

## Shiny app short manual

### *Surplus production models - SPiCT*

The aim of this application is to implement the stochastic Surplus Production Model in Continuous Time (SPiCT, Pedersen & Berg 2016) and its time variant productivity extensions (Mildenberger *et al.* 2020).

When users first launch the application, they are presented with the basic tab panels: Info, Input and Output. The Info tab panel contains information on the code dependencies and basic instructions on how to use the application (e.g. format of the input data) (Figure D1).

## Stock assessment - SPiCT

Info

Input

Run assessment

### General

This application implements the Stochastic Production Model in Continuous Time (SPiCT, Pedersen & Berg 2016) [1] and its time-variant productivity extensions (Mildenberger et al. 2020) [2].

### Dependencies

Runs with spict\_v1.3.0, R version > 4 and requires libraries: shiny, spict, TMB, ggplot2, ellipse, gridExtra, dplyr, googleVis

### Input Data and Settings

To run the assessment, the input data should be provided in a tab delimited text file including one time series of catch data and one or more time series of a biomass index. The input file has an even number of columns, which are: timeC: years of catch data, obsC: catch data, timeI: years of first Index, obsI: first Index, timeI1: years of second Index, obsI1: second Index, etc. For seasonal data, the time columns should be decimal, e.g. 2021,5 will be used to refer to June 2021.

### Acknowledgments

The spict code for the time-variant models was implemented with the help and guidance of Casper Willestofte Berg

### References

[1] Pedersen, M.W., Berg, C.W. 2017. A stochastic surplus production model in continuous time. *Fish and Fisheries*, 18: 226-243.

[2] Mildenberger, T.K., Berg, C.W., Pedersen, M.W., Kokkalis, A., Nielsen, J.R. 2020. Time-variant productivity in biomass dynamic models on seasonal and long-term scales, *ICES Journal of Marine Science*, 77(1): 174-187.

**Figure D1 Info tab** - Stock assessment with the shiny SPiCT application.

In the Input tab, the user can upload the dataset and a message notification is showing the number of indices contained in the uploaded file. Plotting data is available for both catch and biomass index data. Advanced plotting is available which at the same time performs basic model fitting (linear regression) and shows the result (Figure D2). In this tab, the user can also shift the time of the catch and biomass index data if needed (Figure D3).

