Recruitment variability in simulation projections

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This short document has been produced for the purpose of assisting SWG-PEL members and observers to understand the potential influence of the stock-recruitment curve on future projections of the resource. The examples shown in this document have been produced assuming a single sardine stock operating model and the current Candidate Management Procedure for OMP-14 (de Moor 2014, but with a constant maximum directed sardine TAC of 110% of the original HCR value for survey estimates of November biomass between 300 and 600 000t; $\beta = 0.085$ and $\alpha_{ns} = 0.911$). Figure 1 shows the full range of future spawning biomass (i.e. sardine aged 2+) and November recruitment pairs for the 20 000 future simulated years.

The simulated future recruitments are dependent on the model predicted spawning biomass, the stock recruitment relationship, and error assumed about the stock recruitment relationship with associated autocorrelation.

There are 1 000 sets of stock recruitment relationships used when projecting – one for each simulation of 20 consecutive years. Figure 2 contains a small selection of these 1000 simulations to show some examples of the differences in these stock recruitment relationships. The inclusion of error about the stock recruitment relationship decreases the influence of the assumed stock recruitment relationship on future recruitment (contrast Figures 2 and 3).

The influence of the stock recruitment relationship can be seen, for example, when contrasting Figures 2a) and 2b) or Figures 4a) and 4b) which have similar starting points, but the starting point in the "b)" plots is closer to the point above which maximum recruitment would be assumed to occur (without error). Thus there is a greater chance that maximum recruitment will be achieved under the "b)" plots and spawner biomass will grow. However, the maximum (median) recruitment is lower in the "b)" than in the "a)" plots. Thus spawner biomass growth could be faster under the "a)" plots once higher recruitments are achieved.

The influence of the starting point can be seen, for example, when contrasting Figures 2c) and 2d), Figures 3c) and 3d) or Figures 4c) and 4d) which have similar stock recruitment relationships, but the starting points in the "c)" plots are lower on the stock recruitment relationship than the "d)" plots and thus is takes longer in the absence of error to reach a point where maximum recruitment can be achieved.

The standard deviation of the distribution from which each random error about the stock recruitment relationship is drawn is the same (0.45) for all simulations. However, for simulations with high (absolute) autocorrelation, the resultant

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error would be less random and rather influenced by the error of the preceding year. The average correlation coefficient for these simulations is 0.31, with less than 1% of simulations having a very small negative coefficient. There are also no very strong positive correlations, with less than 1% of simulations having a correlation coefficient greater than 0.56. The influence of positive autocorrelation in recruitment can, however, be seen to some extent, for example, in the initial years[1] of Figures 2e) and 2f) compared to 4e) and 4f), where the correlation coefficients for these simulations are 0.64 and 0.60, respectively. Figures 5 and 6 show the time series of residuals for these cases, with the residuals for the time series including autocorrelation being closer to that of the previous year than those without.

References

de Moor, C.L. 2014. OMP-14: Alternative initial directed sardine TAC rules. Department of Agriculture, Forestry and Fisheries Document FISHERIES/2014/OCT/SWG-PEL/53. 21pp

