PRELIMINARY RESEARCH PROPOSAL (COE) (FY07)

TITLE: Evaluation of juvenile salmonid condition in McNary Dam gatewells equipped with prototype vertical barrier screens under various turbine operating conditions

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STUDY CODE: BPS-W-04-1

PROJECT DURATION: FY2004-07

SUBMISSION DATE: August 2006

PROJECT SUMMARY

This study will provide fish condition estimates for run-of-the-river yearling and subyearling Chinook salmon *Oncorhynchus tshawytscha*, sockeye salmon *O. nerka*, and steelhead *O. mykiss* captured from turbine intakes and gatewells equipped with a prototype vertical barrier screen (VBS) under different operating conditions at McNary Dam. Orifice traps in turbine units 4 and 5 (A gatewells) will be used to capture the fish. Fish will be evaluated using standard Fish Transportation Oversight Team (FTOT) criteria.

RELEVANCE

Survival of juvenile salmonids that pass through turbines of hydroelectric projects on the Columbia River has long been lower than desired. While other passage routes such as spillways and bypass systems typically result in higher survivals for juvenile salmonids, improving turbine survival can offer great benefits, especially in low flow years such as 2001. Higher turbine discharges may require modifications to the gatewell bypass system components to minimize any potential impact to juvenile salmonids exposed to more turbulent gatewell conditions. Studies at McNary Dam in 2002 (Normandeau et al. 2003) indicated that juvenile salmonid survival may not be significantly different over a range of turbine discharges. Furthermore, results from studies conducted in 2004 suggested that increases in descaling and injury rates measured during higher turbine discharges may not have been solely related to gatewell conditions (Absolon et al. 2005). Research during the 2006 outmigration addressed these issues by evaluating the gatewell environment to identify components which may have a detrimental effect on fish condition.

This proposal addresses Action Items 58, and 59 of the NMFS 2000 Biological Opinion for Operation of the Federal Columbia River Power System (NMFS 2000), and element OTS-W-04-1 of the U. S. Army Corps of Engineers (COE) Anadromous Fish Evaluation Program. This study also addresses Question 3 of the Ten Key Questions for Salmon Recovery in the NMFS Salmon Research Plan (NMFS 2002).

STUDY OBJECTIVES

We propose to monitor the condition of run-of-the-river yearling and subyearling Chinook salmon, sockeye salmon, and steelhead smolts at McNary Dam. We also propose to hold yearling

Chinook and possibly sockeye salmon for an extended period in seawater to monitor latent mortality. The fish will be captured in orifice traps attached to gatewells equipped with either a prototype rotating vertical barrier screen or the current design vertical barrier screen. Turbine operation will be either standard (62 MW) or high (80 MW) flow.

PROJECT DESCRIPTION

Objective 1: Determine the extent of descaling or obvious external injury that occurs to yearling and subyearling Chinook salmon, sockeye salmon, and steelhead when turbines are operating at high discharge levels at McNary Dam.

Results for studies conducted in 2004 and 2005 at McNary Dam, suggested that when turbines are operated at high discharge levels, descaling and/or other injury may be occurring prior to fish entering gatewells as well as within the confines of the gatewells. The extent of descaling that was measured generally ranged between 3 and 8% for yearling Chinook smolts. Comparatively, results for sockeye salmon smolts were somewhat higher (between 5 and 12%), while that of subyearling Chinook salmon smolts was lower (1 - 3%).

Descaling estimates such as those above have been used as the primary indicator for monitoring fish condition at various collector sites for nearly 30 years and, typically, have enabled researchers to selectively improve or maintain specific features at these same collector sites. A possible problem that has always been evident with this type of monitoring is the subjective nature of the data collection (different people must determine the extent of each examined fish's descaling level). This situation was somewhat mollified by the fact that in most cases a "descaled fish" was quite obvious because well over half the scales on one side of the fish were missing. But, in every sample, there are always outliers that are not easily categorized. For these reasons, descaling

estimates have always been considered to be a gross estimate of actual fish condition. They can be a reasonable method of determining where/when some type of a fish passage problem may exist, but possibly a poor method of determining the seriousness (in relation to fish health) of the problem.

