A NEW METHOD FOR ESTIMATING GROWTH AND MORTALITY PARAMETERS FROM LENGTH-FREQUENCY DATA

by

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A new, simple method has been found to estimate the asymptotic length (L_∞) and the ratio of the coefficients of mortality and growth (Z/K) using only length-frequency data from a fish catch. Theoretical details of the method are given in a paper by J.A. Wetherall, J.J. Polovina, and S. Ralston, to appear in the forthcoming ICLARM proceedings of the 1985 Sicily conference on length-based stock assessment (See Fishbyte 3(1), March 1985). A practical user's guide to the new procedure, with computational algorithms and Turbo Pascal code, will be available soon from the author. In this report only a brief description of the method is given. (see also Pauly, this issue).

The sampled fish population is assumed to be stable, with constant annual recruitment, von Bertalanffy growth, and continuous mortality occurring at a uniform, instantaneous rate. A random sample of n fish are measured, m of these longer than a particular knife-edge selection length. The measurements are retained for analysis, and data on fish shorter than the selection length are neglected. In practice the assumptions on recruitment, growth, mortality and size selection are rarely satisfied. But if they are roughly true, or if corrective steps are taken during analysis, the method provides estimates that are useful for many tropical fishery management decisions and which are superior to estimates produced by other simple procedures.

With the above assumptions, it is shown in the Sicily paper that the mean length of the m selected fish ($\bar{L}$) is a linear function of the knife-edge selection length (L_c):

$$L = L_\infty \left(\frac{1}{1+\theta}\right) + L_c\left(\frac{1}{1+\theta}\right) \qquad (1)$$

where $\theta = Z/K$, Z is the instantaneous mortality rate, and K and L_∞ are the growth coefficient and asymptotic length of the von Bertalanffy model.

Equation (1) is the basis of Beverton and Holt's well-known method of estimating θ given L_∞ ., L_c and $\bar{L}$. Rearrangement of (1) results in their classic formula

$$\theta = \frac{L_\infty - \bar{L}}{\bar{L} - L_c} \qquad (2)$$

The new approach improves on the Beverton-Holt method, allowing the estimation of L_∞ in addition to θ. It does this by making fuller use of information in the sample besides the overall mean length. Specifically, it takes advantage of the linear relationship between sample mean length and the selection length.

For a series of p arbitrary cutoff lengths within the size range of the m

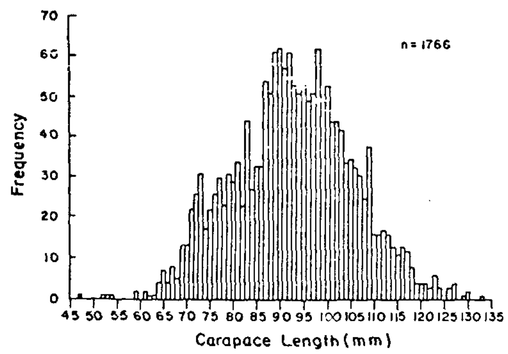

Fig. 1. Length-frequency distribution for male *Panulirus marginatus* on Maro Reef, Northwestern Hawaiian Islands.

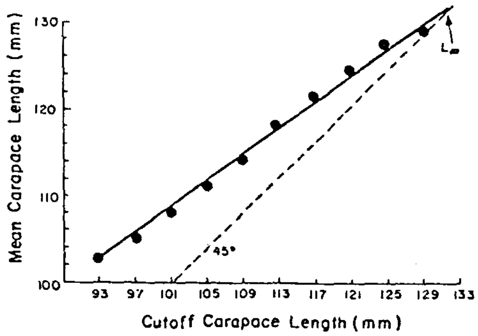

Fig. 2. Regression of mean carapace length on cutoff carapace length for 10 lobster subsamples.

selected fish, we construct a corresponding series of partially overlapping subsamples. The i-th subsample consists of those m_i fish whose lengths exceed L_{ci} ($i=1,\ldots,p$). If the mean lengths for the subsamples are plotted against the cutoff lengths, a positive linear relationship results, as predicted by formula (1). For clarity, we label the intercept and slope of the straight line with conventional symbols:

$$\alpha = \left(\frac{L_\infty}{1+\theta}\right) \qquad (3)$$

and

$$\beta = \left(\frac{\theta}{1+\theta}\right) \qquad (4)$$

The parameters of interest, L_∞ and θ, can be estimated in two simple steps:

Step 1. Compute α and β from a linear regression of $\bar{L}_i$ on L_{ci}. Statistical weights should be used. It will usually suffice to weight each subsample mean length by the reciprocal of its variance, or even by the corresponding subsample size.

Step 2. Given the estimates of α and β, compute L_∞ and θ as the solution of Equations (3) and (4):

$$L_{oo} = \left(\frac{\alpha}{1-\beta}\right) \qquad (5)$$

and

$$\theta = \left(\frac{\beta}{1-\beta}\right) \qquad (6)$$

The standard errors of the estimates of L_∞ and θ can be calculated using methods discussed in the Sicily conference paper.

Figures 1 and 2 show an example, based on male spiny lobsters, *Panulirus marginatus*, taken in 1977 on Maro Reef in the Northwestern Hawaiian Islands (data compliments of J.J. Polovina, Honolulu Laboratory). Out of the entire sample of 1,766 lobsters, 904 lobsters had a carapace longer than the assumed knife-edge selection length of 93 mm. Measurements from these lobsters were partitioned into 10 overlapping subsamples, based on arbitrary cutoff lengths of 93 mm, 97 mm, 101 mm, 105, ..., 129 mm. The linear regression was run using reciprocals of the variances of subsample means as statistical weights. Estimates of the intercept and slope were $\alpha = 0.251$ mm and $\beta = 0.743$ mm^{-1}. Step 2 yielded the final results, $L_\infty = 131.1$ mm and $\theta = 2.89$.