# Biological Model

## fish610.080 EAFM Tools: Atlantis

Haley Frater

February 12, 2025

# Functional groups

There can be a number of functional groups, each modeled as a different type, e.g. vertebrates, invertebrates, primary producers, bacteria, and detritus. How the vertebrates are modeled depend also on if they are fish, shark, mammals, birds or reptiles. The invertebrates are also modeled differently for infaunal, epibenthic and water column invertebrates. The same is for the primary producers but they can be either epibenthic or not and the bacteria is either in the sediment or in the water column. There are three detritus groups: carrion which contains discards, labile detritus and refractory detritus.

There are 52 functional groups in the Icelandic model: 20 fish groups (8 represented at a species level), 5 mammals, 1 seabird group, 16 invertebrates, 5 primary producers, 2 bacteria and 3 detritus groups.

Vertebrates can have up to ten age-classes each with multiple cohorts. A vertebrate with maximum age 30 would have ten age-classes and 3 cohorts in each age class. A vertebrate with maximum age 6 would have

# Reproduction

The reproduction of the vertebrate groups can be modeled with number of different function in the Atlantis model. It can e.g. be modeled as constant per adult, with the Beverton-Holt function or with the Ricker function. In the Icelandic Atlantis model the reproduction of fish groups were modeled with the Beverton-Holt function but the recruitment of the mammals and seabird groups were modeled as constant per adult.

The time of spawning and recruitment is set. At time of spawning the spawning biomass is calculated and the numbers of recruitment. If the ratio between reserve and structural weight is under a certain value (i.e. the group is starving) there will be no reproduction. The groups lose a certain proportion (usually 25-40%) of their biomass at the time of spawning. The larval life stage is to modeled and the recruitment comes into the model at a time set which can be months after the spawning time. The time of recruitment is also the time when aging into older age classes takes place.

# Predation and consumption

The consumption rate of predators is usually modeled with Holling type I-II in the Atlantis model. In the Icelandic Atlantis model the consumption rate ($CR_{ij}$) of predator $j$ on prey $i$ is modeled with Hollig type II as follows:

$$CR_{ij} = \frac{C_j \cdot a_{ij} \cdot B_i}{1 + \frac{C_j}{mum_j}[\sum_{k=1}^{n} a_{kj} \cdot B_k \cdot E_{kj}]} \quad (1)$$

where $mum_j$ is the maximum growth rate and $C_j$ is the clearance rate of predator $j$. The ratio between the $mum$ and the $C$ controls how steep the consumption curve is (Figure). The $B_i$ is the biomass of prey $i$, $a_{ij}$ is the availability of that prey to predator $j$, and the $E_{ij}$ is the assimilation rate of prey $i$ for predator $j$. The assimilation rate was set to 0.8 which means that 80% of what the predator eats it can use for growth. The availability parameter ($a_{ij}$) is tuned to adjust the diet composition of each predator. The availability of each prey is also affected by the gape limitation of the predator. A gape limitation is set in the model so that the prey has to fit into the mouth of the predator. This is usually set so that the prey

# Growth

The growth functions of the functional groups depends on their group type.

The growth of the primary producers depend on their growth rate and is limited by nutrients, light and space.

The growth of invertebrates modeled as biomass pools depends on their growth, (i.e. the proportion of their consumption that can be used for growth), respiration, what is lost because of predation or other mortality.

The growth for age structured groups (vertebrates) is divided between the reserve and structural weight. What affects individual growth of vertebrates are the growth, respiration, and weight lost due to spawning. The the model also tracks the number of individuals of the vertebrates. the changes in numbers depend on recruitment and ageing into the next age group. It also depends on predation mortality and other mortalities.

# Mortality

Mortality can be modeled in many different ways and this also depends on the type of the functional group. Predation mortality is modeled with the consumption function, e.g. Holling type II. Additional mortalities that the model is not able to catch can be modeled with linear and quadratic mortalities. Linear mortality is a constant proportion that dies but quadratic mortality is density dependent, i.e. it increases as the density of the group increases.

# Movement and migration

The modeled area is divided into spatial boxes and into vertical layers. The groups can have different spatial and vertical distribution which can be allowed to change from one season to the next. The distribution can also be different between juveniles and adults. The groups can also have migratory behavior and can migrate in and out of the model area.

```
ERROR: HTTP Error 404: Not Found
Traceback (most recent call last):
  File "/srv/sites/tutor-web-2/src/tutorweb.content/tutorweb/
    data.setData(self._urlConvert(orig))
  File "/srv/sites/tutor-web-2/src/tutorweb.content/tutorweb/
    resp = urllib2.urlopen(urllib2.Request(script))
  File "/usr/lib/python2.7/urllib2.py", line 154, in urlopen
    return opener.open(url, data, timeout)
  File "/usr/lib/python2.7/urllib2.py", line 435, in open
    response = meth(req, response)
  File "/usr/lib/python2.7/urllib2.py", line 548, in http_res
    'http', request, response, code, msg, hdrs)
```

# Initial conditions

Initial conditions need to be set before the model can simulate the ecosystem. The Icelandic Atlantis model starts in 1948 and the initial conditions are therefore set for that year. The initial condition include total numbers and individual weight for each age-class of each vertebrate group and total biomass for groups not with an age structure (invertebrates, primary producer, etc.). The model also requires initial condition of the nutrient concentrations (N, Si and $O_2$) in the ocean.