The impact of natural mortality on reference points and management strategies of forage fish populations

Nis S Jacobsen[1]

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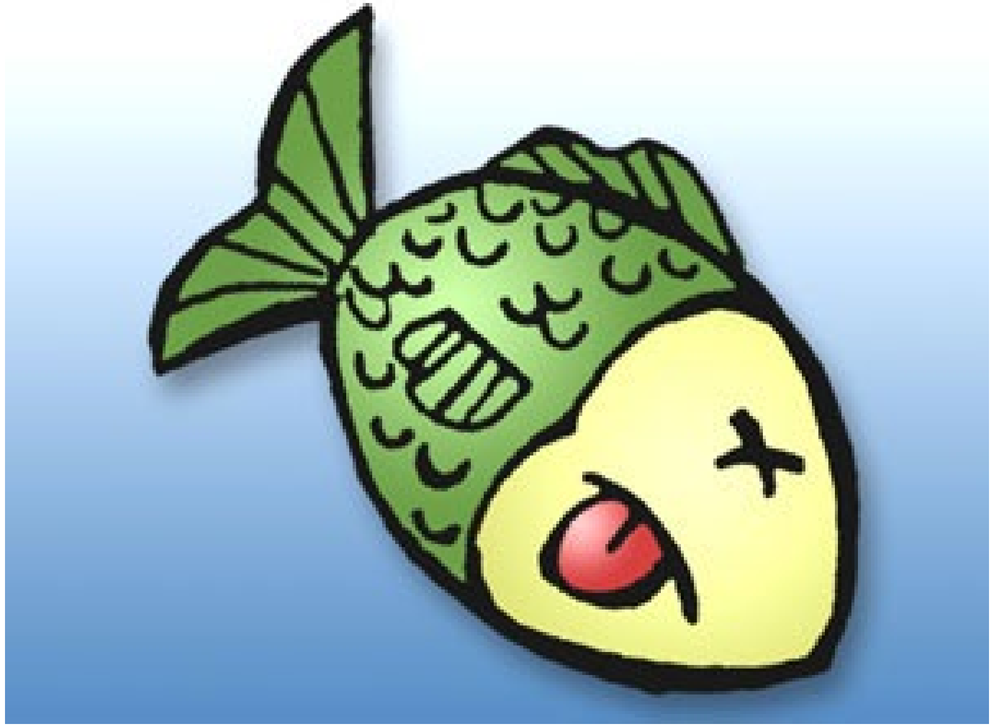
DTU Aqua, Technical University of Denmark
Twitter: @nissandjac
Email nsja@aqua.dtu.dk

Introduction – Forage fish and natural mortality



How can we estimate natural mortality

- Multispecies models
- In integrated assessments as either a random walk, or a constant variable
- Life history parameters
- Guessing?
- But mostly we do not…..

M = ?

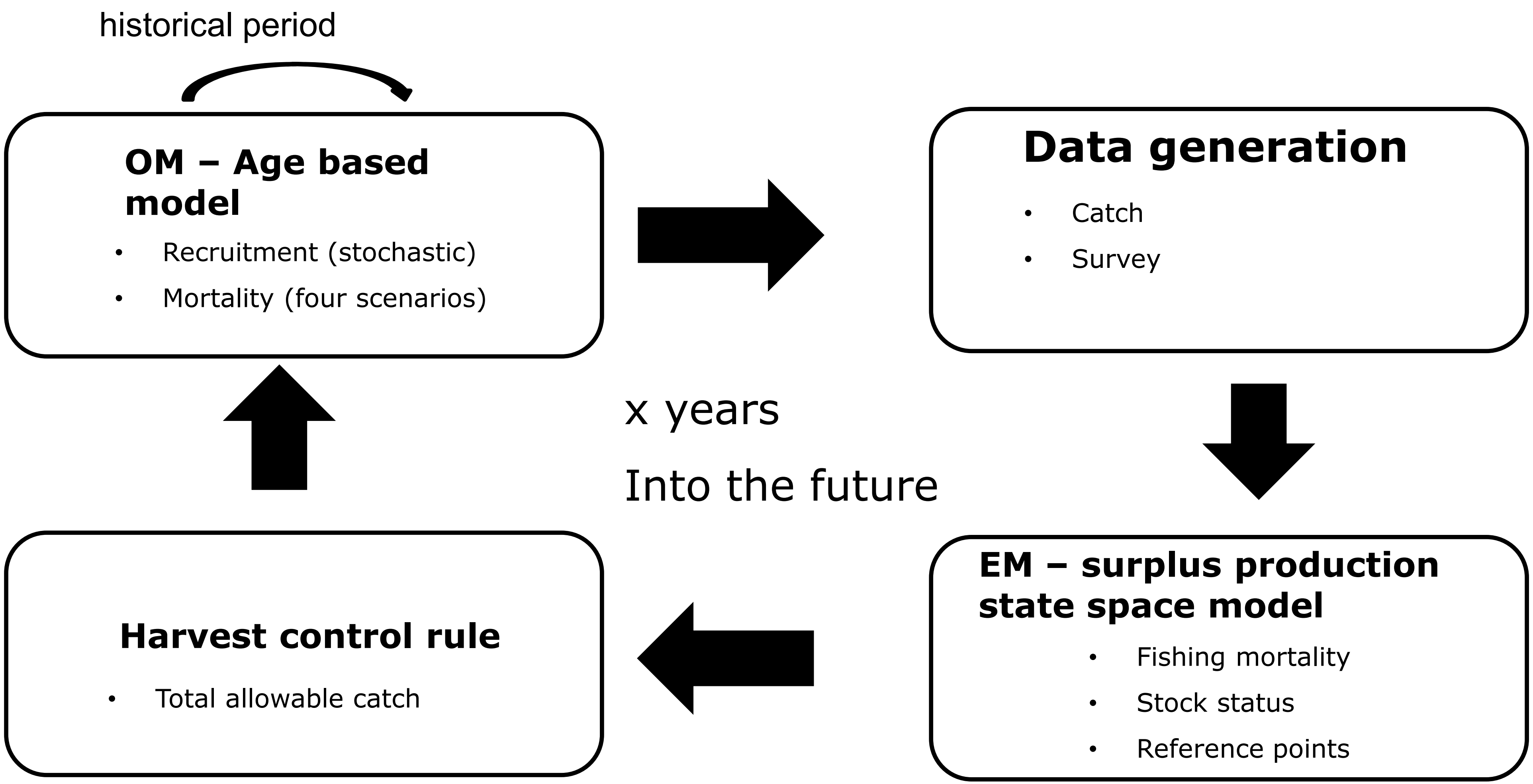
M = .?

