Working Document to

Working Group on International Pelagic Surveys (WGIPS)
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and
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INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) in May – June 2020

Post-cruise meeting on Teams, 16-18 June 2020

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Introduction

In May-June 2020, five research vessels; R/V Dana, Denmark (joined survey by Denmark, Germany, Ireland, The Netherlands, Sweden and UK. Due to the Covid19 situation in 2020 there was only participation from Denmark in the actual cruise), R/V Magnus Heinason, Faroe Islands, R/V Árni Friðriksson, Iceland, R/V G.O. Sars, Norway and R/V Vilnyus, Russia participated in the International ecosystem survey in the Nordic Seas (IESNS). 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 biomass 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 2020 that are stored in the PGNAPES database and supported by national survey reports from each survey (Dana: Cruise Report R/V Dana Cruise 04/2020. International Ecosystem survey in the Nordic Seas (IESNS) in 2020, Magnus Heinason: IESNS Cruise Report Magnus Heinasen, Eliasen et al, FAMRI 2020, Árni Friðriksson: Óskarsson et al. 2019).

Note that the Russian vessel had not finished the survey in the Barents Sea when this report was compiled so it should be considered as a preliminary report until the results from Barents Sea have been included. The final report will then be ready by the end of August 2020.

Material and methods

Coordination of the survey was done during the WGIPS meeting in January 2020 and by correspondence. Planning of the acoustic transects and hydrographic stations and plankton stations were carried out by using the recently developed survey planner function in the r-package Rstox version 1.11 (see www.imr.no/forskning/prosjekter/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, the transects now follow great circles instead of a constant latitude as before, so 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	01/5-25/5
G.O. Sars	Institute of Marine Research, Bergen, Norway	01/5-02/6
Vilnyus	PINRO, Russia	Not confirmed
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	29/4- 11/5
Árni Friðriksson	Marine and Freshwater Research Institute, Iceland	10/5-28/5

Figure 2 shows the cruise tracks, Figure 3a the hydrographic and plankton stations and Figure 3b the pelagic trawl stations. Survey effort by each vessel is detailed in Table 1. Frequent 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 4.

In general, the weather condition did not affect the survey even if there were some days that were not favourable and prevented for example WP2 and Multinet sampling at some stations. 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	Magnus Heinason	Vilnyus
Echo sounder	Simrad EK 60	Simrad EK 80	Simrad EK80	Simrad EK60	Simrad EK60
Frequency (kHz)	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 70, 120, 200	**38**,200	**38,** 120
Primary transducer	ES38BP	ES 38B	ES38-7	ES38B	ES38B
Transducer installation	Towed body	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	5 - 7	8.5	8	3	4.5
Upper integration limit (m)	7 - 9	15	15	7	10
Absorption coeff. (dB/km)	10.1	10.1	10	10.1	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	?	2.425	2.425
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	18	21.9	21.9
2-way beam angle (dB)	-20.5	-20.7	-20.3	-20.8	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.17	26.05	26.9	25.57	25.76
s_A correction (dB)	-0.50	-0.66	-0.02	-0.68	-0.64
3 dB beam width (dg)					
alongship:	6.96	6.48	6.53	7.17	7.09
athw. ship:	6.98	6.22	6.5	7.06	7.01
Maximum range (m)	500	500	500	500	500
Post processing software	LSSS	LSSS	LSSS	LSSS	LSSS

All participants used the same post-processing software (LSSS) and 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. All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls are as follows:

	Dana	G.O. Sars	Arni Friðriksson	Magnus Heinason	Vilnyus
Circumference (m)		**496**	**832**	**640**	**500**
Vertical opening (m)	**25-35**	**25-30**	**20–35**	**45–55**	**50**
Mesh size in codend (mm)	**16**	**24**	**20**	**40**	**16**
Typical towing speed (kn)	**3.5-4.0**	**3.0–4.5**	**3.1–5.0**	**3.0–3.5**	**3.3–4.5**

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. Salient biological sampling protocols for trawl catches are listed in the table below.

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

* Only weighed, not sexed or determination of maturity.

** Will be included in the final report

Acoustic 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 here: www.imr.no/forskning/prosjekter/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 6 strata with pre-defined acoustic transects as agreed during the WGIPS in January 2019. 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 1. 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

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 3a. Most vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m. Zooplankton was sampled by a WPII on all vessels except the Russian vessel which used a Djedi net, 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 g total dry weight per m^2. For the zooplankton distribution map, all stations are presented. For the time series, stations in the Norwegian Sea delimited to east of 14°W and west of 20°E have been included. The zooplankton data were interpolated using objective analysis utilizing a Gaussian correlation function to obtain a time-series for four different areas. The results are given as inter-annual indexes of zooplankton abundance in May. This method was introduced at WGINOR in 2015 (ICES, 2016) and the results match the former used average index. It has been noted that the Djedy net applied by the Russian vessel in the Barents Sea seems to be less effective in catching zooplankton in comparison to WP2 net applied by other vessels in an overlapping area. Thus, the biomass estimates for the Barents Sea are not directly comparable to the other areas, but are comparable among years within the Barents Sea. The Russian data are not included in the 2020 report.

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 5-7. The temperatures in the surface layer (0-50 m) ranged from below 0°C in the Greenland Sea to 9°C in the southern part of the Norwegian Sea (Figure 5). The Arctic front was encountered below 65°N east of Iceland extending eastwards towards about 2° West where it turned northeastwards to 65°N and then almost straight northwards. This front was well-defined at 200-500 m depth while shallower it was unclear. Further to west at about 8° West 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 >6 °C to the Bear Island at 74,5° N in the surface layer.

Relative to a 25 years long-term mean, from 1995 to 2019, the temperatures at 0-50 m were 0-1 °C below the mean for almost the whole Norwegian Sea (Figure 5). Warmest region is in the eastern Greenland Sea with temperatures 2 °C higher than the mean. This warming can be observed at all depths. At 50-200 m the temperatures were also, in most regions, 0-1 °C lower than the long-term mean. An exception is for the southwestern Norwegian Sea, west of the 0 meridian, where the temperatures were about 0-0,5 °C higher than the mean (Figure 6). At 200-500 m depth, the pattern is more fragmented but in the southwestern region the temperatures were near the long-term mean while in more eastern areas the temperatures were in general lower than the mean (Figure 7).

The temperature, salinity and potential density in the upper 800 m at the Svinøy section in 26-28 April 2020 are shown in Figure 8. Atlantic water is lying over the colder and fresher intermediate layer and reach down to 500 m at the shelf edge and shallower westward. The warmest water, above 8 °C, is located near the shelf edge where the core of the inflowing Atlantic Water is located. Westward, temperature and salinity are reduced due to mixing with colder and less saline water. Compared to a 30 years long-term mean, from 1978 to 2007, the temperatures in 2020 were higher than the mean at the shelf edge but westward the temperatures were both lower and higher than the mean due to meandering or eddies. The salinity was however lower than the long-term mean for the whole section above 400 m with the exception in coastal water.

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 only in the last three decades that a similar layer has been observed all over the Norwegian Sea.

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

Zooplankton

The zooplankton biomass (g dry weight m^{-2}) in the upper 200 m is shown in Figure 9. Sampling stations were evenly spread over the area, covering Atlantic water, Arctic water, and the Arctic frontal zone. The highest zooplankton biomasses were not concentrated in a specific area but spread over several locations in the northern part of the sampling area. High biomasses were found in northwestern parts of the central Norwegian Sea, northeast of Iceland and Jan Mayen, and in an area around Lofoten/Vesterålen and north of that area. Lower biomasses were found in the entire southern part of the sampling area, especially in southwest.

Figure 10 shows the zooplankton index given for the sampling area (delimited to east of 14°W and west of 20°E). To examine regional difference in the biomass, the total area where divided into 4 subareas 1) Southern Norwegian Sea including the Norwegian Sea Basin, 2) The Northern Norwegian Sea including the Lofoten Basin, 3) Jan Mayen Arctic front, and 4) East of Iceland. The mean index of subarea 1 and 2 is also given. The zooplankton biomass index for the Norwegian Sea and nearby areas in 2020 was 8.3 g dry weight m^{-2}, which is a decrease from last year. A similar decrease was observed in all sub-areas, except from East of Iceland where an increase was observed.

The zooplankton biomass index for the Norwegian Sea in May has been estimated since 1995. For the period 1995-2002 the plankton index was relatively high (mean 11.5 g) even if varying between years. From 2003-2006, the index decreased continuously and has been at lower levels since then, with a mean of 7.9 g for the period 2003-2020. An increase can be noted in the last part of the low-biomass period. This general pattern applies more or less to all the different sub-areas within the Norwegian Sea. The zooplankton biomass at the Jan Mayen Arctic front was high until 2007 but has since then been at the same level as the Norwegian Sea. The zooplankton biomass East of Iceland was in general higher compared with the other sub-areas until 2015.

The reason for this fluctuation in the zooplankton biomass is not obvious to us. The unusually 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 are 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. Timing effects, as match/mismatch with the phytoplankton bloom, can also affect the zooplankton abundance. It is also worth noting that the period with lower zooplankton biomass coincides with lower-than-average heat contents in the Norwegian Sea (ICES 2018) and reduced inflow of Arctic water into the southwestern Norwegian Sea (Kristiansen et al., 2019). More ecological and environmental research to reveal inter-annual variations and long-term trends in zooplankton abundance are recommended.

Norwegian spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2020. The zero-line was believed to be reached for adult NSS herring in most of the areas. On some of the transects in stratum 2 and 4, however, aggregations of herring were recorded on the easternmost part indicating that the zero-line was not fully reached on those transect although some of the transect were extended. It is, however, recommended that the results from IESNS 2020 can be used for assessment purpose. The herring was primarily distributed in the south-western area where the 2013-year-class dominated, and in the eastern area where the 2016 year-class dominated (Figure 11). 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 12). The distribution of the recruiting 2016 year-class in the eastern part of the Norwegian Sea extends all the way from 70°N south to 64°N. This is different from earlier year-classes recruiting to the Norwegian Sea, which usually do not extend farther south than 69°N.

Four years old herring (year class 2016) dominated both in terms of number (57%) and biomass (41 %) on basis of the StoX baseline estimates for the Norwegian Sea (Tables 2-4). Its number at age 4 is higher than for the 2004 year class at same age (Figure 13), which puts the size of the 2016 year class into perspective. The large 2004 year class, which has dominated the stock together with the 2002 year class, has contributed significantly to the biomass of older age-groups (see paragraph on issues with age determination below). Herring aged 12-18 years old thus comprised 11% of the numbers and 19% of the biomass. Uncertainty estimates for number at age based on bootstrapping within StoX are shown in Figure 14 and Table 5. The relative standard error (CV) of the total biomass estimate is 15 % and 12 % for the total numbers estimate, and the relative standard error for the dominating age groups is around 30 % (Figure 14 and Table 5).

The total estimate of herring in the Norwegian Sea from the 2020 survey was 22.8 billion in number and the biomass was 4.25 million tonnes. The biomass estimate is 0.62 million tonnes (13 %) lower than the 2019 survey estimate while the estimated number is 15 % higher in 2020. 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 15), with the lowest abundance occurring in 2017. Although there is only little change in total abundance and biomass, there is a gradual shift in age and size composition with the 2016 year class becoming more dominant than the older year classes.

In the last 5 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 period, where scales and otoliths for the same fish have been sampled. On basis of that work, a workshop was planned in the spring 2018 to discuss the results. This workshop was postponed indeterminately. 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 could not been done fully since restrictions on the cruise tracks due to COVID-19 prevented the Norwegian vessel to enter stratum 1 and 3. However, in stratum 2 and 4 there was overlap between the Norwegian vessel and the Danish vessel and the age distributions from those strata seems to be relatively similar between the two vessels (Figure 20).

In the IESNS survey in 2020 some differences regarding the acoustic scrutinizing between neighbouring vessels were observed and discussed. The data where re-scruitinized, and there was a better agreement between the vessel. Still, the difference between the original and the re-scrutinization where small, indicating that the difference where not caused by an scrutinization error. There is a need to further discuss the scrutinizing process before next year's survey. The survey group suggest to have a meeting before next year's survey to discuss the protocol for acoustic scrutinizing in the IESNS survey.

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.

In the IESNS 2020 survey, all herring in the Stratum 1 was allocated to NSSH, although the southernmost transect east of the Faroes (Figure 11) contained mainly autumn-spawning type herring, probably local Faroese autumn-spawners or North Sea type autumn-spawners. 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

The spatial distribution of blue whiting in 2020 was similar to the years before, with the highest abundance estimates in the southern and eastern part of the Norwegian Sea, along the Norwegian continental slope. The main concentrations were observed in connections with the continental slopes of Norway and along the Scotland – Iceland ridge (Figure 16). Blue whiting was distributed similar as last year. The largest fish were found in the western and middle part of the survey area (Figure 17). It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

The total biomass index of blue whiting registered during the IESNS survey in 2020 was 0.39 million tonnes, which is a 26 % decrease from the biomass estimate in 2019 (0.53). The abundance index for 2020 was 4.9 billion, which is 21 % lower than in 2019. Age 1 is dominating the acoustic estimate (32.5 % of the biomass and 57% by number). Uncertainty estimates for numbers at age based on bootstrapping with StoX are shown in Figure 18 and Table 6. The relative standard error (CV) of total biomass estimate is 16 % and 17 % for total numbers (Table 6).

In this year's IESNS survey, one-year old blue whiting was at similar level as the estimate of one-year olds in 2019 and more numerous as compared to IESNS 2017 and 2018. The survey group compared age and length distributions by vessel and strata (Figure 20 and 21) and no clear differences were found compared to earlier years.

This year the blue whiting estimate was based on only three of the four vessels. Staffing constraints on Dana due to the Covid-19 situation meant that the survey data was scrutinised after the survey ended rather than during the cruise. This resulted in some discrepancy in the procedure used for scrutinization of blue whiting from Dana. Visual observation of significant inconsistencies between the neighbouring transects of Dana and G. O. Sars lead the survey group to decide to omit the acoustic data from Dana this year. This resulted in a higher total estimate of blue whiting (~21%) but also higher uncertainty. The biological information from Dana was still used.

