SCRS/2017/146

EASTERN BLUEFIN TUNA STOCK ASSESSMENT USING SAM

Abdelouahed Ben Mhamed [1], Anders Nielsen [2] and Laurence Kell [3]

SUMMARY

The assessment of the Mediterranean and Atlantic bluefin tuna was always conducted using the VPA approaches. The uncertainties around the estimates of such approaches make difficult the provision of scientific advice. In this paper a state-space stock assessment model SAM is used as a new approaches to evaluate the impact of uncertainty. A comparison of the results of VPA and SAM was conducted based on the 2014 datasets and the preliminary 2017 datasets. To evaluate the robustness of SAM a range of diagnostics and scenarios was ran according the 2017 bluefin data preparatory meeting.

KEYWORDS

Stock Assessment, Bluefin Tuna, State-Space Model

1 INRH, Bd Sidi Abderrahmane 20220, Ain Diab 2, a.benmhamed@mail.com
2 DTU Aqua
3 ICCAT

1.Introduction

A new assessment of Atlantic bluefin tuna is scheduled in 2017, using both updated data and the datasets recovered and improved under the GBYP. In the previous bluefin stock assessment conducted in 2014, projections and advice were based on Virtual Population Analysis. Uncertainties in both data and the methodology, however, prevented the delivery of clear advice. In this study we use a State Space assessment model (SAM) to better evaluate the impact of uncertainty. SAM allows processes such as selectivity to evolve gradually over time, has fewer parameters than full parametric statistical assessment models, seperates process and measurement error, quantities such as recruitment and fishing mortality are modelled as random effects, and the projection procedure is an integral part of the assessment.

SAM also has a web based interface which helps to ensure traceability (http://stockassessment.org) and allow members of the assessment working group to be involved in intersession work, i.e. to see all details of the implementation, run it, experiment with data, change model assumptions and get help. SAM is also in the ICCAT software catalogue.

SAM is first applied to the East Atlantic and Mediterranean bluefin stock using the 2014 VPA datasets. This allows uncertainty in the estimates provided by VPA and SAM to be compared, and the relative impact of the various sources of uncertainty evaluated using a range of diagnostics. SAM is then applied using the preliminary datasets available for the 2017 stock assessment for a range of scenarios, and diagnostics are presented, based on the the 2017 bluefin data preparatory meeting. Two scenarios of decreasing and increasing the natural moratlity for ages 4+ by 0.05 based on Lorenzen are presented.

To evaluate prediction skill we use hindcasting, i.e. we fit the model is fitted to the first part of the time series and then projected over the period omitted in the original fit. Prediction skill is then be evaluated by comparing the predictions from the projection with the observations.

2.Material and methods

The data used are the VPA inputs from the 2014 assessment and the updated data available to the Bluefin working group on the 22nd May.

2.1.Scenarios

In total five scenarios were run for SAM i.e. 2014 VPA: two datasets with catch-at-age corresponding to the reported and inflated catches. 2017 VPA: three datasets corresponding to i) revised reported catch-at-age, ii) reported catch with increasing natural mortality for ages 4+ by 0.05 and iii) reported catch with decreasing natural mortality for ages 4+ by 0.05.

2.2.Fleet structure

Fourteen fleets for the East and West fisheries were identified for use in the Management Strategy Evaluation. It was agreed that they should be used by analysts when beginning their analyses and adjusted as needed. These are

1) Japanese longline
2) Other longlines
3) Baitboat before 2009
4) Baitboats from 2009 onwards
5) Purse Seine (PS) Mediterranean from 2009 onwards
6) PS Mediterranean Large fish before 2009 (Season2),
7) PS Mediterranean Small fish before 2009 (Seasons 1,3,4),
8) PS Western before 1987
9) PS Western from 1987 onwards
10) Traps before 2009
11) Traps from 2009 onwards
12) Rod and reel Canada,
13) Rod and Reel US (only use comp data from 1988 on due to missing data from some fleets prior to this year).
14) All other fleets

Several fleets were split at 2009 due to the impacts of Recommendation 08-05 that affected fleet operations. It was also agreed at the data preparatory meeting that depending upon the model and how it incorporates indices, that following examination of model diagnostics the fleet structure may require some adjustment from this initial proposal.

The CPUE series used in 2014 are shown in **Figure 1** and those in 2017 in **Figure 2**.

2.3.Methods

The software used is SAM version avilable from the ICCAT Software Catalogue. This includes the modified likelihood that is equivalent to that used by VPA-2box to fit to the CPUE indices.

The characteristics of the different assessment approaches were agreed at the data preparatory meeting. The Group reviewed SCRS/2017/036 to select characteristics the assessment approaches should have, initial fleet structure to be tested, and sensitivity runs to be made. Several characteristics considered essential for base case candidates were agreed, this included tasks related to choice of scenarios, summary outputs and diagnostics.

The basic state-space assessment model (SAM) is described in Nielsen & Berg (2014). The model has been continuously developed and adapted for different stocks. The current implementation (https://github.com/fishfollower/SAM) is an R-package based on Template Model Builder (TMB) (Kristensen et al. 2016).

SAM is a state-space model. The states are the log-transformed stock sizes and fishing mortalities at age. These states are considered to be time-varying unobserved random processes. The observations are log-transformed catches at age and indices of catch per unit effort per age or biomasses. The log-transformed observations are assumed to be normally distributed (possibly correlated). All model parameters (catchabilities and process and observation variances) are maximum likelihood estimated.

The state-space formulation can define flexible models with relative few model parameters, because the time varying part is formulated via the unobserved random processes. The key difference compared to deterministic models or more standard fully parametric statistical assessment models is that state-space assessment models are directly estimating the prediction mechanism, and as such they are able to make predictions for future observations without additional assumptions.

2.4.Assessment scenarios

The following sensitivity analyses were agreed by the data preparatory meeting.

- Change the natural mortality rate, +/- 0.05 for ages 4+, based on Lorenzen.
- Evaluate the influence of each index by e.g. removing them from the assessment one at a time removal
- The Group considered the “Inflated catch” for the East Atlantic and Mediterranean as the best SCRS estimate. These catches should be used in the assessment for Eastern Atlantic and Mediterranean and for mixing. The reported catch can be included as a sensitivity case. A further sensitivity case where the SCRS best estimates of the undeclared catches is increased by an arbitrary 25% is considered optional.
- For the VPA approaches, the effects of different age composition created using various forms of age-slicing or ALKs should be evaluated. These data are not yet available and so this scenario was not run.
- Optionally, test for time varying selectivity/catchability.

2.5.Diagnostics

A range of diagnostics procedures were agreed at the data preparatory meeting, these included, residual plots, restrospective analyses, hindcasting, jackknifing and the bootstrap.

It was also agreed that steps taken to ensure convergence to global best solution, e.g., jitter starting values- test that different starting values achieve same minimum negative log-likelihood, should be reported, and likelihood profiling of key estimated parameters should be conducted. In some cases the Hessian standard errors may be a sufficient diagnostic but it does not diagnose data conflicts and model mis-specification (Lee et al 2014). In addition parameters should be reported with standard errors.

2.6.Residual plots

Residuals plots are presented for the 2014 scenarios for the CPUEs in **Figures 3**, and for the 2017 scenarios in **Figure 4**. The plots shows a good mixing for almost all the fleets for both years.

2.7.Catch composition data

The selection patterns are presented in **Figure 6**. SAM also allows error in the catch-at-age and the residuals for the 2014 scenarios are presented in **Figure 5** and for 2017 in **Figure 8**.

2.8.Retrospective analyses

Figures 9, **10**, **11**, **12** & **13** show the retrospective analysis for the five scenarios corresponding to the 2014 reported and inflated datasets, the 2017 reported dataset and the 2017 reported dataset with increasing and decreasing natural mortality for ages 4+ by 0.05 based on Lorenzen.

3.Results

The results presented are those based on the analysis conducted for the 2014 and preliminary 2017 datasets. These can also be found on stockassessment.org, which will be updated as new data become available and new scenarios are proposed.

Figure 15 compares the results from SAM and VPA for the 2014 dataset and the two catch scenarios. These show time series of SSB, recruits, proportion mature, numbers in the plus group (10+), the relative biomass in the plus group, Fbar, Fapex, harvest rate, the apex age (age at which the highest F occurs) and the ratio between the F in the last true age and the plus group. The confidence intervals around the estimates based SAM are more uncertain compared to the VPA results. **Figure 16** shows the same results for the recent period 2010-2013.

The 2014 scenarios were then modified to include the new catch-at-age and CPUE indices, **Figures 4**, **5** and **7** show the time series and numbers and selection patterns-at-age for the 2017 datasets.

3.1.Diagnostics

Figure 18 shows the observed indices of abundance plotted against the fitted. **Figure 19** shows the standardized residuals by fleet, year and scenario. **Figure 20** shows the quantile-quantile normality plot.

4.Discussion

The comparison between the two models using the different scenarios shows that SAM tend to have large confidence intervals compared to the VPA2. The comparison shows also that VPA tend to detect an increasing pattern in the recent years based on the 2014 dataset. The study shows that the State-Space Model SAM is a powerfull tool that can detect the uncertainties in the assessment datasets. The presentation of the existing uncertainties make the provision of scientific advice to be more cautious.

5.References

H.H. Lee, K.R. Piner, R.D. Methot, M.N. MaunderUse of likelihood profiling over a global scaling parameter to structure the population dynamics model: an example using blue marlin in the Pacific Ocean Fish. Res., 158 (2014), pp. 138-146

Kell, Laurence T., Ai Kimoto, and Toshihide Kitakado. "Evaluation of the prediction skill of stock assessment using hindcasting." Fisheries Research 183 (2016): 119-127.

