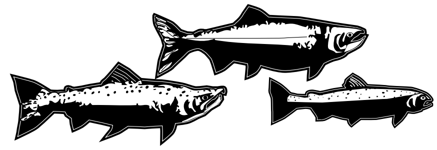
US Army Corps
of Engineers
North Pacific Division

Salmon Passage Notes

Snake and Columbia River Fish Programs

June 1993

Saving Salmon:



The Role of Research

by Gay Monteverde, freelance writer from Portland, Ore.

In 1888, Major William Jones, in charge of one of the Corps of Engineers' Portland offices, reported to Congress "an enormous reduction in the numbers of spawning-fish" in the Columbia River as a result of industry fishing and stream pollution. He admitted he did not have enough information to solve the problem and recommended further study of the salmon.

To the impacts of overfishing, pollution, unscreened irrigation ditches, and spoiled spawning grounds that began over a hundred years ago was added installation of big multiple-purpose dams. The Corps realized the dams posed a threat to the fish runs and acknowledged a responsibility to address those dangers. In 1929, Division Engineer Colonel Gustav Lukesh advised the Chief of Engineers that "provision should be made (in dam design) for the passage upstream of fish, especially salmon migrating to breeding places." When Bonneville Dam was completed in 1938, it contained fish ladders, an experimental lock system for fish, and a migratory canal around the project.

The recommendations of people like Jones and Lukesh are examples of an early commitment to ensure that the design, construction and operation of Columbia and Snake River projects include provisions for the safe and efficient passage of anadromous fish. To meet this commitment, research has pioneered in the areas of fish responses to dam structures, fish passage facilities, and river operation strategies, to evaluate and improve fish passage effectiveness.

These efforts have led to formation of a Corps-funded regional research program. Today, the Corps' Fish Passage Development and Evaluation Program (FPDEP) has about fifty on-going or proposed research studies on juvenile fish bypass and transportation, adult fish passage, and related issues such as spill effectiveness and dissolved gas effects. This applied research program allows a high degree of confidence that costly, extensive design changes for new and existing fish facilities at the dams will bring expected returns in fish passage improvement.

History Lessons

In 1951 the Corps entered an intensive design and construction phase on water resource projects in the Willamette Basin and the lower Snake and Columbia rivers. Very little was known about the migratory behavior of Pacific salmon. A Corps research program was initiated to provide the information needed to design and construct adult fish passage facilities at dams.

During the early years research focused on how to assist adult fish over the fifty to hundred foot climb at the dams. Fish ladder attraction flow and collection system designs were needed. Biologists studied how well the ladders passed fish, and engineers looked at increased design efficiency. Most of the knowledge gained from that research has been carried forward and embodied in subsequent water resource project design and operation throughout the nation.

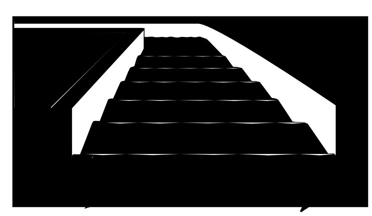
As more dams were completed in the fifties and sixties, more attention was given to the welfare of juvenile salmon and steelhead and their migrations through mainstem reservoirs and dams to reach the ocean. Juvenile fish passage systems that existed at that time were not effective. Many juveniles passed dams over spillways, or through the turbines where injuries and mortality were higher.

During the sixties and early seventies, scientists became aware of the hazard to fish of gas bubble disease (similar to the "bends" in human divers) from supersaturated gases caused by spilling water and fish over the dams. Research concentrated on protection of juvenile fish from both turbines and gas supersaturation. These efforts resulted in the development and installation of spillway deflectors (also called "flip lips") to lessen the problems of supersaturation, and the genesis of turbine intake screens to deflect juvenile fish away from turbines and into bypass systems. Research begun in 1969 by National Marine Fisheries Service (NMFS) on a juvenile fish transport system was stepped up in the 1970s.

Lower Granite, the last of the eight mainstem Corps dams on the lower Snake and Columbia rivers, was completed in 1975. Concern over the possible impact on fish migration from extensive river regulation continued to increase. Research intensified on transportation operations and improving adult and juvenile fish passage facilities. Design of the turbine deflector screens continued to evolve, and transport of fish for release below the dams became a part of yearly operations.

