Research Pre-Proposal

EVALUATION OF WEIR AND FISHWAY MODIFICATIONS IN THE TRANSITION POOL TO IMPROVE PASSAGE OF ADULT SALMON AND STEELHEAD PASSING LOWER GRANITE DAM - 2007

Study Code ADS-00-1

To

Walla Walla District, U. S. Army Corps of Engineers
Walla Walla, Washington

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Project Summary

A. Goals

This work plan describes an evaluation of the effectiveness of weir and fishway modifications to improve passage conditions for adult salmon and steelhead passing Lower Granite Dam and to determine if this modification is applicable to other dams, with the ultimate goal of decreasing adult migrant passage times through the entire Federal Columbia River Power System. Modifications, made during January and February of 2006, were intended to improve flow dynamics and attractiveness for fish passing through the transition pool area of the Lower Granite Dam fishway. This evaluation is associated with previous research for the Anadromous Fish Evaluation Program for the Lower Columbia and Snake rivers funded by the Walla Walla District, USACE, Study Code ADS-00-1.

B. Tasks - 2006

1. Evaluate the effectiveness of weir and fishway modifications to improve passage times and behavior of adult salmon and steelhead through the transition pool and the entire fishway at Lower Granite Dam.
2. Evaluate passage times and behavior of adult salmon and steelhead passing Little Goose Dam, with emphasis on the transition pool area, and compare to data from previous years.

C. Methods

Modifications to the transition pool area at Lower Granite Dam were made by USACE contractors during January and February, 2006. Adult Chinook salmon and steelhead collected at Ice Harbor Dam, outfitted with transmitters, and released to the river near the dam (sites to be the same as in 2006), will be monitored as they pass Little Goose and Lower Granite dams using the existing receiver and antenna arrays at the dams. Passage times and behavior of fish in the junction pool, transition pool, and overall passage times at the dams during 2007 will be compared to data collected before 2000, prior to weir modifications, and to those data collected during 2000-2002 when prototype weir modifications were in place or were alternated with the unmodified condition during the weir modification experiment at Lower Granite Dam.

D. Relevance

The proposed evaluations relate to the NOAA Fisheries Biological Opinion for operation of the Federal Columbia River Power System and identified by the U.S. Army Corps of Engineers and other Action Agencies in the 2005-2007 Implementation Plan for the FCRPS Endangered Species Act Updated Proposed Action in association to factors that affect passage success and survival of adult salmonid migrants. Relevant BIOP RPAs include survival and passage delay (107) and delay and fall out at junction pools (116).

Project Description

A. Background

Adult salmon and steelhead migrating to their natal streams in the tributaries of the Snake River must pass up to eight dams and their reservoirs, four each in the lower Columbia and Snake rivers. Stress, delay, and mortality during migration at each hydroelectric project and associated reservoir should be minimized to succeed in maintaining the native runs of fish and achieve the recovery goals outlined by the Northwest Power Planning Council (NWPPC) and by NOAA Fisheries.

Median times for adult salmon and steelhead to pass Columbia and Snake River dams can often exceed 30 h, with some fish taking 5 d or more to pass individual projects (Keefer et al. 2004; Burke et al. 2005). A significant portion of time to pass dams can be used to successfully negotiate transition pools at the base of ladders, especially for fish that leave the transition pools and exit to the tailrace one or more times before eventually passing the dam. Typically over half of the adult migrants we have monitored reversed course in transition pools and exited fishways at Columbia and Snake River dams (e. g. Bjornn et al. 1998; Bjornn et al. 2000; Keefer et al. 2003a; and see Keefer et al. *In review*). At most dams, this is a higher turn-around rate than in any other segment of the fishway (Burke et al. 2005). It is unknown why this area in the fishways disrupts fish passage. Factors that may impede fish movement include: the low velocities through the transition pool area relative to velocities at fishway entrances and in the ladders, non-uniform flow direction caused by water added to the fishway at diffuser grates, submergence of the first few weirs of the ladders when tailwater elevations are high, or temperature discontinuities (Keefer et al. 2003a; Peery et al. 2003). Time to pass dams could be reduced if passage through the transition pools was more efficient and fewer fish exited the fishways into the tailrace.

