

Fealty to symbolism is no way to save salmon

Peter Kareiva and Valerie Carranza

Beginning in the 1990s, evolutionarily significant units (ESUs) of Pacific Northwest salmon began to be listed under the Endangered Species Act (ESA), with profound implications for the operation of hydroelectric dams as well as for commercial and recreational fisheries. Ultimately, in the Columbia River Basin thirteen salmon ESUs were listed, with four ESUs in the Snake River receiving the most attention. “Saving” these particular ESUs became the rallying call for removing four large federally operated dams on the Snake River.

There are 172 large dams (> 10 m in height) in the Columbia River Basin, and many, if not all, have implications for salmon ecology and biodiversity. One reason the Snake River dams took center stage is because the Snake River was once among the most productive salmon habitats in the entire Northwest. In addition, over the last twenty years the Bonneville Power Authority has spent hundreds of millions of dollars in collecting data on salmon migration, ecology, genetics, and demography for Snake River ESUs. Indeed, Snake River spring/summer chinook salmon, which is the “poster-child” for the Snake River dam debate (see later discussion of New York Times advertisement), may well be the best studied, best monitored, most thoroughly modeled, and most litigated endangered species in the world. And yet progress toward a solution remains elusive.

15.1 Obfuscating models and too little common sense

Prior to 2000, most decision-making regarding Snake River salmon was driven by a huge computer simulation model with several hundred constant coefficients to be selected and hundreds of dynamic variables to be tracked. Diverse stakeholders, ranging from dam operators to Native American tribes and environmental groups, were allowed to comment on and recommend inputs for the model. This led to such a wide variety of alternative assumptions and parameter estimates that, altogether, the model was run for more than 5000 possible permutations. Although the models were not cast as formal stochastic processes, the results were typically wrongly interpreted with language such as “probability of ____.” These “probabilities” were actually fractions; specifically, the fraction of all simulation outputs (each with a different combination of parameter values) that achieved a particular conservation objective.

This complicated modeling effort, known as PATH (Plan for Analyzing and Testing Hypotheses), attempted to inform decisions about dam removal by simulating different management interventions (for example, flow augmentation and harvest reductions vs. dam removal). For a given management action, one could ask what fraction of simulations achieved some population recovery goal. In other

words, if for the full set of assumptions and parameter estimates, model runs with dam removal led to a higher fraction of the computer runs reaching the recovery goal at year 48, then the “data” were said to support the dam removal option. While this may seem reasonable at first glance, there was astonishingly little direct examination of population trajectories, and no attempt to statistically distinguish which model best fit observed population dynamics. In fact, no one looked at, or at least no one displayed and discussed, the population trajectories generated under different assumptions, and thus no one asked if the simulated population trajectories made sense.

Between 1999 and 2002, one of us, Peter Kareiva, headed research at the National Marine Fisheries Service (NMFS) aimed at examining management options for Snake River salmon. This federally funded research effort was labeled the Cumulative Risk Initiative (CRI). When the CRI team actually dug into the raw model outputs (numbers of fish projected in successive years) as opposed to the fraction of runs meeting some management goal, we learned something quite extraordinary. We learned that no matter what, the simulated populations of spring/summer chinook salmon were projected to increase. Thus one could conclude that the salmon would recover under any of the alternative management actions, albeit it at different rates. Suffice it to say, PATH obscured all population biology, was over-parameterized relative to the data, and was impossible to penetrate, much less explain. We direct the readers to the original PATH documents to draw their own conclusions (Marmorek and Peters, 1997, 1998; Marmorek et al., 1998).

Despite an absence of published formal extinction analyses, environmental groups favoring dam removal circulated claims that salmon were doomed to certain extinction if the Snake River dams were not removed. On October 20, 1999, they (the Sierra Club, Trout Unlimited, National Wildlife Federation, American Rivers, etc.) published a “timeline to extinction” in a full page advertisement in the *New York Times*, with the statement if the dams were not promptly removed “*wild Snake River spring chinook salmon, once the largest run of its kind in the world, will be extinct by 2017.*” As we write this, it is 2017, the dams remain, and spring/summer chinook numbers are much higher than they were when that confident prophesy of extinction was printed (Figure 15.1).

