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Process and observation errors of SPMs in MSEs – how to estimate these ?

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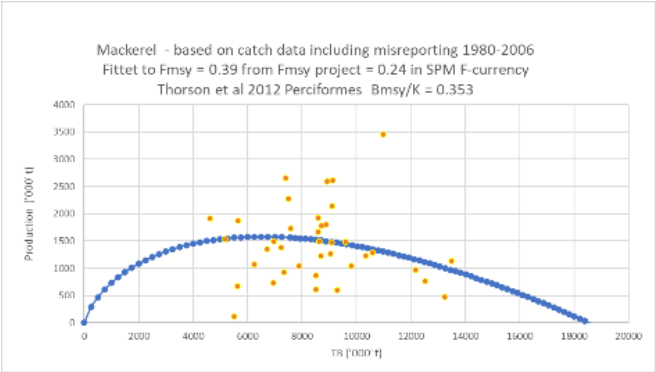
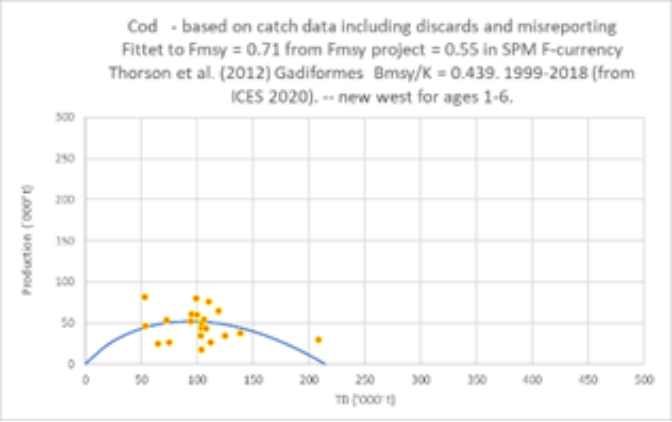
Six stock examples of final SPMs – quite variable annual production vs. TB = Total stock Biomass – reflecting variable production and observation error

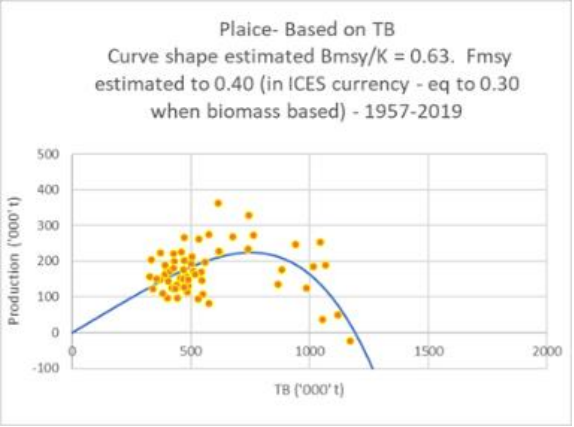
Mackerel - Northeast Atlantic



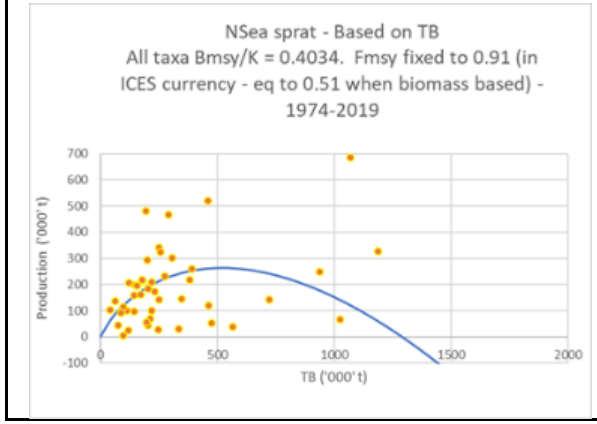
Cod - North Sea



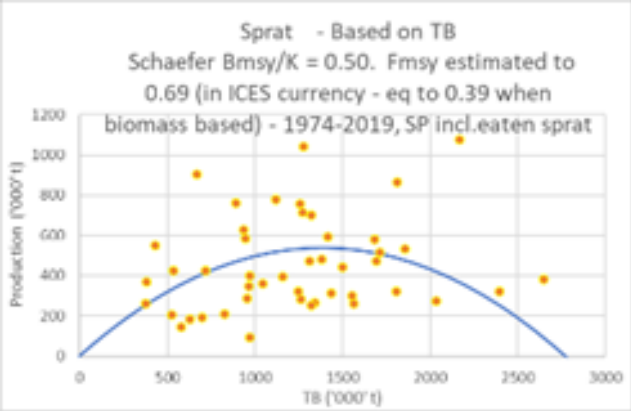
Plaice - North Sea



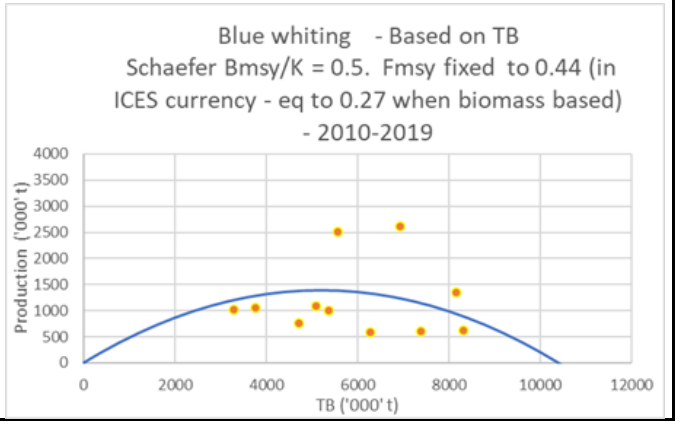
Sprat - North Sea



Sprat - Baltic Sea



Blue whiting - Northeast Atlantic



- The plots in the previous slide are based on the converged part of the assessments, as this is the best available information about historic stock sizes.

