

SH153
.Un5511
2002

Post-construction evaluation of the modified PIT-tag diversion system at Lower Granite Dam, 2001

***Fish Ecology
Division***

***Northwest Fisheries
Science Center***

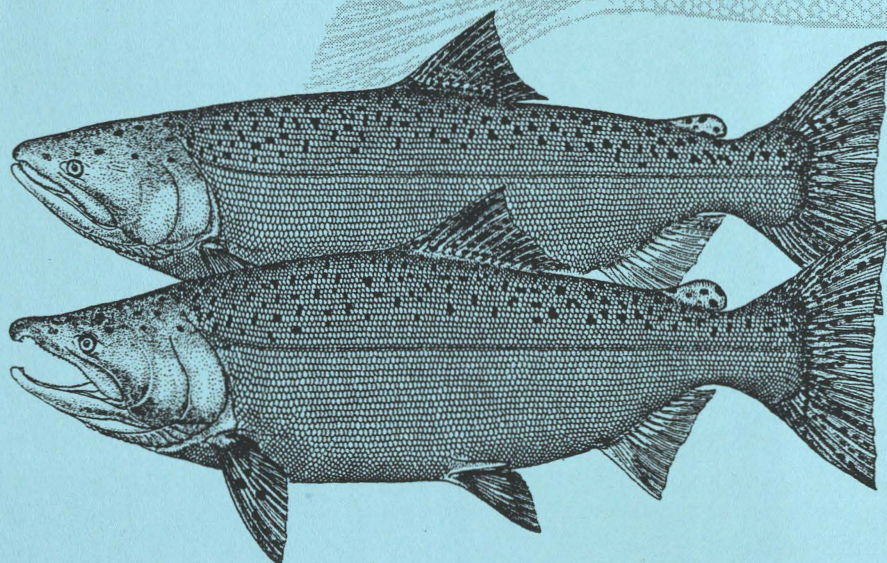
***National Marine
Fisheries Service***

Seattle, Washington

by
Eric E. Hockersmith, Benjamin P. Sandford,
and Douglas B. Dey

December 2002

Library
Northwest Fisheries Science Center
2725 Montlake Blvd. E.
Seattle, WA 98112



~~NWFS 151~~
SH
153
. Un 5511
2002

**Post-Construction Evaluation of the Modified PIT-Tag Diversion System
at Lower Granite Dam, 2001**

Eric E. Hockersmith, Benjamin P. Sandford, and Douglas B. Dey

Report of research by

Fish Ecology Division
Northwest Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
2725 Montlake Boulevard East
Seattle, Washington 98112

to

Walla Walla District
U.S. Army Corps of Engineers
201 North 3rd
Walla Walla, Washington 99362-1876
Contract W68SBV10182881

December 2002

EXECUTIVE SUMMARY

In 1989, the main juvenile fish facility at Lower Granite Dam on the Snake River was retrofitted with a passive integrated transponder (PIT) tag diversion and bypass system to facilitate the monitoring of fish used in research. Since installation, problems with PIT-tag system retrofits to the facility have included fish holding in the system, low detection efficiencies, and possible impacts on fish condition (i.e., descaling, injury, and mortality rates). During 2001, the U.S. Army Corps of Engineers modified the PIT-tag diversion system at Lower Granite Dam in order to improve passage conditions for juvenile salmon. Modifications included reducing the depth and volume of the head box, removing the fish-counting tunnels, and replacing two 4-in conveyance pipes with a single 10-in-diameter pipe.

In 2001, the National Marine Fisheries Service evaluated passage performance for juvenile salmonids passing through the modified portions of the PIT-tag diversion system at Lower Granite Dam. The evaluation included a visual inspection, an evaluation of fish condition and travel time for fish passing through modified portions of the system, and a determination of the effects of the modifications on PIT-tag detection efficiency.

