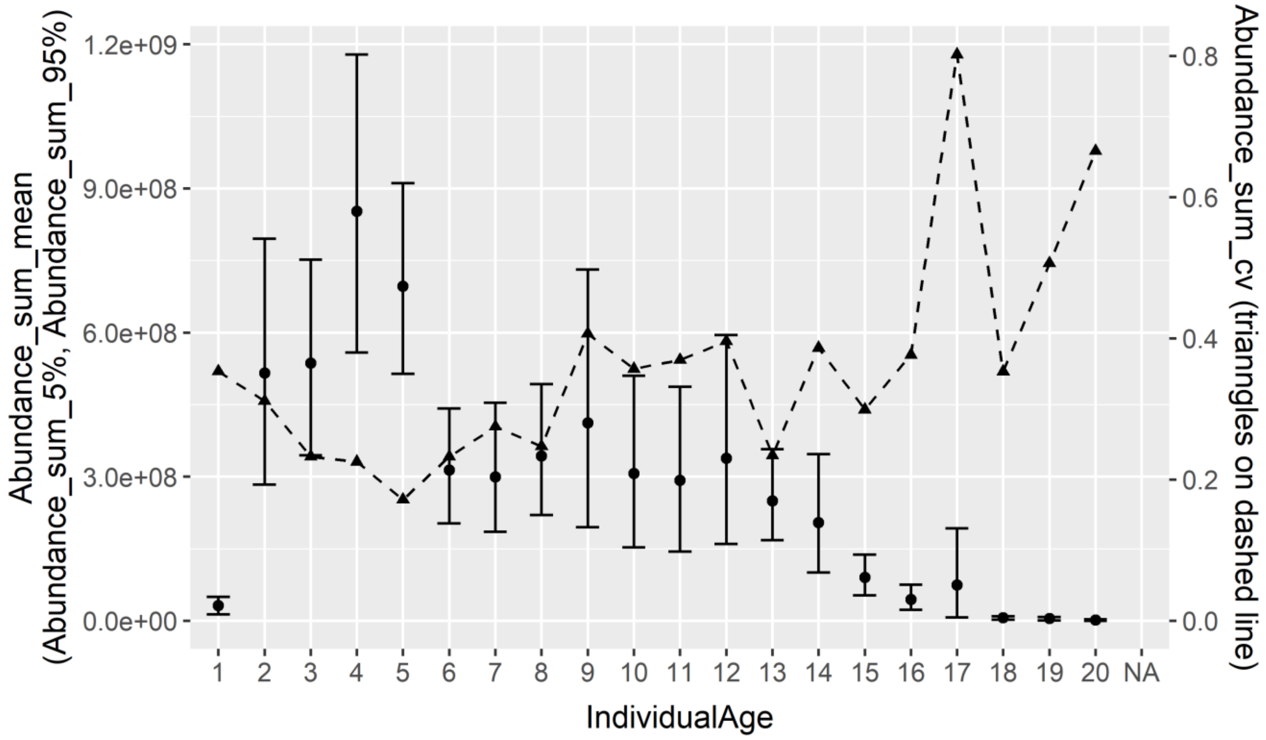


Figure 15. Number by age for mackerel in 2024. Plot of abundance (5% percentile, mean, 95% percentile) and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 7. StoX baseline (point estimate) time series of the IESSNS showing age-disaggregated abundance indices of mackerel (billions) in 2007 and from 2010 to 2024.

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Tot N
2007	1.33	1.86	0.90	0.24	1.00	0.16	0.06	0.04	0.03	0.01	0.01	0.00	0.01	0.00	5.65
2010	0.03	2.80	1.52	4.02	3.06	1.35	0.53	0.39	0.20	0.05	0.03	0.02	0.01	0.01	13.99
2011	0.21	0.26	0.87	1.11	1.64	1.22	0.57	0.28	0.12	0.07	0.06	0.02	0.01	0.00	6.42*
2012	0.50	4.99	1.22	2.11	1.82	2.42	1.64	0.65	0.34	0.12	0.07	0.02	0.01	0.01	15.91
2013	0.06	7.78	8.99	2.14	2.91	2.87	2.68	1.27	0.45	0.19	0.16	0.04	0.01	0.02	29.57
2014	0.01	0.58	7.80	5.14	2.61	2.62	2.67	1.69	0.74	0.36	0.09	0.05	0.02	0.00	24.37
2015	1.20	0.83	2.41	5.77	4.56	1.94	1.83	1.04	0.62	0.32	0.08	0.07	0.04	0.02	20.72
2016	<0.01	4.98	1.37	2.64	5.24	4.37	1.89	1.66	1.11	0.75	0.45	0.20	0.07	0.07	24.81
2017	0.86	0.12	3.56	1.95	3.32	4.68	4.65	1.75	1.94	0.63	0.51	0.12	0.08	0.04	24.22
2018	2.18	2.50	0.50	2.38	1.20	1.41	2.33	1.79	1.05	0.50	0.56	0.29	0.14	0.09	16.92
2019	0.08	1.35	3.81	1.21	2.92	2.86	1.95	3.91	3.82	1.50	1.25	0.58	0.59	0.57	26.4
2020	0.04	1.10	1.43	3.36	2.13	2.53	2.53	2.03	2.90	3.84	1.50	1.18	0.92	0.98	26.47
2021	0.09	2.13	0.71	1.22	1.53	0.37	1.29	0.81	1.05	0.97	0.93	0.46	0.34	0.33	12.22
2022	0.02	3.91	2.36	0.94	1.31	1.04	0.60	0.96	1.00	1.86	1.61	0.90	0.56	0.45	17.51
2023	0.21	0.70	3.54	1.70	0.55	0.46	0.79	0.32	0.48	0.39	0.45	0.44	0.34	0.30	10.67
2024	0.04	0.51	0.52	0.85	0.71	0.32	0.29	0.35	0.37	0.33	0.31	0.32	0.25	0.39	5.56

Table 8. StoX baseline (point estimate) time series of the IESSNS showing age-disaggregated mackerel mean weight (grams) per age in 2007 and from 2010 to 2024.

Year\ Age	1	2	3	4	5	6	7	8	9	10	11	12	13
2007	133	233	323	390	472	532	536	585	591	640	727	656	685
2010	133	212	290	353	388	438	512	527	548	580	645	683	665
2011	133	278	318	371	412	440	502	537	564	541	570	632	622
2012	112	188	286	347	397	414	437	458	488	523	514	615	509
2013	96	184	259	326	374	399	428	445	486	523	499	547	677
2014	228	275	288	335	402	433	459	477	488	533	603	544	537
2015	128	290	333	342	386	449	463	479	488	505	559	568	583
2016	95	231	324	360	371	394	440	458	479	488	494	523	511
2017	86	292	330	373	431	437	462	487	536	534	542	574	589
2018	67	229	330	390	420	449	458	477	486	515	534	543	575
2019	153	212	325	352	428	440	472	477	490	511	524	564	545
2020	99	213	315	369	394	468	483	507	520	529	539	567	575
2021	140	253	357	377	409	451	467	487	497	505	516	523	544
2022	125	263	330	408	438	431	462	508	525	519	531	531	549
2023	128	269	347	371	416	435	462	484	506	526	517	533	557
2024	192	268	343	400	424	461	447	480	536	555	554	584	549

Table 9. StoX baseline (point estimate) time series of the IESSNS showing age-disaggregated estimated mackerel biomass at age (million tonnes) in 2007 and from 2010 to 2024.

Year\ Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Tot B
2007	0.18	0.43	0.29	0.09	0.47	0.09	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.00	1.64
2010	0.00	0.59	0.44	1.42	1.19	0.59	0.27	0.20	0.11	0.03	0.02	0.01	0.01	0.00	4.89
2011	0.03	0.07	0.28	0.41	0.67	0.54	0.29	0.15	0.07	0.04	0.03	0.01	0.01	0.00	2.69*
2012	0.06	0.94	0.35	0.73	0.72	1.00	0.72	0.30	0.17	0.06	0.03	0.01	0.00	0.00	5.09
2013	0.01	1.43	2.32	0.70	1.09	1.15	1.15	0.56	0.22	0.10	0.08	0.02	0.01	0.01	8.85
2014	0.00	0.16	2.24	1.72	1.05	1.14	1.23	0.80	0.36	0.19	0.05	0.03	0.01	0.00	8.98
2015	0.15	0.24	0.80	1.97	1.76	0.87	0.85	0.50	0.30	0.16	0.04	0.04	0.02	0.01	7.72
2016	<0.01	1.15	0.45	0.95	1.95	1.72	0.83	0.76	0.53	0.37	0.22	0.10	0.04	0.04	9.11
2017	0.07	0.03	1.18	0.73	1.43	2.04	2.15	0.86	1.04	0.33	0.28	0.07	0.05	0.03	10.29
2018	0.15	0.57	0.16	0.93	0.50	0.63	1.07	0.85	0.51	0.26	0.30	0.16	0.08	0.05	6.22
2019	0.01	0.29	1.24	0.43	1.25	1.26	0.92	1.86	1.87	0.77	0.65	0.33	0.32	0.32	11.52
2020	<0.01	0.23	0.45	1.24	0.84	1.18	1.22	1.03	1.51	2.03	0.81	0.67	0.53	0.58	12.33
2021	0.01	0.54	0.25	0.46	0.62	0.17	0.60	0.39	0.52	0.49	0.48	0.24	0.18	0.19	5.15
2022	0.00	1.03	0.78	0.39	0.57	0.45	0.28	0.49	0.52	0.97	0.85	0.48	0.31	0.26	7.37
2023	0.03	0.19	1.23	0.63	0.23	0.20	0.36	0.16	0.24	0.20	0.23	0.24	0.19	0.17	4.30
2024	0.01	0.14	0.18	0.34	0.30	0.15	0.13	0.17	0.20	0.19	0.17	0.19	0.14	0.23	2.51

*In 2011 the northern part of the Norwegian was not surveyed, hence the index for that year is not representative of mackerel stock size. See IESSNS 2011 cruise report for details.

Table 10. StoX baseline (point estimate) IESSNS 2024 showing estimates of mackerel abundance, biomass and mean weight by age and length.

Length (cm)	Age in years (year class)														Number (10^6)	Biomass (10^6 kg)	Mean weight (g)
	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+	NA			
18-19															0	0	56
19-20														1	1	0	53
20-21	1														1	0	70
21-22															0	0	76
22-23	2														2	0	91
23-24															0	0	112
24-25	1														1	0	124
25-26														3	3	0	135
26-27	5														5	1	159
27-28	10	1													11	2	182
28-29	12	39													51	11	210
29-30	6	122													128	31	243
30-31		190	9												199	53	267
31-32		84	38	1											123	35	288
32-33		59	103	15	2		8								187	58	312
33-34		17	173	68	9										266	90	339
34-35			150	236	106	27									520	196	377
35-36	1		39	326	252	57	9	7							690	282	408
36-37			9	182	222	64	51	42	17	5	5				597	263	440
37-38				23	97	73	76	106	49	21	10	12	6		472	221	468
38-39					17	79	50	82	71	48	53	49	73		522	268	514
39-40				1		9	13	29	102	120	75	89	150		587	323	549
40-41						9	14	51	53	56	115	55	186		541	299	552
41-42								33	68	79	51	79	138		448	267	595
42-43							66		2	5		17	78		168	93	552
43-44									12		1	20	4		38	24	619
44-45													2		2	1	771
TSN(mill)	37.9	511.7	521.0	852.0	706.2	318.3	287.5	348.6	374.5	333.4	310.9	321.6	637.2	0.0	5,564.9	2518	
TSB(1000 t)	7.3	137.4	178.6	341.2	299.5	146.7	128.6	167.5	200.7	185.0	172.4	187.7	365.6	0.4	2,518.4		
Mean length(cm)	27.1	30.1	33.1	34.8	35.5	36.6	38.2	38.1	39.1	39.4	39.4	39.8	40.0				
Mean weight(g)	192	268	343	400	424	461	447	480	536	555	554	584	574				

Table 11. Bootstrap estimates from StoX (based on 1000 replicates) of mackerel in 2024. Numbers by age and total number (TSN) are in millions and total biomass (TSB) in million tons.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
1	13.2	31.4	49.9	31.4	11.1	0.35
2	283.7	503.3	795.2	515.5	160.4	0.31
3	344.4	531.1	751.7	536.4	124.7	0.23
4	558.3	846.4	1178.8	852.5	192.0	0.23
5	514.0	685.3	911.0	696.2	119.4	0.17
6	202.7	309.3	442.3	313.5	72.9	0.23
7	185.6	290.3	454.3	299.4	82.3	0.27
8	220.3	333.1	492.5	343.3	84.8	0.25
9	194.9	391.8	731.4	412.0	167.5	0.41
10	153.1	291.6	510.0	306.9	109.4	0.36
11	144.3	279.3	486.9	292.3	108.0	0.37
12	159.6	322.9	595.0	338.5	134.0	0.40
13	167.6	242.7	357.1	249.7	58.5	0.23
14	100.3	196.9	346.8	204.3	78.9	0.39
15	53.1	87.0	137.7	90.2	27.0	0.30
16	23.3	41.7	74.9	44.3	16.7	0.38
17	7.2	71.3	192.2	74.8	60.0	0.80
18	2.5	5.9	9.6	6.0	2.1	0.35
19	1.0	4.4	7.9	4.4	2.2	0.51
20	0.1	1.6	3.5	1.6	1.1	0.67
TSN	3997	5520	7596	5618	1087	0.13
TSB	1.75	2.49	3.51	2.55	0.55	0.12

Figure 16. Catch curves for the years 2010; 2012-2024. Each cohort of mackerel is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