- For MSE using SPMs we need the:
  - process error of the annual production S, for each stock size TB
  - observation error of TB at the start of the TAC year in each year in the simulations

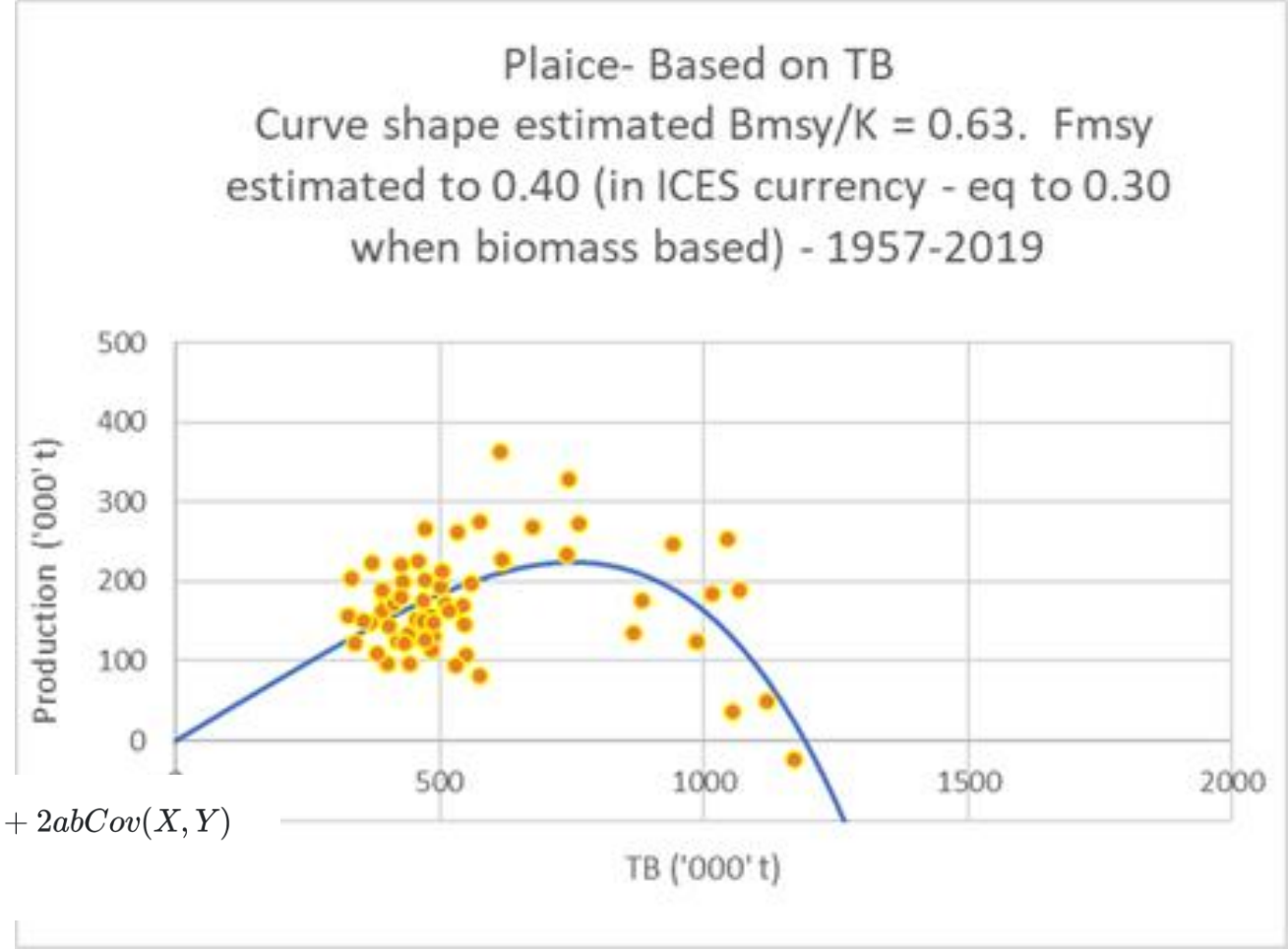
Quite some variation around the model

- Is variation errors?
- The SPM model is not “the truth” – SPM+process errors is closer to “the truth”.
- The observations errors are not only errors in observations here, because it comes from the historic assessment (the CV of TB at the start of the TAC year, where it is both real observation error like errors in age determinations, and process errors using e.g. the SAM model). However, we can probably regard it as observation error with respect to input to the MSE based on SPMs.

Process error

SPM based on TB from ICES assessment, and production is: catch+TB(y)-TB(y-1)

North Sea plaice



– not all variation here is process error.

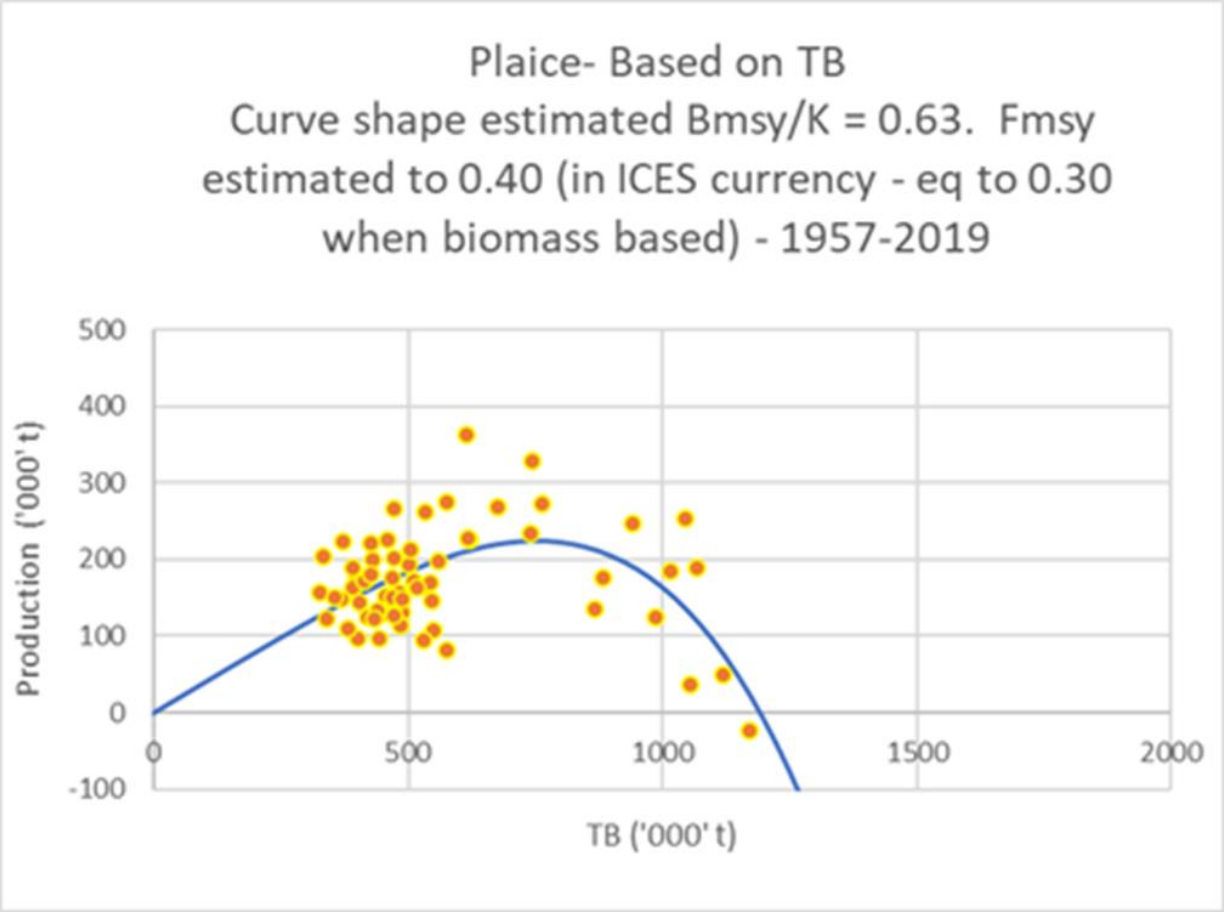
Total stock biomass (TB) even for converged part of the assessment has some observation error (and actually process error connected to SAM which here will be regarded as observation error).