The problems that the Corps is challenged to resolve today are increasingly complex. Three Snake River salmon species are currently listed under the Endangered Species Act as either threatened or endangered: spring/summer chinook, fall chinook, and sockeye salmon. The primary objective is to get fish through the hydroelectric system with minimum mortality and delay.

According to Rudd Turner, Corps of Engineers fishery biologist and FPDEP coordinator, "Much has been learned about project operations and fish passage facility design. But as this information has been acquired, additional factors have come into play. More hydro projects are on line now than in the past, cumulative impacts are greater, habitat quality continues to need improvement, there are more people in the region and more demands on both the fishery and water resource, and the Columbia River Basin has experienced several years of drought. All this has combined to result in a continuing decline, particularly in wild stocks of fish."



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A 40-foot extended submersible traveling screen..

Successful Solutions: Adult Ladders

Research that looked at ladder design was very successful. From 1955 to about 1970, the National Marine Fisheries Service maintained experimental sections of ladders at Bonneville. They worked with slope, flow rates, and placement of orifices in the weirs. The design changes that resulted were more efficient from an engineering standpoint and passed fish as well as or better than the old design.

For example, the newer ladders at the Bonneville second powerhouse are 16 feet across and several hundred feet long, with a one-on-ten slope (one foot of elevation gained for every ten feet of length). The original ladders at the first powerhouse are 40 feet across and have a one-on-sixteen slope, so they are 60 percent longer. The older, larger structure requires more water—about 200 cubic feet per second (cfs) vs. 75 cfs. Salmon migrate just as well with the narrower and steeper ladder. In this case, research led to ladders that are less expensive to construct and require less water, without compromising fish passage.

In Search of Solutions: Juvenile Fish Bypass

The strong forces associated with passage through turbine units can injure and kill juvenile fish on their downstream migration. Turbine deflector screens, known as submersible traveling screens (STSs), have been added to most of the lower Columbia and Snake projects as a result of intensive research on ways to minimize those losses. STSs guide fish away from the turbines and into collection and bypass systems.

The STS design has been extensively studied to find the least stressful and most efficient way to guide juvenile fish away from turbines and up into the bypass system. Research has evaluated the angle at which the screens are placed, porosities of various materials to control the flow of water through the screens, bar versus mesh screens for maintenance considerations, use of lighting to attract fish, and others.

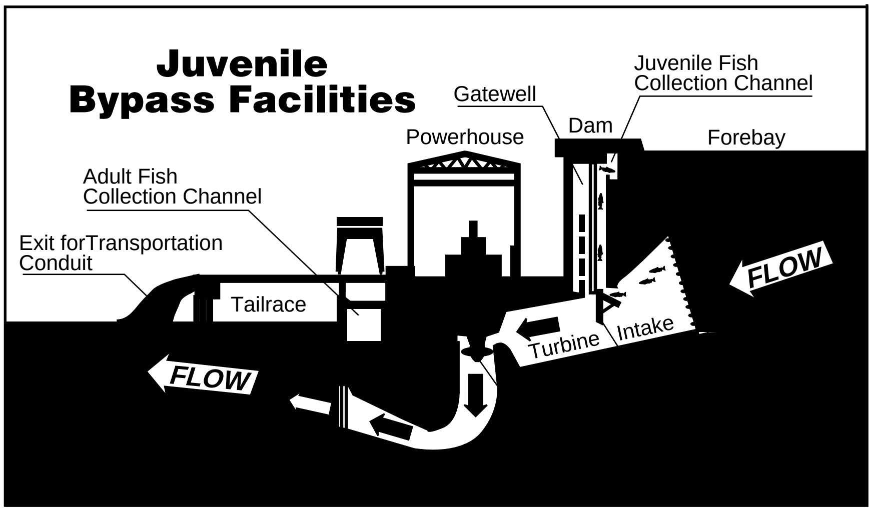
Extended-length STSs are currently being studied. These screens are twice the usual 20-foot length to reach even lower and deflect more fish. But tests of some extended-length screens indicate that increasing the length of the screen beyond a certain point may create its own problems by guiding more water into the gatewell slots and creating stronger, more turbulent flows that can injure fish. The Corps is currently funding studies to address extended-length STS design.

