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 2019

ICES noted that the stock is declining but estimated to be above MSY $B_{trigger}$ (3.184 million tonnes) in 2019. Recruitment was estimated to be average or low since 2007 (2005 year-class). Fishing mortality has increased 2015 but was estimated to be below F_{MSY} in 2018.

A long-term management plan agreed by the European Union, the Faroe Islands, Iceland, Norway and the Russian Federation, is operational since 2019. ICES evaluated the plan and concluded that it is in accordance with the precautionary approach (ICES, 2018b). The management plan implied maximum catches of 525 594 t in 2020.

4.2 The fishery in 2019

4.2.1 Description and development of the fisheries

The distribution of the 2019 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 2019 herring fishing pattern was similar to recent years and the proportion of landings among quarters was similar to the fishery in 2018. 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 had moved into Faroese, Icelandic and Greenlandic waters (Figure 4.2.1.2 quarter 3). In autumn, the fishery partly shifted to the overwintering area in the fjords and oceanic areas off Lofoten, and the central part of the Norwegian Sea. 64% of the catches were taken in the fourth quarter, mainly in the international part of the Norwegian Sea (Figure 4.2.1.2 quarter 4). Catches of Norwegian spring-spawning herring inside the NEAFC regulatory area was estimated by the working group to be 281 092 tonnes in 2019, which represents 36% of the total catch.

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 and was mainly distributed in the eastern and north-eastern part of the Norwegian Sea during this year's ecosystem surveys. These herring concentrations in the eastern part of the Norwegian Sea represent a change in the distribution compared to earlier years, however, the distribution of older herring seems similar to earlier years. 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. The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May-July 2020 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 2019 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Russia, the UK (Scotland), Poland and Sweden. The total working group catch in 2019 was 777 165 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of maximum 525 594 tonnes. The majority of the catches (90%) were taken in area 2.a as in previous years. Samples were not provided by Greenland, The Netherlands, UK, Poland or Sweden (less than 2 % of the total catch were taken by these countries). Sampled catches accounted for 97 % of the total catches, which is on a similar level as in previous years. The sampling levels of catches in 2019 in total, by country and by ICES division is shown in Table 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. 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.

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 the herring. Although discarding may occur on this stock, it is considered to be low and a minor problem to the assessment. This is confirmed by estimates from sampling programmes carried out by some EU countries in the Data Collection Framework. Estimates on 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 years are shown in Table 4.4.3.1. The numbers are calculated using the SALLOC software. In 2019, about 25 % of the catches (in numbers) were taken from the 2013 year-class, followed by the 2011 and 2006 year classes (both contributing about 10% each).

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 2019 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. 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 (2010) decided to use average back-calculated maturity for "normal" and "big" year classes, respectively and 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 2020 the year 2015 could be 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 2020 assessment where several survey indices of this year-class are included, and maturity at age 4 was set to 0.1 for this year-class in the 2020 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 and spawning survey in 2020 are available as working documents to this report. The spawning survey and IESNS in the Norwegian Sea were carried out successfully in 2020, however, the Barents Sea part of IESNS ("Fleet 4") was not carried out in 2020 due to technical issues with the Russian vessel.

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 are 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 2010-2018 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 2015–2019, for Fleet 4 estimates of sampling errors are available for 2009–2019, and for Fleet 5 for 2008–2019. Missing values for sampling variances are imputed using the Taylor function which provides good fits (R^2_{adj}'s are 0.95, 0.98, 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 took place in 2008. The assessment tool TASACS was then chosen to be the standard assessment tool for the stock. The second benchmark took place in 2016 (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 2020

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 2020 assessment, *i.e.* the catch prediction for 2020 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 notice that this has marginal effect on the assessment, but larger effects on the prediction and short-term forecast.

This year's 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), but estimating a scaling constant common for all input data to allow additional variability in the input data that is not controlled by sampling. Other details in 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, the considered age-span was 3–12+ with input data catch-at-age, Fleet 1 and Fleet 5 and in 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 is 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. Input data are listed in Table C.1.1 in the Stock Annex.

The parameter estimates 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) is rather imprecise. The estimate of the scaling constant h is larger than 1 showing 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 and σ_2^2 (variability in the AR process for time varying selectivity) 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 weak 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. The 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 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. 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 which is within the estimated levels of precision (Figure 4.5.1.7), and has a reasonably low Mohn's rho value of ~0.01 (Mohn, 1999; Brooks and Legault, 2016). Note that the retrospective estimates 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. . Here we see a fairly good temporal match between the model estimate of SSB and the survey SSBs 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 2017 to

2019, but a decrease in 2020. It is worth noticing 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. However, the effect on the final assessment is to lift the point estimate of SSB and increase the uncertainty which is in accordance with the data used (Figure 4.5.1.9).

The final assessment results are shown in Figure 4.5.1.9. The estimate of fishing mortality for 2019 is rather high, as a response to the high catch in 2019 with a point estimate of 0.191. In 2018 the fishing mortality is estimated to be lower than 2017 and 2019 (F=0.131 with 95% confidence interval between 0.098-0.164), but still higher than in 2015. The spawning stock shows a declining trend since 2009, and the 95% confidence interval of the stock level in 2020 ranges from ~2.682 to ~3.948 million tonnes with a point estimate of 3.315 which is barely above B_{mp}=3.184 million tonnes, such that the probability of the stock being above B_{lim}=2.5 million tonnes is high. Note the rather large uncertainty in the absolute levels since the peak in 2009 with the further increase in the most recent years. This high uncertainty is a result of the conflicting signals in data concerning the degree of decrease in the stock over this time period.

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 – 2020. The model was run with catch data from 1988 to 2019, and projected forwards through 2020 assuming Fs in 2020 equal to those in 2019, to include survey data from 2020. 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 in 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 in StoX. Additionally, there is no new data for fleet 4 since this survey was not conducted in 2020.

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 in Figure 4.5.2.1.2. The time-series of SSB show similar trends for XSAM and TASACS. For most of the years, the estimates from TASACS are within the confidence limits estimated by XSAM. The SSB on 1 January 2020 is estimated by TASACS to be 3.447 million tonnes, which is slightly higher than the estimated value (point estimate) from XSAM.

4.6 NSSH reference points

ICES last reviewed the reference points of Norwegian spring spawning herring in April 2018 by WKNSSHREF (ICES, 2018a). ICES concluded that B_{lim} should remain unchanged at 2.5 million tonnes and $MSYB_{trigger}$ = B_{pa} was estimated at 3.184 million tonnes. F_{MSY} was estimated at the reference point workshop, but during the Management Strategy Evaluation WKNSSHMSE (ICES, 2018b) the fishing mortality reference points were revisited, because issues were found with numerical instability and settings during the reference point workshop. F_{MSY} was re-estimated at 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 but B_{pa} was estimated at 3.184 million tonnes. WKNSSHMSE estimated F_{pa}=0.227.

4.6.2 MSY reference points

The MSY reference points were evaluated by WKNSSHREF and WKNSSHMSE in 2018. In the ICES MSY framework Bpa 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 2020 is estimated by XSAM to be 3.315 million tonnes which is above B_{pa} (3.184 million t). The stock is declining and the SSB time-series from the 2020 assessment is consistent with the SSB time-series from the 2019 assessment. In the last 20 years, several large year classes have been produced (1998, 1999, 2002, and 2004). The year classes 2005-2015 are estimated to be average or small, while the 2016 year-class is estimated to be above average in the 2020 assessment. Fishing mortality in 2019 is estimated to be 0.186 which is above the management plan F (0.140) that was used to give advice for 2019. A new management plan was implemented for the 2019 advisory year.

4.8 NSSH Catch predictions for 2020

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. As Fleet 4 was not conducted in 2020, *i.e.* no observation of age 2, the number-at-age 2 from the final assessment is equal to the median stochastic recruitment base on the years 1988-2019. The catch weight-at-age, used in the forecast, is the average of the observed catch weights over the last 3 years (2017—2019).

For the weight-at-age in the stock, the values for 2020 were obtained from the commercial fisheries in the wintering areas in January. For the years 2021 and 2022 the average of the last 3 years (2018 —2020) 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 (1988-2020) 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

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

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 2020. Therefore, to obtain an estimate of the total catch to be used as input for the catch-constraint projections for 2020, the sum of the unilateral quotas was used. In total, the expected outtake from the stock in 2020 amounts to 693 915 tonnes. F in 2020 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 693 915 tonnes is taken in 2020, it is expected that the SSB will increase from 3.315 million tonnes on 1 January in 2020 to 3.505 million tonnes in 2021. The weighted F over ages 5-12+ is 0.187. The model estimates the catch in 2021 to be dominated by three age groups, age 5 (24.9%), age 8 (19.3%), and age 12+ (23.2%).

4.9 Comparison with previous assessment

A comparison between the assessments 2008—2020 is shown in Figure 4.9.1. In the years 2008—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 2019 and weighted F in 2018 as estimated in 2019 and 2020.

	ICES 2019	WG 2020	%difference
SSB (2019)	3 965	3 916	-1.2%
Weighted F (2018)	0.128	0.131	2.3%

4.10 Management plans and evaluations

The current management strategy for the Norwegian spring spawning herring fishery was agreed upon 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 plan. 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 2019 is 1.2 % lower in this year's assessment). Results of exploratory runs by another model match with those of XSAM.

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 is however, estimated to be well above average in the 2020 assessment.

Between 1999 and 2018, 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 plan 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 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 (ICES, 2020a). 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 (ICES, 2020c). 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. Under the assumption that circulation patterns do not change, this situation with anomalously fresh Atlantic water in the Norwegian Sea can be expected to continue and even increase in the coming years. The relative minor cooling is due to the anomalous small local heat loss to the atmosphere during the same period.
- The cumulative spawning-stock biomass (SSB) of the three main pelagic species in the Norwegian Sea (Norwegian Spring Spawning herring, Northeast Atlantic mackerel and Blue whiting) increased from approximately 6 million tonnes in early 1980s to 14 million tonnes in the mid-2000s and has since fluctuated between 13 million tonnes and 15 million tonnes (ICES, 2020c).
- In general, the herring stock has had a more westerly feeding distribution (ICES 2020a; 2020b) in the recent years than what was previously observed. However, the relatively large 2016 year class included a more north-eastern distribution than the older age classes in the stock (ICES 2020a,b). The more 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, 2015b; 2020b). In the case of the 2016 year-class in 2020 it is known that incoming strong year classes often have different migratory patterns than the older part of the stock (Huse *et al.* 2010) but the reason for the easterly distribution is unknown.
- 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) but studies showing mackerel being more effective feeder might indicate that the herring is forced to the south western and north eastern fringe of Norwegian Sea (ICES,

2015b; 2016b; 2020b). Whilst higher zooplankton biomass in the southwest could also attract the herring in to this location zooplankton biomass is much lower in the north east (ICES, 2020b).

- 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 (IMR, Bergen RECNOR project, *Pers. Comm.*).
- Herring growth (*i.e.* length-at-age) varied over the period 1994-2015 and was negatively related to stock size (Homrum *et al.*, 2016), which indicates interaction between fish density and prey availability. Since 2015 the SSB has continued to decline but mean length of age 6 fish has remained fairly stable, even decreasing slightly (ICES, 2020c) suggesting that factors other than fish density are currently driving changes in fish size.
- The 2016 year class of herring is the strongest since the 2004 year class in the Norwegian Sea as 4 year old based on the IESNS survey 2020 (ICES, 2020a). This is indicative of good recruitment to the stock over the next ~two years.

In the winter 2017/2018, the overwintering grounds shifted northward along the coast of Norway with older individuals occurring in oceanic areas (ICES, 2020c). 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 is later in the year since the end of the 2000s.

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 5-7 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 slightly 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 have increased again (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. This fishery is now mainly in the central Norwegian Sea, north of the Faroes and east of Iceland, whereas before 2015 it used to be stretched out towards the coast of Norway and up towards the Bear Island. Changes in migration have also resulted in late arrival at the Norwegian coast for this part of the stock during the winter in recent years. The Norwegian coastal fleet (smaller vessel that cannot go that far offshore) have therefore not been able to access this herring during the winter fishery and targeted younger fish (mostly of the 2013 year-class) which overwintered in Norwegian fjords.

4.14 Recommendations

For some years there have been issues with age reading of herring. These issues were raised around 2010, and since then two scale/otolith exchanges and a workshop have been held; and a final workshop was planned after the second exchange. There were, however, concerns with the second scale/otolith exchange and the final workshop was postponed indefinitely. It is therefore recommended to organise a new scale/otolith exchange and a follow up workshop.

There are several topics to cover in the recommended work.

Firstly, age-error matrices are needed as input to the stock-assessment, to evaluate sensitivity to ageing errors, and such age-error matrices are an output of age-reading inter-calibrations.

Secondly, stock mixing is an issue. There are several herring stocks surrounding the distribution area of Norwegian spring spawning (NSS) herring *e.g.* North Sea herring, Icelandic summer spawning herring and Faroese autumn spawning herring. Mixing with these other stocks in the fringe areas of the NSS herring distribution area leads to confounding effects on the survey indices of NSS herring in the ecosystem surveys. Methods to separate the NSS herring stock from the other herring stocks are needed – both with regards to get the most accurate age-reading as well as the confounding effect on the survey indices.

Finally, the experience from earlier exchanges is that age of older fish is more prone to be underestimated when aged by otoliths. Some of the institutes mainly sample and read scales, whereas other institutes use the otoliths.

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4.16 Missing surveys and catch data for Covid-19 disruption – some recommended methods and reporting requirements.

This document contains two pieces of information for working groups that encounter issues caused by missing data as a result of the Covid-19 disruption:

1. Proposed approaches to provide ICES advice in the absence of 2020 data in one or more survey abundance series.
2. Template for reporting deviations from stock annex caused by missing information from Covid-19 disruption

1. Proposed approaches to provide ICES advice in the absence of 2020 data in one or more survey abundance series.

With the occurrence of COVID-19 in 2020, a number of scientific surveys for use in ICES stock assessments have been disrupted. In most ICES assessments, this disruption of the surveys in 2020 will only impact in the assessments to be conducted in 2021. However, there are a number of assessments that actually make use of surveys conducted in-year (a 2020 assessment makes use of a survey conducted earlier in 2020).