We found a minor problem with a gasket protruding approximately 1.5 cm into the inside of the new bypass pipe; however, this was repaired prior to the beginning of the spring outmigration. We found no evidence of mortality, injuries, or descaling for fish passing through the modified portions of the bypass system. The modifications improved passage performance and eliminated delay associated with the PIT-tag head box. Detection efficiency improved for all individual PIT-tag coils on monitors downstream from the modifications, with the greatest improvement for coils on the monitor controlling the two-way separation-by-code gate.

CONTENTS

EXECUTIVE SUMMARY	ii
INTRODUCTION	1
OBJECTIVE 1: Evaluate modifications to assess passage performance in terms of descaling and injury rates and identify areas where holding and other stressors may occur	3
Methods	3
Visual Inspection	3
Juvenile Salmonid Descaling, Injury, and Mortality	3
Travel Time	3
Results and Discussion	4
Visual Inspection	4
Juvenile Salmonid Descaling, Injury, and Mortality	4
Travel Time	4
OBJECTIVE 2: Determine the effects of the modifications on PIT-tag detection efficiency	6
Methods	6
Results and Discussion	6
CONCLUSIONS	8
ACKNOWLEDGMENTS	9
REFERENCES	10

INTRODUCTION

In 1989, the National Marine Fisheries Service (NMFS) developed a system to automatically detect, record, and divert a portion of salmonids marked with passive integrated transponder (PIT) tags as they pass through the juvenile collection facilities at Snake and Columbia River dams (Mathews et al. 1990, Marsh et al. 1999). The principal feature of the diversion system is a slide gate located in the bottom of flumes exiting the fish and debris separator. A PIT-tag monitor triggers the slide gate, which selectively opens to remove or divert PIT-tagged fish to the river without impact to the general population of fish passing through the flumes.

A prototype system was installed at Lower Granite Dam in 1989 and evaluated during 1989, 1990, and 1991 (Mathews et al. 1990, 1992; Achord et al. 1992; Marsh et al. 1999). A similar PIT-tag diversion system was installed at Little Goose Dam during spring 1992 and was evaluated during 1993 (Harmon et al. 1995). Prior to installation of these diversion systems, most collected fish were put in trucks or barges and transported to release sites below Bonneville Dam to maximize survival.

However, this system lacked the ability to evaluate smolt behavior and survival past multiple dams. With the advent of the PIT-tag diversion system it became possible to estimate survival for PIT-tagged fish past multiple dams in the Snake and Columbia Rivers because the systems can return the majority of PIT-tagged fish to the river after detection (Iwamoto et al. 1994).

The PIT-tag diversion and bypass system at Lower Granite Dam was retrofitted to the main juvenile fish facility in 1989. Since the retrofit, problems with the PIT-tag diversion system have included fish holding in the system, low detection efficiencies, and possible impacts on fish condition (i.e., descaling, injury, and mortality rates). During 2001, the U.S. Army Corps of Engineers modified the PIT-tag diversion system at Lower Granite Dam by reducing the volume and depth of the PIT-tag head box, removing the fish-counting tunnels, and replacing two 4-in-diameter conveyance pipes with a single 10-in-diameter pipe.

Prompt evaluation of new or modified fish passage facilities allows unforeseen problems to be detected and corrected as soon as possible, thereby minimizing negative impacts to juvenile migrant salmonids. Previous evaluations of PIT-tag diversion systems on the Snake River include NMFS studies at Lower Granite Dam (Mathews et al. 1990, 1992; Achord et al. 1992), Little Goose Dam (Harmon et al. 1995, Monk et al. 1992), and Lower Monumental Dam (Marsh et al. 1995, 1996; Hockersmith et al. 2000).

This study addresses the Anadromous Fish Evaluation Program objective to "assess descaling, injury, and delay to fish as they pass through the modified portions of the PIT-tag diversion system at Lower Granite Juvenile Fish Facility, as well as documenting the detection efficiency of the system" (USACE 2001, Project BPS-W-01-5). The study also implements measures for juvenile fish passage listed in the

Biological Opinion for Operation of the Federal Columbia River Power System (NMFS 2000, Section 9.6.1.4).

We classified the study objectives as follows: Objective 1) Evaluate modifications to assess passage performance in terms of descaling and injury rates and identify areas where holding and other stressors may occur; and Objective 2) Determine the effects of the modifications on PIT-tag detection efficiency.