Kristensen, K., Nielsen, A., Berg, C.W. , Skaug, H., Bell, B.M., 2016. TMB: Automatic Differentiation and Laplace Approximation. Journal of Statistical Software, doi: 10.18637/jss.v070.i05

Nielsen, A., Berg, C.W., 2014. Estimation of time-varying selectivity in stock assessment using state-space models. Fisheries Research. http://dx.doi.org/10.1016/j.fishres.2014.01.014

Appendix

The links to the studied datasets:
https://www.stockassessment.org/datadisk/stockassessment/userdirs/user229/
sam-tmb-ebft-2014-01 : 2014 reported catch
sam-tmb-ebft-2014-02 : 2014 inflated catch
sam-tmb-ebft-2017-01 : 2017 reported catch
sam-tmb-ebft-2017-01-SC1 : 2017 reported catch with increasing natural mortality for ages 4+ by 0.05
sam-tmb-ebft-2017-01-SC2 : 2017 reported catch with decreasing natural mortality for ages 4+ by 0.05

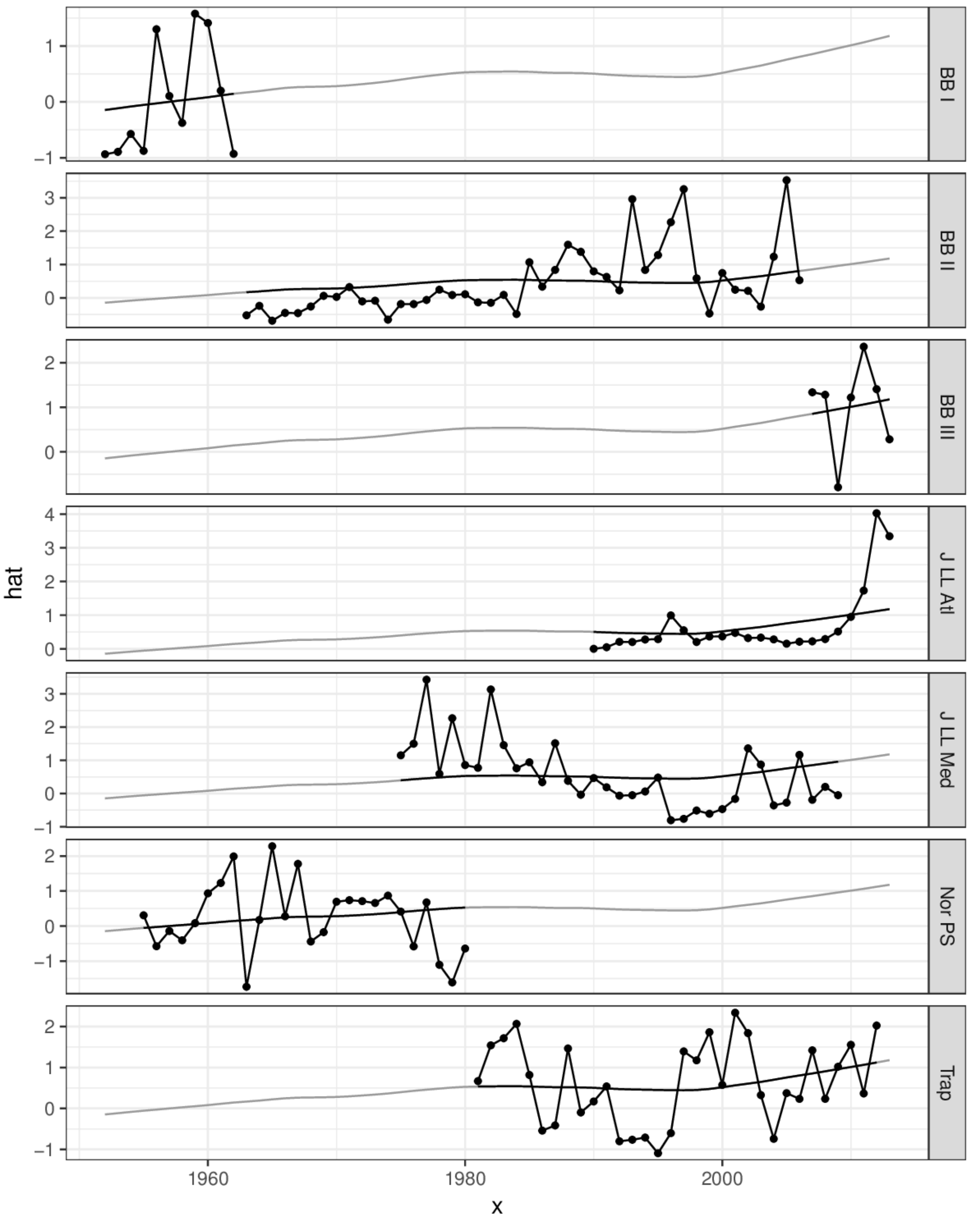

Figure 1: Time series of CPUE indices used in 2014, continuous black line is a lowess smother showing theaverage trend by area (i.e. fitted to year for each area with series as a factor).

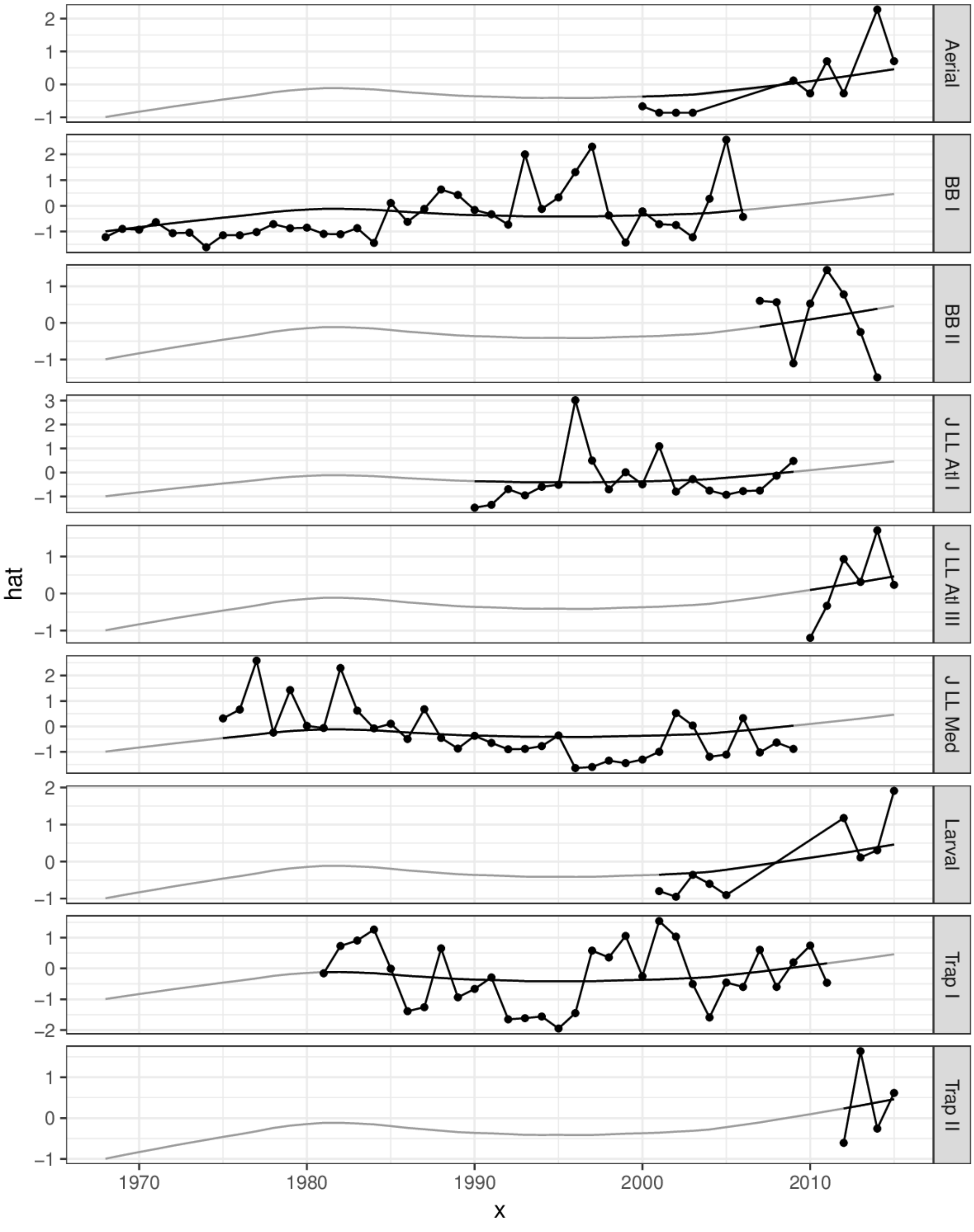

Figure 2: Time series of CPUE indices used in 2017, continuous black line is a lowess smother showing theaverage trend by area (i.e. fitted to year for each area with series as a factor).