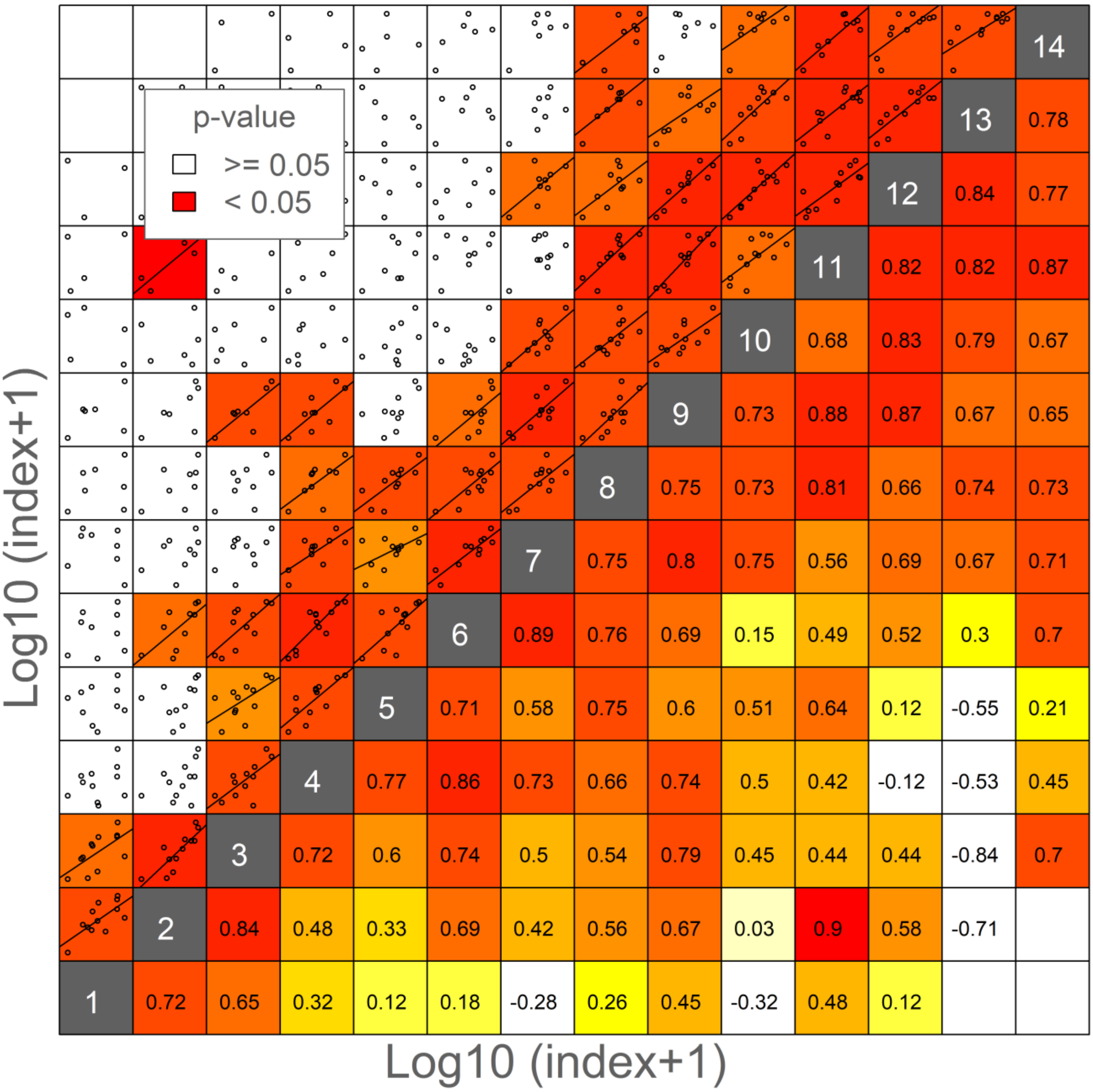


Figure 17. Internal consistency of the of mackerel density index from 2012 to 2024. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*$p<0.05$*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

The swept area method assumes that potential distribution of mackerel outside the survey area – both vertically and horizontally – is a constant percentage of the total biomass. In some years, this assumption may be violated, e.g. mackerel may be distributed below the footrope of the trawl or if the proportion of mackerel outside the survey coverage varies among years. In order to improve the precision of the swept area estimate it would be beneficial to extend the survey coverage further south, such that it covers the southwestern waters south of 60°N, e.g. UK waters.

The standard swept area method using the average horizontal trawl opening by each participating vessel (ranging 63.9 - 72.8 m; Table 5), assuming that a constant fraction of the mackerel inside the horizontal trawl opening are caught. Further, that if mackerel is distributed below the depth of the trawl (footrope), this fraction is assumed constant from year to year.

4.4 Norwegian spring-spawning herring

Norwegian spring-spawning herring (NSSH) was predominantly recorded in the northern part of the Norwegian Sea and in the Jan Mayen zone (Figure 18a, b). The acoustic registrations in the southern and eastern parts of the Norwegian Sea were low. Herring registrations south of 62° N in the eastern part were allocated to a different stock, North Sea herring, while the herring to the south and west in Icelandic waters (west of 14° W south of Iceland) were allocated to Icelandic summer-spawners – these were removed from the biomass estimation of NSSH (Figure 18b), and not shown on the maps.

The total number of NSSH recorded during IESSNS 2024 the total biomass index was 3.78 million tonnes, 24% lower biomass than in 2023. A reduction of 11% was recorded in the abundance for adult fish age 4+.

The 2016 year-class (8-year-olds) dominated in the stock and contributed 56% to the total biomass. Other year classes in the NSSH population were much weaker (less than 10%) compared to the 2016-year class (Figure 19 and Table 12). The 2016 year-class is fully recruited to the adult stock, whereas the younger fish is not recruited to the adult stock and those estimates are very uncertain.

Bootstrap estimates of numbers by age are shown in Figure 19. The uncertainty (CV) around the age disaggregated abundance indices from the 2024 survey was around 25% for the dominating age groups (Figure 19).

The internal consistency among year classes was generally very high for age classes 4 years and older, with the lowest correlation, for the youngest year classes, as expected since they are not fully recruited into the survey (Figure 20).

The zero-boundary of the distribution of the mature part of NSSH was reached in all directions, except for the northwestern area between Jan Mayen and Greenland (Figure 18a, b). The herring was mainly observed in the upper surface layer as relatively small schools. A shallow distribution of herring might have led to an unknown portion of herring being in the "blind zone" above the transducer depth of the vessels (i.e., shallower than 10-15 m, Table 4), and therefore not being registered by the vessels. However, this was not the case in 2024. The group considered the acoustic biomass estimate of herring in 2024 to be of the similar quality as in the previous survey years.

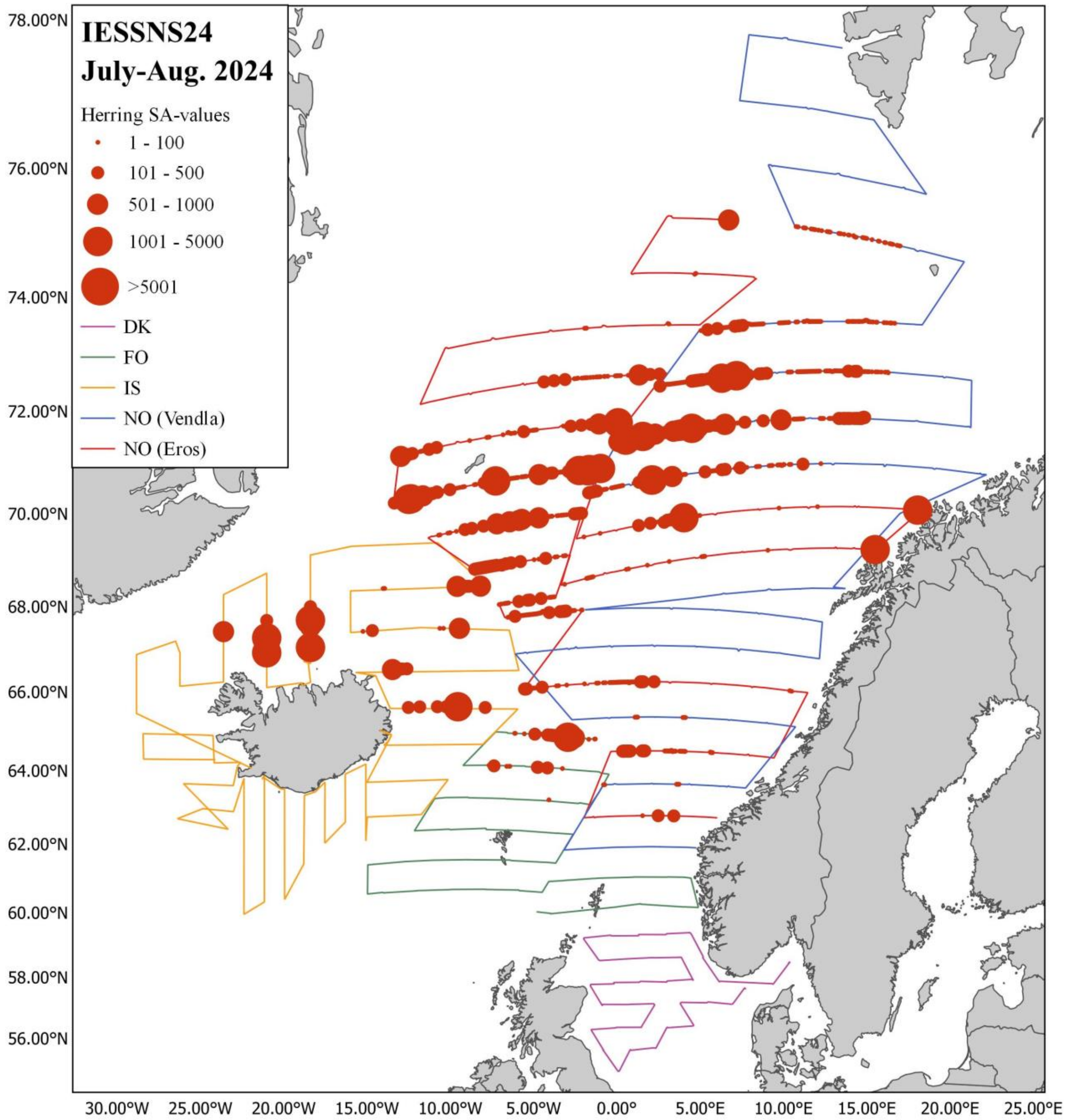


Figure 18a. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise tracks in 2024 presented as contour lines. Values north of 62° N, east of 14° W to the south of Iceland, and all herring north of Iceland are considered to be Norwegian spring-spawning herring. South and west of this area the herring observed are other stocks, *i.e.* Icelandic summer spawners, Faroese autumn spawners and North Sea herring in the southeast; these have been omitted from the map.

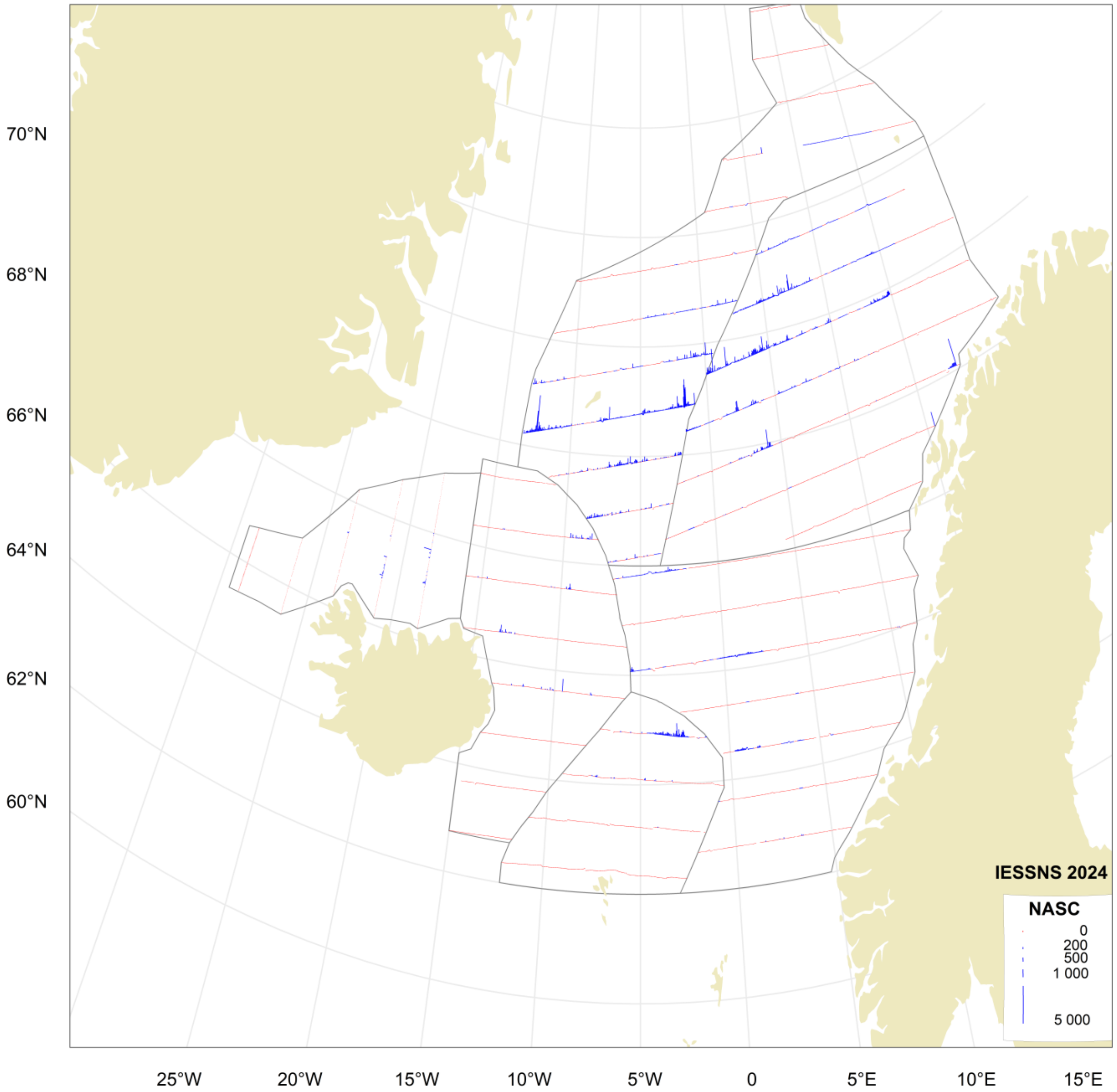


Figure 18b. The s_A/Nautical Area Scattering Coefficient (NASC) values of Norwegian spring-spawning herring along the cruise tracks in 2024, presented as bar plot.