OBJECTIVE 1: Evaluate modifications to assess passage performance in terms of descaling and injury rates and identify areas where holding and other stressors may occur

Methods

Visual Inspection

Prior to rewatering the bypass system at Lower Granite Dam in 2001, we inspected the new juvenile conveyance conduits with a closed-circuit video camera for obstructions or rough areas that could cause injury to fish. Methods for the inspection were similar to those used by Muir et al. (1998).

Juvenile Salmonid Descaling, Injury, and Mortality

In 2001, we released PIT-tagged river-run hatchery yearling chinook salmon into the modified portions of the diversion system to identify areas where injuries or descaling may occur. Fish were collected and PIT-tagged from 16 through 18 April at Lower Granite Dam using techniques described by Prentice et al. (1990). Only run-of-the-river hatchery yearling chinook salmon with no apparent injuries or descaling were used in the evaluation. Run-of-the-river fish were selected because they are more sensitive to passage effects, particularly descaling, than fish obtained directly from hatcheries.

Tagged fish were held in 121-L containers (plastic trash cans) for a minimum of 24 hours after tagging for recovery and determination of post-tagging mortality and/or tag loss. Holding density did not exceed 50 fish per container. Following the 24-hour holding period, treatment groups were released into the PIT-tag head box (upstream from the modified portions of the system) and recaptured in the separation-by-code (SBC) sample tanks.

For this task, the two-way SBC rotating gate was positioned to divert all fish into the sample tank. Reference fish groups were also released directly into the SBC sample tanks to measure the rate of descaling attributable to handling. Recaptured fish were anesthetized, examined for injuries and descaling, and allowed to recover in fresh water prior to being released into a raceway for transportation from the facility.

Travel Time

Travel times of PIT-tagged juvenile salmonids through the modified portions of the PIT-tag diversion system (separator exit monitor to diversion/river exit monitor) during 2001 were compared to travel time data for the 1999 and 2000 outmigrations in order to evaluate the modifications in relation to fish holding within the PIT-tag head box.

Results and Discussion

Visual Inspection

The visual inspection revealed a minor problem with a gasket protruding 1.5 cm into the pipe at one of the flange joints. Project maintenance personnel at Lower Granite Dam modified the gasket prior to rewatering the facility.

Juvenile Salmonid Descaling, Injury, and Mortality

We released 197 treatment and 174 control fish. We did not observe any mortality or injuries during the test. Four fish from the treatment group and three fish from the control group had minor descaling (descaling over less than 3% of the fish body). Based on the similar descaling rates among treatment and control groups, we concluded that descaling was likely caused by handling alone and was not due to passage through the modified bypass system.

Travel Time

During 1999 and 2000, median travel time from the monitor located at the separator exit to the monitor at the diversion gate/river exit varied among species, but was generally longest for wild chinook salmon at approximately 75 minutes in 1999 and 31 minutes in 2000 (Table 1). In contrast, for the same section of the bypass system during 2001, wild chinook salmon had the shortest median travel time, at only 0.3 minutes. Travel time decreased for all other species as well, with no species having a median travel time of more than 1.5 minutes in 2001. We concluded that delay within this section of the bypass system was eliminated by the modifications.

Table 1. Median travel time from the PIT-tag monitor located at the fish and debris separator exit to the PIT-tag monitor located at the diversion/river exit at Lower Granite Dam for PIT-tagged fish during 1999, 2000, and 2001. Standard errors in parentheses.

