FISH PASSAGE AT DAMS

A dam presents an obvious obstacle to migrating fish. Dams block the downstream movement of juvenile fish to the waters where they will spend their adult lives — the ocean for salmon and steelhead, or a lake or river for resident fish like trout, bull trout, or sturgeon. With more than 400 dams in the Columbia River Basin, and more than half of them dedicated fully or partly to generating hydropower, the region's primary source of electricity, fish passage at dams has been a major problem for nearly as long as dams have been built in the basin.

Juvenile salmon and steelhead are sluiced over dam spillways, collected and transported around dams in barges and tank trucks, diverted past dams in fish bypass systems and even, in one brief-lived experiment in the 1970s, flown down the lower Snake and Columbia rivers and dropped from an airplane, giving new meaning to the term "flying fish."

Fish ladders and even water-filled fish elevators have been built to try to improve the survival of adult salmon and steelhead as they return upriver. At some dams there is no fish passage for either juvenile or adult fish. These dams block access to more than 40 percent of the habitat once available to salmon and steelhead in the Columbia River Basin.

The problem of getting juvenile fish safely past dams on their downstream journeys and adult fish safely past dams when they return to spawn was recognized even before the end of the 19th century. In 1890, Washington's Legislature passed a law requiring fishways to be built at dams "wherever food fish are wont to ascend." The law authorized the state commissioner of fisheries to levy fines for violations and ask courts to order the removal of illegal dams, but the law was not well-enforced. By 1922 it was off the books. In 1931, the Oregon Fish Commission adopted a policy to protest applications for new dams or irrigation projects filed with the state if they did not include provisions for protecting the upstream and downstream migration of salmon. Irrigation diversions began to be screened in the 1930s, but the progress was slow. The commission estimated that 50 percent of the prime spawning and rearing habitat in the Columbia Basin had been lost, although surveys would not begin to assess actual losses until 1938. The Commission commented:

"Knowing further that each race [stock] is self-propagating, it becomes perfectly apparent that all parts of the salmon run in the Columbia River must be given adequate protection if the run as a whole is to be maintained. The protection of only one or two portions of the run will not be sufficient, inasmuch as certain races will be left entirely unprotected."

Fish passage at the big dams on the Columbia always has been problematic. Fish passage ends at Chief Joseph Dam at River Mile 545 on the Columbia. Before that dam was completed, fish passage ended at Grand Coulee Dam, 51 miles upriver. In the Snake River system, fish passage ends at Hells Canyon Dam, at River Mile 247, and, on the North Fork Clearwater River, at Dworshak Dam, which is about three miles from the confluence of the North Fork with the mainstem of the Clearwater. The Idaho Power Company attempted fish passage at its complex of three dams on the Snake — Hells Canyon, Oxbow and Brownlee — in the late 1950s, but these were unsuccessful. Subsequently, the company reached agreement with the Federal Power Commission to compensate for the loss of salmon and steelhead spawning habitat upstream of the three-dam complex by producing fish at hatcheries (/history/Hatcheries/) downstream of the dams. Similarly, the Army Corps of Engineers built a fish hatchery a short distance downstream from Dworshak Dam to compensate for the lack of salmon and steelhead passage.

The first dam completed on the mainstem Columbia, Rock Island in 1933, included a gently inclining fish ladder. The dam was built by Northwestern Power Company, which later became part of Puget Sound Power and Light Company (Puget Sound Energy today). The same year Rock Island was completed, the Bureau of Reclamation began construction of Grand Coulee Dam (/history/GrandCouleeHistory/) 143 miles upstream, and the Army Corps of Engineers began work at Bonneville Dam 320 miles downstream. Passage facilities for salmon and steelhead were under consideration at both dams.

In 1933, the Bureau recommended a flume and an elevator to collect and carry fish over or around Grand Coulee. But the United States Commissioner of Fisheries, Frank Bell, studied the plans and determined they would not work because the dam was too high — about 350 feet from the downstream side to the usual level of the reservoir behind the dam. Subsequently the Bureau considered trapping juvenile fish above the dam and hauling them in trucks to a release point below the dam, and also trapping adult fish below the dam and hauling them to a release point above the dam. These ideas, too, were rejected because of their potential complexity, uncertainty and cost. Ultimately, a complex of hatcheries was constructed in Columbia tributaries downstream of the dam in an attempt to relocate and rebuild the runs that would be lost to the dam.

Meanwhile, salmon and steelhead passage at Bonneville Dam presented its own challenges. To this day some people believe — it is in the realm of an urban myth — that the Corps of Engineers never intended to provide fish passage facilities at the dam and that the agency was pressured into providing them. In a word, that is untrue. The Corps was well aware of the importance of providing fish passage at dams and, besides, the Federal Power Act of 1920 required the builders of dams on public waterways to provide either fish passage or hatcheries in compensation for the loss of passage.

