WORKING GROUP ON WIDELY DISTRIBUTED STOCKS (WGWIDE)

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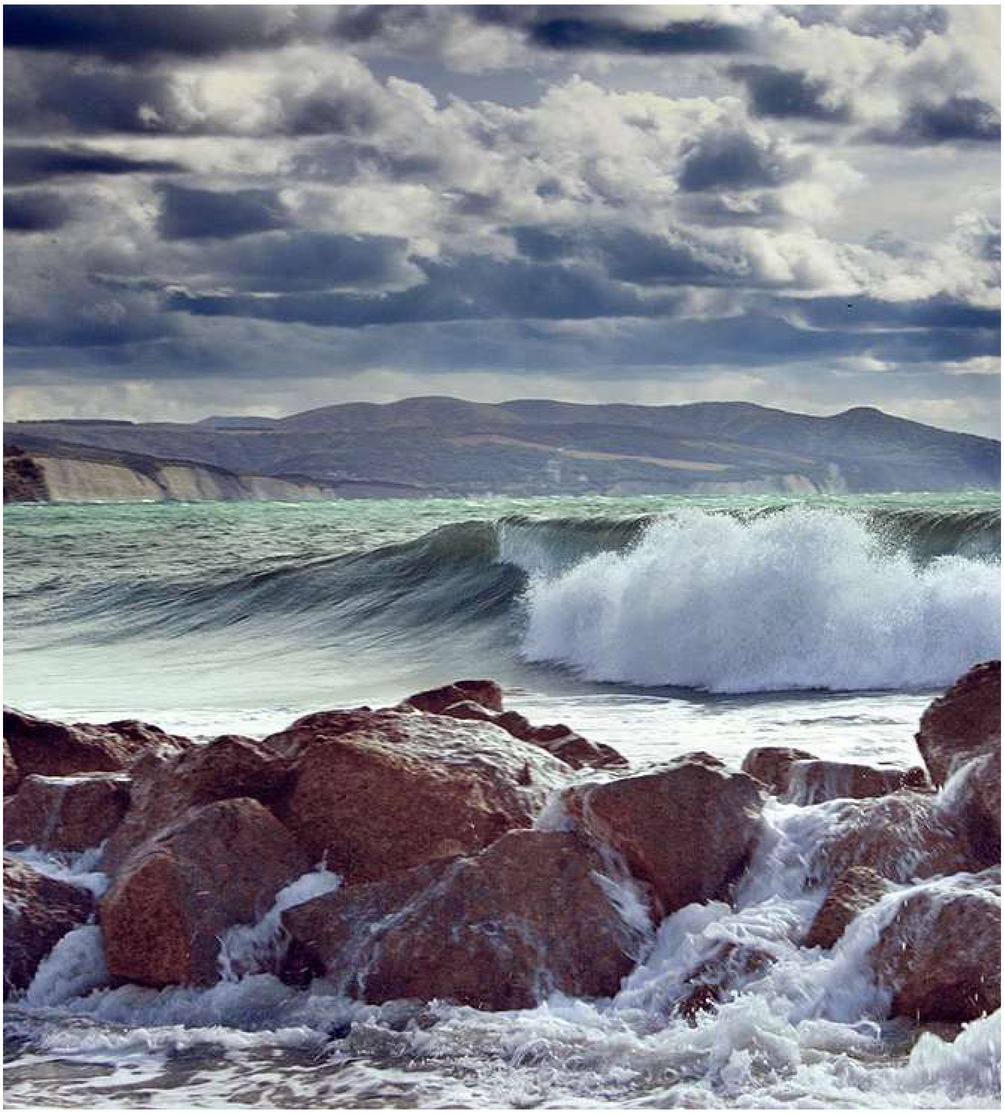

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

COUNSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

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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 2018

ICES noted that the stock is declining but estimated to be above MSY $B_{trigger}$ (3.184 million tonnes) in 2018. Since 1998 four large year classes have been produced (1998, 1999, 2002, and 2004). The 2005 to 2015 year classes are estimated to be average or small. The 2016 year-class, however, is estimated to be above average. Fishing mortality has been increasing since 2015 and is above F_{MSY} in 2017

A long-term management plan agreed by the EU, Faroe Islands, Iceland, Norway and Russia, is operational since 2019. ICES evaluated the plan and concludes that it is in accordance with the precautionary approach. The management plan implies maximum catches of 588 562 t in 2019.

4.2 The fishery in 2018

4.2.1 Description and development of the fisheries

The distribution of the 2018 Norwegian spring-spawning herring (NSSH) fishery for all countries by ICES rectangles per year is shown in Figure 4.2.1.1 and for annual quarter in Figure 4.2.1.2. The 2018 herring fishing pattern was similar to recent years. The fishery began in January on the Norwegian shelf and focused on overwintering, pre-spawning, spawning and post-spawning fish (Figure 4.2.1.2 quarter 1). In the second quarter, the fishery was insignificant (Figure 4.2.1.2 quarter 2, 0.1% of total catch). 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 over-wintering area in the fjords and oceanic areas off Lofoten, and the central part of the Norwegian Sea. In particular, the catches in the international part of the Norwegian Sea were high (Figure 4.2.1.2 quarter 4) but in contrast to 2017 the fishery in 2018 was more easterly distributed. The landings in the 1st quarter constituted 25% of the total landings and the largest proportion of the landings were in the 4th quarter (70%). The proportion of landings among quarters was similar to the fishery in 2017.

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 oceanographic conditions (e.g. limitations due to cold areas). Beside environmental factors, the age distribution in the stock will also influence the migration. Changes in migration pattern of NSSH, as well as 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. No large year classes have entered the stock since 2004, although the 2013 year class is estimated to be above average (since 1988) and was in 2018 observed feeding in the north-eastern part of the Norwegian Sea in May and July. 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) in 2017/2018 while the older fish seemed to have had an oceanic wintering area. A similar wintering pattern was observed in 2018/2019. The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May and July 2019 concentrated in the southwestern 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 2018 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Russia, the UK (Scotland) and Sweden. The total working group catch in 2018 was 592 899 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of maximum 384 197 tonnes. The majority of the catches (96%) were taken in area 2.a as in previous years. Samples were not provided by Greenland, the UK or Sweden (less than 1 % 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 2018 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 2018, about 16 % of the catches (in numbers) were taken from the 2013 year class, followed by the 2006 (13%) and 2011 and 2009 (both 11%) year classes. The 2004 year class still contributes, with 8 % of the catches in 2018.

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 more flat 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 2018 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 in 2014 and seem to have decreased slightly during the most recent years. A similar pattern is observed in weight-at-age in the stock which is presented in Figure 4.4.4.2 and Table 4.4.4.2; however there is an observed increase in mean weight in 2019 for ages older than 5 year. 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 potential 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 recent years since all year classes have to be fully matured before included. Therefore, assumptions have to be made for 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 ycl	0	0	0	0	0.4	0.8	1	1	1	1	1	1	1	1	1	1
strong ycl	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 2019 the year 2014 could be updated with back-calculated values in the present assessment. Assumed and updated values are shown in figure 4.4.5.1. 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 M 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. The 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 (“Fleet 1”) in February.

The cruise reports from the IESNS and spawning survey in 2019 are available as working documents to this report. Both surveys were successfully conducted in 2019.

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.

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 number 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). 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 goods fits (R^2_{adj}'s are 0.94, 0.97, 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 is made available for 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 2016c) 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 2019

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 sum of national quotas) along with the precision of the prediction. This was changed in 2017 as 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 2019 assessment, i.e. the catch prediction for 2019 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 fitted 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 it is referred 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 is 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 tools 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 and 2015 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 10+ in 2015 and 2016 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. However, these data points are given low weights (Figure 4.5.1.3) as they are found imprecise (Tables 4.4.8.1–4.4.8.4). Some serial correlation for residuals for ages 3 and 4 in Fleet 1 can also be detected, but is down weighted by the same reasons. 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 comparing 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 tends 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 Fleet 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 ~0.05 (Mohn, 1999; Brooks and Legault, 2016). The indices from Fleet 1 indicate, on average, a relatively larger abundance than the indices from Fleet 5 for 2015-2019 which is supported by the positive residuals for ages 9–10+ (Figure 4.5.1.4). Consequently, the increased estimates of SSB and decreased estimates of F after 2014 is a response to the indices from Fleet 1 which was not conducted in the years 2009–2014. Note that the retrospective estimates are remarkably stable from 2015 and onwards. To illustrate the conflict in data and increased uncertainty in estimates the most recent years, the abundance indices are scaled to the absolute abundance by the estimated catchabilities. Then the spawning-stock biomass based on each survey index is calculated using the stock weights at age and proportion mature at age (Figure 4.5.1.8). Here we see a fairly good temporal match between the model estimate of SSB and the survey SSBs except for the years 2015 and 2016 for Fleet 1, which display a significantly faster reduction in the stock compared to Fleet 5 which shows a more flat trend in the same years. Also, both Fleet 1 and Fleet 5 indicate an increase in

SSB from 2017 and onwards. It is worth noticing that although the point estimate of SSB based on Fleet 1 appear very much higher than Fleet 5 in 2015 and 2016, 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 estimates of fishing mortality for 2017 is rather high, as a response to the high catch in 2017 with a point estimate of 0.162. In 2018 the fishing mortality is estimated to be lower than 2017 (F=0.128 with 95% confidence interval between 0.092-0.163), 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 2019 ranges from ~3.211 to ~4.717 million tonnes 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—2019. The model was run with catch data from 1988 to 2018, and projected forwards through 2019 assuming Fs in 2019 equal to those in 2018, to include survey data from 2019. The larval survey (SSB fleet) was discontinued in 2017 and no new information is therefore available from this survey. Additionally, no new indices were provided for fleets 6 and 7 due to bad survey coverage in these surveys.

The model fit to the tuning data is shown with Q-Q plots in Figure 4.5.2.1.1. Surveys 1, 2, 3 and 7 seem to fit rather well to the assumed linear relationship in the TASACS model, but surveys 4, 6 and 8 have rather poor fit. Since 2016 the TASACS run Q-Q plots for fleet 5 shows a poorer fit compared to earlier assessments. This is mainly caused by a change in estimated catchability.

Particularly Survey 8 (larval survey) seems to have a poor fit. This can also be seen as a block of positive residuals for this survey in later years (Figure 4.5.2.1.2). The residual plot for survey 5 (IESNS) also shows some pattern with consecutive series of negative and positive residuals indicating year-effects.

The results from TASACS are compared to those from XSAM and TISVPA in Figure 4.5.2.1.3. 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 2019 is estimated by TASACS to be 3.797 million tonnes, which is slightly lower than the estimated value from TISVPA and to the point estimate from XSAM.

4.5.2.2 TISVPA

The TISVPA model was applied using the catch-at-age data with range from 0 to 15+ and data from three surveys (Survey 1, 4 and 5). No data points were down-weighted. Two-parametric selection pattern used in the model revealed some obvious peculiarities in the interaction between the stock and the fishery.

Rather similar signals by position of minima with respect to SSB (2019) were obtained from catch-at-age and surveys 1, 4 and 5. The position of the overall objective function of the model, indicates the SSB value in 2019 about 4.0 million tonnes (see WD02).

The results from TISVPA are compared to those from XSAM and TASACS in Figure 4.5.2.1.3.

4.6 NSSH reference points

ICES last reviewed the reference points of Norwegian spring spawning herring in April 2018. 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 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 2019 is estimated by XSAM to be 3.965 million tonnes which is above B_{pa} (3.184 million t). The stock is declining and the SSB time-series from the 2019 assessment is in line with the SSB time-series from the 2018 assessment. In the last 20 years, several large year classes have been produced (1998, 1999, 2002, and 2004). The following year classes are estimated to be average or small. Fishing mortality in 2018 is estimated to be 0.128 which is above the management plan F that was used to give advice for 2018. A new management plan has been implemented for the 2019 advisory year.

4.8 NSSH Catch predictions for 2019

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 were performed to determine levels of precision in the forecast. Table 4.8.1.1 list the point estimates of the starting values for the forecast. The input stock numbers-at-age 2 and older were taken from the final assessment. The catch weight-at-age, used in the forecast, is the average of the observed catch weights over the last 3 years (2016—2018).

For the weight-at-age in the stock, the values for 2019 were obtained from the commercial fisheries in the wintering areas in January. For the years 2020 and 2021 the average of the last 3 years (2017 —2019) 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 (1988-2019) 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.

The average fishing mortality defined as the average over the ages 5 to 12+ is 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 previous years for this stock but the age range is shifted from 5-11 to 5-12+ from 2018.

There was no agreement on the sharing of the TAC for 2019. To obtain an estimate of the total catch to be used as input for the catch-constraint projections for 2019, the sum of the unilateral quotas was used. In total, the expected outtake from the stock in 2019 amounts to 773 750 tonnes. F in 2019 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 of 773 750 tonnes is taken in 2019, it is expected that the SSB will decrease from 3.965 million tonnes (95% confidence interval 3.212 to 4.717 million tonnes) on 1 January in 2019 to 3.660 million tonnes in 2020. The weighted F over ages 5-12 are 0.186.

4.9 Comparison with previous assessment

A comparison between the assessments 2008—2019 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 (2018) this was further changed to 5—12+.

The table below shows the SSB (thousand tonnes) on 1 January in 2018 and weighted F in 2017 as estimated in 2018 and 2019.

	ICES 2018	WG 2019	%difference
SSB(2018)	3 826	4 103	7.2%
Weighted F (2017)	0.174	0.162	-6.9%

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, 2018?; WKNSSHMSE, ICES, 2018??) 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}, when it is not possible to fish 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.

4.11 Management considerations

Perception of the stock has not changed much since last year's assessment (estimated SSB in 2018 is 7 % higher in this year's assessment). Results of exploratory runs by other models 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 after 2004.

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 adjoining 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.

- The stock's more westerly feeding distribution in recent years (ICES 2019a; 2019b) 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 (Nøttestad *et al.*, 2014; ICES, 2015b; 2017b; 2019b).
- Where herring and mackerel overlap spatially they compete for food to some extent (Bachiller *et al.*, 2015; 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 western and northern fringe of Norwegian Sea, although higher zooplankton biomass there could also attract the herring (Nøttestad *et al.*, 2014; ICES, 2015b; 2016b).
- 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).
- The 2016 year class of herring is the strongest since the 1991 year class in the Barents Sea as 3 year old based on the May survey 2019 (ICES, 2019a). This is indication of good recruitment to the stock over the next two-three years.
- 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.
- 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 in May 2019 the biomass was around the long-term mean. Interestingly, all the areas, excluding

east of Iceland and on few occasions Jan Mayen AF (Figure 6.2), show parallel 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, 2019c). However, during the last two years, 2017 and 2018, the temperature remained relatively warm while the salinity had a marked decrease. Two different mechanisms can explain this, increased fraction of sub-polar 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.

4.13 Changes in fishing patterns

The fishery for Norwegian spring spawning herring has generally been described as progressing clockwise in the Nordic Seas as the year progresses. In the recent years (after ~2013) this pattern has changed, because there has been an extended fishery in the south and southwestern areas in the Norwegian Sea in the 3rd and 4th quarters and thus almost 70% of the herring catch was taken in the last quarter of 2018. The majority of the catches in the 4th quarter are now taken in the central parts of the Norwegian Sea, whereas in the preceding years there was a more significant fishery in northeastern areas (outside northern Norway and southwest of the Bear Island). This change in migration 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) could therefore not access this herring during the winter fishery and targeted younger fish (mostly of the 2013 year class) which overwintered in Norwegian fjords.

