

Developing and running data-limited MSEs using FLR

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Iago MOSQUEIRA

Wageningen Marine Research (WMR), IJmuiden, The Netherlands.



FLR, Fisheries Library in R

A collection of packages in the R statistical language providing a domain-specific programming language for quantitative fisheries science.

Goals

1. Provide tools for effective and reliable implementation of simulation models of the fishery system.
2. Encourage the use of Management Strategy Evaluation for designing robust fisheries management plans.
3. Facilitate the exchange of ideas and algorithms through the establishment of a *lingua franca* for quantitative fisheries science.
4. To do so under the Free/Open Source ethos of transparency, reproducibility and free exchange of ideas and algorithms.

Computational platform



C++
`using std::cpp;`

CppAD



HPC

- From CPU cores to HPC clusters

Design principles

- Object-oriented S4 classes for system elements
 - Same methods work on multiple classes, e.g. `plot` vs. `plotObjectType`
- Modularity
 - MP as a series of modules to be called sequentially
- Flexibility and extendability
 - Write your own MP modules (e.g. HCR, indicator)
- Limited use of default values
 - Choices to be explicit in code
- Adherence to R language conventions
 - e.g. formulas

MSE steps in FLR syntax

1. Identify objectives and performance statistics

```
stats <- list(FMSY=list(~yearMeans(F/FMSY), name="F/F[MSY] ",  
performance(run, statistics, years=2030:2039)
```

2. Specify uncertainties and operating models

- Life history + priors

3. Identify and define management procedures

```
mpcontrol <- mpCtrl(list(  
  est = mseCtrl(method=sam.sa),  
  hcr = mseCtrl(method=hockeystick.hcr,  
    args=list(lim=3e5, trigger=4e5, target=0.25))))
```

MSE steps in FLR syntax

4. Simulate application of management procedure

```
run <- mp(om, oem=oem, ctrl=control, args=list(iy=2017))
```

5. Tune management procedure to objective(s)

```
tuned <- tunebisect(om, oem=oem, control=control,  
  args=mseargs, statistic=statistics["green"],  
  years=2030:2039, tune=list(target=c(0.1, 0.5)), prob=0.5)
```

6. Present results

```
plotBPs(tuned, statistics)
```

Running an MSE

```
# LOAD om, oem
```

```
data(ple4om)
```

```
# DEFINE MP
```

```
control <- mpCtrl(list(  
  est = mseCtrl(method=perfect.sa),  
  hcr = mseCtrl(method=hockeystick.hcr,  
    args=list(lim=3e5, trigger=4e5, target=0.25))))
```

```
# RUN
```

```
run <- mp(om, oem=oem, ctrl=control, args=list(iy=2017))
```

```
run3 <- mp(om, oem=oem, ctrl=control, args=list(iy=2017, fr
```

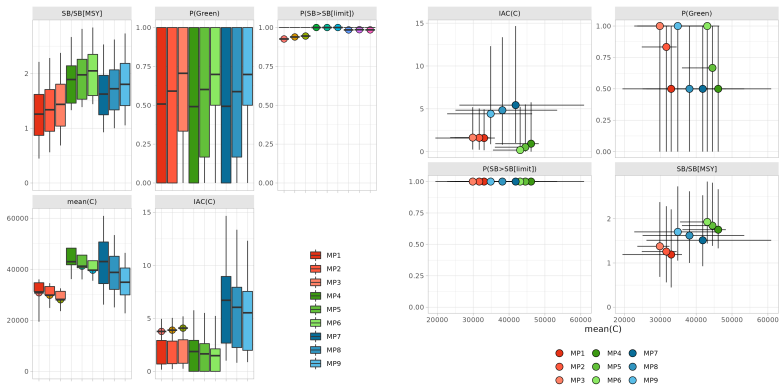
Running an MSE

```
> data(ple4om)
>
> control <- mpCtrl(list(
+   est = mseCtrl(method=perfect.sa),
+   hcr = mseCtrl(method=hockeystick.hcr,
+   args=list(lim=3e5, trigger=4e5, target=0.25))))
>
> run <- mp(om, oem=oem, ctrl=control, args=list(iy=2017))
2017 > 2018 > 2019 > 2020 > 2021 > 2022 > 2023 > 2024 > 2025 > 2026 > 2027 > 2028 > 2029
>
> run3 <- mp(om, oem=oem, ctrl=control, args=list(iy=2017, frq=3))
2017 > 2020 > 2023 > 2026 >
```


