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 2017

ICES noted that the stock is declining and estimated to be below MSY $B_{trigger}$(5 million tonnes) in 2017. Since 1998 four large year classes have been produced (1998, 1999, 2002, and 2004). All year classes since 2005 are estimated to be average or small. Fishing mortality has had an overall declining trend since 2010 and was well below F_{MSY} in 2016.

A long-term management plan agreed by the EU, Faroe Islands, Iceland, Norway and Russia, is operational since 1999. ICES evaluated the plan and concludes that it is in accordance with the precautionary approach. The management plan implies maximum catches of 384 197 t in 2018.

4.2 The fishery in 2017

4.2.1 Description and development of the fisheries

The distribution of the 2017 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 2017 herring fishing pattern was fairly similar to recent years. The fishery began in January on the Norwegian shelf and focused on overwintering, prespawning, 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, 0.5% 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 had shifted to the overwintering area in the fjords and oceanic areas north of Tromsø 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). The landings in the 1st quarter constituted 22% of the total landings and the largest proportion of the landings were in the 4th quarter (69%) which is an increase from 2016, when 52% of the landings were registered in the 4th quarter.

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. The oldest and largest fish move farthest south and west during feeding, and the older year classes were in May and July 2018 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 2017 were available from Denmark, Faroe Islands, Germany, Greenland, Iceland, Ireland, The Netherlands, Norway, Russia, the UK (Scotland), Poland and Sweden. The total working group catch in 2016 was 721 566 tonnes (Table 4.4.1.1) compared to the ICES-recommended catch of maximum 437 364 tonnes. The majority of the catches (91%) were taken in area 2.a as in previous years. Samples were not provided by Greenland, the UK or Poland (2.5 % of the total catch were taken by these countries). Sampled catches accounted for 95 % of the total catches, which on a similar level assign previous years. The sampling levels of catches in 2017 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. An attempt to estimate the level of slipping/bursting (in tonnes) based on these data is planned.

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 2017, about 14 % of the catches (in numbers) were taken from both the 2009 year class and the 2013 year class, followed by the 2006 (13%) and 2011 (12%) year classes. The 2004 year class still contributes, with 10 % of the catches in 2017.

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 2017was 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. These data have been taken from the survey in the wintering area until 2008. The mean weight at age in the stock for age groups 4–11 in the years 2009–2017 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. This was last done in the benchmark assessment in 2016. Therefore, two years (2012 and 2013) 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 2018 are available as working documents to this report. Both surveys were successfully conducted in 2018.

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 4.4.7.3and 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 2010-2017 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 2015–2018, for Fleet 4 estimates of sampling errors are available for 2009–2018, and for Fleet 5 for 2008–2018. Missing values for sampling variances are imputed using the Taylor function which provides goods fits (R^2_{adj}'s are 0.94, 0.98, 0.96, respectively). The resultant relative standard errors are given in Tables 4.4.8.2-4.4.8.4. Due to the very good fits of the Taylor functions, estimates of relative standard where empirical estimates are available, are also replaced by the model predicted values to reduce potential effects of imprecise estimates of errors.

4.4.9 Information from the fishing industry

No information 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 2018

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 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 2018 assessment, i.e. the catch prediction for 2018 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. 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). The indices from Fleet 1 indicate, on average, a relatively larger abundance than the indices from Fleet 5 for 2015-2017 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 not was 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. 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 0.174 although the estimate is rather imprecise since the 95% confidence interval ranges from 0.123 – 0.224. The spawning stock shows a declining trend since 2009, and the 95% confidence interval of the stock level in 2018 ranges from ~3.1 to ~4.6 million tonnes which barely envelopes 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—2018. The model was run with catch data from 1988 to 2017, and projected forwards through 2018 assuming Fs in 2018 equal to those in 2017, to include survey data from 2018. The larval survey (SSB fleet) was discontinued in 2017 and no new information is therefore available from this survey.

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 while TISVPA do not show the same downward trend in the later period. For most of the years, the estimates from TASACS and TISVPA are mostly within the confidence limits estimated by XSAM. The SSB on 1 January 2018 is estimated by TASACS to be 3.693 million tonnes, which is lower than the estimated value from TISVPA but close 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 clear signals about the stock biomass in 2018 were obtained from just catch-at-age and surveys 1, 4 and 5. Catch-at-age and Survey 1 data, as well as the overall objective function of the model, indicate the SSB value in 2018 about 4.7 million tonnes (see WD 12). Surveys 4 and 5 indicate the SSB value about 6 and 4 million tonnes respectively.

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 0.102, but during an ongoing work on Management Strategy Evaluation F_{MSY} has been revisited, because issues were found with numerical instability and settings when F_{MSY} = 0.102 was set. Therefore F_{MSY} is currently being re-estimated.

4.6.1 PA reference points

The PA reference points for the stock were last estimated by WKNSSHREF in 2018. The group concluded that B_{lim} should be kept at 2.5 million tonnes but B_{pa} was estimated at 3.184 million tonnes and F_{pa}=0.182. F_{pa} is presently being revisited in WKNSSHMSE.

4.6.2 MSY reference points

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

4.6.3 Management reference points

In the current management plan the Coastal States have agreed a target reference point defined at F_{target}=0.125 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 0.125 at B_{pa} to 0.05 at B_{lim}.

There is ongoing work (WKNSSHMSE) to answer a request from the Coastal States on updated Management Strategy.

4.7 State of the stock

The SSB on 1 January 2018 is estimated by XSAM to be 3.826 million tonnes which is above B_{pa} (3.184 million t). The stock is declining and the SSB time-series from the 2018 assessment is in line with the SSB time-series from the 2017 assessment. In the last 15 years, five large year classes have been produced (1998, 1999, 2002, 2003, and 2004). The 2005 to 2015 year classes are estimated to be average or small, however, the 2016 year class is estimated to be well above average (from 1988). Fishing mortality in 2017 is estimated to be 0.174 which is above the management plan F that was used to give advice for 2017. A new management plan is being developed for the 2019 advisory year.

4.8 NSSH Catch predictions for 2018

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 (2015—2017).

For the weight-at-age in the stock, the values for 2018 were obtained from the commercial fisheries in the wintering areas in January. For the years 2019 and 2020 the average of the last 3 years (2016 —2018) 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 (1988-2018) 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.

There was no agreement of a TAC for 2018. 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 2018 amounts to 546 448 tonnes. F in 2018 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 546 448 tonnes is taken in 2018, it is expected that the SSB will increase from 3.826 million tonnes (95% confidence interval 3.065 to 4.587 million tonnes) on 1 January in 2018 to 3.859 million tonnes in 2019 (95% confidence interval 3.069 to 4.866 million tonnes). The 95% confidence interval for weighted F over ages 5-11 in 2018 ranges from 0.03 to 0.275 with a mean of 0.117, while the corresponding values for ages 5-12 are 0.035, 0.280 and 0.125, respectively.

4.9 Comparison with previous assessment

A comparison between the assessments 2008—2017 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 2017 and weighted F in 2016 as estimated in 2017 and 2018.

	ICES 2017	WG 2018	%DIFFERENCE
SSB(2017)	4 131	4 235	2.5%
Weighted F (2016)*	0.084	0.092	

*F in the 2017 assessment was based on the age span 5-11 and therefore not directly comparable to the F in the 2018 assessment which was based on the age span 5-12.

4.10 Management plans and evaluations

The long-term management plan of Norwegian spring spawning herring aims for exploitation at a target fishing mortality below F_{pa} and is considered by ICES in accordance with the precautionary approach (WKBWNSSH, ICES, 2013d). The management plan in use contains the following elements:

Every effort shall be made to maintain a level of Spawning-stock biomass (SSB) greater than the critical level (B_{lim}) of 2 500 000 t.

For 2012 and subsequent years, the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of less than 0.125 for appropriate age groups as defined by ICES, unless future scientific advice requires modification of this fishing mortality rate.

Should the SSB fall below a reference point of 5 000 000 t (B_{pa}), the fishing mortality rate, referred under Paragraph 2, shall be adapted in the light of scientific estimates of the conditions then prevailing to ensure a safe and rapid recovery of the SSB to a level in excess of 5 000 000 t. The basis for such adaptation should be at least a linear reduction in the fishing mortality rate from 0.125 at B_{pa} (5 000 000 t) to 0.05 at B_{lim} (2 500 000 t).

The Parties shall, as appropriate, review and revise these management measures and strategies on the basis of any new advice provided by ICES.

A brief history of it is in the stock annex. In general, the stock has been managed in compliance with the management plan.

There is ongoing work to answer a request from the Coastal States on updated Management Strategy, which will be based on the new MSY reference points.

4.11 Management considerations

Perception of the stock has not changed since last year's assessment (estimated SSB in 2017 is 2.5% 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, but the 2016 year class is estimated to be above average (since 1988).

Since 1999 catches have been regulated through an agreed management plan, which is considered to be precautionary. 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.

At present work on management strategy evaluation is ongoing and a new management strategy is expected to be in place 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 2017a; 2017b) might be due to 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; 2016b; 2017b).
- 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*., 2015) 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 2013 year class of herring is the strongest since the 2004 year class. In the May survey it was found both in the north eastern and in the central part of the Norwegian Sea.
- 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 reached the long-term mean in 2014. Zooplankton biomass dropped again in 2015, but has been increasing since then. 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 Subpolar gyre, which has been in a weak state since mid 1990's, has been strengthening during the last three years. If this trend continues, we should expect increased levels of silicate entering the Norwegian Sea over the coming years and consequently a reversal in the declining trend of silicate observed in the Norwegian Sea since 1990. Increasing silicate concentrations are expected to affect growth of silicate demanding phytoplankton, which again will affect zooplankton grazing (ICES, 2018a, and references therein).
- The temperatures of the inflowing Atlantic water were in 2017 above the long-term means (1981-2010) for the whole region. The salinity in the Atlantic Water was below the long-term means in the south and close to or higher than the normal in the north. The heat content increased in the North and Norwegian Seas and it was record-high in the Norwegian Sea. In the Barents Sea the ice cover during 2017 was below the long-term mean during the whole year (ICES, 2018b).

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 (8% and 69% respectively in 2017), and thus almost ¾'s of the herring catch was taken in the last quarter of 2017. 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 2017/2018. 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 and 2014 year classes) which overwintered in Norwegian fjords.

4.14 Recommendation

In the IESNS survey other herring stocks (e.g. Icelandic summer spawning herring and North Sea herring) are found in the boundary regions of the survey area. WGWIDE recommends that WGIPS initiates work to distinguish between herring stocks on the individual level as well as to provide abundance indices by stock.

4.15 References

Aanes, S. 2016a. A statistical model for estimating fish stock parameters accounting for errors in data: Applications to data for Norwegian Spring-spawning herring. WD4 in ICES. 2016. Report of the Benchmark Workshop on Pelagic stocks (WKPELA), 29 February–4 March 2016, ICES Headquarters, Copenhagen, Denmark. ICES CM 2016/ACOM:34. 106pp.

Aanes, S. 2016b. Diagnostics of models fits by XSAM to herring data. WD12 in ICES. 2016. Report of the Benchmark Workshop on Pelagic stocks (WKPELA), 29 February–4 March 2016, ICES Headquarters, Copenhagen, Denmark. ICES CM 2016/ACOM:34. 106pp.

Aanes, S. 2016c. Forecasting stock parameters of Norwegian spring spawning herring using XSAM. WD at WGWIDE in 2016.

Bachiller E., Skaret G., Nøttestad L., Slotte A. 2015 (submitted). Feeding ecology of Northeast Atlantic mackerel, Norwegian spring-spawning herring and blue whiting in the Norwegian Sea. PlosONE.

Debes, H., Homrum, E., Jacobsen, J. A., Hátún, H., and Danielsen, J. 2012. The feeding ecology of pelagic fish in the southwestern Norwegian Sea – Inter species food competition between herring (Clupea harengus) and mackerel (Scomber scombrus). ICES CM 2012/M:07. 19 pp.

Engelhard, G.H., Dieckmann, U and Godø, O.R. 2003. Age at maturation predicted from routine scale measurements in Norwegian spring-spawning herring (*Clupeaharengus*) using discriminant and neural network analyses. ICES Journal of Marine Science, 60: 304–313.

Engelhard, G.H. and Heino, M. 2004. Maturity changes in Norwegian spring-spawning herring before, during, and after a major population collapse. Fisheries Research, 66: 299-310.

Harvey, A.C. 1990. Forecasting, structural time series models and the Kalman Filter. Cambridge University Press. ISBN 0 521 40573 4.

Hirst, D., Storvik, G., Rognebakke, H., Aldrin, M., Aanes, S., and Volstad, J.H. 2012. A Bayesian modelling framework for the estimation of catch-at-age of commercially harvested fish species. Can. J. Fish. Aquat. Sci. 69(12): 2064– 2076.

Homrum, E., Óskarsson, G. J., Slotte, A. 2016. Spatial, seasonal and interannual variations in growth and condition of Norwegian spring spawning herring during 1994-2015. WD to WKPELA, 2016. 53 pp.

ICES 1998. Northern Pelagic and Blue Whiting Fisheries Working Group, ICES CM 1998/ACFM:18

ICES. 2008. Report of the Working Group on Widely Distributed Stocks (WGWIDE). 2-11 September 2008, ICES Headquarters Copenhagen. ICES CM 2008/ACOM:13: 691pp.

ICES. 2010a. Report of the Workshop on estimation of maturity ogive in Norwegian spring-spawning herring (WKHERMAT), 1–3 March 2010, Bergen, Norway. ICES CM 2010/ACOM:51. 47 pp

ICES. 2010b. Report of the Working Group on Widely Distributed Stocks (WGWIDE), 28 August –3 September 2010, Vigo, Spain. ICES CM 2010/ACOM:12.

ICES. 2015b. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) with M/V "Brennholm", M/V "Eros", M/V "Christian í Grótinum" and R/V "Árni Friðriksson", 1 July—10 August 2015. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE), AZTI-Tecnalia, Pasaia, Spain, 25—31 August 2015. 47 pp.

ICES. 2016b. Cruise report from the International Ecosystem Summer Survey i n the Nordic Seas (IESSNS) with M/V "M. Ytterstad", M/V "Vendla", M/V "Tróndur í Gøtu", M/V "Finnur Fríði" and R/V "Árni Friðriksson", 1 – 31 July 2016. WD to ICES Working Group on Widely Distributed Stocks (WGWIDE), ICES HQ, Copenhagen, Denmark, 31 August – 6 September 2016. 41 pp

ICES. 2016c, Report of the benchmark workshop on pelagic stocks (WKPELA). 29 February – 4 March 2016, ICES Headquarters Copenhagen. ICES CM 2016/ACOM:34.

ICES. 2017a. International ecosystem survey in the Nordic Sea (IESNS) in May to June 2017. WD to Working Group on International Pelagic Surveys (WGIPS) and Working Group on Widely distributed Stocks (WGWIDE) Copenhagen, Denmark, 30. August - 5. September 2016. 44 pp

ICES. 2017b. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) with M/V "Kings Bay", M/V "Vendla", M/V "Tróndur í Gøtu", M/V "Finnur Fríði" and R/V "Árni Friðriksson", 3 July – 4 August 2017. WD to ICES Working Group on Widely Distributed Stocks (WGWIDE), ICES HQ, Copenhagen, Denmark, 30 August – 5 September 2016. 45 pp

ICES. 2017. Report of the Working Group on Inter-benchmark Protocol on Northeast Arctic Cod (2017), 4–6 April 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:29. 236 pp.

ICES. 2018a. Interim Report of the Working Group on Integrated Ecosystem Assessments for the Norwegian Sea (WGINOR). ICES WGINOR REPORT 2017 27 November - 1 December 2017. Tórshavn, Faroe Islands. ICES CM 2018/SSGIEA:10. 38 pp.

ICES. 2018b. Interim Report of the Working Group on Oceanic Hydrography (WGOH), 21–23 March 2018, Norwich, UK. ICES CM 2018/EPDSG:08. 131 pp.

