Benchmark Workshop on Sprat (WKSPRAT 2018)

5 – 9 November 2018, ICES HQ, Copenhagen, Denmark

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Contents

Executive summary

The benchmark workshop on sprat (WKSPRAT) was held in ICES headquarters in Copenhagen from 5–9 November 2018. The benchmark process started in June 2017 with a 3 day data compilation meeting, also held at ICES. Three stocks were benchmarked: North Sea sprat, 3.a sprat and the Channel sprat. During the benchmark process, several arguments were put forward on the connection between the North Sea stock and the 3.a stock in Kattegat-Skagerrak. It was therefore agreed to merge the two stocks and assess them as one stock assessment unit.

Sprat in area 4 and 3a

During the 2018 benchmark, enough evidence were presented to merge the sprat stocks in the Skagerrak-Kattegak and in the North Sea. The catch data and the indices of abundance from 3.a were included in the data from area 4. Three surveys are carried out in the area (IBTS in Q1 and Q3 and HERAS survey) and were all used as tuning indices in the model. The IBTS indices were standardized using a delta-GAM approach: the inclusion of 3.a data increased the internal consistency between all age classes for all indices. The SMS model, previously used to assess the North Sea component, was used to assess the new combined stock. The model year is resolved into 4 seasons, where season 1 corresponds to quarter 3 of the calender year. The term 'season' is hence used here to identify the model year, while the term 'quarter' refers to the calendar year. The final model formulation includes a power function for the age 0 catchability of IBTS Q1, a constant maturity ogive and the inclusion of the very few catches reported for season 4 (Q2) into season 1 (Q3) of the following year. The new stock assessment shows a considerable improvement in the retrospective pattern, as well a better fitting to some ages of the IBTS surveys and catches (as indicated by survey and catch CVs).

The stock reference points were revised following ICES standard guidelines. B_{lim} was estimated as the breakpoint of the segmented stock recruitment relationship and B_{pa} was derived from B_{lim}. Short-term forecast settings were updated.

The Management Strategy Evaluation (MSE) settings for the estimation of the F_{cap} were presented and discussed. Several scenarios were proposed to be tested and results will be evaluated during an *ad-hoc* MSE workshop that will take place on 11–12 December 2018.

Sprat in area 7d,e

Not enough evidences were available to change the boundaries of the English Channel stock. The stock is a category 3, and the data available are still scarce. An acoustic survey (PELTIC) is carried out in the English part of area 7.e since 2013. In 2017, the survey has been extended to include also the French part of 7.e and in 2018 the Eastern Channel was surveyed as well. Also, an IBTS index in Q1 is available for the Eastern Channel from 2007 onwards. The time series from the PELTIC survey has been used since 2017 to provide advice. At the benchmark, the updated time series was presented: the method used to produce the acoustic index was revised compared to previous years and it was changed to StoX (StoX, 2015). Concerns were raised because of the uncertainty in the stock distribution, and the fact that the acoustic survey covers only the Western part of the English Channel. No analytical assessment seems to work so far: both a seasonal and non-seasonal SPiCt were attempted during the benchmark workshop, but the short time series in the acoustic index and the lack of any contrast in the data still does not allow the model to converge. The group agreed to provide a seasonal advice based on an empirical method, i.e. to use both indices for trends, but only the

acoustic survey for provision of advice. Two advice rules were proposed: the 1 over 2 rule, and a fixed F rule. Both options will be tested in an MSE framework and presented during the *ad-hoc* MSE workshop that will take place on 11–12 December 2018.

1 Opening of the meeting

This benchmark workshop (Annex 2) considered the assessment method (including projections) and appropriate reference points for three stocks:

- Subarea 4: North Sea;
- Area 3.a: Skagerrak and Kattegat;
- Areas 7.d, e: English Channel;

The benchmark took place over five months with a data compilation meeting on 19–21 June 2018, two WebEx meetings to discuss outcomes from genetic results on 5 September and the 4 October respectively and a five day meeting from 5–9 November 2018. Three independent scientists reviewed all stages and provided comments and input during the discussions: Zeynep Pekcan Hekim (SLU, external chair and reviewer), Alexandra Silva (IPMA, external reviewer) and Leire Ibaibarriage (AZTI, external reviewer).

This report documents and justifies the decisions made by the workshop to establish new assessment and forecast methods that form the basis for the annual ICES fisheries advice. The report should be used as a record of the rational for the new stock annexes which will be used until the next benchmark.

2 The data evaluation meeting

The data coordination workshop in preparation for the benchmark assessments of North Sea sprat (category 1 stock), Kattegat-Skagerrak sprat (category 3 stock) and English Channel sprat (category 3 stock) met at ICES Headquarters, Copenhagen from 19–21 June 2018. The meeting was attended by 10 scientists. Meeting documentation can be found on the WKSPRAT Sharepoint website.

The data evaluation meeting (minutes in Annex 3) focused on reviewing new information and planning the work to be carried out at the benchmark assessment workshop. The main topics of discussion were i) mixing between stock units and stock identity; ii) the assessment methodology to be used; iii) an update of the indices of abundance and iv) ecosystem drivers for short lived species.

After a thorough revision of all the new information available, it was agreed to merge the North Sea and 3.a stocks (a detailed description is available in the Stock ID section of this report). Information on the English Channel sprat is still limited: only few samples were included in the genetic analysis, and on the overall most of the information was limited to the Northern part of division 7.e. An ongoing work on genetics should be able to provide some insights on the stock structure in the area in the near future, and an extension to area 7.d of the PELTIC acoustic survey (currently carried out in 7.e) should help shed some light on the stock dynamics. It was therefore decided that there is still not enough evidence to change the boundaries of what is considered the Channel stock (7.d-e): this will therefore be assessed independently from the others. The assessment model proposed for the new combined stock (North Sea + Skagerrak-Kattegat) was the Stochastic Multi-Species model (SMS), already used to assess the North Sea stock. Sprat in 7.d-e, for the time being, will remain as a category 3 stock, and ICES guidelines will be followed.

A standardization methodology for the indices of abundance using a Delta GAM approach was presented: in particular, this approach was compared with the Stratified Mean Methods used by ICES. The new standardized indices of abundance presented

a higher consistency and were therefore chosen as the preferred option (See for details WD1_NSSpratIndicesIncl3a-Berg).

The natural mortality proposed is the one derived from the SMS multispecies run carried out by the SAM working group (ICES, 2018). Despite some concern in respect to the settings used, especially for the distribution of predators in Q3, no other valid alternative was presented.

The following options were discussed for the model settings:

- 3 different methods for the standardization of indices of abundance will be used and the performances of the estimated indices will be compared. The methods considered will be 1) the stratified mean method (which is the one currently in use) and 2) a Delta-GAM model.
- The inclusion of a density dependent effect in the model to account for the higher catchability of younger ages in correspondence of high recruitment events, to improve the retrospective pattern.
- The addition of an extra natural mortality between Q1 and Q3, to improve the retrospective pattern.
- The use of a shorter time series of catch to reduce the CV (especially important for forecasts).
- Compare the performances of a new maturity ogive, since the one currently in use is very noisy and could strongly affect the forecast.

The minutes and the agenda of the data compilation meeting are available in Annex 3 and 4, respectively.

3 Sprat stocks

Until now, the sprat stocks in the ICES area were considered as belonging to four areas, i.e. the North Sea (Area 4), the Skagerrak and Kattegat (3.a), the English Channel (7.d-e) and the Celtic Seas (Areas 6 and 7, except 7d-e). These units reflect historical centres for the fisheries and hence demands for management advice.

The stock boundaries in the area have been long debated: in particular, to which extent the North Sea stock extend into the Skagerrak-Kattegat and in the English Channel has yet to be quantified.

As reported in ICES (2013), eggs and subsequent larvae in the Skagerrak-Kattegat may be retained in the area or could be exported northward up the Norwegian coast. Eggs and subsequent larvae that spawn in the North Sea, especially the German Bight, could potentially enter 3.a as juveniles (based on drift studies with plaice (Hufnagl *et al*., 2013). In the English Channel, the residual flows are from west to east, thus spawning in this area will result in an eastward shift of eggs and larvae (J. van der Kooij, pers. comm. Cefas, Lowestoft). Young stages from the eastern Channel could end up in the southern North Sea (e.g. especially in the Wadden Sea and the Scheldt Estuary) nursery areas (Hufnagl *et al*., 2013). In regard to connectivity with the Channel to the west, eggs and larvae may drift from the Celtic Sea or Bay of Biscay in to the area and this will be particularly prevalent in winter when there is no stratification (up to April/May). In subsequent months (May–October), a front develops (Ushant front across the Channel roughly from about Plymouth) between the stratified deeper waters in the west and the shallower eastern waters. This front will reduce/stop transport from waters west of Plymouth eastwards.

The principal question for this benchmark was whether there was evidence to either keep the putative stocks/regions separated or to combine them into one or more larger groupings.

3.1.1 Stock identity

The current management units of sprat in the North Sea Ecoregion are the North Sea, the English Channel and the Kattegat-Skagerrak area. Assessment and advice so far have been provided following this division. During the data compilation meeting new evidence from a genetic studies carried out for the Northeast Atlantic were evaluated. Besides, a revision of existing data (catch and surveys), information, and results of analyses relevant to the stock structure of sprat were presented and discussed to support the results from the genetic study. The group concluded that the current stock structure should be reconsidered and supported the merging of the North Sea and Skagerrak-Kattegat into one single stock. Not enough evidence was presented to support the inclusion of the English Channel stock as well, therefore this separation was maintained. Furthermore, the analysis suggested that the sprat inhabiting the Uddevalla and Norwegian Fjords, as well as the the Belt Sea and Øresund are separated from the North Sea and Skagerrak-Kattegat component. Hence, it is likely that the relatively high survey densities of sprat in the very southernmost part of Kattegat bordering the Belt Sea and Øresund (WD1_NSSpartIndicesIncl3a-Berg & WD11_Sprat_Spatial_Distribution) may at least partially belong to the Baltic Sea genotype. Consequently, appropriate considerations should be taken to account for the potential mixing of the North Sea and Baltic Sea stock component in this south-eastern edge of the larger managemet area.

3.1.1.1 Genetic

The genetic study was based on a dataset from 38 locations where spawning individuals were genotyped at 91 SNP loci. The outcome of this analysis allowed us to draw the conclusion that the sprat populations can be distributed in three genetically distinct clusters: 1. Norwegian fjords, 2. Kattegat-Skagerrak, North Sea, Celtic Sea, Bay of Biscay and 3. Baltic Sea. There is little evidence to suggest that off-shore Kattegat sprat samples, at least in the Nortern and central parts covered by the study are genetically differentiated from North Sea sprat. Three of the populations in Kattegak-Skagerrak area (Udevalla, Great Belt and Øresund) share the Baltic genetic signature, as well as show consistent differentiation from the North Sea/off shore Kattegat samples (see WD2 for details). Hence, it is likely that the relatively high densities of sprat observed in the southernmost part of Kattegat bordering the Sound and Belt Sea (WD1_NSSpartIndicesIncl3a-Berg & WD11_Sprat_Spatial_Distribution) may at least partially belong to the Baltic Sea genotype.

3.1.1.2 Indices

We looked at the external consistency in the IBTS survey indices between ICES roundfish areas and internal consistency in the IBTS survey index calculated using the delta GAM method (see working document for details: WD3_Survey_consistency_between_roundfish_areas_etc).

CPUE by age and roundfish area were extracted from the ICES web site. The question in focus was whether population dynamics follow the same patterns in area 4 and 3.a. We therefore focused on inter-annual variation in the survey CPUE for roundfish area 6 and 7 (the main sprat fishing grounds in area 4) and roundfish area 8 and 9 (3.a). Pairwise correlation analyses revealed a significant relationship between adjacent

roundfish areas, also when comparing area 7 and 8, indicating that the stock dynamics of sprat in area 4 is not decoupled from the dynamics in 3.a. This tendency was reflected in both the Q1 and Q3 survey. Internal consistency analyses for the delta GAM survey indices showed a reduction in consistency when including 3.a into the modeled Q1 North Sea indices, but a marked improvement in consistency for Q3 North Sea indices (see also WD1_NSSpratIndicesIncl3a-Berg).

In addition to the consideration of external and internal consistencies of survey indices based on the delta GAM approach, a statistical analysis was performed to detect signs of potential sub-stock structuring based on the spatial patterns of abundance distributions, temporal dynamics and size distributions (see working document for details: WD4). The results of this spatial study indicates that there seem to be some signs of stock separation, where the largest differences occur between the North Sea and the southern part of Kattegat. These results generally support the findings based on genetics demonstrating low genetic differentiation between the North Sea, Skagerrak and at least the northern and central part of the Kattegat, while the southern part of Kattegat and the Belt Sea/The Sound may at least partially belong to the genetically distinct Baltic Sea cluster. However, it should be noted that the actual stock boundaries and their variability in time are unknown and difficult to detect on the basis of this analysis.

In conclusion, although some of the analysis based on survey data identifies signs of sub-stock structuring between the North Sea and at the southernmost part of Kattegat, these results do not support the current stock division between area 4 and 3.a. However, the decision to merge or not merge area 4 and 3.a sprat into one stock should not be based on these results alone, but should be supported with other methods, such as population genetics as described above.

3.1.1.3 Catch data

We compared the length at age observed in commercial samples (see working document for details: WD3_Survey_consistency_between_roundfish_areas_etc). A comparison between the offshore area 4 and 3a was possible only in quarter 4, whereas a comparison between the inshore area 4 and 3.a was possible only in quarter 3 (due to lag of sample overlap). We only included statistical ICES rectangles with a minimum of 5 samples and we only included years where there were at least one rectangle inside the boxes used in the comparison. The final mean length at age was derived as stratified averages by first averaging across squares and thereafter across years. We did not find indications of size differences between the area 3.a and the offshore area 4, whereas, significant differences were found when comparing the inshore area 4 and 3.a, indicating that the observed geographical differences in length at age cannot alone be explained by the existence of a distinct 3.a sub-stock.