In cases where a survey used in a stock assessment has not been conducted, it becomes impossible to conform exactly to the methods described in the stock annex to conduct the assessment. In extreme cases, the assessment simply cannot be updated. The following describes some generic guidance for providing advice in these cases in 2020. In all cases where the stock annex was not followed, this should be adequately documented in the expert group report.

Category 1 and 2 stocks

1) All survey indices missing:

When all survey indices are missing for the most recent years, an update of the assessment is not possible. In these cases, advice could be provided by using the results of the previous assessment (e.g. using the results of the 2019 assessment) and making a two-year projection. For the first of the interim years (2019), the actual catch-at-age from the 2019 fishery would be used to calculate the 2020 interim year beginning of the year numbers.

2) Incomplete index because one or more surveys are missing.

In many cases, a number of surveys are combined to derive an index of abundance for use in a category 1 assessment. In such cases, it may be possible to 'fill-in' the index for the year where one of the survey is missing through a model-based approach. One such approach recently developed is the vector autoregressive spatio-temporal (VAST; Thorson 2019) model that can be implemented using the publicly available VAST (www.github.com/james-thorson/VAST) package. This was used in the case of Black-bellied anglerfish in Subarea 7 and divisions 8.a–b and 8.d (ank.27.78abd). Other models such as generalized linear models (GLMs) have also been used as a method of imputation for missing strata in surveys but they require some assumptions on the distribution of catches (see Rago 2005)

3) No survey for the most recent year of an index but other indices available.

In these cases, the index can still be used in the assessment providing that the model can deal with missing values for an index. It should be noted that this could be problematic if the missing value is used to provide an estimate of recruitment.

Alternatively, the index with missing data for 2020 could be left out of the model. This should only be done after a comparison showing that leaving the survey out produces results that are comparable with an analysis that uses all surveys. Comparisons between the previous assessment conducted with all indices and a similar assessment but without the index that is missing data in 2020 would be instructive in that regard.

Category 3 and 4

1) All survey indices missing:

If the advice is biennial and uses the current year survey (note that most advice in cat 3-4 would not be using the 2020 surveys), updated advice could be provided using the most recent data (in 2020, this would be using the survey index up to 2019). This would mean updating the advice on the basis of one additional point only instead of two.

If the advice is annual and uses the current year survey, then there is no additional information. In these cases if the advice was due, to consider the PA buffer (done every 3 years) then advice could be given by applying the PA buffer. If the PA buffer was not to be considered then advice would remain unchanged but the advice sheet should indicate that the survey information was not available.

2) One or more surveys missing in the calculation of a combined index.

Normally, the individual indices would first be normalized to a common period then would be averaged to produce a combined index. In the case of one or more surveys missing in this index in a particular year, the average is calculated over the available surveys. This approach has been used previously when a survey that was part of a combined index was not available.

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2. Template for reporting deviations from stock annex caused by missing information from Covid-19 disruption.

1. Stock: **Herring (*Clupea harengus*) in subareas 1, 2, and 5, and in divisions 4.a and 14.a, Norwegian spring-spawning herring (the Northeast Atlantic and the Arctic Ocean)**

2. Missing or deteriorated survey data: **Fleet 4, index of numbers at age 2 from acoustic survey in the Barents Sea was not conducted in 2020. This tuning series has a minor influence on the assessment of SSB, but since no new data on recruitment, assumptions of recruitment in 2020 had to be made**

3. Missing or deteriorated catch data: **No, 97% of catch covered by sampling programme**

4. Missing or deteriorated commercial *LPUE*/*CPUE* data: **No**

5. Missing or deteriorated biological data: (e.g. maturity data): **No**

6. Brief description of methods explored to remedy the challenge:

7. Suggested solution to the challenge, including reason for this selecting this solution: (clearly document changes from the normal procedures in the stock annex)
Instead of modelled recruitment based on fleet 4, median stochastic recruitment based on the years 1988–2019 was used as basis for recruitment in 2020

8. Was there an evaluation of the loss of certainty caused by the solution that was carried out? **Young year classes contribute very little to the fishery and there is minor effect on advice**

4.17 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

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

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

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2019.

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	21207	100	9	1024	265
Faroe Islands	113945	90	13	729	690
Germany	4188	100	42	5998	153
Greenland	3190	0	0	0	0
Iceland	108045	100	95	2747	2028
Ireland	2775	40	2	93	71
The Netherlands	5111	0	0	0	0
Norway	430507	100	94	2825	2825
Poland	1327	0	0	0	0
UK_Scotland	1801	0	0	0	0
Sweden	705	0	0	0	0
Russia	84364	100	106	16440	1389
Total for Stock	777165	97	361	29856	7421

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2019.

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
1	310	0	0	0	0	0
2.a	697777	265	265	23953	9	34
4.a	5	0	0	0	0	0
5.a	77419	64	1260	1361	16	18
5.b	1386	32	186	4542	134	3277
14.a	268	0	0	0	0	0
Total	777165	361	7421	29856	10	38

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	I	278.2	2
2	Norway	1	IIa	165553.2	
3	Norway	2	IIa	877.2	2
4	Norway	3	IIa	865.6	
5	Norway	4	IIa	262927.7	
6	Norway	1	IVa	1.8	2
7	Norway	4	IVa	3.1	5
8	Iceland	3	IIa	919	
9	Iceland	4	IIa	48638	
10	Iceland	3	Va	56600	
11	Iceland	4	Va	1888	
12	Faroes	2	IIa	940	
13	Faroes	3	IIa	9270	4,8,21
14	Faroes	4	IIa	84531	
15	Faroes	4	Vb	5	11,23
16	Faroes	3	Va	16993	
17	Faroes	4	Va	1938	11
18	Faroes	3	XIVb	268	16
19	Russia	2	I	32	21
20	Russia	2	IIa	31.5	12
21	Russia	3	IIa	14916	
22	Russia	4	IIa	68003	
23	Russia	3	Vb	1381	
24	Germany	4	IIa	4188.465	
25	Denmark	1	IIa	7222.951	
26	Denmark	4	IIa	13984.33	
27	Greenland	3	IIa	991	4,8,21
28	Greenland	4	IIa	2199	5,9,14,22,24,26,30

Line	Country	Quarter	Div.	Catch (T)	Samples allocated (line)
29	Ireland	1	IIa	1676.914	2,25
30	Ireland	4	IIa	1098.5	
31	Netherlands	4	IIa	5110.8	5,9,14,22,24,26,30
32	Poland	4	IIa	1326.6	5,9,14,22,24,26,30
33	Sweden	1	IIa	705	2,25
34	Scotland	1	IIa	1801	2,25

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
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700

	AGE															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0

	AGE														
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811

Year	AGE 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
2017	0	618	16390	64275	305483	114976	248192	162566	289931	98836	133145	276874	107473	220368	22357	49442

Year	AGE 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

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

Year	age 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
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

	age															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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									
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						

	age															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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		
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		

	age														
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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
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

Year	age 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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

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

Year	AGE 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

	AGE														
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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
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

	AGE															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
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
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

	AGE																
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**		**15+**
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
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

Year	AGE 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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
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

**** 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	0.4	0.8	1	1	1	1	1	1	1	1	1	1
2017	0	0	0	0	0.4	0.8	1	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

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

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 2009–2019 are estimated with StoX (mean of bootstrap with 1000 iterations). "Fleet 4".

	AGEe				
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

	AGEe				
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***					

***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 2008-2020 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

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	0.362	0.197	0.263	0.100	0.358	0.482	0.414	0.312	0.365	0.524	0.375
1989	0.263	0.520	0.484	0.421	0.118	0.491	0.779	0.820	0.499	0.657	0.675
1990	0.306	0.289	0.534	0.333	0.343	0.132	0.670	0.636	0.580	0.550	0.594
1991	0.497	0.371	0.526	0.652	0.311	0.365	0.133	0.544	0.926	1.566	0.627
1992	0.662	0.327	0.241	0.438	0.687	0.332	0.419	0.132	0.545	0.836	0.641
1993	0.389	0.253	0.167	0.178	0.368	0.483	0.250	0.289	0.109	NA	NA
1994	0.376	0.243	0.165	0.113	0.145	0.306	0.375	0.232	0.236	0.095	0.425
1995	0.699	0.203	0.115	0.096	0.095	0.131	0.306	0.304	0.191	0.180	0.085
1996	0.248	0.238	0.092	0.072	0.084	0.110	0.168	0.420	0.387	0.194	0.087
1997	0.275	0.157	0.124	0.069	0.066	0.090	0.117	0.199	0.283	0.243	0.104
1998	0.181	0.190	0.129	0.113	0.069	0.077	0.112	0.157	0.223	0.262	0.131
1999	0.437	0.154	0.235	0.155	0.108	0.071	0.079	0.122	0.167	0.313	0.137
2000	0.313	0.180	0.099	0.237	0.165	0.110	0.076	0.081	0.133	0.189	0.155
2001	0.577	0.169	0.147	0.108	0.230	0.172	0.121	0.087	0.102	0.187	0.208
2002	0.198	0.137	0.095	0.127	0.117	0.249	0.174	0.125	0.094	0.116	0.181
2003	0.451	0.186	0.118	0.091	0.143	0.145	0.271	0.187	0.133	0.099	0.124
2004	0.221	0.266	0.175	0.108	0.092	0.165	0.154	0.258	0.209	0.144	0.094
2005	0.281	0.106	0.173	0.144	0.095	0.084	0.16	0.159	0.231	0.195	0.096
2006	0.218	0.186	0.091	0.181	0.144	0.091	0.089	0.177	0.185	0.248	0.112
2007	0.371	0.132	0.113	0.068	0.149	0.129	0.091	0.102	0.216	0.262	0.146
2008	0.159	0.234	0.100	0.094	0.063	0.137	0.127	0.098	0.113	0.250	0.150
2009	0.164	0.139	0.150	0.078	0.085	0.067	0.152	0.126	0.108	0.130	0.155
2010	0.198	0.169	0.135	0.139	0.081	0.092	0.074	0.143	0.141	0.116	0.127
2011	0.128	0.198	0.168	0.130	0.135	0.090	0.100	0.095	0.176	0.162	0.137
2012	0.323	0.134	0.212	0.161	0.123	0.126	0.090	0.119	0.114	0.208	0.159
2013	0.280	0.200	0.124	0.189	0.164	0.123	0.129	0.097	0.144	0.151	0.215
2014	0.647	0.253	0.202	0.126	0.211	0.189	0.138	0.151	0.112	0.181	0.183
2015	0.501	0.302	0.205	0.209	0.149	0.239	0.194	0.148	0.168	0.137	0.18
2016	0.555	0.218	0.221	0.164	0.179	0.146	0.209	0.188	0.143	0.172	0.126

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2017	0.301	0.196	0.120	0.163	0.128	0.146	0.122	0.171	0.156	0.124	0.110
2018	0.273	0.261	0.200	0.125	0.150	0.142	0.166	0.141	0.179	0.171	0.102
2019	0.566	0.150	0.196	0.140	0.099	0.151	0.133	0.161	0.145	0.155	0.100
2020	0.351	0.216	0.189	0.170	0.168	0.181	0.201	0.213	0.228	0.290	0.237

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	0.318	0.336	0.163	0.452	0.551	0.690	0.541	0.603	0.515	NA
1989	0.648	0.329	0.440	0.190	0.430	0.690	0.881	0.492	NA	0.492
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	0.431	0.507	0.268	0.304	0.479	0.678	0.398	0.505	0.226	0.755
1995	0.309	0.183	0.199	0.223	0.338	0.616	NA	0.426	0.492	0.214
1996	0.376	0.222	0.163	0.214	0.266	0.337	NA	NA	0.403	0.228
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.336	0.260	0.203	0.147	0.162	0.225	0.290	0.387	0.520	0.229
1999	0.235	0.323	0.242	0.208	0.157	0.168	0.231	0.300	0.407	0.278
2000	0.281	0.209	0.423	0.305	0.251	0.187	0.205	0.302	0.503	0.356
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	0.356	0.283	0.219	0.174	0.161	0.288	0.301	0.391	0.439	0.214
2006	0.441	0.173	0.295	0.266	0.197	0.198	0.422	0.446	0.616	0.308
2007	0.323	0.232	0.148	0.270	0.284	0.203	0.200	0.399	0.359	0.259
2008	0.507	0.210	0.205	0.159	0.299	0.306	0.234	0.234	0.388	0.315
2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Year/Age	3	4	5	6	7	8	9	10	11	12+
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	0.297	0.206	0.276	0.199	0.319	0.280	0.207	0.273	0.167	0.215
2016	0.371	0.356	0.290	0.323	0.219	0.355	0.300	0.204	0.284	0.180
2017	0.422	0.254	0.285	0.266	0.312	0.243	0.378	0.367	0.221	0.194
2018	0.396	0.229	0.206	0.307	0.268	0.286	0.253	0.310	0.322	0.197
2019	0.322	0.335	0.262	0.192	0.275	0.266	0.283	0.255	0.277	0.184
2020	0.517	0.196	0.293	0.248	0.198	0.298	0.289	0.324	0.284	0.224

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

Year/Age	2
1991	0.430
1992	0.370
1993	0.337
1994	0.298
1995	0.405
1996	0.681
1997	0.899
1998	0.437
1999	0.434
2000	0.334
2001	0.406
2002	0.449
2003	NA
2004	NA
2005	0.440
2006	0.322
2007	0.453

Year/Age	2
2008	0.639
2009	0.662
2010	0.526
2011	0.449
2012	0.939
2013	0.490
2014	0.465
2015	0.380
2016	0.425
2017	0.466
2018	0.358
2019	0.484
2020	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	0.201	0.135	0.152	0.193	0.237	0.345	0.773	0.911	0.437	0.215
1997	0.271	0.208	0.140	0.152	0.227	0.246	0.423	0.516	0.378	0.218
1998	0.357	0.275	0.198	0.145	0.162	0.237	0.296	0.421	NA	0.327
1999	0.234	0.368	0.284	0.216	0.157	0.183	0.292	0.388	0.987	0.374
2000	0.262	0.221	0.495	0.353	0.264	0.176	0.189	0.248	0.383	0.417
2001	0.170	0.258	0.257	0.423	0.410	0.213	0.188	0.268	0.492	0.420
2002	0.182	0.164	0.259	0.298	0.355	0.292	0.240	0.226	0.259	0.430
2003	0.180	0.163	0.163	0.255	0.303	0.444	0.399	0.243	0.229	0.237
2004	0.254	0.190	0.154	0.160	0.276	0.320	0.518	0.370	0.358	0.226
2005	0.139	0.262	0.246	0.182	0.189	0.311	0.352	0.449	0.386	0.238
2006	0.372	0.149	0.260	0.238	0.180	0.177	0.308	0.305	0.426	0.234
2007	0.219	0.185	0.138	0.266	0.239	0.179	0.187	0.312	0.333	0.220
2008	0.311	0.159	0.170	0.148	0.254	0.232	0.193	0.221	0.330	0.275
2009	0.244	0.231	0.156	0.169	0.164	0.237	0.258	0.224	0.261	0.297

Year/Age	3	4	5	6	7	8	9	10	11	12+
2010	0.321	0.231	0.244	0.170	0.185	0.186	0.287	0.289	0.281	0.302
2011	0.287	0.249	0.208	0.224	0.166	0.198	0.200	0.299	0.284	0.277
2012	0.218	0.347	0.309	0.247	0.224	0.199	0.242	0.235	0.375	0.276
2013	0.304	0.208	0.344	0.271	0.243	0.218	0.197	0.221	0.243	0.245
2014	0.266	0.298	0.221	0.304	0.274	0.224	0.232	0.220	0.274	0.263
2015	0.343	0.263	0.273	0.208	0.264	0.270	0.214	0.226	0.197	0.239
2016	0.208	0.254	0.233	0.246	0.224	0.286	0.275	0.244	0.242	0.198
2017	0.285	0.199	0.269	0.254	0.294	0.259	0.369	0.302	0.281	0.195
2018	0.281	0.240	0.186	0.283	0.259	0.321	0.265	0.360	0.309	0.192
2019	0.224	0.308	0.234	0.195	0.272	0.268	0.285	0.268	0.294	0.205
2020	0.336	0.153	0.329	0.281	0.226	0.298	0.314	0.343	0.307	0.227

Table 4.5.1.1. Norwegian spring-spawning herring. Parameter estimates of the final XSAM model fit. The estimates from the final 2019 assessment are also shown.

