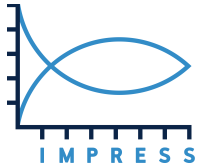

INSTITUTO ESPAÑOL DE OCEANOGRAFÍA

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

M. Cousido-Rocha, S. Cerviño, M.G. Pennino
marta.cousido@ieo.es, santiago.cervino@ieo.es, grazia.pennino@ieo.es

Instituto Español de Oceanografía (IEO), Vigo

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Information

- **Github repository:** https://github.com/IMPRESSPROJECT/Rfishpop.
- **Tutorials:** https://github.com/IMPRESSPROJECT/Tutorials-Rfishpop.
- **Brief explanation:** Video (Youtube).

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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.

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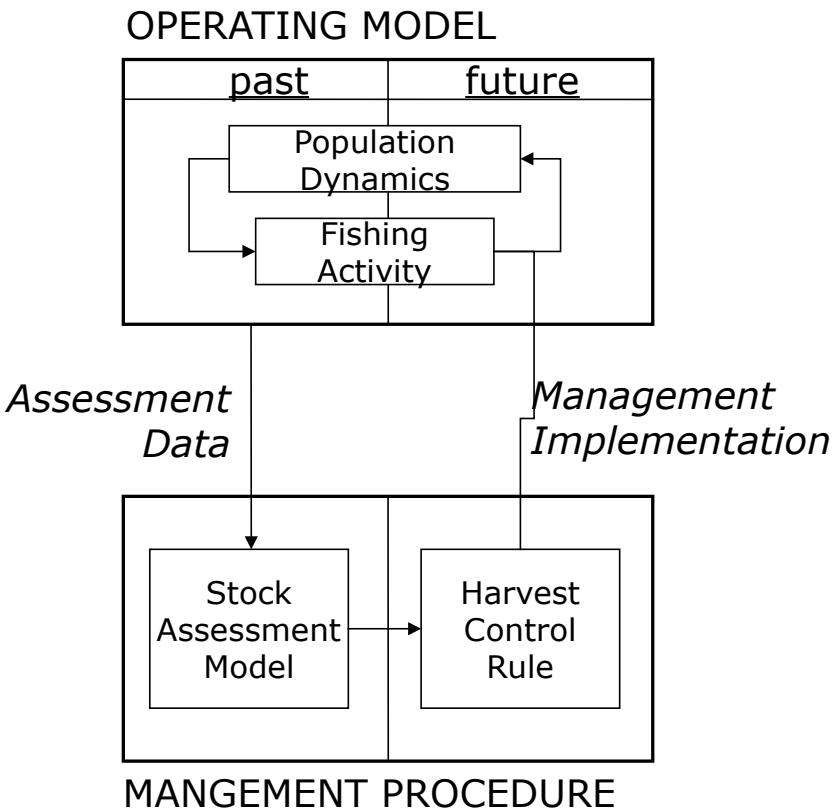

Generic age-structured operating model (OM)

The package includes tools to simulate the **real dynamics of a fishery system using a generic age-structured operating model (OM)**.

Population.Modeling {Rfishpop} R Documentation

Modeling an Exploited Population (Structured by Age)

Description

Provides a flexible and generic operating model (OM) which simulates the real dynamics of the fishery system. The OM is formed by biological, fishery and control components. The stock is described as age structured population along the time.

Usage

```
Population.Modeling(ctrPop, ctrBio, ctrFish, SR)
```

OM includes a biological system with recruitment, growth, maturity and mortality and a fishery system were fishing intensity and selection are modeled.

This system allows to implement structural uncertainty having different options for each process and natural stochasticity playing with variability in these processes.

Maximum Sustainable Yield (MSY) reference points

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.

```
RF(Pop.Mod, 3,3,Method="mean",par=NULL,FM_type="F_msy",iters=1:2)
```

```
## , , 1
##
##              f         F       YPR       BPR        R        Y        B
## [1,] 0.3090528 0.2997637 0.2114027 0.5963804 9329.287 1972.237 5563.804
##
## , , 2
##
##             f        F       YPR       BPR        R        Y        B
## [1,] 0.398899 0.383811 0.2393533 0.5267986 9240.697 2211.792 4867.986
```

Statistical methods to simulate sampling error

Our 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 provides different data types which can suit different assessment methods, from simple data-limited methods to more complex age or length-structured methods.

Help Pages

andersen	Andersen Selectivity Function
BPR	Biomass-per-Recruit
BYR.eq	Total Yield, Biomass and Recruitment in Equilibrium
Data.to.LB.SPR	Length Based Spawning Potential Ratio (LB-SPR)
Data.to.LBI	Data for Length Based Indicators (LBI)
Distribution.length	Stock Length and Catches Length Distribution for each year
FLStock.from.Rfishpop	A FLStock class object
gamma_SEL	Gamma Selectivity Function
Length_VB	Von Bertalanffy Growth Model (Length)
Logistic	Logistic function
plotRF	Reference Points plots
Population.Modeling	Modeling an Exploited Population (Structured by Age)
Population.Modeling.Projections	Projecting our Exploited Population on based of desired catches or efforts
RBH	Beverton-Holt Recruitment Model
RF	Reference Points
RRK	Ricker Recruitment Model
Sampling_Catch	Catch numbers (for each year and age), catch weight (for each year), and sampling catch length (for each year)
Sampling_Survey	Indices of abundance (for each year and age) and biomass (for each year), and sampling stock length (for each year)
selecting_units	Selecting Units
steepness	Steepness of the Stock Recruitment Relationship
Sum.Pop.Mod	Information of the Exploited Population (Structured by Age) simulated using Population.Modeling.
Weight	Length-Weight relationship
YPR	Yield-per-Recruit

Assessment models

The data obtaining 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. Now, the package contains such functions for the data-poor methods, LBI and LB-SPR. The list of functions will be expanded when exploring the application of other assessment models to the data reported by our package.

Data for Length Based Indicators (LBI)

Description

The function provides required information for computing Length Based Indicators: Length distributions of catches and the corresponding average weight per length.

Usage

```
Data.to.LBI(Pop.Mod, CV)
```

Data to Length Based Spawning Potential Ratio (LB-SPR)

Description

The function provides required information for computing Length Based Spawning Potential Ratio (LB-SPR): Length distributions of catches.

Usage

```
Data.to.LB.SPR(Pop.Mod, CV)
```

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 the effort established by the management action.

Projecting our Exploited Population

Description

This function allows us to extend our simulated Population through the years on based of the desired captures for such years (strategy="catch") or on based of the desired effort f (component of fishing mortality F = f * SEL) for such years (strategy="effort") .

Usage

```
Population.Modeling.Projections(
  Pop.Mod,
  new.years,
  my.catch,
  tol,
  limit.f,
  strategy,
  my.effort
)
```

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 managament action are fed back into the operating model, OM. **R allows to implement a complicated procedure as the MSE methodology.**

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- The problem is as often the time of computation required by R to run all the process. For example, 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 possible uncertainty introduced in the OM we can have a large number of stochastic populations.

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- Other problems relate to statistical procedures, for example definition of stochastic matrices. For the length age structured matrix we need to introduce the posibility to define stochastic matrices from the deterministic one (L). However, if we generate the value of the stochastic matrix for each row i (age) and column j (year) from a normal distribution which mean L_{ij} (the corresponding deterministic value) and variance derived from some coefficient of variation a problem appears. The resulting matrix (L^s) can verify $L^s_{ij} > L^s_{i+1,j+1}$ which is not possible since the fish never reduced its length.

Conclusions

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

Acknowledgments

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Thanks for your attention!

Contact: marta.cousido@ieo.es