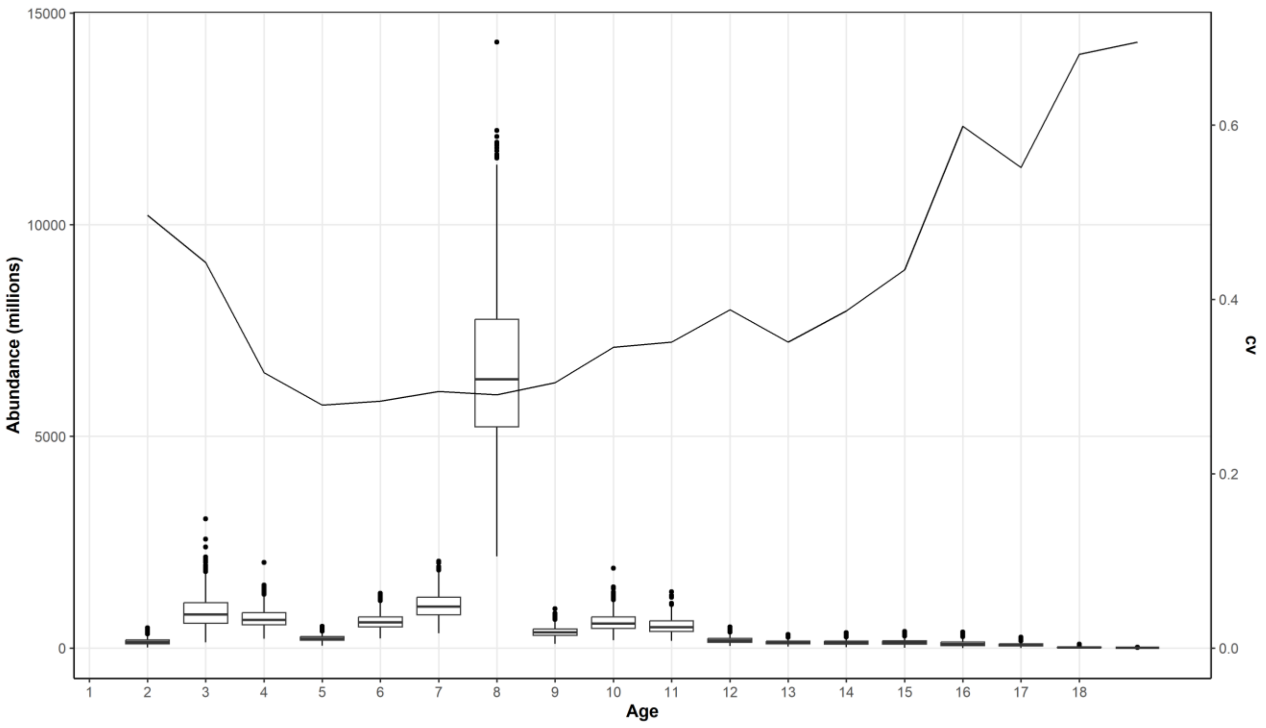


Figure 19. Abundance by age for Norwegian spring-spawning herring during IESSNS 2024. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 12. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring based on calculation in StoX (bootstrap) for IESSNS 2024.

Length	Age in years (year class)																		Number	Biomass	Mean weight
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18			
(cm)	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	(10^6)	(10^6 kg)	(g)
9-10																					
10-11																					
11-12																					
12-13																					
13-14																					
14-15																					
15-16																					
16-17																					
17-18		5.5																	5.5	0.2	40.8
18-19		4.7																	4.7	0.3	48.2
19-20		22.0	51.8																73.7	4.6	58.7
20-21		17.9																	17.9	1.2	67.5
21-22			6.9																6.9	0.7	80.7
22-23		12.5	34.5																47.1	4.6	94.7
23-24		36.0	59.1																95.2	10.4	109.2
24-25		20.2	160.9																181.1	22.6	125.2
25-26		31.3	254.0	13.3															298.5	41.1	137.9
26-27			145.5	3.3	5.4			1.8											156.1	24.8	163.7
27-28		1.8	81.6	24.1	6.7	5.6	3.4	0.9											124.1	23.0	188.1
28-29			8.4	150.9	2.3	6.9	4.7	7.5	3.6	2.9	1.6								189.0	38.3	207.5
29-30			21.7	140.3	18.5	19.0	4.3	8.3	12.5	1.5	3.5	1.5	3.2						234.2	52.4	227.6
30-31			13.6	142.5	14.1	20.7	29.6	7.3	1.1	1.1	10.4	2.4	10.6						253.4	64.1	252.2
31-32			9.9	122.1	43.6	83.0	3.7	32.2	1.3	1.2	5.5								302.4	82.1	270.7
32-33			5.3	88.9	105.2	255.4	196.1	523.0	3.5	10.2	1.1	1.3							1 190.0	350.0	293.6
33-34				10.7	26.0	173.7	403.3	2647.5	17.7	28.1	3.1		6.5						3 316.7	1034.5	310.7
34-35					3.5	43.5	298.5	2537.7	134.0	181.7	91.2	14.5	12.1	9.6					3 326.3	1090.5	327.5
35-36						15.6	55.4	676.1	160.2	222.6	189.4	36.5	13.8	13.4	0.4				1 383.4	480.1	349.4
36-37							6.4	73.8	37.5	135.1	129.6	84.5	31.4	10.3	55.8	14.0	7.1		585.5	213.7	363.5
37-38								23.1	5.3	25.2	61.9	28.7	48.3	47.3	45.0	50.1	20.7	13.8	369.2	141.5	385.0
38-39								3.5	3.6		25.7	13.8	9.6	49.2	16.4	19.1	34.0	4.8	179.6	73.2	405.6
39-40															13.7	22.4	13.9		50.0	25.4	455.3
40-41																				1.2	496.3
41-42																				0.1	529.8
42-43																				0.0	
TSN(mill)		152.0	853.1	696.1	225.2	623.5	1005.4	6542.6	380.3	609.7	523.0	183.1	135.4	129.8	131.3	105.6	75.6	22.6	12 394.5		
cv (TSN)		0.50	0.44	0.32	0.28	0.28	0.29	0.29	0.30	0.34	0.35	0.39	0.35	0.39	0.43	0.60	0.55	0.70	0.27		
TSB(1000 t)		15.2	120.9	166.6	61.6	182.4	312.3	2 098.8	128.6	209.1	184.7	66.2	48.5	49.3	50.2	42.8	31.4	9.7	3 778.6		
cv (TSB)		0.50	0.44	0.31	0.28	0.29	0.30	0.29	0.31	0.35	0.35	0.39	0.35	0.39	0.44	0.60	0.56	0.69	0.27		
Mean length(cm)		22.6	25.3	29.7	30.7	32.0	33.0	33.6	34.0	34.8	35.1	35.9	36.0	36.8	37.0	37.7	37.6	37.1			
Mean weight(g)		107.5	148.9	242.4	261.9	290.3	308.6	321.2	332.1	344.2	351.2	358.6	366.2	380.7	382.9	409.6	416.1	411.7			

Table 13. IESSNS bootstrap time series (mean of 1000 replicates) from 2016 to 2024. StoX biomass estimates of Norwegian spring-spawning herring (millions).

	Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12+	TSB(1000 t)
2016	38	119	747	577	1 622	1 636	1 967	1 588	1 274	2 001	2 164	6 245	6 676
2017	1 232	240	1 318	4 653	1 003	1 184	795	1 716	1 004	1 115	1 657	4 040	5 821
2018	0	587	656	864	3 054	924	1 172	746	971	1 078	663	2 704	4 379
2019	0	143	1 910	616	1 101	3 487	814	751	510	780	470	4 660	4 794
2020	0	15	117	8 280	1 710	2 367	4 087	696	520	305	594	1 827	5 991
2021	1	4	184	398	12 117	1 045	1 398	2 226	502	361	393	1 641	6 103
2022	0	681	1 008	1 251	1 301	14 135	914	1 211	1 734	477	433	1 325	7 143
2023	6 034	817	6 377	321	725	1 335	7 360	503	711	807	291	780	4 989
2024	0	152	853	696	225	623	1 005	6 543	380	610	523	783	3 779

Table 14. IESSNS baseline time series from 2016 to 2024. StoX biomass estimates of Norwegian spring-spawning herring (millions).

	Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12+	TSB(1000 t)
2016	41	146	752	604	1 637	1 559	2 010	1 614	1 190	2 023	2 151	6 467	6 753
2017	1 216	248	1 285	4 586	1 056	1 188	816	1 794	1 022	1 131	1 653	4 119	5 885
2018	0	577	722	879	3 078	931	1 264	734	948	1 070	694	2 792	4 465
2019	0	153	1 870	590	1 067	3 475	859	702	520	700	463	4 808	4 780
2020	0	7	111	8 082	1 697	2 335	4 102	714	491	294	590	1 833	5 930
2021	1	3	196	388	11 988	1 109	1 342	2 292	491	365	386	1 649	6 085
2022	0	724	984	1 225	1 339	14 071	960	1 172	1 762	434	432	1 329	7 135
2023	6 030	683	7 141	293	753	1 272	7 339	520	692	855	280	811	5 056
2024	0	166	858	701	236	633	976	6 725	362	631	534	811	3 815

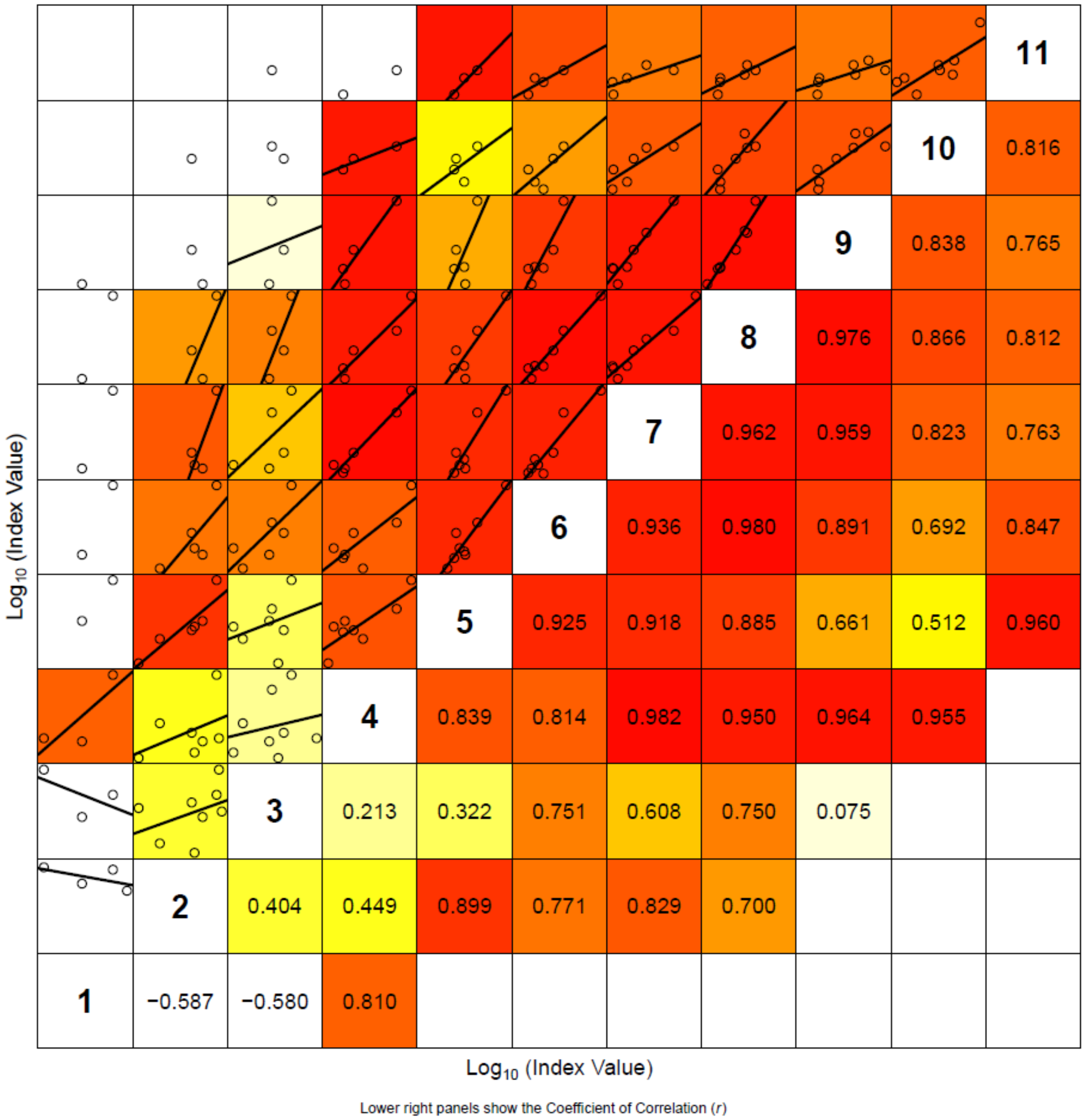


Figure 20. Internal consistency for Norwegian spring-spawning herring within the IESSNS 2024. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows the correlation coefficient (r) for the two ages plotted in that panel. The background colour of each panel is determined by the r value, where red equates to r=1 and white to r<0.

