Preliminary Evaluation of the New Juvenile Collection, Bypass, and Sampling Facilities at Lower Monumental Dam, 1994

CZES

Coastal Zone and Estuarine Studies Division

Northwest Fisheries Science Center

National Marine Fisheries Service

Seattle, Washington

by
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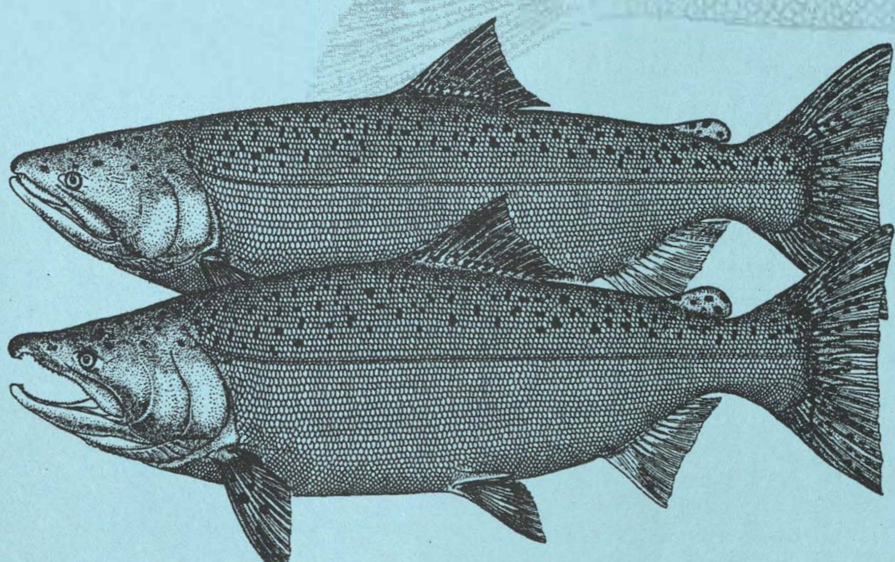
Benjamin P. Sandford, Stephen Achord,
and Gene M. Matthews

July 1996



PRELIMINARY EVALUATION OF THE NEW JUVENILE COLLECTION, BYPASS, AND SAMPLING FACILITIES AT LOWER MONUMENTAL DAM, 1994

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EXECUTIVE SUMMARY

We conducted research to evaluate the new juvenile fish bypass system at Lower Monumental Dam, which was completed and began operating in spring 1993.

Our evaluations began at Lower Monumental Dam in 1993 and were intended to accomplish the following objectives: 1) to determine if mechanical problems existed in the new facility that might affect fish passing though its channels, flumes, and pipes, 2) to determine the accuracy of the facility sampling system, 3) to determine if the outfall pipe safely passed juvenile fish. A fourth objective was added in 1994: 4) to evaluate the efficiency of a newly completed PIT-tag detection and diversion system.

We accomplished part of the first and third objectives and all of the second objective during 1993 evaluations, and in 1994, we completed evaluations for all remaining objectives. Results for the work completed in 1993 were described in a previous report (Marsh et al. 1995). Following is a summary of major findings under Objectives 1, 3, and 4 which were accomplished in 1994.

Objective 1

We found that passage from the newly mined collection channel to the laboratory was satisfactory for outmigrating juveniles. After their release to the collection channel, one juvenile steelhead arrived at the separator (near the laboratory) within 4 minutes, and the median passage time for all juveniles tested was 0.7 hours for steelhead and 2.4 hours for chinook salmon.

To assess the effects of the system on adult fallbacks, we released 20 adult steelhead to the collection channel. Adult downstream passage was not as satisfactory as that of juveniles, and we observed adults holding along the sides of the primary dewaterer. The median passage time of the 16 adults recovered on the separator was 84 hours.

Objective 3

Our efforts in 1993 to recover test fish at the terminus of the outfall pipe using a floating net configuration were unsuccessful due to equipment failure. In 1994, we tried again to recover fish from this area of the bypass system, this time using a boat and purse seine.

