Endangered Species Act 2001 Progress Report for the Federal Columbia River Power System

Appendix A

Dam Passage and Estuary Research

US Army Corps of Engineers
Northwestern Division

May 2002

Table of Contents

Overview

COE conducted approximately 70 research projects in 2001 within the Anadromous Fish Evaluation Program (AFEP), funded under the Columbia River Fish Mitigation (CRFM) Project. The majority of research was oriented around salmon survival in the FCRPS, but a limited number of offsite research projects focused on estuary, ocean, technology, resident fish and laboratory studies. Much of this research is exploratory, intended to find out basic information. Some projects were targeted for a specific action or decision. The following text summarizes each of the groups of studies based on preliminary results presented at a 2001 AFEP Research Review Conference held Nov. 13–16, 2001.

Juvenile Bypass Systems

At most of the Snake and Columbia River dams, the juvenile bypass systems (JBS) have been designed to divert fish before they enter the turbine environment. Once guided, these fish enter a system that bypasses the dam and releases them to the tailrace. One of the major tools for fish passage management incorporates the use of JBSs at the dams.

The goal of these bypass systems is to guide as many fish as possible away from the turbines with minimal impacts to fish due to delay, stress, disease transmission, injury, and direct and indirect mortality. However, adult return data from juvenile chinook released upstream of the hydrosystem indicates there may be lower long-term survival of fish that pass through multiple JBSs compared to fish that were transported around the dams, or bypassed the dams via spill.

Although the data sets are not clear, there is not agreement on the future uses and designs of these systems and their role in the management of the hydrosystem for the improved survival of salmon. There are three areas of focus as to why the multiple bypass systems may cause lower survival: (1) Cumulative impacts on the physiology of the fish, (2) site-specific mortality, and (3) a stock's propensity for diversion through a bypass system. In 2001, research emphasized improving the effectiveness of various components of the JBS and identifying potential problem areas at specific facilities.

Monitoring hydrosystem performance relative to fish survival depends on efficient PIT tag detection and diversion systems in the juvenile bypass facilities. Since the fish that pass through these systems are indicators of the success or failure of experimental operations, designs, or system configuration, it is important they are not delayed or injured by the PIT tag diversion systems. The Lower Granite PIT tag diversion system was improved in 2001, with the following results:

- The new juvenile fish conveyance conduits do not appear to have any obstructions or rough areas that could cause injuries (Hockersmith).
- The modifications have improved passage performance and eliminated delay associated with the PIT tag diversion system.
- PIT tag reading efficiency was similar to detection efficiency prior to the modifications and, at some locations, may have improved.

Once juvenile fish enter bypass facilities, a percentage of them are sampled and anesthetized to collect information on species composition, abundance, migration characteristics, and general health. However, this handling and marking raises concern that subsequent sampling and handling methods may compromise fish survival by increasing the likelihood of disease transmission. To reduce this potential, an ultraviolet (UV) light sterilization system for the sample re-circulation system was evaluated in 2001. The results of this work showed:

- Use of separate recirculation systems for sorting and marking troughs, with separate UV and filtration units, may help to reduce the number of bacteria in these systems.
- The effectiveness of UV units for killing *Renibacterium salmoninarum* in juvenile fish sorting and marking systems at Lower Granite Dam has not been determined (Elliott). (UV penetration through turbid water was thought to be a problem.)

At McNary, a new JBS was built in 1994 and extended-length submerged bar screens and modified vertical barrier screens were installed in 1996 and 1997. Post-construction evaluation showed no delays, injuries, or other problems. However, during a 1999 reach survival study conducted by NMFS, fall chinook periodically experienced up to a 4-day delay passing through the McNary juvenile bypass facility. In 2000 and 2001, a radio telemetry evaluation was conducted

to identify the problem area. The results showed that travel time ranged between 2.6 and 8.6 hours for juvenile fall chinook to pass from the gatewell through the juvenile fish facility. Most of the passage time was spent in the gatewell (91 to 98 percent) and the variability observed in passage time depended on the gatewell the fish passed through (up to a 6-hour difference between the median passage times from the gatewells). The delays documented in the 1999 research were not observed in 2000 or 2001(Axel).