4.5 Blue whiting

Blue whiting was distributed in parts of the survey area dominated by warm Atlantic waters and had a continuous distribution from the southern boundary of the survey area (60° N) to Bear Island (74.30° N) (Figure 21a). High blue whiting density (sA-values) was observed in the southern part of the Norwegian Sea, along the Norwegian continental slope, around the Faroe Islands, and to a lesser extent in the southeast part of Iceland. Concentrations of older fish (age 4+) were higher compared to previous years, with the strong 2020 year-class representing the largest year-class in the survey, followed by the 2021-year-class (Figure 22, Table 16). As in previous years no blue whiting was registered in the cold East Icelandic Current, between Iceland and Jan Mayen.

The total biomass index of blue whiting was very similar in 2024 (1.96 million ton) compared to 2023 (1.98 million ton), with an 1% reduction (Table 16). Estimated stock abundance (ages 1+) was 17.7 billion in 2024 compared to 20.8 billion in 2023 (15% decrease). Age 4 and 3 respectively, dominated the estimate in 2024 as they contributed to 26% and 21% (abundance) and 36% and 27% (biomass), respectively (Table 16). Interestingly, 0-group contributed with 24% in abundance in 2024 (Table 16) mainly recorded in the southwestern survey area.

Bootstrap estimates of numbers by age, with uncertainty estimates, for blue whiting during IESSNS 2024 are shown in Figure 22. Low CV values for dominant ages 4 and 3, with moderate higher CV values for older and younger fish. The baseline point estimates from 2016-2024 are shown in Table 16. The internal consistency among year classes is shown in Figure 23 and indicates good to very good internal consistency for ages 2-5, and moderate to low fit for other ages.

The group considered the acoustic biomass estimate of blue whiting to be of good quality in the 2024 IESSNS as in the previous survey years.

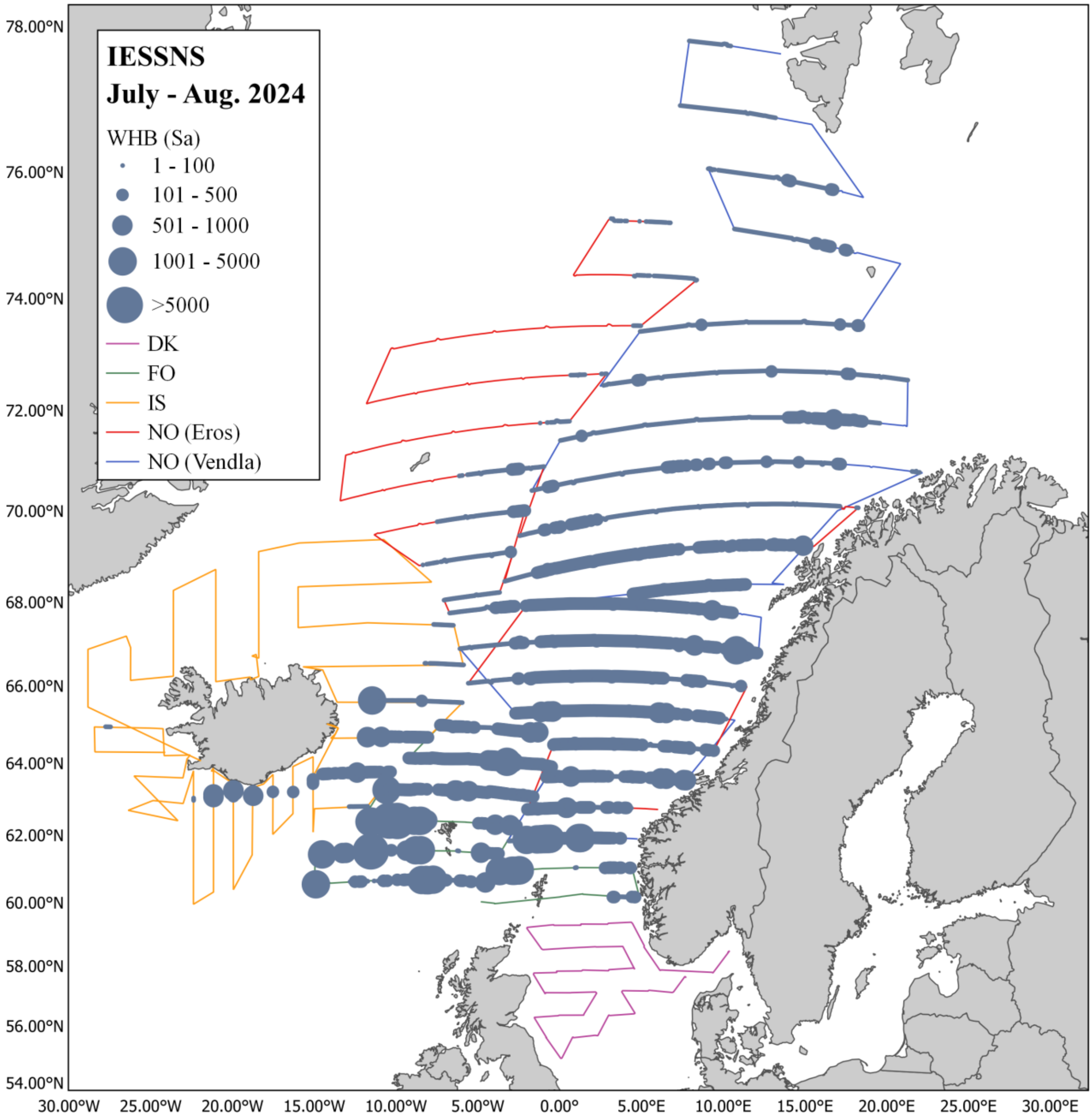


Figure 21a. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2024.

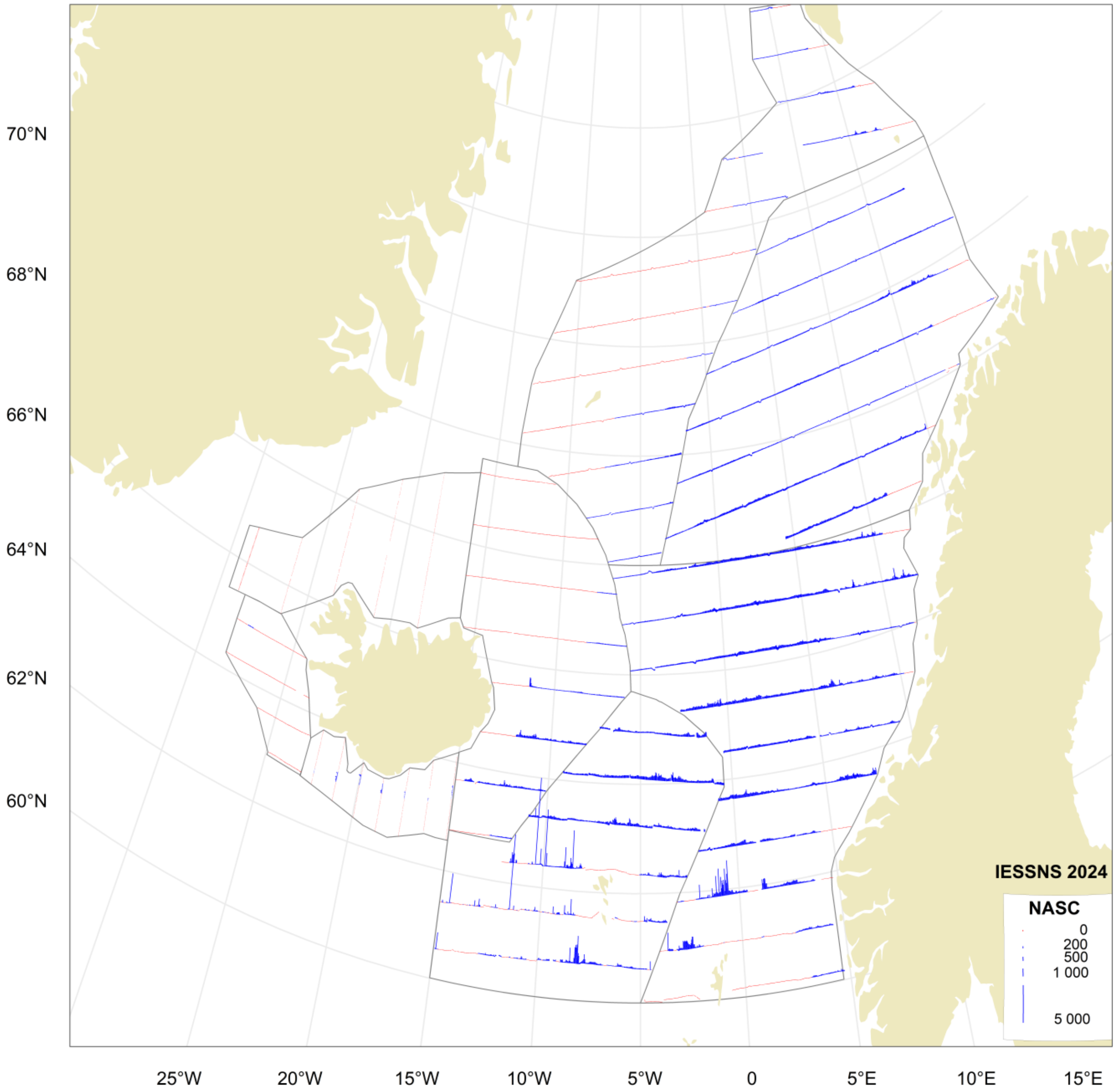


Figure 21b. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2024. Presented as bar plot.

Table 15. Estimates of abundance, mean weight and mean length of blue whiting based on calculation in StoX (bootstrap) for IESSNS 2024.

	Age in years (year class)													Number	Biomass	Mean
Length	0	1	2	3	4	5	6	7	8	9	10	11	12			weight
(cm)	2024	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	(10^6)	(10^6 kg)	(g)
10-11	72.4													72.4	0.5	7.0
11-12	1403.4													1,403.4	12.3	8.8
12-13	1957.8													1,957.8	20.9	10.7
13-14	1015.6													1,015.6	13.4	13.2
14-15	580.5													580.5	9.5	16.3
15-16	312.9													312.9	6.6	20.5
16-17	201.7	14.0												215.7	5.2	24.2
17-18	139.6													139.6	4.2	30.0
18-19	40.1													40.1	1.6	34.5
19-20		262.7												262.7	12.0	43.3
20-21		341.2	37.5											378.7	19.3	50.6
21-22		562.4	70.0				18.9							651.2	36.4	56.9
22-23		758.7	80.2											838.9	55.1	67.0
23-24		346.0	334.8	124.6	28.5									833.9	64.7	77.4
24-25		218.2	458.4	529.5	313.1									1,519.1	131.4	86.9
25-26		6.8	525.5	1311.4	1228.9	283.7	36.3							3,392.5	327.3	96.1
26-27		5.9	366.5	1471.3	1467.7	368.0	4.8	3.6						3,687.9	396.5	108.6
27-28		0.5	145.8	883.7	1503.6	320.7	34.5	7.9	1.7					2,898.5	350.4	122.5
28-29			33.8	425.1	891.1	287.6	62.4	24.3						1,724.3	232.3	137.8
29-30			3.3	92.4	459.0	130.3	14.1	7.4			12.2			718.6	104.7	152.2
30-31		1.0		10.9	197.7	61.2	18.1	18.7	8.9		42.0		16.2	374.5	58.7	166.0
31-32			0.7	3.7	51.4	26.0	33.6	1.4	16.4	1.3	7.1			141.7	24.1	175.6
32-33				3.3	16.0	7.4	32.2	30.6	24.6	12.9	47.4		2.2	176.5	32.4	195.0
33-34		0.8				6.9	11.2	2.9	20.2	8.1	19.8			69.9	14.2	209.1
34-35						1.3	12.8	1.3	17.1	5.4	10.0		1.9	49.8	10.4	213.9
35-36								1.9	1.3	1.9	9.6			14.7	3.8	260.4
36-37															3.5	248.2
37-38						1.3					1.5			2.9	0.8	260.8
38-39																
39-40															0.9	322.0
40-41																
TSN(mill)	5724	2518	2057	4856	6157	1494	279	100	90	30	150		20	23,509.5		
cv (TSN)	0.44	0.36	0.18	0.14	0.11	0.23	0.25	0.38	0.31	0.57	0.37		1.14	0.12		
TSB(1000 t)	73.6	156.8	195.7	525.2	709.1	180.7	38.3	14.8	18.0	5.1	27.5		3.2	1,953.2		
cv (TSB)	0.44	0.31	0.17	0.14	0.11	0.24	0.24	0.38	0.31	0.53	0.39		1.02	0.09		
Mean length(cm	13.1	22.5	25.1	26.5	27.3	27.8	29.6	29.8	32.3	33.2	31.8		31.6			
Mean weight(g)	14	73	102	117	127	131	160	158	199	195	194		188			