These tests were compromised by problems with the equipment, caused partly by higher flows and heavier turbine operations than had been expected and scheduled during the test period. However, in spite of low recovery rates and the loss of one replicate, we observed low or moderate rates of descaling for fish passing through the outfall pipe. Based on this and on previous observations, we concluded that passage through the pipe was safe for outmigrating juvenile salmonids.

Objective 4

We evaluated PIT-tag detection and diversion efficiency by periodically assessing collections of fish that had passed through the detection/diversion system. By sorting and counting these fish, and by counting ratios of untagged fish diverted by the system, we arrived at an efficiency rating for the system as a whole, as well as efficiency ratings for its individual parts.

We concluded that system efficiency was satisfactory, with 93% of all PIT-tagged fish passing through the facility being detected and diverted. Descaling rates through the detection systems were also satisfactory, though they were higher than those observed in the facility overall.

Conclusions and Recommendations

We concluded that the new collection channel, separator, and flumes leading to the laboratory, as well as the outfall pipe, are safe for migrating juvenile salmonids. Overall, the new bypass facility appears to safely pass fish through the dam. In addition, the PIT-tag detection/diversion system now in place at Lower Monumental Dam is operating at efficiencies that are satisfactory for smolt research and monitoring programs. As we completed all four study objectives in 1994, we recommend no additional testing.

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INTRODUCTION

Juvenile bypass systems were first utilized to divert salmonid smolts around hydroelectric powerhouses on the Snake River in the 1970s. These systems received little, if any, evaluation prior to use. Consequently, problems that were not immediately apparent resulted in needless injury to many smolts over a long period (Matthews 1992). To avoid recurrence of these injuries, new bypass systems have undergone intense evaluation as soon as possible after completion. Monk et al. (1992) evaluated the new bypass facility at Little Goose Dam when it became operational in spring 1990. Although no major problems were identified, several minor modifications were made to the facility.

At Lower Monumental Dam, the bypass and collection facility was based on the same design used at Little Goose Dam. However, Lower Monumental Dam was built without an adaquate means to bypass fish; therefore, a collection channel was mined through the dam in 1991 (Fig. 1). Orifices and submersible traveling screens were then added, and the juvenile fish bypass system became operational in 1992. Smolt collection and sampling systems were added to the bypass system, and the completed facility became operational in spring 1993.

We began evaluations of the Lower Monumental Dam bypass facility as soon as it became operational (Marsh et al. 1995). Study objectives in 1993 were 1) to determine if mechanical problems existed that might affect both juvenile and adult salmonids during passage and to observe how juveniles responded physiologically to different parts of the system, 2) to determine the accuracy of the facility sampling system, and 3) to determine if the outfall pipe safely passed juvenile salmonids. Objective 2 and most of Objective 1 were accomplished