	Median travel time (minutes)					
	1999		2000		2001	
Hatchery steelhead	5.3	(0.11)	4.4	(0.07)	0.8	(0.02)
Wild steelhead	5.7	(0.25)	4.6	(0.11)	0.5	(0.01)
Hatchery yearling chinook salmon	73.4	(1.62)	13.9	(0.59)	0.4	(0.03)
Wild yearling chinook salmon	74.6	(2.82)	31.4	(1.55)	0.3	(0.00)
Hatchery subyearling chinook salmon	26.5	(0.86)	19.8	(0.47)	0.5	(0.03)
Sockeye salmon	47.8	(5.47)	24.3	(1.75)	1.0	(0.25)
Coho salmon	43.9	(8.41)	17.2	(3.02)	1.1	(0.41)

OBJECTIVE 2: Determine the effects of the modifications on PIT-tag detection efficiency

Methods

Detection efficiency was measured for each of the three individual coils in the PIT-tag monitors located at the diversion gate/river exit, the two-way SBC gate, and the three-way SBC gate. Cumulative annual detection efficiencies for 2001 were compared to those of 2000 to evaluate the effects of the modifications on PIT-tag detection efficiency. Detection efficiencies measured in 1999 were not comparable to those measured in 2000 and 2001 because of the adoption of 134.2-kHz PIT-tag systems throughout the Snake and Columbia River Basins in 2000.

The new systems were chosen over the older, 400-kHz systems because the 134.2-kHz tags were approved by the International Standards Organization and provided higher tag-reading accuracy and greater reading distance. Therefore, cumulative reading efficiency per coil for 2001 was only comparable to the one year of historical coil efficiency data. Cumulative coil efficiency was estimated using the method described by Prentice et al. (1993).

Results and Discussion

Detection efficiencies downstream from the modifications were higher for all coils in 2001 than in 2000 (Table 2). Individual PIT-tag coils for the monitor that controls the two-way SBC diversion gate had the greatest increase in detection efficiency (3.1 to 7.4%).

Table 2. PIT-tag detection efficiencies for individual coils (3 coils per monitor) and overall efficiencies for monitors located at the diversion gate/river exit, the two-way separation-by-code (SBC) diversion gate, and the three-way SBC gate at Lower Granite Dam during 2000 and 2001.

PIT-tag monitor location	Coil	Detection efficiency (%)	
		2000	2001
Diversion gate/river exit	91	95.5	96.1
	92	96.7	96.9
	93	96.5	97.1
	overall monitor	99.5	99.7
Two-way SBC diversion gate	D1	88.5	95.9
	D2	93.0	96.1
	D3	91.4	96.3
	overall monitor	93.1	99.4
Three-way SBC diversion gate	C1	95.1	97.5
	C2	95.8	97.9
	C3	95.6	97.9
	C4	95.4	98.1
	overall monitor	100.0	100.0

CONCLUSIONS

We found no evidence of obstructions or rough areas that could cause injuries to fish in the modified juvenile fish conveyance conduits. The modifications appear to have improved passage performance and eliminated delays associated with the PIT-tag head box. Reading efficiency was improved for all PIT-tag detector coils downstream from the modifications, especially for coils in the monitor controlling the two-way SBC diversion gate.

ACKNOWLEDGMENTS

We express our appreciation to all who assisted with this research. We particularly thank Michael Halter and Marvin Shuttters of the U.S. Army Corps of Engineers, Walla Walla District, for their help coordinating evaluation activities at Lower Granite Dam. Jerrel Harmon, Douglas Marsh, Kenneth McIntyre, Neil Paasch, Thomas Ruehle, and Jeffrey Moser of the Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service provided valuable assistance with field activities of the evaluation. Carter Stein and staff of the Pacific States Marine Fisheries Commission provided valuable assistance in data acquisition.

