

Rfishpop: A new R-package for the analyses of the fisheries population under uncertainty

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1. Introduction

Rfishpop implements a completed cycle of **management strategy evaluation (MSE)** which is a tool that researchers employ to simulate the behaviour of a fishery system and to evaluate the potential performance of particular management strategies identifying strategies that meet pre-specified management goals.

The analysis of the dynamic of a population has become a fundamental tool, in particular, in fisheries science to assess the status of exploited resources. The difficulty lies in the uncertainty, which is an inherent component in fishery systems, that makes difficult taking management decisions. **Rfishpop** addresses such aims implementing a MSE cycle, i.e., a simulation approach which allow us to identify rebuilding strategies or define harvest strategies, for the next years, which are robust to uncertainty and natural variation.

Package information:

- **Github repository:** <https://github.com/IMPRESSPROJECT/Rfishpop>

- **Tutorials:** <https://github.com/IMPRESSPROJECT/Tutorials-Rfishpop>



https://www.youtube.com/watch?v=8n_cfcBpNdU&feature=youtu.be

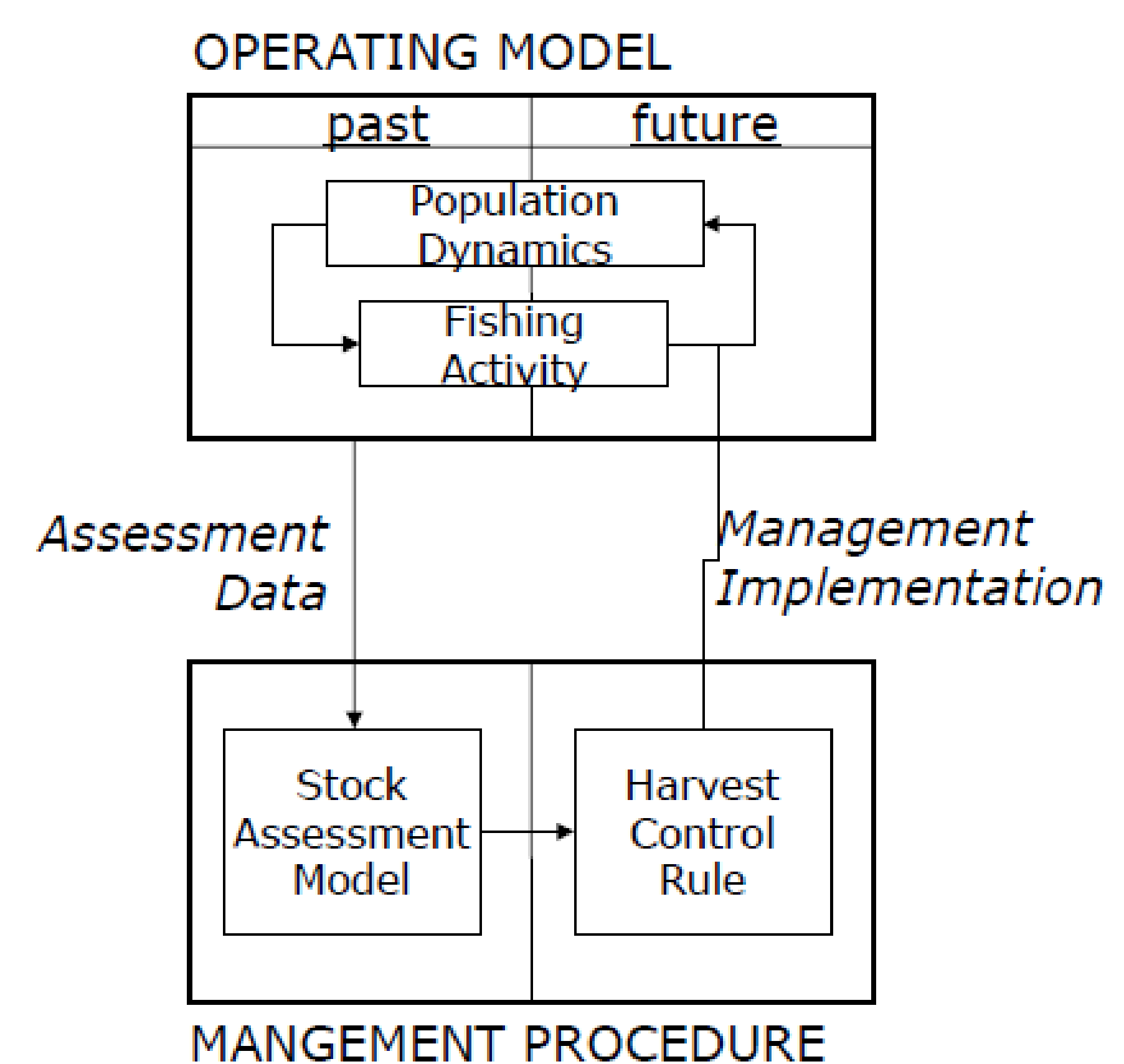
<https://www.youtube.com/watch?v=Y4G5CFRTLhQ&feature=youtu.be>