Langøy, H., Nøttestad, L., Skaret, G., Broms, C. and Fernö, A. 2012. Overlap in distribution and diets of Atlantic mackerel (Scomber scombrus), Norwegian spring- spawning herring (Clupea harengus) and blue whiting (Micromesistius poutassou) in the Norwegian Sea during late summer. Marine biology research, 8: 442—460.

Óskarsson, G.J., A. Gudmundsdottir, S. Sveinbjörnsson & Þ. Sigurðsson 2016. Feeding ecology of mackerel and dietary overlap with herring in Icelandic waters. Marine Biology Research, 12: 16-29.

Salthaug, A. and Aanes, S. 2015. Estimating the Norwegian catch at age of blue whiting, mackerel, North Sea herring and Norwegian spring-spawning herring with the ECA model. Working document in the Report of the working group on widely distributed stocks (WGWIDE). ICES CM 2015 / ACOM:15.

Skaret G., Bachiller E., Langøy H., Stenevik, E.K. 2015. Mackerel predation on herring larvae during summer feeding in the Norwegian Sea. ICES JMS, doi:1

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
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

YEAR	NORWAY	USSR/ RUSSIA	DENMARK	FAROES	ICELAND	IRELAND	NETHERLANDS	GREENLAND	UK	GERMANY	FRANCE	POLAND	SWEDEN	TOTAL
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
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

***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

Table 4.4.1.3 Norwegian spring-spawning herring. Sampling coverage by country in 2017.

COUNTRY	OFFICIAL CATCH	% CATCH COVERED BY SAMPLING PROGRAMME	NO. SAMPLES	NO. MEASURED	NO. AGED
Denmark	19037.4	74	5	704	140
Faroe Islands	98170.3	94	13	806	666
Germany	5201.1	99	5	321	321
Greenland	12569	0	0	0	0
Iceland	90400	100	90	2164	2008
Ireland	3494.7	100	2	91	76
Norway	389383.5	99	94	2222	2222
Poland	0.7	0	0	0	0
The Netherlands	6678.8	94	29	1854	725
UK_Scotland	4358	0	0	0	0
Sweden	1155	0	0	0	0
Russia	91118	99	97	23595	1083
Total for Stock	721566	95	335	31755	7241

Table 4.4.1.4 Norwegian spring-spawning herring. Sampling coverage by ICES Division in 2017.

Area	Official Catch	No Samples	No Aged	No Measured	No Aged/ 1000 tonnes	No Measured/ 1000 tonnes
2.a	660042.9	278	5990	30414	9	46
4.a	426.17	0	0	0	0	0
5.a	44722	57	1251	1341	28	30
5.b	6353.9	0	0	0	0	0
14.a	10021.2	0	0	0	0	0
Total	721566	335	7241	31755	10	44

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

Country	Div.	Q.	Catch (t)	Samples allocated ('fill in')
DE	2a	1	2.2	NO_2a_q1,DK_2a_q1
DE	2a	3	64.5	IS_2a_q3,NL_2a_q3,RU_2a_q3
DE	2a	4	5134.4	
DK	2a	1	14020.6	
DK	2a	4	5016.8	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4
FO	2a	2	54.0	
FO	2a	3	7029.8	
FO	2a	4	84732.6	
FO	5b	2	125.2	FO_2a_q2
FO	5b	3	71.7	FO_2a_q3
FO	5b	4	6157.0	FO_2a_q4
GL	14a	2	1078.0	RU_2a_q2
GL	14a	3	8943.2	IS_2a_q3,NL_2a_q3,RU_2a_q3,IS_5a_q3
GL	2a	3	618.7	IS_2a_q3,NL_2a_q3,RU_2a_q3
GL	2a	4	1929.1	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4
IR	2a	1	2315.8	
IR	2a	4	1178.9	
IS	2a	3	3358.0	
IS	2a	4	42320.0	
IS	5a	3	25446.0	
IS	5a	4	19276.0	
NL	2a	3	616.4	
NL	2a	4	5721.3	
NL	4a	4	341.2	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4
NO	2a	1	144054.6	
NO	2a	2	2156.7	NO_2a_q1
NO	2a	3	773.2	IS_2a_q3,NL_2a_q3,RU_2a_q3
NO	2a	4	242313.9	
NO	3a	2	0.1	NO_2a_q1
NO	4a	1	56.7	NO_2a_q1
NO	4a	2	0.0	NO_2a_q1
NO	4a	3	28.3	NO_2a_q4
PL	2a	1	0.7	NO_2a_q1,DK_2a_q1
RU	2a	1	957.0	NO_2a_q1,DK_2a_q1
RU	2a	2	129.0	
RU	2a	3	9945.0	
RU	2a	4	80087.0	
SE	2a	1	405.0	NO_2a_q1,DK_2a_q1
SE	2a	4	750.0	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4

Country	Div.	Q.	Catch (t)	Samples allocated ('fill in')
UKS	2a	1	4356.2	NO_2a_q1,DK_2a_q1
UKS	2a	4	1.7	NO_2a_q4,FO_2a_q4,IS_2a_q4,NL_2a_q4,RU_2a_q4,DE_2a_q4

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

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1950	5112600	2000000	600000	276200	184800	185500	547000	628600	79500	88600	109500	86900	194500	368300	66400	344300
1951	1635500	7607700	400000	6600	383800	172400	164400	515600	602000	77100	82700	103100	107600	253500	348000	352500
1952	13721600	9149700	1232900	39300	60500	602300	136300	204500	380200	377900	79200	85700	107700	106800	186500	564400
1953	5697200	5055000	581300	740100	46600	100900	355600	81900	110900	314100	394900	61700	91200	94100	98800	730400
1954	10675990	7071090	855400	266300	1435500	142900	236000	490300	128100	199800	440400	460700	88400	100600	133000	803200
1955	5175600	2871100	510100	93000	276400	2045100	114300	189600	274700	85300	193400	295600	203200	58700	84600	580600
1956	5363900	2023700	627100	116500	251600	314200	2555100	110000	203900	264200	130700	198300	272800	163300	63000	565100
1957	5001900	3290800	219500	23300	373300	153800	228500	1985300	72000	127300	182500	88400	121200	149300	131600	281400
1958	9666990	2798100	666400	17500	17900	110900	89300	194400	973500	70700	123000	200900	98700	77400	70900	255600
1959	17896280	198530	325500	15100	26800	25900	146600	114800	240700	1103800	88600	124300	198000	88500	77400	235900
1960	12884310	13580790	392500	121700	18200	28100	24400	96200	73300	203900	1163000	85200	129700	153500	56700	168900
1961	6207500	16075600	2884800	31200	8100	4100	15000	19400	61600	49200	136100	728100	49700	45000	63000	60100
1962	3693200	4081100	1041300	1843800	8000	3100	7200	20200	11900	59100	52600	117000	813500	44200	54700	152300
1963	4807000	2119200	2045300	760400	835800	5300	1800	3600	18300	9300	107700	92500	174100	923700	79600	185300
1964	3613000	2728300	220300	114600	399000	2045800	13700	1500	3000	24900	29300	95600	82400	153000	772800	336800
1965	2303000	3780900	2853600	89900	256200	571100	2199700	19500	14900	7400	19100	40000	100500	107800	138700	883100
1966	3926500	662800	1678000	2048700	26900	466600	1306000	2884500	37900	14300	17400	26200	11000	69100	72100	556700
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

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1975	30600	3600	1800	3268	132	910	30667	5	2	0	0	0	0	0	0	0
1976	.20100	2400	1200	23248	5436	0	0	13086	0	0	0	0	0	0	0	0
1977	43000	6200	3100	22103	23595	336	0	419	10766	0	0	0	0	0	0	0
1978	20100	2400	1200	3019	12164	20315	870	0	620	5027	0	0	0	0	0	0
1979	32600	3800	1900	6352	1866	6865	11216	326	0	0	2534	0	0	0	0	0
1980	6900	800	400	6407	5814	2278	8165	15838	441	8	0	2688	0	0	0	0
1981	8300	1100	11900	4166	4591	8596	2200	4512	8280	345	103	114	964	0	0	0
1982	22600	1100	200	13817	7892	4507	6258	1960	5075	6047	121	37	37	121	0	0
1983	127000	4680	1670	3183	21191	9521	6181	6823	1293	4598	7329	143	40	143	860	0
1984	33860	1700	2490	4483	5388	61543	18202	12638	15608	7215	16338	6478	0	0	0	1650
1985	28570	13150	207220	21500	15500	16500	130000	59000	55000	63000	10000	31000	50000	0	0	2640
1986	13810	1380	3090	539785	17594	14500	15500	105000	75000	42000	77000	19469	66000	80000	0	2470
1987	13850	6330	35770	19776	501393	18672	3502	7058	28000	12000	9500	4500	7834	6500	7000	450
1988	15490	2790	9110	62923	25059	550367	9452	3679	5964	14583	8872	2818	3356	2682	1560	540
1989	7120	1930	25200	2890	3623	5650	324290	3469	800	679	3297	1375	679	321	260	0
1990	1020	400	15540	18633	2658	11875	10854	226280	1289	1519	2036	2415	646	179	590	480
1991	100	3370	3330	8438	2780	1410	14698	8867	218851	2499	461	87	690	103	260	540
1992	1630	150	1340	12586	33100	4980	1193	11981	5748	225677	2483	639	247	1236	0	0
1993	6570	130	7240	28408	106866	87269	8625	3648	29603	18631	410110	0	0	0	0	0
1994	430	20	8100	32500	110090	363920	164800	15580	8140	37330	35660	645410	2830	460	100	2070
1995	0	0	1130	57590	346460	622810	637840	231090	15510	15850	69750	83740	911880	4070	250	450
1996	0	0	30140	34360	713620	1571000	940580	406280	103410	5680	7370	66090	17570	836550	0	0
1997	0	0	21820	130450	270950	1795780	1993620	761210	326490	60870	20020	32400	90520	19120	370330	300
1998	0	0	82891	70323	242365	368310	1760319	1263750	381482	129971	42502	25343	3478	112604	5633	108514
1999	0	0	5029	137626	35820	134813	429433	1604959	1164263	291394	106005	14524	40040	7202	88598	63983
2000	0	0	14395	84016	560379	34933	110719	404460	1299253	1045001	216980	71589	16260	22701	23321	71811
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

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2003	0	3461	4524	75243	323958	730468	175878	167776	22866	74494	217108	567253	219097	38555	8111	6192
2004	125	1846	43800	24299	92300	429510	714433	111022	137940	26656	52467	169196	401564	210547	28028	11883
2005	0	442	20411	447788	94206	170547	643600	930309	121856	123291	37967	65289	139331	344822	126879	15697
2006	0	1968	45438	75824	729898	82107	171370	726041	772217	88701	77115	30339	57882	133665	142240	49128
2007	0	4475	8450	224636	366983	1804495	152916	242923	728836	511664	47215	25384	15316	24488	64755	58465
2008	0	39898	123949	36630	550274	670681	2295912	199592	256132	586583	369620	29633	36025	23775	25195	63176
2009	0	3468	113424	192641	149075	1193781	914748	1929631	142931	262037	423972	238174	45519	9337	10153	70538
2010	0	75981	61673	101948	209295	189784	1064866	711951	1421939	175010	180164	340781	179039	12558	11602	49773
2011	0	126972	249809	61706	104634	234330	210165	755382	543212	642787	90515	117230	136509	45082	6628	11638
2012	0	2680	13083	211630	49999	119627	281908	263330	747839	314694	357902	53109	44982	64273	12420	3604
2013	0	1	20715	60364	276901	71287	112558	283658	242243	591912	169525	145318	24936	10614	9725	2299
2014	0	265	1441	28301	57838	257529	50424	71721	194814	147083	381317	83050	57315	12746	1809	7501
2015	0	647	3244	16139	55749	52369	152347	34046	65728	156075	103393	201141	24310	49373	3369	6397
2016	0	197	2351	45483	43416	112147	85937	164454	52267	73576	174655	96476	179051	38546	32880	8379
2017	0	618	16390	64275	305483	114976	248192	162566	289931	98836	133145	276874	107473	220368	22357	49442

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
1966	0.008	0.017	0.040	0.063	0.246	0.260	0.265	0.301	0.410	0.425	0.456	0.460	0.467	0.446	0.459	0.472
1967	0.009	0.015	0.036	0.066	0.093	0.305	0.305	0.310	0.333	0.359	0.413	0.446	0.401	0.408	0.439	0.430
1968	0.010	0.027	0.049	0.075	0.108	0.158	0.375	0.383	0.364	0.382	0.441	0.410		0.517	0.491	0.485
1969	0.009	0.021	0.047	0.072		0.152	0.296		0.329	0.329	0.341					0.429
1970	0.008	0.058	0.085	0.105	0.171		0.216	0.277	0.298	0.304	0.305	0.309				0.376
1971	0.011	0.053	0.121	0.177	0.216	0.250		0.305	0.333		0.366	0.377	0.388			
1972	0.011	0.029	0.062	0.103	0.154	0.215	0.258		0.322							
1973	0.006	0.053	0.106	0.161	0.213		0.255									
1974	0.006	0.055	0.117			0.249										
1975	0.009	0.079	0.169	0.241			0.381									

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1976	0.007	0.062	0.132	0.189	0.250			0.323								
1977	0.011	0.091	0.193	0.316	0.350				0.511							
1978	0.012	0.100	0.210	0.274	0.424	0.454				0.613						
1979	0.010	0.088	0.181	0.293	0.359	0.416	0.436				0.553					
1980	0.012			0.266	0.399	0.449	0.460	0.485				0.608				
1981	0.010	0.082	0.163	0.196	0.291	0.341	0.368	0.380	0.397							
1982	0.010	0.087	0.159	0.256	0.312	0.378	0.415	0.435	0.449	0.448						
1983	0.011	0.090	0.165	0.217	0.265	0.337	0.378	0.410	0.426	0.435	0.444					
1984	0.009	0.047	0.145	0.218	0.262	0.325	0.346	0.381	0.400	0.413	0.405	0.426				0.415
1985	0.009	0.022	0.022	0.214	0.277	0.295	0.338	0.360	0.381	0.397	0.409	0.417	0.435			0.435
1986	0.007	0.077	0.097	0.055	0.249	0.294	0.312	0.352	0.374	0.398	0.402	0.401	0.410	0.410		0.410
1987	0.010	0.075	0.091	0.124	0.173	0.253	0.232	0.312	0.328	0.349	0.353	0.370	0.385	0.385	0.385	
1988	0.008	0.062	0.075	0.124	0.154	0.194	0.241	0.265	0.304	0.305	0.317	0.308	0.334	0.334	0.334	
1989	0.010	0.060	0.204	0.188	0.264	0.260	0.282	0.306			0.422	0.364				
1990	0.007		0.102	0.230	0.239	0.266	0.305	0.308	0.376	0.407	0.412	0.424				
1991		0.015	0.104	0.208	0.250	0.288	0.312	0.316	0.330	0.344						
1992	0.007		0.103	0.191	0.233	0.304	0.337	0.365	0.361	0.371	0.403			0.404		
1993	0.007		0.106	0.153	0.243	0.282	0.320	0.330	0.365	0.373	0.379					
1994			0.102	0.194	0.239	0.280	0.317	0.328	0.356	0.372	0.390	0.379	0.399	0.403		
1995			0.102	0.153	0.192	0.234	0.283	0.328	0.349	0.356	0.374	0.366	0.393	0.387		
1996			0.136	0.136	0.168	0.206	0.262	0.309	0.337	0.366	0.360	0.361	0.367	0.379		
1997			0.089	0.167	0.184	0.207	0.232	0.277	0.305	0.331	0.328	0.344	0.343	0.397	0.357	
1998			0.111	0.150	0.216	0.221	0.249	0.277	0.316	0.338	0.374	0.372	0.366	0.396	0.377	0.406
1999			0.096	0.173	0.228	0.262	0.274	0.292	0.307	0.335	0.362	0.371	0.399	0.396	0.400	0.404
2000			0.124	0.175	0.222	0.242	0.289	0.303	0.310	0.328	0.349	0.383	0.411	0.410	0.419	0.409
2001			0.105	0.166	0.214	0.252	0.268	0.305	0.308	0.322	0.337	0.363	0.353	0.378	0.400	0.427
2002			0.056	0.128	0.198	0.255	0.281	0.303	0.322	0.323	0.334	0.345	0.369	0.407	0.410	0.435
2003		0.062	0.068	0.169	0.218	0.257	0.288	0.316	0.323	0.348	0.354	0.351	0.363	0.372	0.376	0.429

