Life History Relationship

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Introduction

Many studies have shown relationships between growth, maturity and natural mortality. Life history traits have been used for providing advice for data poor stocks, developing priors for use in data rich stock assesments and to parameterise ecological models.

`FLife` package brings together a variety of methods for modelling life history traits and ecological processes and can be used to create `FLR` objects such as `FLBRP` and `FLStock` to model species, populations or stocks.

Life history relationships

In data poor situtuations only the maximum size (l_{max}) may be known. Life history relationships allow parameters for growth, maturity, natural mortality to derived from empirical relationship (Gislason et al. 2008). The `lhPar` method uses life history relationships to fill in missing values in data poor datasets.

k of the (Von Bertalanffy 1957) growth equation

$$k = 3.15 l_{\infty}^{-0.64} \tag{1}$$

and maturity from

$$l_{50} = 0.72 l_{\infty}^{0.93} \tag{2}$$

from l_{∞}, and natural mortality from length (l)

$$M = 0.55(l_{-1.66} l_{\infty}^{1.44} k \tag{3}$$

where $m_1 = 0.55(l_{\infty}^{1.44})k$ and $m_2 = -1.61$

There are alternative relationship, for example (Lorenzen and Enberg 2002) derived M from mass (w)

$$M = m_1 * w_2^m \tag{4}$$

The `lhPar` method takes as its first argument an `FLPar` object with as a minimum a value for `linf` and uses these relationships to derive `k` and $l50$

```
par=lhPar(FLPar(linf=100))
```

There are defaults for other values, which can not be derived from life history theory; these include a and b of the length weight relationship $w = al^b$, `ato95` the age at which 95% of fish are mature, the offset to age at which 50% are mature, selectivity-at-age parameters, `sl` and `sr` the standard deviations of left and righthand limbs of the double normal and parameters for the stock recruitment relationship, `s` steepness of stock recruitment relationship, `v` virgin biomass.

Then functions for growth, maturity and natural mortality, e.g. `vonB`, `sigmoid`, and `lorezen` methods can be used. These take as their first argument an object for age, length or weight and an `FLPar` as the second argument with the life history parameters.

```
age=FLQuant(0:20,dimnames=list(age=0:20))

ln =vonB(age,par)
mat=sigmoid(age,par)
wt =par["a"]*ln^par["b"]
wt =len2wt(ln,par)
```

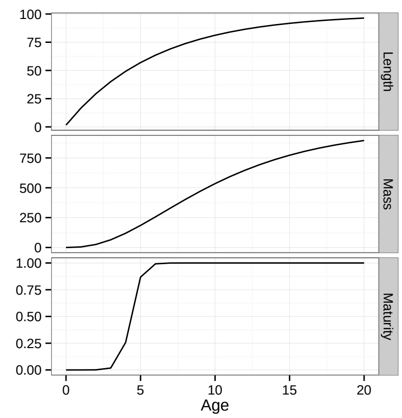

Figure 1: Biological properties

Natural mortality can either be a function of mass or length

Selection pattern can be modelled as flat topped or dome shaped by using the double normal function

FLBRP

The `FLPar` objected created can be used to parameterise an `FLBRP` equilibrium object

and then create an `FLStock` object to simulate time series

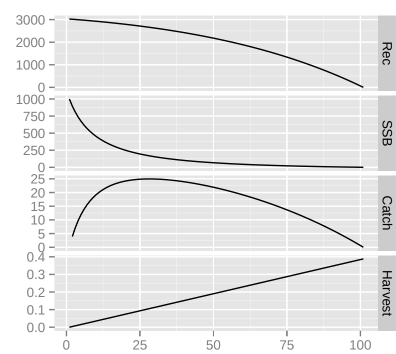

Figure 2: Time series

Examples

Simulation

Data

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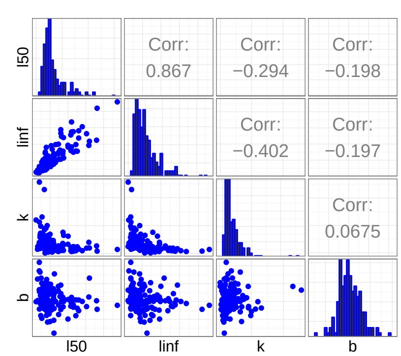

Figure 3: Parameters in teleost dataset.

