Preliminary analysis to include data from autumn acoustic surveys in the assessment of the Iberian sardine stock

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1 Introduction

In 2012 the model used to assess the Iberian sardine stock (Divisions 8c9a) changed from AMCI [4] to Stock Synthesis (SS). Since 2019, the version of SS used is version 3.30. The last benchmark was in February 2017 [1]. The main modifications were related to updated information on stock delimitation and the description of the fisheries, methods to estimate the initial population, the stock-recruitment relationship, the acoustic survey selectivity-at-age and the fishery selectivity-at-age [1].

The Iberian sardine assessment is age-based and assumes a single area, a single fishery, a yearly season and genders combined. Input data include catch (in biomass), age composition of the catch, total abundance (in numbers) and age composition from an annual acoustic survey and spawning–stock biomass (SSB) from a triennial DEPM survey. The assessment includes fishery data up to year y (final year of the assessment) and acoustic data up to year $y+1$ (interim year).

2 Inclusion of a new index - recruitment index

The current assessment model only has information on recruitment up to the final year of the assessment (year y) that is provided by the spring acoustic survey that takes places in the interim year (year $y+1$, age 1 individuals) just before the assessment of the state of the stock takes places and advice is provided for the following year ($y+2$).

The inclusion of another source of information on recruitment is thought to improve the advice that is provided since small pelagic species such as sardine may have highly variable recruitment events that have major impacts in the stock biomass. In the case of the Iberian sardine there is a time series of autumn acoustic surveys that can provide data on recruitment in the interim year and is not yet included in the assessment model. This was one of the reasons for changing the advice calendar, where the assessment was moved from June to November.

2.1 Autumn acoustic surveys

Sardine distribution off the Iberia shows three core habitats: coastal areas in northern and southern Biscay (outside the distributional range of the southern stock), the Gulf of Cadiz and the central Portuguese shelf (where mean abundance is the highest and constitutes juvenile core area).

Over the **last** decades, several autumn acoustic surveys have been carried out in the main sardine recruitment areas with the objective of assessing the incoming recruitment to the fishery in the next year. These surveys have had a different spatial coverage and seasonality, but have always covered the main area of juvenile concentration within the stock (subdivision 9a Central North). The time series, with gaps, began in 1986 with the SAR survey in the western and south area, then the JUVESAR survey was conducted during the autumn from 2013 in the part of the western Iberia, and recently this survey has been expanded (IBERAS from 2018) to the entire western coast (9aN, 9aCN and 9aCS) (Table 1).

In November 2020, during ICES WGACEGG, results of the investigation of consistency of juvenile surveys for potential future incorporation in the assessments were presented. A high and significant correlation (0.75, p¡0.001) was found between the abundance of juvenile sardines estimated in the recruitment surveys carried out in the main recruitment area for the stock (subdivision 9aCN, survey series SAR+JUVESAR+IBERAS) and the abundance of sardine estimated in the spring acoustic surveys that are used in the assessment (PELAGO & PELACUS) in the following year. This high correlation supports the progress of this work and testing the inclusion of the western recruitment survey series in the assessment.

Table 1: Acoustic surveys providing direct estimates for sardine juveniles in subdivision 9a.

Survey	SAR	JUVESAR	IBERAS
Subdivisions	9.a CN-9.a S	9.a CN	9.a N 9.a CN 9.a CS
Year/month			
1998	Nov		
1999			
2000	Nov		
2001	Nov		
2002			
2003	Nov		
2004			
2005	Nov		
2006	Nov		
2007	Nov		
2008	Nov		
2009			
2010			
2011			
2012			
2013		Nov	
2014		Nov	
2015		Dec	
2016		Dec	
2017		Dec	
2018			Nov
2019			Sep
2020			Sep

2.2 Model development

Acoustic autumn survey data since 1998 were used as additional data to the already existing Iberian sardine model (base model; Figure 1). The parameters set in the input files were left the same as for the existing assessment, with the exception of additional parameters required to incorporate the autumn acoustic surveys. The data was included as an index of abundance with a selectivity tailored to young fish. Age selectivity options were used to choose a single age, age 0.

During the workshop suggestions to change from time-blocks in selectivity of fleet number 1, purse seine fleet, and changing the random-walk parameterization for fleets 1, purse-seine fleet, and fleet 2, the spring acoustic survey, were made (Figures 2 and 3). Therefore, the previous model was also run with a different selectivity pattern (model 02).