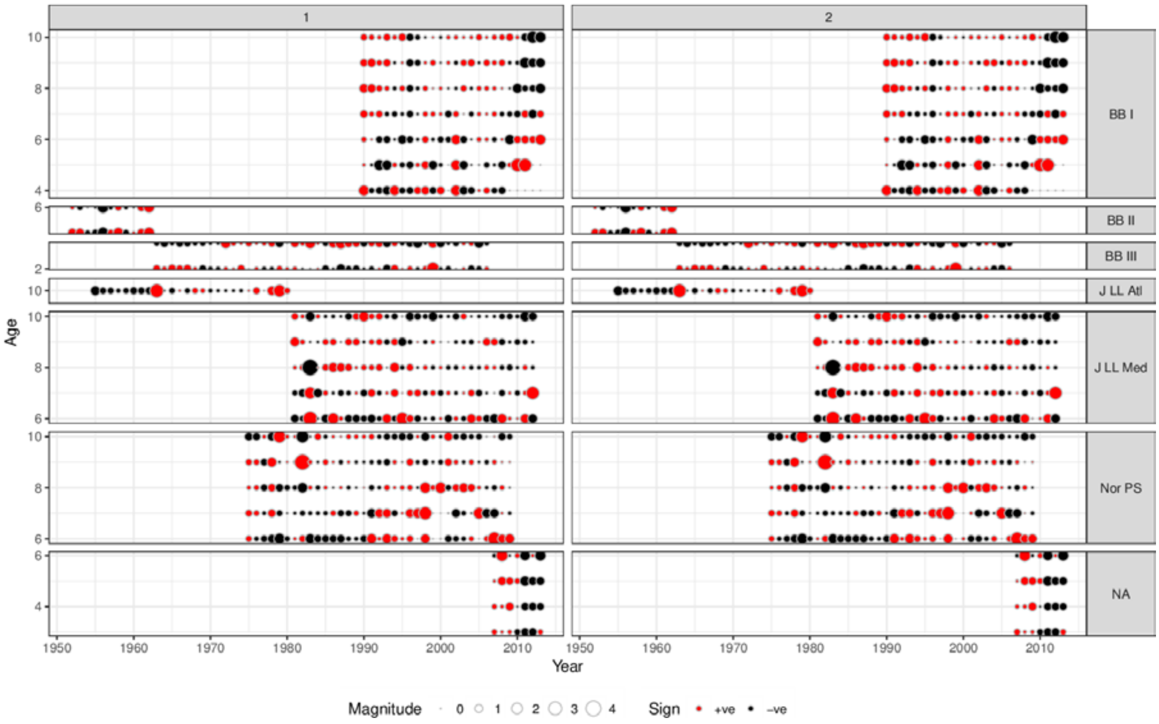

Figure 2: Residuals for CPUE, 2014 assessment.

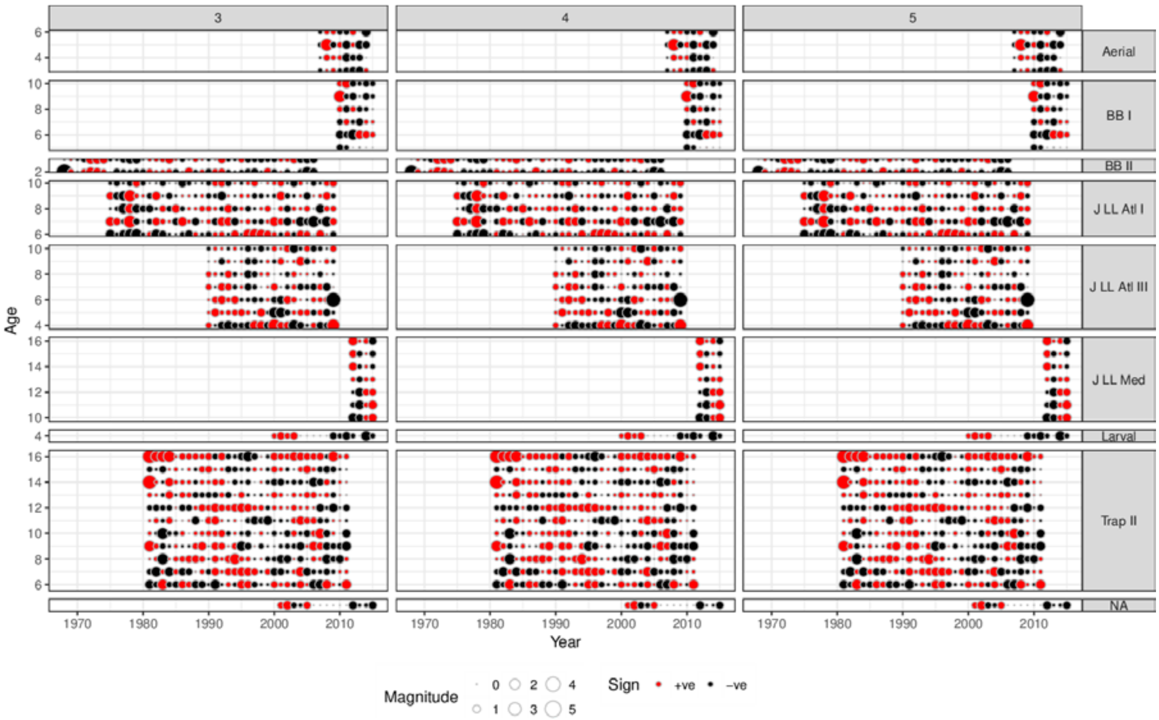

Figure 4: Residuals for CPUE, 2017 assessment.

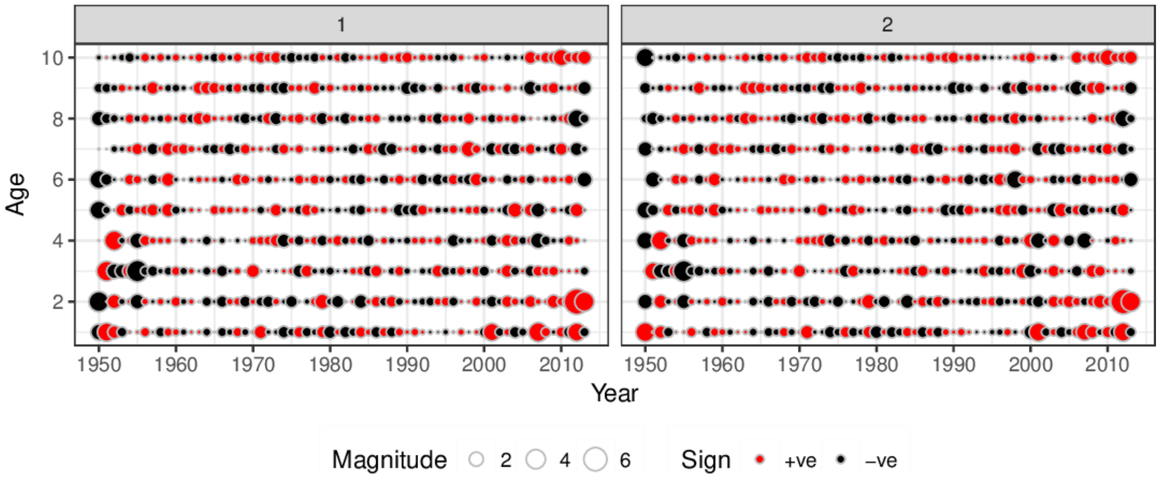

Figure 5: Residuals for Catch, 2014 assessment.