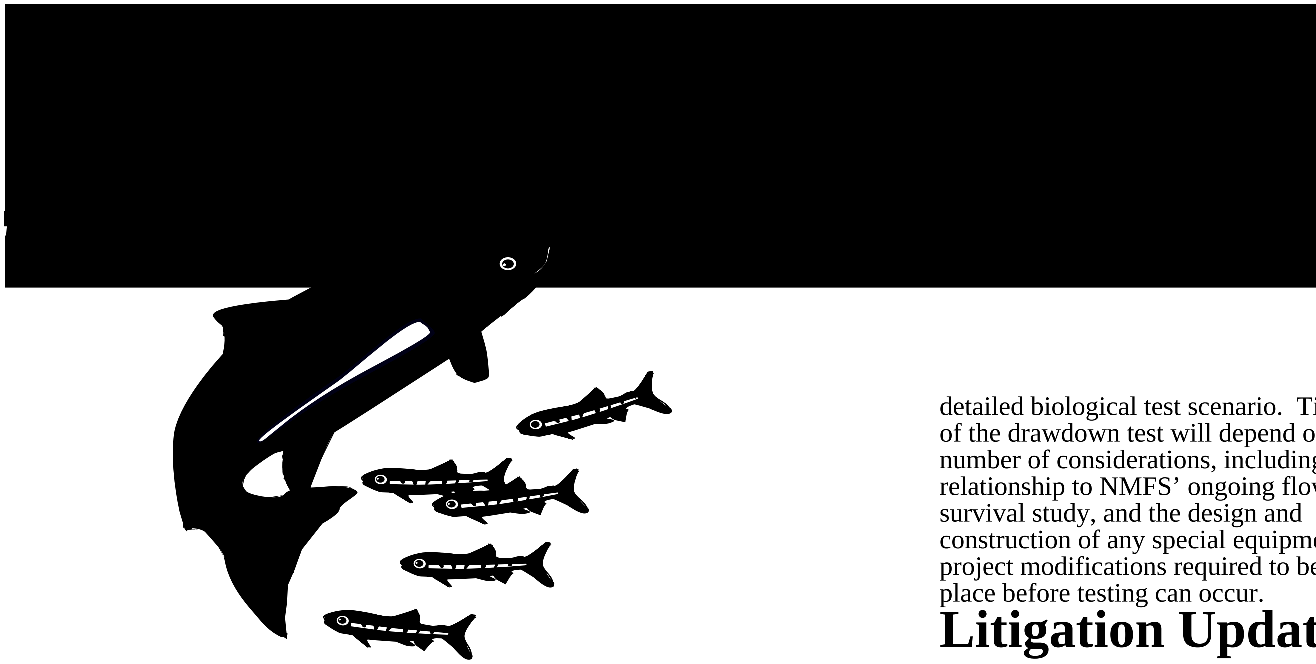
Another area of study associated with juvenile bypass systems is reducing the predictability associated with where juveniles are discharged back to the river. A bypass system deposits the fish at constant, fixed points in the tailrace downstream of the dam, and predators quickly learn where those points are. The Corps is considering alternatives for improving bypass outfalls—varied locations for discharging fish from the system, putting more fish in the middle of the river where the current is stronger, and transporting the juveniles to different locations several miles below the dam—so predator populations do not build up at one location.

Controversial Solutions—Juvenile Fish Transportation

Four lower Snake and Columbia river dams—Lower Granite, Little Goose, Lower Monumental and McNary—have juvenile collection and transport facilities. Juvenile fish diverted away from the turbines are collected and placed into barges or trucks for transport below Bonneville Dam. The Corps began experimental barging in the early 1970s because of the problems with cumulative impacts of gas supersaturation, turbine mortality and predators on the juvenile fish moving through the reservoirs and past the projects.

Research on the transport program has resulted in many improvements to barging. A constant supply of fresh water pumped into the barge directly from the river provides fish with homing cues. The number of fish that can be safely carried, based on a maximum loading rate of one-half pound per gallon of water, is factored





revitalize declining salmon runs.