# Stock assessment - SPiCT

Info Input Run assessment

Input Data Model

Data Catch - Index

Browse... test\_dat

Upload complete

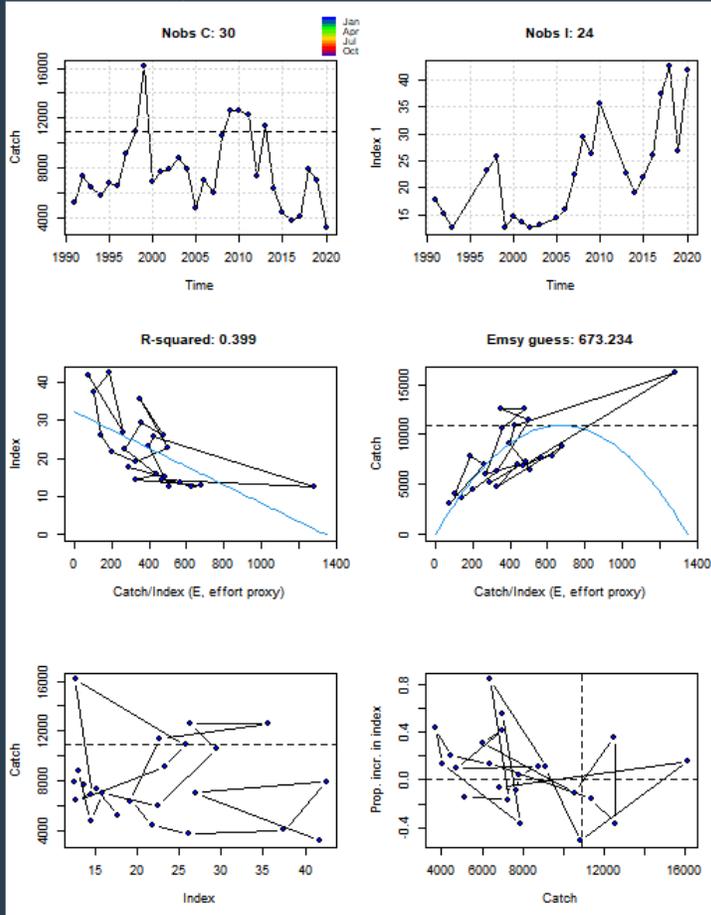
One index

No seasonal data

Plotting data

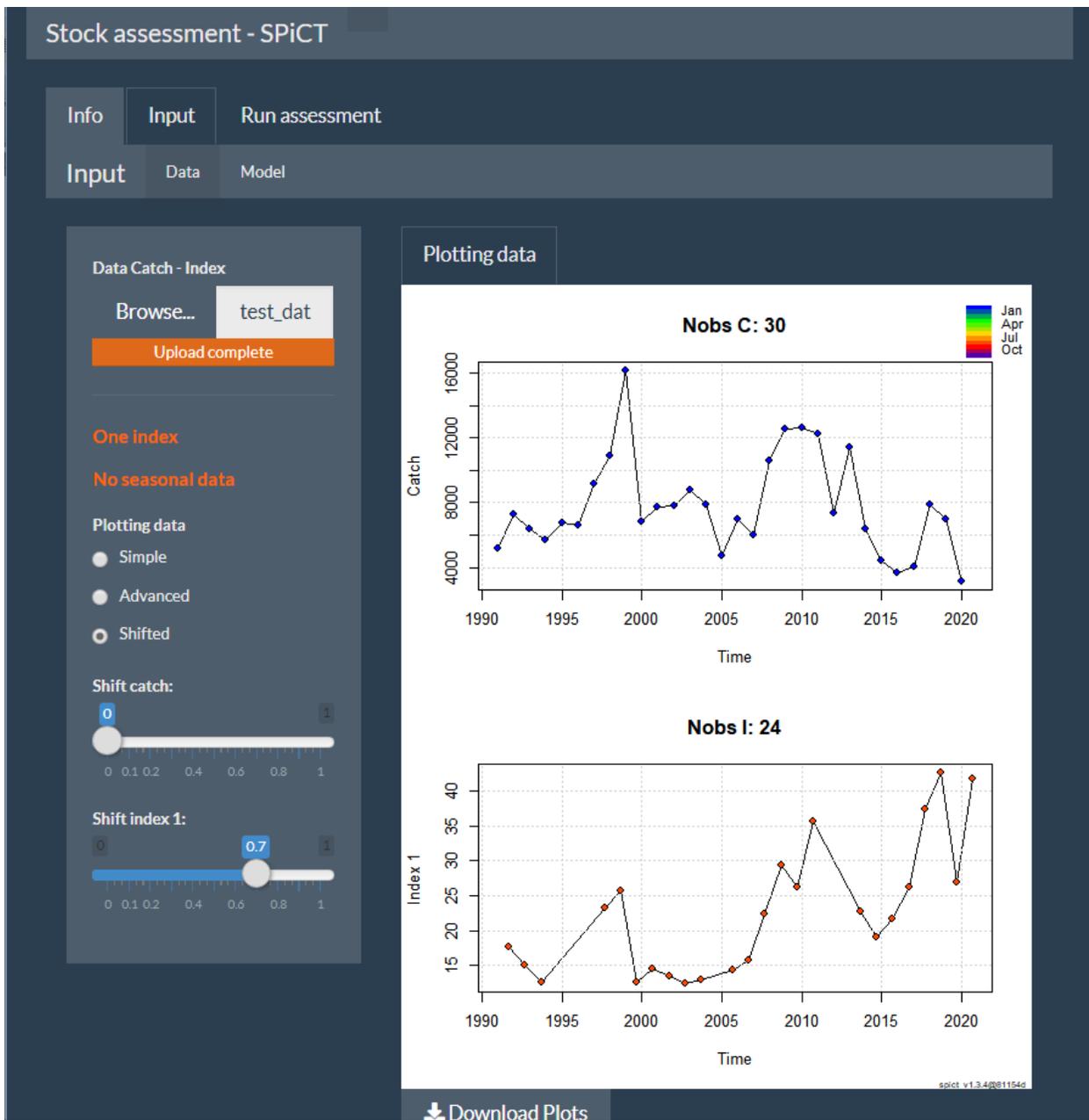
- Simple
- Advanced
- Shifted

## Plotting data



Download Plots

Figure D2 Input data tab - Advanced plotting using the test data provided in the application.



**Figure D3 Input data tab - Shift of the biomass index data by 7 months.**

In the Input model tab, the user can select the model. The available models are Original, Regime shift and Gradual shift model. If the uploaded data set contains seasonal data, then the corresponding seasonal version of the above three models is implemented. The user has the following options to parameterize the assessment:

- Fix the production curve to Schaefer model
- Disable the default alpha and beta priors and use priors on *sdi*, *sdc*, *sdb*
- Use priors of model parameters

The use of priors is useful if the model is not able to converge with the data available. The model parameters to which priors can be applied in this app are the intrinsic growth rate ( $r$ ), MSY ( $m$ ), carrying capacity ( $K$ ), biomass ( $B$ ), fishing mortality ( $F$ ), relative biomass ( $BBmsy$ ), relative fishing mortality ( $FFmsy$ ) and the initial biomass fraction ( $bkfrac$ ). For all the priors the user is asked to provide the mean and standard deviation (these are translated to  $\mu$  and  $\sigma$  parameters of the lognormal distribution within the application). Additionally, for  $B$ ,  $F$ ,  $FFmsy$  and  $BBmsy$  the year that the prior should be applied is also needed. By selecting “*Disable the default alpha and beta priors and use priors on sdi, sdc, sdb*”, the application disables the default priors on alpha and beta noise ratios and applies semi-informative priors directly on the error parameters  $sdi$ ,  $sdc$ ,  $sdb$ . As an example we use the test data set (*test\_data.txt*) provided with the application. For the purpose of demonstration, the assessment is run fixing the production curve to Schaefer curve and a prior on the intrinsic growth rate (Figure D4).

In the case of seasonal data, in addition to the above, the user can also specify the following:

- Seasonal pattern of fishing mortality (1: fixed pattern (default), or 2: varying pattern)
- Change the order of the seasonal spline

Finally, in the Regime Shift model the user needs to set the year of the shift.

Stock assessment - SPiCT

Info Input Run assessment

Input Data Model

Select model

Original model

Fix the production curve to Schaefer model

Disable the default alpha and beta priors and use priors on sdi, sdc, sdb

Use priors

Select priors

r

Mean-r:

0.8

Sd:-r

0.4

**Figure D4 Input model tab** - Original model for the test data set with options: select to fix the production curve to Schaefer model, disable the default alpha and beta priors and use priors on sdi, sdc, sdb and use priors for the intrinsic growth rate (mean=0.8, sd=0.4).

After determining the options in the Input tab, by pressing the Output tab the assessment is implemented. Within the Output tab, the results available for the user are:

- **Summary plot**  
This produces a multipanel plot with the most important outputs.
- **Single plots**  
Under this tab the user can plot and save separately each panel (single plot) of the summary plot.
- **Residuals and diagnostics**  
It is very important to check the residuals of the model in order to identify possible model deficiencies (Figure D6).
- **Retrospective**

The retrospective plots are used to evaluate the robustness of the model fit (Figure D7).

- **Simulating data**

Simulating data procedure will generate catch and index data of same length as the input catch and index time series at the time points of input data (Figure D8).

- **Model parameters**

Mean values of the most important parameter estimates are presented (Figure D9).

- **Forecasting**

Forecast is a useful step for fisheries management. SPiCT allows all quantities estimated to be forecasted in the future under several scenarios (Figure D10).

All plots can be downloaded and saved using the “Download Plot” button.

