FILE
STATE REPORTS

THE STUDY OF GROWTH IN FISH

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The body-scale technique is an established method of studying the past growth of fish. Normally, this method consists of determining the relationship between some dimension of the scales and body length of fish. Once the relationship is established, it is used to study the growth history of individual fish (back-calculation of length at each annulus). Occasionally, back-calculations are based on an assumed relationship (usually 1:1) between body growth and scale growth.

In spite of the acceptance of the body-scale technique by fisheries workers, there are a number of problems associated with its use which, if not taken into account, can lead to erroneous results or interpretations. Some of the more serious of these are (Shields, 1958; Lindroth, 1963):

1. Differential mortality related to size of fish
2. Segregation of individual age classes into groups based on size of fish
3. Selectivity of sampling gear related to size of fish
4. Differential growth rates in body length related to sex
5. Differential growth rates in scale size related to position on body
6. Varying relationships between body growth and scale growth related to environmental factors
7. Varying lengths of growing seasons.

As a result of these conditions, it is widely recognized that assumed relationships and those extrapolated to other populations or the same population in other years are very unreliable. We agree that these limitations are justified, but would extend them to include the same sample of fish from which the relationship is established. In other words, we feel that in general it is not possible to establish a body-scale relationship for a population of fish that is valid for all year classes in that population.

As an alternative, we recommend that growth in individual fish be established in terms of length at last annulus only. This approach apparently was first suggested by Carlander (1950). The advantage of this method is that it provides the most accurate picture of the size of fish in each year class in the population at the time the last annulus was formed. These are the population elements that should be used for comparison, on an age-class basis, with populations in other locations and/or years. The apparent disadvantage of the method, of course, is that it ignores the growth histories of fish at ages prior to the last annulus. We feel, however, that since there is no reliable way of determining these, it is better to have no information than incorrect information.

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In order to standardize the method, we suggest the following guidelines for gathering and interpreting body-scale data:

1. When practical, ensure that each age class of interest is sampled representatively according to size and sex; this may have to be done by using different modes of capture in each of a number of different areas throughout the water.

2. Select scales from a key area of each fish; this area may differ from one family to another.

3. Measure the scale radius in units and at a magnification that ensures reasonable accuracy. The units and magnification themselves are not important because all data are converted ultimately to fish lengths. Clutter and Whitesel (1956) recommend using the anterior ventral 20° radial line for sockeye salmon, but we feel that this is not justification for its blanket application to other species. Rather, the anterior portion of the anterior-posterior axis seems to be a more rational choice in general, in lieu of species-specific studies that indicate otherwise.

4. For each fish in the sample, calculate

$$L_a = LR_a/R$$

where L_a = estimated length of fish at last annulus
L = length of fish at time of capture
R_a = scale radius at last annulus
R = scale radius at time of capture

Although this calculation assumes a 1:1 relationship between body growth and scale growth, which normally will not be valid, the discrepancy between calculated L_a and true (unknown) L_a will be minimal because of the relatively small increments of growth involved.

5. For each age class in the sample, calculate

$$\bar{L}_a(i) = \frac{1}{n_i}\sum_j L_a(i,j)$$

$$\hat{\sigma}^2\{\bar{L}_a(i)\} = \frac{1}{n_i(n_i-1)}\{\sum_j L_a^2(i,j) - n_i\bar{L}_a^2(i)\}$$

where $\bar{L}_a(i)$ = sample mean length of fish in age class i
n_i = sample number of fish in age class i
$L_a(i,j)$ = length of jth sample fish in age class i ($j = 1,\ldots,n_i$)
$\hat{\sigma}^2\{\bar{L}_a(i)\}$ = sample variance of $\bar{L}_a(i)$

If a plot of the length frequency distribution of sample fish in a given age class is reasonably normal, then $100(1-\alpha)$ percent confidence limits can be imposed on $\bar{L}_a(i)$ as

$$\bar{L}_a(i) \pm t_{\alpha/2}\hat{\sigma}\{\bar{L}_a(i)\}$$

where $t_{\alpha/2}$ = tabulated t value corresponding to the $\alpha/2$ probability level and n_i-1 degrees of freedom.

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