Mackerel

Trawl catches of mackerel are shown in Figure 22 Mackerel was present in the southern and eastern part of the Norwegian Sea (up to 69°N) in the beginning of May. No further quantitative information can be drawn from these data as this survey is not designed to monitor mackerel.

General recommendations and comments

Recommendation	Adressed to
1. Continue the methodological research in distinguishing between Herring and blue whiting in the interpretation of echograms.	WGIPS
2. It is recommended that a workshop based on the ongoing otolith and scale exchange will take place before next year's IESNS survey.	WGBIOP, WGWIDE
3. It is recommended that the WGIPS meeting in 2021 includes a workshop on how to deal with stock components of herring in the IESNS-survey.	WGIPS
4. It is recommended that the WGIPS meeting in 2021 discusses the possible implementation of sonar observations in IESNS and other acoustic surveys.	WGIPS

Next year's post-cruise meeting

We will aim for next meeting in 15-17 June 2021. The final decision will be made at the next WGIPS meeting.

Concluding remarks

- The sea temperature in 2020 at 0-200 m depth was generally below the long-term mean (1995-2019) in the Norwegian Sea.
- The 2020 index of meso-zooplankton biomass in the Norwegian Sea and adjoining waters decreased a bit from last year.
- The total biomass estimate of NSSH in herring in the Norwegian Sea was 4.25 million tonnes, which is a 13 % decrease from the 2019 survey estimate. The estimate of total number of NSSH was 22.8 billion, which is a 15 % higher than in the 2019 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 (57%) and biomass (41%), and it is on the same level as the strong 2004 year class at the same age (in the 2008 survey).
- The biomass of blue whiting measured in the 2020 survey decreased by 26 % from last year's survey and 21 % in terms of numbers. Age 1 (2019 year class) is the dominating year class (32.5 % of the biomass and 57% by number)

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in May - June 2020.

Data for Vilnyus will be updated for final report in August 2020.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Ctd stations	Aged fish (HER)	Length fish (HER)	Plankton stations
Dana	01/05-25/05	1893	25	29	468	1866	34
Magnus Heinason	29/4-11/5	1319	15	22	394	775	22
Árni Fridriksson	12/5-26/5	3188	14	34	830	2758	30
G.O.Sars	01/5-02/6	3632	73	66	659	2065	60
Vilnyus							
Total		**10032**	**127**	**151**	**2351**	**7464**	**146**

Table 2. IESNS 2020 in the Norwegian Sea. Baseline estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring.

	age																				
LenGrp	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
14-15	15775	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15775	276.1	17.50
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2379	2379	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8387	8387	385.8	46.00
20-21	20596	46719	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	67315	3942.2	58.56
21-22	-	42542	23662	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	66204	4583.0	69.23
22-23	-	124419	109173	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	233593	18657.3	79.87
23-24	-	63233	286786	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	350019	31906.0	91.16
24-25	-	63676	1122561	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1186237	118331.1	99.75
25-26	-	26921	2767160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2794080	313130.6	112.07
26-27	-	24267	2575099	7327	-	30359	-	-	-	-	-	-	-	-	-	-	-	-	2637052	323632.1	122.72
27-28	-	96829	1389284	-	3530	24990	14119	-	-	3586	-	-	-	-	-	-	-	-	1532337	213322.6	139.21
28-29	-	5884	1927200	78548	47422	153158	41188	-	-	-	-	-	-	-	-	-	-	-	2253401	357169.5	158.50
29-30	-	-	1929251	84784	114419	415279	144971	45132	13717	-	9145	-	-	-	-	-	-	-	2756696	484901.5	175.90
30-31	-	-	731038	211152	282243	388372	287591	71245	39794	9036	8689	-	-	-	-	-	-	-	2029160	402964.2	198.59
31-32	-	-	89081	163380	260560	238699	50907	90121	78299	101878	27584	11822	-	-	-	-	-	-	1112330	248182.8	223.12
32-33	-	-	11658	22823	165992	404084	14312	30234	42153	49547	-	-	-	-	-	-	-	-	740803	179908.2	242.86
33-34	-	-	18429	2096	63689	517652	52388	40442	19271	2096	12573	-	-	-	-	-	-	-	728636	184875.2	253.73
34-35	-	-	9607	11823	64531	293609	125357	92216	28374	33103	7094	7094	4729	2365	9458	-	-	-	689359	193224.9	280.30
35-36	-	-	-	-	32093	81692	70022	164132	113785	163384	64187	140044	72939	35011	11670	-	-	-	948959	293187.8	308.96
36-37	-	-	-	-	-	25001	25001	44233	58296	211548	92913	180777	278740	115390	38463	17308	-	-	1087672	351837.7	323.48
37-38	-	-	-	-	-	-	2778	25002	27780	104176	57361	141679	255578	230576	137512	25002	-	-	1007445	340918.5	338.40
38-39	-	-	-	-	-	-	-	-	14787	11375	6825	44362	85311	109198	101236	32987	11375	-	417455	148142.6	354.87
39-40	-	-	-	-	-	-	-	-	-	-	-	19266	23799	-	36266	20400	5667	-	105398	39859.4	378.18
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10205	10205	-	-
41-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1136	1136	-	-
TSN(1000)	36371	494488	12989989	581932	1034479	2572896	828633	602757	436258	689729	286370	545043	721097	492539	334605	95697	17041	22107	22782032	-	-
TSB(1000 kg)	1471.2	47893.6	1755258.9	112070.0	232978.9	593613.9	192408.4	159723.7	119478.0	210165.6	90037.0	177472.5	238730.4	165718.0	116523.5	33343.8	6065.9	385.8	-	4253339.0	-
Mean length (cm)	17.81	23.76	26.86	30.19	31.15	31.50	31.37	33.21	33.68	34.82	35.10	36.18	36.60	36.83	37.25	37.59	38.33	29.75	-	-	-
Mean weight (g)	40.45	96.85	135.12	192.58	225.21	230.72	232.20	264.99	273.87	304.71	314.41	325.61	331.07	336.46	348.24	348.43	355.95	46.00	-	-	186.81

Table 4. IESNS 2020 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of blue whiting.

LenGrp	age 1	2	3	4	5	6	7	8	10	Number (1E3)	Biomass (1E3kg)	Mean W (g)
16-17	3175	-	-	-	-	-	-	-	-	3175	69.8	22.00
17-18	56465	-	-	-	-	-	-	-	-	56465	1442.4	25.54
18-19	260128	-	-	-	-	-	-	-	-	260128	7978.6	30.67
19-20	895640	-	-	-	-	-	-	-	-	895640	33357.1	37.24
20-21	708352	39471	-	-	-	-	-	-	-	747823	33457.2	44.74
21-22	510440	49345	26468	-	-	-	-	-	-	586253	31207.9	53.23
22-23	267390	91340	18972	-	-	-	-	-	-	377703	23374.3	61.89
23-24	95144	105467	56782	-	-	-	-	-	-	257393	18312.6	71.15
24-25	24788	82626	122028	-	-	-	-	-	-	229442	19304.4	84.14
25-26	-	47957	171008	17439	10899	-	-	-	-	247304	23504.4	95.04
26-27	-	57515	154081	22617	19547	-	-	-	-	253760	26919.0	106.08
27-28	-	6822	31835	6822	9096	2656	11629	-	-	68860	8684.8	126.12
28-29	-	-	51237	24091	44665	79472	10325	9822	-	219613	32134.2	146.32
29-30	-	-	17933	73231	103619	39343	19603	-	-	253729	42296.7	166.70
30-31	-	-	30704	98407	120707	50174	27940	10235	-	338168	59325.9	175.43
31-32	-	-	-	13533	26074	45444	20141	-	-	105191	20992.3	199.56
32-33	-	-	-	-	17544	9029	2567	4695	-	33836	7113.2	210.23
33-34	-	-	-	-	-	2109	-	-	-	2109	493.6	234.00
34-35	-	-	-	-	-	-	-	-	-	-	-	-
36-37	-	-	-	-	-	-	-	-	382	382	113.9	298.20
TSN(1000)	2821522	480543	681050	256141	352152	228228	92204	24752	382	4936973	-	-
TSB(1000 kg)	126992.5	36024.1	68641.8	40862.5	57978.5	39223.4	16101.6	4143.9	113.9	-	390082.3	-
Mean length (cm)	20.09	23.27	25.44	28.95	29.36	29.55	29.59	29.63	36.00	-	-	-
Mean weight (g)	45.01	74.97	100.79	159.53	164.64	171.86	174.63	167.42	298.20	-	-	79.01

Table 5. IESNS 2020. Bootstrap estimates from StoX (based on 1000 replicates) of Norwegian spring-spawning herring. Numbers by age and total number (TSN) are in millions and total biomass (TSB) in thousand tons.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
2	9.0	40.0	85.4	42.7	24.0	0.563
3	245.8	466.7	714.2	471.9	144.8	0.307
4	10156.8	13067.0	16037.7	13064.5	1826.4	0.140
5	216.9	512.5	808.0	512.7	175.7	0.343
6	528.3	977.8	1585.3	1009.2	317.5	0.315
7	1543.8	2446.6	3602.0	2492.2	633.2	0.254
8	404.4	758.2	1262.3	786.4	263.5	0.335
9	340.3	615.7	965.8	629.4	196.7	0.313
10	219.4	418.0	684.5	433.8	144.0	0.332
11	357.6	678.3	1071.4	694.2	223.6	0.322
12	152.4	311.2	528.3	323.8	113.2	0.349
13	231.7	484.8	843.4	505.1	192.8	0.382
14	356.1	698.5	1166.3	725.6	257.6	0.355
15	228.9	466.9	777.6	483.0	177.6	0.368
16	118.5	292.8	543.5	307.8	133.3	0.433
17	30.7	92.0	175.7	96.6	46.1	0.477
18	0.0	12.7	34.3	14.4	11.1	0.768
Unknown	9.0	21.7	40.8	22.8	10.0	0.439
TSN	18020.8	22708.0	27299.3	22615.9	2795.2	0.124
TSB	3161.1	4206.4	5296.1	4209.9	638.3	0.152

Table 6. IESNS 2020. Bootstrap estimates from StoX (based on 1000 replicates) of blue whiting. Numbers by age and total number (TSN) are in millions and total biomass (TSB) in thousand tons.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
1	1931.0	2777.9	3834.2	2817.2	597.2	0.21
2	319.1	486.1	701.5	492.9	119.6	0.24
3	448.1	667.5	955.3	680.6	156.6	0.23
4	123.3	245.7	398.3	251.6	82.9	0.33
5	174.2	339.8	539.6	345.1	113.0	0.33
6	133.6	235.2	349.8	237.8	68.1	0.29
7	46.4	88.1	151.7	92.3	32.1	0.35
8	7.0	23.0	42.0	23.4	10.5	0.45
10	0.0	0.4	1.3	0.4	0.3	0.81
TSN	3682.9	4928.6	6231.0	4942.5	777.7	0.16
TSB	283.6	391.1	497.5	388.8	64.3	0.17

Figures

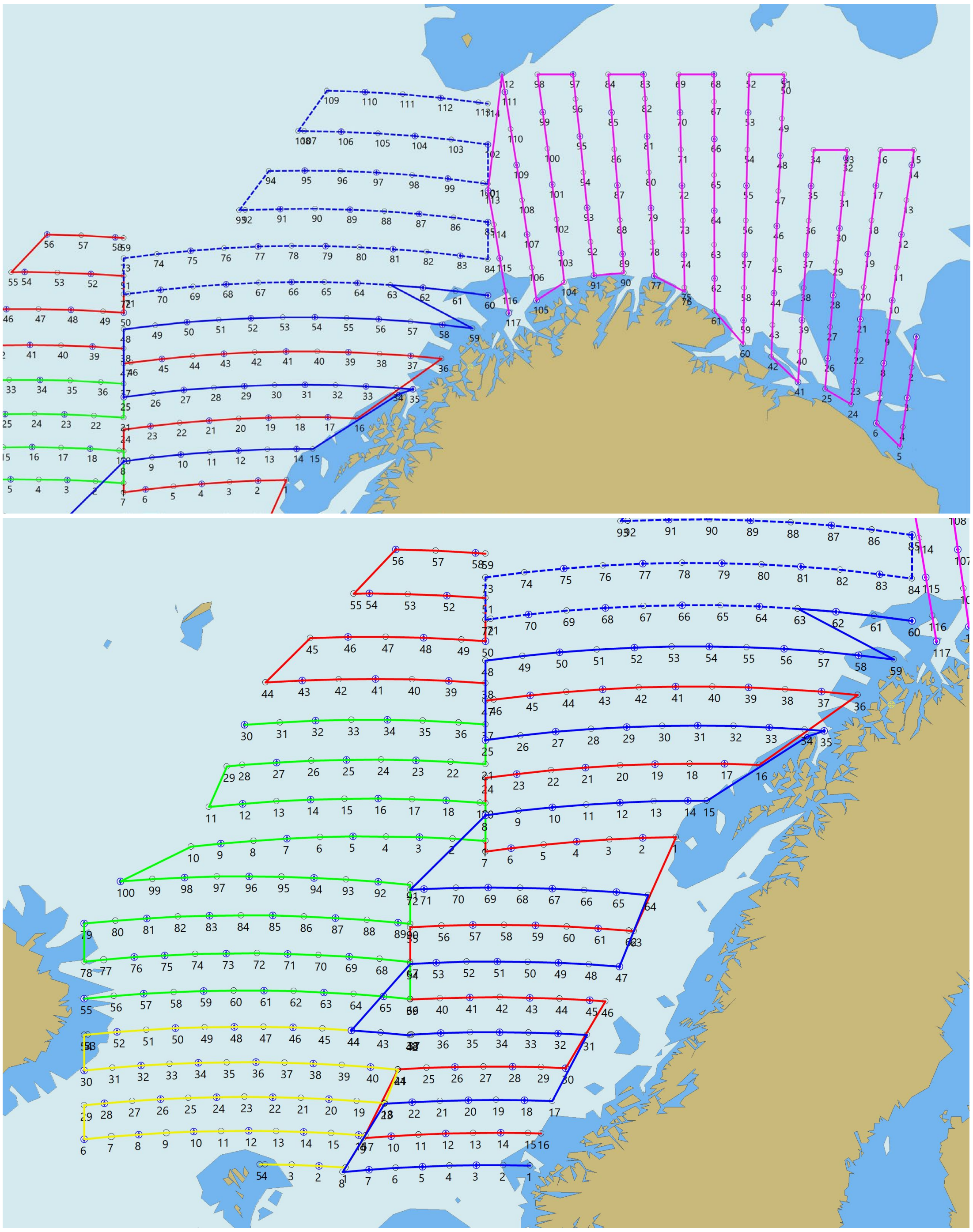


Figure 1. The pre-planned strata and transects for the IESNS survey in 2020 (red: EU, dark blue: Norway, yellow: Faroes Islands, violet: Russia, green: Iceland). Hydrographic stations and plankton stations are shown as blue circles with diamonds. All the transects have numbered waypoints for each 30 nautical mile and at the ends**.**