Presenting results

```
# COMPUTE performance statistics  
perf <- performance(run3,  
  statistics=statistics[c('FMSY', 'BMSY')])  
  
# PLOT performance  
plotBPs(perf)  
  
# PLOT trade-offs  
plotT0s(perf)
```

Presenting results



Operating Model

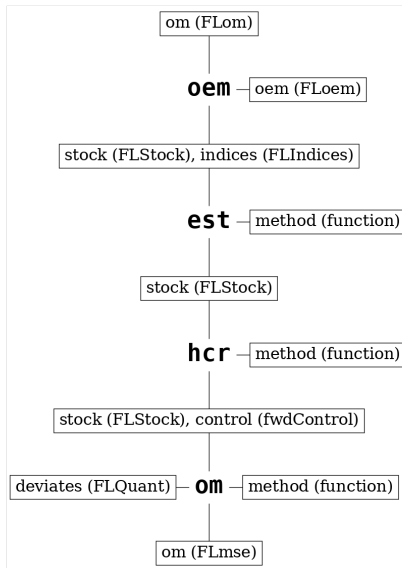
FLom class

- Stock
 - N-at-age, weight-at-age, maturity, fecundity, SRR
- Fishery or fisheries
 - Landings and discards, selectivities, prices
- Reference points

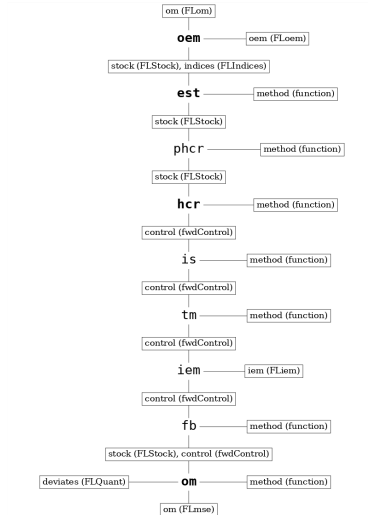
FLoem class

- Observations: stock, indices.
- Deviances: catch,

MSE basic modules



MSE modules



Length-based indicators

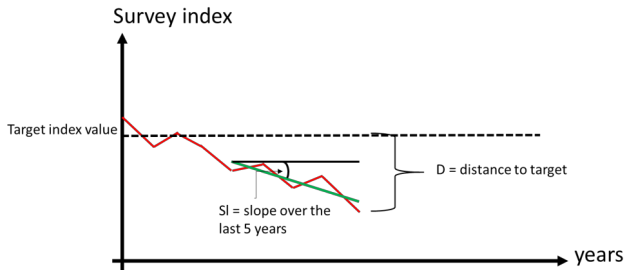
- Length-based indicators *len.ind*
 - observation (catch-at-age), Von Bertalanffy model
 - indicator
 - number of years, CV ALK

LBIs

- Length at 50% of modal abundance, L_c
- Mean length, L_{bar}
- Mean length of individuals, L_{mean}
- Mean length of largest 5%, $L_{max5\%}$

CPUE / survey trends

- CPUE trends $\text{cpue.ind} + \text{cpue.hcr}$
 - observation (index)
 - number of years



OM conditioning

Life-history

- Correlations among life history traits: Linf to OM
- Add data to substitute correlations
- Uncertainties and priors defined for any value

Feasible trajectories

- Priors for steepness (h), carrying capacity (K) and initial depletion (d).
- Simulate initial population, project for catch or survey/CPUE biomass.
- Accept trajectories based on catch, cohort and SSB trends.

ABC

- Approximate Bayesian Computation
- Distance metrics for any data source (catch, lengths, CPUE, effort)

Evaluation of the skill of length-based indicators to identify stock status and trends

Laurence T. Kell ^{1,*}, C  il  n Minto ² and Hans D. Gerritsen³

¹Centre for Environmental Policy, Imperial College London, Weeks Building, 16-18 Princes Gardens, London SW7 1NE, UK

²Marine and Freshwater Research Centre, Galway-Mayo Institute of Technology, Dublin Road, Galway H91 T8NW, Ireland

³Marine Institute, Rinville, Oranmore Co., Galway H91 R673, Ireland

*Corresponding author: tel: +44 7517071190; e-mail: l.kell@imperial.ac.uk.

