4 Herring (*Clupea harengus*) in subareas 1, 2, and 5, and in divisions 4.a and 14.a, (Northeast Atlantic) (Norwegian Spring Spawning)

4.1 ICES advice in 2021

ICES advised that when the long-term management strategy agreed by the European Union, the Faroe Islands, Iceland, Norway, and the Russian Federation is applied, catches in 2022 should be no more than 598 588 tonnes. The advice for 2022 was 8% lower than that for 2021.

4.2 The fishery in 2021

4.2.1 Description and development of the fisheries

The distribution of the 2021 Norwegian spring-spawning herring (NSSH) fishery for all countries by ICES rectangles is shown in Figure 4.2.1.1. The catches by ICES statistical rectangle and quarter are seen in Figure 4.2.1.2. The 2021 herring fishing pattern was similar to recent years. The fishery began in January on the Norwegian shelf and focused on overwintering, pre-spawning, spawning and post-spawning fish (Figure 4.2.1.2, quarter 1). In the second quarter, the fishery was insignificant (Figure 4.2.1.2, quarter 2). In summer, the fishery moved into mainly Icelandic and International waters and in early autumn commenced in the overwintering area off Lofoten (Figure 4.2.1.2, quarter 3). In autumn and winter, the fishery continued in Icelandic and Faroese waters but also in the overwintering area in the fjords and oceanic areas off Lofoten (Figure 4.2.1.2, quarter 4). 60% of the catches were taken in the fourth quarter. Catches of Norwegian spring-spawning herring inside the NEAFC regulatory area was estimated by the working group to be 20 347 tonnes in 2021, which represents 2% of the total catch. Note though that this does not include catches from the Russian Federation.

Since spatial and seasonal data were not available from the Russian fleet, Russian landings were not included in the description of the fisheries in 2021.

4.3 Stock Description and management units

4.3.1 Stock description

A description of the stock is given in the Stock Annex.

4.3.2 Changes in migration

Generally, it is not clear what drives the variability in migration of the stock, but the biomass and production of zooplankton are likely factors, as well as feeding competition with other pelagic fish species (*e.g.* mackerel and to a lesser extent blue whiting) and oceanographic conditions (*e.g.* limitations due to cold areas). Besides environmental factors, the age distribution in the stock will also influence the migration. Changes in the migration pattern of NSSH, as well as that of other herring stocks, are often linked to large year classes entering the stock initiating a different migration pattern, which subsequent year classes will follow. The large 2016 year-class has now entered the adult stock. The distribution of the 2016 year-class in the feeding area in 2022 as observed in the ecosystem survey in May appeared to be distributed throughout the survey area. In 2017/2018 there was a shift in wintering areas. While wintering has been observed in fjords west of Tromsø (Norway) for several years, the 2013 year-class wintered in fjords farther north (Kvænangen) since 2017/2018 while the older fish seemed to have had an oceanic wintering area. A similar pattern was observed during the winter 2021/2022. The old fish wintered in the Norwegian Sea while part of the 2016 year-class wintered in Kvænangen. From Norwegian catches during winter, it was, however observed that a large fraction of the 2016 year-class wintered in the ocean further north (north of 70°N). The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May-July 2022 concentrated in the south-western areas during the feeding season.

4.4 Input data

4.4.1 Catch data

Catches in tonnes by ICES division, ICES rectangle and quarter in 2021 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Poland and Sweden. This year the only information available from Russia was total catch by ICES division from the ICES preliminary catches data base. The total working group catch in 2021 was 851 813 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of a maximum of 651 033 tonnes. The majority of the catches (around 85%) were taken in division 2.a as in previous years. Samples were not provided by Russia, Greenland, Ireland, Poland or Sweden. Sampled catches accounted for 88 % of the total catches, which is somewhat lower compared to previous years. The sampling levels of catches in 2021 in total, by country and by ICES division are shown in Tables 4.4.1.2, 4.4.1.3 and 4.4.1.4. Catch by nation, ICES division and quarter are shown in Table 4.4.1.5. Regarding the Russian catch, some assumptions were made in order to make it possible to handle these data using the existing method: see next paragraph. The software SALLOC (ICES, 1998) was used to calculate total catches in numbers-at-age and mean weight at age representing the total catch. Samples allocated (termed fill-in in SALLOC) to cells (nation, ICES division and quarter) without sampling information are shown in Table 4.4.1.5. Note that the cells with Russian catches were assumed unsampled, so sample information from other countries in the same cells were allocated.

4.4.1.1 Missing catch data in 2021

No Russian catch data or samples by ICES sub-division and quarter were delivered for 2021. The only information available on Russian catches in 2021 is from the ICES preliminary catches database for the entire year: 92840 tonnes in sub-division 2.a and 1 ton in 5.b, which corresponds to about 11% of total catches. Some assumptions regarding the spatial and temporal distribution of the Russian catches had to be made in order to make it possible to estimate numbers and weights at age for the total international catch, and it was decided to base these assumptions on data from the period 2018-2020. Figure 4.4.1.1.1 shows the proportion by quarter of the Russian catch within each of the years 2018-2020, and the proportions are quite constant between years with most of the catches taken in the last two quarters. Table 4.4.1.1.1 shows the proportion of Russian catches by ICES sub-division for the years 2018-2020 and in practice all the catch was taken in area 2.a. Figures 4.4.1.1.2 and 4.4.1.1.3 show the Russian catch by ICES rectangle compared with the corresponding total international catch; the Russian fishery has been conducted in the same areas as the other nation's fishery in 2018-2020. Based on these results it was decided to assume that the Russian catch in 2021 (taken from the ICES preliminary catch database) was taken in area 2.a and that the distribution by quarter corresponded to the average proportions in 2018-2020. The Russian catches in the different quarter-area cells were treated as unsampled and sample information from other nations was allocated to these according to the standard SALLOC procedure. Two additional figures are shown here that are relevant for the assumptions in the forecast: Figure 4.4.1.1.4 shows the Russian proportions of the total international catch per year in the period 2001-2020 and Figure 4.4.1.1.5 shows the Russian landings as a function of ICES advice for the period 2001-2020. The Russian proportions have been quite constant in recent years and there is a strong linear relationship between ICES advice and Russian landings.

4.4.2 Discards

In 2008, the Working Group noted that in this fishery an unaccounted mortality caused by fishing operations and underreporting probably exists (ICES, 2008). It has not been possible to assess the magnitude of these extra removals from the stock, and considering the large catches taken after the recovery of the stock, the relative importance of such additional mortality is probably low. Therefore, no extra mortality to account for these factors has been added since 1994. In previous years, when the stock and the quotas were much smaller, an estimated amount of fish was added to the catches.

The Working Group has not had access to comprehensive data to estimate discards of herring. Although discarding may occur on this stock, it is considered to be low and a minor problem for the assessment. This is confirmed by estimates from sampling programmes carried out by some EU countries in the Data Collection Framework. Estimates of discarding in 2008 and 2009 of about 2% in weight were provided for the trawl fishery carried out by the Netherlands. In 2010 and 2012, this métier was sampled by Germany. No discarding of herring was observed (0%) in either of the two years. An investigation on fisheries induced mortality carried out by IMR with EU partners on fisheries induced and unreported mortality in mackerel and herring fisheries in the North Sea concluded with an estimated level of discarding at around 3%.

In order to provide information on unaccounted mortality caused by fishing operations in the Norwegian fishery, Ipsos Public Affairs, in cooperation with IMR and the fishing industry, conducted a survey in January/February 2016. The survey was done by phoning skippers and interviewing them. A total of 146 herring skippers participated in the survey, 31 skippers representing the bigger vessel group and 115 skippers representing the smaller vessel group. The data provided an indication that there have been periods of increased occurrence of net bursting. This was seen especially in the period 2007–2010. There was, however, no trend in the size of catches where bursting has occurred.

When it comes to slipping, the data showed a steady increase in the percentage that has slipped herring from 2004–2012, and then a significant decline in recent years. The variations in the proportion that have slipped herring were largely driven by the skippers on smaller coastal purse-seiners. Average size of purse-seine hauls slipped seems to be relatively steady over the period. However, the average size of net hauls slipped was lowest in the recent period.

4.4.3 Age composition of the catch

The estimated catch-at-age in numbers by year are shown in Table 4.4.3.1. The numbers are calculated using the SALLOC software. In 2021, catches (in numbers) were dominated by the 2016 year-class which comprised around 50 % of the catch. Catch curves were made on the basis of the international catch-at-age (Figure 4.4.3.1). For comparison, lines corresponding to Z=0.3 are drawn in the background. The big year classes, in the periods of relatively constant effort, show a consistent decline in catch number by cohort, indicating a reasonably good quality of the catch-at-age data. Catch curves for year classes 2005 onwards show a flatter curve than for previous year classes indicating a lower F or a changed exploitation pattern.

4.4.4 Weight-at-age in catch and in the stock

The weight-at-age in the catches in 2021 was computed from the sampled catches using SALLOC. Trends in weight-at-age in the catch are presented in Figure 4.4.4.1 and Table 4.4.4.1. The mean weights at age for most of the age groups have generally been increasing in 2010–2013 but levelled off around 2014. In the most recent years the weight-at-age seems to have decreased slightly for most ages – earlier for the younger ages than for the older. The decrease from 2020 to 2021 was generally larger than the preceding years. A similar pattern is observed in weight-at-age in the stock which is presented in Figure 4.4.4.2 and Table 4.4.4.2. The mean weight-at-age in the stock was based on the survey in the wintering area until 2008. Since then the mean weight-at-age in the stock was derived from samples taken in the fishery in the same area and at the same time as the wintering surveys were conducted in.

4.4.5 Maturity-at-age

In 2010 the method for estimating maturity-at-age in the stock assessment of NSSH was changed based on work done by the “workshop on estimation of maturity ogive in Norwegian spring-spawning herring” (WKHERMAT; ICES, 2010a). The method which was adopted by WGWIDE in 2010 (ICES, 2010b) is based on work by Engelhard *et al*. (2003) and Engelhard and Heino (2004). They developed a method to back-calculate age-at-maturity for individual herring based on scale measurements, and used this to construct maturity ogives for the year classes 1930–1992.

The NSSH has irregular recruitment pattern with a few large year classes dominating in the stock when it is on a high level. Most of the year classes are, however, relatively small and referred to as “normal” year classes. The back-calculation dataset indicates that maturation of the large year classes is slower than for “normal” year classes.

WKHERMAT and WGWIDE considered the dataset derived by back calculation as a suitable candidate for use in the assessment because it is conceived in a consistent way over the whole period and can meet standards required in a quality-controlled process. However, the back-calculation estimates cannot be used for the most recent years since all year classes have to be fully matured before the calculation can be made. Therefore, assumptions have to be made for the recent year classes. For recent year classes, WGWIDE (ICES, 2010b) decided to use average back-calculated maturity for “normal” and “big“year classes thereby reducing maturity-at-age for ages 4, 5 and 6 when strong year classes enter the spawning stock. The default maturity ogives used for “normal” and “big” year-classes are given in the text table below.

age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
normal year class	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
strong year class	0	0	0	0	0.1	0.6	0.9	1	1	1	1	1	1	1	1	1

Assumed values should be replaced by back-calculated values in the annual assessments for each year where updated values are available. In 2022 the year 2017 was updated with back-calculated values used in the present assessment. Assumed and updated values are shown in figure 4.4.5.1. The 2016 year-class was considered a strong year-class by the working group based on the assessment where several survey indices of this year-class are included, and maturity at age 6 was set to 0.9 for this year-class in the 2022 assessment according to the table above. The maturity ogives used in the present assessment are presented in Table 4.4.5.1.

4.4.6 Natural mortality

In this year's assessment, the natural mortality M=0.15 was used for ages 3 and older and M=0.9 was used for ages 0–2. These levels of natural mortality are in accordance to previous years and their justification is provided in the stock annex. Information about deviations from these levels in the time-series, *e.g.* due to diseases, are also provided in the stock annex.

4.4.7 Survey data

The surveys available for the assessment are described in the stock annex. Only two of the available surveys are used in the final assessment and will therefore be dealt with in this section:

1) The International Ecosystem Survey in the Nordic Seas (IESNS) in May. This survey covers the entire stock during its migration on the feeding grounds, the adults in the Norwegian Sea and adjacent waters ("Fleet 5") and the juveniles in the Barents Sea ("Fleet 4")

2) The Norwegian acoustic survey on the spawning grounds in February ("Fleet 1")

The cruise reports from the IESNS (WD05) and spawning survey (WD04) in 2022 are available as working documents to this report. The spawning survey and IESNS in the Norwegian Sea were both carried out successfully in 2022, however, the IESNS in the Barents Sea was not carried out by Russia this year.

The abundance estimates from "Fleet 1" are shown in Table 4.4.7.1 and Figure 4.4.7.2; from "Fleet 4" in Table 4.4.7.2 and Figure 4.4.7.1 and "Fleet 5" in Table 4.4.7.3 and Figure 4.4.7.1. In 2020 it was decided to use the bootstrap mean values as point estimates of abundance instead of the baseline estimates. This applies to the years were the software Stox is used to estimate abundance. Variance estimates from the bootstrap runs were already being used in the assessment, thus it is more logical to also use point estimates from the bootstrap. A comparison using point estimates for both bootstrap and baseline was made, and the effect on the assessment was negligible.

Catch curves were made on the basis of the abundance estimates from the surveys "Fleet 1" (Figure 4.4.7.3) and "Fleet 5" (Figure 4.4.7.4). The same arguments are valid for the interpretation of the catch curves from the surveys as from the catches. In 2010, the numbers of all age groups decreased suddenly in "Fleet 5" and this is seen as a drop in the catch curves that year. This drop has continued for some of the year classes and the year classes 1998 and 1999 are disappearing faster from the stock than expected. This observed fast reduction in these age classes may also be influenced by the changes in "Fleet 5" catchability, with seemingly higher catchability in years 2006—2009. Like the catch curves from commercial landings, the corresponding curves from "Fleet 5" are also quite flat for year classes 2005 onwards. As "Fleet 1" was not conducted in the years 2009–2014, there is a gap in the catch curves, making it difficult to interpret them.

4.4.8 Sampling error in catches and surveys

Sampling errors for Norwegian catch-at-age for the years 2010-2021 is estimated using ECA (Salthaug and Aanes 2015, Hirst *et al.* 2012). Using the Taylor function (Aanes 2016a) to model the sampling variance of the catches yields a very good fit ($R^2_{adj} = 0.94$) and using this function to impute missing sampling variances for catch-at-age yields relative standard errors shown in Table 4.4.8.1. It is assumed that the relative standard errors in the total catches are equal to the Norwegian catches (which comprise ~60% of the total catches). Sampling errors for survey indices are estimated using StoX (http://www.imr.no/forskning/prosjekter/stox/nb-no) and Johnsen *et al*. (2019). For Fleet 1, estimates are available for the years 1988–1989, 1994–1996, 1998–2000, 2005–2008, and 2015–2021, for Fleet 4 estimates of sampling errors are available for 2009–2019 and 2021, and for Fleet 5 for 2008–2021. Missing values for sampling variances are imputed using the Taylor function which provides good fits (R^2_{adj}'s are 0.95, 0.98 and 0.96 respectively). The resultant relative standard errors are given in Tables 4.4.8.2-4.4.8.4. Due to the very good fits of the Taylor functions, estimates of relative standard where empirical estimates are available, are also replaced by the model predicted values to reduce potential effects of imprecise estimates of errors.

4.4.9 Information from the fishing industry

No information was made available to the working group.

4.5 Stock assessment

The first benchmark of the NSSH assessment took place in 2008 with the assessment tool TASACS selected as the standard assessment tool for the stock. A second benchmark took place in 2016 (WKPELA - ICES, 2016) where three assessment models were explored - TASACS, XSAM and one separable model. WKPELA accepted XSAM as the standard assessment tool for the NSSH.

4.5.1 XSAM final assessment 2022

The XSAM model is documented in Aanes 2016a and 2016b. XSAM includes the option to utilize the prediction of total catch in the assessment year (typically the sum of national quotas) along with the precision of the prediction. This approach was changed in 2017 when it was found that the model estimated a highly variable and significantly lower catch compared to the working group's prediction (sum of national quotas). In addition, this caused an abrupt change in the selection pattern from 2017 and onwards. The abrupt change in the selection pattern was not fully understood by the working group, but the effect was less pronounced if not using the catch prediction from the model for 2017. Therefore, it was decided to not utilize the prediction of total catches in 2017 when fitting the model to data (*i.e.* the assessment) and consequently in the short-term forecast. The same approach is taken in the 2022 assessment, *i.e.* the catch prediction for 2022 is not included when fitting the model to data. The resulting estimated selection pattern is gradual (Figure 4.5.1.1) and in line with the current knowledge about the fishery. It is important to note that this has marginal effect on the assessment, but larger effects on the prediction and short-term forecast.

The 2022 XSAM assessment was performed with the same model options as in 2017. In summary, this means that the model was fit with time varying selectivity and effort according to AR(1) models in the model for fishing mortality; the recruitment was modelled as a process with constant mean and variance; the standard errors for all input data were predetermined using sample data (Tables 4.4.8.1–4.4.8.4), and a scaling constant common for all input data to allow additional variability in the input data that is not controlled by sampling is estimated. Additional details on the assessment settings are given in the Stock Annex.

The same input data over the same age ranges was used as in 2017. At the 2016 benchmark, data from 1988 and onwards was used from ages 3–12+ with input data catch-at-age, Fleet 1 and Fleet 5, At WGWIDE 2016, it was decided to start the model at age 2 to enable short-term predictions with reasonable levels of variability. To achieve this, age 2 from Fleet 4, and age 2 in catch-at-age was included in input data. Evaluation of diagnostics including lower ages than 2 and/or other fleets resulted in excluding lower ages than 2 and other fleets for the final assessment.

The parameter estimates from the 2022 assessment are shown in Table 4.5.1.1 and in Figure 4.5.1.10. For a precise definition of the parameters, refer to Aanes 2016a in ICES (2016). Note that the variance components σ_1^2 (variability in the separable model for F) and σ_R^2 (variability in recruitment) are rather imprecise. The estimate of the scaling constant h is larger than 1, indicating that the model adds additional variability on the observation errors than explained by the sampling errors alone.

The catchabilities for all the fleets are on average positively correlated indicating some uncertainty due to a common scaling of all surveys to the total abundances although the correlations in general are small (Figure 4.5.1.2). There is a slight negative correlation between σ_1^2 (variability in the separable model for F, logs2_1 in figure) and σ_2^2 (variability in the AR process for time varying selectivity, logs2_2 in figure) indicating little contrast in data for separating variability in the separable model from variability due to changes in selection pattern. The slopes in the multivariate AR model for time-varying selectivity gradually changes from negative to positive, but is expected as it is imposed due to the sum to zero constraint for the selection (see Aanes 2016a for details).

The weights each datum is given in the model fit (inverse of the sampling variance) is proportional to the empirical weights derived from sampling variances (Tables 4.4.8.1–4.4.8.4) which shows that the strong year classes in general are given larger weight to the model than weaker year classes, and the ordering of the average weights (from high to low) is Catch-at-age, Fleet 5, Fleet 1 and Fleet 4 (Figure 4.5.1.3).

Two types of residuals are considered for this model. The first type is the model prediction (based on all data) vs. the data. In such time-series models, the residuals based on the prediction which uses all data points will be serially correlated although useful as they explain the unexplained part of the model (*cf* Harvey 1990 p 258). This means that patterns in residuals over time is to be expected and questions the use of *e.g.* qq-plots as an additional diagnostic tool to assess distributional assumptions. To obtain residuals which follow the assumptions about the data in the observation models (*e.g.* serially uncorrelated) single joint sample residuals are extracted (ICES, 2017). In short these are obtained by sampling predicted values from the conditional distribution of values given the observations. This sample corresponds to a sample from the joint distribution of latent variables and observations. A third approach could have been to extract the one step ahead observation residuals which are standard for diagnostics for regular state-space models (*cf* Harvey 1990). This is not done here.

The negative residuals tracing the 1983 year-class for catch-at-age represents low fishing mortalities examining the type 1 residuals (Figure 4.5.1.4). This effect is less pronounced considering the type 2 residuals. The type 2 residuals are qualitatively comparable with the type 1 residuals but generally display more mixed residuals as predicted by the theory. Otherwise the residuals for catch-at-age appears fairly mixed apart for some serial correlation for age 2 and 3 (which are very low), and some negative residuals for the plus group the most recent years. The residuals for Fleet 1 in year 1994, 1999, 2006 for young and old ages are all of the same signs and may appear as year effects. Also note that the residuals for Fleet 1 for ages 12+ from 2015 are all positive (Figure 4.5.1.4) which shows that the abundance indices from Fleet 1 displays a larger stock size over these ages and years compared to the assessment using all input data. Some serial correlation for residuals for ages 3 and 4 in Fleet 1 can also be detected, but is down weighted as these is found to be uncertain. Serial correlation in residuals for age 2 in Fleet 4 can also be detected indicating trends over time in mismatch between estimates and observations of abundance at age 2. Residuals for Fleet 5 appears adequate compared to previous years although some serial correlations can be detected also here.

The residuals for small values are bigger than residuals for the larger values since smaller values in general have higher variances than larger values (Tables 4.4.8.1–4.4.8.4) (Figure 4.5.1.5). The qq-plots for the standardized residuals show that the distributional assumptions on the observation errors are adequate, except for the smallest and largest values of catch-at-age and indices from Fleet 1 and the smallest indices for Fleet 4. As qq-plots for residuals of type 1 may be questioned (see above) it is noted that qq-plots for residuals of type 2 is more relevant and generally shows a significantly better fit based on a visual inspection compared to using type 1.

The marginal likelihood and the components for each data source (see Aanes 2016b for details) are profiled over a range of the common scaling factor h for all input data (Figure 4.5.1.6). It is apparent that the optimum of the marginal likelihood is clearly defined. The catch component is decreasing with decreasing values of h indicating that the model puts more weight on the catch component than indicated by the comparison of sampling errors for all input data. This is in line with the findings in Aanes (2016a and 2016b) who showed that these types of models tend to put too much weight on the catch data if the weighting is not constrained. However, the likelihood component for the catch is overruled by the information in Fleets 1, 4 and 5 such that the optimum for the marginal likelihood is clearly defined. The point estimates of SSB and F is insensitive to different values of h.

The retrospective runs for this model shows estimates within the estimated levels of precision (Figure 4.5.1.7), and has a reasonably low Mohn's rho value for SSB of -0.04 and -0.13 for F (Mohn, 1999; Brooks and Legault, 2016). Note that the retrospective patterns are remarkably stable.

Figure 4.5.1.8 illustrates the conflict in data and increased uncertainty in estimates for the most recent years. The spawning-stock biomass shown for each survey index is calculated using the stock weights at age and proportion mature at age, with the abundance indices are scaled to the absolute abundance by the estimated catchabilities. A fairly good temporal match between the model estimate of SSB and the survey SSBs is seen, except for the years 2015 for Fleet 1, which displays a significantly faster reduction in the stock compared to Fleet 5 which shows a flatter trend in the same years. Both Fleet 1 and Fleet 5 indicate an increase in SSB from 2007 to 2009, then a decrease in 2020 before an increase in 2021. It is worth noting that, although the point estimate of SSB based on Fleet 1 appears very much higher than Fleet 5 in 2015, the uncertainty in the estimates are very high, such that the respective estimates do not appear as significantly different. Since 2016 the conflict between Fleet 1 and Fleet 5 has become less.

The results of leave-one-out runs are presented in Figure 4.5.1.11 and can be used to assess the influence of individual data sources on the assessment. Removing Fleet 1 leads to a downward revision of SSB and an upward revision of F. The overall assessment uncertainty is similar to the base run which includes all data sources. Removing Fleet 5 results in an upward revision of SSB and a downward revision of F, with an increase in uncertainty. Removing Fleet 4 does not influence the SSB nor F.

The final 2022 assessment results are shown in Figure 4.5.1.9. The estimate of fishing mortality for 2019 to 2021 is rather high, as a response to the high catch in both years with a point estimates from ~0.17 to ~0.19. In 2018 the fishing mortality is estimated to be lower than in 2017 and 2019 (F=0.129). The spawning stock shows a declining trend since 2009 but an increase in 2021 and then a small decrease in 2022, and the 95% confidence interval of the stock level in 2022 ranges from ~3.134 to ~4.6 million tonnes with a point estimate of 3.867 which is above B_{mp}=3.184 million tonnes, such that the probability of the stock being above B_{lim}=2.5 million tonnes is high.

The final results of the assessment are also presented in Tables 4.5.1.2 (stock in numbers), 4.5.1.3 (fishing mortality) and Table 4.5.1.4 is the summary table of the assessment.

4.5.2 Exploratory assessments

4.5.2.1 TASACS

TASACS was run according to the benchmark in 2008 using the VPA population model in the TASACS toolbox with the same model options as the benchmark (see Stock Annex). The information used in the TASACS run is catch data and survey data from eight surveys. The analysis was restricted to the years 1988–2022. The model was run with catch data from 1988 to 2021, and projected forwards through 2022 assuming Fs in 2022 equal to those in 2021, to include survey data from 2022. The larval survey (SSB fleet) was discontinued in 2017 and no new information is therefore available from this survey. Additionally, no new index was provided for fleet 7 since 2019 (0-group from the autumn survey in the Barents Sea) since this index was not updated by the survey group. This time series (0-group) is presently being re-calculated.

