DISTRIBUTION AND ABUNDANCE OF NORWEGIAN SPRING-SPAWNING HERRING DURING THE SPAWNING SEASON IN 2025

RAPPORT FRA HAVFORSKNINGEN
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Tittel (norsk og engelsk):

Distribution and abundance of Norwegian spring-spawning herring during the spawning season in 2025

Fordeling og mengde av norsk vårgytende sild under gytesesongen i 2025

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Sammendrag (norsk):

I perioden 15. februar - 3. mars 2025 ble gytefeltene til norsk vårgytende sild fra Møre (62º15´N) til Tromsøflaket (71ºN) dekket akustisk med det kommersielle fiskefartøyet MS Eros og forskningsfartøyet RV G.O. Sars. Den estimerte biomassen var omtrent 23 % lavere, og det estimerte antallet omtrent 29 % lavere sammenlignet med fjorårets tokt. Usikkerheten i årets estimater er høyere enn i fjor. Den målte delen av bestanden var dominert av 2016-årsklassen med 54 % i antall og 56 % i vekt. Mesteparten av gytebestanden befant seg vest og sørvest av Lofoten år. I likhet med de siste årene ble det observert veldig lite sild på de tradisjonelt viktige gytefeltene sør for Røstbanken. På årets tokt ble det observert en høyere andel gytende sild enn i de åtte foregående årene. Det anbefales å bruke estimatene av antall per alder fra toktet i 2025 i ICES sin bestandsvurdering av norsk vårgytende sild.

Sammendrag (engelsk):

During the period 15th of February to 3rd of March 2025 the spawning grounds of Norwegian spring-spawning herring from Møre (62º15 ´ N) to Tromsøflaket (71 º N) were covered acoustically by the commercial fishing vessel Eros and the research vessel G.O. Sars. The estimated biomass was about 23 % lower, and the estimated total number was about 29 % lower this year compared to last year’s survey. The uncertainty of the estimates in 2025 was higher than last year. The surveyed population was dominated by the 2016 year class; 54 % in numbers and 56 % in biomass. Most of the spawning stock was found west and southwest of Lofoten this year. As in the most recent years very low quantities of herring were observed on the traditionally important spawning grounds south of the Røst bank. A higher proportion of the biomass consisted of spawning herring in this year’s survey compared to the eight preceding years. The estimates of abundance by age group from the survey in 2025 are recommended to be used in this year’s ICES stock assessment of Norwegian spring-spawning herring.

Innhold

1 - Introduction

Acoustic trawl surveys on Norwegian spring-spawning herring (NSSH) during the spawning season has been carried out by the Institute of Marine Research in Norway (IMR) since 1988, with some breaks (in 1992-1993, 1997, 2001-2004 and 2009-2014). It was decided to terminate the survey from 2009 onwards, however, in 2015, the survey time series was initiated again partly based on the feedback from fishermen and fishermenâ€™s organizations that IMR should conduct more surveys on this commercially important stock. From 2015 onwards, the NSSH spawning survey has been carried out annually. In 2015 and 2016 the surveys were conducted in the first half of February, and from 2017 onwards in the second half of February as this was considered more appropriate since the spawning seemed to take place near the end of February. In the ICES benchmark assessment of NSS herring in 2016 (ICES 2016) it was decided to use the data from this survey time series as input to the stock assessment, together with the international ecosystem survey in the Norwegian Sea in May and catch data. Thus, the results from the NSSH spawning survey have significant influence on the ICES catch advice on NSSH.

The main objective of the NSSH spawning survey 2025 was to estimate the abundance by age group (both mean and sampling uncertainty), for use in the ICES WGWIDE stock assessment. Moreover, other biological information about the spawning stock of NSS herring is estimated: spatial distribution of biomass and acoustic densities, total biomass and stock numbers with sampling uncertainty, spatial patterns in maturity and variations in temperature.

2 - Material and methods

2.1 - Survey design

During the period 15th February to 3rd March 2025 (approximately same period as in 2017-2024) the continental shelf along the Norwegian coast from Møre (62º15´N) to Tromsøflaket (71ºN) were covered by the commercial fishing vessel Eros and the research vessel G.O. Sars. The survey was planned based on information from the previous spawning cruises and the distribution of the herring fishery during the autumn 2024 up to the survey start February 15th 2025 (Figure 1). The Norwegian fishery in the winter season 2024/2025 mainly took place in and around the wintering area in the Kvænangen and Alta fjord areas (Salthaug et al. 2025). Prior to the survey, in the first half of February 2025 the fishery indicated that the herring were entering the spawning grounds from the wintering areas north of Tromsø, but a few catches in the Norwegian Sea in November also indicated that some of the herring wintered in oceanic areas and therefore was expected to enter the spawning areas from west (see Fig. 1). A northerly distribution of the spawning stock similar to the last years was expected, however, the survey area included all known important spawning areas. The survey design followed a standard stratified design (Jolly and Hampton 1990), where the survey area was stratified before the survey start according to the assumed density structures of herring during the spawning migration (based on previous surveys and fisheries). All strata were covered with a zigzag design (Strindberg og Buckland 2004) since this is the most efficient use of survey effort (Harbitz 2019). The Rstox surveyPlanner (https://github.com/Sea2Data/Rstox) was used to generate the transects, and this function generates survey tracks with uniform coverage of strata and a random starting position in the start of each stratum. Each straight line in the zigzag track within a stratum was considered as a transect and a primary sampling unit (Simmonds and MacLennan 2005). Transit tracks between strata, i.e. from the end of the zigzag in one stratum to the start of the zigzag in the next stratum, were not used as primary sampling units. Based on the a priori assumed distribution of the spawning stock, the degree of coverage (distance of acoustic transects divided by the square root of the stratum area, see Aglen 1989) was planned to be low to moderate south of 66°N and higher north of this.

2.2 - Data sampling

The acoustic data were collected in CW (continuous wave) mode with 18, 38, 70, 120, 200 and 333 kHz Simrad EK80 echo sounders installed on a drop keel. Most of the time the vessel speed was 10 knots, and the sampling rate 1 Hz and pulse duration 1.024 ms.

The software LSSS version 2.17.0 was used for post-processing (Korneliussen et al. 2016). Echogram scrutinization was carried out by the cruise leader and the chief instrument officer, and based on the acoustic backscatter signal and trawl samples the backscatter were categorized into one of the following categories: “herring”, “other”, ”capelin” or “air bubbles” (upper 20 meters from the transducer near field). The remaining NASC with a threshold of -70dB in a layer or school box regarded to contain herring was in most cases categorized as herring (however a bit stronger threshold of around -60 was used for the upper 50 meters). The acoustic density values were based on 38 kHz data stored by acoustic category in nautical area scattering coefficient (NASC) [m2 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.

Trawl sampling was planned to be carried out on a regular basis during the survey to confirm the acoustic observations and to be able to give estimates of abundance for different size and age groups. The sampling trawls used were Multpelt 832 on Eros and VITO trawl on G.O. Sars, both with small meshed (24 mm) inner net in the codend and a slit (so called “splitt”) close to the codend to avoid too large catches. The following variables of individual herring were recorded from each station with herring catch: total weight in grams and total length in cm (rounded down to the nearest 0.5 cm) of up to 100 individuals per haul. In addition, age from scales, sex, maturity stage, stomach fullness and gonad weight in grams were measured in up to 50 individuals per haul. Genetic samples and otoliths were also collected from these individuals.

