ECOLOGY

As Salmon Stage Disappearing Act, Dams May Too

Opponents are squaring off over a controversial proposal to save salmon by breaching four dams on Washington's Snake River

Each spring, millions of young Chinook salmon in the Snake River have to get past four killers as they make their way to the open sea. They go by the names of Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. These dams, erected in Washington state in the 1960s and 1970s to generate power for the Pacific Northwest, can be just as deadly as any predator: Smolts can get pureed by turbine blades or plunge over spillways to their deaths. Survivors are delayed by sluggish water behind the dams that might cripple their ability to adapt to salt water.

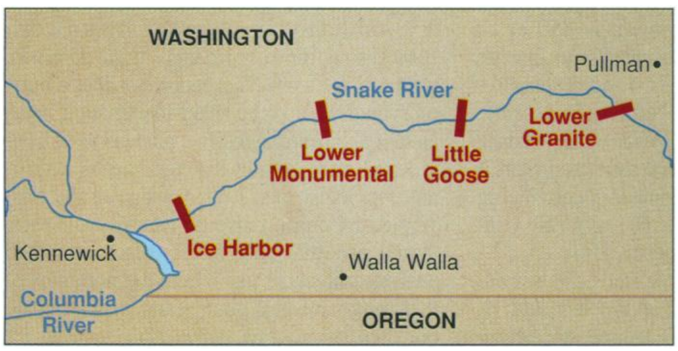
The Army Corps of Engineers, which is supposed to run the dams while protecting the salmon, has spent years and hundreds of millions of dollars to try to reduce the annual slaughter by capturing smolts and trucking or barging them to the Columbia River, upstream of Portland, where the fish have an unfettered run at the Pacific. But this strategy is failing, experts say: According to tagged-fish studies, less than 0.5% of the barged salmon survive to return a few years later to their spawning grounds. Wild salmon from the Snake River Basin have declined nearly 90% in the last 30 years, and every population has either been driven to extinction or is so threatened it is shielded by the Endangered Species Act. Now, the federal government is considering a drastic, and controversial, solution: tearing down the Snake River dams.

The lead agency for ensuring the salmon's protection under the act, the National Marine Fisheries Service (NMFS), has asked the Army Corps to recommend by year's end a course of action to save the imperiled fish. Their options boil down to four: leave the river be, step up efforts to haul smolts around the dams, modify turbines and spillways, or drain the reservoirs and tear out the dams' earthen portions to allow the Snake River to flow freely. An NMFS report last week gave lukewarm support to the last option—a remedy that could cost up to $1.2 billion—saying it is "more likely than any other" option to help salmon recover.

Lower the boom? Lower Granite may yield to salmon.

The NMFS study comes on the heels of a much stronger statement from 200 scientists, mostly fisheries biologists, who argued in a letter last month to President Clinton that dam breaching is "the surest way" to restore fish populations. "The needs of salmon are clear: If dams stay, salmon go. If dams go, salmon stay," says Ted Koch, a Fish and Wildlife Service biologist in Idaho who, like many others who signed the letter, says he's not speaking for his employer. Joining their cause are some 300 organizations, ranging from the Center for Marine Conservation to the Federation of Fly Fishers, that have endorsed a dam-breach petition. "Every year we spend millions more on bizarre schemes to try to save these fish, and every year fewer and fewer fish return to spawn," says Rebecca Wodder, president of American Rivers, which led the petition drive along with the group Taxpayers for Common Sense. "The science is in," Wodder says. "There is no longer any excuse for delay."

Not everyone agrees that the dams should go. But supporters can point to a precedent: Last summer, Secretary of the Interior Bruce Babbitt announced plans to boost Atlantic salmon, sturgeon, and other migratory fish by removing a small hydropower dam on Maine's Kennebec River, a project slated to begin later this year (*Science*, 8 August 1997, p. 762). However, observers say, punching holes in that dam is child's play compared to the much more massive Snake River dams.



Endangered species. The dams that may be breached.

Debate over the Snake's fate caught fire last December, when a task force formed in 1995 by NMFS and the Bonneville Power Administration, which markets power from the Snake dams, weighed in on how best to save the salmon. Using computer modeling of population dynamics and bringing to bear their own expertise on salmon biology, the 35-person Plan for Analyzing and Testing Hypotheses (PATH) group, primarily fisheries scientists, concluded that restoring free flow to the Snake River stands the best chance of saving the salmon. Barging spreads disease among the fish too readily, they said, and making the dams more fish-friendly would fail to address the critical time element. "These fish are undergoing changes in their kidneys, gearing up for going into salt water," says PATH member Earl Weber, a fisheries scientist with the Columbia River Intertribal Fish Commission. "Delay is thought to be harmful." In an analysis of the PATH report released last week, NMFS highlighted the uncertainties of predicting salmon survival but backed PATH's bottom line, noting that delays in undertaking any rescue operation could drive populations to extinction.

The Army Corps, in the meantime, has been putting the finishing touches to a $22 million study on the technical requirements and costs of bypassing the dams versus better smolt hauling. The Corps has released a section on breaching that indicates just how complicated a task it would be.

First, engineers would throw open the turbine intakes to drain the lakes behind the dams. Battalions of earthmovers would then tear away the earthen embankments that are part of each dam, chasing the receding waterline. Next, levees would be built to guide the river through its new meanders, bypassing the dam structures and leaving them high and dry. In a race against time, engineers would have a 4-month window, starting in August, when the Snake's waters are low enough to undertake the tricky operation without triggering catastrophic flooding, says Army Corps civil engineer Steve Tatro. Up to 6 million cubic meters of earth must be removed at each dam in less than 70 days, he says.