M = .2

Issues

- Changes in natural mortality can't be observed
- In models the signal is hard to distinguish from recruitment, selectivity and fishing mortality
- Data doesn't support estimation of time varying parameters
- Sufficient data is rarely available to perform full integrated age based models
- It's uncertain what changes in time varying mortality does to management of exploited stocks

Methods - management strategy evaluation

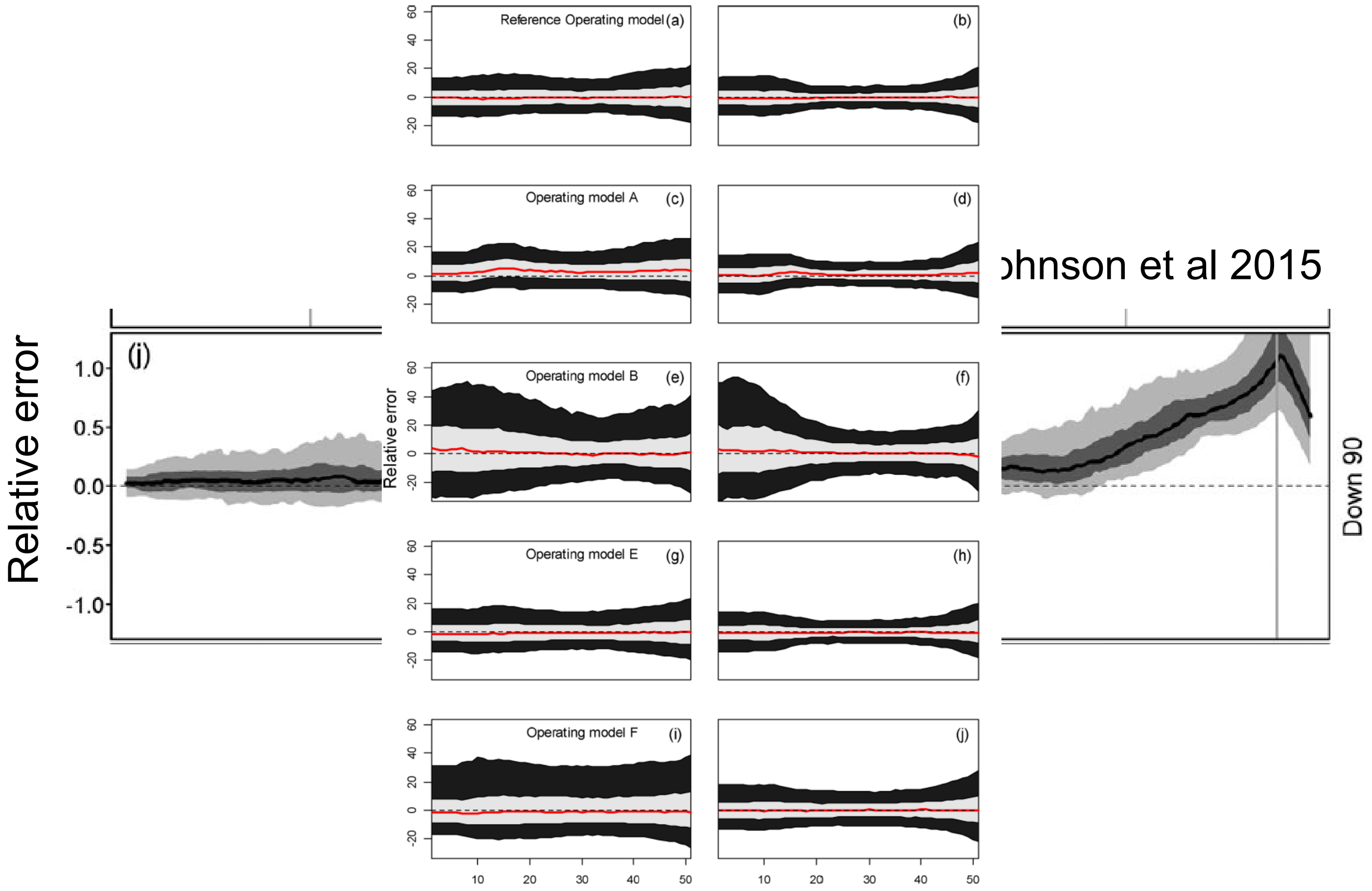


Research questions

How does a surplus production model of forage fish perform, if natural mortality is changing over time?

Which harvest control rule performs best for a forage fish with time varying natural mortality?

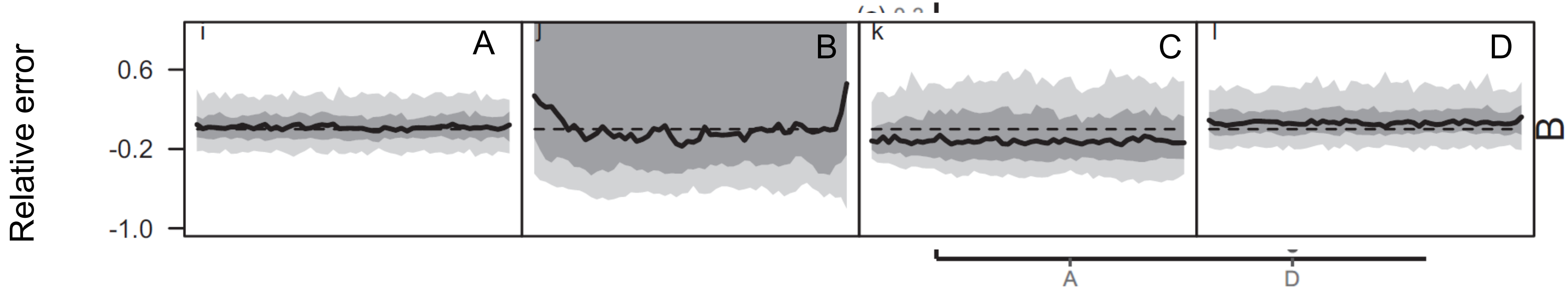
What happens if M is misspecified?

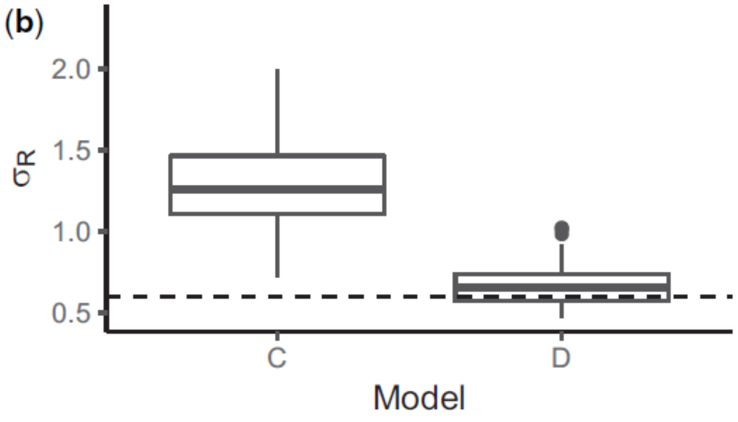


ohnson et al 2015

Punt et al 2020

Sometimes the variation goes elsewhere when the operating model has time varying mortality





σ_R: Estimated recruitment variability

σ_M: Estimated natural mortality variability

Model estimations
A: Time varying mortality
B: Deterministic
C: Recruitment deviations
D: Recruitment deviations and time varying mortality