CTD casts (using Seabird 911 systems) were taken by both vessels, spread out haphazardly in the survey area.

2.3 - Abundance estimation

The survey estimates are calculated using Stox 4.1.2 (Johnsen et al. 2019), where the sampling means and sampling variance are derived from 1000 bootstrap runs. More details and equations from the estimation process can be found in Salthaug et al. (2021). In StoX, all trawl stations with herring (with at least ten sampled individuals) were used to derive a common length distribution for all transect within the respective strata and all stations had equal weight. The following acoustic target strength (TS)-to-fish length (L in cm) relationship was used for herring: $TS = 20 \log L - 71.9$ (Foote 1987).

3 - Results and discussion

3.1 - Survey coverage

The cruise tracks of the NSSH spawning survey in 2025, together with pelagic trawl stations and CTD stations are shown in Figure 2. Since Eros started 4 days earlier than G.O. Sars (both from Bergen) Eros covered the area north to Vestfjorden (cirka 66°N) alone with a low degree of coverage, since the a priori assumption was zero abundance in this area. However, an adaptive element of the plan was to do an additional coverage of a stratum (or part of a stratum) in the opposite direction, i.e. south, if herring was observed. A high degree of coverage was planned for Stratum 6-8 since we expected to observe the majority of the spawning stock in this area. G.O. Sars sailed directly to Stratum 6 and started the coverage from south on 20th February, 12 hours later than Eros that started on the 19th of February.

The weather conditions were challenging this year, with strong winds from the south during most of the period when Stratum 6-9 were covered. However, as the wind direction was the same as the survey progression, the acoustic data collection was not hindered, and the data quality was considered to be acceptable. Both vessels covered Stratum 6-9 simultaneously during 19. - 26. February. After this Eros finished the survey while G.O. Sars went to Tromsø for crew change. During 28. February to 3. March, G.O. Sars covered Stratum 6 and 7 a second time, since most of the herring was observed in this area during the first coverage (more coverage and sampling were expected to increase the quality of the abundance estimates). Because the wind still blew strongly from the south during the second coverage, the survey direction was the same as in the first coverage, from south to north.

Pelagic trawl hauls were carried out regularly (Fig. 2) in the areas where herring like marks were observed on the echo sounder, to confirm the acoustic observations based on species composition in the catch and to obtain biological samples of individual length, weight, maturity stage and age of herring. A total of 31 pelagic trawl hauls and 17 CTD casts were carried out (Fig. 2). Only one of the trawl hauls did not result in catch of herring.

The time difference between the first and second coverage of Stratum 6 and 7 was one week, and some of the herring might have finished spawning and started to leave the spawning grounds. To test if the collected data indicated a reduced abundance during the second coverage we tested the average NASC of the primary sampling units in Stratum 6 and 7 (strata merged for convenience in this analysis) based on the following selection of acoustic data from; (1) Eros, (2) G.O. Sars first coverage and (3) G.O. Sars second coverage. If the mean NASC from (3) was significantly lower than both (1) and (2) this would indicate reduced abundance during the second coverage and suggest that these data should be removed from the estimation process. The results are presented in Table 1 and Figure 3; the mean NASCs are not significantly different from each other (all the confidence intervals overlap). Based on this, the data from the second coverage of Stratum 6 and 7 was included. Note that the mean NASC based data from Eros was approximately half of the two means based on G.O. Sars. We attribute this difference to randomness (the lower the degree of coverage the less precise estimates).

Nautical area scattering coefficients (NASC) allocated to herring from acoustic transects by each nautical mile are shown in Figure 4. One herring school was observed near Træna, while a significant amount of herring schools first started to appear on the echosounders around 40 nautical miles southwest of Røst. Herring was also caught in pelagic trawl hauls here (the two southernmost trawl hauls in Fig. 2). Herring was observed in the echograms and in trawl hauls in all strata north of this. The highest concentrations were observed in the Stratum 6 (west and southwest of Lofoten), both around the shelf edge and on the shelf. Herring was also observed in the three northernmost strata. Some capelin schools were observed in the two northernmost strata, both on the echograms and in the pelagic trawl samples.

3.2 - Survey estimates

The abundance estimates from this survey are regarded as relative indices of abundance in the ICES stock assessment, since there are highly uncertain scaling parameters like acoustic target strength and compensation for herring migrating. The abundance estimates are shown in Table 2 and 3. Note that all ages from and including 12 years and older are grouped in the same age category (12+), which is different from the previous survey reports. The reason is to make the age categories in line with the ICES stock assessment where the plus group is 12. In terms of the mean estimates, the 2016 year class (age 9) dominated both in numbers (54 %) and biomass (56 %). Compared with the mean estimates from last year (see Salthaug and Stenevik 2024) the 2016 year class decreased by 29 % in numbers. The mean estimate of total stock biomass (TSB) in the survey area was 2.56 million tons which is a decrease of 23 % compared to last year. The time series of mean of total stock biomass from the survey is shown in Figure 5, and the 2025 estimate is one of the lowest in the time series. The mean estimate of total stock number (TSN) in the survey area was 9.7 billion, which is 29 % lower than last year's estimate. The relative standard error (RSE) of TSB and TSN is 30 % and 28 %, respectively (Tab. 2 and 3), which is higher, around the double, of last year's RSEs. The RSE per age group (Tab.2, Tab. 3 and Fig. 6) shows a high uncertainty for the very young and old ages and lower uncertainty for the most abundant age groups in the survey. The RSEs by age are higher than last year. Figure 7 shows point estimates of abundance per year class in the four most recent surveys. These numbers are expected to decline between consecutive years due to mortality, for ages that are fully recruited to the survey (seems to be age 5 or 6). Such declining trend is observed for the strong 2016 year class. The estimates of some of the other year classes are probably too imprecise to "behave" as expected. Mean weight and length from the 2025 spawning survey are shown in Table 4. The mean estimates are similar to those observed last year.

3.3 - Spatial distribution of the stock and maturity

The relative distribution of the estimated biomass per stratum is shown in Figure 8. Most of the biomass (79 %) was found in Stratum 6 (west of Lofoten), and a significant proportion was found in Stratum 7 and 8 (10% in both). Figure 9 shows the proportion of the estimated population in different maturation stages from the spawning surveys during 2017-2025. As mentioned in the Introduction, the surveys in these years were carried out in approximately the same period, second part of February, which makes the distribution of maturation stages comparable. In 2025 the proportion of spawning herring (running gonads) was the highest observed, around 18 % (Fig. 9). This proportion was also almost identical in the two coverages in 2025 (Fig. 10). However, the proportion of spent individuals increased considerably from first to second coverage with a corresponding decrease in maturing and ripe individuals (Fig. 10). This shows that a large proportion of the observed herring had finished spawning around the end of February, and probably soon about to leave the spawning grounds and hence the area covered by the spawning survey.

