RESEARCH PROPOSAL (FY05)

TITLE: A study to compare SARs of inriver migrating versus transported Columbia River anadromous salmonids

PROJECT LEADERS:
Douglas M. Marsh
National Marine Fisheries Service
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Boulevard East
Seattle, Washington 98112
(206) 860-3251

ADMINISTRATIVE:
Kurt Gores
National Marine Fisheries Service
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Boulevard East
Seattle, Washington 98112
(206) 860-3270

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PROJECT SUMMARY

The goal of this project is to provide statistically valid information on the smolt-to-adult return rates (SAR) of Columbia River anadromous salmonids that migrate inriver compared to those transported around dams of the Federal Columbia River Power System (FCRPS). We propose to evaluate transportation of hatchery-reared yearling chinook salmon (*Oncorhynchus tshawytscha*) and hatchery-reared steelhead (*O. mykiss*) and subyearling chinook salmon at McNary Dam on the Columbia River.

Evaluations of transportation from McNary Dam were delayed until adult PIT-tag detectors became operational in the fish ladders at the dam, which occurred in 2002. Beginning in summer 2001, we PIT-tagged subyearling chinook salmon to begin an evaluation of transportation of these fish from McNary Dam which continued in 2002. In 2005, we will continue to collect adult returns from these tagging years. We also propose to continue an evaluation of transportation vs. full-flow bypass at McNary Dam begun in 2003 using hatchery-reared steelhead PIT tagged and released from Columbia River hatcheries located upstream from McNary Dam. Similar to the subyearling chinook salmon evaluation on the Snake River, transport and full-flow-bypass study groups will be established as the fish migrate downstream through McNary Dam. We will continue the collection of adult returns from study years 2002-2004.

Research proposed here was called for specifically in Action Items 45, 46, and 47 of Section 9.6.1.3, Action Item 185 of Section 9.6.5.3.5.1, and Action Item 53 of Section 9.6.1.3.4 of the 2000 FCRPS Biological Opinion. Analyses of data based on this research and research conducted under various other contracts will provide critical information to compare overall SARs of transported and inriver-migrating or bypassed anadromous salmonids, to examine potential seasonal effects of transportation, to evaluate the effects of transportation on homing of adults, and to estimate differential delayed mortality ("D") of transported fish. The studies will be conducted using state-of-the-art facilities and technologies and under environmental conditions known to provide as favorable inriver passage conditions as possible through the FCRPS as it is currently configured and operated.

BACKGROUND

Research to evaluate the effects of transporting juvenile salmonids around dams began over 30 years ago. Evaluation of transportation of yearling chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) was conducted from various Snake River dams from 1968 through 1980. In addition, transportation of subyearling chinook salmon and steelhead was evaluated at McNary Dam on the Columbia River from 1978 through 1983.

From these early studies, the apparent benefits of transportation varied by species. For subyearling chinook salmon and steelhead, results consistently showed that more marked/transported fish returned to the point of release than did marked fish released to migrate inriver. However, for yearling chinook salmon, study results were less consistent. Results from the earliest studies, during 1968-73, demonstrated conclusively that significantly more marked fish that were transported returned to the point of marking than did marked fish released to migrate inriver (Ebel et al. 1973, Slatick et al. 1975, Ebel 1980). However, studies conducted between 1976 and 1980 yielded inconclusive results because very low numbers of marked adults returned from either group (Park 1985).

Matthews (1992) postulated that severe physical traumas suffered by many smolts during collection and marking were a primary cause of low returns of yearling chinook salmon adults during the 1976-80 studies. From 1981 through 1984, the COE and fisheries agencies addressed this problem by modifying or otherwise improving many features of the smolt collection and bypass systems at dams, particularly at Lower Granite Dam. Moreover, the preanesthetic system of handling and marking smolts (Matthews et al. 1997) was introduced at Lower Granite Dam in 1983. This system eliminated much of the major physical traumas associated with the handling and marking process. All indications suggest that the modifications and improvements increased survival substantially.

A study to re-evaluate smolt transportation of yearling chinook salmon and steelhead migrants from the Snake River, after the substantial modifications to collection and bypass facilities were made, was initiated at Lower Granite Dam in 1986. Yearling chinook salmon and steelhead smolts were marked in 1986 and 1989 at Lower Granite Dam. Approximately one-half of the smolts were placed in barges at Lower Granite Dam and released below Bonneville Dam. The remainder

were trucked to a release site downstream from Little Goose Dam to continue their inriver migration. Although significantly more marked adults of both species returned from those fish barged compared to fish that migrated inriver, concern was raised that the studies were flawed because the inriver migrating fish were transported to below Little Goose Dam (Ward et al. 1997). Further, inriver conditions were not considered optimal for the survival of inriver migrating fish; therefore, potential benefits to inriver fish were not evaluated.