4.14 Recommendation

No recommendations

4.15 References

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4.16 Tables

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

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

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

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

***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

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2018.

COUNTRY	OFFICIAL CATCH	% catch covered by sampling programme	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	17051.6	100	7	632	160
Faroe Islands	82062.3	95	9	582	582
Germany	1989.4	93	3	185	185
Greenland	2465.3	0	0	0	0
Iceland	83393	100	58	2796	1396
Ireland	2428.5	95	2	122	96
Norway	332027.5	99	83	2158	2158
The Netherlands	4289.6	50	10	604	250
UK_Scotland	2581.6	0	0	0	0
Sweden	425	0	0	0	0
Russia	64185	100	81	15027	1220
Total for Stock	592898.8	97	253	22106	6047

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2018.

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
2.a	570284.6	229	5456	20934	10	37
4.a	309.8	0	0	0	0	0
5.a	22304	24	591	1172	26	53
14.a	0.34	0	0	0	0	0
Total	592898.8	253	6047	22106	10	37

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	2.a	124493.2	
2	Norway	2	2.a	831.4	1
3	Norway	3	2.a	1421.1	4
4	Norway	4	2.a	204972	
5	Norway	2	4.a	1	1
6	Norway	3	4.a	240.3	4
7	Norway	4	4.a	68.5	4
8	Iceland	3	2.a	1162	
9	Iceland	4	2.a	59927	
10	Iceland	3	5.a	14336	
11	Iceland	4	5.a	7968	
12	Faroe Islands	2	2.a	0.3	1,16,24
13	Faroe Islands	3	2.a	4433	14
14	Faroe Islands	4	2.a	77629	
15	Sweden	1	2.a	425	1,16,24
16	Denmark	1	2.a	17051.6	
17	Germany	1	2.a	0.4	1,16,24
18	Germany	2	2.a	2.1	1,16,24
19	Germany	3	2.a	132.9	20
20	Germany	4	2.a	1854	
21	Greenland	3	2.a	898.4	8,29
22	Greenland	4	2.a	1566.6	4,9,14,20,27,30
23	Greenland	3	14.a	0.3	8,29
24	Ireland	1	2.a	2306	
25	Ireland	4	2.a	122.5	4,9,14,20,27,30
26	Netherlands	3	2.a	51.9	27
27	Netherlands	4	2.a	4237.7	
28	Russia	1	2.a	37	1,16,24

29	Russia	3	2.a	8964	
30	Russia	4	2.a	55184	
31	Scotland	1	2.a	2581.6	1,16,24

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

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

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

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

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

	AGE														
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
2017	0	618	16390	64275	305483	114976	248192	162566	289931	98836	133145	276874	107473	220368	22357	49442
2018	0	1261	22414	25638	59802	264182	150759	179628	109121	180968	85954	99061	212052	113841	136096	39249

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

	age															
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1950	0.007	0.025	0.058	0.110	0.188	0.211	0.234	0.253	0.266	0.280	0.294	0.303	0.312	0.32	0.323	0.334
1951	0.009	0.029	0.068	0.130	0.222	0.249	0.276	0.298	0.314	0.330	0.346	0.357	0.368	0.377	0.381	0.394
1952	0.008	0.026	0.061	0.115	0.197	0.221	0.245	0.265	0.279	0.293	0.308	0.317	0.327	0.335	0.339	0.349
1953	0.008	0.027	0.063	0.120	0.205	0.230	0.255	0.275	0.290	0.305	0.320	0.330	0.34	0.347	0.351	0.363
1954	0.008	0.026	0.062	0.117	0.201	0.225	0.250	0.269	0.284	0.299	0.313	0.323	0.333	0.341	0.345	0.356
1955	0.008	0.027	0.063	0.119	0.204	0.229	0.254	0.274	0.289	0.304	0.318	0.328	0.338	0.346	0.350	0.362
1956	0.008	0.028	0.066	0.126	0.215	0.241	0.268	0.289	0.304	0.320	0.336	0.346	0.357	0.365	0.369	0.382
1957	0.008	0.028	0.066	0.127	0.216	0.243	0.269	0.290	0.306	0.322	0.338	0.348	0.359	0.367	0.371	0.384
1958	0.009	0.030	0.070	0.133	0.227	0.255	0.283	0.305	0.321	0.338	0.355	0.366	0.377	0.386	0.390	0.403
1959	0.009	0.030	0.071	0.135	0.231	0.259	0.287	0.310	0.327	0.344	0.360	0.372	0.383	0.392	0.397	0.409
1960	0.006	0.011	0.074	0.119	0.188	0.277	0.337	0.318	0.363	0.379	0.360	0.420	0.411	0.439	0.450	0.447
1961	0.006	0.010	0.045	0.087	0.159	0.276	0.322	0.372	0.363	0.393	0.407	0.397	0.422	0.447	0.465	0.452
1962	0.009	0.023	0.055	0.085	0.148	0.288	0.333	0.360	0.352	0.350	0.374	0.384	0.374	0.394	0.399	0.414
1963	0.008	0.026	0.047	0.098	0.171	0.275	0.268	0.323	0.329	0.336	0.341	0.358	0.385	0.353	0.381	0.386
1964	0.009	0.024	0.059	0.139	0.219	0.239	0.298	0.295	0.339	0.350	0.358	0.351	0.367	0.375	0.372	0.433
1965	0.009	0.016	0.048	0.089	0.217	0.234	0.262	0.331	0.360	0.367	0.386	0.395	0.393	0.404	0.401	0.431

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

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

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

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

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

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

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

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

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

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

**** 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. Mature at age. The time-series was provided by WKHERMAT in 2010 and are used in the assessment since 2010.

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

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1978	0	0	0	0.2	0.9	1	1	1	1	1	1	1	1	1	1	1
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

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2008	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
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	0.4	0.8	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

Table 4.4.7.1. Norwegian Spring-spawning herring. Estimated indices (with 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	375	299	8066	86	33	11	38	22	41	0	0	0	0	8970	1631
1989	164	17	336	89	3995	106	12	8	59	0	4	39	0	8	4835	1175
1990	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1991	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1992*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1993*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1994	43	99	48	851	480	73	15	152	43	1838	3	3	0	0	3651	1215
1995	4	409	4643	3186	1986	292	18	0	141	76	2299	0	0	0	13053	3669
1996	126	147	1885	7923	2384	887	314	0	0	121	0	1830	0	0	15616	3382
1997*	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
1998	41	330	984	3012	13089	8214	1909	588	194	35	0	359	0	1415	30169	7008
1999	119	1572	379	1366	2593	9356	6979	1632	495	124	0	0	360	359	25333	6235
2000	1399	672	2617	103	485	1139	4193	2864	547	48	2	0	15	217	14301	3282
2001**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2002**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2003**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2004**	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
2005	39	270	662	2086	5871	8223	660	457	183	113	557	1138	595	6	20859	5223
2006	27	98	6073	478	912	3291	3290	122	67	25	72	54	265	63	14836	3392
2007	32	369	1594	12175	622	646	2842	3258	137	223	34	179	262	554	22925	5238
2008	15	70	2449	2699	9060	530	476	1599	1600	153	104	49	138	152	19094	4581
2009	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2010	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2011	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2012	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2013	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1		
2015	230	516	2748	768	3223	377	650	2868	720	7251	336	1733	50	229	21712	6390
2016	17	218	253	539	404	2288	242	569	2792	681	4144	197	982	107	13433	4338
2017	13	95	1078	666	868	411	1376	176	231	1903	295	2600	74	697	10486	3295
2018	95	145	1779	2780	485	824	622	1083	463	378	1188	360	1524	321	12047	3260
2019	2	360	304	939	3655	799	896	644	1034	740	395	1845	209	2201	14139	4249

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. "Fleet 4".

	age				
Year	**1**	**2**	**3**	**4**	**5**
1991	24.3	5.2			
1992	32.6	14	5.7		
1993	102.7	25.8	1.5		
1994	6.6	59.2	18	1.7	
1995	0.5	7.7	8	1.1	
1996*	0.1	0.25	1.8	0.6	0.03
1997**	2.6	0.04	0.4	0.35	0.05
1998	9.5	4.7	0.01	0.01	0
1999	49.5	4.9	0	0	0
2000	105.4	27.9	0	0	0
2001	0.3	7.6	8.8	0	0
2002	0.5	3.9	0	0	0
2003***					
2004***					
2005	23.3	4.5	2.5	0.4	0.3
2006	3.7	35.0	5.3	0.87	0
2007	2.1	3.7	12.5	1.9	0
2008^					
2009	0.286	0.286	0.215	0.072	0
2010	5.121	1.366	0	0	0
2011	1.079	3.802	0.039	0	0
2012	0.884	0.015	0	0	0
2013	0.132	1.982	0.264	0.088	0
2014	3.727	3.055	1.797	0.131	0.044
2015	0.33	11.471	1.218	0.198	0
2016	1.677	5.463	1.668	0.103	0.042
2017	14.658	3.266	0	0	0

	age				
Year	**1**	**2**	**3**	**4**	**5**
2018	6.866	17.404	0.943	0.009	0
2019	0.112	2.305	17.315	0.023	0

***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 2008-2019 are estimated indices by StoX. "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	1240	631	10809	8271	14827	1513	2257	4848	2734	449	149	151	270	491	48665	10558
2009	0	144	1669	2159	12300	8994	9527	2147	1435	2466	1411	188	193	123	231	43082	9728
2010	234	125	542	2334	1781	8351	5988	5601	869	882	983	578	90	72	57	28622	6633
2011	0	1205	977	1528	3607	2564	9420	4542	4298	825	892	712	261	37	39	30917	7395

	Age															Total
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**	**Biomass**
2012	0	378	2895	412	670	1646	2560	4226	2026	2097	298	607	315	155	47	18331	4435
2013	0	205	776	3955	434	1211	2036	3070	4652	2767	1873	692	805	186	83	22747	5888
2014	17	517	1231	798	2790	749	1065	2681	2285	2842	1119	778	350	76	198	17505	4555
2015	0	385	468	1299	1176	3548	1399	1160	3178	2523	4350	712	788	262	194	21443	5846
2016	0	75	3549	1508	2215	1779	2683	929	1143	1770	1851	2877	928	439	136	21889	5419
2017	11	132	1063	4363	1192	1522	874	1453	327	727	975	1785	2229	538	238	17441	4203
2018	0	500	1052	2063	5686	973	1434	561	1328	338	689	1565	1478	1529	488	19684	5042
2019	6	167	2595	691	2170	4785	1255	1208	922	1295	805	687	1381	938	816	19728	4874

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	0.35	0.201	0.262	0.108	0.346	0.454	0.395	0.306	0.352	0.49	0.361
1989	0.261	0.486	0.456	0.401	0.125	0.461	0.703	0.737	0.468	0.602	0.617
1990	0.3	0.285	0.498	0.324	0.333	0.139	0.613	0.585	0.538	0.512	0.549
1991	0.467	0.358	0.492	0.597	0.305	0.352	0.14	0.507	0.824	1.329	0.577
1992	0.606	0.319	0.242	0.416	0.627	0.323	0.399	0.139	0.508	0.75	0.589
1993	0.374	0.252	0.173	0.183	0.355	0.455	0.249	0.285	0.117	NA	NA
1994	0.362	0.243	0.171	0.121	0.152	0.3	0.361	0.233	0.236	0.103	0.405
1995	0.637	0.206	0.123	0.104	0.103	0.138	0.3	0.298	0.195	0.185	0.093
1996	0.248	0.239	0.1	0.08	0.092	0.118	0.174	0.401	0.372	0.198	0.095
1997	0.272	0.163	0.132	0.077	0.074	0.098	0.125	0.203	0.279	0.243	0.112
1998	0.186	0.195	0.136	0.121	0.077	0.085	0.12	0.163	0.225	0.261	0.138
1999	0.415	0.16	0.236	0.161	0.116	0.079	0.087	0.129	0.173	0.306	0.144
2000	0.307	0.185	0.107	0.238	0.171	0.118	0.084	0.09	0.141	0.194	0.162
2001	0.535	0.175	0.153	0.116	0.231	0.178	0.129	0.095	0.11	0.192	0.211
2002	0.202	0.144	0.103	0.134	0.125	0.249	0.179	0.133	0.102	0.124	0.186
2003	0.428	0.191	0.125	0.099	0.15	0.152	0.269	0.191	0.141	0.107	0.132
2004	0.223	0.264	0.18	0.116	0.1	0.171	0.16	0.257	0.212	0.151	0.103
2005	0.277	0.114	0.179	0.151	0.103	0.093	0.166	0.166	0.232	0.199	0.104
2006	0.221	0.19	0.099	0.186	0.151	0.1	0.098	0.182	0.189	0.248	0.12
2007	0.357	0.139	0.121	0.077	0.156	0.136	0.099	0.11	0.218	0.261	0.153
2008	0.165	0.235	0.108	0.102	0.072	0.144	0.134	0.106	0.121	0.249	0.157
2009	0.17	0.146	0.157	0.086	0.093	0.075	0.159	0.133	0.116	0.137	0.161
2010	0.202	0.175	0.142	0.146	0.089	0.1	0.082	0.15	0.148	0.124	0.135
2011	0.135	0.202	0.174	0.138	0.142	0.098	0.108	0.103	0.181	0.168	0.144
2012	0.315	0.142	0.215	0.167	0.131	0.133	0.099	0.127	0.122	0.211	0.165
2013	0.276	0.203	0.131	0.194	0.17	0.13	0.136	0.106	0.151	0.158	0.218
2014	0.594	0.253	0.206	0.134	0.214	0.193	0.145	0.157	0.12	0.185	0.188
2015	0.47	0.297	0.208	0.212	0.156	0.24	0.198	0.155	0.174	0.144	0.185

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2016	0.516	0.22	0.223	0.17	0.184	0.152	0.212	0.192	0.15	0.178	0.134
2017	0.295	0.2	0.128	0.169	0.135	0.153	0.13	0.176	0.162	0.131	0.118
2018	0.27	0.26	0.204	0.133	0.156	0.149	0.171	0.148	0.184	0.176	0.111
2019	0.332	0.22	0.191	0.174	0.173	0.184	0.203	0.214	0.229	0.288	0.24

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	0.324	0.341	0.165	0.448	0.553	0.703	0.536	0.604	0.527	NA
1989	0.639	0.332	0.444	0.193	0.428	0.69	0.754	0.486	NA	0.502
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	0.434	0.509	0.271	0.307	0.464	0.657	0.395	0.521	0.229	0.804
1995	0.318	0.186	0.203	0.225	0.342	0.631	NA	0.402	0.46	0.218
1996	0.398	0.227	0.166	0.216	0.268	0.337	NA	NA	0.415	0.229
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.333	0.262	0.205	0.149	0.165	0.227	0.294	0.375	0.546	0.23
1999	0.237	0.323	0.244	0.212	0.16	0.17	0.235	0.305	0.413	0.281
2000	0.285	0.211	0.43	0.306	0.254	0.191	0.207	0.298	0.509	0.359
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	0.348	0.286	0.222	0.177	0.164	0.286	0.31	0.379	0.422	0.218
2006	0.435	0.176	0.307	0.267	0.201	0.201	0.415	0.473	0.587	0.311
2007	0.325	0.236	0.151	0.29	0.288	0.208	0.202	0.404	0.363	0.26
2008	0.468	0.215	0.21	0.161	0.3	0.308	0.236	0.236	0.395	0.312
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	0.302	0.209	0.277	0.202	0.324	0.287	0.207	0.281	0.169	0.217
2016	0.365	0.353	0.299	0.319	0.218	0.357	0.296	0.208	0.284	0.18
2017	0.438	0.257	0.286	0.269	0.318	0.244	0.383	0.36	0.227	0.196
2018	0.399	0.23	0.209	0.306	0.273	0.29	0.257	0.309	0.323	0.2
2019	0.327	0.339	0.265	0.197	0.274	0.268	0.288	0.259	0.279	0.186