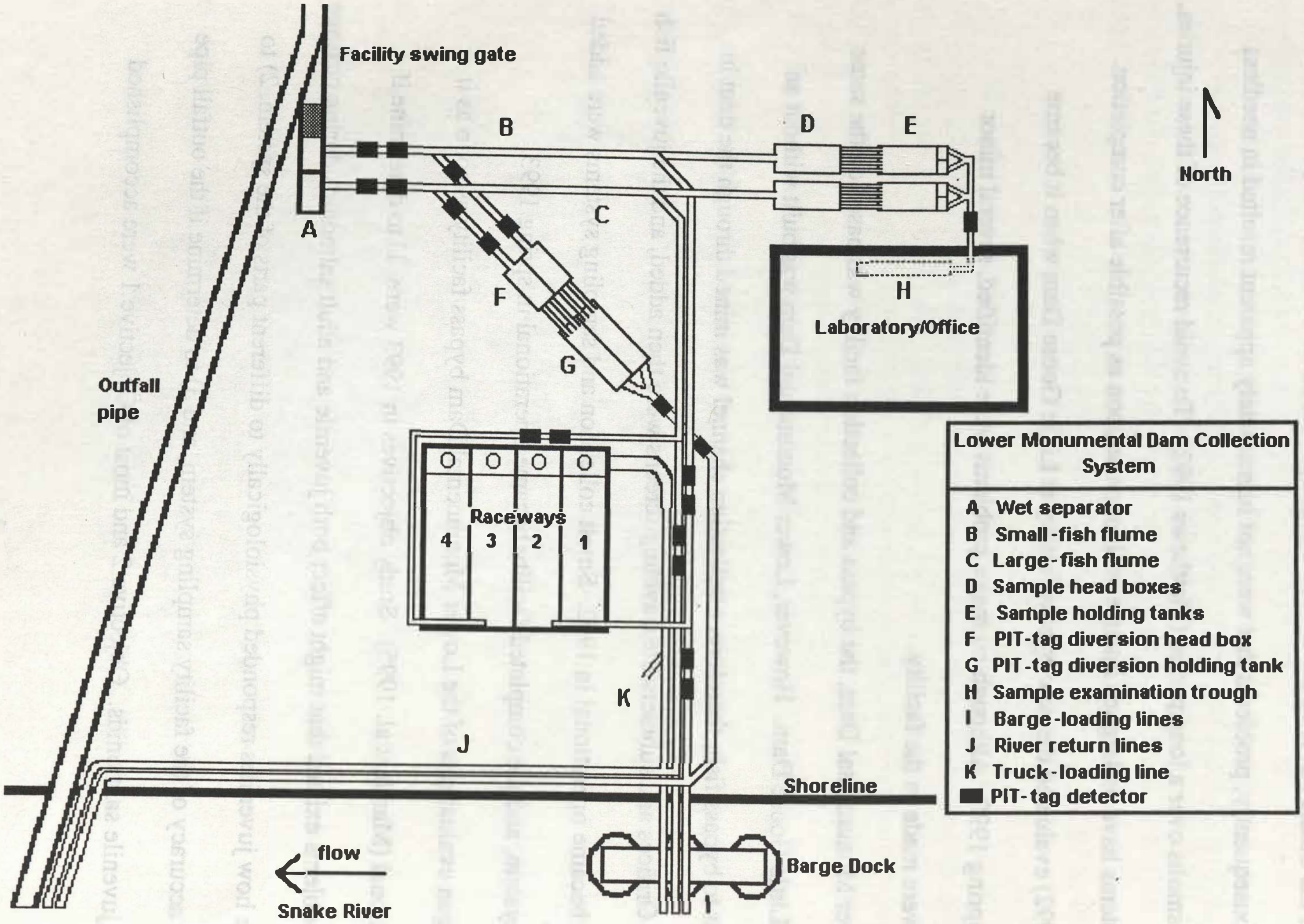

Figure 1. Schematic of the juvenile bypass system at Lower Monumental Dam.

in 1993. Objective 3 was attempted, but due to equipment problems, the evaluation could not be accomplished.

In 1994, we continued work on Objectives 1 and 3, and a fourth objective was added--to examine the reliability and efficiency of the PIT-tag detection/diversion system installed in spring 1994 and to determine if any major modifications were needed to retain high efficiency while maintaining minimal levels of slide-gate injury and/or mortality. In this report we detail progress on Objective 4 and completion of Objectives 1 and 3.

OBJECTIVE 1:

Evaluate the condition and survival of juvenile spring/summer chinook salmon and juvenile and adult steelhead after passage through the collection facility.

Approach

Descaling, Injury, and Mortality Evaluation

The only part of the juvenile facility not tested for mechanical problems in 1993 was the area between the collection channel and the laboratory. To test this area, fish were released into the collection channel at three different turbine units: 1B, 3B, and 6C (Table 1, Release Group 1). These fish were allowed to volitionally move from the collection channel through the dewaterer and separator. They were recaptured with the facility sampling system, which was set to divert 100% of all fish leaving the separator to the sample holding tanks, where they were held until the end of the collection day. The fish were then passed from the sample holding tanks into the laboratory, where they were examined for descaling, injuries, and mortalities.