The environmental groups who predicted spring/summer chinook would be extinct today in the Snake River all do excellent work on behalf of the environment and biodiversity. The campaign for dam removal was, and still is, well intended. There is no doubt that dams have caused salmon declines, but the operators of the dams have spent billions of dollars to improve the safety of their dams for salmon, and it is not certain that dams now cause higher mortality than would arise in a free-flowing river. Of course dams cause other damage to the environment beyond their effects on fish populations, and as they age dams can even become a risk factor for humans. The problem is that a complex species and river management issue had been reduced to a simple symbolic battle—a battle invoking a choice between evil dams and the certain loss of an iconic species. Moreover, predictions of doom were made with minimal scientific support—in fact to this day

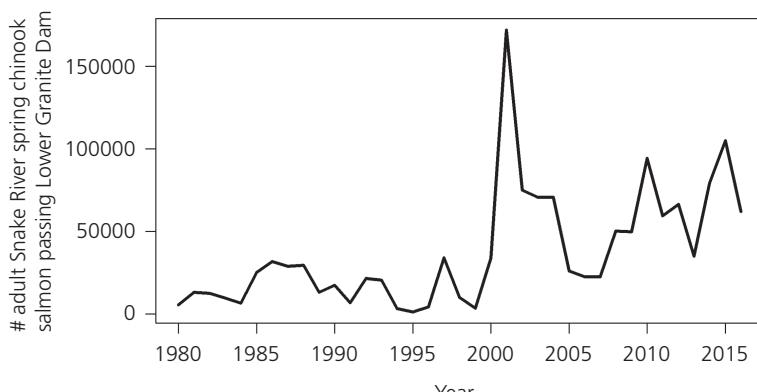


Figure 15.1 The number of adult spring chinook salmon (*Oncorhynchus tshawytscha*) passing Lower Granite Dam. Data are from the Columbia River DART (2017).

we have been unable to uncover any scientific paper that generates a 100% extinction probability for chinook salmon on such a short time frame. As conservationists, we want to save salmon. But that quest is more likely to succeed if we pay close attention to actual data on population trends (Figure 15.1), and resist seductive stories of certain loss.

15.2 A story of dams, engineering, and remarkable measures

When the Snake River dams were built between 1962 and 1975, salmon populations had already been decimated because of harvest, habitat degradation, and numerous previously built dams (Lichatowich, 1999). But the Snake River dams clearly made matters worse, and further reduced both the number of salmon and their productivity, measured as recruits per spawner (Levin and Tolimieri, 2001). Dams harm salmon populations by blocking or slowing upstream and downstream migration, flooding spawning habitats, injuring individuals that pass through turbines, and in some cases totally blocking access to habitat. In recognition of this, the Bonneville Power Authority has spent billions of dollars to make dam operation more fish-friendly. Between 2001 and 2013 alone, \$1.8 billion was spent on improving fish passage at the four Snake River dams (Federal Caucus, 2017). Engineering solutions include spilling water over dams as opposed to running it through turbines, building weirs and screened bypass systems to divert salmon away from turbines, and transporting juvenile fish in barges to the mouth of the Columbia River.

In addition to re-engineering dams, money has been spent on predator removal, habitat restoration, and basic research to better understand salmon demography and migration. By inserting small pit tags into millions of individual juvenile salmon, detailed demographic data regarding survival and the timing of migration have allowed population biologists to build sophisticated demographic models (Pacific States Marine Fisheries Commission, 2017). In light of climate change and warmer water, the US Army Corps of Engineers is now building “chimneys” at certain dams that bring cooler water from lower depths to the surface to keep salmon cool while they climb back upstream (US Army Corps

of Engineers, 2016). The net effect of all this investment is that juvenile Snake River salmon do quite well during their downstream migration, with in-river dam passage survival rates varying between 86% and 99% at all dams and survival nearing 100% for barged individuals (Bonneville Power Administration, 2013). In fact, the survival of Snake River juvenile salmon during their out-migration is now comparable to the survival of juvenile salmon out-migrating from the free-flowing Fraser River (Hilborn, 2013). There is debate, however, as to whether this directly observed survival tells the whole story—more on that later.

