Post-construction evaluation of the modified PIT-tag diversion and bypass system at Little Goose Dam, 2002

Fish Ecology Division

Northwest Fisheries Science Center

National Marine Fisheries Service

Seattle, Washington

by
Eric E. Hockersmith, Sandra L. Downing, and Douglas B. Dey

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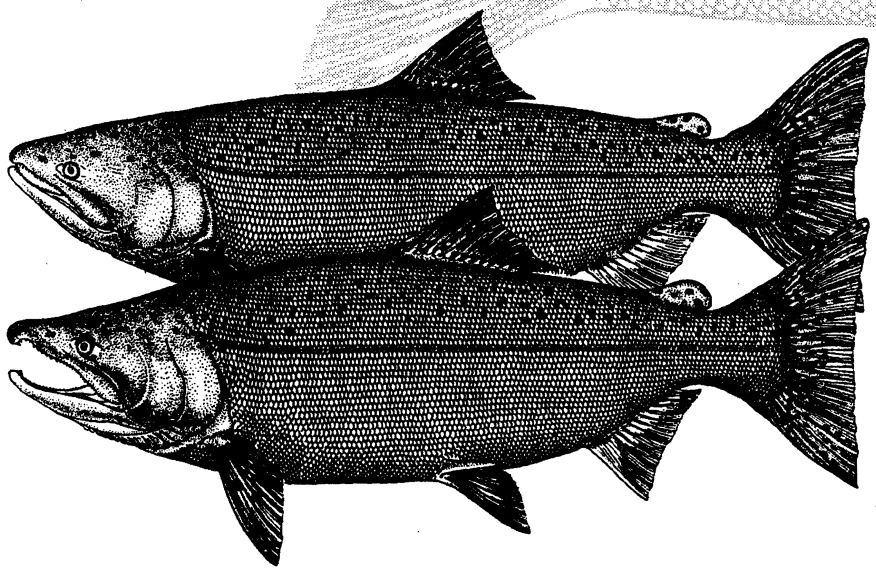

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Report of research by

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EXECUTIVE SUMMARY

The original PIT-tag diversion and bypass system at Little Goose Dam on the Snake River was retrofitted to the main juvenile fish facility in 1992 to facilitate the monitoring of fish used in research. Since installation, problems with retrofits to the facility have included fish delay in the system, low PIT-tag detection efficiencies, and possible impacts on fish condition.

In 2002, the U.S. Army Corps of Engineers modified the PIT-tag diversion system at Little Goose Dam to improve passage conditions for juvenile salmonids. The modifications consisted of removing the PIT-tag head boxes and fish counting tunnels, adding a new secondary dewatering system downstream from the slide gate, installing a new separation-by-code (SbyC) sampling system, replacing two 6-inch diameter conveyance pipes with a single 8-inch diameter pipe between the slide gate and diversion river-exit PIT-tag monitor, and replacing the 6-inch-diameter river-exit conveyance pipe with a 10-inch diameter pipe.

In 2002, the National Marine Fisheries Service evaluated passage performance for juvenile salmonids through the modified portions of the PIT-tag diversion system at Little Goose Dam. The evaluation included a camera inspection, evaluations of fish condition (descaling, injury, and mortality rates) and travel time through the modified portions of the PIT-tag bypass system, and determination of the effects of the modifications on PIT-tag detection efficiency, diversion efficiency, and fish condition for the modified diversion and bypass system.

The camera inspection revealed no obstructions or rough areas which could cause injury to fish inside the new fish conveyance pipes. In addition, we found no evidence that passage through the modified portions of the bypass system contributed to mortality, injury, or descaling for juvenile salmonids. The modifications improved passage performance and eliminated delay associated with the PIT-tag diversion system.

PIT-tag detection efficiency for individual coils associated with the SbyC sample gate and diversion river-exit monitor was similar to historical estimated detection efficiency. The new SbyC sample gate was more efficient than the previous system at Little Goose Dam, resulting in a substantial reduction in the proportion of bycatch (from 71.8% in 2001 to 42.6% in 2002).