Residuals of the tuning series are shown in Figure 4.5.2.1.1. Particularly survey 8 (larval survey) seems to have a poor fit. This is seen as a block of positive residuals for this survey in later years. The residual plot for survey 5 (IESNS) also shows some pattern with consecutive series of negative and positive residuals indicating year-effects.

The results from TASACS are compared to those from XSAM and SAM in Figure 4.5.2.1.2. The time-series of SSB show similar trends for XSAM, SAM (configured as XSAM) and TASACS, although SSB in recent years are higher in TASACS due to an upward revision in the 2021 TASACS assessment. For most of the years, the estimates from TASACS are within the confidence limits estimated by XSAM except for the assessment year 2022 where the SSB from TASACS is slightly above the upper confidence limit. The SSB on 1 January 2022 is estimated by TASACS to be 4.63 million tonnes.

4.6 NSSH reference points

ICES last reviewed the reference points of Norwegian spring spawning herring in April 2018 during WKNSSHREF (ICES, 2018a). ICES concluded that B_{lim} should remain unchanged at 2.5 million tonnes and MSY $B_{trigger} = B_{pa}$ was estimated at 3.184 million tonnes. F_{MSY} was estimated at the reference point workshop, but during the subsequent Management Strategy Evaluation WKNSSHMSE (ICES, 2018b) the fishing mortality reference points were revisited as issues were found with numerical instability and settings during the reference point workshop. F_{MSY} was re-estimated to be 0.157.

4.6.1 PA reference points

The PA reference points for the stock were last estimated by WKNSSHREF and WKNSSHMSE in 2018. The WKNSSHREF group concluded that B_{lim} should be kept at 2.5 million tonnes and B_{pa} was estimated at 3.184 million tonnes. WKNSSHMSE estimated F_{pa}=0.227. However, following recent ICES guidelines F_{pa} is now based on Fp05 which was estimated at 0.157 by WKNSSHMSE in 2018.

4.6.2 MSY reference points

The MSY reference points were evaluated by WKNSSHREF and WKNSSHMSE in 2018. In the ICES MSY framework B_{pa} is proposed/adopted as the default trigger biomass $B_{trigger}$ and was estimated by WKNSSHREF at 3.184 million tonnes. F_{MSY} was estimated by WKNSSHMSE at 0.157.

4.6.3 Management reference points

In the current management strategy, which was agreed upon in October 2018, the Coastal States have agreed a target reference point defined at F_{target} = 0.14 when the stock is above B_{pa}. If the SSB is below B_{pa}, a linear reduction in the fishing mortality rate will be applied from 0.14 at B_{pa} to 0.05 at B_{lim}.

4.7 State of the stock

The SSB on 1 January 2022 is estimated by XSAM to be 3.87 million tonnes which is above B_{pa} (3.184 million t). The spawning stock has been declining since 2009 but increased in 2021 followed by a decrease again in 2022. The SSB time-series from the 2022 assessment is consistent with the SSB time-series from the 2021 assessment. In the last 20 years, several large year classes have been produced (1998, 1999, 2002, and 2004). The year classes 2005-2015 and 2017-2019 are estimated to be average or small, while the 2016 year-class is estimated to be above average in the 2022 assessment. Since there was no recruitment survey in 2022, the size of the 2020 year-class at age 2 was defined as the stochastic median recruitment in the time series. Fishing mortality in 2021 is estimated to be 0.168 which is above the management strategy F (0.140) that was used to give advice for 2021. A new management strategy was implemented for the 2019 advisory year.

4.8 NSSH Catch predictions for 2023

4.8.1 Input data for the forecast

Forecasting was conducted using XSAM according to the method described in the Stock Annex and by Aanes (2016c). WGWIDE 2016 decided to use the point estimates from this forecast as basis for the advice. In short, the forecast is made by applying the point estimates of the stock status as input to set TAC, then based on the TAC a stochastic forecast was performed to determine levels of precision in the forecast. Table 4.8.1.1 lists the point estimates of the starting values for the forecast. The input stock numbers-at-age 2 and older were taken from the final assessment. The catch weight-at-age, used in the forecast, is the average of the observed catch weights over the last 3 years (2019-2021).

For the weight-at-age in the stock, the values for 2022 were obtained from the commercial fisheries in the wintering areas in January. For the years 2023 and 2024 the average of the last 3 years (2020-2022) was used.

Standard values for natural mortality were used. Maturity-at-age was based on the information presented in Section 4.4.5.

The exploitation pattern used in the forecast is taken from the predictions made by the model (see Aanes 2016c for details). The resultant mean annual exploitation pattern is shown in Figure 4.8.1.1 and displays a shift towards older fish in the recent years and further in the prediction. Prediction of recruitment at age 2 is obtained by the model with a mean that in practice represents the long term (1988-2021) estimated mean recruitment (back-transformed mean at log scale) and variance the corresponding recruitment variability over the period. Forecasted values of recruits are highly imprecise but have little influence on the short-term forecast of SSB as the herring starts to mature at age 4. Note that the 2016 year-class is regarded as large; hence, the maturity is set to be lower than for smaller year-classes. This results in the contribution of the 2016 year-class to the SSB being delayed.

The average fishing mortality is defined as the average over the ages 5 to 12+, weighted over the population numbers in the relevant year

$$\bar{F}_y = \sum_{a=5}^{12} N_{a,y} F_{a,y} \bigg/ \sum_{a=5}^{12} N_{a,y}$$

where $F_{a,y}$ and $N_{a,y}$ are fishing mortalities and numbers by age and year. This procedure is in accordance with that used in previous years for this stock although the age range was shifted from 5-11 to 5-12+ from 2018.

There was no agreement between the fishing parties on the sharing of the TAC for 2021. Therefore, to obtain an estimate of the total catch to be used as input for the catch-constraint projections for 2022, the sum of the unilateral quotas was used. In total, the expected outtake from the stock in 2021 amounts to 827 963 tonnes. F in 2022 is estimated by XSAM based on this catch.

4.8.2 Results of the forecast

The Management Options Table with the results of the forecast is presented in Table 4.8.2.1. Assuming a total catch 827 963 tonnes is taken in 2022, it is expected that the SSB will decrease from 3.867 million tonnes on 1 January in 2022 to 3.532 million tonnes in 2023. The weighted F over ages 5-12+ is 0.192. The model predicts that the catch in 2023 to be dominated by three age groups, age 7 (46%), age 10 (11%), and age 12+ (12%).

4.9 Comparison with previous assessment

A comparison between the assessments 2011-2022 is shown in Figure 4.9.1. In the years 2011-2015 the assessments were made with TASACS, whereas since 2016 XSAM has been applied, as accepted by WKPELA 2016. With the change of the assessment tool in 2016 the age of the recruitment changed from 0 to 2 and the age span in the reference F changed from 5-14 to 5-11. In WKNSSHREF (ICES, 2018a) this was further changed to 5-12+.

The table below shows the SSB (thousand tonnes) on 1 January in 2021 and weighted F in 2020 as estimated in 2021 and 2022.

	ICES 2021	WG 2022	%difference
SSB (2021)	3 765	3 930	4.4%
Weighted F (2020)	0.188	0.19	1.1%

4.10 Management plans and evaluations

The current management strategy for the Norwegian spring spawning herring fishery was agreed by the Coastal States in October 2018.

The implemented long-term management strategy of Norwegian spring spawning herring is consistent with the precautionary approach and the MSY approach (WKNSSHREF, ICES, 2018a; WKNSSHMSE, ICES, 2018b) and aims at ensuring harvest rates within safe biological limits. The management strategy in use contains the following elements:

As a priority, the long-term management strategy shall ensure with high probability that the size of the spawning stock is maintained above B_{lim}.

In the case that the spawning biomass is forecast to be above or equal to $B_{trigger}$ (=B_{pa}) on 1 January of the year for which the TAC (*i.e.* the TAC agreed by Coastal States) is to be set, the TAC shall be fixed to a fishing mortality of F_{mgt} = 0.14.

If F_{mgt} (0.14) would lead to a TAC, that deviates by more than 20% below or 25% above the TAC of the preceding year, the Parties shall fix a TAC that is respectively no more than 20% less or 25% more than the TAC of the preceding year. The TAC constraint shall not apply if the spawning biomass at 1 January in the year for which the TAC is to be set is less than $B_{trigger}$.

If SSB is forecast to be lower than $B_{trigger}$ but above B_{lim} on the 1 January of the TAC-year, TAC is to be set using F, which decreases linearly from F_{mgt} to F = 0.05 over the biomass range from $B_{trigger}$ to B_{lim}.

The Coastal States Parties may transfer 10% of quotas between neighbouring years, except when SSB is less than B_{lim}; those years the management plan does not allow fishing of next year's quota.

The Coastal States Parties, on the basis of ICES advice, shall review the long-term management strategy at intervals not exceeding five years. The first such review shall take place no later than 2023.

A brief history of management strategies is in the stock annex. In general, the stock has been managed in compliance with the management strategy. There has, however, been no agreement on sharing of the TAC since 2013, resulting in the total catch being higher than the advised catch.

4.11 Management considerations

Perception of the stock has not changed since last year's assessment (estimated SSB in 2021 is 5% higher in this year's assessment).

Historically, the size of the stock has shown large variations and dependency on the irregular occurrence of very strong year classes. Between 1998 and 2004 the stock produced several strong year classes which lead to an increase in SSB until 2009. Since then, SSB has declined due to absence of strong year classes in 2005-2015. The 2016 year-class was however, estimated to be well above average in the 2021 assessment and resulted in an increase in SSB from 2020 to 2021. SSB, however, declined in 2022 and is predicted to be below B_{mgt} in 2024 even if the management strategy (F=0.14) is applied in 2023.

Between 1999 and 2013, catches were regulated through an agreed management. However, since 2013, a lack of agreement by the Coastal States on their share in the TAC has led to unilaterally set quotas which together are higher than the TAC indicated by the management strategy resulting in steeper reduction in the SSB than otherwise.

A new management strategy was implemented for the advisory year 2019.

4.12 Ecosystem considerations

NSS herring juveniles and adults are an important part of the ecosystems in the Barents Sea, along the Norwegian coast, in the Norwegian Sea and in adjacent waters. This refers both to predation on zooplankton by herring and herring being a food resource to higher trophic levels (*e.g.* cod, saithe, seabirds, and marine mammals). The predation intensity of and on herring have seasonal, spatial and temporal variation as a consequence of variation in migration pattern, prey density, stock size, size of year classes and stock sizes of competing stocks for resources and predators. Recent features of some of these ecosystem factors of relevance for the stock are summarized below.

- Following a maximum in zooplankton biomass in May during the early 2000s the biomass declined with a minimum in 2006. From 2010, the trend turned to an increase and the last five years the zooplankton biomass has fluctuated around the long-term mean in the Lofoten and Norwegian Basins (IESNS survey report - ICES, 2022a), but is still low compared to the early years in East Iceland waters and the Jan Mayen front. Interestingly, all the areas, excluding east of Iceland and on few occasions Jan Mayen, show co-varying changes in zooplankton biomass.
- The Atlantic water mass in the Norwegian Sea was warmer and saltier over the period 2000–2016 than the long-term mean (WGINOR - ICES, 2022b). However, during the period, 2017-2020 the temperature remained relatively warm while the salinity had a marked decrease. Two different mechanisms can explain this, increased fraction of subpolar water (fresh and cold) and low heat loss to the atmosphere in the Norwegian Atlantic flow. The recent trend of colder and fresher Atlantic Inflow into the Norwegian Sea has ceased. The extent of Arctic water continues to increase (ICES, 2022b).
- The sea temperature in 2022 was generally below the long-term mean (1995-2021) in the Norwegian Sea, but the pattern was more fragmented below 50 m depth. The Arctic front in the southern Norwegian Sea was more southerly and easterly located in 2022 compared to the long-term mean.
- In general, the herring stock has had a more westerly feeding distribution (ICES, 2022a; IESSNS survey report - 2022c) in the recent years than what was previously observed. In May 2022, the herring in west was more northerly distributed than in recent years. The large 2016 year -lass was now widely distributed into the south-western feeding area. The westerly distribution might be due to either better feeding opportunities there or a response to feeding competition with mackerel but the consequence is a less spatial overlap of herring and mackerel in Norwegian Sea and adjoining waters since around 2014 (ICES, 2022c).
- Where herring and mackerel overlap spatially they compete for food to some extent (Bachiller *et al*., 2016, 2018; Debes *et al*., 2012; Langøy *et al*., 2012; Óskarsson *et al*., 2016). There are studies showing mackerel being more effective feeder, which might indicate that the herring is forced to the south western and north eastern fringe of Norwegian Sea (ICES, 2021b). Alternatively, the higher zooplankton biomass in the southwest could also attract the herring into this location, since zooplankton biomass is much lower in the north east (ICES, 2022b).
- Results of stomach analyses of mackerel on the Norwegian coastal shelf (between about 66°N and 69°N) suggest that mackerel fed opportunistically on herring larvae, and that predation pressure therefore largely depends on the degree of overlap in time and space (Skaret *et al*., 2015). Sampling in June 2017 and 2018, specifically studying mackerel predation on herring larvae, found significant numbers of herring larvae in mackerel stomachs in the area just south of Lofoten (Allan *et al*., 2021).
- The 2016 year-class of herring was the strongest since the 2004 year class in the Norwegian Sea as 4 year olds but as expected abundance is now beginning to visibly decrease (see the IESNS survey 2022 (Table 4.4.7.3).
- In the winter 2017/2018, the overwintering grounds shifted northward along the coast of Norway with older individuals occurring in oceanic areas. Such changes previously coincided with large year classes entering the spawning stock, however this recent change did not. Also, the onset of the overwintering period has been later in the year since the end of the 2000s.

  Around spawning time of 2022 most of the spawning stock was found outside Lofoten and Vesterålen, further north and more concentrated than usual. The observed maturity indicated a later spawning compared to the previous year (WGWIDE WD04).

4.13 Changes in fishing patterns

The fishery for Norwegian spring spawning herring has previously (before 2013) been described as progressing clockwise in the Nordic Seas during the year. However, the last 5-8 years the annual progression of the fishery has changed into a pendular behaviour, starting in the winter along the Norwegian coast, moving gradually to the west towards Iceland in the summer, and then east again into the central Norwegian Sea in the last quarter of the year.

The fishery reached its lowest catches since the mid-nineties in 2015, after which the catches increased again, reaching a maximum in 2021 of 850 000 tonnes (Table 4.4.1.1). It is mainly the fishery in the fourth quarter that has increased since 2015, with up to 2/3 of the catches taken in this quarter. The fishery in quarter four in the last few years has partly been north of Lofoten and partly in the central Norwegian Sea, whereas before 2015 it used to be stretched out towards the coast of Norway and north towards the Bear Island.

The change in migration pattern since 2017/18, where the part of the stock (old fish) overwinters in the central Norwegian Sea, has caused the fishery in this area to be extended to later in the winter, and in 2021 there was fishery in the central Norwegian Sea in the first quarter as well as the fourth.

Annual fishing pattern 2011-2020 is shown in Section 1.8.

4.14 Recommendations

For some years there have been issues with age reading of herring. WGWIDE has recommended organising a scale/otolith exchange and workshop. This workshop is now scheduled for April 2023 with a preceding exchange in winter 2022/2023.

4.15 References

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4.16 Tables

Table 4.4.1.1 Total landings (ICES estimate) of Norwegian spring-spawning herring (tons) since 1972. Data provided by Working Group members.

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
1972	13161	-	-	-	-	-	-	-	-	-	-	-	-	13161
1973	7017	-	-	-	-	-	-	-	-	-	-	-	-	7017
1974	7619	-	-	-	-	-	-	-	-	-	-	-	-	7619
1975	13713	-	-	-	-	-	-	-	-	-	-	-	-	13713
1976	10436	-	-	-	-	-	-	-	-	-	-	-	-	10436
1977	22706	-	-	-	-	-	-	-	-	-	-	-	-	22706
1978	19824	-	-	-	-	-	-	-	-	-	-	-	-	19824
1979	12864	-	-	-	-	-	-	-	-	-	-	-	-	12864
1980	18577	-	-	-	-	-	-	-	-	-	-	-	-	18577
1981	13736	-	-	-	-	-	-	-	-	-	-	-	-	13736
1982	16655	-	-	-	-	-	-	-	-	-	-	-	-	16655
1983	23054	-	-	-	-	-	-	-	-	-	-	-	-	23054
1984	53532	-	-	-	-	-	-	-	-	-	-	-	-	53532
1985	167272	2600	-	-	-	-	-	-	-	-	-	-	-	169872
1986	199256	26000	-	-	-	-	-	-	-	-	-	-	-	225256

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
1987	108417	18889	-	-	-	-	-	-	-	-	-	-	-	127306
1988	115076	20225	-	-	-	-	-	-	-	-	-	-	-	135301
1989	88707	15123	-	-	-	-	-	-	-	-	-	-	-	103830
1990	74604	11807	-	-	-	-	-	-	-	-	-	-	-	86411
1991	73683	11000	-	-	-	-	-	-	-	-	-	-	-	84683
1992	91111	13337	-	-	-	-	-	-	-	-	-	-	-	104448
1993	199771	32645	-	-	-	-	-	-	-	-	-	-	-	232457
1994	380771	74400	-	2911	21146	-	-	-	-	-	-	-	-	479228
1995	529838	101987	30577	57084	174109	-	7969	2500	881	556	-	-	-	905501
1996	699161	119290	60681	52788	164957	19541	19664	-	46131	11978	-	-	22424	1220283
1997	860963	168900	44292	59987	220154	11179	8694	-	25149	6190	1500	-	19499	1426507
1998	743925	124049	35519	68136	197789	2437	12827	-	15971	7003	605	-	14863	1223131
1999	740640	157328	37010	55527	203381	2412	5871	-	19207	-	-	-	14057	1235433
2000	713500	163261	34968	68625	186035	8939	-	-	14096	3298	-	-	14749	1207201
2001	495036	109054	24038	34170	77693	6070	6439	-	12230	1588	-	-	9818	766136
2002	487233	113763	18998	32302	127197	1699	9392	-	3482	3017	-	1226	9486	807795
2003*	477573	122846	14144	27943	117910	1400	8678	-	9214	3371	-	-	6431	789510
2004	477076	115876	23111	42771	102787	11	17369	-	1869	4810	400	-	7986	794066

Year	Norway	USSR/ Russia	Denmark	Faroes	Iceland	Ireland	Netherlands	Greenland	UK	Germany	France	Poland	Sweden	Total
2005	580804	132099	28368	65071	156467	-	21517	-	-	17676	0	561	680	1003243
2006	567237	120836	18449	63137	157474	4693	11625	-	12523	9958	80	-	2946	968958
2007	779089	162434	22911	64251	173621	6411	29764	4897	13244	6038	0	4333	0	1266993
2008	961603	193119	31128	74261	217602	7903	28155	3810	19737	8338	0	0	0	1545656
2009	1016675	210105	32320	85098	265479	10014	24021	3730	25477	14452	0	0	0	1687371
2010	871113	199472	26792	80281	205864	8061	26695	3453	24151	11133	0	0	0	1457015
2011	572641	144428	26740	53271	151074	5727	8348	3426	14045	13296	0	0	0	992997
2012	491005	118595	21754	36190	120956	4813	6237	1490	12310	11945	0	0	705	826000
2013	359458	78521	17160	105038	90729	3815	5626	11788	8342	4244	0	0	23	684743
2014	263253	60292	12513	38529	58828	706	9175	13108	4233	669	0	0	0	461306
2015	176321	45853	9105	33031	42625	1400	5255	12434	55	2660	0	0	0	328740
2016	197501	50455	10384	44727	50418	2048	3519	17508	4031	2582	0	0	0	383174
2017	389383	91118	19037	98170	90400	3495	6679	12569	4358	5201	0	1	1155	721566
2018	332028	64185	17052	82062	83393	2428	4290	2465	2582	1989	0	0	425	592899
2019	430507	84364	21207	113945	108045	2775	5111	3190	1801	4188	0	1327	705	777165
2020	409436	74936	16523	103029	98173	2704	5060	3546	143	2969	0	1352	3065	720937
2021**	489632	92841	15854	114291	114299	1793	10939	6456	0	3365	0	1242	1101	851813

***In 2003 the Norwegian catches were raised of 39433 to account for changes in percentages of water content.**

****The Russian catch for 2021 was taken from the ICES preliminary catches database**

Table 4.4.1.1.1 Proportion (%) of Russian catches by ICES sub-division for the years 2018-2020.

	1	2.a	5.b
2018	0	100	0
2019	0.04	98.33	1.64
2020	0	99.93	0.07

Table 4.4.1.2 Norwegian spring-spawning herring. Sampling coverage by year.

Year	TOTAL CATCH	% catch covered by sampling programme	No. samples	No. Measured	No. Aged
2000	1207201	86	389	55956	10901
2001	766136	86	442	70005	11234
2002	807795	88	184	39332	5405
2003	789510	71	380	34711	11352
2004	794066	79	503	48784	13169
2005	1003243	86	459	49273	14112
2006	968958	93	631	94574	9862
2007	1266993	94	476	56383	14661
2008	1545656	94	722	81609	31438
2009	1686928	94	663	65536	12265
2010	1457015	91	1258	124071	12377
2011	992.997	95	766	79360	10744
2012	825.999	93	649	59327	14768
2013	684.743	91	402	33169	11431
2014	461.306	89	229	18370	5813
2015	328.739	92	177	25156	5039
2016	383.174	91	203	39120	5892
2017	721566	95	335	31755	7241
2018	592899	97	253	22106	6047
2019	777165	97	361	29856	7421
2020	720937	98	232	34232	6742
2021	851813	88	207	18830	5975

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2021.

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	15854	100	11	1129	292
Faroe Islands	114291	98	17	958	861
Germany	3365	100	32	10555	337
Greenland	6456	0	0	0	0
Iceland	114299	100	55	2446	1958
Ireland	1793	0	0	0	0
The Netherlands	10939	100	12	1514	299
Norway	489632	100	80	2228	2228
Poland	1242	0	0	0	0
UK	0	0	0	0	0
Sweden	1101	0	0	0	0
Russia	92841	0	0	0	0
Total for Stock	851814	88	207	18830	5975

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2021.

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
2.1	725400	161	4038	16763	6	23
4.a	113	0	0	0	0	0
5.a	126279	46	1937	2067	15	16
5.b	21	0	0	0	0	0
Total	851813	207	5975	18830	7	22

Table 4.4.1.5 Norwegian spring-spawning herring. Catch data provided by working group members and samples allocated to unsampled catches in SALLOC.

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
1	Norway	1	2a	203631.8	
2	Norway	2	2a	168.2	1
3	Norway	3	2a	22706.5	
4	Norway	4	2a	263110	

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
5	Norway	3	4a	15.9	3
6	Iceland	2	2a	516	
7	Iceland	3	2a	6302	
8	Iceland	3	5a	57001	
9	Iceland	4	5a	50480	
10	Faroe Islands	1	2a	10574	
11	Faroe Islands	2	2a	163	6
12	Faroe Islands	3	2a	1800	3,7
13	Faroe Islands	4	2a	82935	
14	Faroe Islands	3	5a	49	8
15	Faroe Islands	4	5a	18749	
16	Faroe Islands	3	5b	21	3,7,8
17	Russia	1	2a	236.3	1,10
18	Russia	2	2a	58.4	6
19	Russia	3	2a	13868.4	3,7
20	Russia	4	2a	78677.9	4,13,21,23,24
21	Denmark	4	2a	15854.5	
22	Germany	3	2a	0.5	3,7
23	Germany	4	2a	3364.9	
24	Netherlands	4	2a	10939.1	
25	Greenland	3	2a	71.9	3,7
26	Greenland	4	2a	6384	4,13,21,23,24
27	Ireland	4	2a	1792.6	4,13,21,23,24
28	Poland	4	2a	1144.3	4,13,21,23,24
29	Poland	4	4a	97.4	4,13,21,23,24
30	Sweden	4	2a	1101	4,13,21,23,24

Table 4.4.3.1. Norwegian spring spawning herring. Catch in numbers (thousands).