Parameter	Estimate	Std. Error	CV	Estimate 2019	Std. Error 2019
$\log(N_{3,1988})$	7.079	0.168	0.024	7.075	0.17
$\log(N_{4,1988})$	6.611	0.208	0.031	6.604	0.209
$\log(N_{5,1988})$	9.583	0.070	0.007	9.584	0.076
$\log(N_{6,1988})$	4.813	0.378	0.079	4.812	0.369
$\log(N_{7,1988})$	3.498	0.524	0.150	3.487	0.506
$\log(N_{8,1988})$	3.068	0.583	0.190	3.115	0.554
$\log(N_{9,1988})$	4.062	0.453	0.112	4.08	0.445
$\log(N_{10,1988})$	3.269	0.659	0.202	3.275	0.645
$\log(N_{11,1988})$	3.161	0.690	0.218	3.054	0.693
$\log(N_{12,1988})$	3.557	0.746	0.210	3.502	0.728
$\log(q_3^{F1})$	-9.633	0.182	0.019	-9.594	0.188
$\log(q_4^{F1})$	-8.073	0.130	0.016	-8.102	0.138
$\log(q_5^{F1})$	-7.547	0.120	0.016	-7.555	0.125
$\log(q_6^{F1})$	-7.299	0.119	0.016	-7.31	0.124
$\log(q_7^{F1})$	-7.134	0.130	0.018	-7.165	0.138

Parameter	Estimate	Std. Error	CV	Estimate 2019	Std. Error 2019
$\log(q_8^{F1})$	-6.925	0.094	0.014	-6.925	0.099
$\log(q_2^{F4})$	-14.304	0.179	0.012	-14.304	0.177
$\log(q_3^{F5})$	-7.637	0.108	0.014	-7.609	0.111
$\log(q_4^{F5})$	-7.105	0.097	0.014	-7.157	0.1
$\log(q_5^{F5})$	-6.922	0.096	0.014	-6.911	0.098
$\log(q_6^{F5})$	-6.795	0.098	0.014	-6.779	0.101
$\log(q_7^{F5})$	-6.720	0.104	0.016	-6.707	0.108
$\log(q_8^{F5})$	-6.536	0.111	0.017	-6.533	0.114
$\log(q_9^{F5})$	-6.527	0.123	0.019	-6.517	0.127
$\log(q_{10}^{F5})$	-6.469	0.138	0.021	-6.477	0.143
$\log(q_{11}^{F5})$	-6.424	0.135	0.021	-6.442	0.143
$\log(\sigma_1^2)$	-5.000	1.420	0.284	-5	1.472
$\log(\sigma_2^2)$	-2.730	0.255	0.094	-2.718	0.271
$\log(\sigma_4^2)$	-2.204	0.308	0.140	-2.167	0.31
$\log(\sigma_R^2)$	-0.082	0.261	3.186	-0.146	0.261
$\log(h)$	1.575	0.066	0.042	1.587	0.068
μ_R	9.329	0.176	0.019	9.344	0.173
α_Y	-0.519	0.307	0.591	-0.537	0.311
β_Y	0.808	0.111	0.137	0.806	0.112
α_{2U}	-1.238	0.169	0.137	-1.241	0.172
α_{3U}	-0.625	0.098	0.157	-0.621	0.1
α_{4U}	-0.219	0.062	0.284	-0.215	0.064
α_{5U}	0.045	0.053	1.165	0.046	0.054
α_{6U}	0.200	0.057	0.284	0.201	0.059
α_{7U}	0.264	0.061	0.233	0.265	0.063
α_{8U}	0.326	0.068	0.208	0.324	0.07
α_{9U}	0.365	0.074	0.202	0.364	0.076
α_{10U}	0.415	0.080	0.193	0.431	0.082
β_U	0.604	0.054	0.089	0.602	0.054

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	660	1187	743	14520	123	33	22	58	26	24	35
1989	1171	255	957	621	12006	101	27	16	40	16	42
1990	4307	471	215	810	521	10003	84	22	12	29	46
1991	11401	1745	400	182	681	435	8356	69	17	10	60
1992	18620	4630	1494	341	154	572	365	6964	57	14	57
1993	49953	7564	3970	1269	286	129	477	303	5758	46	58
1994	59830	20288	6480	3348	1035	231	105	386	244	4561	81
1995	15722	24290	17375	5457	2623	775	177	81	298	183	3430
1996	5704	6375	20751	14548	4164	1751	506	128	59	205	2235
1997	2156	2308	5411	17165	11130	2799	1123	331	89	40	1353
1998	10836	870	1914	4357	13077	7744	1744	658	205	54	753
1999	6446	4375	716	1478	3359	9566	5415	1115	408	121	456
2000	32789	2610	3645	559	1128	2493	6782	3628	696	241	297
2001	28974	13285	2184	2720	418	828	1779	4630	2236	406	264
2002	11399	11747	11267	1740	1994	312	613	1279	3211	1476	443
2003	6675	4615	9925	9097	1282	1396	226	429	868	2134	1277
2004	57781	2706	3909	8204	7143	944	1019	164	302	584	2230
2005	24348	23447	2300	3258	6632	5500	702	738	119	212	1744
2006	42944	9875	19826	1895	2604	5076	3892	478	499	78	1122
2007	12059	17417	8397	16406	1524	2036	3721	2666	330	345	700
2008	17566	4884	14774	6915	12587	1154	1490	2532	1766	222	709
2009	7036	7086	4132	12175	5348	8774	814	1024	1618	1113	618
2010	5004	2822	5931	3391	9410	3804	5700	545	636	964	1063
2011	15176	2008	2352	4873	2701	7093	2649	3548	341	391	1095
2012	5323	6090	1677	1929	3926	2108	5343	1797	2365	221	938
2013	8062	2152	5097	1383	1552	3108	1611	3922	1266	1652	812
2014	5299	3266	1813	4177	1114	1229	2419	1203	2867	913	1922
2015	18059	2150	2778	1512	3390	902	984	1902	921	2159	2264
2016	7769	7332	1835	2338	1249	2764	734	788	1503	713	3528

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2017	4537	3154	6255	1539	1915	1000	2203	579	613	1143	3286
2018	27096	1839	2667	5131	1218	1428	733	1594	418	421	3153
2019	3305	10991	1561	2219	4145	926	1072	540	1179	302	2502
2020	11255	1340	9310	1285	1747	3067	670	744	373	827	1761

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	0.065	0.029	0.040	0.045	0.046	0.150	0.231	0.351	0.178	0.178
1989	0.011	0.021	0.017	0.027	0.033	0.036	0.078	0.110	0.153	0.092	0.092
1990	0.004	0.012	0.015	0.024	0.031	0.030	0.053	0.073	0.099	0.071	0.071
1991	0.001	0.005	0.011	0.019	0.025	0.025	0.032	0.044	0.057	0.048	0.048
1992	0.001	0.004	0.013	0.024	0.030	0.030	0.035	0.040	0.055	0.056	0.056
1993	0.001	0.005	0.020	0.054	0.063	0.059	0.064	0.069	0.083	0.104	0.104
1994	0.001	0.005	0.022	0.094	0.140	0.115	0.100	0.108	0.135	0.152	0.152
1995	0.003	0.007	0.028	0.120	0.254	0.275	0.177	0.171	0.222	0.330	0.330
1996	0.005	0.014	0.040	0.118	0.247	0.294	0.274	0.212	0.243	0.440	0.440
1997	0.008	0.037	0.067	0.122	0.213	0.323	0.384	0.328	0.352	0.465	0.465
1998	0.007	0.044	0.108	0.110	0.163	0.208	0.297	0.329	0.381	0.422	0.422
1999	0.004	0.032	0.099	0.120	0.148	0.194	0.250	0.321	0.374	0.512	0.512
2000	0.003	0.028	0.143	0.140	0.160	0.187	0.232	0.334	0.390	0.562	0.562
2001	0.003	0.015	0.078	0.161	0.142	0.150	0.180	0.216	0.266	0.264	0.264
2002	0.004	0.019	0.064	0.155	0.206	0.173	0.206	0.238	0.259	0.257	0.257
2003	0.003	0.016	0.040	0.092	0.156	0.164	0.171	0.204	0.247	0.275	0.275
2004	0.002	0.013	0.032	0.063	0.111	0.145	0.173	0.174	0.204	0.328	0.328
2005	0.002	0.018	0.044	0.074	0.118	0.196	0.235	0.241	0.265	0.405	0.405
2006	0.002	0.012	0.039	0.068	0.096	0.160	0.228	0.220	0.219	0.389	0.389
2007	0.004	0.015	0.044	0.115	0.128	0.162	0.235	0.262	0.247	0.238	0.238
2008	0.008	0.017	0.043	0.107	0.211	0.199	0.225	0.298	0.312	0.260	0.260
2009	0.014	0.028	0.048	0.108	0.191	0.281	0.253	0.326	0.368	0.338	0.338
2010	0.013	0.032	0.046	0.078	0.133	0.212	0.324	0.319	0.337	0.465	0.465

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2011	0.013	0.030	0.048	0.066	0.098	0.133	0.238	0.256	0.281	0.310	0.310
2012	0.006	0.028	0.043	0.068	0.084	0.119	0.159	0.201	0.209	0.206	0.206
2013	0.004	0.021	0.049	0.067	0.083	0.100	0.142	0.163	0.177	0.098	0.098
2014	0.002	0.012	0.032	0.059	0.061	0.072	0.091	0.117	0.134	0.075	0.075
2015	0.001	0.008	0.023	0.041	0.054	0.056	0.073	0.086	0.107	0.076	0.076
2016	0.002	0.009	0.026	0.049	0.072	0.077	0.087	0.101	0.123	0.105	0.105
2017	0.003	0.017	0.048	0.084	0.143	0.161	0.173	0.175	0.225	0.190	0.190
2018	0.002	0.014	0.034	0.064	0.124	0.137	0.156	0.152	0.177	0.206	0.206
2019	0.003	0.016	0.045	0.089	0.151	0.174	0.215	0.218	0.205	0.315	0.315
2020	0.003	0.016	0.045	0.089	0.144	0.166	0.200	0.211	0.215	0.307	0.307

able 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 Pressure: F Ages 5-12	High	Low
1988	660	977	342	2122	2404	1840	135	0.042	0.06	0.025
1989	1171	1654	687	3281	3717	2844	104	0.033	0.048	0.019
1990	4307	5356	3259	3551	4014	3088	86	0.03	0.043	0.017
1991	11401	13374	9429	3328	3760	2895	85	0.031	0.045	0.017
1992	18620	21410	15830	3354	3767	2941	104	0.039	0.055	0.022
1993	49953	55595	44310	3326	3697	2954	232	0.076	0.101	0.051
1994	59830	66137	53523	3456	3826	3086	479	0.128	0.161	0.095
1995	15722	18168	13277	3524	3879	3169	906	0.218	0.261	0.175
1996	5704	6863	4546	4107	4464	3750	1220	0.191	0.224	0.158
1997	2156	2733	1578	5365	5789	4941	1427	0.194	0.223	0.164
1998	10836	12679	8993	5939	6405	5473	1223	0.188	0.219	0.157
1999	6446	7705	5187	5827	6316	5339	1235	0.214	0.25	0.178
2000	32789	36929	28648	4848	5297	4400	1207	0.258	0.304	0.212
2001	28974	32798	25151	4020	4423	3617	766	0.204	0.244	0.164
2002	11399	13364	9433	3548	3923	3174	808	0.225	0.269	0.181
2003	6675	8002	5348	4180	4595	3766	790	0.152	0.182	0.122

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
2004	57781	64349	51213	5272	5774	4769	794	0.128	0.153	0.103
2005	24348	27911	20785	5399	5929	4868	1003	0.173	0.206	0.14
2006	42944	48551	37336	5364	5886	4842	969	0.177	0.212	0.141
2007	12059	14310	9808	6904	7547	6261	1267	0.156	0.185	0.126
2008	17566	20592	14540	6988	7668	6308	1546	0.201	0.238	0.165
2009	7036	8524	5547	6956	7679	6233	1687	0.207	0.243	0.171
2010	5004	6141	3867	6160	6858	5463	1457	0.215	0.256	0.175
2011	15176	17977	12375	5815	6528	5103	993	0.16	0.192	0.128
2012	5323	6570	4076	5650	6384	4916	826	0.142	0.173	0.112
2013	8062	9894	6231	5277	5994	4560	685	0.122	0.15	0.094
2014	5299	6719	3879	5086	5802	4370	461	0.086	0.106	0.065
2015	18059	22277	13841	4719	5400	4038	329	0.069	0.087	0.05
2016	7769	10236	5303	4477	5119	3835	383	0.087	0.11	0.065
2017	4537	6457	2617	4450	5081	3820	722	0.165	0.205	0.125
2018	27096	37286	16906	4072	4697	3447	593	0.131	0.164	0.098
2019	3305	6131	479	3916	4569	3263	777	0.191	0.24	0.141
2020	11255	32781	0	3315	3948	2682				