CONTENTS

INTRODUCTION

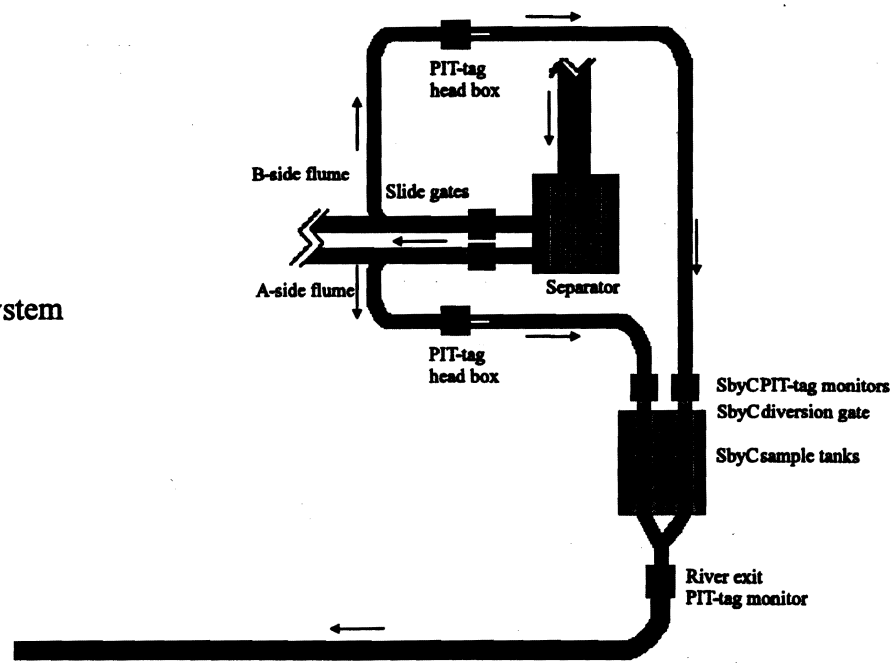
In 1989, the National Marine Fisheries Service (NMFS) developed a system to automatically detect, record, and divert a portion of salmonids marked with passive integrated transponder (PIT) tags as they pass through the juvenile fish collection facilities at Snake and Columbia River dams (Matthews et 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 computer program records and time-stamps the PIT-tag code and triggers the slide gate for preselected tag codes. The gate then opens to remove or divert PIT-tagged fish to the river with minimal impact to the general population of fish passing through the flumes (Downing et al. 2001).

A prototype system was installed at Lower Granite Dam in 1989 and evaluated during 1989, 1990, and 1991 (Matthews 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 the installation of PIT-tag 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 and reservoirs. With the advent of the PIT-tag diversion system it became possible to estimate survival for PIT-tagged fish past multiple dams and reservoirs 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 Little Goose Dam was retrofitted to the main juvenile fish facility in 1992. Since the retrofit, problems identified with the PIT-tag diversion system have included fish delay in the system, low detection efficiencies, and possible impacts on fish condition (i.e., descaling, injury, and mortality). In 2002, the U.S. Army Corps of Engineers modified the PIT-tag diversion system at Little Goose Dam by removing the PIT-tag head boxes and fish counting tunnels, adding a new secondary dewatering system downstream from the slide gate, installing a new separation-by-code (SbyC) sampling system, replacing two 6-inch diameter conveyance pipes with a single 8-inch diameter pipe between the slide gate and diversion river-exit PIT-tag monitor, and replacing the 6-inch-diameter river-exit conveyance pipe with a 10-inch diameter pipe (Figure 1).

Prompt evaluation of new or modified fish passage facilities allows 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 (Matthews et al. 1990, 1992; Achord et al. 1992; Hockersmith et al. 2002), Little Goose Dam (Monk et al. 1992; Harmon et al. 1995), and Lower Monumental Dam (Marsh et al. 1995, 1996; Hockersmith et al. 2000).