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	5112600	2000000	600000	276200	184800	185500	547000	628600	79500	88600	109500	86900	194500	368300	66400	344300
1951	1635500	7607700	400000	6600	383800	172400	164400	515600	602000	77100	82700	103100	107600	253500	348000	352500
1952	13721600	9149700	1232900	39300	60500	602300	136300	204500	380200	377900	79200	85700	107700	106800	186500	564400
1953	5697200	5055000	581300	740100	46600	100900	355600	81900	110900	314100	394900	61700	91200	94100	98800	730400
1954	10675990	7071090	855400	266300	1435500	142900	236000	490300	128100	199800	440400	460700	88400	100600	133000	803200
1955	5175600	2871100	510100	93000	276400	2045100	114300	189600	274700	85300	193400	295600	203200	58700	84600	580600
1956	5363900	2023700	627100	116500	251600	314200	2555100	110000	203900	264200	130700	198300	272800	163300	63000	565100
1957	5001900	3290800	219500	23300	373300	153800	228500	1985300	72000	127300	182500	88400	121200	149300	131600	281400
1958	9666990	2798100	666400	17500	17900	110900	89300	194400	973500	70700	123000	200900	98700	77400	70900	255600
1959	17896280	198530	325500	15100	26800	25900	146600	114800	240700	1103800	88600	124300	198000	88500	77400	235900
1960	12884310	13580790	392500	121700	18200	28100	24400	96200	73300	203900	1163000	85200	129700	153500	56700	168900
1961	6207500	16075600	2884800	31200	8100	4100	15000	19400	61600	49200	136100	728100	49700	45000	63000	60100
1962	3693200	4081100	1041300	1843800	8000	3100	7200	20200	11900	59100	52600	117000	813500	44200	54700	152300
1963	4807000	2119200	2045300	760400	835800	5300	1800	3600	18300	9300	107700	92500	174100	923700	79600	185300
1964	3613000	2728300	220300	114600	399000	2045800	13700	1500	3000	24900	29300	95600	82400	153000	772800	336800
1965	2303000	3780900	2853600	89900	256200	571100	2199700	19500	14900	7400	19100	40000	100500	107800	138700	883100

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700
1967	426800	9877100	70400	1392300	3254000	26600	421300	1132000	1720800	8900	5700	3500	8500	8900	17500	104400
1968	1783600	437000	388300	99100	1880500	1387400	14220	94000	134100	345100	2000	1100	830	2500	2600	17000
1969	561200	507100	141900	188200	800	8800	4700	700	11700	33600	36000	300	200	200	200	2400
1970	119300	529400	33200	6300	18600	600	3300	3300	1000	13400	26200	28100	300	100	200	2000
1971	30500	42900	85100	1820	1020	1240	360	1110	1130	360	4410	6910	5450	0	20	120
1972	347100	41000	20400	35376	3476	3583	2481	694	1486	198	0	494	593	593	0	0
1973	29300	3500	1700	2389	25200	651	1506	278	178	0	0	0	0	0	180	0
1974	65900	7800	3900	100	241	24505	257	196	0	0	0	0	0	0	0	0
1975	30600	3600	1800	3268	132	910	30667	5	2	0	0	0	0	0	0	0
1976	.20100	2400	1200	23248	5436	0	0	13086	0	0	0	0	0	0	0	0
1977	43000	6200	3100	22103	23595	336	0	419	10766	0	0	0	0	0	0	0
1978	20100	2400	1200	3019	12164	20315	870	0	620	5027	0	0	0	0	0	0
1979	32600	3800	1900	6352	1866	6865	11216	326	0	0	2534	0	0	0	0	0
1980	6900	800	400	6407	5814	2278	8165	15838	441	8	0	2688	0	0	0	0
1981	8300	1100	11900	4166	4591	8596	2200	4512	8280	345	103	114	964	0	0	0
1982	22600	1100	200	13817	7892	4507	6258	1960	5075	6047	121	37	37	121	0	0

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0
1984	33860	1700	2490	4483	5388	61543	18202	12638	15608	7215	16338	6478	0	0	0	1650
1985	28570	13150	207220	21500	15500	16500	130000	59000	55000	63000	10000	31000	50000	0	0	2640
1986	13810	1380	3090	539785	17594	14500	15500	105000	75000	42000	77000	19469	66000	80000	0	2470
1987	13850	6330	35770	19776	501393	18672	3502	7058	28000	12000	9500	4500	7834	6500	7000	450
1988	15490	2790	9110	62923	25059	550367	9452	3679	5964	14583	8872	2818	3356	2682	1560	540
1989	7120	1930	25200	2890	3623	5650	324290	3469	800	679	3297	1375	679	321	260	0
1990	1020	400	15540	18633	2658	11875	10854	226280	1289	1519	2036	2415	646	179	590	480
1991	100	3370	3330	8438	2780	1410	14698	8867	218851	2499	461	87	690	103	260	540
1992	1630	150	1340	12586	33100	4980	1193	11981	5748	225677	2483	639	247	1236	0	0
1993	6570	130	7240	28408	106866	87269	8625	3648	29603	18631	410110	0	0	0	0	0
1994	430	20	8100	32500	110090	363920	164800	15580	8140	37330	35660	645410	2830	460	100	2070
1995	0	0	1130	57590	346460	622810	637840	231090	15510	15850	69750	83740	911880	4070	250	450
1996	0	0	30140	34360	713620	1571000	940580	406280	103410	5680	7370	66090	17570	836550	0	0
1997	0	0	21820	130450	270950	1795780	1993620	761210	326490	60870	20020	32400	90520	19120	370330	300
1998	0	0	82891	70323	242365	368310	1760319	1263750	381482	129971	42502	25343	3478	112604	5633	108514
1999	0	0	5029	137626	35820	134813	429433	1604959	1164263	291394	106005	14524	40040	7202	88598	63983

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811
2001	0	0	2076	102293	160678	426822	38749	95991	296460	839136	507106	73673	23722	3505	3356	22164
2002	0	0	62031	198360	643161	255516	326495	29843	93530	264675	663059	339326	52922	12437	7000	10087
2003	0	3461	4524	75243	323958	730468	175878	167776	22866	74494	217108	567253	219097	38555	8111	6192
2004	125	1846	43800	24299	92300	429510	714433	111022	137940	26656	52467	169196	401564	210547	28028	11883
2005	0	442	20411	447788	94206	170547	643600	930309	121856	123291	37967	65289	139331	344822	126879	15697
2006	0	1968	45438	75824	729898	82107	171370	726041	772217	88701	77115	30339	57882	133665	142240	49128
2007	0	4475	8450	224636	366983	1804495	152916	242923	728836	511664	47215	25384	15316	24488	64755	58465
2008	0	39898	123949	36630	550274	670681	2295912	199592	256132	586583	369620	29633	36025	23775	25195	63176
2009	0	3468	113424	192641	149075	1193781	914748	1929631	142931	262037	423972	238174	45519	9337	10153	70538
2010	0	75981	61673	101948	209295	189784	1064866	711951	1421939	175010	180164	340781	179039	12558	11602	49773
2011	0	126972	249809	61706	104634	234330	210165	755382	543212	642787	90515	117230	136509	45082	6628	11638
2012	0	2680	13083	211630	49999	119627	281908	263330	747839	314694	357902	53109	44982	64273	12420	3604
2013	0	1	20715	60364	276901	71287	112558	283658	242243	591912	169525	145318	24936	10614	9725	2299
2014	0	265	1441	28301	57838	257529	50424	71721	194814	147083	381317	83050	57315	12746	1809	7501
2015	0	647	3244	16139	55749	52369	152347	34046	65728	156075	103393	201141	24310	49373	3369	6397
2016	0	197	2351	45483	43416	112147	85937	164454	52267	73576	174655	96476	179051	38546	32880	8379

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2017	0	618	16390	64275	305483	114976	248192	162566	289931	98836	133145	276874	107473	220368	22357	49442
2018	0	1261	22414	25638	59802	264182	150759	179628	109121	180968	85954	99061	212052	113841	136096	39249
2019	0	769	2205	148669	64237	185336	557804	146597	217346	119855	167569	133910	104730	220400	91773	121229
2020	0	1299	8252	49455	544337	70633	150932	412498	118081	156696	94975	188852	100408	96557	132619	103350
2021	204	3644	2368	25015	110359	1432164	162903	203923	345729	117846	127846	73558	68834	60477	40165	113929

Table 4.4.4.1. Norwegian spring spawning herring. Weight at age in the catch (kg).

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.007	0.025	0.058	0.110	0.188	0.211	0.234	0.253	0.266	0.280	0.294	0.303	0.312	0.32	0.323	0.334
1951	0.009	0.029	0.068	0.130	0.222	0.249	0.276	0.298	0.314	0.330	0.346	0.357	0.368	0.377	0.381	0.394
1952	0.008	0.026	0.061	0.115	0.197	0.221	0.245	0.265	0.279	0.293	0.308	0.317	0.327	0.335	0.339	0.349
1953	0.008	0.027	0.063	0.120	0.205	0.230	0.255	0.275	0.290	0.305	0.320	0.330	0.34	0.347	0.351	0.363
1954	0.008	0.026	0.062	0.117	0.201	0.225	0.250	0.269	0.284	0.299	0.313	0.323	0.333	0.341	0.345	0.356
1955	0.008	0.027	0.063	0.119	0.204	0.229	0.254	0.274	0.289	0.304	0.318	0.328	0.338	0.346	0.350	0.362
1956	0.008	0.028	0.066	0.126	0.215	0.241	0.268	0.289	0.304	0.320	0.336	0.346	0.357	0.365	0.369	0.382
1957	0.008	0.028	0.066	0.127	0.216	0.243	0.269	0.290	0.306	0.322	0.338	0.348	0.359	0.367	0.371	0.384
1958	0.009	0.030	0.070	0.133	0.227	0.255	0.283	0.305	0.321	0.338	0.355	0.366	0.377	0.386	0.390	0.403

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1959	0.009	0.030	0.071	0.135	0.231	0.259	0.287	0.310	0.327	0.344	0.360	0.372	0.383	0.392	0.397	0.409
1960	0.006	0.011	0.074	0.119	0.188	0.277	0.337	0.318	0.363	0.379	0.360	0.420	0.411	0.439	0.450	0.447
1961	0.006	0.010	0.045	0.087	0.159	0.276	0.322	0.372	0.363	0.393	0.407	0.397	0.422	0.447	0.465	0.452
1962	0.009	0.023	0.055	0.085	0.148	0.288	0.333	0.360	0.352	0.350	0.374	0.384	0.374	0.394	0.399	0.414
1963	0.008	0.026	0.047	0.098	0.171	0.275	0.268	0.323	0.329	0.336	0.341	0.358	0.385	0.353	0.381	0.386
1964	0.009	0.024	0.059	0.139	0.219	0.239	0.298	0.295	0.339	0.350	0.358	0.351	0.367	0.375	0.372	0.433
1965	0.009	0.016	0.048	0.089	0.217	0.234	0.262	0.331	0.360	0.367	0.386	0.395	0.393	0.404	0.401	0.431
1966	0.008	0.017	0.040	0.063	0.246	0.260	0.265	0.301	0.410	0.425	0.456	0.460	0.467	0.446	0.459	0.472
1967	0.009	0.015	0.036	0.066	0.093	0.305	0.305	0.310	0.333	0.359	0.413	0.446	0.401	0.408	0.439	0.430
1968	0.010	0.027	0.049	0.075	0.108	0.158	0.375	0.383	0.364	0.382	0.441	0.410		0.517	0.491	0.485
1969	0.009	0.021	0.047	0.072		0.152	0.296		0.329	0.329	0.341					0.429
1970	0.008	0.058	0.085	0.105	0.171		0.216	0.277	0.298	0.304	0.305	0.309				0.376
1971	0.011	0.053	0.121	0.177	0.216	0.250		0.305	0.333		0.366	0.377	0.388			
1972	0.011	0.029	0.062	0.103	0.154	0.215	0.258		0.322							
1973	0.006	0.053	0.106	0.161	0.213		0.255									
1974	0.006	0.055	0.117			0.249										
1975	0.009	0.079	0.169	0.241			0.381									

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1976	0.007	0.062	0.132	0.189	0.250			0.323								
1977	0.011	0.091	0.193	0.316	0.350				0.511							
1978	0.012	0.100	0.210	0.274	0.424	0.454				0.613						
1979	0.010	0.088	0.181	0.293	0.359	0.416	0.436				0.553					
1980	0.012			0.266	0.399	0.449	0.460	0.485				0.608				
1981	0.010	0.082	0.163	0.196	0.291	0.341	0.368	0.380	0.397							
1982	0.010	0.087	0.159	0.256	0.312	0.378	0.415	0.435	0.449	0.448						
1983	0.011	0.090	0.165	0.217	0.265	0.337	0.378	0.410	0.426	0.435	0.444					
1984	0.009	0.047	0.145	0.218	0.262	0.325	0.346	0.381	0.400	0.413	0.405	0.426				0.415
1985	0.009	0.022	0.022	0.214	0.277	0.295	0.338	0.360	0.381	0.397	0.409	0.417	0.435			0.435
1986	0.007	0.077	0.097	0.055	0.249	0.294	0.312	0.352	0.374	0.398	0.402	0.401	0.410	0.410		0.410
1987	0.010	0.075	0.091	0.124	0.173	0.253	0.232	0.312	0.328	0.349	0.353	0.370	0.385	0.385	0.385	
1988	0.008	0.062	0.075	0.124	0.154	0.194	0.241	0.265	0.304	0.305	0.317	0.308	0.334	0.334	0.334	
1989	0.010	0.060	0.204	0.188	0.264	0.260	0.282	0.306			0.422	0.364				
1990	0.007		0.102	0.230	0.239	0.266	0.305	0.308	0.376	0.407	0.412	0.424				
1991		0.015	0.104	0.208	0.250	0.288	0.312	0.316	0.330	0.344						
1992	0.007		0.103	0.191	0.233	0.304	0.337	0.365	0.361	0.371	0.403			0.404		

	age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1993	0.007		0.106	0.153	0.243	0.282	0.320	0.330	0.365	0.373	0.379					
1994			0.102	0.194	0.239	0.280	0.317	0.328	0.356	0.372	0.390	0.379	0.399	0.403		
1995			0.102	0.153	0.192	0.234	0.283	0.328	0.349	0.356	0.374	0.366	0.393	0.387		
1996			0.136	0.136	0.168	0.206	0.262	0.309	0.337	0.366	0.360	0.361	0.367	0.379		
1997			0.089	0.167	0.184	0.207	0.232	0.277	0.305	0.331	0.328	0.344	0.343	0.397	0.357	
1998			0.111	0.150	0.216	0.221	0.249	0.277	0.316	0.338	0.374	0.372	0.366	0.396	0.377	0.406
1999			0.096	0.173	0.228	0.262	0.274	0.292	0.307	0.335	0.362	0.371	0.399	0.396	0.400	0.404
2000			0.124	0.175	0.222	0.242	0.289	0.303	0.310	0.328	0.349	0.383	0.411	0.410	0.419	0.409
2001			0.105	0.166	0.214	0.252	0.268	0.305	0.308	0.322	0.337	0.363	0.353	0.378	0.400	0.427
2002			0.056	0.128	0.198	0.255	0.281	0.303	0.322	0.323	0.334	0.345	0.369	0.407	0.410	0.435
2003		0.062	0.068	0.169	0.218	0.257	0.288	0.316	0.323	0.348	0.354	0.351	0.363	0.372	0.376	0.429
2004	0.022	0.066	0.143	0.18	0.227	0.26	0.29	0.323	0.355	0.375	0.383	0.399	0.395	0.405	0.429	0.439
2005		0.092	0.106	0.181	0.235	0.266	0.290	0.315	0.344	0.367	0.384	0.372	0.384	0.398	0.402	0.413
2006		0.055	0.102	0.171	0.238	0.268	0.292	0.311	0.330	0.365	0.374	0.376	0.388	0.396	0.398	0.407
2007	0.000	0.074	0.137	0.162	0.228	0.271	0.316	0.332	0.342	0.358	0.361	0.381	0.390	0.400	0.405	0.399
2008	0.000	0.026	0.106	0.145	0.209	0.254	0.296	0.318	0.341	0.353	0.363	0.367	0.395	0.396	0.386	0.413
2009		0.040	0.156	0.184	0.220	0.251	0.291	0.311	0.338	0.347	0.363	0.375	0.382	0.375	0.375	0.387

	age														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2010		0.059	0.107	0.177	0.218	0.261	0.279	0.311	0.325	0.343	0.362	0.370	0.388	0.391	0.376	0.441
2011		0.011	0.098	0.200	0.257	0.273	0.300	0.316	0.340	0.348	0.365	0.371	0.387	0.374	0.403	0.401
2012		0.034	0.126	0.211	0.272	0.301	0.308	0.331	0.335	0.351	0.354	0.370	0.389	0.389	0.382	0.388
2013		0.048	0.163	0.237	0.276	0.300	0.331	0.339	0.351	0.357	0.370	0.373	0.394	0.391	0.389	0.367
2014		0.057	0.179	0.233	0.271	0.293	0.322	0.342	0.353	0.367	0.365	0.374	0.375	0.378	0.418	0.371
2015		0.059	0.146	0.203	0.272	0.323	0.331	0.358	0.370	0.372	0.383	0.382	0.392	0.386	0.383	0.391
2016		0.048	0.111	0.212	0.255	0.290	0.333	0.339	0.361	0.367	0.370	0.381	0.378	0.388	0.383	0.395
2017		0.092	0.143	0.205	0.241	0.292	0.322	0.350	0.360	0.382	0.392	0.391	0.396	0.399	0.407	0.394
2018		0.068	0.127	0.207	0.240	0.276	0.321	0.348	0.371	0.380	0.399	0.404	0.400	0.407	0.408	0.418
2019		0.135	0.186	0.209	0.235	0.269	0.298	0.327	0.345	0.376	0.387	0.403	0.409	0.423	0.417	0.449
2020		0.131	0.170	0.204	0.236	0.274	0.306	0.317	0.342	0.358	0.374	0.395	0.402	0.408	0.415	0.444
2021	0.050	0.122	0.130	0.195	0.229	0.256	0.278	0.319	0.325	0.363	0.364	0.384	0.386	0.397	0.412	0.431

Table 4.4.4.2. Norwegian spring spawning herring. Weight at age in the stock (kg).

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1951	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1952	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1953	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1954	0.001	0.008	0.047	0.100	0.204	0.230	0.255	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1955	0.001	0.008	0.047	0.100	0.195	0.213	0.260	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1956	0.001	0.008	0.047	0.100	0.205	0.230	0.249	0.275	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1957	0.001	0.008	0.047	0.100	0.136	0.228	0.255	0.262	0.290	0.305	0.315	0.325	0.330	0.340	0.345	0.364
1958	0.001	0.008	0.047	0.100	0.204	0.242	0.292	0.295	0.293	0.305	0.315	0.330	0.340	0.345	0.352	0.363
1959	0.001	0.008	0.047	0.100	0.204	0.252	0.260	0.290	0.300	0.305	0.315	0.325	0.330	0.340	0.345	0.358
1960	0.001	0.008	0.047	0.100	0.204	0.270	0.291	0.293	0.321	0.318	0.320	0.344	0.349	0.370	0.379	0.378
1961	0.001	0.008	0.047	0.100	0.232	0.250	0.292	0.302	0.304	0.323	0.322	0.321	0.344	0.357	0.363	0.368
1962	0.001	0.008	0.047	0.100	0.219	0.291	0.300	0.316	0.324	0.326	0.335	0.338	0.334	0.347	0.354	0.358
1963	0.001	0.008	0.047	0.100	0.185	0.253	0.294	0.312	0.329	0.327	0.334	0.341	0.349	0.341	0.358	0.375
1964	0.001	0.008	0.047	0.100	0.194	0.213	0.264	0.317	0.363	0.353	0.349	0.354	0.357	0.359	0.365	0.402
1965	0.001	0.008	0.047	0.100	0.186	0.199	0.236	0.260	0.363	0.350	0.370	0.360	0.378	0.387	0.390	0.394
1966	0.001	0.008	0.047	0.100	0.185	0.219	0.222	0.249	0.306	0.354	0.377	0.391	0.379	0.378	0.361	0.383

	AGE														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1967	0.001	0.008	0.047	0.100	0.180	0.228	0.269	0.270	0.294	0.324	0.420	0.430	0.366	0.368	0.433	0.414
1968	0.001	0.008	0.047	0.100	0.115	0.206	0.266	0.275	0.274	0.285	0.350	0.325	0.363	0.408	0.388	0.378
1969	0.001	0.008	0.047	0.100	0.115	0.145	0.270	0.300	0.306	0.308	0.318	0.340	0.368	0.360	0.393	0.397
1970	0.001	0.008	0.047	0.100	0.209	0.272	0.230	0.295	0.317	0.323	0.325	0.329	0.380	0.370	0.380	0.391
1971	0.001	0.015	0.080	0.100	0.190	0.225	0.250	0.275	0.290	0.310	0.325	0.335	0.345	0.355	0.365	0.390
1972	0.001	0.010	0.070	0.150	0.150	0.140	0.210	0.240	0.270	0.300	0.325	0.335	0.345	0.355	0.365	0.390
1973	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.404	0.461	0.520	0.534	0.500	0.500	0.500	0.500
1974	0.001	0.010	0.085	0.170	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1975	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1976	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1977	0.001	0.010	0.085	0.181	0.259	0.343	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1978	0.001	0.010	0.085	0.180	0.294	0.326	0.371	0.409	0.461	0.476	0.520	0.543	0.500	0.500	0.500	0.500
1979	0.001	0.010	0.085	0.178	0.232	0.359	0.385	0.420	0.444	0.505	0.520	0.551	0.500	0.500	0.500	0.500
1980	0.001	0.010	0.085	0.175	0.283	0.347	0.402	0.421	0.465	0.465	0.520	0.534	0.500	0.500	0.500	0.500
1981	0.001	0.010	0.085	0.170	0.224	0.336	0.378	0.387	0.408	0.397	0.520	0.543	0.512	0.512	0.512	0.512
1982	0.001	0.010	0.085	0.170	0.204	0.303	0.355	0.383	0.395	0.413	0.453	0.468	0.506	0.506	0.506	0.506
1983	0.001	0.010	0.085	0.155	0.249	0.304	0.368	0.404	0.424	0.437	0.436	0.493	0.495	0.495	0.495	0.495

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1984	0.001	0.010	0.085	0.140	0.204	0.295	0.338	0.376	0.395	0.407	0.413	0.422	0.437	0.437	0.437	0.437
1985	0.001	0.010	0.085	0.148	0.234	0.265	0.312	0.346	0.370	0.395	0.397	0.428	0.428	0.428	0.428	0.428
1986	0.001	0.010	0.085	0.054	0.206	0.265	0.289	0.339	0.368	0.391	0.382	0.388	0.395	0.395	0.395	0.395
1987	0.001	0.010	0.055	0.090	0.143	0.241	0.279	0.299	0.316	0.342	0.343	0.362	0.376	0.376	0.376	0.376
1988	0.001	0.015	0.050	0.098	0.135	0.197	0.277	0.315	0.339	0.343	0.359	0.365	0.376	0.376	0.376	0.376
1989	0.001	0.015	0.100	0.154	0.175	0.209	0.252	0.305	0.367	0.377	0.359	0.395	0.396	0.396	0.396	0.396
1990	0.001	0.008	0.048	0.219	0.198	0.258	0.288	0.309	0.428	0.370	0.403	0.387	0.440	0.440	0.440	0.44
1991	0.001	0.011	0.037	0.147	0.210	0.244	0.300	0.324	0.336	0.343	0.382	0.366	0.425	0.425	0.425	0.425
1992	0.001	0.007	0.030	0.128	0.224	0.296	0.327	0.355	0.345	0.367	0.341	0.361	0.430	0.470	0.470	0.46
1993	0.001	0.008	0.025	0.081	0.201	0.265	0.323	0.354	0.358	0.381	0.369	0.396	0.393	0.374	0.403	0.4
1994	0.001	0.010	0.025	0.075	0.151	0.254	0.318	0.371	0.347	0.412	0.382	0.407	0.410	0.410	0.410	0.41
1995	0.001	0.018	0.025	0.066	0.138	0.230	0.296	0.346	0.388	0.363	0.409	0.414	0.422	0.410	0.410	0.426
1996	0.001	0.018	0.025	0.076	0.118	0.188	0.261	0.316	0.346	0.374	0.390	0.390	0.384	0.398	0.398	0.398
1997	0.001	0.018	0.025	0.096	0.118	0.174	0.229	0.286	0.323	0.370	0.378	0.386	0.360	0.393	0.391	0.391
1998	0.001	0.018	0.025	0.074	0.147	0.174	0.217	0.242	0.278	0.304	0.310	0.359	0.340	0.344	0.385	0.369
1999	0.001	0.018	0.025	0.102	0.150	0.223	0.240	0.264	0.283	0.315	0.345	0.386	0.386	0.386	0.382	0.395
2000	0.001	0.018	0.025	0.119	0.178	0.225	0.271	0.285	0.298	0.311	0.339	0.390	0.398	0.406	0.414	0.427

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2001	0.001	0.018	0.025	0.075	0.178	0.238	0.247	0.296	0.307	0.314	0.328	0.351	0.376	0.406	0.414	0.425
2002	0.001	0.010	0.023	0.057	0.177	0.241	0.275	0.302	0.311	0.314	0.328	0.341	0.372	0.405	0.415	0.438
2003	0.001	0.010	0.055	0.098	0.159	0.211	0.272	0.305	0.292	0.331	0.337	0.347	0.356	0.381	0.414	0.433
2004	0.001	0.010	0.055	0.106	0.149	0.212	0.241	0.279	0.302	0.337	0.354	0.355	0.360	0.371	0.400	0.429
2005	0.001	0.010	0.046	0.112	0.156	0.234	0.267	0.295	0.330	0.363	0.377	0.414	0.406	0.308	0.420	0.452
2006	0.001	0.010	0.042	0.107	0.179	0.232	0.272	0.297	0.318	0.371	0.365	0.393	0.395	0.399	0.415	0.428
2007	0.001	0.010	0.036	0.086	0.155	0.226	0.265	0.312	0.310	0.364	0.384	0.352	0.386	0.304	0.420	0.412
2008**	0.001	0.010	0.044	0.077	0.146	0.212	0.269	0.289	0.327	0.351	0.358	0.372	0.411	0.353	0.389	0.393
2009***	0.001	0.010	0.044	0.077	0.141	0.215	0.270	0.306	0.336	0.346	0.364	0.369	0.411	0.353	0.389	0.393
2010****	0.001	0.01	0.044	0.077	0.188	0.22	0.251	0.286	0.308	0.333	0.344	0.354	0.373	0.353	0.389	0.393
2011	0.001	0.01	0.044	0.118	0.185	0.209	0.246	0.277	0.310	0.322	0.339	0.349	0.364	0.363	0.389	0.393
2012	0.001	0.01	0.044	0.138	0.185	0.256	0.273	0.290	0.305	0.330	0.342	0.361	0.390	0.377	0.389	0.393
2013	0.001	0.01	0.044	0.138	0.204	0.267	0.305	0.309	0.320	0.328	0.346	0.350	0.390	0.377	0.389	0.393
2014	0.001	0.01	0.044	0.138	0.198	0.274	0.301	0.326	0.333	0.339	0.347	0.344	0.362	0.362	0.389	0.393
2015	0.001	0.01	0.044	0.138	0.187	0.243	0.299	0.326	0.319	0.345	0.346	0.354	0.382	0.376	0.389	0.393
2016	0.001	0.01	0.054	0.115	0.186	0.247	0.293	0.320	0.334	0.353	0.354	0.352	0.361	0.370	0.380	0.388
2017	0.001	0.01	0.054	0.115	0.190	0.247	0.282	0.322	0.338	0.351	0.359	0.361	0.361	0.368	0.380	0.386