Production has observation error in catch and in TB(y)-TB(y-1). Remember: Var(a-b+c)=Var(a)+Var(b)+Var(c) +covariance

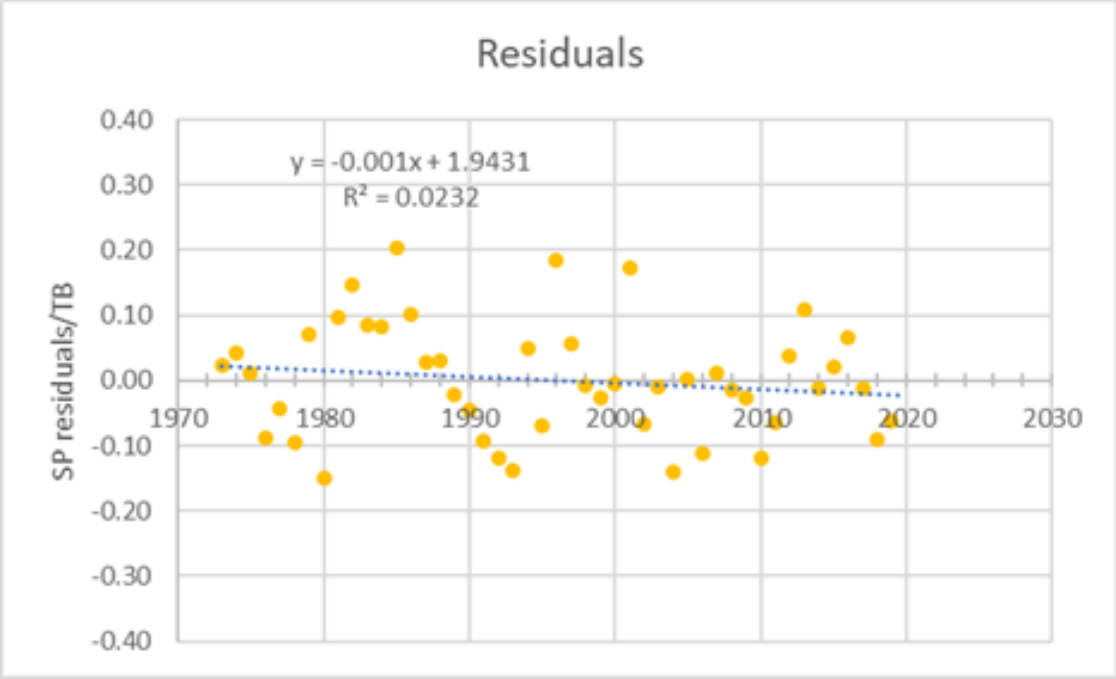
$$Var(aX + bY + cZ) = a^2 Var(X) + b^2 Var(Y) + c^2 Var(Z) + 2abCov(X, Y) + 2acCov(X, Z) + 2bcCov(Y, Z)$$

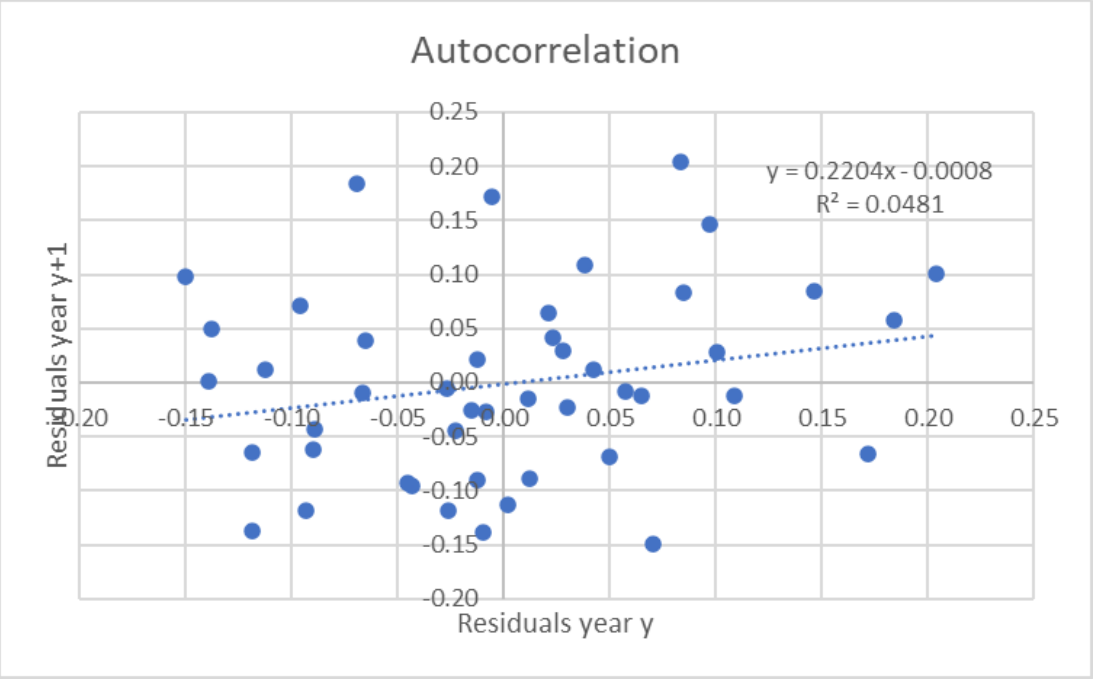
A CV linearly related to TB seems the obvious choice

Autocorrelation in process error



Does this indicate autocorrelation in process error? …not much in this case





Process error

Probably not much autocorrelation in process error – this little we see could be from the autocorrelation in the assessment TB?