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

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

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

	AGE															
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1976	0.001	0.010	0.085	0.181	0.259	0.342	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1977	0.001	0.010	0.085	0.181	0.259	0.343	0.384	0.409	0.444	0.461	0.520	0.543	0.482	0.482	0.482	0.482
1978	0.001	0.010	0.085	0.180	0.294	0.326	0.371	0.409	0.461	0.476	0.520	0.543	0.500	0.500	0.500	0.500
1979	0.001	0.010	0.085	0.178	0.232	0.359	0.385	0.420	0.444	0.505	0.520	0.551	0.500	0.500	0.500	0.500
1980	0.001	0.010	0.085	0.175	0.283	0.347	0.402	0.421	0.465	0.465	0.520	0.534	0.500	0.500	0.500	0.500
1981	0.001	0.010	0.085	0.170	0.224	0.336	0.378	0.387	0.408	0.397	0.520	0.543	0.512	0.512	0.512	0.512
1982	0.001	0.010	0.085	0.170	0.204	0.303	0.355	0.383	0.395	0.413	0.453	0.468	0.506	0.506	0.506	0.506
1983	0.001	0.010	0.085	0.155	0.249	0.304	0.368	0.404	0.424	0.437	0.436	0.493	0.495	0.495	0.495	0.495
1984	0.001	0.010	0.085	0.140	0.204	0.295	0.338	0.376	0.395	0.407	0.413	0.422	0.437	0.437	0.437	0.437
1985	0.001	0.010	0.085	0.148	0.234	0.265	0.312	0.346	0.370	0.395	0.397	0.428	0.428	0.428	0.428	0.428
1986	0.001	0.010	0.085	0.054	0.206	0.265	0.289	0.339	0.368	0.391	0.382	0.388	0.395	0.395	0.395	0.395
1987	0.001	0.010	0.055	0.090	0.143	0.241	0.279	0.299	0.316	0.342	0.343	0.362	0.376	0.376	0.376	0.376
1988	0.001	0.015	0.050	0.098	0.135	0.197	0.277	0.315	0.339	0.343	0.359	0.365	0.376	0.376	0.376	0.376
1989	0.001	0.015	0.100	0.154	0.175	0.209	0.252	0.305	0.367	0.377	0.359	0.395	0.396	0.396	0.396	0.396
1990	0.001	0.008	0.048	0.219	0.198	0.258	0.288	0.309	0.428	0.370	0.403	0.387	0.440	0.440	0.440	0.44
1991	0.001	0.011	0.037	0.147	0.210	0.244	0.300	0.324	0.336	0.343	0.382	0.366	0.425	0.425	0.425	0.425
1992	0.001	0.007	0.030	0.128	0.224	0.296	0.327	0.355	0.345	0.367	0.341	0.361	0.430	0.470	0.470	0.46
1993	0.001	0.008	0.025	0.081	0.201	0.265	0.323	0.354	0.358	0.381	0.369	0.396	0.393	0.374	0.403	0.4
1994	0.001	0.010	0.025	0.075	0.151	0.254	0.318	0.371	0.347	0.412	0.382	0.407	0.410	0.410	0.410	0.41
1995	0.001	0.018	0.025	0.066	0.138	0.230	0.296	0.346	0.388	0.363	0.409	0.414	0.422	0.410	0.410	0.426
1996	0.001	0.018	0.025	0.076	0.118	0.188	0.261	0.316	0.346	0.374	0.390	0.390	0.384	0.398	0.398	0.398
1997	0.001	0.018	0.025	0.096	0.118	0.174	0.229	0.286	0.323	0.370	0.378	0.386	0.360	0.393	0.391	0.391
1998	0.001	0.018	0.025	0.074	0.147	0.174	0.217	0.242	0.278	0.304	0.310	0.359	0.340	0.344	0.385	0.369
1999	0.001	0.018	0.025	0.102	0.150	0.223	0.240	0.264	0.283	0.315	0.345	0.386	0.386	0.386	0.382	0.395
2000	0.001	0.018	0.025	0.119	0.178	0.225	0.271	0.285	0.298	0.311	0.339	0.390	0.398	0.406	0.414	0.427
2001	0.001	0.018	0.025	0.075	0.178	0.238	0.247	0.296	0.307	0.314	0.328	0.351	0.376	0.406	0.414	0.425
2002	0.001	0.010	0.023	0.057	0.177	0.241	0.275	0.302	0.311	0.314	0.328	0.341	0.372	0.405	0.415	0.438
2003	0.001	0.010	0.055	0.098	0.159	0.211	0.272	0.305	0.292	0.331	0.337	0.347	0.356	0.381	0.414	0.433

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

**** 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
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

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1994	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
1995	0	0	0	0	0	0.6	1	1	1	1	1	1	1	1	1	1
1996	0	0	0	0	0	0.5	0.9	1	1	1	1	1	1	1	1	1
1997	0	0	0	0.1	0	0.4	0.9	1	1	1	1	1	1	1	1	1
1998	0	0	0	0	0.6	0.4	0.9	1	1	1	1	1	1	1	1	1
1999	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2000	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2001	0	0	0	0	0.3	0.9	0.9	1	1	1	1	1	1	1	1	1
2002	0	0	0	0	0.1	0.9	1	1	1	1	1	1	1	1	1	1
2003	0	0	0	0	0.2	0.7	1	1	1	1	1	1	1	1	1	1
2004	0	0	0	0	0.3	0.9	1	1	1	1	1	1	1	1	1	1
2005	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2006	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2007	0	0	0	0	0.2	0.8	1	1	1	1	1	1	1	1	1	1
2008	0	0	0	0	0.1	0.7	0.9	1	1	1	1	1	1	1	1	1
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	0.4	0.8	1	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

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		
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		

Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	Biomass
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

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 2009–2017 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
2018	6.866	17.404	0.943	0.009	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 2008-2017 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
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

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	0.346	0.205	0.263	0.114	0.343	0.442	0.388	0.305	0.349	0.475	0.357
1989	0.263	0.472	0.444	0.394	0.132	0.449	0.668	0.698	0.455	0.577	0.591
1990	0.3	0.285	0.483	0.322	0.33	0.145	0.587	0.562	0.519	0.495	0.529
1991	0.454	0.353	0.477	0.573	0.304	0.349	0.147	0.491	0.775	1.216	0.554
1992	0.581	0.317	0.244	0.407	0.599	0.321	0.392	0.145	0.492	0.71	0.565
1993	0.368	0.255	0.178	0.188	0.351	0.443	0.252	0.285	0.124	NA	NA
1994	0.357	0.246	0.177	0.128	0.158	0.299	0.357	0.236	0.239	0.11	0.397
1995	0.608	0.21	0.13	0.111	0.11	0.145	0.3	0.298	0.2	0.19	0.1
1996	0.251	0.242	0.107	0.086	0.099	0.124	0.18	0.393	0.367	0.203	0.102
1997	0.273	0.169	0.138	0.083	0.081	0.105	0.132	0.207	0.28	0.246	0.119
1998	0.191	0.199	0.143	0.127	0.084	0.091	0.126	0.169	0.228	0.263	0.145
1999	0.406	0.166	0.239	0.167	0.122	0.086	0.093	0.136	0.178	0.305	0.15
2000	0.306	0.19	0.114	0.241	0.176	0.124	0.091	0.096	0.147	0.198	0.167
2001	0.516	0.18	0.159	0.122	0.234	0.183	0.135	0.102	0.117	0.197	0.215
2002	0.206	0.151	0.11	0.141	0.132	0.251	0.185	0.139	0.109	0.13	0.191
2003	0.418	0.196	0.132	0.106	0.156	0.158	0.27	0.196	0.147	0.113	0.138
2004	0.227	0.266	0.185	0.122	0.107	0.176	0.166	0.259	0.216	0.157	0.109
2005	0.278	0.121	0.184	0.157	0.11	0.099	0.172	0.171	0.235	0.203	0.11
2006	0.224	0.195	0.106	0.191	0.157	0.106	0.104	0.187	0.194	0.25	0.126
2007	0.353	0.146	0.128	0.083	0.162	0.143	0.106	0.117	0.222	0.262	0.159
2008	0.171	0.238	0.114	0.108	0.078	0.15	0.141	0.112	0.127	0.252	0.163
2009	0.175	0.152	0.163	0.093	0.1	0.081	0.165	0.14	0.123	0.143	0.167
2010	0.207	0.18	0.148	0.152	0.096	0.107	0.088	0.156	0.155	0.13	0.141
2011	0.142	0.206	0.179	0.144	0.148	0.105	0.115	0.11	0.186	0.174	0.15
2012	0.314	0.148	0.219	0.173	0.137	0.14	0.105	0.133	0.128	0.215	0.171
2013	0.277	0.208	0.138	0.199	0.176	0.137	0.143	0.112	0.157	0.164	0.222
2014	0.57	0.255	0.21	0.14	0.218	0.198	0.151	0.163	0.126	0.191	0.193
2015	0.458	0.297	0.212	0.216	0.162	0.242	0.203	0.161	0.18	0.15	0.19
2016	0.499	0.224	0.227	0.176	0.189	0.158	0.216	0.197	0.156	0.183	0.14
2017	0.295	0.204	0.134	0.175	0.142	0.159	0.136	0.182	0.168	0.138	0.125
2018	0.331	0.222	0.194	0.179	0.178	0.189	0.207	0.218	0.232	0.291	0.247

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	0.334	0.353	0.159	0.476	0.599	0.781	0.579	0.661	0.569	NA
1989	0.703	0.343	0.472	0.189	0.453	0.765	0.843	0.521	NA	0.54
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	0.46	0.548	0.274	0.315	0.495	0.725	0.415	0.562	0.228	0.904
1995	0.327	0.182	0.199	0.223	0.355	0.694	NA	0.422	0.49	0.216
1996	0.418	0.226	0.16	0.214	0.271	0.348	NA	NA	0.438	0.228
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0.344	0.265	0.202	0.142	0.159	0.226	0.3	0.391	0.591	0.23
1999	0.236	0.333	0.244	0.21	0.154	0.165	0.234	0.312	0.436	0.285
2000	0.29	0.209	0.456	0.314	0.255	0.187	0.205	0.305	0.548	0.374
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	0.361	0.291	0.221	0.172	0.159	0.291	0.318	0.397	0.446	0.216
2006	0.461	0.171	0.315	0.269	0.198	0.198	0.437	0.505	0.641	0.319
2007	0.335	0.236	0.144	0.296	0.293	0.205	0.198	0.425	0.378	0.262
2008	0.5	0.212	0.208	0.155	0.307	0.315	0.235	0.235	0.414	0.321
2009	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2010	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2011	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2012	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2014	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2015	0.309	0.207	0.281	0.199	0.333	0.292	0.205	0.285	0.164	0.215
2016	0.38	0.367	0.306	0.328	0.216	0.371	0.302	0.206	0.289	0.175
2017	0.465	0.259	0.291	0.273	0.327	0.244	0.4	0.375	0.226	0.193
2018	0.42	0.229	0.206	0.314	0.276	0.296	0.259	0.317	0.333	0.196

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

Year/age	2
1991	0.351
1992	0.337
1993	0.286
1994	0.423
1995	0.61
1996	0.767
1997	0.483
1998	0.402
1999	0.318
2000	0.285
2001	0.656
2002	0.61
2003	NA
2004	NA
2005	0.354
2006	0.459
2007	0.498
2008	0.865
2009	0.661
2010	0.439
2011	0.547
2012	0.563
2013	0.738
2014	0.459
2015	0.648
2016	0.514
2017	0.378
2018	0.421

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	0.206	0.139	0.157	0.198	0.243	0.35	0.776	0.912	0.443	0.22
1997	0.276	0.213	0.145	0.156	0.232	0.251	0.429	0.521	0.383	0.223
1998	0.362	0.28	0.203	0.149	0.167	0.242	0.302	0.426	NA	0.333
1999	0.239	0.373	0.289	0.221	0.161	0.188	0.298	0.393	0.986	0.38
2000	0.267	0.226	0.5	0.358	0.27	0.181	0.194	0.254	0.389	0.423
2001	0.175	0.264	0.262	0.428	0.415	0.218	0.193	0.274	0.498	0.425
2002	0.186	0.169	0.264	0.304	0.36	0.298	0.246	0.232	0.264	0.435
2003	0.185	0.168	0.168	0.261	0.308	0.449	0.405	0.248	0.235	0.242
2004	0.259	0.195	0.159	0.165	0.282	0.326	0.523	0.376	0.363	0.231
2005	0.143	0.267	0.251	0.187	0.194	0.317	0.358	0.454	0.392	0.244
2006	0.378	0.154	0.265	0.244	0.185	0.182	0.314	0.31	0.432	0.239
2007	0.224	0.19	0.142	0.272	0.244	0.184	0.192	0.317	0.339	0.225
2008	0.319	0.165	0.175	0.153	0.26	0.237	0.198	0.227	0.346	0.283
2009	0.254	0.24	0.16	0.172	0.17	0.24	0.264	0.232	0.265	0.308
2010	0.331	0.235	0.251	0.175	0.189	0.192	0.296	0.295	0.288	0.302
2011	0.288	0.26	0.213	0.23	0.17	0.201	0.204	0.3	0.294	0.284
2012	0.224	0.353	0.315	0.255	0.23	0.205	0.243	0.241	0.38	0.279
2013	0.304	0.208	0.348	0.274	0.243	0.221	0.2	0.226	0.248	0.251
2014	0.273	0.302	0.226	0.307	0.283	0.228	0.236	0.225	0.279	0.265
2015	0.342	0.27	0.276	0.213	0.265	0.277	0.219	0.231	0.204	0.245
2016	0.213	0.261	0.238	0.251	0.228	0.292	0.278	0.251	0.248	0.203
2017	0.283	0.203	0.275	0.26	0.296	0.263	0.372	0.309	0.288	0.199
2018	0.283	0.242	0.191	0.289	0.264	0.328	0.268	0.369	0.313	0.196

Table 4.5.1.1. Norwegian spring-spawning herring. Parameter estimates of the final XSAM model fit. The estimates from last year's assessment (from October 2017) are also shown.