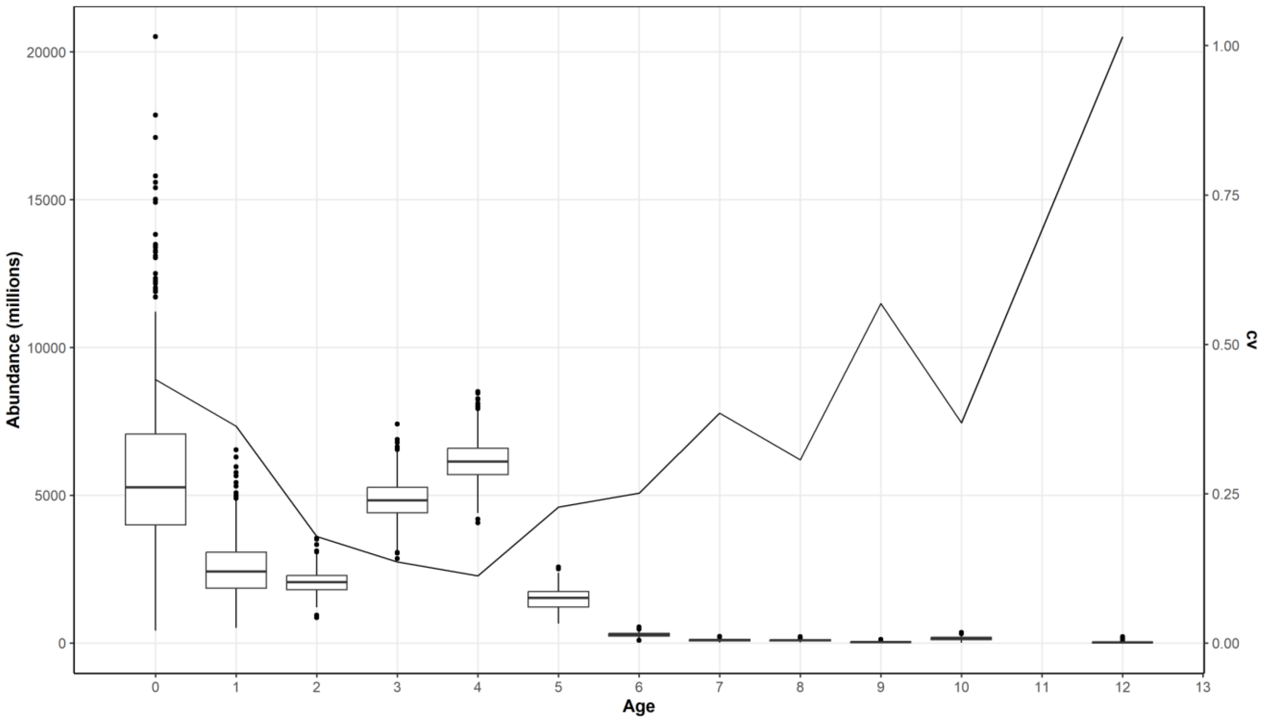


Figure 22. Number by age with uncertainty for blue whiting during IESSNS 2024. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 16. IESSNS baseline time series from 2016 to 2024. StoX biomass estimates of blue whiting (millions).

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+	TSB(1000 t)
2016	3,869	5,609	11,367	4,373	2,554	1,132	323	178	177	8	233	2,283
2017	23,137	2,558	5,764	10,303	2,301	573	250	18	25	0	25	2,704
2018	0	915	1,165	3,252	6,350	3,151	900	385	100	52	41	2,039
2019	2,153	640	1,933	2,179	4,348	5,434	1,151	209	229	5	8	2,028
2020	4,066	5,804	2,996	1,629	1,205	1,718	1,990	939	201	21	30	1,806
2021	4,023	18,056	2,300	1,664	841	982	1,543	609	60	91	74	2,238
2022	978	12,454	9,773	2,279	904	314	520	303	678	177	71	2,241
2023	2,881	3,991	9,673	5,635	764	260	241	125	57	316	23	2,005
2024	5,368	2,476	1,995	4,976	6,202	1,550	292	87	82	27	157	1,963

Table 17. IESSNS bootsrap time series from 2016 to 2024. StoX biomass estimates of blue whiting (millions).

	Age											
Year	0	1	2	3	4	5	6	7	8	9	10+	TSB(1000 t)
2016	4,019	5,781	11,423	4,324	2,353	1,190	351	158	160	7	205	2,269
2017	20,547	2,423	5,901	10,066	2,172	626	238	15	29	0	17	2,618
2018	0	893	1,208	3,198	6,434	3,070	938	371	107	47	43	2,039
2019	2,471	704	1,906	2,254	4,317	5,318	1,174	181	186	9	9	2,023
2020	4,461	6,027	2,903	1,608	1,135	1,762	1,924	929	186	33	37	1,799
2021	4,470	18,484	2,372	1,494	845	851	1,493	635	71	79	84	2,237
2022	955	12,623	9,748	2,175	883	313	510	303	691	148	67	2,224
2023	3,141	3,765	9,925	5,555	721	199	196	131	45	282	24	1,983
2024	5,724	2,518	2,057	4,856	6,157	1,494	279	100	90	30	170	1,953

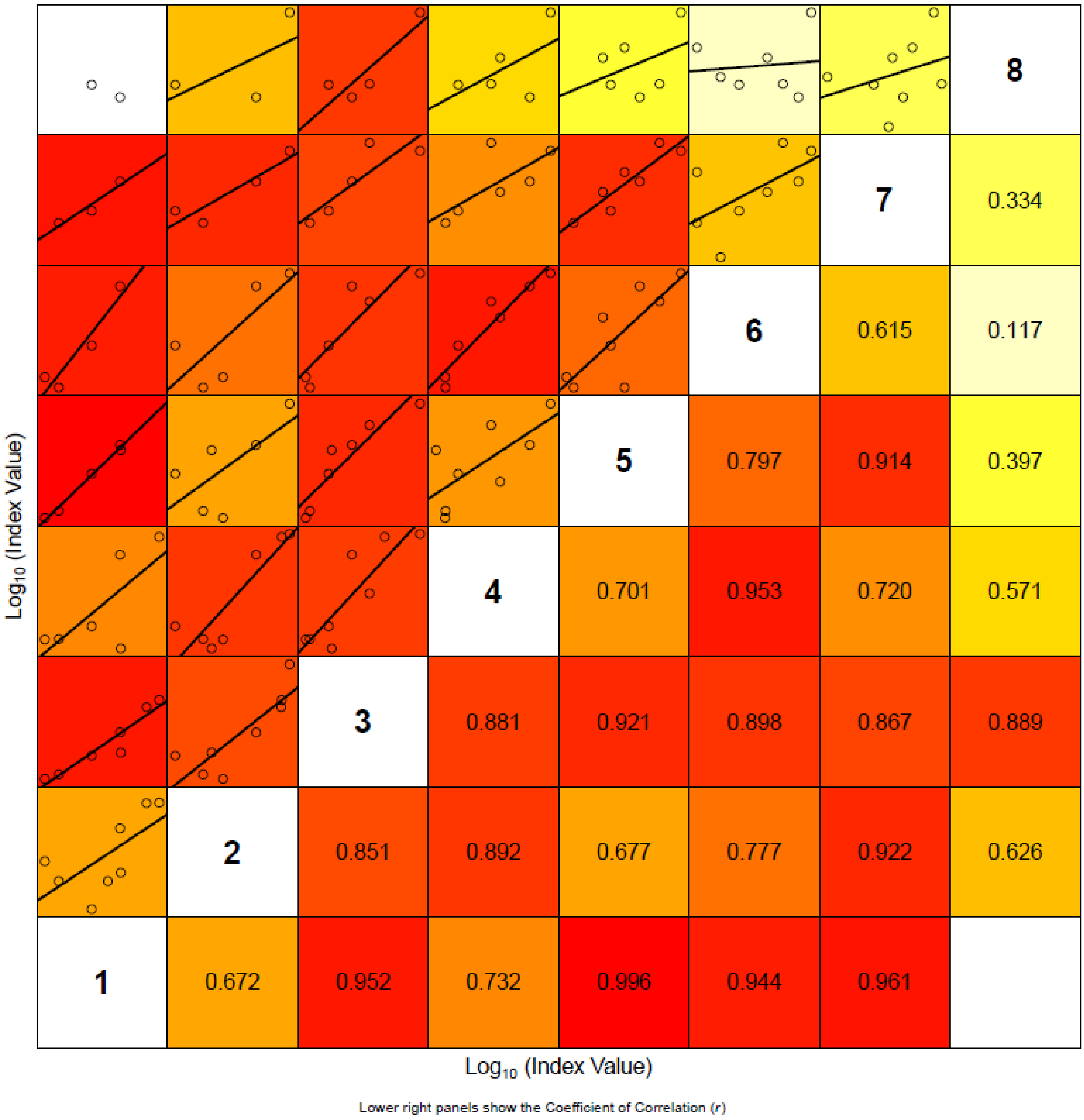


Figure 23. Internal consistency for blue whiting within the IESSNS. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows the correlation coefficient (r) for the two ages plotted in that panel. The background colour of each panel is determined by the r value, where red equates to r=1 and white to r<0.

4.6 Other species

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in 68% of trawl stations across the five vessels (Figure 24) and where lumpfish was caught, 77% of the catches were ≤ 10kg. Lumpfish was distributed across the entire survey area, from west of Iceland to the Barents Sea in the northeast, and into the North Sea in the southern part of the covered area. Abundance was greatest north of 71°N, with lower densities in the central Norwegian Sea and mostly absent south of 58°N. The zero line was not hit to the northeast, northwest and west of the survey so it is likely that the distribution of lumpfish extends beyond the survey coverage.

The length of lumpfish caught varied from 5 to 48.5 cm with a bimodal distribution with the left peak (5-19 cm) likely corresponding to 1-group lumpfish and the right peak consisting of a mixture of age groups (Figure 25). Only a small number of fish were sexed (151 of 1612) but for fish in which sex was determined, the males (n=48) were 14-36 cm in length. The females (n=103) ranged in length from 12 to 46 cm.

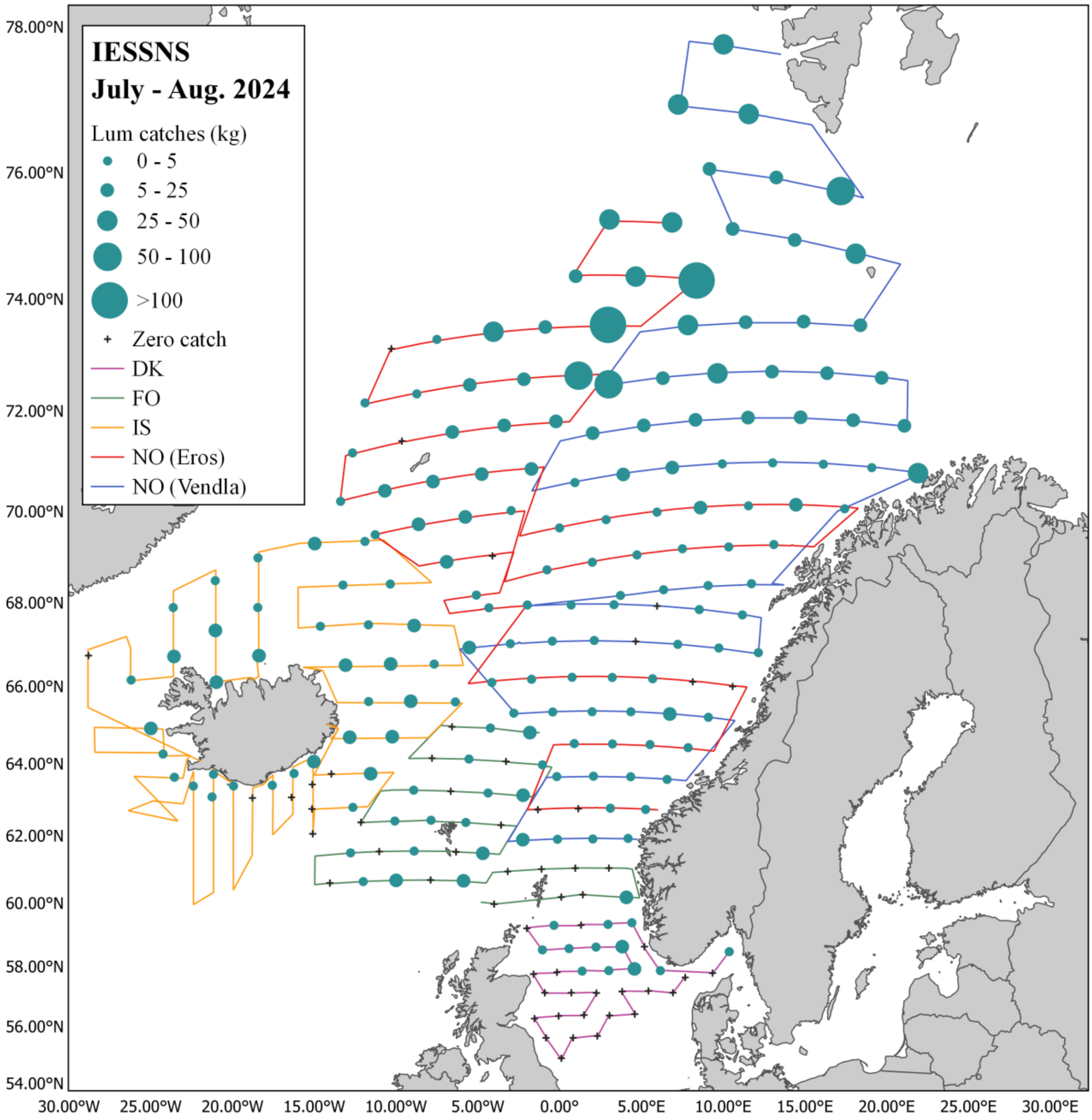


Figure 24. Lumpfish catches at surface trawl stations during IESSNS 2024.