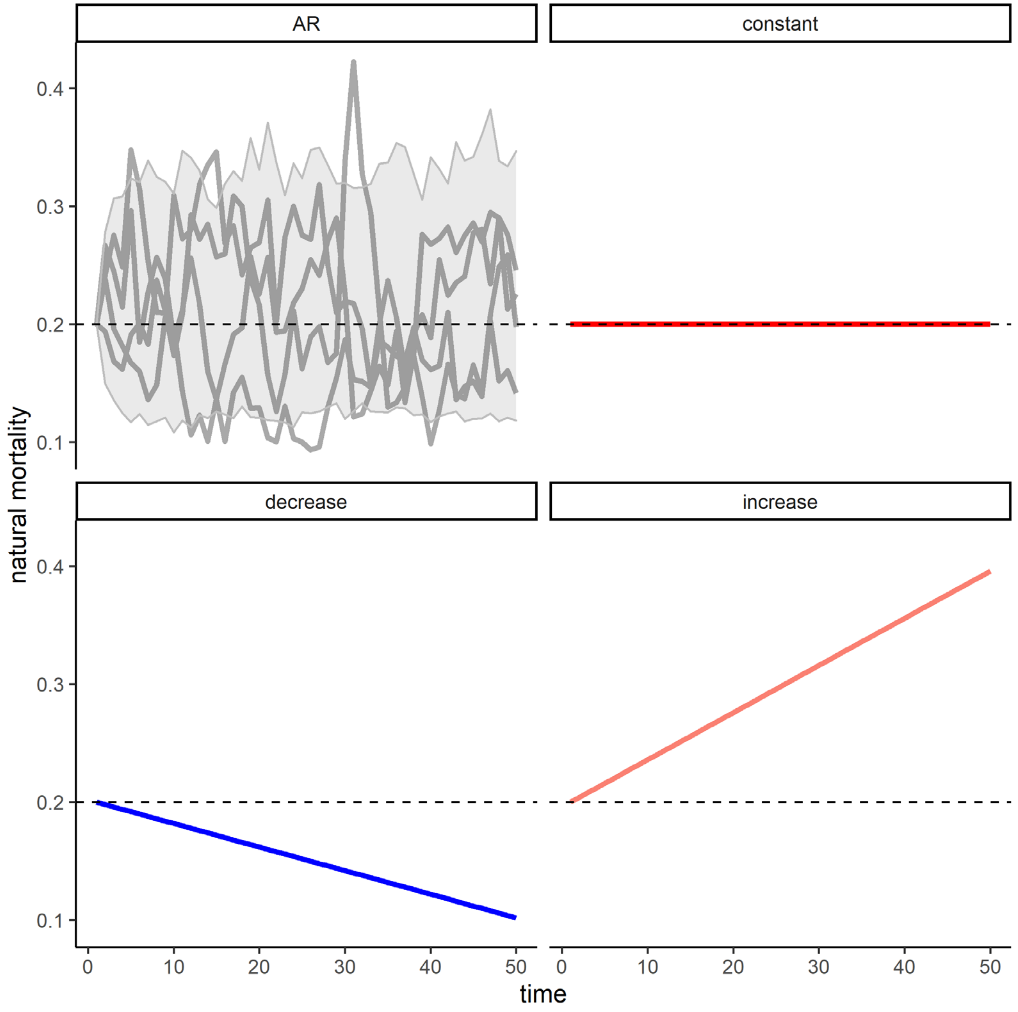
Jacobsen et al 2018

Operating model

- Age based model
- Natural mortality assumed to be constant among ages
- Life histories determined by forage fish in the RAM stock assessment database (supplemented by FishLife) (n = 20)
- Recruitment is autocorrelated, and size of deviations depend on life history parameters

Natural mortality scenarios

- Four natural mortality scenarios



Estimation model

- Pella Tomlinson surplus-production model
- State space version that estimates interannual variability as random effects (process error)
- The model uses an annual survey (with uncertainty σ^2_S) and annual catch (with uncertainty σ^2_C) as input data
- Estimates B_t, C_t as random effects
- r K, q (survey catchability), and σ^2_B σ^2_S, σ^2_C as fixed effects

