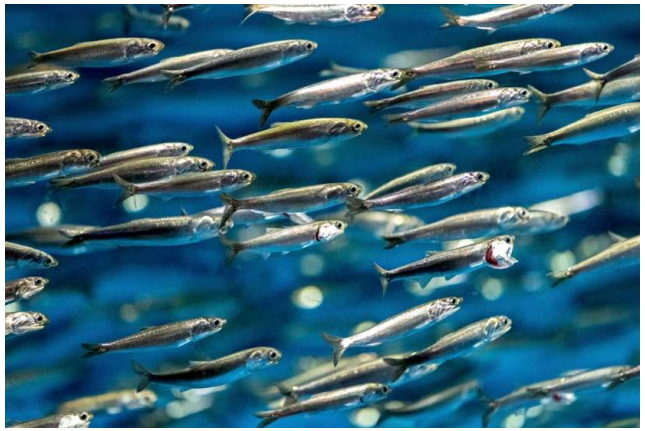
Nis Sand Jacobsen

Running MSE with environmental change

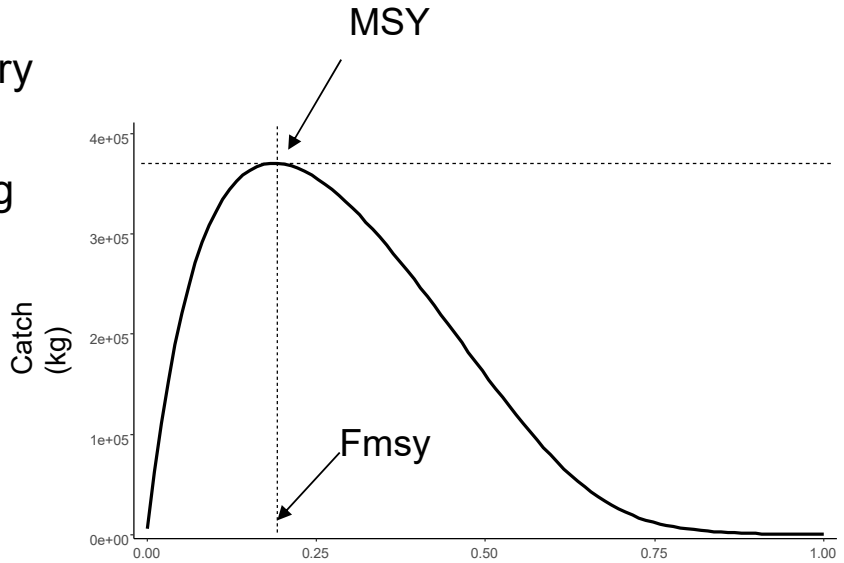
Outline

- Introduction to management strategy evaluation (MSE) in an ecosystem context
- Examples of models that can be used in MSE
- Operating and estimation models
- Environmental relationships within and outside stock assessment models
- Exercise estimating environmentally mediated SRR and running as MSE

Stock assessment



- Estimates the number or biomass of an exploited fish stock
- Uses state of the art statistical models, survey and catch data, combined with a life history model to estimate parameters and state of the stock
- Used to estimate *reference points* and sustainability of a fishery
- Gives advice on the quota or 'TAC' for the following year using harvest control rules (HCR)