3.4 - Geographical variation in temperatures experienced by the herring

Temperatures experienced by herring from close to the surface and down to 250 m are shown in Figure 11 for the areas south and north of 67°N, for the years after 2016 when the survey has been carried out in the same period (latter half of February). The temperatures in 2025 varied from 8°C at 100 m depth south of 67°N to 6.1°C at 5 m depth north of 67°N. Both the levels and variation in temperature among different depths is slightly higher in 2025 than in 2024 but quite normal compared to the other years from 2017 onwards. At typical spawning depths of herring at 100-200 m depth, the temperature conditions were quite similar to those observed during the most recent NSSH spawning surveys.

3.5 - Quality of the survey

In 2025 both vessels were equipped with multifrequency echo sounders on a drop keel. Despite challenging weather conditions, acoustic data with good quality was recorded and trawling on registrations could be carried out adequately most of the time. To conclude, the acoustic and biological data recorded in 2025 on the NSSH spawning survey were of satisfactory quality and the estimates from the survey are recommended to be used in the stock assessment of Norwegian spring-spawning herring in 2025.

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5 - Tables

Table 1. Herring NASC per coverage part in Stratum 6 and 7 (in this case the two strata are merged into one) from the spawning survey 15. February - 3. March 2025. Each individual underlying NASC observation is mean NASC by transect (primary sampling unit), and the total mean of these is weighted by transect distances.

coverage	mean NASC	95% confidence interval
Eros 19. - 22. Feb.	422	153 - 690
G.O. Sars 20. - 23. Feb. (GOS_1)	1092	262 - 1923
G.O. Sars 28. Feb. - 3. Mar. (GOS_2)	1207	138 - 2275

Table 2. Abundance estimates (million individuals) of Norwegian spring-spawning herring during the spawning survey 15. February - 3. March 2025, based on 1000 bootstrap replicates in Stox.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
3	90	179	304	186	65	0.35
4	791	1275	1907	1293	345	0.27
5	404	724	1182	744	236	0.32
6	28	67	132	71	32	0.44
7	302	604	1038	629	231	0.37
8	355	712	1227	745	278	0.37
9	2609	4757	7518	4881	1537	0.31
10	132	278	503	294	118	0.40
11	118	230	411	242	91	0.37
12+	332	611	989	628	202	0.32
uknown	0	1	5	2	3	1.58
TSN	5633	9527	14429	9715	2733	0.28

Table 3. Abundance estimates (thousand tons) of Norwegian spring-spawning herring during the spawning survey 15. February - 3. March 2025, based on 1000 bootstrap replicates in Stox.

Age	5th percentile	Median	95th percentile	Mean	SD	CV
3	10	21	35	21	8	0.36
4	109	173	252	176	45	0.26
5	84	152	253	157	51	0.32
6	7	17	35	19	8	0.46
7	81	161	277	168	62	0.37
8	98	198	340	207	78	0.38
9	756	1387	2205	1422	451	0.32
10	42	88	161	93	38	0.41
11	38	74	133	78	30	0.38
12+	113	207	338	214	70	0.33
unknown	0	0	0	0	1	4.40

TSB	1407	2495	3878	2555	767	0.30

Table 4. Estimated length and weight of individuals by age group of Norwegian spring-spawning herring during the spawning survey 15. February - 3. March 2025, based on 1000 bootstrap replicates in Stox.

Age	mean weight (g)	CV(weight)	mean length (cm)	CV(length)
3	111.7	0.024	25.7	0.007
4	131.3	0.023	26.9	0.006
5	206.6	0.015	30.4	0.004
6	247.5	0.042	32.5	0.012
7	266.5	0.012	32.7	0.003
8	275.8	0.016	33.2	0.004
9	289.7	0.006	33.8	0.002
10	316.3	0.021	34.8	0.005
11	321.3	0.013	35.3	0.003
12+	336.7	0.010	35.8	0.003

6 - Figures

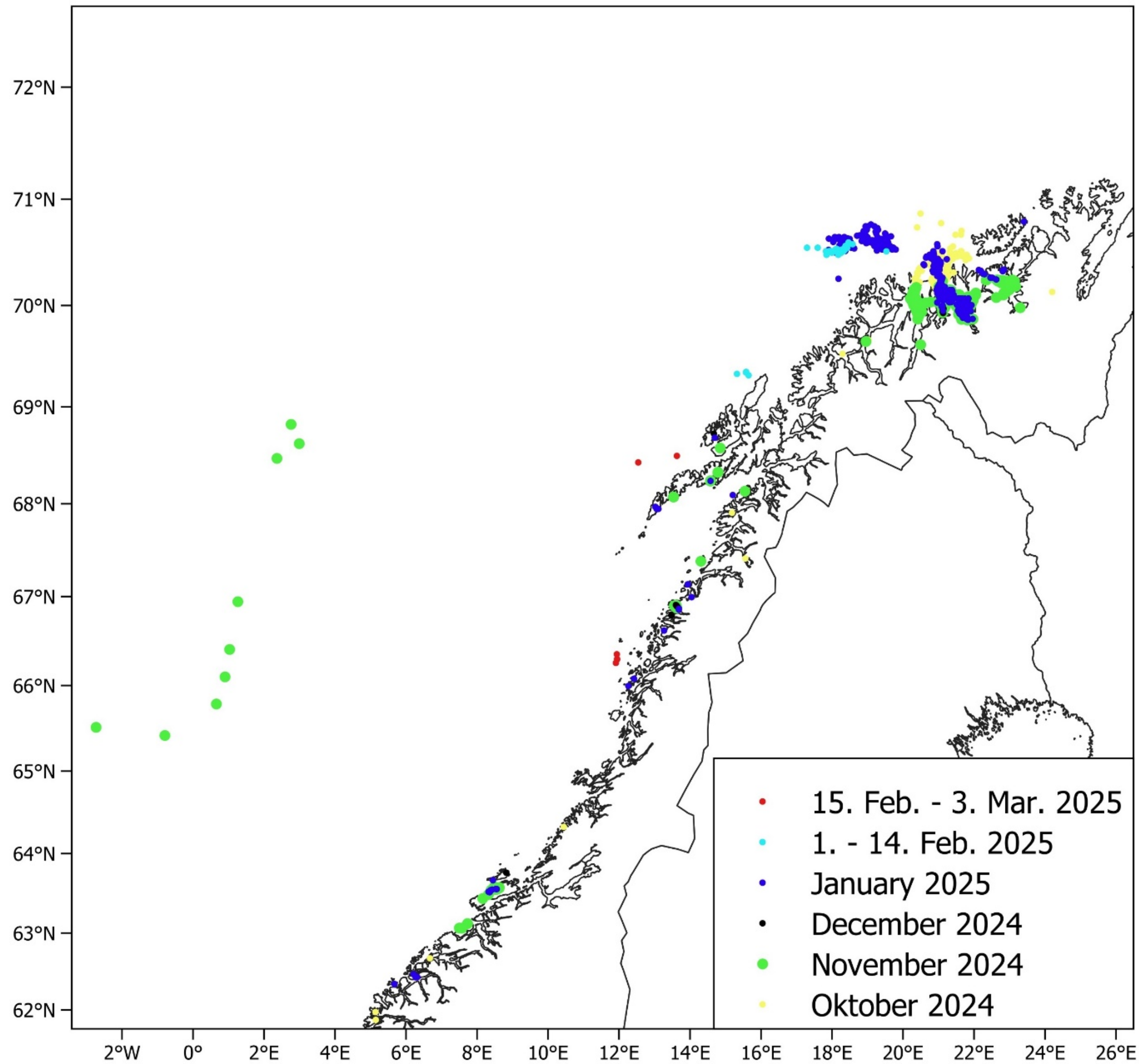

Figure 1. Distribution of commercial catches of Norwegian spring-spawning herring from October 2024 until the beginning of March 2025, based on electronic logbooks. Each point represents one catch, only catches larger than 10 tons are shown.

