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Survey report

MS *Eros*, MS *Kings Bay* MS *Vendla* 13.-25.02.2017

Distribution and abundance of Norwegian spring-spawning herring during the spawning season in 2017

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Summary

During the period 13-25th of February 2017 the spawning grounds from Møre (62ºN) to the borderline Troms-Finnmark at Tromsøflaket (71º) were covered acoustically by the commercial vessels MS *Eros*, MS *Kings Bay* and MS *Vendla.* The survey was carried out under very good weather conditions, with no abruptions, and with a denser coverage using more transects than in 2016. Sonar investigations indicated that that echo sounder biomass estimations were not seriously biased by unaccounted fraction of herring in the upper layers, and that no significant fraction of herring was distributed in the echo sounder blind zone. Compared with 2016 there was a 23% drop in the estimated biomass index, but the uncertainty linked to the estimate was much lower in 2017 (CV=14.2%) compared with 2016 (CV=40%). In 2016, when the survey was run from 2-14th February, the herring appeared in a real high density bulk within a small area 66-67ºN, and this was the reasons for the high uncertainty in the estimate (CV of 40%). Therefore, the start of the 2017 survey was delayed until 13th February, as it was anticipated that the herring was more spread out along the coast leading to less uncertainty in the estimation. This was in fact also the case, the herring was very evenly distributed along the coast and observed at most of the transects. About 90% of the biomass was found between 63°-67°N, and the 10% rest was found up to 71°N. No herring was observed at four transects westwards in the known oceanic wintering area, suggesting that the majority of the wintering herring had reached the covered area along the coast. In 2016 herring were sampled from biological analyses with aging from 32 trawl hauls, whereas in 2017 as much as 52 herring samples were analysed from trawl stations along the coast. As in 2016, the estimate of 2017 was still predominated by old fish from three year classes; 2004 most abundant, with 2006 and 2009 coming next. However, the 2013 year class showed signs of new recruitment to the spawning stock, now being almost as abundant as the 2009 year class, and dominating in the areas north of 67°N. The main part of a year class is not entering the spawning survey until age 5, so until 2018 the future contribution of the 2013 year class still remains uncertain.

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Introduction

Acoustic surveys on NSS 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 based on the pressure from fishermen and fishermen's organizations that IMR should conduct more surveys on this commercially important stock. Since then this has continued with a survey design using three commercial vessels, and IMR has contracted the same vessels to run this survey during the period 2017-2020. The ICES WKPELA benchmark in 2016 also decided to use the data from this time series as input to the future ICES stock assessments, together with the ecosystem survey in the Norwegian Sea in May in addition to catch data, meaning that the results of the survey have significant influence on quota advice.

Hence, the objective of the NSS spawning survey 2017 was to continue the index for use in the ICES WGWIDE stock assessment, more specifically to estimate indices of year class abundance and spawning stock biomass during the period of spawning migration from wintering areas at/off the northern Norwegian coast and in the Norwegian Sea towards the coastal spawning ground further south. Finally, it was also a purpose that the results of the survey should be compared with recent surveys.

Material and methods

Survey design

During the period 13-25th of February 2017 the spawning grounds from Møre (62ºN) to Troms (71ºN) were covered acoustically by the commercial fishing vessels MS Eros*, MS Kings Bay* and MS *Vendla*.

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 expected density and age structures of herring (Figure 1). A southern strata 1, was not covered as there were no news from the fishing fleet about herring in this area. Similarly a strata 11, westwards in the Norwegian up to 67°N Sea was also not covered, as there were no news about herring in this area prior to the onset of the survey. Within each of the covered stratum 2-10 and 12, parallel east-west transects with a constant distance and a random starting position was used as the primary sampling unit (Simmonds and MacLennan 2008). The distance between transects were 5 nm up to 66°N and 10 nm to the north of this, with exception of strata 12 where 20 nm distance was used) (Figure 2). It was further decided that all vessels should sail as close as possible to the coast, and that the western limits of the transects were defined to be ended when no herring was observed for about 5 nm). These design rules made small changes to the predefined stratum polygons during the survey. In strata 9, increased sampling effort was added by doubling of transects in the western parts, for inspecting the density distribution of young herring observed at the shelf edge. This effect of this ad-hoc change in the survey design on the estimate was insignificant, and the doubled transects were not used in the final estimate.

Biological sampling

Trawl sampling was carried out on a regular basis to confirm the acoustic observations, and for analyses of spatial variations in the age structure (Figure 3). Number of trawl stations with samples of herring increased heavily from 31 stations in 2016 to 52 stations in 2017. The following variables of individual herring were analysed for each of the 52 trawl stations with herring catch: Total weight (*W*) in g and total length (L_T) in cm (measured to nearest 0.5 cm below) on up to 100 individuals per sample and totally 4535 individuals (compared with 2971 individuals in 2016), and in addition the sex, maturity stage, stomach fullness and gonad weight (W_G) in g (given maturity stage<7) were measured in 50 individuals per sample and totally in 2088 individuals (compared with 1394 individuals in 2016). The maturity stages were determined by visual inspection of gonads as recommended by ICES (Anon. 1962): immature = 1 and 2, maturing = 3 to 4, ripe = 5, spawning = 6, spent = 7 and recovering = 8.

Environmental sampling

CTD casts (using Seabird 911 systems) were taken by MS Eros and Vendla, spread out in the survey area, often in connection with herring trawl hauls (Figure 4)

Echo sounder data

Multifrequency (18, 38, 70, 120, 200 kHz) acoustic data were recorded with a SIMRAD EK 60 echo sounder and echo integrator onboard all three vessels. All three vessels were calibrated at the tip of the fishing pier in Ålesund prior to the survey according to standard methods (Foote et al., 1987), adjusted for split beam methods as described in Ona (1999) and (Demer et al., 2015). All vessels were satisfactorily calibrated, and the calibration reports with new gain estimates and raw data are stored on the survey disc at NMD. The calibration reports of each vessel is shown in Annex 1. The low frequency sonars were also calibrated according to procedures described in Macaulay et al., (2016).

LSSS, Large Scale Survey System (Korneliussen et al., 2006) was applied for the interpretation of the multi-frequency data. The recorded area echo abundance, i.e. the nautical area backscattering coefficient (NASC) (MacLennan et al., 2002), was interpreted and distributed to herring and 'other' fish species at 38 kHz. The frequency response of schools and layers (Korneliussen & Ona, 2002) were used to identify herring from other targets. After scrutinizing, the data were stored with a resolution of 1 nmi on the horizontal scale and 10 m depth intervals.

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 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. 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:

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

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

$$\overline{L}_i = \frac{1}{n_i} \sum_{t=1}^{n_i} L_{it} \qquad (2)$$

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

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

Variance by stratum is estimated as:

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

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

The global variance is estimated as

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

The global relative standard error of NASC

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

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 at a total of 54 stations (Figure 3). All trawl stations 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 carrying out a by combining Monto Carlo selection from estimated NASC distributions by stratum with a 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, etc 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. <s_A>is the mean backscattering coefficient [m^2/nmi.2] (NASC). 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 target strength (TS) is used for the conversion where $\sigma = 4\pi\ 10^{(TS/10)}$ is used for estimating the backscattering cross section. Traditionally, TS = 20logL – 71.9 (Foote 1987) has been used for herring during the spawning surveys, however, several papers question this target strength. Ona (2003) describes how the target strength of herring changes with depth, and measured the target strength of herring to be TS = 20logL – 2.3 log(1 + z/10) – 65.4 where z is depth in meters. Still, 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 ICES WGWIDE 2016 as another year in the time series. Special investigations were made from MS Kings Bay in order to investigate the TS of spawning herring. A Simrad WBAT, portable EK80 were lowered with two split beam transducers into a layer of spawning herring at about 200 m depth, transmitting alternate series of 100 pings at each frequency at high PRF over three hours. The WBAT system was hanging from a surface buoy with positional devices, and was left on drift by the vessel. Trawling and surveying the layer was conducted at 2 -4 nautical miles distance from the buoy until the measurement were finalized. Results from these TS measurements will be analyzed on a later stage and is not included in the report.

The StoX software developed by IMR were used in the abundance estimation in 2017, just as in 2015 and 2016. StoX is an open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes. The underlying high resolution data matrix structure ensures future implementations of e.g. depth dependent target strength and high resolution length and species information collected with camera systems. Despite this complexity, the execution of an index calculation can easily be governed from user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Accessing StoX from external software may be an efficient way to process time series or to perform boot-strapping on one dataset, where for each run, the content of the parameter dataset is altered. Various statistical survey design models can be implemented in the R-library, however, in the current version of StoX the stratified transect design model developed by Jolly and Hampton (1990)[i] is implemented.

Sonar data and analyses

Data from Simrad SIMRAD low frequency sonars SU90 were logged onboard all vessels. In the survey on the shelf, the sonar was recording horizontally to 450 m range, at -3 degrees tilt, and with the combined Omni/180 vertical sections, shooting alternatively. The main task was to observe if the herring were situated in the upper 50 meters towards the surface for potential blind zone corrections of the echo sounder estimates. In the off-shelf area in the North, the sonar were operated in search modus to 3500 m, -4 degree tilt, to search for schools between the surface and 200 m depth. The skipper could then use his favourite settings for herring school searching.

Deviating acoustic observations

A few schools and layers in strata had a peculiar frequency response, deviation from the normal response. The layer then had a strong backscattering at 18 kHz, and at 200 kHz, with weaker response at 38, 70 and 120. The response in the 4 higher frequencies could resample the response of Atlantic mackerel, but with the deviating r(f) at 18 kHz. Repeated sampling showed that this was spawning herring, but the sampling with a big trawl prevented us from detailed sampling inside the layers. Inspections of the swimbladder of 20 herring during sampling indicated normal swimbladder conditions, at least in the caught herring. Detailed inspections of the acoustic registration indicated that some of the herring, but not all, must have either released all air in the bladder (to explain the mackerel response) but still have air in the bulla system of the inner ear (making the bulla resonant at 18 kHz). No content in the stomach which could explain the peculiar r(f) was found, as the herring here has not been feeding at all.

Results and discussion

Description of acoustic registrations

A few examples of typical herring registrations in some of the strata covered are given in Figure 5. Only small quantities of herring were observed in the southern survey region (strata 2 and 3 including Buagrunnen). A few small scattered schools were recorded acoustically in the northern part of stratum 2, but only two schools were sampled with trawl hauls. The herring in the area may be local herring populations spawning or overwintering in the area. No herring was caught in a test trawl haul at the southernmost transect in stratum 3 during night time.

In stratum 4 (63 17ºN-64 13ºN, including Frøyabanken) the first large schools of herring were recorded acoustically and sampled with several trawl hauls.. The herring was mainly in large schools close to the Norwegian coast where the bottom depth was 100-200 m. The herring schools were located vertically between 50-100 m depth. No herring was observed in layers close to the bottom. Although several schools were recorded, the size of the southernmost herring schools was smaller than recorded last year. Hence, the southern front of the herring spawning migration was smaller than in the previous year.

In strata 5 and 6 (64 13ºN - 66 04ºN including Haltenbanken and Sklinnabanken) herring were recorded over a large geographic area. However, the large mid-water schools seen in area 4 was not present in this region although some distinct schools were still observed close to the coast at around 50 m depth. Instead, herring was distributed in layers or small to medium sized schools close to the bottom over a larger geographic area. The layers varied in thickness and density but normally gradually diminished when going westward. Bottom depth in the region was mainly 200-300 m and the layers were located from the bottom to 20-150 meters above the seafloor.

In stratum 7 (66 06 ºN-67 21 ºN) the spatial distribution of herring was more variable than in the first southern regions. Herring were recorded both in schools towards the surface, in layers at the bottom and in large shoals covering the whole water column. In the southern region herring was abundant and occasionally recorded from the surface and down to below 300 m depth. In the northeastern corner, at the opening of Vestfjorden, large areas were absent of herring. Although there were large differences within this region, the total biomass of herring was large.

In stratum 8 (67 21 ºN – 69 29 ºN, including Lofoten and Vesterålen) the abundance of herring was low. Outside Røst herring was distributed in scattered thin layers close to the bottom. In the eastern region only a few small schools were recorded. Further north there were herring layers in the western region along the shelf edge. This herring layers were recorded towards the bottom at the shelf or in layers/schools right outside the shelf edge. Trawl sampling in the region was a challenge due to few herring recordings and areas where trawling was not possible due to stationary fishing gear targeting cod, but some trawl samples were successfully taken.

In stratum 9 (69 29 ºN -70 34 ºN) there were few recordings of herring. Occasional schools were recorded scattered in the region. These schools were often close to the surface, and some schools may have been too shallow to be ensonified by the echo sounder. Sampling was scare due to few observations of herring, stationary fishing gears and shallow waters not suitable for trawling. It was decided to put more effort close to the edge in the western boundary due to recordings of schools at the edge. This area was covered during nighttime and these schools were located at 0-50 m depth. It was also recorded herring in layers towards the bottom at the western edge.

In stratum 10 (70 34 ºN -71 16 ºN) only scattered schools of herring were recorded. The presence of capelin was very clear in this area with a lot of dense schools in the northern part out on Tromsøflaket. The abundance of herring in area 10 was low, and limited to the southern part.

In stratum12 (66 05 ºN -68 00 ºN, west of area 7/8) only a couple of small schools were recorded, with insignificant contribution to the estimation.

