Working Document to

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Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS)
1st July – 3rd August 2022

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1 Executive summary

The International Ecosystem Summer Survey in the Nordic Seas (IESSNS) was performed within approximately 5 weeks from July 1st to August 3rd in 2022 using six vessels from Norway (2), Iceland (1), Faroe Islands (1), Greenland (1) and Denmark (1). The main objective is to provide annual age-segregated abundance index, with an uncertainty estimate, for northeast Atlantic mackerel (*Scomber scombrus*). The index is used as a tuning series in stock assessment according to conclusions from the 2017 and 2019 ICES mackerel benchmarks. A standardised pelagic swept area trawl method is used to obtain the abundance index and to study the spatial distribution of mackerel in relation to other abundant pelagic fish stocks and to environmental factors in the Nordic Seas, as has been done annually since 2010. Another aim is to

construct a new time series for blue whiting (*Micromesistius poutassou*) abundance index and for Norwegian spring-spawning herring (NSSH) (*Clupea harengus*) abundance index. 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 seven years (2016-2022).

The survey coverage area included in calculations of the mackerel index was 2.9 million km^2 in 2022, which is 32% larger coverage compared to 2021. Survey coverage was increased in the western areas (Iceland and Greenland waters) compared to in 2021. Furthermore, 0.28 million km^2 was surveyed in the North Sea in July 2022, but those stations are excluded from the mackerel index calculations.

The total swept-area mackerel index in 2022 was 7.37 million tonnes in biomass and 17.51 billion in numbers, an increase by 43% for biomass and 43% for abundance compared to 2021. In 2022, the most abundant year classes were 2020, 2019, 2010, 2011, respectively. The cohort internal consistency improved compared to last year, particularly for ages 5-8 years.

Most of the surveyed mackerel still appears to be in the Norwegian Sea. The mackerel were more westerly distributed than in the last 2 years.

The zero-line was reached south and north of Iceland and in the west in Greenland waters. It was not reached in the north-western and north-eastern part of the Norwegian Sea but given that the polar front with water too cold for mackerel is usually found close to the northwesternmost catches, we assume that the zero-line was practically reached here as well. Towards the Barents Sea the zero-line was not reached but considered of less quantitative importance based on low catch rates. The zero-line was not reached on the European shelf, where mackerel are present west of the British Isles and in the southern North Sea

Total number of NSSH recorded during IESSNS 2022 was 25.0 billion and the total biomass index was 7.14 million tonnes, or 22% (abundance) and 17% (biomass) higher than in 2021. The 2016 year-class (6-year-olds completely dominated in the stock and contributed to 58% and 56% to the total biomass and total abundance, respectively, whereas the 2013 year-class (9-year-olds) contributed 8% and 7% to the total biomass and total abundance, respectively. The 2016 year-class is fully recruited to the adult stock.

The zero-line of the distribution of the mature part of NSSH was considered to be reached in all directions. The group considered the acoustic biomass estimate of herring in 2022 to be of the similar quality as in the previous survey years. The herring was mainly observed in the upper surface layer as relatively small schools.

Total biomass of blue whiting registered during IESSNS 2022 was 2.2 million tons, which is to the same as in 2021. Estimated stock abundance (ages 1+) was 27.5 billion compared to 26.2 billion in 2021. Age 1 and 2 respectively, dominated the estimate in 2022 as they contributed to 44% and 33% (abundance) and 30% and 33% (biomass), respectively. The group considered the acoustic biomass estimate of blue whiting to be of good quality in the 2022 IESSNS as in the previous survey years.

As in previous years, there was overlap in the spatio-temporal distribution of mackerel and herring. This overlap occurred between mackerel and North Sea herring in the North Sea and partly in the southernmost part of the Norwegian Sea. There were also some overlapping distributions of mackerel and Norwegian spring-spawning herring (NSSH) particularly in the western, north-western part of the Norwegian Sea.

Other fish species also monitored are lumpfish (*Cyclopterus lumpus*) and Atlantic salmon (*Salmo salar*). Lumpfish was caught at 71% of surface trawl stations distributed across the surveyed area from southwestern part of Iceland, central part of North Sea to southwestern part of the Svalbard. Abundance was greater north of latitude 72°N compared to southern areas. A total of 60 North Atlantic salmon were caught in 38 stations both in coastal and offshore areas from 61°N to 76°N in the upper 30 m of the water column. The salmon ranged from 0.028 kg to 4.1 kg in weight, dominated by post-smolt and 1 sea-winter individuals. We caught from 1 to 6 salmon during individual surface trawl hauls. The length of the salmon ranged from 15 cm to 74 cm, with the highest fraction between 20 cm and 30 cm

Satellite measurements of sea surface temperature (SST) in the Northeast Atlantic in July 2022 show that parts of central Norwegian Sea and areas east and north of Iceland were slightly cooler 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 that the long-term average. The SST in the Irminger Sea and Iceland Basin were slightly warmer than the average.

The zooplankton biomass varied between areas with a patchy distribution throughout the area. In the Norwegian Sea areas, the average zooplankton biomass was at similar level as last year, slightly lower in Icelandic waters, and higher in Greenlandic waters.

2 Introduction

During approximately four weeks of survey in 2022 (1st of July to 3rd of August), six vessels; the M/V "Eros" and M/V "Vendla" from Norway, "Jákup Sverri" operating from Faroe Islands, the R/V "Árni Friðriksson" from Iceland; R/V "Tarajoq" from Greenland 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. 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 time series 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 when 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 and Atlantic salmon. Opportunistic whale observations are also recorded from Norway, Iceland, and Faroe Islands. 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).

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 standardization were conducted in 2010. Smaller 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 but was back in 2022 with their new research vessel R/V "Tarajoq".

The North Sea was included in the survey area for the fifth time in 2022, 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 with the 2018 - 2021 results).

3 Material and methods

Coordination of the IESSNS 2022 was done during the WGIPS 2022 virtual meeting in January 2022, and by correspondence in spring and summer 2022. The participating vessels together with their effective survey periods are listed in Table 1.

Overall, the weather conditions were rougher than usual for the Norwegian vessels in the first part of the survey. However, in the second part, the weather conditions and progress were good. The Icelandic vessel, operating in Icelandic waters, experienced calm weather for duration of the survey with no survey delay, and no CTD or WP2-net sampling was skipped due to high winds. The weather was worse than what is has been previous years for the Faroese vessel which operated in Faroese and Icelandic waters. This resulted in slow progression and the Icelandic vessel had to cover the northernmost transect line for R/V Jakup Sverri. The chartered vessel Ceton had good weather conditions throughout the survey.

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 also 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.

Table 1. Survey effort by each of the five vessels during the IESSNS 2022. 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 period	Length of cruise track (nmi)	Total trawl stations/ Fixed stations	CTD stations	Plankton stations
Árni Friðriksson	4-21/7	4082	48/46	46	46
Jákup Sverri	1-17/7	2768	33/27	28	28
Ceton	3-12/7	1905	38/34	34	-
Vendla	5/7-3/8	5369	74/60	59	59
Eros	5/7-3/8	5233	67/57	56	56
Tarajoq	21/7-1/8	1522	19/19	19	19
Total	1/7-3/8	20879	275/247	242	208

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. Tarajoq used a SEABIRD SBE 19plus. Ceton used a Seabird SeaCat offline CTD. The CTD-sensors were used for recording temperature, salinity, and pressure (depth) from the surface down to 210 m, or to the bottom when at shallower depths.

Zooplankton was sampled with a WP2-net on 4 of 5 vessels, excluding Ceton which operates in the North Sea. Mesh sizes were 180 μm (Eros and Vendla) and 200 μm (Árni Friðriksson, Jákup Sverri and Tarajoq). 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 CTD and plankton stations 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. 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 for fish, and total weight per species recorded. The processing of trawl catch varied between nations. The Icelandic and 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 90 kg (if it was clean catch of either herring or mackerel) to 200 kg (if it was a mixture of herring and mackerel). 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 2018, 2019, 2020, 2021 and 2022.

Table 2. Trawl settings and operation details during the international mackerel survey in the Nordic Seas from 1st July to 3rd August 2022. 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**	**Tarajoq**	**Influ-ence**
Trawl producer	Hampiðjan new 2017 trawl	Egersund Trawl AS	Egersund Trawl AS	Vónin	Egersund Trawl AS	Hampiðjan	0
Warp in front of doors	Dynex-34 mm	Dynex -34 mm	Dynex	Dynex – 38 mm	Dynex-34 mm	Dynex-34 mm	+
Warp length during towing	350	350	290-305	350	350-400	350	0
Difference in warp length port/starb. (m)	16	2-10	10	0-7	5-10	10-20	0
Weight at the lower wing ends (kg)	2×400 kg	2×400	2×400	2×400	2×400	2×500	0
Setback (m)	14	6	6	6	6	6	+
Type of trawl door	Jupiter	Seaflex 7.5 m^2 adjustable hatches	Thybron type 15	Vónin Twister	Seaflex 7.5 m^2 adjustable hatches	T-20vf Flipper	0
Weight of trawl door (kg)	2200	1700	1970	1650	1700	2000	+
Area trawl door (m^2)	6	7.5 with 25% hatches (effective 6.5)	7	4.5	7 with 50% hatches (effective 6.5)	7 with 50% hatches (effective 6.5)	+
Towing speed (knots) mean (min-max)	5.3 (4.6-5.7)	4.6 (4.1-5.5)	5.1 (4.5-5.6)	4.4 (3.6-6)	4.7 (4.1-5.725)	4.9 (4.4-5.4)	+
Trawl height (m) mean (min-max)	32 (26-41)	28-37	30 (25-35)	43 (35–50)	25-32	-	+
Door distance (m) mean (min-max)	107 (95 - 115)	121.8 (118-126)	131.2 (126-137)	115 (107 – 135)	135 (113-140)	105.4 (92-109)	+
Trawl width (m)*	63.75	63.8	72.0	63.4	67.5	61.4	+
Turn radius (degrees)	5-10	5-12	5-10	5 BB turn	5-8 SB turn	6-8 SB turn	+
Fish lock front of cod-end	Yes	Yes	Yes	Yes	Yes	Yes	+
Trawl door depth (port, starboard, m) (min-max)	3-21, 4-8	6-22, 8-23	6-15, 8-20	7-26, 7-20	(6-20)	-	+
Headline depth (m)	0	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 buoys on each wingtip	Kite + 2 buoy on each wingtips	Kite + 1 buoy on each wingtips	+

Weighing of catch	All weighted	All weighted	All weighted	Catch < 12 tonnes weighed	All weighted	All weighted	+

* calculated from door distance (Table 6)

Table 3. Protocol of biological sampling during the IESSNS 2022. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

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

*Length measurements / weighed individuals
**Sampled at every third station
*** 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.
^^Numbers changed from 100 to 50 during survey.

This year's survey was well synchronized in time and was conducted over a relatively short period (less than 5 weeks) given the large spatial coverage of around 2.9 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 July. The main argument for this time period was to make the 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

M/V "Eros" and M/V "Vendla" employed an underwater video camera (GoPro HD Hero 4 and 5 Black Edition, www.gopro.com) to observe mackerel aggregation, swimming behaviour and possible escapement from the cod end and through meshes. The camera was put in a waterproof box which tolerated pressure down to approximately 100 m depth. No light source was employed with cameras; hence, recordings were limited to day light hours. Some recordings were also taken during night-time when there was midnight sun and good underwater visibility. Video recordings were collected at 70 trawl stations. The camera was attached on the trawl in the transition between 200 mm and 400 mm meshes.

3.3 Marine mammals

Opportunistic observations of marine mammals were conducted by scientific personnel and crew members from the bridge between 5th July and 2nd August 2022 onboard M/V "Eros" and M/V "Vendla", and onboard R/V Árni Friðriksson from 4th until 21st July 2022. On board Jákup Sverri (1st – 17th July) opportunistic observations were done from the bridge by crew members.

3.4 Lumpfish tagging

Lumpfish caught during the survey by vessels R/V "Árni Friðriksson", M/V "Eros", M/V "Vendla" and R/V Tarajoq were tagged with Peterson disc tags and released. When the catch was brought aboard, any lumpfish caught were transferred to a tank with flow-through sea water. After the catch of other species had been processed, all live lumpfish larger than ~15 cm were tagged. The tags consisted of a plastic disc secured with a titanium pin which was inserted through the rear of the dorsal hump. Contact details of Biopol (www.biopol.is) were printed on the tag. The fish were returned to the tank until all fish were tagged. The fish were then released, and the time of release was noted which was used to determine the latitude and longitude of the release location.

3.5 Acoustics

Multifrequency echosounder

The acoustic equipment onboard Vendla and Eros were calibrated 4th July 2022 for 18, 38, 70, 120 and 200 kHz. Árni Friðriksson was calibrated 28th of May 2022 for frequencies 18, 38, 70, 120 and 200 kHz. Jákup Sverri was calibrated on 24th April 2022 for 18, 38, 120, 200 and 333 kHz. Tarajoq was calibrated on 20th May 2022 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). Acoustic measurements were not conducted onboard Ceton in the North Sea. 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 = 20.0 log(L) – 71.9 dB

Table 4. Acoustic instruments and settings for the primary frequency (38 kHz) during IESSNS 2022.

	R/V Árni Friðriksson	M/V Vendla	Jákup Sverri	Eros	Tarajoq*
Echo sounder	Simrad EK80	Simrad EK60	Simrad EK80	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	18, **38**, 70, 120, 200, 333
Primary transducer	ES38-7	ES38B	ES38-7	ES38B	ES38-7
Transducer installation	Drop keel	Drop keel	Drop keel	Drop keel	Drop keel
Transducer depth (m)	9.6	8	6-9	6	7
Upper integration limit (m)	15	15	15	15	
Absorption coeff. (dB/km)	10.5	9.9	9.5	9.3	
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	3.064	2.43	
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	18	21.90	21.9	21.9	
2-way beam angle (dB)	-20.30	-20.70	-20.6	-20.7	
TS Transducer gain (dB)	27.03	25.22	27.27	25.22	
s_A correction (dB)	-0.04	-0.73	-0.01	-0.72	
3 dB beam width alongship:	6.43	6.88	6.86	6.85	
3 dB beam width athw. ship:	6.43	6.76	6.89	6.79	
Maximum range (m)	500	500	500	500	750
Post processing software	LSSS v.2.12.0	LSSS 2.12.0	LSSS 2.12.0	LSSS 2.12.0	LSSS 2.12.0

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

*Acoustic data collected but not post-processed at the time of report writing.

Multibeam sonar

Both M/V Eros and M/V Vendla were equipped with the Simrad fisheries sonar SH90 (frequency range: 111.5-115.5 kHz), 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 six 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 35-90 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 July-August 2022 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.

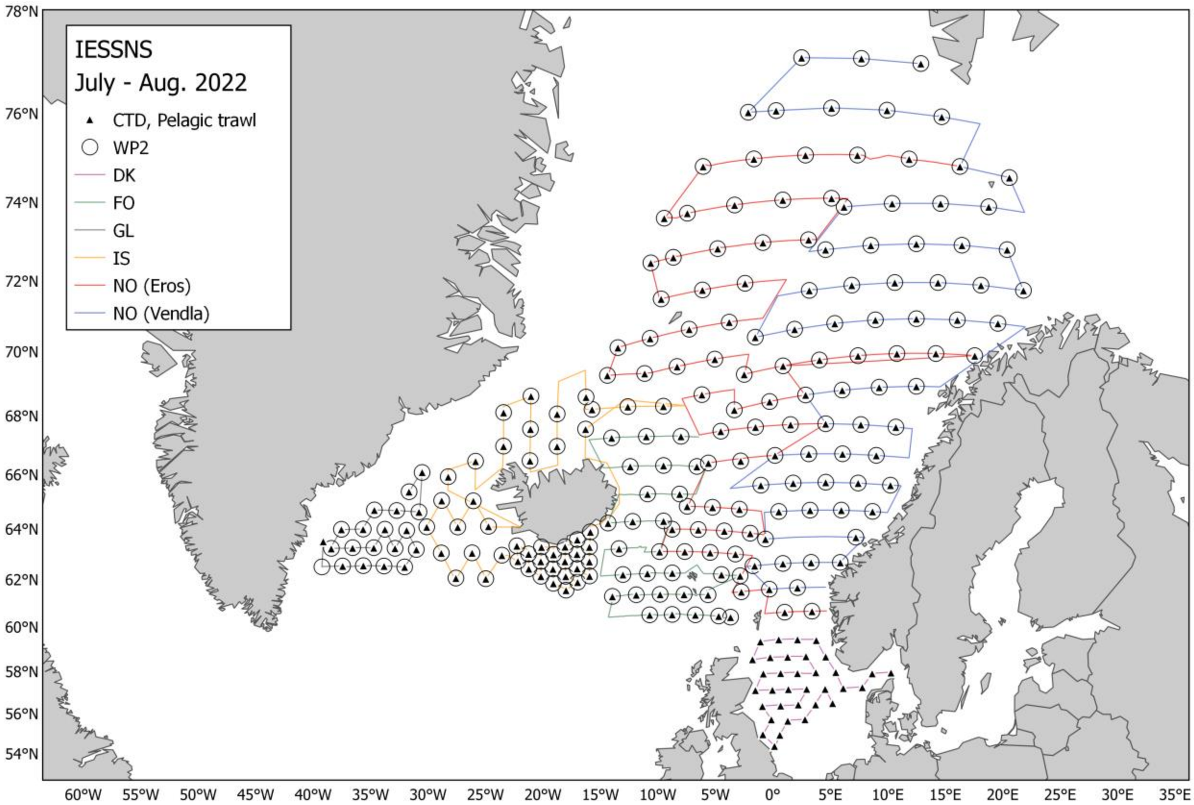

Figure 1. Fixed predetermined trawl stations (shown for CTD and WP2) included in the IESSNS from July 1st to August 3rd 2022. At each station a 30 min surface trawl haul, a CTD station (0-500 m) and WP2 plankton net samples (0-200 m depth) was performed.

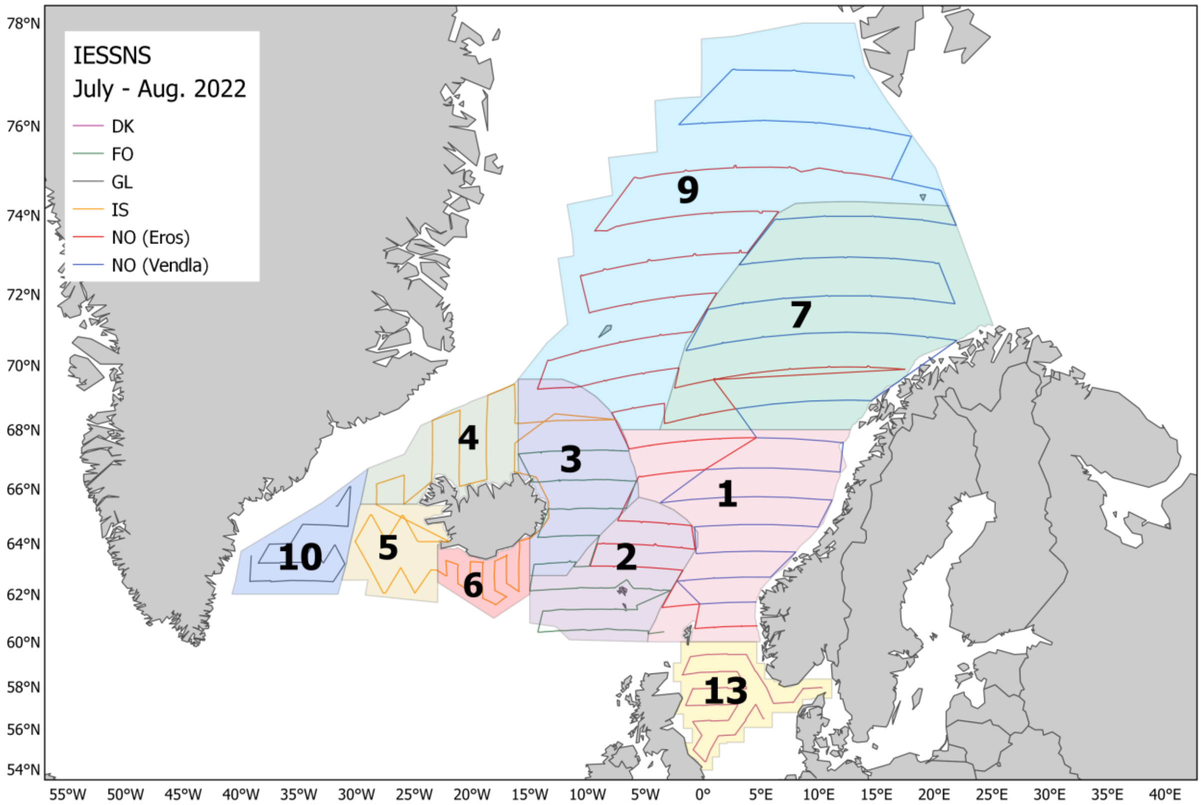

Figure 2. Permanent and dynamic strata used in StoX for IESSNS 2022. The survey area is split into 10 strata, of which 6 are permanent (1, 2, 3, 7, 10 and 13) and four dynamic (4, 5, 6 and 9). The former stratum 8 (along the Norwegian coast) was merged into adjacent strata 1 and 7. The former stratum 11 (southern Greenland) has not been surveyed the last few years. 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).

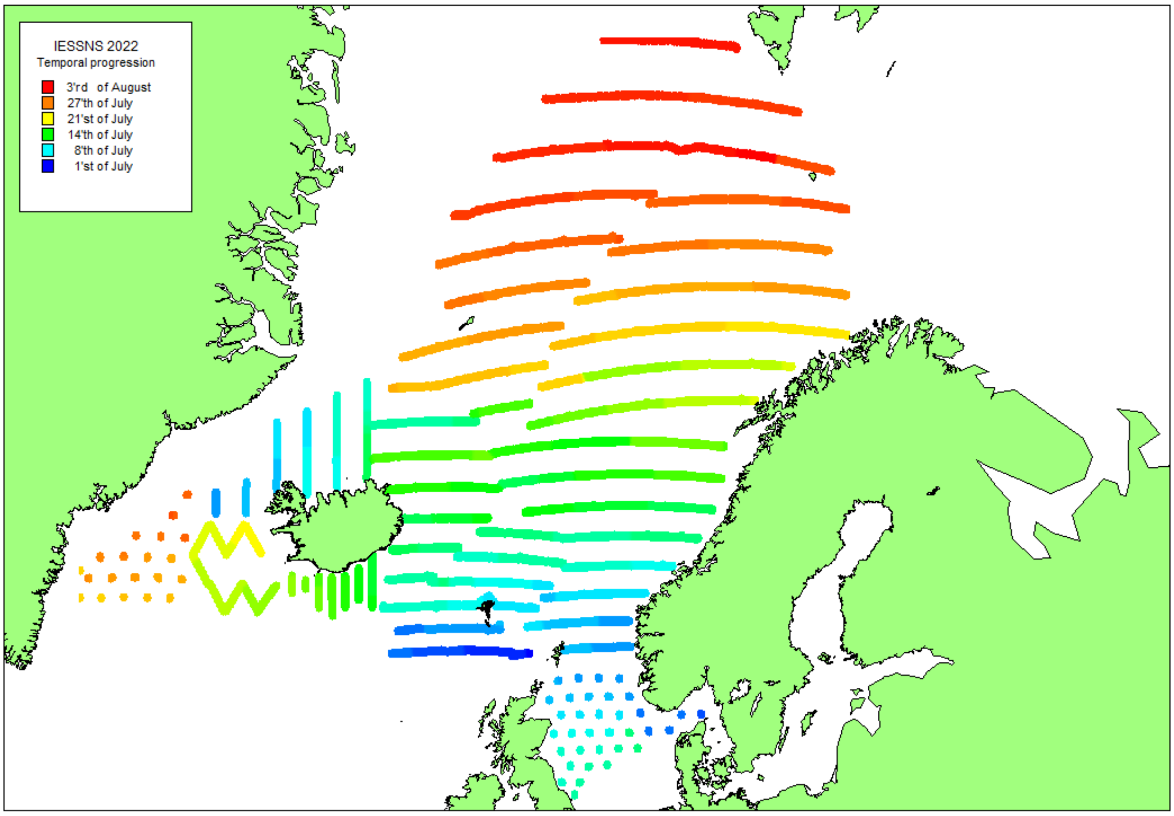

Figure 3. Temporal survey progression by vessel along the cruise tracks during IESSNS 2022: Blue represents effective survey start (1'st of July) progressing to red representing a five-week span (survey ended 3rd of August). As Ceton and Tarajoq did not submit acoustics, they have been represented by station positions.

3.6 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 3.5.0. The herring and blue whiting acoustic abundance indices were calculated using StoX version 3.4.0.

3.7 Swept area index and biomass estimation

This year the input data for the swept area calculations were taken from the ICES database in contrast to previous years where the input data were extracted from the PGNAPES database.

The swept area age segregated index is calculated separately for each stratum (see stratum definition in Figure 2). 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 2022. 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 2022 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	Tarajoq
Trawl doors horizontal spread (m)						
Number of stations	27	44	57	60	34	19
Mean	115	107	122	112	131.2	105.4
max	125	115	136	120	136.7	109.4
min	107	95	115	100	126.4	92.4
st. dev.	4.1	3.9	4.8	4.0	2.7	
Vertical trawl opening (m)						
Number of stations	27	45	59	60	34	-
Mean	43	31.7	35	32.5	29.5	-
max	47	25.8	33	37.0	35.5	-
min	35	41.3	25	18.8	24.9	-
st. dev.	3.8	3.0	2.9	4.33	2.2	-
Horizontal trawl opening (m)						
Mean	63.4	63.75	67.5	63.8	72.0	61.4
Speed (over ground, nmi)						
Number of stations	27	45	57	60	34	19
Mean	4.4	5.3	4.5	4.7	5.1	4.9
max	6	5.7	5.3	5.6	5.6	5.4
min	3.4	4.6	3.0	4.1	4.5	4.4
st. dev.	0.5	0.2	0.5	0.3	0.2	0.2

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. See also Appendix 4.

	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	56.6	57	57.2	57.7	58.2	58.7	59.2	59.7	60.2	60.7	61.1	61.6	62.1
101	56.9	57.3	57.6	58.1	58.6	59.1	59.6	60.1	60.6	61.1	61.5	62	62.4
102	57.3	57.7	58.1	58.6	59	59.5	60	60.5	60.9	61.4	61.9	62.4	62.8
103	57.7	58.1	58.5	59	59.5	59.9	60.4	60.9	61.3	61.8	62.3	62.7	63.2
104	58.2	58.6	59	59.4	59.9	60.3	60.8	61.3	61.7	62.2	62.6	63.1	63.5
105	58.6	59	59.4	59.9	60.3	60.8	61.2	61.7	62.1	62.6	63	63.5	63.9
106	59	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	62.5	62.9	63.3	63.8	64.2	64.6
108	59.9	60.3	60.7	61.1	61.6	62	62.4	62.9	63.3	63.7	64.1	64.6	65
109	60.4	60.8	61.2	61.6	62	62.4	62.8	63.2	63.7	64.1	64.5	64.9	65.3
110	60.8	61.2	61.6	62	62.4	62.8	63.2	63.6	64.1	64.5	64.9	65.3	65.6
111	61.3	61.6	62	62.4	62.8	63.2	63.6	64	64.4	64.8	65.2	65.6	66
112	61.7	62.1	62.5	62.9	63.3	63.7	64	64.4	64.8	65.2	65.6	66	66.3
113	62.2	62.5	62.9	63.3	63.7	64.1	64.4	64.8	65.2	65.6	65.9	66.3	66.6
114	62.6	63	63.4	63.7	64.1	64.5	64.9	65.2	65.6	66	66.3	66.6	67
115	63.1	63.5	63.8	64.2	64.5	64.9	65.3	65.6	66	66.3	66.7	67	67.3
116	63.6	63.9	64.3	64.6	65	65.3	65.7	66	66.4	66.7	67	67.3	67.6
117	64	64.4	64.7	65	65.4	65.7	66.1	66.4	66.8	67.1	67.4	67.7	68
118	64.5	64.8	65.1	65.5	65.8	66.1	66.5	66.8	67.2	67.5	67.8	68	68.3
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	68.6
120	65.4	65.7	66	66.3	66.6	67	67.3	67.6	67.9	68.2	68.5	68.7	68.9
121	65.8	66.1	66.5	66.8	67.1	67.4	67.7	68	68.3	68.6	68.8	69	69.3
122	66.2	66.5	66.9	67.2	67.5	67.8	68.1	68.4	68.7	69	69.1	69.4	69.6

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 2022 were slightly cooler than the long-term average for July 1990-2009 based on SST anomaly plots (Figure 4). The northern regions of the Nordic Seas were slightly warmer than the average while the East Greenland Current was cooler that the long-term average. The SST in the Irminger Sea and Iceland Basin were slightly warmer than the average.

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 4-5). However, since the anomaly is based on the average for the whole month of July, it should give representative results of the surface temperature.

In situ measurements from the survey showed that the upper layer (10 m depth) in 2022 generally was slightly cooler than 2021, except for the northern areas with slightly warmer surface layer (Figure 5, upper left panel). However, in the deeper layers (50 m and deeper; Figure 5, upper right panel and bottom panels), the hydrographical features in the area were similar to previous years. The increased presence of the East Icelandic Current visible in the surface might be due to the relatively cold July month in 2022 with less summer stratification in the that area. 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.

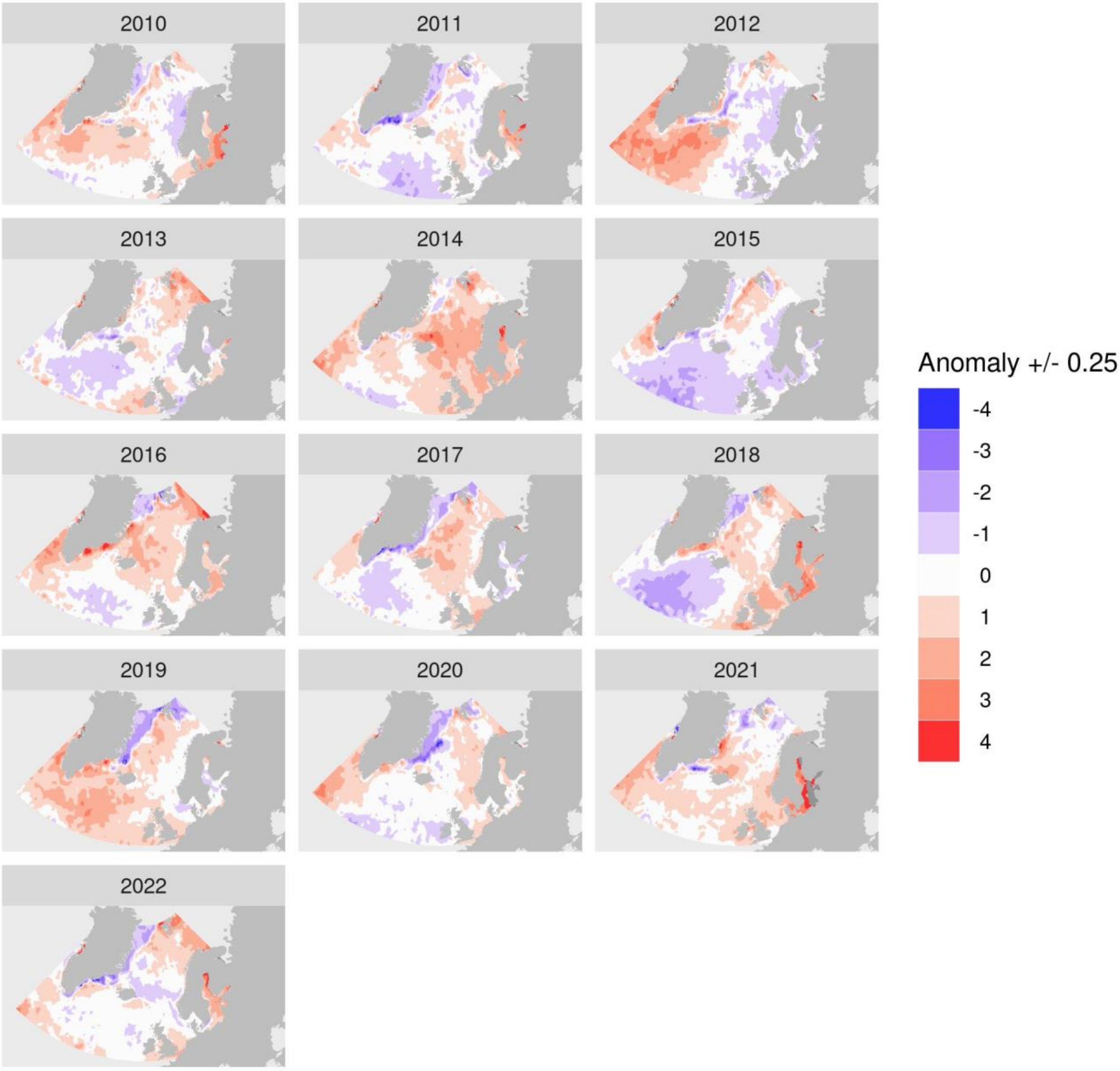

Figure 4. Annual sea surface temperature anomaly (-4 to +4°C) in Northeast Atlantic for the month of July from 2010 to 2022 showing warm and cold conditions in comparison to the average for July 1990-2009. Based on monthly averages of daily Optimum Interpolation Sea Surface Temperature (Ver. 2.1 NOAA OISST, AVHRR-only, Banzon et al. 2016, https://www.ncdc.noaa.gov/oisst).

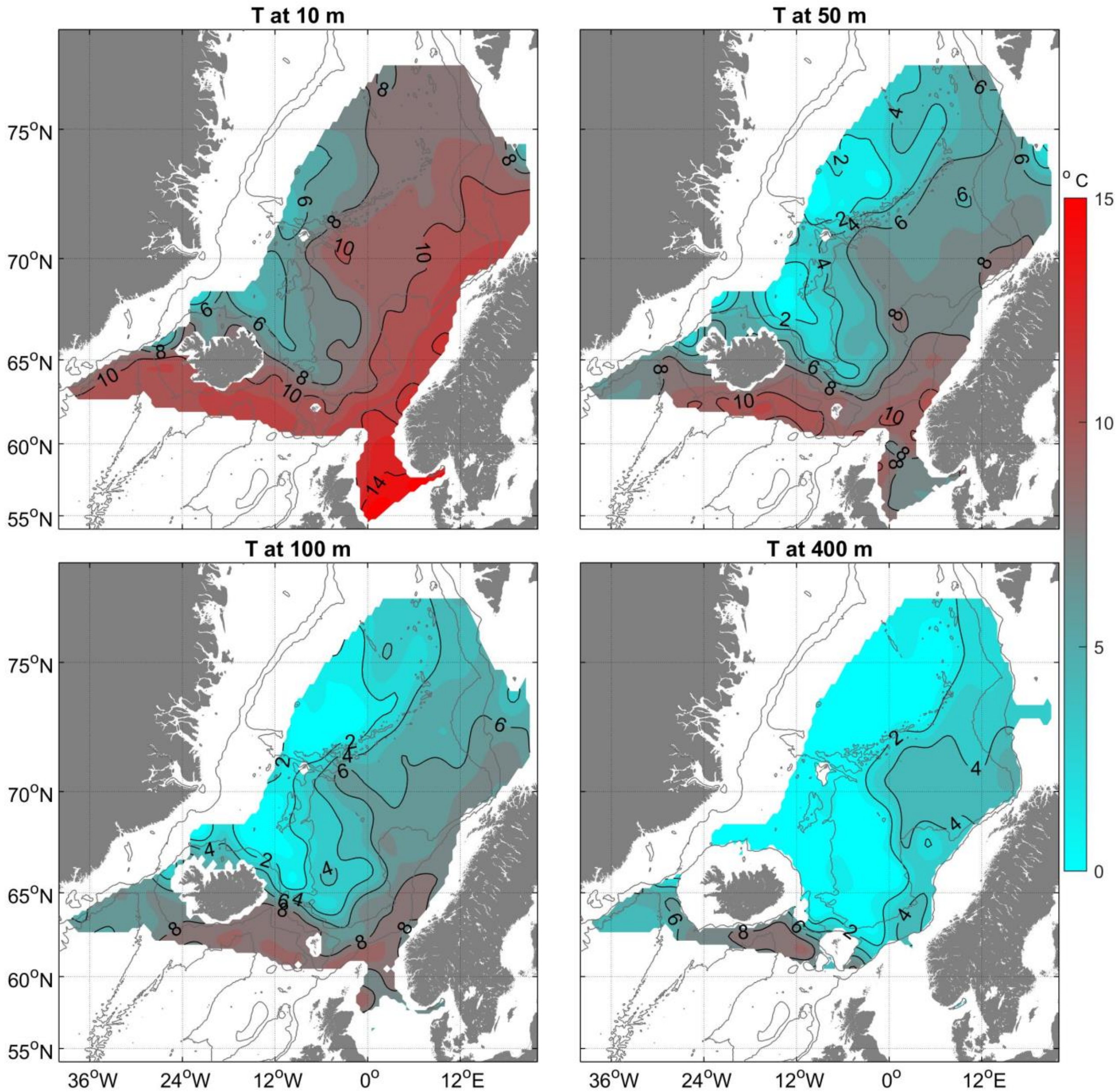

Figure 5. Temperature (°C) at 10, 50, 100 and 400 m depth in Nordic Seas and the North Sea in July-August 2022. 500 m and 2000 m depth contours are shown in light grey.

4.2 Zooplankton

The zooplankton biomass varied between areas with a patchy distribution throughout the area (Figure 6a). In the Norwegian Sea areas, the average zooplankton biomass was at the same level as last year.

The time-series of average zooplankton biomass averaged by three subareas: Greenland region, Iceland region and the Norwegian Sea region is shown in Figure 6b (see definitions in legend). In the Greenland area an increase was observed in 2022 compared to the low 2020 value (not surveyed in 2021). In the Icelandic region the level was the same as in 2021. The Greenland and Iceland time-series co-vary (2014-2020, 2022 r = 0.89). The biomass index in the Norwegian Sea varied less compared to the other two indices, and showed a slight decrease in 2022 from a relatively stable level since 2013 (Figure 6b). The lower variability 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.

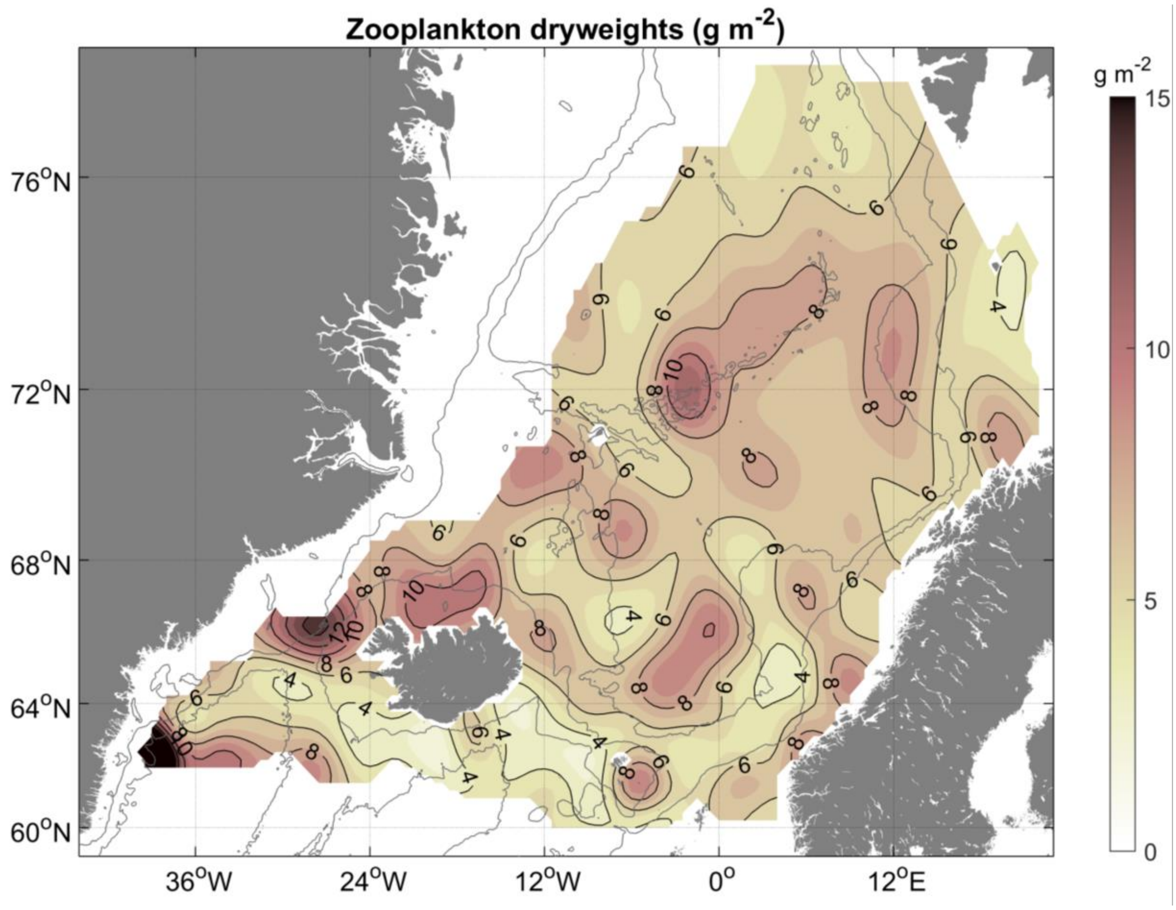

Figure 6a. Zooplankton biomass (g dw/m2, 0-200 m) in Nordic Seas in July-August 2022. 500 m and 2000 m depth contours are shown in light grey.

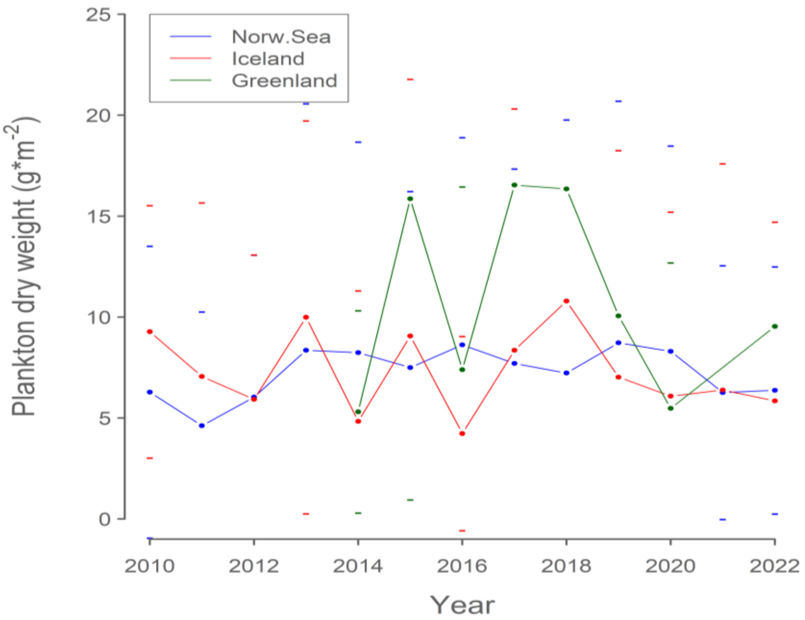

Figure 6b. Zooplankton biomass indices (g dw/m2, 0-200 m). Time-series (2010-2022) of mean zooplankton biomass for three subareas within the survey range: Norwegian Sea (between 14°W-17°E & north of 61°N), Icelandic waters (14°W-30°W) and Greenlandic waters (2014-2022, west of 30°W).

4.3 Mackerel

The total swept-area mackerel index in 2022 was 7.37 million tonnes in biomass and 17.51 billion in numbers, an increase of 43% for biomass and 43% for abundance compared to 2021. The survey coverage area (excl. the North Sea, 0.28 million km²) was 2.9 million km² in 2022, which is 32% larger compared to 2021. The mackerel catch rates varied from zero to 103 tonnes/km² (mean = 2.3 tonnes/km², with two very large values (70 and 103, see CPUE by station in Figure 7 together with the mean catch rates per 2° lat. x 4° lon. rectangles). These two hauls contributed with 33% of the total biomass index (Appendix 3). This is also explains the very high uncertainty of the estimate. It is worth noting that western part of the northern Norwegian Sea (stratum 9) was oversampled as three surface trawl stations were added, at the dynamic stratum boundary, at only half the distance from next station, 35 nm instead of 70 nm. Mackerel was caught at all these station and max catch per station was about one ton. All three stations were included in the index calculations and the dynamic stratum boundary extended 35 nm westward of these three stations.

Most of the surveyed mackerel still appears to be in the Norwegian Sea. The mackerel were more westerly distributed than in the last 2 years.

The zero-line was reached south and north of Iceland and in the west in Greenland waters. It was not reached in the northwestern and northeastern part of the Norwegian Sea but given that the polar front with water too cold for mackerel is usually found close the northwestern most catches, we assume that the zero-line was practically reached here as well. Towards the Barent Sea the zero-line was not reached but considered of less quantitative importance based on low catch rates. The zero-line was not reached on the European shelf, where mackerel are present west of the British Isles and in the southern North Sea (Campbell, 2021).

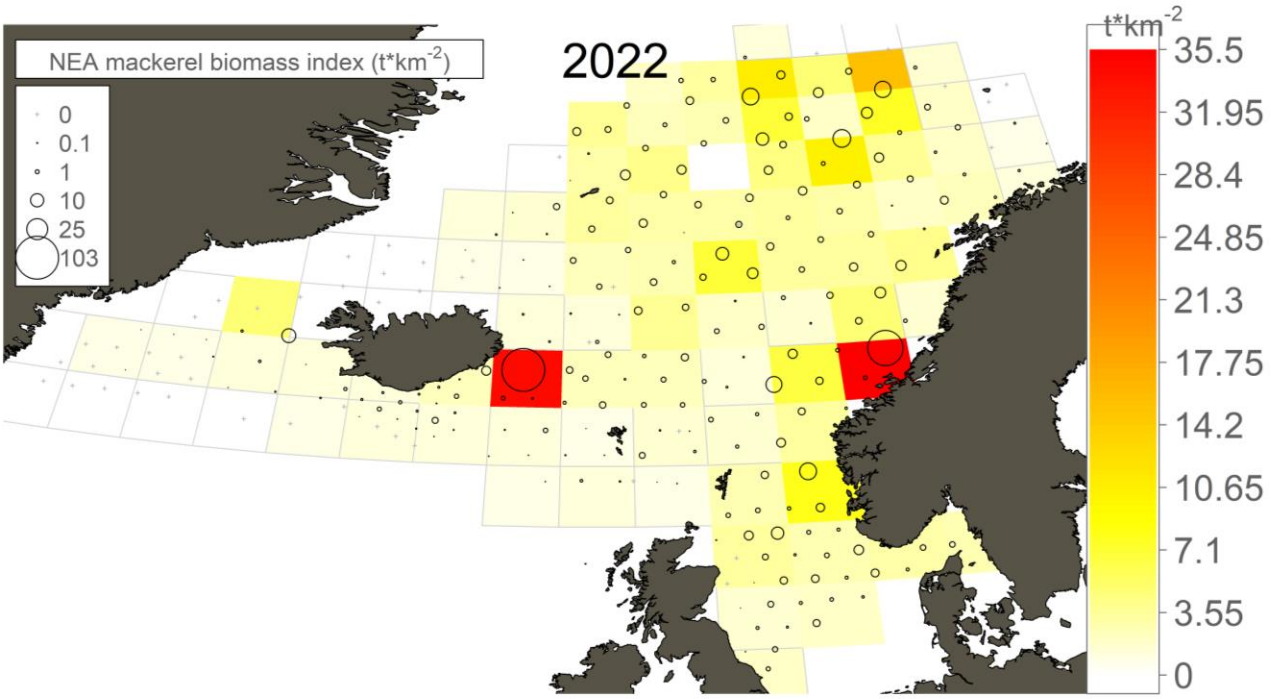

Figure 7. Mackerel catch rates by Multpelt 832 pelagic trawl haul at predetermined surface trawl stations (circle areas represent catch rates in kg/km²) overlaid on mean catch rates per standardized rectangles (2° lat. x 4° lon.) in Nordic Seas in July-August 2022.

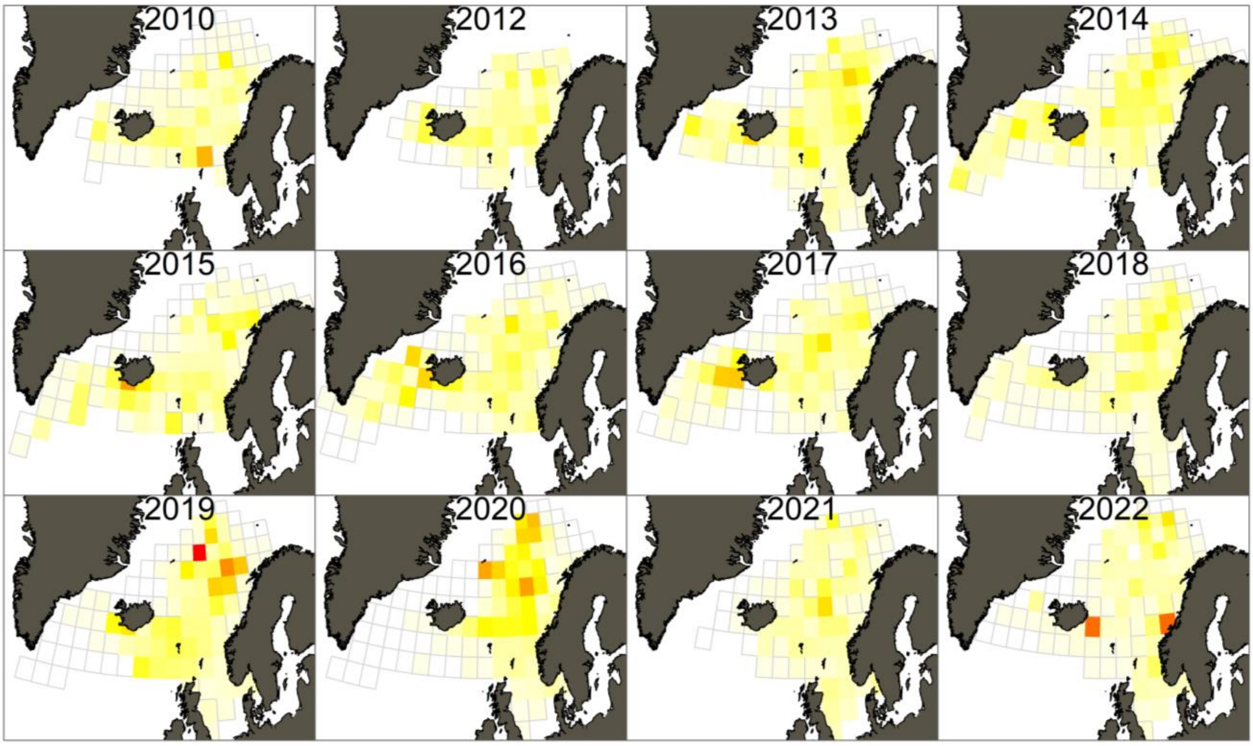

Figure 8. Annual distribution of mackerel proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations in Nordic Seas in June-August 2010-2022. Colour scale goes from white (= 0) to red (= maximum value for the highest year).

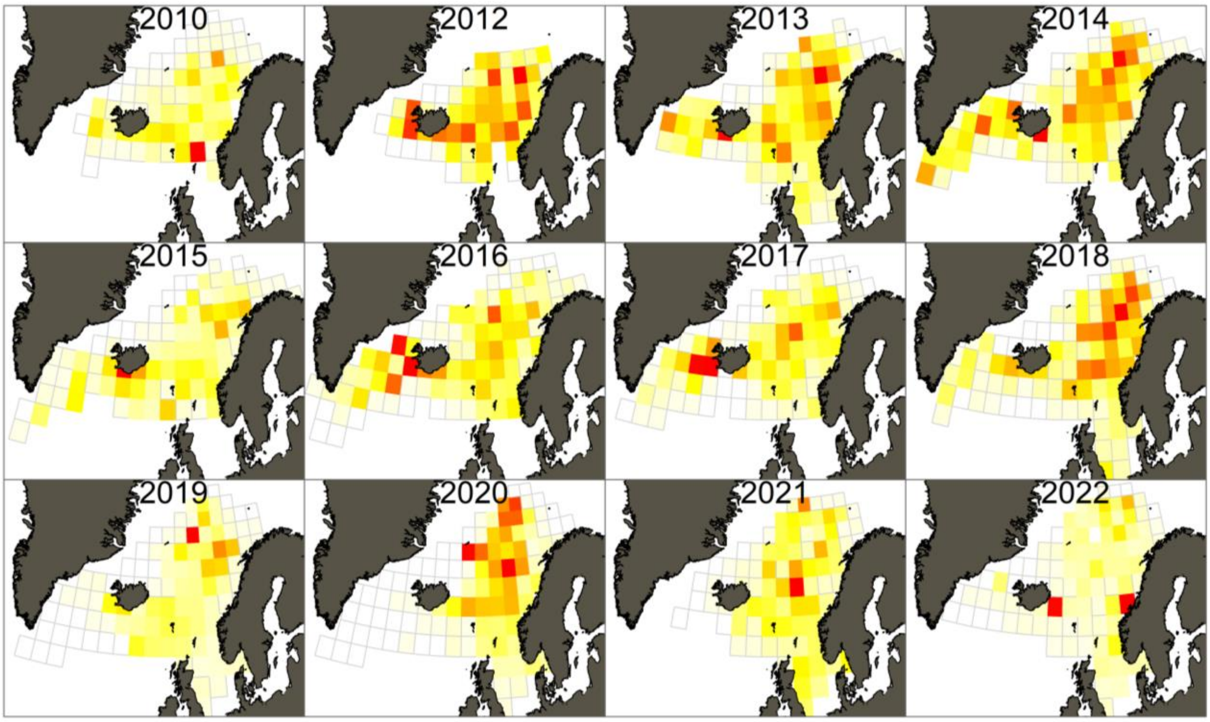

Figure 9. Annual distribution of mackerel proxied by the relative distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations stations in Nordic Seas in June-August 2010-2022. Colour scale goes from white (= 0) to red (= maximum value for the given year).

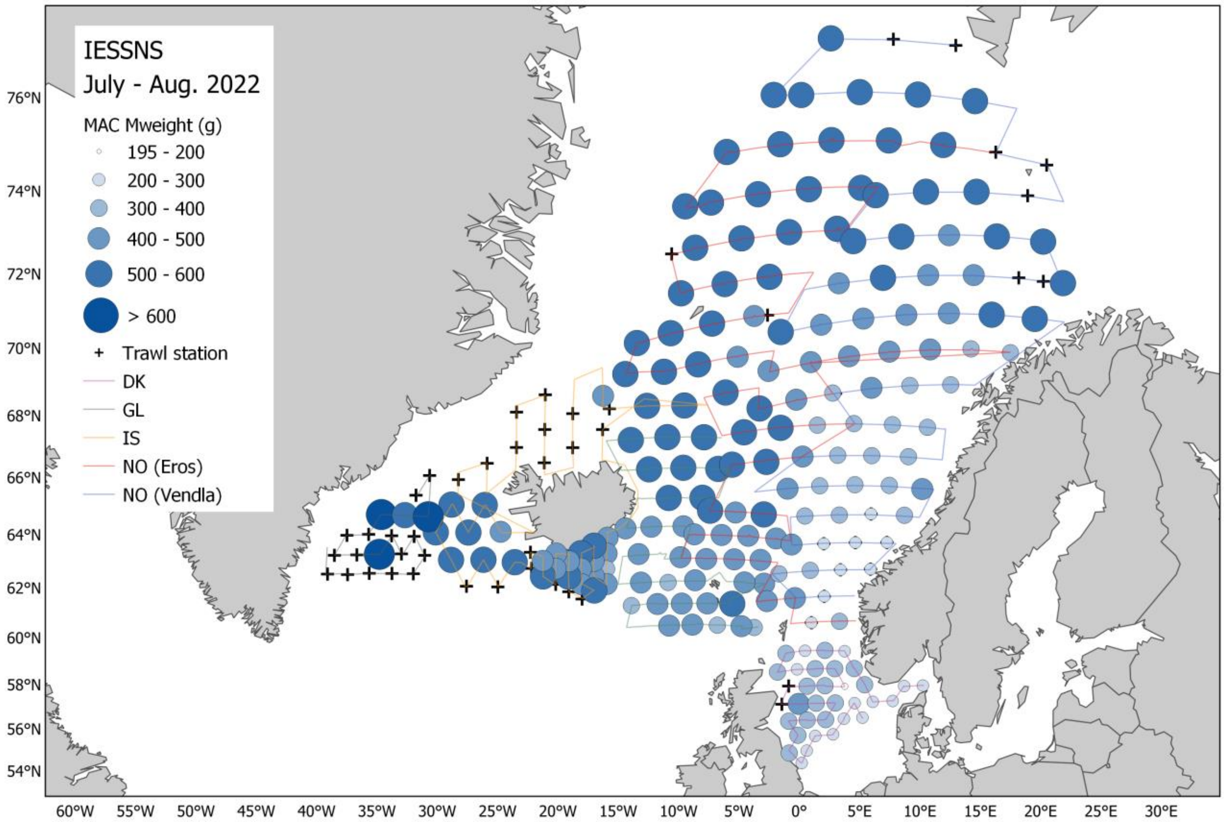

Figure 10. Average weight of mackerel at predetermined surface trawl stations during IESSNS 2022.

The mackerel weight varied between 48 to 872 g with an average of 388 g. The length of mackerel caught in the pelagic trawl hauls onboard the five vessels varied from 18 to 46 cm, with an average of 33 cm. Individuals in the length range 30-31 cm and 36-40 cm dominated in numbers and biomass. Mackerel length distribution followed the same overall pattern as previous years both in the Norwegian Sea, with increasing size towards the distribution boundaries in the north and the north-west, and in the western area with increasing size westward (Figure 10). The spatial distribution and overlap between the major pelagic fish species (mackerel, herring, blue whiting) in 2022 according to surface trawl catches is shown in Figure 11.

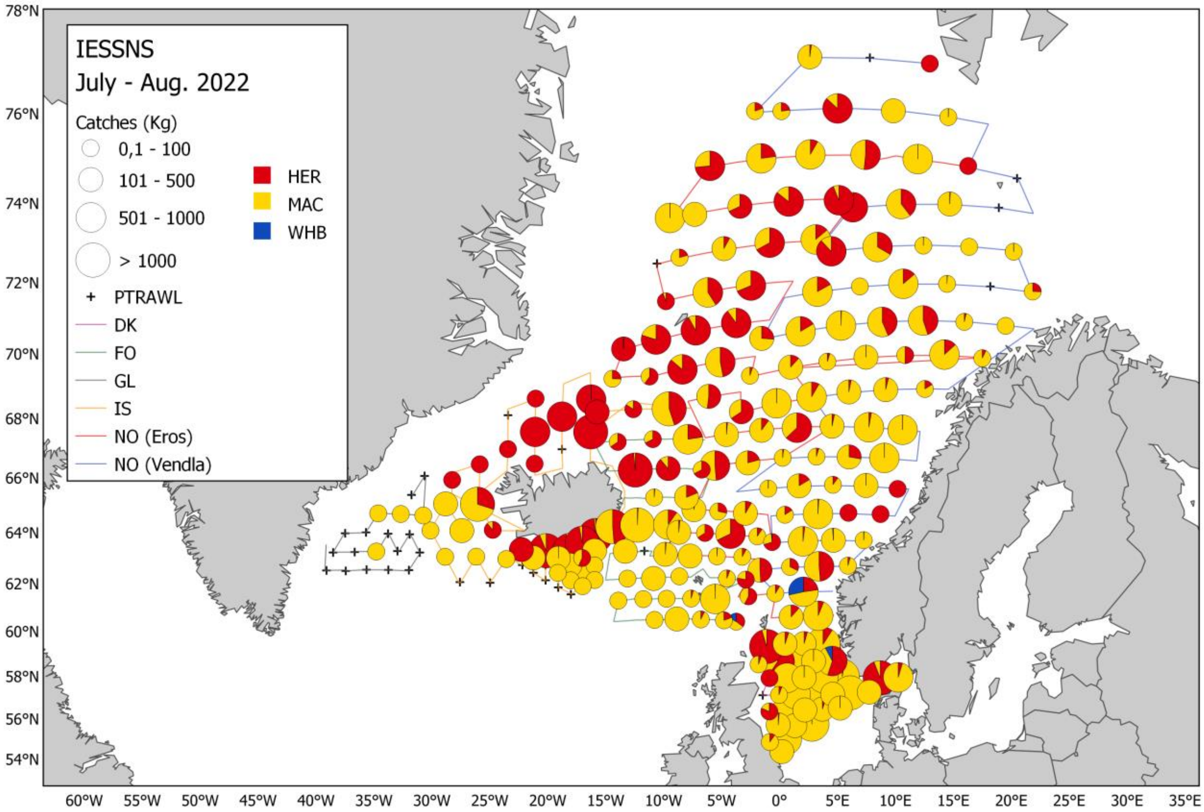

Figure 11. Distribution and spatial overlap between mackerel, herring, and blue whiting, at all surface trawl stations during IESSNS 2022. Vessel tracks are shown as continuous lines and predetermined surface trawl stations with no catch of the three species is displayed as +.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass from the 2022 IESSNS were based on abundance of mackerel per stratum (see strata definition in Figure 2) and calculated in StoX version 3.5.0. Mackerel abundance index in 2022 was slightly lower than the time series mean of 18.9 billion (Table 7a; Figure 12) and the biomass index was slightly higher than the mean of 7.28 million tons (Table 7c). Mackerel estimates of abundance, biomass and mean weight by age and length are displayed in Table 7d. There is no pattern in changing size-at-age between years (Table 7b). In 2022, the most abundant year-classes were respectively 2020 (age 2), 2019 (age 3), 2012 (age 10), and 2011 (age 11) (Figure 13). Mackerel of age 1, 2 and to some extent also age 3 are not completely recruited to the survey (Figure 15), information on recruitment is therefore uncertain. Variance in age index estimation is provided in Figure 14.

The overall internal consistency was slightly improved compared to last year (Figure 16). There is a good to strong internal consistency for the younger ages (1-5 years) and older ages (9-14 years) with r between 0.70 and 0.91. However, the internal consistency is more variable between age 5 to 9, with r=0.43 between 5 and 6 years (r=0.43) and r=0.22 between 7 and 8 years. The reason for the relatively low consistency for these year groups are not clear.

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 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 WGIWIDE are the number-at-age indices for age 3 to 11 year (Table 7a).

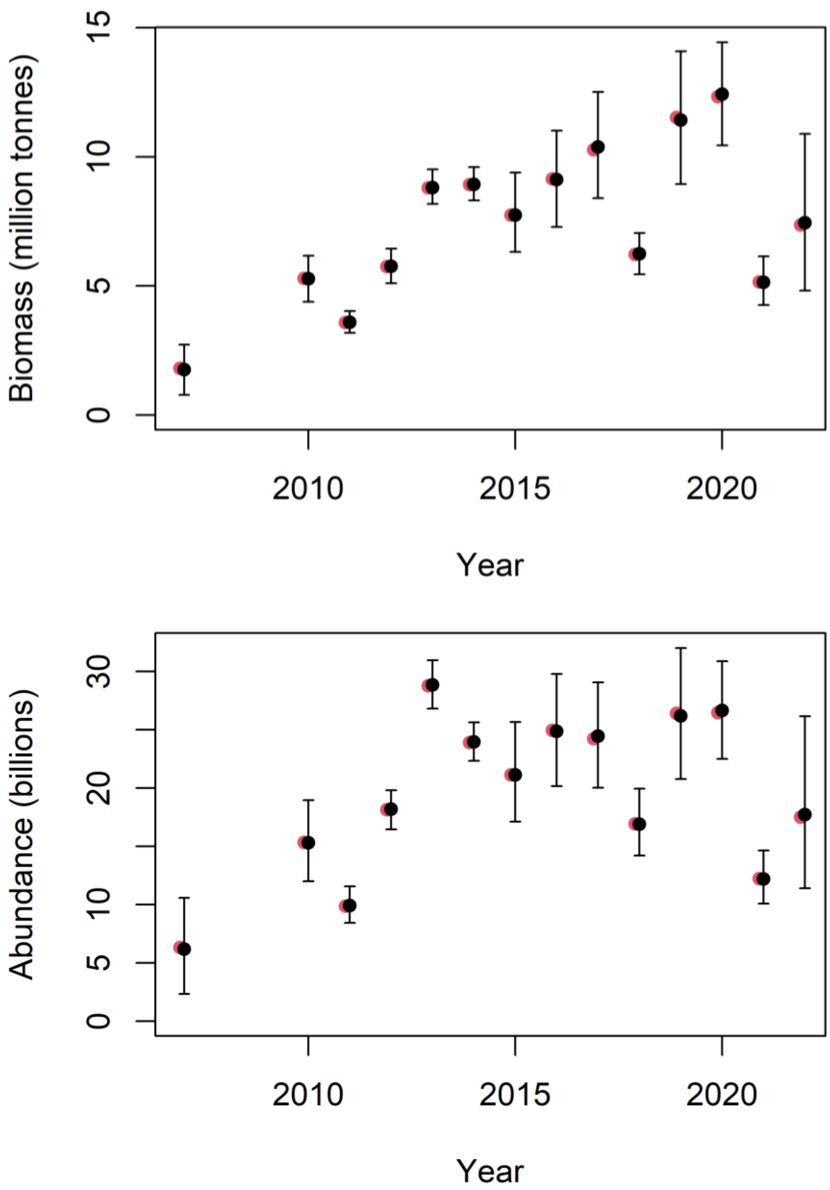

Figure 12. Estimated total stock biomass (upper panel) and total stock numbers (lower panel) of mackerel from StoX for the years 2007 and from 2010 to 2022. The red dots are baseline estimates, the black dots are mean of 1000 bootstrap replicates while the error bars represent 90 % confidence intervals based on the bootstrap.

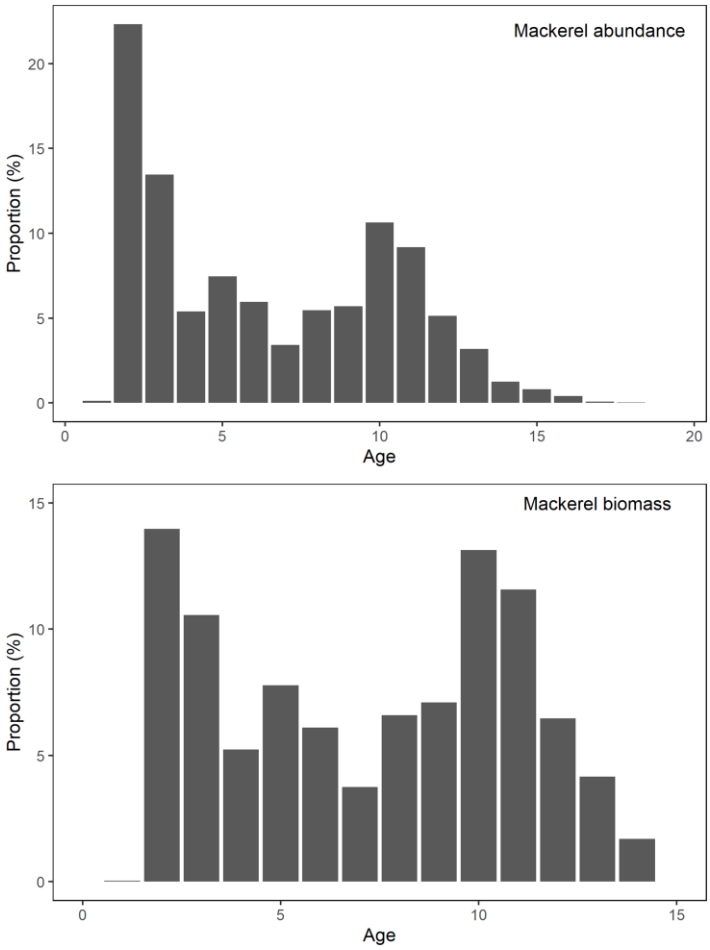

Figure 13. Mackerel age distribution in numbers (%) and in biomass (%) from IESSNS 2022.

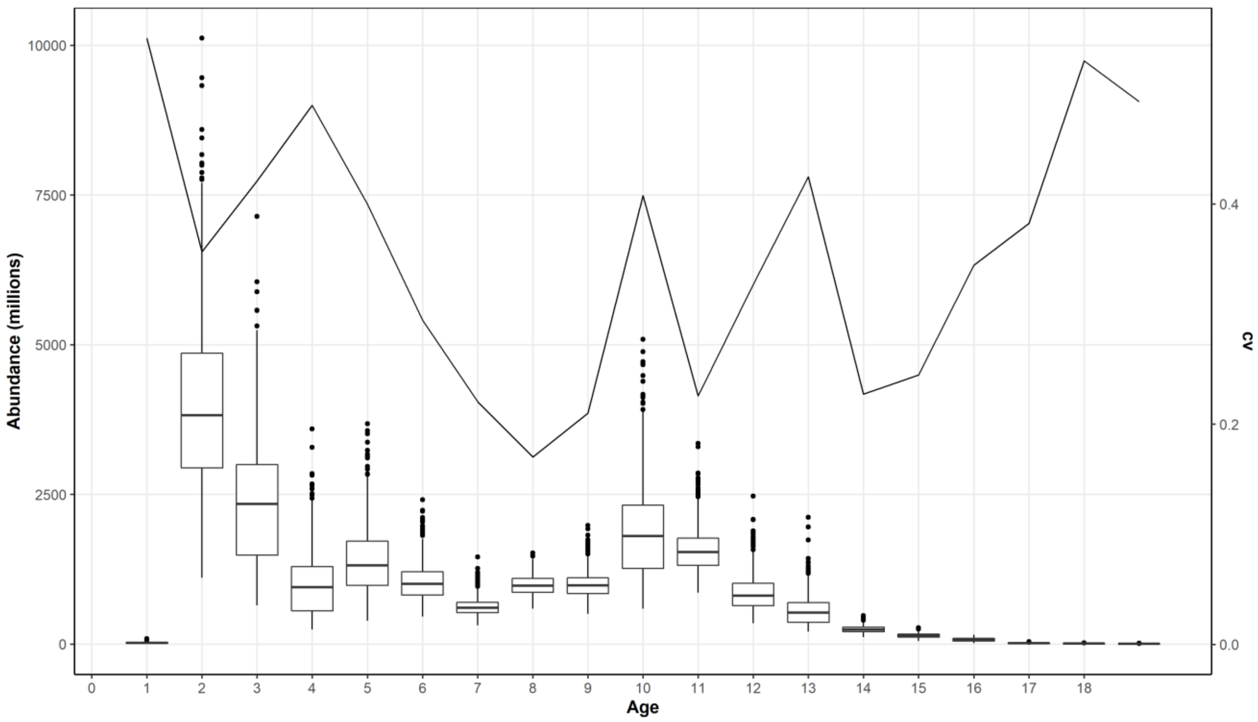

Figure 14. Number by age for mackerel in 2022. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 7. a-d) StoX baseline (point estimate) time series of the IESSNS showing (a) age-disaggregated abundance indices of mackerel (billions), (b) mean weight (grams) per age, (c) estimated biomass at age (million tonnes) in 2007 and from 2010 to 2022, and (d) estimates of abundance, biomass and mean weight by age and length.

a)

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

b)

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

c)

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

d) Length (cm)	Age in years (year class) 1 2021	2 2020	3 2019	4 2018	5 2017	6 2016	7 2015	8 2014	9 2013	10 2012	11 2011	12 2010	13+	NA	Number (10^6)	Biomass (10^6 kg)	Mean weight (g)
18-19	1														1	0	46.7
19-20	8														8	0	58.1
20-21	3														3	0	66.4
21-22	3														3	0	74.5
22-23														0	0	0	88.0
23-24															0	0	
24-25														0	0	0	126.0
25-26															0	0	
26-27	0														0	0	166.0
27-28															0	0	
28-29	8	64													72	15	214.4
29-30		805	30	3											838	200	239.1
30-31		1 809	9		4	3									1 825	471	258.1
31-32		993	353	2	34	5									1 386	390	281.7
32-33		178	637	25	5	5									851	265	311.5
33-34		34	711	96	43	10	3		0	0					896	301	336.3
34-35	0	16	384	95	133	52	0					0			681	248	363.6
35-36		3	204	70	104	279	125	13	7	3	2				808	313	387.6
36-37			26	477	219	236	77	38	1	17	26	0	4		1 120	471	420.5
37-38		4	1	168	439	269	153	127	84	403	97	43	11		1 799	835	464.1
38-39			1	7	171	161	158	461	195	435	527	295	226		2 639	1321	500.5
39-40		4	0	1	157	17	41	198	511	465	497	301	188		2 382	1256	527.5
40-41					0	3	28	111	174	493	341	159	297		1 606	910	566.5
41-42				0		4	12	4	19	40	98	82	203		464	280	606.3
42-43								2	5	6	17	8	56		94	61	642.4
43-44								3			1	9	21		33	22	687.6
44-45													3		3	2	704.0
45-46														1	1	1	803.8
46-47														0	0	0	872.0
TSN(mill)	23.4	3 909.5	2 355.9	944.4	1 307.8	1 043.4	598.2	956.1	995.9	1 862.0	1 605.7	897.6	1 011.3	2.2	17 513.5	7365	
TSB(1000 t)	2.9	1 028.7	777.1	385.4	572.3	449.4	276.5	485.8	522.7	967.2	851.5	476.6	567.8	1.4	7 365.3		
Mean length(cm)	22.7	30.2	32.7	35.5	36.4	36.2	37.1	38.2	38.8	38.6	38.9	39.0					
Mean weight(g)	125	263	330	408	438	431	462	508	525	519	531	531					

Table 8. Bootstrap estimates from StoX (based on 1000 replicates) of mackerel in 2022. 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	3.9	20.3	41.5	21.3	12.0	0.56
2	1945.0	3822.1	6590.4	3974.3	1416.0	0.36
3	1019.0	2341.4	4200.5	2384.2	1002.9	0.42
4	382.1	950.4	1858.6	988.8	483.8	0.49
5	575.8	1311.0	2357.8	1380.1	551.4	0.40
6	617.4	1006.7	1609.3	1043.2	306.7	0.29
7	434.8	602.8	845.6	618.9	136.3	0.22
8	704.6	972.9	1250.1	980.5	166.5	0.17
9	696.4	977.0	1367.3	991.6	207.9	0.21
10	874.3	1801.7	3269.0	1872.5	763.0	0.41
11	1068.4	1534.8	2206.6	1567.8	353.6	0.23
12	487.9	808.9	1340.7	849.8	277.5	0.33
13	283.9	522.3	983.6	556.4	236.2	0.42
14	162.4	241.0	343.9	245.3	55.7	0.23
15	88.7	141.7	201.7	142.8	34.9	0.24
16	33.6	78.2	112.2	74.5	25.6	0.34
17	6.5	14.1	25.4	14.8	5.6	0.38
18	1.1	6.0	12.7	6.6	3.6	0.55
19	0.0	2.5	7.6	2.7	2.7	1.03
TSN	11388	17196	26156	17719	4558	0.26
TSB	4.82	7.23	10.89	7.44	1.87	0.25

Figure 15. Catch curves for the years 2010; 2012-2022. Each cohort of mackerel is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

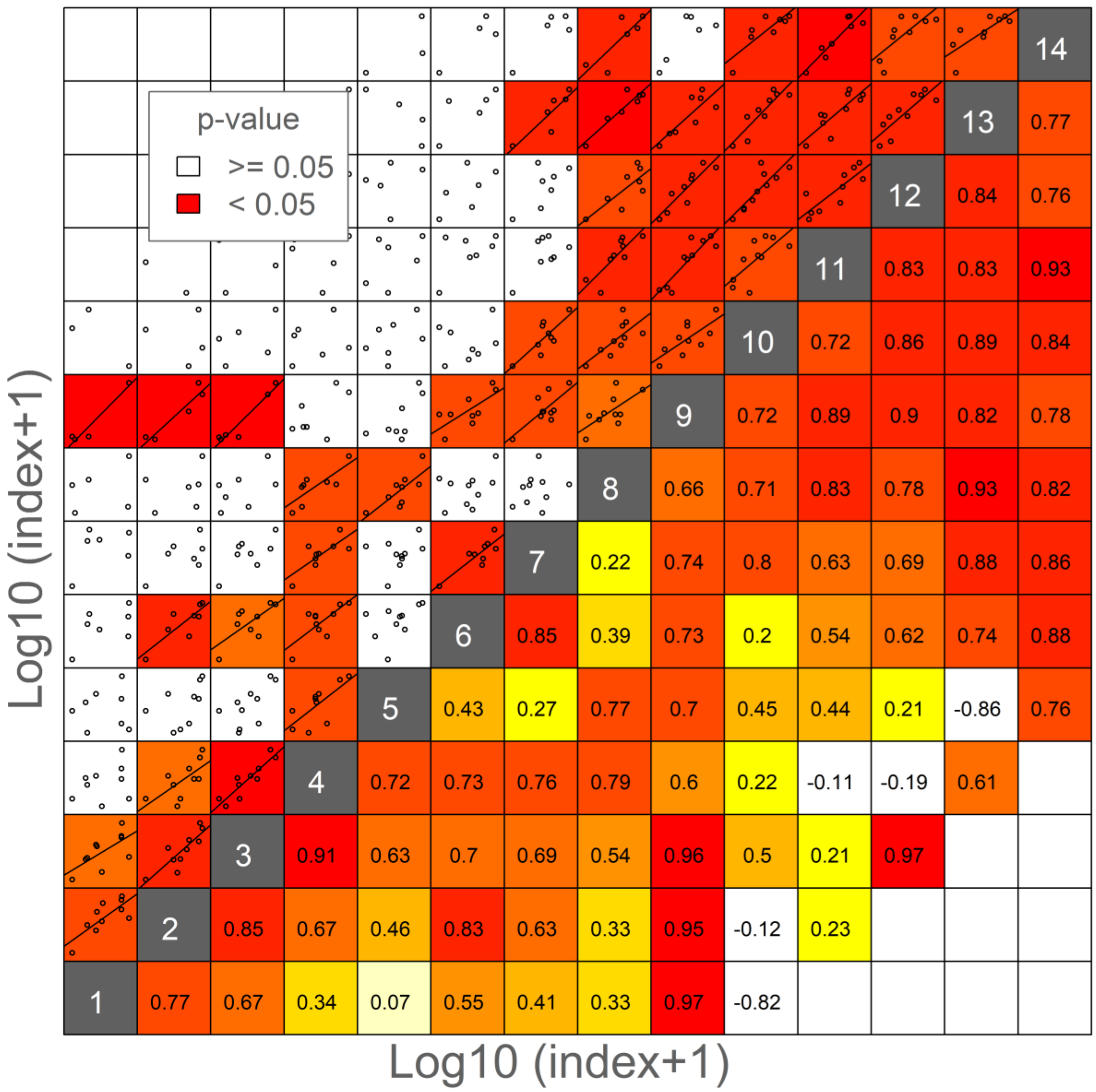

Figure 16 Internal consistency of the of mackerel density index from 2012 to 2022. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given 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 56.6.5-75.4 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.

As in previous years, there was overlap in the spatio-temporal distribution of mackerel and herring (Figure 11). This overlap occurred mostly between mackerel and Norwegian spring-spawning herring (NSSH) in the western, north-western and north-eastern part of the Norwegian Sea.

4.4 Norwegian spring-spawning herring

Norwegian spring-spawning herring (NSSH) was recorded in the southwestern (east and north of Iceland), central and northern part of the Norwegian Sea basin (Figure 17a). The acoustic registrations in the eastern parts of the Norwegian Sea were low in July 2022. A relatively large part of the adult NSSH stock was distributed north of 68°N (Figure 17a). 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, except some putative North Sea herring in the southeastern area north of Shetland (Figure 17b).

The total number of NSSH recorded during IESSNS 2022 was 25.0 billion and the total biomass index was 7.14 million tonnes, or 22% (abundance) and 17% (biomass) higher than 2021 (Table 10 and 11).

The 2016 year-class (6 year-olds) completely dominated in the stock and contributed 58% and 56% to the total biomass and total abundance, respectively, whereas the 2013 year-class (9 year-olds) contributed 8% and 7% to the total biomass and total abundance, respectively (Figure 18 and Table 9). The 2016 year-class is fully recruited to the adult stock.

Bootstrap estimates of numbers by age are shown in Figure 18. The uncertainty (CV) around the age disaggregated abundance indices from the 2022 survey was very low, except for the highly dominating 6 year-olds (2016 year class) (Figure 18).

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 19).

The 0-boundary of the distribution of the adult part of NSSH was considered to be reached in all directions. The herring was mainly observed in the upper surface layer as relatively small schools. This 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. The group considered the acoustic biomass estimate of herring in 2022 to be of the similar quality as in the previous survey years.

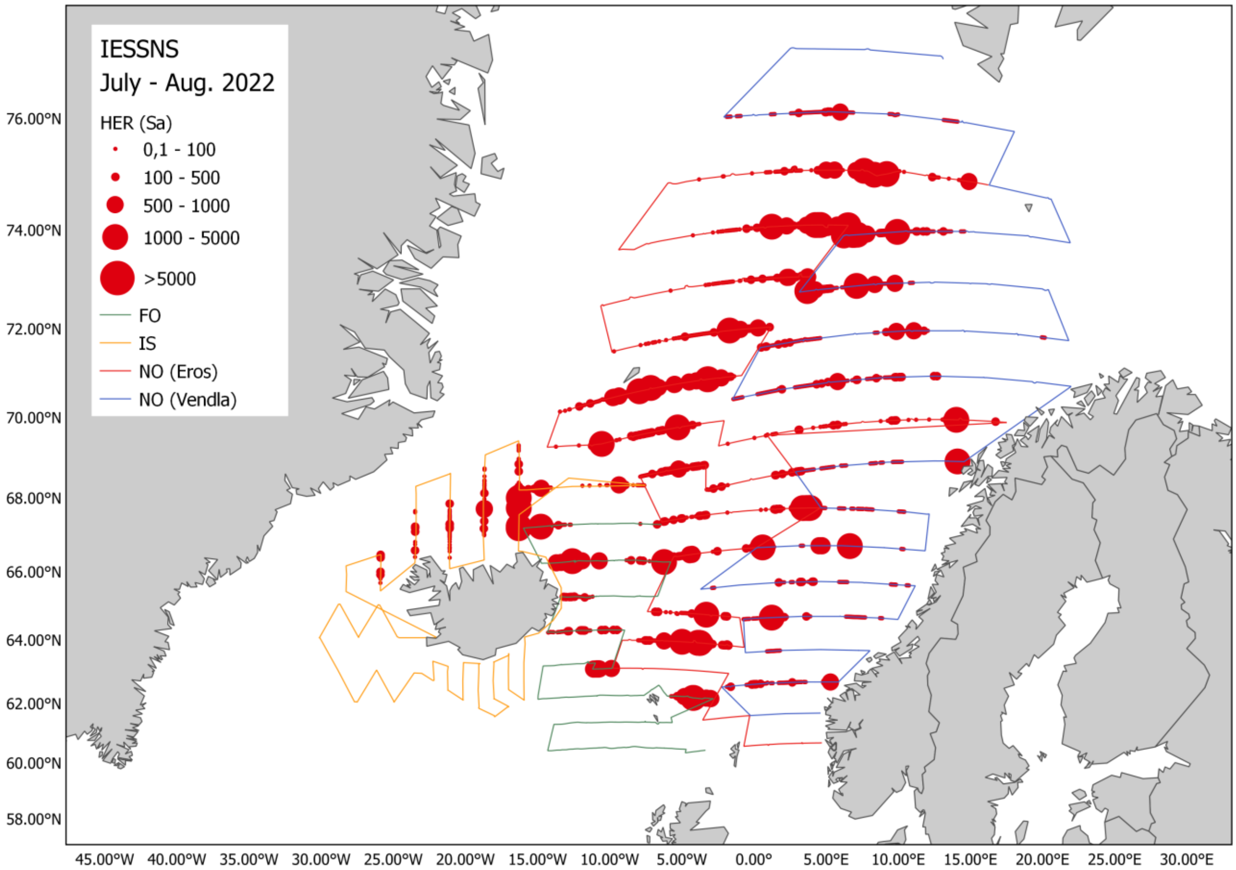

Figure 17a. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise tracks in 2022 presented as contour lines. Values north of 62ºN, and east of 14ºW, are considered to be Norwegian spring-spawning herring. South and west of this area the herring observed are other stocks, *i.e.* Icelandic summer spawners, Faroese autumn spawners and North Sea herring in the southeast.

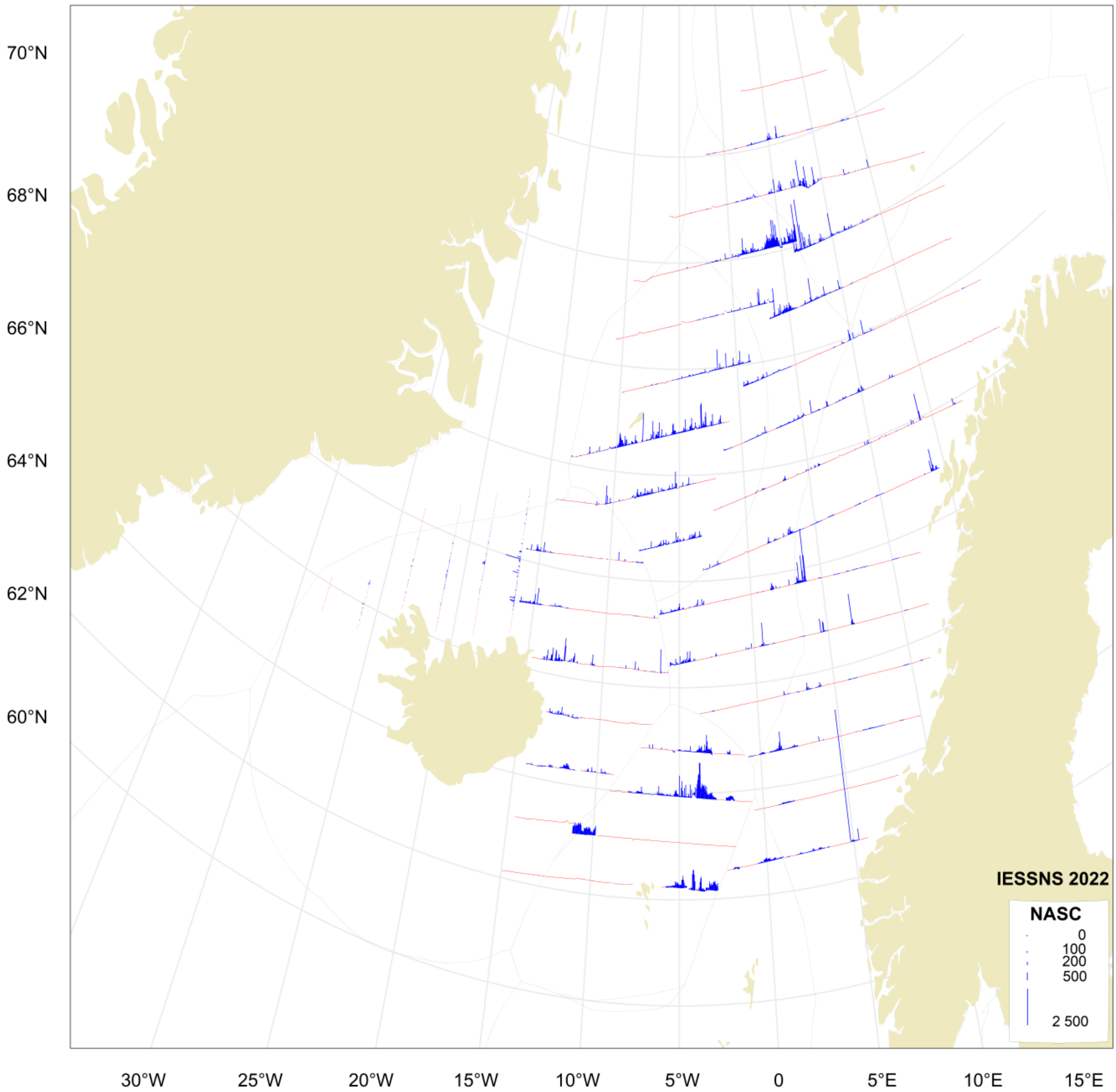

Figure 17b. The sA/Nautical Area Scattering Coefficient (NASC) values of Norwegian spring-spawning herring along the cruise tracks in 2022, presented as bar plot.

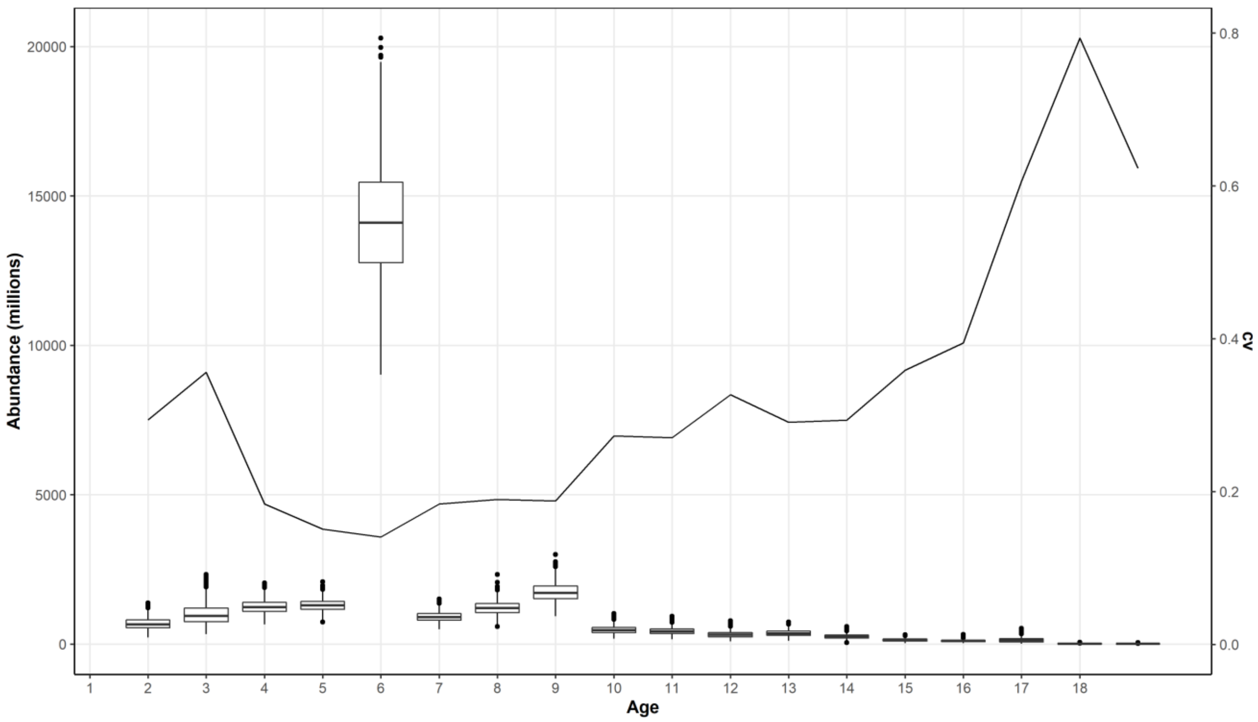

Figure 18. Abundance by age for Norwegian spring-spawning herring during IESSNS 2022. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

Table 9. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring based on calculation in StoX (bootstrap) for IESSNS 2022.

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)	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	(10^6)	(10^6 kg)	(g)
15-16																					
16-17																					
17-18																					
18-19																					
19-20			30.1																30.1	2.6	85.0
20-21		17.7	26.7																44.3	3.4	70.7
21-22		9.0	82.6																91.6	8.5	89.6
22-23		149.0	45.6																194.6	19.5	100.4
23-24		217.2	143.0	4.4															364.6	41.6	114.8
24-25		156.8	55.5	9.6															221.9	29.1	131.1
25-26		86.0	108.8	93.4	7.4														295.7	44.7	150.2
26-27		45.4	68.8	222.9	73.2														410.4	68.6	167.1
27-28			70.3	225.9	57.9	51.9			6.5										412.5	78.5	186.4
28-29			143.3	228.1	113.2	67.0	24.1	15.3	60.7	22.7									674.2	145.7	213.0
29-30			135.9	191.7	141.3	117.0	43.6	3.6	218.8	3.1		11.8							866.9	207.5	238.7
30-31			39.4	127.1	337.6	857.1	24.2	42.5	141.5	55.1	47.3	21.1	12.3	24.7	10.5				1 740.3	454.0	259.0
31-32			55.8	119.6	264.1	3301.7	37.3	94.8	82.4	73.6	32.6	19.9	3.5						4 085.2	1142.3	278.0
32-33				23.2	252.2	5232.2	134.8	120.5	46.7	28.4	36.0	2.2		21.8					5 898.0	1748.0	296.1
33-34			2.3		49.8	3249.0	217.9	184.0	58.5	14.7	10.8			21.2	11.0				3 819.3	1199.2	313.1
34-35				4.8		1107.3	259.0	355.6	371.5	45.6	21.3		17.0			10.5			2 192.5	738.5	335.9
35-36						141.1	126.0	300.9	448.1	48.4	40.3	20.8	47.7	22.1		12.2	2.2		1 209.8	440.0	361.7
36-37					4.2		22.7	84.2	233.8	112.1	88.3	24.7	81.9	65.7	5.3	5.0	3.4		731.3	278.8	376.2
37-38						10.8	13.0	9.3	65.6	61.7	109.1	91.8	136.5	25.6	47.1	29.3	22.2	5.1	627.2	251.8	402.4
38-39							11.6			11.7	33.8	90.9	48.1	37.3	41.8	43.4	48.8	4.8	372.2	156.9	422.0
39-40											13.8	19.3	12.6	16.5	19.1	5.3	43.8	4.1	134.6	60.5	445.9
40-41												12.7	3.6	18.3	6.3		5.3		46.2	20.7	454.9
41-42																1.1	4.8		5.9	20.7	489.3
42-43																		0.6	0.6	2.8	510.9
TSN(mill)		681.2	1008.0	1250.7	1301.0	14135.1	914.3	1210.8	1734.0	477.1	433.3	315.1	363.1	253.2	141.1	106.9	130.5	14.6	25 009.4		
cv (TSN)		0.29	0.36	0.18	0.15	0.14	0.18	0.19	0.19	0.27	0.27	0.33	0.29	0.29	0.36	0.39	0.61	0.82	0.12		
TSB(1000 t)		82.2	171.4	262.4	332.5	4 190.8	294.3	399.0	571.1	161.4	158.4	121.4	141.4	95.8	55.4	42.4	57.2	6.4	7 143.4		
cv (TSB)		0.29	0.29	0.18	0.15	0.14	0.19	0.20	0.20	0.26	0.29	0.34	0.30	0.30	0.37	0.40	0.61	0.80	0.13		
Mean length(cm		23.5	26.1	28.3	30.1	32.1	33.4	33.8	33.9	34.9	35.2	37.1	36.5	37.0	37.2	37.3	38.2	39.1			
Mean weight(g)		123.3	175.1	215.6	256.3	296.6	324.3	330.7	341.4	363.0	367.3	400.8	393.0	402.9	401.2	406.3	437.4	480.0			

Table 10. IESSNS bootstrap time series (mean of 1000 replicates) from 2016 to 2022. StoX abundance 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

Table 11. IESSNS baseline time series from 2016 to 2022. StoX abundance 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

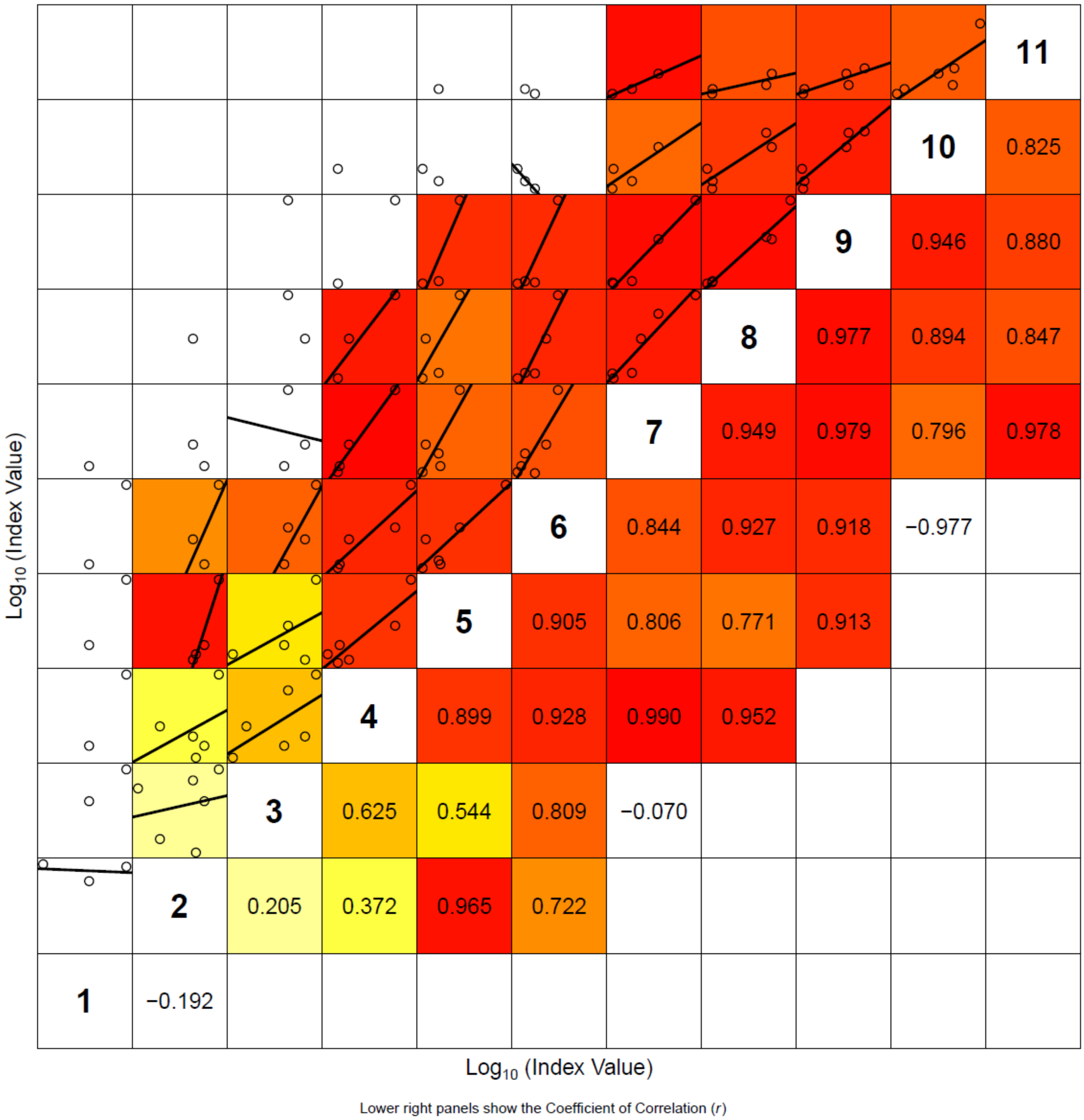

Figure 19. Internal consistency for Norwegian spring-spawning herring within the IESSNS 2022. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows 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 Spitsbergen (72 °N). 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 southeast of Iceland. Concentrations of older fish (age2+) were low, and they were mainly observed on the continental slopes, both in the eastern and the southern part of the Norwegian Sea (Figure 20). The distribution in 2022 is comparable to the last two years with juvenile blue whiting recorded south and southwest of Iceland. As in previous years no blue whiting was registered in the cold East Icelandic Current, between Iceland and Jan Mayen.

The total biomass of blue whiting registered during IESSNS 2022 was 2.2 million tons (Table 12), which is about the same level as in 2021. Estimated stock abundance (ages 1+) was 27.5 billion compared to 26.2 billion in 2021. Age 1 and 2 respectively, dominated the estimate in 2022 as they contributed to 44% and 33% (abundance) and 30% and 33% (biomass), respectively.

Bootstrap estimates of numbers by age, with uncertainty estimates, for blue whiting during IESSNS 2022 are shown in Figure 21. The baseline point estimates from 2016-2022 are shown in Table 13. The internal consistency among year classes is shown in Figure 22 and indicates very good internal consistency for ages 3-5, and moderate to good fit for other ages.

The group considered the acoustic biomass estimate of blue whiting to be of good quality in the 2022 IESSNS as in the previous survey years.