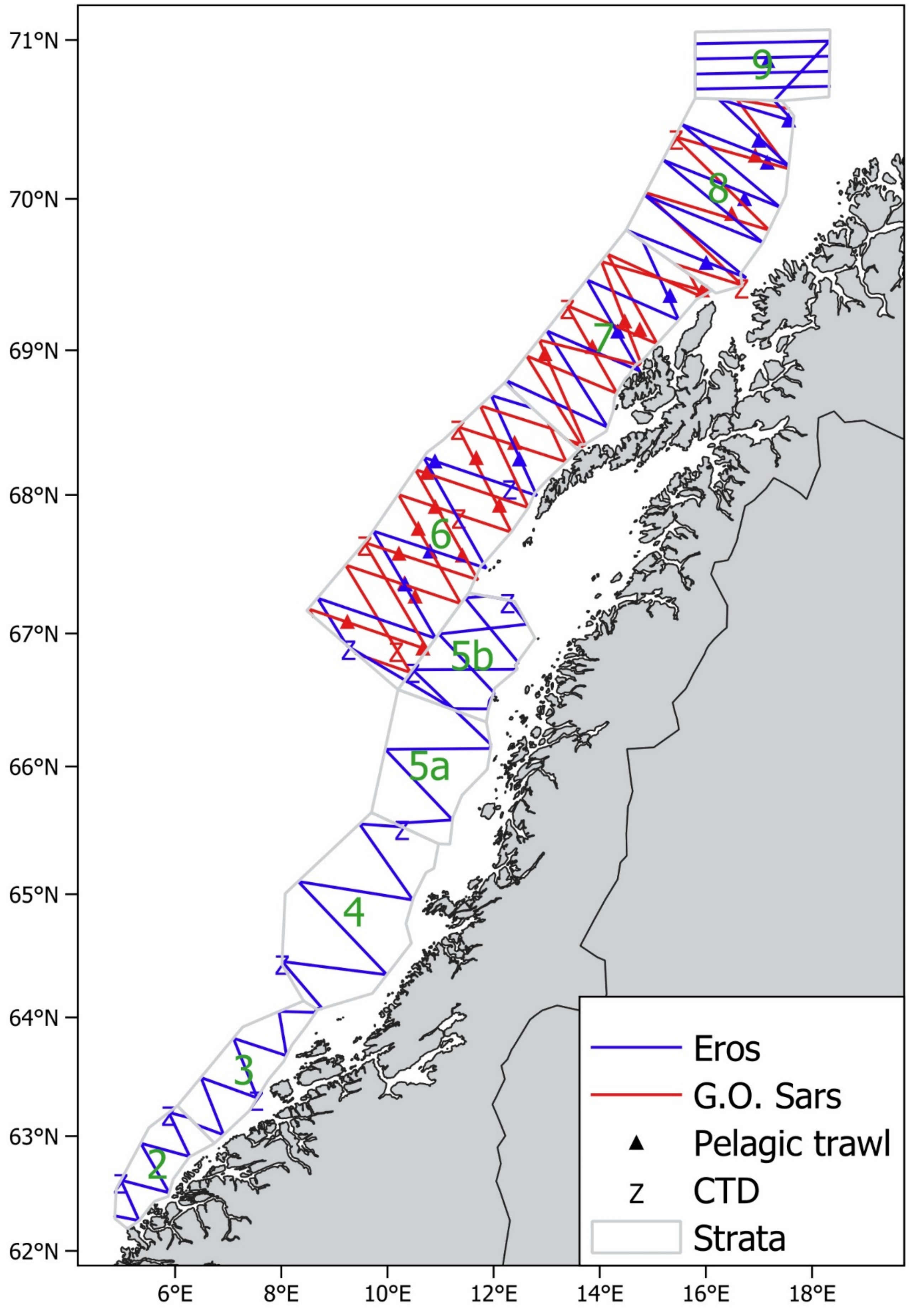

Figure 2. Cruise tracks (mostly acoustic transects), pelagic trawl stations , and CTD stations covered by Eros and G.O. Sars on the

Norwegian spring-spawning herring spawning survey 15. February - 3. March 2025. The strata are shown as grey polygons with green numbers.