PIT-tag diversion system prior to 2002



PIT-tag diversion system after 2002 modifications

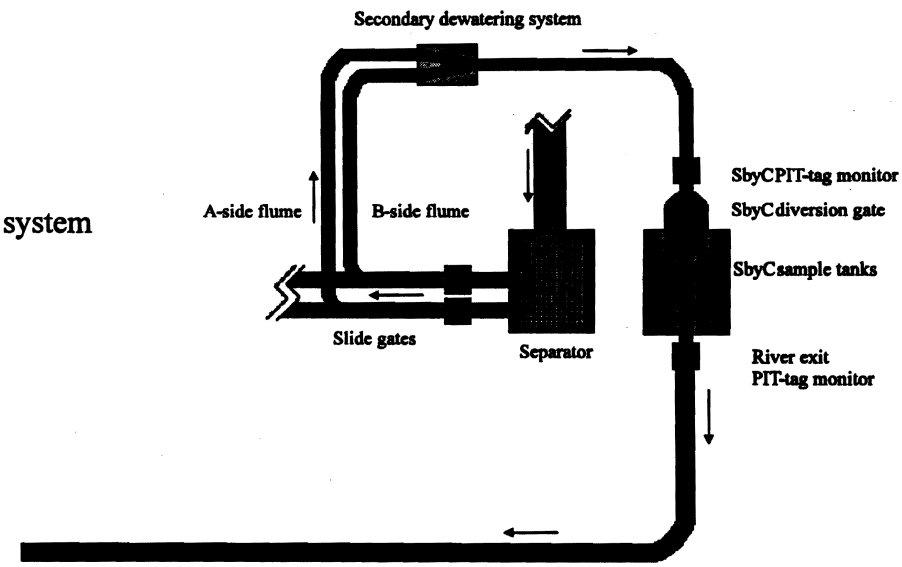


Figure 1. Schematic above shows components of the PIT-tag detection and separation-by-code (SbyC) diversion system at Little Goose Dam prior to 2002; lower schematic shows current system components.

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 Little Goose Juvenile Fish Facility, as well as documenting the detection efficiency of the system. The study also implements measures for improving juvenile fish passage listed in the Biological Opinion for Operation of the Federal Columbia River Power System (NMFS 2000, Section 9.6.1.4).

Specific objectives of the study during 2002 were 1) to assess modifications to the bypass system for potential injury, descaling, and mortality both prior to and during the juvenile salmonid migration; 2) to evaluate PIT-tag detection and diversion efficiency for the SbyC system prior to and during the juvenile migration; 3) to determine travel time for river-run fish passing through the modified system.

ASSESSMENT OF DESCALING, INJURY, AND MORTALITY IN MODIFIED AREAS OF THE BYPASS SYSTEM

Video Observations

On 6 March 2002, prior to watering up the bypass system at Little Goose Dam, we inspected the new juvenile fish 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) and Hockersmith et al. (2002). The camera inspection revealed no obstructions or rough areas that could cause injury to fish inside the new fish conveyance pipes.

Preseason Evaluations using Hatchery Fish

In late March, prior to the arrival of most juvenile migrants, we released PIT-tagged hatchery subyearling chinook salmon and steelhead to evaluate the physical condition of fish passing through the modified bypass system. Fish were PIT-tagged at Lyons Ferry Hatchery using the methods described by Prentice et al. (1990). They were then transported to the Little Goose Dam juvenile fish facility and released on 27 March 2003 into 1) the secondary dewatering structure, 2) the A-side flume upstream from the PIT-tag slide gate, and 3) the B-side flume upstream from the PIT-tag slide gate (Figure 1). The SbyC diversion gate was programed to divert these fish into either the north SbyC tank, the south SbyC tank, or to allow them to pass straight through at a ratio of about 1:1:1.