2. Methodology: Management Strategy Evaluation

A prototypical MSE incorporates a number of interlinked model structures. The steps for a MSE cycle can be described as follows.

1. **Population dynamics and fishing activity (Operating Model, OM):** An operating model is typically used to generate “true” ecosystem dynamics including the natural variations in the system.
2. **Data collection:** Data are sampled from the OM to mimic collection of fishery dependent data and research surveys (and their inherent variability).
3. **Data analysis, stock assessment and Harvest Control Rule (HCR):** These data are passed to the assessment model. Based on this assessment and the HCR, a management action is determined (e.g., a change in the Total Allowable Catches, TAC).
4. **Implementation of the HCR:** Corresponding fleet effort and catch are then modelled, and resulting catches are fed back into the operating model, OM.

By repeating this cycle the full management process is modelled. It is possible to test the effect of modifying any part of this cycle including changes to the operating model, assumptions about noise, etc. Alternative Management Procedures (MPs) can be compared by running many stochastic simulations, each for several years, to identify the performance of a rule according to different metrics under the likely range of conditions.



3. Implementation

- **Operating model (OM):** The package includes tools to simulate the real dynamics of a fishery system using a generic age-structured OM including a biological system with recruitment, growth, maturity and mortality and a fishery system where fishing intensity and selection are modeled. The package also contains a set of methods to estimate Maximum Sustainable Yield (MSY) reference points. These allow to identify management targets in terms of fishing intensity, population status and yield.
- **Statistical methods to simulate sampling error:** The package also contains statistical methods for sampling data from the OM simulating sampling error, which is another source of uncertainty in fishery management. These methods provide different data types which can suit different assessment methods, from simple data-limited methods to more complex age or length-structured methods.
- **Assessment models:** The data obtained from the sample functions are passed to the assessment model. Our package does not implement any assessment models, the idea is to use available implementations of the assessment models. The package contains specific functions to change the format of the data into the required format of the assessment model function, for some methods.
- **Implementation of the HCR:** Finally, the package contains functions to implement the resulting management action, determined from the assessment and the HCR, projecting our exploited population through the years on basis on the catches or effort established by the management action.

4. Issues

MSE cycle contains a number of interlinked model structures which are not simple, and furthermore this cycle is not run once, we need to run the cycle over and over, once the resulting catches of the management action are fed back into the operating model, OM. R allows to implement a complicated procedure as the MSE methodology.

The problem is as often the time of computation required by R to run all the process. At Step 4 of the cycle we need to find the effort corresponding to the catches derived from the management action. We need to do that for each of the years through the population must be projected, and furthermore for each iteration of the population generated from OM, due to the uncertainty introduced by the OM we have a large number of stochastic populations. The code has been parallelized for the different iterations but the procedure is not so fast as it would be. Efforts to improve it are necessary.

5. Conclusions

The described functions of **Rfishpop** package allow us to verify the performance of management strategies or procedures in different settings generated from the OM.

The package is also useful to check the performance of assessment models when some of their assumptions are violated or some parameters are misspecified.

It is important to stand out that this package is an open project, future aims focus on introducing new possibilities at some steps of the MSE cycle and also on improving some of the procedures already implemented.

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