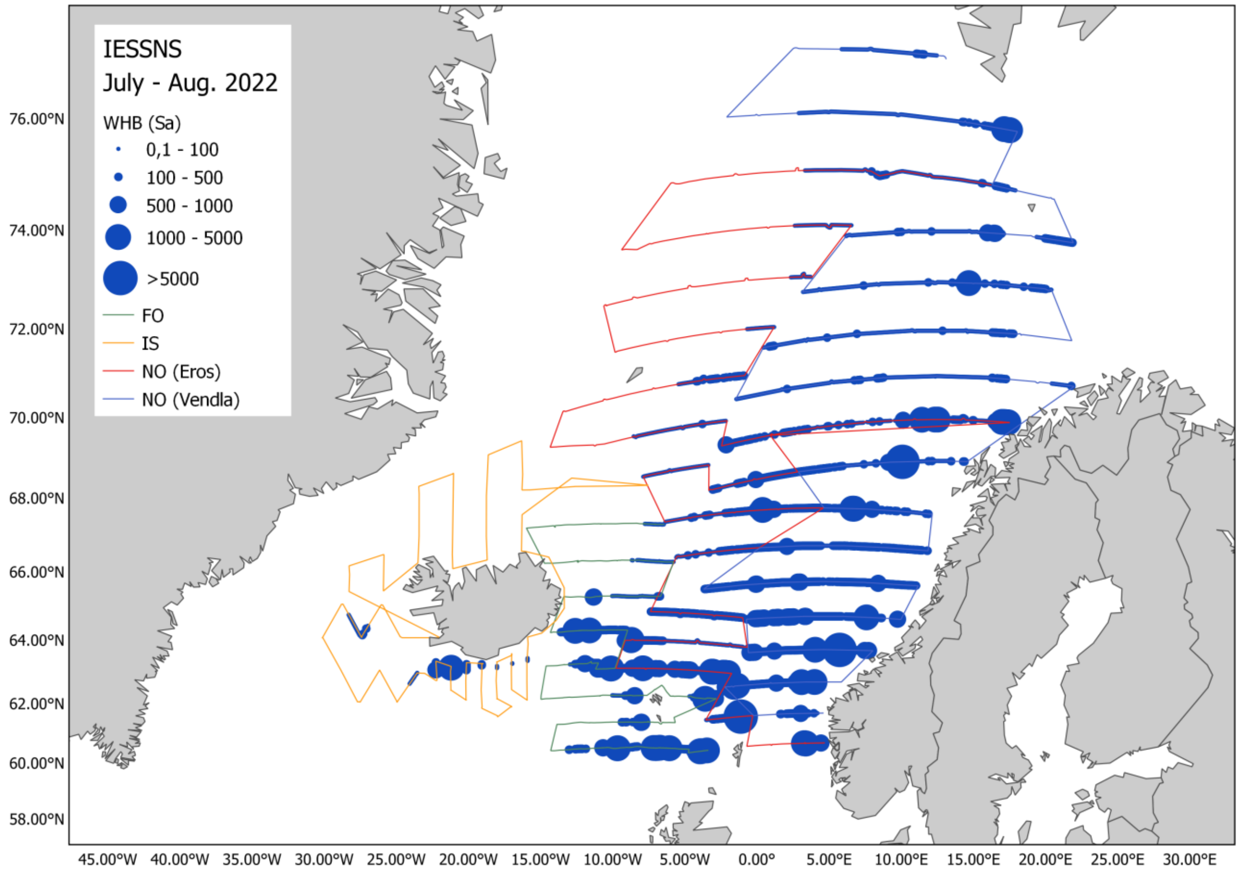

Figure 20a. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2022.

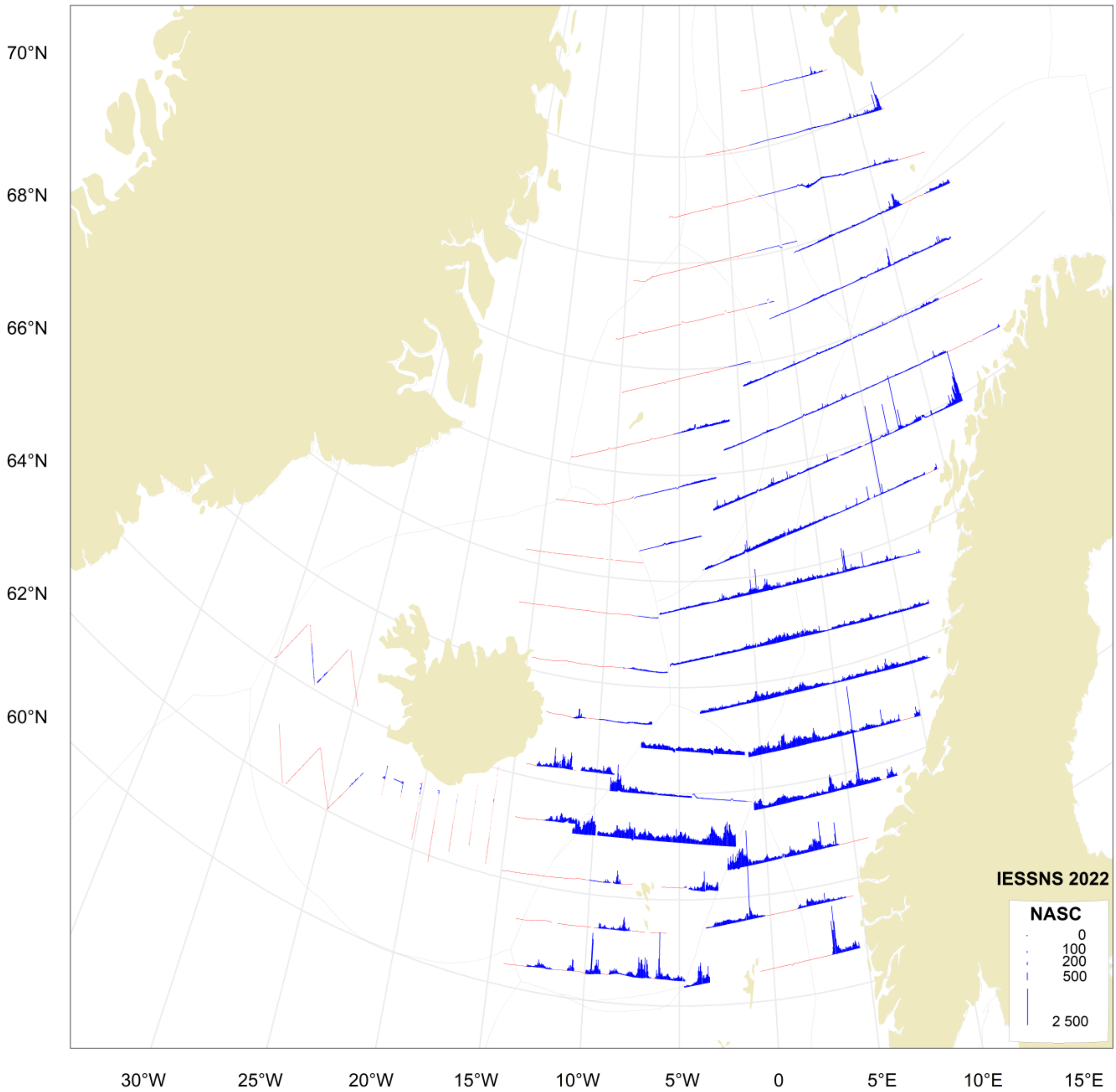

Figure 20b. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2022. Presented as bar plot.

Table 12. Estimates of abundance, mean weight and mean length of blue whiting based on calculation in StoX (bootstrap) for IESSNS 2022.

Length	Age in years (year class)											Number	Biomass	Mean
	0	1	2	3	4	5	6	7	8	9	10			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	(10^6)	(10^6 kg)	(g)
10-11														
11-12	135.2											135.2	1.1	8.2
12-13	414.1											414.1	4.7	11.3
13-14	236.6											236.6	3.5	14.9
14-15	169.0											169.0	2.9	17.1
15-16													0.2	22.0
16-17														
17-18													0.4	30.0
18-19		152.9										152.9	6.2	37.2
19-20		1567.2										1 567.2	68.3	44.1
20-21		4498.5										4 498.5	225.8	50.8
21-22		4136.4	277.3	44.9								4 458.5	251.9	57.1
22-23		1687.7	902.5									2 590.2	166.9	64.0
23-24		484.9	2723.7	21.6								3 230.2	244.4	76.6
24-25		84.2	2921.4	101.8								3 107.4	263.9	85.7
25-26		5.9	1837.0	336.5								2 179.4	207.8	95.5
26-27		4.0	729.4	396.6	19.4	6.8						1 156.3	121.6	106.5
27-28			243.2	564.3	144.2	6.5						958.2	107.7	115.1
28-29		1.1	99.4	437.5	151.5	11.7		46.8	26.3			774.4	95.5	127.3
29-30				81.2	240.6	34.8	67.3	65.6	101.5	54.1	54.1	699.3	90.1	133.3
30-31			14.4	190.4	8.9	19.7	125.3	43.1	249.8			651.7	96.1	154.1
31-32					174.0	26.1	178.4	36.0	64.3	74.0		552.8	89.0	167.6
32-33					97.6	43.9	53.9	26.7	145.2			367.3	66.5	187.2
33-34					47.2	65.8	66.9	35.7	72.8		6.4	294.8	58.3	200.8
34-35						64.9	7.0	49.6	18.4			139.8	29.7	221.0
35-36						24.4	10.9		11.9			47.2	11.8	244.2
36-37						7.8				19.5	6.4	33.7	8.7	267.6
37-38														
38-39													0.5	285.0
39-40									0.7			0.7	0.2	282.6
TSN(mill)	955	12623	9748	2175	883	313	510	303	691	148	67	28 503.1		
cv (TSN)	1.04	0.18	0.17	0.27	0.35	0.36	0.37	0.34	0.34	0.50	0.79	0.11		
TSB(1000 t)	12.2	683.9	826.3	240.1	127.5	58.4	81.9	48.5	111.4	22.9	9.0	2 223.7		
cv (TSB)	1.04	0.18	0.17	0.27	0.36	0.38	0.37	0.35	0.34	0.46	0.71	0.12		
Mean length(cm)	12.5	21.3	24.0	26.8	29.6	32.0	31.0	31.1	31.0	31.6	32.3			
Mean weight(g)	13	60	87	114	152	190	167	173	167	168	180			

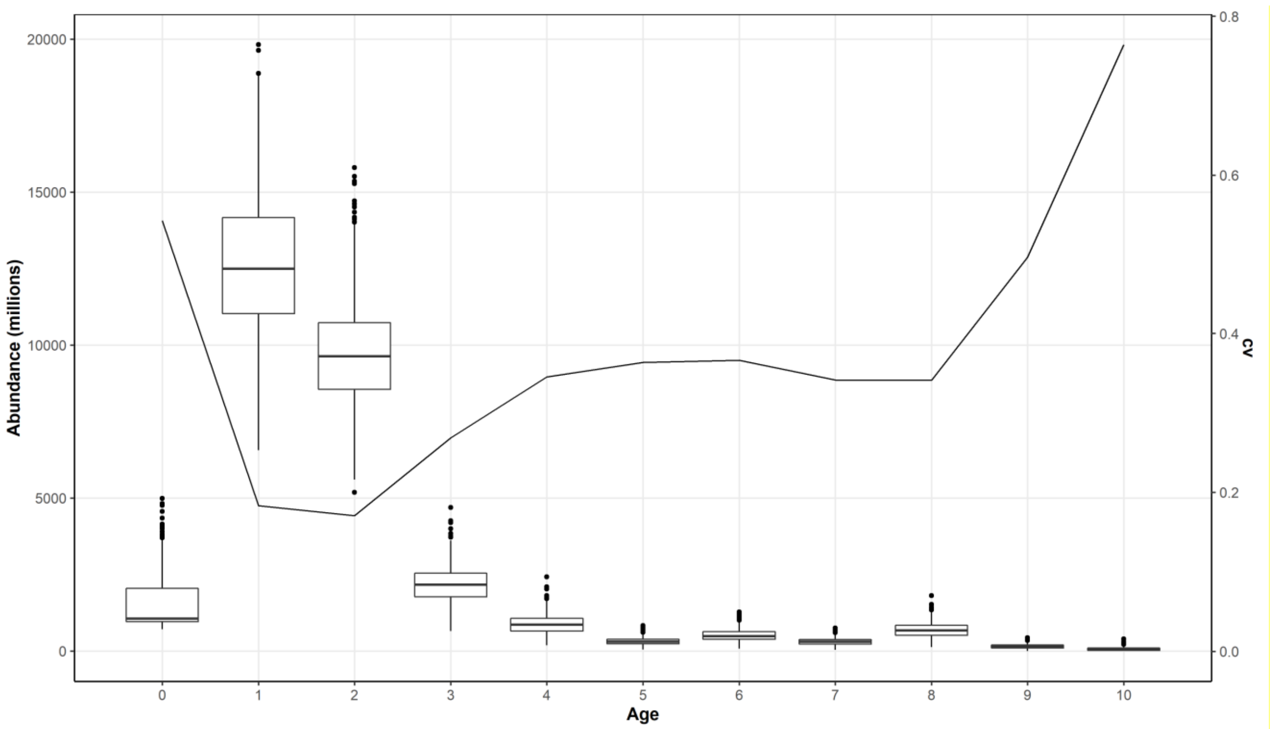

Figure 21. Number by age with uncertainty for blue whiting during IESSNS 2022. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

Table 13. IESSNS baseline time series from 2016 to 2022. StoX abundance 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

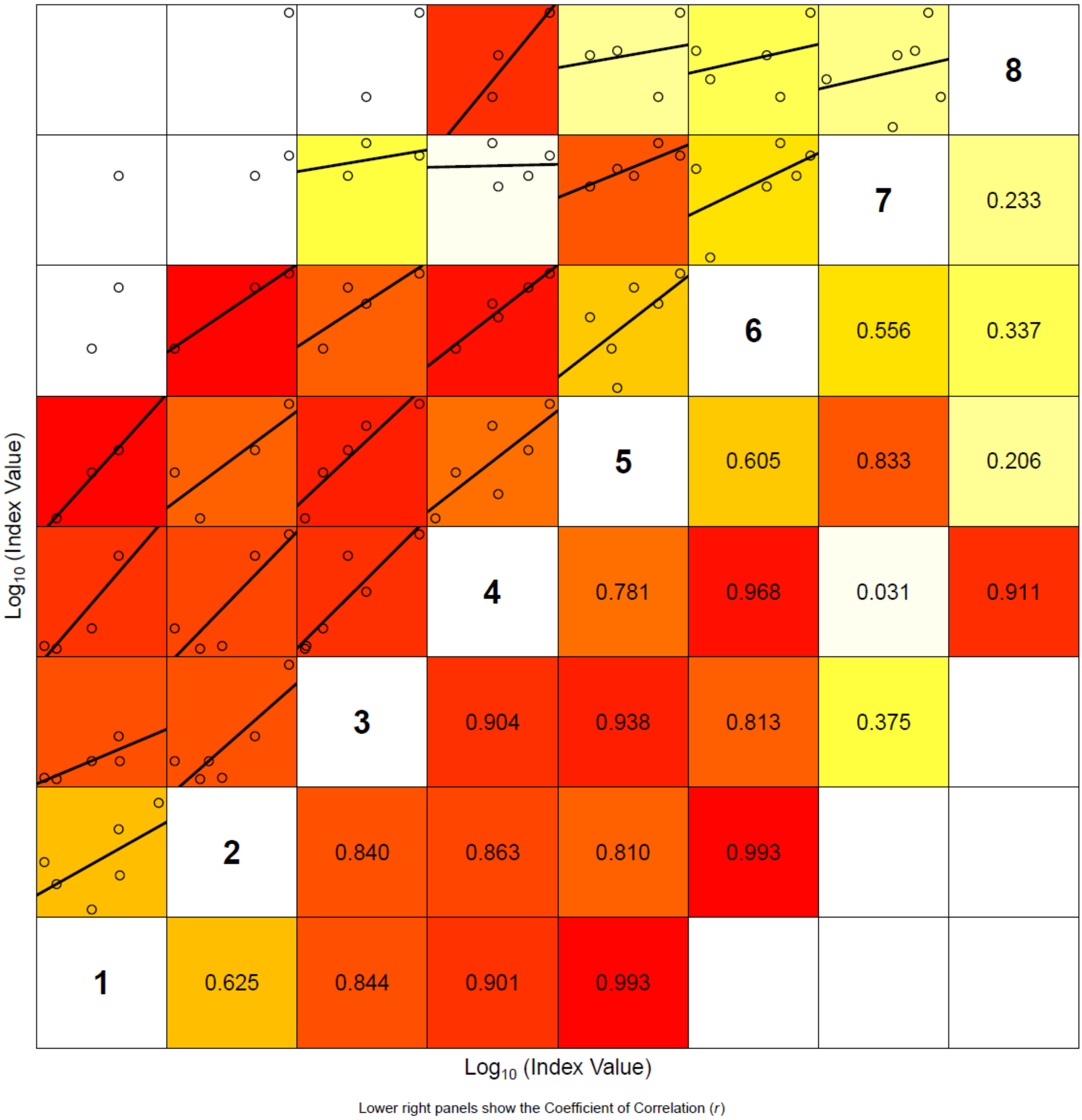

Figure 22. Internal consistency for blue whiting within the IESSNS. The upper left part of the plots shows the relationship between log index-at-age within a cohort. Linear regression line shows the best fit to the log-transformed indices. The lower-right part of the plots shows the correlation coefficient (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 71% of trawl stations across the five vessels (Figure 23) and where lumpfish was caught, 69% of the catches were ≤10kg. Lumpfish was distributed across the entire survey area, from east of Greenland to the Barents Sea in the northeast part of the covered area.

Abundance was greatest north of 71°N, with lower densities in the central Norwegian Sea and mostly absent directly south of Iceland, and south and southwest of the North Sea. The zero line was not hit to the northeast, northwest and southwest 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 51 cm with a bimodal distribution with the left peak (5-20 cm) likely corresponding to 1-group lumpfish and the right peak consisting of a mixture of age groups (Figure 24). For fish ≥20 cm in which sex was determined, the males exhibited a unimodal distribution with a peak around 25-27 cm. The females also exhibited a bimodal distribution but with a peak around 24-30 cm and another around 35-45 cm. Generally, the mean length and mean weight of the lumpfish was highest in Faroese waters, and around Iceland and along the shelf edges of Norway and lowest in the central and northern Norwegian Sea.

A total of 294 fish (67 by R/V "Árni Friðriksson", 83 by M/V "Eros", 96 by M/V Vendla and 48 by Tarajoq) between 5 and 52 cm were tagged during the survey (Figure 25).

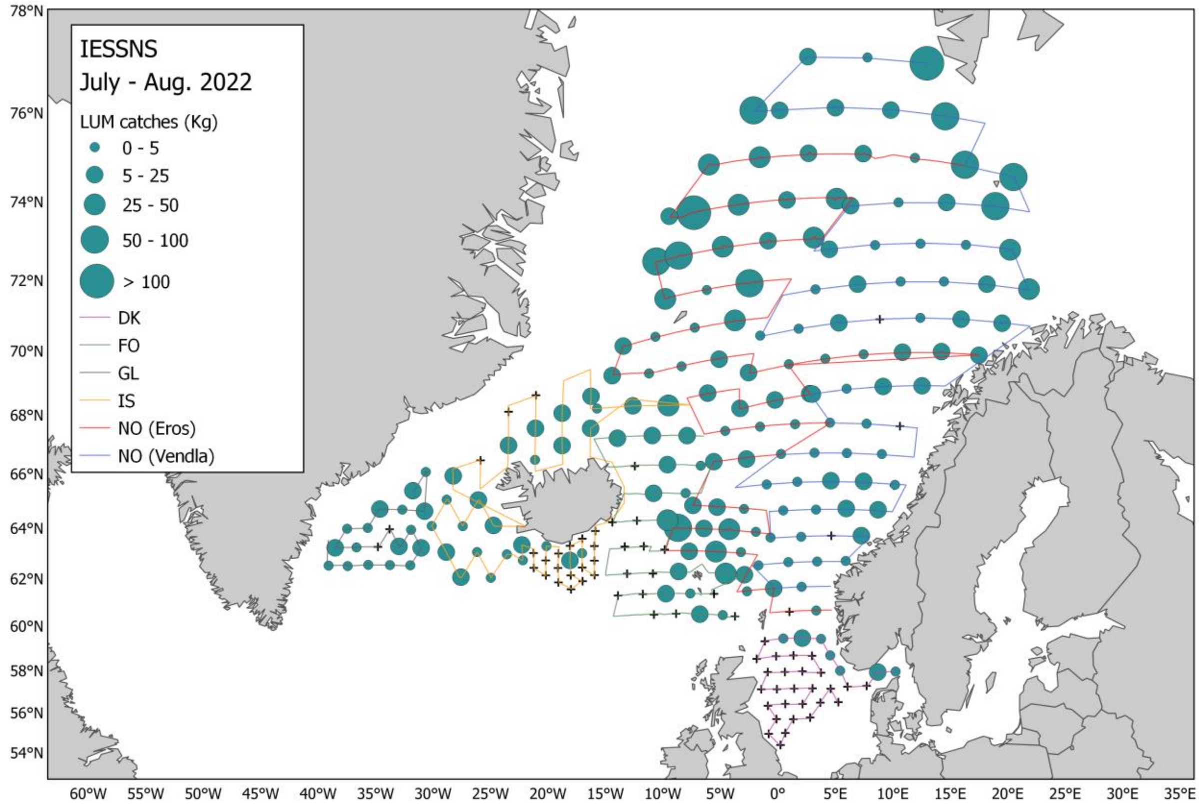

Figure 23. Lumpfish catches at surface trawl stations during IESSNS 2022.

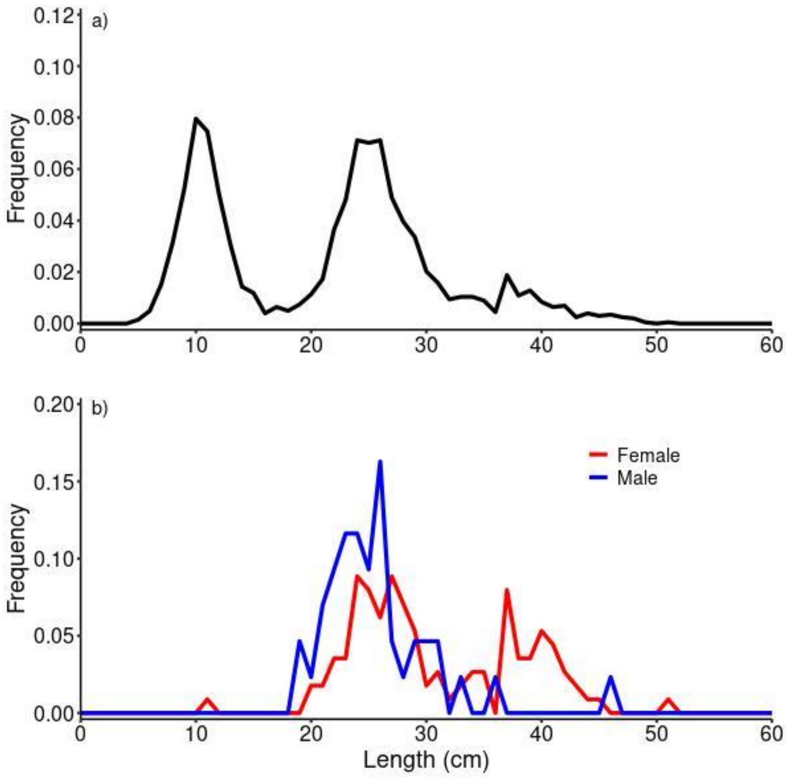

Figure 24. Length distribution of a) all lumpfish caught during the survey and b) length distribution of fish in which sex was determined.

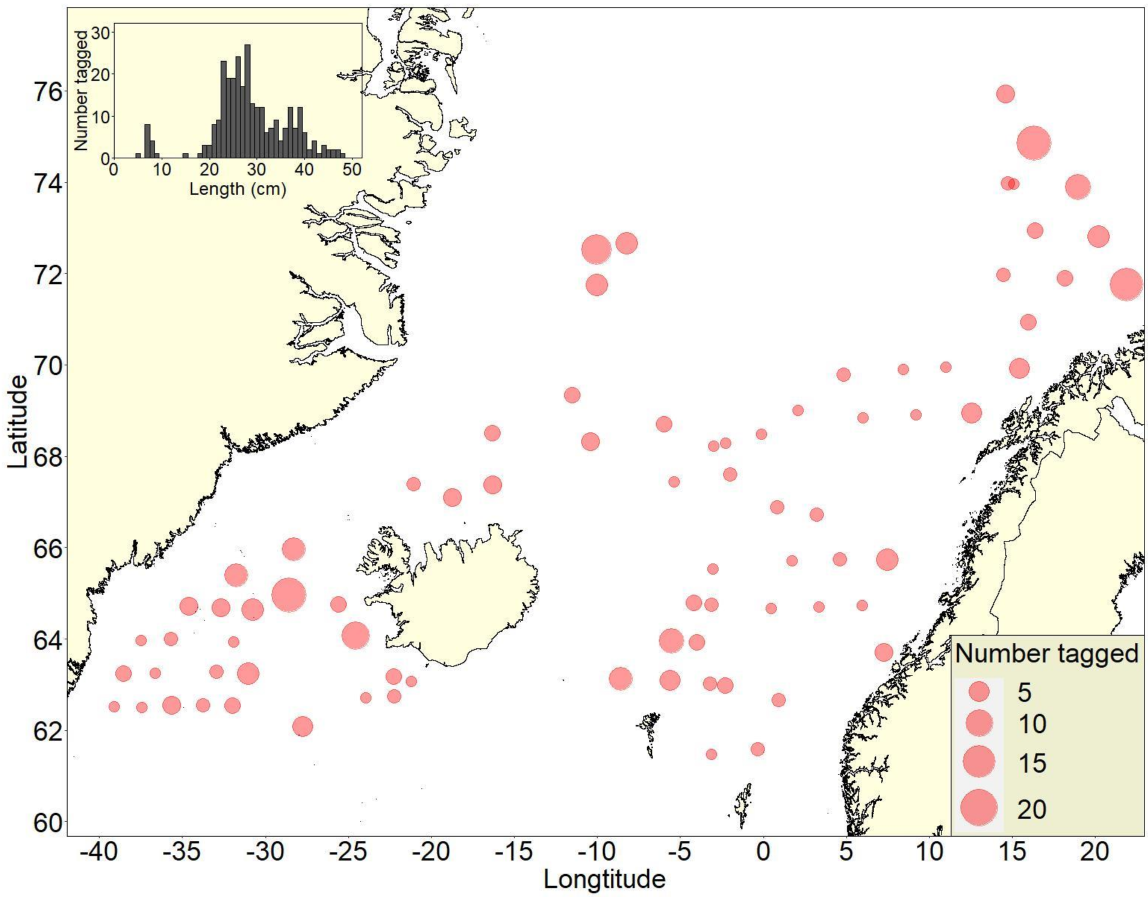

Figure 25. Number tagged, and release location, of lumpfish. Insert shows the length distribution of the tagged fish.

Salmon (*Salmo salar*)

A total of 60 North Atlantic salmon were caught in 38 stations both in coastal and offshore areas from 61°N to 76°N in the upper 30 m of the water column during IESSNS 2022 (Figure 26). The salmon ranged from 0.028 kg to 4.1 kg in weight, dominated by post-smolt and 1 sea-winter individuals. We caught from 1 to 6 salmon during individual surface trawl hauls. The length of the salmon ranged from 15 cm to 74 cm, with the highest fraction between 20 cm and 30 cm.

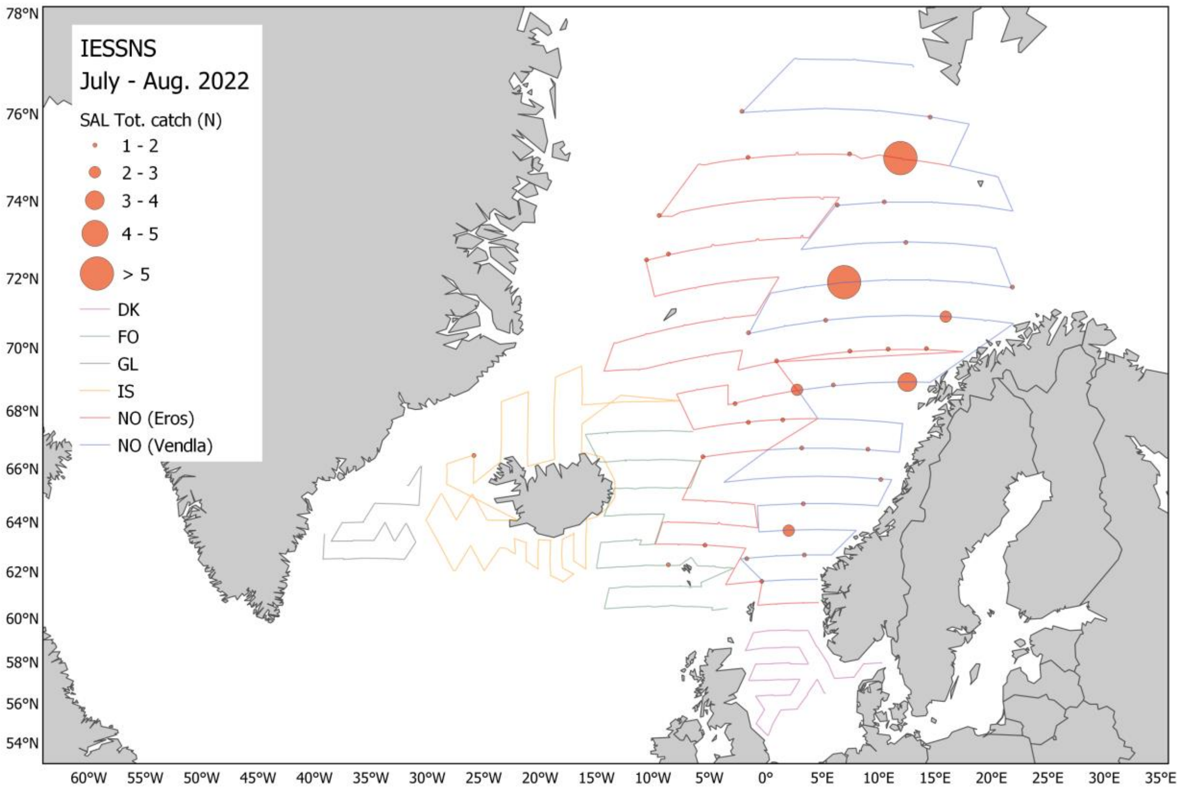

Figure 26. Catches of salmon at surface trawl stations during IESSNS 2022.

Capelin (*Mallotus villosus*)

Capelin was caught in the surface trawl on 22 stations primarily along the cold fronts: Between East Greenland and Iceland, west and North of Jan Mayen and at the entrance to the Barents Sea (Figure 27). This is 10 stations more than in 2021 partly because of the lack of Greenland coverage in 2021 and partly because of more stations with capelin around Iceland this year (11 in 2022, 6 in 2021).

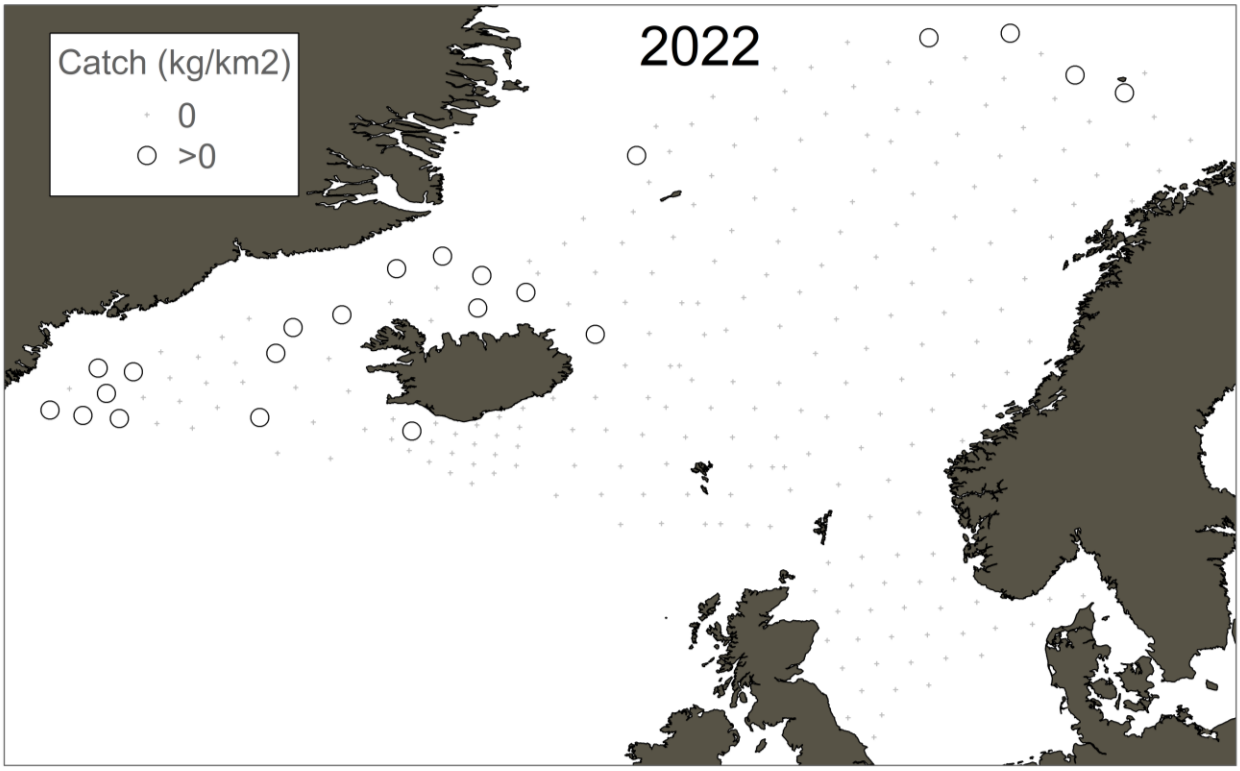

Figure 27. Presence of capelin in surface trawl stations during IESSNS 2022.

4.7 Marine Mammals

Opportunistic whale observations were done by M/V “Eros” and M/V “Vendla” from Norway in addition to R/V “Árni Friðriksson” from Iceland and R/V “Jákup Sverri” from Faroe Islands in from 1st July to 3rd August 2022 (Figure 28). Overall, 711 marine mammals of 11 different species were observed, which was a decrease from an overall 1029 marine mammals and eight species observed in 2021.

The species that were observed included fin whales (*Balaenoptera physalus*), minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), Northern bottlenose whales (*Hyperoodon ampullatus*), pilot whales (*Globicephala sp.*), killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), sei whales (*Baleanoptera borealis*), white sided dolphins (*Lagenorhynchus acutus*) white beaked dolphins (*Lagenorhynchus albirostris*), harbour porpoise (*Phocoena phocoena*). A basking shark (*Cetorhinus maximus*) was also observed during the survey. The dominant number of marine mammal observations were found around Iceland, Faroe Islands and along the continental shelf between the north-eastern part of the Norwegian Sea and in a line between Finnmark to southwest of Svalbard. We observed very few marine mammals in the central part of the Norwegian Sea in July 2022. Fin whales (n = 48, group size = 1-12 (average group size = 2.5)) and humpback whales (n = 44, group size = 1-30 (average group size = 3.9)) dominated among the large whale species, and they were present west and northwest of Iceland and from Norwegian coast outside Finnmark stretching north/northwest via Bear Island to southwest of Svalbard. Very few sperm whales (n = 8, group size = 1 (average group size = 1.0)) where observed. Killer whales (n = 121, group size = 1-30 (average groups size = 10.1)) dominated in the southern, northern and north-eastern part of the Norwegian Sea, partly overlapping and presumably feeding on NEA mackerel in the upper water masses. Pilot whales (n = 30, group size = 5-15 (average groups size = 10)) where mostly observed in Faroese waters during IESSNS 2022. A sei whale and one northern bottlenose whale were observed in Icelandic waters, whereas a basking shark was observed in Faroese waters. White beaked dolphins (n = 229, group size = 1-22 (average groups size = 8.5)) were present in the northern part of the Norwegian Sea. Two pods of white sided dolphins (group size = 15) were observed in the southern part of the Norwegian Sea. Minke whales (n = 53, group size = 1-10 (average group size = 1.7)) were distributed over large areas from western coast of Norway to western part of Iceland, and from 60°N to 75°N, including overlapping and likely feeding on NSS herring in the upper 40 m of the water column. There is available a new publication summarizing the main results on marine mammals from the IESSNS surveys from 2013 to 2018, with major focus on hot spot areas of fin whales and humpback whales from 2013 to 2018 (Løviknes et al. 2021)

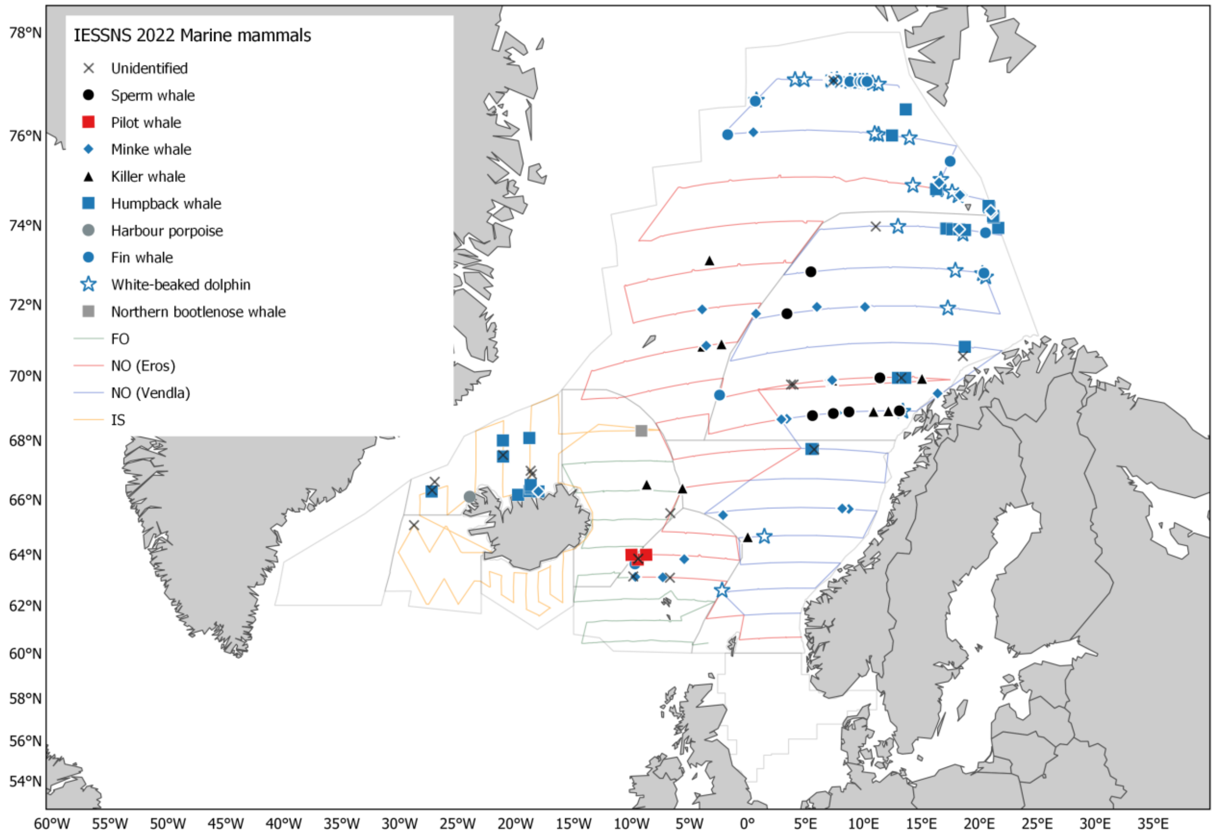

Figure 28. Overview of all marine mammals sighted during IESSNS 2022.

5 Recommendations

The group suggested the following recommendation from WGIPS	To whom
The occasional large catches of mackerel have a relatively large impact on the overall results and possibly bias the stock indices. WGIPS recommends that the ability of the present and alternative methods (such as more advanced statistical models) to represent this overdispersion is evaluated, preferably at the WGISDAA meeting 25.-27.October, 2022.	National institutes and WGISDAA
The surveys conducted by Denmark in 2018-2022 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
It is recommended that WGIPS contacts the country representatives for the IESSNS survey to update the respective sections (e.g. trawl performance, trawl station data collection) in the survey manual prior to the WGIPS meeting 23.-27.January 2023.	WGIPS

6 Action points for survey participants

Action points	Responsible
Criteria and guidelines should be established for discarding substandard trawl stations using live monitoring of headline, footrope and trawl door vertical depth, and horizontal distance between trawl doors. For predetermined surface trawl station, discarded hauls should be repeated until performance is satisfactory. Explicit guideline for incomplete trawl hauls is to repeat the station or exclude it from future analysis. It is not acceptable to visually estimate mackerel catch, it must be hauled onboard and weighed. If predetermined trawl hauls are not satisfactory according to criteria the station will be excluded from mackerel index calculations, i.e. treated as if it does not exist, but not as a zero mackerel catch station.	All
All survey participants are encouraged to continue the international tagging of lumpfish.	All
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 2022 the IESSNS survey in the North Sea has been conducted for five consecutive years (2018-2022). It is recommended that a comprehensive report is written about the major results from the NEA mackerel time series from the IESSNS surveys in the North Sea, where the internal consistency between years in the survey for selected age groups is also evaluated. 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)

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8 Acknowledgements

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10 Appendices

Appendix 1

Denmark joined the IESSNS in 2018 for the first time 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.

In 2022, 34 stations were taken (PT and CTD. The locations of stations differed slightly from the previous year focussing on the area north and west of Doggerbank and extended into the eastern Skagerrak. However, due to shortage of available survey time only 34 out of the planned 38 stations were covered.

Average mackerel catch in 2022 amounted 1689 kg/km^2, which was considerably lower than in the previous year (2021: 2429 kg/km^2) but higher or similar than in the period 2018-2020 (2020: 1318 kg/km^2, 2019: 1009 kg/km^2, 2018: 1743 kg/km^2). The length and age composition indicate a relative low amount of small (< 25 cm) individuals whereas the abundance of older (≥ age 2) mackerel was on a similar level than in the previous year (Fig. A.1.).

StoX (version 3.5.0) estimate of mackerel biomass in the North Sea for 2022 is 471 948 tonnes (Table A1-1) which is the second highest biomass values in the time series. The biomass and abundance estimates are based on a preliminary defined polygon for the surveyed area covered in all years since 2018 in which the northern border was set to 60 °N (border to stratum 1; Fig. 2), and the eastern, southern, and western limits were either the coastline or extrapolated using half the longitudinal or latitudinal distance between the adjacent stations. The area of this polygon is 278 525 km^2.

For 11 out of 35 individuals in the size range of 18 to 20 cm the first wintering was not visible applying the standard age reading procedure. These fish should be attributed to the 2021-year class rather than be treated as 0-group fish considering the spawning period of mackerel in the North Sea. However, the aspect of the non-visible first age ring, which might be related to the presently prevailing warm winter conditions in the North Sea, warrants further investigations.

Based on the experiences made in the previous years, new limits for the stratum in the North were defined which shall be used for the station allocation for future surveys (Fig. A2). 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 were 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 easter 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.

Table A1-1. StoX (version 3.5.0) baseline estimates of age segregated and length segregated mackerel indices for the North Sea in 2022.

Length	Age in years / Year class															Number	Biomass	Mean
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14			weight
(cm)	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	(10^6)	(ton)	(g)
17-18		0.1														0.1	4	40
18-19	15.5	15.3														30.8	1488	48
19-20	36.3	87.1														123.4	6753	55
20-21	1.8	120.4														122.1	8024	66
21-22		42.0														42.0	3162	75
22-23		12.6														12.6	1153	92
23-24		11.3														11.3	1237	109
24-25		26.7														26.7	3318	124
25-26		12.6														12.6	1747	139
26-27		7.4														7.4	1161	157
27-28		15.3								0.8						16.1	3013	187
28-29		147.9	23.2													171.1	36138	211
29-30		496.5	23.2													519.7	126715	244
30-31		204.9	160.3													365.2	97338	266
31-32		26.2	134.1	13.3												173.6	49252	284
32-33			103.7	13.1	0.6											117.4	36622	312
33-34			35.2	30.1	5.4	0.6										71.3	23661	332
34-35			3.6	29.6	18.9	2.3										54.3	19943	367
35-36				5.7	13.5	7.6	6.6	4.4								37.8	14858	393
36-37				0.7	8.9	11.3	7.1	0.2	0.5	0.8						29.5	12106	410
37-38					1.5	6.3	9.4	3.9	0.1							21.1	9138	433
38-39						1.2	0.7	4.1	2.4	0.5						8.9	4416	498
39-40					1.1	4.2	2.5	0.7	0.9	0.5						9.8	4963	504
40-41						1.1	0.8	1.3	0.5	0.3	0.7					4.6	2537	549
41-42								1.1		0.1						1.3	699	542
42-43								0.4					0.4		0.1	1.0	648	675
43-44										1.8						1.8	1250	682
44-45							1.3									1.3	1281	950
TSN (mill)	53.6	1226.4	483.3	92.4	49.8	34.4	28.5	16.3	4.3	4.8	0.7	0.0	0.4	0.0	0.1	1,995	472626	
TSB (ton)	2913	242385	136351	30981	19206	14533	13103	7731	2195	2535	345	0	259	0	90	472,626		
Mean length (cm)	18.7	26.8	30.8	33.0	34.7	36.3	36.9	37.4	38.2	38.1	40.0		42.0		42.0			
Mean weight (g)	54	198	282	335	385	422	460	474	511	525	525		638		746			

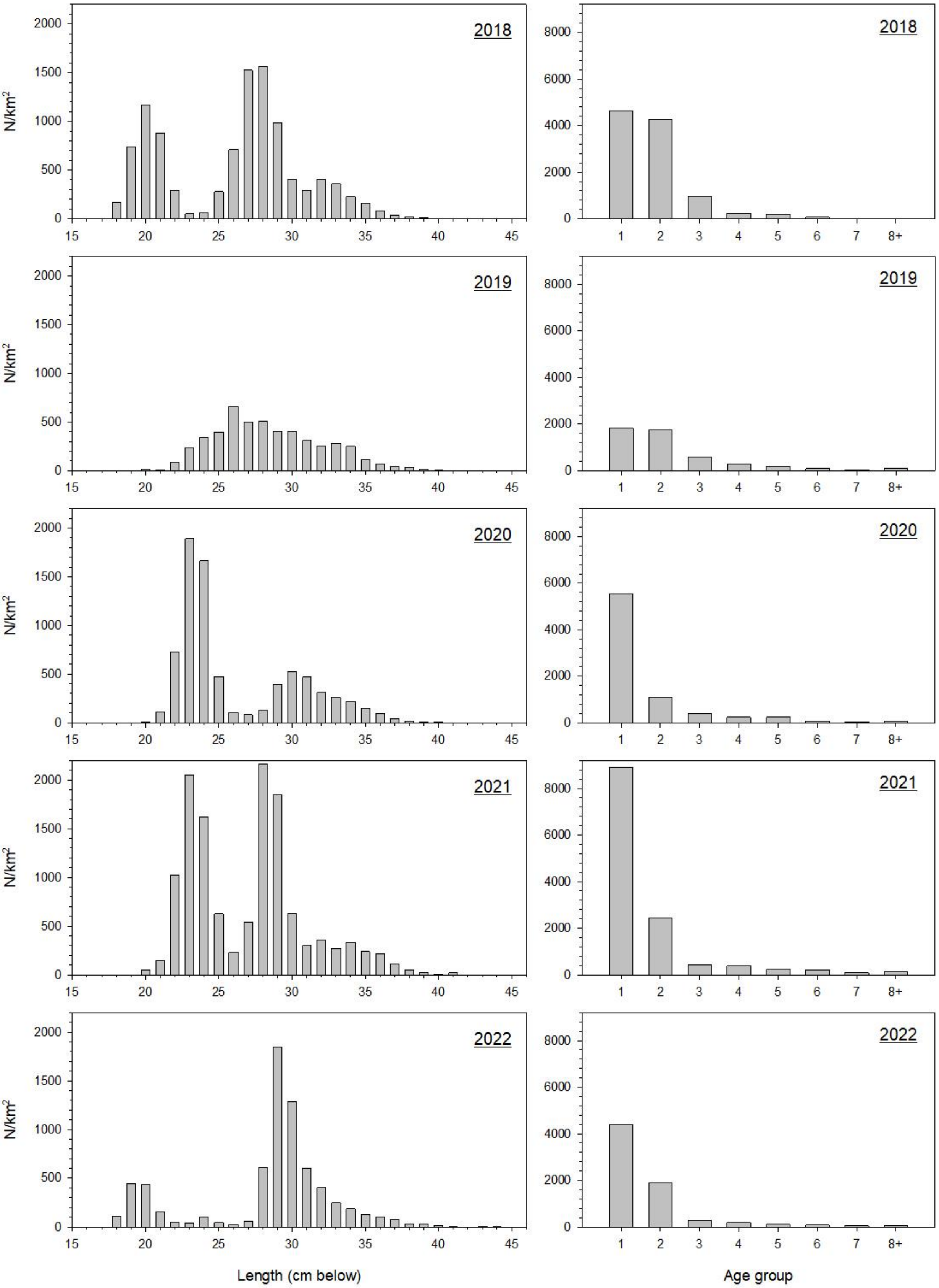

Fig. A1-1. Comparison of length and age distribution of mackerel in the North Sea 2018 to 2022.

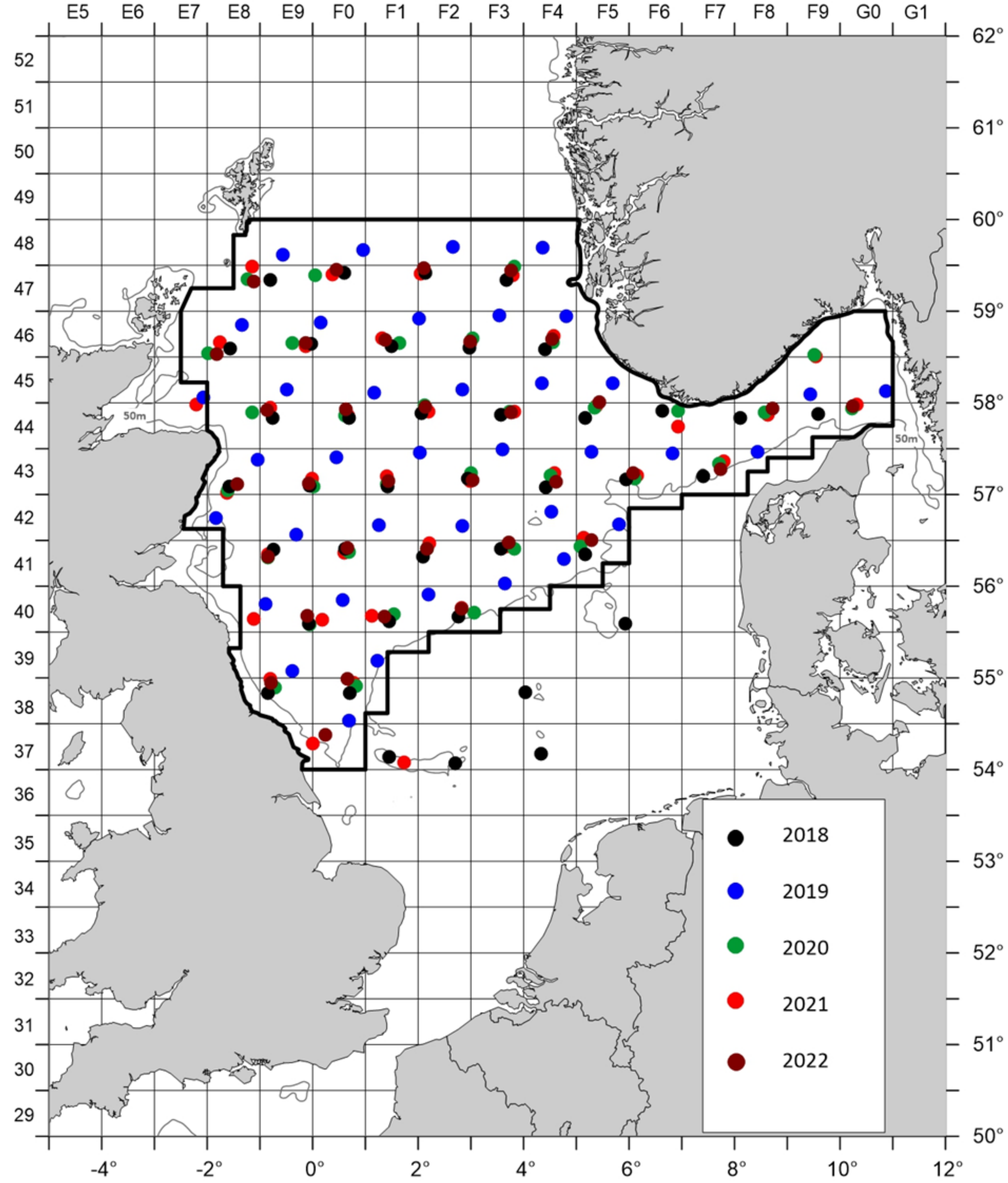

Fig. A1-2. Limits of the North Sea stratum for future surveys and sampling positions achieved in the period 2018-2022.

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 2022 (Table A2-1). Map of included and excluded trawl stations displayed in Figure A2-1.

Table A2-1: Trawl station exclusion list and average horizontal trawl opening per vessel for IESSNS 2022 for calculating the mackerel abundance index.

Vessel	Country	Horizontal trawl opening (m)	Exclusion list Cruise	 Stations
Vendla	Norway	67.5	2022816	60, 75, 80, 82, 85, 88, 90, 91, 95, 104, 109, 113, 120, 124
Eros	Norway	63.5	2022817	28, 30, 44, 46,51, 55, 59, 63, 72, 73, 91
R/V Árni Friðriksson	Iceland	63.75	A8-2022	295, 311
R/V Jákup Sverre	Faro Islands	63.4	2230	5, 23, 24, 35, 46, 61*
R/V Tarajoq	Greenland	61.4	TA-2022-04	none
Ceton	Denmark	72.0	IESSNS2022	none

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

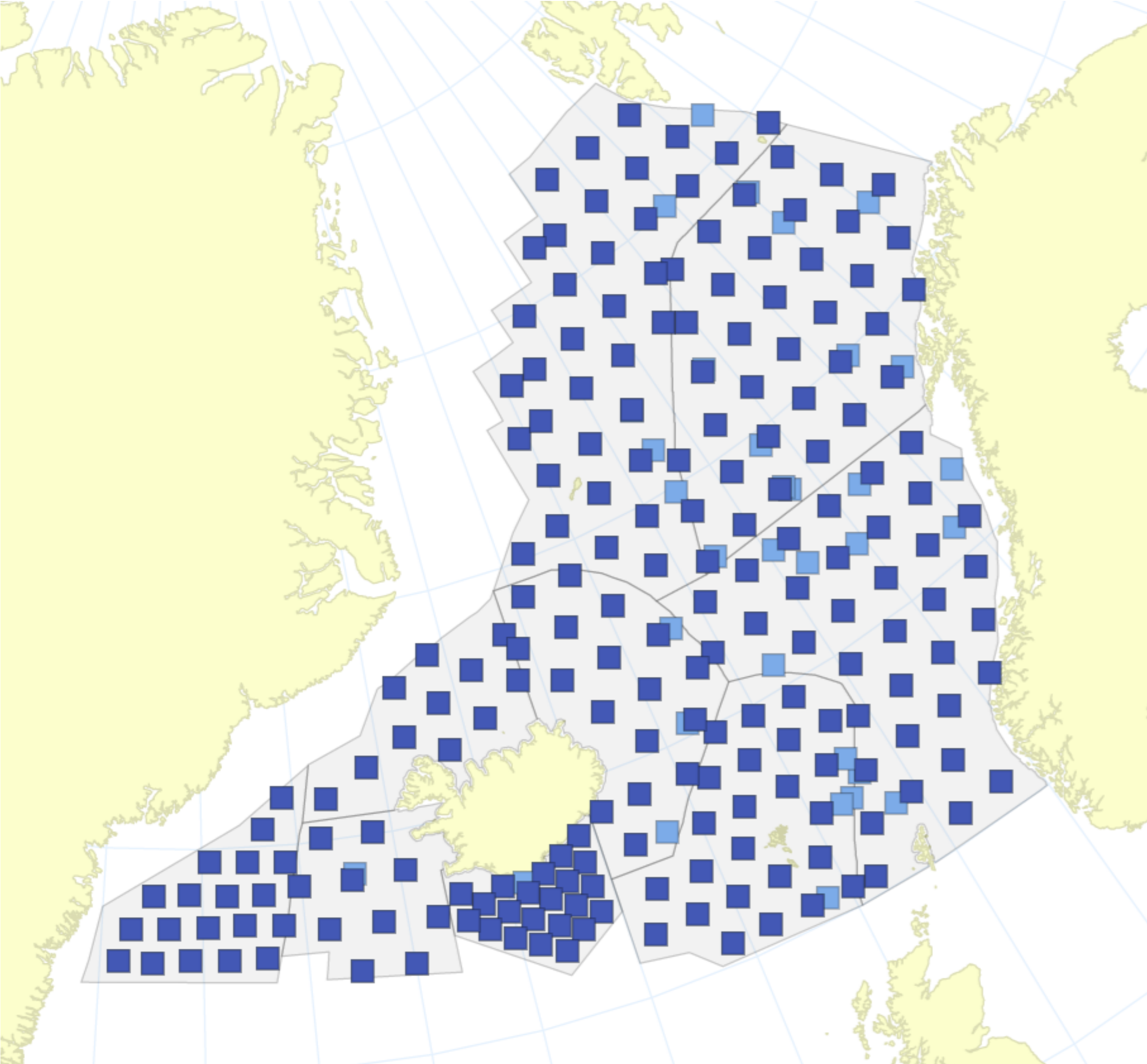

Figure A2-1. IESSNS 2022. Surface trawl stations included (filled dark blue rectangle) and excluded (filled light blue rectangle) in calculations of mackerel age segregated index used in the assessment. Strata boundary also displayed (grey solid lines).

Appendix 3: Impact of large hauls on abundance and biomass estimates

In 2022 there were two large mackerel hauls. In order to investigate the effect of these on the StoX estimates, an additional run of StoX was made without these hauls (Figure A3-1).

If the two stations with the highest catches (slightly above 20 tons on each) are removed, the baseline estimate of total abundance is reduced by 34 % and the baseline estimate of total biomass is reduced by 33 % (from 7.37 to 4.91 million tons). Moreover, the relative standard error of total abundance from 1000 bootstrap replicates is 26 % when all stations are used, while becomes reduced to 12 % when the two highest stations are removed. The relative standard error of total biomass from 1000 bootstrap replicates is 25 % when all stations are used, while becomes reduced to 11 % when the two highest stations are removed.

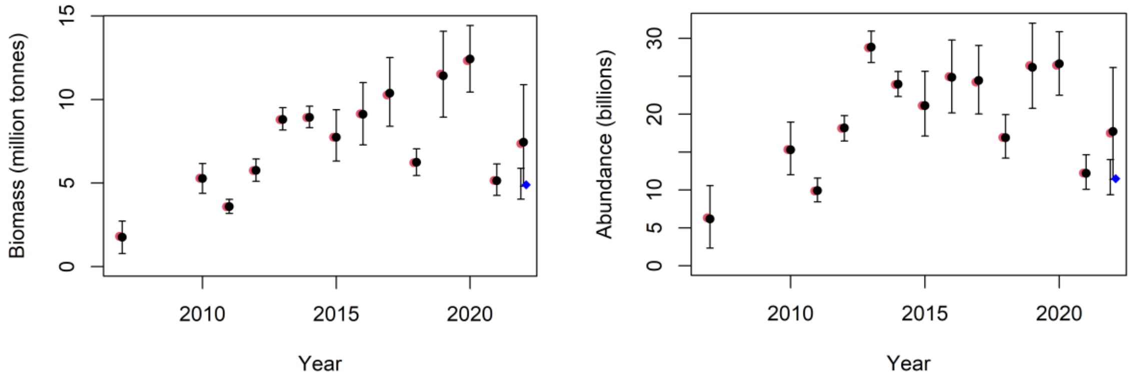

Figure A3-1. StoX runs with (black/red 2022 dot) and without (blue 2022 dot) large hauls. Biomass (left panel) and abundance (right panel).

Appendix 4:

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 A4-1.

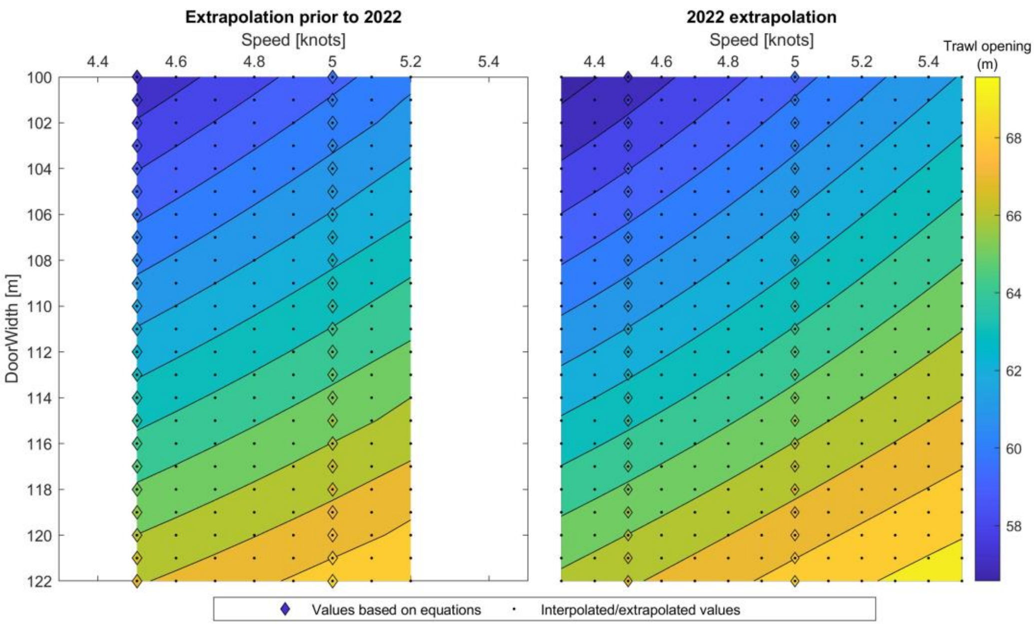

Figure A3-1. Table 6 in the report shown as a plot.

Working document 02, WGWIDE 2022

PFA self-sampling report for WGWIDE 2022

Martin Pastoors, 24/08/2022 12:41:15 (v2)

PFA report 2022_07

Executive summary

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 15 (in 2021) freezer trawlers in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers aimed at assessing the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions by haul and regularly taking length measurements from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Martin Pastoors (PFA chief science officer) with support of Floor Quirijns (contractor). The self-sampling program has been incrementally implemented in the fishery and by 2018 all vessels in the PFA fleet participated in the self-sampling.

This report for WGWIDE presents an overview of the results of the Pelagic Freezer-Trawler Association (PFA) self-sampling program for the fisheries for widely-distributed pelagic stocks: Northeast Atlantic mackerel, Blue whiting, Horse mackerel and Atlanto-scandian herring (herring caught north of 62 degrees). The selection of hauls to be included in the analyses was based on first summing all catches by vessel, trip, species and week. For each vessel-trip-species-week combination, the proportion of the species in the catch were calculated. The following filter criteria have applied to the weekly data:

- for horse mackerel: latitude > 45, proportion in the catch > 10%, weekly catch > 10 tonnes
- for mackerel : latitude > 45, proportion in the catch > 10%, weekly catch > 10 tonnes
- for blue whiting : latitude > 50, proportion in the catch > 10%, weekly catch > 10 tonnes
- for herring : division = 27.2.a, proportion in the catch > 10%, weekly catch > 10 tonnes

Trips from 2016 up to 11/08/2022 have been processed for this overview. Pelagic fisheries within the Pelagic Freezer-trawler Association are carried out by vessels from different countries. Overall, around 48% of the catch volume of trips in this overview were taken by Dutch trawlers, 22% German trawlers, 14% UK trawlers and 16% other countries. Blue whiting constitutes the majority of the catch in those trips (54%), followed by mackerel (23%) and horse mackerel (12%). Atlanto-scandian herring only constitutes around 3% of the volume in the PFA widely distributed fishery. Note that the North Sea herring fishery is not included in this overview.

The **Mackerel fishery** takes place from October through to March of the subsequent year. Bycatches of mackerel may also occur during other fisheries,e.g. for horse mackerel or herring. Overall, the self-sampling activities for the mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 465 fishing trips with 6352 hauls, a total catch of 386474 tonnes and 103745 individual length measurements. The main fishing areas are ICES division 27.4.a and division 27.6.a. Compared to the previous years, mackerel in the catch in 2021 have been relatively large with a median length of 36.4 cm compared to 33.6-36.2 in the preceding years. Also, the median weight has been somewhat higher with median weight of 435 gram compared to 385-422 gram in the preceding years.

The **Western horse mackerel fishery** takes place from October through to March of the subsequent year. Overall, the self-sampling activities for the Western horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 250 fishing trips with 3316 hauls, a total catch of 128553 tonnes and 130146 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.b and division 27.7.j. Western horse mackerel have a wide range in the length distributions in the catch. Median lengths in divisions 27.6.a, 27.7.b and 27.7.j have fluctuated between 25.2 and 31.9 cm (with one low median length of 22.7 cm in 27.6.a in 2018). In ICES division 27.7.h, median lengths in the catch have been smaller and fluctuated between 20.7 and 24.5 cm.

The **North Sea horse mackerel fishery** takes place from October through to January of the subsequent year. Overall, the self-sampling activities for the North Sea horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 109 fishing trips with 900 hauls, a total catch of 46322 tonnes and 38983 individual length measurements. The main fishing areas is ICES division 27.7.d with some minor catches in 27.4.c. Catches in division 27.4.a have been counted as Western Horse mackerel. North Sea horse mackerel have a narrow range in the length distributions in the catch. Median lengths in division 27.7.d have fluctuated between 20.7 and 24.3 cm.

The **blue whiting** fishery takes place from February through to May although some minor fisheries for blue whiting may remain over the other months. Overall, the self-sampling activities for the horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 320 fishing trips with 8234 hauls, a total catch of 810714 tonnes and 466229 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.c and division 27.7.k. Compared to the previous years, blue whiting in the catches during 2020-2022 have been relatively large with a median length of 27.8 cm compared to 24.1-24.5 in the preceding years.

The fishery for **Atlanto-scandian herring** (ASH) is a relatively smaller fishery for PFA and takes place mostly in October. Overall, the self-sampling activities for the horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 32 fishing trips with 297 hauls, a total catch of 17705 tonnes and 5147 individual length measurements. Only the herring fishery in ICES division 27.2.a is considered for ASH. Note that there are herring catches in other divisions within the selected trips. These are trips where North Sea herring has been fished with some bycatches of mackerel for example. Atlanto-scandian herring have a relatively narrow range in the length distributions in the catch. Median lengths have been between 30 and 35 cm.

In this 2022 self-sampling report, a standardized CPUE calculation has been included for the first time for most of the stocks. The standardized CPUE is based on a GLM model with a negative binomial distribution. The response variable is the catch by week and vessel, with an offset of the log effort (number of fishing days per week) and explanatory variables year, GT category, month, division and depth category. An assumed technical efficiency increase of 2.5% per year has been included in the fitting of the model (Rousseau et al 2019)

1 Introduction

The Pelagic Freezer-trawler Association (PFA) is an association that has nine member companies that together operate 18 freezer trawlers (in 2022) in six European countries (www.pelagicfish.eu). In 2015, the PFA has initiated a self-sampling program that expands the ongoing monitoring programs on board of pelagic freezer-trawlers by the specialized crew of the vessels. The primary objective of that monitoring program is to assess the quality of fish. The expansion in the self-sampling program consists of recording of haul information, recording the species compositions per haul and regularly taking random length-samples from the catch. The self-sampling is carried out by the vessel quality managers on board of the vessels, who have a long experience in assessing the quality of fish, and by the skippers/officers with respect to the haul information. The scientific coordination of the self-sampling program is carried out by Martin Pastoors (PFA chief science officer) with support of Floor Quirijns (contractor).

2 Overview of self-sampling methodology

The PFA self-sampling program has been implemented incrementally on many vessels that belong to the members of the PFA. The self-sampling program is designed in such a way that it follows as closely as possible the working practices on board of the different vessels and that it delivers relevant information for documenting the performance of the fishery and to assist stock assessments of the stocks involved. The following main elements can be distinguished in the self-sampling protocol:

- haul information (date, time, position, weather conditions, environmental conditions, gear attributed, estimated catch, optionally: species composition)
- batch information (total catch per batch=production unit, including variables like species, average size, average weight, fat content, gonads y/n and stomach fill)
- linking batch and haul information (essentially a key of how much of a batch is caught in which of the hauls)
- length information (length frequency measurements, either by batch or by haul)

The self-sampling information is collected using standardized Excel worksheets. Each participating vessel will send in the information collected during a trip by the end of the trip. The data will be checked and added to the database by Floor Quirijns and/or Martin Pastoors, who will also generate standardized trip reports (using RMarkdown) which will be sent back to the vessel within one or two days. The compiled data for all vessels is being used for specific purposes, e.g. reporting to expert groups, addressing specific fishery or biological questions and supporting detailed biological studies. The PFA publishes an annual report on the self-sampling program.

A major feature of the PFA self-sampling program is that it is tuned to the capacity of the vessel-crew to collect certain kinds of data. Depending on the number of crew and the space available on the vessel, certain types of measurements can or cannot be carried out. That is why the program is essentially tuned to each vessel separately. And that is also the reason that the totals presented in this report can be somewhat different dependent on which variable is used. For example the estimate of total catch is different from the sum of the catch per species because not all vessels have supplied data on the species composition of the catch.

In order to supply relevant information to WGWIDE, the PFA self-sampling data has been filtered using the following approach. First, all catches per vessel, trip and species have been summed by week. For each vessel-trip-species-week combination, the proportion of the species in the catch were calculated. Then the following filter criteria have applied to the weekly data:

- for horse mackerel: latitude > 45, proportion in the catch > 10%, catch > 10 tonnes
- for mackerel : latitude > 45, proportion in the catch > 10%, catch > 10 tonnes

- for blue whiting : latitude > 50, proportion in the catch > 10%, catch > 10 tonnes
- for herring : division = 27.2.a, proportion in the catch > 10%, catch > 10 tonnes

For this report, data have been processed for 2016 - 2022 (up to 11/08/2022).

3 Results

3.1 General

An overview of all the self-sampled trips for mac, hom, whb, her_ash in 27.2.a, 27.4.a, 27.6.a, 27.7.b, 27.7.j, 27.7.h, 27.4.c, 27.7.d, 27.7.c, 27.7.k, 27.5.b. The percentage non-target species is defined as the catch of non-pelagic species relative to the catch of pelagic species.

year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nontarget	nlength	nbio
2016	9	45	591	1,307	113,900	193	0.50%	65,212	0
2017	12	62	840	1,781	177,887	212	0.26%	91,357	0
2018	16	86	1,219	2,677	253,237	208	0.22%	170,306	641
2019	16	97	1,226	2,658	224,886	183	0.29%	124,288	1,055
2020	17	112	1,424	3,038	305,282	214	0.36%	163,955	2,379
2021	19	119	1,398	2,874	282,097	202	0.52%	138,481	1,411
2022*	18	62	733	1,694	144,718	197	0.84%	65,457	4,004
(all)		583	7,431	16,029	1,502,007			819,056	9,490

*Table 3.1.1: PFA fisheries for widely distributed species Self-sampling Summary of number of vessels, trips, days, hauls, catch (tonnes), catch per day and number of fish measured. * denotes incomplete year*

Catch and number of self-sampled hauls by year and division

division	2016	2017	2018	2019	2020	2021	2022*	all	perc
27.6.a	34,822	75,493	126,130	116,241	125,729	113,522	57,044	648,981	43.2%
27.4.a	24,771	23,842	36,129	39,494	63,061	61,135	13,684	262,116	17.5%
27.7.c	7,516	29,371	30,524	26,772	44,548	28,885	20,835	188,451	12.5%
27.7.k	7,489	96	7,646	2,036	11,339	16,684	29,327	74,616	5.0%
27.2.a	11,784	20,469	18,096	4,607	10,000	2,595	0	67,551	4.5%
27.7.j	4,822	663	3,648	8,635	16,322	14,976	14,801	63,868	4.3%
27.7.d	10,456	8,404	9,853	10,373	10,763	9,934	2,303	62,086	4.1%
27.7.b	4,614	8,605	5,324	10,530	11,649	13,205	5,997	59,924	4.0%
27.5.b	5,721	8,061	7,933	3,925	10,277	8,689	514	45,120	3.0%
27.7.h	1,381	1,330	6,571	1,236	111	9,012	212	19,851	1.3%
27.4.c	523	1,555	1,385	1,036	1,483	3,460	0	9,442	0.6%
(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

division	2016	2017	2018	2019	2020	2021	2022*	all	perc
27.6.a	411	668	1,267	1,281	1,209	966	711	6,513	40.6%
27.4.a	194	191	374	436	548	560	139	2,442	15.2%
27.7.c	87	255	243	252	328	255	159	1,579	9.8%
27.7.d	162	153	187	187	187	206	55	1,137	7.1%
27.7.j	52	17	60	137	208	289	273	1,036	6.5%
27.7.b	101	139	88	175	207	202	86	998	6.2%
27.2.a	129	237	207	86	142	24	0	825	5.1%
27.7.k	77	3	59	17	95	131	244	626	3.9%
27.5.b	57	66	82	38	87	54	5	389	2.4%
27.7.h	25	30	94	24	6	144	22	345	2.2%
27.4.c	12	22	16	25	21	55	0	151	0.9%
(all)	1,307	1,781	2,677	2,658	3,038	2,886	1,694	16,041	100.0%

*Table 3.1.2: PFA fisheries for widely distributed species Self-sampling Summary of catch (top) and number of hauls (bottom) per year and division. * denotes incomplete year*

Catch and number of self-sampled hauls by year and month

month	2016	2017	2018	2019	2020	2021	2022*	all	perc
Jan	12,789	28,644	25,647	35,499	37,485	51,537	41,028	232,629	15.5%
Feb	10,196	19,369	32,600	32,829	28,300	31,967	28,025	183,285	12.2%
Mar	16,154	29,388	32,673	27,992	47,769	36,936	40,093	231,004	15.4%
Apr	14,420	28,510	58,665	28,857	66,042	29,472	25,878	251,844	16.8%
May	7,763	12,367	30,227	21,332	29,189	14,466	8,521	123,866	8.2%
Jun	1,649	0	6,866	1,498	4,219	2,467	0	16,699	1.1%
Jul	1,977	665	791	6,185	1,566	12,330	1,174	24,688	1.6%
Aug	886	6,545	4,551	3,844	4,234	4,779	0	24,839	1.7%
Sep	1,990	9,898	8,334	7,775	12,586	9,134	0	49,717	3.3%
Oct	18,517	17,478	22,975	25,417	27,648	39,924	0	151,960	10.1%
Nov	18,307	21,875	20,385	22,205	27,061	30,033	0	139,865	9.3%
Dec	9,251	3,148	9,522	11,453	19,184	19,052	0	71,610	4.8%
(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

month	2016	2017	2018	2019	2020	2021	2022*	all	perc
Jan	174	311	309	452	355	568	482	2,651	16.5%
Feb	142	206	325	362	287	344	301	1,967	12.3%
Mar	160	226	297	314	410	333	389	2,129	13.3%
Apr	114	201	494	289	574	240	359	2,271	14.2%
May	105	145	372	250	312	167	144	1,495	9.3%
Jun	14	0	77	23	97	42	0	253	1.6%
Jul	25	12	10	75	26	113	19	280	1.7%
Aug	5	58	39	41	53	33	0	229	1.4%
Sep	38	130	145	149	154	187	0	803	5.0%
Oct	204	198	232	299	295	398	0	1,626	10.1%
Nov	223	269	291	315	331	305	0	1,734	10.8%
Dec	103	25	86	89	144	156	0	603	3.8%
(all)	1,307	1,781	2,677	2,658	3,038	2,886	1,694	16,041	100.0%

Table 3.1.3: PFA fisheries for widely distributed species Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch and number of self-sampled hauls by year and country (flag)

flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
DEU	27,803	27,500	55,468	40,385	69,108	54,075	26,246	300,585	20.0%
FR	0	0	11,936	19,356	14,506	12,257	9,128	67,184	4.5%
LIT	0	0	0	1,414	13,744	23,150	6,467	44,775	3.0%
NL	68,790	114,844	139,403	106,898	117,284	124,171	69,345	740,736	49.3%
POL	0	0	15,966	28,022	54,615	29,675	13,599	141,877	9.4%
UK	17,306	35,543	30,464	28,811	36,026	35,341	19,932	203,423	13.5%
NA	0	0	0	0	0	3,428	0	3,428	0.2%
(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
DEU	340	276	637	456	623	463	269	3,064	19.1%
FR	0	0	236	357	243	205	165	1,206	7.5%
LIT	0	0	0	34	142	165	36	377	2.4%
NL	807	1,177	1,403	1,314	1,374	1,385	886	8,346	52.1%
POL	0	0	111	183	322	187	113	916	5.7%
UK	160	328	290	314	334	394	225	2,045	12.8%
NA	0	0	0	0	0	75	0	75	0.5%
(all)	1,307	1,781	2,677	2,658	3,038	2,874	1,694	16,029	100.0%

Table 3.1.4: PFA fisheries for widely distributed species Self-sampling summary of catch (top) and number of hauls (bottom) per year and month.

Catch by species and year

species	english_name	scientific_name	2016	2017	2018	2019	2020	2021	2022	all	perc
whb	blue whiting	Micromesistius poutassou	48,666	79,108	154,733	113,262	174,647	149,325	90,974	810,715	54.0%
mac	mackerel	Scomber scombrus	33,544	63,026	55,756	54,005	84,290	69,094	26,569	386,283	25.7%
hom	horse mackerel	Trachurus trachurus	21,808	20,853	28,497	31,565	25,061	33,995	13,096	174,876	11.6%
her	herring	Clupea harengus	4,509	6,870	7,851	17,286	9,154	19,912	3,123	68,704	4.6%
arg	argentines	Argentina spp	1,560	2,596	4,097	4,566	7,036	5,457	9,595	34,906	2.3%
her_ash	NA	NA	2,109	4,913	1,367	3,373	3,563	2,379	0	17,706	1.2%
boc	boarfish	Capros aper	226	245	153	288	603	844	680	3,039	0.2%
pil	pilchard	Sardina pilchardus	719	61	371	155	32	325	140	1,805	0.1%
hke	hake	Merluccius merluccius	266	107	270	197	181	239	333	1,593	0.1%
spr	sprat	Sprattus sprattus	382	0	0	0	415	138	0	934	0.1%
sqr	squid	Loligo vulgaris	0	0	8	8	26	133	55	229	0.0%
had	haddock	Melanogrammus aeglefinus	11	5	15	46	42	66	37	222	0.0%
brb	black seabream	Spondyliosoma cantharus	29	2	22	3	83	5	3	148	0.0%
bor	boarfish	Caproidae	0	0	0	0	0	59	73	132	0.0%
whg	whiting	Merlangius merlangus	13	0	24	31	31	30	2	130	0.0%
oth	NA	NA	57	101	74	102	119	95	37	585	0.0%
(all)	(all)	(all)	113,900	177,887	253,237	224,886	305,282	282,097	144,718	1,502,007	100.0%

Table 3.1.5: PFA fisheries for widely distributed species Self-sampling Summary of total catch (tonnes) by species. OTH refers to all other species that are not the main target species

Haul positions

An overview of all self-sampled hauls in the PFA fisheries for widely distributed species.

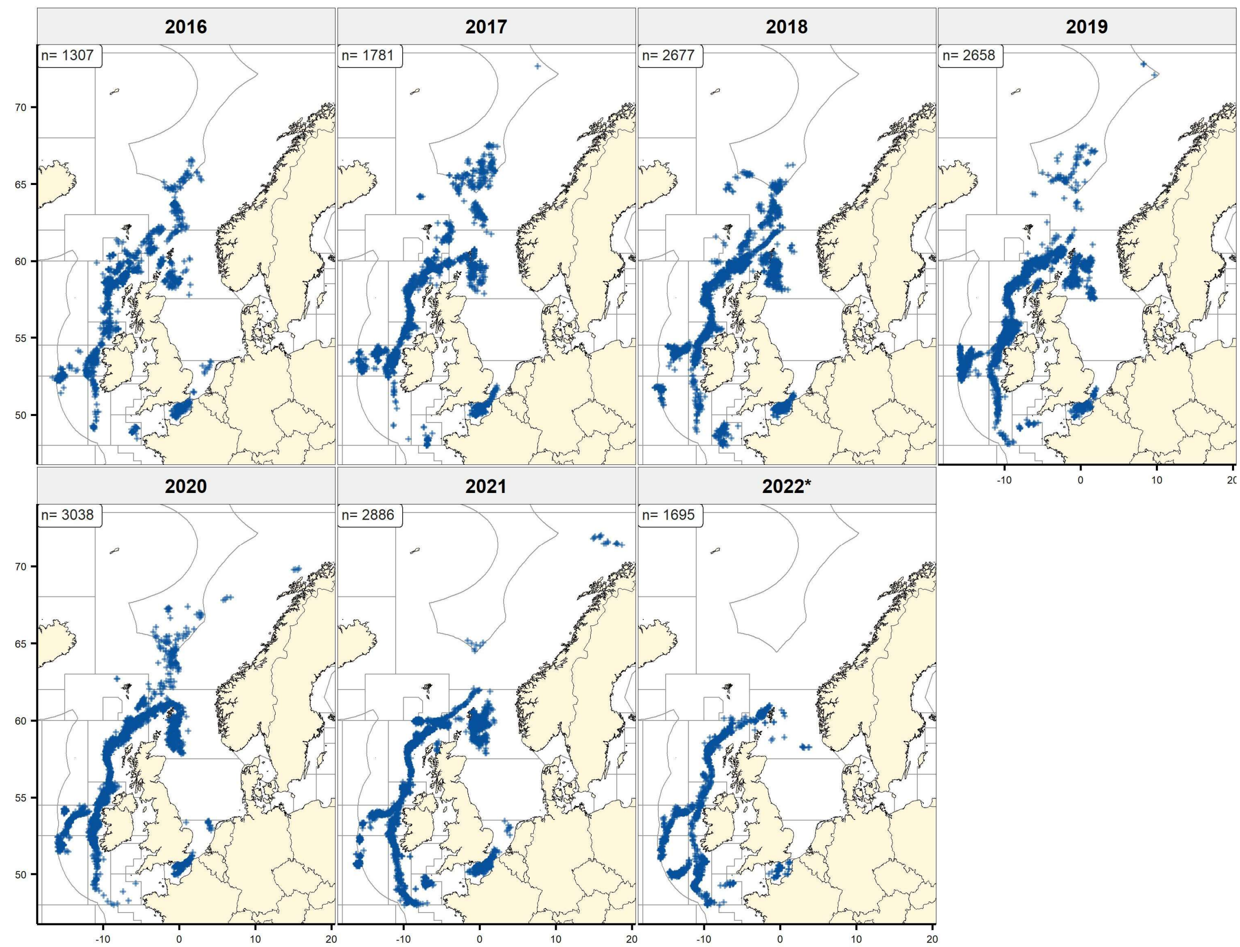

Figure 3.1.1: PFA fisheries for widely distributed species Self-sampling haul positions. N indicates the number of hauls.

Catches for the main target species

Summed catches (tonnes) of the main target species aggregated in rectangles.

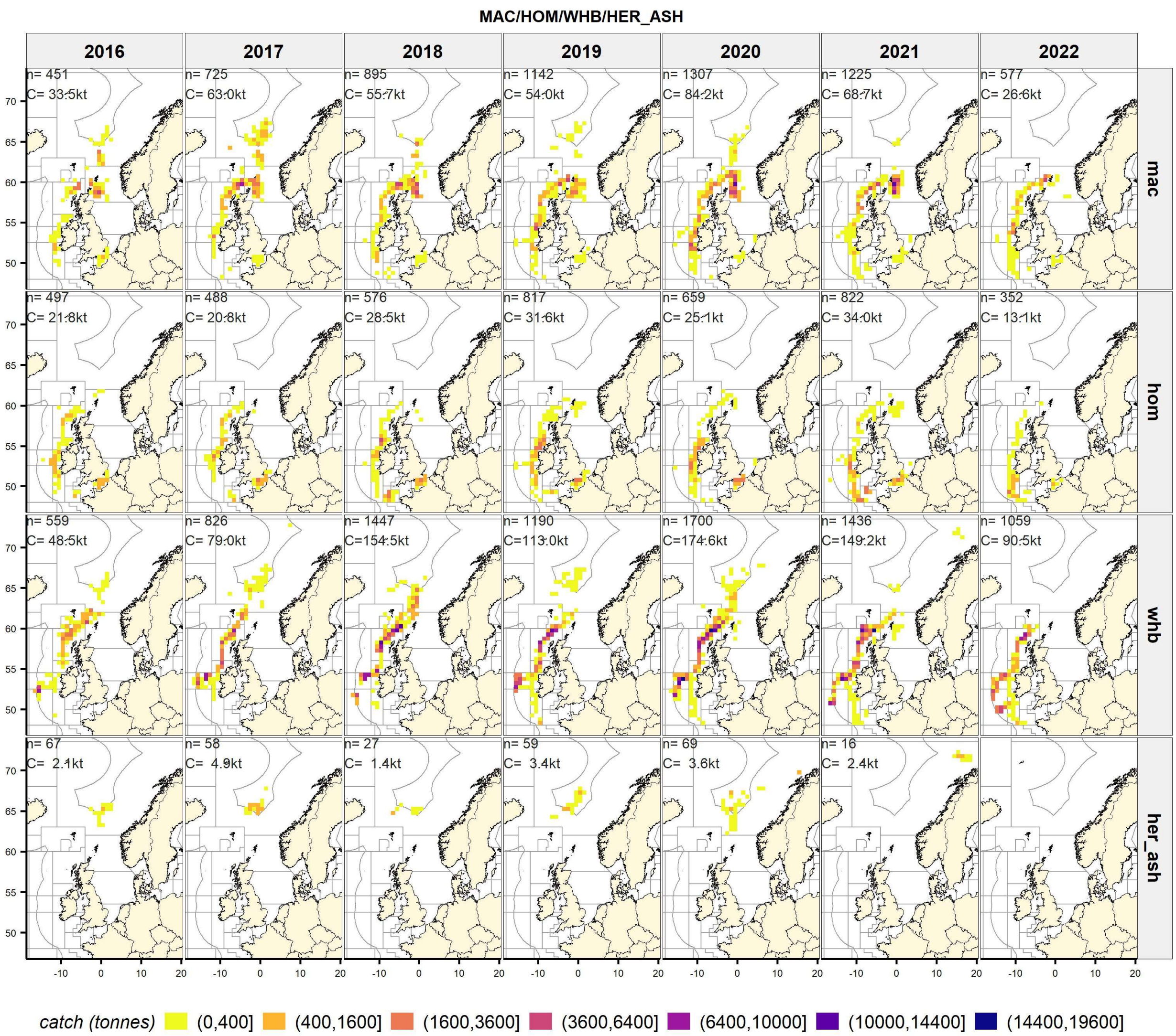

Figure 3.1.2: PFA fisheries for widely distributed species Self-sampling catch per species and per rectangle. N indicates the number of hauls. Catch refers to the total catch per year.

Catch rates (catch/day) for the main target species

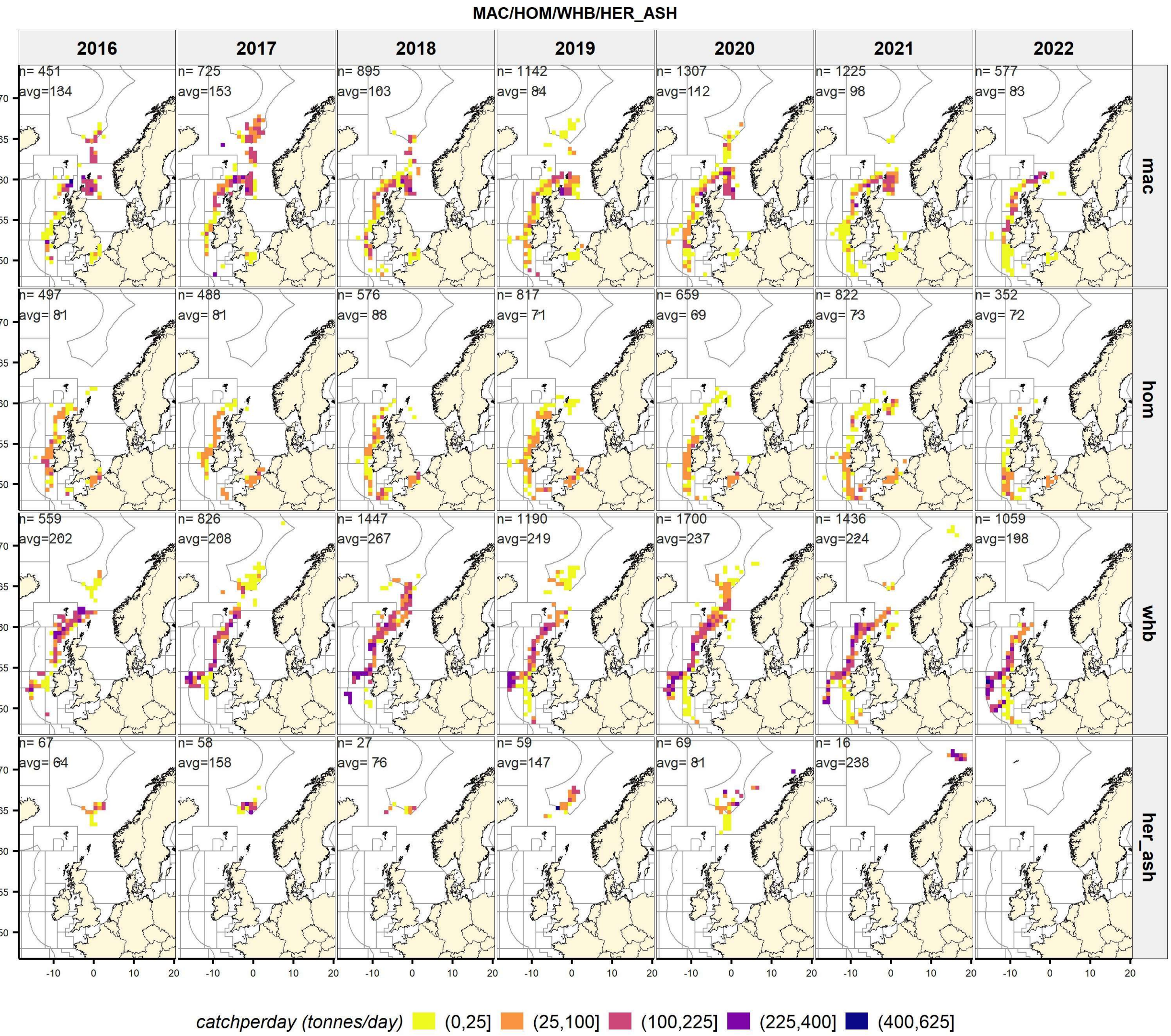

Figure 3.1.3: Average catch per day, per species and per rectangle. N indicates the number of hauls; avg refers to the average catch per day.

Average surface temperature by quarter and by rectangle.

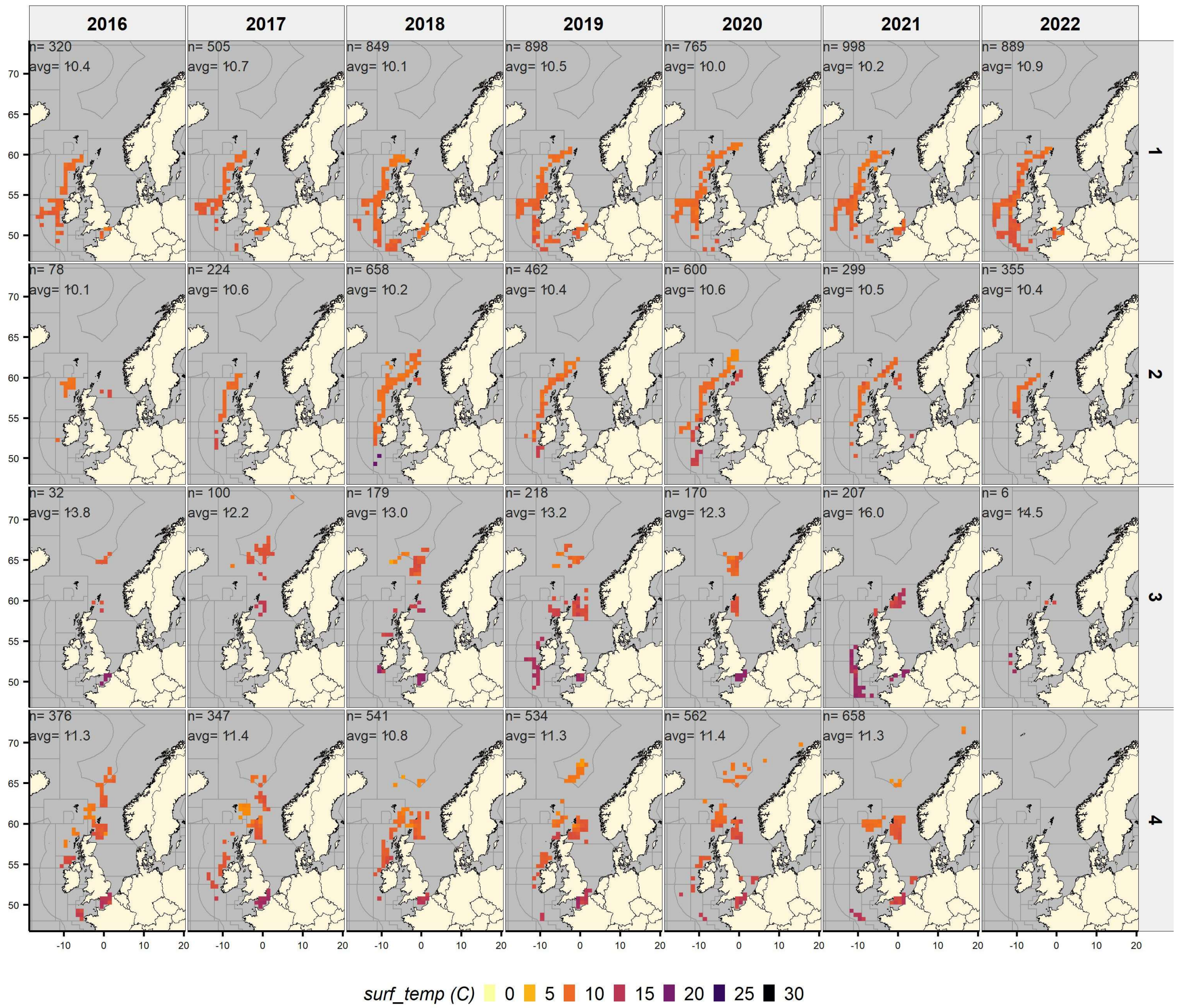

Figure 3.1.4: PFA fisheries for widely distributed species Average surface temperature (C) by year and quarter. N indicates the number of hauls. Avg refers to the average temperature.

Average fishing depth.

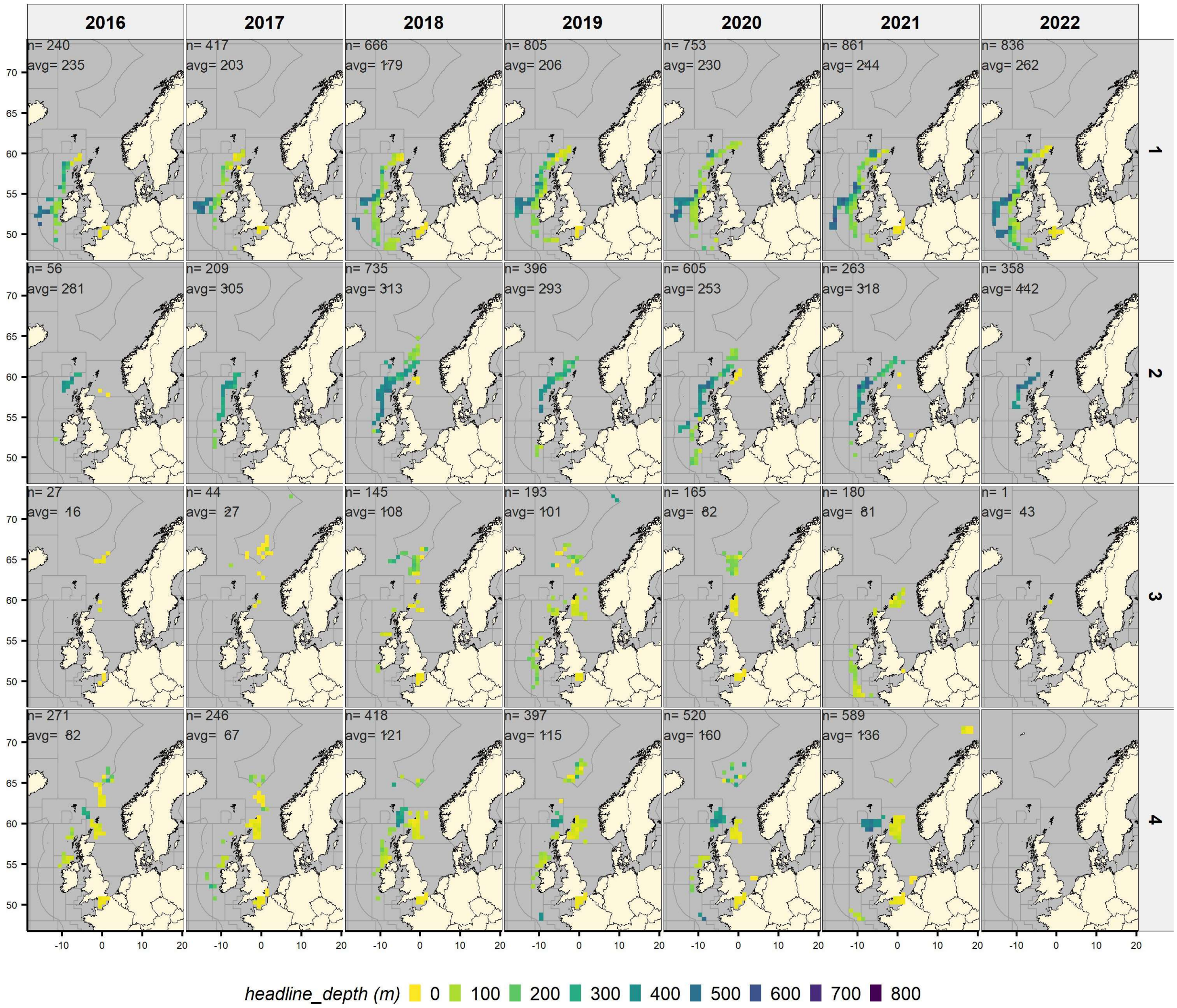

Figure 3.1.5: PFA fisheries for widely distributed species Average fishing depth (m) by year and quarter. N indicates the number of hauls. Avg refers to the average fishing depth.

Average wind force.

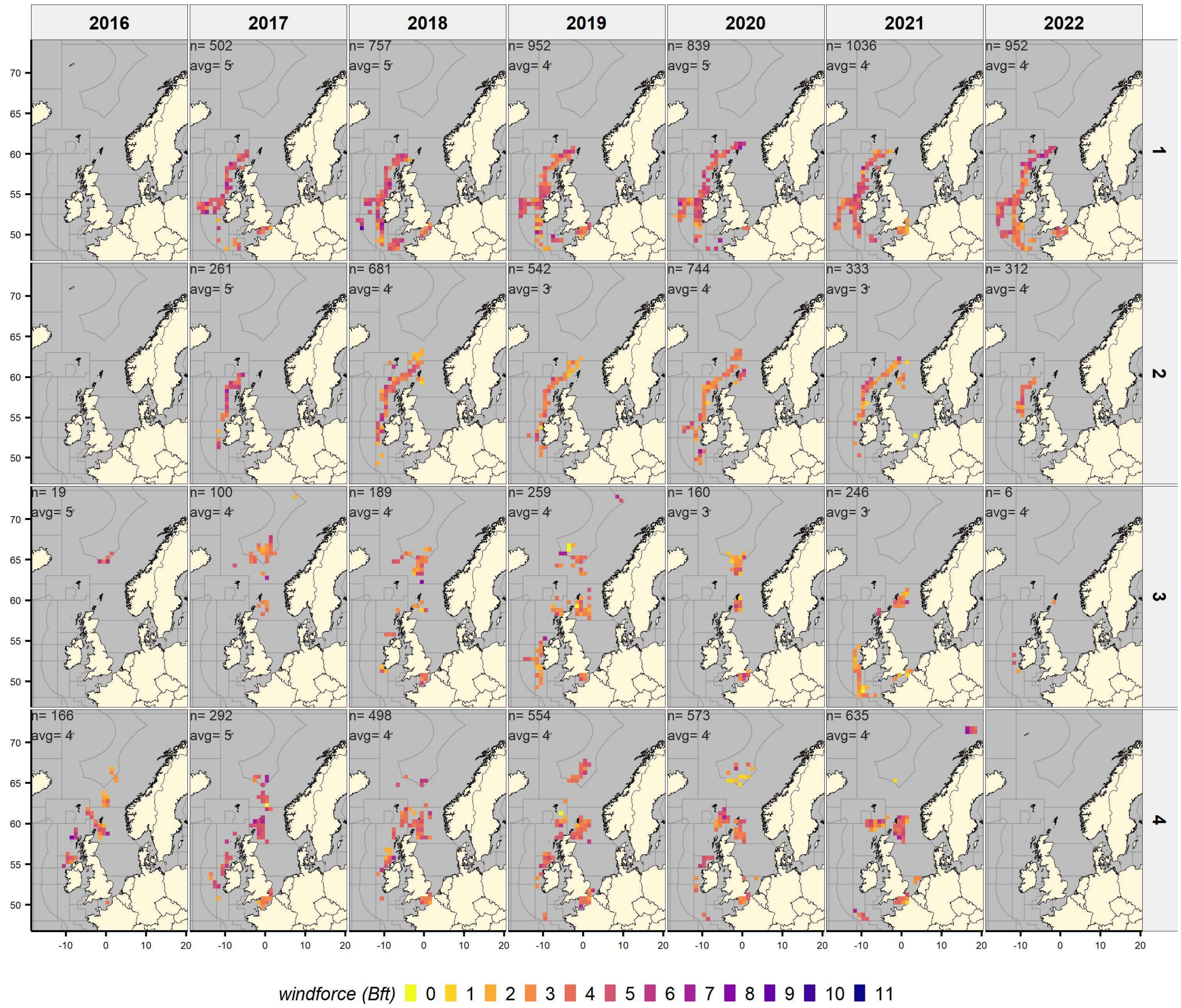

Figure 3.1.6: PFA fisheries for widely distributed species Average windforce (Bft) by year and quarter. N indicates the number of hauls. Avg refers to the average windforce.