We released groups of 130, 142, and 145 subyearling chinook salmon and 163, 133, and 147 steelhead to the secondary dewatering structure, the A-side flume, and the B-side flume, respectively. The majority of these fish were diverted to their correct routes (100% of the subyearling chinook salmon and 93.4% of the steelhead). About two-thirds from each release group were recaptured in the north and south SbyC tanks and examined for incidence of injury and mortality. The remaining third of each release group passed through the system and back to the river.

During these preseason evaluations, we were unable to evaluate descaling using fish transported directly from Lyons Ferry Hatchery. Because the tests were conducted several weeks prior to the juvenile migration season, the fish had not fully developed as smolts to a stage where descaling would be expected to occur.

Evaluations of Migrating River-Run Fish

During the 2002 juvenile migration season, the SbyC system at Little Goose Dam was operated from 8 April to 28 June to collect wild yearling chinook salmon smolts previously PIT-tagged for a Bonneville Power Administration (BPA) study (Project 1991-028-00 Contract 00005619). Target and non-target fish collected in the SbyC system were anesthetized, examined for injuries and descaling, and allowed to recover in fresh water prior to being released into the river-exit conveyance pipe.

We recaptured 844 salmonid smolts during operation of the SbyC. After recapture in the SbyC tanks, fish were examined to determine the incidence of descaling, injuries, and mortality after passing through the modified PIT-tag bypass system at Little Goose Dam (Table 1). Descaling, injury, and mortality rates observed for recaptured fish were low and at levels consistent with those expected for juvenile salmonids subjected to collection and handling.

Table 1. Summary of river-run migrating salmonids collected in the separation-by-code (SbyC) system and examined to determine the incidence of descaling, injuries, and mortality for fish passing through the modified PIT-tag bypass system at Little Goose Dam during 2002.

Species and rear type	Collected	Mortality		Injury		Descaled	
	n	n	%	n	%	n	%
Wild yearling chinook salmon	537	3	0.6	1	0.2	5	0.9
Hatchery yearling chinook salmon	205	0	0.0	0	0.0	0	0.0
Wild steelhead	11	0	0.0	0	0.0	0	0.0
Hatchery steelhead	84	0	0.0	0	0.0	0	0.0
Sockeye	1	0	0.0	0	0.0	0	0.0
Coho	6	0	0.0	0	0.0	0	0.0
Overall	844	3	0.4	1	0.1	5	0.6

EVALUATIONS OF PIT-TAG DETECTION AND DIVERSION EFFICIENCY

Prior to the juvenile migration, we set and tested the timing for the SbyC diversion gate by releasing stick tags (PIT tags embedded in wooden sticks) either to the bypass system between the separator and PIT-tag slide gate or to the secondary dewatering structure downstream from the slide gate. Based on these tests, we set the delay before opening of the three-way SbyC gate at 50 msec and the SbyC gate open timing at 800 msec. Water velocity in the bypass pipe immediately upstream from the SbyC PIT-tag monitor was 8.6 fps during this evaluation.

Preseason Releases of Hatchery Fish

Detection and separation efficiencies were further evaluated using the Lyons Ferry Hatchery fish released to assess incidence of injury and mortality (417 subyearling chinook salmon and 443 steelhead). PIT-tag coil and monitor detection efficiency was defined as the ratio of fish detected at an individual coil or set of coils to the number of fish available for detection. Separation efficiencies of the SbyC system were defined as the ratio of the number of fish correctly diverted to a specified route to the total number of fish available for diversion to that route.

Detection efficiencies for each of the four coils in the SbyC PIT-tag monitor ranged from 96.5 to 100% for subyearling chinook salmon and from 97.5 to 100% for steelhead (Table 2). The overall probability of being missed by the SbyC PIT-tag monitor was less than 0.0001% for both subyearling chinook salmon and steelhead.