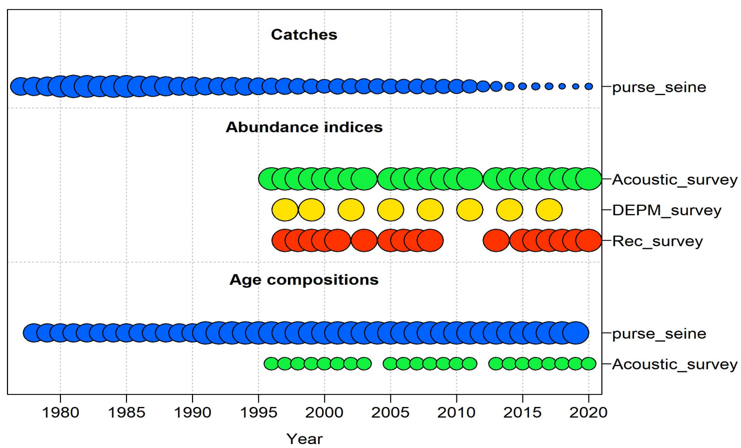
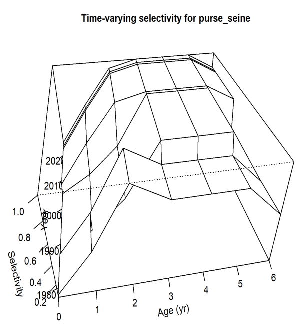
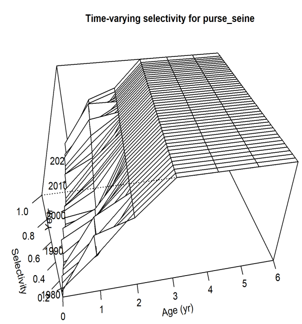


Figure 1: Data presence by year for each fleet, where circle area is relative within a data type. Circles are are scaled relative to maximum within each type, the scaling within separate plots should not be compared.



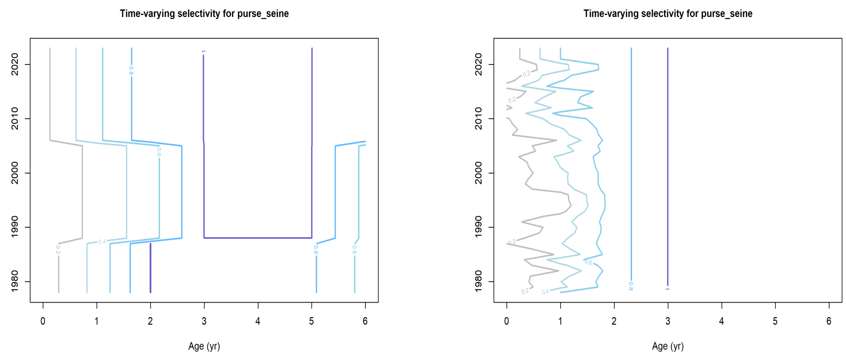
(a) Base model



(b) Model 02

Figure 2: Time-varying selectivity surface for fleet 1, purse seine.

The models tested in this study were based on the most recent Iberian sardine stock assessment model (reference model), fitted to data from 1978-2020 [2]. Model diagnostics were explored using standard graphs created using ss3diag [5]. Finally, results from the most recent Iberian sardine stock assessment model were compared with the two models.



(a) Base model (b) Model 02

Figure 3: Time-varying selectivity contour for fleet 1, purse seine.

3 Results

Model diagnostics for each of the new models were similar between them and also in comparison with the current assessment model. Pearson residuals for purse seine fishing fleet have small changes with apparently more positive positive residuals, specially in the final years of the assessment (Figure 4).

The fit to index data for the acoustic survey and for the DEPM survey are similar to those for the current assessment model, with similar trends and peaks (Figures 5 and 6).

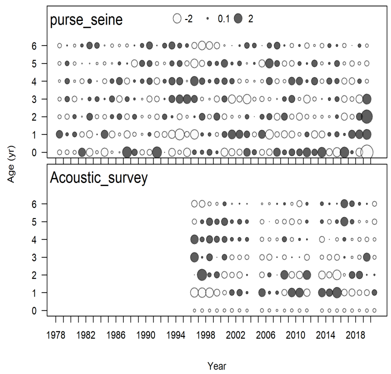
The fit to index data for the autumn/recruitment acoustic survey in the base case and in model 02 are similar, following trends of the observed index and with a poor fit for higher index value points mainly in the early period of time series (Figure 7).

Figure 8 shows the standardized indices overlaid. The model fit to the autumn acoustic survey in year 2000, where a very high value of the index of recruitment was observed, stands out.

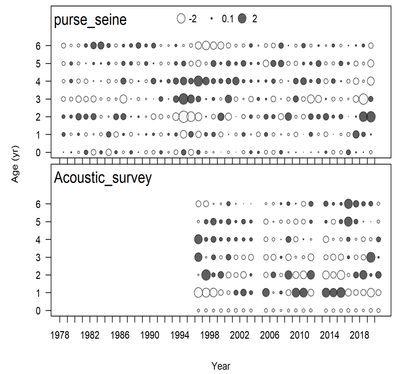
Settings for recruitment deviation were modified to accommodate for the new index series (last year of main recruitment deviations in now the interim year as opposed to the last year of catch data) and to incorporate the least squares estimate of alternative bias adjustment relationship for recruitment deviations done automatically by SS (for more information, see [3]. Patterns for recruitment deviations are similar between models (Figure 9), the bigger changes occur at the beginning of the series and in the last two recruitment points.

Overall, age composition fit is very good for all models (current assessment model and the two new tested models) (Figure 10). Looking closer at age composition by year we can say that it improves slightly in both the base model (Figures 11, 12 and 13) and model 02 (Figures 14 and 15).

