SPiCt model for anchovy 9a South

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Abstract

An SPiCt model has been fitted to anchovy 9a South data using catches biomass time series and PELAGO and ECOCADIZ survey indexes, available until 2020, testing different model features. Results of different scenarios will be presented and also a comparison with the current model used as basis for the assessment which is a Gadget model.

1. Model Description

SPiCt model fits an stochastic surplus production model in continuous time incorporating dynamics in both biomass and fisheries and observation error of both catches and biomass indices. The model has a general state-space form that can contain process and observation-error as well as state-space models that assume error-free catches (Pedersen and Berg, 2017).

The general SPiCT model description and all the options available can be found in Pedersen and Berg (2017), as well as a user guide available at `https://github.com/DTUAqua/spict/raw/master/spict/inst/doc/spict_manual.pdf`. The version of the model including seasonal productivity is described in detail in Mildenberger et al. (2020).

2. Data and priors

Quarterly catches time series from 1989 to the second quarter of 2020. For the first two quarters of year 2020, provisional catches estimations of Spanish (until May 18th) purse-seine fleet were used and catches for June were estimated as the **38%** of January to May catches based on historical records from 2009 to **2019**. There were not any catches for Portuguese purse-seine in these two quarters. ECOCADIZ and PELAGO acoustic survey biomass indexes were provided at the exact time of the year when the surveys were carried out. For ECOCADIZ that corresponds to March of 2004 and 2006, April of 2007, 2009, 2010, 2014-2019, and May of 2013, and for

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PELAGO to February of 1998, 2000-2002 and April of 2005-2010, 2013-2020. Data summary is presented in Figure 1.

Priors for parameters were set to default.

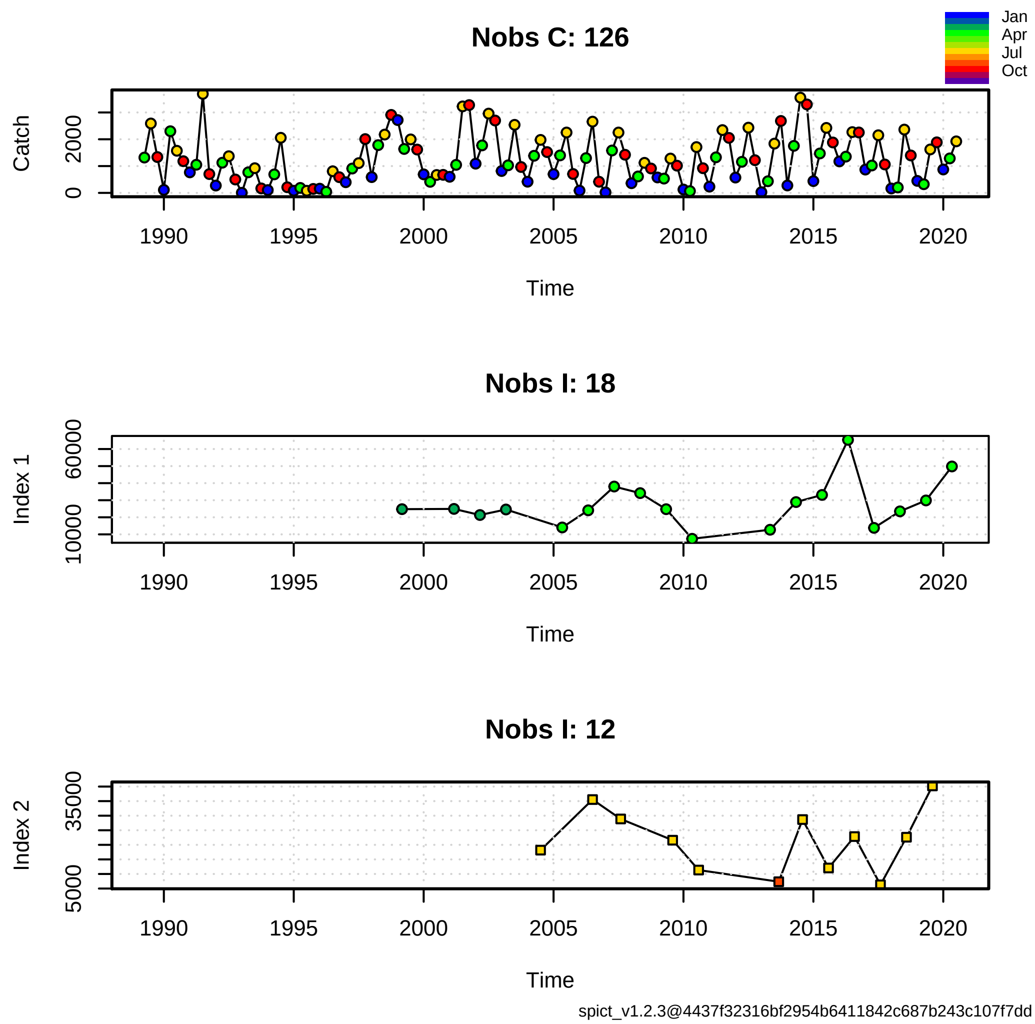

Figure 1: Summary of data used for the SPiCt model

3. Scenarios

Four different scenarios were tested, the first one with no seasonal productivity, the second one assuming seasonal productivity, the third one with no seasonal productivity and with time-varying growth and the last one with no seasonal productivity, no time-varying growth and with the data restricted to the 1999-2019 period where there is a more stable length distribution pattern.

