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WORKSHOP ON TOOLS AND DEVELOPMENT OF STOCK ASSESSMENT MODELS USING A4A AND STOCK SYNTHESIS (WKTADSA)

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Contents

i Executive summary

This report summarises the work carried out during the Workshop on Tools and Development of Stock Assessment Models using a4a and Stock Synthesis (WKTADSA). It provides a brief description of the two assessment frameworks used and information on available re-sources to help the assessment scientist develop their stock assessment. Additionally, a brief overview of each of the case studies are provided with full documentation of the models and explorations presented in working documents at Annex 5.

The workshop brought together ICES stock assessors developing or working with Stock Synthesis (SS) and Assessment 4 All (a4a) with the method development experts of the two frameworks explored. The format of the meeting was split into two 5-day meetings with the first providing an introduction and overview of each of the frameworks, through presentations from the experts. This allowed for a much larger participation from the wider ICES community. The second meeting focused on the application of the two assessment approaches to develop the assessments of ten ICES stock units given in section 2 and Annex 4.

Both meetings gave valuable training, information, and support to participants with a wide and varied background in a4a and SS. Furthermore, the experts made themselves available to provide additional support during the intersessional period between meetings and prior to the first meeting being held, advancing the progress of each of the assessments being developed.

All ten case studies provided a first (base case) model for further development. Much progress was made during the workshop and between the two workshop meetings. Two assessments, megrim and sardine both in divisions 8.c and 9.a, were considered ready for an assessment benchmark, only requiring sensitivity analyses which could be carried as part of an assessment benchmark workshop.

To continue the tremendous progress made, similar workshops using the format of the second meeting, or informal meetings could be scheduled with the experts specific to the approach used to further prepare the assessments for benchmark workshops. Stock units considered close to completion were both black-bellied anglerfish, white anglerfish in divisions 7 and 8.a, b, d, four-spot megrim in divisions 8.c and 9.a and megrim in divisions 7.b-k and 8.a, b, d.

The other three stock units, both hake stocks and white anglerfish in divisions 8.c and 9.a required further exploration as well as reviewing of input data used in the assessment and would therefore require additional time before they would be ready for an assessment benchmark workshop.

ii Expert group information

Expert group name	Workshop on Tools and Development of Stock Assessment Models using a4a and Stock Synthesis. (WKTADSA)
Expert group cycle	Annual
Year cycle started	2020
Reporting year in cycle	1/1
Chair	Lisa Readdy, UK
Meeting venue(s) and dates	16-20 November 2020, online meeting, (46 participants)
	18-22 January 2021, online meeting, (20 participants)

1 Introduction

The workshop, WKTADSA, provided an opportunity for ICES stock assessors developing or working with Stock Synthesis (SS) and Assessment 4 All (a4a) to work closely with method development experts, listed in Annex 1, to advance their ICES stock assessments. The interactive workshop consisted of two online meetings and intersessional subgroup meetings and communications.

The first meeting provided an introduction and overview of each of the frameworks. The workshop introduced the concepts of the modelling frameworks and examined the structures of the input files, the parameterization, and the resulting outputs. Additionally, other supporting software and R packages and R-project (R Core Team, 2014) packages were introduced which provide visualisation tools to assess diagnostics and to make use of the model outputs in simulation exercises such as for management strategy evaluations.

The intersessional work and second meeting focused on the application and development of the assessment models to progress the ten ICES stocks given in section 2 and Annex 4, where there were twenty participants, Annex 2. Both meetings gave valuable training and support to participants with a wide and varied background in a4a and SS.

1.1 Overview of the stock assessments methods and resources.

1.1.1 Assessment for all (a4a).

The a4a stock assessment modelling framework is a statistical catch-at-age stock assessment developed as part of a European Commission Joint Research Centre initiative to enable more scientists with limited background in statistics to perform stock assessments (Jardim *et al.*, 2015) and build capacity.

The stock assessment framework is a non-linear model consisting of five submodels, linear in form, for initial age structure, recruitment, fishing mortality, catchability-at-age for abundance indices and observation variance of catch-at-age and abundance indices (Jardim *et al.*, 2017). Within the a4a assessment framework there is the ability to carry out a full assessment fit which provides all parameter estimates and their respective covariances or a reduced (management procedure) fit which does not calculate estimates of covariances, reducing the time it takes to complete.

1.1.1.1 Resources

The a4a modelling framework is implemented in R and FLR (Kell *et al.*, 2007) and uses AD model builder (ADMB) (Fournier *et al.*, 2012). All are available from the following websites: www.r-project.org, flr-project.org, www.admb-project.org, https://github.com/flr.

Supporting material and tutorials are available from the main FLR web pages by following the links, with specific diagnostic tools for a4a available on the FLR GitHub. Experts and developers of a4a recommended reviewing STECF assessment reports for inspiration on the initial set up of models.

1.1.2 Stock Synthesis (SS).

Stock synthesis is an age-structured population dynamics modelling framework, an integrated assessment that combines several sources of data into a single analysis constructing a join likelihood for the observed data (Maunder and Punt, 2013). The framework can be adapted to data-poor situations operating an age structured production model to a more complex model (Methot and Wetzel, 2013) incorporating multiple datasets of different types, accounting for both biological and environmental processes. Stock synthesis has been developed over the last 30 years with the most recent major development translating the source code to ADMB (Methot and Wetzel, 2013).

1.1.2.1 Resources

Although stock synthesis is constructed using AD model builder, the software is not needed to run a stock synthesis model, the only requirements are the input files and the stock synthesis executable. All of the information required to set-up and run a stock synthesis model can be found on a dedicated stock synthesis website (https://vlab.ncep.noaa.gov/web/stock-synthesis/home).

There are multiple ways to view the inputs and outputs of a model run and include a stock synthesis GUI as well as an excel viewer (SS-OUTPUT), all downloadable from the same website. Another ways of viewing the output files is using R packages such as r4ss. The r4ss package, a collection of R functions for summarising, plotting and visualising the input and output data among other things can be downloaded from the r-project website. However, to access the most recent (development) version, r4ss can be obtained from the GitHub (https://github.com/r4ss/r4ss) along with other packages such as those for simulation using SS files to support management strategy evaluations (ss3sim).

Additional to r4ss, other packages are being developed such as ss4diags which reproduces key model diagnostics including simultaneous visualisation of residuals from multiple indices. It also provides an evaluation of the predictive skill, through hindcasting of the models. In a hindcast a model is fitted to the first part of a time series and then projected over the period omitted in the original fit (Kell *et al.*, conditionally accepted, Carvalho *et al.*, conditionally accepted). The r package can also be downloaded from the GitHub (https://github.com/JABBAmodel/ss3diags).

1.1.3 Other resources

1.1.3.1 Biological and fishery reference points

Regardless of the assessment approach the ICES-MSY package which estimates equilibrium reference points required to provide catch advice and to assess the status of stock units can be applied. The ICES-MSY, available at https://github.com/ices-tools-prod/msy, requires a specific format for the input files. The structure of these files is similar to the output files from a4a so very little data manipulations is required. However, the stock synthesis output requires some restructuring of the data and an r package has been developed to reformat the SS output into the format needed to run the ICES-MSY package (code available from https://github.com/flr/ss3om).

Although ICES-MSY is available to use the preference would be to include the full process with in one modelling framework. This would enable the uncertainty in the input data to propagate through to the estimation of stock status, forecast and reference points.

1.1.3.2 Life-history parameters

For all stocks the experts noted the uncertainty around the life-history parameters used with in the stock assessment, such as those used in the stock-recruit relationship where steepness had been fixed at 0.99 in the Beverton and Holt S-R. To help identify a more plausible value it was recommended to make use of the FishLife r-package (https://github.com/James-Thorson-NOAA/FishLife) which contains predictions of life-history parameters for all described fish (Thorson *et al.*, 2017).

2 Case studies

Ten ICES stocks were selected as case studies, nine from the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) and one from the Working Group on Southern Horse Mackerel, Anchovy, and Sardine (WGHANSA). Of those selected, three stocks; Northern hake (hke.27.3a46-8abd), Southern white anglerfish (mon.27.8c9a), and sardine (pil.27.8c9a) have accepted assessment using the integrated assessment framework stock synthesis. There is one stock for which a new assessment model is in an advanced stage of development (a4a model for meg.27.7b-k8ad (ICES, 2020)).

As there are a number of stocks with similar biological characteristics and similar data availability to those with either already accepted assessments or those in the advanced stages of development (e.g. ank.27.78abd, ank.27.8c9a, hke.27.8c9a, ldb.27.8c9a, meg.27.8c9a, and mon.27.78abd), similar models and model structures were applied. Three stock unit assessments were developed using a4a and seven were developed using stock synthesis, three of which already had accepted assessment using this approach.

2.1 Assessments developed in a4a.

2.1.1 Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b-k, 8.a-b and 8.d.

Megrim in divisions 7.b-k, 8.ab and 8.d is assessed using a customised Bayesian statistical catch-at-age model implemented since 2012 to resolve the issue with the limited availability of data from the discarded component of the total catch and different levels of temporal aggregation across the time-series, a mix of quarterly and annual time steps. With the resolution of this issue in 2016 (ICES, 2016) the complex and the length of time the model needed to run, WGBIE proposed that a more standardised method could be used.

Data for megrim are available by age and length allowing for multiple types of modelling frameworks to be used. Here, a4a with in the FLR framework was selected for its simplicity and linkage to other FLR packages. An initial a4a model was presented to the expert working group, WGBIE, which showed promising preliminary results (ICES, 2020) with similar trends and absolute values to the Bayesian statistical catch-at-age already in use.

From the preliminary model additional model settings and sensitivities were explored during the workshop and four are presented in Annex 5, Section A.5.1 WD01. The final model selected which provided the best fit, lowest AIC and Mohn's rho, was the model which down weighted the historical catch. Additional exploration is required to investigate the use of smoothers for fishing mortality (f) and catchability (q) and the addition of blocks given that three distinct data periods were observed.

2.1.2 Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a.

Megrim in divisions 8.c and 9.a is assessed using the extended survivor analysis (XSA) in the VPA95 Lowestoft suite. As with most stocks, estimates of recent SSB and F are affected by inaccurate or noisy input data. This megrim unit has a number of sources, such as the estimation of the proportion of *lepidorhombus whiffiagonis* in the landings and discards of *lepidorhombus* spp as both megrim and four-spot megrim are landed together. Additionally, the estimation of discards where for some years the absence of data is replaced by averaging the closest years (stock annex

ICES, 2020). As XSA is a deterministic assessment method it does not provide a measure of how observation uncertainty propagates to uncertainty in the parameter estimates (Gårdmark *et al.*, 2010) and can therefore provide an unrealistic accuracy of stock status and level. In order to quantify the uncertainty WGBIE agreed that a statistical assessment method approach similar to that presented for megrim in 7.b-k, 8a, b, d could be applied to this stock given the similarity between the stocks and their data structures.

As with the megrim stock unit in section 2.1.1 data are available by age and year. The input file structure used in the XSA assessment are comparable to the input files required for the a4a assessment model, which helps with the transition from one modelling framework to another.

Various model specifications were explored with four of the models presented in Annex 5, section A.5.1, WD02. All, but one model presented showed similar trends and absolute values to that provided by the XSA model. The a4a assessment model for this stock showed promising results. The next phase is to carry out further sensitivity analyses and diagnostics in preparation for a benchmark.

2.1.3 Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a.

Four-spot megrim in divisions 8.c and 9.a is assessed using XSA in the VPA95 Lowestoft suite. Similar to that of megrim in the same area, four-spot megrim is also subject to noise data with WGBIE agreeing that a statistical model is more appropriate to try and quantify the uncertainty and that a4a, as with both the megrim stocks, should be utilised.

Numerous model specifications were explored with four of the models presented in Annex 5, section A.5.1, WD02. All models presented where similar in absolute value to that provided by the XSA assessment however the trends in the more recent period differed slightly. The next steps for this stock unit would be to explore additional model configurations paying particular attention to the number of knots used in the year dimension reducing the potential to over parameterise the model. Additionally, conduct further sensitivity analyses and diagnostics in preparation for a benchmark.

2.2 Assessments developed in SS.

2.2.1 White anglerfish (*Lophius piscatorius*) in Subarea 7 and divisions 8.a-b and 8.d.

White anglerfish in Subarea 7 and divisions 8.a, b and d is assessed using the a4a framework, an age based assessment. This assessment method, first applied in 2018, was the first time since 2007 that a full analytical assessment had been utilised due to ageing issues (ICES, 2007 and ICES 2018). To obtain catch and survey data at age needed for the assessment inputs, length data were converted into pseudo-ages using a von Bertalanffy growth function (VBGF). The VBGF Parameters were estimated using the growth rate from the first two cohorts with maximum length (Linf) estimated as 90% of the largest observed individual (ICES, 2018). It was noted that during the WKAngler workshop (ICES, 2018) the preference would be to use a framework that would convert the length information to ages internally allowing the model to quantify the uncertainty in the underlying sample data.

WKAngler developed a stock synthesis model alongside the a4a model but due to limited time in completing all the specified configurations was not accepted. A simple model using the recent version of stock synthesis was developed during WKTADSA and modification to selectivity, equilibrium catch and extending the time-series historically were explored.

Additional exploration was recommended which include:

- Age specific natural mortality;
- Sex specific growth;
- Selectivity – In the presented model there is one commercial fleet which is a mix of different gear groups, and therefore selectivity, which can vary over time;
- Sample size and adjusted sample sizes.

Given the lack of certainty around growth this stock unit was considered a good candidate for providing fishing opportunity advice using ensemble methodologies.

2.2.2 White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a.

White anglerfish in divisions 8.c and 9.a is assessed using stock synthesis implemented and accepted as the primary source for catch advice since 2012. Similar to the stock unit in section 2.2.1 reliable age estimation is not available given the inconsistency of the pattern of increments (annual rings) being laid down in the calcified structures used for age reading (Landa *et al*., 2008). Therefore, a modelling framework capable of converting length data to age internally was necessary using the VBGF, fixing the growth, from growth studies, and allowing the model to estimate Linf and length-at-age 0.75.

As this stock unit already had an accepted stock synthesis assessment the main purpose of the workshop was to aid in fine tuning the assessment. A number of configurations were explored during the workshop and include modifying selectivity, replacing an LPUE index with an effort series and including time varying catchability. All changes implemented showed very different perceptions of stock status in the recent period with the most pessimistic being that with time varying catchability (Annex 5, Section A.5.2, WD04).

Additional exploration was recommended for a future benchmark:

- Update sample size using actual sample size and explore adjusted sample sizes;
- Model simplification by using annual data instead of quarterly data;
- Biological parameters and CV sensitivities;
- Standardisation of the LPUE index.

2.2.3 Black-bellied anglerfish (*Lophius budegassa*) in Subarea 7 and divisions 8.a-b and 8.d.

Black-bellied anglerfish in Subarea 7 and divisions 8.a, b, d is landed with white anglerfish under a combined species group, *Lophius* spp., similar to Megrim and four-spot megrim. This stock is assessed using a data limited approach under ICES category 3 (ICES, 2012a). In comparison to while anglerfish in the same area, growth parameters are more difficult to estimate because cohorts are less distinct in the length-frequency distribution, leading to greater uncertainty. Development of an analytical assessment has been challenging as analytical models requiring age data are considered no longer appropriate, given uncertainties in direct aging. Additionally, the lack of contrast in the data tends to cause biomass production models to fail through non-convergence or result in large uncertainty in the model outputs of biomass and/or fishing mortality.

As with white anglerfish, a stock synthesis model was developed during WKAngler (ICES, 2018) but due to limited time in completing all the specified configurations was not accepted. During this workshop a simpler model structure using the recent version of stock synthesis was developed. Modifications to the simple base model were explored and presented in Annex 5, section A.5.2. WD05. A final model was accepted to take forward for further exploration considering selectivity and retention of the commercial fleet, age specific natural mortality, historical catch and sample size and sample size weighting.

2.2.4 Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a.

Black-bellied anglerfish in divisions 8.c and 9.a is assessed as a category 3 stock using a stochastic production model in continuous time (SPiCT) (Pedersen and Berg, 2017). During the two last benchmark workshops that this stock unit was reviewed, stock synthesis models were explored. The stock synthesis model showed promise but required further investigation to improve the model fit (ICES, 2012b) and despite its consistency in estimates of SSB and F with the other modelling frameworks explored, the model had difficulty in converging (ICES, 2018). It was recommended to simplify the stock synthesis model, aggregating similar commercial fleets. Therefore, the initial model presented at WKTADSA includes two fleets reduced from four and annual data reduced from quarterly. Further investigation to test different model configurations were explored and include changes to selectivity by fixing some parameters and using different methods for estimating effective sample sizes for the compositional (length distribution) data. Results of the explorations are presented in Annex 5, section A.5.2, WD06. To progress the model further in readiness for a benchmark it was suggested to explore recruitment deviations and investigate the sensitivity of the model to different values for fixed parameters, through jitter analysis and likelihood profiling.

2.2.5 Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d.

Hake in Sub areas 4, 6, 7 and divisions 3.a, and 8.a, b, d, northern stock of hake, has been assessed using the stock synthesis framework since 2010 and continues to be developed and modified as new science and data become available. The purpose of this stock unit being chosen as a case study is to allow for further development and fine tuning of the model, and also provide a good example for workshop members to gain familiarity with the detail of the parameterisation within the framework given the assessment complexity.

Some of the areas that were addressed during the workshop included updating from SS v3.24 to v3.30 which required the conversion of the input files. Exploration of, through sensitivity analysis, the parameterisation of the model. Additionally, investigation into the lack of convergence for some of the sensitivities and retrospective analysis that have been encountered (Annex 5, section A.5.2, WD07). To begin the preparation for a benchmark workshop additional explorations were recommended which include:

- Explore possible values for life-history parameters using data and meta-analysis, including tagging data;
  - L_{inf} and k from the VBGF
  - Natural mortality
  - Stock-Recruit parameters
- Investigate the use of logistic selectivity for some of the fleets;
- Investigate the use of data weighting for length distribution data.

2.2.6 Hake (*Merluccius merluccius*) in divisions 8.c and 9.a.

The assessment approach used for this stock unit, hake in divisions 8.c and 9.a, is GADGET, Globally Applicable Area-Disaggregated General Ecosystem Toolbox (Begley and Howell, 2004). During the EWG WGBIE 2020 the assessment was rejected and downgraded to use an ICES category 3 assessment approached based on survey and CPUE trends (ICES, 2020). As the Northern stock of hake is assessed using Stock Synthesis, ICES (WGBIE 2020) considered it was appropriate to test the suitability of the approach to assess hake in divisions 8.c and 9.a.

During the workshop development of the input files commenced following the structure for northern hake and mirroring the GADGET model parameterisation (Annex 5, Section A.5.2, WD08). Given the complexity of the model structure and data input further work was needed to get a suitable first model run and provide the outputs needed to assess the appropriateness of the approach. During workshop plenary sessions the group considered that increasing the time-series of catches, historically, would benefit the model performance along with having true sampling levels included for the distribution data rather than setting all to a fixed value. Other areas that will be considered in preparation for a benchmark are similar to those described for northern hake.

2.2.7 Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a.

Sardine in divisions 8.c and 9.a has been assessed using stock synthesis since 2012, similar to northern hake it continues to be developed and modified as new information becomes available. This stock unit was selected as a case study to develop the model further and to provide another completed stock synthesis model for the group to see an alternative set up of the input files.

In the last benchmark workshop for this stock unit recommendations included the possibility of adding additional surveys to provide regional recruitment estimates (ICES, 2017). Adding an additional survey index timed to provide recruitment information to coincide with the fishery was investigated during this workshop as well as further tunning of the model.

In preparation for a benchmark, suggestions were made to relook at the time-blocks used for selectivity and change to a random walk as it was unclear why blocks were chosen. Results of the sensitivities explored during the workshop are presented in WD09 (Annex 5, section A.5.2), and shows that the model is ready for a benchmark.

3 Conclusions

3.1 Conduct of the meeting

Both meetings were held remotely via WebEx with the first meeting having over 40 participants. The lack of in-person interaction with the online nature of the meeting presented a barrier to a fully interactive session. Therefore, plenaries were scheduled to not only take account of the different time zones of the participants but were reduced so that more intersessional work could be completed. During the first workshop introductions were limited to the experts only, the experts then provided presentations, lecture style, with some time set aside for questions. With participants only asking few questions, it is uncertain how well they were able to understand the different modelling approaches presented.

Feedback from the group suggested having more and shorter plenary sessions per day, providing participants the time to think of questions to ask the experts. With the format of the first session being expert driven the workshop may have benefitted from having breakout sessions lead by the individual experts so that participants had the opportunity to ask more specific questions related to their stock assessment.

Lessons learnt from the first workshop were taken forward with much shorter sessions and longer breaks scheduled. Those with case studies provided presentations on their progress and more time was allocated for discussion and questions.

3.2 Progress of the case studies

Much progress had been made towards developing stock assessments in one of the two frameworks, however, the stage at which a model was considered ready for a benchmark and able to provide advice was variable. In order to continue the momentum for developing the models in preparation for a benchmark, follow-up meetings either informal or formal or by correspondence with stock synthesis or a4a experts would be beneficial (Annex 3).

Of the three stocks for which assessments are accepted, one, sardine in division 8.c and 9.a, was in the advanced stages of being ready for an inter-benchmark to include the addition of a new recruitment survey series. The other two, the northern stock of hake and white anglerfish in divisions 8.c and 9.a, provided an update of the accepted assessment model in the new SS version which did not pose any issues in its use for this years' provision of advice. New settings and data changes explored and suggested during the workshop would require further investigations before a benchmark workshop would be needed.

Stocks for which new assessments were being developed, six are in the advanced stages of being completed in readiness for an assessment benchmark workshop. As benchmark workshops have yet to be scheduled, model development should continue intersessionally to address the suggestions and recommendations discussed during this workshop, outlined in section 2 and in the working documents in Annex 5. Any progress made on the model development intersessionally should be presented to the assessment working group to reassess the suitability for a benchmark.

During the meeting there was discussion around exploring the potential use of ensemble approaches given that six of the stocks exhibit high uncertainty around the life-history parameters, in particular growth, natural mortality, and stock-recruit. This approach of combining multiple models with different combination of plausible life-history parameters should be considered and explored further for the provision of catch advice (Annex 3).

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Annex 1: List of Invited Experts

Name	Modelling framework	Institute	Country (of institute)
Cecilia Pinto	a4a	European Commission, Joint Research Council	Italy
Colin Millar	a4a	International Council for the Exploration of the Sea (ICES)	Denmark
Ernesto Jardim	a4a	European Commission, Joint Research Council	Italy
Henning Winker	a4a, SS	European Commission, Joint Research Council	Italy
Iago Mosqueira	a4a	Wageningen University & Research	The Netherlands
Ian Taylor	SS	National Oceanic and Atmospheric Administration (NOAA)	USA
Kathryn Doering	SS	National Oceanic and Atmospheric Administration (NOAA)	USA
Kelli Johnson	SS	National Oceanic and Atmospheric Administration (NOAA)	USA
Christoph Konrad	a4a	European Commission, Joint Research Council	Italy
Massimiliano Cardinale	SS	Institute of Marine Research	Sweden
Richard Methot	SS	National Oceanic and Atmospheric Administration (NOAA)	USA
Vladlena Gertseva	SS	National Oceanic and Atmospheric Administration (NOAA)	USA

Annex 2: List of participants

Workshop on Tools and Development of Stock Assessment Models Using a4a and SS (WKTADSA), 18-22 January 2021.

Name	Institute	Country (of institute)
Agurtzane Urtizberea	AZTI	Spain
Andreia Silva	IPMA	Portugal
Ane Iriondo	AZTI	Spain
Anne Cooper	ICES	Denmark
Cristina Silva	IPMA	Portugal
Dorleta Garcia	AZTI	Spain
Esther Abad	IEO - Vigo	Spain
Gwladys Lambert	Cefas	UK
Hans Gerritsen	Marine Institute	Ireland
Hugo Mendes	IPMA	Portugal
Iago Mosqueira	Wageningen University & Research	The Netherlands
Jette Fredslund	ICES	Denmark
Kathryn Doering	NOAA	USA
Kelli Johnson	NOAA	USA
Laura Wise	IPMA	Portugal
Lisa Readdy (chair)	Cefas	UK
Massimiliano Cardinale	Institute of Marine Research	Sweden
Paz Sampedro	IEO, A Coruña	Spain
Santiago Cerviño	IEO, Vigo	Spain
Teresa Moura	IPMA	Portugal

Annex 3: Recommendations

The table below provides a list of recommendations from WKTADSA

Recommendation:	**For follow up by:**
Members of the workshop recommended that ICES coordinate follow-up meetings with relevant experts to continue the development of the stock assessments in preparation for the benchmark process. This could either be formally by correspondence and / or egroup meetings or informally.	ICES Secretariat
Progress has been made to incorporate ICES forecast requirements in the same assessment frameworks as used for the assessment, however this is not the case for the estimation of biological reference points; F_{MSY}, F_{pa}, F_{lim}, MSY $B_{trigger}$, B_{lim}, B_{pa}. Members and invited experts recommended that further progress is made to combine the assessment, forecast and biological reference point estimation in a single assessment framework.	ACOM Leadership
Some of the stock units presented as case studies have high uncertainty around the life-history parameters, the group recommended the potential to explore ensemble approaches for the provision of catch advice.	WKENSEMBLE

Annex 4: Resolutions

WKTADSA - Workshop on Tools and Development of Stock Assessment Models Using a4a and Stock Synthesis.

2020/2/FRSG54 The **Workshop on Tools and Development of Stock Assessment Models Using a4a and Stock Synthesis (WKTADSA)** chaired by Lisa Readdy (UK) with Invited Experts Colin Millar (ICES) and Vladlena Gertseva (USA) will meet 16–20 November 2020 and 18–24 January 2021 by web conference to address the objectives below:

The purpose of this workshop is to provide an opportunity for ICES stock assessors working with Stock Synthesis (SS) and Assessment 4 All (a4a) to work closely with method development experts to advance ICES stock assessments. Participants are encouraged to bring forth stock assessment test cases on which they are working, whether they are in an exploratory or advanced stage of development. WKTADSA will:

a) Provide an overview of SS and a4a and the features of these packages that allow them to apply to a range of stocks and data scenarios.
b) Direct participants to key resources (peer-reviewed publications, user guides, complementary tools, etc.) that support the development of stock assessments based on SS and a4a.
c) Provide demonstrations of stock assessments built with SS and a4a, beginning with input data formatting, model decision-making and configuration, to processing, interpretation, and communication of results.
d) Provide expert feedback, and assistance in developing robust and appropriate models to selected ICES stocks in anticipation of a future benchmark.

WKTADSA will report by 11 February 2021 for the attention of the Fisheries Resources Steering Group and ACOM.

Supporting information

Priority	The WKTADSA will ensure that ICES can use the best available scientific information and tools to provide advice for the stocks considered in this workshop. Consequently, these activities are considered to have a very high priority.
Scientific justification	There are at least two ICES stocks for which new assessment models are in an advanced stage of development (SS model for mon.27.78abd and a4a model for meg.27.7b-k8ad (WGBIE 2020)). There are also a number of other stocks, with similar biological characteristics and similar data availability (e.g. ank.27.78abd, meg.27.8c9a, ldb.27.8c9a, ank.27.8c9a), to which very similar models could be applied. The Gadget assessment model of hke.27.8c9a was rejected in 2020 and the stock is now assessed as a category 3. The Northern hake stock, hke.27.3a46-8abd, is assessed using Stock Synthesis and ICES (WGBIE 2020) considered it was appropriate to test the suitability of the method to assess the hke.27.8c9a. Furthermore, some convergence issues have been detected in the assessment of hke.27.3a46-8abd stock that need to be investigated. The above issues will be explored by intersessional subgroup sessions and the final WKTADSA meeting will provide valuable training and support to stock assessors in the development and application of these alternative stock assessment models.

Stock code	Stock name	Present assessment model	ICES WG
mon.27.78abd	White anglerfish (*Lophius piscatorius*) in Subarea 7 and divisions 8.a-b and 8.d (Celtic Seas, Bay of Biscay)	a4a	WGBIE
mon.27.8c9a	White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	SS	WGBIE
meg.27.7b-k8ad	Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b-k, 8.a-b, and 8.d (west and southwest of Ireland, Bay of Biscay)	Bayesian statistical catch at age	WGBIE
ank.27.78abd	Black-bellied anglerfish (*Lophius budegassa*) in Subarea 7 and divisions 8.a-b and 8.d (Celtic Seas, Bay of Biscay)	Data-limited	WGBIE
meg.27.8c9a	Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)	XSA	WGBIE
ldb.27.8c9a	Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters East)	XSA	WGBIE
ank.27.8c9a	Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)	SPiCT	WGBIE
hke.27.8c9a	Hake (*Merluccius merluccius*) in divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters)	Data-limited / GADGET*	WGBIE
hke.27.3a46-8abd	Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d, Northern stock (Greater North Sea, Celtic Seas, and the northern Bay of Biscay)	SS	WGBIE
pil.27.8c9a	Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea	SS	WGHANSA

	and Atlantic Iberian waters)
Resource requirements	All the preparatory work will be developed by web conferences
Participants	6 to 10 participants, 2 invited experts, 1 chair
Secretariat facilities	Meeting facilities and support for the final meeting
Financial	None
Linkages to advisory committees	FRSG, ACOM
Linkages to other committees or groups	There is a very close working relationship with other assessment working groups and WGMIXFISH-ADVICE.
Linkages to other organizations	None

Annex 5: Working documents

A.5.1 Assessment 4 all (a4a)

WD01 Megrim (*Lepidorhombus whiffiagonis*) in divisions 7.b-k, 8a-b and 8.d.
WD02 Megrim (*Lepidorhombus whiffiagonis*) in divisions 8.c and 9.a. and Four-spot megrim (*Lepidorhombus boscii*) in divisions 8.c and 9.a.

A.5.2 Stock Synthesis (SS).

WD03 White anglerfish (*Lophius piscatorius*) in Subarea 7 and divisions 8.a-b and 8.d.
WD04 White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a.
WD05 Black-bellied anglerfish (*Lophius budegassa*) in Subarea 7 and divisions 8.a-b and 8.d.
WD06 Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a.
WD07 Hake (*Merluccius merluccius*) in subareas 4, 6, and 7, and divisions 3.a, 8.a-b, and 8.d.
WD08 Hake (*Merluccius merluccius*) in divisions 8.c and 9.a.
WD09 Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a.

WKTaDSA – 1. 16th November to 20th November 2020

WKTaDSA – 2. 18th January to 22nd January 2021

PRELIMINAR RESULTS OF A4A ASSESSMENT MODEL FOR MEGRIM (*L. WHIFFIAGONIS*) IN ICES DIVISIONS 7B-K AND 8A,B,D

by

Ane Iriondo, Agurtzane Urtizberea, Sonia Sanchez and Dorleta García

1 Introduction

Megrim *(L. whiffiagonis)* is assessed in ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) with a Bayesian catch-at-age model considered as a full analytical assessment since 2016.

During WGBIE 2019, as it is yearly presented, an issue list was presented for this stock in order to improve the assessment for next years. The identified issues are listed in the table below:

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?
(New) data to be Considered and/or quantified			
Tuning series	France: No update of LPUEs data series are provided to the group from 2008 onwards.	Provide LPUE data from France for different bottom trawl fleet from 2008 onwards.	IFREMER to provide FU LPUE data series reviewed.
Discards			
Biological Parameters	Biological Parameters	Old maturity ogive	Update the new maturity ogive presented in WD 07 in this report. Statistical method review.

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?
Fisheries & ecosystem issues and data			
Assessment method	The Bayesian SCA model was ad-hoc implemented to solve the lack of discard data from France. After IBP Megrim 2016 discard from France where provided, so the problem disappeared. Therefore, a change to a more standardized model is proposed to ease the implementation and shorten the iteration times.	Intersessional work should be done to try different models.	Data are available.
Biological Reference Points			
Landing Obligation	Impact of LO on model settings and data arrangement		

Therefore, one of the issues to be solved is related to the assessment method:

"The Bayesian SCA model was ad-hoc implemented to solve the lack of discard data from France. After IBP Megrim 2016 discard from France where provided, so the problem disappeared. Therefore, a change to a more standardized model is proposed to ease the implementation and shorten the iteration times."

2 Material and methods

A4a statistical catch at age model developed as part of the Assessment For All (a4a) initiative of the European Commission Joint Research Centre using R a4a package was implemented:

http://www.flr-project.org/doc/Statistical_catch_at_age_models_in_FLa4a.html

For doing so, all the input data for the assessment were converted to FLStock objetct were data were standardized to the FLR data format.

```
stock <- FLStock(catch.n =catches.n, landings.n= landings.n, discards.n=discards.n,

catch.wt=catches.wt,landings.wt=landings.wt, discards.wt=discards.wt, stock.wt=stock.wt, catch= catches,landings=landings, discards=discards,

 m=m, mat=mat, harvest.spwn=harvest.spwn,m.spwn=m.spwn)
```

For tuning índices, data were formatted based on FLR data format for indices, generating FLIndices object based on FLIndex object of each of the five tuning fleets:

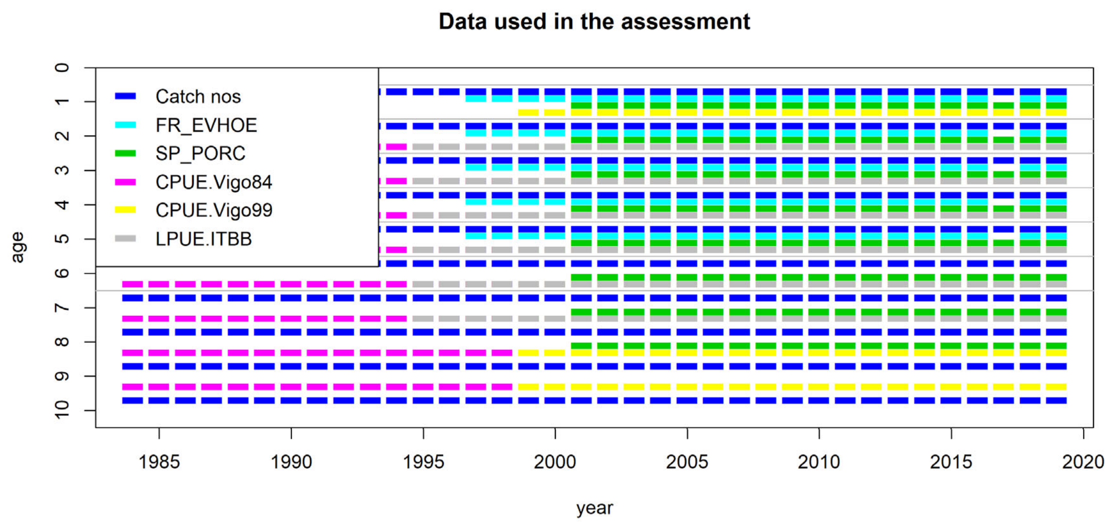
```
tun <- FLIndices(Tun1,Tun2,Tun3,Tun4,Tun5)
```

2.1 Data and data exploration

Input data for applying a4a R package were included in this two files: inputMegrim78As.RData and MegIndices.RData.

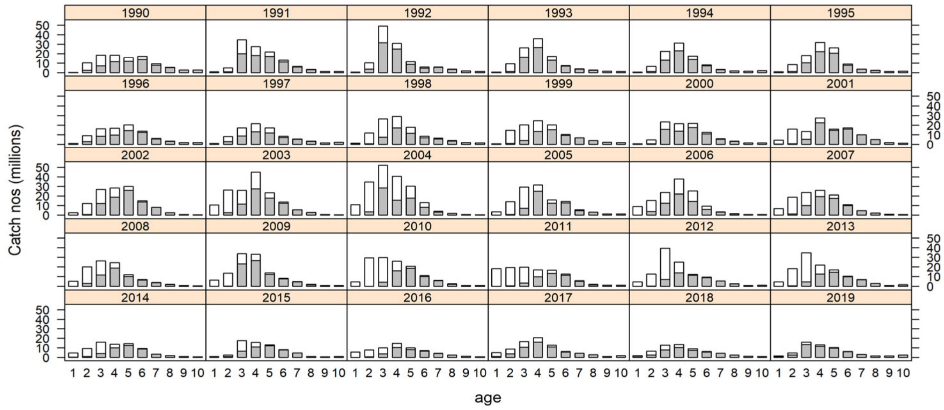
Input data for the assessment are formatted as FLR object, FLStock and FLIndices.

Data exploration was done based on the script: **3.meg_Dataexploration.Rmd** were a file is generated with all the exploratory data analysis. Catch data and and 5 tuning fleets are used for the assessment.

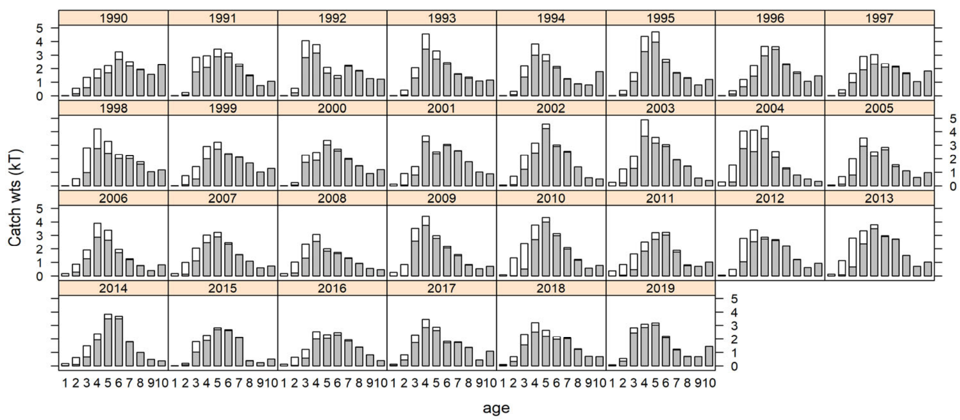


DATA	YEARS	AGES	NOTES
Catches	1984-2019	1-10	
Survey EVHOE	1997-2019	1-5	French IBTS survey index in 7 and 8; Catch in numbers per hour;L. whiffiagonnis (ages 1-5, 1997-2019)
Survey PORCUPINE	2001-2019	1-8	Spanish IBTS Porcupine survey; Cpue in numbers per 30min; L. whiffiagonnis (ages 1-8, 2001-2019)
Commercial VIGO 84	1984-1998	2-9	Spanish demersal trawlers (Vigo) in subarea 7 from 1984-1998; L. whiffiagonnis (ages 2-9, 1984-1998)
Commercial VIGO 99	1999-2019	1-9	Spanish demersal trawlers (Vigo) in subarea 7 from 1999-2019; L. whiffiagonnis (ages 1-9, 1999-2019)
Commercial IRTBB	1995-2019	2-7	Irish beam trawlers; unit Standardised to N0/10SqKm; L. whiffiagonnis (ages 2-7, 1995-2019)

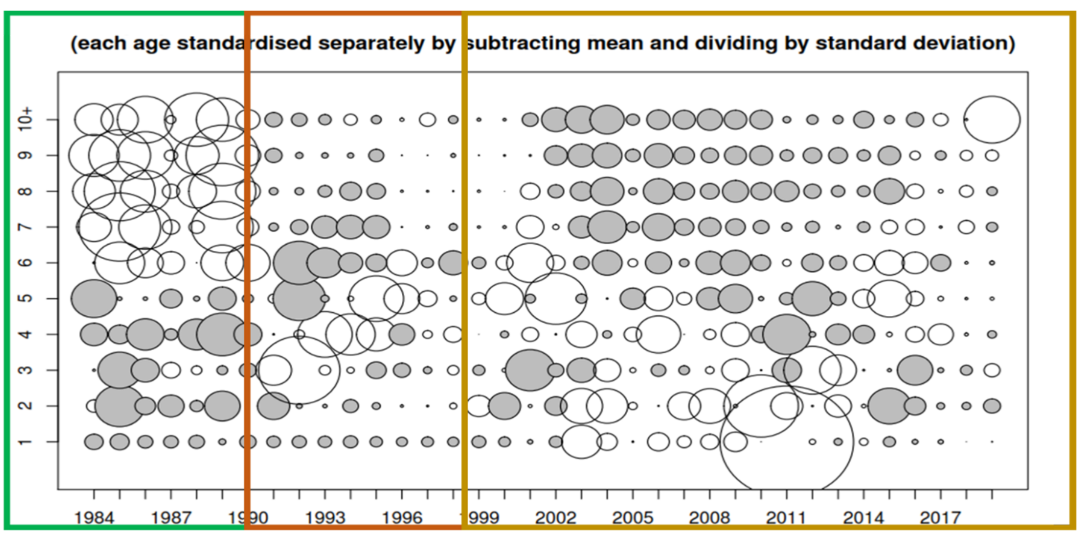
Catch numbers at age: landings (grey), discards (white).



Catch weight at age: landings (grey), discards (white).



Buble plots, grey is below average, white is above average



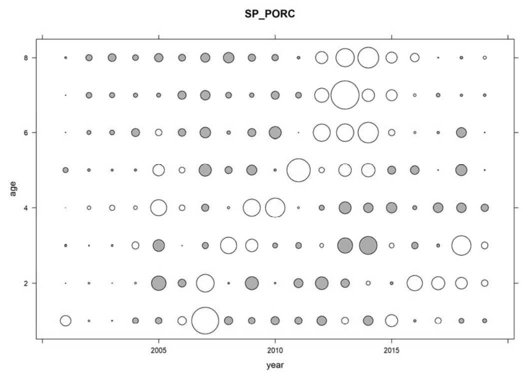
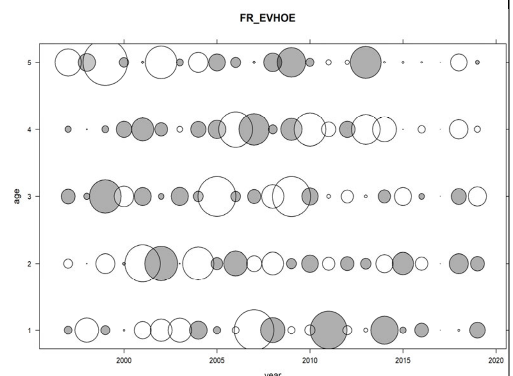
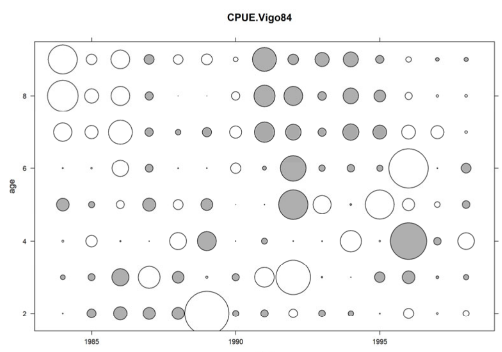
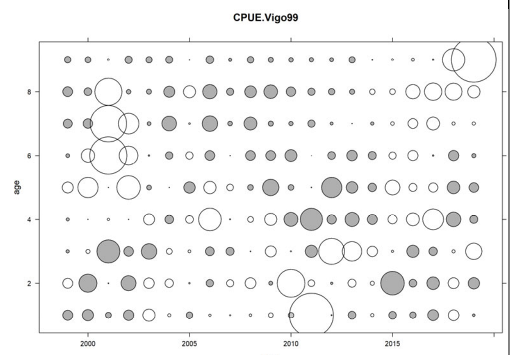
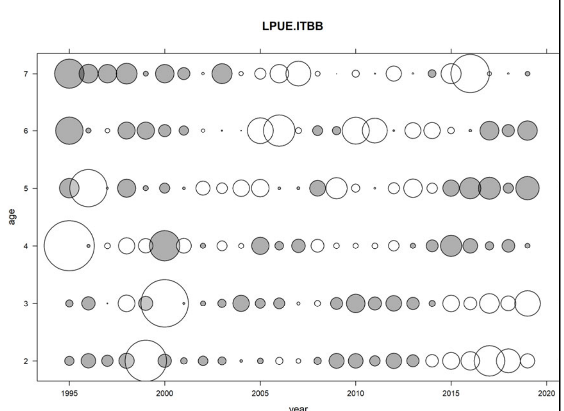
LANDINGS AND DISCARD BY COUNTRY: 1999____2019

CATCH DATA: 1984__1989

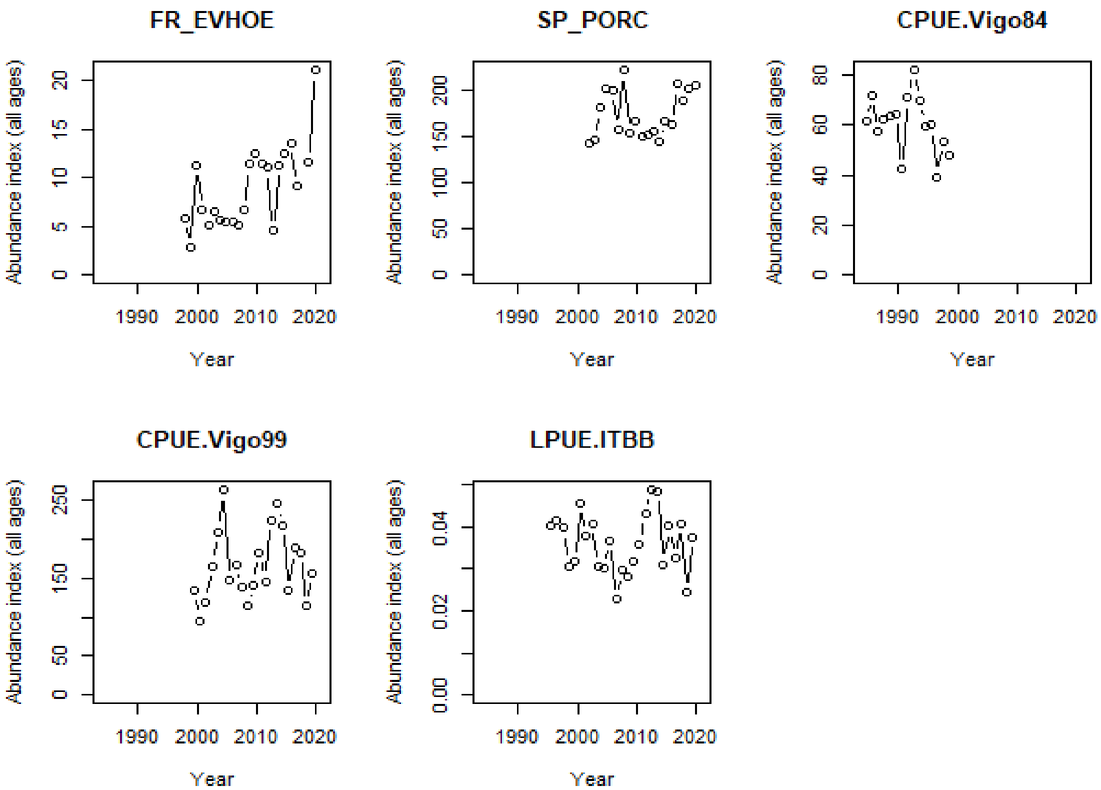
LANDINGS BY COUNTRY AND TOTAL DISCARD DATA: 1990____1998

In the catch at age data there are data from year 1984 to 2019 and ages 1 to 10. Three data periods could be observed, the first from year 1984 to 1989 where catch data by country were available. The second period from 1990 to 1998 where landing data was provided by country but for the discard data, a total discards were estimated. And the third period from year 1999 onwards, since 2000, an EU framework for the collection and management of fisheries data is in place, so all countries started to provide discard information by country and this could be reason to the increase of small ages in catch data.

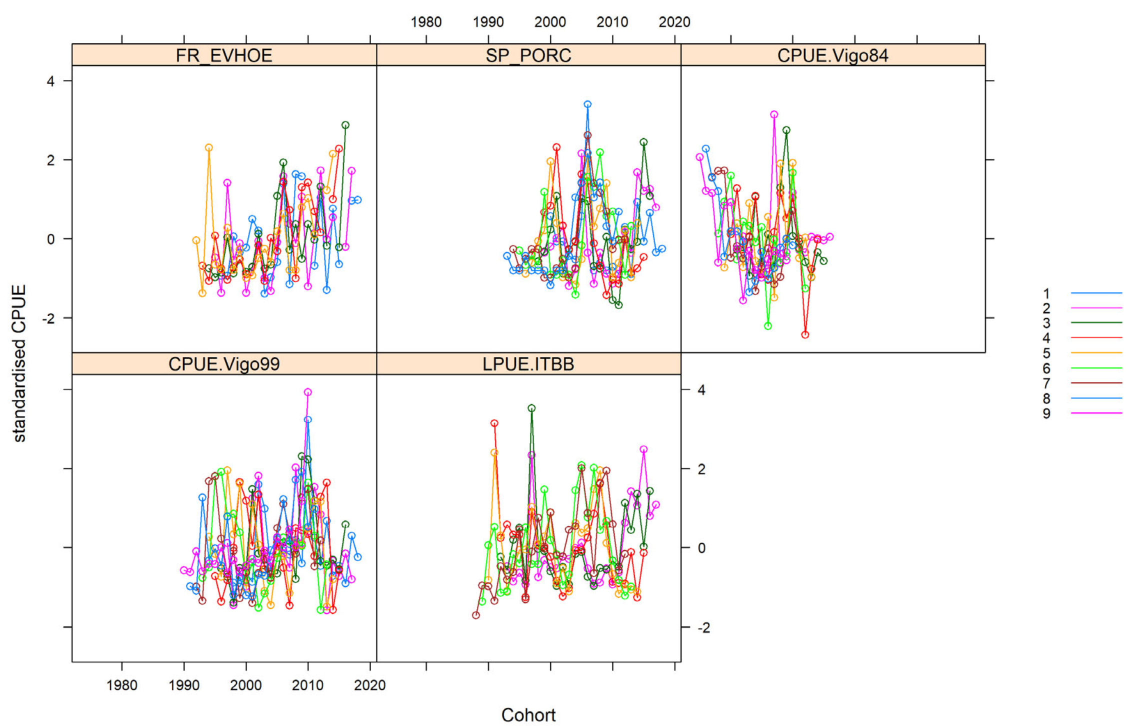
Cohort tracking in the tuning fleets.

Survey PORCUPINE 	Survey EVHOE 
Commercial VIGO 84 	Commercial VIGO 99 
Commercial IRTBB 	

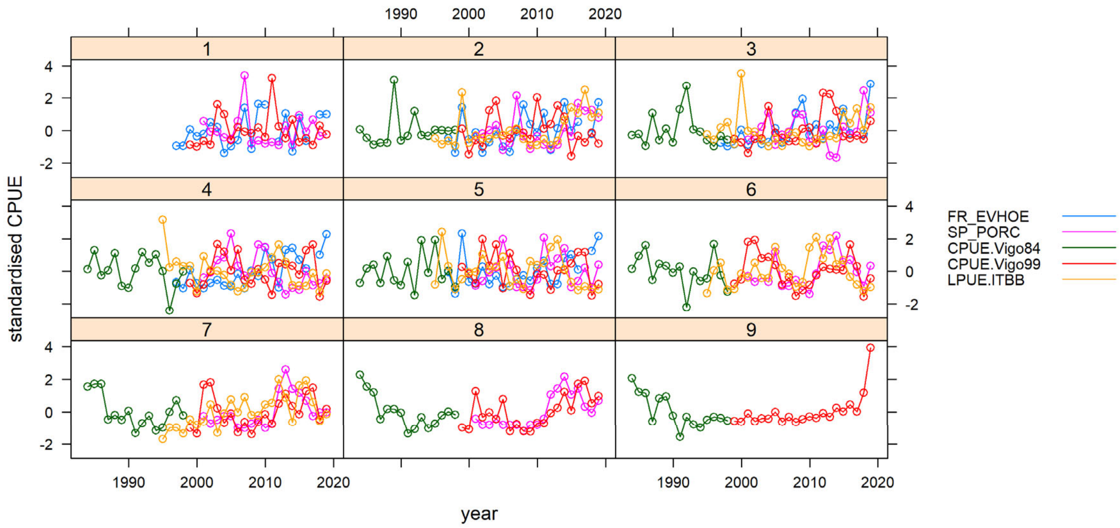
Abundance indices for all ages.



Standardised CPUE by cohort of the tunig fleets to analize the internal consistency of ages. Despite SP-Porcu survey shows a bit of consistency, in general all are a bit noisy.

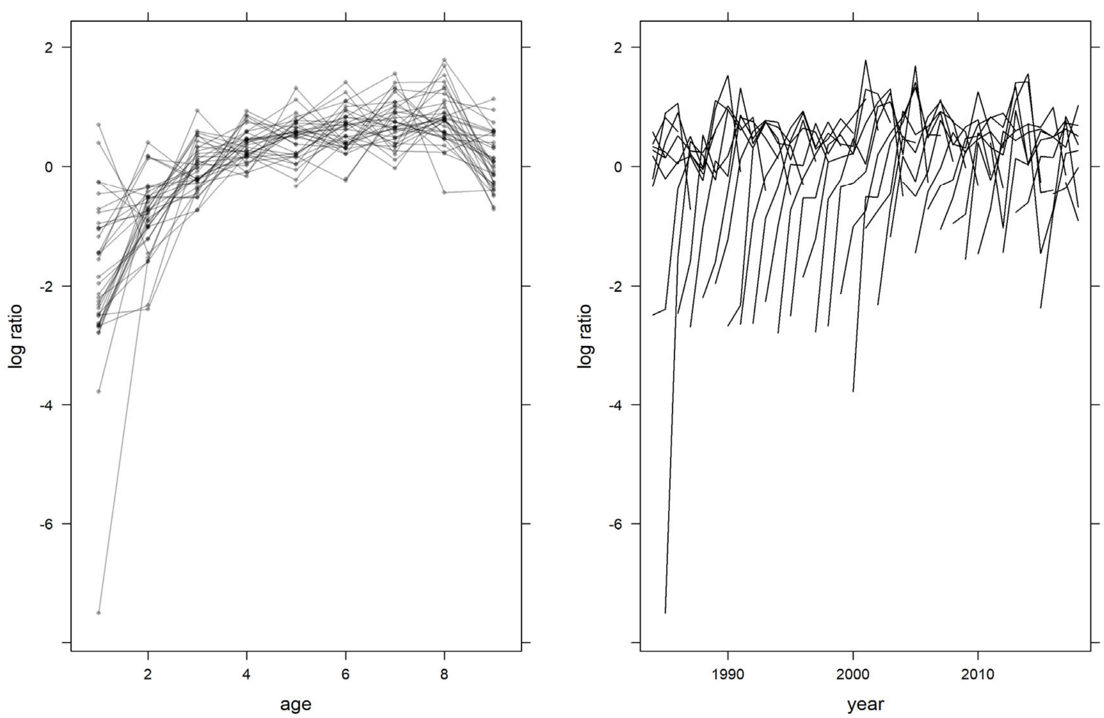


Standardised CPUE by cohort of the tunig fleets to analize the internal consistency of tuning fleets, in general all are a bit noisy.

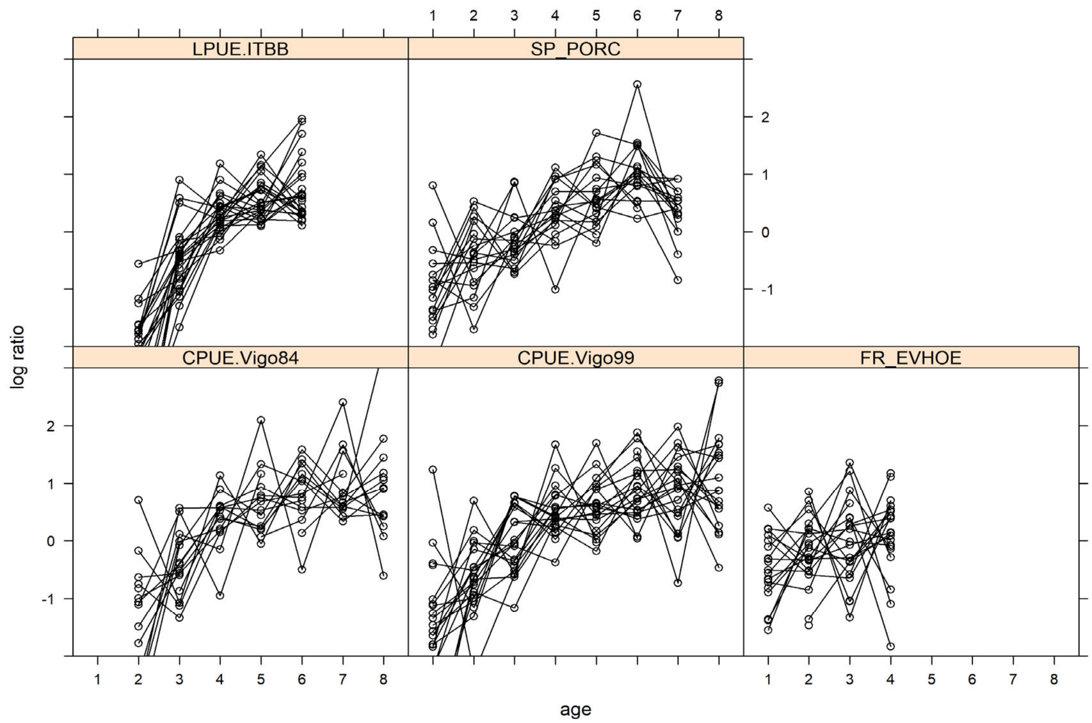


The log-ratios of the catch and tuning data can give an indication of the selectivity pattern of the fleets and surveys.

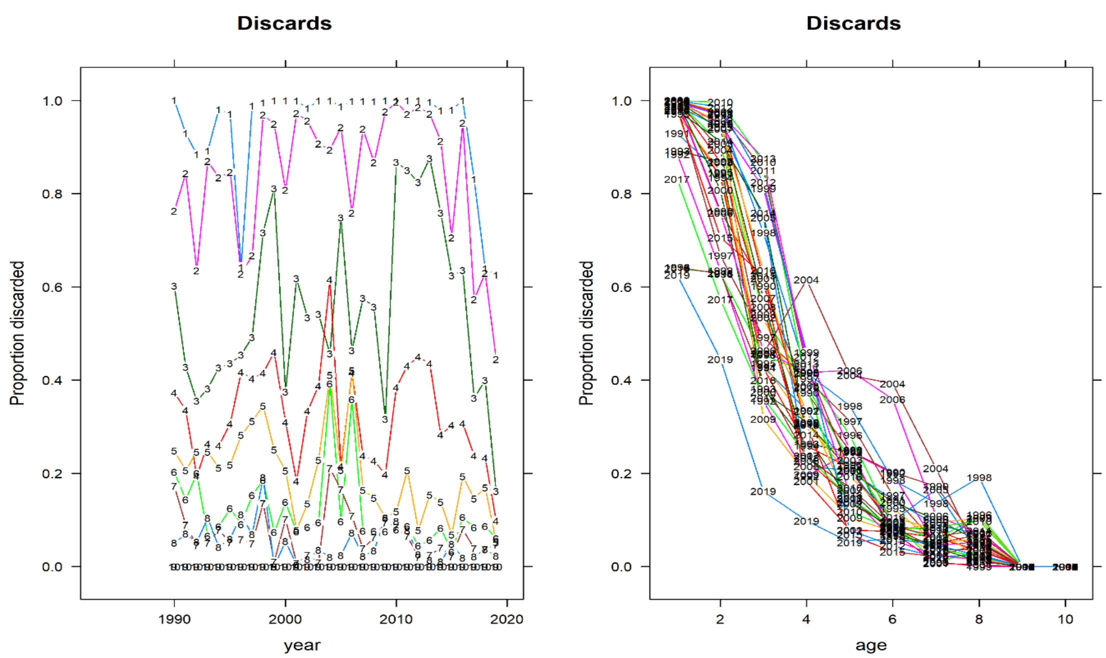
Log ratio of the catch data. This pattern suggest a relatively flat-topped selection. A logistic selectivity may be appropriate. this class encapsulates results of a log ratio at age per cohort method.



Log-ratios of tuning fleet data. For LPUE.ITBB, SP-PORC, CPUE.Vigo84. CPUE.Vigo99 a logistic curve may be appropriate. For FR-EVHOE survey a 'flat? Catchability model may be appropriate (i.e. same q for all years).



Discard data



Discard data by country are available from 1990 onwards. Discards occur mainly from years 1 to 3 and it is observerd that due to the landing obligation, the discard percentage shows a decrease from year 2019.

3 Results

Based on the exploratory analysis, several exploratory assessments are proposed:

3.1 Run 1: BASE CASE

An initial assessment was condicted using all fleets.

The **submodels** should be defined and for the initial run, they were defined as follows:

-fmod(F at age): a formula object depicting the model for log fishing mortality at age.

fmod <- ~factor(replace(age,age>9,9)) + factor(year)

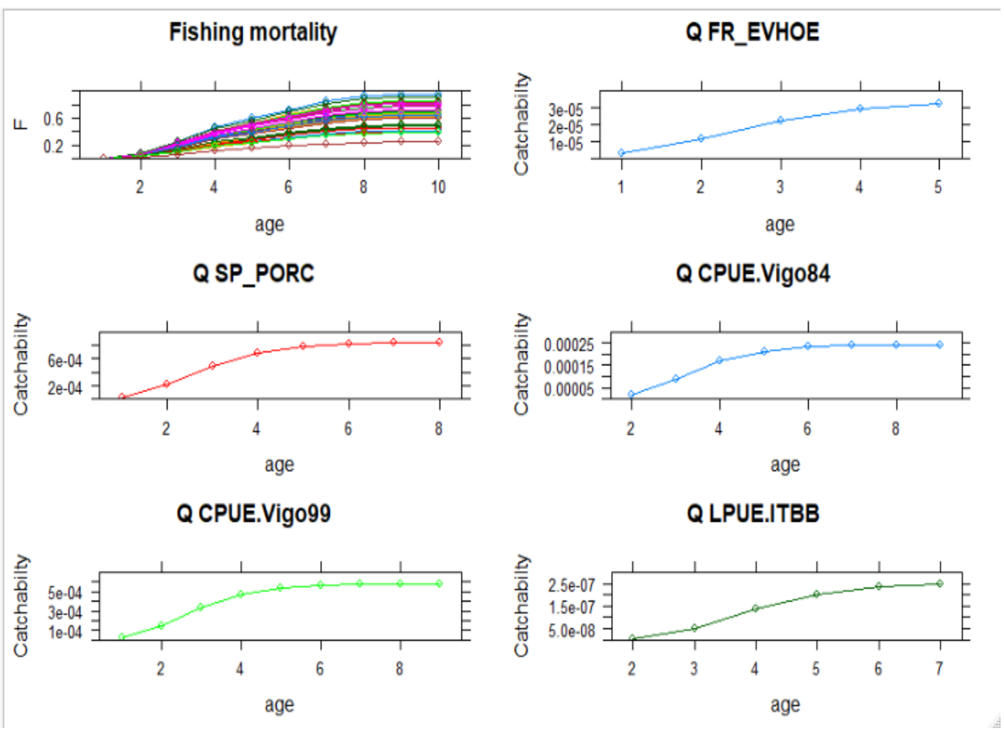
-srmod (model for recruitmen): a formula object depicting the model for log recruitment

srmod <- ~factor(year) #this stock-recruitment model (srmod) is 'free'; i.e. there is no restriction on the estimated recruitment, based on the SSB.

-qmod (catchability at age): a list of formula objects depicting the models for log survey catchability at age.

#the order for megrim tuning fleet is: "FR_EVHOE" ,"SP-PORC", VIGO84, VIGO99, IRTBB.