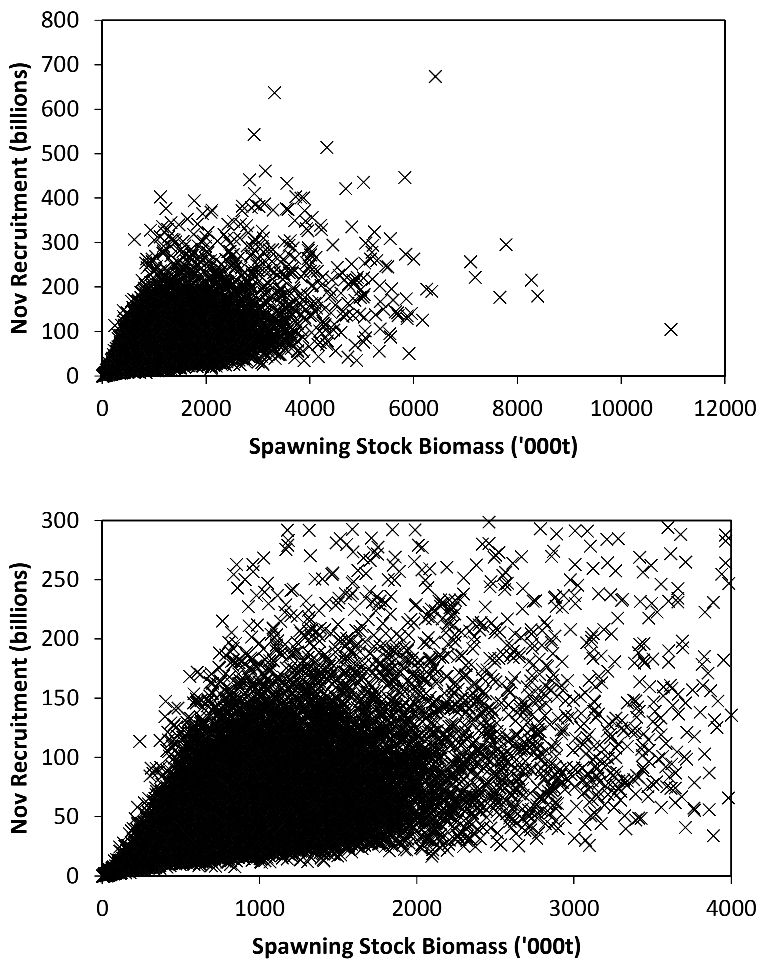

Figure 1. Future sardine recruitment (in November) plotted against spawner biomass. The lower plot is a repeat of the upper plot, but over a smaller range.

[1] The differences in the latter years of the time series are confounded by differences over time in the spawner biomass between the time series.