3.1.1.4 Norwegian Fjords component

Approximately 120 stations along the Norwegian Skagerrak coast have been sampled annually by beach seine in September–October since 1920. Young (0 group) sprat occur in these samples. The present study compared the annual abundance of 0 group sprat in the beach seine with the total IBTS indices for the whole Greater North Sea Ecoregion from quarter 1 and 3, as well as the corresponding ages 0–2 for the North Sea, Skagerrak-Kattegat (Division 3.a), but none of the comparisons showed significant correlations. In addition, the beach seine abundance was compared with a newly estimated IBTS index that combines both areas for ages 0–2 and from quarter 1 and 3, but these comparisons showed no significant correlation. These results confirm the outcomes

from the genetic studies and demonstrate that the dynamics of sprat along the Norwegian Skagerrak coast is not influenced by the dynamics of sprat in the central part of Skagerrak and Kattegat or the North Sea. For details, see "WD12_Berg et al 2018_Abundance of young sprat (Sprattus sprattus) along the Norwegian Skagerrak coastline".

3.1.1.5 Otolith shape analysis

The shape of sprat otoliths were studied in three areas of the Greater North Sea ecoregion, with a particular focus on the Swedish west coast, with the intent to support inference on sprat population structure in the North Sea and Kattegat-Skagerrak. The study concluded that the otolith shape analysis supports the merging of North Sea and 3.a assessment units. But the results also point out a need for caution on the sprat occurring within the Swedish Skagerrak fjords which may be part of a local component. The results also indicate a possible mixing zone in the southern Kattegat for which the boundaries remain to be defined (WD10_Otolith shape analysis).

3.1.2 Environmental drivers

An exploratory statistical analysis was performed to identify environmental indicators of North Sea sprat stock status and discuss its potential use within short-term forecasts and advice, with particular emphasis on recruitment and growth (WD5_Environmental indicators). Since previous experimental, modelling and field studies of sprat in the Baltic Sea have demonstrated clear effects of temperature and availability of zooplankton prey on both recruitment and growth (e.g., Nissling 2004; MacKenzie and Köster 2004; Casini *et al.*, 2011) our working hypothesis is that similar relationships exist between recruitment, growth and these environmental variables. The result of the analysis in terms of the fitted statistical models (including GAMs and random forest), the out-of-sample prediction skills and the significance of the selected environmental covariates support our expectations of the effects of temperature and food availability, as well as density-dependence on both recruitment success and growth. We suggest that these models will be updated and quality controlled during the upcoming 5-year assessment period as part of the WGS2D. If the models and relationships are robust and perform better than using the currently applied sliding averages of receruitment and weight-at-age their operational use within short-term forecast and advice should be considered as part of the next benchmark.

4 Sprat in subarea 4 and 3.a

North Sea and Skagerrak-Kattegat

Stock coordinator: Anna Rindorf

Stock Assessor: Mikael van Deurs

4.1 Issue list

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified					
Tuning series	Determine the most appropriate index area from IBTS. Other survey data	Estimating the most appropriate index area from IBTS. Historical data from a Norwegian beach seine series not used so far will be available and acoustic data may be available. Investigate whether MIK samples can provide information of late spawned sprat. Investigate whether other data sources are available.	IBTS data are already available from DATRAS. Norwegian beach seine and acoustic data from IMR. MIK samples from	Casper Berg (DTU) Richard Nash (IMR) Richard Nash (IMR)	
Discards					
Biological Parameters	Stock structure	Genetic analyses of stock (on the way, Norwegian/Danish project) to investigate whether 4 and 3.a sprat are separate stocks, Moray Firth and English channel probably not well resolved, coastal sprat also an issue.	Genetic analyses results from IMR and DTU	Cecilie Kvamme (IMR) and Dorte Bekkevold (DTU)	Stock ID expertise/

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
Fisheries & ecosystem issues and data	Historic catch reliability	Reanalyses of historic catches, investigating the ratio of herring to sprat in biological samples from the industrial fishery to see if historical catches should be corrected for unallocated herring catches.	Historic samples of species composition. Available from Denmark.	Kirsten Håkansson (DTU)	Small pelagic fish biology and ecology/
	Reliability of age reading	New information on the accuracy of age reading from WKARSPRAT.	Report already available		
	Recruitment autocorrelation	Importance of autocorrelation, short and long term, and modelling this for forecasts.	Stock assessment input data	Martin Lindegren and Mollie Brooks (DTU)	
	Growth and maturity prediction	Model weight in the stock differently to make sure growth is smooth and does not jump. Investigations of the possibility to use mean weight predictions and maturity predictions in forecasts. Work will be initiated once benchmark is agreed. Importance of correlations between ages and years.	Stock assessment input data.	Mollie Brooks (DTU)	

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	Responsible expert from WG	External expertise needed at benchmark type of expertise / proposed names
Assessment method	Evaluate the use of old data Exploitation pattern development Model type	Evaluate the use of old data, How appropriate is the assumption about exploitation pattern? Attempt age based and biomass based model for 3.a if separate stock, attempt SESAM model for 4,	Assessment input data	Anna Rindorf (DTU) Tobias Mildenberger (DTU), Casper Berg (DTU)	Modelling expertise/
Biological Reference Points	Updated reference points	Update reference points based on new data/model and according WKMSYREF5 guidelines	WKMSYREF5 guidelines, stock data available in WG	Mollie Brooks (DTU)	
Other	Development of ecosystembased indicators	Development of indicators to show changes in productivity, analyses of intraspecific correlations with other pelagic fish, role of sprat as predator on other fish early life stages, possible link to WGINOSE	Review and data available in the WG, temperature data	Martin Lindegren (DTU)	

4.2 Input data

Most of the data remained unchanged from the previous benchmark and the group focused mostly on the assessment model. The main updates concerned the inclusion of 3.a data to the data from area 4, the update of the indices used and the revision of the maturity at age. For details on all other data, please refers to ICES (2014).

4.2.1 Catch Data

No updates to catch data have been supplied. The new timeseries used in the assessment results from the merging of the North Sea and the Skagerrak-Kattegat landings. As previously, the catch data does not include the so called Fjord stock component. No revisions to discard estimates or information from recreational fisheries have been submitted. The group considered that based on the available information, the catch data quality seems reasonable for the whole time series. Most of the uncertainty is related to catches in 3.a, where in some years there is a big difference between ICES catches -based on a combination of official catches and other information about the fisheries- and the official catches. In 2013, WKSPRAT tried to corroborate the landings given in the old reports to find the underlying reasons for the differences; however, there was insufficient written evidence as to why the changes were made. It is known that in some years juvenile herring was recorded as sprat (i.e. official catch >ICES catch), and in other years sprat was recorded as other species because of problems with overshoot of the sprat TAC (i.e. official catches). A sensitivity run removing this historical part was carried out to assess the effect of the early catches on the model.

4.2.2 Weight, maturity and natural mortality

4.2.2.1 Weight

The weight-at-age used in the assessment was updated to include information from 3.a (Figure 4.2.2.1). Weight at age in the cathes is equal to weight at age in the stock.

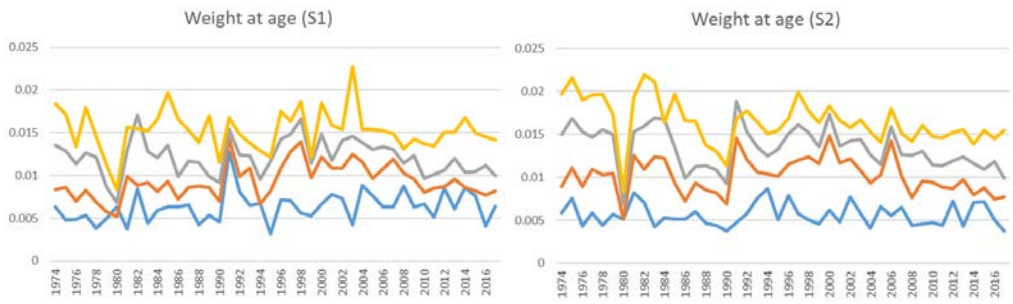

Figure 4.2.2.1 Sprat NS-SK. Weight-at-age in Season 1 and season 2 as used in the assessment model.

4.2.2.2 Maturity

Data on maturity were available from IBTS Q1 and IBTS Q3 survey. During the last benchmark in 2013 it was agreed that the estimated maturity ogive derived from IBTS Q3 was not appropriate due to the difficulties to distinguish between immature and spent by visual inspection only. The maturity ogive from Q3 was therefore excluded from further testing.

A time-varying maturity ogive based on IBTS Q1 only was available from the previous assessment. Details on how the maturity was estimated are available in ICES (2013).

The group considered that, since sprat in the North Sea and in the Kattegat-Skagerrak spawn in spring-summer, the maturity estimates in Q1 are not representative of the spawning season and therefore might not be appropriate. The group suggested to test the assessment model both with a fixed maturity ogive derived by averaging the estimates provided by IBTS Q1 survey, and the time-varying maturity from the same survey as used in previous assessement.

4.2.2.3 Natural mortality

Quarterly and annual natural mortalities were taken from the updated North Sea Multispecies SMS key run (ICES, 2018 and Figure 4.2.2.3.1). The value for age 3+ was used for both age 3+ in the second half of the year and for the sprat with more than three winter rings in the first half of the year. A three year running mean is used to smooth the year to year variation. Natural mortalities as used in the assessment are given in Figure 4.2.2.3.2 (run based on quarterly catch data). The group higlighted some concern on the natural mortalities in Q3 and Q4, which is mostly ascribed to mackerel. According to mackerel biology, such high values are unlikely because this species migrates outside the North Sea at the end of summer. Due to lack of any acceptable alternative, it was decided to recommend WGSAM to investigate the issue, and the current natural mortality values were used in the assessment.

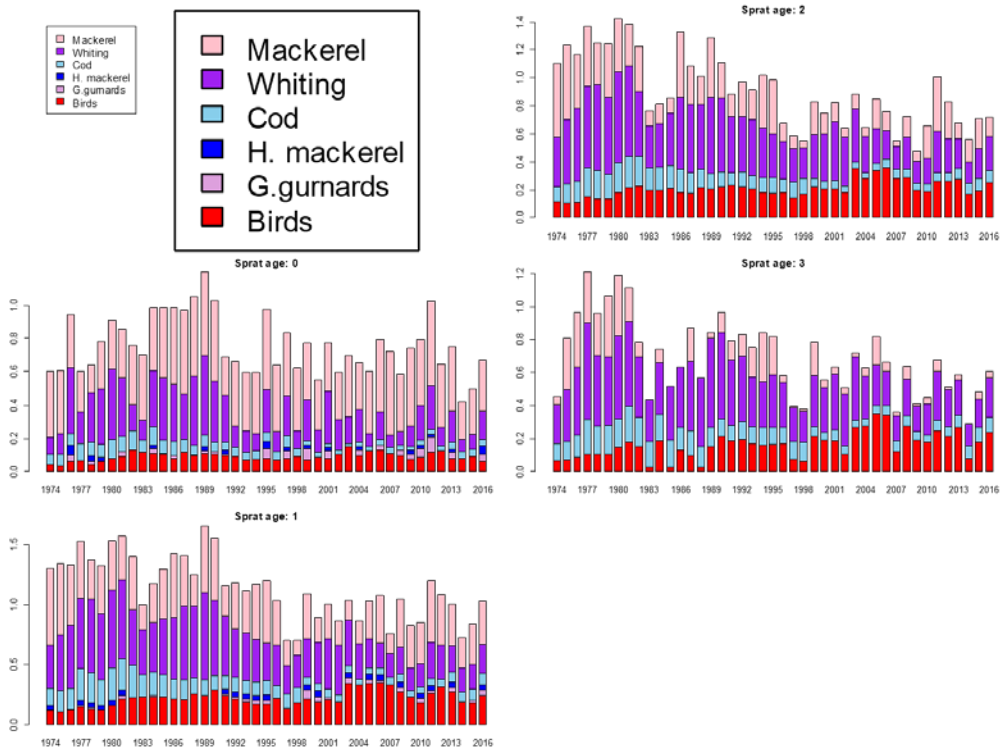

Figure 4.2.2.3.1 Sprat NS-SK. Predation mortality by age for sprat as resulting from the 2017 SMS key run.

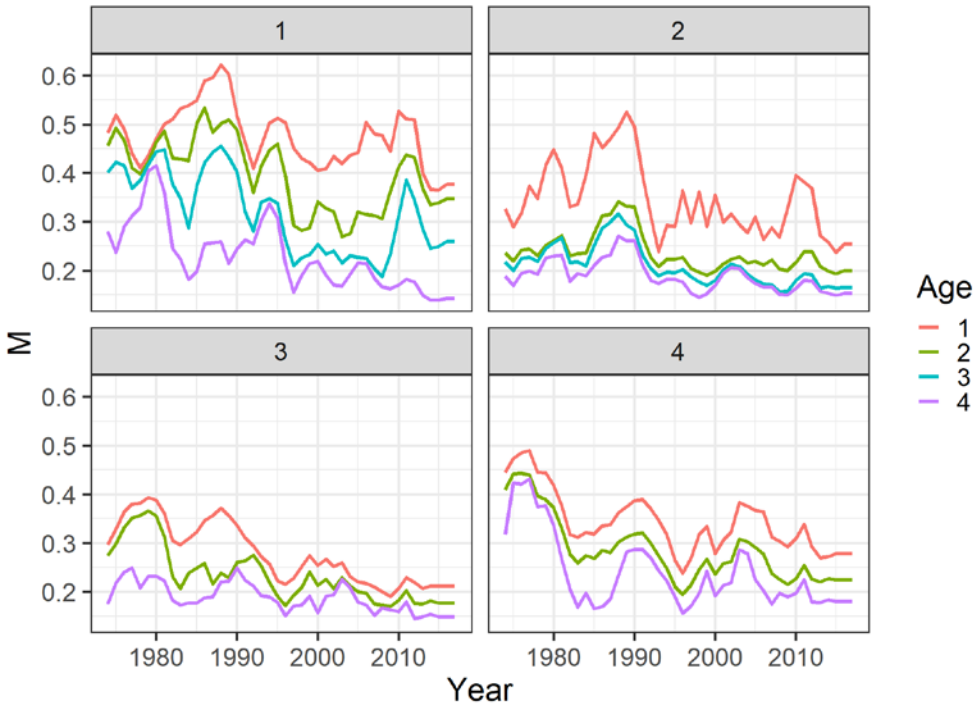

Figure 4.2.2.3.2 Sprat NS-SK. Natural mortality by age and quarter as used in the SMS single species assessment model.