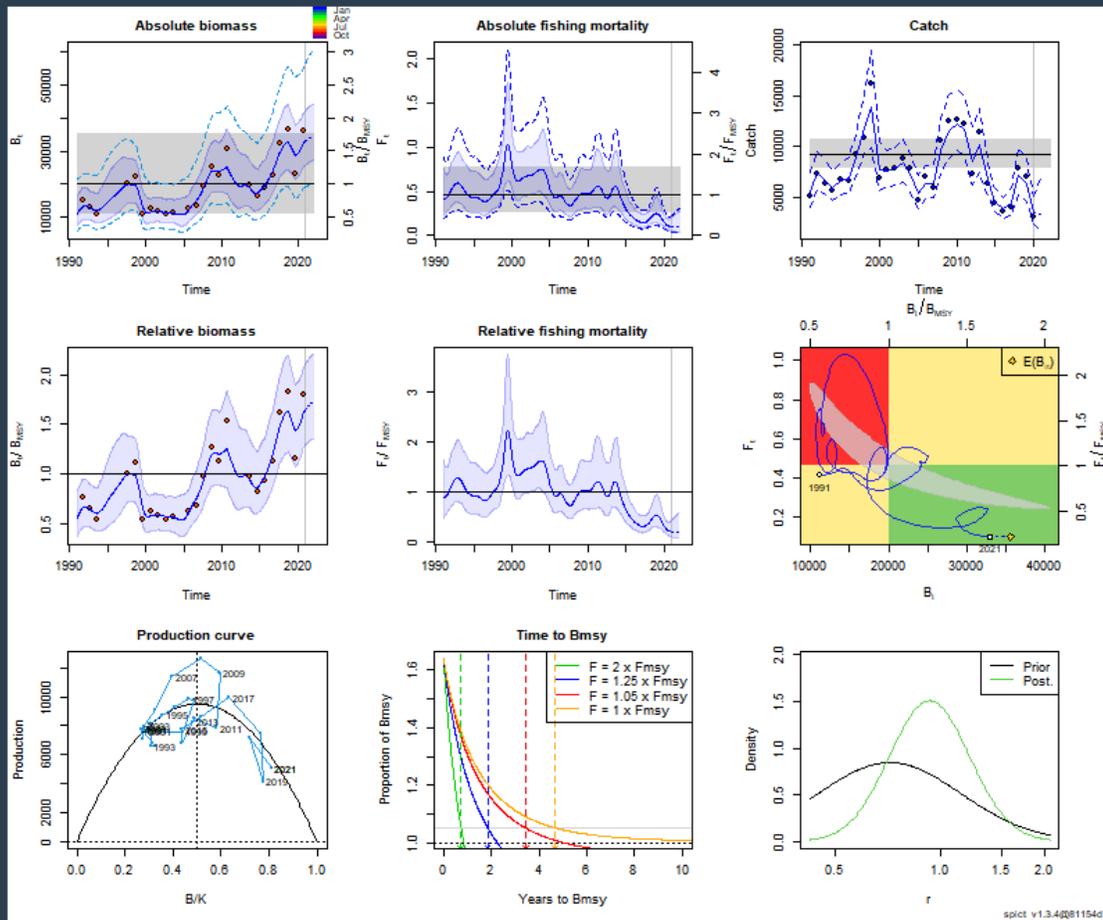
# Stock assessment - SPiCT

Info   Input   **Run assessment**

## Output

Summary plot   Single plots   Residuals and diagnostics   Retrospective   Simulating data   Model parameters

Forecasting



[Download Plot](#)

Figure D5 Summary plot results for the example test data set with parametrization in Figure D4.

# Stock assessment - SPiCT

Info

Input

Run assessment

## Output

Summary plot

Single plots

Residuals and diagnostics

Retrospective

Simulating data

Model parameters

Forecasting

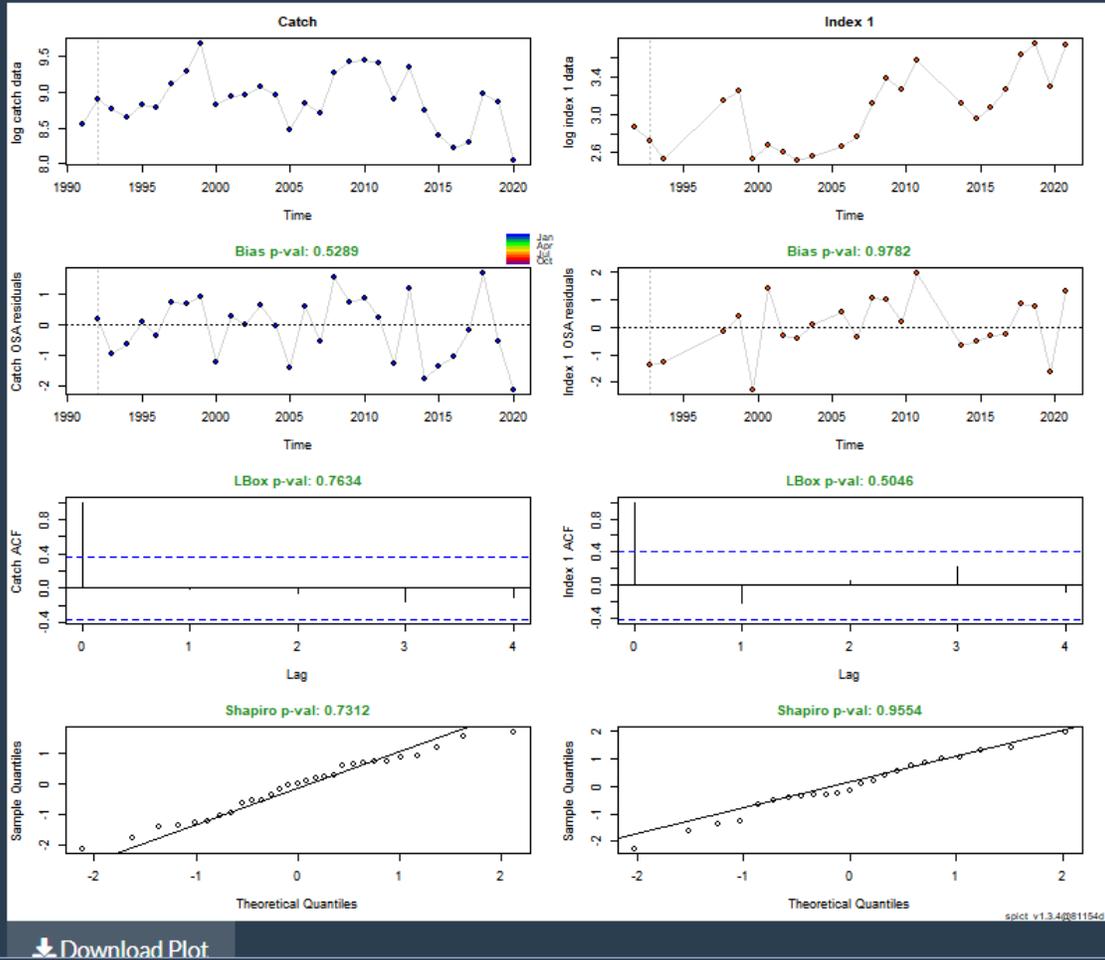


Figure D6 Residuals and diagnostics for the assessment of the test data set.

# Stock assessment - SPiCT

Info Input **Run assessment**

## Output

Summary plot Single plots Residuals and diagnostics **Retrospective** Simulating data Model parameters  
Forecasting