Overall separation efficiency for the SbyC diversion gate for subyearling chinook salmon was 100% (Table 3). SbyC separation efficiency for steelhead ranged from 85.4 to 100% and was 95.3% overall. Lower separation efficiency for the steelhead was probably due to their relatively large size and ability to swim against the flow in the bypass conduit. For subyearling chinook salmon and steelhead combined, overall separation efficiency was 97.6%.

Table 2. Detection efficiency for individual coils and overall for the separation-by-code (SbyC) gate monitor for preseason releases of Lyons Ferry Hatchery fish at Little Goose Dam juvenile fish facility, 2002.

		Detection efficiency (%)				
	released	overall	coil C1	coil C2	coil C3	coil C4
Subyearling chinook salmon						
Secondary dewatering system	130	100.0	99.2	100.0	100.0	100.0
Separator exit A-flume release	142	100.0	100.0	99.3	99.3	96.5
Separator exit B-flume release	145	100.0	96.6	97.2	98.6	98.6
Steelhead						
Secondary dewatering system	163	100.0	98.2	97.5	98.2	98.2
Separator exit A-flume release	133	100.0	99.2	99.2	100.0	100.0
Separator exit B-flume release	147	100.0	100.0	100.0	100.0	100.0

Table 3. Separation-by-code (SbyC) diversion system separation efficiency for preseason releases of Lyons Ferry Hatchery fish at Little Goose Dam juvenile fish facility, 2002.

	Subyearling chinook salmon			Steelhead		
	divert left	no diversion	divert right	divert left	no diversion	divert right
Secondary dewatering system						
number to 3-way gate	44	44	42	59	49	55
correct route	44	44	42	58	49	51
separation efficiency (%)	100.0	100.0	100.0	98.3	100.0	92.7
Separator exit A-flume release						
number to 3-way gate	48	48	46	45	46	42
correct route	48	48	46	43	46	40
separation efficiency (%)	100.0	100.0	100.0	95.6	100.0	95.2
Separator exit B-flume release						
number to 3-way gate	52	41	52	48	46	53
correct route	52	41	52	41	45	49
separation efficiency (%)	100.0	100.0	100.0	85.4	97.8	92.5

Evaluations with River-Run Fish

During the juvenile migration, detection efficiency was measured for each of the four individual coils in the PIT-tag monitors located at the SbyC diversion gate and the river-exit monitors (Figure 1). Cumulative annual detection efficiencies for 2002 were compared to those of 2000 and 2001 to evaluate the effects of the modifications on PIT-tag detection efficiency. Detection efficiencies measured prior to 2000 could not be compared to those determined prior to 2000 because all 400-kHz PIT-tag systems were replaced with 134.2-kHz systems throughout the Snake and Columbia River Basins in 2000.

The 134.2-kHz systems provided higher tag-reading accuracy and greater reading distance than the 400-kHz systems, and were approved by the International Standards Organization. Because of the greater accuracy and reading-range of the 132.4 kHz system, cumulative reading efficiency per coil for 2002 could only be compared to the previous two years of coil efficiency data. Cumulative coil efficiency was estimated using the method described by Prentice et al. (1993).

We compared diversion efficiency for the new 3-way SbyC system at Little Goose Dam in 2002 to diversion efficiency for the two older 2-way gate systems that operated during 2001 while collecting previously PIT-tagged wild yearling chinook salmon smolts (BPA Project 1991-028-00, Contract 00005619).

During the juvenile migration, estimated detection efficiencies during 2002 for individual coils in the SbyC and diversion river-exit PIT-tag monitors were similar to detection efficiencies during 2000 and 2001 (Table 4). In addition, overall estimated detection efficiency for the SbyC and diversion river-exit PIT-tag monitors was unchanged by the modifications.

The SbyC system at Little Goose Dam operated for 77 days during 2001 and 81 days during 2002. Targeted PIT-tagged wild yearling chinook salmon smolts collected in the SbyC system at Little Goose Dam totaled 490 and 487 during 2001 and 2002, respectively (Table 5). The new 3-way SbyC sampling system had 39.2% less bycatch than the two older 2-way gate SbyC systems that operated during 2001, thus improving diversion efficiency.