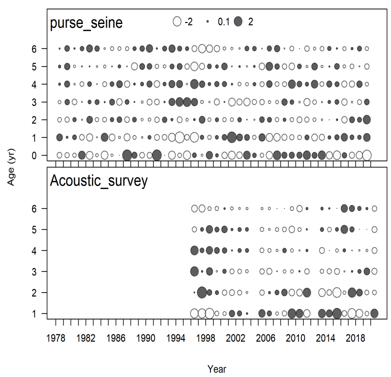
Since both models tested seems to be good models in terms of fit to data, following trends and have similar fits to the current assessment model, model



(a) Base model



(b) Model 02

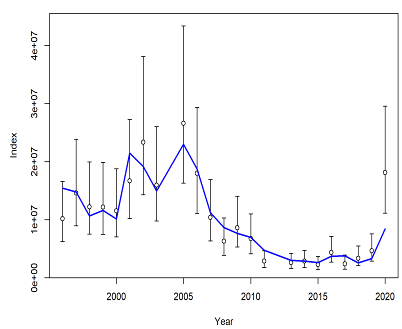


(c) Current assessment model

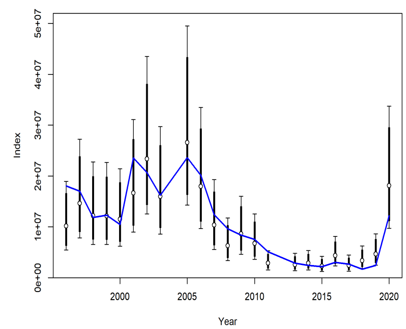
Figure 4: Pearson residuals for age composition, comparing across fleets 01 (purse seine) and fleet 02 (acoustic survey). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

diagnostics were explored using standard graphs (Figures 16 to 21)created using the R-packages ss3diags [5].

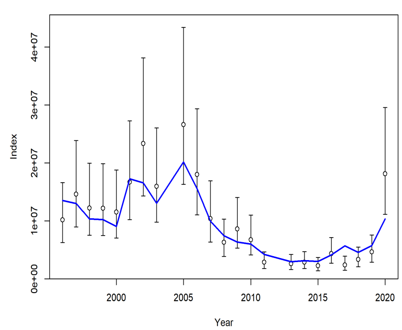
Spawning stock biomass and recruitment time-series, as estimated by the two models tested, follow the same trends as the current assessment model (Figure 22. For spawning stock biomass, we observe that the base model only diverges from the current assessment model in the most recent 8 years while model 2 diverges at the start and end of the time series. Recruitment trends seem to follow the current assessment model very well except for years 2015-2018 in both cases, and at the start of the time series in the case of the base model. Both model show that the population in 2020 is smaller than the current assessment.



(a) Base model

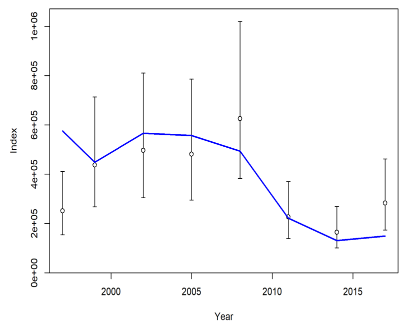


(b) Model 02

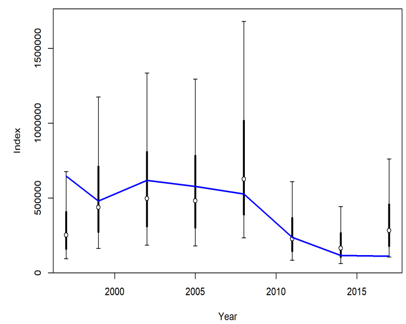


(c) Current assessment model

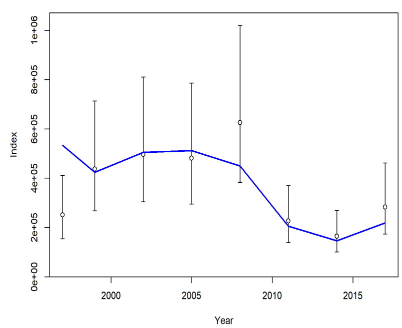
Figure 5: Fit to index data for the spring Acoustic survey. Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines (if present) indicate input uncertainty before addition of estimated additional uncertainty parameter.



(a) Base model

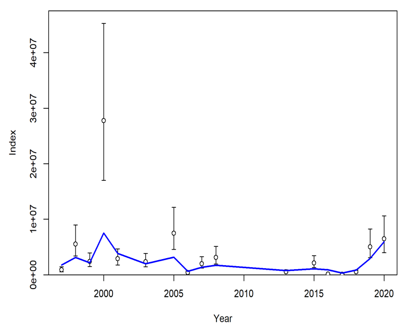


(b) Model 02

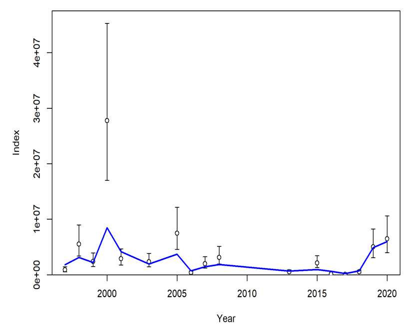


(c) Current assessment model

Figure 6: Fit to index data for the DEPM survey. Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines (if present) indicate input uncertainty before addition of estimated additional uncertainty parameter.