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
Average	16341	19711	13283	4654	5186	4123	791	0.145	0.175	0.114

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	2020							
	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	11255	0.9	0	0	0	0.054	0.003	0.152
3	1340	0.15	0	0	0	0.104	0.016	0.207
4	9310	0.15	0.1	0	0	0.150	0.043	0.239
5	1285	0.15	0.8	0	0	0.203	0.086	0.279
6	1747	0.15	1	0	0	0.266	0.138	0.314
7	3067	0.15	1	0	0	0.301	0.159	0.341
8	670	0.15	1	0	0	0.328	0.192	0.359
9	744	0.15	1	0	0	0.343	0.203	0.379
10	374	0.15	1	0	0	0.358	0.206	0.393
11	827	0.15	1	0	0	0.366	0.294	0.399
12	1761	0.15	1	0	0	0.379	0.294	0.409

Input for	2021 and 2022							
	Stockno.	Natural	Maturity	Proportion of M	Proportion of F	Weight	Exploitation	Weight
age	1-Jan.	mortality	ogive (2021/2022)	before spawning	before spawning	in stock	pattern	in catch
2	11255	0.9	0/0	0	0	0.054	0.012	0.152
3		0.15	0/0	0	0	0.108	0.057	0.207
4		0.15	0.4/0.4	0	0	0.150	0.158	0.239
5		0.15	0.6/0.8	0	0	0.210	0.312	0.279
6		0.15	1/0.9	0	0	0.268	0.486	0.314
7		0.15	1/1	0	0	0.300	0.565	0.341
8		0.15	1/1	0	0	0.324	0.672	0.359
9		0.15	1/1	0	0	0.347	0.722	0.379
10		0.15	1/1	0	0	0.357	0.767	0.393
11		0.15	1/1	0	0	0.363	1	0.399
12		0.15	1/1	0	0	0.378	1	0.409

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

Basis:	
SSB (2020):	3.315 million t
Landings(2020):	693 915 t (sum of national quotas)
SSB(2021):	3.505 million t
Fw5-12+(2020)	0.187
Recruitment(2020-2022):	11.255, 11.255, 11.255

The catch options:

Rationale	Catches (2021)	Basis	FW (2021)	SSB (2022)	P(SSB2022 <Blim)	% SSB change	%TAC change	%CATCH change
Management strategy	651033	F=0.14	0.14 (0.110,0.189)*	3.683 (2.780,4.984)*	0.005	5 (-21,42)*	24	-6
Fmsy	722694	F=0.157	0.157 (0.122,0.211)*	3.623 (2.663,4.846)*	0.006	3 (-24,38)*	38	4
Zero Catch	0	F=0	0	4.225(3.330,5.421)*	0	21 (-5,55)*	-100	-100
Fpa	1004581	0.227	0.227 (0.178,0.308)*	3.390 (2.497,4.718)*	0.026	-3 (-29,35)*	91	45
Flim	1242950	0.291	0.232 (0.229,0.408)*	3.195 (2.298,4.356)*	0.086	-9 (-34,24)*	136	79
$SSB_{2022}=B_{lim}$	2099298	F=0.568	0.568 (0.438,0.912)*	2.500 (1.613,3.682)*	0.532	-29 (-54,-5)*	299	203
$SSB_{2022}=B_{pa}$	1256299	F=0.295	0.295 (0.227,0.416)*	3.184 (2.274,4.463)*	0.074	-9 (-35,27)	139	81
Status quo	846569	F=0.187	0.187 (0.143,0.258)*	3.521 (2.585,4.796)*	0.017	0 (-26,37)*	64.1	22

***95% confidence interval**

4.18 Figures

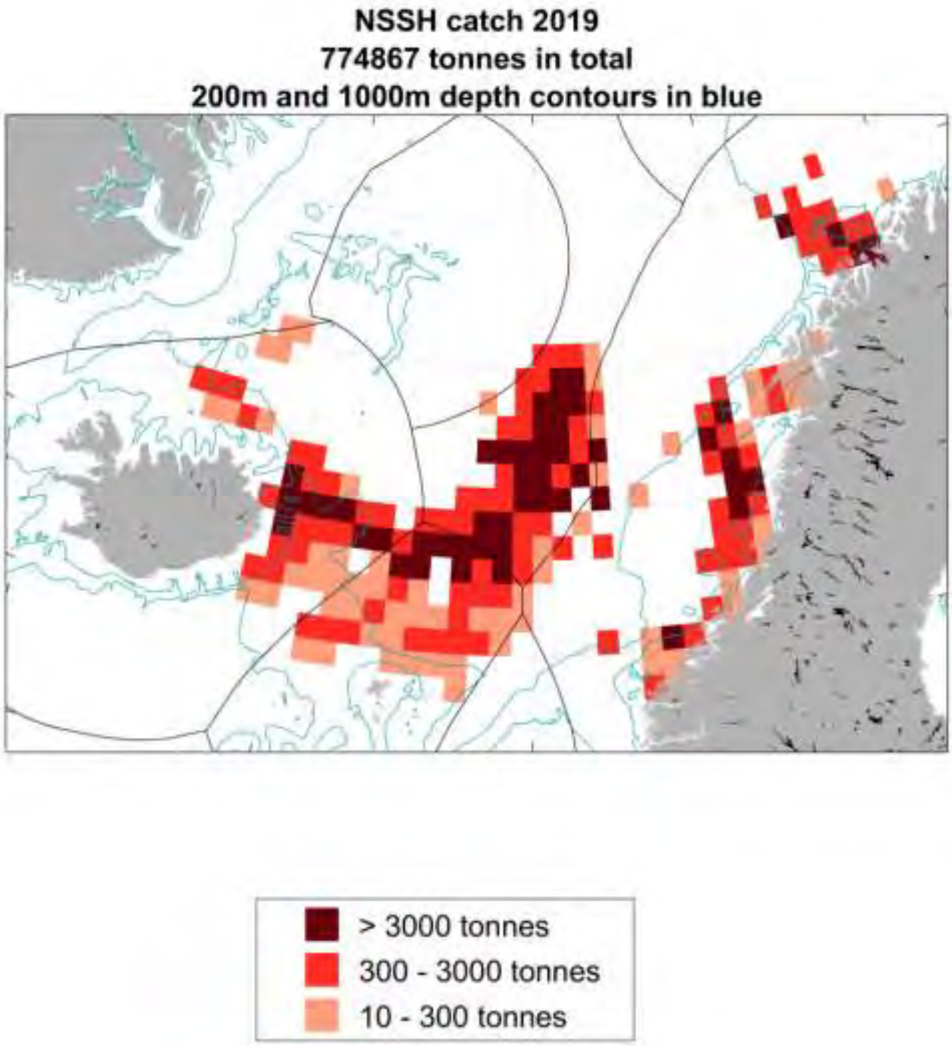

Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2019 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99.7% of the reported landings.

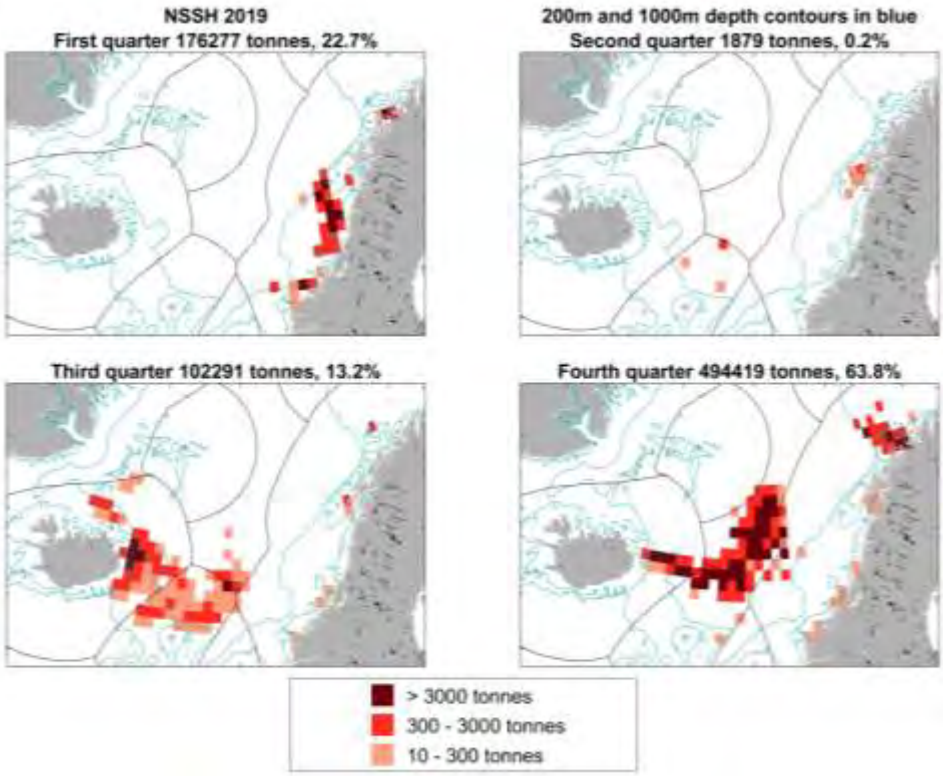

Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2019 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99.7% of the reported landings

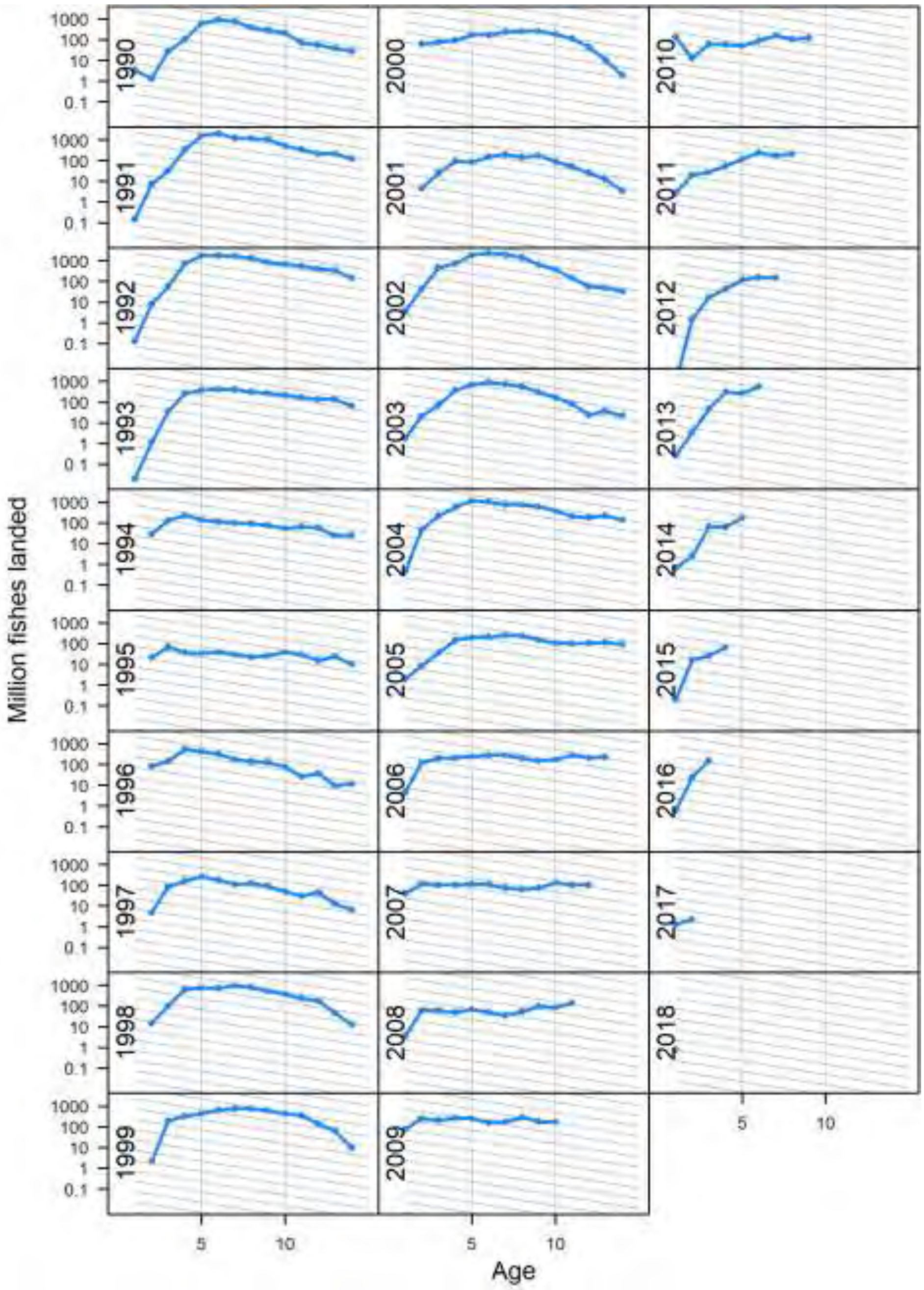

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated landings in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

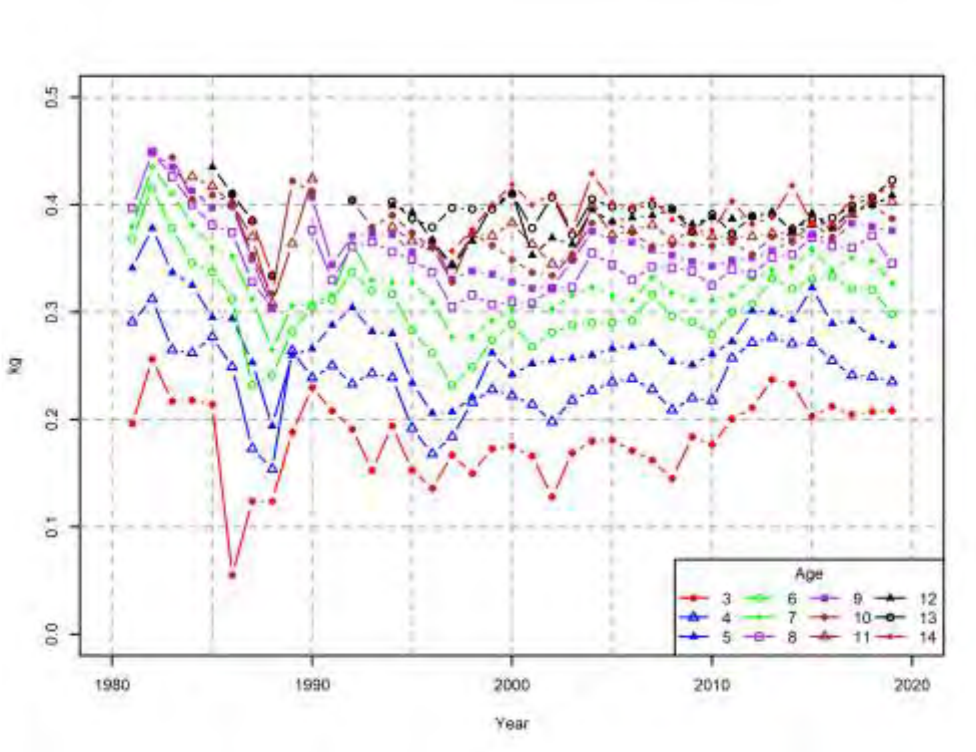

Figure 4.4.4.1. Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2019 in the landings.