At Lower Granite, Little Goose, Lower Monumental, and McNary dams, the JBS also collect fish for transport by truck or barge around the remaining dams to a release point in the upper estuary. One of the processes contributing to successful transportation is the separation of smaller fish (usually chinook) from the larger steelhead. Separation allows for different management of the species. Also, chinook may experience additional stress when they are confined and transported with steelhead, which may affect their ability to survive following their release from the transportation barges. Finally, separation reduces the opportunity for large steelhead to prey on small chinook.

Since the mid-90s, researchers have evaluated separator improvements. The 2001 research focused on refining the design and performance of existing and high velocity flume separators. At Ice Harbor Dam, the tests conducted in the prototype high velocity flume separator showed that total separation was increased under lighted conditions with a dark substrate (82 percent) but descaling increased (1.1 percent increase). No delay or holding was observed under any test conditions. At McNary Dam, an insert to the production separator was tested throughout the out-migration season. Results showed the insert was more efficient in separating juvenile chinook from steelhead than the existing separator and lighted conditions contributed to the highest observed separation efficiency. There was no difference in descaling rates during operation of the test insert compared to the existing separator at McNary (McComas).

Fish Guidance Efficiency (FGE) tests were conducted at the Bonneville second powerhouse with a modified intake area. Results suggest that passage times through the forebay were very fast with spring fish passing in 0.2 hour and summer fish passing in 0.7 hour. Fyke net testing suggested the modified intake increased FGE from 15 to 33 percent compared to previous years. However, hydroacoustic results indicated that adjacent units had higher overall FGE in 2001, which made it difficult to determine the actual FGE increase associated with intake modifications. Additional tests are planned in 2002.

Transport and Delayed Mortality

Transportation of juvenile fish from the Snake River and McNary Dam began in the late 1960s in an effort to avoid exposing juvenile salmon to high levels of dissolved gas and poor in-river conditions. Since then, transportation practices, facilities, and hydrosystem operations have improved. Current hydrosystem operations use a “spread-the-risk” policy that allows some migrating fish to remain in-river for the duration of their out-migration and pass the dams through spill and/or bypass systems and others to be transported around the dams to a release site in the upper estuary.

In the mid 1990s, a comprehensive transport evaluation was started to compare the adult returns of transported, PIT tagged fish to returns of those that remained in-river but under the best river conditions that could be provided. The study design was changed over the years to reduce the number of wild fish handled and marked and to increase the sample size of fish remaining in-river. The evaluation has five main elements:

- Marking fish to compare adult returns of transported fish vs. in-river fish.
- Evaluation of physiological conditions at the onset of transportation and evaluation of physiological changes due to transport vs. in-river migration on survival.
- Evaluation of post-transport release behavior and survival compared to run-of-river migrating fish.
- Evaluation of whether transportation affects returning adult homing and straying rates.
- Evaluation of delayed mortality.

Results of the past several years’ transportation evaluations of spring/summer chinook from Lower Granite indicate there are seasonal differences in survival and post-transport release behavior. This suggests we may need to change how, when and where barge transport occurs to improve spring/summer chinook survival. Since steelhead and

chinook out-migrations overlap, we planned to determine if similarities exist in steelhead post-release behavior before we conduct experimental testing of new barging strategies.

Juveniles transported out of the Snake River in 1998 and 1999 generally survived better and returned more adults than fish that remained in-river. This was true even for in-river migrants that were not detected passing through bypass systems despite their tendency in previous years to return the largest numbers of adults. Only one in six comparisons indicated that in-river survival exceeded transport survival (Marsh). No in-river experiments were conducted in 2001 due to drought conditions. However such experiments would likely have demonstrated even more extreme benefits of transportation in returning adults in future years, similar to that observed in the 1977 drought.