While the Bureau chose hatcheries to compensate for the losses that would be caused by Grand Coulee, the Corps always intended to provide passage at Bonneville. The written record is clear on that point. For example, in a March 8, 1929, letter to the Corps' Chief of Engineers in Washington, D.C., Portland Division Engineer Gustave Lukesh wrote: "In connection with tentative design of dams for [the] Columbia River and certain tributaries it appears that provision should be made for the passage upstream of fish, especially salmon, migrating to breeding places." The Corps already had installed fish passage facilities at dams on the Willamette River and at the Ballard Locks in Seattle.

In 1933, Portland District Engineer Major Oscar Kuentz wrote about the planning for Bonneville Dam in the January-February issue of Military Engineer magazine. He wrote that ". . .studies must be made to determine the best method of passing the salmon over the [proposed] high structure . . . " of the dam. Written before construction of the dam began, Lukesh's letter and Kuentz' comments in his article show that the Corps was planning to build fish passage facilities at the dam and was not forced to do so.

However, the facilities that eventually were built were more complex and expensive than originally planned. The Corps' original budget for fishways at the dam was $640,000. The eventual cost was more than $7 million after numerous additions to the original plan were made, many in response to public concerns. But the fishway worked. In 1937, the annual report of the U.S. Commissioner of Fisheries commented, "Salmon are climbing the fish ladder at Bonneville Dam with ". . .far less effort than their forebears that fought upstream through the swirling rapids that are now buried beneath fifty feet of water."

And as a matter of historical trivia, Grand Coulee Dam did have a fish ladder for a short time during construction. The ladder was completed in 1937 to allow salmon and steelhead to cross the foundation of the dam. At the time, the river was flowing through 25-foot-wide slots in the concrete foundation. The ladder was considered temporary. It was built from logs and formed seven pools, or steps, for the fish to climb over the foundation.

While fishways, or fish ladders, were for adult fish, dam passage was considered problematic for juvenile fish, and research steadily would prove the assumption. In 1942, Ivan Donaldson, who was hired the previous year as the Corps of Engineers' first biologist on the Columbia River, suggested various measures to protect what he called his "beloved fish" from the turbines at Bonneville Dam, including experiments to determine juvenile fish mortality, fish screens at the power house, Bradford Island fish ladders and removing predatory fish below the dam. In a memo to Captain R.B. Cochrane on September 17, 1942, Donaldson wrote that initially some engineers at Bonneville Dam did not "want to be bothered with the concerns of a scientist" and that an engineer "in a high place" told him, "I don't know anything about fish except that they are a damn nuisance." In the memo, Donaldson described the attitude of the engineers as, "to hell with the fish, I'm here to build a dam."

Soon fish advocates took up the cause, badgering the Corps to pay attention to the impacts on juvenile fish. In 1937, at a public hearing in Lewiston where the Corps took testimony on whether to build dams on the lower Snake River, V.E. Bennington remarked that the Corps did not propose enough money for fish passage. He warned the Inland Empire Waterways Association (IEWA), which represented barge lines and ports and was the chief advocate of the dams, that it could expect a "considerable fight" from sport and commercial fishing interests unless the association supported more money for fish passage. The IEWA promptly wrote a supportive letter to Congress. Others, however, were less willing to openly support expenditures for fish passage. In 1945, The Dalles Chamber of Commerce, which was a member of the IEWA, urged the association to "adopt measures to effectively combat" the "highly organized" opposition to Snake River dams by fish and wildlife agencies. According to the Chamber, "these agencies are going out of bounds, and we contend that in some activities [they are] are exceeding their authority."

Fish advocates entered the battle too late to effectively derail dam advocates like the IEWA, which had been working for years to win congressional authorization of McNary Dam and the Snake River dams. The Corps seemed convinced, too, that dams were not dangerous to juvenile salmon and steelhead. In 1955, the Walla Walla District of the Corps announced that a year of studying juvenile fish passage at McNary Dam yielded results that ". . .discount considerably the claims of the fish industries that dams on the river are a hindrance to the anadromous hordes" and that the real culprit in the salmon decline is the "... commercial fishermen's nets and sportsmen's lures." Oregon's director of fisheries denounced these statements as "propaganda." It was the same word that dam advocates had been using since the early 1940s to define the concerns of fish advocates.