Another problematic situation has also been associated with most descaling monitoring and that is the quantity of data that is usually gathered. Generally, only a few hundred fish of a given species have been collected and examined, and the samples were usually taken at specific intervals (for instance, if a new type of material was being considered for use with a fish guidance device, then data from only a few hours of operation would be used to determine if the material was acceptable). Again, this method was reasonable if the data were being used to determine where/when problems may have been occurring. However, if more specific information (the amount of latent mortality involved, for instance) is desired, this methodology alone will be inadequate. Also, every year, the juvenile salmonid outmigration at a given collector site is in a continuous state of flux, as is the river environment and species composition.

During the 2006 field season, we attempted to improve on the quantity and quality of our descaling estimates by continuously monitoring run-of-the-river smolts captured in two orifice traps at McNary Dam. Monitoring was done twice each hour, 24 hours per day, 6 days per week. The sampling took place throughout both the spring and summer juvenile salmonid outmigrations (late April until mid July). The orifice traps are attached to the south orifices in Turbine Units 4 and 5 at McNary Dam. Unit 5 was operated under the basic McNary fish passage condition, with an extended length bar screen and standard vertical barrier screen. Unit 4 was operated with an extended length bar screen, and was also equipped with the prototype rotating vertical barrier screen and a flow control device in the downstream portion of the vertical barrier screen slot.

Our basic test scenario included a control (both traps collecting fish with the turbines operating at the standard load of 62 MW), a test where turbine 5 was operated at 62MW and turbine 4 was operated at 80 MW, and another test where turbine 5 ran at 62 MW with turbine 4 at 80 MW with the flow control device deployed. Each test replicate was set up for 48 hours of continuous flow and fish monitoring.

During the spring, data for all species was collected with the primary focus on yearling Chinook salmon. Descaling data for sockeye salmon and steelhead was collected when these fish were available. The process was repeated with subyearling chinook salmon during the June - July period.

Data from the 2006 study are still in the preliminary stages of analyses and will be reported on as they are completed. Presently, we are expecting to repeat much of the same 2006 test scenario in 2007. This will essentially include monitoring passage at the higher (80 MW) operation as well as at the standard (62 MW) flow conditions.

Objective 2: Compare the long-term survival (180-day) of yearling Chinook salmon and possibly sockeye salmon smolts held in seawater between smolts exposed to bypass and gatewell conditions in turbine units equipped with prototype VBSs and operated at 80 MW and those operated under standard conditions at 62 MW.

Data collected over the past few years at McNary Dam suggested that descaling was somewhat higher for smolts collected in turbine units operated with prototype rotating VBSs at 80 MW than for those fish collected in standard turbine units operated at 62 MW. However, contemporary levels and patterns of descaling are such that detecting statistically significant differences between study groups has become difficult during individual tests, even though trend data suggest that higher descaling rates are more likely associated with fish collected from units

operated at higher discharge rates. Even so, in most instances, descaling rates for fish collected from the units operated at higher discharge are not unusually or excessively high for smolts collected at this or other dams. At the currently-observed levels of descaling, it may take a considerable effort over several years to definitively detect the relatively small differences in descaling resulting from different operational scenarios. Even then, it would not be known if these differences in descaling rates are meaningful relative to survival. Recent data from acquired from adult returns of PIT-tagged yearling Chinook salmon smolts strongly imply that contemporary levels and patterns of descaling may not negatively affect longer-term survival at all.

In the 1970s and, to a lesser extent the 1980s, salmon smolts suffered considerably more physical damage during passage and bypass at dams than they do nowadays. It was demonstrated then that fish condition in terms of descaling and injury greatly impacted short-term survival and was also presumed to negatively influence the long-term survival of salmon smolts, i.e., that overall survival rates decreased as descaling rates and injury rates increased. However, data collected from recent adult returns for yearling Chinook salmon PIT tagged at Lower Granite Dam no longer support this presumption (Marsh et al. 2000). In this study, yearling Chinook salmon smolts were recorded as descaled (10% or >of the scales missing) or not descaled (10% or < of the scales missing) at time of tagging according to FTOT criteria. Overall, 24-hour, post-tagging delayed mortality was very low, but was somewhat elevated for the fish recorded as descaled at tagging. Conversely, the smolt-to-adult-return rate (SAR) was actually somewhat higher for descaled than non-descaled smolts, suggesting that any mortality resulting from contemporary descaling incidences likely manifests itself rather quickly, and that the overall effect of this type of descaling appears to be rather minuscule on a life-cycle scale.

