Research Pre-Proposal

EFFECTS OF DAM PASSAGE ON SURVIVAL AND REPRODUCTIVE FITNESS OF ADULT SALMON AND STEELHEAD – 2007:

Study Codes: ADS-00-13

for

U. S. Army Corps of Engineers - Portland District

Project Leaders:

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For the period: 1 January 2007 to 31 December 2007

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Project Summary

A. Goal

The study plan outlined here investigates factors that effect success of adult salmon and steelhead migrants for the Anadromous Fish Evaluation Program proposed to the Portland District, U.S. Army Corps of Engineers (USACE). Work proposed for 2007 investigate the relation between passage through the FCRPS and potential delayed effects on adult salmon and steelhead survival and reproductive fitness.

B. Primary Objective – Year 2007

1. Evaluate potential effects of different upstream migratory passage histories, tributary conditions, and ocean conditions on survival and reproductive fitness of known source fish. (ADS-00-13).

C. Methods

In 2007, we propose to use returning PIT-tagged summer Chinook salmon from the South Fork Salmon River (McCall Hatchery) to relate passage through the hydrosystem, as determined from PIT and telemetry monitoring, and energetic condition to migration and spawning success. Energetic condition at the start and completion of migration would be categorized using non-lethal measures of morphometrics and lipid content we have previously developed. Study fish will also be outfitted with temperature recorders to characterize temperature exposures while migrating through and upstream of the FCRPS. Migration and spawning success would be determined by inspecting individual carcasses of study fish during serial surveys of spawning areas of the South Fork Salmon River. This would be the third year of monitoring the SFSR Chinook population using known-source fish PIT tagged as juveniles for this purpose. For 2007, we propose to monitor additional populations: one fall Chinook salmon population, those that spawn in the mainstem Clearwater River, and at least one spring Chinook salmon population from the Grande Ronde, Imnaha, and Tucannon rivers. These additional populations would be monitored in partnership with the Nez Perce Fisheries biologists and their partners.

D. Relevance

Research proposed herein addresses priority research areas related to improving passage and survival of adult salmonids identified by the U.S. Army Corps of Engineers, fish agencies, and NOAA Fisheries in the Federal Columbia River Power System Biological Opinion related to recovery of threatened and endangered Columbia and Snake River salmon and steelhead. Recovery goals established for ESA-listed populations, such as Snake River Chinook salmon and steelhead, by NOAA Fisheries depend on accurate knowledge of escapement and reproductive success of naturally spawning fish (RPA 107), including that of naturally spawning hatchery fish (RPAs 182 and 184) and potential delayed effects from transit of the FCRPS that could cause prespawn mortality (RPA 118) (NMFS 2000). This information is largely lacking.

Project Description

A. Background

Adult salmon and steelhead migrating to their natal streams in tributaries of the Columbia River must pass up to nine dams and associated reservoirs, four each in the lower Columbia and Snake rivers and five in the mid Columbia River (Figure 1). Stress, delay, and mortality during migration at each hydroelectric project and associated reservoir must be minimized to succeed in maintaining native fish runs and to achieve the recovery goals outlined by the Northwest Power Planning Council (NWPPC) and by NOAA Fisheries. It is also important to account for other factors that may affect reproductive success of listed populations, such as fish condition, which may be related to ocean productivity, mainstem and tributary temperatures, and density effects.