Parameter	Estimate	Std. Error	CV	Estimate 2017	Std. Error 2017
$\log(N_{3,1988})$	7.072	0.173	0.024	7.073	0.168
$\log(N_{4,1988})$	6.606	0.212	0.032	6.624	0.205
$\log(N_{5,1988})$	9.577	0.079	0.008	9.594	0.076
$\log(N_{6,1988})$	4.792	0.371	0.077	4.796	0.363
$\log(N_{7,1988})$	3.474	0.508	0.146	3.471	0.494
$\log(N_{8,1988})$	3.132	0.557	0.178	3.126	0.538
$\log(N_{9,1988})$	4.079	0.455	0.112	4.082	0.444
$\log(N_{10,1988})$	3.28	0.653	0.199	3.29	0.638
$\log(N_{11,1988})$	2.989	0.716	0.239	3.015	0.691
$\log(N_{12,1988})$	3.479	0.732	0.21	3.496	0.711
$\log(q_3^{F1})$	-9.544	0.199	0.021	-9.566	0.212
$\log(q_4^{F1})$	-8.064	0.14	0.017	-8.119	0.159
$\log(q_5^{F1})$	-7.507	0.126	0.017	-7.551	0.146
$\log(q_6^{F1})$	-7.31	0.127	0.017	-7.323	0.145
$\log(q_7^{F1})$	-7.134	0.14	0.02	-7.161	0.158
$\log(q_8^{F1})$	-6.917	0.103	0.015	-6.945	0.108
$\log(q_2^{F4})$	-14.46	0.189	0.013	-14.418	0.182
$\log(q_3^{F5})$	-7.597	0.116	0.015	-7.56	0.117
$\log(q_4^{F5})$	-7.127	0.104	0.015	-7.109	0.105
$\log(q_5^{F5})$	-6.891	0.102	0.015	-6.892	0.103
$\log(q_6^{F5})$	-6.768	0.106	0.016	-6.752	0.106
$\log(q_7^{F5})$	-6.693	0.112	0.017	-6.668	0.112
$\log(q_8^{F5})$	-6.509	0.119	0.018	-6.482	0.119
$\log(q_9^{F5})$	-6.508	0.133	0.02	-6.46	0.134
$\log(q_{10}^{F5})$	-6.439	0.15	0.023	-6.405	0.151
$\log(q_{11}^{F5})$	-6.438	0.15	0.023	-6.441	0.152
$\log(\sigma_1^2)$	-5	1.486	0.297	-5	1.422
$\log(\sigma_2^2)$	-2.651	0.275	0.104	-2.493	0.246
$\log(\sigma_4^2)$	-2.108	0.314	0.149	-2.209	0.322
$\log(\sigma_R^2)$	-0.09	0.267	2.973	-0.066	0.269
$\log(h)$	1.581	0.07	0.044	1.553	0.072
μ_R	9.361	0.18	0.019	9.312	0.186
α_Y	-0.535	0.32	0.598	-0.459	0.303
β_Y	0.803	0.115	0.144	0.838	0.11
α_{2U}	-1.245	0.176	0.141	-1.234	0.176
α_{3U}	-0.615	0.102	0.165	-0.608	0.103
α_{4U}	-0.201	0.066	0.329	-0.203	0.07
α_{5U}	0.054	0.057	1.054	0.056	0.061
α_{6U}	0.195	0.061	0.314	0.19	0.065
α_{7U}	0.261	0.066	0.251	0.247	0.069
α_{8U}	0.316	0.072	0.228	0.32	0.076

Parameter	Estimate	Std. Error	CV	Estimate 2017	Std. Error 2017
α_{9U}	0.373	0.079	0.211	0.366	0.081
α_{10U}	0.425	0.085	0.2	0.422	0.087
β_U	0.605	0.055	0.091	0.61	0.054

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

Year/Age	2	3	4	5	6	7	8	9	10	11	12+
1988	640	1178	739	14435	120	32	23	59	27	20	32
1989	1168	248	950	619	11941	99	26	17	40	16	37
1990	4275	470	209	804	519	9943	82	21	13	30	41
1991	11293	1732	399	177	677	433	8297	67	17	10	57
1992	18521	4586	1483	340	150	568	364	6918	55	14	56
1993	49735	7525	3933	1260	286	125	475	303	5720	45	57
1994	59395	20202	6447	3317	1029	232	102	385	243	4529	79
1995	15537	24118	17304	5428	2606	774	179	80	298	183	3414
1996	5706	6301	20605	14477	4149	1754	510	129	58	205	2227
1997	2086	2309	5350	17031	11085	2804	1129	334	90	39	1364
1998	10762	842	1915	4300	12956	7712	1750	661	206	54	759
1999	6439	4346	693	1480	3306	9448	5368	1115	406	120	457
2000	33070	2608	3621	541	1129	2451	6695	3599	697	240	302
2001	28868	13404	2183	2713	406	829	1750	4567	2226	406	268
2002	11423	11708	11367	1740	1994	303	615	1260	3165	1471	447
2003	6582	4626	9891	9175	1282	1395	220	431	853	2093	1282
2004	57638	2669	3919	8171	7204	945	1018	160	303	574	2214
2005	24130	23391	2268	3264	6599	5552	703	737	116	212	1736
2006	42853	9787	19783	1868	2605	5043	3937	479	497	76	1131
2007	11871	17381	8322	16368	1501	2035	3700	2710	330	343	711
2008	17281	4808	14743	6853	12594	1137	1488	2523	1795	221	723
2009	6603	6972	4067	12142	5303	8812	803	1022	1608	1129	631
2010	4053	2648	5832	3333	9387	3780	5726	536	633	953	1084
2011	15792	1625	2203	4781	2647	7071	2634	3568	335	387	1098
2012	4658	6341	1354	1801	3838	2062	5318	1791	2367	217	935
2013	7854	1883	5307	1113	1443	3030	1575	3909	1261	1649	804
2014	4789	3181	1585	4346	890	1136	2353	1176	2860	908	1915
2015	15817	1943	2705	1319	3525	716	907	1846	899	2156	2255
2016	8816	6422	1658	2272	1086	2870	580	722	1451	694	3525
2017	7135	3579	5475	1385	1853	866	2281	453	553	1095	3263
2018	24928	2891	3025	4454	1082	1377	624	1655	310	368	3089

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	0.05	0.066	0.028	0.04	0.05	0.056	0.156	0.232	0.352	0.204	0.204
1989	0.011	0.021	0.016	0.025	0.033	0.039	0.075	0.106	0.148	0.091	0.091
1990	0.004	0.013	0.014	0.023	0.031	0.031	0.052	0.074	0.1	0.07	0.07
1991	0.001	0.005	0.011	0.018	0.024	0.025	0.032	0.043	0.056	0.043	0.043
1992	0.001	0.004	0.013	0.023	0.028	0.029	0.033	0.04	0.054	0.051	0.051
1993	0.001	0.005	0.02	0.053	0.06	0.056	0.062	0.068	0.083	0.098	0.098
1994	0.001	0.005	0.022	0.091	0.135	0.111	0.096	0.106	0.134	0.15	0.15
1995	0.002	0.007	0.028	0.119	0.246	0.268	0.173	0.171	0.221	0.329	0.329
1996	0.005	0.014	0.041	0.117	0.242	0.291	0.272	0.21	0.242	0.429	0.429
1997	0.007	0.037	0.068	0.123	0.213	0.321	0.385	0.334	0.358	0.465	0.465
1998	0.007	0.044	0.108	0.113	0.166	0.212	0.301	0.337	0.393	0.426	0.426
1999	0.004	0.033	0.097	0.121	0.149	0.194	0.25	0.32	0.376	0.497	0.497
2000	0.003	0.028	0.139	0.139	0.159	0.187	0.232	0.33	0.389	0.555	0.555
2001	0.003	0.015	0.077	0.158	0.14	0.149	0.179	0.217	0.264	0.262	0.262
2002	0.004	0.019	0.064	0.155	0.208	0.172	0.205	0.24	0.263	0.253	0.253
2003	0.003	0.016	0.041	0.092	0.155	0.165	0.168	0.203	0.246	0.272	0.272
2004	0.002	0.013	0.033	0.064	0.111	0.145	0.173	0.175	0.204	0.324	0.324
2005	0.002	0.018	0.044	0.075	0.119	0.194	0.234	0.244	0.268	0.394	0.394
2006	0.002	0.012	0.039	0.069	0.097	0.16	0.223	0.223	0.222	0.379	0.379
2007	0.004	0.015	0.044	0.112	0.128	0.163	0.233	0.262	0.249	0.227	0.227
2008	0.008	0.017	0.044	0.106	0.207	0.198	0.226	0.301	0.314	0.253	0.253
2009	0.014	0.028	0.049	0.107	0.189	0.281	0.254	0.329	0.373	0.334	0.334
2010	0.014	0.034	0.049	0.08	0.133	0.211	0.323	0.322	0.343	0.468	0.468
2011	0.012	0.032	0.051	0.07	0.1	0.135	0.236	0.26	0.285	0.313	0.313
2012	0.006	0.028	0.046	0.072	0.086	0.119	0.158	0.2	0.212	0.209	0.209
2013	0.004	0.022	0.05	0.074	0.089	0.103	0.143	0.163	0.179	0.097	0.097
2014	0.002	0.012	0.034	0.059	0.067	0.076	0.093	0.118	0.133	0.074	0.074
2015	0.001	0.009	0.024	0.044	0.056	0.062	0.077	0.091	0.109	0.074	0.074
2016	0.002	0.01	0.03	0.054	0.077	0.08	0.096	0.117	0.132	0.107	0.107
2017	0.003	0.018	0.057	0.097	0.147	0.177	0.171	0.23	0.258	0.194	0.194
2018	0.003	0.017	0.052	0.093	0.139	0.164	0.172	0.219	0.244	0.184	0.184

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	640	338	942	2108	1794	2422	135	0.042	0.022	0.062
1989	1168	687	1649	3260	2774	3747	104	0.034	0.017	0.05
1990	4275	3179	5371	3528	3013	4043	86	0.031	0.016	0.046
1991	11293	9162	13423	3303	2822	3783	85	0.031	0.016	0.046
1992	18521	15447	21596	3331	2872	3789	104	0.038	0.021	0.056
1993	49735	43368	56103	3302	2890	3714	232	0.076	0.048	0.104
1994	59395	52269	66520	3431	3022	3841	479	0.125	0.089	0.161
1995	15537	12910	18163	3508	3114	3902	906	0.215	0.167	0.263
1996	5706	4485	6927	4096	3696	4496	1220	0.188	0.152	0.225
1997	2086	1518	2655	5355	4873	5836	1427	0.195	0.16	0.229
1998	10762	8793	12731	5908	5378	6438	1223	0.192	0.156	0.228
1999	6439	5110	7768	5770	5219	6322	1235	0.214	0.173	0.256
2000	33070	28460	37680	4799	4296	5303	1207	0.257	0.205	0.309
2001	28868	24671	33066	3986	3535	4437	766	0.203	0.159	0.248
2002	11423	9310	13536	3528	3109	3946	808	0.226	0.176	0.276
2003	6582	5193	7972	4172	3707	4637	790	0.151	0.118	0.184
2004	57638	50230	65046	5270	4706	5834	794	0.127	0.099	0.155
2005	24130	20221	28038	5401	4810	5993	1003	0.172	0.135	0.208
2006	42853	36496	49210	5365	4783	5947	969	0.175	0.136	0.215
2007	11871	9462	14280	6901	6176	7627	1267	0.153	0.12	0.186
2008	17281	13971	20591	6987	6215	7759	1546	0.2	0.158	0.242
2009	6603	5061	8146	6956	6128	7784	1687	0.207	0.165	0.249
2010	4053	2955	5151	6149	5338	6960	1457	0.217	0.169	0.264
2011	15792	12222	19361	5774	4938	6610	993	0.163	0.125	0.2
2012	4658	3283	6033	5544	4684	6404	826	0.144	0.109	0.179
2013	7854	5529	10178	5158	4320	5997	685	0.125	0.092	0.158
2014	4789	3038	6539	4924	4091	5757	461	0.087	0.063	0.11
2015	15817	10382	21253	4615	3811	5419	329	0.071	0.05	0.092
2016	8816	4504	13129	4336	3577	5095	383	0.092	0.065	0.12
2017	7135	2158	12112	4235	3485	4985	722	0.174	0.123	0.224
2018	24928	0	57788	3826	3065	4587				
Average	16765	13046	20741	4672	4072	5271	798	0.144	0.110	0.178

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	2018							
	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	24928	0.9	0	0	0	0.054	0.003	0.133
3	2891	0.15	0	0	0	0.115	0.014	0.207
4	3025	0.15	0.4	0	0	0.149	0.043	0.256
5	4454	0.15	0.8	0	0	0.225	0.076	0.301
6	1082	0.15	1	0	0	0.226	0.114	0.328
7	1377	0.15	1	0	0	0.289	0.135	0.349
8	624	0.15	1	0	0	0.312	0.142	0.364
9	1655	0.15	1	0	0	0.343	0.18	0.374
10	310	0.15	1	0	0	0.359	0.201	0.382
11	368	0.15	1	0	0	0.361	0.152	0.384
12	3089	0.15	1	0	0	0.375	0.152	0.389
Input for	2019 and 2020							
	Stockno.	Natural	Maturity	Proportion of M	Proportion of F	Weight	Exploitation	Weight
age	1-Jan.	mortality	ogive	before spawning	before spawning	in stock	pattern	in catch
2	11621	0.9	0	0	0	0.054	0.014	0.133
3		0.15	0	0	0	0.115	0.071	0.207
4		0.15	0.4	0	0	0.175	0.21	0.256
5		0.15	0.8	0	0	0.24	0.385	0.301
6		0.15	1	0	0	0.278	0.565	0.328
7		0.15	1	0	0	0.31	0.669	0.349
8		0.15	1	0	0	0.328	0.726	0.364
9		0.15	1	0	0	0.349	0.888	0.374
10		0.15	1	0	0	0.357	1	0.382
11		0.15	1	0	0	0.358	0.855	0.384
12		0.15	1	0	0	0.374	0.855	0.389

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

BASIS:	
SSB (2018):	3.826 (3.065, 4.587) * million t
Landings(2018):	546 448 t (sum of national quotas)
SSB(2019):	3.859 (3.069,4.866)* million t
Fw5-11 (2018):	0.117 (0.030, 0.275)*
Fw5-12(2018)	0.125 (0.035,0.280)*
Recruitment(2018-2020):	24.928 (0,57.788)*, 11.621 (1.009,48.205)*, 11.621 (1.009,48.205)*

The catch options:

RATIONALE	CATCHES (2019)	BASIS	FW(2019)	SSB2020	P(SSB2020 <BLIM)	% SSB CHANGE	%TAC CHANGE**
ZERO CATCH	0	F=0	0	4.510 (3.468,6.056)*	0	17 (3,52)*	-100
STATUS QUO	530319	F=0.125	0.125 (0.099,0.165)*	4.065 (3.050,5.552)*	0.001	5 (-9,36)*	-3
MANAGENENT PLAN 1999–2017	420197	F=0.091**	0.091** (0.053,0.12)*	4.157 (3.126,5.883)*	0	8 (-6,44)*	-23
F=0.085	367038	F=0.085	0.085 (0.067,0.109)*	4.202 (3.170,5.711)*	0	9 (-5,42)*	-33
F=0.125***	529333	F=0.125	0.125 (0.099,0.161)*	4.066 (3.099,5.581)*	0	5 (-9,39)*	-3
F=0.157	654642	F=0.157	0.157 (0.126,0.205)*	3.962 (2.950,5.387)*	0	2 (-12,35)*	20
$SSB_{2020}=B_{PA}$	1598052	F=0.436	0.436 (0.341,0.652)*	3.184 (2.114,4.726)*	0.124	-18 (-35,13)	192
$SSB_{2020}=B_{LIM}$	2449509	F=0.771	0.771 (0.593,1.360)*	2.500 (1.450,4.106)*	0.539	-35 (-55,-2)*	348

***95% confidence interval**

****compared to sum of national quotas in 2017, not advice for 2017**

*****difference in fourth decimal compared to F status quo**

4.17 Figures

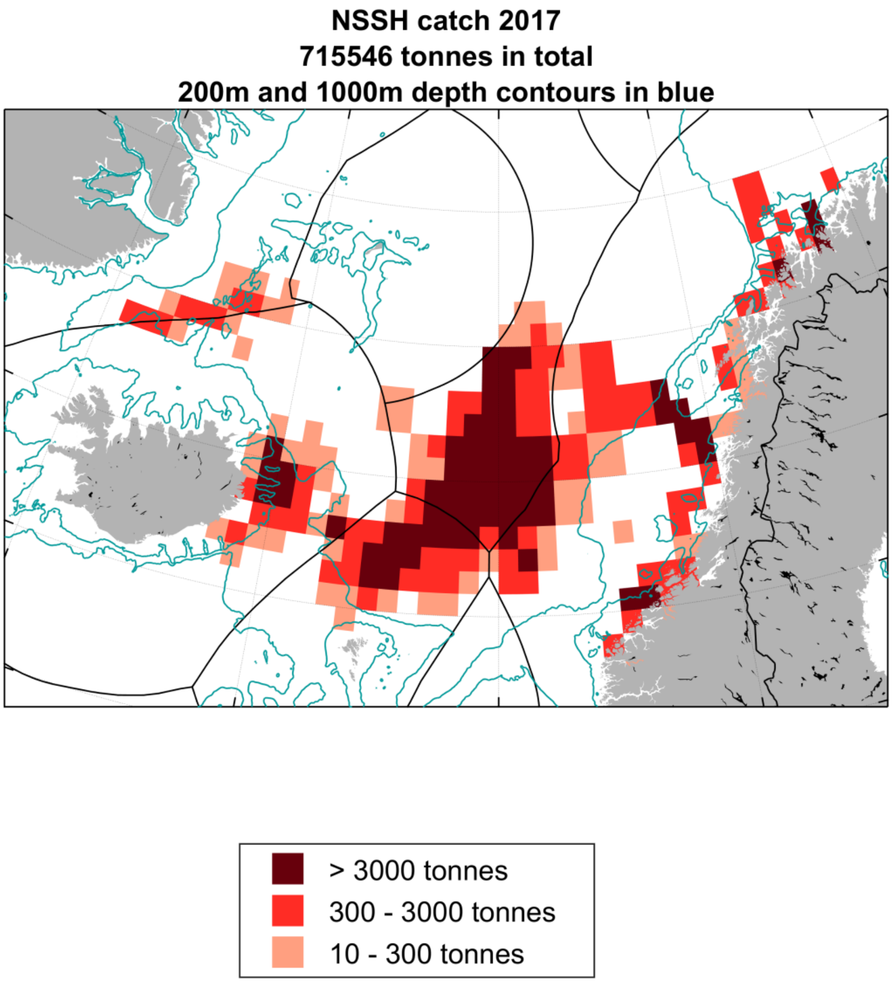

Figure 4.2.1.1. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2017 by ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99% of the reported landings.