CV of residuals around the SPM curve are likely overestimates of process error due to observations errors in historic assessment.

Process error

At least the CV of TB, available from many the assessments, should be subtracted. IF CV of the catch is also available, this could also be subtracted?

A fifty-fifty split of the CV might be a “good practise”?

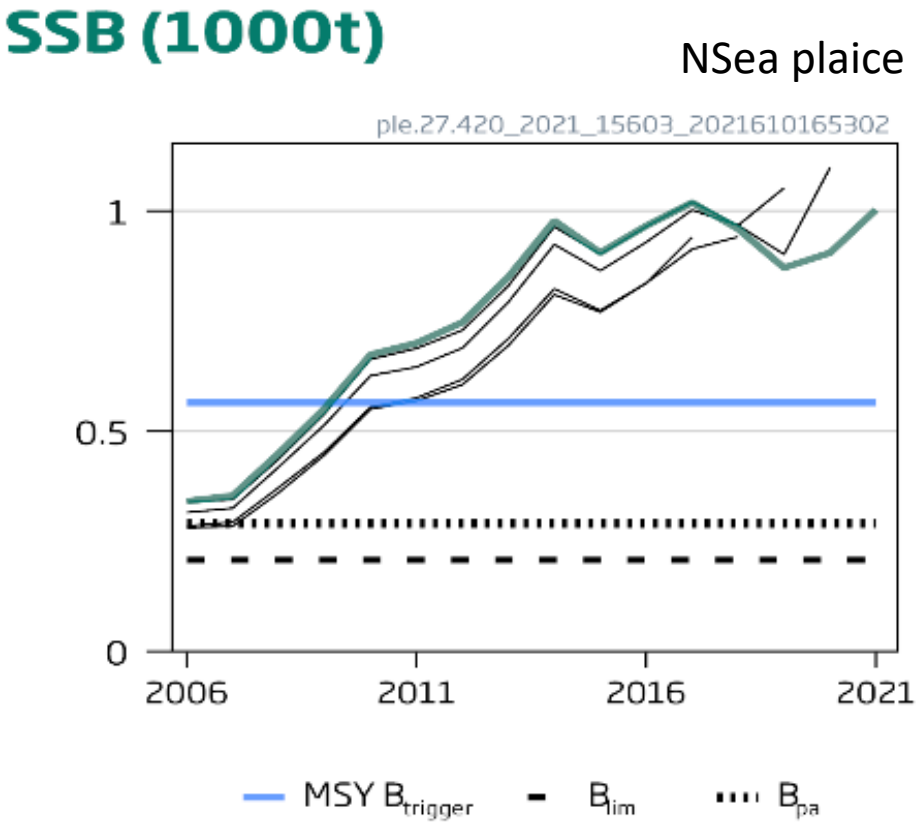
Observation error

The ICES retrospective plot represents SSB 2 years before the start of the TAC-year – the best we have easily available for observation error of SSB. Observation error of TB is probably similar to that of SSB.

CV about 0.10-0.20?

Only little autocorrelation it seems

NSea plaice



ICES Guidelines - WKGMSE2 2019

- "*Assessment uncertainty in the projections can be estimated using analytical assessment retro-spectives with a number of peels* (i.e. years removed, one by one) *between 10 to 15*"

We could alternatively go through all ICES advice sheets from the past years and extract the SSB (or TB) at the start of the TAC-year and calculate the CV and autocorrelation in relation to the most recent assessment ?

Would that be better?

We often run into problems of changes in stock definitions, changes in discard data, changes in M in the time series …

Meta –analysis

- If we have analysed many stocks - each probably of a quite short time period with consistency – we might get some useful info about observation error which could be used as a prior or in an model-ensemble approach.

Some assessment models that integrates short-term prediction (SS? SAM? Others?) give the CV of TB at the start of the TAC-year directly.

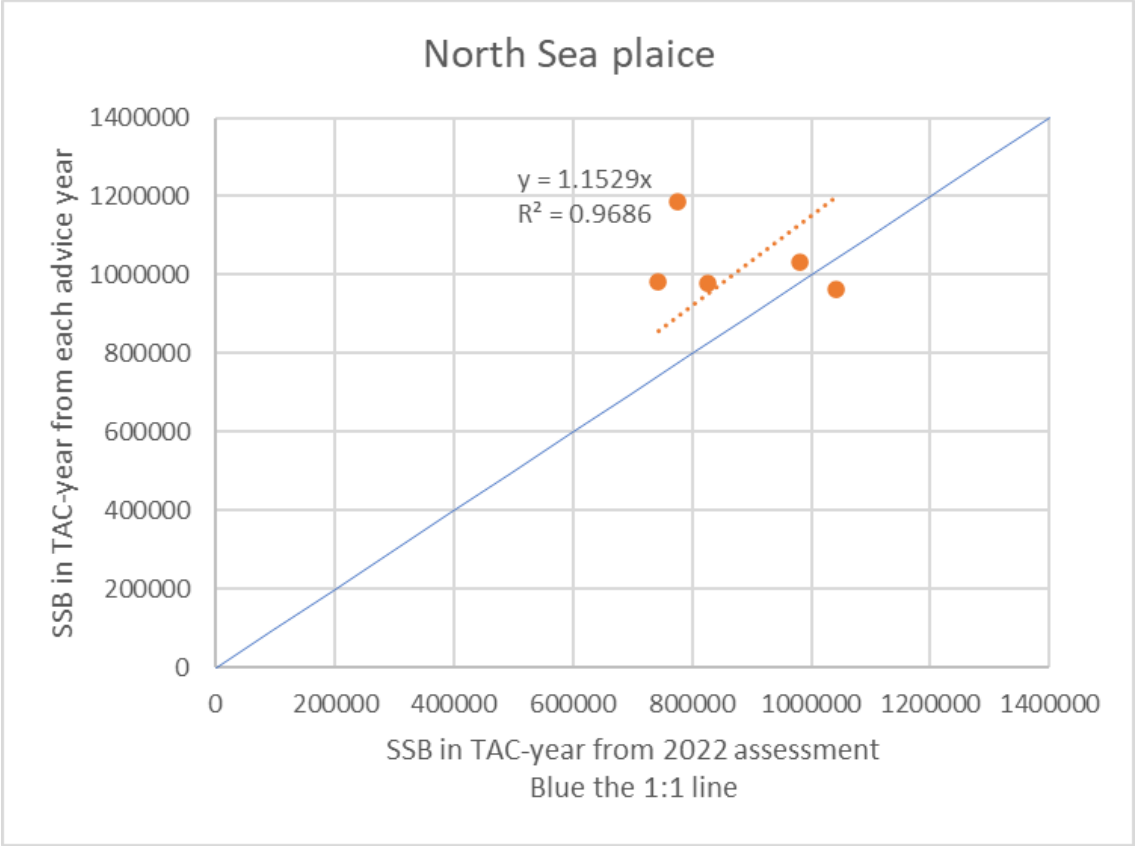
…do they give autocorrelation that is relevant? – they probably could do.

it is of course not a “real” retrospective approach – but it might be close enough until a new benchmark assessment is agreed.