3.2 Northeast Atlantic mackerel (MAC, Scomber scombrus)

Northeast Atlantic mackerel self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
mac	2016	9	30	213	395	32,894	154	6,964	0
mac	2017	11	48	386	690	62,715	162	11,614	0
mac	2018	16	56	501	841	55,186	110	13,700	32
mac	2019	15	72	615	1,105	53,525	87	17,894	476
mac	2020	17	84	712	1,258	83,876	118	31,381	646
mac	2021	18	78	606	1,054	68,466	113	11,294	684
mac	2022	14	40	296	538	26,515	90	6,591	3,733
(all)	(all)		408	3,329	5,881	383,176		99,438	5,571

Table 3.2.1: Northeast Atlantic mackerel. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Northeast Atlantic mackerel. Catch by division

species	division	2016	2017	2018	2019	2020	2021	2022*	all	perc
mac	27.2.a	7,381	12,967	4,803	204	706	9	0	26,069	6.8%
mac	27.4.a	15,291	17,325	28,511	24,293	50,545	44,514	11,715	192,194	50.2%
mac	27.6.a	8,678	28,288	18,071	21,298	15,847	21,989	9,854	124,025	32.4%
mac	27.7.b	186	3,640	1,111	5,386	6,044	1,094	4,539	21,999	5.7%
mac	27.7.j	1,359	496	2,689	2,345	10,734	861	406	18,889	4.9%
(all)	(all)	32,894	62,715	55,186	53,525	83,876	68,466	26,515	383,176	100.0%

Table 3.2.2: Northeast Atlantic mackerel. Self-sampling summary with the catch (tonnes) by year and division

Northeast Atlantic mackerel. Catch by month

species	month	2016	2017	2018	2019	2020	2021	2022*	all	perc
mac	Jan	7,848	18,550	11,546	18,715	20,750	14,806	12,735	104,950	27.4%
mac	Feb	1,189	8,199	7,297	11,862	19,376	5,678	6,942	60,544	15.8%
mac	Mar	139	4,469	1,292	4,374	5,114	2,840	6,613	24,841	6.5%
mac	Apr	701	955	1,226	1,326	604	366	98	5,276	1.4%
mac	May	30	288	192	489	1,239	97	71	2,406	0.6%
mac	Jun	124	0	60	96	173	35	0	489	0.1%
mac	Jul	192	89	0	262	83	907	55	1,588	0.4%
mac	Aug	120	237	59	431	296	360	0	1,503	0.4%
mac	Sep	943	9,096	4,779	3,039	6,284	2,624	0	26,765	7.0%
mac	Oct	13,857	7,866	19,437	11,457	20,161	30,743	0	103,521	27.0%
mac	Nov	7,625	11,595	8,934	1,473	9,461	10,009	0	49,097	12.8%
mac	Dec	128	1,370	363	0	334	0	0	2,195	0.6%
(all)	(all)	32,894	62,715	55,186	53,525	83,876	68,466	26,515	383,176	100.0%

Table 3.2.3: Northeast Atlantic mackerel. Self-sampling summary with the catch (tonnes) by year and month

Northeast Atlantic mackerel. Catch by country

species	flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
mac	DEU	6,127	6,934	9,760	8,735	22,795	10,305	7,859	72,515	18.9%
mac	FR	0	0	8,096	8,962	6,375	7,086	2,997	33,516	8.7%
mac	LIT	0	0	0	0	827	6,876	0	7,704	2.0%
mac	NL	16,107	29,171	12,670	14,885	27,424	20,674	5,035	125,966	32.9%
mac	POL	0	0	4,051	3,601	5,502	1,771	0	14,926	3.9%
mac	UK	10,660	26,610	20,608	17,341	20,952	19,704	10,815	126,691	33.0%
mac	NA	0	0	0	0	0	2,049	0	2,049	0.5%
(all)	(all)	32,894	62,715	55,186	53,525	83,876	68,466	26,707	383,368	100.0%

Table 3.2.4: Northeast Atlantic mackerel. Self-sampling summary with the catch (tonnes) by year and country

Northeast Atlantic mackerel. Catch by rectangle

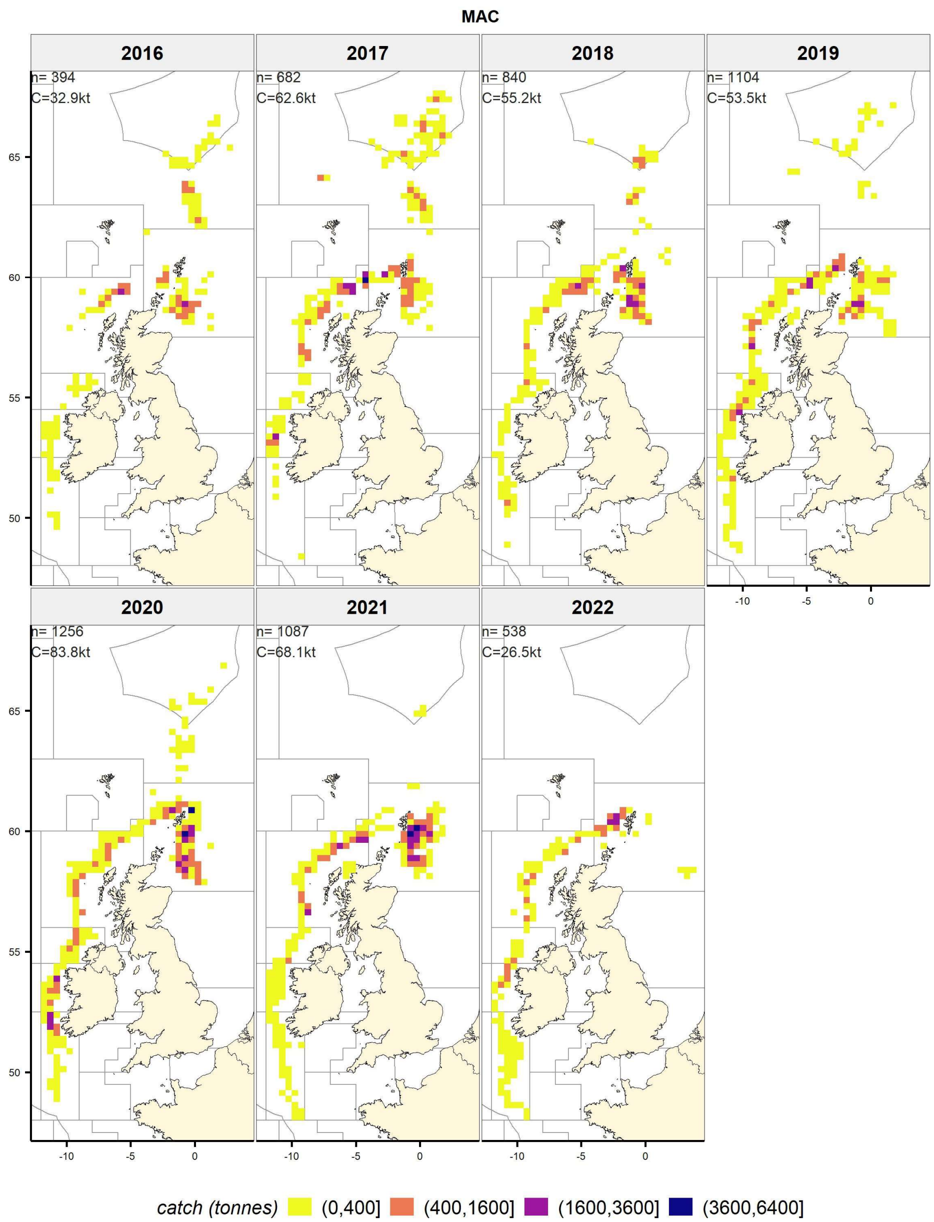

Figure 3.2.1: Northeast Atlantic mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Northeast Atlantic mackerel. Catchrate (ton/day) by rectangle

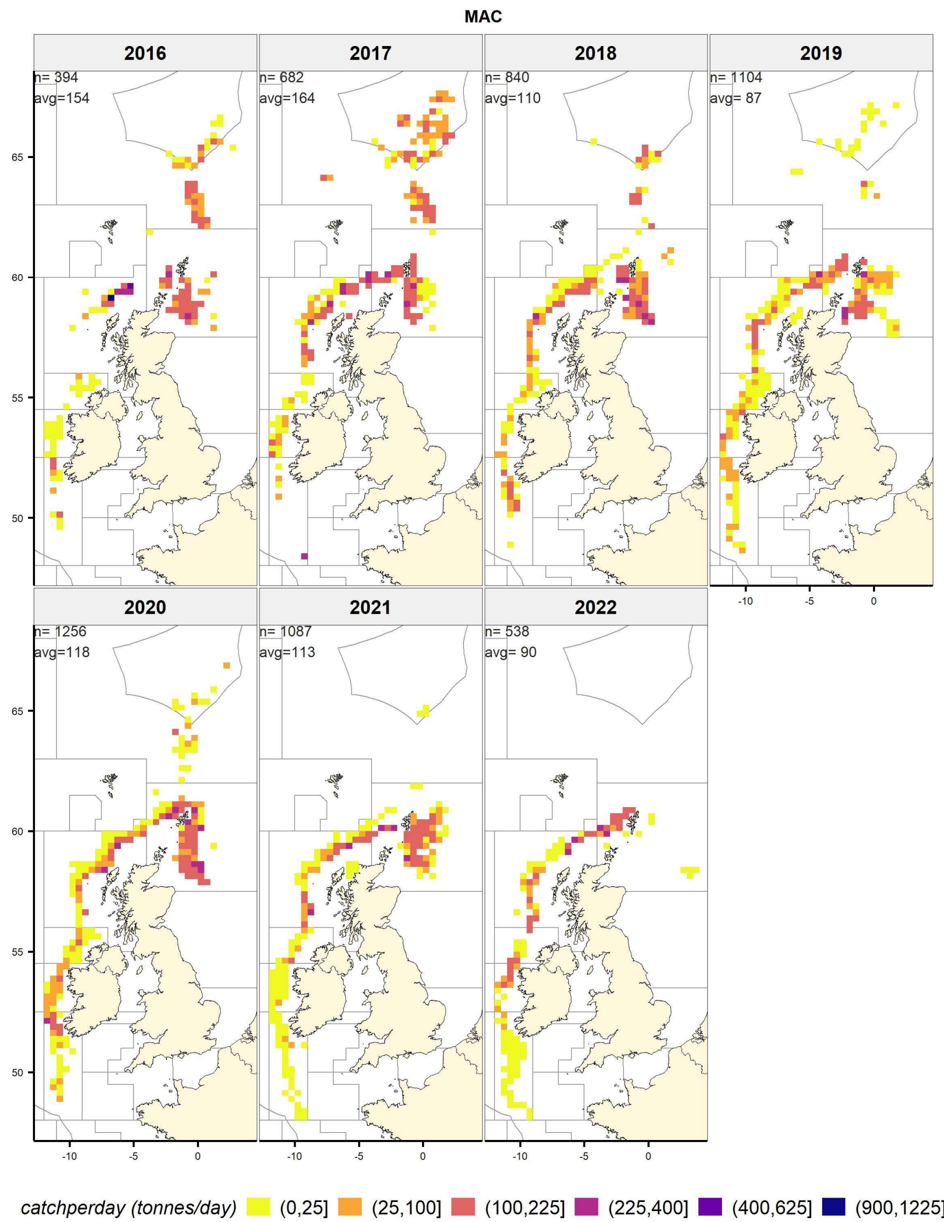

Figure 3.2.2: Northeast Atlantic mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Northeast Atlantic mackerel. Spatio-temporal evolution of catch by month and rectangle

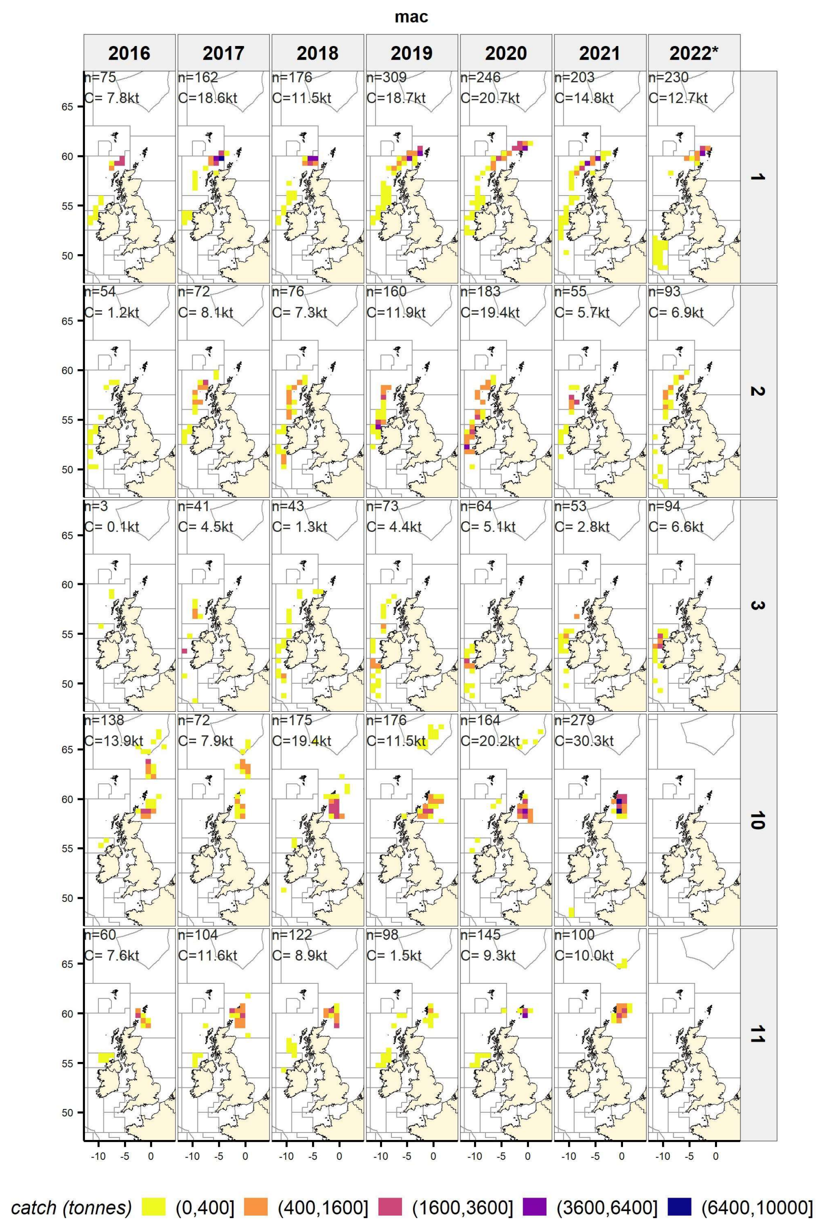

Figure 3.2.3: Northeast Atlantic mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Northeast Atlantic mackerel. Catch proportion at depth

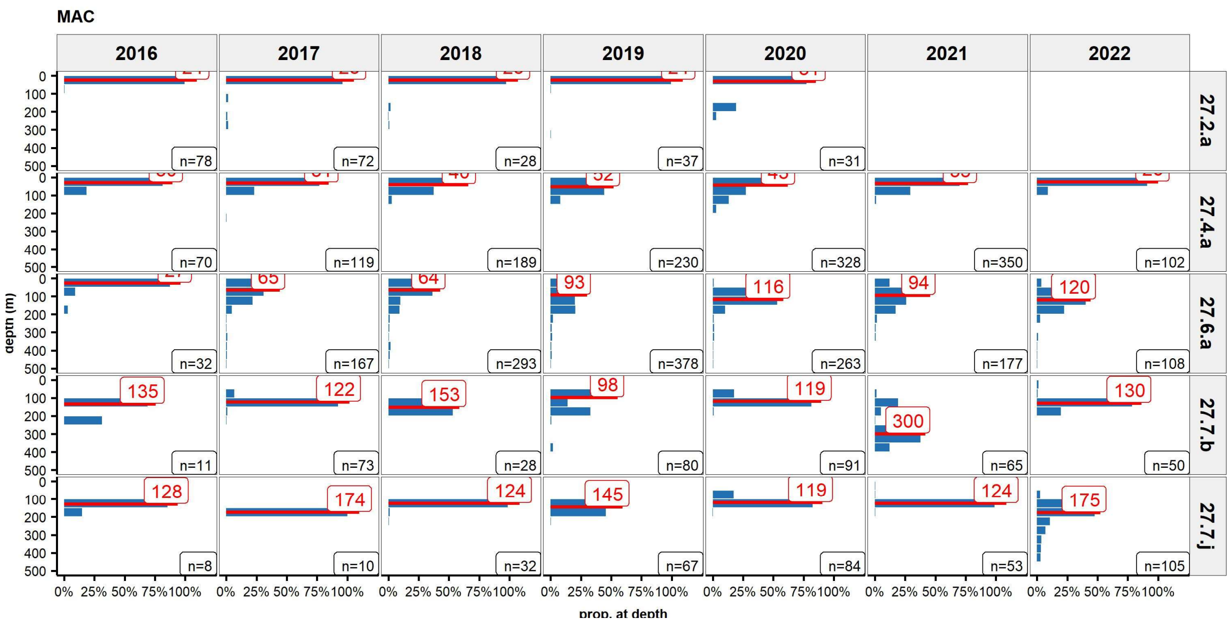

Figure 3.2.4: Northeast Atlantic mackerel. Catch proportion at depth. N indicates the number of hauls.

Northeast Atlantic mackerel. Length distributions of the catch

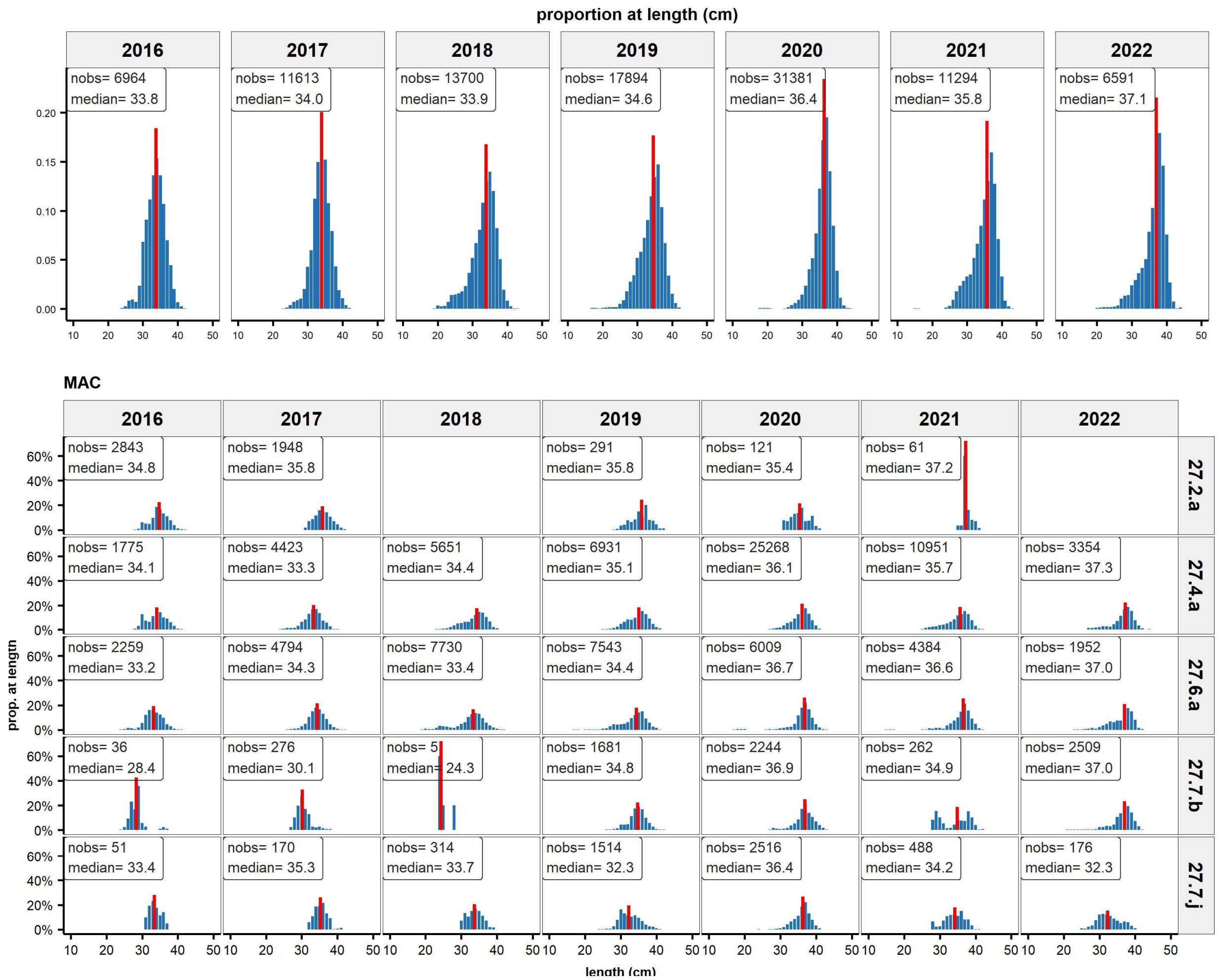

Figure 3.2.5: Northeast Atlantic mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Northeast Atlantic mackerel. Length distributions as proportions by (large) rectangle

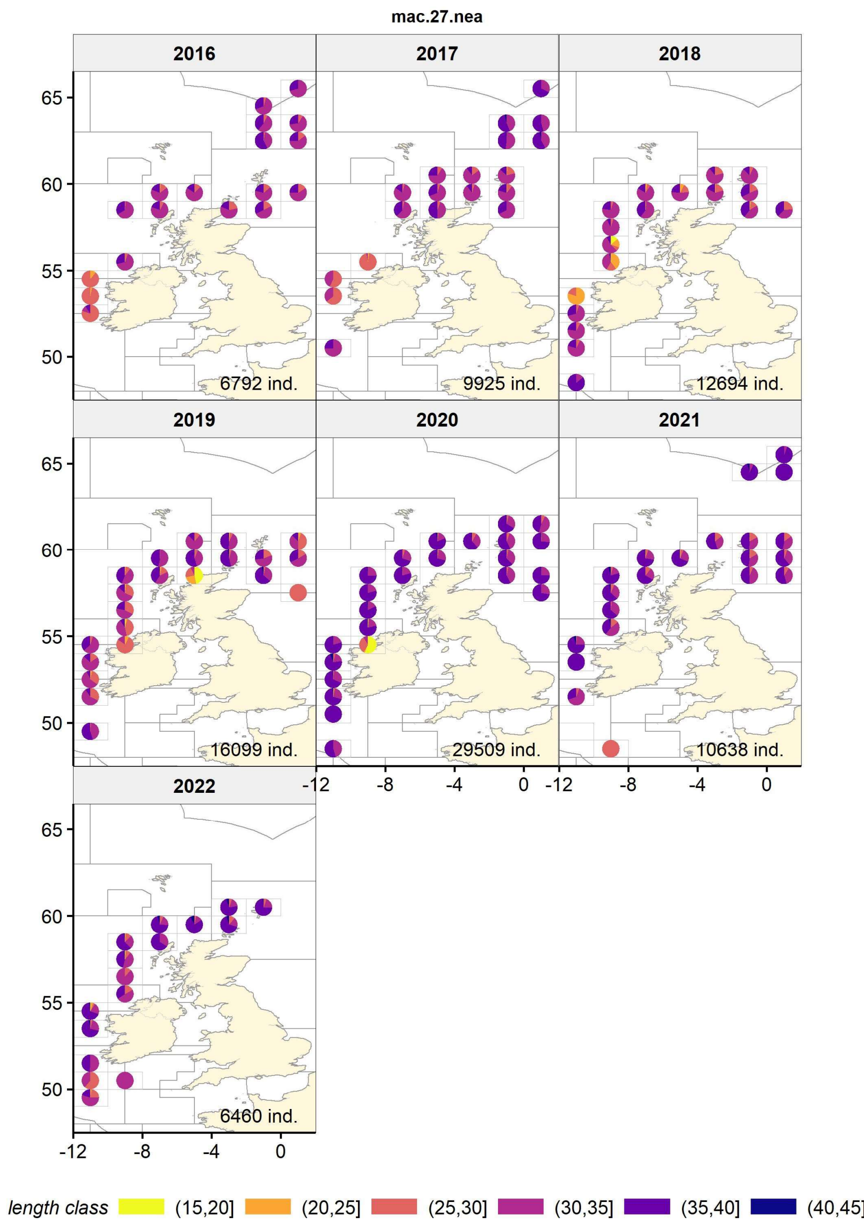

Figure 3.2.6: Northeast Atlantic mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Northeast Atlantic mackerel. Average length, weight and fat content by year and month

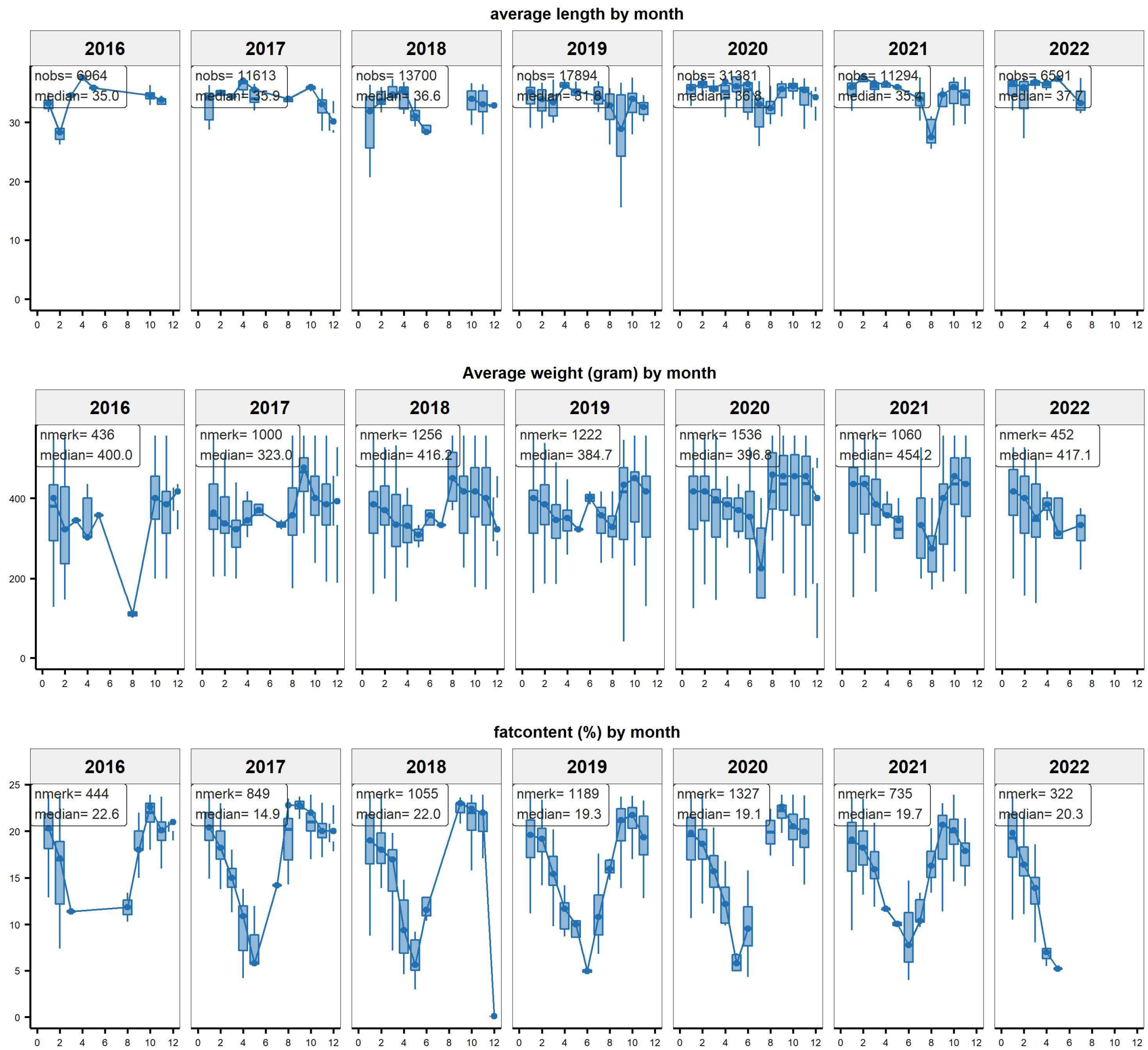

Figure 3.2.7: Northeast Atlantic mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Northeast Atlantic mackerel (MAC). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

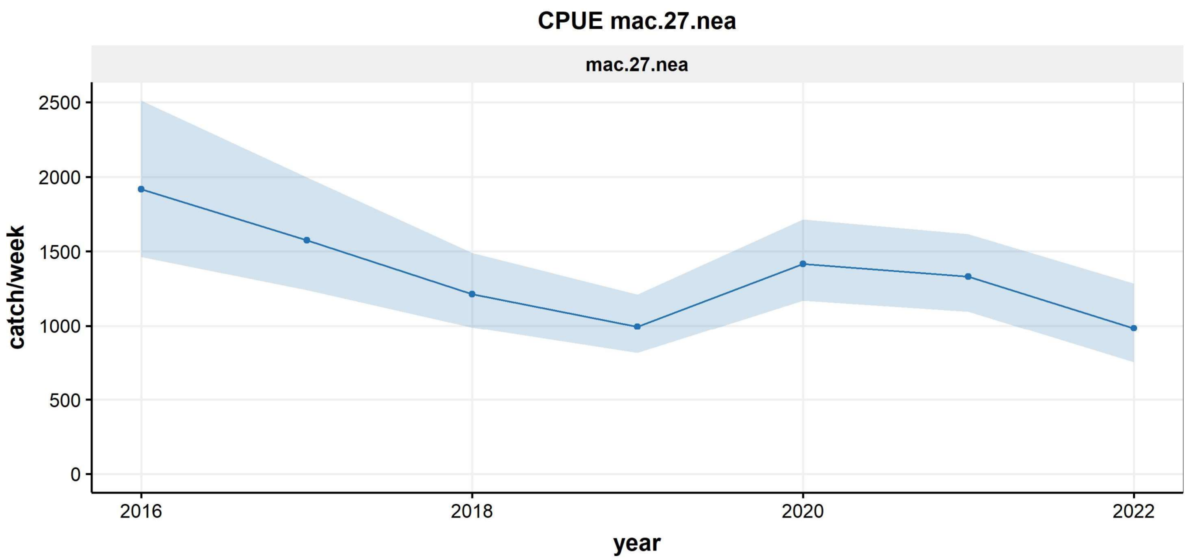

Figure 3.2.8: Northeast Atlantic mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.3 Western horse mackerel (HOM, Trachurus trachurus)

Western horse mackerel self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
hom	2016	7	21	171	314	13,382	78	11,154	0
hom	2017	10	25	161	304	11,578	72	8,176	0
hom	2018	13	35	244	431	21,412	88	21,756	0
hom	2019	15	47	363	668	24,022	66	14,172	25
hom	2020	14	40	268	508	16,334	61	13,531	203
hom	2021	17	53	366	643	26,576	73	24,753	59
hom	2022	14	28	166	330	12,183	73	8,976	269
(all)	(all)		249	1,739	3,198	125,486		102,518	556

Table 3.3.1: Western horse mackerel. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Western horse mackerel. Catch by division

species	division	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	27.4.a	7	6	0	11	13	1,007	9	1,054	0.8%
hom	27.6.a	4,751	5,343	12,067	13,849	5,901	1,564	552	44,027	35.1%
hom	27.7.b	4,313	4,741	2,250	4,176	5,226	4,743	335	25,784	20.5%
hom	27.7.h	1,297	1,329	6,282	984	55	8,551	197	18,695	14.9%
hom	27.7.j	3,015	159	813	5,002	5,138	10,712	11,089	35,927	28.6%
(all)	(all)	13,382	11,578	21,412	24,022	16,334	26,576	12,183	125,486	100.0%

Table 3.3.2: Western horse mackerel. Self-sampling summary with the catch (tonnes) by year and division

Western horse mackerel. Catch by month

species	month	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	Jan	3,350	6,666	10,627	9,610	7,017	4,894	10,232	52,397	41.8%
hom	Feb	5,361	3,052	5,392	3,257	4,774	6,634	1,264	29,734	23.7%
hom	Mar	60	212	3,027	1,284	1,237	245	413	6,478	5.2%
hom	Apr	174	0	31	45	0	6	0	257	0.2%
hom	May	176	156	7	42	529	2	0	911	0.7%
hom	Jun	2	0	227	1,357	642	0	0	2,228	1.8%
hom	Jul	1,728	112	15	5,342	420	5,809	274	13,699	10.9%
hom	Aug	0	0	0	8	0	1,005	0	1,013	0.8%
hom	Sep	0	0	429	335	0	4,300	0	5,065	4.0%
hom	Oct	27	15	126	259	1	831	0	1,259	1.0%
hom	Nov	1,608	1,262	1,410	2,483	1,713	2,629	0	11,105	8.8%
hom	Dec	896	103	120	0	0	221	0	1,340	1.1%
(all)	(all)	13,382	11,578	21,412	24,022	16,334	26,576	12,183	125,486	100.0%

Table 3.3.3: Western horse mackerel. Self-sampling summary with the catch (tonnes) by year and month

Western horse mackerel. Catch by country

species	flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	DEU	3,710	1,803	4,069	2,602	977	4,155	725	18,042	14.4%
hom	FR	0	0	622	864	1,370	788	1,400	5,043	4.0%
hom	NL	9,211	9,239	14,617	18,011	11,535	18,234	9,605	90,452	72.1%
hom	POL	0	0	0	4	1,005	1,210	0	2,219	1.8%
hom	UK	461	535	2,104	2,541	1,447	2,014	452	9,555	7.6%
hom	NA	0	0	0	0	0	175	0	175	0.1%
(all)	(all)	13,382	11,578	21,412	24,022	16,334	26,576	12,183	125,486	100.0%

Table 3.3.4: Western horse mackerel. Self-sampling summary with the catch (tonnes) by year and country

Western horse mackerel. Catch by rectangle

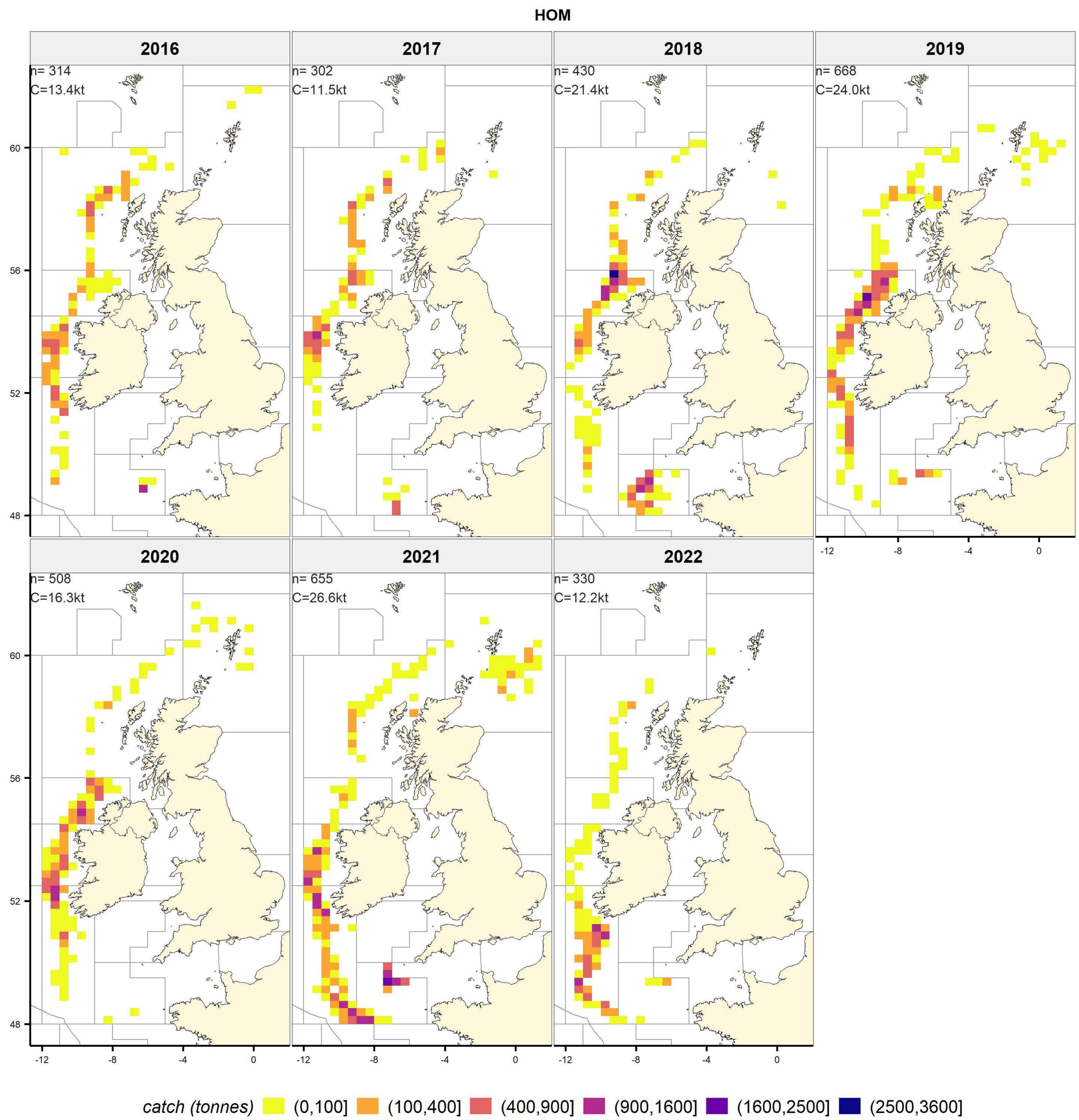

Figure 3.3.1: Western horse mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Western horse mackerel. Catchrate (ton/day) by rectangle

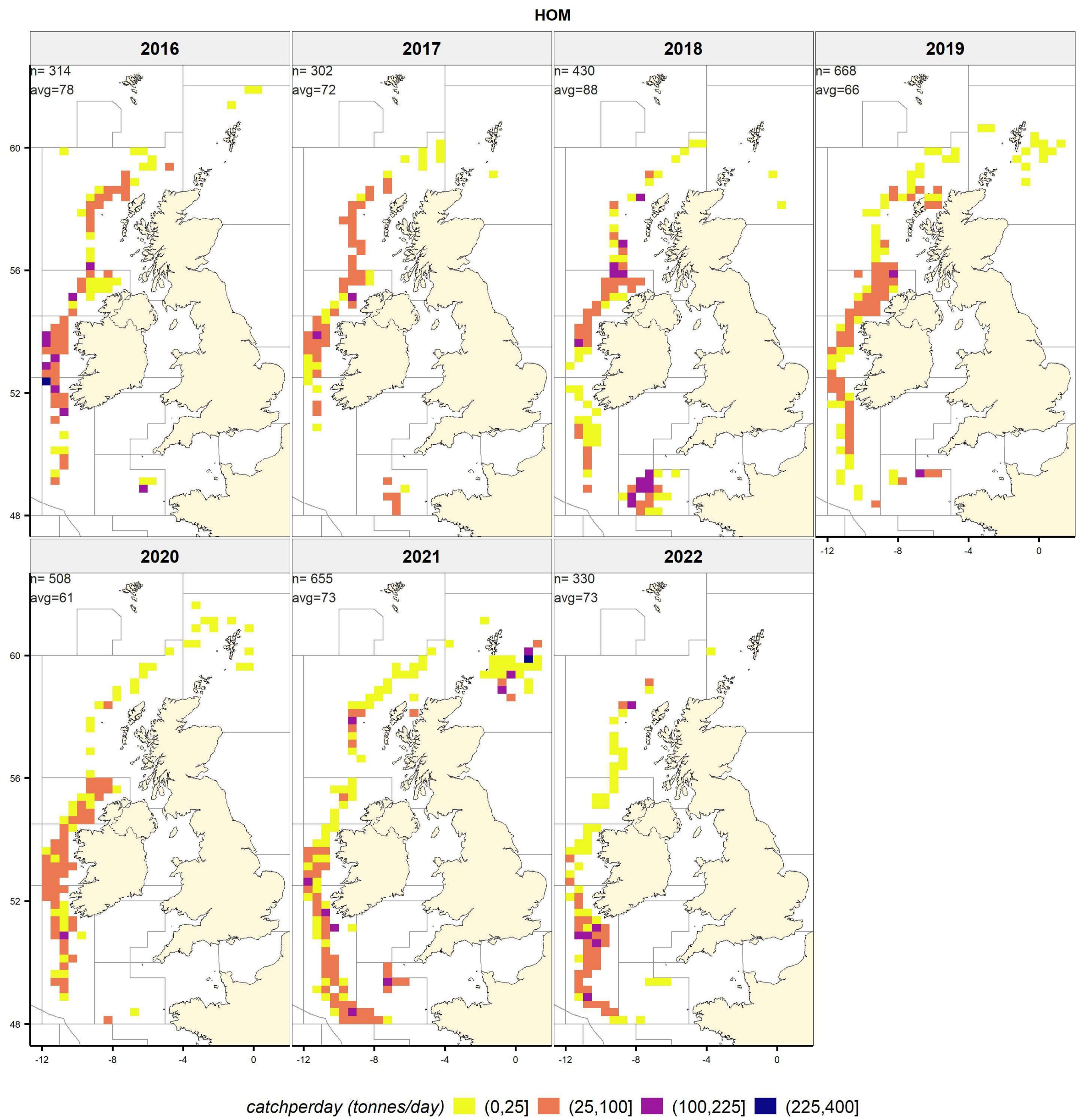

Figure 3.3.2: Western horse mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Western horse mackerel. Spatio-temporal evolution of catch by month and rectangle

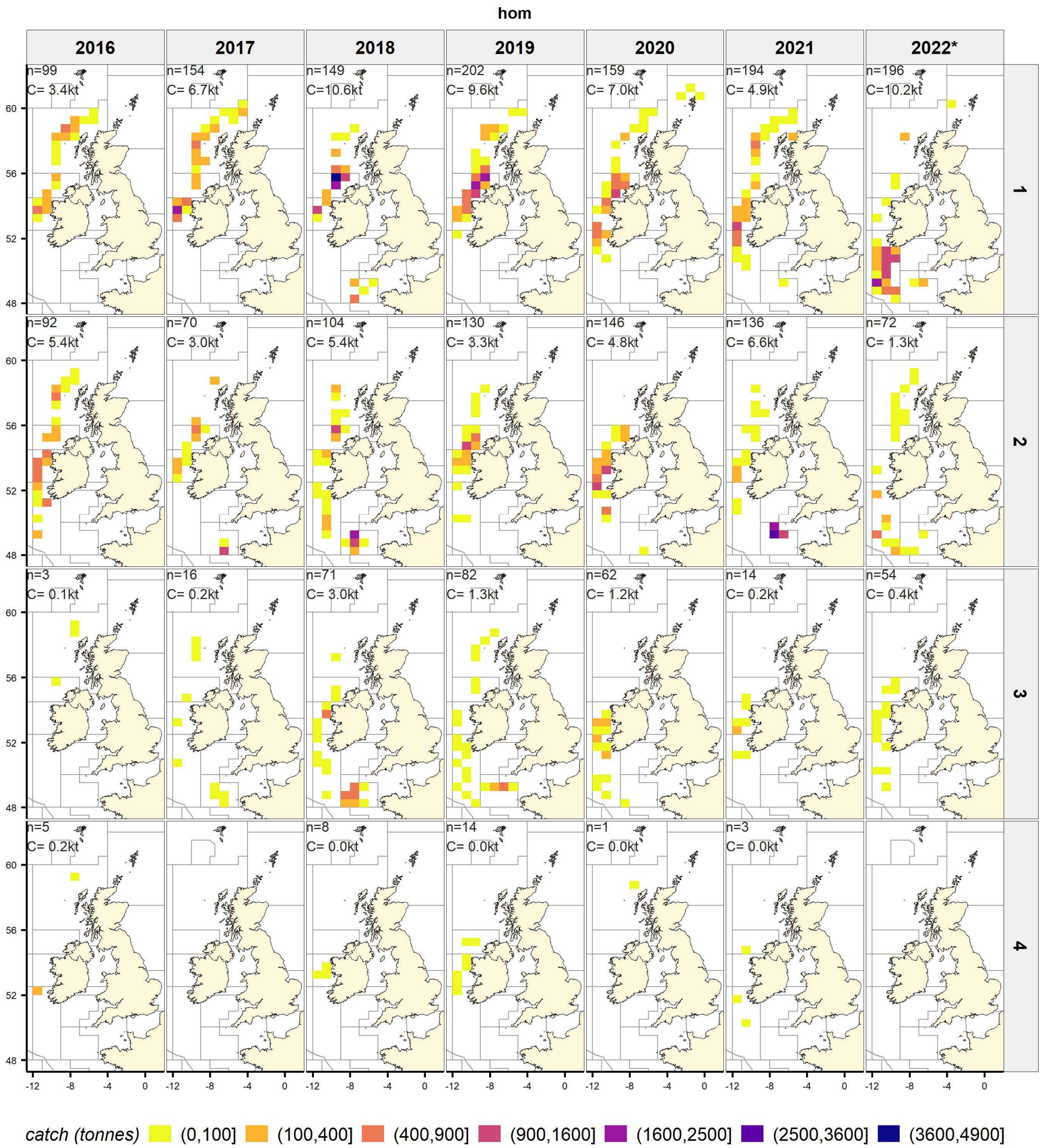

Figure 3.3.3: Western horse mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Western horse mackerel. Catch proportion at depth

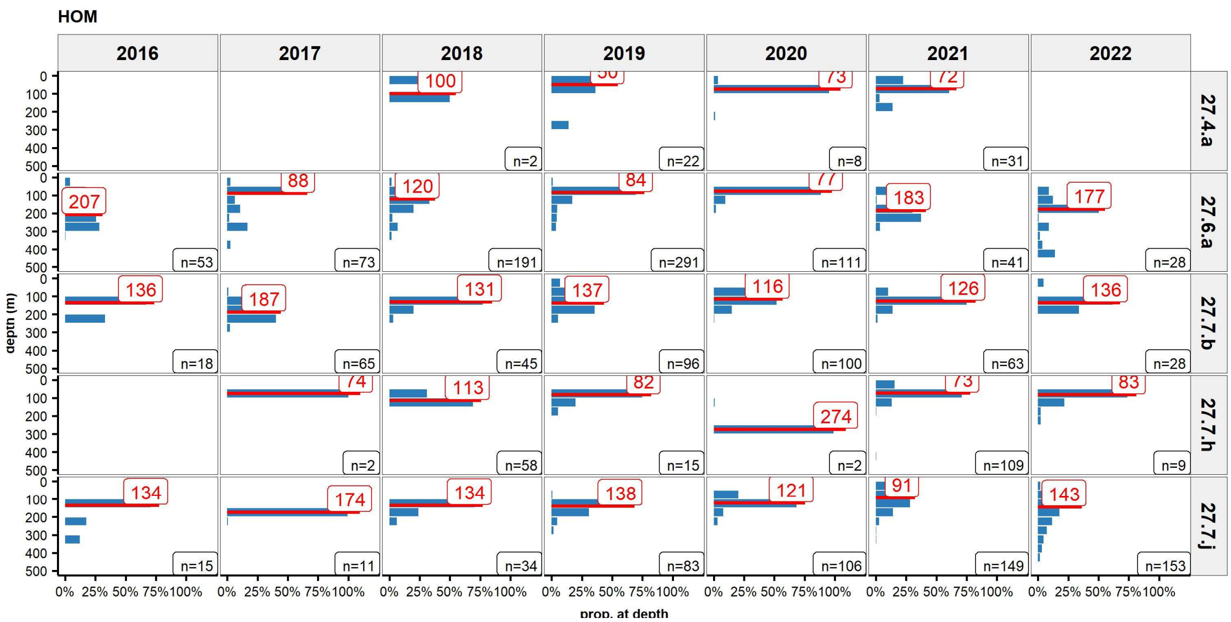

Figure 3.3.4: Western horse mackerel. Catch proportion at depth. N indicates the number of hauls.

Western horse mackerel. Length distributions of the catch

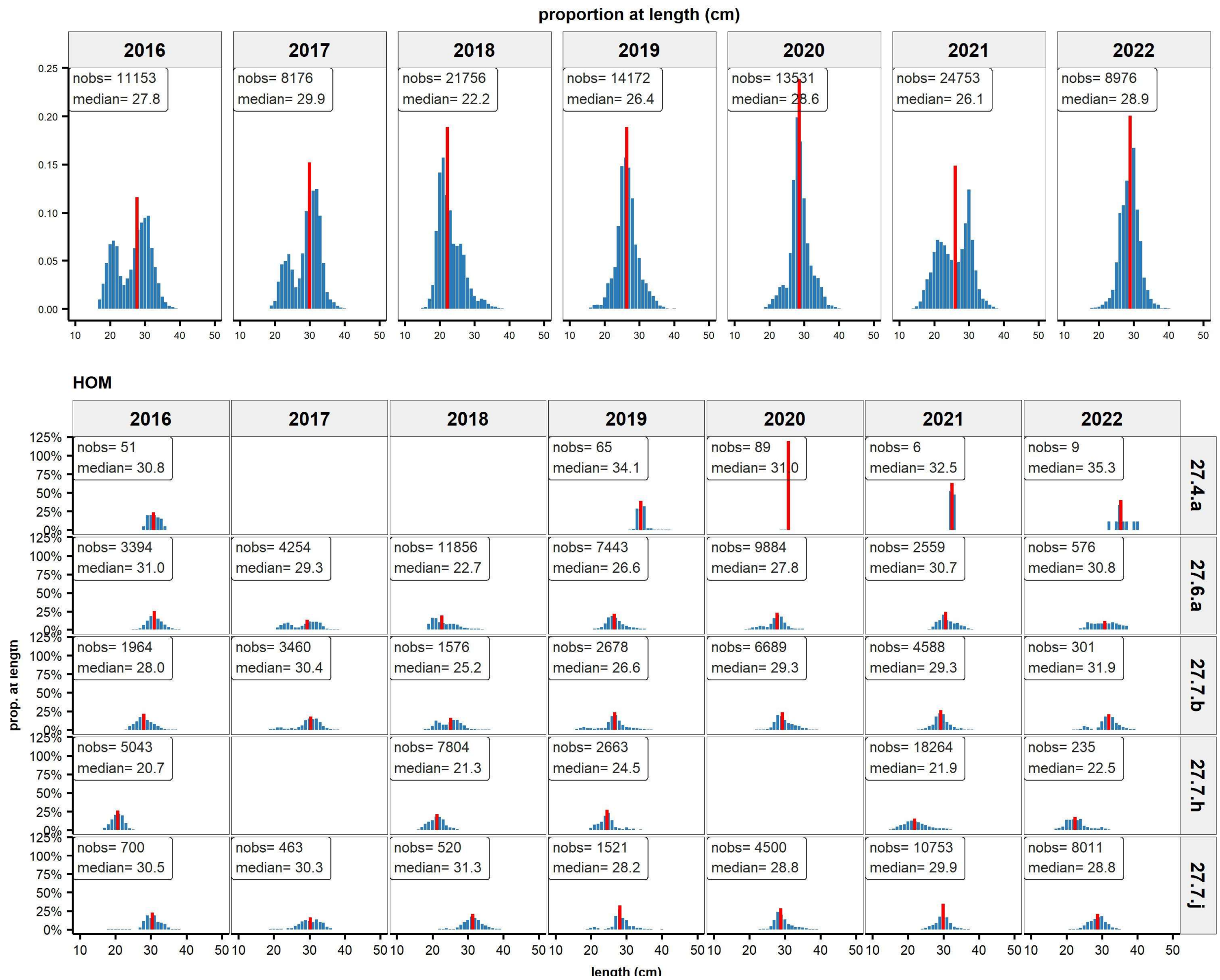

Figure 3.3.5: Western horse mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Western horse mackerel. Length distributions as proportions by (large) rectangle

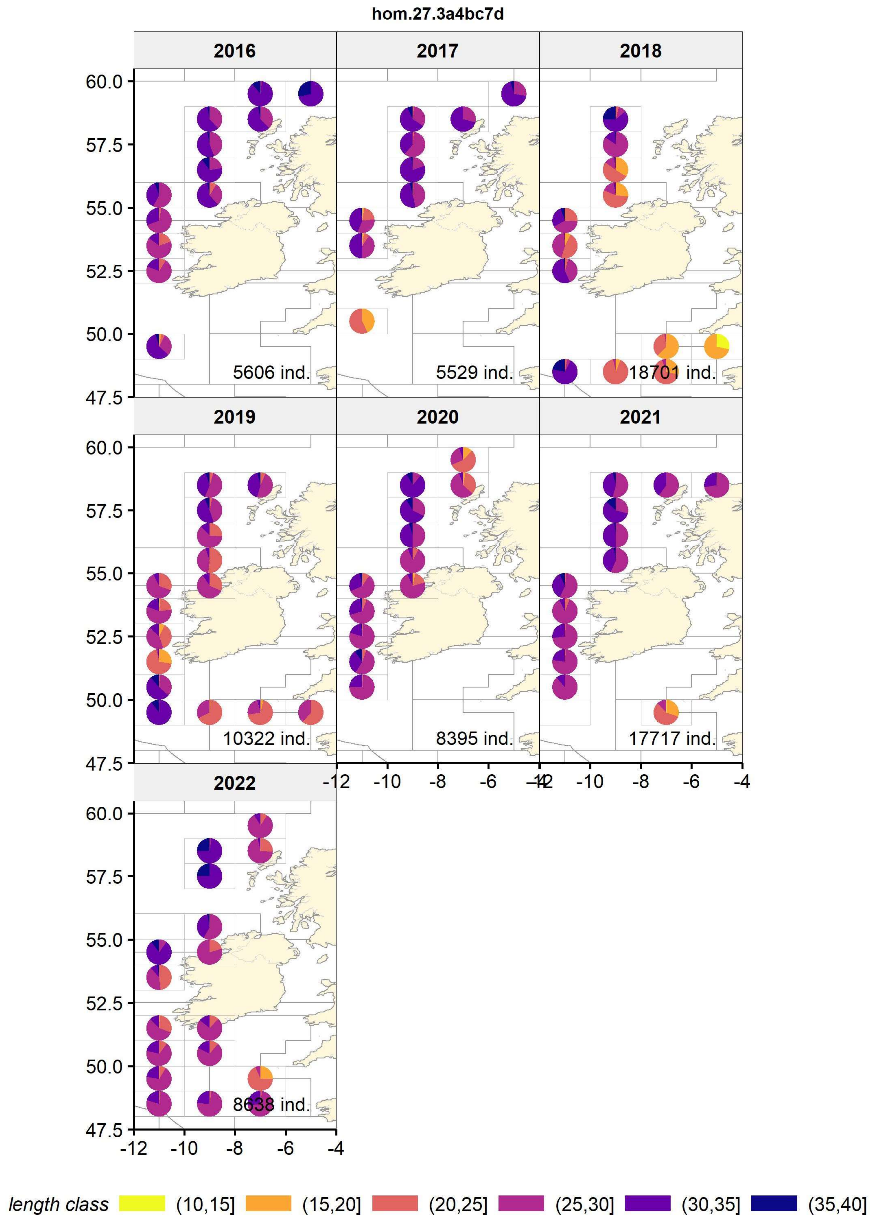

Figure 3.3.6: Western horse mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Western horse mackerel. Average length, weight and fat content by year and month

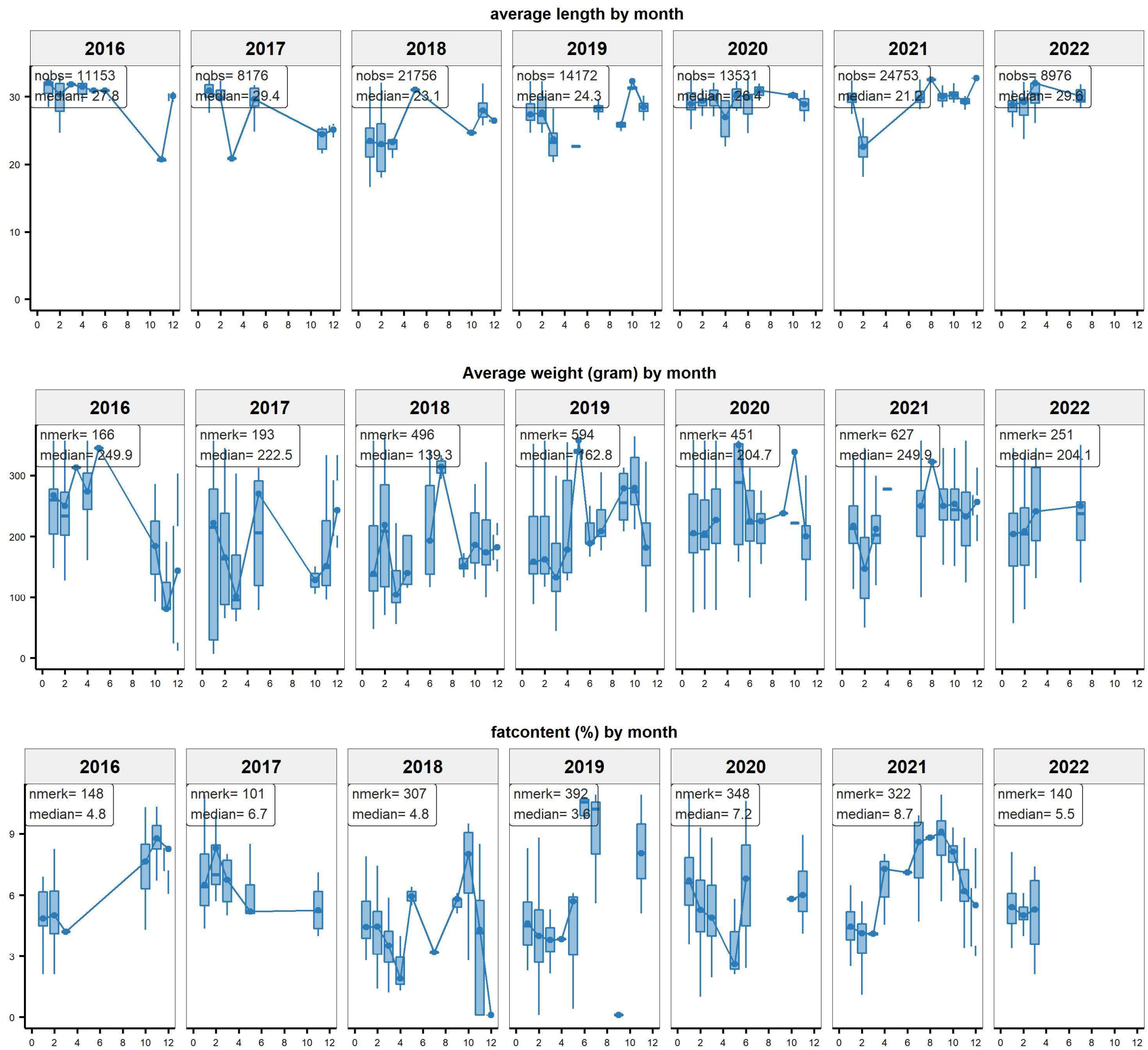

Figure 3.3.7: Western horse mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Western horse mackerel (HOM). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

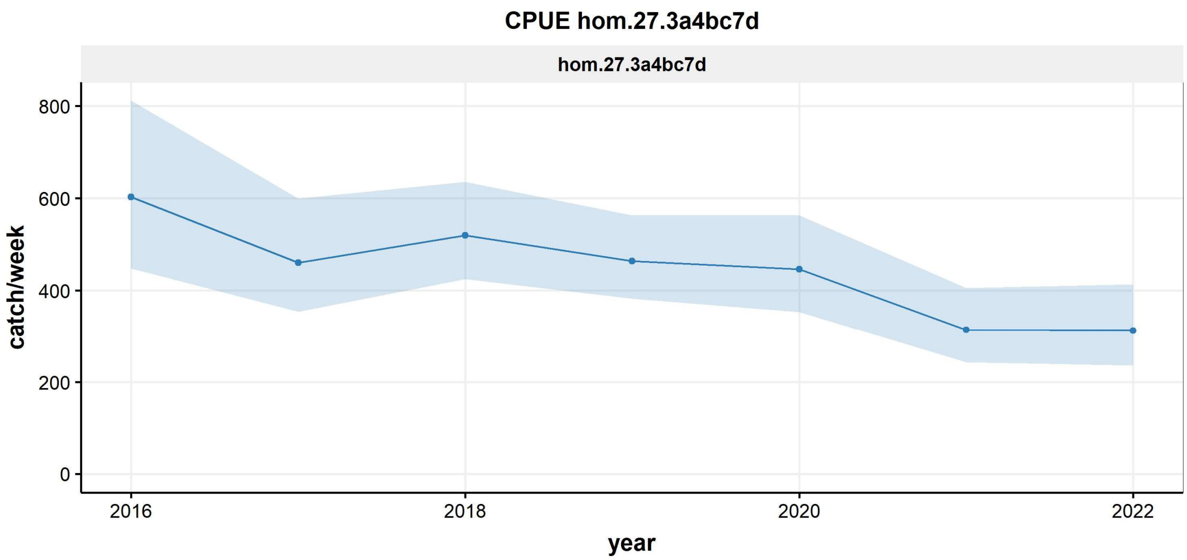

Figure 3.3.8: Western horse mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.4 North Sea horse mackerel (HOM, Trachurus trachurus)

North Sea horse mackerel self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
hom	2016	5	16	77	130	6,359	83	6,313	0
hom	2017	6	14	81	156	8,568	106	1,013	0
hom	2018	5	13	80	146	7,079	88	4,349	0
hom	2019	8	14	78	143	7,417	95	9,448	0
hom	2020	7	21	94	150	8,726	93	10,685	829
hom	2021	8	22	94	153	7,259	77	6,320	0
hom	2022	5	9	17	22	914	54	855	0
(all)	(all)		109	521	900	46,322		38,983	829

Table 3.4.1: North Sea horse mackerel. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

North Sea horse mackerel. Catch by division

species	division	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	27.4.c	0	1,371	853	369	898	1,149	0	4,640	10.0%
hom	27.7.d	6,358	7,198	6,226	7,048	7,829	6,111	914	41,682	90.0%
(all)	(all)	6,359	8,568	7,079	7,417	8,726	7,259	914	46,322	100.0%

Table 3.4.2: North Sea horse mackerel. Self-sampling summary with the catch (tonnes) by year and division

North Sea horse mackerel. Catch by month

species	month	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	Jan	0	2,362	892	1,382	2	1,013	538	6,189	13.4%
hom	Feb	879	0	310	0	0	97	376	1,662	3.6%
hom	Mar	38	0	0	0	0	0	0	38	0.1%
hom	Jun	0	0	0	0	6	25	0	31	0.1%
hom	Jul	0	0	0	0	0	0	0	0	0.0%
hom	Aug	6	0	0	0	0	0	0	6	0.0%
hom	Sep	447	135	1,471	2,009	3,860	422	0	8,344	18.0%
hom	Oct	1,802	4,490	1,391	1,967	1,834	2,349	0	13,833	29.9%
hom	Nov	2,873	1,581	2,018	1,110	1,463	1,218	0	10,263	22.2%
hom	Dec	312	0	998	949	1,561	2,134	0	5,954	12.9%
(all)	(all)	6,359	8,568	7,079	7,417	8,726	7,259	914	46,322	100.0%

Table 3.4.3: North Sea horse mackerel. Self-sampling summary with the catch (tonnes) by year and month

North Sea horse mackerel. Catch by country

species	flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
hom	DEU	593	0	1,378	958	0	0	0	2,930	6.3%
hom	FR	0	0	422	400	238	202	0	1,261	2.7%
hom	LIT	0	0	0	1,373	0	0	0	1,373	3.0%
hom	NL	2,383	4,887	1,578	1,682	4,167	2,356	436	17,487	37.8%
hom	UK	3,383	3,682	3,701	3,004	4,322	3,674	478	22,243	48.0%
hom	NA	0	0	0	0	0	1,028	0	1,028	2.2%
(all)	(all)	6,359	8,568	7,079	7,417	8,726	7,259	914	46,322	100.0%

Table 3.4.4: North Sea horse mackerel. Self-sampling summary with the catch (tonnes) by year and country

North Sea horse mackerel. Catch by rectangle

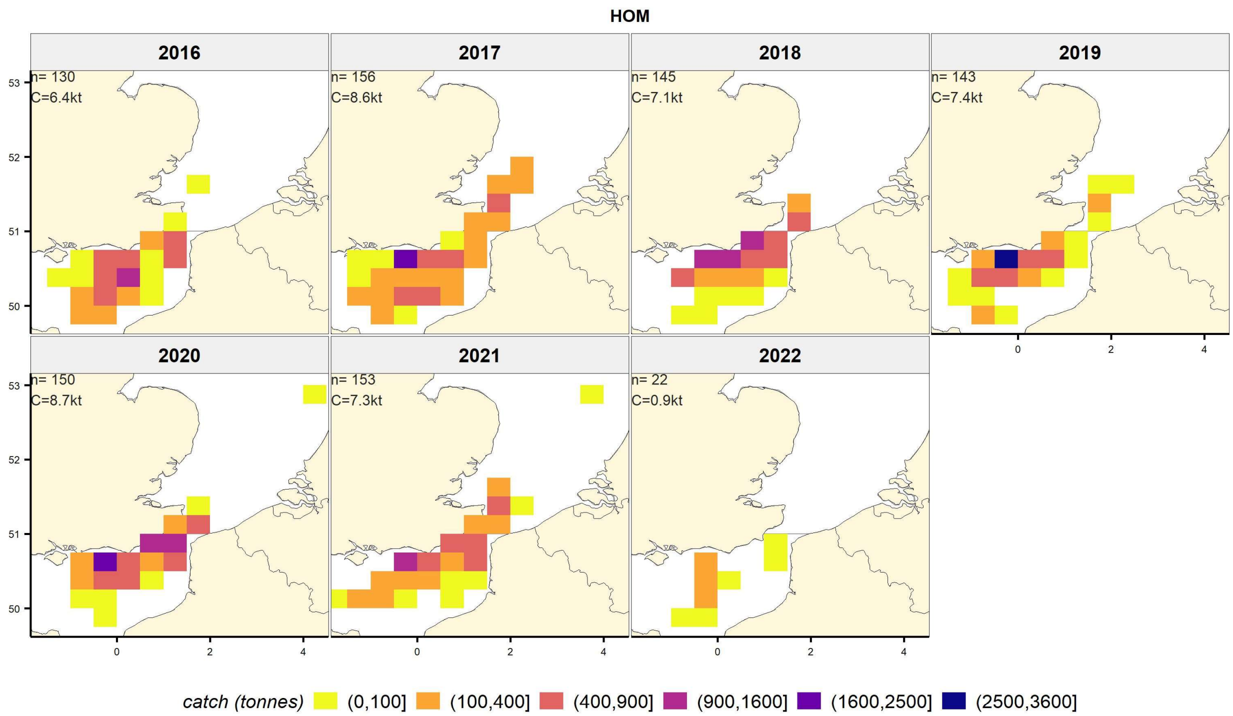

Figure 3.4.1: North Sea horse mackerel. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

North Sea horse mackerel. Catchrate (ton/day) by rectangle

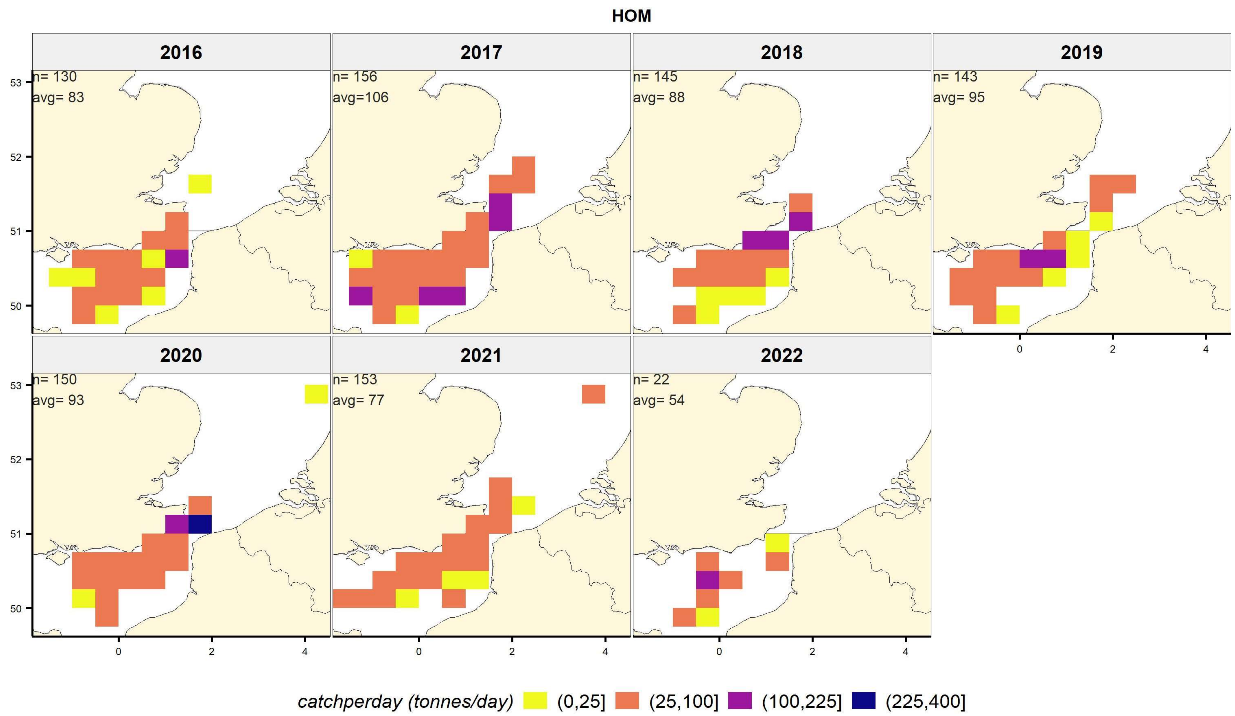

Figure 3.4.2: North Sea horse mackerel. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

North Sea horse mackerel. Spatio-temporal evolution of catch by month and rectangle

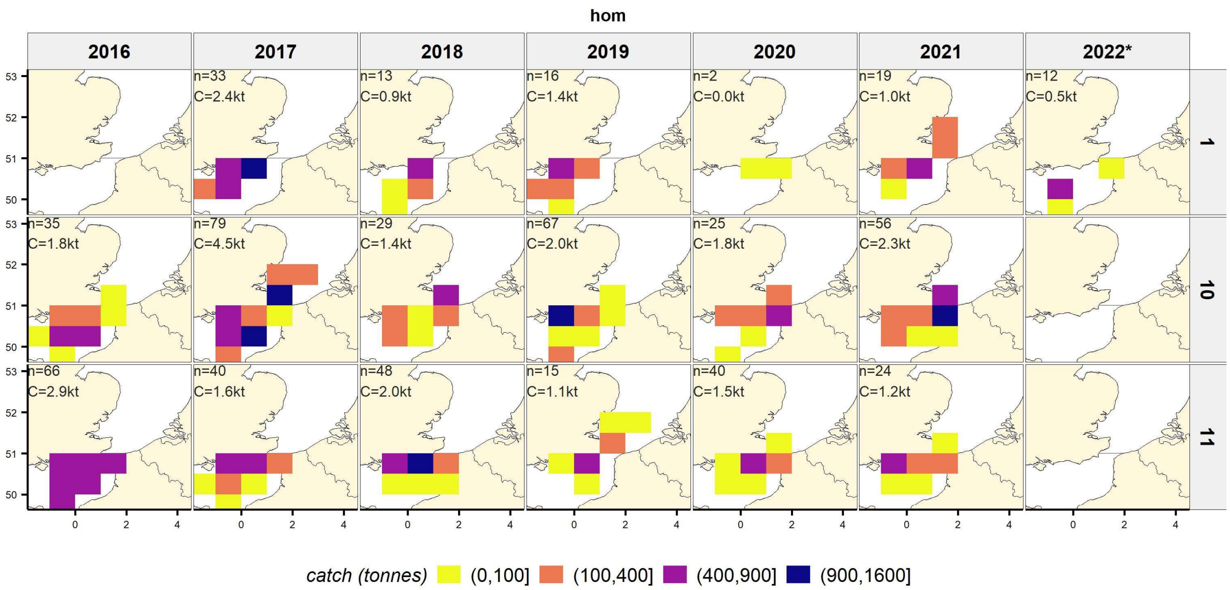

Figure 3.4.3: North Sea horse mackerel. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

North Sea horse mackerel. Catch proportion at depth

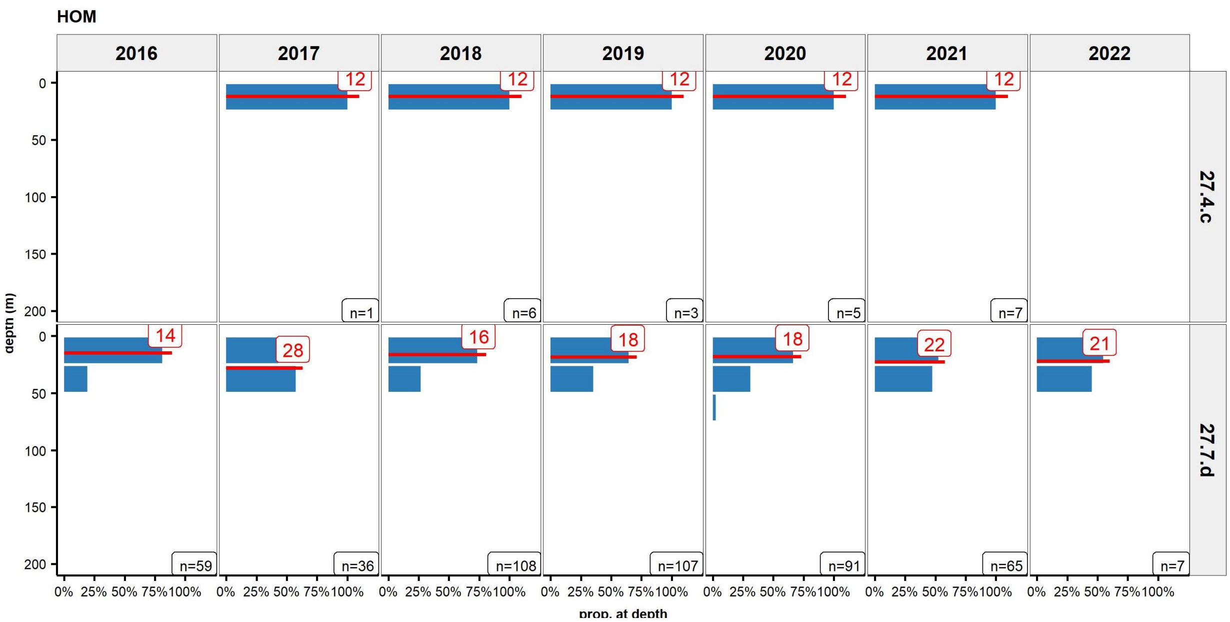

Figure 3.4.4: North Sea horse mackerel. Catch proportion at depth. N indicates the number of hauls.

North Sea horse mackerel. Length distributions of the catch

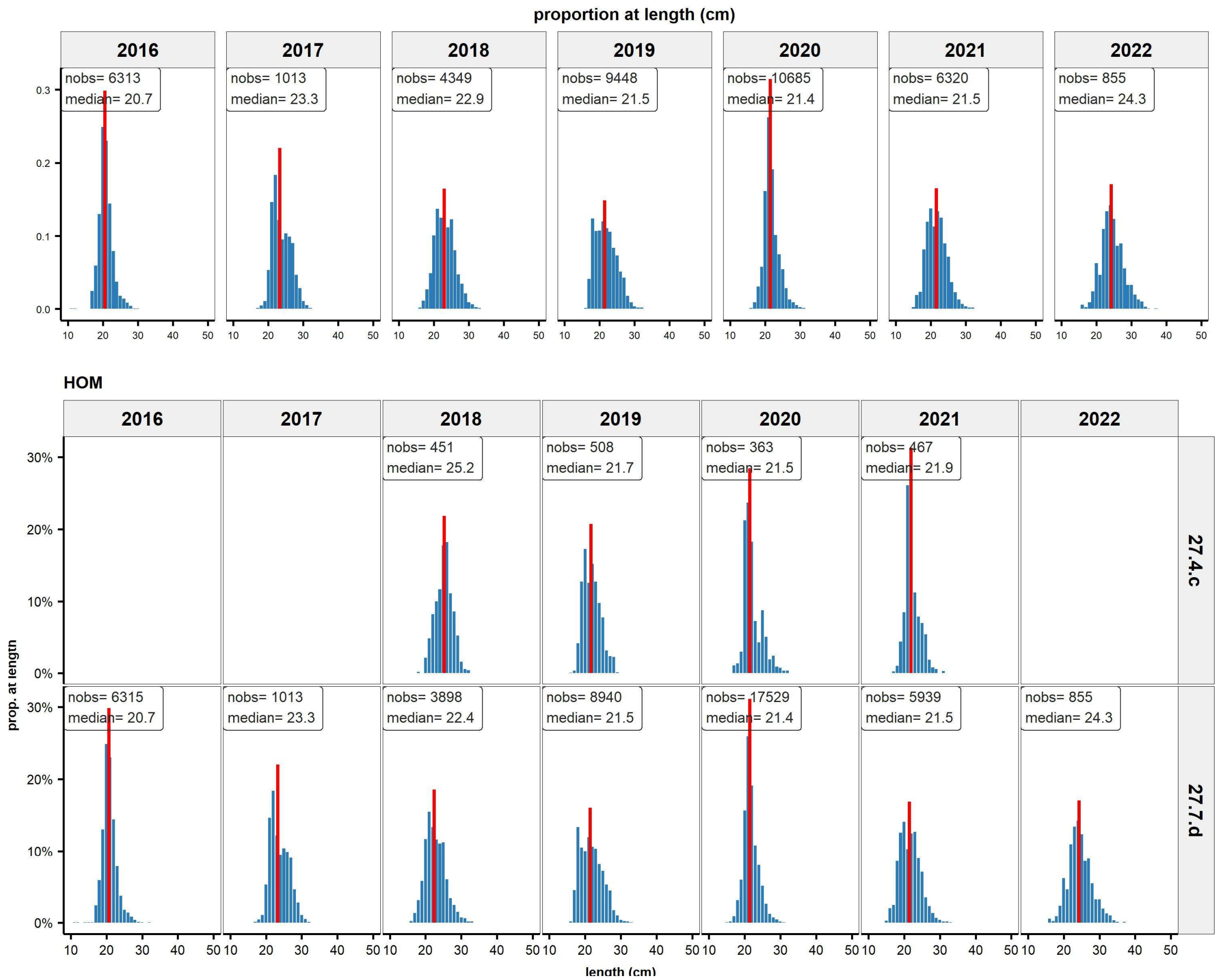

Figure 3.4.5: North Sea horse mackerel. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

North Sea horse mackerel. Length distributions as proportions by (large) rectangle

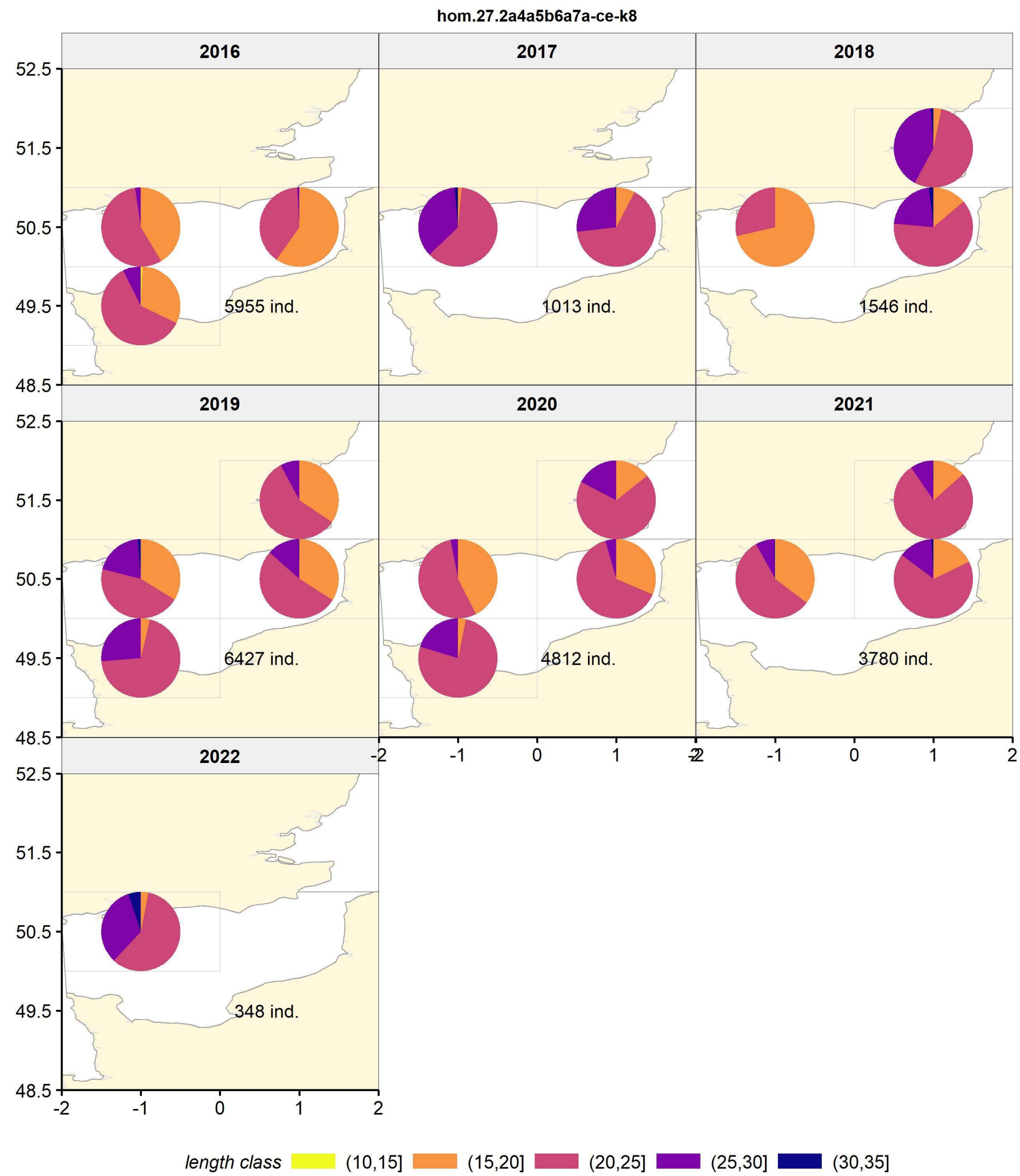

Figure 3.4.6: North Sea horse mackerel. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

North Sea horse mackerel. Average length, weight and fat content by year and month

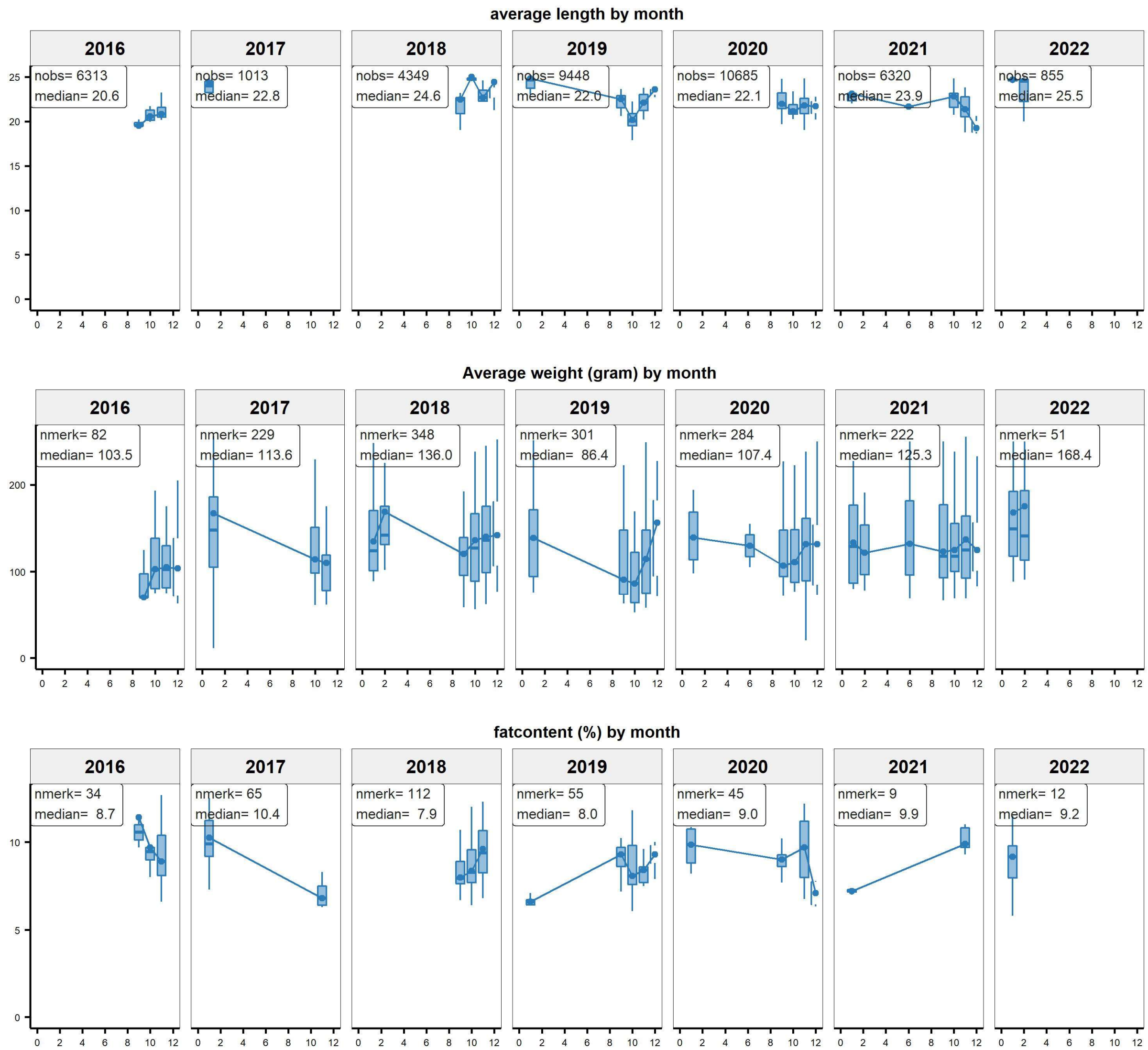

Figure 3.4.7: North Sea horse mackerel. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

North Sea horse mackerel (HOM). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

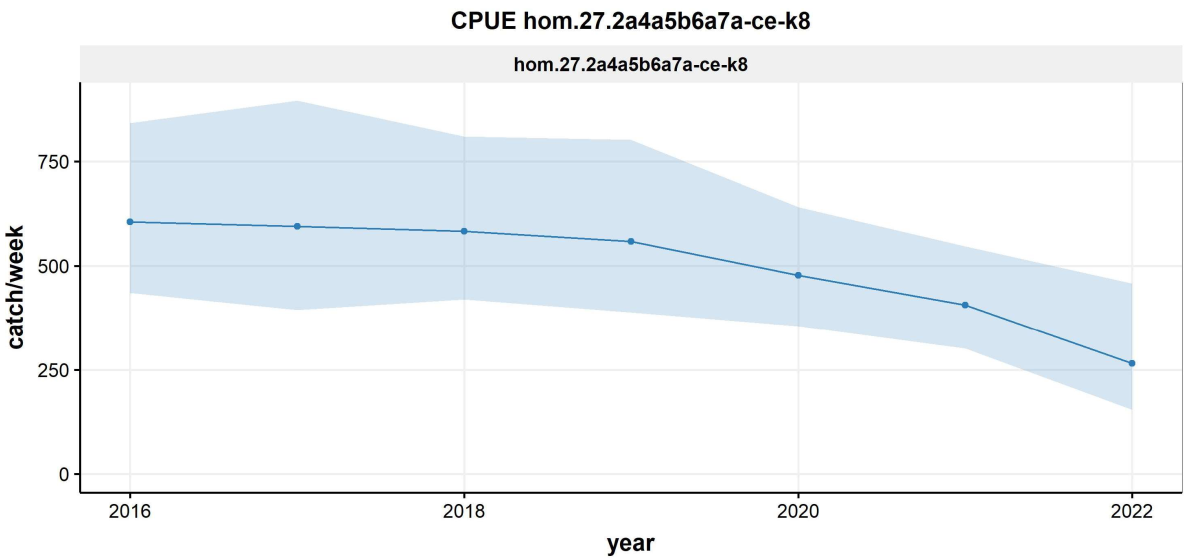

Figure 3.4.8: North Sea horse mackerel. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.5 Blue whiting (WHB, Micromesistius pouttasseu)

Blue whiting self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength	nbio
whb	2016	8	22	198	462	40,535	205	27,315	0
whb	2017	8	32	343	753	78,325	228	63,682	0
whb	2018	12	42	550	1,375	149,723	272	112,492	0
whb	2019	14	46	457	1,089	109,234	239	50,057	0
whb	2020	13	57	670	1,581	168,786	252	83,177	178
whb	2021	14	52	532	1,185	138,946	261	58,391	0
whb	2022	15	33	406	962	87,325	215	34,068	0
(all)	(all)		284	3,156	7,407	772,874		429,182	178

Table 3.5.1: Blue whiting. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Blue whiting. Catch by division

species	division	2016	2017	2018	2019	2020	2021	2022*	all	perc
whb	27.2.a	2,294	2,550	11,907	998	5,718	190	0	23,657	3.1%
whb	27.5.b	5,577	7,960	7,928	3,905	10,220	8,665	514	44,769	5.8%
whb	27.6.a	19,730	39,085	91,738	75,707	97,232	84,794	36,680	444,967	57.6%
whb	27.7.c	5,445	28,731	30,504	26,587	44,309	28,613	20,803	184,993	23.9%
whb	27.7.k	7,489	0	7,646	2,036	11,307	16,684	29,327	74,488	9.6%
(all)	(all)	40,535	78,325	149,723	109,234	168,786	138,946	87,325	772,874	100.0%

Table 3.5.2: Blue whiting. Self-sampling summary with the catch (tonnes) by year and division

Blue whiting. Catch by month

species	month	2016	2017	2018	2019	2020	2021	2022*	all	perc
whb	Jan	85	185	957	4,287	9,527	29,603	14,391	59,034	7.6%
whb	Feb	1,683	8,027	19,108	17,504	4,051	18,915	16,468	85,755	11.1%
whb	Mar	15,317	24,683	26,954	21,389	41,128	30,134	32,907	192,513	24.9%
whb	Apr	13,328	27,316	55,518	26,391	61,978	25,146	19,539	229,216	29.7%
whb	May	5,001	9,390	24,093	15,465	22,506	8,571	4,020	89,045	11.5%
whb	Jun	697	0	5,004	0	697	0	0	6,398	0.8%
whb	Jul	10	0	0	7	13	0	0	30	0.0%
whb	Aug	0	1,265	4,219	337	2,043	0	0	7,864	1.0%
whb	Sep	50	538	414	246	1,327	2	0	2,576	0.3%
whb	Oct	266	39	92	407	2,401	4	0	3,209	0.4%
whb	Nov	1,665	5,623	6,413	13,841	7,283	11,275	0	46,099	6.0%
whb	Dec	2,432	1,260	6,952	9,361	15,834	15,296	0	51,135	6.6%
(all)	(all)	40,535	78,325	149,723	109,234	168,786	138,946	87,325	772,874	100.0%

Table 3.5.3: Blue whiting. Self-sampling summary with the catch (tonnes) by year and month

Blue whiting. Catch by country

species	flag	2016	2017	2018	2019	2020	2021	2022*	all	perc
whb	DEU	13,545	15,914	35,831	23,479	39,647	33,190	16,635	178,240	23.1%
whb	FR	0	0	1,625	4,892	5,069	2,786	4,188	18,561	2.4%
whb	LIT	0	0	0	0	10,146	15,807	6,467	32,421	4.2%
whb	NL	26,940	59,027	98,499	53,538	60,454	52,365	41,147	391,969	50.7%
whb	POL	0	0	11,764	23,192	45,791	26,288	11,237	118,273	15.3%
whb	UK	50	3,385	2,004	4,133	7,678	8,510	7,650	33,410	4.3%
(all)	(all)	40,535	78,325	149,723	109,234	168,786	138,946	87,325	772,874	100.0%

Table 3.5.4: Blue whiting. Self-sampling summary with the catch (tonnes) by year and country

Blue whiting. Catch by rectangle

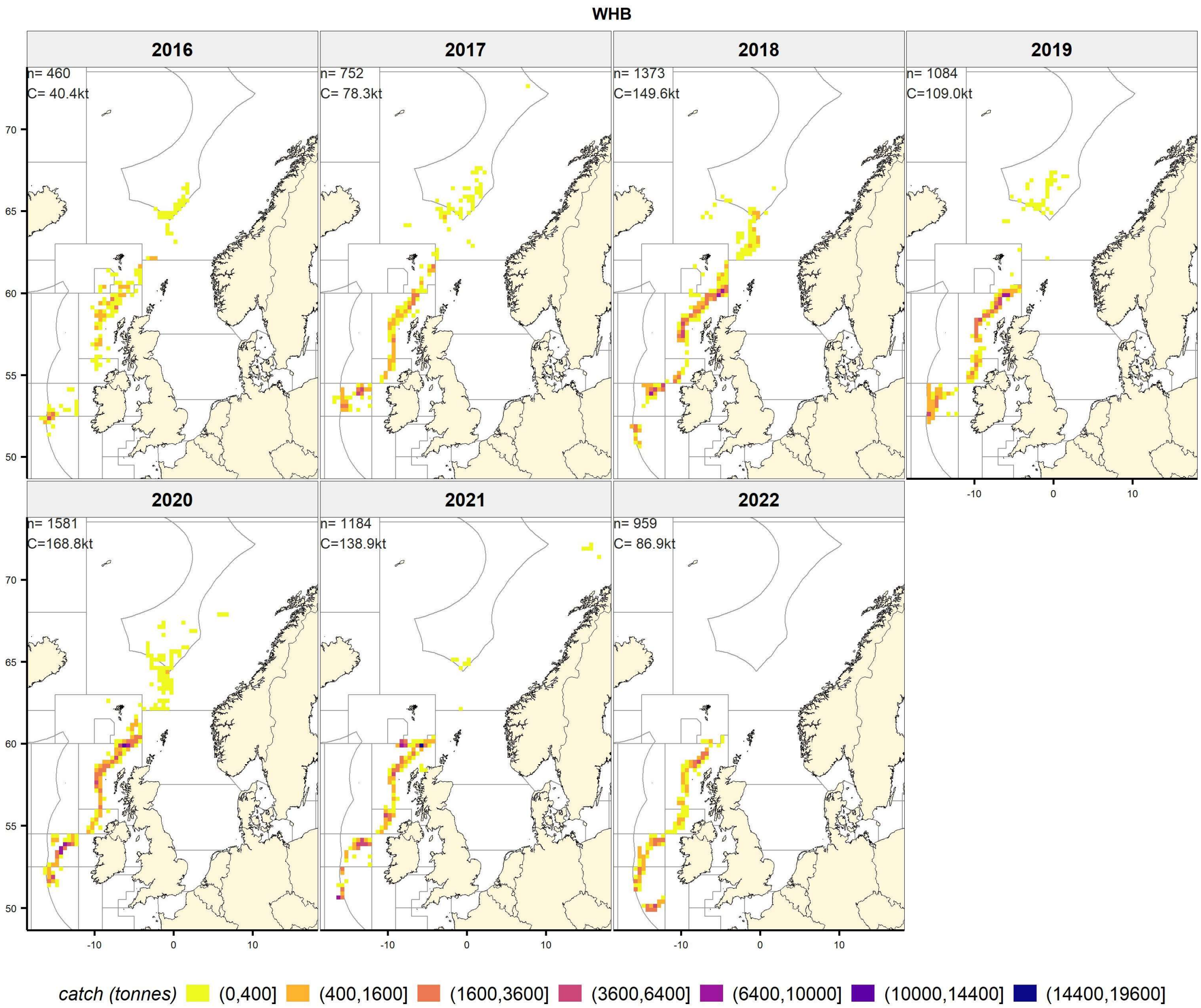

Figure 3.5.1: Blue whiting. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Blue whiting. Catchrate (ton/day) by rectangle

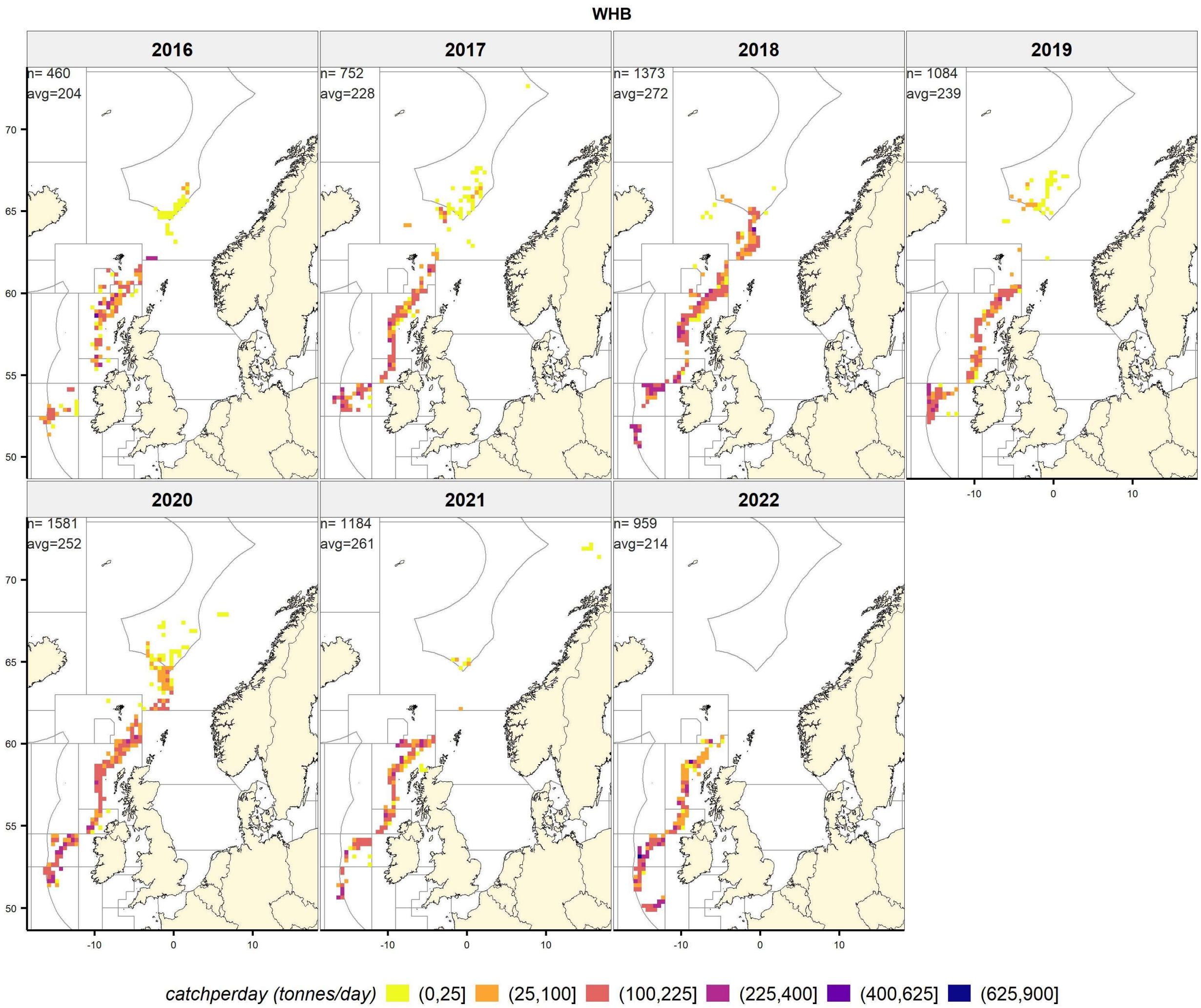

Figure 3.5.2: Blue whiting. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Blue whiting. Spatio-temporal evolution of catch by month and rectangle

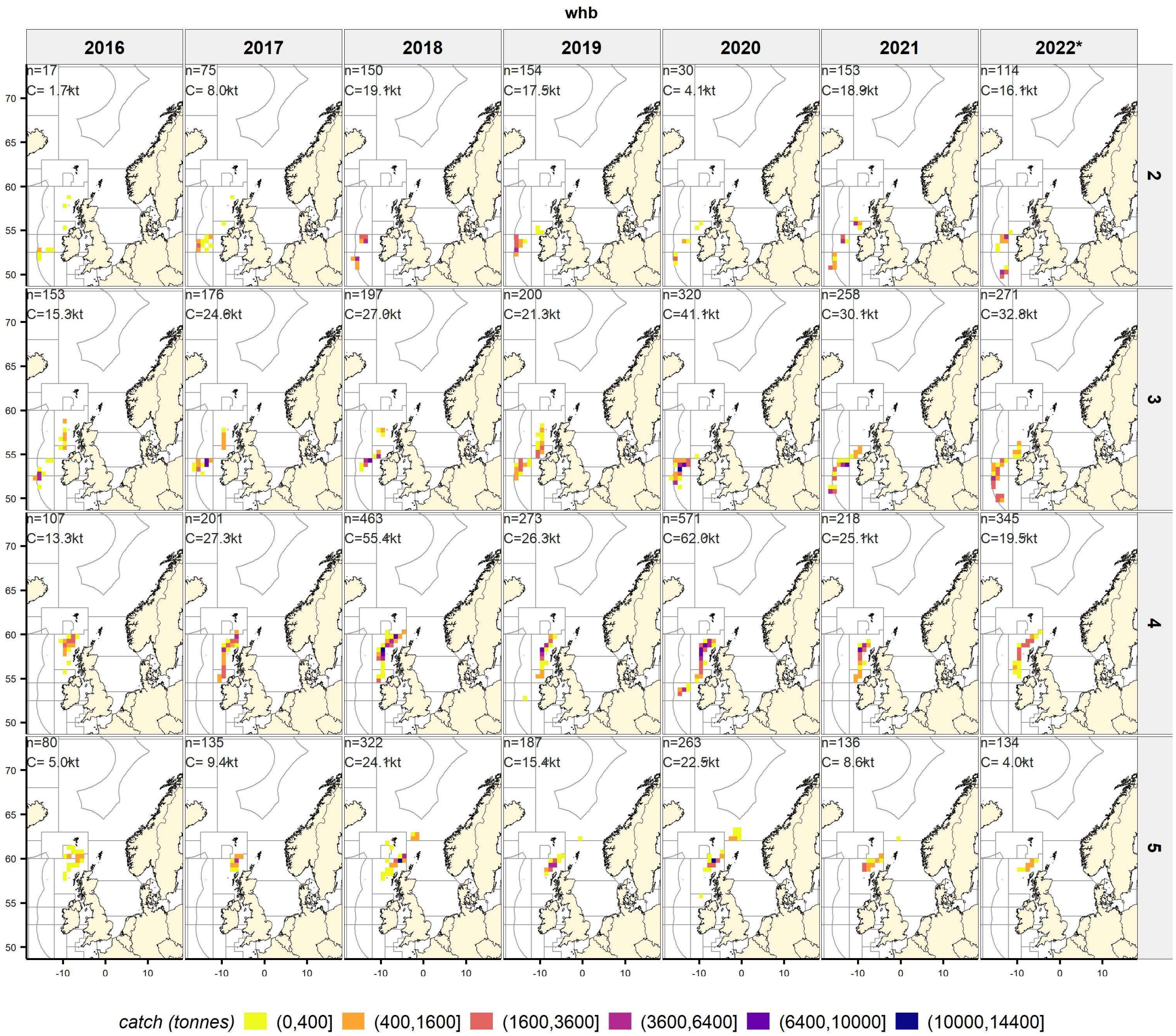

Figure 3.5.3: Blue whiting. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Blue whiting. Catch proportion at depth

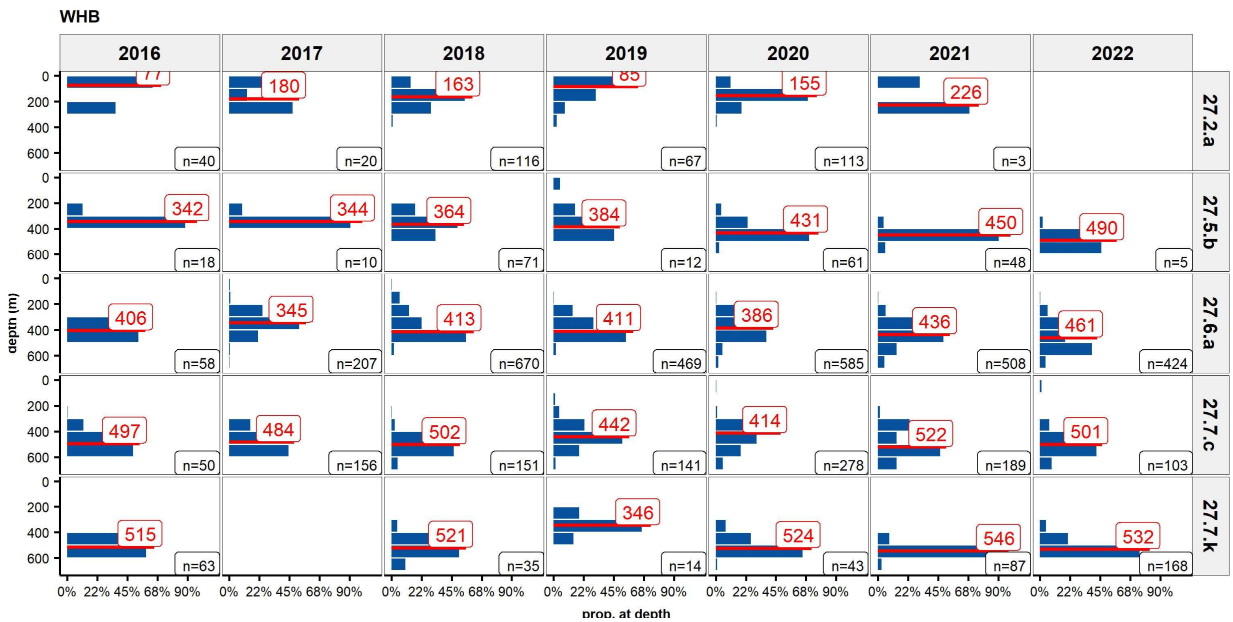

Figure 3.5.4: Blue whiting. Catch proportion at depth. N indicates the number of hauls.