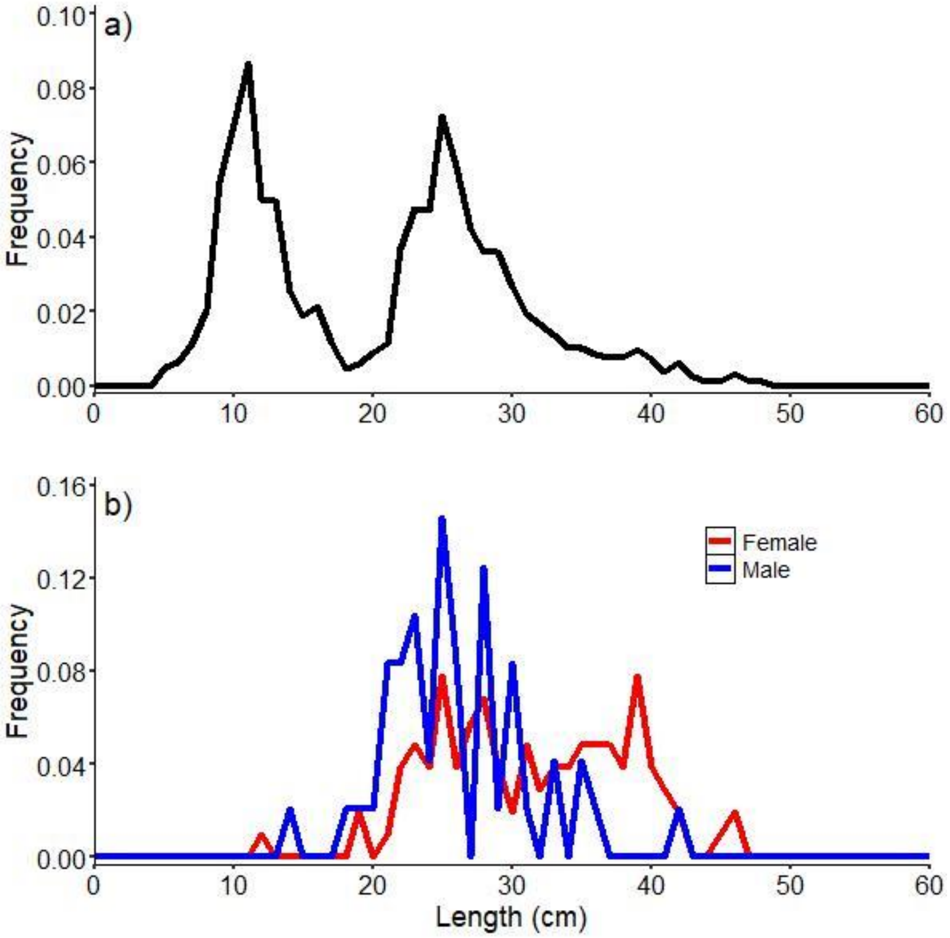


Figure 25. Length distribution of a) all lumpfish caught during the survey and b) length distribution of fish in which sex was determined.

Salmon (*Salmo salar*)

A total of 48 North Atlantic salmon were caught in 25 stations both in coastal and offshore areas from 62° N to 72.6° N in the upper 30 m of the water column. The salmon ranged from 0.087 kg to 2.27 kg in weight, dominated by post-smolt and 1 sea-winter individuals. Between 1 to 10 salmon were caught during individual surface trawl hauls. The length of the salmon ranged from 20 cm to 66 cm, with the highest fraction between 22 cm and 26 cm.

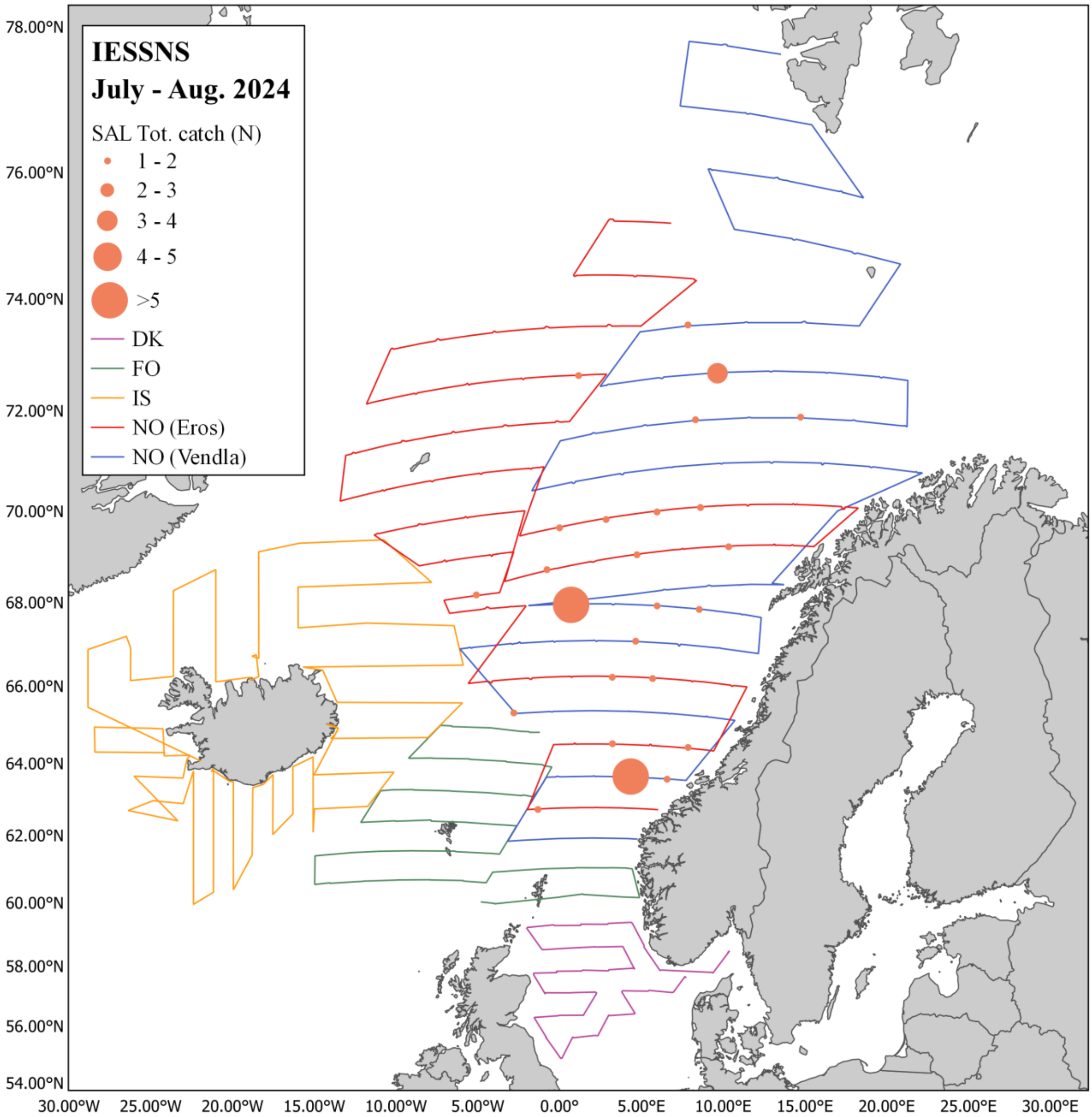


Figure 26. Catches of salmon at surface trawl stations during IESSNS 2024.

Capelin (*Mallotus villosus*)

Capelin was caught in the surface trawl on 24 stations along the cold fronts around Iceland, north of Jan Mayen and consistently along the north-eastern edge of the the survey area (Figure 27). Both juvenile and adult capelin were caught during the survey.

Polar cod (*Boreogadus saida*)

Polar cod was caught one surface trawl station, three specimen, located northwest of Iceland (position: 66.75° N and 28.80° W) which is much less than last year when polar cod was caught at 11 stations north and northeast of Iceland. Due to limited amount of polar cod caught no map is provided in the current report.

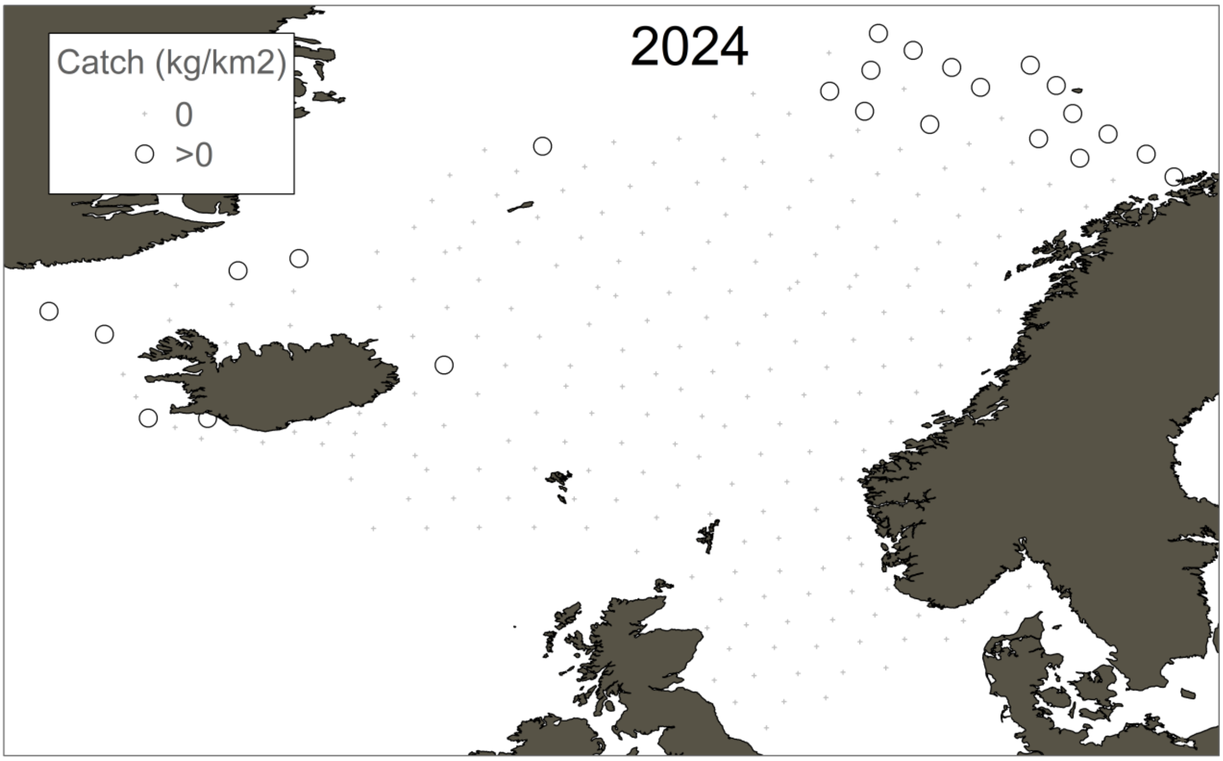


Figure 27. Presence of capelin in surface trawl stations during IESSNS 2024.

4.7 Marine Mammals

Results from the dedicated marine mammals observations onboard M/V "Eros", "Árni Friðriksson" and "Jákup Sverri" will be presented in a dedicated report from NAMMCO.

5 Recommendations

The group suggested the following recommendation from WGIPS	To whom
The surveys conducted by Denmark in 2018-2024 have clearly demonstrated that the IESSNS methodology works also for the northern North Sea (i.e. north and west from Doggerbank) and the Skagerrak area deeper than 50 m. The survey provides essential fishery-independent information on the stock during its feeding migration in summer and WGIPS recommends that the Danish survey should continue as a regular annual survey.	WGWIDE, RCG NANSEA

6 Action points for survey participants

Action points	Responsible
We encourage registrations of opportunistic marine mammal observations.	All
We should consider calculating the zooplankton index from annually gridded field polygons to extract area-mean time-series. WGINOR is currently working on Norwegian Sea polygons, and further work on this issue will start when their work is finalized.	All
In 2024 the IESSNS survey in the North Sea has been conducted for seventh consecutive years (2018-2024). It is recommended that a comprehensive report is written about the major results from the IESSNS surveys in the North Sea, where an update of the internal consistency between years in the survey for selected age groups is also evaluated. This report should be made available for consideration in the next benchmark. A major aim will be to at some stage evaluate and consider the possibility to include and implement the IESSNS survey in the North Sea as an abundance index used in ICES for NEA mackerel.	DTU-Aqua (KW and co-workers)

7 Survey participants

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Lab team:
Jesper Knudsen, National Institute of Aquatic Resources, Denmark (Mackerel otolith extraction)
Maria Jarnum, National Institute of Aquatic Resources, Denmark (Mackerel age reading)

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10 Appendices

Appendix 1

Denmark joined the IESSNS in 2018 thus extending the original survey area into the North Sea. The commercial fishing vessels "Ceton S205" was used. No problems applying the IESSNS methods were encountered. Area coverage, however, was restricted to the northern part of the North Sea at water depths larger 50 m. No plankton samples were taken, and no acoustic data were recorded because this is covered by the HERAS survey in June/July in this area.

Based on the experiences made in the previous years, new limits for the stratum in the North Sea were defined in 2022 (Figure 2, stratum 13). The northern limit for the North Sea and the Skagerrak were defined as 60° N and 59° N, respectively. The western geographical limit in the North Sea was set to 1° 30′ W in the north and 2° 30′ W further south following the UK coastline where the Inner Moray Firth and the Firth of Forth were excluded because mackerel was not recorded there and a high abundance of 0-group gadoids, sandeel and other species makes a quantitative analysis of the catches very time consuming. The eastern limit in the Skagerrak was set to 11° E, and the southern limit in the North Sea was approximated by the 50 m isobath, which is about the shallowest depth limit for a safe setting of the Multpelt 832 trawl.

In 2024, 34 valid stations were taken (PT and CTD). Average mackerel catch amounted to 2004 kg/km^2, which were 18 % lower than in the previous year (2023: 2362 kg/km^2) but is still the third highest in the time series (2021: 2429 kg/km^{2,} 2020: 1318 kg/km^2, 2019: 1009 kg/km^2, 2018: 1743 kg/km^2) (Fig. A1-1). The length and age composition indicate a low amount of small (< 25 cm) individuals and the abundance of older (≥ age 3) mackerel was also lower than in the previous years (Figure A1-2).

The StoX (version 4.0.0) baseline estimates of mackerel biomass and abundance in the North Sea for 2024 were 556 655 tonnes and 2.2 billion individuals (Table A1-1) which is a 14 % lower biomass and a 33 % lower abundance than last year. The biomass and abundance estimates are based on the stratum limits as shown in Figure 2 (stratum 13). The area of this polygon is 285 781 km^2. A summary of the StoX estimates for previous years is given in table A1-2. It is noteworthy that the mean length of the 1-group in 2024 was by far the highest in the time series.