4.2.3 Surveys

Three surveys cover this stock and expand in both the North Sea and Skagerrak-Kattegat area. An International Bottom Trawl Survey (IBTS) covers the stock in the first and third quarters of the year. Additionally, the herring acoustic survey (HERAS) covers the same area in July. A problem with the surveys in 3.a is that they mainly cover the central parts of Skagerrak-Kattegat, whereas all the Norwegian and some of the Swedish catches are taken in coastal areas not covered adequately by the surveys. Also, most of the sprat is concentrated in a very small part of the survey area, meaning that only a few trawl hauls/transects give survey information about sprat, making the survey indices more vulnerable to random variation. The proportion of the 3.a component is however much lower than the North Sea component: therefore, when combining the data, this noise is masked and the inclusion of the 3.a component actually improves the overall survey consistency.

Two methods to estimate the average indices of abundance from IBTS were examined: stratified mean and delta-GAM (see WD1_NSSpratIndicesIncl3a-Berg). The methods were evaluated based on the internal consistency of the indices produced. The indices derived by the delta-GAM (figures 4.2.3.1, 4.2.3.2, and 4.2.3.3) method showed a higher internal and external consistency. Concerns were raised on the fact that the estimates using this approach will change from year to year, but this change was predicted to be small due to the length of the time series.

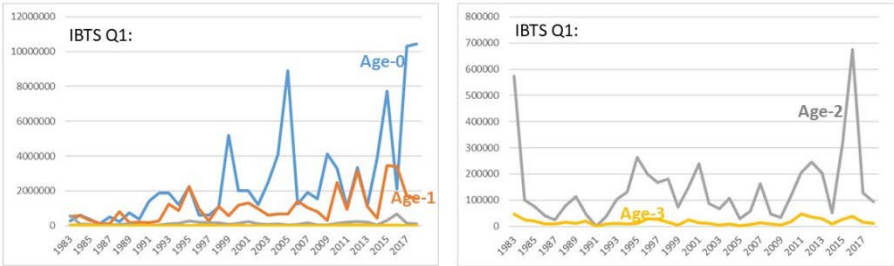

Figure 4.2.3.1 Sprat NS-SK. Time-series of delta GAM IBTS Q1 indices.

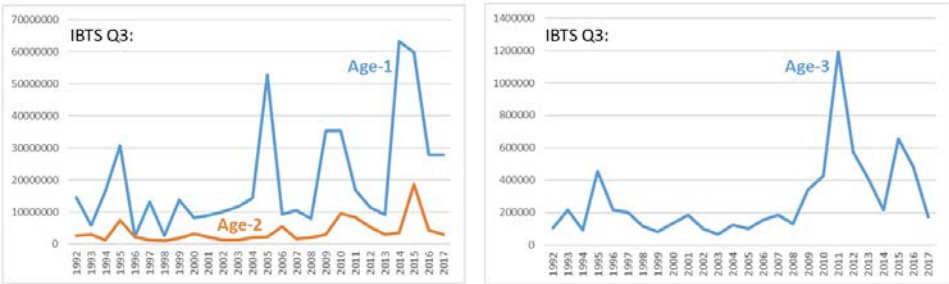

Figure 4.2.3.2 Sprat NS-SK. Time-series of delta GAM IBTS Q3 indices.

To achieve area 4 + 3.a HERAS time-series, we simply summed the biomass time-series for area 4 and 3.a.

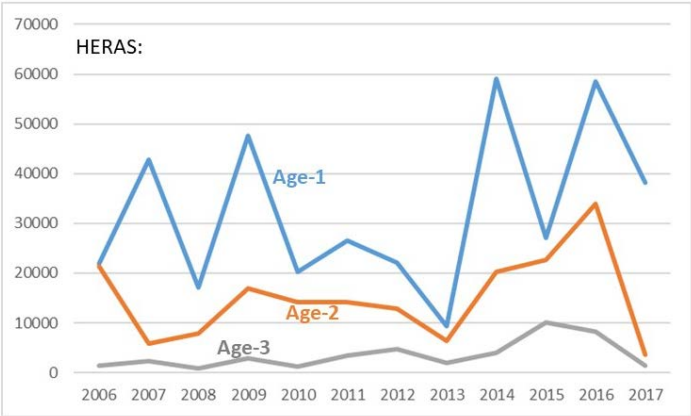

Figure 4.2.3.3 Sprat NS-SK. Time-series of HERAS indices.

4.3 Assessment

4.3.1 SMS model developments

The basic SMS model is described in Lewy and Vinther (2004) and WD6_SMS-description. The model is built in a seasonal fashion, with Q3 corresponding to season 1 in the model year, and Q1 to season 3 in the model year. The term "season" is used throughout this report to identify the model year, while the term "quarter" is used to refer to the calendar year (Figure 4.3.1). The model has been further developed for the sprat stock: in particular, a power function for the age 0 catchability in the IBTS Q1 survey was included. This feature was introduced to account for the higher catchability of younger ages in correspondence of high recruitment events, therefore preventing the strong retrospective pattern that has been observed in the past.

The equation would then be:

$$E\left(\log\left(CPUE_{survey,a,y}\right)\right) = \log\left(Q_{survey,a} \quad \left(\bar{N}_{SURVEYa,y}\right)^{Pa1}\right)$$

Where P is an exponent applied to the younger age group in the survey. The effect of including this new term was evaluated during the working group: the results are included as part of the sensitivity analysis, detailed in WD7_Explorative_runs and discussed in the following sections.

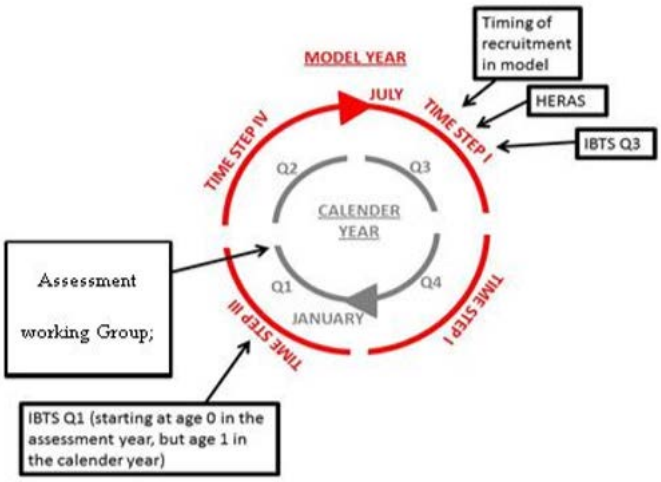

Figure 4.3.1 The schematic explanation and definition of the seasons in the model year and the corresponding quarters in the calendar year used in the assessment model for Norther Sea and 3a.

4.3.2 Base Case

During WKSPRAT, all exploratory runs were based on the data agreed during the data evaluation meeting. Catch-at-age data are available from 1974 until 2018 for ages 0 to 3 (plus group). The survey indices, standardized using the Delta GAM approach (WD1_NSSpratIndicesIncl3a-Berg) were:

- IBTS Q1 index covering the years 1983 to 2018, ages 0 to 3 .
- IBTS Q3 index covering the period 1980-2015, ages 1 to 3.
- HERAS acoustic survey index from 2003 to 2018, ages 1 to 3.

During the benchmark meeting, the effect of the change or addition of different data sources were investigated. Those changes were done in a stepwise fashion and using a consistent set

of diagnostics to assess the differences between each exploratory run and the base case assessment. The exploratory assessments were judged on the basis of statistical and goodness of fit criteria, rather than on the resulting stock trends. The main criteria used were:

- AIC comparison when the models were fitted on the same data
- Estimated CV for the different components
- Residuals plots
- Retrospective analyses and Mohn's Rho estimates

During the benchmark, a routine to evaluate the residuals based on additional statistics (i.e. normality test, autocorrelation, trend and presence of breakpoints) was produced (WD8_Residual diagnostics): these diagnostics were used to support some of the model choices when very similar results were obtained.

4.3.3 Removal of Density-dependence option for Q1 catchability

Data and model configuration

The base case model includes a power function for the age 0 catchability in the IBTS Q1 index of abundance. For simplicity, we will refer to that as density-dependence. A run without this feature was performed, i.e. a linear function was used.

Results

The AIC value when removing the density-dependence increases of 2 points and the variances of both catch and survey tend to get higher. The retrospective pattern get worst. The routine developed during WKSPRAT was used for a in depth assessment of the residuals: no major changes were detected.

Conclusions

The group agreed that, despite no major improvements were detected, the inclusion of a density-dependent feature seems to benefit the retrospective pattern. It is not clear whether this power function is effectively responding to a density-dependent behaviour or to some other mechanism. However, it is a common feature in many assessment models and it was considered beneficial in this specific case. The group concluded that this feature should be included in the final assessment.

4.3.4 Leave-one-out survey

Data and model configuration

In order to test the sensitivity to the exclusion of particular indices the base case model was fit using the same data and configuration, but omitting IBTS Q3 and HERAS one at the time. No runs were performed removing the IBTS Q1 index because it's the only index to provide information on recruitment.

Results

Regarding CV estimates, residuals and retrospective, there was no clear improvement when omitting the HERAS survey. When the IBTS in Q3 was omitted, the model estimated a lower observation variance for catches in season 4: this results was not considered an improvement, given the very low and uncertain values of catches in season 4 (Q2). Besides, the retrospective pattern worstened considerably.

The stock development estimated from all models is very similar, with the major changes observed in the recruitment and SSB estimates when the IBTS Q3 survey was removed.

Conclusions

The model seems quite robust to the omission of any of the indices of abundance included. Given the fact that all the three indices are deemed representative of the sprat stock in area 4 and 3.a, it was agreed to include all the indices in the final run.

4.3.5 Breakpoint

Data and model configuration

During the last benchmark (ICES, 2013) the group decided to include a change in the exploitation pattern (i.e. breakpoint) in 1996. This feature was justified by the removal of a strong pattern in the catch residuals and consequent improvement in the overall diagnostics. The base case assessment model presented at this benchmark did not show any strong pattern in the residuals, hence the breakpoint was not included. This choice implies a time invariant exploitation pattern for the whole time series (44 years). As this is considered a strong assumption, the inclusion of a breakpoint was tested. At first, the breakpoint was set in 1996, as in the previous assessment, but since the choice was somehow arbitrary, the sensitivity of the model to different breakpoints was tested. The sensitivity test was carried out for the years 1983 (the first year of the IBTS Q1 survey), 1987, and then all years from 1990 to 2008.

Results

The inclusion of the breakpoint in 1996 lowered the AIC by 31 units and reduced the variance in particular for the IBTS Q1 survey (ages 1 to 3) and catch in season 1 (Q4). The visual scrutiny of the residuals plots didn't show any improvement but the retrospective pattern doubled, meaning a deterioration of the predictive capacity of the model. The routine developed during WKSPRAT was used for a in depth assessment of the residuals: the analysis showed slightly improved residuals with the inclusion of the breakpoint (i.e. removal of trend, lower autocorrelation and removal of breakpoints in the residuals) (WD7_Explorative runs).

The AIC and the mohn's rho wer used to evaluate the sensitivity of the model to different breakpoints. The AIC profile doesn't seem to find a well defined minimum (Figure 4.3.5.1, left), and the mohn's rho of the recruitment decreases at higher AIC values (Figure 4.3.5.1, right).

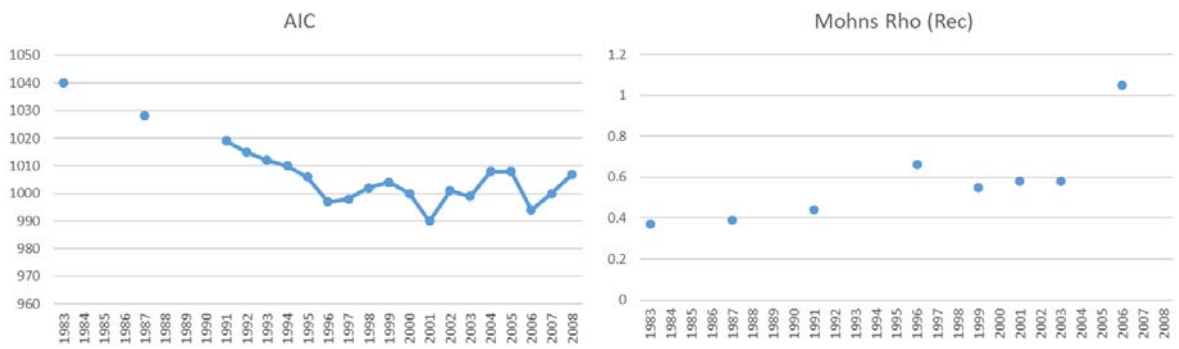

Figure 4.3.5.1 Sprat NS-SK. Sensitivity testing to different breakpoint years. AIC values on the left and recruitment Mohn's Rho values to the right.

Conclusions

Despite improvements in the residuals and CV, the inclusion of the breakpoint doesn't find any justification from a biological or fisheries perspective. The choice on where to put the breakpoint would also be arbitrary, because both the input data and the residuals do not show any obvious change in the exploitation pattern. Besides, the inclusion of the breakpoint significantly worsened the retrospective pattern for all quantities. It was suggested that the improvements in the residuals and in the AIC might just be a consequence of the introduction of an extra parameter, which is able to track some noise, but that doesn't necessarily have any biological meaning. In light of these considerations, the group didn't find enough justifications for the inclusion of a change in exploitation in the model, and it was therefore agreed to exclude the breakpoint from the final model.

4.3.6 Maturity

Data and model configuration

A constant maturity-at-age, calculated from IBTS Q1 as the long term average of the time varying maturity-at-age, was tested. The change affects only the SSB estimates and consequently the forecasts but does not affect the fitting or any of the diagnostics.

Results

The spawning stock biomass (Figure 4.3.6.1.) as well as the stock recruitment (Figure 4.3.6.2.) resulting from the two options were compared. Also, correlation between maturity and weight at age was investigated (Figure 4.3.6.3.).