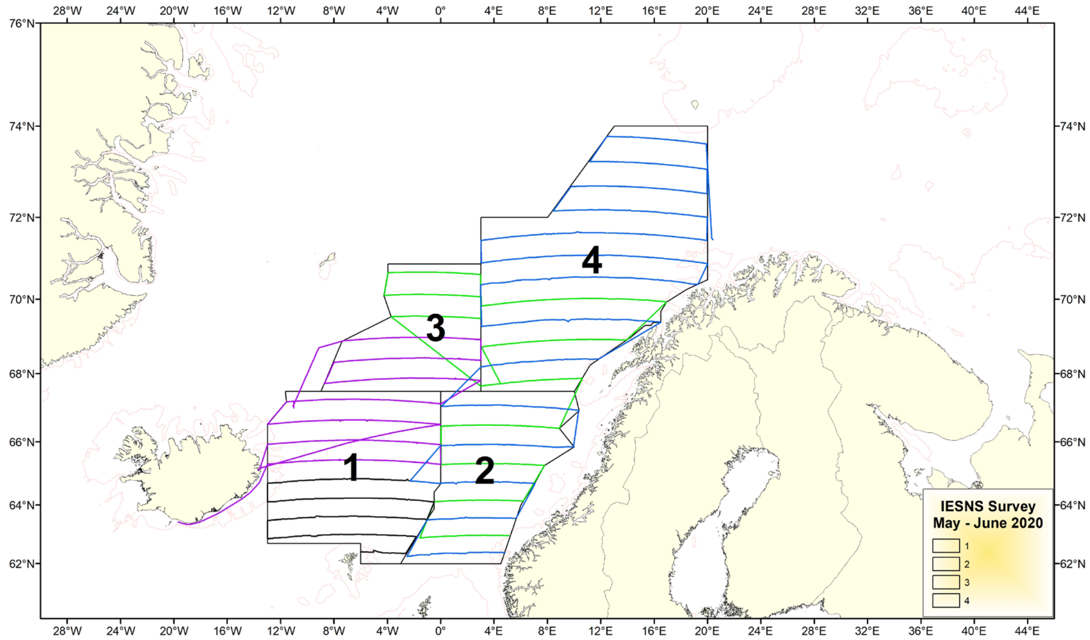


Figure 2. Cruise tracks and strata (with numbers) for the IESNS survey in May 2020.

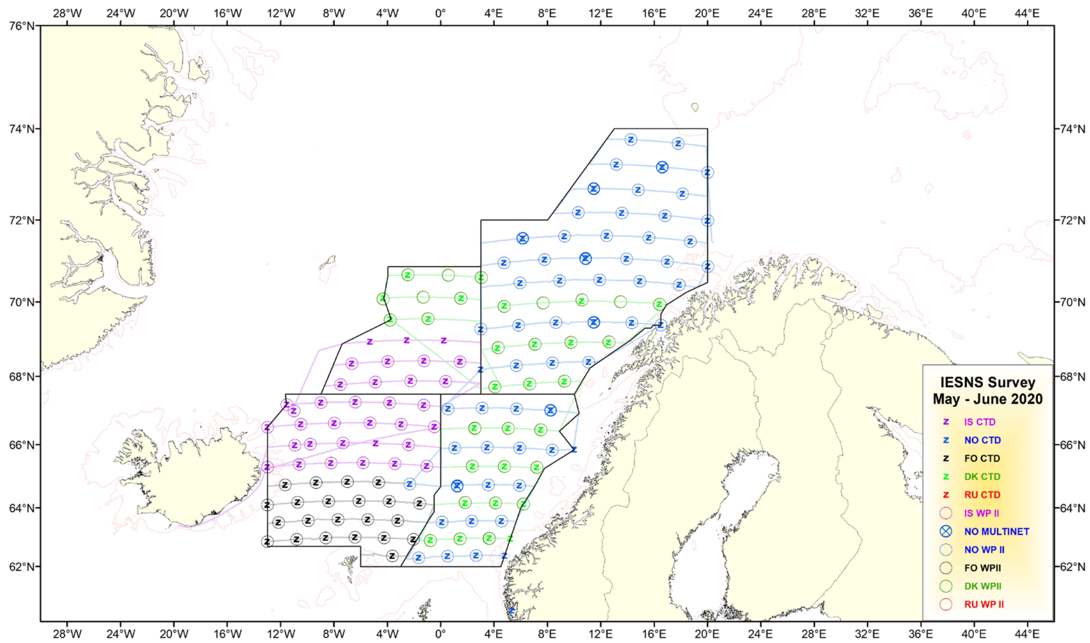


Figure 3a. IESNS survey in May 2020: location of hydrographic and plankton stations. The strata are shown.

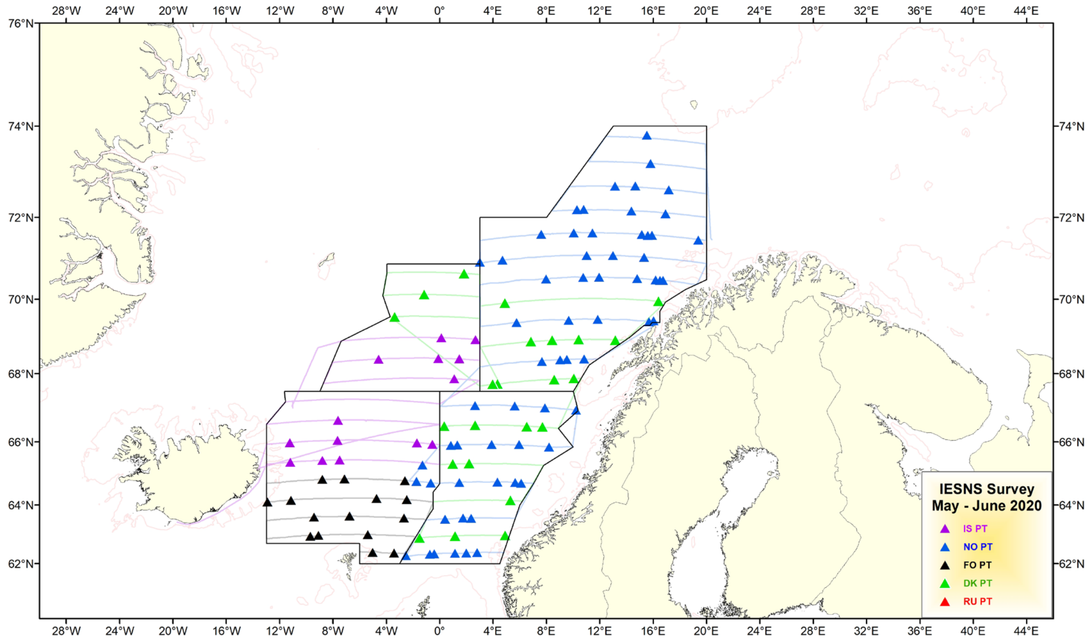


Figure 3b. IESNS survey in May 2020: location of pelagic trawl stations. The strata are shown.

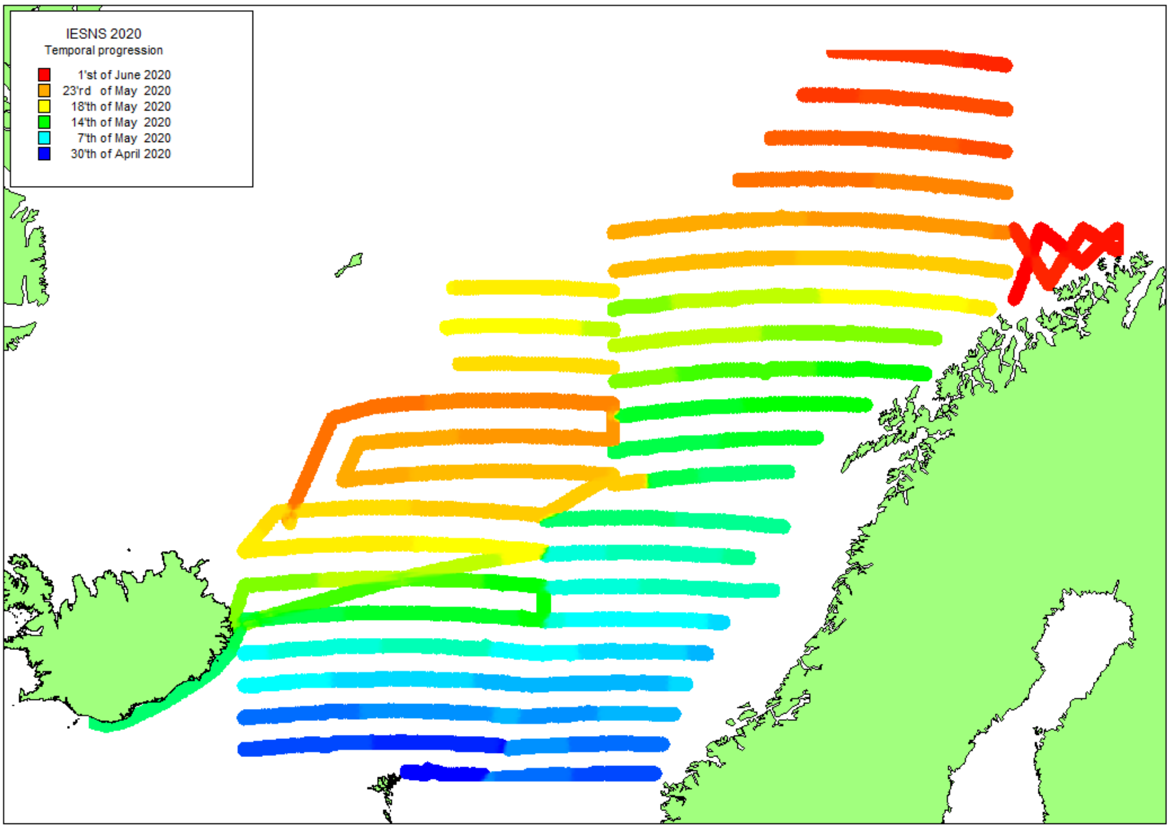


Figure 4. Temporal progression IESNS in May-June 2020.

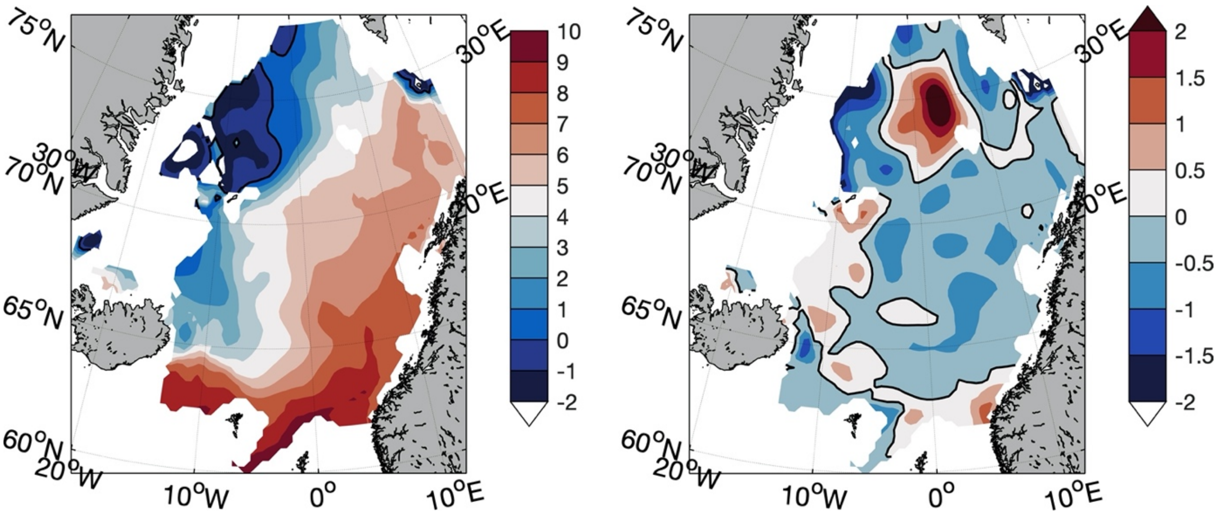


Figure 5. Temperature (left) and temperature anomaly (right) averaged over 0-50 m depth in May 2020. Anomaly is relative to the 1995-2019 mean.