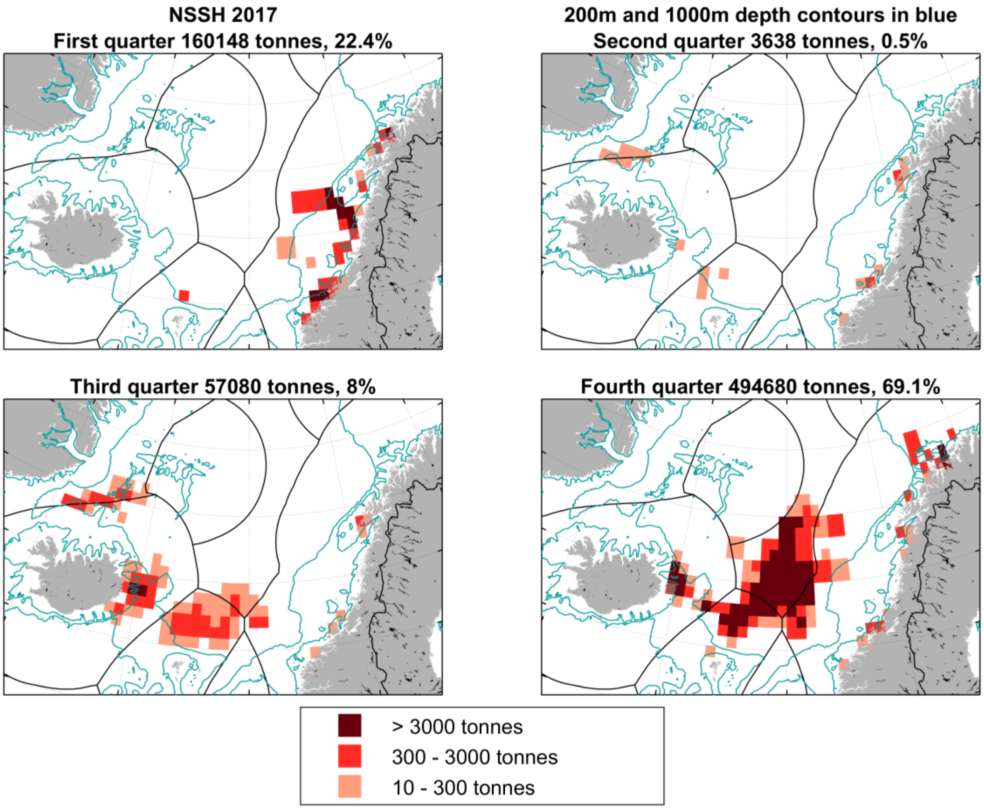

Figure 4.2.1.2. Total reported landings (ICES estimates) of Norwegian spring-spawning herring in 2017 by quarter and ICES rectangle. Landings below 10 tonnes per statistical rectangle are not included. The landings with information on statistical rectangle constitute 99% of the reported landings.

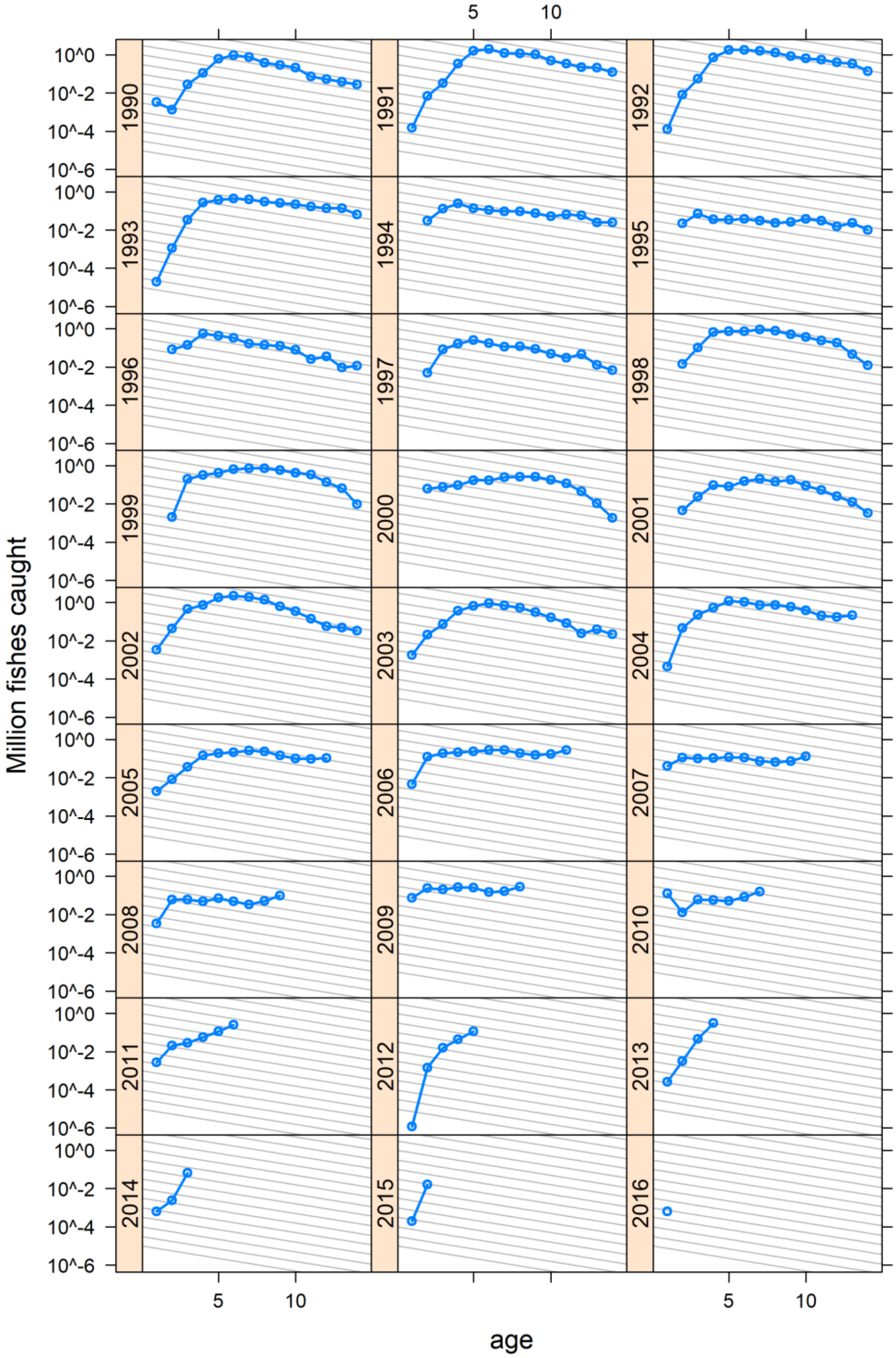

Figure 4.4.3.1. Norwegian spring spawning herring. Age disaggregated catch in numbers plotted on a log scale. Age is on x-axis. The labels indicate year classes and grey lines correspond to Z = 0.3.

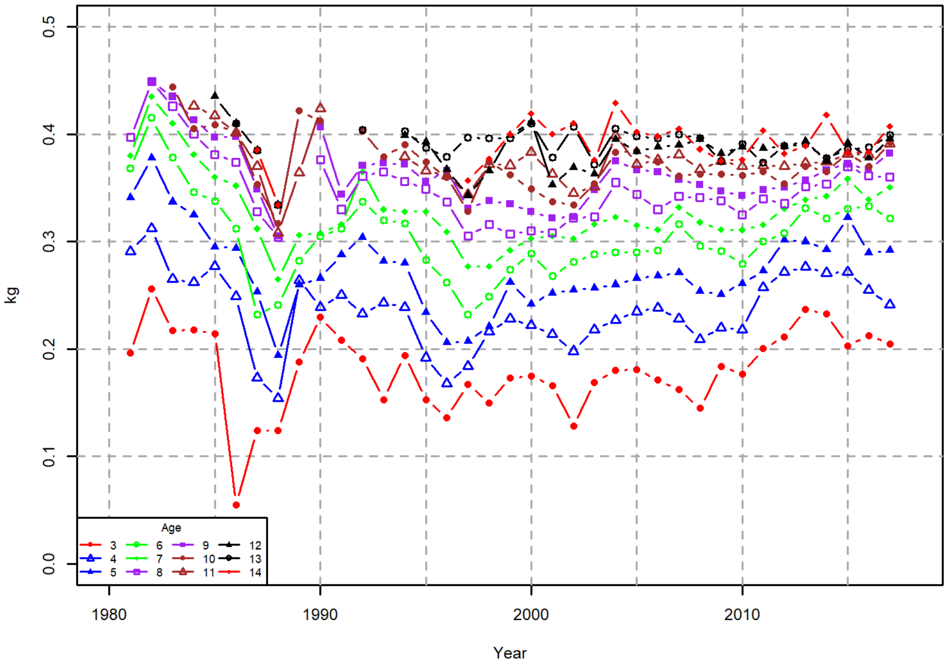

Figure 4.4.4.1.Norwegian spring spawning herring. Mean weight at age by age groups 3–14 in the years 1981—2017 in the catch (weight at age for zero catch numbers were omitted).

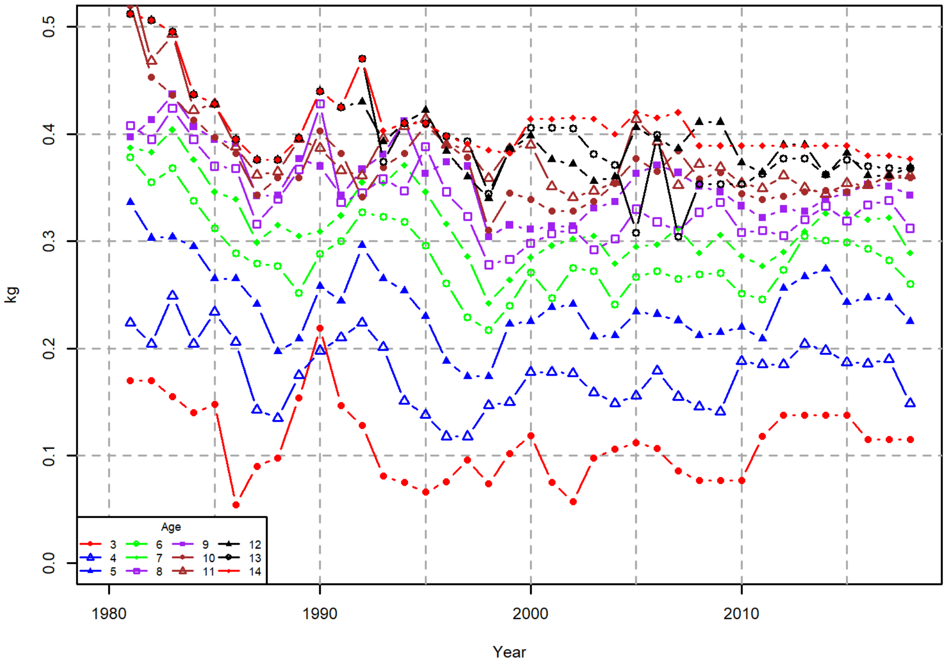

Figure 4.4.4.2.Norwegian spring-spawning herring. Mean weight at age in the stock 1981—2018.

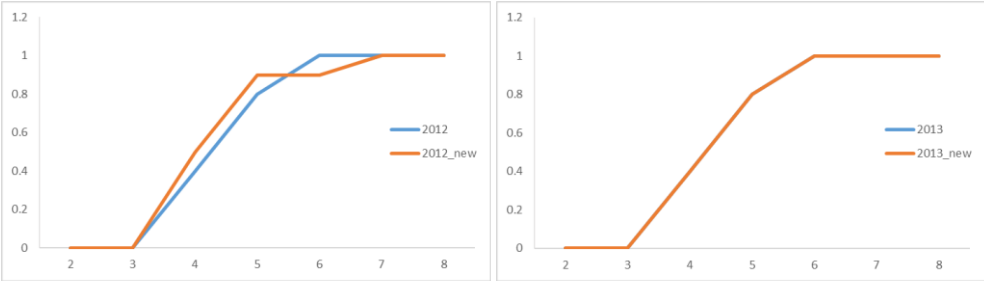

Figure 4.4.5.1. Assumed (blue line) and updated (orange line) maturity-at-age for the years 2012 and 2013.

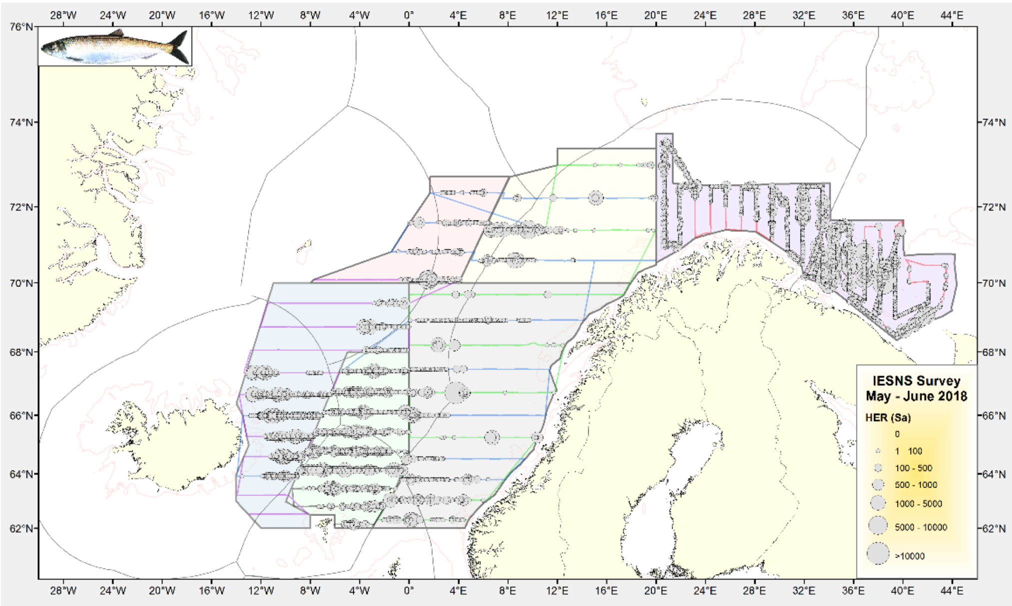

Figure 4.4.7.1.Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in April-June 2018 in terms of NASC values (m^2/nm^2) for every 1 nautical mile. The stratification of the survey area is shown on the map.