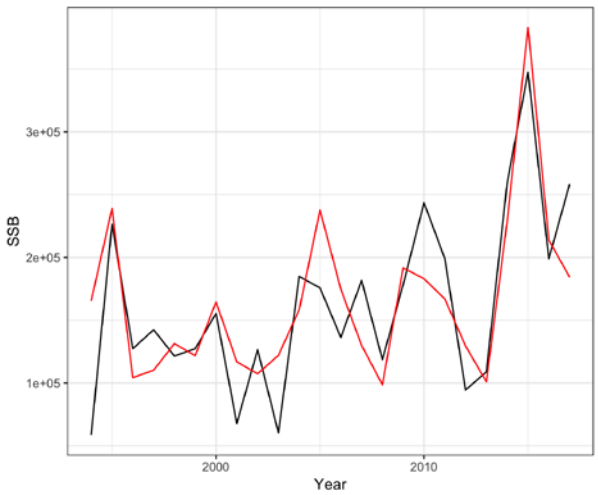

Figure 4.3.6.1 SSB estimates using a time-varying maturity ogive (in black) and a fixed maturity ogive (in red).

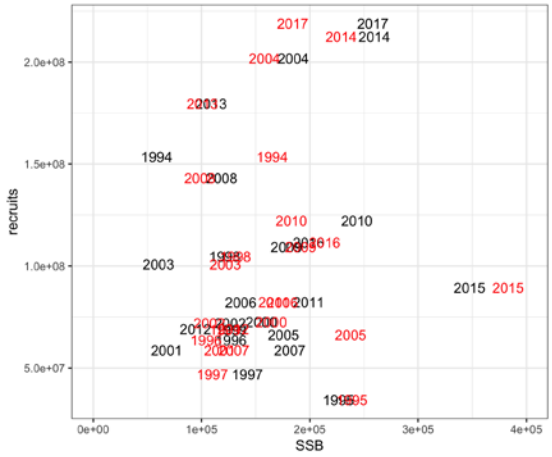

Figure 4.3.6.2 Comparison of stock recruitment relationship using a time-varying maturity (in black) and a constant maturity (in red).

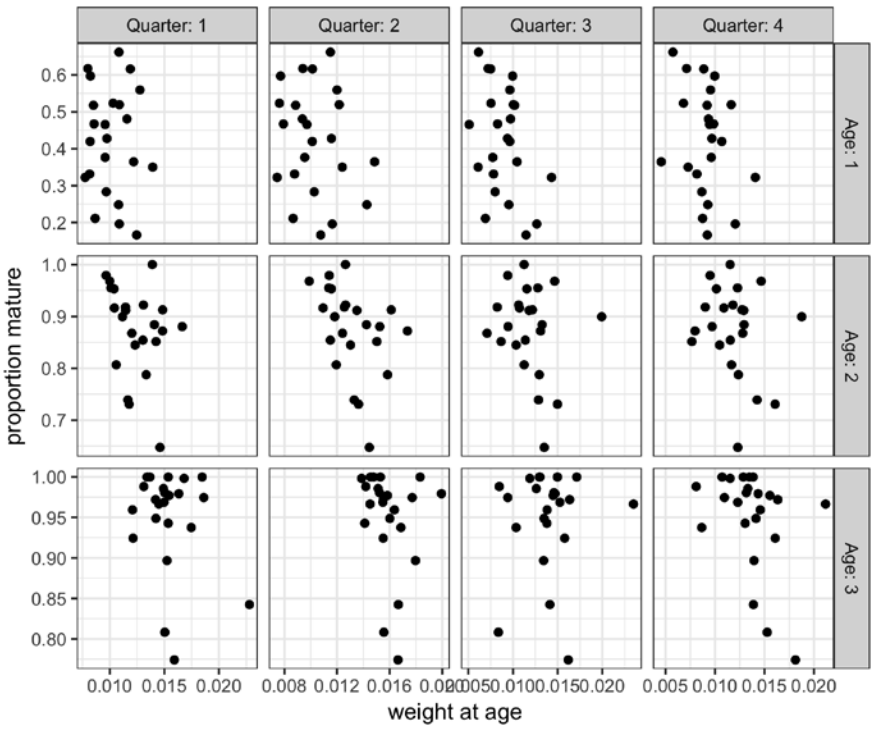

Figure 4.3.6.3 Scatterplot of weight-at-age by quarter *vs* maturity in Q1 by age and quarter for sprat.

Conclusions

In light of the lack of correlation between maturity and weight-at-age as well as maturity and stock productivity, the poor consistency between Q1 and Q3 maturity estimates, and the fact that the Q1 is not evaluating the stock at spawning time, the group agreed that there is little support for the use of a time-varying maturity. It was concluded that the variability depicted by the data reflected most likely only noise and therefore the final model included a constant maturity ogive for the whole time period.

4.3.7 Historical catches

Data and model configuration

Catches before 1983 are considered uncertain due to a potential high mis-reporting of herring as sprat. This seems to be true particularly for 3.a. A run excluding the years from 1974 to 1982 was tested and the results were compared with the base case.

Results

The exclusion of the historical period slightly improved the CV for IBTS in Q1, but worsened the CV of the catches for each age-season. The retrospective pattern, as well as the residuals, didn't show any significant change.

Conclusions

The group didn't find any support for the exclusion of the old time series. The historical period does not change the final estimates for the most recent years. Also, the inclusion of the historical part provides valuable information on the stock status and offer an overview of the potential productivity of the stock in earlier years. The group therefore agreed to keep the historical data in the final assessment.

4.3.1 Inclusion of age 0 from IBTS Q3

Data and model configuration

The inclusion of age 0 from IBTS Q3 was tested.

Results

The survey CV of age-0 in IBTS Q3 was very high (1.30 to be precise). Hence, we concluded that no improvement of the model was made by including the IBTS Q3 age-0 index.

Conclusions

The group didn't find any support for the inclusion of age 0 from Q3 IBTS and it was therefore agreed to exclude it from the final run.

4.3.2 Moving catch from Q4 to Q1

Data and model configuration

Most of the catches happens in Q3 and Q4 in the North Sea and in Q1 in 3.a. In general, catches in Q2 (season 4) are either very low or equal to 0. In previous assessments, catch values lower than a threshold were set to zero, to avoid the model trying to fit those. During WKSPRAT, it was tested the effect of moving the catches in season 4 to season 1 of the following year, and set catches in season 4 for the whole time series equal to zero.

Results

The variance in the catch for ages 2 and 3 improves when removing season 4 catches. Besides, the CV of IBTS Q1 improved considerably. The variance for all the other season-age combinations either remained the same or increased slightly. The retrospective pattern, on the other hand, improved significantly, with the average mohn's Rho over 5 years reducing from 0.3 to 0.18.

Conclusions

The group agreed that the inclusion of season 4 catches in season 1 improved significantly the model and concluded that this change should be adopted in the final model.

4.3.3 Survey catchability

Data and model configuration

The base case model has catchability for age 2 much lower from the catchability of age 3 in the acoustic survey, i.e. the capacity of the survey to catch age 2 and age 3 is different. During the workshop it was argued that this feature is not realistic, and it was suggested to test the performances of the model when tying together age 2 and age 3 catchability in the acoustic survey (i.e. impose catchability at age 2 being equal to catchability at age 3).

Results

The AIC for the model with tyed catchability saw an increase in the AIC value. Despite a slight improvement in the catch CVs, the survey variance for all indices of abundance worsened. The retrospective pattern as well deteriorated, with an increase in the Mohn's Rho values.

Conclusions

The group discussed that there is no biological rational for the catchability at age to be so different between the two older age groups in the acoustic survey. However, the diagnostics of the model when forcing the same selectivity showed an overall deterioration. It was therefore agreed to maintain the base settings, but to further investigate this issue in the future.

4.3.4 Stratified mean method for indices of abundance

Data and model configuration

As a sensitivity test, a run with the indices of abundance standardized with the stratified mean method used in previous assessments was carried out. ICES provided this new version of the merged (North Sea + 3.a) indices of abundance to allow us to evaluate the effect on the model of shifting from stratified mean to the delta GAM method (see working document on explorative assessment runs; note that to make the two runs comparable, the base model was re-run using IBTS Q1 from 1990, since the indices provided by ICES only went back to 1990). The comparison between the 2 versions of the abundance indices is presented in Figure 4.3.4.1. To make the two runs comparable, the base model was re-ran using IBTS Q1 from 1990.

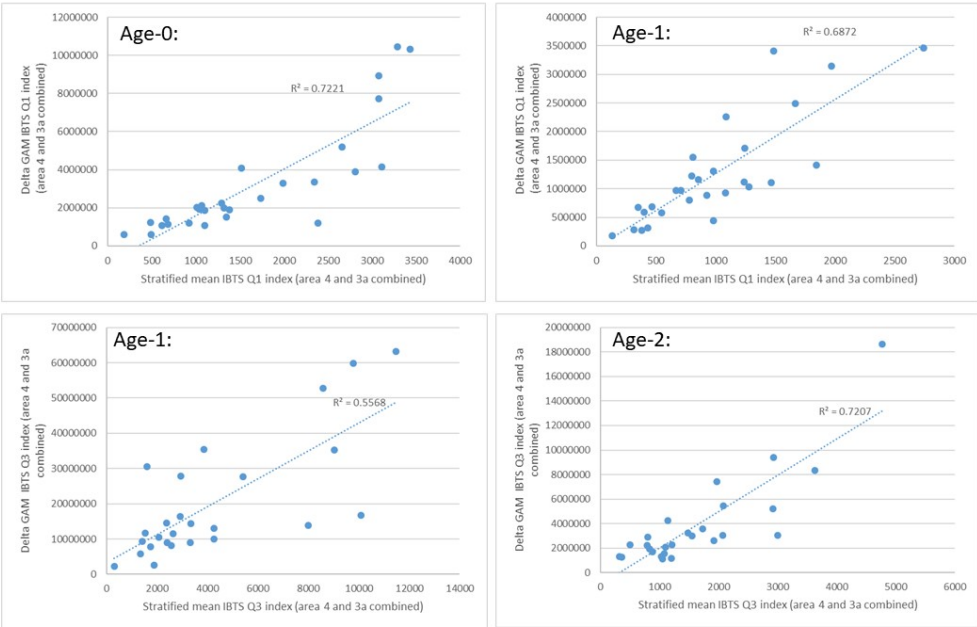

Figure 4.3.4.1 External consistency between the stratified IBTS indices and the delta GAM indices (IBTS Q1 to graphs and IBTS Q3 bottom graphs)

Results

While the catch variance slightly decreased for most age/season combinations, the CV of the IBTS Q1 and Q3 for ages 1 to 3 and the CV for the HERAS survey age 1 increased considerably. The Mohn's Rho decreased compared to the base model.

Conclusions

This was just a sensitivity analysis to explore the effect on the assessment model of the two different standardization methods. The use of the Delta GAM approach allows a better fitting of the assessment model to the indices of abundance due to an improved internal consistency, and was therefore chosen as the prefered option.

4.3.5 Final assessment model

During the 2018 WKSPRAT benchmark, a number of changes have been explored, discussed and accepted for sprat in the North Sea and Skagerrak-Kattegat. The final accepted assessment now combines the data from area 4 and area 3.a into one single stock. It uses 3 indices of abundance, all standardized using the delta GAM method. The update assessment uses a power function for the age 0 catchability in IBTS Q1 survey. The catch at age matrix was modified to include catches from Q2 (season 4) into the subsequent Q3 (all catches in Q2 were then set to 0). One exploitation pattern for the whole time series is assumed, as well as a constant maturity at age (WD9_Final assessment).

The 2018 WKSPRAT assessment gives the perception of a stock in good state, with the SSB at the highest level since the late seventies. Fishing mortality fluctuates widely from a minimum of 0.2 in 1989 to a maximum of 2.5 in 2016. Recruitment remain at low levels, with a mild increase observed in the last year (Figure 4.3.5.1).

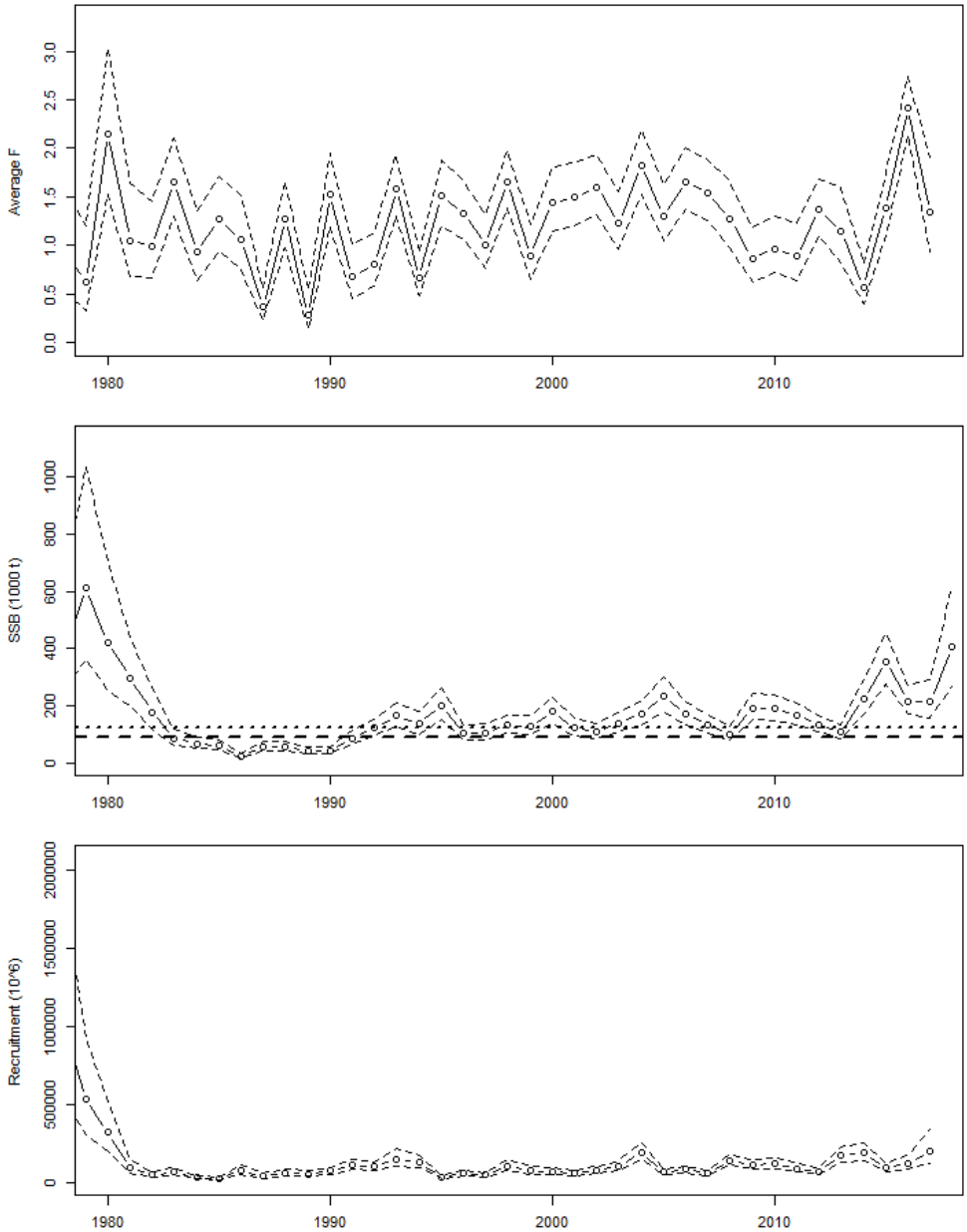

Figure 4.3.5.1 Sprat NS-SK. F, SSB, and recruitment including +/- 1 standard deviation calculated on logged data (therefore tit is asymmetric around the mean).