Table 1. Release groups, species, area evaluated, and release and collection sites for each test under Objective 1. Test fish in Release Group 1 were of hatchery origin, while test fish in Release Group 3 were river-run. The adult steelhead in Release Group 2 were from Lyons Ferry Hatchery.

Release Group	Species	Area evaluated	Release site	Collection site
1	Yr. chin. salmon Yr. steelhead	1) Collection channel to laboratory	Collection channel (Units 1B, 3B, 6C)	Laboratory
2	Adult steelhead	1) Collection channel to separator	Collection channel (Unit 6C)	Separator
3	Yr. chin. salmon Juv. steelhead	1) Passage time -- collection channel through separator	Collection channel (Unit 6C)	Detected leaving separator (PIT-tagged)

Test fish in Release Group 1 were yearling spring chinook salmon *(Oncorhynchus tshawytscha*) and yearling steelhead *(O. mykiss*) from Dworshak National Fish Hatchery. The spring chinook salmon arrived at McNary Dam on 9 March 1994, and the steelhead arrived on 16 and 23 March. Fish were caudal-fin clipped (upper and lower) and maintained on a minimum-subsistence diet at McNary Dam. During the first week of April, the fish were transported to Lower Monumental Dam.

After transport to Lower Monumental Dam, 600 fish of each caudal-fin clip type (upper and lower) were divided into 3 groups of 200 fish each. This grouping was done for both species. Two groups from each caudal-fin clip type were then fin-clipped a second time: one group received a left pectoral-fin clip, and one group received a right pectoral-fin clip. This provided six distinctly marked groups of fish from each species. All groups of fish were held for 24 hours prior to release to assess handling mortality.

Two replicate releases were made 24 hours apart at each of the three turbine units (1B, 3B, and 6C), with 200 fish of each species released at each turbine unit. Results from both releases at each turbine unit were pooled for data analysis.

While counting out the release groups before a test, each fish was examined for injuries and descaling. Our descaling criterion was that any fish with 20% descaling on one side qualified as a descaled fish. Furthermore, any fish that showed signs of injury or descaling during pre-test counts was not used for testing.

In addition to tests using juvenile salmonids, adult steelhead from Lyons Ferry Hatchery were used to evaluate the effects of this area of the facility on adults. A total of 20 adult steelhead were released: 10 on 23 October and 10 on 24 October 1994. Each adult steelhead was anesthetized with MS-222 and marked below the dorsal fin on either the right or left side of the body with a Floy Tag[1] that was unique to each side. After each fish recovered, it was released into the collection channel at Unit 6C. The 10 fish released on 23 October were those tagged on the left side of their body, while the fish released on 24 October were those tagged on their right side. Notes were made of each fish's length, the date and time of release, and any marks on the body at the time of tagging.

Fish were allowed to volitionally move from the collection channel at Unit 6C downstream to the fish and debris separator. Every adult steelhead observed on the separator was checked for a tag. If a tag was found, the fish was examined for injuries and the tag was removed and attached to a report form. The location of the tag was recorded, along with the date and time it was observed and any injuries that were observed. Each fish was then released to the river through the adult river-return line.

All testing ended on 1 November, when collection at the facility was terminated for the year. The facility was operated in bypass mode until 1 December, when the entire facility was dewatered for the year.

Passage Time Evaluation

To determine passage time of juvenile salmonids through the collection channel and separator, we PIT tagged and released 100 river-run yearling spring/summer chinook salmon and 100 river-run juvenile steelhead (Table 1, Release Group 3). PIT-tagged fish were released into

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[1] Use of trade names does not imply endorsement by the National Marine Fisheries Service.

the upper end of the collection channel (Unit 6C), and the date and time of release were recorded for each fish. PIT-tag detection units read tags as each fish passed through the flumes exiting the separator, and an observation date and time were recorded for each detection. By comparing the release time of each fish with its observation time, we determined individual passage times from the collection channel through the separator. Using the individual passage times, we developed a 95% bootstrap confidence interval around the median passage time (Efron 1982).