	AGE															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2018	0.001	0.01	0.054	0.115	0.149	0.225	0.260	0.289	0.312	0.343	0.359	0.361	0.369	0.368	0.377	0.386
2019	0.001	0.01	0.054	0.104	0.151	0.203	0.277	0.311	0.331	0.355	0.353	0.363	0.381	0.376	0.385	0.382
2020	0.001	0.01	0.054	0.104	0.150	0.203	0.266	0.301	0.328	0.343	0.358	0.366	0.374	0.367	0.384	0.391
2021	0.001	0.01	0.054	0.104	0.160	0.209	0.266	0.284	0.302	0.325	0.352	0.366	0.384	0.376	0.404	0.391
2022	0.001	0.01	0.054	0.104	0.125	0.168	0.243	0.287	0.303	0.323	0.352	0.366	0.384	0.376	0.404	0.391

**** mean weight at ages 11 and 13 are mean of 5 previous years at the same age. These age groups were not present in the catches of the wintering survey from which the stock weight are derived.**

***** derived from catch data from the wintering area north of 69°N during December 2008 – January 2009 for age groups 4—11.**

******derived from catch data from the wintering area north of 69°N during January 2010 for age groups 4—12.**

Table 4.4.5.1. Norwegian Spring-spawning herring. Maturity at age.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
1951	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
1952	0	0	0	0	0.1	0.6	1	1	1	1	1	1	1	1	1	1
1953	0	0	0	0	0.3	0.4	0.9	1	1	1	1	1	1	1	1	1
1954	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
1955	0	0	0	0.1	0.4	0.4	1	1	1	1	1	1	1	1	1	1
1956	0	0	0	0	0.5	0.7	0.6	1	1	1	1	1	1	1	1	1
1957	0	0	0	0	0.3	0.8	0.8	0.7	1	1	1	1	1	1	1	1
1958	0	0	0	0	0.3	0.5	0.9	0.9	1	1	1	1	1	1	1	1
1959	0	0	0	0	0.7	0.8	1	0.9	1	1	1	1	1	1	1	1
1960	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
1961	0	0	0	0	0.1	0.8	1	0.9	1	1	1	1	1	1	1	1
1962	0	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1
1963	0	0	0	0	0.1	0.4	1	1	1	1	1	1	1	1	1	1
1964	0	0	0	0	0.1	0.4	0.8	1	1	1	1	1	1	1	1	1
1965	0	0	0	0	0.5	0.4	0.9	0.8	1	1	1	1	1	1	1	1
1966	0	0	0	0	0.5	0.7	0.9	1	1	1	1	1	1	1	1	1
1967	0	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1
1968	0	0	0	0	0	0.7	0.9	1	1	1	1	1	1	1	1	1
1969	0	0	0	0.1	0.2	0.3	1	1	1	1	1	1	1	1	1	1
1970	0	0	0	0	0.4	0.3	0.4	1	1	1	1	1	1	1	1	1
1971	0	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1
1972	0	0	0	0	0.4	0.3	1	1	1	1	1	1	1	1	1	1
1973	0	0	0	0.1	0.6	1	1	1	1	1	1	1	1	1	1	1
1974	0	0	0	0	0.6	0.9	1	1	1	1	1	1	1	1	1	1
1975	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1	1
1976	0	0	0	0.1	0.9	0.9	1	1	1	1	1	1	1	1	1	1
1977	0	0	0	0.3	0.8	1	1	1	1	1	1	1	1	1	1	1
1978	0	0	0	0.2	0.9	1	1	1	1	1	1	1	1	1	1	1

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1979	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1980	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1981	0	0	0	0.1	1	1	1	1	1	1	1	1	1	1	1	1
1982	0	0	0	0.1	0.8	1	1	1	1	1	1	1	1	1	1	1
1983	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1	1
1984	0	0	0	0.1	0.7	1	1	1	1	1	1	1	1	1	1	1
1985	0	0	0	0.1	0.8	0.9	1	1	1	1	1	1	1	1	1	1
1986	0	0	0	0	0.5	0.9	0.9	1	1	1	1	1	1	1	1	1
1987	0	0	0	0	0.1	0.8	0.9	0.9	1	1	1	1	1	1	1	1
1988	0	0	0	0	0.2	0.7	0.9	1	1	1	1	1	1	1	1	1
1989	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
1990	0	0	0	0.2	0.5	0.9	1	1	1	1	1	1	1	1	1	1
1991	0	0	0	0	0.9	0.9	1	1	1	1	1	1	1	1	1	1
1992	0	0	0	0	0.8	1	1	1	1	1	1	1	1	1	1	1
1993	0	0	0	0	0.5	1	1	1	1	1	1	1	1	1	1	1
1994	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
1995	0	0	0	0	0	0.6	1	1	1	1	1	1	1	1	1	1
1996	0	0	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1
1997	0	0	0	0.1	0	0.4	0.9	1	1	1	1	1	1	1	1	1
1998	0	0	0	0	0.6	0.4	0.9	1	1	1	1	1	1	1	1	1
1999	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2000	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2001	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2002	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
2003	0	0	0	0	0.2	0.7	1	1	1	1	1	1	1	1	1	1
2004	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2005	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2006	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2007	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2008	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2009	0	0	0	0	0.1	0.4	0.9	1	1	1	1	1	1	1	1	1
2010	0	0	0	0	0.2	0.4	0.7	1	1	1	1	1	1	1	1	1
2011	0	0	0	0	0.4	0.7	0.8	0.9	1	1	1	1	1	1	1	1
2012	0	0	0	0	0.5	0.9	0.9	1	1	1	1	1	1	1	1	1
2013	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2014	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2015	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2016	0	0	0	0	0.1	0.5	0.9	1	1	1	1	1	1	1	1	1
2017	0	0	0	0	0.2	0.6	0.8	1	1	1	1	1	1	1	1	1
2018	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2019	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2020	0	0	0	0	0.1	0.8	1	1	1	1	1	1	1	1	1	1
2021	0	0	0	0	0.4	0.6	1	1	1	1	1	1	1	1	1	1
2022	0	0	0	0	0.4	0.8	0.9	1	1	1	1	1	1	1	1	1

Table 4.4.7.1. Norwegian Spring-spawning herring. Estimated indices (mean of bootstrap with 1000 iterations in StoX) from the acoustic surveys on the spawning grounds in February-March. Numbers in millions. Biomass in thousand tonnes. "Fleet 1".

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1988	0	392	307	8015	81	33	12	36	22	45	0	0	0	0	8943	1621
1989	161	16	338	91	3973	101	12	4	55	0	4	42	0	9	4813	1169
1990																
1991																
1992																
1993																
1994	37	100	48	848	483	62	13	144	49	1836	4	4	0	0	3665	1207
1995	4	450	4679	3211	1957	299	20	0	106	55	2327	0	0	0	13745	2860
1996	119	186	1976	7960	2326	875	301	0	0	136	0	1760	0	0	15645	3366
1997																
1998	51	308	978	2982	12859	8133	1851	592	163	43	0	329	0	1400	29705	6886
1999	114	1530	369	1351	2669	9334	7004	1666	511	130	0	0	353	373	25438	6262
2000	1394	691	2600	109	477	1144	4282	2838	493	50	2	0	7	228	14315	3285
2001																
2002																
2003																
2004																

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2005	38	238	661	2128	5947	8328	613	503	156	92	576	1152	587	9	21026	5260
2006	26	90	6054	548	882	3362	3311	110	86	20	89	58	246	63	14951	3431
2007	33	367	1618	12397	815	655	2956	3205	141	228	40	204	284	470	23427	5350
2008	15	48	2564	2824	8882	522	471	1566	1567	161	102	46	128	136	19090	4553
2009																
2010																
2011																
2012																
2013																
2014																
2015	204	533	2754	744	3267	388	692	2715	784	7222	367	1658	51	237	21662	6365
2016	18	197	237	594	365	2119	240	514	2930	652	3995	199	824	97	12982	4182
2017	19	110	1076	641	880	428	1326	181	206	2026	303	2542	80	729	10550	3314
2018	104	146	1720	2771	459	845	639	1095	444	370	1159	368	1538	354	12013	3262
2019	2	372	310	940	3778	754	879	660	1054	736	412	1807	182	2161	14166	4250
2020	6	44	3502	571	1212	3337	530	609	364	650	131	279	677	825	12750	3274
2021	21	112	293	10210	733	738	1932	427	451	312	219	395	208	1153	17250	4021
2022	27	72	162	760	6393	317	563	1515	301	486	301	255	385	630	12183	3302

Table 4.4.7.2. Norwegian spring-spawning herring. Acoustic estimates (billion individuals) of immature herring in the Barents Sea in May/June from IESNS. Values in the years 2009–2022 are estimated with StoX (mean of bootstrap with 1000 iterations). "Fleet 4".

	age				
Year	1	2	3	4	5
1991	24.3	5.2			
1992	32.6	14	5.7		
1993	102.7	25.8	1.5		
1994	6.6	59.2	18	1.7	
1995	0.5	7.7	8	1.1	
1996*	0.1	0.25	1.8	0.6	0.03
1997**	2.6	0.04	0.4	0.35	0.05
1998	9.5	4.7	0.01	0.01	0
1999	49.5	4.9	0	0	0
2000	105.4	27.9	0	0	0
2001	0.3	7.6	8.8	0	0
2002	0.5	3.9	0	0	0
2003***					
2004***					
2005	23.3	4.5	2.5	0.4	0.3
2006	3.7	35.0	5.3	0.87	0
2007	2.1	3.7	12.5	1.9	0
2008^					
2009	0.289	0.300	0.233	0.060	
2010	5.196	1.380	0.000	0.000	
2011	1.166	3.920	0.041	0.000	
2012	0.787	0.030	0.000	0.000	
2013	0.107	2.190	0.211	0.070	
2014	4.239	3.110	1.728	0.127	0.043
2015	0.345	11.760	1.183	0.206	0.000
2016	1.826	5.620	1.568	0.101	0.038

	age				
Year	1	2	3	4	5
2017	14.522	3.080	0.000	0.000	
2018	7.329	17.420	0.827	0.009	
2019	0.113	2.370	17.481	0.044	
2020***					
2021	0.021	0.002	0.086	0.002	
2022***					

***Average of Norwegian and Russian estimates**

****Combination of Norwegian and Russian estimates as described in 1998 WG report, since then only Russian estimates**

*****No surveys**

^Not a full survey

Table 4.4.7.3. Norwegian spring-spawning herring. Estimates from the international acoustic survey on the feeding areas in the Norwegian Sea in May (IESNS). Numbers in millions. Biomass in thousands. Values in the years 2008-2022 are estimated indices by StoX (mean of bootstrap with 1000 iterations). “Fleet 5”.

	Age															**Total**
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
1996	0	0	4114	22461	13244	4916	2045	424	14	7	155	0	3134			50514	8532
1997	0	0	1169	3599	18867	13546	2473	1771	178	77	288	190	60	2697		44915	9435
1998	24	1404	367	1099	4410	16378	10160	2059	804	183	0	0	35	0	492	37415	8004
1999	0	215	2191	322	965	3067	11763	6077	853	258	5	14	0	158	128	26016	6299
2000	0	157	1353	2783	92	384	1302	7194	5344	1689	271	0	114	0	75	20758	6001
2001	0	1540	8312	1430	1463	179	204	3215	5433	1220	94	178	0	0	6	23274	3937
2002	0	677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	0	26089	4628
2003	32073	8115	6561	9985	9961	1499	732	146	228	1865	2359	1769		287	0	75580	6653
2004	0	13735	1543	5227	12571	10710	1075	580	76	313	362	1294	1120	10	88	48704	7687
2005	0	1293	19679	1353	1765	6205	5371	651	388	139	262	526	1003	364	115	39114	5109
2006	0	19	306	14560	1396	2011	6521	6978	679	713	173	407	921	618	243	35545	9100
2007	0	411	2889	5877	20292	1260	1992	6780	5582	647	488	372	403	1048	1010	49051	12161
2008	0	1213	655	10997	8406	14798	1543	2232	4890	2790	511	148	172	244	529	49187	10655
2009	0	137	1817	2280	12118	8599	9735	2054	1433	2608	1375	237	198	112	248	43057	9692
2010	231	119	572	2296	1828	8395	5918	5676	923	888	1002	550	89	42	62	28772	6649
2011	0	1110	921	1663	3592	2605	9303	4390	4257	771	956	732	269	29	33	30731	7336

	Age															Total
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2012	0	396	2942	410	668	1736	2633	4328	1884	2148	297	604	303	139	41	18540	4476
2013	0	201	718	3555	425	1161	1859	2905	4449	2772	1865	678	790	222	102	21722	5653
2014	13	515	1258	784	2788	715	1118	2634	2268	2806	1118	703	337	72	212	17350	4504
2015	0	391	432	1316	1132	3535	1309	1191	3156	2526	4457	687	816	290	211	21450	5851
2016	0	75	3550	1538	2229	1749	2631	938	1092	1806	1882	2853	934	436	130	21851	5408
2017	10	131	948	4295	1198	1543	826	1414	317	738	1008	1741	2230	507	237	17159	4152
2018	0	496	1004	1968	5664	970	1409	569	1279	354	675	1564	1464	1498	500	19412	4987
2019	4	157	2625	680	2187	4656	1158	1223	952	1232	823	655	1406	917	803	19487	4805
2020	0	43	472	13065	513	1009	2492	786	629	434	694	324	505	726	902	22616	4210
2021	15	34	1109	1290	11906	698	1051	2039	501	551	476	462	442	615	1515	22984	5096
2022	0	507	383	1207	1286	9633	1151	1640	2064	577	339	325	293	115	288	19817	4427

Table 4.4.8.1 Norwegian spring-spawning herring. Relative standard error of estimated catch-at-age used by XSAM.

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	0.366	0.190	0.260	0.092	0.361	0.497	0.422	0.312	0.369	0.544	0.380
1989	0.259	0.539	0.499	0.430	0.109	0.507	0.832	0.879	0.515	0.693	0.713
1990	0.305	0.287	0.554	0.334	0.345	0.124	0.708	0.670	0.607	0.573	0.622
1991	0.514	0.375	0.546	0.687	0.311	0.369	0.125	0.566	1.002	1.760	0.659
1992	0.699	0.328	0.237	0.448	0.727	0.333	0.427	0.124	0.567	0.897	0.675
1993	0.395	0.249	0.159	0.170	0.373	0.498	0.246	0.287	0.101	NA	NA
1994	0.381	0.238	0.158	0.105	0.138	0.305	0.380	0.227	0.231	0.087	0.435
1995	0.740	0.196	0.107	0.088	0.087	0.123	0.306	0.303	0.184	0.173	0.077
1996	0.244	0.234	0.084	0.064	0.076	0.101	0.161	0.429	0.393	0.187	0.079
1997	0.272	0.149	0.116	0.061	0.059	0.082	0.109	0.193	0.280	0.238	0.096
1998	0.173	0.183	0.121	0.105	0.062	0.069	0.104	0.149	0.217	0.259	0.123
1999	0.447	0.146	0.230	0.147	0.100	0.064	0.071	0.113	0.160	0.312	0.129
2000	0.313	0.173	0.091	0.232	0.157	0.102	0.068	0.074	0.125	0.182	0.147
2001	0.603	0.162	0.139	0.100	0.224	0.165	0.113	0.079	0.094	0.181	0.202
2002	0.191	0.129	0.087	0.119	0.109	0.245	0.167	0.117	0.086	0.108	0.174
2003	0.463	0.179	0.109	0.083	0.135	0.137	0.268	0.180	0.125	0.091	0.116
2004	0.215	0.263	0.167	0.100	0.084	0.157	0.146	0.254	0.202	0.136	0.086
2005	0.278	0.098	0.166	0.136	0.087	0.077	0.152	0.152	0.226	0.188	0.088
2006	0.213	0.179	0.083	0.174	0.136	0.083	0.082	0.170	0.178	0.244	0.103
2007	0.375	0.124	0.105	0.061	0.141	0.121	0.083	0.094	0.210	0.259	0.138
2008	0.151	0.229	0.092	0.086	0.056	0.129	0.119	0.090	0.105	0.246	0.143
2009	0.156	0.130	0.142	0.070	0.077	0.060	0.144	0.118	0.100	0.121	0.147
2010	0.192	0.162	0.127	0.131	0.073	0.084	0.066	0.135	0.133	0.108	0.119
2011	0.120	0.192	0.160	0.122	0.127	0.082	0.092	0.087	0.168	0.154	0.129
2012	0.324	0.126	0.206	0.153	0.115	0.117	0.083	0.111	0.106	0.202	0.151
2013	0.277	0.193	0.115	0.183	0.156	0.114	0.121	0.089	0.136	0.144	0.209
2014	0.682	0.249	0.196	0.118	0.205	0.182	0.130	0.143	0.104	0.173	0.176
2015	0.518	0.301	0.198	0.203	0.141	0.234	0.188	0.140	0.161	0.129	0.173

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2016	0.578	0.212	0.216	0.157	0.171	0.138	0.203	0.181	0.135	0.165	0.118
2017	0.300	0.189	0.112	0.155	0.120	0.138	0.114	0.163	0.148	0.115	0.102
2018	0.270	0.258	0.194	0.117	0.142	0.134	0.158	0.133	0.171	0.163	0.094
2019	0.591	0.142	0.189	0.132	0.091	0.143	0.125	0.153	0.137	0.148	0.092
2020	0.378	0.207	0.092	0.183	0.142	0.101	0.154	0.140	0.166	0.131	0.099
2021	0.576	0.260	0.157	0.066	0.138	0.128	0.107	0.154	0.150	0.181	0.115

Table 4.4.8.2 Norwegian spring-spawning herring. Relative standard error of Fleet 1 used by XSAM.

Year/Age	3	4	5	6	7	8	9	10	11	12+
1988	0.316	0.334	0.161	0.449	0.549	0.687	0.538	0.600	0.512	NA
1989	0.645	0.327	0.438	0.189	0.427	0.687	0.878	0.489	NA	0.489
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	0.428	0.505	0.266	0.302	0.477	0.675	0.395	0.502	0.224	0.752
1995	0.306	0.182	0.198	0.221	0.336	0.613	NA	0.423	0.489	0.212
1996	0.373	0.220	0.161	0.212	0.264	0.335	NA	NA	0.400	0.226
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.333	0.258	0.201	0.145	0.161	0.224	0.288	0.384	0.517	0.227
1999	0.233	0.320	0.240	0.206	0.156	0.166	0.229	0.298	0.404	0.275
2000	0.278	0.207	0.420	0.302	0.249	0.185	0.203	0.300	0.500	0.353
2001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2004	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2005	0.353	0.281	0.217	0.172	0.160	0.286	0.299	0.388	0.436	0.212
2006	0.439	0.172	0.293	0.264	0.196	0.196	0.419	0.443	0.613	0.305
2007	0.321	0.230	0.146	0.268	0.282	0.201	0.198	0.397	0.357	0.257
2008	0.505	0.208	0.203	0.158	0.296	0.303	0.232	0.232	0.385	0.312

Year/Age	3	4	5	6	7	8	9	10	11	12+
2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	0.295	0.205	0.274	0.197	0.317	0.278	0.205	0.271	0.165	0.213
2016	0.368	0.353	0.288	0.321	0.217	0.352	0.297	0.202	0.282	0.178
2017	0.419	0.252	0.283	0.264	0.310	0.241	0.375	0.365	0.219	0.192
2018	0.394	0.227	0.204	0.305	0.266	0.283	0.251	0.307	0.320	0.195
2019	0.320	0.333	0.260	0.191	0.273	0.264	0.281	0.253	0.275	0.183
2020	0.514	0.194	0.291	0.246	0.196	0.295	0.286	0.321	0.282	0.222
2021	0.418	0.337	0.153	0.275	0.274	0.221	0.310	0.306	0.332	0.220
2022	0.461	0.385	0.273	0.170	0.331	0.291	0.234	0.335	0.301	0.232

Table 4.4.8.3 Norwegian spring-spawning herring. Relative standard error of Fleet 4 used by XSAM.

Year/Age	2
1991	0.462
1992	0.419
1993	0.395
1994	0.364
1995	0.444
1996	0.620
1997	0.741
1998	0.466
1999	0.464
2000	0.392
2001	0.445
2002	0.475
2003	NA

Year/Age	2
2004	NA
2005	0.468
2006	0.383
2007	0.477
2008	0.595
2009	0.609
2010	0.525
2011	0.474
2012	0.763
2013	0.502
2014	0.485
2015	0.426
2016	0.458
2017	0.486
2018	0.410
2019	0.498
2020	NA
2021	1.006
2022	NA

Table 4.4.8.4 Norwegian spring-spawning herring. Relative standard error of Fleet 5 used by XSAM.

Year/Age	3	4	5	6	7	8	9	10	11	12+
1996	0.203	0.136	0.154	0.195	0.239	0.347	0.774	0.912	0.44	0.216
1997	0.273	0.21	0.142	0.153	0.229	0.248	0.425	0.518	0.38	0.22
1998	0.359	0.277	0.2	0.147	0.164	0.239	0.298	0.423	NA	0.329
1999	0.236	0.37	0.286	0.218	0.159	0.185	0.294	0.39	0.987	0.376
2000	0.264	0.223	0.497	0.355	0.266	0.178	0.191	0.25	0.385	0.42
2001	0.172	0.26	0.259	0.425	0.412	0.215	0.19	0.27	0.495	0.422
2002	0.183	0.166	0.261	0.301	0.357	0.295	0.242	0.228	0.261	0.432
2003	0.182	0.165	0.165	0.258	0.305	0.446	0.401	0.245	0.231	0.239

Year/Age	3	4	5	6	7	8	9	10	11	12+
2004	0.256	0.192	0.156	0.162	0.279	0.322	0.52	0.373	0.36	0.228
2005	0.14	0.264	0.248	0.184	0.191	0.313	0.354	0.451	0.388	0.24
2006	0.375	0.151	0.262	0.24	0.182	0.179	0.31	0.307	0.428	0.236
2007	0.221	0.187	0.139	0.268	0.241	0.181	0.189	0.314	0.336	0.222
2008	0.313	0.161	0.172	0.15	0.256	0.235	0.195	0.223	0.332	0.277
2009	0.246	0.233	0.157	0.171	0.166	0.239	0.26	0.226	0.263	0.299
2010	0.323	0.233	0.246	0.172	0.186	0.188	0.289	0.291	0.283	0.304
2011	0.289	0.251	0.21	0.226	0.168	0.2	0.201	0.301	0.286	0.279
2012	0.22	0.35	0.312	0.249	0.226	0.201	0.244	0.237	0.377	0.278
2013	0.306	0.21	0.347	0.274	0.245	0.22	0.199	0.223	0.245	0.247
2014	0.268	0.3	0.223	0.307	0.276	0.226	0.234	0.222	0.276	0.265
2015	0.345	0.266	0.275	0.21	0.266	0.272	0.216	0.228	0.199	0.241
2016	0.21	0.256	0.235	0.248	0.226	0.288	0.278	0.247	0.244	0.2
2017	0.287	0.201	0.272	0.256	0.296	0.261	0.371	0.304	0.283	0.197
2018	0.283	0.242	0.188	0.285	0.261	0.324	0.267	0.362	0.311	0.194
2019	0.226	0.31	0.236	0.197	0.274	0.27	0.287	0.27	0.297	0.207
2020	0.338	0.155	0.332	0.283	0.229	0.3	0.316	0.345	0.309	0.229
2021	0.277	0.267	0.158	0.308	0.28	0.24	0.333	0.326	0.337	0.218
2022	0.355	0.271	0.267	0.166	0.274	0.252	0.239	0.323	0.366	0.282

Table 4.5.1.1. Norwegian spring-spawning herring. Parameter estimates of the final XSAM model fit. The estimates from the final 2021 assessment are also shown.

