How to create, implement, and evaluate Performance Statstics

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Outcomes of this lecture/practical:

Gain appreciation of performance statistics

The importance of performance statistics in the MSE process.

Technical skills 1

Ability to formulate performance statistics.

Technical skills 2

Ability to implement performance statistics in the FLR/mse framework.

What are Performance Statistics?

An MSE is (Reminder):

Robustness test of Management Procedure through closed loop simulation of different operation models and scenarios. If successful, the MP is robust to erroneous assumptions as well as potential changes in the environment.

Performance Statistics are tests that assess the management procedure with regards to strucutural and environmental stochasticity. They should be unambiguous and come with clearly defined levels of assessment (risk-based management).

Performance Statistics are also used to tune HCRs to desired end states.

Management Objectives are required to be translated into Performance Statistics.

Examples of Performance Statistics

Management objective: Healthy stock

- $p(\frac{B_t}{B_{msy}} < 1) < 0.05$ in any given year
- $p(\frac{F_t}{F_{msy}} > 1) < 0.05$ in any given year
- $\frac{B_t - B_{t-1}}{B_{t-1}} > 0.95$

Management objective: High stability in catch

- $0.9 * C_{t-1} < C_t < 1.1 * C_{t-1}$
- $0.9 * Rev_{t-1} < Rev_t < 1.1 * Rev_{t-1}$

Purpose of Performance Statistics

Performance Statistics serve several purposes, but most importantly: They formalise the process of checking whether the management objectives are attained.

- To track management objectives across multiple OMs, MPs, tuning parameters etc
- Risk based management - enable quantifying risk.
- To allow tuning parameters of HCRs to fulfill management objectives.
- **Stakeholders to express their preferred outcomes.**

Formulation of PerfStats

The PerfStats should be formulated by the scientists, but **informed of the management objectives**.

PerfStats decided in common with **stakeholders and fisheries management**. This is the stage when **stakeholders** (Fishers and NGOs alike) **can have real effect on MSE**.

The scientist needs to translate the management objectives into equation, whilst paying attention to:

- the PerfStats being sufficient to summarise the management objectives.
- the possibility management objectives be implemented in the MSE.
- legal requirements of the fisheries being fulfilled (e.g. CFP).

When to draw up PerfStats

- As the PerfStats are an integral part to the MSE, they should be drawn up at the beginning of the process. Good practise sets the MOs and thus the PerfStats at an initial meeting. Alongside the PerfStats, thresholds of acceptable failure/success levels need to be agreed.
- In theory, the MP is only successfull if all PerfStats are within thresholds. But...
- Remember: it is always possible to define OMs that will break any MP. This should be discussed when assessing incidence probability.

Risk based management

- Quantiles of simulations will provide probability.
- Which range to use depends on PerfStats and MOs.
- (Test if simulations are sufficient: check coverage probability of quantiles)

Different types of PerfStats - Yearly calculated PerfStats

Performance statistics across iterations

These are performance stats that are calculated across iterations for each year, e.g. $p(\frac{B_t}{B_{msy}} < 1) < 0.05$

The full equation for this indicator would be $\frac{|\frac{B_t}{B_{msy}} < 1|}{|iter|} < 0.05$ for every year.

Performance statistics calculated along iterations

Examples of these type of performance statistcs include catch stability. Also give equation. (None of the implemented performance statistics in `mse` are of this type, meaning you will have to do the coding)

Different types of PerfStats - time-point specific

PerfStats calculated at specific time points

These are performance stats that are calculated across iterations at a given year, the most pedestrian choice would be the end year.

E.g. rebuilding a stock to B_{msy} in 20 years, with the caveat to reach 75% of B_{msy} within 10 years with a certainty of 95%:
$p(\frac{B_{t=10}}{B_{msy}} < 1) < 0.05$

The full equation for this indicator would be $\frac{|\frac{B_{t=10}}{B_{msy}} < 1|}{|iter|} < 0.05$

Exercise 1

Part1

Invent three Performance Statistics, preferably different types.

Part 2

Formulate them in Equation form or R code (whatever is easier for you).

PerfStats in mse

A few performance statistics are already implemented in mse. They can be accessed and complemented if necessary:

Code-chunk 1: Performance statistics in mse

```
library(mse)
data(indicators)
indicators
```

They are called using performance()

PerfStats in mse cont'd

1. Mean spawner biomass relative to unfished
2. Mean spawnwer biomass relative to SBMSY
3. Mean fishing mortality relative to target
4. Mean fishing mortality relative to FMSY
5. Probability of being in Kobe green quadrant
6. Probability of being in Kobe red quadrant
7. Probability of SB greater or equal to SBMSY
8. Probability that spawner biomass is above Blim
9. Mean catch over years
10. Catch variability
11. Probability of fishery shutdown

PerfStats in mse cont'd

Explore the indicators object and see how they are coded. There are three components to each performance statistic:

- "[[1]]": **R**-code
- "$name": Rudimentary equation
- "$desc": Text-descriptor

Example

```
indicators[[1]]
[[1]]
~yearMeans(SB/SB0)
$name
[1] "SB/SB[0]"
$desc
[1] "Mean spawner biomass relative to unfished"
```

Performance Statistics in mse

Example (Using performance() with indicators)

```
refs <- FLPar(
SBMSY = res.dr@refpts["msy", "ssb"],
Ftarget = res.dr@refpts["f0.1","harvest"],
FMSY = res.dr@refpts["msy", "harvest"],
SBlim = res.dr@refpts["spr.30","ssb"])

metrics <- list(SB = ssb, F = fbar, C = catch)

performance(stock(res.dr), refpts = refs, indicators=inds,
  metrics = metrics, years=list(2016:2041))
```

Exercise 2

Part1

Investigate the `indicators` object. Pay attention to the **R**-code. It is written using FLR syntax.

Part 2

Use indicators on one of your mp() output files.

Part 2.1

TORs: - Fishing at 90% Fmsy - Healthy stocks after 10 years - Never hitting Blim - Year to year catch variation less than 10- Less than 5% risk to drop below Bmsy in each year - Less than 10% risk to go over Fmsy - Catch should not be less than 80% of current catch

Hacks that work

Example (Iago did not want me to show this (f/fmsy))

```
stk <- stock(res.dr)

moo <- fbar(stk)/res.dr@refpts["msy","harvest"]

b <- FLQuant(moo@.Data)

res <- numeric(26)


for (i in 1:26){
res[i] <- sum(c(b[,i]) > 1)/25
}
```

The End