Blue whiting. Length distributions of the catch

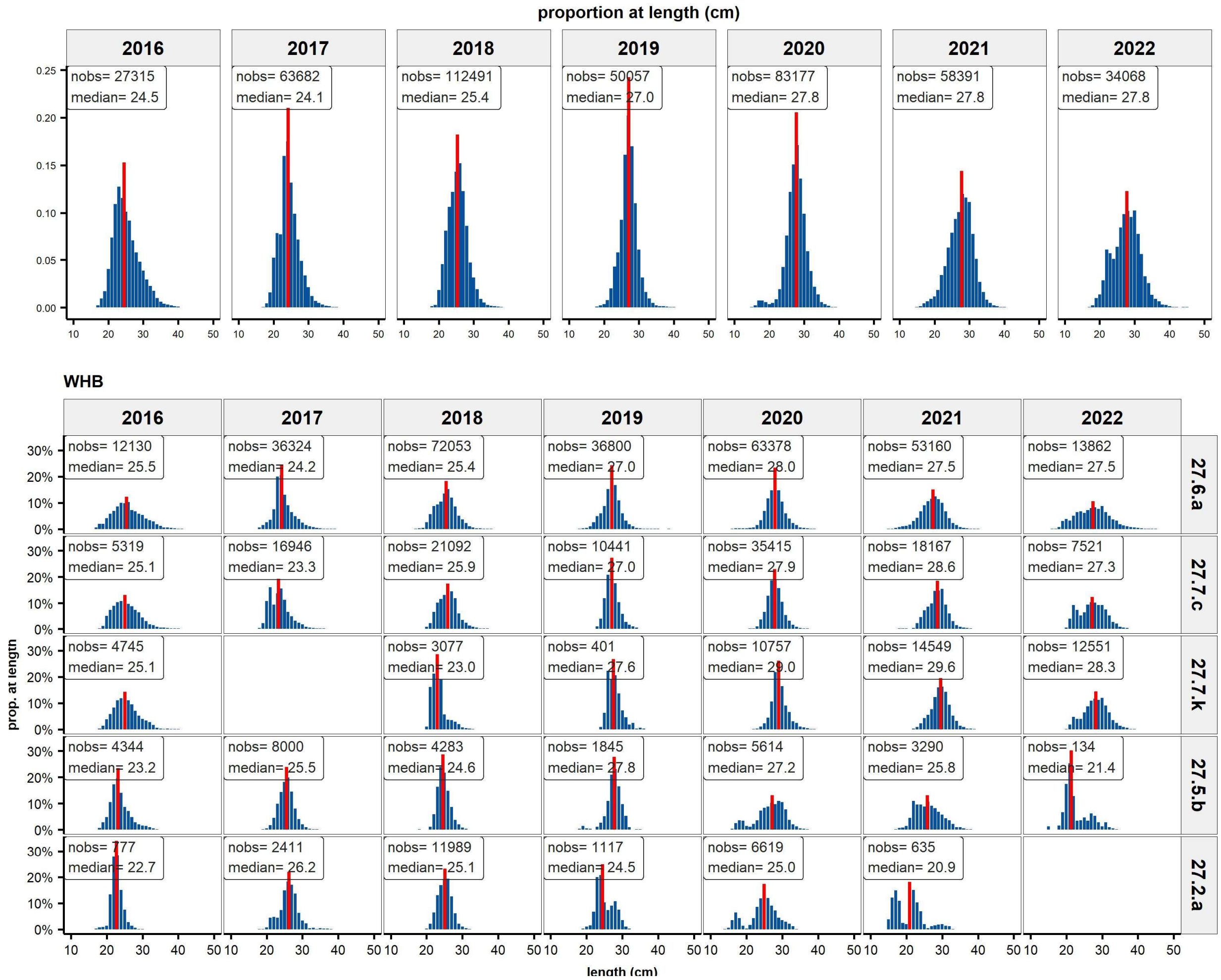

Figure 3.5.5: Blue whiting. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Blue whiting. Length distributions as proportions by (large) rectangle

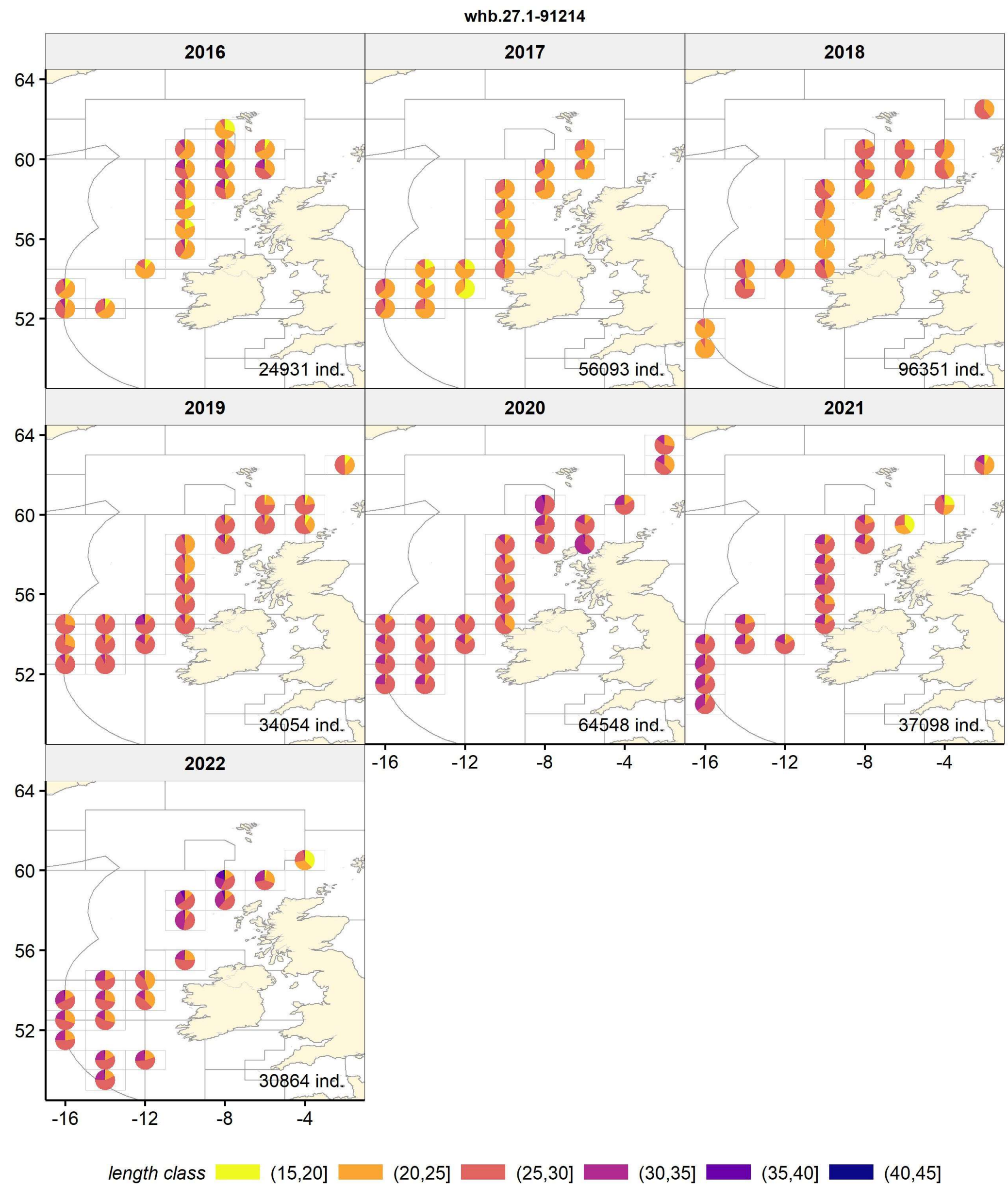

Figure 3.5.6: Blue whiting. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Blue whiting. Average length, weight and fat content by year and month

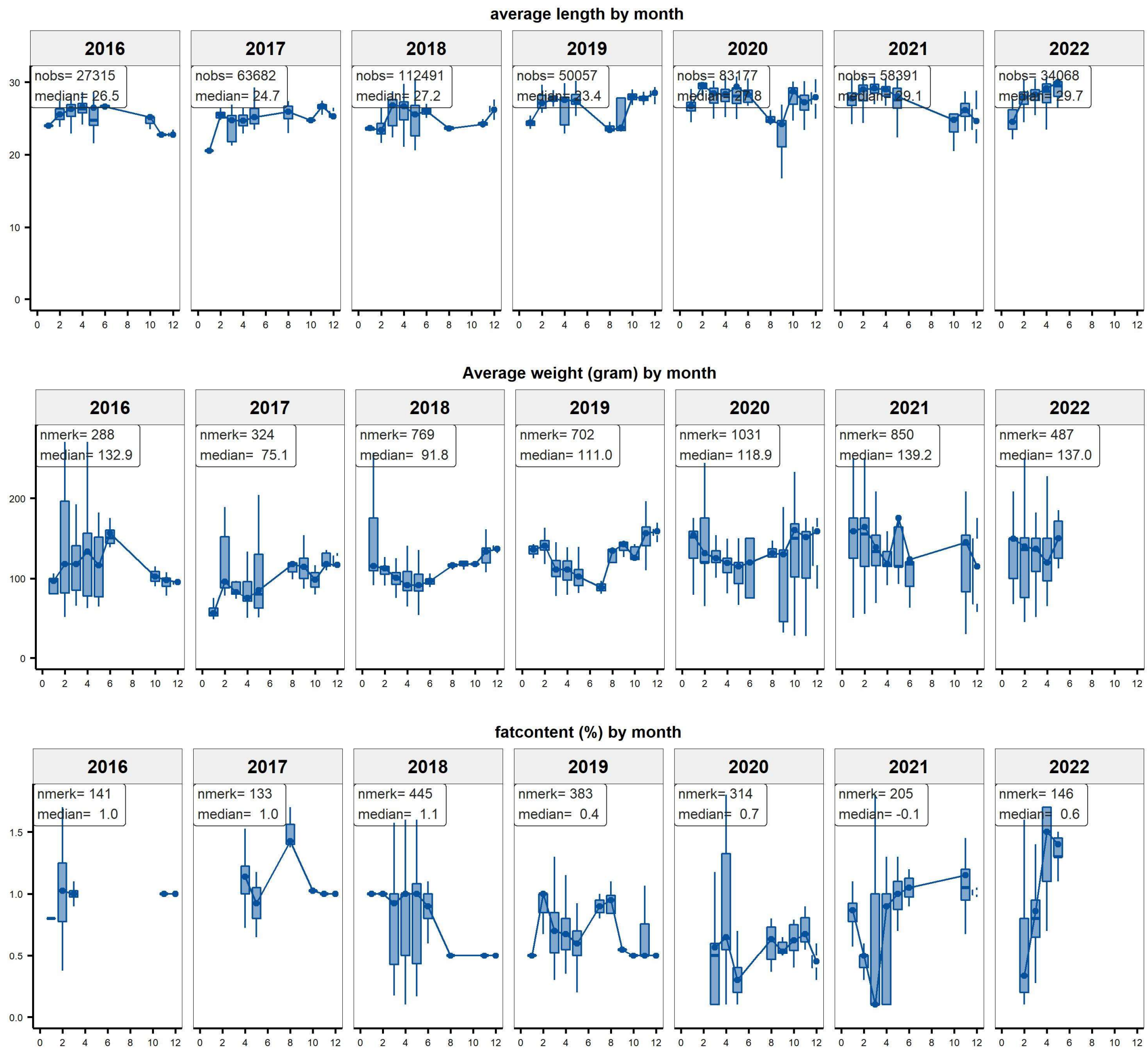

Figure 3.5.7: Blue whiting. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

Blue whiting (WHB). Standardized CPUE

Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset. It is assumed that a 2.5% annual efficiency increase takes place (Rousseau et al 2019).

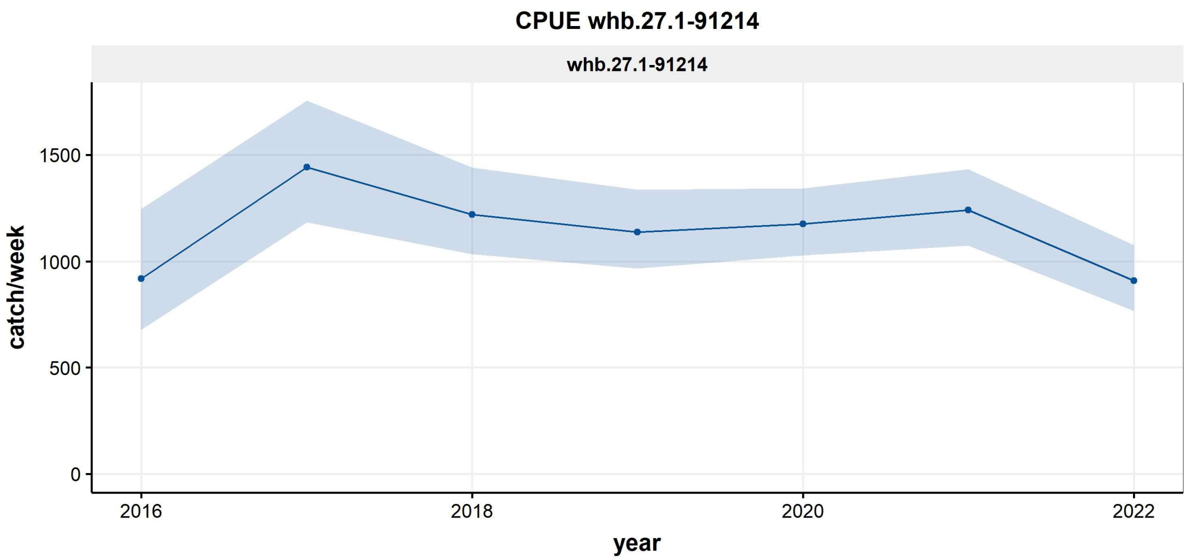

Figure 3.5.8: Blue whiting. Standardized CPUE (ton/day) from GLM model with factors year, month, GT, division and depth with log(days) as offset

3.6 Atlanto-scandian herring (HER_ASH, Clupea harengus)

Atlanto-scandian herring self-sampling summary.

species	year	nvessels	ntrips	ndays	nhauls	catch	catch/day	nlength
her_ash	2016	6	7	33	68	2,109	64	1,206
her_ash	2017	4	7	31	58	4,913	158	678
her_ash	2018	2	3	18	27	1,367	76	2
her_ash	2019	3	4	23	59	3,373	147	817
her_ash	2020	6	8	44	69	3,563	81	976
her_ash	2021	3	3	10	16	2,379	238	1,469
(all)	(all)		32	159	297	17,706		5,148

Table 3.6.1: Atlanto-scandian herring. Self-sampling summary with the number of days, hauls, trips, vessels, catch (tonnes), catch rate (ton/day), number of fish measured, number of biological observations.

Atlanto-scandian herring. Catch by division

species	division	2016	2017	2018	2019	2020	2021	all	perc
her_ash	27.2.a	2,109	4,913	1,367	3,373	3,563	2,379	17,706	100.0%
(all)	(all)	2,109	4,913	1,367	3,373	3,563	2,379	17,706	100.0%

Table 3.6.2: Atlanto-scandian herring. Self-sampling summary with the catch (tonnes) by year and division

Atlanto-scandian herring. Catch by month

species	month	2016	2017	2018	2019	2020	2021	all	perc
her_ash	May	0	0	0	0	26	0	26	0.1%
her_ash	Aug	0	118	52	0	61	0	232	1.3%
her_ash	Sep	54	7	405	362	53	0	881	5.0%
her_ash	Oct	2,055	4,788	910	2,184	2,480	1,659	14,076	79.5%
her_ash	Nov	0	0	0	828	942	721	2,491	14.1%
(all)	(all)	2,109	4,913	1,367	3,373	3,563	2,379	17,706	100.0%

Table 3.6.3: Atlanto-scandian herring. Self-sampling summary with the catch (tonnes) by year and month

Atlanto-scandian herring. Catch by country

species	flag	2016	2017	2018	2019	2020	2021	all	perc
her_ash	DEU	1,237	707	0	719	1,036	721	4,419	25.0%
her_ash	LIT	0	0	0	0	1,098	0	1,098	6.2%
her_ash	NL	775	4,185	1,367	2,654	524	1,659	11,164	63.1%
her_ash	POL	0	0	0	0	859	0	859	4.9%
her_ash	UK	97	21	0	0	48	0	166	0.9%
(all)	(all)	2,109	4,913	1,367	3,373	3,563	2,379	17,706	100.0%

Table 3.6.4: Atlanto-scandian herring. Self-sampling summary with the catch (tonnes) by year and country

Atlanto-scandian herring. Catch by rectangle

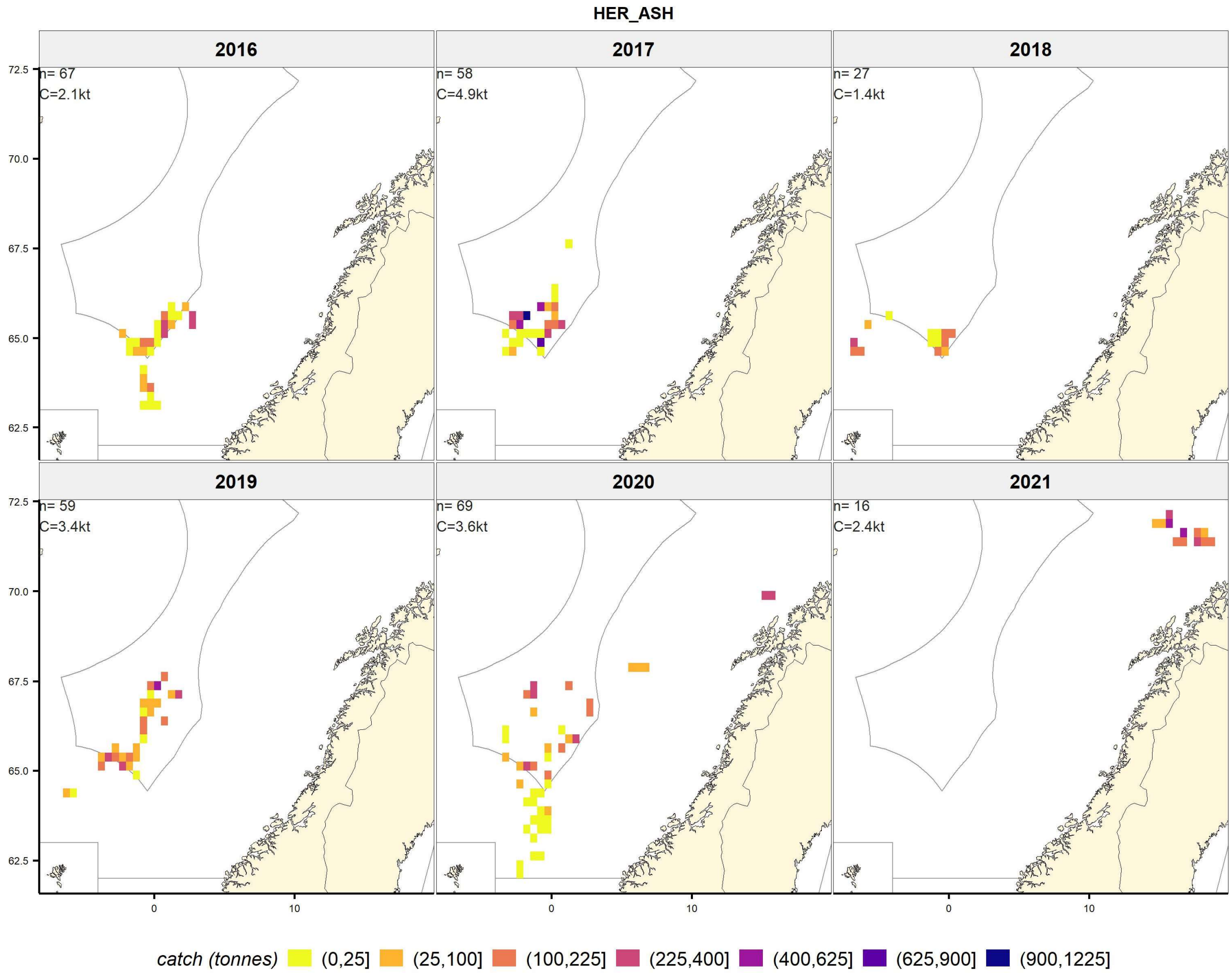

Figure 3.6.1: Atlanto-scandian herring. Catch per per rectangle. N indicates the number of hauls; Catch refers to the total catch per year.

Atlanto-scandian herring. Catchrate (ton/day) by rectangle

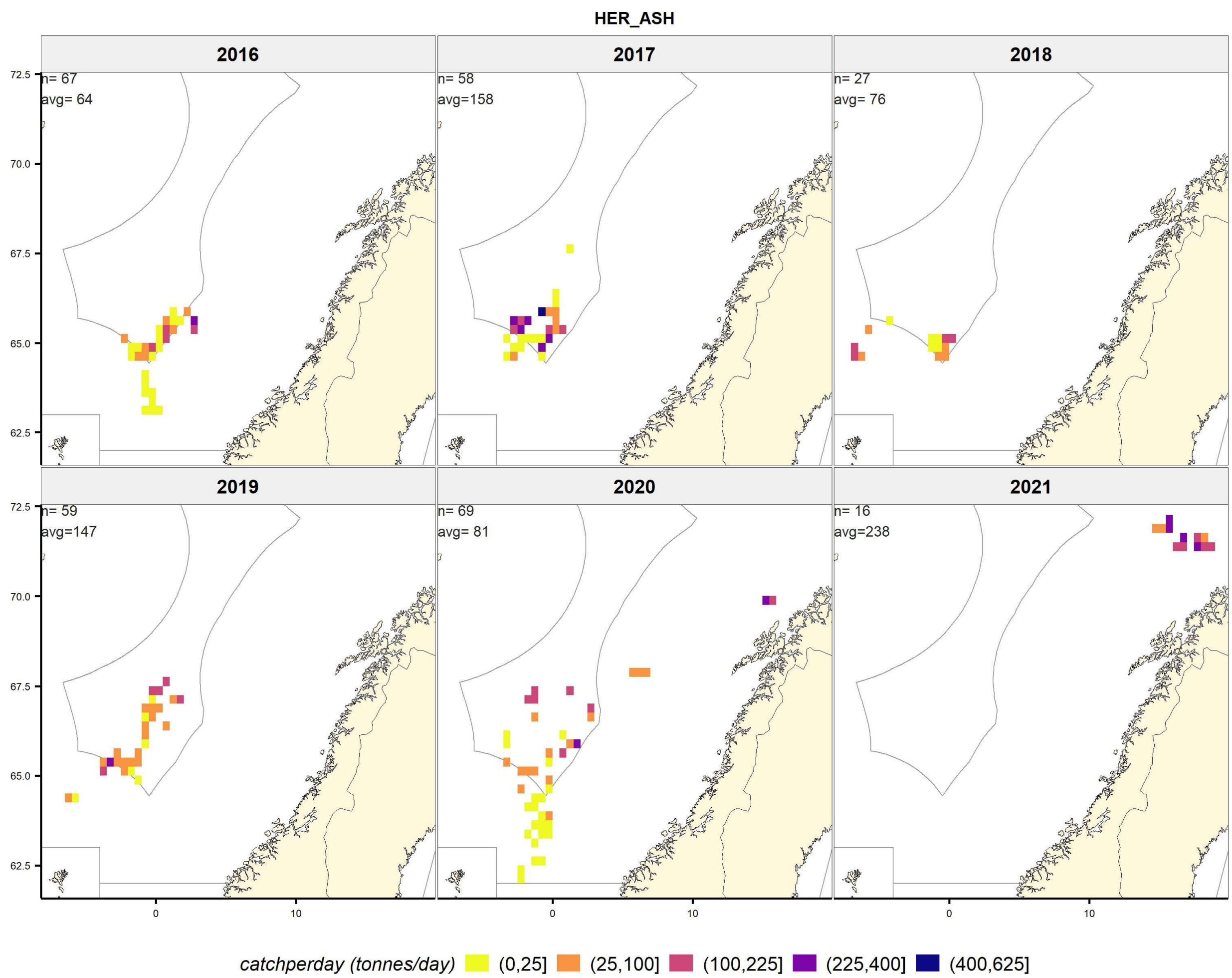

Figure 3.6.2: Atlanto-scandian herring. Catchrate (ton/day) per rectangle. N indicates the number of hauls; Avg refers to the average catchrate per rect.

Atlanto-scandian herring. Spatio-temporal evolution of catch by month and rectangle

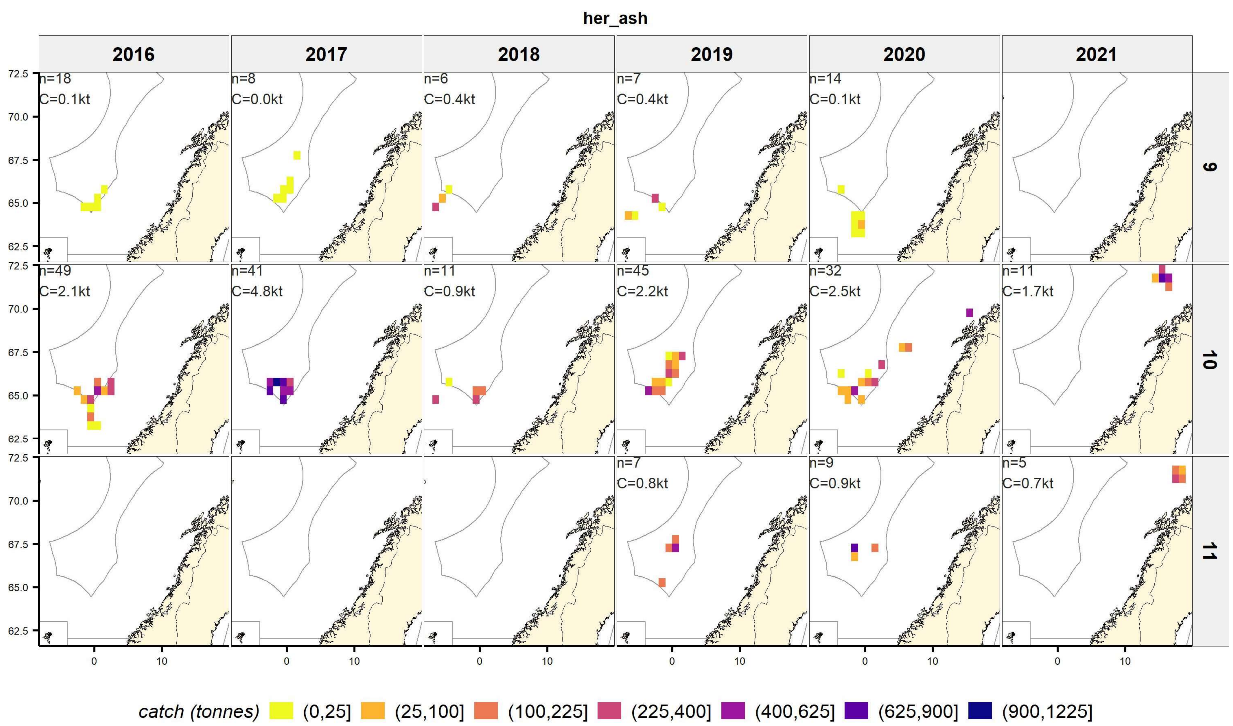

Figure 3.6.3: Atlanto-scandian herring. Spatio-temporal evolution of the catches per rectangle and month. N indicates the number of hauls; C refers to the total catch by year and month.

Atlanto-scandian herring. Catch proportion at depth

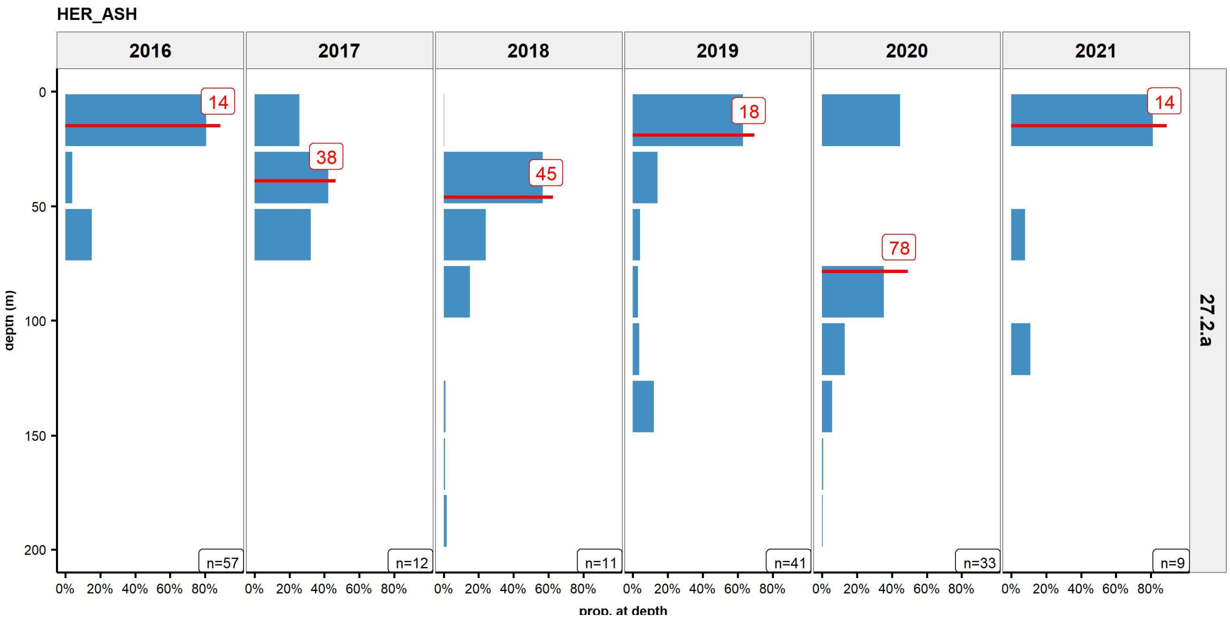

Figure 3.6.4: Atlanto-scandian herring. Catch proportion at depth. N indicates the number of hauls.

Atlanto-scandian herring. Length distributions of the catch

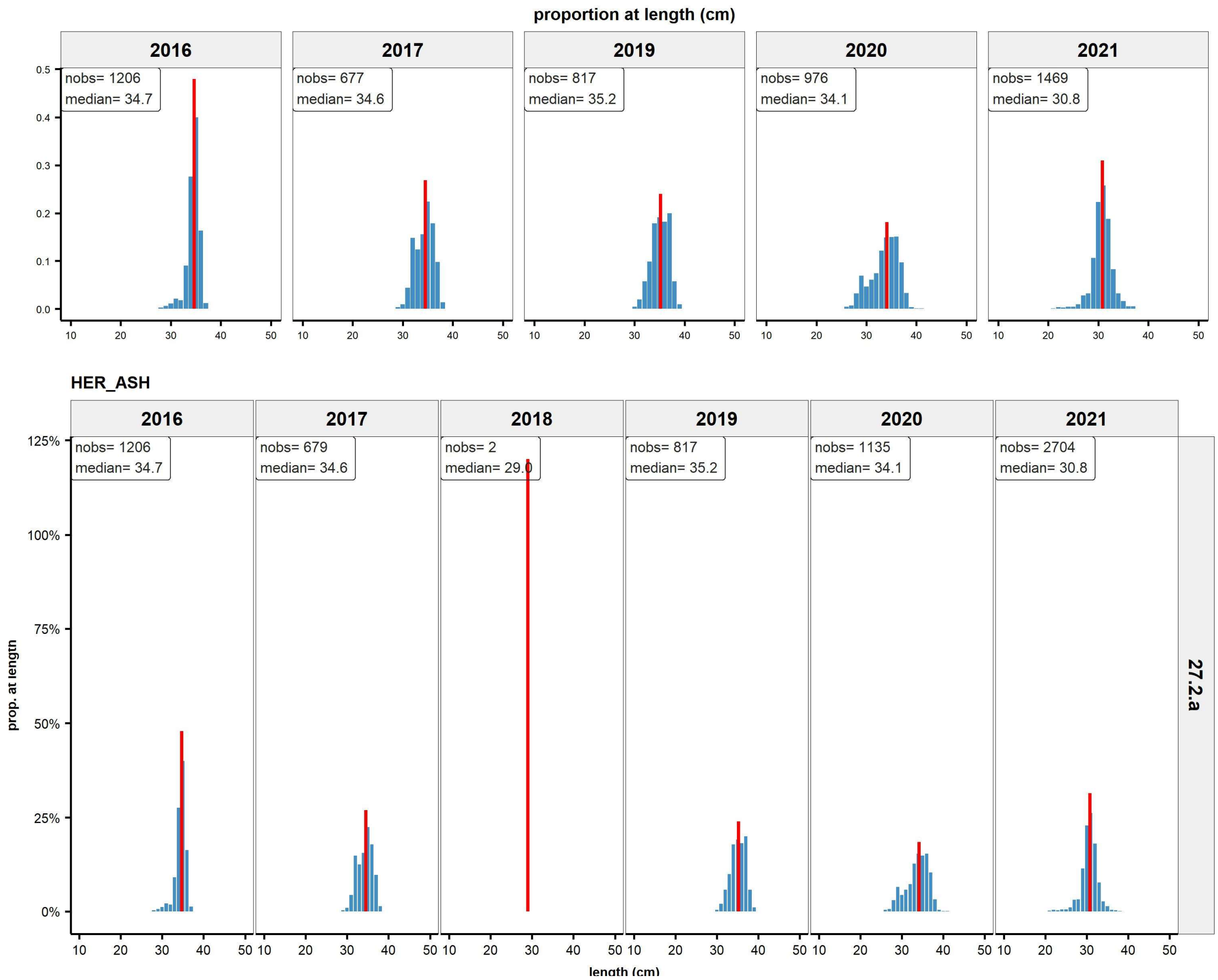

Figure 3.6.5: Atlanto-scandian herring. Length distributions by year (top) and by year and division (bottom). Nobs refers to the number of observations; median denotes the median length.

Atlanto-scandian herring. Length distributions as proportions by (large) rectangle

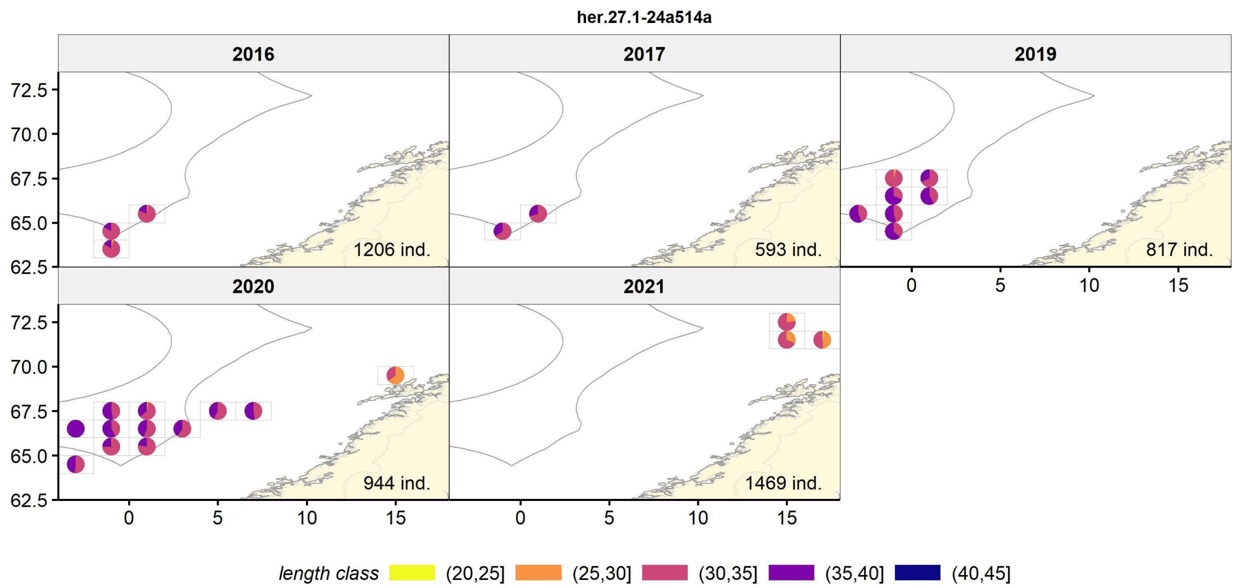

Figure 3.6.6: Atlanto-scandian herring. Length distributions as proportions by large rectangle. Ind. refers to the number of length measurements

Atlanto-scandian herring. Average length, weight and fat content by year and month

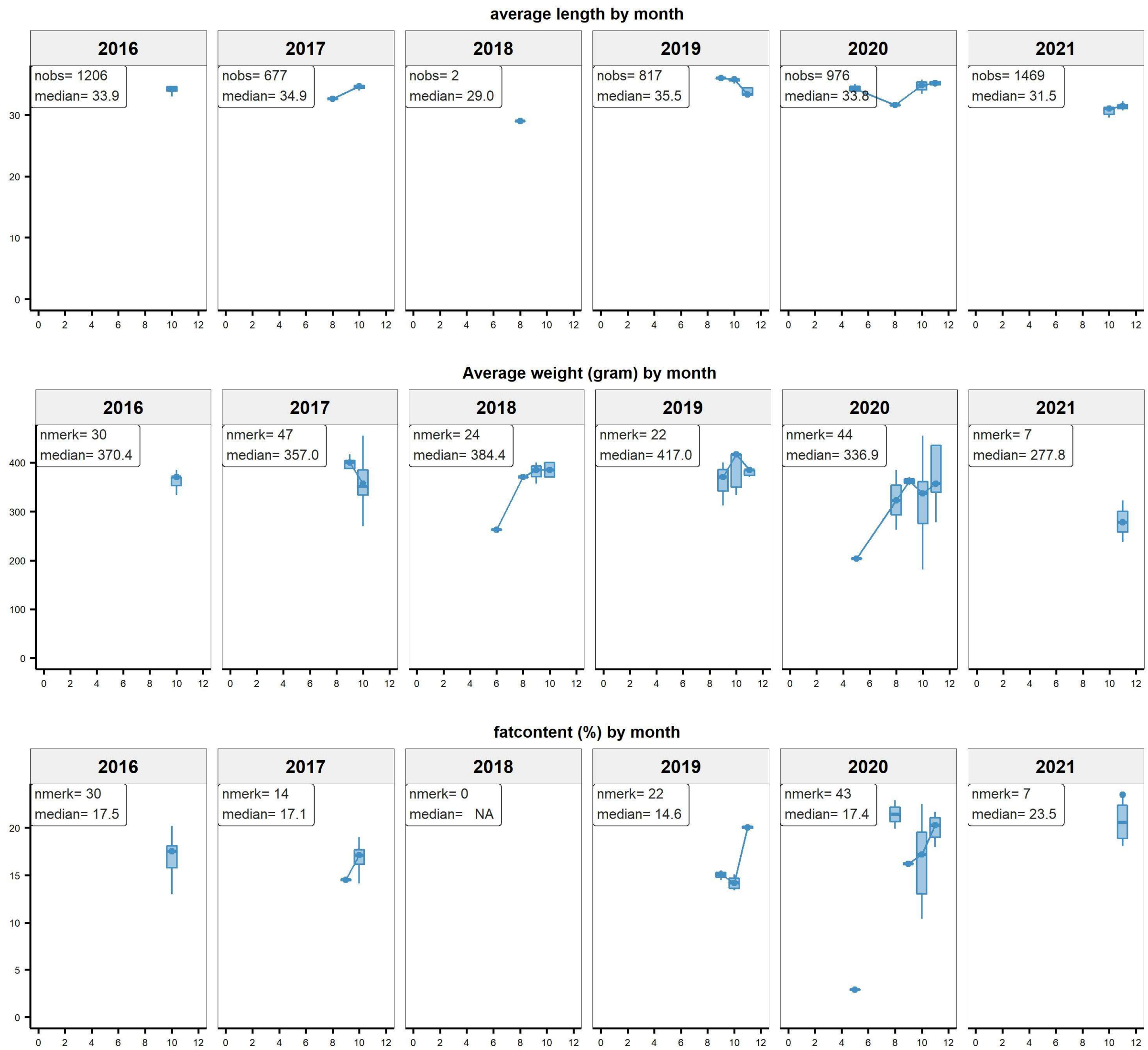

Figure 3.6.7: Atlanto-scandian herring. Average length, average weight, and average fat content. Nobs indicates the number of measurements, median indicates the median values

4 Discussion and conclusions

The PFA self-sampling program has been carried out for the seventh year in a row (2015-2021). Here, results have been presented for the years 2016-2022 in terms of meta-information on the sampling (number of vessels, trips, days and length measurements per area and/or season), in terms of the spatio-temporal distribution of catches and the length and weight compositions by area and/or season.

The definition of what constitutes the 'widely distributed fishery' has been approached by selecting all combination of vessel-trip-weeks where hauls were taken in a certain area and where the catch composition consisted of a minimum percentage of certain species (blue whiting, mackerel, horse mackerel, Atlanto-scandian herring) and a minimum weekly catch of 10 tons. Although for herring we aimed to select only trips for Atlanto-scandian herring (in division 27.2.a) some trips with North Sea herring have been included because they were combined with some fishing for mackerel.

Trips from 2016 up to 11/08/2022 have been processed for this overview. Pelagic fisheries within the Pelagic Freezer-trawler Association are carried out by vessels from different countries. Overall, around 48% of the catch volume of trips in this overview were taken by Dutch trawlers, 22% German trawlers, 14% UK trawlers and 16% other countries. Blue whiting constitutes the majority of the catch in those trips (54%), followed by mackerel (23%) and horse mackerel (12%). Atlanto-scandian herring only constitutes around 3% of the volume in the PFA widely distributed fishery. Note that the North Sea herring fishery is not included in this overview.

The **Mackerel fishery** takes place from October through to March of the subsequent year. Bycatches of mackerel may also occur during other fisheries,e.g. for horse mackerel or herring. Overall, the self-sampling activities for the mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 465 fishing trips with 6352 hauls, a total catch of 386474 tonnes and 103745 individual length measurements. The main fishing areas are ICES division 27.4.a and division 27.6.a. Compared to the previous years, mackerel in the catch in 2021 have been relatively large with a median length of 36.4 cm compared to 33.6-36.2 in the preceding years. Also, the median weight has been somewhat higher with median weight of 435 gram compared to 385-422 gram in the preceding years.

The **Western horse mackerel fishery** takes place from October through to March of the subsequent year. Overall, the self-sampling activities for the Western horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 250 fishing trips with 3316 hauls, a total catch of 128553 tonnes and 130146 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.b and division 27.7.j. Western horse mackerel have a wide range in the length distributions in the catch. Median lengths in divisions 27.6.a, 27.7.b and 27.7.j have fluctuated between 25.2 and 31.9 cm (with one low median length of 22.7 cm in 27.6.a in 2018). In ICES division 27.7.h, median lengths in the catch have been smaller and fluctuated between 20.7 and 24.5 cm.

The **North Sea horse mackerel fishery** takes place from October through to January of the subsequent year. Overall, the self-sampling activities for the North Sea horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 109 fishing trips with 900 hauls, a total catch of 46322 tonnes and 38983 individual length measurements. The main fishing areas is ICES division 27.7.d with some minor catches in 27.4.c. Catches in division 27.4.a have been counted as Western Horse mackerel. North Sea horse mackerel have a narrow range in the length distributions in the catch. Median lengths in division 27.7.d have fluctuated between 20.7 and 24.3 cm.

The **blue whiting** fishery takes place from February through to May although some minor fisheries for blue whiting may remain over the other months. Overall, the self-sampling activities for the horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 320 fishing trips with 8234 hauls, a total catch of 810714 tonnes and 466229 individual length measurements. The main fishing areas are ICES division 27.6.a, division 27.7.c and division 27.7.k. Compared to the previous years, blue whiting in the catches during 2020-2022 have been relatively large with a median length of 27.8 cm compared to 24.1-24.5 in the preceding years.

The fishery for **Atlanto-scandian herring** (ASH) is a relatively smaller fishery for PFA and takes place mostly in October. Overall, the self-sampling activities for the horse mackerel fisheries during the years 2016 - 2022 (up to 11/08/2022) covered 32 fishing trips with 297 hauls, a total catch of 17705 tonnes and 5147 individual length measurements. Only the herring fishery in ICES division 27.2.a is considered for ASH. Note that there are herring catches in other divisions within the selected trips. These are trips where North Sea herring has been fished with some bycatches of mackerel for example. Atlanto-scandian herring have a relatively narrow range in the length distributions in the catch. Median lengths have been between 30 and 35 cm.

In this 2022 self-sampling report, a standardized CPUE calculation has been included for the first time for most of the stocks. The standardized CPUE is based on a GLM model with a negative binomial distribution. The response variable is the catch by week and vessel, with an offset of the log effort (number of fishing days per week) and explanatory variables year, GT category, month, division and depth category. An assumed technical efficiency increase of 2.5% per year has been included in the fitting of the model (Rousseau et al 2019).

5 Acknowledgements

The skippers, officers and the quality managers of many of the PFA vessels are putting in a lot of effort to make the PFA the self-sampling work. Without their efforts, there would be no self-sampling.

6 References and publications

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7 More information

Please contact Martin Pastoors (mpastoors@pelagicfish.eu) if you would have any questions on the PFA self-sampling program or the specific results presented here.

8 Northeast Atlantic mackerel: detailed tables

Northeast Atlantic mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	402	58	22	162	513
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Northeast Atlantic mackerel Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1	158	0.0003
mac	2021	1	27	27.7.b	TL	33	1	9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3	27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7	44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11	69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18	125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15	112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7	44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1	9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6	128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12	256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9	192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8	171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8	106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11	149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9	85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7	149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3	21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1	19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3	54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7	77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9	115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14	180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11	161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8	99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6	94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4	66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1	15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1	6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1	6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1	9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5	43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12	97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2	10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2	9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10	98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23	131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16	127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28	166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23	149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26	179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23	173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25	179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24	155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19	123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11	74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2	13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4	14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17	60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14	49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5	17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2	7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9	112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13	203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11	141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7	76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4	25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6	23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4	35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13	115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8	64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2	23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7	66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2	17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1	3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1	2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16	151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11	47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9	53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12	62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6	27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18	116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14	154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29	191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32	259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076

mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Northeast Atlantic mackerel Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274 2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214 2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117 1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29 282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7 89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3 34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5 57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7 80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7 80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4 46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5 57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4 46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4 35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3 31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7 84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25 216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24 196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31 296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45 315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72 507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162 1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203 1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201 1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270 1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211 1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110 751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34 283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6 46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3 9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1 10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2 6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1 3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3 14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6 20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10 46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20 74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16 73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13 59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15 55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15 44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16 30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17 21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11 26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8 18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6 12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3 4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4 20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5 31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5 28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6 27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6 28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3 14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1 2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1 2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1 3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1 3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9 102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68 847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65 831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53 568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36 409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11 109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4 54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4 67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5 74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3 47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1 873	0.0833
mac	2022	3	27	27.7.b	TL	34	5 4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1 873	0.0833
mac	2022	3	27	27.7.b	TL	36	1 873	0.0833
mac	2022	3	27	27.7.b	TL	37	2 1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1 873	0.0833
mac	2022	3	27	27.7.b	TL	40	1 873	0.0833
mac	2022	3	27	27.7.j	TL	31	1 4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2 17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1 12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1 9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3 14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2 9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1 13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

9 Western horse mackerel: detailed tables

Western horse mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	402	58	22	162	513
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Western horse mackerel Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1 158	0.0003
mac	2021	1	27	27.7.b	TL	33	1 9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3 27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7 44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11 69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18 125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15 112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7 44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1 9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6 128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12 256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9 192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8 171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8 106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11 149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9 85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7 149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3 21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1 19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3 54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7 77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9 115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14 180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11 161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8 99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6 94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4 66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1 15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1 6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1 6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1 9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5 43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12 97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2 10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2 9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10 98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23 131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16 127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28 166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23 149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26 179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23 173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25 179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24 155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19 123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11 74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2 13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4 14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17 60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14 49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5 17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2 7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9 112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13 203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11 141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7 76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4 25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6 23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4 35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13 115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8 64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2 23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7 66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2 17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1 3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1 2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16 151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11 47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9 53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12 62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6 27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18 116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14 154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29 191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32 259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Western horse mackerel Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274 2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214 2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117 1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29 282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7 89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3 34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5 57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7 80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7 80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4 46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5 57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4 46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4 35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3 31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7 84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25 216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24 196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31 296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45 315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72 507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162 1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203 1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201 1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270 1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211 1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110 751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34 283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6 46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3 9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1 10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2 6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1 3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3 14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6 20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10 46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20 74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16 73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13 59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15 55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15 44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16 30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17 21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11 26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8 18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6 12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3 4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4 20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5 31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5 28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6 27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6 28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3 14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1 2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1 2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1 3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1 3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9 102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68 847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65 831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53 568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36 409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11 109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4 54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4 67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5 74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3 47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1 873	0.0833
mac	2022	3	27	27.7.b	TL	34	5 4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1 873	0.0833
mac	2022	3	27	27.7.b	TL	36	1 873	0.0833
mac	2022	3	27	27.7.b	TL	37	2 1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1 873	0.0833
mac	2022	3	27	27.7.b	TL	40	1 873	0.0833
mac	2022	3	27	27.7.j	TL	31	1 4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2 17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1 12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1 9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3 14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2 9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1 13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

10 North Sea horse mackerel: detailed tables

North Sea horse mackerel Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	402	58	22	162	513
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

North Sea horse mackerel Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1 158	0.0003
mac	2021	1	27	27.7.b	TL	33	1 9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3 27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7 44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11 69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18 125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15 112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7 44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1 9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6 128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12 256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9 192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8 171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8 106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11 149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9 85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7 149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3 21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1 19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3 54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7 77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9 115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14 180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11 161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8 99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6 94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4 66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1 15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1 6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1 6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1 9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5 43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12 97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2 10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2 9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10 98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23 131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16 127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28 166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23 149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26 179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23 173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25 179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24 155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19 123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11 74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2 13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4 14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17 60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14 49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5 17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2 7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9 112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13 203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11 141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7 76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4 25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6 23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4 35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13 115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8 64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2 23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7 66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2 17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1 3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1 2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16 151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11 47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9 53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12 62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6 27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18 116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14 154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29 191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32 259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

North Sea horse mackerel Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

11 Blue whiting: detailed tables

Blue whiting Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	402	58	22	162	513
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Blue whiting Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1 158	0.0003
mac	2021	1	27	27.7.b	TL	33	1 9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3 27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7 44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11 69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18 125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15 112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7 44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1 5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1 9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1 21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6 128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12 256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9 192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8 171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8 106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11 149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9 85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7 149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3 21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1 19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3 54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7 77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9 115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14 180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11 161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8 99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6 94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4 66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1 15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1 6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1 6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1 9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5 43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12 97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2 10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2 9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10 98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23 131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16 127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28 166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23 149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26 179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23 173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25 179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24 155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19 123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11 74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2 13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4 14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17 60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14 49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5 17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2 7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9 112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13 203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11 141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7 76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4 25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6 23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4 35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13 115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8 64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2 23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7 66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2 17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1 3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1 2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16 151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11 47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9 53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12 62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6 27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18 116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14 154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29 191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32 259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Blue whiting Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

12 Atlanto-scandian herring: detailed tables

Atlanto-scandian herring Sampling overview

species	year	quarter	area	division	catch	sampleweight	nsamples	count	catchnumber
mac	2021	1	27	27.4.a	739	20	1	49	370
mac	2021	1	27	27.6.a	21577	490	69	2483	22508
mac	2021	1	27	27.7.b	672	28	6	67	452
mac	2021	1	27	27.7.j	334	26	2	76	1325
mac	2021	2	27	27.4.a	38	NA	NA	NA	NA
mac	2021	2	27	27.6.a	406	25	6	64	883
mac	2021	2	27	27.7.b	53	0	1	2	12
mac	2021	3	27	27.4.a	2991	46	20	252	1742
mac	2021	3	27	27.6.a	4	1	1	42	148
mac	2021	3	27	27.7.b	368	24	9	87	909
mac	2021	3	27	27.7.j	525	73	27	208	1394
mac	2021	4	27	27.2.a	8	29	3	61	31
mac	2021	4	27	27.4.a	40743	2269	201	7902	74412
mac	2021	4	27	27.7.j	0	0	1	1	1
mac	2022	1	27	27.4.a	11645	1045	72	3281	23588
mac	2022	1	27	27.6.a	9707	502	42	1570	15056
mac	2022	1	27	27.7.b	4535	443	33	1447	10193
mac	2022	1	27	27.7.j	402	58	22	162	513
mac	2022	2	27	27.4.a	23	NA	NA	NA	NA
mac	2022	2	27	27.6.a	146	12	8	32	158
mac	2022	3	27	27.4.a	238	77	12	259	3116
mac	2022	3	27	27.7.b	3	5	1	12	10
mac	2022	3	27	27.7.j	3	4	4	14	103

Atlanto-scandian herring Length frequencies 2021

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2021	1	27	27.4.a	TL	27	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	28	3	22662	0.0612
mac	2021	1	27	27.4.a	TL	29	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	30	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	31	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	32	1	7554	0.0204
mac	2021	1	27	27.4.a	TL	33	2	15108	0.0408
mac	2021	1	27	27.4.a	TL	34	4	30216	0.0816
mac	2021	1	27	27.4.a	TL	35	7	52878	0.1429
mac	2021	1	27	27.4.a	TL	36	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	37	5	37770	0.1020
mac	2021	1	27	27.4.a	TL	38	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	39	6	45324	0.1224
mac	2021	1	27	27.4.a	TL	40	4	30216	0.0816
mac	2021	1	27	27.6.a	TL	20	1	7036	0.0003
mac	2021	1	27	27.6.a	TL	21	1	5983	0.0003
mac	2021	1	27	27.6.a	TL	22	2	12764	0.0006
mac	2021	1	27	27.6.a	TL	24	2	10452	0.0005
mac	2021	1	27	27.6.a	TL	25	9	47828	0.0021
mac	2021	1	27	27.6.a	TL	26	10	61280	0.0027
mac	2021	1	27	27.6.a	TL	27	25	245675	0.0109
mac	2021	1	27	27.6.a	TL	28	16	198136	0.0088
mac	2021	1	27	27.6.a	TL	29	30	303481	0.0135
mac	2021	1	27	27.6.a	TL	30	43	331822	0.0147
mac	2021	1	27	27.6.a	TL	31	36	222011	0.0099
mac	2021	1	27	27.6.a	TL	32	88	746047	0.0331
mac	2021	1	27	27.6.a	TL	33	145	1154437	0.0513
mac	2021	1	27	27.6.a	TL	34	193	1641334	0.0729
mac	2021	1	27	27.6.a	TL	35	270	2158065	0.0959
mac	2021	1	27	27.6.a	TL	36	372	3205188	0.1424
mac	2021	1	27	27.6.a	TL	37	498	4794277	0.2130
mac	2021	1	27	27.6.a	TL	38	386	3699361	0.1644
mac	2021	1	27	27.6.a	TL	39	195	2138953	0.0950
mac	2021	1	27	27.6.a	TL	40	110	1122308	0.0499
mac	2021	1	27	27.6.a	TL	41	40	322748	0.0143
mac	2021	1	27	27.6.a	TL	42	8	58488	0.0026
mac	2021	1	27	27.6.a	TL	43	2	11590	0.0005
mac	2021	1	27	27.6.a	TL	46	1	9415	0.0004
mac	2021	1	27	27.7.b	TL	31	1	158	0.0003

mac	2021	1	27	27.7.b	TL	32	1	158	0.0003
mac	2021	1	27	27.7.b	TL	33	1	9116	0.0202
mac	2021	1	27	27.7.b	TL	34	3	27349	0.0605
mac	2021	1	27	27.7.b	TL	35	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	36	7	44463	0.0983
mac	2021	1	27	27.7.b	TL	37	11	69334	0.1534
mac	2021	1	27	27.7.b	TL	38	18	125023	0.2765
mac	2021	1	27	27.7.b	TL	39	15	112427	0.2487
mac	2021	1	27	27.7.b	TL	40	7	44475	0.0984
mac	2021	1	27	27.7.b	TL	41	1	5243	0.0116
mac	2021	1	27	27.7.b	TL	42	1	9116	0.0202
mac	2021	1	27	27.7.j	TL	28	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	29	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	30	1	21375	0.0161
mac	2021	1	27	27.7.j	TL	31	6	128253	0.0968
mac	2021	1	27	27.7.j	TL	32	12	256507	0.1935
mac	2021	1	27	27.7.j	TL	33	9	192380	0.1452
mac	2021	1	27	27.7.j	TL	34	8	171004	0.1290
mac	2021	1	27	27.7.j	TL	35	8	106877	0.0806
mac	2021	1	27	27.7.j	TL	36	11	149629	0.1129
mac	2021	1	27	27.7.j	TL	37	9	85502	0.0645
mac	2021	1	27	27.7.j	TL	38	7	149629	0.1129
mac	2021	1	27	27.7.j	TL	39	3	21375	0.0161
mac	2021	2	27	27.6.a	TL	32	1	19069	0.0216
mac	2021	2	27	27.6.a	TL	33	3	54106	0.0613
mac	2021	2	27	27.6.a	TL	34	7	77064	0.0873
mac	2021	2	27	27.6.a	TL	35	9	115011	0.1303
mac	2021	2	27	27.6.a	TL	36	14	180151	0.2040
mac	2021	2	27	27.6.a	TL	37	11	161067	0.1824
mac	2021	2	27	27.6.a	TL	38	8	99500	0.1127
mac	2021	2	27	27.6.a	TL	39	6	94816	0.1074
mac	2021	2	27	27.6.a	TL	40	4	66247	0.0750
mac	2021	2	27	27.6.a	TL	42	1	15967	0.0181
mac	2021	2	27	27.7.b	TL	38	1	6127	0.5000
mac	2021	2	27	27.7.b	TL	40	1	6127	0.5000
mac	2021	3	27	27.4.a	TL	24	1	9442	0.0054
mac	2021	3	27	27.4.a	TL	25	5	43353	0.0249
mac	2021	3	27	27.4.a	TL	26	12	97836	0.0561
mac	2021	3	27	27.4.a	TL	27	2	10111	0.0058
mac	2021	3	27	27.4.a	TL	28	2	9810	0.0056
mac	2021	3	27	27.4.a	TL	29	10	98209	0.0563
mac	2021	3	27	27.4.a	TL	30	23	131613	0.0755
mac	2021	3	27	27.4.a	TL	31	16	127653	0.0732
mac	2021	3	27	27.4.a	TL	32	28	166532	0.0955
mac	2021	3	27	27.4.a	TL	33	23	149258	0.0856
mac	2021	3	27	27.4.a	TL	34	26	179596	0.1030
mac	2021	3	27	27.4.a	TL	35	23	173859	0.0998
mac	2021	3	27	27.4.a	TL	36	25	179053	0.1027
mac	2021	3	27	27.4.a	TL	37	24	155003	0.0889
mac	2021	3	27	27.4.a	TL	38	19	123471	0.0708
mac	2021	3	27	27.4.a	TL	39	11	74916	0.0430
mac	2021	3	27	27.4.a	TL	40	2	13203	0.0076
mac	2021	3	27	27.6.a	TL	14	4	14157	0.0952
mac	2021	3	27	27.6.a	TL	15	17	60167	0.4048
mac	2021	3	27	27.6.a	TL	16	14	49549	0.3333
mac	2021	3	27	27.6.a	TL	17	5	17696	0.1190
mac	2021	3	27	27.6.a	TL	18	2	7078	0.0476
mac	2021	3	27	27.7.b	TL	28	9	112126	0.1232
mac	2021	3	27	27.7.b	TL	29	13	203625	0.2238
mac	2021	3	27	27.7.b	TL	30	11	141073	0.1550
mac	2021	3	27	27.7.b	TL	31	7	76669	0.0843
mac	2021	3	27	27.7.b	TL	32	4	25451	0.0280
mac	2021	3	27	27.7.b	TL	33	6	23804	0.0262
mac	2021	3	27	27.7.b	TL	34	4	35446	0.0390
mac	2021	3	27	27.7.b	TL	35	13	115133	0.1265
mac	2021	3	27	27.7.b	TL	36	8	64557	0.0710
mac	2021	3	27	27.7.b	TL	37	2	23926	0.0263
mac	2021	3	27	27.7.b	TL	38	7	66987	0.0736
mac	2021	3	27	27.7.b	TL	39	2	17577	0.0193
mac	2021	3	27	27.7.b	TL	40	1	3499	0.0038
mac	2021	3	27	27.7.j	TL	27	1	2840	0.0020
mac	2021	3	27	27.7.j	TL	28	16	151373	0.1086
mac	2021	3	27	27.7.j	TL	29	11	47096	0.0338
mac	2021	3	27	27.7.j	TL	30	9	53242	0.0382
mac	2021	3	27	27.7.j	TL	31	12	62300	0.0447
mac	2021	3	27	27.7.j	TL	32	6	27933	0.0200
mac	2021	3	27	27.7.j	TL	33	18	116680	0.0837
mac	2021	3	27	27.7.j	TL	34	14	154071	0.1105
mac	2021	3	27	27.7.j	TL	35	29	191132	0.1371
mac	2021	3	27	27.7.j	TL	36	32	259037	0.1858

mac	2021	3	27	27.7.j	TL	37	32	150305	0.1078
mac	2021	3	27	27.7.j	TL	38	15	80969	0.0581
mac	2021	3	27	27.7.j	TL	39	7	70033	0.0502
mac	2021	3	27	27.7.j	TL	40	5	16515	0.0118
mac	2021	3	27	27.7.j	TL	41	1	10581	0.0076
mac	2021	4	27	27.2.a	TL	35	4	1061	0.0337
mac	2021	4	27	27.2.a	TL	36	4	1141	0.0362
mac	2021	4	27	27.2.a	TL	37	14	18943	0.6011
mac	2021	4	27	27.2.a	TL	38	19	5141	0.1631
mac	2021	4	27	27.2.a	TL	39	10	2534	0.0804
mac	2021	4	27	27.2.a	TL	40	8	2202	0.0699
mac	2021	4	27	27.2.a	TL	41	2	490	0.0155
mac	2021	4	27	27.4.a	TL	23	1	11982	0.0002
mac	2021	4	27	27.4.a	TL	24	9	108983	0.0015
mac	2021	4	27	27.4.a	TL	25	21	231669	0.0031
mac	2021	4	27	27.4.a	TL	26	76	793340	0.0107
mac	2021	4	27	27.4.a	TL	27	138	1561556	0.0210
mac	2021	4	27	27.4.a	TL	28	138	1922592	0.0258
mac	2021	4	27	27.4.a	TL	29	190	2253457	0.0303
mac	2021	4	27	27.4.a	TL	30	253	2750277	0.0370
mac	2021	4	27	27.4.a	TL	31	318	3004111	0.0404
mac	2021	4	27	27.4.a	TL	32	392	4157073	0.0559
mac	2021	4	27	27.4.a	TL	33	482	5170802	0.0695
mac	2021	4	27	27.4.a	TL	34	651	6524440	0.0877
mac	2021	4	27	27.4.a	TL	35	902	8714365	0.1171
mac	2021	4	27	27.4.a	TL	36	1037	9457713	0.1271
mac	2021	4	27	27.4.a	TL	37	1253	11146124	0.1498
mac	2021	4	27	27.4.a	TL	38	1084	8877236	0.1193
mac	2021	4	27	27.4.a	TL	39	603	4858841	0.0653
mac	2021	4	27	27.4.a	TL	40	263	2138178	0.0287
mac	2021	4	27	27.4.a	TL	41	69	522747	0.0070
mac	2021	4	27	27.4.a	TL	42	17	176805	0.0024
mac	2021	4	27	27.4.a	TL	43	3	24148	0.0003
mac	2021	4	27	27.4.a	TL	44	2	5576	0.0001
mac	2021	4	27	27.7.j	TL	30	1	1413	1.0000

Atlanto-scandian herring Length frequencies 2022

species	year	quarter	area	division	lengthtype	length	count	catchnumber	prop
mac	2022	1	27	27.4.a	TL	26	9	33098	0.0014
mac	2022	1	27	27.4.a	TL	27	52	340439	0.0144
mac	2022	1	27	27.4.a	TL	28	44	336042	0.0142
mac	2022	1	27	27.4.a	TL	29	54	396568	0.0168
mac	2022	1	27	27.4.a	TL	30	59	388841	0.0165
mac	2022	1	27	27.4.a	TL	31	62	440724	0.0187
mac	2022	1	27	27.4.a	TL	32	68	505194	0.0214
mac	2022	1	27	27.4.a	TL	33	84	482556	0.0205
mac	2022	1	27	27.4.a	TL	34	159	1033678	0.0438
mac	2022	1	27	27.4.a	TL	35	241	1684979	0.0714
mac	2022	1	27	27.4.a	TL	36	392	2663419	0.1129
mac	2022	1	27	27.4.a	TL	37	576	4055936	0.1719
mac	2022	1	27	27.4.a	TL	38	626	4511764	0.1913
mac	2022	1	27	27.4.a	TL	39	481	3759345	0.1594
mac	2022	1	27	27.4.a	TL	40	256	1875541	0.0795
mac	2022	1	27	27.4.a	TL	41	92	770072	0.0326
mac	2022	1	27	27.4.a	TL	42	21	243746	0.0103
mac	2022	1	27	27.4.a	TL	43	2	7439	0.0003
mac	2022	1	27	27.4.a	TL	44	3	58790	0.0025
mac	2022	1	27	27.6.a	TL	17	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	18	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	19	1	4150	0.0003
mac	2022	1	27	27.6.a	TL	23	4	15424	0.0010
mac	2022	1	27	27.6.a	TL	24	5	30313	0.0020
mac	2022	1	27	27.6.a	TL	25	8	34891	0.0023
mac	2022	1	27	27.6.a	TL	26	12	85246	0.0057
mac	2022	1	27	27.6.a	TL	27	14	137644	0.0091
mac	2022	1	27	27.6.a	TL	28	24	273784	0.0182
mac	2022	1	27	27.6.a	TL	29	22	150308	0.0100
mac	2022	1	27	27.6.a	TL	30	45	398239	0.0265
mac	2022	1	27	27.6.a	TL	31	64	554722	0.0368
mac	2022	1	27	27.6.a	TL	32	84	782862	0.0520
mac	2022	1	27	27.6.a	TL	33	120	1156090	0.0768
mac	2022	1	27	27.6.a	TL	34	95	882994	0.0586
mac	2022	1	27	27.6.a	TL	35	115	1091725	0.0725
mac	2022	1	27	27.6.a	TL	36	105	1096835	0.0728
mac	2022	1	27	27.6.a	TL	37	209	2050525	0.1362

mac	2022	1	27	27.6.a	TL	38	274	2565070	0.1704
mac	2022	1	27	27.6.a	TL	39	214	2171710	0.1442
mac	2022	1	27	27.6.a	TL	40	117	1193579	0.0793
mac	2022	1	27	27.6.a	TL	41	29	282289	0.0187
mac	2022	1	27	27.6.a	TL	42	7	89517	0.0059
mac	2022	1	27	27.7.b	TL	20	3	34527	0.0034
mac	2022	1	27	27.7.b	TL	21	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	22	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	23	7	80563	0.0079
mac	2022	1	27	27.7.b	TL	24	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	25	5	57545	0.0056
mac	2022	1	27	27.7.b	TL	26	4	46036	0.0045
mac	2022	1	27	27.7.b	TL	27	4	35245	0.0035
mac	2022	1	27	27.7.b	TL	28	3	31860	0.0031
mac	2022	1	27	27.7.b	TL	29	7	84735	0.0083
mac	2022	1	27	27.7.b	TL	30	25	216377	0.0212
mac	2022	1	27	27.7.b	TL	31	24	196195	0.0192
mac	2022	1	27	27.7.b	TL	32	31	296552	0.0291
mac	2022	1	27	27.7.b	TL	33	45	315556	0.0310
mac	2022	1	27	27.7.b	TL	34	72	507485	0.0498
mac	2022	1	27	27.7.b	TL	35	162	1101891	0.1081
mac	2022	1	27	27.7.b	TL	36	203	1318078	0.1293
mac	2022	1	27	27.7.b	TL	37	201	1323574	0.1298
mac	2022	1	27	27.7.b	TL	38	270	1866023	0.1831
mac	2022	1	27	27.7.b	TL	39	211	1395078	0.1369
mac	2022	1	27	27.7.b	TL	40	110	751821	0.0738
mac	2022	1	27	27.7.b	TL	41	34	283483	0.0278
mac	2022	1	27	27.7.b	TL	42	6	46318	0.0045
mac	2022	1	27	27.7.b	TL	43	3	9300	0.0009
mac	2022	1	27	27.7.b	TL	44	1	10778	0.0011
mac	2022	1	27	27.7.j	TL	25	2	6604	0.0129
mac	2022	1	27	27.7.j	TL	26	1	3302	0.0064
mac	2022	1	27	27.7.j	TL	27	3	14565	0.0284
mac	2022	1	27	27.7.j	TL	28	6	20668	0.0403
mac	2022	1	27	27.7.j	TL	29	10	46168	0.0899
mac	2022	1	27	27.7.j	TL	30	20	74332	0.1448
mac	2022	1	27	27.7.j	TL	31	16	73536	0.1432
mac	2022	1	27	27.7.j	TL	32	13	59549	0.1160
mac	2022	1	27	27.7.j	TL	33	15	55851	0.1088
mac	2022	1	27	27.7.j	TL	34	15	44410	0.0865
mac	2022	1	27	27.7.j	TL	35	16	30610	0.0596
mac	2022	1	27	27.7.j	TL	36	17	21822	0.0425
mac	2022	1	27	27.7.j	TL	37	11	26273	0.0512
mac	2022	1	27	27.7.j	TL	38	8	18422	0.0359
mac	2022	1	27	27.7.j	TL	39	6	12616	0.0246
mac	2022	1	27	27.7.j	TL	40	3	4754	0.0093
mac	2022	2	27	27.6.a	TL	34	4	20848	0.1319
mac	2022	2	27	27.6.a	TL	35	5	31786	0.2011
mac	2022	2	27	27.6.a	TL	36	5	28235	0.1786
mac	2022	2	27	27.6.a	TL	37	6	27219	0.1722
mac	2022	2	27	27.6.a	TL	38	6	28043	0.1774
mac	2022	2	27	27.6.a	TL	39	3	14125	0.0894
mac	2022	2	27	27.6.a	TL	40	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	41	1	2102	0.0133
mac	2022	2	27	27.6.a	TL	42	1	3602	0.0228
mac	2022	3	27	27.4.a	TL	26	1	3261	0.0010
mac	2022	3	27	27.4.a	TL	29	9	102965	0.0330
mac	2022	3	27	27.4.a	TL	30	68	847404	0.2719
mac	2022	3	27	27.4.a	TL	31	65	831571	0.2668
mac	2022	3	27	27.4.a	TL	32	53	568987	0.1825
mac	2022	3	27	27.4.a	TL	33	36	409378	0.1313
mac	2022	3	27	27.4.a	TL	34	11	109308	0.0351
mac	2022	3	27	27.4.a	TL	35	4	54797	0.0176
mac	2022	3	27	27.4.a	TL	36	4	67573	0.0217
mac	2022	3	27	27.4.a	TL	37	5	74347	0.0239
mac	2022	3	27	27.4.a	TL	38	3	47380	0.0152
mac	2022	3	27	27.7.b	TL	32	1	873	0.0833
mac	2022	3	27	27.7.b	TL	34	5	4369	0.4168
mac	2022	3	27	27.7.b	TL	35	1	873	0.0833
mac	2022	3	27	27.7.b	TL	36	1	873	0.0833
mac	2022	3	27	27.7.b	TL	37	2	1747	0.1667
mac	2022	3	27	27.7.b	TL	38	1	873	0.0833
mac	2022	3	27	27.7.b	TL	40	1	873	0.0833
mac	2022	3	27	27.7.j	TL	31	1	4751	0.0457
mac	2022	3	27	27.7.j	TL	32	2	17221	0.1656
mac	2022	3	27	27.7.j	TL	33	1	12469	0.1199
mac	2022	3	27	27.7.j	TL	34	1	9293	0.0894
mac	2022	3	27	27.7.j	TL	35	3	14255	0.1371
mac	2022	3	27	27.7.j	TL	36	2	9503	0.0914
mac	2022	3	27	27.7.j	TL	37	1	13494	0.1298

mac	2022	3	27 27.7.j	TL	38	2 18246	0.1755
mac	2022	3	27 27.7.j	TL	39	1 4751	0.0457

North Sea mackerel daily egg production and spawning stock biomass estimation in 2021

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Introduction

The North Sea Mackerel Egg Survey (NSMEGS) is designed to estimate the spawning stock biomass (SSB) of mackerel of the North Sea spawning component of the Northeast-Atlantic stock on a triennial basis. Up to and including 2017 this was undertaken utilizing the annual egg production method (AEPM). This method estimates and combines total annual egg production (TAEP), realized fecundity per gram female, and sex (male to female) ratio to calculate SSB.

Spatial and temporal coverage in the North Sea was reduced with the withdrawal of Norway from the NSMEGS in 2014, with the Netherlands left as the sole survey participant in 2015 and 2017. In 2020 Denmark was recruited as a new participant for the NSMEGS, but due to the Covid-19 pandemic and the implementation of associated measures it was not possible to complete the survey in 2020. After consultation with WGMEGS chairs and the mackerel assessor it was agreed to postpone the survey to 2021.

An issue for the NSMEGS is that since 1982 it has been impossible to collect and sample pre-spawning mackerel, which are necessary in order to estimate the potential fecundity. For SSB estimation using the AEPM, the realized fecundity value used was from the 1982 estimate (Iversen and Adoff, 1983). Also, the planned coverage for 2020 (which was postponed to 2021) of the mackerel spawning in the North Sea, both temporally and spatially, was far from ideal for the Annual Egg Production Method (AEPM; ICES 2018). Consequently, WGMEGS discussed utilizing the Daily Egg Production Method (DEPM) for the NSMEGS. The DEPM requires only one full sweep, in a short time period, of the entire mackerel spawning area, and preferably during peak spawning time, in order to estimate the Daily Egg Production (DEP). A disadvantage of the DEPM is that it requires many more mackerel ovary samples to be collected to estimate batch fecundity and spawning fraction. Considering the pros and cons of the AEPM and DEPM for the NSMEGS, at the 2018 meeting WGMEGS decided to switch to the DEPM for the NSMEGS in 2020 (which was then postponed to 2021; ICES 2018).

Survey

In 2021 Netherlands and Denmark conducted the NSMEGS. Whilst completing an exploratory egg survey along the Norwegian Sea, similar to those in 2017 and 2018 to the west of Faroes, Scotland was also able to contribute several additional survey transects within the Northern North Sea that were then incorporated into the 2021 NSMEGS dataset.

During 2021, Covid 19 measures continued to pose significant challenges that impeded the execution of the survey plan. The Dutch vessel was not permitted to enter foreign harbours during survey breaks, instead being required to undertake the long steam back to a Dutch harbour. As a consequence the Netherlands was unable to sample the most northerly transect. However, Scotland was able to complete this transect during their exploratory survey.

The samples were collected and analysed according to the WGMEGS manuals (ICES 2019a, 2019b). The Netherlands and Scotland sampled eggs with a Gulf VII plankton sampler while Denmark used a Nackthai sampler. The Netherlands and Denmark utilised a 500 µm plankton net whereas Scotland used a 250 µm plankton net. At each station a double oblique haul was performed from the surface to 5 m above the bottom, a maximum depth of 200 m, or 20 m below the thermocline in case of stratification of the water column. Temperature and salinity were measured during the haul with a CTD mounted on top of the plankton sampler. Electronic flowmeters were mounted on the plankton sampler to monitor flow.

The NSMEGS was carried out from 25th May to 12th June (Table 1). During this period the spawning area between 53ºN and 62ºN was surveyed once, receiving a single coverage (Fig. 1). The survey is designed to cover the entire spawning area with samples collected every half ICES statistical rectangle (ICES, 2014). In total 294 plankton stations were sampled. In 26 of the half rectangles more than one plankton sample was collected (Fig. 1a). These rectangles were used to estimate the CV and variance of the DEP. On each transect at least one pelagic trawl haul was performed for the collection of mackerel adult samples (Fig. 1b).

Following the WGMEGS manual temperature at 5m depth was used to estimate egg development (ICES 2019a). For the DEPM only the mackerel eggs in development stage 1A are used to estimate daily egg production.

Results

Mackerel daily egg production

During the survey the weather was fine. Denmark and Scotland managed to sample all their planned plankton stations. The Netherlands missed 4 plankton stations due to technical issues and limited sampling time.

The spatial egg distribution is shown in Fig. 2. The standard MEGS interpolation rules (ICES, 2019a) were applied where needed (see interpolated stations in Fig. 2). The interpolated egg production accounted for 7.3% of the DEP. The egg distribution is comparable to previous surveys in the same area and period, with the highest numbers of eggs found in the south western area. Previous surveys did not sample above 59ºN and no comparison with previous years is available for this area.

The DEP was calculated for the total investigated area (Table 2). For comparison with the previous survey, a DEP was also calculated for the area between 53.5 and 59ºN and 0.5ºW and 5.5ºE, which was the area sampled in 2017 in the same period of the year (extended period 2 of 2017; see Fig. 2 for sampled area in 2017). DEP of 2021 was 10% higher compared to 2017 (Table 3), however the sampled area in 2021 was also larger (9%) due to coastal stations not sampled or interpolated in 2017.

Adult parameters

Denmark sampled 817 mackerel and collected ovary samples of 119 females. Of these 34 were suitable for estimating batch fecundity, and 112 for POF analyses for spawning fraction estimation. The Netherlands sampled 524 mackerel during the survey and collected ovary samples of 164 females. Of these 164 ovaries 73 qualified for batch fecundity estimation, and 108 for POF analyses.

Denmark did not deliver the results of the batch fecundity and POF analyses. In agreement with the chairs of WGMEGS, the DEPM adult parameters were therefore estimated with the data provided by the Netherlands. Adult parameters are presented in Table 4.

Of the samples analysed for batch fecundity 54 could be used for batch fecundity estimation. In these samples the batch was clearly separated from the standing stock of vitellogenic oocytes. In the remaining 19 samples the new batch of oocytes was not separated from the standing stock. Batch fecundity was 18735 eggs (Table 4). This is higher compared to the estimate of 12391 in the Atlantic in 2019 (ICES, 2021). Corrected female weight was lower compared to the Atlantic in 2019, 331 and 346 grammes respectively. Spawning fraction in the North Sea was 18%, while this was 23% in the Atlantic in 2019. Sex ratio was 0.53 and this was similar compared to the Atlantic.

SSB

Using the stage 1A (stage duration of 1A is 1 day) egg data and the estimated adult parameters, the DEP for the entire sampled area in 2021 amounts to an SSB of 2380 * 10^3 tonnes (Table 4). This estimate is an order of magnitude higher compared to the estimates of previous surveys in the North Sea using the AEPM. The SSB estimated in 2017 using the AEPM was 287 * 10^3 tonnes.

The total area sampled in 2021 was much larger compared to the area sampled in 2017 (Fig. 2). In 2017 sampling was only conducted south of 59ºN. In 2021 sampling was carried out as far as 62ºN with substantial numbers of eggs being found in this northern area (Fig. 2). In the area above 59ºN there maybe overlap with the western component.

For comparison between 2021 and 2017 a DEPM estimation of SSB was done using the egg production in the area between 53.5 and 59ºN. No adult parameters were available for 2017, so these were assumed to be same as in 2021. The SSB in the area between 53.5 and 59ºN is substantially lower compared to the entire sampled area in 2021 and would be 915 * 10^3 tonnes (Table 5). In 2017 the SSB would be 821 * 10^3 tonnes. For 2017 this is 3 times higher compared to the AEPM estimate of 287 * 10^3 tonnes. Kraus *et al*. (2012) and Köster *et al*. (2020) compared the AEPM and DEPM methods for a time-series of cod in the Baltic. They found the trend and SSB in most years were similar using both methods and similar to the ICES estimate of SSB. However, in years with high SSB the two methods diverged (Kraus *et al*. 2012, Köster *et al*. 2020).

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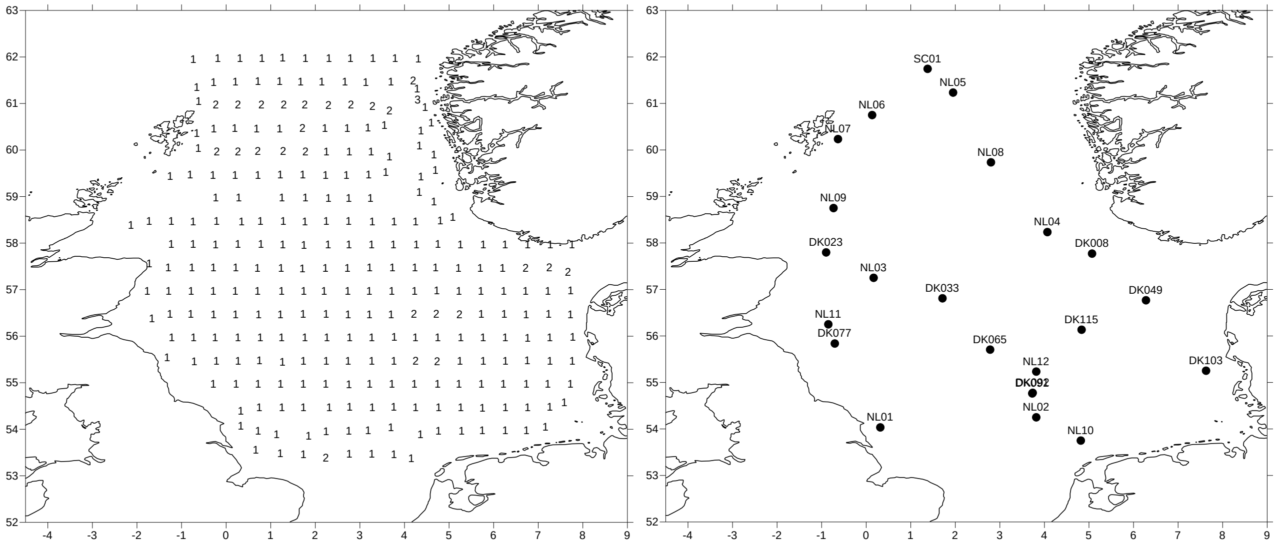

Figure 1. Number of samples for NSMEGS 2021; plankton samples per half ICES rectangle (left) and pelagic trawl hauls for mackerel adult samples (right; all hauls included).

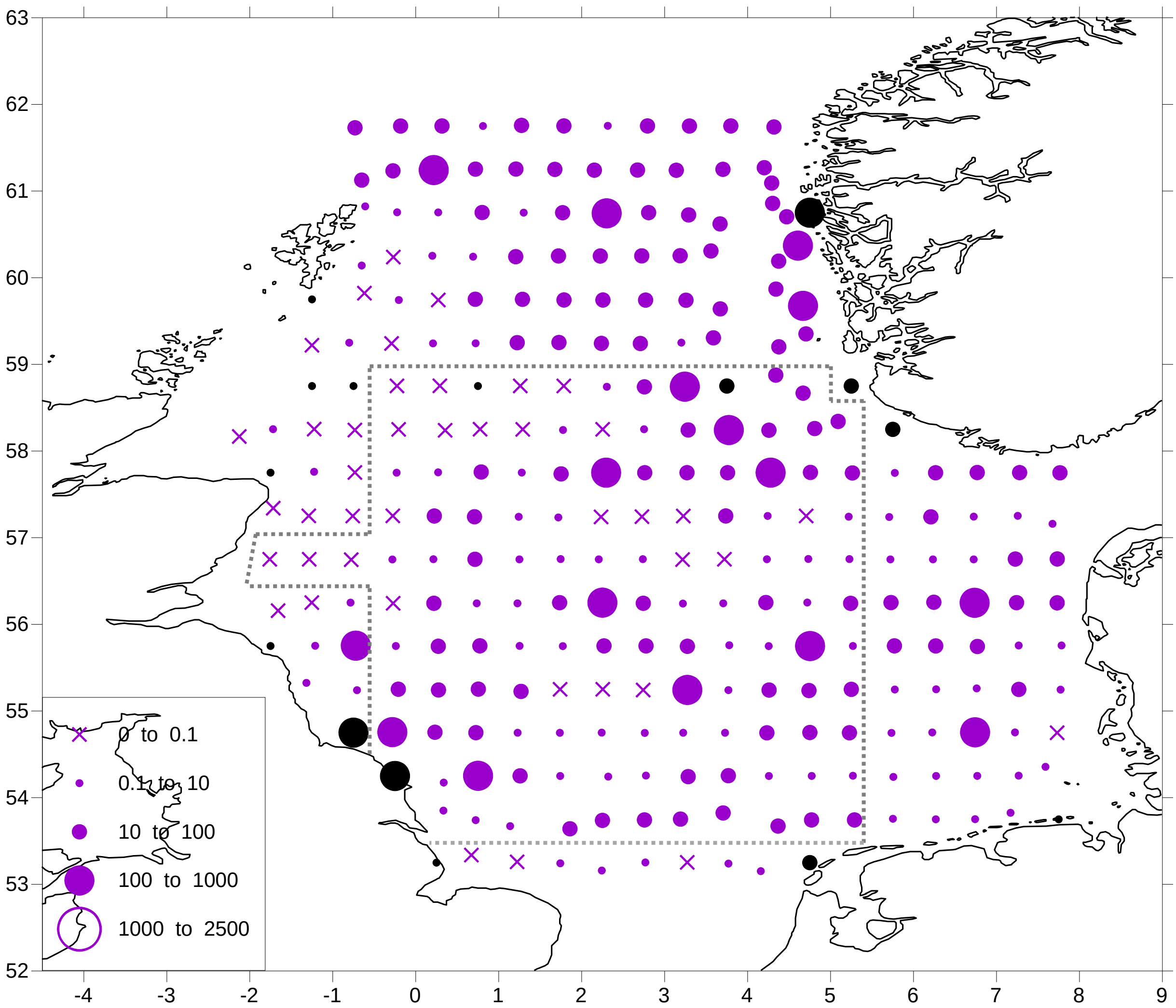

Figure 2. Stage 1A mackerel egg production (eggs/m^2/day) by half rectangle for NSMEGS 2021. Purple circles represent observed values, black circles represent interpolated values, and crosses represent

observed zeros. Dashed line shows sampled area in extended period 2 in 2017 which was used for comparison calculation between the years.

Table 1. NSMEGS surveys cruise dates in 2021 (For Scotland only stations used in the NSMEGS DEP calculation are shown.)

Country	**NL**	**DK**	**SCO**
Period	1	1	1
Dates	25.05-12.06	31.05-9.06	8.06-11.06
Plankton stations sampled	174	91	29
Pelagic trawl hauls	12	10	1

Table 2. Daily egg production estimate (stage 1A) in the North Sea.

Year	**DEP $*10^{13}$**	**CV DEP**
2021	1.28	16%

Table 3. Comparison of Daily Egg production (stage 1) between 2021 and 2017, in the area between 53.5 and 59ºN.

Year	**2021**	**2017 Extended period 2**
DEP $*10^{12}$	4.94	4.43
Area sampled ($* 10^{11}$ m^2)	2.25	2.01

Table 4. Adult parameters and SSB.

Year	**2021**
Batch fecundity	18735
Relative batch fecundity (N/g)	42.7
CV Batch fecundity	0.87
Spawning fraction	0.18
Sex ratio	0.53
Female weight (g)	331.4
SSB ($* 10^3$ tonnes)	2380

Table 5. Comparisons EPM calculation of stage 1 eggs between 2021 and 2017 (extended period 2). (For 2017 the same batch fecundity, S and R are used as for 2021, as these data were not available for 2017.)

Year	**DEP $*10^{12}$**	**SSB ($*10^{3)}$ tonnes**		
		AEPM	**DEPM (below 59⁰N)**	**DEPM (total area)**
2021	4.94	-	915	2380
2017 Extended period 2	4.43	287	821	-

DISTRIBUTION AND ABUNDANCE OF NORWEGIAN SPRING-SPAWNING HERRING DURING THE SPAWNING SEASON IN 2022

Author(s): Are Salthaug, Erling Kåre Stenevik, Sindre Vatnehol and Aril Slotte (IMR)
Cruise leader(s): Are Salthaug and Erling Kåre Stenevik (IMR)

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Summary (English):

During the period 14-27th of February 2022 the spawning grounds of Norwegian spring-spawning herring from Møre (62º15´N) to Troms (71ºN) were covered acoustically by the commercial vessels MS Eros and MS Vendla. The estimated biomass was about 18 % lower, and the estimated total number was about 29 % lower this year compared to the last year's survey. The uncertainty of the estimates in 2022 was approximately equal to last year. The surveyed population of NSS herring was dominated by the 2016 year class; 52 % in numbers and 46 % in biomass. The 2016 year class was reduced by 37 % in numbers from last year's survey. Most of the spawning stock was found outside Lofoten and Vesterålen this year, further north and more concentrated than usual. The observed maturity indicates a bit later spawning compared to last year and like last year a more northern spawning than normal. As usual, the herring in the southern part of the spawning area were older than those found in the northern part. The estimates of relative abundance from the survey in 2022 are recommended to be used in this year's ICES stock assessment of Norwegian spring-spawning herring.

Summary (Norwegian):

I perioden 14. - 27. Februar 2022 ble gytefeltene til norsk vårgytende sild fra Møre (62º15´N) til Troms (71ºN) dekket akustisk med de kommersielle fartøyene MS Eros og MS Vendla. Den estimerte biomassen var omtrent 18 % lavere, og det estimerte antallet omtrent 29 % lavere sammenlignet med fjorårets tokt. Usikkerheten i årets estimat er på samme nivå som i fjor. Gytebestanden var dominert av 2016-årsklassen med 52 % i antall og 46 % i vekt. Sammenlignet med toktet i fjor var antallet av 2016-årsklassen redusert med 37 %. Mesteparten av gytebestanden befant seg vest av Lofoten og Vesterålen i år. Sammenlignet med tidligere år stod silda lenger nord og var mer konsentrert. Sammenlignet med toktet i fjor var silda kommet noe senere i modningsprosessen i år. I likhet med tidligere år så var det mer eldre sild i den sørlige delen av gyteområdet og silda i nord var yngre. Det anbefales å bruke estimatene av relativ mengde fra toktet i 2022 i ICES sin bestandsvurdering av norsk vårgytende sild.

Content

1 - Introduction

Acoustic surveys on Norwegian spring-spawning herring during the spawning season has been carried out regularly since 1988, with some breaks (in 1992-1993, 1997, 2001-2004 and 2009-2014). In 2015 the survey was initiated again partly based on the feedback from fishermen and fishermen’s organizations that IMR should conduct more surveys on this commercially important stock. Since then this survey, hereafter termed the NSSH spawning survey, has continued using hired commercial fishing vessels. In the ICES benchmark assessment of NSS herring in 2016 it was decided to use the data from this time series as input to the stock assessment, together with the ecosystem survey in the Norwegian Sea in May and catch data. Thus, the results from the NSSH spawning survey, have significant influence on the ICES catch advice.

The objective of the NSSH spawning survey 2022 was to continue the time series of abundance estimates, both mean estimates and uncertainty, for use in the ICES WGWIDE stock assessment. Moreover, other biological information about the surveyed spawning stock of Norwegian spring-spawning herring is also presented: spatial distribution of biomass and acoustic densities, total biomass and stock numbers with sample uncertainty, spatial patterns in age and maturity and variations in temperature.

2 - Material and methods

2.1 - Survey design

During the period 14-27th of February 2022 (same period as in 2017-2021) the spawning grounds from Møre (62º15´N) to Troms (71ºN) were covered acoustically by the commercial fishing vessels MS *Eros* and MS *Vendla*. The survey was planned based on information from the previous spawning cruises and the distribution of the herring fishery during the autumn 2021 up to the survey start February 14th 2022 (Figure 1). The fishery prior to the survey in 2022 indicated that the herring wintering in the Norwegian Sea were entering the coast in the Træna deep south of Røst as observed in previous years. However, unlike previous years the fishery did not move south of Røst before the survey started. Like in the last winter season an extensive fishery in October-February 2021/2022 occurred along the continental slope north of Andenes in addition to the fishery in the Kvænangen fjord area that also have been taking place the five previous years. Biological samples from catches from the northern fishery indicate that the 2016 year class dominated in this area. The survey coverage was therefore planned to also take account of a potentially large flux of herring entering the spawning area from the north. As seen from Figure 1, the fishery during the survey in 2022 mainly took place between Røst and Træna (66.3-67.4°N) which is farther north than usual at this time.

The survey design followed a standard stratified design (Jolly and Hampton 1990), where the survey area was stratified before the survey start according to the assumed density structures of herring during the spawning migration (based on previous surveys and fisheries). All strata except the northernmost one were covered with a zigzag design since this is the most efficient use of survey effort (Harbitz 2019). The survey planner function in the Rstox_1.11 package in r was used to generate the transects, and this function generates survey tracks with uniform coverage of strata and a random starting position in the start of each stratum. Each straight line in the zigzag track within a stratum was considered as a transect and a primary sampling unit (Simmonds and MacLennan 2005). Transit tracks between strata, i.e. from the end of the zigzag in one stratum to the start of the zigzag in the next stratum, were not used as primary sampling units. At the start of the survey in 2022 the fishing fleet was located west of Røst and it was estimated that the fleet had moved south to the Træna area around 66.5°N when the survey entered this area. Hence, the survey coverage (see Aglen 1989) was planned to be relatively low south of 65°N since it was assumed that the fishing fleet followed the front of the herring migrating south and that the abundance of herring south of the fleet therefore was insignificant.

2.2 - Biological sampling

Trawl sampling was planned to be carried out on a regular basis during the survey to confirm the acoustic observations and to be able to give estimates of abundance for different size and age groups. Both vessels used a Multpelt 832 scientific sampling trawl with small meshed (20 mm) inner net in the codend and a slit (so called “splitt”) close to the codend to avoid too large catches. The following variables of individual herring were analysed from each station with herring catch: total weight in grams and total length in cm (rounded down to the nearest 0.5 cm) of up to 100 individuals per sample. In addition, age from scales, sex, maturity stage, stomach fullness and gonad weight in grams were measured in up to 50 individuals per sample. Some genetic samples and otoliths were also collected to be used in later research projects.

2.3 - Additional data collection

CTD casts (using Seabird 911 systems) were taken by both vessels, spread out haphazardly in the survey area. ADCP data was recorded on Eros as described in Annex 2 in Salthaug et al. (2020). These data will later be used to analyse swimming speed and direction of herring below the vessel.

2.4 - Acoustic data processing

Echosounder data from the 38 kHz transducers was, as usual, the basis for measurement of fish density. The software

LSSS version 2.12.0 was use for post-processing. Echogram scrutinization was carried out by the cruise leader and the chief instrument officer. Data was partitioned into the following categories: “herring”, “other” and “air bubbles” (upper 20 meters from the transducer near field).

2.5 - Abundance estimation methods

The acoustic density values were stored by species category in nautical area scattering coefficient (NASC) [m^2 $n.mi.^{-2}$] units (MacLennan et al. 2002) in a database with a horizontal resolution of 0.1 nmi and a vertical resolution of 10 m, referenced to the sea surface. To estimate the mean and variance of NASC, we use the methods established by Jolly and Hampton (1990) and implemented in the software Stox version 3.3 (Johnsen et al. 2019). The primary sampling unit is the sum of all elementary NASC samples of herring along the transect multiplied with the resolution distance. The transect (*t*) has NASC value (*s)* and distance length *L* . The average NASC (S) in a stratum (*i*) is then:

$$\hat{S}_i = \frac{1}{n_i} \cdot \sum_{i=1}^{n_i} w_{it} s_{it} \quad (1)$$

where $w_{it} = L_{it} / L_t$ (t= 1,2,.. n_i) are the lengths of the n_i sample transects, and

$$L_i = \frac{1}{n_i} \sum_{t=1}^{n_i} L_{it} \quad (2)$$

The final mean NASC is given by weighting by stratum area, A;

$$\hat{S} = \frac{\sum_i A_i \hat{S}_i}{\sum_i A_i} \quad (3)$$

Variance by stratum is estimated as:

$$\hat{V}\left(\hat{S}_i\right) = \frac{n}{n_i - 1} \sum_{t=1}^{n} w_{it}^2 \left(s_t - \bar{s}\right)^2 \text{ with } \bar{s}_i = \frac{1}{n_i} \cdot \sum_{t=1}^{n_i} s_t \quad (4)$$

Where $w_{it} = L_{it} / L_t$ (t= 1,2,.. n_i) are the lengths of the n_i sample transects.

The global variance is estimated as

$$\hat{V}(\hat{S}) = \frac{\sum_i A_{i=1}^2 \hat{V}(\hat{S})}{\left(\sum_i A\right)^2} \quad (5)$$

The global relative standard error of NASC

$$RSE = 100 \sqrt{\frac{\hat{V}(\hat{S})}{N}} / \hat{S} \quad (6)$$

where N is number of strata.