There is evidence that adult salmon and steelhead prefer to pass weirs in the ladders through the submerged orifices rather than over the weirs (see Naughton et al. 2005). But when weirs at the bottom of the ladders are submerged because of high tailwater, flow through orifices is reduced. In 2000, the bottom five weirs in the ladder at Lower Granite Dam were modified to increase the head at weirs and flow velocities through submerged orifices, to determine if fish would pass through the transition pool faster. The modification increased the height of the center non-overflow section of the weirs and provided the capability to add vertical panels as needed to reduce the width of the overflow section. This modification allowed us to maintain a head differential of 0.25 to 1 ft at each weir in the lower end of the ladder, and thereby force more water through the orifices of submerged weirs. A head of 0.25 ft produces a velocity of about 4 fps through the submerged orifices. Weirs were modified by mid-May 2000 and were in operation during the passage of spring–summer and fall Chinook salmon, and steelhead. There was evidence that passage times were faster in 2000 and that fewer fish exited the fishway into the tailrace, but passage rates were also faster at other dams (i.e. Little Goose Dam) compared to earlier years, confounding our interpretation of test results.

Because of the difficulties of comparing data between years, 2001 and 2002 studies were changed to a paired-treatment test comparing passage with high and low head levels at the first two weirs in the transition pool. At the completion of that test, we compared passage success (proportion of fish that passed through transition pools on their first attempt) and passage times between the high and low head/velocity conditions. We found that a greater proportion of fish passed through transition pools on their first attempt, and median transit times through the transition pool were lower, when the prototype weir modification was fully deployed (Naughton and Peery 2003; Naughton et al.2005).

Based on results from the 2000-2002 evaluations, plans were developed for permanent modifications to the Lower Granite fishway. The proposed modification consists of two components, 1) narrowing the width of the junction pool area from 38 to 20 ft between the transition pool and the south end of the collection channel to increase velocity and directional flow of attraction water through this segment of the fishway (Figure 1), and 2) modifying the shape of the first 11 weirs (weirs 634 through 644) in the ladder to produce target velocities of 2.5 to 3.0 fps (head differential of 0.8 to 1.2 ft per weir) through submerged orifices (Figure 2). Construction and installation of modifications occurred during January and February 2006.

In 2006, we evaluated modifications to the fishway at Lower Granite Dam by monitoring a sample of adult Chinook salmon and steelhead outfitted with radio transmitters at Ice Harbor Dam. At Lower Granite Dam, an array of telemetry receivers and antennas was used to monitor movements of radio-tagged salmon and steelhead as they moved through the fishway, particularly the transition pool and bottom of the ladder. The 2006 test is ongoing and weekly updates have been sent to system managers and biologists. To date, 242 spring and summer Chinook salmon have been tagged and released at Ice Harbor Dam, prior to the onset of warm water temperatures in the Snake River. This break in tagging activities was anticipated in built into the tag schedule for this evaluation. In our preliminary analysis, passage times at Little Goose Dam this spring have been similar to those observed in recent previous years while passage times at Lower Granite Dam are at the upper end of the range seen in previous years when the prototype modification was in place. Monitoring of adult steelhead and fall Chinook salmon should continue sometime during mid to late August. At this writing it would be preliminary to state if results from 2006 were conclusive enough to state with confidence that fishway modifications improved fish passage at Lower Granite Dam. Repeating this study in 2007 will provide additional information to isolate interannual effects from treatment effects.

Fish behavior and performance during 2007 will be monitored using the same methods as in 2006 and compared to data from previous years of monitoring, prior to modifications and during testing of prototype modifications. To better assess year effects on passage performance, we propose to also closely compare passage of radio-tagged fish at Little Goose Dam in 2006 and 2007 to information collected in previous years (i.e., Little Goose Dam will serve as a control to help isolate interannual variability).