4.4 Short term forecast

The reference points (see Section 4.5) and the input used in the short term projections were revised for the combined stock North Sea and Kattegat-Skagerrak. During the benchmark the group agreed to use constant maturity values for the assessment due to the poor timing of the maturity ogive samples from Q1 and the poor consistency between maturity ogives in Q1 and Q3. Thus the same constant maturity was used for the short-term projections. F and M before spawning were set to 0. Weight-at-age in the stock and weight-at-age in the catch were set as average of the last 3 assessment years. Exploitation is constant in the assessment model, and so it is in the forecast. For the recruitment in the coming year, the group also agreed to use a geometric mean of the last 10 years, excluding the last point of the estimated

recruitment: this allows to capture any long term variation, but avoid to take into account the historical period of very high recruitment, possibly indication of a regime shift. The final input for the short-term projctions can be found in the updated Stock Annex.

4.5 Reference points

The reference points were revised at the benchmark based on the SMS run with all re-vised input data. The graphs of the stock recruitment estimated by SMS in the new assessment were examined (Figure 4.5.1). It was decided to omit years before 1981 because they appeared to be in a different regime, with extremely high recruitment estimates (average 6.25 times higher compared to after 1980). We agreed that the stock recruitment relationship could be stock type 1 or 2 because there is evidence of impaired recruitment at low SSBs and recruitment asymptotes at larger SSBs (ICES, 2017). The method for a type 1 stock gives B_{lim} at the lowest SSB with high recruitment, which was either 86 744.3 (1991) or 101 584.0 (2008). The B_{lim} estimate for a type 2 stock is the break point of a hockey-stick model. The hockey-stick model was calculated using two methods (maximum likelihood estimation in R using the optim method and the FLR package) because the first method showed that the answer was sensitive to starting values. Both methods estimated the breakpoint at SSB = 94 000 when reasonable starting points were given. We calculated the likelihood of each possible breakpoint from 50 000 to 200 000 with steps of 1000 and that analysis also agreed that 94 000 was the best estimate for the SSB break point (Figure 4.5.2). Considering the stock recruitment relationship type as a type 1 or a type 2 does not massively affect the perception of B_{lim}. The group favoured the use of the hockey stick model to identify the appropriate value and hence B_{lim} was set at 94 000.

B_{pa} was calculated from B_{lim}, using the following equation:

$$B_{pa} = B_{lim} \times \exp(1.645 \times \sigma)$$

Where sigma is the CV of the 2017 SSB estimate (i.e. the last assessment year with estimated stock numbers at age), equal to 0.173. B_{pa} resulted equal to 124 946.

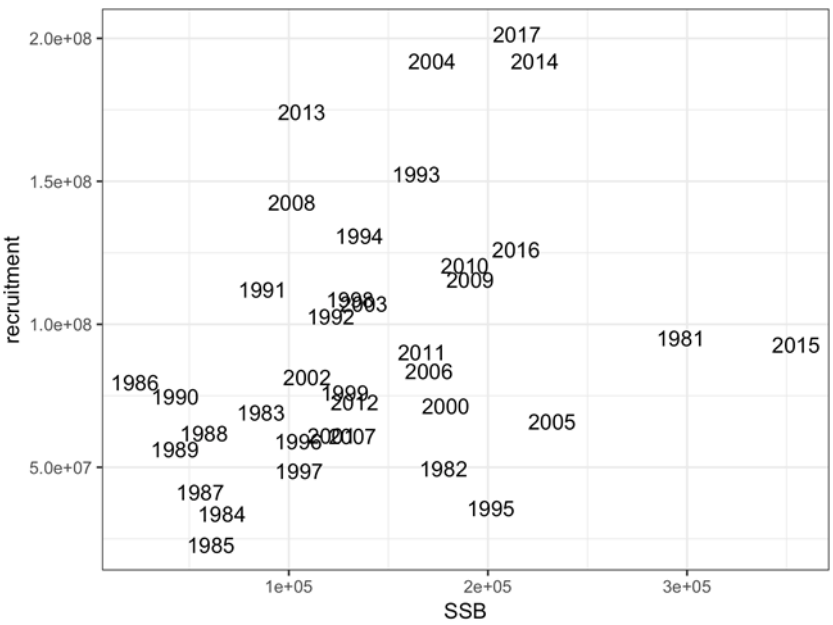

Figure 4.5.1 Stock recruitment. Recruitment and SSB estimates for each year since 1981 estimated by the new SMS assessment.

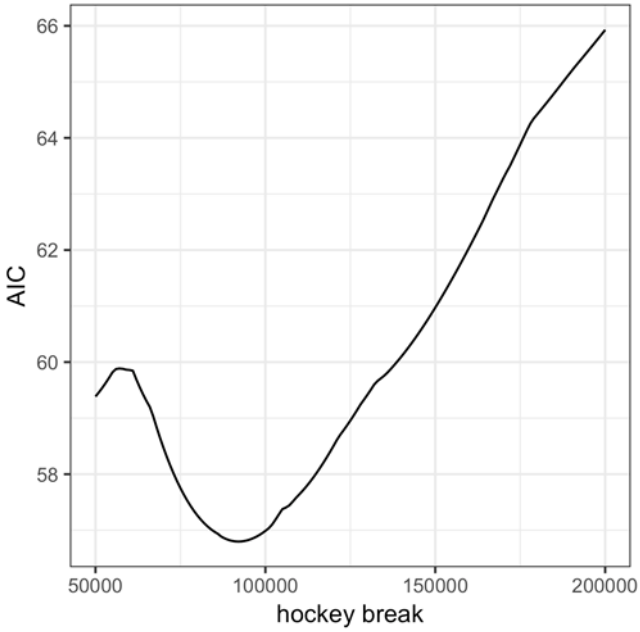

Figure 4.5.2 Breakpoint estimation. The hockey-stock model of stock recruitment was estimated while holding the breakpoint of the hockey-stick constant for a range of different SSB values (x-axis). For each estimated model, the AIC was calculated (y-axis). The optimal breakpoint occurs at the SSB producing the minimum AIC, which is SSB = 94 000.

5 Sprat in 7.d, e (English Channel)

Stock coordinator: Piera Carpi

Stock Assessor: Piera Carpi

5.1 Issue list

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Reference point estimation	Length based data-limited approaches for short lived species are not appropriate. Attempts were made using the SPiCt model but this does not converge, so no reference points are available for this stock.	Investigate SPiCt settings (fixing catchability to 1, quarterly SPiCt). Review input on short lived stocks from WKLIFE 2018.	Seasonal/quarterly catch.	Piera, Tobias
Advice	UK contributes to about 90% of the sprat catch in the Channel. The fishery is seasonal, starts in July/August and lasts till January/February. Currently, catches are planned based on calendar year quotas, however, would be more consistent if this could be done in a seasonal fashion, i.e. provide advice in spring to have quota established for fishing season (Quarter 3-4-1).	Change from an annual TAC to a seasonal one.	Seasonal/quarterly catch	Piera
	Sprat in the English Channel is short lived, has an early maturity and a fast growth. The "2 over 3" rule currently used is inappropriate for such a stock, since the years used will most likely include cohort that have already died off. Besides, the rule is not appropriate with stock highly dependent from recruitment success and whose biomass fluctuate widely from year to year.	Testing different advice rules to verify consistency with precautionary approach.		Piera, Anna

5.2 Input data updates

5.2.1 PELTIC survey

A pelagic survey is undertaken in Autumn in the western English Channel and Eastern Celtic Sea to acoustically asses the biomass of the small pelagic fish community within this area (divisions 7.e–g). The data have been used since 2016 to provide advice for sprat in 7.d, e based on the 2:3 rule for data poor stocks. The biomass estimates were previously estimated using the EchoR software. An update version of the index using StoX was presented and put forward to be used in future assessment (Figure 5.2.1.1) (WD 13). The two estimates are fairly similar, and echoR estimates are within the confidence intervals estimated from StoX for all except one year.

The group agreed to use the estimates from StoX, which provide as well confidence intervals.

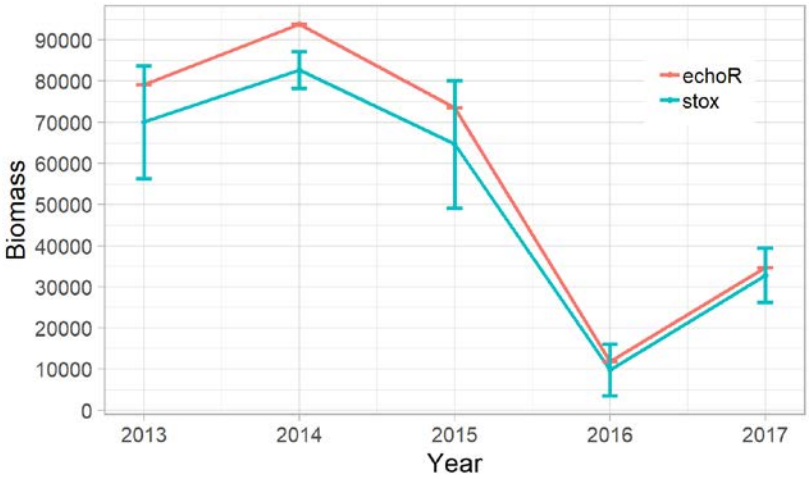

Figure 5.2.1.1 Sprat 7de. Biomass estimates from the PELTIC acoustic survey as estimated using EchoR and StoX.

5.2.2 IBTS

Starting in 2006, the French started to carry out additional tows in the Eastern English Channel as part of the standard IBTS survey in quarter 1. This proved successful and starting in 2007 the RV 'Thalassa' carried out 8 GOV trawls and 20 MIK stations.

During the IBTSWG in 2009, Roundfish Area 10 was created to cover these new stations fished by France and the Netherlands.

Data are stored in DATRAS database and available for the period 2007 to 2018 (Figure 5.2.2.1).

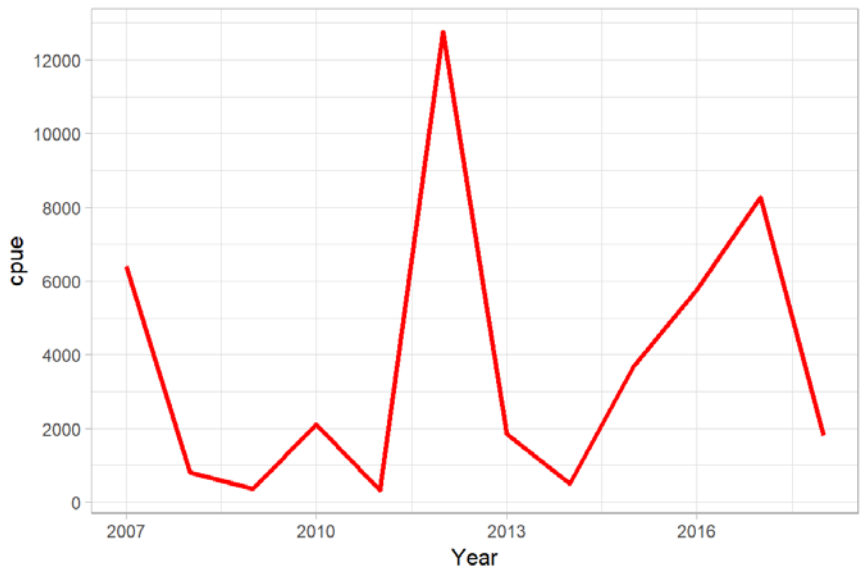

Figure 5.2.2.1 Sprat 7de. Cpue estimates from IBTS survey carried out in the Eastern English Channel.

The survey targets the adult fraction of the population, with the weighted mean length ranging from 10.5 cm in 2016 to 12.1 cm in 2012 (Figure 5.2.2.2).

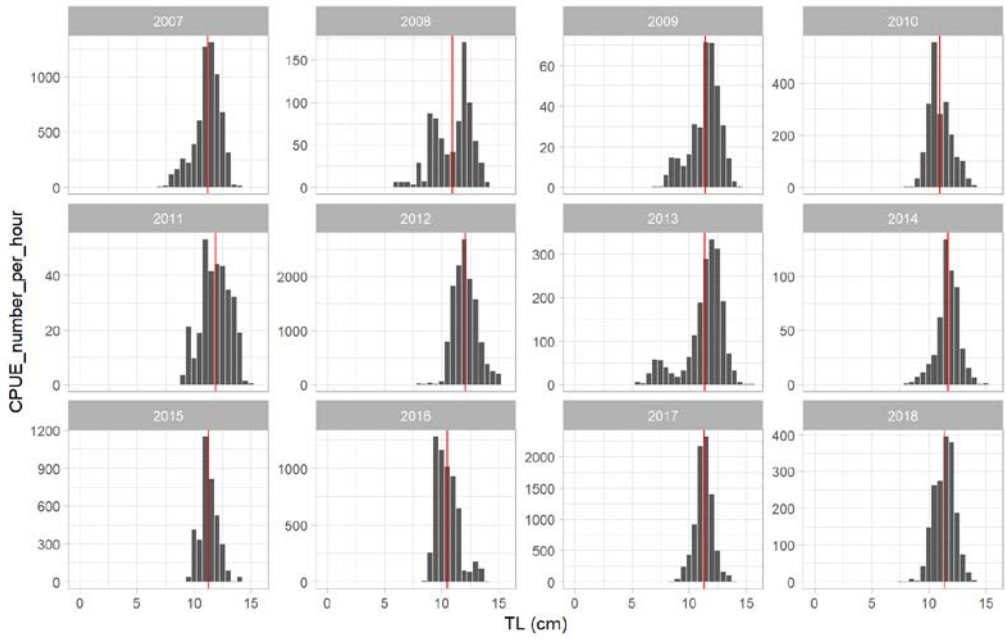

Figure 5.2.2.2 Sprat 7de. Length frequency distribution of the cpue index from the IBTS survey carried out in the Eastern English Channel.