(a) Base model

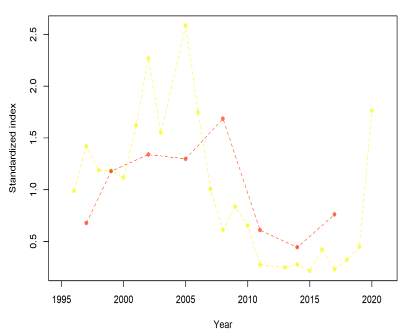


(b) Model 02

Figure 7: Fit to index data for the autumn acoustic survey. Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines (if present) indicate input uncertainty before addition of estimated additional uncertainty parameter.

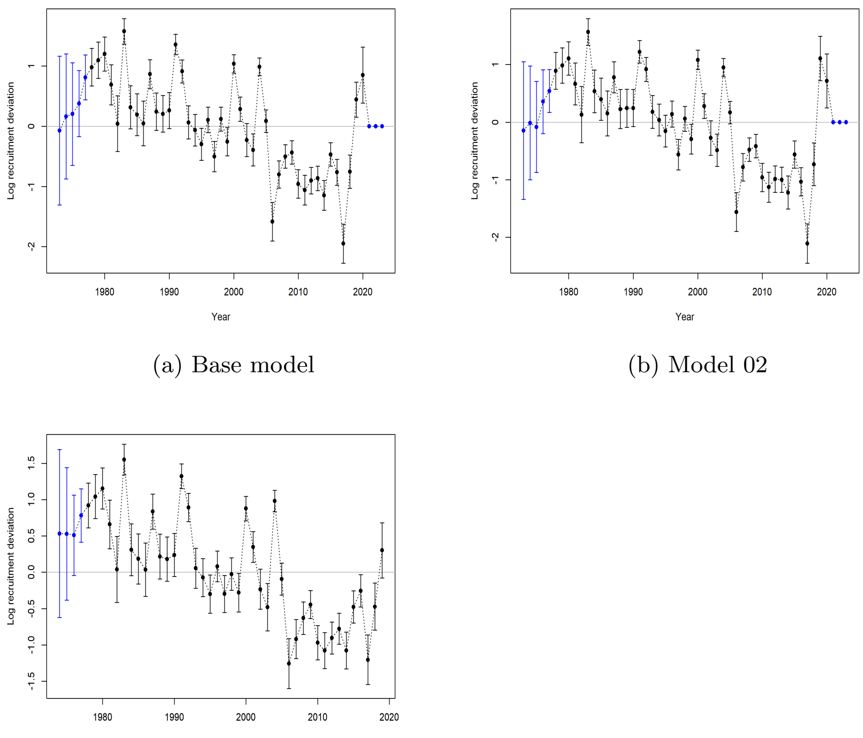
(a) Base model

(b) Model 02



(c) Current assessment model

Figure 8: Standardized indices overlaid. Each index is rescaled to have mean observation = 1.0.

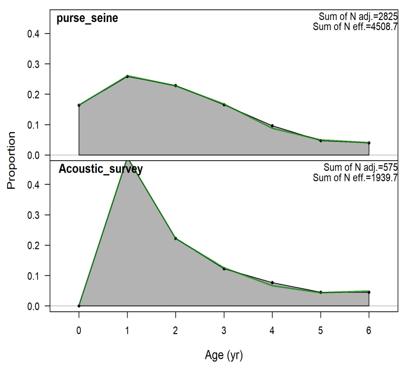


(a) Base model

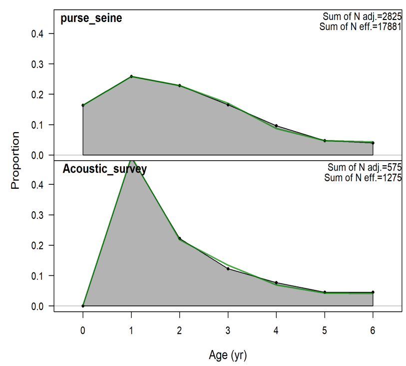
(b) Model 02

(c) Current assessment model

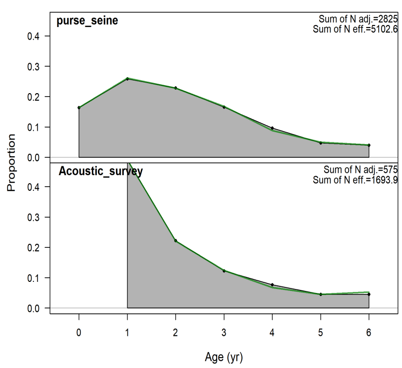
Figure 9: Recruitment deviations with 95% intervals.