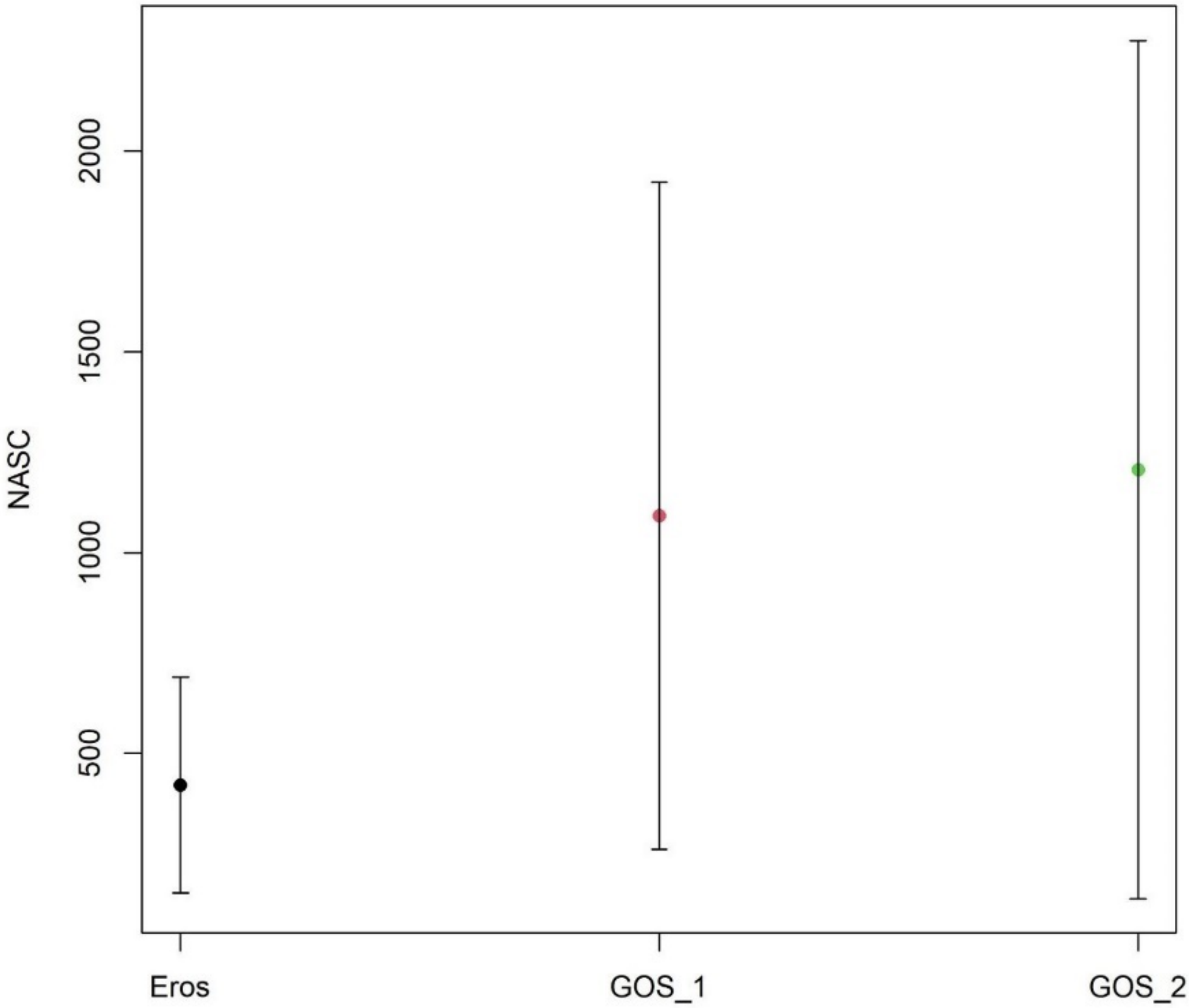

Figure 3. Herring NASC per coverage part in Stratum 6 and 7 (in this case the strata are merged into one) from the spawning survey 15. February - 3. March 2025 (dates for each coverage part are given in Table 1). Each individual underlying NASC observation is mean NASC by transect (primary sampling unit), and the total mean of these is weighted by transect distances.

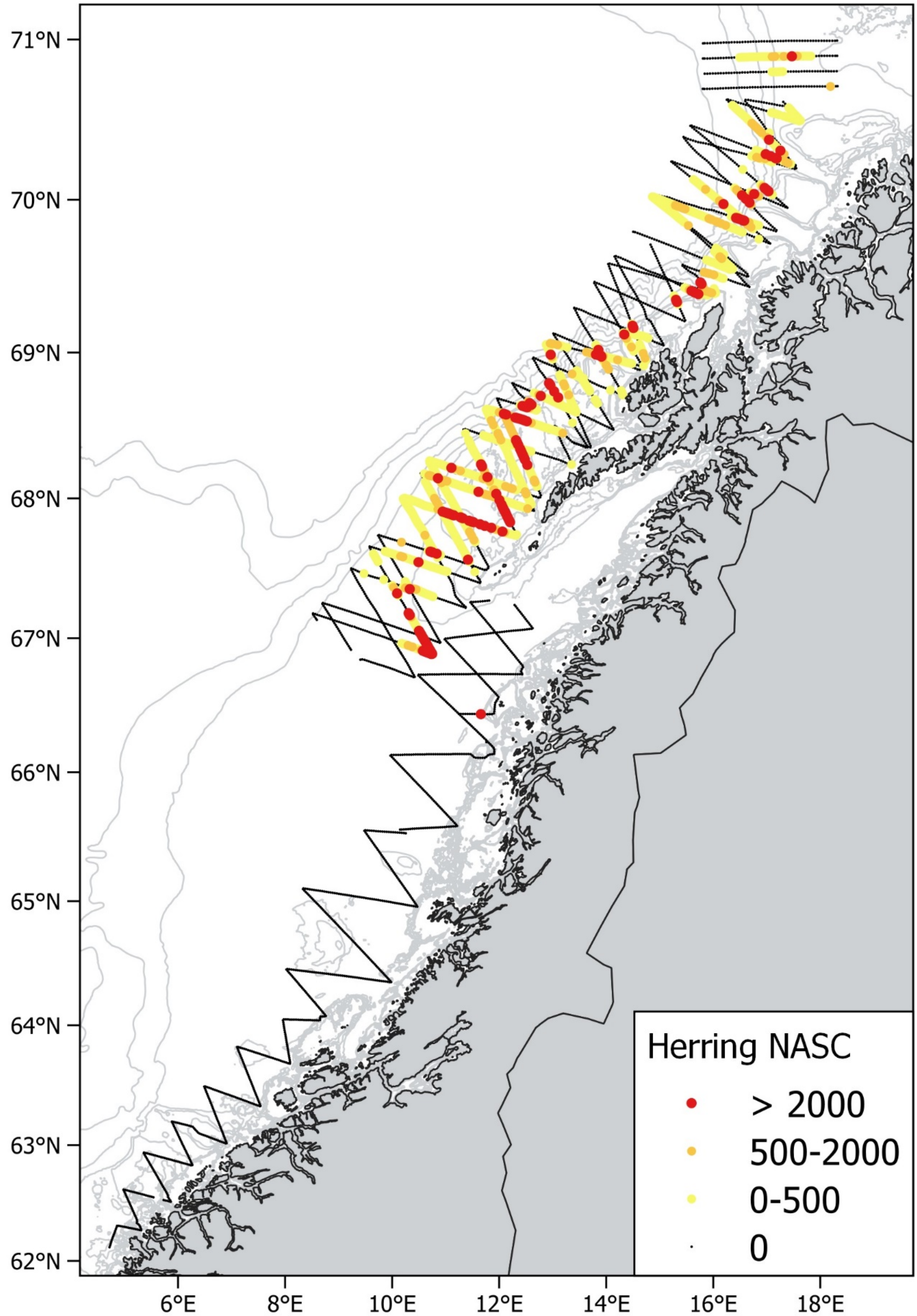

Figure 4. Acoustic densities (NASC) of herring recorded during the Norwegian spring-spawning herring spawning survey 15. February

- 3. March 2025. Points represent NASC values per nautical mile. Depth contours are shown for 50 m, 100 m, 150 m, 200 m, 500 m, 1000 m, 1500 m and 2000 m.