Sprat is present in more than 60% of the hauls in all years, and in 3 years was captured in 100% of the hauls (Figure 5.2.2.3).

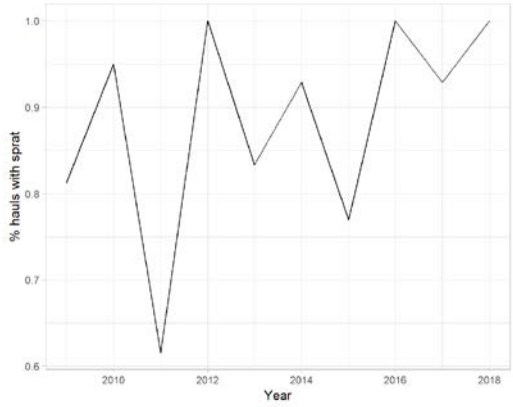

Figure 5.2.2.3 Percentage of hauls where sprat was caught for IBTS in area 7.d. The exchange file used to calculated this percentage contained data from 2009 only.

Sprat is caught mostly on the Southern part of the Eastern English Channel (Figure 5.2.2.4). However, no hauls are carried out at the boundary between 7.d and 7.e, therefore no information on the potential mixing and flows between the two is available.

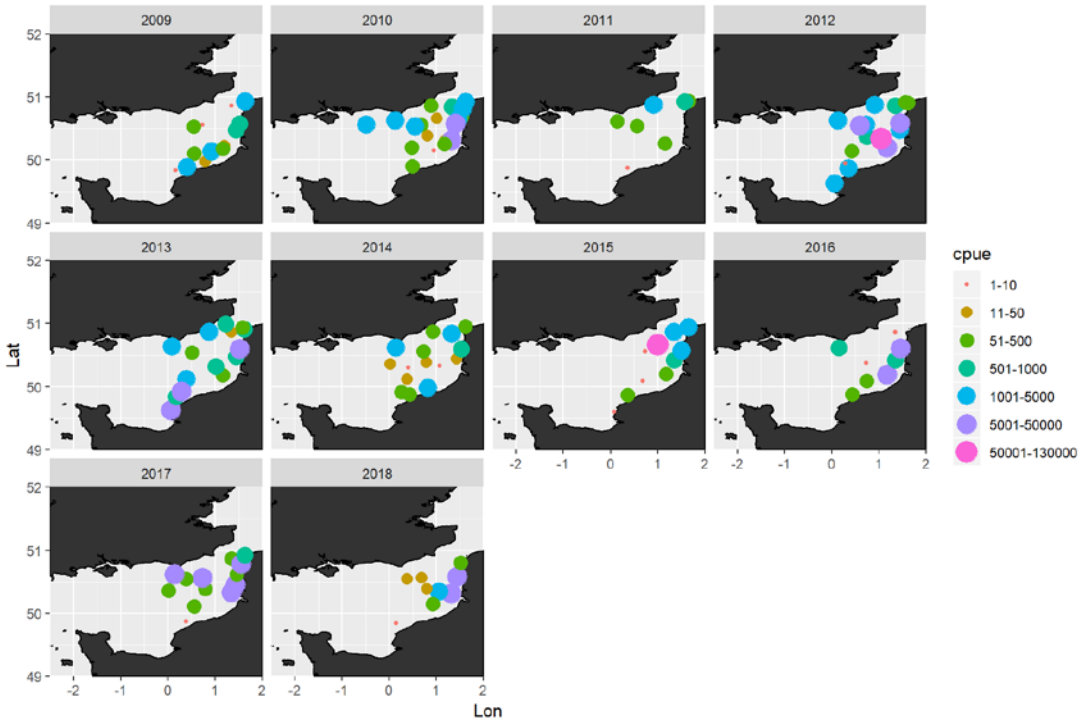

Figure 5.2.2.4 Sprat cpue from the IBTS survey carried out in area 7.d. The exchange file used to produces these maps contained data from 2009 only.

The centres of gravity for each year and each survey independently was calculated (Figure 5.2.2.5): The purpose was to see if there were similar dynamics in the distribution of this two components of the assessment unit. However, no pattern in the centres of gravity calculated for the two surveys was detected.

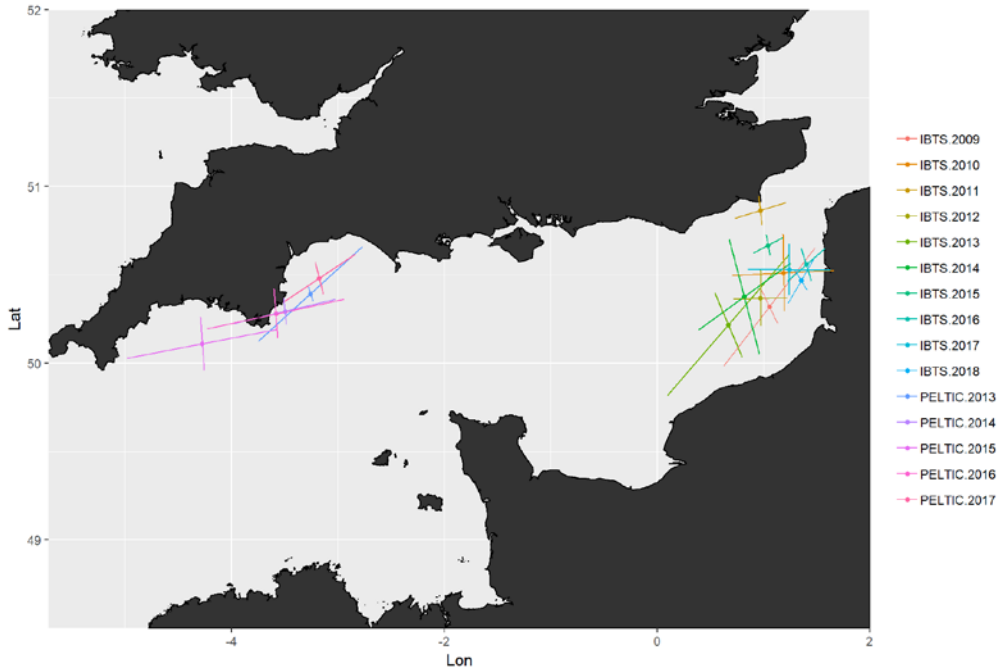

Figure 5.2.2.5 Centre of gravity and relative inertia from the PELTIC survey (points on the left) and the IBTS survey (points on the right).

5.2.3 Catch

Total landings from the international sprat fishery are available since 1950 (see Figure 5.2.3.1). According to official catch statistics large catches were taken by Danish trawlers in the late 1970s and 1980s from the English Channel. However, the identity of the catches was not confirmed by the Danish data managers raising the question of whether those reported catches were the result of species misreporting (i.e. herring misreported as sprat). Therefore, ICES cannot verify the quality of catch data prior to 1988. For the last 20 years, most of the catches have been caught by UK.

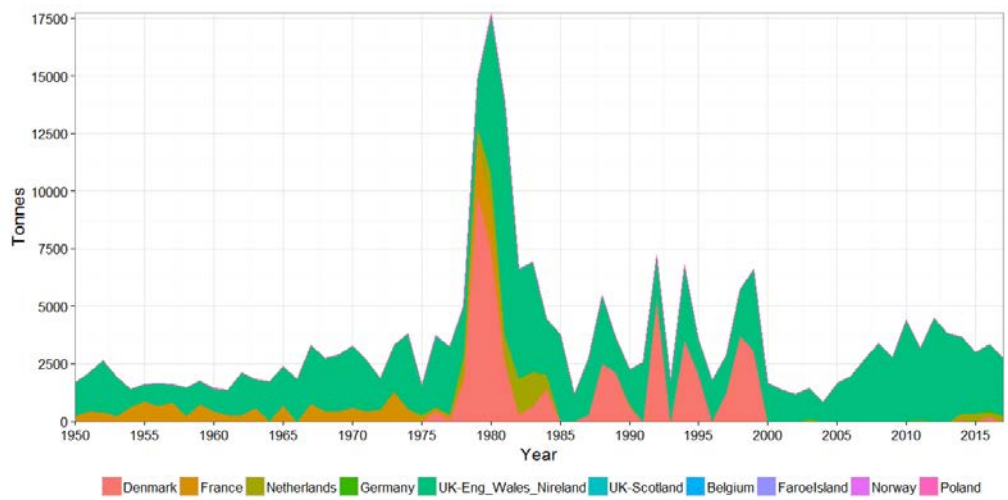

Figure 5.2.3.1 Sprat 7de. Landings of sprat by country from 1950–2017.

More than 80% of the catches occur in Q3 and Q4, about 15% in Q1 and very little in Q2. Given the seasonal nature of the fishery, it was suggested to provide advice on a seasonal basis (July–June). A comparison between seasonal catches and calendar year catches is provided in Figure 5.2.3.2.

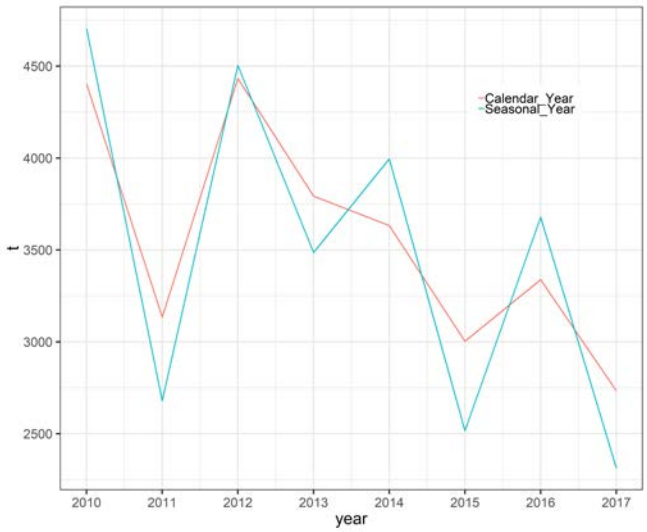

Figure 5.2.3.2 Spr 7de. Seasonal catches (July–June) vs Calendar year (January–December) catches from 2010 to 2017.

5.3 Assessment

ICES guidelines for data poor stocks foresee the use of SPiCt (Pedersen and Berg, 2017) to estimate proxy reference points. Several attempts were done to fit a surplus production model to the data available, using both landings data and the indices of abundance presented in the previous section. The lack of contrast in the data and the short time series of the two indices, do not allow the model to converge. Several combination of data and different settings were attempted, namely longer and shorter time series, the use of both indices separately and the testing of different starting values, but only non-convergences or false-convergences were obtained.

The group therefore agreed to use an empirical advice rule based on the indices of abundance. Since the acoustic survey cover the area where 90% of the catches occur, it was decided to use both indices for trends, but only the acoustic survey for provision of advice.

The seasonal harvest rate (catches/acoustic biomass) was compared with the calendar year Harvest rate is well below 10% in all years with exception of 2016, when a very low biomass was recorded (Figure 5.3.1).

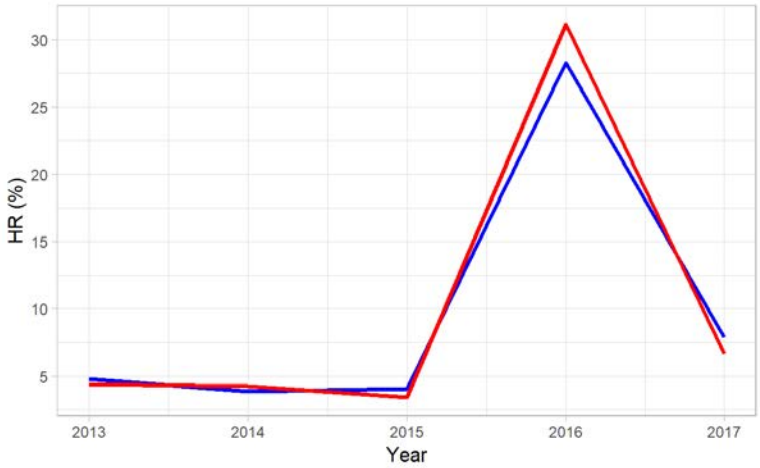

Figure 5.3.1 Sprat 7.de. Calendar year harvest rate (blue) and seasonal harvest rate (red).

5.4 Advice

The fishing season starts in June-July and ends in February-March. A seasonal advice from 1 June to 31 May of the following year was suggested.

Two empirical advice rules were proposed:

1. Fixed F, i.e. constant harvest rate.
2. 1:2 rule.

The group was not able to reach a consensus on any of those, and decided to test the rules within the MSE framework for the North Sea stock. The results will be presented and discussed during the MSE workshop scheduled for 12–13 December, and a decision will be taken then.

6 Ecosystem indicators

Ecosystem indicators help assess the status of the system and form the basis for an Ecosystem Based Fisheries Management (EBMF). One of the challenges for the translation of these indicators into an EBFM is the identification of the main indicators relative to each species, group of species or ecosystem and the evaluation of whether they are a function of fishing effort (Link, 2005). Fish growth and productivity can be potentially used as indicators of ecosystem productivity. Climate induced changes in productivity in the North Sea has been shown to have substantial effects on forage fish MSY and F_{MSY} (Clausen *et al.*, 2018).

The group identified two main indicators appropriate for sprat that could help assess the status of the system. These are the mean weight-at-age and recruitment. Weight-at-age is indicative of several key processes, one being that the fisheries directs the size structure of the fish population towards smaller individuals by targeting larger individuals by age. A decrease in mean weight can indicate increased inter and intra-specific competition resulting in low food availability. This can lead to a worsening of the body condition and consequently to the reduction of reproduction output.