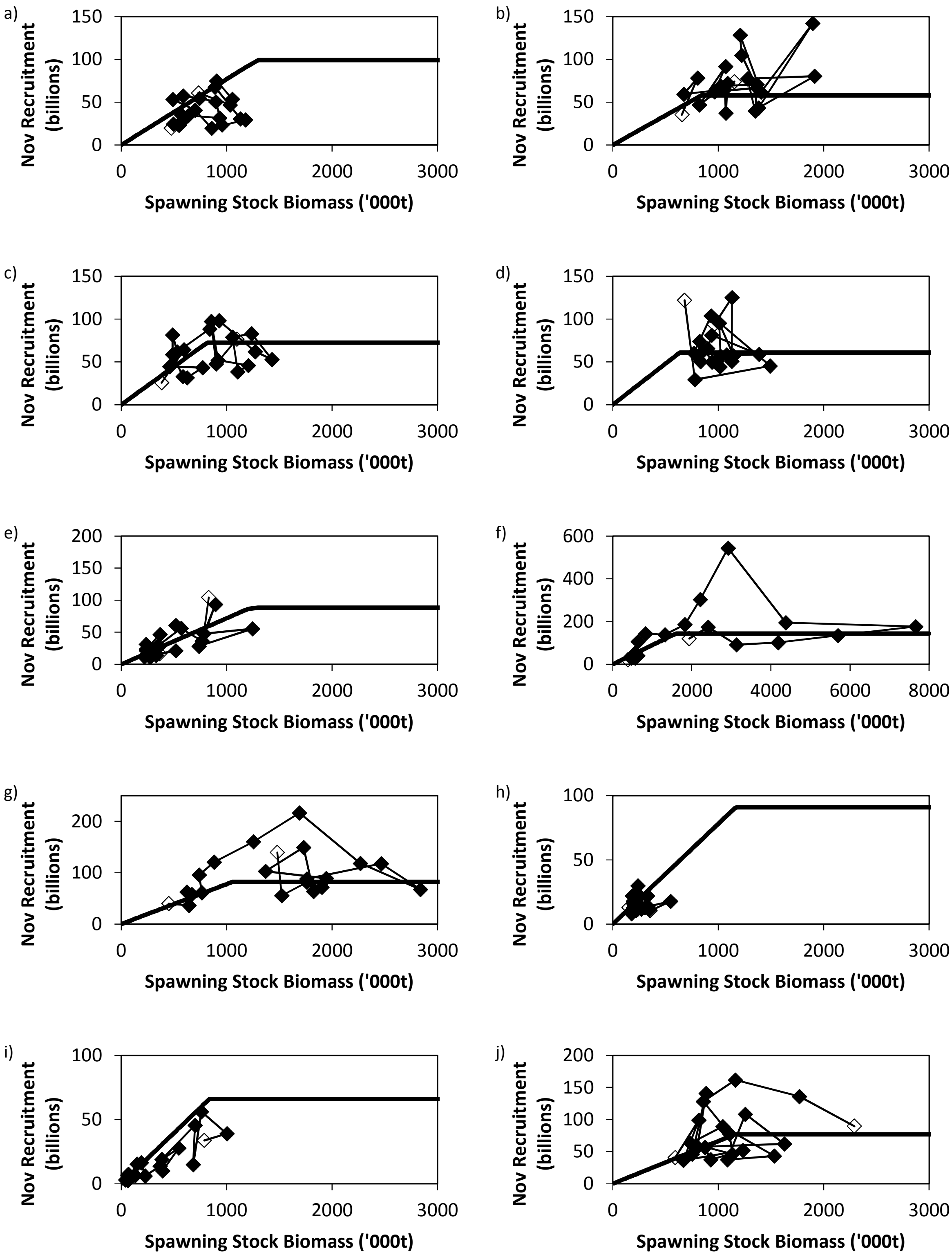

Figure 2. Future sardine recruitment (in November) plotted against spawner biomass, with the associated Hockey Stick stock recruitment relationship for 10 out of 1000 simulations. Note that the range of the vertical axis differs between the plots. The first and last year of each simulation are indicated by open diamonds.