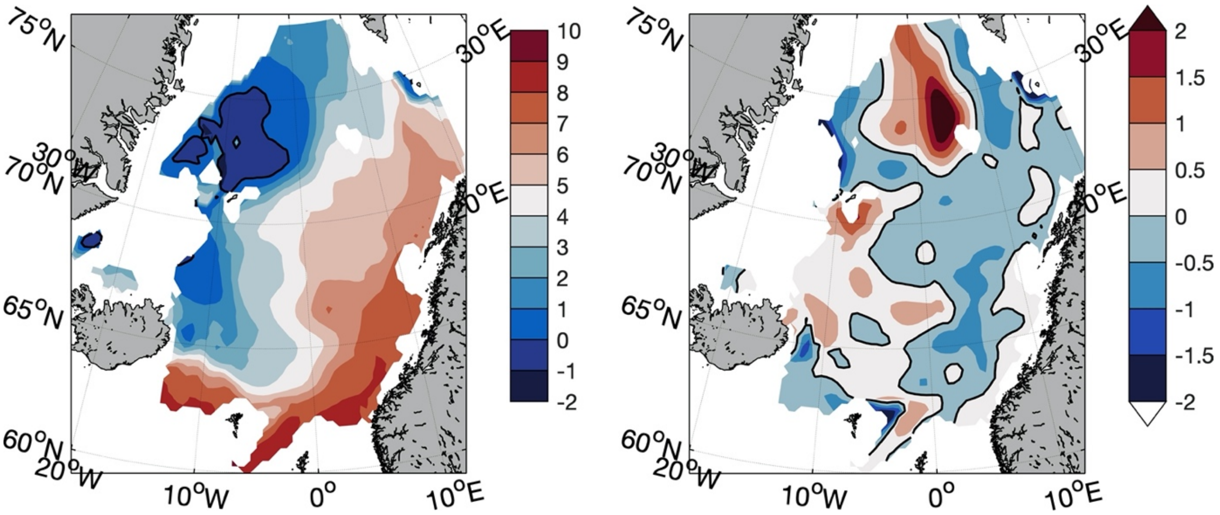


Figure 6. Same as above but averaged over 50-200 m depth.

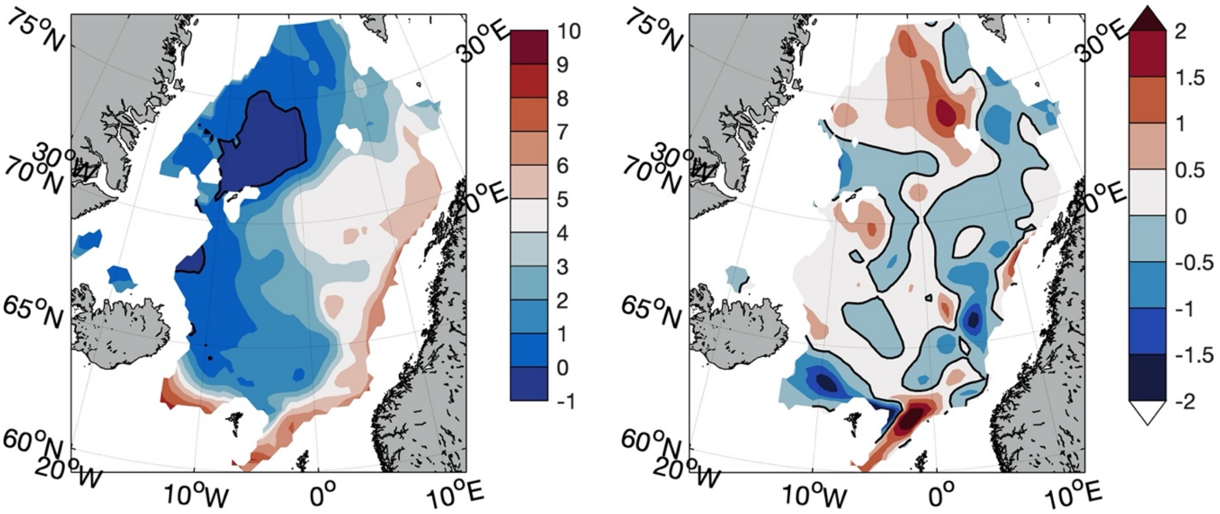


Figure 7. Same as above but averaged over 200-500 m depth.

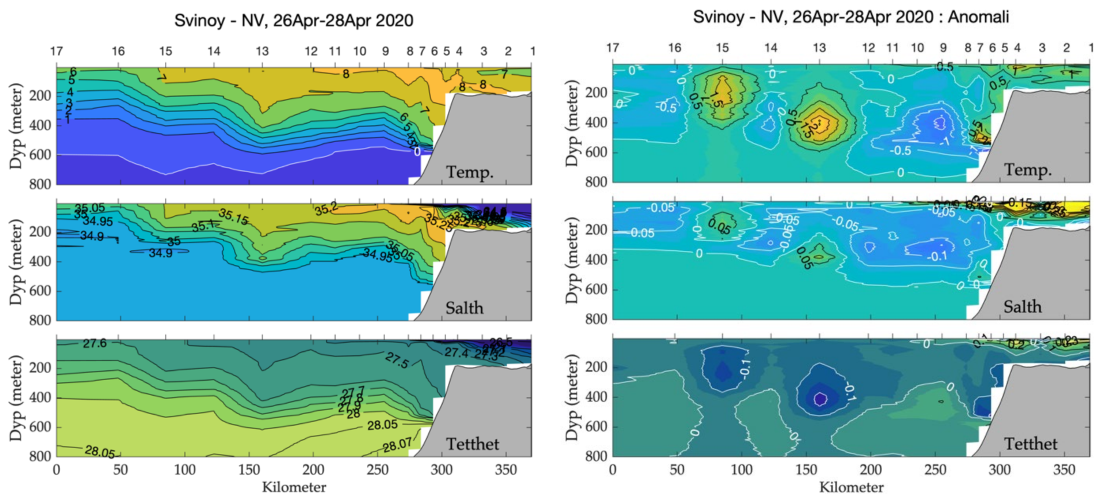


Figure 8. Temperature, salinity and potential density (sigma-t) (left figures) and anomalies (right figures) in the Svinøy section, 26-28 April 2020. Anomalies are relative to a 30 years long-term mean (1978-2007).

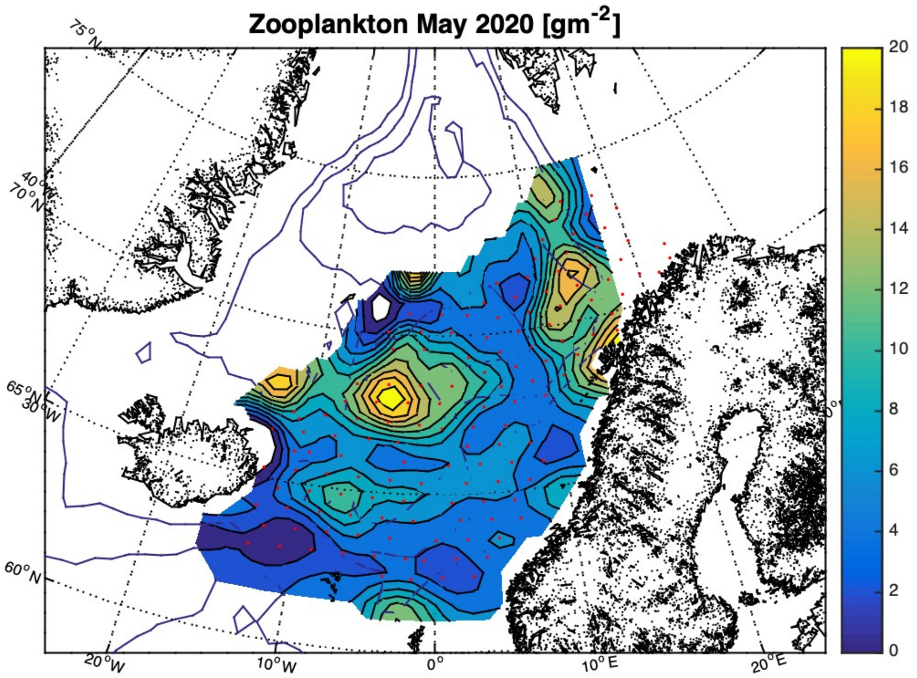


Figure 9. Representation of zooplankton biomass (g dry weight m^{-2}; at 0-200 m depth) in May 2020.

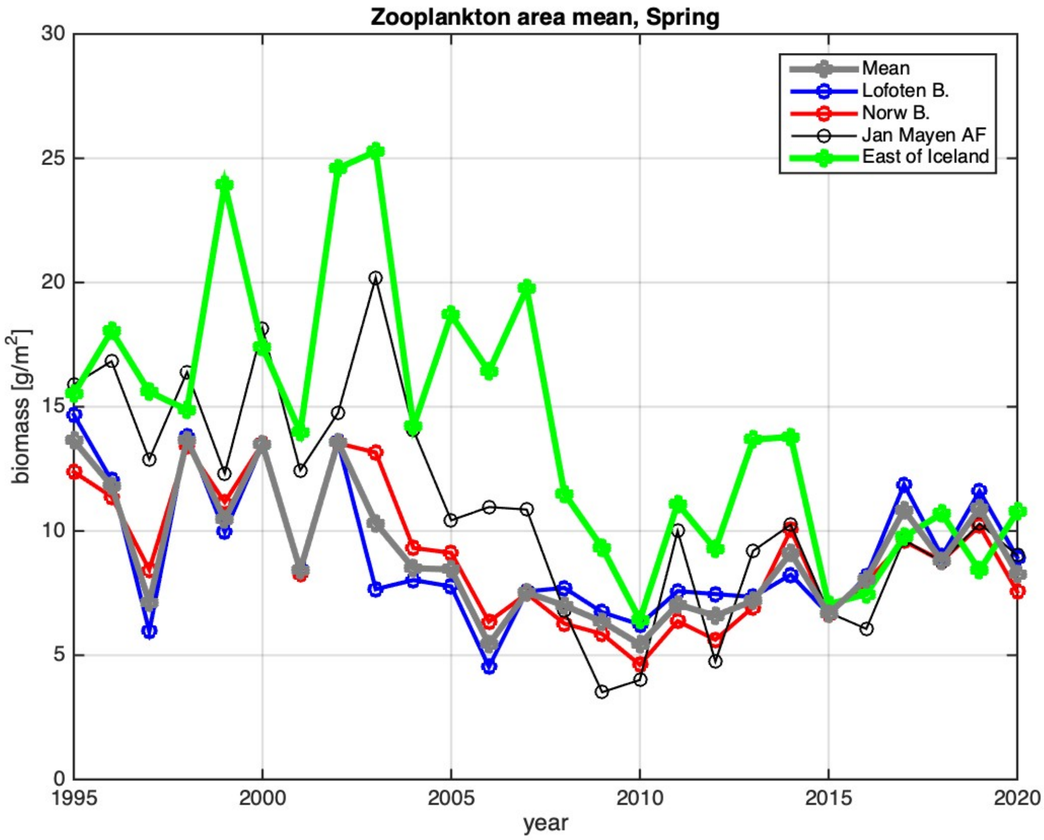
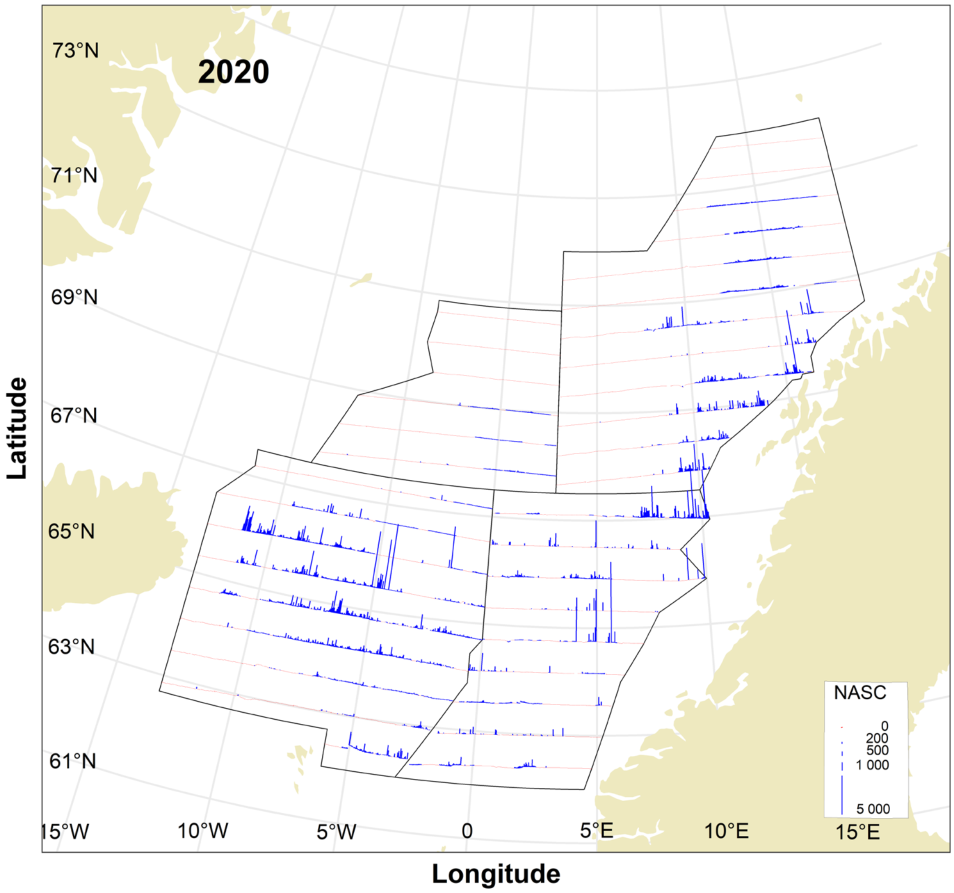


Figure 10. Indices of zooplankton dry weight (g m^{-2}) sampled by WP2 in May in (a) the different areas in and near Norwegian Sea from 1995 to 2020 as derived from interpolation using objective analysis utilizing a Gaussian correlation function (see details on methods and areas in ICES 2016).