Distribution and density

As opposed to the situation in 2016 when the bulk of herring appeared in as real high densities within a small area 66-67ºN, the herring in 2017 was more evenly distributed along the coast 63-71ºN with over 60% found in the area 64-67ºN (Figures 6-7). The survey started at 62ºN in the south, but no herring was observed until Buagrunnen (63ºN) was reached. Here there was an ongoing fishery on the first herring arriving these spawning grounds. After this herring was observed on most transects northwards. This was the first time this survey covered Tromsøflaket, a potential spawning ground for herring in terms of substrates, but here several schools of capelin were observed and no herring. It was apparent that the sexually mature herring did not distribute much further than Fugløybanken. A few schools were observed in the deeper part between Fugløybanken and Tromsøflaket, south in Strata 10, else the main species in this area at the moment was capelin.

Index of abundance and biomass

The official estimate of a spawning stock biomass index using StoX, to be treated as a relative one, was 3.3 million tonnes in 2017 (Table 1, Annex 2) with an uncertainty (CV) of 14.2%. This was a drop in the index of 23% from 4.3 million t estimated in 2016, but the uncertainty in 2016 was much higher with a CV at 40% (Figure 8). The huge CV in 2016 was related to the fact that the main bulk of herring was only measured in high density over a few transects, as compared to 2017 when the herring was distributed over much larger area. The trend since the Spawning surveys started in 2015 is clearly negative (Figure 8), emphasising the need for new recruitment to the stock.

As in 2016, the estimate of 2017 was dominated by three year classes; 2004 most abundant, with 2006 and 2009 coming next (Table 1) (Figure 9), which clearly confirm the problem with no large year classes recruiting to the spawning stock in recent years. However, there was a sign of new recruitment, with the 2013 year class coming in as the fourth most abundant, about 10% in numbers and 5% in biomass. The uncertainty in the estimated of numbers by age show an acceptable uncertainty for the 4 year olds compared with the older fish (Figure 10, Table 2), suggesting that the sign of this new year class trustworthy. Still, normally the vast majority of herring does not appear in the spawning survey until the age of 5 years, so we still have to wait until 2018 before concluding more on the final contribution of the year class.

Sonar observations

Sonar investigations in 2017 indicated that that in general echo sounder biomass estimations were not seriously biased by unaccounted fraction of herring in the upper layers, and that no significant fraction of herring was distributed in the echo sounder blind zone. However, in strata 9, where only 1.25% of the total biomass was recorded, the night-time registrations indicated that there were significant herring densities inside the echo sounder blindzone. Hence, the estimate in this stratum must be considered an underestimate. Sonar data from this area will be put into further analyses to look into the potential underestimation more quantitively, but it is is clear that the total quantities of herring in the areas were not large, and that the underestimation is not of significant importance for the total estimated index. In the rest of the strata, all herring was registered well within the most favourable ranges of the echo sounders.

Geographical variations in age, length, weight

The age and size of the herring was relatively stable all over the area 63-67ºN, with some tendencies deceasing size and age northwards. North of 67ºN younger and smaller herring, predominated by the 4 year olds (2013 year class), started to be most abundant in the samples (Figures 11-13).

This size dependent distribution pattern is in accordance with the observations in earlier years, which has been thoroughly discussed in Slotte and Dommasnes, 1997, 1998, 1999, 2000; Slotte, 1998*b*; Slotte, 1999*a*, Slotte 2000, 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, 1999*b*). 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.

Temperatures experiences by the herring

Temperatures experienced by herring from close to the surface and down to deeper waters than 200 m varied from 5°-8°C, clearly colder close to the surface (Figures 14-16). At the main spawning depths of herring 100-200 m temperature did not vary much along the coast, being rather stable at 7°-8°C.

Quality of the survey for abundance estimation

In 2017 all vessels were equipped with multifrequency equipment on a drop keel. All vessels were able to trawl (in 2015 only one vessel could trawl), which resulted in more sampling on acoustic registrations and more quality of the scrutiny process into herring and other targets.

Weather conditions in 2017 were exceptionally well suited for acoustic surveying, the acoustic data recorded were of high quality from all three vessels. The survey was allowed to be run continuously at 10 knots for the whole survey period ensuring a really good coverage with low distance between transects. There were few problems with air bubble attenuation, or other problems related to acoustic noise in the data, often occurring in periods of bad weather on smaller vessels without a drop keel. Except for a small area in Strata 9, there is no need for processing the sonar data for blind zone estimation, or avoidance related problems.

The acoustic registrations were sampled with pelagic trawling at higher numbers than in previous years, the amount of biological samples, individuals samples and aged, have never been higher in the time series, indicating that the basis for age segregated abundance indices should be good.

No schools were however registered in the off-shelf wintering area around 67ºN, and the herring had also by the time of the survey left the wintering areas in the fjords further north. It was therefore assumed that the survey had an acceptable coverage of the spawning stock migration to and along the coast southwards to spawn. Still, one cannot rule out that some herring were not covered, arriving later from oceanic wintering in the west after the survey covered an area, or perhaps left the area as spent fish prior to the arrival of the survey.

To conclude, the survey must be considered to be a success, as overall, the acoustic and biological data recorded were of best possible quality, and that the distribution of the herring was wide spread leading to a good statistical coverage with many transects. Hence, compared with 2016, the acoustic data in 2017 were less uncertain, with a much lower CV.

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Tables

Table 1. The overall areas estimate of abundance (TSN), total biomass (TSB) and spawning stock biomass (SSB) of Norwegian spring-spawning herring during the spawning season 13-25. February 2017.

									Age													
Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Unknown	Number (1000)	Biomass (tonnes)	Mean weight (g)
15-16	1240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1240	18.jun	15
16-17	1240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1240	31	25
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	3720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3720	111.6	30
19-20	3720	1240	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4960	174.8	35.25
20-21	3246	6229	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9475	427.5	45.12
21-22	-	6965	:-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6965	357.8	51.37
22-23	-	11330	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11330	760	67.08
23-24	-	13737	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13737	997	72.58
24-25	-	8839	3063	1456	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13357	1157.1	86.63
25-26	-	11707	28046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39754	3964	99.71
26-27	-	4189	62635	2297	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69122	7962.9	115.2
27-28	-	1531	180064	6762	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	188358	25353.4	134.6
28-29	-	12549	286964	21562	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	321076	49742.9	154.93
29-30	-	8366	288356	121266	22473	-	4327	-	-	-	-	-	-	-	-	-	-	-	-	-	444787	79780.1	179.37
30-31	-	8366	143074	146763	94381	4183	10984	8675	-	-	-	-	-	-	-	-	-	-	-	-	416426	85833.8	206.12
31-32	-	-	44687	165043	201675	-	8366	-	-	-	-	2164	-	-	-	-	-	-	-	-	421935	96440.5	228.57
32-33	-	-	29501	94969	171851	23337	12223	-	-	-	-	-	-	-	-	-	-	-	-	-	331881	85484.6	257.58
33-34	-	-	8668	59030	177407	98916	213894	-	-	14762	4183	17324	-	1493	-	-	-	-	-	-	595678	173819.4	291.8
34-35	-	-	766	37567	98651	142408	393284	22729	62708	312077	51587	250626	-	18211	-	-	-	-	-	-	1390612	446759.3	321.27
35-36	-	-	-	9072	81727	71709	486918	86676	113899	713403	120664	879455	35754	117451	-	-	-	-	4536	-	2721263	934987.3	343.59
36-37	-	-	-	-	17538	37364	170836	46226	46141	618280	81325	1029952	16732	178408	1895	10653	8366	-	-	-	2263717	822601.1	363.39
37-38	-	-	2167	-	2033	33024	67579	7465	8659	225962	30696	303977	16897	203025	16732	19085	-	-	-	-	937301	362177.1	386.4
38-39	-	-	-	-	-	-	-	4659	-	16440	6988	112600	4659	95135	-	-	-	-	-	-	240481	99522.7	413.85
39-40	-	-	-	-	-	-	7262	-	-	1744	-	4183	-	18842	-	-	-	3527	-	-	35557	15776.1	443.68
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2169	2169	1030.1	475
TSN(1000)	13165	95049	1077991	665786	867735	410941	1375673	176430	231406	1902667	295443	2600282	74042	632564	18628	29738	8366	3527	4536	2169	10486138	-	-
TSB(1000 kg)	436.3	10308.9	179144	148545.2	230863.7	131801.5	458160.7	60683.8	79015.5	672650.7	103171.1	930887.3	26933.4	237170.9	7291.2	10998.8	3103.8	1524.8	1549	1030.1	-	**3295270.6**	-
Mean length (cm)	18.48	25.11	28.72	31.04	32.55	34.5	34.83	35.35	35.27	35.67	35.62	35.91	36.07	36.67	37.01	36.89	36.25	39.25	35.5	40.5	-	-	-
Mean weight (cm)	33.14	108.46	166.18	223.11	266.05	320.73	333.04	343.95	341.46	353.53	349.21	357.99	363.76	374.94	391.42	369.86	371	432.32	341.5	475	-	-	314.3
% mature	0	45	96	98	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100				
SSB (1000 kg)	0	4639.005	71978.24	5574.296	230863.7	131801.5	458160.7	60683.8	79015.5	672650.7	103171.1	930887.3	26933.4	237170.9	7291.2	10998.8	3103.8	1524.8	1549			3277997.7	

Table 2. Norwegian spring-spawning herring during the spawning season 13 -25 February 2016. Uncertainty estimates from 500 boostrap replicates in StoX, by age (total estimates in millions).

Age	5the percentile	median	95th percentile	mean	SD	CV
2	0.000	8.165	30.354	10.514	11.192	1.064
3	39.237	88.943	154.735	91.520	36.567	0.400
4	696.561	1075.913	1618.754	1106.916	273.758	0.247
5	468.983	641.568	892.303	653.164	128.506	0.197
6	644.285	882.541	1192.475	895.013	167.126	0.187
7	310.594	415.041	546.251	420.660	71.173	0.169
8	969.855	1332.344	1789.895	1353.708	249.618	0.184
9	126.418	176.419	240.856	178.881	34.870	0.195
10	132.721	202.045	293.229	205.377	48.258	0.235
11	1581.278	2016.511	2544.384	2032.524	298.757	0.147
12	219.869	298.837	409.378	304.481	57.313	0.188
13	1963.196	2514.219	3234.228	2552.465	388.111	0.152
14	46.421	80.599	130.076	82.429	26.094	0.317
15	504.977	657.222	845.351	659.082	105.262	0.160
16	0.012	9.565	28.644	11.366	9.260	0.815
17	10.140	34.117	75.937	37.352	19.367	0.519
18	0.000	10.283	30.026	11.006	11.178	1.016
19	0.000	3.397	11.545	4.248	3.930	0.925
20	0.000	5.138	16.143	5.764	5.658	0.982

Figures

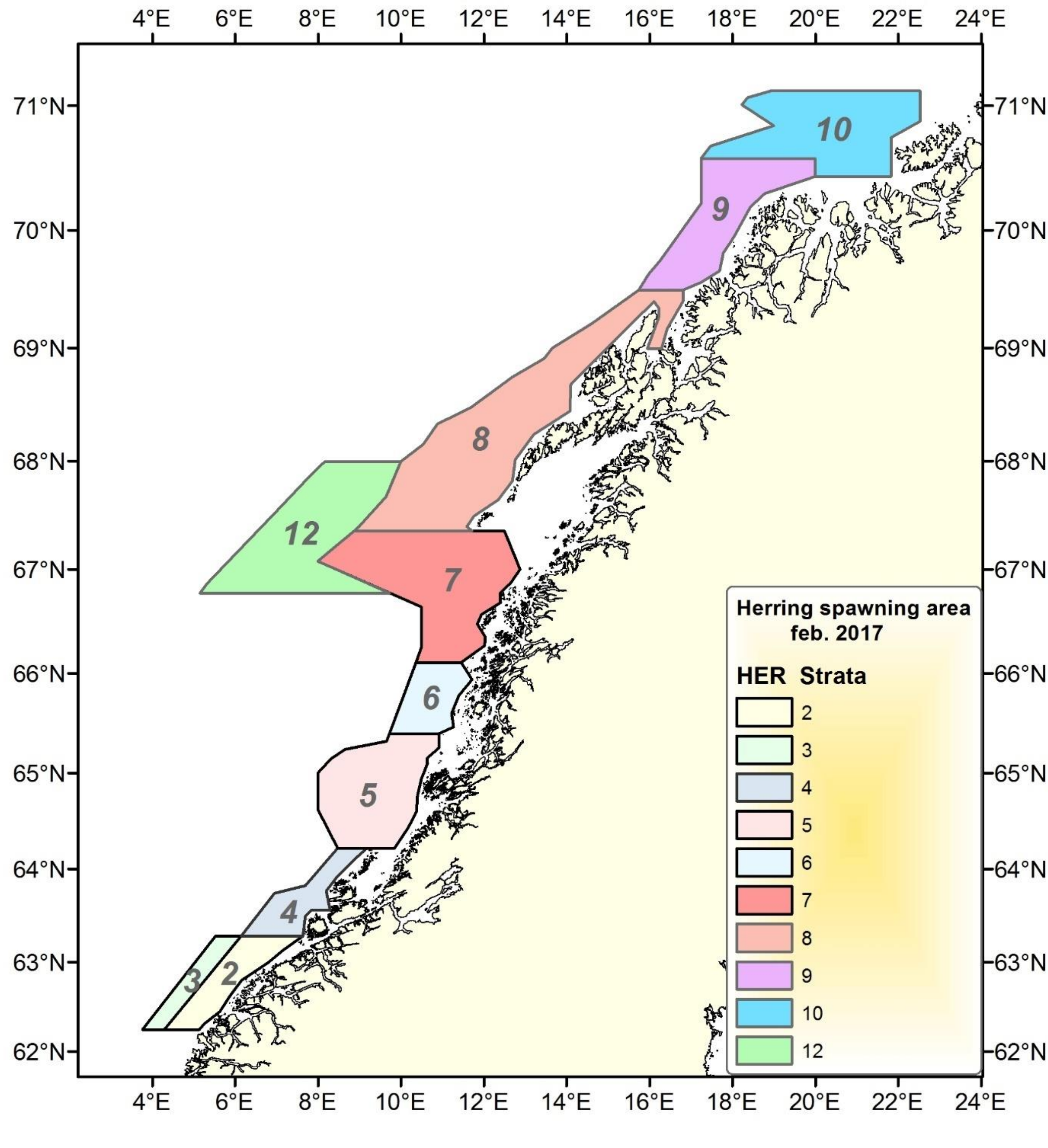

Figure 1. Strata covered during 13-25. February 2017 with MS *Eros, Kings Bay* and *Vendla*