Parameter	Estimate	Std. Error	CV	Estimate 2021	Std. Error 2021
$\log(N_{3,1988})$	7.088	0.164	0.023	7.087	0.167
$\log(N_{4,1988})$	6.631	0.203	0.031	6.621	0.206
$\log(N_{5,1988})$	9.584	0.066	0.007	9.584	0.069
$\log(N_{6,1988})$	4.837	0.380	0.079	4.825	0.381
$\log(N_{7,1988})$	3.527	0.532	0.151	3.518	0.529
$\log(N_{8,1988})$	3.079	0.594	0.193	3.087	0.591
$\log(N_{9,1988})$	4.073	0.455	0.112	4.076	0.457

Parameter	Estimate	Std. Error	CV	Estimate 2021	Std. Error 2021
$\log(N_{10,1988})$	3.282	0.669	0.204	3.286	0.667
$\log(N_{11,1988})$	3.191	0.691	0.216	3.180	0.695
$\log(N_{12,1988})$	3.585	0.753	0.210	3.578	0.753
$\log(q_3^{F1})$	-9.657	0.173	0.018	-9.669	0.179
$\log(q_4^{F1})$	-8.143	0.124	0.015	-8.108	0.128
$\log(q_5^{F1})$	-7.487	0.111	0.015	-7.474	0.115
$\log(q_6^{F1})$	-7.283	0.110	0.015	-7.296	0.117
$\log(q_7^{F1})$	-7.165	0.123	0.017	-7.152	0.128
$\log(q_8^{F1})$	-6.926	0.086	0.012	-6.939	0.091
$\log(q_2^{F4})$	-14.525	0.189	0.013	-14.515	0.193
$\log(q_3^{F5})$	-7.654	0.105	0.014	-7.653	0.107
$\log(q_4^{F5})$	-7.133	0.093	0.013	-7.123	0.095
$\log(q_5^{F5})$	-6.913	0.091	0.013	-6.904	0.093
$\log(q_6^{F5})$	-6.796	0.094	0.014	-6.805	0.097
$\log(q_7^{F5})$	-6.721	0.101	0.015	-6.734	0.103
$\log(q_8^{F5})$	-6.541	0.106	0.016	-6.557	0.109
$\log(q_9^{F5})$	-6.537	0.118	0.018	-6.543	0.121
$\log(q_{10}^{F5})$	-6.474	0.132	0.020	-6.490	0.135
$\log(q_{11}^{F5})$	-6.433	0.126	0.020	-6.433	0.131
$\log(\sigma_1^2)$	-5.000	1.409	0.282	-5.000	1.441
$\log(\sigma_2^2)$	-2.777	0.243	0.088	-2.769	0.256
$\log(\sigma_4^2)$	-2.281	0.299	0.131	-2.250	0.303
$\log(\sigma_R^2)$	-0.022	0.255	11.598	-0.008	0.275
$\log(h)$	1.565	0.063	0.040	1.595	0.065
μ_R	9.275	0.176	0.019	9.275	0.180
α_Y	-0.492	0.294	0.596	-0.513	0.300
β_Y	0.816	0.107	0.131	0.810	0.108
α_{2U}	-1.239	0.164	0.133	-1.242	0.167

Parameter	Estimate	Std. Error	CV	Estimate 2021	Std. Error 2021
α_{3U}	-0.629	0.095	0.151	-0.620	0.096
α_{4U}	-0.215	0.059	0.273	-0.214	0.060
α_{5U}	0.054	0.049	0.916	0.043	0.051
α_{6U}	0.199	0.054	0.271	0.196	0.055
α_{7U}	0.263	0.058	0.222	0.264	0.060
α_{8U}	0.319	0.065	0.203	0.327	0.066
α_{9U}	0.368	0.070	0.191	0.368	0.072
α_{10U}	0.419	0.076	0.182	0.420	0.078
β_U	0.603	0.052	0.086	0.603	0.053

Table 4.5.1.2 Norwegian spring-spawning herring. Point estimates of Stock in numbers (millions).

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	672	1197	759	14529	126	34	22	59	27	24	36
1989	1173	260	967	635	12012	104	28	16	40	16	44
1990	4339	471	219	818	531	10012	86	22	13	30	47
1991	11466	1758	401	186	687	444	8370	71	18	10	62
1992	18683	4656	1505	341	157	577	372	6977	58	15	59
1993	50101	7589	3992	1278	286	131	482	310	5769	47	59
1994	59953	20347	6502	3367	1041	231	106	389	249	4571	83
1995	15751	24339	17426	5476	2632	778	177	83	301	187	3436
1996	5722	6386	20794	14597	4174	1750	507	128	60	207	2243
1997	2152	2315	5420	17205	11160	2798	1122	333	89	41	1353
1998	10941	868	1919	4366	13115	7770	1742	659	207	54	754
1999	6461	4417	715	1480	3371	9610	5447	1117	410	122	458
2000	32626	2615	3680	557	1130	2504	6817	3652	698	243	299
2001	28927	13217	2189	2739	416	830	1788	4661	2248	406	267
2002	11339	11726	11211	1742	2003	311	615	1286	3236	1483	446
2003	6678	4590	9908	9050	1282	1405	226	432	873	2155	1284
2004	57658	2707	3888	8191	7103	944	1027	164	303	587	2247
2005	24428	23396	2301	3240	6622	5467	703	745	119	213	1753

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2006	43044	9907	19779	1895	2590	5071	3862	479	504	78	1122
2007	12127	17457	8425	16363	1524	2027	3714	2639	331	349	695
2008	17706	4911	14809	6936	12530	1154	1484	2526	1747	222	705
2009	7109	7141	4155	12207	5361	8717	815	1022	1613	1102	614
2010	5074	2851	5979	3412	9431	3809	5662	546	635	963	1055
2011	15315	2035	2376	4915	2719	7112	2651	3524	341	390	1095
2012	5658	6144	1700	1950	3964	2124	5363	1798	2352	222	939
2013	8319	2287	5142	1403	1569	3140	1623	3936	1265	1644	813
2014	5491	3370	1928	4213	1130	1244	2446	1211	2875	913	1917
2015	17709	2228	2868	1609	3420	916	997	1924	927	2162	2259
2016	7341	7190	1902	2414	1330	2791	746	799	1521	717	3525
2017	4432	2980	6134	1595	1979	1068	2229	590	622	1158	3288
2018	39850	1797	2521	5028	1264	1483	789	1622	427	428	3167
2019	5149	16169	1527	2097	4059	965	1120	588	1204	308	2521
2020	4358	2088	13732	1257	1649	3012	706	791	413	847	1786
2021	1958	1766	1767	11303	990	1245	2203	504	545	282	1693
2022	10671	793	1491	1431	8497	716	882	1547	331	353	1346

Table 4.5.1.3 Norwegian spring-spawning herring. Point estimates of Fishing mortality.

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	0.050	0.064	0.029	0.040	0.042	0.042	0.142	0.224	0.334	0.170	0.170
1989	0.012	0.021	0.018	0.028	0.032	0.035	0.077	0.110	0.152	0.092	0.092
1990	0.004	0.012	0.015	0.024	0.030	0.029	0.052	0.073	0.098	0.071	0.071
1991	0.001	0.005	0.011	0.019	0.025	0.025	0.032	0.044	0.057	0.050	0.050
1992	0.001	0.004	0.013	0.025	0.031	0.031	0.035	0.040	0.055	0.058	0.058
1993	0.001	0.005	0.020	0.055	0.063	0.059	0.063	0.068	0.083	0.105	0.105
1994	0.002	0.005	0.022	0.096	0.142	0.116	0.099	0.107	0.135	0.153	0.153
1995	0.003	0.007	0.027	0.121	0.258	0.278	0.175	0.171	0.223	0.330	0.330
1996	0.005	0.014	0.039	0.118	0.250	0.295	0.271	0.213	0.244	0.444	0.444
1997	0.008	0.038	0.066	0.121	0.212	0.324	0.382	0.325	0.352	0.464	0.464

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1998	0.007	0.044	0.109	0.109	0.161	0.205	0.294	0.326	0.378	0.417	0.417
1999	0.004	0.032	0.100	0.120	0.147	0.193	0.250	0.321	0.373	0.514	0.514
2000	0.004	0.028	0.145	0.141	0.158	0.187	0.230	0.335	0.391	0.557	0.557
2001	0.003	0.015	0.078	0.163	0.141	0.150	0.180	0.215	0.266	0.262	0.262
2002	0.004	0.018	0.064	0.157	0.205	0.171	0.204	0.237	0.256	0.257	0.257
2003	0.003	0.016	0.040	0.092	0.156	0.163	0.170	0.203	0.248	0.276	0.276
2004	0.002	0.013	0.032	0.063	0.112	0.145	0.172	0.174	0.204	0.330	0.330
2005	0.002	0.018	0.044	0.074	0.117	0.197	0.234	0.240	0.266	0.411	0.411
2006	0.002	0.012	0.040	0.068	0.095	0.161	0.231	0.220	0.219	0.396	0.396
2007	0.004	0.015	0.045	0.117	0.128	0.162	0.236	0.262	0.248	0.242	0.242
2008	0.008	0.017	0.043	0.108	0.213	0.199	0.224	0.298	0.311	0.262	0.262
2009	0.014	0.028	0.047	0.108	0.192	0.281	0.250	0.326	0.366	0.336	0.336
2010	0.013	0.032	0.046	0.077	0.132	0.213	0.324	0.321	0.337	0.462	0.462
2011	0.013	0.030	0.048	0.065	0.097	0.132	0.238	0.254	0.281	0.308	0.308
2012	0.006	0.028	0.043	0.067	0.083	0.119	0.159	0.202	0.208	0.205	0.205
2013	0.004	0.021	0.049	0.066	0.082	0.100	0.143	0.164	0.177	0.098	0.098
2014	0.002	0.011	0.031	0.059	0.060	0.071	0.090	0.117	0.135	0.075	0.075
2015	0.001	0.008	0.022	0.040	0.053	0.055	0.072	0.085	0.107	0.077	0.077
2016	0.002	0.009	0.026	0.049	0.069	0.075	0.084	0.100	0.123	0.105	0.105
2017	0.003	0.017	0.049	0.082	0.138	0.152	0.168	0.173	0.225	0.189	0.189
2018	0.002	0.013	0.034	0.064	0.120	0.130	0.145	0.148	0.175	0.205	0.205
2019	0.003	0.013	0.044	0.090	0.148	0.163	0.198	0.203	0.202	0.310	0.310
2020	0.003	0.017	0.045	0.089	0.131	0.163	0.187	0.222	0.231	0.292	0.292
2021	0.004	0.019	0.061	0.135	0.174	0.195	0.203	0.269	0.284	0.233	0.233
2022	0.004	0.018	0.054	0.113	0.152	0.175	0.191	0.236	0.257	0.269	0.269

Table 4.5.1.4 Norwegian spring spawning herring. Final stock summary table. High and low represent approximate 95 % confidence limits.

Year	Recruitment (Age 2) millions	High	Low	Stock Size: SSB thousnd tonnes	High	Low	Catches thousand tonnes	Fishing Pres-sure: F Ages 5-12	High	Low
1988	672	996	349	2126	2389	1863	135.301	0.042	0.058	0.026
1989	1173	1653	693	3287	3694	2881	103.830	0.033	0.046	0.019
1990	4339	5358	3320	3562	3993	3131	86.411	0.029	0.042	0.017
1991	11466	13340	9592	3340	3743	2937	84.683	0.031	0.044	0.018
1992	18683	21308	16058	3368	3753	2982	104.448	0.039	0.054	0.023
1993	50101	55342	44859	3340	3687	2993	232.457	0.076	0.100	0.053
1994	59953	65811	54096	3471	3817	3125	479.228	0.129	0.160	0.099
1995	15751	18082	13419	3536	3868	3205	905.501	0.219	0.259	0.179
1996	5722	6843	4601	4118	4450	3787	1220.283	0.192	0.223	0.162
1997	2152	2716	1587	5374	5765	4984	1426.507	0.193	0.220	0.166
1998	10941	12719	9163	5954	6383	5526	1223.131	0.186	0.214	0.158
1999	6461	7677	5246	5854	6304	5403	1235.433	0.214	0.247	0.180
2000	32626	36501	28751	4873	5287	4458	1207.201	0.257	0.300	0.215
2001	28927	32527	25328	4043	4416	3669	766.136	0.204	0.241	0.167
2002	11339	13212	9465	3565	3913	3218	807.795	0.224	0.265	0.183
2003	6678	7956	5399	4189	4571	3806	789.510	0.153	0.181	0.125
2004	57658	63732	51584	5269	5734	4805	794.066	0.129	0.152	0.105
2005	24428	27784	21072	5389	5880	4898	1003.243	0.174	0.204	0.143
2006	43044	48247	37840	5350	5832	4868	968.958	0.178	0.211	0.145
2007	12127	14277	9976	6882	7471	6294	1266.993	0.157	0.184	0.130
2008	17706	20549	14863	6965	7584	6346	1545.656	0.202	0.235	0.169
2009	7109	8536	5681	6937	7588	6285	1687.373	0.207	0.239	0.174
2010	5074	6171	3977	6154	6775	5533	1457.014	0.215	0.251	0.178
2011	15315	17846	12785	5824	6450	5198	992.998	0.158	0.188	0.129
2012	5658	6812	4504	5673	6312	5034	825.999	0.142	0.169	0.115
2013	8319	9879	6760	5307	5926	4687	684.743	0.122	0.147	0.097

Year	Recruitment (Age 2) millions	High	Low	Stock Size: SSB thousnd tonnes	High	Low	Catches thousand tonnes	Fishing Pressure: F Ages 5-12	High	Low
2014	5491	6681	4300	5123	5741	4506	461.306	0.086	0.105	0.067
2015	17709	20913	14504	4772	5360	4183	328.740	0.068	0.085	0.052
2016	7341	9094	5588	4220	4750	3690	383.174	0.086	0.106	0.066
2017	4432	5752	3113	4091	4596	3585	721.566	0.162	0.196	0.127
2018	39850	48793	30907	4110	4630	3590	592.899	0.129	0.157	0.100
2019	5149	7231	3066	3934	4463	3406	777.165	0.187	0.228	0.147
2020	4358	6757	1958	3393	3895	2891	720.937	0.190	0.236	0.144
2021	1958	3768	148	3930	4555	3304	851.813	0.168	0.208	0.127
2022	10671	31681	0	3867	4600	3134	NA	NA	NA	NA
Average	16011	19044	13273	4605	5091	4120	790.000	0.146	0.175	0.118

Table 4.8.1.1 Norwegian Spring-spawning herring. Input to short-term prediction. Stock size is in millions and weight in kg.

Input for	2022							
	Stockno.	Natural	Maturity	Proportion of M	Proportion of F	Weight	Exploitation	Weight
age	1-Jan.	mortality	ogive	before spawning	before spawning	in stock	pattern	in catch
2	10671	0.90	0.0	0	0	0.054	0.004	0.162
3	793	0.15	0.0	0	0	0.104	0.020	0.202
4	1491	0.15	0.4	0	0	0.125	0.059	0.233
5	1431	0.15	0.8	0	0	0.168	0.124	0.266
6	8497	0.15	0.9	0	0	0.243	0.167	0.294
7	716	0.15	1.0	0	0	0.287	0.191	0.321
8	882	0.15	1.0	0	0	0.303	0.209	0.338
9	1547	0.15	1.0	0	0	0.323	0.258	0.365
10	331	0.15	1.0	0	0	0.352	0.281	0.375
11	353	0.15	1.0	0	0	0.366	0.294	0.394
12	1346	0.15	1.0	0	0	0.389	0.294	0.418
2	10671	0.90	0.0	0	0	0.054	0.014	0.162
3		0.15	0.0	0	0	0.104	0.066	0.202
4		0.15	0.4	0	0	0.145	0.192	0.233
5		0.15	0.8	0	0	0.193	0.395	0.266

Input for	2022							
	Stockno.	Natural	Maturity	Proportion of M	Proportion of F	Weight	Exploitation	Weight
age	1-Jan.	mortality	ogive	before spawning	before spawning	in stock	pattern	in catch
6		0.15	1.0	0	0	0.258	0.547	0.294
7		0.15	1.0	0	0	0.291	0.633	0.321
8		0.15	1.0	0	0	0.311	0.705	0.338
9		0.15	1.0	0	0	0.330	0.842	0.365
10		0.15	1.0	0	0	0.354	0.933	0.375
11		0.15	1.0	0	0	0.366	1.000	0.394
12		0.15	1.0	0	0	0.386	1.000	0.418

Table 4.8.2.1 Norwegian spring spawning herring. Short-term prediction.

Basis:	
SSB (2022):	3.867 million t
Landings(2022):	827 963 t (sum of national quotas)
SSB(2023):	3.532 million t
Fw5-12+(2022)	0.192
Recruitment(2022-2024):	10.671,10.671,10.671

The catch options:

Rationale	Catches (2023)	Basis	FW (2023)	SSB (2024)*	P(SSB2024 <Blim)	% SSB change*	%TAC change	%CATCH change
Management strategy	511171	F=0.14	0.14(0.109, 0.184)	3147.97(2346.187, 4370.752)	0.072	-10.863(-34,24)	-14.6	-38
Fmsy	568410	F=0.157	0.157(0.122, 0.205)	3098.334(2311.504, 4137.013)	0.085	-12.268(-35,17)	-5	-31
Zero Catch	0	F=0.0	0(0, 0)	3592.99(2805.748, 4706.388)	0.001	1.738(-21,33)	-100	-100
Fpa	568410	F=0.157	0.157(0.123, 0.208)	3098.334(2310.189, 4164.463)	0.076	-12.268(-35,18)	-5	-31
Flim	986742	F=0.291	0.291(0.224, 0.391)	2736.98(1977.623, 3870.454)	0.318	-22.5(-44,10)	64.8	19
$SSB_{2024}=B_{lim}$	1262850	F=0.39	0.39(0.303, 0.545)	2500.025(1716.133, 3502.222)	0.514	-29.21(-51,-1)	111	53
$SSB_{2024}=B_{pa}$	469646	F=0.128	0.128(0.101, 0.17)	3184.005(2376.571, 4212.338)	0.054	-9.843(-33,19)	-21.5	-43
Status quo	684536	F=0.192	0.192(0.15, 0.254)	2997.77(2265.999, 4034.589)	0.128	-15.116(-36,14)	14.4	-17

***95% confidence interval**

4.17 Figures

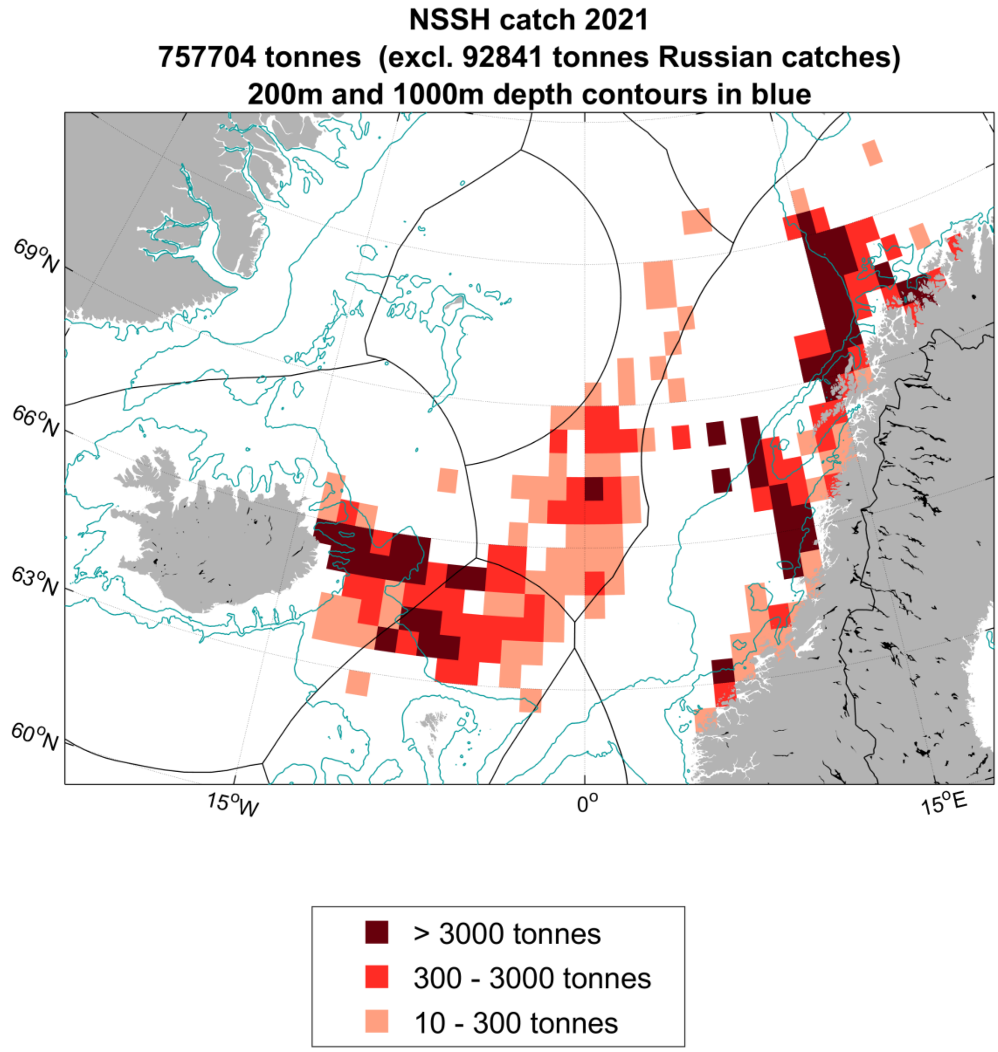

Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2021 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. Catch data by ICES rectangle from Russia are not available. The landings with information on statistical rectangle constitute 89% of the reported landings.

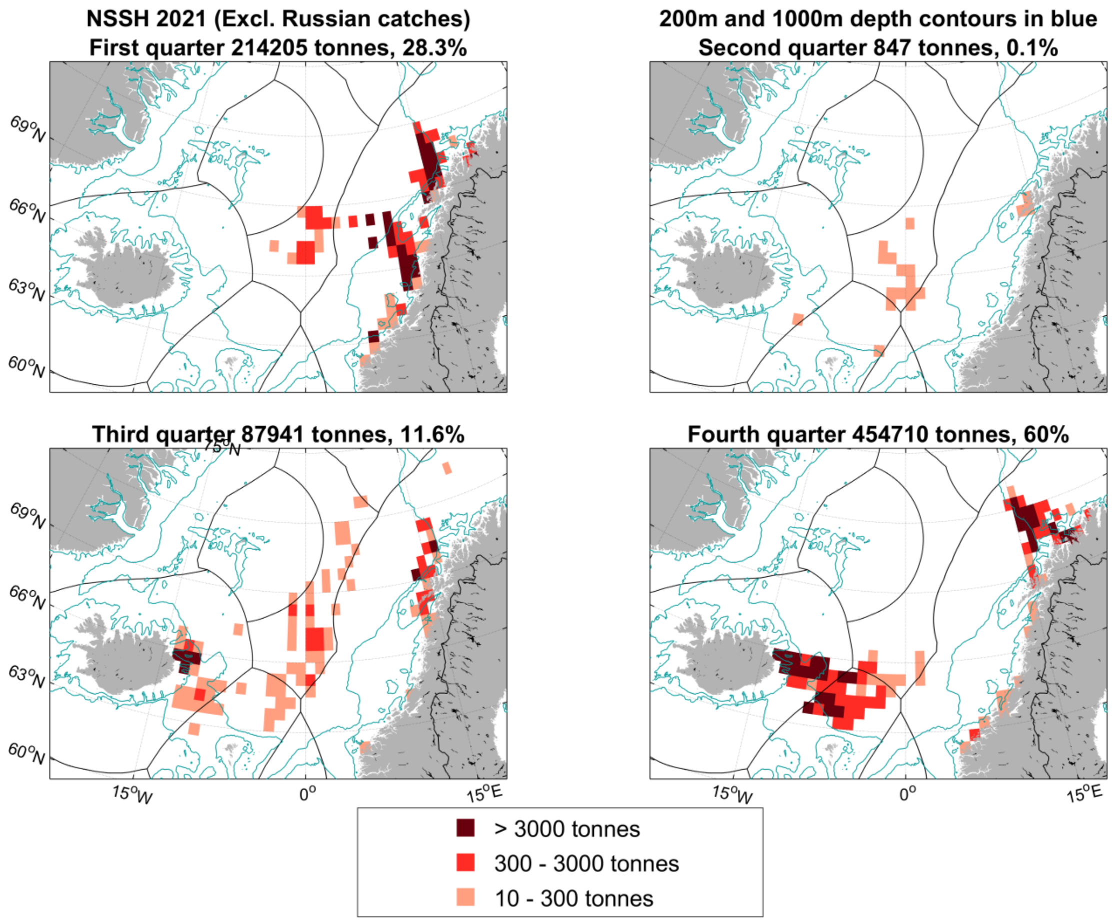

Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2021 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. Catch data by ICES rectangle from Russia are not available. The landings with information on statistical rectangle constitute 89% of the reported landings.