Results and Discussion

Descaling, Injury, and Mortality Evaluation

Our testing demonstrated that juvenile salmonids passed from the collection channel to the laboratory with little or no negative effects (Table 2 and Appendix Table 1). Both juvenile chinook salmon and steelhead from Release Group 1 showed little or no descaling, injury, or mortality. Most mortalities were due to procedural problems (fish being struck by the gates of the sample-holding tanks).

During initial testing in 1993, a gap had been discovered in the fish and debris separator that allowed fish to strike the exposed ends of pipes used in the construction of a fish size-separation screen (Marsh et al. 1995). This resulted in a characteristic semi-circular descaling pattern. The COE filled the gap in spring 1993, and our testing in 1995 demonstrated that the modification alleviated this particular descaling problem.

Table 2. Results from Objective 1 testing.

A. Release Group 1 - mortality, descaling, and injury for hatchery-reared juvenile spring chinook salmon and steelhead released into the collection and sampling facilities at Lower Monumental Dam in 1994.

Test location and species	Mortality (%)	Descaling (%)	Eye/Head Injury (%)
Yearling chinook salmon			
- Unit 1B	0.5	0.5	0.0
- Unit 3B	0.3	0.0	0.0
- Unit 6C	0.2	0.5	0.2
Yearling steelhead			
- Unit 1B	0.6	0.0	0.4
- Unit 3B	0.2	0.0	0.2
- Unit 6C	0.6	0.0	0.0

B. Release Group 2 - passage time (days) and mortality, descaling, and injury for hatchery adult steelhead released into the collection channel at Lower Monumental Dam in 1994.

			Of fish observed					
			Mortality		Descaling		Eye/Head Injury	
Test species	n	Median passage time (days)	n	(%)	n	(%)	n	(%)
Adult steelhead	14	3.5	0	0.0	1	6.3	1	6.3

C. Release Group 3 - passage time (hours) from the collection channel (Unit 6) to the first PIT-tag detector (located immediately downstream of the fish/debris separator).

	n	Median passage time (hours)	Confidence interval
Yearling chinook salmon	77	0.7	(0.6, 1.1)
Juvenile steelhead	98	2.4	(1.7, 3.0)

Because few adult steelhead fall back at Lower Monumental Dam during the spring, we were unable to perform the adult study (Release Group 2) during the spring 1994 testing period. However, we were able to conduct the test in fall 1994 using adult steelhead from Lyons Ferry Hatchery. Water temperatures were still in the 16-20° C range; therefore, we believed that passage time would not be detrimentally affected by temperature. This testing demonstrated that adult salmonids passed from the collection channel to the separator with little or no negative effects (Table 2 and Appendix Table 2).

Based on the results of similar testing at Little Goose Dam in 1990 (Monk et al. 1992), we expected adults to move through the system quickly; however, we found that the median passage time of the 16 adults recaptured on the separator was 84 hours (Fig. 2). This was over six times longer than the time required at Little Goose Dam. As at Little Goose Dam, we noticed adults holding along the sides of the primary dewatering section.

In addition, passage patterns tended to coincide with weather patterns: most adults crossed the separator during periods of overcast skies, with few fish crossing on clear days. Also, most fish crossed the separator during late night and early morning hours (between 2300 and 0800 hours). Only one fish was observed with any descaling or injuries.