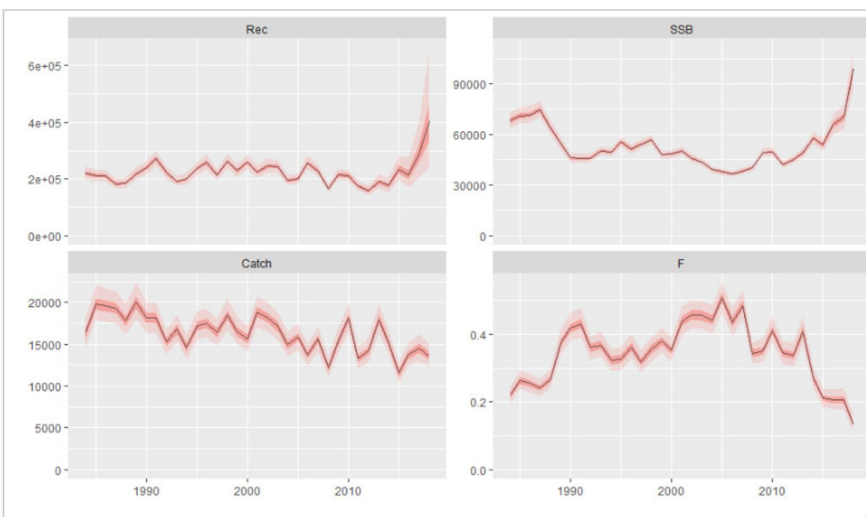
qmod <- list(~I(1/(1 + exp(-age))),~I(1/(1 + exp(-age))),~I(1/(1 + exp(-age))),~I(1/(1 + exp(-age))),~I(1/(1 + exp(-age))))# logistic function for all tuning fleets

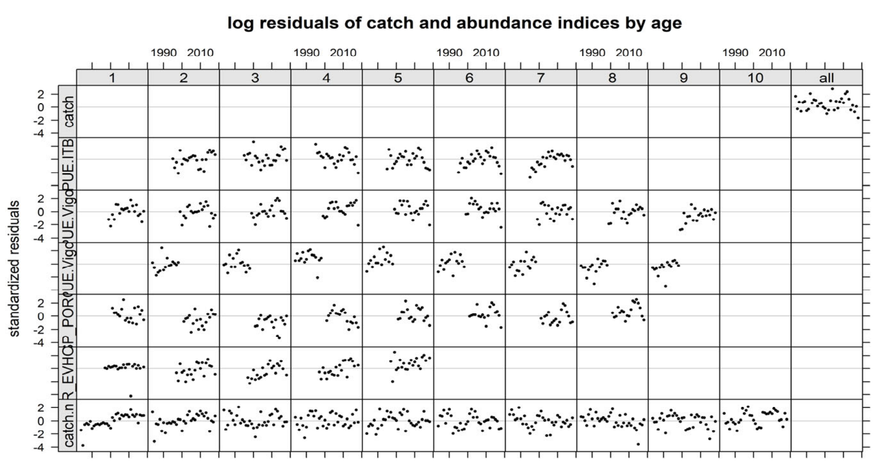


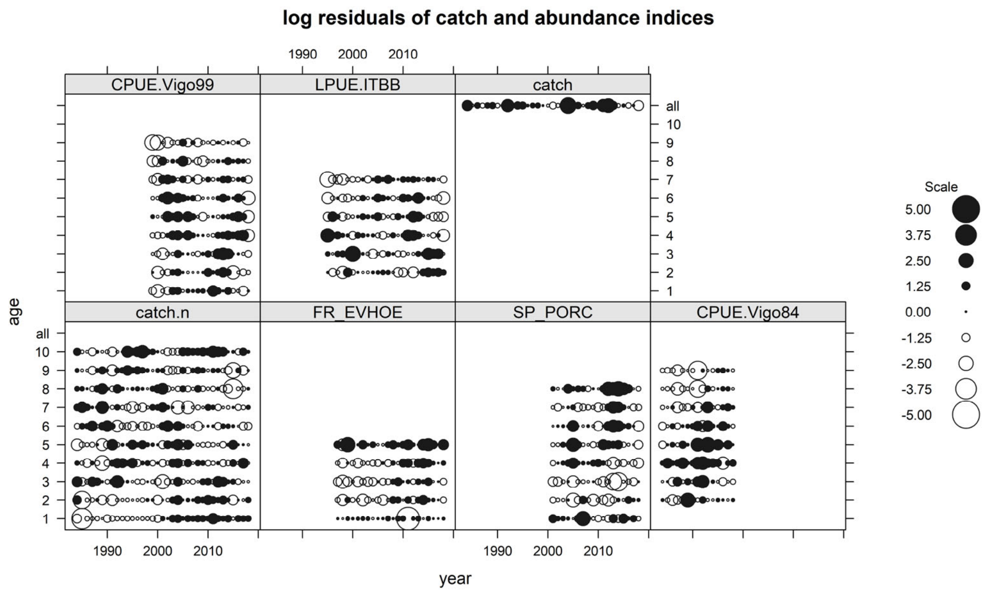
```
fit1 <- sca(stock,tun.sel,fmodel=fmod,qmodel=qmod,srmodel=srmod)
submodels(fit1)
fmodel: ~factor(replace(age, age > 9, 9)) + factor(year)
            srmodel: ~factor(year)
            n1model: ~s(age, k = 3)
             qmodel:
               FR_EVHOE:    ~I(1/(1 + exp(-age)))
               SP_PORC:     ~I(1/(1 + exp(-age)))
               CPUE.Vigo84: ~I(1/(1 + exp(-age)))
               CPUE.Vigo99: ~I(1/(1 + exp(-age)))
               LPUE.ITBB:   ~I(1/(1 + exp(-age)))
             vmodel:
               catch:       ~s(age, k = 3)
               FR_EVHOE:    ~1
               SP_PORC:     ~1
               CPUE.Vigo84: ~1
               CPUE.Vigo99: ~1
               LPUE.ITBB:   ~1
```

3.1.1 Results: Base Case

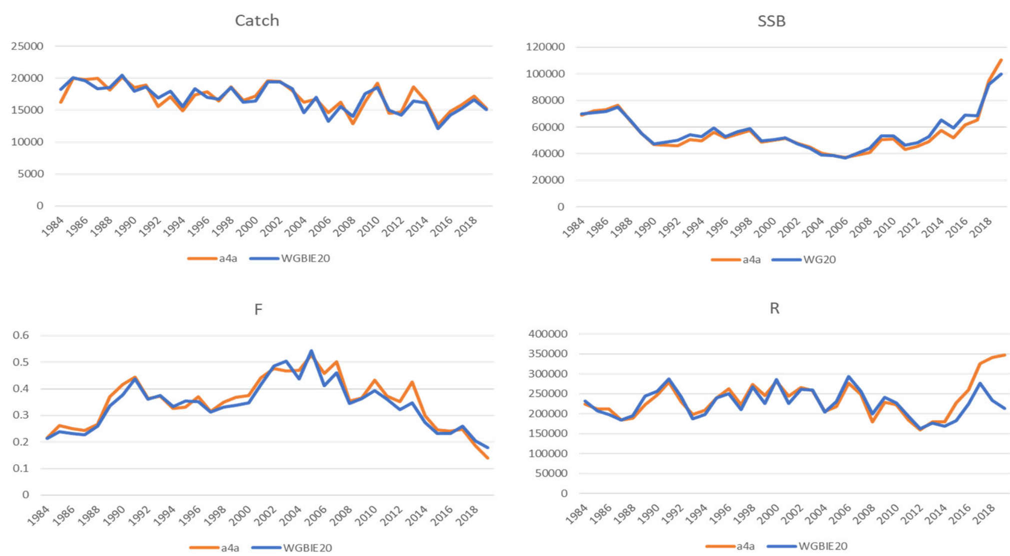
In the initial exploratory run using logistic curve for catchability (qmod) for all fleets.







When comparing the stock status estimates using a4a and the results obtained in the WGBIE 2020



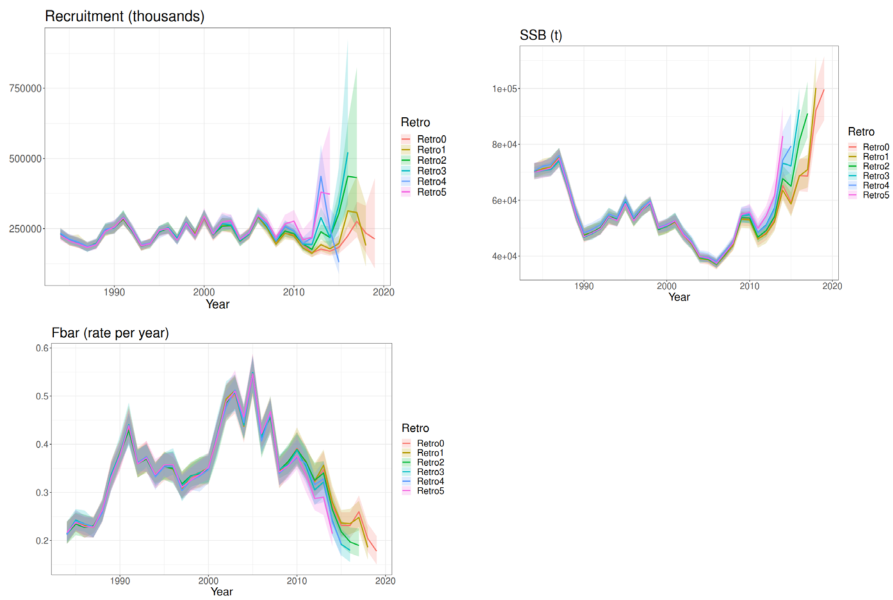
3.1.2 Retrospective pattern: Base Case

Retrospective analysis was conducted for 6 years, the retrospective time-series of most relevant indicators.

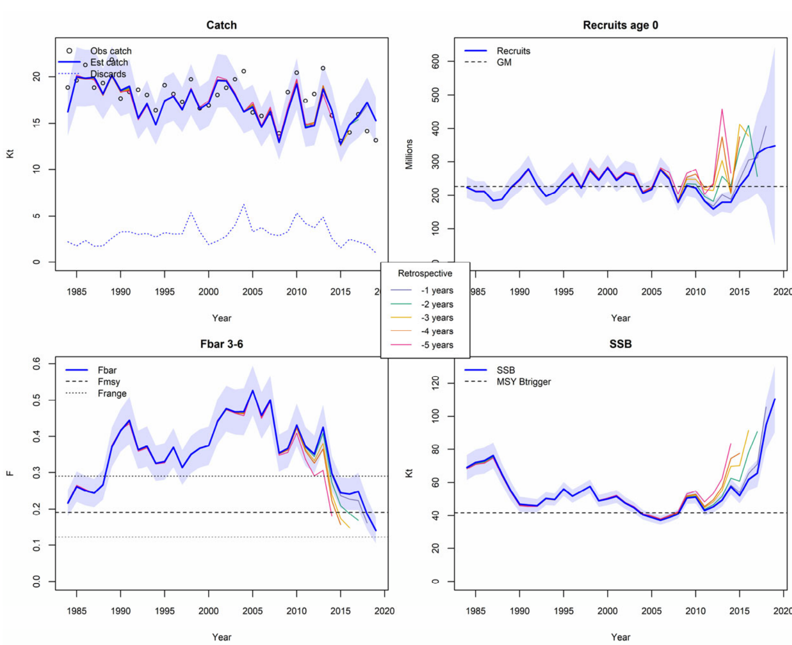
	RETRO A4A:	RETRO (WGBIE 20)
> mohn(Retro_F,plot=T)	-0.33	-0.1914
> mohn(Retro_SSB,plot=T)	0.36	0.2735
> mohn(Retro_R,plot=T) =	0.44	0.5239

R

RETRO WGBIE 2020



RETRO a4a 2020



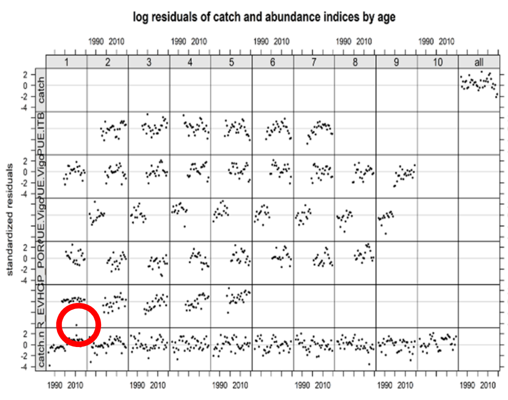
3.2 Run 2: Remove small values from EVHOE

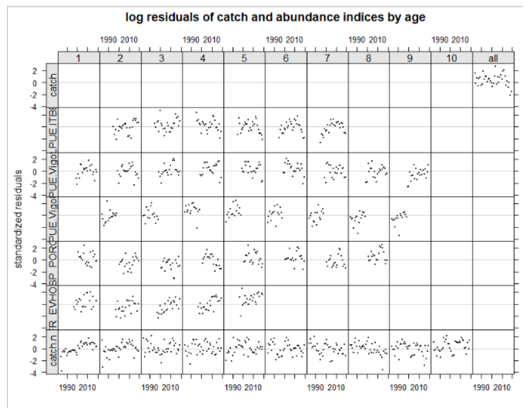
There was an error in a small value in Evhoe survey for age 1 in year 2011. The correct data was NA because there was no information for age 1 in year 2011 Evhoe survey, but when running the Bayesian model using NA, the model did not run, so 0.0001 value included.

But when analyng the residuals the outliers was observed and it was decided to replace it with NA.

replace very small survey value

index(tun.sel$FR_EVHOE)["1", "2011"] <- NA

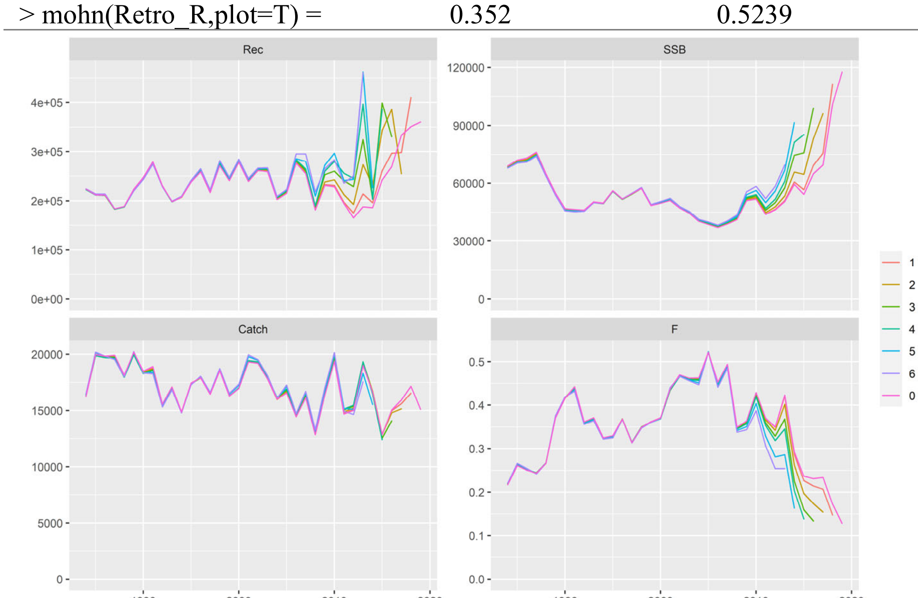




3.2.1 Retrospective pattern: Remove small values from EVHOE

Retrospective analysis was conducted for 6 years, the retrospective time-series of most relevant indicators.

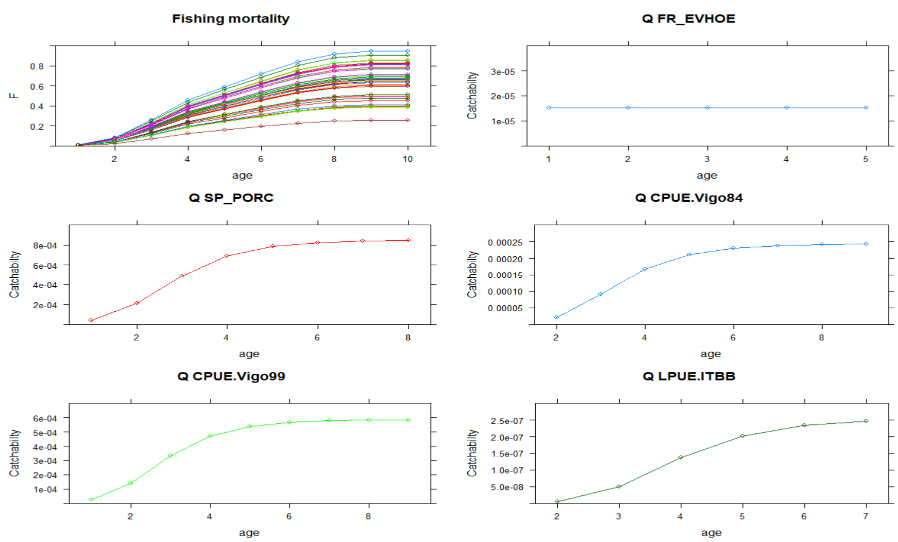
	RETRO A4A:	RETRO (WGBIE 20)
> mohn(Retro_F,plot=T)	-0.368	-0.1914
> mohn(Retro_SSB,plot=T)	0.415	0.2735
> mohn(Retro_R,plot=T) =	0.352	0.5239



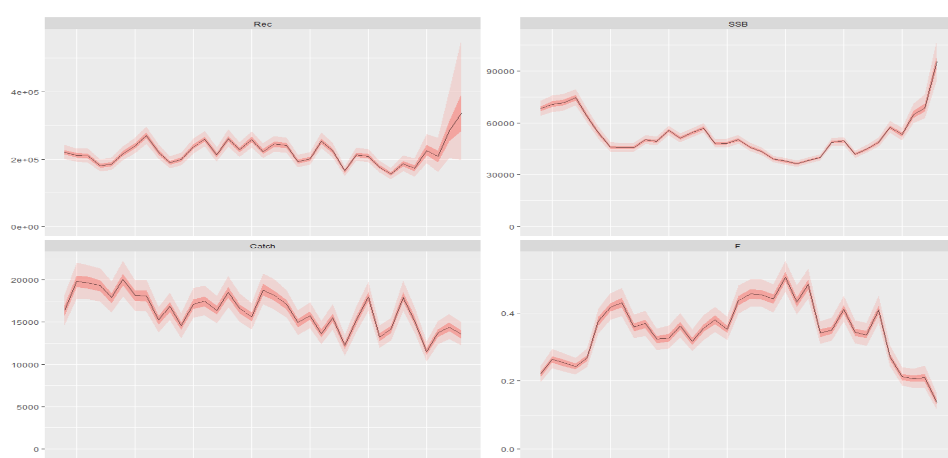
3.3 Run 3: Flat Q for EVHOE

In the data exploratory analysis, EVHOE survey catchabilities did not present a clear logistic curve, therefore a run applying flta catchability was applied.

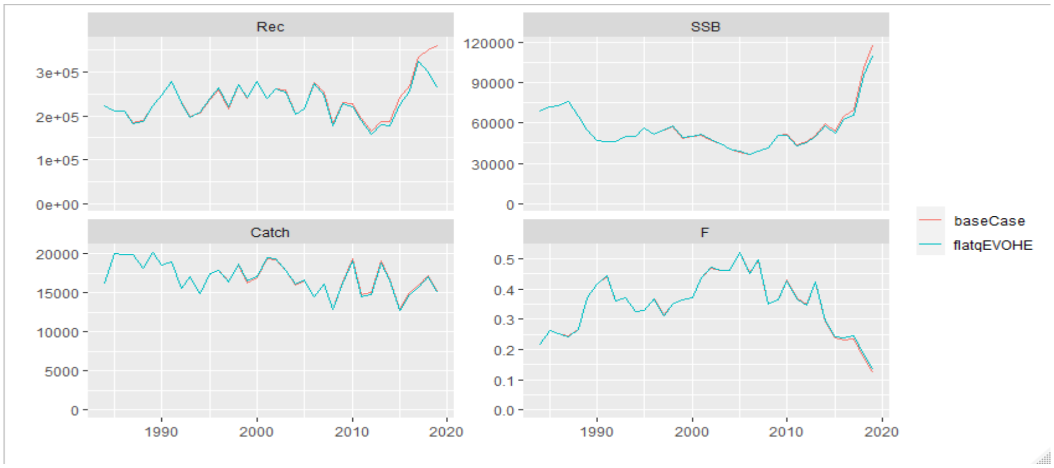
DATA	YEARS	AGES	RUN 1 q mod	RUN 2 q mod
Survey EVHOE	1997-2018	1-5	I(1/(1 + exp(-age)))	-1 (flat q: the same for all ages)
Survey PORCUPINE	2001-2018	1-8	I(1/(1 + exp(-age)))	I(1/(1 + exp(-age)))
Commercial VIGO 84	1984-1998	2-9	I(1/(1 + exp(-age)))	I(1/(1 + exp(-age)))
Commercial VIGO 99	1999-2018	1-9	I(1/(1 + exp(-age)))	I(1/(1 + exp(-age)))
Commercial IRTBB	1995-2018	2-7	I(1/(1 + exp(-age)))	I(1/(1 + exp(-age)))



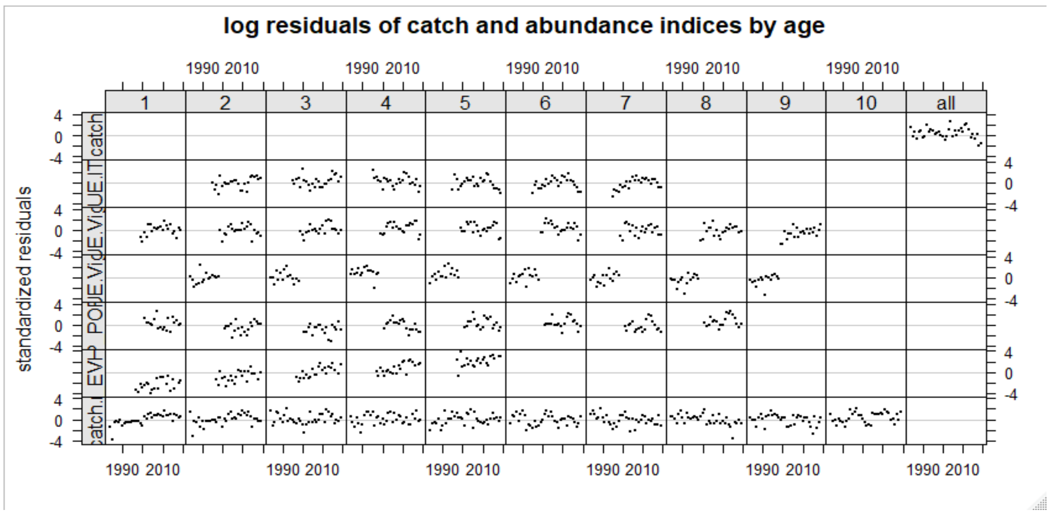
3.3.1 Results: flat Q for Evhoe

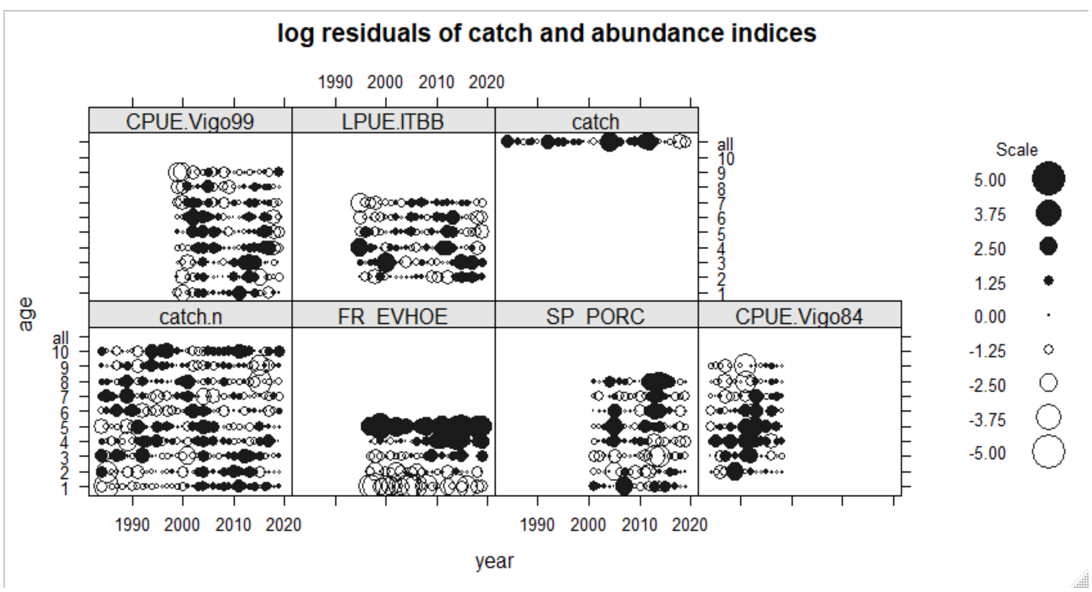


The comparison of Base Case with the run using q flat for EVHOE survey.



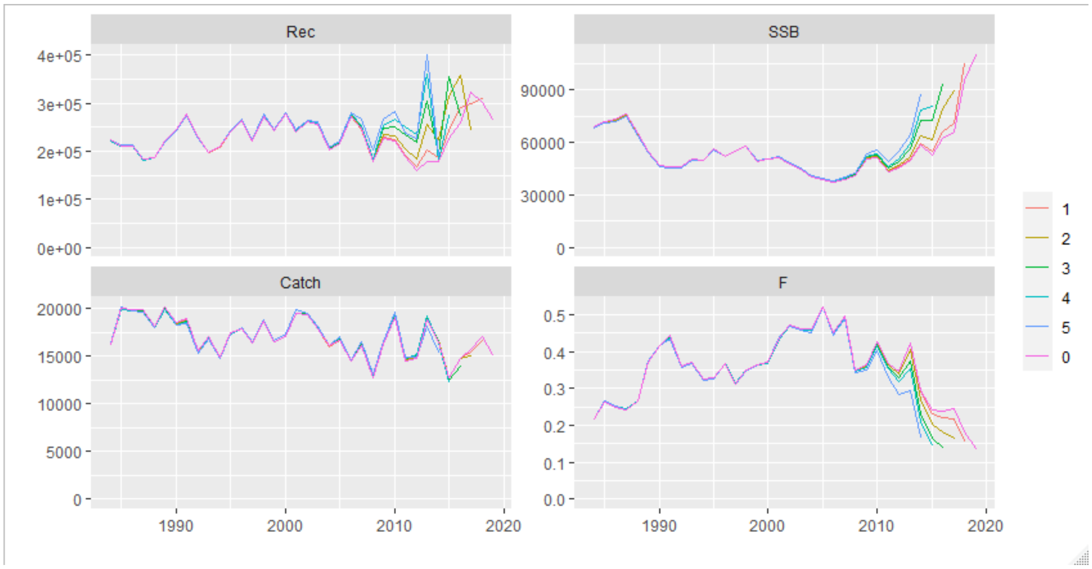
Using q flat for EVHOE survey.





3.3.2 Retrospective pattern: flat q for Evhoe

Retrospective analysis was conducted for 5 years using q flat for EVHOE survey, the retrospective time-series of most relevant indicators are shown in figure below.

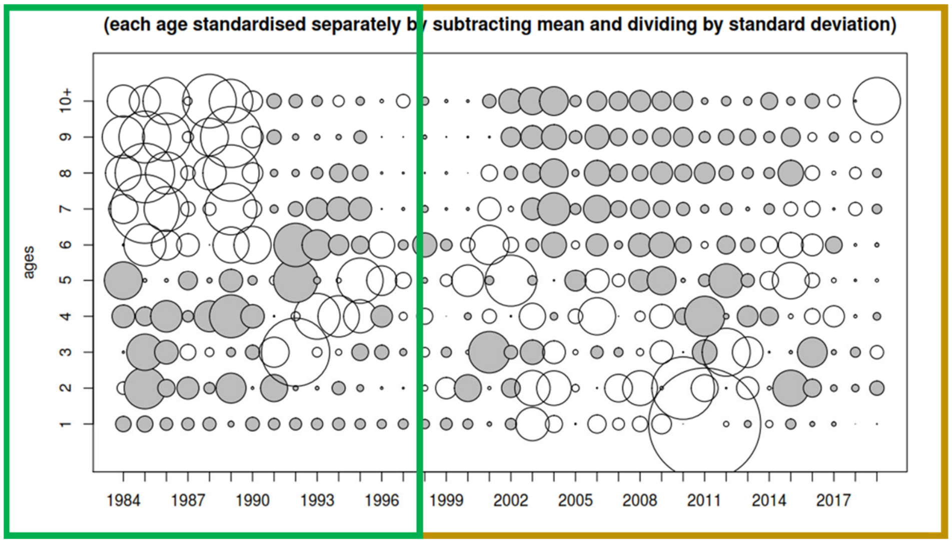


When comparing the retro values obtained in the 3 runs for the time-series of most relevant indicators, the lowest values for the Mohn indicator were the ones form the A4A Base Case.

	RETRO (WGBIE 20)	RETRO A4A:BASE CASE	RETRO A4A:QFLAT_EVHOE
> mohn(Retro_F,plot=T)	-0.191	-0.33	-0.335
> mohn(Retro_SSB,plot=T)	0.273	0.36	0.394
> mohn(Retro_R,plot=T) =	0.524	0.44	0.027

3.4 Run 4: Higher variance to data series from 1984 to 1998

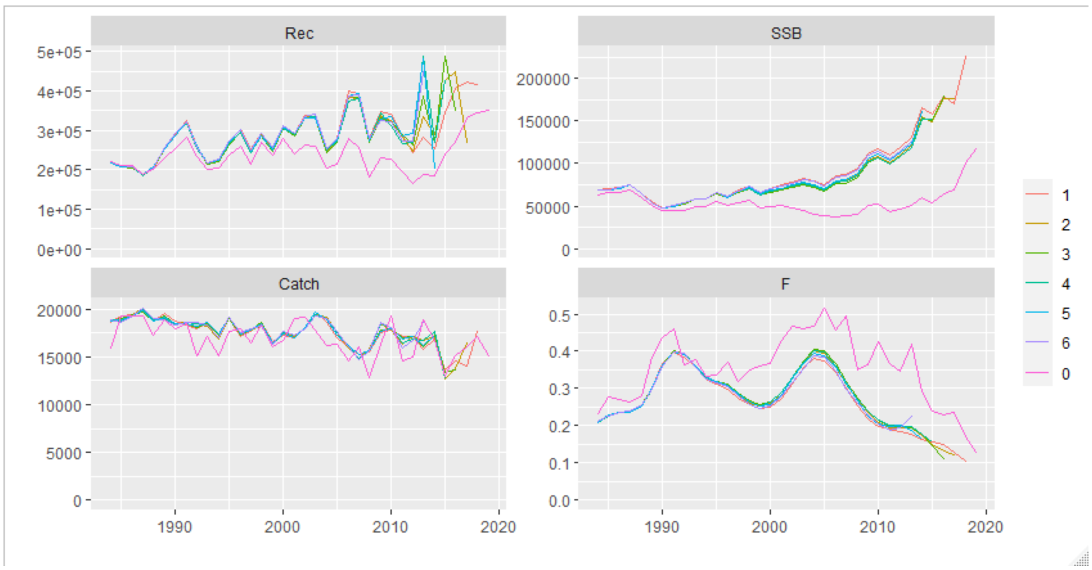
In the catch data table different periods are observed based on the residual of each of the periods. Therefore, weighting of catches was done giving less weight to the period from 1984:1998 (higher variance).

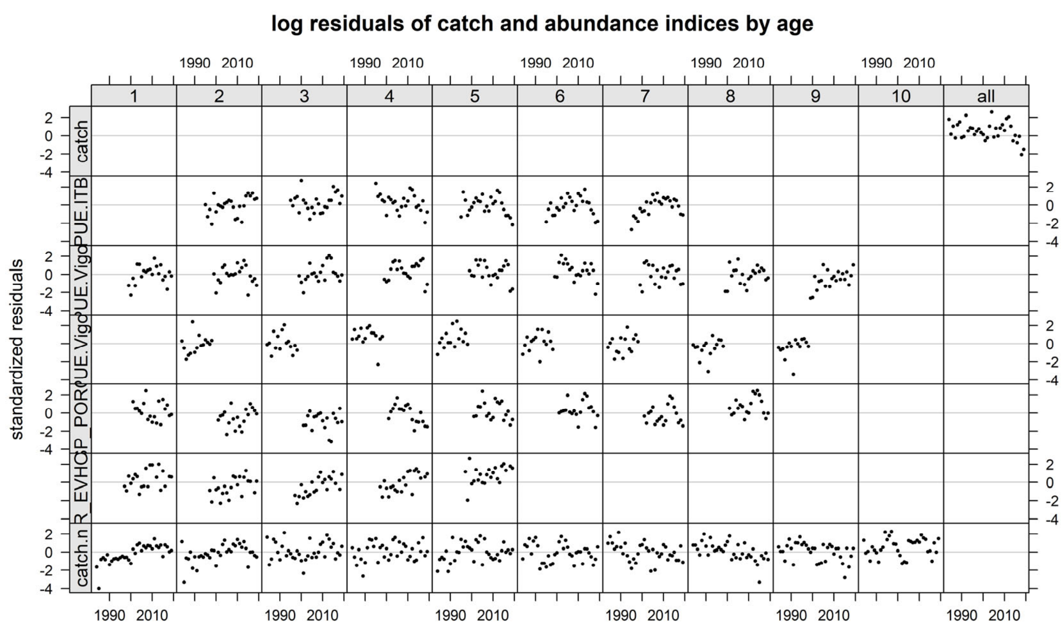



```
catch.n <- catch.n(stock)
catch.n.var <- replace(catch.n, TRUE, 1)
catch.n.var[,paste(1984:1998)] <- 2
catch.n_with_wts <- FLQuantDistr (catch.n, catch.n.var )
stock_with_wts <- stock catch.n(stock_with_wts) <- catch.n_with_wts
```

Retrospective plots show strange pattern, different for the last year assessment. As for the Mohr´ rho calculation lst year is not taken into account, the values are low, however it is not realistic value.

	AIC	BIC	Mohr´ rho (Retro_F)	Mohr´ rho (Retro_SSB)	Mohr´ rho (Retro_R)
Run 4: years 1984:1998 (higher variance)	1682	2186	-0.0064	-0.0147	0.0239





3.5 Run 5: List of different smooth for F and catchability

To analyse different smooth and catchabilities, a list of different options was proposed for f value and also for q values.

```
fmod_list <-
  list(
    sep_factor = ~ factor(replace(age, age > 9, 9)) + factor(year),
    sep_smooth1.1 = ~ factor(replace(age, age > 9, 9)) + s(year, k = 17),
    sep_smooth1.2 = ~ factor(replace(age, age > 9, 9)) + s(year, k = 15),
    sep_smooth1.3 = ~ factor(replace(age, age > 9, 9)) + s(year, k = 13),
    sep_smooth2.1 = ~ s(age, k = 5) + s(year, k = 17),
    sep_smooth2.2 = ~ s(age, k = 5) + s(year, k = 15),
    sep_smooth2.3 = ~ s(age, k = 5) + s(year, k = 13),
    sep_smooth3.1 = ~ s(age, k = 4) + s(year, k = 17),
    sep_smooth3.2 = ~ s(age, k = 4) + s(year, k = 15),
    sep_smooth3.3 = ~ s(age, k = 4) + s(year, k = 13),
    full = ~ s(age, k = 3) + s(year, k = 20) + te(age, year, k = c(3, 7)))
srmod <- ~ factor(year)
qmod_list <-list(
    logit = lapply(1:5, function(x) ~ I(1 / (1 + exp(-age)))),
    smooth = lapply(1:5, function(x) ~ s(age, k = 3)) )
```

F model	Q model	AIC	BIC	nopar
sep_smooth2.3	logit	1748.4	2117.3	74
sep_smooth2.2	logit	1740.5	2119.3	76
sep_smooth1.3	logit	1739.6	2128.5	78
sep_smooth1.2	logit	1731.5	2130.3	80
sep_smooth2.1	logit	1741.8	2130.6	78
sep_smooth3.3	logit	1773.2	2137.1	73
sep_smooth3.2	logit	1764.8	2138.6	75
sep_smooth1.1	logit	1732.8	2141.5	82
sep_smooth3.1	logit	1766.1	2150.0	77
sep_smooth2.3	smooth	1760.5	2154.3	79
sep_smooth2.2	smooth	1755.0	2158.8	81
sep_smooth2.1	smooth	1756.8	2170.5	83
sep_smooth1.3	smooth	1762.8	2176.6	83
sep_smooth1.2	smooth	1754.6	2178.3	85
sep_smooth1.1	smooth	1756.2	2189.8	87
sep_smooth3.3	smooth	1802.7	2191.5	78
sep_smooth3.2	smooth	1794.0	2192.7	80
sep_smooth3.1	smooth	1795.7	2204.5	82
sep_factor	logit	1743.5	2247.0	101
full	logit	1765.6	2249.1	97
full	smooth	1761.6	2270.0	102
sep_factor	smooth	1766.6	2294.9	106

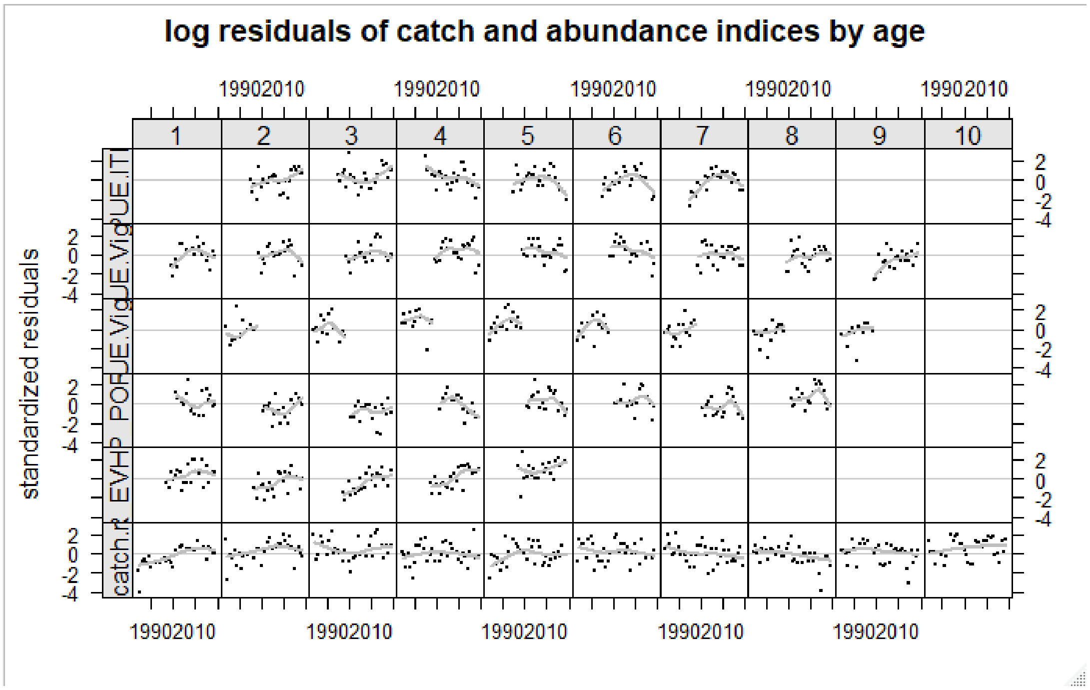
BEST FIT: based on the AIC and BIC values, this is the best model fit.

sep_smooth2.3 = ~ s(age, k = 5) + s(year, k = 13) #AI: the best fit for fmod based on AIC and BIC values.

fmod<-sep_smooth2.3 # best fmod

qmod<-lapply(1:5, function(x) ~ I(1 / (1 + exp(-age)))) #best qmod

fit_best<-sca(stock, tun.sel, fmodel = fmod, qmodel = qmod, srmodel = srmod)



The retrospective pattern of this run is not available due to a problem with the output of the script when using smooth values.

4 Sensibility analysis

Different runs are executed to analyse the effect of tuning fleets used in the assessment:

a) Leave one index out

- no "FR_EVHOE"
- no "SP_PORC"
- no "CPUE.Vigo84"
- no "CPUE.Vigo99"
- no "LPUE.ITBB"

b) One index at a time

-only "FR_EVHOE"
-only "SP_PORC"
-only "CPUE.Vigo84"
-only "CPUE.Vigo99"
-only "LPUE.ITBB"

c) No scientific surveys or only surveys

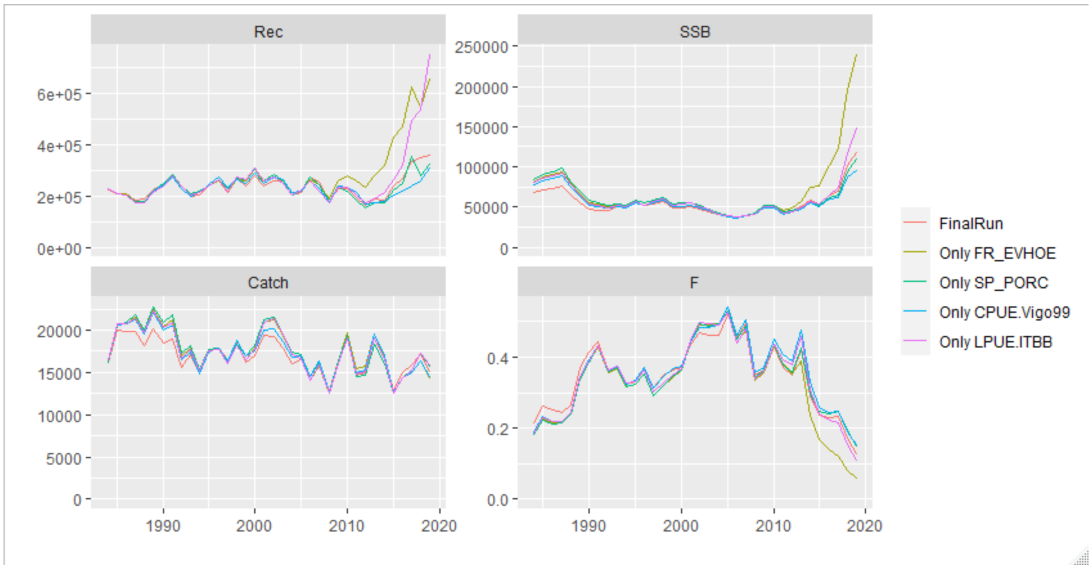
-no scientific surveys (i.e. only CPUEs and LPUEs)
-only surveys

Leave one index out:

When living one index out, the trends were very similar for the most important indicators.

Only one index

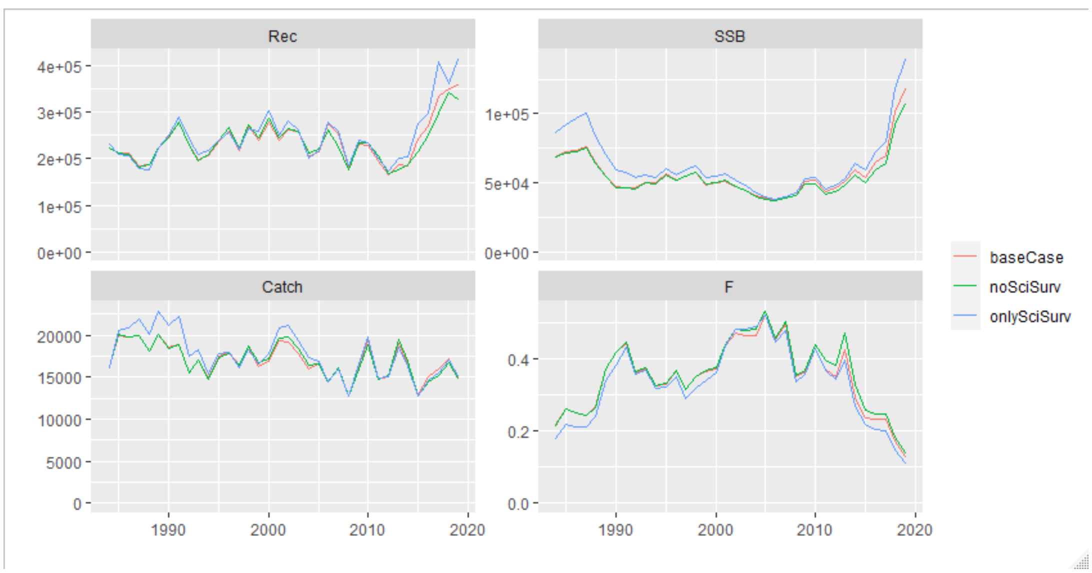
When using one index, in the case of using CPUE.Vigo84, results differ significantly as this time series goes from 1984 to 1998, so the runs for this index are leave out.



No scientific surveys or only surveys

Comparison of results using no scientific surveys and using only scientific surveys.

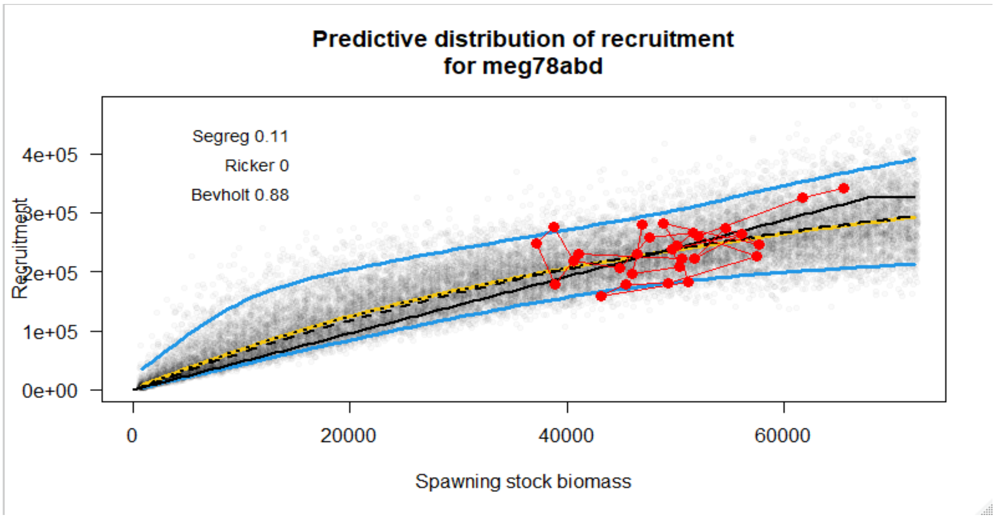
In this case, trends are very similar and results show small difference in the most recent years.



5 BRP, Forecast and catch option table

When implementing a new assessment with a new model, biological reference points (BRP) should be calculated. So first, refpts.R script was run to calculate new BRP. Then based on this new BRP, to provide the forecast and catch option table the scripts forecast.R and catch table.R (developed by Iago Mosqueira) were run to obtain this catch option table.

The preliminar runs of these codes were done with the fit of Run 2 (base case with removal of small values from EVHOE survey).



Based on ICES guidelines for reference points TYPE 5 was considered: “Stocks with no evidence that recruitment has been impaired or no relation between stock and recruitment apparent”. Where Blim = Bloss.

These are the new reference points estimated in WKTADSA 2021:

Btrigger	51600
Fmsy	0.153
Blim	37100
Bpa	51600
Flim	0.634
Fpa	0.0633
Fmsy (lower)	0.0961
Fmsy (upper)	0.221
F05	0.598

Basis	**Catch**	**Wanted**	**Un-wanted**	**F**	**Fwanted**	**F un-wanted**	**SSB**	**SSB change**	**TAC-change**	**Advice change**
MSY approach: F[MSY]	22185	20077	2108	0.153	0.107	0.014	146222	6.5	8.1	8.1
F=MAP F[MSY lower]	14393	13038	1354	0.096	0.067	0.009	154719	12.7	-30	-30
F=MAP F[MSY upper]	30757	27801	2956	0.221	0.154	0.021	136902	-0.32	50	50
MSY approach: F[MSY]	22185	20077	2108	0.153	0.107	0.014	146222	6.5	8.1	8.1
F[mp]	28201	25500	2701	0.2	0.14	0.019	139678	1.70	37	37
F=0	0	0	0	0	0	0	170467	24	-100	-100
F[pa]	9663	8759	904	0.063	0.044	0.006	159887	16.4	-53	-53
F[lim]	70830	63589	7241	0.633	0.442	0.059	93835	-32	250	250
SSB (2022)=B[pa]	111590	99122	12467	1.405	0.98	0.132	51608	-62	440	440
SSB(2022)=B[lim]	126380	111616	14764	1.925	1.343	0.181	37139	-73	520	520
SSB(2022)=MSY B[trigger]	111590	99122	12467	1.405	0.98	0.132	51608	-62	440	440
F[2020]	20487	18544	1943	0.14	0.098	0.013	148072	7.8	-0.191	-0.191
Roll-over TAC	20526	18580	1946	0.141	0.098	0.013	148030	7.8	0.00	0.00

6 Conclusion

Results obtained from the comparison of a4a model and Bayesian model using default setting on the same data show similar trends and absolute values.

Several runs were done using different setting. In this WD five of them are presented. The run with the lowest AIC values and low Mohr´ rho index is the run 4, where the variance is higher for the older data in the catch data times series. However, retro plots in this case show strange pattern and despite some revision was done to the script, more work in needed to improve this retro output.

Some sensitivity analysis were presented to analyse the effect of tuning fleets used in the assessment. In general, when leaving one index out, including one index at a time or doing the assessment only with scientific surveys, results are very robust. Despite there are some changes in the absolute values the trends follow the same pattern.

During WKTADSA new reference points and assessment forecast scripts were applied and catch option table was presented for the base case.

Results of a4a model seems to be promising, and a lot of work has been already done. The change to this more standardized model is proposed to ease the implementation, shorten the iteration times from the previous Bayesian model and include this stock aseesment into the ICES Transparent Assessment Framework (TAF).

	AIC	BIC	Mohr´ rho (Retro_F)	Mohr´ rho (Retro_SSB)	Mohr´ rho (Retro_R)
Run 1: Base Case	1743	2247	-0.368	0.36	0.44
Run 2: Remove small value EVHOE	1743	2247	-0.368	0.415	0.352
Run 3: Flat Q for EVHOE			-0.335	0.394	0.027
Run 4: years 1984:1998 (higher variance)	1682	2186	-0.0064	-0.0147	0.0239
Run 5: List of different smooth	1747	2206	-0.157	0.147	0.135

WKTaDSA – 1. 16th to 20th November 2020

WKTaDSA – 2. 18th to 22nd January 2021

Preliminary assessments of megrim (*Lepidorhombus whiffiagonis*) and Four-spot megrim (*L. boscii*) in 8c9a using a4a model

By

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1 Introduction

Both southern megrims stocks *(L. whiffiagonis* and *L. boscii)* are assessed in ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). The model used in the assessment is Extended Survivors Analysis (XSA) (Shepherd, 1992), software VPA95 Lowestoft suite.

The XSA is a deterministic model. In recent years, the working group considers that it would be much more appropriate to use a model that incorporates uncertainty, especially since discards were included in the assessment.

During WGBIE 2020, a preliminary assessment with a4a statistical catch at age model was presented for megrim in 78abd. Based on that working document, this model was also chosen in a working group agreement to be tested in southern stocks.

2 Material and methods

The stock assessment model is a4a (assessment for all). It is a non-linear catch-at-age model implemented in R and FLR, and using ADMB. The model structure is defined by submodels, which are the different parts that require structural assumptions. There are 5 submodels in operation: a model for F-at-age, a model for the initial age structure, a model for recruitment, a (list) of model(s) for abundance indices catchability-at-age, and a list of models for the observation variance of catch-at-age and abundance indices (http://www.flr-project.org/doc/Statistical_catch_at_age_models_in_FLa4a.html).

A FLStock object is needed and it was adapted from XSA input data. This object includes catches, landings, discards, weights at age, natural mortality, maturity, harvest before spawning and mortality before spawning.

stock <- FLStock(catch.n =catches.n, landings.n= landings.n, discards.n=discards.n,
catch.wt=catches.wt,landings.wt=landings.wt, discards.wt=discards.wt, stock.wt=stock.wt,
catch= catches,landings=landings, discards=discards,
m=m, mat=mat,
harvest.spwn=harvest.spwn,m.spwn=m.spwn)

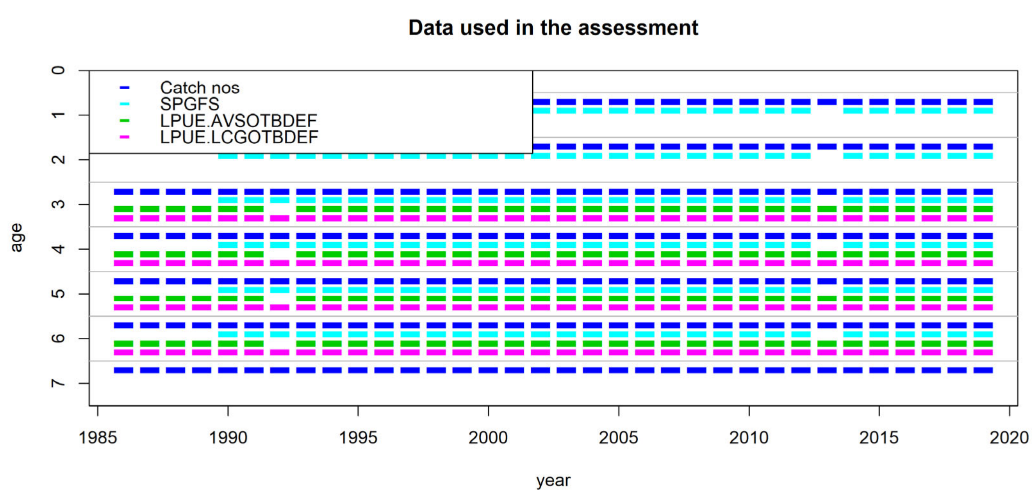
Also, for tuning indices, a FLIndices object was created for the three tuning fleets:

tun <- FLIndices(Tun1,Tun2,Tun3)

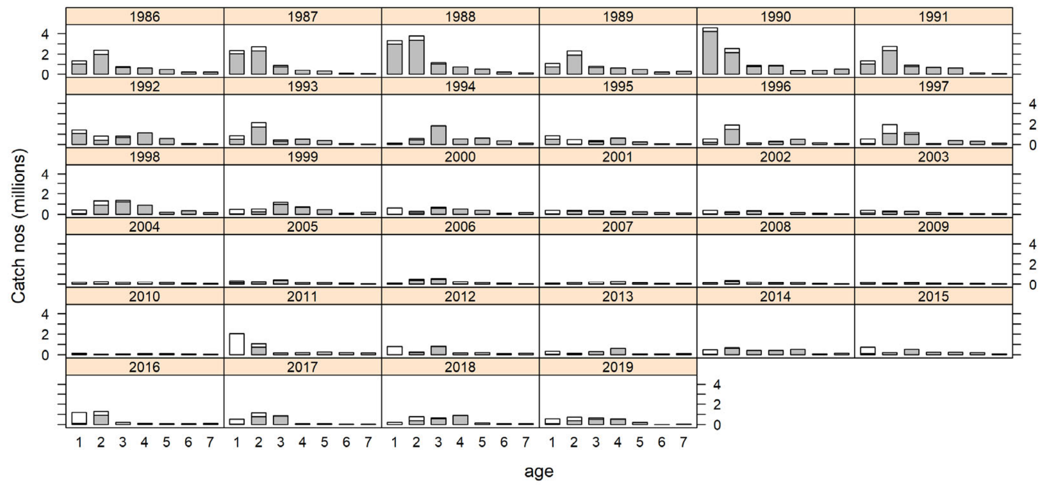
2.1. Input data and exploration: Megrim (*L. whiffiagonis*)

Input data, those defined in FLStock and FLIndices, were included in files inputmeg8c9a.RData and meg8c9aIndices.RData.

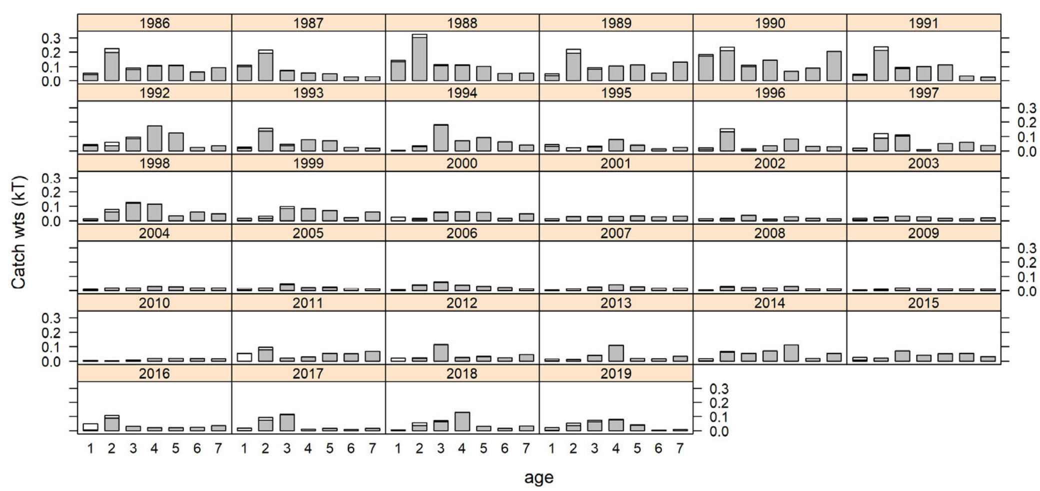
Tuning data for this stock are one Spanish groundfish survey (SpGFS-WIBTS-Q4) available since 1990 and two LPUE for the Spanish bottom trawlers targeting demersal fish based in A Coruña port (SP-LCGOTBDEF) and in Avilés port (SP-AVSOTBDEF) fishing in Division 8c since 1986. Data exploration can be seen in next outputs.



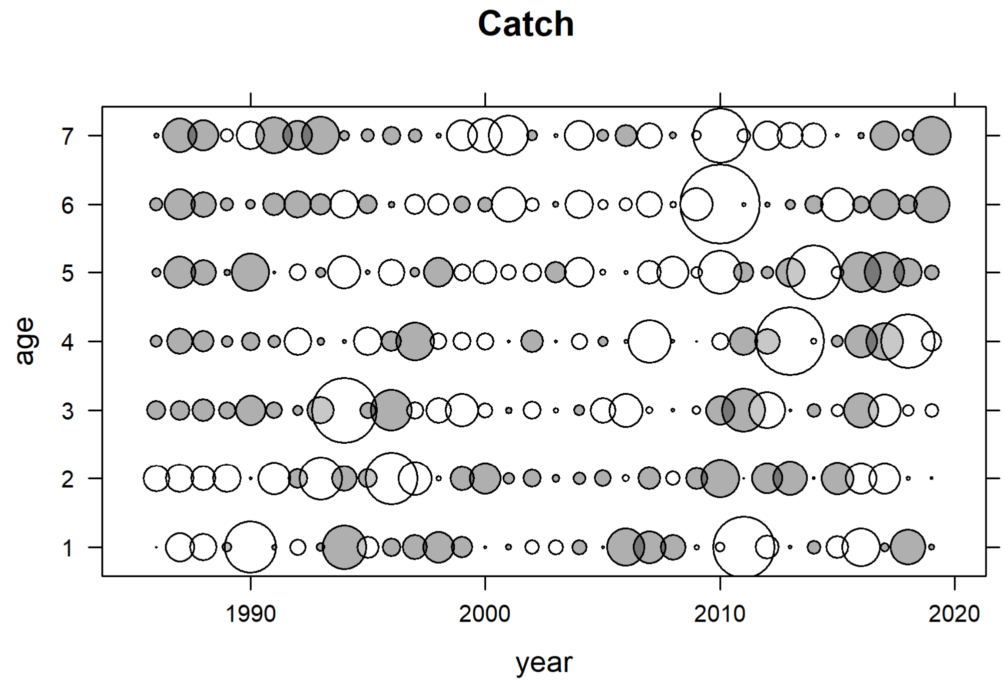
a. Input data used in the assessment. Catch (landings from Spain and Portugal, discards from Spain) and the three tuning fleets.



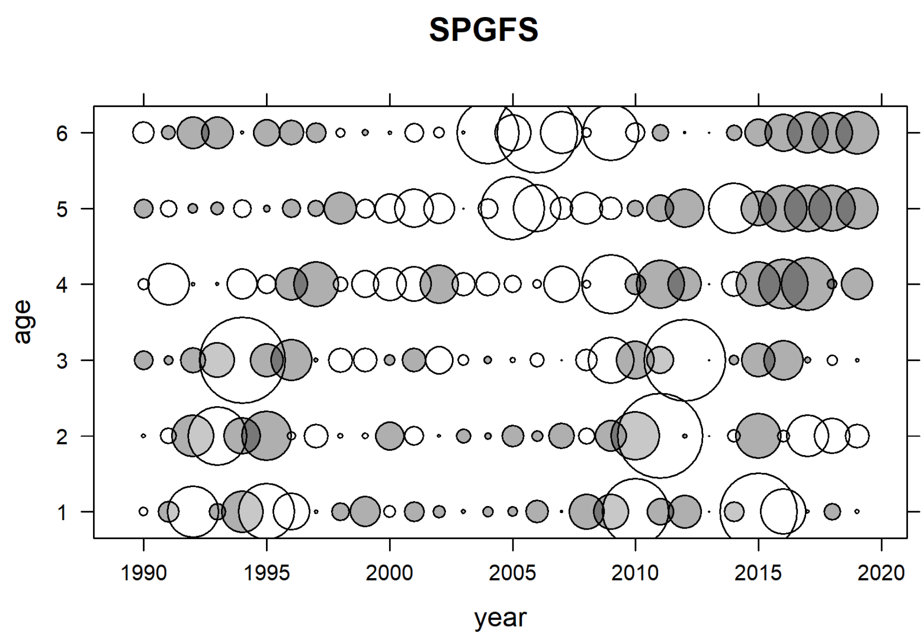
b. Catch numbers at age: landings are in grey, discards in white.



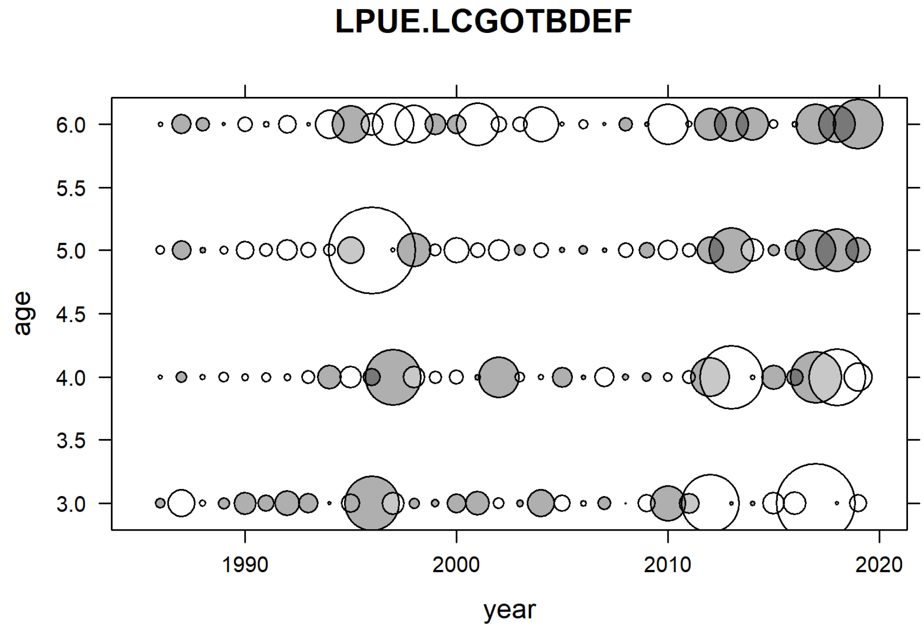
c. Catch weight at age: landings are in grey, discards in white.