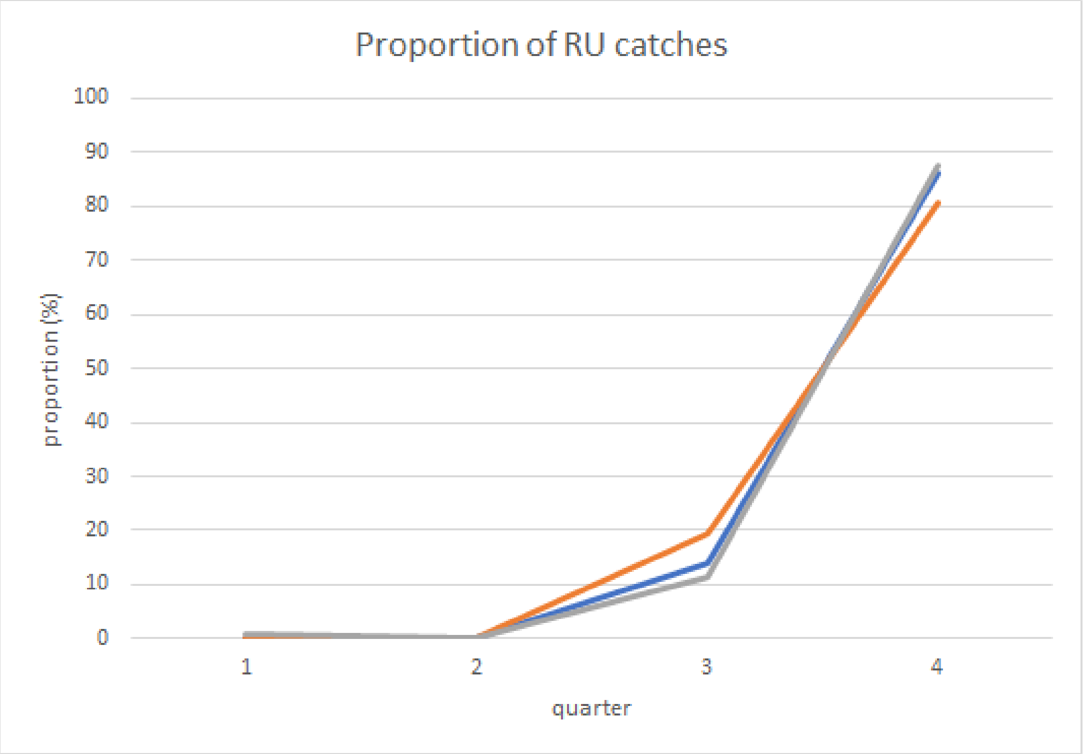

Figure 4.4.1.1.1. Proportion of Russian catches by quarter for the years 2018-2020.

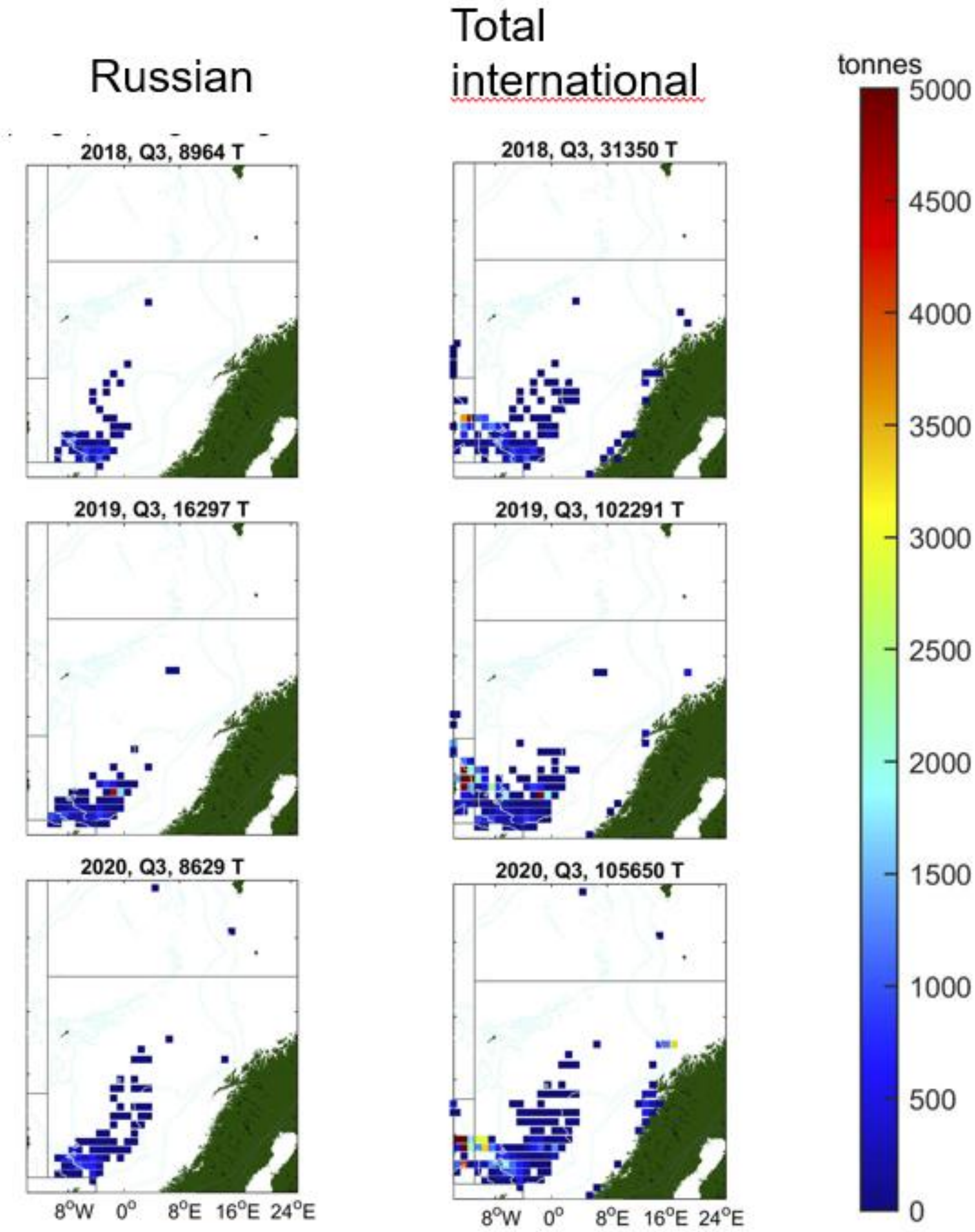

Figure 4.4.1.1.2. Russian and international catch per ICES rectangle in quarter 3 for the years 2018-2020. Lines in the map are limits for ICES sub-divisions.

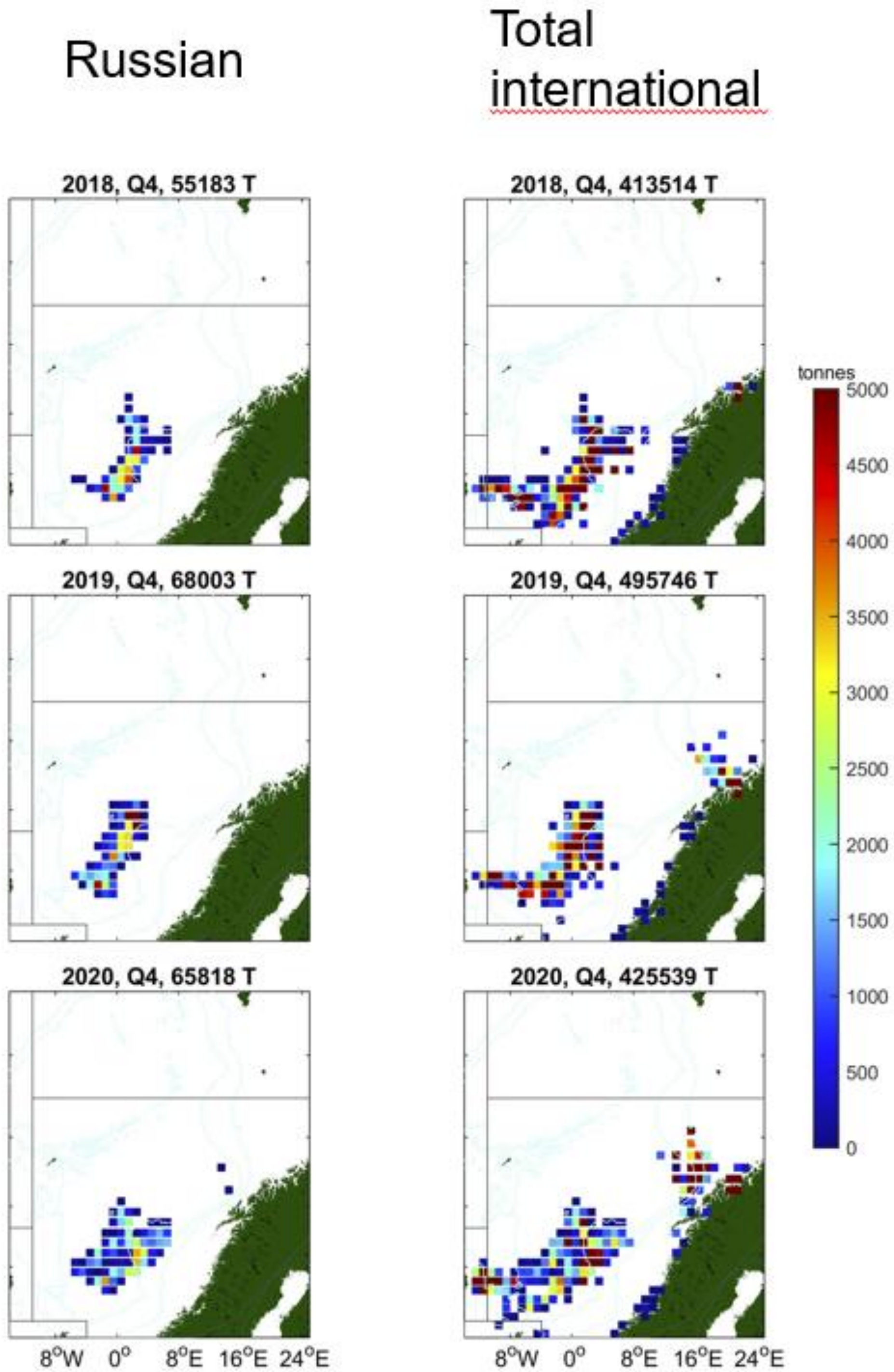

Figure 4.4.1.1.3. Russian and international catch per ICES rectangle in quarter 4 for the years 2018-2020. Lines in the map are limits for ICES sub-divisions.

Figure 4.4.1.1.4. Russian proportion of the total international catch for the period 2001-2020.

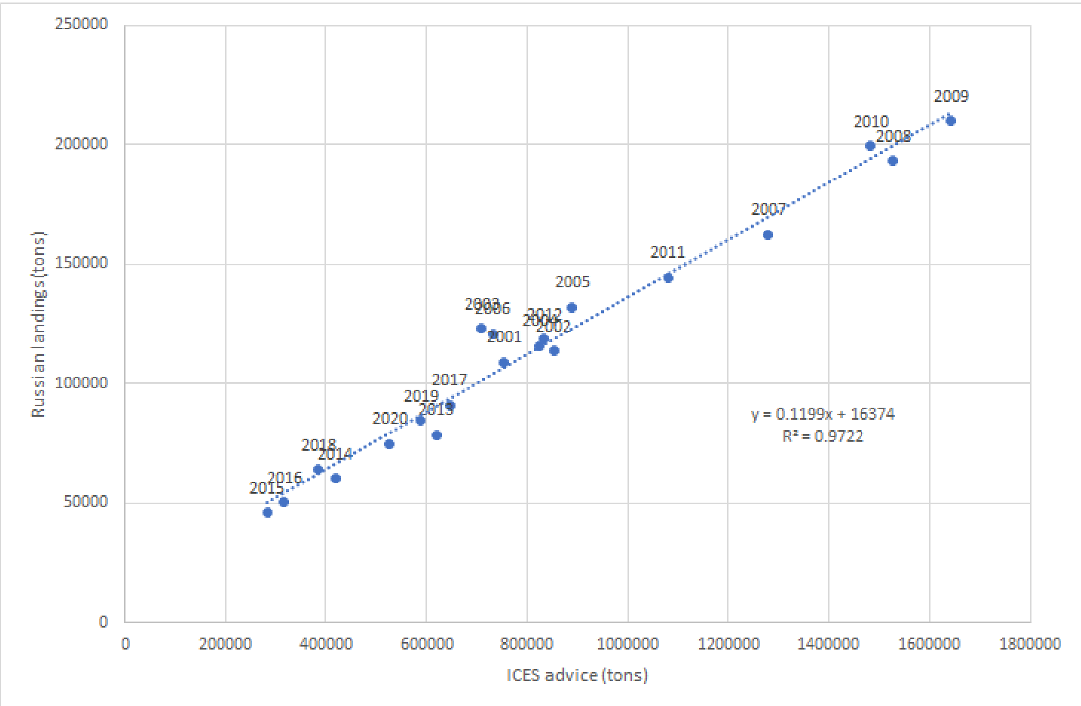

Figure 4.4.1.1.5. Russian landings and ICES advice for the period 2001-2020.

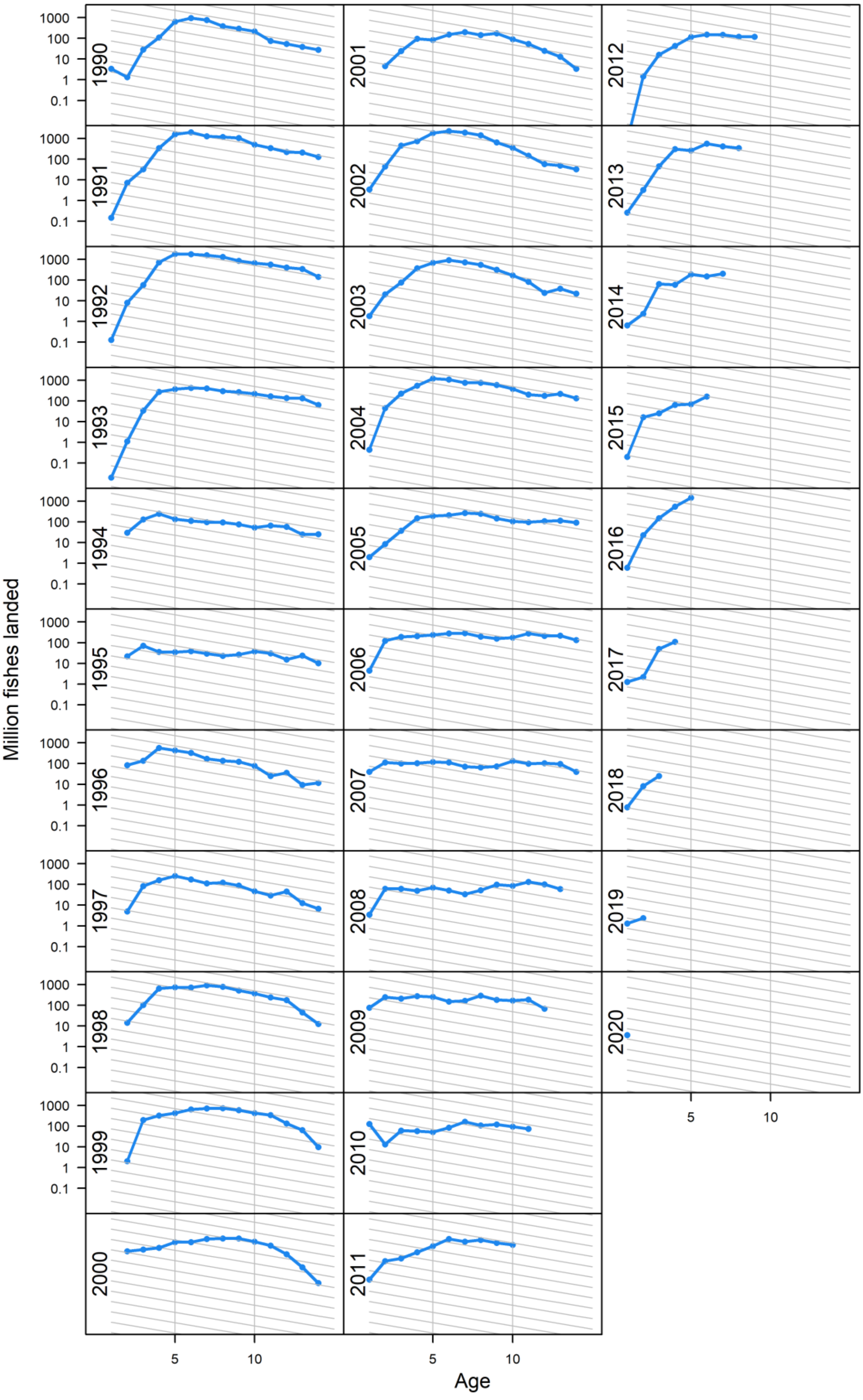

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated landings in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

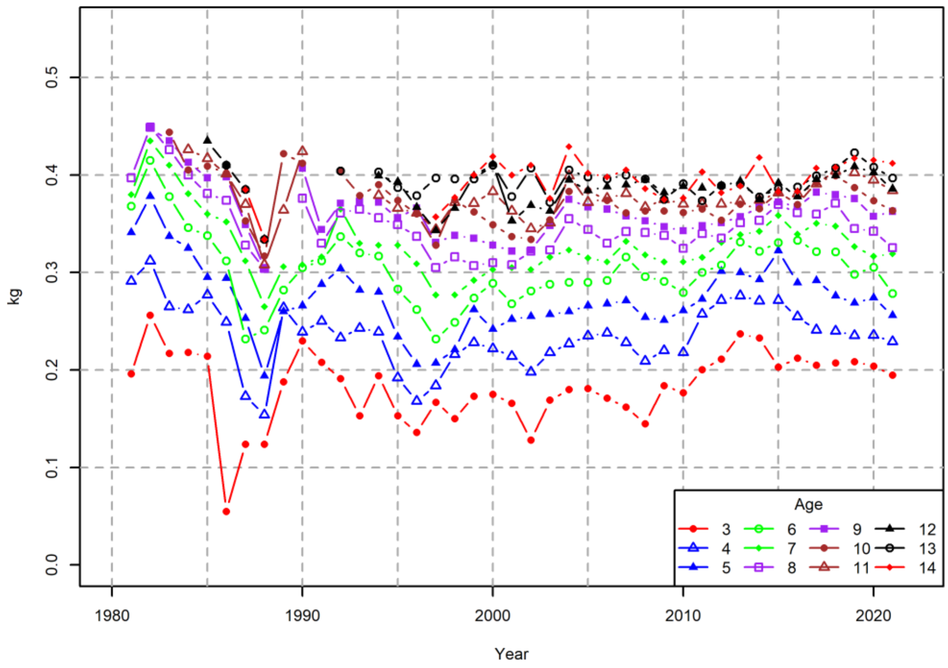

Figure 4.4.4.1. Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2021 in the landings.

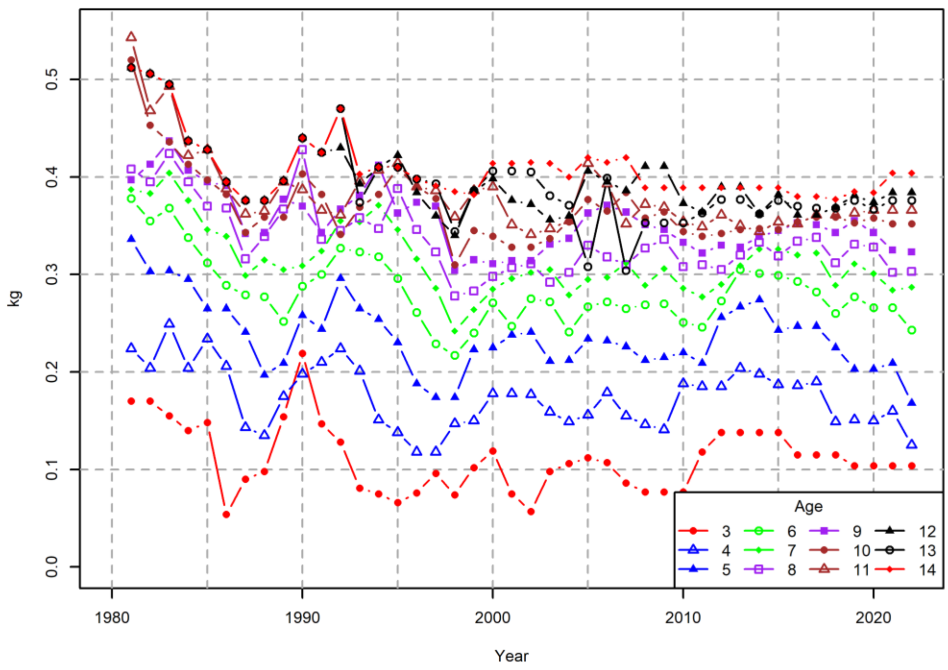

Figure 4.4.4.2. Norwegian spring-spawning herring. Mean weight at age in the stock by age groups 3–14 for the years 1981—2022.

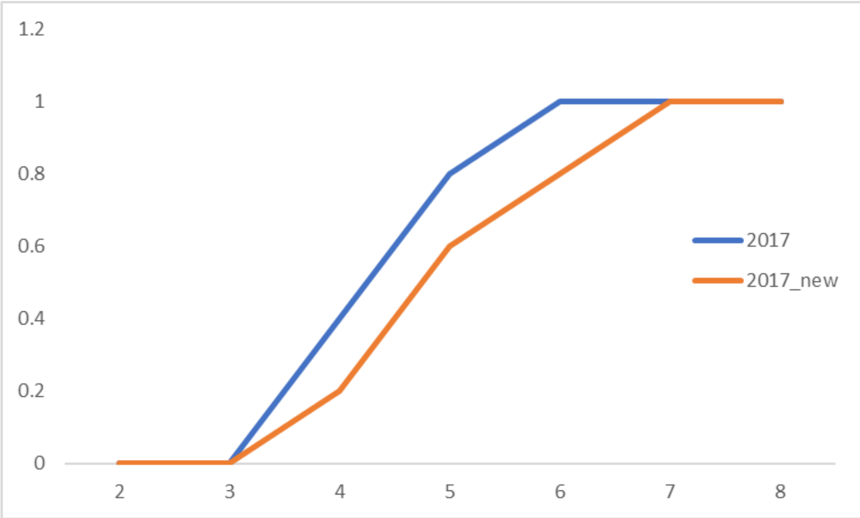

Figure 4.4.5.1. Assumed (blue line) and back-calculated (orange line) maturity-at-age for the year 2017.

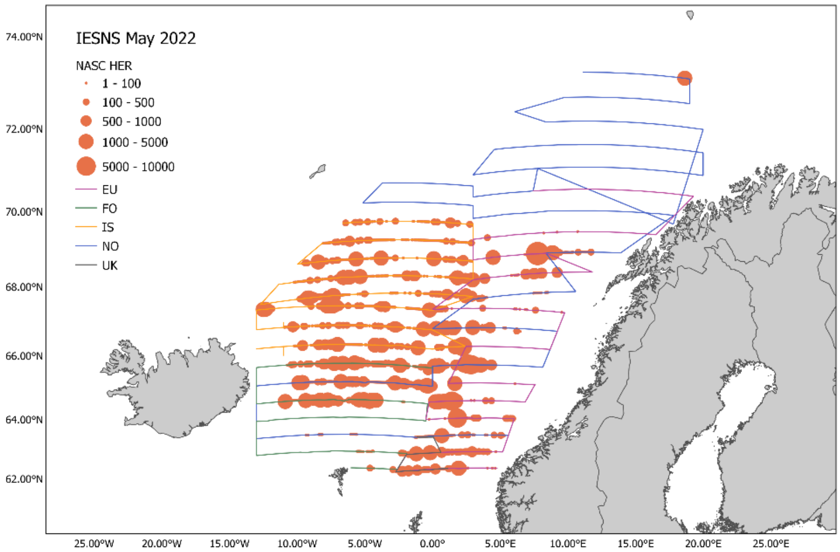

Figure 4.4.7.1. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2022 in terms of NASC values (m^2/nm^2).

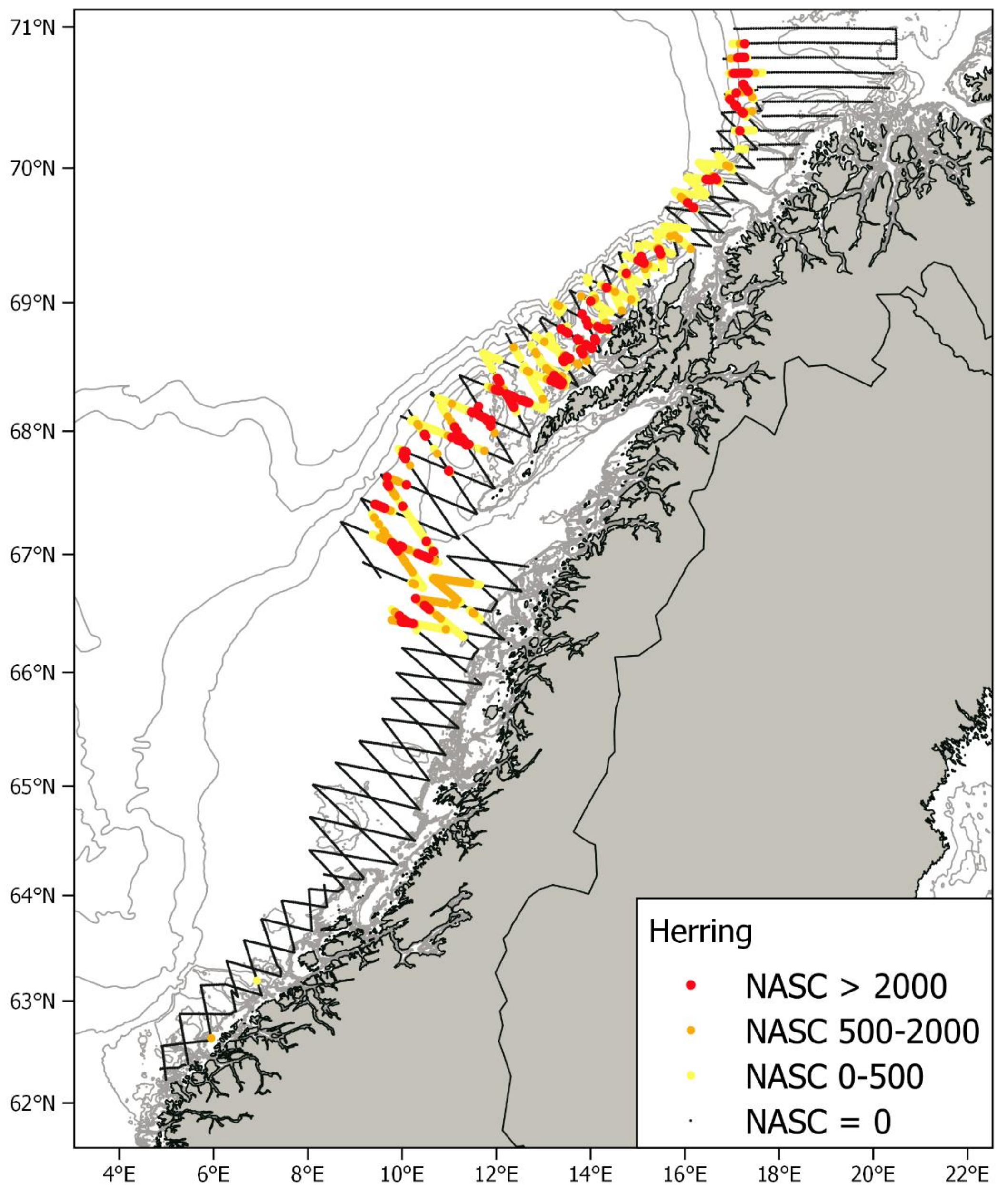

Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2022.