Observation error

This stock changed definition in the 2015 advice to include Subdivision 20 (Skagerrak) – therefore only 5 data points to determine CV and autocorrelation

CV = 0.27
Autocorrelation = 0.45



Observation error

Thorson, J. T., Jensen, O. P., and Hilborn, R. 2015. Probability of stochastic depletion: an easily interpreted diagnostic for stock assessment modelling and fisheries management. – ICES Journal of Marine Science, 72: 428–435.

Autocorrelation formula:……not sure this is the best one but probably ok?

$$\varepsilon_t \sim N\left(\rho\varepsilon_{t-1} - \frac{\sigma^2}{2(1-\rho^2)}, \sigma^2\right)$$

σ^2 conditional variance

ρ autocorrelation

Ralston et al.(2011) : A meta-analytic approach to quantifying scientific uncertainty in stock assessments

- Results indicate that for 17 groundfish (US westcoast) and coastal pelagic species, the mean coefficient of variation of terminal biomass is 18%. In contrast, the coefficient of variation ascribable to model specification error (i.e., pooled among-assessment variation) is 37%.

Observation error

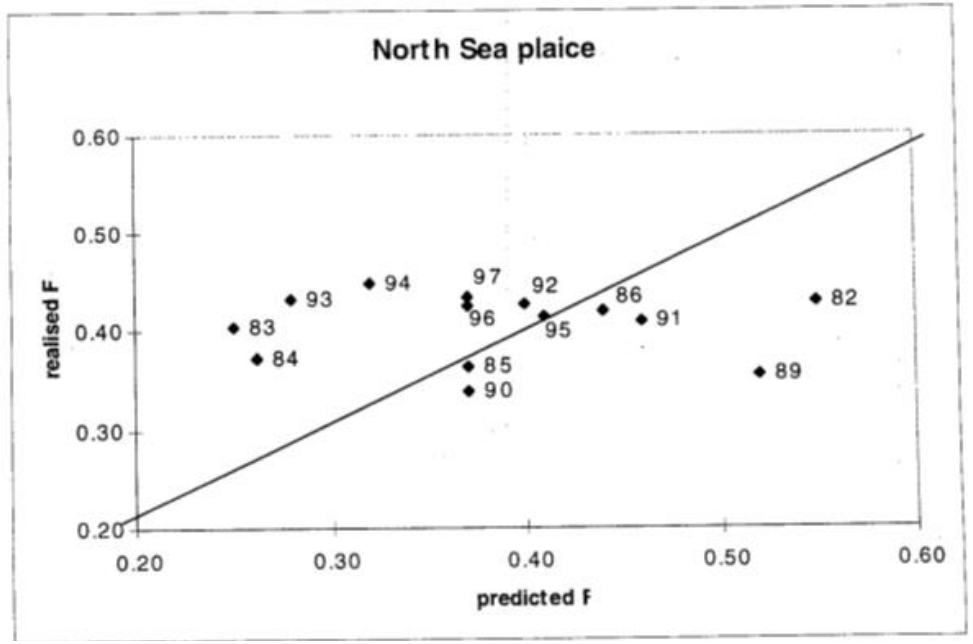
International Council for
the Exploration of the Sea

ICES C.M. 1999/R:04
Theme session:
Fishing Capacity, Effort and mortality

Evaluating ICES catch forecasts: the relationships between implied and realised fishing mortality

F.A. van Beek and M.A. Pastoors

Figure 4 North Sea Plaice For legends see Fig.1.



Relationship between implied F according to WG catch forecast (Y-axis) and realised F in latest prediction WG 1998 (X-axis; labels without points indicate years in which implied F is outside the scale).

Observation error

WG DOC ACFM May 2002

Quality of ACFM advice: **How good have forecasts been since 1988**?

By

Mette Bertelsen and Henrik Sparholt

SSB in TAC-year+1 given the catch in the TAC-year.