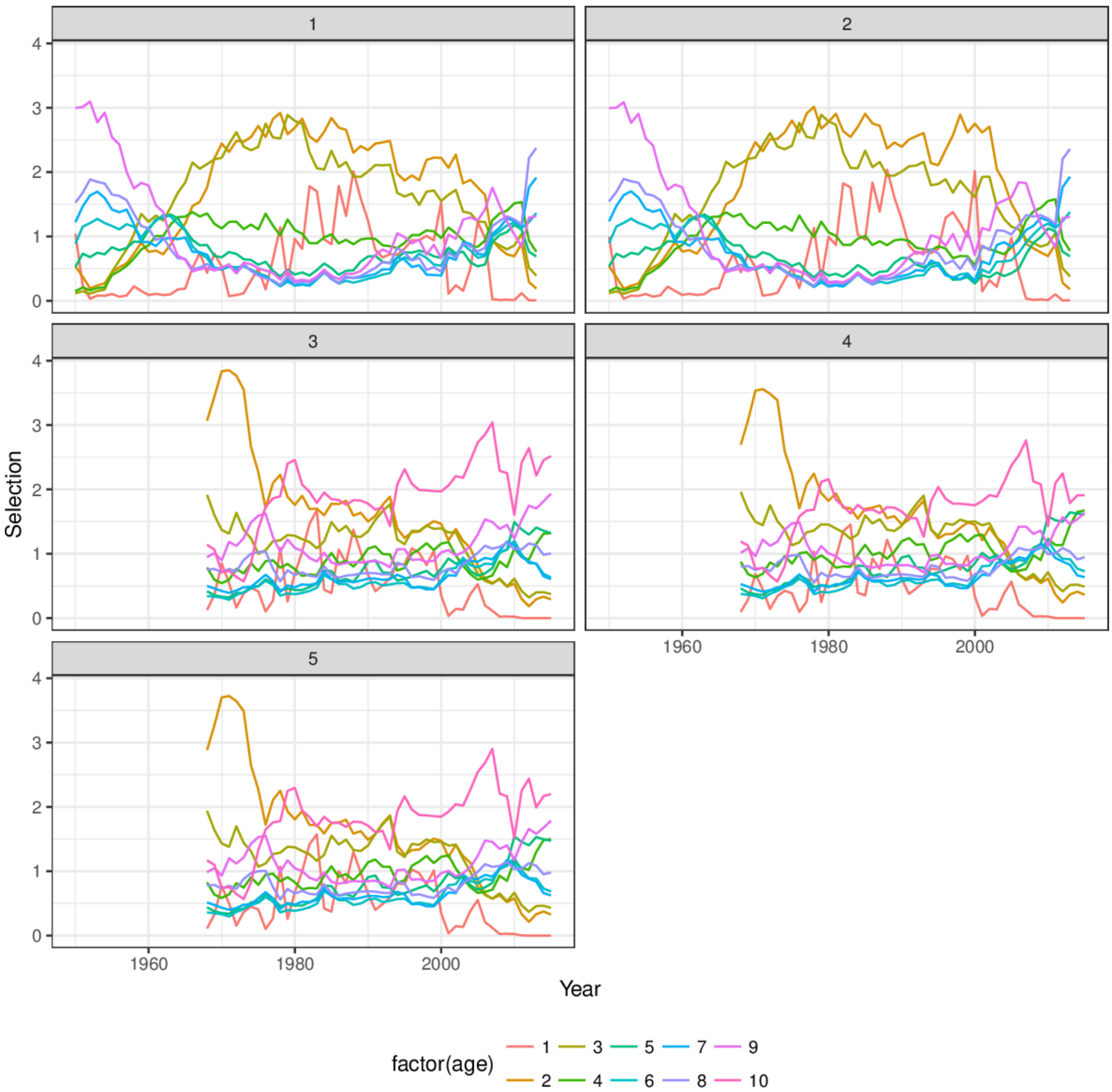

Figure 6: Selectivity over time and catch residuals.

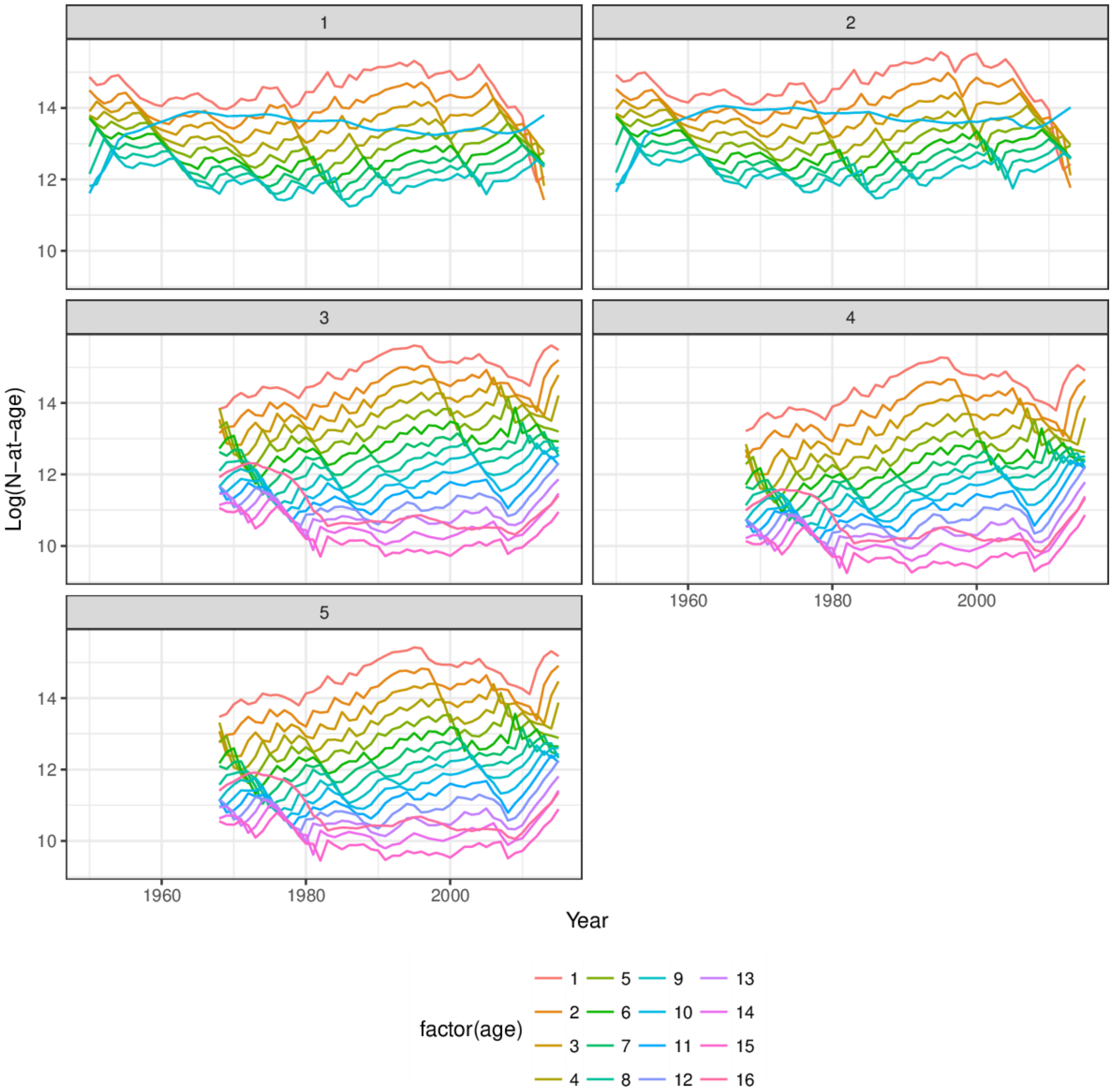

Figure 3: Numbers-at-age by Scenario.

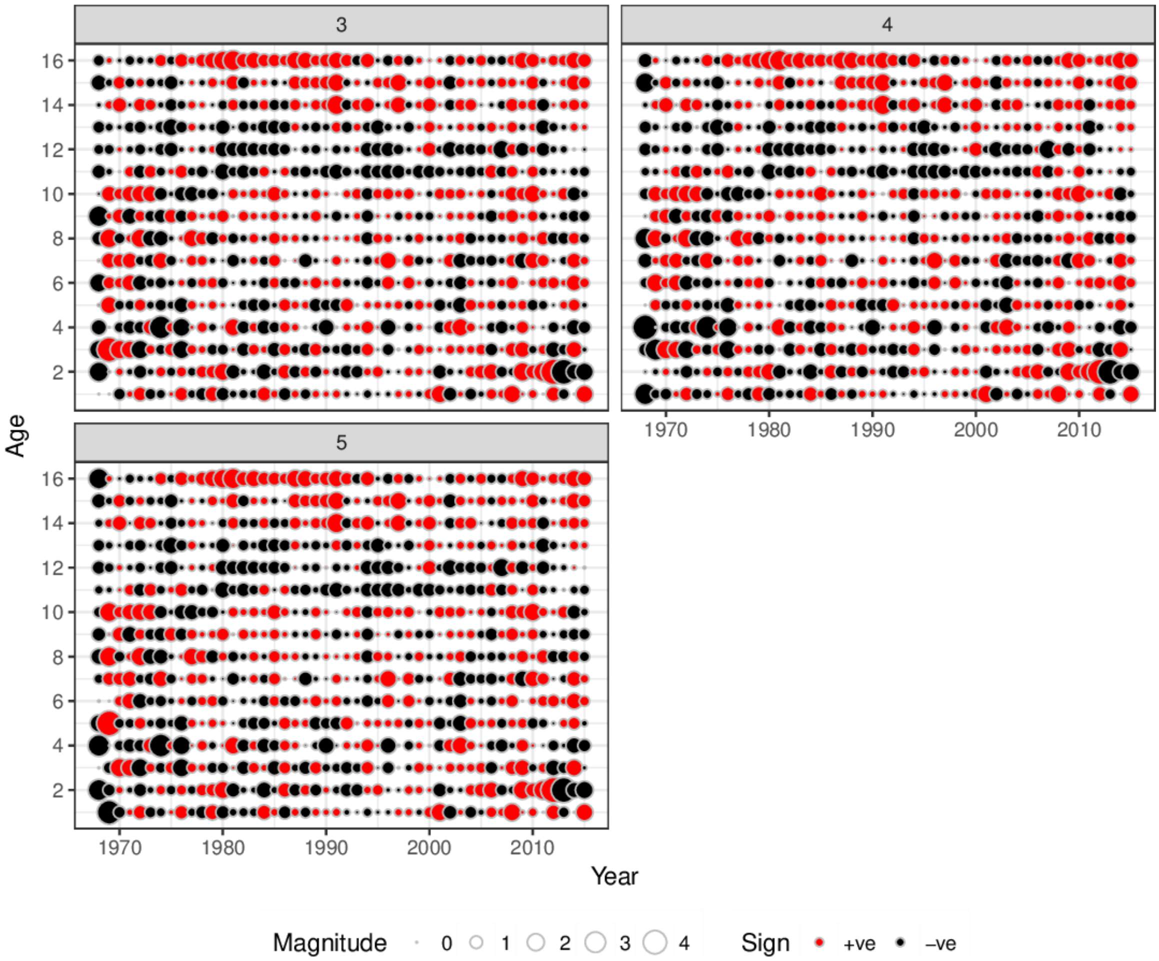

Figure 8: Residuals for Catch, 2017 assessment.