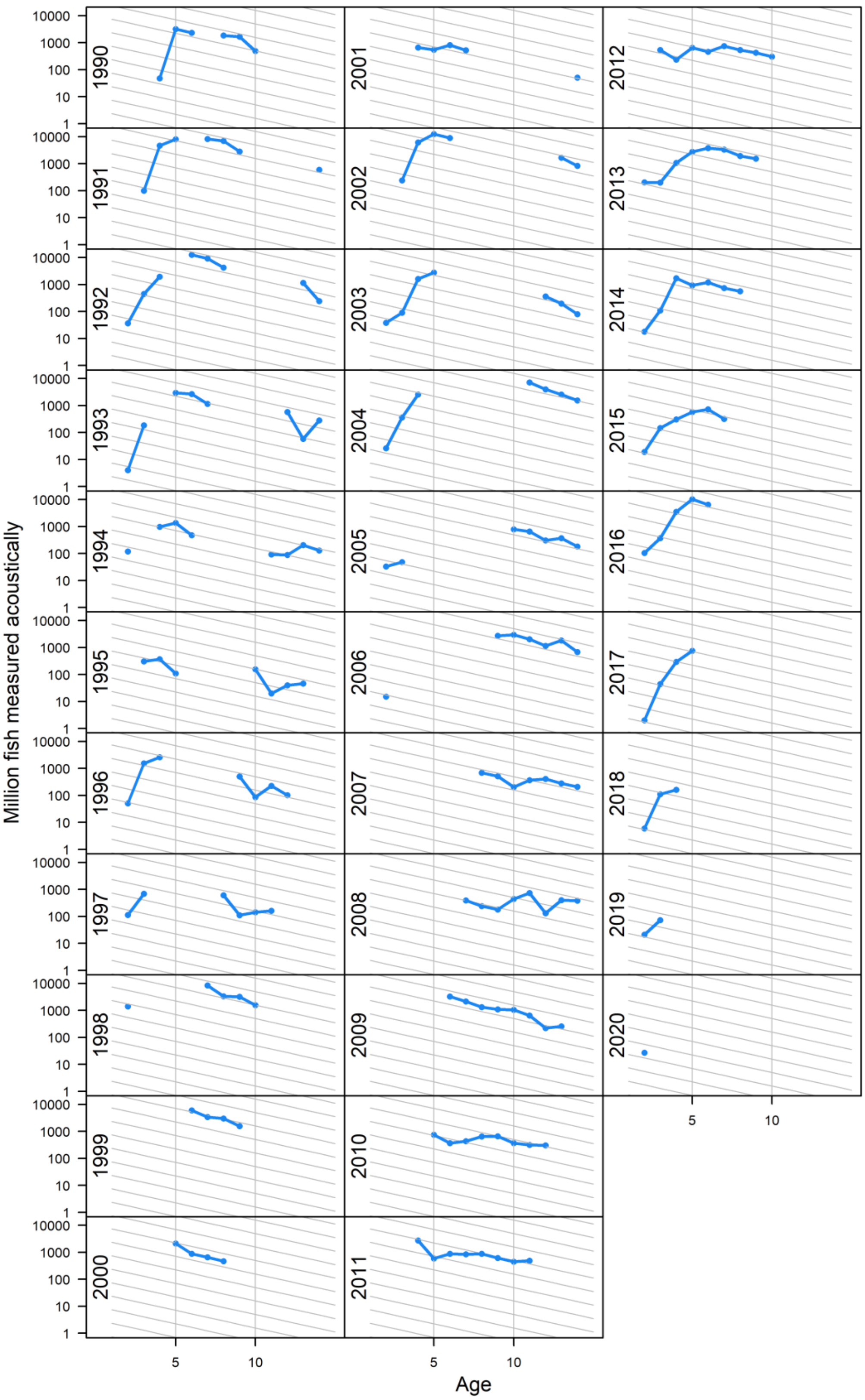

Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the spawning area in February-March (Fleet 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis.

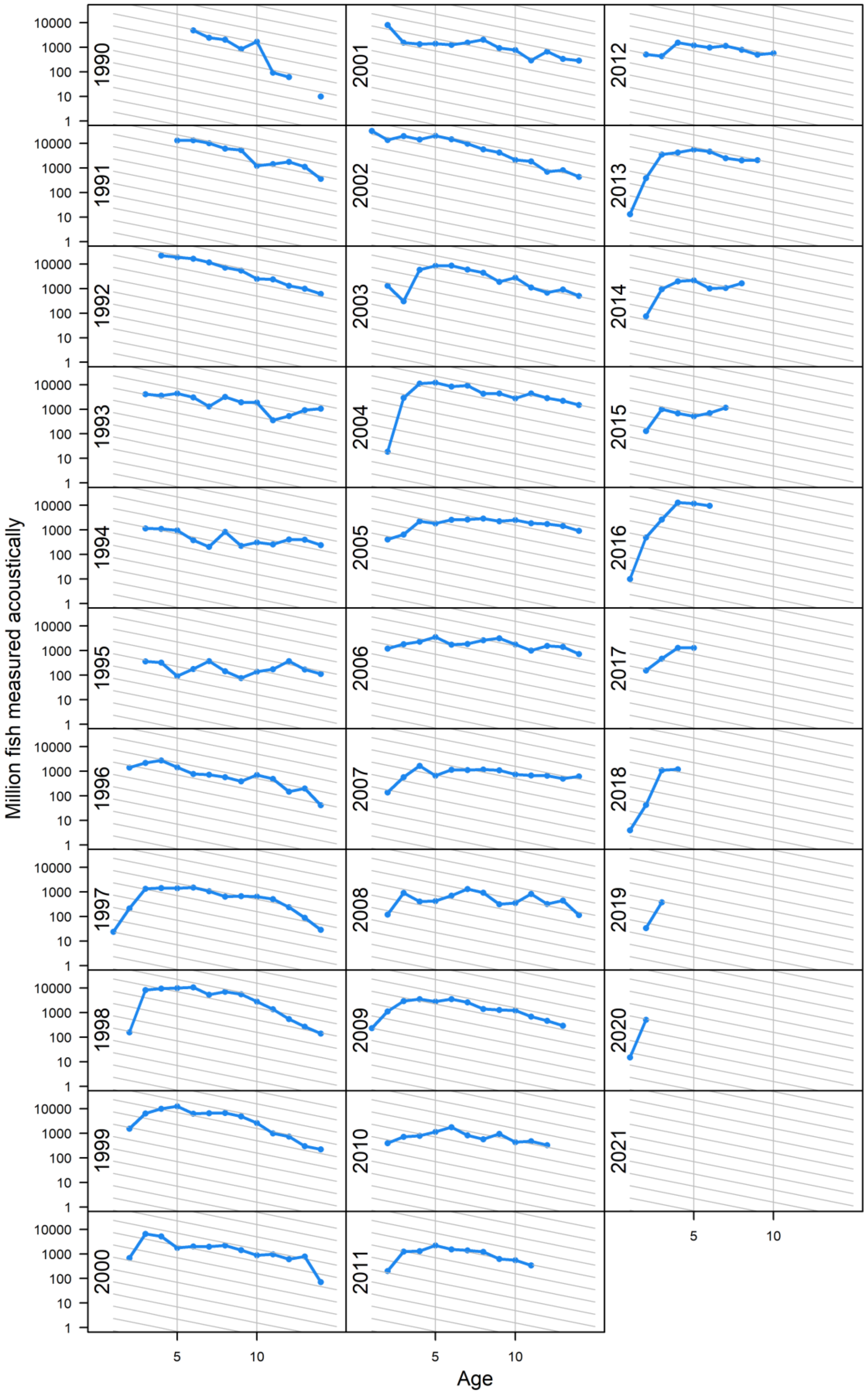

Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey in the feeding area in the Norwegian Sea in May (Fleet 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

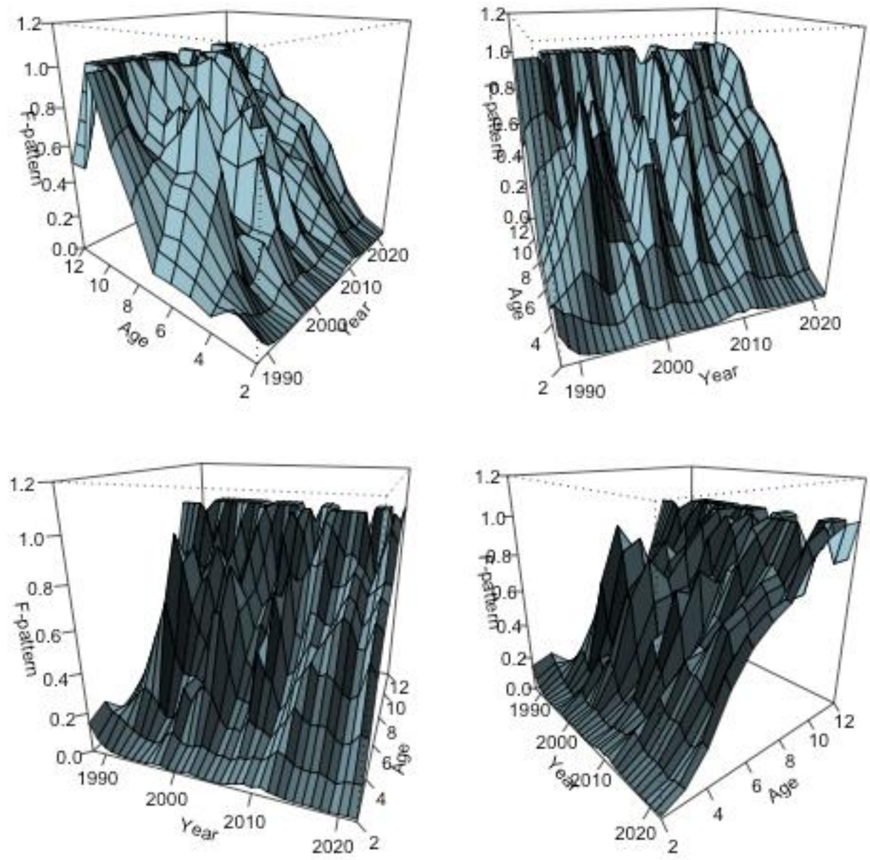

Figure 4.5.1.1. Estimated exploitation pattern for the years 1988–2022 by the XSAM model fit. All panels show the same data, but depicted at different angles to improve visibility at different time periods

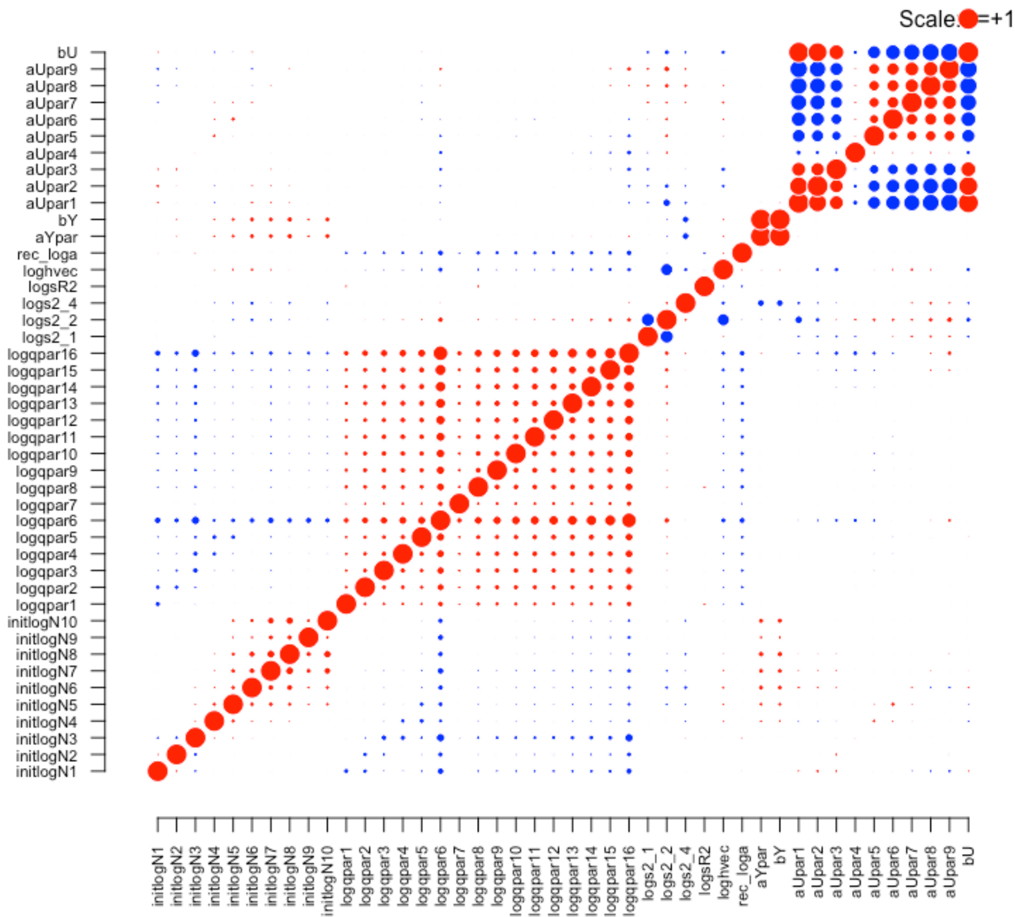

Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

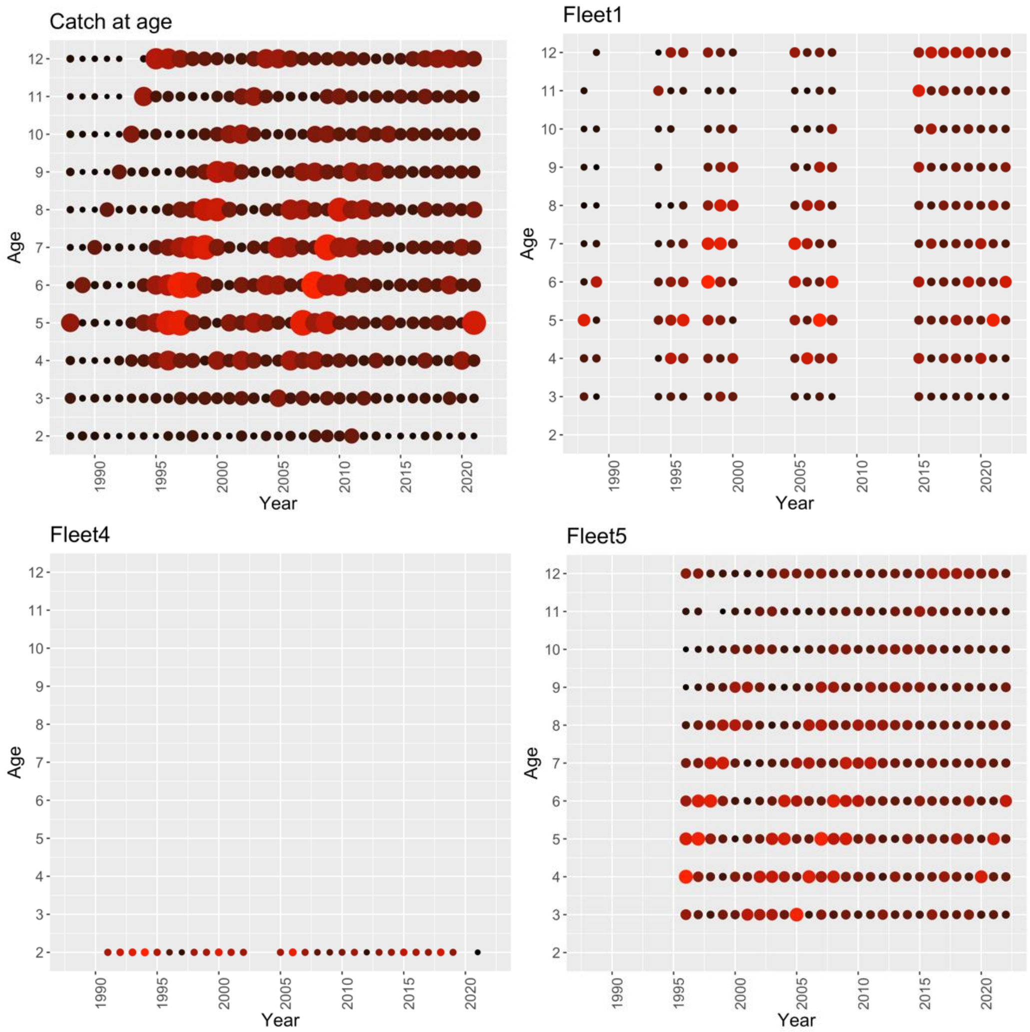

Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

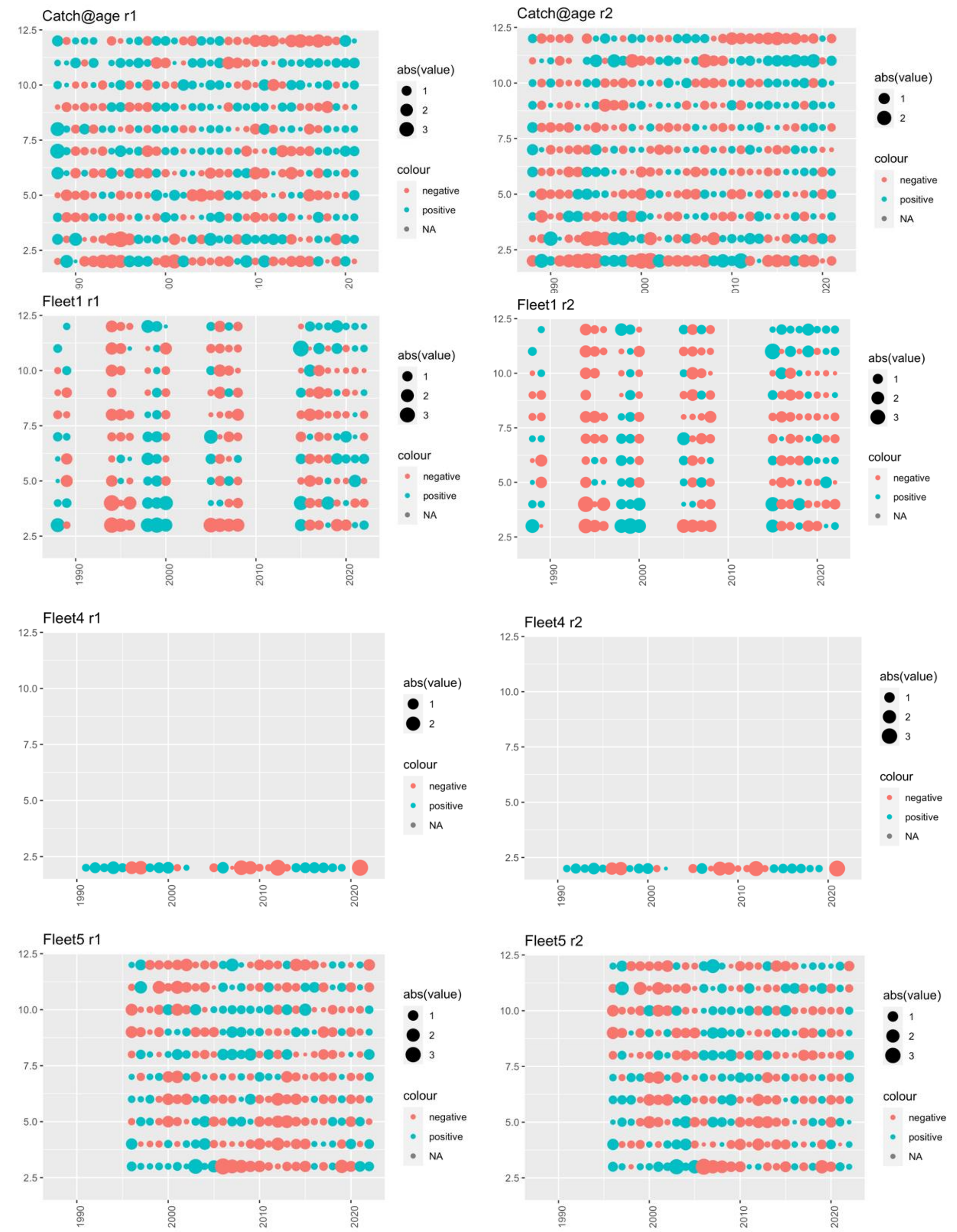

Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit. Red is negative and blue is positive residuals.