Passage Time Evaluation

Release Group 3 consisted of river-run (actively migrating) yearling spring/summer chinook salmon and juvenile steelhead released into the collection channel at Unit 6C. Fish were released at approximately 1800 hours, and the first steelhead was detected leaving the separator

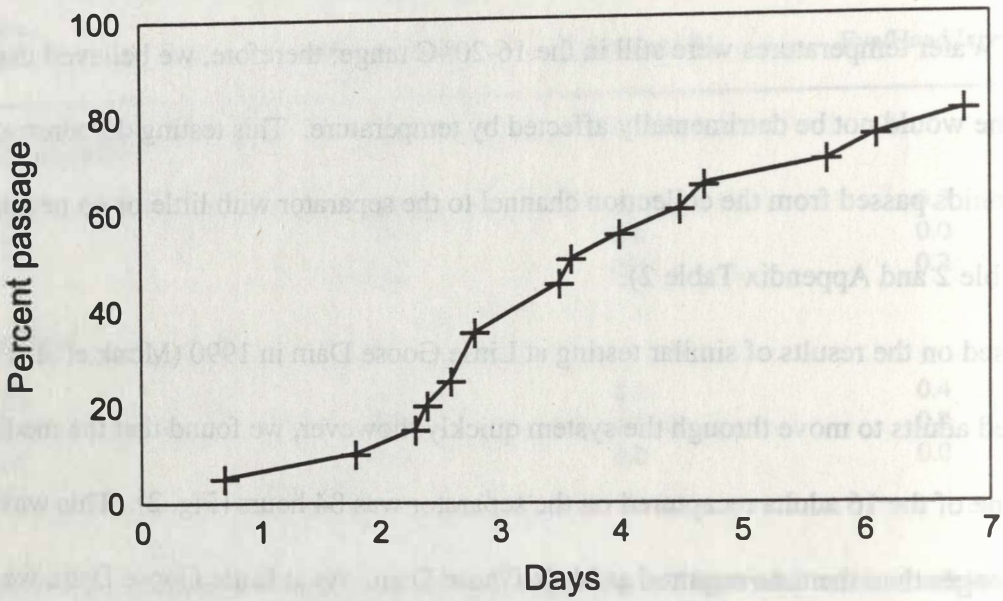

Figure 2. Percent passage of 20 adult steelhead released into the collection channel (Unit 6C) and recaptured on the fish/debris separator at Lower Monumental Dam, October 1994. (Four fish were not observed leaving the channel prior to separator dewaterering.)

approximately 4 minutes later. The first chinook salmon left the separator approximately 10 minutes after release. Median passage times for chinook salmon and steelhead were 0.7 and 2.4 hours, respectively (Table 2 and Appendix Table 3). In contrast, a median passage time of 17.8 hours was recorded for juvenile steelhead passing through the juvenile collection system at McNary Dam. No comparison of chinook salmon is available because no chinook salmon were tested at McNary Dam (Marsh et al. in prep.).

Three main differences between conditions for Lower Monumental and McNary Dam releases may account for this contrast in passage timing observed for steelhead. First, the powerhouse at McNary Dam contains 14 turbine units, and thus its collection channel is over twice as long as the channel at Lower Monumental Dam. Second, the release time was different--while fish at Lower Monumental Dam were released at 1800 hours, fish at McNary Dam were released at 1000 hours. However, inspection of the observation records at both dams indicated that the earlier release time at McNary Dam did not seem to affect passage times. This is because at Lower Monumental Dam, 98% of detected fish had been detected within 24 hours of release, while at McNary dam, only 60% of detected fish were detected within the first 24 hours, and 10% still had not been detected after 48 hours. The third difference was that at McNary Dam, the dewatering unit is inside the dam structure at the downstream end of the collection channel. This makes the dewatering area at McNary Dam darker than at Lower Monumental Dam, where the dewaterer is located on a separate structure away from the dam. Also, an area of extremely low flow exists where the dewaterer transits to the transfer pipe at McNary Dam. The low flow, added to the darker environment, may induce fish to hold longer in this area than in the dewaterer at Lower Monumental Dam.

OBJECTIVE 3

Evaluate the bypass system outfall pipe.

Approach

Fisheries agencies and tribes were concerned that passage through the 76-cm diameter outfall pipe, used to move fish from the facility swing gate to the offshore release site, might be detrimental to juvenile salmonids. Another concern was high water velocity in the pipe and at its terminus. Therefore, we tested the pipe and its associated plunge into the river.