4. Results

4.1. Scenario 1

Most important outputs for scenario 1 are displayed in figure 2. This scenario assumes no seasonal productivity, no time-varying growth and uses the whole data set available. Diagnostics are displayed in figure 3 and the following is the results summary:

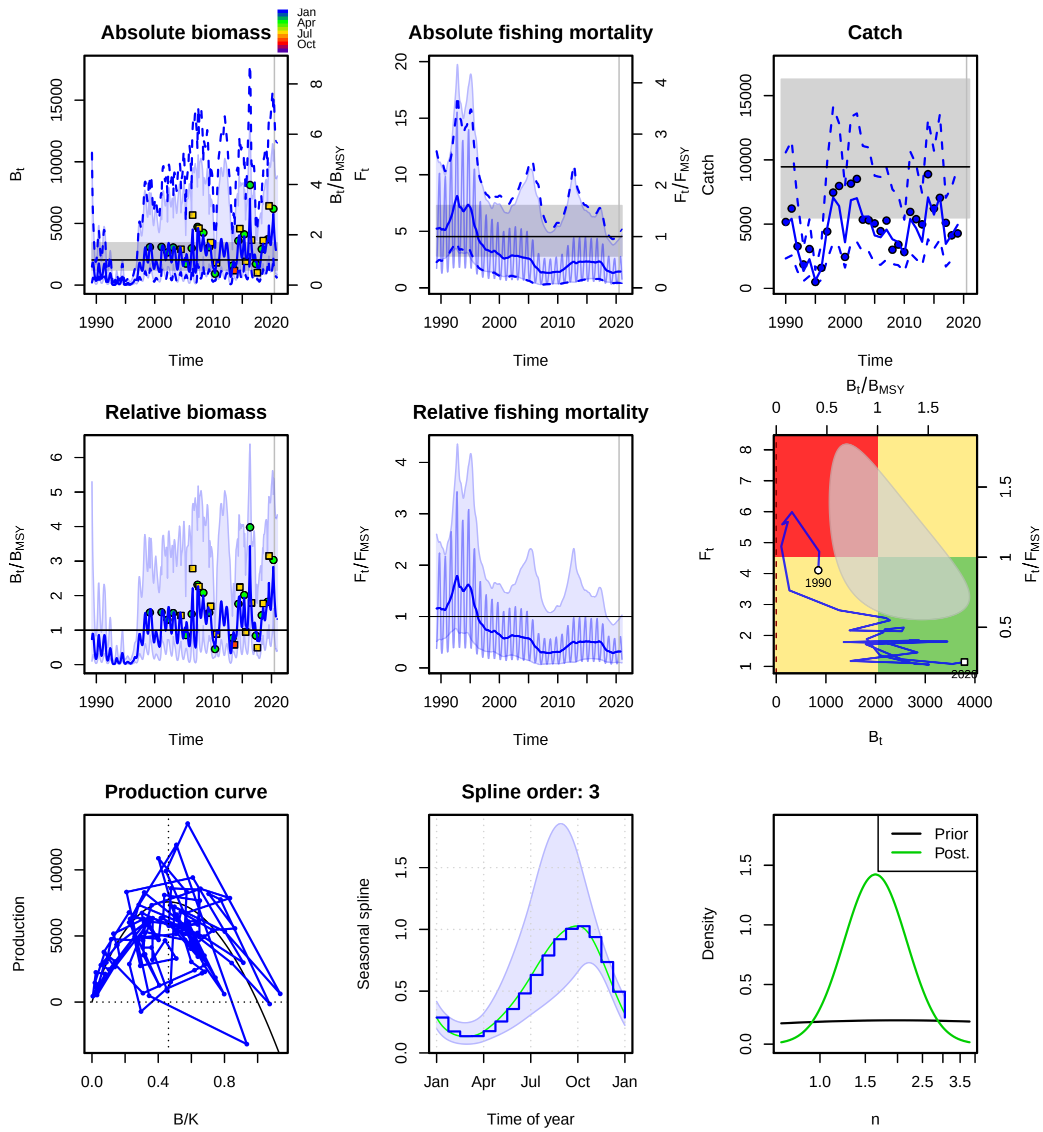

Figure 2: Summary of SPiCt results for scenario 1

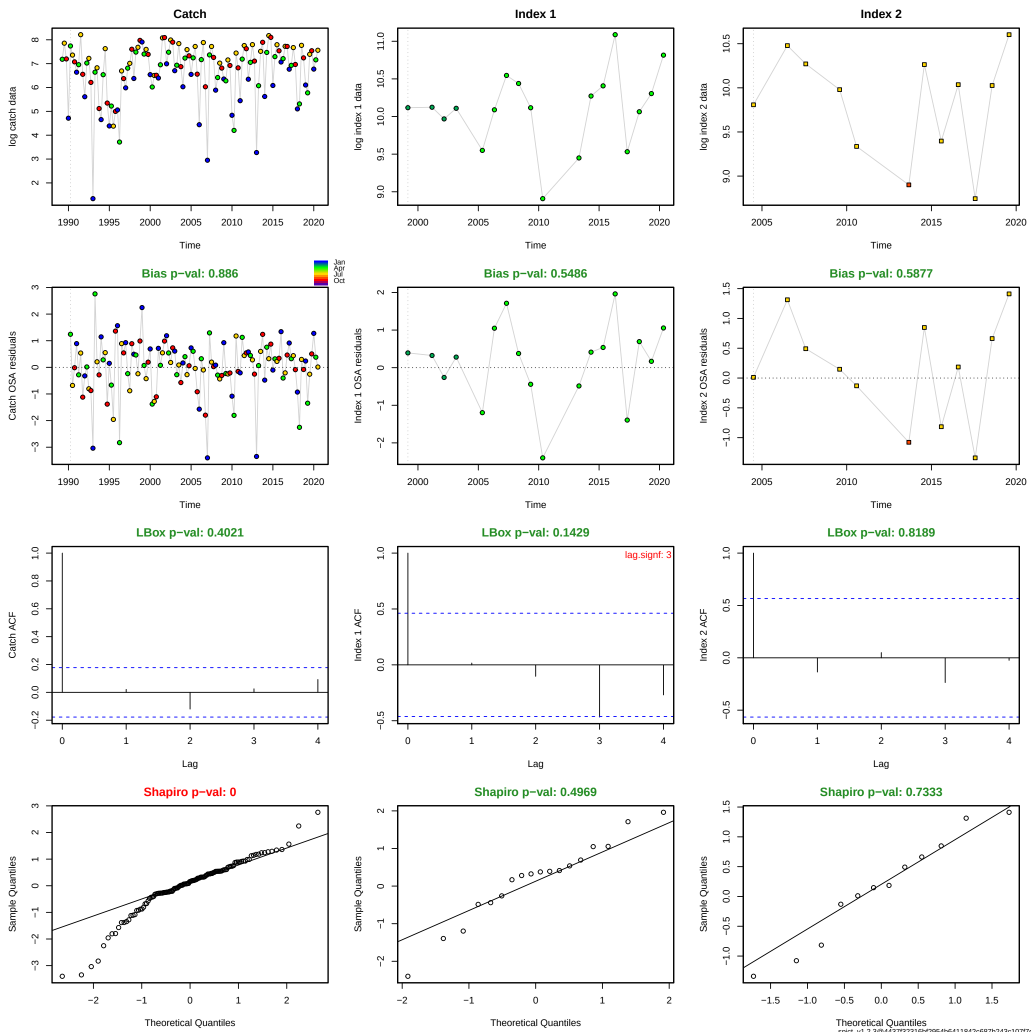

Figure 3: Summary of SPiCt diagnostics for scenario 1

4.2. Scenario 2

Most important outputs for scenario 2 are displayed in figure 4. This scenario assumes a seasonal productivity, no time-varying growth and uses the whole data set available. No diagnostics are available because of the lack of convergence, nevertheless, a plot on how the model estimates the seasonal productivity pattern is presented in figure 5. The following is the results summary:

```
null device
          1
```