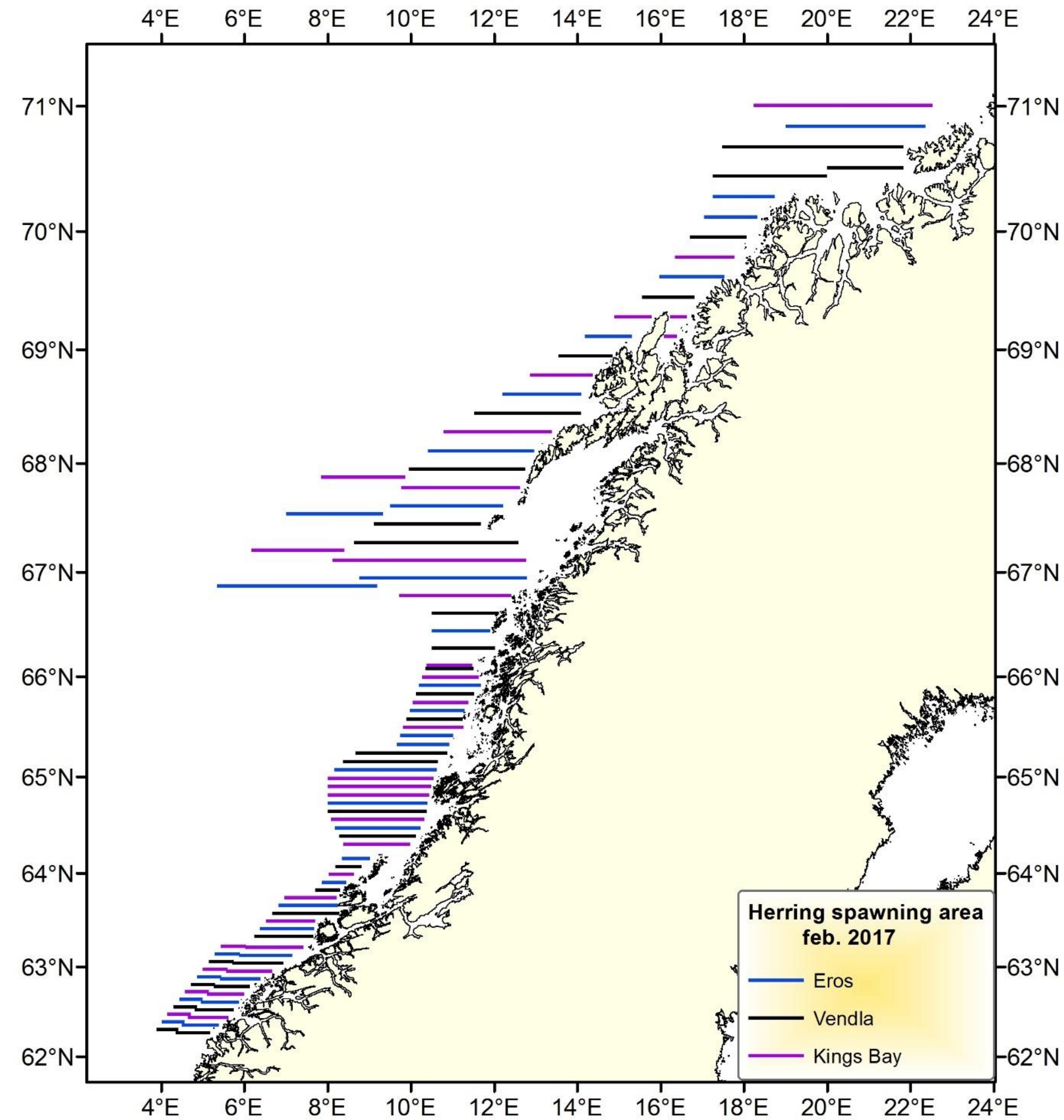

Figure. 2. Acoustic transects covered with *Eros, Kings Bay* and *Vendla* 13-25 February 2017.

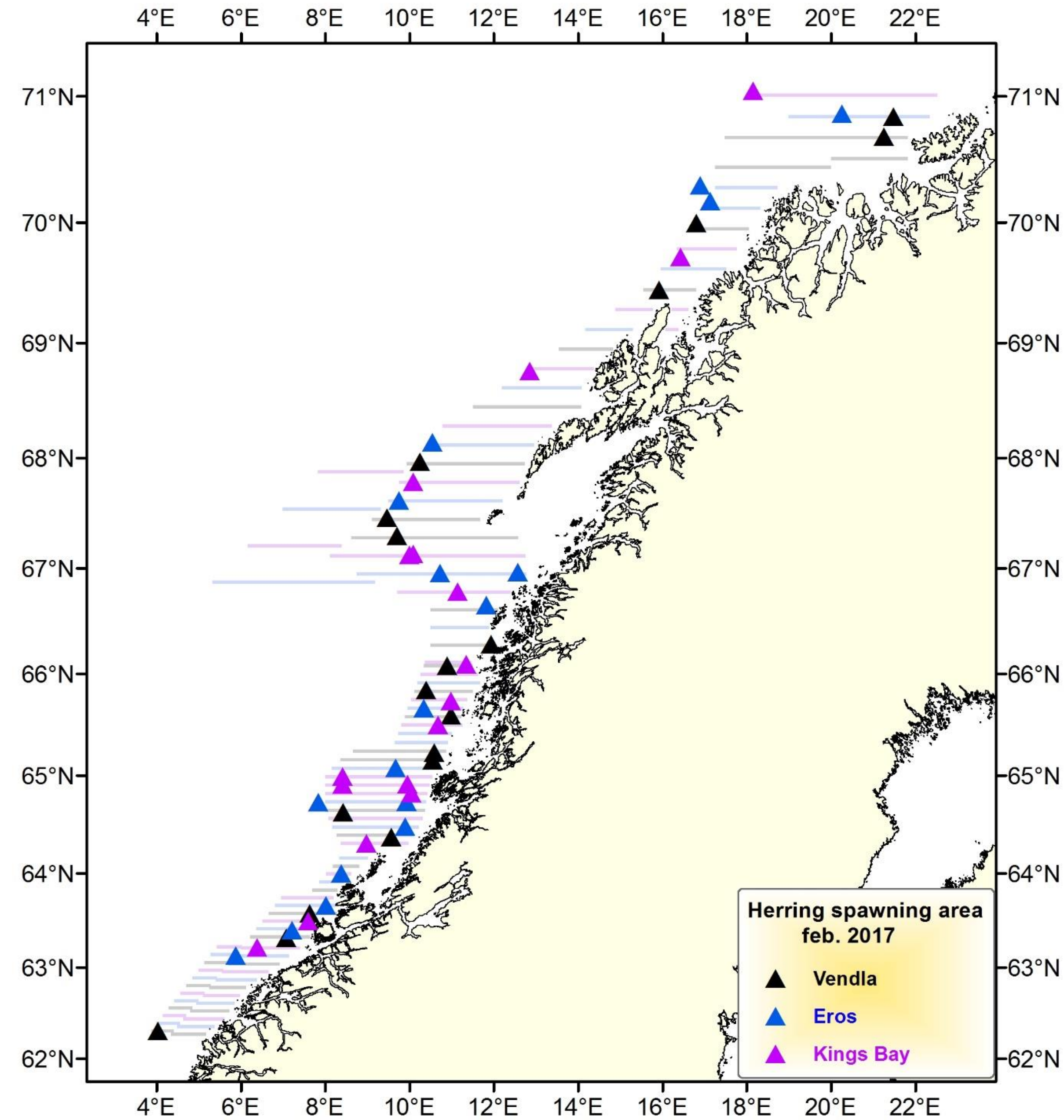

Figure. 3. Trawl stations with MS *Eros, Kings Bay* and *Vendla* taken at acoustic registrations 13-25 February 2017.

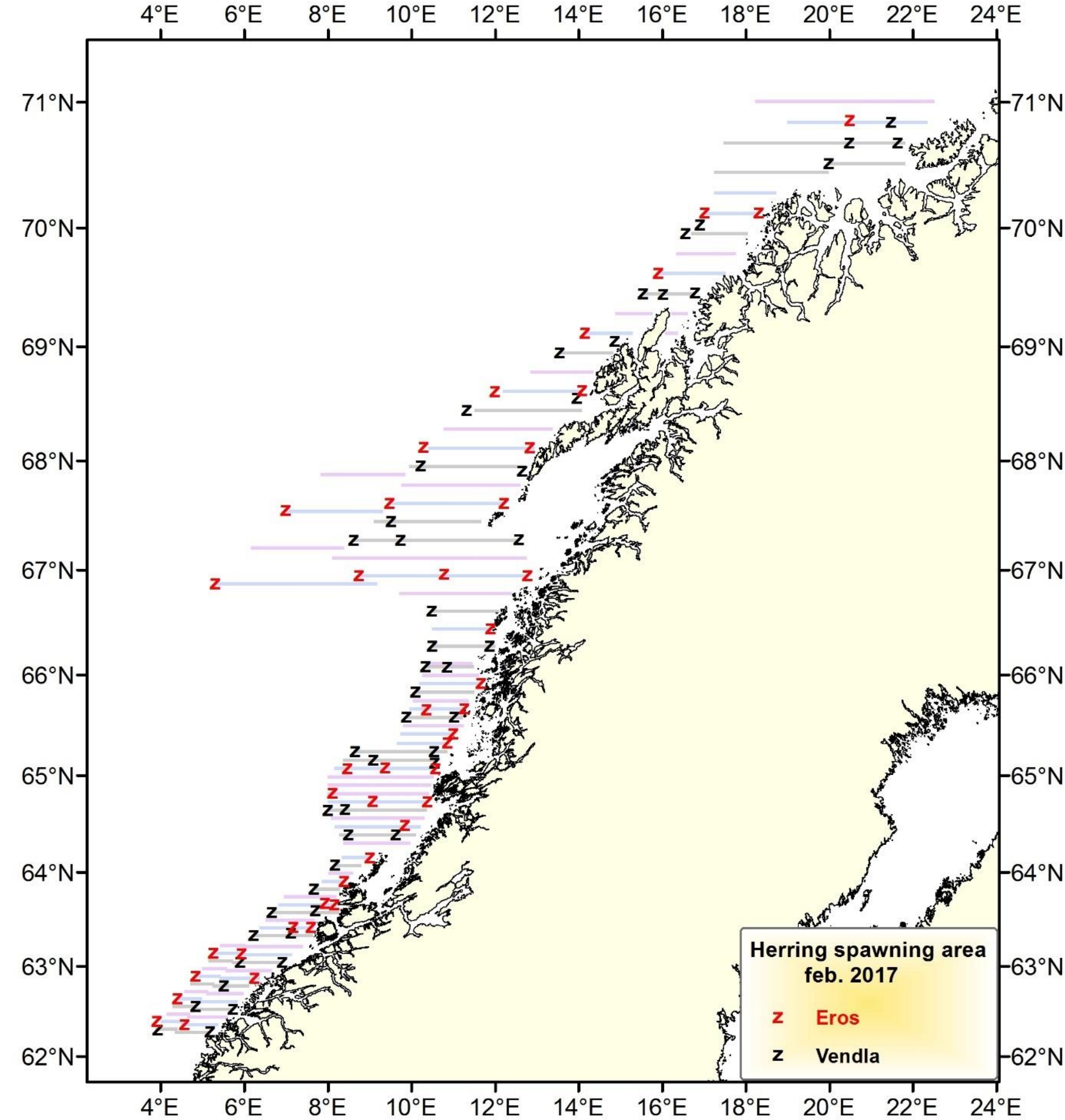

Figure. 4. CTD (Seabird) stations with MS *Eros, Kings Bay* and *Vendla* taken at acoustic registrations 13-25 February 2017.