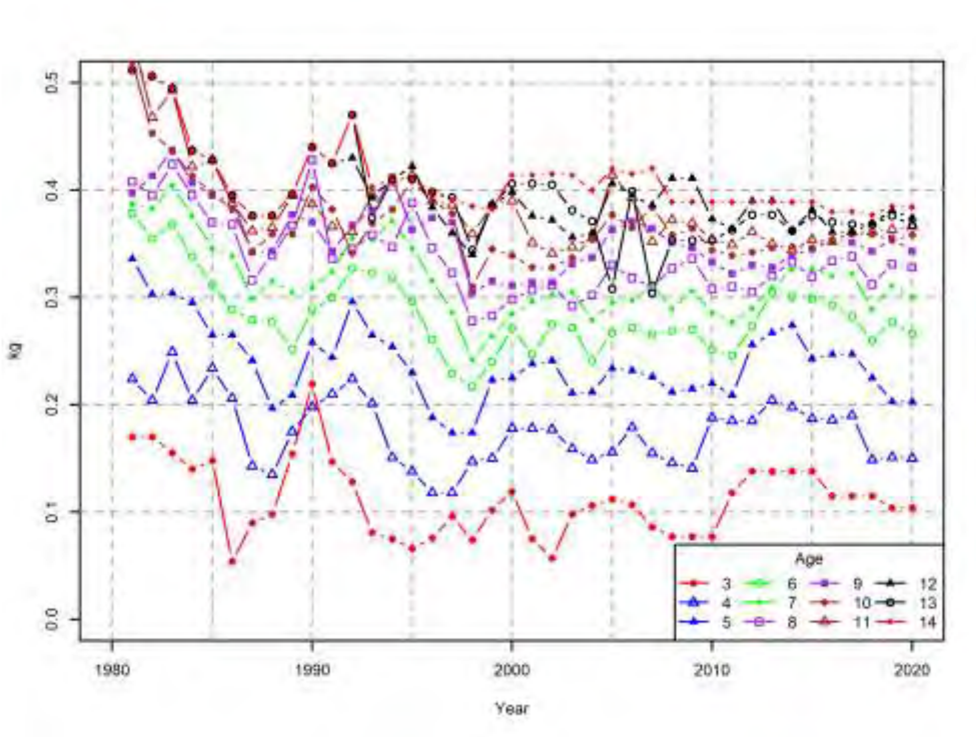

Figure 4.4.4.2. Norwegian spring-spawning herring. Mean weight at age in the stock by age groups 3–14 for the years 1981—2020.

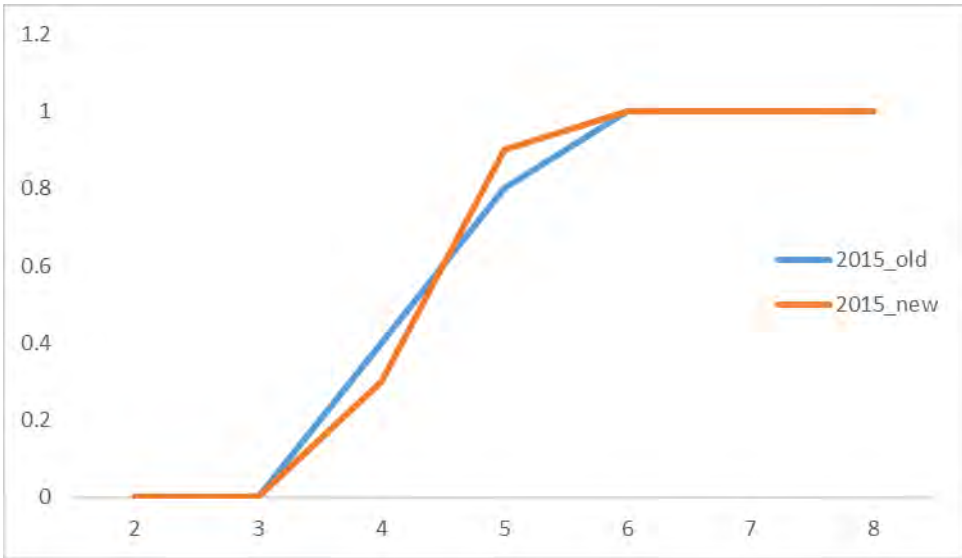

Figure 4.4.5.1. Assumed (blue line) and updated (orange line) maturity-at-age for the year 2015.

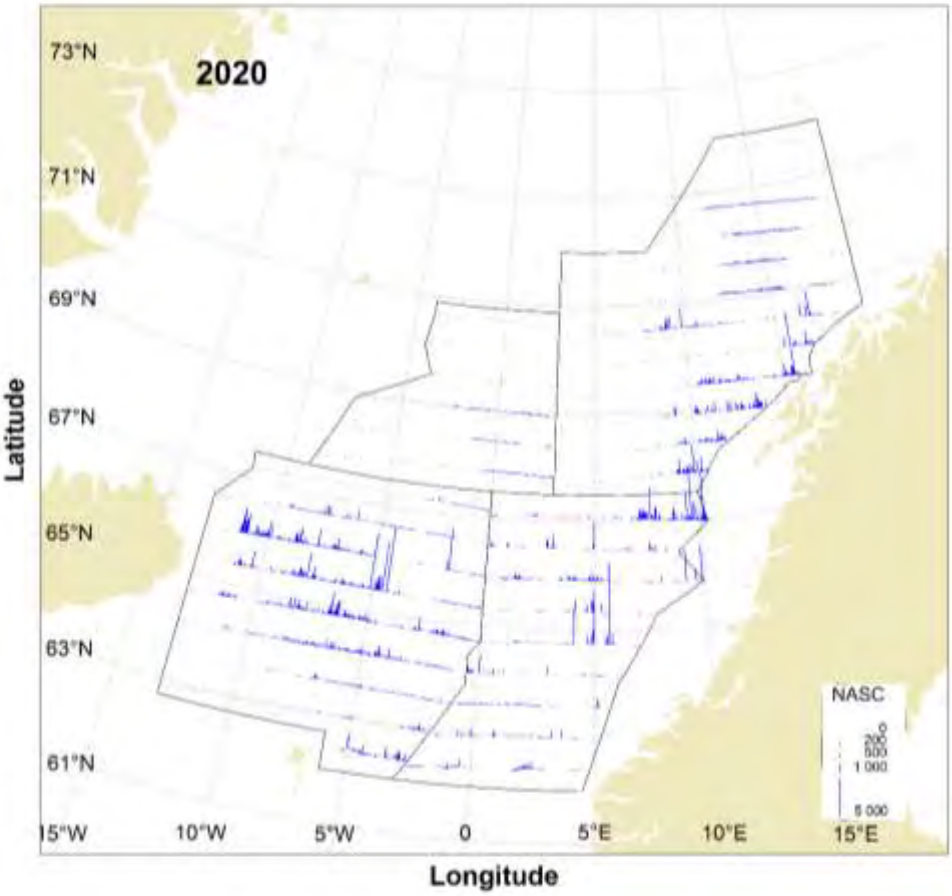

Figure 4.4.7.1. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2020 in terms of NASC values (m^2/nm^2) for every 1 nautical mile.

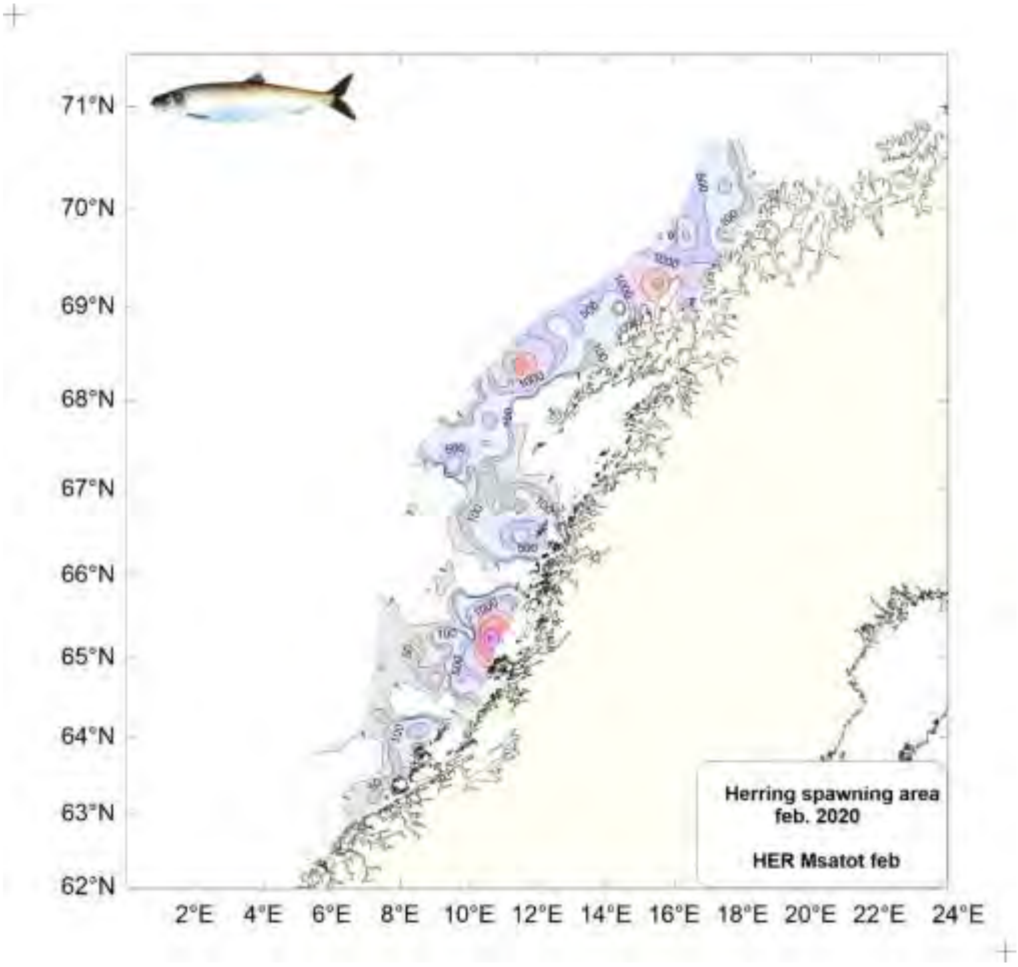

Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2020.

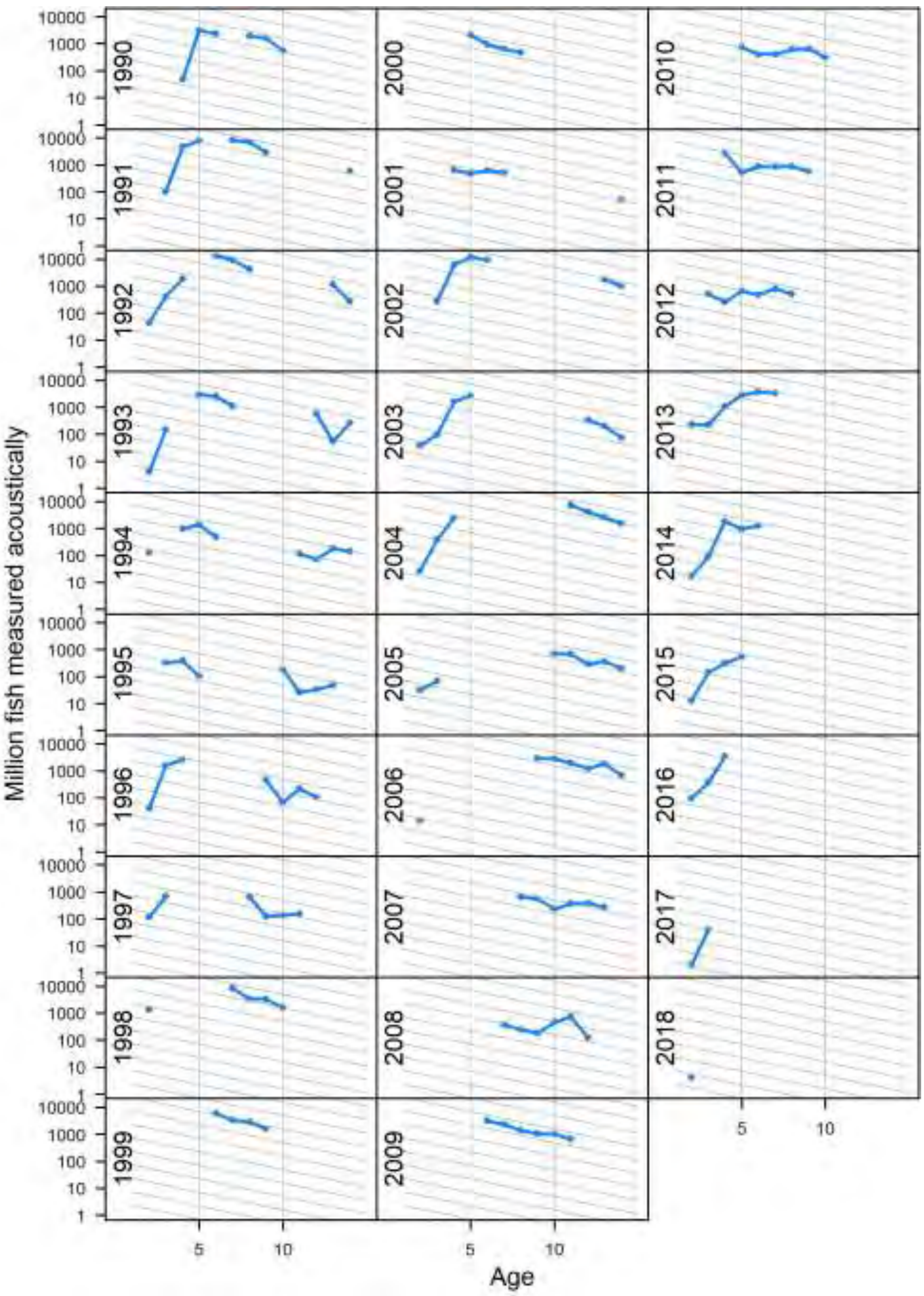

Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the spawning area in February-March (Fleet 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis.