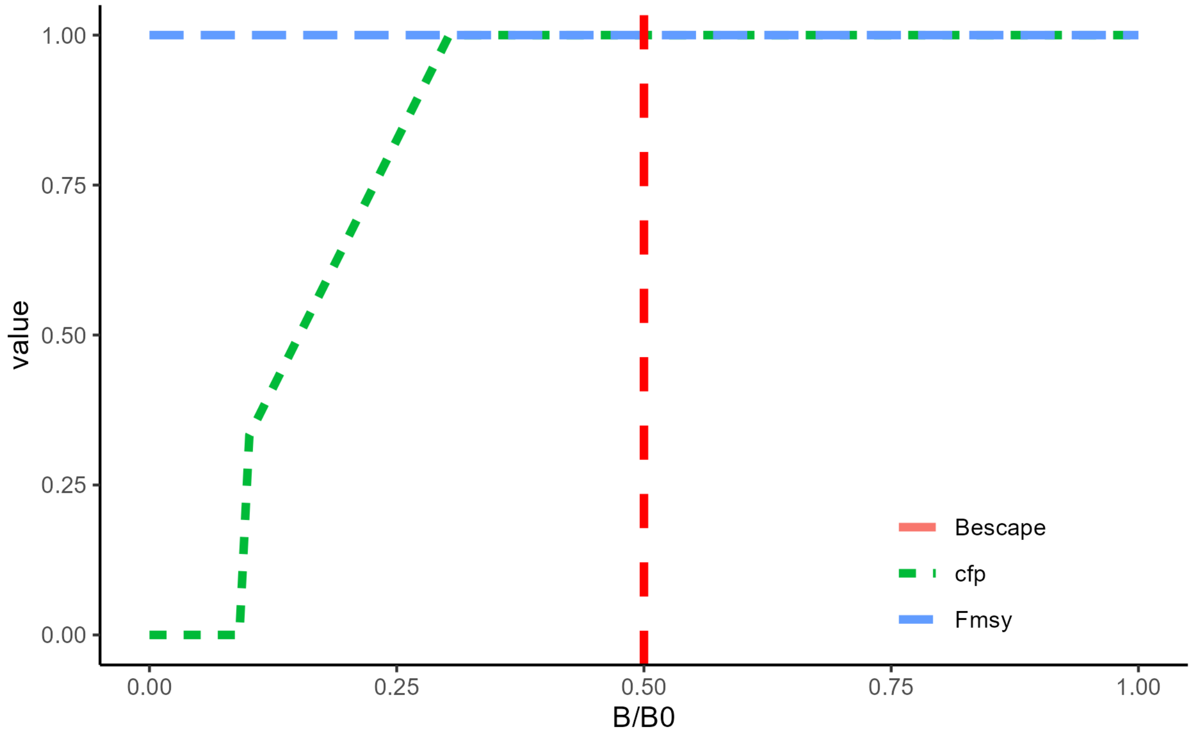
$$SP_{t+1} = \left(m\gamma \left(\frac{B_t}{K}\right) - m\gamma \left(\frac{B_t}{K}\right)^n \right) \epsilon_t$$

$$\gamma = \frac{n^{\frac{n}{n-1}}}{n-1} \qquad m = \frac{rK}{n^{\frac{n}{n-1}}}$$