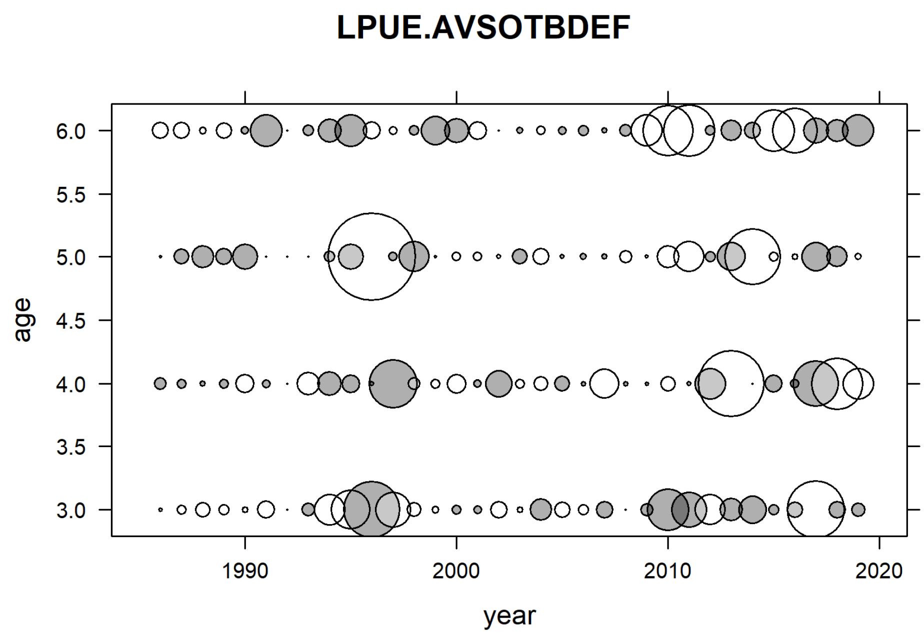
d. Catch by age data bubble plots, grey is below average, white is above average



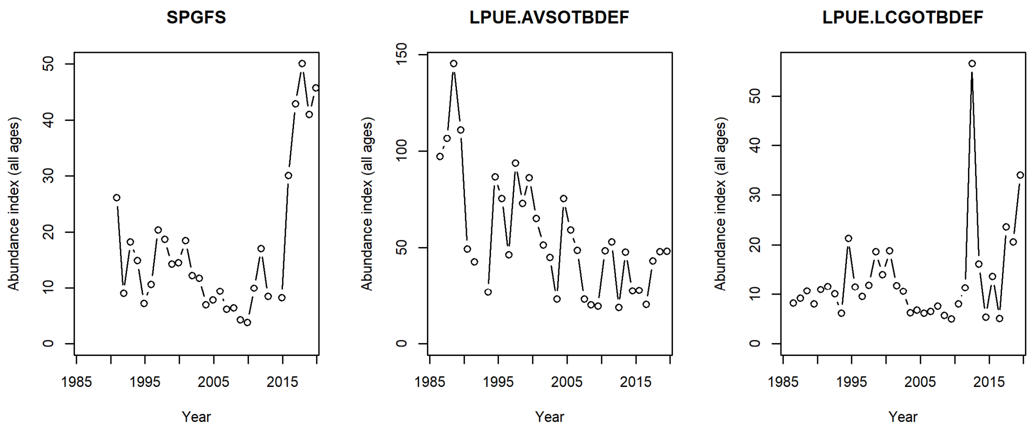
e. SpGFS-WIBTS-Q4 by age data bubble plots, grey is below average, white is above average



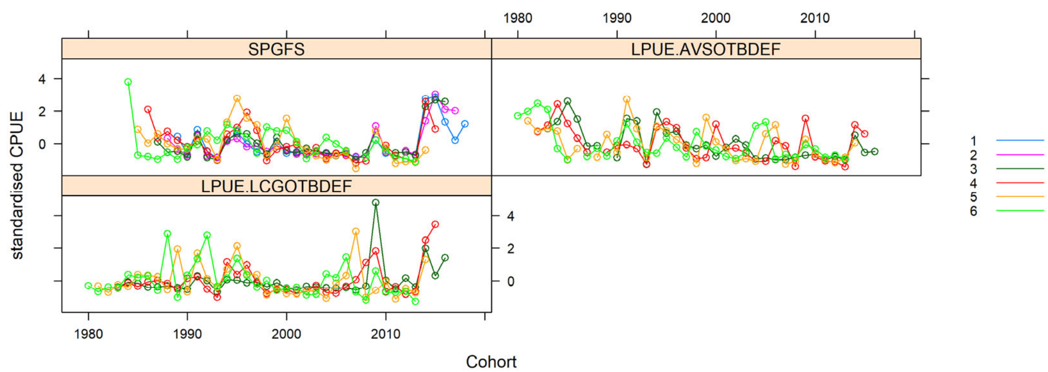
f. Commercial Coruña trawl by age data bubble plots, grey is below average, white is above average



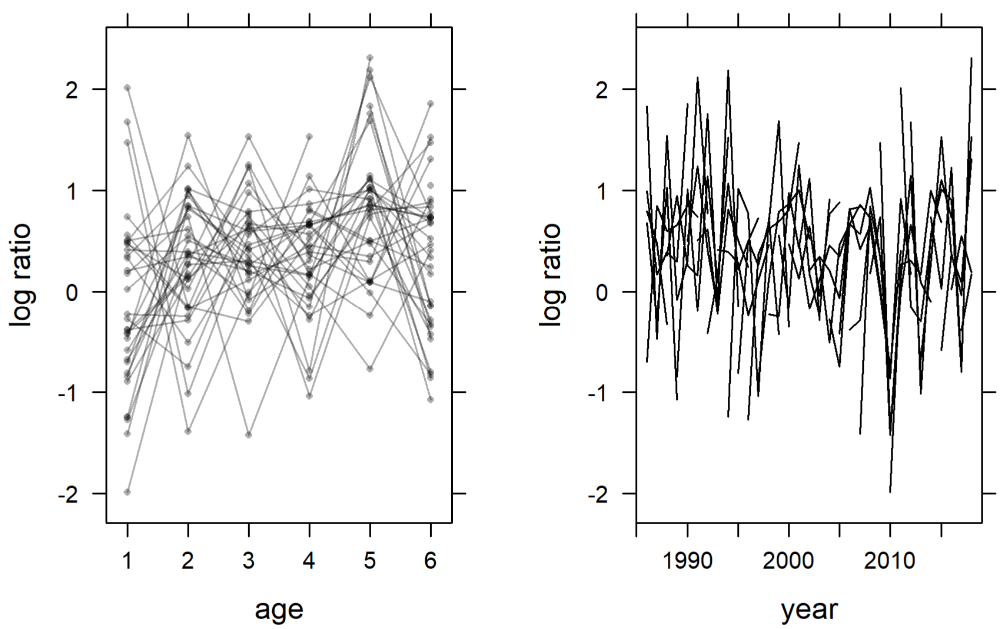
g. Commercial Avilés trawl by age data bubble plots, grey is below average, white is above average



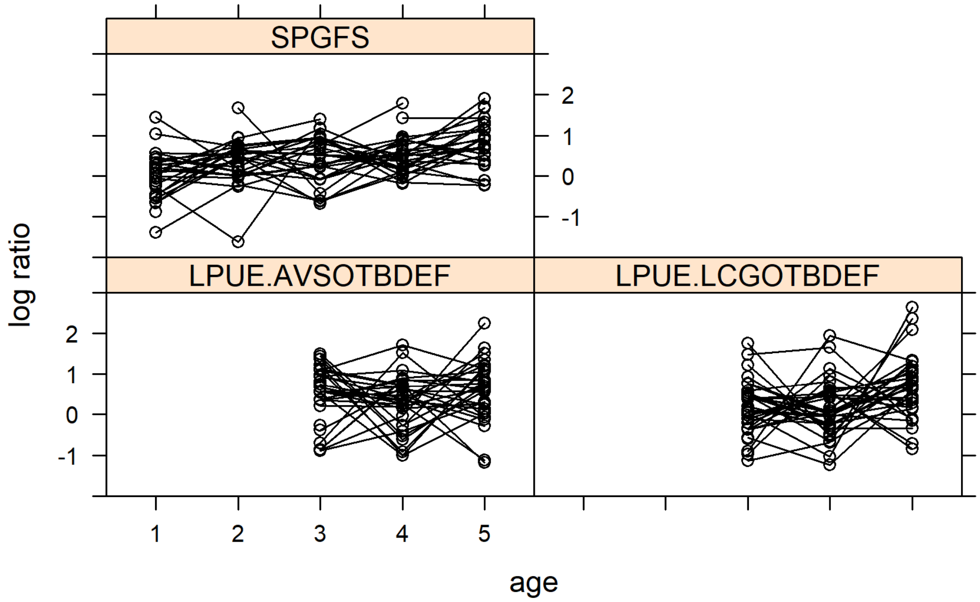
h. Abundance indices for all ages.



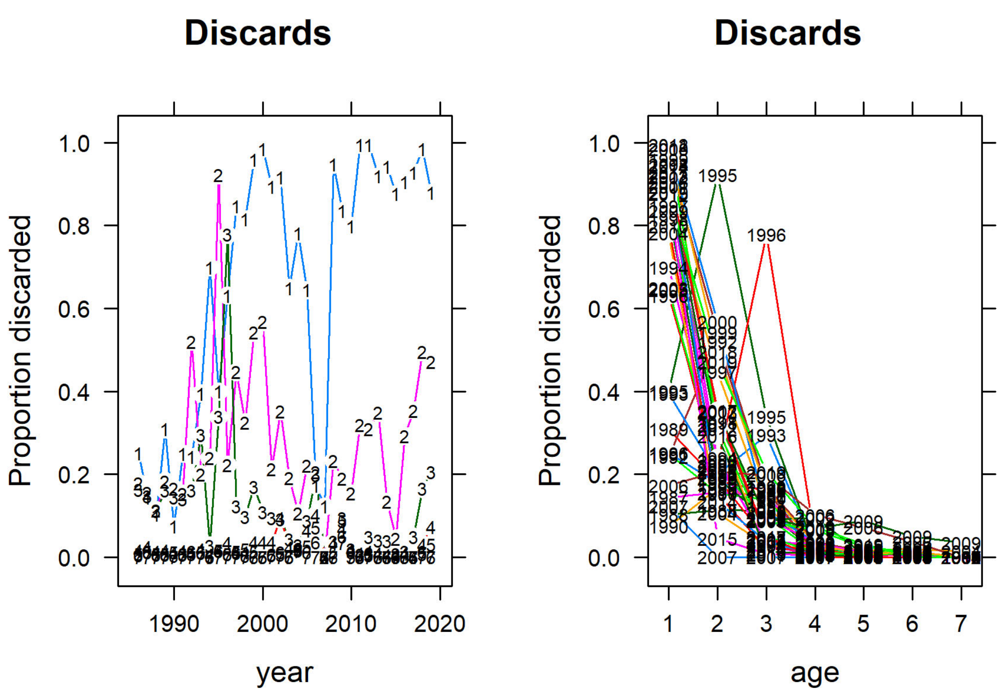
i. Standardised CPUE and LPUE by cohort of the tuning fleets.



j. Log ratio of the catch data by a age and by year.



k. Log-ratios of tuning fleet data

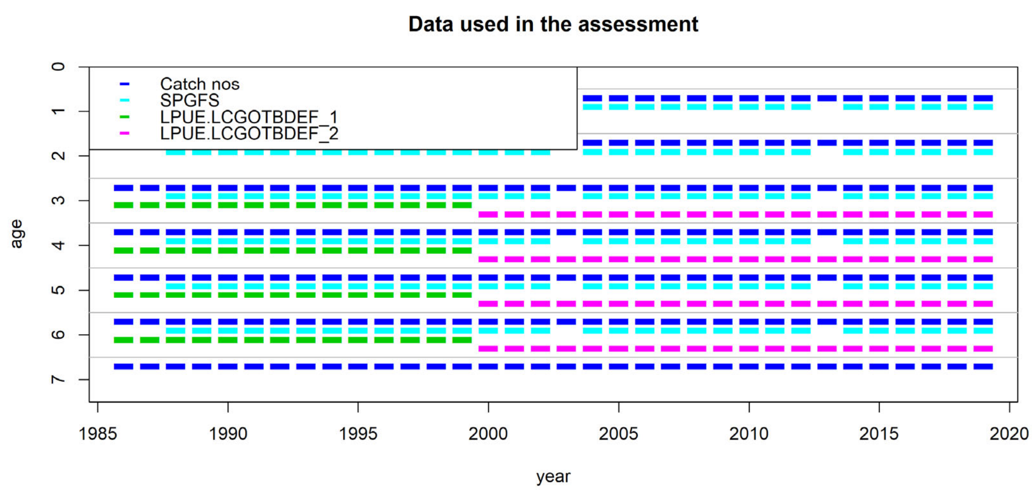


l. Proportion discarded by age and by year.

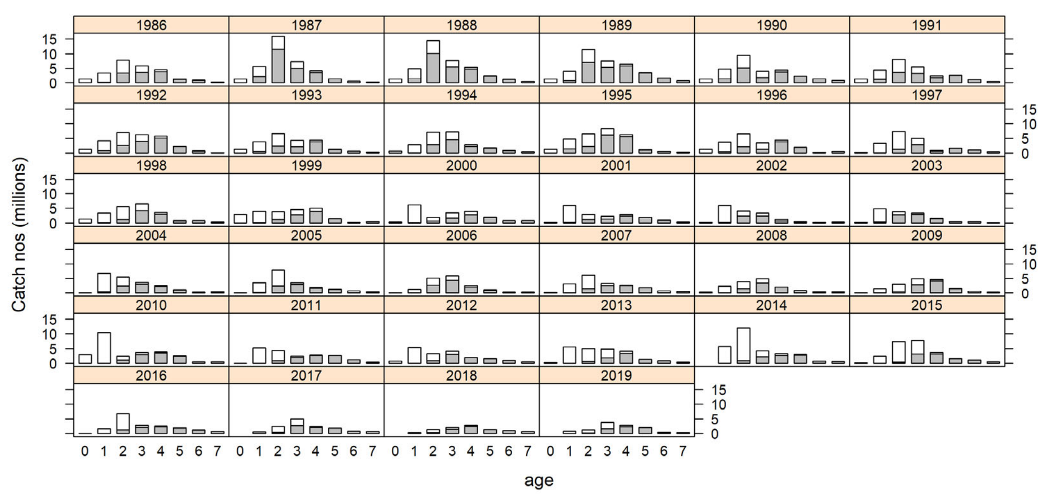
2.2. Input data and exploration: Four-spot megrim (*L. boscii*)

Input data, those defined in FLStock and FLIndices, were included in files inputldb8c9a.RData and ldb8c9aIndices.RData.

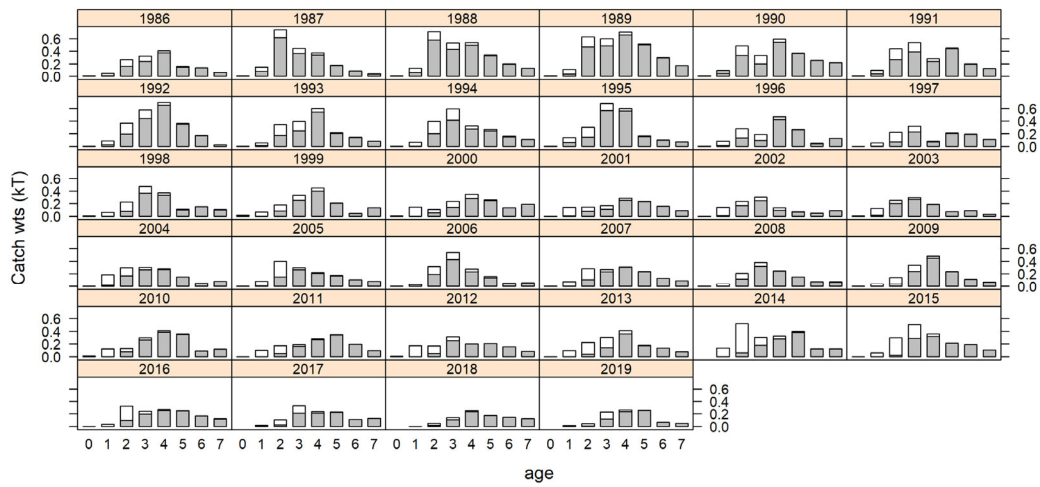
Tuning data for this stock are one Spanish groundfish survey (SpGFS-WIBTS-Q4) available since 1988 and two LPUEs for the Spanish bottom trawlers targeting demersal fish based in A Coruña port (SP-LCGOTBDEF-1 and SP-LCGOTBDEF-2) fishing in Division 8c and 9a which is really an index divided into two periods, from 1986 to 1990 and from 2000 onwards. Data exploration can be seen in next outputs.



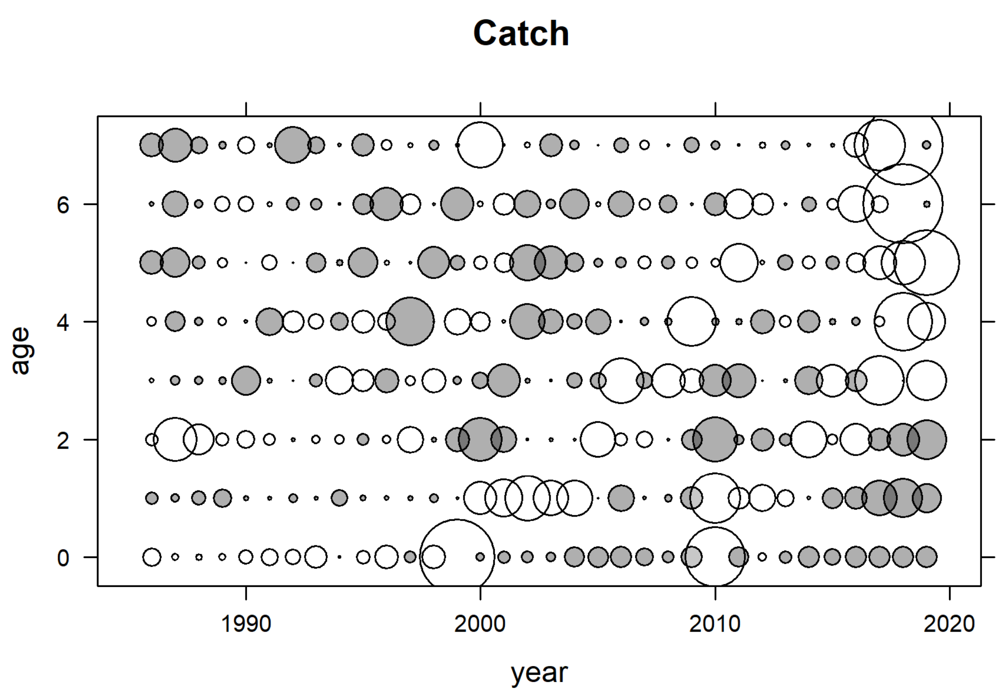
a. Input data used in the assessment. Catch (landings from Spain and Portugal, discards from Spain) and the three tuning fleets.



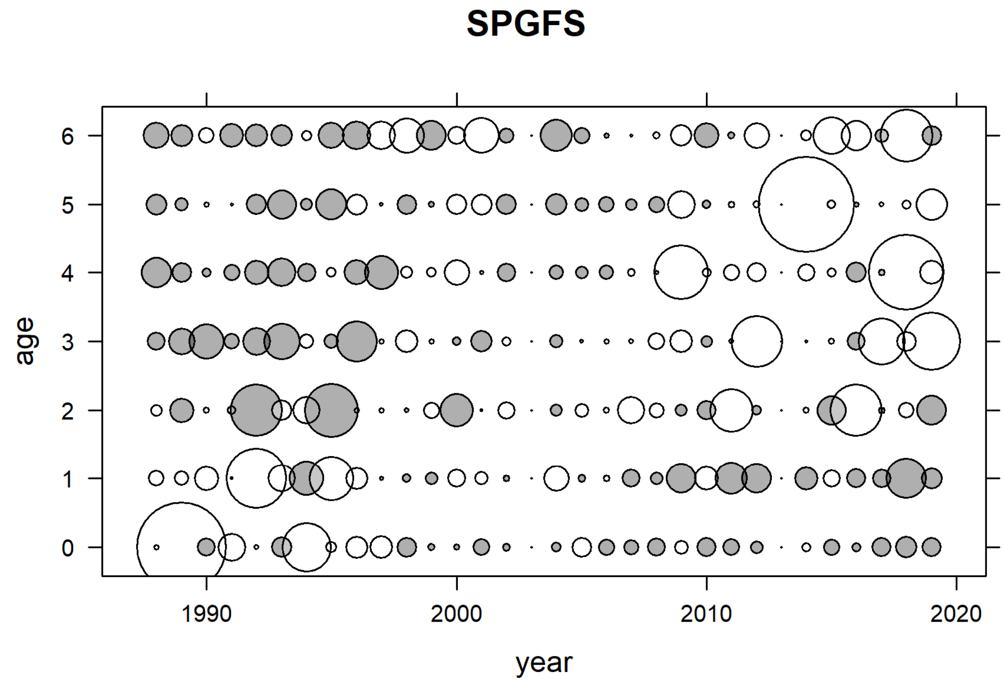
b. Catch numbers at age: landings are in grey, discards in white.



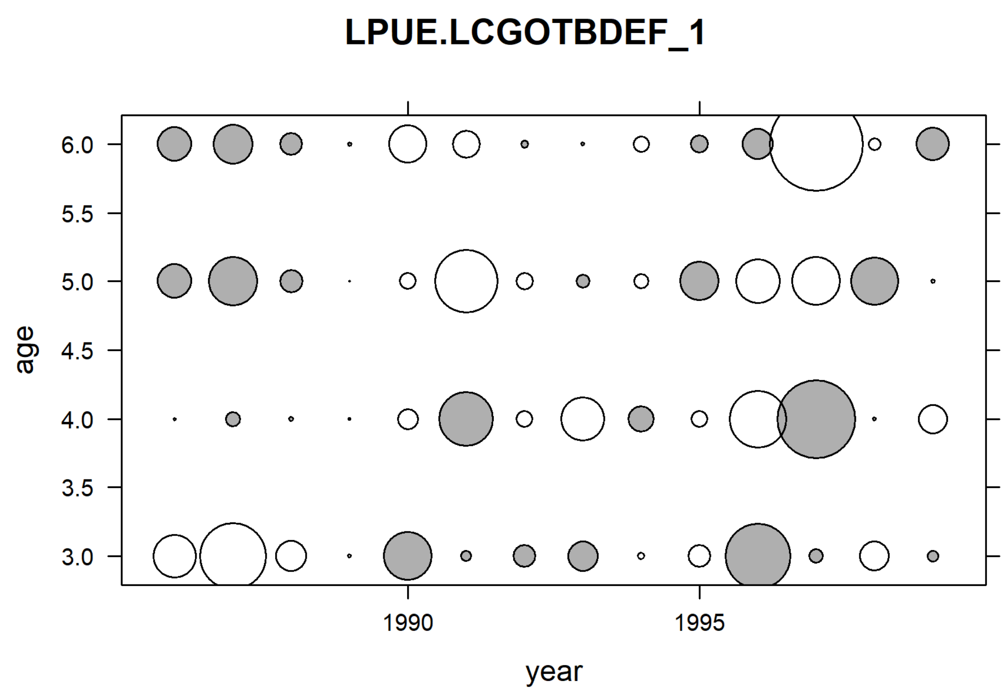
c. Catch weight at age: landings are in grey, discards in white.



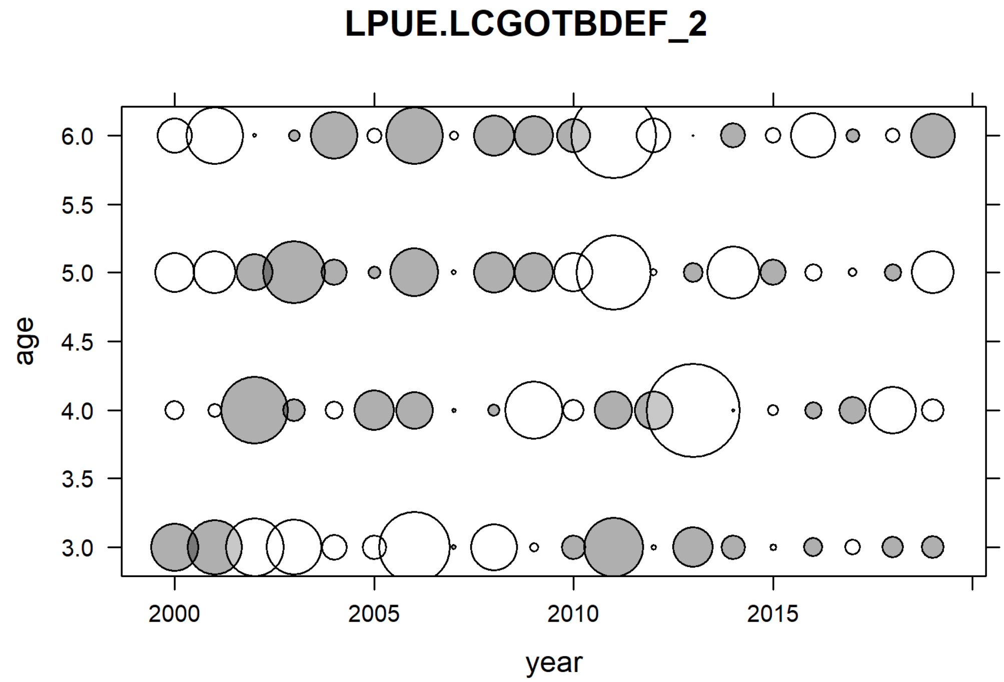
d. Catch by age data bubble plots, grey is below average, white is above average



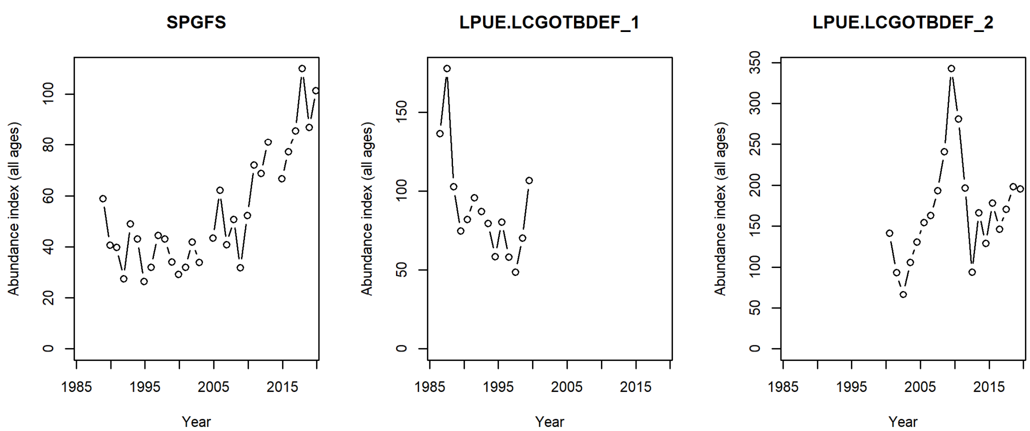
e. SpGFS-WIBTS-Q4 by age data bubble plots, grey is below average, white is above average



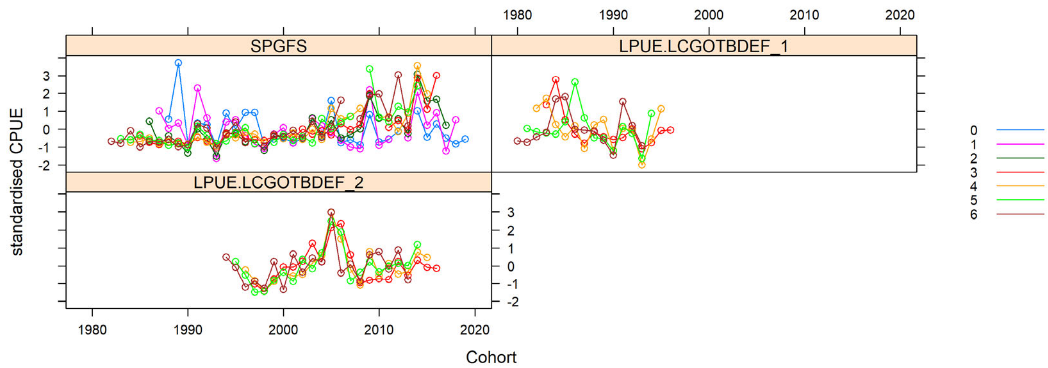
f. Commercial Coruña trawl LCGOTBDEF-1 by age data bubble plots, grey is below average, white is above average.



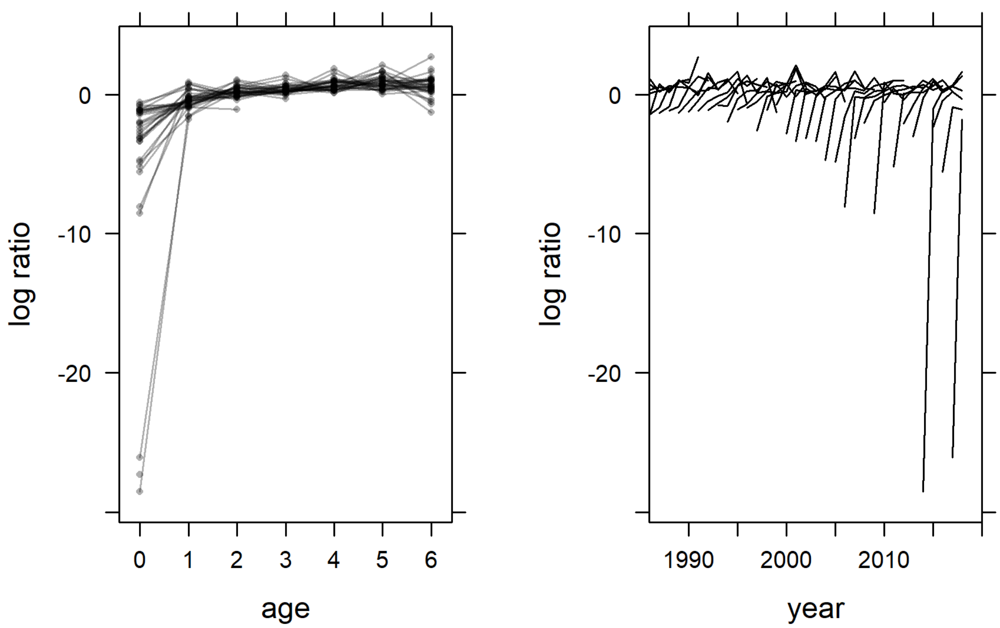
g. Commercial Coruña trawl LCGOTBDEF-2 by age data bubble plots, grey is below average, white is above average.



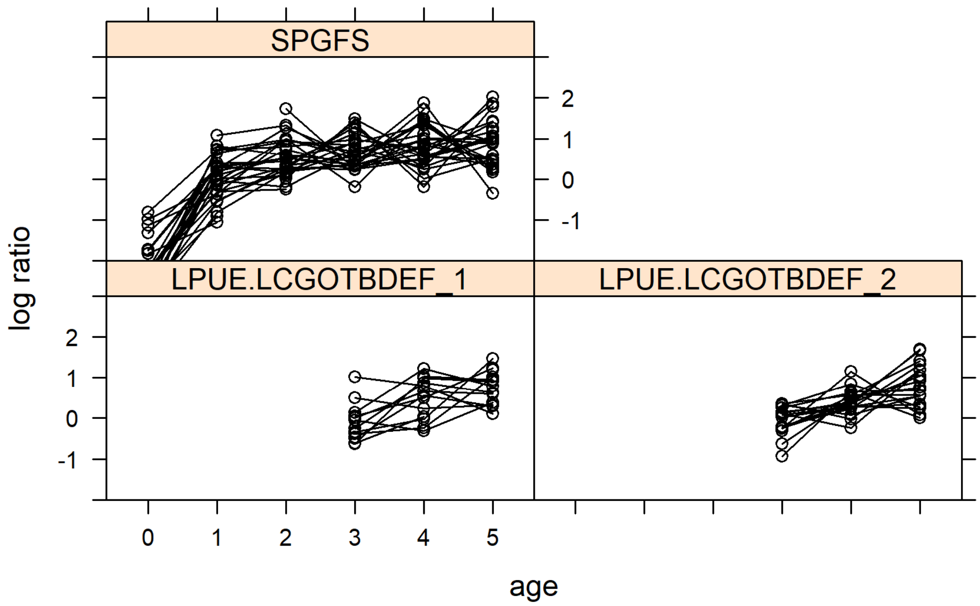
h. Abundance indices for all ages.



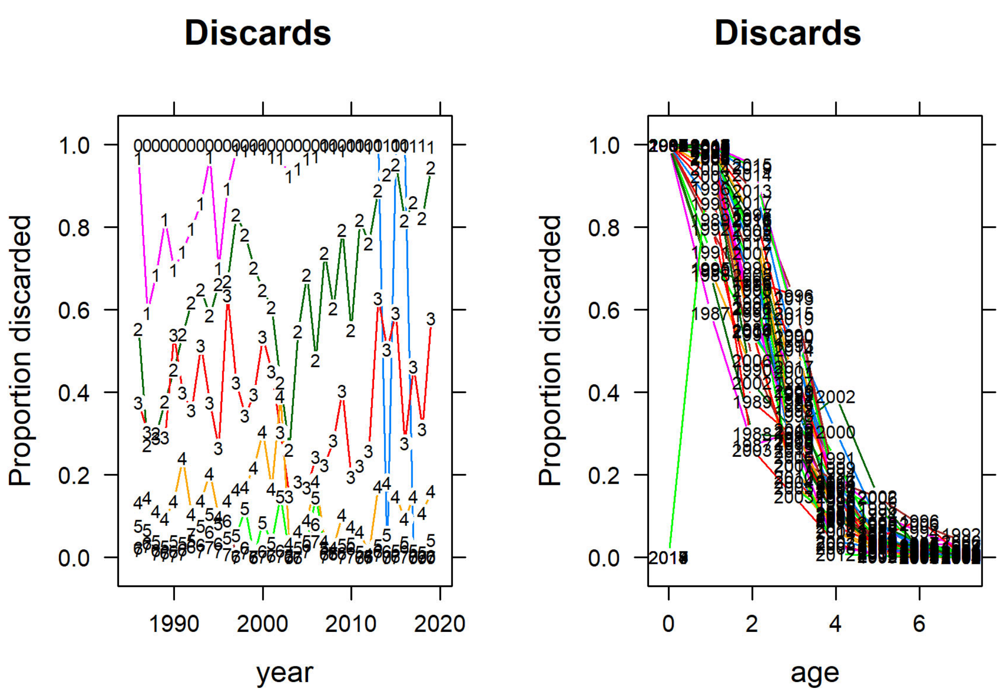
i. Standardised CPUE and LPUE by cohort of the tuning fleets.



j. Log ratio of the catch data by age and by year.



k. Log-ratios of tuning fleet data



l. Proportion discarded by age and by year.

3 Preliminary assessments (*L. whiffiagonis)*

Several fits have been tested in order to find an appropriate configuration for this stock. In this document the most relevant ones are presented.

3.1 Fit 1: Base case

The starting point, fit 1, was a default setting with the next submodels:

fmod (F at age): a formula object depicting the model for log fishing mortality at age.

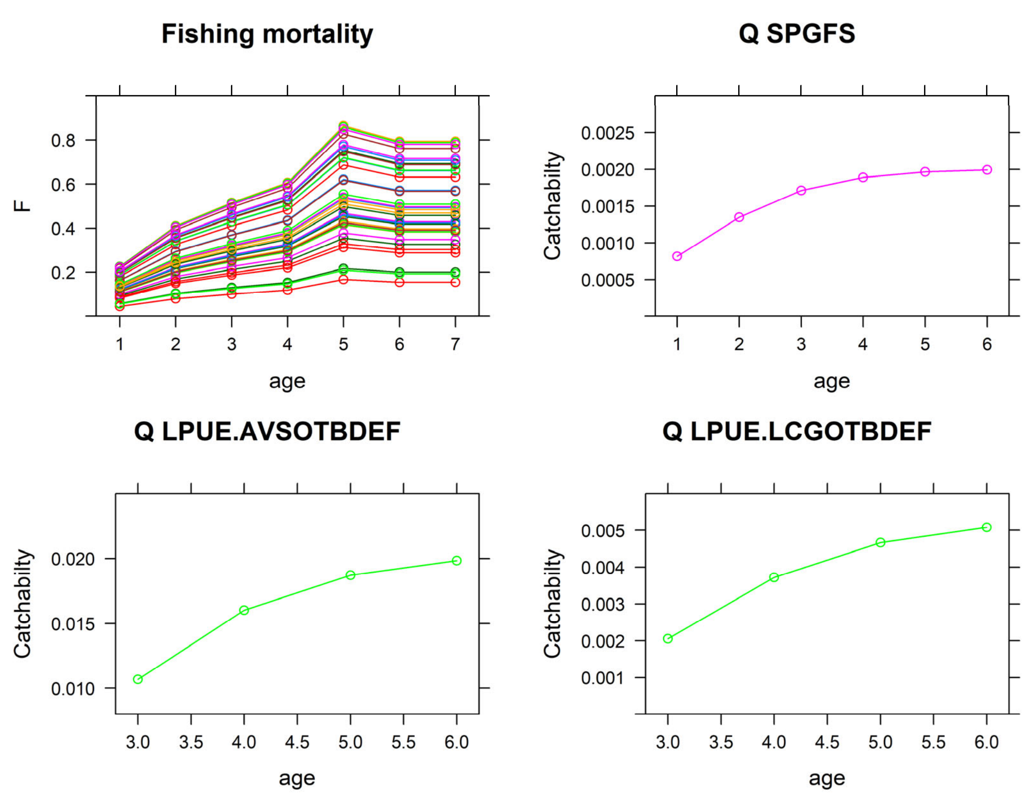
```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year)
```

srmod (model for recruitment): a formula object depicting the model for log recruitment.

```
srmod <- ~factor(year) #this stock-recruitment model (srmod) is 'free
```

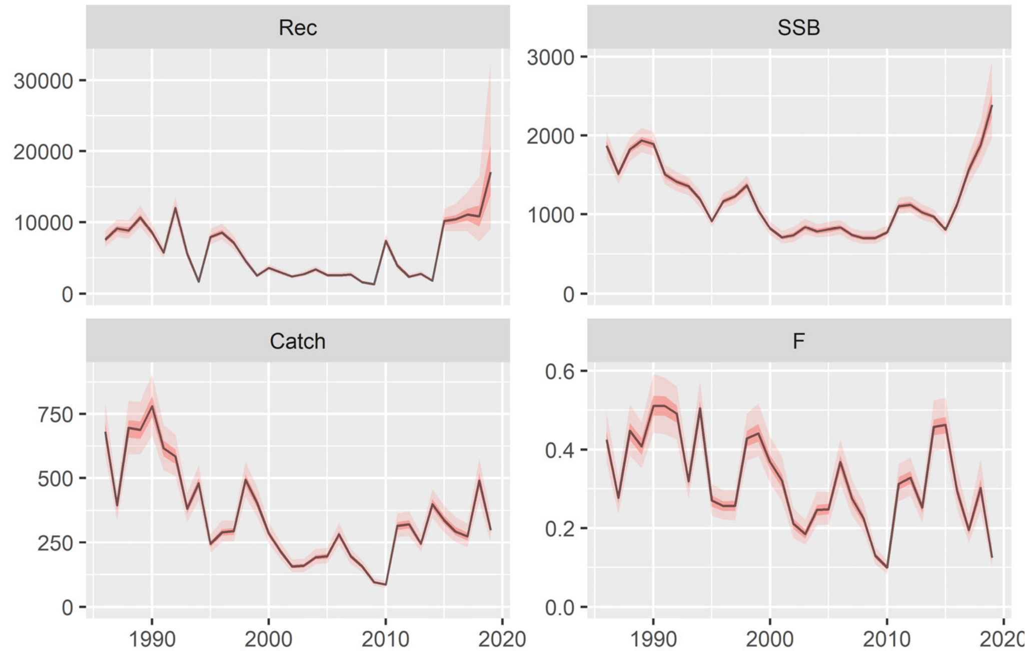
qmod (catchability at age): a list of formula objects depicting the models for log survey catchability at age.

```
qmod <- list(~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age)))
# logistic function for all tuning fleets
```

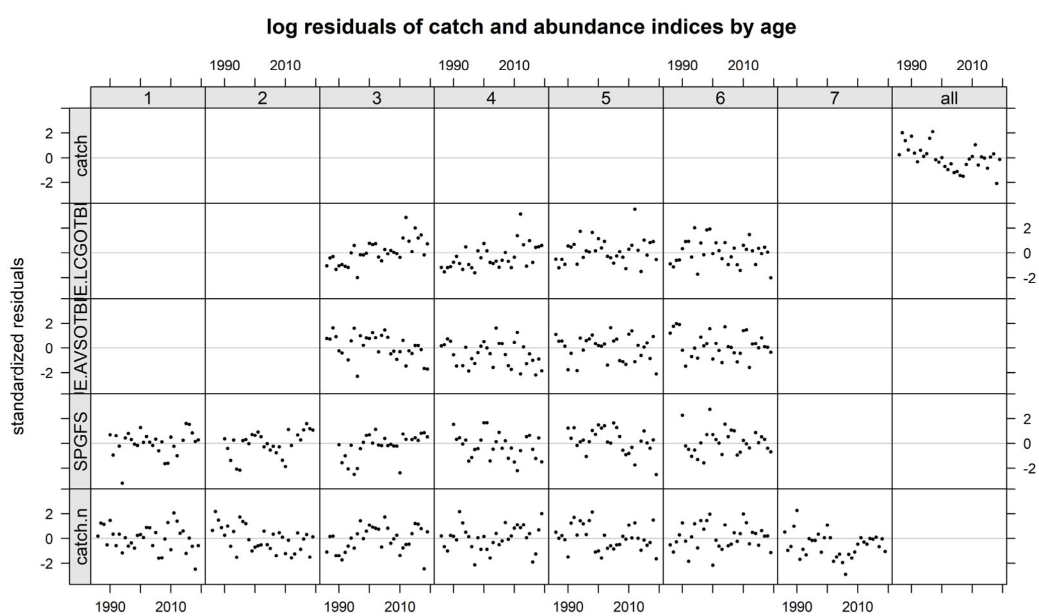


a. Fishing mortality and catchability of tuning fleets.

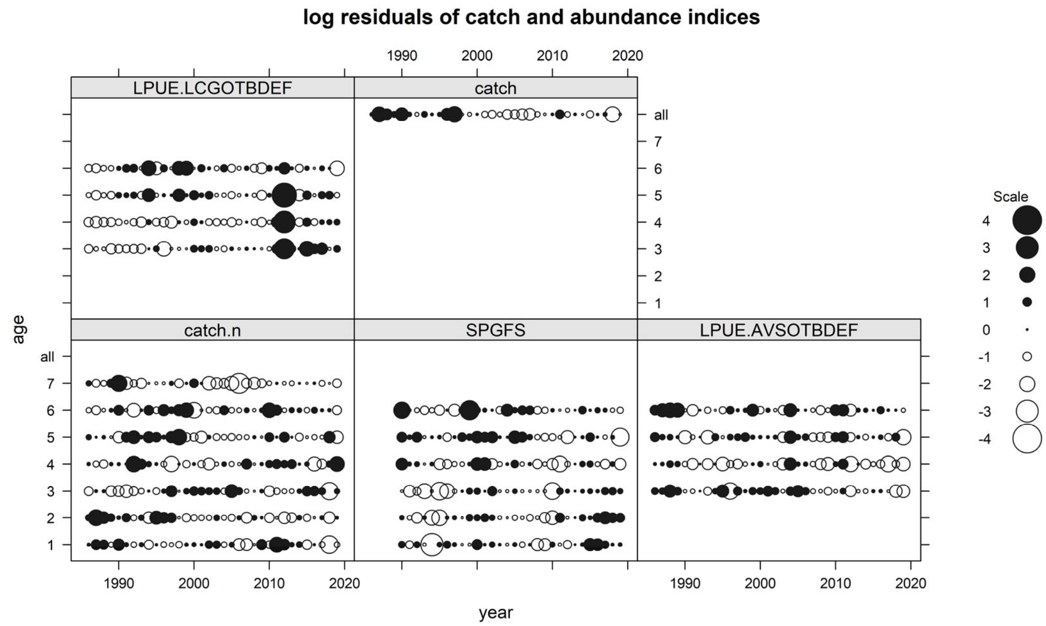
The results of this initial case were:



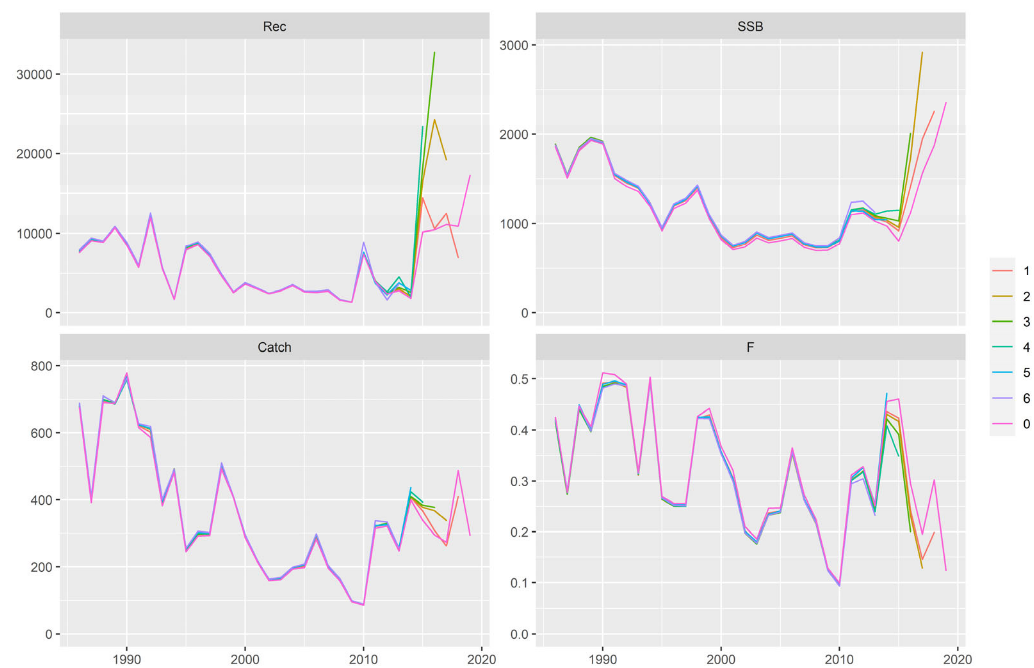
b. Outputs of the assessment; Recruitment, SSB and F.



c. Log residuals of catch and abundance indices by age.



d. Bubble plots of log residuals of catch and abundance indices by age.

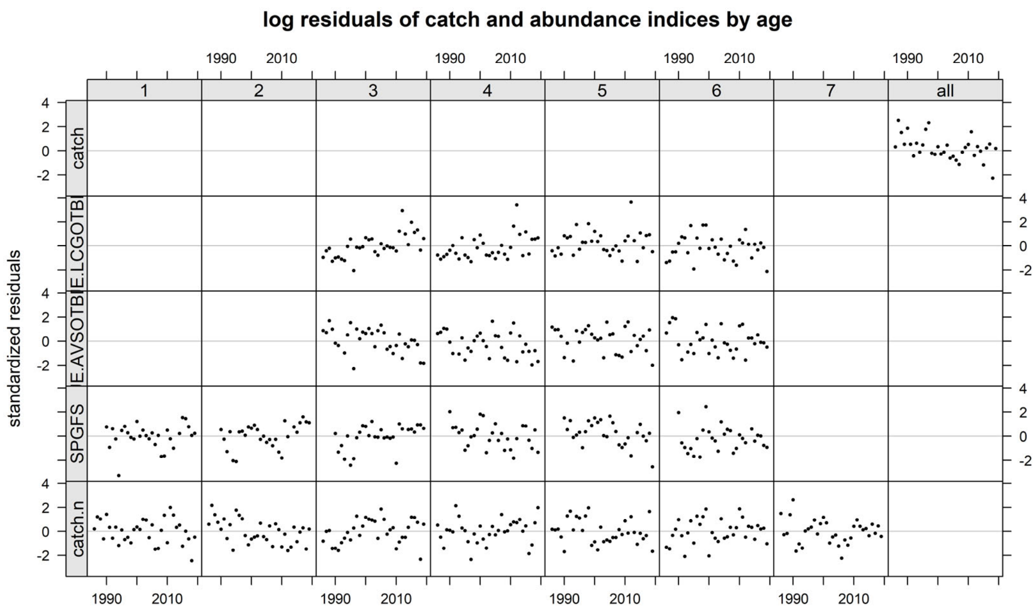


e. Retrospective pattern plots over the last 6 years

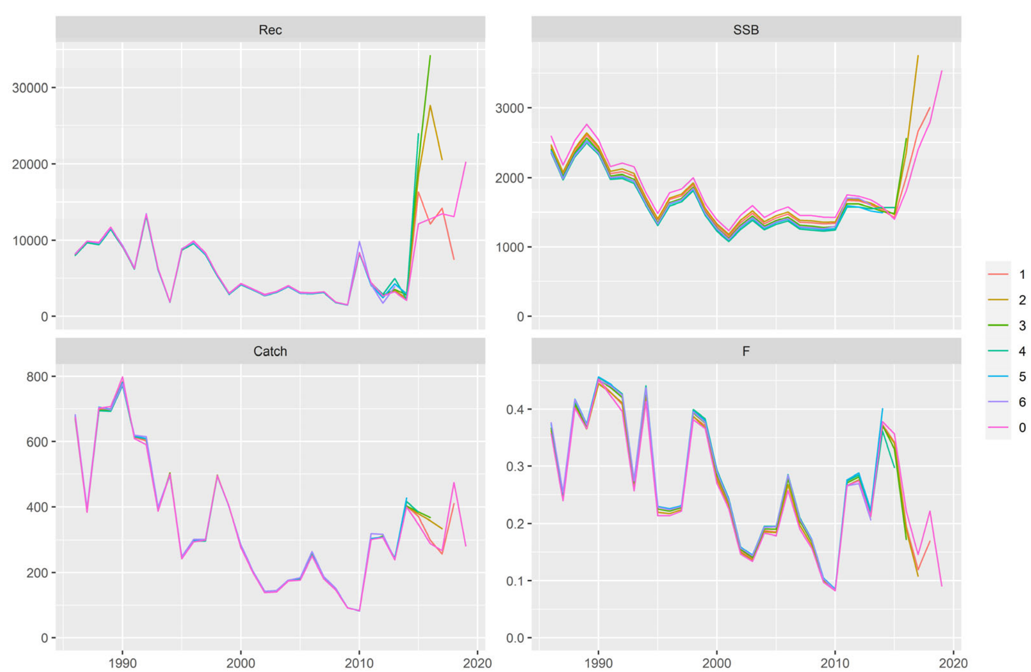
3.2 Fit 2: Adding a smooth term in the catchability model for the survey

Starting from the previous case, a smooth term is added to avoid the age effect in the survey index. The added term is the next one:

qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 3),
    ~I(1/(1 + exp(-age))),
    ~I(1/(1 + exp(-age))))



a. Log residuals of catch and abundance indices by age.

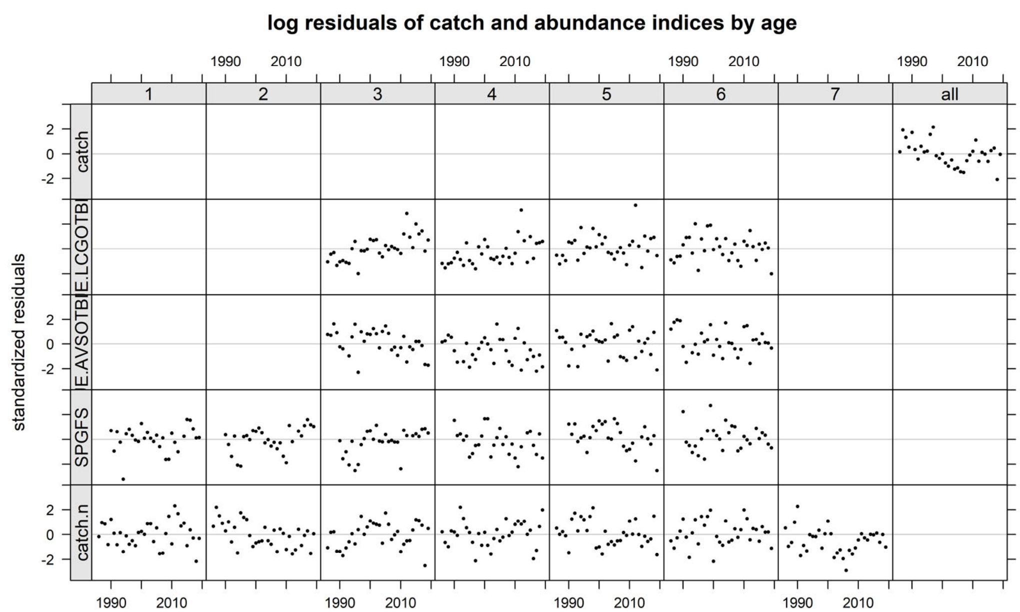


b. Retrospective pattern plots over the last 6 years

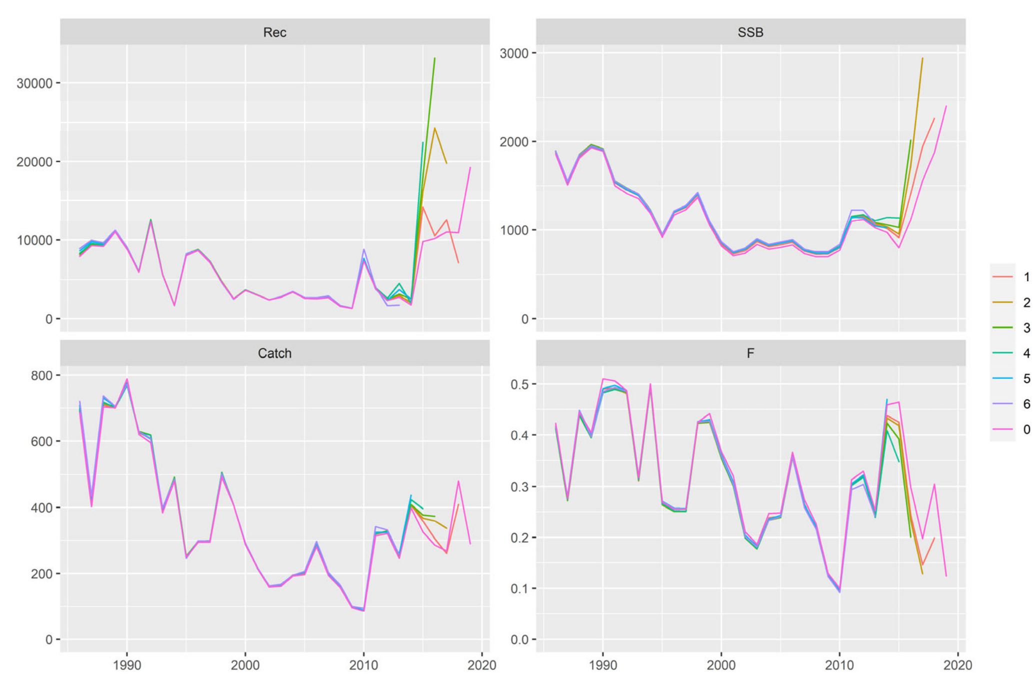
3.3 Fit 10: Adding a smooth term to age 1 in fishing mortality model.

This case was done to reduce the variability that is usually associated to the first age. To do this we added a smooth term to the fishing mortality model of the base case.

fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 1))



a. Log residuals of catch and abundance indices by age.

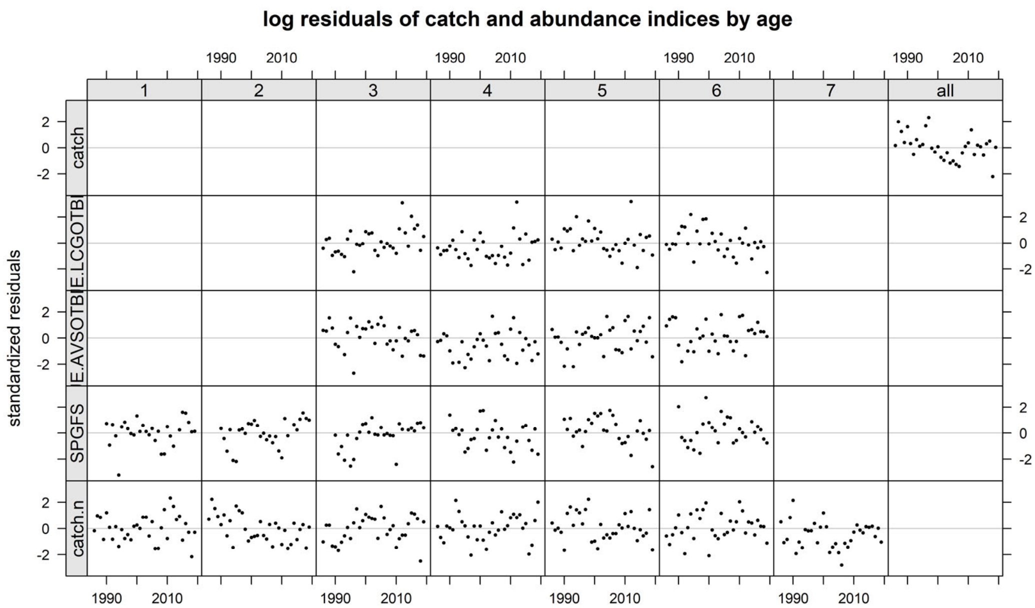


b. Retrospective pattern plots over the last 6 years

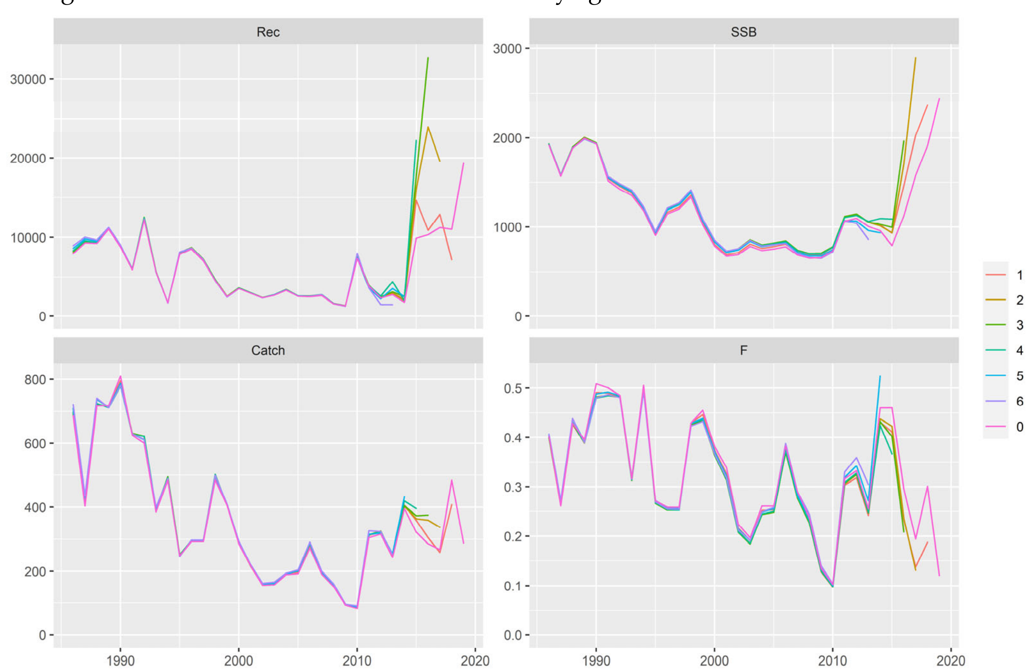
3.4 Fit 13: Adding a smooth term to age 1 in fishing mortality model and smooth terms in the catchability model for the commercial fleets.

In the last case presented, to the options of the previous one smooth terms were added to the catchability model of the commercial fleet indices to smooth the variability by years.