It is hypothesized that prolonged migration through the FCRPS subjects juvenile fish to poor feeding conditions and energy depletion (Congleton). Data showed migrants were in better condition (had lost less energy compounds) in 2000 compared to 2001 after migrating through the FCRPS, although there were also better flow conditions in 2000 than 2001. Multiple bypasses did not seem to explain any of the variation. It is hypothesized that prolonging the normal passage time of 2 to 6 weeks to 3 to 9 weeks reduces the amount of energy available to smolts when they reach the estuary (Congleton). Dietary mineral content (Cu, Zn, Se) is also an important element of stress. Significant loss of selenium after transport may reduce seawater conversion and survival. Additional research needs to be conducted to determine if the observed selenium losses are sufficient to reduce the osmoregulatory ability of fish after they have entered seawater.

To fully understand the usefulness of transportation as a tool for salmon survival, any delayed mortality caused by transportation must be understood. Delayed mortality is the indirect mortality occurring after transport that is attributed to some yet unknown impact of operation, design, or hydrosystem management that selectively reduces the long-term survival of transported fish. Delayed mortality estimates vary considerably between years and species. While the data is inconsistent, there is confidence that delayed mortality does exist.

A series of studies were initiated in 2001 to help identify the causes of differential delayed transportation mortality. Speculation about these causes has been attributed to several sources:

- Cumulative physiological changes in fish that reduce their ability to make a transition to the saltwater environment, grow, avoid predators, and resist injury or exposure to diseases.
- Transportation may alter smolts' migration and schooling behavior, making them more vulnerable to predators in the post-release environment.
- Operation of the transport program may release juvenile fish into the estuary too early in their life cycle to successfully enter the ocean or may release fish at a location that exposes them to extreme levels of predation.

To address questions related to cumulative physiological effects, new 23,000-gallon seawater facilities were built at Bonneville Dam and at Newport, Oregon, to monitor differences in mortality rate of juvenile chinook that have different migration histories (spill/inriver transport and multiple bypass). Any observed differences will be correlated to physiological condition of the fish to develop a cause and effect relationship for future improvements and testing. Results of the first-year pilot study showed little difference between run-of-river and barged fish.

To provide information on the differences in fish behavior and migration timing that may contribute to delayed transport mortality, PIT tagged fish were monitored using a PIT tag trawl in the upper estuary. Valuable information on survival downstream of the FCRPS is emerging from this PIT tag data (Ledgerwood).

PIT tag trawl data in the estuary also enables survival estimates in the last reach (JDA-BON) of the FCRPS and gives information on travel time and survival for transported fish from releases downstream of Bonneville to Jones Beach. Travel speed from Bonneville Dam to Jones Beach was significantly slower in 2001 than previous years due in part to lower river flows. The average survival estimates for in-river migrants from Lower Granite to Bonneville Dam were 28 percent for yearling chinook salmon and 4 percent for steelhead, both significantly lower than in 1998 and 2000. To detect PIT tags in estuary salt water, a smaller and more maneuverable trawl was tested that will be more effective in changing ocean conditions.

To understand behavior and site-specific causes of mortality, post-release behavior of transported chinook has been evaluated for several years using radio telemetry. Information from these studies provides strong evidence that timing barge releases to the tidal cycle through the saltwater interface is a critical factor in the rapid movement of chinook into

the saltwater environment. Before we modify current barging practices, the post-release behavior of steelhead and fall chinook are being evaluated to ensure there would be no negative impact from such changes. Results this year showed that steelhead migrated through the upper estuary (Bonneville to river km 89.4) in 40.1–109.0 hours and fall chinook in 50.4–99 hours, with no difference between dates and migration histories. Most of the steelhead release groups successfully migrated through the upper estuary to the downstream detection site. Most mortality for steelhead in the estuary was attributed to avian predation. Fall chinook losses in the estuary have been attributed to tag malfunction (Jepsen).