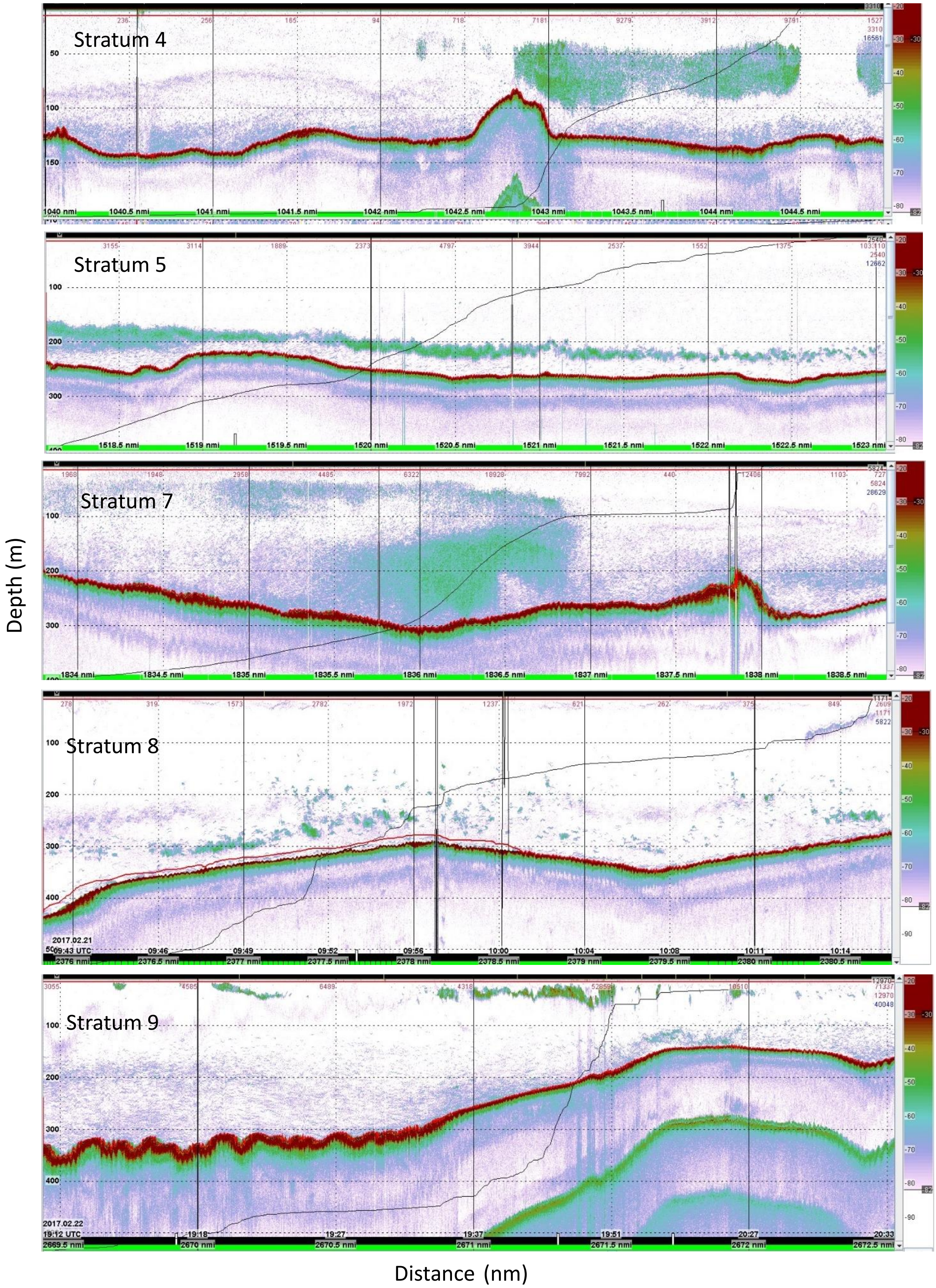

Figure 5. Examples of acoustic registrations og herring recorded in some of the strata along the coast 13-25. February 2017.

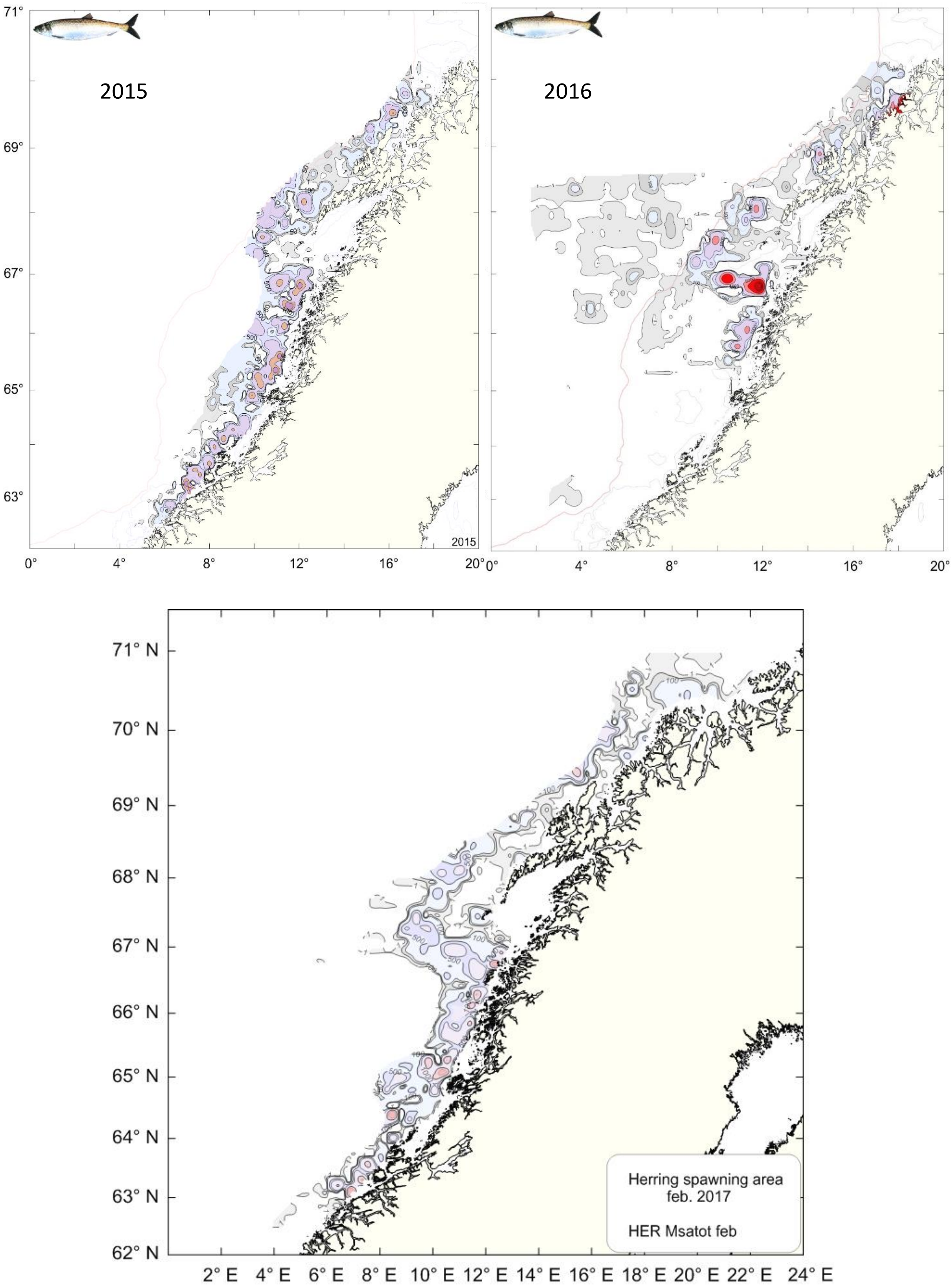

Figure 6. Distribution and acoustic density of herring recorded during 13-25.February 2017 (bottom), compared with the situations in 2015 and 2016 (top).

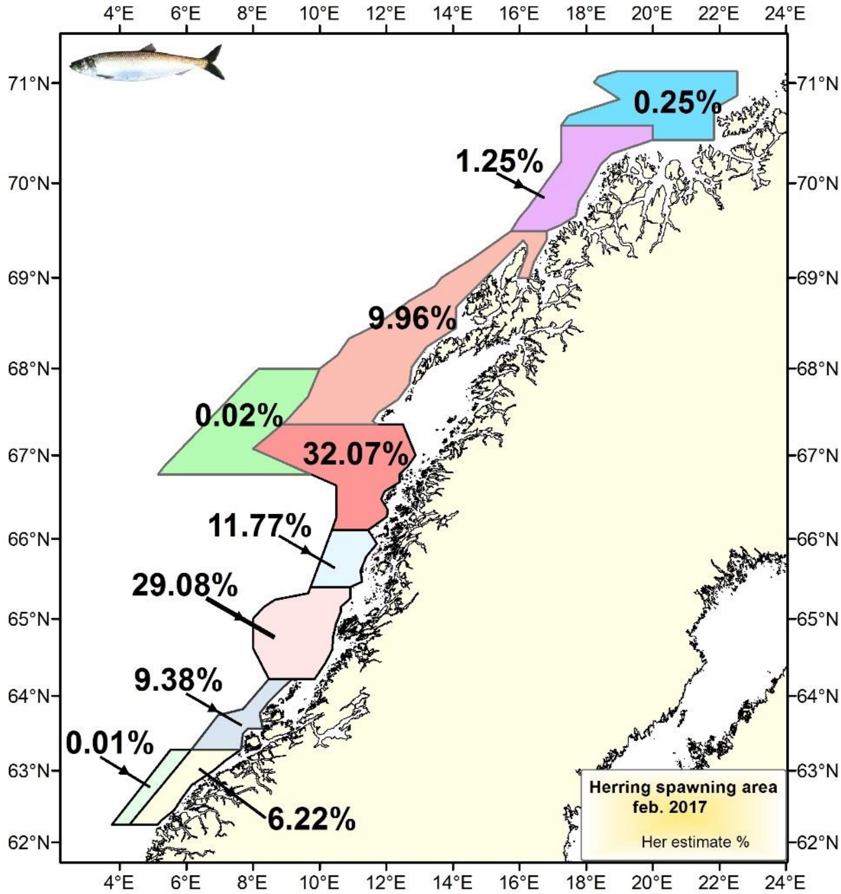

Figure 7. Percent of total biomass estimated in the different strata surveyed 13-25.February 2017.

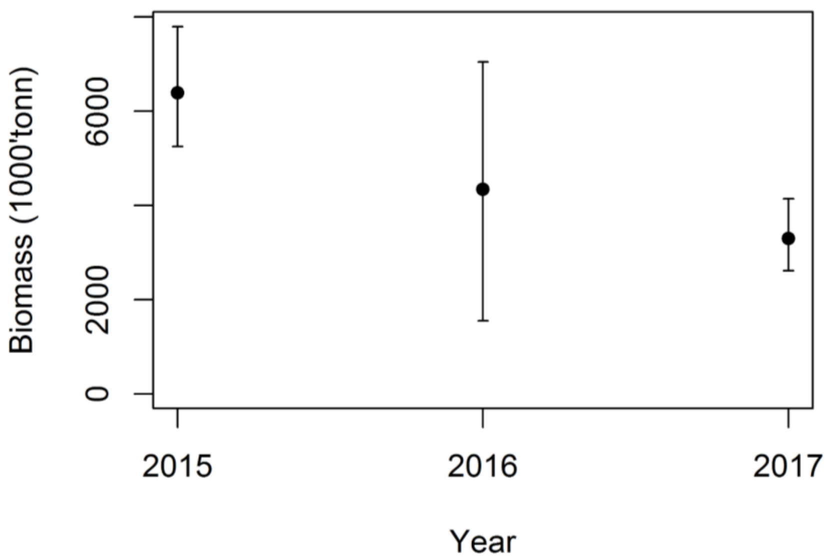

Figure 8. Biomass index estimated from the Norwegian spring-spawning herring spawning surveys 2015-2017 (the error bares represent ±90% confidence intervals).

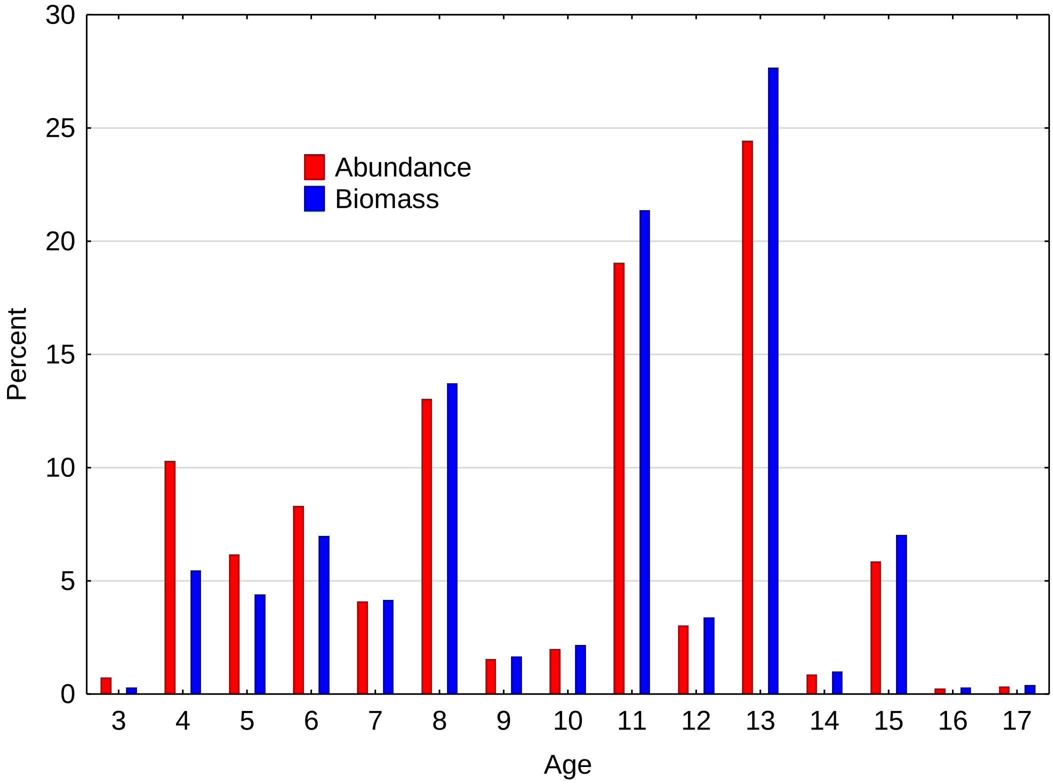

Figure 9. The age distribution in abundance and biomass index estimated during 13-25. February 2017.