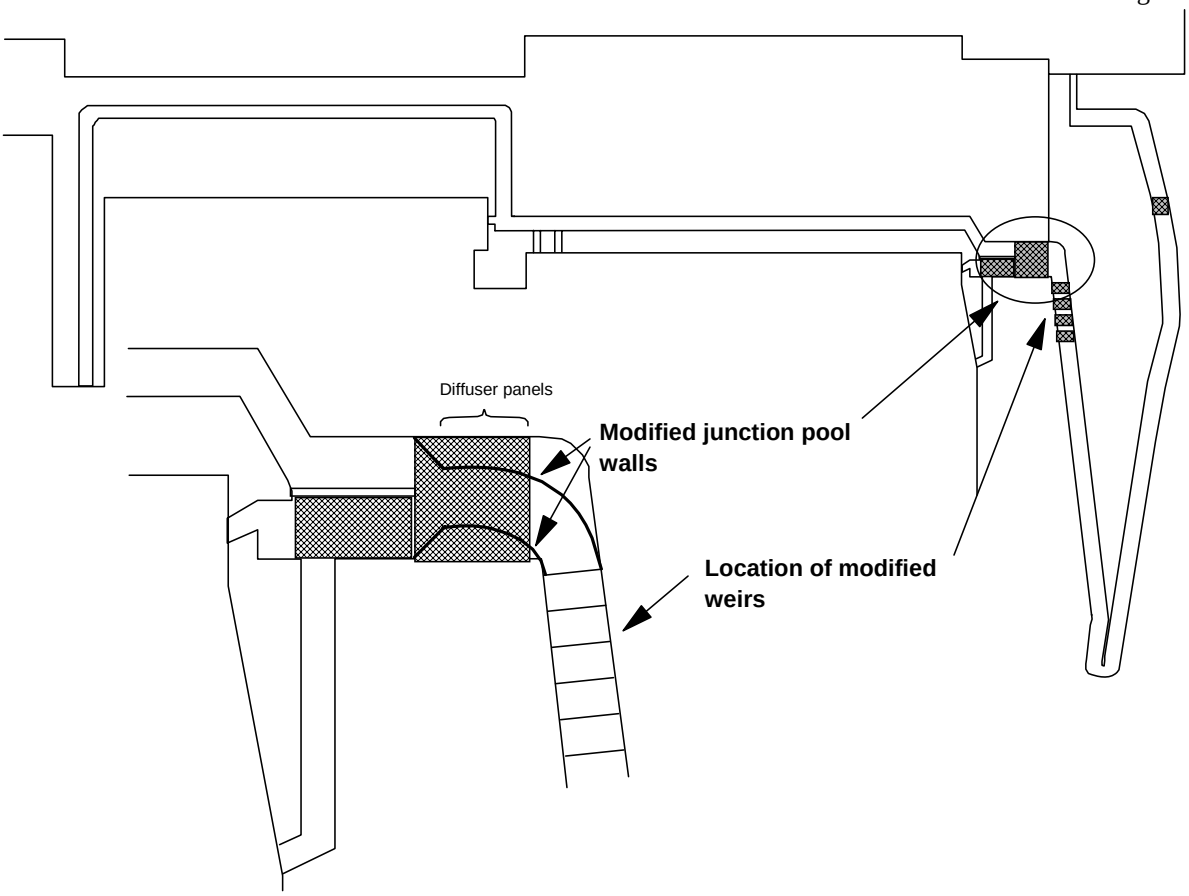

Figure 1. Drawing of Lower Granite Dam and fishways and detail of modification to junction pool walls.