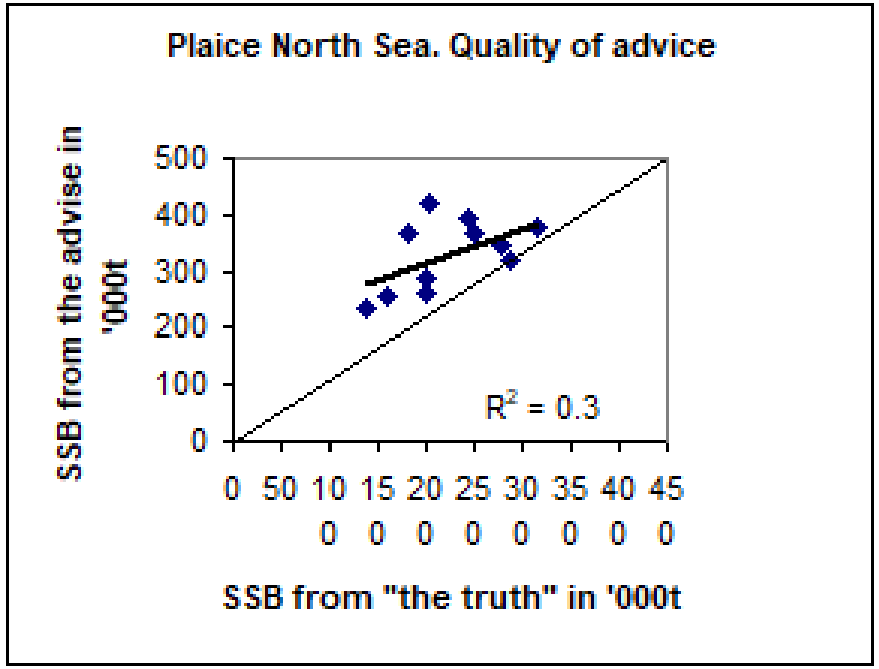


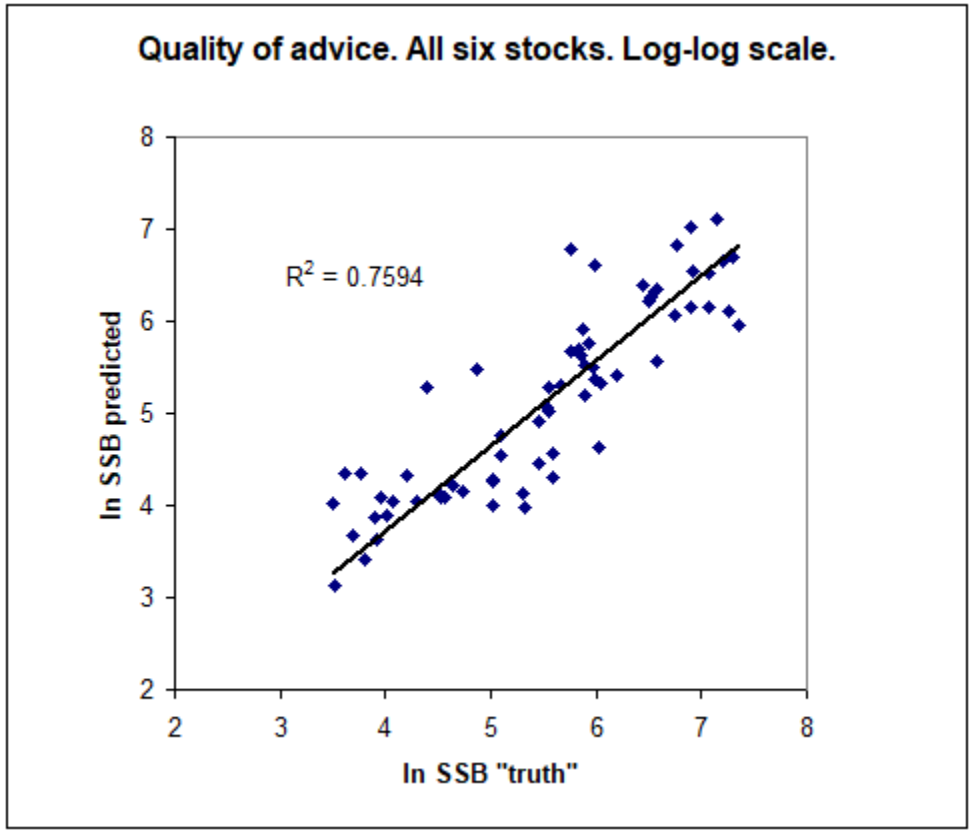
Figure 1. Forecasted SSB in “TAC year”+1 plotted against “true SSB”.

Quality of ACFM advice: **How good have forecasts been since 1988**?

Observation error

By

Mette Bertelsen and Henrik Sparholt



Forecasted SSB in the “TAC year”+1 plotted against the “true SSB”. All stocks on the same plot.

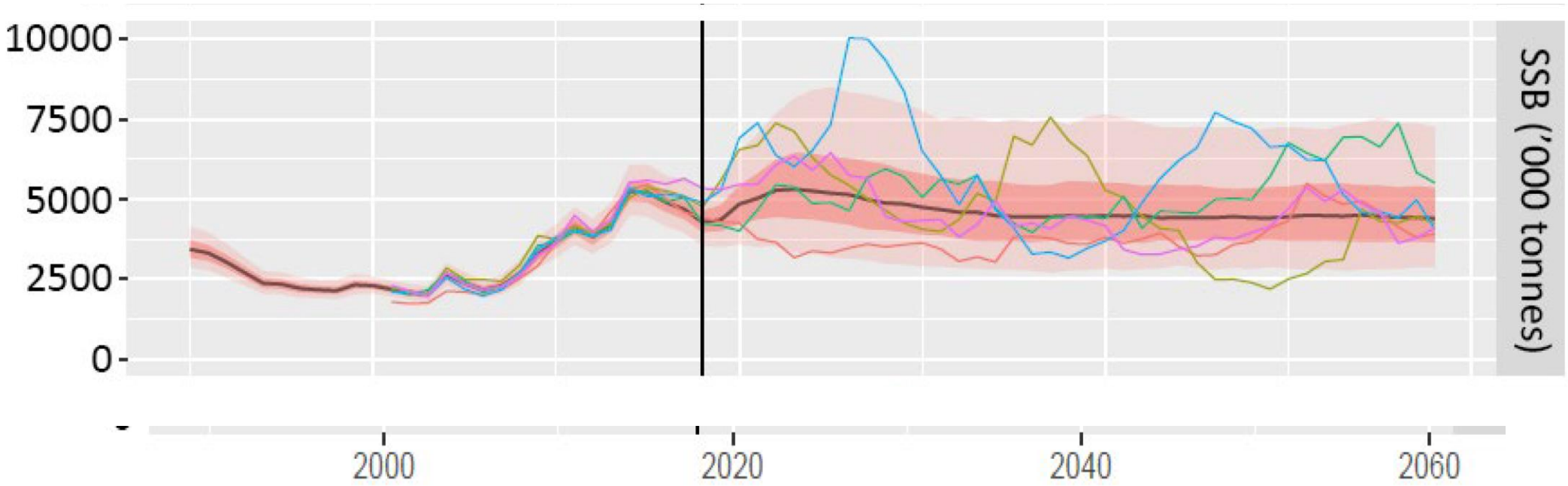
Based on a regression analysis (Figure 2) CV is on average 54%.

Ralston et al (2011) got 55%

Observation error

From ICES advice 2020 – MSE of mackerel

CV of SSB seems to around 15% but not clear if this is observed SSB or true SSB



line represents the median value with the darker shaded area, indicating the 25th and 75th percentiles, and the light shaded area the 5th and 95th percentiles. The results for five individual iterations are shown as solid coloured lines.