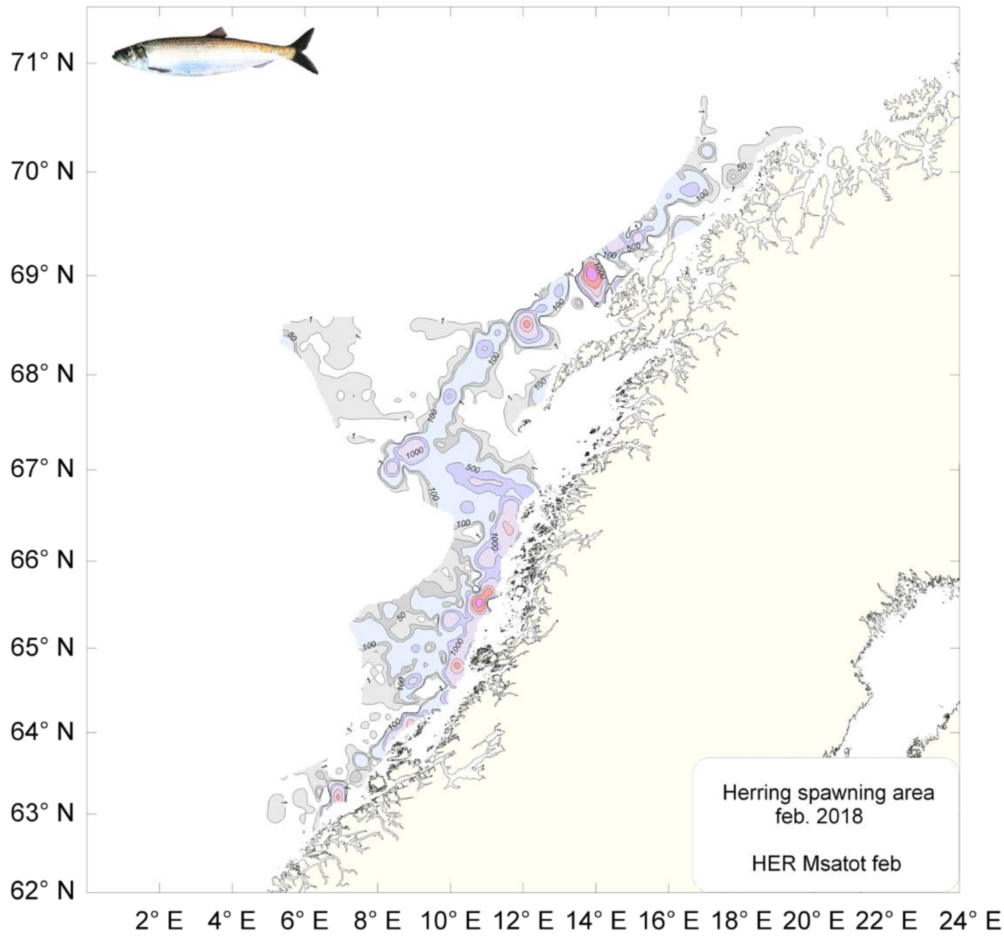

Figure 4.4.7.2. Norwegian acoustic survey on the NSSH spawning grounds. Distribution and acoustic density of herring recorded in 2018.

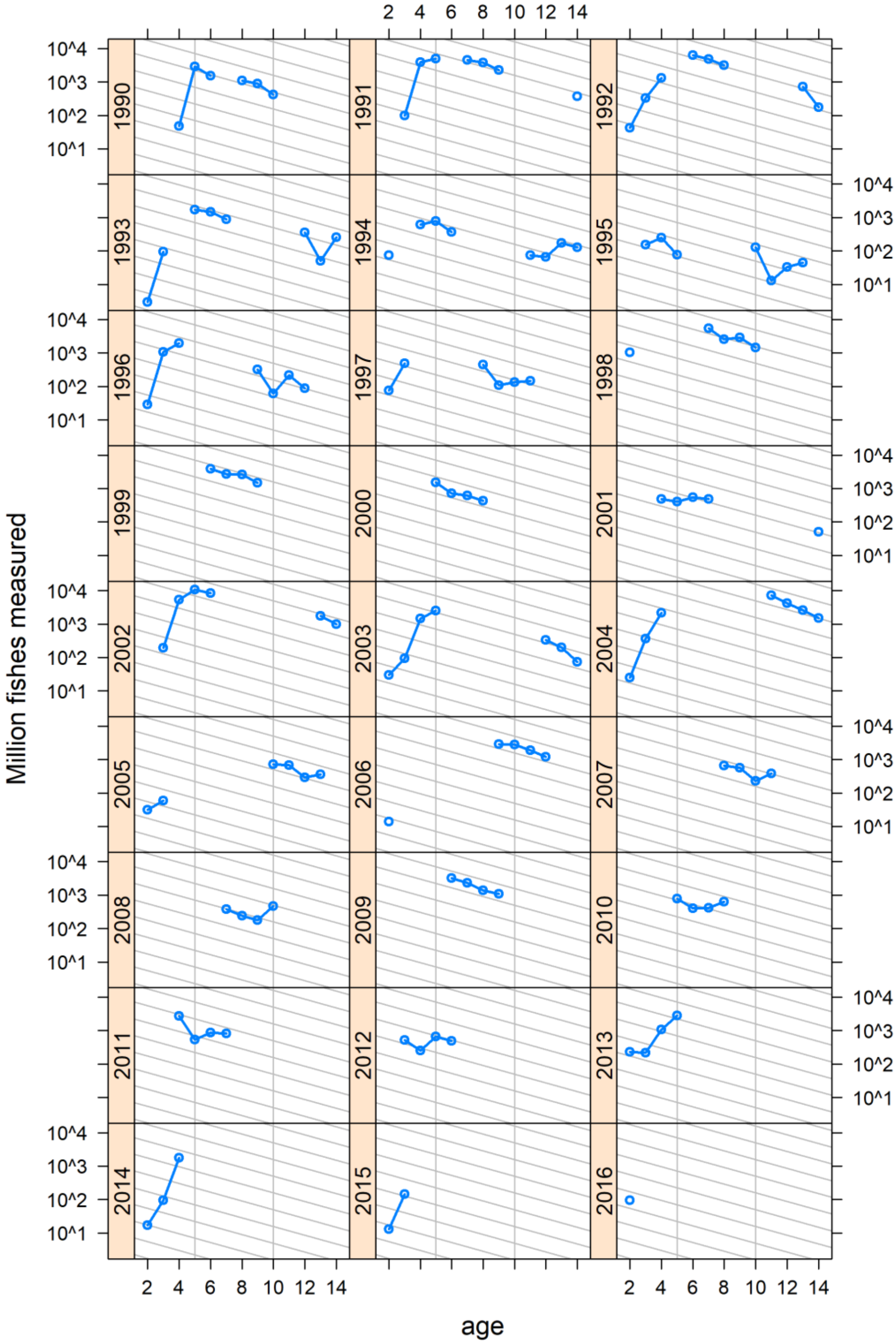

Figure 4.4.7.3. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the spawning area in February-March (survey 1) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3. Age is on x-axis. The labels indicate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

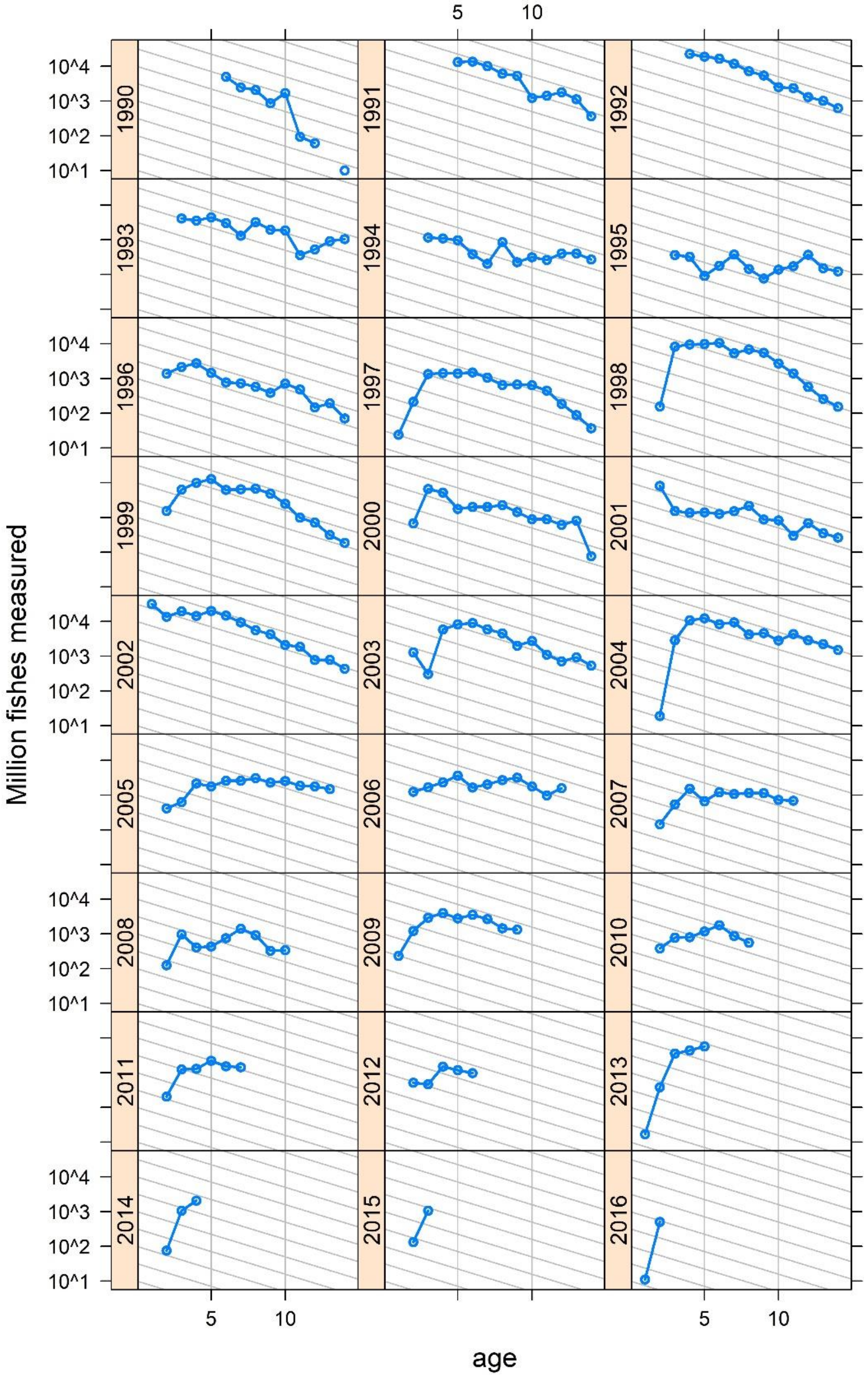

Figure 4.4.7.4. Norwegian spring spawning herring. Age disaggregated abundance indices (billions) from the acoustic survey on the feeding area in the Norwegian Sea in May (survey 5) plotted on a log scale. The labels indicate year classes and grey lines correspond to Z = 0.3.

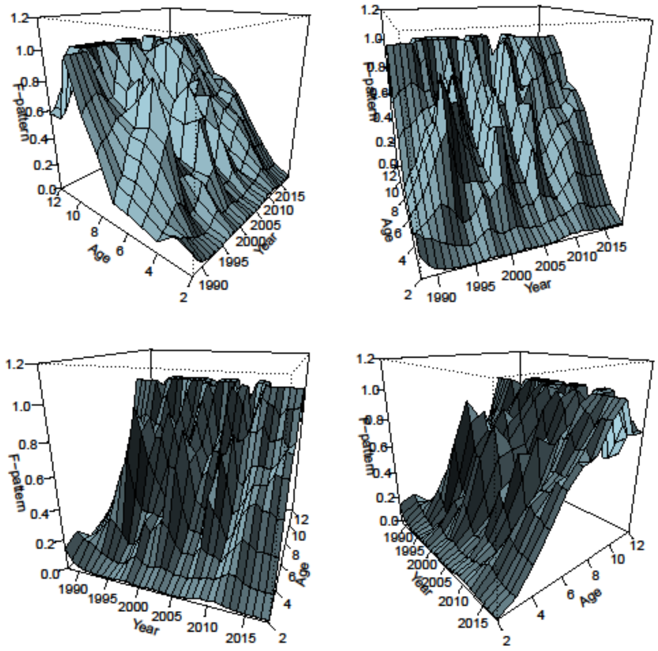

Figure 4.5.1.1.Estimated exploitation pattern for the years 1988–2018 by the XSAM model fit. All panels shows includes the same data, but shown at different angles to improve visibility at different time periods

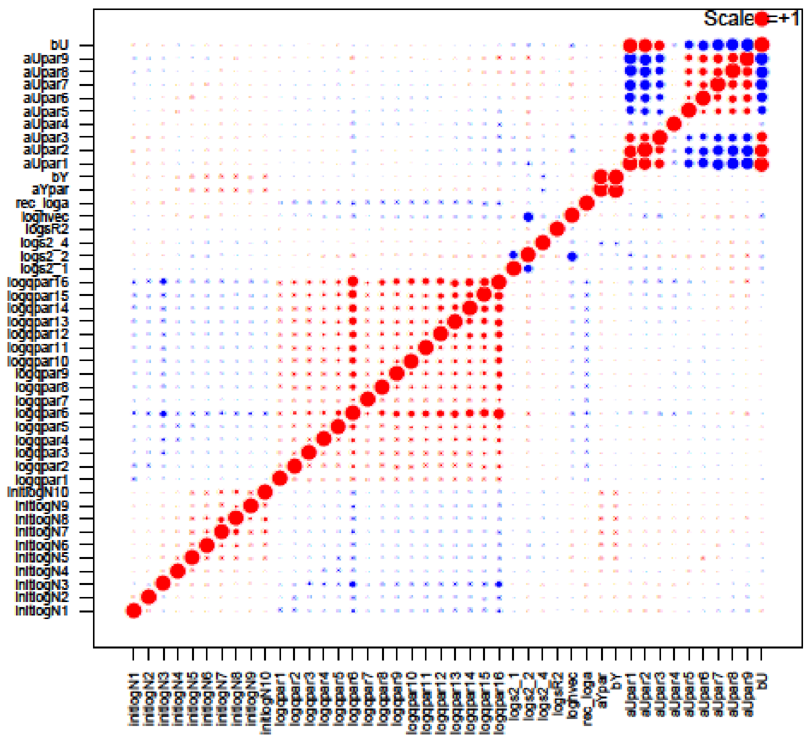

Figure 4.5.1.2. Norwegian spring spawning herring. Correlation between estimated parameters in the final XSAM model fit.

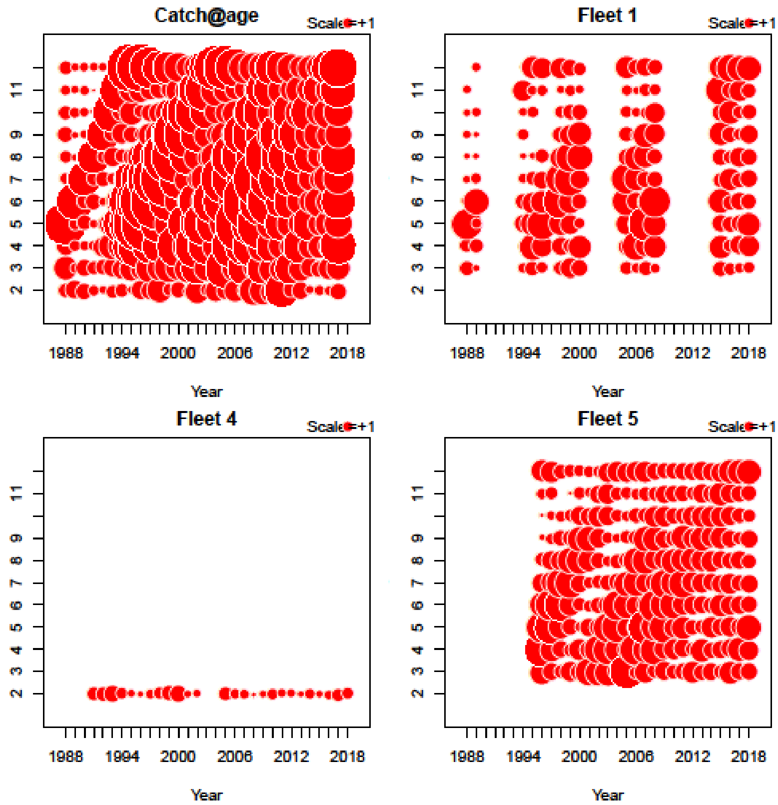

Figure 4.5.1.3. Norwegian spring spawning herring. Weights (inverse of variance) of data-input of the final XSAM model fit.