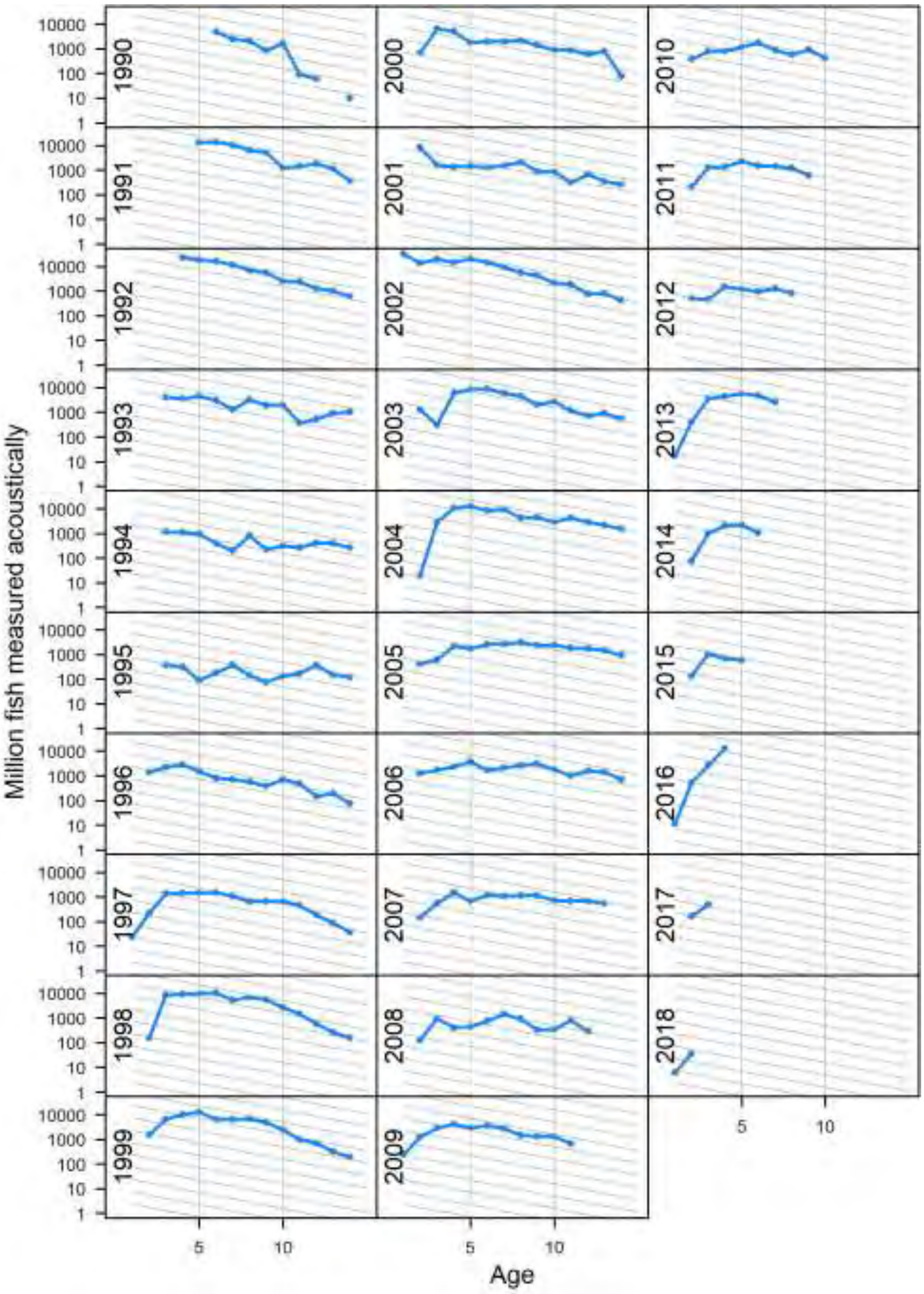

Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the feeding area in the Norwegian Sea in May (Fleet 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

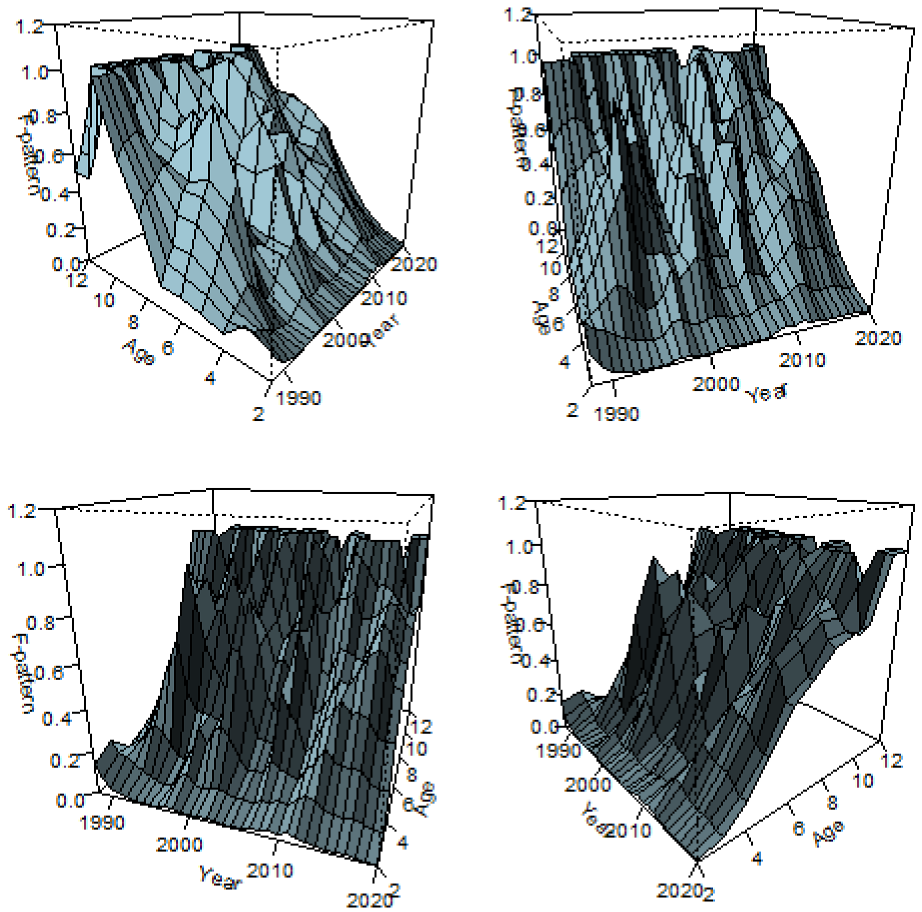

Figure 4.5.1.1. Estimated exploitation pattern for the years 1988–2020 by the XSAM model fit. All panels show the same data, but depicted at different angles to improve visibility at different time periods

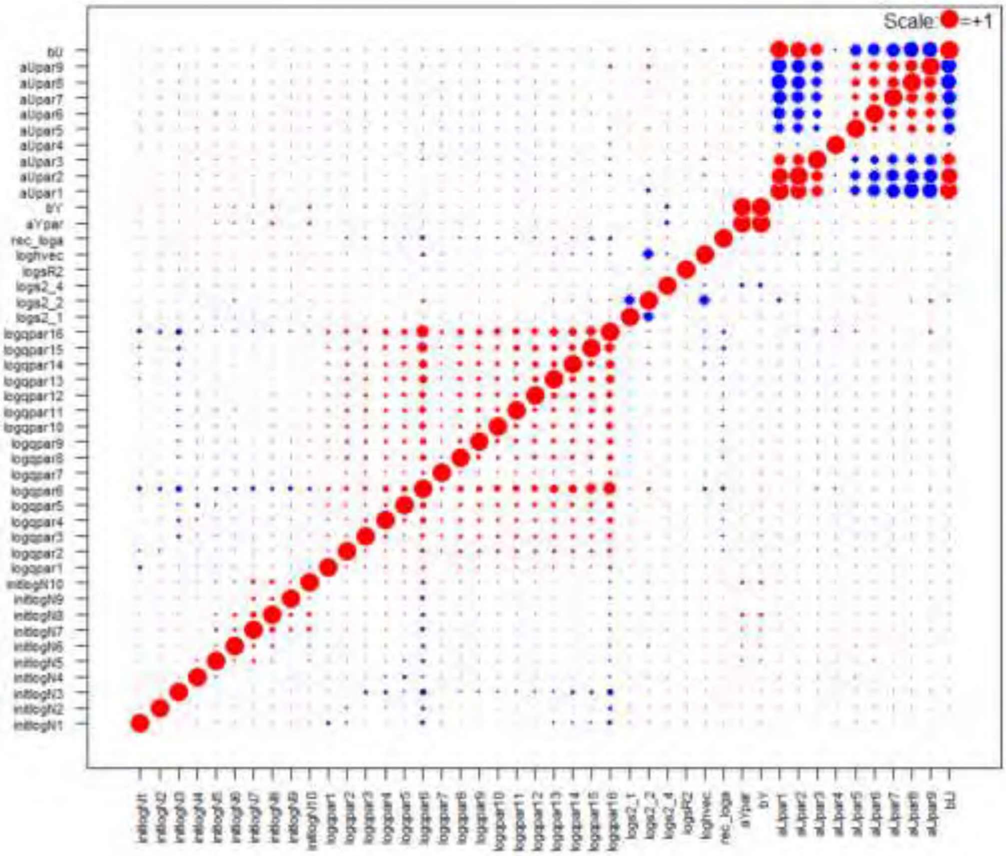

Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

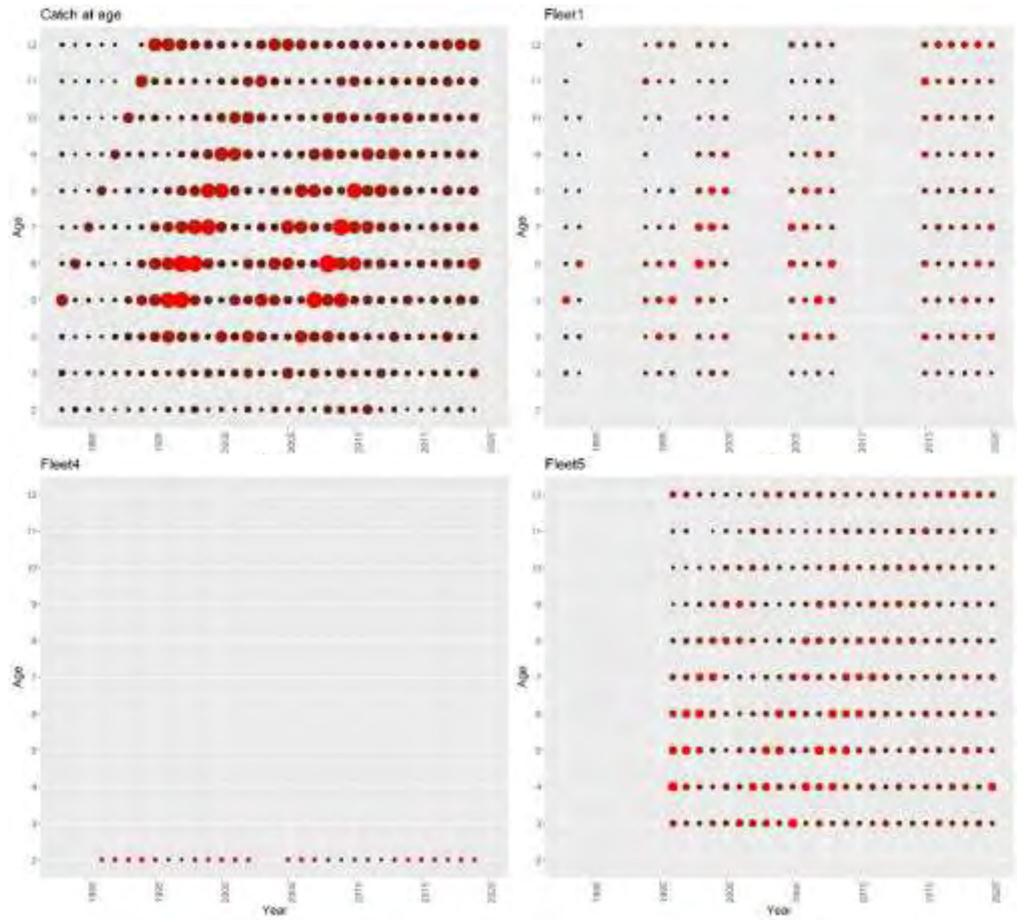

Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

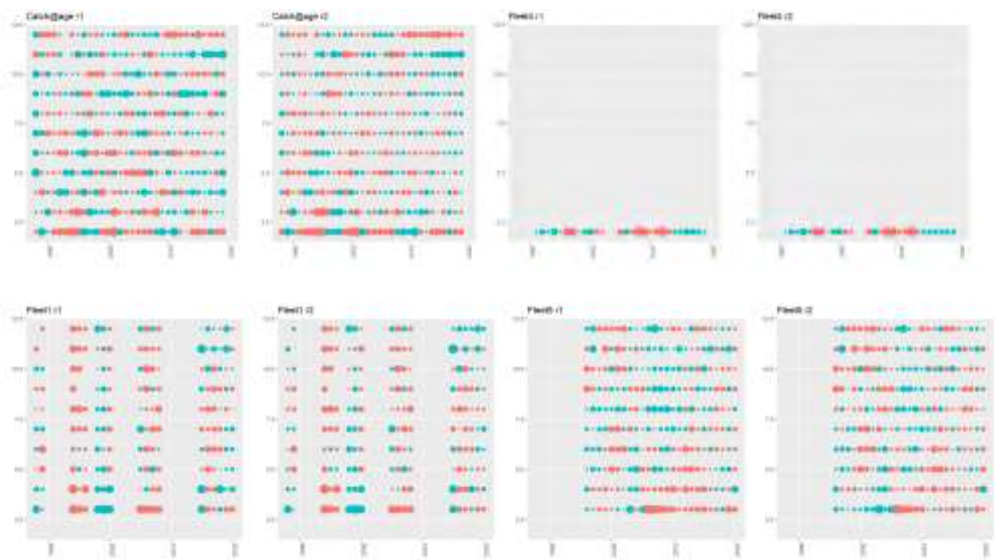

Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit. Red is positive and blue is negative residuals.