Passage through the Columbia River hydrosystem by migrating juvenile salmonids may weaken their condition without causing mortality until they are exposed to the added stress of saltwater entry in the estuary and near-shore environment. This delayed mortality in the near-shore environment is poorly understood. As a companion study to the radio telemetry evaluation, research was initiated to assess the methodology that will be used to monitor the behavior of the same groups of fish once they enter the saltwater interface and move through the Columbia River plume into the ocean environment. Results in 2001 confirm that the tidal cycle strongly influences migration speed and once the fish exit the rivermouth, steelhead move north from the Columbia River plume (Clements).

Adult Passage

Adult movement through the FCRPS was studied extensively in 2001, providing significant practical benefits for improving FCRPS operations. Highlights of the 2001 adult program include:

- At Bonneville Dam, overall 2001 spring/summer chinook fallback rates were the lowest (6.9 percent) since in-depth telemetry began. This was the first year to have no-spill periods early in the spring and still there was a fallback rate of 5.1 percent during no-spill periods. During times of spill, fallback was 10.9 percent. Steelhead fallback (3 percent through October 10) was also the lowest ever observed. Most of the chinook fallback was through the ice/trash sluiceway (73 percent) with no spill and through the spillway (70 percent) when spill occurred. For steelhead, 47 percent of fallbacks occurred through the navlock; 33 percent via spillway. The preliminary turbine fallback rate was less than 10 percent.
- 2000–2001 evaluations of potential exit sites for a new or modified Bradford Island fishway to reduce fallback by adult salmonids found a strong shoreline orientation with forebay-released fish more likely to migrate along the Oregon shore and less likely to fall back than fish exiting Bradford Island. In 2000, most releases were after spill was over and little spill occurred in 2001. Tests still need to be conducted with releases at all test sites during more normal spill periods.
- In tests of open vs. closed orifice gates at Bonneville's first powerhouse, no differences in passage times were observed. Median passage times were higher at dams with orifice gates open, but differences were not significant. Overall, results since 1997 point to no negative effects from closing orifice gates.
- Using CART tags and more intensive tracking efforts, nearly every fish released in Bonneville pool was accounted for: 66 percent of spring chinook were recaptured in fisheries or at hatcheries, 28 percent passed McNary, 3 percent were last located in tributaries, 1 of 131 was out of the water, 1 was stationary in The Dalles tailrace, and 1 disappeared in the The Dalles pool. For summer chinook, 19 percent were recaptured or reached hatcheries, while 76 percent passed McNary. By early October, 15 percent of fall chinook and 13 percent of steelhead were recaptured or reached hatcheries, 49 percent of fall chinook and 43 percent of steelhead passed McNary; the remaining fish are still in the study area.
- Preliminary results of 2001 homing and straying data for spring/summer chinook, with both PIT tags and radio transmitters found about 2 percent straying rates and indicated that barging juveniles appears to negatively affect adult homing. Passage times from Bonneville to Lower Granite were similar for PIT tagged fish with and without radio transmitters, but survival may be lower for fish with radios.
- Evaluation of temperature effects on steelhead migration found that travel time increases with increases in water temperature. Temperatures above 20°C can delay steelhead runs in the Snake River. The majority of steelhead migrating through the Bonneville pool delay at tributaries. These migrants have lower mean body temperatures and take longer to negotiate a given reach. Earlier migrants do not delay longer than later migrants.