From ICES WKMSEMAC 2020 - CV of SSB observed also about 20%

Observation error

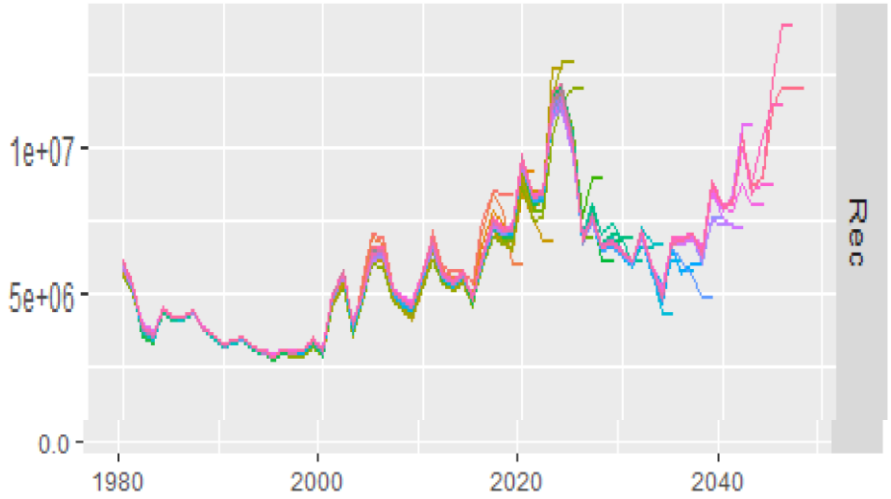


Figure 3.5.7. Comparison of the successive assessment output for a single iteration in the simulations

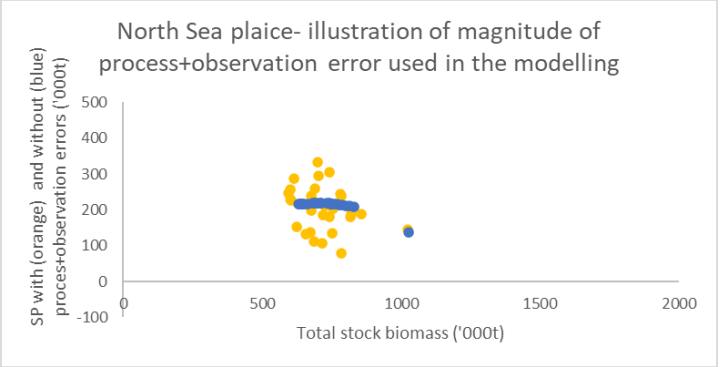
What can we conclude from these analysis?

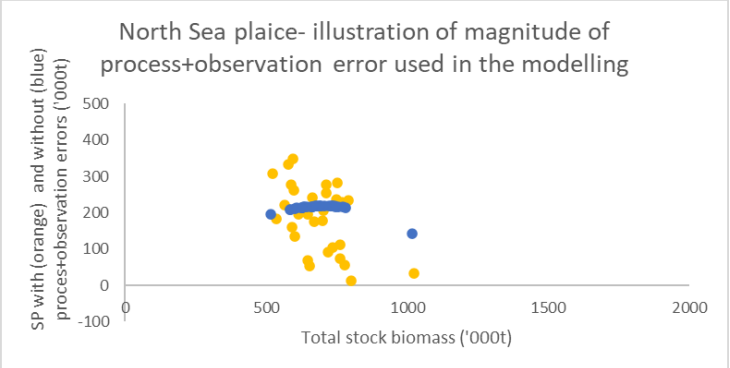
- CV about 0.2-0.5 of observation error of TB in the TAC-year and auto-correlation apparent.

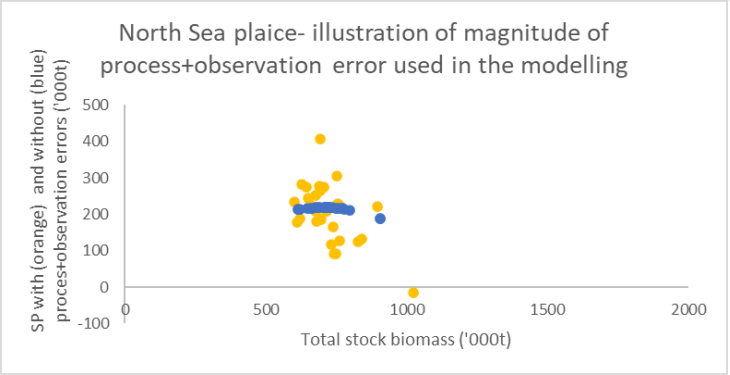
Process and observation error

If we in the MSE mimic the variation around the SPM model are we then about OK?

…or should the variation be larger?