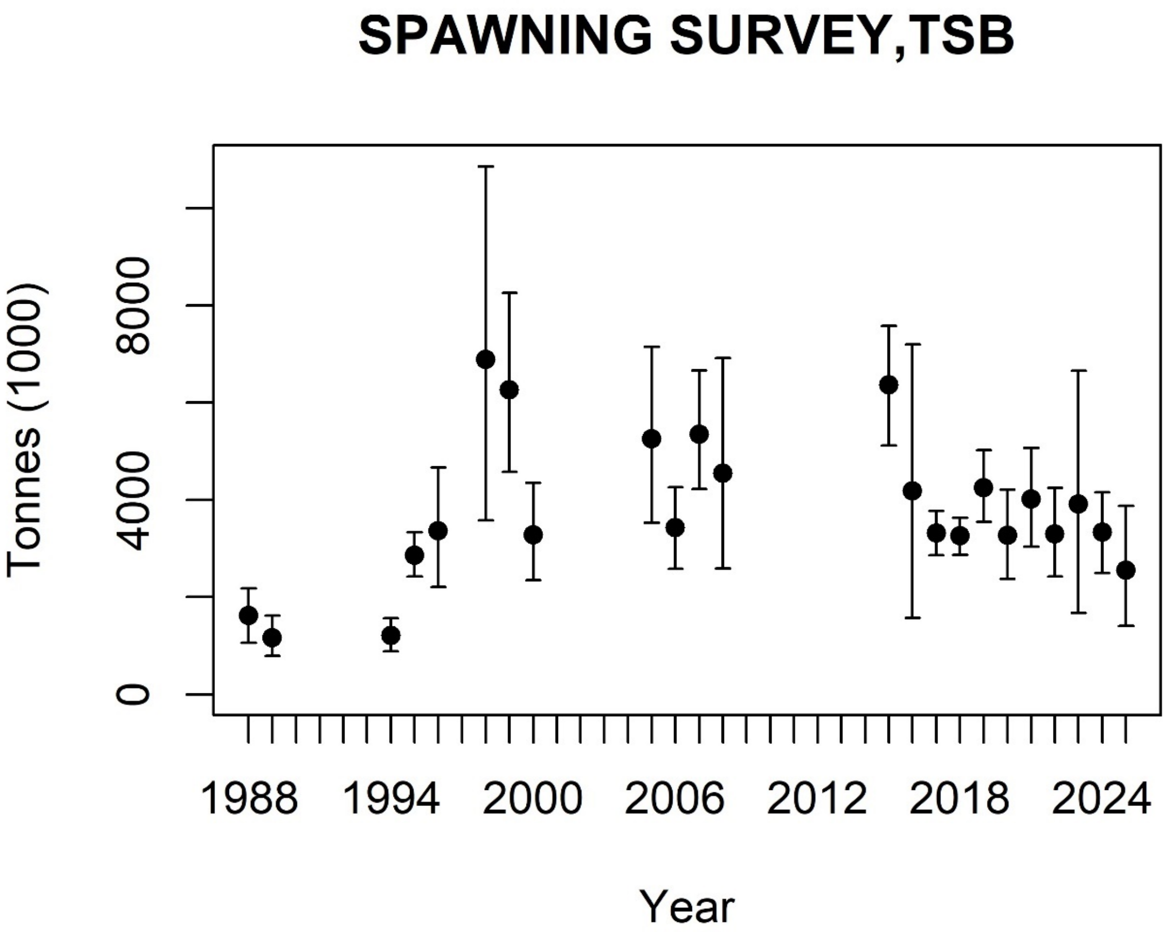

Figure 5. Estimates of total biomass from the Norwegian spring-spawning herring spawning surveys during 1988-2025. The estimates are mean of 1000 bootstrap replicates in Stox and the error bars represent 90 % confidence intervals.

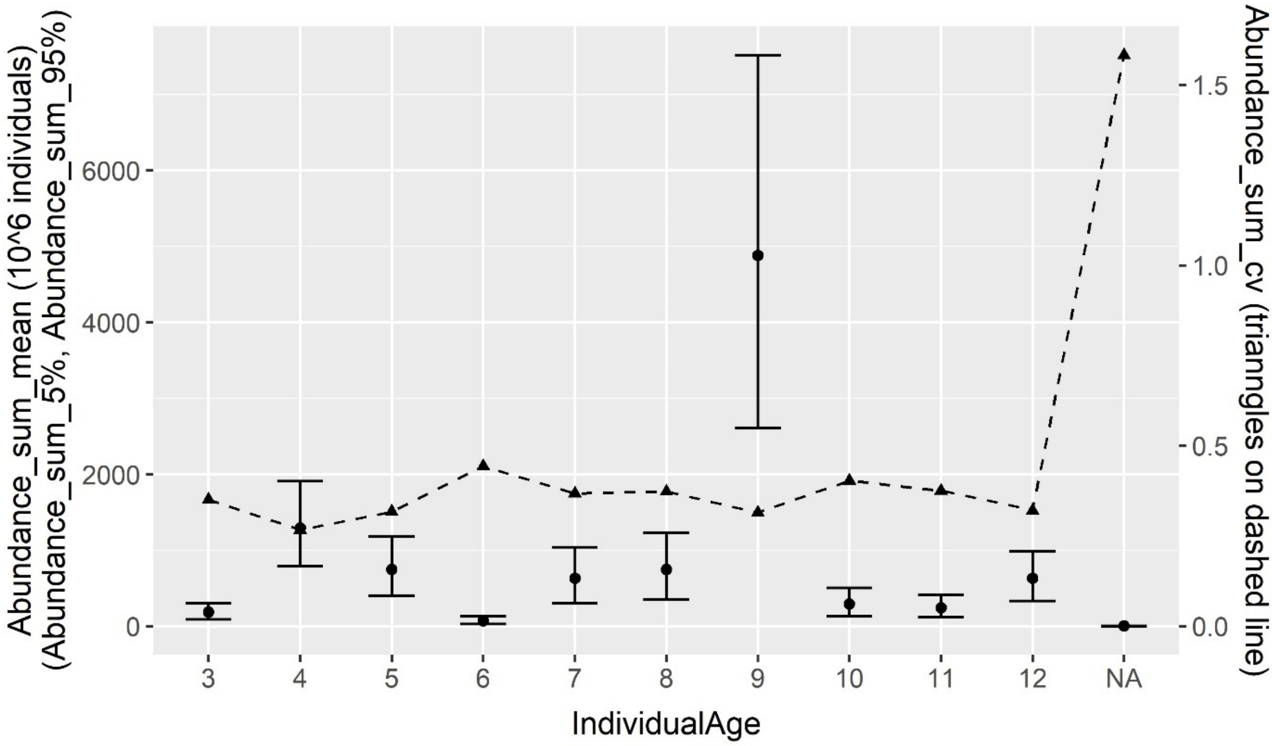

Figure 6. Abundance estimates (left axis) and relative standard error (right axis) by age from the the Norwegian spring-spawning herring spawning survey 15. February - 3. March 2025. Black dots are mean of 1000 boostrap replicates in Stox, error bars represent 90 % confidence intervals and triangles relative standard error (RSE).