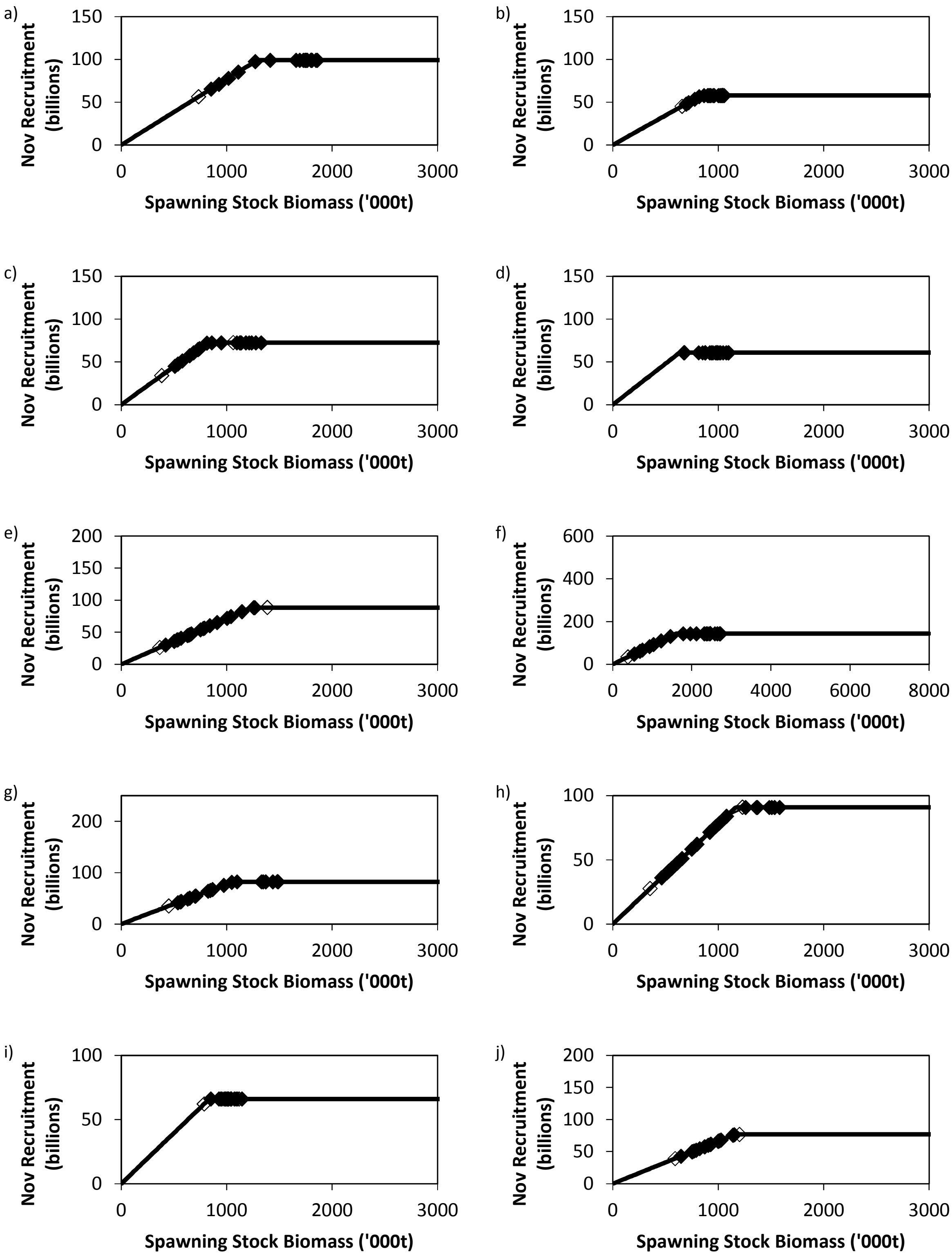

Figure 3. As for Figure 2, but without any error about the stock recruitment relationship.

