DWR: Feather River Trap Efficiency and Emigration Estimate

Trap efficiency is evaluated using fish collected in the RSTs. Evaluations are conducted using salmon captured in their respective traps (i.e. salmon trapped at Live Oak are generally used for Live Oak trap efficiency evaluations). Evaluations are performed between mid-December and mid-April, the period when nearly all emigration occurs. For each evaluation, approximately 1000 marked fish are transported roughly two kilometers upstream of each RST. Fish are released in equal proportions along the river margin (i.e. if 1000 fish are tagged, approximately 500 are released on river right and 500 on river left). Because holding trials revealed insignificant losses of fish held for 24 hours after marking, fish are generally released within an hour of marking. However, when elastomer tags are applied in addition to Bismarck Brown, fish are held for 24 hours prior to release. Furthermore, previous diel sampling (DWR 2002) revealed that nearly all salmon are captured at night and therefore time of release is unlikely to influence recapture rates. Only healthy fish (based on visual observations) are released and time of release is recorded (i.e. time of day). Although most recaptures occurr within the first day of release, catch is monitored for recaptures for at least seven days. However, because the traps are searched daily for marked fish, individuals can be recovered several weeks after release. Mortality between the release point and the trap is assumed to be negligible.

All salmon are marked with Bismarck Brown (Spectrum Chemical, Gardena, California) dye at a concentration of 2.8 grams to 115 L of water for 30 minutes. Most released fish are also tagged with colored latex elastomer in the nose (Northwest Marine Technology, Shaw Island, Ishington). The secondary tag served two purposes; (1) it allowed multiple release groups to be identified separately, and (2) it provided long-term identification of marked individuals (tags often lasted several months).

Trap efficiency is defined as the proportion of the total number of emigrants that are captured as they moved past the trap. The approximate estimate of trap efficiency (TE) for each sampling period is similar to that given by Roper and Scarnecchia (2000):

$$TE = \frac{\sum_{i=1}^{n} R_{ji}}{M_j}$$

Where R_{ji} is the number of recaptured fish from the jth release group on the ith day, and M_j is the number of marked fish released.

Assumptions and Restrictions

This estimate of efficiency assumes that (1) all released fish continue downstream after release (sometime during the recapture period), (2) handling does not affect fish behavior, (3) mortality rate until recapture is zero, and (4) marked fish mix randomly with unmarked fish.

Efficiency values are only applied to data for their respective year and location. Although efficiency tests are performed separately each week, two adjoining weeks of efficiency values are averaged to calculate daily trap efficiency and daily emigration past each trap for the respective time-period. This is done to avoid bias associated with few recaptures (less than 7; Roper and Scarnecchia, 1999). For weeks between 1 December and 15 April without efficiency tests, the average efficiency value for the year is used to calculate daily passage. Efficiency values are only applied to RST catch between 1 December and 15 April (or until evaluations cease). For periods when the trap is set for less than seven consecutive days, Daily Catch for the Un-sampled period (*DCU*) is estimated by the following formula, where CS1 = total catch in the sample days before the un-sampled period; CS2 = the total catch after the un-sampled period; D_1 = the number of days in sample period one and D_2 = the number of days in sample period two.

$$DCU = \frac{\sum(C_{S1}) + \sum(C_{S2})}{D_1 + D_2}$$

Daily passage estimates (DPE) are not made for periods when the trap is set for less than seven consecutive days, so as to avoid making unreasonable inferences about longer un-sampled periods (Roper and Scarnecchia, 2000). Daily Passage Estimates and 95% confidence intervals are calculated by Chapman's (1951) expressions:

$$DPE = [(Mj+1)(Cj+1)/(Rj+1)] - 1$$

$$C.I. = DPE + Z_{\alpha(2)}[(VarDPE)]^{1/2}$$

Whereby *Mj* is the number of marked salmon released for the trap efficiency during time period j, Cj is the number of unmarked salmon captured in the trap during the time period j and Rj is the total number of recaptures during period j.

where

$$Var(DPE) = DPE^2(Cj - Rj)/[(Cj+1)(Rj+2)]$$

The annual emigration estimate (EE) is the sum of Daily Passage Estimates plus the sum of raw daily catch (DC) for periods without DPEs.

$$EE = \sum_{d=dec.1}^{Apr.15}(DPE) + \sum_{d=Apr.15}^{July1}(DC)$$

The resulting emigration estimate is inherently low for two reasons. First, it uses only raw catch before December 1 and after 15 April and in periods when the trap is fished for less than seven consecutive days. Second, and more importantly, the trap is not always fished during high flows (> 15,000 cfs) and heavy debris loads.

The emigration estimate for the river can then be used to calculate an emigration index (EI) using the spawning escapement estimate from the previous fall. The emigration index is a per-capita production estimate that may be used to compare production from year to year. The index is calculated by dividing the emigration estimate (EE) for the river by the estimated number of adult/grilse females (F) determined by the fall escapement survey.

$$EI = \frac{EE}{F}$$

Juvenile salmon survival rate (SR) for the Low Flow Channel is computed as follows

$$SR = \frac{EE}{SF \times 5522}$$

Where SF is the number of successfully spawned females in the Low Flow

Channel, 5522 is the expected average fecundity of Feather River Chinook salmon females (personal communication with Armando Quinones, California Department of Fish and Game) and EE is the total juvenile Fall-run salmon emigration estimate for the Low Flow Channel (or High Flow Channel).

Primary References:

Roper, B.B. and D.L. Scarnecchia. 1999. Emigration of age-0 chinook salmon (Oncorhynchus tshawytscha) smolts from the upper South Umpqua River basin, Oregon, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences. 56: 939-46.

Roper B.B. and D.L. Scarnecchia. 2000. Key Strategies for Estimating Population Sizes of Emigrating Salmon Smolts with a Single Trap. Rivers 7(2):77-88.