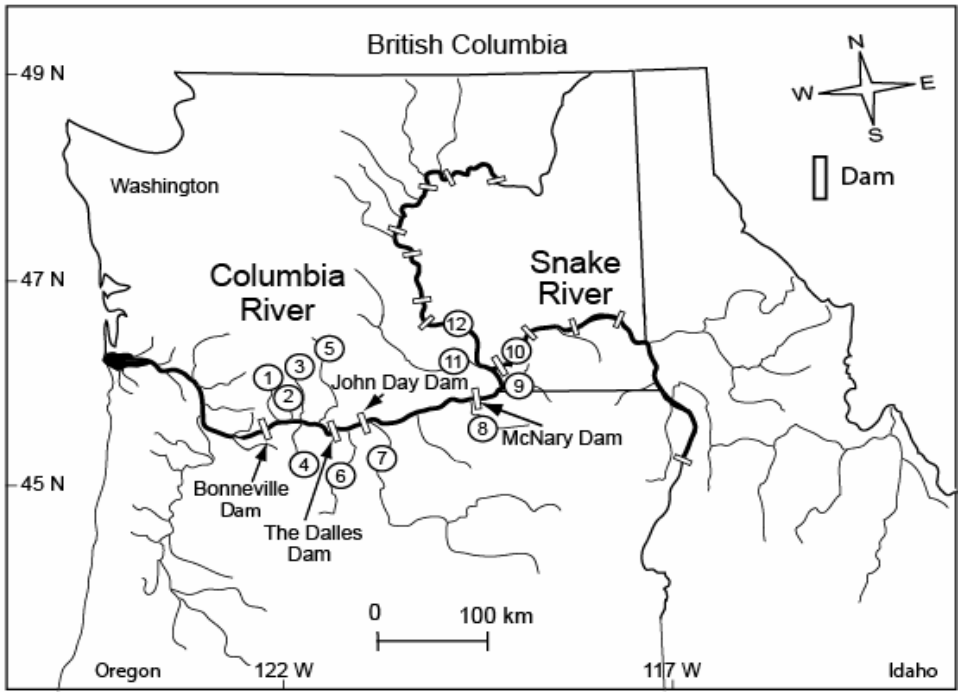

Figure 1. Columbia River basin, including mainstem dams and major tributary basins.

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 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 proposal has been developed in consultation with personnel from the USACE.

During 2002 and 2003, we developed procedures to non-lethally estimate energy reserves and evaluate spawning success of adult Chinook salmon returning to the South Fork Salmon River. We found that a model using several morphometric measures estimated lipid and energy content with reasonable accuracy (R^2 = 0.90). In 2005, we explored the use of a lipid meter to estimate fish energy condition. Results appear promising to use this method, along with a few body measures

(fork length and weight), to characterize lipid levels of live fish with limited handling.

With the cooperation of Idaho Department of Fish and Game, juveniles from the South Fork Chinook salmon stock reared at McCall Hatchery, ID, were PIT-tagged during the springs of 2003, 2004, and 2005 for this evaluation. Spawning success on the SFSR has ranged from 29% to 75% of carcasses inspected. For 2006, we were able to sample 32 SFSR at Bonneville Dam and ten additional fish were purchased from Tribal fisherman for tissue proximate analyses. We are currently surveying SFSR fish at spawning areas. In 2007, we propose the third and final year of SFSR fish PIT-tagged as juveniles for this evaluation and to initiate coordinated sampling at Bonneville Dam and in spawning areas for Snake River spring and fall Chinook salmon.

B. Specific Objectives for 2007:

1. Evaluate potential effects of different upstream migratory passage histories, tributary conditions, and ocean conditions on survival and reproductive fitness of known source fish. (ADS-00-13).

   1a. Monitor initial condition of known source Chinook salmon and steelhead stocks (includes South Fork Salmon River summer Chinook salmon) and relate to passage success as determined from PIT detections through the FCRPS. (Includes outfitting select fish with temperature recorders and radio transmitters if available.)

   1b. Conduct intensive spawner/carcass surveys in South Fork Salmon River to evaluate final energy condition, spawner success, temperature exposures, and in-river conditions (i.e. temperatures, spawner density).

   1c. Coordinate with other State, Federal and Tribal agencies to standardize spawner/carcass surveys at other locations to develop comparable information for Snake River spring and fall Chinook salmon populations.

C. Methods

Objective 1. Evaluate potential effects of different upstream migratory passage histories, tributary conditions, and ocean conditions on survival and reproductive fitness of known source fish. (ADS-00-13).

This objective relates to RPA 107 (survival and reproductive success, energy expenditure) and 118 (pre-spawning mortality) listed in Section 9.6.1 of the 'Hydrosystem' Biological Opinion released by NMFS, December 2000.

For 2007, we propose to collect a sample of returning adult Chinook salmon at Bonneville Dam, gather morphometric and energy reserves data, and then monitor migrations and resample adults at Lower Granite Dam and on spawning grounds. Carcasses located in spawning areas will be inspected to determine spawning state and measured for final energetic condition. Information on initial and final energetic conditions, migration history, ocean conditions, and mainstem and tributary water temperatures salmon encountered will be related to migration and spawning success for these sample populations using logistic regression, ANCOVA, and simulation models. Use of

this designated group of fish will aid evaluation of relationships between migration history through the Federal hydrosystem, ocean and river conditions, energy use, and reproductive success.