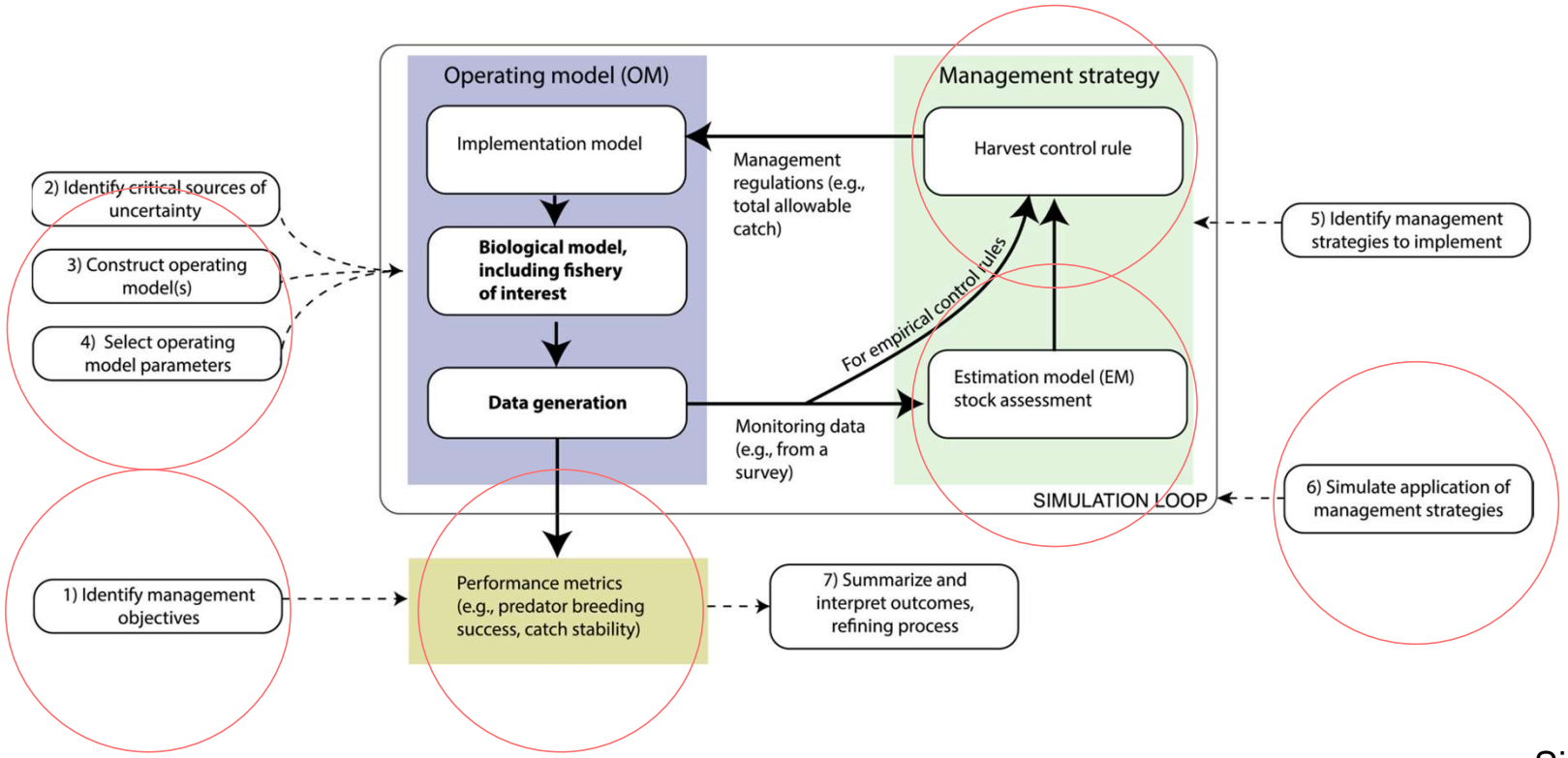
Stock assessment pitfalls

- Rarely takes ecosystem effects into account
- Insufficient or noisy data
- Models that poorly describe the state of a stock
- Lack of understanding of primary drivers of productivity

How can we manage resources that have large variability? Management strategy evaluation (MSE)

- Investigate uncertainty, management rules, and potential biological changes
- A collaborative effort between stakeholders, scientists, and managers
- Closed loop simulation which includes an *operating model*, *estimation model* and a *management model*

Management strategy evaluation in ecosystem contexts

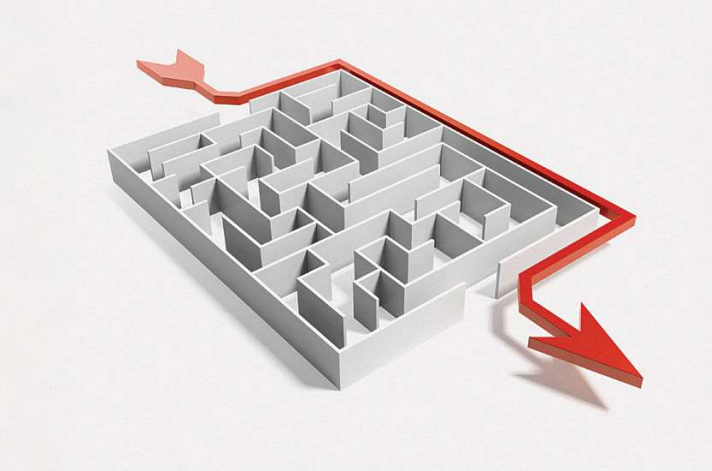


Siple et al 2021

Advantages of including environmental covariates in OM, EM or management model

Short-cut vs full MSE

- Short cut MSEs contain only the computational aspects of an MSE
- Full MSE includes stakeholder input
- More often than not; short-cut MSEs do not use the real stock assessment model as estimation model (big time save!)
- May lead to inaccurate descriptions of uncertainty
- Application of shortcut vs full MSE depends on the question being asked