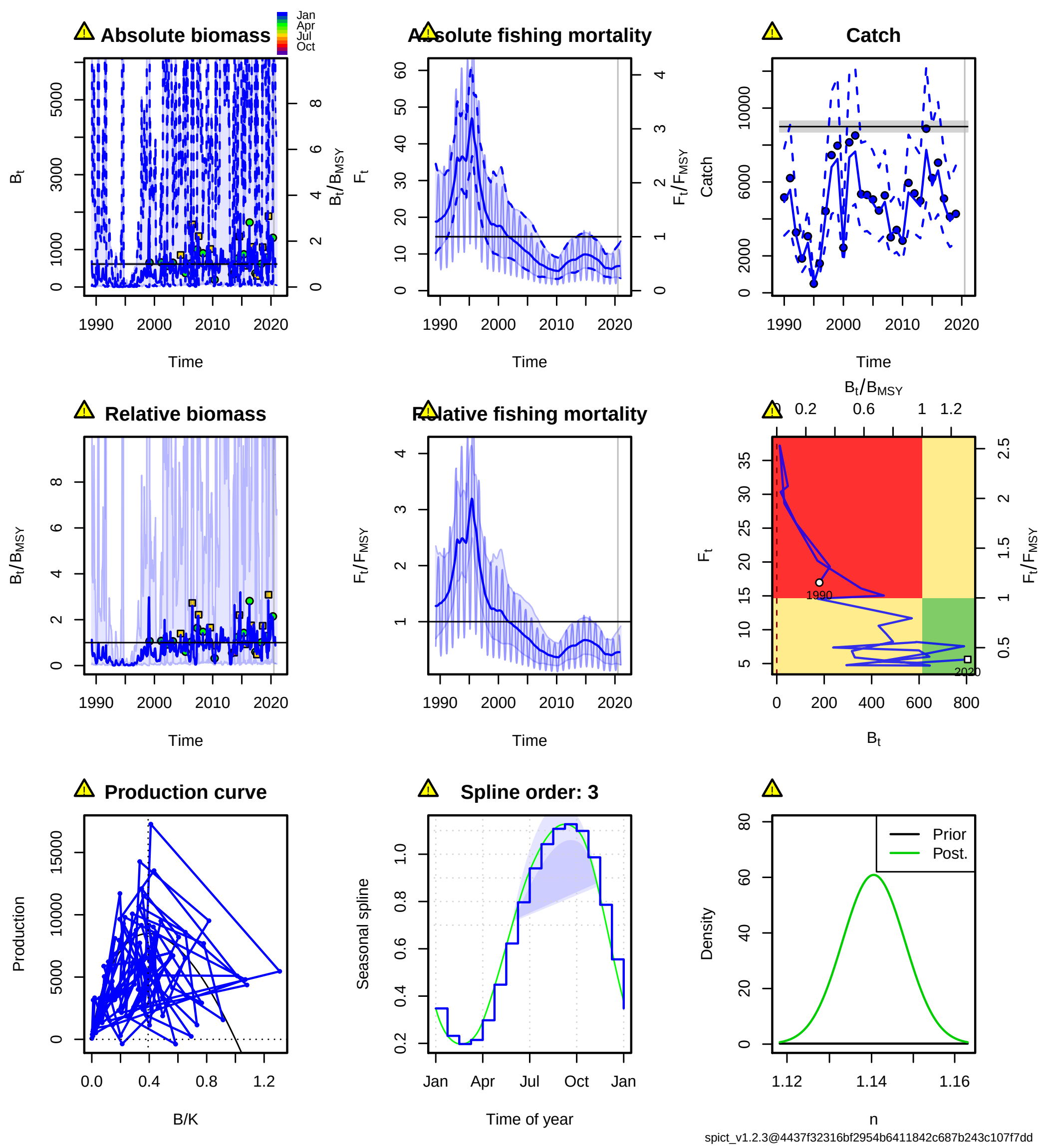

Figure 4: Summary of SPiCt results for scenario 2

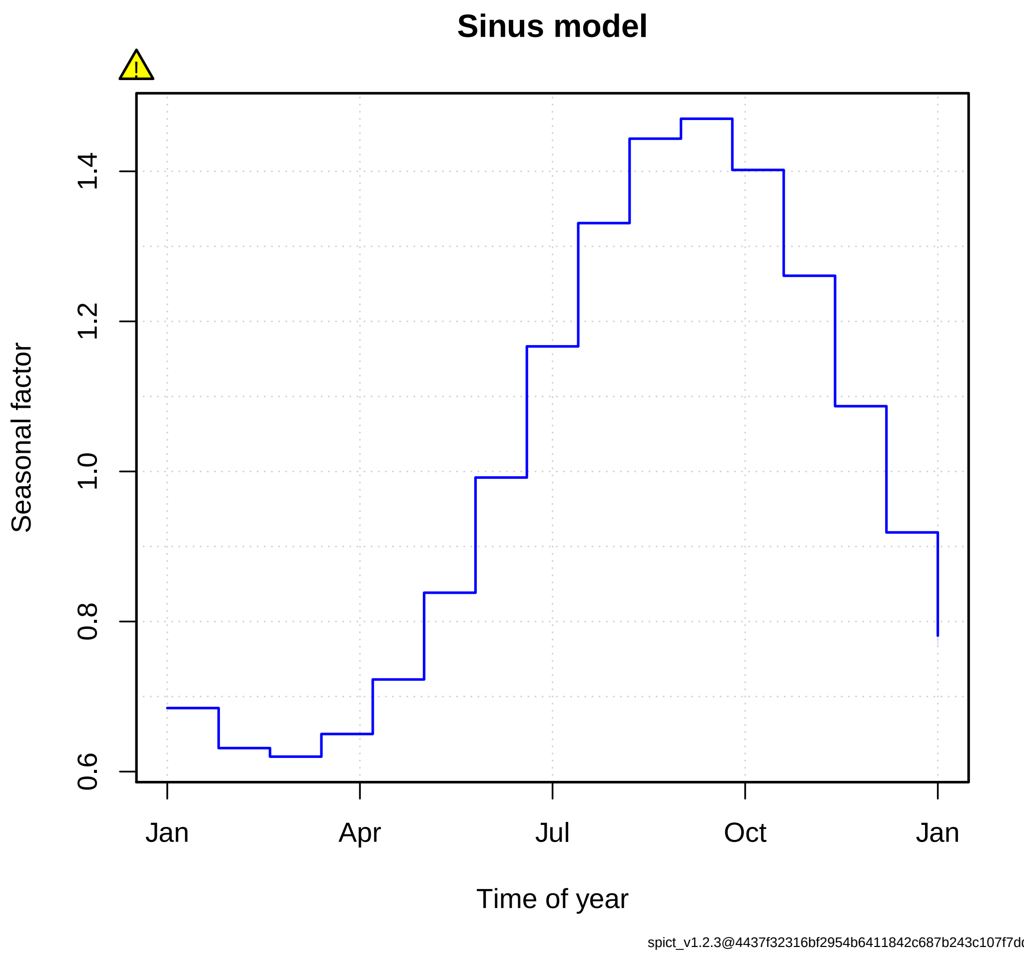

Figure 5: Estimation of the seasonal productivity pattern in scenario 2

4.3. Scenario 3

Most important outputs for scenario 3 are displayed in figure **??**. This scenario assumes no seasonal productivity, time-varying growth and uses the whole data set available. Diagnostics are displayed in figure 6 and the following is the results summary:

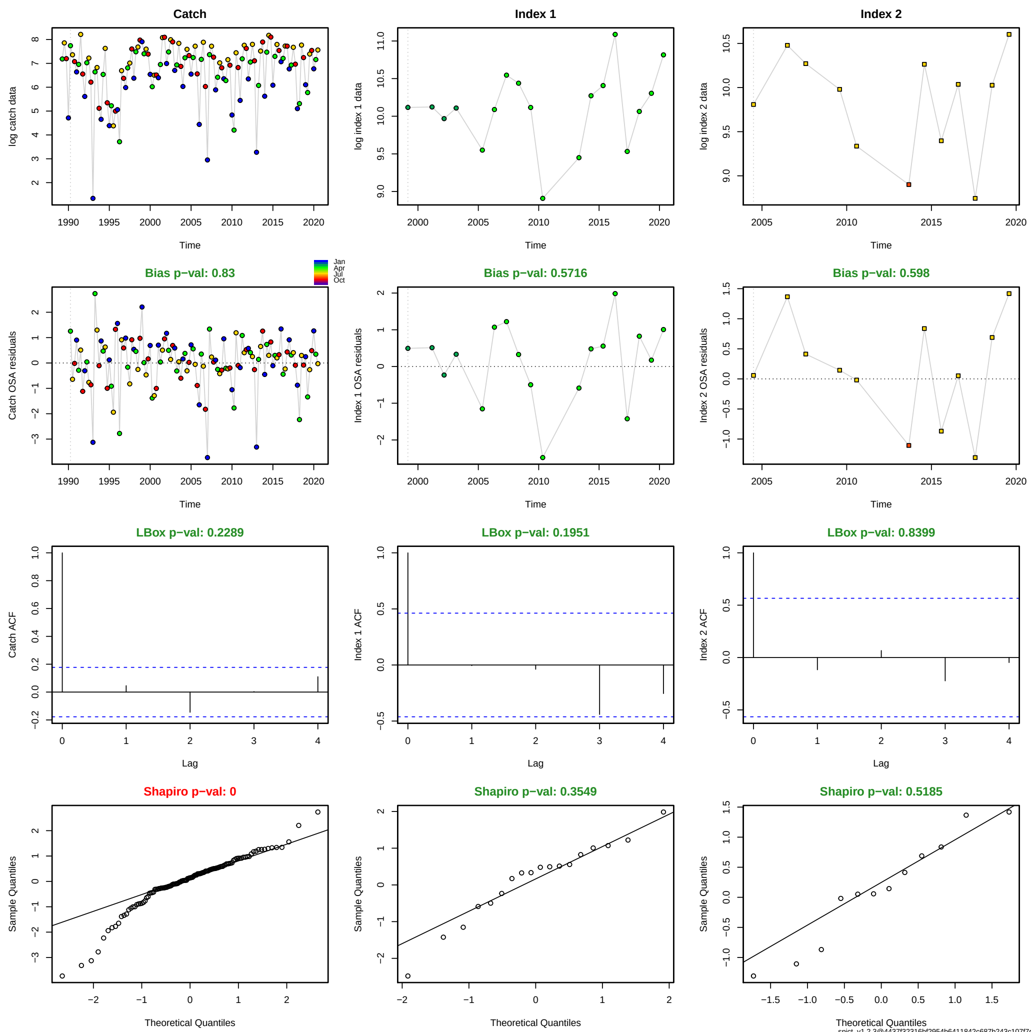

Figure 6: Summary of SPiCt diagnostics for scenario 3

4.4. Scenario 4

Most important outputs for scenario 4 are displayed in figure 7. This scenario assumes no seasonal productivity, no time-varying growth and uses a restricted dataset, with data only for the 1999-2019 period where there is a more stable length distribution pattern. Diagnostics are displayed in figure 8 and the following is the results summary:

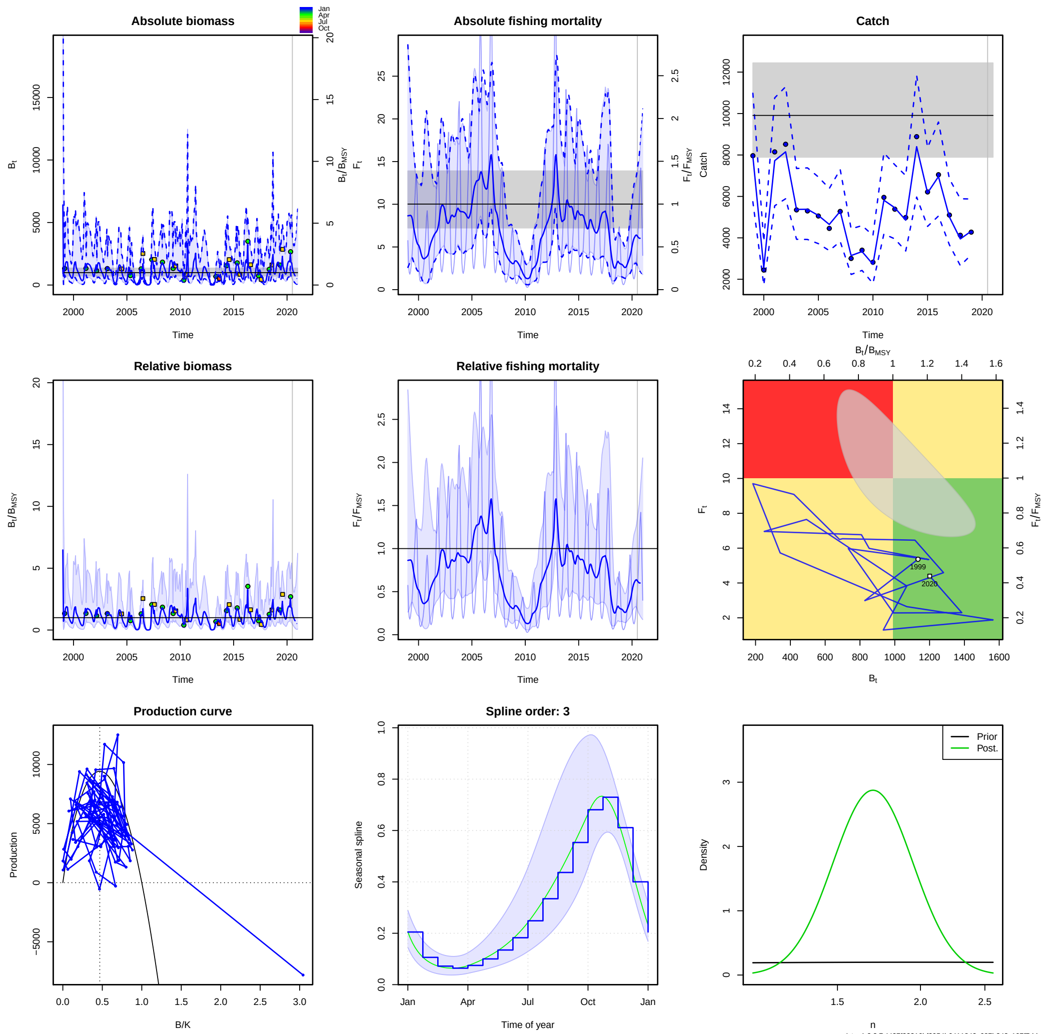

Figure 7: Summary of SPiCt results for scenario 4

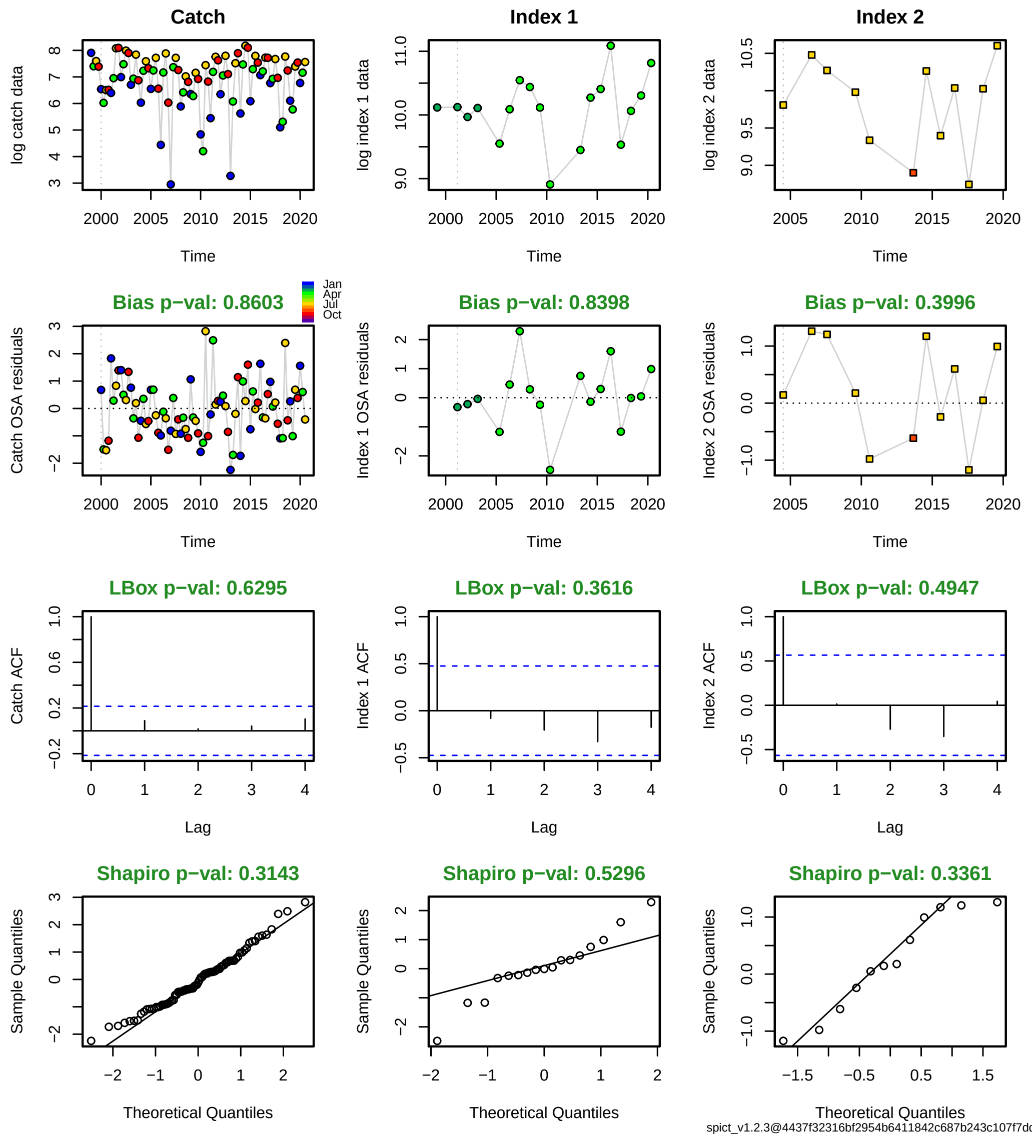

Figure 8: Summary of SPiCt diagnostics for scenario 4

5. Scenario 1 detailed model output

According to the previous plots, scenario 1 results are more consistent regarding uncertainty intervals and diagnostics, thus more detailed information about its output is presented

```
> summary(fit1)

Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 191.5553781
Euler time step (years):  1/16 or 0.0625
Nobs C: 126,  Nobs I1: 18,  Nobs I2: 12

Residual diagnostics (p-values)
    shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.0000 0.8860 0.1848 0.4021     ***    -   -    -
 I1  0.4969 0.5486 0.0474 0.1429       -    -   *    -
 I2  0.7333 0.5877 0.4134 0.8189       -    -   -    -

Priors
     logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha1    0.1500161    0.0263926 8.526944e-01 -1.8970130
 alpha2    0.2581998    0.0691201 9.645113e-01 -1.3540214
 beta      1.9976305    0.8534965 4.675506e+00  0.6919617
 r         5.5785227    1.7461581 1.782193e+01  1.7189240
 rc        6.7973357    3.0766562 1.501753e+01  1.9165307
 rold      8.6976185    3.7445113 2.020252e+01  2.1630492
 m      7573.7985299 4864.6661424 1.179165e+04  8.9324500
 K      4825.5323568 2080.7202763 1.119120e+04  8.4816763
 q1        8.0511334    3.5635780 1.818979e+01  2.0858129
 q2        6.2595990    2.6129244 1.499568e+01  1.8341161
 n         1.6413851    0.9472899 2.844055e+00  0.4955404
 sdb       1.2003848    0.6501406 2.216326e+00  0.1826422
 sdf       0.3130694    0.1375802 7.124024e-01 -1.1613303
```

```
 sdi1      0.1800770    0.0363820 8.913131e-01 -1.7143708
 sdi2      0.3099392    0.1029656 9.329548e-01 -1.1713792
 sdc       0.6253970    0.4919972 7.949667e-01 -0.4693686
 phi1      0.0819407    0.0386710 1.736256e-01 -2.5017597
 phi2      0.3789405    0.1822619 7.878550e-01 -0.9703760
 phi3      1.0525103    0.4532576 2.444036e+00  0.0511781

Deterministic reference points (Drp)
          estimate       cilow        ciupp  log.est