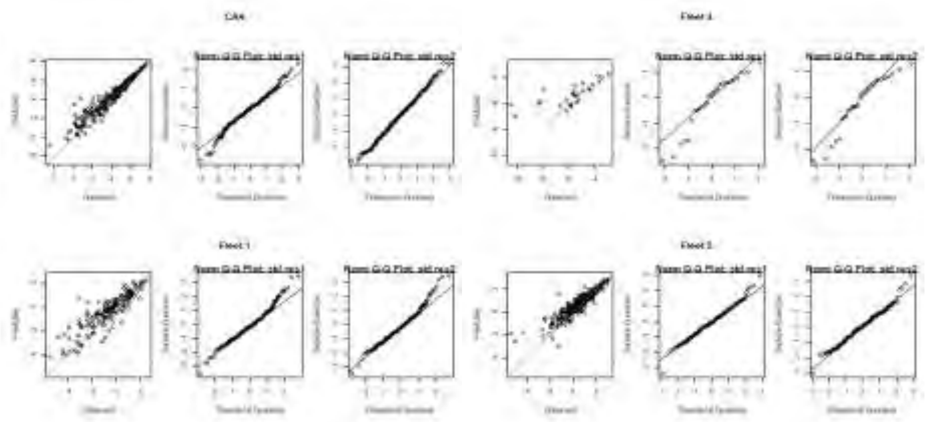

Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

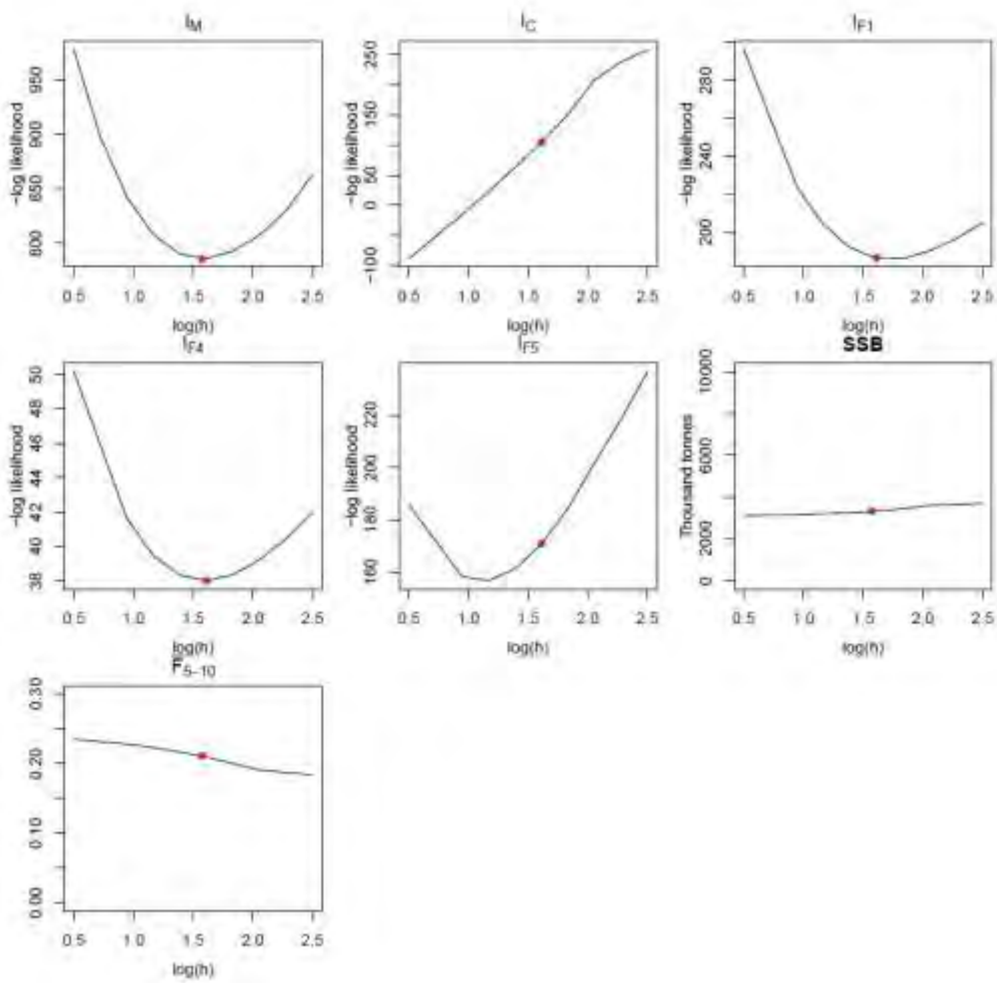

Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood $\mathbf{l_M}$, the catch component $\mathbf{l_C}$, Fleet 1 component $\mathbf{l_{F1}}$, Fleet 4 component $\mathbf{l_{F4}}$, Fleet 5 component $\mathbf{l_{F5}}$, point estimate of SSB and average F (ages 5-12+) in 2020 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.

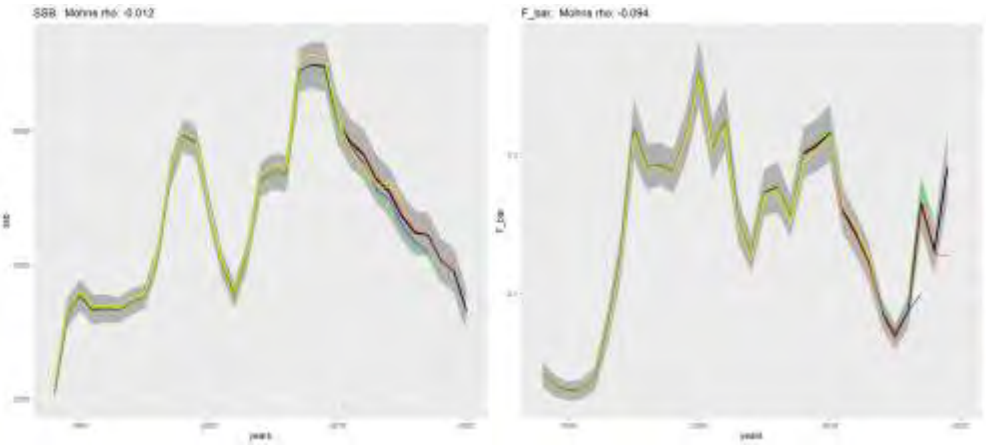

Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-12 for the years 2015-2020. Mohn's rho is shown in figure title.

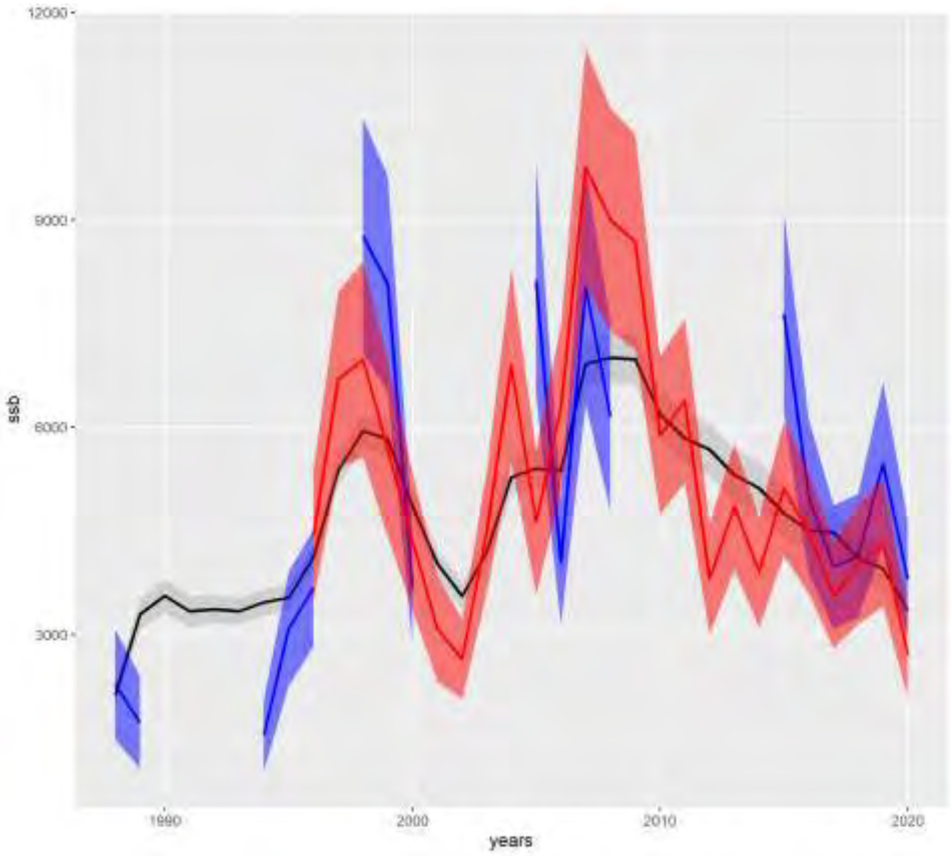

Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2019 from model (black lines) and by survey indices from Fleet 1 (red) and Fleet 5 (blue). Shaded area is approximate to standard deviation.

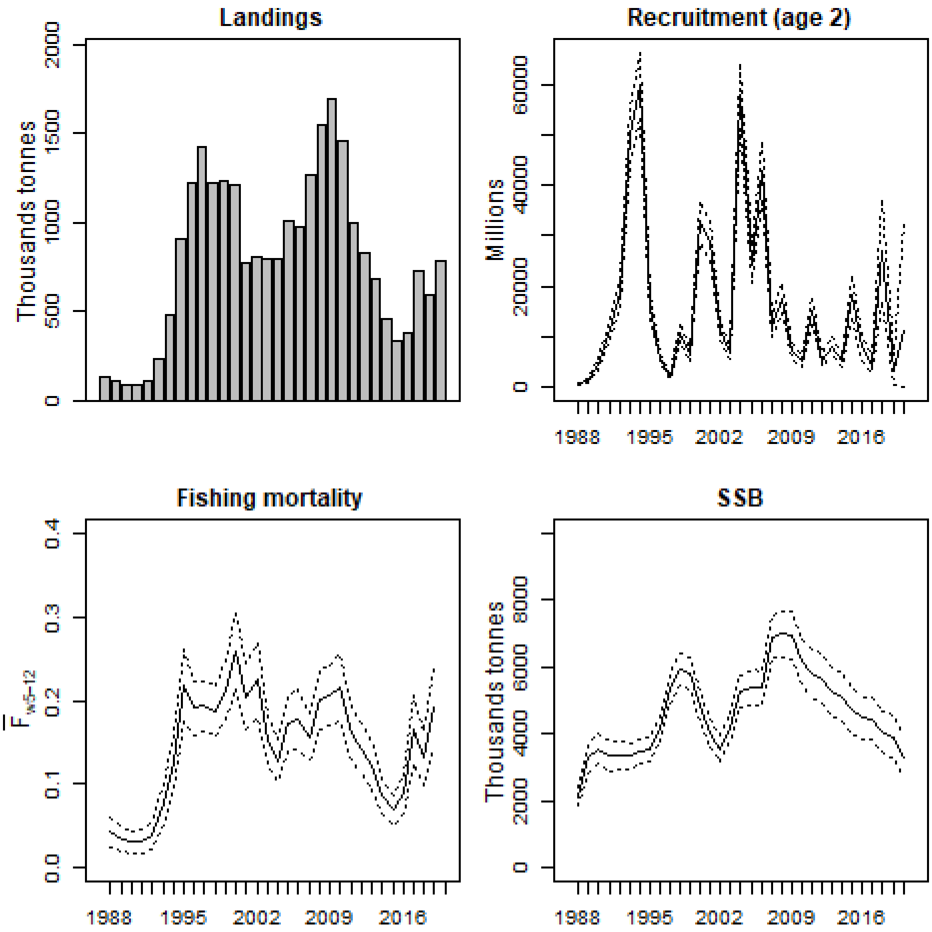

Figure 4.5.1.9. Total reported landings 1988–2019, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2020 based on the final XSAM model fit.