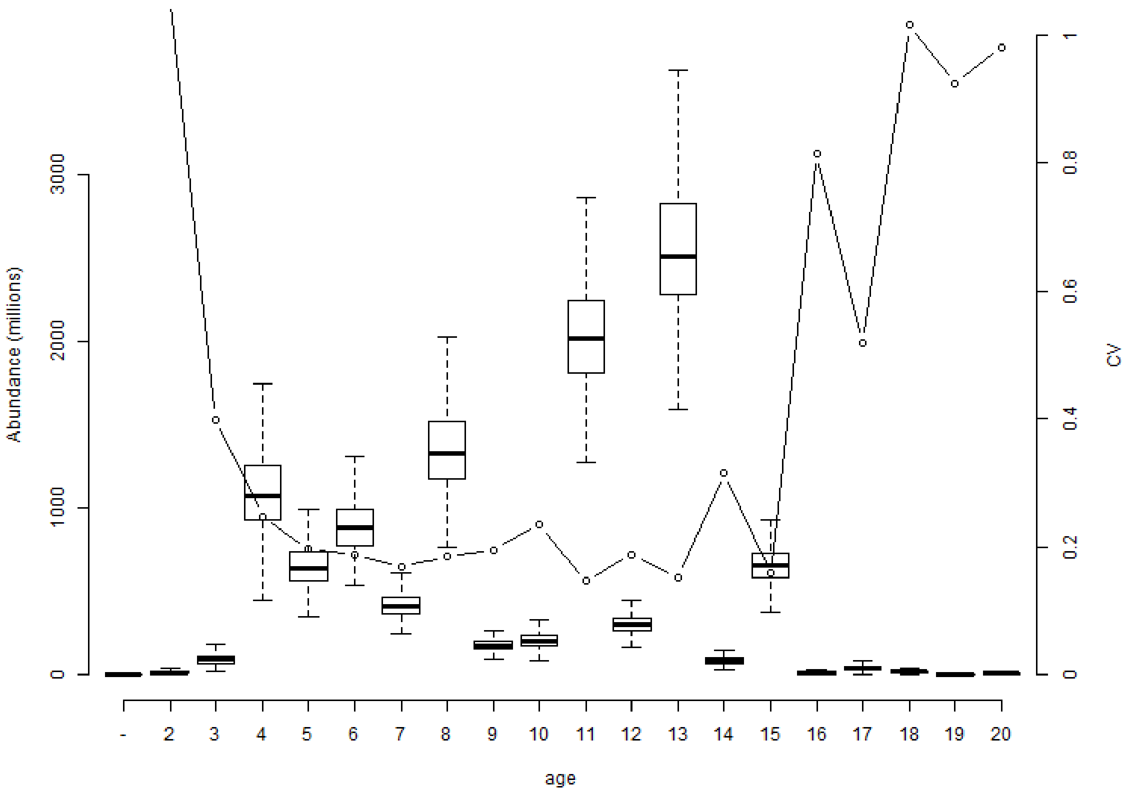

Figure 10. Standard box plot of abundance by age estimated during 13-25. February 2017, based on 500 bootstrap replicates in StoX

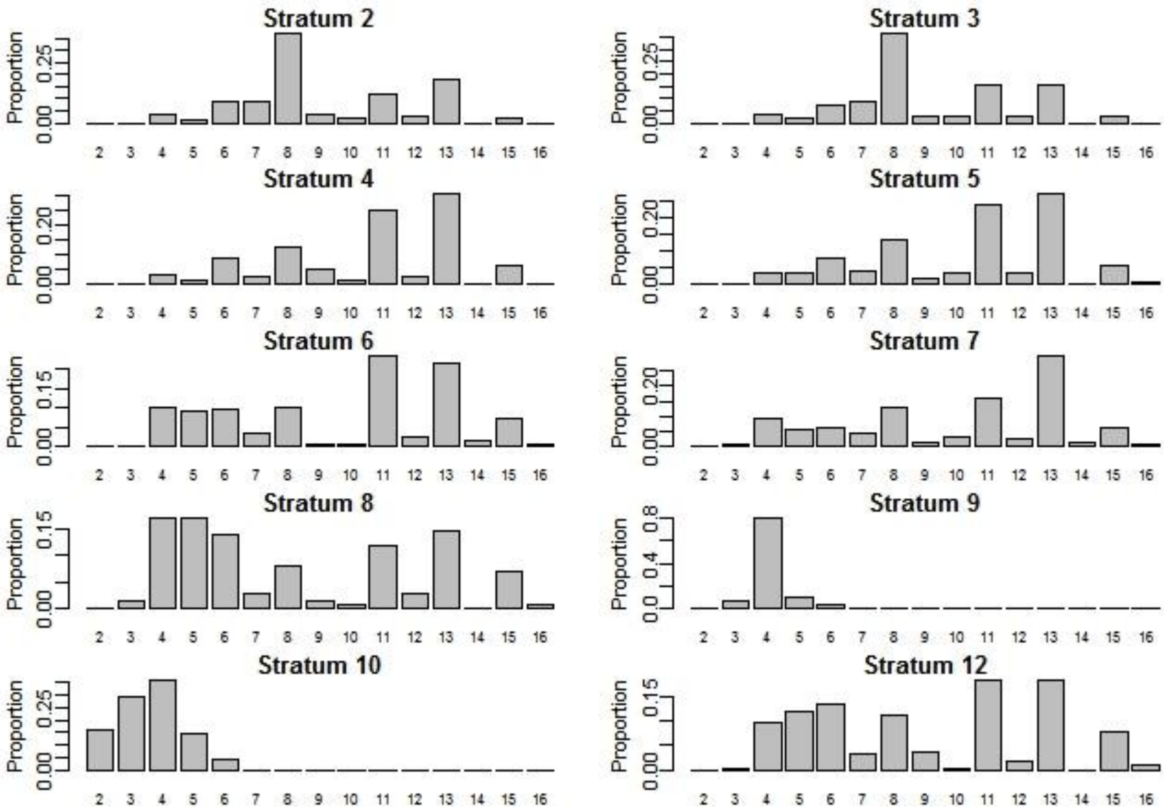

Figure 11. Comparison of relative age composition estimated in the different strata 13-25. February 2017.

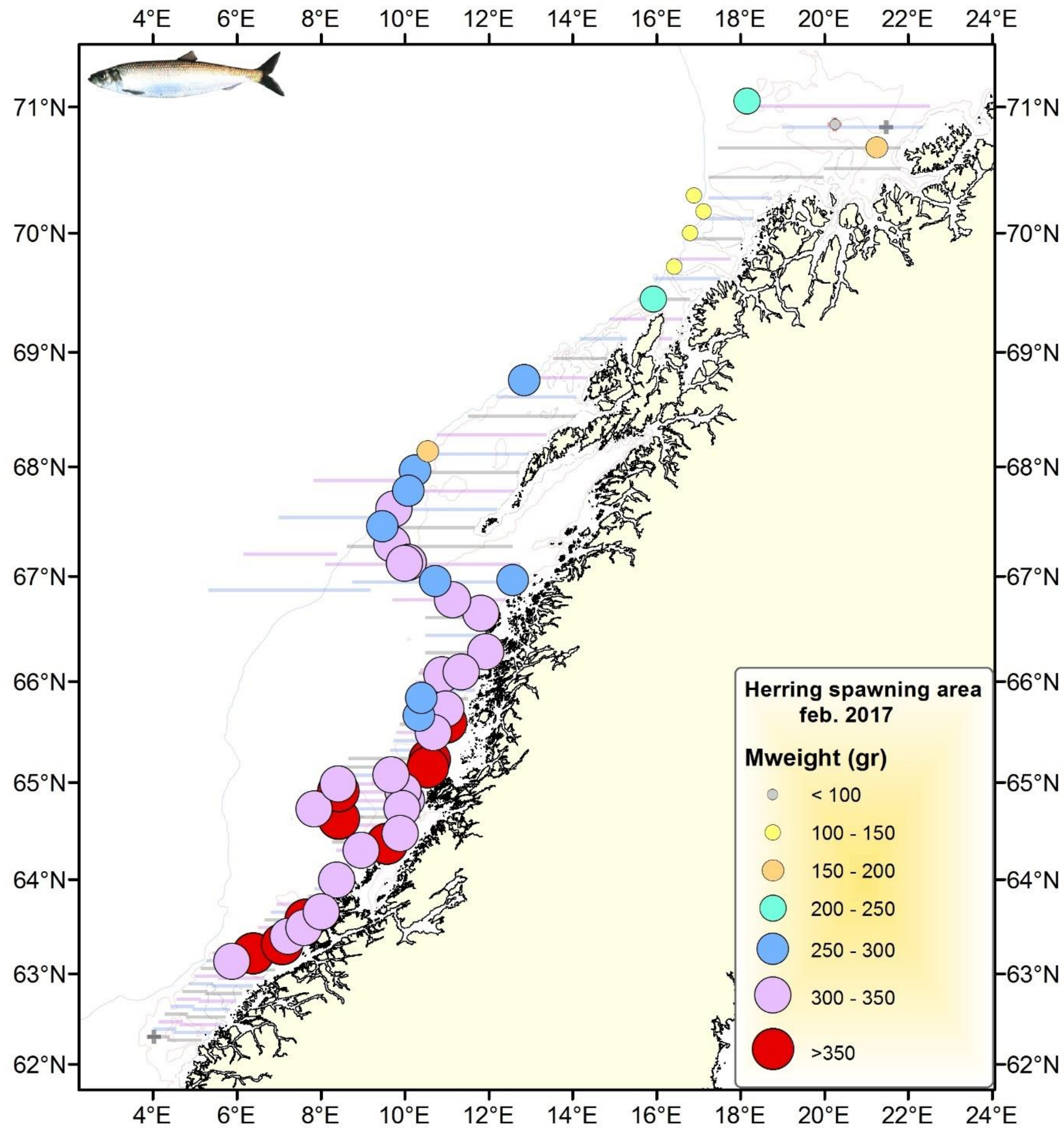

Figure 12. Spatial differences in mean herring weight (g) in the survey during 13-25. February 2017.

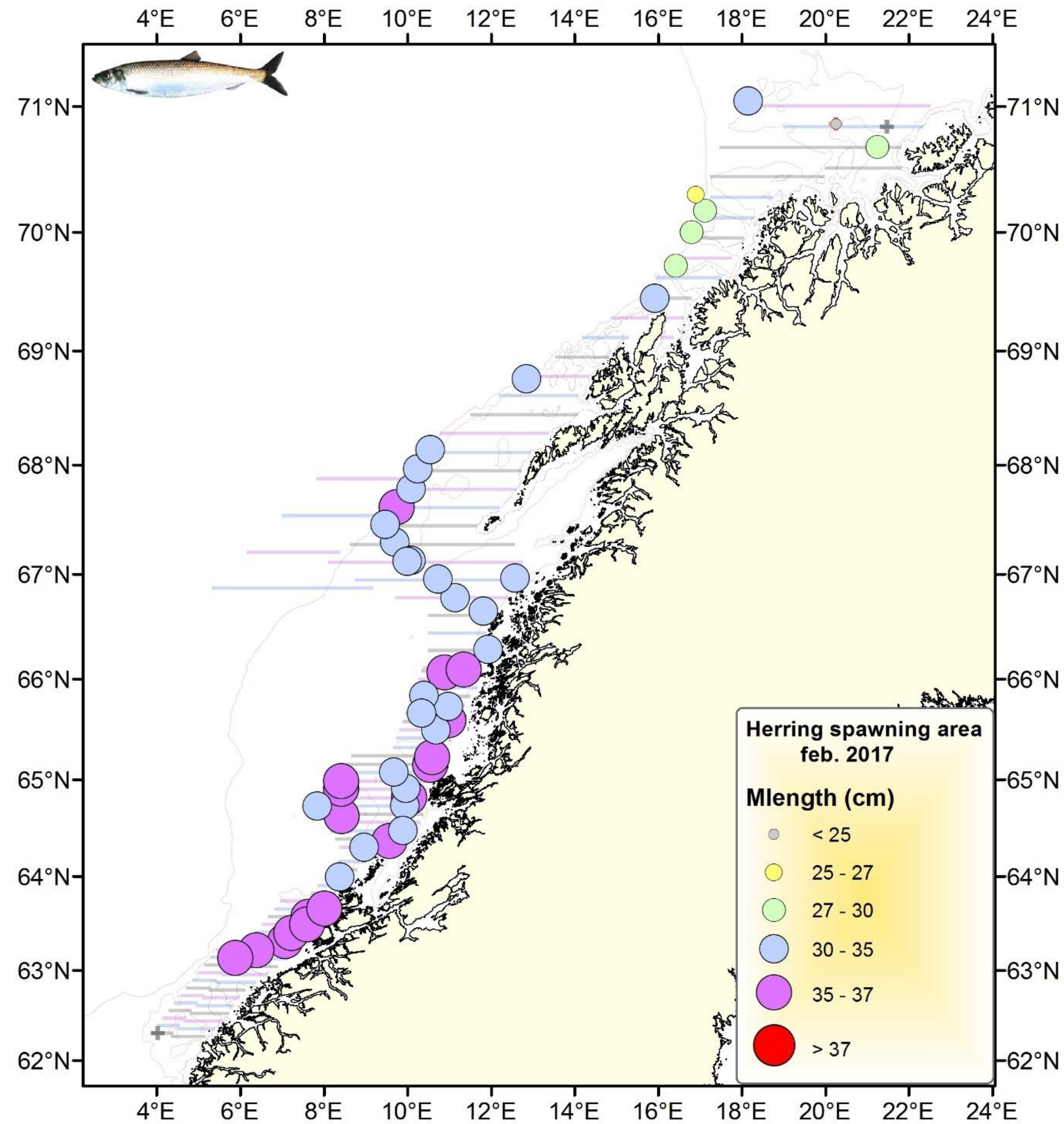

Figure 13. Spatial differences in mean herring body length (cm) in the survey during 13-25. February 2017.