REFERENCES

- Achord, S., J. R. Harmon, D. M. Marsh, B. P. Sandford, K. W. McIntyre, K. L. Thomas, N. N. Paasch, and G. M. Mathews. 1992. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1991. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 57 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Harmon, J. R., D. J. Kamikawa, B. P. Sandford, K. W. McIntyre, K. L. Thomas, N. N. Paasch, and G. M. Mathews. 1995. Research related to transportation of juvenile salmonids on the Columbia and Snake Rivers, 1993. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 37 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Hockersmith, E. E., W. D. Muir, B. P. Sandford, and S. G. Smith. 2000. Evaluation of specific trouble areas in the juvenile fish facility at Lower Monumental Dam for fish passage improvement, 1999. Report to U.S. Army Corps of Engineers, Contract W66QKZ91521283, 24 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Iwamoto, R. N., W. D. Muir, B. P. Sandford, K. W. McIntyre, D. A. Frost, and J. G. Williams. 1994. Survival estimates for the passage of juvenile chinook salmon through Snake River dams and reservoirs. Report to Bonneville Power Administration, Contract DE-AI79-93BP10891, 126 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Marsh, D. M., G. M. Mathews, S. Achord, T. E. Ruehle, and B. P. Sandford. 1999. Diversion of salmonid smolts tagged with passive integrated transponders from an untagged population passing through a juvenile collection system. *N. Am. J. Fish. Manage.* 19:1142-1146.
- Marsh, D. M., B. P. Sandford, and G. M. Matthews. 1995. Preliminary evaluation of the new juvenile collection, bypass, and sampling facilities at Lower Monumental Dam, 1993. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 48 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)

- Marsh, D. M., L. K. Timme, B. P. Sandford, S. Achord, and G. M. Matthews. 1996. Preliminary evaluation of the new juvenile collection, bypass, and sampling facilities at Lower Monumental Dam, 1994. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 54 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Matthews, G. M., S. Achord, J. R. Harmon, O. W. Johnson, D. M. Marsh, B. P. Sandford, N. N. Paasch, K. W. McIntyre, and K. L. Thomas. 1992. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1990. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 51 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Matthews, G. M., J. R. Harmon, A. Achord, O. W. Johnson, and L. A. Kubin. 1990. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake Rivers, 1989. Report to U.S. Army Corps of Engineers, Contract DACW68-84-H-0034, 59 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Monk, B. H., B. P. Sandford, and J. G. Williams. 1992. Evaluation of the juvenile fish collection, transportation, and bypass facility at Little Goose Dam, 1990. Report to U.S. Army Corps of Engineers, Contract E86900057, 50 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- Muir, W. D., S. G. Smith, K. W. McIntyre, and B. P. Sandford. 1998. Project survival of juvenile salmonids passing through the bypass system, turbines, and spillways with and without flow deflectors at Little Goose Dam, 1997. Report to U.S. Army Corps of Engineers, Contract E86970085, 30 p. plus Appendix. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- NMFS (National Marine Fisheries Service). 2000. Endangered Species Act, Section 7 Consultation, Biological Opinion: Reinitiation of consultation on operation of the Federal Columbia River power system, including the juvenile fish transportation program and 19 Bureau of Reclamation projects in the Columbia Basin. (Available from NMFS Northwest Regional Office, 525 NE Oregon Street, Suite 500, Portland, OR 97232 or via internet at www.nwr.noaa.gov/1hydroweb/docs/Final/2000Biop.html accessed 18 July 2002.)

- Prentice, E. F., T. A. Flagg, C. S. McCutcheon, D. F. Brastow, and D. C. Cross. 1990. Equipment, methods, and an automated data-entry station for PIT tagging. *In* N. C. Parker et al. (editors), *Fish-marking techniques*, p. 335-340. Am. Fish. Soc. Symp. 7.
- Prentice, E. F., D. J. Maynard, P. Sparks-McConkey, C. S. McCutcheon, D. Neff, W. Steffens, F. W. Waknitz, A. L. Jensen, L. C. Stuehrenberg, S. L. Downing, B. P. Sanford, and T. W. Newcomb. 1993. A study to determine the biological feasibility of a new fish tagging system, 1989. Report to Bonneville Power Administration, Portland, OR, Contract DE-AI79-84BP11982, Project 83-319, 193 p. (Available from Northwest Fisheries Science Center, 2725 Montlake Boulevard E., Seattle, WA 98112-2097.)
- USACE (U.S. Army Corps of Engineers). 2001. Corps of Engineers funded research, anadromous fish evaluation program, Walla Walla District, FY 01. (Available from Walla Walla District, 201 North 3rd, Walla Walla, WA 99362-1876 or via internet at www.nww.usace.army.mil/planning/ep/fishres/main.html accessed 17 July 2002.)