fish610.060 EAFM Tools: Gadget

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`http://minouw-project.eu/`

Contents

1 Introduction to Gadget

1.1 What is Gadget?

At its core, Gadget is a simulator which projects forward the number of fish per cell.
The fish in a cell correspond to
a species a length group
an age group
a spatial unit
a temporal unit
a maturity stage
a sex

1.2 Gadget processes

Consumption: Suitability functions
Mortality: Due to predation or other natural or fishing
Growth: Can depend on consumption. Several growth update implementations
Migration: Through migration matrices
Maturation: Move from immature to mature stock component
Spawning: Lose weight and generate yearclass
Symmetric: All species can be implemented in same way - fleet is also a predator

1.3 Estimation in Gadget

Gadget estimates unknown parameters using least squares (or maximum likelihood)
Most parameters can be set to initial values
Most parameters can be either estimated or fixed
Each forward projection results in a population trajectory
The projection can be compared to data
The comparison gives sums of squares (or likelihoods)
The estimation is done by repeating the process

2 Stock Assessment Models

2.1 Population model classes

Gadget inherits its model classes from traditional stock assessment models.
For a data-rich species a model will specify ages, length etc
For a data-poor species one may only have a bulk-biomass model (i.e. single age group)
Various models can be used to estimate growth and other functional relationships
Modularity ensures that new functional descriptions can be added

3 Fishing Fleet Models

3.1 Fishing fleets in Gadget

The most common Gadget implementations use a single fleet catching a single species, much like a traditional single species assessment
More elaborate schemes may allow a single fleet to catch multiple species
Similarly multiple fleets may catch multiple species
The selectivity of a fleet for an individual species can be estimated
An per-species catchability multiplier for a fleet can then be estimated and used with an annual effort index to obtain overall fishing mortality for each species

4 Multi-Species Models

4.1 Several species in Gadget

Gadget is sometimes used for multiple species
Normally this only involves technical interactions
Species interactions or consumption are rarely modelled
Exception: cod-capelin, cod-shrimp, cod cannibalism

4.2 Technical interactions

"Technical interactions" means several species get caught in the same fishing operation
Examples: Most bottom trawling
Typical model for one fleet:
fishing mortality on species s in year y= overall effort on * catchability of species s
or

$$F_{sy} = q_s E_y$$

So increased effort affects all the species in the model, as it should

4.3 True species interactions

Very simple models:

$$N_{s,a+1,y+1} = N_{s,a,y} e^{-F_{s,a,y} - M_{s,a,y}}$$

M=Natural mortality
$M_{s,a,y}$ = function of other species' abundance

5 Nonlinear estimation

5.1 Biological systems are typically nonlinear

- Growth
- Mortality

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so the models should be nonlinear

5.2 A relatively simple problem, ADAPT

The ADAPT assessment model

$$min_{N_{0,y},N_{a,0},q_a} \sum_{ay} w_{ay} \left(ln(I_{ay}) - ln(q_a N_{ay}) \right)^2$$

$$\text{w.r.t.} N_{a+1,y+1} = \left(N_{ay} e^{-M/2} - C_{ay} \right) e^{-M/2}$$

where M is fixed and the catches, C_{ay} are given as numbers by age and year.
But the weighting factors w_{ay} need to be specified.

5.3 Gadget biological components

5.3.1 Details

Core: Parametric forward simulation model

- Consumption: Suitability functions
- Mortality: Due to predation or other natural or fishing
- Growth: Can depend on consumption. Several growth update implementations
- Migration: Through migration matrices
- Maturation: Move from immature to mature stock component
- Spawning: Lose weight and generate yearclass
- Symmetric: All species implemented in same way - fleet is also a predator

5.4 Data are typically not Gaussian

- Length distributions
- Survey indices

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Data from a normal distribution are actually very rare in fishery science. Obvious modifications to assumptions such as the multinomial typically does not improve anything.

5.5 Nonlinearity is not an issue per se

- Use nonlinear minimisation algorithms for estimation
- Can handle a lot of unknown parameters
- Can in principle estimate variances using Hessian matrices or bootstrap

5.6 Consider each data set

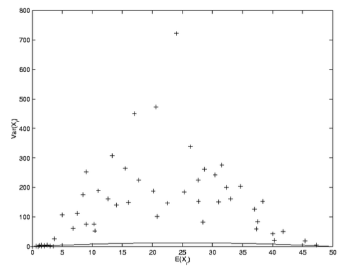
Look at single data sets and try to estimate true variances in each
Compare point estimates from each data set
Try to test formally whether results differ

5.7 Diagnostics for likelihood functions

Most likelihood functions can be verified, e.g. using Kolmogorov-Smirnov tests.
One should not be happy with a model which is rejected!

5.8 Likelihoods - Assumption

Take 50 fish from each station - compare with binomial



5.8.1 Details

Take 50 fish from each station - compare with binomial

5.9 Parsimony and flexibility

If data sources indicate different outcomes then the model is wrong!
Data are just data - they are not wrong.
Example: Catchability may vary in time and fleets may increase their catchability.
Need to add parameters until model is appropriately flexible. Notably add time series parameters...

5.9.1 A nice set of references

A special issue in Fisheries Research:

Mark N. Maunder, Paul R. Crone, Andre E. Punt, Juan L. Valero, Brice X. Semmens, Data conflict and weighting, likelihood functions and process error, Fisheries Research, Volume 192, 2017, Pages 1-4, ISSN 0165-7836, https://doi.org/10.1016/j.fishres.2017.03.006.

Available from: http://www.sciencedirect.com/science/article/pii/S0165783617300735

6 Where is Gadget going?

6.1 The next few steps

Gadget has most of the functionality needed for multispecies/multifleet work
It has also been linked to databases for bootstrapping
But it is too slow
Output and input is commonly through the R statistical package
The next step is to make the entire Gadget environment faster and smoothly integrated into R