In order to verify acoustic observations and to analyse year class structure over the surveyed area, trawling was carried out regularly along the transects. All trawl stations with herring were used to derive a common length distribution for all transect within the respective strata. All stations had equal weight.

Relative standard error by number of individuals by age group was estimated by combining Monto Carlo selection from estimated NASC distributions by stratum with bootstrapping techniques of the assigned trawl stations.

The acoustic estimates presented in this report use the 38 kHz NASC, and the mean was calculated for data scrutinized as herring and collected along the transects (acoustic recordings taken during trawling, and for experimental activity are excluded). The number of herring (*N*) in each length group (*l*) within each stratum (*i*) is then computed as:

$$N_l = \frac{f_l \cdot \hat{S}_i \cdot A_i}{\langle \sigma \rangle}$$

Where

$$f_l = \frac{n_l L_i^2}{\sum_{l=1}^{m} n_l L_l}$$

is the "acoustic contribution" from the length group L_l to the total energy and $\langle s_i \rangle$is the mean nautical area scattering coefficient [m^2/nmi^2] (NASC) of the stratum. A is the area of the stratum [nmi^2] and σ is the mean backscattering cross section at length L_l . The conversion from number of fish by length group (*l)* to number by age is done by estimating an age ratio from the individuals of length group *(l)* with age measurements. Similar, the mean weight by length and age grouped is estimated.

The mean target strength (TS) is used for the conversion where $\sigma = 4\pi\ 10^{(TS/10)}$ is used for estimating the mean backscattering cross section. Traditionally, TS = 20logL – 71.9 (Foote 1987) has been used for mean target strength of herring during the spawning surveys, however, several papers question this mean target strength. Ona (2003) describes how the target strength of herring may change with changes with depth, due to swimbladder compression. He measured the mean target strength of herring to be TS = 20logL – 2.3 log(1 + z/10) – 65.4 where z is depth in meters. Given that previous surveys were estimated using Foote (1987), the estimation this year was also done with this TS, for direct comparison and possible inclusion in the stock assessment by ICES WGWIDE 2021 as another year in the time series.

3 - Results and discussion

3.1 - Survey coverage

The cruise tracks of the NSSH spawning survey in 2022, together with pelagic trawl stations and CTD stations are shown in Figure 2. As mentioned above, the coverage south of 65°N was fairly low since we expected low abundance in this area, which turned out to be the case (see below). Thus, most of the available survey effort was used to carry out dense coverage of the strata north of 65°N. The survey coverage (see Aglen 1989) of the first three strata was 5, 7 and 9 respectively (starting from south) and 11 in the four next strata with zigzag transects. The northernmost stratum with parallel transects had a survey coverage of 9. Pelagic trawl hauls were carried out regularly (Fig. 2) in the areas where herring like marks were observed on the echo sounder, to confirm the acoustic observations based on species composition in the catch and to obtain biological samples like size, maturity stage and age of herring. A total of 34 CTD casts were carried out in the surveyed area (Fig. 2). Nautical area scattering coefficients (NASC) allocated to herring from acoustic transects by each nautical mile are shown in Figure 3. Significant herring marks on the echosounders started to occur slightly north of 66°N, which is unusually far north in mid-February, and herring was observed in the entire area north of this. South of Lofoten the herring was mainly distributed around the shelf edge of the Røst bank, but outside Lofoten and Vesterålen herring was also observed on the banks nearer land. North of Vesterålen the herring was distributed along the shelf edge as usual, and the zero-line was established in the north around 70.9°N. Capelin marks started to appear around 69.7°N (confirmed by trawl samples) and was observed regularly north of this, in particular around the shelf edge area in the northernmost part. The herring schools appeared to be deeper and clearly separated from the more shallow capelin schools, an observation that the trawl sampling also supported. No more capelin results are presented in this report as the focus is on herring.

3.2 - Estimates of abundance

The abundance estimates from this survey are viewed as relative, i.e. as indices of abundance, since there are highly uncertain scaling parameters like acoustic target strength and compensation for herring migrating in the opposite direction of the survey. The abundance estimates are shown in Table 1 and 2. The 2016 year class (age 6) dominated both in numbers (52 %) and biomass (46 %), followed by the 2013 year class (age 9) which contributed 12 % in numbers and 15 % in biomass. Compared with the point estimates from last year (see Salthaug et al. 2021) the 2016 year class was reduced by 37 % in numbers and the 2013 year class by 22 %. The point estimate of total stock biomass (TSB) in the survey area was 3.302 million tons which is 18 % lower than last year's estimate (mean of 1000 bootstrap replicates). The time series of total stock biomass from the survey is shown in Figure 4. The point estimate of total stock number (TSN) in the survey area was 12.2 billion which is 29 % lower than last year's estimate. The time series of total stock number from the survey is shown in Figure 5. This year's estimates of TSB and TSN are slightly below the respective means of the time series. The relative standard error (CV) of the TSB and TSN estimates in 2021 are both 17 % (Tab. 1 and 2). These estimates of sample uncertainty are quite similar to those from the two previous surveys. The CV per age (Tab.1 and 2) shows the normal pattern with high uncertainty for the very young and old year classes and moderate (20-30 %) for the most abundant ages in the survey. Figure 6 shows estimates of number per year class in the eight most recent surveys. The estimated numbers from the survey in 2022 seems to decline as excepted for the year classes that are fully recruited to the survey. In addition, like in the most recent surveys the 2016 and 2013 year classes are estimated to be the most abundant which shows that this survey is internally consistent. Mean weight and length from the 2021 spawning survey are shown in Table 3. The Stox project used to calculate abundance and related parameters is openly available and can be found here:

http://metadata.nmdc.no/metadata-api/landingpage/2870f9f21da64f3a01641dfe12512b33

3.3 - Spatial distribution of the stock

The relative distribution of the estimated biomass per stratum is shown in Figure 7. This year most of the biomass

(84%) was found in the two strata west of Lofoten and Vesterålen, while only a small fraction was found in the strata to the north and south of these. The spawning stock was much more concentrated and further north than usual this year. Age compositions per stratum are shown in Figure 8. The southernmost stratum where herring was recorded was dominated by herring older than eight years, which is consistent with earlier observations; the largest and oldest fish are in the front of the spawning migration. The 2016 year class dominated in the rest of the strata, and the proportion of younger herring was as usual highest in the north.

The pattern with large and old fish in the southern part of the spawning area and younger and older herring in the north has been thoroughly discussed in Slotte and Dommasnes, 1997, 1998, 1999, 2000; Slotte, 1998b; Slotte, 1999a, Slotte 2001, Slotte et al. 2000, Slotte & Tangen 2005, 2006). The main hypothesis is that this could be due to the high energetic costs of migration, which is relatively higher in small compared to larger fish (Slotte, 1999b). Large fish and fish in better condition will have a higher migration potential and more energy to invest in gonad production and thus the optimal spawning grounds will be found farther south (Slotte and Fiksen, 2000), due to the higher temperatures of the hatched larvae drifting northwards and potentially better timing to the spring bloom (Vikebø et al. 2012).

Figure 9 shows the proportion of different maturation stages in each stratum. Most of the herring was classified as maturing or ripe, and the proportions of maturing herring were larger than last year which indicates later spawning this year. The old herring in the southernmost stratum was dominated by maturing individuals indicating that these fish would swim further south before spawning. The fishery also indicated that this was the case since catches moved further south after the survey covered the area (see Fig. 1). A small fraction of the herring outside Lofoten and Vesterålen were spawning and this, together with the large proportion of ripe individuals, indicate that much of the 2016 year class spawned in this area. Like last year this shows a very northern spawning this year, which also was confirmed through the fishery that was very low at the historically important spawning grounds off Møre.

3.4 - Geographical variation in temperatures experienced by the herring

Temperatures experienced by herring from close to the surface and down to 250 m are shown in Figure 10 for the areas south and north of 67ºN, for the years after 2016 when the survey has been carried out in the same period (latter half of February). The temperatures in 2022 varied from 7.7°C at 250 m depth south of 67 ∞ N to 5.4°C at 5 m depth north of 67ºN. The temperatures near the surface were quite low this year, and also varied more with depth compared to earlier years. At typical spawning depths of herring at 100-200 m depth, the temperature conditions were quite similar to those observed during the most recent NSSH spawning surveys.

3.5 - Quality of the survey

In 2022 both vessels were equipped with multifrequency equipment on a drop keel. The weather conditions were exceptionally good this year so that acoustic data with good quality was recorded and trawling on registrations could be carried out all of the time. No correction for air bubble attenuation (as described in Annex 3 in Slotte et al. 2019) had to be carried out this year due to the nice weather. As opposed to last year the zero line was clearly established in the north, and we are not aware of any observations that indicates presence of mature NSS herring outside the survey area during the survey this year. To conclude, the acoustic and biological data recorded in 2022 on the NSSH spawning survey were of satisfactory quality and the estimates from the survey are recommended to be used in the stock assessment of Norwegian spring-spawning herring in 2022.

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5 - Tables

Table 1. Abundance estimates (mill ion individuals) of Norwegian spring-spawning herring during the spawning survey 14.-27. February 2022 , based on 1000 bootstrap replicates.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
2	1	23	62	27	19	0.72
3	13	71	134	72	36	0.50
4	51	154	310	162	78	0.48
5	406	738	1148	760	234	0.31
6	4473	6314	8475	6393	1256	0.20
7	205	308	458	317	76	0.24
8	377	557	788	563	126	0.22
9	1066	1500	2063	1515	298	0.20
10	174	294	458	301	89	0.30
11	303	477	707	486	122	0.25
12	175	297	439	301	79	0.26
13	137	247	393	255	80	0.31
14	206	380	584	385	119	0.31
15	37	71	122	73	26	0.36
16	227	384	602	395	117	0.30
17	18	52	109	57	29	0.50
18	36	86	157	89	37	0.41
20	0	13	42	15	15	1.04
TSN	8910	12126	15591	12183	2051	0.17

Table 2 . Abundance estimates (thousand tons) of Norwegian spring-spawning herring during the spawning survey 14.-27. February 2022 , based on 1000 bootstrap replicates.

Age	**5th percentile**	**Median**	**95th percentile**	**Mean**	**SD**	**CV**
2	0	1	4	2	1	0.77
3	1	8	18	9	5	0.59
4	7	23	44	24	11	0.48
5	76	131	204	136	41	0.30
6	1083	1511	2035	1533	303	0.20
7	57	87	128	89	22	0.24
8	115	169	239	171	38	0.22
9	336	478	660	481	96	0.20
10	58	102	160	104	31	0.30
11	104	165	245	168	42	0.25
12	64	108	158	109	29	0.26
13	51	92	147	95	30	0.32
14	75	138	213	140	43	0.31
15	14	27	46	28	10	0.36

Age	5th percentile	Median	95th percentile	Mean	SD	CV
16	87	148	232	151	45	0.30
17	6	19	41	21	11	0.51
18	13	33	60	34	14	0.41
20	0	5	16	6	6	1.03
TSB	2424	3291	4246	3302	557	0.17

Table 3 . Estimated length and weight of individuals by age group of Norwegian spring-spawning herring during the spawning survey 14.-27. February 2022 , based on 1000 bootstrap replicates.

Age	mean weight (g)	CV weight	mean length (cm)	CV length
2	56.7	0.063	21.2	0.017
3	105.7	0.230	24.9	0.053
4	137.6	0.066	27.4	0.017
5	171.3	0.026	29.1	0.006
6	230.0	0.012	31.3	0.003
7	277.0	0.021	33.0	0.005
8	301.1	0.018	34.1	0.005
9	315.2	0.010	34.3	0.003
10	343.4	0.018	35.6	0.007
11	342.3	0.019	35.6	0.006
12	362.1	0.017	36.6	0.003
13	371.7	0.021	36.9	0.004
14	362.5	0.017	36.5	0.005
15	373.7	0.023	37.1	0.006
16	380.9	0.014	37.2	0.003
17	362.5	0.037	37.3	0.008
18	379.1	0.024	37.1	0.011
20	387.6	0.032	37.0	0.000

6 - Figures

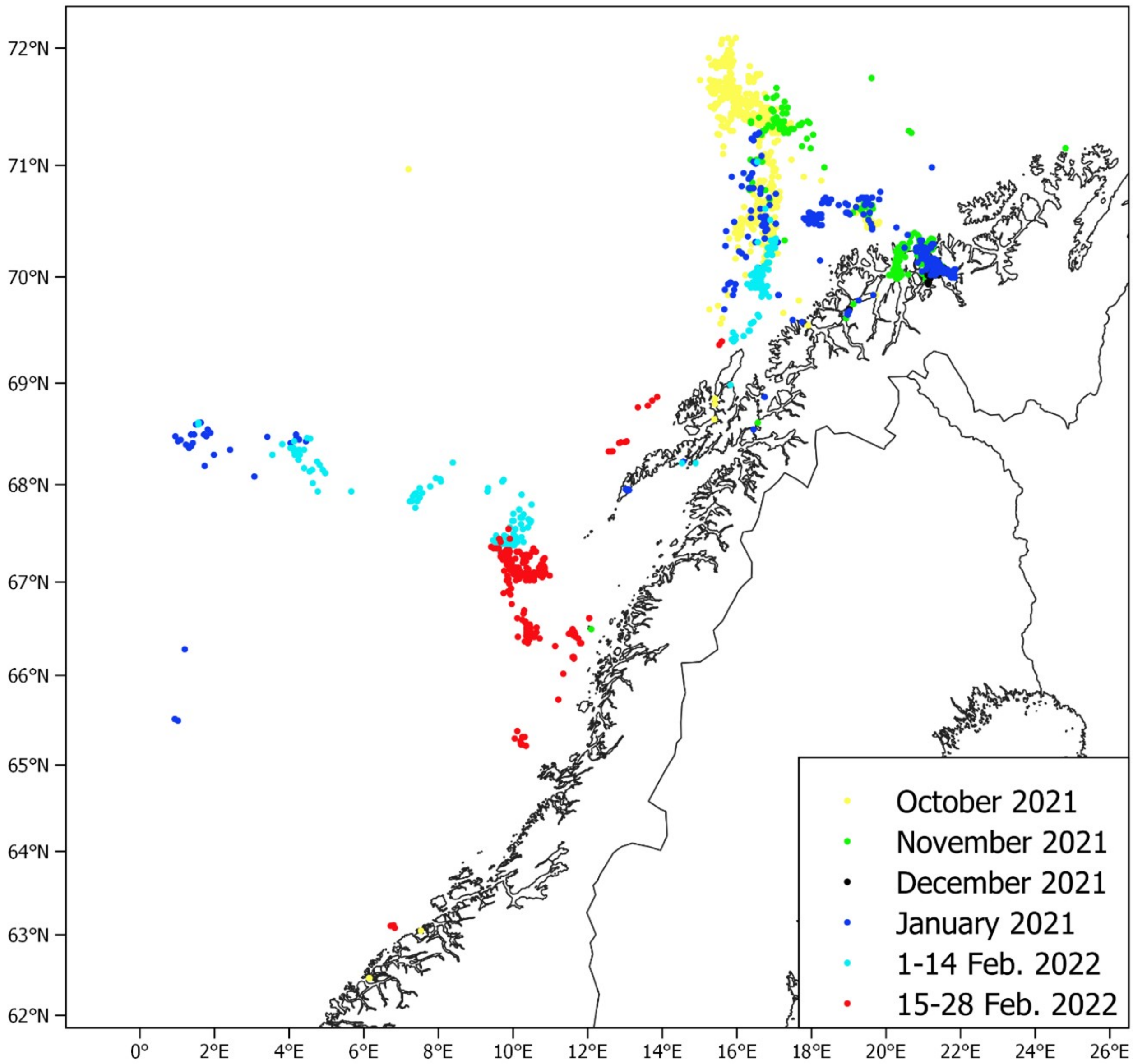

Figure 1. Distribution of commercial catches of Norwegian spring-spawning herring from October 2021 until February 2022, based on electronic logbooks. Each point represent one catch, only catches larger than 10 tons are shown.

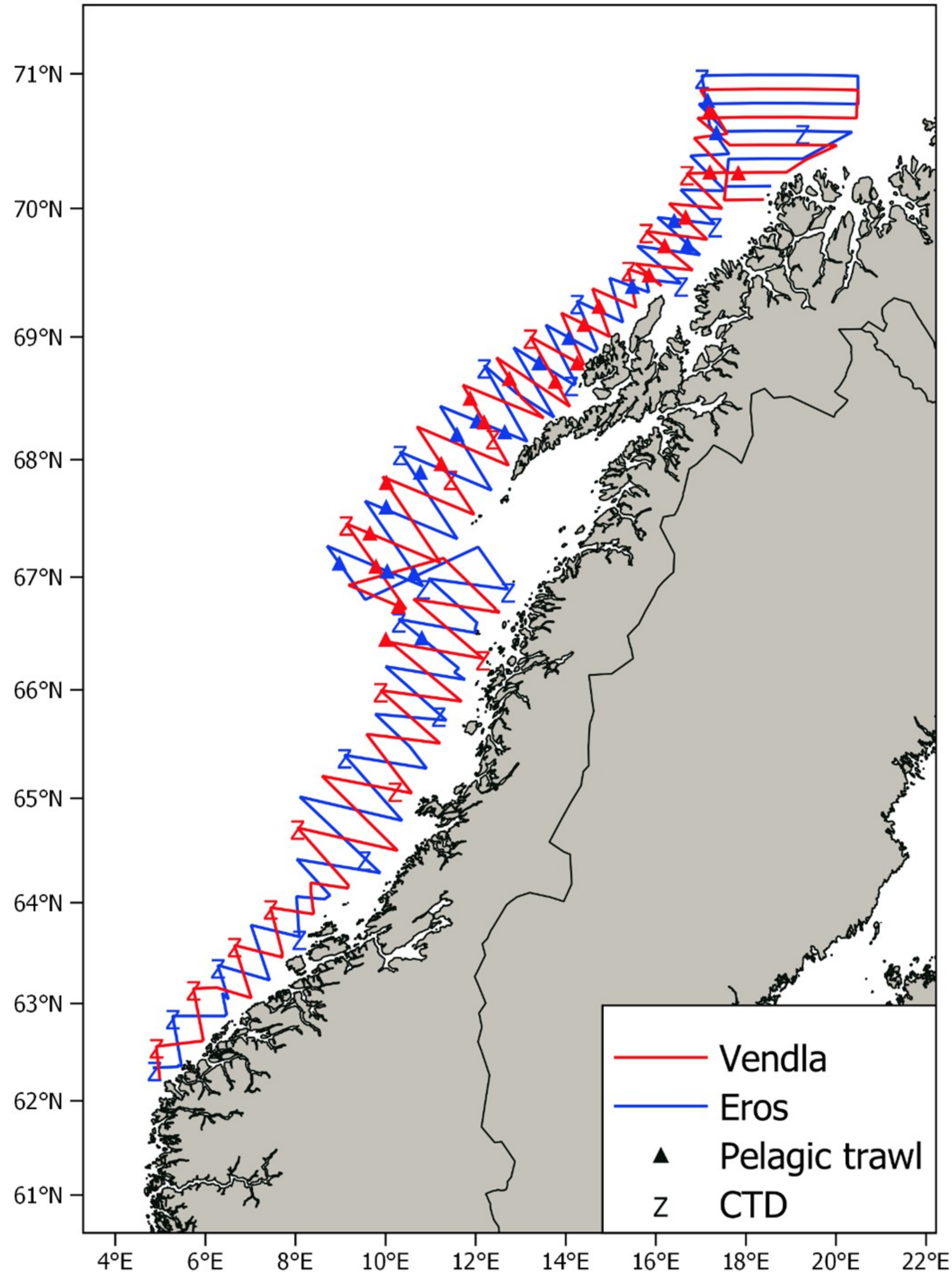

Figure. 2. Cruise tracks (mostly acoustic transects), pelagic trawl stations (triangles), and CTD stations (Z) covered by Eros and Vendla on the Norwegian spring-spawning herring spawning survey 14.-27. February 2022.

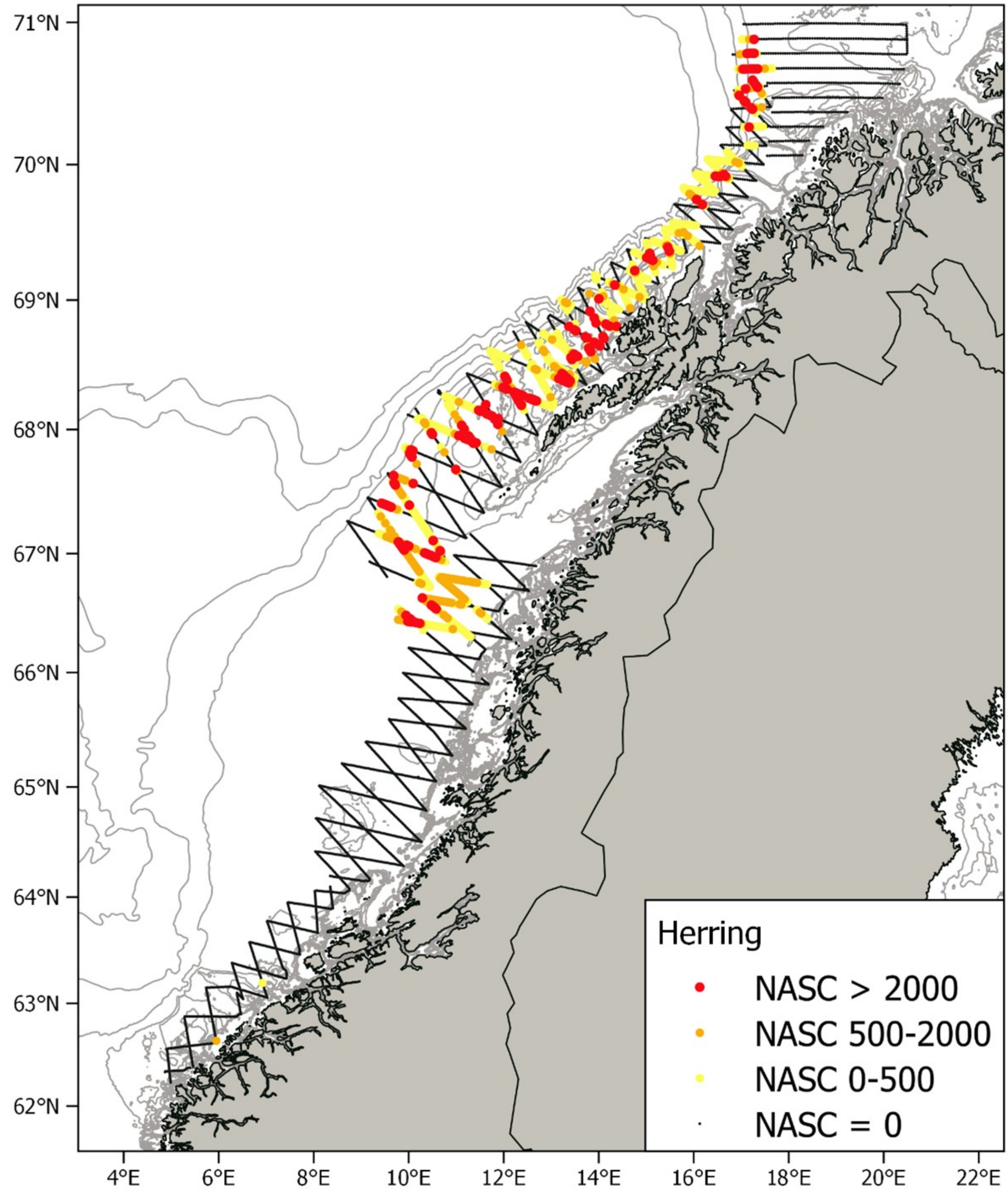

Figure 3. Acoustic densities (NASC) of herring recorded during the Norwegian spring-spawning herring spawning survey 14.-27. February 2022. Points represent NASC values per nautical mile. Depth contours are shown for 50 m, 100 m, 150 m, 200 m, 500 m, 1000 m, 1500 m and 2000 m.

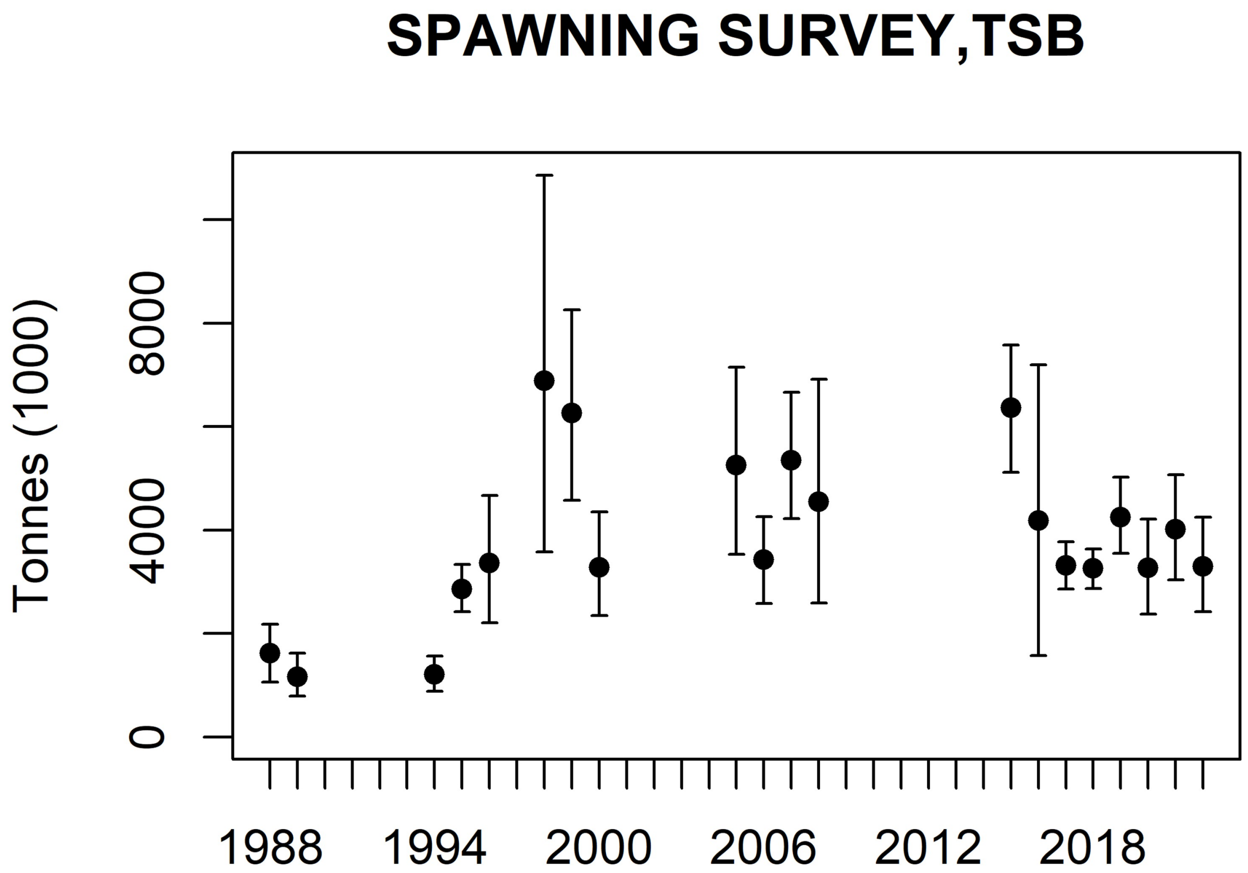

Figure 4. Estimates of total biomass from the Norwegian spring-spawning herring spawning surveys during1988-2022. The estimates are mean of 1000 bootstrap replicates and the error bars represent 90 % confidence intervals.

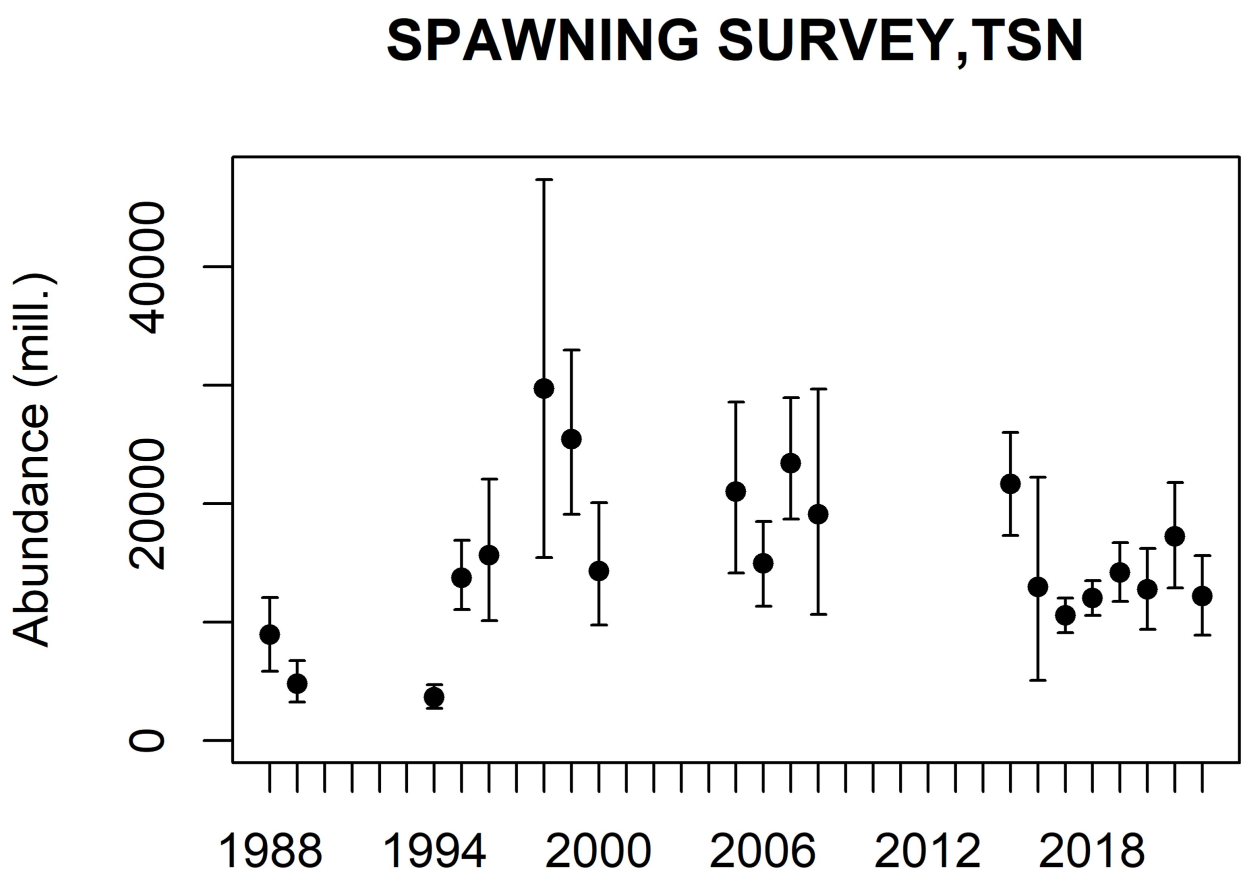

Figure 5. Estimates of total number from the Norwegian spring-spawning herring spawning surveys during1988-2022. The estimates are mean of 1000 bootstrap replicates and the error bars represent 90 % confidence intervals.

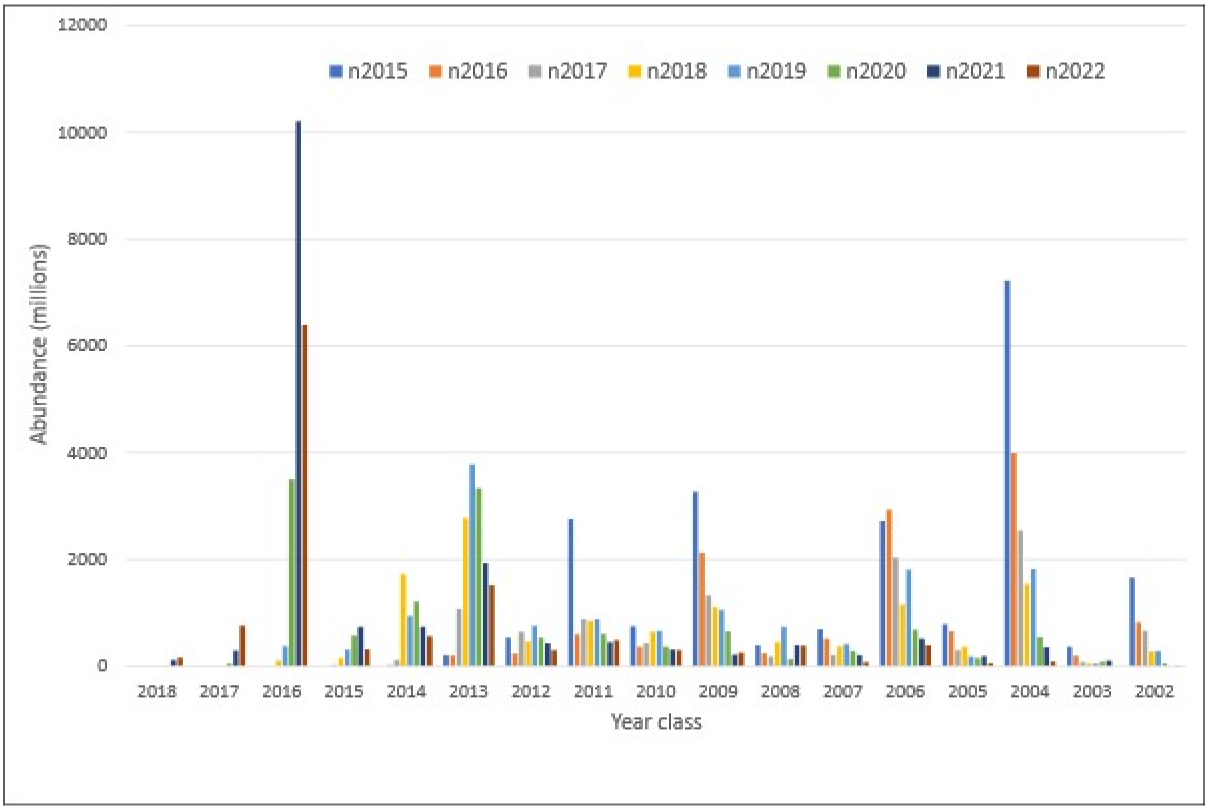

Figure 6. Abundance by year class estimated during the Norwegian spring-spawning herring spawning surveys 2015-2022 (mean of 1000 bootstrap replicates). Legend: Separate colour for each survey year.

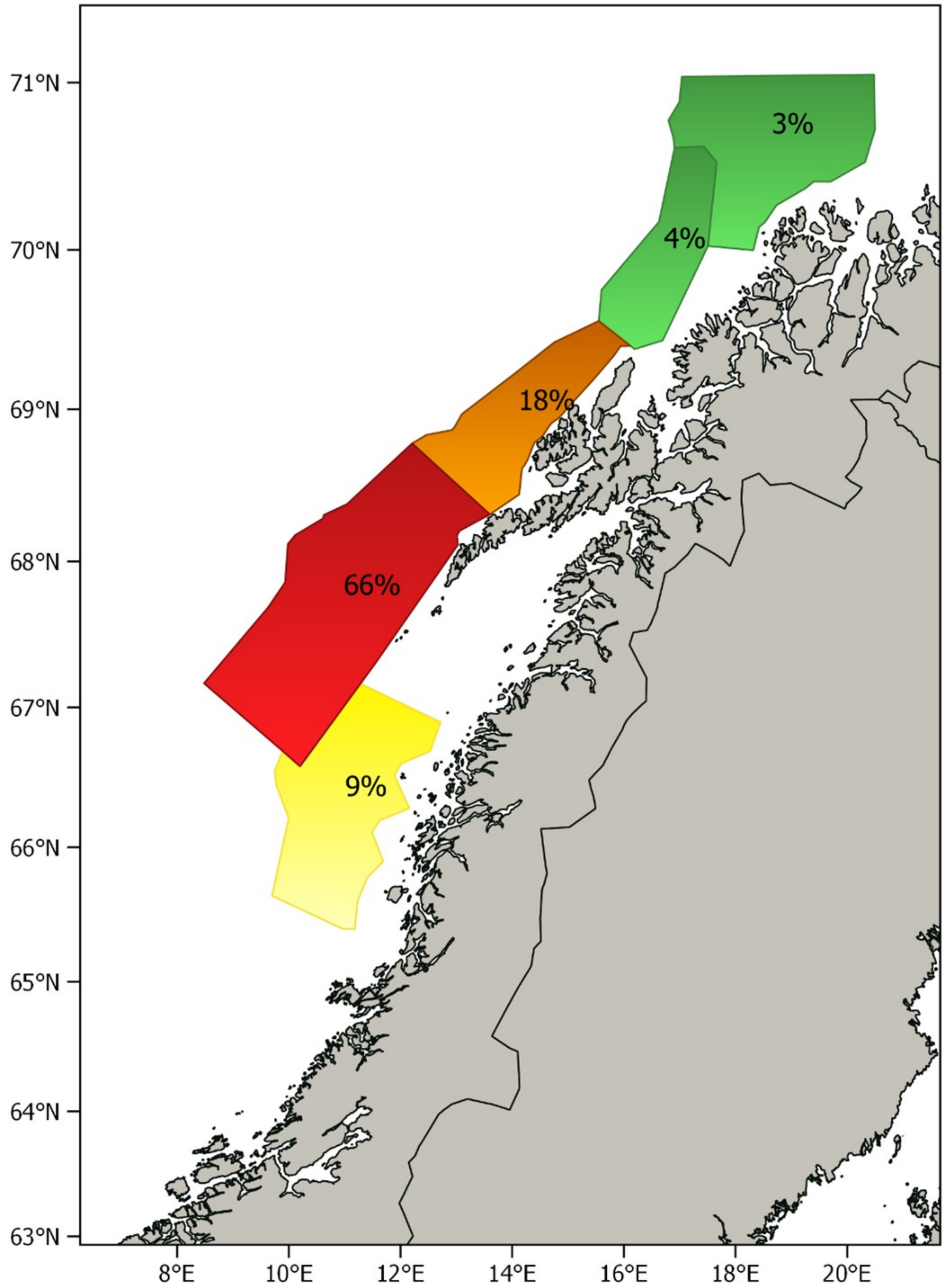

Figure 7. Relative distribution by stratum of the biomass of herring from the Norwegian spring-spawning herring spawning survey 14.-27. February 2022 .

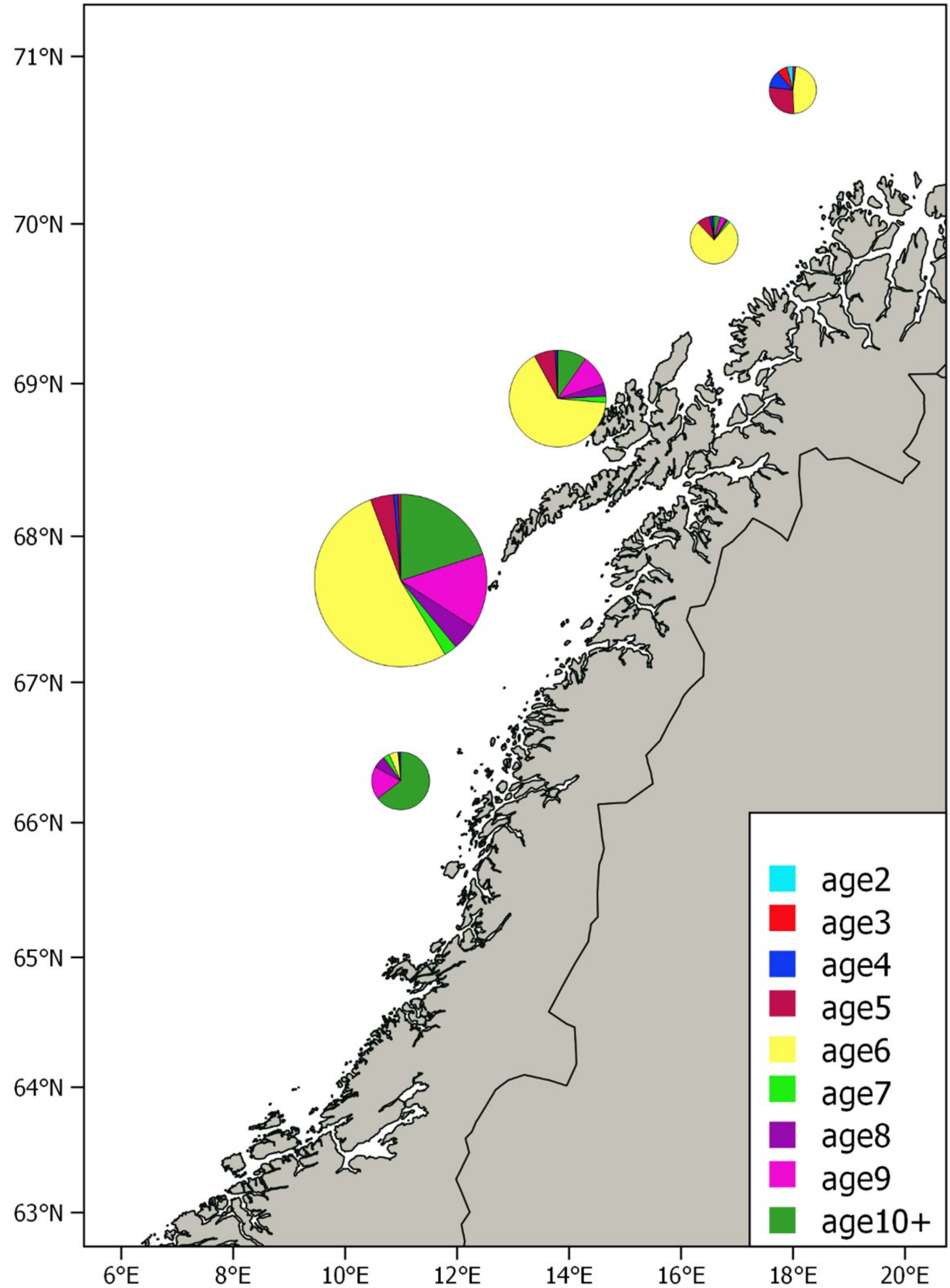

Figure 8. Age distribution per stratum from the Norwegian spring-spawning herring spawning survey 14.-27. February 2022 . The area of the bubbles is scaled with the total number estimated in each stratum.

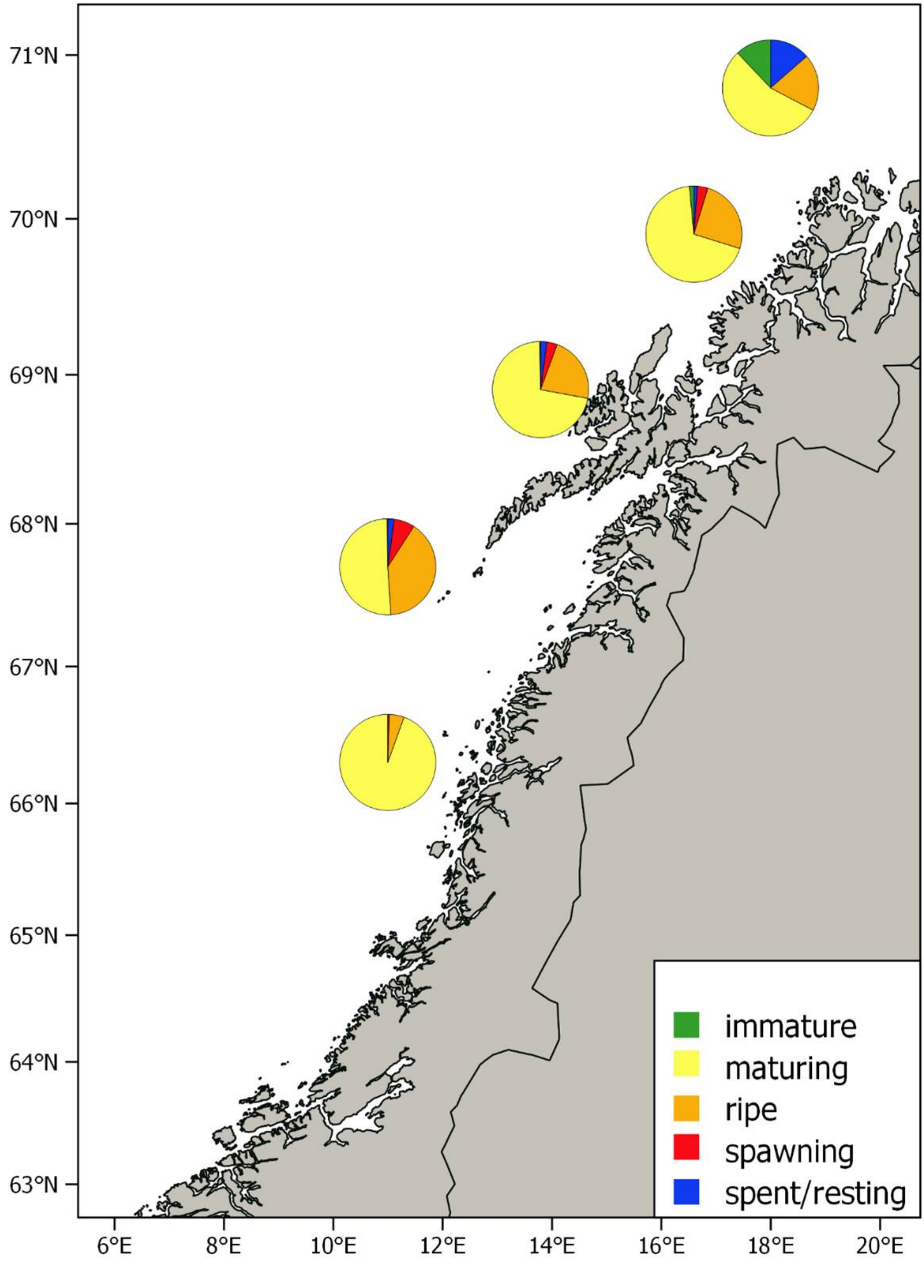

Figure 9. Proportions of different maturity stages from the Norwegian spring-spawning herring spawning survey 14.-27. February 2022 .

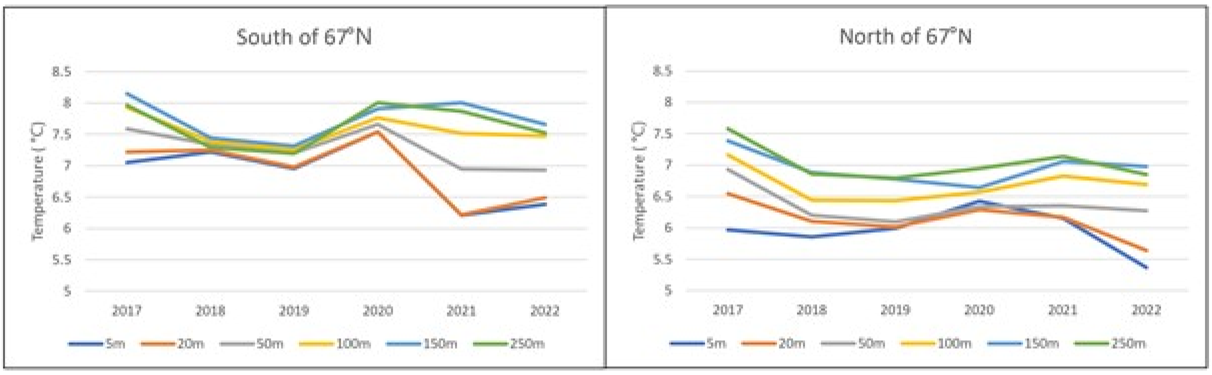

Figure 10. Mean temperatures at 5, 20, 50, 100, 150, 250 m in the area covered during the Norwegian spring-spawning herring spawning surveys in 2017-2022.

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Working Document to

Working Group on International Pelagic Surveys (WGIPS)
23 – 27 January 2023
and
Working Group on Widely Distributed Stocks (WGWIDE)
24 – 30 August 2022

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) in April - May 2022

Post-cruise meeting on Teams, 14-16 June 2022

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Sigurvin Bjarnason[4]
RV Árni Friðriksson

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Introduction

In April-May 2022, four research vessels and one hired commercial vessel participated in the International ecosystem survey in the Nordic Seas (IESNS); R/V Dana, Denmark (joint 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). It should be noted that this was the first year that UK participated in the survey, and the plan is to continue the participation in the coming years. The Barents Sea is usually surveyed by a Russian research vessel, but that was not possible in 2022. 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 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey.

This report represents analyses of data from this International survey in 2022 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 03/2022. International Ecosystem survey in the Nordic Seas (IESNS) in 2022, Árni Friðriksson: Report on Survey A5-2022, Bjarnason, 2022, Jákup Sverri: Preliminary Report Cruise no. 2216).

Material and methods

Coordination of the survey was done during the WGIPS meeting in January 2022 and by correspondence. Planning of the acoustic transects and 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	22/04-20/05
G.O. Sars	Institute of Marine Research, Bergen, Norway	26/04-30/05
Jákup Sverri	Faroe Marine Research Institute, Faroe Islands	28/04-08/05
Árni Friðriksson	Marine and Freshwater Research Institute, Iceland	04/05-23/05
Resolute	CEFAS, United Kingdom	24/04-06/05

Note that Resolute covered the UK EEZ in the southernmost part of the IESNS survey area, but this area was also covered by G.O. Sars and Dana. The reason for this double coverage was to ensure consistency with previous year's surveys (the UK coverage went well and these data were used in the abundance estimation). Figure 2 shows the cruise tracks, 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. UK also covered an area south of the IESNS survey area and this is described in Annex A.

In general, the weather conditions did not affect the survey even if there were some days that were not favourable and trawling, WP2 and Multinet sampling at some stations were prevented. 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)	4-6	6	8	6-9	6
Upper integration limit (m)	10	15	15	15	10
Absorption coeff. (dB/km)	10.05	10.1	10.5	10.3	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	2.425	3.06	
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
Sv Transducer gain (dB)	25.31				
Ts Transducer gain (dB)		26.12	27.03	26.94	26.62
s_A correction (dB)	-0.61	-0.13	-0.04	-0.13	-0.04
3 dB beam width (dg)					
alongship:	6.98	6.42	6.43	6.47	6.35
athw. ship:	6.94	6.29	6.43	6.54	6.54
Maximum range (m)	500	500	500	500	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 a 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. Immediately after the 2022 survey an online meeting was held to standardise the scrutiny and to agree on particularly difficult scrutiny situations encountered. 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**	**44–55**	**30-50**
Mesh size in codend (mm)	**20/40**	**24**	**20**	**45**	**100**
Typical towing speed (kn)	**3.5-4.5**	**3.0–4.5**	**3.1–5.0**	**3.7 (3–4.5)**	**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**	**250**

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 a coming age reading and stock identity workshop, genetic samples were collected of herring. 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	300	100-300	100
	Blue whiting	200-300	100	50	100-200	100
	Mackerel	100-200	100	50	100-200	100
	Other fish sp.	50	30	30	100-150	30
Weighed, sexed and maturity determination	Herring	50	25-100	100	50*	50
	Blue whiting	50	25-100	50	50*	50
	Mackerel	50	25-100	50	50	50
	Other fish sp.	0	0	0	0*	0
Otoliths/scales collected	Herring	50	25-30	100	50	50
	Blue whiting	50	25-30	50	25-50	50
	Mackerel	0	25-30	50	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	50

* Number of weighed individuals significantly higher.

Acoustic data were analysed using the StoX software package (version 3.4.0) 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: 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 (this year only 4 strata, as the Barents Sea was not surveyed). 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: $TS = 20 \log(L) - 65.2$ 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. Most vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m. Zooplankton was sampled by WPII 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. All samples were split in two and one half was preserved in formalin while the other half was dried and weighed. 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 mg total dry weight per m^2. For the zooplankton distribution map, all stations are presented. Interpolation was carried out using Bratseth's Successive Correction Method (Bratsheth, 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 rx and ry is the geographic distance in the zonal and meridional directions, and Ha and Ho 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. This front was sharper below 50 m than above. 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 6 °C to the Bear Island at 74.5° N in the surface layer.

Relative to the long-term mean, from 1995 to 2021, the temperatures at 0-50 m were below the mean in most of the Norwegian Sea (Figure 7a). Below 50 m depth, the patterns were more fragmented, but the Norwegian Sea was still in general colder than the long-term mean (Figures 7b-c). Largest negative temperature anomalies were between Iceland and Faroe Islands due to a more southern located Iceland-Faroe front compared to the long-term mean. This was found for all depths, and the temperatures in this region were in some locations 3 °C lower than the mean (Figures 7a-c). Also, in the centre of the Norwegian Basin, the temperatures were 1 °C lower than the mean, probably because of a more eastern located Arctic front. Warmest regions, relative to the long-term mean, were in the eastern Greenland Sea, with temperatures 2 °C higher than the mean, and in some areas below 50 m depth in southern and southwestern parts of the Norwegian Sea.

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. To a large extent this water 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 (mg dry weight m-2) in the upper 200 m is shown in Figure 8. Sampling stations were evenly spread over the area, covering Atlantic water, Arctic water, and the Arctic frontal zone. The highest zooplankton biomasses were found in the eastern and southeastern parts. Within the eastern area, several locations had high biomass and a large patch was found at ca. 3°W and 64.5°N. Lower biomasses were found in central and western parts of the Norwegian Sea.

Figure 9 shows the zooplankton indices for the sampling area (delimited to east of 14°W and west of 20°E). To examine regional biomass differences, the area was divided into 4 sub-areas 1) East of Iceland, 2) the Jan Mayen Arctic front, 3) the Lofoten Basin (covering the northern Norwegian Sea, and 4) the Norwegian Sea Basin (covering the southern Norwegian Sea). The zooplankton biomass index for 2022 was respectively: 4563, 6627, 9237 and 9962 mg dry weight m^{-2}, and while the subareas east of Iceland and Jan Mayen arctic front showed a decrease compared to last year, the Lofoten- and Norwegian Basin increased. The zooplankton biomass indices for the Norwegian Sea in May have been estimated since 1995. All subareas had a high biomass period until mid-2000, and a lower period thereafter. The decrease was most pronounced in the Iceland Sea, where the reduction was 59 %. In the Lofoten- and Norwegian Basins there has been an increasing trend during the low-biomass period.

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). 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 2022. The zero-line was believed to be reached for adult NSS herring in most of the areas. It is recommended that the results from IESNS 2022 can be used for assessment purpose. The herring was primarily distributed in the central and southwestern area (Figure 10). In the westernmost area old herring dominated, but in general, the 2016-year-class was the most abundant year class throughout the survey area. It is a commonly observed pattern that the older fish are distributed in the southwest while the younger fish are found closer to the nursery areas in the Barents Sea (Figure 11).

Six-year-old herring (2016-year class) dominated both in terms of number (49%) and biomass (48%) on basis of the StoX bootstrap estimates for the Norwegian Sea (Table 2). The abundance of the 2016 year-class decreased by 19 % compared to last year’s estimate which could be expected since this year-class was fully recruited to the survey last year (Figure 12). The second largest year-class in the survey was the 2013 year-class (10% in numbers), and older age groups (10-18 years old) contributed with less than 10% to the abundance estimate. 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 21 % both for the total biomass and for the total numbers estimate, and the relative standard error for the dominating age groups is around 20-30 % (Figure 13).

The total estimate of herring in the Norwegian Sea from the 2022 survey was 19.8 billion in number and the biomass was 4.4 million tonnes. The biomass estimate is 13 % lower than the 2021 survey estimate and also the estimated number is about 13% lower than in 2021. The biomass estimate decreased significantly from 2009 to 2012 and has since then been rather stable at 4.2 to 5.9 million tonnes with similar confidence interval (Figure 14), with the lowest abundance occurring in 2017. The 2016 year class now appears to be fully recruited, distributed widely in the feeding area and more dominant than the older year classes.

There was no coverage of juvenile herring in strata 5 (the Barents Sea) in May 2022.

In the last 6 years, there have been concerns regarding age reading of herring, because the age distributions from the different participants have showed differences – particularly older specimens appear to have uncertain ages. A scale and otolith exchange has been ongoing for some time, where scales and otoliths for the same fish have been sampled. As a follow-up on that work, a new exchange and following workshop are currently being planned for April 2023. The survey group emphasizes the necessity of having this workshop before next year’s survey takes place.

With respect to age-reading concerns in the recent years, the comparison between the nations in this year’s survey for the most part appeared to be in good agreement (Figure 15).

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 target 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).

Blue whiting

Boostrap estimates of abundance, biomass, mean length and mean weight of blue whiting during IESNS 2022 are shown in Table 3. The estimated biomass was 1.5 million tons (CV=0.13) which is a 76 % increase from last year's estimate, and one of the two highest estimates after 2007 (together with the 2016 estimate). The estimated total abundance was 17.2 billion (CV=0.13) which is a 112 % increase from last year's estimate. The stock is totally dominated by 1 and 2 year old (2021 and 2022 year classes) and the estimates of total abundance, abundance of age 1 and abundance of age 2 are all the highest observed after 2007. 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 2022 is shown in Figure 16. As usual, most of the fish was registered in the eastern part of the Norwegian Sea. However, higher concentrations than in later years were observed in more central areas, in particular around the zero meridian in the southern part. This corresponds well with the high abundance estimate. The largest fish was found in the northwestern part of the of the survey area this year (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. This year the catches did not extend as far north as compared with recent years, only north to circa 64°N. This is the lowest northward extent of mackerel catches during IESNS after 2007 (first year with data from all participating vessels). 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. It is recommended that the the planned age reading workshop in April 2023 also includes a session n how to deal with stock components of herring in the IESNS-survey.	WG

Next year's post-cruise meeting

We will aim for next meeting in 13-15 June 2023. The final decision will be made at the next WGIPS meeting.

Concluding remarks

- The sea temperature in 2022 was generally below the long-term mean (1995-2021) in the Norwegian Sea, but the pattern was more fragmented below 50 m depth. The Arctic front in the southern Norwegian Sea was more southerly and easterly located in 2022 compared to the long-term mean.
- The 2022 indices of meso-zooplankton biomass in the Norwegian Sea and adjoining waters were fairly similar to last year's estimates.
- The total biomass estimate of NSSH in herring in the Norwegian Sea was 4.4 million tonnes, which is a 13 % decrease from the 2021 survey estimate. The estimate of total number of NSSH was 19.8 billion, which is 13 % lower than in the 2021 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 (49%) and biomass (48%). The abundance of the 2016 year-class decreased by 19 % compared to last year's estimate
- The biomass of blue whiting measured in the 2022 survey increased by 76 % from last year's survey and 112 % in terms of numbers. The stock is dominated by the 2020 and 2021 year classes) and the estimates of total abundance, abundance of age 1 and abundance of age 2 are all the highest observed after 2007.

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in May - June 2022.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Ctd stations	Aged fish (HER)	Length fish (HER)	Plankton stations
Dana	26/4-16/5	2495	20	36	253	873	35
Jákup Sverri	28/4-8/5	1464	19	23	325	1093	23
Árni Fridriksson	8/5-23/5	3013	14	40	863	2747	34
G.O. Sars	26/4-30/5	5103	37	60	375	1107	59
Resolute	24/4-06/5	1158	11	22	290	537	22
Total		**13233**	**101**	**181**	**2106**	**6357**	**173**

Table 2. IESNS 2022 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.

	Age in years (year class)																		Number	Biomass	Mean
Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown			weight
(cm)	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004		(10^6)	(10^6 kg)	(g)
17-18	18.6																		18.6	0.7	38.0
18-19	37.3																		37.3	1.6	42.5
19-20	27.4																		27.4	1.5	56.0
20-21	113.7																	4.2	117.8	7.2	59.5
21-22	107.8																		107.8	7.8	72.6
22-23	116.3																	0.6	116.9	9.7	82.9
23-24	71.4	22.9																	94.3	8.9	93.3
24-25		46.8	142.5		5.9													1.7	197.0	21.3	108.6
25-26		61.2	229.3																290.6	33.6	116.3
26-27		27.1	252.4	49.3															328.9	44.7	134.8
27-28		72.1	134.8	5.8	6.8														219.5	33.0	152.2
28-29		46.7	94.5	168.3	57.5	37.7				12.8									417.3	70.3	168.7
29-30	14.7	46.9	174.7	336.4	304.1	81.4	116.3		58.3										1 132.8	210.4	185.2
30-31		28.4	149.5	297.3	1411.4	239.3	378.3	187.0	29.2	26.0									2 746.4	549.4	199.1
31-32		30.8	24.6	212.9	3210.3	353.7	374.9	411.2	79.3			88.9							4 786.7	1034.1	215.0
32-33			4.7	203.8	2986.8	144.5	138.6	383.8	113.2	29.2	68.7	21.1							4 094.4	956.8	232.9
33-34				12.0	1427.9	98.0	163.1	243.8	121.0	6.9	110.7			6.5					2 189.9	554.7	254.2
34-35					190.5	157.7	213.7	491.8	10.9	4.8									1 069.5	299.5	280.0
35-36					29.5	38.3	197.5	235.6	56.4	77.0	39.2	31.1	10.4		7.2	15.6			737.8	219.3	296.8
36-37					2.7		57.8	99.3	70.3	80.7	60.1	32.4	29.5	35.6	6.1	14.1			488.7	154.9	316.9
37-38								11.1	38.1	60.1	32.6	97.2	72.0	56.7	33.9	10.9			412.5	139.7	338.7
38-39										24.2	13.6	22.7	3.4	28.6	26.1	17.6			136.2	49.7	363.3
39-40										17.1				5.4	7.0	6.0	5.6	0.2	41.5	15.1	366.1
40-41															5.0			2.5	7.5	3.1	408.0
TSN(mill)	507.2	383.0	1207.1	1285.8	9633.2	1150.5	1640.3	2063.6	576.6	338.9	324.9	293.4	115.3	132.9	85.4	64.2	5.6		19 817.1		
cv (TSN)	0.59	0.49	0.45	0.34	0.23	0.36	0.37	0.34	0.40	0.31	0.42	0.40	0.39	0.35	0.44	0.45	1.12		0.21		
TSB(1000 t)	37.7	58.0	182.1	252.4	2 132.2	266.1	400.6	531.5	152.2	102.0	89.7	86.2	37.1	45.1	29.8	20.5	2.0		4 427.0		
cv (TSB)	0.55	0.48	0.41	0.35	0.23	0.34	0.35	0.32	0.38	0.31	0.39	0.35	0.39	0.36	0.46	0.46	1.12		0.21		
Mean length(cm)	21.2	27.6	27.9	30.0	31.5	32.2	33.0	33.6	34.0	35.8	35.2	35.9	36.6	36.9	37.3	36.7	39.0				
Mean weight(g)	76.0	165.2	169.1	199.6	223.0	246.3	262.7	273.6	285.3	314.2	299.6	320.7	321.4	341.9	346.6	319.4	365.4				

Table 3. IESNS 2022 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.

	Age in years (year class)									Number	Biomass	Mean
Length	1	2	3	4	5	6	7	8	Unknown			weight
(cm)	2021	2020	2019	2018	2017	2016	2015	2014		(10^6)	(10^6 kg)	(g)
14-15	7.6								2.6	10.2	0.1	16.0
15-16	232.7									232.7	4.9	20.8
16-17	1304.5	29.8								1 334.3	32.5	24.4
17-18	4114.3	122.2								4 236.5	125.6	29.7
18-19	5637.5	135.3								5 772.8	199.4	34.6
19-20	4229.8	161.9	6.7							4 398.5	173.8	39.9
20-21	1206.1	387.6	66.5							1 660.2	78.4	47.5
21-22	271.7	1526.6	123.7							1 922.0	109.8	57.4
22-23	135.6	2649.2	58.5							2 843.2	183.6	65.5
23-24	1.9	2821.4	207.0							3 030.3	221.0	74.5
24-25	27.0	2116.0	308.7							2 451.8	199.0	83.2
25-26		495.9	277.6	12.9						786.4	72.5	93.1
26-27		117.2	145.7	27.8						290.7	30.4	105.0
27-28		11.7	34.6	25.9	31.6	7.1	9.4			120.2	14.2	118.4
28-29			50.1	13.5			4.9			68.5	9.0	128.6
29-30					2.3	9.2	16.7	12.9	0.0	41.2	5.9	141.6
30-31				17.6	20.8		10.0	17.7		66.1	10.5	159.2
31-32					26.5	20.2	5.7			52.3	9.7	182.3
32-33							46.2	16.4	0.2	62.8	12.6	199.5
33-34							9.5	8.0	0.1	17.7	4.2	239.4
34-35					7.9				3.4	11.3	3.0	271.5
35-36												
36-37					2.2					2.2	0.7	330.0
TSN(mill)	17169	10575	1279	98	91	36	102	55		29 411.9		
cv (TSN)	0.16	0.15	0.20	0.39	0.36	0.51	0.54	0.54		0.13		
TSB(1000 t)	603.3	729.5	105.7	11.9	15.2	5.9	17.7	10.5		1 500.6		
cv (TSB)	0.15	0.16	0.19	0.40	0.38	0.53	0.55	0.53		0.13		
Mean length(cm)	18.2	22.7	24.1	27.2	29.7	29.9	30.6	30.5				
Mean weight(g)	36	72	85	121	167	159	168	183				

Figures

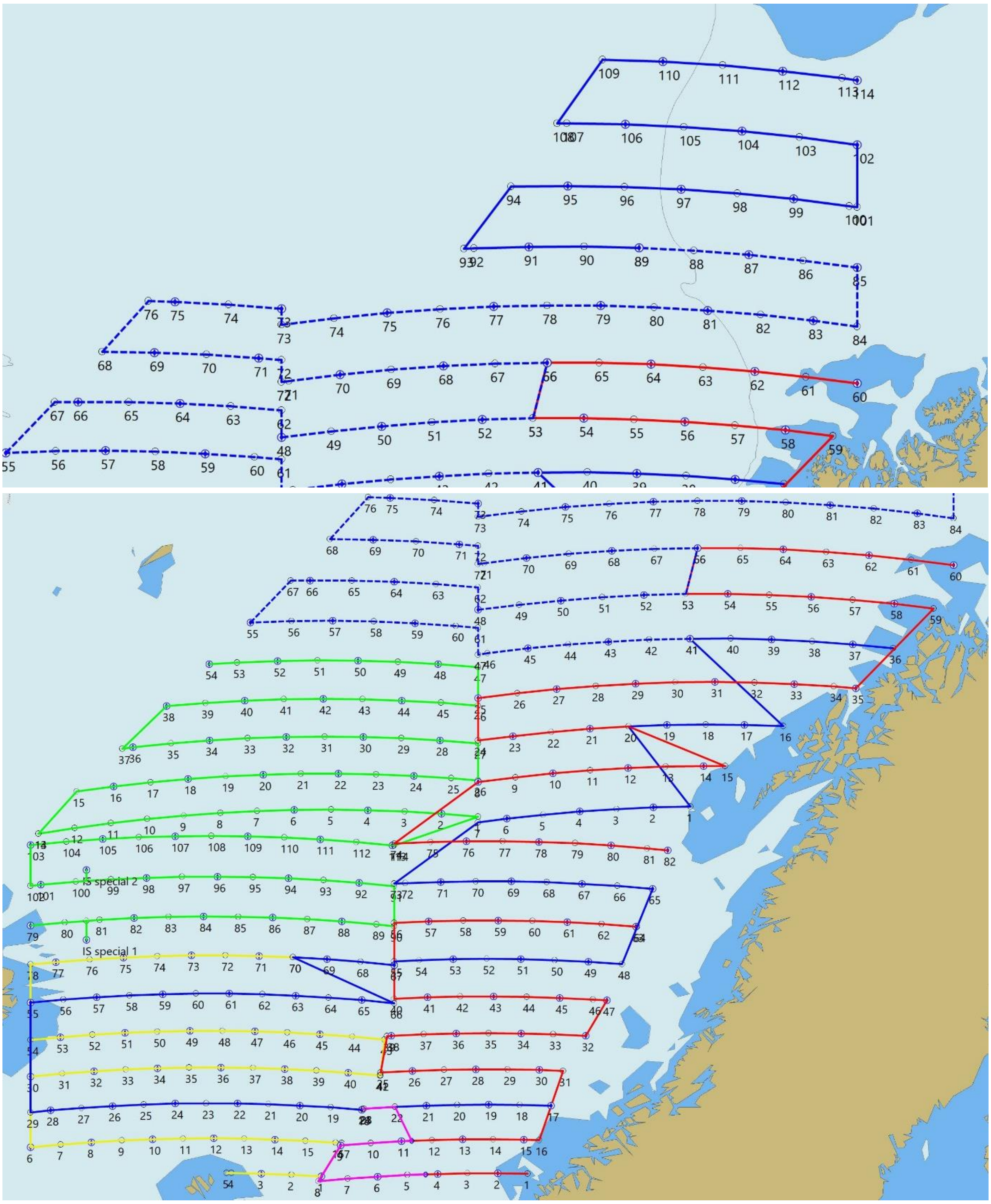


Figure 1. The pre-planned strata and transects for the IESNS survey in 2022 (red: EU, dark blue: Norway, yellow: Faroes Islands, violet: UK, green: Iceland). Hydrographic stations and plankton stations are shown as blue circles with diamonds. All the transects have numbered waypoints for each 30 nautical mile and at the ends**.**

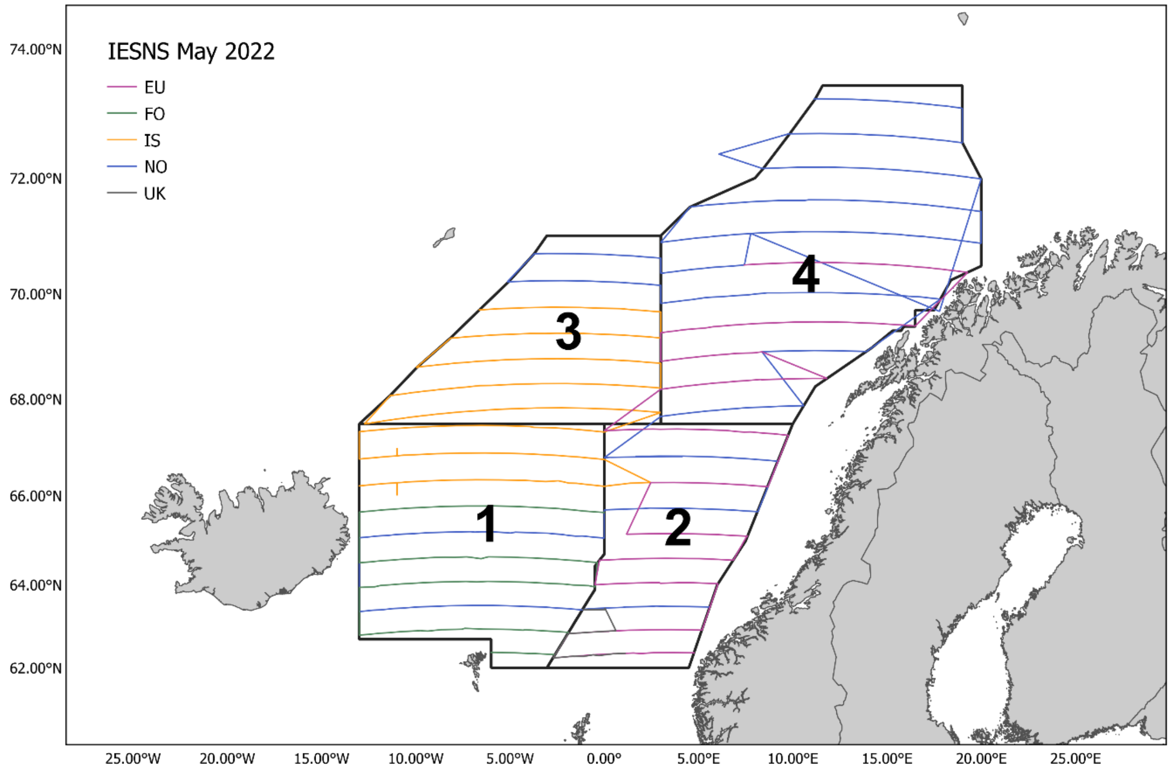


Figure 2. Cruise tracks and strata (with numbers) for the IESNS survey in May 2022.

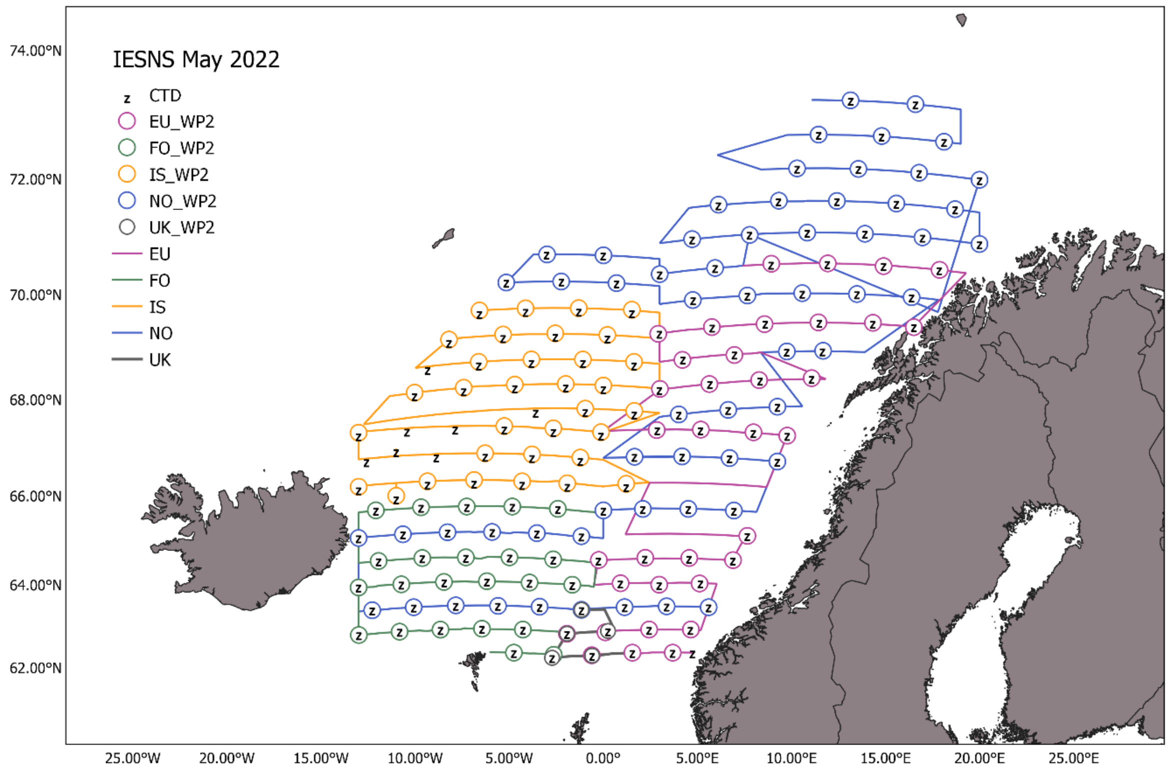


Figure 3. IESNS survey in May 2022: location of hydrographic and WPII plankton stations.

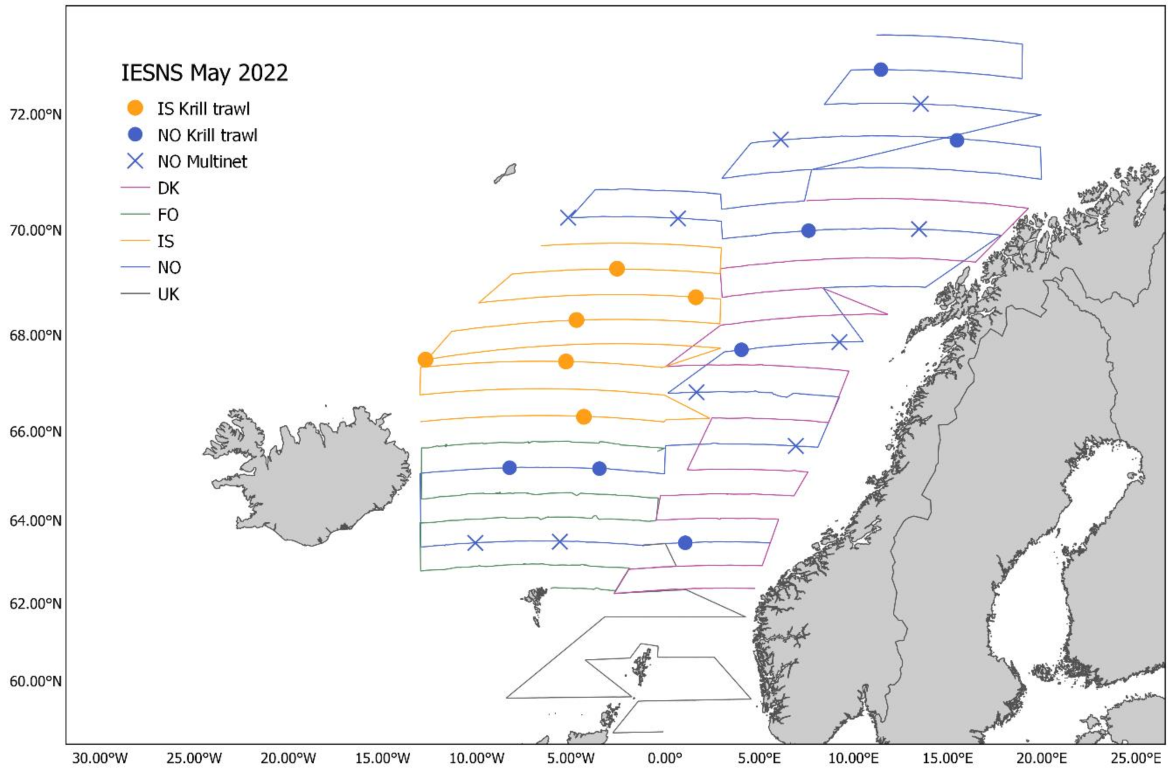


Figure 4. IESNS survey in May 2022: location of Macroplankton/Krill trawl and Multinet stations.

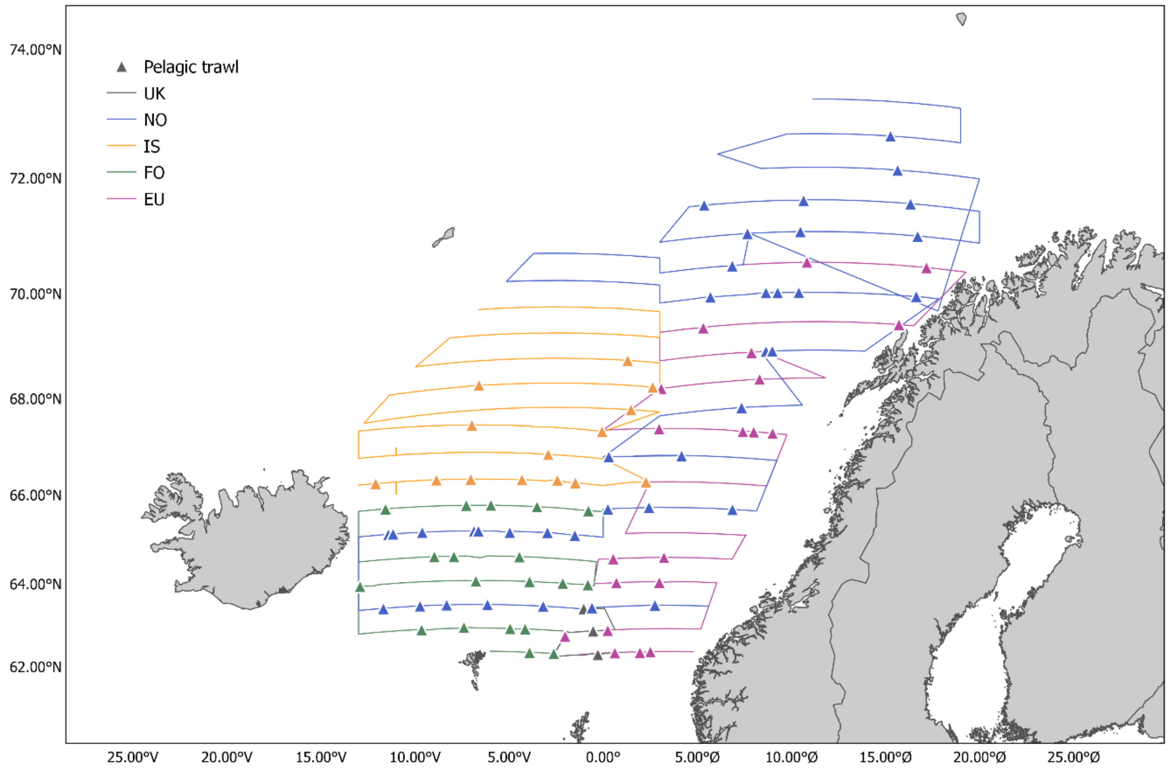


Figure 5. IESNS survey in May 2022: location of pelagic trawl stations.

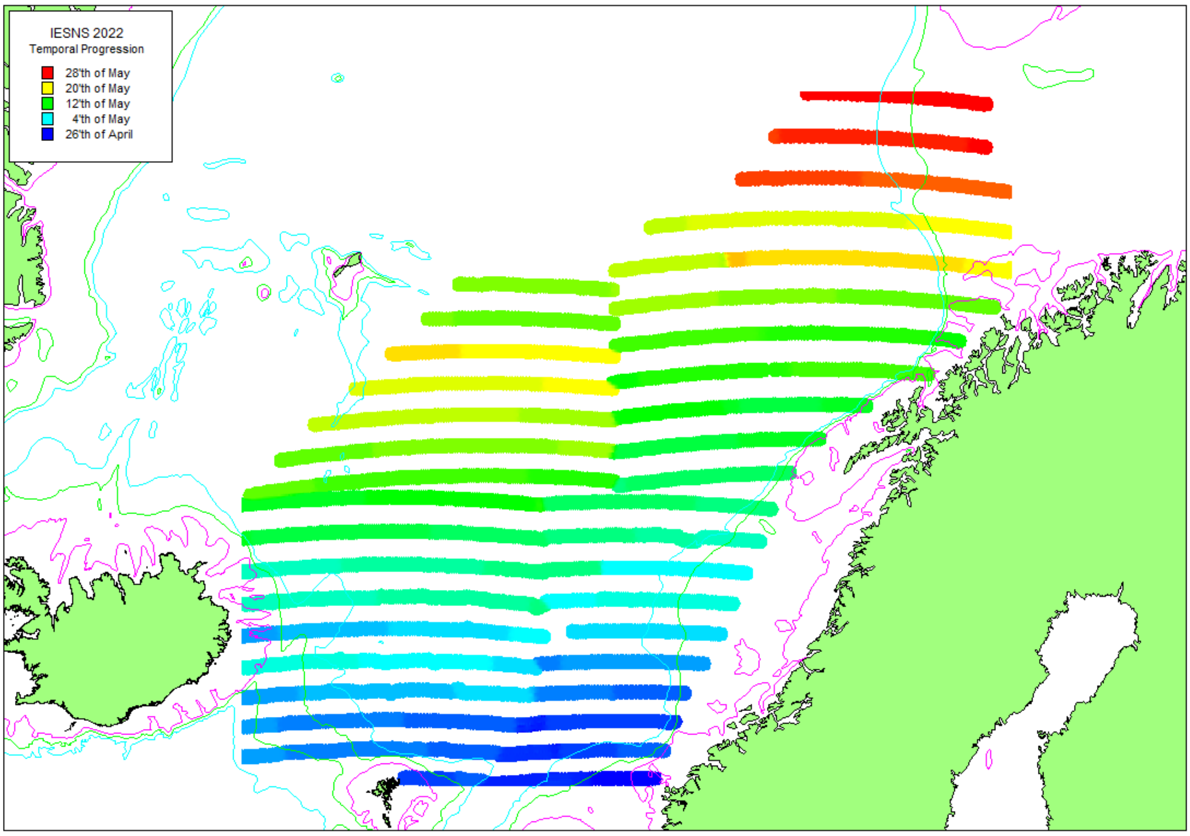


Figure 6. Temporal progression IESNS in April-May 2022.

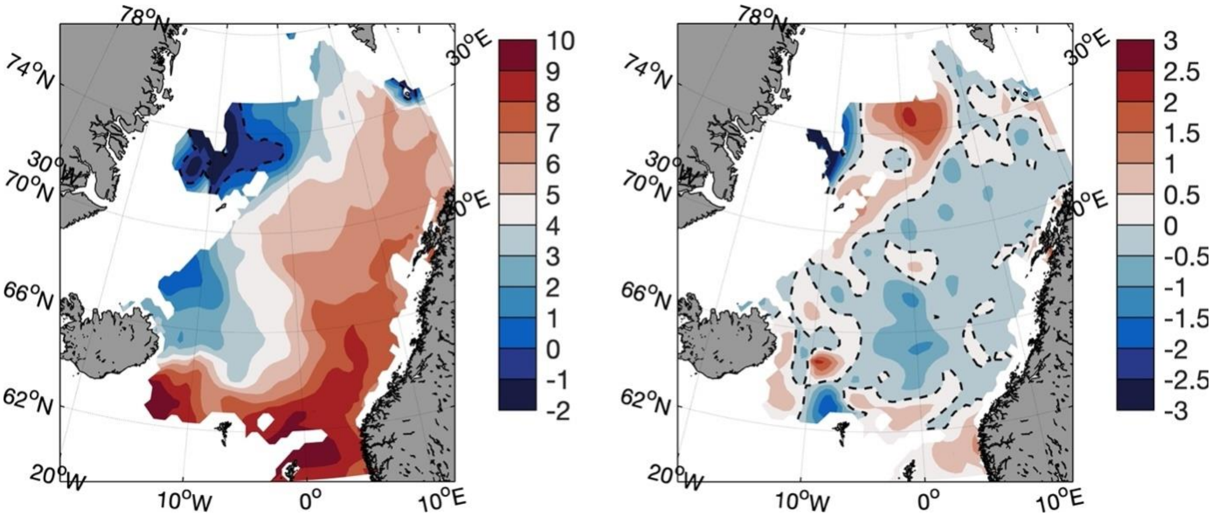


Figure 7a. Temperature (left) and temperature anomaly (right) averaged over 0-50 m depth in May 2021. Anomaly is relative to the 1995-2019 mean.

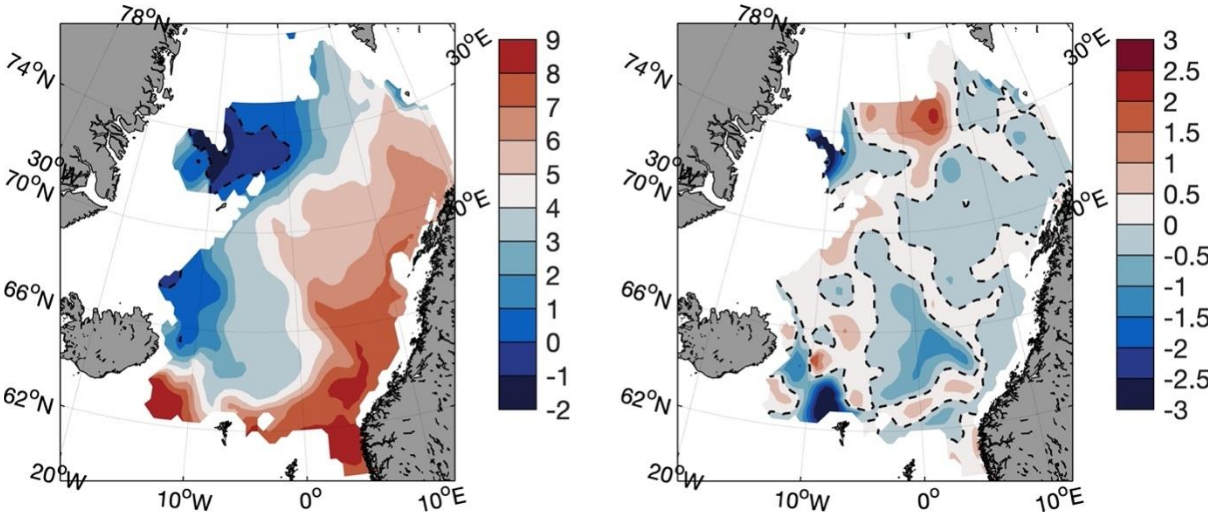


Figure 7b. Same as above but averaged over 50-200 m depth.

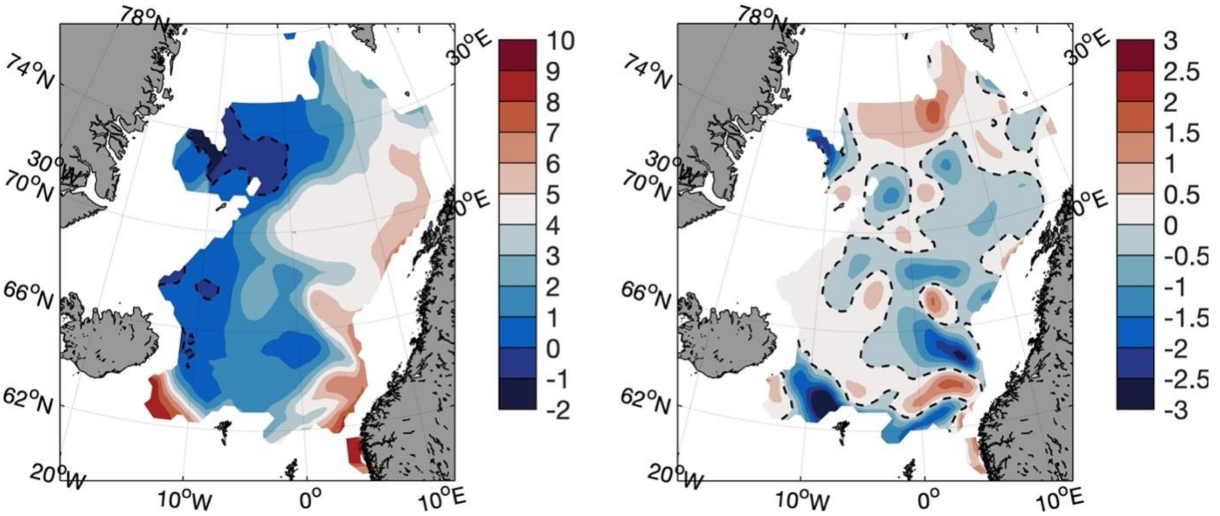


Figure 7c. Same as above but averaged over 200-500 m depth.

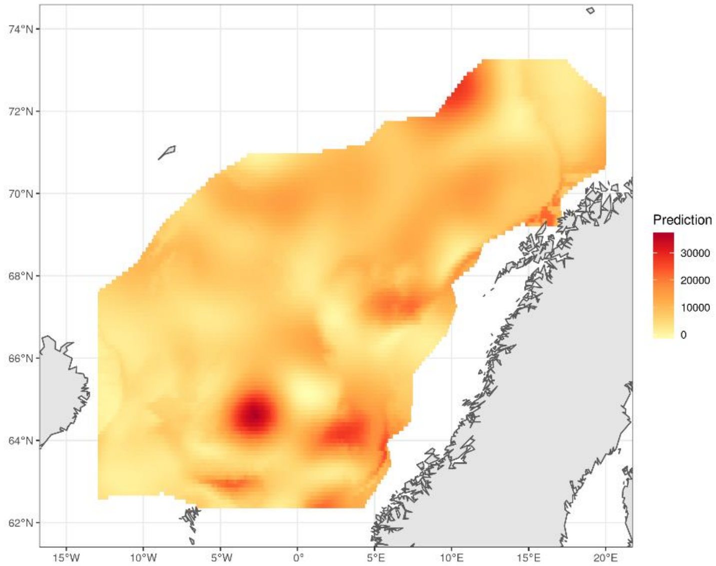


Figure 8. Distribution of zooplankton biomass (mg dry weight m^{-2}) in the upper 200 m in May 2022.

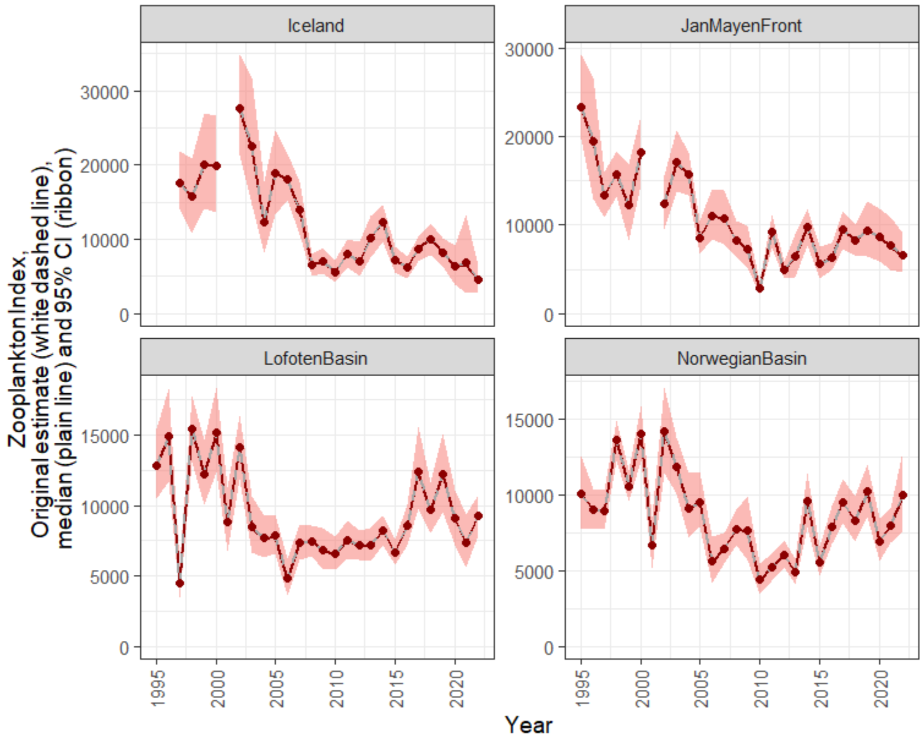
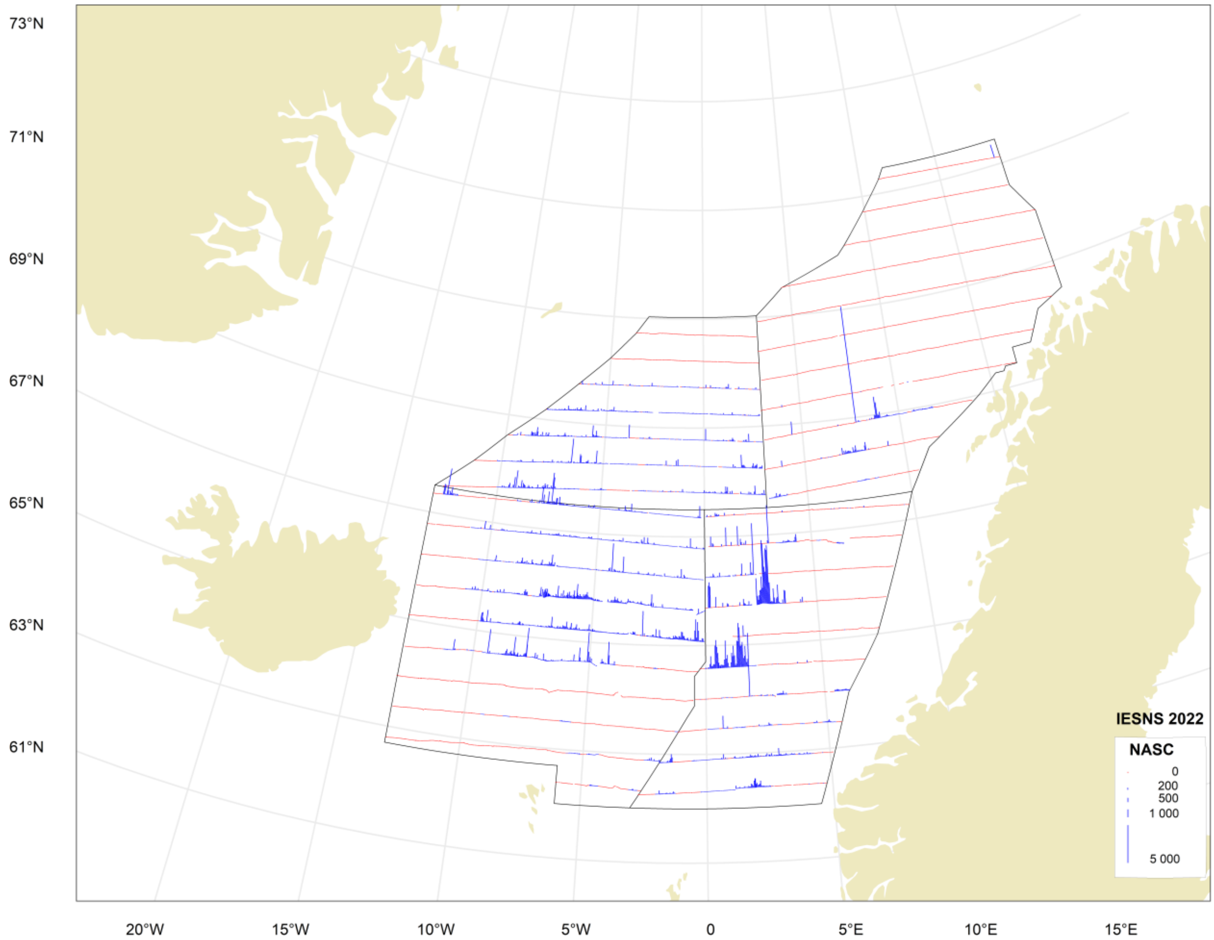


Figure 9. Indices of zooplankton biomass (mg dry weight m^{-2}) sampled by WP2 in May in the Norwegian Sea and adjacent waters from 1995-2022.

(a)



(b)

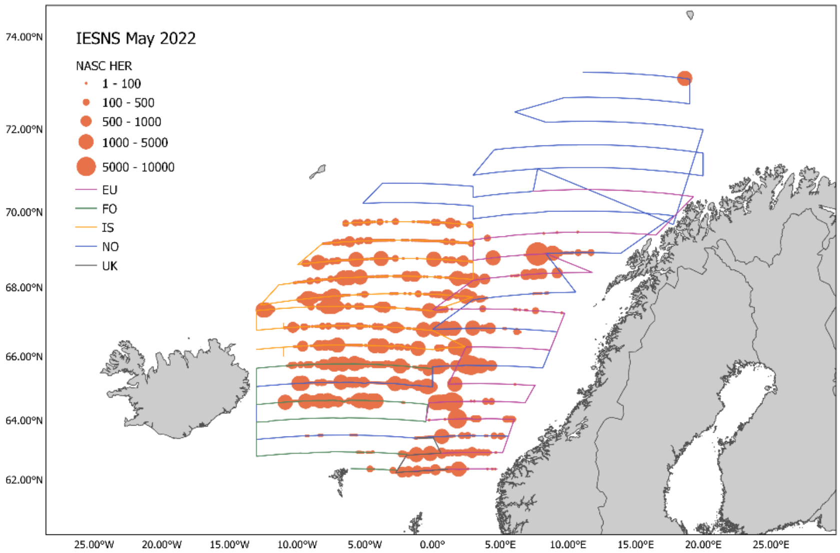


Figure 10. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2021 in terms of NASC values (m²/nm²) averaged for every 1 nautical mile.

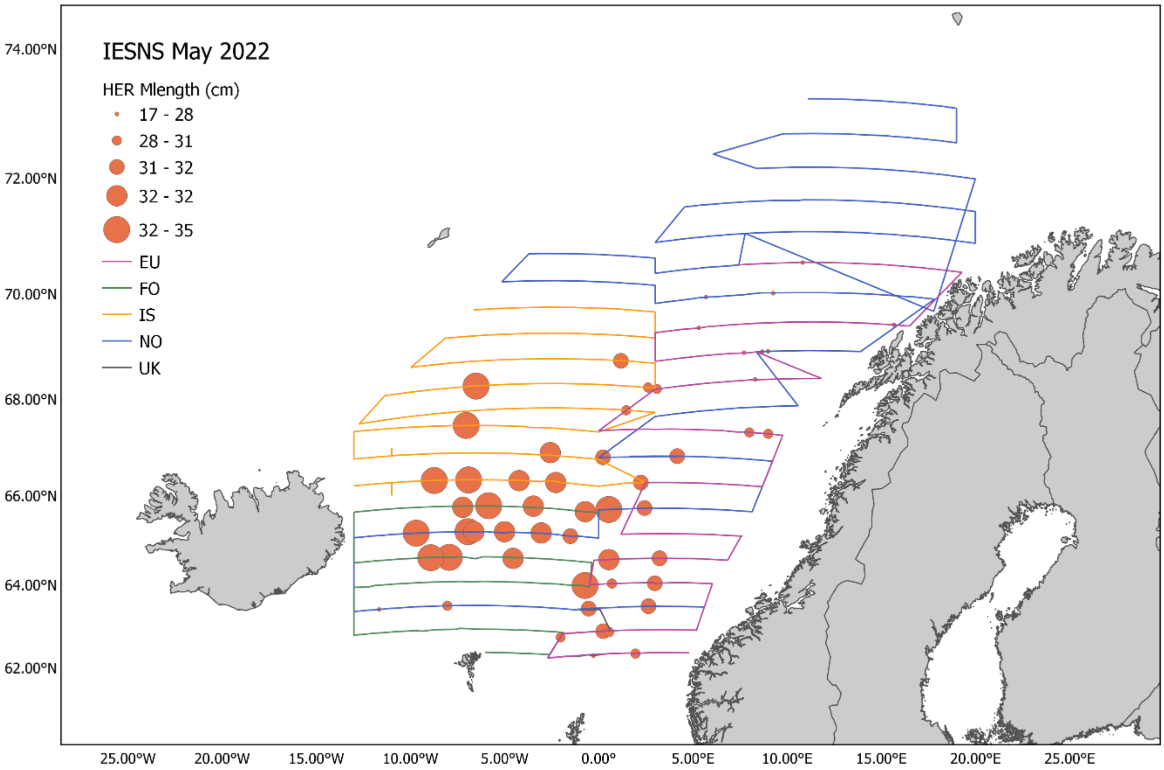


Figure 11. Mean length of Norwegian spring-spawning herring in all hauls in May 2022.