In 1994, a new smolt collection and transportation facility became operational at McNary Dam. Without adult PIT-tag detectors at lower river dams, little transportation research with PIT-tagged fish was conducted from this new facility. However, in 2002, the adult fishways at Bonneville and McNary Dams were equipped with PIT-tag interrogation systems. We, therefore, began transport evaluations with PIT-tagged anadromous salmonid juveniles migrating through McNary Dam beginning in summer 2001 and continuing in summer 2002. For 2005, we will continue collecting returning adults from these two marking years. In 2002, we began a study of spring transportation at McNary Dam using yearling chinook salmon PIT-tagged at Columbia River hatcheries upstream from the dam to specifically compare the return of transported smolts to the return of fish returned to the river via the new full-flow-bypass pipe at McNary Dam. In 2003, this study was expanded to include steelhead marked at Columbia River hatcheries above McNary Dam. We propose to continue this study with steelhead in 2005. Also in 2005, we will continue collecting returning adults from the 2002-2004 marking years.

These evaluations will provide new data to assess inriver migration and transportation as means to increase adult returns of anadromous salmonids to the Columbia River. Results will also be compared to concurrent, inriver-smolt-survival estimates using the Single-Release Model (Iwamoto

et al. 1994). These combinations of studies will provide the basis for estimating "D" values for the various groups of transported fish.

APPROACH

Objective 1

Compare SARs of yearling chinook salmon and steelhead PIT tagged and released from hatcheries in the Columbia River upstream from and subsequently transported from McNary Dam to below Bonneville Dam with the SARs of the same fish collected and returned to the tailrace of the dam via the full-flow-bypass pipe, and with the SARs of the same fish that passed McNary Dam without being detected.

Even though several, multi-species transportation studies were conducted from the dam from the late 1970s through the late 1980s, the tests were conducted under conditions that no longer exist. New transportation studies are needed to ensure that correct decisions are being made concerning listed anadromous salmonids of the Columbia River. In 2002, a new study of hatchery yearling spring chinook salmon transportation from McNary Dam was begun using modern technologies and conducted under contemporary conditions. In 2003, hatchery steelhead were added to the study.

Currently, spring-migrating smolts are not transported from McNary Dam. For fish collected at the dam, there are only two primary options--transport them to below Bonneville Dam or bypass the raceway system completely by returning them to the river through the full-flow-bypass pipe which is now equipped with a PIT-tag detection system. In 2003 and 2004, to determine whether smolts collected at the dam should be transported or returned to the river via the full-flow pipe,

smolts were PIT-tagged upstream from the dam. For those fish collected at McNary Dam, transportation or return to the river was conducted on an every-other-day basis.

Studies have shown that steelhead collection at McNary Dam is very low, ranging from 15 to 19%. In 2003, collection of hatchery steelhead PIT-tagged for this study was only 6.3%. Because of this, the number of steelhead smolts collected for both transportation and bypass were far less than expected (only 55.0% and 58.2%, respectively). It is not known whether this was a one-time occurrence, or an average collection efficiency for upper-Columbia River steelhead. For 2005, we propose to continue the study as developed for 2003.

Task 1.1:

PIT tag and release yearling steelhead in Columbia River hatcheries upstream from McNary Dam to establish transport and full-flow-bypass test groups at the dam in 2005.

Transport and full-flow-bypass will occur on an alternating-day basis as the fish pass through McNary Dam.

Sample Size Calculations

Sample size calculations for a transport study using transport SARs relative to inriver SARs can be based on determining precision around the estimated T/I such that the ½ width of a confidence interval on the true T/I will not contain the value 1, or the confidence interval on the true natural-log-transformed T/I, LN(T/I), will not contain 0. Therefore, for a desired α and β and specified true T/I, the number of fish needed can be determined in the following manner.