(a) Base model

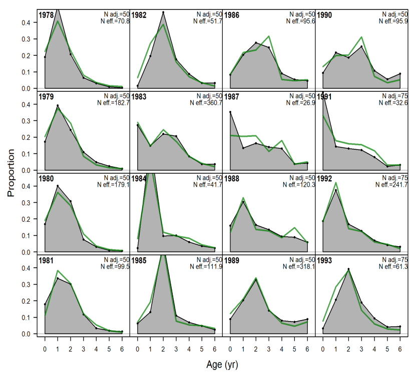


(b) Model 02

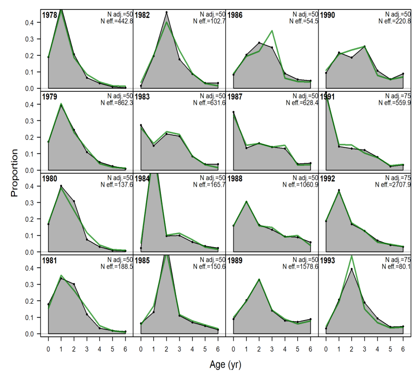


(c) Current assessment model

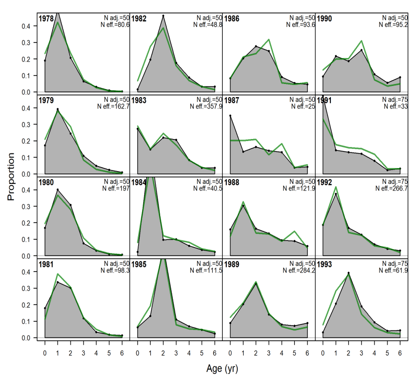
Figure 10: Age composition, aggregated across time by fleet.



(a) Base model

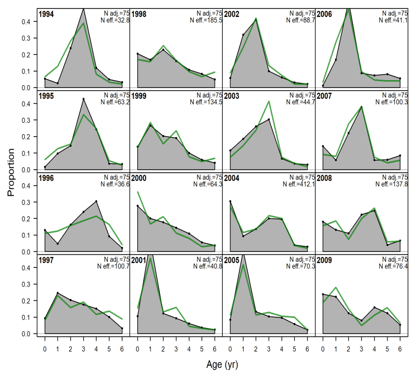


(b) Model 02

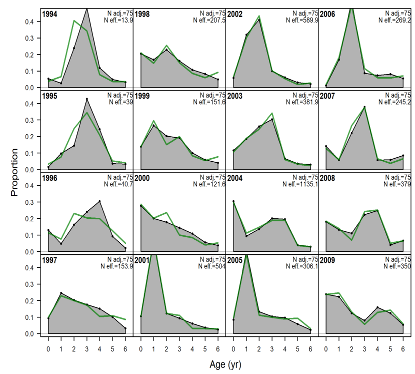


(c) Current assessment model

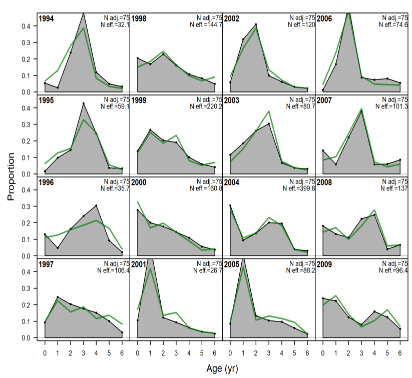
Figure 11: Age composition, whole catch, purse seine (plot 1 of 3). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

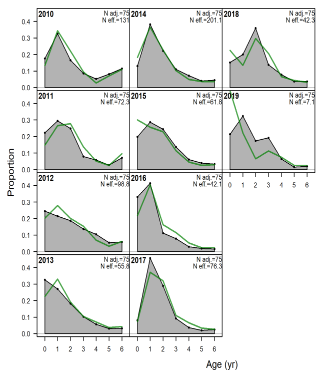


(b) Model 02

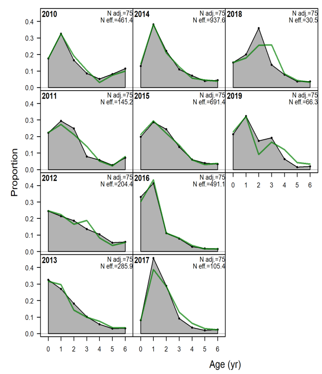


(c) Current assessment model

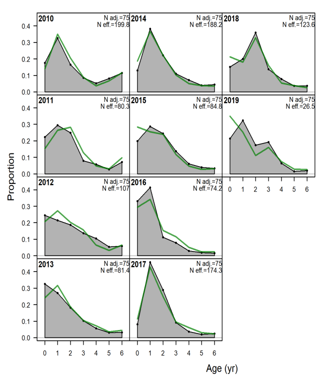
Figure 12: Age composition, whole catch, purse seine (plot 2 of 3). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

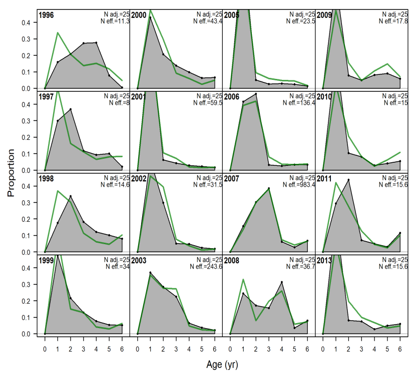


(b) Model 02

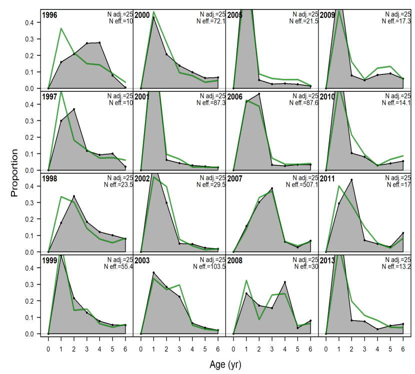


(c) Current assessment model

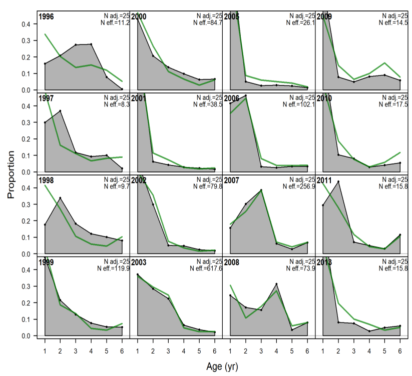
Figure 13: Age composition, whole catch, purse seine (plot 3 of 3). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