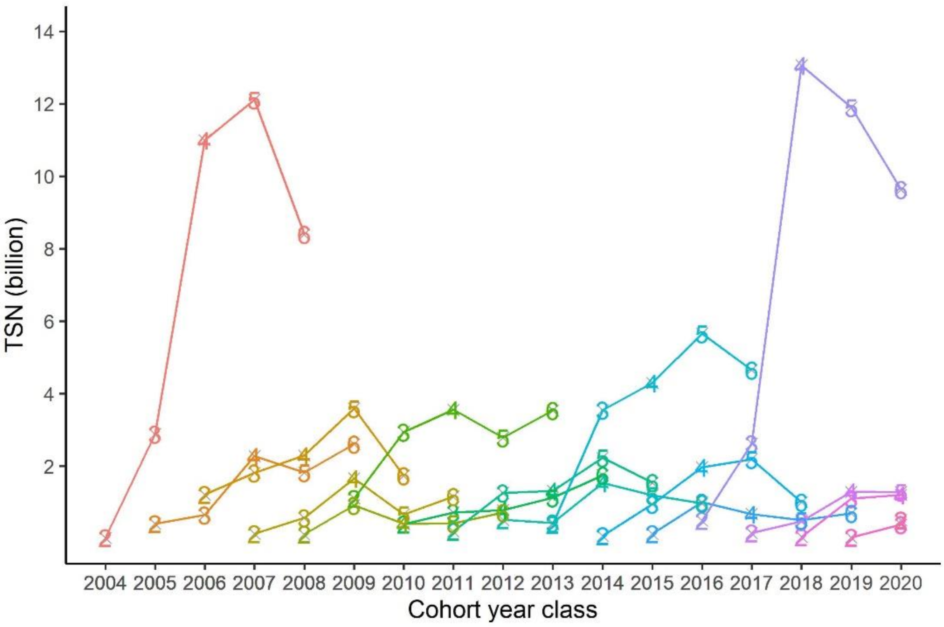


Figure 12. Tracking of the Total Stock Number at age (TSN, in billions) of Norwegian spring-spawning herring for each cohort since 2004 from age 2 to age 6. From 2008, stock is estimated using the StoX software. Prior to 2008, stock was estimated using BEAM.

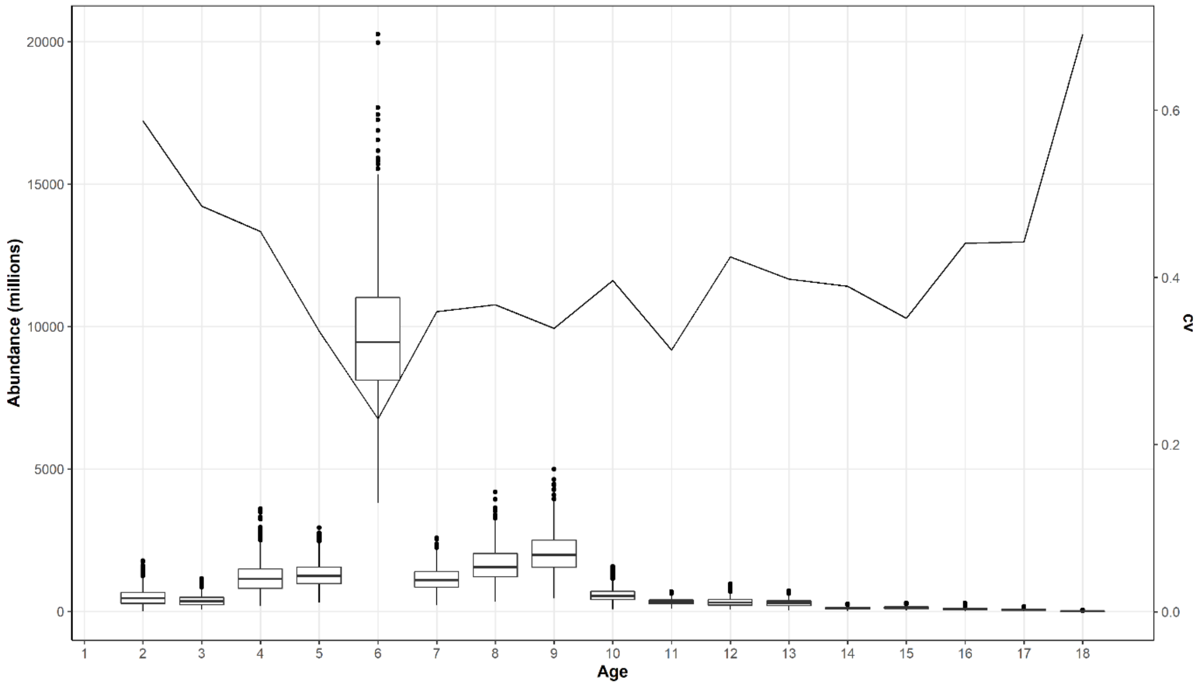


Figure 13. Norwegian spring-spawning herring in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

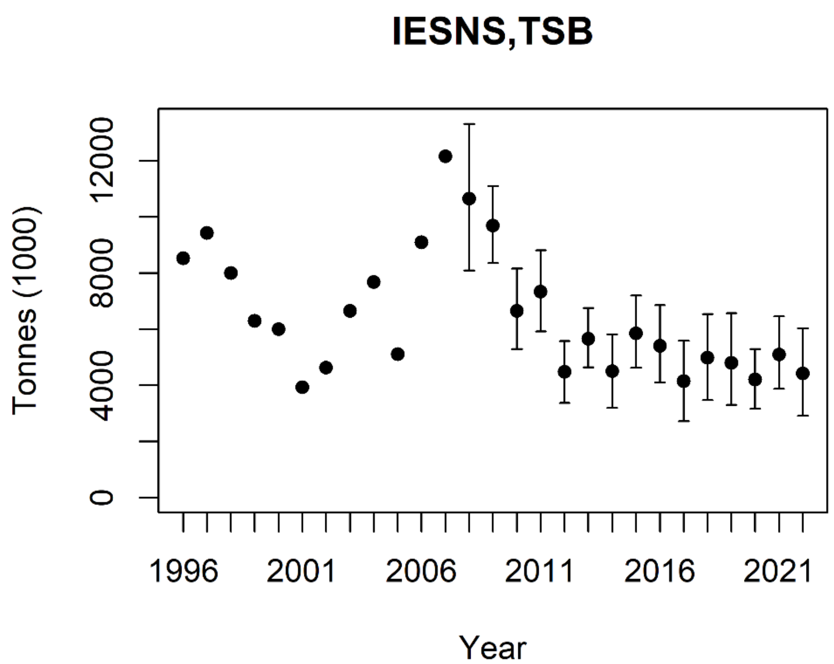


Figure 14. Biomass estimates of Norwegian-spring spawning herring in the IESNS survey (Barents Sea, east of 20°E, is excluded) from 1996 to 2022 as estimated using BEAM (1996-2007; calculated on basis of rectangles) and as estimated with the software StoX (2008-2021; bootstrap means with 90% confidence interval; calculated on basis of standard stratified transect design).

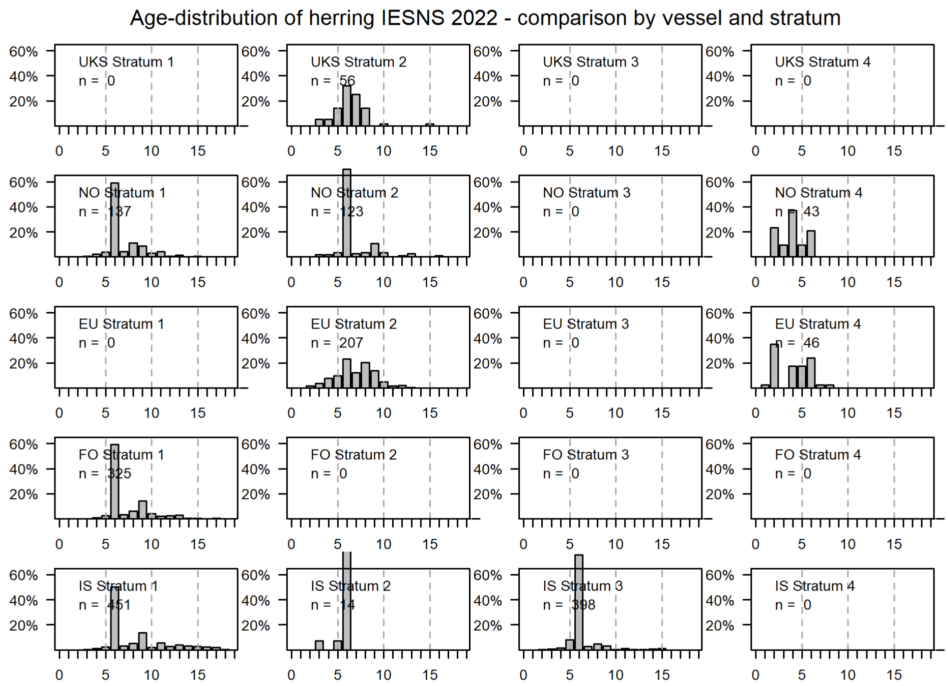
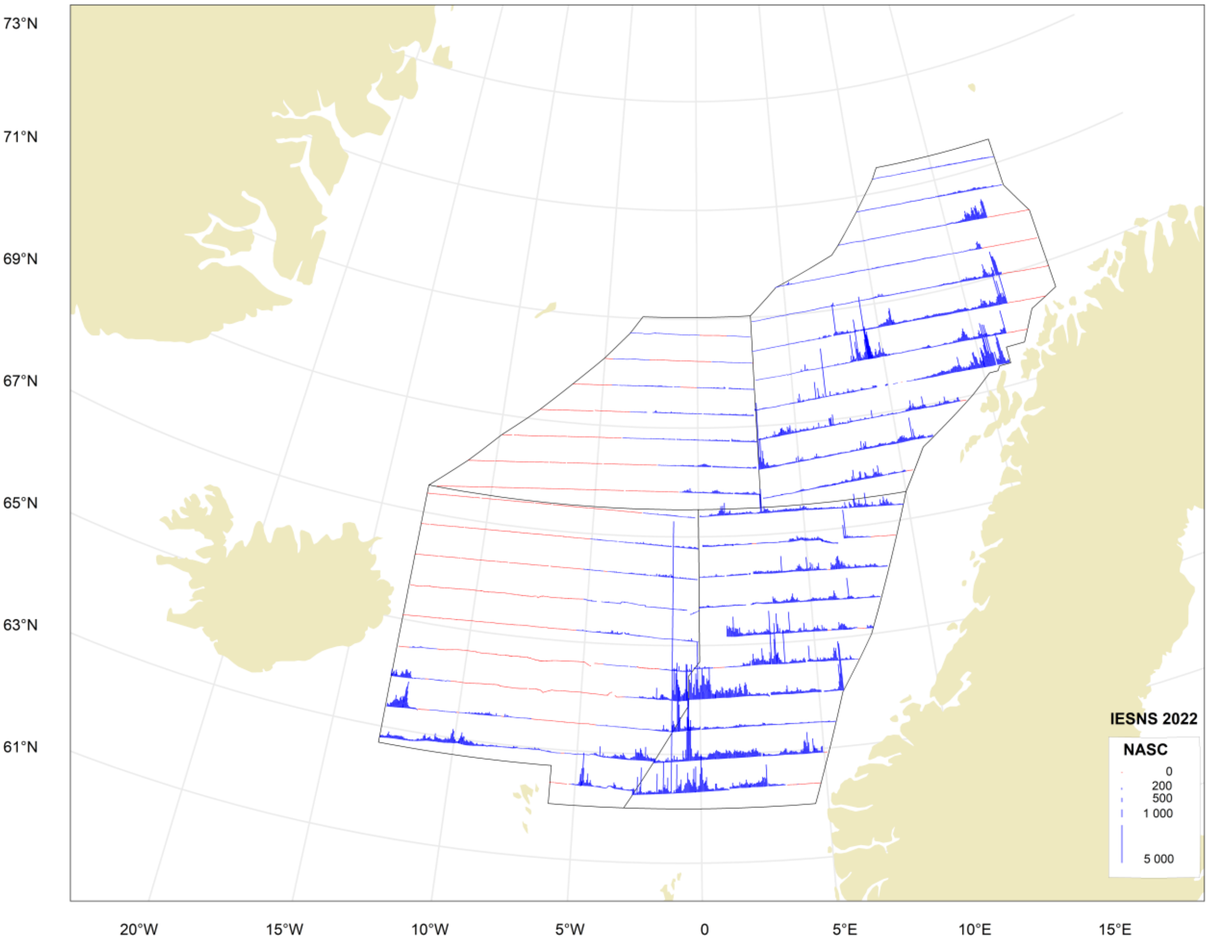


Figure 15. Comparison of the age distributions of NSS-herring by stratum and country in IESNS 2022. The strata are shown in Figure 3.

(a)



(b)

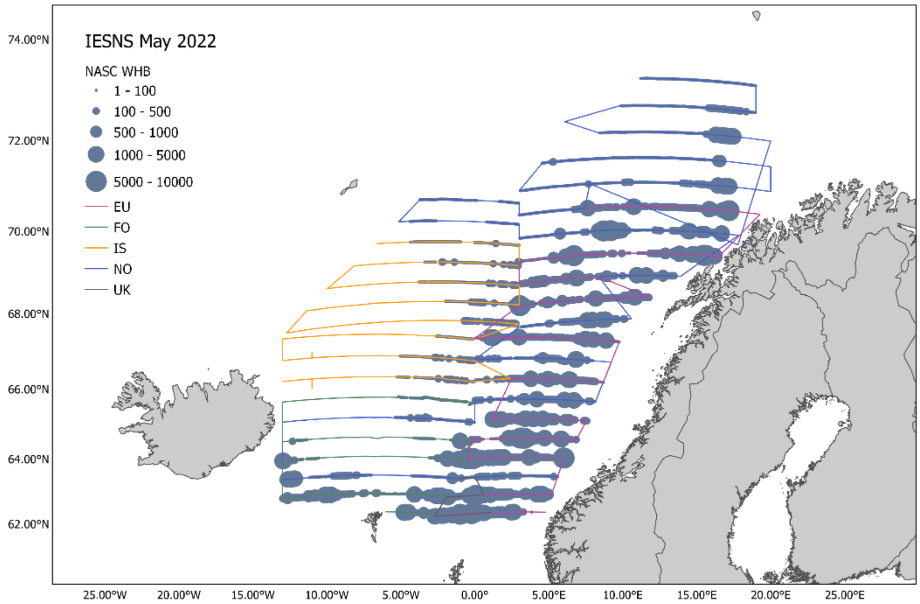


Figure 16. Distribution of blue whiting as measured during the IESNS survey in May 2022 in terms of NASC values (m²/nm²) (a) averaged for every 1 nautical mile.

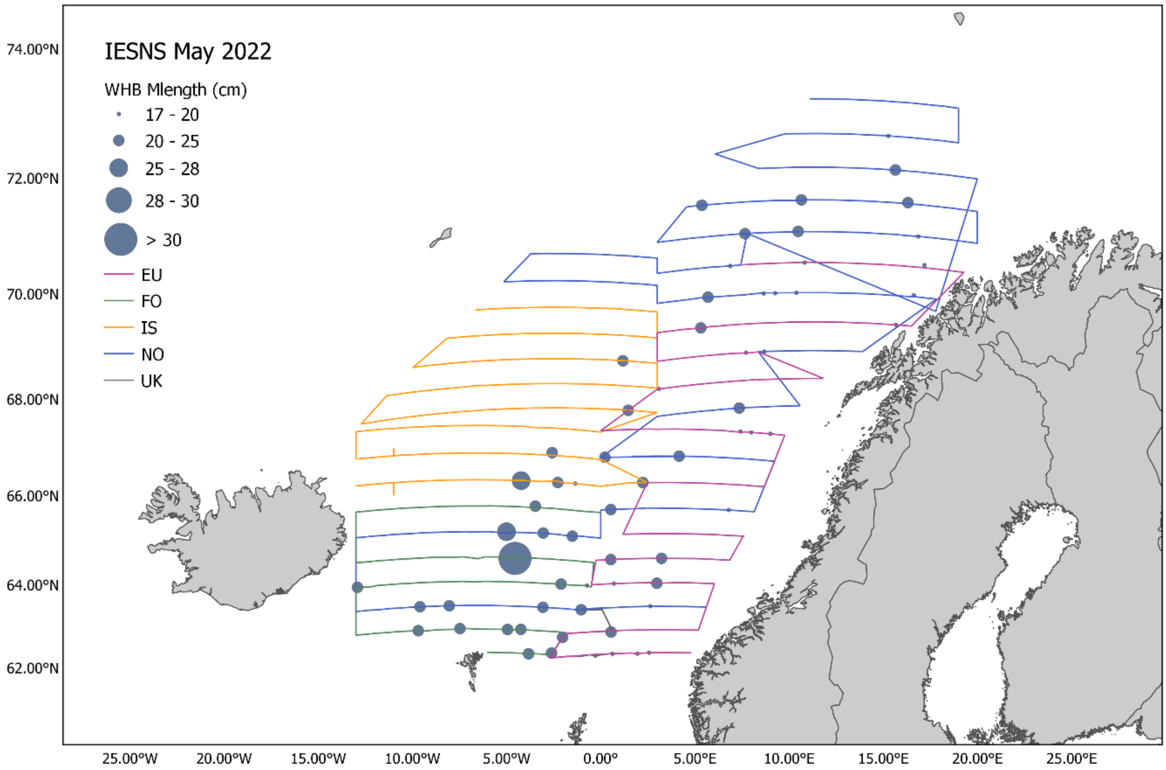


Figure 17. Mean length of blue whiting in all hauls in IESNS 2022. The strata are shown.

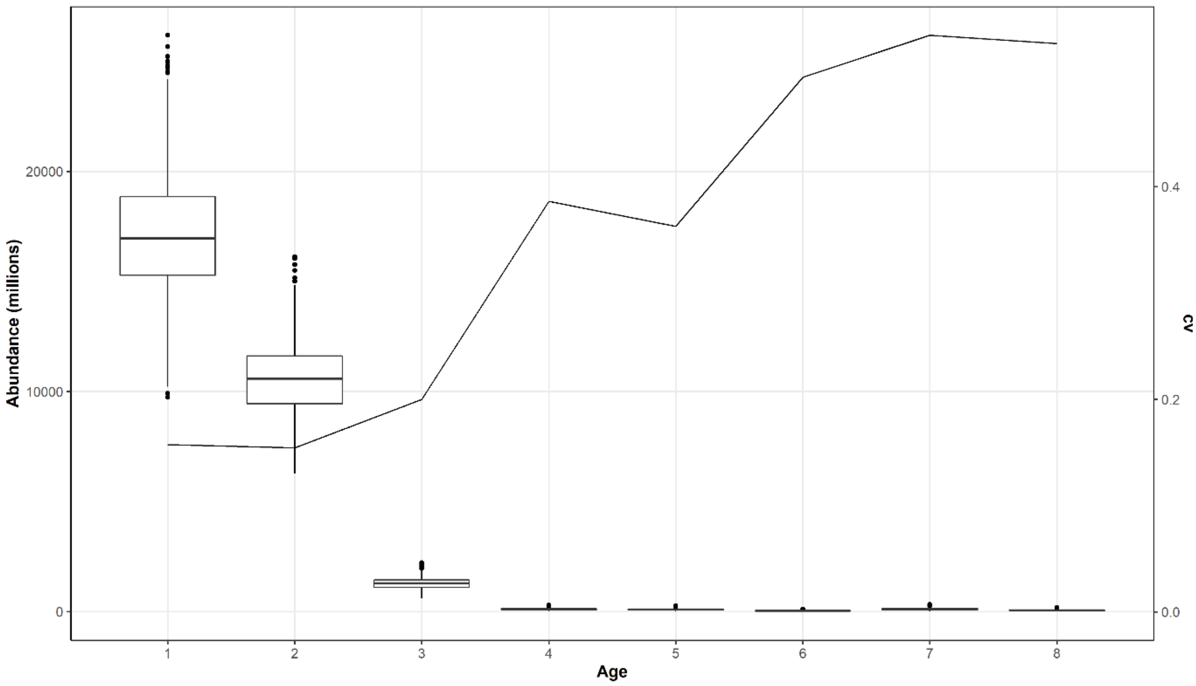


Figure 18. Blue whiting in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

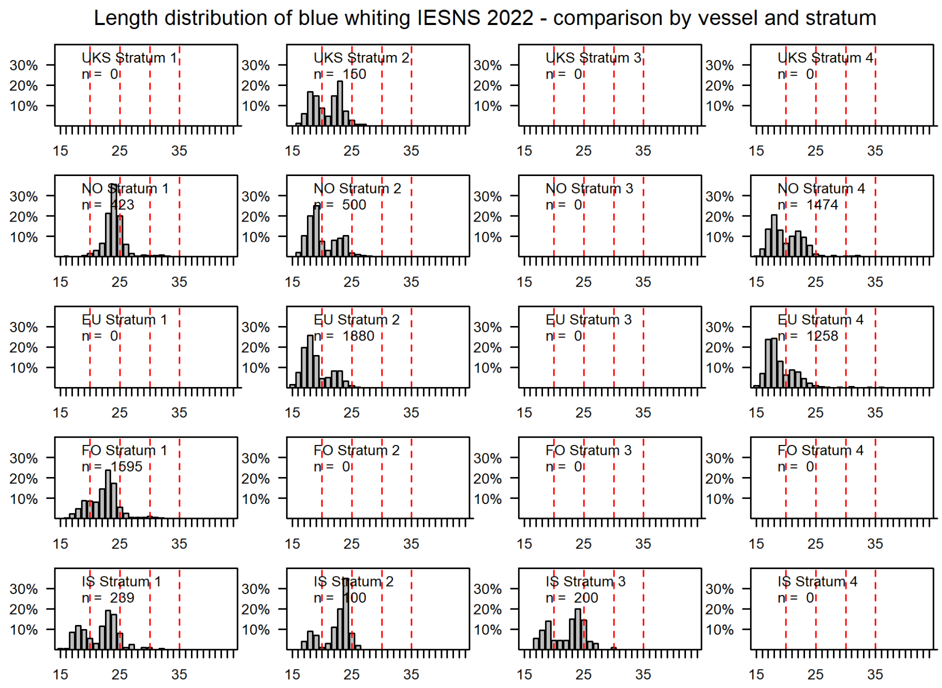


Figure 19. Comparison of the length distributions of blue whiting by stratum and country in IESNS 2022. The strata are shown in Figure 3.

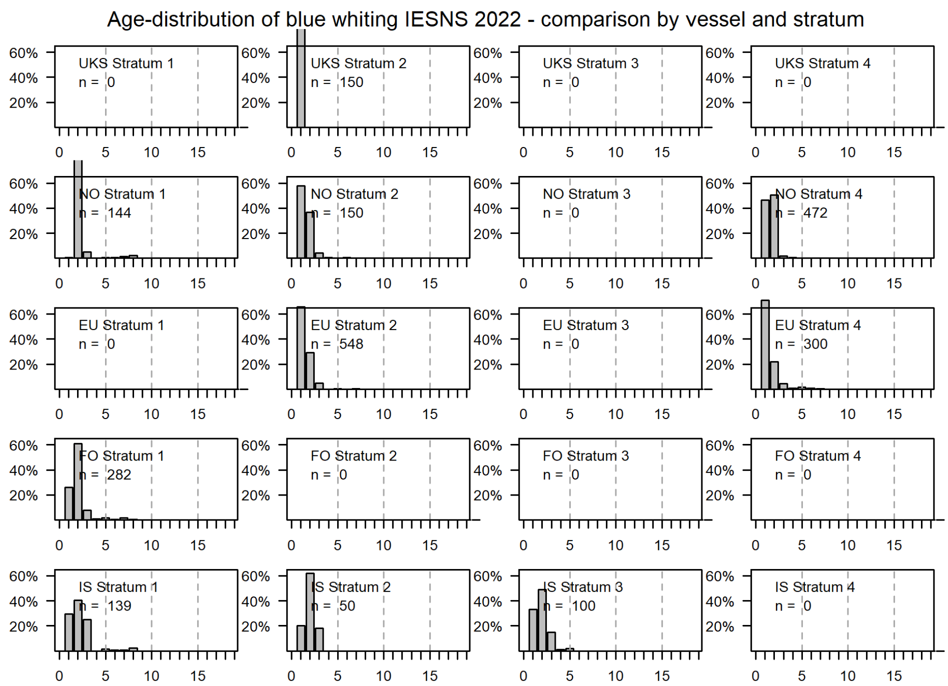


Figure 20. Comparison of the age distributions of blue whiting by stratum and country in IESNS 2022. The strata are shown in Figure 3.

IESNS post-cruise meeting, Teams 14-16/6 2022

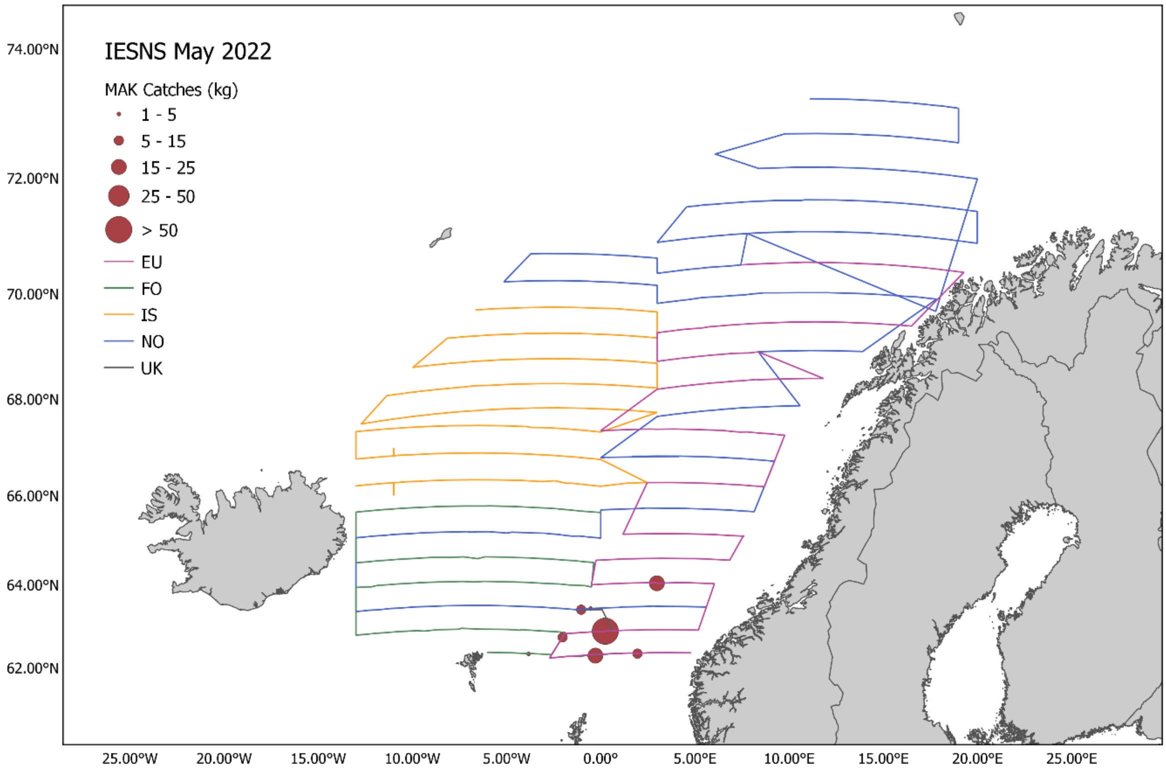


Figure 21. Pelagic trawl catches of mackerel in IESNS 2022.

ANNEX A

UK contribution to IESNS 2022

Background

In 2022 the UK participated to the IESNS survey by running a full survey on a chartered vessel that covered the UK EEZ within the IESNS survey area and an additional area south to 62° N, which is currently considered as the southern boundary of the Norwegian Spring-spawning herring stock. The main objective of the survey was to determine the distribution abundance and age structure of herring and blue whiting in the area south to the IESNS traditional coverage and detect and quantify potential mixing between different herring stocks (e.g. NSSH, NSAS, WoS).

Materials and methods

The survey was conducted onboard the commercial pelagic trawler F/V Resolute from 24/04/2022 to 06/05/2022. All the details about characteristics of the vessel, sampling, acoustic settings used, and data processing are listed in the previous section of this report. The acoustic transects and location of the hydrographic and plankton stations are shown in fig. A1. The survey area was split into 2 strata: a northern stratum that included the area north of 62° N which overlapped with the same area covered by the RV Dana and a southern stratum that covered the rest of the survey area (Fig. A2-a). For blue whiting, the southern stratum was further split into 2 additional strata to account for the habitat preferences of the species (Fig.A2-b).

Results and discussion

In total 9 acoustic transects were completed covering a total of 1158 nmi of acoustic sampling unit. A total of 11 pelagic trawls were carried out to provide groundtruth information about the species and size composition and to collect biological information (Fig. A3). In addition, CTD and plankton sampling were performed on 22 fixed stations.

Herring was patchily distributed over the whole survey area with higher densities located primarily around the Shetlands and at the southernmost transect of the survey located west of Orkney (Fig. A4). Herring size ranged from 21 to 33.5 cm with larger sizes found in the northern part of the survey area (Fig. A5). The total biomass estimate was 450,258 t (northern stratum: 43.550, southern stratum: 406,708) and a total number of 2.89 billion. Three-years-old and four-years-old herring were the most abundant age classes in terms of numbers accounting for 23% and 21% respectively of the total estimate (Fig. A6). The relative standard error (CV) is 40 % for both the total biomass and for the total numbers estimate.

Blue whiting was mainly distributed over the slope area in the north and western part of the survey areas (Fig. A7). Blue whiting aggregations primarily consisted of continuous and dense layers distributed between 200-400 m depth in the water column. Blue whiting size ranged from 16 to 33.5 cm with an overall average of 22.5 cm (Fig. A8). The total biomass estimate was 449,656 t (northern stratum: 261,872 t, southern stratum: 187,784 t) and a total number of 6.4 billion. Two-years-old was the most abundant age class in terms of numbers accounting for 89% of the total estimate (Fig A9). The relative standard error (CV) is 24 % for both the total biomass and for the total numbers estimate.

Mackerel was caught in almost all the trawls carried out. The size ranged from 18 to 41 cm with an overall average size of 33 cm (Fig. A10). No further quantitative information can be drawn from these data as this survey was not designed to monitor mackerel.

Future work

Genetic analysis is planned to be performed on herring fin clips samples collected during the survey (290 samples collected across 7 locations) to characterise the different stocks present in the survey area and the potential level of mixing with the Norwegian spring spawning herring.

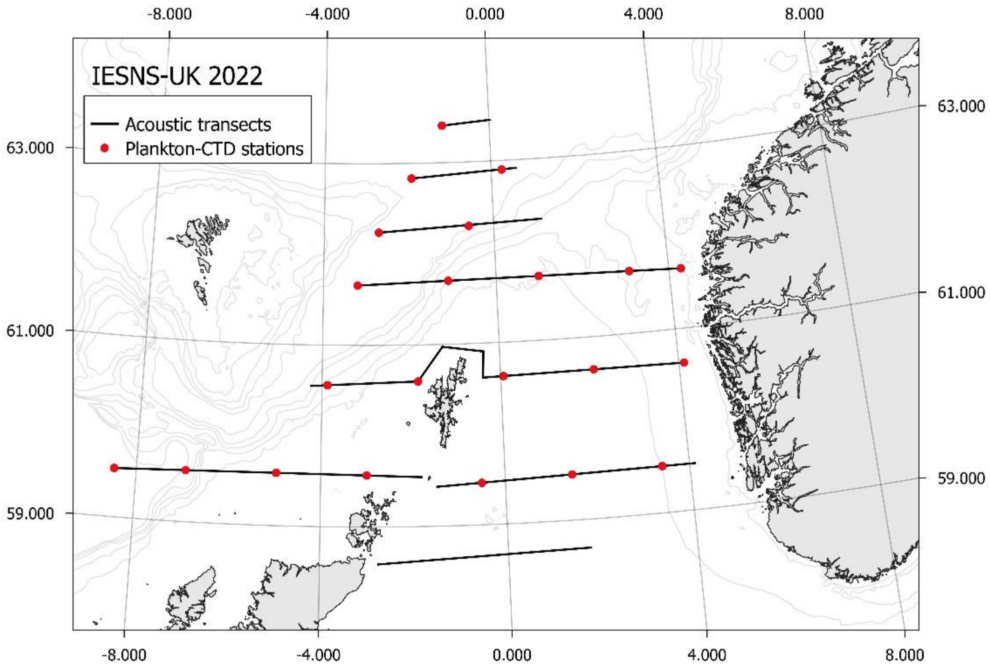


Figure A1 – Acoustic transects and location of hydrographic and plankton stations.

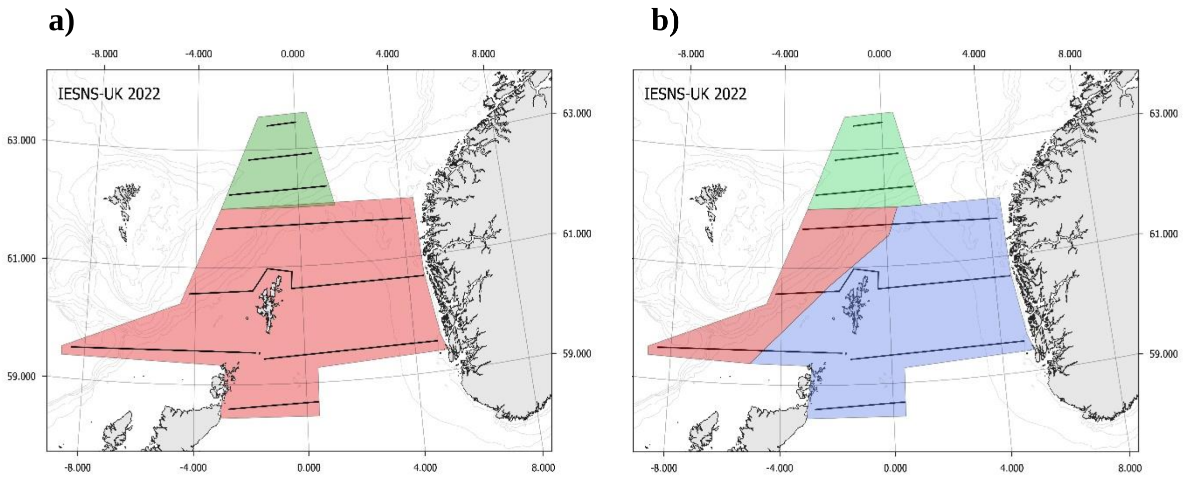


Figure A2 – Strata used for biomass estimation for herring (a) and blue whiting (b).

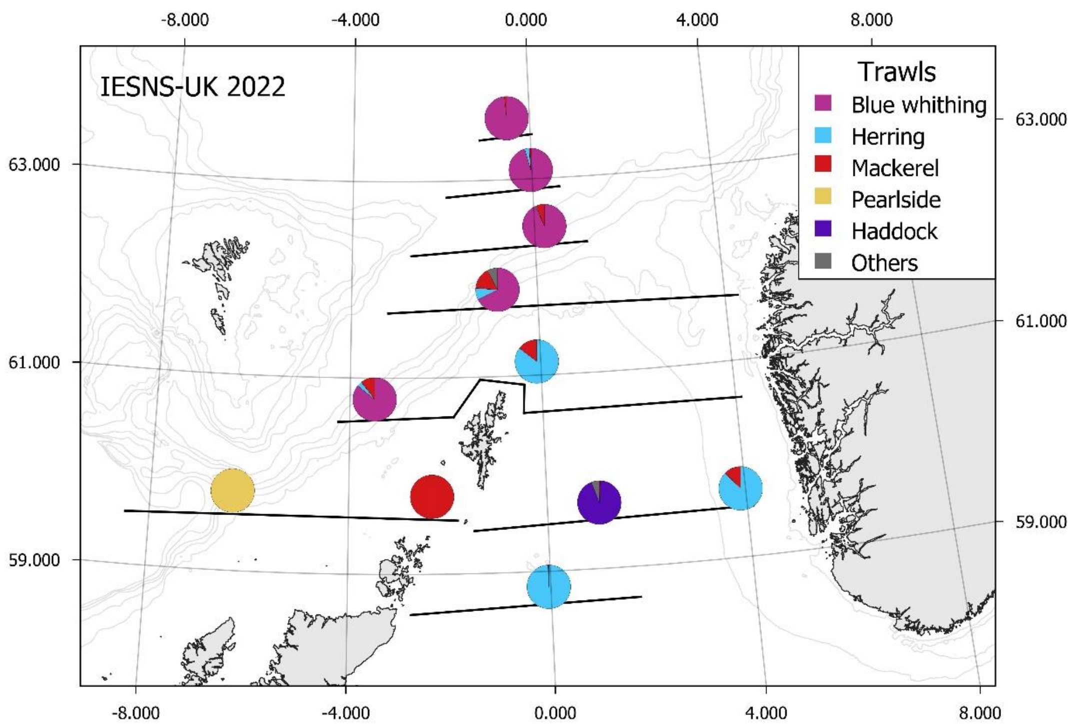


Figure A3 - Location and catch composition of the pelagic trawl stations.

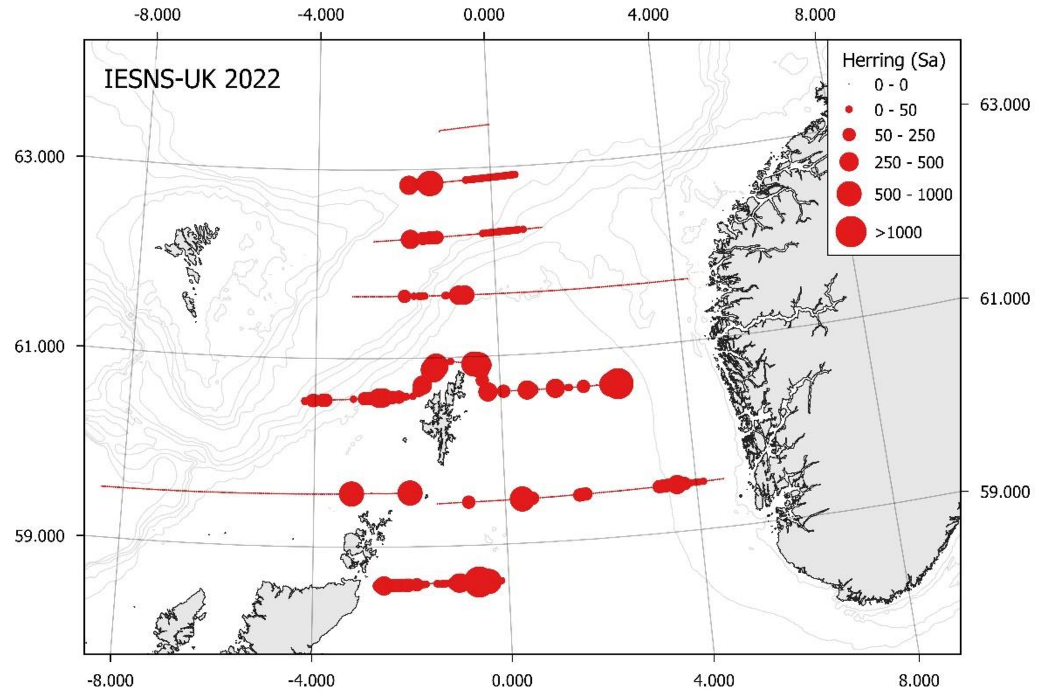


Figure A4 - Distribution of herring in terms of NASC values (m^2/nm^2) averaged for every 1 nautical mile.

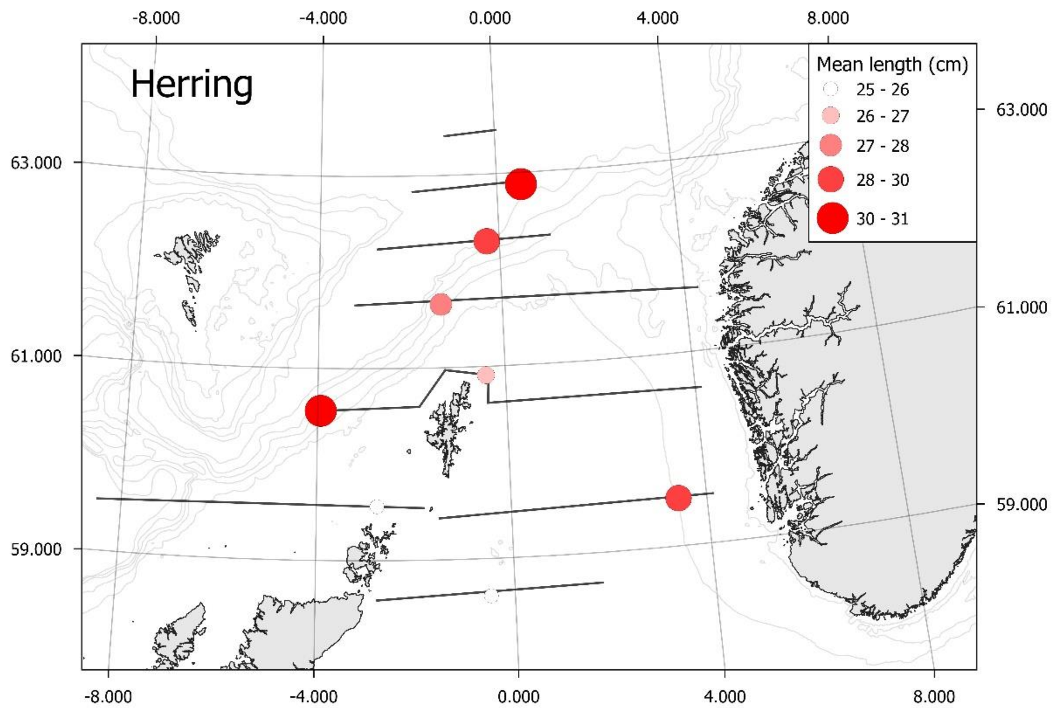


Figure A5 – Distribution of the mean length of herring measured in the pelagic trawl catches.

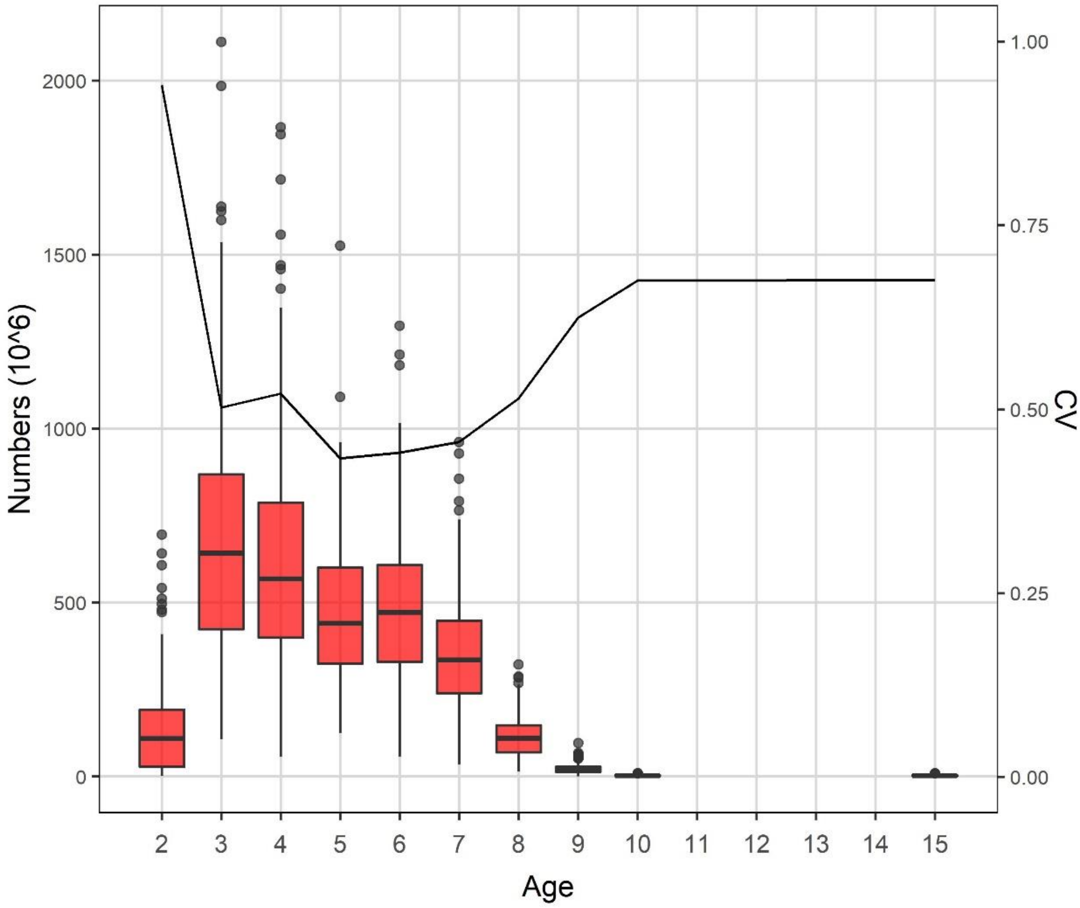


Figure A6 - Boxplot of herring abundance at age and relative standard error (CV) obtained by bootstrapping using the StoX software.

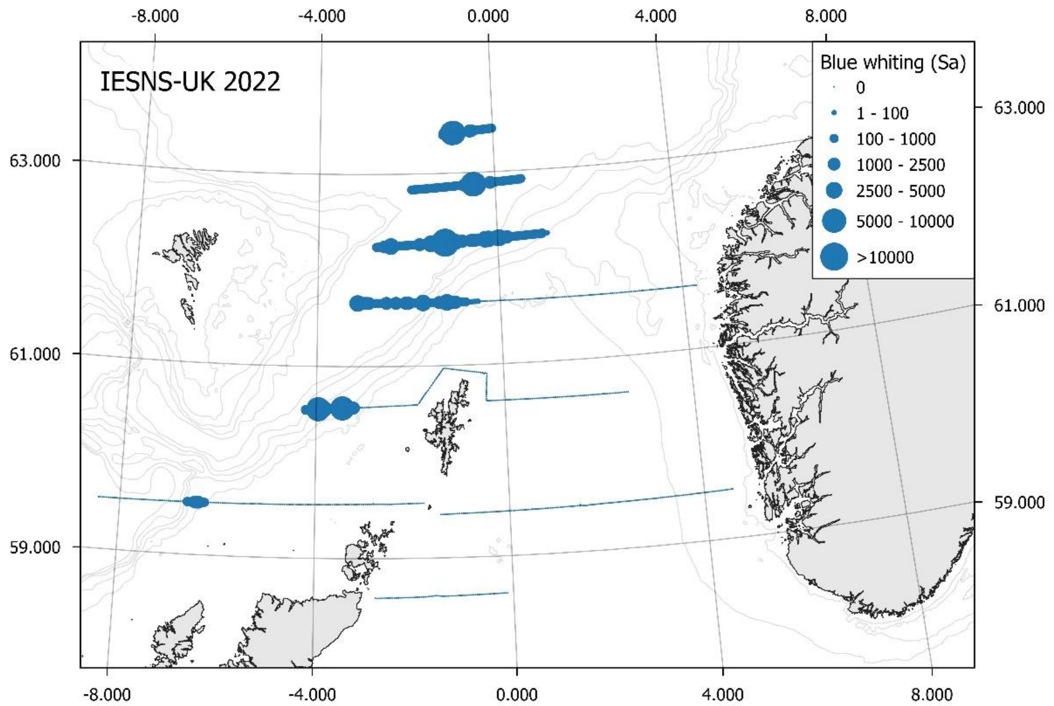


Figure A7 - Distribution of blue whiting in terms of NASC values (m^2/nm^2) averaged for every 1 nautical mile.

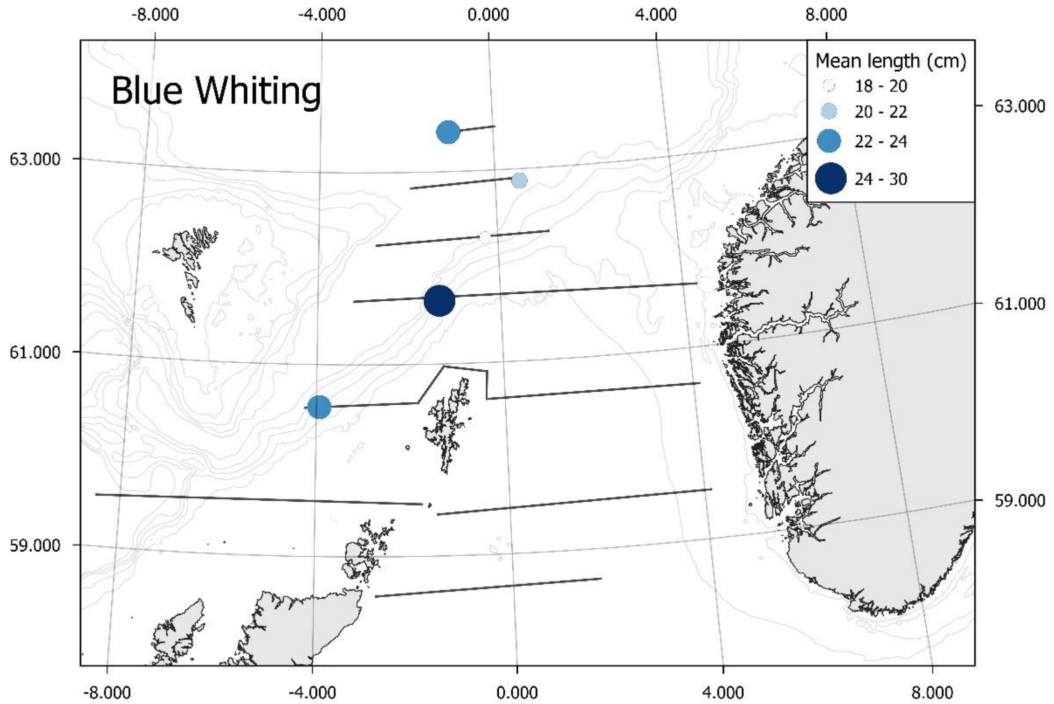


Figure A8 – Distribution of the mean length of blue whiting measured in the pelagic trawl catches.

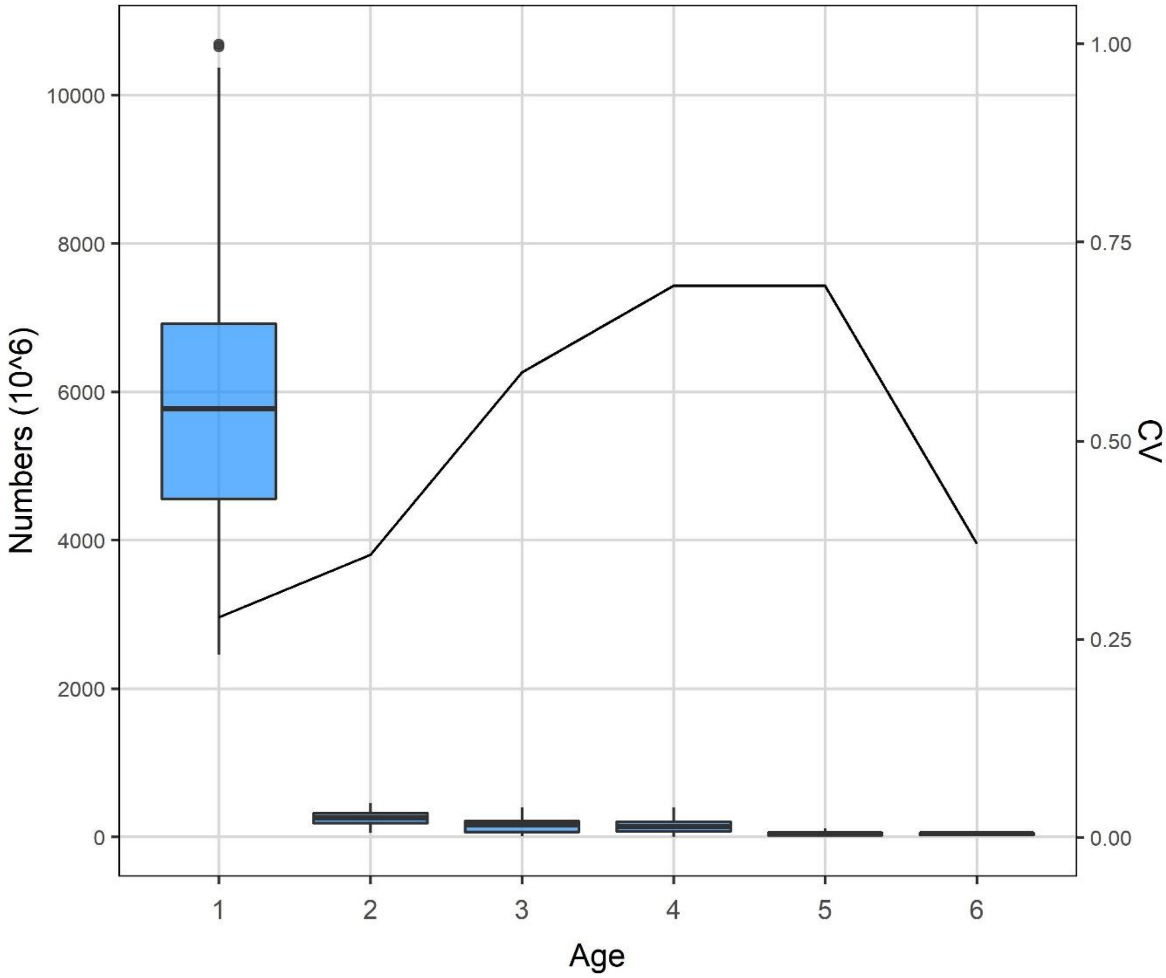


Figure A9 - Boxplot of blue whiting abundance at age and relative standard error (CV) obtained by bootstrapping using the StoX software.

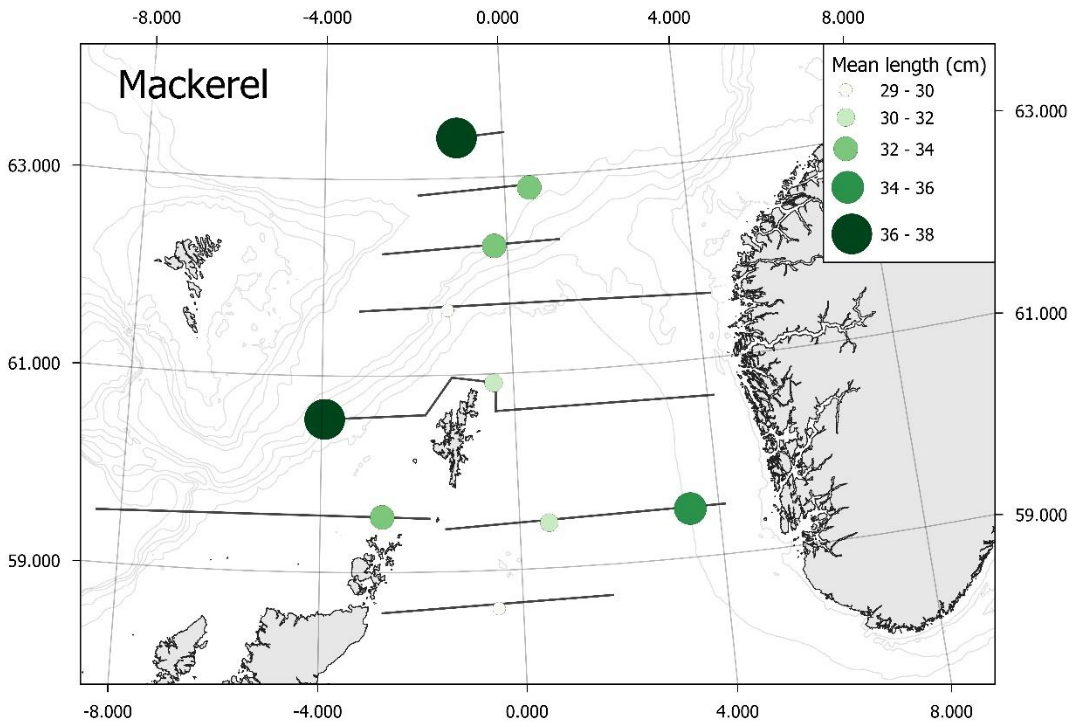


Figure A10 – Distribution of the mean length of mackerel measured in the pelagic trawl catches.

North Sea mackerel total egg production for 2022 using the daily egg production method

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Introduction

The North Sea Mackerel Egg Survey (NSMEGS) is designed to estimate the spawning stock biomass (SSB) of mackerel of the North Sea spawning component of the Northeast-Atlantic stock on a triennial basis. Up to and including 2017 this was undertaken utilizing the annual egg production method (AEPM) and generally undertaken in the year following the survey covering the western components. This method estimates and combines total annual egg production (TAEP), realized fecundity per gram female, and sex (male to female) ratio to calculate SSB.

Spatial and temporal coverage in the North Sea was reduced with the withdrawal of Norway from the NSMEGS in 2014, with the Netherlands left as the sole survey participant in 2015 and 2017. In 2020 Denmark was recruited as a new participant for the NSMEGS, and in 2021 the UK (England) announced that they were willing to participate.

An issue for the NSMEGS is that since 1982 it has been impossible to collect and sample pre-spawning mackerel, which are necessary in order to estimate the potential fecundity. For SSB estimation using the AEPM, the realized fecundity value used was from the 1982 estimate (Iversen and Adoff, 1983). For a number of years it was recognised that an AEPM survey wasn't producing the best results for the North Sea. Therefore, at the WGMEGS meeting in 2018 a decision was made to use the Daily Egg Production Method (DEPM) for future North Sea surveys (ICES 2018). The DEPM requires only one full sweep, in a short time period, over the entire mackerel spawning area, preferably during peak spawning time. A disadvantage of the DEPM is that it requires many more mackerel ovary samples to be collected to estimate batch fecundity and spawning fraction.

Survey

In 2022 the UK and Denmark conducted the North Sea survey. Whilst planning the survey it became apparent that the vessel time available from the two countries would not be sufficient to cover the area. As a result, Norway agreed to survey the four northernmost transects in the North Sea at the start of their period 6 survey.

The samples were collected and analysed according to the WGMEGS manuals (ICES 2019a, 2019b). UK and Norway sampled eggs with a Gulf VII plankton sampler while Denmark used a Nackthai sampler. The UK and Denmark utilised a 500 µm plankton net which is standard protocol for the North Sea due to issues with clogging, while Norway used a 250µm mesh. At each station a double oblique haul was performed from the surface to 5 m above the bottom, a maximum depth of 200 m, or 20 m below the thermocline in case of stratification of the water column. Temperature and salinity were measured during the haul with a CTD mounted on top of the plankton sampler. Either electronic or mechanical flowmeters were mounted on the plankton sampler to monitor flow.

The NSMEGS was carried out from 5th – 24th June (Table 1). During this period the spawning area between 54ºN and 62ºN was surveyed once, receiving a single coverage (Fig. 1). The survey is designed to cover the entire spawning area with samples collected every half ICES statistical rectangle (ICES, 2014). In total 259 plankton stations were sampled, with 19 stations interpolated. On each of the Danish transects at least one pelagic trawl haul was performed for the collection of mackerel adult samples. Due to problems with their fishing gear CEFAS carried out a number of rod and line fishing events.

Following the WGMEGS manual temperature at 5m depth was used to estimate egg development (ICES 2019a). For the DEPM only the mackerel eggs in development stage 1A are used to estimate daily egg production.

Results

Mackerel daily egg production

The spatial egg distribution is shown in Fig. 1. Standard MEGS interpolation rules (ICES, 2019a) were applied where needed. Egg distributions are comparable to 2021, however egg numbers seem to be more evenly distributed throughout the survey area this year.

The total area sampled in 2022 was slightly smaller than the area sampled in 2021, the first full transect was started at 54° 15'N compared to 53° 15'N in 2021. The two southern transects were sampled but there were issues with many of the stations re the accuracy of the flow data. This resulted in three valid stations south of 54°N with a further three being interpolated. The invalid stations do give an indication of the presence and absence (qualitative data) of mackerel stage 1A and above over this area.

The DEP was calculated for the total investigated area (Table 2). Total egg production for 2022 was $0.6699*10^{13}$ eggs. This is a 50% decrease on egg numbers reported in 2021 (Table 3).

Adult parameters

Denmark conducted 33 hauls, from which they sampled 1180 mackerel and collected ovary samples from 364 females. England conducted 20 rod and line fishing events of which 9 were positive, biologically sampling 225 mackerel and collecting ovary samples of 74 females. Norway collected 239 female mackerel samples from 5 fishing hauls, (Table 1). As these samples were collected in June no analysis has been carried out on them. Batch fecundity and POF counting will take place before the end of the year, with the results to be delivered prior to the WGMEGS meeting in April 2023.

SSB

As there are no data available from the adult parameters, WGMEGS is just reporting egg production for 2022.

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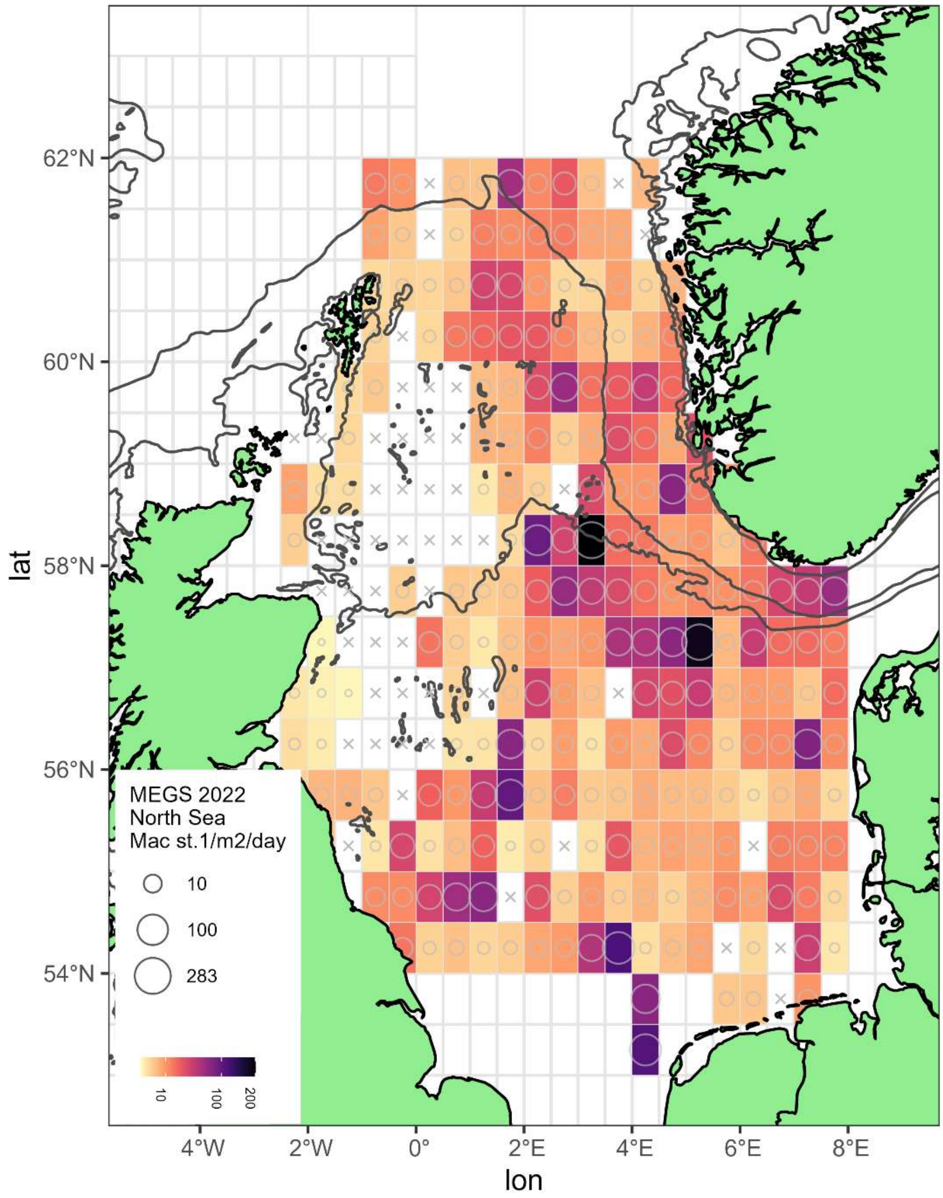

Figure 1. Heat map of Stage 1A mackerel egg production (eggs. m^{-2}. day^{-1}) by half rectangle for the North Sea, 2022. Grey circles represent observed values, crosses represent observed zeros.

Table 1. NSMEGS surveys cruise dates in 2022 (For Norway only stations used in the NSMEGS DEP calculation are shown). UK=UK England, DK=Denmark, NO=Norway.

Country	**UK**	**DK**	**NO**
Period	1	1	1
Dates (2022)	5.06-24.06	08.06-17.06	7.06-19.06
Plankton stations sampled	135	79	45
Pelagic trawl hauls		33	5
Positive rod and line events	9		

Table 2. Total egg production using the Daily egg production estimate (stage 1A abundance) in the North Sea for 2022.

Year	**DEP $*10^{13}$**	**CV DEP**
2022	0.67	

Table 3. Comparison of total stage 1A egg production for 2022 and 2021 in the North Sea estimated by the Daily Egg production method.

Year	**2022**	**2021**
DEP $*10^{13}$	0.67	1.28

2022 Mackerel and Horse Mackerel Egg Survey

Preliminary Results

by

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1 Introduction

The mackerel and horse mackerel egg survey is an ICES-coordinated international study in the north east Atlantic conducted during the first half of 2022. This study is a combined plankton and fishery investigation formed by a series of individual surveys which have taken place triennially since the late 1970s and is coordinated by the ICES Working Group on Mackerel and Horse Mackerel Egg Surveys (WGMEGS). Historically a North sea mackerel egg survey is carried out in the year after the western and southern surveys. in 2022, due to the presence of new participants, the all surveys were carried out in the same year

The main objective of this series of individual cruises from January until July is to produce both an index and a direct estimate of the biomass of the north east Atlantic mackerel stock and an index for the southern and western horse mackerel stocks. The results have been used in the assessment for mackerel since 1977 and from 1992 for horse mackerel. The mackerel and horse mackerel egg survey is still a principal source of data providing fisheries independent information for these stocks.

The general method is to quantify the freshly spawned eggs in the water column on the spawning grounds. To be able to establish a relationship between eggs and biomass of the spawning stock, the fecundity of the females must also be determined. This is undertaken by sampling ovaries before and during spawning. In cases where the annual egg production method is applied the potential fecundity is counted from whole mount volumetric subsamples using a dissecting microscope while atresia is counted histologically from slides. Realised fecundity is estimated as potential fecundity minus atresia. The realised fecundity is used in combination with the calculated number of freshly spawned eggs in the water to estimate the spawning stock biomass.

To provide reliable estimates of spawned eggs and fecundity an extensive coverage of the spawning area is required both in time and space. The spawning of the southern horse mackerel stock and mackerel starts in late December off the Portuguese coast. Spawning proceeds further north along the continental shelf edge as water temperature increases during late winter and spring. In the past peak spawning of mackerel has normally occurred in April-May in the area of the Sole Banks with an extension to the Porcupine Bank. Whilst the distribution and timing of peak western horse mackerel spawning has remained fairly stable during recent surveys the same cannot be said for NEA mackerel. The 2010 and 2013 MEGS surveys saw peak mackerel spawning in February – March with 2013 also demonstrating a shift in the geographical centre of spawning further south within the southern Biscay region. Since then however mackerel spawning is now observed over a large region of the Northeast Atlantic both on and off the continental shelf, ranging as far west as Hatton Bank, as far north as Iceland and the Faroe Islands and in recent years around the Shetland Islands and the Norwegian coast in the Northeast.

This survey report presents the preliminary results of the 2022 mackerel and horse mackerel egg survey provided for WGWIDE in August 2022. The survey report and the analysis will be finalised during the next WGMEGS meeting in April 2023. Although every effort was made to ensure that WGWIDE were provided with the most recent and accurate data-set, WGMEGS cannot guarantee that there will not be changes prior to the analysis being finalised. This is due to the extremely large numbers of plankton and fecundity samples to be analysed following the surveys as well as the tight deadline set by WGWIDE for delivering these estimates. This has resulted in a very limited time within which to process the 2022 MEGS data.

Survey effort

As a consequence of the long spawning period and the large survey area involved, the mackerel and horse mackerel egg surveys have always relied on broad international participation. In 2022 a total of 18 individual cruises were carried out, 16 in the Atlantic and 2 in the North sea, for a total of 321 at-sea survey days. Individual contributions were; Spain (IEO: 42 days at sea, AZTI: 30 days), Scotland (53 days), the Netherlands (39 days), Ireland (28 days), Portugal (34 days), Germany (23 days), Norway (15 days), Faroe Islands (14 days), England (23 days) and Denmark (14 days). Denmark joined the group in 2020 and participated in the 2021 North Sea survey along with the Netherlands. England rejoined the group in 2021 and in 2022 conducted the North Sea survey in participation with Denmark.

Survey design

The aim of the triennial egg survey is to determine the annual egg production (AEP). This is calculated using the mean daily egg production rates per pre-defined sampling period for the complete spawning area of the Northeast Atlantic Mackerel and Horse Mackerel Stocks. To achieve this, one plankton haul per each half rectangle (separated by approximately 15-20 NM, depending on latitude) is conducted on alternating transects covering the complete spawning area. The 2022 egg survey was designed in order to maximise both the spatial and temporal coverage in each of the sampling periods. Given the very large area to be surveyed this design minimises the chances of under/overestimation of the egg production (ICES 2008).

The 2022 survey plan was split into 6 sampling periods (Table 1). Portugal were assigned to start the survey in the southern area during Period 2. No sampling was scheduled to take place in ICES division 9a after Period 2. Sampling of the western area commenced in Period 3, and included coverage of the west of Scotland, west of Ireland, Biscay and the Cantabrian Sea. Surveying in the Cantabrian Sea ended at the end of Period 5. In Periods 6 and 7 the surveys were designed to identify a southern boundary of spawning and to survey all areas north of this boundary.

Maximum deployment of effort in the western area was during Periods three, four, five and six. Historically these periods would have coincided with the expected peak spawning of both mackerel and horse mackerel. Recent years have seen mackerel peak spawning taking place during Periods 3 and 5.

Due to the expansion of the spawning area which has been observed since 2007 the emphasis was even more focused on full area coverage and delineation of the spawning boundaries. Cruise leaders had been asked to cover their entire assigned area using alternate transects and then use any remaining time to fill in the missed transects.

Table 1. Participating countries, vessels, areas covered, dates and sampling periods of the 2022 surveys.

Country	Vessel	Area	Dates	Period
Portugal	Vizconde de Eza	Portugal	Jan 23rd – Feb 26th	2
Ireland	Celtic Explorer	West of Ireland, Celtic sea, Biscay,	March 2nd – 22nd	2
	Corystes	West of Ireland, west of Scotland	June 11th – 18th	6
Scotland	Altaire	West of Scotland	April 12th – 27th	4
	Scotia	West of Scotland, west of Ireland	May 12th – June 1st	5
	Altaire	West of Scotland, west of Ireland, Celtic sea, Biscay	July 4th – 27th	7
Spain (IEO)	Miguel Oliver	Cantabrian sea, Galicia, southern Biscay	March 14th – April 3rd	3
	Vizconde de Eza	Cantabrian sea, Galicia, Biscay	April 4th – April 30th	4
Spain (AZTI)	Ramon Margalef	Northern Biscay	March 10th – 30th	3
	Vizconde de Eza Ramon Margalef	Biscay, Cantabrian sea	April 30th – May 19th	5
Germany	Walther Herwig	Celtic sea, west of Ireland	March 31st – April 8th	3
	Walther Herwig	Celtic sea, west of Ireland, west of Scotland	April 10th – 22nd	4
Netherlands	Tridens	Northern Biscay, Celtic sea	May 8th – 26th	5
	Tridens	Biscay, Celtic sea	June 5th – 24th	6
Norway	Brennholm	Faroes & Norway	June 7th – 20th	6
Faroes	Magnus Heinason	Faroes, Iceland	May 19th – June 1st	5
Denmark	Dana	North Sea	June 7th – 18th	
England	Cefas Endeavour	North Sea	June 4th - 25th	

Processing of samples

The analysis of the plankton and fecundity samples were carried out according to the sampling protocols as described in the WGMEGS Manuals for Survey (ICES, 2019a) and Fecundity (ICES, 2019b).

A total of 1780 plankton samples were collected and sorted. Mackerel and horse mackerel eggs were identified and the egg development stages determined. Depending on the vessel facilities and the experience of the participants this was done either during the cruise or back in the national institutes.

Double micropipette samples and slices from ovaries of mackerel were taken during each survey. Additional samples were collected during periods 3 and 4 by participants in an effort to carry out DEPM analysis, along with AEPM analysis. Fecundity sampling for horse mackerel only took place during the expected peak spawning Periods, 6 and 7.

In order to increase the number of samples available for fecundity analysis additional mackerel gonads were collected from some Dutch pelagic vessels, and also on the Dutch and Irish Blue whiting surveys in Periods 2, 3 and 4.

After each survey the ovary screening and fecundity samples were shared between the participating research institutes for histological and whole mount analysis to determine the realised fecundity (potential fecundity minus atresia). Screening samples, and fecundity samples, have to be analysed in the laboratory upon return from sea. These procedures are not straightforward and require time. The last histology samples were collected in July and because of the narrow time frame only a selection of the fecundity samples have been analysed up to this date. Samples were therefore only analysed from sampling Periods 2 and 3 for the preliminary estimate.

Horse mackerel is considered to be an indeterminate spawner and therefore since 2007 IPMA has adopted the DEPM methodology for the southern horse mackerel stock (div. 9a). The egg survey design in the western area is directed at the AEP method for mackerel which produces an estimate of SSB. Fecundity samples for horse mackerel were taken during the survey in the western areas in order to develop a modified DEPM approach for estimating the biomass of the horse mackerel stocks. Additional samples were collected during the Irish WESPAS survey in the Celtic Sea and west of Ireland in Periods 6 and 7.

Even though the partial processing of the screening samples has identified ovaries to be analysed for DEPM, none of these samples have been analysed yet.

Survey coverage and mackerel egg production by period

Period 2 – Portugal started the 2022 survey series on January 23rd. This is a DEPM survey mainly targeting the southern horse mackerel stock and is designed for this purpose, but it provides mackerel egg samples as well. The survey is usually undertaken between Cadiz and Galicia and is confined to ICES division 9a.

Period 3 – Period 3 marks the commencement of the western area surveys as well as a continuation of sampling in the southern area. Sampling was undertaken by Ireland (West of Scotland, west of Ireland, Celtic Sea), Germany (Celtic Sea) and AZTI (northern Biscay). Further south the Bay of Biscay, Cantabrian Sea and Galicia were covered by Spain (IEO).

No eggs were found by Ireland in northern waters so after a number of days the vessel turned south and sampled in the Celtic sea. Due to issues with Covid cases among the crew the German survey was delayed starting, however it subsequently linked with the Irish vessel. Both IEO and AZTI suffered difficulties with their vessels, and lost a number of sampling days, however full coverage was achieved (Fig. 1.1).

Egg numbers were quite low to the west of Ireland, however further south large numbers of eggs were found close to the 200m contour line. In Biscay and the Cantabrian Sea IEO and AZTI recorded a number of stations with large egg numbers. 298 stations were sampled and there were only 13 interpolations. There were 52 replicate samples with the majority being completed in the Cantabrian Sea.

Period 4 – This period was covered by three surveys. Scotland sampled the area from the northwest of Ireland to the Shetland islands. Germany surveyed west of Ireland, Celtic sea and northern Biscay while IEO completed the survey coverage in southern Biscay and the Cantabrian Sea (Fig. 1.2).

Due to difficulties in acquiring diplomatic clearance the Scottish survey was unable to sample in Irish waters. As a result Germany extended their survey area to ensure continuity of sampling coverage.

Once again moderate levels of eggs were recorded throughout the area, with the highest concentrations still being found close to the 200m contour line. Large egg numbers were recorded to the west of Scotland, however numbers were lower than those reported for 2019 within this area and time period. 327 stations were sampled and there were 46 interpolations. 52 replicate samples were taken and once again most of these were collected from the Cantabrian Sea.

Period 5 – In Period 5, the entire spawning area from the Cantabrian Sea to the West of Scotland, and up to Faroese waters at around 61°N was surveyed by AZTI, the Netherlands, Scotland, and Faroes.

Spawning in the Cantabrian Sea was tailing off with only low egg numbers being found. Throughout Biscay and into the southern Celtic Sea numbers were generally low to moderate (Fig. 1.3). This pattern continued west of Ireland, to around 54°N, with spawning remaining on and around the Shelf edge. North of this however, and similar to that noted in 2016 and 2019, spawning activity fanned out both westwards and northwards. Due to the large area Scotland had to survey their vessel was forced to restrict exploration of the western boundary around the SW of Rockall Bank. Egg numbers in 2022 within this area were lower than reported in 2019 so while the western boundary wasn't delineated, MEGS is happy that major egg production isn't being missed. North of this the Faroese survey completed stations North of Hatton Bank and up towards the Icelandic coast. Some egg production was found to the north of Rockall, however the largest number of eggs were encountered west of the Shetlands. In total 444 stations were sampled and there were 214 interpolations. No replicate samples were taken.

Period 6 – During period 6 northern Biscay, from 46°N and also the Celtic Sea were covered by the Netherlands while Ireland was to cover west of Ireland and also west of Scotland. Norway surveyed the area north of 59°N from the south of Iceland to the Norwegian coast, as well as carrying out four transects in the northern North Sea to assist England and Denmark provide full coverage for the DEPM survey.

Ireland was due to charter a research vessel from Northern Ireland to conduct the survey. One week before the survey was due to depart this vessel had to go to dry dock for emergency repairs. After much searching a smaller Welsh RV was contracted. Once at sea however it quickly became clear that the replacement vessel was not going to be suitable for the survey. Only two successful stations were carried out before a decision was eventually made to abandon the survey. Norway and Netherlands both completed their survey sampling successfully.

Low levels of spawning were observed in Biscay and to the south to the West of Ireland and Porcupine bank (Fig. 1.4). Similarly in the northern area spawning was persistent at low levels, apart again from the area west of the Shetland. Due to an unavoidable reduction in the number of survey days available Norway was unable to secure either the western or northern boundary in the northern area, however Netherlands secured the western boundary in their area. 184 stations were sampled with 36 interpolations. No replicate stations were completed.

Period 7 – This period was covered entirely by Scotland sampling on alternate transects in the area from 47°15N in the south to north of the Hebrides and 59°N (Fig. 1.5). Due to the lack of eggs encountered the Scottish survey adhered very closely to the 200m contour and 144 stations were sampled with 24 interpolations. 2 replicate station was completed. Only very low levels of spawning were observed and these were confined to the continental shelf and shelf edge with all spawning boundaries being delineated successfully.

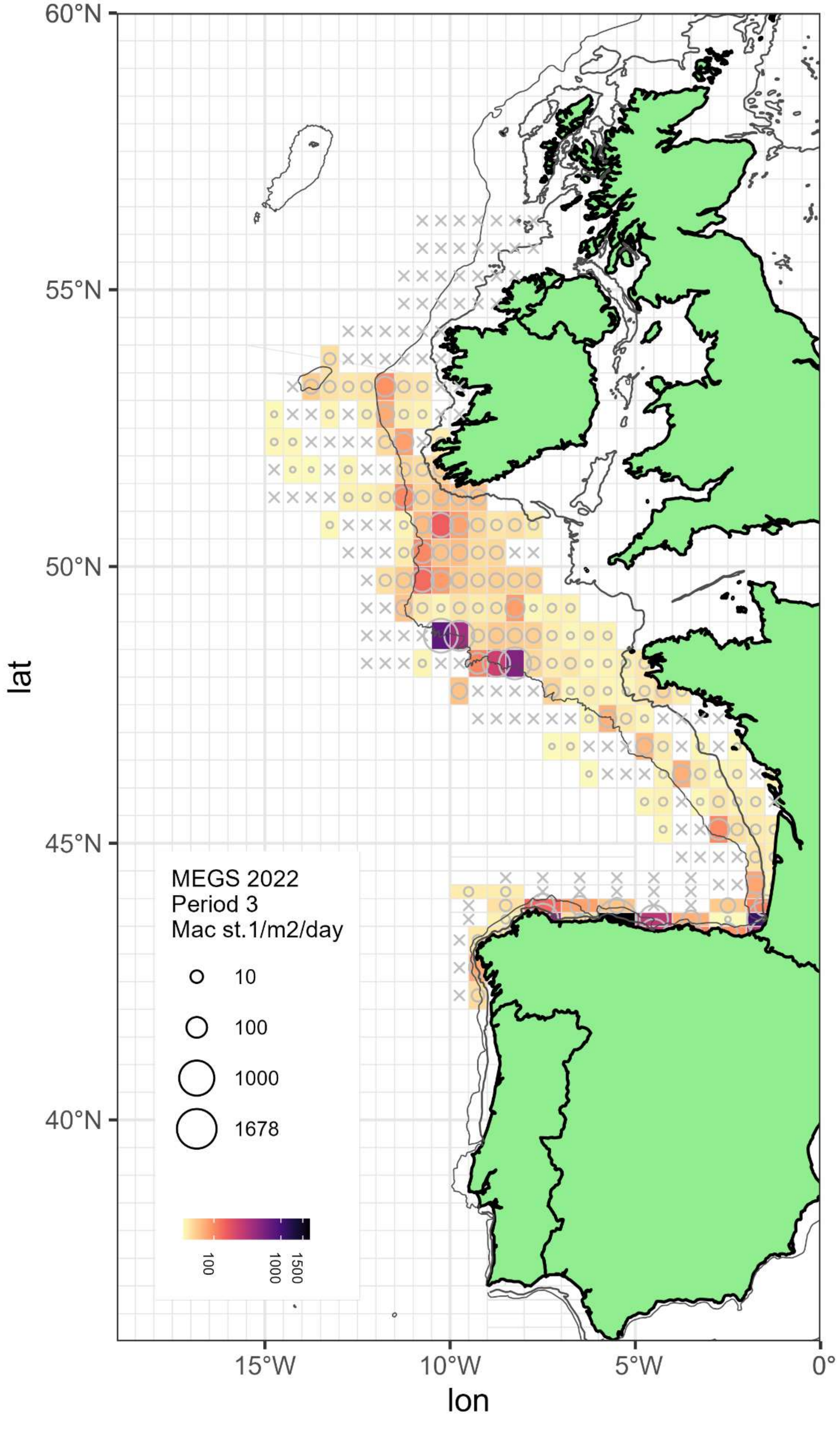

Figure 1.1: Mackerel egg production by half rectangle for period 3 (Mar 4th – Apr 8th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

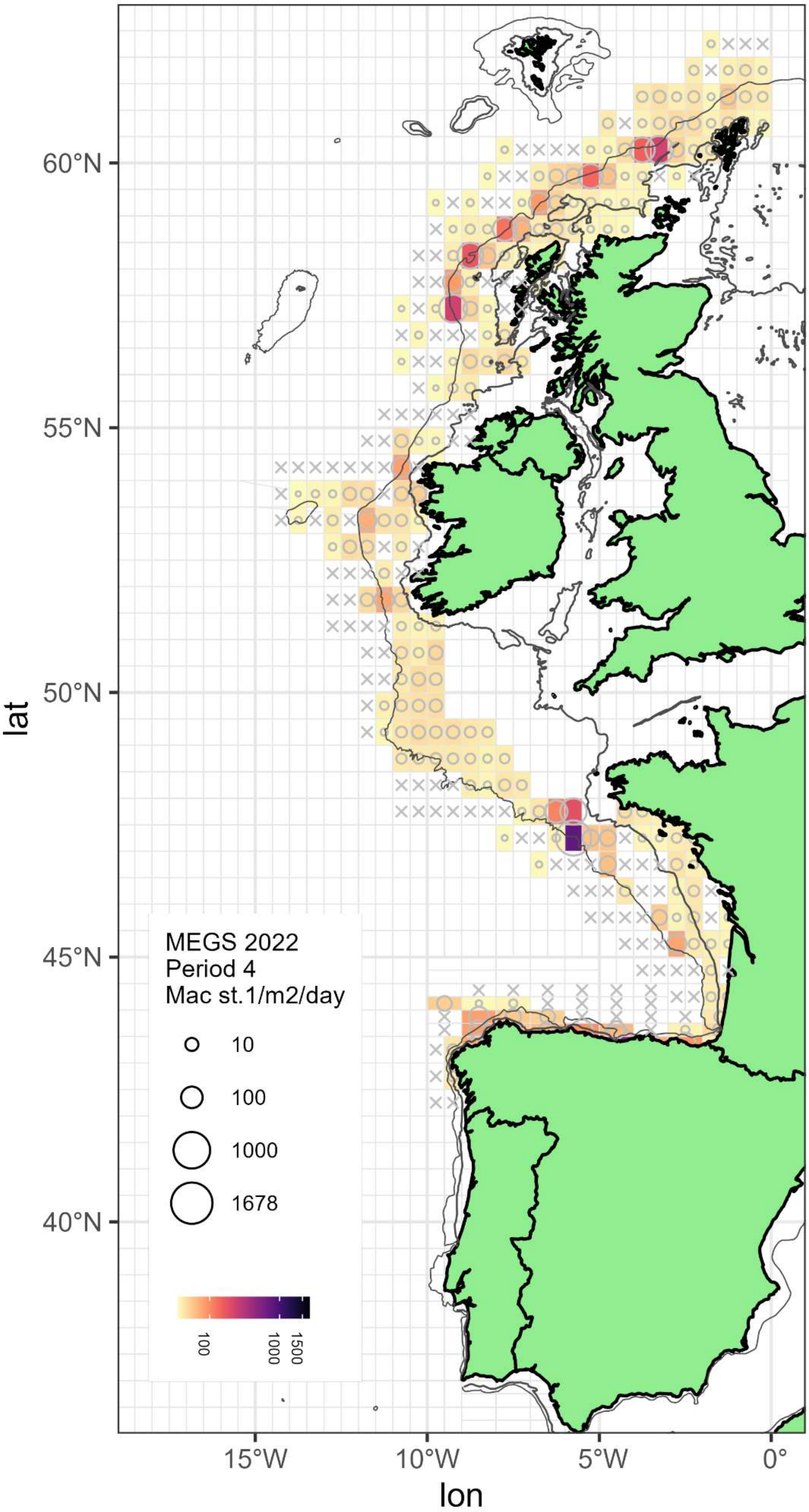

Figure 1.2: Mackerel egg production by half rectangle for period 4 (Apr 9th – 29th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

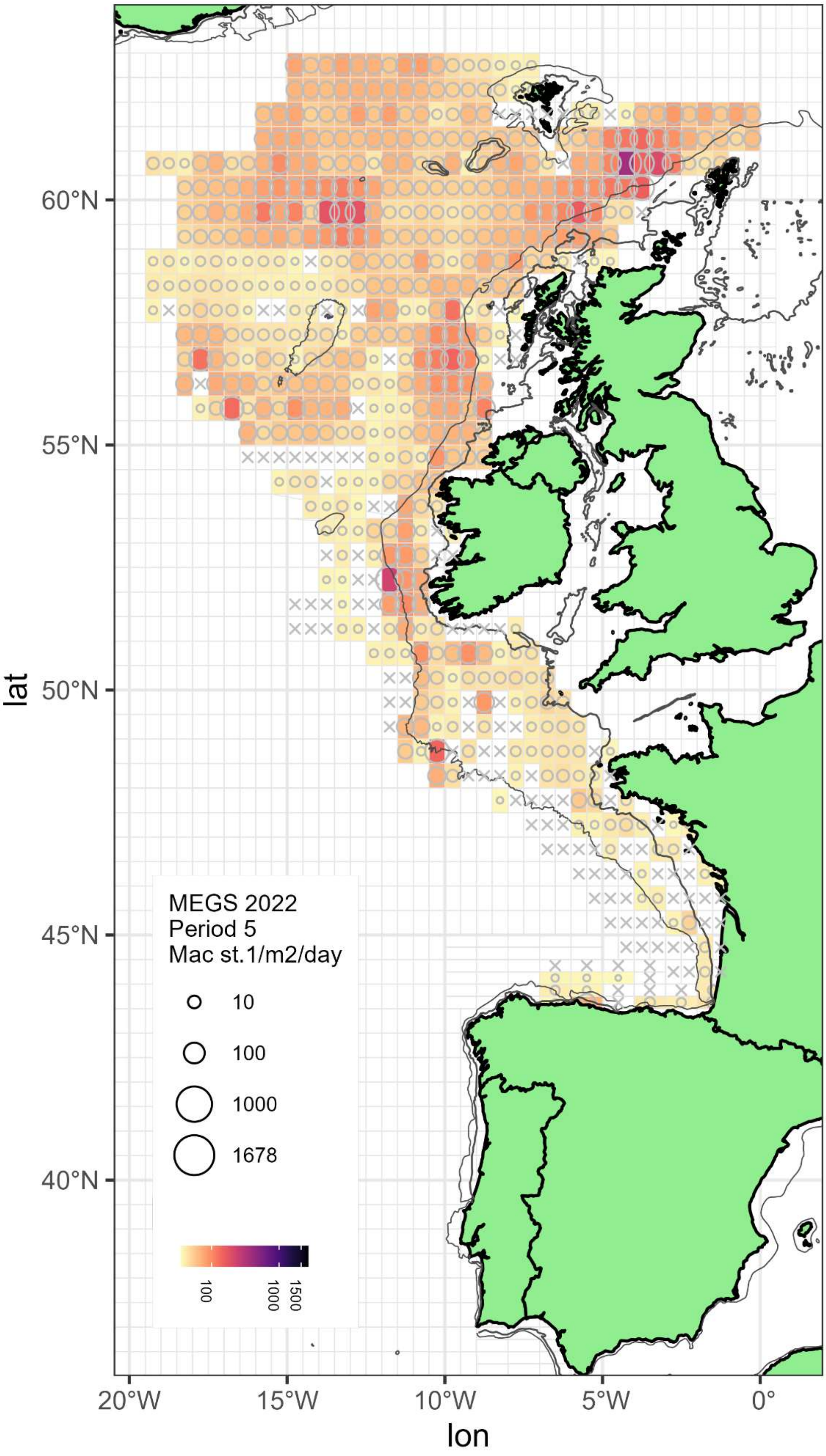

Figure 1.3: Mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

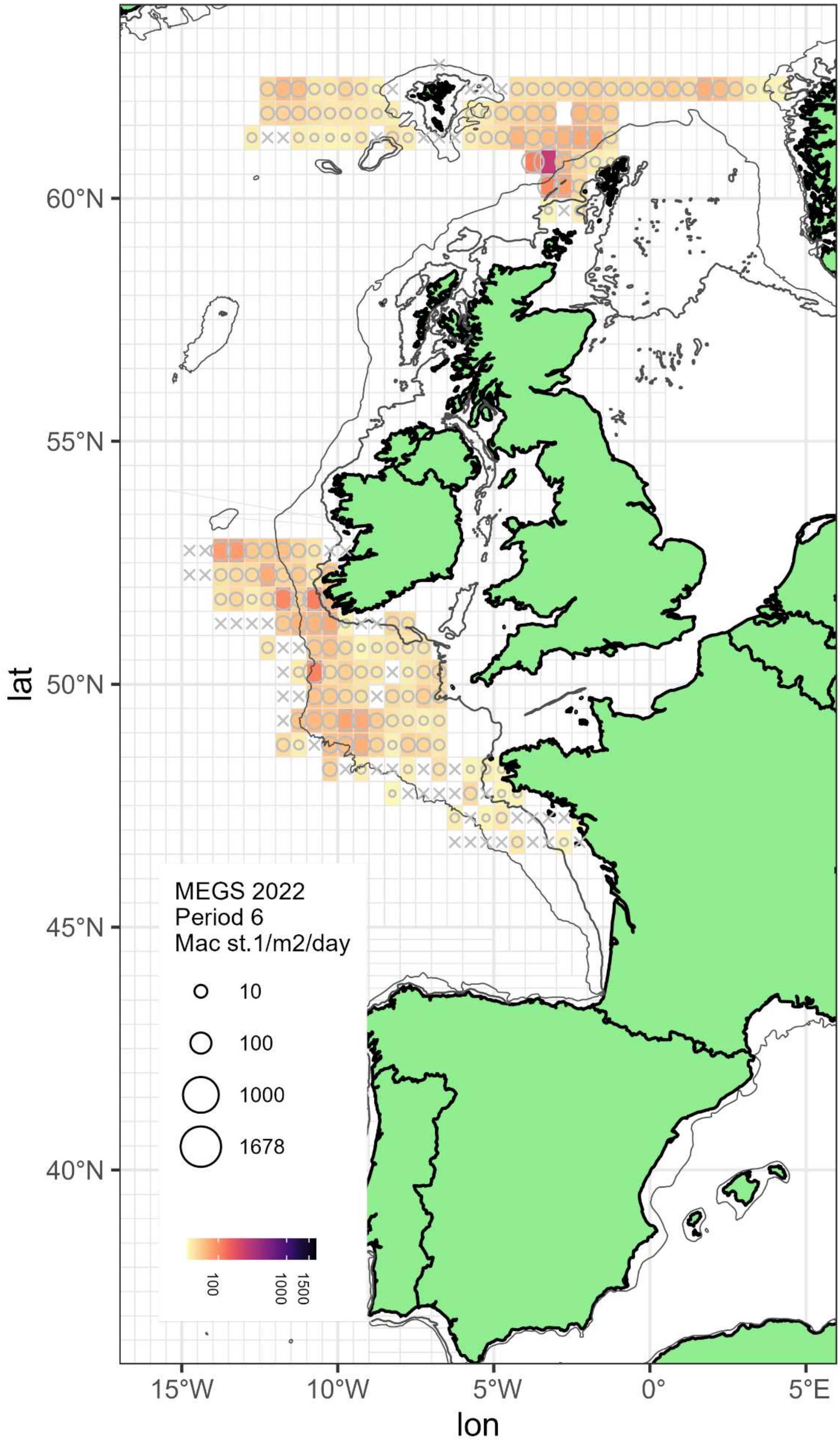

Figure 1.4: Mackerel egg production by half rectangle for period 6 (June 1st – 30th). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

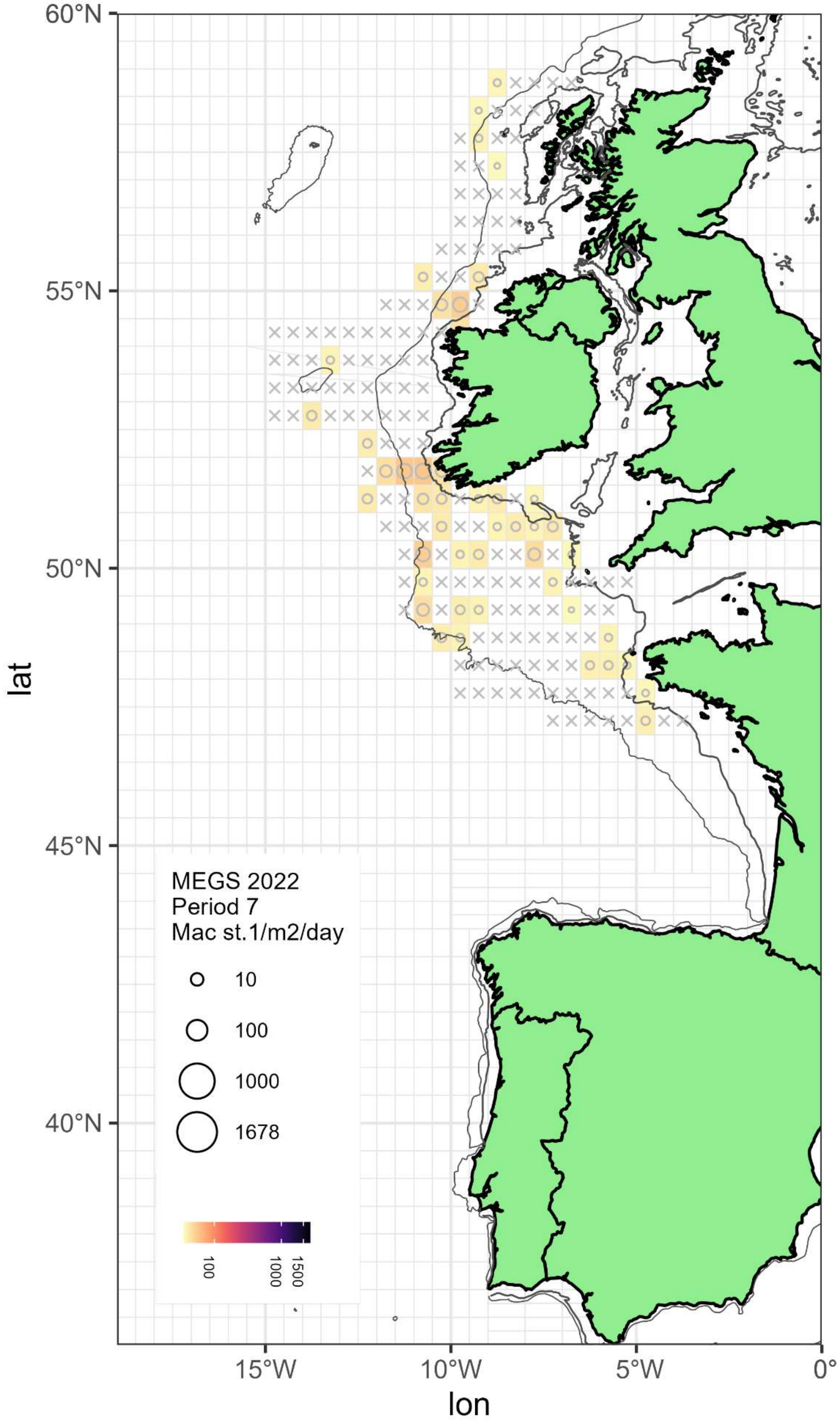

Figure 1.5: Mackerel egg production by half rectangle for period 7 (July 1st – 31st). Circle areas and colour scale represent mackerel stage I eggs/m2/day by half rectangle. Crosses represent zero values.

2 Results - MACKEREL

Stage 1 Egg production in the Western Areas

The cancelling of the Irish survey in period 6 was addressed by MEGS. The group estimated the spawning area that was missed and also estimated mean daily egg production for the period. The survey area from 53N to 61N, and 3.5W to 21W was looked at for the 2013, 2016 and 2019 surveys. Positive stations were selected where stage 1 eggs were found in a rectangle on at least two occasions over these three surveys (Fig. 2.1, blue rectangles). MEGS estimated this amounted to 127 missed stations during the period and also estimated mean daily egg production for period 6 in 2022 at 19.58 stage 1 eggs/m^2/day. Figure 2.2 shows the spawning curve for 2022, with and without the correction for the Irish survey.

2010 provided an unusually large spawning event early in the spawning season, 2013 yielded an even larger spawning event indicating that spawning was probably taking place well before the nominal start date of 10th February (Fig. 2.3). In 2016 the first survey commenced on February 5th which is five days prior to the nominal start date. That year however mackerel migration was later and slower than that recorded in the previous two surveys (Fig. 2.3 & Table 2).

In 2016 concern was expressed that survey coverage may have underestimated the total egg production estimate. The expansion observed in western and northwestern areas during Periods 5 and 6 in 2016 was once again reported during 2022, however this year production in Periods 5 and 6 was lower in these northwestern areas. The 2022 spawning curve is very similar to that of 2016, with peak spawning again occurring during Period 5. Annual egg production since 1992 is shown in Figure 2.4. Mackerel egg production by period since 2004 is shown in Figure 2.5.

In 2017 and 2018 MEGS organised exploratory egg surveys in this region. These surveys provide significant evidence that while some spawning has been missed the loss of egg abundance is not sufficiently large to significantly impact the SSB estimate.

Overall, the inclusion of the estimated egg abundance for the missing stations in Period 6 has a impact of 10% on the annual egg production 2022.

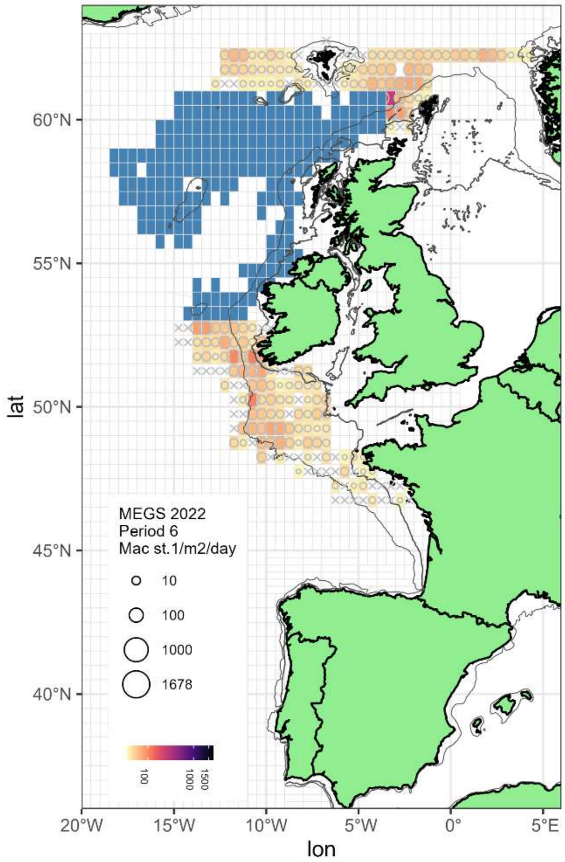

Figure 2.1: Area, blue colour, from period 6 where it is estimated eggs would have been found

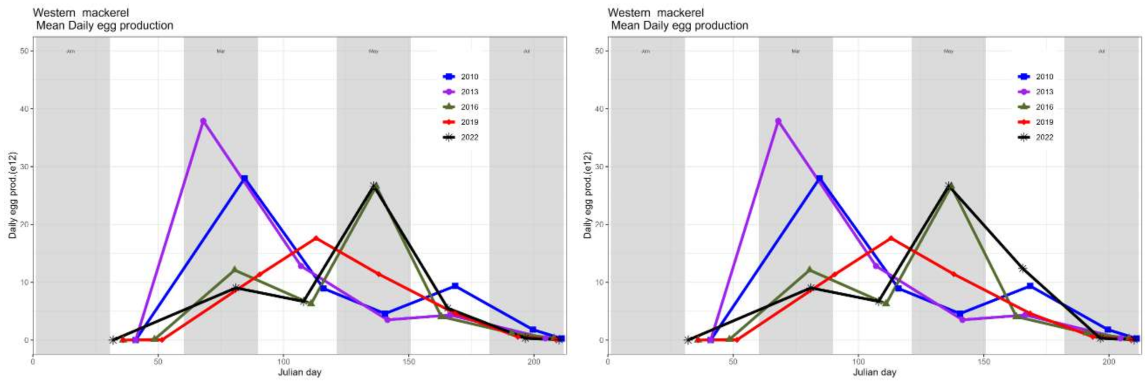

Figure 2.2: 2022 spawning curve showing uncorrected (left) and corrected (right) egg estimates for Period 6 (black line). The left hand plot shows the data from the Netherlands and Norwegian surveys. The right hand plot includes the addition of the estimated egg abundance calculated for the missing Irish Period 6 survey.