Today WES research, along with biological and physical research on the river, is contributing vital knowledge to help the Corps make physical improvements and better operate the hydro-system for anadromous fish.

NMFS/Corps to conduct biological test of reservoir drawdown

Officials of National Marine Fisheries Service and the Corps of Engineers announced April 6 that they plan to conduct a biological test of reservoir drawdown. Their objective is to gather scientific data to help in deciding whether operation of Lower Snake River reservoirs below normal operating ranges is an effective means of increasing juvenile salmon survival.

The concept of lowering the reservoirs has been proposed as a means of increasing water velocity through the reservoirs. In theory, increased water velocity reduces the time needed for juvenile salmon to reach the ocean and increases their survival rate.

Both the Corps and NMFS consider biological testing of reservoir drawdown an essential element in evaluating and making a decision on the use of drawdown for recovery of the listed salmon species.

In 1992, when the Corps conducted a two-reservoir drawdown test to gather information on the physical effects of a drawdown condition, few salmon were present. NMFS has initiated a study this year to gather biological data on the relationship of river flows to juvenile fish survival. The next step is a drawdown test when salmon are present so that biological effects can be measured.

According to NMFS, their recovery planning process requires sound scientific information to determine how the Federal projects could be operated longterm to assist recovery of the listed salmon stocks. The Corps also needs the information to support its technical analyses in both the ongoing System Configuration Study and the multi-agency System Operation Review. In response to the Northwest Power Planning Council's Fish and Wildlife Program, these studies are examining potential modifications to federal dams and reservoirs and how they are operated under drawdown alternatives.

NMFS and the Corps will prepare an Environmental Impact Statement covering the biological test options. As a part of that effort public meetings were held in May to present test alternatives and solicit comments and suggestions.

Currently, the two agencies are working with regional experts to design a detailed biological test scenario. Timing of the drawdown test will depend on a number of considerations, including the relationship to NMFS' ongoing flow-survival study, and the design and construction of any special equipment or project modifications required to be in place before testing can occur.

Litigation Update

On April 1, 1993, Federal Judge Malcolm F. Marsh dismissed a series of suits filed in the United States District Court for the District of Oregon against various federal agencies by the power interests under the Endangered Species Act. In an 83-page decision, Judge Marsh ruled that the various plaintiffs did not have standing to pursue their claims against the federal agencies.

Following the heels of that ruling, another complaint was filed April 19 in the same court by Northwest Resource Information Center, Inc., the Confederated Tribes and Bands of the Yakima Indian Nation, American Rivers, Oregon Natural Resources Council and the Sierra Club.

This suit challenged the Corps of Engineers juvenile fish transportation program and the issuance of a permit for the program by the National Marine Fisheries Service on April 14. Plaintiffs sought a temporary restraining order and preliminary injunction to stop the Corps from proceeding with the transport program.

After an April 22 hearing, Judge Marsh denied the request for a temporary restraining order and—on April 29—after a continuation of the previous hearing, he denied plaintiffs' request for a preliminary injunction. In denying the injunctive relief, Judge Marsh indicated in to the operation. And the barges are equipped with aeration chambers which remove supersaturated gases from the water.

Although there is debate over whether the transport system is the appropriate way to get juvenile fish downriver, most research indicates that it has benefitted fish stocks. Many people prefer allowing in-river migration, however, barging is currently considered a necessary interim solution for safer fish passage. (Also see Litigation Update, this issue.)

The Process

Research funded through FPDEP is developed and coordinated with a number of other regional bodies including NMFS, U.S. Fish and Wildlife Service, Columbia River Inter-Tribal Fish Commission, and Oregon, Idaho and Washington fish and wildlife/game agencies. Other entities also participate in advising and recommending research activities.

The scope of research is developed during each fiscal year including recommendations from the Tribes and state and federal fish and wildlife agencies, and coordinated with their programs. Participants meet regularly to coordinate work, discuss research progress and proposals, and stay informed of specific problems being encountered at the projects.