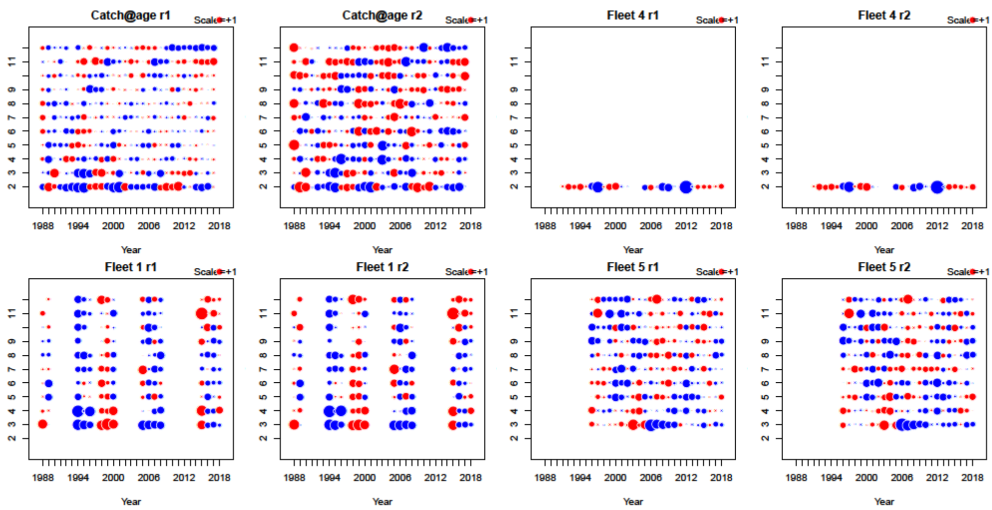

Figure 4.5.1.4. Norwegian spring spawning herring. Standardized residuals type 1 (left) and type 2 (right) (see text) of data-input of the final XSAM model fit.

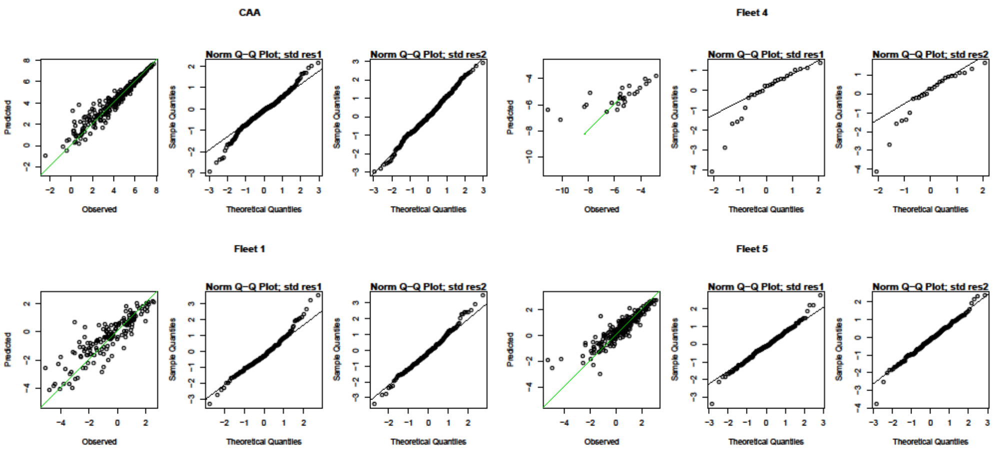

Figure 4.5.1.5. Norwegian spring spawning herring. Observed vs. predicted values (left column) and qq-plot based on type 1 (middle) and type 2 (right) residuals (see text) based on the final XSAM model fit.

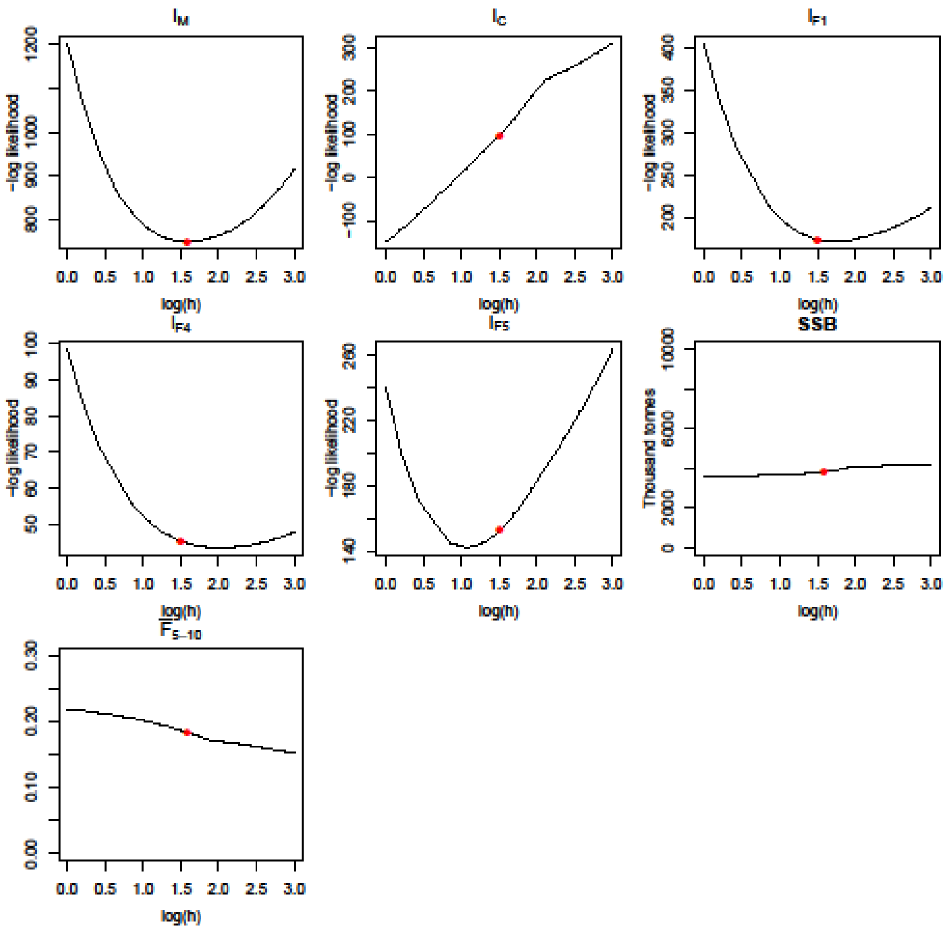

Figure 4.5.1.6. Norwegian spring spawning herring. Profiles of marginal log-likelihood l_M, the catch component l_C, Fleet 1 component l_{F1}, Fleet 4 component l_{F4}, Fleet 5 component l_{F5}, point estimate of SSB and average F (ages 5-12+) in 2017 over the common scaling factor for variance in data h for the final XSAM fit. The red dots indicate the value of the respective scaling factors for which the log-likelihood is maximized.

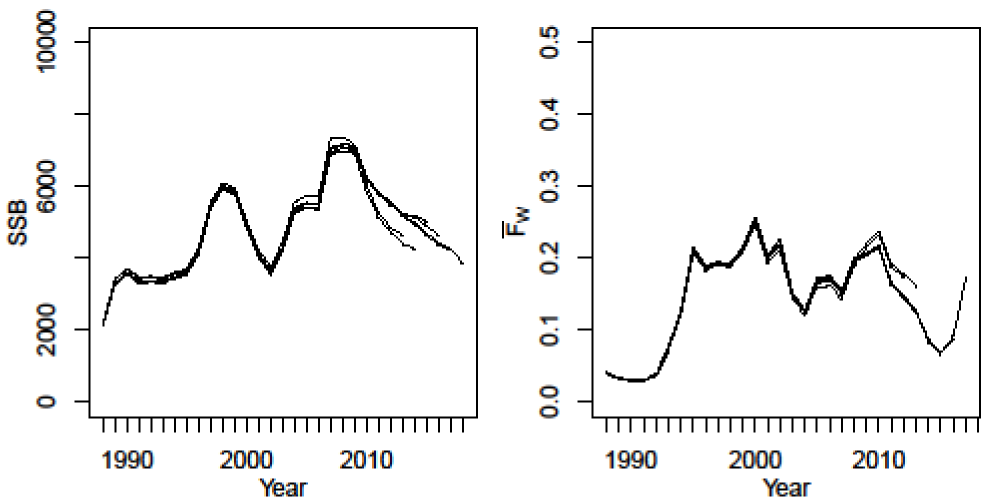

Figure 4.5.1.7. Norwegian spring spawning herring. Retrospective XSAM model fits of SSB and weighted average of fishing mortality ages 5-11 for the years 2012-2017.

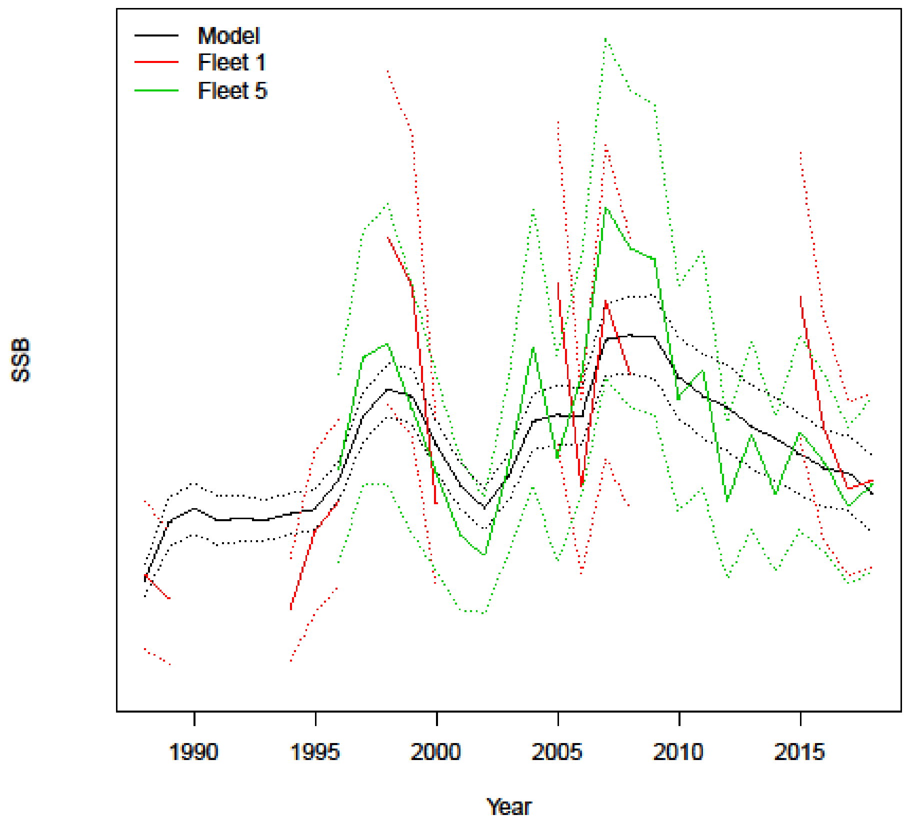

Figure 4.5.1.8. Norwegian spring spawning herring. Point estimates of Spawning-stock biomass by years 1988-2018 from model (black lines) and by survey indices from Fleet 1 (red) and Fleet 5 (green). Dotted lines are approximate 95% confidence interval.

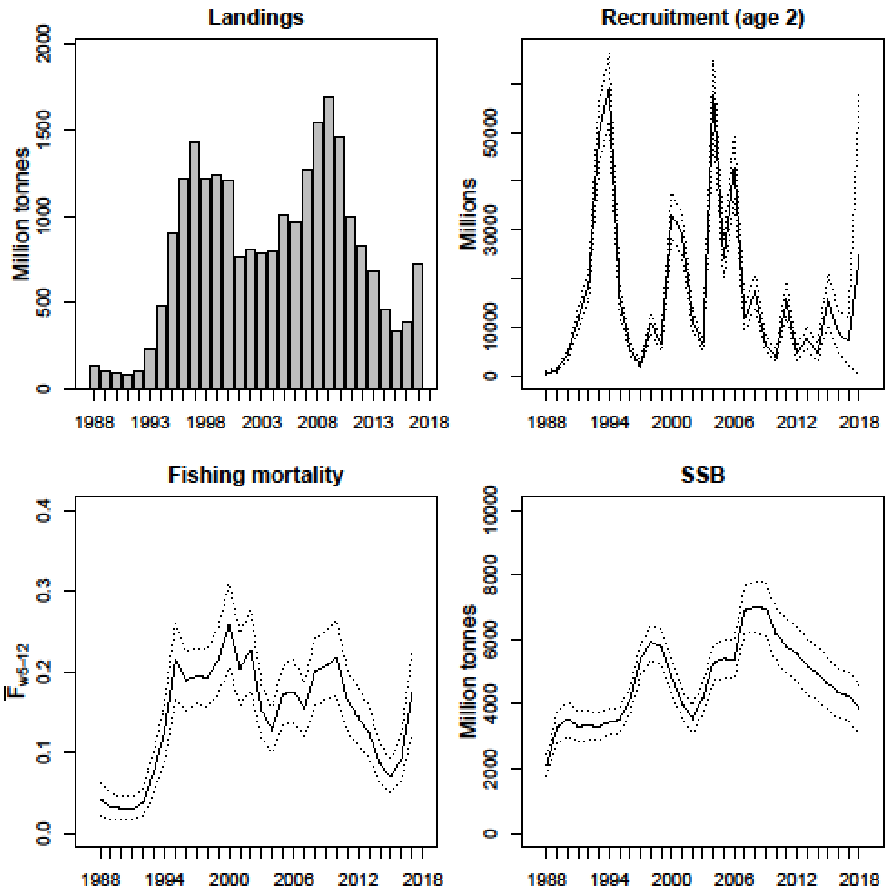

Figure 4.5.1.9. Total reported landings 1988-2017, estimated recruitment, weighted average of fishing mortality (ages 5-12) and spawning-stock biomass for the years 1988–2018 based on the final XSAM model fit. The broken lines are approximate 95% confidence limits.