Environmental inputs to recruitment

- Evaluating whether recruitment is correlated with environmental inputs is a tale as old as time
- However fitting recruitment after estimation can lead to lack of signal to noise ratio
- One other option is to fit recruitment inside the assessment model

$$R_y = \frac{4hR_0SSB_y}{SSB_0(1-h) + SSB_y(5h-1)} e^{\epsilon_R + \sum \beta_i E_{i,y} - 0.5\sigma_R}$$

Using environmental input in MSEs

- Environmental input can either come from observations or (biogeochemical) models
- If you have output from a model there might also be a future projection for MSE
- Environmental data often has to be aggregated to the same scale as the stock assessment
- For examples of model output see e.g., the Copernicus project

smsR model

- A seasonal stock assesment model
- Exists as both a multispecies and a single species model
- Can also include environmental effects, such as temperature effects on recruitment, or time varying natural mortality based on predator abundance
- Is implemented in R with some useful helper functions – the stock assessment uses TMB (with a C++ template)
- Can include random effects parameter estimation

Helper functions and looking at the outputs

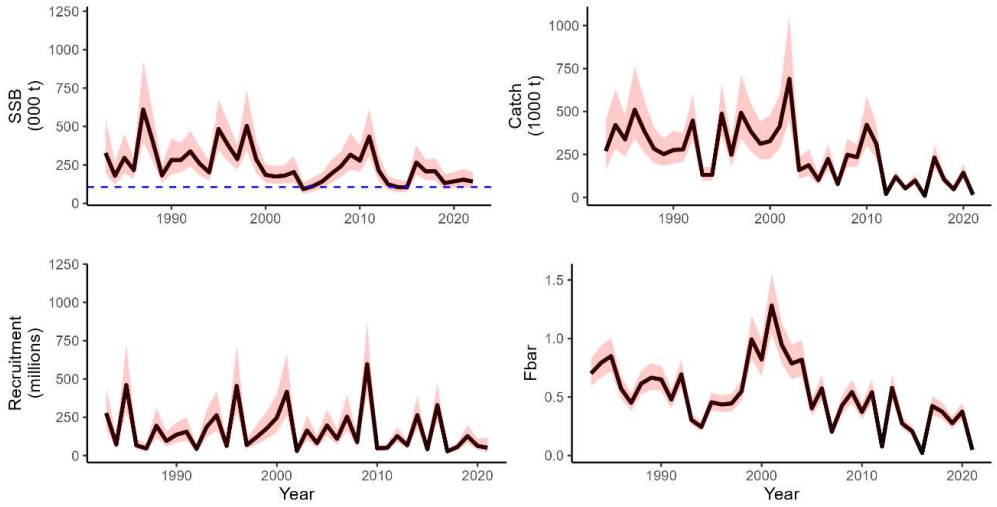
- Software has a range of output functions that help analyzing the model fit

```
plot(sas)
```

- Or some easy helper functions to extract standard output in data frames

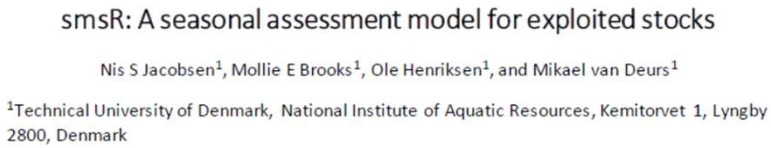
```
getSSB(df.tmb, sas)
getR(df.tmb, sas)
getFbar(df.tmb, sas)
```

Try ?smsR::get…



Future outlook for smsR and multispecies models

- smsR is under developement, but already has several MSE modules
- Environmental data can be used in recruitment estimation
- Natural mortality can be estimated as a random walk
- Multispecies model is being produced



smsR: A seasonal assessment model for exploited stocks

Nis S Jacobsen[1], Mollie E Brooks[1], Ole Henriksen[1], and Mikael van Deurs[1]

[1]Technical University of Denmark, National Institute of Aquatic Resources, Kemitorvet 1, Lyngby 2800, Denmark

Exercise

- We’re gonna estimate environmental impacts on Gulf of Riga herring recruitment
- We’ll use an MSE to run a couple of simulations (usually one would do 100s, but it is time consuming)
- Try to analyse the output and plot some diagnostics
- Se html file on Github (insert link)