A shift in North Sea fish productivity reflected in recruitment and growth of individuals were closely related to well-documented shifts in the plankton community (Clausen *et al.*, 2018). However, the steep decline in sprat recruitment has also been positively correlated to temperature (Baumann *et al.*, 2006). Short lived species such as sprat are strongly dependent on spasmodic recruitment events, which are not necessarily related to the adult stock size. An impairment of these recruitment events, a change in the frequency of high recruitment events occurring, or a change in the magnitude of these events, might indicate a change in the ecosystem, the occurrence of a regime shifts, and can directly impact the biomass of predator and the prey that are dependenant on that.

In the North Sea, major predators of sprat include mackerel, horse mackerel and whiting, and many other species are more minor predators, including marine mammals and seabirds. So predation levels in the North Sea do not show the dramatic variation from year to year that can occur in the Baltic. Nevertheless, these predation impacts are taken into account explicitly in the stock assessment for North Sea sprats by including annual estimates of natural mortality imposed by predators based on predator abundances, prey preferences and abundances of other prey stocks.

7 Data to advice on TAC splitting between NS and 3.a

After this benchmark, ICES will deliver one catch advice covering sprat in both area 3.a and Subarea 4. During the meeting the potential need for clients to have separate advices for area 3a and 4 was discussed. It was argued that such an exercise is difficult unless the basis for the separation is provided *a priori*. The group agreed that what can be provided is guidelines on the spatial distribution of total biomass between the two areas. However, as long as the total catch combined in the two areas does not overshoot the catch advice, splitting catch opportunities into areas would not have implication for the legitimacy of the advice.

Several data sources that potentially could be used to guide the decision on how to split the catch advice into areas were discussed and a non-exhaustive table of various data sources is provided (Table 7.1, Figure 7.1).

Table 7.1 List of data available to guide the decision on how to split the catch advice into areas.

Data available	Assumptions	Data considerations
Catch	Time period. Purpose of catches (e.g. industrial vs human consumption)	By catch self regulation in 3a (from 2016). Other regulations and historical development of the fishery in the 2 areas.
Survey (IBTS Q1, Q3, HERAS)	Time period. Which survey or how to combine information from all three.	Timing and spatial distribution of the survey in relation to the time and distribution of the fishery.
TAC	Time period.	TAC was often independent from biological considerations in 3a.
Advice	Time period.	The advice per se includes the limitations of the assessment: 3a was assessed using a data limited approach (category 3), while the North Sea stock was assessed using a full analytical assessment.
Size of the management area		Assumption on homogenous spatial distribution accross the whole area (coastal/non-coastal areas).
Catch at age & survey at age	Time period. Purpose of catches (e.g. industrial vs human consumption). Which survey.	By catch self regulation in 3a (from 2016). Other regulations and historical development of the fishery in the 2 areas. Timing and spatial distribution of the survey in relation to the time and distribution of the fishery.
Catch of mature/immature fish	Time period.	By catch self regulation in 3a (from 2016). Other regulations and historical development of the fishery in the 2 areas.
Size of the fishing area	Time period.	Assumption that your fishing area represent the overall distribution of the stock.

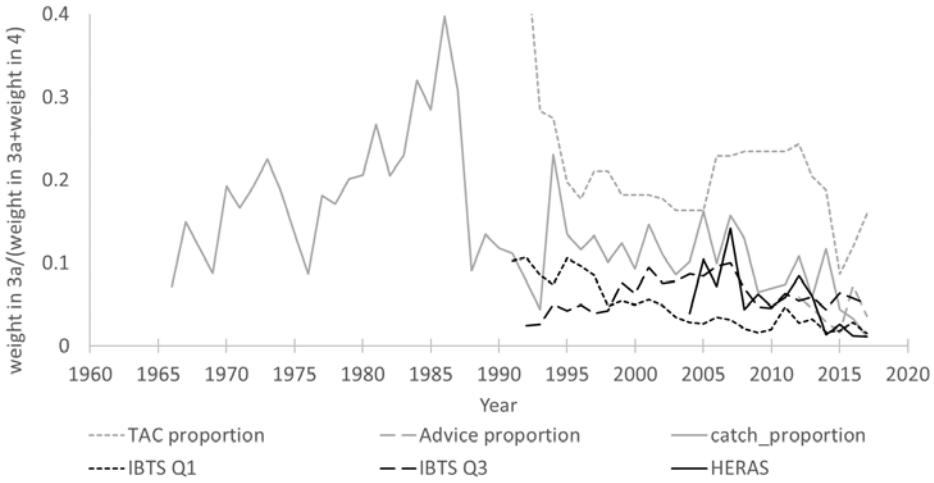

Figure 7.1 Examples of splitting between 3.a and North Sea based on different data sources.

8 Future research and data requirements.

Research needs on the effects of temperature and food availability, as well as density-dependence on both recruitment success and growth and how to incorporate these in the short term forecasts.

Work is needed regarding the stock identity in 7.d,e to assess connection within the Channel and with adjacent areas, specifically the North Sea and the Celtic Sea.

9 Recommendations

Recommendation	Adressed to
Revise natural mortality estimates and mackerel distribution.	WGSAM

10 Working documents to WKSPRAT

WD1: Survey Index Calculations for North Sea (inclusive area 3.a) Sprat from IBTS data

WD2: Genetic analyses of sprat populations using SNP markers: Preliminary results

WD3: Survey consistency between roundfish areas

WD4: Sub structuring

WD5: Environmental indicators

WD6: SMS-description

WD7: Explorative_runs

WD8: Residual diagnostics

WD9: Final assessment

WD10: Otolith shape analysis

WD11: Sprat spatial distribution

WD12: Berg et al 2018_Abundance of young sprat (Sprattus sprattus) along the Norwegian Skagerrak coastline.

WD13: StoX description.

11 External reviewers' report

Zeynep Pekcan-Hekim (S), Leire Ibaibarriaga (ES) and Alexandra Silva (PT) acted as external experts for the benchmark workshop on North Sea, Skagerrak and Kattegat and English Channel sprat (WKSPRAT 2018) that took place at ICES Headquarters in Copenhagen during November 5–9, 2018. New assessment analyses and results were reviewed and discussed with sprat stock assessment scientists, stakeholders and ICES staff. The external Review Panel commends all the participants for their efforts and work during the benchmark process.

Following the Issue list and the discussions at the benchmark meeting, the External Review Panel's thoughts on the meeting were as follows:

Sprat Subarea 4 (North Sea) and Division 3.a (Skagerrak and Kattegat)

Stock identity

The sprat in subarea 4 (North Sea) and division 3a (Skagerrak and Kattegat) were joined as one assessment unit based on the genetics, otolith shape and cohort dynamics data presented at the workshop. The reviewers agree that the evidence presented supports the above decision. The evidence from the genetics data showed that the samples from the North Sea sprat and Skagerrag and Kattegat gave similar signals suggesting that they are originated from the same stock with exception of three local populations from Uddevalla, Great Belt and Öresund which showed a similar signal from the Baltic Sea. There was also evidence that sprat from the Norwegian fjords are genetically close and clearly separated from the North Sea. Recruitment dynamics derived from catch and survey data and otolith shape analysis provided support to the single stock scenario and also to the separation of sprat from the Norwegian coastal areas. As the group, the reviewers think that the boundary of this stock with sprat from the Baltic, the link with possibly local populations and with the English Channel needs to be further investigated.

Input for stock assessment

Natural mortality: sprat predation mortality is provided to the assessment by the Working Group on Multispecies Assessment Methods (WGSAM) based on the multispecies SMS model of the North Sea that is run every 3 years using the same input data (catch-at-age, surveys, etc.) as the single species SMS. To smoothen year-to year variations a 3-year running mean of natural mortality is used. Non-predation natural mortality is considered to be 0.2 for all years and ages. The group decided to continue to use the natural mortality (varying along ages and years) provided by WGSAM. This implies assuming that predation mortality in area 3.a is comparable to that in area 4, which needs to be further investigated. The group identified uncertainities on the predation estimates of mackerel in Q3 and Q4 and decided to forward a recommendation to the WGSAM group to revise the predation pressure of mackerel on sprat and reconsider the natural mortality estimations.

Maturity: The maturity values used in the previous assessment were based on annual maturity estimates from IBTS Q1 survey. The group identified two major issues with the maturity: ogives that were measured before the spawning season and the high year-to-year variability in the maturity estimates. The group concluded this variability reflected mainly noise since maturity was uncorrelated with weight-at-age and stock productivity (recruits per spawner) as well as a poor relationship with maturity-at-age estimated from IBTS Q3 survey data. The possibility of using B1+ as indicator of stock size instead of SSB was also discussed but was not pursued further. An average maturity ogive calculated from the IBTS Q1 survey

was agreed to be used. However it is acknowledged that the SSB estimates coming from these ogives are probably understimated because the time period is too early in the year to capture the maturation of fish, especially for the first-time spawners.

Survey indices: The methods for calculating the abundance indices used in the assessment were revised based on the issue list. The delta-GAM method was considered a better method to estimate IBTS survey indices than the stratified mean used in the previous assessment because it improved the internal consistency of the indices, the external consistency between them and with the HERAS survey. The assessment runs with indices calculated using Delta GAM model showed improved CV's in comparison to the indices calculated using the stratified mean method. The group acknowledged that the estimates using this approach will vary from year to year but this variation was considered likely to be small as the historical series are relatively long. The reviewers agree that IBTS indices calculated with the Delta GAM method should be used in the revised assessment due to the better internal consistency and improve of the fit of the assement model compared to indices calculated as stratified means.

Stock assessment settings: sensitivity analyses

Different runs of the assessment were conducted to explore the sensitivity of the assessment model:

a) assuming a linear relationship or a power function in the observation model for 0 age in the IBTS Q1 survey: For simplification the assumption of a power function was termed density dependent effect. The mechanism behind the power function is uncertain and may not be related to the actual density dependence. However, it is commonly observed in many short lived species to have a catchability model where population numbers are related to the observations by a power function. The assessment run with density dependent recruitment index improved the retrospective pattern (Mohn's rho) and the overall model fit (AIC) thus the reviewers agree to include the density dependent factor in the assessment.

b) not including a breakpoint in the exploitation pattern: The former assessment included a breakpoint for the exploitation pattern at year 1996 in the time series. Besides the visual inspection of improved residuals in the previous benchmark there was no explanation for why this year was selected. It was admitted that having a constant exploitation pattern in such a long period might not be very realistic. However, after a thorough analysis (detailed statistical analysis of residual patterns and sensitivity analysis to a range of breakpoint values) there was no clear basis to select the location of the breakpoint. Further, the inclusion of the breakpoint slightly improved the model fit but resulted in much worse retrospective pattern (Mohn's rho). Therefore, the reviewers agree with the decision of the group to leave out the break point for the exploitation effect in the assessment.

c) shortening the historical time series: The assessment was run with a short (starting 1982) and long (starting 1974) time series. The catches before 1982 are uncertain due to possiblemisrecording of herring as sprat in unknown proportions in the catches (although some correction was carried out in the past). A comparison of the base run with the short time series showed small differences thus there was no support to discard the older (long time series) data. The WG also considered that there was no new information basis to change the length of the assessment series. Based on this the reviewers agree to keep the historical catches in the revised assessment since it gives valuable information on the stock state in the earlier, possibly more productive years.

d) widrawing one survey at a time from the assessment model: There seemed to be a pattern in the IBTS Q3 residuals when the acoustic index is introduced. Sensitivity of the stock assessment to the removal of the acoustic index and the IBTS Q3 index, one at a time, was tested. However this did not significantly improve the model fit nor the residual pattern of the the indices thus the reviewers agree to keep all surveys in the assessment model.

e) moving (adding) season 4 (Q2) catches to season 1 (Q3): the group decided to move the very low catches taking place at the end of the season (season 4, Q2) to season 1 (Q3) and assume that there are no catches in season 4. Poor samping associated with low catches resulted in poor fitting of the model in this season. Stakeholders corroborated that there is almost no fishing for sprat in April and May because of bad weather. During the benchmark it was realised that moving the very low catches that are obtained in Q2 (season 4) to Q3 (season 1) greatly improved the model fit both looking at the CV's of the observation equations and retrospective Mohn's ro's. Thus reviewers agree to move the season 4 catches to season 1.

f) Fishery selectivity: was not part of the issue list but was discussed during the workshop. The estimated selectivity is dome shaped in Q3 and Q4 and increasing/flat in Q1 and Q2. The group acknowledged that the causes for the dome shaped pattern in some quarters and for the seasonal differences in selectivity were uncertain. The reviewers agree that the dome shaped selectivity is however a common pattern in stock assessments.

g) Survey catchability: was not part of issue list but discussed during the workshop. The selectivity-at-age estimated for the IBTS surveys is relatively flat at ages 1+, a pattern the reviewers considered to be reasonable in a small pelagic fish as sprat due the the fast growth and common spatial distribution of spawning fish. However, the reviewers consider there is no biological rational for the selectivity pattern estimated in the acoustic survey, which increased sharply with age, with catchablity at age 3 twice the catchability at age 2. A model run was carried out for ages 2 and 3+ catchability in the acoustic survey. This resulted in a slightly worse diagnostics and higher AICs. There was a slight increase in the fishery selectivity at ages 2 and 3 although this increase was not markedly high. The WG and reviewers agreed to keep the acoustic selectivities free and make a note that this should be further investigated.

h) Age 0 from the IBTS Q3 index: The inclusion of age 0 from the IBTS Q3 index did not give lower CVs for the observation equations of the surveys, so it was not considered further.

Reference points

Due to the change in the stock delimitation and the assessment settings, new B_{lim} and B_{pa} reference points were estimated. Data before 1980 were excluded from reference point calculations because they were considered to correspond to a higher productivity regime not seen subsequently. The WG considered that the stock recruitment scatterplot was more consistent with Type 2 than with any of the other SR Types and followed the ICES guidelines to estimate B_{lim}. The estimated (94 thousand t) is considered to be robust since trials using alternative minimizing approaches to fit the hockey stick indicated breakpoint values of the same order of magnitude. TMB and FLR gave the same value which in TMB corresponded to a clear minimum in the likelihood profile.