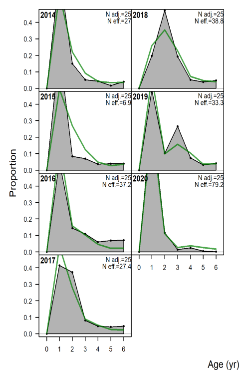


(b) Model 02

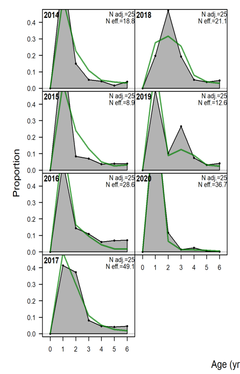


(c) Current assessment model

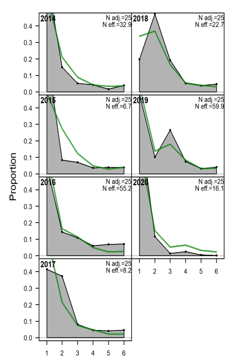
Figure 14: Age composition, whole catch, acoustic survey (plot 1 of 2). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

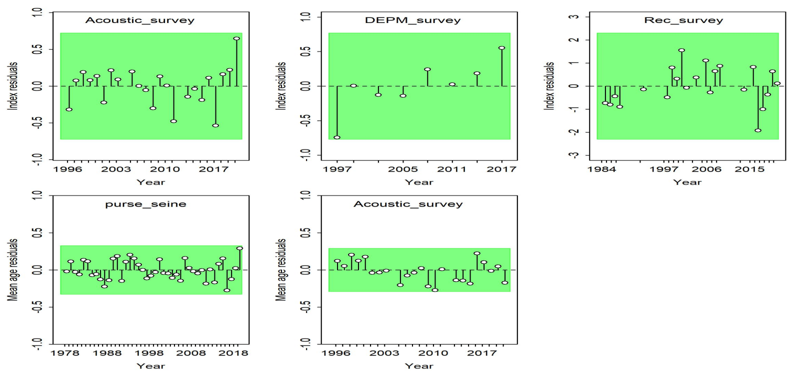


(b) Model 02

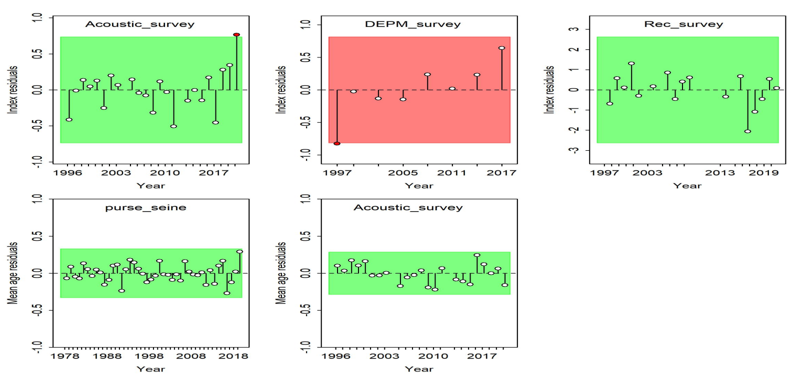


(c) Current assessment model

Figure 15: Age composition, whole catch, acoustic (plot 2 of 2). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.

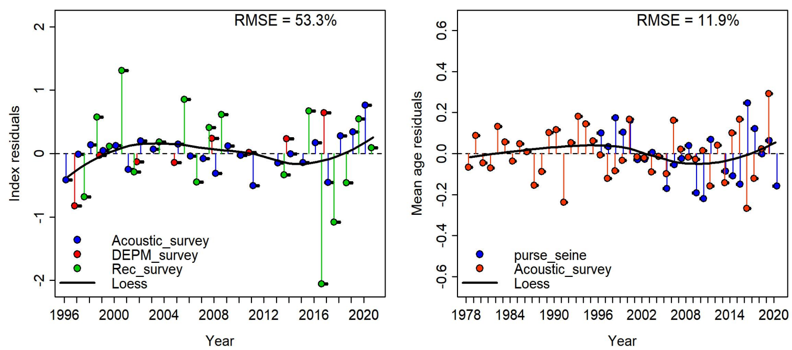


(a) Base model

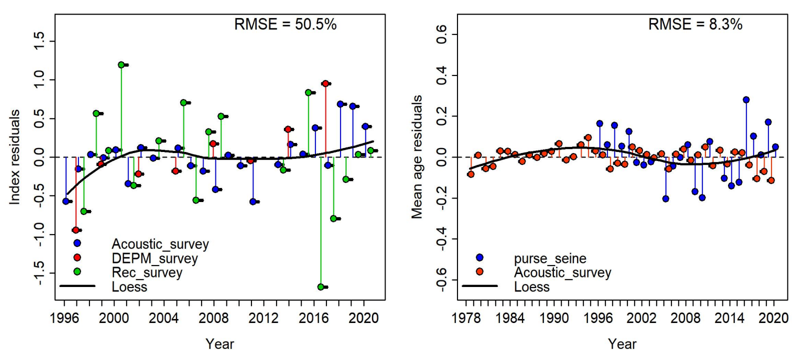


(b) Model 02

Figure 16: Runs Test residuals for mean composition data.

