Description of the VBtag model

Arni Magnusson

8 July 2022

Growth

Growth follows a traditional von Bertalanffy form:

$$\hat{L}_i \;=\; L_\infty\Big(1 - e^{-k(t_i - t_0)}\Big)$$

Likelihood

A traditional normal likelihood is used:

```
dnorm(y, mu, sigma)
```

The model has three likelihood components, baesd on the fit to observed lengths at tag release, lengths at tag recaptures, and lengths from the otolith data:

$$f \;=\; \log L_{\text{rel}} \;+\; \log L_{\text{rec}} \;+\; \log L_{\text{oto}}$$

Unequal variances

The variability in length at age (σ) varies with age:

$$\log \sigma_i \;=\; \text{intercept} \;+\; \text{slope} \times t_i$$

Model parameters

L_∞, k, t_0	growth curve coefficients
σ_a, σ_b	sd(length) at ages a and b
age	vector of estimated age at release for all tagged fish

Parameters are estimating using traditional MLE, except the sigma parameters are fixed (estimated iteratively and externally).

Input data

```
DATA_VECTOR(Lrel);        // length at release (tags)
DATA_VECTOR(Lrec);        // length at recapture (tags)
DATA_VECTOR(liberty);     // time at liberty (tags)
DATA_VECTOR(Aoto);        // age (otoliths)
DATA_VECTOR(Loto);        // length (otoliths)
DATA_SCALAR(a);           // younger age where sd(length) is sigma_a
DATA_SCALAR(b);           // older age where sd(length) is sigma_b
```

Source code

Link to GitHub (requires GitHub login).

Background and model variations

GCM

SPC is exploring various methods to estimate growth parameters for the 2022 stock assessment of skipjack tuna. As part of this exploration, there was interest in fitting a growth cessation model (GCM), described in Maunder et al. (2018).

Mark Maunder shared the GCM model code with the SPC growth modelling team via email (2022-05-28). This model is written in Template Model Builder (TMB) and estimates ages from tagging data, based on the observed length increase between the date of release and date of recapture.

L_∞, k, $r_{\max}$	growth curve coefficients
A_{fix}, L_{fix}	additional growth curve coefficients
σ_a, σ_b, σ_{MEb}	sd(length) coefficients
age	vector of estimated age at release for all tagged fish

VBtag

The SPC data do not show clear signs of growth cessation, so the SPC team decided to write a similar model that uses a traditional von Bertalanffy model.

The VBtag model is simpler than the GCM model, describing the growth curve with 3 parameters (L_∞, k, t_0) instead of 5 parameters (L_∞, k, $r_{\max}$, A_{fix}, L_{fix}).

The main difference between VBtag and a 'plain vanilla' von Bertalanffy model is that VBtag estimates the release age of tagged fish, using the same approach as the GCM model. The parameter vector of estimated ages uses half of the degrees of freedom from the tagging data, where each tagged fish provides two observed values to be fitted by the model: length at release and length at recovery.

GCM_oto

The GCM_oto model is the same as the GCM model, with the addition of including the otolith data. This introduces no additional parameters.

VBtag_oto

The VBtag_oto model is the same as the VBtag model, with the addition of including the otolith data. This introduces no additional parameters.