Dam Breaching and Chinook Salmon Recovery

The Report by Kareiva *et al*. on recovery and management options for spring/summer chinook salmon (*1*) has the potential to have a major impact in deciding whether to breach dams on the Snake River. Based on interpretation of their model results, they argue that dam breaching would be insufficient to reverse the decline of salmon. An examination of the specifics of their model, however, suggests that, despire their argument, dam breaching remains a viable recovery option for chinook salmon.

In the study, they apply a population model to two scenarios, with and without delayed transportation mortality. Population growth anchors the model. All elements of the population matrix are specified except first-year survival, s_1, for which they solve ($s_1 = 0.022$ for their index stock). All unspecified mortality, and hence all uncertainty, is apportioned to s_1.

In the model of Kareiva *et al*., without delayed mortality and with dam breaching, stocks would continue to decline. If first-year survival, s_1, were misapportioned and actually higher, however, second-year survival, s_2, would have to be adjusted downward. Estimates of first-year survival within the Columbia basin are available (*2*–*6*), and range from 0.023 to 0.15. Using an average value, $s_1 = 0.075$, we calculate that the s_2 value cited by Kareiva *et al*. would have to be multiplied by 0.29. If this adjustment applies to barging or dam-passage survival, then we calculate that dam breaching could reverse the decline of these salmon stocks.

Kareiva *et al*. conclude that dam breaching would recover salmon if delayed (indirect) mortality were significant. They do not, however, present this conclusion in the abstract, dismissing it as speculative simply because indirect mortality is difficult to evaluate. Although their model can be interpreted as supporting dam breaching, or reasonably modified to support dam breaching, Kareiva *et al*. would have us believe that "modest reductions" in mortality, such as simultaneously doubling survival rates s_1 (survival throughout natal streams of the Snake River basin) and s_e (survival in the estuarine/early ocean environment), may be preferable to removal of man-made obstacles. Model interpretations not based on a full range of reasonable alternatives should be judged with caution.

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29 November 2000; accepted 5 January 2001

Response: Citing higher egg-to-smolt survival values from several sources, Dambacher *et al*. suggest that we have apportioned too much mortality to the first year of life in the freshwater environment (*1*). In fact, the range of first-year survival rates we estimated (1.5 to 4.1%) falls within the range of documented values [high estimate of 15% (*2*); low estimate of 1.1% (*3*)]. In addition, the single study that reported a first-year survival rate greater than 10% (*2*) estimated survival only for the subset of juveniles that remained in the study area before smoltification. Finally, it is important to recognize that we derived our estimates of first-year survival from data collected for the specific stocks and period of interest.

Second, the suggestion by Dambacher *et al*. that the conclusions of our report should be fundamentally altered—because mortality must be apportioned elsewhere—is biologically tenuous. They propose that second-year survival should be reduced to 0.0038 (the value of our s_2 estimate, multiplied by 0.29). However, s_2 is not a completely free parameter, but is given by the equation $s_2 = [zs_z + (1 - z)s_d]s_e$, where z is the proportion of smolts transported downstream in trucks and barges, s_z is their survival, s_d is the survival of instream migrants, and s_e is survival in the estuary and during entry into the ocean (*1*). Widely accepted estimates of $z = 0.729$ and $s_z = 0.98$ (*4*), coupled with our estimate of $s_e = 0.017$, imply that for s_2 to equal 0.0038, s_d would have to have a negative value (–1.81)—an obvious impossibility. Indeed, the most recent data from PIT-tag studies suggest that s_d is actually substantially higher than the value we used in our model (*6*); we purposely selected the lower estimate derived from PATH models (*5*) to give the dam-breaching option its best chance of showing effective results.

Of course, $s_2 = 0.0038$ can be achieved by assuming a sufficiently low s_e. But s_e is survival below all of the dams; hence, any argument about the merits of dam breaching must return to the point we made [figure 5 of (*1*)] regarding mortality outside of the migration corridor attributable to the hydropower system. Thus, the conclusions reported in (*1*) remain solid: reducing mortality in the first year of life and in the estuarine/early ocean phase can substantially improve the population growth rates of these stocks.

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8 December 2000; accepted 5 January 2001

Science

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Science **291** (5506), 939.
DOI: 10.1126/science.291.5506.939a