**Tag-recapture Antarctic toothfish random effects environment**

Authors: D’Arcy N. Webber1, James T. Thorson2

1Quantifish

1 Saint Michaels Crescent

Kelburn

Wellington 6012

New Zealand

2Fisheries Resource Assessment and Monitoring Division

Northwest Fisheries Science Center

National Marine Fisheries Service

National Oceanic and Atmospheric Administration

2725 Montlake Blvd. East

Seattle, WA 98112

**Abstract**

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## Introduction

Variation among individuals can be studied by treating each individual's demographic parameters as a random effect that arises from a population-level distribution. We start with the specialized von Bertalanffy growth function:

where *dL/dt* is change in length as a function of time, *a* scales with energy acquisition, and *b* represents metabolic upkeep costs. Individuals that are more highly active may obtain more food (increased *a*) and simultaneously have greater upkeep costs (increased *b*). Following Shelton et al. (2013), we include this correlation via the following equation:

(2)

where *γ* and *Ψ* approximate the allometric scaling of energy costs and acquisition. Integration then yields:

where

where *Δt* is the number of time-periods elapsed between length intervals, and where the Brody growth coefficient (as in the conventional von Bertalanffy growth function). The asymptotic length can be found by setting Eqn. 1 equal to zero, substituting in Eqn. 2, and rearranging:

Penalized likelihood, the prior on the Linf par acts as a penalty function.

Set at mu=and sig= (Dunn et al. 2006).

Readers are referred to Shelton et al. (2013) for an expanded model that incorporates variability in *γ* over time, although we retain the assumption that *b* varies among individuals (and hence has subscript *i*), where it follows a normal distribution (truncated at zero) with estimated mean and variance parameters.

Following previous notation, parameters are estimated by integrating across all random effects ***b***, while noting that Eq. 3 also requires estimation of *Li(t0)*, i.e., the length upon first observation for each individual.

We implement this model using the *Template Model Builder* (*TMB*) software called from *R* using the *TMB* package and provide the code as an example of how to call *TMB* from *R* (Appendix A). We fit the model to data collected in the Antarctic toothfish (*Dissostichus mawsoni*) tagging programme wherein each individual is uniquely tagged and aged at recapture.

So

Sex-specific gamma could not be estimated (see v7).

Table 1 – List of model runs.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Model run | Time-step | Linf penalty | L0 penalty | tvi | Y devs | Area devs |
|  | Daily |  |  |  |  |  |
| V9 | Weekly | x |  | x |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

## Simulation

A simulation study was done to validate the model.

## Discussion

Mention how when the model was fit to annual rather than daily growth increments that the estimated parameters resulted in biased high growth schedules.

**Bibliography**

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**Appendix A – Code for calling *TMB* from within *R***

Table 2 – List and definition of symbols used in the text and equations.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter name | Symbol | Units | Dimensions |
| Individual |  |  |  |
| Time |  | Days |  |
| Sex |  |  | 2 |
| Area |  |  |  |
| Length |  | cm |  |
| The hypothetical length at |  | cm |  |
|  |  | Days |  |
| Anabolic rate |  |  |  |
| Catabolic rate |  |  |  |
|  |  |  | 1 |
|  |  |  | 1 |
| Time variation |  |  |  |
| Asymptotic maximum length |  | cm |  |
| Brody growth coefficient |  |  |  |
| The hypothetical time at which |  | Days |  |
| Observation error standard deviation |  |  | 1 |
| Catabolic rate standard deviation |  |  |  |
|  |  |  | 1 |
|  |  |  | 1 |
|  |  |  | 1 |