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Fish to be used for this objective will be collected at Bonneville Dam for initial sampling. Fish will be selected based on existing PIT tags, received when fish were juveniles, using the sort-by-code procedure at the adult fish facility (AFF). Variables of interest are ocean condition indices, such as the Pacific Decadal Oscillation (PDO), initial energy content, migration history, and temperature exposures as adult migrants transit the FCRPS. In 2002-2004, we collected Chinook salmon at Bonneville Dam and from spawning grounds in the Salmon River for proximate tissue analysis to develop a non-lethal measure of energy content and use. From those analyses we found that a combination of body metrics (length, weight, and two depth measures) was correlated with total lipid content ($r^2 > 0.8$). During 2006, we investigated use of a lipid meter (Hendry and Beall 2004; Crossin and Hinch, 2005), as another non-lethal means to estimate muscle lipid content. Temperature exposures are determined by outfitting fish with archival thermistors that record and store hourly temperatures. Temperature recorders can be mounted externally using surgical sutures or internally using gastric insertion (Figure 1).

Figure 1. Gastric (left, threaded on antenna of radio transmitter) and external (right) mounts for archival temperature recorders used to record thermal history of adult salmon migrants.

Fish with PIT tags can currently be detected at Bonneville, McNary, Ice Harbor and Lower Granite dams. Detections at these four locations can be used to determine time to transit most of the FCRPS (between tops of ladders at Bonneville and Lower Granite dams). Also it is possible to infer fallback events at these four projects using multiple detection records as fish reascend ladders (Burke and Jepson *In press*). Ideally, more detailed migration histories can be

determined by outfitting sample fish with radio transmitters, which can provide information concerning delays below dams, passage at tops of most ladders, and locations once fish reach spawning areas using remote receiver sites. Transmitters also increase the chance that individual fish can be re-located in spawning areas so that final conditions and spawning success can be determined for a larger sample size (see sub-objectives 1b and 1c). In the past we have been able to re-use transmitters from previous studies that were returned to us from fishermen, hatcheries, and agencies conducting spawner surveys. We will attempt to do so again in 2007 if transmitters with sufficient battery life are available. Initial energy condition, sample date, fish size, population of origin and rearing history (hatchery, natural) will be related to migration success through FCRPS (from PIT or RT records) using logistic regression analyses. Using data from multiple years, we will also correlate migration success with several indices of ocean conditions.

During 2007, we propose to sample spring Chinook salmon from the Grande Ronde and Imnaha rives, and possibly the Tucannon River, summer Chinook salmon from the South Fork Salmon River, and fall Chinook salmon returning to the Clearwater River (140,000 PIT-tagged juveniles), all populations from the Snake River upstream from Lower Granite Dam. We are also exploring the potential to add a steelhead population to the evaluation. Each year from 2003 to 2005, 20,000 McCall Hatchery Chinook salmon juveniles were PIT tagged for use in future adult studies. These fish were added to the approximately 50,000 juveniles PIT tagged for the Comparative Survival Studies (CSS). During 2005 and 2006, the first group of PIT-tagged South Fork Salmon River (SFSR) salmon returned and were sampled at Bonneville Dam. Most fish returning as adults in 2007 will have spent two years rearing in the ocean (2005 release), although a portion of the run will be three-ocean fish (2004 release). Spring (about 48,000 PIT-tagged juveniles from Grande Ronde and Imnaha rivers) and fall (over 140,000 PIT-tagged) Chinook salmon to be sampled were originally PIT tagged for hatchery evaluations and transport studies. Sampling of these fish during 2007 will be a trial evaluation to determine the feasibility of collecting migration and spawner success information. PIT codes would be added to the sort-by-code procedure at Bonneville Dam so that target fish can be diverted for sampling. Each diverted fish will be weighed, measured for length and two depths, and for lipid content using the lipid meter. A thermograph will be externally mounted to each fish at the base of the dorsal fin. All sampled fish will be released back to the ladder to continue their migration. Similar sampling can be conducted at Lower Granite Dam to obtain condition near the end of each fish's passage of the hydrosystem and to retrieve thermographs.

1b. Conduct intensive spawner/carcass surveys in South Fork Salmon River to evaluate final energy condition, spawner success, temperature exposures and in-river conditions (temperatures, spawner density).

On the South Fork Salmon River, serial surveys would be made of spawning areas. Fish that are collected at the South Fork Weir will be sampled and tagged with a Floy tag then released back to the river to spawn. Each carcass encountered and fish collected at the South Fork weir will be scanned for PIT tags. Fish with PIT and Floy tags will be sampled again as described above to measure terminal energetic condition and inspected for spawning success.

Water temperature exposure histories for each fish will be determined from thermographs. Degree days that exceeded 20ºC will be used as an index of thermal exposure. Temperature data will be augmented with mainstem Columbia and Snake River temperatures available from

water quality monitoring stations operated by the USACE and from temperature recorders placed in the South Fork Salmon River near key spawning and holding areas. Information on initial and final energetic conditions, migration history, and mainstem and tributary water temperatures will be related to migration and spawning success for this sample population using logistic regression, ANCOVA, and simulation models.