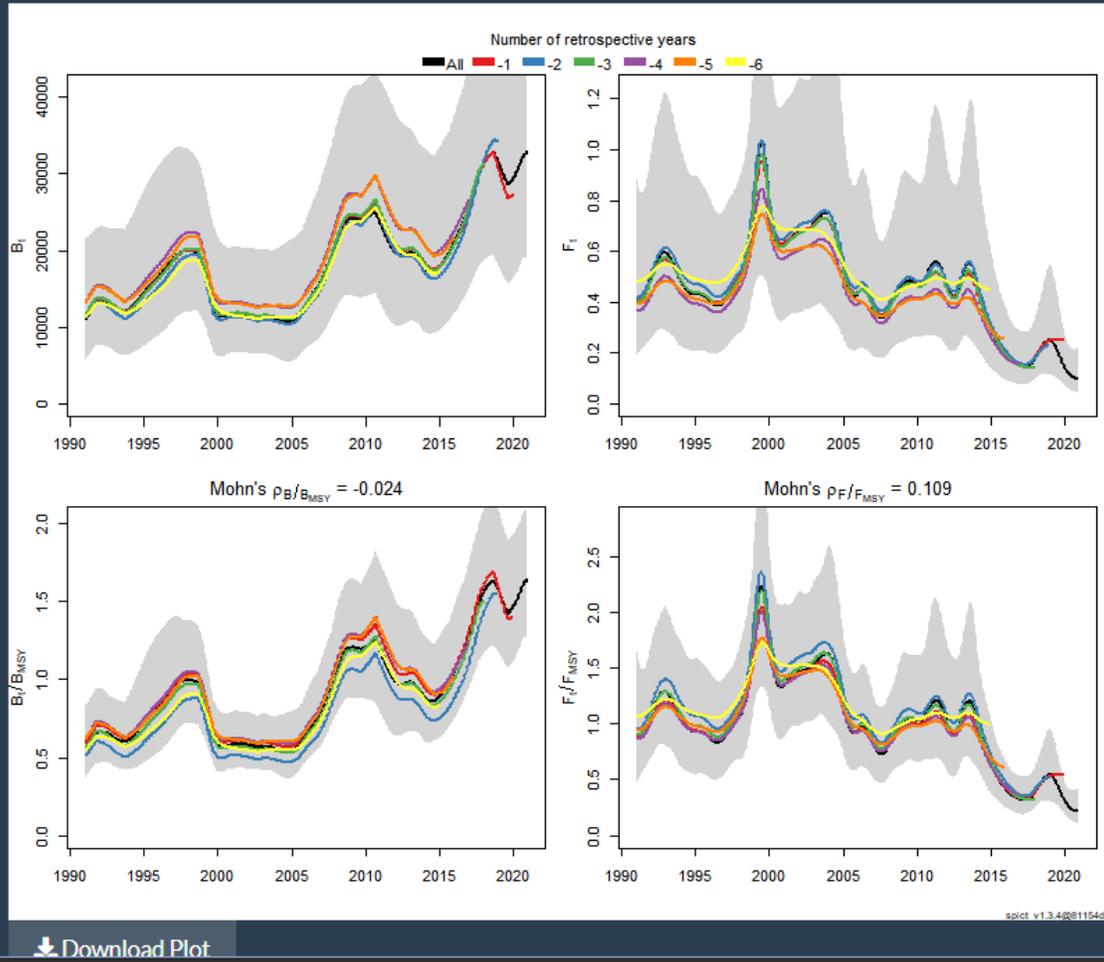


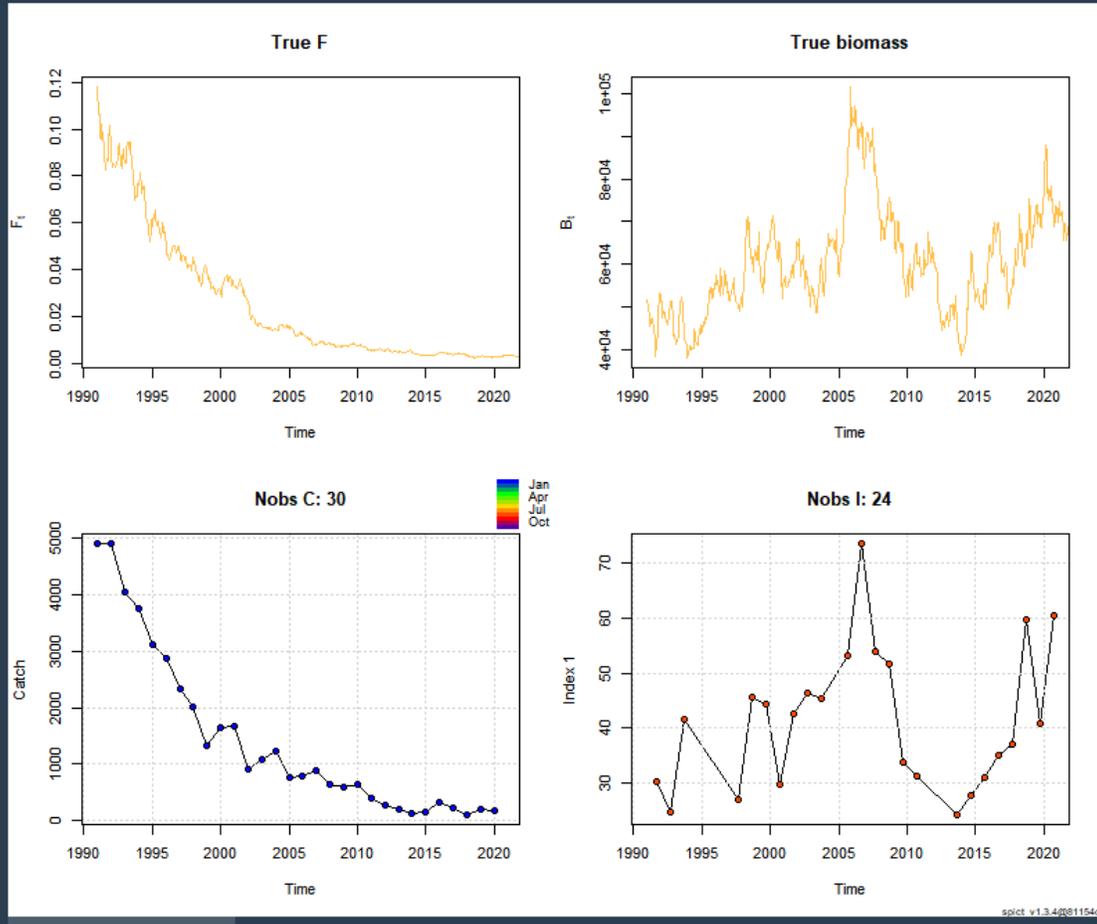
Figure D7 Retrospective plots for the assessment of the test data set.

# Stock assessment - SPiCT

Info Input **Run assessment**

## Output

Summary plot Single plots Residuals and diagnostics Retrospective **Simulating data** Model parameters  
Forecasting



[Download Plot](#)

Figure D8 Simulated data for the assessment of the test data set.

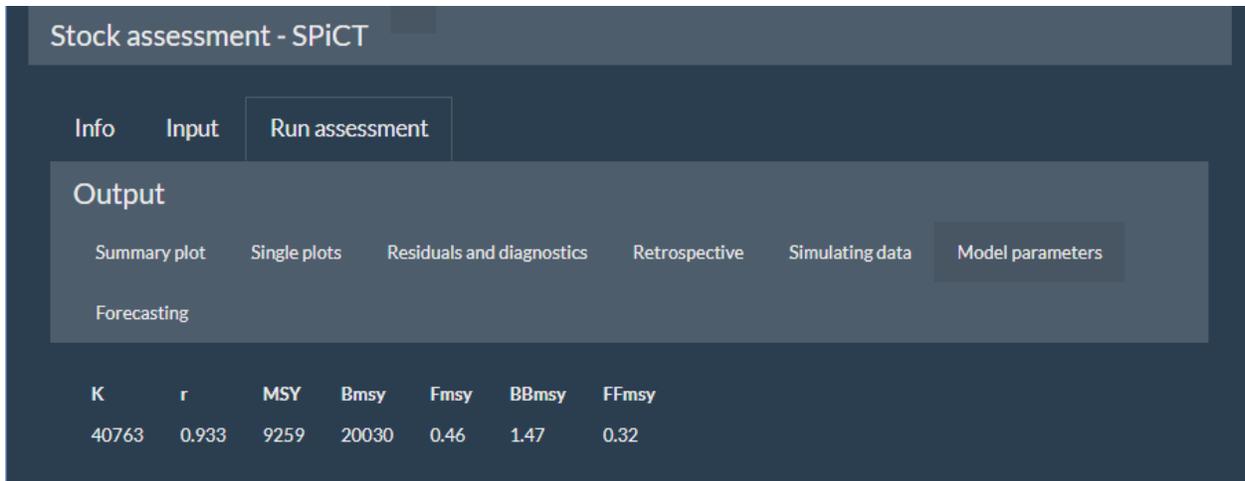


Figure D9 Model parameters for the assessment of the test data set.

