Investigation into Bias and Variability in Estimates of Population Size and Biomass when Catches of Individuals are Large Relative to the Total Population

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Biomass of fish populations has traditionally been estimated by multiplying the average weight of captured fish by the estimated number of fish, with its variance estimated as the product of two variances. We present a method for estimating fish biomass in small streams (< 5 m wetted width) that uses a finite population correction factor (FPC) to take advantage of the fact that a relatively high proportion of the total population is normally captured and can be weighed during removal estimates. For these captured fish, measurement error is related to scale accuracy and field conditions. For the portion of the population that is not captured, we used a randomly stopped sums estimator (RSS) to estimate the total weight and variance of this non-captured proportion of the population. We also evaluated FPC and RSS methods individually to determine which of the four methods--(1) combination of FPC and RSS (FPCRSS), (2) traditional (hereafter OLD), (3) FPC, or (4) RSS—performed best. We also incorporated biomass estimates for fish that were captured, but not weighed, using length-weight regression predictions (FPCRSSreg). Performance of these estimators was evaluated using both simulated and field data. We based performance on reduction in the coefficient of variation (CV) of the biomass estimate and coverage of 95-percent confidence intervals (proportion of trials for which the 95-percent estimated biomass confidence intervals included the true biomass). The FPCRSS method had the narrowest CVs and the OLD method had the widest CVs for both the field and simulated data. Because of the high variance for the OLD method, 95-percent CIs for this method included the true biomass for a higher proportion of trials (nearly 100%) than 95-percent CIs for the FPCRSS method, but the coverage of the FPCRSS method for two-pass removal estimates was 80 percent or better for capture probabilities of 0.5 or higher. Using simulated data, we found that removal

estimators are biased and that these biases are more pronounced at lower capture probabilities and lower population sizes. This bias in removal population estimators causes a bias in biomass estimates and was partly responsible for poorer coverage of 95-percent CIs. Our attempts to correct for population estimate bias resulted in much wider confidence intervals for both population and biomass estimates. For 607 field biomass estimates where all captured fish were weighed, the median CV for the FPCRSS method (0.05) was significantly lower (Wilcoxon sign-ranked test: $P < 0.001$) than the OLD method (0.76). When a portion of captured fish was not weighed, but estimated using length-weight regression relationships, the FPCRSSreg method had significantly lower CVs (median = 0.06; Wilcoxon sign-ranked test: $P < 0.001$, n = 130) than the old method (median = 0.86).