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 1))
qmod <- list(~I(1/(1 + exp(-age))),
        ~I(1/(1 + exp(-age)))+s(year, k = 3),
        ~I(1/(1 + exp(-age)))+s(year, k = 3))
```

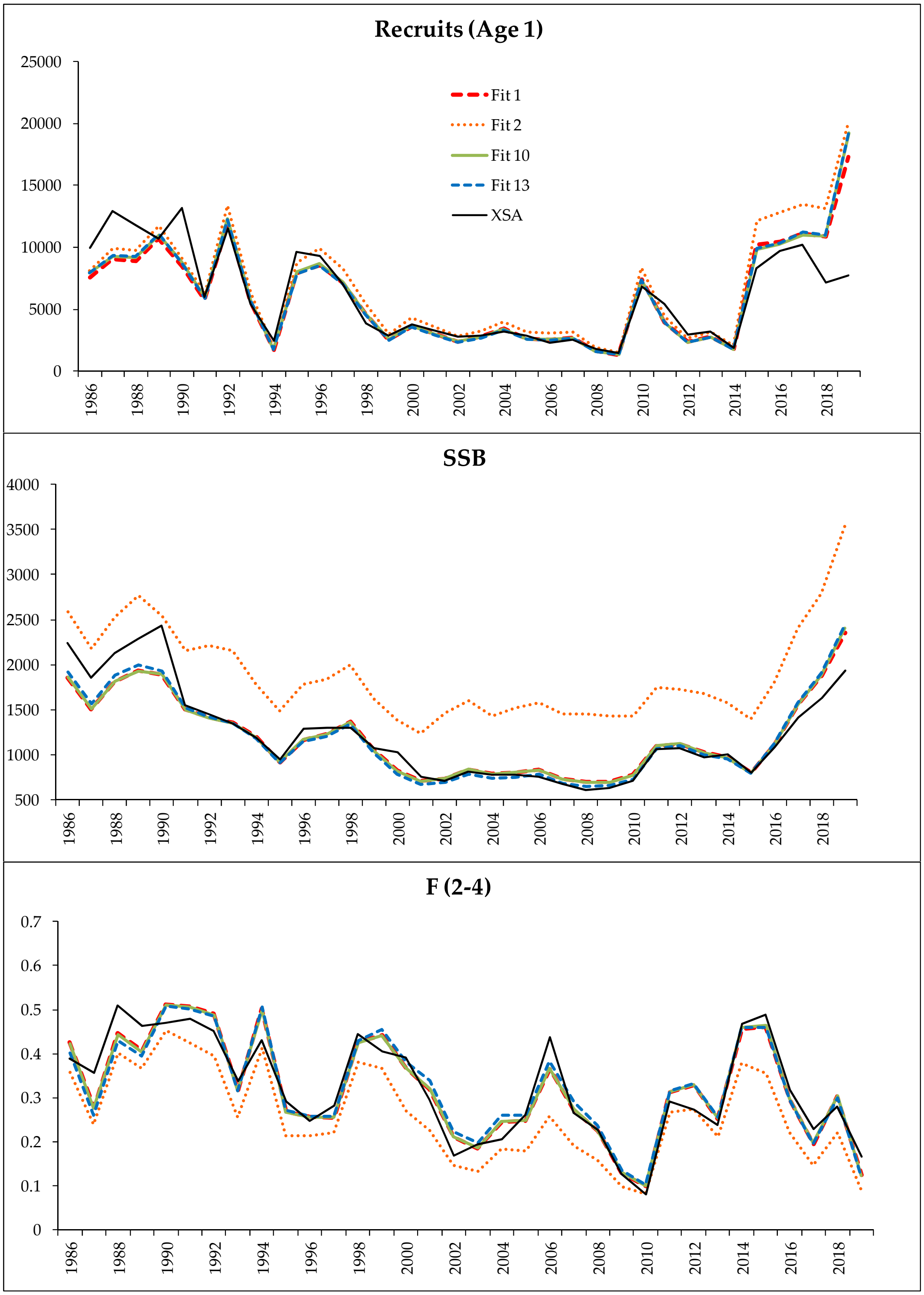


c. Log residuals of catch and abundance indices by age.



d. Retrospective pattern plots over the last 6 years

4 Comparison with the current assessment (XSA, 2020WGBIE).



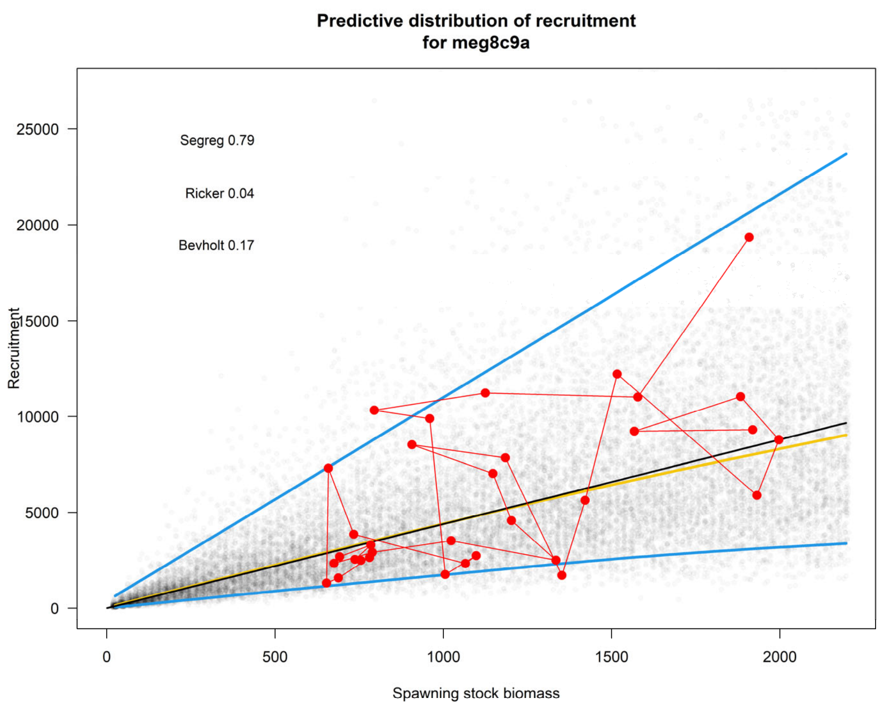
a. XSA Stock status estimates versus a4a estimates in the studied fits for *L. whiffiagonis*.

b. Table with AIC, BIC and Mohn’s Rho values of the different fits.

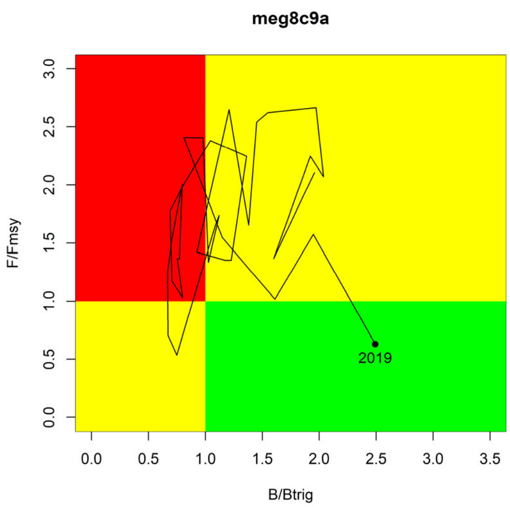
	AIC	BIC	Mohn's Rho (Retro_F)	Mohn's Rho (Retro_SSB)	Mohn's Rho (Retro_R)
XSA WG2020			-0.34	0.35	0.17
Fit 1	1158.2	1556.2	-0.086	0.252	0.756
Fit 2	1143.4	1554.9	-0.058	0.152	0.623
Fit 10	1160.8	1557.9	-0.083	0.241	0.619
Fit 13	1140.6	1565.6	0.042	0.134	0.533

5 Preliminary Biological Reference Points, forecast and Catch option table

With the availability of codes to estimate the biological reference points and the catch projections, fit 13 was selected to obtain preliminary values. This selection was based on the best AIC and Mohn's Rho values.



a. Stock-Recruitment plot.



Btrigger	907.2
Fmsy	0.164
Blim	652.9
Bpa	907.2
Flim	0.415
Fpa	0.299
lFmsy	0.116
uFmsy	0.269
F05	1.072

b. Kobe plot and BRP values.

c. Catch options table:

basis	catch	wanted	unwanted	F	Fwanted	Funwanted	SSB	ssbchange	advicechange
MSY approach: F[MSY]	630	609	21	0.164	0.187	0.044	3185	-13	20
F=MAP F[MSY lower]	459	444	15	0.116	0.132	0.031	3388	-7.5	-12.4
F=MAP F[MSY upper]	970	937	33	0.269	0.307	0.073	2784	-24	85
MSY approach: F[MSY]	630	609	21	0.164	0.187	0.044	3185	-13	20
F[mp]	753	727	26	0.2	0.229	0.054	3040	-17	44
F=0	0	0	0	0	0	0	3933	7.4	-100
F[pa]	1059	1023	37	0.299	0.342	0.081	2680	-27	102
F[lim]	1373	1325	48	0.415	0.475	0.112	2312	-37	162
SSB (2022)=B[pa]	2600	2502	98	1.173	1.341	0.317	907	-75	400
SSB(2022)=B[lim]	2832	2723	108	1.448	1.655	0.391	653	-82	440
SSB(2022)=MSY B[trigger]	2600	2502	98	1.173	1.341	0.317	907	-75	400
F[2020]	477	461	16	0.121	0.138	0.033	3366	-8.1	-8.9
Roll-over TAC	524	506	18	0.133	0.153	0.036	3311	-9.6	0

6 Preliminary assessments (*L. boscii)*

For this stock several fits have been tested too and the most relevant are presented.

6.1 Fit 1: Base case

Fit 1, the base one, is the same that was shown for megrim:

fmod (F at age): a formula object depicting the model for log fishing mortality at age.

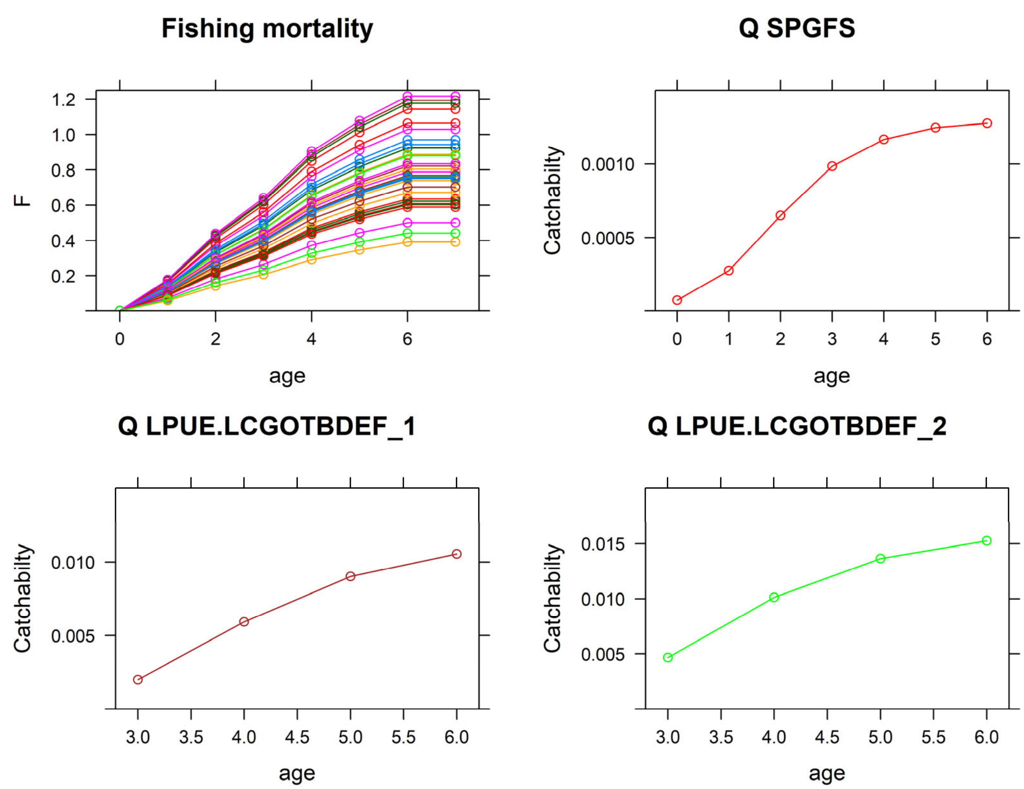
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year)

srmod (model for recruitment): a formula object depicting the model for log recruitment.

srmod <- ~factor(year) #this stock-recruitment model (srmod) is 'free

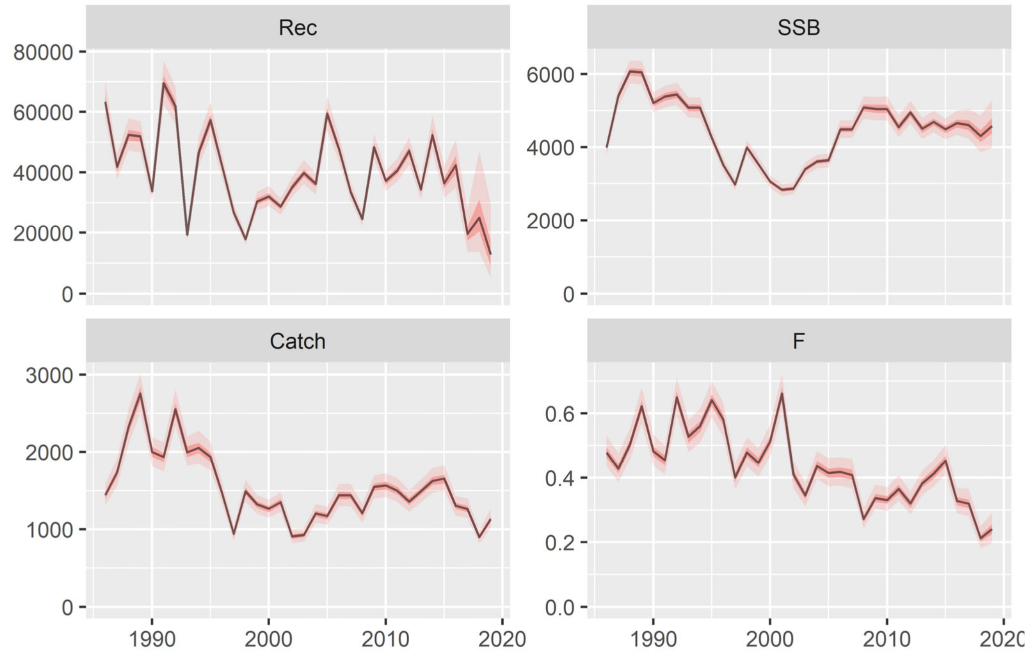
qmod (catchability at age): a list of formula objects depicting the models for log survey catchability at age.

```
qmod <- list(~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age))),
             ~I(1/(1 + exp(-age)))
# logistic function for all tuning fleets
```

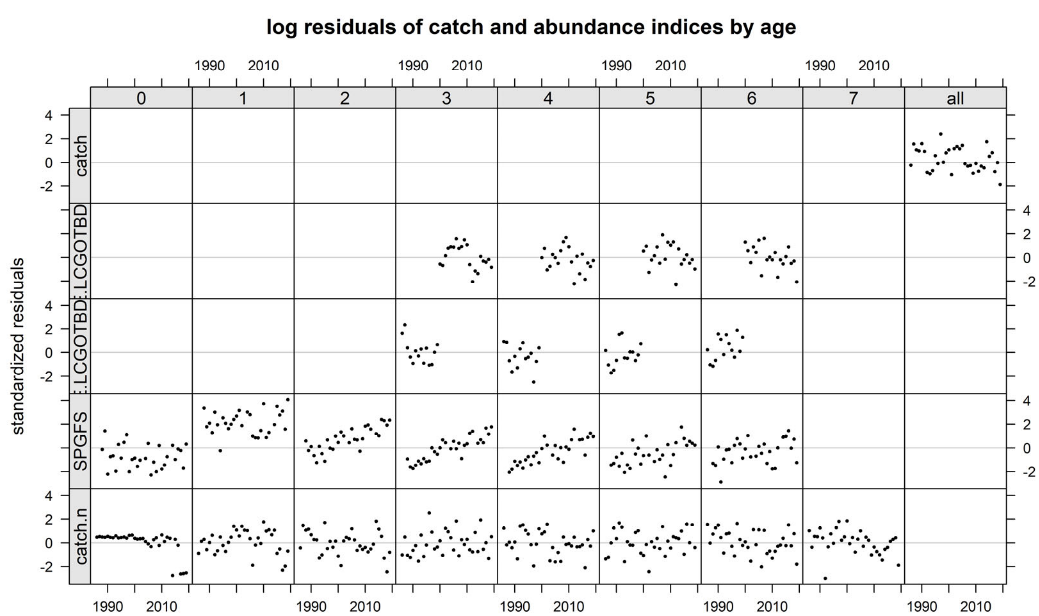


f. Fishing mortality and catchability of tuning fleets.

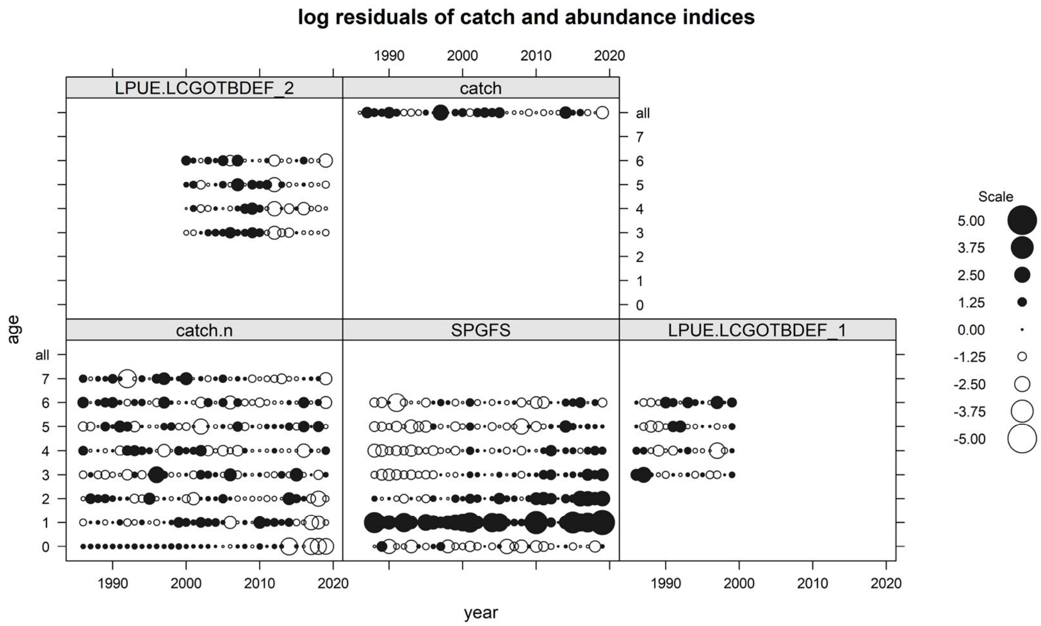
The results of this initial case were:



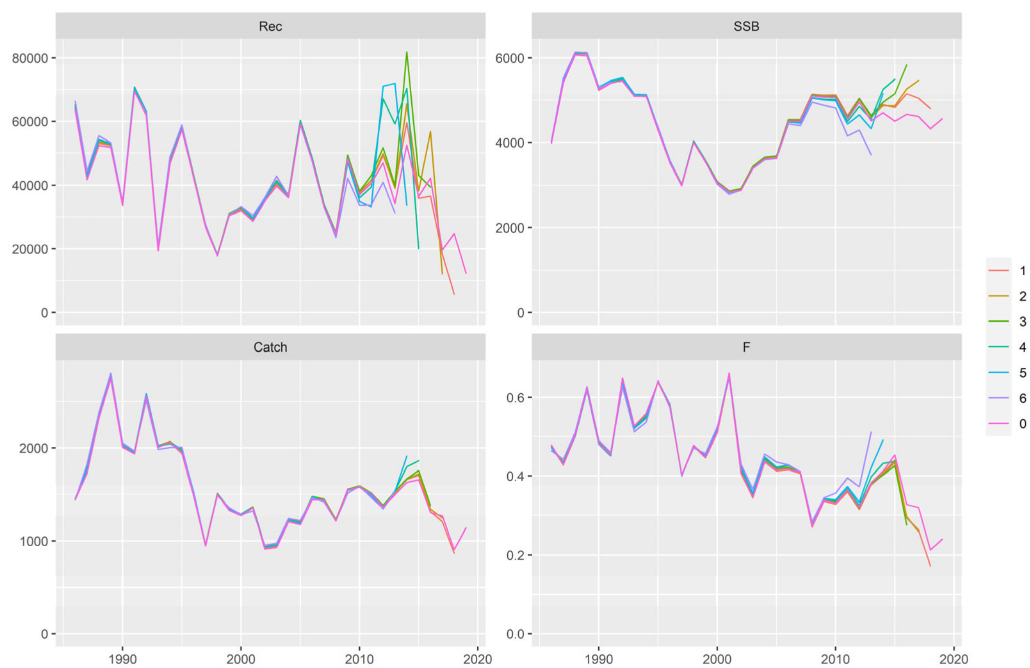
g. Outputs of the assessment; Recruitment, SSB and F.



h. Log residuals of catch and abundance indices by age.



i. Bubble plots of log residuals of catch and abundance indices by age.



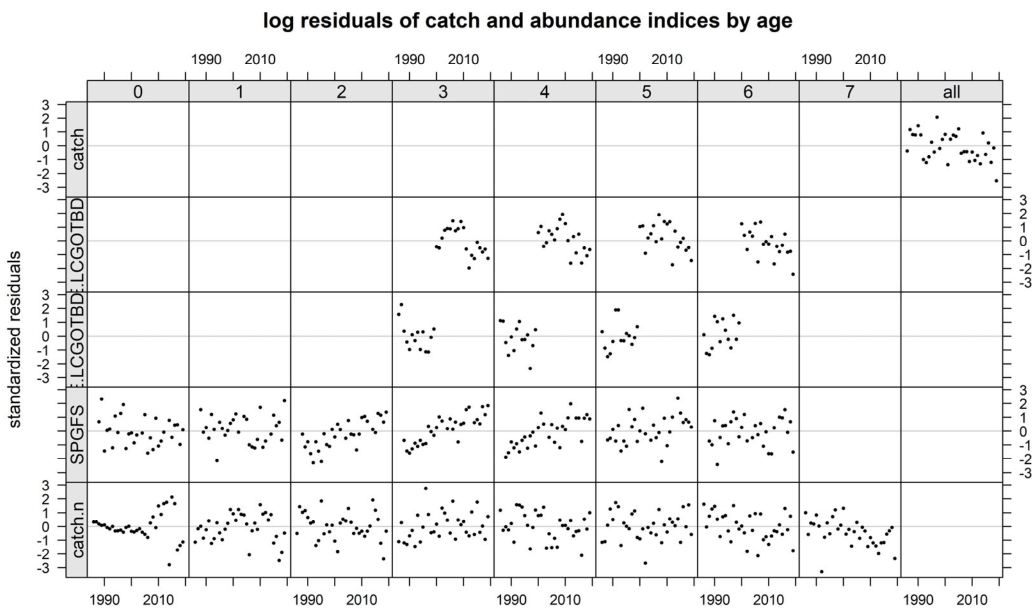
j. Retrospective pattern plots over the last 6 years

6.2 Fit 12: Adding a smooth term to age 0 in fishing mortality model and a smooth term in the catchability model for the survey.

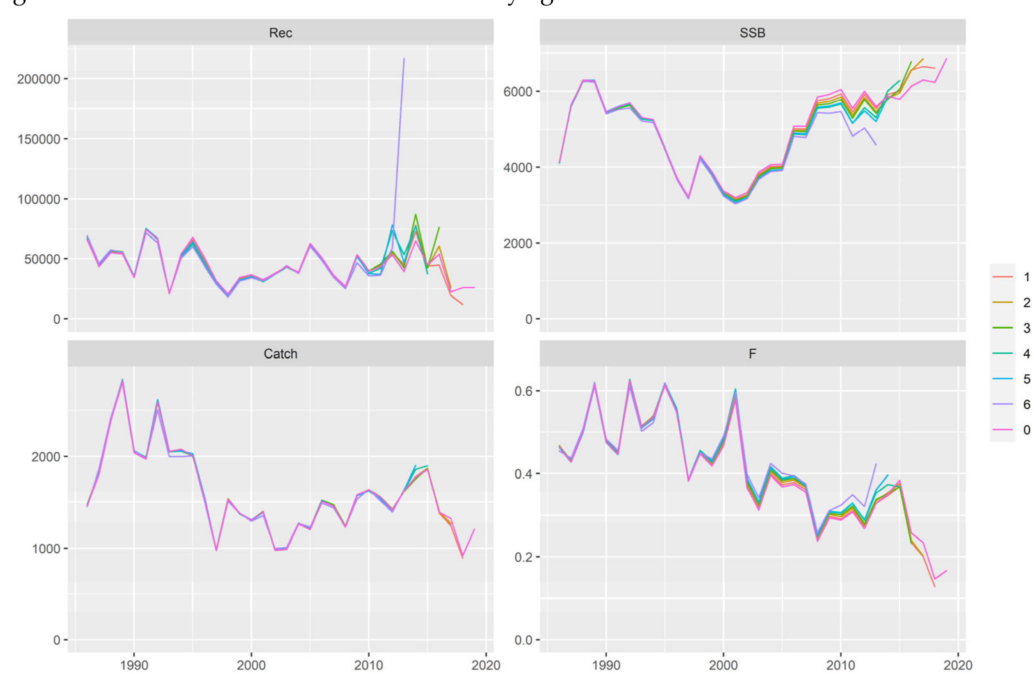
Residuals in fit 1 showed issues in age 0 in the catch and in age 1 in the survey. Smooth terms are added to try to improve the residuals. They are:

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 0))

qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 5),
        ~I(1/(1 + exp(-age))),
        ~I(1/(1 + exp(-age))))
```



c. Log residuals of catch and abundance indices by age.

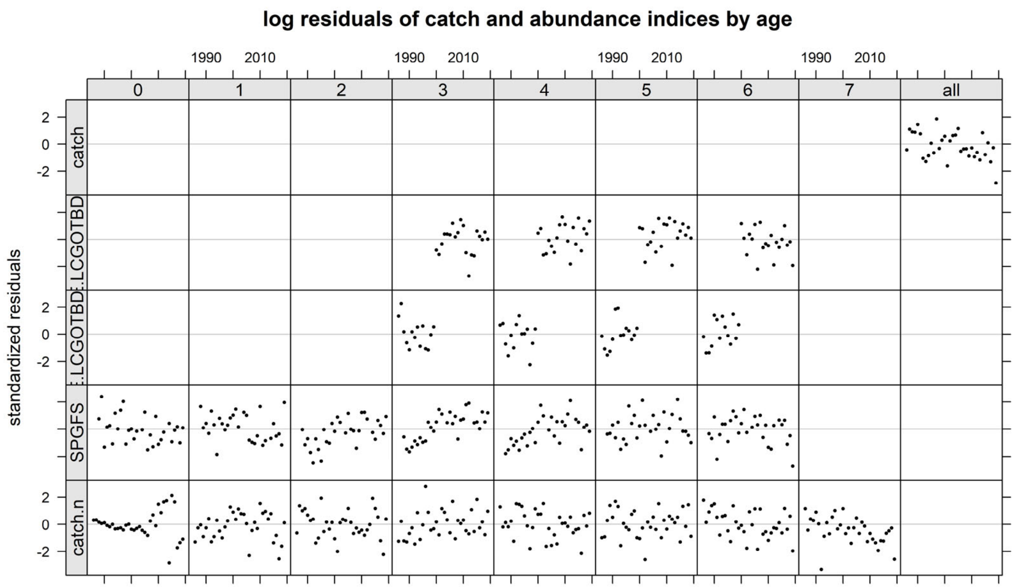


d. Retrospective pattern plots over the last 6 years

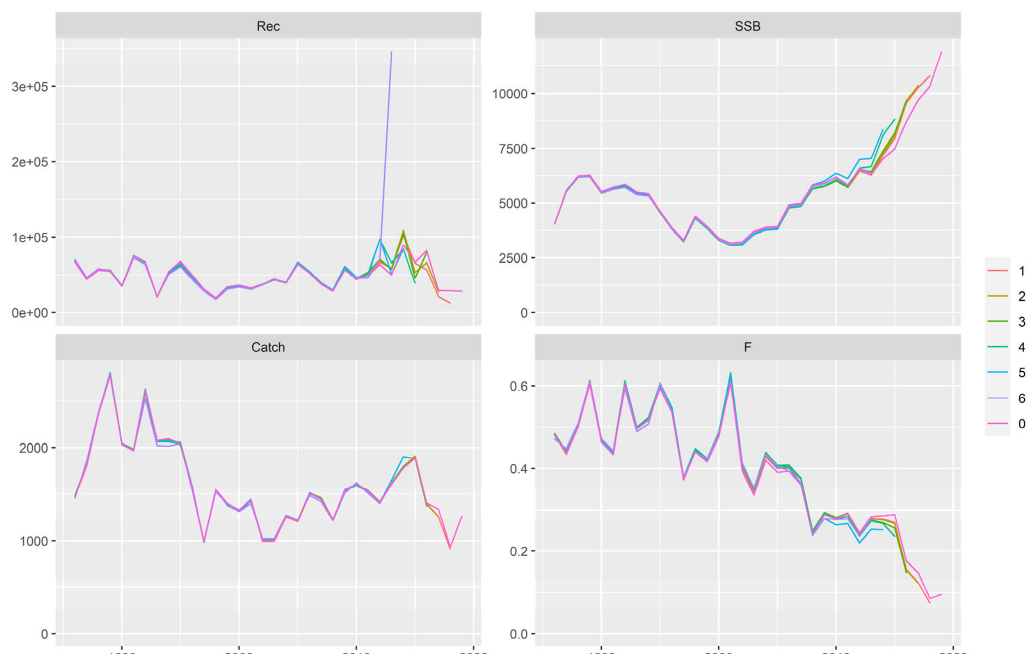
6.3 Fit 13: Adding a smooth term to age 0 in fishing mortality model and smooth terms in the catchability models for the survey and the commercial fleets.

The age 0 residual pattern in the catch is still not adequate. Smooth terms were added to the previous case in the catchability submodel of LPUEs.

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 3, by = as.numeric(age == 0))
qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 5),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3))
```



e. Log residuals of catch and abundance indices by age.

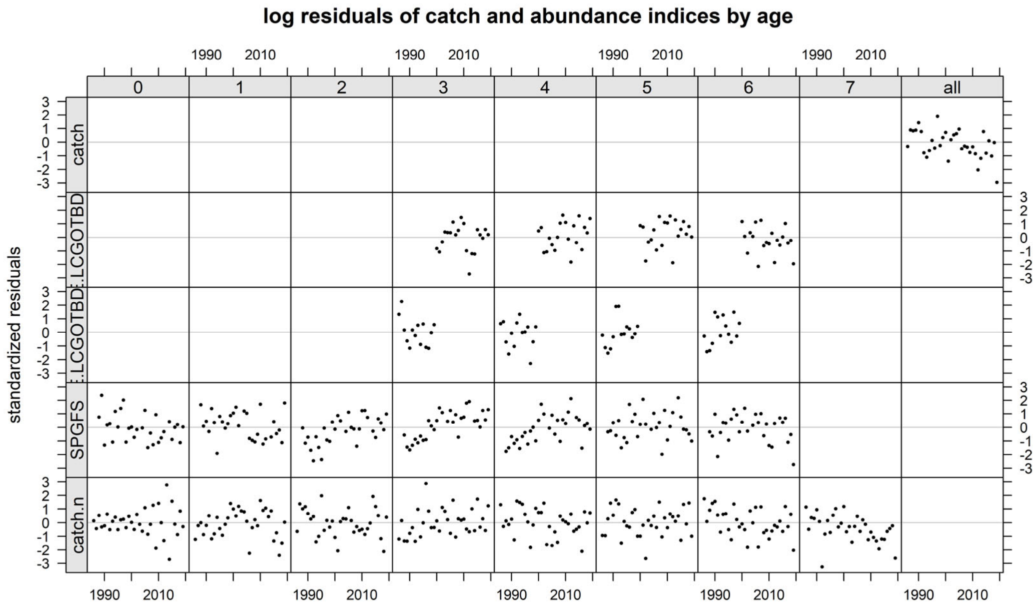


f. Retrospective pattern plots over the last 6 years

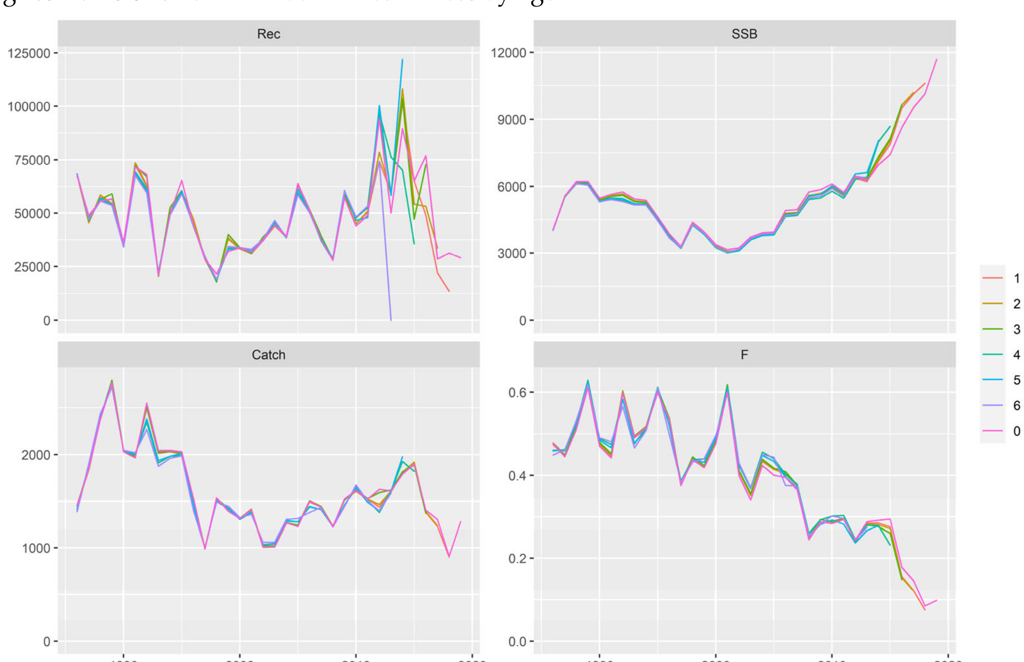
6.4 Fit 16: Increasing k value in the smooth term in the fishing mortality submodel.

In the last case presented, k value in the smooth term in the fishing mortality submodel was increased in relation to the previous one. This is aimed at trying to resolve issue residuals of age 0 in the capture.