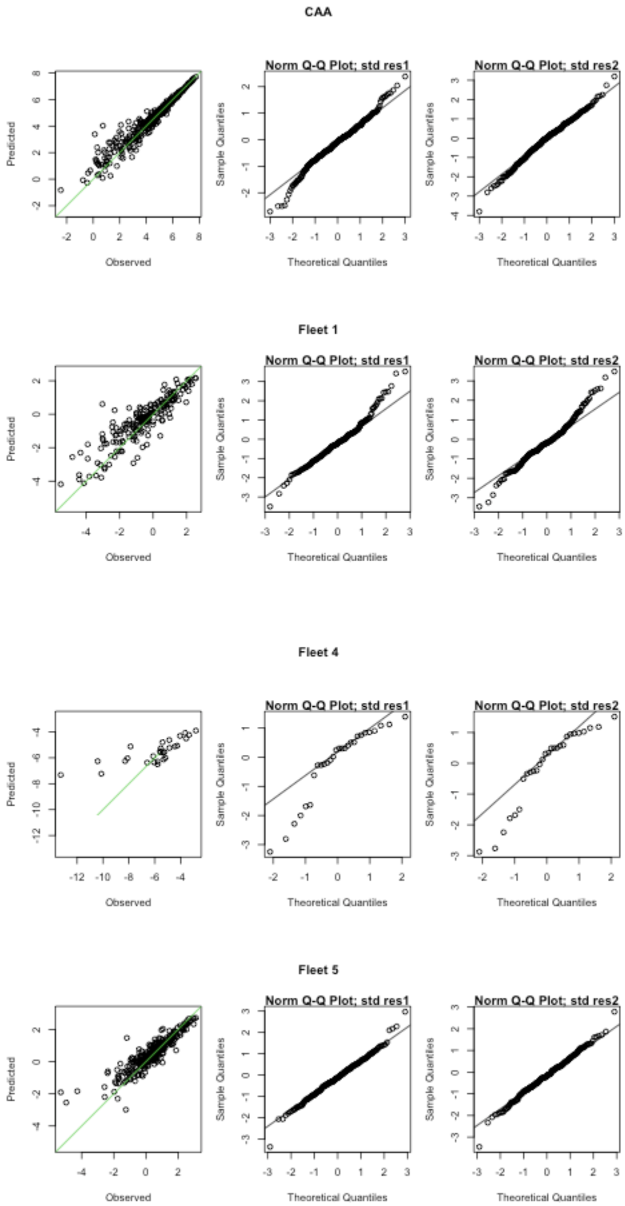

Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

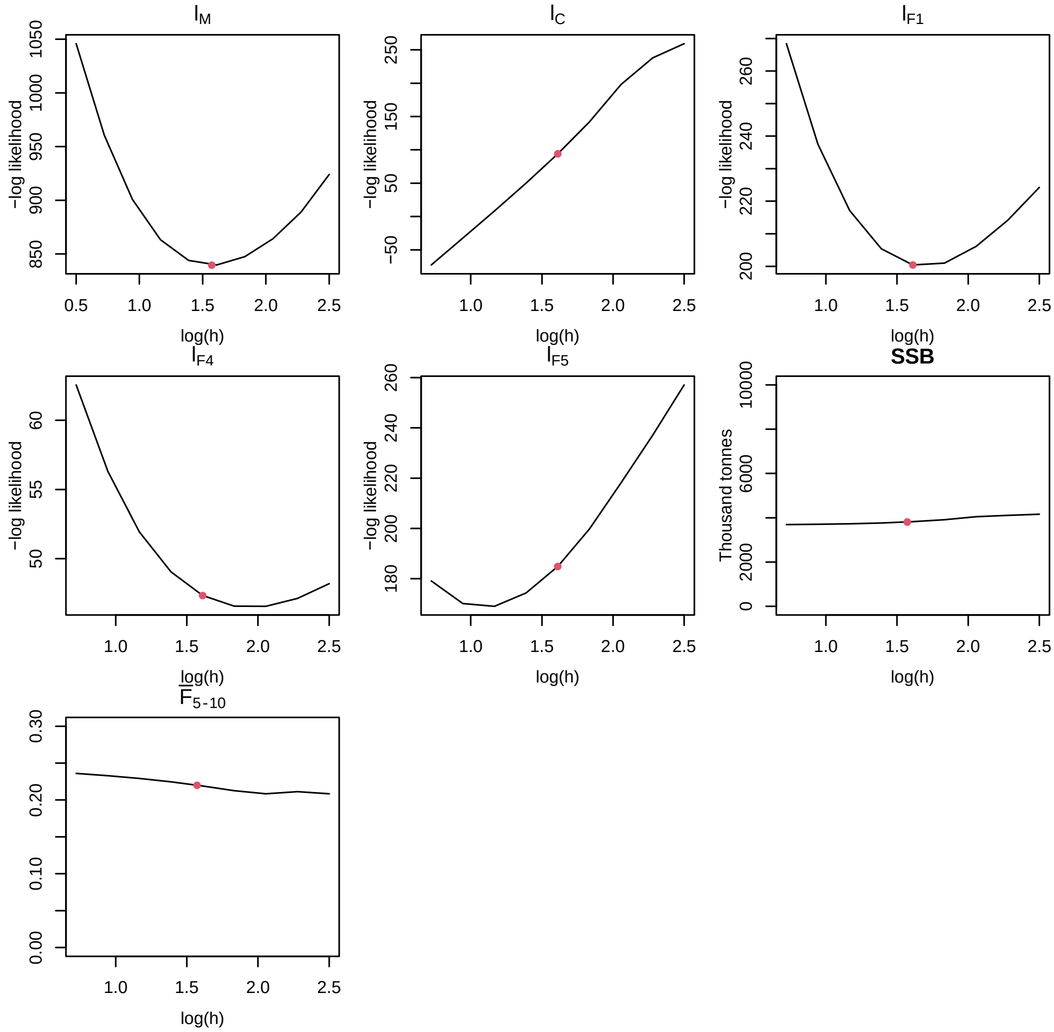

Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood $\mathbf{l_M}$, the catch component $\mathbf{l_C}$, Fleet 1 component $\mathbf{l_{F1}}$, Fleet 4 component $\mathbf{l_{F4}}$, Fleet 5 component $\mathbf{l_{F5}}$, point estimate of SSB and average F (ages 5-12+) in 2022 over the common scaling factor for variance in data $\mathbf{h}$ for the final XSAM fit. The red dots indicate the value of the respective scaling factors for which the log-likelihood is maximized.

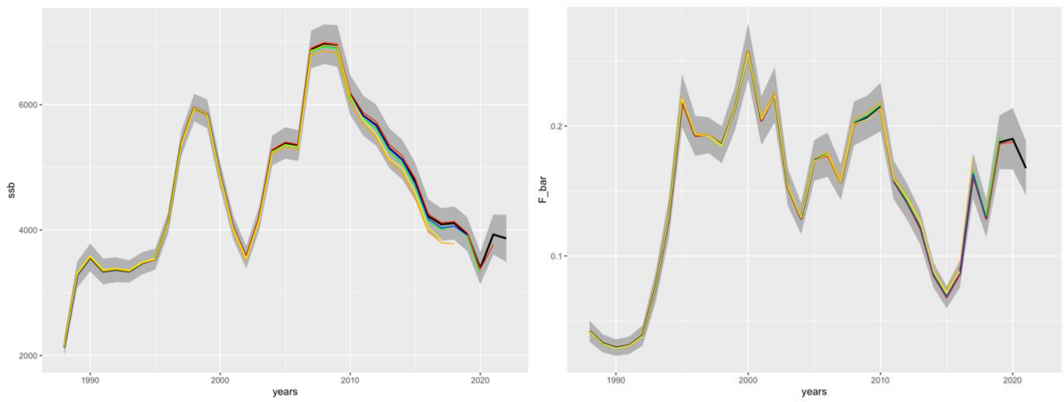

Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-12 for the years 2017-2022. Mohn's rho computed to be -0.04 for SSB and -0.12 for F.

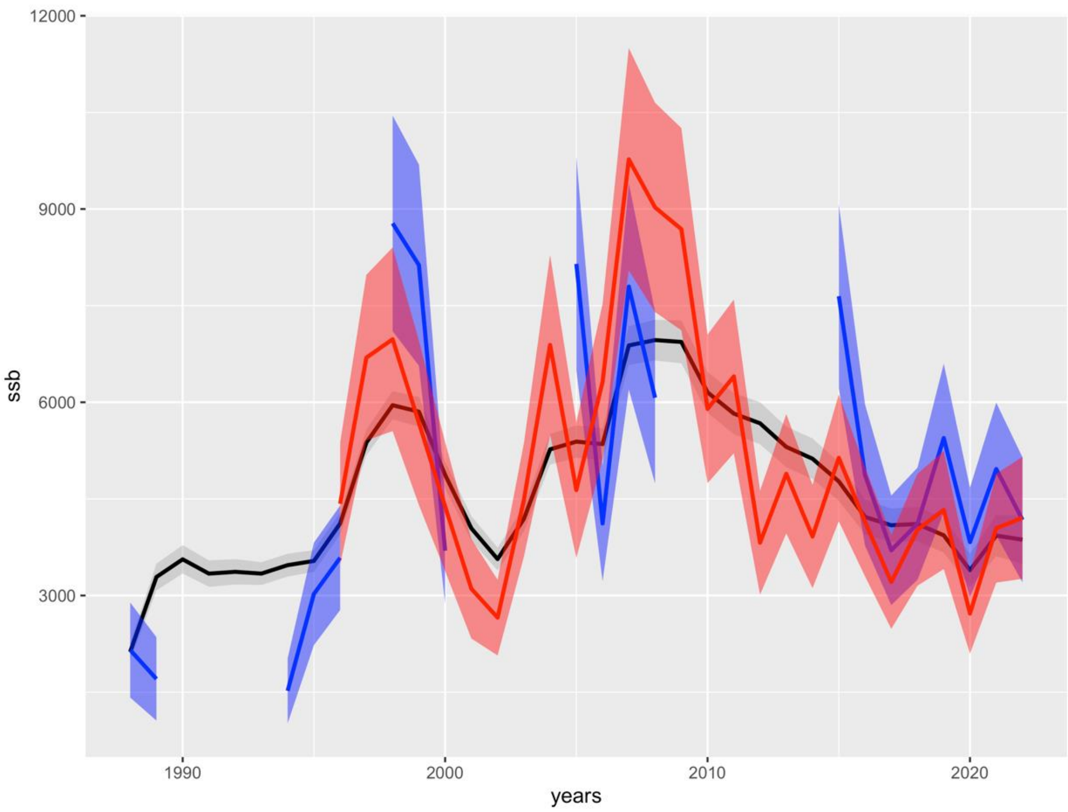

Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2022 from model (black lines) and by survey indices from Fleet 1 (blue) and Fleet 5 (red). Shaded area is approximate to standard deviation.

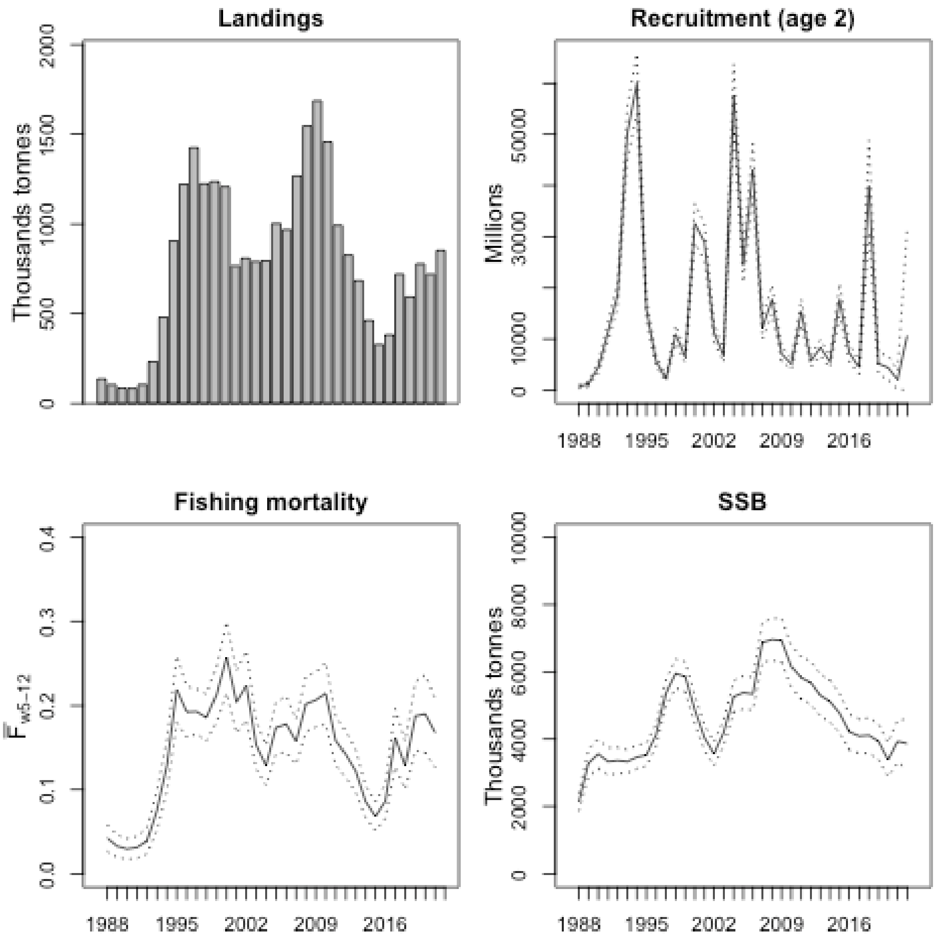

Figure 4.5.1.9. Total reported landings 1988-2021, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2022 based on the final XSAM model fit.

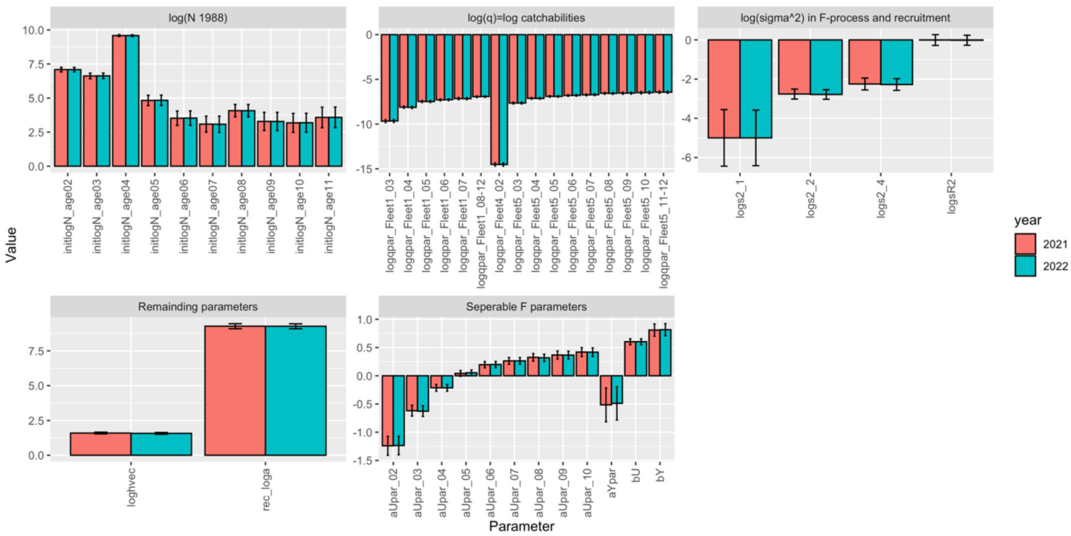

Figure 4.5.1.10. Norwegian spring-spawning herring. A visual representation of parameter estimates of the final XSAM model fit (see table 4.5.1.1). The estimates from the 2021 assessment are also shown (red).

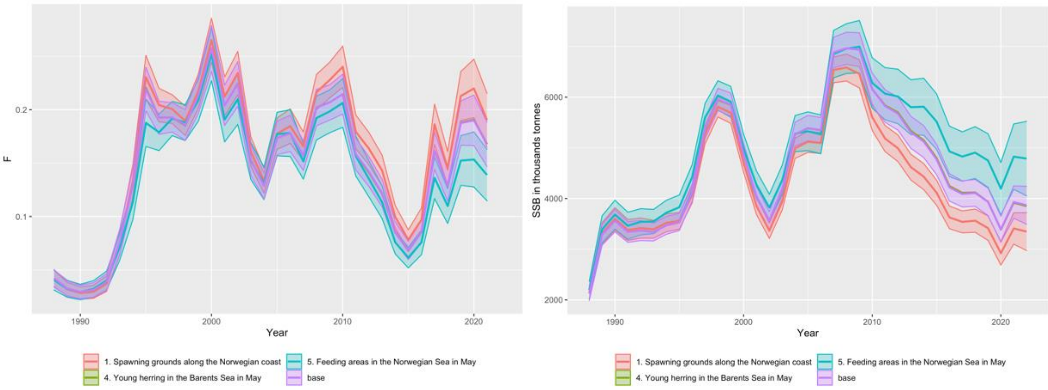

Figure 4.5.1.11. Norwegian spring-spawning herring. Alternative runs showing the effect of leaving one fleet out. The F is shown to the left and SSB to the right. The base run is shown as purple, leaving out Fleet 1 is red, leaving out Fleet 4 is green and leaving out Fleet 5 is shown as blue. Shaded regions show the standard deviation.

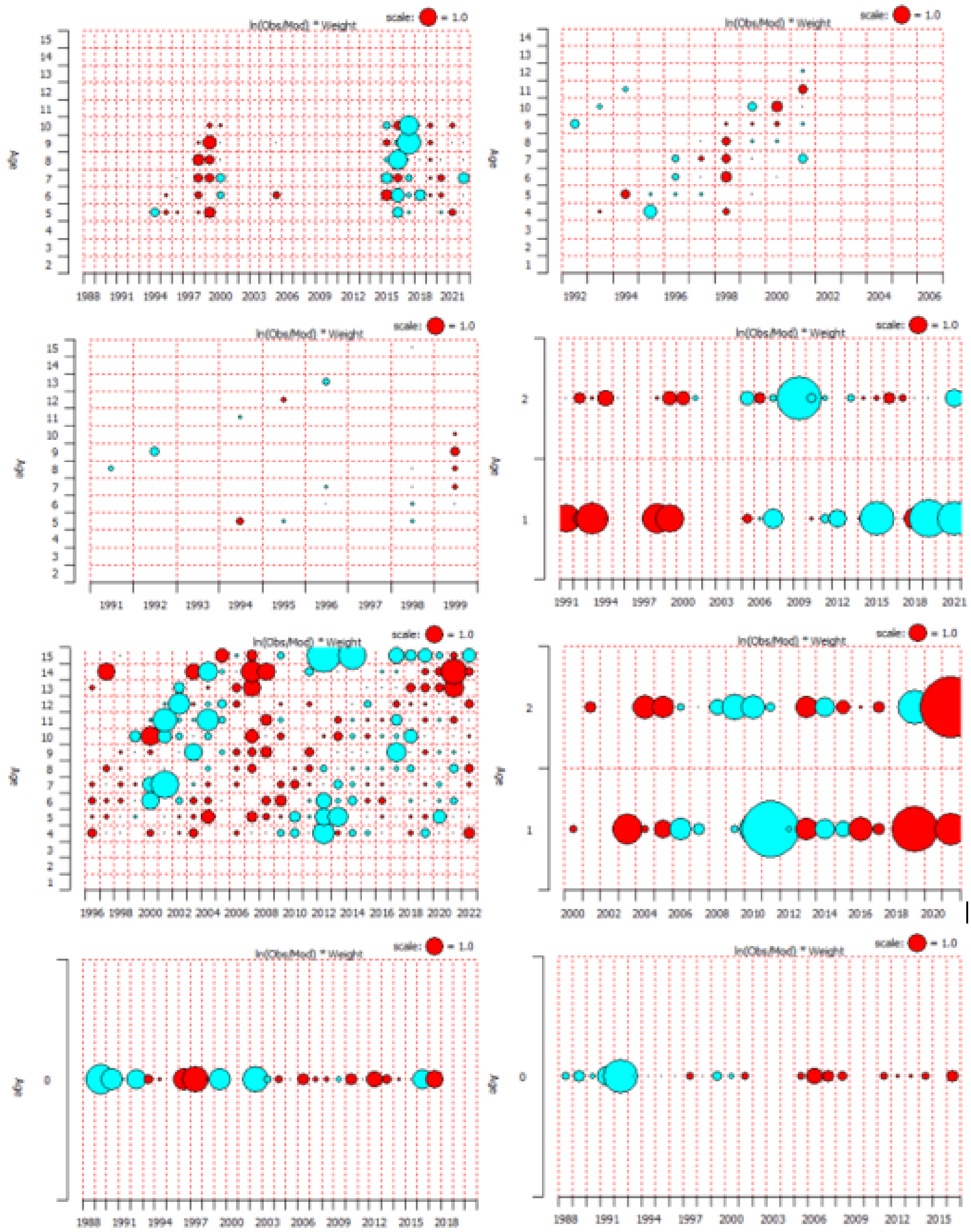

Figure 4.5.2.1.1. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

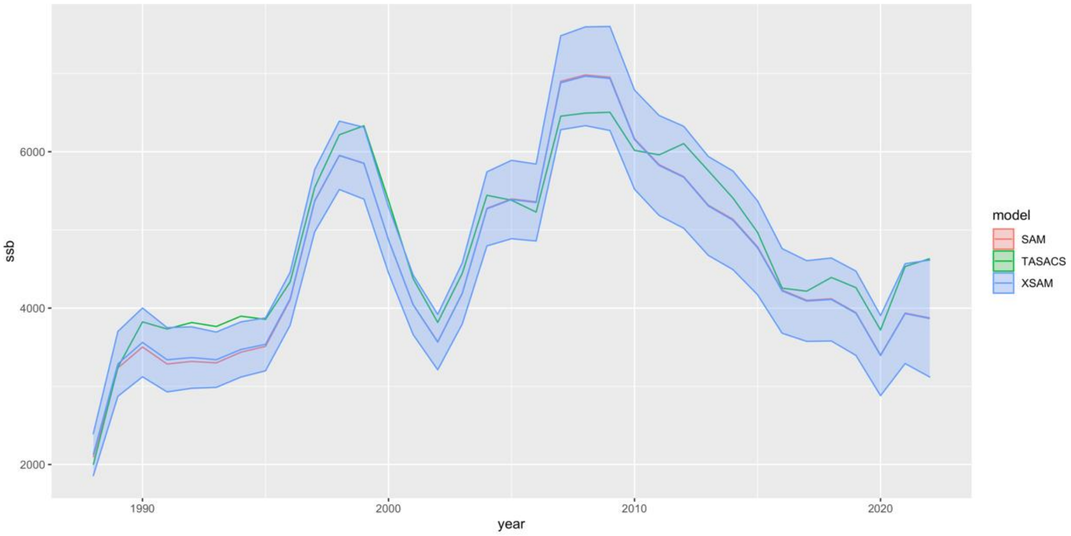

Figure 4.5.2.1.2. Comparison of SSB time-series from the final assessment from XSAM (blue) and exploratory runs from TASACS (green) following the 2008 benchmark procedure) and SAM (red) with XSAM configurations.

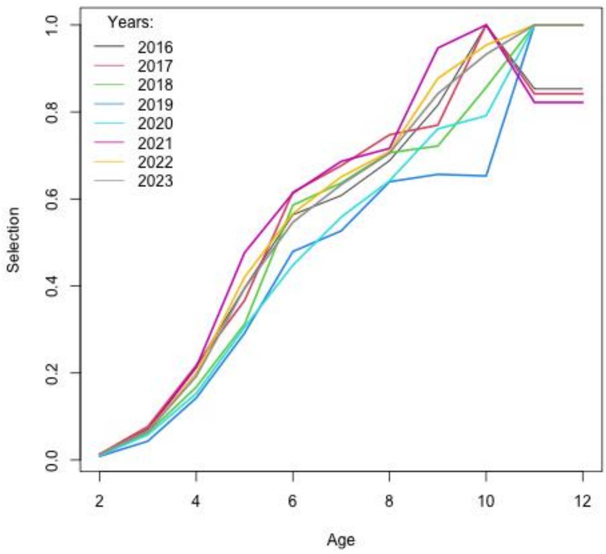

Figure 4.8.1.1. XSAM estimated selection pattern; selected years (estimates for 2016–2021 and predictions for 2022-2023) are shown in colours as indicated in the legend.

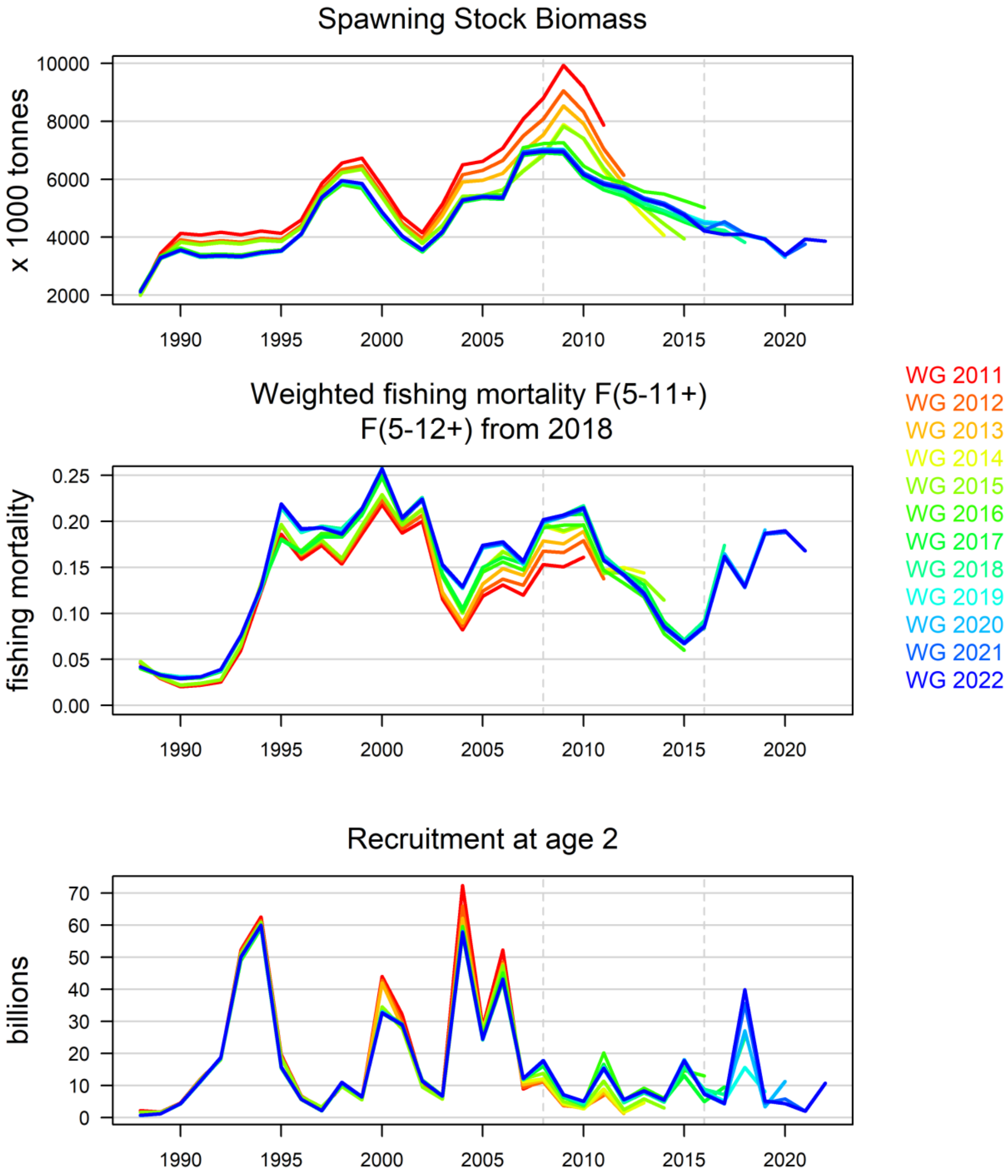

Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F(5-11/5-12+); and recruitment at age 2 with previous assessments. In 2016 the proportion mature in the years 2006-2011 was changed; recruitment age changed from 0 to 2 and fishing mortality is calculated over ages 5 to 11. In 2018 (WKNSSHREF) the age range for the fishing mortality changed to ages 5 to 12+. The vertical dotted lines indicate the benchmark years 2008 and 2016.