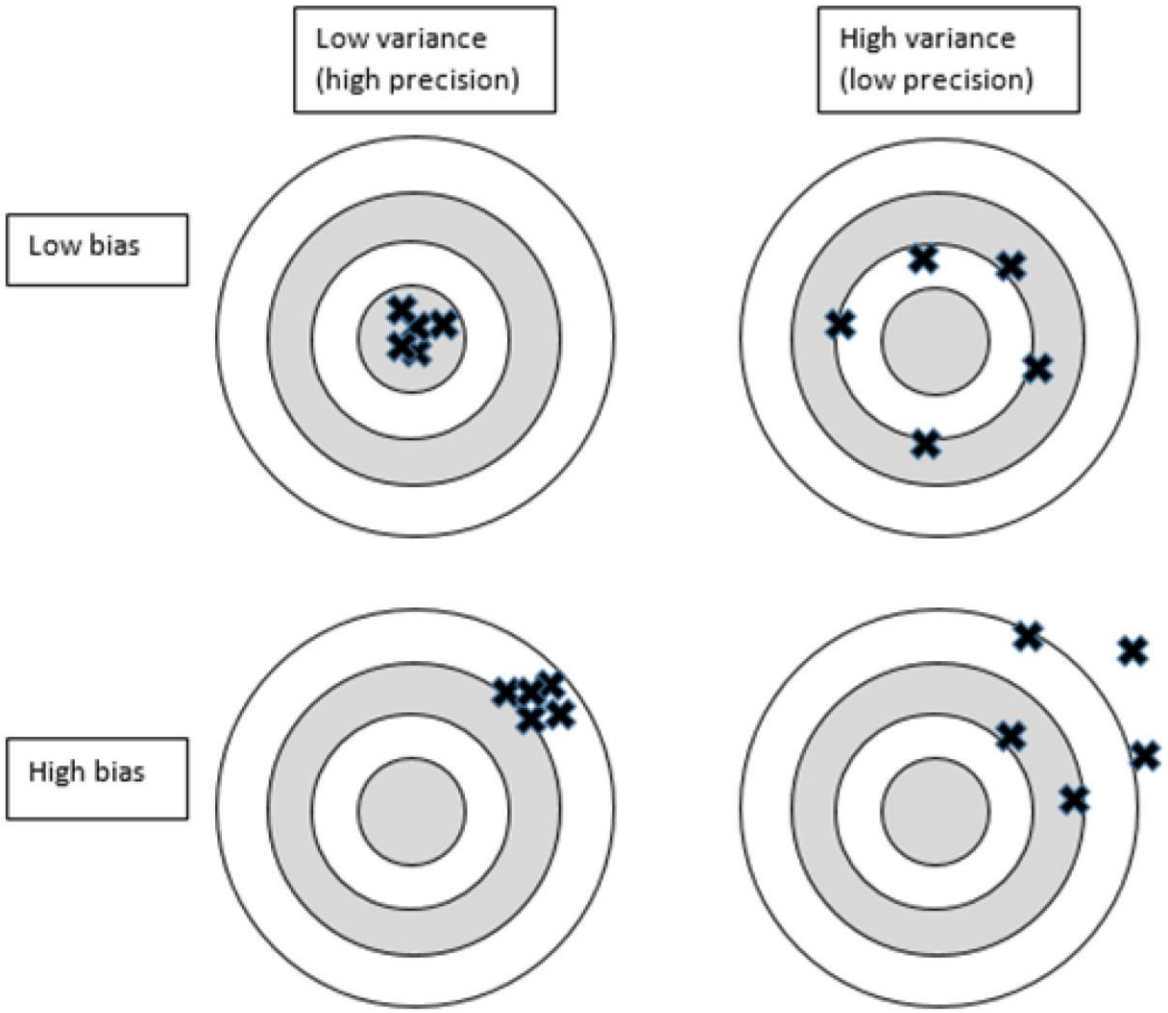


Conclusion - tentative

- Process error: CV of residuals around the SPM curve are likely overestimates mainly due to observations errors in historic assessment. Only little autocorrelation. A fifty-fifty split might be a "good practise".
- Observation error: CV of TB ideally taken from ICES advice sheets TAC-year TB estimates, compared to the most recent assessment TB estimate by year – autocorrelation calculated on the same basis. Some assessment models that integrate short-term predictions give this already –it is of course not a "real" retrospective approach, but it might be close enough until new benchmark assessment is agreed. Use the Thorson *et al.* (2015) formula to get parameters.

Thank you !

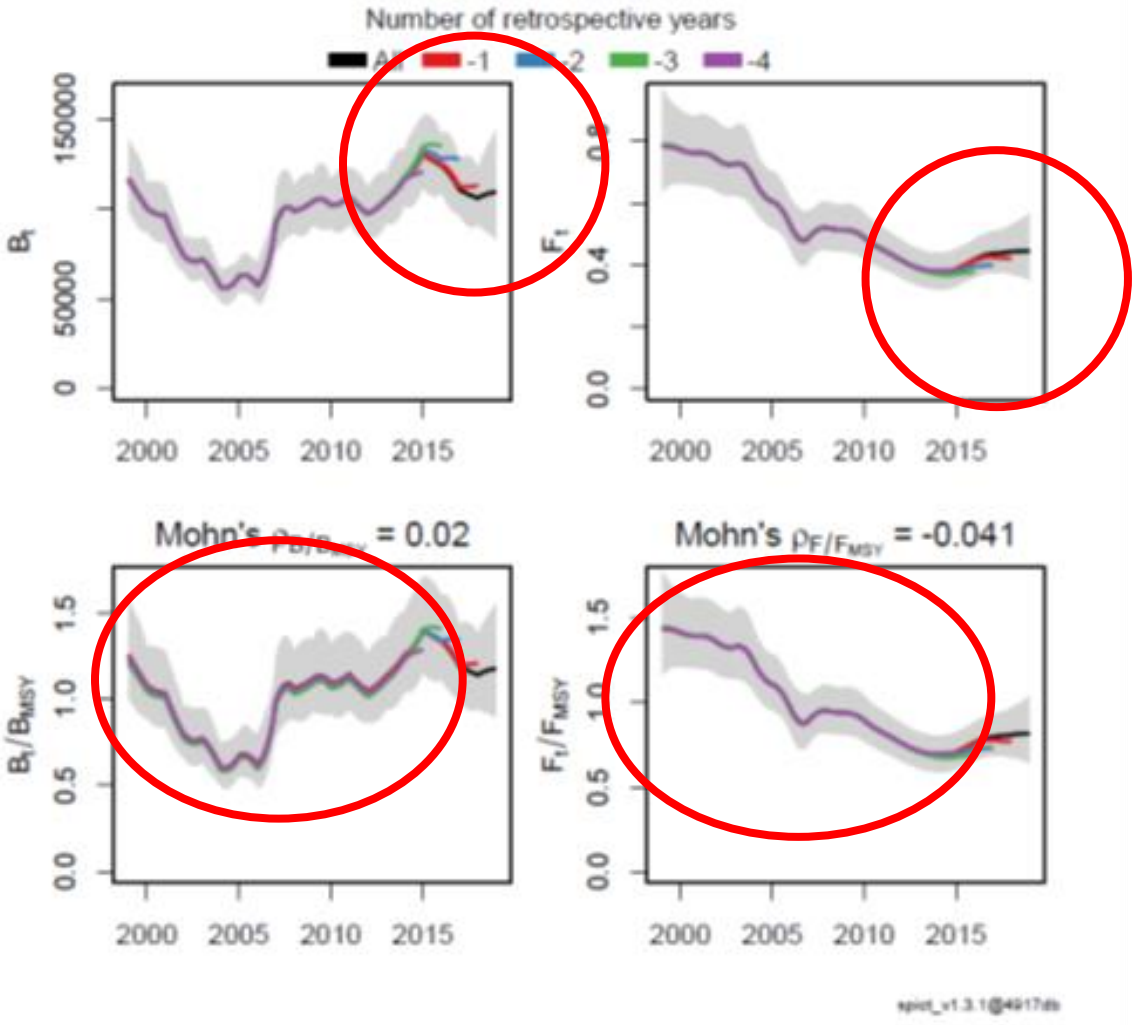
- Supplementary slides


Low variance
(high precision)
High variance
(low precision)
Low bias
High bias

Sprat - North Sea…very robust to adding a new data year

SPM model #6	Number of para-meters estima-ted	Bmsy/K (curve shape parameter)	R^2	AICc	SSBmsy '000' t	MSY in '000' t	K (Carrying capacity) '000' t	MSY/ TBmsy (Fmsy)
1996-2015	1	0.265	0.70	22.5	227	186	1388	0.51
1996-2016	1	0.265	0.71	22.4	232	191	1421	0.51
1996-2017	1	0.265	0.71	23.6	233	191	1426	0.51
1996-2018	1	0.265	0.71	24.4	231	190	1416	0.51
1996-2019	1	0.265	0.71	25.1	234	192	1429	0.51

Cod - North Sea…retrospective analysis using SPiCT, quite robust



Caveat for this and the previous 2 slides – it is only the SPM which have been tested – not the annual assessment it is based on.