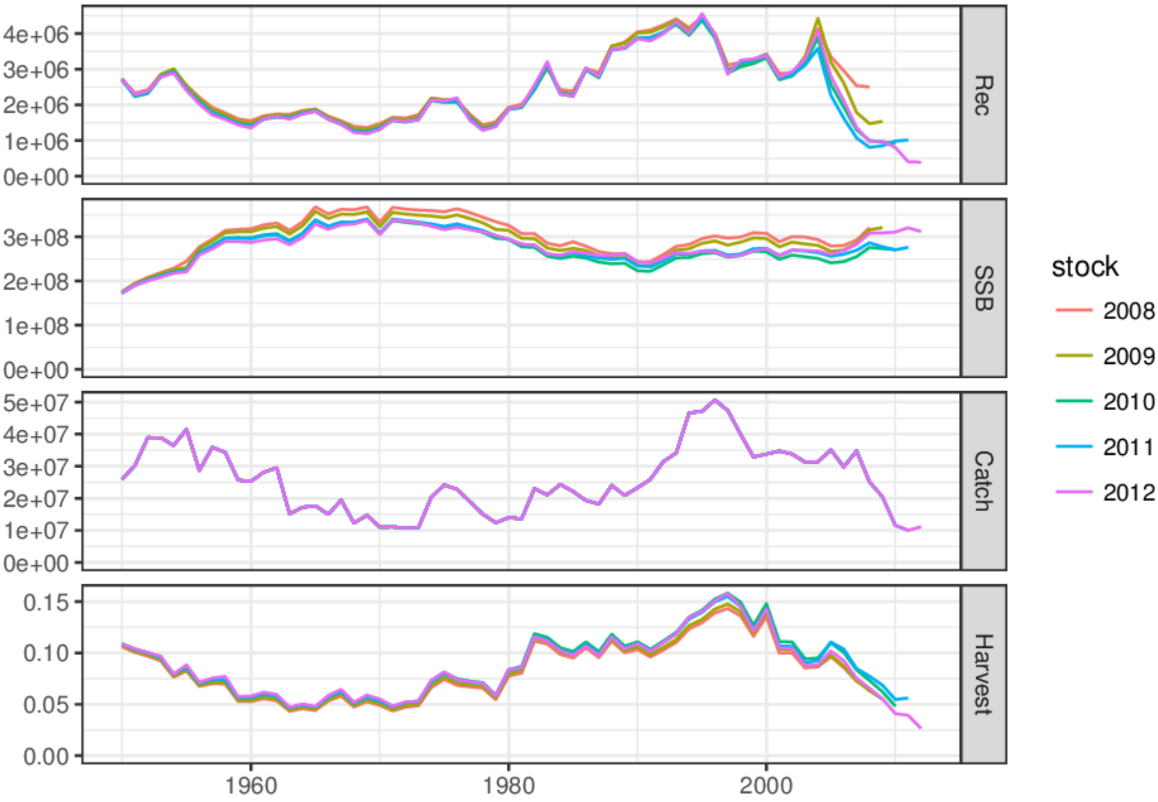

Figure 4: Retrospective analyses for scenario 1.

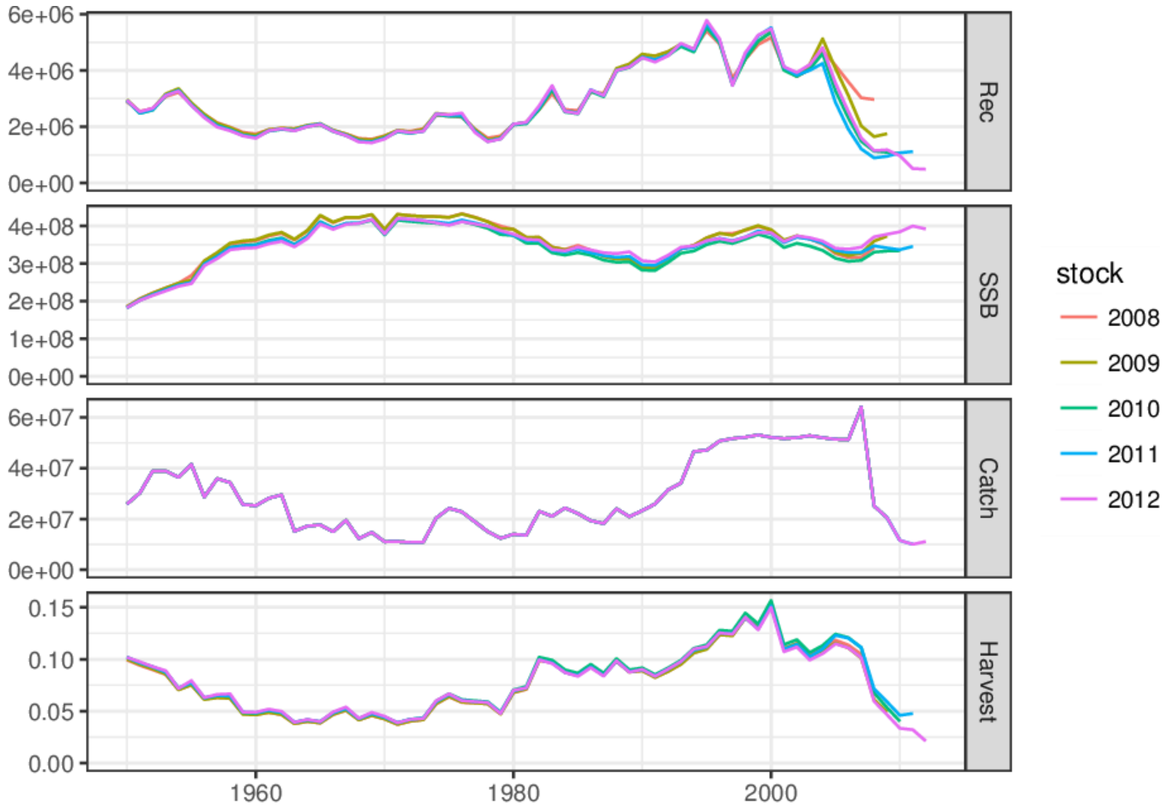

Figure 5: Retrospective analyses for scenario 2.

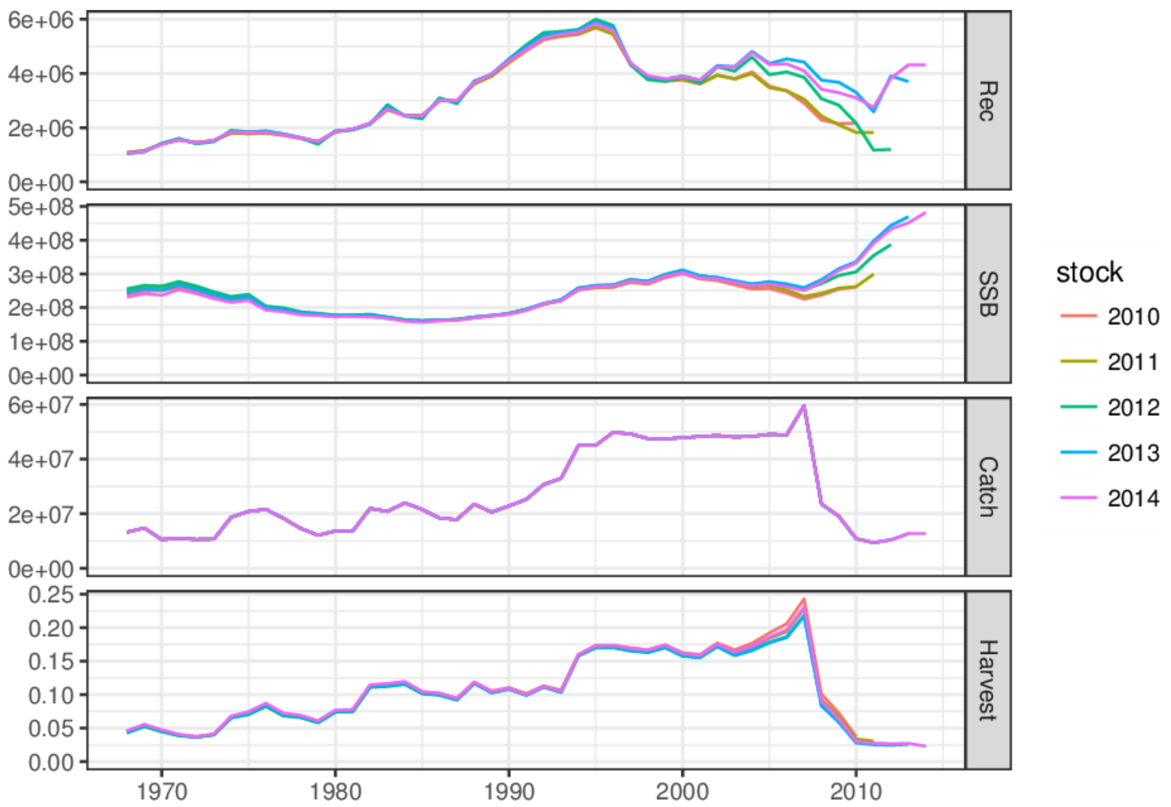

Figure 6: Retrospective analyses for scenario 3.