 Bmsyd 2228.460940 1032.323330  4810.545318 7.709066
 Fmsyd    3.398668    1.538328     7.508764 1.223383
 MSYd  7573.798530 4864.666142 11791.646640 8.932450
Stochastic reference points (Srp)
          estimate       cilow        ciupp  log.est rel.diff.Drp
 Bmsys 2039.821232 1216.082809  3421.535628 7.620617  -0.09247855
 Fmsys    4.531853    2.822374     7.276742 1.511131   0.25004892
 MSYs  9457.933044 5493.907566 16282.126408 9.154609   0.19921208

States w 95% CI (inp$msytype: s)
                    estimate        cilow        ciupp    log.est
 B_2020.50      4069.6356432 1179.4259659 1.404237e+04  8.3113088
 F_2020.50         1.4445672    0.4326156 4.823622e+00  0.3678098
 B_2020.50/Bmsy    1.9950943    0.7929830 5.019529e+00  0.6906913
 F_2020.50/Fmsy    0.3187586    0.1070864 9.488324e-01 -1.1433211

Predictions w 95% CI (inp$msytype: s)
                  prediction       cilow        ciupp    log.est
 B_2020.75      2844.3262034 690.0175239 1.172462e+04  7.9530815
 F_2020.75         1.4438795   0.4171718 4.997433e+00  0.3673336
 B_2020.75/Bmsy    1.3943997   0.4571585 4.253121e+00  0.3324640
 F_2020.75/Fmsy    0.3186069   0.1029483 9.860323e-01 -1.1437973
 Catch_2020.75  1453.1820191 629.9886794 3.352025e+03  7.2815109
 E(B_inf)       3381.8325751          NA           NA  8.1261730
```

6. Comparison of harvestable biomass estimation obtained in scenario 1 with harvestable biomass estimated by Gadget

Figures 9 and 10 show model comparison estimates of absolute (in tonnes) and relative harvestable biomass at the end of the second quarter, respectively. The models used for this comparison are, the SPiCt scenario 1 and the Gadget model used in the latest anchovy 9a South assessment (Rincón et al., 2020). The data used for the SPiCt scenario was also the same used in this assessment. In Figure 9 it can be observed that the two models present different trends mostly before 2005 (the year when PELAGO survey starts). A comparison between SPiCt estimates of harvestable biomass with catches time series (Figure 11) suggest that catches time series have a big influence on the SPiCT estimates.