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

Year/age	2
1991	0.418
1992	0.359
1993	0.327
1994	0.287
1995	0.394
1996	0.669
1997	0.887
1998	0.425
1999	0.422
2000	0.323
2001	0.395
2002	0.437
2003	NA
2004	NA
2005	0.428
2006	0.312
2007	0.441
2008	0.627

Year/age	2
2009	0.655
2010	0.514
2011	0.439
2012	1.032
2013	0.486
2014	0.454
2015	0.37
2016	0.415
2017	0.45
2018	0.347
2019	0.474

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	0.134	0.152	0.192	0.237	0.344	0.772	0.91	0.437	0.214
1997	0.27	0.207	0.14	0.151	0.226	0.245	0.422	0.515	0.377	0.217
1998	0.356	0.274	0.197	0.144	0.162	0.236	0.295	0.42	NA	0.327
1999	0.233	0.367	0.283	0.215	0.156	0.183	0.291	0.387	0.986	0.373
2000	0.261	0.22	0.494	0.352	0.263	0.176	0.188	0.248	0.382	0.416
2001	0.17	0.258	0.256	0.422	0.409	0.213	0.188	0.268	0.492	0.419
2002	0.181	0.164	0.258	0.298	0.354	0.292	0.24	0.226	0.258	0.429
2003	0.18	0.162	0.163	0.255	0.302	0.443	0.398	0.242	0.229	0.236
2004	0.253	0.189	0.154	0.16	0.276	0.319	0.517	0.369	0.357	0.225
2005	0.138	0.261	0.245	0.182	0.188	0.311	0.351	0.448	0.385	0.238
2006	0.371	0.149	0.259	0.238	0.18	0.177	0.307	0.304	0.425	0.233
2007	0.218	0.184	0.137	0.266	0.238	0.178	0.187	0.311	0.333	0.219
2008	0.313	0.159	0.17	0.148	0.254	0.231	0.193	0.221	0.339	0.277
2009	0.248	0.234	0.155	0.167	0.164	0.234	0.257	0.226	0.258	0.302
2010	0.324	0.229	0.245	0.17	0.183	0.186	0.29	0.289	0.282	0.296
2011	0.282	0.254	0.207	0.224	0.165	0.196	0.198	0.294	0.288	0.277

Year/Age	3	4	5	6	7	8	9	10	11	12+
2012	0.218	0.346	0.308	0.249	0.224	0.199	0.237	0.235	0.374	0.273
2013	0.298	0.202	0.342	0.268	0.237	0.215	0.195	0.22	0.242	0.245
2014	0.267	0.296	0.22	0.3	0.276	0.222	0.231	0.219	0.273	0.259
2015	0.336	0.264	0.27	0.208	0.259	0.271	0.213	0.225	0.198	0.239
2016	0.208	0.254	0.232	0.245	0.222	0.285	0.272	0.245	0.242	0.198
2017	0.276	0.198	0.269	0.254	0.29	0.257	0.366	0.303	0.282	0.193
2018	0.277	0.236	0.186	0.282	0.257	0.322	0.262	0.363	0.306	0.191
2019	0.224	0.306	0.233	0.193	0.266	0.268	0.286	0.264	0.295	0.204

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

Parameter	Estimate	Std. Error	CV	Estimate 2018	Std. Error 2018
$\log(N_{3,1988})$	7.075	0.17	0.024	7.072	0.173
$\log(N_{4,1988})$	6.604	0.209	0.032	6.606	0.212
$\log(N_{5,1988})$	9.584	0.076	0.008	9.577	0.079
$\log(N_{6,1988})$	4.812	0.369	0.077	4.792	0.371
$\log(N_{7,1988})$	3.487	0.506	0.145	3.474	0.508
$\log(N_{8,1988})$	3.115	0.554	0.178	3.132	0.557
$\log(N_{9,1988})$	4.08	0.445	0.109	4.079	0.455
$\log(N_{10,1988})$	3.275	0.645	0.197	3.28	0.653
$\log(N_{11,1988})$	3.054	0.693	0.227	2.989	0.716
$\log(N_{12,1988})$	3.502	0.728	0.208	3.479	0.732
$\log(q_3^{F1})$	-9.594	0.188	0.02	-9.544	0.199
$\log(q_4^{F1})$	-8.102	0.138	0.017	-8.064	0.14
$\log(q_5^{F1})$	-7.555	0.125	0.017	-7.507	0.126
$\log(q_6^{F1})$	-7.31	0.124	0.017	-7.31	0.127
$\log(q_7^{F1})$	-7.165	0.138	0.019	-7.134	0.14
$\log(q_8^{F1})$	-6.925	0.099	0.014	-6.917	0.103
$\log(q_2^{F4})$	-14.304	0.177	0.012	-14.46	0.189

Parameter	Estimate	Std. Error	CV	Estimate 2018	Std. Error 2018
$\log(q_3^{F5})$	-7.609	0.111	0.015	-7.597	0.116
$\log(q_4^{F5})$	-7.157	0.1	0.014	-7.127	0.104
$\log(q_5^{F5})$	-6.911	0.098	0.014	-6.891	0.102
$\log(q_6^{F5})$	-6.779	0.101	0.015	-6.768	0.106
$\log(q_7^{F5})$	-6.707	0.108	0.016	-6.693	0.112
$\log(q_8^{F5})$	-6.533	0.114	0.017	-6.509	0.119
$\log(q_9^{F5})$	-6.517	0.127	0.02	-6.508	0.133
$\log(q_{10}^{F5})$	-6.477	0.143	0.022	-6.439	0.15
$\log(q_{11}^{F5})$	-6.442	0.143	0.022	-6.438	0.15
$\log(\sigma_1^2)$	-5	1.472	0.294	-5	1.486
$\log(\sigma_2^2)$	-2.718	0.271	0.1	-2.651	0.275
$\log(\sigma_4^2)$	-2.167	0.31	0.143	-2.108	0.314
$\log(\sigma_R^2)$	-0.146	0.261	1.793	-0.09	0.267
$\log(h)$	1.587	0.068	0.043	1.581	0.07
μ_R	9.344	0.173	0.018	9.361	0.18
α_Y	-0.537	0.311	0.579	-0.535	0.32
β_Y	0.806	0.112	0.139	0.803	0.115
α_{2U}	-1.241	0.172	0.139	-1.245	0.176
α_{3U}	-0.621	0.1	0.161	-0.615	0.102
α_{4U}	-0.215	0.064	0.296	-0.201	0.066
α_{5U}	0.046	0.054	1.167	0.054	0.057
α_{6U}	0.201	0.059	0.292	0.195	0.061
α_{7U}	0.265	0.063	0.238	0.261	0.066
α_{8U}	0.324	0.07	0.215	0.316	0.072
α_{9U}	0.364	0.076	0.208	0.373	0.079
α_{10U}	0.431	0.082	0.192	0.425	0.085
β_U	0.602	0.054	0.09	0.605	0.055

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	648	1183	738	14526	123	33	23	59	26	21	33
1989	1171	251	953	617	12016	101	27	17	40	16	39
1990	4311	471	211	807	518	10008	84	21	13	30	43
1991	11347	1746	400	179	679	432	8355	68	17	10	58
1992	18561	4608	1495	341	152	570	363	6964	56	14	56
1993	49849	7540	3951	1271	287	127	476	302	5760	46	57
1994	59854	20247	6460	3333	1038	232	103	385	243	4560	80
1995	15663	24302	17340	5440	2618	780	179	80	298	182	3436
1996	5726	6352	20760	14511	4158	1760	513	129	58	205	2240
1997	2182	2317	5392	17165	11110	2807	1133	337	90	39	1366
1998	10787	880	1922	4338	13067	7731	1754	665	209	54	760
1999	6420	4355	725	1487	3340	9542	5391	1120	411	122	458
2000	33024	2599	3630	567	1136	2477	6764	3615	702	243	303
2001	29019	13382	2176	2720	425	833	1768	4615	2236	409	270
2002	11483	11767	11348	1735	1999	317	618	1273	3201	1476	451
2003	6659	4650	9941	9165	1280	1400	230	433	864	2121	1287
2004	58091	2700	3939	8216	7199	943	1022	167	305	581	2234
2005	24506	23573	2295	3282	6640	5548	702	740	121	214	1752
2006	43239	9939	19938	1891	2622	5079	3936	479	501	80	1138
2007	12056	17537	8452	16503	1520	2049	3728	2709	331	346	718
2008	17519	4883	14876	6963	12697	1152	1500	2544	1800	222	729
2009	7027	7068	4131	12259	5393	8888	814	1032	1628	1134	635
2010	4663	2819	5917	3389	9486	3849	5794	545	642	969	1094
2011	15793	1871	2350	4859	2697	7154	2689	3629	343	395	1122
2012	5255	6343	1563	1927	3911	2105	5390	1835	2427	223	962
2013	8010	2125	5314	1288	1550	3095	1611	3969	1299	1700	834
2014	5362	3245	1791	4361	1036	1227	2410	1206	2912	939	1984
2015	17625	2176	2761	1494	3546	838	983	1896	926	2199	2341

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2016	8039	7156	1858	2323	1234	2893	682	787	1499	717	3634
2017	5185	3263	6105	1557	1903	988	2309	537	612	1139	3380
2018	15643	2101	2760	5007	1233	1421	725	1684	386	417	3235
2019	8111	6343	1784	2296	4042	941	1069	537	1257	272	2585

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	0.049	0.065	0.029	0.04	0.047	0.051	0.152	0.232	0.349	0.195	0.195
1989	0.011	0.021	0.017	0.026	0.033	0.038	0.076	0.107	0.15	0.092	0.092
1990	0.004	0.012	0.014	0.023	0.031	0.031	0.052	0.073	0.1	0.07	0.07
1991	0.001	0.005	0.011	0.018	0.024	0.025	0.032	0.043	0.057	0.045	0.045
1992	0.001	0.004	0.013	0.023	0.029	0.03	0.034	0.04	0.054	0.053	0.053
1993	0.001	0.005	0.02	0.052	0.061	0.057	0.063	0.068	0.084	0.1	0.1
1994	0.001	0.005	0.022	0.091	0.136	0.112	0.098	0.106	0.135	0.151	0.151
1995	0.003	0.008	0.028	0.119	0.248	0.268	0.175	0.17	0.223	0.329	0.329
1996	0.005	0.014	0.04	0.117	0.243	0.29	0.271	0.209	0.245	0.432	0.432
1997	0.007	0.037	0.067	0.123	0.213	0.32	0.383	0.327	0.358	0.465	0.465
1998	0.007	0.043	0.106	0.112	0.164	0.21	0.299	0.331	0.388	0.424	0.424
1999	0.004	0.032	0.097	0.12	0.149	0.194	0.25	0.317	0.375	0.501	0.501
2000	0.003	0.028	0.139	0.139	0.16	0.187	0.232	0.33	0.389	0.553	0.553
2001	0.003	0.015	0.077	0.158	0.141	0.149	0.179	0.216	0.265	0.261	0.261
2002	0.004	0.019	0.064	0.154	0.206	0.172	0.205	0.237	0.262	0.254	0.254
2003	0.003	0.016	0.041	0.091	0.155	0.164	0.169	0.201	0.246	0.272	0.272
2004	0.002	0.013	0.032	0.063	0.11	0.145	0.172	0.172	0.203	0.325	0.325
2005	0.002	0.017	0.044	0.075	0.118	0.193	0.233	0.24	0.265	0.397	0.397
2006	0.002	0.012	0.039	0.068	0.097	0.159	0.224	0.219	0.221	0.378	0.378
2007	0.004	0.015	0.044	0.112	0.127	0.162	0.232	0.259	0.249	0.229	0.229
2008	0.008	0.017	0.044	0.105	0.207	0.197	0.225	0.297	0.312	0.254	0.254
2009	0.013	0.028	0.048	0.106	0.187	0.278	0.251	0.324	0.369	0.331	0.331
2010	0.013	0.032	0.047	0.078	0.132	0.209	0.318	0.314	0.337	0.459	0.459

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
2011	0.012	0.03	0.048	0.067	0.098	0.133	0.232	0.252	0.279	0.305	0.305
2012	0.006	0.027	0.043	0.068	0.084	0.117	0.156	0.195	0.206	0.202	0.202
2013	0.004	0.021	0.048	0.068	0.084	0.1	0.14	0.16	0.174	0.095	0.095
2014	0.002	0.011	0.031	0.057	0.062	0.071	0.09	0.114	0.131	0.072	0.072
2015	0.001	0.008	0.023	0.041	0.053	0.057	0.073	0.085	0.106	0.073	0.073
2016	0.002	0.009	0.026	0.049	0.072	0.075	0.088	0.101	0.125	0.102	0.102
2017	0.003	0.017	0.048	0.083	0.142	0.16	0.166	0.18	0.234	0.184	0.184
2018	0.003	0.014	0.034	0.064	0.121	0.135	0.149	0.142	0.2	0.195	0.195
2019	0.003	0.013	0.035	0.066	0.111	0.127	0.144	0.145	0.192	0.155	0.155

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

Year	Recruitment (Age 2)	High	Low	Stock Size: SSB	High	Low	Catches	Fishing Pressure: F	High	Low
	millions			thousnd tonnes			thousand tonnes	Ages 5-12		
1988	648	954	342	2122	2424	1819	135	0.042	0.061	0.023
1989	1171	1651	691	3281	3750	2812	104	0.033	0.049	0.018
1990	4311	5389	3232	3550	4046	3054	86	0.031	0.045	0.016
1991	11347	13415	9278	3324	3788	2861	85	0.031	0.046	0.017
1992	18561	21519	15603	3352	3794	2910	104	0.038	0.055	0.022
1993	49849	55929	43769	3323	3720	2925	232	0.076	0.103	0.049
1994	59854	66667	53041	3452	3847	3056	479	0.126	0.16	0.091
1995	15663	18216	13111	3524	3904	3145	906	0.216	0.262	0.17
1996	5726	6922	4530	4109	4493	3726	1220	0.189	0.224	0.154
1997	2182	2771	1592	5373	5833	4914	1427	0.194	0.226	0.161
1998	10787	12701	8872	5941	6448	5435	1223	0.19	0.224	0.156
1999	6420	7715	5126	5816	6345	5288	1235	0.214	0.253	0.174
2000	33024	37454	28595	4842	5326	4358	1207	0.257	0.306	0.208
2001	29019	33078	24960	4018	4453	3584	766	0.203	0.246	0.16
2002	11483	13542	9423	3552	3955	3148	808	0.225	0.273	0.178