```
fmod <- ~factor(replace(age, age > 6, 6)) + factor(year) +s(year, k = 25, by = as.numeric(age == 0))
qmod <- list(~I(1/(1 + exp(-age)))+s(replace(age, age > 5, 5), k = 5),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3),
             ~I(1/(1 + exp(-age)))+ s(year, k = 3))
```

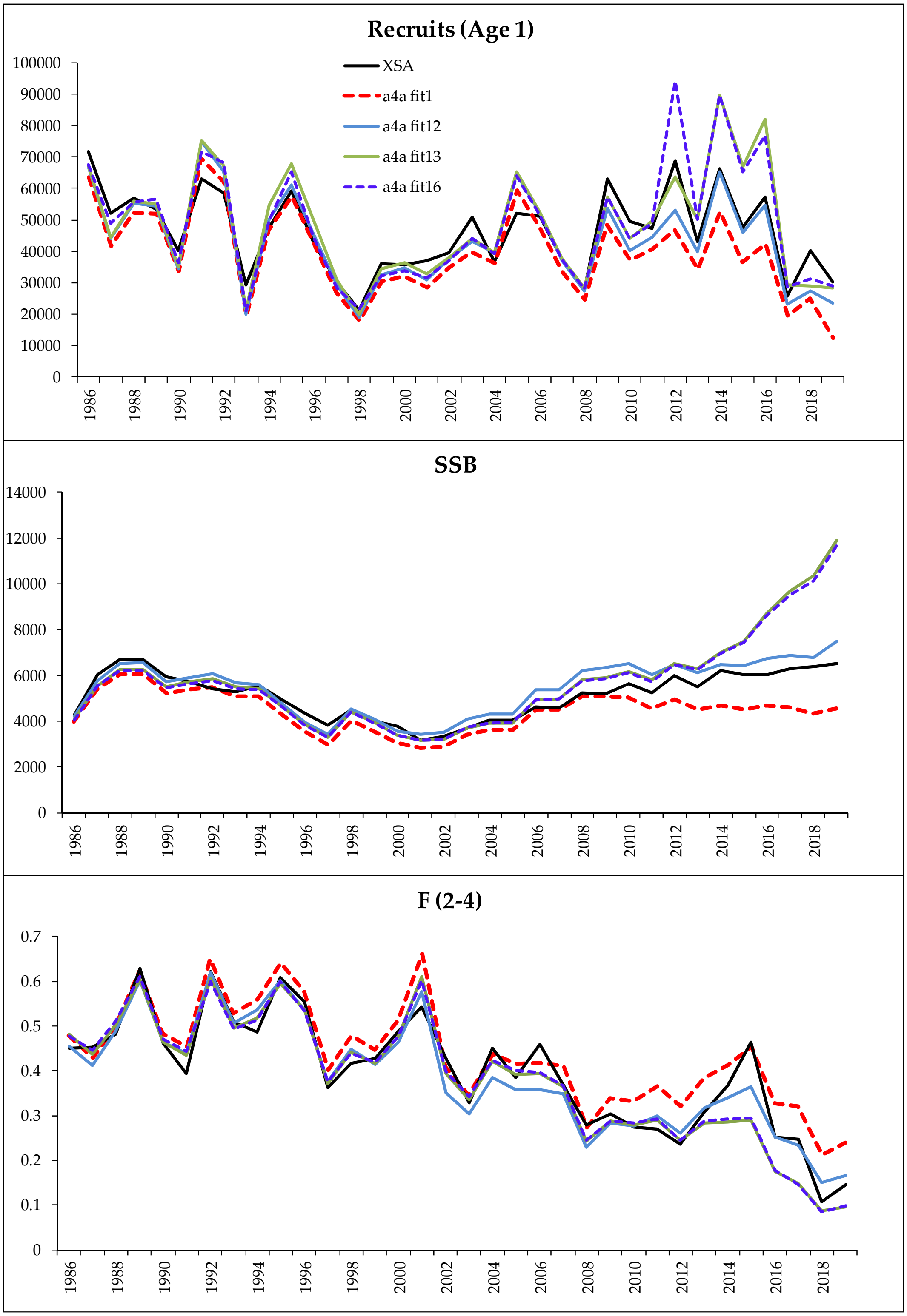


g. Log residuals of catch and abundance indices by age.



h. Retrospective pattern plots over the last 6 years

7 Comparison with the current assessment (XSA, 2020WGBIE)



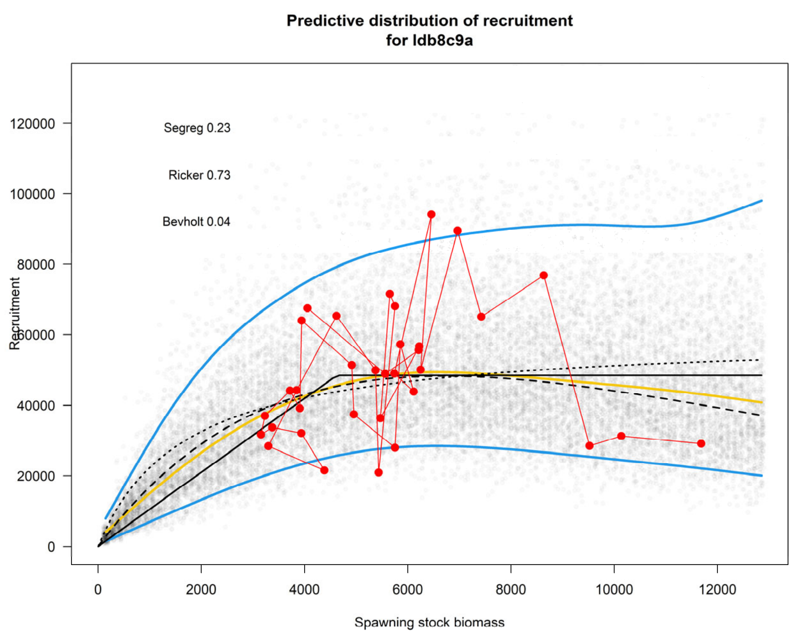
c. XSA Stock status estimates versus a4a estimates in the studied fits for *L. boscii*.

d. Table with AIC, BIC and Mohn’s Rho values of the different fits.

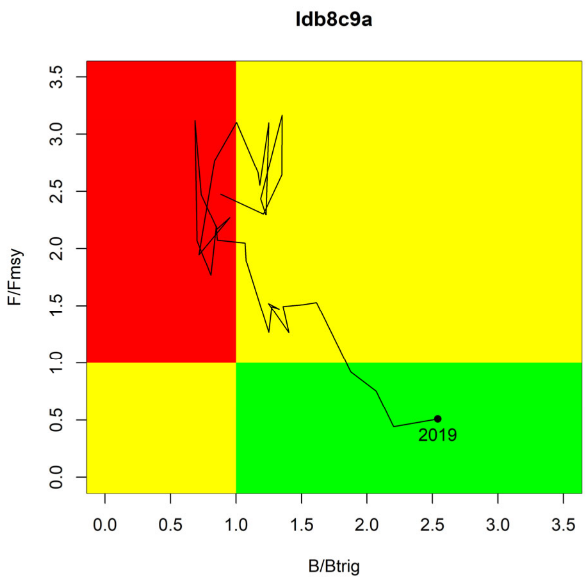
	AIC	BIC	Mohn's Rho (Retro_F)	Mohn's Rho (Retro_SSB)	Mohn's Rho (Retro_R)
XSA WG2020			-0.13	0.15	-0.11
Fit 1	1067.2	1459.5	0.101	0.042	-0.269
Fit 12	928.1	1348.6	0.085	-0.015	0.949
Fit 13	872.2	1310.5	-0.056	0.062	0.985
Fit 16	856.6	1392.2	-0.054	0.056	-0.050

8 Preliminary Biological Reference Points, forecast and Catch option table

Fit 16 was selected to obtain preliminary values. This selection was based on the best AIC, Mohn's Rho values and residuals.



d. Stock-Recruitment plot.



Btrigger	4385.8
Fmsy	0.161
Blim	3156.2
Bpa	4385.8
Flim	0.444
Fpa	0.32
lFmsy	0.113
uFmsy	0.263
F05	0.803

e. Kobe plot and BRP values.

f. Catch options table:

basis	catch	wanted	unwanted	F	Fwanted	Funwanted	SSB	ssbchange	advicechange
MSY approach: F[MSY]	2097	1963	134	0.161	0.151	0.072	9566	-17.4	11.3
F=MAP F[MSY lower]	1517	1421	96	0.113	0.106	0.051	10200	-11.9	-19.5
F=MAP F[MSY upper]	3212	3003	210	0.263	0.247	0.118	8353	-28	70
MSY approach: F[MSY]	2097	1963	134	0.161	0.151	0.072	9566	-17.4	11.3
F[mp]	2545	2381	164	0.2	0.188	0.09	9079	-22	35
F=0	0	0	0	0	0	0	11860	2.4	-100
F[pa]	3771	3522	249	0.32	0.3	0.144	7747	-33	100
F[lim]	4854	4525	329	0.444	0.417	0.2	6576	-43	158
SSB (2022)=B[pa]	6900	6406	494	0.756	0.71	0.341	4386	-62	270
SSB(2022)=B[lim]	8067	7465	602	1.015	0.953	0.457	3156	-73	330
SSB(2022)=MSY B[trigger]	7317	6785	531	0.839	0.788	0.378	3945	-66	290
F[2020]	1337	1253	84	0.098	0.092	0.044	10396	-10.2	-29
Roll-over TAC	1885	1765	120	0.143	0.134	0.064	9798	-15.4	0.00

9 Conclusion

The results for both stocks are promising and the work carried out shows that the a4a model is a strong candidate to be chosen for the assessments. Progress has been considerable and much work has been developed that would facilitate the change to the proposed model.

Many fits with different settings have been performed for the workshop. The residuals of the base case of the megrim did not present big issues, but the following configurations were made with a view to improving the AIC and Mohn's Rho values.

The four-spot megrim did need an improvement since its residuals had some patterns on the catch and the survey index at early ages. Several configurations were studied, reaching one that significantly improved the residuals.

Comparisons between fits done with the two models, XSA and a4a, show similar results with the same trends. Also the calculated BRPs and forecast for the selected ones during the WKTADSA do not differ by large amounts. The selected fits were fit 13 for *L. whiffiagonis* and fit 16 for *L. boscii*. The selection was base on best AIC, Mohn's Rho values and residuals.

From the selected settings the analysis can be adjusted in order to select the most suitable configurations for both stocks. Additional diagnostics can also be performed which would include prediction skill through retrospective prediction of model inputs and runs tests. As all the scripts are available and have been tested in different configurations, there is a lot of advanced work.

All of the above postulates that the a4a stock assessment model is adequate to leave a deterministic model and update the assessment of these two stocks.

WORKING DOCUMENT

ICES WKTADSA 2020-WKTDSA2021

PRELIMINARY ANALYSIS AS ALTERNATIVE STOCK ASSESSMENT MODEL WITH STOCK SYNTHESIS FOR WHITE ANGLERFISH IN DIVISIONS 7, 8 abd

by

Agurtzane Urtizberea and Hans Gerritsen

Abstract

A4a is the model used in the assessment of white anglerfish in the Division 7,8 abd. The model is based on age, but due to some aging problems there is not age data, and therefore, the data are transformed from length to age outside the model with a growth pattern estimated from a cohort analysis from survey and commercial data. The assessment model has also some retrospective pattern that should be studied, eventhough the mohn's rho are within the accepted ranges. Therefore, in order to solve those issues, in this study we use stock synthesis as first steps of a base case.

1 Introduction

In 2007, there was not an accepted assessment for *Lophius piscatorius* due to the deficiencies on input data, especially on discards data and aging problems. In 2018, during the benchmark (WKANGLER 2018), discards data were collected since 2003 and a4a model (Millar and Jardim) was analysed and accepted for assessment. A4a model is based on age, so in the case of anglerfish data based on length has to be transform into ages. Growth was estimated with a length frequency analysis presented during the benchmark (WD04 WKANGLER 2018-Batts and Gerritsen, 2018). But the retrospective pattern shown during WGBIE, suggests that the model should be revised to improve it. However, the estimated Mohn's Rho values were within the acceptable range values, so the absolute values were lower than 0.2 (for Recruitment -0.106, for *SSB* 0.136 and for *F* 0.0106). The recruits are estimated with quite high precision but in some years, the retrospective estimates are outside the confidence limits; indicating that the precision of the recruitment estimate might be lower than the estimated. The estimated recruitment in 2017 is highly uncertain because there was no recruitment index available for 2017. There is a retrospective adjustment of both *SSB* and *F* at the start of the time series (in the period where no survey data is available). This is because in a separable assessment the F-pattern of the entire time series is adjusted with each new year of data. However, in both cases the retrospective pattern is inside of their confidence intervals.

In this study, we use the last version of stock synthesis v3.30 (NOAA Fisheries Toolbox, 2011). This model is also age-structured; but the length data are transformed into ages within the model. This model is a highly flexible statistical model framework which allows the building of simple to complex models using a mix of data compositions available. We developed a preliminary base case model with ss3 starting from the simplest possibility that the data and dynamic of the fishery allow us.

2 Data

The data used are the same to the data used in the ICES assessment of 2020 before the transformation to age. We introduced catch data in a similar way as in the assessment model defining only one fleet, but with landings and discards disaggregated and landings data extended until 1968 with official data (Figure 1). The official landings data aggregate both species, and then the species were disaggregated assuming the same historical proportions by country historically. The length frequency data of commercial fleet and catch data are annual. The index of two surveys FR-IE-IBTS joint index, and the irish monkfish survey and their length frequency of these surveys in the same way as in the assessment. However, the index and length frequency of SPGFS survey is estimated only considering the largest fish (> 40cm) due to the difficulties on explaining the selection of the smallest fish (Figure 2).

3 Model

The base case (BC) was built starting from the simplest model structure and afterwards the model was modified depending mainly on the expert knowledge and the fit to the data.

Fleet: Only one fleet is considered following the same assumption than in the assessment model. The fleet by gear did not show any big changes with time (Figure 3).

Biology: The growth used in the BC is the same as in the AsMod, which was estimated following a cohort analysis using commercial length frequency data and survey data (WD04, WKANGLER-Batts and Gerritsen, 2018).

Stock Recruitment: Beverthon and Holdt relationship with steepness of 0.92. The steepness was estimated for *L. Piscatorius* using the library FishLife (Thorson 2019). The standard deviation of the SR is assumed a value of 0.6. The recruitment deviates start in 1986 at the same time as the length frequency data. The advanced option is activated and the biased stock recruitment is corrected with the settings assumed by r4ss (Table 1).

Selectivity: Double normal selecitivity is assumed for all the fleets with time varying selectivity for the commercial fleets in landings and discards.

Indices: The indices were introduced with the same cv of 0.2 for the all the fleets and years. Following the Dirichlet method the last 15 size bins of this fleets were aggregated because the fits of these fleet are improved since the value of theta is smaller than 5.

Initial equilibrium catch: it was assumed 20000 tonnes, which is close to the average of the last 10 years.

4 Results

In this study we developed a preliminary base case for the northern white anglerfish.

Table 2 list the estimated parameters with the BC model and table 3 the likelihoods.

Figure 4 shows the length at age. The estimated length at age of 0.75, the age until the growth is assumed linear, is 23.42 cm.

Figure 5 shows selectivity of commercial fleet and surveys. The model estimates a bit weird selectivity for the smallest fish for the FR-IE-IBTS joint index as well as for the monkfish survey Figure 5 also shows the time varying variability on the discards size, and in the retention.

Figure 6 shows the fit to the length composition (LC) of the discards, retained and surveys. The fit of the LC smallest fish of the FR-IE-IBTS seem good although the model overestimates a bit discards in the mode length. In the case of the retained selectivity the fits are good but in the case of SPGFS are not so good.

Figure 7 shows that the estimated mean length of the commercial fleet fits quite well the observed data, also for FR-IE-IBTS. Although the last years seem to overestimate the mean length observed by the survey. The problem is the mean length of the SPGFS surveys which is overestimated the all-time series.

Figure 8 shows that the fit to the indices is quite good although the fit of the last year overestimates the observed indices of the SPGFS and monkfish survey.

Figure 9 shows that the estimated virgin biomass is very high in comparison to the estimated total biomass during the period of 1968 and 2020. The recruitment deviates shows a regime shift in 2000. The fishing mortality values are a bit lower than the estimated during the assessment.

5 Discussion

There is a big uncertainty on how the fishery was previous to 1968. In the base case is assumed that the initial equilibrium catch was like the average of the last 10 years. However, different assumptions should be tested such as for example a homogeneous increase with time of catches.

The model does not fit well the length composition of the SPGFS survey, but when the selectivity of the surveys is modified to age based, this biased is corrected (Figure 10) but then the recruitment deviates are negative at the beginning of the time series and the fishing mortality is very low (Figure 11).

The negative recruitment deviates at the beginning of the time series also happen with different initial catch scenarios for example, when we assume a gradual increase of catches in the past. So for the moment we need to work more on that and also we should analyse the effect of different type of weighting the data and also a natural mortality following for example a Lorenzen curve.

6 References

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7 Tables

Table 1: The advanced option of stock recruitment relationship

1981 #_last_yr_nobias_adj_in_MPD; begin of ramp

1985 #_first_yr_fullbias_adj_in_MPD; begin of plateau

2019 #_last_yr_fullbias_adj_in_MPD

2020 #_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS sets bias_adj to 0.0 for fcast yrs)

0.95 #_max_bias_adj_in_MPD (-1 to override ramp and set biasadj=1.0 for all estimated recdevs)

Table 2 The fixed and estimated parameters values, ranges, standard deviation and gradients when the parameter is estimated on the BC.

	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Prior	Pr_SD	Pr_Like	Afterbound
L_at_Amin_Fem_GP_1	23.420600	2	10.0	35	24.00000	OK	0.2790560	8.88358e-06	No_prior	NA	NA	NA	OK
SR_LN(R0)	10.615000	1	1.5	30	9.30000	OK	0.0403356	-0.00011591	No_prior	NA	NA	NA	OK
InitF_seas_1_flt_1FL1	1.202600	1	0.0	3	0.10000	OK	0.4230400	-9.41928e-06	No_prior	NA	NA	NA	OK
F_fleet_1_YR_1968_s_1	0.561831	2	0.0	4	0.30000	act	0.1284180	1.97625e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1969_s_1	0.567658	2	0.0	4	0.30000	act	0.1287060	2.15923e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1970_s_1	0.572060	2	0.0	4	0.30000	act	0.1360910	2.79443e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1971_s_1	0.672893	2	0.0	4	0.30000	act	0.1621780	-4.41508e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1972_s_1	0.699648	2	0.0	4	0.30000	act	0.1716130	9.39523e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1973_s_1	0.480244	2	0.0	4	0.30000	act	0.1260090	9.3563e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1974_s_1	0.533118	2	0.0	4	0.30000	act	0.1463470	1.65924e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1975_s_1	0.521180	2	0.0	4	0.30000	act	0.1586110	-2.24093e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1976_s_1	0.498223	2	0.0	4	0.30000	act	0.1716300	2.88142e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1977_s_1	0.416262	2	0.0	4	0.30000	act	0.1442520	-1.6886e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1978_s_1	0.426157	2	0.0	4	0.30000	act	0.1434660	-7.78569e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1979_s_1	0.426664	2	0.0	4	0.30000	act	0.1377020	1.36417e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1980_s_1	0.542726	2	0.0	4	0.30000	act	0.1642150	3.32323e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1981_s_1	0.511830	2	0.0	4	0.30000	act	0.1485180	-5.23364e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1982_s_1	0.570877	2	0.0	4	0.30000	act	0.1581380	1.7154e-07	F	NA	NA	NA	OK
F_fleet_1_YR_1983_s_1	0.681317	2	0.0	4	0.30000	act	0.1788270	3.47747e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1984_s_1	0.424255	2	0.0	4	0.30000	act	0.0859901	-3.75571e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1985_s_1	0.382630	2	0.0	4	0.30000	act	0.0743465	-3.91095e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1986_s_1	0.341843	2	0.0	4	0.30000	act	0.0393902	-7.50423e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1987_s_1	0.357812	2	0.0	4	0.30000	act	0.0425248	2.64265e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1988_s_1	0.325100	2	0.0	4	0.30000	act	0.0381517	1.29465e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1989_s_1	0.381932	2	0.0	4	0.30000	act	0.0423586	2.21999e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1990_s_1	0.382436	2	0.0	4	0.30000	act	0.0436711	-2.84227e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1991_s_1	0.387185	2	0.0	4	0.30000	act	0.0468894	3.16543e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1992_s_1	0.344434	2	0.0	4	0.30000	act	0.0421240	-2.09895e-06	F	NA	NA	NA	OK

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	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Prior	Pr_SD	Pr_Like	Afterbound
F_fleet_1_YR_1993_s_1	0.362368	2	0.0	4	0.30000	act	0.0420314	-9.33847e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1994_s_1	0.335191	2	0.0	4	0.30000	act	0.0376369	-6.74981e-06	F	NA	NA	NA	OK
F_fleet_1_YR_1995_s_1	0.358672	2	0.0	4	0.30000	act	0.0390384	-1.31814e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1996_s_1	0.392768	2	0.0	4	0.30000	act	0.0416853	1.16333e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1997_s_1	0.461469	2	0.0	4	0.30000	act	0.0491097	-3.76257e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1998_s_1	0.523330	2	0.0	4	0.30000	act	0.0558177	2.67012e-05	F	NA	NA	NA	OK
F_fleet_1_YR_1999_s_1	0.622091	2	0.0	4	0.30000	act	0.0669109	2.25094e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2000_s_1	0.448035	2	0.0	4	0.30000	act	0.0487662	-5.47232e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2001_s_1	0.526929	2	0.0	4	0.30000	act	0.0556636	7.71636e-06	F	NA	NA	NA	OK
F_fleet_1_YR_2002_s_1	0.565107	2	0.0	4	0.30000	act	0.0598502	1.96547e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2003_s_1	0.555253	2	0.0	4	0.30000	act	0.0526625	-2.08059e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2004_s_1	0.530997	2	0.0	4	0.30000	act	0.0501128	5.91173e-06	F	NA	NA	NA	OK
F_fleet_1_YR_2005_s_1	0.543690	2	0.0	4	0.30000	act	0.0532366	-9.91436e-06	F	NA	NA	NA	OK
F_fleet_1_YR_2006_s_1	0.427227	2	0.0	4	0.30000	act	0.0417631	3.14343e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2007_s_1	0.462429	2	0.0	4	0.30000	act	0.0429432	5.29135e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2008_s_1	0.469193	2	0.0	4	0.30000	act	0.0450043	-2.43952e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2009_s_1	0.496041	2	0.0	4	0.30000	act	0.0501296	-1.15703e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2010_s_1	0.471919	2	0.0	4	0.30000	act	0.0481427	-1.49966e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2011_s_1	0.413104	2	0.0	4	0.30000	act	0.0421590	-2.73159e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2012_s_1	0.414430	2	0.0	4	0.30000	act	0.0412663	5.0072e-06	F	NA	NA	NA	OK
F_fleet_1_YR_2013_s_1	0.434782	2	0.0	4	0.30000	act	0.0433822	-6.67175e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2014_s_1	0.440767	2	0.0	4	0.30000	act	0.0439390	9.31686e-06	F	NA	NA	NA	OK
F_fleet_1_YR_2015_s_1	0.395240	2	0.0	4	0.30000	act	0.0415948	2.39148e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2016_s_1	0.378702	2	0.0	4	0.30000	act	0.0403578	-1.46052e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2017_s_1	0.328099	2	0.0	4	0.30000	act	0.0380412	-1.51188e-06	F	NA	NA	NA	OK
F_fleet_1_YR_2018_s_1	0.274440	2	0.0	4	0.30000	act	0.0348864	3.71771e-05	F	NA	NA	NA	OK
F_fleet_1_YR_2019_s_1	0.235494	2	0.0	4	0.30000	act	0.0332356	-1.62053e-05	F	NA	NA	NA	OK
Size_DblN_peak_FL1(1)	29.418700	4	5.0	100	45.00000	OK	4.9367800	4.54045e-05	No_prior	NA	NA	NA	OK
Size_DblN_top_logit_FL1(1)	-0.915999	5	-15.0	4	-15.00000	OK	0.0767460	5.15439e-05	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_FL1(1)	4.264580	5	-1.0	20	5.00000	OK	0.1792390	-6.50429e-05	No_prior	NA	NA	NA	OK

	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Prior	Pr_SD	Pr_Like	Afterbound
Size_DblN_descend_se_FL1(1)	7.256400	5	-1.0	30	6.00000	OK	0.1405390	-2.341e-05	No_prior	NA	NA	NA	OK
Retain_L_infl_FL1(1)	20.920900	4	5.0	100	30.00000	OK	5.3866200	0.000139329	No_prior	NA	NA	NA	OK
Retain_L_width_FL1(1)	2.675630	5	0.1	40	5.00000	OK	0.1103840	8.83186e-06	No_prior	NA	NA	NA	OK
Retain_L_asymptote_logit_FL1(1)	4.366860	5	-10.0	20	3.73864	OK	0.2857010	-4.97355e-05	No_prior	NA	NA	NA	OK
Size_DblN_peak_FR-IE-IBTS(2)	62.471100	4	5.0	100	10.00000	OK	4.3935300	2.81244e-05	No_prior	NA	NA	NA	OK
Size_DblN_top_logit_FR-IE-IBTS(2)	-11.481000	5	-15.0	4	-15.00000	OK	57.2882000	1.86995e-06	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_FR-IE-IBTS(2)	8.216490	5	-9.0	9	5.00000	OK	0.1997970	-3.08182e-05	No_prior	NA	NA	NA	OK
Size_DblN_descend_se_FR-IE-IBTS(2)	7.305750	5	-5.0	30	6.00000	OK	0.3007670	-5.42849e-05	No_prior	NA	NA	NA	OK
Size_DblN_peak_IE_MONKSURVEY(3)	74.532200	4	5.0	130	45.00000	OK	4.3768100	-1.32525e-05	No_prior	NA	NA	NA	OK
Size_DblN_top_logit_IE_MONKSURVEY(3)	-11.060500	5	-15.0	4	-15.00000	OK	62.4720000	-5.94301e-07	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_IE_MONKSURVEY(3)	7.593540	5	-15.0	9	5.00000	OK	0.1572750	3.18284e-06	No_prior	NA	NA	NA	OK
Size_DblN_descend_se_IE_MONKSURVEY(3)	6.720230	5	-15.0	30	6.00000	OK	0.4156760	-2.09479e-05	No_prior	NA	NA	NA	OK
Size_DblN_peak_SPGFS(4)	64.202800	4	5.0	130	45.00000	OK	0.7033780	-5.33111e-05	No_prior	NA	NA	NA	OK
Size_DblN_top_logit_SPGFS(4)	-6.006260	5	-15.0	4	-15.00000	OK	172.6430000	5.91935e-07	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_SPGFS(4)	5.048810	5	-1.0	9	5.00000	OK	0.0748524	7.38535e-05	No_prior	NA	NA	NA	OK
ln(DM_theta)_3	3.286350	5	-5.0	5	5.00000	OK	1.2922700	3.71275e-06	No_prior	NA	NA	NA	OK

Table 3: Likelihoods of the base case (BC).

	values	lambdas
TOTAL	1.28511e+03	NA
Catch	4.46738e+00	NA
Equil_catch	1.38534e-02	1
Survey	-3.93678e+01	NA
Discard	-7.34832e+00	NA
Length_comp	1.25211e+03	NA
Recruitment	6.65462e+00	1
InitEQ_Regime	2.09712e-31	1
Forecast_Recruitment	0.00000e+00	1
Parm_priors	5.05000e+01	1
Parm_softbounds	8.06732e-03	NA
Parm_devs	1.80700e+01	1
Crash_Pen	0.00000e+00	1

8 Figures

Figure 1: Official landings data of both species aggregated.

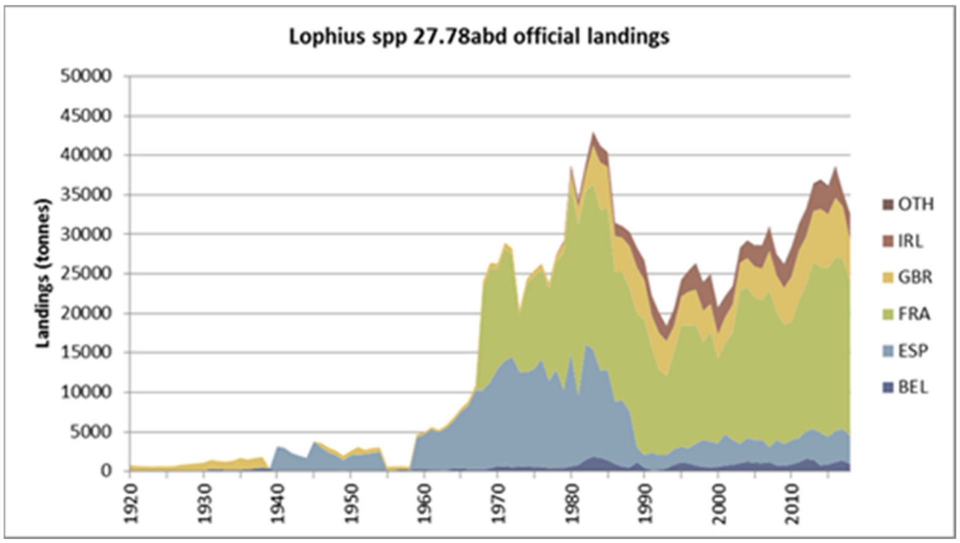


Figure 2: The length frequency of the fleets and the surveys:fishery is the commercial fleet, f2 is the FR-IE-IBTS survey, f3 is the Irish monkfish survey and f4 is the SPGS survey.

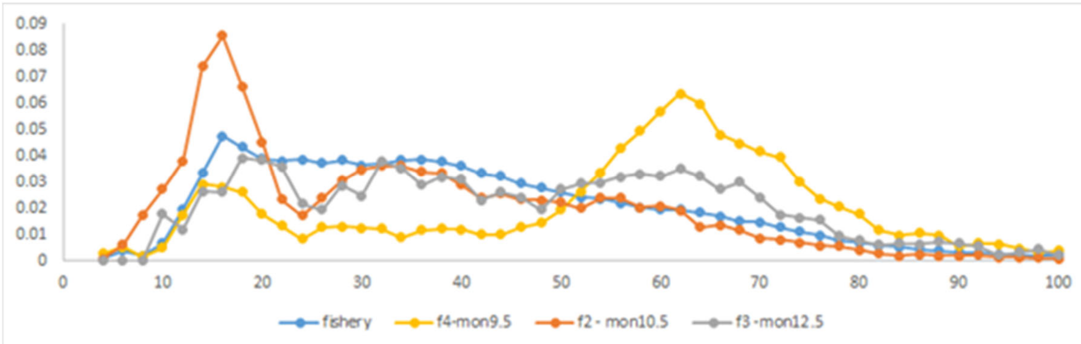


Figure 3: *The proportion of catch by gear with time.*

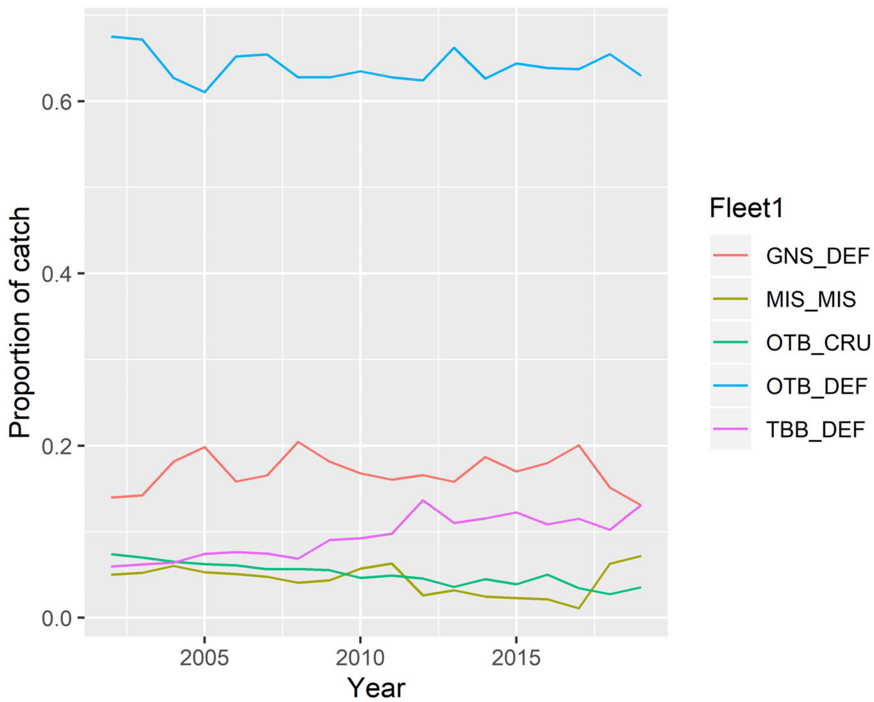


Figure 4: Figure shows the length at age at the end of the year of the BC, the selectivity

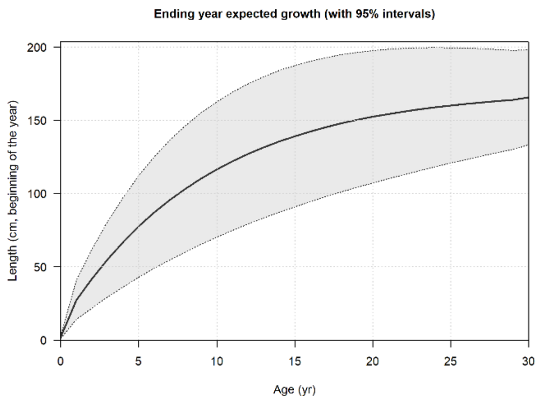


Figure 5: Selectivity of the commercial fleet and surveys and the bottom left and right the time varying selectivity in retention and in landings of the BC model.

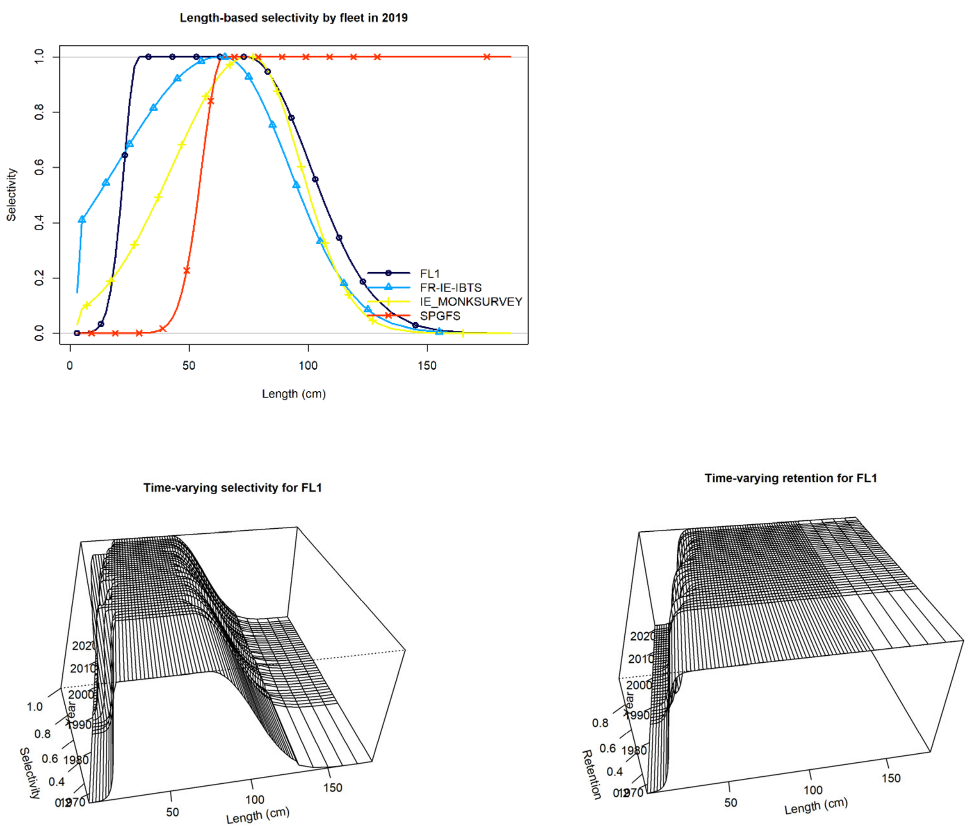


Figure 6: The aggregated length composition and fits of the model to the discards, retained and surveys.

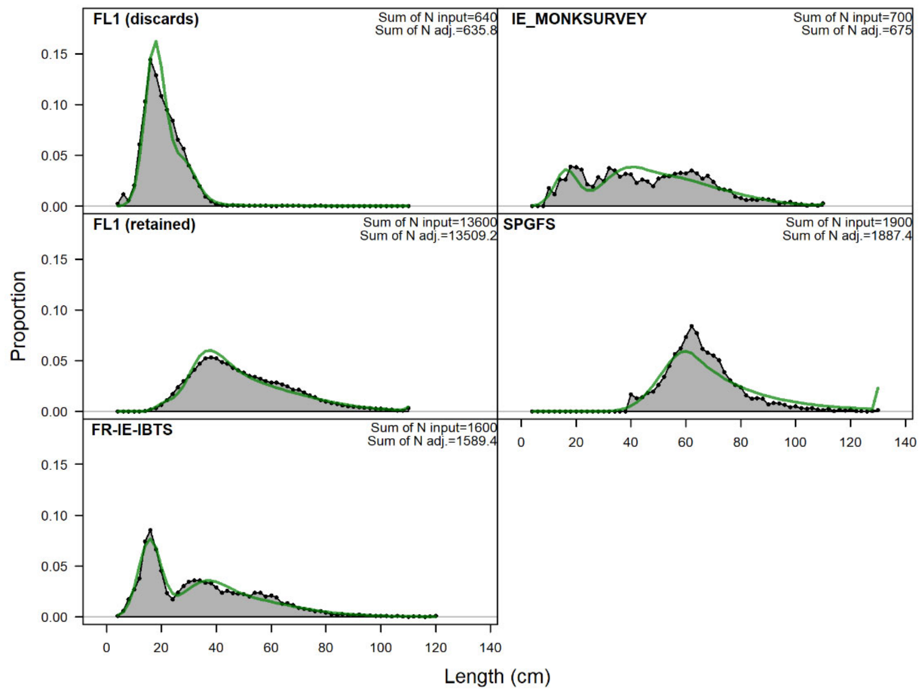


Figure 7: a) The fit of the indices: FR-IE-IBTS join index, b) Monkfish survey, c) SP-Porc Survey.

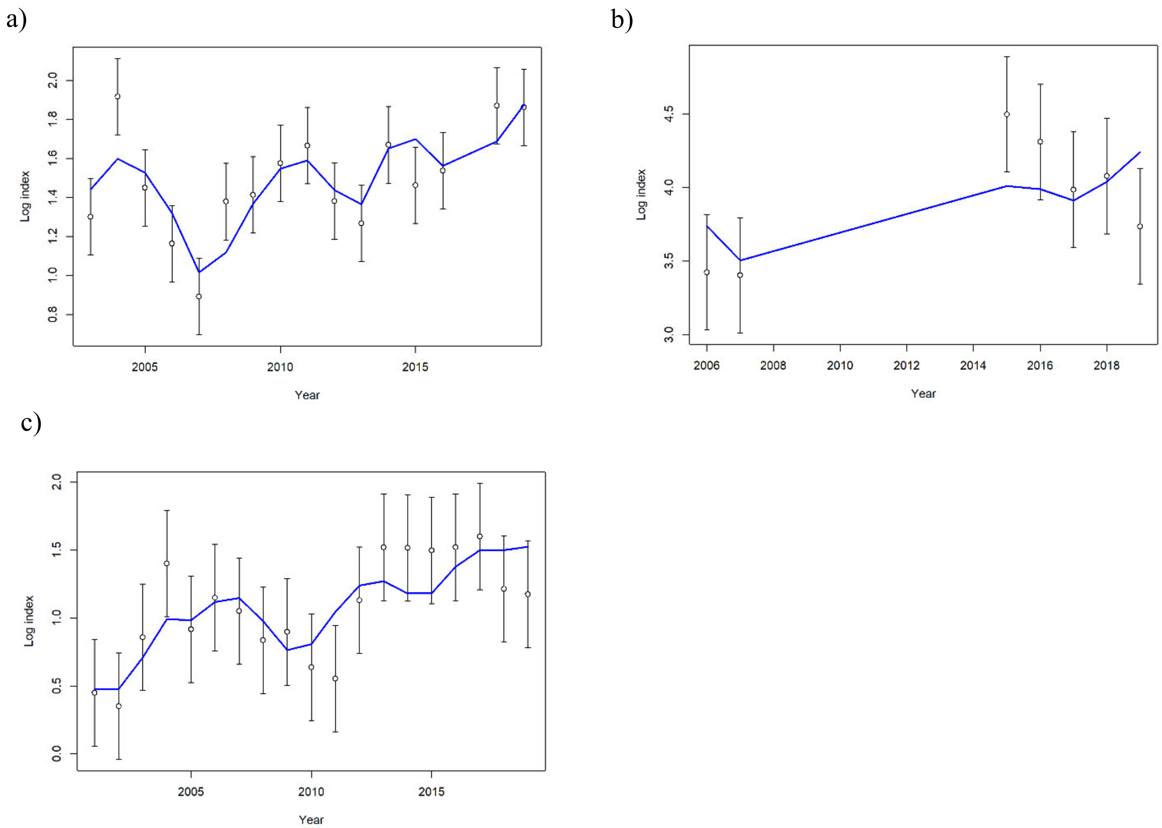


Figure 8: Time series of size for the fleet and for each of the survey observed values in black and the fitted in blue.

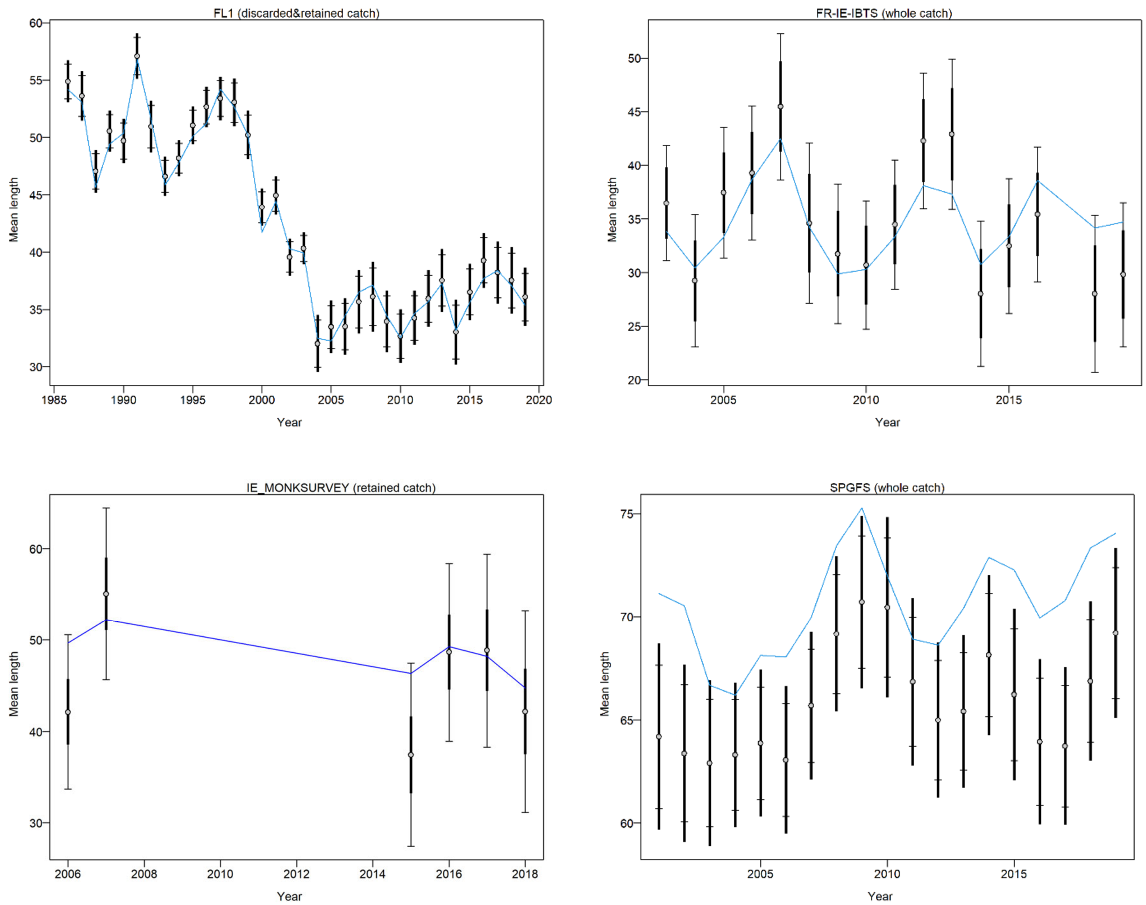


Figure 9: The estimated time series of total biomass, recruitment deviates and fishing mortality with the base case.

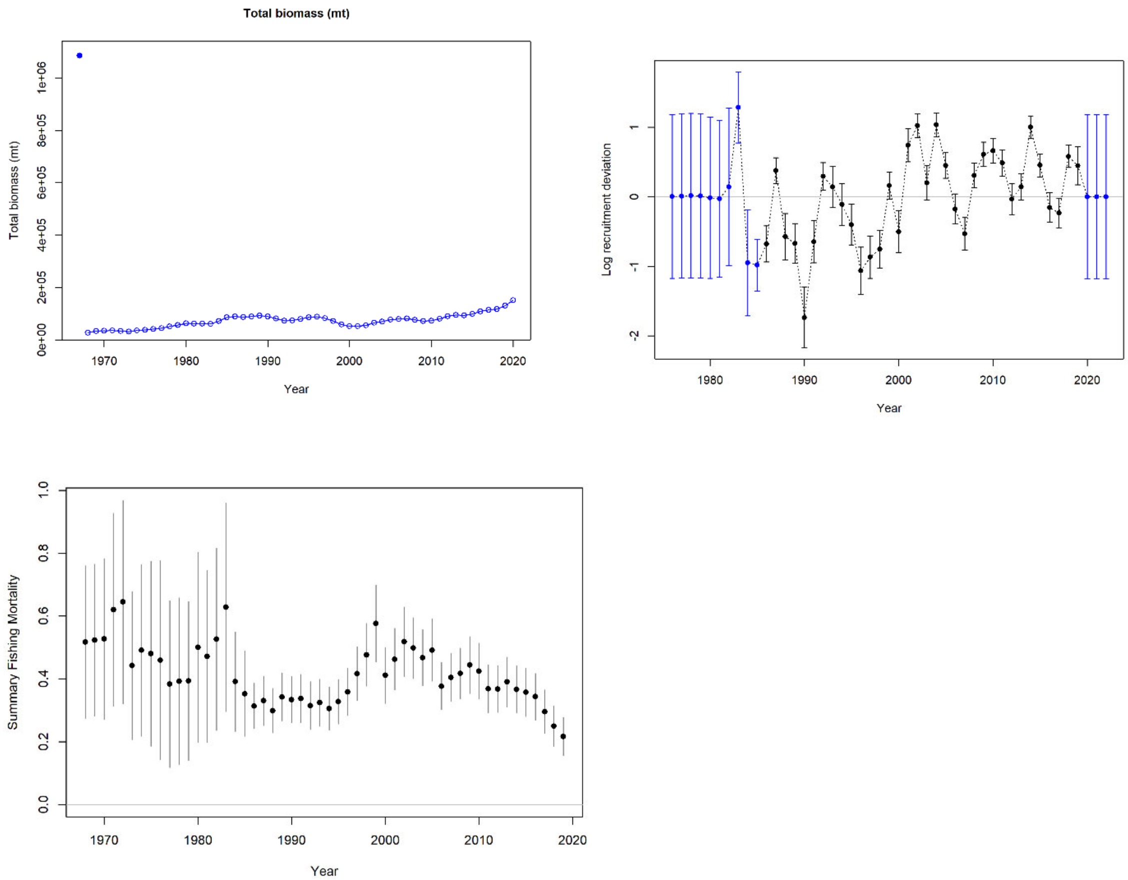


Figure 10: The length and age-based selectivity for the fleets simulated in a sensitivity analysis and the estimated time series of mean length of SPGFS survey.

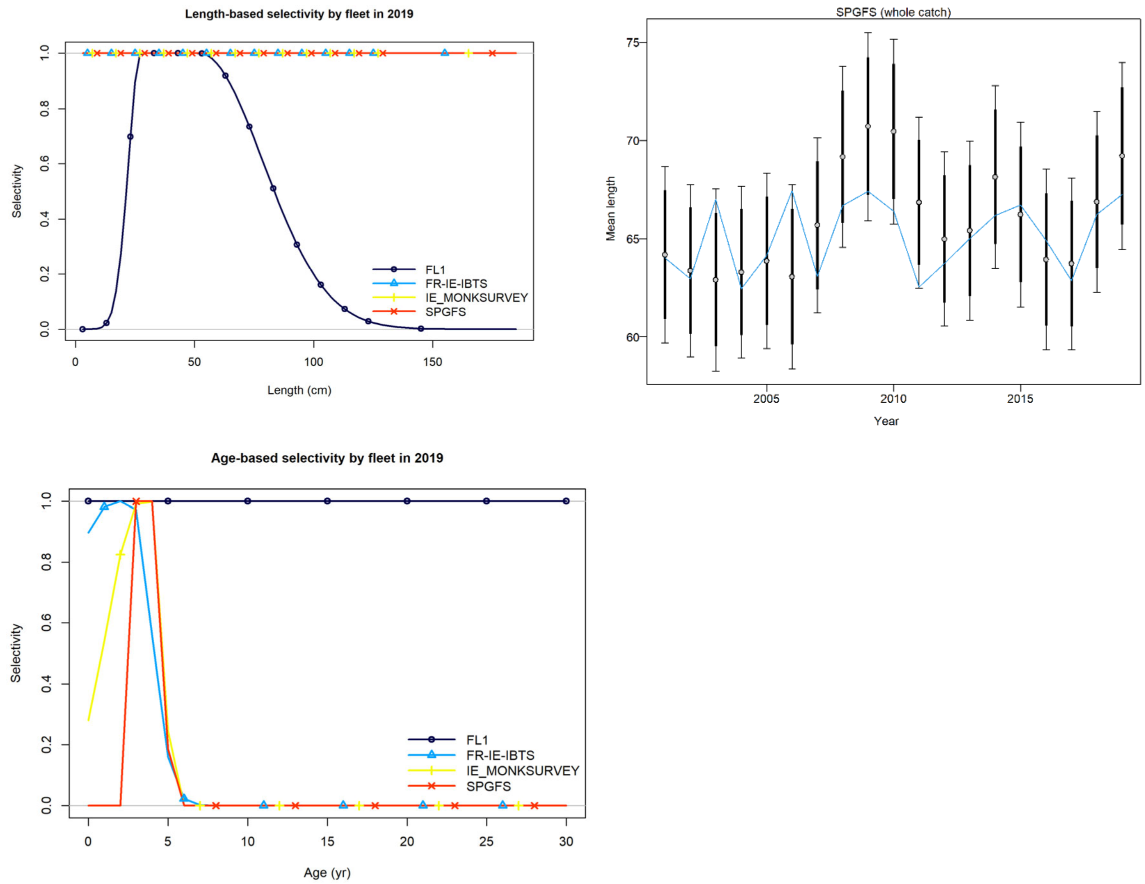
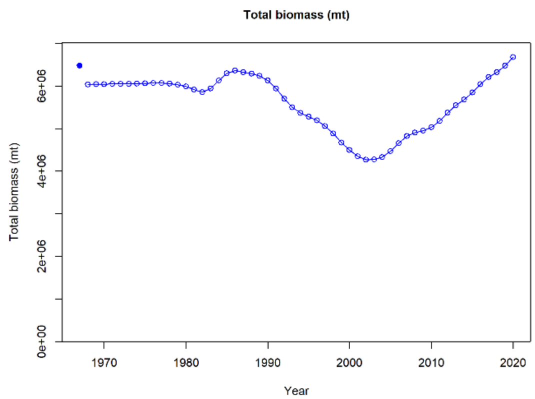
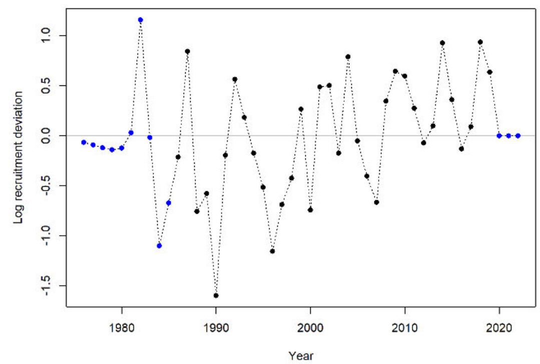
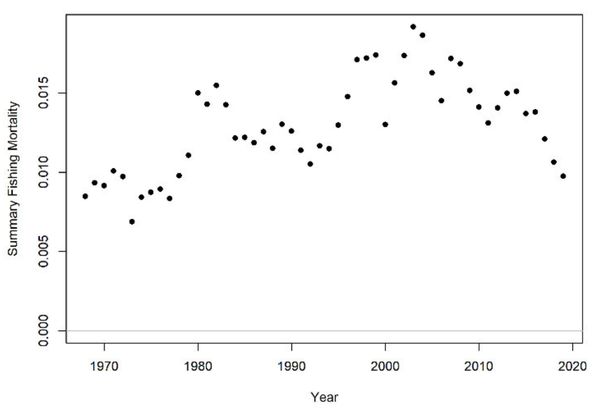


Figure 11: The length and age based selectivity for the fleets simulated in a sensitivity analysis and the estimated time series of mean length of SPGFS survey.







Working document presented to the WKTaDSA 2nd meeting,

Training and development a stock assessment model for white anglerfish in Divisions 8c and 9a using Stock Synthesis

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1. Introduction

L. piscatorius (white anglerfish) is distributed from Norway (Barents Sea) to the Strait of Gibraltar (and including the Mediterranean and the Black Sea). Anglerfish occur in a wide range of depths, from shallow waters to at least 1000 m. Information about spawning areas and seasonality is scarce, therefore the stock structure remains unclear. This lack of information is due to their particular spawning behaviour. Anglerfish eggs and larvae are rarely caught in scientific surveys.

White anglerfish in Divisions 8c and 9a (mon8c9a) is mainly caught by Spanish and Portuguese bottom trawlers and gillnet fisheries. For some gillnet fishery, it is an important target species, while it is also a by catch of the trawl fishery targeting hake or crustaceans. Since 2010, Spanish landings were on average 84% of total landings of the stock. The length distribution of the landings is considerably different between both fisheries, with the gillnet landings showing higher mean lengths compared to those landed by trawls. From 2005 to 2019, the Spanish landings were on average 39% from the trawl fleet (in 2019, mean lengths of 63 cm and 73 cm in Divisions 8c and 9a, respectively were observed) and 61% from the gillnet fishery (mean length of 85 cm in Division 8c was observed in 2019). For the same period, Portuguese landings were on average 11% from bottom trawlers (mean length of 54 cm in 2019) and 89% from the artisanal fleet (mean length of 70 cm in 2019).

Until 2011 white anglerfish stock was assessed with a non-equilibrium production model (ASPIC software). Results from growth studies provide a growth pattern for this stock allowing the application of a length-based assessment model. Stock Synthesis (SS) was considered a suitable model to assess this stock by WKFLAT (ICES, 2012). During the WKANGLER (ICES, 2018), some settings and input data of SS assessment model for white anglerfish were modified.

The objectives of this document are to explore alternative configuration of the assessment model following the suggestions proposed by SS experts to address the concerns of the current model and to identify input data and model settings that should be considered in a future benchmark of the stock.

2. Current assessment model

The current model uses Stock Synthesis (Methot, 2000) with the software Stock Synthesis v3.30.10 (Methot *et al.*, 2018). The SS model has been designed for a particular set of data and specifications. White anglerfish is harvested by four fleets, and two commercial lpue series and one fishery-independent survey provide information about relative abundance. No discard information is considered. Length composition data are available from both the fisheries and surveys. No age information is available for this stock.

Input data

Years: 1980–2019.

Model structure:

- Temporal unit: quarterly based data (landings, lpue and length–frequency) were used in SS calculations.
- Spatial structure: One area.
- Sex: Both sexes combined.

Fleet definition:

Four *fleets* were defined attending to the gear type and country:

- Spanish trawlers in ICES divisions8.c–9.a (SPTR8C9A)
- Spanish artisanal in ICES Division 8.c (SPART8C)
- Portuguese trawlers in ICES Division 9.a (PTTR9A)
- Portuguese artisanal in ICES Division 9.a (PTART9A)

Landed catches:

Quarterly landings entered the model as biomass (in weight) for the four fleets. Landings data for January 1980 to December 2019 were used to conduct the stock assessment of white anglerfish.

From 1980 to 1988 quarterly landings were estimated using the average proportion for the further five years (1989–1993) by fleet. In the case of SPART8C quarterly landings were estimated from 1980 to 1993 using the average proportion for the further five years (1994–1998).

Abundance indices:

- A Coruña trawlers (SPCORTR8C): Quarterly lpue in weight from 1982 to 2012. It is entered as four separate indices, one index per quarter.
- Cedeira gillnetters (SPCEDGN8C): Quarterly lpue in weight from 1999 to 2011. It is entered as four separate indices, one index per quarter.
- Spanish Groundfish Survey (SPGFS): Abundance index in numbers from 1983 to 2019, except for 1987.

Length composition of data:

The length bin was set by 2 cm, from 4 to 100 cm, by 10 cm from 100 to 160 cm and by 40 cm from 160 to 200 cm. Length composition for the four fishing fleets and the three abundance indices were used. The available length data and their disaggregated level differ among fleets:

Length composition of Fleets:

- SPTR8C9A: 1986–2019, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach available in SS.
- SPART8C: 1986–2019, quarterly basis. From 1986 to 1994 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach available in SS.
- PTTR9A: 1986–2009, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach presented in SS.
- PTART9A: 1986–2009, quarterly basis. From 1986 to 1988 quarterly length proportions were estimated from an annual proportion using the Data Super-Period approach present in SS.

Length composition of Abundance Indices:

- SPCORTR8C: 1982–2012, quarterly basis. Gaps are presented in years 1982, 1984, 1985 and 1986.
- SPCEDGN8C: 1999–2011, quarterly basis.
- SPGFS: length composition for fourth quarter, from 1983–2019. 1987 length composition is missing.

Model assumptions and parameters

- Natural mortality: M=0.2 for all ages and years.
- Growth: vonBertalanffy function: K=0.11 fixed, L_{max} and mean length-at-age 0.75 are estimated.
- Maturity ogive: length-based logistic, L_{50}=61.84 and slope=-0.1001, constant over time.
- Weight-at-length: a=2.5×10-5 b=2.853, not estimated.
- Recruitment allocation in Quarter 3.
- Stock–recruitment relationship: Beverton–Holt model: steepness h=0.999, sigmaR=0.4, R0 estimated.
- Selectivity: For all fleets selectivity was only length-based and was modelled as a double normal function. Selectivity for fishery PTART9A was set to be flattop. Selectivity varies among fleets, but is assumed to be time-invariant.

Main results

The results from the latest ICES assessment of this stock showed that the spawning-stock biomass has increased from 2007 to 2019 (Figure 1). SSB in 2020 is estimated at 12.5 Kt which is well above of Bpa (2 769 t) and MSY Btrigger (6 283 t). Fishing mortality in 2019 has decreased by 12% relative to 2018. F in 2019 is estimated to be at a value of 0.087, below Fpa (0.4) and FMSY (0.24). An increase in landings occurred from 1.1 Kt in 2011 to 2.0 Kt in 2014 but declined to 0.9 Kt in 2019. For the period 2015-2018, recruitments were extremely low, being the main concern about the status of the stock. In 2019, the recruitment estimated indicates a moderate increase in the abundance of age-0.

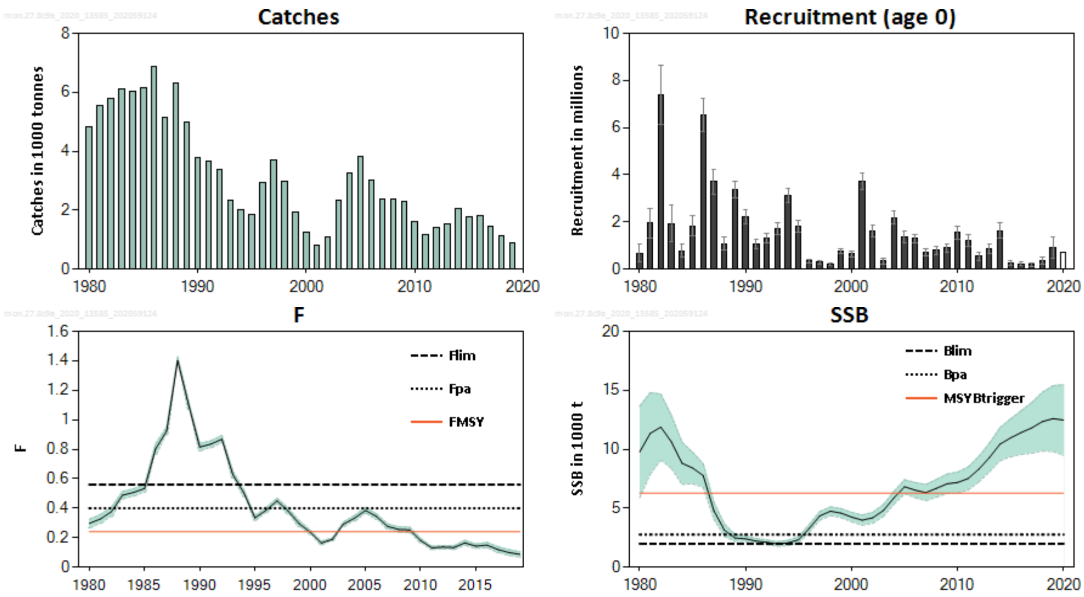

Figure 1. Main results of the latest ICES assessment for mon8c9a.

Quality considerations

Uncertainty of the assessment model may have increased due to the missing data for commercial abundance indices since 2012. For the last 10 years, the model lacks of an abundance indicator for larger individuals which might have an impact on the precision of SSB estimates.

In order to avoid a 'cryptic' biomass phenomenon, which may translate to population estimates of larger fish that are not comparable to those observed through sampling efforts, the selectivity of the fleet PT-ART-9a is forced to be asymptotic. However, this fleet is down-weighted in the model due to its low sample size, thus, potentially reducing its capacity of buffering the cryptic biomass.

3. Alternative model configuration

During the first meeting of WKTaDSA the quality considerations of the current model were commented to the Stock Synthesis experts and, as a result of their advice, different alternative run were tested and they are presented below. The base case model is the current assessment model.

3.1. Run SELLOG. Forcing the selectivity of the fishery SPART8C to be logistic.

The results of the latest assessment indicated that, despite the very low recruitments detected the last 4 years and the high decrease in landings since 2017, the stock biomass has never stopped to increase since 2007. Although the selectivity of the fishery PTART9A was forced to be logistic in the current model, the low representativeness of this fishery on recent years could be not enough to allow the model to estimate fishing mortality for larger individuals and causing the effect of "cryptic" biomass. For this reason, it is proposed to force the selectivity of SPART8C to be logistic.

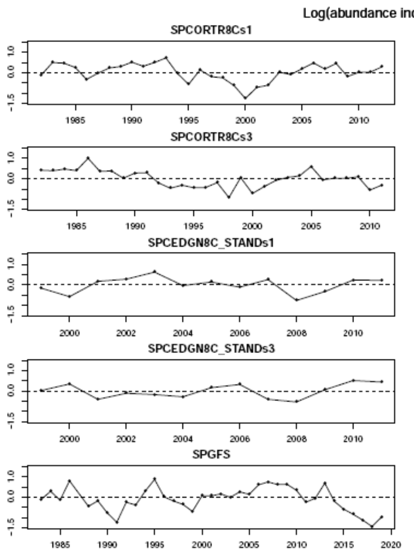

Figure 2. Run SELLOG. Log residuals for the abundance indices used in the assessment.

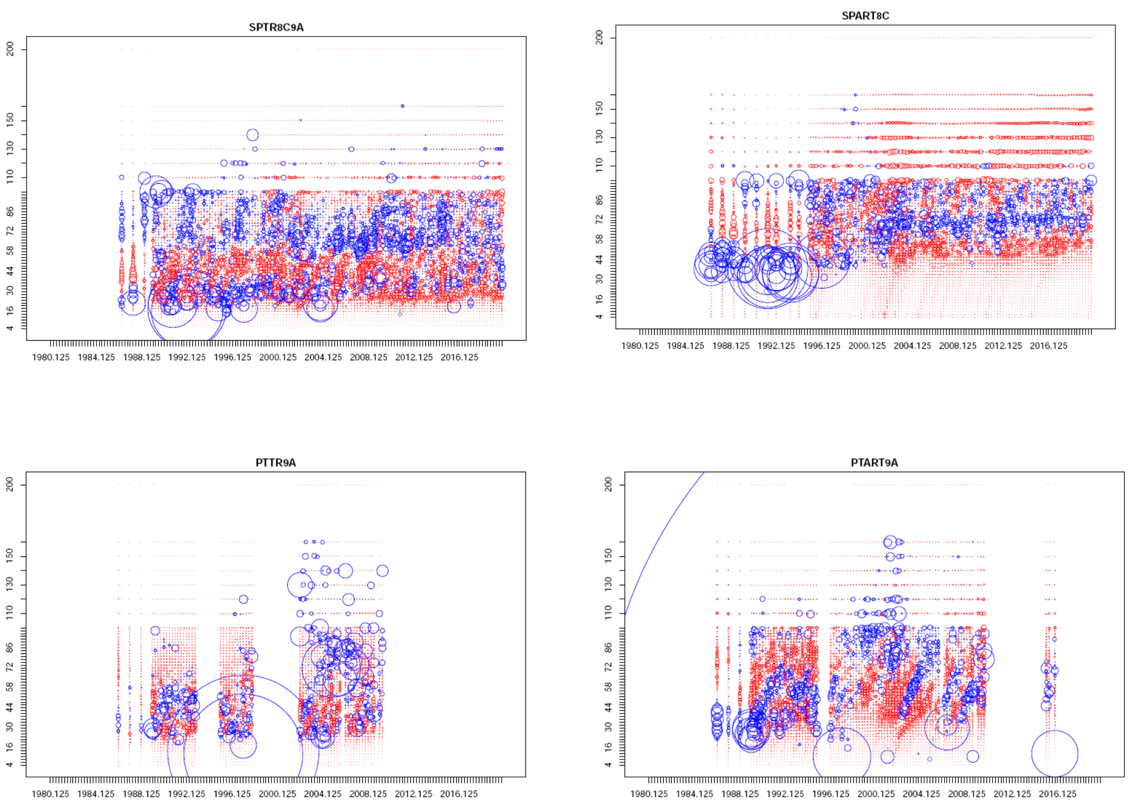

Figure 3. Run SELLOG. Pearson residuals of the fit to the length distributions of the fisheries. Blue=positive residuals and red=negative residuals.

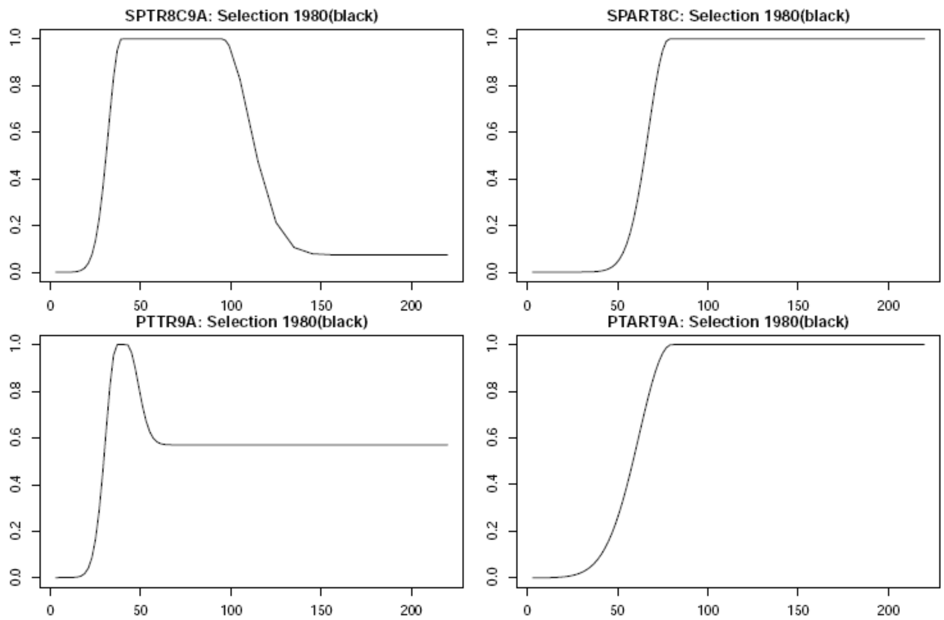

Figure 4. Run SELLOG. Relative selection patterns at length by fishery estimated by SS. SPART8C and PTART9A are forced to be logistic.

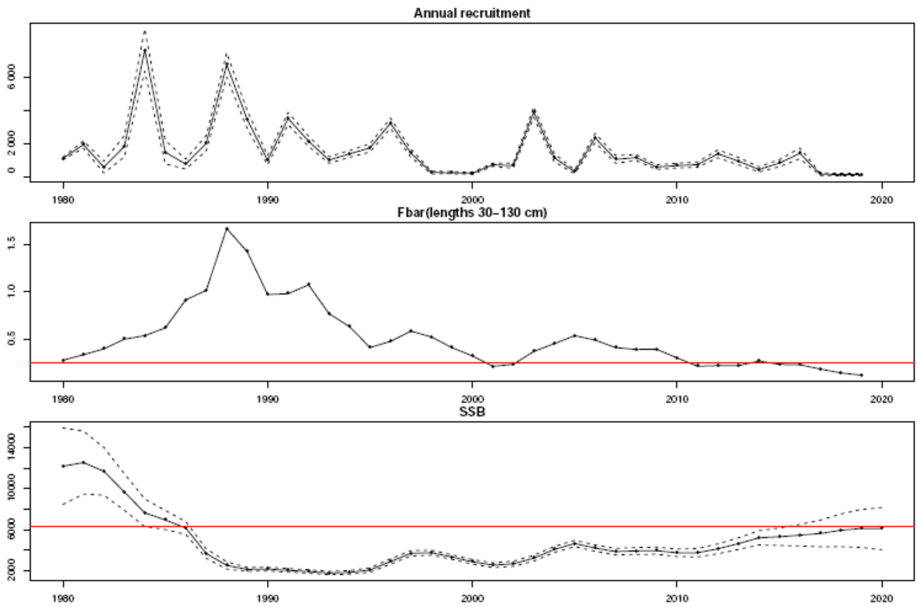

Figure 5. Run SELLOG. Summary plots of stock trends (with 95% intervals).

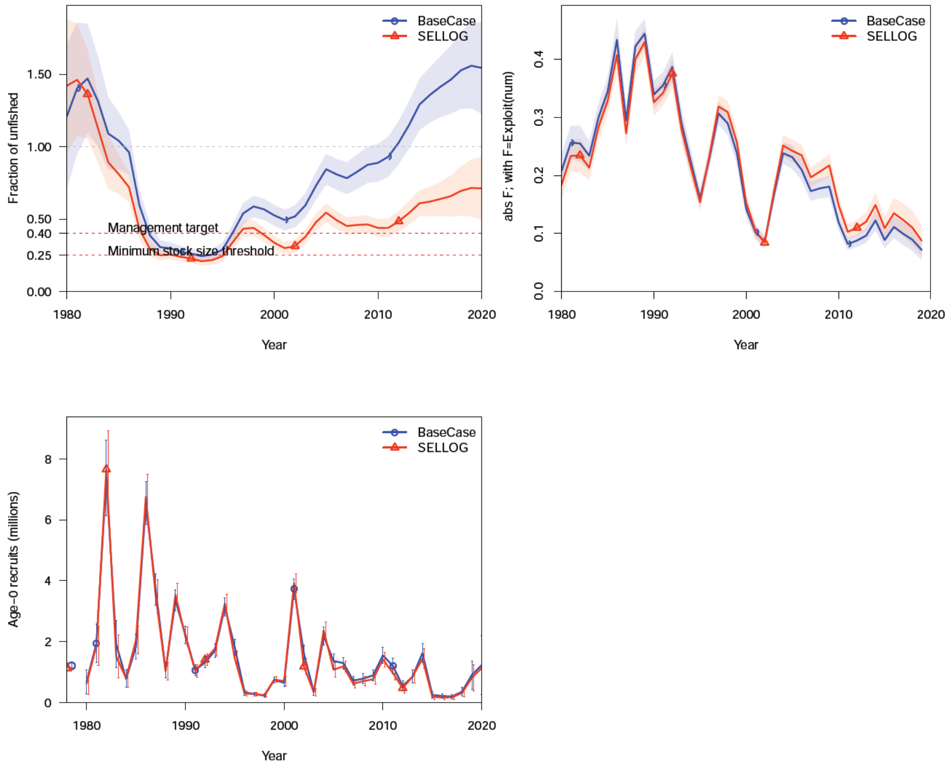

Figure 6. Run SELLOG. Comparison of Base Case – Run SELLOG model results.

As it was expected, the change in selectivity had a big impact on the results of the model (Figure 6). SSB estimates were quite sensitive to this change. Until 1995, SSB showed similar estimates for both runs. Since this year the SSB trends were similar but the absolute values were markedly lower when assuming a logistic selectivity. Even if selectivity of SPART8C is flat-topped, the increase in SSB in the last years is maintained.

There are reasons that indicate that is not recommended to force selectivity modelled based on observations to be logistic. A dome-shaped selectivity could be a real representation of the catchability of the fleet, and the enforced change will affect not only to the biomass (change that was expected) but the fishing mortality and reference points.

3.2 Run EFFCOR. Use effort information for the abundance index LPUE- SPCORTR8C (1982-2019)

The effort series of the abundance index SPCORTR8C for the whole period available (1982-2019) was used in the model as an abundance index. Effort information was used instead of LPUE, trying to avoid the impact of the changes on catchability along the time series. There are evidences that are indicating that catchability could have been modified since 2012. The configuration of the run SELLOG was used to run the model.

The fit of the model was poor and the model couldn’t follow the effort values (Figure 7). It was considered that the option of using the effort information for the SPCORTR8C is not supported and this configuration was discarded.

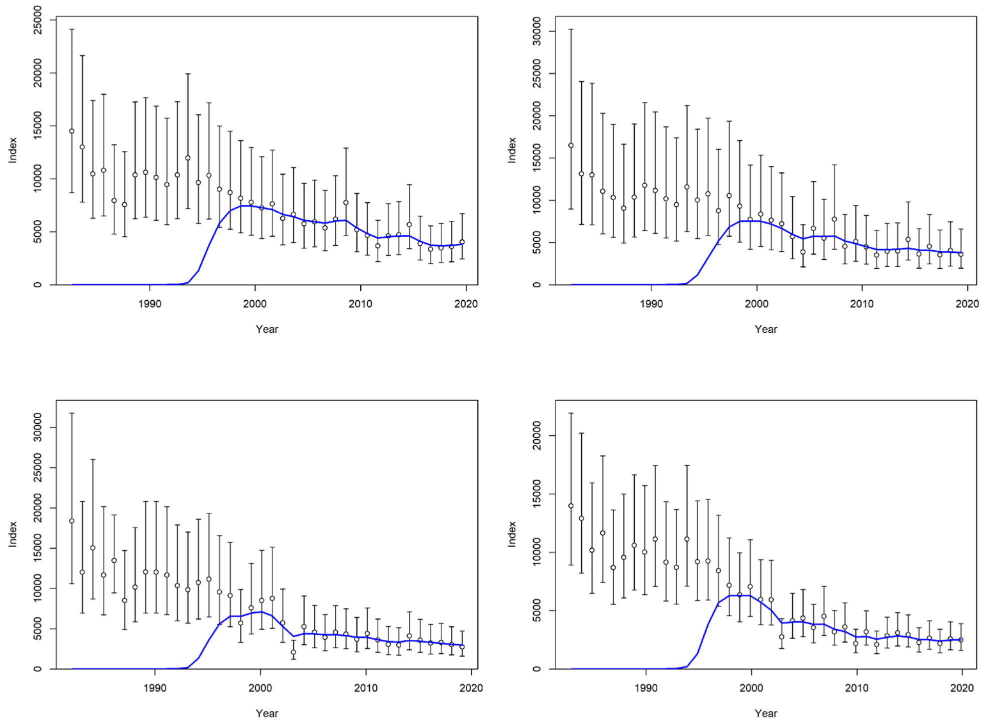

Figure 7. Run EFFCOR. Model fit to the effort values of the quarterly abundance series of SPCORTR8C.

3.3 Run QCOR. Incorporate time-varying catchability for the abundance index LPUE-SPCORTR8C (1982-2019) using random walk.

Although the abundance index LPUE-SPCORTR8C is available for the period 1982-2019, this is a non-standardized index and it is known that changes in its catchability might have occurred since 2012. Raw data of the index are not available, making not possible the standardization of the series. In order to use the whole time series of the index in the model, taking into account changes in the catchability of the SPCORTR8C, the catchability was allowed to follow a random walk. The model configuration of the run SELLOG was used to this model.

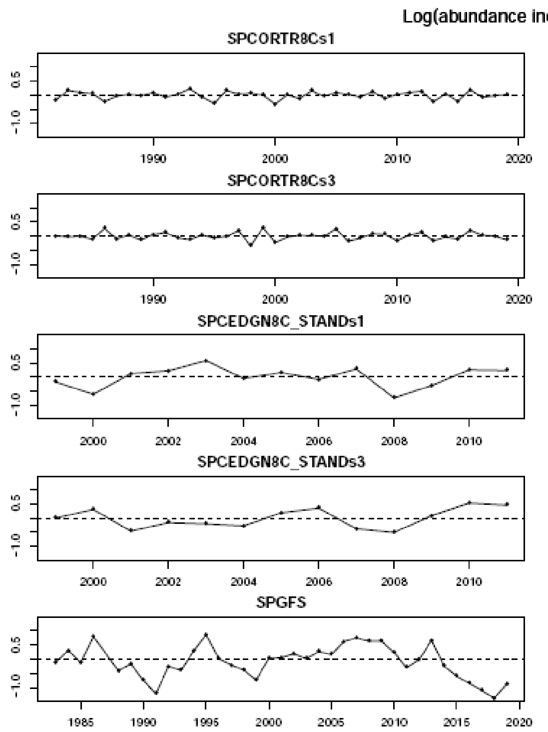

Figure 8. Run QCOR. Log residuals for the abundance indices used in the assessment.

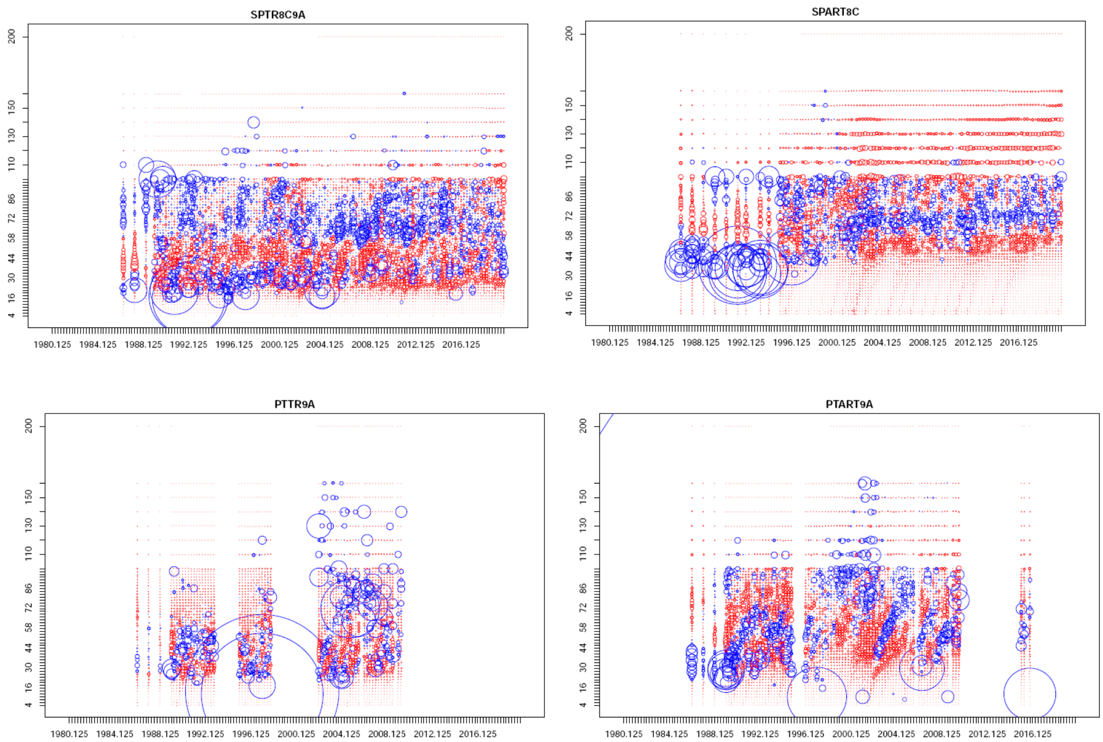

Figure 9. Run QCOR Pearson residuals of the fit to the length distributions of the fisheries. Blue=positive residuals and red=negative residuals.

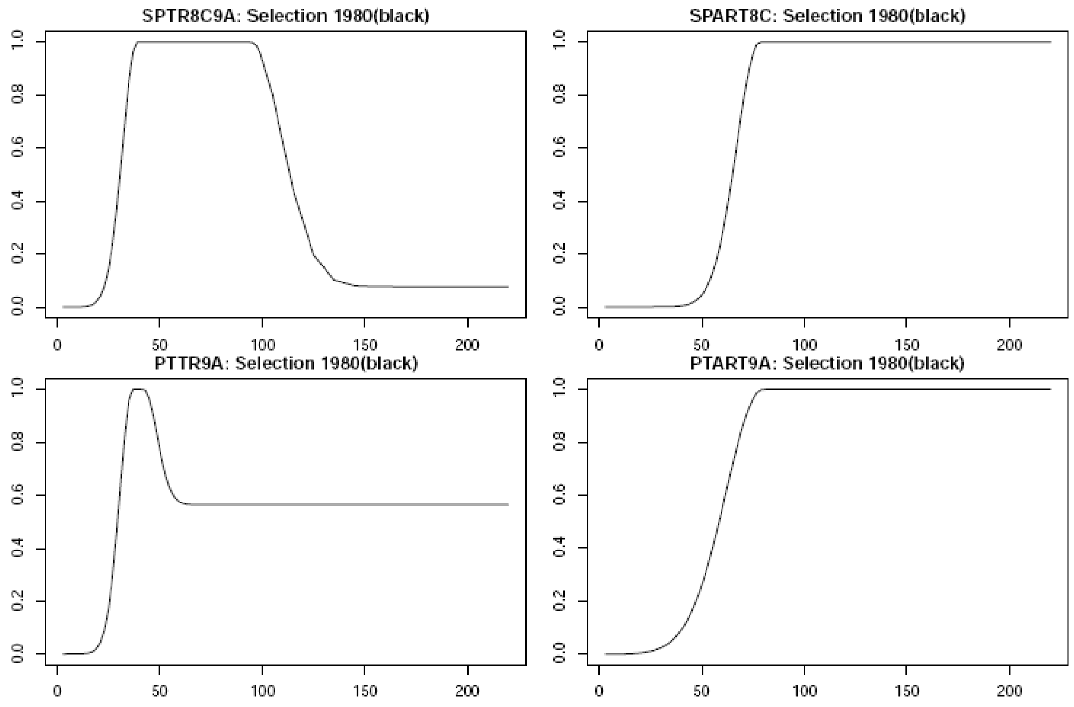

Figure 10. Run QCOR. Relative selection patterns at length by fishery estimated by SS. SPART8C and PTART9A are forced to be logistic.

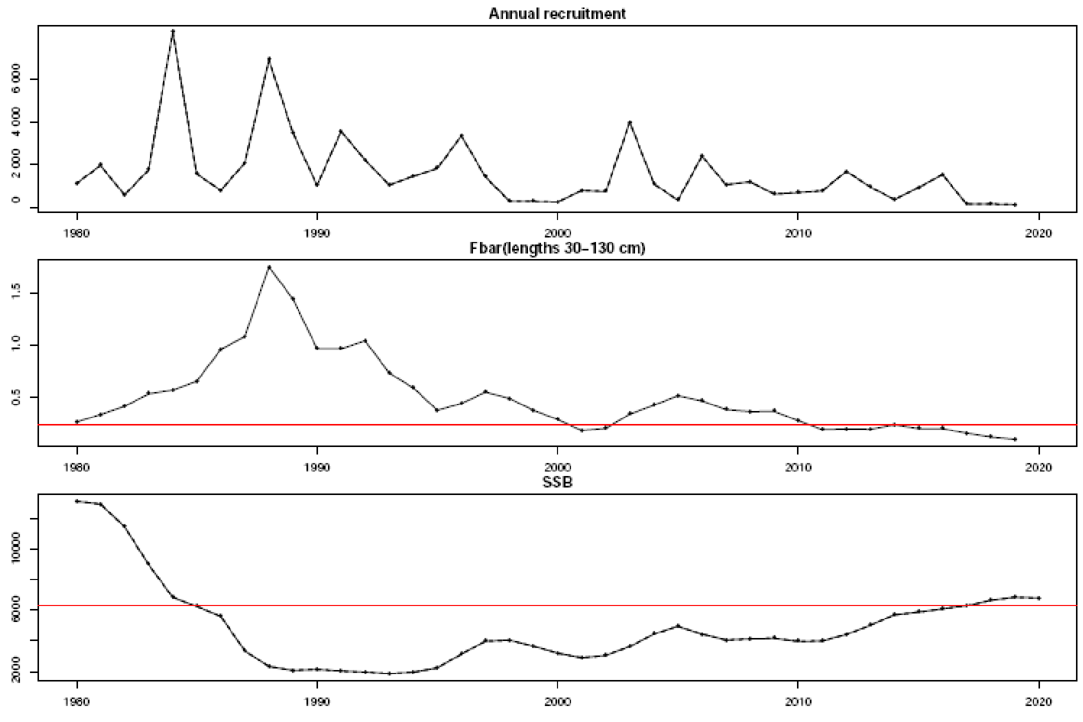

Figure 11. Run QCOR. Summary plots of stock trends.

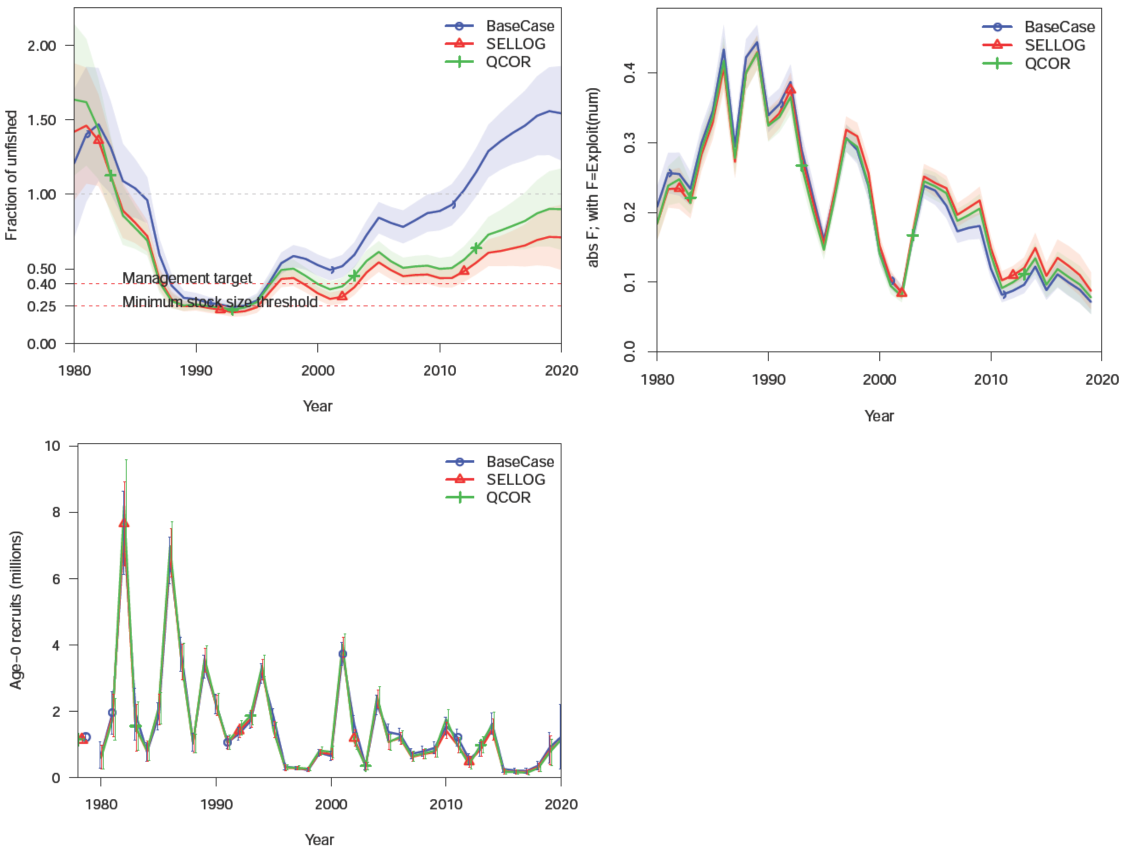

Figure 12. Comparison of runs Base Case, SELLOG AND QCOR model results.

This run was very time-consuming, as 144 parameters related with catchability had to be calculated. Every year a value of Q is calculated for each of quarterly index of SPCORTR8C. The bigger impact was on the SSB (Figure 12), where the inclusion of the whole time-series of LPUE SPCORTR8C supposed an increase in the SSB estimates in the last 9 years.

3.4. Run QCOR-TRENDS. Incorporate time-varying catchability for the abundance index SPCORTR8C using period trends.

This run using the configuration of run SELLOG, the catchability of SPCORTR8C is allowed to change by period trends. With this configuration the number of parameters to be calculated by the model is significantly reduced.

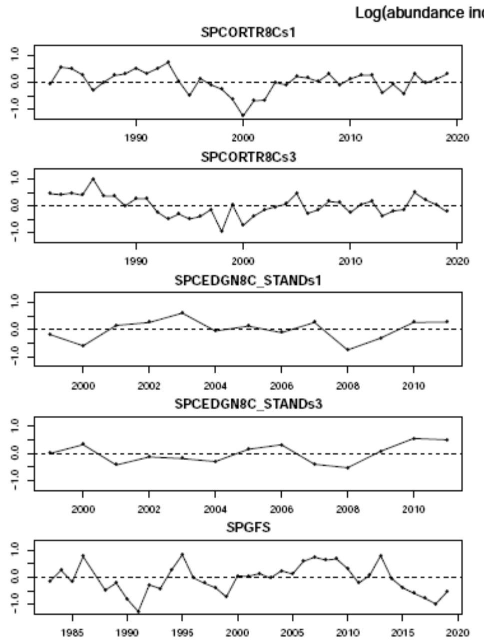

Figure 13. Run QCOR-TRENDS. Log residuals for the abundance indices used in the assessment.

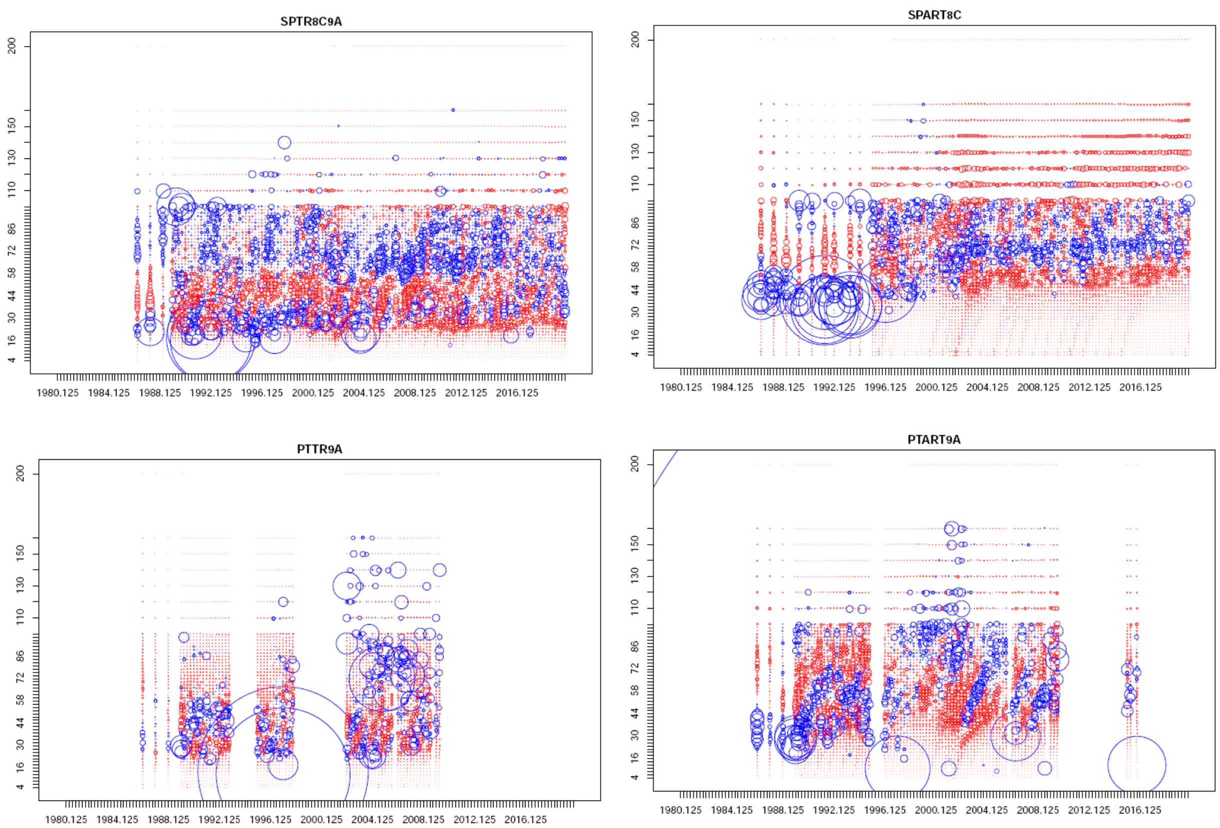

Figure 14. Run QCOR-TRENDS. Pearson residuals of the fit to the length distributions of the fisheries. Blue=positive residuals and red=negative residuals.

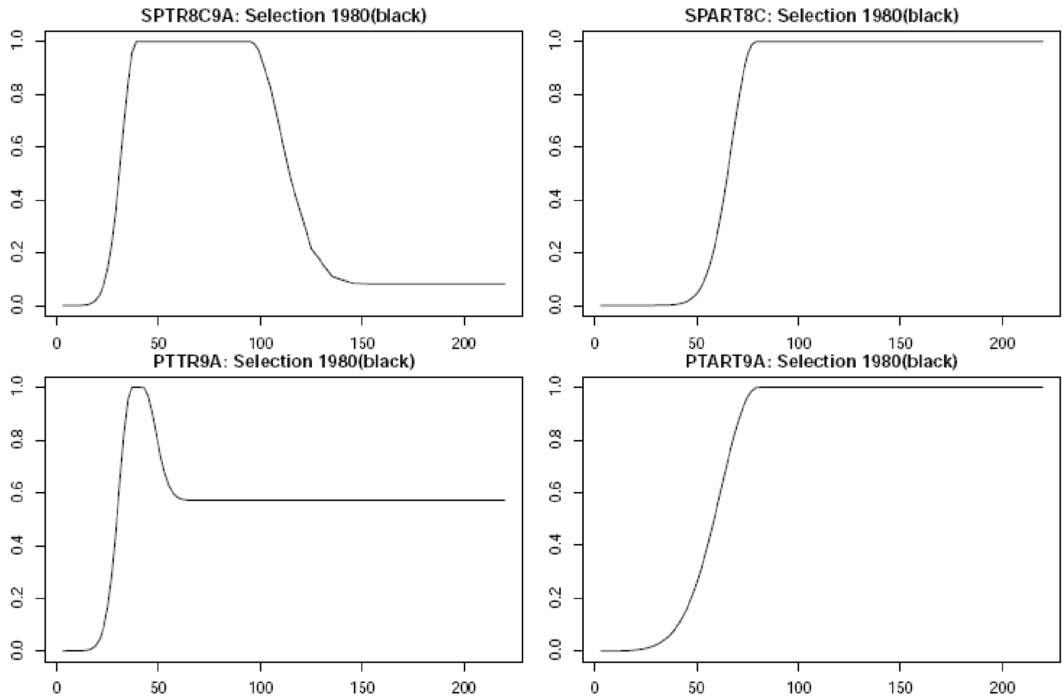

Figure 15. Run QCOR-TRENDS. Relative selection patterns at length by fishery estimated by SS.

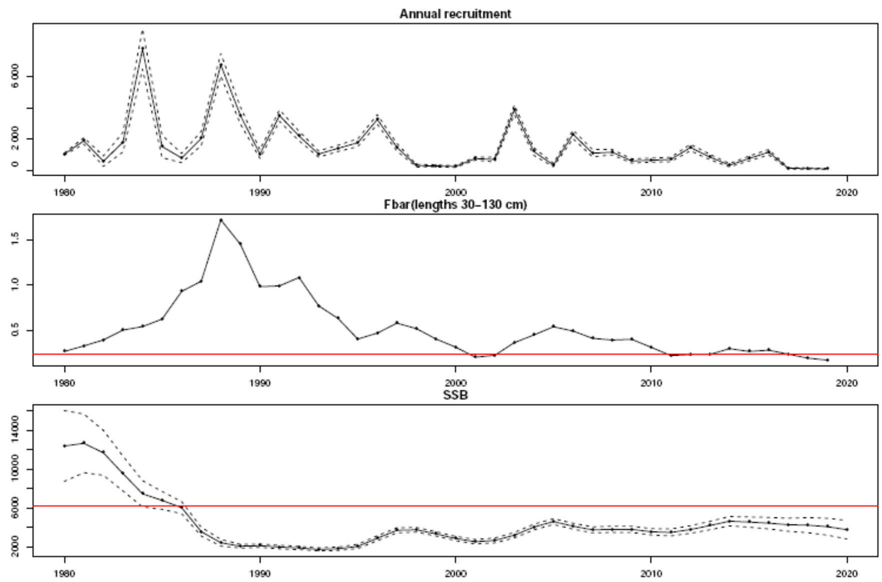

Figure 16. Summary plots of stock trends.

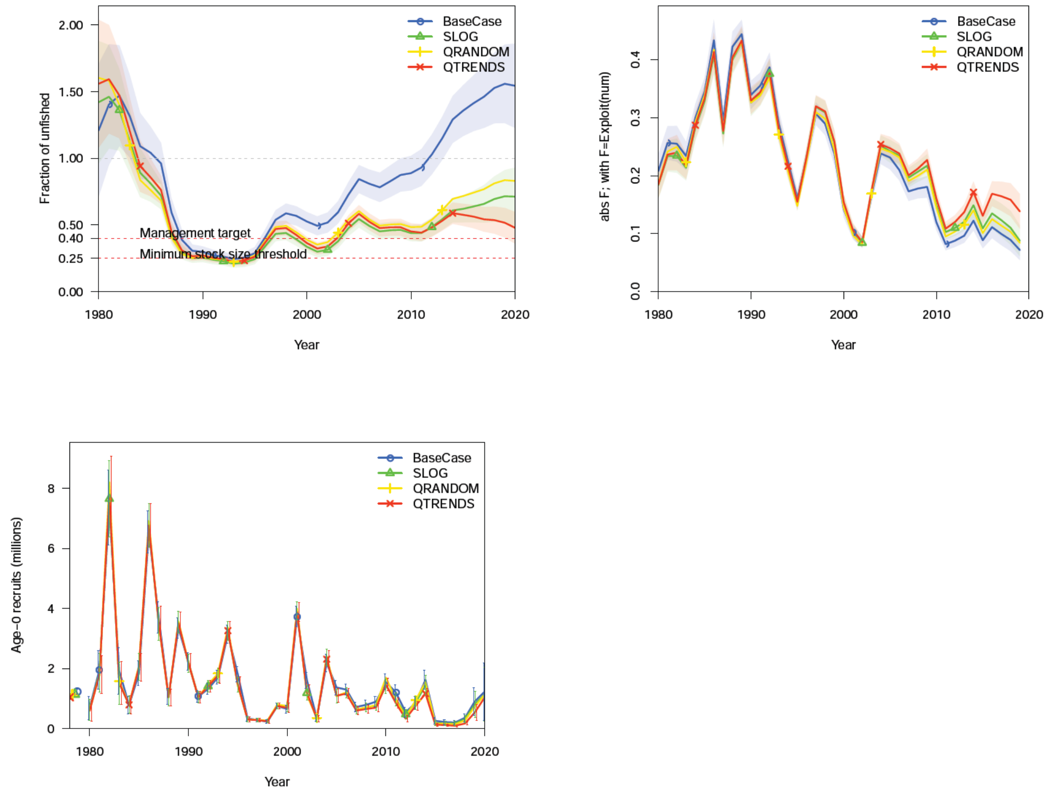

Figure 17. Comparison of runs Base Case, SELLOG, QCOR AND and QCORTRENDS model results.

The results indicated that this scenario is the most pessimistic in terms of SSB. Since 2015 the SSB steadily decreased which could be in line with the observed reduction in catches. Similarly, from 2003 to 2019 the F values were the highest of the runs performed.

4 Issues identified to address in a future benchmark of mon8c9a stock.

The general recommendations for all stocks were: 1) to use the last version of Stock Synthesis (=> v3.30.), as it includes relevant improvements and new options respect to the previous SS versions; 2) apply a selected range of diagnostic to identify data conflict and model misspecification. A selected range of diagnostics can include:

a) simultaneous visualization of residuals from multiple indices using Just Another Bayesian Biomass Assessment (JABBA) residual plots including in the package *ss3diags* (github.com/JABBAmodel/ss3diags)
b) run tests applied to individual abundance indices, to size composition data and to estimated recruitment deviations
c) retrospective analyses
d) jittering the starting values of the parameters to evaluate whether the model converges to a global solution, rather than a local minimum.
e) likelihood component profiles

f) Markov Chain Monte Carlo (MCMC)
g) evaluate the prediction skill (hindcasting) of the models. In a hincast a model is fitted to the first part of a time series and then projected over the period omitted in the original fit.

From the review and analysis of the current model configuration for mon8c9a, some recommendations to improve the model arose during the WKSTADSA. First, it was decided to explore the change the time-step of the model to be annual. It would reduce the computing time and make easier the performance of the model and the collection of new input data. Also, it would allow the comparison and/or combination of the assessment with other anglerfish stocks that are proposing models with an annual time-step.

Set the recruitment in quarter 1. Some explorations of the model seemed to indicate that the first quarter is the most appropriate period to set the recruitment. Instead of 3rd quarter that is set in the current model. Two options were also proposed: 1) to set 90% of recruitment in quarter 1 and 10% shared among the other quarters; 2) to set 100% of recruitment in quarter 1.

The current model fixes the steepness parameter at 0.99. A meta-analysis of parameters based on life history parameters of the species, estimates the steepness h = 0.9155146 (*Fishlife* package, (Thorson et al. 2017)) for *Lophius piscatorius*. It is recommended to explore the impact of different values of the steepness in the model fit means a likelihood profile.

