Box 11.1. Removal Model Abundance Estimates: Wrong but Useful?

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All models are wrong, but some models are useful—a truism to live by for fisheries managers. Consider the removal model, which uses standard depletion methods to generate an estimate of fish abundance. A primary assumption of the model is that sampling efficiency, or the proportion of fish removed from a site per capture event, is the same for all depletion capture events. However, fish that remain after the first depletion event are often more difficult to capture during subsequent events because they seek cover that is difficult to sample or continue to evade netters due to their relatively small size. When sampling efficiency declines from depletion event to depletion event, the removal model yields biased results: an underestimation of population size and an overestimation of sampling efficiency (e.g., Riley and Fausch 1992; Peterson et al. 2004).

This was the case for rainbow trout in small, headwater streams in the Boise River basin in Idaho (Rosenberger and Dunham 2005). Rainbow trout were marked and left in 31 sites (approximately 100 m in length) between two block nets to form "known" population sizes (following Peterson et al. 2004). After overnight recovery from initial capture and marking, marked trout were sampled by means of standard backpack electrofishing depletion procedures. The removal model generated rainbow trout abundances from depletion data that nearly always underestimated the number of marked fish actually present, averaging only 75% of marked fish.

The model yielded biased results. But could it still be useful? Managers faced with this kind of bias may assert that, although the estimates are incorrect, removal estimates can still be used as a relative index of fish abundance over space and through time. Methods need only be standardized and consistent, creating a highly precise, though wrong, answer. Further, estimates could be calibrated to known values with a simple correction factor to reflect actual fish numbers. This practice assumes that bias, though present, is consistent and based primary on the methods used. It should not be influenced by variables that will change through space and time.

A study in Idaho unfortunately refutes the assumption of constant sampling efficiency (Rosenberger and Dunham 2005). Not only were the removal estimates of rainbow trout abundance biased, but bias was inconsistent and influenced by stream habitat. Larger streams and streams with more instream structure in the form of dead wood yielded more biased estimates than did smaller streams with less instream cover. These stream features negatively affected electrofishing sampling efficiency, implying that what decreases sampling efficiency can increase the bias of removal estimates (also see Peterson et al. 2004). Common differences among sites over space and through time, including size of habitat, presence of structure, size of fish, water temperature, and the density of fish, can affect the sampling efficiency of electrofishing (e.g., Bayley and Dowling 1993; Dolan and Miranda 2003; Peterson et al. 2004). The Idaho study indicates that thorough validation of the removal model for generating absolute or comparable estimates of fish abundance is needed before use. Therefore, a new motto is suggested: all models are wrong; validate and proceed cautiously.

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