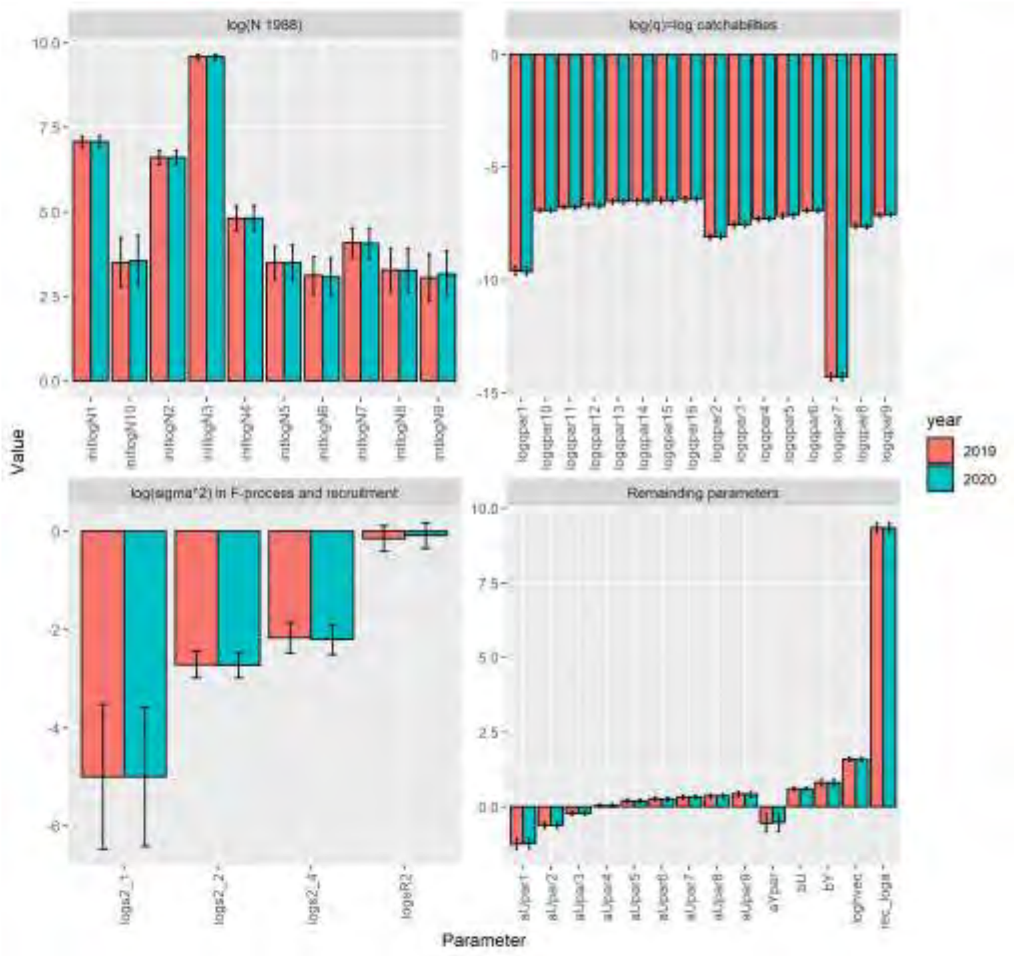

Figure 4.5.1.10. Norwegian spring-spawning herring. A visual representation of parameter estimates of the final XSAM model fit (see table 4.5.1.1). The estimates from the 2019 assessment are also shown (blue).

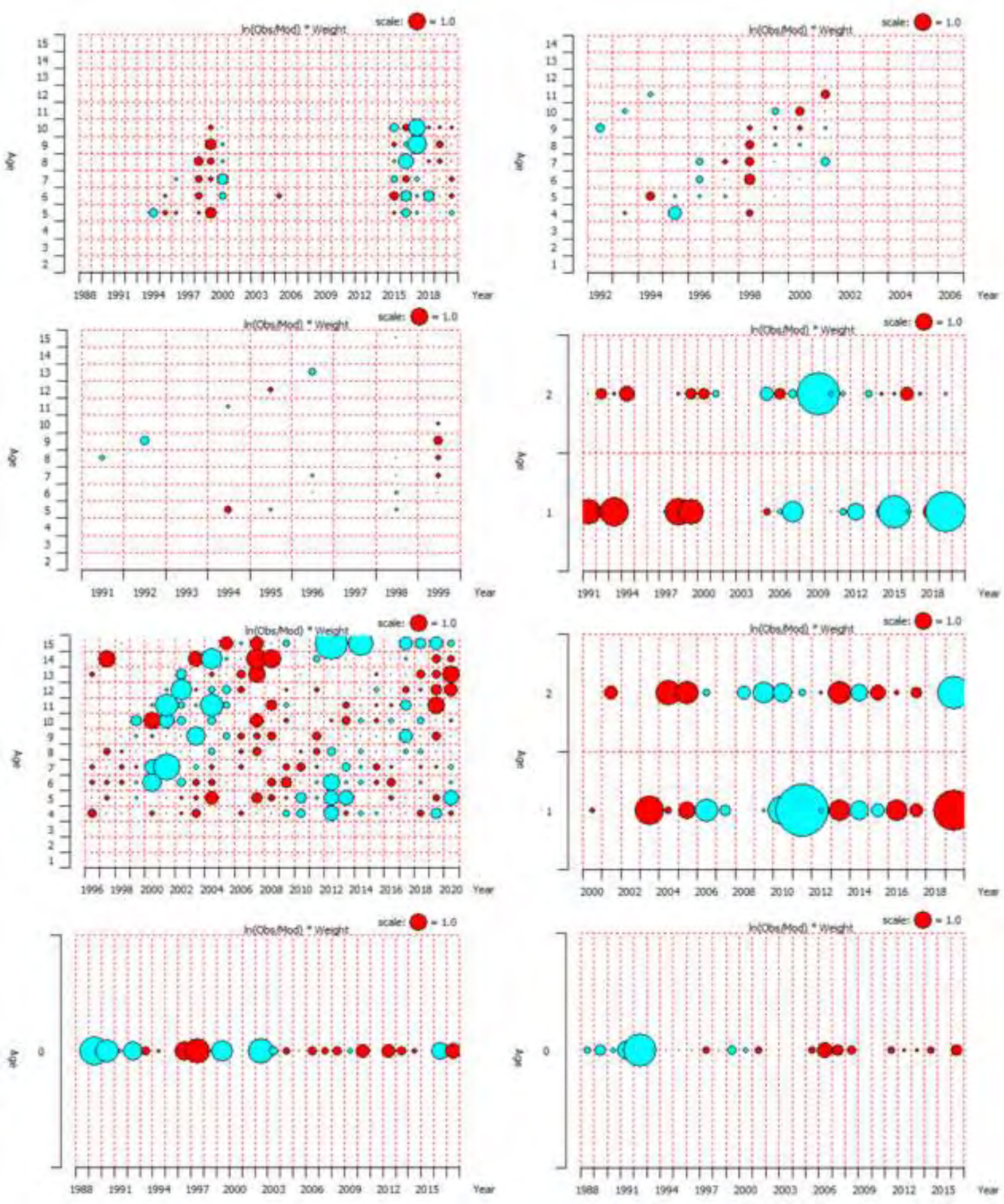

Figure 4.5.2.1.1. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

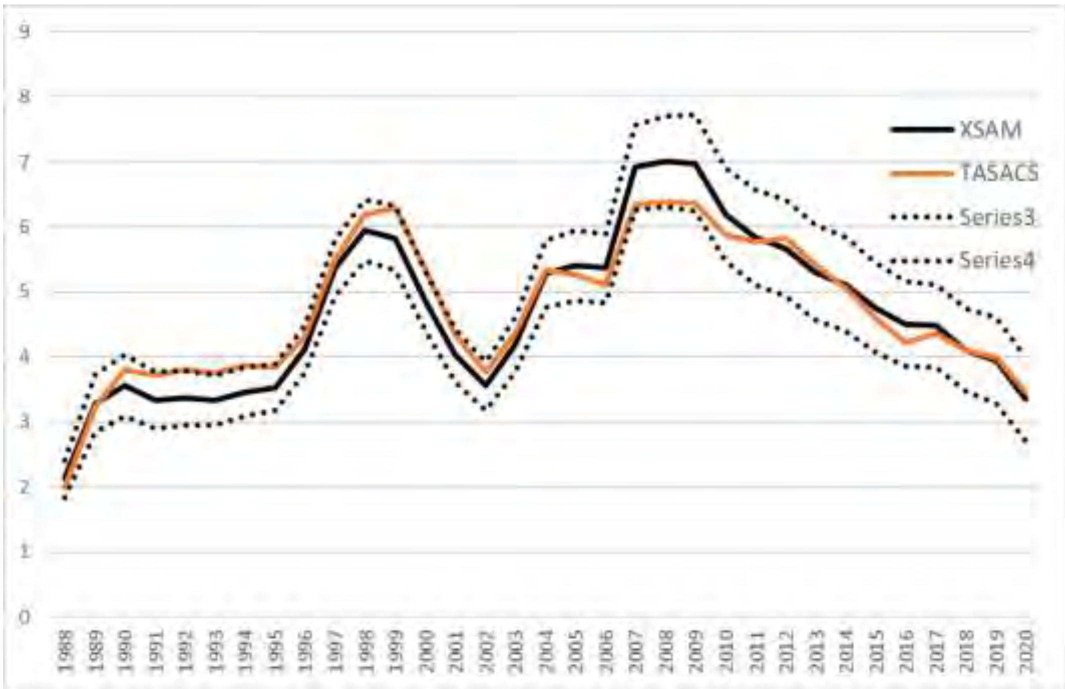

Figure 4.5.2.1.2. Comparison of SSB time-series from the final assessment from XSAM and exploratory runs from TASACS (following the 2008 benchmark procedure). 95% confidence intervals from the XSAM final assessment are shown (dotted lines).

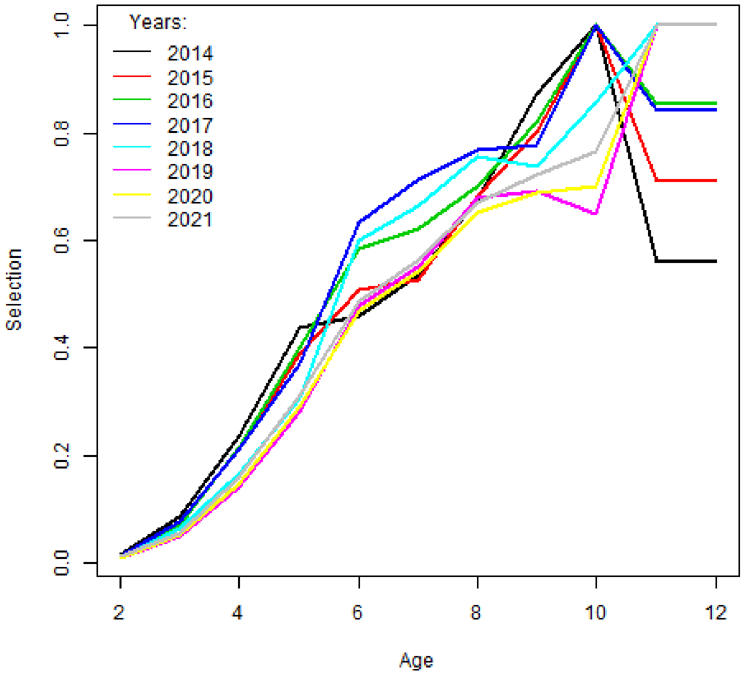

Figure 4.8.1.1. XSAM estimated selection pattern; selected years (estimates for 2014–2019 and predictions for 2020-2021) are shown in colours as indicated in the legend.

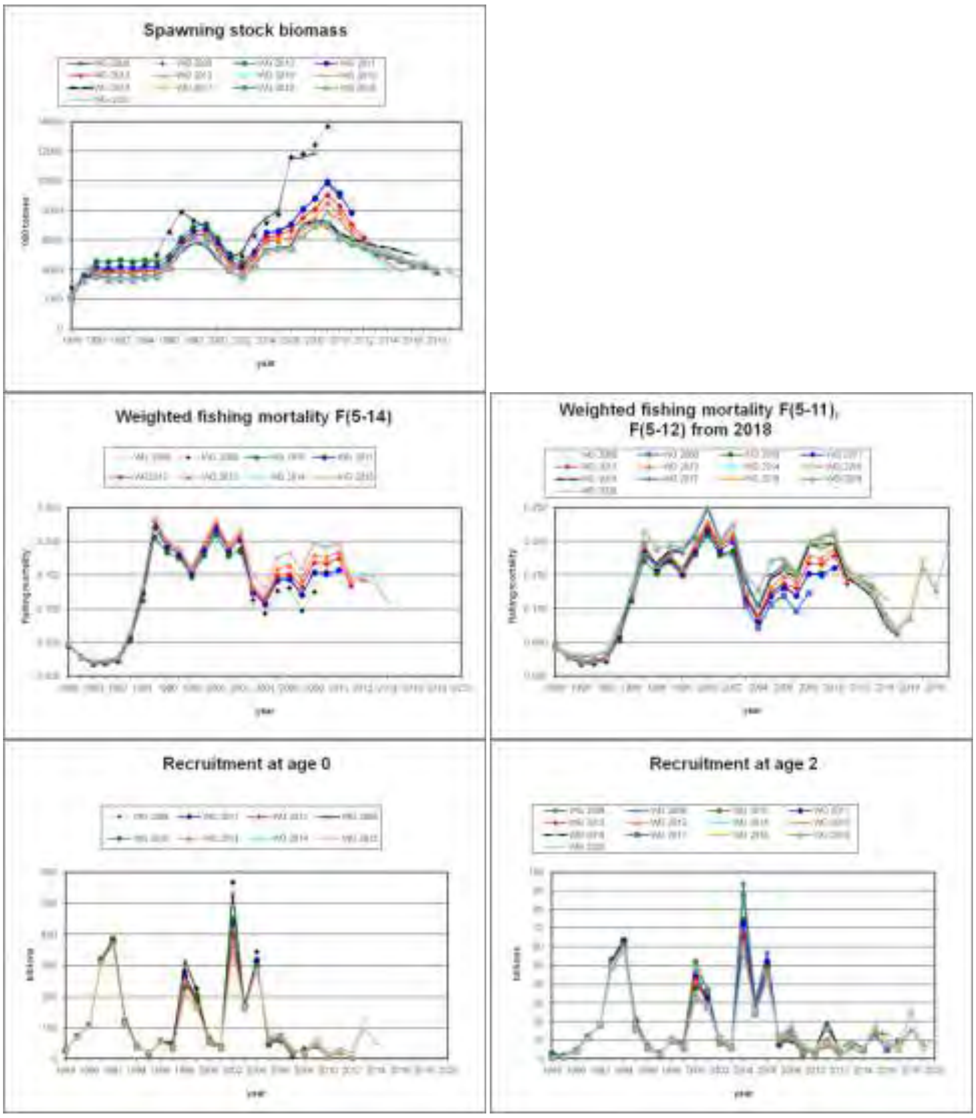

Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F(5-14) and F(5-11/5-12); and recruitment at age 0 and age 2 with previous assessments. In 2016 the proportion mature in the years 2006-2011 was changed; recruitment age changed from 0 to 2 and 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.