(a)



(b)

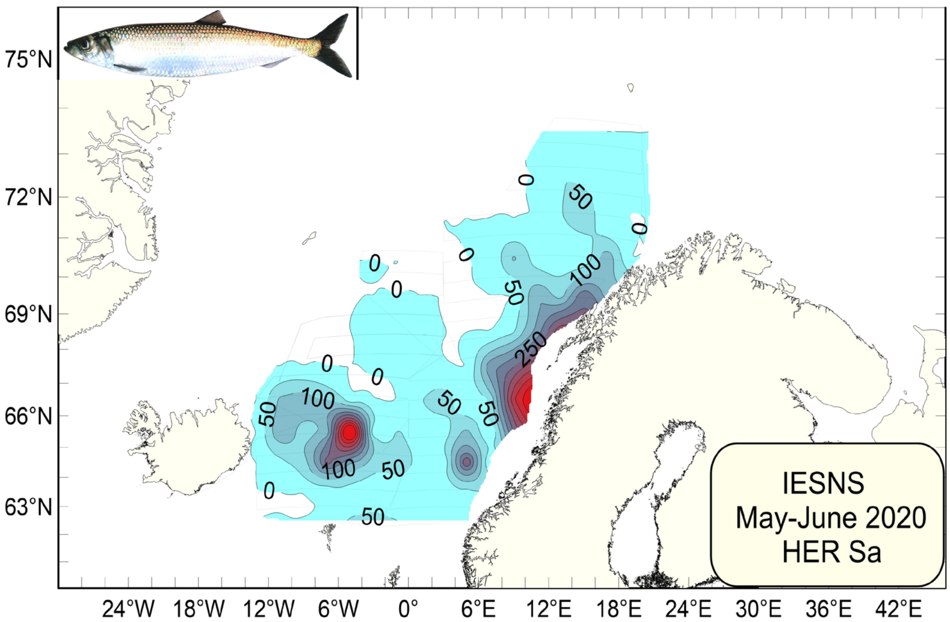


Figure 11. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2020 in terms of NASC values (m²/nm²) averaged for every 1 nautical mile and (b) represented by a contour plot.

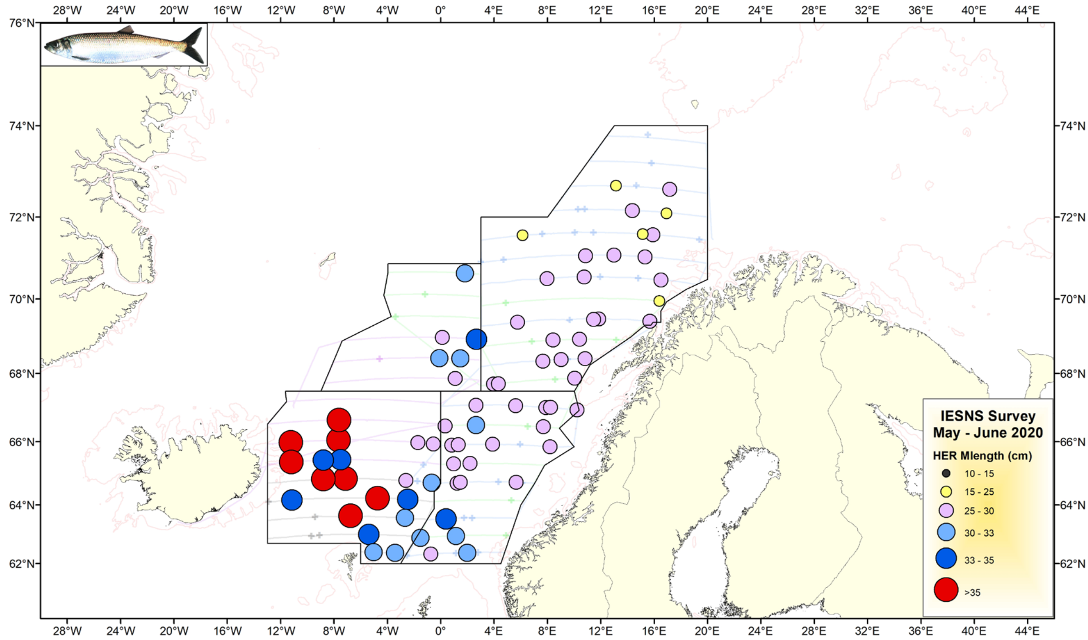


Figure 12. Mean length of Norwegian spring-spawning herring in all hauls in May 2020. The strata are shown.

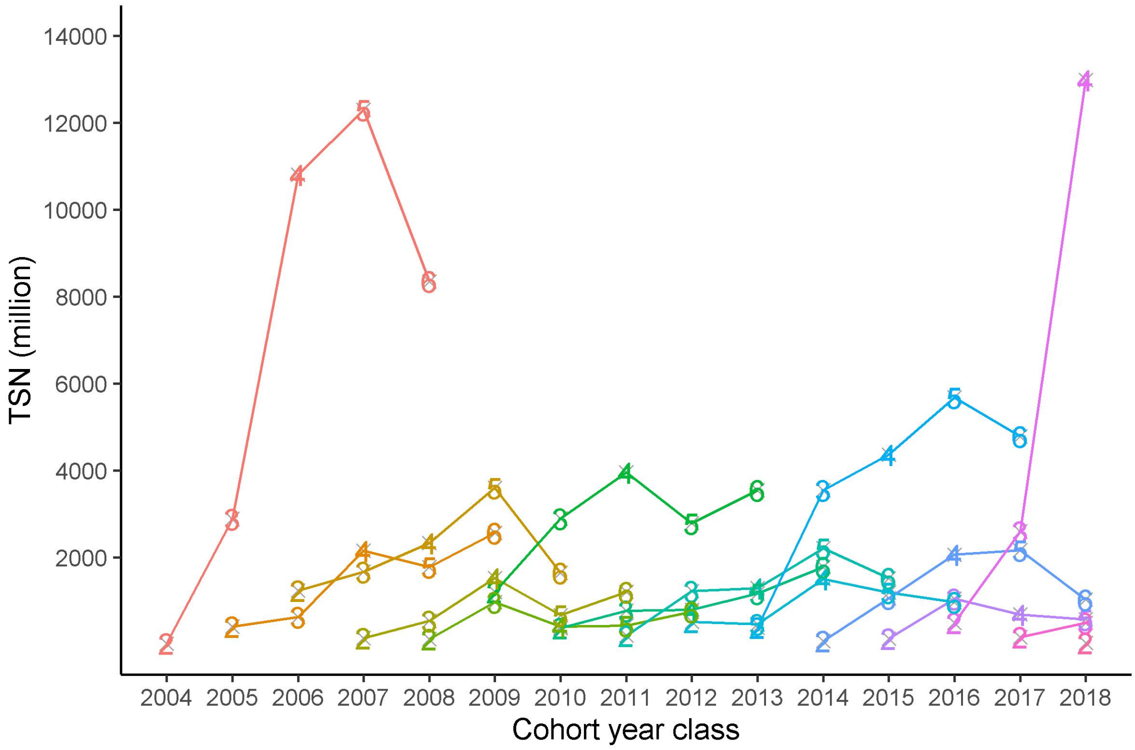


Figure 13. Tracking of the Total Stock Number (TSN, in millions) of Norwegian spring-spawning herring for each cohort since 2004 from age 2 to age 6. From 2008, stock is estimated using the StoX software. Prior to 2008, stock was estimated using BEAM.

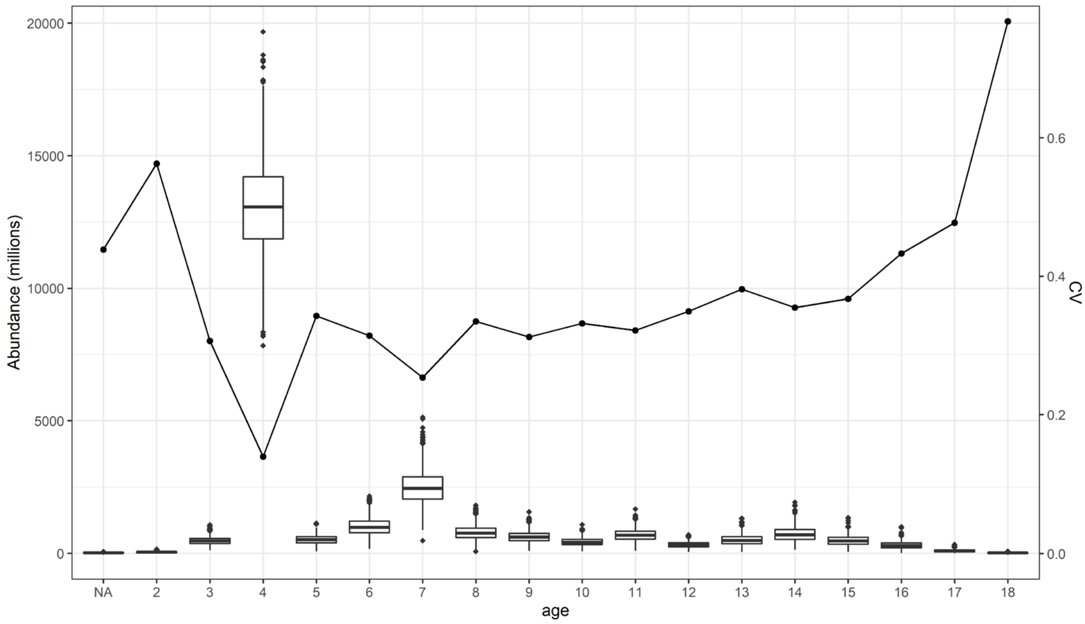


Figure 14. Norwegian spring-spawning herring in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

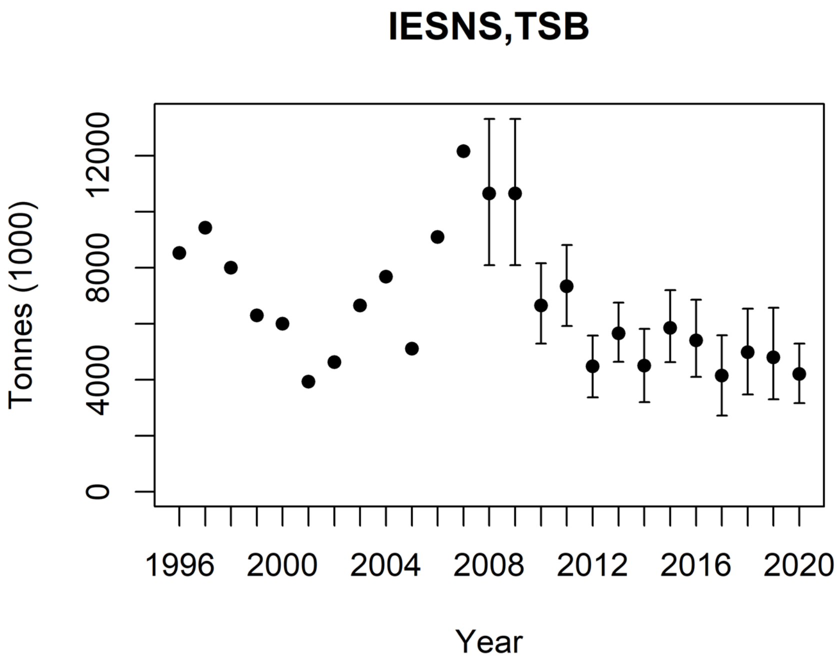
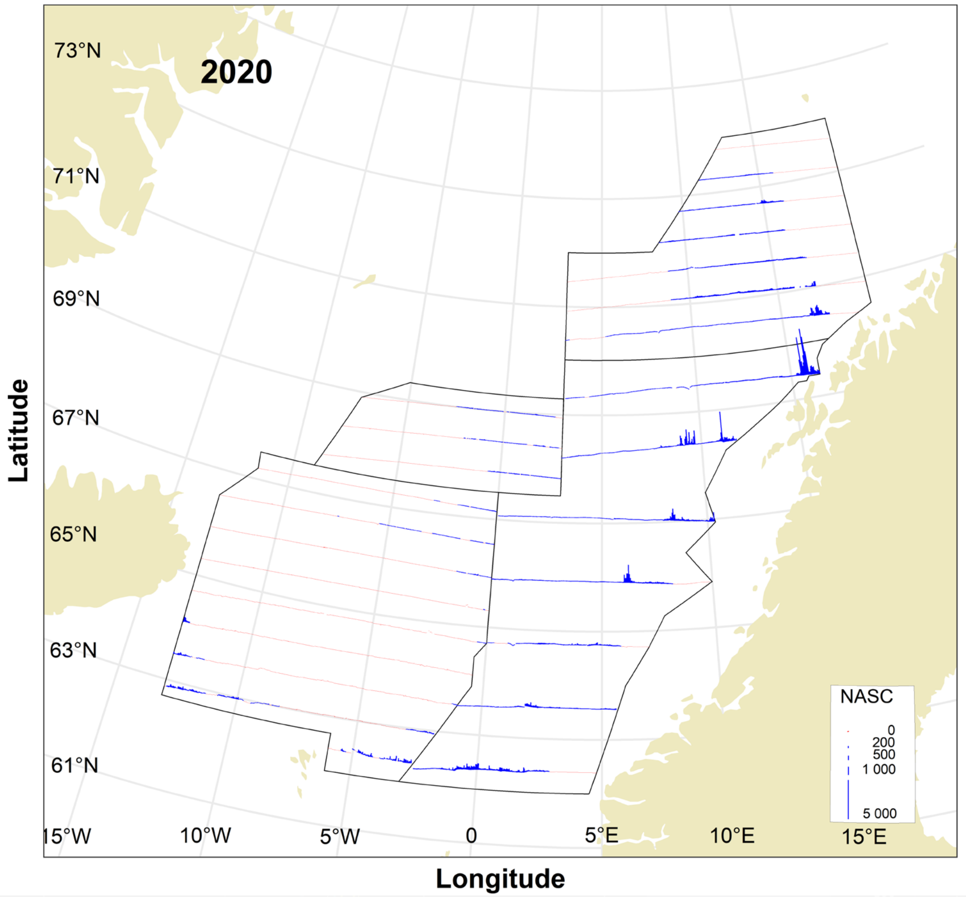


Figure 15. Biomass estimates of Norwegian-spring spawning herring in the IESNS survey (Barents Sea, east of 20°E, is excluded) from 1996 to 2020 as estimated using BEAM (1996-2007; calculated on basis of rectangles) and as estimated with the software StoX (2008-2020; boostrap means with 90% confidence interval; calculated on basis of standard stratified transect design).