Current research includes:

(1) transportation studies looking at improved collection and handling techniques, the impact of bacterial kidney disease on spring/summer chinook, and lower fish barge release sites on the Columbia river;

(2) adult passage studies on such topics as determination of hatchery/wild ratios, mainstem dam passage patterns, and evaluation of adult fallback at dams;

(3) survival studies of juveniles through turbines or bypass systems;

(4) fish passage efficiency studies, including techniques for determining fish guidance efficiency of structures within turbine intakes, and effectiveness of different extended-length traveling screens; and others.

Is There a Light at the End?

FPDEP is an applied environmental studies program—a set of scientific investigations directed toward understanding biological phenomena, addressing specific practical problems, and providing design and operation criteria. The Corps and other operating and fishery management agencies want to understand more about salmon behavior, to improve the efficiency of project operations, both biologically and practically.

Turner notes, “I think the Corps can still improve juvenile and adult salmon passage success. But there are also other problems in the Columbia river basin that need to be taken care of. Everyone needs to work to preserve wild stocks of fish—to provide high quality spawning and rearing habitat, reduce competition from hatchery stocks, control adult harvest, as well as provide safe mainstem passage conditions—otherwise, the endangered species list could grow.”

It is a complicated problem that will require complex solutions. Is it possible? Turner says he believes so. “I’d have a hard time coming to work if I didn’t. A crucial goal is maintaining wild fish stocks. Maintaining the natural diversity of species results, over the long term, in population resiliency that can overcome environmental problems. That’s where we need to head now."

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WES

Corps research lab looking at ways to increase salmon survival

By Dawn Edwards, Portland District

Vicksburg, Mississippi, 3,000 miles from Portland, is home to the Corps’ Waterways Experiment Station (WES), a 673-acre compound with six research laboratories: Hydraulics, Coastal Engineering, Geotechnical, Structures, Environmental and Information Technology. At WES, working physical models of Northwest dams are helping engineers and biologists find ways to increase anadromous fish survival rates and rebuild the Northwest’s traditional fish runs.

Established in 1929, WES’s original mission was to develop flood control plans for the Mississippi River after the disastrous 1927 flood. Today WES is one of the largest and most diverse engineering research and development organizations in the world. Its mission is “to conceive and execute engineering and scientific investigations in support of the military and civil programs of the Corps of Engineers, the Army and the nation.”

In the Hydraulics Lab, most of the work WES is currently doing for the North Pacific Division is related to fish passage. Researchers are looking for the best ways to move adult and juvenile fish past the Corps projects as they migrate to and from the ocean.

Leading edge research techniques are used on models of the Columbia and Snake river projects. General models, built at a scale of 1' to 80' or 1' to 100', reproduce large portions of projects. General models of Bonneville, The Dalles, McNary and Lower Granite dams are useful tools for analyzing general flow conditions. Scientists can evaluate hydraulic conditions salmon encounter as they pass the projects, and thus narrow the range of on-site tests needed.

There are also sectional models at WES. Those models focus on specific portions of projects and are generally constructed at a larger scale such as 1' to 25'. Sectional models currently being used for fish passage studies include three-bay turbine intake sectionals of Lower Granite, McNary, Bonneville and The Dalles and the Lower Granite spillways.

One WES model is a replica of Bonneville Lock and Dam and 3.4 miles of the Columbia River above and below the project. The model is more than half a football field long, and includes the first and second powerhouses, the spillway and the new navigation lock. At the project, Turbine Intake Extensions (TIES), also called roof extensions, are installed over the turbine bays on the upstream side of the second powerhouse. These extensions break up the flow at the river surface, creating flow patterns that guide juvenile fish toward the fish screens and up the gatewell more successfully. At WES, tests were performed to determine the most effective TIE placement and length for this installation.

The Dalles general model includes the powerhouse, fish ladders, spillway (gates, chute and stilling basin) and navigation lock, as well as a two and one-half mile stretch of the Columbia River. A deep channel in the basalt floor of the river downstream of The Dalles dam is clearly visible in the model and is a determining factor in flow patterns below the dam. Model operators can duplicate river flows through The Dalles powerhouse, adjusting discharges to simulate various river

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Sectional model of Lower Granite Dam spillway.

