A SIMPLE METHOD OF ESTIMATION OF MORTALITY

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ABSTRACT

A simple method of estimating the Instantaneous rate of mortality (Z) from length-frequency data is proposed. This approach also facilitates simultaneous estimation of the standard error of the estimate.

In fish-stock assessment, estimation of total instantaneous rate of mortality (Z) is a prerequisite for understanding the dynamics of exploited fish populations. If the age distribution of the population is known then estimation of Z is quite straightforward. However, in tropical waters estimation of age poses a lot of problems and, hence, for estimating the vital parameters of the population recourse has to be taken to the length-frequency distribution. There are various methods available in literature for estimating Z that make use of growth parameters along with the length-frequency data. Alagaraja (1984) has proposed some simple methods for estimating Z. Jones (1984) has given an account of various methods in literature. In this paper a simpler method of estimating Z is proposed along with the standard error of the estimate.

The Method

Let N_t be the number of fish at time t and we assume that the numbers decline exponentially with time in the following functional form,

$$N_t = N_o e^{-Zt}$$

Where N_o is the number at time $t = 0$ and Z is the total instantaneous rate of mortality.

The number of fish in the interval t, t+dt is given by

$$N_{t,t+dt} = (N_o/Z) e^{-Zt} (1 - e^{-Zdt})$$

The number of fish in the interval t, ∞ is

$$N_{t,\infty} = (N_o/Z) e^{-Zt}$$

Thus, the proportion of individuals in the interval t, t+dt is

$$P_{t,\,t+dt} = N_{t,\,t+dt} / N_{t,\,\infty} = 1 - e^{-Zdt}$$

From the above we get,

$$Z = -(1/dt) \ln (1 - p_{t,\,t+dt}) \qquad \ldots\ldots\ldots\ldots (1)$$

Now, let us assume that the fishing mortality rate F is constant for $t \geq t_c$ and the natural mortality rate M is constant and let $C_{t,\,t+dt}$ and / $\sum_{\geq t} C_t$ be be the numbers caught in the interval $(t, t+dt)$ and the cumulative catch from t_c onwards, respectively. Then, the proportion caugh $q_{t,\,t+dt}$ is $C_{t,\,t+dt} / \sum_{\geq t} C_t$ and (1) takes the following form

$$Z = -(1/dt) \ln (1 - q_{t,\,t+dt}) \qquad \ldots\ldots\ldots\ldots (2)$$

If we assume the growth in length follows von Bertallanffy's growth formula then

$$dt = (1/K) \ln ((l_\infty - l_t) / (l_\infty - l_{t,\,t+dt}))$$

where l_t and $l_{t,\,t+dt}$ are the lengths at ages t and t + dt, respectively, and l_∞ and K have their usual meaning.

TABLE 1. *Hypothetical Example* (l_∞ = 100 cm, K = 0.2 and l_c = 50 cm)

Length cm	Numbers caught	Cum Nos. C_t	q	1-q (1)	$l_\infty - l_t$ (2)	$l_\infty - l_{t,\,t+dt}$ (3)	ln (2/3)	Z/K=ln (1)/4
30-35	5	420	0.012					
35-40	10	415	0.024					
40-45	30	405	0.074					
45-50	45	375	0.120					
50-55	51	330	0.155	0.845	50	45	0.105	1.604
55-60	49	279	0.176	0.824	45	40	0.118	1.641
60-65	44	230	0.191	0.809	40	35	0.134	1.582
65-70	41	186	0.220	0.780	35	30	0.154	1.613
70-75	36	145	0.248	0.752	30	25	0.182	1.566
75-80	33	109	0.303	0.607	25	20	0.223	1.619
80-85	28	76	0.368	0.632	20	15	0.288	1.593
85-90	23	48	0.479	0.521	15	10	0.405	1.610
90-95	17	25	0.680	0.320	10	5	0.693	1.644
95-100	8	8						

The portion used for estimation of Z|K is from the length classes (50-55) to (90-95)
(q for 30-35 = 5|420 = 0.012 .... for 50-55 q = 51|330 = 0.155 etc.)
Average Z|K is (1.604 + 1.641 + ... + 1.644)|9 = 1.608 and standard error of Z/K is $s\,Z/K = \sum_{i=1}^{n} (x_i - \bar{x})^2 / (n-1)$ where n is the number of length-classes considered for estimation and x_i is the ith Z|K value $\bar{x}$ is the average Z|K.

For this example the standard error of Z|K is 0.009. Since K = 0.2 we have Z = 1.608 X 0.2 = 0.322, and standard error of Z is 0.2 X 0.009 = 0.002.

Then (2) takes the form

$$Z/K = -\ln(1-q_{t,t+dt}) / \ln((l_\infty - l_t)/(l_\infty - l_{t,t+dt}))$$

Thus, using this, if l_∞ and K are known, Z can be estimated from a given length-frequency data. One advantage of this approach, besides its simplicity in computation, is that it provides standard error of the estimate. Suppose n length-classes are considered for estimating Z|K, then there will be n estimates of Z|K, from which standard error can be computed. The method of estimation and computation of the standard error are demonstrated with the help of an example (Jones 1984) (See Table 1).

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