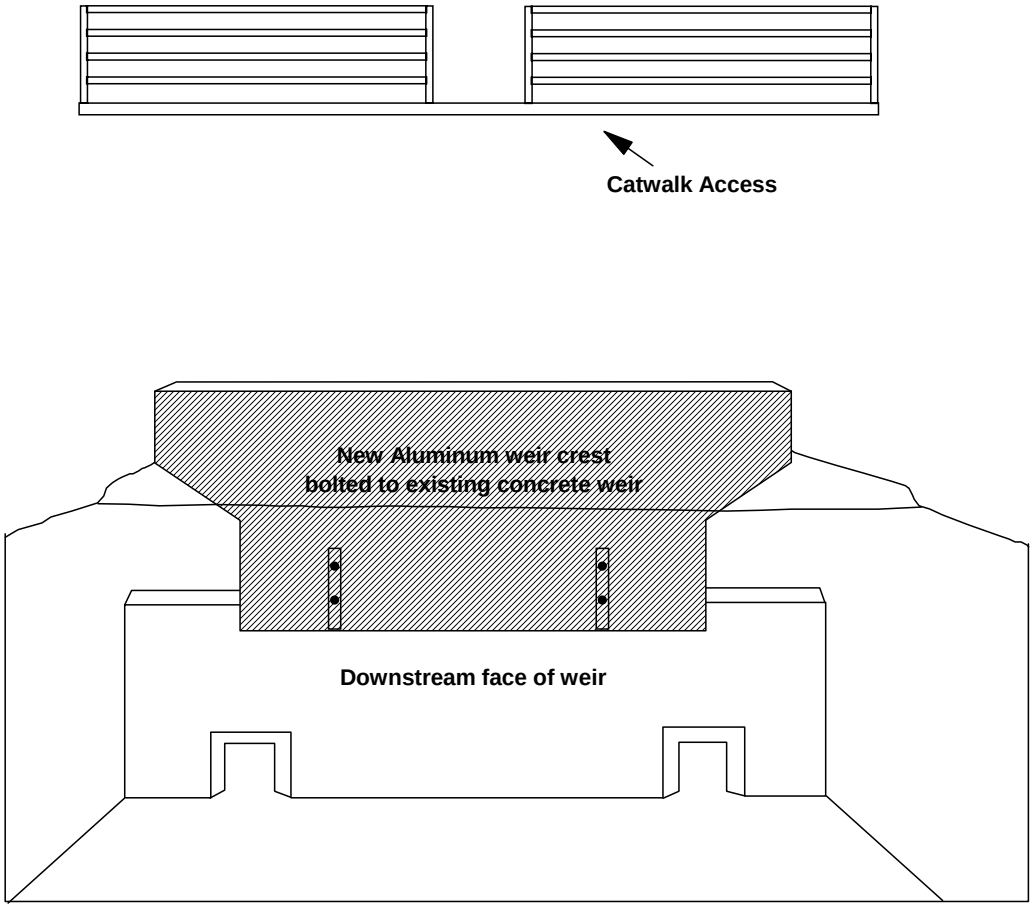

Figure 2. Example of proposed weir modification to be added to first eight weirs in Lower Granite Dam adult fish ladder (transition pool area).

This proposal was developed in response to requests for preliminary proposals issued by the U.S. Army Corps of Engineers (USACE) in July 2005, and Request for Proposal issued 6 March 2006, and addresses concerns of the USACE, the NWPPC in the Columbia River Basin Fish and Wildlife Program, and by NOAA Fisheries in the Proposed Recovery Plan for Snake River Salmon, and Biological Opinion issued in 2000 (which supercedes the 1995 and 1998 Biological Opinions). The proposals have been developed in consultation with personnel from the USACE and NOAA Fisheries.

The study proposed here is a continuation of monitoring and evaluation of adult salmon and steelhead passage and survival through the Columbia and Snake River hydrosystem conducted in recent years to develop means to improve passage efficiency. Reports from previous year's research are available at http://www.cnr.uidaho.edu/uiferl/. Evaluations of adult salmon passage through the lower Snake River by University of Idaho began in the early 1990's (Bjornn et al. 1998, 1999, 2003) and included studies of the lower Columbia River in cooperation with NOAA Fisheries beginning in 1996 when fish were collected and outfitted with transmitters at Bonneville Dam (Bjornn et al. 2000; Keefer et al. 2002; Keefer et al. 2003b). Data collected during 2007 will be processed and analyzed during 2007 and early 2008 and a final report will be available during 2008.

B. Objectives - 2007.

1. Evaluate the effectiveness of weir and fishway modifications to improve passage times and behavior of adult salmon and steelhead through the transition pool and the entire fishway at Lower Granite Dam.

2. Evaluate passage times and behavior of adult salmon and steelhead passing Little Goose Dam, with emphasis on the transition pool area, and compare to data from previous years.

C. Methods

We propose to tag a sample of 300 each adult spring/summer, and fall Chinook salmon and steelhead at Ice Harbor Dam, release them to the river, and monitor their behavior and passage as they pass Little Goose and Lower Granite dams. Methods for collecting and tagging fish at Ice Harbor Dam, downloading of data from receivers, and processing of the data will be similar to those developed in prior years (see below).