In the short term, the breaching could harm salmon—particularly those that spawn

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in the fall. According to Army Corps study manager Greg Graham, about 100 million cubic meters of sediment—half mud, half sand—has settled behind the four dams. Although the mud should erode quickly and get flushed out to sea, the sand will tumble downstream slowly. "Mother Nature is going to take charge and redistribute sediments as she sees fit," says Graham. Because the project's early stages would kick up so much sediment, Tatro's group has drafted plans to capture salmon heading upstream and truck them around the dams. A more prolonged problem is that after the Snake is channeled around Lower Monumental and Ice Harbor, it could run too swiftly for upstream-bound fish. The Army Corps may stud channels with boulders to create artificial rapids with eddies where fish can rest.

The Army Corps isn't expected to release its full report—including its favored option—until the end of this year. But opponents are already taking aim at any dam breach. One prominent critic is Senator Slade Gorton (R–WA), who argues that the cost of such an operation outweighs its uncertain benefits. Business and agriculture leaders are also up in arms. For instance, Bruce Lovelin, executive director of the Columbia River Alliance, a Portland-based trade association, predicts that if the dams are retired, utility customers would foot the bill for the lost 1200 megawatts generated each year, about 5% of the supply in the Pacific Northwest—enough to power Seattle.

After choosing a strategy, the Army Corps will have to sell it to other agencies, the public, and finally to Congress, which must approve funds to pay for it. Graham says it's too early to bet against the dams. "We see a lot of news articles [saying] the Corps wants to tear out dams," he says. "We haven't concluded anything." Many scientists, however, are pushing for strong measures, and fast. "Unless something is done soon," says Koch, "most of the remaining runs will go extinct." That would deprive the region of a resource even more valuable, perhaps, than megawatts.

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MEETING VERTEBRATE PALEONTOLOGY

From Embryos and Fossils, New Clues to Vertebrate Evolution

LONDON—Nearly 200 paleontologists, developmental biologists, molecular phylogenists, and other researchers gathered here on 8 and 9 April for a meeting on "Major Events in Early Vertebrate Evolution." They heard that studies revealing the molecular programs underlying embryonic development are helping paleontologists better interpret their fossils, while new fossil finds show that organisms once had a wider range of shapes and sizes than thought. Together, these efforts are changing our view of how vertebrates came to be.

Something Fishy About Fin Evolution

One of the key unanswered questions about the evolution of fish is how they got their fins, appendages that have helped this group of organisms be so successful. It's an answer that concerns landlubbers as well, as fins eventually became limbs for seagoing creatures venturing onto drier habitats. Now it appears that fins evolved multiple times in primitive fish.

The current view holds that both sets of the paired fins of modern fish arose from the same precursor tissue on the belly of an ancestral fish. But new 400-million-year-old fossils imply separate origins for the two sets of paired fins, which are especially important for the successful adaptations of modern fish and are also the precursors of land animals' limbs. "The materials are truly fantastic and eye-opening," says Xiaobo Yu, a paleontologist at Kean University in Union, New Jersey. "My entire repertoire of existing ideas on fins needs to be reorganized."

Two of the fish fossils that are roiling the waters came from a rich deposit of fish fossils located high up in the Mackenzie mountains of Canada's Northwest Territories, near the Yukon border. Collected by paleontologist Mark Wilson and his colleagues at the University of Alberta in Edmonton, both of the fossils have elaborate sets of spines and fins not seen before.

Modern fish have a set of pectoral fins, one on each flank behind the gills, and a set of pelvic fins, located on the belly just before the anus. A theory dating to the late 1800s says that both pairs of fins evolved from flaps of skin extending all along the bottom of the fish's body. Then the pair nearest the front of the fish somehow migrated upward on the body to form the pectoral fins while the backmost pair remained in their original location as the pelvic fins. According to a more recent theory, proposed by Michael Coates of University College London and Martin Cohn of the University of Reading, both in the United Kingdom, pelvic fins were a later invention brought about when the genetic program for the first set of fins somehow got turned on further back along the body.

Fins galore. The plethora of paired fins in this fossil fish goes against current thinking on the origins of these appendages.

CREDIT: M. WILSON

But Wilson says the new fossil fish don't fit comfortably with that picture. One fossil, called *Kathemacanthus* (meaning necklace of spines), has a large pectoral fin and spine lying high on each side of the animal just behind the head and gill slits. So a series of spines, suggestive of a necklace, runs down each side of the fish below the fin. *Kathemacanthus* also has a second series of paired spines along its belly that get progressively larger and culminate in what appear to be real pelvic fins. The other species, *Brochoadmones*, has the series of intermediate pelvic spines but only a single pectoral fin spine.

Because the pectoral fins are located so high up even in these early fish, Wilson thinks the fins may have first appeared there and not along the belly, as the other views suggest. In addition, he says, "the pectoral [spines] get more finlike as they go up and the pelvic [spines] get more finlike as you go back." Finding such advanced fin structures in two places suggests to Wilson that the early fish didn't start with just the pectoral fins but with pelvic fins as well, likely relying on different sets of genetic instructions for producing the two types.

Some of Wilson's colleagues think this indeed may prove to be how fins arose. "[Wilson] may be right that pelvic and pectoral fins arose independently on two differ-