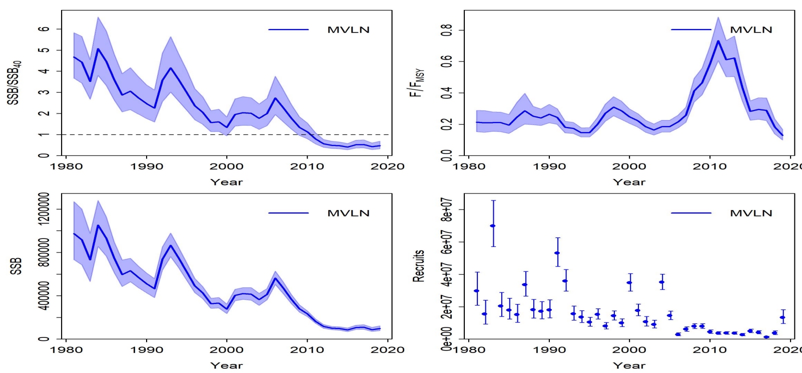


(a) Base model

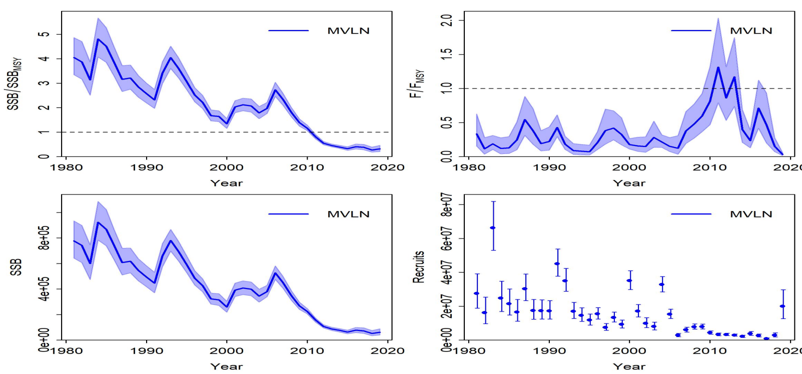


(b) Model 02

Figure 17: Joint residuals to check for conflicts.

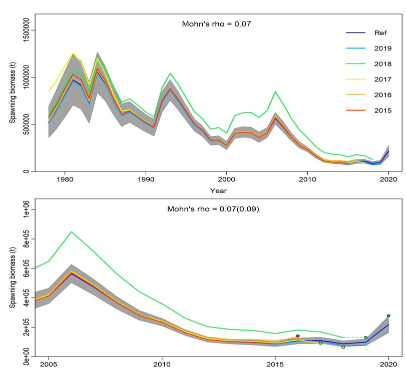


(a) Base model

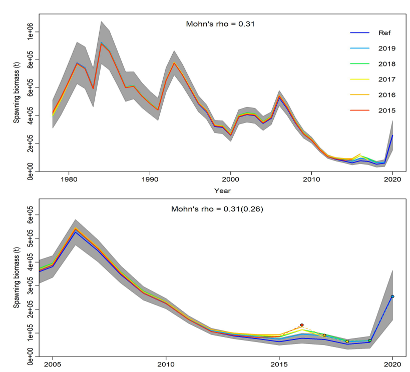


(b) Model 02

Figure 18: Approximate uncertainty with MVLN (hessian).