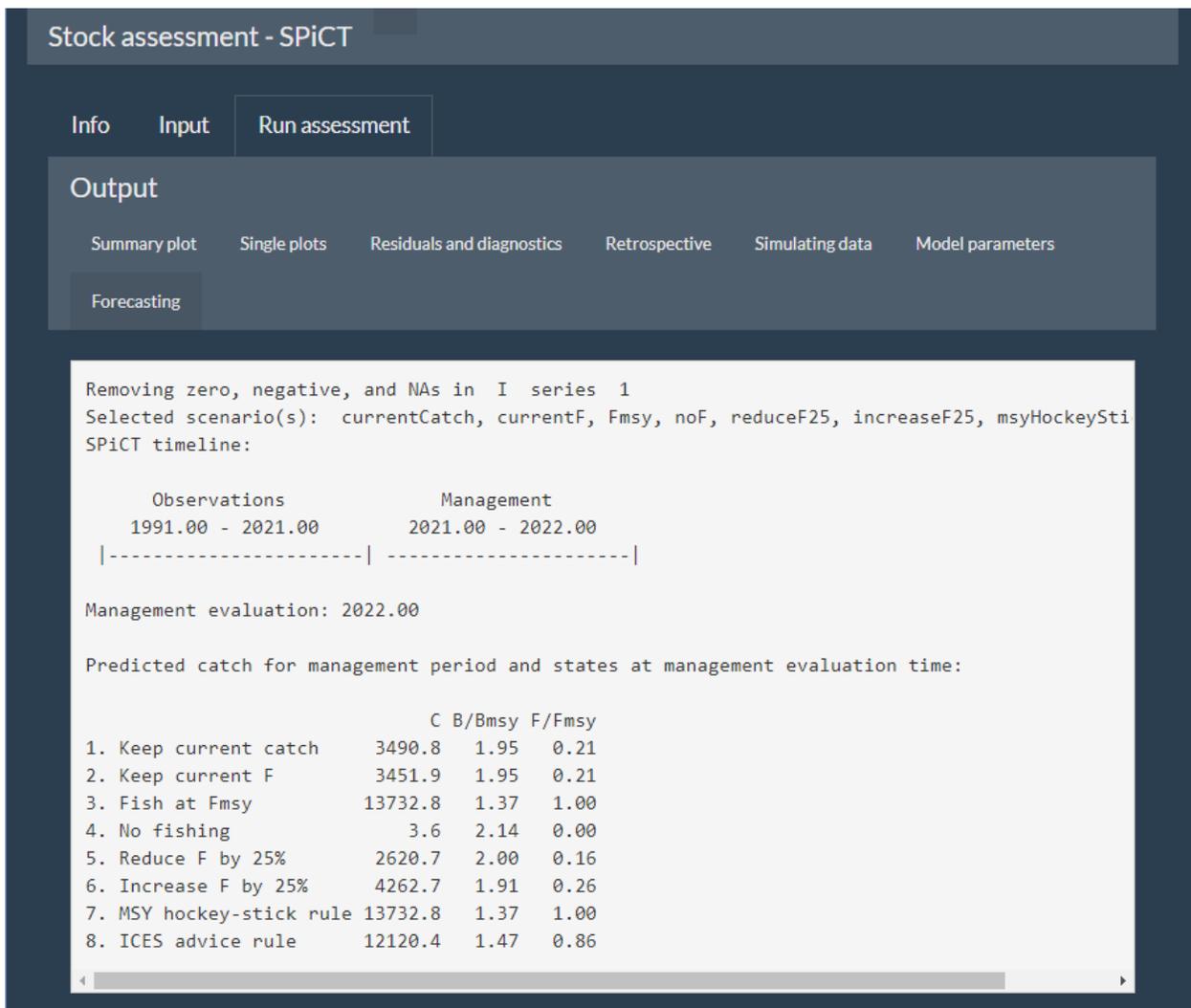


Figure D10 Forecasting management scenarios results for the assessment of test data set.

### Analytical Catch at Age models – a4a (print screens only – Draft mode)

This app implements the a4a statistical catch-at-age assessment model (Jardim *et al.*, 2015). To perform the assessment, the user should provide two R data files, one with the stock object and one with the index object, containing a list of one or multiple elements (i.e. the index or indices to be used in the assessment). As soon as the objects are loaded, the “Inspect Input” tab presents a plot of catch, landings and discards as a function of time. Through a drop down menu, the user can plot stock and index catch-at-age distributions by year as well as stock and index cohort consistency plots (Figure D11). Next, the functional form of the three submodels to be fitted to the data (fmodel, qmodel, srmodel) should be supplied either manually or selected through a dropdown menu. Alternatively, the user can select to fit default submodels. In Figure D12, the following submodels have been supplied manually for the test data set (provided with the application):

fmodel:  $\sim s(\text{age}, 8) + s(\text{year}, k = 15)$

qmodel:  $\sim \text{factor}(\text{age})$

srmodel:  $\sim \text{geomean}(\text{CV}=0.3)$

Note that the provided test data set can also run with the default submodel settings, however the default settings might not work for most data sets. If more than one index is contained in the index object, the user must supply as many qmodels as the number of indices. In this case, the qmodel will be a list, with each element specifying the functional form to be fitted (spline or factor) to the corresponding index, keeping the same order by which the indices appear in the index object. For example, suppose that a second index is supplied, which is an environmental index with no age structure. In this case, the following qmodel can be used:  $\text{qmodel} = \sim \text{list}(\text{factor}(\text{age}), 1)$ . The second element of the list is “1”, meaning that the qmodel in this case does not depend on age, i.e. is a constant catchability to be specified by the fit. The same setting would apply if the second index were a biomass or abundance index (aggregated in age). Currently, the addition of more qmodels can only be done ‘manually’ in the application. After specifying submodels, the assessment is implemented by pressing the “Run Assessment” button. A number of output tabs provide plots of the results, diagnostics of the fit and reference points:

- **Assessment**

This tab presents a multipanel plot with the estimated (median) recruitment, spawning stock biomass (SSB), catch and fishing mortality as a function of time as well as 75% (dark red) and 95% (light red) CI that result from 1000 MC simulations. On the same tab, at the bottom of the screen, an additional plot shows just the median of the above variables (Figure D12).

- **Diagnostics**

A number of fit diagnostics can be plotted under this tab by selecting one of the following options from the drop-down menu: aggregated catch diagnostics, standardized log residuals for catch and index, bubble plot of log residuals for catch and index, fitted vs. observed catch at age distributions and fitted vs. observed index at age distributions (Figure D13).