Year	Recruitment (Age 2)	High	Low	Stock Size: SSB	High	Low	Catches	Fishing Pressure: F	High	Low
2003	6659	8029	5289	4192	4640	3743	790	0.151	0.183	0.119
2004	58091	65225	50958	5292	5836	4748	794	0.127	0.154	0.101
2005	24506	28317	20694	5425	5997	4853	1003	0.171	0.206	0.136
2006	43239	49327	37152	5396	5961	4831	969	0.175	0.212	0.137
2007	12056	14414	9698	6952	7654	6250	1267	0.153	0.184	0.122
2008	17519	20732	14307	7050	7796	6303	1546	0.198	0.238	0.159
2009	7027	8576	5477	7030	7829	6231	1687	0.205	0.244	0.166
2010	4663	5799	3527	6231	7009	5452	1457	0.213	0.258	0.169
2011	15793	19015	12570	5878	6680	5077	993	0.159	0.194	0.124
2012	5255	6627	3882	5692	6518	4866	826	0.141	0.173	0.108
2013	8010	10073	5948	5322	6129	4516	685	0.121	0.15	0.091
2014	5362	7008	3716	5154	5963	4346	461	0.084	0.105	0.062
2015	17625	22504	12745	4798	5569	4028	329	0.067	0.087	0.048
2016	8039	11102	4975	4535	5262	3808	383	0.087	0.111	0.062
2017	5185	7916	2454	4490	5205	3775	722	0.162	0.205	0.119
2018	15643	25104	6182	4103	4818	3389	593	0.128	0.163	0.092
2019	8111	19137	0	3965	4717	3212				
Average	16338	19588	13179	4721	5303	4139	791	0.142	0.174	0.110

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	2019							
	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	8111	0.9	0	0	0	0.054	0.004	0.127
3	6343	0.15	0	0	0	0.104	0.02	0.208
4	1784	0.15	0.4	0	0	0.151	0.051	0.245
5	2296	0.15	0.8	0	0	0.203	0.097	0.286

6	4042	0.15	1	0	0	0.277	0.164	0.325
7	941	0.15	1	0	0	0.311	0.188	0.346
8	1069	0.15	1	0	0	0.331	0.213	0.364
9	537	0.15	1	0	0	0.355	0.215	0.376
10	1257	0.15	1	0	0	0.353	0.284	0.387
11	272	0.15	1	0	0	0.363	0.23	0.392
12	2585	0.15	1	0	0	0.381	0.23	0.394
Input for	**2020 and 2021**							
	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	11428	0.9	0	0	0	0.054	0.014	0.127
3		0.15	0	0	0	0.111	0.07	0.208
4		0.15	0.4	0	0	0.163	0.187	0.245
5		0.15	0.8	0	0	0.225	0.358	0.286
6		0.15	1	0	0	0.273	0.573	0.325
7		0.15	1	0	0	0.307	0.662	0.346
8		0.15	1	0	0	0.327	0.756	0.364
9		0.15	1	0	0	0.35	0.793	0.376
10		0.15	1	0	0	0.357	1	0.387
11		0.15	1	0	0	0.362	0.897	0.392
12		0.15	1	0	0	0.377	0.897	0.394

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

Basis:	
SSB (2019):	3.965 million t
Landings(2019):	773 750 t (sum of national quotas)
SSB(2020):	3.652 million t
Fw5-12(2019)	0.186
Recruitment(2019-2021):	8.111, 11.428, 11.428

The catch options:

Rationale	Catches (2020)	Basis	FW (2020)	SSB (2021)	P(SSB2021 <Blim)	% SSB change	%TAC change	%CATCH change
Management plan	525594	F=0.14	0.14 (0.112,0.185)*	3.660 (2.787,4.773)*	0.004	0 (-9,14)*	-11	-32
Fmsy	584722	F=0.157	0.157 (0.127,0.207)*	3.611 (2.748,4.710)*	0.006	-2 (-11,12)*	-1	-24
Zero Catch	0	F=0	0	4.106 (3.212,5.171)*	0	12 (4,26)*	-100	-100
Fpa	818335	0.227	0.227 (0.179,0.299)*	3.414 (2.540,4.468)*	0.02	6 (-17,8)*	39	6
Flim	1018785	0.291	0.232 (0.232,0.404)*	3.246 (2.385,4.341)*	0.056	-11 (-22,3)*	32	73
$SSB_{2021}=B_{lim}$	1920272	F=0.638	0.638 (0.497,1.072)*	2.500 (1.591,3.525)*	0.501	-32 (-47,-15)*	226	148
$SSB_{2021}=B_{pa}$	1092679	F=0.316	0.316 (0.25,0.428)*	3.184 (2.320,4.277)*	0.065	-13 (-24,1)	41	86
Status quo	683925	F=0.186	0.186 (0.15,0.242)*	3.527 (2.670,4.541)*	0.01	-4 (-13,9)*	16	-12

***95% confidence interval**

4.17 Figures

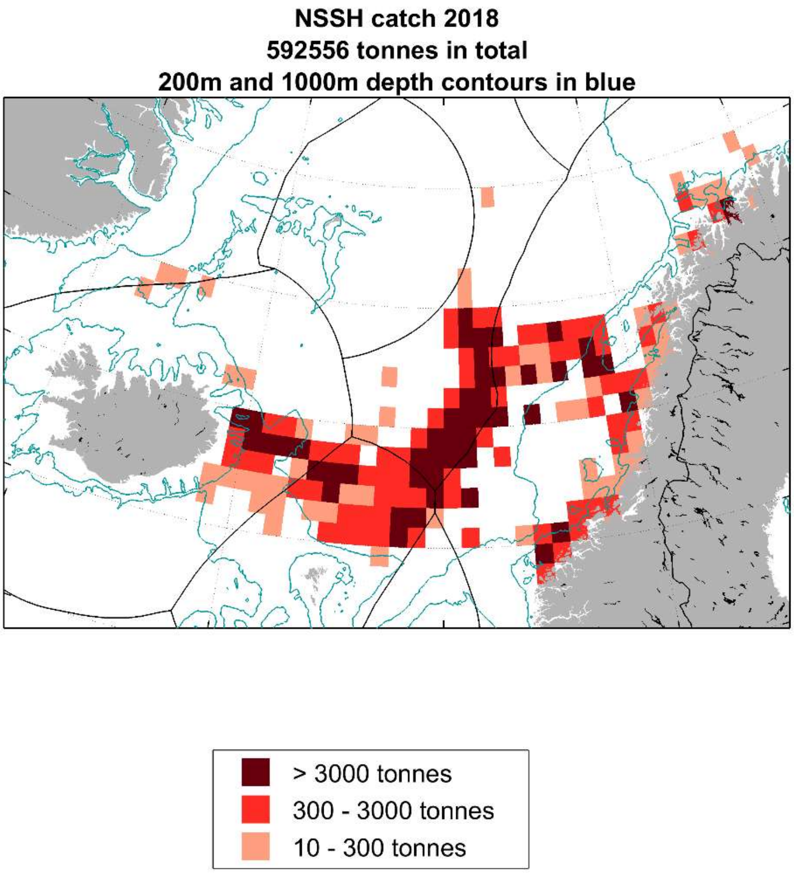

Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2018 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99.9% of the reported landings.

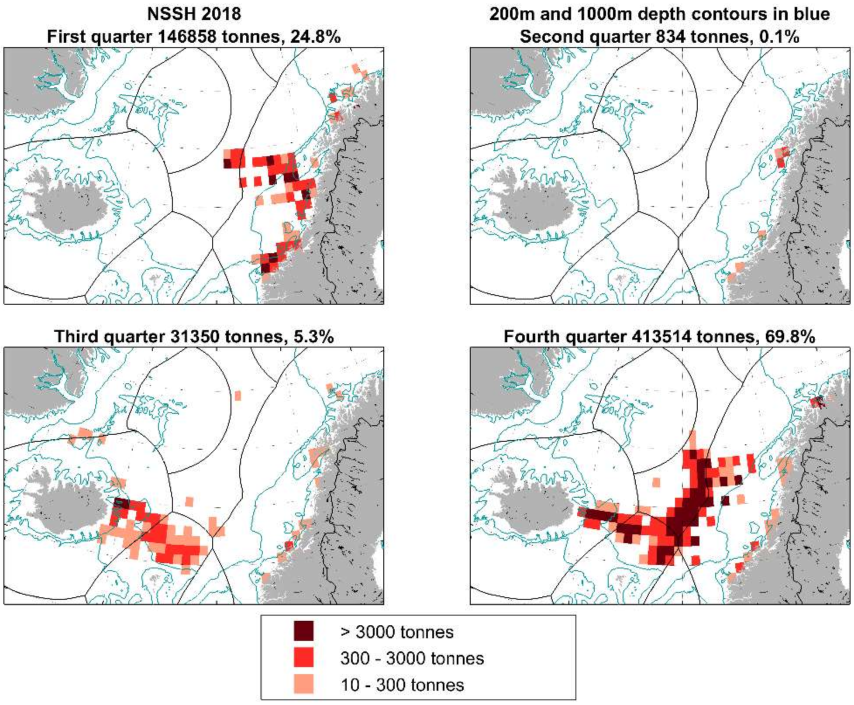

Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2018 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99.9% of the reported landings.

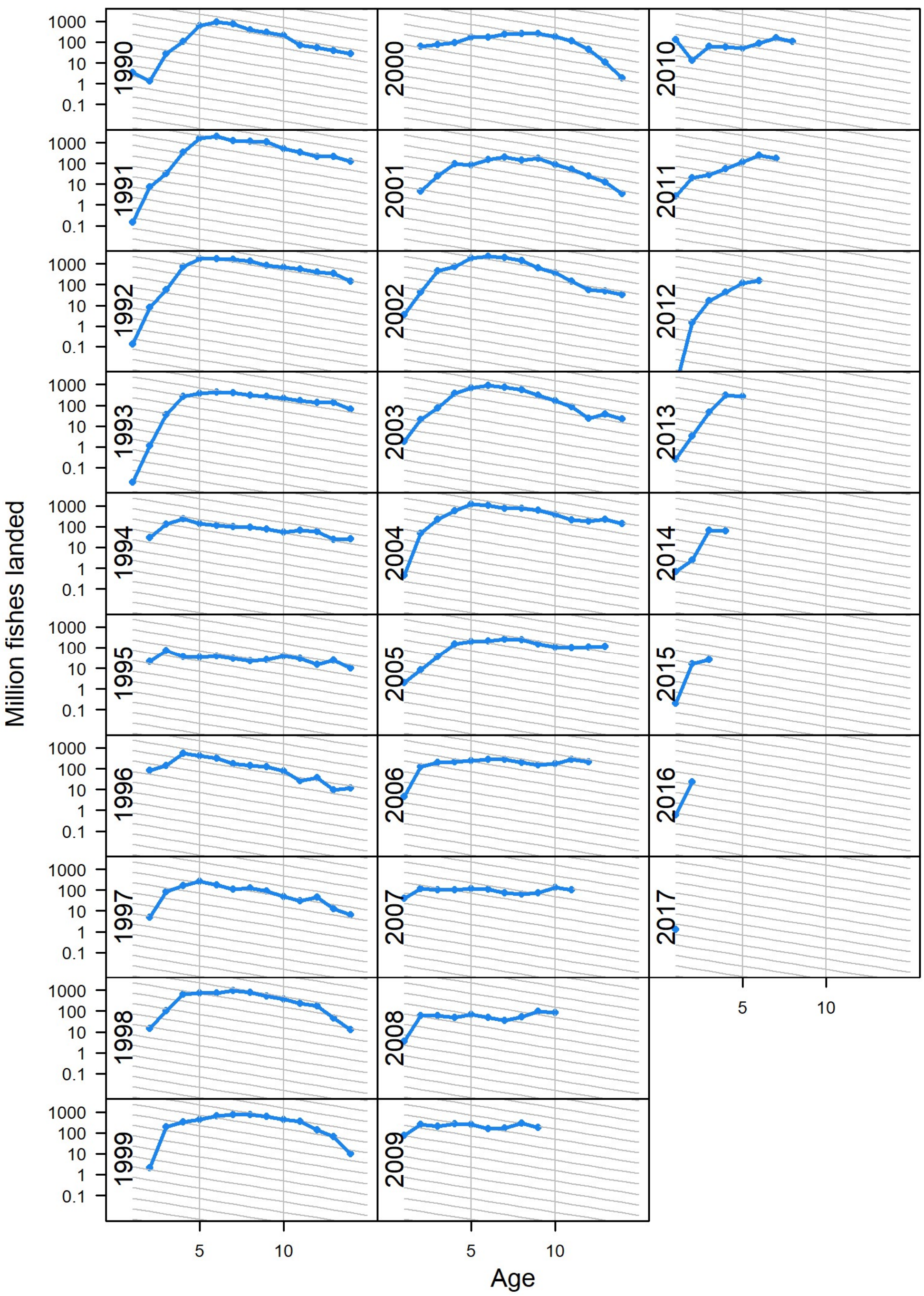

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated landings in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

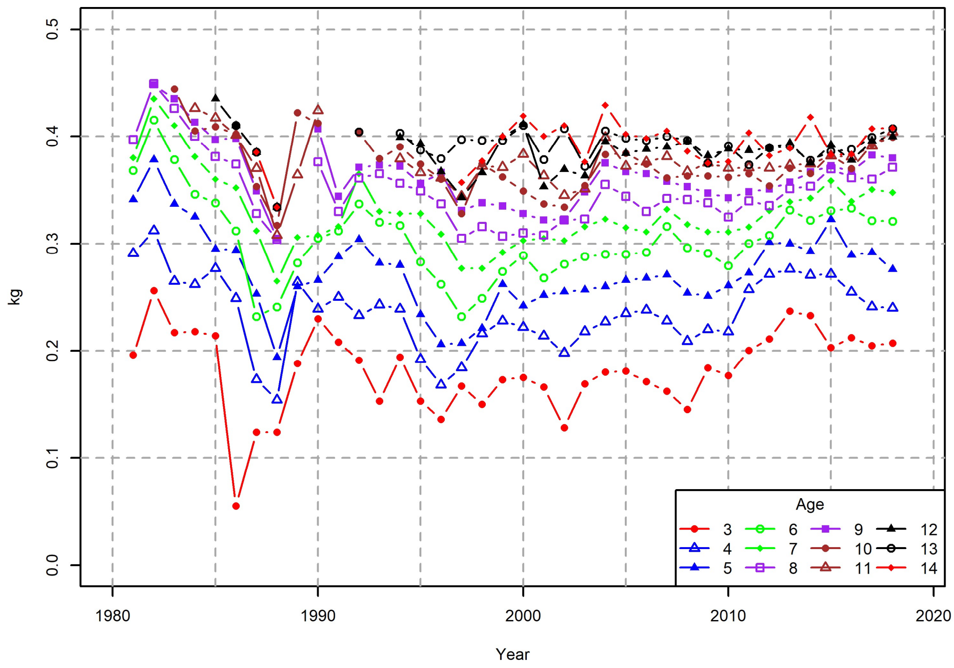

Figure 4.4.4.1.Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2018 in the landings.