■ <https://doi.org/10.1093/icesjms/fsac043>

Relevant examples



TENTH WORKSHOP ON THE DEVELOPMENT OF QUANTITATIVE ASSESSMENT METHODOLOGIES BASED ON LIFE-HISTORY TRAITS, EXPLOITATION CHARACTERISTICS, AND OTHER RELEVANT PARAMETERS FOR DATA-LIMITED STOCKS (WKLIFE X) VOLUME 2 | ISSUE 98

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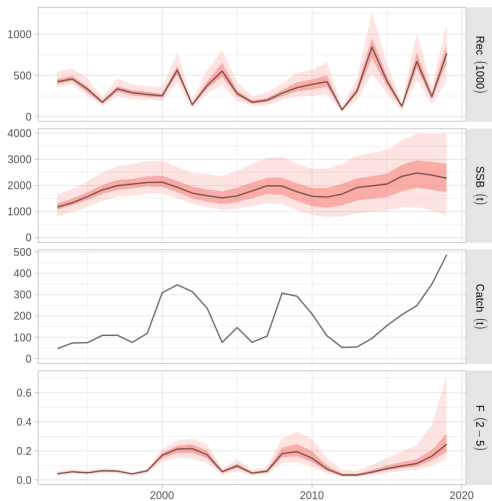
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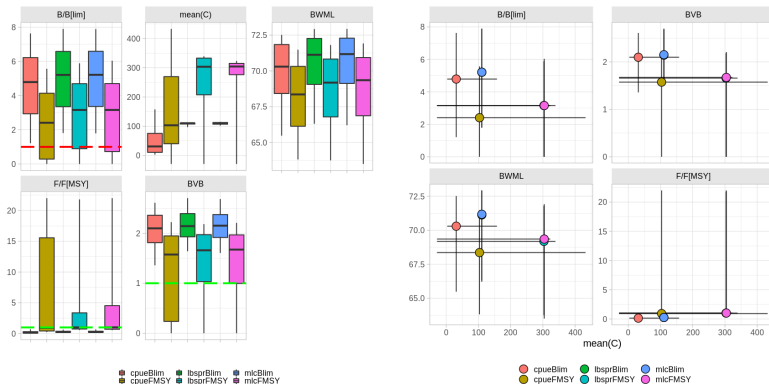
Example: MPs for stocks in the IJsselmeer, NL

- Stocks of pikeperch, perch, bream and roach.
- Data: total catch, catch at length, survey.
- Issues: short time series, data uncertainty.
- MPs
 - LBSPR + hockey-stick 40/10 HCR
 - Survey biomass + trend HCR
 - Mean length in catch + 40/10 HCR
- MP considers bird food needs.
- Tuning for 60% FMSY or 5% Blim.

IJsselmeer pikeperch OM



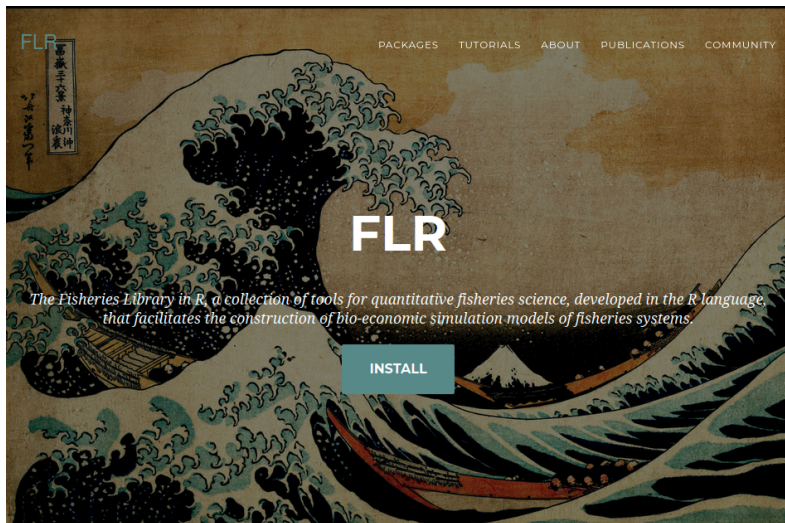
IJsselmeer pikeperch MP performance



IJsselmeer pikeperch value of information



<https://flr-project.org>



FLR

PACKAGES TUTORIALS ABOUT PUBLICATIONS COMMUNITY

FLR

The Fisheries Library in R, a collection of tools for quantitative fisheries science, developed in the R language, that facilitates the construction of bio-economic simulation models of fisheries systems.