- **Submodels**

3-D plots of  $f$  and  $q$  submodels are produced under this tab by pressing the corresponding buttons (Figure D14).

- **Retrospective**

A retrospective plot is produced using 3 retrospective years as a default. The user can select a different number of retrospective years, up to a maximum of 5 years (Figure D15).

- **Reference points**

This tab presents the estimates of the reference point  $f_{01}$ , the current (last assessment year) fishing mortality,  $f_{current}$  (or  $f_{bar}$ ) and their ratio  $f_{current}/f_{01}$ , which is a measure of the stock's status. The distribution of these three indicators is also presented in plots (Figure D16).

Finally, the fitted object can be downloaded and saved using the "Download fitted object" button at the bottom left of the screen.

# a4a Stock assessment

Stock object  
Browse... stock.Rdata  
Upload complete

Index object  
Browse... index.Rdata  
Upload complete

Choose method of Submodel input:

- Default sub-models
- Manually
- Drop down menu

fmodel:

qmodel (separate qmodels with &):

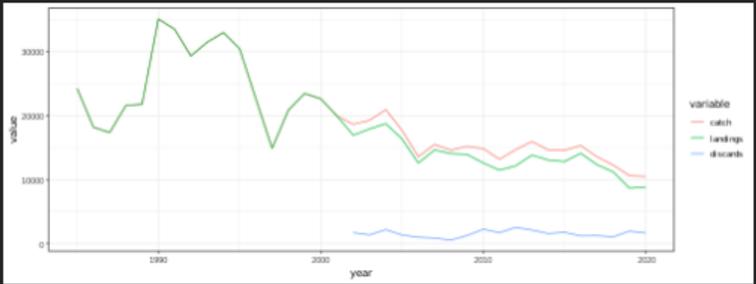
  

srmodel:

Run Assessment

Download fitted object

Inspect Input Assessment Diagnostics Submodels Retrospective Reference points



Choose plot:  
Catch at age

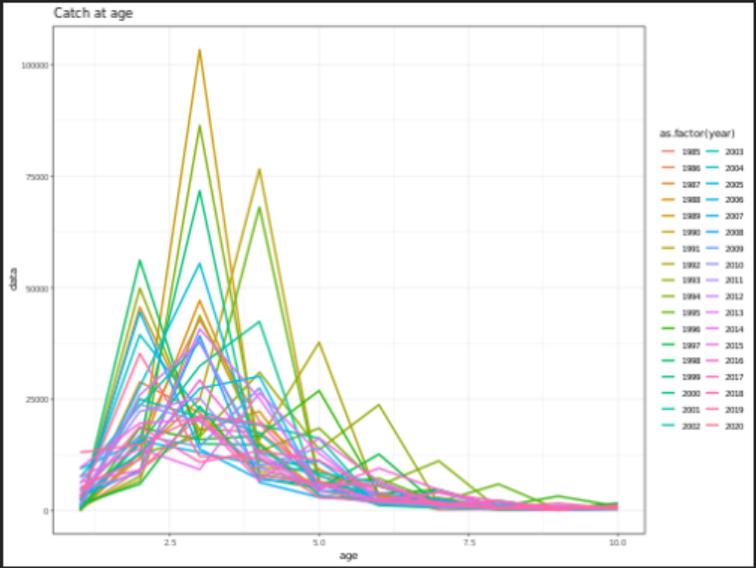
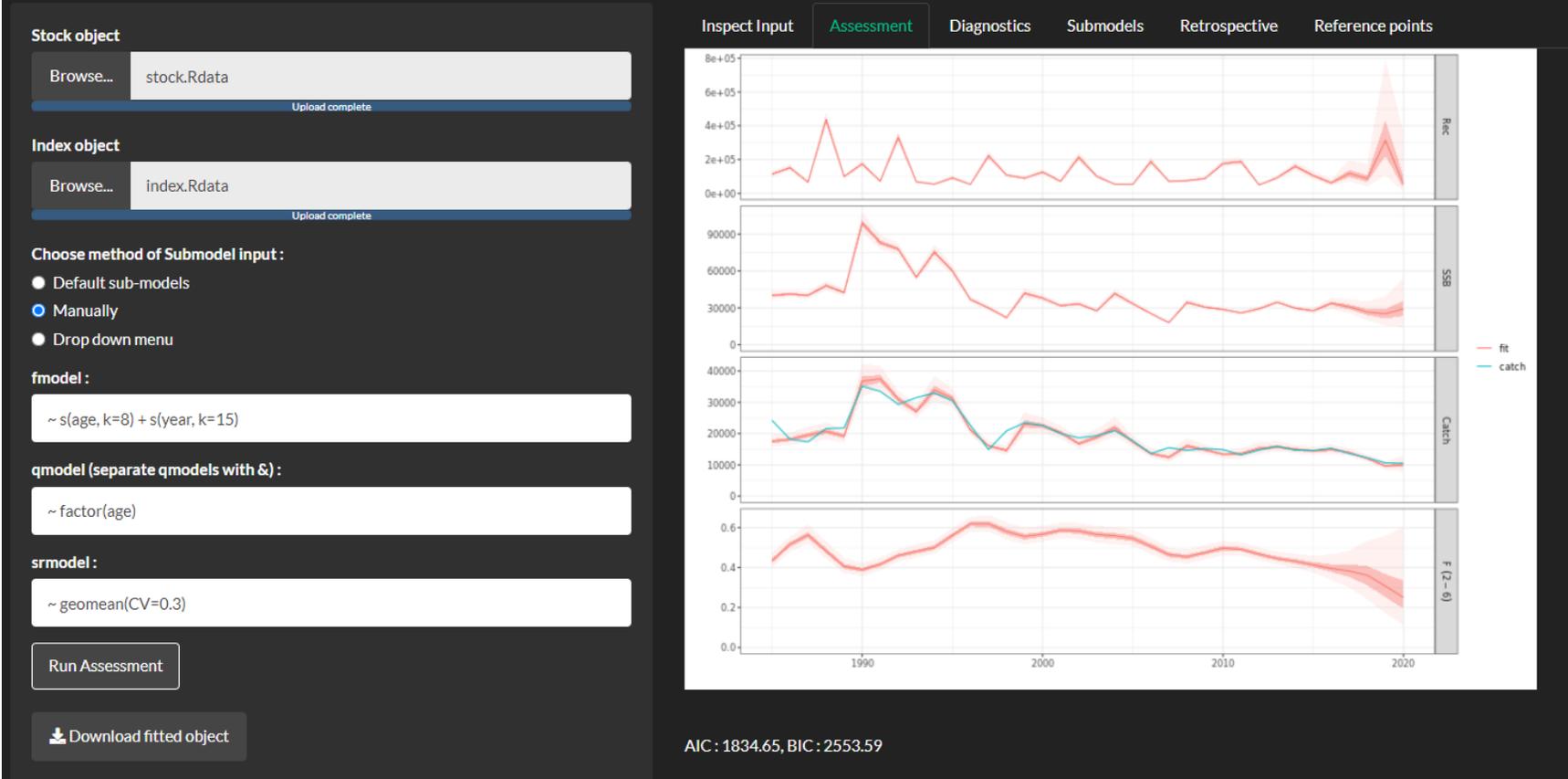


Figure D11 "Inspect Input" tab showing plot of catch, landings and discards and catch-at-age distribution for the test data set.