(a)



(b)

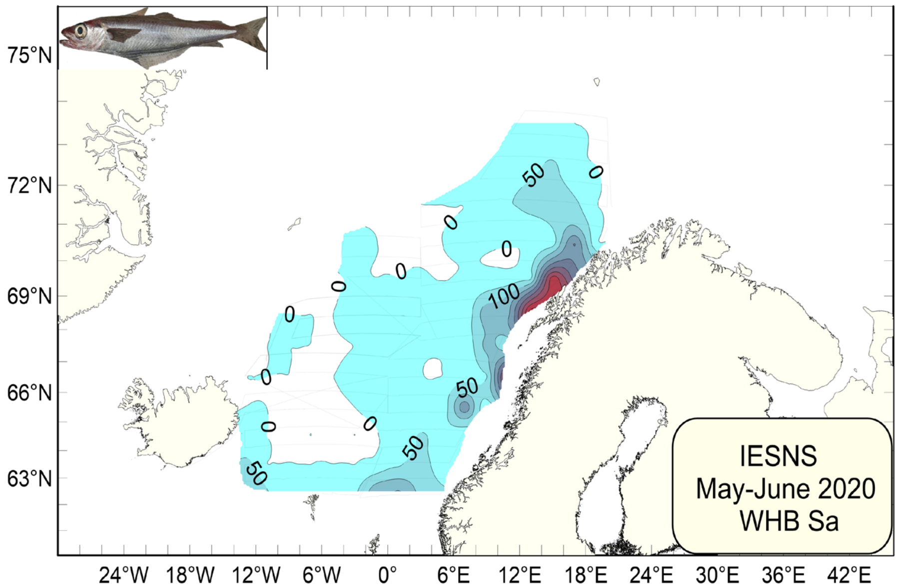


Figure 16. Distribution of blue whiting as measured during the IESNS survey in May 2020 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile and (b) represented by a contour plot. Note that the coverage in the Barents Sea is not included in b.

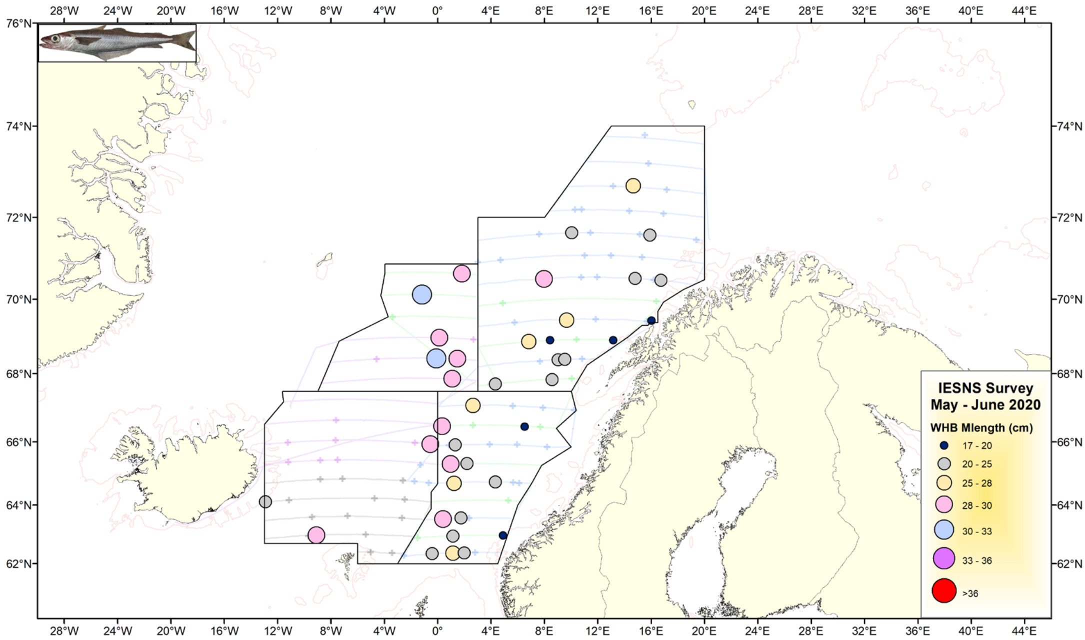


Figure 17. Mean length of blue whiting in all hauls in IESNS 2020. The strata are shown.

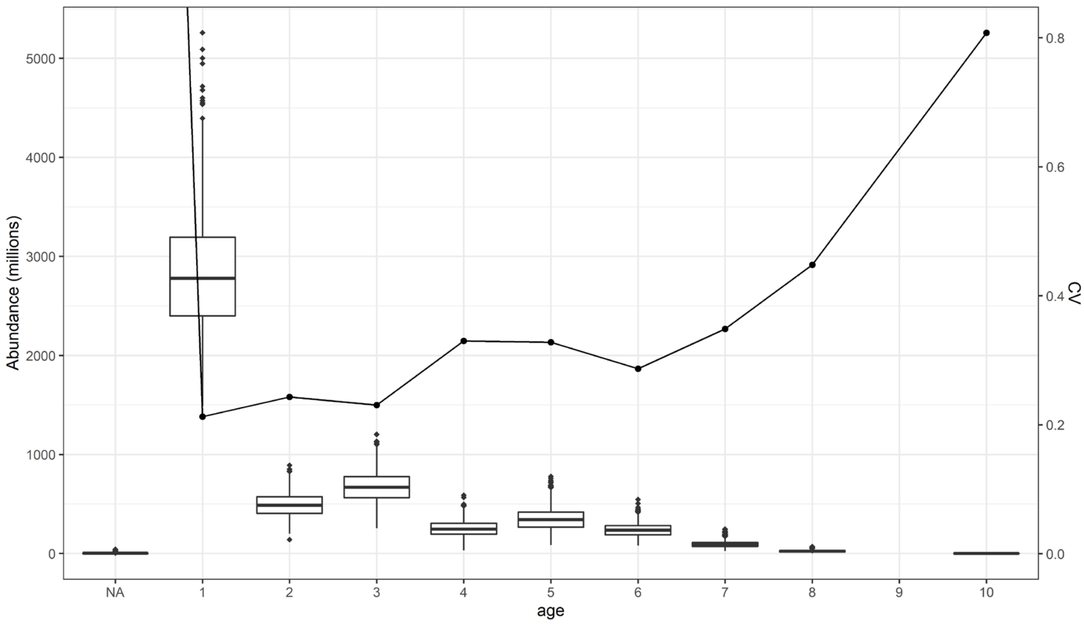


Figure 18. Blue whiting in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 1000 replicates using the StoX software.

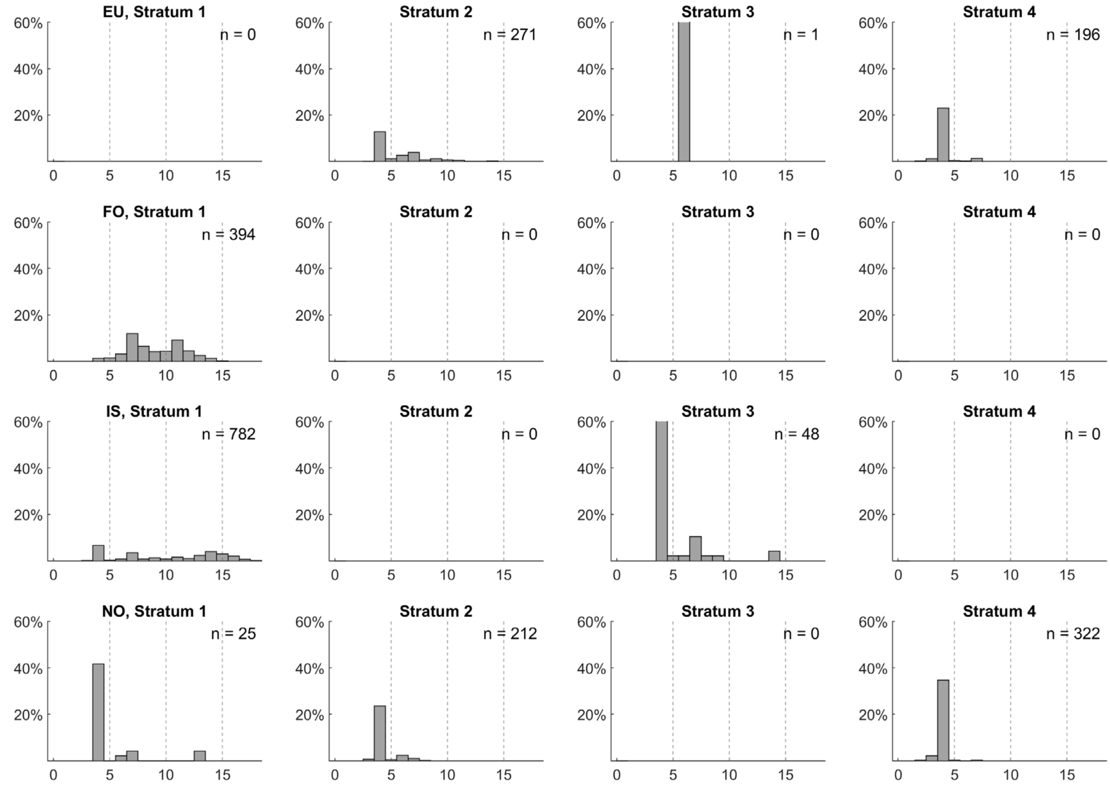


Figure 19. Comparison of the age distributions of NSS-herring by stratum and country in IESNS 2020. The strata are shown in Figure 3.

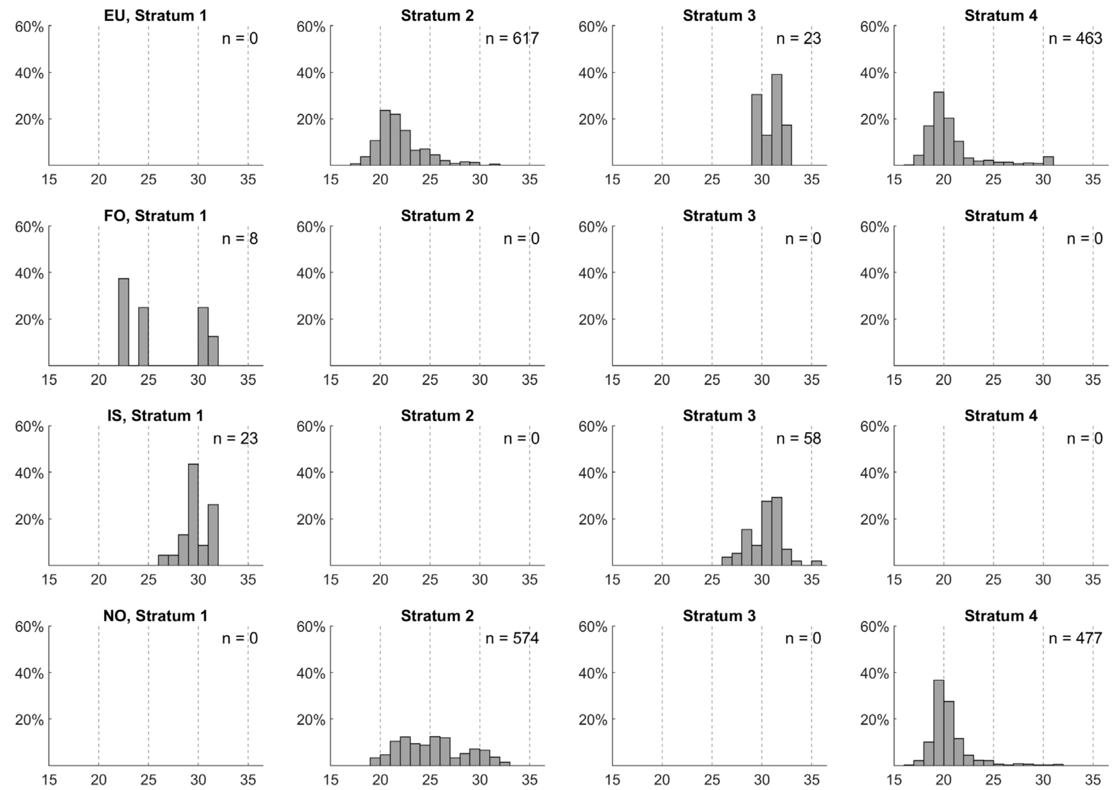


Figure 20. Comparison of the length distributions of blue whiting by stratum and country in IESNS 2020. The strata are shown in Figure 3.