Task 1. Evaluate the effectiveness of weir and fishway modifications to improve passage times and behavior of adult salmon and steelhead through the transition pool and the entire fishway at Lower Granite Dam.

H_o: Adult salmon and steelhead passage times and behavior in junction and transition pool areas of Lower Granite Dam will not be significantly different relative to previous year's observations, taking into account interannual variation (see Objective 2) after weir modifications have been made.

Objective 2. Evaluate passage times and behavior of adult salmon and steelhead passing Little Goose Dam, with emphasis on the transition pool area, and compare to data from previous years.

H_o: Passage times and behavior of adult salmon and steelhead at Little Goose Dam will be within the range of observations made during previous years.

C.1 Sample Size.

Our final recommendation is to tag 300 fish per group at Ice Harbor Dam for monitoring at Little Goose and Lower Granite dams. We believe this sample size provides an acceptable compromise between sampling effectiveness and study costs. Below is the explanation of sample size considerations that went into this recommendation.

Numbers of fish needed to adequately describe dam passage (passage times, passage success, entrance use, etc.) varies with the complexity of the project (i.e. numbers of possible entry and passage routes) and variability in the data. In general, at relatively simple projects such as the upper three Snake River dams, a minimum of 200 fish per run is needed to provide baseline descriptions of passage behavior (i.e., proportion of fish that pass, total median passage time, etc.), ensuring that no individual fish makes up more than 0.5% of the sample. However, because telemetry monitoring (like most sampling techniques) is not 100% effective, the sample size should be increased by approximately 10% to 20%, to 220 to 240 tagged fish per run to compensate for fish that miss being detected at individual receiver/antenna sites. Snake River projects and

fishways are smaller and less complex than those on the Columbia River. In addition, fallback rates are lower, and the variability in many fish behaviors is relatively low (for example, see Table 1). Any within-season comparative studies (e.g., survival of fish that do and do not fallback, behavior of fish with and without transition pool modifications) also necessitate larger samples (approximately double) so sufficient numbers of fish will occur in each comparison group. Using power analysis, we estimate a sample of 400 fish would be needed to detect a 25% difference in performance between two treatment conditions at the alpha 0.05 level and with a power of 0.80. The estimated sample size increases to 620 fish if the detectable difference is reduced to 20%.

For the proposed study, the comparison group(s) would be fish monitored during 2007 and previous years of study, so half the estimated sample size (200 to 310 fish) per group would need to be monitored at Lower Granite Dam during 2007. Escapement between Ice Harbor and Lower Granite Dam is relatively high, averaging 97.7% for spring–summer Chinook salmon and 90.2% for adult steelhead (Keefer et al. 2005). In more recent years, escapement between the two dams has been slightly higher, about 98% for Chinook salmon and 92% for steelhead. Adjusting fish tagged by these percentages produces sample sizes of 204 to 316 Chinook salmon and 217 to 337 steelhead. As noted above, some fish may not be recorded when passing some individual receiver and antenna locations. Possible causes are that fish may swim through the detection range of an antenna between transmitter signals (typically 5 s burst rates), external electronic noise interferes with a fish's transmitter signal, or because of a malfunction in detection equipment. Because of the narrow focus of the proposed study, monitoring a relatively small group of fish at a single project, we believe boosting samples by 10% should be sufficient to offset this potential occurrence of non-detections. This equates to an estimated sample size of 226 to 351 spring–summer Chinook salmon (and a similar number for fall Chinook salmon), and 241 to 374 steelhead tagged at Ice Harbor Dam, or a total of 693 to 1,099 total fish tagged during 2007. The difference between these low and high sample sizes would produce an estimated improvement of detectable difference of 5% (from 25 to 20% minimum detectable effect). These estimates of sample size fall within the range of the number of fish used for evaluations at Lower Granite Dam during previous years, about 250 to 350 individuals per group.

Table 1. Examples of fallback percentages and complete dam passage times for radio-tagged spring–summer Chinook salmon monitored from 1996-2001, showing generally faster passage and lower fallback at Lower Snake River dams as compared to Lower Columbia River dams. (Data from Boggs et al. 2004 and Keefer et al. 2004.)