At WES, working physical models of Northwest dams are helping engineers and biologists find ways to increase anadromous fish survival rates and rebuild the Northwest's traditional fish runs.

conditions. Dye and confetti are used to track flow patterns at varying velocities. Dye illustrates flows from the surface to the river bottom, while confetti tracks surface flow patterns. Other techniques, such as video tracking which provides velocity information, are also used at WES.

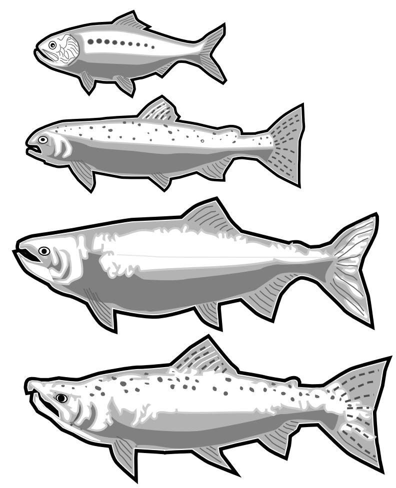
The Portland District office is currently designing a mile-long transportation flume to move juvenile fish through and downstream of The Dalles project. This flume is part of a new juvenile bypass system being designed for The Dalles. Current model work is under way to determine the best site for releasing juveniles from the flume back into the Columbia river.

Also at WES are three models of Lower Granite Lock and Dam— a sectional model of the spillway, a general model of the entire dam, and a turbine intake sectional model. The general model includes the Snake River environment from 2,000 feet upstream of the dam to 3,500 feet downstream.

These models are being used to evaluate physical effects of possible drawdown operations for the Lower Snake River reservoirs—Lower Granite, Little Goose, Lower Monumental and Ice Harbor—and what structural modifications may be required if drawdown is implemented as a long-term option. Annual operation of one or more of these projects at levels substantially below their normal levels (drawdown) is under study as one alternative for improving salmon migration conditions past the dams.

A March 1992 drawdown test at the Lower Granite and Little Goose projects did not provide biological information regarding effects of drawdown on juvenile fish travel time and survival. Although the model studies at WES will not provide this missing piece of information, they will help provide information necessary to the decision process, such as what happens in the spilling basins under drawdown spill conditions. (Please see related article on planning for biological test of drawdown in this issue.)

Model testing saves time and money. The models allow researchers to test many alternative operational techniques more quickly and thoroughly than they could with on-site testing. An advantage of modeling over physical site testing is that modeling allows evaluation of a variety of alternatives quickly, with no effects on other elements of the river system, including existing ecosystems. Using data from monitoring on-site river conditions, combined with modeling results, Corps researchers and designers can identify alternatives that will most benefit the anadromous fish population. That knowledge is needed now, as regional interests work together to



General WES model of working dam.

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that it was not his role to substitute his judgment for that of the agencies after they had properly considered other operational alternatives as well as conflicting scientific material. Judge Marsh indicated that the agencies' decision to commence the barging program was not arbitrary or capricious.

The Fish Transport Debate

What is this battle over barging all about? Readers of previous Salmon Passage Notes have learned how the system of hydro-projects on the Snake and Columbia rivers—so beneficial in terms of power, irrigation, flood control, navigation and recreation—have created difficult migration conditions for salmon, particularly young salmon going downstream to the ocean.

Dangers in the slow-moving reservoirs include predation and the potential for nitrogen supersaturation when water is spilled over the dams. And, while many juvenile fish are diverted through the powerhouse bypass systems, some are still killed or injured as they pass through turbines.

Over the years, NMFS has conducted numerous studies which indicate that transportation has increased survival of Snake River salmon. More recent studies were conducted in 1986 when river flows were average and 1989, when flows were low. The NMFS studies found that transportation increased the spring/summer chinook survival rate by about 1.6 times in 1986 and 2 times in 1989 compared to in-river migration.

These same studies became the subject of controversy this year when an ad hoc review group of the Columbia Basin Fish & Wildlife Authority (CBFWA) issued a report critical of the NMFS studies. CBFWA represents state and federal fish agencies and Northwest Indian tribes.

Judge Marsh, in his April 22 decision not to grant a temporary restraining order to stop barging salmon, expressed concern that scientists on both sides of the issue were losing sight of science and becoming advocates. "Let's just deal with this...from a scientific standpoint," he said.

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