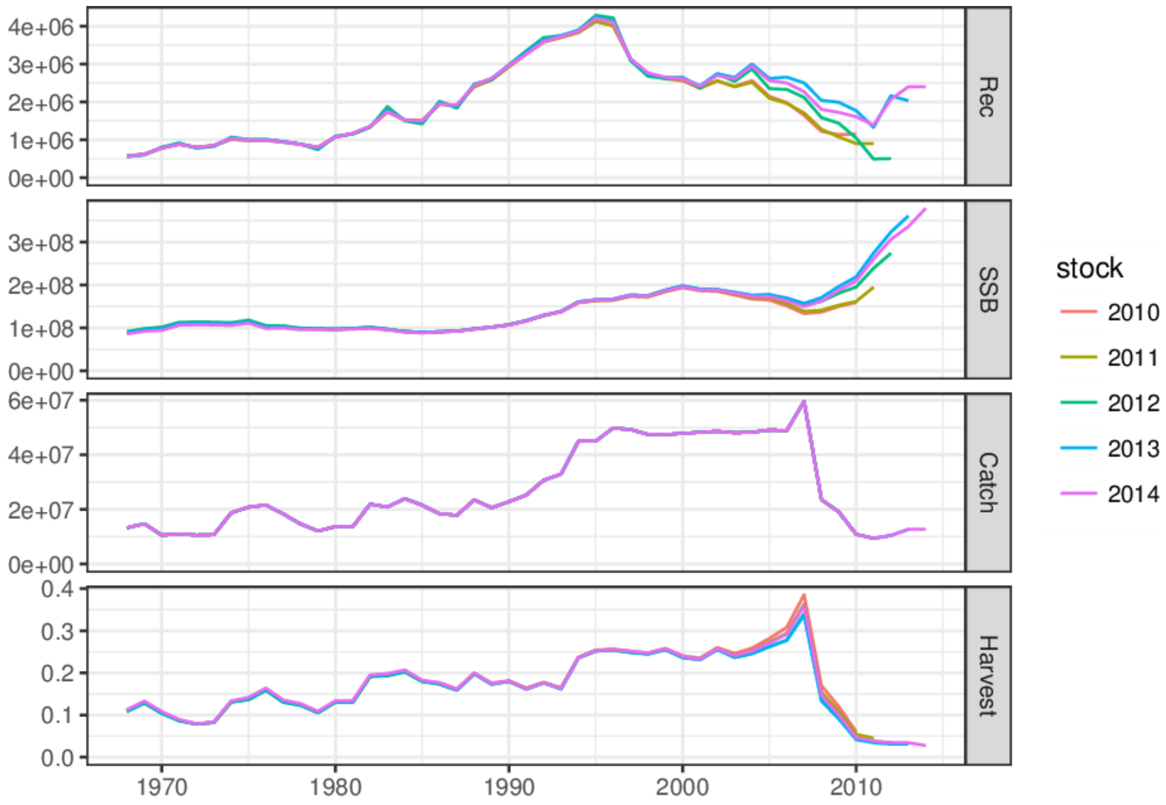

Figure 7: Retrospective analyses for scenario 4.

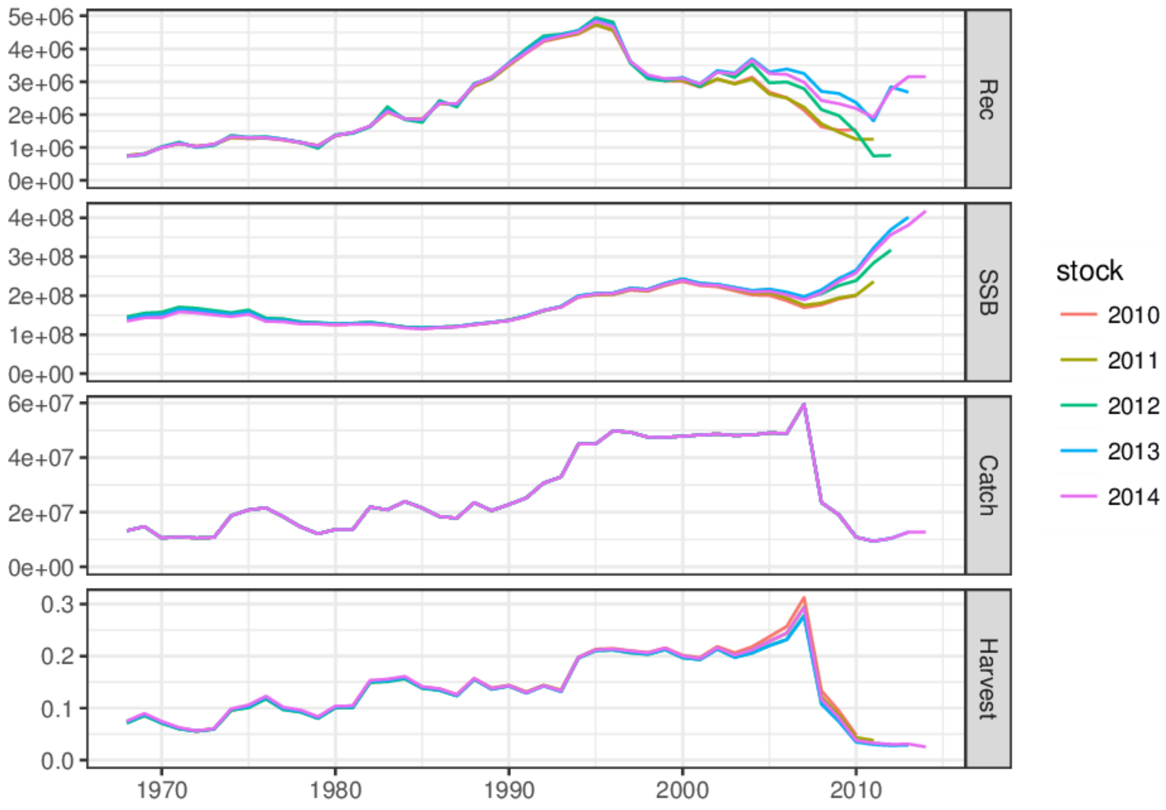

Figure 8: Retrospective analyses for scenario 5.

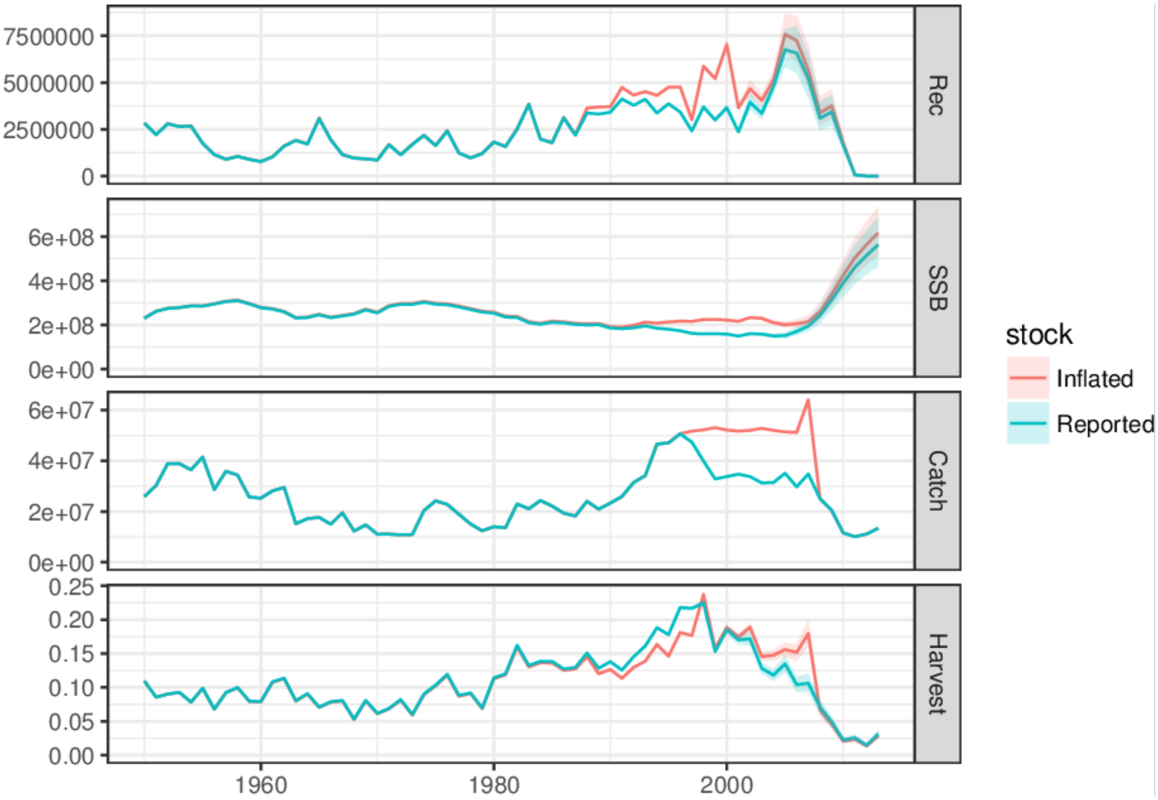

Figure 9: Comparison of time series from 2014 VPA.

Figure 10: Comparison of 2014 VPA runs with SAM equivalents.