T/I is needed such that:

$$LN(T/I) - (t_{\alpha/2} + t_{\beta})*SE(LN(T/I)) \approx 0$$

and SE(LN(T/I)) $\approx$SQRT($1/n_T + 1/n_I$) = SQRT(2/n), where $n_T = n_I = n$ is the number of adult returns per treatment (n for transport and inriver groups set equal for simplicity). The previous two statements imply that the sample of adults needed is:

$$n \approx 2*(t_{\alpha/2} + t_{\beta})^2 / [LN(T/I)]^2.$$

Setting $\alpha = 0.05$, $\beta = 0.20$ and an expected transport SAR of at least 2.0% for each of the three demes, sample sizes needed to detect a 1.2 transport to full-flow-bypass ratio (T/B) at McNary Dam are listed below (N denotes the number of juveniles):

T/B	n	N_T	N_B (=N_T*T/B)	N_{total}
1.2	473	23,650	28,380	52,030

The above numbers are what is required at McNary Dam. Releasing tagged fish from hatcheries upstream from the dam will require increasing the numbers of fish tagged to provide sufficient numbers collected for transport and bypass at the dam. Since survival from the hatcheries to the dam and collection efficiencies at the dam differ among the three populations of fish, the numbers required for tagging at the hatcheries will also differ. To account for these differences, we examined the estimated survival to the dam and detection probabilities for the three populations of hatchery fish released previously in the Columbia River above McNary Dam.

In one study, PIT-tagged hatchery steelhead smolts were released into the Wells Dam tailrace between 24 April and 16 May 2000. The fish passed McNary Dam primarily in May when the percentage of water spilled was fairly steady at 40% of the total river flow. Survival of these fish to McNary Dam was 0.578 (s.e. 0.016) and the detection probability at the dam was 0.170 (s.e.0.006).

Using these values, roughly 480,000 (52,030/0.578/0.170) PIT-tagged hatchery steelhead would be required from this area to satisfy the study design.

We propose to tag fish of each population at several hatcheries upstream from McNary Dam and in numbers roughly proportional to each hatchery's contribution to the total number of fish released.

The following table provides numbers of fish proposed for tagging at each hatchery:

Population	Hatchery	Number tagged
Steelhead	Wells	240,000
	Eastbank complex	95,000
	Priest Rapids/Ringold	95,000
	Winthrop	50,000
		480,000

Task 1.2:

Recover adult yearling chinook salmon and steelhead previously PIT tagged at Columbia River hatcheries and either transported from McNary Dam or returned to the river through the full-flow-bypass pipe and analyze these data.

Adult PIT-tag detection systems located in the Bonneville and McNary Dam fish ladders will serve as the principal recovery sites for adults returning to the Columbia River. Data from the adult PIT-tag detection systems in the Ice Harbor, Rock Island, and Wells Dams fish ladders will also be monitored as will returns to hatcheries. To analyze results, statistical tests will be applied when adult returns for the study are complete. Confidence intervals for the T/B will be calculated using the ratio (survival) estimate (Burnham et al. 1987) and its associated empirical variance. The study will produce overall, statistically-bound T/B estimates for tagged hatchery fish returning to the Columbia River. We will also estimate differential delayed transport mortality by comparing T/B to an

independent estimate of inriver survival to below Bonneville Dam based on the Single-Release Model. Because the origin of tagged fish will be known, detections of returning adults as they pass upstream through the dams to the hatcheries will also provide data to compare homing characteristics of transported and inriver-migrating study fish.

Task 1.3:

Examine PIT-tag detection histories of adults as they migrate upstream through the hydropower system.

Currently, Bonneville, McNary, Ice Harbor, Priest Rapids, Rock Island and Wells Dams are equipped with adult PIT-tag detection systems and detection systems are planned for installation in other dams in the future. At these dams, all PIT-tagged fish passing through the fish ladders are susceptible to detection. Similar systems are also in place at certain hatcheries in the Columbia River Basin.

To evaluate the potential for transportation as juveniles to influence the homing characteristics of returning adults, we will compare the PIT-tag detection histories of transported and non-transported adult study fish as they pass upstream through the appropriate PIT-tag detection systems within the Basin.

Objective 2

Compare SARs of subyearling chinook salmon juveniles PIT tagged and transported from McNary Dam to below Bonneville Dam with the SARs of inriver migrating juveniles of these species PIT tagged at the dam and released into the tailrace.

For yearling chinook salmon and steelhead, the great majority of smolts passing McNary Dam originate in hatcheries upstream of the dam. Therefore, a tagging scheme to evaluate

transportation that relies on tagging fish in hatcheries above the dam will represent the great majority of the actual population of fish arriving at the dam. The same is not true for subyearling chinook salmon. The majority of these fish are products of natural spawning in the Hanford Reach and further upstream. Additionally, these wild fish have a later timing distribution at the dam than do the hatchery-reared fish. To provide a holistic approach to evaluating transportation of subyearling chinook salmon from McNary Dam, we believe it would be wise to PIT tag a group that actually represents the majority of the population arriving at the dam. To this end, we PIT-tagged subyearling chinook salmon at McNary Dam during summer 2001and 2002. Adults from these marking years will continue returning through 2006 and 2007, respectively.