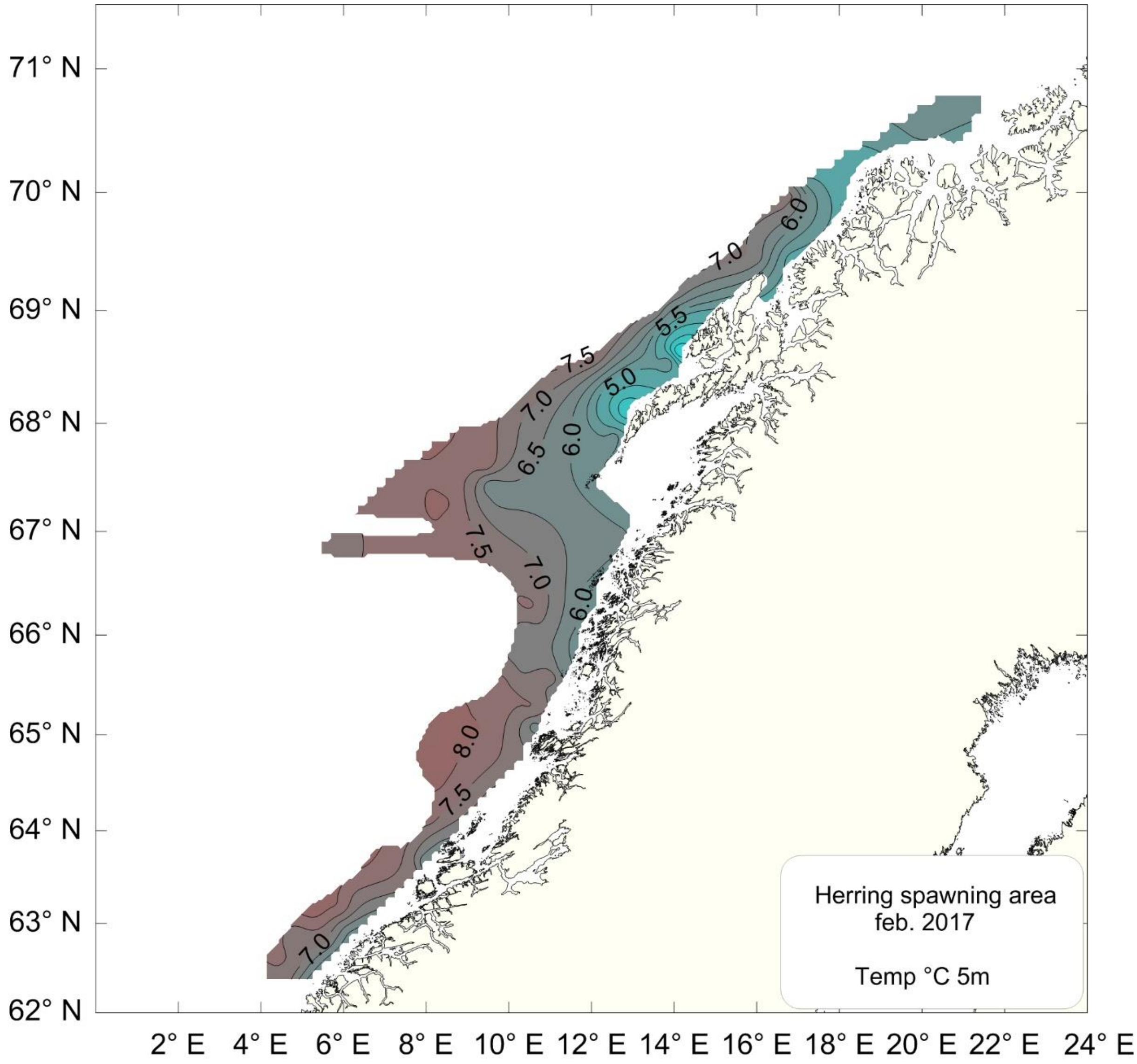

Figure 14. Temperature at 5 m in the survey area covered 13-15.February 2017.

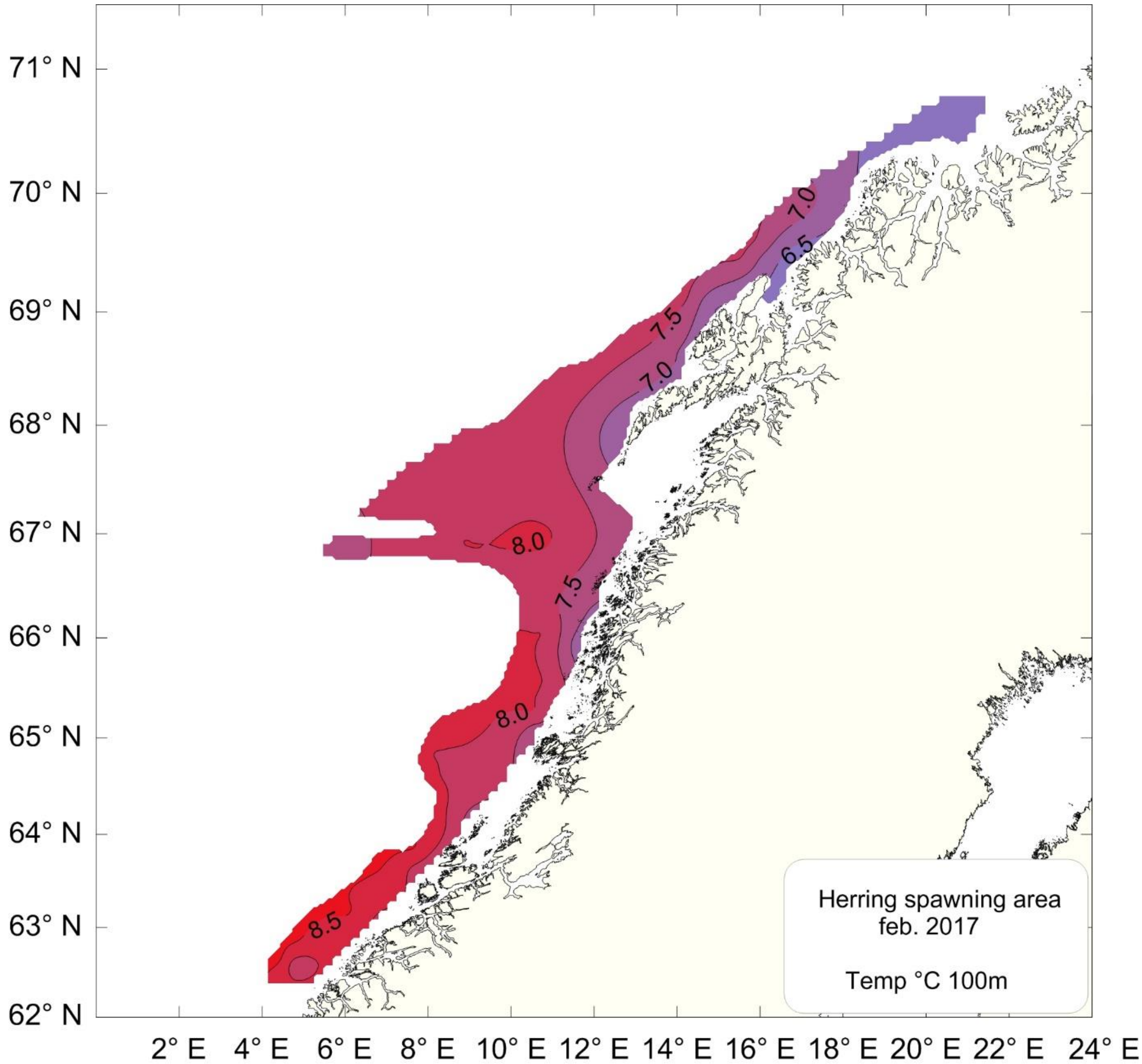

Figure 15. Temperature at 100 m in the survey area covered 13-15.February 2017.

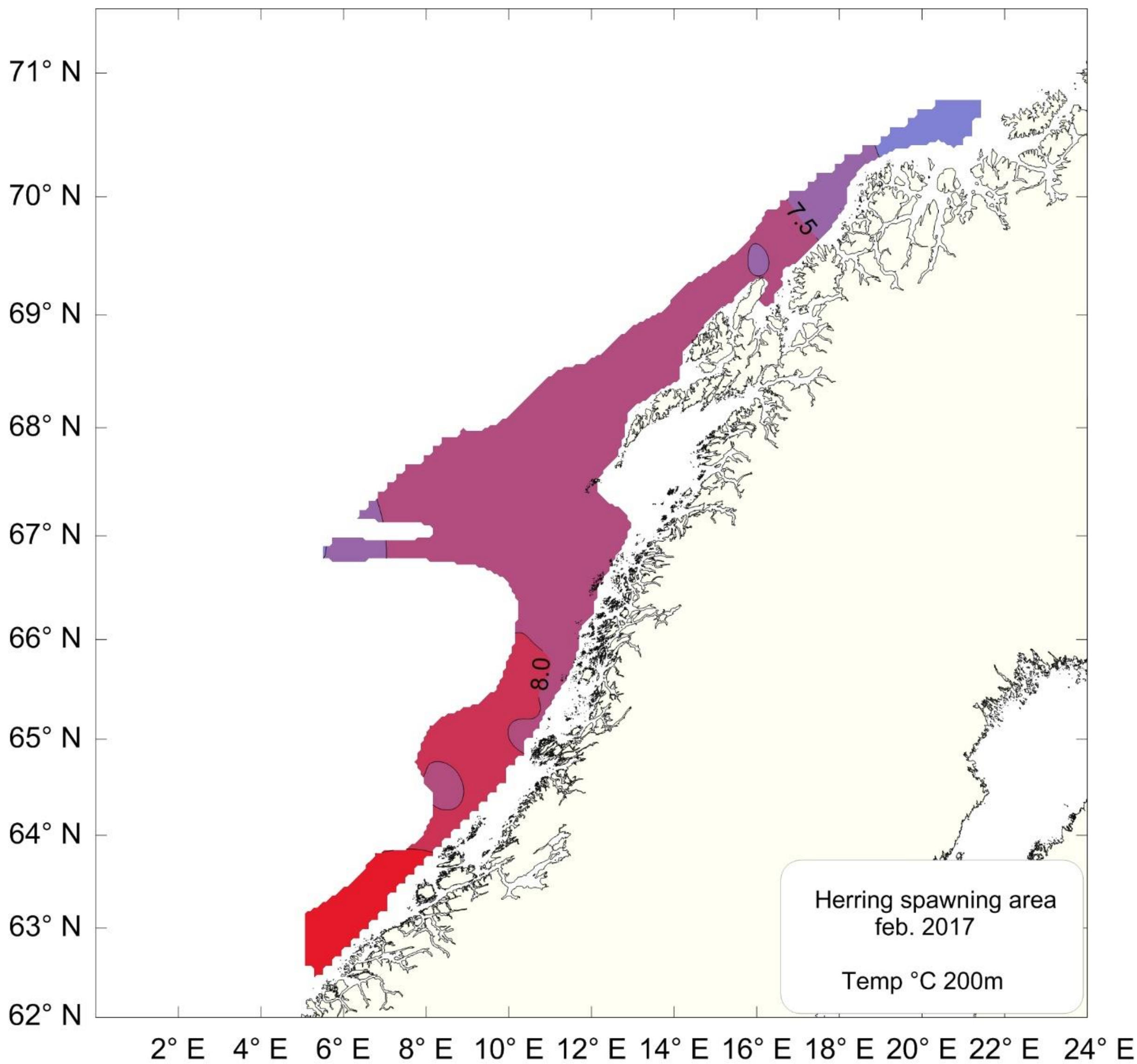

Figure 16. Temperature at 200 m in the survey area covered 13-15.February 2017.

Annex 1. Calibration results and settings

CALIBRATION RESULTS AND SETTINGS OF EK60 OF 3 VESSELS PARTICIPATING IN THE SURVEY

Table 1. The EK60 echo sounder technical specifications and settings employed during the survey aboard the FRV “Kings Bay”, spawning herring survey February 2017. Calibrations of the systems were conducted at the fisheries pier (35 m depth) in Ålesund, Norway on 13.02.2017.

EK60 ECHO SOUNDER SYSTEM	18 kHz	38kHz	70 kHz	120 kHz	200 kHz
TRANSDUCER					
Model	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Equivalent beam angle 10log Ψ [dB]	-17.0	-20.6	-21.0	-21.0	-20.7
CALIBRATION					
Sphere	CU64	CU60	WC-38.1	WC-38.1	WC-38.1
Range to sphere [m]	20	19	21	20	20
Sound speed [m/s]	1483	1483	1483	1483	1483
Absorption coefficient [dB km^{-1}]	2.7	9.8	21.8	31.3	48.8
Gain [dB]	22.91	22.94	26.39	26.58	27.44
Sa correction [dB]	-0.65	-0.64	-0.31	-0.32	-0.32
Beams					
Alongship half power opening angle [deg]	10.51	7.07	6.61	6.58	6.67
Offset Along. Angle [deg]	0.14	0.16	-0.04	-0.36	-0.09
Athwartship half power opening angle deg]	10.78	7.08	6.75	7.17	6.54
Offset Athwart. Angle [deg]	0.05	0.05	-0.06	-0.20	0.20
Survey Settings					
Sound speed [m/s]	1483	1483	1483	1483	1483
Pulse duration [ms]	1.024	1.024	1.024	1.024	1.024
Electrical Power (W)	2000	2000	750	250	150
NL (survey speed, 10 knots)	-149/38	-151/38	-143/51	-164/36	-160/42
(dB re. 1W/ dB re.1 uPa /√Hz), 38 kHz					

Table 2. The EK60 echo sounder technical specifications and settings employed during the survey aboard the FRV “EROS”, spawning herring survey February 2017. Calibrations of the systems were conducted at the fisheries pier (35 m depth) in Ålesund, Norway on 13.02.2017.

EK60 ECHO SOUNDER SYSTEM	18 kHz	38kHz	70 kHz	120 kHz	200 kHz
TRANSDUCER					
Model	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Equivalent beam angle 10log Ψ [dB]	-17.0	-20.6	-21.0	-21.0	-20.7
CALIBRATION					
Sphere	CU64	CU60	WC-38.1	WC-38.1	WC-38.1
Range to sphere [m]	24	24	24	23	23
Sound speed [m/s]	1483	1483	1483	1483	1483
Absorption coefficient [dB km^{-1}]	2.7	9.7	21.4	33.8	47.6
Gain [dB]	22.05	25.72	26.77	26.36	26.02
Sa correction [dB]	-0.70	-0.57	-0.33	-0.29	-0.28
Beams					
Alongship half power opening angle [deg]	11.18	7.24	6.92	6.61	6.19
Offset Along. Angle [deg]	0.13	0.08	-0.19	-0.02	-0.07
Athwartship half power opening angle [deg]	10.96	7.20	6.66	6.59	6.34
Offset Athwart. Angle [deg]	0.12	0.04	0.09	-0.04	0.07
Survey Settings					
Sound speed [m/s]	1483	1483	1483	1483	1483
Pulse duration [ms]	1.024	1.024	1.024	1.024	1.024
Electrical Power (W)	2000	2000	750	250	150
NL (survey speed, 10 knots)	-140/47	-157/34	-157/37	-163/36	-168/38
(dB re. 1 W/ dB re. 1 uPa /√Hz), 38 kHz					

Table 3. The EK60 echo sounder technical specifications and settings employed during the survey aboard the FRV "Vendla", spawning herring survey February 2017. Calibrations of the systems were conducted at the fisheries pier (35 m depth) in Ålesund, Norway on 13.02.2017.

EK60 ECHO SOUNDER SYSTEM	18 kHz	38kHz	70 kHz	120 kHz	200 kHz
TRANSDUCER					
Model	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Equivalent beam angle 10log Ψ [dB]	-17.0	-20.6	-21.0	-21.0	-20.7
CALIBRATION					
Sphere	CU64	CU60	WC-38.1	WC-38.1	WC-38.1
Range to sphere [m]	25	25	24	24	23
Sound speed [m/s]	1483	1483	1483	1483	1483
Absorption coefficient [dB km^{-1}]	2.7	9.6	21.6	34.4	48.5
Gain [dB]	22.75	25.51	26.47	27.14	27.87
Sa correction [dB]	-0.57	-0.72	-0.34	-0.33	-0.32
Beams					
Alongship half power opening angle [deg]	10.91	7.09	6.56	6.52	6.15
Offset Along. Angle [deg]	-0.02	-0.16	0.01	0	0
Athwartship half power opening angle [deg]	10.98	7.05	6.65	6.61	6.25
Offset Athwart. Angle [deg]	-0,19	0.06	-0.05	-0.01	-0.06
Survey Settings					
Sound speed [m/s]	1483	1483	1483	1483	1483
Pulse duration [ms]	1.024	1.024	1.024	1.024	1.024
Electrical Power (W)	2000	2000	750	250	120
NL (survey speed, 10 knots)	-133/50	-155/35	-147/49	-157/42	-153/50
(dB re. 1W/ dB re. 1 uPa /√Hz), 38 kHz					

Annex 2. Index of abundance estimates and biomass by strata

Variable: Abundance
EstLayer: 1
Stratum: 2
SpecCat: SILDG03

LenGrp	age 4	5	6	7	8	9	10	11	12	13	15	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-30	2895	-	-	-	-	-	-	-	-	-	-	2895	524.0	181.00
30-31	2888	-	-	-	-	8663	-	-	-	-	-	11550	2416.9	209.25
31-32	-	2895	5790	-	-	-	-	-	-	-	-	8684	2159.5	248.67
32-33	5790	-	8684	-	-	-	-	-	-	-	-	14474	4075.8	281.60
33-34	8655	-	8655	-	8655	-	-	-	-	-	-	25966	7455.1	287.11
34-35	-	5752	5752	8628	40262	-	-	5752	-	-	-	66145	21511.6	325.22
35-36	-	-	11508	14385	92062	11508	2877	31646	8631	14385	-	187002	65706.7	351.37
36-37	-	-	8645	25935	46106	-	-	25935	-	43225	2882	152728	58039.4	380.02
37-38	-	-	-	-	20175	-	8647	5764	8647	14411	8647	66290	27060.8	408.22
38-39	-	-	-	-	-	-	-	-	-	31669	-	31669	13465.0	425.18
39-40	-	-	-	-	5761	-	-	-	-	-	-	5761	2681.6	465.50
TSN(1000)	20227	8647	49034	48947	213022	20170	11523	69097	17277	103689	11528	573163	-	-
TSB(1000 kg)	5258.4	2498.0	15669.0	17524.1	75695.5	6062.7	4347.2	25293.3	6888.4	40943.0	4916.8	-	205096.3	-
Mean length (cm)	31.93	33.16	34.00	35.59	35.55	33.21	36.63	35.77	36.25	36.82	36.88	-	-	-
Mean weight (g)	259.97	288.90	319.56	358.02	355.34	300.58	377.25	366.05	398.69	394.86	426.50	-	-	357.83

Variable: Abundance
EstLayer: 1
Stratum: 3
SpecCat: SILDG03

LenGrp	age 4	5	6	7	8	9	10	11	12	13	15	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-30	4	-	-	-	-	-	-	-	-	-	-	4	0.8	181.00
30-31	4	-	-	-	-	13	-	-	-	-	-	17	3.5	209.25
31-32	-	4	8	-	-	-	-	-	-	-	-	13	3.2	248.67
32-33	8	-	13	-	-	-	-	-	-	-	-	21	6.0	281.60
33-34	13	-	13	-	13	-	-	-	-	-	-	38	10.9	287.11
34-35	-	13	4	8	63	-	-	8	-	-	-	97	31.5	325.22
35-36	-	-	17	34	114	13	13	63	13	8	-	274	96.2	351.37
36-37	-	-	4	30	76	-	-	51	-	55	8	224	85.0	380.02
37-38	-	-	-	-	34	-	13	8	8	17	17	97	39.6	408.22
38-39	-	-	-	-	-	-	-	-	-	46	-	46	19.7	425.18
39-40	-	-	-	-	8	-	-	-	-	-	-	8	3.9	465.50
TSN(1000)	30	17	59	72	308	25	25	131	21	127	25	839	-	-
TSB(1000 kg)	7.7	4.9	18.4	25.5	109.1	7.1	9.8	47.7	8.3	51.0	10.8	-	300.3	-
Mean length (cm)	31.93	33.50	33.60	35.56	35.60	32.75	36.25	35.76	36.00	37.02	36.75	-	-	-
Mean weight (g)	259.25	289.42	311.33	356.20	354.43	280.71	387.01	365.33	394.23	402.86	427.34	-	-	357.83

Variable: Abundance
EstLayer: 1
Stratum: 4
SpecCat: SILDG03

LenGrp	age 4	5	6	7	8	9	10	11	12	13	14	15	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28-29	1493	-	-	-	-	-	-	-	-	-	-	-	1493	258.3	173.00
29-30	5972	-	-	-	-	-	-	-	-	-	-	-	5972	1055.6	176.75
30-31	8958	-	4479	-	-	-	-	-	-	-	-	-	13437	2845.7	211.78
31-32	11944	-	-	-	-	-	-	-	-	-	-	-	11944	2747.1	230.00
32-33	-	7465	17916	-	-	-	-	-	-	-	-	-	25381	6764.8	266.53
33-34	-	7465	10451	-	1493	-	-	-	-	8958	-	1493	29860	8537.0	285.90
34-35	-	-	16423	2986	37325	-	4479	35832	-	19409	-	7465	123919	40709.7	328.52
35-36	-	-	28367	13437	38818	32846	7465	64199	11944	107496	4479	10451	319502	109056.3	341.33
36-37	-	-	2986	7465	17916	5972	-	74650	4479	83608	-	19409	216485	78729.0	363.67
37-38	-	-	-	2986	14930	7465	-	38818	5972	41804	-	13437	125412	48939.1	390.23
38-39	-	-	-	-	-	-	-	7465	-	8958	-	2986	19409	8008.5	412.62
39-40	-	-	-	-	1493	-	-	-	-	-	-	1493	2986	1309.4	438.50
TSN(1000)	28367	14930	80622	26874	111975	46283	11944	220964	22395	270233	4479	56734	895801	-	-
TSB(1000 kg)	5986.9	3998.3	24503.1	9528.3	38437.3	16034.8	4068.4	79550.1	7841.2	96477.8	1630.4	20903.5	-	308960.3	-
Mean length (cm)	30.42	32.85	33.83	35.61	35.37	35.71	35.00	35.87	35.97	35.85	35.17	36.20	-	-	-
Mean weight (g)	211.05	267.80	303.93	354.56	343.27	346.45	340.63	360.01	350.13	357.02	364.00	368.45	-	-	344.90

Variable: Abundance
EstLayer: 1
Stratum: 5
SpecCat: SILDG03

LenGrp	age 4	5	6	7	8	9	10	11	12	13	14	15	17	20	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-28	4337	2169	-	-	-	-	-	-	-	-	-	-	-	-	-	6506	980.2	150.67
28-29	15180	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15180	2563.3	168.86
29-30	51922	10817	12980	-	4327	-	-	-	-	-	-	-	-	-	-	80046	15102.8	188.68
30-31	21640	12984	23804	-	2164	-	-	-	-	-	-	-	-	-	-	60593	12798.0	211.21
31-32	2164	12983	41113	-	-	-	-	-	-	2164	-	-	-	-	-	58424	13883.3	237.63
32-33	-	34681	37159	2477	2477	-	-	-	-	-	-	-	-	-	-	76795	20457.1	266.39
33-34	-	9841	44287	19683	71351	-	-	14762	-	-	-	-	-	-	-	159924	48031.4	300.34
34-35	-	12294	31966	51637	113109	17212	14753	98356	12294	83602	-	4918	-	-	-	440142	144106.0	327.41
35-36	-	9072	34019	13608	113396	13608	47626	213184	45358	299365	2268	27215	-	4536	-	823254	285093.0	346.30
36-37	-	-	-	-	55986	13437	33591	257534	31352	273210	-	35831	6718	-	-	707660	260100.7	367.55
37-38	2167	-	-	21672	21672	-	-	93190	6502	86688	4334	52013	13003	-	-	301242	116931.8	388.17
38-39	-	-	-	-	-	4659	-	6988	6988	18636	4659	27954	-	-	-	69885	29307.3	419.37
39-40	-	-	-	-	-	-	-	-	-	-	-	17349	-	-	-	17349	7817.8	450.62
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2169	2169	1030.1	475.00
TSN(1000)	97410	104842	225328	109077	384482	48915	95971	684015	102495	763666	11261	165279	19722	4536	2169	2819167	-	-
TSB(1000 kg)	18440.6	27235.4	61697.2	36293.8	129486.3	17226.7	34080.6	244146.1	36554.6	274198.9	4395.7	64496.6	7370.9	1549.0	1030.1	-	958202.7	-
Mean length (cm)	29.50	32.12	32.63	34.76	34.77	35.52	35.38	35.75	35.81	35.81	37.21	36.97	36.83	35.50	40.50	-	-	-
Mean weight (g)	189.31	259.78	273.81	332.74	336.78	352.17	355.11	356.93	356.65	359.06	390.34	390.23	373.75	341.50	475.00	-	-	339.89

Variable: Abundance
EstLayer: 1
Stratum: 6
SpecCat: SILDG03

	age																	
LenGrp	3	4	5	6	7	8	9	10	11	12	13	14	15	17	19	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	1744	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1744	78.5	45.00
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27-28	-	3487	-	-	-	-	-	-	-	-	-	-	-	-	-	3487	528.3	151.50
28-29	-	15692	1744	-	-	-	-	-	-	-	-	-	-	-	-	17436	2842.1	163.00
29-30	-	45333	10462	-	-	-	-	-	-	-	-	-	-	-	-	55795	10114.6	181.28
30-31	-	25504	20867	11593	-	4637	-	-	-	-	-	-	-	-	-	62601	12944.4	206.78
31-32	-	19940	5982	35892	-	-	-	-	-	-	-	-	-	-	-	61813	14410.4	233.13
32-33	-	17436	17436	3487	-	3487	-	-	-	-	-	-	-	-	-	41846	10168.6	243.00
33-34	-	-	31861	41817	-	19913	-	-	-	-	-	-	-	-	-	93592	26036.4	278.19
34-35	-	-	11656	9713	29139	36910	-	5828	40795	5828	5828	-	5828	-	-	151524	47137.5	311.09
35-36	-	-	-	7817	11725	52763	-	1954	72305	11725	76213	3908	13679	-	-	252090	86699.3	343.92
36-37	-	-	-	5902	3935	5902	5902	-	106244	9837	125919	-	39350	3935	-	306929	110464.8	359.90
37-38	-	-	-	-	-	10768	-	-	30509	5384	52045	12563	25125	-	-	136394	51783.0	379.66
38-39	-	-	-	-	-	-	-	-	1986	-	19861	-	9931	-	-	31778	13088.7	411.88
39-40	-	-	-	-	-	-	-	-	1744	-	-	-	-	-	1744	3487	1475.1	423.00
TSN(1000)	1744	127393	100006	116221	44799	134380	5902	7782	253583	32774	279867	16471	93913	3935	1744	1220515	-	-
TSB(1000 kg)	78.5	24884.2	23842.3	30819.5	14426.5	43774.7	2213.4	2410.9	89425.0	11441.6	102074.9	6111.9	34351.6	1290.7	625.9	-	387771.7	-
Mean length (cm)	20.50	29.99	31.89	32.68	34.70	34.69	36.33	34.50	35.80	35.75	36.24	36.75	36.31	36.50	39.50	-	-	-
Mean weight (g)	45.00	195.33	238.41	265.18	322.03	325.75	375.00	309.81	352.65	349.10	364.73	371.07	365.78	328.00	359.00	-	-	317.71

Variable: Abundance
EstLayer: 1
Stratum: 7
SpecCat: SILDG03

	age																	
LenGrp	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	4183	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4183	330.5	79.00
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	4183	-	-	-	-	-	-	-	-	-	-	-	-	-	4183	460.1	110.00
26-27	-	4183	-	-	-	-	-	-	-	-	-	-	-	-	-	4183	556.3	133.00
27-28	-	33464	-	-	-	-	-	-	-	-	-	-	-	-	-	33464	4869.1	145.50
28-29	12549	100393	12549	-	-	-	-	-	-	-	-	-	-	-	-	125491	20003.3	159.40
29-30	8366	108759	37647	-	-	-	-	-	-	-	-	-	-	-	-	154772	27436.6	177.27
30-31	8366	58563	50196	20915	4183	4183	-	-	-	-	-	-	-	-	-	146406	30423.2	207.80
31-32	-	4183	71112	46013	-	8366	-	-	-	-	-	-	-	-	-	129674	30465.1	234.94
32-33	-	4183	8366	71112	12549	4183	-	-	-	-	-	-	-	-	-	100393	26445.2	263.42
33-34	-	-	-	41830	75295	104576	-	-	-	4183	8366	-	-	-	-	234250	69626.7	297.23
34-35	-	-	4183	29281	33464	138040	-	37647	112942	33464	117125	-	-	-	-	506148	163431.3	322.89
35-36	-	-	-	-	12549	138040	16732	46013	280264	25098	326277	25098	50196	-	-	920269	317245.9	344.73
36-37	-	-	-	-	-	33464	20915	12549	104576	16732	422487	16732	54380	-	8366	690201	250689.5	363.21
37-38	-	-	-	-	8366	-	-	-	29281	4183	92027	-	79478	16732	-	230067	89002.5	386.85
38-39	-	-	-	-	-	-	-	-	-	-	25098	-	33464	-	-	58563	24278.4	414.57
39-40	-	-	-	-	-	-	-	-	-	-	4183	-	-	-	-	4183	1589.6	380.00
TSN(1000)	33464	317911	184054	209152	146406	430853	37647	96210	527063	83661	995563	41830	217518	16732	8366	3346431	-	-
TSB(1000 kg)	5567.6	54517.5	39743.1	54680.7	44754.3	138948.0	13440.1	31786.9	183547.6	28658.0	355140.0	14795.4	81443.8	6726.3	3103.8	-	1056853.2	-
Mean length (cm)	28.44	28.86	30.51	32.36	33.81	34.42	35.78	35.09	35.37	35.03	35.82	35.60	36.66	37.12	36.25	-	-	-
Mean weight (g)	166.38	171.49	215.93	261.44	305.69	322.50	357.00	330.39	348.25	342.55	356.72	353.70	374.42	402.00	371.00	-	-	315.82

Variable: Abundance
EstLayer: 1
Stratum: 8
SpecCat: SILDG03

LenGrp	age 3	4	5	6	7	8	9	10	11	12	13	15	16	17	19	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	2542	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2542	211.0	83.00
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	4321	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4321	406.2	94.00
25-26	7879	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7879	772.1	98.00
26-27	1888	11328	-	-	-	-	-	-	-	-	-	-	-	-	-	13216	1552.0	117.43
27-28	-	33096	-	-	-	-	-	-	-	-	-	-	-	-	-	33096	4481.7	135.41
28-29	-	84052	1910	-	-	-	-	-	-	-	-	-	-	-	-	85962	13068.2	152.02
29-30	-	52208	52208	9492	-	-	-	-	-	-	-	-	-	-	-	113909	20183.3	177.19
30-31	-	23969	52296	30506	-	-	-	-	-	-	-	-	-	-	-	106771	21308.4	199.57
31-32	-	6444	66585	66585	-	-	-	-	-	-	-	-	-	-	-	139613	30173.6	216.12
32-33	-	2076	26982	31133	8302	2076	-	-	-	-	-	-	-	-	-	70569	16994.7	240.82
33-34	-	-	9846	29537	3938	7877	-	-	-	-	-	-	-	-	-	51197	13878.4	271.08
34-35	-	-	3669	5504	16511	27519	5504	-	18346	-	23850	-	-	-	-	100903	29428.8	291.65
35-36	-	-	-	-	5959	51649	11919	7946	51649	17878	55622	15892	-	-	-	218514	70971.4	324.79
36-37	-	-	-	-	-	11347	-	-	49171	18912	81321	26477	1891	-	-	189120	64365.0	340.34
37-38	-	-	-	2024	-	-	-	-	28340	-	16194	24292	-	6073	-	76923	28133.6	365.74
38-39	-	-	-	-	-	-	-	-	-	-	8310	20775	-	-	-	29085	11337.0	389.79
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1779	1779	896.7	504.00
TSN(1000)	16630	213174	213496	174781	34711	100467	17423	7946	147506	36790	185297	87435	1891	6073	1779	1245400	-	-
TSB(1000 kg)	1629.0	34229.7	44288.6	40638.1	9234.0	31650.5	5678.5	2310.3	50535.9	11769.2	61403.8	30999.9	563.6	2334.0	896.7	-	328161.9	-
Mean length (cm)	24.65	28.63	30.73	31.68	33.91	34.85	35.18	35.38	35.85	35.80	35.85	36.81	36.00	37.33	39.00	-	-	-
Mean weight (g)	97.96	160.57	207.44	232.51	266.02	315.03	325.93	290.75	342.60	319.90	331.38	354.55	298.00	384.33	504.00	-	-	263.50

Variable: Abundance
EstLayer: 1
Stratum: 9
SpecCat: SILDG03

LenGrp	age 2	3	4	5	6	13	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-
20-21	766	766	-	-	-	-	1531	75.0	49.00
21-22	-	766	-	-	-	-	766	42.9	56.00
22-23	-	3828	-	-	-	-	3828	262.6	68.60
23-24	-	4594	-	-	-	-	4594	339.2	73.83
24-25	-	3063	3063	-	-	-	6125	526.8	86.00
25-26	-	3828	17610	-	-	-	21438	2140.7	99.86
26-27	-	2297	42110	2297	-	-	46704	5324.3	114.00
27-28	-	1531	105658	4594	-	-	111783	14491.3	129.64
28-29	-	-	60485	5359	-	-	65845	9621.0	146.12
29-30	-	-	14547	8422	-	-	22969	3793.0	165.13
30-31	-	-	1531	5359	3063	-	9953	2028.9	203.85
31-32	-	-	-	2297	3063	-	5359	1210.5	225.86
32-33	-	-	-	-	2297	-	2297	546.7	238.00
33-34	-	-	-	-	766	-	766	219.7	287.00
34-35	-	-	766	-	-	766	1531	343.0	224.00
35-36	-	-	-	-	-	-	-	-	-
36-37	-	-	-	-	-	-	-	-	-
37-38	-	-	-	-	-	766	766	245.8	321.00
38-39	-	-	-	-	-	-	-	-	-
TSN(1000)	766	20672	245770	28329	9188	1531	306256	-	-
TSB(1000 kg)	38.3	1786.2	32041.2	4765.3	2084.8	495.4	-	41211.3	-
Mean length (cm)	20.50	24.11	27.30	28.80	31.25	36.00	-	-	-
Mean weight (g)	50.00	86.41	130.37	168.22	226.92	323.50	-	-	134.57

Variable: Abundance
EstLayer: 1
Stratum: 10
SpecCat: SILDG03

LenGrp	age 2	3	4	5	6	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	1240	-	-	-	-	1240	18.6	15.00
16-17	1240	-	-	-	-	1240	31.0	25.00
17-18	-	-	-	-	-	-	-	-
18-19	3720	-	-	-	-	3720	111.6	30.00
19-20	3720	1240	-	-	-	4960	174.8	35.25
20-21	2480	3720	-	-	-	6200	274.0	44.20
21-22	-	6200	-	-	-	6200	315.0	50.80
22-23	-	4960	-	-	-	4960	286.4	57.75
23-24	-	4960	-	-	-	4960	327.4	66.00
24-25	-	1456	-	1456	-	2911	224.2	77.00
25-26	-	-	6254	-	-	6254	591.0	94.50
26-27	-	-	5014	-	-	5014	529.8	105.67
27-28	-	-	-	-	-	-	-	-
28-29	-	-	9596	-	-	9596	1375.5	143.33
29-30	-	-	6685	1671	-	8356	1557.6	186.40
30-31	-	-	-	5014	-	5014	1047.9	209.00
31-32	-	-	-	3127	3127	6254	1353.9	216.50
32-33	-	-	-	-	-	-	-	-
33-34	-	-	-	-	-	-	-	-
34-35	-	-	-	-	-	-	-	-
35-36	-	-	-	-	-	-	-	-
36-37	-	-	-	-	-	-	-	-
37-38	-	-	-	-	-	-	-	-
38-39	-	-	-	-	-	-	-	-
TSN(1000)	12400	22535	27549	11268	3127	76878	-	-
TSB(1000 kg)	398.0	1247.0	3749.7	2126.6	697.3	-	8218.6	-
Mean length (cm)	18.35	21.80	27.61	29.49	31.25	-	-	-
Mean weight (g)	32.10	55.34	136.11	188.74	223.00	-	-	106.90

Variable: Abundance
EstLayer: 1
Stratum: 12
SpecCat: SILDG03

LenGrp	age 3	4	5	6	7	8	9	10	11	12	13	15	16	17	19	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-27	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0.5	127.00
27-28	-	21	-	-	-	-	-	-	-	-	-	-	-	-	-	21	3.0	140.20
28-29	-	72	-	-	-	-	-	-	-	-	-	-	-	-	-	72	11.3	157.53
29-30	-	30	38	-	-	-	-	-	-	-	-	-	-	-	-	67	12.0	177.50
30-31	-	17	46	21	-	-	-	-	-	-	-	-	-	-	-	84	16.9	199.85
31-32	-	13	59	84	-	-	-	-	-	-	-	-	-	-	-	156	34.0	217.62
32-33	-	8	38	51	8	-	-	-	-	-	-	-	-	-	-	105	25.8	244.44
33-34	-	-	17	51	-	17	-	-	-	-	-	-	-	-	-	84	23.7	280.95
34-35	-	-	-	8	34	55	13	-	46	-	46	-	-	-	-	202	59.9	295.85
35-36	-	-	-	-	13	76	51	4	93	17	89	17	-	-	-	358	118.4	330.39
36-37	-	-	-	-	-	38	-	-	118	13	127	72	4	-	-	371	127.7	344.13
37-38	-	-	-	8	-	-	-	-	51	-	25	17	-	8	-	110	40.9	372.81
38-39	-	-	-	-	-	-	-	-	-	-	21	25	-	-	-	46	18.3	394.27
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	2.1	504.00
TSN(1000)	4	160	198	224	55	186	63	4	308	30	308	131	4	8	4	1687	-	-
TSB(1000 kg)	0.5	28.0	42.8	55.5	14.9	59.4	20.3	1.3	105.0	9.7	102.5	47.9	1.3	3.1	2.1	-	494.4	-
Mean length (cm)	26.00	29.01	30.96	32.22	34.19	34.95	35.17	35.50	35.82	35.64	35.88	36.61	36.00	37.50	39.00	-	-	-
Mean weight (g)	127.00	174.89	215.87	248.19	272.54	320.09	321.53	300.00	341.21	328.71	332.86	366.13	298.00	371.50	504.00	-	-	293.07