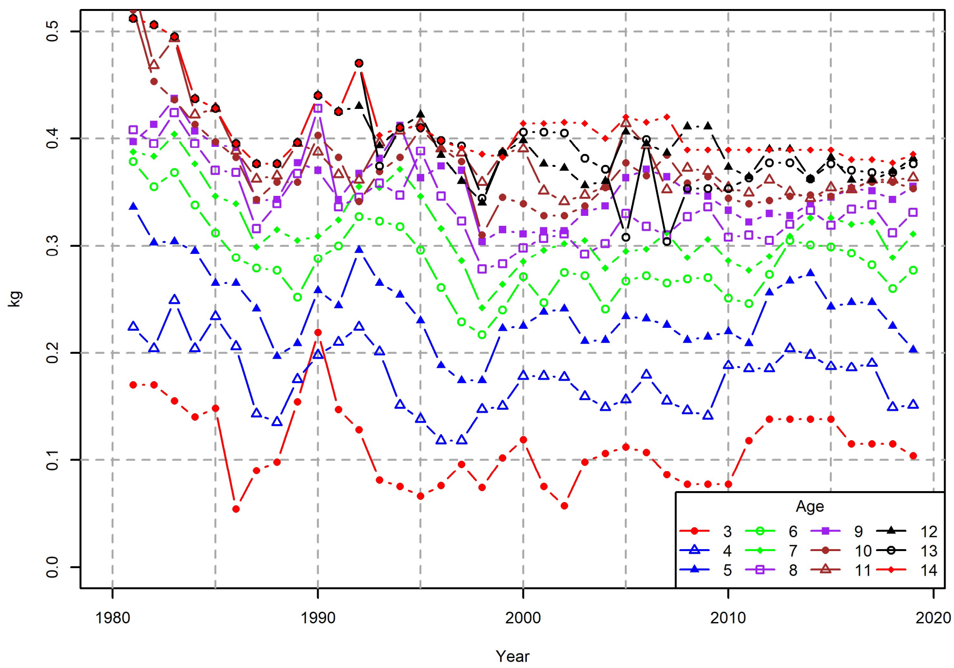

Figure 4.4.4.2.Norwegian spring-spawning herring. Mean weight at age in the stock by age groups 3–14 for the years 1981—2019.

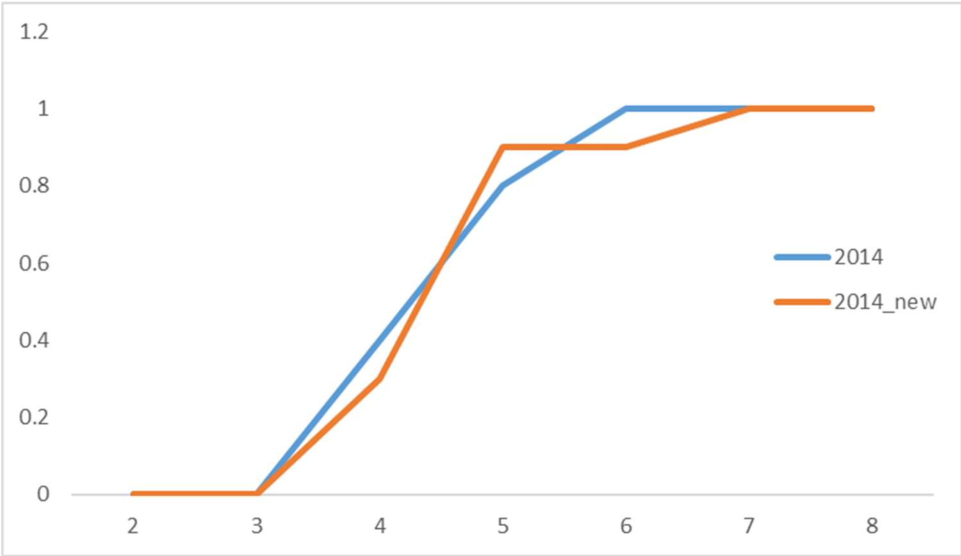

Figure 4.4.5.1. Assumed (blue line) and updated (orange line) maturity-at-age for the year 2014.

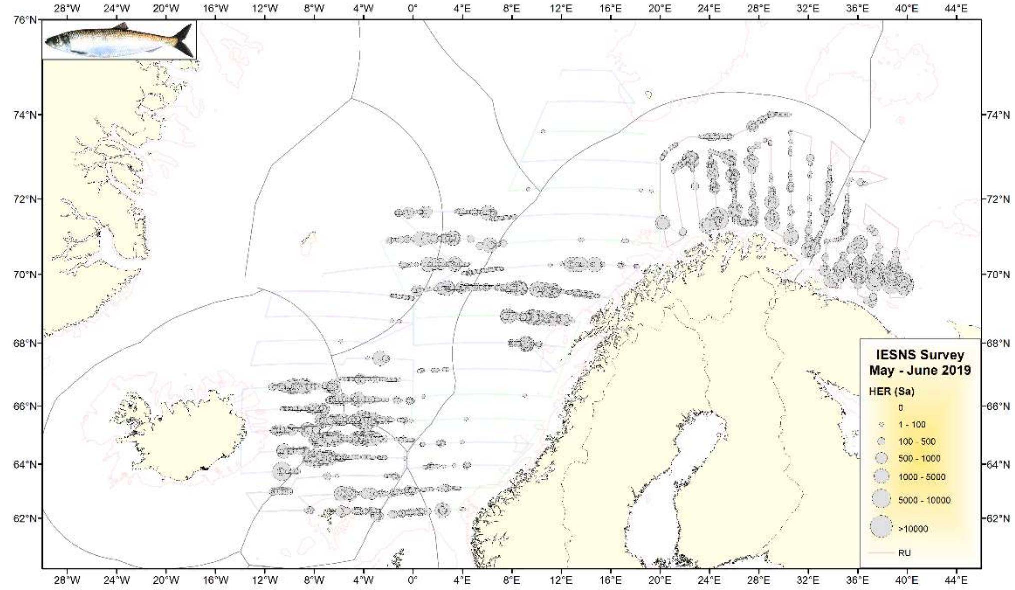

Figure 4.4.7.1. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2019 in terms of NASC values (m^2/nm^2) for every 1 nautical mile.

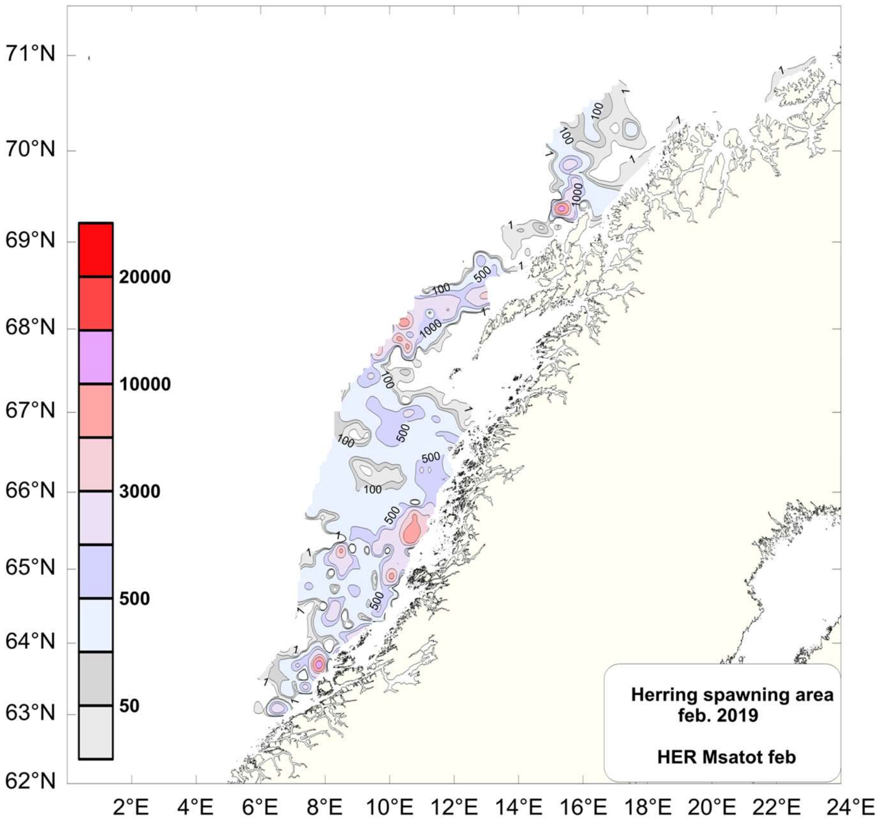

Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2019.

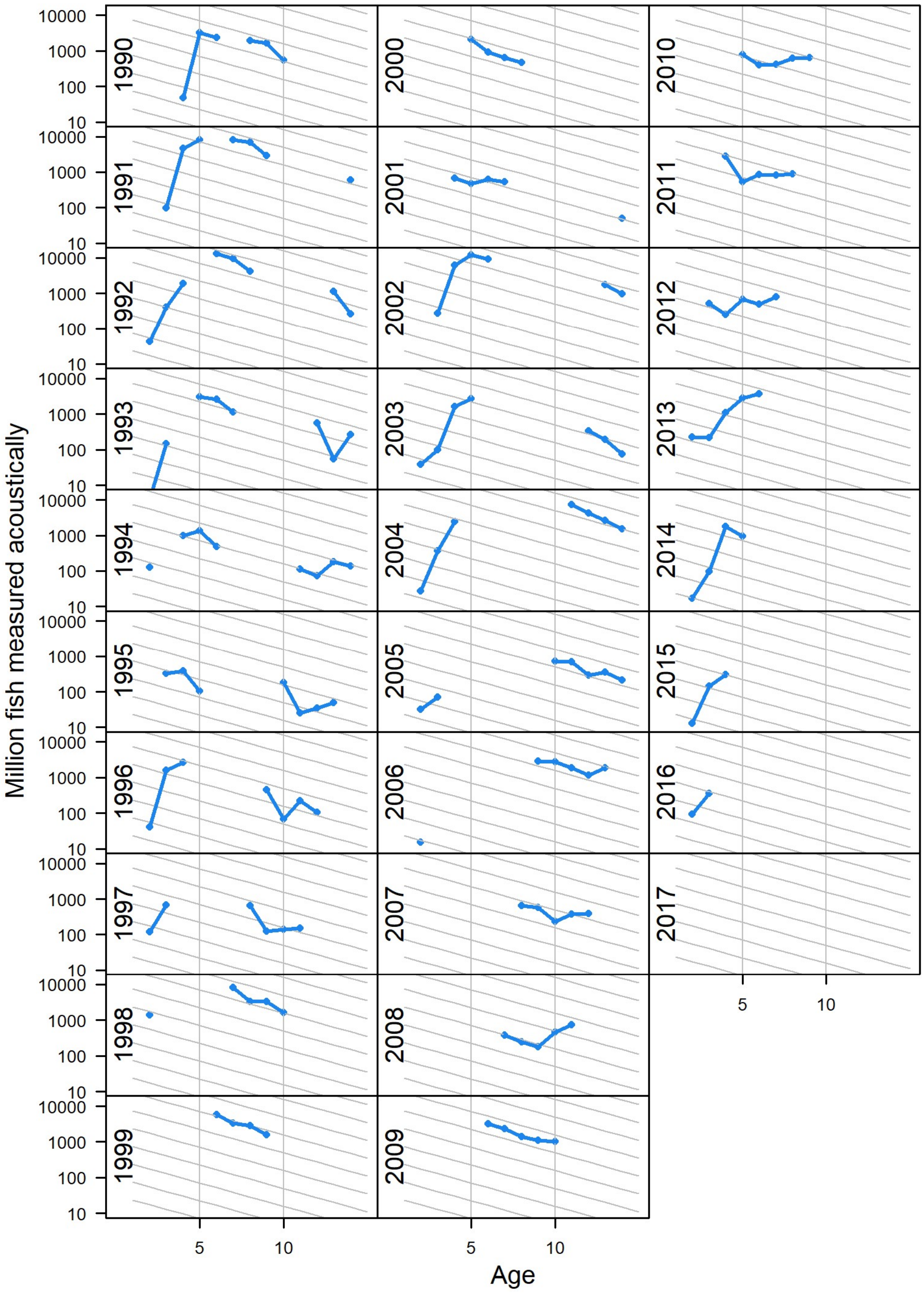

Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the spawning area in February-March (survey 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis. The labels indicate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

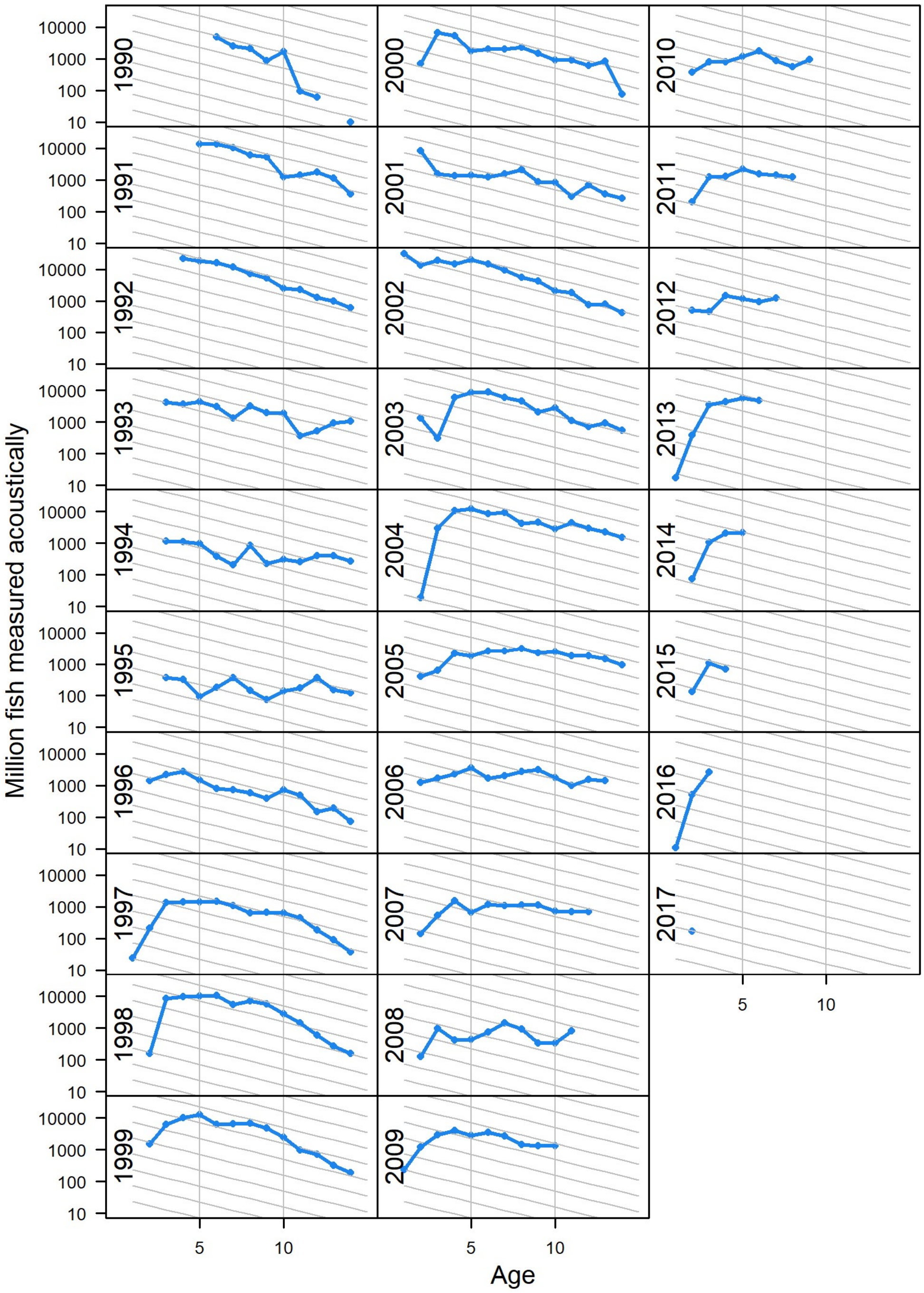

Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (millions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