15.3 Simple stage-structured modeling and BACI analysis reveal the naked emperor

Soon after the CRI was established in 1999, a decision was made by NMFS scientists to replace PATH with classical population biology and risk analysis. This decision was made because of the PATH’s lack of clear population metrics (such as the intrinsic rate of population change and the probability of extinction in a stochastic environment), and the overall obfuscation of the PATH approach. The CRI research team produced three major scientific conclusions. First, a simple population model showed that even if in-river migratory survival were set to 100%, spring/summer chinook would still decline (Kareiva et al., 2000). This suggests that removing the four Snake River dams would not, by itself, rescue the salmon. Second, a Before-After-Control-Impact (BACI) analysis of salmon stocks navigating the Snake River dams versus stocks that did not have to navigate those dams indicated no impact of those dams on salmon productivity as measured by recruits per spawner (Levin and Tolimieri, 2001). Third, a careful examination of other factors, such as non-native trout predation on juvenile salmon, habitat degradation, and negative impacts of massive releases of hatchery fish led to what was called the 4-H framework (Ruckelshaus et al., 2002). Instead of couching salmon prospects strictly in terms of dams or no dams, it became clear that habitat degradation, hatcheries, harvest, and hydropower all hindered salmon recovery. The 4-H framework

opened the possibility of keeping the dams and their electricity, yet still saving salmon if the other three H's were adequately addressed.

In addition to analyzing the listed Snake River salmon stocks, the CRI team examined population trends and extinction risks for 152 salmon stocks representing twelve different listed ESUs throughout the Columbia River Basin (McClure et al., 2003). This approach allowed a basin-wide portrait highlighting places where small improvements in salmon survival were likely to reverse population declines. This approach also produced estimates of how much could likely be accomplished simply by curtailing harvest and improving fish passage. If the goal truly is to maximize the chances of maintaining as much salmon diversity as possible, as opposed to taking out four particular dams no matter what, this basin-wide analysis reveals several opportunities. To our knowledge, a basin-wide strategy has not been pursued, perhaps because litigation surrounding the four Snake River dams has demanded the attention and focus of the National Oceanic and Atmospheric Administration's fishery biologists and conservation scientists.

While PATH was abandoned fifteen years ago as a scientific framework for salmon decisions, there remain some lingering legacies and arguments that will perhaps never be resolved (Hilborn, 2013). One of the biggest points of contention concerns a phenomenon called "delayed differential mortality." Because many fish are transported in barges, and fish passage at dams has been dramatically improved, the direct survival of salmon between their spawning sites and the mouth of the Columbia is now quite high. These extraordinarily high in-river survivorship data make it hard to argue that we must remove dams to save the salmon. Enter the notion of delayed differential mortality. If, as a result of the arduous journey either through multiple dams or in barges, salmon later die at a higher rate than they otherwise would (in the ocean), then dam removal may be essential after all (regardless of high in-river survival).

This then is the quandary. There is solid evidence that harvest, poor estuarine habitats, poor ocean conditions, non-native species, and hatchery fish reduce the net replacement rate of wild salmon. Those factors imply certain management actions. But delayed differential mortality could also be reducing salmon

recruitment, in which case dam removal becomes a reasonable management action. The problem is delayed differential mortality is next to impossible to directly observe. The reader will have to admit—just the label "delayed differential mortality" gives one pause. Two recent studies that have explicitly sought to estimate delayed differential mortality using new approaches conclude it is negligible or non-existent (Welch et al., 2008; Rechisky et al., 2013). But as Hilborn (2013) argues, the controversy is unlikely to go away, because what seems to be about salmon is really about getting rid of the dams.