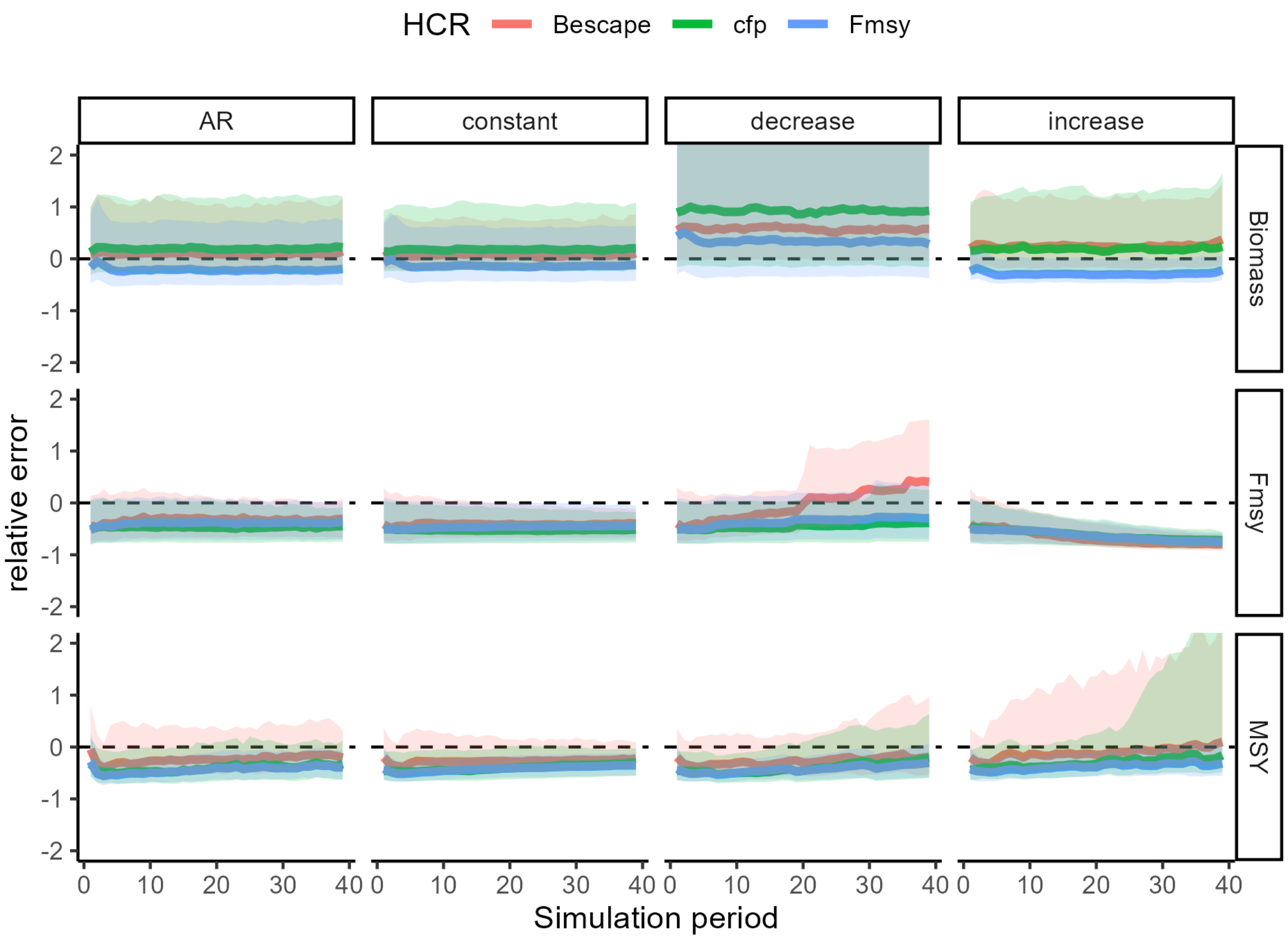
$$\epsilon_t \sim N(0, \sigma_B^2)$$

Harvest control rules

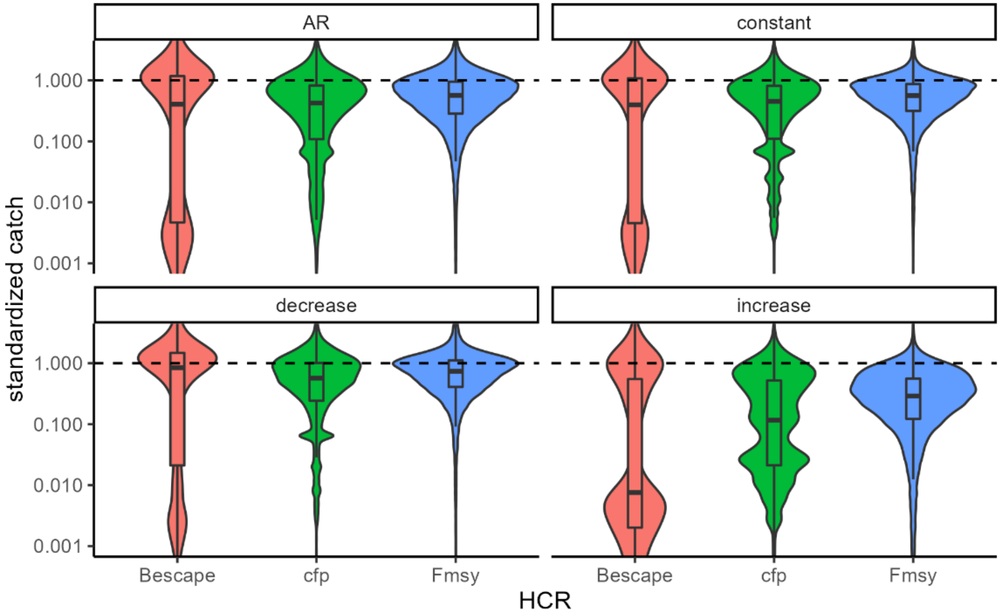
- Fmsy
- CFP
- Bescape