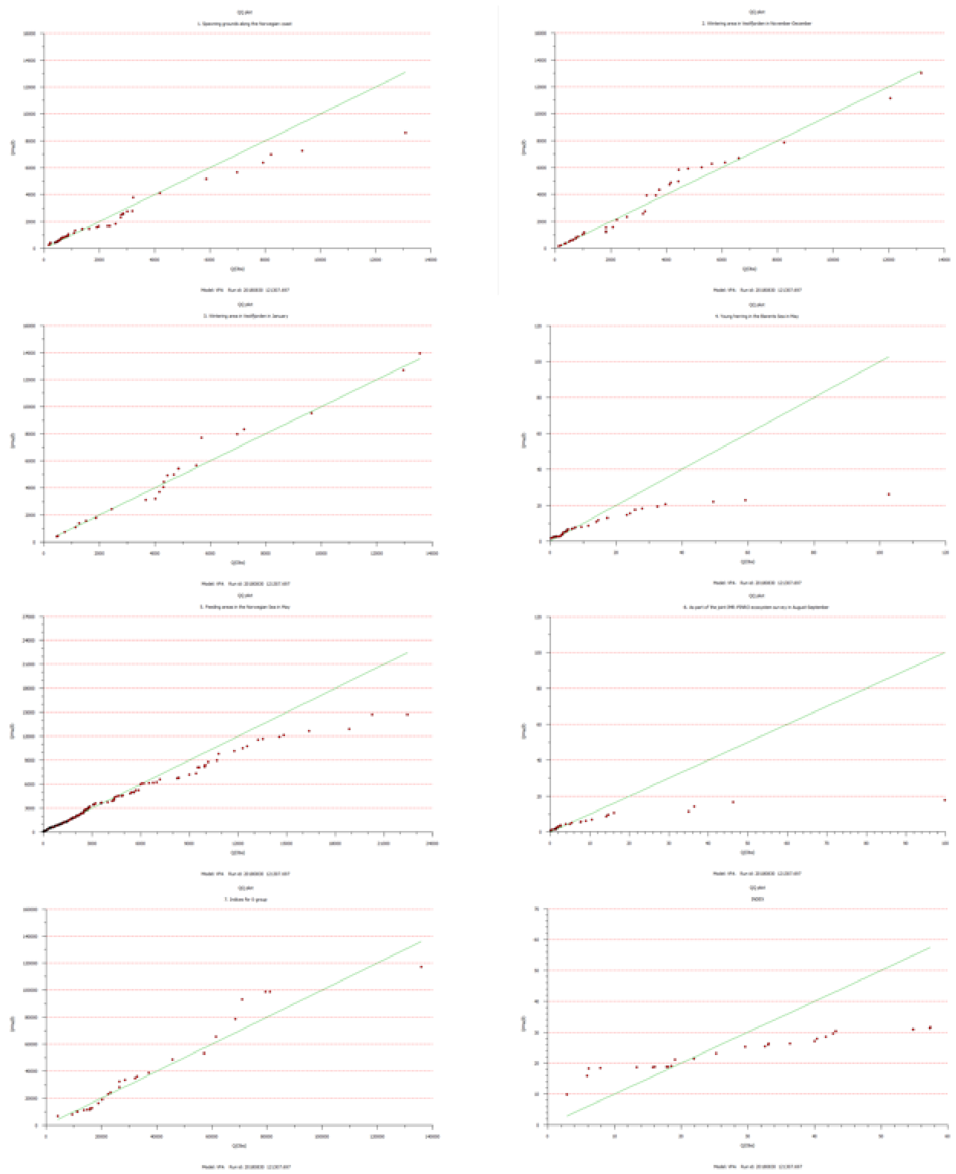

Figure 4.5.2.1.1. Norwegian spring spawning herring. Q-Q plot from the eight different surveys used in tuning in TASACS. First row starts with survey 1 and the last one in row four is larval survey.

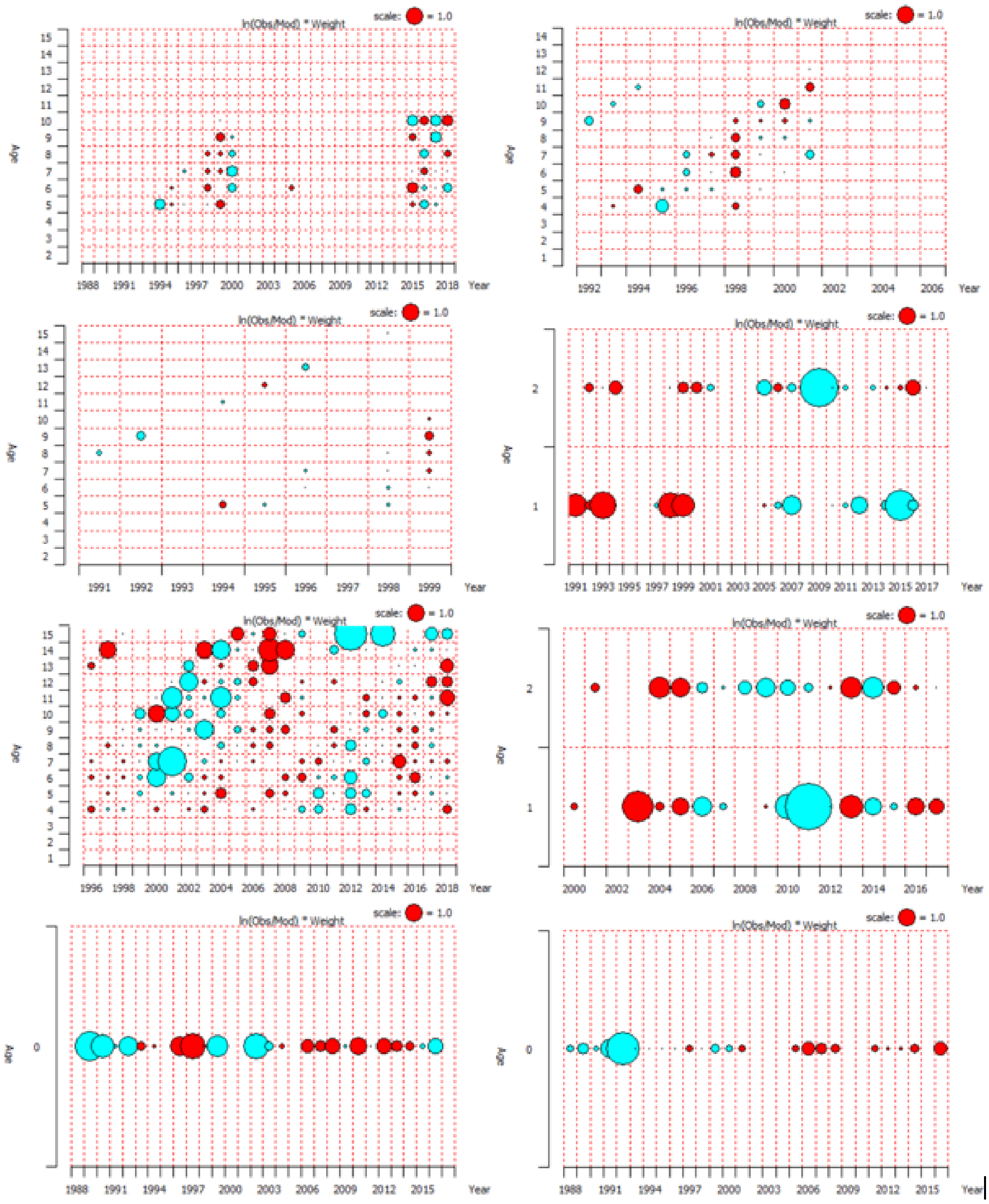

Figure 4.5.2.1.2. Norwegian spring-spawning herring. Residual sum of squares in the surveys separately from TASACS. First row starts with survey 1 and the last one in row four is larval survey.

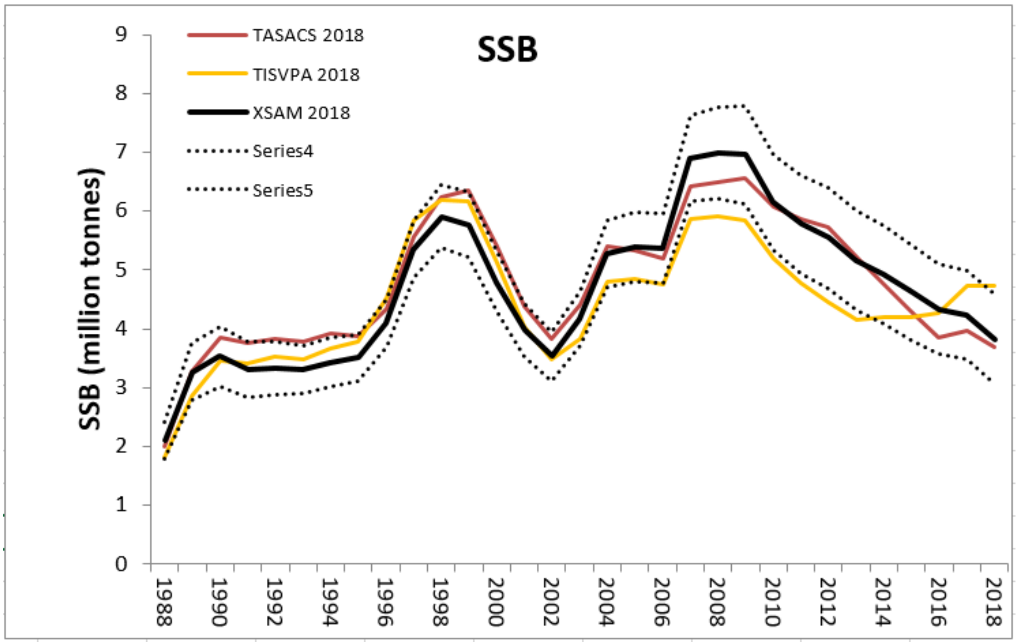

Figure 4.5.2.1.3. Comparison of SSB time-series from the final assessment from XSAM and exploratory runs from TASACS (following the 2008 benchmark procedure) and TISVPA. 95% confidence intervals from the XSAM final assessment are shown.

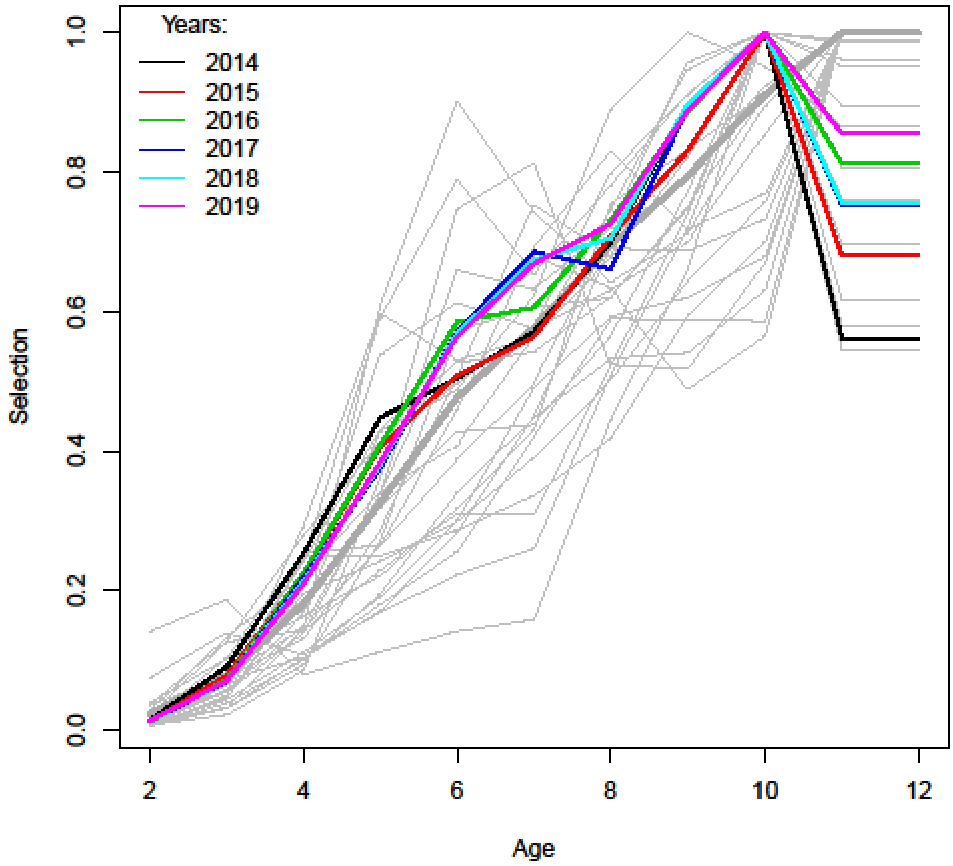

Figure 4.8.1.1. Estimated selection pattern by XSAM; thin grey lines shows annual estimates 1988–2017, the median value is indicated by the thick grey line, while selected years (estimates for 2014–2017 and predictions for 2018-2019) are shown in colours as indicated in the legend.

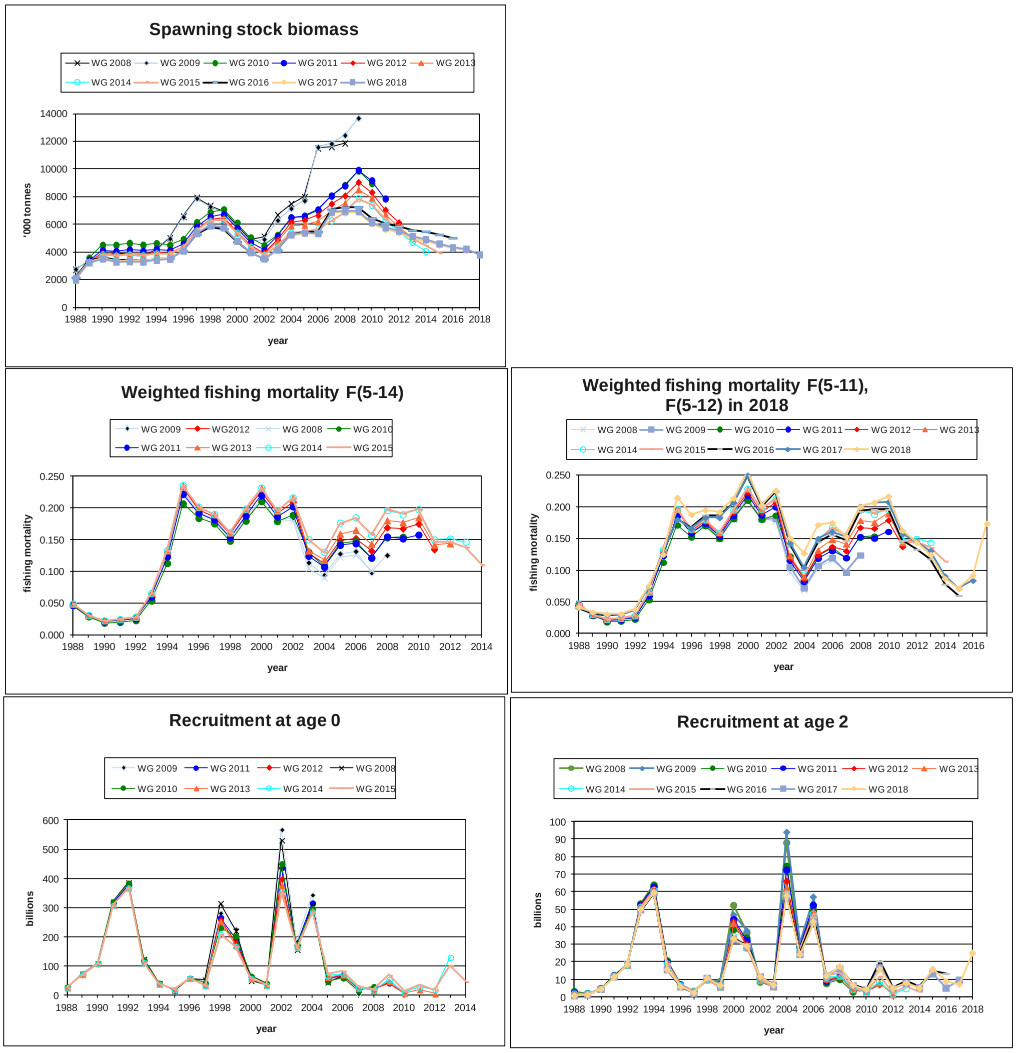

Figure 4.9.1. Norwegian spring spawning herring. Comparisons of spawning stock; weighted fishing mortality F(5-14) and F(5-11); and recruitment at age 0 and age 2 with previous assessments. In 2016 the proportion mature in the years 2006-2011 was changed; recruitment age changed from 0 to 2 and fishing mortality is calculated over ages 5 to 11. In 2018 (WKNSSHREF) the age range for the fishing mortality changed to ages 5-12.