Short term forecast

The assumptions for the short term forecast were reviewed to be consistent with the assessment proposed in this benchmark. The reviewers endorse the new approach taken by the group to calculate the catches for season 3 (Q1) to project the stock in the interim season/year. The new approach uses the reported catches known to the HAWG in March and the length and age composition samples of the fishery in January (most of the catches in this quarter are in January) to calculate catches-at-age in season 3 (Q1) to project the stock to the 1st of July. Instead of assuming a % of the historical catches and the age composition of the previous survey (which has a different fishery selectivity), this method uses data representative of the caches-at-age in season 3 (Q1) and is therefore considered more reliable. The same rationale will be used to calculate the catch weights-at-age. The reviewers agree to adopt a 10-year geometric mean recruitment in the interim year but consider that this option should be adapted depending on the state of the stock (i.e if SSB is estimated below Blim, then, the R assumption could be changed accordingly). The reviewers note that the maturity assumed for age 1 fish (40%) has a non negligible impact on the biomass surviving the forecast year and therefore on the advice coming from a Bescapement strategy. Given that the short term forecast is part of the escapement strategy that will be tested within a MSE framework, the reviewers suggest that this framework could be used not only to find an appropriate value of Fcap but also to test the main assumptions of the short term forecast.

Stock advice and management areas

The benchmark agreed on the methodology to provide advice for the sprat stock in the North Sea (4) and Skagerrak-Kategat (3.a) areas. Since the stock covers two management areas the group identified data which may possibly help the managers to split the catch advice between these areas.

Sprat Divisions 7.d and 7.e (English Channel)

The reviewers agree with the group that sprat in 7d,e should be evaluated as a separate stock. The genetics (only technique that looked into it) indicated homogeneity of Channel and North Sea sprat but this result was based on a few samples. Therefore, the connectivity between sprat in the English Channel and adjacent waters should be further studied.

The reviewers support the change in the management year from the calendar year to July-June as it would allow to provide the most up-to-date advice based on the PELTIC survey. This survey was considered appropriate to provide advice, given that it covers the area where most of the fishery occurs. The group suggested inclusion of the IBTS survey index for the 7de sprat however, finally due to the coverage area of the survey being far from the fishery area this was considered to be not informative. However, the index can be used as an additional source of information to monitor the population in the eastern Channel.

The group discussed various rules to provide advice based on the PELTIC survey. The constant catch was not considered to be a good idea for small pelagics. The ½ rule was considered more appropriate for short lived species, as it is more reactive than the 2/3 rule. Alternatively a constant harvest rate rule was also proposed. All these rules will be tested in a MSE framework using the same life-traits in sprat in the North Sea and Skagerrak and Kattegat for a final decision.

MSE: To be included after the meeting takes place on 11th and 12th of December 2018.

The reviewers confirm that the outcomes of the benchmark are appropriate to provide scientific advice.

Recommendations for future research

1) Otolith shape analysis showed similarities between North Sea and Skagerrak and Kateggat supporting the evidence of the same stock. It is preliminary work which can be developed in the future by assigning with genetics to improve knowledge on stock identification.

2) Connectivity between sprat in the English Channel and adjacent waters.

3) Effects of temperature (environmental factors) and food availability on recruitment success of sprat.

4) Investigate whether sprat natural mortality in area 3.a can be assumed to be comparable to that in area 4

5) Evaluate the maturity ogives by histological analysis of gonad samples from both Q1 and Q3 IBTS surveys and HERAS; consider the possibility to estimate maturity ogives with samples from the fishery collected during the main spawning season

6) Standardize the terminology of years/quarters in the report (use always model seasons and model years)

7) Investigate the causes for the increasing catchability estimated for the acoustic survey

8) Develop methods and guidelines to provide advice for short-lived stocks in Category 3–6.

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Annex 2: Agenda

WKSPRAT - Assessment meeting – Agenda
05–09 of November 2018

Date	Time	Topic	General outputs expected & additional notes
05-nov	10:00	Introduction	
	10:30	Overview of the work to be carried out	Presentation of agenda and the issue lists.
	11:30	Presentation of assessments (NS-3a)	Technical description of SMS assessment model. Main assumptions of SMS model.
	13:00	Lunch	
	14:00	Cont. Presentation of assessments (NS-3a)	Input data. Consequences of merging two stocks on the assessment model. Presentation of base case model (NS + 3a). Definition of different assessments to be tested (e.g. test the effect of different standardization methods for the indices used; density dependent effect; extra M between Q1 and Q3; shorter catch time series; new maturity vector)
	15:30	Break	
	15:45	Presentation of assessments (7de)	Presentation of acoustic data Advice rule
	18:00	End of day	
06-nov	09:00	Working on Assessment	
	10:30	Break	
	10:45	Cont. Working on Assessment	
	13:00	Lunch	
	14:00	Cont. Working on Assessment	
	15:30	Break	
	15:54	Cont. Working on Assessment	
	18:00	End of day	
07-nov	09:00	Revision of final assessment	Otolith shape analysis from Sweden (Valerio) Beach seine survey (Florian)
	10:30	Break	
	10:45	Revision of final assessment	

	13:00	Lunch	
	14:00	Definition of forecast method	MSE model used to calculate the Fcap (Mollie)
	15:30	Break	
	15:45	Definition of forecast method	Discussion on MSE (David Miller) Presentation on ecosystem based indicators (Martin)
	17:00	End of day	
08-nov	09:00	Reference points estimation and basis for advice (NS+3a, 7de)	Implications for advice when merging the two stocks Advice rule
	10:30	Break	
	10:45	Cont. Reference points estimation and basis for advice	
	13:00	Lunch	
	14:00	Cont. Reference points estimation and basis for advice	
	15:30	Break	
	15:45	Cont. Reference points estimation and basis for advice	
	17:00	End of day	
09-nov	09:00	Cont. Reference points estimation and basis for advice	
	10:30	Break	
	10:45	Cont. Reference points estimation and basis for advice	
	13:00	Lunch	
	14:00	Final discussions	
	16:00	End of day	

Annex 3: Minutes of Data Compilation meeting

Minutes of the Data compilation meeting of WKSPRAT (Copenhagen, 19–21 June 2018)

1 Stock identity

4 sprat units have been defined, namely one in the North Sea (Division 4), one in the Kattegat-Skagerrak (Division 3.a), one in the English Channel (Division 7.d, e) and one in the Norwegian and Swedish Fjords. Currently, they are all assessed separately, with the exception of Kattegat-Skagerrak and Fjords units that are assessed together.

New insights on stock ID in the area were evaluated during WKSPRAT. The main conclusions are:

- There are not enough evidences to change the boundaries of what it is considered the Channel stock (7.d, e): this will therefore be assessed independently from the others.
- IBTS data would suggest that the North Sea and the Kattegat-Skagerrak are two separate stocks, with possibly some degree of mixing in the Skagerrak region.
- Preliminary results from genetic analyses show a weak gradient from the North Sea to the Baltic, but don't support a clear distinction between the North Sea, the Kattegat-Skagerrak and the Fjords stocks. Further analysis will be carried out before the benchmark to increase the number of samples and provide more robust results. No samples are available from the Western Channel.
- A beach seine survey has been carried out along the Norwegian coast in the Skagerrak since 1919: potential correlations between age classes abundance from this survey and the IBTS survey conducted in the Skagerrak will be investigated.

In light of this considerations, 4 stock scenarios were identified:

1) North Sea stock – 3.a + Fjords stock – 7.d, e (Current Subdivision)
2) North Sea + 3.a + Fjords stock – 7.d, e
3) North Sea + 3.a – Fjords stock – 7.d, e
4) North Sea stock – 3.a – Fjords stock – 7.d, e

Results from genetic should be available by the end of August; besides, the internal and external consistency of the IBTS survey in the Kattegat region will be calculated. All this information will be used to define the assessment units of sprat in the area.

2 Assessment models

North Sea sprat: the stock is currently assessed using SMS with quarterly time steps. The model includes three surveys: IBTS Q1 ages 1–4+, IBTS Q3 ages 1–3 and HERAS (Q3) ages 1–3. This is so far the most promising model, however there are some issues that need to be addressed, i.e. i) a strong retrospective pattern (tendency to overestimate both recruitment and SSB in the final year), ii) a cohort effect observed in the residuals and iii) high CV in the catches.

The following will be tested:

- 3 different methods for the standardization of indices of abundance will be used and the performances of the estimated indices will be compared. The methods considered will be 1) the standard ICES methodology, 2) the stratified mean method (which is the one currently in use) and 3) a Delta-GAM model.
- The inclusion of a density dependent effect in the model to account for the higher catchability of younger ages in correspondence of high recruitment events, to improve the retrospective pattern.
- The addition of an extra natural mortality between Q1 and Q3, to improve the retrospective pattern.
- The use of a shorter time series of catch to reduce the CV (especially important for forecasts).
- Compare the performances of a new maturity, since the one currently in use is very noisy and could strongly affect the forecast.

The natural mortality currently in use comes from the 2017 North Sea key run from WGSAM: since no other validate alternatives have been presented, the same values will be used for the benchmark.

3.a sprat: the stock is assessed using a data limited approach with input from IBTS Q1-Q3 survey and HERAS (Q3). One of the main issue is the poor coverage of the surveys, that cover only the central part of 3.a and are very noisy. Besides, the stock shows a negative autocorrelation in recruitment indices from both IBTS Q1 and HERAS.

Currently the stock in 3.a includes data from what it is believed to be a separate Fjord stock: this situation will be revised at the benchmark, depending on the new information that will be provided in support of one or the other hypothesis.

If enough evidences will support the merging of the 3.a stock with the North Sea one, then the data will be merged, but the advice will be still provided separately. On the other hand, if the stock will be considered a separate unit, some of the following options will be explored:

- Comparison between the indices resulting by the application of the stratified mean method and by the application of the new Delta-GAM approach.
- Evaluation of the internal and external consistency of the indices when considering the Kattegat area only.

English Channel sprat: the stock is assessed using an index of biomass from acoustic survey. The main issue concerns the coverage of the survey, that might not cover the whole extension of the stock since it is carried out in area 7.e only. Besides, no CV has been provided so far due to the method used to process the data.

- Both Echo-R and StoX will be considered and tested to provide estimate of biomass with associated CV.
- Internal consistency between age classes will be evaluated.

3 Reference points

North Sea sprat: different values of F_{cap} will be tested.

4 Forecasts

North Sea sprat:

- Consider using a shorter time series for forecast estimations.
- Consider different values for maturity.
- Consider using a different weight at age (currently an average of the last 3 years is used): the potential candidate could be a weight at age that takes into account a cohort effect and/or an environmental effect (e.g. zooplankton, temperature).

5 Ecosystem drivers for short-lived species

The ecosystem drivers suggested are:

1. Total mortality
2. Weight at age
3. Recruitment success

6 Recommendations for WKLIFE

WKSPRAT recommends WKLIFE to:

- Test the effectiveness of an escapement strategy when an absolute index of abundance is available.
- Test the effectiveness of a bycatch rule, together with a fixed TAC.
- Advice on best practices when there is autocorrelation in the indices of abundance used for advice.

7 Expected working documents

- Results of genetic analyses (by the end of August).
- Spatial distribution of sprat from IBTS data (by the end of August).
- Comparison between internal and external consistency in IBTS data from Kattegat area only and Kattegat/Skagerrak area (by the end of August).
- Norwegian beach seine survey and some relevant information on Fjords sprat (by the end of August).
- Standardization of IBTS indices using the Delta-GAM methodology (already available on the sharepoint).
- Processing of the acoustic data for the English Channel sprat (by November).

- Estimation of a new weight at age for North Sea sprat (by November).
- Considerations on ecosystem drivers (by November).

8 Upcoming meetings

- Results from genetic analysis are expected by the end of August. A webex has been scheduled for 5 September to discuss about assessment areas and stocks units.
- The assessment workshop will take place from 5–9 November 2018.
- A webex will be scheduled after the assessment workshop to discuss about Management Strategy Evaluation (MSE).
- A MSE meeting will take place on the 4–5 December.

Annex 4: Annex 4: Agenda of Data Compilation meeting

WKSPRAT 2018, 19-21 June – Data compilation meeting, ICES HQ

Date	Time	Topic	General outputs expected, & additional notes	Presentations
19-Jun	10:00	Introduction		
	10:30	Overview of the work to be carried out	Presentation of the ToRs, the agenda and the issue lists; list of presentations available	
	11:30	Stock structure	Genetic (results from IMR and DTU) Information from survey Life history data	Dorte Bekkevold: **Population genetic structure of European sprat *Sprattus sprattus* L.** Martin Lindegren: **Investigating sub-stock structuring of sprat in the North Sea based on fishery-independent survey data** Mikael von Deurs: **Distribution of catches**
	13:00	Lunch		
	14:00	Catch data	Reliability of historic catch data Reliability of age reading (reporting from WKARSPRAT) Discard	
	15:30	Break		
	15:45	Fishery independent data	Acoustic IBTS Others (e.g. Norwegian beach seine)	Casper Berg: **Survey Index Calculations for North Sea Sprat from IBTS data** Silvia Rodrigues-Climent: **Pelagic ecosystem survey in western Channel and eastern Celtic sea** Cecilie Kvamme: **Beach Seine Survey**
	17:00	End of day		
20-Jun	09:00	Ecosystem considerations		Martin Lindgren: **Investigating factors affecting sprat growth throughout ontogeny**
	09:30	Assessment	Data available Methodology Exploitation pattern	Mikael von Deurs: **Presentation on SMS sprat model** Cecilie Kvamme: **3a Sprat**
	10:30	Break		
	10:45	Cont. Assessment		Anna Rindorf: **Natural mortality of North Sea Sprat**
	13:00	Lunch		
	14:00	Cont. Assessment	Main issues with assessment (e.g retro bias…)	
	15:30	Break		

	15:54	Reference points	MSY and PA reference points	
	17:00	Stakeholders view and input		
	17:30	Review of progress and pending issues		
	18:00	End of day		
21-Jun	09:00	Basis for advice	WKLIFE Escapement strategy Rules for category 3 stocks Ecosystem based indicators	
	10:30	Break		
	10:45	Recommendation for WKLIFE 2018	Advice rules to be tested.	
	11:45	Review of progress. Identify any work to be completed after the meeting, with responsibilities and deadlines.		
	13:00	Closure of the meeting		