Over time, the four Snake River dams were built, despite opposition from fish advocates. The dams have fish ladders for adult fish, and each is capable of passing fish through spillways. Over time, collection facilities for juvenile fish were installed at three of the four dams. But when the dams were built, the primary passage method for juveniles was through turbines. The first dam, Ice Harbor, was completed in 1962 and the last, Lower Granite, in 1975.

Congress long had recognized that dams kill fish. The Fish and Wildlife Coordination Act of 1934, amended in 1946 and 1958, required that potential impacts on fish and wildlife be addressed in planning and building federal dams. At Ice Harbor, the Corps quickly recognized that juvenile fish were dying or being injured in the turbines. Tests at McNary Dam using marked smolts demonstrated the danger, and the Corps responded with studies of alternative turbine designs. But then research showed that juvenile fish actually sought out the bulkhead slots above the turbine entrances, apparently to avoid going through turbines. There was no escape from the bulkhead slots, but with a little innovation there could be.

In 1967, the Corps of Engineers created a juvenile fish bypass system at Ice Harbor by drilling six-inch holes between the bulkhead slots and the ice/trash sluiceway on the other side. Once in the sluiceway, the fish could pass the dam — literally with the floating debris and trash in the river, but it was a much safer passage route than through the turbines. In 1969 the Corps and the National Marine Fisheries Service tested the first submerged traveling fish screen, a device installed in front of a turbine entrance at Ice Harbor that would deflect juvenile fish up to the gatewells and into the bypass system.

The traveling screens look a bit like railroad flat cars wrapped lengthwise with a nylon mesh that moves constantly upward on rollers. The screens are angled into the water from the face of the dam above the turbine entrances, and the fish ride upward on a cushion of water. Once in the bulkhead slots, the fish are attracted to lights that mark the entrances to the bypass system.

Further research and refinements over the years improved the fish-passage efficiency of the screens and bypass systems, and ultimately the Corps installed screens and bypass systems at all Columbia and Snake river mainstem dams where salmon and steelhead pass. Only The Dalles Dam does not have a bypass system, but that is because the ice and trash sluiceway always provides effective passage for juvenile fish.

There have been problems at some dams, however. The second powerhouse at Bonneville Dam, for example, is a notorious fish killer. Ironically, it is the newest powerhouse on the mainstem river, completed in 1982. For reasons that never were completely clear, but apparently had something to do with the shape of the river bed in front of the dam, juvenile fish were swept by the current almost directly into the turbines. The problem became so bad that the Corps had to shut down the powerhouse during the juvenile salmon migration period for most of the 1990s while an effective bypass system was designed and tested. A juvenile fish collection device, installed in 2003, appeared to solve the problem, finally.

Predation on juvenile fish as they emerge from bypass systems or turbines, sometimes stunned or dead, also has been a problem. Piscivorous birds and fish — Caspian terns, gulls, northern pikeminnow, walleye and bass — prey on juvenile salmon and steelhead, and the federal river management agencies have gone to great lengths to protect the fish. The Bonneville Power Administration finances a bounty reward fishery for pikeminnow (267,213 fish were turned in at receiving stations in 2004, a record for the program to that point), and the Corps has remodeled bypass system outfalls to carry the juvenile fish to release points in swift-moving water away from predator fish. It is an ongoing battle.

Meanwhile, research by NOAA Fisheries shows that survival of juvenile fish through the eight dams of the lower Snake and Columbia rivers in the first few years of the 21^{st} century is as good as or better than survival before the Snake River dams were built. Federal research on fish passage survival and potential passage improvements at the dams is continuing. This research is reported on the website of the NOAA's Northwest Fisheries Science Center (external link (http://www.nwfsc.noaa.gov/)).

Fish in a tube

If fish passage at hydroelectric dams can kill juvenile salmon and steelhead migrating to the ocean, why not devise a means of keeping the fish away from the dams? It's a simple proposition, and it is at the heart of various fish-passage techniques that have been tried with varying degrees of success at the big dams on the lower Snake and Columbia rivers.

One idea that never caught on despite repeated proposals in various configurations, was to build a migratory channel around the dams for the fish. One variation was to build a canal along the shoreline; another was to install a floating tube in the river, presumably connecting to the bypass systems at each dam. Each proposal suffered the same flaws — how to get salmon into the tube or canal and keep them there; how to keep water moving through the devices and keep predators out of them; how to create a “natural” migration experience for the tiny fish, which tend to rest and feed during daylight hours and migrate primarily at night; and how to ensure the fish obtain nutrients and other ecological cues and services that are fundamental to the salmon life cycle. The U.S. Army Corps of Engineers studied various options and, in the Columbia River System Configuration Study Phase 1 Report, issued in 1994, determined that all such migratory canal and pipeline proposals would be eliminated from further consideration because of the concerns and uncertainties about biological impacts.