Table 4. Annual PIT-tag detections and detection efficiencies for river-run migrating juvenile salmonids by individual coil (three or four coils per monitor) and by monitor for monitors located at the separation-by-code (SbyC) diversion gate and at the river-exit conveyance pipe at Little Goose Dam during 2000, 2001, and 2002.

		Number detected (Detection efficiency)		
PIT-tag monitor	Coil ID	2000	2001	2002
SbyC Diversion gate				
A-side diversion	D1	17,064 (0.986)	47,762 (0.984)	
	D2	17,097 (0.988)	47,889 (0.987)	
	D3	17, 138 (0.991)	47,961 (0.982)	
	overall	17,303 (1.000)	48,532 (1.000)	
B-side diversion	C1	34,672 (0.983)	68,004 (0.986)	
	C2	34,757 (0.985)	67,919 (0.984)	
	C3	34,824 (0.987)	67,799 (0.983)	
	overall	35,278 (1.000)	69,008 (1.000)	
New 3-way diversion	C1			85,080 (0.984)
	C2			85,383 (0.987)
	C3			85,450 (0.988)
	C4			85,561 (0.989)
	overall			86,460 (1.000)
River-exit monitor	91	51,847 (0.984)	115,229 (0.984)	84,217 (0.987)
	92	51,992 (0.987)	115,552 (0.987)	84,392 (0.989)
	93	52,040 (0.988)	115,560 (0.987)	84,415 (0.989)
	overall	52,667 (1.000)	117,066 (1.000)	85,297 (1.000)

Table 5. Separation-by-code (SbyC) sampling and separation efficiency for targeted PIT-tagged wild yearling chinook salmon smolts (BPA Project 1991-028-00, Contract 00005619) during the spring outmigration at Little Goose Dam juvenile fish facility during 2001 and 2002.

SbyC sample	2001	2002
Target fish	490	487
Bycatch	1,250	361
PIT-tagged	162	17
Not PIT-tagged	1,088	344
Bycatch (%)	71.8	42.6

ASSESSMENT OF TRAVEL TIMES

Travel times of run of the river PIT-tagged juvenile salmonids through the modified portions of the PIT-tag diversion system (separator exit monitor to diversion/river-exit monitor) during 2002 were compared to travel time data for the 1999, 2000, and 2001 outmigrations to evaluate the modifications in relation to fish holding within the PIT-tag bypass system.

During 1999, 2000, and 2001 travel time from the monitor located at the separator exit to the river-exit monitor ranged from 1.6 to 29.3 minutes for the 90th percentile and varied among species and years (Table 6). In contrast, for the same section of the bypass system during 2002, the 90th percentile passed through this section in 0.3 minutes or less. Travel times were reduced for all species and were consistent across species. We concluded that delay within this section of the bypass system was eliminated by the modifications.

Table 6. Travel time for PIT-tagged fish between the PIT-tag monitor located at the fish and debris separator exit and the river exit PIT-tag monitor at Little Goose Dam during 1999, 2000, 2001, and 2002.

	90th percentile travel time (minutes)			
	1999	2000	2001	2002
Hatchery steelhead	3.5	5.1	3.1	0.3
Wild steelhead	3.1	5.3	2.7	0.3
Hatchery yearling chinook salmon	4.2	7.2	2.8	0.3
Wild yearling chinook salmon	8.7	11.5	4.4	0.3
Hatchery subyearling chinook salmon	5.9	6.2	4.8	0.3
Sockeye salmon	29.3	2.6	1.6	0.3
Coho salmon	7.7	9.9	13.1	0.3
n	135,741	51,757	111,548	78,293

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 boxes. Estimated reading efficiency was identical to previous years (100%) for all PIT-tag monitors affected by the modifications. The new SbyC sample gate substantially reduced bycatch and does not appear to cause any injuries to sampled fish.

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