# a4a Stock assessment



**Figure D12** The *fmodel*, *qmodel* and *srmodel* have been supplied manually (left of the screen). After pressing the “Run Assessment” button, the main results of the fit are shown on the “Assessment” tab on the right. The multipanel plot shows estimated median recruitment, spawning stock biomass (SSB), catch and fishing mortality as a function of time as well as 75% (dark red) and 95% (light red) CI that result from 1000 MC simulations. In the “catch” panel, the observed catch is also shown in light blue.

# a4a Stock assessment

## Stock object

Browse... stock.Rdata

Upload complete

## Index object

Browse... index.Rdata

Upload complete

## Choose method of Submodel input :

- Default sub-models
- Manually
- Drop down menu

## fmodel :

~ s(age, k=8) + s(year, k=15)

## qmodel (separate qmodels with &):

~ factor(age)

## srmodel :

~ geomean(CV=0.3)

Run Assessment

Download fitted object

Inspect Input

Assessment

Diagnostics

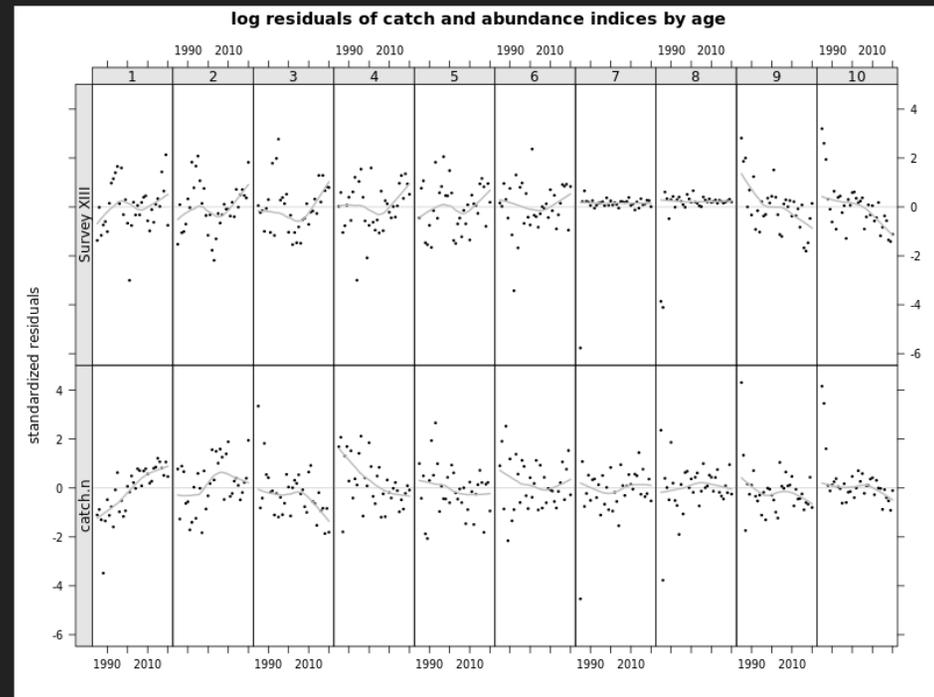
Submodels

Retrospective

Reference points

## Choose diagnostics plot :

Standardized log residuals



**Figure D13** On the “Diagnostics” tab, the drop down menu provides a selection of different diagnostics. Here, the standardized log residuals of the catch and the survey index of the test data set have been plotted.

## a4a Stock assessment

**Stock object**

Browse... stock.Rdata  
Upload complete

**Index object**

Browse... index.Rdata  
Upload complete

**Choose method of Submodel input :**

- Default sub-models
- Manually
- Drop down menu

**fmodel :**

~ s(age, k=8) + s(year, k=15)

**qmodel (separate qmodels with &) :**

~ factor(age)

**smodel :**

~ geomean(CV=0.3)

Run Assessment

Download fitted object

Inspect Input   Assessment   Diagnostics   **Submodels**   Retrospective   Reference points