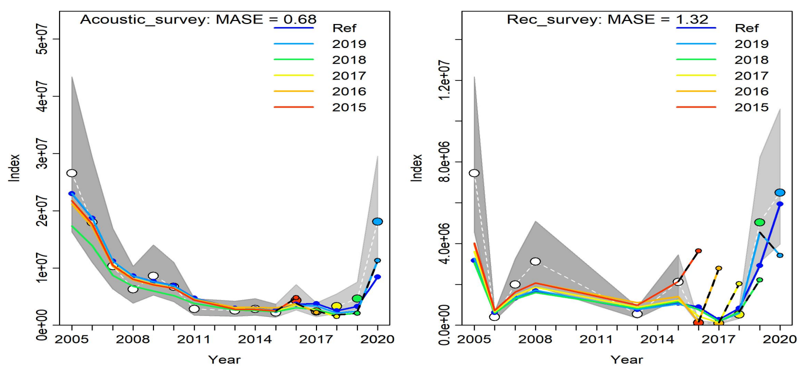


(a) Base model

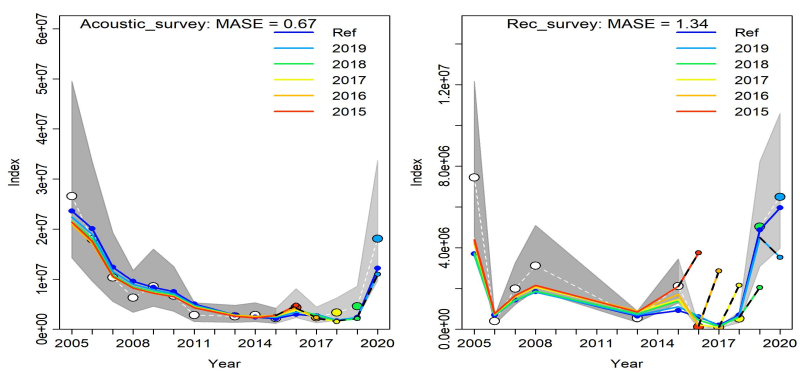


(b) Model 02

Figure 19: Retrospective Analysis with one-step ahead Forecasts

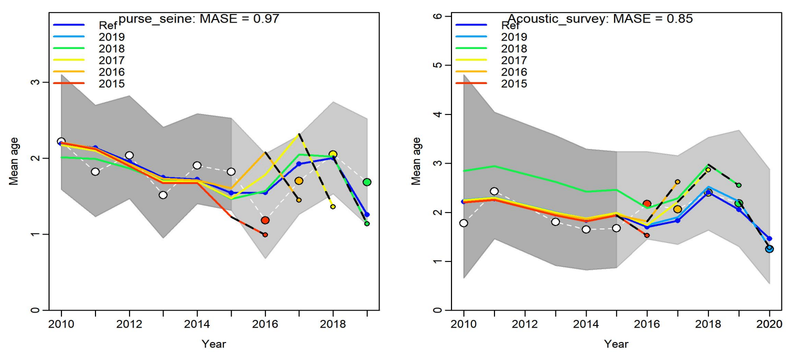


(a) Base model

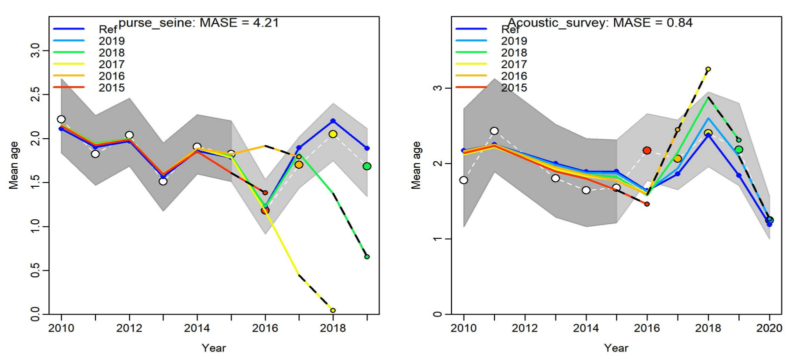


(b) Model 02

Figure 20: Hindcast with Cross-Validation of CPUE observations for Index

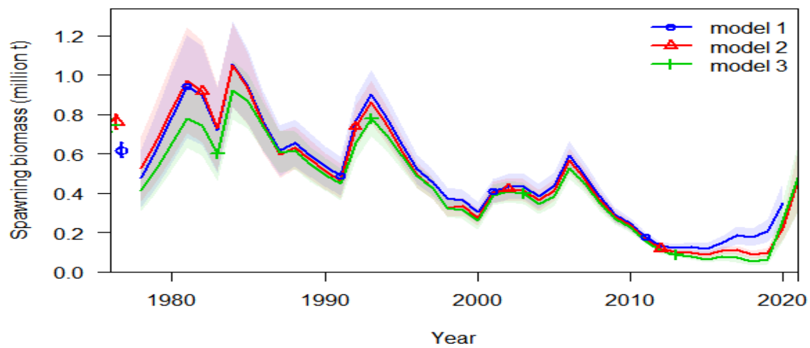


(a) Base model

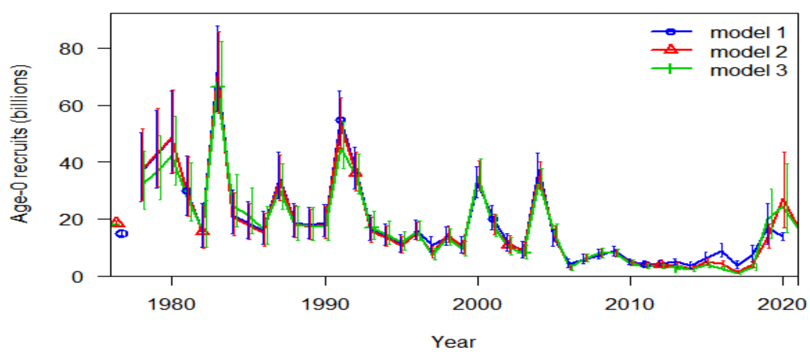


(b) Model 02

Figure 21: Hindcast with Cross-Validation for mean age.



(a) Base model



(b) Model 02

Figure 22: Model comparison for SSB and Recruitment. The blue line is the current assessment model, the red line is the base model and the green line is model 02.

4 Conclusions

The results of this study show that the inclusion of data from recruitment acoustic survey since 1998 does not change mucg the fit of the model and diagnostic are still quite good except for the fit of the DEPM model in model 02. However, model 02 seems to have less uncertainty when estimating SSB and a smaller retrospective pattern.

We recommend that the inclusion of autumn acoustic surveys is considered at a inter-benchmark during 2021 or in the next benchmark, and propose that further inter-session work is carried out to evaluate if changes in selectivity should be made.

References

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