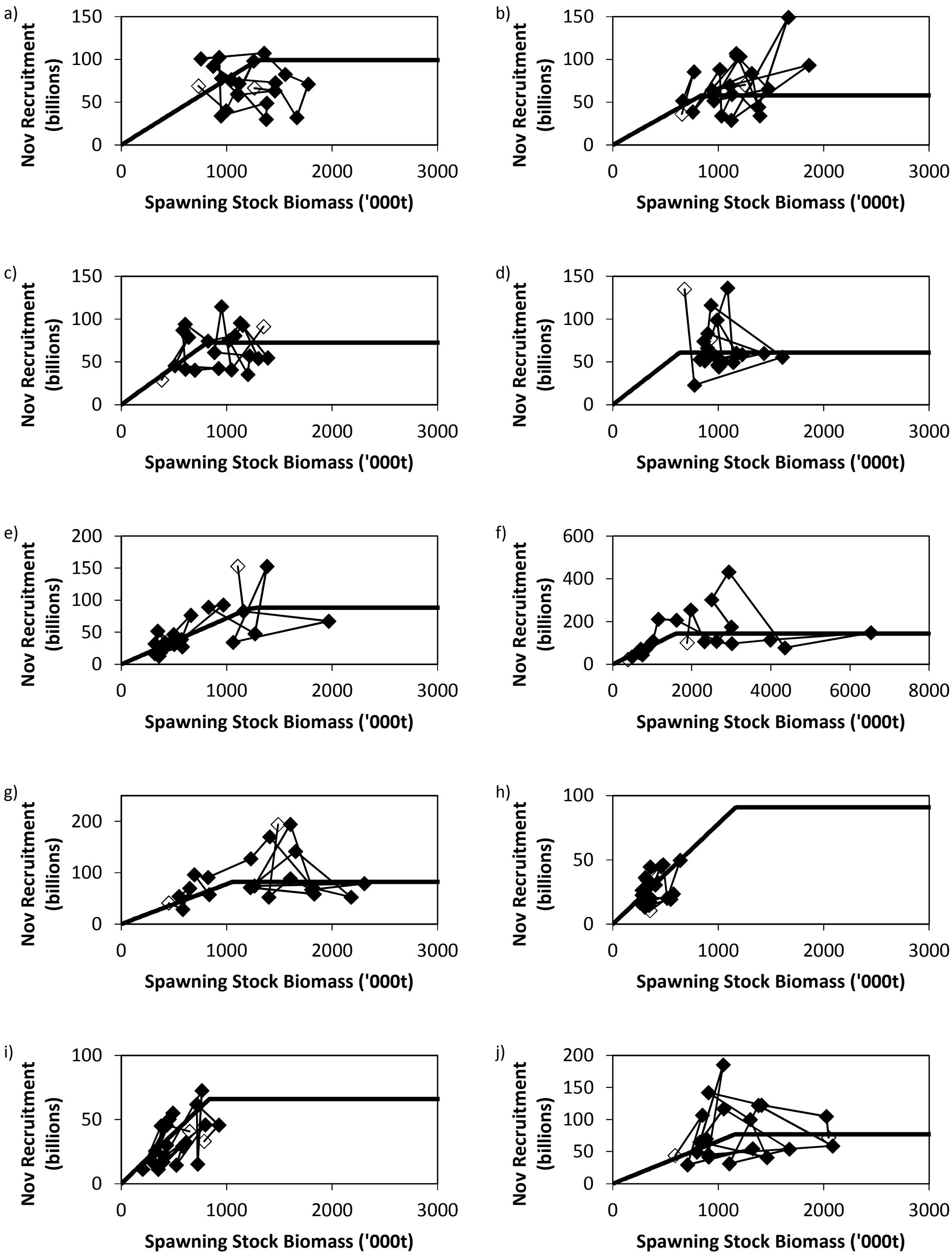

Figure 4. As for Figure 2, but without any autocorrelation in the future sardine recruitment.

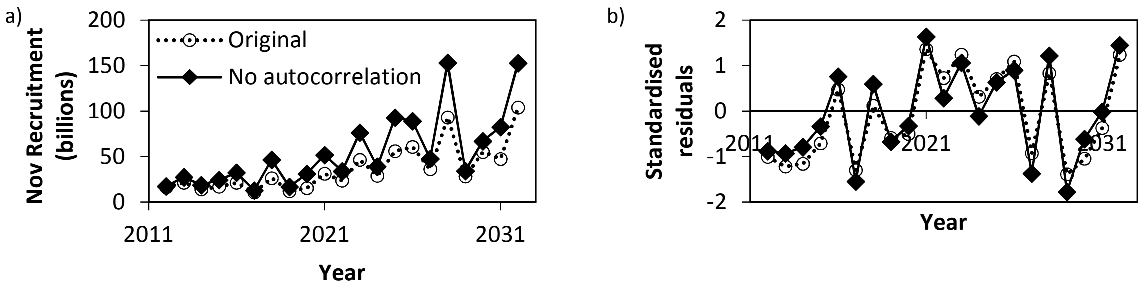

Figure 5. The time series of a) November recruitment and b) standardised residuals corresponding to Figures 2e and 4e.

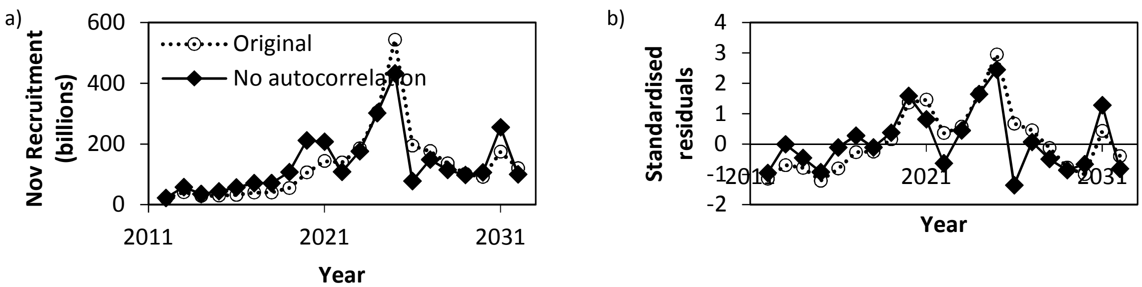

Figure 6. The time series of a) November recruitment and b) standardised residuals corresponding to Figures 2f and 4f.