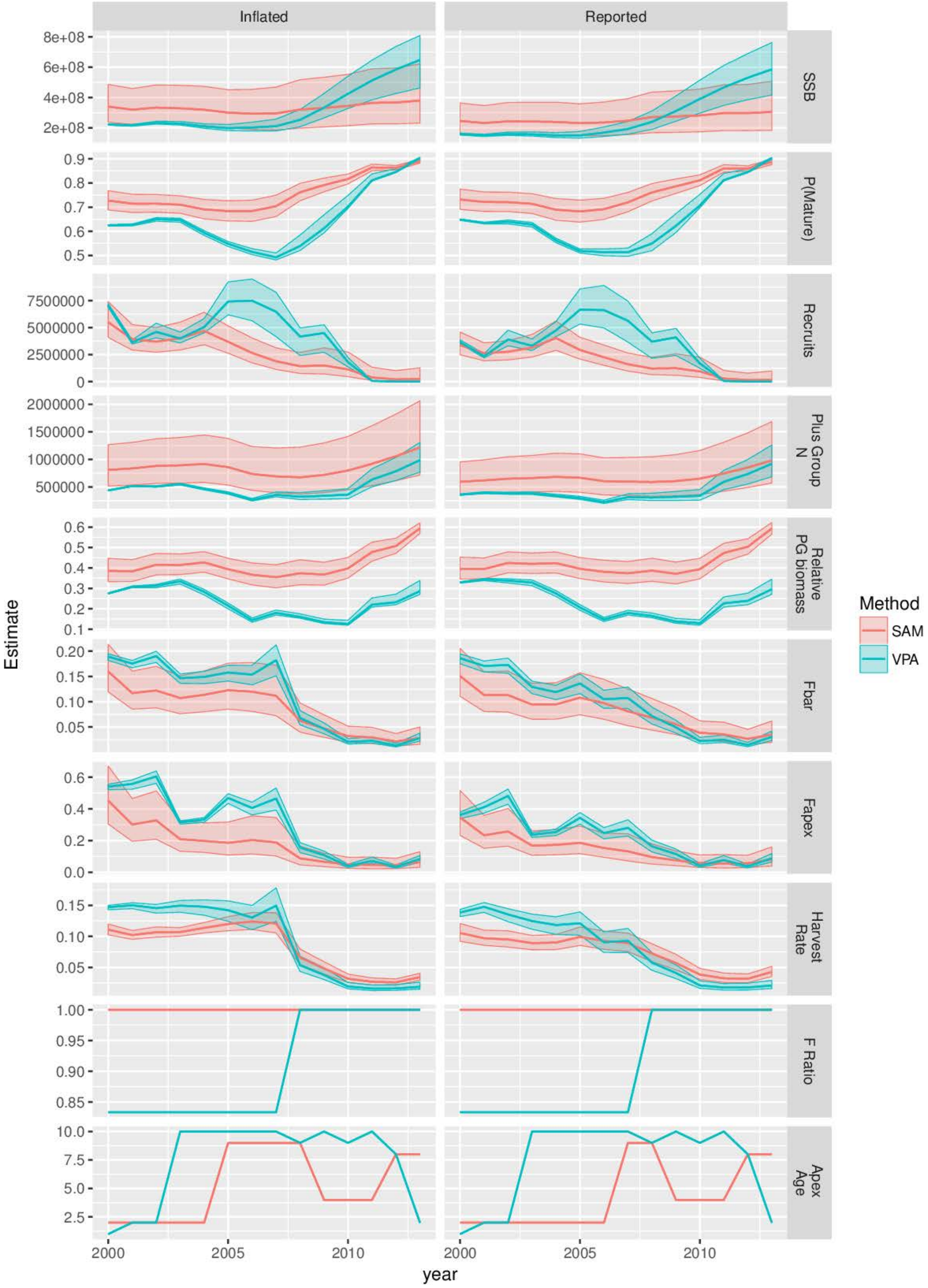

Figure 11: Comparison of 2014 VPA runs with SAM equivalents, recent period only.

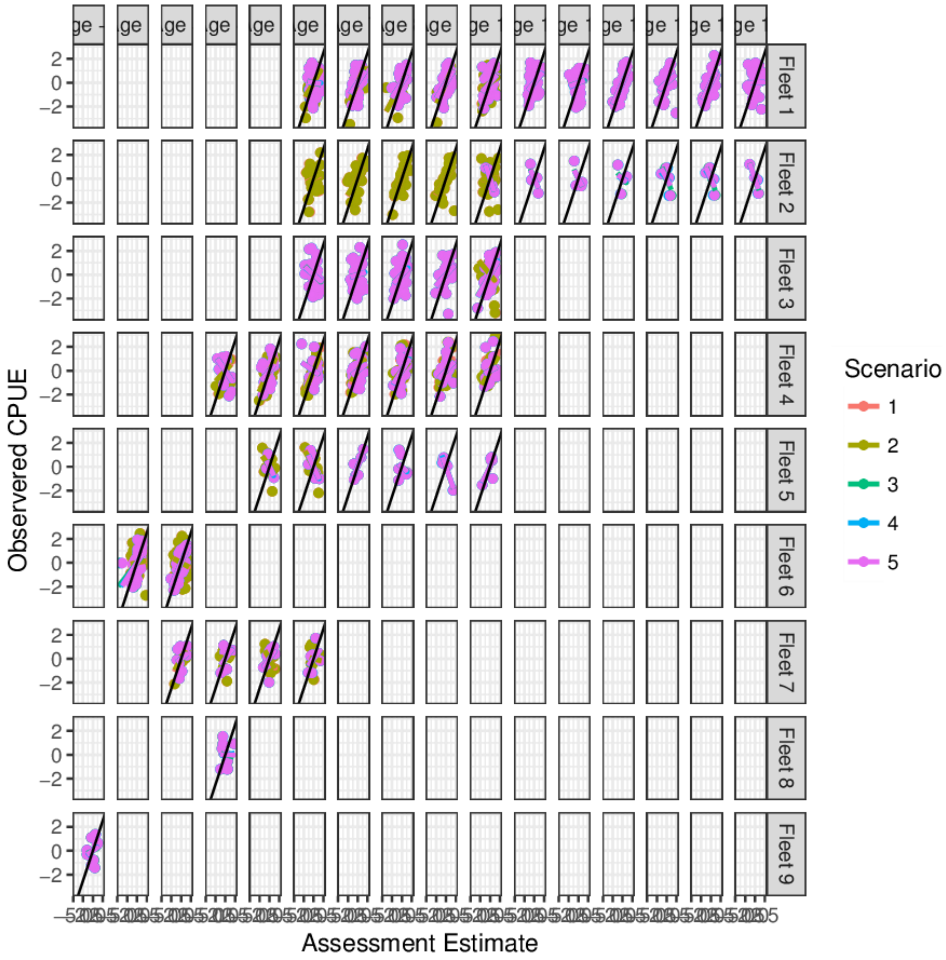

Figure 12: Observed against fitted CPUE points.

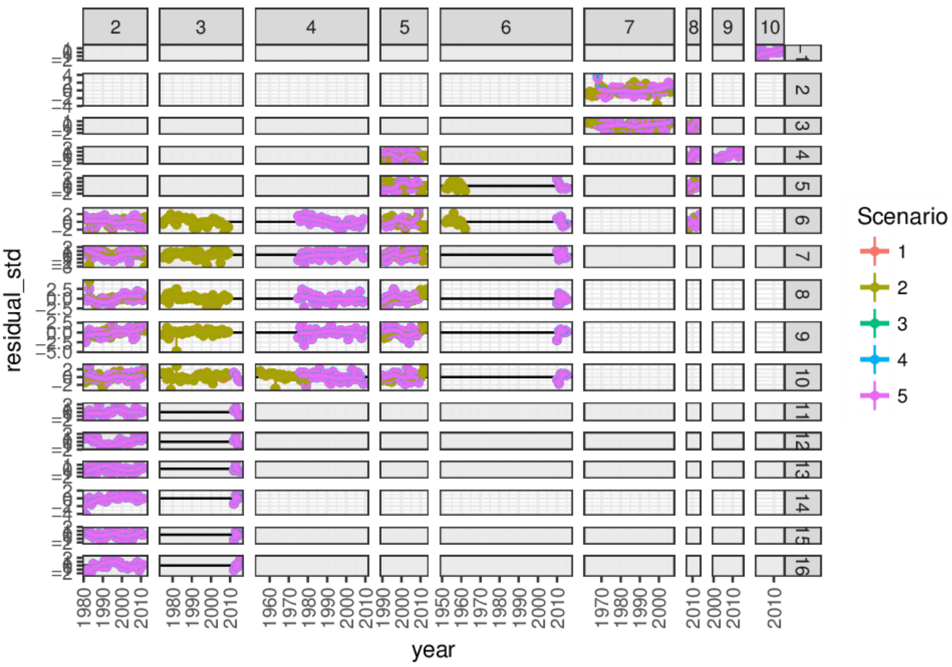

Figure 13: Standardised residuals by year.