Plot F model

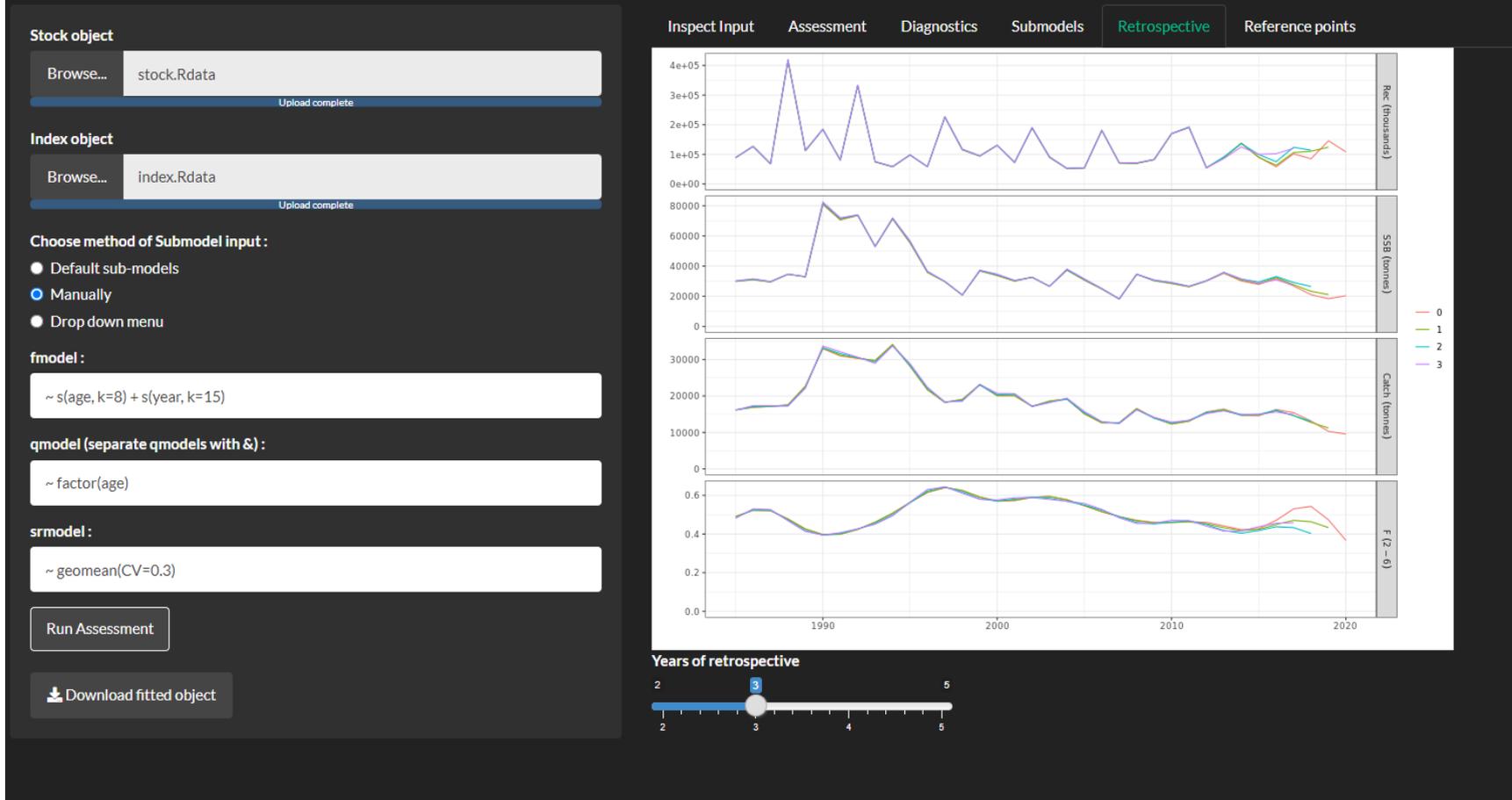
Choose index to plot :  
Survey XIII

Plot q model

The 3D plot displays the fitted fmodel surface. The vertical axis represents the model value, ranging from 0.5 (dark blue) to 2.0 (yellow). The horizontal axes are age (0 to 8) and year (1985 to 2020). The surface shows a prominent peak around age 2-4 in the early 1990s, followed by a general decline and a secondary, smaller peak around age 2-4 in the late 1990s/early 2000s.

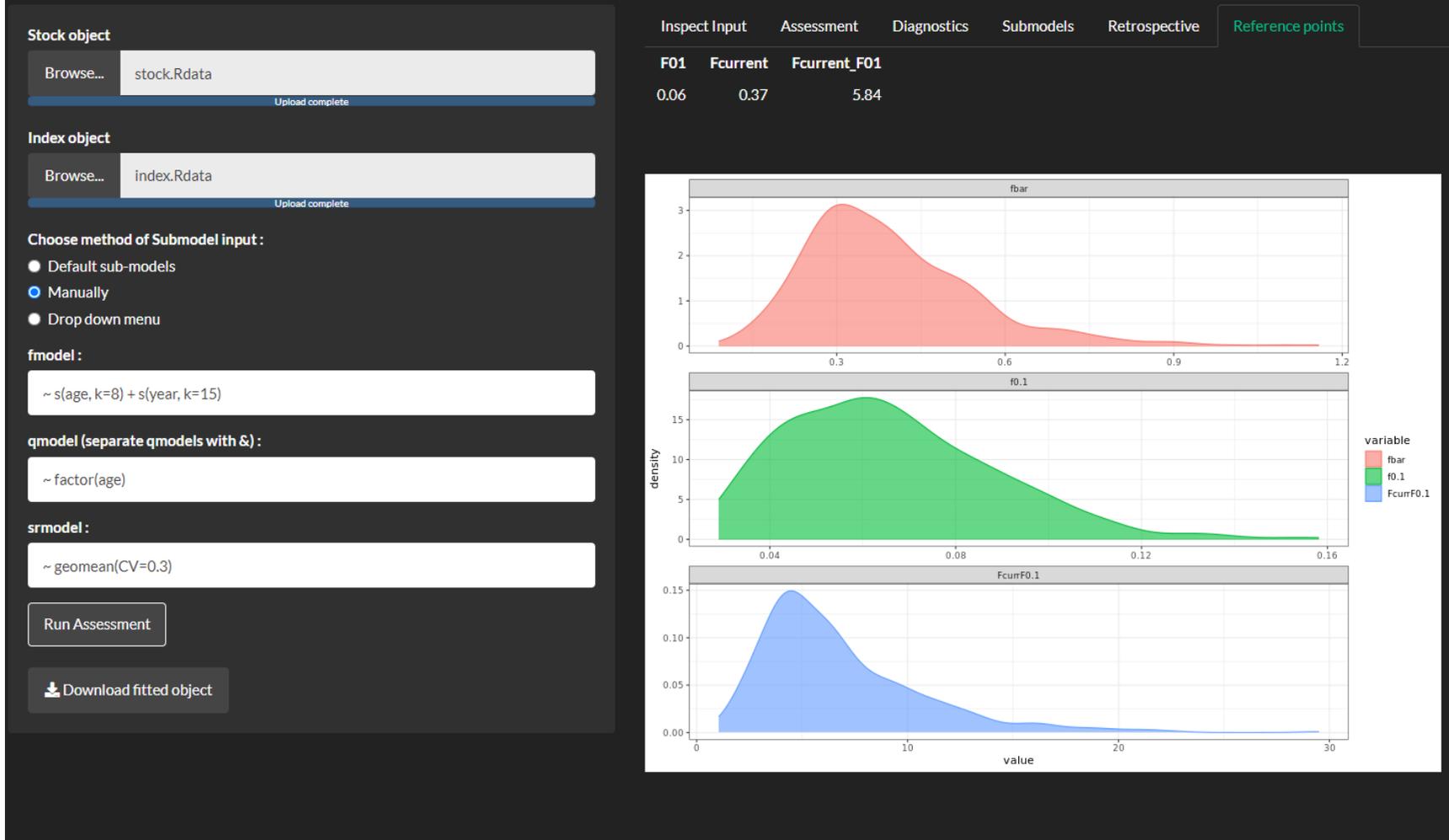
**Figure D14** On the “Submodels” tab, the 3-D fmodel is plotted on the top of the screen after pressing the corresponding button. The qmodel can be plotted by pressing the “Plot q model” button and will appear at the bottom of the screen. The 3-D plots can be rotated to be viewed from different angles.

## a4a Stock assessment



**Figure D15** On the “Retrospective” tab a retrospective plot can be created. Here, the retrospective plot for the fit of the test data set is shown using 3 retrospective years.

## a4a Stock assessment



**Figure D16** The “Reference points” tab shows the estimated  $f_{01}$ ,  $f_{current}$  ( $f_{bar}$ ) and their ratio  $f_{current}/f_{01}$ . The distribution of the above parameters is shown in the plots.

## Acknowledgments

We would like to thank Casper W. Berg and Iago Mosqueira for their valuable comments and suggestions regarding the parameterization of the SPiCT and the a4a models respectively.

## References

- Jardim, E., Millar, C.P., Mosqueira, I., Scott, F., Osio, G.C., Ferretti, M., Alzorriz, N., Orio, A. 2015. *What if stock assessment is as simple as a linear model? The a4a initiative. ICES Journal of Marine Science*, 72: 232-236.
- Mildenberger, T.K., Berg, C.W., Pedersen, M.W., Kokkalis, A., Nielsen, J.R. 2020. *Time-variant productivity in biomass dynamic models on seasonal and long-term scales. ICES Journal of Marine Science*, 77(1): 174-187.
- Pedersen, M.W., Berg, C.W., 2017. *A stochastic surplus production model in continuous time. Fish and Fisheries*, 18: 226-243.