```
> library(Fishlife)
> Predict <- Plot_taxa(
Search_species(Genus="Lophius",Species="piscatorius")$match_taxonomy )
> Predict[[1]]$Mean_pred["h"]
        h
0.9155146
```

Modify the extra variance included from the Taylor weighting process performed in last Benchmark 2018. The weighting process (balance of the model) should be carried out once a final model configuration has been decided. The method is not the most appropriate because it is still under revision.

Among the available methods to weight the input data of the model, Dirichlet-multinomial distribution is recommended for this stock. Dirichlet's method estimates a unique parameter per fleet to calculate the effective sample size of length compositions. Besides, this method is indicated when the nsamples of lenth compositions is a relative value instead of number of sampled trips.

Increase the value of SigmaR. Currently, SigmaR=0.4 but the recommendation of the Stock Synthesis output of the current model is to increase it to 0.6-0.8.

Current natural mortality is age-independent and time-invariant, one value for all ages and years. The model should use values of M dependent on age. The vector of M-at-age estimated from meta-analysis approach in latest benchmark WKANGLER (ICES, 2018) of the stock will be used as input of the model.

A general recommendation of the work-flow in Stock Synthesis is that all biological parameters, except the L-at-min, should be fixed and their CV should be increased. Once the biological parameters are decided, the values for the rest of model parameters can be explored. Follow this recommendation implies that Lmax must be fix in the mon8c9a model.

Natural mortality and K are two parameters intrinsically related and their misspecification in a model could lead to a spurious results. It is needed to explore the impact of these parameters on model fit and results.

In order to optimize the calculation process in Stock Synthesis several actions were pointed out. The measures that can be applied to mo8c9a model are: the parameters 3, 4, and 5 of the selectivity curves can be fixed without altering the definition of the selectivity curves; the phase of calculation of selectivity parameters can be changed to phase 4 or 5. And, finally, to treat the catchability of surveys and CPUEs as floated, meaning that the units of the survey or fishery CPUE are treated as dimensionless and an analytical solution is used, this will reduce the number of parameters to be estimated and, therefore, will save time of calculation.

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WORKING DOCUMENT

ICES WKTADSA 2020-WKTDSA2021

PRELIMINARY STOCK SYNTHESIS MODEL FOR BLACK ANGLERFISH IN AREAS 7,8abd

by

Hans Gerritsen and Agurtzane Urtizberea

Abstract

A preliminary

1 Introduction

In 2018, during the last benchmark (WKANGLER 2018) data and biological parameters were collated and validated but no assessment model could be agreed. The proposed models were too sensitive to critical assumptions and there was insufficient time to explore the consequences of these. Instead it was agreed to base the advice on a combined French-Irish IBTS survey index (an ICES category 3 assessment) with aspiration of developing a category 1 assessment in preparation for a future benchmark.

One of the main issues with this stock is the inability to obtain accurate age readings from otoliths or illicia. In other senses, it is a fairly data-rich stock, with a reasonable time series of catch length distribution data, two survey time series and reasonably accurate estimates of life-history parameters. Therefore, a model framework like Stock Synthesis appears to be suitable for developing an assessment model.

In this study, we use the last version of stock synthesis v3.30 (NOAA Fisheries Toolbox, 2011). This model is age-structured; but the length data are transformed into ages within the model. This model is a highly flexible statistical model framework which allows the building of simple to complex models using a mix of data compositions available. We developed a preliminary base case model with ss3 starting from the simplest possibility that the data and dynamic of the fishery allow us.

2 Data

The data used are the same to the data used in the last benchmark (WKANGLER 2018), updated up to 2019 for catch data and the French-Irish IBTS survey and 2020 for the Irish Monkfish survey and a longer time series of landings volume. The following data were included:

- Landings volume: 1968-present.
- Landings length compositions: 1986-present
- Discards volume and length compositions: 2003-present
- FR-IE-IBTS survey data: 2003-present (excluding 2017)
- IE-MONK survey data: 2006-7 and 2015-present

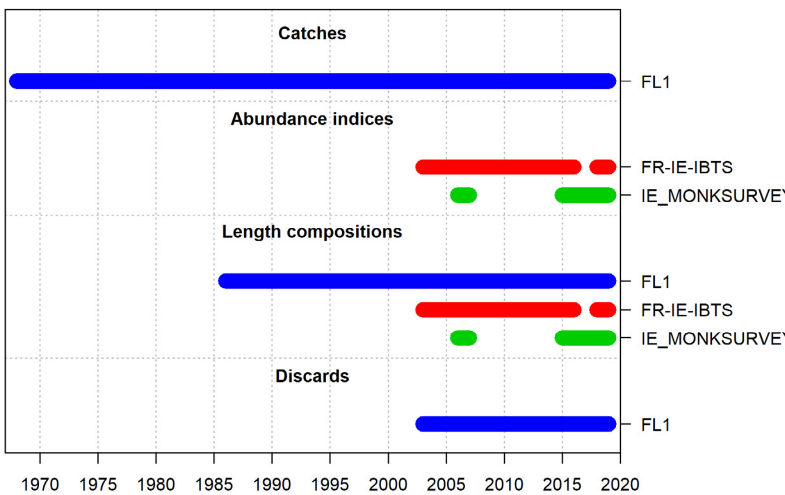

Figure 1. Data used in the assessment. FL1 is the commercial fleet.

We introduced catch data as a single fleet; in fact, there are a number of gear types, countries and fishing areas but the historic data could not be disaggregated into distinct fleets. Any changes in selectivity over time, resulting from changes between the fleets can be accounted for by time-varying selectivity, if required.

The official landings data aggregate both species (Fig 2), and then the species were disaggregated assuming the same historical proportions by country historically. The length frequency data of commercial fleet and catch (landings and discard) data are aggregated up to the annual level. The index of two surveys: the FR-IE-IBTS joint index, and the Irish monkfish survey and their length frequency of these surveys in the same way as presented to WGBIE.

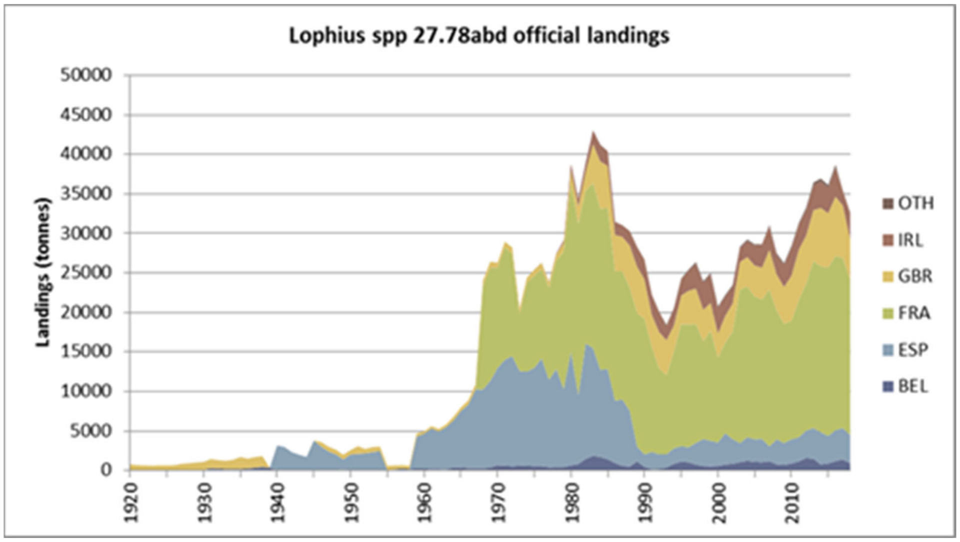

Figure 2. Official landings of the combined lophius species (budegassa and piscatorius).

3 Model

The base case (BC) was built starting from the simplest model structure and afterwards the model was modified depending mainly on the expert knowledge and the fit to the data. The main development steps are outlined below:

- Started with simple model, quarterly catch data, mainly default settings
- Changed catch assumptions before the start of the time series: extended landings time series further back in time, included assumption on equilibrium catch before the start of the time-series
- Fixed growth parameters to the best available estimates.
- Split catches into landings and discards, allow model to estimate discards back in time, based on observed selection patterns.
- Included time-varying retention to allow changes in on-board selection over the observed period
- Changed from quarterly landings/discards to annual, added sub-seasons to account for in-year growth
- Changed settings on recruit deviations, SR model and parameters
- Freed up some growth parameters
- Increased survey variance to allow model to account for conflict between surveys and increased discard variance
- Improved length fit by releasing L_at_Amin and CV_young.

The ‘final’ base case model is summarised below:

Data

- 1 Season; 1 area; 1 gender; 1 commercial fleet (landings and discards); 2 survey fleets
- Equilibrium catch of 9000 (average first 10 years of time series)
- CPUE provided in biomass (instead of numbers)
- Length bins in 2cm up to 130cm; 10cm thereafter.
- No age or tagging data

Control

- 1 growth pattern; 1 platoon; 1 settlement event (Jan); no rec_dist; no blocks
- 1 para nat mort (0.25, fixed)
- Von B growth (L_at_Amin and CV_young estimated)
- BH stock-rectuit, steepness 0.93 (Fixed, estimated using FishLife (Thorson 2019))
- Size selection (length): Single logistic for commercial fleet, double normal for surveys
- Size selection (age): NA

Biology: The growth parameters estimated by the WKANGLER 2018 benchmark were updated by analysing the cohort development in the survey data (Figures 3 and 4).

Further development

Not all ideas for development could be fully explored. The base case appears to be a reasonable model but the following suggestions are yet to be addressed:

- Flat-topped selection is unlikely: explore dome-shaped selection for commercial fleets and surveys.
- Fishing practices are likely to change over time: explore time-varying selection for commercial feet
- Single parameter natural mortality is unrealistic: explore age-based (e.g. scaled lorenzen or similar)
- Historic catch, data are unreliable but can explore linear ramping up of catch from WWII to 1968 when more reliable data are available.
- Explore setting historic discards to zero, rather than assuming unchanged gear selection and on-board selection for period with no data.
- Explore weighting (e.e. Dirichilet)

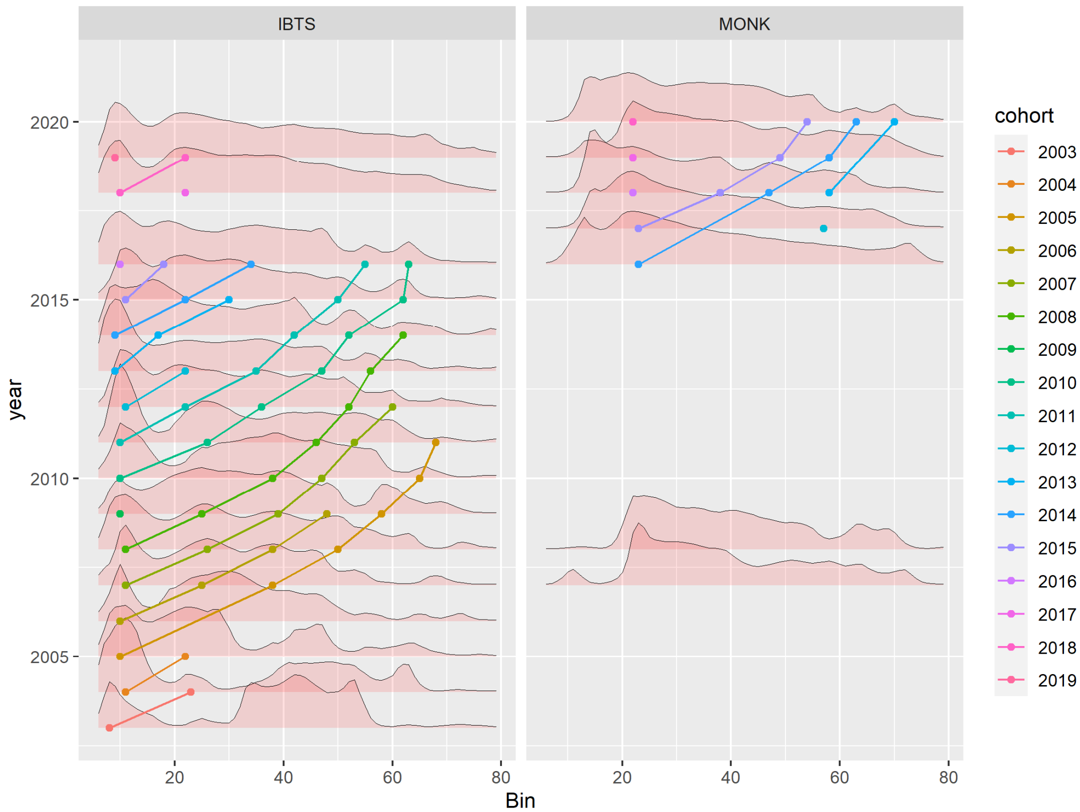

Figure 3. Length distributions of the survey (square-root transformed and loess smoothened for visualisation). Cohorts were identified manually.

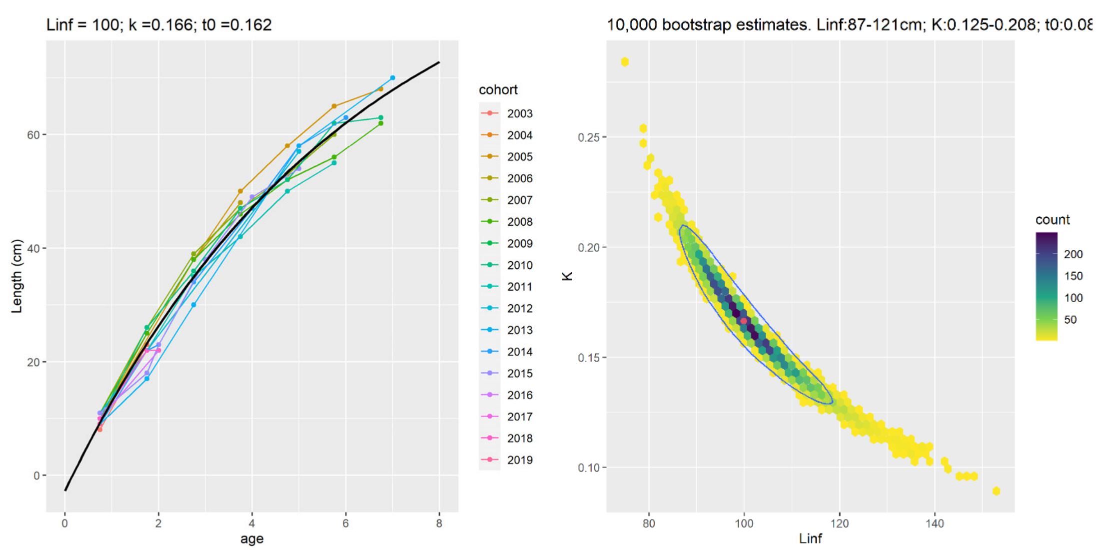

Figure 4. Fitted growth curve from cohort analysis (left) and bootstrapped growth parameters (right)

4 Model results

In this study we developed a preliminary base case for the northern black anglerfish.

Table 1 list the estimated parameters with the BC model and table 2 the likelihoods.

Figure 5 shows the length at age.

Figure 6 shows selectivity of commercial fleet and surveys and the time varying variability on the discards size, and in the retention.

Figure 7 shows the fit to the length composition (LC) of the discards, retained and surveys. The fit of the LC smallest fish of the FR-IE-IBTS seem good although the model overestimates a bit the lengths of the discards and seems to under-estimate the length of the landings.

Figure 8 shows that the fit to the survey indices. There is a conflict between the surveys that the model cannot resolve.

Figure 9 shows the time series of F and SSB. The base-case model estimates are similar to those of the a4a model that was rejected by the WKANGLER 2018 benchmark.

5 Discussion

There is a considerable uncertainty on how the fishery was previous to 1968. In the base case is assumed that the initial equilibrium catch was like the average of the last 10 years. However, different assumptions should be tested such as for example a homogeneous increase with time of catches.

The model does not fit all length compositions very well, which requires further investigation

Overall, significant progress has been made, and further suggestions remain to be explored. Overall, the stock appears to be almost ready for a new benchmark assessment.

6 References

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7 Tables

Table 1 The estimated parameters values, ranges, standard deviation and gradients when the parameter is estimated on the BC.

	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Prior
L_at_Amin_Fem_GP_1	15.436600	2	3.000	30.0	20.200000	OK	0.4975520	0.000167208	No_prior	
CV_young_Fem_GP_1	0.340767	2	0.005	0.5	0.200000	OK	0.0134442	9.39276e-05	No_prior	
SR_LN(R0)	10.594000	1	1.500	30.0	9.300000	OK	0.1057010	0.00267707	No_prior	
InitF_seas_1_flt_1FL1	0.945013	1	0.000	3.0	0.300000	OK	0.1183310	-4.29365e-05	No_prior	
F_fleet_1_YR_1968_s_1	0.536942	2	0.000	7.0	0.050000	act	0.1032470	-2.96236e-05	F	
F_fleet_1_YR_1969_s_1	0.473349	2	0.000	7.0	0.050000	act	0.0961450	-5.62291e-05	F	
F_fleet_1_YR_1970_s_1	0.469020	2	0.000	7.0	0.050000	act	0.0973064	-4.86452e-05	F	
F_fleet_1_YR_1971_s_1	0.536406	2	0.000	7.0	0.050000	act	0.1092470	-4.75358e-05	F	
F_fleet_1_YR_1972_s_1	0.580744	2	0.000	7.0	0.050000	act	0.1166370	-6.68881e-05	F	
F_fleet_1_YR_1973_s_1	0.453036	2	0.000	7.0	0.050000	act	0.0973026	-6.03548e-05	F	
F_fleet_1_YR_1974_s_1	0.473926	2	0.000	7.0	0.050000	act	0.1026410	-6.49585e-05	F	
F_fleet_1_YR_1975_s_1	0.477318	2	0.000	7.0	0.050000	act	0.1070190	-7.2608e-05	F	
F_fleet_1_YR_1976_s_1	0.495329	2	0.000	7.0	0.050000	act	0.1178480	-8.19486e-05	F	
F_fleet_1_YR_1977_s_1	0.415948	2	0.000	7.0	0.050000	act	0.1117200	-5.91969e-05	F	
F_fleet_1_YR_1978_s_1	0.443315	2	0.000	7.0	0.050000	act	0.1234460	-9.59811e-05	F	
F_fleet_1_YR_1979_s_1	0.401948	2	0.000	7.0	0.050000	act	0.1104400	-9.17019e-05	F	
F_fleet_1_YR_1980_s_1	0.541680	2	0.000	7.0	0.050000	act	0.1384050	-0.00013009	F	
F_fleet_1_YR_1981_s_1	0.442868	2	0.000	7.0	0.050000	act	0.1149570	-0.000110865	F	
F_fleet_1_YR_1982_s_1	0.578550	2	0.000	7.0	0.050000	act	0.1415300	-0.00014329	F	
F_fleet_1_YR_1983_s_1	0.688698	2	0.000	7.0	0.050000	act	0.1715560	-0.000207362	F	
F_fleet_1_YR_1984_s_1	0.647758	2	0.000	7.0	0.050000	act	0.1432090	-0.000230183	F	
F_fleet_1_YR_1985_s_1	0.610757	2	0.000	7.0	0.050000	act	0.1118290	-0.000328168	F	
F_fleet_1_YR_1986_s_1	0.517360	2	0.000	7.0	0.050000	act	0.0461401	-0.000231616	F	
F_fleet_1_YR_1987_s_1	0.449372	2	0.000	7.0	0.050000	act	0.0396054	-0.000195216	F	
F_fleet_1_YR_1988_s_1	0.452593	2	0.000	7.0	0.050000	act	0.0374762	0.00039928	F	
F_fleet_1_YR_1989_s_1	0.466730	2	0.000	7.0	0.050000	act	0.0371330	-0.000397171	F	
F_fleet_1_YR_1990_s_1	0.544958	2	0.000	7.0	0.050000	act	0.0434417	-3.34699e-05	F	
F_fleet_1_YR_1991_s_1	0.559228	2	0.000	7.0	0.050000	act	0.0466173	-1.36526e-05	F	
F_fleet_1_YR_1992_s_1	0.595238	2	0.000	7.0	0.050000	act	0.0536894	-0.00033978	F	
F_fleet_1_YR_1993_s_1	0.511262	2	0.000	7.0	0.050000	act	0.0496646	0.000159217	F	
F_fleet_1_YR_1994_s_1	0.409543	2	0.000	7.0	0.050000	act	0.0384790	-3.18796e-05	F	
F_fleet_1_YR_1995_s_1	0.425152	2	0.000	7.0	0.050000	act	0.0357026	2.47292e-05	F	
F_fleet_1_YR_1996_s_1	0.468577	2	0.000	7.0	0.050000	act	0.0368061	0.000263186	F	
F_fleet_1_YR_1997_s_1	0.481721	2	0.000	7.0	0.050000	act	0.0372609	-6.00726e-06	F	
F_fleet_1_YR_1998_s_1	0.559090	2	0.000	7.0	0.050000	act	0.0425866	3.96537e-05	F	
F_fleet_1_YR_1999_s_1	0.511580	2	0.000	7.0	0.050000	act	0.0422556	0.000270812	F	
F_fleet_1_YR_2000_s_1	0.623680	2	0.000	7.0	0.050000	act	0.0612977	0.000142222	F	
F_fleet_1_YR_2001_s_1	0.596951	2	0.000	7.0	0.050000	act	0.0616115	-7.89945e-06	F	
F_fleet_1_YR_2002_s_1	0.477309	2	0.000	7.0	0.050000	act	0.0399196	0.00012401	F	
F_fleet_1_YR_2003_s_1	0.500678	2	0.000	7.0	0.050000	act	0.0324551	7.95727e-05	F	
F_fleet_1_YR_2004_s_1	0.524320	2	0.000	7.0	0.050000	act	0.0364246	-0.000277036	F	
F_fleet_1_YR_2005_s_1	0.540792	2	0.000	7.0	0.050000	act	0.0401693	-0.000411162	F	
F_fleet_1_YR_2006_s_1	0.414151	2	0.000	7.0	0.050000	act	0.0302076	-0.000261441	F	
F_fleet_1_YR_2007_s_1	0.374562	2	0.000	7.0	0.050000	act	0.0264999	-0.000519018	F	
F_fleet_1_YR_2008_s_1	0.383205	2	0.000	7.0	0.050000	act	0.0272022	0.000237058	F	
F_fleet_1_YR_2009_s_1	0.397991	2	0.000	7.0	0.050000	act	0.0282373	0.000452278	F	
F_fleet_1_YR_2010_s_1	0.382110	2	0.000	7.0	0.050000	act	0.0262012	0.000103557	F	
F_fleet_1_YR_2011_s_1	0.425652	2	0.000	7.0	0.050000	act	0.0303228	0.000543273	F	
F_fleet_1_YR_2012_s_1	0.413871	2	0.000	7.0	0.050000	act	0.0317346	0.000732097	F	
F_fleet_1_YR_2013_s_1	0.548160	2	0.000	7.0	0.050000	act	0.0436660	-0.0005057	F	
F_fleet_1_YR_2014_s_1	0.535191	2	0.000	7.0	0.050000	act	0.0463269	7.98397e-05	F	
F_fleet_1_YR_2015_s_1	0.447200	2	0.000	7.0	0.050000	act	0.0401712	-0.000635123	F	
F_fleet_1_YR_2016_s_1	0.398876	2	0.000	7.0	0.050000	act	0.0403569	0.000289082	F	
F_fleet_1_YR_2017_s_1	0.399718	2	0.000	7.0	0.050000	act	0.0499702	0.000380489	F	
F_fleet_1_YR_2018_s_1	0.309689	2	0.000	7.0	0.050000	act	0.0492794	0.000458936	F	
F_fleet_1_YR_2019_s_1	0.276404	2	0.000	7.0	0.050000	act	0.0558006	-0.000571956	F	
Q_extraSD_IE_MONKSURVEY(3)	0.117694	3	0.000	1.0	0.100000	OK	0.0791556	-6.91923e-06	No_prior	
Size_inflection_FL1(1)	13.600000	4	5.000	100.0	14.447800	OK	0.1674980	-7.92425e-05	No_prior	
Size_95%width_FL1(1)	2.300720	5	-10.000	20.0	2.825860	OK	0.1621910	0.000177616	No_prior	

	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Prior
Retain_L_infl_FL1(1)	26.481100	4	5.000	100.0	27.550900	OK	0.3964360	-0.000151031	No_prior	
Retain_L_width_FL1(1)	2.303090	4	0.100	20.0	2.144960	OK	0.0875130	-9.35025e-05	No_prior	
Retain_L_asymptote_logit_FL1(1)	5.548300	4	-10.000	10.0	6.566210	OK	0.3781320	9.3861e-05	No_prior	
Size_DblN_peak_FR-IE-IBTS(2)	12.597500	4	5.000	100.0	5.000000	OK	0.3212950	-1.6537e-05	No_prior	
Size_DblN_top_logit_FR-IE-IBTS(2)	-0.895001	5	-15.000	5.0	-0.909816	OK	0.1727310	-0.000215749	No_prior	
Size_DblN_ascend_se_FR-IE-IBTS(2)	2.189980	5	-15.000	18.0	10.000000	OK	0.1720090	-4.60794e-06	No_prior	
Size_DblN_descend_se_FR-IE-IBTS(2)	5.655650	5	2.000	15.0	5.765070	OK	0.7631150	-8.63515e-05	No_prior	
Size_DblN_peak_IE_MONKSURVEY(3)	11.130500	4	5.000	100.0	5.000000	OK	0.0230227	-0.00144732	No_prior	
Size_DblN_top_logit_IE_MONKSURVEY(3)	-1.742740	5	-15.000	5.0	-0.909816	OK	0.5264380	7.19921e-05	No_prior	
Size_DblN_ascend_se_IE_MONKSURVEY(3)	-6.556420	5	-15.000	18.0	10.000000	OK	33.9179000	1.28352e-06	No_prior	
Size_DblN_descend_se_IE_MONKSURVEY(3)	7.442800	5	2.000	15.0	5.765070	OK	0.6803080	4.36528e-05	No_prior	

Table 3: Likelihoods of the base case (BC).

Component	logL*Lambda	Lambda
TOTAL	943.257	NA
Catch	0.347768	NA
Equil_catch	1.26094	NA
Survey	-21.1805	NA
Discard	-5.75016	NA
Length_comp	953.475	NA
Recruitment	-2.5765	1
InitEQ_Regime	0	1
Forecast_Recruitment	0	1
Parm_priors	0	1
Parm_softbounds	0.006254	NA
Parm_devs	17.6741	1
Crash_Pen	0	1

8 Figures

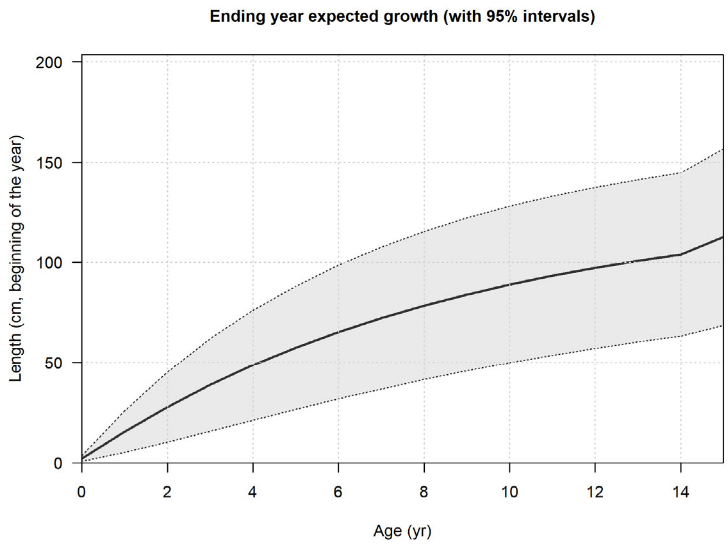

Figure 5: Figure shows the length at age at the end of the year of the BC

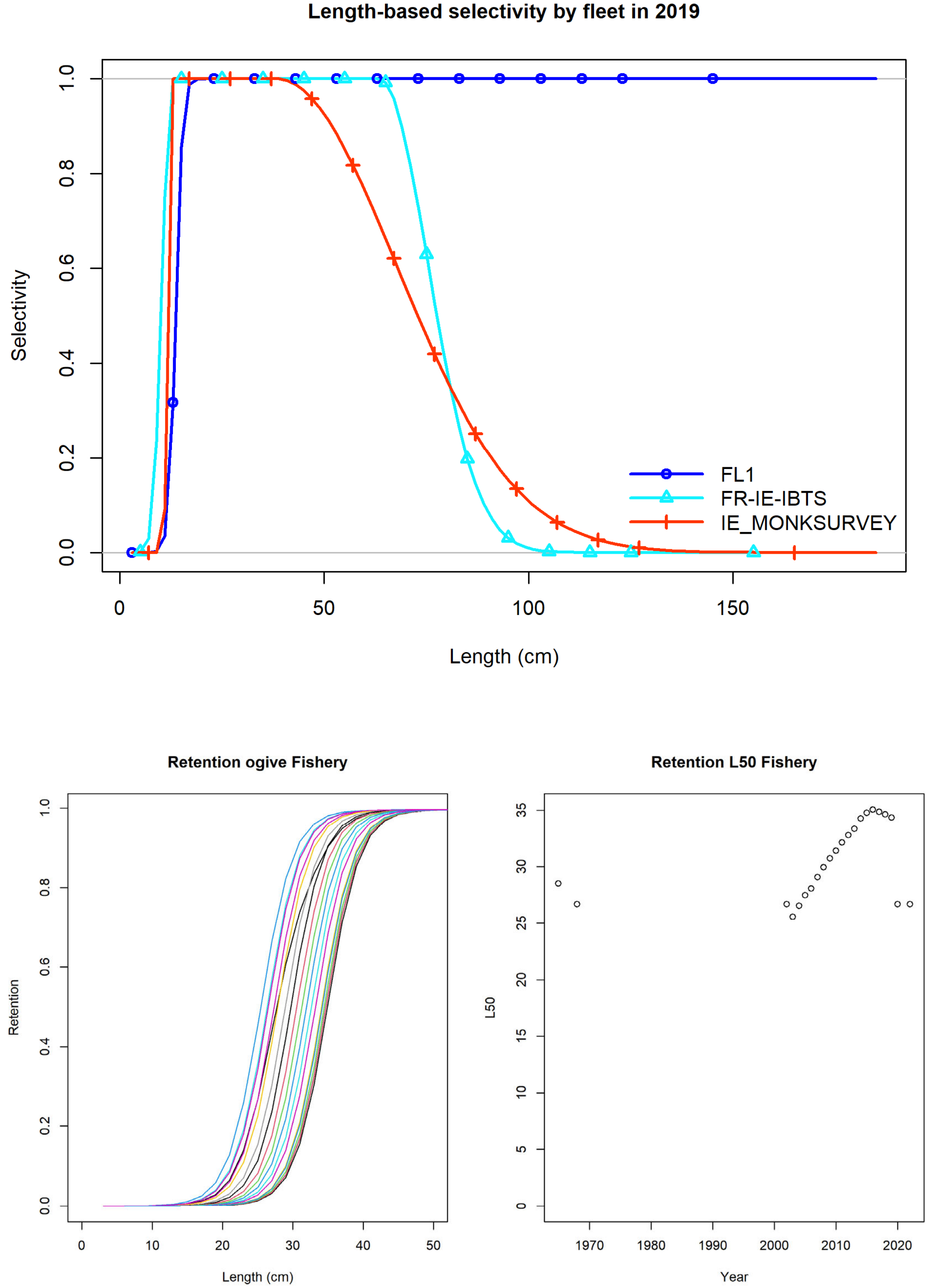

Figure 6: Selectivity of the commercial fleet and surveys (top) and the time-varying selectivity in retention and in landings of the BC model (bottom).

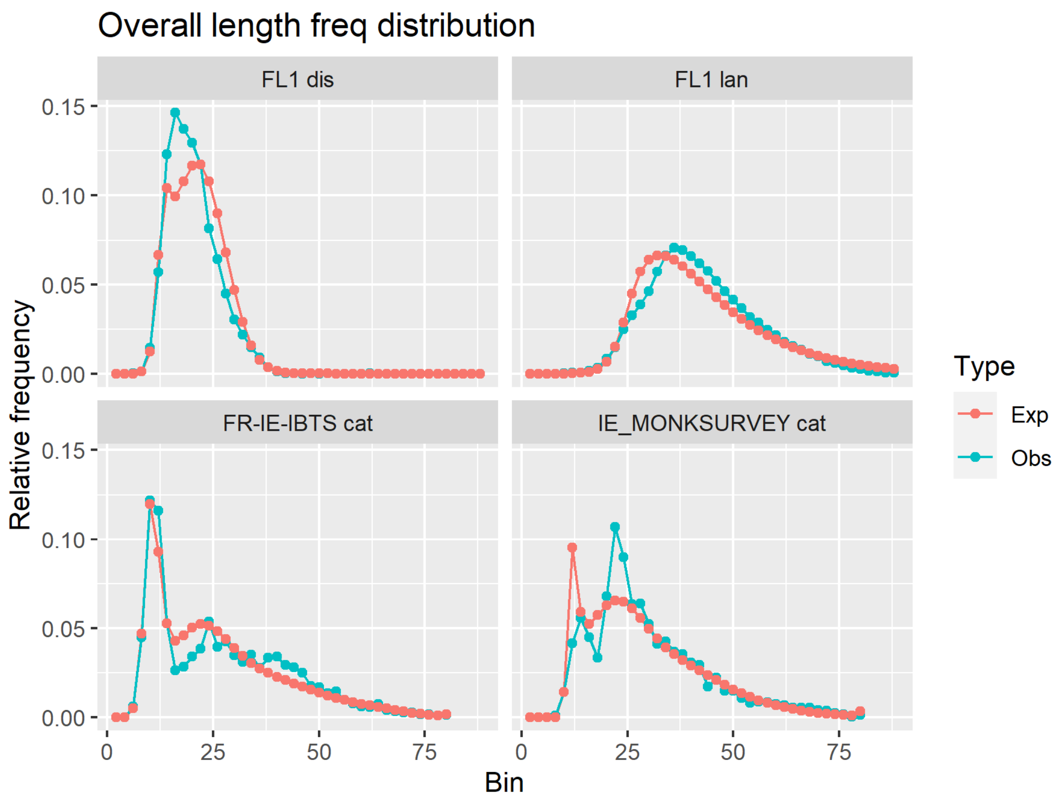

Figure 7: The aggregated length composition and fits of the model to the discards, retained and surveys.

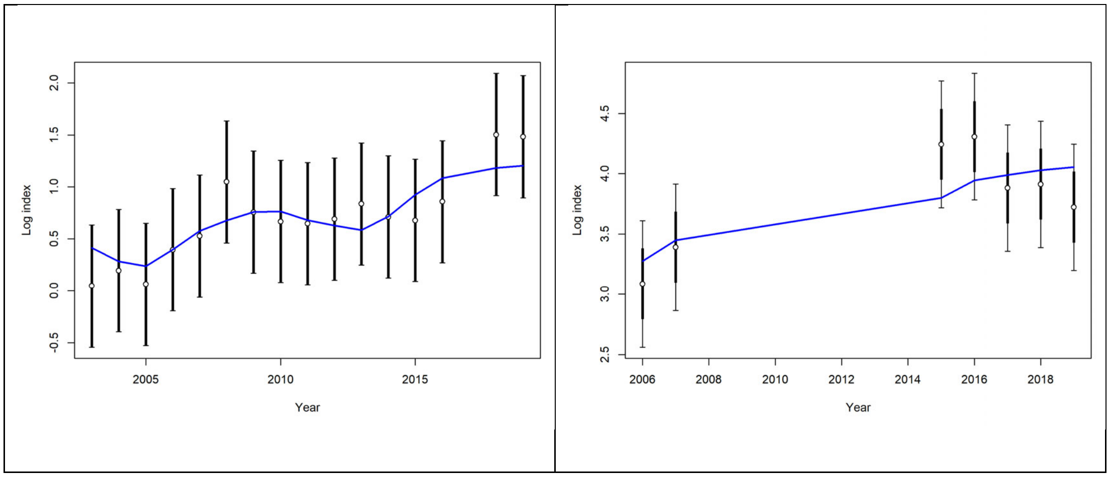

Figure 8: The fit of the indices: FR-IE-IBTS index (left), Monkfish survey (right)

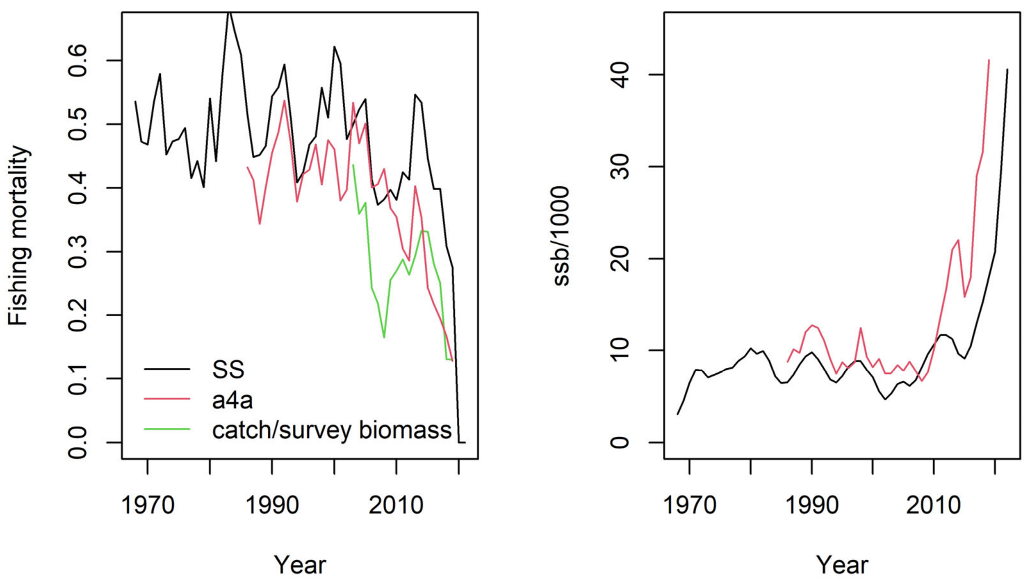

Figure 9: The estimated time series of fishing mortality (left, black line) compared with that estimated by the rejected a4a model from WKANGLER 2018 (updated with recent data; red line) and a relative measure of F based on the ratio of catch and survey biomass. The right-hand plot shows the biomass estimate (SS: black; a4a:red)

Working document presented to the Workshop on Tools and Development of Stock Assessment Models Using a4a and Stock Synthesis (WKTaDSA)

Black-bellied anglerfish (*Lophius budegassa*) in divisions 8c and 9a (Cantabrian Sea, Atlantic Iberian waters): development of a stock synthesis model

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1. Introduction

Black-bellied anglerfish (*Lophius budegassa*) in divisions 8c and 9a is currently assessed with a stochastic production model in continuous-time (SPiCT) (Pedersen and Berg, 2017), as proposed at WKANGLER (ICES, 2018a). The model uses, as input data, landings and commercial LPUEs from three fleets. Given the uncertainties regarding the absolute levels of biomass and fishing pressure, SPiCT estimates were considered as indicative of trends only and advice followed guidelines for category 3.2 stocks, with proxy reference points (ICES, 2018b). Given the above, it is appropriate to improve the assessment of the stock and explore new methodologies.

In the last benchmark workshops (WKFLAT in 2012 and WKANGLER in 2018), trials with stock synthesis (Methot and Wetzel, 2013) were conducted. The model was considered promising but more work was needed. More information about these trials can be found in ICES (2012) and ICES (2018a).

The present working document reports advances in the development of a stock synthesis model, achieved during the Workshop on Tools and Development of Stock Assessment Models Using a4a and Stock Synthesis (WKTaDSA).

2. Data

A brief summary of the information used in the model and rationale for their use, is presented below. More information about the data available can be found in the stock annex or at WKANGLER report (ICES, 2018a).

2.1. Stock ID

This stock (ank.27.8c9a) distributes in the Cantabrian Sea and Atlantic Iberian waters down to the Gulf of Cadiz (Figure 1). WKANGLER concluded that there may be some structure within the NE Atlantic area for both *Lophius* species but there is also some degree of mixing, and that there is not sufficient information to change the current stock areas (ICES, 2018a).

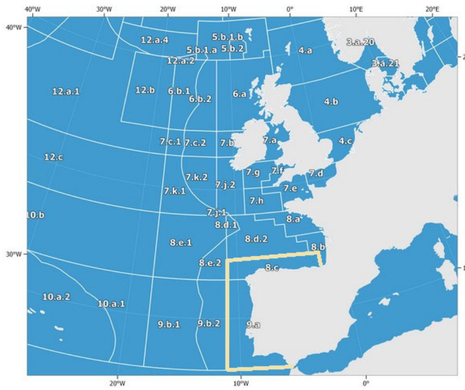

Figure 1. *Lophius budegassa* in ICES divisions 8c and 9a.

2.2. Biological information

Reliable growth estimates are lacking for this stock. Results from a preliminary study to estimate growth parameters based on length frequency distribution were presented to WKANGLER, using data for ICES area 7, and estimated k= 0.118 y^{-1} and L_{inf} as 119.84 cm (Batts and Gerritsen, 2018 WD). Maximum size sampled is ~120 cm, but landings are usually < 100 cm. Sexual dimorphism is known to occur with females attaining larger sizes than males, but information by sex is lacking.

Reproduction takes place between November and February (Duarte et al., 2001). Maturity data for ICES divisions 8c and 9a are available. Length of first maturity is estimated as 53 cm and 36 cm for females and males, respectively (Landa et al., 2014).

2.3. Fisheries dependent data

In this area, the commercial interest for both *Lophius* started in the late 1970´s (Duarte 2002), and gained a special interest in the 1980´s due to its acceptance in the market trade (Azevedo, 1996). In both countries, target fisheries developed, particularly with gillnet and trammel nets.

2.3.1. Landings

Quarterly landing data are reported by ICES division and métier by Spain (since 1978), Portugal (since 1978) and France (since 2002), this last country with a relatively low contribution to the overall landings. Landings for this stock derive, in a great extent, from trawl fleets and fleets operating with gillnet and trammel nets (herein net fleet) operating in both ICES Divisions 8c and 9a. Landings data were combined for trawl and net fleets (mainly Portuguese and Spanish landings) (Figure 2).

Misidentification in landing ports is known to ocuur, with this species being usually landed with the white anglerfish *Lophius piscatorius*. Estimates of each species in Spanish landings and Portuguese landings are derived from their relative proportions in the market samples.

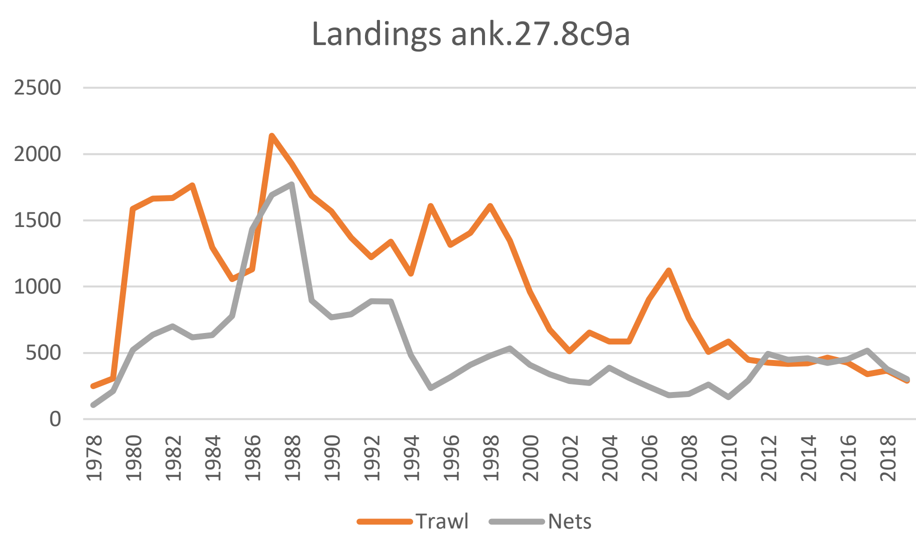

Figure 2. *Lophius budegassa* in ICES divisions 8c and 9a. Total landings by fleet: trawl and nets, for all countries combined.

2.3.2. Discards

The assessment currently excludes discards, which have been considered negligible for Portuguese fleets and low for Spanish fleets. Therefore, the model does not include discards.

2.3.3. Length frequency - landings

Length compositions of landings are available for the main métiers/fleets from Portugal and Spain. This species is caught by fisheries from ~25 cm to ~120 cm.

2.3.4. CPUE indices

The assessment of ank.27.8c9a currently uses three CPUE indices. From these, only two were included in the initial model, the Portuguese trawlers targeting crustaceans in Division 9a (PT-OTB-CRUST) and the Coruña Trawl Fleet in Division 8c (SP-CORTR8c) (Figure 3). PT-OTB-CRUST (1989-2019) operates in the southwest and south coasts of Portugal and represents an average of 3% of international catches of black anglerfish along the time-series. CPUE consists on the biomass caught (in kg) by hour and is estimated from logbook data.

SP-CORTR8c (1982-2012) corresponds to a mixed-fishery targeting demersal (hake, megrims, anglerfish) and pelagic species (mackerel, horse mackerel). This fleet represents an average of 18% of international catches of black anglerfish along the available time-series.

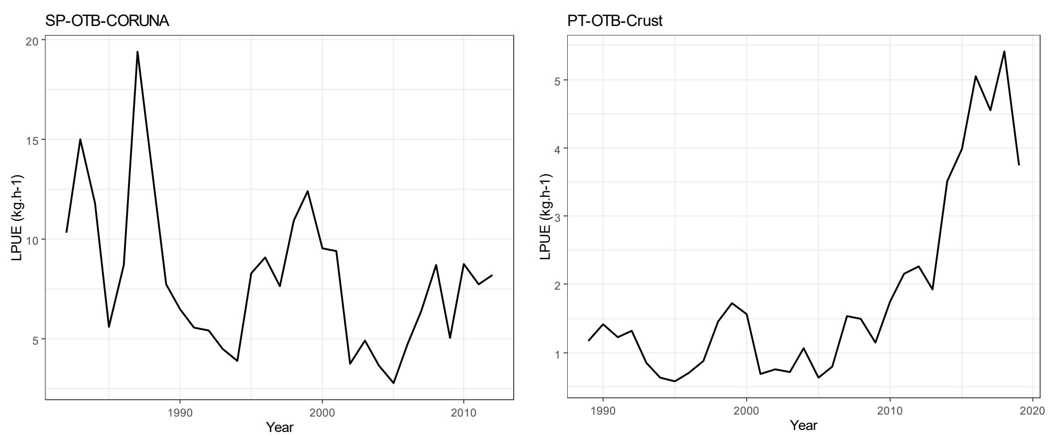

Figure 3. *Lophius budegassa* in ICES divisions 8c and 9a. Commercial CPUE from the a) Coruña Trawl Fleet (SP-CORTR8c; 1982-2012) and b) Portuguese trawlers targeting crustaceans (PT-TRC9a; 1989-2019).

2.4. Fisheries independent data

2.4.1. Survey information and biomass indices

The research surveys carried out in 8c and 9a cover the distribution of the stock (Figure 4). However, catchability is low in most of the surveys. The use of these surveys to inform on recruitment can be considered, particularly of the Northern Spanish Shelf Groundfish Survey in the Cantabrian Sea and Off Galicia (SP-NSGFS).

The Spanish survey SP-NSGFS covers the northern Spanish shelf comprised in ICES Division 8c and the northern part of 9a, including the Cantabrian Sea and off Galicia waters. The surveys are conducted from 30 to 800 m depth, usually starting at the end of the third quarter. Biomass index data and the respective standard deviation and length compositions are available for the period 1983–2019 with the exception of year 1987 (Figure 5). This survey index may be a good indicator for smaller individuals (<20 cm) abundance (ICES, 2018a).

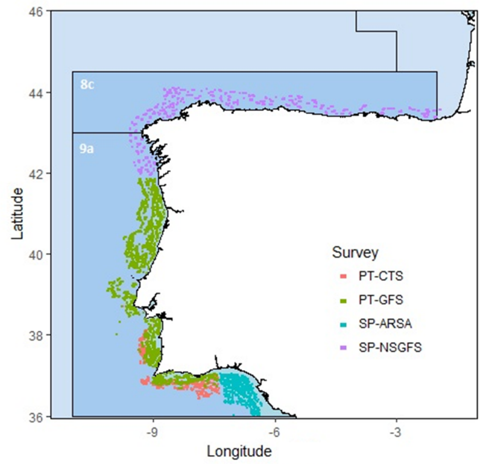

Figure 4. *Lophius budegassa* in ICES divisions 8c and 9a. Research survey distribution.

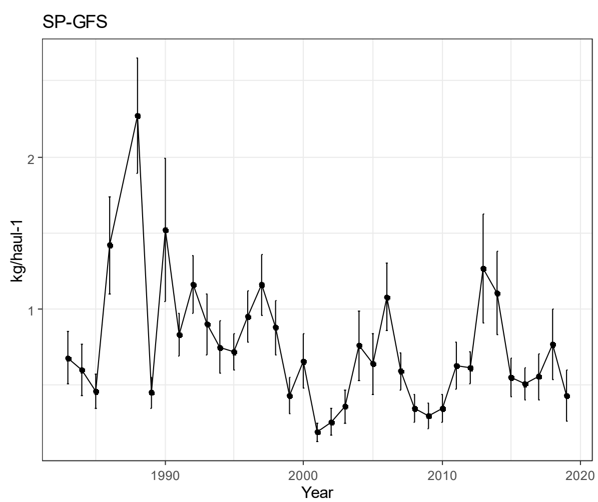