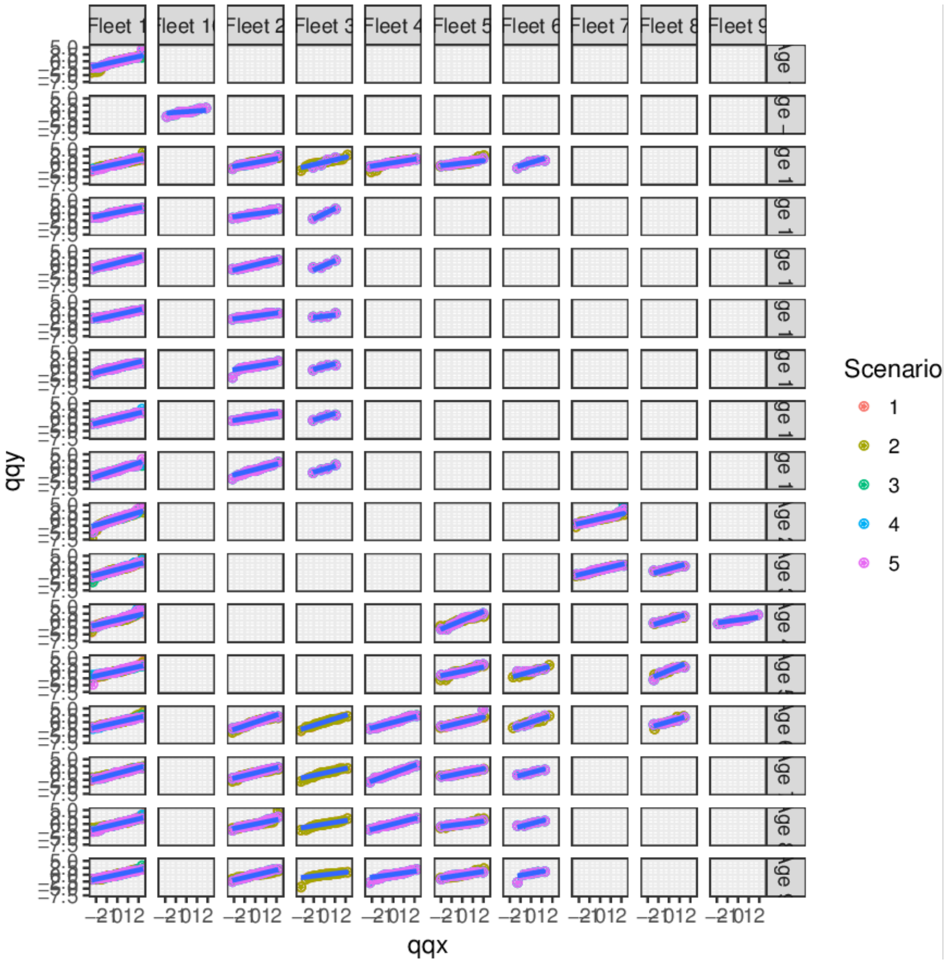

Figure 14: Quantile-quantile plot to check for normality.

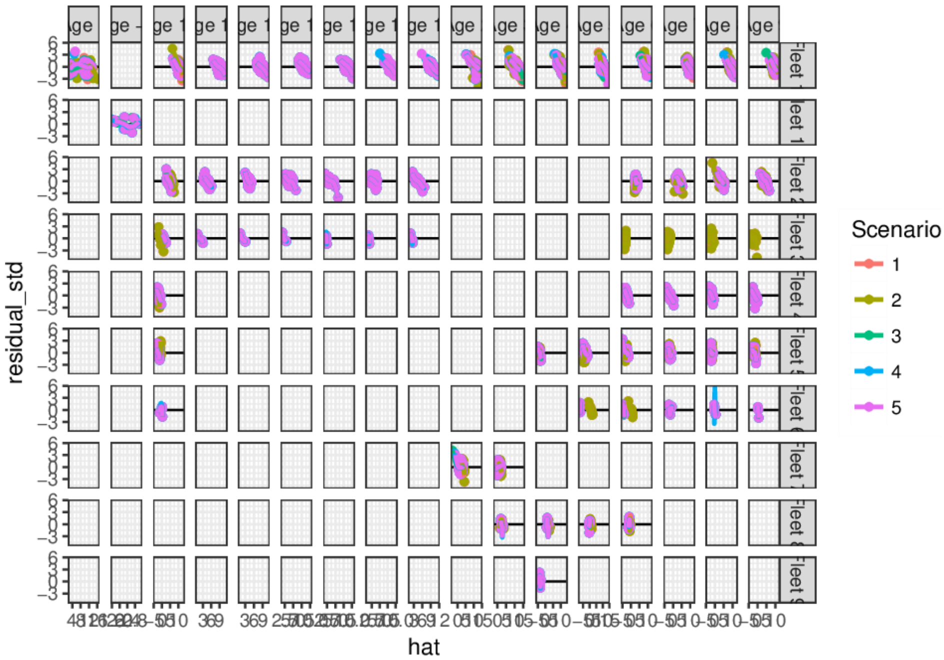

Figure 15: Plot of residuals against fitted values to check variance function.

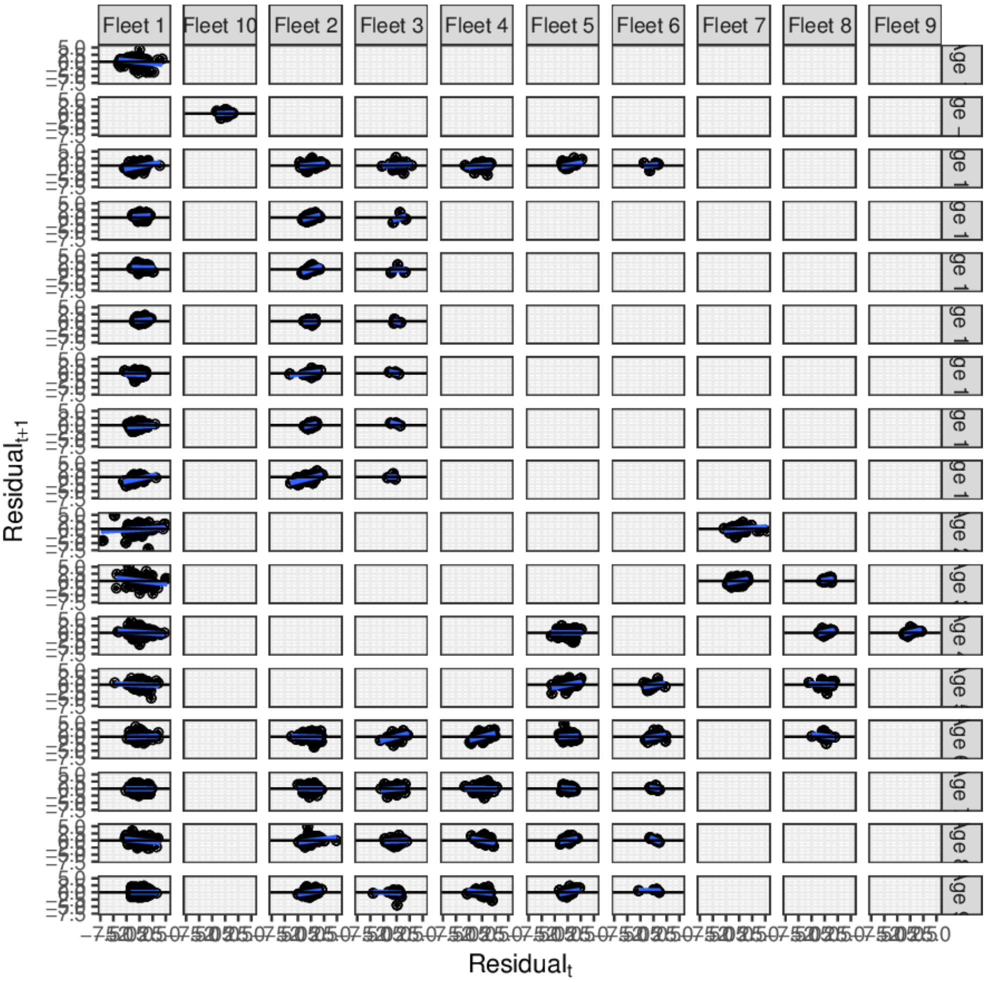

Figure 16: Check for autocorrelation.

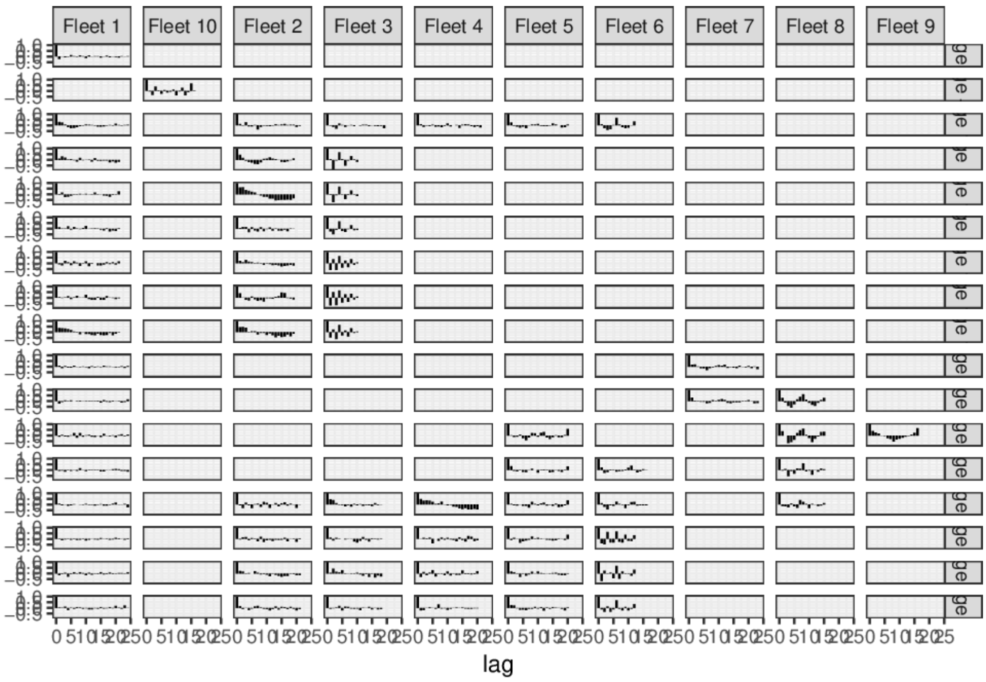

Figure 17: Autocorrelation function.