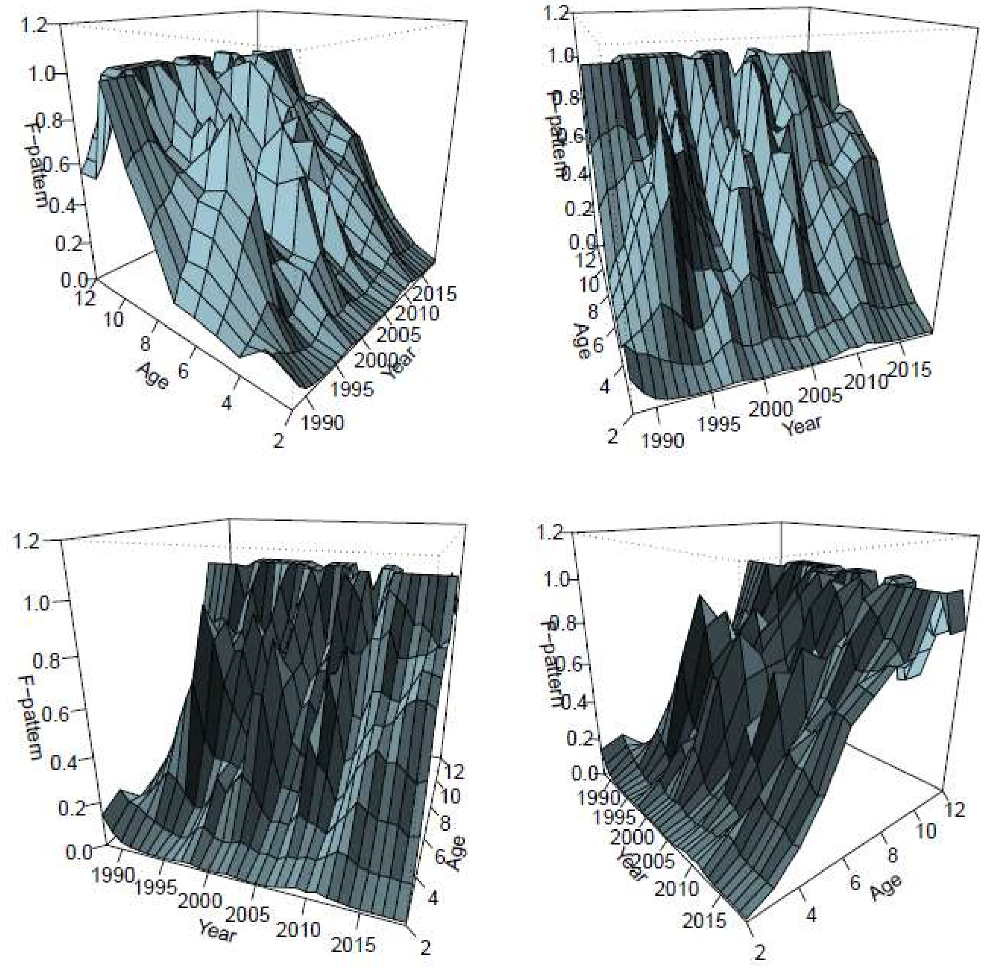

Figure 4.5.1.1. Estimated exploitation pattern for the years 1988–2019 by the XSAM model fit. All panels shows includes the same data, but shown at different angles to improve visibility at different time periods

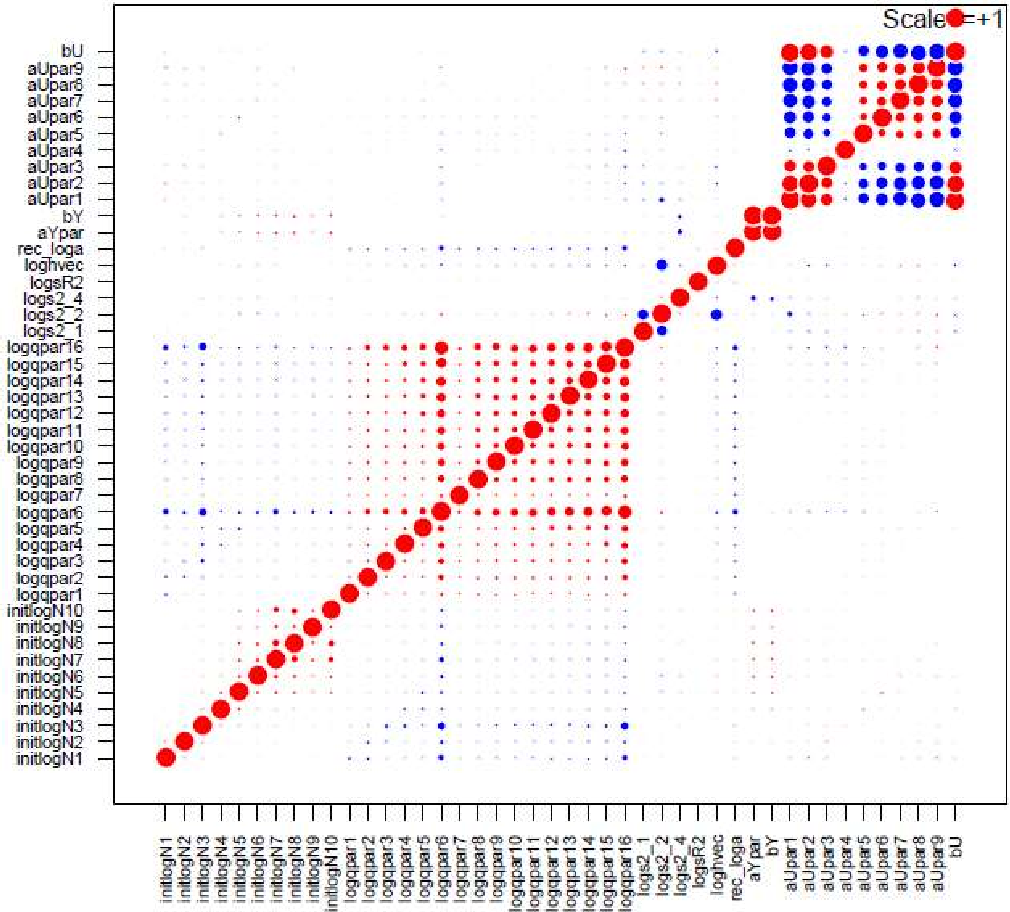

Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

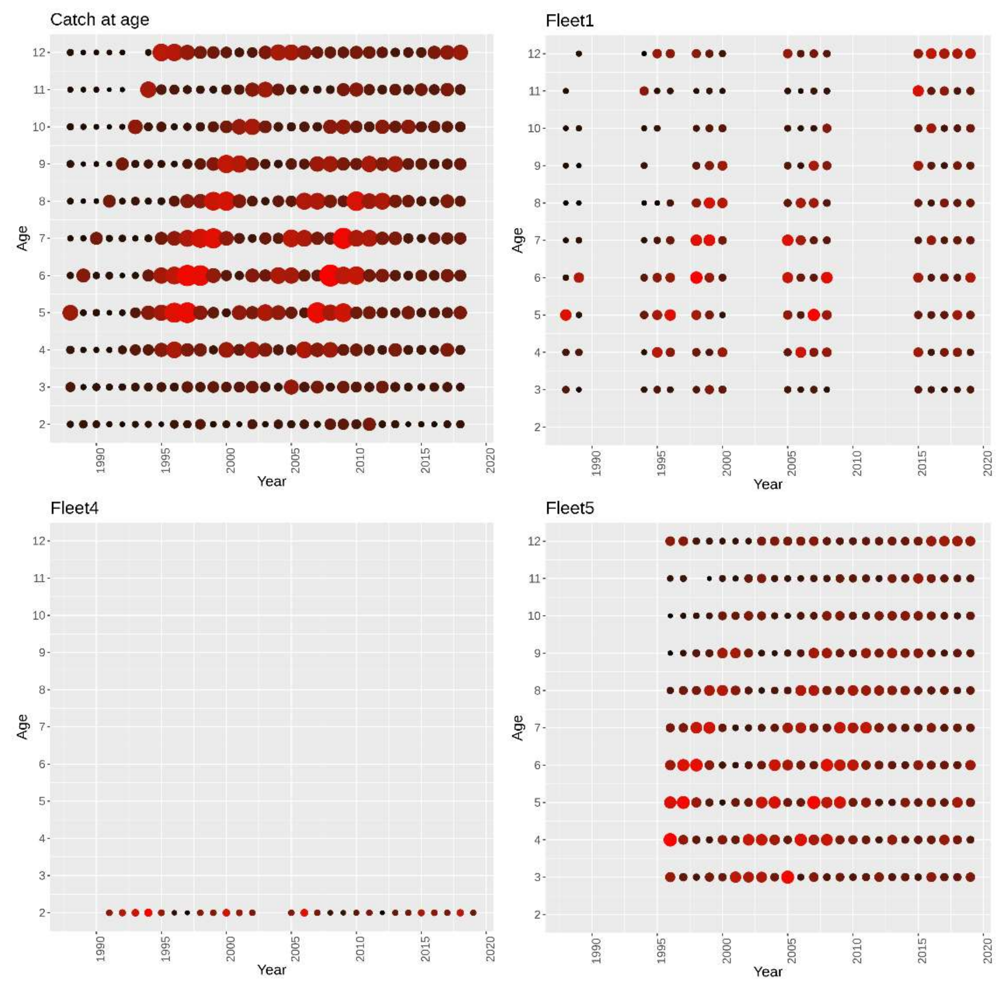

Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

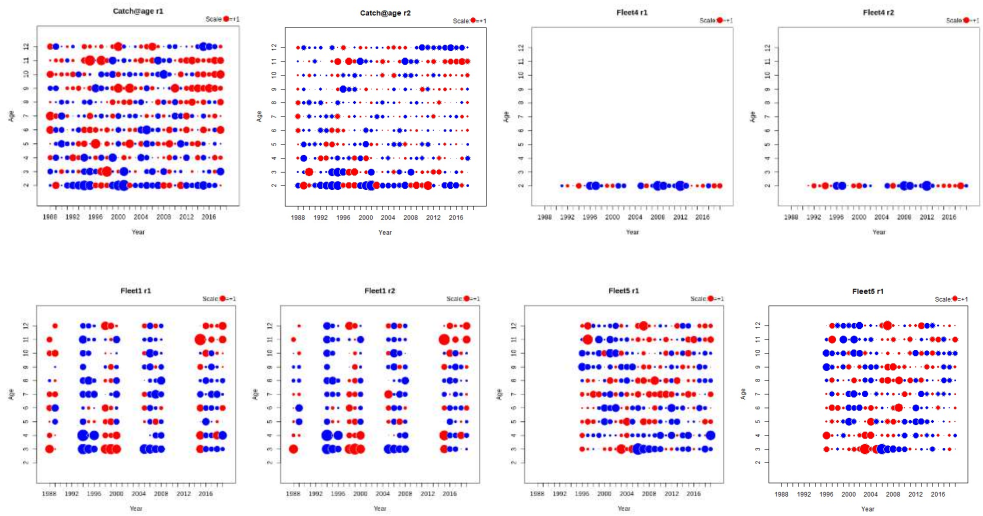

Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit.

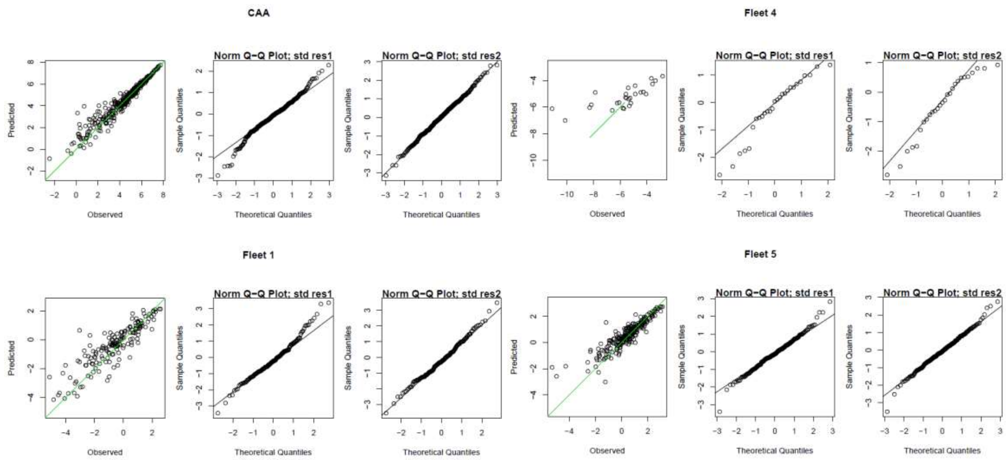

Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

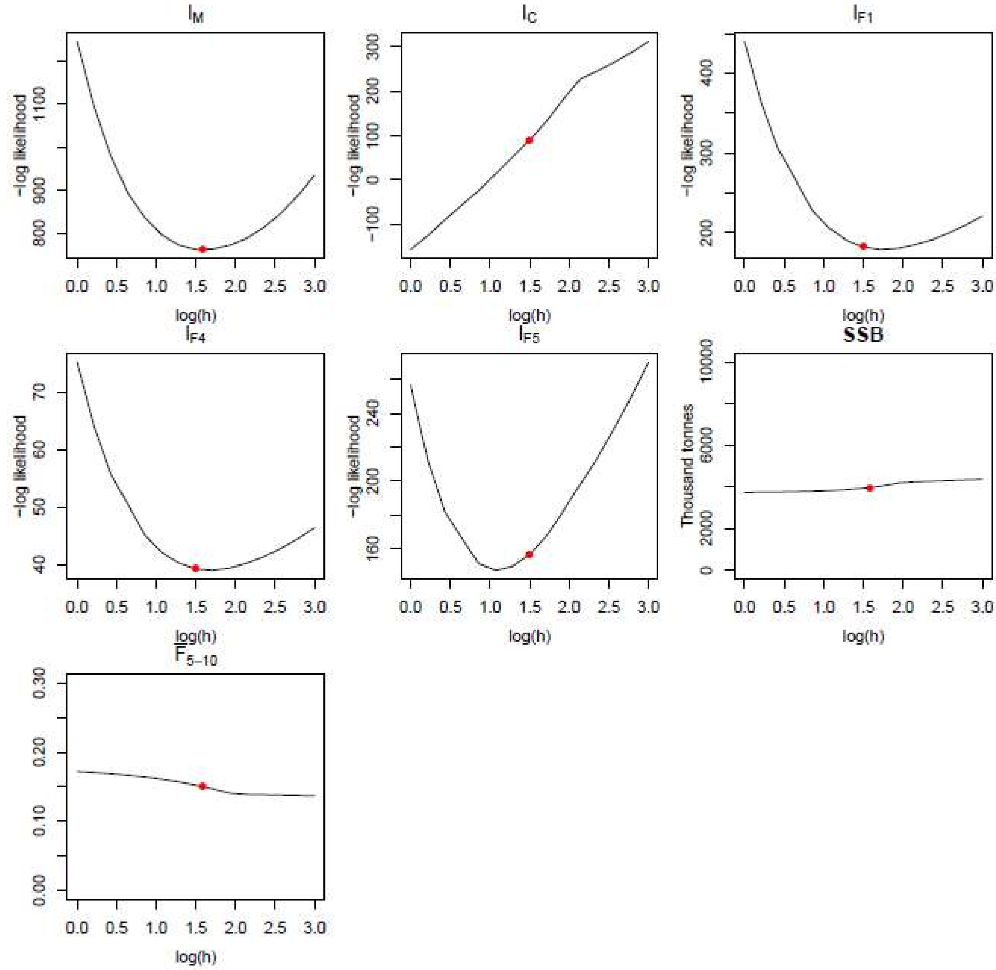

Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood $\mathbf{l_M}$, the catch component $\mathbf{l_C}$, Fleet 1 component $\mathbf{l_{F1}}$, Fleet 4 component $\mathbf{l_{F4}}$, Fleet 5 component $\mathbf{l_{F5}}$, point estimate of SSB and average F (ages 5-12+) in 2018 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.