15.4 Redefining the problems to be solved

We believe the endless litigation, doom and gloom environmental advertisements, and scientific controversy about delayed differential mortality reflect an ill-posed problem. The broader question is what does the public want from Northwestern rivers, and then how do we best achieve that goal? Instead of having that discussion in a transparent and inclusive manner, the ESA is being used as a lever to get rid of dams—perhaps because it is seen as the only lever available. If in the end salmon are indeed saved, then from a conservation perspective the effort will be a success. But it has become clear that salmon conservation is being used a "means to an end" (dam removal) as opposed to an "end" of its own accord.

The ESA is the most important and effective piece of national legislation ever enacted on behalf of conservation. But because so much conservation science is driven by litigation, conservation scientists can become trapped in a reactive as opposed to proactive mode. Nowhere is this more apparent than in the Columbia River Basin system, which includes the Snake River. This river system is important for recreation, fisheries, transportation, irrigation, hydropower, and of course salmon. There is no question that the splurge of dams built in the twentieth century has decimated salmon populations and disrupted natural river functions. The dams have turned spectacular wild rivers into highly engineered systems that put iconic species at risk. But they have also provided reservoirs for irrigation, inexpensive transport for wheat, and clean, cheap energy.

Perhaps the best goal is to manage the entire Columbia River system to obtain as many diverse values as possible. To this end, we might ask: which dams should be removed to achieve the maximum benefits for salmon with minimal costs in terms of the benefits that dams provide? If the decision were approached in this manner, the age of dams would certainly be a factor to consider. The older a dam is, the more sediment it has accumulated and the greater its risk of failure. The four Snake River dams are among the younger dams in the basin and thus would not be selected on the basis of age (Figure 15.2).

The amount of emission-free electricity produced by an existing dam should also influence any decision about its breaching. Fewer than half (68 out of 172) of large Columbia Basin dams are primarily used to produce electricity (US Army Corps of Engineers 2017). Other factors to consider might be the percentage of original salmon spawning habitat that is opened up by dam removal, which could be calculated for any portfolio of dam removals. And then there is cost—larger dams are more expensive to remove. At 63.3 meters (m), 68.8 m, 68.8 m, and 69.4 m, three of the four Snake River dams would be the largest dams ever breached (the current world record being the Glines Canyon dam on the Elwha River at 64 m) (USGS, 2017).

Symbolism is visceral and compelling. Another advertisement used in 1999 to advocate dam breaching depicted a young girl looking at a salmon mounted on the wall with the epithet “extinct 2017”

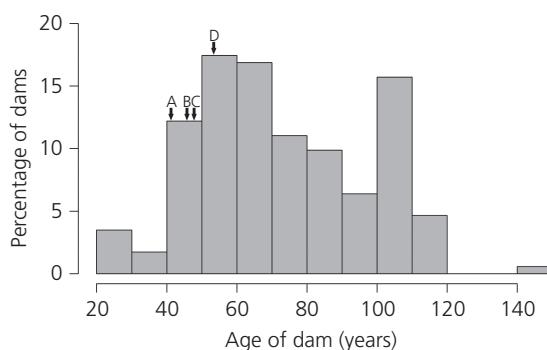


Figure 15.2 The age distribution of the 172 dams larger than 10 m in the Columbia River Basin. The ages of the four Snake River dams targeted for removal are indicated: (A) Lower Granite; (B) Little Goose; (C) Lower Monumental; and (D) Ice Harbor. Data are from the US Army Corps of Engineers (2017).

and was captioned, “if we do not remove the dams our children will never be able to see a wild salmon spawning.” But symbolism makes everything a black-or-white choice. It also makes it harder to negotiate and sustain solutions that must satisfy diverse stakeholders with diverse values. Dams are and will continue to be important infrastructure for human well-being. New dams will be built for energy or water storage, and old ones will be breached for safety or for conservation purposes. It need not simply be a choice between fish and hydropower (Kareiva, 2012). For example, an elegant analysis of Willamette River watershed in Oregon showed that one could remove 12 dams and reconnect over half of the river basin for fish, while sacrificing less than 2% of hydropower and water storage capacity (Kuby et al., 2005). Solutions, not symbols, are what we need.

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