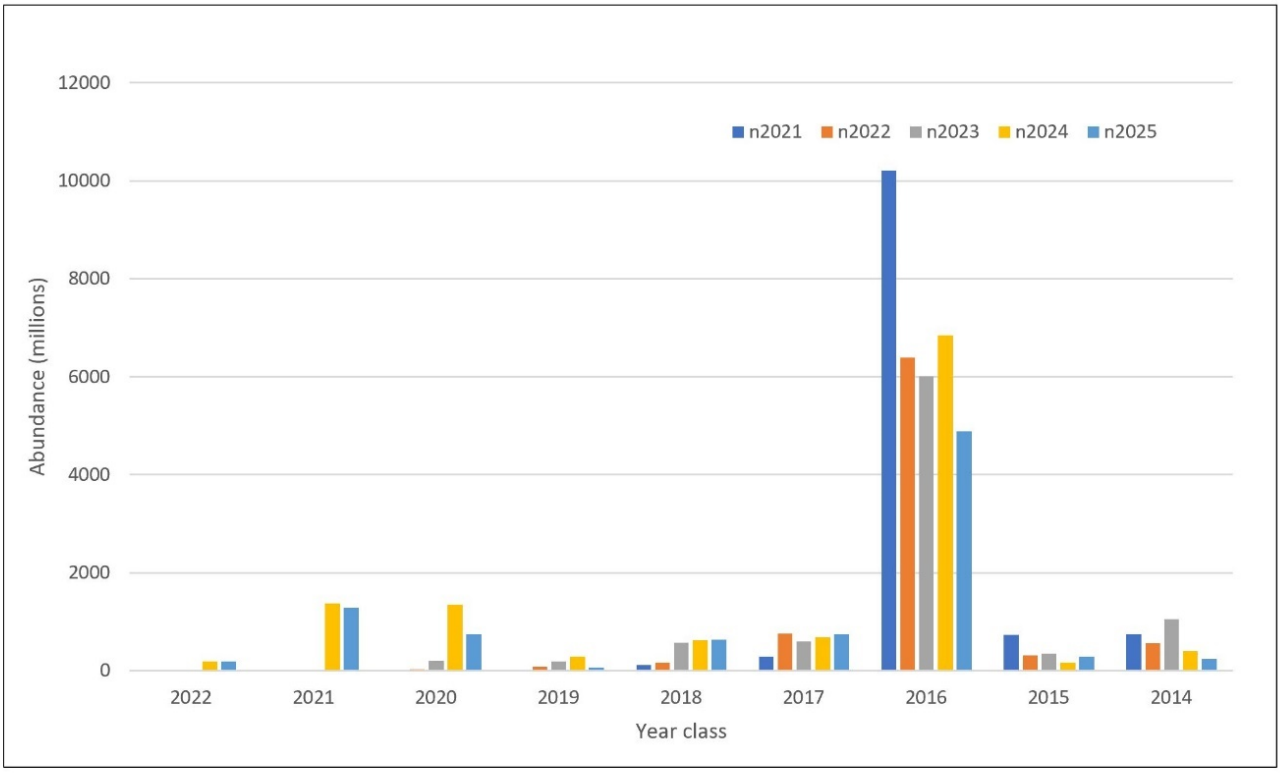

Figure 7. Abundance by year class estimated during the Norwegian spring-spawning herring spawning surveys 2021-2025 (mean of 1000 bootstrap replicates). Legend: Separate color for each survey year.

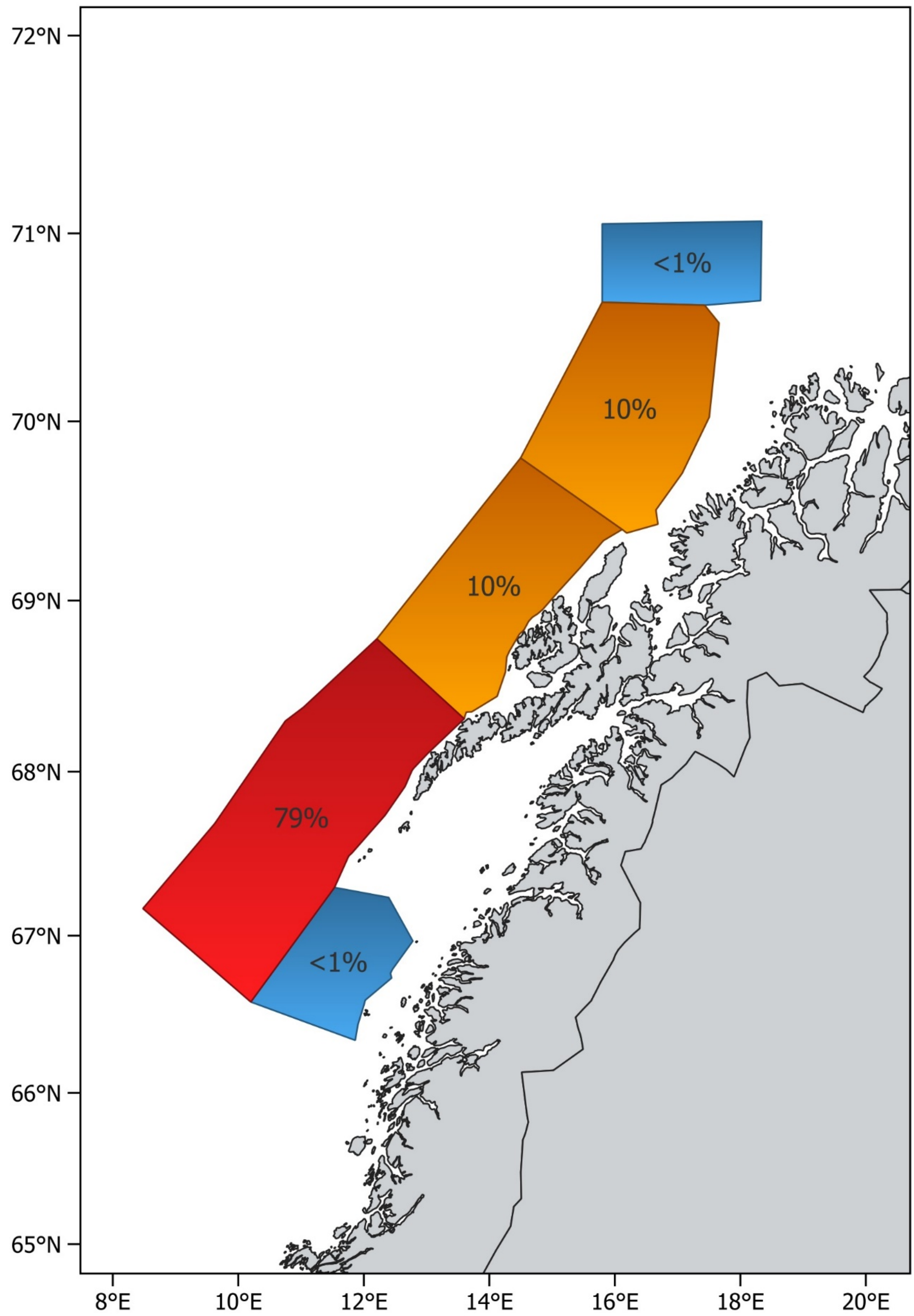
72°N
71°N
70°N
69°N
68°N
67°N
66°N
65°N
8°E
10°E
12°E
14°E
16°E
18°E
20°E
<1%
10%
10%
79%
<1%

Figure 8. Relative distribution by stratum of the biomass of herring from the Norwegian spring-spawning herring spawning survey15. February - 3. March 2025.