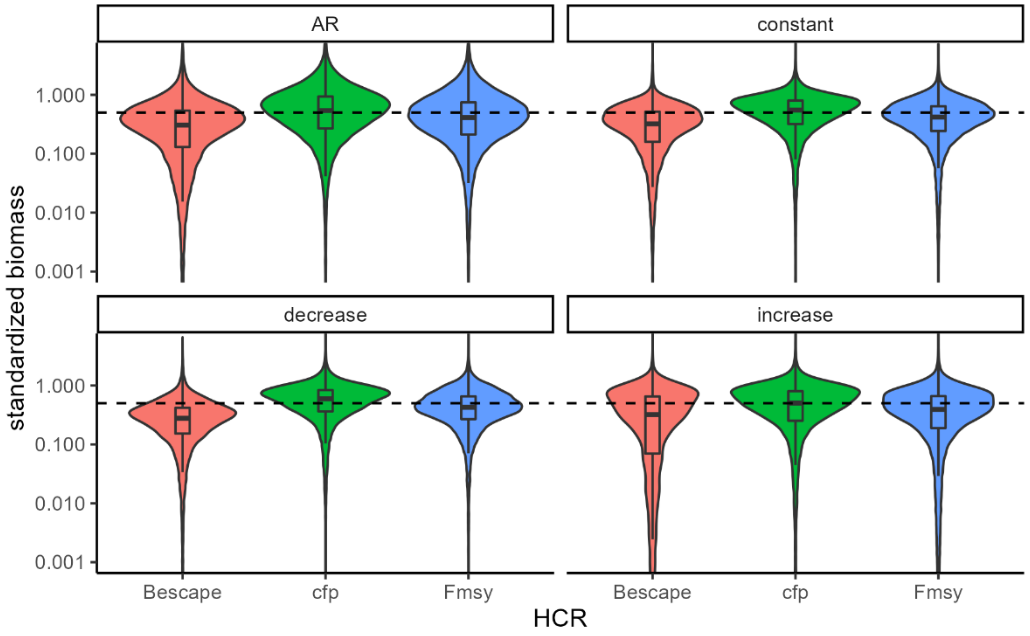


Results – How well a state space surplus production model estimate biomass?



Which harvest control rule performs best?