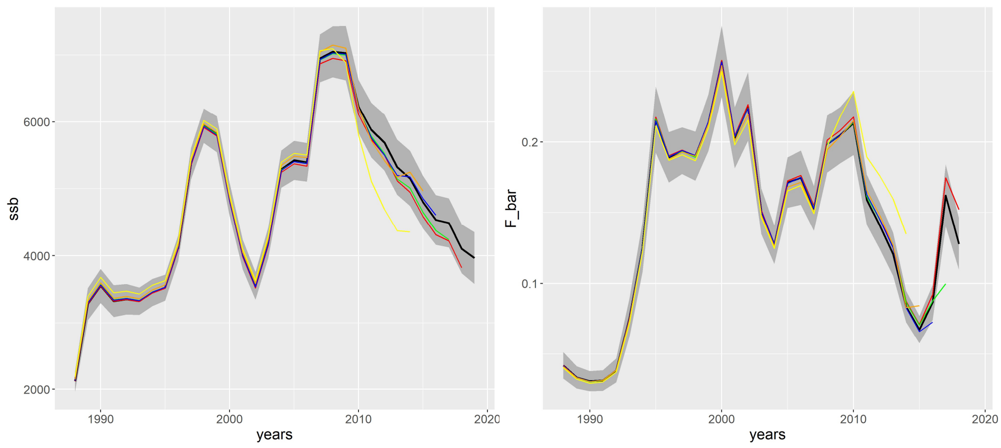

Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-12 for the years 2012-2018.

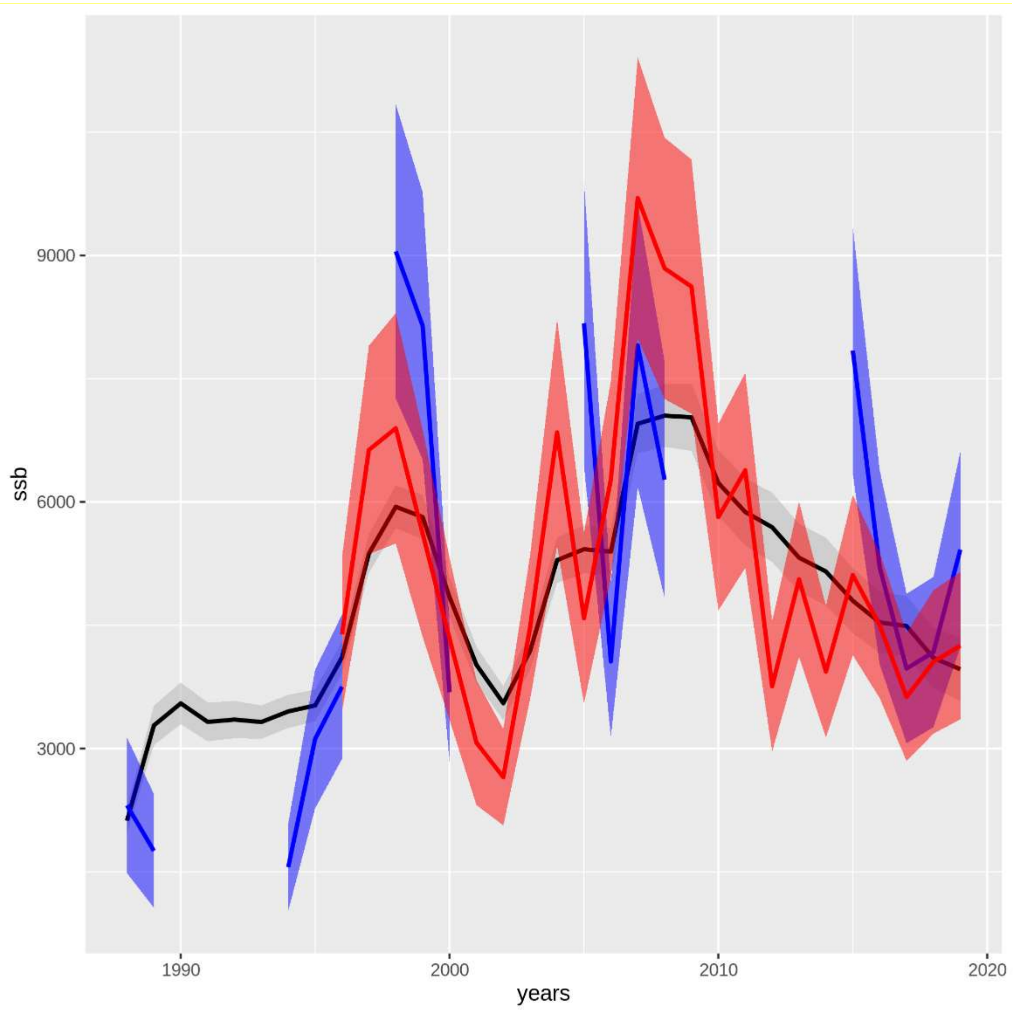

Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2019 from model (black lines) and by survey indices from Fleet 1 (red) and Fleet 5 (blue). Shaded area is approximate to standard deviation.

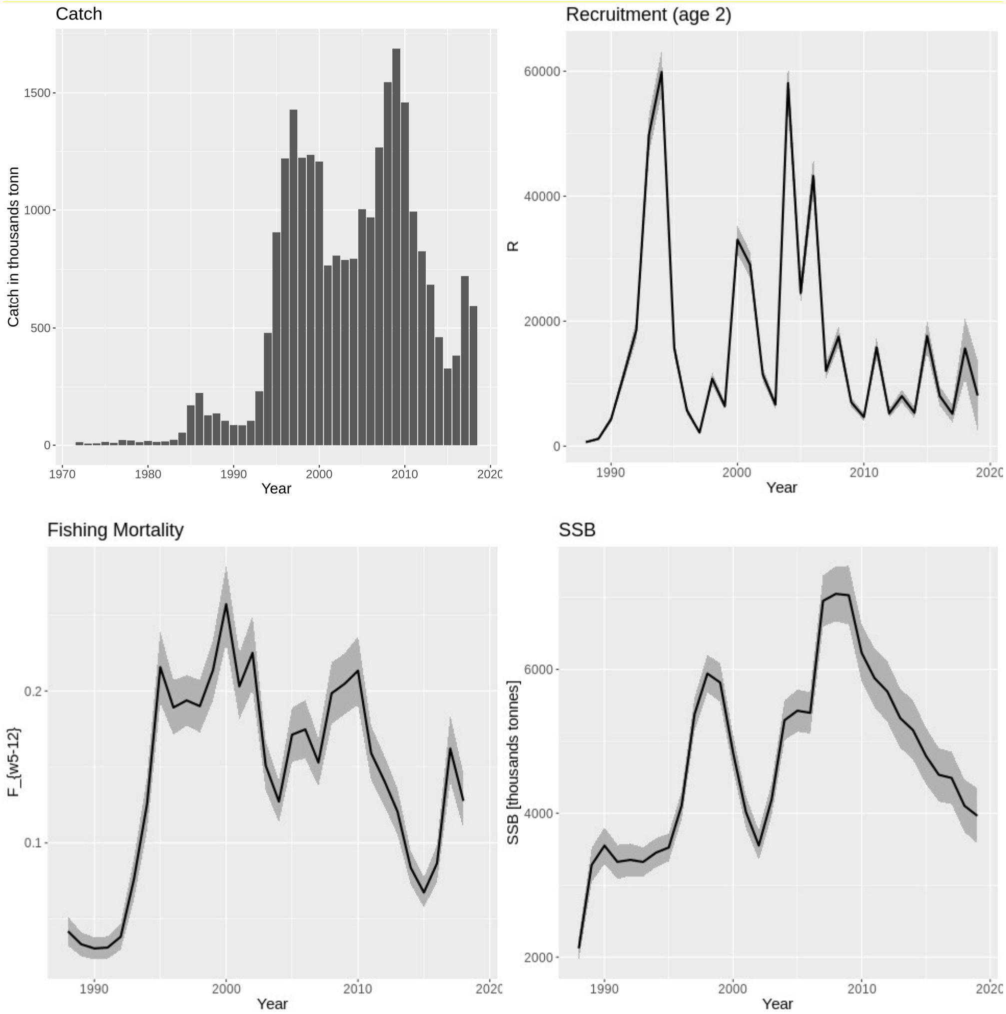

Figure 4.5.1.9. Total reported landings 1988-2018, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2019 based on the final XSAM model fit.

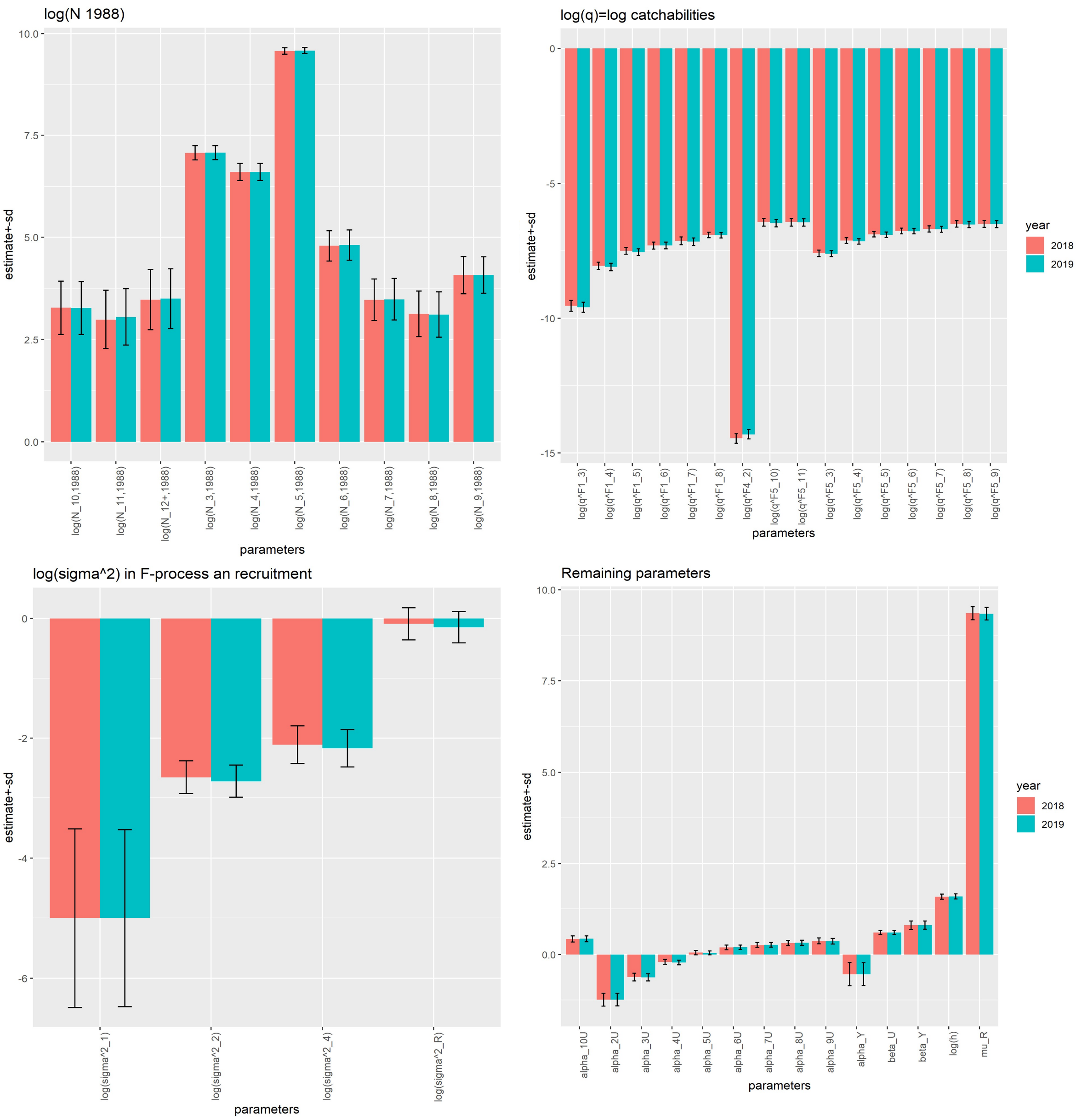

Figure 4.5.1.10. Norwegian spring-spawning herring. A visual representation of parameter estimates of the final XSAM model fit, table 4.5.1.1. The estimates from last year's assessment are also shown (blue).