Catches curves indicate that all ages including ages 1 to 5 are well represented in the survey data, and the 2022-year class is the highest at age 1 in the time series (Figure A1-3).

The internal consistency plots (Figure A1-4), however, do not show any significant correlations. This is likely due to the low number of observations which are so far available. Furthermore, interannual variations in the migration of the cohorts in and out of the North Sea may have an effect as well.

Table A1-1. StoX (version 4.0.0) baseline estimates of age segregated and length segregated mackerel indices for the North Sea in 2024.

	Age in years / Year class														Number	Biomass	Mean weight
Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14			
(cm)	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	(10^6)	(ton)	(g)
17-18																	
18-19																	
19-20																	
20-21																	
21-22																	
22-23	1.8														1.8	161	89
23-24	8.2														8.2	805	98
24-25	14.3														14.3	1740	122
25-26	40.8														40.8	5376	132
26-27	49.3														49.3	7609	154
27-28	113.4	19.6													133.0	24391	183
28-29	464.8	45.4													510.2	105650	207
29-30	539.9	28.6													568.5	123959	218
30-31	140.4	51.8	0.1												192.3	46620	242
31-32	6.2	99.4	5.9	0.0											111.4	30225	271
32-33		74.7	38.4	9.8											123.0	36732	299
33-34		49.3	62.3	21.6											133.2	43841	329
34-35		3.0	48.8	65.6	22.2	0.7									140.2	50350	359
35-36			2.5	19.6	26.2	9.5	10.8	0.9							69.4	27516	396
36-37			3.2	1.0	2.1	13.8	15.4	2.5	0.6						38.7	16486	426
37-38					4.6	2.1	14.5	8.3	2.1						31.5	14006	445
38-39						1.2	2.9	10.0	7.9	2.9					24.8	12077	486
39-40							4.1	1.5	3.6	0.1	0.6	1.4			11.4	5916	519
40-41							0.1	0.8	1.7	0.2					2.7	1545	567
41-42								0.5			0.1	0.2			0.8	445	582
42-43								0.2				0.6			0.8	510	676
43-44												0.4			0.4	286	658
44-45														0.4	0.4	408	938
TSN (mill)	1379.1	371.7	161.0	117.7	55.0	27.3	47.8	24.7	15.9	3.2	0.7	2.6	0.0	0.4	2,207	556655	
TSB (ton)	285740	98490	52892	42588	21533	11558	20251	11836	7763	1724	326	1544	0	408			
Mean length (cm)	28.3	30.6	33.1	33.8	34.8	35.8	36.5	37.6	38.2	38.2	39.2	40.5	0.0	44.0			
Mean weight (g)	207	265	328	362	391	424	424	480	488	532	462	593	0	938			

Table A1-2. StoX baseline time series of abundance indices, mean weight at age, biomass indices and mean length at age for mackerel in the North Sea 2018-2023 (data taken from annual IESSNS reports, note: 2022 0-group estimates attributed to 1-group considering a correction of the age readings).

Abundance indices (thousands)																	
Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Tot N
2018	774717	1093847	210679	43338	34070	13095	2816	1437	1017								2175016
2019	346531	307470	149154	110147	41361	29349	12925	11119	5522	2530	87	499					1016694
2020	754967	299966	112643	39540	63685	30054	6754	3442	1242	1366	974	125	18	157	0	61	1314994
2021	1901737	598817	75522	109484	65742	50577	18160	11916	9999	5884	1337	4431	930	72	64		2854672
2022	1279964	483303	92432	49849	34440	28463	16307	4294	4830	657		405	0	120			1995064
2023	1965848	710280	349134	127399	72514	53336	32644	26907	6956	1384	1746	537	322				3349007
Mean weight (g)																	
Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
2018	93	200	291	343	380	415	519	457	187								
2019	135	207	272	303	341	352	415	428	450	502	640	505					
2020	121	257	304	337	351	418	442	458	477	521	557	550		649	516	596	
2021	154	232	313	341	368	405	400	453	478	508	421	418	581	672	700		
2022	192	282	335	385	422	460	474	511	525	525		638		746			
2023	113	274	317	336	366	387	399	462	530	476	522	494	476				
Biomass (tonnes)																	
Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Tot B
2018	72289	218580	61214	14858	12934	5429	1461	657	190								387613
2019	46889	63755	40511	33332	14102	10337	5370	4753	2486	1271	56	252					223112
2020	91064	76959	34213	13320	22367	12552	2985	1576	592	711	543	69	0	11	81	36	257079
2021	291991	139041	23664	37357	24174	20503	7260	5400	4775	2987	563	1850	540	48	45		560198
2022	245298	136351	30981	19206	14533	13103	7731	2195	2535	345	0	259	0	90			472627
2023	222558	194721	110530	42839	26509	20636	13029	12420	3690	658	911	265	153				648919
Mean length (cm)																	
Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
2018	21.7	28.3	32.7	34.0	35.6	36.8	38.7	37.9	27.4								
2019	25.4	28.9	31.5	32.7	34.4	35.0	36.4	37.4	37.6	38.9	41.6	39.9					
2020	24.1	30.4	32.4	33.3	34.6	35.7	37.0	37.8	38.6	38.4	40.0	40.0		42.0	40.0	42.0	
2021	25.7	29.4	32.9	34.1	34.9	36.0	36.6	38.0	37.7	40.2	37.7	36.9	40.8	41.5	45.0		
2022	26.5	30.8	33.0	34.7	36.3	36.9	37.4	38.2	38.1	40.0		42.0		42.0			
2023	23.5	31.1	32.9	33.6	35.0	35.8	36.4	37.7	39.2	38.6	40.0	39.2	40.0				

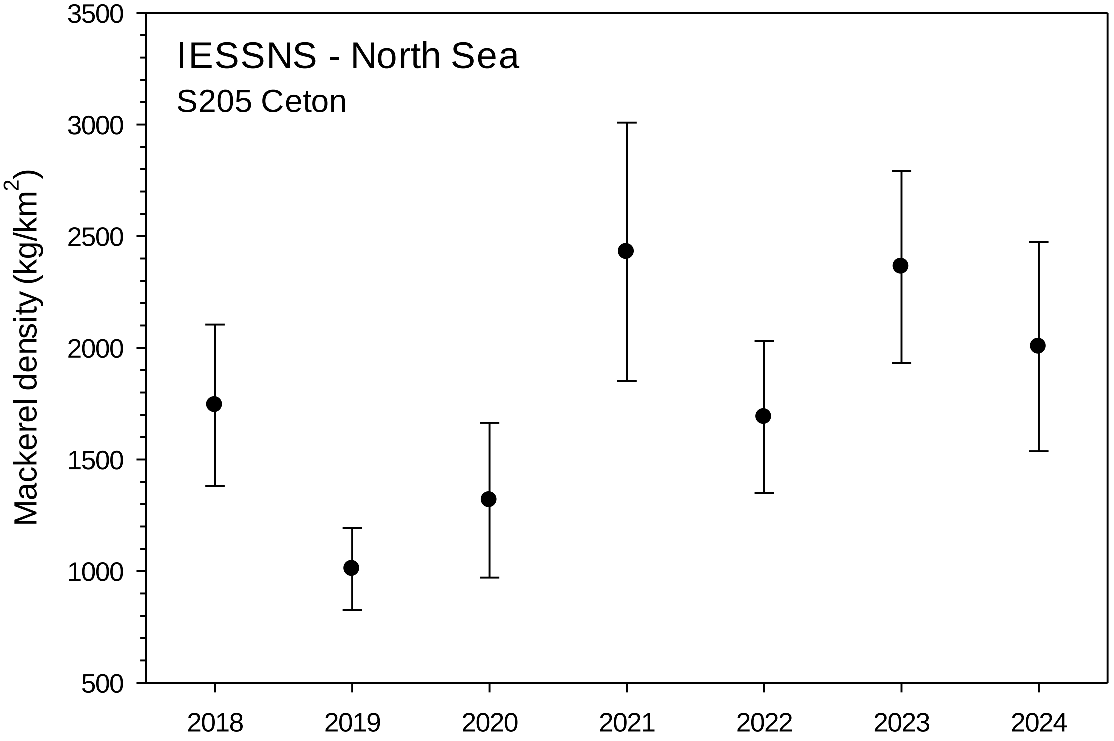

Fig. A1-1. Biomass density (mean and standard error) of mackerel in the North Sea 2018 to 2024.

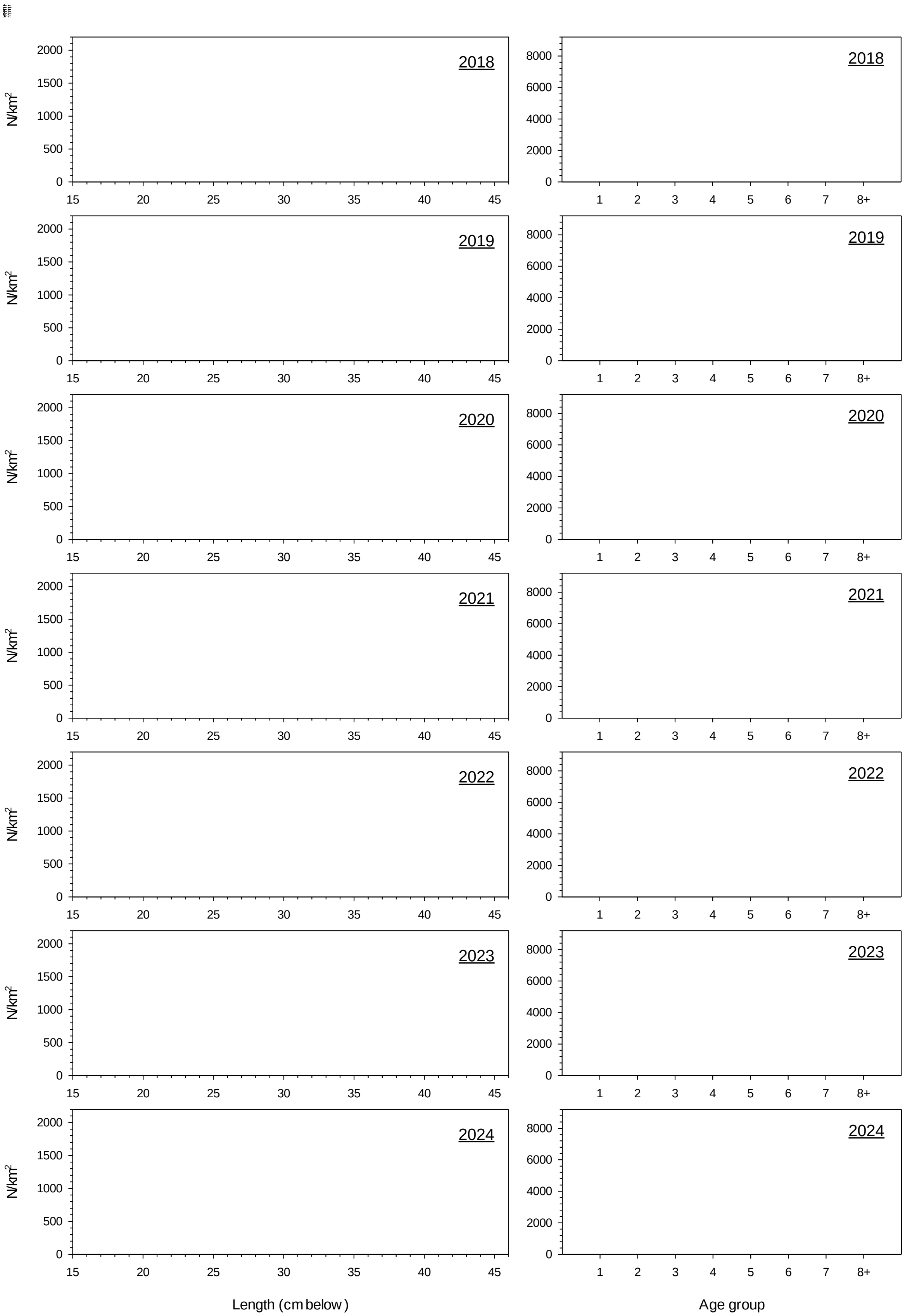

Fig. A1-2. Comparison of length and age distribution of mackerel in the North Sea 2018 to 2024.

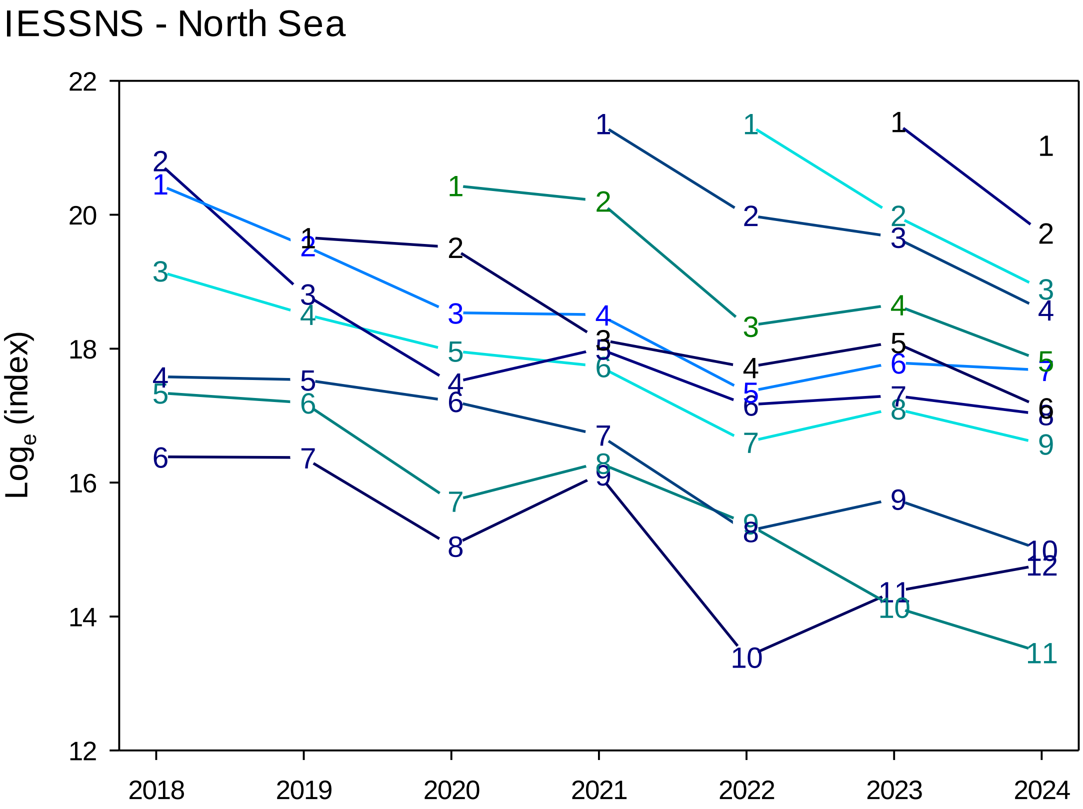

Fig. A1-3. Catch curves for mackerel year classes 2012 to 2024 in the North Sea (lines represents cohorts, numbers denote ages).