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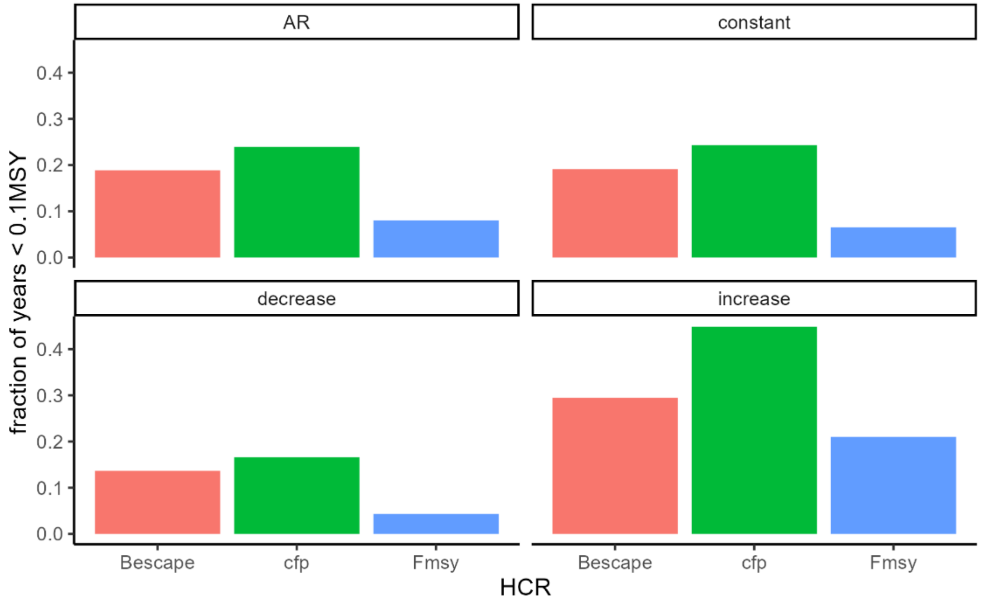
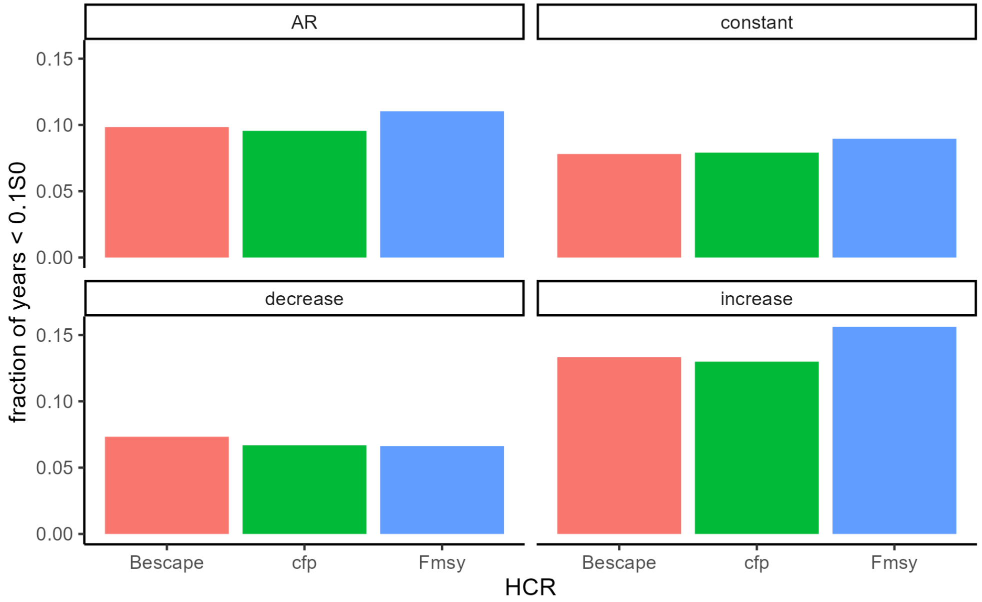
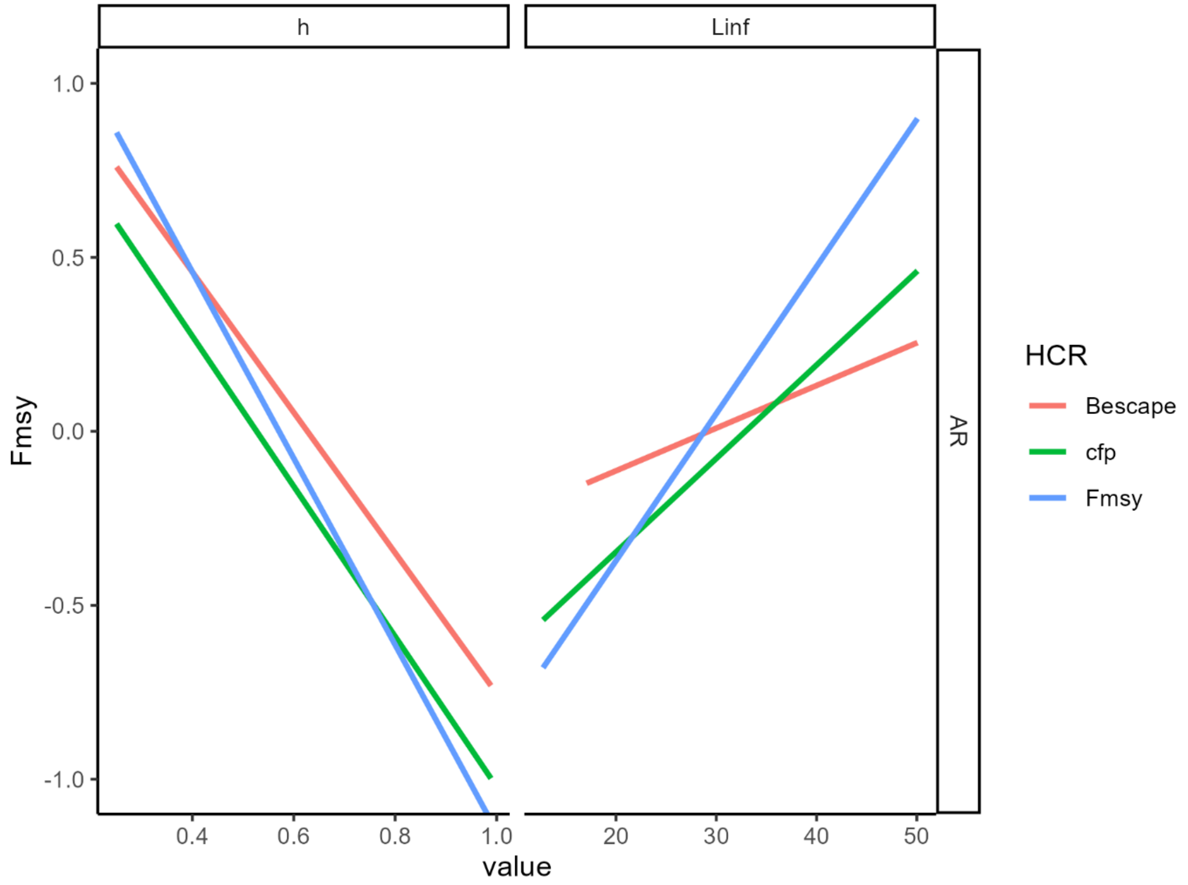




Influence of life history parameters



Conclusions

- Changes in natural mortality does not significantly change how well biomass is estimated due to the inherent high variability

- Directional natural mortality can lead to poor estimation of states

- Life history parameters impacts estimation

- Fmsy seemed to perform best in these scenarios in comparison with the other control rules

Perspectives and lessons learned

- Contrast in historical data is important to gauge changes in productivity
- Time varying productivity can be informative but hard to estimate
- Is Fmsy or MSY really attainable long term reference points if they are changing over time?
- Empirical harvest control rules may provide better options for short lived species such as forage fish
- State space models are efficient at identifying interannual variability regardless of the source

Photo: Getty images

DTU

Thank you

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SEAWISE

CARLSBERGFONDET

Nis Sand Jacobsen
DTU Aqua, Technical University of Denmark

Email: nsja@aqua.dtu.dk
Twitter: @nissandjac