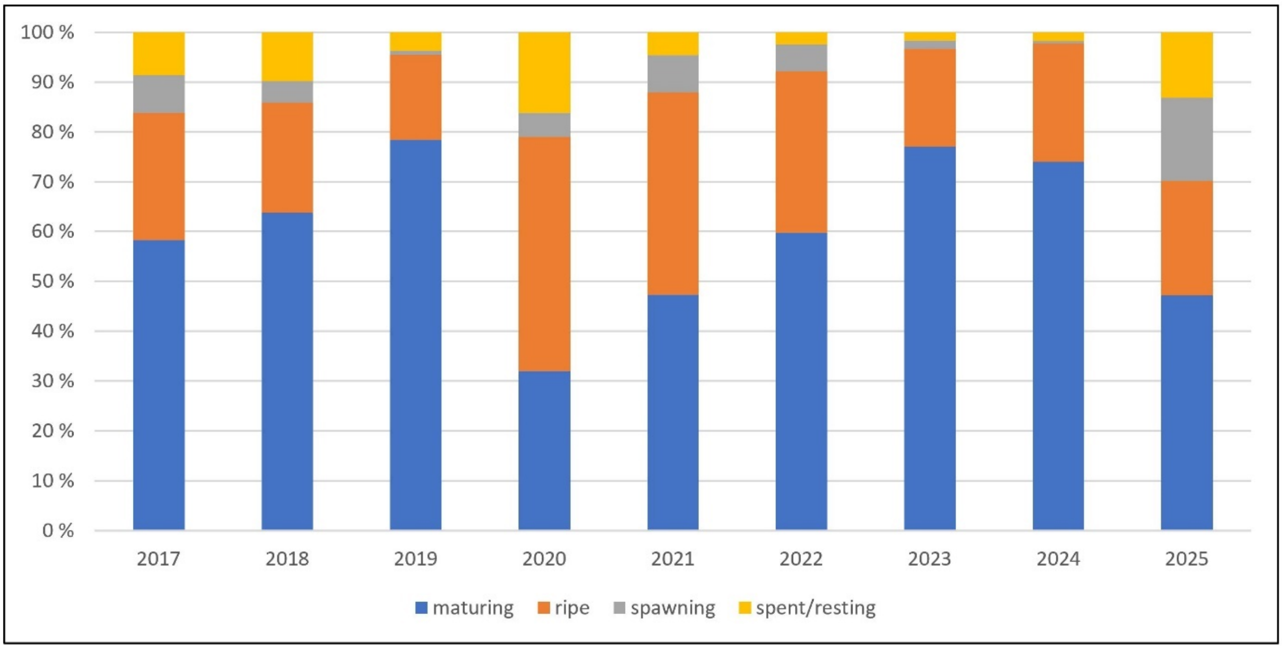

Figure 9. Proportion of the different maturity stages in the estimated population of mature herring from the Norwegian spring-spawning herring spawning surveys in 2017-2025.

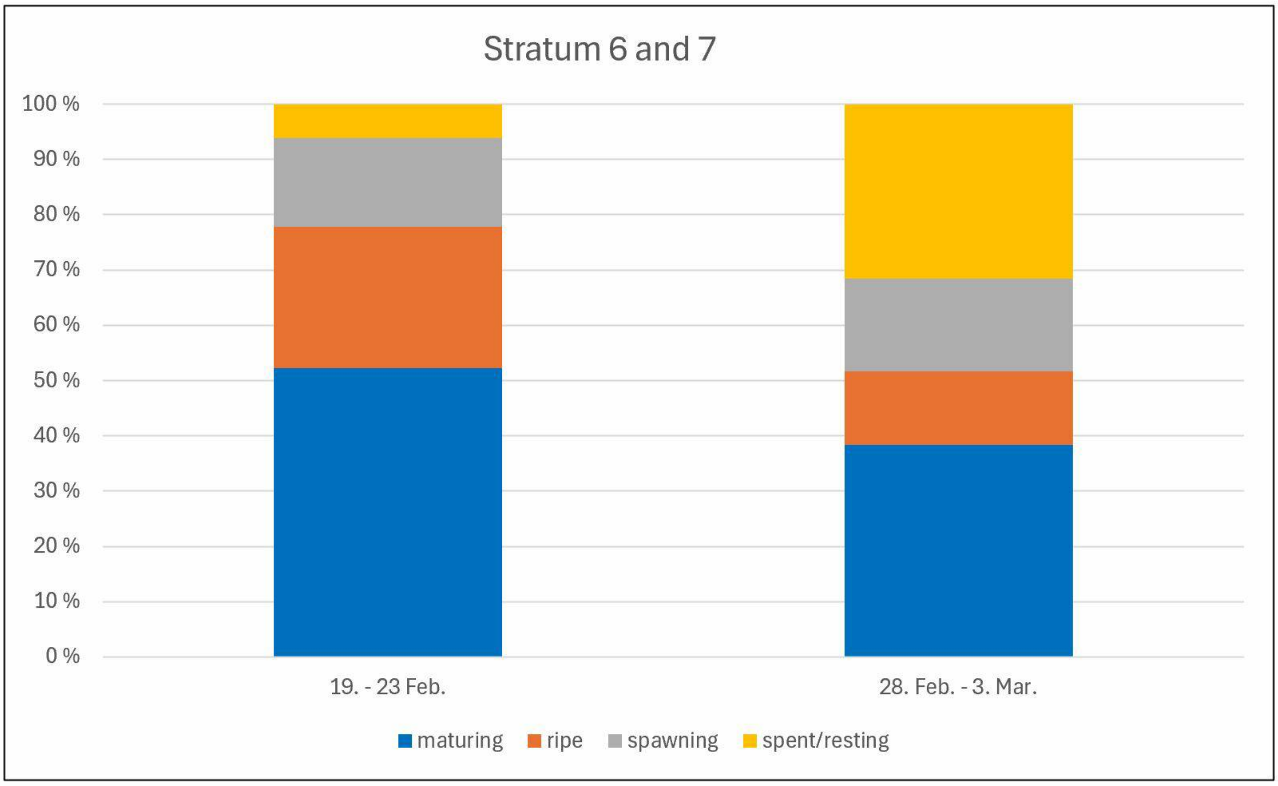

Figure 10. Proportion of the different maturity stages in the samples of mature herring from the Norwegian spring-spawning herring spawning surveys in 2025, in stratum 6 and 7, by coverage (these two strata were covered twice).

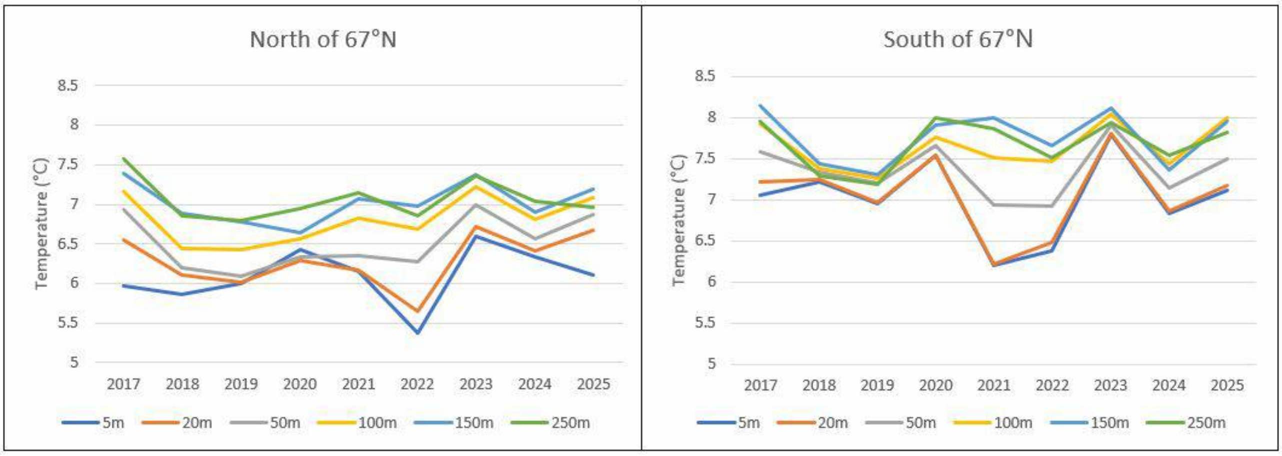

Figure 11. Mean temperatures at 5, 20, 50, 100, 150, 250 m in the area covered during the Norwegian spring-spawning herring spawning surveys in 2017-2025.

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