The nominal end of spawning date of the 31st July is the same as was used during previous survey years and the shape of the egg production curve for 2022 does not suggest that the chosen end date needs to be altered. The provisional total annual egg production (TAEP) for the western area in 2022 was calculated as **1.795 * 10^{15}** (Table 2). This is a 47% increase on the 2019 TAEP estimate which was 1.22 * 10^{15}.

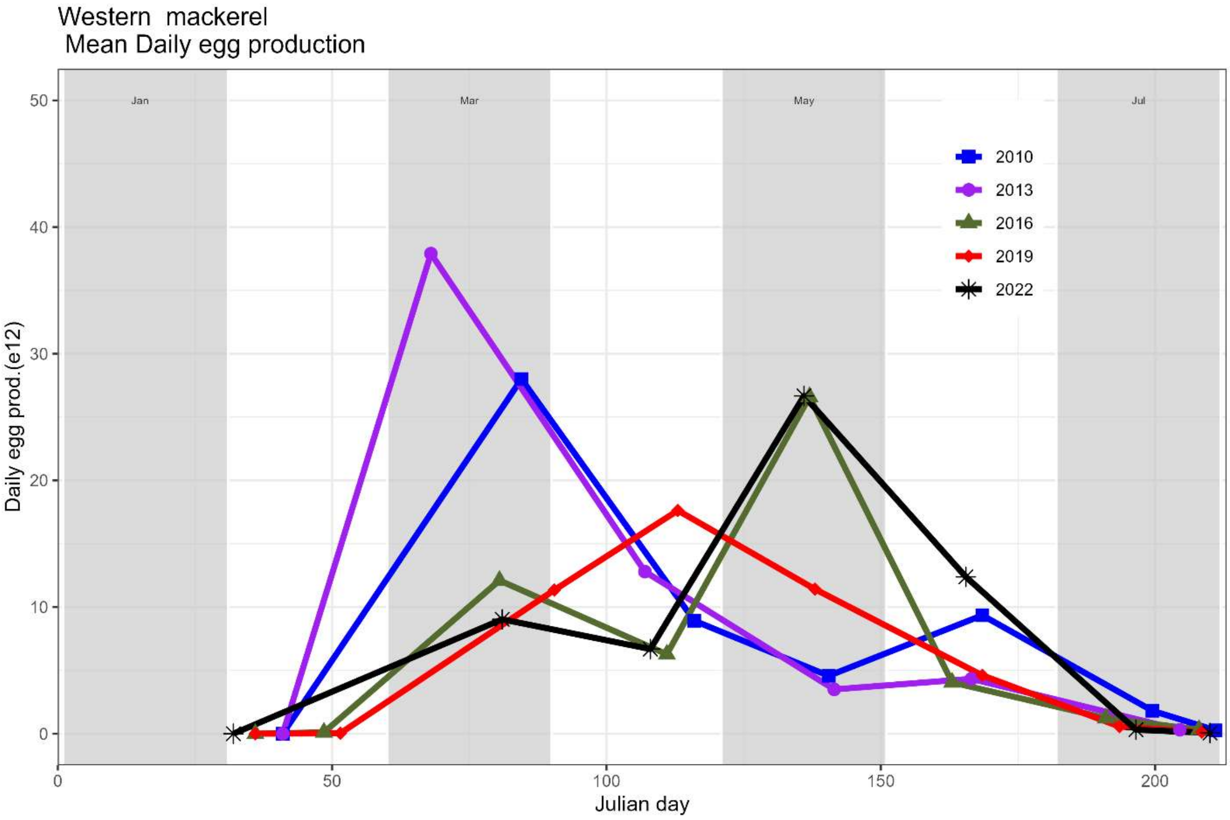

Figure 2.3: Provisional annual egg production curve for mackerel in the western spawning component in 2022, (black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

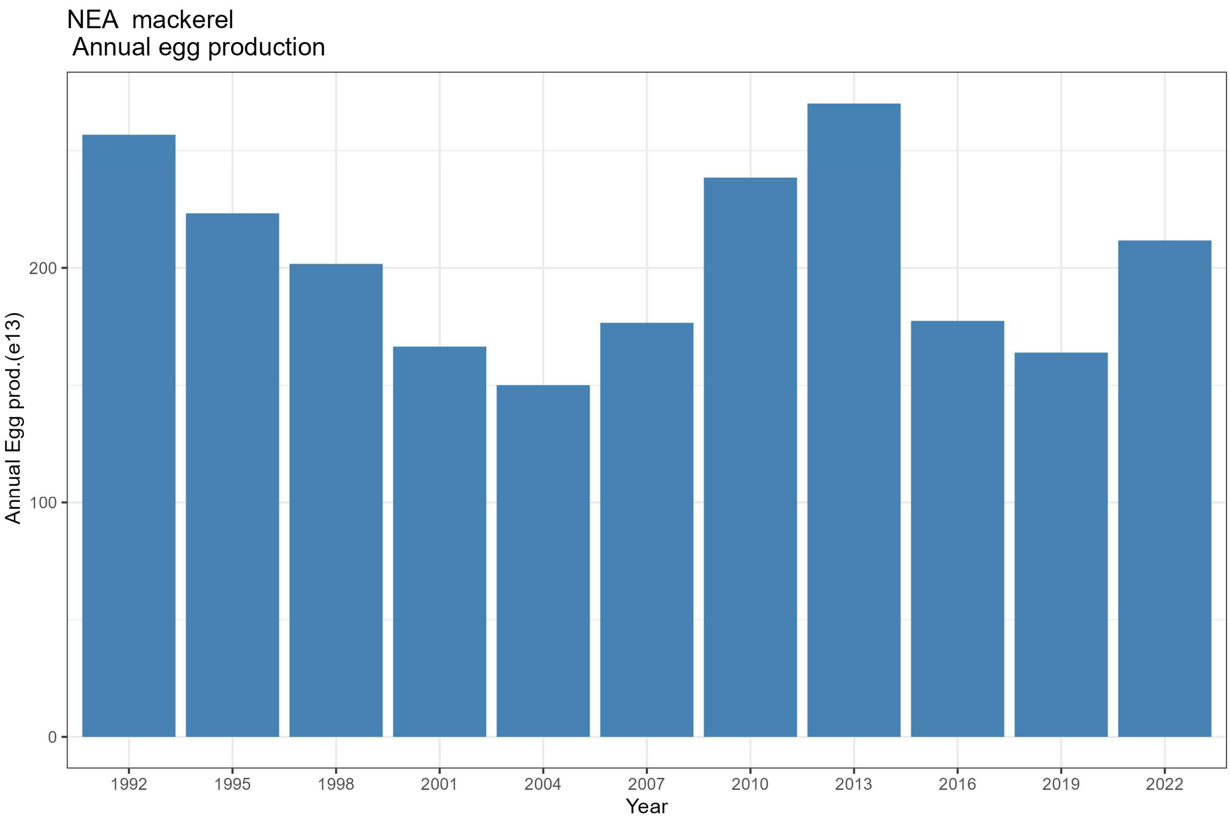

Figure 2.4: Provisional annual egg production for 2022 for the western spawning component.

Bars from 1992 are included for comparison.

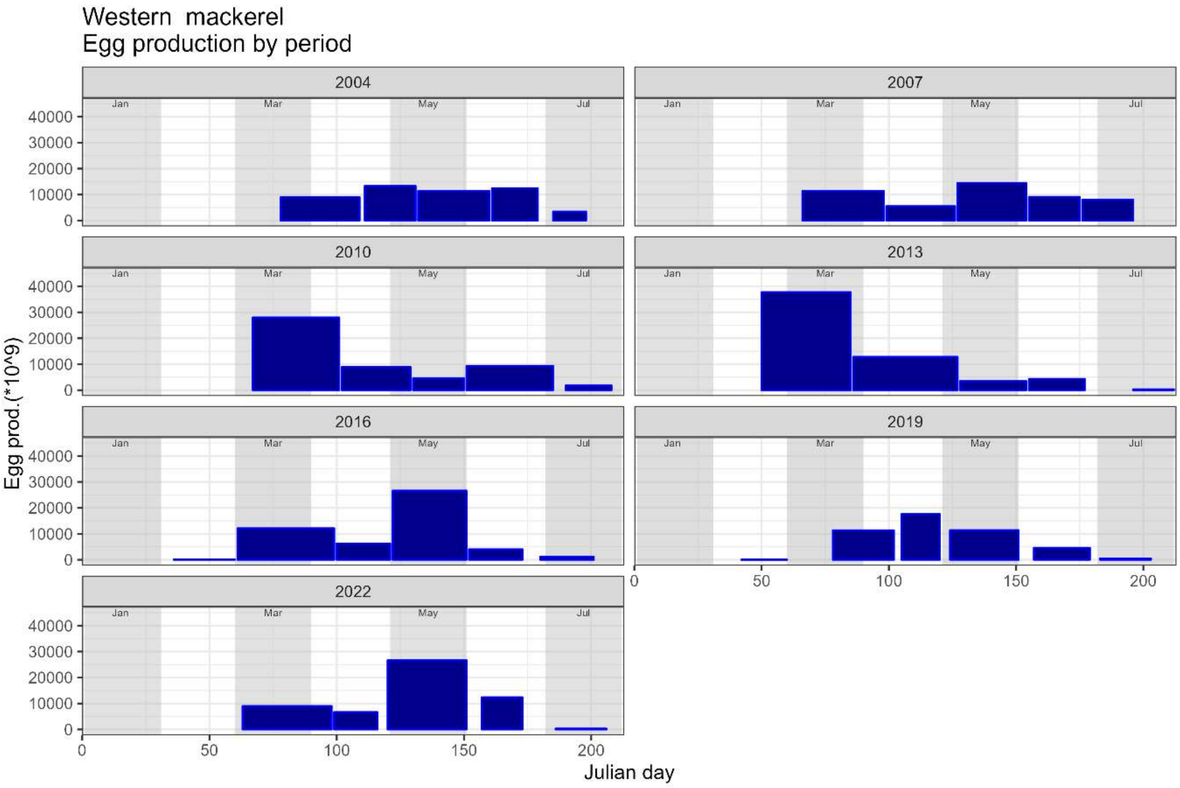

Figure 2.5: Egg production by period for the western spawning component since 2004

Table 2. Western estimate of mackerel total stage I egg production by period using the histogram method for 2022.

Dates	Period	Days	Annual stage I egg production $* 10^{15}$
Feb 5th – Mar 3rd	Pre 3	31	0.09
Mar 4th – April 8th	3	36	0.325
Apr 9th – April 26th	4	18	0.120
April 27th – Apr 29th	4 - 5	3	0.043
Apr 30th – May 31st	5	32	0.853
Jun 1st – 5th	5 - 6	5	0.067
Jun 6th – June 22nd	6	17	0.21
June 23rd – July 4th	6 – 7	12	0.081
July 5th – July 25th	7	21	0.007
July 26th – 31st	Post 7	6	0.0003
Total			1.795

Stage 1 Egg production in the Southern Areas

The start date for spawning in the southern area was the 23rd January (Table 3). Portugal surveyed in Period 2 in division 9a. Sampling in the Cantabrian Sea where the majority of spawning occurs within the Southern area commenced on the 18th March. The same end of spawning date of the 17th July was used again this year and the spawning curve suggests that there is no reason for this to change (Fig. 2.4). As in 2019 the survey periods were not completely contiguous and this has been accounted for (Table 3). The mackerel egg production by period since 2004 is shown in Figure 2.6. The provisional total annual egg production (TAEP) for the southern area in 2022 was calculated as **3.21 * 10^{14}** (Table 3). This is a 25% decrease on the 2019 TAEP estimate which was 4.23 * 10^{14} (Fig. 2.5).

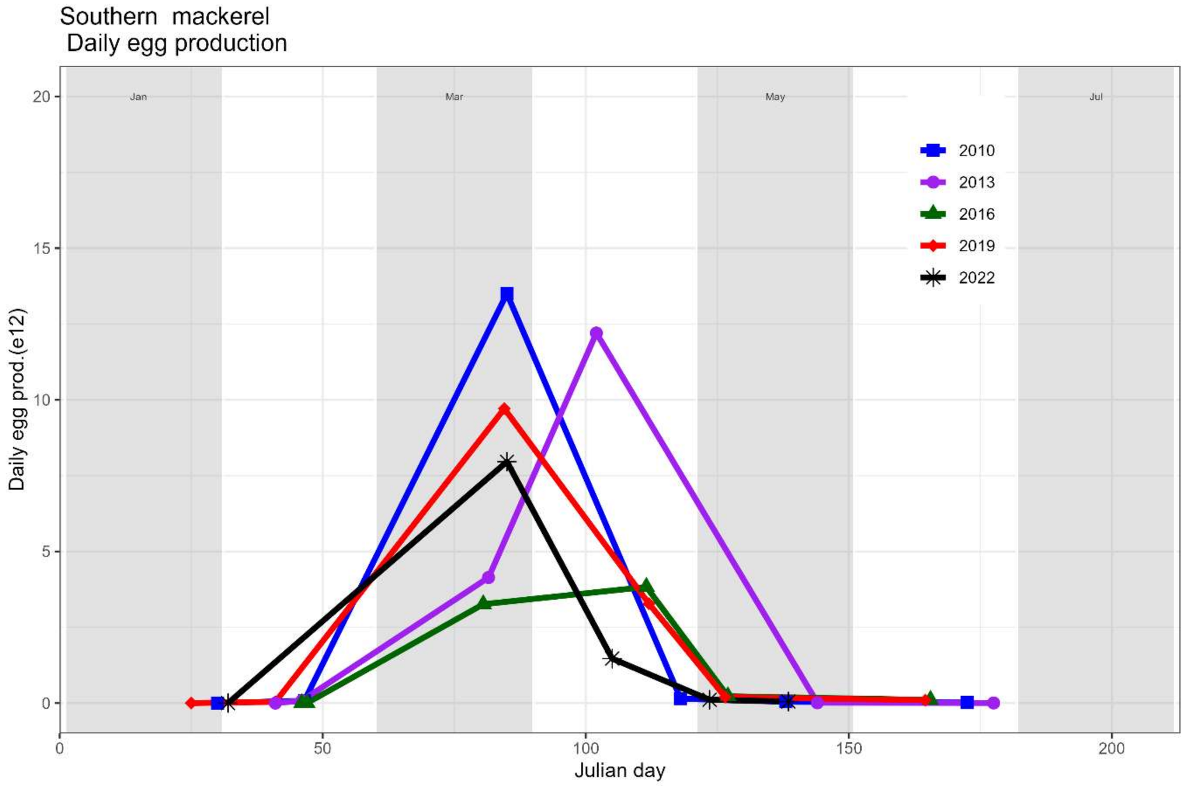

Figure 2.4: Provisional annual egg production curve for mackerel in the southern spawning component for 2022, black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

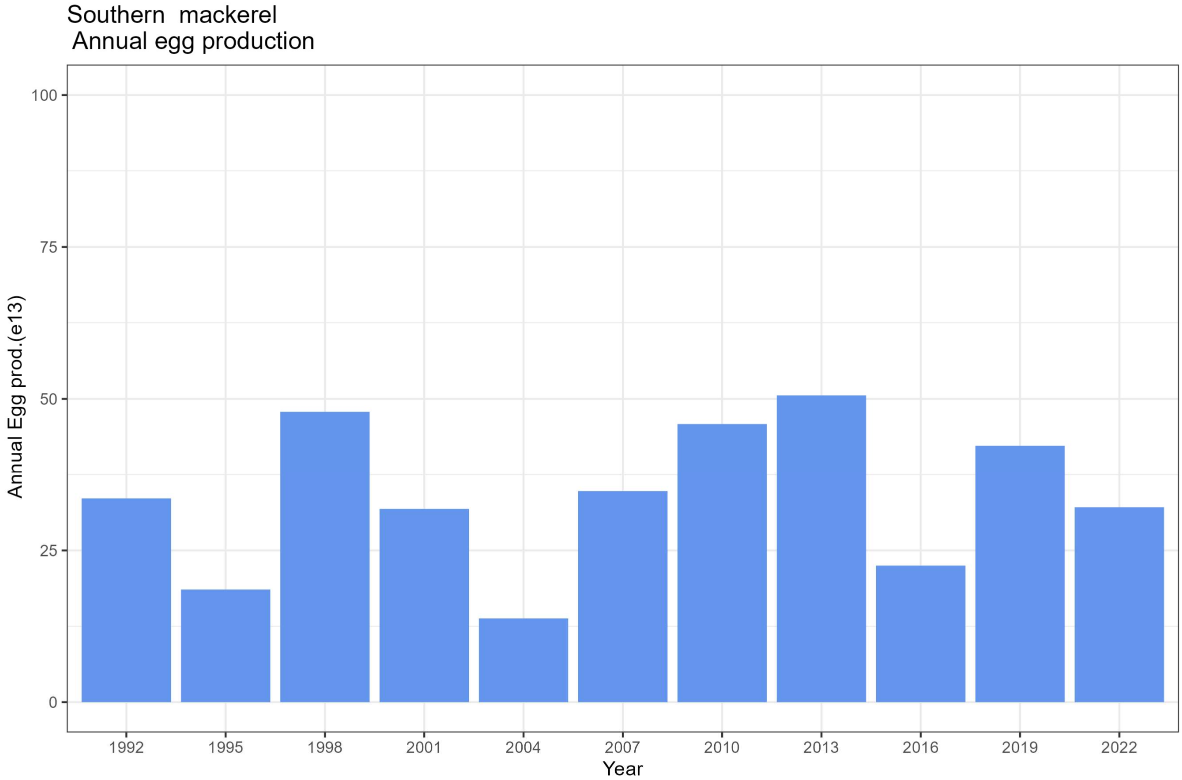

Figure 2.5: Provisional annual egg production for the southern spawning component for 2022. Bars from 1992 are included for comparison.

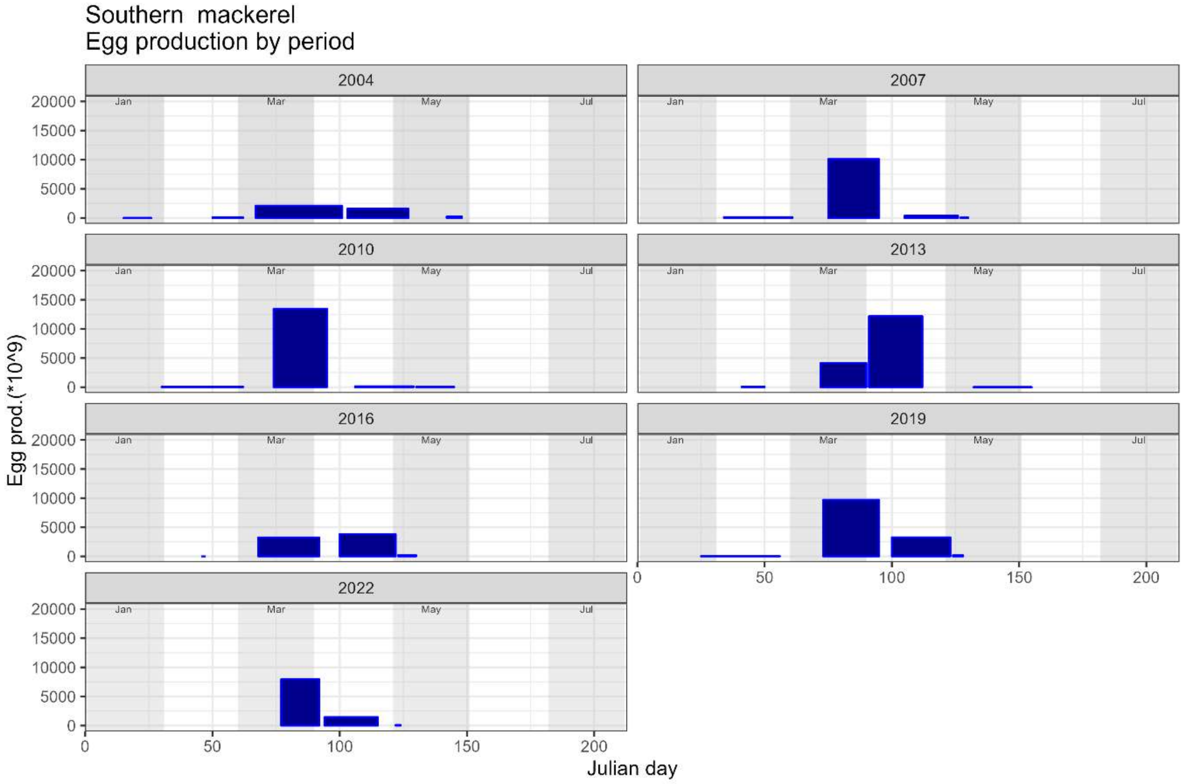

Figure 2.6: Egg production by period for the southern spawning component since 2004

Table 3. Southern estimate of mackerel total stage I egg production by period using the histogram method for 2022.

Dates	Period	Days	Annual stage I egg production x 10^{14}
Feb 1st – Mar 17th	2 - 3	45	1.52
March 18th – April 2nd	3	16	1.27
April 3rd	3 - 4	1	0.052
April 4th – 25th	4	22	0.323
Apr 26th – May 1st	4 - 5	6	0.026
May 2nd – 4th	5	3	0.003
May 5th –July 17th	Post 5	71	0.014
Total	3.212		

Total egg production

Total annual eggs production (TAEP) for both the western and southern components combined in 2022 is **2.116*10^{15}.** (Fig. 2.3). This is an increase in production of **29%** compared to 2019, 1.64*10^{15} (Fig. 2.3).

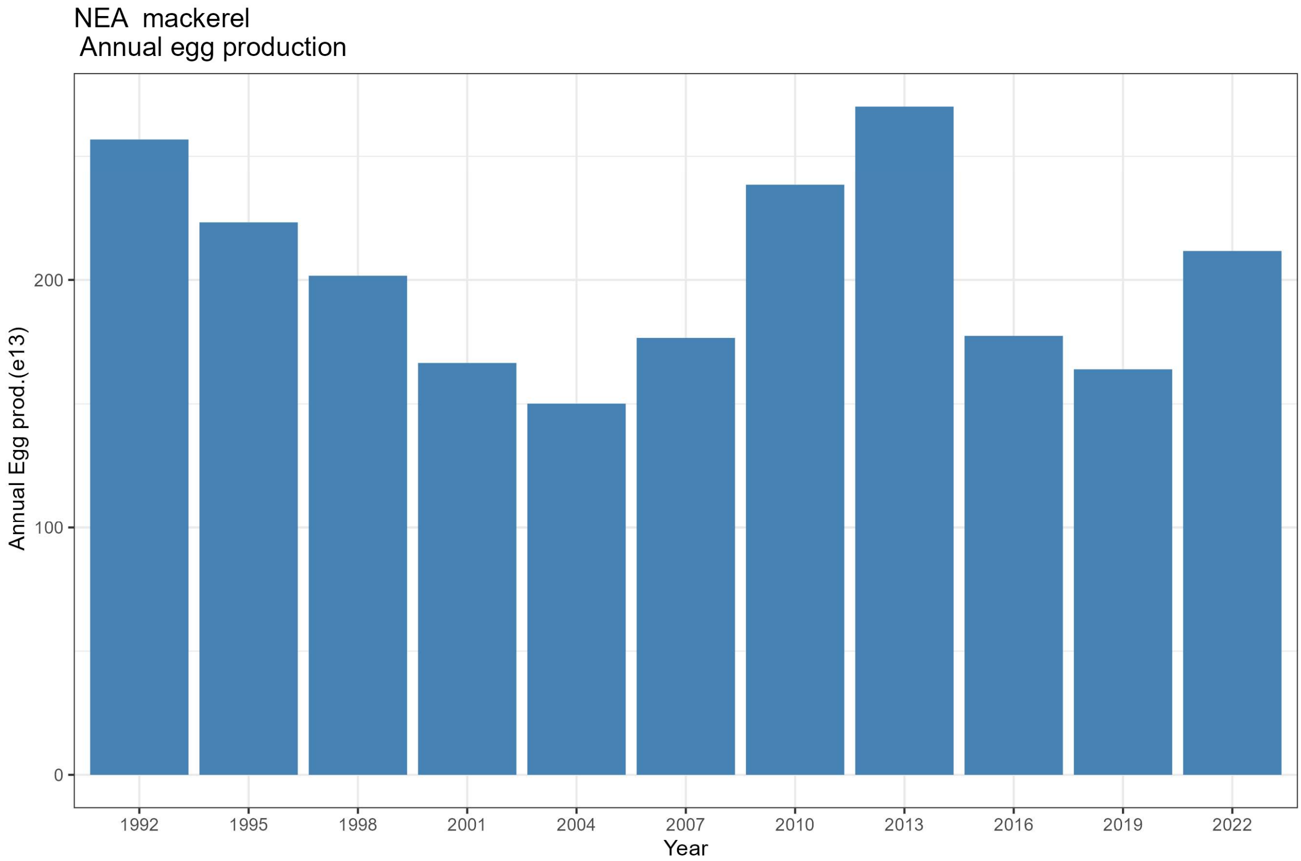

Figure 2.3: Combined mackerel TAEP estimates (*10^{13}) - 1992 – 2022.

Fecundity – Preliminary estimates

Adult Parameters

Fecundity Sample distribution

Atlantic mackerel samples were collected during periods 2-7 spread over an area with a bounding box of 59.36N 14.20W – 36.54N 2.32W. Nine institutes participated. The histological screening of samples was performed by five institutes while fecundity was analysed by six of them.

As usual for the preliminary report, only samples from Periods 2 and 3 were selected. This is because there is not enough time to analyse samples from the other periods. For the final report samples from the other periods will be included also. Experience from earlier surveys is that the preliminary estimate and the final estimate is close.

Screening

Potential fecundity counts were based on whole mount samples taken from maturing females which had not started spawning. To select these samples, a histological screening procedure was used followed by a screening procedure on the selected whole mount samples.

A total of 918 samples were screened, of which 793 were from periods 2 and 3 (
Table). Of those, 482 samples showed spawning markers, i.e. migratory nucleus stage (MIG), hydrated oocytes, eggs, and post ovulatory follicles (POFs). A total of 175 samples from periods 2-3 showed presence of atresia without considering those that were classified as “spent” or having “massive atresia”.

From previous survey reports we know that POF scoring has varied considerably between periods. WKFATHOM2 (2018) discussed this issue and came up with more detailed criteria for POF staging. Looking at screening results from 2022, POFs were identified less frequently than in 2019 for periods 2 and 3, i.e. 58 % vs 74% (Table 4).

Table 4. POF scoring using histology by periods 2-3.

Period	Screened	Spawning Markers	POFs	Fecundity Histology	Fecundity Whole mount	Atresia Presence
2	32	24	21	2	2	3
3	675	541	494	38	33	156

Results from previous surveys showed that POF scoring could vary considerably between periods. At WKFATHOM2 (ICES 2018) this issue was discussed and more detailed criteria for POF staging were elaborated. Looking at screening results from 2022, POFs were identified less frequently than in 2019 for periods 2 and 3, i.e. 58 % vs 74% (Table 5).

Table 5. POF scoring using histology (Periods 2-3).

Period	No POF	POF	%POF	%POF 2019
2	66	55	52	66
3	260	404	60	74
2-3	326	459	58	74

A total of 159 samples from periods 2-3 showed presence of atresia without considering those that were classified as “spent” or having “massive atresia” (Table).

Looking at the oocyte stage most of the samples in periods 2-3 were at MIG or hydrated oocyte stage (n = 545) and that less than half (n = 217) were in vitellogenic oocyte stage.

Potential fecundity

For the 2022 preliminary estimate of potential fecundity, 169 samples were available, which represents 21% of all samples screened for periods 2 and 3. This number is much higher than in 2019, when 34 samples were available for the preliminary report.

The potential fecundity estimate is based on samples from pre-spawning fish. The pre-spawning status is confirmed using a detailed histology screening procedure that detects the most advanced oocyte stage (stage 1-5) as well as spawning markers (POF´s, post ovulatory follicles and eggs). This year the fecundity estimate is based on samples that may also include the MIG oocyte stage. This is different from previous surveys (in recent time) where the most advanced oocyte stage included was stage 3 (advanced vitellogenesis). However, the MIG oocyte stage is not a true spawning marker, but a marker that shows that spawning likely will take place within a few days. For previous surveys samples with MIG´s were excluded for precautious reasons.

Since the 2013 MEGS survey, the median has been used for relative fecundity estimation rather than the mean which was used previously. The reason for the change is related to the fact that that unlike the mean, the median is not influenced by extreme values. A posterior analysis showed that the median for relative potential fecundity was close to the arithmetic mean in most years. The largest difference was in 2013, but even then, the median was within the confidence interval of the potential fecundity arithmetic mean. WGMEGS 2018 (ICES 2018) discussed whether to use the trimmed mean instead of the median for the potential fecundity estimate. A trimmed mean is preferred for calculation of confidence intervals. However, until the time-series data is reanalyzed in the near future, it was decided that the relative fecundity estimate should still be based on the median rather than the mean.

The distribution of relative potential fecundity values (Figure 2.4) was close to a normal distribution and ranged from 623 to 1972 (n/g). The distribution was almost similar both for samples with the MIG oocyte stage (stage 4) and stage 3 (Figure 2.4). The median value for stage 3 samples was 1247 (mean 1282, SD 290) while for the MIG stage the median was 1256 (mean 1300, SD 267). This shows that including samples with MIG´s in the fecundity estimate have not significantly changed the median or mean value, and that our previous cautious procedure excluding MIG´s is probably unnecessary.

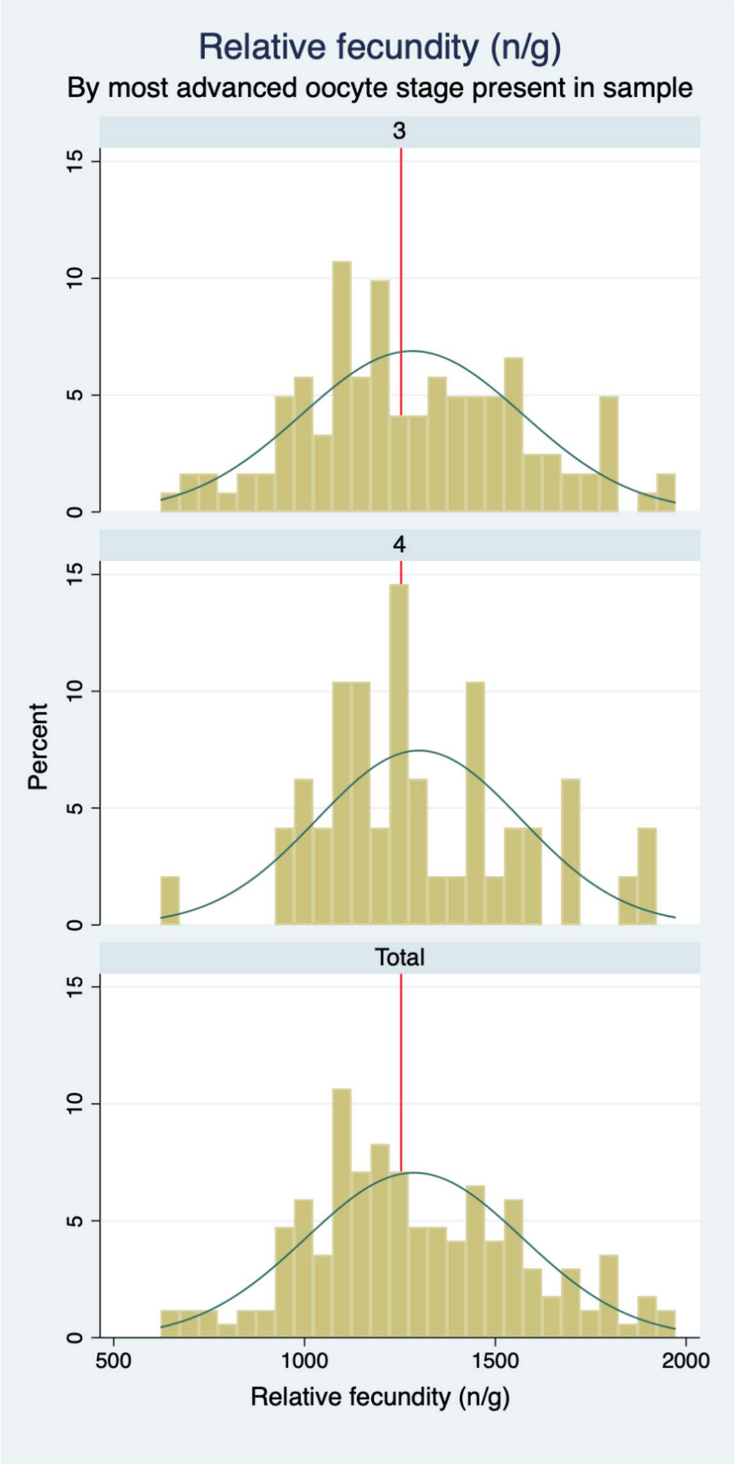

Figure 2.4. Relative fecundity preliminary estimation in 2022. The panels show the distribution (in %) of relative fecundity using samples in which the most advanced oocyte stage present was 3 (advanced vitellogenesis, top panel), samples where the most advanced oocyte stage was MIG (stage 4, middle panel) and the combined histogram (bottom panel).

The preliminary relative potential fecundity in 2022 was slightly higher than in 2019 (1253 and 1191, respectively)

Table 6 Estimate of relative fecundity (n/g fish) and statistics.

Year	N	Median	Mean	sd	Max	Min	95%CI
2022	169	1253	1288	283	1972	623	1252-1324
2019	34	1215	1263	285	2029	564	1163-1362

Biological data of fish samples to fecundity

The distribution of fish length, weight, Fulton's condition factor (100 × weight/length^3), and gonad-somatic index (GSI; 100 × Ovary weight/Fish weight) is shown in Figure 2.5.

Similar to the previous surveys only fish with condition factor between 0.5 and 1.2, and GSI between 1 and 25 were included (ICES 2014) in the fecundity and atresia estimates. For this preliminary estimation, no females needed to be excluded from the analysis based on these biological parameters.

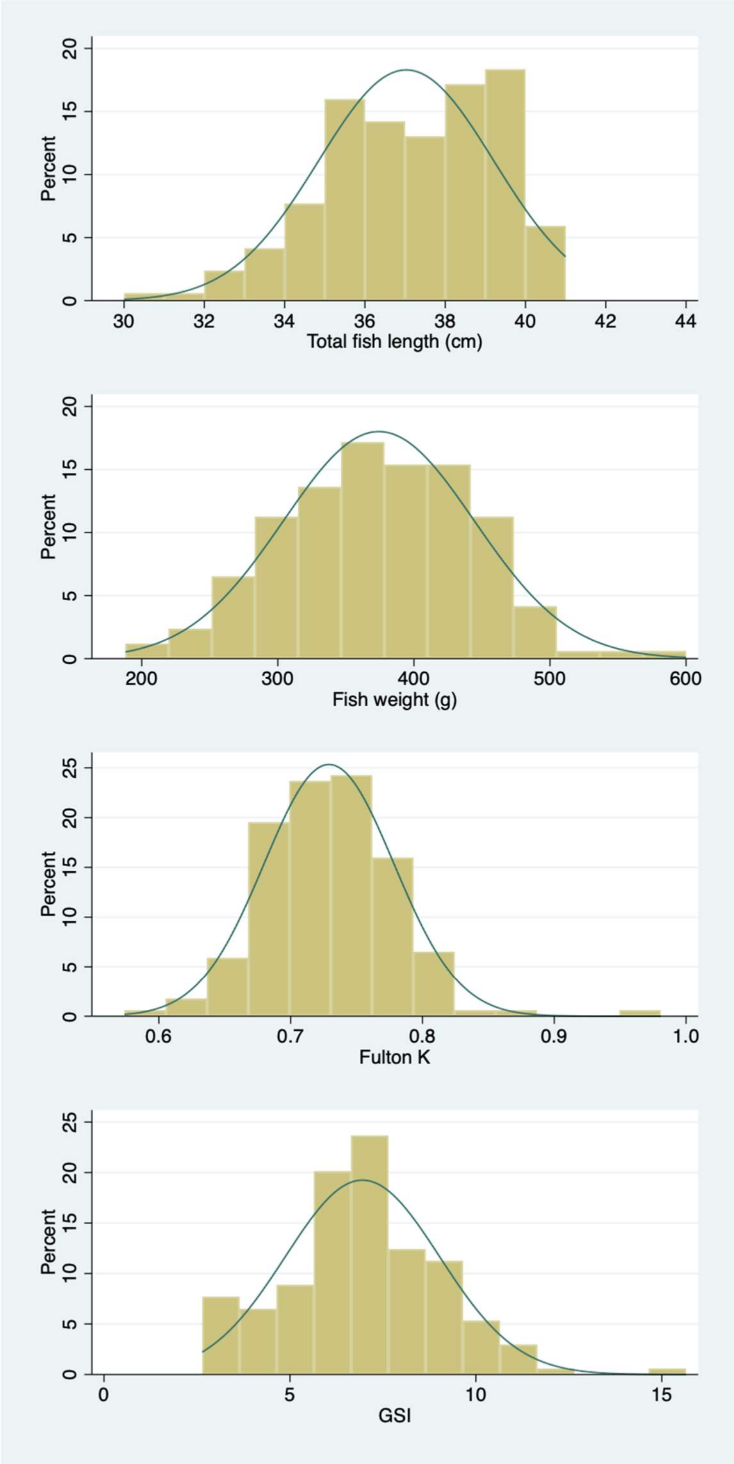

Figure 2.5. Fish length and weight, Fulton's Condition index and GSI of individuals analysed for fecundity.

Atresia

Atresia is the loss of oocytes by reabsorption before spawning and must be subtracted from the potential fecundity (whole mount fecundity counting) to estimate the realised fecundity. In this preliminary report, intensity of atresia can not be presented due to the time consumed for the histology screening.

The prevalence of atresia estimated by histological screening may however be a good indicator of the level of atresia. Prevalence of atresia is defined as the percentage of spawning fish which have early stage atresia (early alpha-atresia). Among the 559 samples considered the prevalence of atresia estimated was 0.28, (fish from period 2-3, excluding spent fish and fish with massive atresia).

Realised fecundity

Realised fecundity is defined as the potential fecundity minus the loss by atresia. The loss by atresia is a function of both intensity of atresia and prevalence of atresia. The intensity of atresia for 2022 is still unavailable, therefore the loss was calculated from the average loss from the surveys since 2001 (Table). The relative loss by atresia from this period (2001-2019) ranged from 6-9% (average 6%).

Based on this, the preliminary realised fecundity-estimate for 2022 was 1178 oocytes/gram female. The estimate is well within the observed range of realized fecundity (1009-1209, average 1087 egg per gram female) from all previous surveys back to 2001 (Table 7). For the three most recent surveys, realized fecundity varied between 1087 and 1209 eggs per gram female (average 1148).

Table 7. Summary table of mackerel fecundity and atresia by survey year.

	Survey year							
	2001	2004	2007	2010	2013	2016	2019	2022 Prel.
Fecundity samples (n)	187	205	176	74	132	97	62	169
Prevalence of atresia (n)	290	348	416	511	732	713	895	559
Intensity of atresia (n)	290	348	416	511	56	66	64	
Relative potential fecundity (n/g)	1097	1127	1098	1140	1257*	1159*	1191*	1253*
Prevalence of atresia	0.2	0.28	0.38	0.33	0.22	0.3	0.28	0.28
Geometric mean intensity of atresia (n/g)	40	33	30	26	27	30	20	
Potential fecundity lost per day (n/g)	1.07	1.25	1.48	1.16	0.8	1.2	0.73	
Potential fecundity lost (n/g)	64	75	89	70	48	72	44	75
Relative potential fecundity lost (%)	6	7	9	6	4	6	4	6
Realised fecundity (n/g)*	1033	1052	1009	1070	1209	1087	1147	1178

*Median not mean relative potential fecundity.

Biomass estimation

Total spawning stock biomass (SSB) was estimated using a preliminary fecundity estimate of 1178 oocytes/g female, a sex ratio of 1:1 and a raising factor of 1.08 (ICES, 1987) to convert pre-spawning to spawning fish. This gave an estimate of spawning stock biomass of:

- 3.292 million tonnes for western component (2019: 2.29).
- 0.589 million tonnes for southern component (2019: 0.80).
- 3.881 million tonnes for western and southern components combined (2019: 3.09)

3 Results – HORSE MACKEREL

Horse mackerel egg production by period

Period 3 – In period 3 horse mackerel spawning started in the Cantabrian Sea and southern Biscay, but numbers of eggs found were very low. Higher spawning took place in the Celtic Sea but numbers were still low (Fig. 3.1).

Period 4 – Horse mackerel spawning continued in the Cantabrian Sea, extending into southern Biscay. Eggs were again found in the Celtic Sea but numbers were lower than in period 3 (Fig. 3.2).

Period 5 – Horse mackerel spawning continues in the Cantabrian Sea, Celtic Sea and northern Bay of Biscay, but still in low numbers. Some eggs were also found south and west of Ireland (Fig. 3.3).

Period 6 –Spawning continued in northern Biscay, the Celtic Sea and to the southwest of Ireland. For the first time in a number of years large numbers of eggs were reported in a number of stations close to the 200m contour. Peak spawning took place in this period (Fig. 3.4).

Period 7 – Eggs were found from northern Biscay to west of Scotland, being concentrated off the southwest of Ireland. In general egg numbers were low but occasional stations with moderate to high counts were observed (Fig. 3.5).

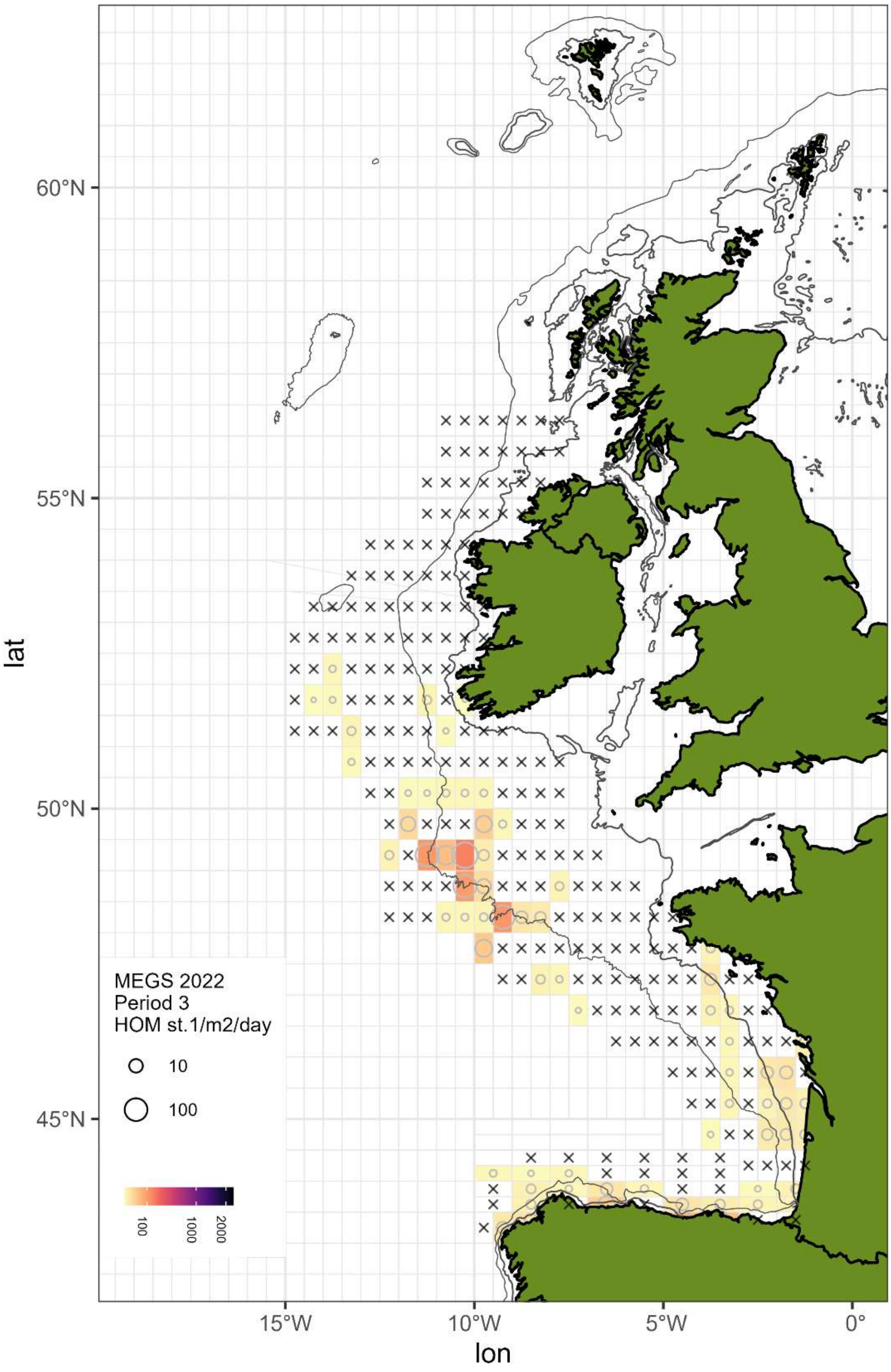

Figure 3.1: Horse mackerel egg production by half rectangle for period 3 (March 4th – April 8th). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

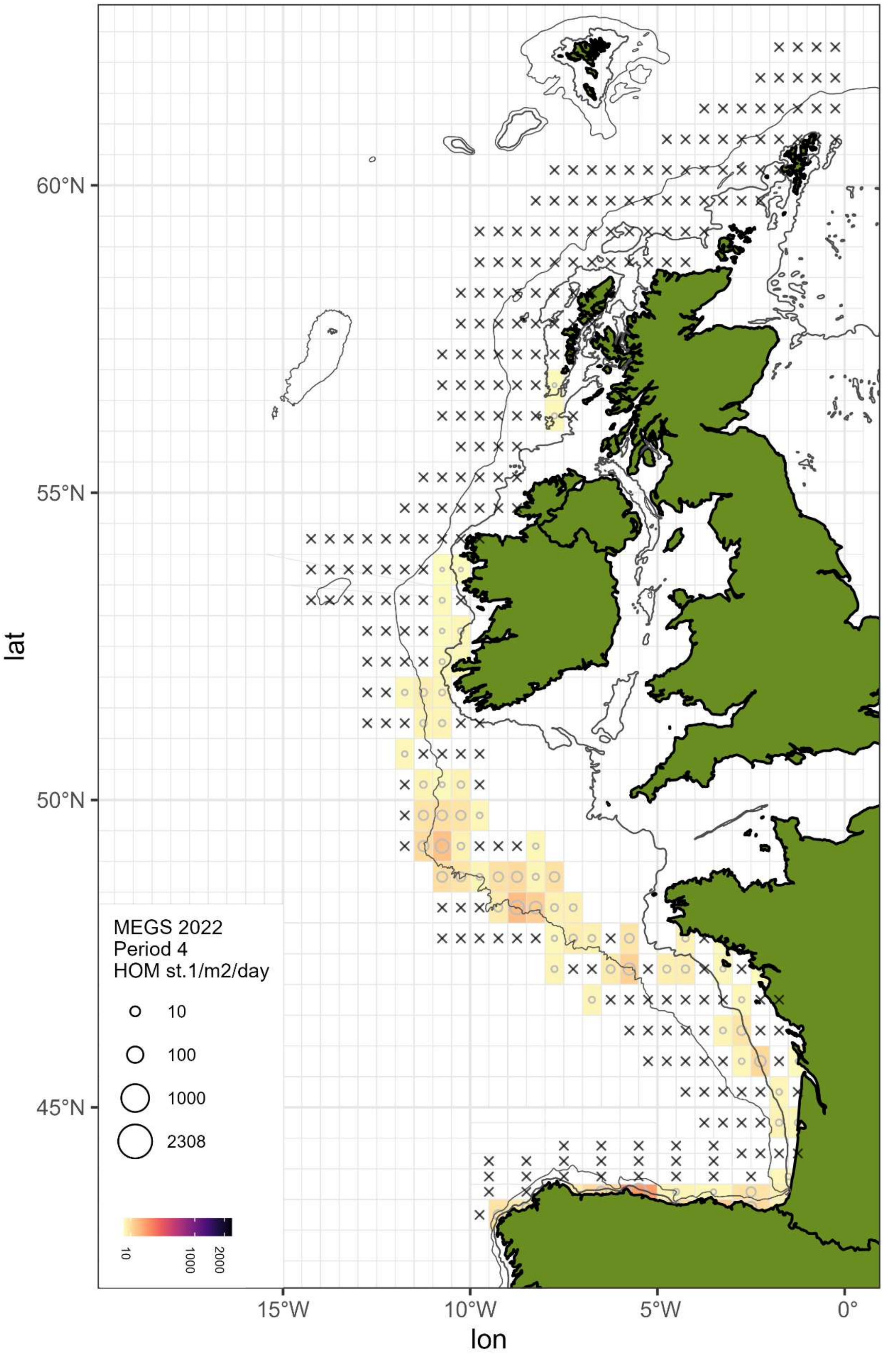

Figure 3.2: Horse mackerel egg production by half rectangle for period 4 (April 9th – 29th). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

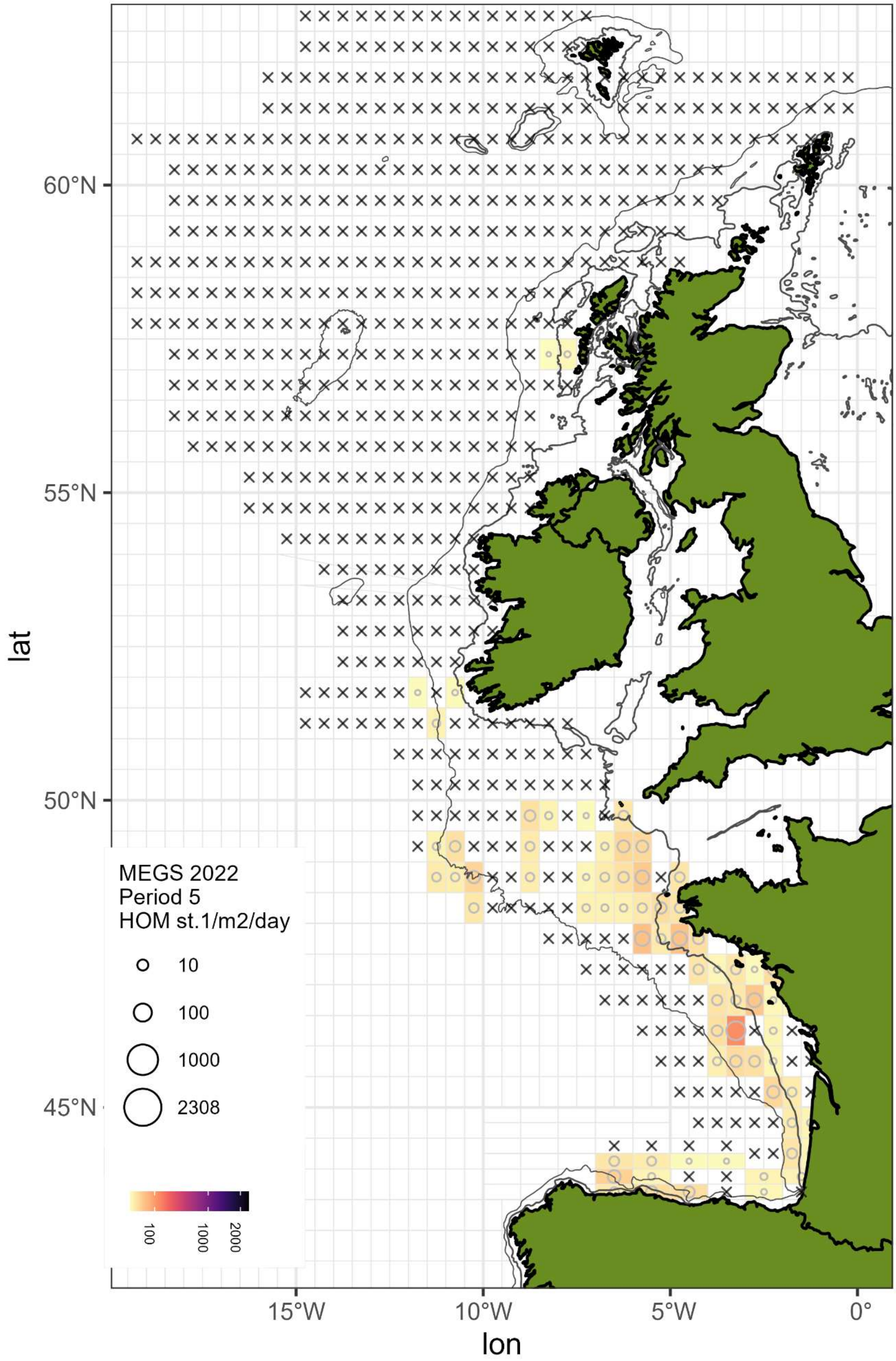

Figure 3.3: Horse mackerel egg production by half rectangle for period 5 (Apr 30th – May 31st). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

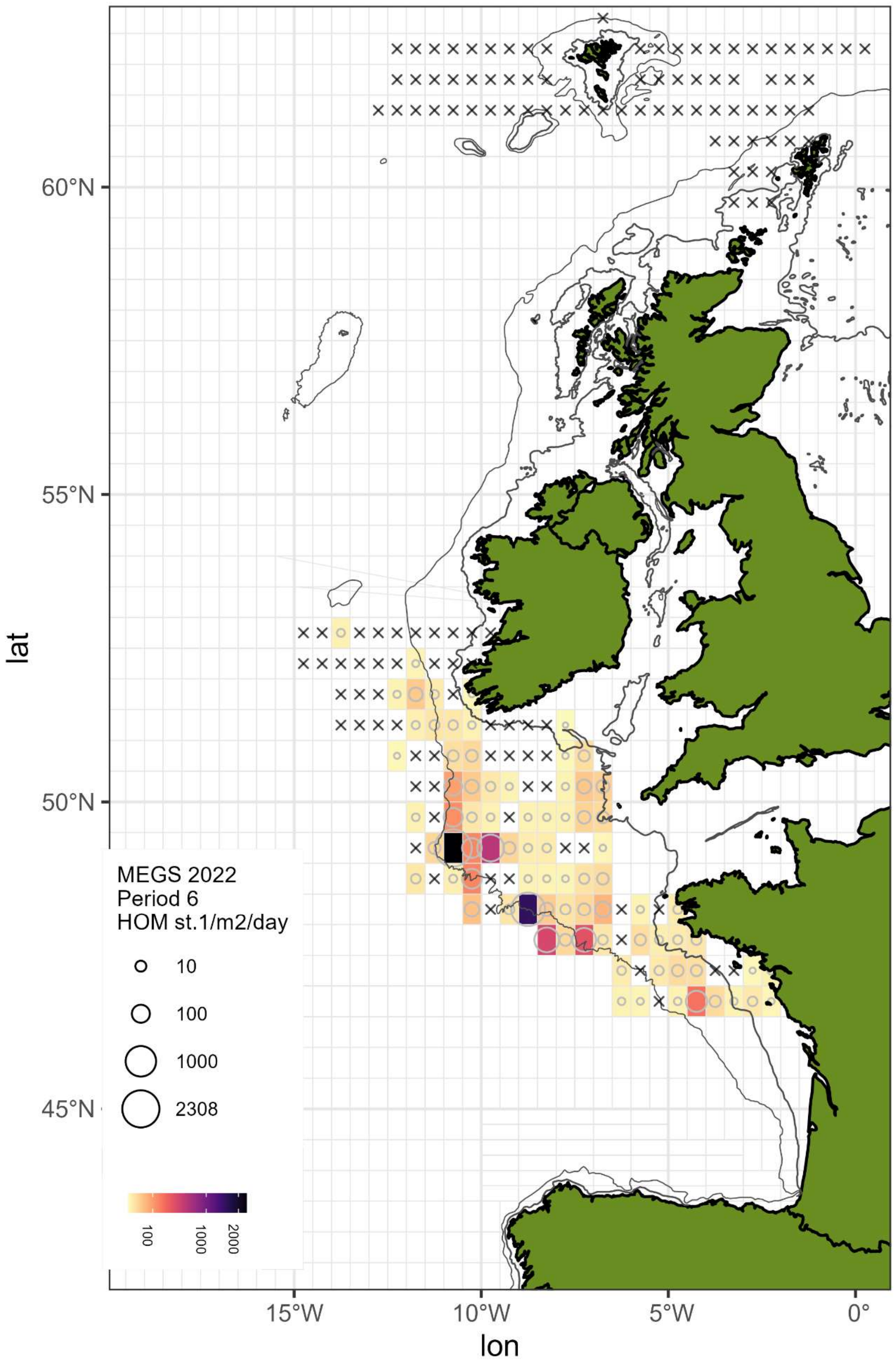

Figure 3.4: Horse mackerel egg production by half rectangle for period 6 (June 1st – 30th). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

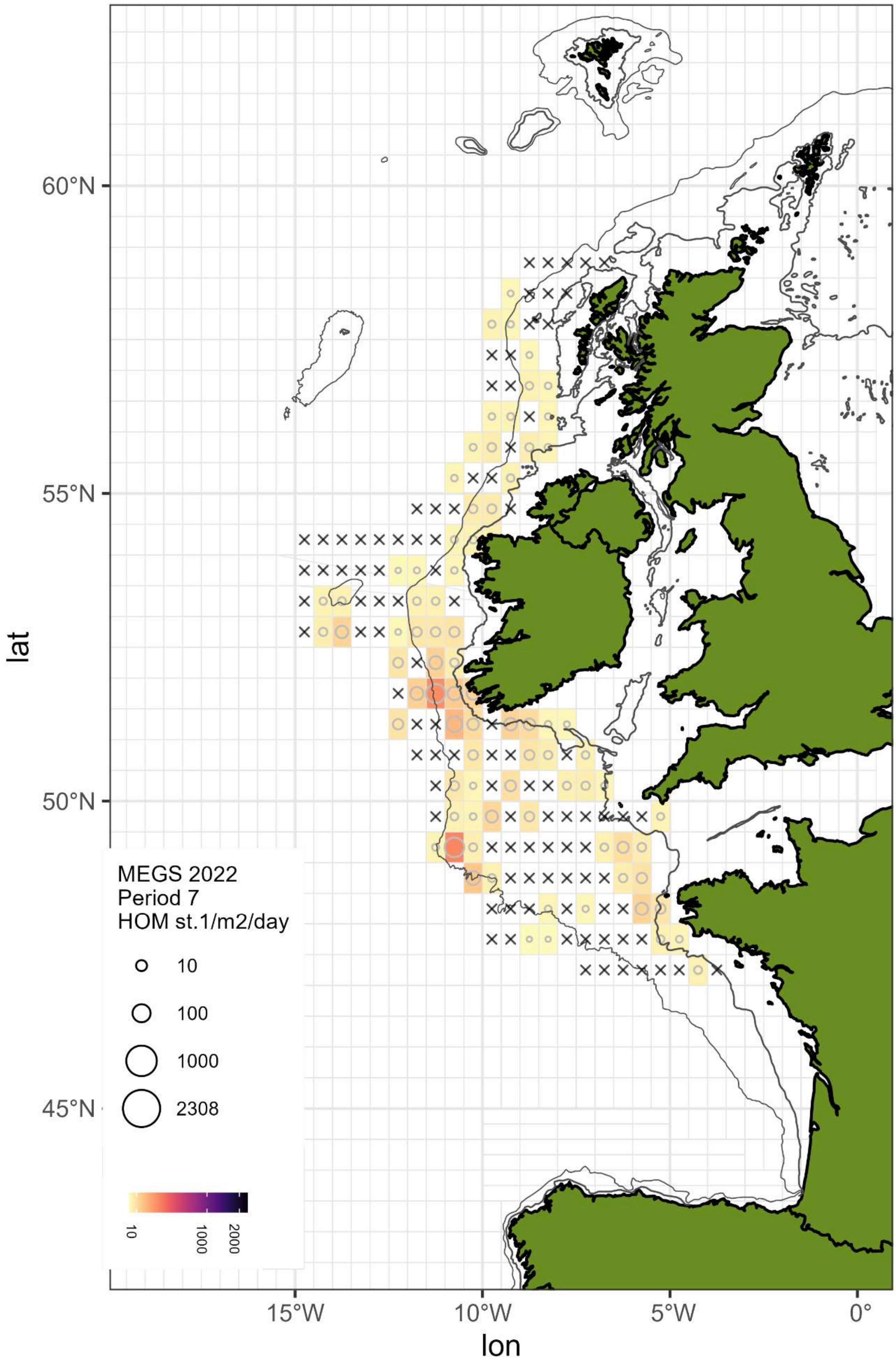

Figure 3.5: Horse mackerel egg production by half rectangle for period 7 (July 1st – July 31st). Circle areas and colour scale represent horse mackerel stage I eggs/m^2/day by half rectangle. Crosses represent zero values.

TAEP results – Western Horse Mackerel

Period number and duration are the same as those used to estimate the western mackerel stock, as are the dates defining the start and end of spawning (Table 6). The shape of the egg production curve does not suggest that those dates should be altered for 2022 (Fig. 3.6). An exercise, similar to the one carried out for mackerel in period 6, was not carried out for horse mackerel as MEGS feel that the Netherlands period 6 survey delineated the northern boundary of horse mackerel spawning during this period. The total annual egg production was estimated at **5.15 x 10^{14}**. This is almost a threefold increase on 2019 which was 1.78 × 10^{14} which was the lowest estimate of annual egg production ever recorded for this species (Fig. 3.7). Horse mackerel egg production by period since 2007 is shown in Figure 3.8.

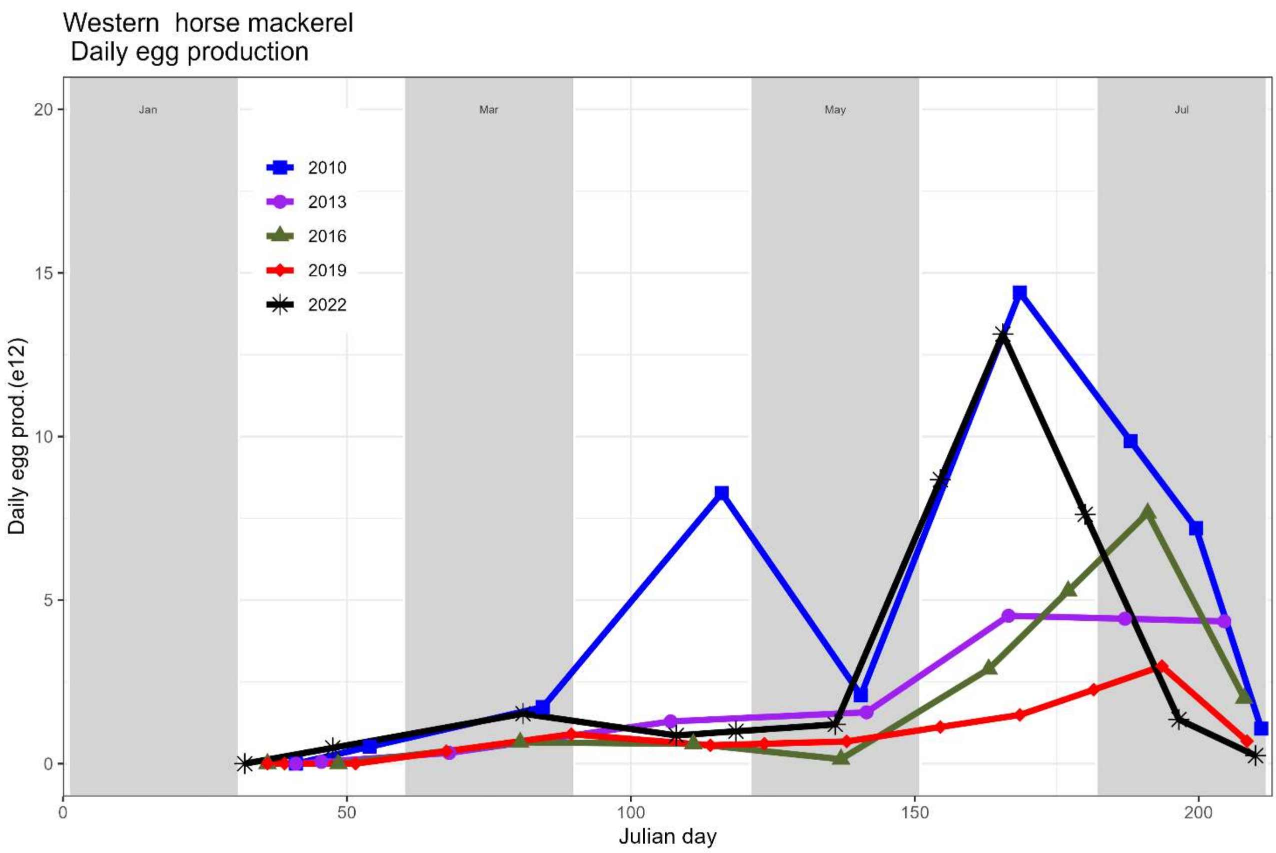

Figure 3.6: Provisional annual egg production curve for western horse mackerel for 2022, (black line). The curves for 2010, 2013, 2016 and 2019 are included for comparison.

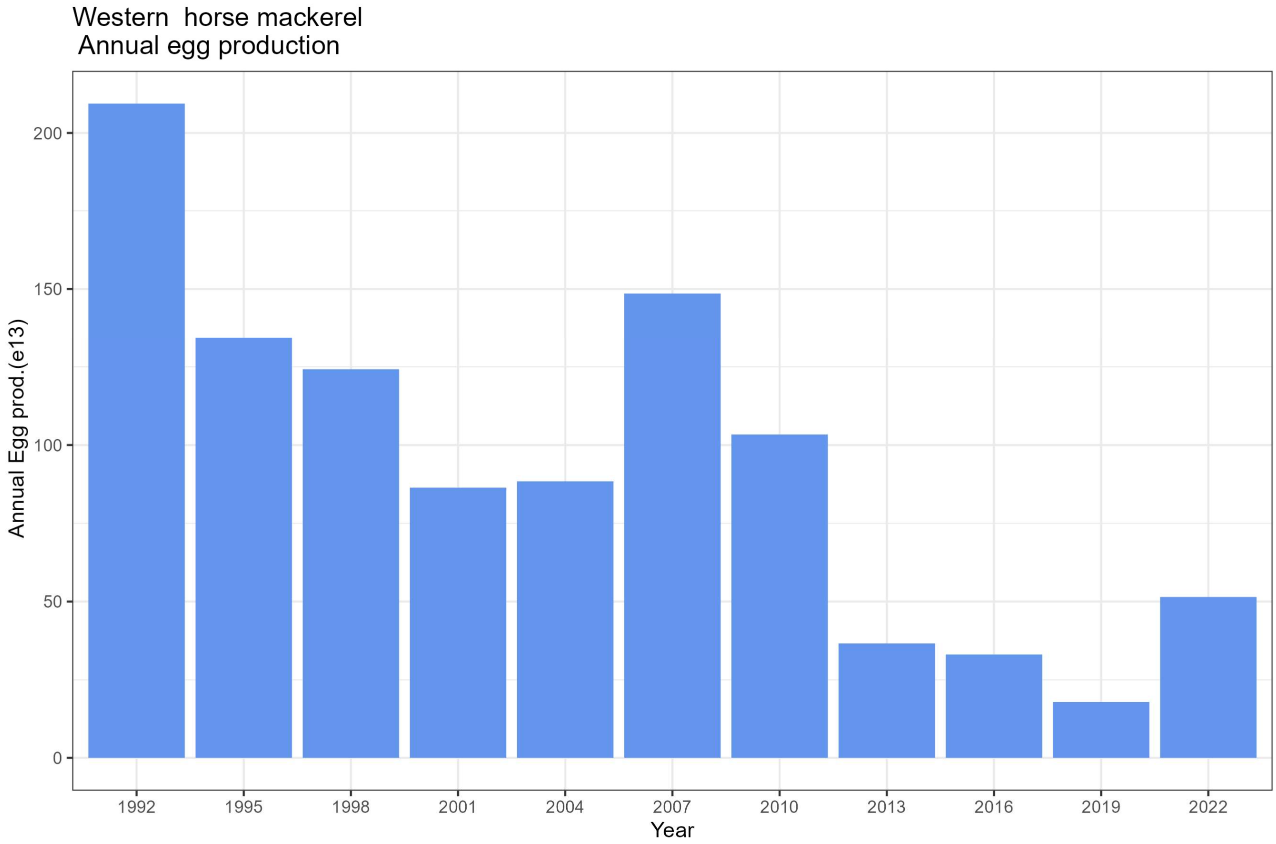

Figure 3.7: Provisional total annual egg production for western horse mackerel. Production figures back to 1992 are included for comparison.

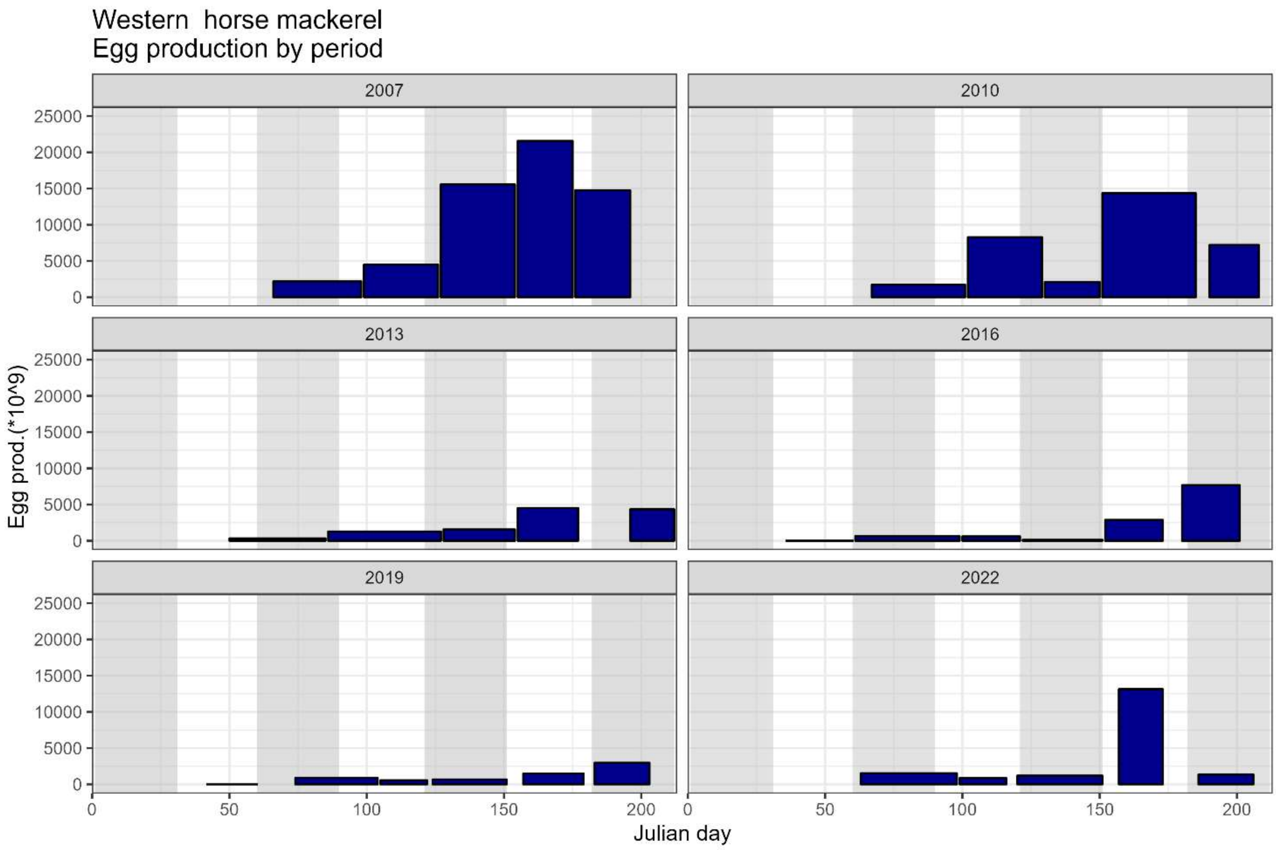

Figure 3.8: Egg production by period for the western horse mackerel spawning component since 2007

Table 6: Western estimate of horse mackerel total stage I egg production by period using the histogram method for 2022.

Dates	Period	Days	Annual stage I egg production $* 10^{15}$
Feb 1st – Mar 3rd	Pre 3	31	0.016
Mar 4th – April 8th	3	36	0.055
Apr 9th – 26th	4	18	0.016
Apr 27th – 29th	4 - 5	3	0.003
Apr 30th – May 31st	5	32	0.038
Jun 1st – 5th	5 - 6	5	0.043
Jun 6th – 22nd	6	17	0.223
June 5 – July 4th	6 – 7	12	0.091
July 5th – 25th	7	21	0.028
July 26th – 31st	Post 7	6	0.001
Total	0.514		

Fecundity investigations

This year for horse mackerel only DEPM ovary samples were collected during Periods 6 and 7, during peak of spawning. In addition to those samples collected during the MEGS surveys additional samples were collected from the Irish WESPAS surveys in periods 6 and 7. Since horse mackerel fecundity is at this moment not used for estimating the spawning stock biomass the focus of the fecundity analysis has been on mackerel. Therefore, at this time no horse mackerel fecundity results are ready to be presented. All samples will be analysed and results presented at the 2023 WGMEGS meeting.

DEPM results –Western Horse Mackerel

The horse-mackerel egg data of the DEPM survey are still under revision. Samples will be analyzed before and results will be presented to the 2023 WGMEGS meeting.

4 Discussion

Since 2004 and subsequent to demands for up-to-date data for the assessment, WGMEGS has endeavored to provide an estimate of NEA mackerel biomass and western horse mackerel egg production within the same calendar year as the survey and in time for the assessment meetings taking place. This report represents the preliminary results of the 2022 egg survey. WGMEGS cannot guarantee that there will be no changes prior to the presentation of the final survey results at WGMEGS in April 2023. However, despite the tight deadline nearly all plankton samples were analyzed for mackerel (southern and western area) and horse mackerel (western area only) stage 1 eggs. Portugal still has to supply data for their Period 2 survey in division 9a. Historically not many mackerel are caught during this survey therefore only negligible changes in the total egg production values are to be expected

As with 2019 no fecundity samples from Period 1 were available, instead samples from Periods 2 and 3 were included in the potential fecundity estimate. For the final fecundity estimate the later periods will also be included, as was done for previous surveys. No estimate of loss by atresia is yet available for 2022. The realised fecundity estimate is therefore based on the average atretic loss found in the period from 2001-2019. Since the atretic loss has always been a small number compared to the potential fecundity, using this average value will likely not give a large error. The prevalence of atresia for 2022 (28%) is comparable to previous survey estimates, it is thus highly likely that the atretic loss will also be at the same level. Atretic loss will however be analysed and included in the final fecundity estimate at the WGMEGS meeting in 2023.

Previous surveys in 2010 and 2013 were dominated by the issue of the early peak of western mackerel spawning and its close proximity to the nominal start date. In 2016 peak spawning reverted to May / June, a time that would traditionally be considered normal. In 2019, peak spawning in the western area was found to have occurred slightly earlier in Period 4. For 2022 the spawning pattern is remarkably similar to that reported for 2016.

During 2016, high levels of spawning were recorded over a large area of the Northeast Atlantic with a large number of the stations being reported over deepwater and well away from the continental shelf. In 2019 numbers of stage 1 eggs recorded on these northerly and western boundary stations were much reduced, although still present. The expansion was repeated in 2022 during Periods 5 and 6, however spawning densities recorded in these areas were significantly lower than reported in 2016 and 2019. Available surveys deployed during these periods were unable to fully delineate all boundaries however WGMEGS are satisfied that significant additional egg production is not being missed in these northern and western areas.

For the first time in a number of surveys western horse mackerel has shown an increase in egg production.

The MEGS group is confident that this survey accurately reflects the spawning patterns as exhibited by both species and as is presented in this working document. Despite the inability to secure a northern spawning boundary for western mackerel during periods 5 and 6, results from the recent exploratory MEGS surveys undertaken within these regions and reported to WGWIDE in 2021 (ICES,

2021) provide reassurance that the fraction of spawning missed is a minor one and that the survey has indeed been successful in capturing the majority of spawning activity. The potential issue arising from the missing Irish survey has also been satisfactorily addressed.

5 References

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ICES, 2021. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 3:95. 874 pp. http://doi.org/10.17895/ices.pub.8298 (Annex 05, WD 15)

Blue whiting

An updated alternative assessment including more surveys*

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Introduction

During WGWIDE 2020 we saw how vulnerable a stock assessment is when we only have one survey input to base the assessment on, and that survey is cancelled. In 2020 it was due to the covid-19 pandemic, but in the future there might be other unforeseen events that may cause the survey being cancelled or something may go wrong in the data collection so that we do not have reliable data for a specific year. To avoid this issue of potentially having no fishery independent data and make the assessment more robust against problems with the IBWSS, we will in this report consider including the IESNS and IESSNS survey data for blue whiting in the assessment.

Data description

For the IESNS survey we have data from 2008 to 2022 and for the IESSNS from 2016 to 2022. We use ages from 1-4+ and 1-6+ from the two surveys. This age selection was made based on the consistency plots in Figure 4. From the original assessment, we also have catch data (ages 1-10+, 1981-2022) and the IBWSS (ages 1-8, 2004-2022), where 2010 and 2020 is missing. The model has been configured based on data available in 2020, but we will include everything that is available at the time of the WGWIDE 2022 meeting in 24.-30. August 2022. An overview of the data selected for the alternative assessment is found in Figure 5 and each time series is plotted in Figure 6 for each age group and Figure 7 for each year class.

Model description

Today's assessment is using the R package stockassessment and the SAM model. Including additional survey data as input in this framework is a relatively simple task. The effort is mostly needed for deciding how to set up the configuration of the model. The procedure of how we have selected the model configuration is that we have included the two additional survey data sources and start out with a default SAM configuration. Then we start at the top of the configuration and make incremental changes and compare different settings until we get the best model fit in terms of AIC. Then we move on to the next configuration setting. We only consider configurations that are somewhat sensible. For instance, we do not consider putting the same catchability on 1 year old and 8-year-old fish, with some other catchability for those in-between. We only consider cases where neighbouring age groups share the same parameters. The final configuration file is included in the appendix. For details on diagnostic, see appendix.

Model output

Once we have fitted the model, we can look at model output. In Figure 1 we have plotted SSB, Fbar and recruitment for the period 1980-2022 according to the fitted model. The black line with grey confidence

*Updated working document from WD11 for WGWIDE2021 to WGWIDE2022.

interval is the official WGWIDE2022 assessment model for comparison.

In terms of SSB, the two models follow each other closely, with a slightly lower SSB for the alternative model in recent years. The main difference is clearly that we get smaller confidence intervals, i.e. higher accuracy, by adding more data to the model. For Fbar the picture is more or less the same. The two models are close to each other, only the alternative model point estimate is higher than WGWIDE for the last 3-4 years.In recruitment we see a bigger discrepancy. The alternative model gives a higher recruitment in 2016 and also for the last two years, 2021 and 2022. This is most likely due to high values for these years in the two additional survey indices.The confidence intervals are narrower for the alternative model compared to WGWIDE2022. Hence, the alternative assessment is consistent with the WGWIDE2022 assessment, but it has higher accuracy.

Leave-out analysis

A standard diagnostic is to leave out one survey at the time and see what effect this has on the output. This is achieved by taking out one data source at the time and refitting the model. This can give us an idea of how that particular data source affects the total. The leaveout plots are presented in Figure 2.

For the SSB the differences are small and the four curves are close to each other. If we take out IESSNS the SSB is slightly lower and if we take out IESNS it increases in the recent years. Taking out IBWSS increases the uncertainty the most, which is natural as it is the largest survey in terms of observations. We also see a similar pattern for Fbar. For the recruitment, taking out IESSNS will give the lowest recruitment, while if we take out IBWSS we get the highest for 2021. Going back in time, the leaveout scenarios give more or less the same result.

Another interesting scenario we can run is: What if we take out all the surveys and run the SAM model with only catch data. The results of such a model run is presented in Figure 3 compared to the WGWIDE2022 assessment. In short, it gives a lower point estimate for SSB and Recruitment and higher Fbar. It also widens the confidence intervals when taking out all surveys.

Conclusion

This exploratory model run shows that it is possible to include IESNS and IESSNS into the SAM model for Blue Whiting. It reduces the uncertainty and may provide more information about the younger fish. It will certainly reduce the risk for not having any survey to base the assessment on, by having two-three surveys instead of just one. The data is already being collected, and ready to use.

Appendix

Diagnostics

Jit run

A jitter run means that we re-estimate the model using randomly selected initial values and report the maximum difference in each parameter and model output. Ideally there should not be any major changes due to the initial values. The results from the jitter run indicates that there is little effect on the different model parameters due to varying the initial values.

```
##                     max(|delta|)
## logFpar             1.708855e-12
## logSdLogFsta        1.119327e-12
## logSdLogN           3.281819e-13
## logSdLogObs         3.246112e-12
## logSdLogTotalObs    5.225820e-12
## transfIRARdist      1.073452e-11
## itrans_rho          2.763567e-12
```

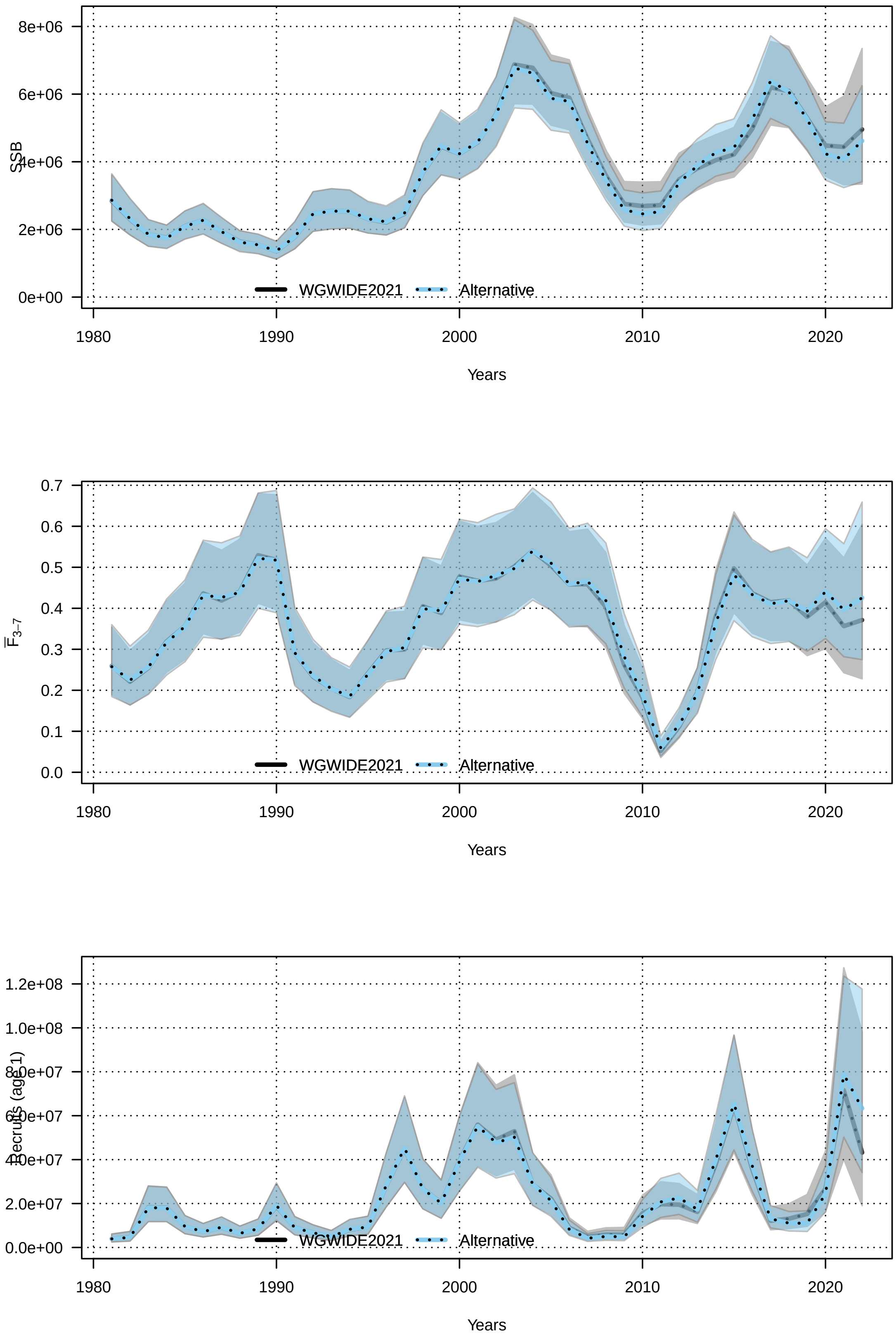


Figure 1: Model output in terms of SSB, Fbar and recruitment with 95 percent confidence intervals.

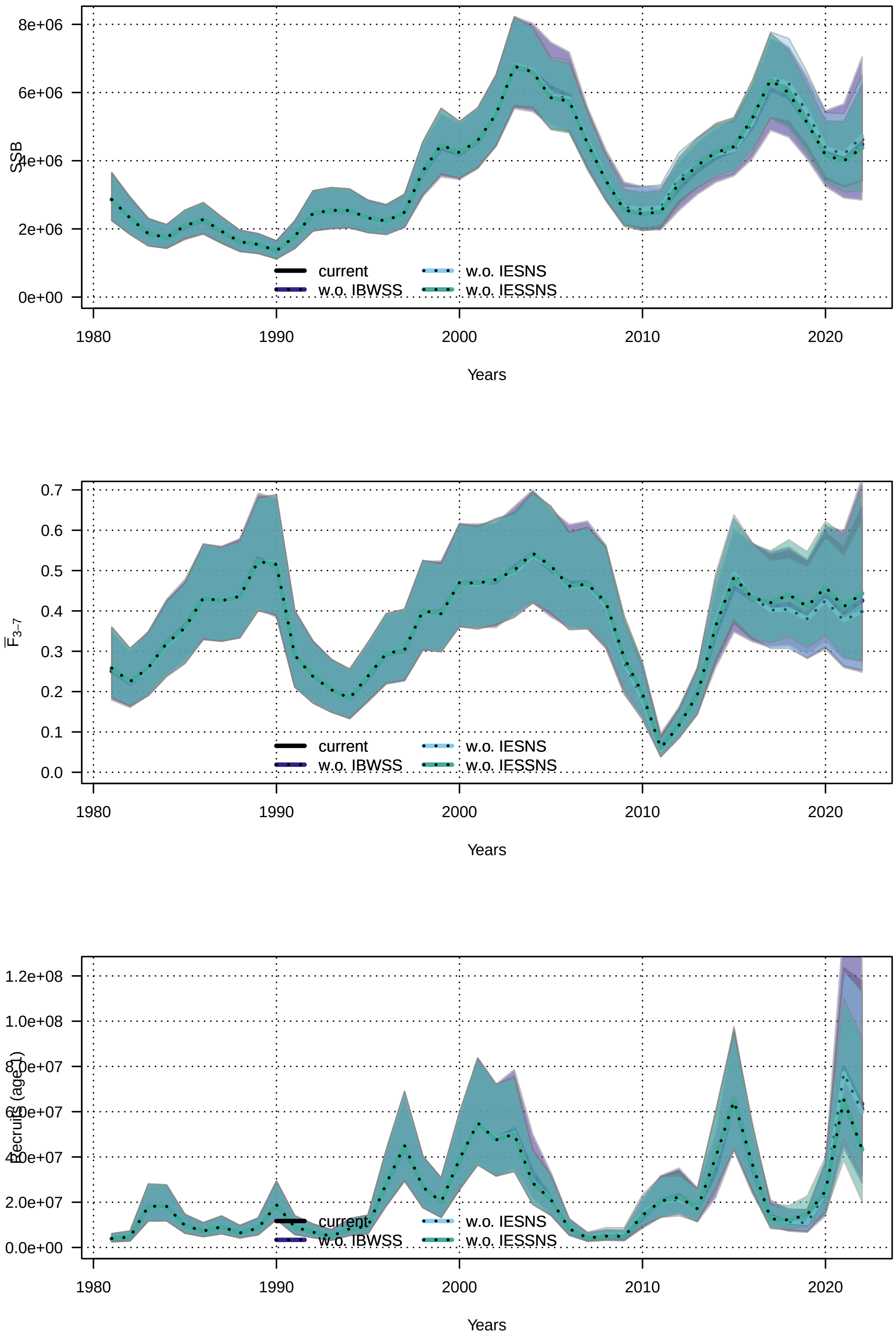


Figure 2: Leaveout plots for alternative assessment.

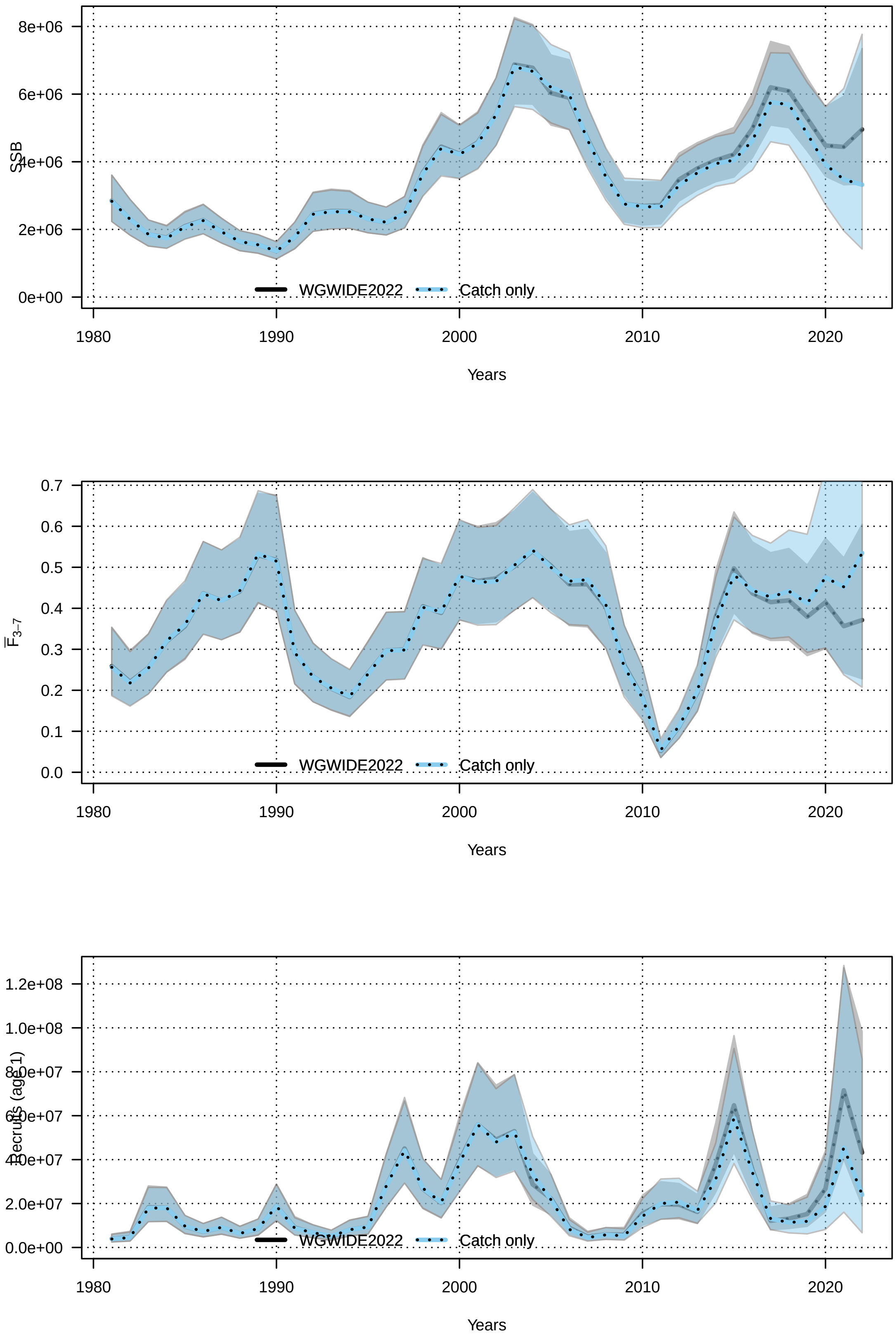


Figure 3: Comparison of assessment with catch only vs WGWIDE2021 assessment.

```
## logFScaleMSY          6.995491e-01
## implicitFunctionDelta 5.901470e-01
## logScaleFmsy          5.912467e-01
## logScaleFmax          5.875044e-01
## logScaleF01           6.409693e-01
## logScaleFcrash        6.993916e-01
## logScaleFext          5.391787e-01
## logScaleFlim          6.193291e-01
## logF                  1.629119e-10
## logN                  2.133138e-10
## missing               2.507221e-10
## ssb                   5.337661e-04
## fbar                  4.384876e-11
## rec                   9.316012e-03
## catch                 8.541672e-05
## logLik                2.537490e-10
```

Simulation study

Another test is to do a simulation study, where we simulate the processes going into the model and compare this to the model output based on the observations. Ideally, the simulations should stay within the 95% confidence intervals with a probability of 0.95. Here we use 50 simulations. It seems that most of the simulations fall within the confidence intervals, with some exceptions. This is expected.

Retrospective plots

Peeling off one year at the time and fitting the model based on those data. In the retrospective plots (Figure 13) we can see how well the last year's assessment fits with what the model predicts with one more year of data. Mohn's ρ for the retrospective analysis of SSB, Fbar and recruitment is respectively, 0.0069, -0.0094 and -0.0736.

Figures

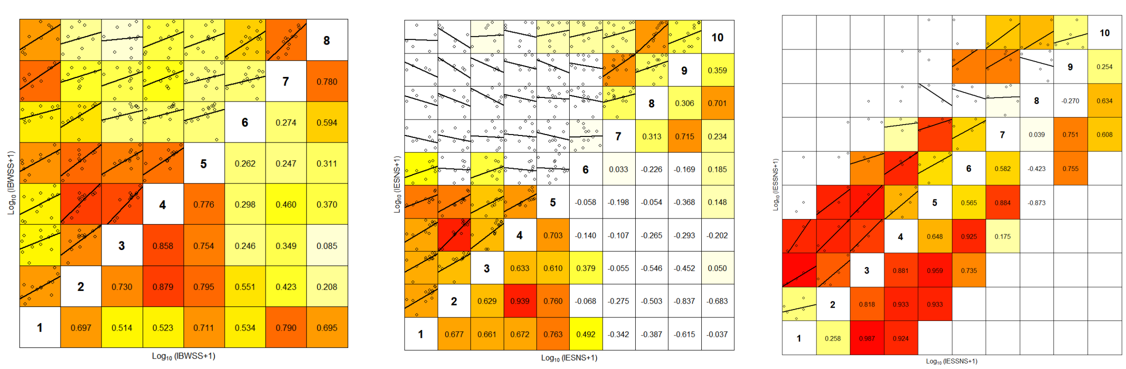


Figure 4: Internal consistency/correlation plots for IBWSS, IESNS and IESSNS. We use $\log(x+1)$ to avoid issues when x is 0. For IBWSS ages 1-8 are used, while in the alternative model 1-4+ and 1-6+ is used for IESNS and IESSNS, respectively.

Figure 5: Dataplot showing for which ages and years we use observations from the different data sources. For all except IBWSS the oldest age group is a plus group.

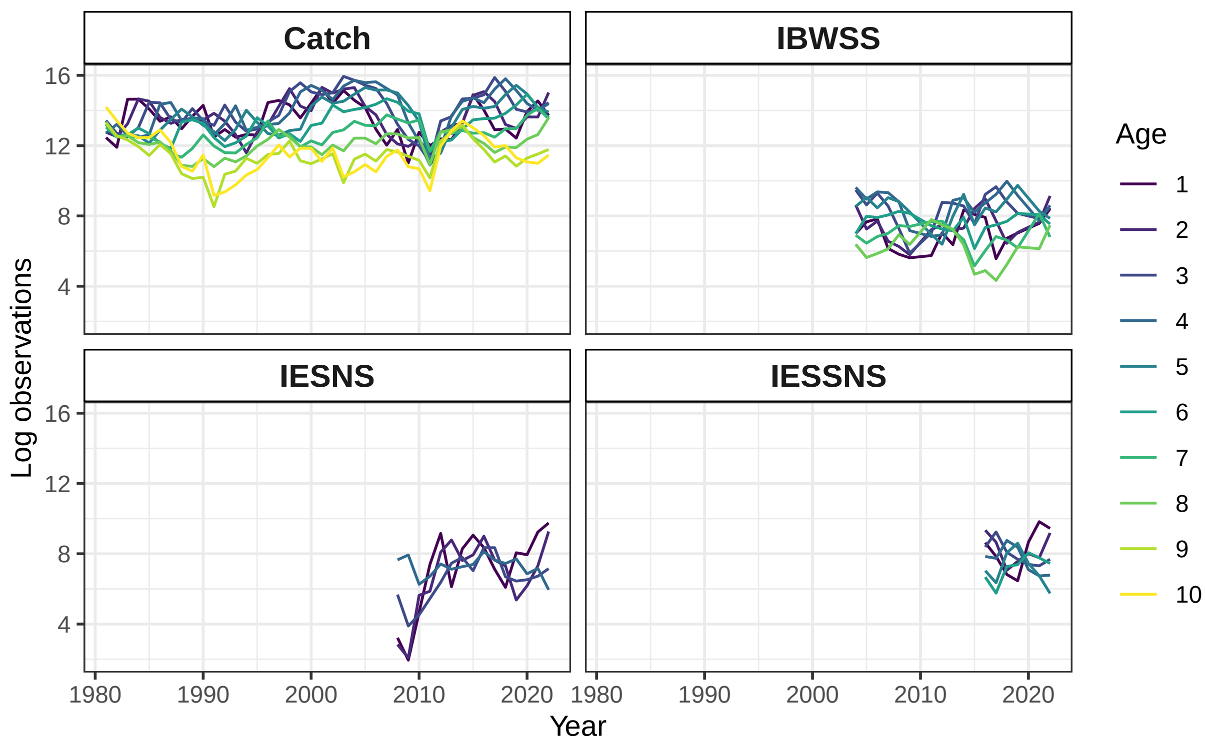


Figure 6: Time series for all data sources on log scale – one line per age group.

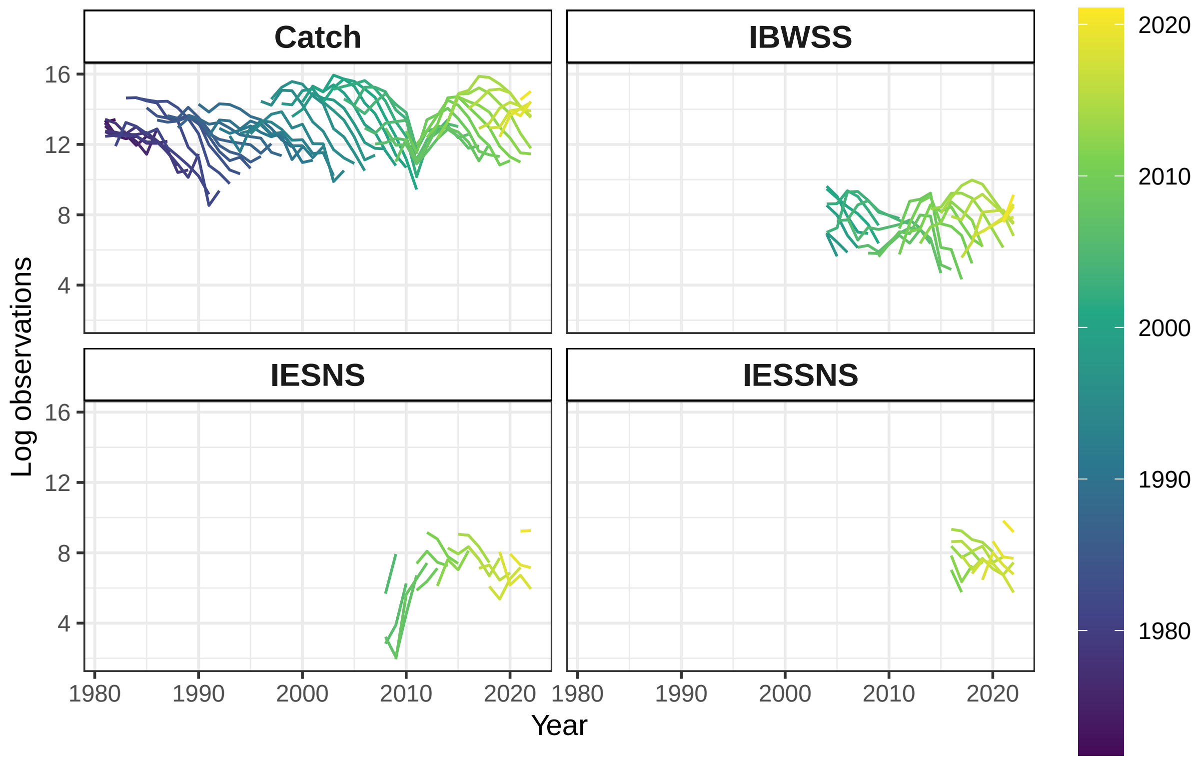


Figure 7: Time series of the different data sources on log scale – one line per year class.

