Appendix

Calculation of Fiducial Limits on the Williams Creek Population Estimate

To calculate error limits for the population estimate, large sample statistics have been utilized.

In the expression:

$$(9) \cdots\cdots \quad P = \frac{F}{L} \cdot \frac{t_a}{t_b} \cdot \frac{t_o / S_o}{t_e / S_e}$$

P_n is subject to error derived from sampling errors associated with P_1, L, F, t_b and t_e. t_a, S_o and S_e; constants representing the numbers of fish in three different samples, and are not subject to sampling error. F_1, the estimated total number of fish that would have been seen if daily creek surveys had been made is subject to systematic errors rather than random sampling errors; variation in the ability of different surveyors to observe fish is an important source of error in this case. An estimate of the error might be obtained by comparing the numbers of fish seen during simultaneous surveys made by two or more individuals or two or more surveys made on the same day by a single observer. Although the above procedures have been carried out elsewhere (e.g., see App. No.) Ann. Rep. Pac. Biol. Stn., 1952, by the author), it was not feasible to carry out such a programme on Williams Creek this year. However, the number of fish seen during each survey ~~(P_1, P_2 ... P_n)~~ is a relatively large number and errors in counting would tend to be small. ~~Therefore, assuming that P_1, P_2 ... P_n are not subject to too wide a range of variability, the accuracy of P_2 is dependent on how accurately the graph of P_2 relating "p" with time reflects the course of the run. The more~~ The more frequently creek surveys are carried out the more accurate will the graph relating number of fish seen to time reflect the pattern of the true run. Considering the length of stream life of the fish (approx. 14 days), it is likely that during weekly surveys the possibility of seeing every fish that ascended Williams was realized. If surveys had been made at intervals greater than the life-span of the fish, then some doubt as to the representative nature of the graph might be raised. In view of these considerations, F_1, though subject to systematic error, can be considered a constant for the purposes of the present calculation.

Rearranging (9) we obtain:

$$P = \frac{F \cdot t_a \cdot S_e}{S_o} \cdot \frac{t_o}{L \cdot t_b \cdot t_e}$$

$$(10) \cdots\cdots \text{ or } \quad P = K \cdot \frac{t_o}{L \cdot t_b \cdot t_e}$$

where K = a constant

Using large sample statistics (Tuttle and Satterly, pp. 217-219, 1925) the standard error of P_n may be estimated:

$$(11) \cdots \text{ if } \quad \bar{X} = K x_1^{a} \cdot x_2^{b} \cdot x_3^{c} \cdots\cdots$$

Where K is any constant and a. b. c.... may have any value integral or fractional, positive or negative

$$(12) \cdots \text{ Then } \quad R^2 = a^2 r_1^2 + b^2 r_2^2 + c^2 r_3^2$$

Where R = "relative" standard error of $\bar{X}$ and $R_{\bar{x}}$ = "relative" standard error of $\bar{x}$

(13) - - - - $r_{\bar{x}_1}$ = relative standard error of $\bar{x}_1$

$$= \frac{s_{\bar{x}_1}}{\bar{x}_1}$$

The standard error of $\hat{P}_n$ may be calculated by determining the standard errors of t_o, t_b, t_e and L and applying formula (7). The standard error of L may be obtained by direction calculation.

$$L = 14.2 \qquad s_L = 4.03 \qquad s_{\bar{L}} = 0.95$$

t_o, t_b and t_e represent numbers of tagged fish occurring in large samples of fish examined. As t_o, t_b and t_e are small with respect to the numbers of fish examined, distributions of values of the t's obtained in a large number of similar samples would be best approximated by the Poisson distribution. In this case, the standard error of the t values may be estimated.

$$s_{\bar{t}} = \sqrt{t}$$

Thus

$$s_{\bar{t}_o} = \sqrt{212} = 14.6$$

$$s_{\bar{t}_b} = \sqrt{\cancel{104}\,65} = 8.06$$

$$s_{\bar{t}_e} = \sqrt{104} = 10.2$$

and

$$r_{\bar{t}_o} = \frac{14.6}{212} = .069$$

$$r_{\bar{t}_b} = \frac{8.06}{65} = .124$$

$$r_{\bar{L}} = \frac{0.95}{14} = .068 \qquad r_{\bar{t}_e} = \frac{10.2}{104} = .098$$

as the powers a, b, c in (7) are ~~all~~ equal to ± 1

$$R_p^2 = r_{\bar{t}_o}^2 + r_{\bar{t}_b}^2 + r_{\bar{t}_e}^2 + r_{\bar{L}}^2$$

$$= .069^2 + .124^2 + .098^2 + 0.068^2$$

$$= .0341$$

$$R_p = .185$$

From (13)

$$s_{\hat{P}} = \hat{P} \times R_p$$

$$= 9932 \times .185$$

$$= 1837$$

95% fiducial limits of P
are $P \pm 1.96\, S_P$
In this case $P = 9932 \pm 3601$
Upper and lower limits are 13,533 and 6331