INSTALL

FLR Tutorials

Introduction

- [A quick introduction to FLR](#)
- [An overview of the FLCore classes](#)

Input

- [Loading your data into FLR](#)

Fisheries Modelling

- [Modelling stock recruitment with FLRS](#)
- [Using information on Life History relationships](#)
- [Statistical catch at age models in FL4a](#)
- [Modelling growth and its uncertainty in FL4a](#)
- [Natural mortality modelling in FL4a](#)
- [Stock assessment using extended Survivors Analysis with FLXSA](#)
- [Modelling Life History Relationships](#)

Management Advice

- [Running Medium Term Forecasts with FLash](#)
- [Short Term Forecasting for advice using FLash](#)
- [Forecasting on the Medium Term for advice using Flasher](#)
- [Reference points for fisheries management with FLBRP](#)

Management Strategy Evaluation

- [An introduction to MSE using FLR](#)

Management Strategy Evaluation using FLBEIA


- [Conditioning FLBEIA using Smart Conditioning Functions](#)
- [A simple example on how to use FLBEIA](#)
- [A simple example with multiple dimensions in FLBEIA](#)
- [Using Stock Assessment models in the Management procedure of FLBEIA](#)
- [Testing different Management Strategies in FLBEIA](#)
- [Data Limited MSE in FLBEIA](#)


Visualization

- [ggplotFL plotting FLR objects with ggplot2](#)
- [Plotting FLR objects using lattice](#)

Internals


<https://github.com/flr>


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Core package of FLR, fisheries modelling in R
● R ☆ 11 🍴 17

 **mse** (Public) ⋮
Tools for running Management Strategy Evaluations using FLR
● R ☆ 3 🍴 5

 **Flasher** (Public) ⋮
New version of Flash
● C++ ☆ 1 🍴 4


Repositories

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FLSRTMB (Public)
Fitting and analyzing stock-recruitment relationships with TMB in FLR
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FLXSA (Public)
The FLXSA package
● C++ ☆ 1 🍴 3 ⌚ 1 🛠️ 0 Updated 7 days ago

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r-universe/flr

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FLSRTMB: FLSR in TMB

Estimates FLR spawner recruitment relationships in TMB

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[c++](#)

[1.31 score](#)
[40 dependencies](#)

[Henning Winker](#)

FLXSA: eXtended Survivor Analysis for FLR

Calculates stock numbers and fishing mortality at age from commercial catch data and one or more indices of abundance using the method in Darby and Flatman (1994) and Shepherd (1999).

Last updated 7 days ago

[c++](#)

[1 stars](#)
[1.00 score](#)
[34 dependencies](#)

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bbm: FLR Implementation of a Two-Stage Stock Assessment Model

The two-stage biomass-based model for the Bay of Biscay anchovy (Ibaibarriaga et al., 2008).

Last updated 11 days ago

[c++](#)

[0.23 score](#)
[40 dependencies](#)

[Leire Ibaibarriaga](#)

FLAssess: Generic Classes and Methods for Stock Assessment Models

A generic set of classes for stock assessment models are provided here. Individual assessment packages should extend the basic classes.

Last updated 13 days ago

[c++](#)

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a4adiags: Additional Diagnostics for FLA4a stock Assessment Models

A series of extra diagnostics for the FLA4a model, including prediction skill through retrospective prediction of model inputs and runs tests. Contains ggplot-based plot functions of diagnostics outputs.

Last updated 12 days ago

[0.23 score](#)
[57 dependencies](#)

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ss3om: Tools for Conditioning Fisheries Operating Models Using Stock Synthesis 3

Tools for loading Stock Synthesis (SS3) models into FLR. Used in conditioning of Operating Models based on SS3 by ...

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FLR

[r-universe/flr](#)

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Links

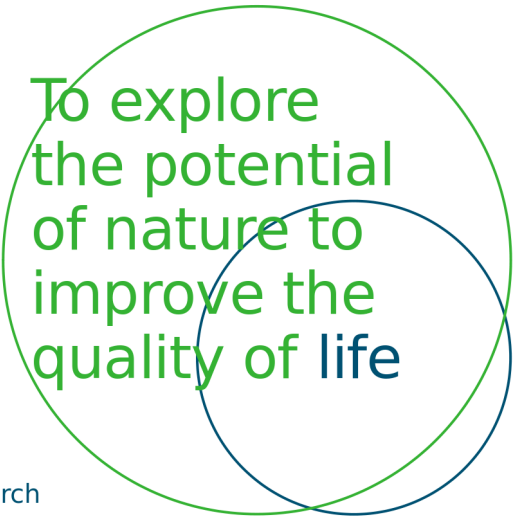
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To explore
the potential
of nature to
improve the
quality of life

Iago MOSQUEIRA

Wageningen Marine Research

iago.mosqueira@wur.nl