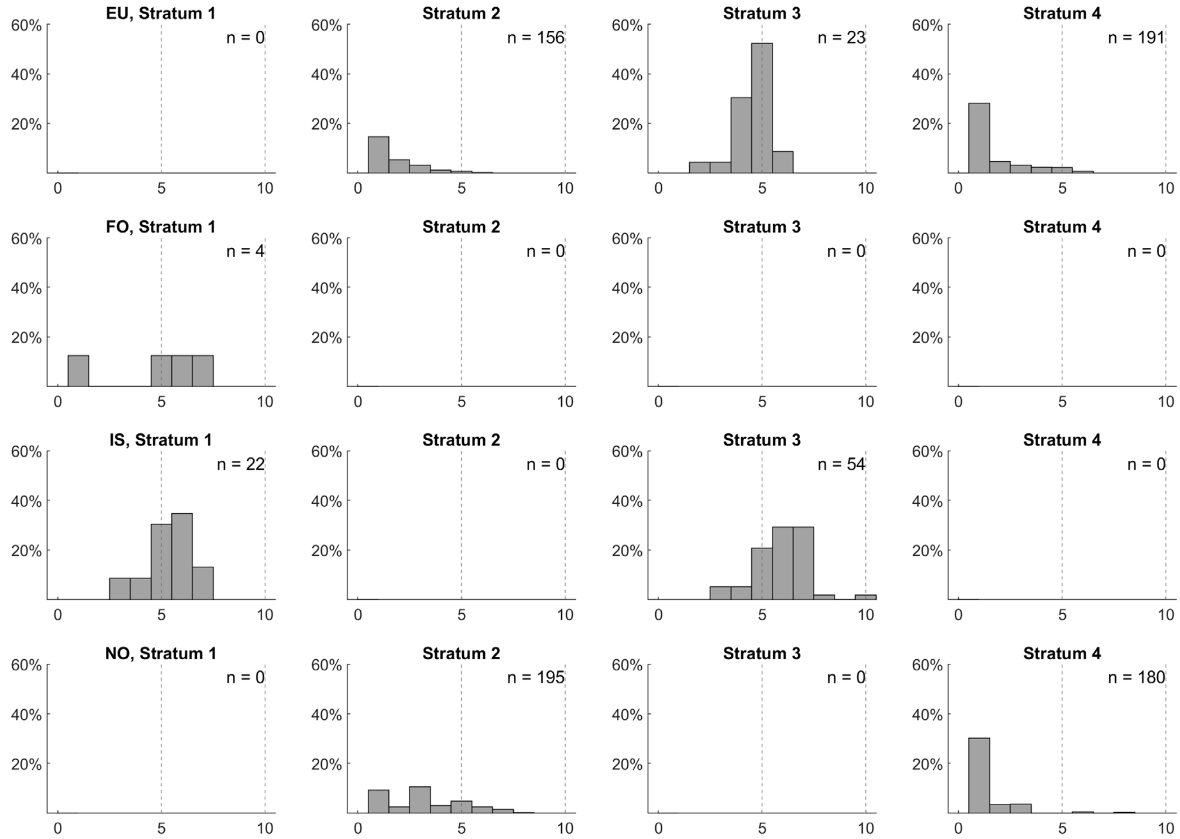


Figure 21. Comparison of the age distributions of blue whiting by stratum and country in IESNS 2020. The strata are shown in Figure 3.

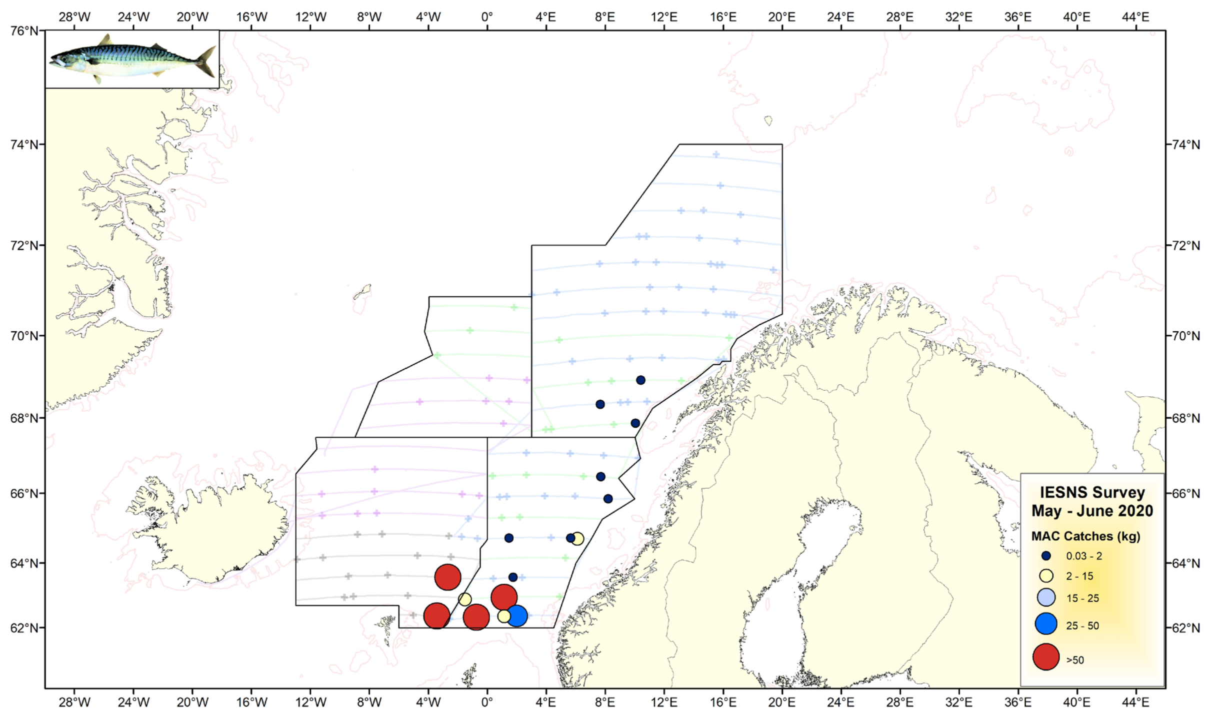


Figure 22. Pelagic trawl catches of mackerel in IESNS 2020. The strata are shown.

Appendix A

Distribution of NASC in the IESNS survey in the period 2014 – 2019.

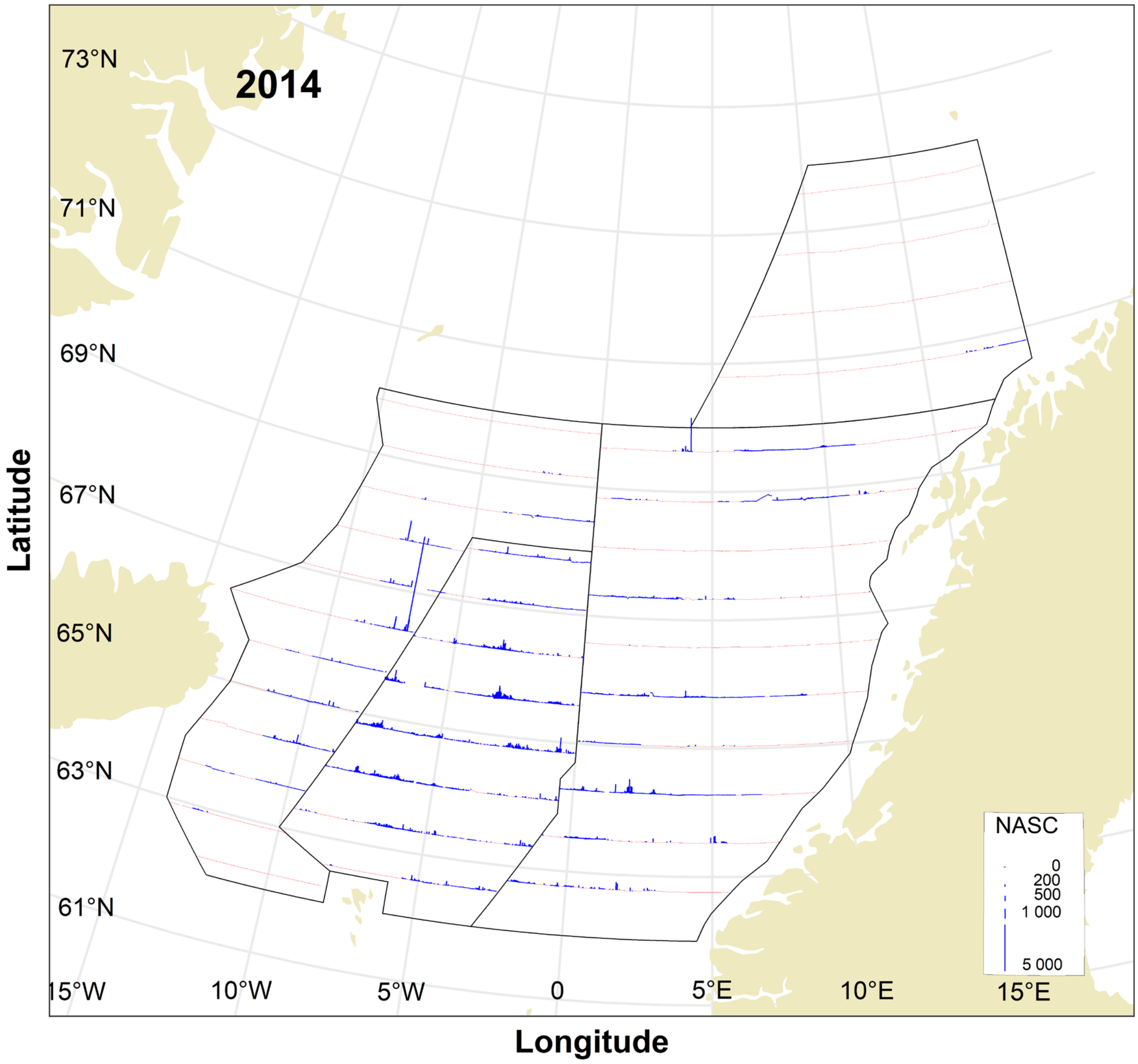


Figure A1. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2014 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile

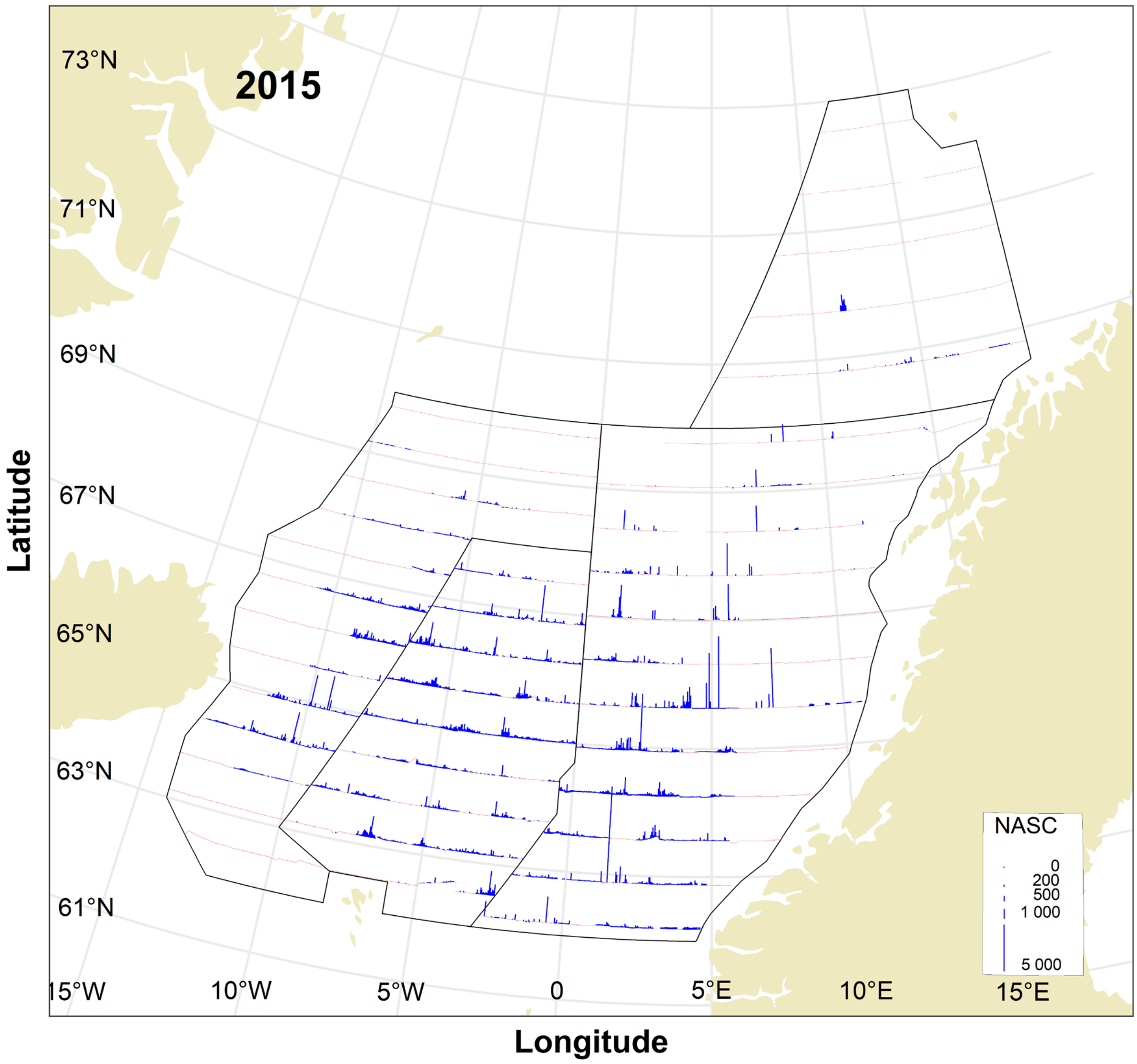


Figure A2. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2015 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile

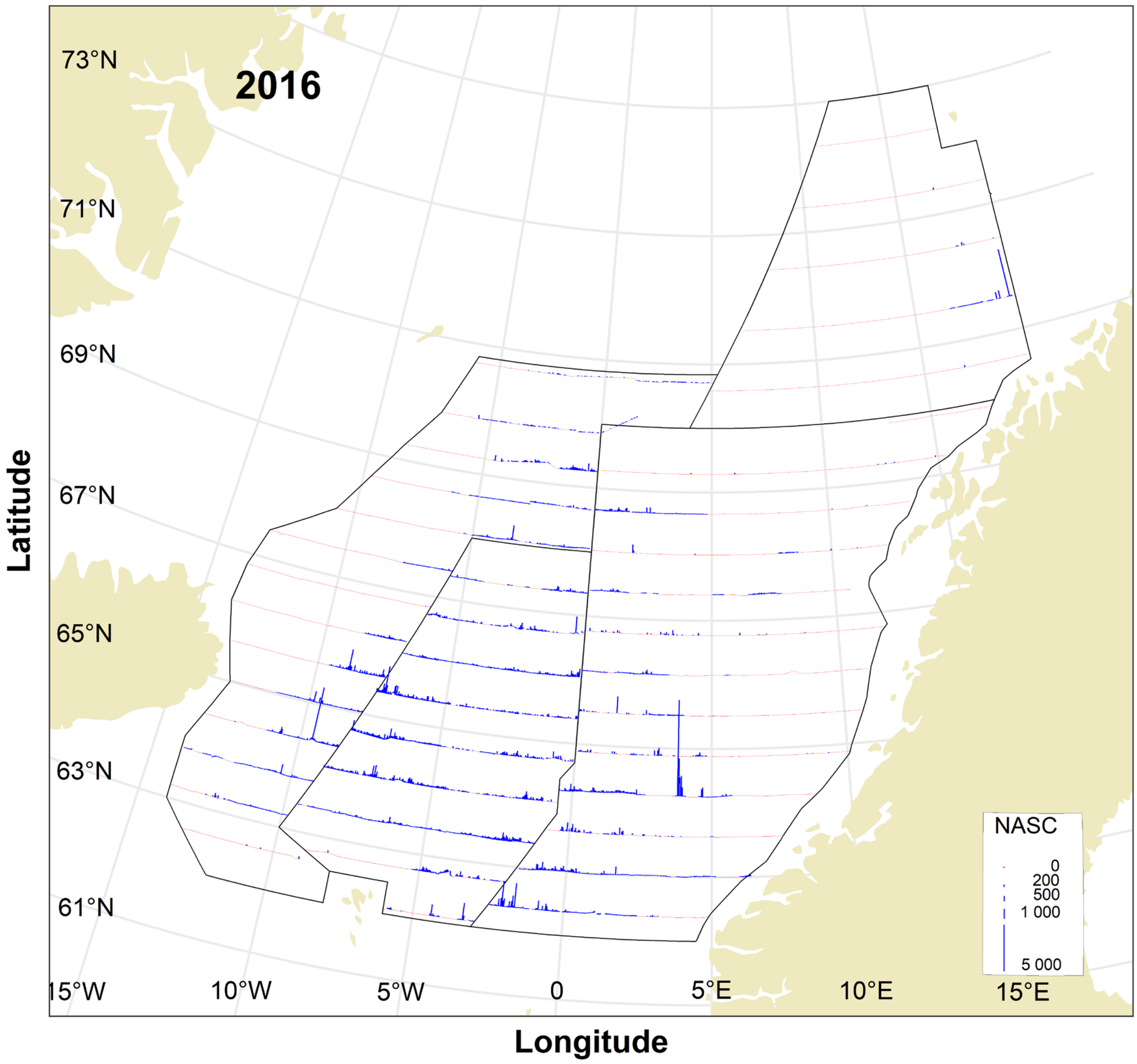


Figure A3. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2016 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile

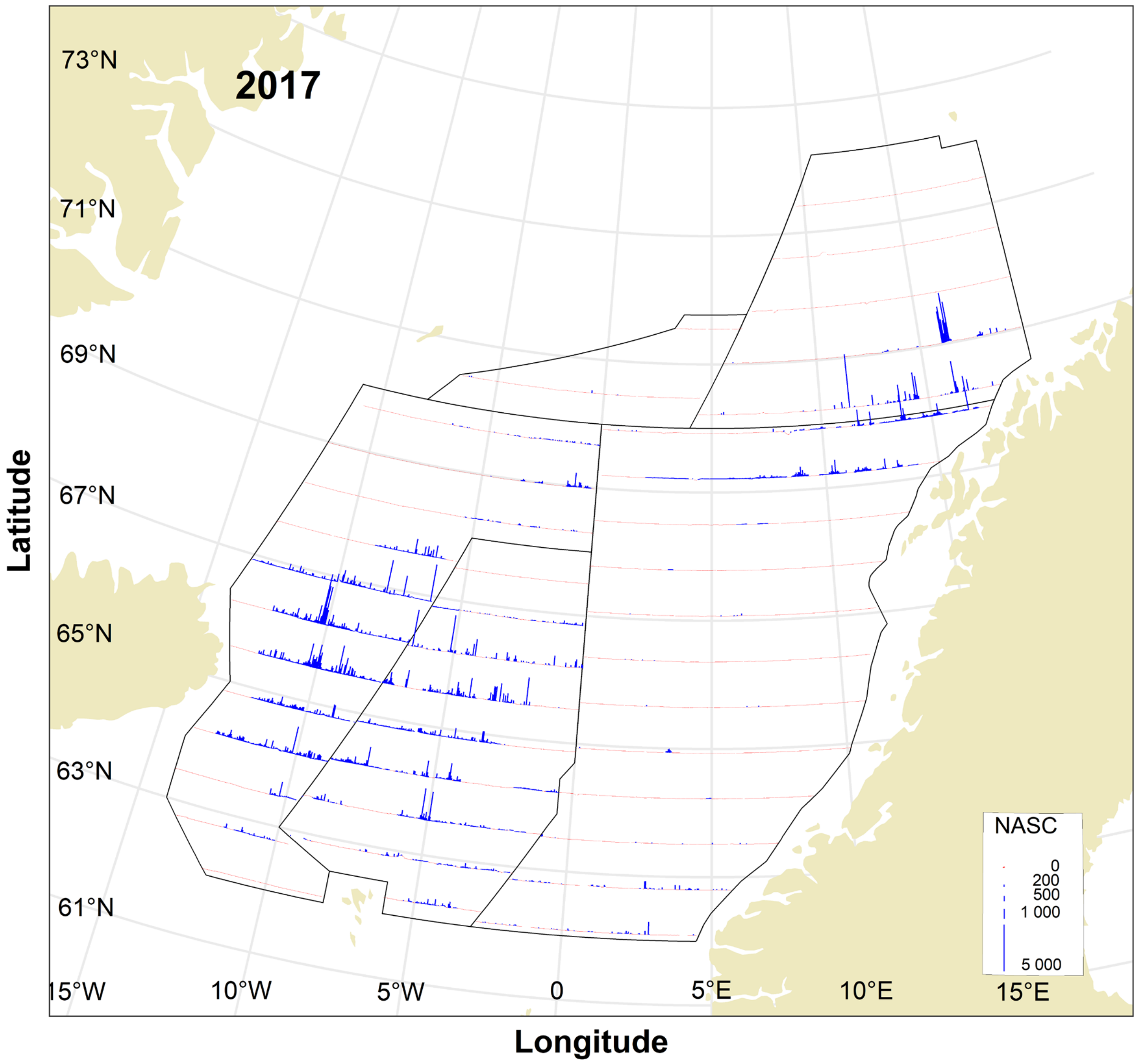


Figure A4. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2017 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile

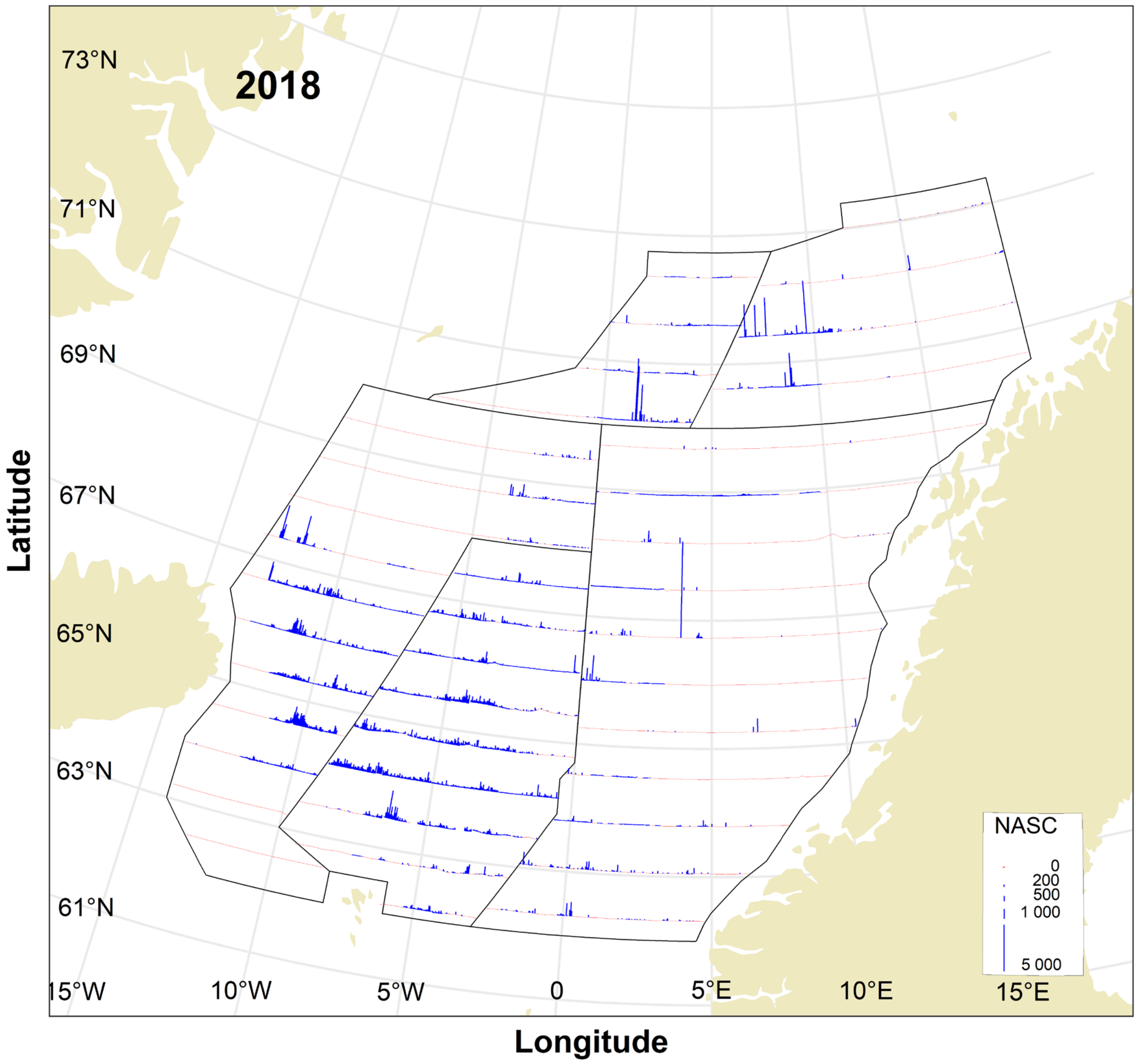


Figure A5. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2018 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile

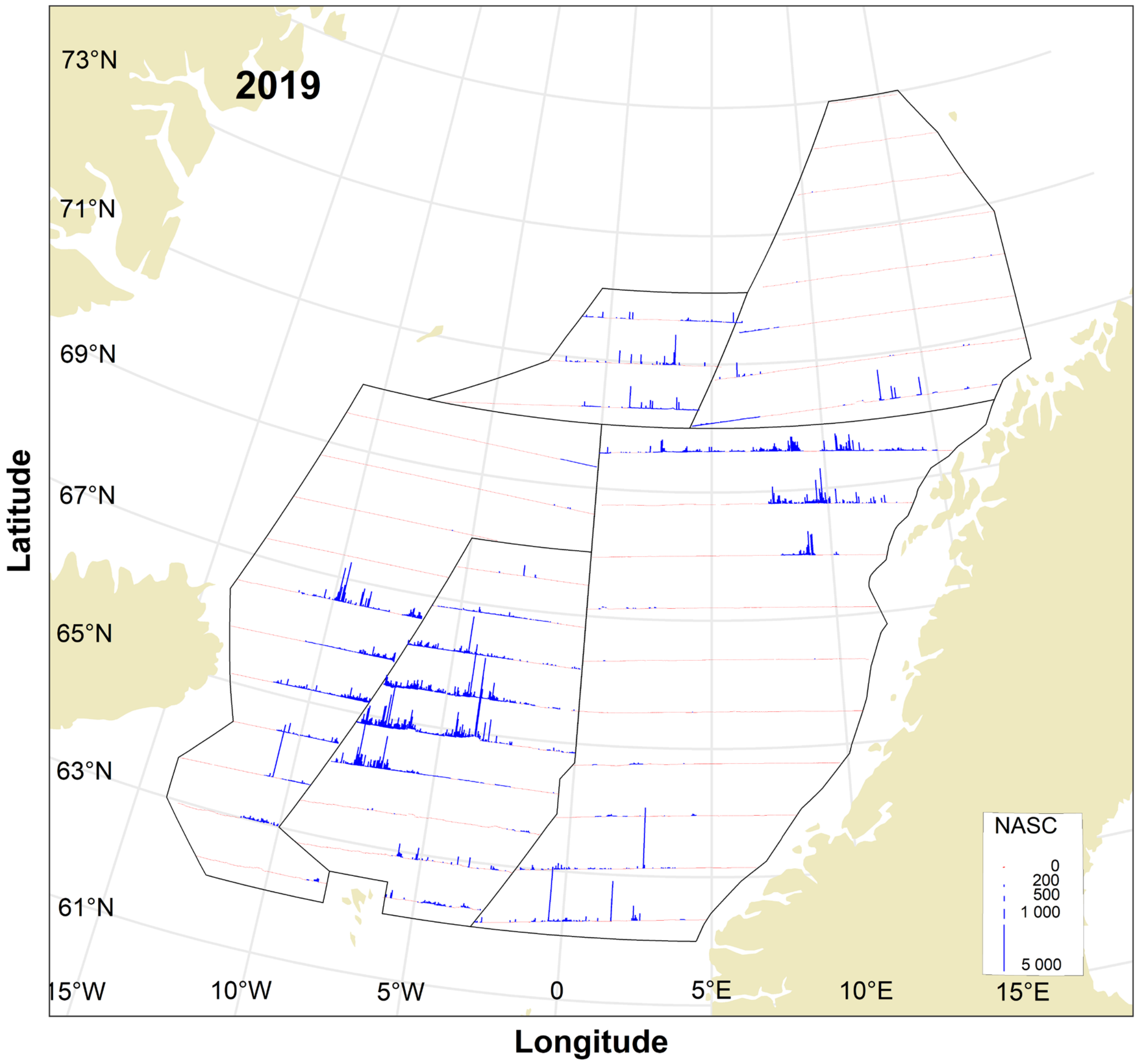


Figure A6. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2019 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile.