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Survey report

MS *Eros*, MS *Kings Bay* MS *Vendla* 13.-25.02.2018

Distribution and abundance of Norwegian spring-spawning herring during the spawning season in 2018

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Summary

During the period 13-25th of February 2018 the spawning grounds from Møre (62ºN) to the borderline Troms-Finnmark at Tromsøflaket (71°) 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 more of the survey time was used as transects than in 2017 due to the introduction of a zigzag survey design instead of a parallel transect design as used in the previous surveys. The trawl sampling of herring was considered successful with 62 samples evenly spread out over the distribution in all strata. A total of 5985 individuals were measured for weight and length and 2785 individuals were aged. The conditions for estimating herring biomass with echo sounder were very good, with most of the herring distributed in deep layers from 150-300 m depth. In addition, sonar investigations indicated that that echo sounder biomass estimations were not seriously biased by unaccounted fraction of herring in the upper layers (i.e. vessel avoidance and/or distribution of fish in the blind zone between the surface and the echo sounder transducer). The estimated biomass index of 3.3 was the same as in 2017, but with a lower uncertainty of CV= 7.4 % compared with CV = 14.2 % in 2017. Still a decrease in the biomass of 6 year olds and older fish of 18 % was observed between 2017 and 2018. The stability in the total biomass index was a result of new recruitment to the spawning stock; i.e. there was an increase of 146 % in the biomass of 5 year olds (2013 year class) and younger fish compensating for the decrease in older fish. The 2013 year class was now the most abundant year class in the survey contributing with 23 % in numbers compared with 10% in 2017. Also, the 2014 year class was abundant contributing with 14% compared with 1% in 2017. Among the older fish the 2009, 2006 and 2004 year classes were the strongest as also observed in 2017. With regard to distribution of the stock, the first significant herring observations was observed north on the Møre shelf at Buagrunnen 63°N, and from here and northwards the herring was evenly distributed along the coast and observed on most of the transects until south of Tromsøflaket 70°30N. About 75 % of the biomass was found between 63° and 67°30N, and the rest was found up to 71°N. The presence of the 2013 and 2014 year classes clearly increased northwards, and they predominated north of 68°30N. Insignificant amounts of herring (0.2 %), predominated by 91 % summer spawners, was observed in the westernmost stratum in the known oceanic wintering area, suggesting that the wintering herring had reached the covered area along the coast. The GSI (% gonads relative to total weight) was decreasing northwards in the survey area, indicating that the ripest fish was in the south and less ripe fish lagging behind or spawning further north.

Survey participants:

MS *Eros*		
Are Salthaug	Survey leader	13-25.02.2018
Jarle Kristiansen	Instrument/Acoustics	13-25.02.2018
Endre Grimsbø	Instrument/Acoustics	13-25.02.2018
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Jostein Røttingen	Biology	13-25.02.2018
MS *Kings Bay*		
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Egil Ona	Head of acoustics	13-25.02.2018
Gunnar Lien	Instrument/Acoustics	13-25.02.2018
Rokas Kubilius	Instrument/Acoustics	13-25.02.2018
Stine Karlson	Biology	13-25.02.2018
Adam Custer	Biology	13-25.02.2018
MS *Vendla*		
Åge Høines	Survey leader	13-25.02.2018
Erling Kåre Stenevik	Scientist Biology	13-25.02.2018
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Valantine Anthonypillai	Biology	13-25.02.2018
Justine Diaz	Biology	13-20.02.2018

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 partly based on the feedback from fishermen and fishermen's organizations that IMR should conduct more surveys on this commercially important stock. Since then this 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 decided to use the data from this time series as input to the stock assessment, together with the ecosystem survey in the Norwegian Sea in May 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 2018 was to continue the index for use in the ICES WGWIDE stock assessment, more specifically to estimate indices of abundance at age and 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 with comparable effort and design during 2015-2017.

Material and methods

Survey design

During the period 13-25th of February 2018 (exact same period as in 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 was planned based on the information we had from the distribution of the fishery during the autumn 2017 up to the survey start 13. February 2018 (Figure 1), indicating that the herring wintering in the Norwegian Sea were entering the coast in the Træna deep south of Røst and following the eastern shelf edge 200 m depth southwards from Træna as also observed in 2016-2017. This information also suggested that smaller and younger herring recruiting to the spawning stock initiated their spawning migration from wintering grounds further north of 70ºN west of Tromsøflaket and in Kvænangen fjord area, which was the basis for the planned survey coverage this far north. Furthermore, when the survey started the southernmost landings were reported from Buagrunnen (63°N), which was the basis for starting the survey at Stadt (62°N).

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 2). A southern stratum 1, was not covered as there were no news from the fishing fleet about herring in this area (Figure 1). Similarly, potential strata 15-16, westwards on the on the shelf 64-67°N were also not covered, as there was no news about herring in this area prior to the onset of the survey (Figure 1), and there was no information about herring observations westwards in the Norwegian Sea south of 67°N from vessels going to Iceland and back for capelin prior to the survey. However, it was decided to cover westwards in the Norwegian Sea (Stratum 17) in an area overlapping with the distribution of fishery in January (Figure 1), in case part of the stock was delayed in the spawning migration.

With exception of strata 14 and 17, all strata this year was covered with a zig zag design instead of parallel west-east transects each (Figure 3). The introduction of a zig-zag design was based on the wish to reduce the uncertainty related to stock coverage, using more of the survey time on transects and thereby increasing the survey coverage. In 2015-2017, a significant part of the survey time was used as transport between transects, whereas in 2018 insignificant time was use on transport. Each straight line in the zig-zag design were considered as transects and primary sampling units (Simmonds and MacLennan 2008), with uniform coverage of strata and a random starting position. It was further decided that the western limits of the transects were defined to be extended if herring were still observed at the end of the transects. These design rules made some small changes to the predefined stratum polygons during the survey (see west at Stratum 5), and this ad-hoc change in the survey design on the statistical uncertainty estimation was considered insignificant.

Biological sampling

Trawl sampling was carried out on a regular basis during the survey to confirm the acoustic observations and to be able to give estimates of abundance for different size and age groups. The positions of the trawl hauls are shown in Figure 4. The number of trawl stations with samples of herring increased heavily from 31 stations in 2016 to 52 stations in 2017. The trawl sampling of herring in the 2018 survey was even higher with 62 samples evenly spread out over the distribution in all strata. The following variables of individual herring were analysed for each of the 62 trawl stations with herring catch: Total weight (W) in grams and total length (L_T) in cm (rounded down to the nearest 0.5 cm) of up to 100 individuals per sample and in totally 5985 individuals in 2018, compared with 2971 individuals in 2016 and 4535 individuals in 2017. In addition, sex, maturity stage, stomach fullness and gonad weight (W_G) in grams were measured in 50 individuals per sample and totally in 2785 individuals (compared with 1394 individuals in 2016 and 2088 individuals in 2017). The maturation stages were determined by visual inspection of gonads as recommended by ICES (Anon. 1962): immature = 1 and 2, early maturing = 3, late maturing = 4, ripe = 5, spawning = 6, spent = 7 and resting/recovering = 8. Data from the subjective evaluation of maturation stages were used to split between immature and mature herring in the estimation of spawning stock biomass (SSB), as well as to demonstrate spatial differences in maturation. The gonadosomatic index (GSI=gonad weight/total weightx100) was also used to demonstrate spatial differences in maturation along the coast.

Environmental sampling

CTD casts (using Seabird 911 systems) were taken by MS Eros and Vendla, spread out in the survey area (Figure 5)

Echo sounder data

Multifrequency (18, 38, 70, 120, 200 kHz) acoustic data were recorded with a SIMRAD EK 60 echo sounder and echo integrator on board Eros and Vendla, and SIMRAD EK 80 on board Kings Bay. 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). Eros and Vendla were both satisfactorily calibrated, but it appeared during the survey coverage that the calibration of 38 kHz at Kings Bay was not satisfactorily giving lower values then expected relative to the other frequencies despite that the calibration followed correct procedures and appeared successful. This problem with Kings Bays was dealt with after the survey involving Simrad, and it turned out that there was an error in the calibration software of EK80, which was significant with the sphere used. This error was fixed and the new and corrected (approximate increased back scattering of 13-14%) calibration was used on the Kings Bay data. The calibration reports with new gain estimates and raw data were stored in the IMR data base. The calibration reports of each vessel are shown in Annex 1. The low frequency sonars were also calibrated at the pier in Ålesund according to procedures described in Macaulay et al., (2016), see also sonar report in Annex 2. 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’ species at 38 kHz. Various characteristics of the acoustic recordings like frequency response (Korneliussen & Ona, 2002) and visual appearance) were used to identify herring from other targets.

Abundance estimation methods

The acoustic density values were stored by species category in nautical area scattering coefficient (NASC) [m^2 $n.mi.^{-2}$] units (MacLennan et al. 2002) in a database with a horizontal resolution of 0.1 nmi and a vertical resolution of 10 m, referenced to the sea surface. To estimate the mean and variance of NASC, we use the methods established by Jolly and Hampton (1990) and implemented in the software StoX. 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:

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

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

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

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

$$\hat{S} = \frac{\sum_i A_i \hat{S}_i}{\sum_i A_i} \tag{3}$$

Variance by stratum is estimated as:

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

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

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

The global relative standard error of NASC

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

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 68 stations (Figure 4), of which 62 contained herring. All trawl stations with herring were used to derive a common length distribution for all transect within the respective strata. All stations had equal weight.

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

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

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

Where

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

is the ”acoustic contribution” from the length group L_l to the total energy. $\langle s_A \rangle$is the mean nautical area scattering 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 mean target strength (TS) is used for the conversion where $\sigma = 4\pi\ 10^{(TS/10)}$ is used for estimating the mean backscattering cross section. Traditionally, TS = 20logL – 71.9 (Foote 1987) has been used for 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 2018 as another year in the time series.

As in the 2016 and 2017, special investigations were made from MS Kings Bay for investigating if the mean target strength of herring during spawning is different from non-spawning herring.. Some target strength measurements were conducted on shallow layers of herring, and the vessel then stopped the surveying, and set the exho sounders on maximum ping rate to 100 meters. Very good TS data were in this way collected at 5 frequencies over 2 to 3 hours, followed by a trawl hauld for sizing. Addittionally, at two locations Simrad WBAT, portable EK80 were lowered with two split beam transducers (38 and 70 kHz, broad band 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 idea behind these investigations is that a new depth dependent TS will be developed and used to re-estimate all years of this survey. This will be a more realistic mean target strength for spawning herring, measured in situ. The depth term is also expected to remove potential bias related to variable depth distribution of the herring between surveys.

The StoX software developed by IMR were used in the abundance estimation in 2018, just as in 2015-2017. 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 low-frequency sonars were logged onboard all vessels with the objective to measure the presence and magnitude of potential bias related to vertical distribution (fish in blind zone above the echo sounder transducer) and avoidance behaviour of the herring relative to the presence of the vessel. Data from calibrated fisheries sonars have been collected from all participating vessels since 2015. Methods to quantify or evaluate the extend of these biases are presently being developed. See Annex 2 for more information on sonar logging and data.

Results and discussion

Acoustics densities along the transects

The distribution and densities of herring in the area covered in 2018 was quite similar as that observed in 2017. As opposed to the situation in 2016 when the bulk of herring appeared in real high densities within a small area 66-67ºN, the herring in 2017-2018 was more evenly distributed along the coast 63-71ºN (Figures 6 and 7). Most of the herring in 2018 were distributed in deep acoustic layers at 150-300 m depth, but along the western part of the Vesterålen shelf area and northwards along the coast (north of 67°30N) high densities were also observed at depths 20-40 m below surface (Figure 8). Several examples of acoustic registrations of herring in the survey area using EK80 echo sounder are given in Annex 3.

Estimated biomass index

The estimate of a stock biomass index using StoX, to be treated as a relative one, was 3.3 in 2018 (Table 1) with a very low uncertainty (CV) of 7.4 %. The biomass index was the same in 2017, yet with a little higher CV=14.2 % in 2017 (Figure 9). The huge CV in 2016 (Figure 9) was related to the fact that the main bulk of herring was only measured in high density over a few transects, as compared to 2017-2018 when the herring was distributed over much larger area. The improved CV in 2018 relative to 2017 is likely a result of higher survey coverage related to the use of zig-zag design. The expected gain in CV relative to degree of coverage (DC) can be computed from Aglen (1983).

Estimated abundance index by age

Although the biomass index was stable between 2017 and 2018, there was a clear change in the age structure in the stock, where 2013 year class now dominate (Figure 10, Table 2). The estimated abundance index by age appeared with low uncertainty and CVs mostly ranging between 10-20 % for ages 5-14, whereas the estimates were less precise with CVs above 20% for younger and older fish (Figure 10, Table 2). This CV pattern is quite normal since few very old and very young fish are caught.

Trends in biomass index and abundance index by age 2015-2018

The stability in total biomass index between 2017 and 2018 seems to be a result of new recruitment to the spawning stock. There was an increase of 146 % in the biomass of 5 year olds (2013 year class) and younger fish compensating for an 18 % decrease in biomass of older fish (Tables 1-2, Figure 10). The 2013 year class was now the most abundant year class in the survey contributing with 23 % in numbers compared with 10 % in 2017. Also the 2014 year class was quite abundant contributing with 14 % compared with 1 % in 2017. Among the older fish the 2009, 2006 and 2004 year classes were the strongest in 2018 as also observed in 2017. A more detailed inspection of the trends in number of fish per year class over all surveys 2015-2018 clearly demonstrate a steady decrease in all year exploited year classes (Figure 11). The estimated trends in year class abundance over time in this survey is considered a sign of quality or consistency, indicating that the survey captures quite well the trends in abundance. It also signifies that the new recruitment, although stabilising the current biomass, seems to be moderate if compared to the 2004 year class, which have dominated in the spawning stock for many years.

Geographical variation in biomass and abundance index by age

With regard to distribution of the stock, the first significant herring observations was observed north on the Møre shelf at Buagrunnen 63°N, and from here and northwards the herring was very evenly distributed along the coast and observed at most of the transects until south of Tromsøflaket 70°30N. Looking at the biomass index and abundance index by age per strata (Table 3), it appears that about 75% of the biomass was found between 63°-67°30N, and the 25 % rest was found up to 71°N. The age and size of the herring was relatively stable all over the area 63-67ºN, but further north size and age of the herring decreased (Figures 12-14). North of 68º30N it was the younger and smaller herring predominated by the 2013-2014 year classes that contributed to the index (Figures 11-13). Insignificant amounts of herring (0.2 %), predominated by 91 % summer spawners, was observed in the stratum westwards in the known oceanic wintering area, suggesting that the wintering herring had reached the covered area along the coast.

This observed size dependent distribution pattern in 2018 is similar to what was observed in 2015-2017. It is also 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 2001, Slotte et al. 2000, Slotte & Tangen 2005, 2006). The main hypothesis is that this could be due to the high energetic costs of migration, which is relatively higher in small compared to larger fish (Slotte, 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.

Geographical variation in maturation

Quite clear geographical trends in the maturation of the herring were observed during the survey coverage and biological sampling, both by the subjective scaling of gonads, and by looking at the gonadosomatic index (GSI = gonad weight × 100/total weight) (Figure 15). The most mature fish appeared to be found in the south, closer to the Møre spawning area. In the north, the young herring appeared to be later in their maturation with a delayed spawning compared with the older fish. This is in accordance with a general perception that the first time spawners tend to spawn later in the season, in a second wave (Slotte 2001, Slotte et al. 2000). An interesting observation was that in the area 67-68°N, herring with resting gonads (stage 8) considered to be autumn spawners were present also at the coast, not only in the samples offshore. This was not as apparent in 2017 and earlier years, and a possible reason is that these fish followed the main mass of spring-spawners to the coast from the wintering area in the Norwegian Sea. Alternatively, that they already were present in the area, when the spring spawners arrived. These areas along Helgeland, Lofoten and Vesterålen is believed to the main spawning area of the summer spawners.

Geographical variation in temperatures experienced 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 (Figure 16). At typical spawning depths of herring 100-200 m temperature did not vary much along the coast, being rather stable at 7°-8°C as also observed in 2017.

Quality of the survey for abundance estimation

In 2018 all vessels were equipped with multifrequency equipment on a drop keel. Weather conditions in 2018 were exceptionally well suited for acoustic surveying, the acoustic data recorded were of high quality from all three vessels. The weather conditions and vessels allowed for a survey speed of 10 knots for the whole survey period, ensuring an extra good coverage zig-zag design, with no lost time traveling between transects. There were no 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.

During the survey, there was special focus on potential blind zone problems and avoidance always flowing registrations on the sonar at the same time as the echo sounder (Annex 2). The main conclusion is that we did not have a significant bias in the survey related to these factors. The main part of the estimated biomass (75 %) (Table 3) was found south of Vesterålen distributed very deep in layers both during day and night, mostly at 150-300 m depth close to the bottom, not expecting to avoid the vessels (Figure 3). However, further north along Vesterålen and Troms at night time some strong registrations of young herring were observed close to the surface at 20-40 m depth (Figure 3). However, the echo sounder data suggested that they were not in the blind zone closer to the surface, as they were located 10-30 m below the transducer. Also, trials with putting on a lot of light on sea surface did not result in higher acoustic densities below transducer. Normally this is seen when herring is at the surface during night time, they dive and are visible below the transducer when light is hitting them. Still, in these northernmost strata we may have had some avoidance of the young herring close to the surface, and hence some underestimation of the young fish during transects carried out at night. During daytime, however, these young fish were also registered very deep, typically at 200 m and deeper along the shelf edge.

In 2018 all vessels were able to trawl (in 2015 only one vessel could trawl), which resulted in more sampling on acoustic registrations and higher quality of the scrutiny process into herring and other targets, as well as higher quality on estimation of abundance index by age. The acoustic registrations were sampled with pelagic trawling at higher numbers than in previous years, the number of biological samples, individual samples and aged, have never been higher in the time series, indicating that the basis for age segregated abundance indices is good.

With regard to coverage, and potential herring outside the covered area, there were no data suggesting that this may have been a potential bias in the survey. Only a few schools were registered westwards in the off-shelf wintering area (Stratum 17) where the fishery on Norwegian spring spawning herring took place prior to the survey in Janaury. The herring in this area contributed with only 0.2% of the total biomass index, and it was pre-dominated by 91% summer spawners. This suggests that the spring spawning herring by the time of the survey coverage had left the wintering areas and entered the survey area. Vessels fishing capelin of Iceland, leaving and arriving at different ports along the Norwegian coast, did not report about significant amounts of herring west of the survey area prior to and during the survey. In conclusion, it was assumed that the survey had an acceptable coverage of the spawning stock along the coast. 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.

In summary, the survey was satisfactorily conducted, and the index can be recommended used for stock assessment purposes. 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 the other years the uncertainty in the biomass index was the lowest in the time series, a CV of 7.4% is very low, also in general terms in acoustic surveys. The introduction of zig-zag design is likely the main reason for this, as more survey time is used as transects, and it will also be the chosen design the next years. We have had two years now with very good weather conditions, and we cannot expect to be that lucky every year, so it will be expected that higher uncertainties may occur in the years to come despite a good design

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Tables

Table 1. Estimated total index of abundance (TSN), total biomass (TSB) and spawning stock biomass (SSB) of Norwegian spring-spawning herring during the spawning season 13-25. February 2018.

										Age										Total	
Length (cm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	Number	Biomass	MeanW (g
15-16	4708	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4708	95	20,1
16-17	22000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22000	493	22,4
17-18	32083	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32083	854	26,6
18-19	24750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24750	787	31,8
19-20	6417	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6417	240	37,4
20-21	2750	4227	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6977	334	47,8
21-22	1833	917	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2750	151	55,0
22-23	-	21838	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21838	1445	66,2
23-24	-	26982	5144	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	32126	2405	74,9
24-25	-	35092	21849	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56941	4976	87,4
25-26	-	22207	99722	917	-	-	-	-	-	-	-	-	-	-	-	-	-	-	122845	12751	103,8
26-27	-	15432	394112	25720	-	-	-	-	-	-	-	-	-	-	-	-	-	-	435264	49481	113,7
27-28	-	3300	606957	113126	-	-	-	-	-	-	-	-	-	-	-	-	-	-	723383	92903	128,4
28-29	-	10488	393143	369559	-	-	-	-	-	-	-	-	-	-	-	-	-	-	773190	113906	147,3
29-30	-	2934	91011	439341	-	-	17135	-	-	-	-	-	-	-	-	-	-	-	550421	95776	174,0
30-31	-	1467	53464	688129	40260	21137	-	-	-	8094	-	-	-	-	-	-	-	-	812551	163786	201,6
31-32	-	-	28962	560576	79822	44713	4227	-	-	2142	-	-	2492	-	-	-	-	-	722934	166688	230,6
32-33	-	-	60233	357160	163413	176235	43889	5489	17151	-	-	-	-	-	-	-	-	-	823569	213181	258,9
33-34	-	-	22712	191730	95290	218202	100000	45848	9967	12295	-	-	17442	-	-	-	-	-	713484	203154	284,7
34-35	-	-	2092	33842	89735	243359	141055	251009	48513	44960	105330	17927	74339	-	6641	-	-	-	1058803	332498	314,0
35-36	-	-	-	-	13270	107390	233838	528896	195614	98327	487639	82006	469070	2923	43368	-	-	-	2262341	766970	339,0
36-37	-	-	-	-	2744	12633	71933	203456	165949	173637	427388	165042	613907	11587	71699	-	7989	8233	1936197	690628	356,7
37-38	-	-	-	-	-	-	9650	47824	26163	38748	146399	86259	299440	16699	98040	-	3415	-	772638	294138	380,7
38-39	-	-	-	-	-	-	-	-	-	-	21508	8971	42197	9889	31750	2934	-	2744	119993	48458	403,8
39-40	-	-	-	-	-	-	-	-	-	-	-	-	5489	3543	-	-	-	-	9032	4060	449,5
TSN(1000)	94541	144885	1779400	2780101	484534	823669	621727	1082522	463356	378203	1188265	360205	1524375	44641	251498	2934	11404	10977	**12047235**	-	-
TSB (t)	2682	13314	245054	573219	128311	240245	195051	362349	155591	130418	415645	128649	547895	17520	94556	1106	4444	4108	-	**3260157**	-
MeanL (cm)	17,5	24,5	27,6	30,4	32,6	33,5	34,5	35,2	35,5	35,6	35,8	36,2	36,1	37,2	36,7	38,0	36,6	36,9	-	-	-
MeanW (g)	28,4	91,9	137,7	206,2	264,8	291,7	313,7	334,7	335,8	344,8	349,8	357,2	359,4	392,5	376,0	377,0	389,7	374,3	-	-	**270,6**
%mature	0	21,8	90,8	98,6	100,0	100,0	100,0	100,0	100,0	100,0	99,9	100,0	100,0	100,0	100,0	100,0	100,0	100,0			
SSB (t)	0	2908	222478	565399	128311	240245	195051	362349	155591	130418	415124	128649	547895	17520	94556	1106	4444	4108		**3216151**	

Table 2. Uncertainty estimates in the abundance index of Norwegian spring-spawning herring during the spawning season 13 -25 February 2018. Uncertainty estimates are from 500 boostrap replicates in StoX. See also Figure 10 for graphical presentation of data.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
2	1,3	78,0	300,1	99,4	110,3	1,11
3	74,8	142,9	239,7	147,3	49,3	0,33
4	1032,0	1682,2	2500,1	1719,0	441,7	0,26
5	2057,8	2730,5	3778,6	2785,5	522,3	0,19
6	345,6	456,2	584,7	459,8	72,7	0,16
7	678,5	847,5	1018,4	848,3	107,5	0,13
8	458,7	633,8	838,2	638,1	125,1	0,20
9	910,4	1088,4	1308,8	1098,0	122,7	0,11
10	346,8	441,2	555,1	443,4	63,9	0,14
11	279,4	371,6	461,5	371,5	57,8	0,16
12	951,5	1159,1	1369,9	1159,9	123,5	0,11
13	256,8	368,9	494,5	371,0	72,3	0,19
14	1253,1	1535,6	1840,7	1540,3	175,1	0,11
15	26,7	50,8	79,6	51,7	16,6	0,32
16	206,1	274,5	350,5	276,5	43,1	0,16
17	0,0	3,5	9,4	3,5	3,3	0,93
18	0,2	9,5	22,9	10,4	6,9	0,66
20	0,0	11,6	31,2	13,2	10,0	0,76

Table 3. Estimated index of abundance (TSN), total biomass (TSB) and spawning stock biomass (SSB) of Norwegian spring-spawning herring by the strata covered during the spawning season 13-25. February 2018.

						Stratum							
Age	2	3	4	5	6	7	8	9	10	11	13	14	17	Total
2	0	0	0	1	0	0	0	0	0	0	93	0	0	95
3	2	0	0	8	0	0	9	0	0	80	45	0	0	145
4	13	0	6	2	5	93	47	1	5	1437	170	0	0	1779
5	37	0	36	21	182	302	245	53	95	1666	141	0	2	2780
6	6	0	16	14	90	113	110	5	19	106	5	0	2	485
7	24	0	23	4	102	261	265	3	70	63	5	0	3	824
8	56	0	47	69	75	200	106	2	54	8	0	0	5	622
9	56	0	151	43	187	327	224	2	81	8	0	0	3	1083
10	38	0	27	52	92	140	103	0	3	4	0	0	4	463
11	30	0	45	28	125	71	59	2	19	0	0	0	0	378
12	51	0	170	95	270	357	166	1	72	4	0	0	2	1188
13	7	0	17	11	105	167	34	0	18	0	0	0	2	360
14	31	0	90	52	439	598	192	2	114	4	0	0	2	1524
15	0	0	1	5	5	8	19	0	6	0	0	0	0	45
16	7	0	12	16	60	96	31	0	28	0	0	0	2	251
17	0	0	0	0	0	0	3	0	0	0	0	0	0	3
18	0	0	0	0	7	0	1	0	2	0	0	0	1	11
20	0	0	0	0	0	11	0	0	0	0	0	0	0	11
SSN (millions)	358	1	643	421	1744	2744	1613	72	585	3382	458	0	27	**12047**
B (1000 tonn)	108	0	216	145	589	890	499	16	190	546	52	0	8	**3260**
% Mature	100	100	100	98	100	100	100	100	100	92	62	0	100	**96**
SSB (1000 tonn	108	0	216	142	589	890	499	16	190	502	32	0	8	**3130**

Figures

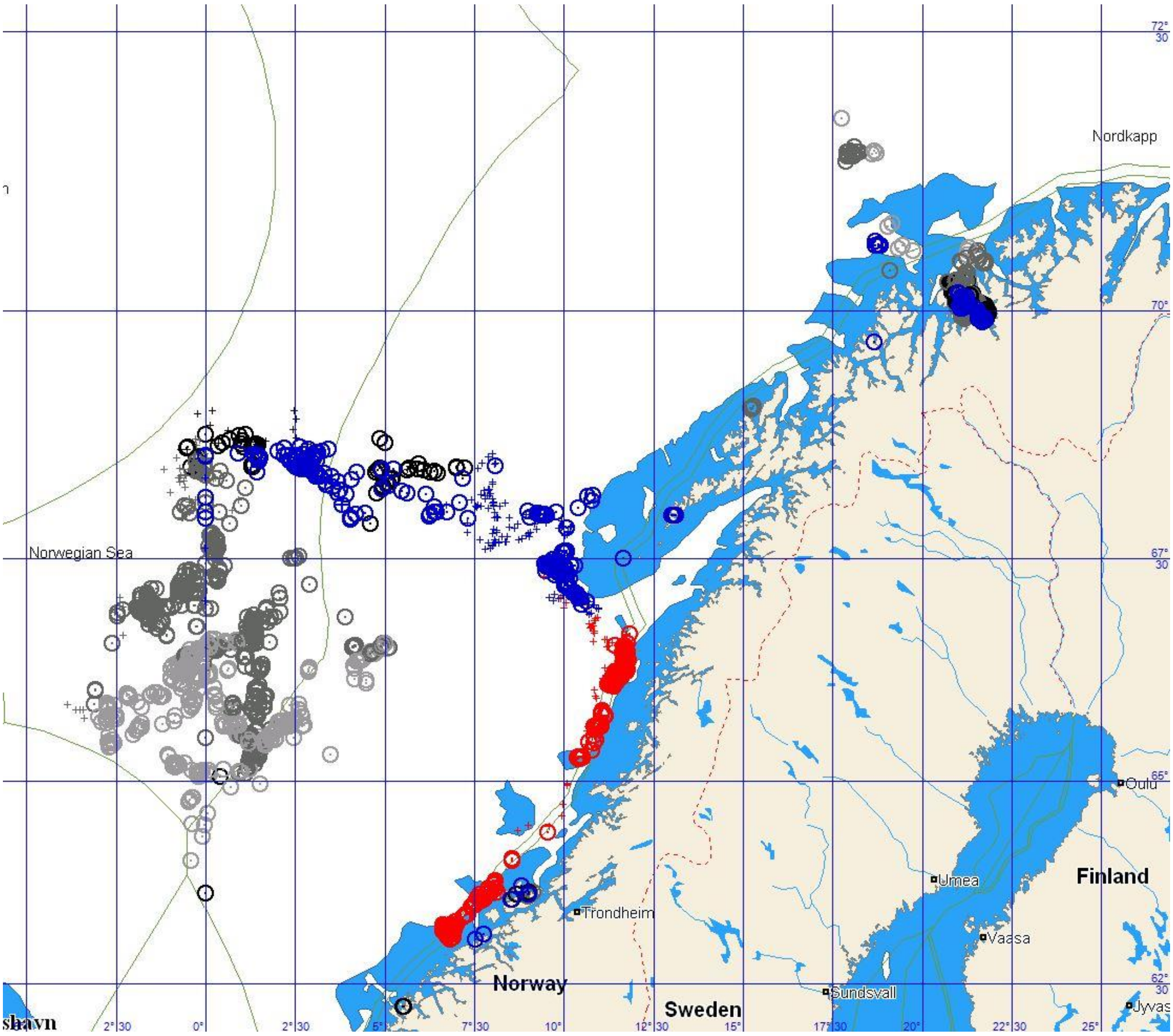


Figure 1. Monthly distribution of catches of Norwegian Spring spawning herring from October 2017 until onset of the survey 13.February 2018, based on electronic logbooks. Each point represent one catch, only catches larger then 5 tonnes are shown. Small crosses=trawl catches, circles (with dot inside)=purse seine, light grey=October, dark grey=November, black=December, blue=January, red=February up to 13th.

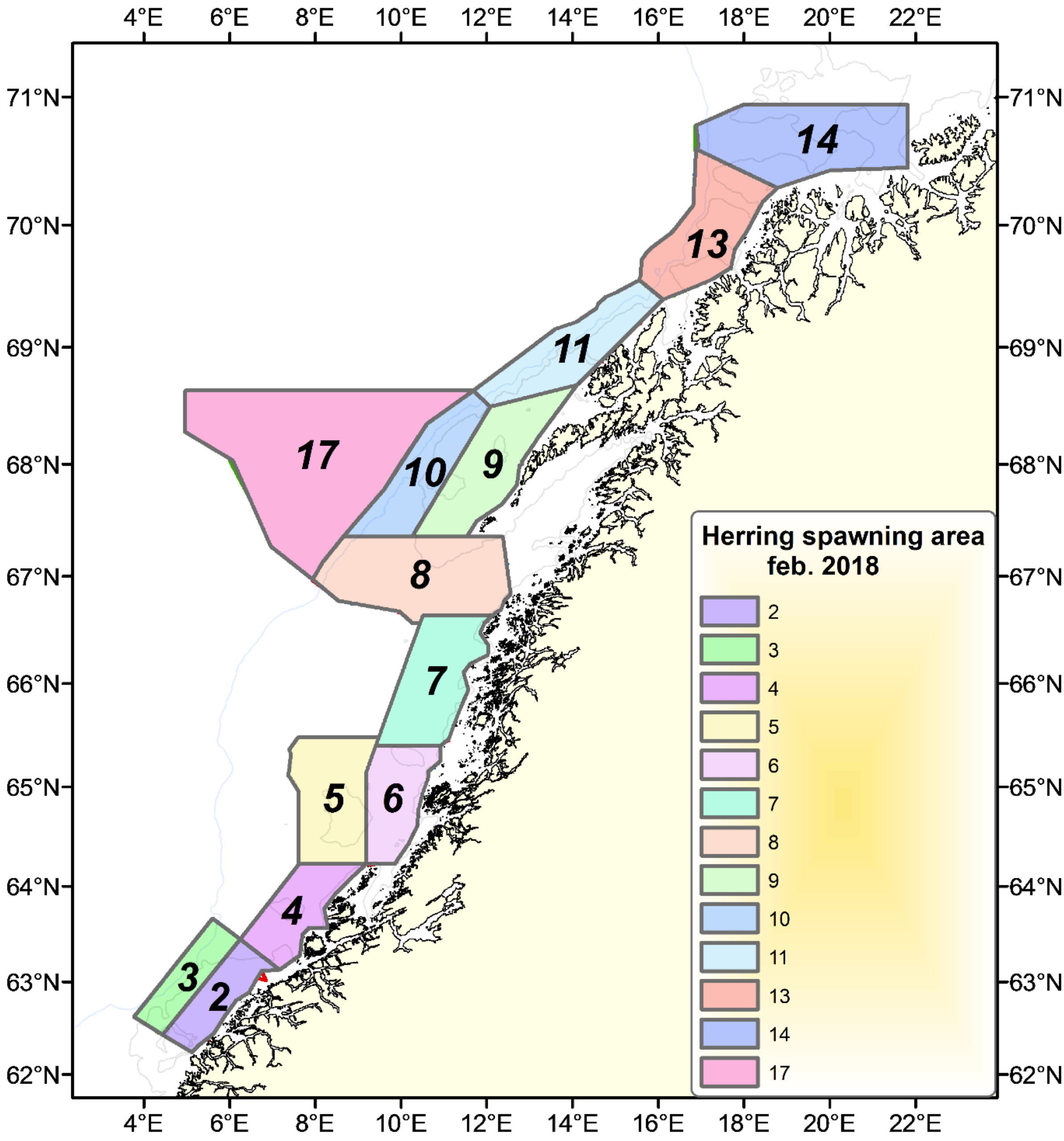


Figure 2. Strata covered during 13-25. February 2018 with MS *Eros, Kings Bay* and *Vendla*

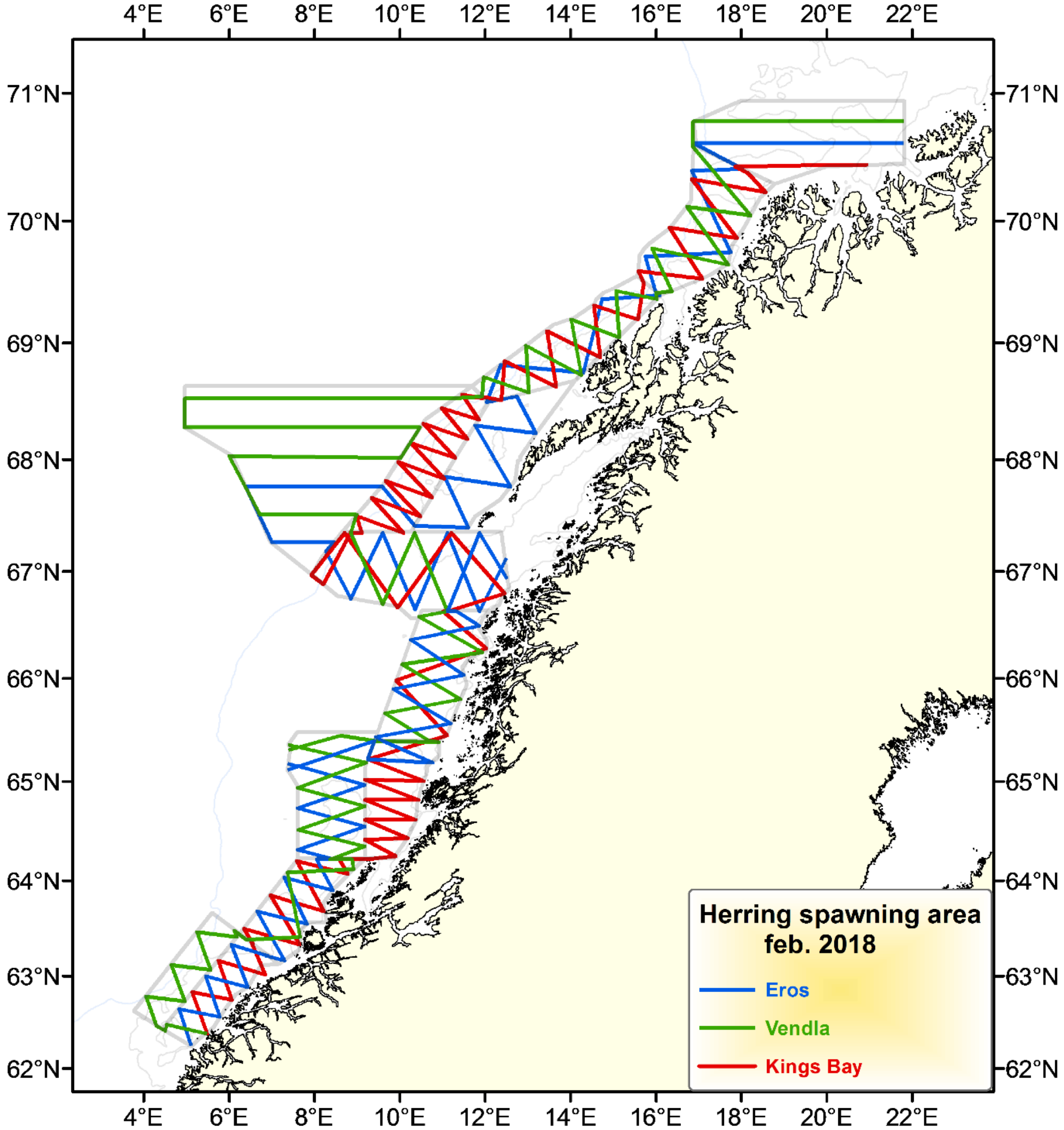


Figure. 3. Acoustic transects covered with *Eros, Kings Bay* and *Vendla* 13-25 February 2018.

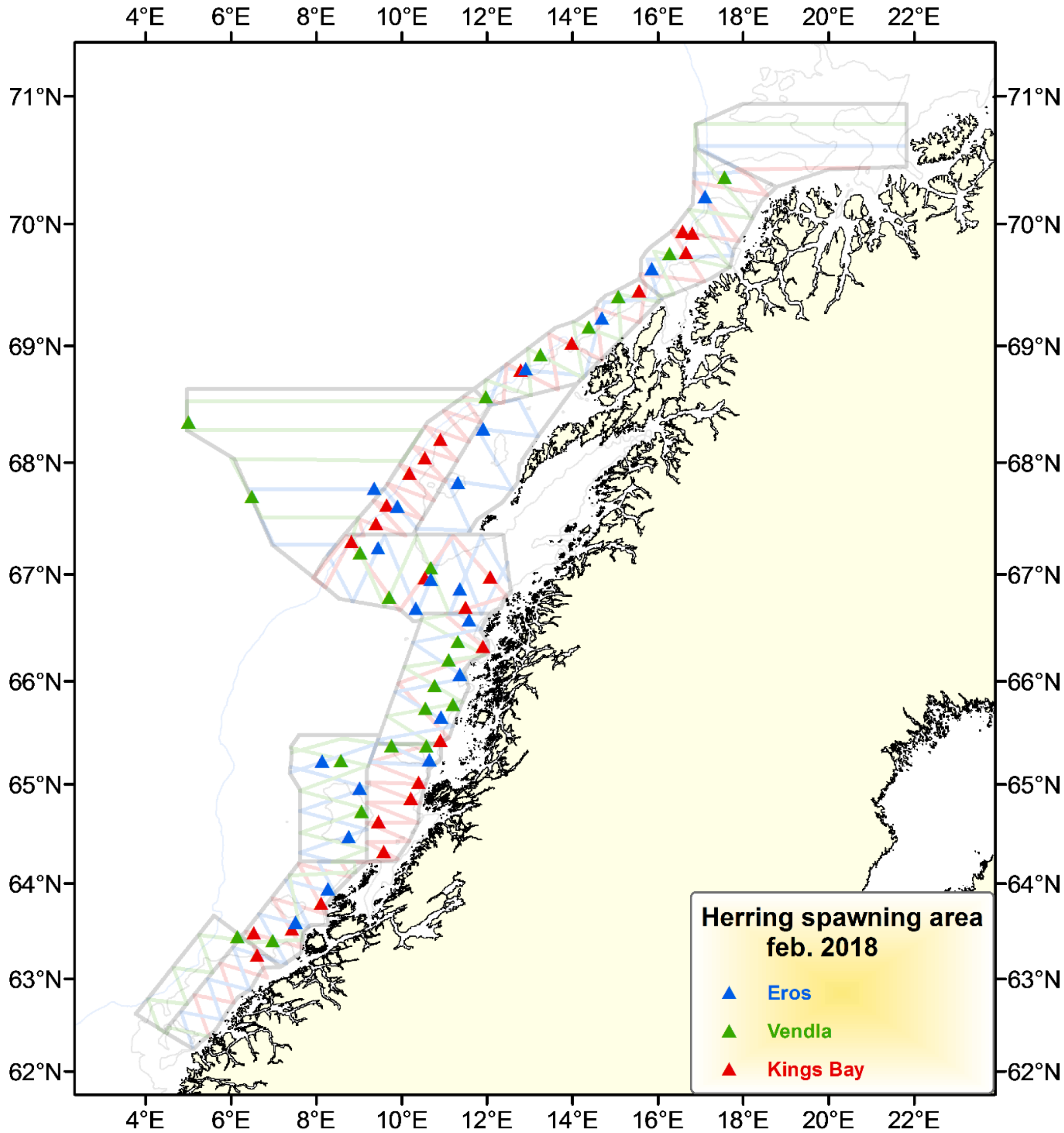


Figure. 4. Trawl stations with MS *Eros, Kings Bay* and *Vendla* taken at acoustic registrations 13-25 February 2018.

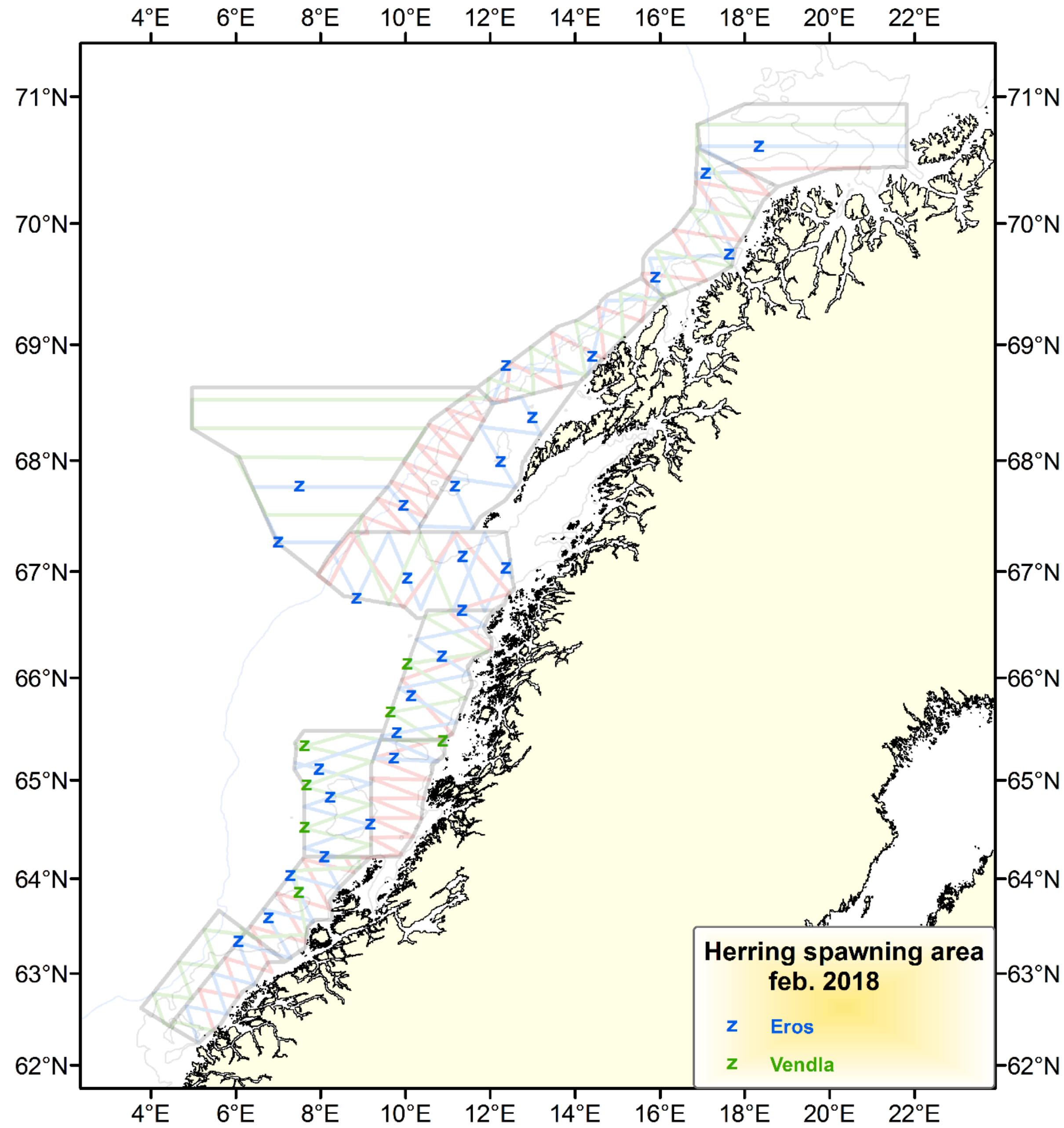


Figure. 5. CTD (Seabird) stations taken by MS *Eros* and *Vendla* during 13-25 February 2018.

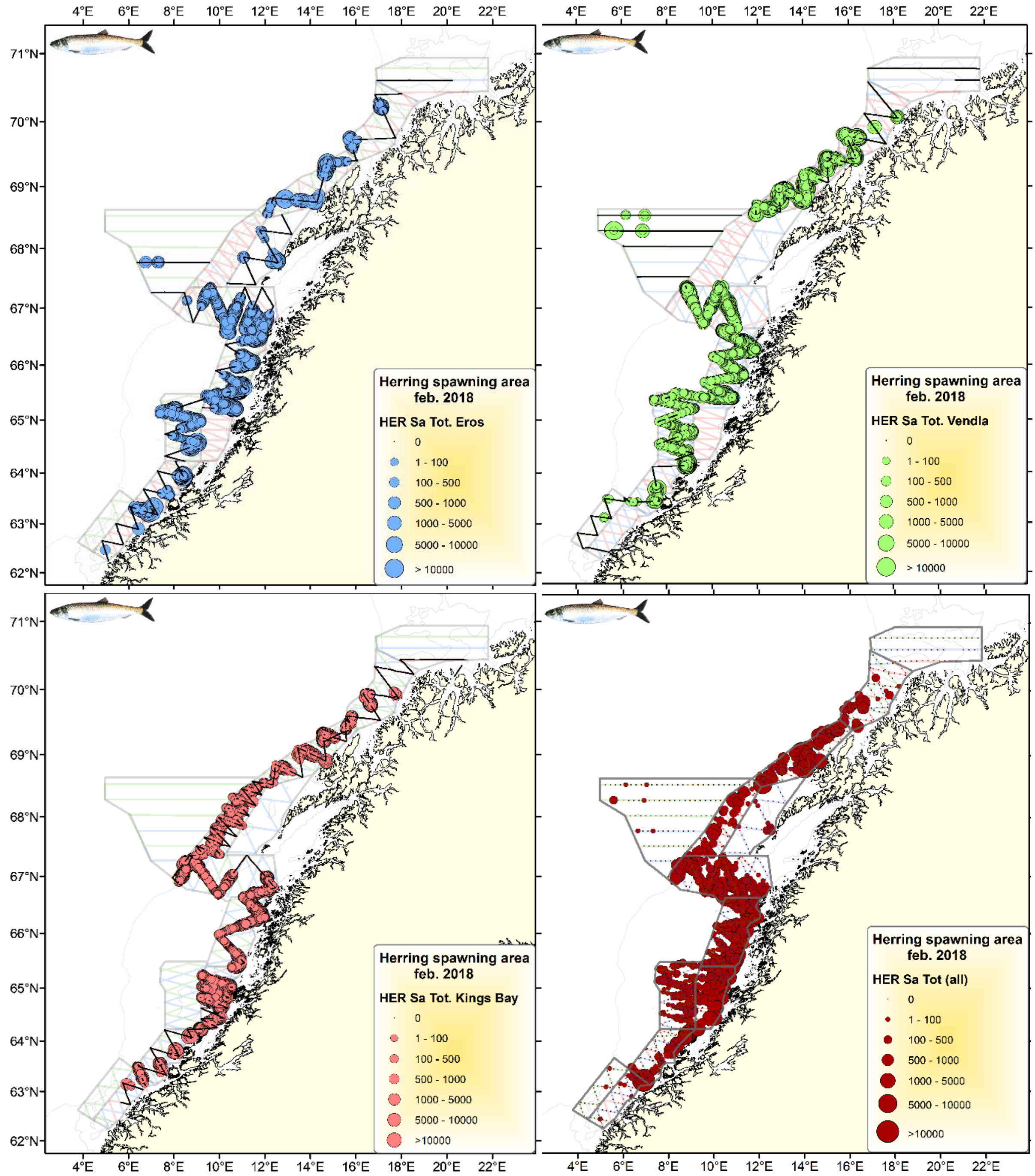


Figure 6. Acoustic density (NASC) of herring recorded during 13-25. February 2018. Bubbles represent 0.1 nm acoustic registrations when shown by per vessels (Eros, Kings Bay and Vendla) and 5 nm registrations when shown for all vessels merged (bottom right). See also Annex 3 for examples of acoustic registrations in the surveys area from Kings Bay.

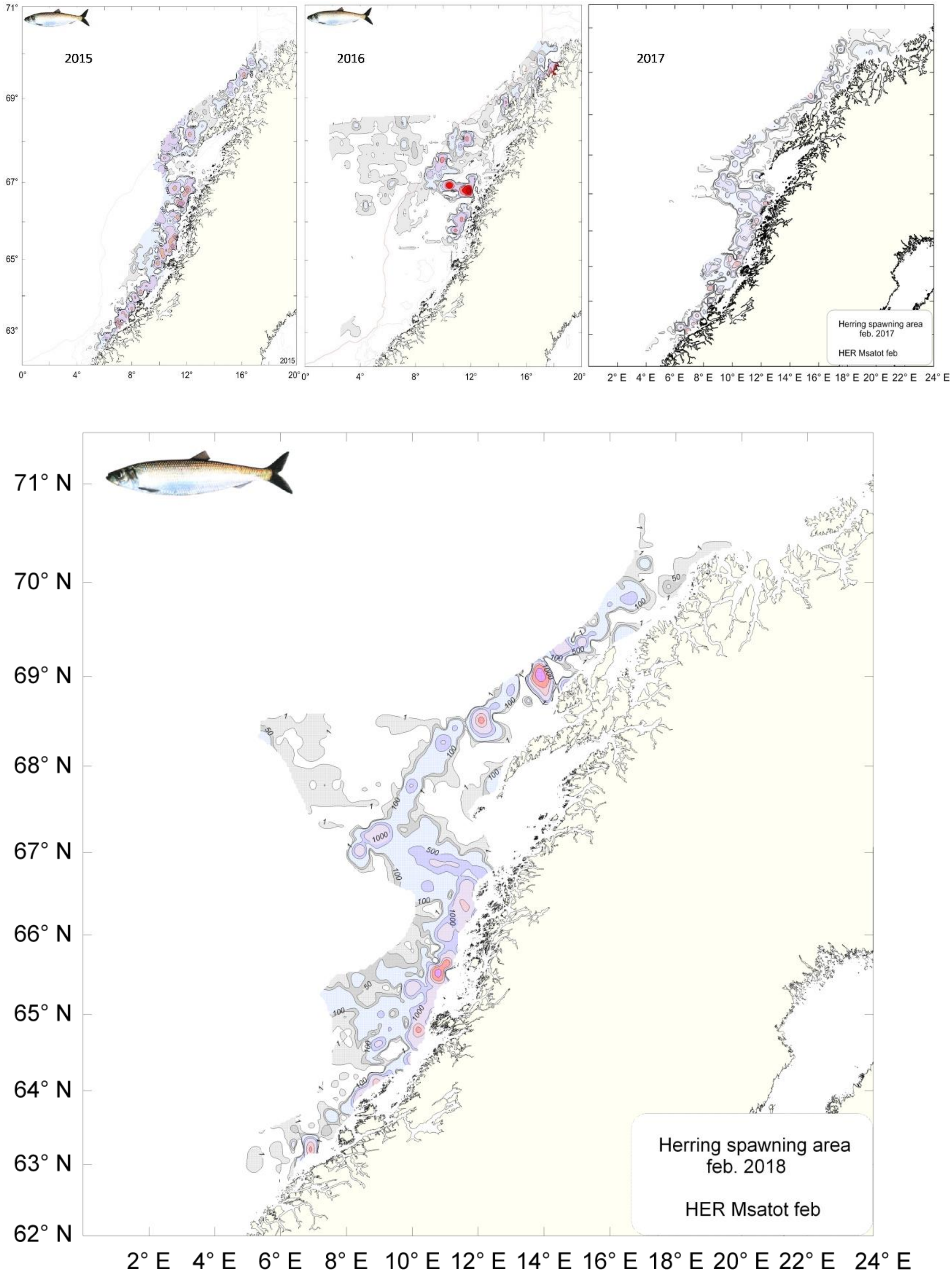


Figure 7. Acoustic density of herring recorded during 13-25. February 2018 (bottom), compared with the situations in 2015, 2016 and 2017 (top).

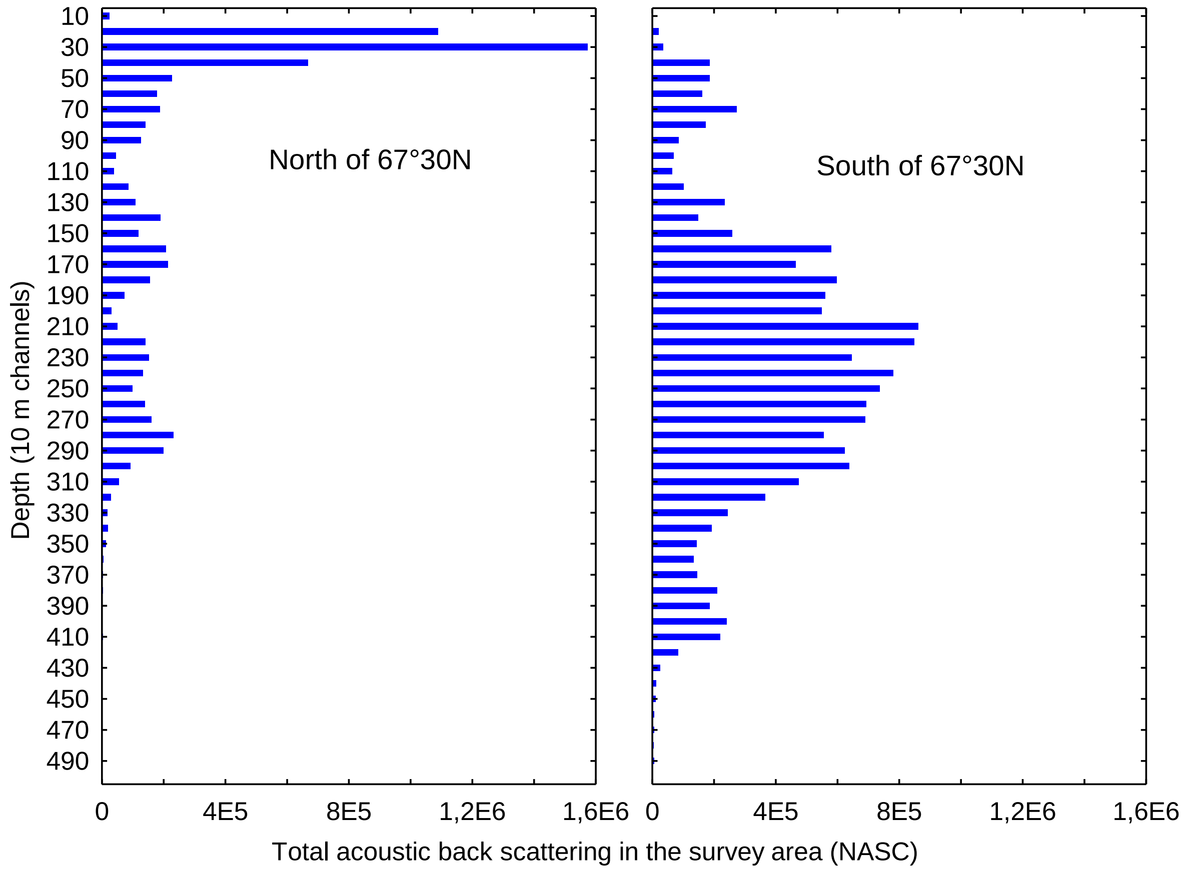


Figure 8. Total acoustic back scattering (NASC) by 10 m depth channels in the survey area during 13-25. February 2018. Comparison between areas the south and north of 67°N.

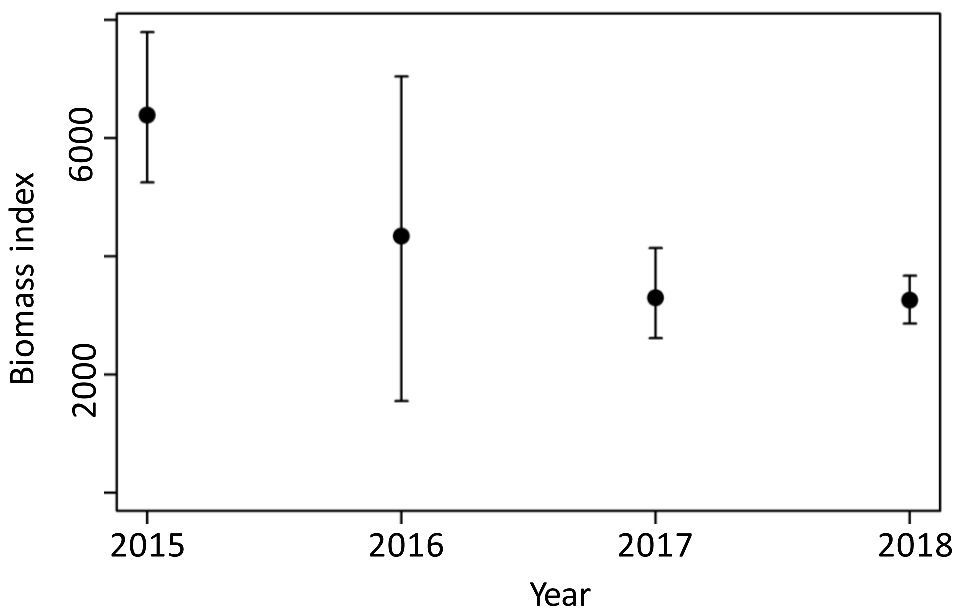


Figure 9. Biomass index estimated from the Norwegian spring-spawning herring spawning surveys 2015-2018 (the error bars represent 90% confidence intervals).

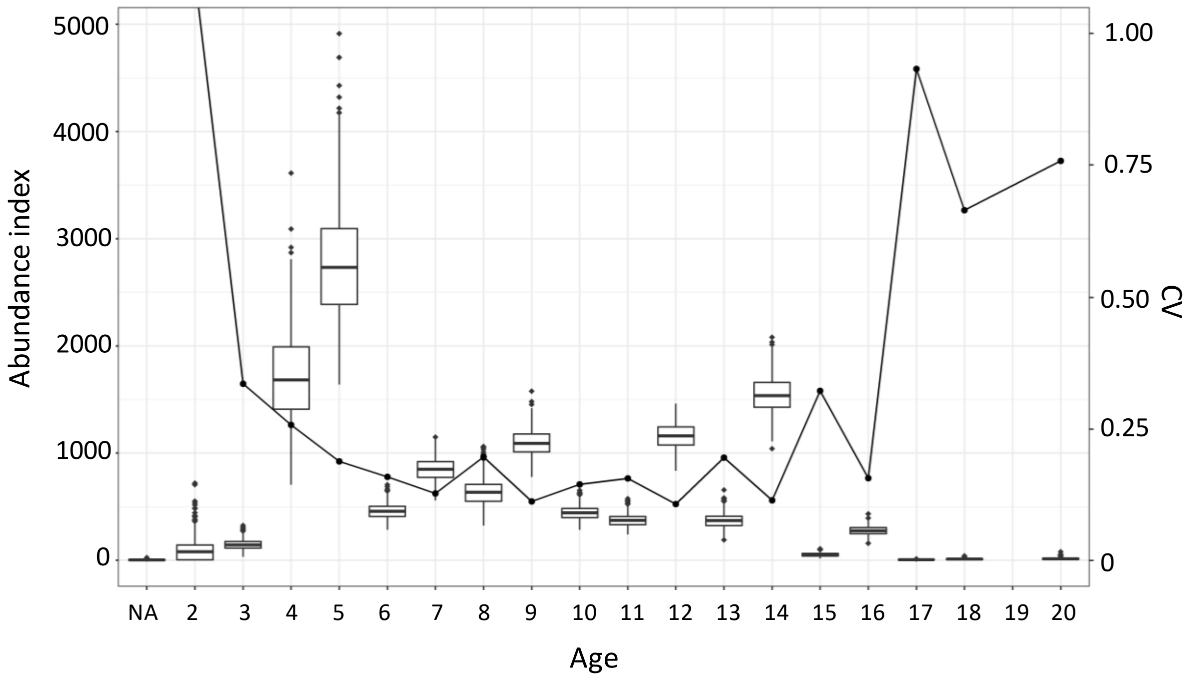


Figure 10. Standard box plot of abundance index by age with uncertainty as estimated during 13-25. February 2018. The Uncertainty estimates were based on 500 bootstrap replicates in StoX. See Table 3 for details on the data presented.

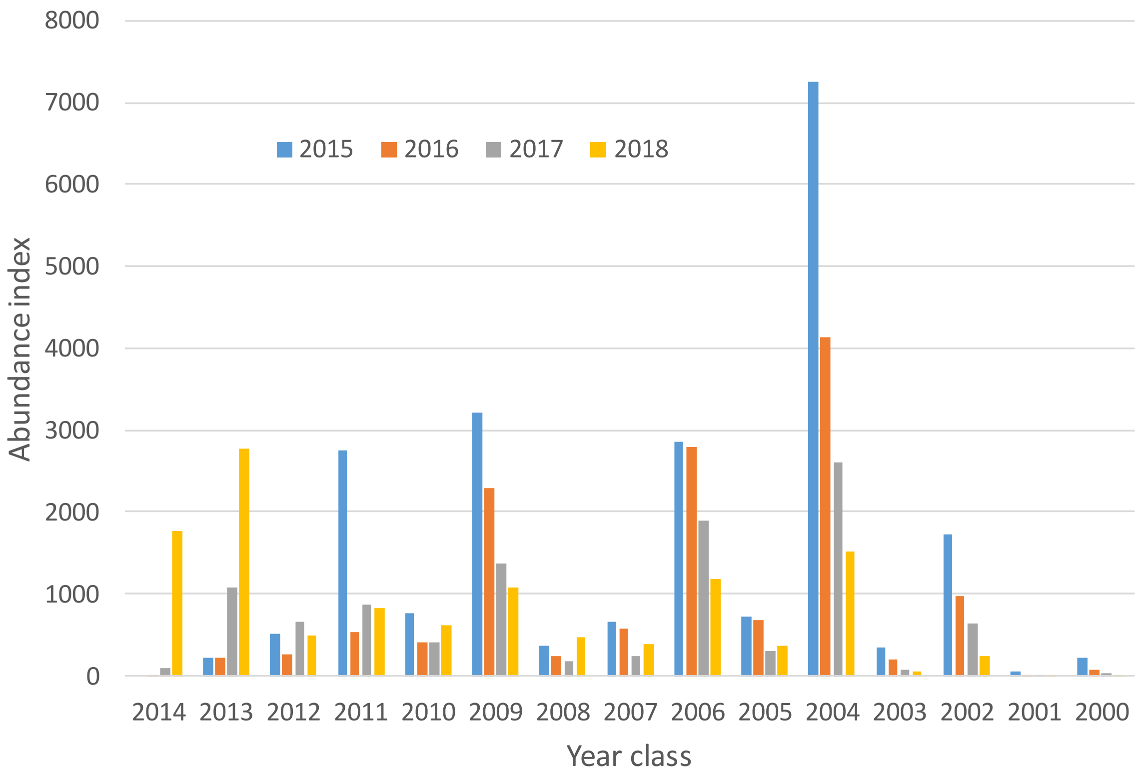


Figure 11. Abundance index by year class estimated during the Norwegian spring-spawning herring surveys 2015-2018.

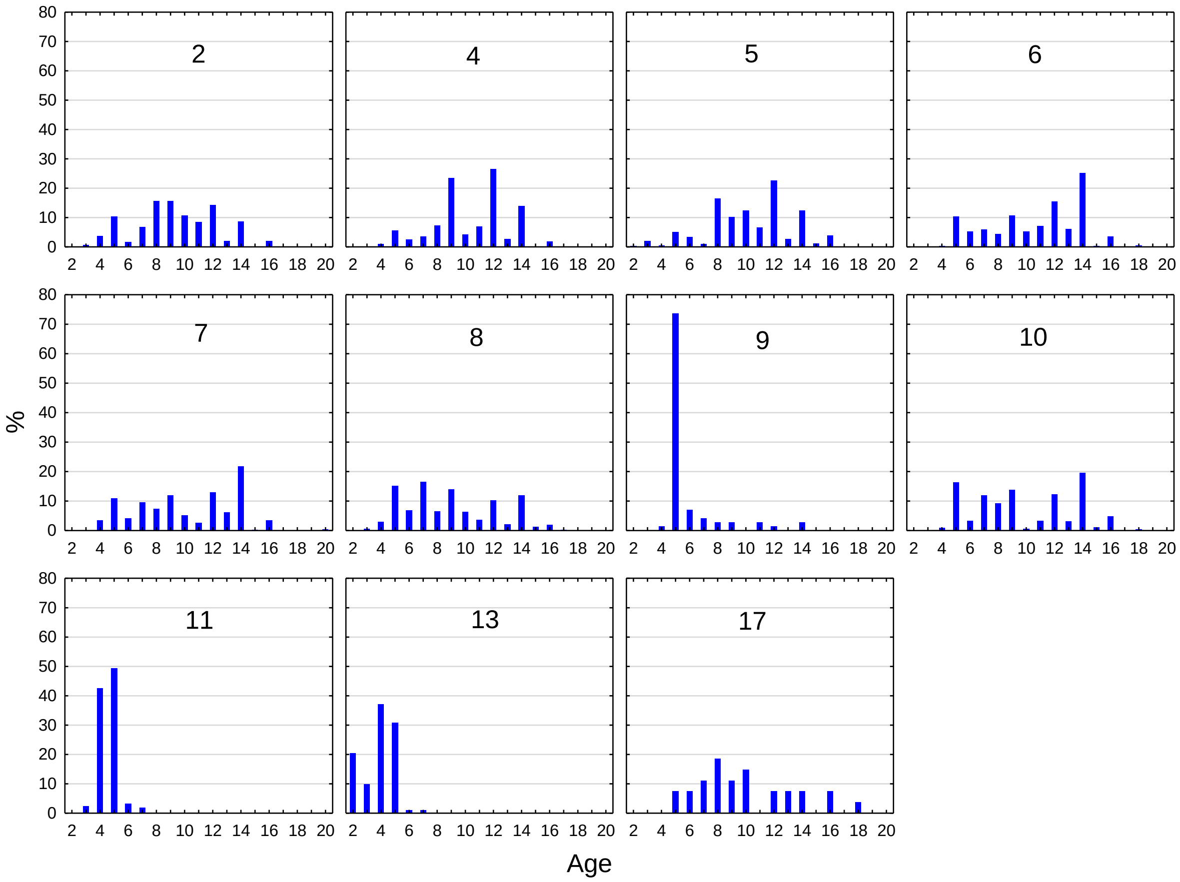


Figure 12. Comparison of relative age composition (%) estimated in the different strata covered during 13-25. February 2018. Se Figure 1 for spatial distribution of strata and Table 2 for index of abundance by strata.

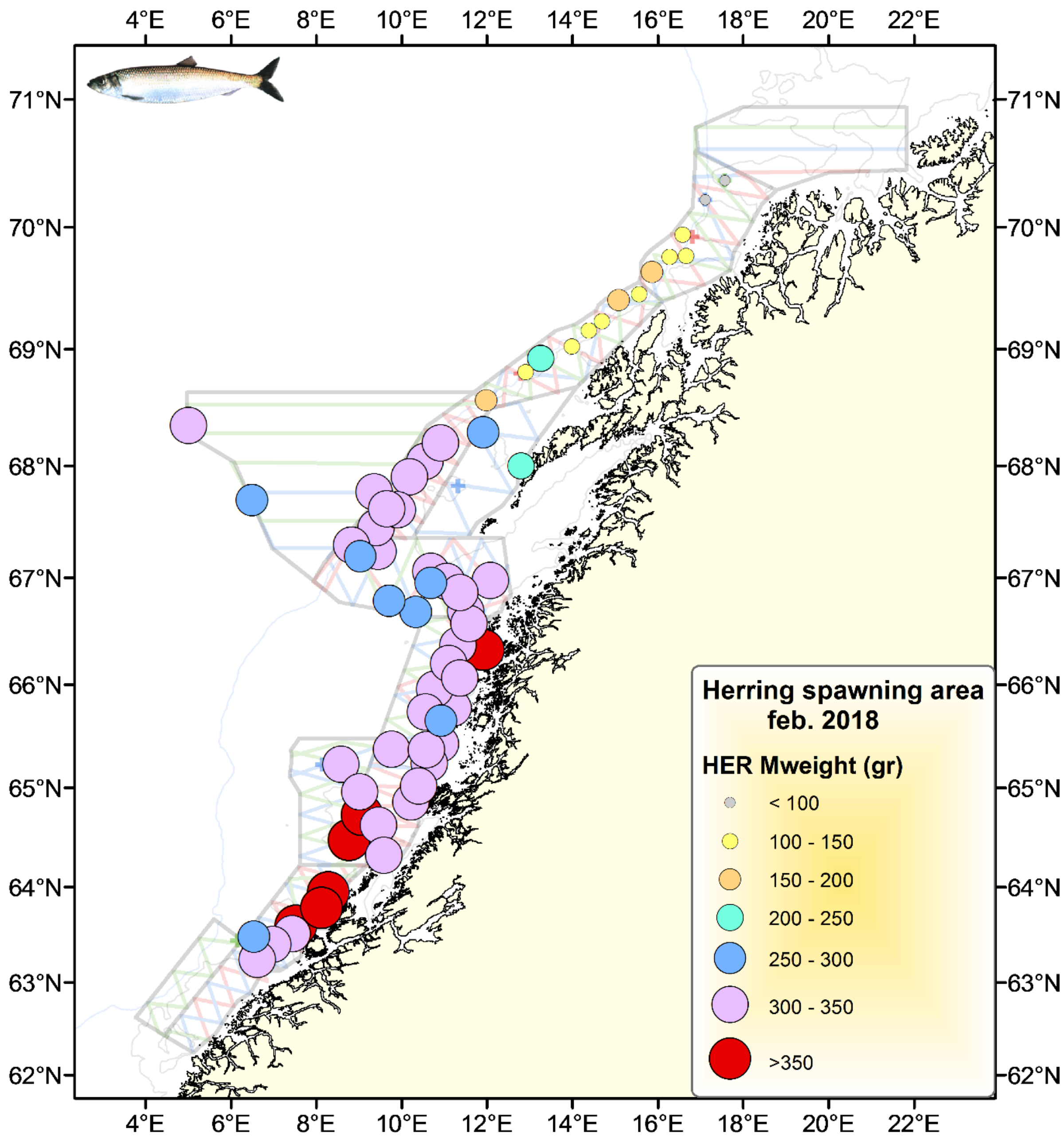


Figure 13. Spatial differences in mean herring weight (g) during the Norwegian spring-spawning herring survey13-25. February 2018.

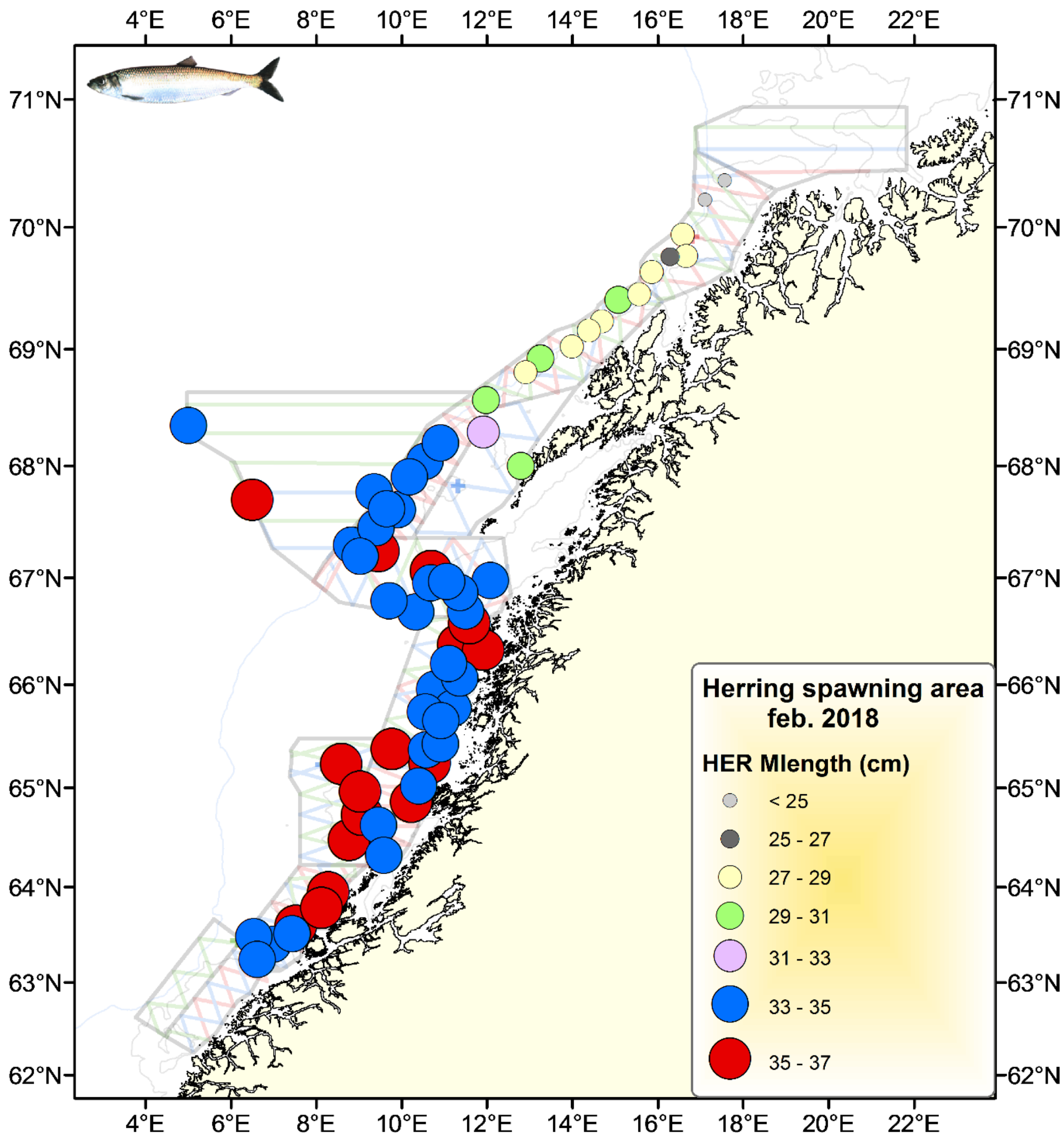


Figure 14. Spatial differences in mean herring body length (cm) during the Norwegian spring-spawning herring survey 13-25. February 2018.

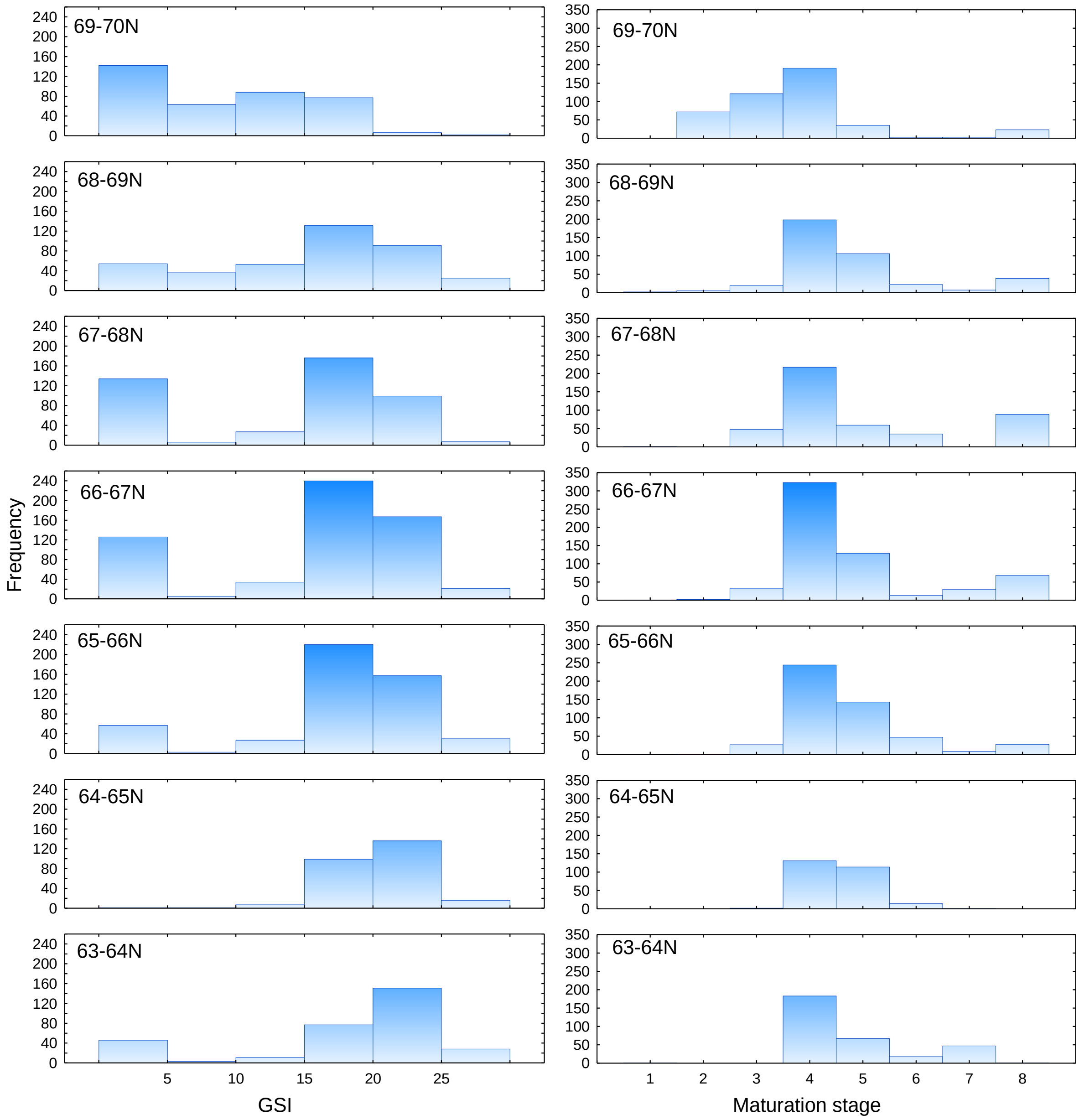


Figure 15. Latitudinal variation in maturation during the Norwegian spring-spawning herring survey13-25. February 2018. Data are not weighted by acoustics, simply frequency of fish analysed. Shown in GSI (gonadosomatic index - % gonad weight relative to total weight), as well as maturation stage on a subjective scale, where 1-2= immature, 3=early maturing, 4=late maturing, 5=ripe, 6=spawning, 7=spent, 8=resting stages.

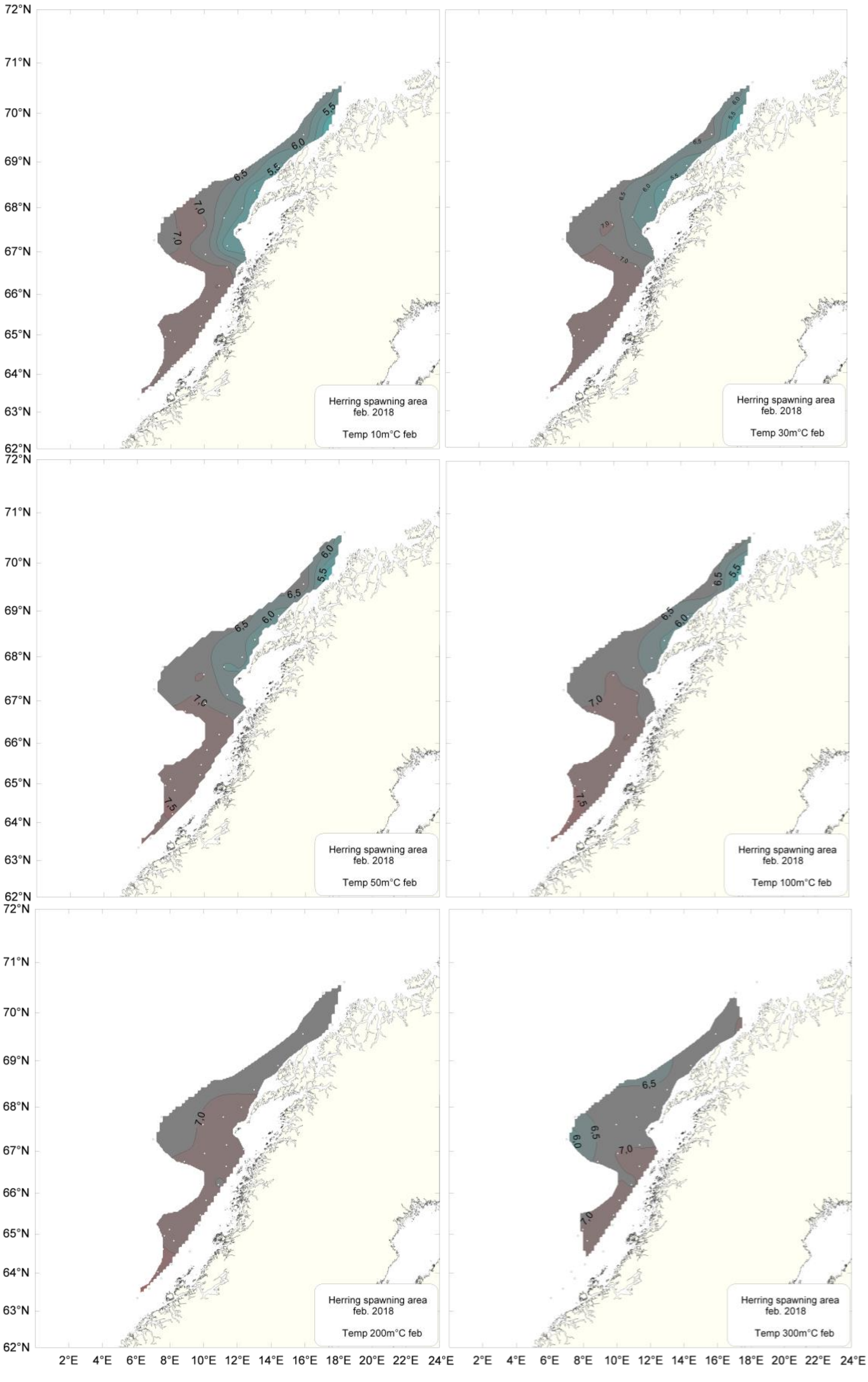


Figure 16. Temperature at 5, 30, 50, 100, 200, 300 m in the area covered during the Norwegian spring-spawning herring survey13-25. February 2018.

Annex 1. Calibration results and settings

Table 1. Calibration data and parameter settings of Simrad EK80 and EK60 split-beam echo sounders mounted on Kings Bay, Vendla and Eros as used during data collection. WC57.2 calibration sphere was used in Ålesund, with tabulated values for the sphere TS on EK60, and with the internally computed for EK80. An error in the calibration program of the EK80 at 18 and 38 kHz was discovered during the survey, and the transducer gain was changed after the survey and re-run for new LUF files at 38 kHz was generated. The adjustment was +13% in the nautical area scattering coefficient. Correct gain indicated in bold numbers. For the two other vessels, using Simrad EK60, the calibration data below was used, as measured in Aalesund February 13. 2018.

MS Kings Bay, Simrad EK80

Parameter					
	Survey data sample 20180218 02:37UTC. Simrad EK80, narrow-band				
Transducer type	ES18	ES38B	ES70-7C	ES120-7C	ES200-7C
Transmission frequency [kHz]	18	38	70	120	200
Transmission power [W]	2000	2000	750	250	150
Pulse duration [ms]	1.024	1.024	1.024	1.024	1.024
TS Transducer Gain [dB]	22.4/**23.09**	24.33/**24.06**	27.54	27.2	27.49
Sa Correction (dB)	0.002	0.008	-0.07	0.03	-0.03
Equivalent beam angle [dB]	-17.0	-20.7	-20.7	-20.7	-20.7
Absorption coefficient [dB km^{-1}]	2.61	9.59	22.4	36.9	52.15
Half power beam widths (along/athwart ship) [deg]	10.4/10.13	7.0/7.0	7.31/9.9	6.45/6.22	6.67/6.43
Transducer angle sensitivity (along ship and athwart ship)	15.5	23.0	23.0	23.0	23.0
Sound speed [m s^{-1}]	1474	1474	1474	1474	1474

M/S Vendla, Simrad EK60

Parameter					
	Calibration 20180218 Simrad EK60, CW narrow-band				
Transducer type	ES18	ES38B	ES70-7C	ES120-7C	ES200-7C
Transmission frequency [kHz]	18	38	70	120	200
Transmission power [W]	2000	2000	750	250	120
Pulse duration [ms]	1.024	1.024	1.024	1.024	1.024
TS Transducer Gain [dB]	22.83	25.56	26.59	27.21	27.60
Sa Correction (dB)	-0.57	-0.65	-0.32	-0.32	-0.24
Equivalent beam angle [dB]	-17.0	-20.6	-20.7	-21.0	-20.7
Absorption coefficient [dB km^{-1}]	2.61	9.2	20.7	33.2	47.1
Half power beam widths (along/athwart ship) [deg]	10.78/10.71	7.03/7.09	6.57/6.63	6.72/6.72	6.19/6.51
Transducer angle sensitivity (along ship and athwart ship)	15.5	23.0	23.0	23.0	23.0
Sound speed [m s^{-1}]	1474	1474	1474	1474	1474

M/S EROS, Simrad EK60

Parameter					
	Calibration 20180218, Simrad EK60, CW narrow-band				
Transducer type	ES18	ES38B	ES70-7C	ES120-7C	ES200-7C
Transmission frequency [kHz]	18	38	70	120	200
Transmission power [W]	2000	2000	375	150	90
Pulse duration [ms]	1.024	1.024	1.024	1.024	1.024
TS Transducer Gain [dB]	22.25	26.02	26.84	26.59	26.03
SaCorrection (dB)	-0.73	-0.56	-0.34	-0.26	-0.27
Equivalent beam angle [dB]	-17.0	-20.6	-20.7	-21.0	-20.7
Absorption coefficient [dB km^{-1}]	2.7	9.8	20.7	34.1	48.0
Half power beam widths (along/athwart ship) [deg]	10.90/10.75	7.24/7.20	6.52/6.59	6.76/6.64	6.41/6.45
Transducer angle sensitivity (along ship and athwart ship)	15.5	23.0	23.0	23.0	23.0
Sound speed [m s^{-1}]	1474	1474	1474	1474	1474

Annex 2. Sonar report

By Sindre Vatnehol

Purpose for using sonar

Fish in the echo sounder's blind zone and avoidance behaviour of fish, caused by the presence of the vessel, are often referred to as potential sources of bias when developing annual indices (Løland et al. 2007). Horizontally observing equipment, such as scientific and fisheries sonars, may have the potential to measure the presence and magnitude of these measurement biases and if these have changed between years/areas. Data from calibrated fisheries sonars have been collected from all participating vessels since 2015. Methods to quantify or evaluate the extend of these biases are presently being developed.

A second objective was to circumnavigate a few selected fish schools, to obtain information of the school's acoustic backscatter directivity (Cutter and Demer 2007), and to evaluate the migration of the fish in the off-shore strata.

Sonar preparation:

The low-frequency sonars, either the Simrad SX90 or the Simrad SU90, was calibrated 13th of February in the harbour of Ålesund. The calibration was carried out according to the description made by Macaulay et al. (2016). Given the considerable size of the data stream from 64 beams, all sonar data was stored directly to a 2TB external hard drive. Backup was repeatedly made by IMR's personnel on each vessel.

We used the same sonar setting that has been used since 2015.

- The horizontal beam fan was slightly tilted to8 degree below the horizon (Horizontal mode)
- For vertical mode, the fan of beams was set to observe perpendicular to the vessel's heading direction.
- Frequency of 30 kHz

- Range of 600 meter
- Noise-filter was switched off as this filter corrupts the data.

In the outer survey area outside the continental shelf, in the herring's wintering area, the sonar range was set to 2500 meters and a tilt angle of 4 degree below the horizon.

Sonar performance

The logging of the data was checked regularly. Several times, often while copying data for backup, the sonar stopped transmitting and had to be restarted. A small surveillance program was made to detect when the sonar stopped transmitting, and larger periods without logging data were then prevented.

Visual interpretation of the data

Methods for evaluating the extension of the biases are still being developed; hence, no temporarily estimates will be presented here. However, some remarks of what was observed is made.

In-shore strata:

For the transect in the in-shore strata's, most of the fish was observed by the echo-sounder to be close to the seabed. This is an unfavourable fish distribution for the sonars since separation between fish and seabed is than difficult, and the fish data may also be corrupted by the strong reflection from the seabed. A few times, and in the western part of the strata, some fish was aggregating into schools (Figure 1).

Off-shore strata:

A few aggregations of summer/fall spawning herring were observed in the off-shore strata (i.e. Figure 2). Typically, these aggregations were at a depth between 200 to 300 meters; and, both the aggregation's volume and the backscattering strength appear to be less than what had been observed in-shore. Some of these aggregations where circumnavigated for a closer inspection. Unfortunately, the aggregation was located too deep to obtain a representative presentation of the directivity as a beams' tilt angle around 30-50 degrees was needed.

An indication of the swimming speed and direction of a few of the aggregations were made by using utilities in the sonar software. This information was then compared to the water current speed and direction; and, apparently, the aggregations moved withthe same speed and direction as the water. This was concluded on aggregations both before and after the vessel had passed, and during trawling operations. This indicate the fish in the off-shore strata was not actively migrating, at least when the measurements were made. The data for the current profile was not accessible for logging.

The northern strata:

In the northern strata the fish was distributed closer to the sea surface, and was thus also recorded by the sonar. Some of these registrations originated from relatively young herring; although, acoustic registrations and trawl catches of capelin became more dominant as the vessel moved further north.

Figures

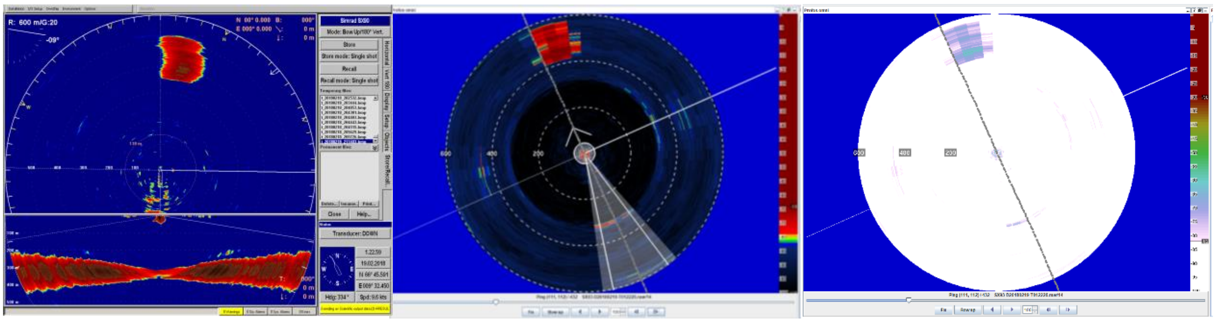


Figure 1. To the left, screen dump of the sonar display when recording a fish aggregation in the in-shore strata. In the middle, a representation of the data collected from the same aggregation of fish. The colour scale was continuously adapted by the user to increase the visibility. To the right, the same data as in the middle, but with the same colours as used for echo-sounder recordings. This colour scale is fixed, (SV, -70, -34, standard), where colour now represents a fixed herring density.

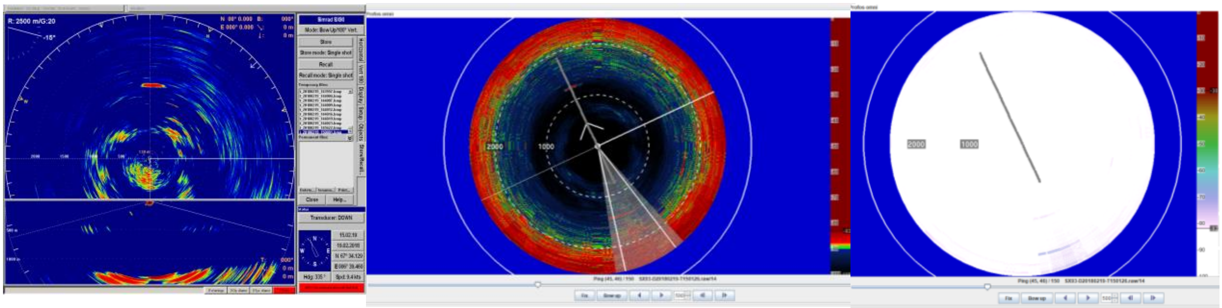


Figure 2. To the left, screen dump of the sonar display when recording a fish aggregation in the off-shore strata. In the middle, a representation of the data collected from the same aggregation of fish. The colour scale was continuously adapted by the user to increase the visibility. To the right, the same data as in the middle, but with the same colours as used for echo-sounder recordings. This colour scale is fixed.

References:

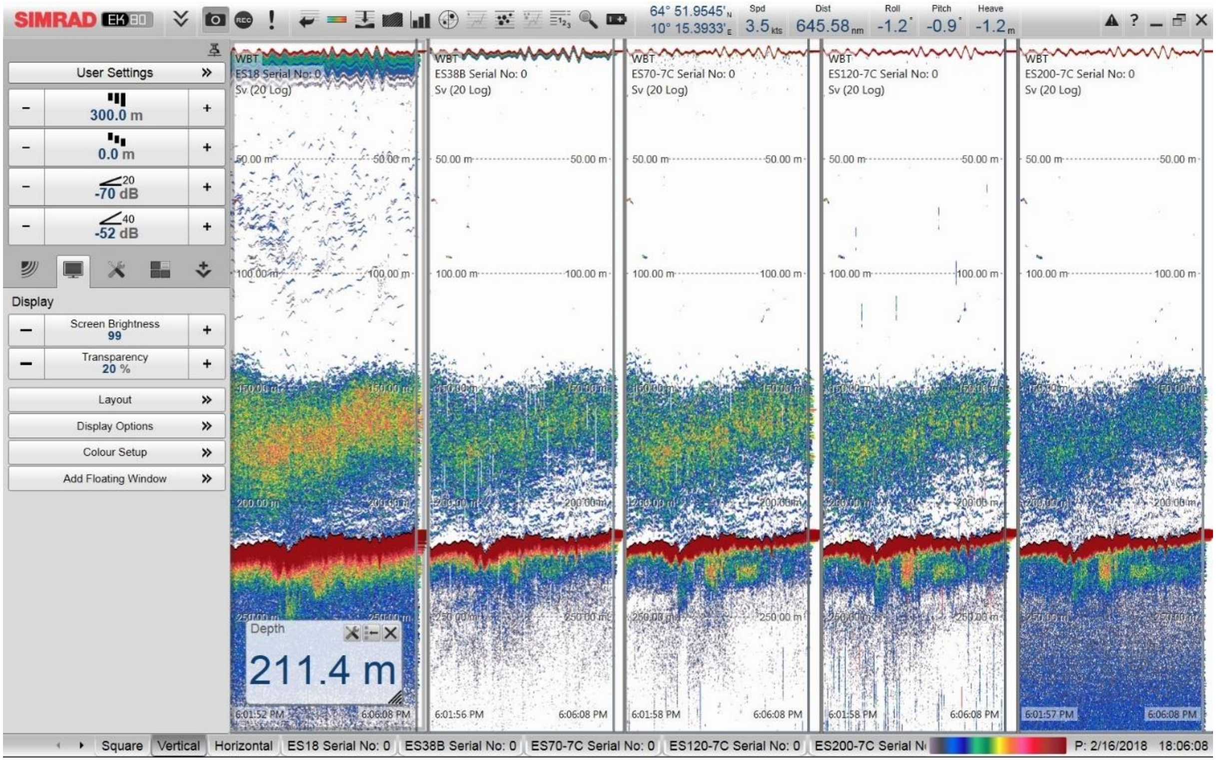
Cutter, George R., and David A. Demer. 2007. "Accounting for Scattering Directivity and Fish Behaviour in Multibeam-Echosounder Surveys." *ICES Journal of Marine Science* 64 (9): 1664–74. doi:10.1093/icesjms/fsm151.

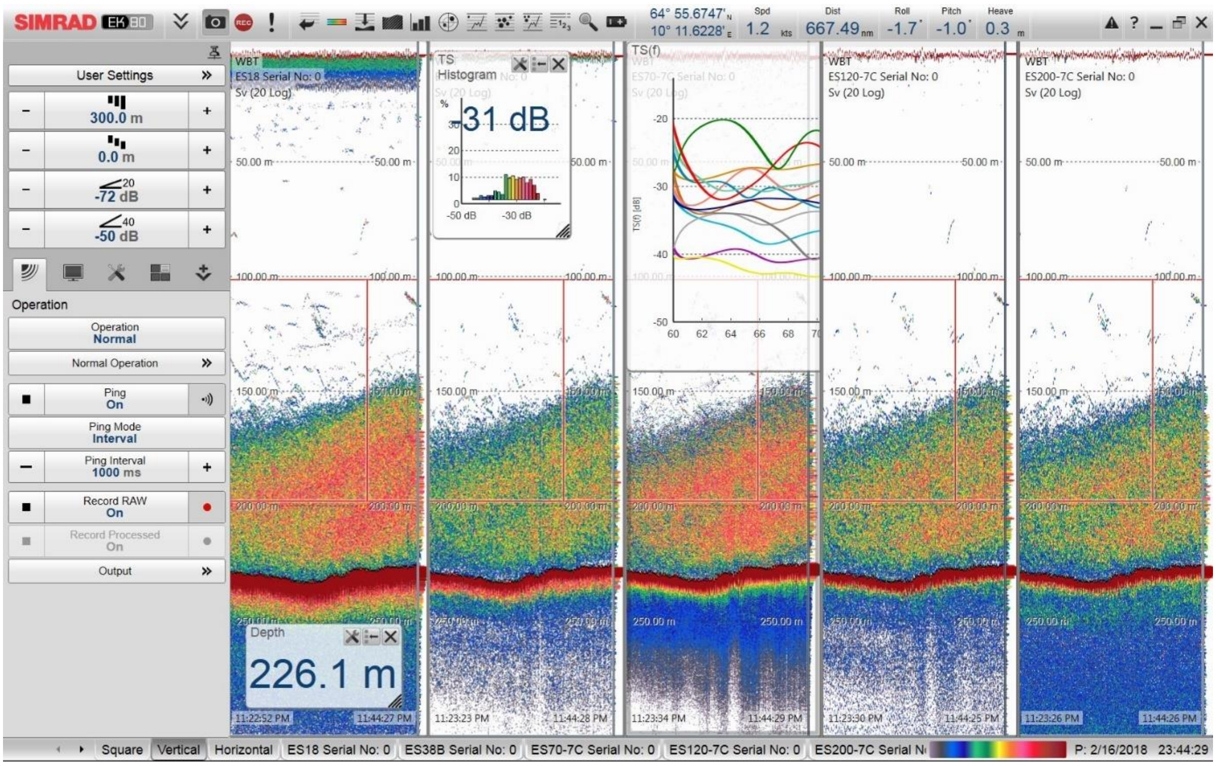
Løland, Anders, Magne Aldrin, Egil Ona, Vidar Hjellvik, and Jens Christian Holst. 2007. "Estimating and Decomposing Total Uncertainty for Survey-Based Abundance Estimates of Norwegian Spring-Spawning Herring." *ICES Journal of Marine Science* 64 (7): 1302–12. doi:10.1093/icesjms/fsm116.

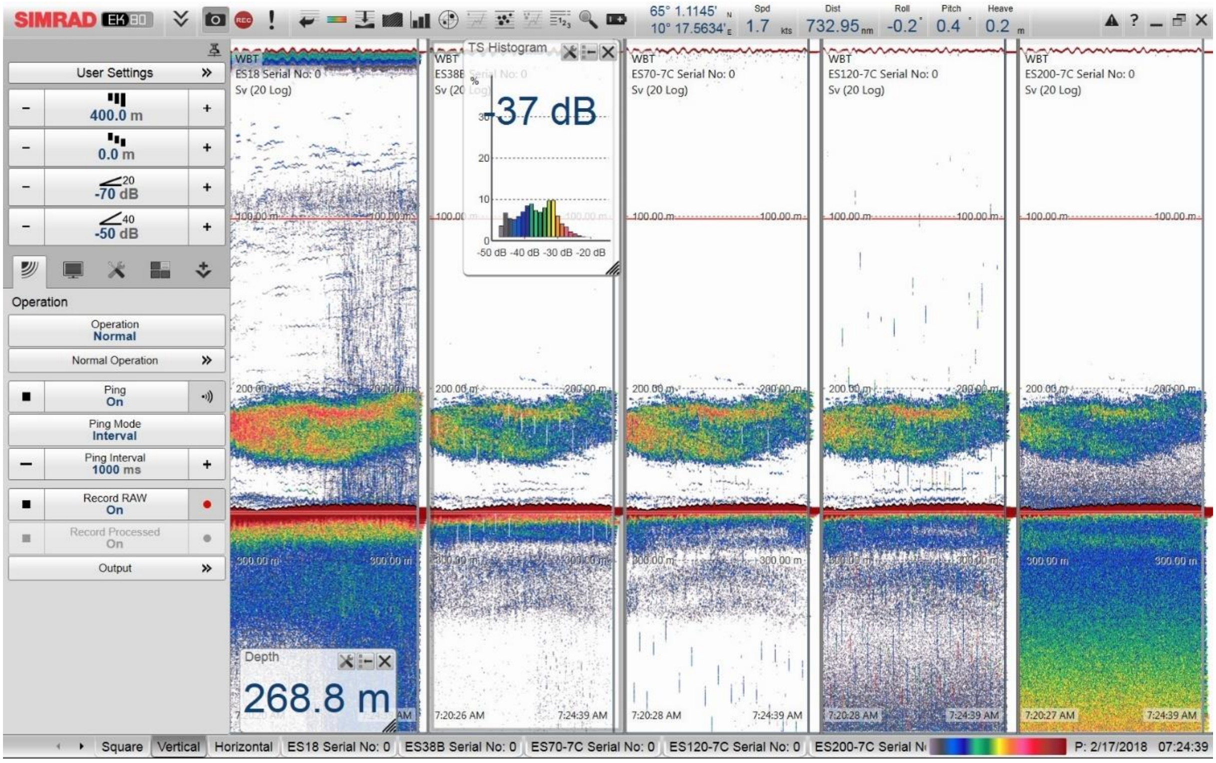
Macaulay, Gavin John, Sindre Vatnehol, Ole Bernt Gammelsæter, Egil Ona, and Hector Pena. 2016. "Practical Calibration of Ship-Mounted Omni-Directional Fisheries Sonars." *Methods in Oceanography* 17: 206-220.

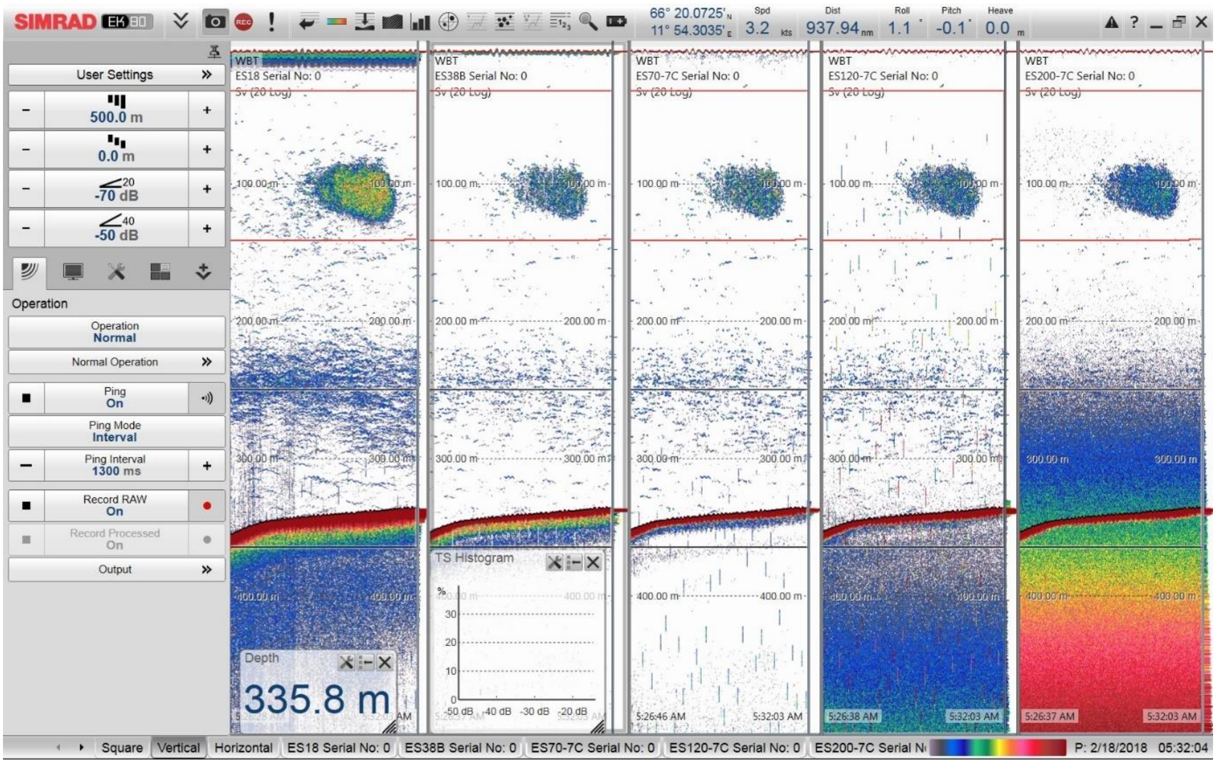
Annex 3. Examples of acoustic registrations with EK80 at Kings Bay

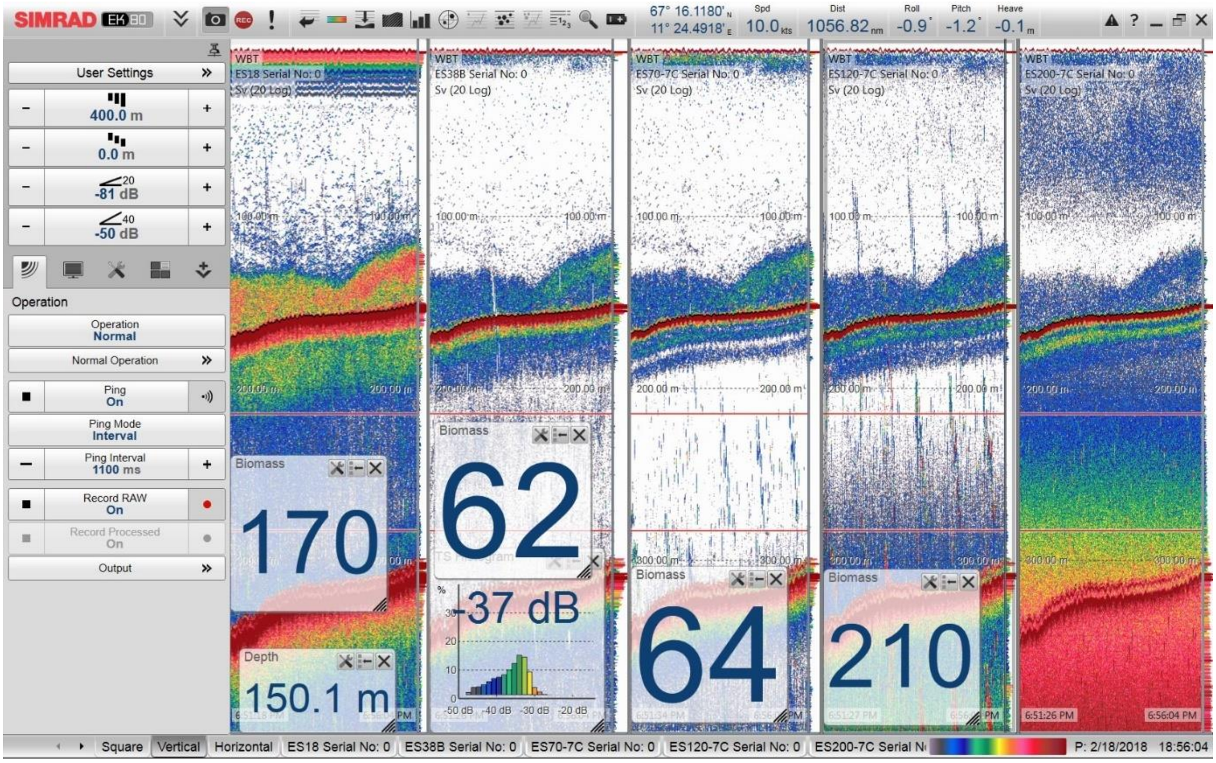
Below is given several examples of acoustic registrations (echograms) of herring in the survey area between 64°N and 70°N using EK80 and frequencies 18, 38, 70, 120 and 200 kHz. Position of registrations is seen in on the top of each echogram, starting in the south and ending in the north at the end of the annex.

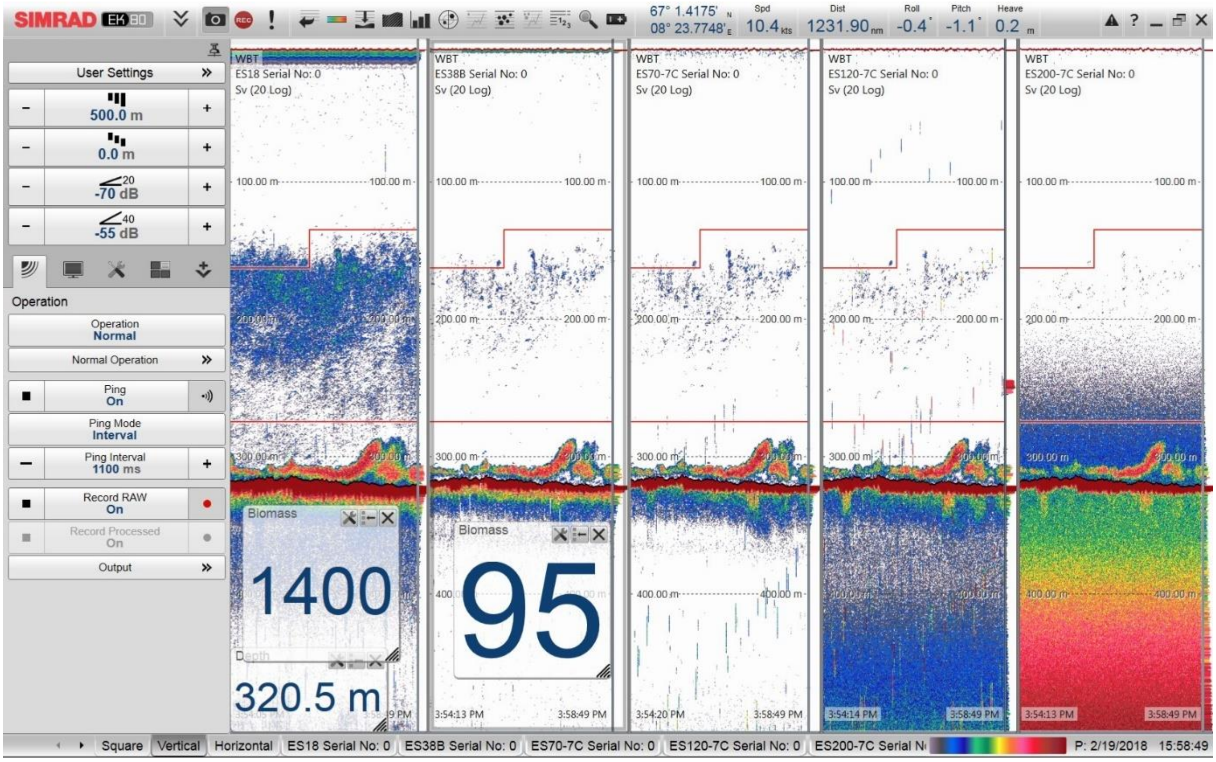


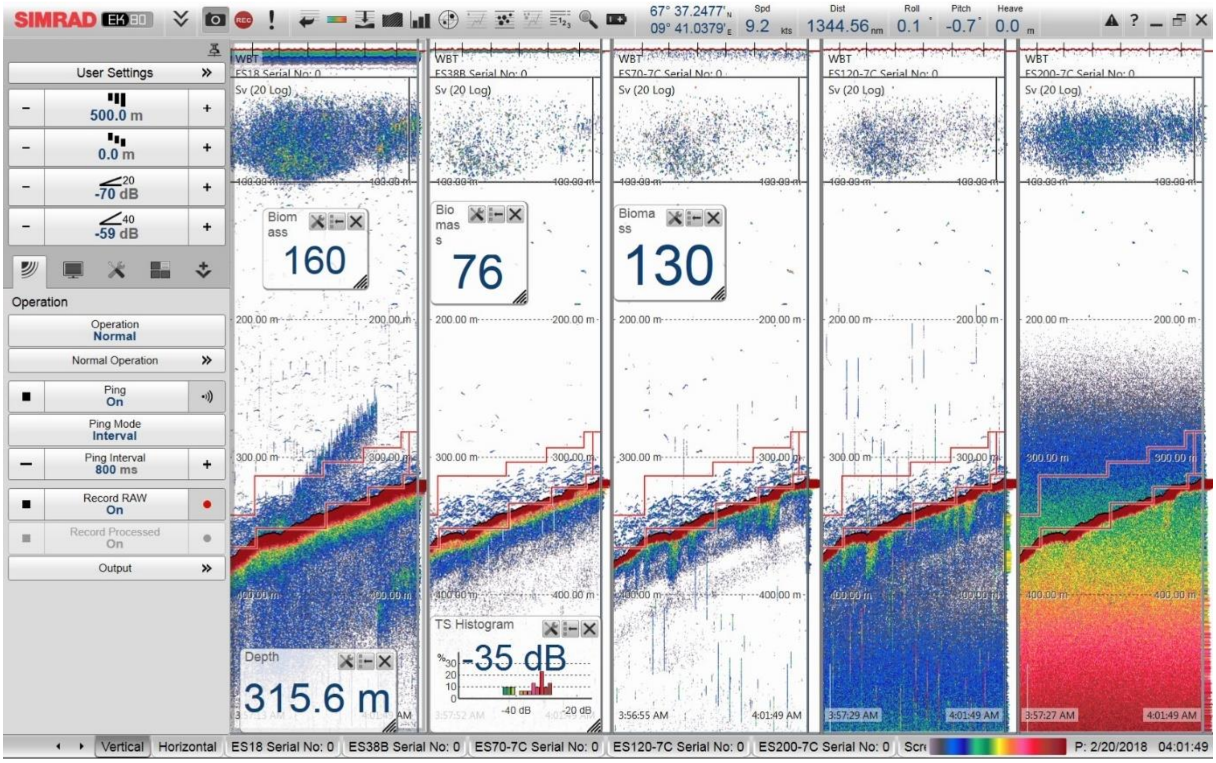


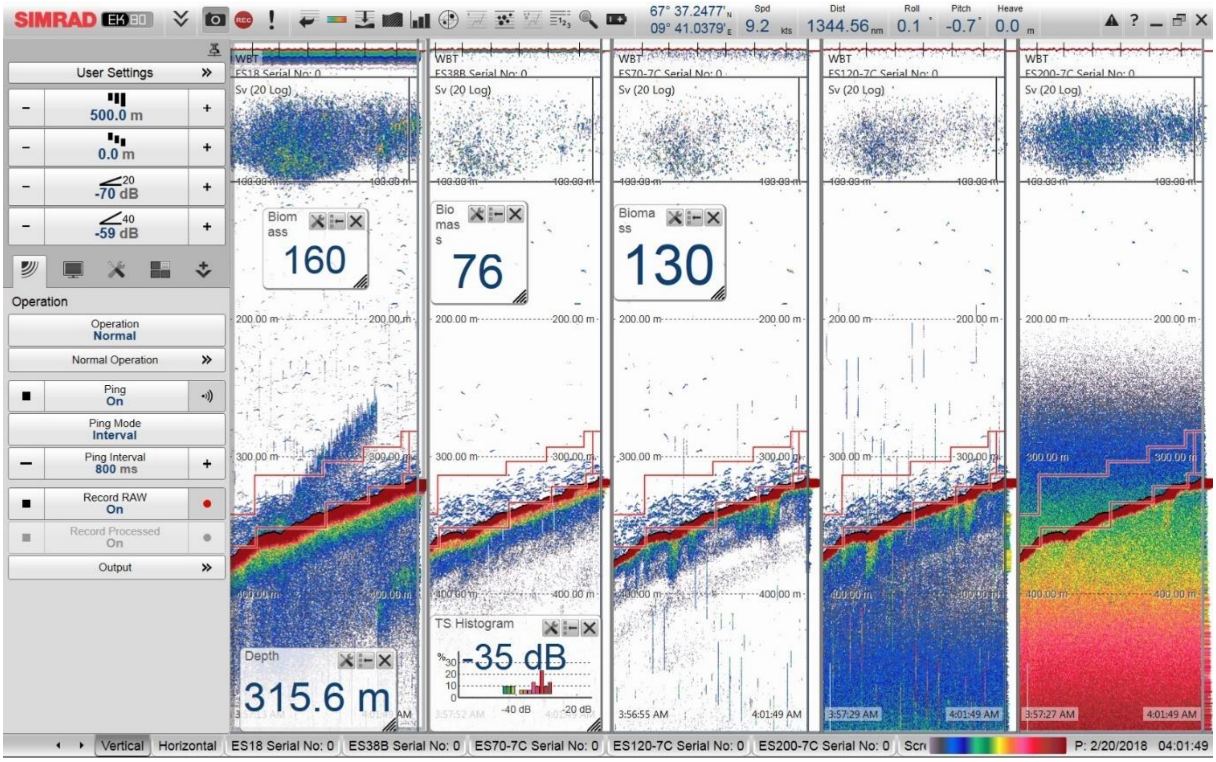


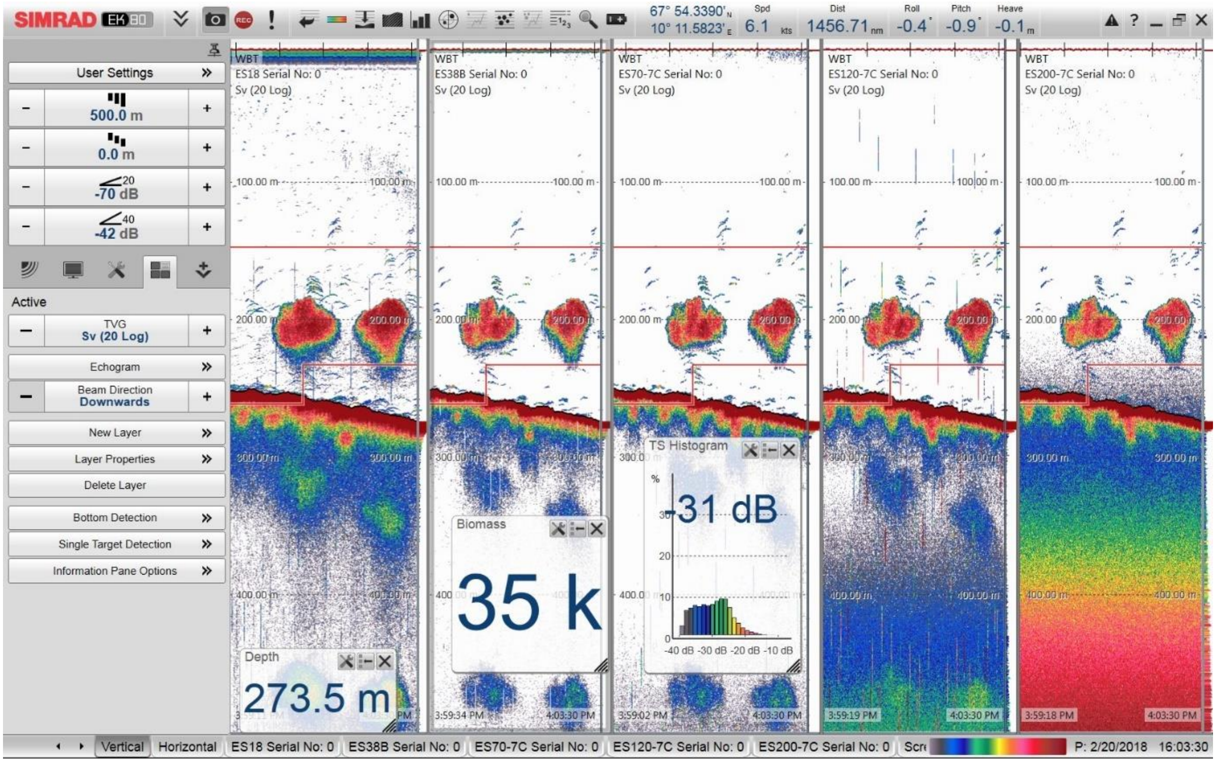


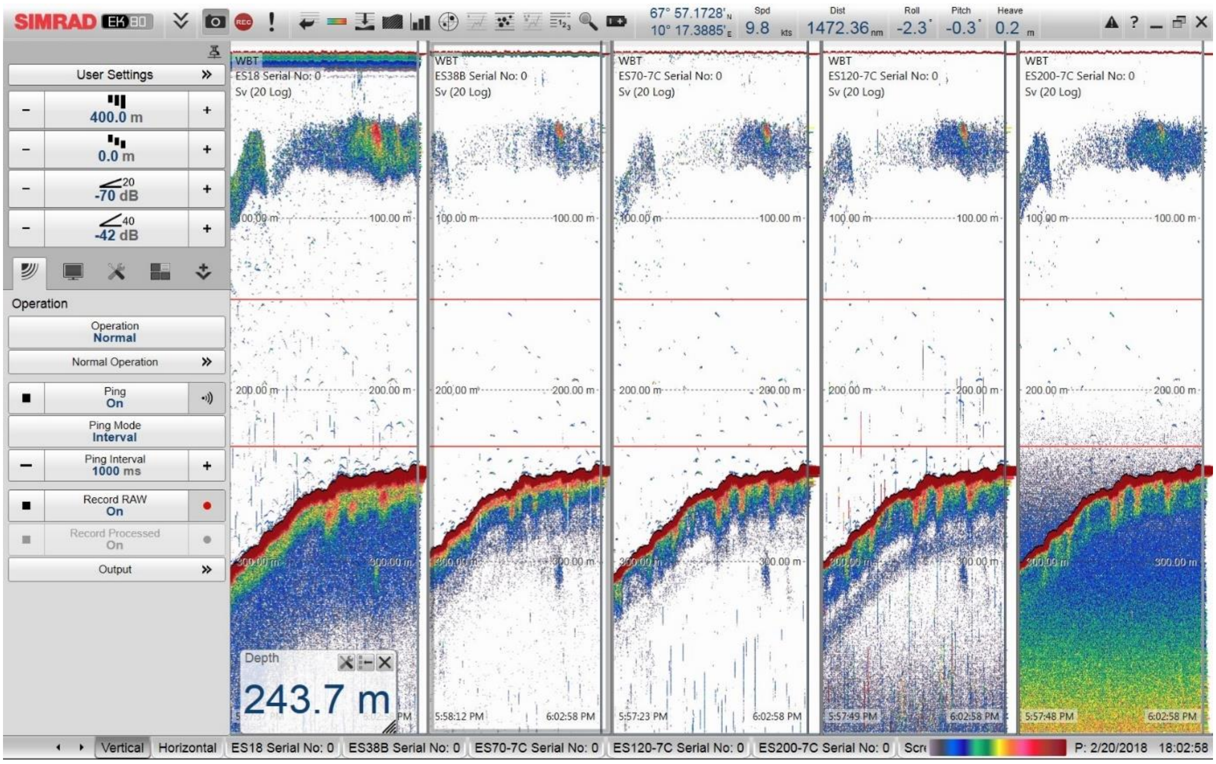

SIMRAD EK80
67° 16.1180' N
11° 24.4918' E
Spd 10.0 kts
Dist 1056.82 nm
Roll -0.9°
Pitch -1.2°
Heave -0.1 m
User Settings
400.0 m
0.0 m
-81 dB
-50 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 1100 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
100.00 m
200.00 m
300.00 m
Biomass
170
62
64
210
Depth
150.1 m
-37 dB
-50 dB
-40 dB
-30 dB
-20 dB
6:51:26 PM
6:56:04 PM
Square
Vertical
Horizontal
P: 2/18/2018 18:56:04

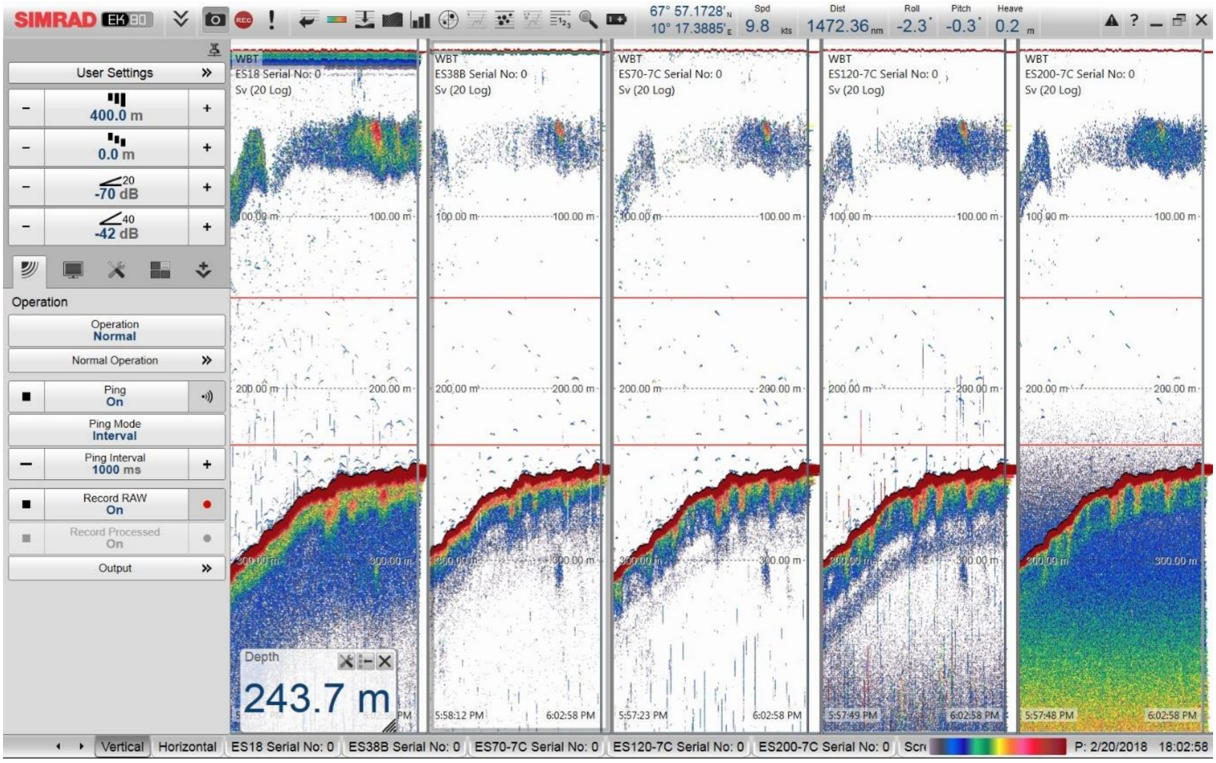

SIMRAD EK80
67° 1.4175' N
08° 23.7748' E
Spd 10.4 kts
Dist 1231.90 nm
Roll -0.4°
Pitch -1.1°
Heave 0.2 m
User Settings
500.0 m
0.0 m
-70 dB
-55 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 1100 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
100.00 m
200.00 m
300.00 m
400.00 m
Biomass
1400
95
Depth
320.5 m
3:54:13 PM
3:58:49 PM
Square
Vertical
Horizontal
P: 2/19/2018 15:58:49

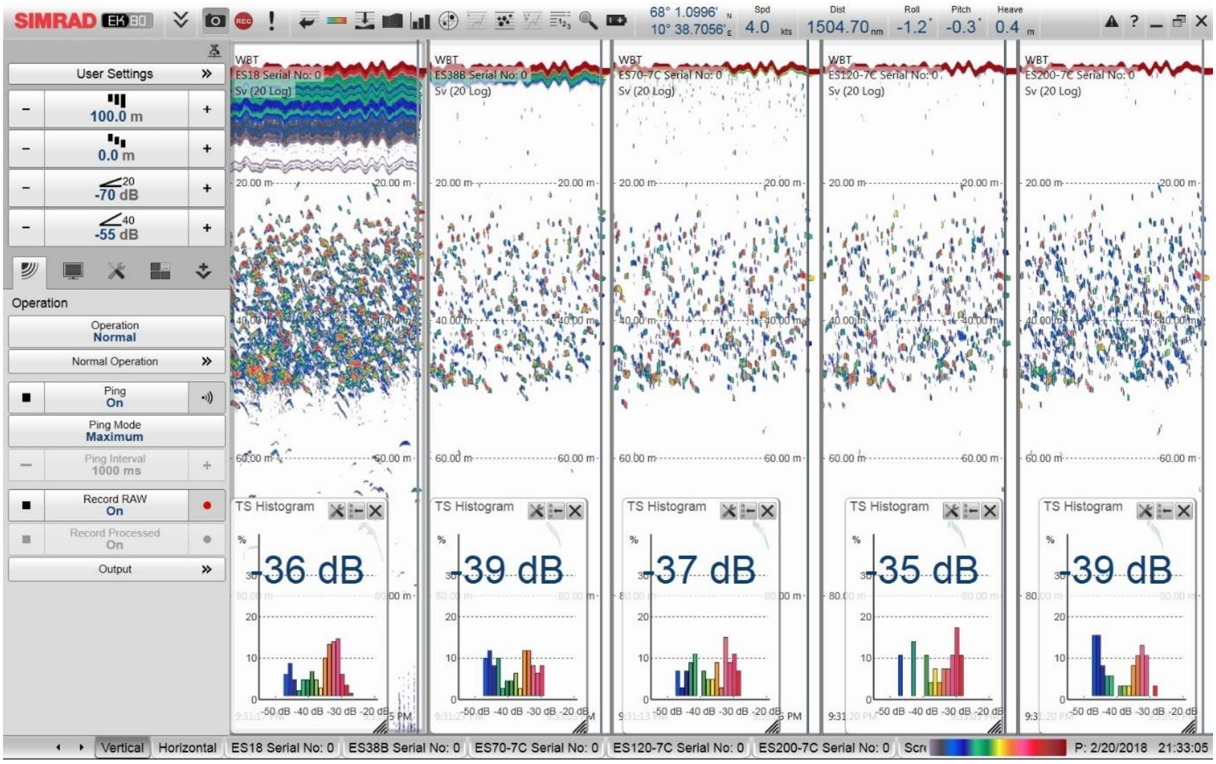

SIMRAD EK80
67° 37.2477' N
09° 41.0379' E
Spd 9.2 kts
Dist 1344.56 nm
Roll 0.1°
Pitch -0.7°
Heave 0.0 m
User Settings
500.0 m
0.0 m
-70 dB
-59 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 800 ms
Record RAW On
Record Processed On
Output
Biomass 160
Biomass 76
Biomass 130
TS Histogram
-35 dB
Depth
315.6 m
Vertical
Horizontal
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
P: 2/20/2018 04:01:49

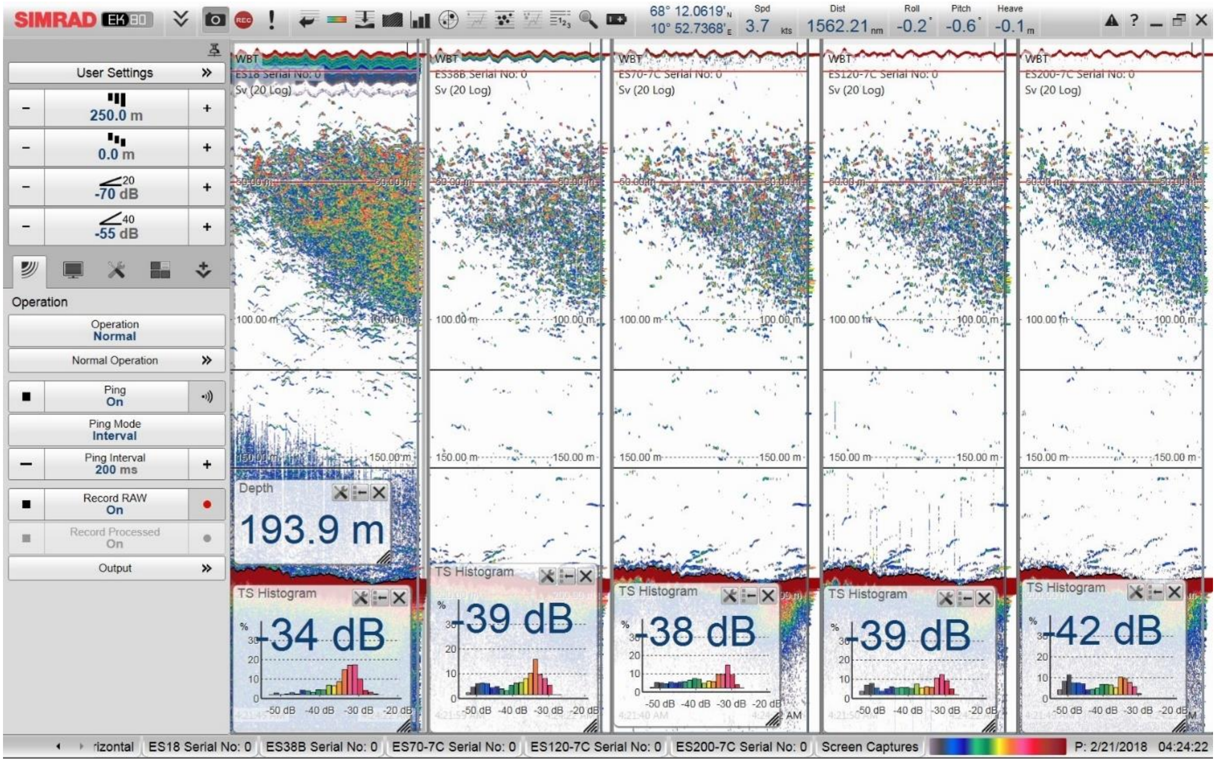

SIMRAD EK80
67° 37.2477' N
09° 41.0379' E
Spd 9.2 kts
Dist 1344.56 nm
Roll 0.1°
Pitch -0.7°
Heave 0.0 m
User Settings
500.0 m
0.0 m
-70 dB
-59 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 800 ms
Record RAW On
Record Processed On
Output
Biomass 160
Biomass 76
Biomass 130
TS Histogram
-35 dB
Depth
315.6 m
Vertical
Horizontal
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
P: 2/20/2018 04:01:49

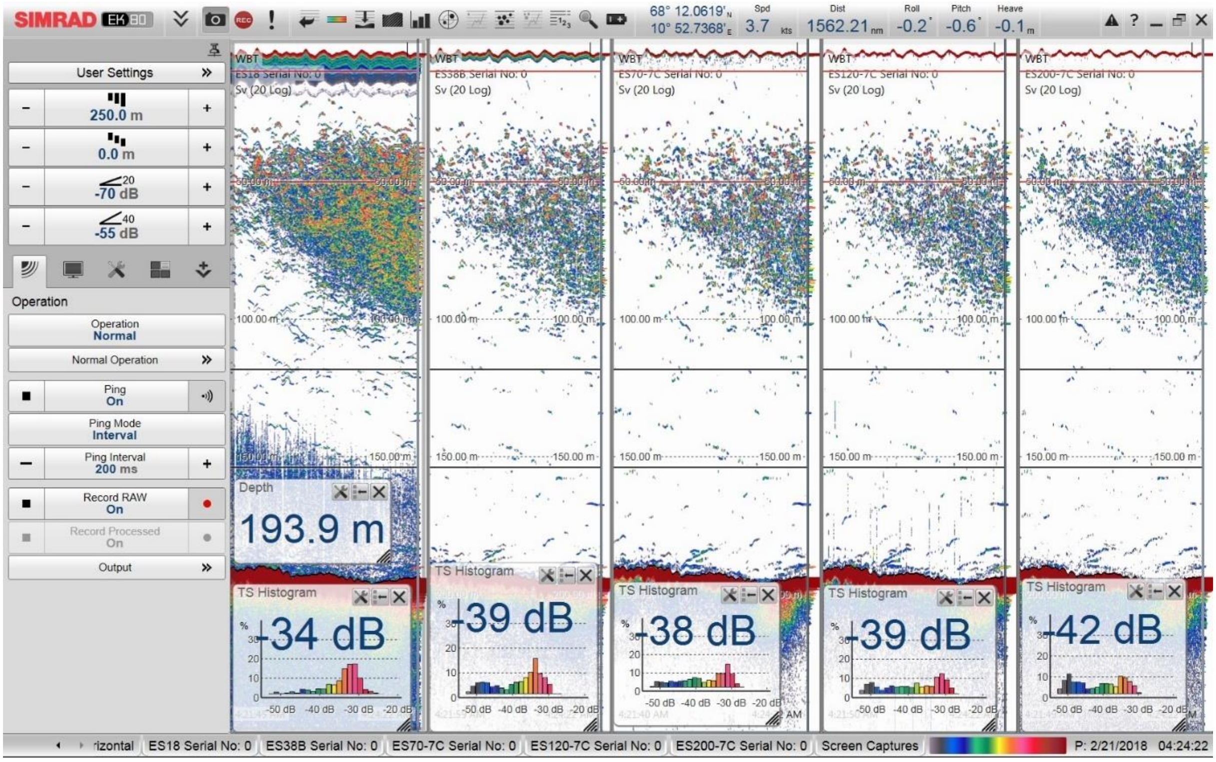

SIMRAD EK80
67° 54.3390' N
10° 11.5823' E
Spd 6.1 kts
Dist 1456.71 nm
Roll -0.4°
Pitch -0.9°
Heave -0.1 m
User Settings
500.0 m
0.0 m
-70 dB
-42 dB
Active
TVG
Sv (20 Log)
Echogram
Beam Direction
Downwards
New Layer
Layer Properties
Delete Layer
Bottom Detection
Single Target Detection
Information Pane Options
WBT
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
Depth
273.5 m
Biomass
35 k
TS Histogram
-31 dB
Vertical
Horizontal
P: 2/20/2018 16:03:30

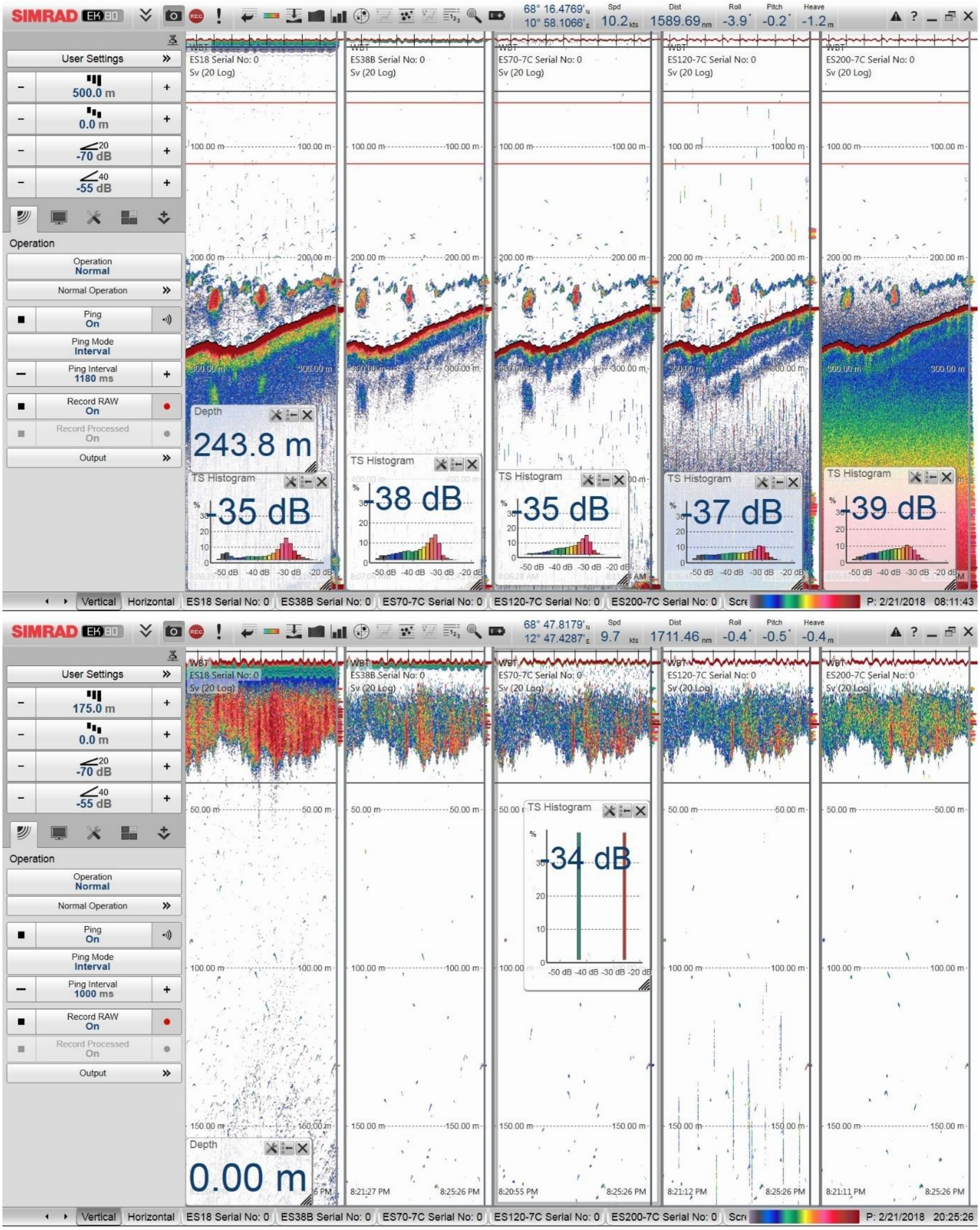

SIMRAD EK80
67° 57.1728' N
10° 17.3885' E
Spd 9.8 kts
Dist 1472.36 nm
Roll -2.3°
Pitch -0.3°
Heave 0.2 m
User Settings
400.0 m
0.0 m
-70 dB
-42 dB
Operation
Operation
Normal
Normal Operation
Ping
On
Ping Mode
Interval
Ping Interval
1000 ms
Record RAW
On
Record Processed
On
Output
WBT
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
Depth
243.7 m
Vertical
Horizontal
P: 2/20/2018 18:02:58

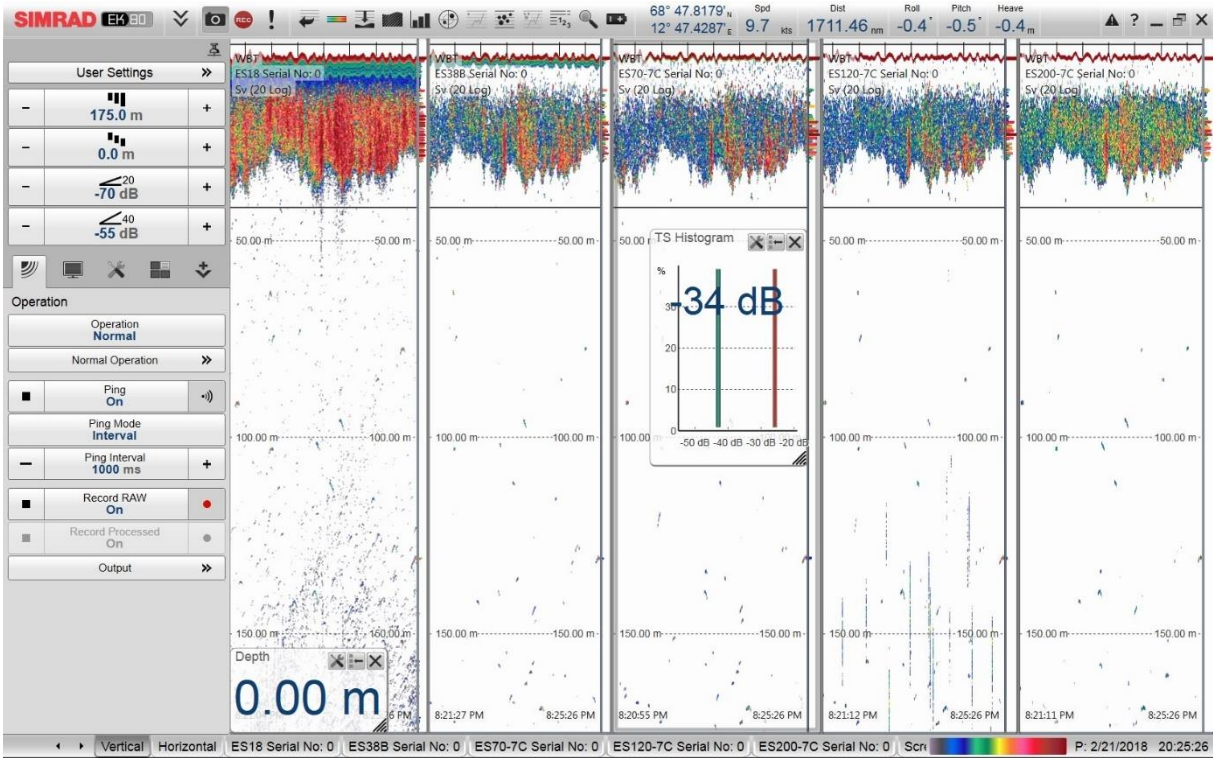

SIMRAD EK80
67° 57.1728' N
10° 17.3885' E
Spd 9.8 kts
Dist 1472.36 nm
Roll -2.3°
Pitch -0.3°
Heave 0.2 m
User Settings
400.0 m
0.0 m
-70 dB
-42 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 1000 ms
Record RAW On
Record Processed On
Output
WBT ES18 Serial No: 0 Sv (20 Log)
WBT ES38B Serial No: 0 Sv (20 Log)
WBT ES70-7C Serial No: 0 Sv (20 Log)
WBT ES120-7C Serial No: 0 Sv (20 Log)
WBT ES200-7C Serial No: 0 Sv (20 Log)
100.00 m
200.00 m
300.00 m
Depth
243.7 m
5:58:12 PM
5:57:23 PM
5:57:49 PM
5:57:48 PM
6:02:58 PM
Vertical
Horizontal
P: 2/20/2018 18:02:58

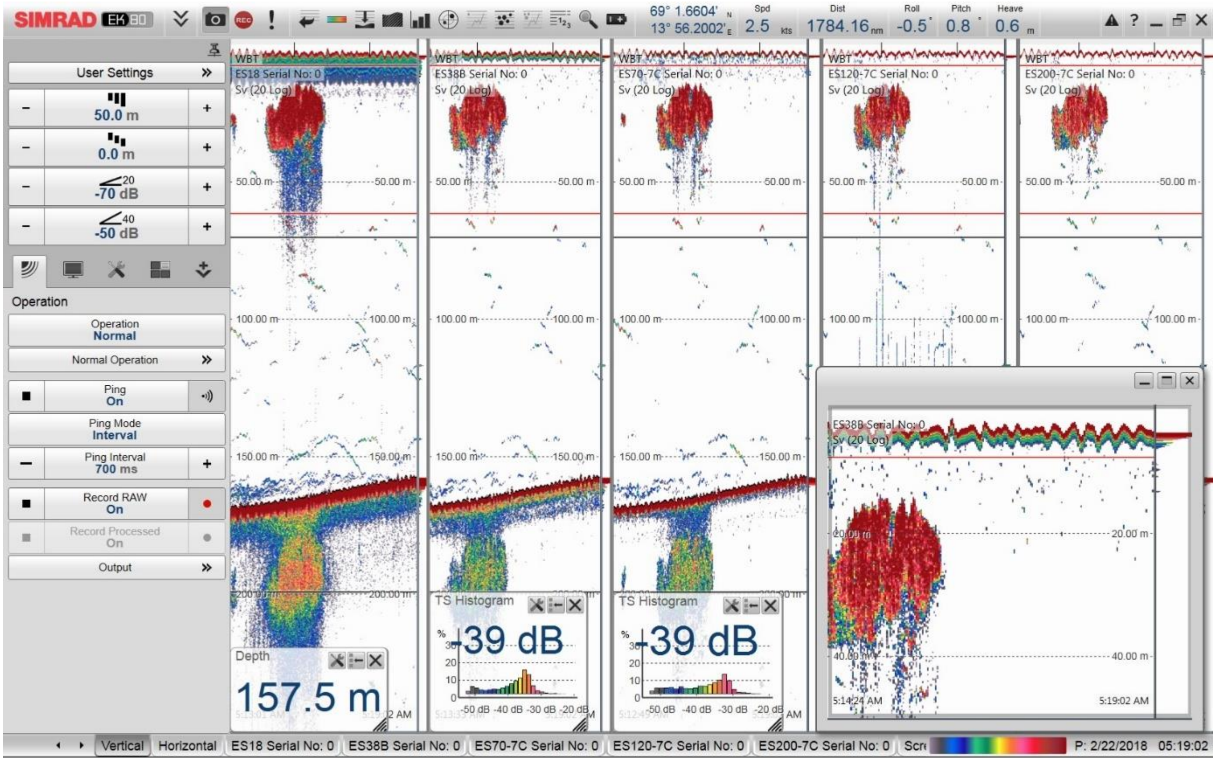

SIMRAD EK80
68° 1.0996' N
10° 38.7056' E
Spd 4.0 kts
Dist 1504.70 nm
Roll -1.2°
Pitch -0.3°
Heave 0.4 m
User Settings
100.0 m
0.0 m
-70 dB
-55 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Maximum
Ping Interval 1000 ms
Record RAW On
Record Processed On
Output
WBT ES18 Serial No: 0 Sv (20 Log)
WBT ES38B Serial No: 0 Sv (20 Log)
WBT ES70-7C Serial No: 0 Sv (20 Log)
WBT ES120-7C Serial No: 0 Sv (20 Log)
WBT ES200-7C Serial No: 0 Sv (20 Log)
20.00 m
40.00 m
60.00 m
TS Histogram
-36 dB
-39 dB
-37 dB
-35 dB
-39 dB
-50 dB -40 dB -30 dB -20 dB
Vertical
Horizontal
P: 2/20/2018 21:33:05

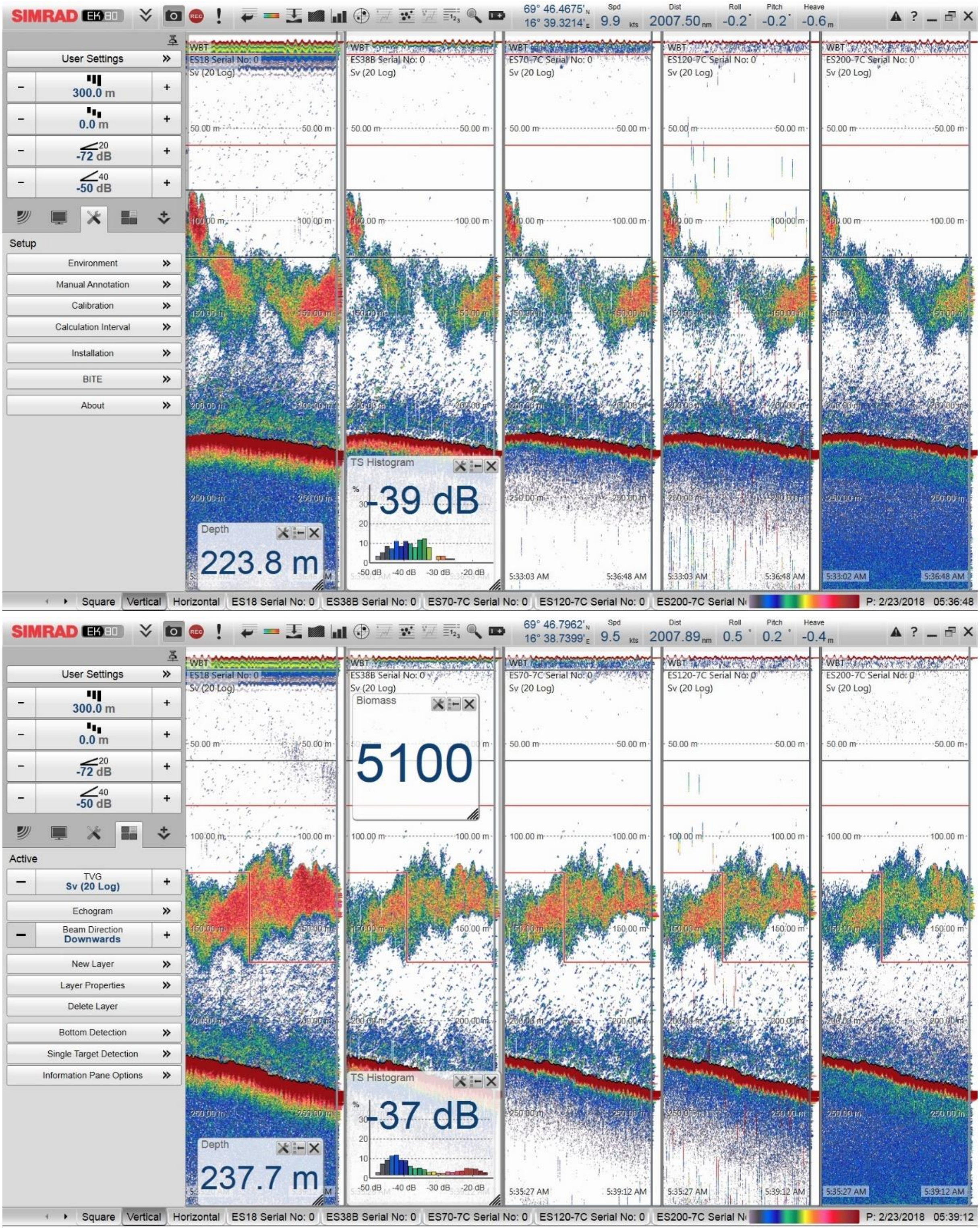

SIMRAD EK80
68° 12.0619' N
10° 52.7368' E
Spd 3.7 kts
Dist 1562.21 nm
Roll -0.2°
Pitch -0.6°
Heave -0.1 m
User Settings
250.0 m
0.0 m
-70 dB
-55 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 200 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
100.00 m
150.00 m
Depth
193.9 m
TS Histogram
-34 dB
-39 dB
-38 dB
-39 dB
-42 dB
-50 dB -40 dB -30 dB -20 dB
Screen Captures
P: 2/21/2018 04:24:22


SIMRAD EK80
68° 12.0619' N
10° 52.7368' E
Spd 3.7 kts
Dist 1562.21 nm
Roll -0.2°
Pitch -0.6°
Heave -0.1 m
User Settings
250.0 m
0.0 m
-70 dB
-55 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 200 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
100.00 m
150.00 m
Depth
193.9 m
TS Histogram
-34 dB
-39 dB
-38 dB
-39 dB
-42 dB
-50 dB -40 dB -30 dB -20 dB
Screen Captures
P: 2/21/2018 04:24:22


SIMRAD EK80
68° 16.4769' N
10° 58.1066' E
10.2 kts
1589.69 nm
-3.9°
-0.2°
-1.2 m
User Settings
500.0 m
0.0 m
-70 dB
-55 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 1180 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
Depth
243.8 m
TS Histogram
-35 dB
-38 dB
-35 dB
-37 dB
-39 dB
Vertical
Horizontal
P: 2/21/2018 08:11:43
68° 47.8179' N
12° 47.4287' E
9.7 kts
1711.46 nm
-0.4°
-0.5°
-0.4 m
175.0 m
0.0 m
-70 dB
-55 dB
Ping Interval 1000 ms
-34 dB
Depth
0.00 m
P: 2/21/2018 20:25:26


SIMRAD EK80
User Settings
175.0 m
0.0 m
-70 dB
-55 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 1000 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
TS Histogram
-34 dB
Depth
0.00 m
Vertical
Horizontal
P: 2/21/2018 20:25:26


SIMRAD EK80
User Settings
50.0 m
0.0 m
-70 dB
-50 dB
Operation
Operation Normal
Normal Operation
Ping On
Ping Mode Interval
Ping Interval 700 ms
Record RAW On
Record Processed On
Output
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
TS Histogram
-39 dB
TS Histogram
-39 dB
Depth
157.5 m
Vertical
Horizontal
P: 2/22/2018 05:19:02


SIMRAD EK80
69° 46.4675' N
16° 39.3214' E
Spd 9.9 kts
Dist 2007.50 nm
Roll -0.2°
Pitch -0.2°
Heave -0.6 m
User Settings
300.0 m
0.0 m
-72 dB
-50 dB
Setup
Environment
Manual Annotation
Calibration
Calculation Interval
Installation
BITE
About
ES18 Serial No: 0
ES38B Serial No: 0
ES70-7C Serial No: 0
ES120-7C Serial No: 0
ES200-7C Serial No: 0
Sv (20 Log)
TS Histogram
-39 dB
Depth
223.8 m
Square
Vertical
Horizontal
P: 2/23/2018 05:36:48
69° 46.7962' N
16° 38.7399' E
Spd 9.5 kts
Dist 2007.89 nm
Roll 0.5°
Pitch 0.2°
Heave -0.4 m
Biomass
5100
Active
TVG Sv (20 Log)
Echogram
Beam Direction Downwards
New Layer
Layer Properties
Delete Layer
Bottom Detection
Single Target Detection
Information Pane Options
-37 dB
237.7 m
P: 2/23/2018 05:39:12