To determine if turbine operations at McNary Dam influence the survival of bypassed fish, we propose to sample yearling Chinook and possibly sockeye salmon smolts from orifice traps A-slot gatewells of turbine units operated at 80 MW and that contain a prototype VBS, and from A-slot gatewells of turbine units operated at 60 MW and that contain a standard VBS. Sampled fish will be anesthetized and descaling rates will be measured for each study group using FTOT criteria. Study fish will be loaded into transport containers and moved to the seawater rearing facility at Bonneville Dam where they will be ponded into the seawater holding tanks at appropriate densities.

Recently-obtained data strongly implies that truck transportation of yearling Chinook salmon smolts for 4 h is essentially a benign process (Doug Marsh, NOAA Fisheries, pers. commun., June 2005). Two groups of PIT-tagged fish (one transported by truck for 4 h and one not transport) were released into the Lower Granite Dam tailrace simultaneously and nearly daily over about a 3-week period in spring 2005. Subsequent detection rates for the two groups were identical at McNary Dam, indicating no delayed effects from 4 h of truck transport, which will be roughly the same amount of time required to transfer the test fish from McNary Dam to Bonneville Dam.

Study fish will be fed to satiation twice daily. Based on our previous experience, the daily ration will be about 2.0% of estimated fish weight. Water temperature will be maintained at 10-12°C and salinity at 29-30 ppt. Water quality parameters including temperature, oxygen, pH, salinity, total ammonia nitrogen, nitrate-nitrogen, and nitrite-nitrogen will be monitored. We will replace approximately 10% of system volume each week during the rearing period. Makeup water will be well water acquired from Little White Salmon River National Fish Hatchery. Alarm

systems will be built into the system to alert staff to a variety of conditions, including high and low water levels in various system components, temperatures outside of the desired range, and disruption of water flow.

System monitoring will include daily removal and tabulation of mortalities and notation of external fish condition. All mortalities will be preserved (frozen at -20°C) for later necropsy. Study fish will be maintained in the system until the last fish ponded have been on hand for a minimum of 180 days. Assuming all fish are ponded by the end of May 2006, the test would terminate about 1 December 2006.

SAMPLE SIZE ESTIMATION

Assuming survival probabilities follow a binomial distribution, and setting $\alpha = 0.05$ and $\beta = 0.20$, sample size (n) can be determined from the following equation:

where:

n = sample size for any treatment (sample size is set for a pairwise comparison)

p_1 = survival of the highest surviving treatment

d = detectable difference in survival between treatments.

As an example and based on results of our seawater holding study in 2002, we estimate that 60% survival will be observed for fish in the highest surviving group. Solving the above equation for $p_1 = 0.6$ and $d = 0.1$ gives a sample size requirement of 1,085 fish per treatment group. A study design that details expected differences in survival

among the study groups and the sample sizes required to detect those differences will be forthcoming in the final detailed proposal.

PROJECT IMPACTS

1. Fish handling and storage conexes will required on the McNary Dam intake deck from approximately 1 April through 31 August 2007.
2. Turbine loading will have to remain constant at the selected loading for 24 - 48 hours during the different test conditions.
3. Collection, monitoring, and fish-holding operations at McNary Dam during April through July will be coordinated with the Project Office and Smolt Monitoring Program personnel.
4. Activities related to handling fish may occur during all hours; therefore, unusual vehicle traffic and activity may occur outside normal COE duty hours during April through July.

PERMIT REQUIREMENTS

These studies will be carried out under an ESA Section 10 Permit issued to NOAA Fisheries and under any necessary state permits.

TECHNOLOGY TRANSFER

Information acquired during the proposed work will be transferred to the fisheries community by presentations at meetings and workshops, by personal contact, by annual and final reports to the U.S. Army Corps of Engineers, and through scientific publications.

KEY PERSONNEL AND DUTIES

Michael H. Gessel	Co-Principal Investigator
Dean Brege	Co-Principal Investigator
Lyle G. Gilbreath	Co-Principal Investigator
Thomas E. Ruehle	Field Coordinator
Steven G. Smith	Statistician
Benjamin P. Sandford	Statistician

REFERENCES

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