Task 2.1:

Recover adult subyearling chinook salmon previously PIT tagged at McNary Dam and analyze adult return data.

Adult PIT-tag detection systems located in the fish ladders of Bonneville and/or McNary Dams will serve as the principal recovery sites for adults. Data acquired from other areas will be considered ancillary. To analyze results, statistical tests will be applied when adult returns for the study are complete. Confidence intervals for the T/I will be calculated using the ratio (survival) estimate (Burnham et al. 1987) and its associated empirical variance. The study will produce an overall, statistically-bound T/I estimate for tagged fish returning to the Columbia River. Additionally, we will compare the T/I to an estimate of inriver survival to below Bonneville Dam based on the Single-Release Model.

Task 2.2:

Examine PIT-tag detection histories of adults as they migrate upstream through the hydropower system.

Currently, Bonneville, McNary, Priest Rapids, Rock Island, Wells, Ice Harbor, and Lower Granite Dams are equipped with adult PIT-tag detection systems and detection systems are planned for installation in other dams in the future. At these dams, all PIT-tagged fish passing through the

fish ladders are susceptible to detection. Similar systems are also in place at certain hatcheries in the Columbia River Basin.

To evaluate the potential for transportation as juveniles to influence the homing characteristics of returning adults, we will compare the PIT-tag detection histories of transported and non-transported adult study fish as they pass upstream through the appropriate PIT-tag detection systems within the Basin.

FISH REQUIREMENTS FOR FY 2005

Columbia River Hatcheries

The COE will contract the PIT-tagging of 480,000 steelhead in Columbia River hatcheries upstream from McNary Dam in 2004-2005.

SCHEDULES

Activity	Time FY04	Outyears
Task 1.1		
Smolt marking and release	April-Aug	Same
Task 1.2		
Adult recovery	March-Dec	Same
Task 2.1		
Adult recovery	Aug-Dec	Same

PROJECT IMPACTS, FACILITIES, AND EQUIPMENT

None

PROJECT PERSONNEL AND DUTIES

1. Douglas M. Marsh--biologist and co-principal investigator working on Objectives 1-2.
2. Steven Smith–statistician working on Objectives 1-2.
3. Benjamin Sandford–statistician working on Objectives 1-2.

TECHNOLOGY TRANSFER

Technology transfer will be in the form of written and oral research reports as required. A draft report for spring chinook salmon will be provided to the COE by 15 November each year, with a final report provided by 15 March the following spring. A draft report for fall chinook salmon and steelhead will be provided to the COE by 15 August each year, with a final report provided by 15 December. In this way, complete returns for each age class of adults can be included in the final report for each study year. Results will also be published in appropriate scientific journals.

CITATIONS

Ebel, W. J. 1980. Transportation of chinook salmon, *Oncorhynchus tshawytscha*, and steelhead, *Salmo gairdneri*, smolts in the Columbia River and effects on adult returns. Fish. Bull. 78:491-505.

Ebel, W. J., D. L. Park, and R. C. Johnsen. 1973. Effects of transportation on survival and homing of Snake River chinook salmon and steelhead trout. Fish. Bull. 71:549-563.

Iwamoto, R. N., W. D. Muir, B. P. Sandford, K. W. McIntyre, D. A. Frost, J. G. Williams, S. G. Smith, and J. R. Skalski. 1994. Survival estimates for the passage of juvenile chinook salmon through Snake River dams and reservoirs. Annual research report to the Bonneville Power Administration, Project 93-29, Contract DE-A179-93BP10891. 140 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112-2097).

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Matthews, G. M., N. N. Paasch, S. Achord, K. W. McIntyre, and J. R. Harmon. 1997. A technique to minimize the adverse effects associated with handling and marking salmonid smolts. Prog. Fish Cult. 59:307-309.

Park, D. L. 1985. A review of smolt transportation to bypass dams on the Snake and Columbia Rivers. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 66 p. (Available from Northwest Fisheries Center, 2725 Montlake Blvd. E., Seattle, Washington 98112-2097.)

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Ward, D. L., R. R. Boyce, F. R. Young, and F. E. Olney. 1997. A review and assessment of transportation studies for juvenile chinook salmon in the Snake River. North American Journal of Fisheries Management 17:652-662.