1c. Coordinate with other State, Federal and Tribal agencies to standardize spawner/carcass surveys at other locations to develop comparable information for Snake River spring and fall Chinook salmon populations.

Studies of the nature described have been focused exclusively on the SFSR summer Chinook salmon stock to date. While a valuable data set is being developed from this effort, its utility is limited without the replication that would allow results to be put in context for the larger salmonid meta-population management units. In discussions with regional fisheries researchers, we have identified other Chinook salmon populations that have the potential to provide ecological comparisons with the SFSR Chinook salmon. Working primarily with the Nez Perce Tribal Fisheries, but also their partners (USFWS, ODFW, WDFW), we propose to augment ongoing sampling efforts to develop comparable data sets on migration success, spawner success, and energy use for Chinook salmon returning to the Grande Ronde, Imnaha, and Clearwater rivers. We are also currently exploring the potential to sample at least one steelhead population in Idaho. UI and Nez Perce personnel will coordinate survey methods, as described above, to intensively survey spawning areas to determine final energy and spawner condition of all carcasses encountered. All fish will be scanned for PIT tags and any radio and temperature recorders will be retrieved. Analyses as described in sub-objective 1b will be used here.

D. Facilities and Equipment

Computers, vehicles, and sampling equipment will be supplied by the researchers as needed on a rental basis.

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 2006.

Assistance from project personnel will be required to provide access to the AFF lab adjacent to the Washington-shore ladder at Bonneville Dam to collect fish for sampling. We will coordinate use of AFF lab with USACE personnel and personnel from other agencies working in the facility during 2007. We will develop sort-by code datasets and provide to PSMFC personnel to implement in the AFF computer prior to the sampling season.

We will coordinate with other researchers using radio telemetry to avoid duplicate use of frequencies and codes in transmitters.

Biological Effects:

Sampling of fish at Bonneville Dam in 2007 will follow similar procedures used in 2006;

collection will take place 7 d per week, May through July. Fish will be diverted from the fishway into the AFF, selected for sampling using the sort-by-code procedure, anesthetized, measured, fitted with temperature recorders and radio transmitters (if available), and released into a recovery area from which fish can voluntarily leave. Tagged fish will then be able to swim a short distance through the bypass ladder to re-join the Washington-shore ladder upstream from the AFF. During previous research radio-tagging adult salmon at Bonneville Dam, we have documented less than 0.09% mortality resulting from tagging operations. The indirect effect on salmon from tagging is a 3-4 hr delay for fish to recover from anesthesia and return to the main fishway at Bonneville Dam. During July, when temperatures can exceed 20ºC, we will add ice (river water) to the anesthetic and tagging tanks to keep temperatures near or below 20ºC. Tagging will be limited to 4 d per week when water temperatures exceed 21.1°C and tagging will be halted when water temperatures exceed 22.2º C. All State and Federal permits will be acquired prior to sampling. All fish sampled will be from a listed ESU from the Snake River.

F. Collaborative Arrangements and or Sub-contracts

The adult passage research outlined here is a collaborative effort between personnel from University of Idaho, Idaho Cooperative Fish and Wildlife Research Unit (ICFWRU) and NOAA Fisheries and in cooperation with Nez Perce Tribe Fisheries. Project leaders will be responsible for preparation and submission of project proposals and respective work plans. NOAA Fisheries will continue to maintain databases of telemetry data developed during 1996-2006 field seasons. ICFWRU would be responsible for obtaining permits and sample fish at Bonneville and Lower Granite dams and on the South Fork Salmon River and final reporting for this objective.

Key Personnel

Project planning, administration, final reporting:
Principle investigators, C. Peery, ICFWRU
B. Burke, NOAA Fisheries
Work plan preparation, protocols, computer programs, permits:
C. Peery, C. Caudill, S. Lee, M. Jepson, B. Daigle, ICFWRU, B. Burke, K. Frick, NOAA Fisheries
Equipment and supplies specifications and purchase:
S. Lee, ICFWRU
Fish sampling and spawning ground surveys;
S. Lee, C. Anderson ICFWRU
Maintenance of past telemetry databases and updates to data access website.
B. Burke, K. Frick, M. Jepson
Analysis of data and preparation of report segments and presentations
C. Peery, G. Naughton, C. Caudill, ICFWRU, B. Burke, K. Frick, NOAA Fisheries

Technology Transfer

Information and analyses from this study will be provided regularly to managers via final reports and verbal presentations. Information would be used to determine if there are delayed effects from passing through the hydrosystem that affects salmon reproductive potential. Information that is appropriate will be published in technical journals. Special efforts will be made to provide information for managers as requested.

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