

Stock Reduction Analysis using catch at length data

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Abstract

Last thing to be written

1 Introduction

Modern stock assessments typically attempt to fit population dynamics models to catch at age and catch at length data, in hopes of extracting information from these data about age/size vulnerability and fishing mortality patterns (Methot and Wetzel, 2013; Hilborn and Walters, 1992). In cases where age data are lacking, softwares like MULTIFAN-CL attempt to obtain estimates of vulnerability and fishing mortality only from size distribution data (Fournier et al., 1998). Combined with a few assumptions regarding the structure and variability in length at age, this procedure can even be used to attempt to recover information about changes in body growth patterns if there is a strong age-class signal in the length frequency data (Fournier et al., 1998). Some older assessment methods attempt to put aside the length frequency data, by converting these data to age compositions using age-from-length tables, perhaps using iterative methods to estimate proportions of fish at age for each length interval (e.g. Shirippa and Goodyear, ref.). It is typical for assessment results from length-based assessment models to show substantial deviations between predicted and observed length distributions of catches, reflecting both sampling variation in the length composition data and incorrect assumptions about stability of both growth and vulnerability patterns.

Here we suggest an alternative approach to assessment modeling that begins by assuming that the assessment model should exactly reproduce the observed catch at length distribution. This is similar to the classical assumption in virtual population analysis that reconstructed numbers at age should exactly match observed catch at age data, or the suggestion by Schnute (ref) that statistical catch at age models might best be run in a conditioned on catch format by subtracting observed catches at age from modeled numbers at age in estimation

25 of numbers at age over time. The suggested approach may have two key advantages over statistical catch at age
26 and/or catch at length models: (1) it does not require estimation of age or size vulnerability schedules, and (2)
27 catch at length data are commonly available for every year, even when age composition sampling has not been
28 conducted.

29 **2 Methods**

30 In this section we describe the stock reduction analysis with catch at length data, describe the simulation
31 analysis and scenarios used to test the model and provide a description of the real data used to illustrate the
32 model applicability.

33 **2.1 Stock reduction analysis with catch at length data**

34 The stock reduction analysis described here starts by calculating , the proportions of individual at length
35 for each age class (Table 2. The calculation of such proportions relies on three main assumptions regarding the
36 distribution of length at age: (1) The mean length at age follows a von Bertalanffy growth curve T1.5, (2) The
37 length at age is normally distributed T1.2 and (3) The standard deviations of the length at age distributions is
38 given by the product of the mean length at age and a constant cv T1.6.

39 Once the length composition at age has been determined, the next step in the model is to propagate the
40 population dynamics forward with a age structured population dynamics model. We assume that

41 **2.2 Simulation routines and scenarios**

42 **2.3 Real data examples**

43 equations and data description go here

44 **3 Results**

45 show figures with real and simulated data

46 **4 Discussion**

47 Does the model work

Table 1: Age at Length

Variable definition	
$P_{l a}$	Matrix of proportions of length at age
$z1_{a,l}$	Normalized Z score for lower limit length bins
$z2_{a,l}$	Normalized Z score for upper limit length bins
$b1_l$	Lower limit of length bins
$b2_l$	upper limit of length bins
\bar{L}_a	Mean length at age
σ_{L_a}	Standard deviation of length at age
L_{inf}	Maximum average length
k	rate of approach to L_{inf}
t_o	Theoretical time in which length of individuals is zero
cvL	Coefficient of variation for length curve (T1.1)
Age-schedule information	
$P_{l a} = \int_{z1_{a,l}}^{z2_{a,l}} \mathcal{N}(0, 1)$	(T1.2)
$z1_{a,l} = \frac{b1_l - \bar{L}_a}{\sigma_{L_a}}$	(T1.3)
$z2_{a,l} = \frac{b2_l - \bar{L}_a}{\sigma_{L_a}}$	(T1.4)
$\bar{L}_a = L_{inf} \cdot (1 - \exp^{(-k \cdot (a - t_o))})$	(T1.5)
$\sigma_{L_a} = \bar{L}_a \cdot cvL$	(T1.6)

Table 2: Age at Length

Variable definition	
$P_{l a}$ = Matrix of proportions of length at age	
Age-schedule information	
$N_{a,t} = \begin{cases} \frac{a \cdot SB_{t-1}}{1+b \cdot SB_{t-1}} \cdot \exp(wt), & a = 1 \\ N_{a-1,t-1} \cdot S_a \cdot (1 - U_{a-1,t-1}), & 1 < a < A \\ \frac{N_{a-1,t-1} \cdot S_a \cdot (1 - U_{a-1,t-1})}{1 - S_a \cdot 1 - U_{a,t}}, & a = A \end{cases}$	
	(T2.1)
$U_{a,t} = \sum_a P_{l a} \cdot U_{l,t}$	(T2.2)
$U_{l,t} = \frac{C_{l,t}}{N_{l,t}}$	(T2.3)
$N_{l,t} = \sum_a (P_{l a} \cdot N_{a,t})$	(T2.4)

References

- Fournier, D. A., Hampton, J., and Sibert, J. R. (1998). MULTIFAN-CL: A length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. *Canadian Journal of Fisheries and Aquatic Sciences*, 55(9):2105–2116.
- Hilborn, R. and Walters, C. J. (1992). *Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty/Book and Disk*. Springer Science & Business Media.
- Methot, R. D. and Wetzel, C. R. (2013). Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. *Fisheries Research*, 142:86–99.