Figure 5. *Lophius budegassa* in ICES divisions 8c and 9a. Biomass and abundance indices from the Northern Spanish Shelf Groundfish Survey in the Cantabrian Sea and Off Galicia (SP-NSGFS) (1983-2019).

3. Stock synthesis model development

3.1. Data and settings – Model 1

A length-based model was developed. The following initial settings and data were used (Figure 6):

- 1 area
- 1 season, 12 months
- Spawning in January
- Catch data:
  - -nets (data from Portugal and Spain combined: 1982-2019)
  - - trawlers (data from Portugal and Spain combined: 1982-2019)
- CPUE/LPUE indices:
  - SP-CORTR8c (1982-2012)
  - PT-OTB-CRUST (1989-2019)
  - SP-NSGFS (research survey; 1982-2019)
- Length data:
  - -nets (data from Portugal and Spain combined: 1982-2019)
  - - trawlers (data from Portugal and Spain combined: 1982-2019)
  - - OTB- a coruña (1982-2012)
  - - SP-NSGFS (research survey; 1982-2019)
- Natural mortality: 0.2
- L_{inf} :132 cm
- L_{50}: 53 cm
- Recruitment follows a the Beverton-Holt recruitment curve (with steepness, *h,* fixed to 0.999)
- Double-normal selectivity for all surveys (except for PT-OTB-crust, for which length-frequency data are not available; the same length frequency distribution of the trawl fleet was assumed)
- Linear growth: 0.75

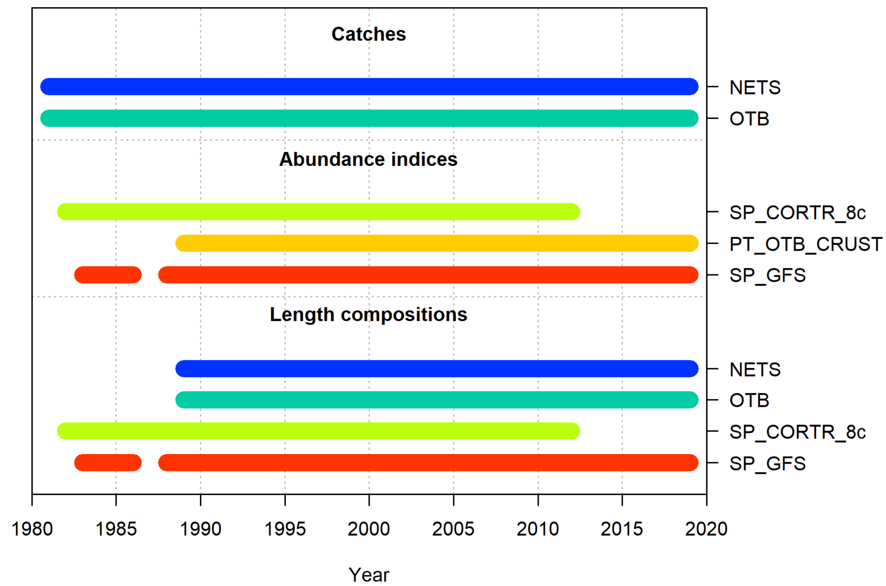

Figure 6. Development of a stock synthesis model for ank.27.8c9a. Input data.

3.2. Results – Model 1

Parameter estimates are presented in Table 1. The growth parameter rate (*k*) was estimated as 0.11 y^{-1}, similar to the value estimated by Bats and Gerritsen (2018 WD).

Selectivity curves are resented in Figure 7. As expected, the model identifies that net fleets catch the largest individuals. The model fits well to the length frequency distributions but not so well to the survey data (Figure 8).

Stock trends for this first model configuration are presented in Figure 10. The model shows an increasing biomass trend from 2010 to 2020 and declining trend in F. These trends are in accordance with those observed in the current SPiCT model (although this latter shows a decrease in biomass in the last two years of the series), but the two approaches give a different perception of the stage of the stock at initial years in relation to the last years.

Table 1. Model 1: parameter estimates and input settings.

	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Afterbound
L_at_Amin_Fem_GP_1	31.069000	3	4.00	35.0	31.070800	OK	0.3704640	-7.66649e-08	No_prior	OK
VonBert_K_Fem_GP_1	0.112644	3	0.03	0.9	0.110000	OK	0.0088794	-3.11208e-07	No_prior	OK
SR_LN(R0)	7.473160	1	1.50	23.0	7.600720	OK	0.1053850	-6.33441e-06	No_prior	OK
SR_sigmaR	0.631863	1	0.10	2.0	0.695684	OK	0.0671824	2.97463e-07	No_prior	OK
LnQ_base_SP_CORTR_8c(3)	-5.940820	1	-25.00	-5.0	-5.767160	OK	0.1410100	7.08272e-07	No_prior	OK
LnQ_base_PT_OTB_CRUST(4)	-7.893910	1	-25.00	-5.0	-7.704520	OK	0.1248070	-1.72482e-06	No_prior	OK
LnQ_base_SP_GFS(5)	-8.059690	1	-25.00	-1.0	-8.481840	OK	0.1647820	-8.30198e-07	No_prior	OK
Size_DblN_peak_NETS(1)	62.449800	2	30.00	80.0	60.000000	OK	1.6630400	-1.42148e-07	No_prior	OK
Size_DblN_top_logit_NETS(1)	-9.559190	2	-10.00	3.0	-9.000000	OK	11.6716000	-1.85671e-08	No_prior	OK
Size_DblN_ascend_se_NETS(1)	6.029060	2	-6.00	12.0	5.677620	OK	0.1157460	2.66596e-07	No_prior	OK
Size_DblN_descend_se_NETS(1)	5.531470	2	-2.00	40.0	6.000000	OK	0.2056160	-2.28287e-07	No_prior	OK
Size_DblN_start_logit_NETS(1)	-13.674600	2	-15.00	5.0	-15.000000	OK	28.0181000	-5.32649e-08	No_prior	OK
Size_DblN_end_logit_NETS(1)	-5.872570	2	-7.00	5.0	-6.000000	OK	2.0133000	6.77829e-09	No_prior	OK
Size_DblN_peak_OTB(2)	18.173900	2	10.00	50.0	18.200500	OK	5.1744300	-1.17726e-07	No_prior	OK
Size_DblN_top_logit_OTB(2)	-2.268950	2	-12.00	2.0	-2.268950	OK	0.6125140	-1.11164e-06	No_prior	OK
Size_DblN_ascend_se_OTB(2)	0.186917	2	-12.00	14.0	0.186917	OK	8.8112800	6.05727e-08	No_prior	OK
Size_DblN_descend_se_OTB(2)	7.161380	2	1.00	40.0	7.161380	OK	0.2067300	-4.83231e-06	No_prior	OK
Size_DblN_start_logit_OTB(2)	-4.849700	2	-15.00	15.0	-4.849820	OK	0.5138190	8.78095e-08	No_prior	OK
Size_DblN_end_logit_OTB(2)	-13.224500	2	-15.00	9.0	-13.224500	OK	34.5526000	-1.12634e-07	No_prior	OK
Size_DblN_peak_SP_CORTR_8c(3)	21.647500	2	10.00	50.0	21.576100	OK	1.5592600	2.07891e-07	No_prior	OK
Size_DblN_top_logit_SP_CORTR_8c(3)	-2.961940	2	-12.00	2.0	-2.961930	OK	0.8056930	7.02231e-08	No_prior	OK
Size_DblN_ascend_se_SP_CORTR_8c(3)	1.814190	2	-6.00	14.0	1.814190	OK	0.7423390	1.73948e-07	No_prior	OK
Size_DblN_descend_se_SP_CORTR_8c(3)	6.881420	2	1.00	40.0	6.307890	OK	0.1795260	2.14961e-06	No_prior	OK
Size_DblN_start_logit_SP_CORTR_8c(3)	-13.663000	2	-15.00	15.0	-14.261300	OK	27.1768000	1.78227e-07	No_prior	OK
Size_DblN_end_logit_SP_CORTR_8c(3)	-10.776800	2	-11.00	9.0	-9.000000	OK	6.3796300	-8.31585e-09	No_prior	OK
Size_DblN_peak_SP_GFS(5)	15.025700	2	5.00	50.0	15.095800	OK	0.0197306	-9.07772e-06	No_prior	OK
Size_DblN_top_logit_SP_GFS(5)	-12.797700	2	-16.00	2.0	-12.797700	OK	53.6985000	-4.54576e-09	No_prior	OK
Size_DblN_ascend_se_SP_GFS(5)	-9.595960	2	-20.00	15.0	-9.595960	OK	45.2037000	2.28471e-08	No_prior	OK
Size_DblN_descend_se_SP_GFS(5)	6.956760	2	0.00	15.0	6.956760	OK	0.0834889	-6.04005e-07	No_prior	OK
Size_DblN_start_logit_SP_GFS(5)	-2.046860	2	-20.00	20.0	-2.046860	OK	0.1639690	7.93423e-08	No_prior	OK
Size_DblN_end_logit_SP_GFS(5)	-4.892560	2	-9.00	9.0	-4.892560	OK	0.8603090	-1.71959e-07	No_prior	OK

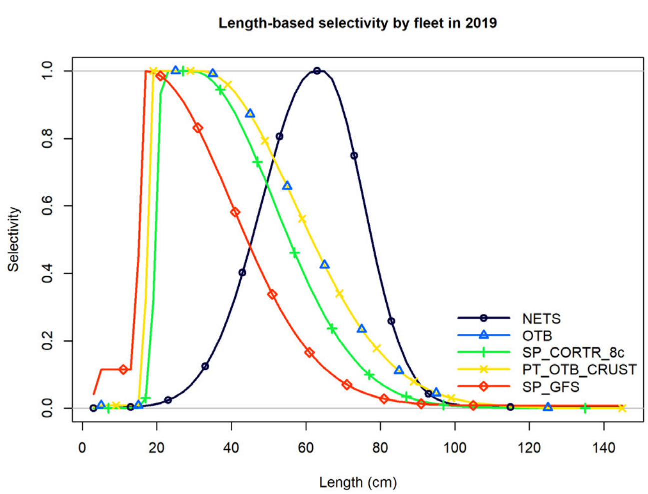

Figure 7. Model 1: selectivity curves.

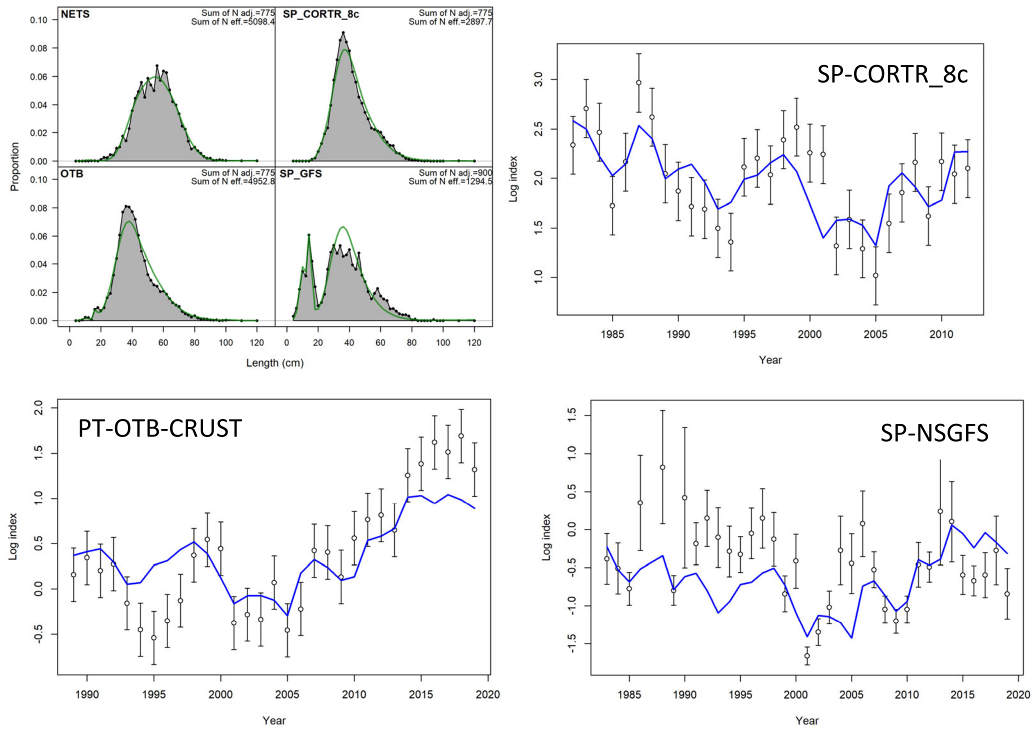

Figure 8. Model 1: fit to the length compositions and survey data.

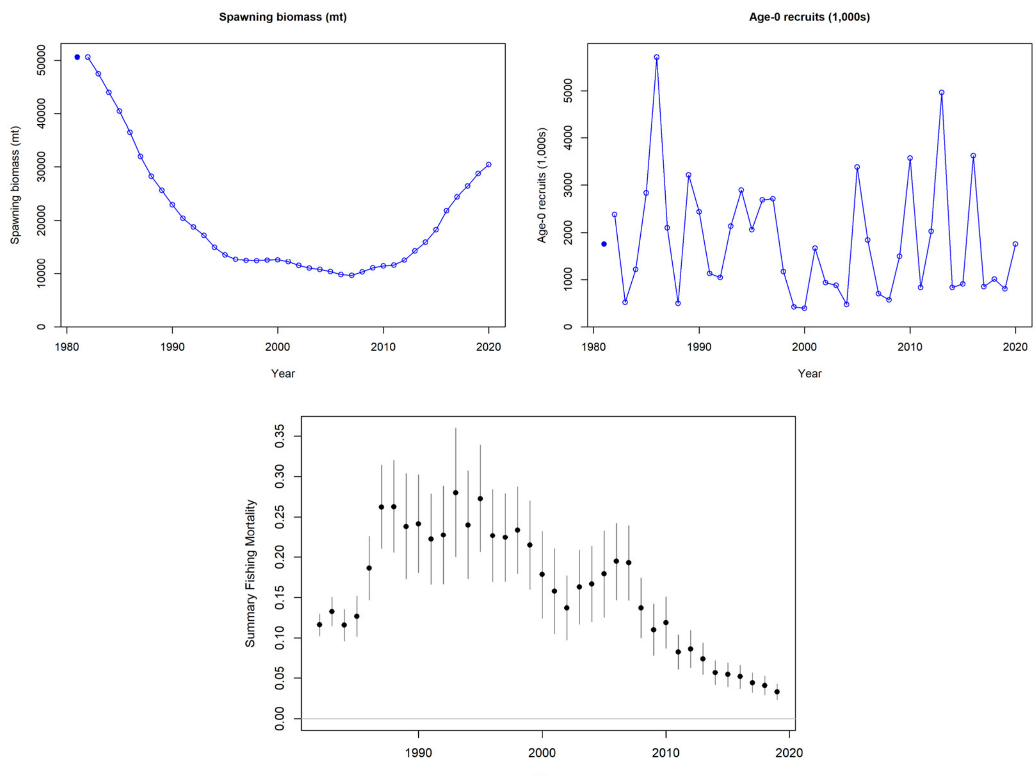

Figure 9. Model 1: Spawning biomass, recruitment and fishing mortality time series.

3.3. Data and settings – Model 2

A second model configuration was run with the same data and parameters as model 1 but with the changes described below, proposals made to the initial model configuration:

a) Fix the selectivity parameters 2, 5 and 6 in "selex" option 24. This change allows to recreate the same range of shapes as with all 6 parameters and decreases the number of parameters being estimated.
b) Switch "selex" parameters estimates to later phases (phases 4 and 5)
c) Add the "float" option in survey Q settings to allow the model to estimate fewer parameters.
d) Add equilibrium catch to the model. The initial model assumed no fishing before first year of the modelling period (1982). Landings reported for 1978 were added for both fleets and standard error of 0.05. Those values are relatively smaller than the values reported for the first year with landing data.
e) Data weighting by both weighting the indices and tuning of compositional data. Regarding the latter, the Dirichlet-multinomial weighting was first used. Input sample sizes were also revised.
f) Changes in recruitment deviations. Initial and final year for recruitment deviations were assumed as 1975 and 2019, respectively, but no advanced options were defined.

3.4. Results – Model 2

This new model configuration resulted in a lower length at minimum age (25.6 cm) and *k* (0.09 y^{-1}) and also changes in SP-NSGFS selectivity (Figure 11). Moreover, there is a lack of fit of the model to the survey data (Figure 12). Recruitment deviations shows negative values at the beginning of the time series and that should be improved (Figure 13). The inclusion of equilibrium catch values shows a less optimistic stage of the stock at the first years of the series, but overall trend in SSB is similar to model 1 (Figure 14).

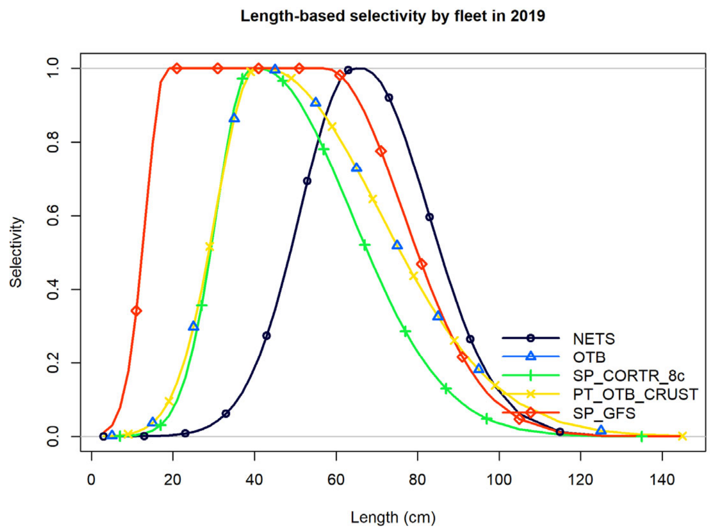

Figure 11. Model 2: selectivity curves.

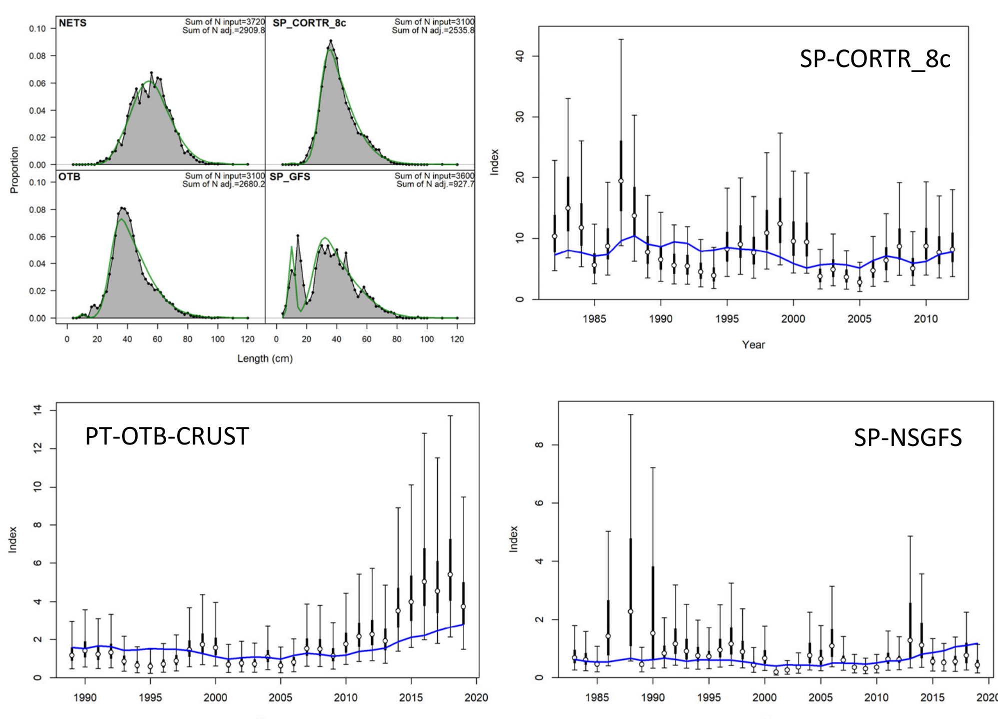

Figure 12. Model 2: fit to the length compositions and survey data.

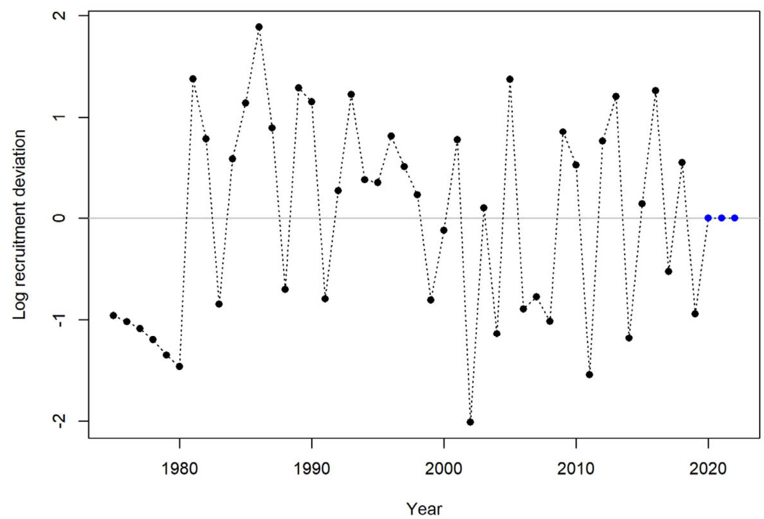

Figure 13. Model 2: recruitment deviations

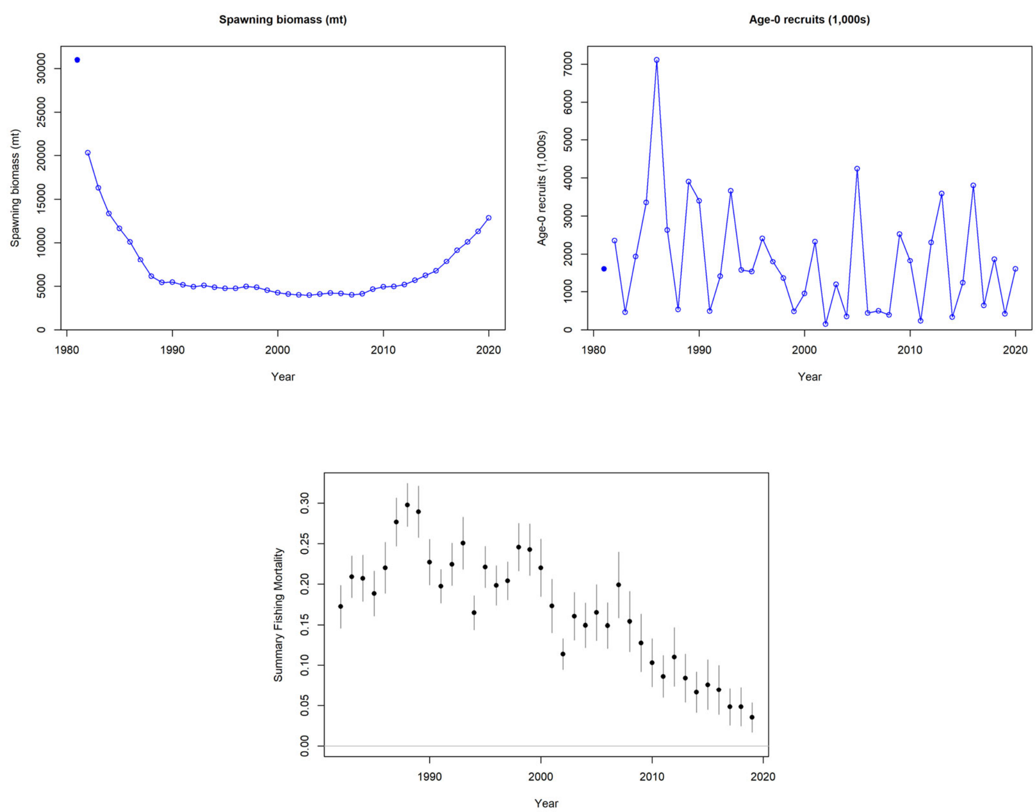

Figure 14. Model 2: Spawning biomass, recruitment and fishing mortality time series.

3.5. Models 3 and 4

Based on model 2 configuration, Francis and McAllister – Ianelli weighting methods were also tested to check for improvements in the survey fits (model 3 and model 4, respectively). Results from both new model configurations are similar and results are presented in Figures 15 and 16 for model 3. The fit to the survey data improved but is still poor.

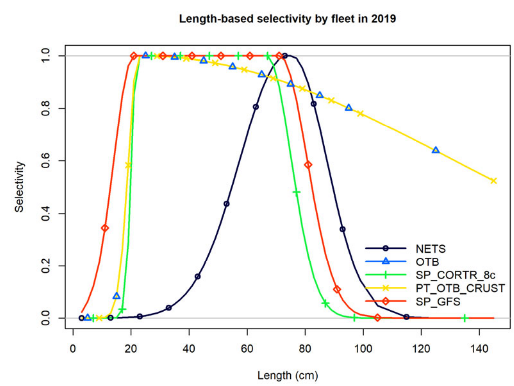

Figure 15. Model 3: selectivity curves.

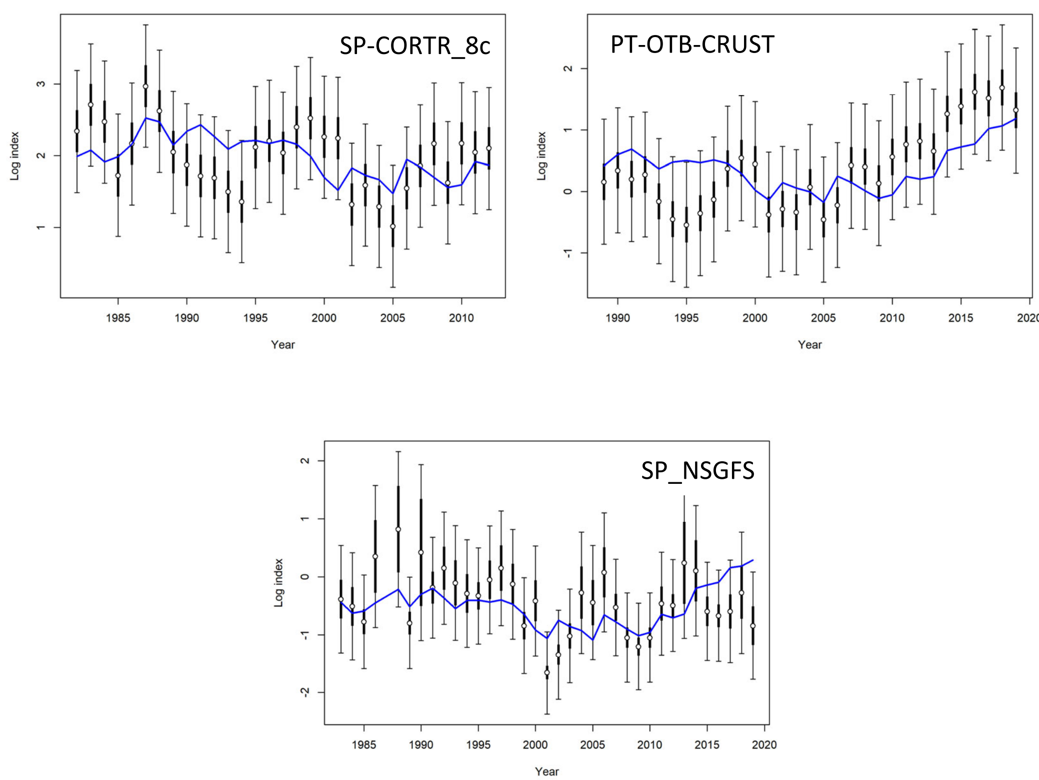

Figure 16. Model 3: fit to the length compositions and survey data.

1. Conclusion and next steps

The main objective for this workshop was to build a starting model with a simple configuration and get training and tools for further development. Since this stock is currently under the WKMSYSPiCT benchmark (with the SPiCT model), data available for the stock will be revised. Therefore, it was suggested to explore model 2 configuration with revised data and work on recruitment deviations settings, which will probably improve the fit. In addition, future work should focus on checking sample sizes, change recruitment settings (*h* value should not be fixed and is currently unrealistic) and SigmaR (which can be fixed to 0.6) and test different equilibrium catch values. Sensitivity analysis to the fixed parameters should also be considered in the future.

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Analysis of Northern hake assessment (*hke.27.3a46-8abd*)

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January 27, 2021

Abstract

An ICES `SS3` and `a4a` workshop was held by ICES in November 2020 to improve the assessment of some stocks managed with these assessment models or that could be potentially managed using them. In May some problems were detected in the fit of SS3 to hake data so one of the objectives of the workshop was to investigate what was going on and how could be solved. Furthermore, the impossibility of estimating growth parameters within the model and the high sensitivity of the results to some settings such as the selectivity curves have been always a problem in the assessment of this stock. The group of SS3 experts from NOAA and other European experts made many suggestions to improve the assessment model fit. However, most of the suggestions led to a qualitative change in the perception of the stock. Hence, further investigation is needed to assess if they are really appropriate and a benchmark process should be required to approve the new model configuration. Furthermore, alternative analysis were carried out to investigate the sensitivity of the model to different data sources and input parameters.

1 Introduction

Northern stock of hake (*hke.27.3a46-8abd*) is assessed using Stock Synthesis (SS) Methot and Wetzel [2013] since 2010. Before a problem in the age determination of hake individuals was detected which made it not possible to assess the stock using traditional age structured assessment methods. Thus, at that time, SS was set up using length based data and allowing the model to estimate the growth rate parameter (K) and fixing the maximum mean length L_∞. However, in 2013 a problem was detected in the goodness of fit of the assessment, there was a high retrospective pattern related with the inter annual variability in the estimation of K. Hence, in 2013 assessment the K parameter was fixed to the value estimated in 2012 assessment and since then the value has been maintained constant. The problem with the retrospective pattern in the assessment was not completely solved and in 2014 a benchmark was carried out. The recruitment estimates in the most recent period were revised upwards year by year and this produced a big increase in the estimation of spawning stock biomass (SSB) year by year. The retrospective pattern was improved introducing more variability in the selectivity and retention of the fleets (blocks and random walks). Finally, in 2018 an inter-benchmark workshop was carried out to introduce into the assessment the discards of some fleets (gillnetters and trawlers in areas 8abd and 7) and test the performance of an egg-survey. The discards were included adequately in the assessment but the egg survey was not because the impact in the results was very low and it was preferred to wait to have a longer time series.

The sensitivity of the model to the selectivity curves of the fleets and the impossibility of estimating the growth parameters properly have been always a concern in the assessment of this stock. Furthermore, this year, when only a minor change in the data of one survey was made, a convergence problem in the retrospective pattern of the model was detected, some of the years did not converge. Thus, the working grop organized by ICES to advance in the application of SS in stock assessment was considered a good opportunity to improve the quality of the assessment of the stock. Several test were made to investigate the sensitivity of the model to different data sources and input parameters. These results allowed us to define the following steps to improve the stock assessment for this stock.

2 Update to version 3.30

First, the input files from SS version 3.24 were updated to the last version of SS 3.30. The conversion was done almost automatically with the available software but it was necessary to make some changes manually related with the blocks used in some parameters. The initial offset for recruitment was also tuned manually.

The comparison between the SS3 estimates between the two versions are shown in Figure 1. The results obtained for the main indicators were very similar and also the likelihood value. Hence

A retrospective analysis was carried out using the new version with the WG-BIE configuration to see if the convergence problem persisted. The retrospective did not converge for time series up to 2017 (retro-2) and 2015 (retro-4).

A jitter analysis was also carried out for 10 iterations, i.e, the starting points were changed varying the value of the parameters in a 10% randomly. Two iterations did not converge, there was set of 6 iterations with similar likelihoods and that provided similar SSB, recruitment and F restuls and finally there were other two iterations that converged to different values but which likelihood was higher (Figure **??**, Table 1). Among the set that converged to similar results there were small differences in the likelihood value, but the likelihood of the WGBIE configuration was similar to the lowest one. Hence, it was considered that the model fit obtained in 2020 has converged to the right values.

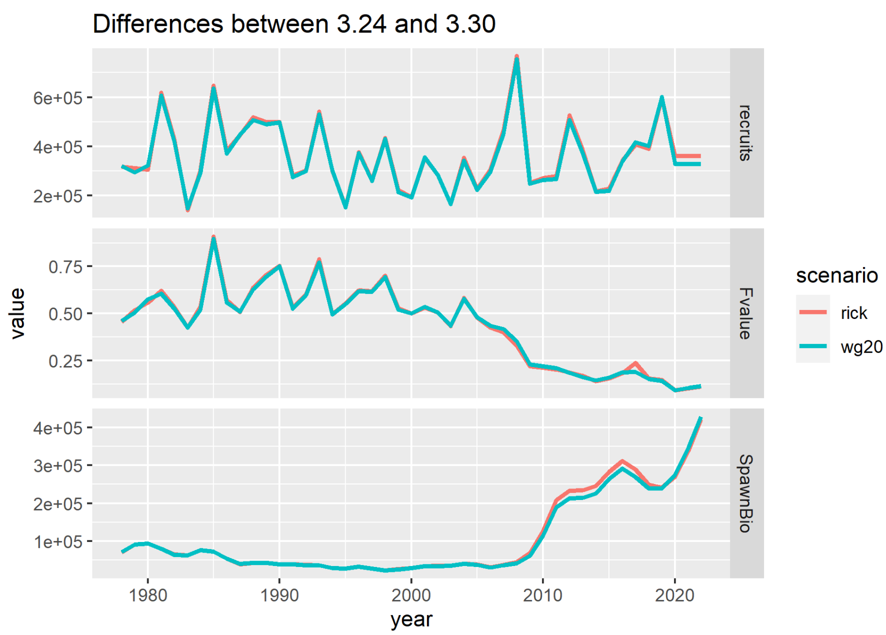

Figure 1: Main indicators obtained using SS3 version 3.30 and the input files developed by R.Methot (rick) and the indicators obtained with version 3.24 in WGBIE-2020.

Comp.	jit-1	jit-2	jit-3	jit-4	jit-5	jit-6	jit-7	jit-8	jit-9	jit-10
TOTAL	978798	20844	20836	20822	20818	21162	100966	20856	20827	21177
Catch	280505	57	51	52	53	54	0	58	52	59
Equil_catch	1928	0	0	0	0	0	518	0	0	0
Survey	838	-21	-17	-14	-16	-13	40	-23	-17	-21
Discard	99378	511	478	514	542	556	23762	540	518	511
Length_comp	596096	20177	20193	20138	20112	20421	76595	20159	20142	20496
Recruitment	-36	-24	-22	-23	-23	-23	-38	-24	-23	-25
InitEQ_Regime	0	0	0	0	0	0	0	0	0	0
Forecast_Recruitment	0	1	1	1	1	0	0	1	1	1
Parm_priors	76	76	76	76	76	76	76	76	76	76
Parm_softbounds	0	0	0	0	0	0	0	0	0	0
Parm_devs	13	66	76	78	73	90	12	70	77	79
Crash_Pen	0	0	0	0	0	0	0	0	0	0

Table 1: Likelihood of the jitter fits using WGBIE configuration

3 Sensitivity trials

3.1 Increasing the bounds

Year by year the ranges of some parameters related with selectivity and retention must expanded because the estimates hit the bounds. In the last year assessment this was the case for the retention curves of Spanish trawlers. The ranges for those parameters were extended and the model fit was compared with the base case and a retrospective was carried out.

The differences between both model runs were more apparent in recruitment from 1990 to 1995. In the last year the SSB was also slightly lower when lower bounds were used (Figure 2). The likelihood was slightly bigger when the ranges were increased, which shouldn't happen. However, the differences was so small (0.1%), that it was not considered a problem.

A retrospective analysis of the model fit with extended ranges (Figure 3). With the wider ranges the convergence problems in the retrospective analysis were solved.

3.2 Natural Mortality

Natural mortality for this stocks is assumed to be equal to 0.4 without any strong biological basis behind. Before, when the growth of the individuals was assumed to be the half it is assumed now, natural mortality equal to 0.2 was used. As it was the case for in many stock assessment around the world. Thus, as the growth was doubled it was considered appropriate to double the natural mortality, i.e, M = 0.4. A likelihood profile on natural mortality was carried out to analyse if the fit (likelihood) improved with any of the values used and to analyse how did it impacted the main indicators.

The model was fit for values of M between 0.15 and 0.5 with with intervals between values of 0.05. The differences in likelihood were very low (Table 2) highlighting, as expected, the little information available to estimate M using available data. In proportion the biggest difference was observed in surveys that were better fitted, in terms of likelihood, when high values of M were used. Could it be because the information available in the surveys is more compatible with higher M-s? supporting what we know about high mortality in small fishes due to cannibalism or predation?

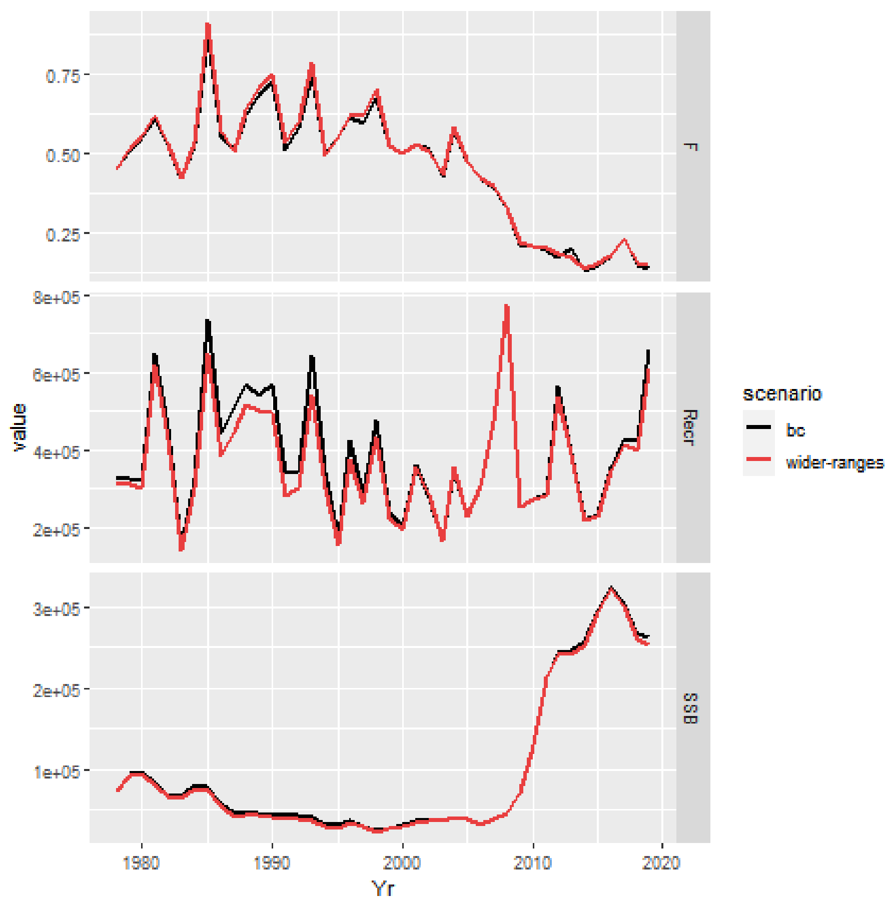

Figure 2: Main indicators obtained in the base case and the base case with wider ranges in retention curves.

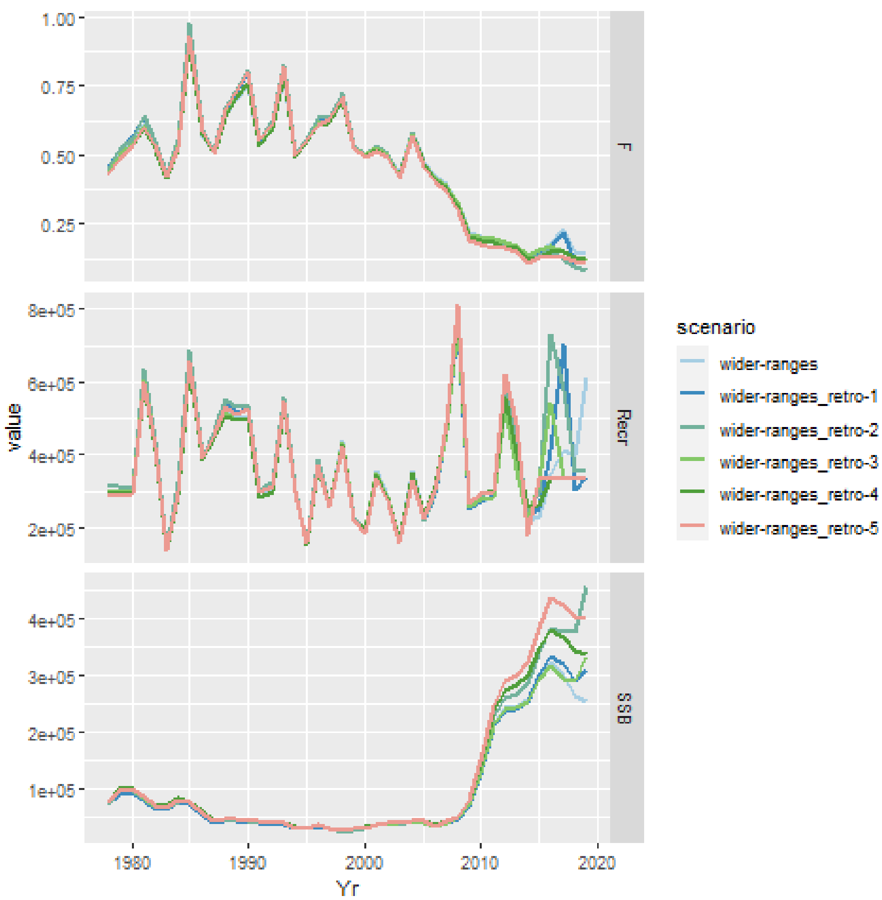

Figure 3: Retrospective patters of the main indicators obtained in the base case e with wider ranges in retention curves.

The obtained trends in the main indicators were similar but the overall level was different. The higher the natural mortality the higher the estimated recruitment and SSB-s and the opposite with fishing mortality.

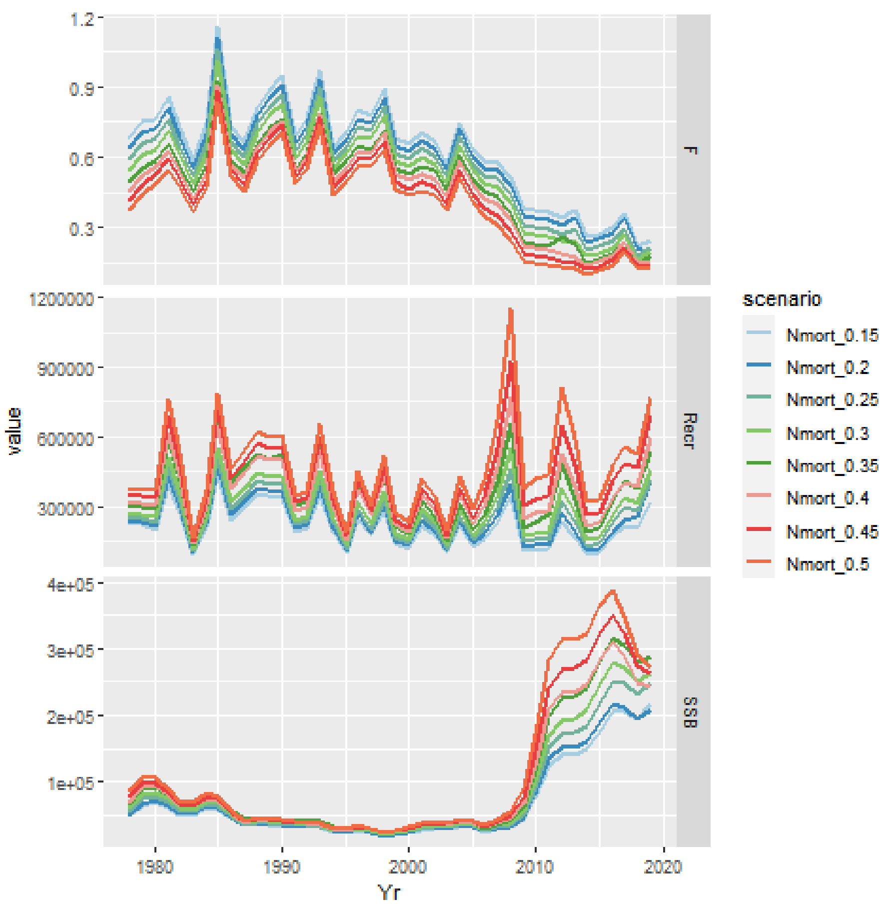

Figure 4: Main indicators obtained in the base case and the base case with wider ranges in retention curves.

3.3 Growth parameters from tagging

de Pontual et al. [2013] analysed the growth of hake using the tag recoveries of the large tagging study carried out by Ifremer from 2004 to 2007. They found that the model that best described the data was the model with $L_\infty = 126$ and $K = 0.17$, both below the parameters currently used in the assessment of the stock. The model was fitted using these parameters. The trend of the main indicators were similar but the SSB level was significantly higher with the values derived from the tagging study.

Comp.	M_0.15	M_0.2	M_0.25	M_0.3	M_0.35	M_0.4	M_0.45	M_0.5
TOTAL	21009	20861	20862	20857	20822	20864	20876	20879
Catch	67	63	63	61	55	57	54	53
Equil_catch	0	0	0	0	0	0	0	0
Survey	-5	-6	-12	-16	-15	-21	-22	-24
Discard	520	498	528	531	542	513	448	450
Length_comp	20291	20179	20156	20155	20114	20196	20275	20278
Recruitment	-20	-21	-23	-24	-23	-24	-23	-23
InitEQ_Regime	0	0	0	0	0	0	0	0
Forecast_Recruitment	1	1	1	1	1	1	1	1
Parm_priors	79	78	77	76	76	76	76	76
Parm_softbounds	0	0	0	0	0	0	0	0
Parm_devs	74	69	72	71	73	67	67	66
Crash_Pen	0	0	0	0	0	0	0	0

Table 2: Likelihood of the likelihood profile on Natural mortality using WGBIE configuration

The likelihood was slightly lower with the parameters proposed by de Pontual et al. [2013]. However, the likelihood component of the survey improved significantly (by more than 60%, Table 3) but as most of likelihood corresponds to the length frequency distributions, overall the improvement in surveys was not hidden. This highlights the importance of re-weighting the model to balance the weight of the model components in the likelihood.

Component	bc	GrowthPontual
TOTAL	20821	20772
Catch	52	53
Equil_catch	0	0
Survey	-17	-28
Discard	516	508
Length_comp	20137	20121
Recruitment	-23	-23
InitEQ_Regime	0	0
Forecast_Recruitment	1	1
Parm_priors	76	76
Parm_softbounds	0	0
Parm_devs	78	65
Crash_Pen	0	0

Table 3: Likelihood of the base case and the model using the growth parameters proposed by de Pontual et al. [2013]

3.4 Length frequency distributions

The assessment of northern hake has a great amount of length frequency distributions (LFD) and most of the likelihood belongs to corresponding component. As the sensitivity of the model to the selectivity and retention curves, which are derived from LFD data, is high, it is important to know how each of the LFDs impact on the model results. To analyse it we fit two different model configurations for each of the fleets and surveys:

1. We remove the LFD for the fleet in the whole time series (*single fleet* configuration).
2. We fit the model using only the LFD of the fleet (*all but one* configuration).

The main indicators obtained for the two model runs for each of the fleets are presented in Appendix [**?**].

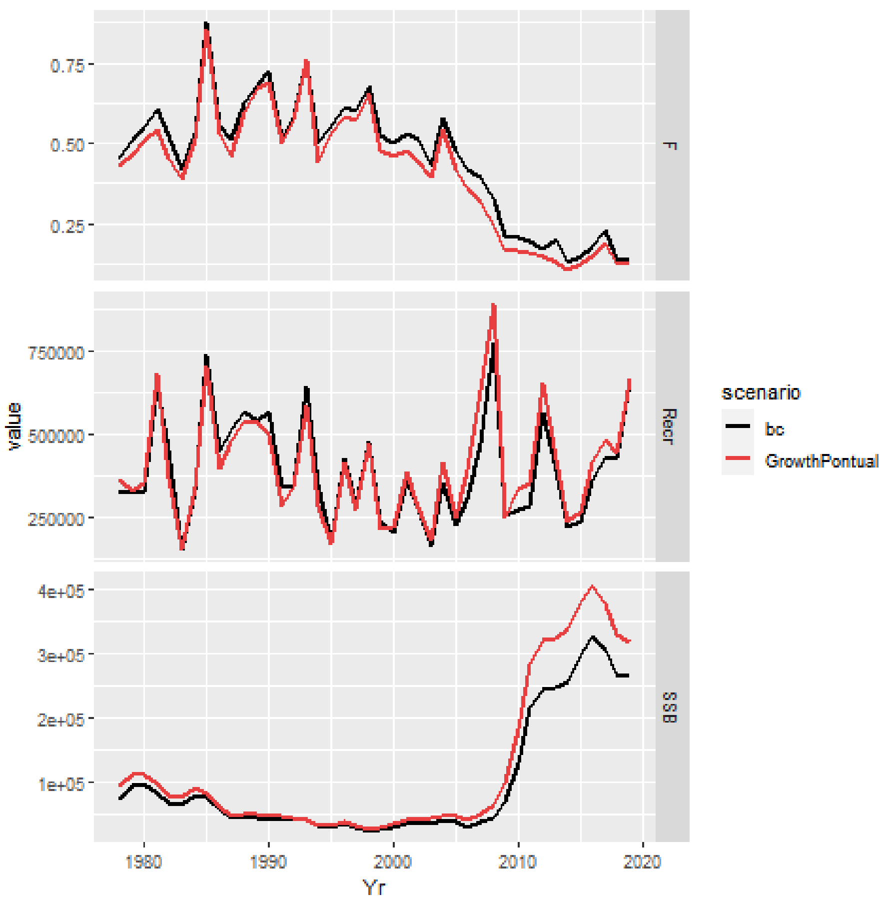

Figure 5: Main indicators obtained in the base case and the model with the growth parameters proposed by de Pontual et al. [2013].

Removing the fleets that provide information in small individuals (IE_GFS, EVHOE and the Spanish trawlers) has little impact on the output because there are many LFD-s that provide information on small individuals. However, removing the LFD of TRAWLOTH, LONGLINE and OTHER fleet, that catch bigger individuals, have a big impact on the results.

- Removal of TRAWLOTH, produces a big increase in SSB
- Removal of LONGLINE produces a big decrease in SSB specially in recent years (this fleet catches big individuals).
- Removal of OTHER fleet produces a big decrease in SSB (this fleet also catches big individuals).

Thus, the data in TRAWLOTH and that in LONGLINE and OTHER fleets contain opposite information. As TRAWLOTH and OTHER fleets have logistic selectivity which is a strong assumption and have usually a big impact on the results. The impact of those fleets could be lower if the shape of the selectivity curve was dome shaped. It could be interesting to test dome shape selectivity for this fleets.

This exercise highlights the importance of balancing the weights in the model configuration.

3.5 Recruitment and settlement

R. Methot proposed several changes in the modelling of recruitment:

- Recruitment distribution method from 2 to 3 (Line 14 control file, main effects for GP to 'each settle entity').
- Settlement assigments from 3 to 4, although later on using only is suggested because in the first season the recruitment is almost null and having 3 saves computational time.
- New block in recruitment from years 2010 to 2022 (in the same line as the offset for the initial recruitment)
- Age (post-settlement) (Amin) decreased from 0.75 to 0.15, linear growth below this age.
- Length at Amin, estimated yearly, base year 1985 (the first year a survey RESSGASQ is available) and then deviations from this value.

  5 18 12.42686 10.4 3 0 6 0 5 1986 2019 5 0 0 * L_at_Amin_Fem_GP_1

- The recruitment distribution among seasons changed, from

  0 0 0 0 0 0 -3 0 0 0 0 0 0 0 * RecrDist_GP_1
  0 0 0 0 0 0 -3 0 0 0 0 0 0 0 * RecrDist_Area_1
  -8 8 0 0 0 0 -2 0 0 0 0 0 0 0 * RecrDist_timing_1

-12 12 0.423608 0 0 0 6 0 5 1978 2018 4 0 0 * RecrDist_Seas_2
-12 12 -0.126765 -0.56 0 0 6 0 0 0 0 0 0 0 * RecrDist_Seas_3

to

-8 8 -3 0 0 0 5 0 0 0 0 0 0 0 * RecrDist_GP_1_area_1_month_1
-12 12 -2 0 0 0 4 0 0 1978 2018 4 0 0 * RecrDist_GP_1_area_1_month_4
-12 12 0 0 0 0 -4 0 0 0 0 0 0 0 * RecrDist_GP_1_area_1_month_7
-12 12 -3 0 0 0 5 0 0 0 0 0 0 0 * RecrDist_GP_1_area_1_month_10

So in the configuration proposed the main modelling occurs in season 4 instead of season 2. The first two lines disappear, presumibly because now we use option 3, instead of option 2 to model settlement. Before the first season was the base (i.e equal to 0 and not estimated) and in the proposed version it is the base is the third season.

- Time varying MG parameters now changed from:

  0.0001 2 1.5 0.5 0.5 6 -5 * RecrDist_timing_2_dev_se
  -0.99 0.99 0 0 0.5 6 -6 * RecrDist_timing_2_dev_autocorr

  to

  0.0001 2 1.8 0.5 0.5 6 -5 * L_at_Amin_Fem_GP_1_dev_se
  -0.99 0.99 0 0 0.5 6 -6 * L_at_Amin_Fem_GP_1_dev_autocorr

  Basically the same, only the labels changed, so I understant that the parametesrs are more related to 'L_at_min' than to recruitment. The value of the first parameter changed from 1.5 to 1.8.

- SR regime block added from 2010, but a - added to the phase so I guess the option is annulled.

- In the advance recruiment options several years and options changed:
  1900 (before 990) *_last_yr_nobias_adj_in_MPD; begin of ramp
  1986 (before 1975) *_first_yr_fullbias_adj_in_MPD; begin of plateau
  2019 (before 2022) *_last_yr_fullbias_adj_in_MPD