	Lower Columbia River dams				Lower Snake River dams			
	BO	TD	JD	MN	IH	LM	LGo	LGr
Percent that fell back – spring–summer Chinook salmon								
Mean	11.3%	10.9%	8.3%	6.4%	7.0%	3.6%	4.9%	2.9%
SD	*(3.8%)*	*(3.1%)*	*(3.3%)*	*(3.1%)*	*(2.9%)*	*(1.6%)*	*(2.7%)*	*(2.0%)*
Median time (d) to pass dam – spring Chinook salmon								
Mean	1.2	1.4	1.3	1.0	0.9	0.7	0.8	1.0
SD	*(0.2)*	*(0.7)*	*(0.4)*	*(0.2)*	*(0.3)*	*(0.2)*	*(0.2)*	*(0.4)*
Median time (d) to pass dam – summer Chinook salmon								
Mean	0.7	0.6	1.4	0.6	0.6	0.6	0.5	1.1
SD	*(0.0)*	*(0.0)*	*(0.5)*	*(0.1)*	*(0.2)*	*(0.1)*	*(0.1)*	*(0.4)*

C.2 Fish Collection and Tagging

Adult fish to be used for this study will be collected using a removable trap at the south shore ladder at Ice Harbor Dam. Screens will be lowered into the V-weir opening in the top pool of the ladder to guide fish through the trap box where they can be observed and selected for tagging, or allowed to continue their migration. Fish of a suitable size will be diverted from the trap box into an adjacent holding pen where they will be held until the number needed is collected. The holding pen will be lifted by crane to the top forebay deck and the fish will be drained into a transport tank on a truck or trailer. The lower 45 cm of the holding pen is constructed of sheet metal to retain water when lifted from the ladder so fish are always in water. A canvas sleeve attached to a hole in the bottom of the holding pen will be used to transfer fish from pen to transport tank. The transport tank will be filled with water from the forebay and a mild anesthetic to keep the fish calm and to prepare them for transport and tagging.

Once transported to the tagging and release area, each fish will be placed into a vinyl-coated sleeve and moved to a smaller tank filled with full-strength anesthetic where lengths, weights, and presence of marks and injuries will be recorded, and the fish will be tagged. Each fish will receive a radio transmitter inserted into the stomach through the mouth and a PIT tag injected into the abdomen, if one is not present. Tagging generally requires about 6 min per fish and the fish are anesthetized and submerged at all times except when moved between tanks and when measured for length. Fish would be transported to a boat ramp, approximately 1 km upstream from the dam. After all fish are tagged, they will be individually placed into a pen in the river to recover. Fish will be kept in the recovery pen until they swim volitionally from the pen. The holding period is to allow full recovery from anesthesia and to check for transmitter retention. Fish usually swim away from the holding pen and out of view immediately after release. No "jack" salmon will be tagged. Fish will not be tagged when water temperatures reach 72°F (22°C) according to Fish Passage Plan (FPP) protocols.

Tagging operations will occur 4 d per week, M-Th. Tag periods will coincide with the peak period when Chinook salmon or steelhead are passing Ice Harbor Dam (i.e. Figure 3). Spring–summer Chinook salmon will be tagged from mid-April through early July while fall Chinook salmon and steelhead tagging will occur during August through October. All tagging operations will be completed by noon of each day.

C.3 Telemetry Monitoring

We propose to use 3- and 7-volt transmitters that emit a digitally coded radio signal (containing the frequency and code of the transmitter) every 3 s. All transmitters are cylindrical with 43-47 cm antennas. The 7-volt transmitters weigh 29 g in air, 13 g in water (8.3 by 1.6 cm), 3-volt transmitters, used in fish 50 to 65 cm fork length, weigh 11 g in air, 4.1 g in water (1.4 by 4.3 cm). Code sets will allow us to monitor up to 523 fish on each frequency. The smaller 3 volt transmitters will be used in the smaller (“A-run”) steelhead.