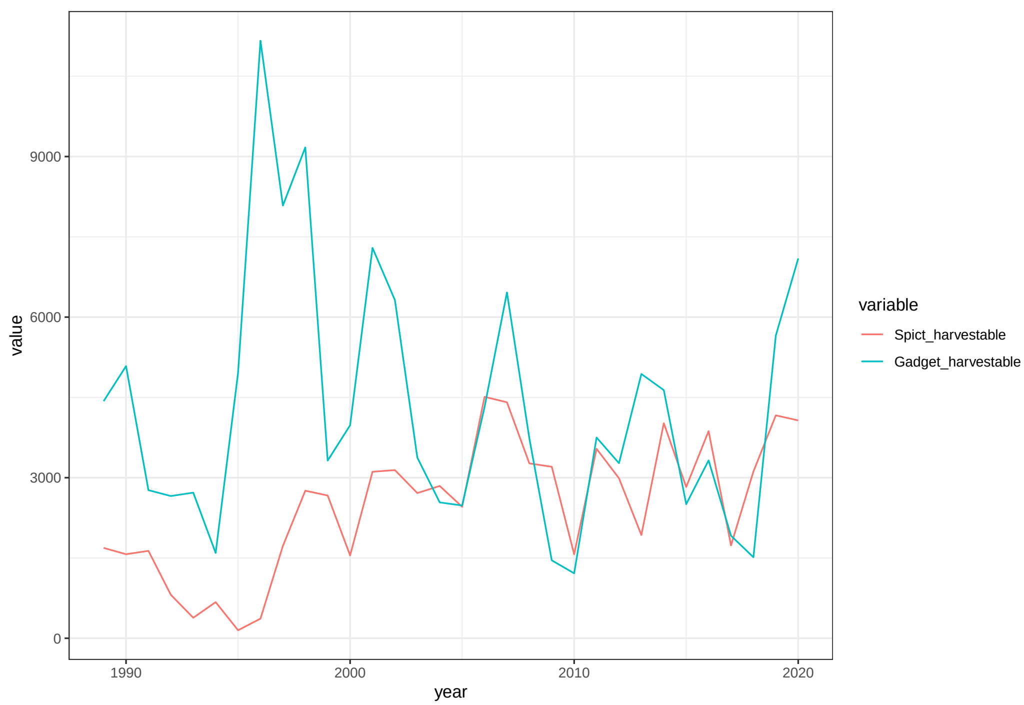

Figure 9: Comparison of absolute harvestable biomass estimates at the end of the second quarter of each year by Spict (scenario 1) and Gadget, pink and blue lines, respectively.

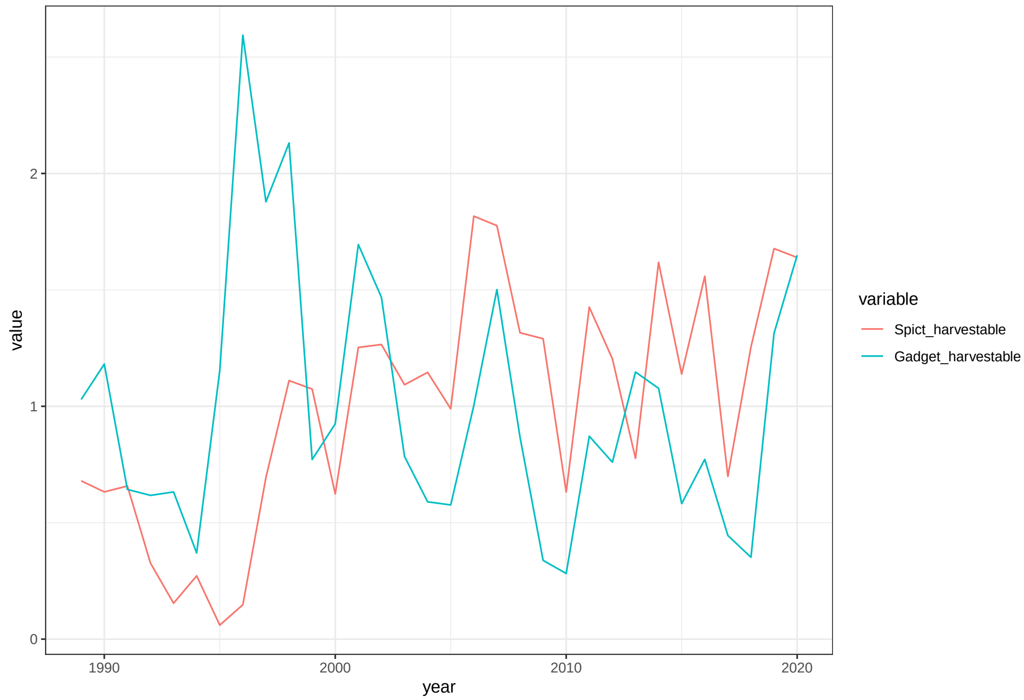

Figure 10: Comparison of relative harvestable biomass estimates at the end of the second quarter of each year by Spict (scenario 1) and Gadget, pink and blue lines, respectively.

Figure 11: Comparison of absolute harvestable biomass estimates at the end of the second quarter of each year by Spict (scenario 1) and catches time series, pink and blue lines, respectively.

7. References

Mildenberger, T., Berg, C., Pedersen, M., Kokkalis, A., Nielsen, J., 2020. Time-variant productivity in biomass dynamic models on seasonal and long-term scales. I C E S Journal of Marine Science 77, 174–187. doi:10.1093/icesjms/fsz154.

Pedersen, M.W., Berg, C.W., 2017. A stochastic surplus production model in continuous time. Fish and Fisheries 18, 226–243. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/faf.12174, doi:10.1111/faf.12174, arXiv:https://onlinelibrary.wiley.com/doi/pdf/10.1111/faf.12174.

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