  2023 *_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS sets bias_adj to 0.0 for fcast yrs)
  0.8 (before 1) *_max_bias_adj_in_MPD (typical 0.8; -3 sets all years to 0.0; -2 sets all non-forecast yrs w/ estimated recdevs to 1.0; -1 sets biasadj=1.0 for all yrs w/ recdevs)

  Note from the manual on this *"The first year with full bias adjustment should be a few years into the data-rich period so that SS will apply the full bias-correction only to those recruitment deviations that have enough data to inform the model about the full range of recruitment variability. Defaults for the four year values: Start year – 1000, Start year – Nages, Main recruitment deviation final year, End year + 1."*

The changes proposed by R. Methot to model settlement and recruitment produced a slight increase in likelihood. The values of SSB and recent values of fishing mortality were very similar with both configurations but there were big differences in values of recruitment and fishing mortality in not recent years. However, trends were similar in all the cases.

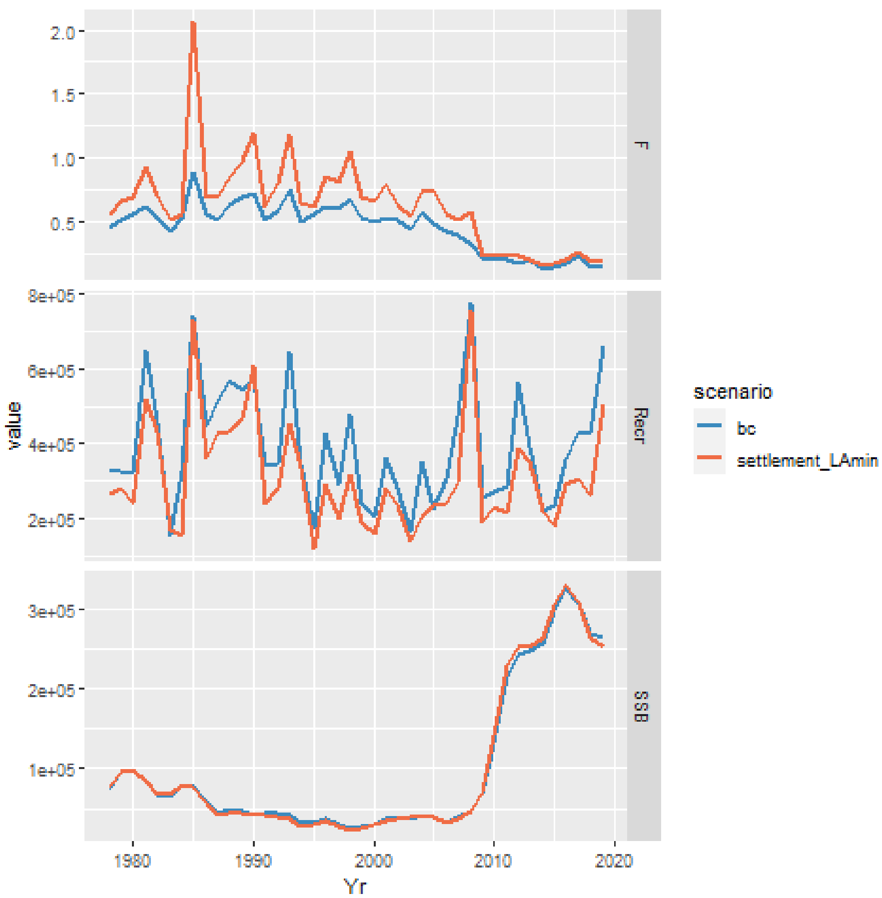

Figure 6: Main indicators obtained in the base case and the model with the settlement and recruitment settings proposed by R. Methot.

3.6 Settlement, recruitment and estimated growth parameters

R. method made other recommendations listed below:

- Estimate growth parameters
- It provides initial F for all the fleets and seasons (before only was provided for season 1). Include this in future configurations.

- Use the same 'q' for all the RESSGASQ surveys. Include this in future configurations.
- TRAWLOTH to dome-shape selectivity.
- RESSGASQ selectivity from 5 to 15.
- Selectivity: Several changes in the ranges, initial values, phases where the parameters are estimated, some parameters made fixed...

The likelihood decreased in a 4% with the new configuration. The main indicators were very different to those obtained in the base case: at the beginning of the time series the values in recruitment were similar and the values of fishing mortality were not very different. However, in most recent years the difference was high. The SSB was very different and in the last period it increased enormously.

3.7 L_∞

In the model configuration proposed by R.Method we perform a likelihood profile to analyse if the model was able to estimate it adequately and if they were conflicting data.

The standardized likelihood for the different components of the model are shown in Figure 8. The model in previous section estimated L_∞ around 85 cm. However, none of the components show a clear signal on which should be $Linf$. The Survey data pointed out to $Linf$ values above 115 cm, but in the range of 115 to 135 the differences in likelihood were low. On the contrary the equilibrium catch data had the minimum between 80 to 95 cm. Apparently, the length composition did not provide any information on $Linf$ because the variation in likelihood was very low. Table 9 shows the information about likelihood. Survey data is the only one that pointed out to high values of $Linf$, but is the one that showed the strongest signal.

The main indicators are shown in Figure 10. The lower the L_∞ value the higher the SSB and recruitment and the lower the fishign mortality. The trends in all for all the L_∞ values were similar. However the differences were bigger in recent years.

3.8 σ_R and steepness

We increase σ_R and fit SS3 using the same settings. The main indicators are shown in Figure **??**. The results were pretty much the same. The most remarkable differences is that in the beginning of the time series the recruitment was somewhat lower when σ_R was increased.

The loglikelihood was slightly higher when σ_R was increased (20821 versus 20851). While surveys and discards were better fitted with the increase in σ_R the length frequency distributions (LFD) were worst fitted.

Rick Methot was likely applying the increase in σ_R to a different model configuration where the impact was different.

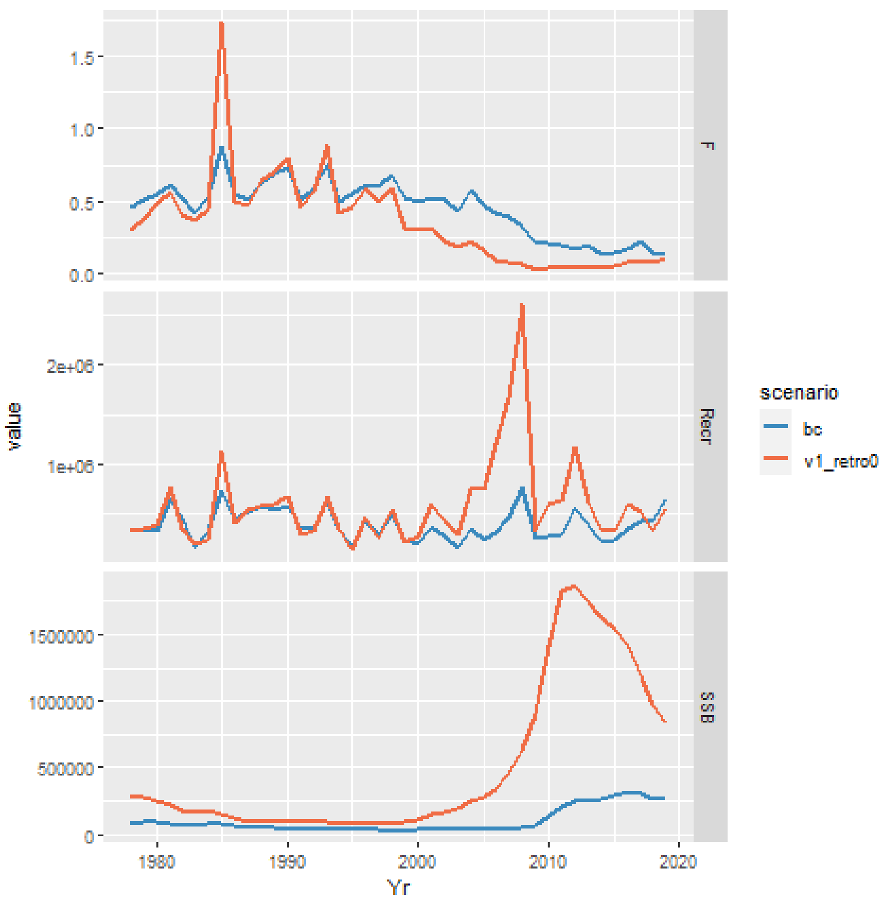

Figure 7: Main indicators obtained in the base case and the model configuration proposed by R. Methot (control_330g.ss).

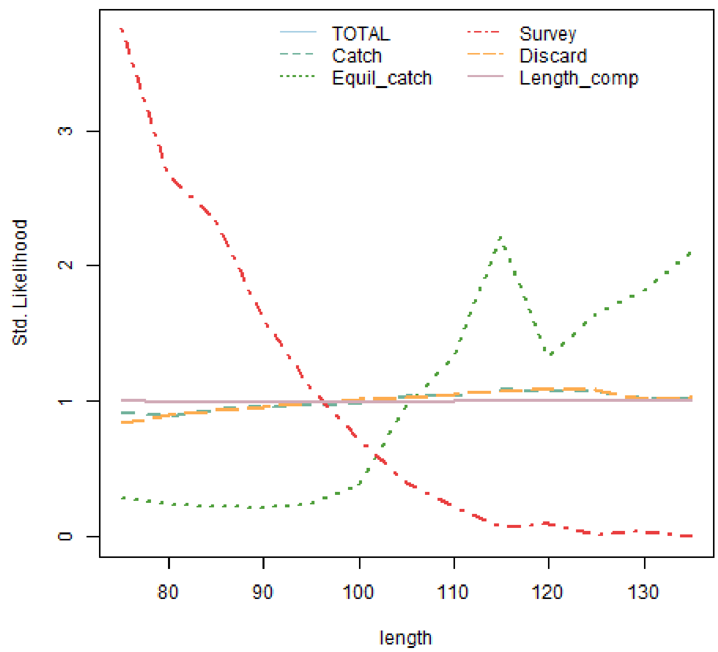

Figure 8: Standardized likelihood for the main components of the model for the likelihood profile of L_∞.

	Linf = 75	Linf = 80	Linf = 85	Linf = 90	Linf = 95	Linf = 100	Linf = 105	Linf = 110	Linf = 115	Linf = 120	Linf = 125	Linf = 130	Linf = 135
TOTAL	20057	19758	19593	19616	19662	19716	19758	19798	19839	19977	19998	19981	19996.8
Catch	44	42	45	45	46	47	49	50	52	51	51	48	48.5
Equil_catch	0.0015	0.0013	0.0012	0.0011	0.0013	0.0021	0.0052	0.0072	0.0119	0.0072	0.0089	0.0098	0.0114
Survey	26	8	2	-10	-19	-25	-30	-33	-36	-36	-37	-36	-37.1
Discard	395	423	438	450	463	475	484	491	502	508	512	478	480.6
Length_comp	19506	19214	19032	19061	19106	19156	19194	19231	19263	19396	19415	19434	19448.9
Recruitment	18.4	10.5	11.6	7.8	4.7	2.5	0.3	-1.1	-2.2	-2.5	-3.2	-4.0	-4.4
InitEQ_Regime	0.5	0.5	0.4	0.4	0.4	0.4	0.6	0.7	0.8	0.7	0.7	0.6	0.6
Forecast_Recruitment	0.4	0.3	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.3	0.3	0.3	0.3
Parm_priors	12	12	12	12	12	12	12	12	12	12	12	12	12.1
Parm_softbounds	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1
Parm_devs	55	47	52	50	48	48	48	48	48	47	47	47	47.1
Crash_Pen	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 9: Likelihood for the main components of the model for the likelihood profile of L_∞

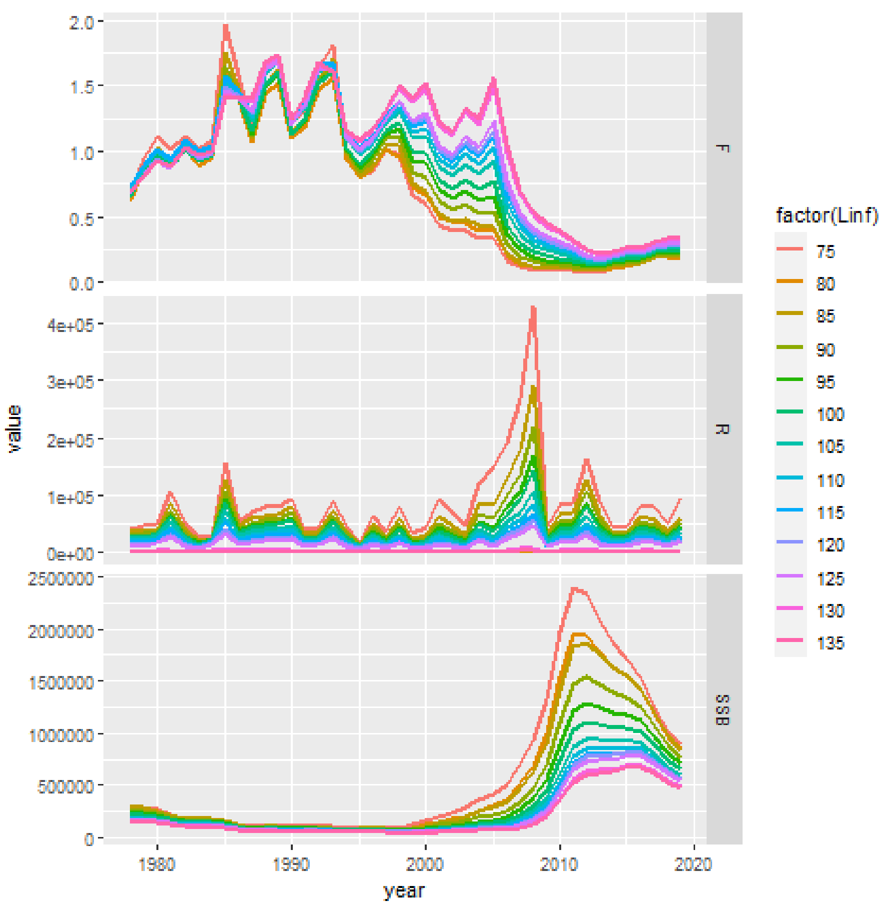

Figure 10: Main indicators obtained in the likelihood profile of L_∞.

4 R.Methot's comments

4.1 σ_R

The RMSE of the recrdevs was greater than 0.4. I get better estimates with sigmaR=0.6. Your maxbias adjustment of 0.8 seems about right.

4.2 Steepness

It currently is fixed at 0.999. It get better performance with steepness estimated and it goes to about 0.82. This is because the data indicate increasing recruitment at the end of the time series, so if SSB is decreased in the early and middle of the time series due to higher F, then the increasing SSB after about 2010 leads to higher recruitment with steepness lower than 0.999.

4.3 Survey data

The survey data are precise, but they do not provide the right information. Most surveys are sampling just the age 0, 1, 2 fish. So they provide a very good recruitment index, but little info on trends in the ages of fish that are in the fishery. The Porcupine survey does cover larger fish, but the area is different. This is unfortunate, and a big limitation in how well the model can perform.

4.4 Length data

There is a wealth of length data. This is why the model runs so slowly. The data are highly informative about young fish growth rates and time of settlement. However, because nearly all fleets have dome-shaped selectivity and because of the uncertainty about Linf, the length data have little information about the mortality rates on older hake. The overall model results are highly dependent on Linf and on the shape of the selectivity curves. If you fix linf and fix selectivity curves to be more asymptotic, then the model converges better. However, the result is then dependent on those assumptions.

4.5 Settlement

The length data are also highly informative about the timing of settlement. My current exploration models have recruitment nearly entirely in quarters 3 and 4, plus a little fixed amount in quarter 2. I put none in season 1, which makes model a bit faster because one less cohort to track. The length data also are informative enough to indicate that settlement timing is not the same each year. This appears in the data as the age 0 fish, at the time of the quarter 3 and quarter 4 surveys, fluctuating in size from year to year. Whether this is due to recruitment timing or due to age 0 growth does not matter because it has the same effect on the data we see. Your base model deals with this by allowing for a single growth curve for all seasonal cohorts and by adding year-to-year variability in the proportion of recruits from each quarter. My exploratory models do about 1000 logL better by also allowing for size-at-age 0 to fluctuate, but this time-varying growth then cause much slower model execution. I am unsure what to recommend. The reality is probably that there is a single primary settlement event and its timing spans the 3rd and 4th quarter, I can envision what the best model configuration would be, but neither SS or any other model can do it today.

4.6 Growth

The wealth of length data will be misleading to SS unless the growth curve is consistent with those data. It is easy to get the young fish growth right, but old fish growth is quite uncertainty and highly dependent on the form of the selectivity curve. I experimented quite a lot. Even have tried a model that had logistic length selectivity for smaller fish and inverse logistic age selectivity for older fish (to mimic their migration towards deeper water) and even tried using 3 growth platoons to mimic size-dependent survivorship for the fast growing platoon. No magical solution emerged, but I do find it a fascinating problem.

4.7 Conclusions

- For WGBIE in 2021 using the updated version of SS3 (330) is recommended, using the configuration in the base case but with wider ranges in retention and selectivity parameters to avoid hitting bounds and convergence problems.
- It is recommended to go to benchmark with Southern stock of hake to coordinate the work, specially in the biology of the species.
- L_∞ can not be estimated with the available data. Hence, it should be estimated externally using tagging data and other data sources.
- *Natural mortality* value used currently is not based on existing data or knowledge. Hence, it would be desirable to investigate possible values based on life history traits or meta-analysis.
- R. Methot suggested to estimate *steepness*, during the working group, the difficulty in estimating it was pointed out. However, it was highlighted the need o using a value lower than 0.99.
- Increasing σ_R should be considered in the benchmark.
- The recommendations made by R. Methot to model *recruitment and settlement* should be further investigated and contrasted with experts.
- *Data weighting* (dirichlet or Francis) should be tested as length frequency distribution have a big contribution to the likelihood and balancing the components is highly recommendable.
- The correlation between L_∞ and selectivities should be investigated.

- *Likelihood profile* on key parameters should be conducted to investigate which of them are well estimated by the model.
- Investigate the use of logistic *selectivity* curve for TRAWLOTH and OTHER fleet. Apparently, it is a best practive to use dome-shape selectivity curves by default.
- When the model is not able to adequately estimate parameters and it can not be estimated externally using data or expert knowledge, for example natural mortality, steepness or L_∞, a grid of values should be considered for the parameters and a *model ensemble approach* should be used.
- Automate the use of **ss3diags**.

A Length frequency distributions: Figures

References

H. de Pontual, A. Jolivet, F. Garren, and M. Bertignac. New insights on european hake biology and population dynamics from a sustained tagging effort in the bay of biscay. *ICES Journal of Marine Science: Journal du Conseil*, 70(7):1416–1428, 2013.

R. D. Methot and C. R. Wetzel. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research*, 142:86–99, 2013.

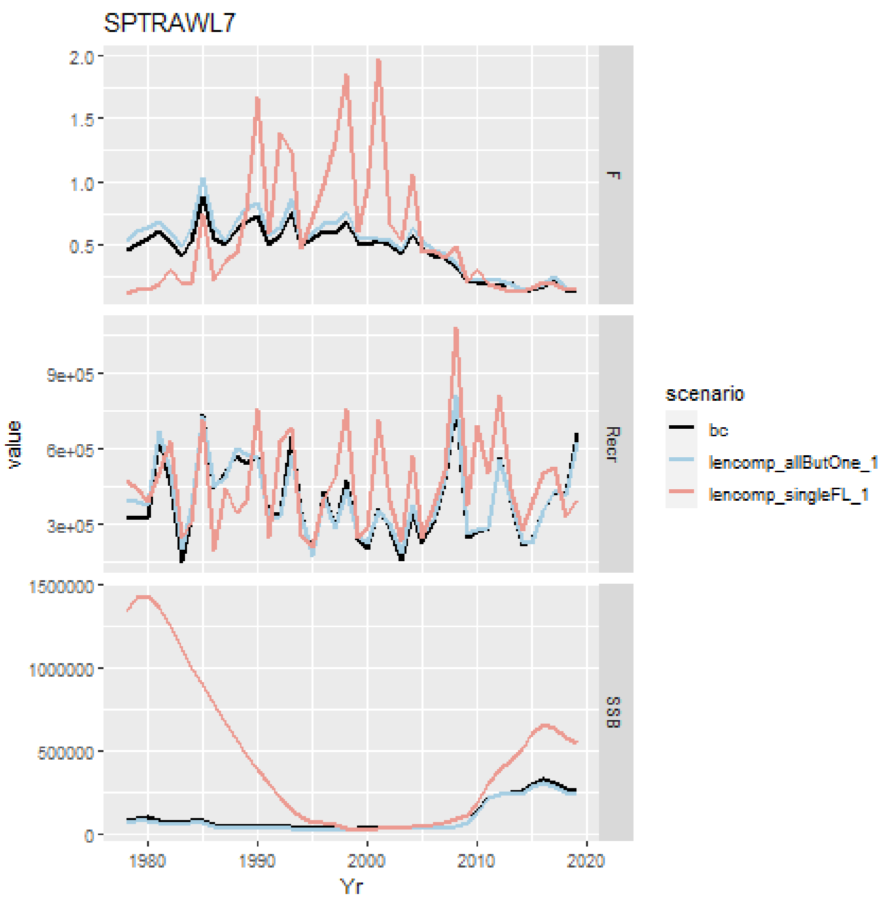

Figure 11: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

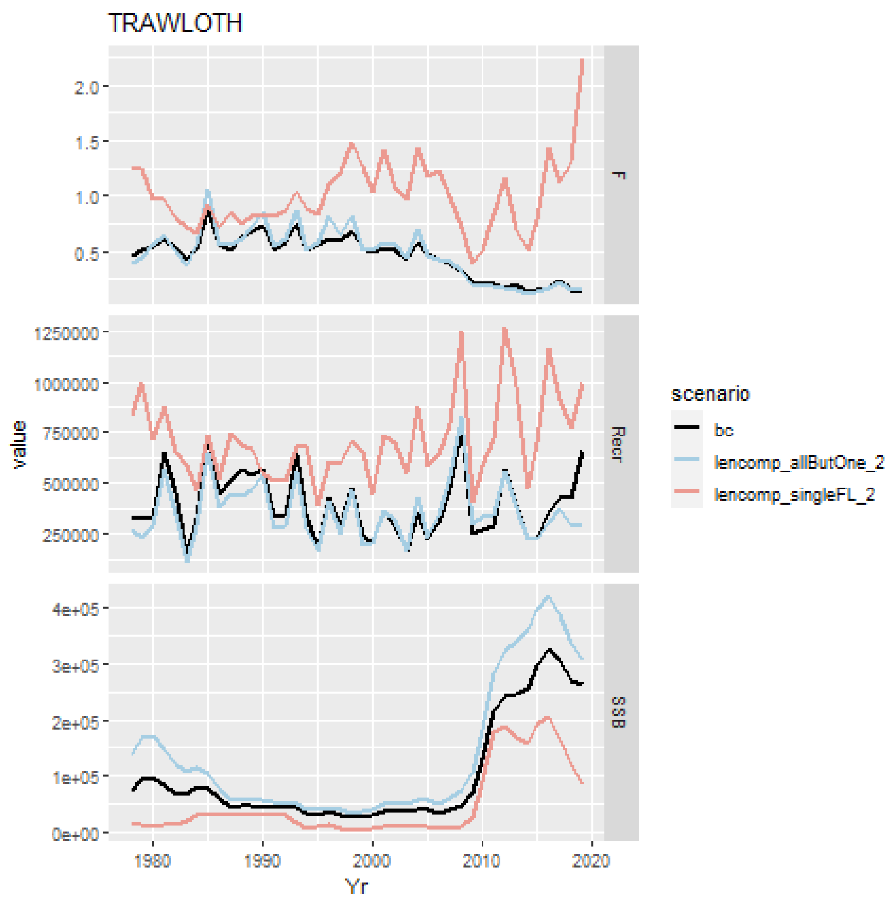

Figure 12: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

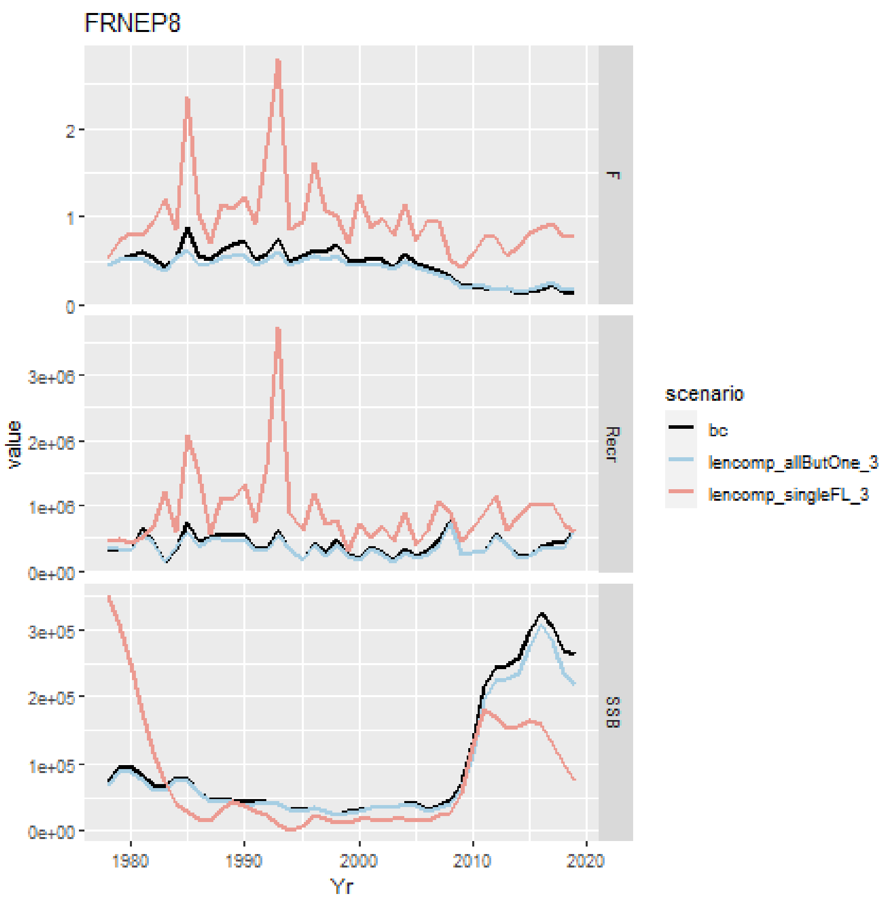

Figure 13: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

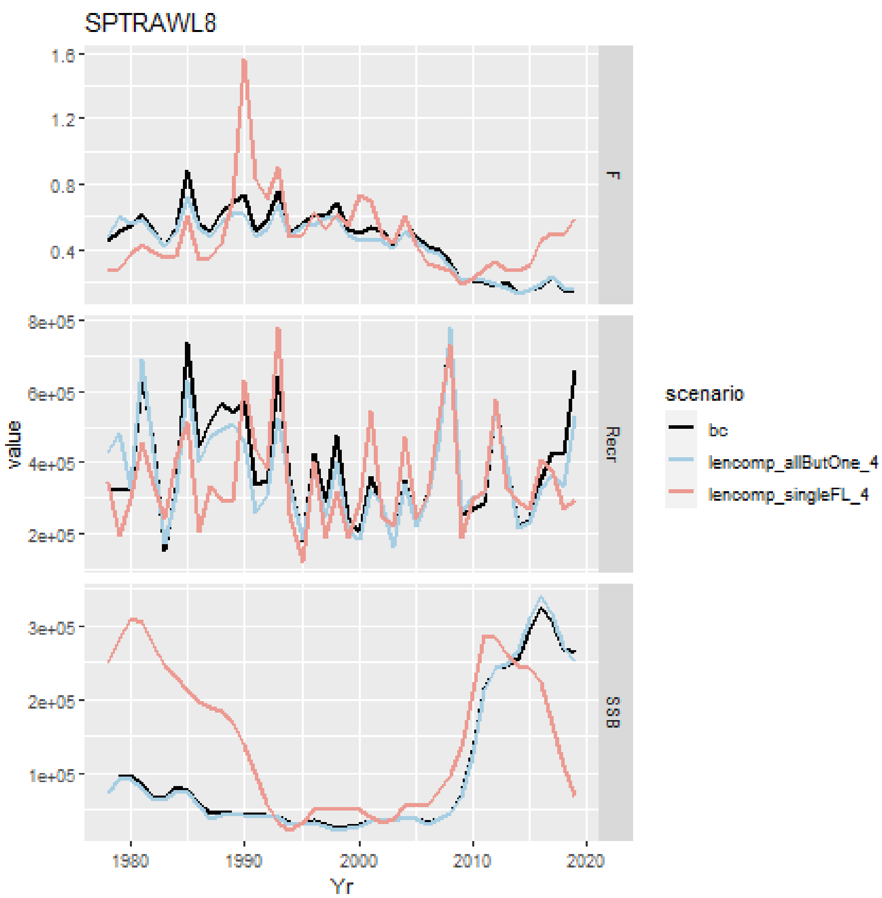

Figure 14: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

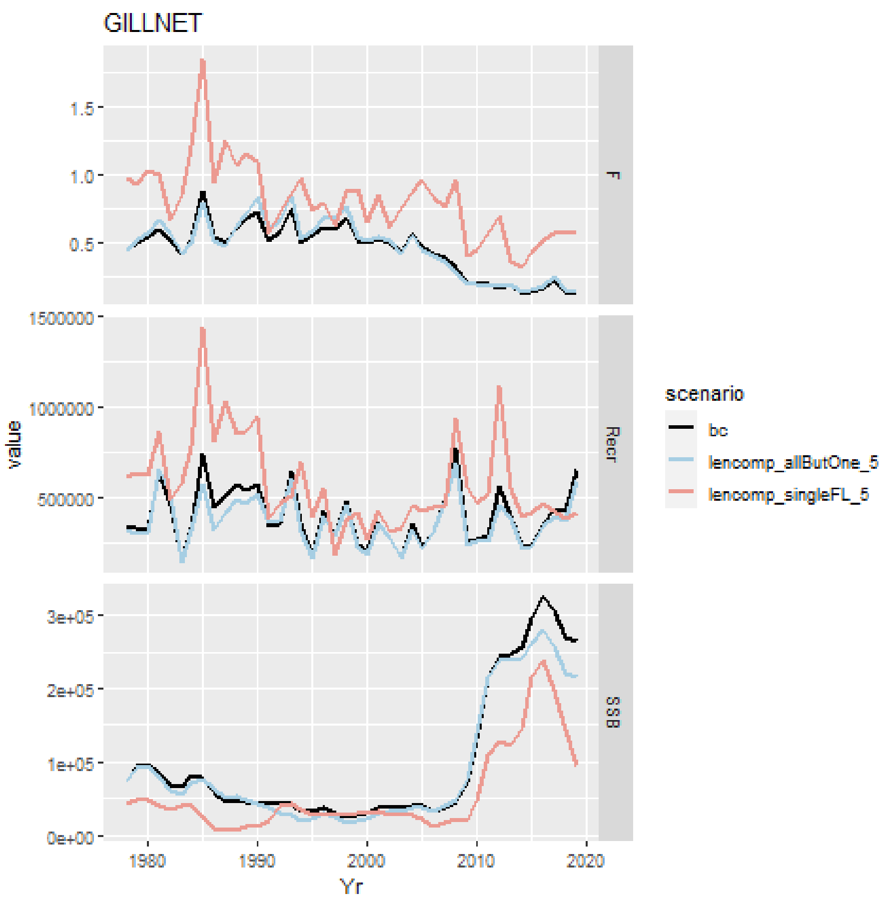

Figure 15: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

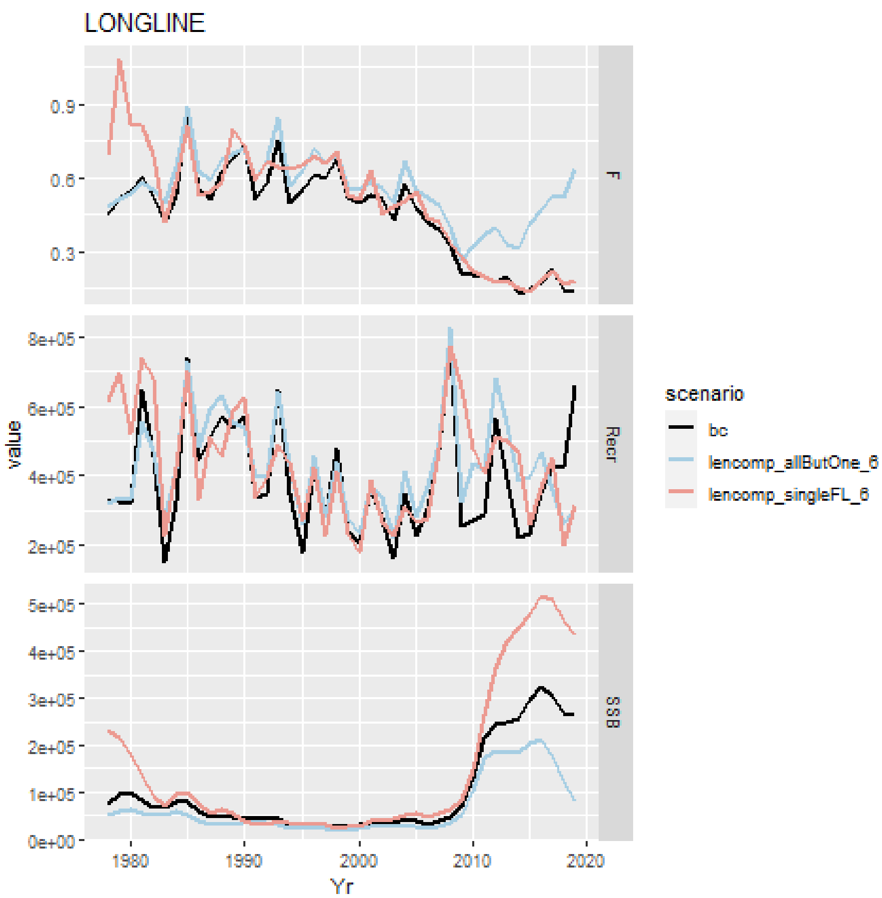

Figure 16: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

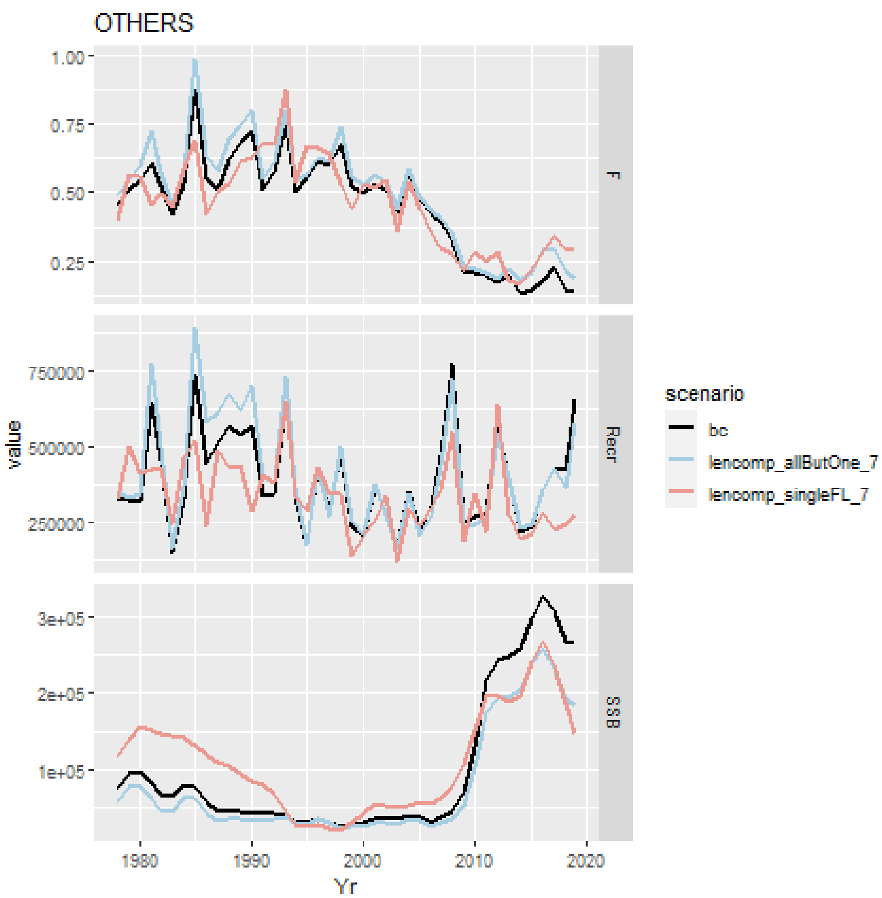

Figure 17: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

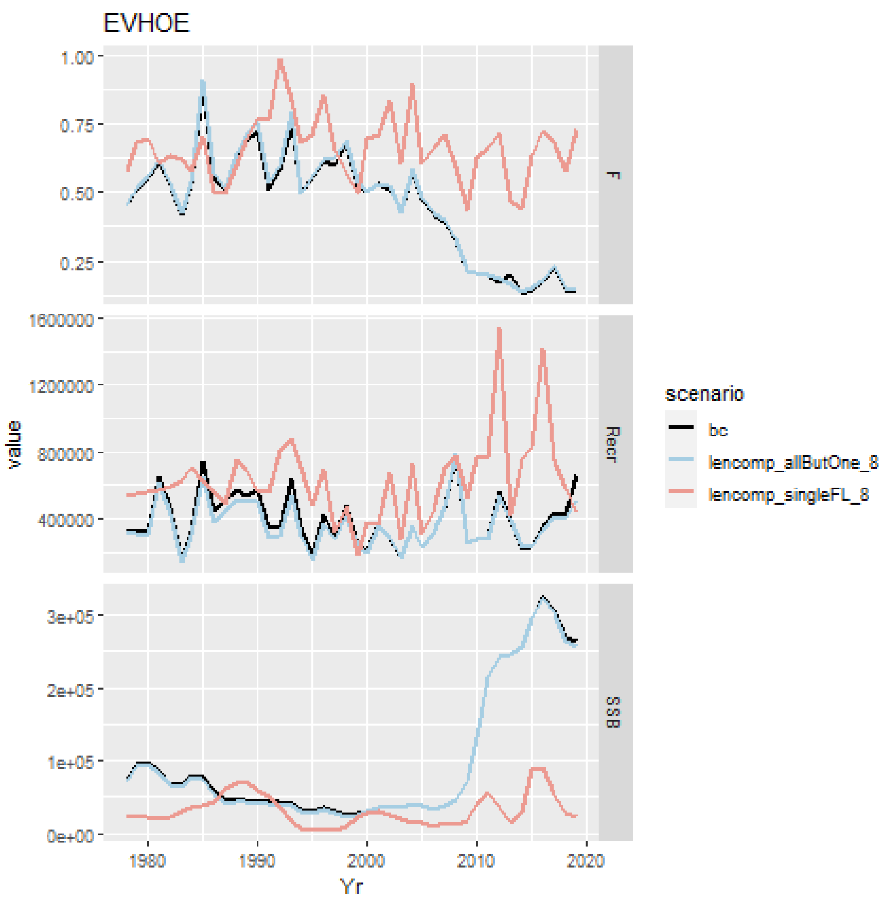

Figure 18: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

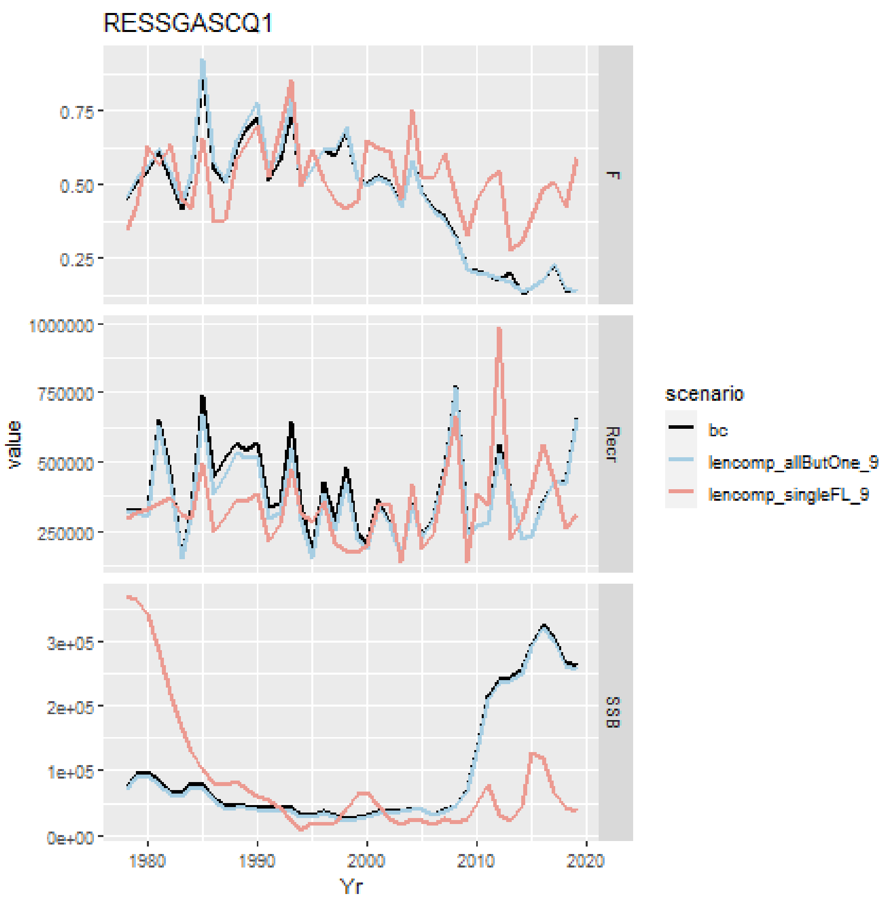

Figure 19: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

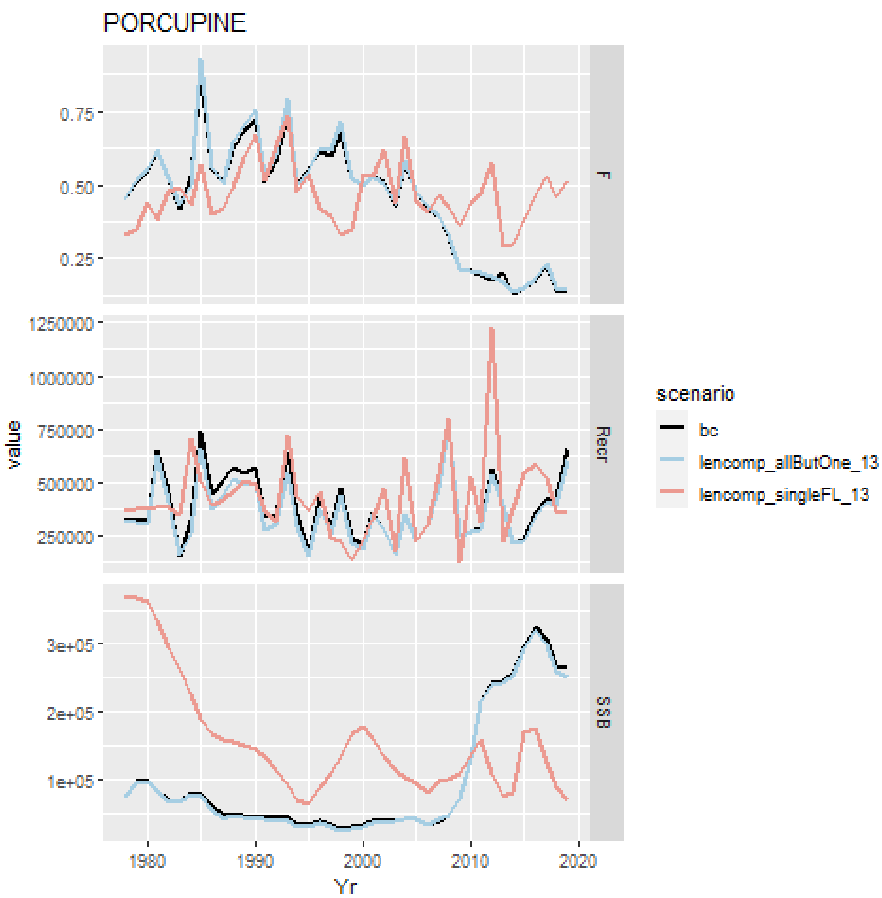

Figure 20: Main indicators obtained using the WGBIE configuration but removing one fleet or survey (red) or removing all the fleet but one (blue). The removed or maintained fleet is the one indicated in the title of the plot.

Development of a new stock assessment model with SS3 for hake (*Merluccius merluccius*) in divisions 8.c and 9.a, Southern stock (Cantabrian Sea and Atlantic Iberian waters)

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1. Reasons for moving from GADGET to SS3

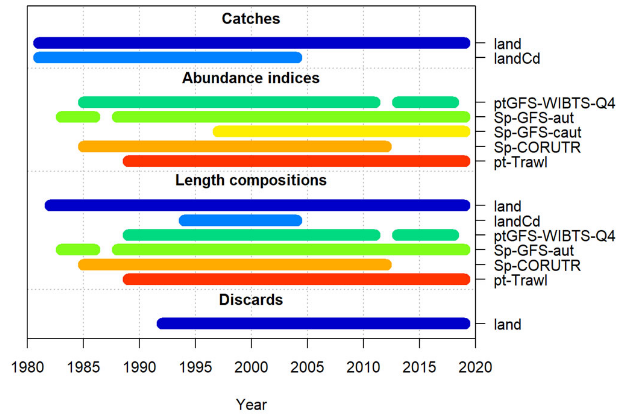
Southern hake stock assessment has been carried out through GADGET (length based) since 2010. However some problems were indentified with this assessment model in latest years resulting in a rejection of the model by WGBIE to be used to TAC advice. The main problem is the strong retrospective pattern, but also some convergence difficulties. The causes of the retrospective problem were analyzed without a clear solution (ICES, 2020) and we decided to explore the use of SS3 as an alternative. The main reasons are:

- SS3 has multiple modeling options for stock assessment as it's focused on that.
- SS3 allows to include and to estimate the error of each model parameter all together giving a more easy and complete measure of uncertainty.
- Northern hake stock is already assessed with SS3, and there is no ecological reason to Split both stocks. Regarding future aims, it would be quite interesting to try a multi area single stock model and to investigate this issue.

We are working with view in a benchmark in 2022 and we would like to have a full model analysis to present before, in WGBIE 2021 (May).

2. Data

A general data review is currently in progress. By now, there are landings and discards and 5 fleets indices corresponding to Spain and Portugal: 2 CPUE and 3 surveys .



There is a bad quality of the catch data before 1994 (only yearly, no discards) and also before 1982 (hake catch mixed with catches from North Africa). In addition, at the moment all fleets are together but we need to analyze in depth in order to Split them and see the possible effect on the model results.

Parallel study on biological data in progress. Some information on growth and maturity priors available.

parametro	funcion	Merluza norte	Merluza sur
Linf/Lmat	normal	mean=2.75; sd=0.49	
k/M	lognormal	median=0.63; CV=0.39	
L 50%	normal	mean=42.29; sd=2.24	mean=37.95; sd=3.09
Linf (Von Bertalanffy)	normal	Mean=116.39.42; sd=21.54	Mean=100.17; sd=18.62
k (Von Bertalanffy)	lognormal	median=0.14; CV=0.31	median=0.17; CV=0.30
M	lognormal	median=0.23; CV=13.58	median=0.28; CV=15.33

3. Starting point at WKTADSA

For the first WKTADSA meeting (16-20 November 2020) we started from a very simple SS3 model (v3.24) constructed from the Northern Hake one with Southern hake data trying to mimic the GADGET model. This was an experimental model in 2010 that was updated as follow:

- Update available data (not definitive data) from 2010 up to 2019.
- Convert model files to v3.30
- Learn how to run the model through SS3 and programming workflow.

For the second WKTADSA meeting (18-24 January 2021), we knew how to work with r4ss in order to edit, save, run the model, do retrospectives and check basis diagnostics (residuals, likelihood, jitter). We presented a preliminary model with these main characteristics:

<u>Data file</u>

- Single area
- Period (1982,2019)

- Multisession: 4 seasons per year (3,3,3,3)
- 7 fleet indices from Spain and Portugal: 2 CPUE, 2 landings, 1 discard, 3 surveys
- All units of catch presented in biomass (in tons)
- Number of ages: 15
- Weighting/NSample always set to 125 for LFD

Control file

- 1 Growth pattern
- 1 platoon within growth pattern
- 2 Recruitment settlement assignments, 1º and 4º terms.
- 3 block patterns [1982,1993], [1982,1991], [1981,1981] regarding selectivity
- Growth model: Von Bertalanffy (k=0.165 and Linf=130)
- Maturity option: length logistic (constant in time)
- First mature age is 0
- Spawner-recruitment: standard Beverton-Holt with h=0.999 and CV=0.8
- Fishing mortality: 0.3
- F method: instant. F rates by fleet and season.

4. SS3 not working issues

We are in a very preliminary model, and a lot of work needs to be done. However, we are trying to fit the model step by step, and the most important questions we wanted to solve at the second meeting were:

- Length composition data likelihood had the most of model weight
- How to properly weight the model instead of having NSamp=125 for all entries
- Problem with the ramp (recruitment deviation results) that were not displaying.
- NAs appearing in the results main likelihood table
- Catch data initial values (at equilibrium) was set only to the first term, and settings to each term gave awful results

5. Current work after WKTADSA

Following the WKTADSA participants and specially Massimiliano Cardinale’s suggestions:

- One of the main suggestions has been to use historical catches data (before 1982) even if we don’t trust very much on them as it will help to feed the model and to properly construct the recruitment ramp. We are now collecting this data.
- Regarding the weighting issue, we have set 100 to all LFD but we are also collecting data from ICES reports about sampling levels. Once we have the data we will assign the real simple size weights in NSAMP.
- The recruitment deviation configuration has been restated with recruitment advanced options.
- The problem about catch at equilibrium initial data have been solved and set to quarters with the help of Kathryn Doering.
- Double normal is now used for all indices unless fleet 1, which shows a better behavior with a logistic.

6. Future aims

- Understand better model options and diagnostics
- Split fleets and explore selectivity options
- Indices
    - Standardization Spanish CPUE (in progress)
- Explore biological parameter estimation (k, Linf, M, recruitment)
    - Maturity each year including Portuguese data
    - Estimate growth parameters
    - SR relationship
    - M explore alternatives including variable at length
- Later
    - Multi area model?
    - Sex separated model.

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

Laura Wise, Isabel Riveiro

February 2021

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).

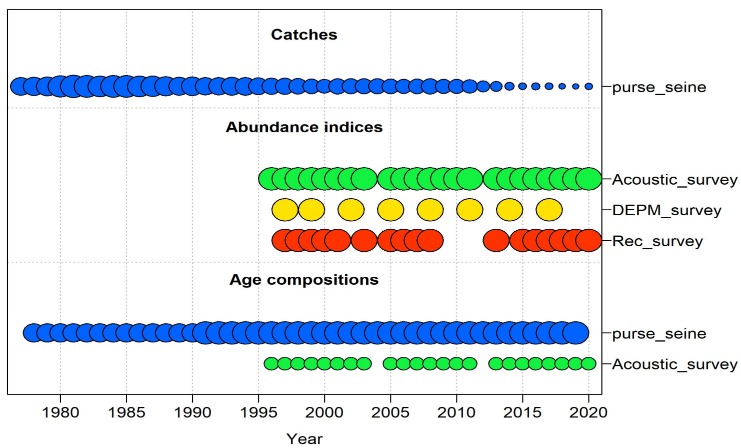
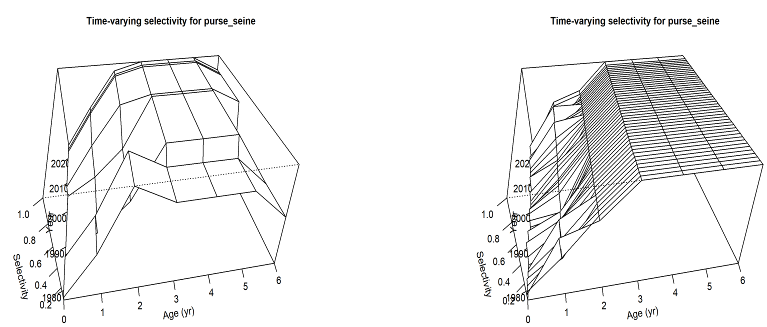


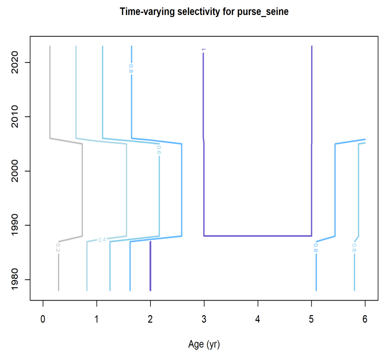
Figure 1: Data presence by year for each fleet, where circle area is relative within a data type. Circles are are scaled relative to maximum within each type, the scaling within separate plots should not be compared.



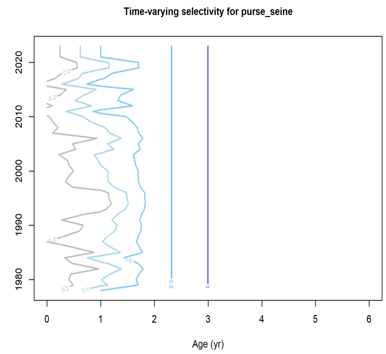
(a) Base model (b) Model 02

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).

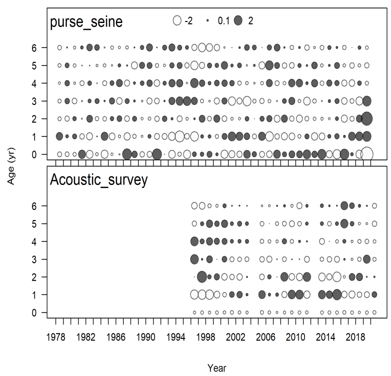
The fit to index data for the autumn/recruitment acoustic survey in the base case and in model 02 are similar, following trends of the observed index and with a poor fit for higher index value points mainly in the early period of time series (Figure 7).

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.

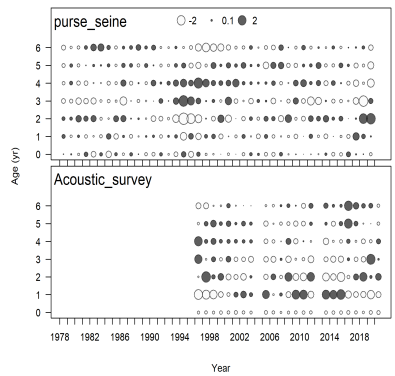
Settings for recruitment deviation were modified to accommodate for the new index series (last year of main recruitment deviations in now the interim year as opposed to the last year of catch data) and to incorporate the least squares estimate of alternative bias adjustment relationship for recruitment 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).

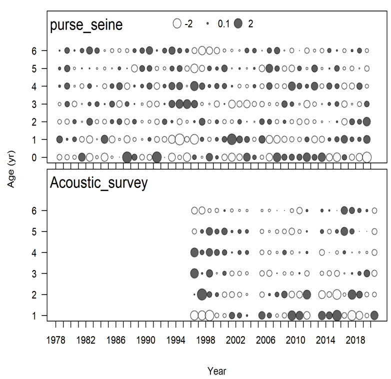
Since both models tested seems to be good models in terms of fit to data, following trends and have similar fits to the current assessment model, model



(a) Base model



(b) Model 02

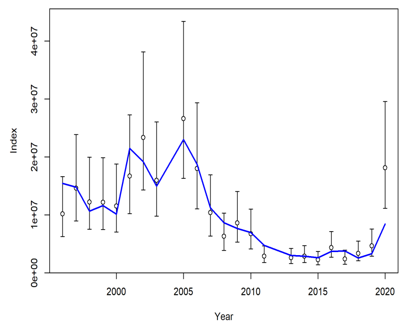


(c) Current assessment model

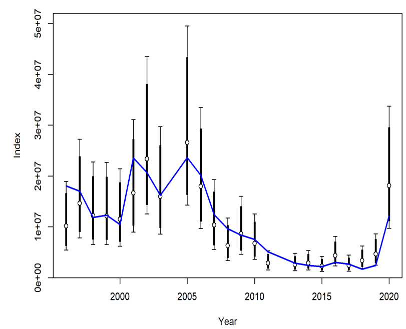
Figure 4: Pearson residuals for age composition, comparing across fleets 01 (purse seine) and fleet 02 (acoustic survey). Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

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

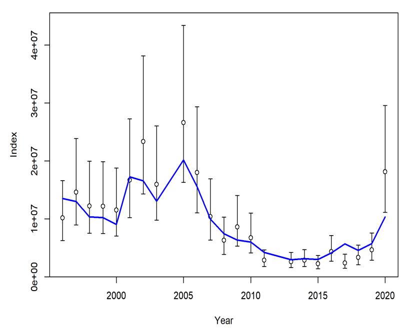
Spawning stock biomass and recruitment time-series, as estimated by the two models tested, follow the same trends as the current assessment model (Figure 22. For spawning stock biomass, we observe that the base model only diverges from the current assessment model in the most recent 8 years while model 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

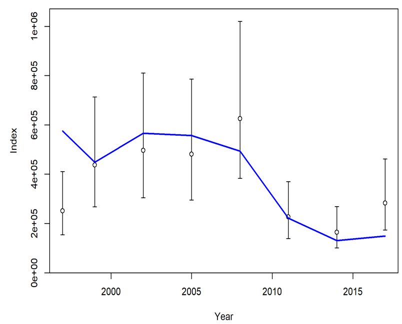


(b) Model 02

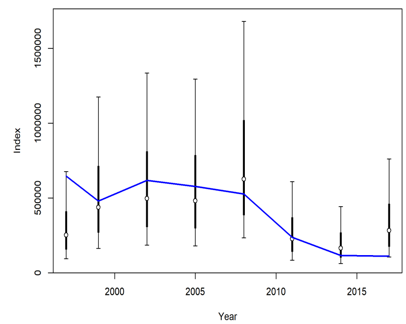


(c) Current assessment model

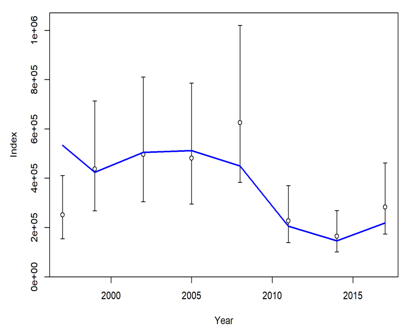
Figure 5: Fit to index data for the spring Acoustic survey. Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines (if present) indicate input uncertainty before addition of estimated additional uncertainty parameter.



(a) Base model

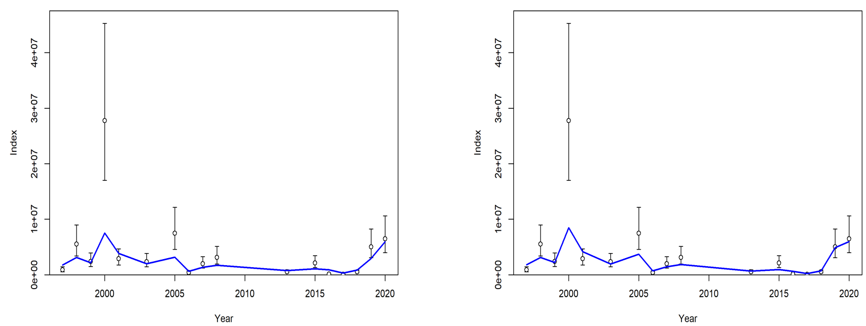


(b) Model 02



(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.

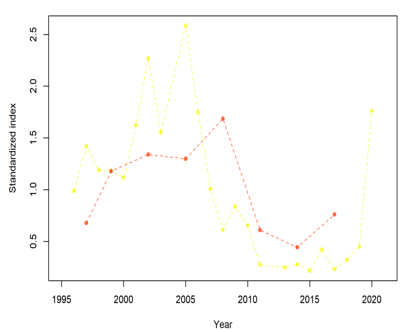


(a) Base model (b) Model 02

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.

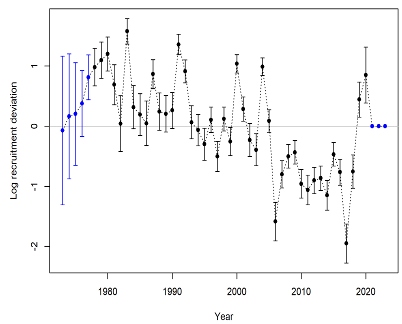
(a) Base model

(b) Model 02

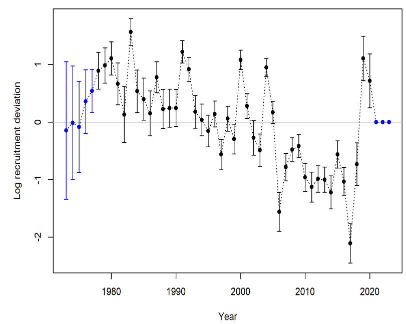


(c) Current assessment model

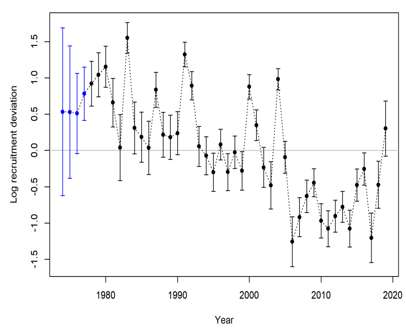
Figure 8: Standardized indices overlaid. Each index is rescaled to have mean observation = 1.0.



(a) Base model

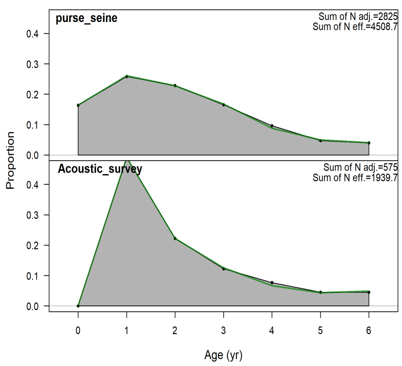


(b) Model 02

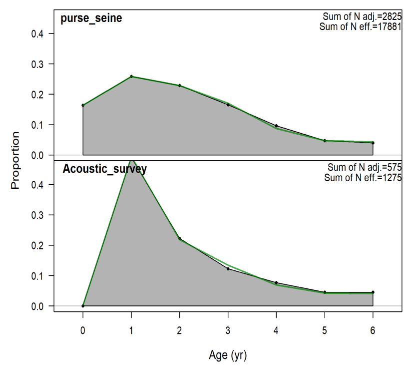


(c) Current assessment model

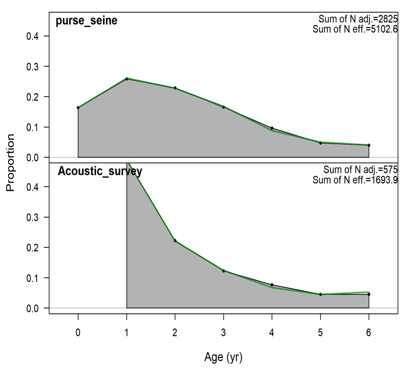
Figure 9: Recruitment deviations with 95% intervals.



(a) Base model

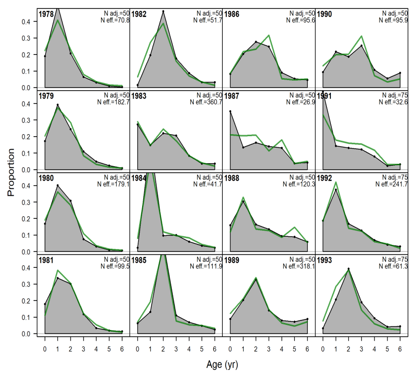


(b) Model 02

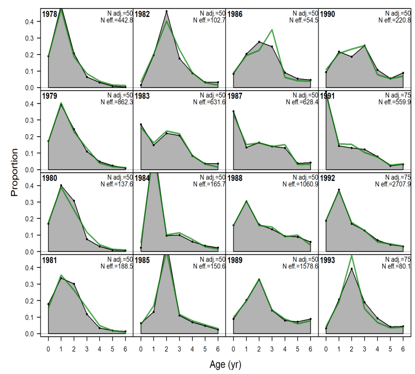


(c) Current assessment model

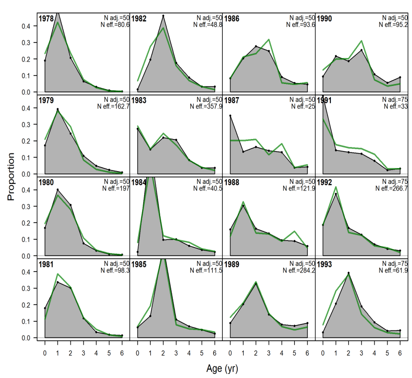
Figure 10: Age composition, aggregated across time by fleet.



(a) Base model

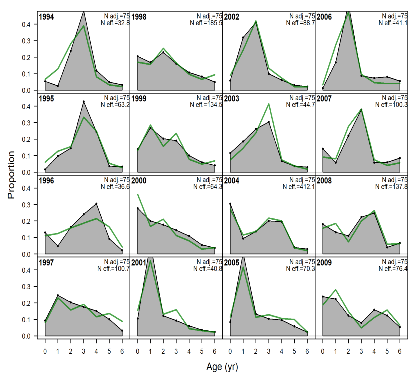


(b) Model 02

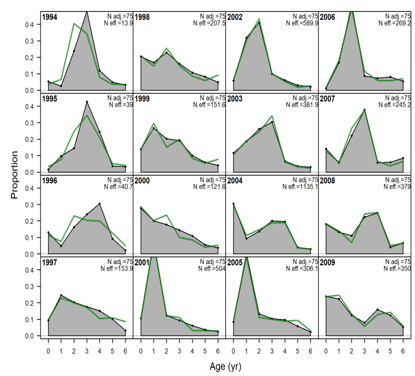


(c) Current assessment model

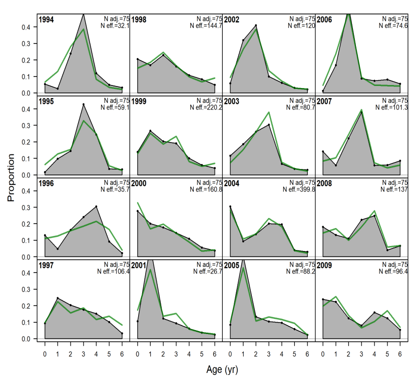
Figure 11: Age composition, whole catch, purse seine (plot 1 of 3). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

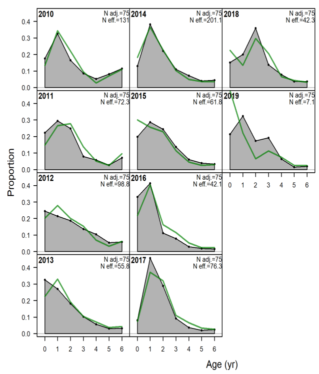


(b) Model 02

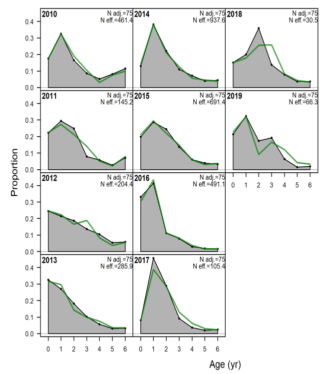


(c) Current assessment model

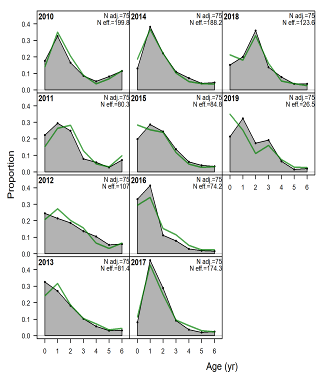
Figure 12: Age composition, whole catch, purse seine (plot 2 of 3). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

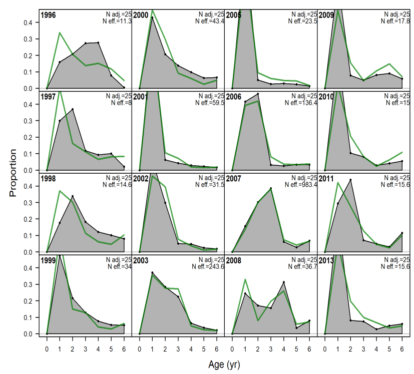


(b) Model 02

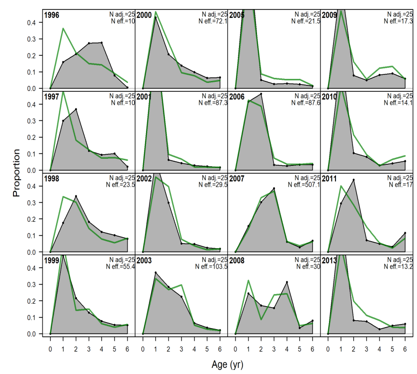


(c) Current assessment model

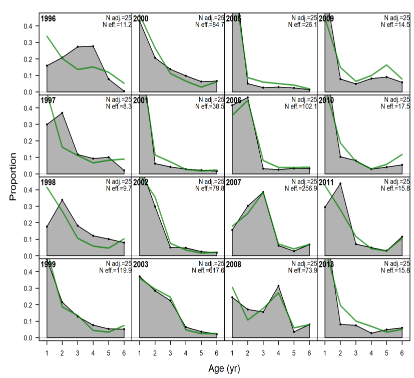
Figure 13: Age composition, whole catch, purse seine (plot 3 of 3). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

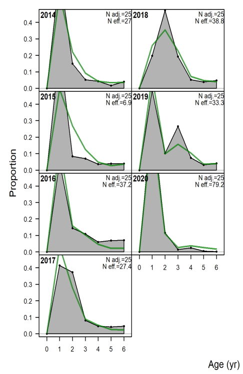


(b) Model 02

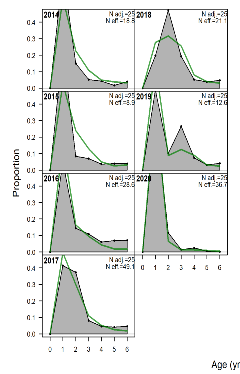


(c) Current assessment model

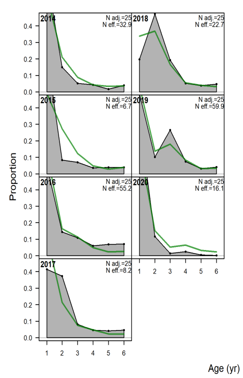
Figure 14: Age composition, whole catch, acoustic survey (plot 1 of 2). 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Iannelli tuning method.



(a) Base model

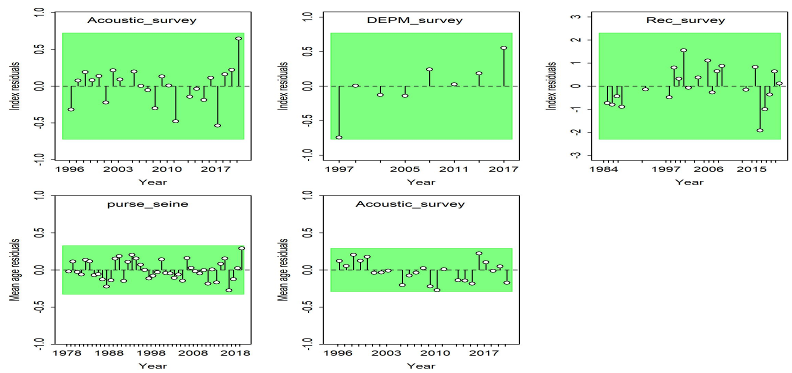


(b) Model 02

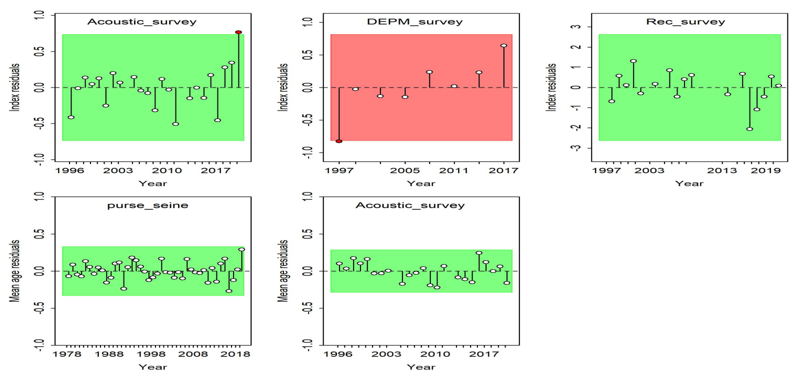


(c) Current assessment model

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.

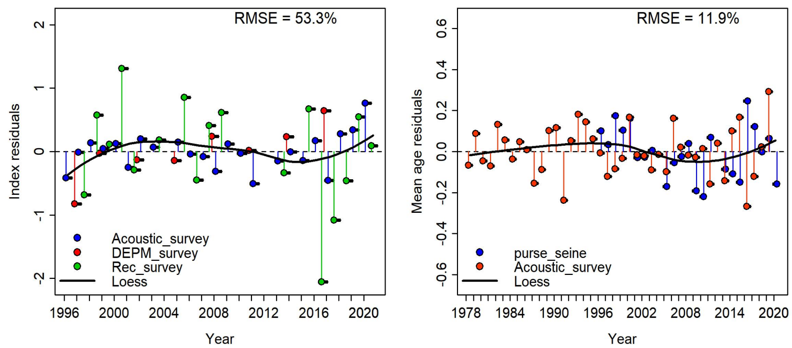


(a) Base model

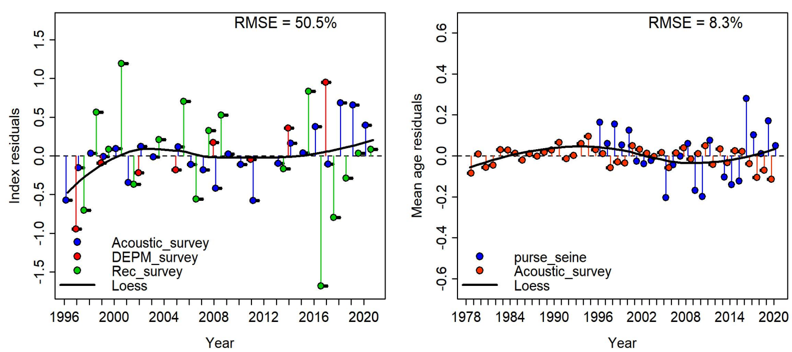


(b) Model 02

Figure 16: Runs Test residuals for mean composition data.

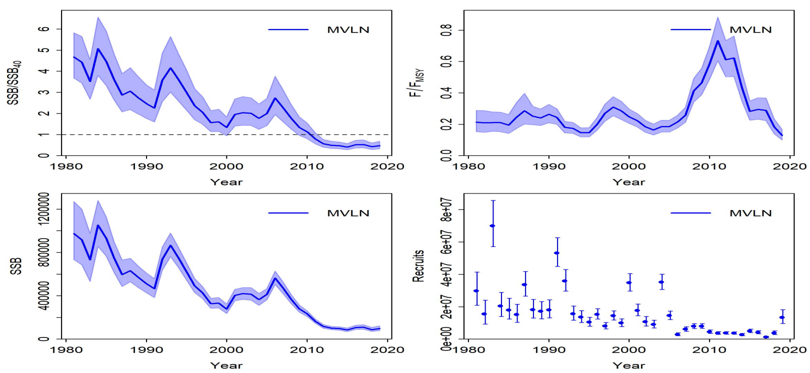


(a) Base model

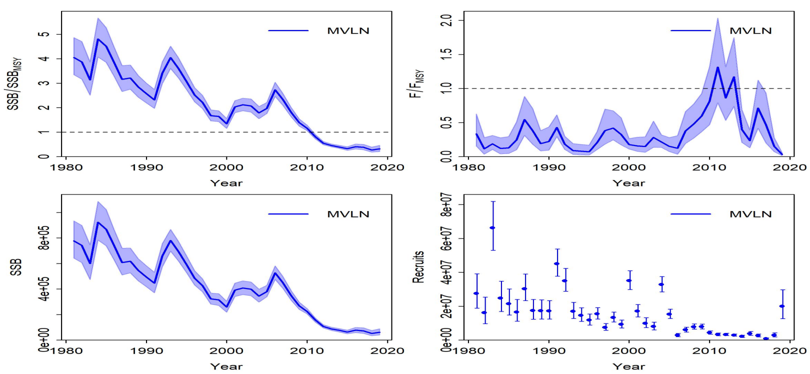


(b) Model 02

Figure 17: Joint residuals to check for conflicts.

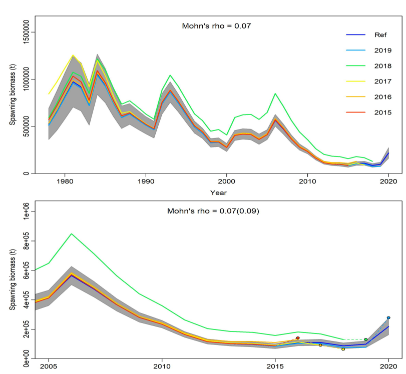


(a) Base model

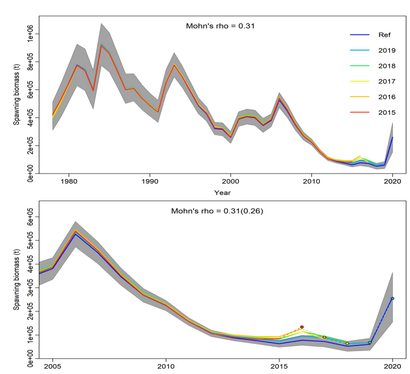


(b) Model 02

Figure 18: Approximate uncertainty with MVLN (hessian).

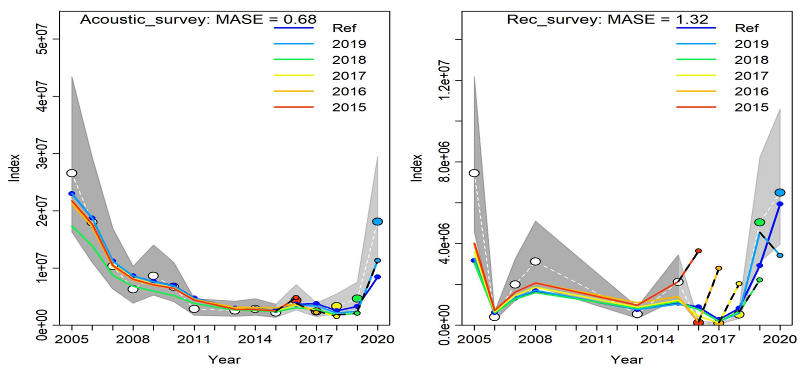


(a) Base model

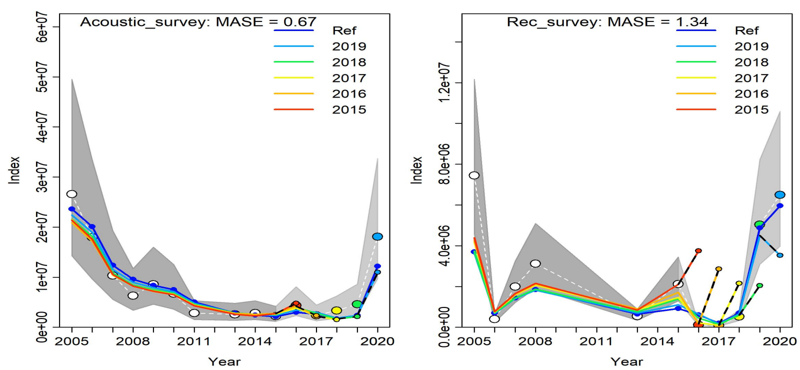


(b) Model 02

Figure 19: Retrospective Analysis with one-step ahead Forecasts

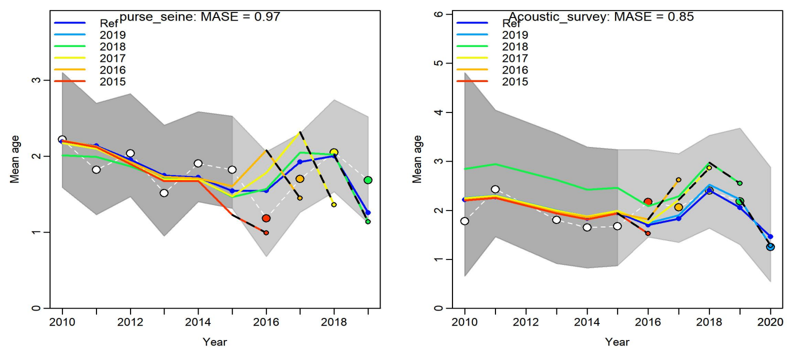


(a) Base model

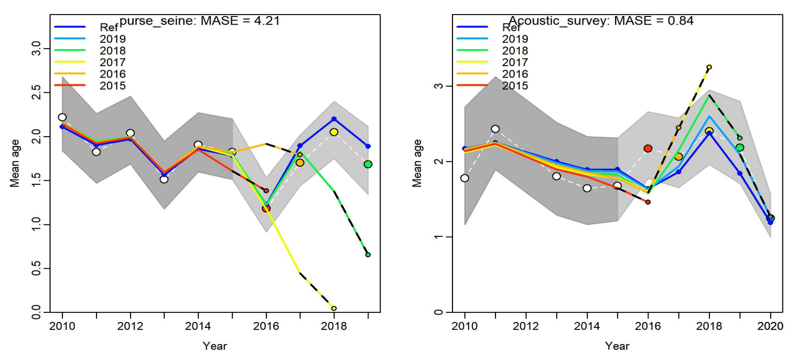


(b) Model 02

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

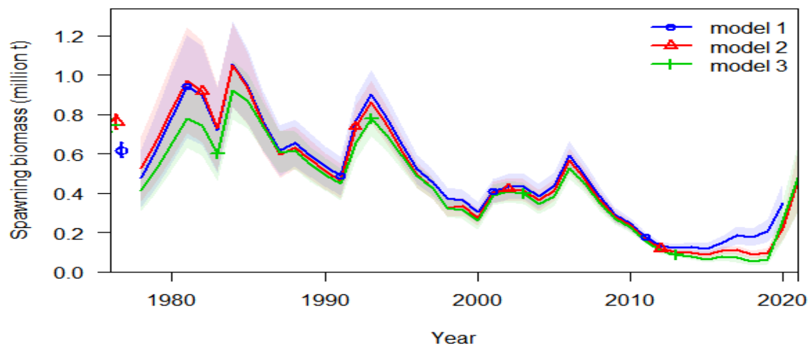


(a) Base model

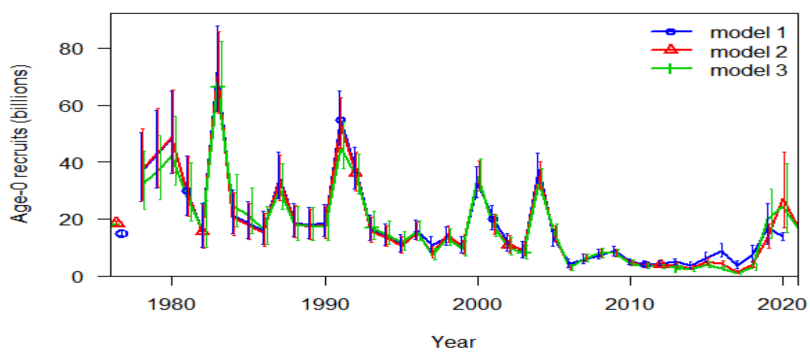


(b) Model 02

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.

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