Basic Concepts of Mark-Recapture Population Estimates

Most of the common methods for estimating the size of a fish or wildlife population use mark-recapture methods. Idaho Department of Fish and Game uses mark-recapture for estimating the size of fish populations on the Henry’s Fork. The simplest of these is called the Peterson method, in which a random sample of fish is initially caught and marked. In Box Canyon and other reaches of the Henry’s Fork, these fish are captured with boat-mounted electrofishing gear and marked with a small hole punched in one of their fins. The removed fin tissue grows back shortly after the population estimate is completed. The marked individuals are released back into the population and given 7-14 days to randomly mix with the rest of the fish, which are unmarked. This 7-14 day window is sufficiently long to allow the marked fish to disperse among the unmarked fish but is short enough that individuals are not added to or removed from the population.

After 7-14 days, the same electrofishing method is used to capture another random sample of fish. This time, some of the captured fish are those marked during the initial round of fishing. The proportion of marked fish that are recaptured in this second sample provides an estimate of what is called the capture efficiency of the fishing method. The capture efficiency gives the extrapolation factor that allows estimation of the population size from the number of fish captured in the second sample. In mathematical terms, the Peterson method uses the following numbers:

\[ M = \text{number of fish initially marked} \]
\[ C = \text{number of fish captured in the second sample} \]
\[ R = \text{number of fish in the second sample that are marked (recaptures)} \]

The estimate of capture efficiency is

\[ E = \frac{R}{M}, \]

which is simply the fraction of the initially marked fish that are recaptured in the second sample. The estimate of the population size is then given by

\[ N = \frac{C}{E}. \]

As an example representative of mark-recapture studies on the Henry’s Fork, suppose that our population contains 10,000 individuals, and the capture efficiency is 10%. Then we would expect to capture about 1000 individuals during any given round of fishing. In particular, we would capture and mark roughly 1000 fish during the initial sampling. During the second sampling round, we would also expect to capture around 1000 fish, of which 10%, or 100, would be marked. In this example, we would have

\[ M = 1000, C = 1000, \text{ and } R = 100. \]

The capture efficiency would be

\[ E = \frac{R}{M} = \frac{100}{1000} = 0.1, \]
and the population estimate would be

\[ N = \frac{C}{E} = \frac{1000}{0.1} = 1000 \times 10 = 10,000. \]

Suppose now that the population is still the same but that the flow conditions are more favorable for capturing fish, so the capture efficiency is higher. We might obtain the numbers

\[ M = 2000, C = 2000, \text{ and } R = 400. \]

The capture efficiency would be

\[ E = \frac{R}{M} = \frac{400}{2000} = 0.2, \]

and the population estimate would be

\[ N = \frac{C}{E} = \frac{2000}{0.2} = 2000 \times 5 = 10,000. \]

Notice that the estimate of the population is exactly the same, even though the capture efficiency was higher.

As illustrated by these two examples, the population estimate itself is insensitive to the capture efficiency. When capture efficiency is high, more fish are marked during the initial run, and more marked fish are recaptured. However, the extrapolation factor is lower (e.g., 5 versus 10 in the examples above), resulting in an identical estimate of the population size. The primary effect of increased capture efficiency is to decrease the uncertainty in the population estimate. Using more complicated mathematical formulas, it can be shown that in the above examples, the standard error (a measure of uncertainty due to sampling variability) is 883 in the first example (capture efficiency 0.1) and 398 in the second example (capture efficiency 0.2).