- Energy expenditures of adult spring chinook migrating in 2001 in the vicinity of the Bonneville Dam were greatest for fish in the tailrace, followed by the upper end of the ladder near the serpentine weirs, and least for fish in the forebay.
- Evaluations of 2001 steelhead kelt found 3.3 percent of those released at Lower Granite Reservoir reached the Bonneville tailrace. Fifty-eight percent of kelts released at McNary and 65 percent at John Day reached the I-205 bridge, of which 5 percent overall returned by November (10 percent of Hood River fish). FGE at Bonneville first and second powerhouses was 79 and 50 percent, respectively. At the Dalles, 63 percent passed over the spillway.
- In 2001, 98 percent of tagged lamprey returned to Bonneville Dam and 44 percent passed the dam. There was nearly a 10 percent greater passage rate through the Washington shore ladder test section with plates attached over the diffusers. Lamprey had difficulty passing at the first serpentine weirs above the counting station. A higher percentage of fish with nannotags passed the dam than those with regular-sized tags.
- A 2001 study of adult passage through modified weirs at Lower Granite Dam (Peery) showed increased orifice velocity reduced passage times. Passage through ladder entry pools dropped from 4.1 to 0.5 hour, with total ladder passage reduced on average from 38 to 19 hours.

McNary Dam Water Temperature Issues

Due to water temperature problems in the forebay of McNary Dam, the use of mixers was tested to blend deeper, cooler water with warmer surface water. Elevated water temperatures at fish ladder entrances is problematic at Ice Harbor and other lower Snake River dams (Peery), requiring applied solutions or testable hypotheses to alleviate delay. Adults appear to follow cooler thermals at deeper reservoir locations in Lower Granite Reservoir (LGR) as afforded by cold water released from Dworshak that slides into LGR. After Dworshak flow augmentation was discontinued at the end of the fish flow season, a rapid rise in the thermal environment for migrating adults was observed. Additionally, there were steep geographic thermal gradients at the confluence of the Clearwater and Snake rivers that might also have been problematic for fish migrating up the Snake. Evaluation of the effects of cool water releases on fish passage and survival will continue.

Estuary

Research begun in 2001 on salmon use and survival in the estuary and plume is in its infancy compared to other FCRPS salmon-related research. Accomplishments in 2001 included: (1) setup and testing of juvenile index sites to evaluate juvenile abundance and timing in the estuary, and (2) development of a new sonic tag system that will enable evaluation of several size ranges of juvenile fish and partitioning mortality of known source fish as they pass through the estuary and through the saltwater intrusion zones.

Fish Research Technologies

Current technology enables us to characterize fish environmental preferences such as temperature, dissolved gas, and hydraulic velocity during migration (Richmond). Behavior of migrating (radio-tagged) juveniles likewise showed specific responses to reservoirs, dams, flows, and passage routes through the dams, including reversal of downstream migration for steelhead as velocities in forebays slowed (Adams). Work was also done at Lower Granite in 2001 to refine technologies for using acoustic tags to track fish in three dimensions.

Predation

Fish predation studies at a new trash boom at Little Goose forebay might increase our conditional knowledge there (Bennett); however, unless such studies have more rigor and are tied to decisions about system configuration, we may not be getting the fullest return on research dollars.

Terns and other seabirds consumed an estimated 7.3 million juvenile salmon and steelhead in 2000. The program was able to successfully relocate terns from Rice Island to East Sand Island in 2001. Moving the birds a few miles closer to the ocean reduced consumption in 2001 to an estimated 4.4 million smolts (Ryan). New tern relocations are under consideration for 2002.

Resident Fish

A bull trout study in Dworshak Reservoir demonstrated where these fish were spawning, when they were using the reservoir, and estimated population levels (Schriever). The bull trout leave the reservoir in order to spawn in the upper watershed prior to summer drawdown, thus avoiding potential entrainment. Although the preliminary work of this study shows that adult bull trout may not be impacted by summer operation of Dworshak, it is not known how this operation impacts sub-adults that may remain in the reservoir.

Passage and Survival

Fish passage efficiency and project survival tests were conducted at Ice Harbor, John Day, The Dalles, and Bonneville Dams. The evaluations included project survival as well as route-specific survival at many of the projects' juvenile passage facilities.