Config

Here we print out the configuration file for the alternative assessment.

```
print(conf)
```

```
## $minAge
## [1] 1
##
## $maxAge
## [1] 10
##
## $maxAgePlusGroup
## [1] 1 0 1 1
##
## $keyLogFsta
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,]  0  1  2  3  4  5  6  7  8   8
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [3,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [4,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
##
## $corFlag
## [1] 2
##
## $keyLogFpar
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
```

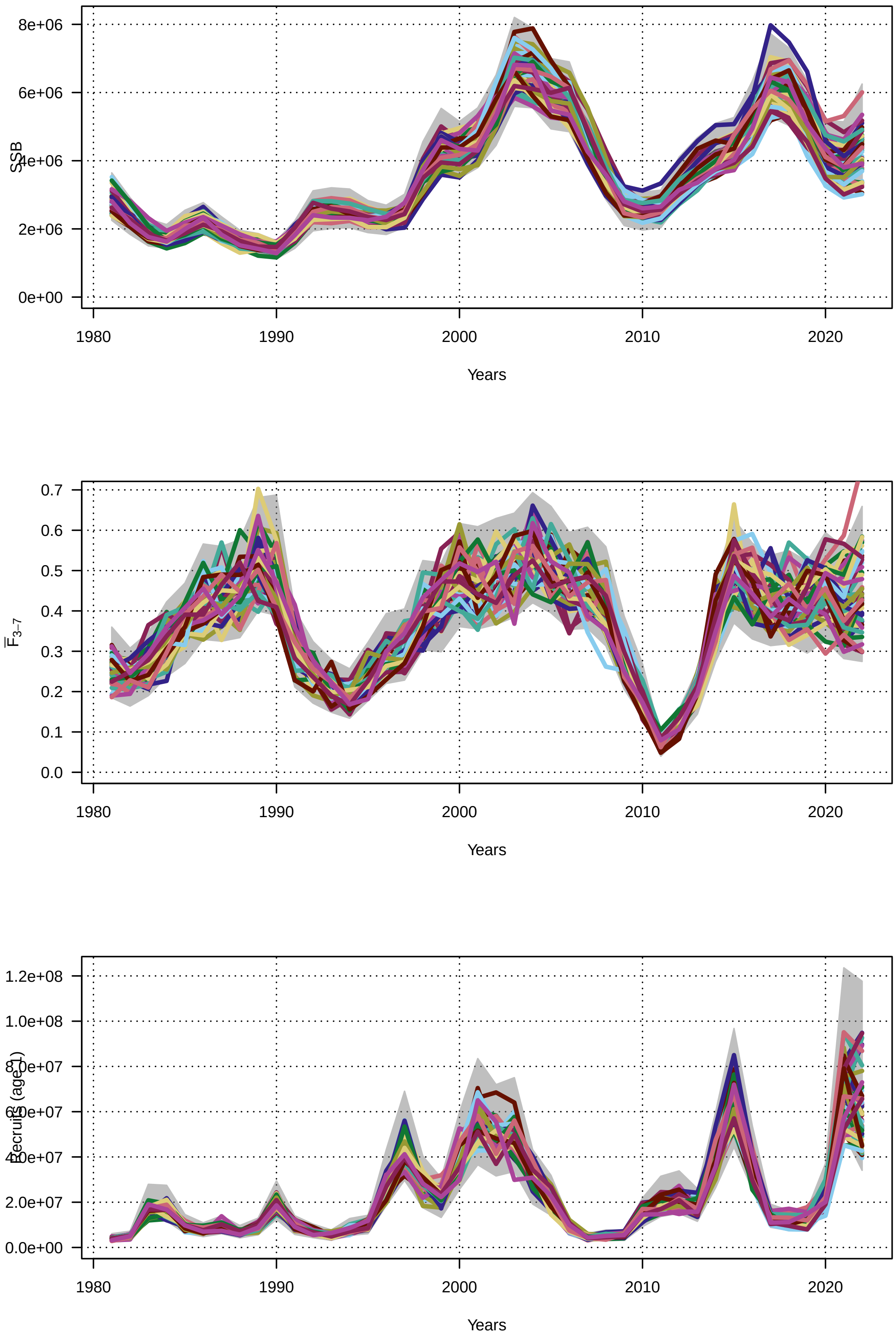


Figure 8: QQ-normality plots for model residuals by data source.

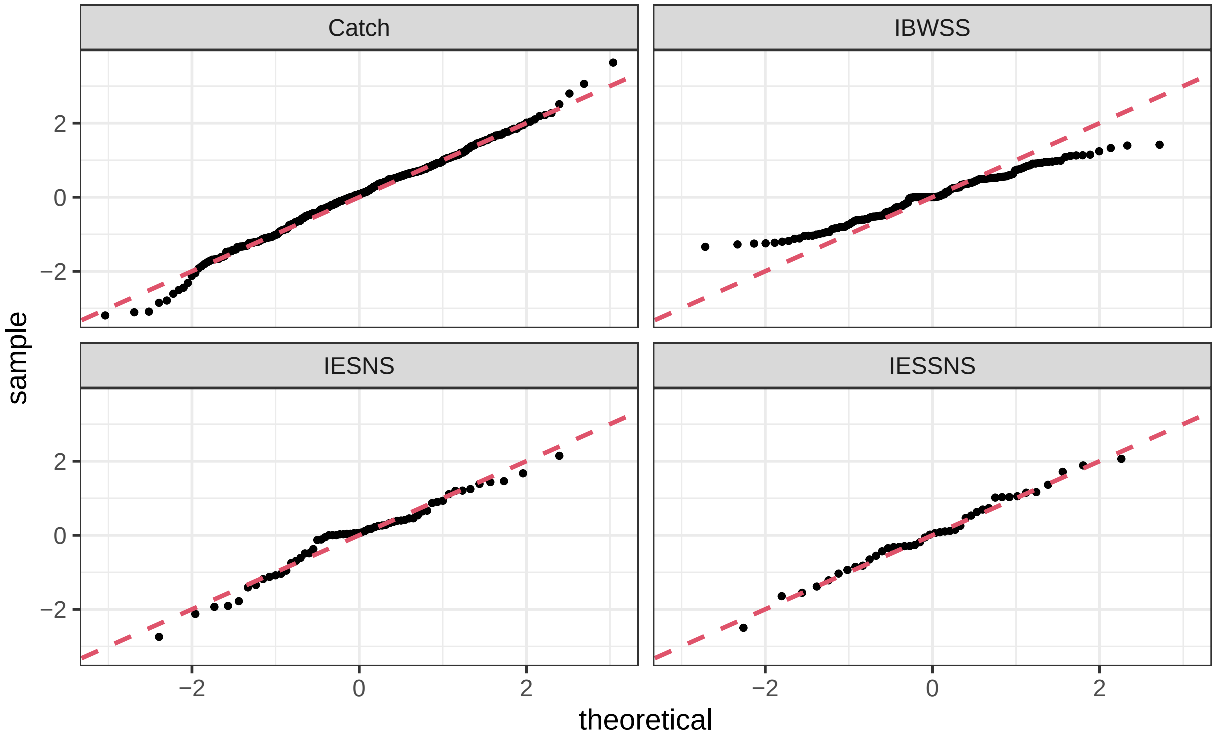


Figure 9: QQ-normality plots for model residuals by data source.

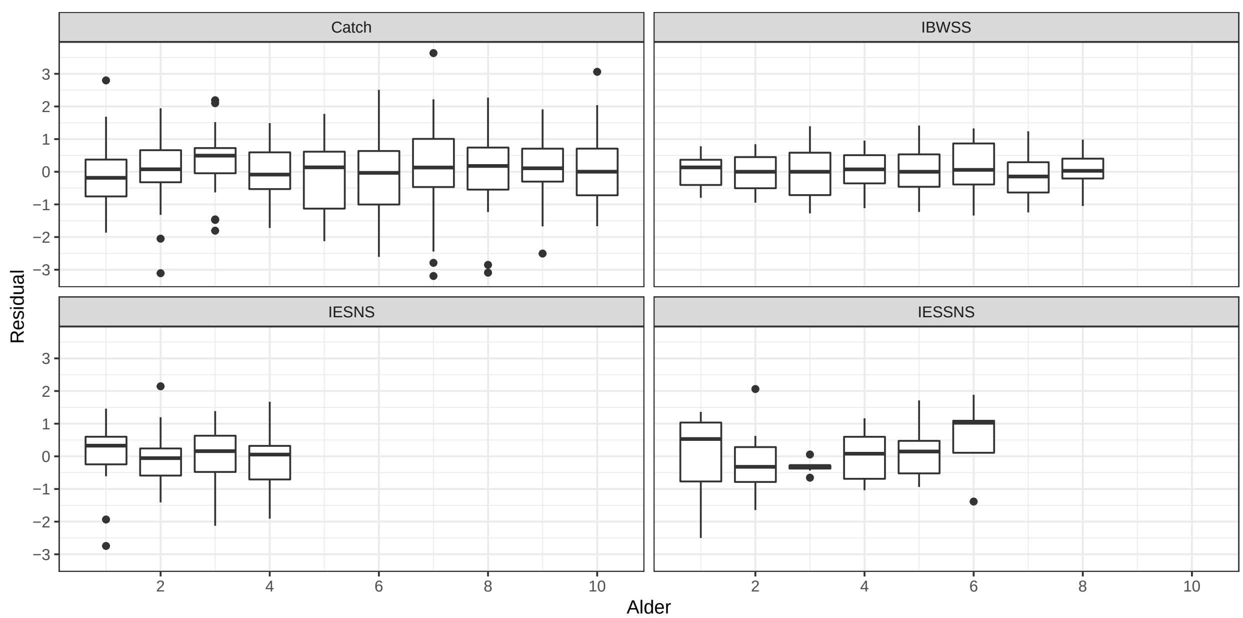


Figure 10: Boxplots of residuals by age for each fleet.

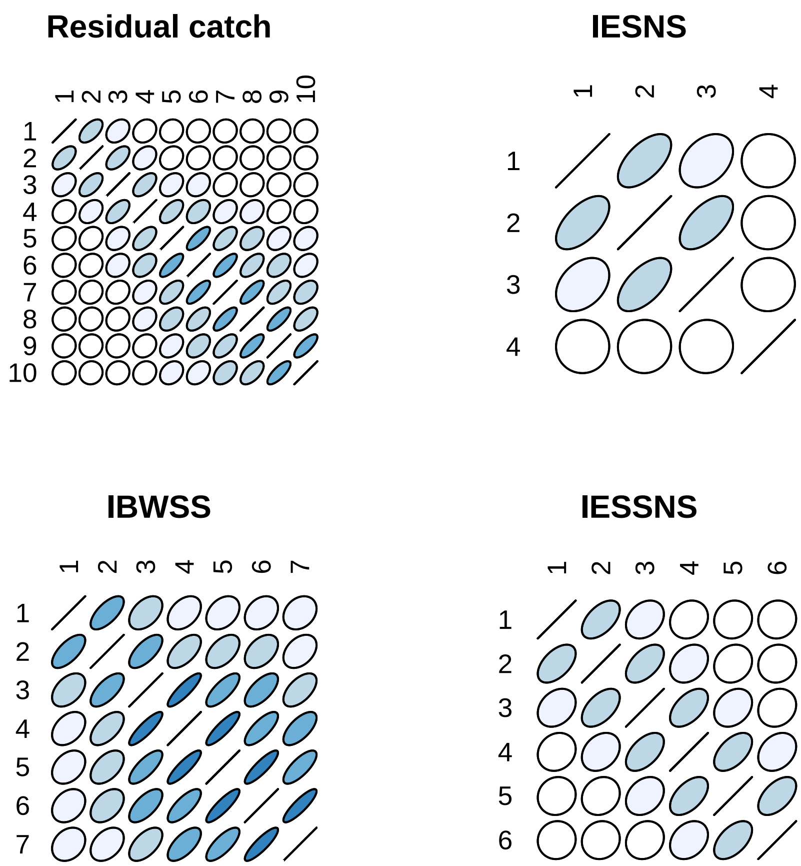


Figure 11: Correlation plot (model estimated).

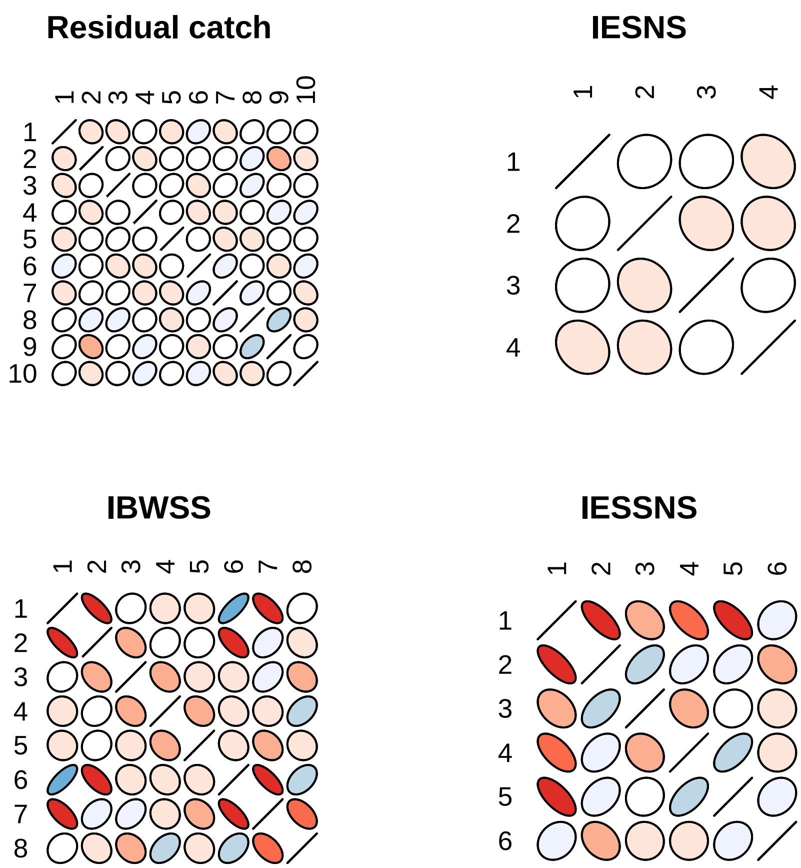


Figure 12: Empirical correlation plot.

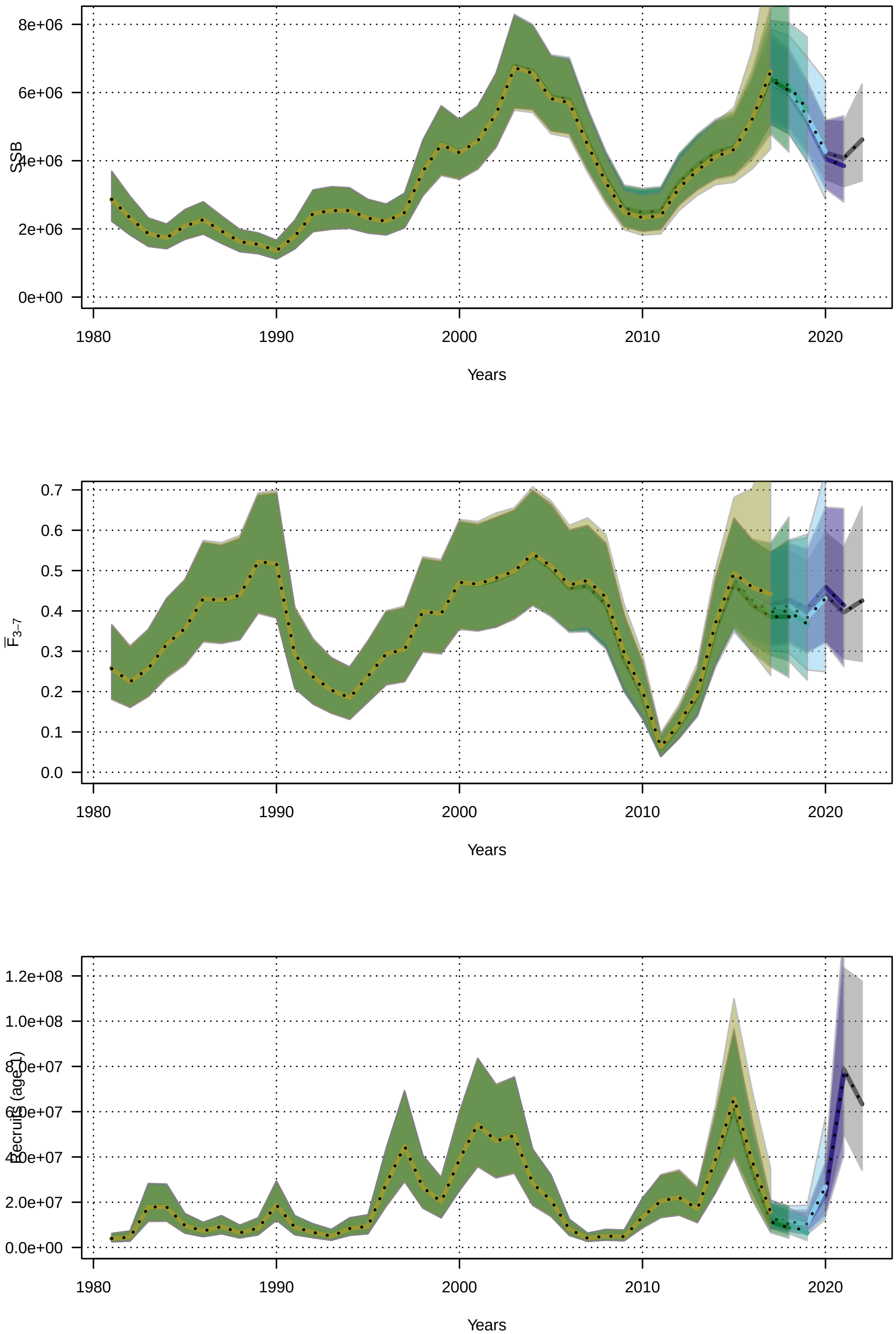


Figure 13: Retrospective plots for SSB, Fbar and Recruitment.

```
## [2,]  0  1  2  3  4  4  4  4 -1  -1
## [3,]  5  6  7  7 -1 -1 -1 -1 -1  -1
## [4,]  8  9 10 10 10 10 -1 -1 -1  -1
##
## $keyQpow
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [3,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [4,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
##
## $keyVarF
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,]  0  0  0  0  0  0  0  0  0   0
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [3,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [4,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
##
## $keyVarLogN
##  [1] 0 1 1 1 1 1 1 1 1 1
##
## $keyVarObs
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,]  0  1  2  2  2  2  2  2  3   3
## [2,]  4  5  6  7  7  7  8  8 -1  -1
## [3,]  9  9 10 10 -1 -1 -1 -1 -1  -1
## [4,] 11 11 11 11 11 11 -1 -1 -1  -1
##
## $obsCorStruct
## [1] AR AR AR AR
## Levels: ID AR US
##
## $keyCorObs
##      V1 V2 V3 V4 V5 V6 V7 V8 V9
## [1,]  0  0  0  0  1  1  1  1  1
## [2,]  2  2  3  3  3  3  3 -1 -1
## [3,]  4  4  5 -1 -1 -1 -1 -1 -1
## [4,]  6  6  6  6  6 -1 -1 -1 -1
##
## $stockRecruitmentModelCode
## [1] 0
##
## $noScaledYears
## [1] 0
##
## $keyScaledYears
## numeric(0)
##
## $keyParScaledYA
## <0 x 0 matrix>
##
## $fbarRange
## [1] 3 7
##
```

```
## $keyBiomassTreat
## [1] -1 -1 -1 -1
##
## $obsLikelihoodFlag
## [1] LN  ALN LN  LN
## Levels: LN ALN
##
## $fixVarToWeight
## [1] 0
##
## $fracMixF
## [1] 0
##
## $fracMixN
## [1] 0
##
## $fracMixObs
## [1] 0 0 0 0
##
## $constRecBreaks
## numeric(0)
##
## $predVarObsLink
##      V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
## [1,] -1 -1 -1 -1 -1 -1 -1 -1 -1  -1
## [2,] -1 -1 -1 -1 -1 -1 -1 -1 NA  NA
## [3,] -1 -1 -1 -1 NA NA NA NA NA  NA
## [4,] -1 -1 -1 -1 -1 -1 NA NA NA  NA
##
## $hockeyStickCurve
## [1] 20
##
## $stockWeightModel
## [1] 0
##
## $keyStockWeightMean
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyStockWeightObsVar
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $catchWeightModel
## [1] 0
##
## $keyCatchWeightMean
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyCatchWeightObsVar
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $matureModel
## [1] 0
##
## $keyMatureMean
```

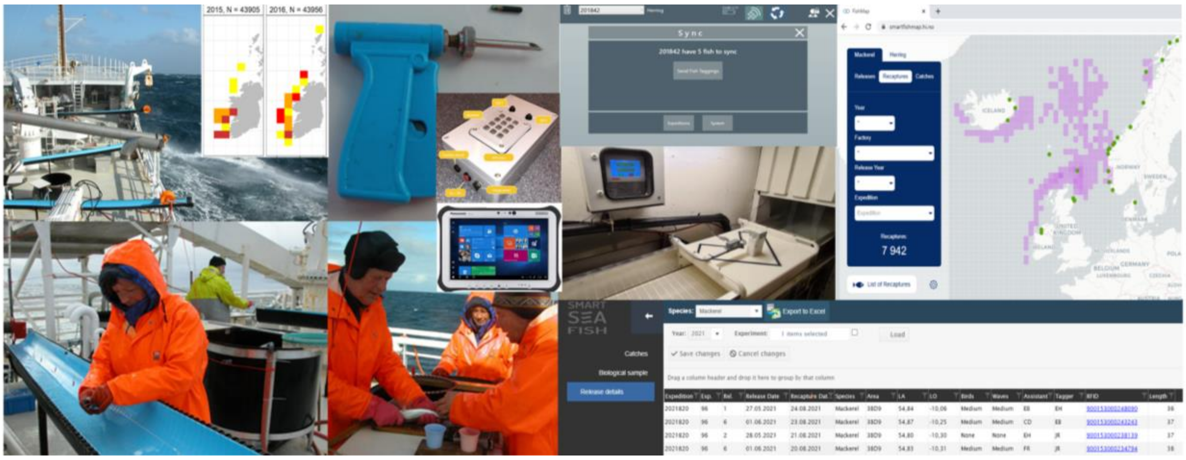
```
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $mortalityModel
## [1] 0
##
## $keyMortalityMean
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyMortalityObsVar
##  [1] NA NA NA NA NA NA NA NA NA NA
##
## $keyXtraSd
##      [,1] [,2] [,3] [,4]
```

WD ICES WGWIDE 20201

The 2022 updated RFID tag-recapture data on NEA mackerel – Trends in abundance with different filtering

By Aril Slotte and Sondre Hølleland

Institute of Marine Research, Bergen, Norway



Summary

A full overview and update of the RFID tagging experiments of mackerel 2011-2022, as well as the recaptures and scanned fish 2012-2021 is given. Since the benchmarking process during ICES IBPNEAMac 2019 and decisions therein, the data included in the SAM stock assessment has been filtered to only include mackerel tagged at ages 5-11, release years 2013 and later and recaptures limited to year 1 and 2 after release. The RFID data set used as input to the SAM stock assessment is a complex one with numbers released per age in a release year, and the numbers scanned and recaptured of these year classes annually in all the years after release; i.e not typical abundance indices per age per year as normally included in age-based stock assessments. Hence, the overview does not only focus on the input data themselves and quality assurance of these, but the actual trends they show for both the different year classes and biomass. Special effort in put on demonstrating trends in actual data included in assessment compared with other ways of filtering the data, such as including more age groups and more years with recaptures after release then the current assessment. Finally, the year class trends, mortality trends in the RFID data are compared with the other age-based input data from commercial catches and the international trawl survey in the Norwegian Sea (IESSNS).

Background

The Institute of Marine Research in Bergen (IMR) has conducted tagging experiments on mackerel on annual basis since 1968, both in the North Sea and to the west of Ireland during the spawning season May–June. Information from steel-tagged mackerel tagged west of Ireland and British Isles was introduced in the mackerel assessment during ICES WKPELA 2014 (ICES, 2014), and data from release years 1980-2004, and recapture years 1986-2006 has been used in the update assessments after this. The steel tag experiments continued to 2009, with recaptures to 2010, but this part of the data was at the time considered less representative and was excluded.

What is used in the SAM stock assessment is a table of data showing numbers of steel tagged fish per year class in each release year, and the corresponding numbers scanned and recaptured of the same year classes in all years after release. The steel tag data and the corresponding trends in the data in terms of index of total biomass and year class abundance by year is described in (Tenningen et al., 2011).

The steel tag methodology involved a whole lot of manual processes, demanding a lot of effort and reducing the possibility to scan larger proportions of the landings. The tags were recovered at metal detector/deflector gate systems installed at plants processing mackerel for human consumption. External personnel were hired to monitor the systems during processing. Among the typical 50 fish deflected, they had to find the tagged fish with a hand-hold detector and send the fish to IMR for further analysis. It was decided in the end to go for a change in methodology to radio-frequency identification (RFID), which would allow for more automatic processes and increased proportion of scanned landings.

RFID tag recapture methodology and data quality assurance

The RFID tagging project on NEA mackerel was initiated in 2011 by IMR, and the data were used in update assessments after the ICES WKWIDE2017 benchmark meeting (ICES, 2017b). The data format was the same as for steel tags, but the time series were treated with a different scaling parameter in the assessment.

RFID is a technology that uses radio waves to transfer data from an electronic tag, called an RFID tag, through a reader for the purpose of identifying and tracking the object. The tags used for mackerel are passive, commonly called PIT-tags, specifically developed for tagging fish and animals. They are made of biocompatible glass (specific type used for mackerel is ISO FDX-B 134,3 kHz, 3.85x23mm glass tags) which are equipped with a one-time programmable microchip with a unique ID. Information to the reader is released as it passes an electric field in the antenna system, and information is automatically updated in an IMR database over internet. When tagging and releasing the fish, information is also synced to the IMR database regularly over internet.

There is a web-based software solution (SmartSeaFish) and database that is used to track the different scanning systems at the factories, import data on catch information, and biological sampling data of released fish and screened catches. Based on this information the software is used to allocate the biological data to releases and catches, and to further estimate numbers released every year, and the concurrent numbers screened and recaptured over the next years (by year class).

The development of the tagging data time series is dependent on the work from each country's research institutes, fisheries authorities or the industry it selves to provide additional data about catches screened through the RFID systems, such as total catch weight, position of catch (ICES rectangle), mean weight in catch, etc. Regular biological sampling of the catches landed at these factories is also needed. Altogether, these data are essential for the estimation of numbers screened per year class. Responsible scientists in Norway, Iceland, Faroes and Scotland have been following up the factories, and delivering the catch data and biological data. Currently the responsibilities are as below:

Iceland: Anna Olavsdottir (HAFRO) responsible scientist

- uploading catch data and biological data to SmartSeaFish database
- allocating recaptures and biological samples to the different landings
- testing the 3 Icelandic factories for efficiency, 10 test tags in 10 different landings every year.
- initiates servicing of RFID-antenna systems if needed
-

Scotland: Steve Mackingson (Scottish Pelagic Fishermen's Association) responsible scientist

- uploading catch data to SmartSeaFish database (we still use Norwegian biological data from same period/ICES area)
- allocating recaptures to the different landings
- testing the 5 Scottish factories for efficiency, 10 test tags in 10 different landings every year/season.
- initiates servicing of RFID-antenna systems if needed
-

Norway: Aril Slotte (IMR) responsible scientist for the Norwegian RFID tagging program for mackerel and herring, main responsible for final estimations needed to procuce the data table delivered to ICES WGWIDE

- uploading catch data and biological data to SmartSeaFish database
- allocating recaptures and biological samples to the different landings (including biological data to Scottish landings)
- Norway now has 15 factories with RFID antenna systems for scanning mackerel and herring. All factories are serviced 1 time per year and when there are apparent issues to be solved

A new monitoring system has been developed (Figure 1), which is now placed at all 15 Norwegian factories and the 3 Icelandic factories. This monitoring system is continuously overviewing that RFID antennas and readers are functioning. Voltage variations are measured and every 15 min the reading capabilities are tested automatically with a status tag, and these tests are also stored in the SmartFish database for further analyses of efficiency. This monitoring system has replaced the manual testing with 10 test tags in 10 different landings every year/season. The plan is that same systems are placed out at the Scottish factories, or any new factories installing the system.

Based on results from the online monitoring system in addition to the manual test off recapture efficiencies or the online monitoring, responsible scientists decides if data from a factory have to be excluded from final estimation and data input to ICES WGWIDE assessment. Factories that do not function properly are put in an 'out of order' list (Figure 2), where catch data and recapture data from these 'out of order' periods are excluded during estimation.

To conclude regarding quality assurance, we have made progress and the current monitoring of efficiencies at factories that has been raised as a main issue is now at an acceptable level. Still, there is need for more quality control of both all raw tag-recapture data, biological data and allocations of these to landings, as well as the final estimations of data included in the ICES WGWIDE stock assessment. In the future we potentially need to develop annual sworkshops prior to the assessment, where more scientists go through the new data being updated from new tagging experiments, as well as recaptures from all previous experiments, undertake quality assurance of the data and other analyses of the trends in the data outside of the assessment model. The idea is that this should work similarly as post-cruise meetings where all involved scientists take part in final report.

Status of updated RFID tag recapture data

The RFID tagging technology is clearly a more cost-effective than the old steel tag technology. We are now scanning about 10 times more biomass than during the period with steel tags. An overview of the RFID tagging data in terms of numbers tagged, biomass scanned, and numbers recaptured is given in Tables 1-3, and geographical distributions of data in Figures 3-6.

During the period 2011— 2022 as many as 556953 mackerel have been tagged with RFID (Table 1). This includes an experiment off the Norwegian Coast on young mackerel in September 2011 as well as five experiments carried out in August in Iceland 2015-2019, none of which are included as input data in the assessment. Data from the releases at the spawning grounds in May-June of Ireland and the Hebrides are the only data included in the assessment.

By 26. August 2022 as many as 10124 RFID-tagged mackerel have been recaptured from all experiments. Looking only recaptures 2012-2021 full years and the experiments of Ireland and British Isles used in update asssessments, 8488 mackerel has been recaptured at landings scanned at 25 European factories processing mackerel for human consumption (Tables 2- 3). The project started with RFID antenna reader systems connected to conveyor belt systems at 8 Norwegian factories in 2012. Now there are 5 operational systems at 4 factories in UK (Denholm has 2 RFID systems) and 3 in Iceland. Norway has installed RFID systems at 8 more factories in 2017-2018, most of which with the purpose of scanning Norwegian spring spawning herring catches (IMR started tagging herring in 2016), but some also processing mackerel. Recently one factory, Pelagia Austevoll is terminated, so currently 15 factories are scanning for RFID tags in Norway. More systems are also bought by Ireland (3), which up to now has been non-operational.

During ICES WGWIDE 2018 (ICES, 2018d) meeting bias issues were described for RFID tag data, in addition to potential weighting issues of the tag data inside the model. After the intermediate benchmark meeting ICES IBPNEAMac 2019 (ICES, 2019a), these issues were overcome by using a subset of data for release years (exclude 2011-2012), recapture years (only use recaptures from year 1 and 2 after release) and age groups (exclude youngest fish ages 2-4, use ages 5-11). This is now the subset of data to be used in update assessments.

The exclusion of release years 2011-2012, and recapture years 2012-2013 is mainly based in lack of distributional coverage of scanned fishery, which changed significantly when more countries joined the program and scanned landings from 2014 onwards (Figures 4-5).

The exclusion of recaptures in year 3 or longer after the release year was because data indicated tag loss over time, and that the large majority was recaptured prior to year 3 after release. In year recaptures are not used. However, following recaptures from in year (years out=0) and further through year 1-3+ after tagging, it is apparent that tagged fish are quite quickly distributed in the fishery, and the distributional patterns of recaptures are maintained over time (Figure 6). Hence, potentially more recapture years could be included it one overcame how to adjust for potential tag loss.

The exclusion of ages 1-4, was mainly based in noisy data from these age groups, and the fact that in the early tagging years fish in these age groups were relatively few compared with the scanned fish year 1 and 2 after release. The few fish from these ages were not considered representative for the behaviour of the year classes. However, over time this picture has changed considerable. The age structure of tagged and scanned fish year 1-2 after release are now overlapping, and high proportions of tagged mackerel are now at ages 2-4 (Figure 7). This means that given current filtering we will exclude large proportions of the RFID tag recapture data in coming years, so this is a decision that will have to be revised. Hence, in the following focus is on the actual trends and consistency in the RFID tag data, having in mind that the current filtering may have to be revised in near future.

Status of RFID tag recapture data trends and consistency for use in stock assessment

Estimates of year class abundance for unfiltered RFID tag-recapture data show trends over time that seems informative for stock assessment (Figure 8), and this is also supported by the tests of consistency in the data (Figure 9), implying a potential for including younger age groups in future assessments.

However, the information coming from the RFID tag data is easier to interpret when comparing age aggregated biomass indices estimated from the RFID data (based on year 1-2 with scanning and recaptures) with SSB from the stock assessment, as shown in Figure 10. The decision to exclude release years 2011-2012 is supported by this plot, showing noisy estimates above the confidence intervals of the assessment. However, by including only release years 2013 onwards as in current assessments, the biomass trend in the RFID tag data is more in line with the SSB of the assessment, especially the decrease in SSB from 2017-2020 is also very evident regardless of ages aggregated from RFID data. This again signifies that over time, and in a future benchmark process, information of tag recaptures from younger age groups may be included again if trends are informative for the assessment.

In recent years we have seen a trend that the information from RFID tag recapture data about abundance in a release year increase when adding one more year with recaptures and scanned data. Figures 11-12 illustrates this issue for single year classes as well as various age aggregated abundance estimates. This supports the decision to stick to only using recapture and scanned data for year 1 and 2 after release. Moreover, it also implies the last year included in the stock assessment always based on s will be revised in next update assessment, with a recent clear tendency that adding the second year with data lifts the perception of abundance in a release year.

One more way of looking at the information from RFID tag recapture data relative to the other sources of input data and the stock assessment itself, is to compare signals of total mortality rate (Z) by estimating slope of decrease in abundance of year classes 2003-2014 of fully mature fish aged 4-12

(Figure 13). Here it is apparent that mortality signals from RFID data seem informative following a steady decrease as the catch data, whereas IESSNS data sticks out as a bit noisier trend. When looking at the estimated Z for each data source, it is evident that the RFID data show signals of higher mortality rate than the catch data, whereas Z estimates for the IESSNS data are even lower. Z estimates from the WGWIDE2022 assessment are also above the catch data, but below the tag estimates, signifying that the model put some weight on the tag data. Note that RFID data shows more uncertain estimates of Z for recent year classes with very few years, fewer than the other sources, which means the estimates may change over time.

The overall conclusion is still that the RFID data seems quite informative, and that the current filtering and exclusion of data for use in stock assessment should be revised in near future. Only looking at the relative year class structure in the tag estimates 2019-2020 compared with the structure seen in catch data, IESSNS, and WGWIDE2022 assessment (Figure 14), we see very similar structure. In addition, here it is evident that the RFID-estimates also how large new year classes such as 2016, which is not used yet in assessment because of the exclusion of young fish. Also noticeable is that yearclasses such as 2012-2013 are relatively smaller in the RFID-estimates than in the IESSNS and catch data, which likely may be due to age reading issues. The tag estimates are based on fewer readers.

Finally, on a totally different issue. Do mackerel growing up in the North Sea belong to a specific component? Figure 15 demonstrates that recaptures from very young fish tagged in the North Sea at the western Norwegian coast (Bømlo Island) over the year adapted the same migration pattern as the fish tagged at older ages along Ireland-Hebrides. This supports the hypothesis that mackerel growing up in the North Sea do not belong to a North Sea component, but to a large dynamic mackerel population changing migration pattern and spawning areas as the stock fluctuates in abundance and age structure.

Link to official publication of all raw data needed to produce input data set to the assessment is: Aril Slotte (IMR), Anna Ólafsdóttir (MFRI), Sigurður Þór Jónsson (MFRI), Jan Arge Jacobsen (FAMRI) and Steve Mackinson (SPFA) (2021) PIT-tag time series for studying migrations and use in stock assessment of North East Atlantic mackerel (Scomber Scombrus) http://metadata.nmdc.no/metadata-api/landingpage/f9e8b1cff4261cf6575e70e56c4c3b3e This is the correct citation when using the data. The data are available through this link as various APIs that are updated daily. There is also an R-package https://github.com/IMRpelagic/taggart can be used to download data from the APIs.

Tables

Table 1. Overview of numbers released in the different RFID tagging experiments, and numbers recaptured per year. Recaptures from experiments and recapture years used in 2022 stock assessment, based on decisions in the ICES IBPNEAMac 2019 (ICES 2019) are outlined and marked grey. However, note that these numbers also include recaptures from some factories excluded in the final estimation of tag table used in the stock assessment 2022 (see Tables 2-3), due to low efficiency or misfunctions. Note that recaptures in 2022 are preliminary by 26. August.

Survey	N-Released	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	All years
Iceland 2015	806	0	0	0	6	2	3	0	0	0	0	0	11
Iceland 2016	4884	0	0	0	0	59	48	28	19	13	10	0	177
Iceland 2017	3890	0	0	0	0	0	28	27	9	13	4	5	86
Iceland 2018	1872	0	0	0	0	0	0	5	16	13	8	3	45
Iceland 2019	3614	0	0	0	0	0	0	0	5	25	12	3	45
Norway2011	31253	9	31	24	32	26	16	20	7	13	6	2	186
Ireland-Hebrides 2011	18645	27	24	29	24	17	5	9	7	3	2	0	147
Ireland-Hebrides 2012	32135	31	57	60	64	34	21	12	5	6	5	4	299
Ireland-Hebrides 2013	22792	0	26	89	104	61	30	21	10	8	5	1	355
Ireland-Hebrides 2014	55184	0	0	112	311	277	139	91	44	45	29	3	1051
Ireland-Hebrides 2015	43905	0	0	0	115	217	177	93	49	41	20	9	721
Ireland-Hebrides 2016	43956	0	0	0	0	124	324	183	121	92	48	12	904
Ireland-Hebrides 2017	56073	0	0	0	0	0	134	344	174	146	80	21	899
Ireland-Hebrides 2018	38136	0	0	0	0	0	0	204	248	229	132	37	850
Ireland-Hebrides 2019	51179	0	0	0	0	0	0	0	290	541	435	123	1389
Ireland-Hebrides 2020	48968	0	0	0	0	0	0	0	0	517	811	207	1535
Ireland-Hebrides 2021	49173	0	0	0	0	0	0	0	0	0	755	269	1024
Ireland-Hebrides 2022	50488	0	0	0	0	0	0	0	0	0	0	400	400
All surveys	556953	67	138	314	656	817	925	1037	1004	1705	2362	1099	10124
All Ireland-Hebrides	510634	58	107	290	618	730	830	957	948	1628	2322	1086	9574

Table 2. Overview of numbers of tonnes scanned for RFID tags per factory per year. Data from years used in 2022 stock assessment (2014 and onwards), based on decisions in the ICES IBPNEAMac 2019 (ICES 2019), are outlined and marked grey. Based on an evaluation of efficiency of the scanners, data from some factories are excluded as they were not functioning or having poor data quality, and these are not marked grey.

Factory	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	All years
FO01 Vardin Pelagic	0	0	10460	11565	7895	4844	0	0			34763
GB01 Denholm Coldstore	0	0	0	4377	4710	5365	7806	5191	8809	8957	45215
GB01 Denholm Factory	0	0	14939	17509	18840	17913	13609	12018	13951	6284	115064
GB02 Lunar Freezing Peterhead	0	0	22586	17830	16473	9745	9857	14300	24382	24751	139924
GB03 Lunar Freezing Fraserburgh	0	0	0	8797	14282	12684	9452	5729			50943
GB04 Pelagia Shetland	0	0	21436	41117	40200	26935	25350	15128	22573	18312	211051
GB05 Northbay Pelagic	0	0	0	0	0	0	15353	12667	15478	19377	62875
IC01 Vopnafjord	0	0	18577	18772	21716	22935	18869	18547	21191	15729	156336
IC02 Neskaupstad	0	0	0	6288	21887	19558	16757	26633	28180	32216	151519
IC03 Höfn	0	0	0	0	0	0	0	10592	13488	10087	34167
NO01 Pelagia Egersund Seafood	20930	21442	36724	14375	15905	0	48373	25404	51013	37196	271361
NO02 Skude Fryseri	7546	8250	16719	14172	8671	16760	3108	1285	17661	18611	112783
NO03 Pelagia Austevoll	6405	6134	10314	4203	2216	0	7293	3533	8351		48449
NO04 Pelagia Florø	9986	12838	17379	12592	7749	0	0	0			60544
NO05 Pelagia Måløy	13344	14632	13942	21051	15762	22405	13341	8591	21287	22724	167079
NO06 Pelagia Selje	17731	26878	39525	41209	29897	35416	28972	32047	31678	34835	318189
NO07 Pelagia Liavågen	9442	10968	22395	18144	13911	19989	12398	11888	17487	21515	158138
NO08 Brødrene Sperre	14425	15048	20182	34307	36736	18814	34280	8515	32333	28283	242924
NO09 Lofoten Viking	0	0	0	0	0	0	3380	2457	3823	17924	27584
NO10 Pelagia Træna	0	0	0	0	0	0	0	0		10509	10509
NO11 Nergård Sild	0	0	0	0	0	0	0	0	2	2524	2527
NO12 Pelagia Lødingen	0	0	0	0	0	0	0	0	950	4883	5833
NO13 Pelagia Tromsø	0	0	0	0	0	0	0	0	0	180	180
NO14 Nils Sperre	0	0	0	0	0	0	28304	26272	30265	33901	118742
NO15 Grøntvedt Pelagic	0	0	0	0	0	0	6411	0	0	6778	13190
NO16 Vikomar	0	0	0	0	0	0	12512	6480	15679	16915	51585
All factories	99808	116190	265178	286310	276850	233363	315426	247277	378582	392491	2611475

Table 3. Overview of numbers of RFID tagged mackerel recaptured per factory per year. Only recaptures from Ireland surveys (Table 1) that are used as basis stock assessment are shown. Recaptures from years used in 2022 stock assessment from 2014 and onwards, based on decisions in the ICES IBPNEAMac 2019 (ICES 2019), are outlined and marked grey. Based on an evaluation of efficiency of the scanners, data from some factories are excluded as they were not functioning or having poor data quality, and these are not marked grey. See Table 2 for biomass scanned.

Factory	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	All years
FO01 Vardin Pelagic	0	0	13	35	20	11	0	0	0	0	79
GB01 Denholm Coldstore	0	0	0	10	10	24	36	19	46	61	206
GB01 Denholm Factory	0	0	25	62	77	113	54	53	92	64	540
GB02 Lunar Freezing Peterhead	0	0	32	49	60	38	41	54	123	137	534
GB03 Lunar Freezing Fraserburgh	0	0	0	9	14	7	25	34	0	0	89
GB04 Pelagia Shetland	0	0	21	124	148	137	98	82	134	134	878
GB05 Northbay Pelagic	0	0	0	0	0	0	57	59	81	136	333
IC01 Vopnafjord	0	0	22	55	65	59	62	54	146	180	643
IC02 Neskaupstad	0	0	0	19	65	54	35	114	127	284	698
IC03 Höfn	0	0	0	0	0	0	0	44	65	117	226
NO01 Pelagia Egersund Seafood	10	22	18	7	1	0	137	80	184	184	643
NO02 Skude Fryseri	5	6	21	17	25	51	13	3	34	88	263
NO03 Pelagia Austevoll	1	1	7	4	0	0	28	17	48	0	106
NO04 Pelagia Florø	5	12	27	21	16	0	0	0	0	0	81
NO05 Pelagia Måløy	5	13	18	43	37	77	36	28	97	121	475
NO06 Pelagia Selje	15	27	37	76	59	85	87	153	172	257	968
NO07 Pelagia Liavågen	10	11	29	31	26	97	48	51	111	138	552
NO08 Brødrene Sperre	7	15	20	56	107	77	52	12	0	99	445
NO09 Lofoten Viking	0	0	0	0	0	0	10	3	5	66	84
NO10 Pelagia Træna	0	0	0	0	0	0	0	0	0	67	67
NO11 Nergård Sild Senjahopen	0	0	0	0	0	0	0	0	0	10	10
NO12 Pelagia Lødingen	0	0	0	0	0	0	0	0	1	16	17
NO14 Nils Sperre	0	0	0	0	0	0	109	68	73	80	330
NO15 Grøntvedt Pelagic	0	0	0	0	0	0	11	0	0	18	29
NO16 Vikomar	0	0	0	0	0	0	18	20	89	65	192
All factories	58	107	290	618	730	830	957	948	1628	2322	8488

Figures

Figure 1. Example of how the new monitoring systems looks like. It follows the traffic light systems, where red implies that we currently may have issues with either voltage variations or reduced efficiency of RFID tags.

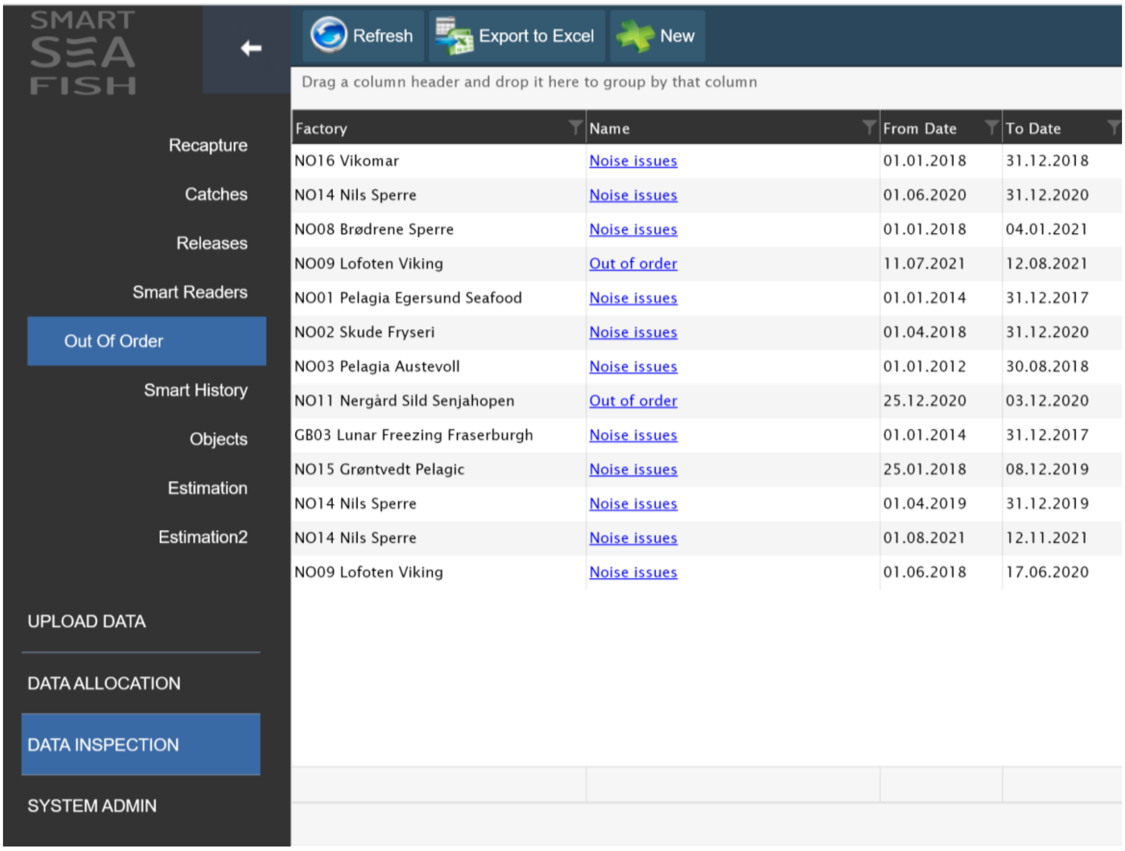


Figure 2. Example of how it looks like in the SmartSeaFish web-based software where factories having issues with recapture efficiency are put in an 'Out of order' list. Catch data and recapture data from these factories and periods are excluded in final estimation of data table being included in the ICES WGWIDE stock assessment.

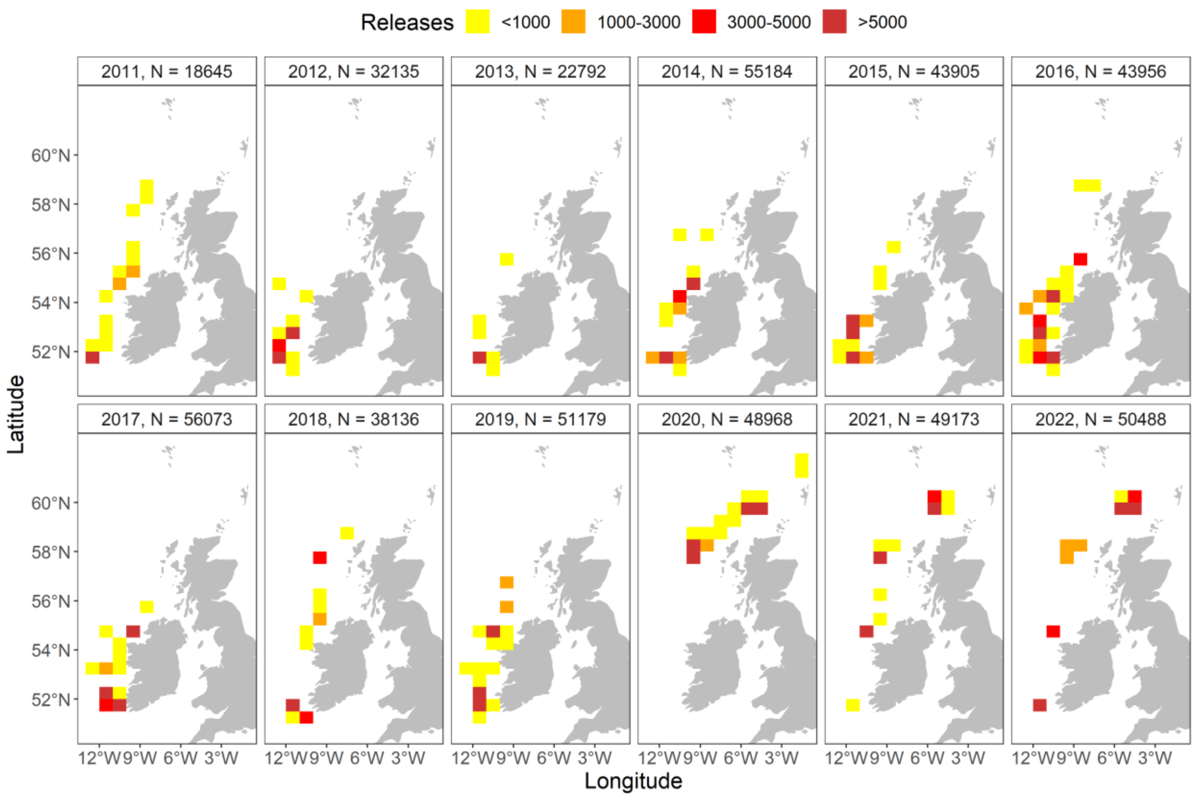


Figure 3. Distribution of RFID tagged mackerel from experiments west of Ireland-Hebrides during 2011-2022. Number of released fish is summed per ICES rectangle. See Table 1 for details on numbers released. Note that data from releases 2011-2012 are not used in the stock assessment, based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019), and data from experiments in 2021-2022 are not included as there are no full years with recaptures yet.

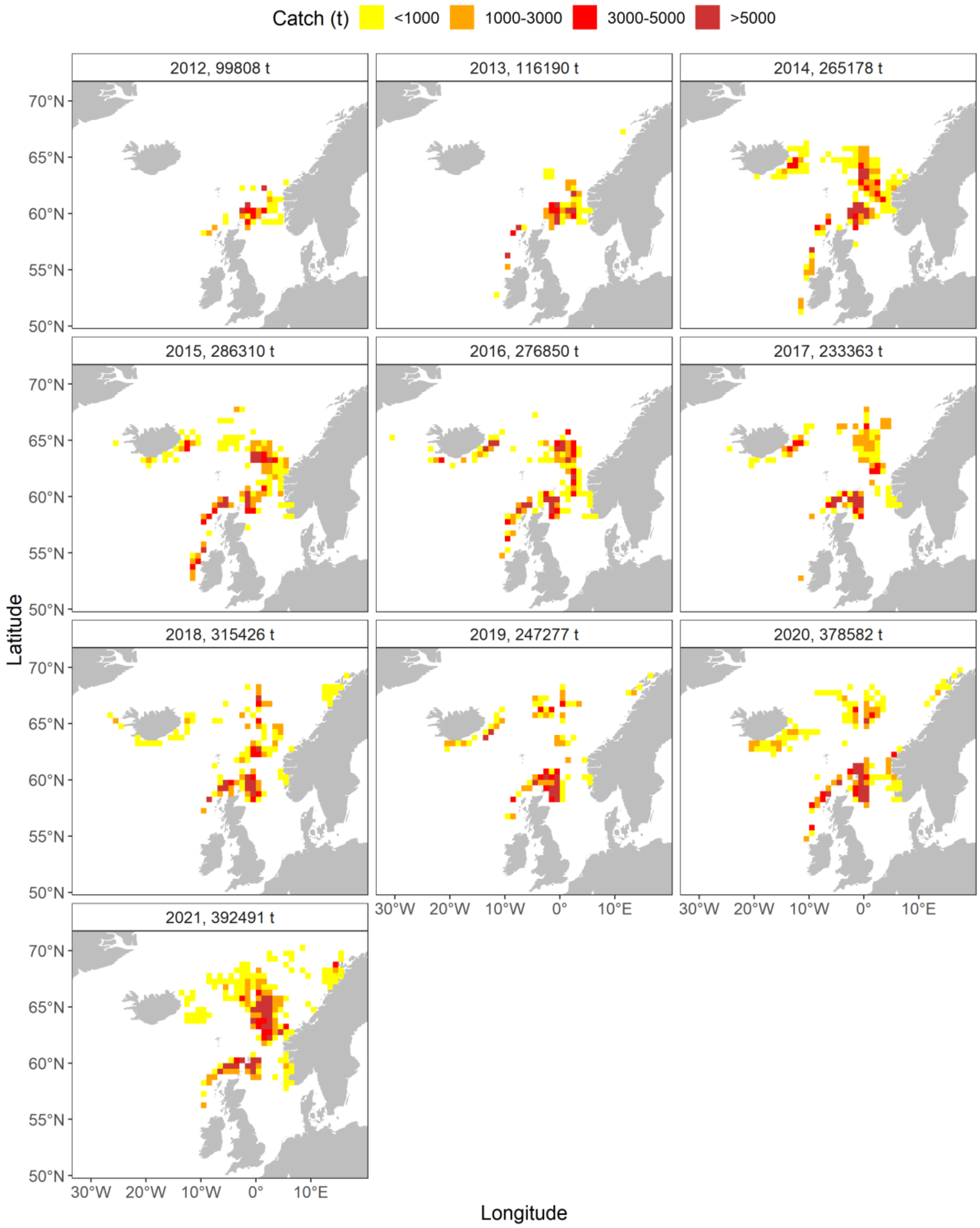


Figure 4. Distribution (summed per ICES rectangle) of catches scanned for RFID tagged mackerel during 2012-2021. Note that data on scanned catches in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Detailed data on scanned biomass per factory and year are given in Table 2.

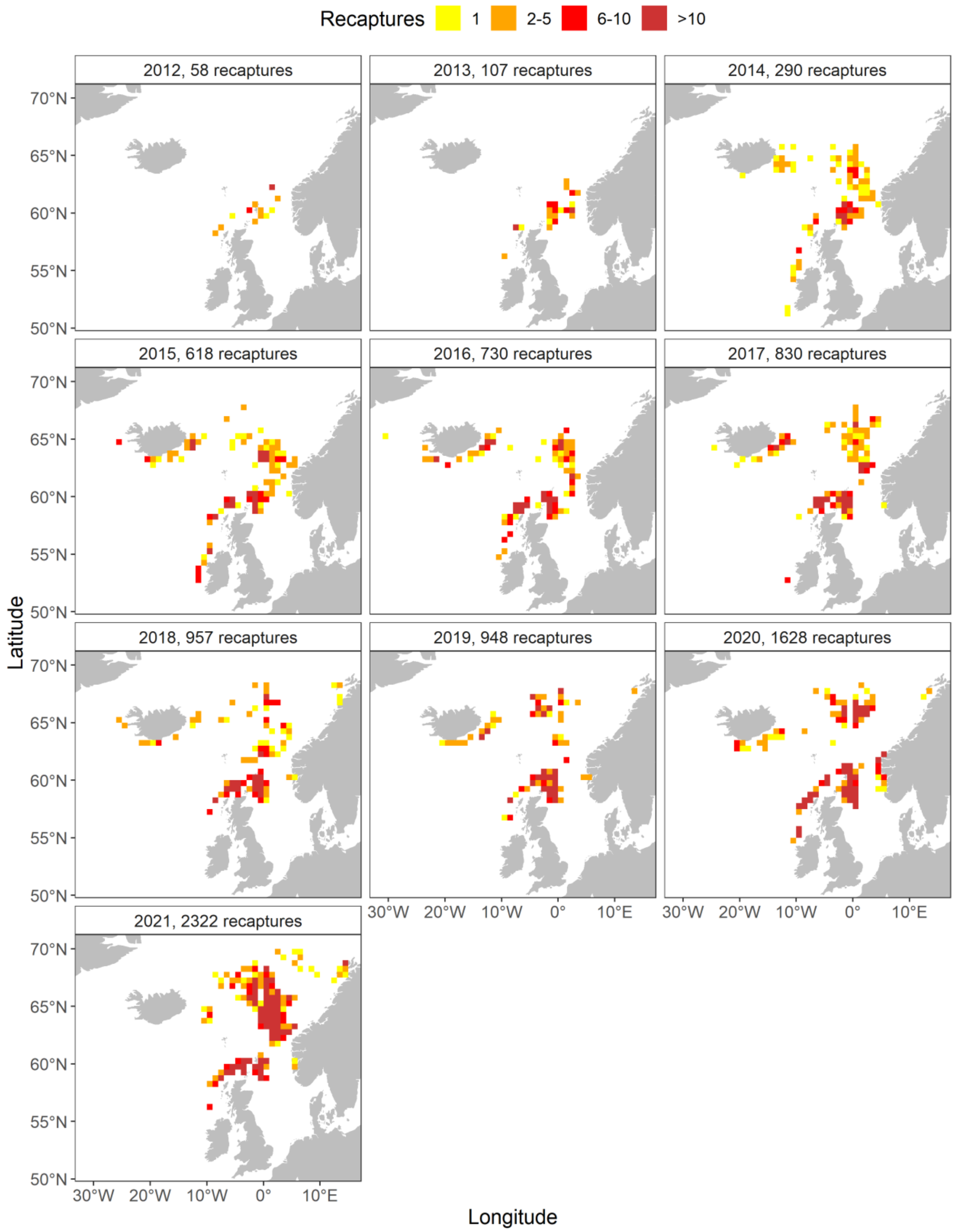


Figure 5. Distribution (summed per ICES rectangle) of recaptures of RFID tagged mackerel during 2012-2021. Note that data on recaptures in 2012-2013 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Detailed data on recaptures per factory and year are given in Table 3.

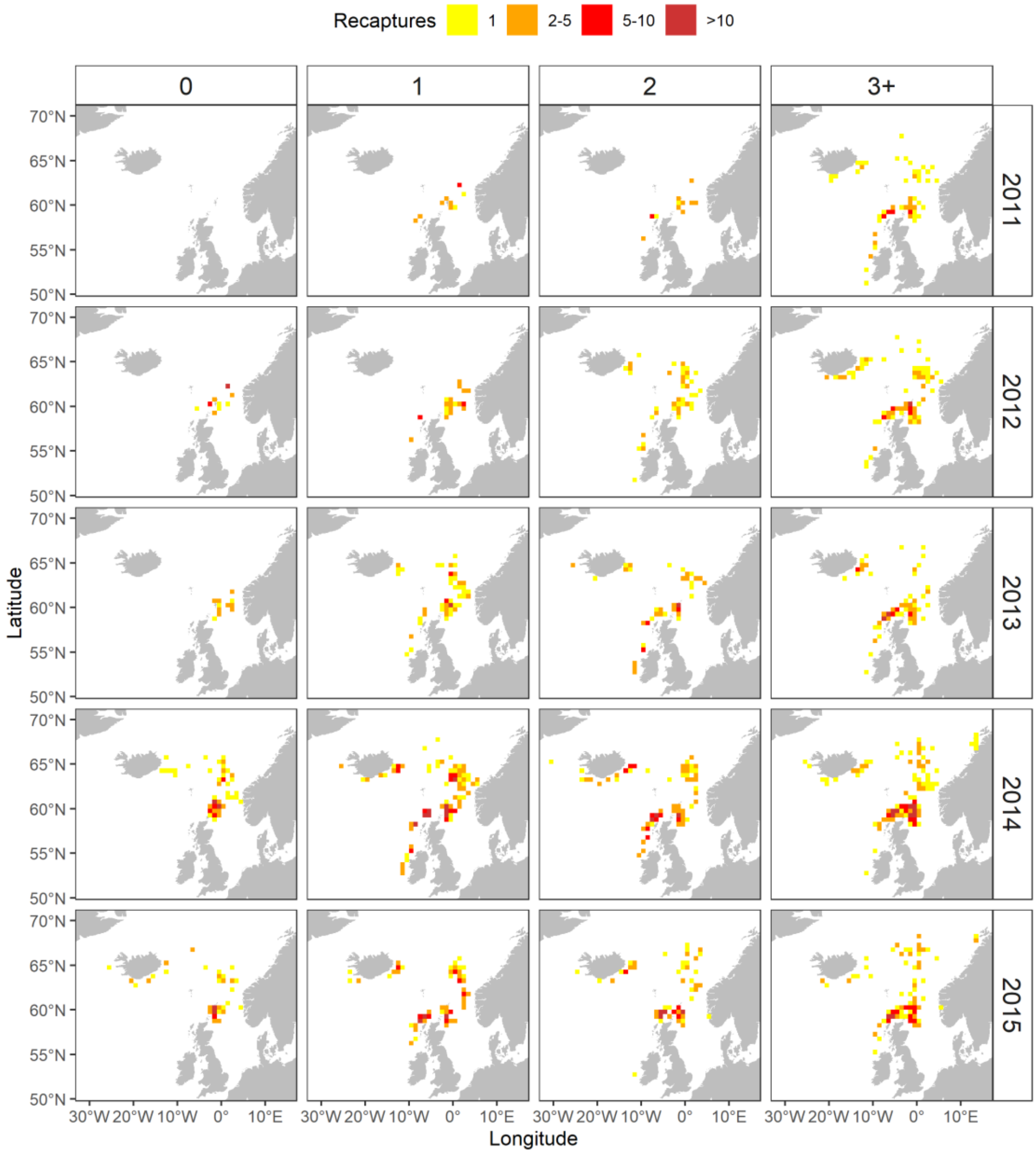


Figure 6. Distribution (summed per ICES rectangle) of recaptures of RFID tagged mackerel related to release years 2011-2015 and years after release (0=same year as tagging, 1= year after tagging etc.). Note that data on recaptures from 2011-2012 release years and from year 0 and 3+ after tagging are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Note also tha t in 2011 scanning had not started (Figure 4), so no in year recaptures.

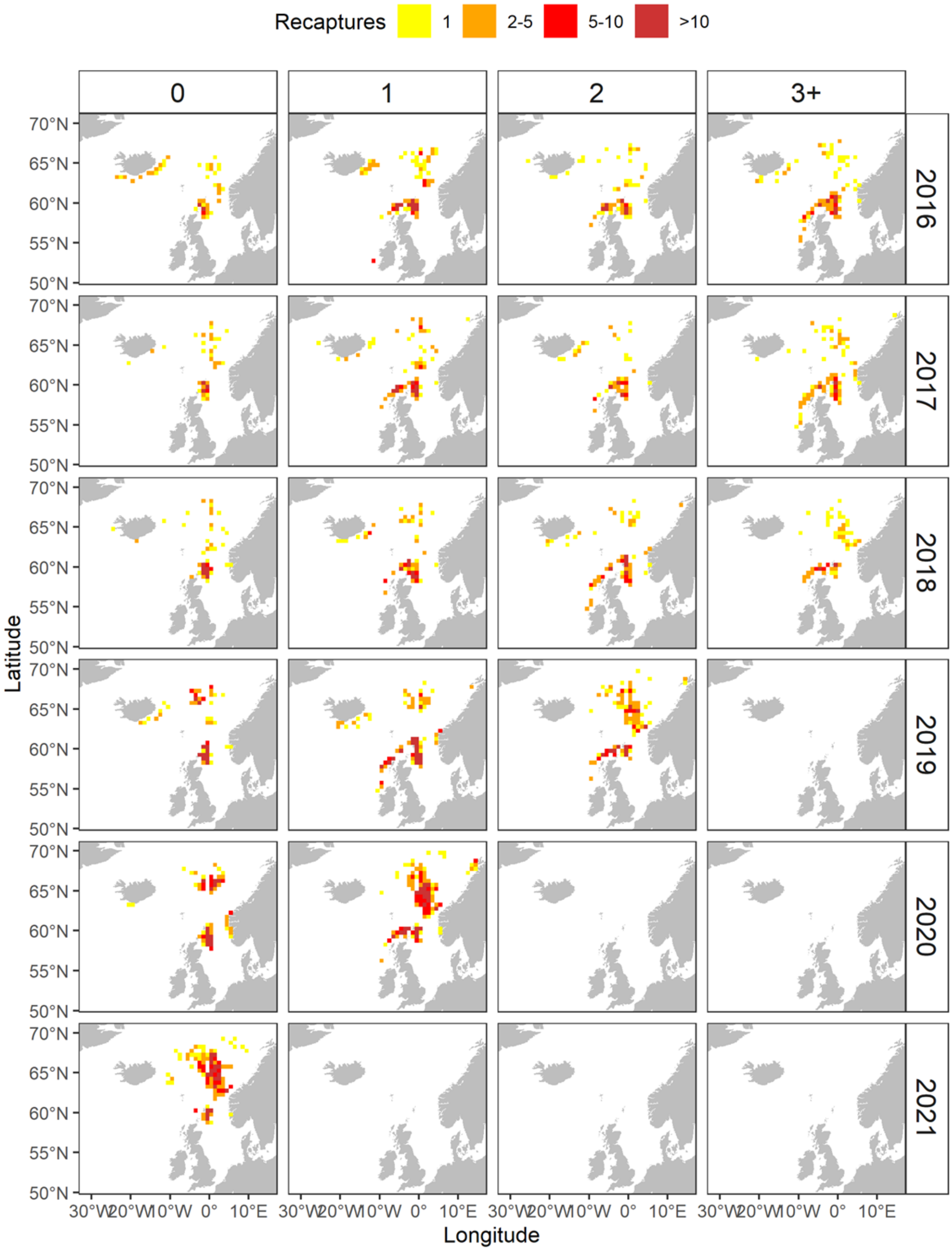


Figure 6 continued for release years 2016-2021. Preliminary recaptures in 2022 are not included as allocations to catches are not completed.

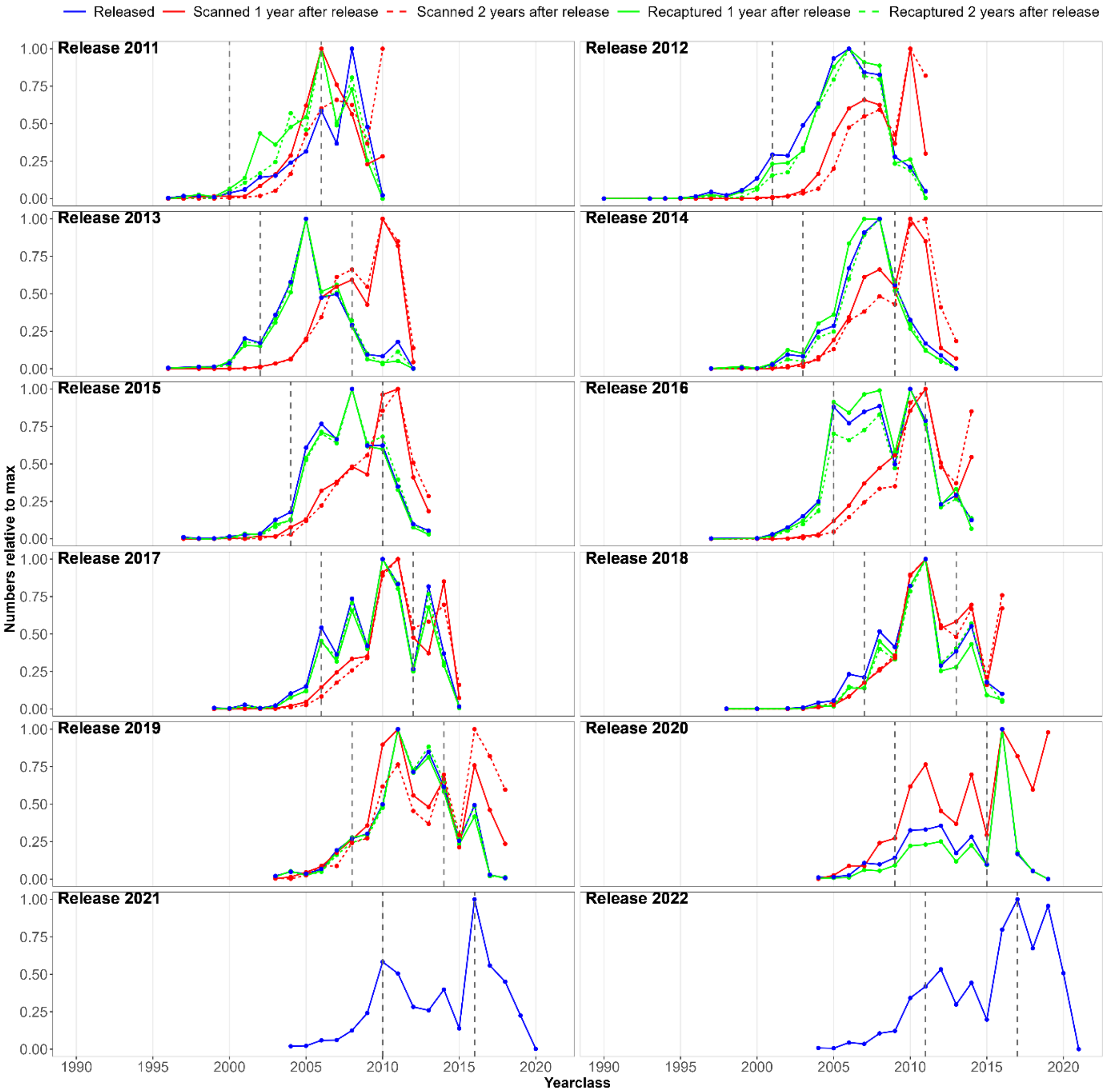


Figure 7. Overview of the relative year class distribution among RFID tagged mackerel per release year from experiments west of Ireland-Hebrides in May-June, compared with the number scanned and recaptured in year 1 and 2 after release of the same year classes. See Figure 3 for distribution of the tagged fish and the respective distribution of recaptures in year 1 and 2 after release in Figures 4-5. Note that data from releases in 2011-2012 are not used in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019). Note also that it was decided to only use ages 5-11 in updated assessments, and limits for this age span is marked (vertical grey dotted lines) for each release year. Details on actual numbers released and recaptured are given in Table 1 and 3, also for other tagging experiments not included in the stock assessment.

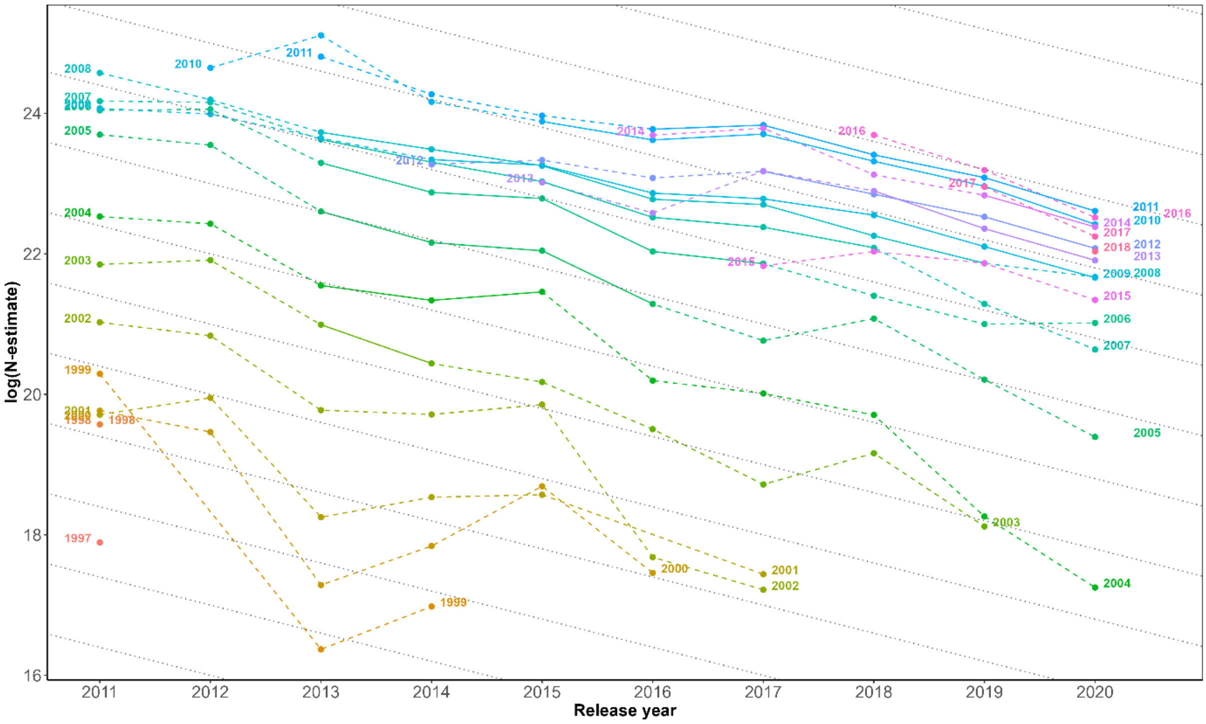


Figure 8. Trends in year class abundance (N=numbers released/numbers recaptured*numbers scanned year 1 and 2 after release) from RFID tag-recapture data based on aggregated data on recaptures and scanned numbers in year 1 and 2 after each release year. Data excluded in the stock assessment based on decisions in the ICES IBPNEAMac 2019 meeting (ICES 2019), release years 2011-2012 and ages 2-4 and 12+, are marked with dotted lines in year class trends. Note that dotted grey lines are showing a total mortality Z=0.4 for comparison with year class trends.

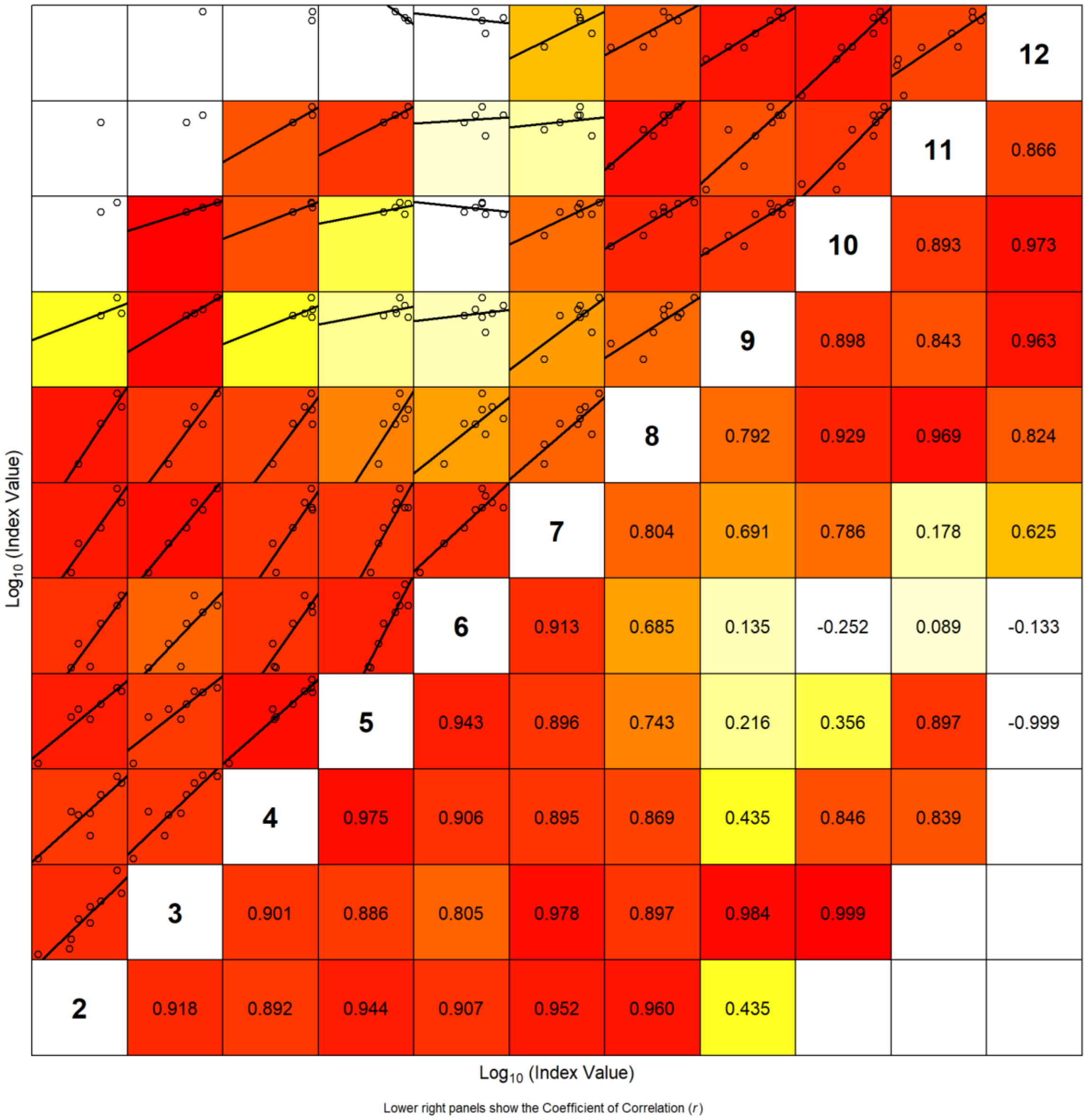


Figure 9. Internal consistency of the of mackerel RFID abundance index from release years 2011 to 2020, based on indices from Figure 8. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

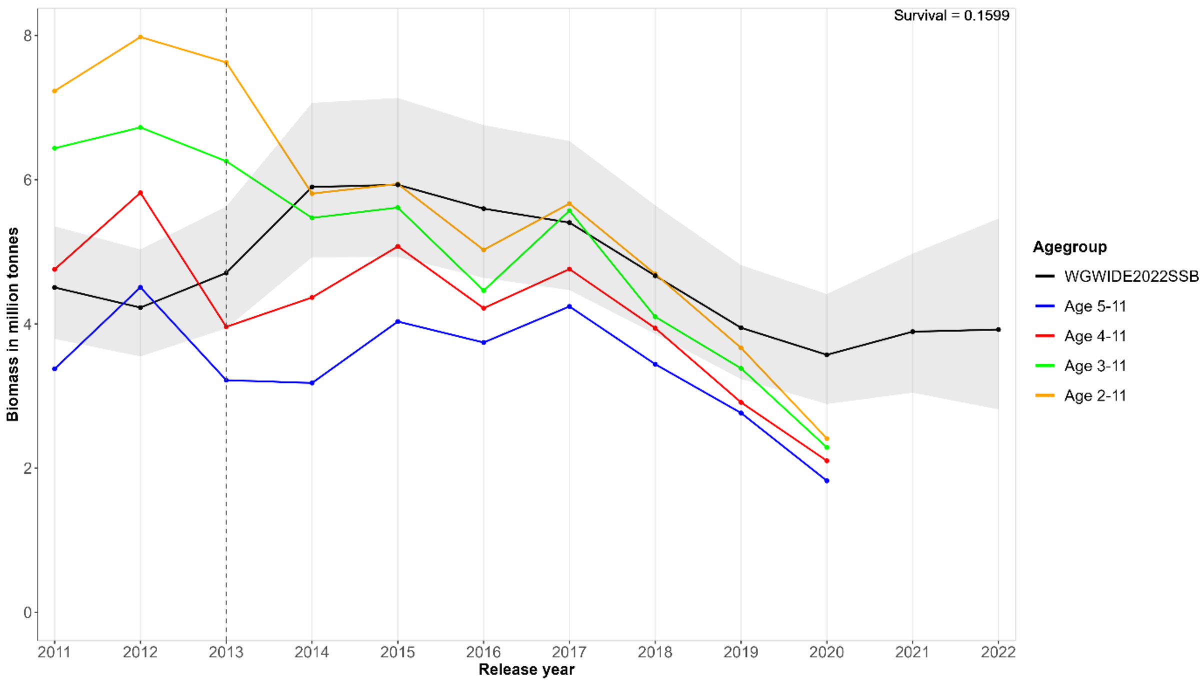


Figure 10. Trends in various age aggregated biomass indices from RFID tag-recapture data compared with the SSB (±95 confidence intervals) from the WGWIDE 2022 stock assessment. Data are based on a combination of estimated numbers by year class from Figure 8 scaled by survival parameter estimated by SAM in WGWIDE 2022 (0.1599) and weight at age in stock form same assessment. Vertical dotted line marks the starting year where RFID tagging experiments are used in the stock assessment based on decisions in the ICES IBPNEAMac 2019. meeting (ICES 2019), and the trend of ages 5-11 is representing the subset of ages used in updated assessments. Note that final year with data 2020 is only based on recapture year 1 after release, whereas the other years are based on recapture year 1-2 after release, i.e. completed. In recent years (2016-2018) the estimates have tended to increase when adding the second recapture year (See Figures 11-12).

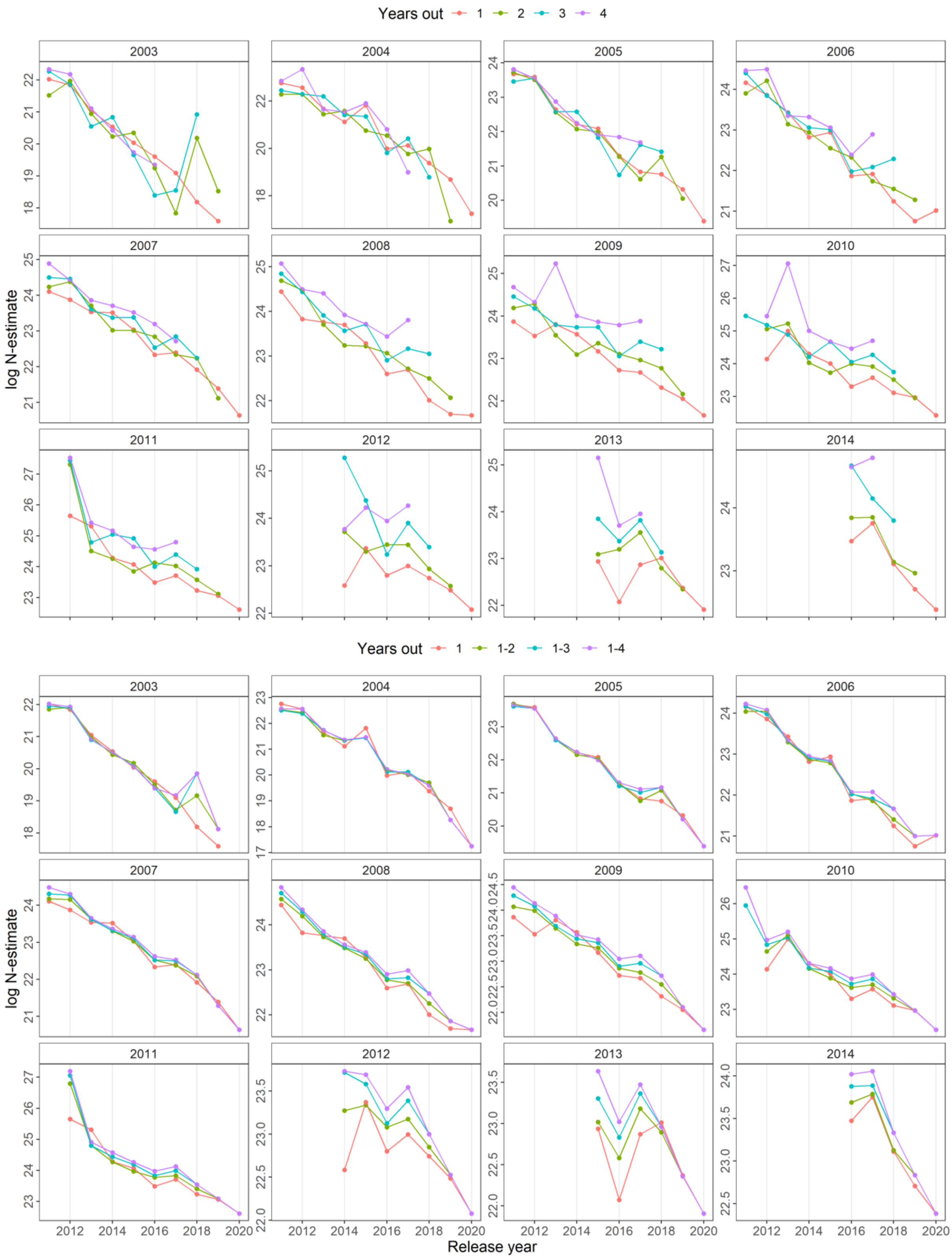


Figure 11. Trends in year class abundance (N=numbers released/numbers recaptured*numbers scanned) from RFID tag-recapture data based on different filtering of recapture year included. Upper panels show the difference between basing the estimate on either year 1, 2, 3, or 4 after release, whereas bottom panels show the difference between using year 1 after release versus various intervals of years after release. Note that data are shown for all ages (1-max 16) with data.

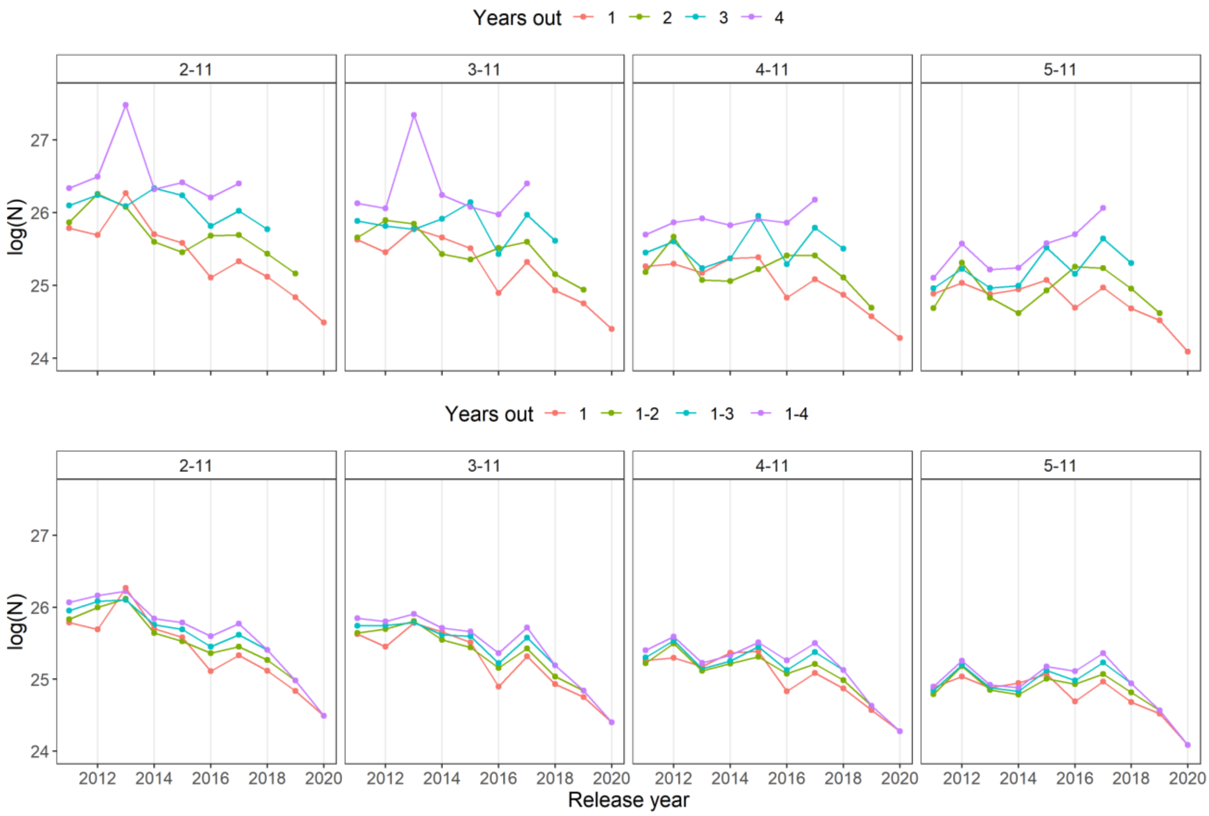


Figure 12. Trends in various age aggregated biomass indices from RFID tag-recapture data based on different filtering of recapture year included. Upper panels show the difference between basing the estimate on either year 1, 2, 3, or 4 after release, whereas bottom panels show the difference between using year 1 after release versus various intervals of years after release.

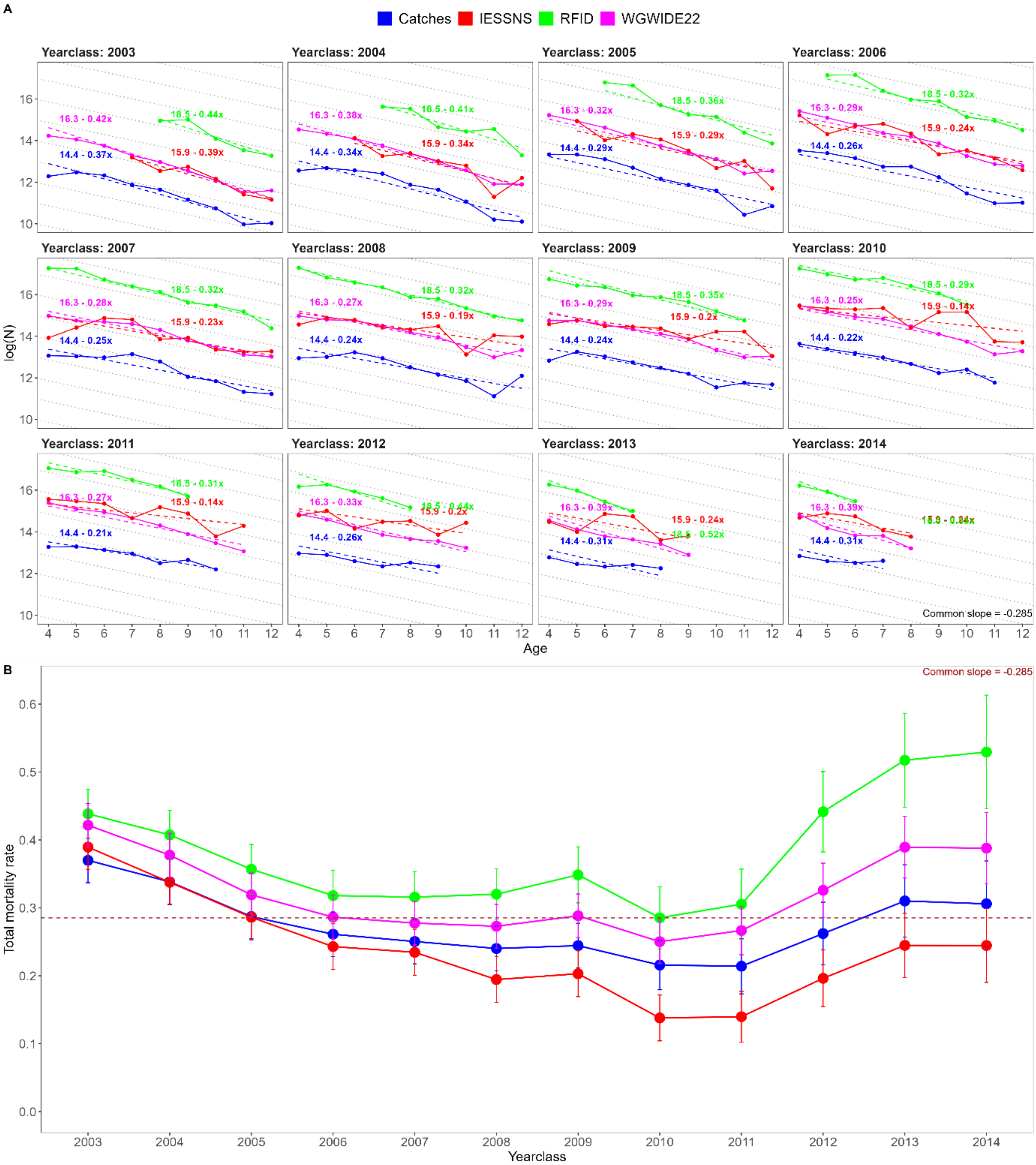


Figure 13. Signals of total mortality rate in input data to the mackerel stock assessment. (A)Upper panels show the trends in year class abundance and estimated slope of decrease from the age 4 when it is fully recruited to the spawning stock until age 12 (interpreted as signal of total mortality), of various sources of unscaled input data to the mackerel stock assessment (RFID, IESSNS and catch data) compared with the final trend estimated in the stock assessment (WGWIDE 2022). (B) Bottom panels summarize the year class differences in estimated total mortality rate (with 95% confidence intervals), and differences between the various data sources.

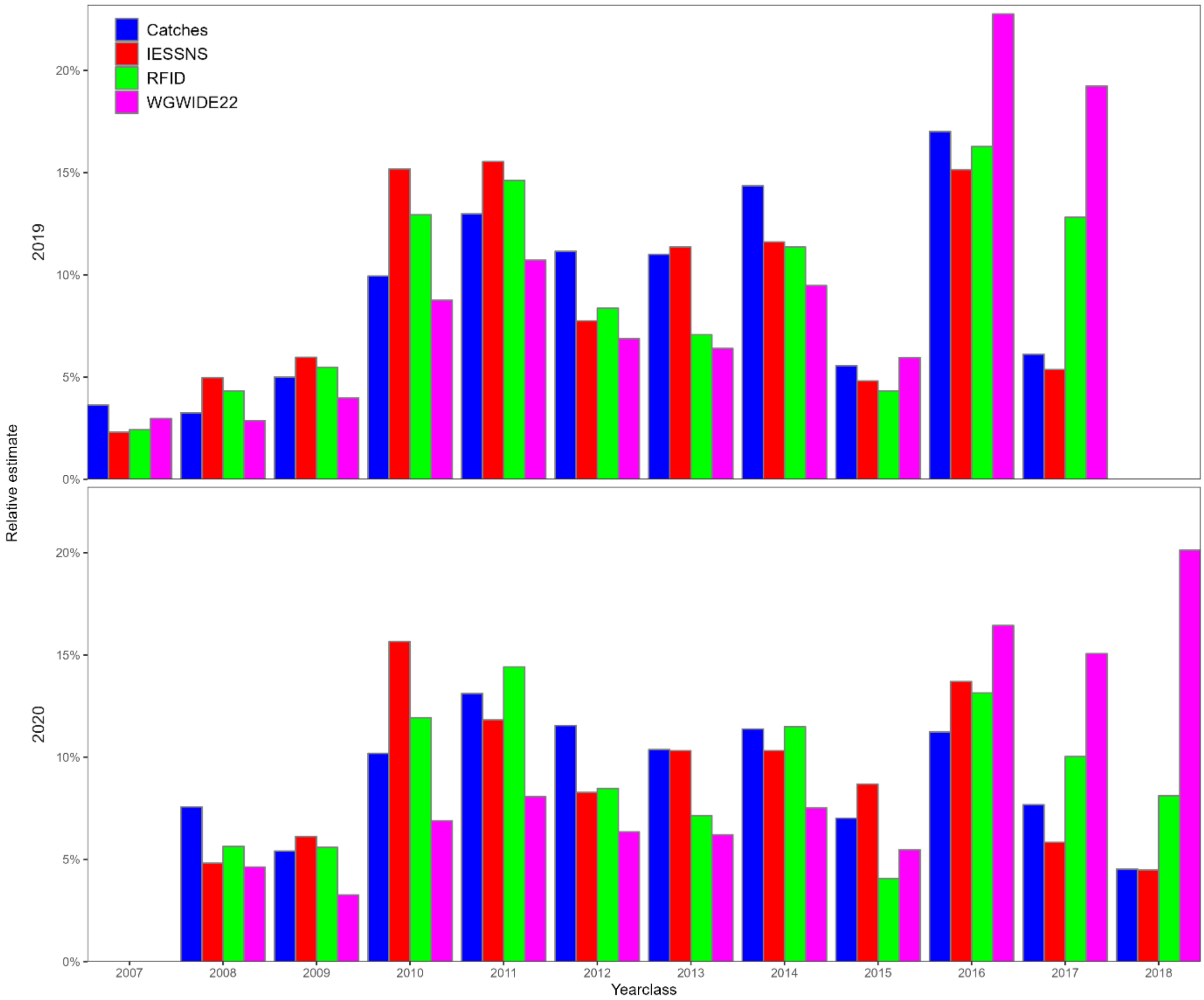


Figure 14. Comparison of relative year class contributions between RFID-tag estimates, catch data, IESSNS data and the WGWIDE2022 stock assessment it self.

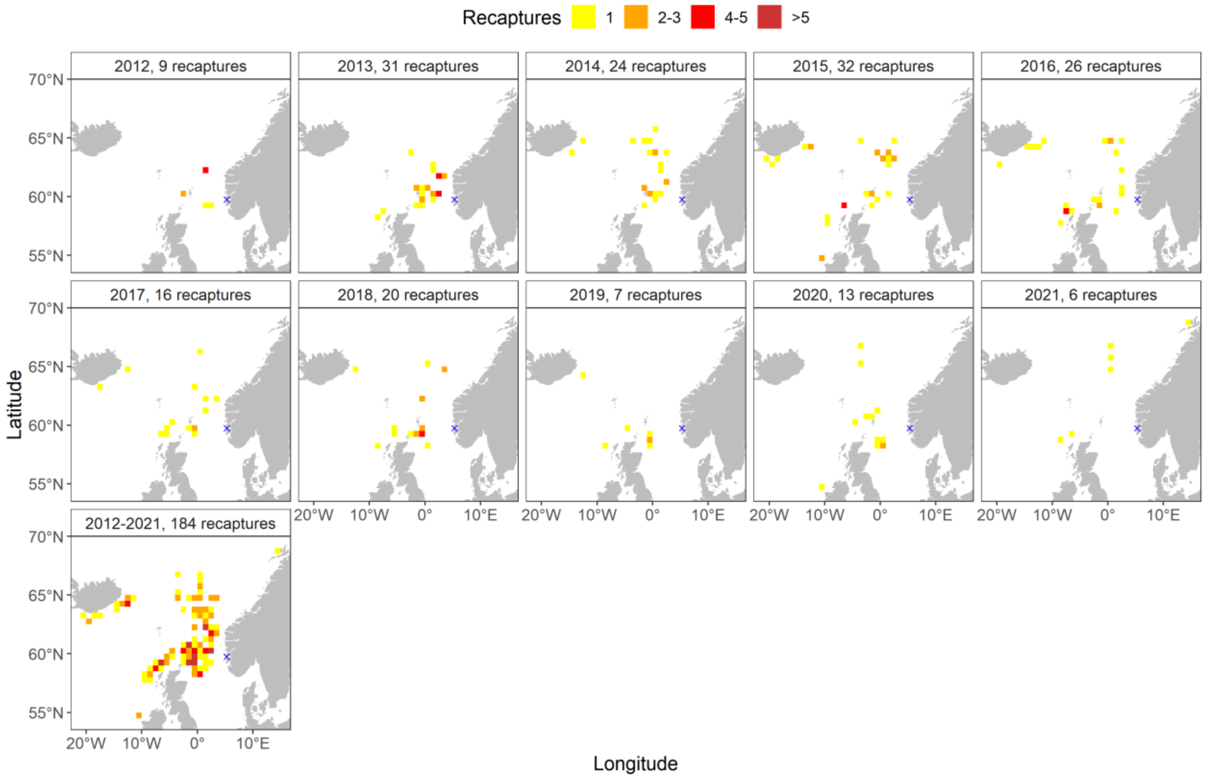


Figure 15. Distribution (summed per ICES rectangle) of recaptures 2012-2022 from an RFID tagging experiment on mackerel in the North Sea at the Norwegian West coast (blue dot) in 2011. This was mainly young mackerel tagged, where 88% were 1 year olds and 6.5% 2 year olds, using the North Sea/Norwegian coast as nursery.