Tagged fish will be released near Ice Harbor Dam and monitored as they reach and then pass Little Goose and Lower Granite dams. The final number and location of receivers and antennas used at the two dams will be similar and comparable to arrays used in previous years. Two SRX sequentially scanning receivers with yagi aerial antennas, one on each shore, will be used to determine when fish first enter the tailrace area at the dams. Digital spectrum processors (DSP) added to SRX receivers can simultaneously monitor several frequencies and will be used

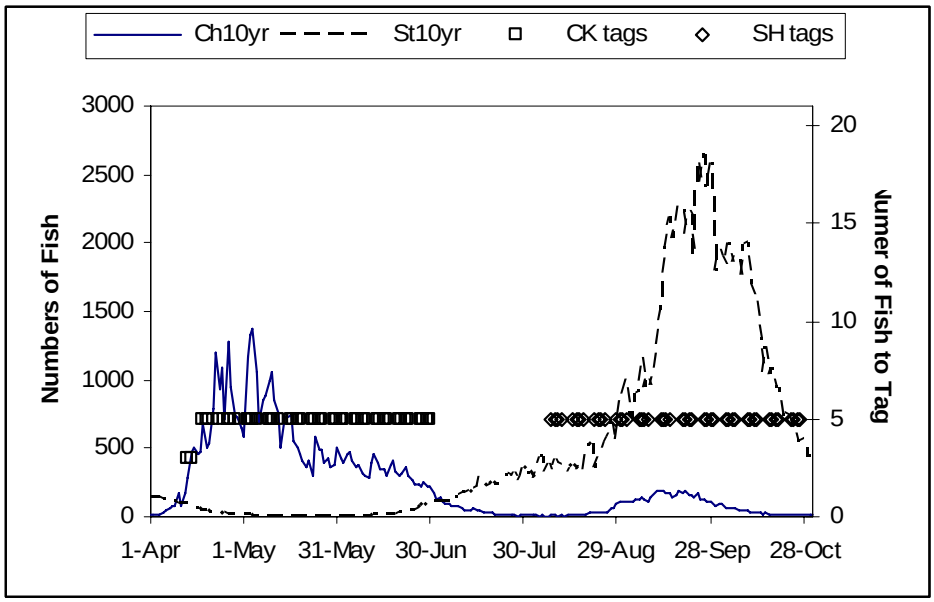

Figure 3. Proposed tag schedule for Ice Harbor Dam and ten-year average counts for adult salmon and steelhead at the dam.

with coaxial cable underwater antennas to monitor inside and outside all major fishway entrances, the junction pool, transition pool, and the fishway exit. All receivers record and store transmitter channel and code, relative power of signal, antenna receiving the signal, and date and time. Stored information will be downloaded from receivers to computers approximately every 1 to 2 days.

We will coordinate with all research groups using radio telemetry for both adult and juvenile salmon, steelhead, and other fishes to insure efficient use of the equipment and resources available. As in past years, we will coordinate use of transmitter frequencies and codes by all groups using radio telemetry in the study area to prevent duplicate use of frequencies and codes that would lead to confounded data.

Radio telemetry receivers will be maintained and returned to the manufacturer, for repairs and updates, prior to the 2007 field season. All required receivers and antennas will be installed prior to the start of tagging of spring Chinook salmon in April of 2007.

C.4 Telemetry Data Processing and Analyses

Downloaded data files will be screened to remove obvious errors and records produced from electronic background noise and then loaded to the database. Once each dataset is complete, the telemetry data will be coded. Coding involves inspection of all records for a fish and assigning a code to appropriate records that define behavior of a fish (e.g. first passage of the tailrace receiver, entrance or exit from a fishway). The initial data coding is performed using an automated program. Coded records are then manually inspected for accuracy and incorporated into the main database to be used for data analyses.

Data collected at Little Goose and Lower Granite dams during 2007 will include total time for fish to pass the dam, from first detection of fish in the tailrace until last detection of fish at top of the

ladder, and times for fish to transit each segment of the fishway: tailrace until first approach at a fishway entrance, first entry to a fishway, first entry to the junction pool, first entry to the transition pool area, first entrance into the ladder, and time to ascend the ladder (from the last exit of the transition pool until exiting the top of the ladder). Times and behavior of the fish within the junction pool and transition pool areas will also be categorized to identify the proportion of fish that transit these areas on first attempts or reverse direction of movement and exit areas one or more times before eventually passing the dam. Although similar work was performed in 2006, more than one year is required to determine interannual variability. Results from 2006 and 2007 monitoring will be compared to similar types of passage indices derived from data collected during 1996-1998 (three years for Chinook salmon and two years for steelhead) prior to the evaluations of the prototype weir modifications, and during 2000-2004 when prototype weir modifications were either fully or partially in place (the “down” and “up” panel paired treatments). Chi-square, ANOVA, and time-to-event analyses will be used to compare data from the different treatment groups. We will attempt to control for inter-annual variation in flow, temperature, and date of passage by incorporating these as covariates into analyses. Comparisons with data collected at Little Goose Dam will also allow us to account for effects of intra-annual variation on fish passage.