Ice Harbor

A study was conducted in 2001 to estimate survival of hatchery yearling chinook releases above Ice Harbor Dam to McNary Dam (a 68-km reach) using both PIT tags and radio telemetry. The objectives of this study included determining migrational characteristics and timing between Ice Harbor and McNary dams, estimating survival from release above Ice Harbor Dam to McNary Dam, partitioning reach survival between the two dams, and comparing survival estimates derived from PIT tag and radio tag methodologies. Preliminary findings from this study show median travel times to McNary Dam were 4.2 days for PIT tagged and 3.6 days for radio-tagged fish released into the Ice Harbor Dam forebay, and 2.7 days for radio-tagged fish released into the tailrace of Ice Harbor Dam. Preliminary survival estimates for Ice Harbor Dam to McNary Dam are 72.4 percent (0.008), 69.8 percent (0.021), and 78.4 percent (0.023) for forebay-released PIT tagged, forebay-released radio-tagged, and tailrace-released radio-tagged fish, respectively.

John Day Dam

The juvenile bypass system was the only route evaluated in 2001 due to little or no spill during the fish passage season. Project survival estimates were consistent with reach survival, indicating lower than usual bypass survival. Survival rates ranged from 87 percent for subyearlings to 93 percent for yearling chinook. We are planning to repeat the test in 2002, assuming a more normal water year, with the spillway included in the evaluation.

The Dalles Dam

Significant progress was made to evaluate spillway conditions at The Dalles. Results of previous studies suggest spillway mortality is higher than anticipated at other spillways in the Lower Columbia River, but did not isolate the reason. Studies in 2001 were initiated to partition mortality/injury and determine methods to improve survival of juveniles passing the spillway. Direct injury assessments were tested with Hi-Z tagging techniques, which suggests the method has merit for isolating injury rates for individual spill bays. Injury rates ranged from 2 to 14 percent between bay 4 and bay 11. In addition, radio tracking was initiated to determine how long fish are present in the immediate tailrace zone, which is a highly turbulent environment. The purpose of these studies will be to assist the region in developing alternative design measures for The Dalles stilling basin.

Direct injury assessments were also conducted for the ice-trash sluiceway at The Dalles. Results suggest few fish are injured by passing through the sluiceway. The sluiceway was also evaluated for passage survival with radio-tracking techniques. Results indicated survival was high for both spring and summer released fish. Interesting to note was that 84 percent of the radio-tracked fish released into the sluiceway were delayed near the bridge Islands for significant periods of time. However, the survival results did not indicate lower survival associated with this delay.

Predator activity at The Dalles was evaluated in 2000 and reported in 2001. The field evaluation sampled northern pikeminnow and smallmouth bass in the tailrace area. One potentially significant result was that the catch per unit effort (CPUE) for small-mouth bass was more than twice that of northern pikeminnow.

Turbine occlusion devices (J-blocks) were also installed and tested at The Dalles in 2001. Problems with hoist frames compromised the test, which will be repeated in 2002. An acoustic camera was installed to evaluate the gaps associated with the j-blocks. The camera allows identification of fish movement and response when passing through the gaps and approaching the ice-trash sluiceway. The technique appears feasible for many testing applications that require visual identification where normal hydroacoustics and standard cameras don't work.

Bonneville Dam

Fish passage efficiency and survival were evaluated for juveniles at Bonneville Dam, suggesting that juvenile passage was fastest for the second power-house versus the spillway. Passage rates ranged from 0.2 hour (spring) to 0.7 hour (summer) at the second power-house and 0.3 (spring) to 1.5 (summer) hour at the spillway. This was much faster than expected due to the low river flows and low spill rates at Bonneville in 2001. Lower spill levels also likely contributed to lower fish passage efficiency at Bonneville. Both hydroacoustic and radio tracking results suggested that most fish passed through the second powerhouse in 2001. Overall survival rates were 94 percent in the spring and 90 percent in the summer, although the confidence intervals were high for summer fish. Survival through the bypass system was approximately 96 percent in the spring and 90 percent in the summer. Again the summer confidence levels were approximately +/- 10 percent.

Note: All references come from AFEP Program 2001, Walla Walla, November 13–16.