Simulation of fish populations from life history using the FLife R package

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Contents

Abstract

1 Introduction

Scientific fisheries management frameworks rely upon an description of the characteristics of a 'stock' so that its biological reaction to being exploited can be rationally predicted and the predictions tested. The definition of a stock may be made on either an ecological, evolutionary, or operational basis Waples and Gaggiotti (2006). Normally in fisheries stock assessment it is the later and it is also assumed that there is no immigration or emigration and that a stock is homogeneous, i.e. there are no spatial differences in population dynamics.

For data rich stocks, i.e. where there are estimates of catches and indices of abundance, in order to provide advice to control exploitation stock assessment models are fitted to historical data, the models are then projected forward for a range of scenarios about resource dynamics to determine the effect of alternative management options. A few years later the process is repeated and advice updated. Incorrect assumptions about the population dynamics, however, can have a substantial impact on stock assessment results and management advice (Dickey-Collas et al., 2015, see).

Due to a lack of data the productivity, current exploitation level and stock status are unknown for a substantial fraction of fish stocks both targeted and bycaught in fisheries world wide, such stocks are term "data-poor, data-limited or information-poor (Thorson et al., 2015). There are many possible reasons why a fish stock may not have been assessed, including: (1) the fishery has developed recently, (2) data are insufficient to conduct a stock assessment, (3) technical expertise or capacity to conduct assessments is lacking, (4) the stock is small and the fishery is low-value, bycatch, or low-priority, or (5) available data are uninformative regarding stock status, productivity, or exploitation rate.

In both data rich and poor cases life history traits for growth; sexual maturity; reproduction; and mortality are important to describe exploited resources.

Expand on

- Life history traits useful in population ecology, fisheries management and conservation.
- Life history invariants help explaining population responses to management regimes
- Understanding biological processes is required if we are to develop robust management advice
- Life history theory can be used to generate simulation models
- Limitation of models, and the importance of feedback control
- FLR (Kell et al., 2007)

2 Examples

2.1 Life history invariants

- Empirical relationships between k, L_∞, L_{50}
- Ogives, growth curves, ...
- Relationships with natural mortality and stock recruitment
- Selection patterns

2.2 FLR

- Flow of processes implemented in FLife
- Equation and references for each step

2.3 Equilibrium Dynamics

Productivity and reference points

- Ecology, e.g. r
- MSY and MSY-proxies
- Emprical

2.4 Time series dynamics

2.4.1 Simulation

- How to go from equilibrium to time series
- How to recreate different historical data sets

2.4.2 Density Dependence

- SRR
- M
- Growth

2.4.3 Description

Summarise importance for feedback control of

- Resonant Cohort Effects
- Frequency Domain

2.5 Examples

- Length based assessment
- Priors
- Simple MSE

References

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