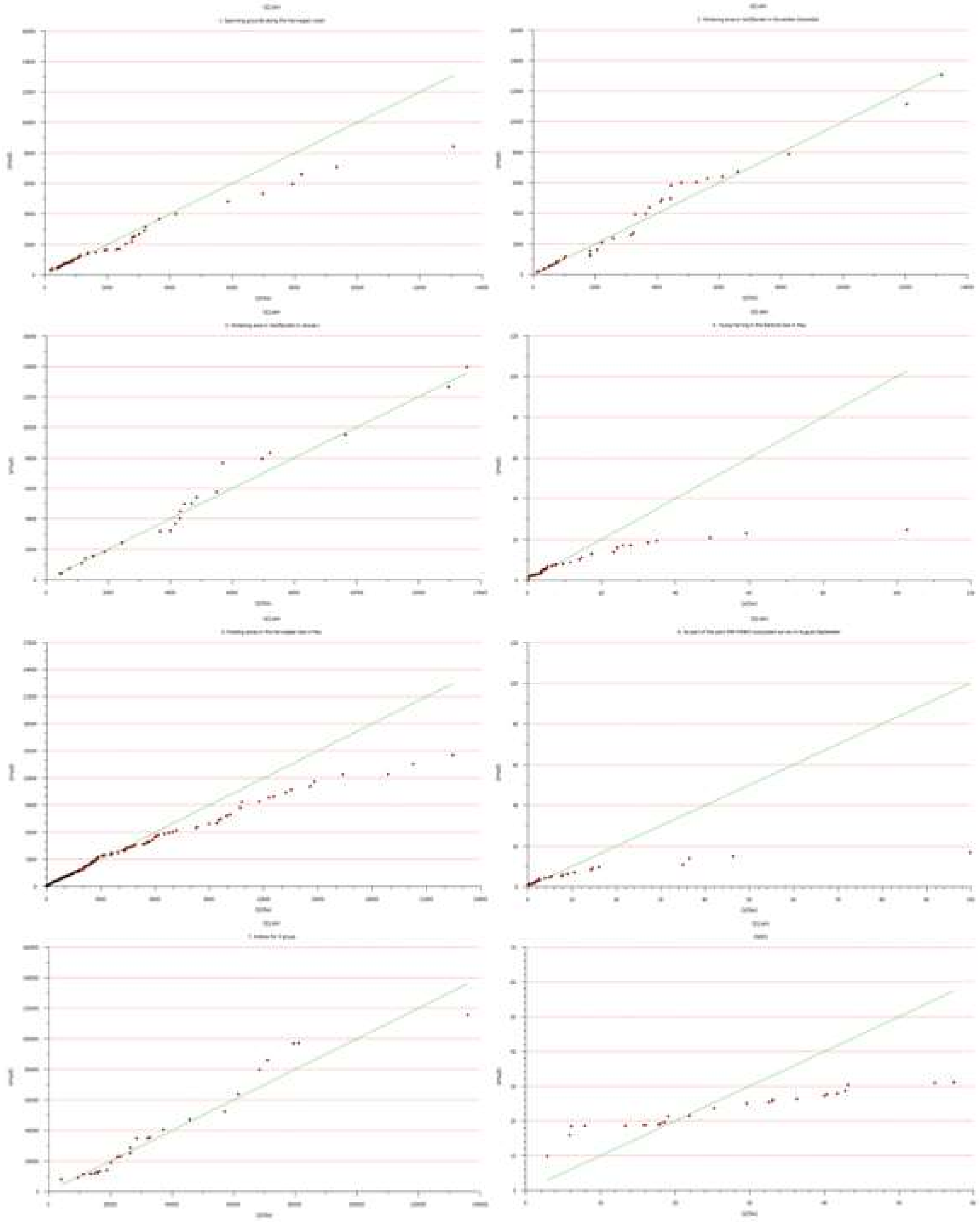

Figure 4.5.2.1.1. Norwegian spring spawning herring. Q-Q plot from the eight different surveys used in tuning in TASACS. First row starts with survey 1 and the last one in row four is larval survey.

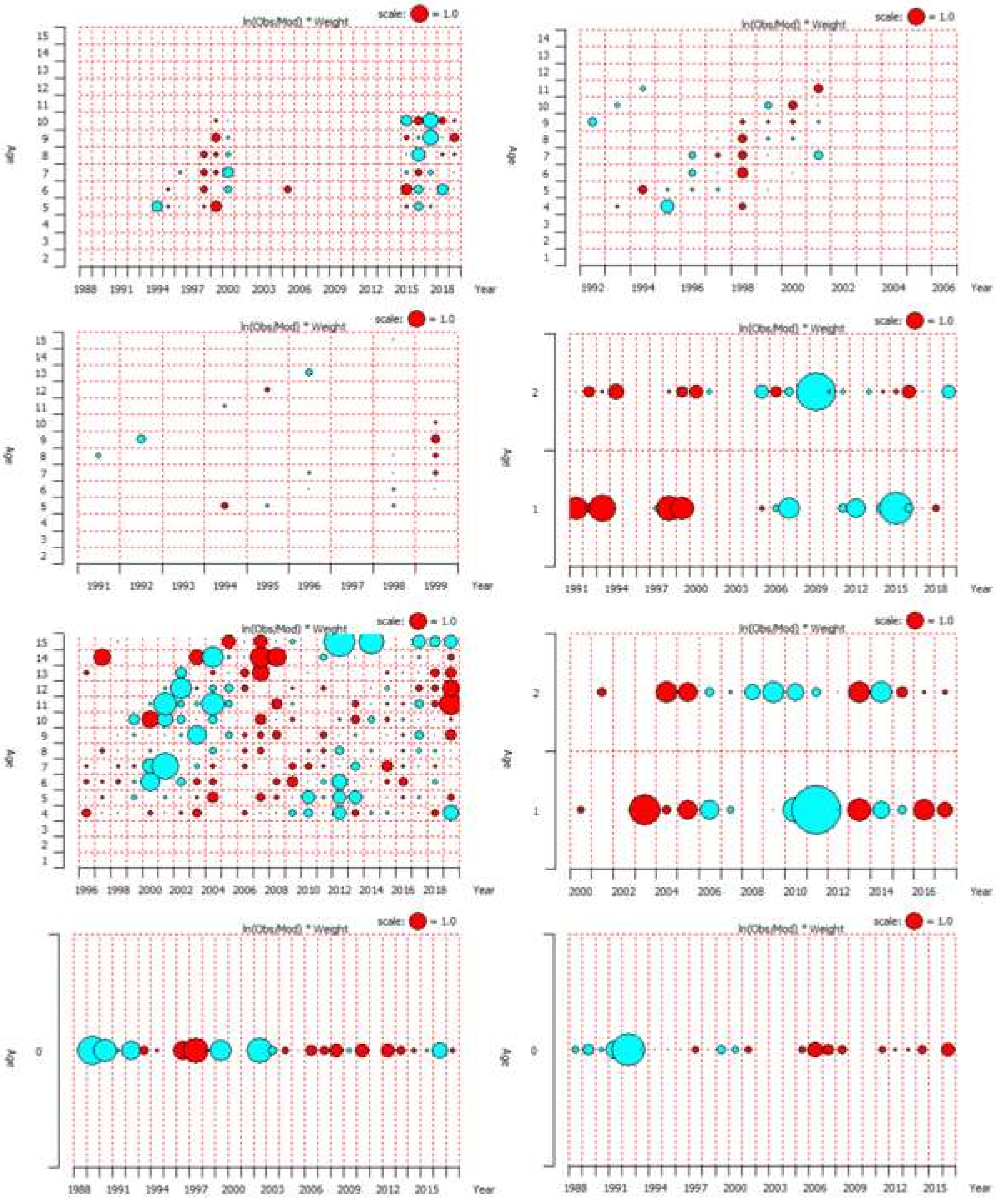

Figure 4.5.2.1.2. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

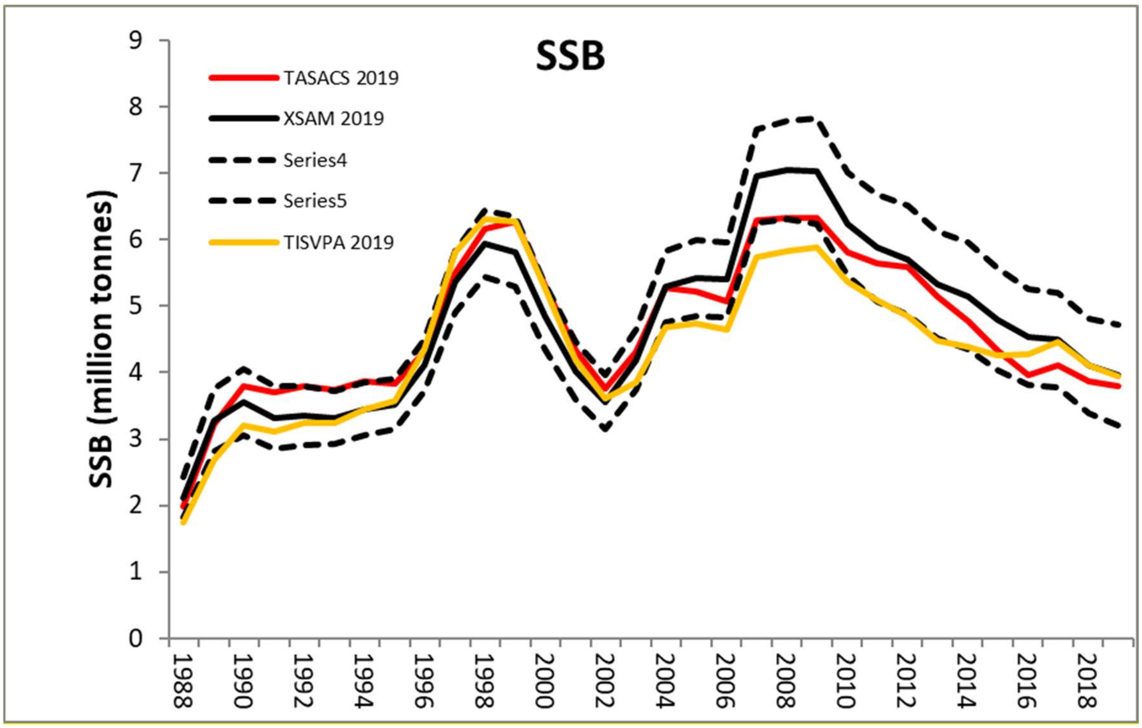

Figure 4.5.2.1.3. Comparison of SSB time-series from the final assessment from XSAM and exploratory runs from TASACS (following the 2008 benchmark procedure) and TISVPA. 95% confidence intervals from the XSAM final assessment are shown (dotted lines).

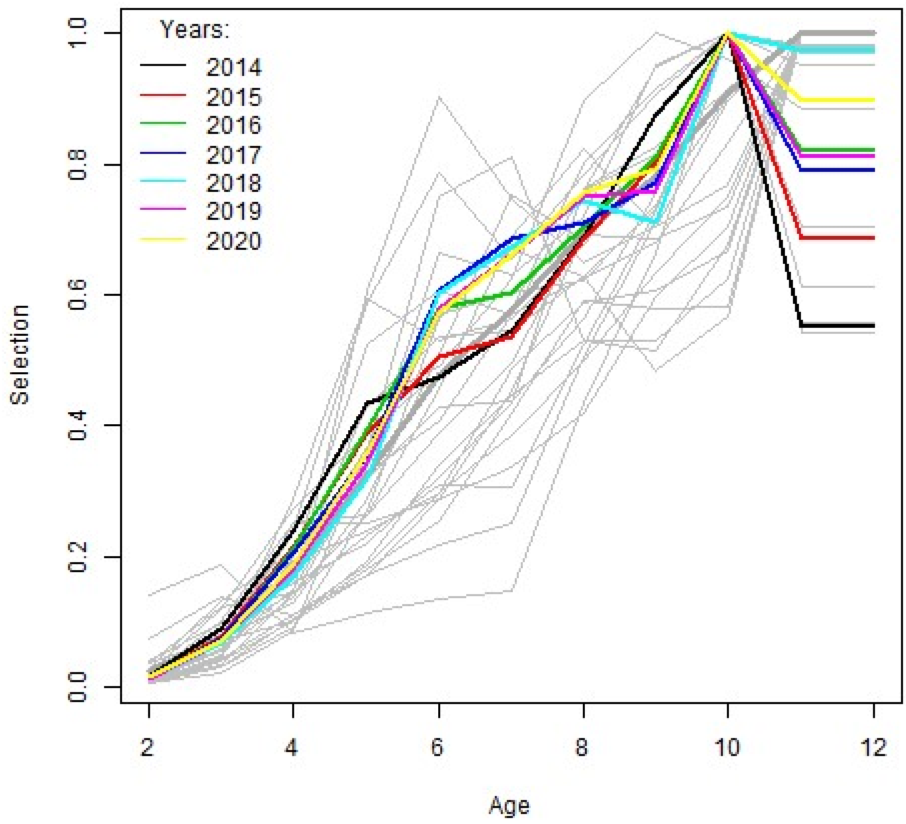

Figure 4.8.1.1. Estimated selection pattern by XSAM; thin grey lines shows annual estimates 1988–2018, the median value is indicated by the thick grey line, while selected years (estimates for 2014–2018 and predictions for 2019-2020) are shown in colours as indicated in the legend.

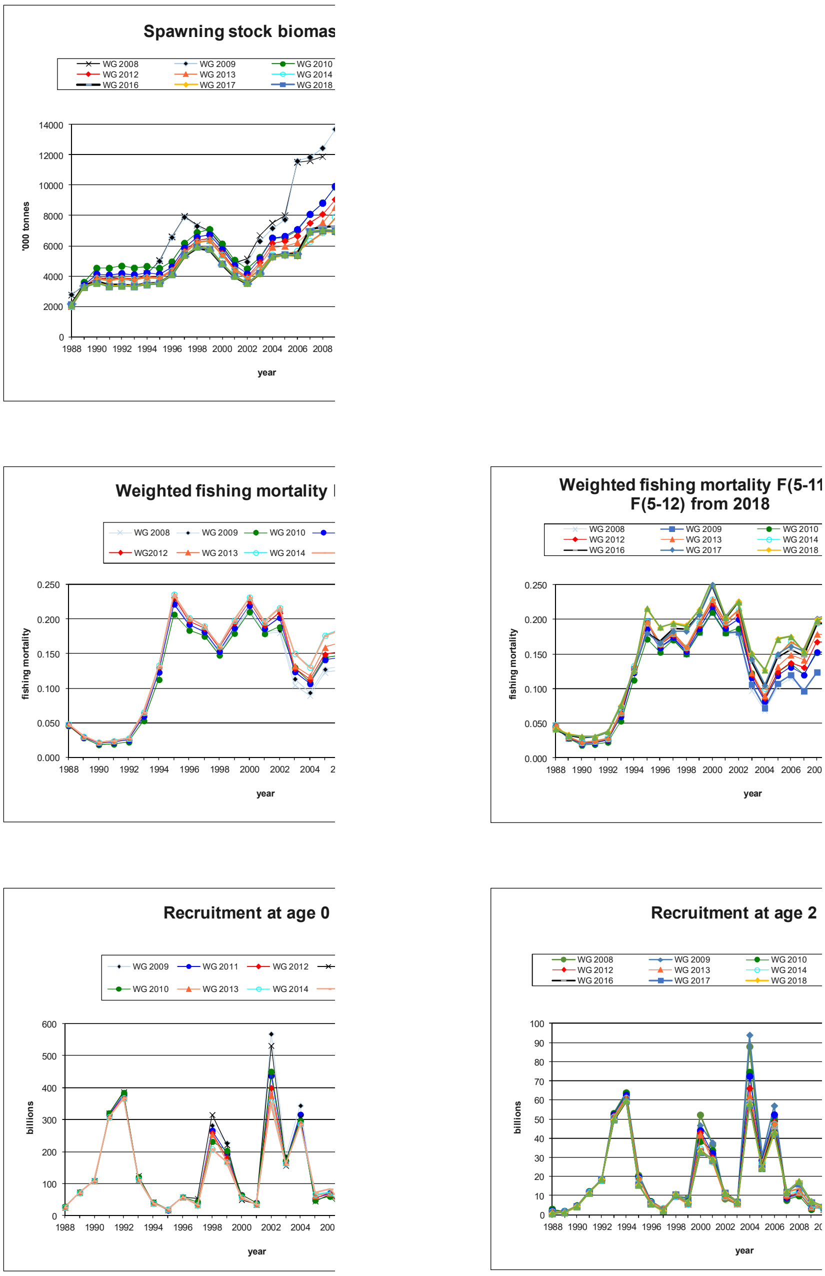

Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F(5-14) and F(5-11/5-12); and recruitment at age 0 and age 2 with previous assessments. In 2016 the proportion mature in the years 2006–2011 was changed; recruitment age changed from 0 to 2 and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