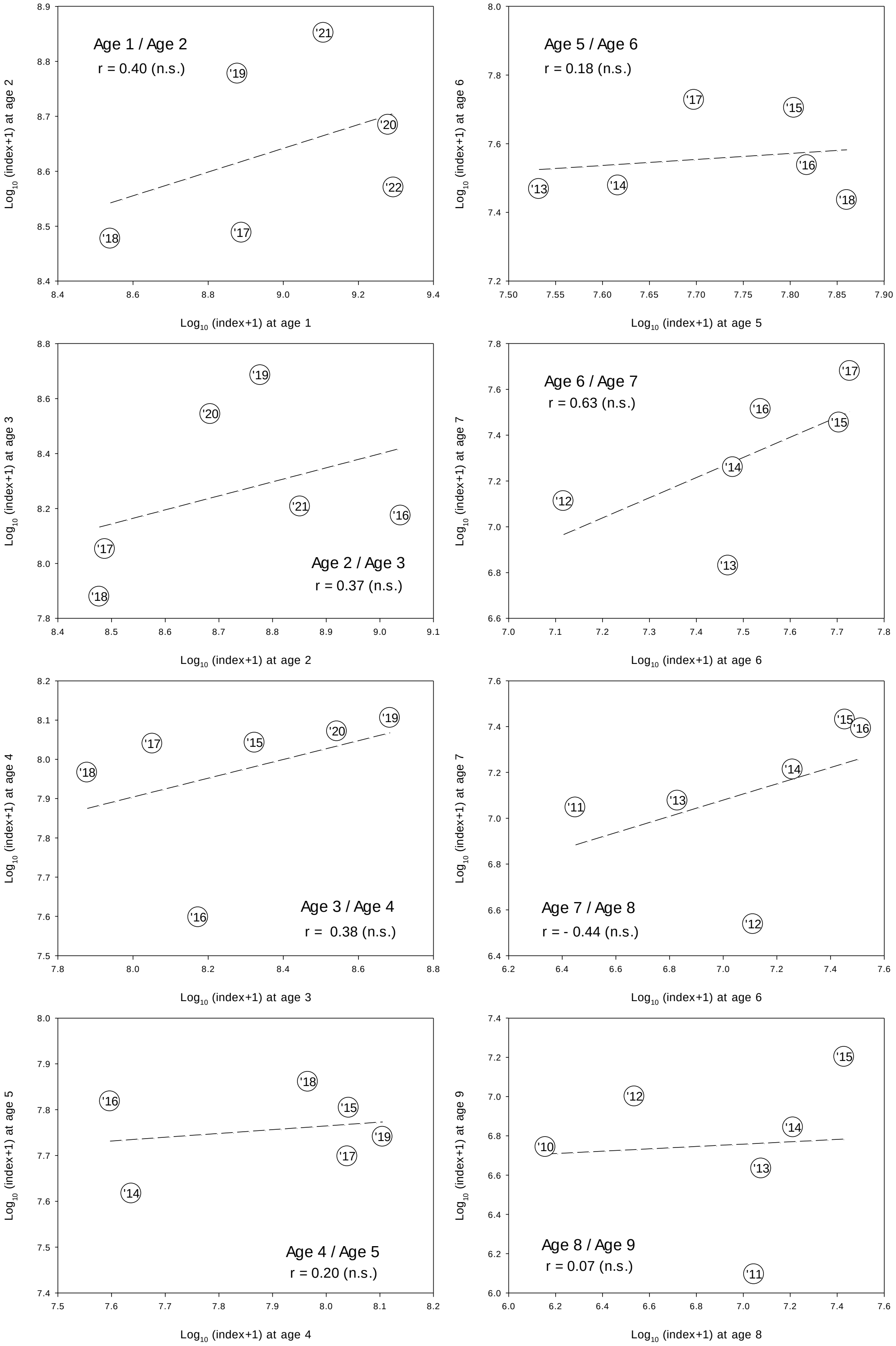

Fig. A1-4. Internal consistency of mackerel density indices ages 1 to 9 for the North Sea from 2018 to 2024 (numbers in symbols indicate 2000'er year classes).

Appendix 2

The mackerel index is calculated on all valid surface stations. That means, that invalid and potential extra surface stations and deeper stations need to be excluded. Below is the exclusion list used when calculating the mackerel abundance index for IESSNS 2024.

Vessel	Country	Horizontal trawl opening (m)	Exclusion list	
			Cruise	Stations
Vendla	Norway	63.8	2024203003	32, 35, 40, 45, 51, 56, 60, 66, 70, 75, 79, 85, 91, 95, 99, 102, 105, 110, 112
Eros	Norway	72.8	2024204002	20, 26, 30, 36, 37, 45, 48, 51, 55, 59, 64, 70, 71, 77, 88
R/V Árni Friðriksson	Iceland	66.0	A8-2024	400, 407, 410, 411, 416, 425, 429, 435, 437, 441
R/V Jákup Sverri	Faroe Islands	63.9	234-1005-2428	09, 38, 49, 59, 72
Ceton	Denmark	68.0	IESSNS_DK_2024	19

* Observe that in PGNAPES and the national database station numbers are 4-digit numbers preceded by 2230 (e.g. ‘22300005’)

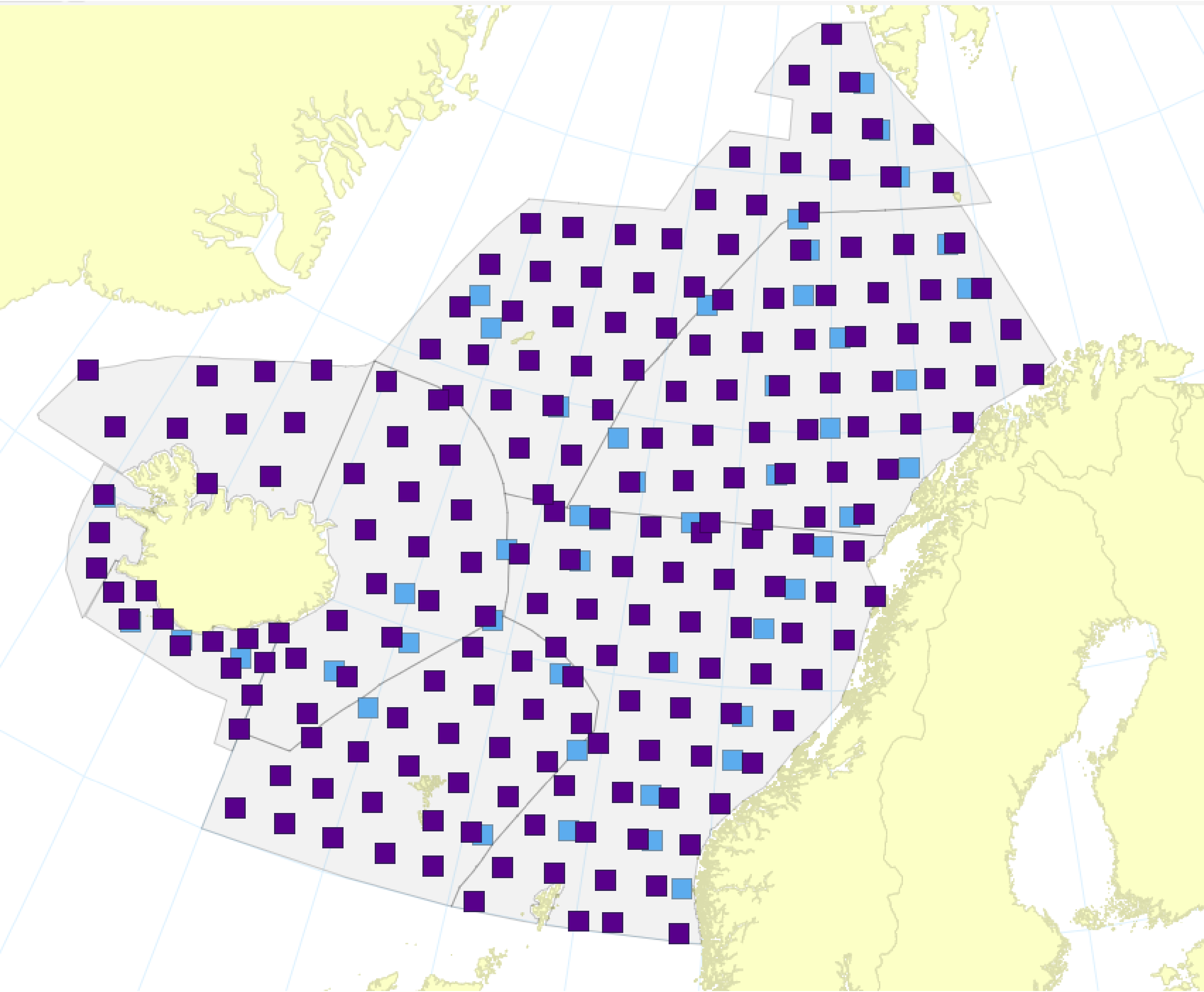

Figure A2-1. IESSNS 2024. Surface trawl stations included (filled dark blue rectangle) and excluded (filled light blue rectangle) in calculations of mackerel age segregated index used in the assessment. Strata boundary also displayed (grey solid lines).

Appendix 3

Horizontal trawl opening of the Multpelt 832 trawl is a function of trawl door spread and tow speed (Table 6 in the 2022 report). The estimates in table 6 are originally based on flume tank simulations in 2013 (Hirtshals, Denmark) where two formulas were empirically derived for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 × Door spread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 × Door spread (m) + 20.094

In 2017, the towing speed range was increased to 5.2 knots, i.e. an extrapolation of the trawl opening as a function of door spread and speed was performed. In 2022 the towing speed range was further extended down to 4.3 knots and up to 5.5 knots, using a kriging gridding method, see figure A3-1. In 2023, the trawl opening was extended to 135m (Table 6).

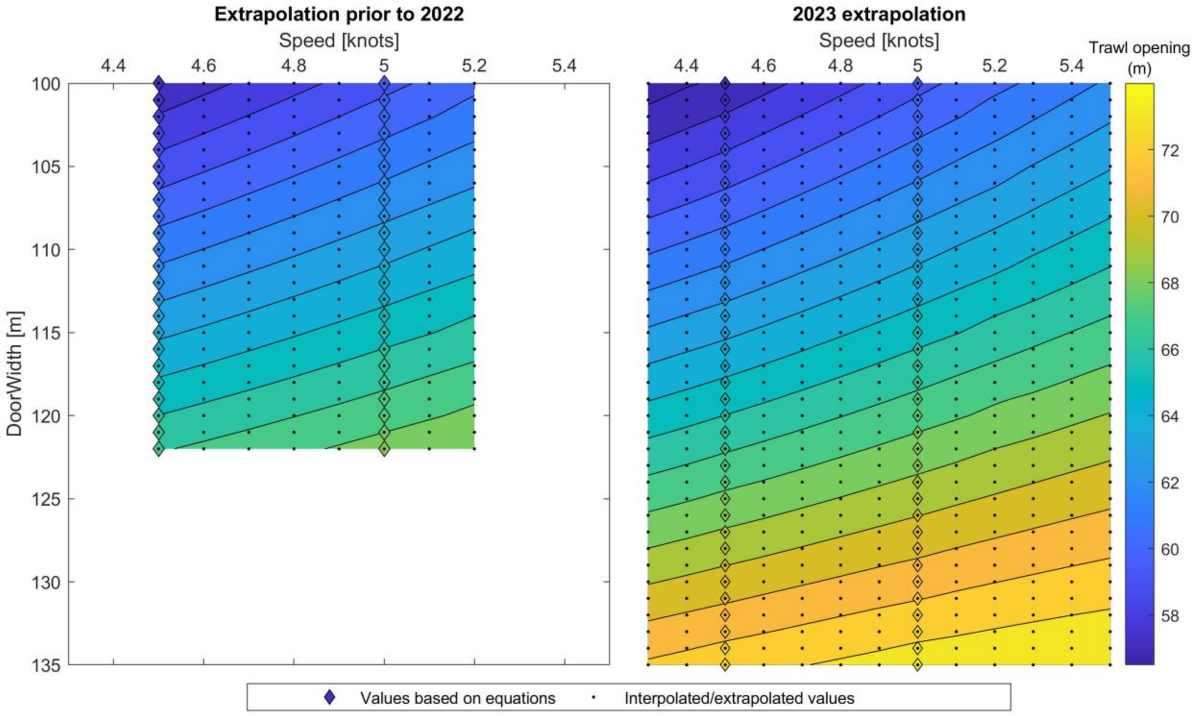

Figure A3-1. Table 6 in the report shown as a plot.

Appendix 4

Separate capelin coverage in the Jan Mayen zone