D. Facilities and Equipment

Radio telemetry equipment used during 2007 will be similar to that used in 2006 and previous years with updates and repairs made as required. The required number of transmitters will be ordered by USACE personnel to insure delivery by start of the 2007 field season. Computers, vehicles, and other necessary equipment will be supplied by the researchers as needed on a rental basis. Installation of new antennas and repairs to existing antennas will be made during the winter maintenance periods at the dam, and will be completed prior to commencement of tagging in spring of 2007.

E. Impacts of study on USACE projects and other activities

Division or district USACE personnel will be needed to provide technical review of research proposed for 2007.

Assistance from project personnel will be required as follows:

1. Provide electrical power supply at Little Goose and Lower Granite dams for electronic gear that will be used in the fishways and tailrace areas during 2007.
2. During the 2006-2007 fall and winter maintenance period we will inspect and repair antennas at each of the dams and will need access to the fishways.
3. Provide access to tailraces and fishways, including transition pool areas, for regular downloading of radio receivers and measurement of environmental variables during the study period.
4. Provide access to trap facility at Ice Harbor Dam for repairs and/or modifications prior to 2006 field season and for operation during sampling period.
5. Provide use of USACE fish transport truck at Ice Harbor Dam, when not needed for fish salvage operations.

It is not anticipated that work proposed here will interfere with other planned studies in the system.

Biological Effects:

Fish for studies outlined here would be collected and tagged at Ice Harbor Dam during 2007. Fish will be delayed for a period of up to several hours while they recover from effects of anesthesia.

F. Collaborative Arrangements

The research outlined here is a collaborative effort between personnel from the University of Idaho, Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU), and NOAA Fisheries. Project leaders will be responsible for preparation and submission of all project proposals and respective work plans. ICFWRU personnel will secure research permits, collect and tag adult salmon and steelhead, install, maintain, and download telemetry equipment and track gamete condition at hatcheries. NOAA personnel will maintain the telemetry databases for new and previously collected information in Seattle (Funding for stated NOAA portion of the studies provided directly through Portland District USACE). ICFWRU personnel will code the telemetry records to define movements and behavior of the fish and maintain related databases in Moscow.

G. Key Personnel

Project planning, administration, reporting:
Principle investigators, C. A. Peery
B. J. Burke, NOAA Fisheries**
Work plan preparation, protocols, computer programs, permits:
C. Peery, G. Naughton, S. Lee
Equipment specifications and purchase:
T. Dick, A. Snider
Tagging of fish
T. Dick, E. Johnson
Monitoring of receivers at dams and downloading data
T. Dick, E. Johnson, D. Joosten
Database management
B. Burke, K. Frick, NOAA Fisheries**
Data coding
M. Jepson
Analysis of data and preparation of report segments
C. Peery, C. Caudill, G. Naughton

**Costs associated with activities conducted by personnel from NOAA Fisheries in association with this research project will be covered under separate funding agreements with USACE.

H. Reporting Schedule

Information and analyses from this study will be provided regularly to managers via reports and verbal presentations. Informal progress reports will be provided bi-weekly to the USACE POC to ensure salmon passage at Lower Granite Dam is not impeded by weir modifications. Formal presentations of results will be provided at up to three meetings (SRWG, FFDRWG, etc.), as requested by the POC and oral presentations summarizing 2006 field effort will be provided at the 2006 AFEP Review. Additional information, updates, summaries, etc., will be provided for other managers as needed and when time allows.

A draft report of this study would be completed March 2007. The final report should be completed approximately 30 days following receipt of USACE review comments on the draft report, no later than by the end of May 2007.

Information that is appropriate will be published in peer-reviewed journals.

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