Stability

An important factor determining a population's response to perturbation is stability which can be measured in a variety of ways (e.g. Pimm 1984). In its simplest form, a population can be considered stable if it returns to equilibrium after a perturbation. Other definitions expand on this and involve the time taken to return to equilibrium after a perturbation, known as the characteristic return time or population resilience. The lower the characteristic return time, or higher the resilience, the more stable the population. The stability of a population is strongly influenced by the life history of the population and also the pattern of density dependence. For some population models the stability is a good indicator of a population's response to noise (Taylor 1992), but generally stability is insufficient on its own to predict the response (Horwood 1993). Here we use it to indicate how quickly management can cause an effect in a population, e.g. to recover a stock to a level that would support MSY. In this way, stability can be used as a guide to how controllable the stock is. For discrete, structured populations this can be calculated using the magnitude of the dominant eigenvalue of the Jacobian matrix evaluated at the equilibrium point (Beddington 1974; Caswell 2001). If the magnitude of this is less than 1 the population will return to equilibrium after a disturbance, with the stability decreasing as the magnitude approaches 1. When the magnitude of the dominant eigenvalue is 1 there is a bifurcation and past this point non-equilibrium dynamics, including extinction, are seen.

```
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values (geom_path).

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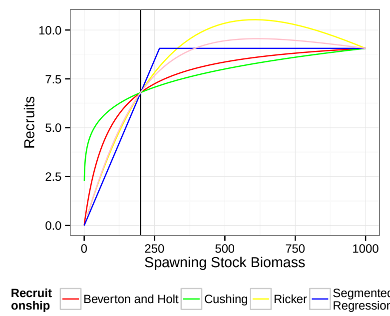


Figure 4: Stock recruitment relationships

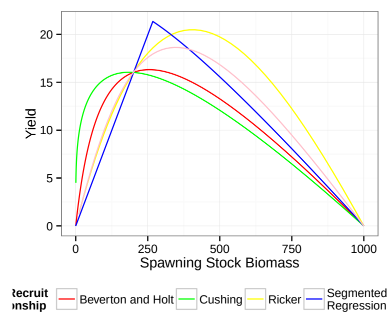


Figure 5: Production functions

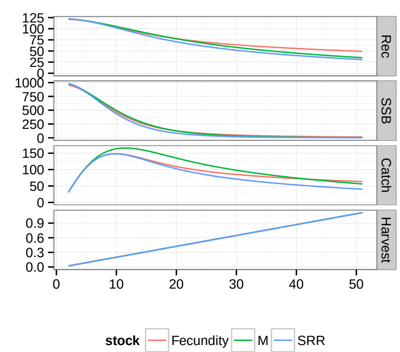
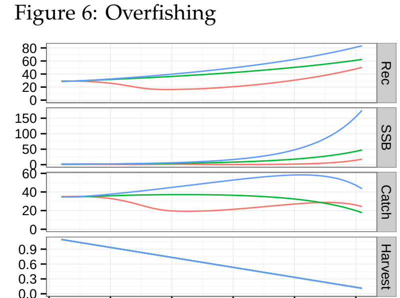


Figure 6: Overfishing



```
later versions of FLCore

=================== 101 ===================
=================== 104 ===================
=================== 107 ===================
=================== 110 ===================
=================== 113 ===================
=================== 116 ===================
=================== 119 ===================
```

Gislason, H., J.G. Pope, J.C. Rice, and N. Daan. 2008. "Coexistence in North Sea Fish Communities: implications for Growth and Natural Mortality." *ICES Journal of Marine Science: Journal Du Conseil* 65 (4): 514–530.

Lorenzen, Kai, and Katja Enberg. 2002. "Density-Dependent Growth as a Key Mechanism in the Regulation of Fish Populations: evidence from Among-Population Comparisons." *Proceedings of the Royal Society of London. Series B: Biological Sciences* 269 (1486): 49–54.

Von Bertalanffy, L. 1957. "Quantitative Laws in Metabolism and Growth." *Quarterly Review of Biology*: 217–231.

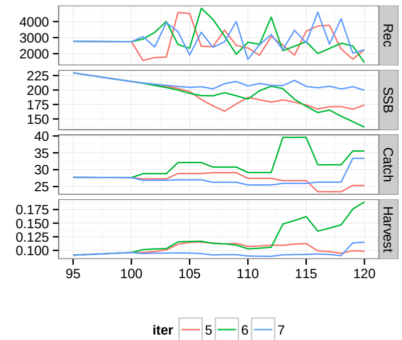


Figure 13: d

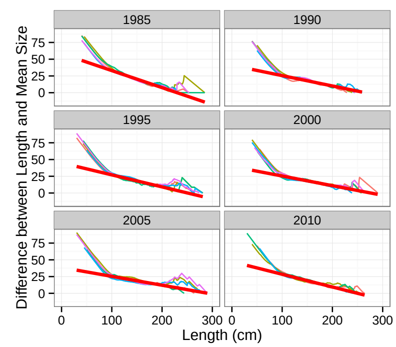


Figure 14: e