The outfall pipe was designed to discharge water at a rate of 0.85 m^3/s, but it actually discharged water at 1.02 m^3/s. Water velocities were estimated at 10.7 meters per second (mps) in the steepest section of pipe, 4.6 mps at the pipe terminus, and 9.1 mps on entry into the tailrace.

The test required a method to recover test fish from the river after passage through the outfall pipe. In 1993, we attempted to perform this task using a floating recapture-net, which was held in place by a barge (Marsh et al. 1995). This net was too small and resulted in an average net-descaling rate of 23%. We also encountered problems holding the net in place with the barge and crane. Since a larger net would be even more difficult, if not impossible to maneuver, a different recapture system was needed.

In October 1993, we conducted a test at Lower Monumental Dam to determine if a purse seine could be used as a recapture device. Three tests of the purse seine were made using subyearling steelhead from Lyons Ferry Hatchery. Each test involved releasing 100 test fish at the facility swing gate and 100 control fish directly into the seine prior to closure. The efficacy of the purse seine to collect mortalities and injured fish was tested by releasing 100 mortalities with the 100 test fish during the third release.

Unfortunately, results from the first and third releases were compromised--the seine moved out from under the outfall pipe during the first release, and the purse-seine boat drifted over the cork line of the seine while pursing after the third release. However, seining after the second release produced recapture percentages of 85-88%. Based on these results, we decided to use a purse seine as a recapture device to accomplish this objective the following spring.

This test was conducted twice during spring 1994--once using hatchery fish from Dworshak National Fish Hatchery (8-9 April), and a second time (6-8 May) using river-run fish collected at Lower Monumental Dam. For this objective, 4,400 fish of each species were caudal-fin-clipped--2,200 at the upper lobe for use as test fish, and 2,200 at the lower lobe for use as control fish. These numbers were derived from the following formula, and were based on a 3% expected difference between the test and control fish, with an expected net-descaling rate of 5%:

$$n = \frac{8[p_1(1-p_1) + p_2(1-p_2)]}{d^2}$$

where: n = number of fish needed

d = expected detection level

p_1 = net-descaling rate

p_2 = $p_1 + d$

This formula yields $n \approx 1{,}100$ fish. We assumed a purse-seine recapture rate of 50%, which raised the required number for each treatment to 2,200 fish.

To conduct the tests, the outfall pipe was shut off while the purse-seine boats were moved into position under the pipe. A support boat pulled the purse seine under the outfall pipe, the facility was put into bypass mode, and flows in the outfall pipe and tailrace were allowed to stabilize. As the test fish were being released just above the facility swing gate, the purse seine was deployed.

Control fish were released from a boat into the center of the purse seine just prior to its closure, and corks were released with each bucket of test fish. When the purse seine crew could see all of the corks, the purse seine was closed, pursed, and retrieved. Fish were dipped from the closed seine using a sanctuary dip net and placed into troughs containing MS-222 anesthetic. In the troughs, they were examined for descaling and injuries, sorted, and counted.

For the April tests, yearling spring chinook salmon and steelhead from Dworshak National Fish Hatchery that were previously marked during holding at McNary Dam were used. Testing occurred over 2 days, and the primary purposes for this first round of testing were to determine if gross mechanical problems existed within the outfall pipe and to determine if the purse seine would perform as well as during the October 1993 trials.

Three steelhead replicates of 400 test fish, 400 control fish, and 200 moribund fish were released on the first day. The next day we released 3 chinook salmon replicates of 400 test fish, 400 control fish, and 200 moribund fish. A fourth steelhead replicate was released concurrent with the third chinook salmon release. For this replicate, moribund fish were released at the facility switch gate with the test fish to determine the efficiency of the purse seine for collecting injured and dead fish.

Marking for the May tests began on 30 April and lasted until 4 May. Numbers of fish arriving at Lower Monumental Dam decreased each day, especially steelhead. In addition, we competed for fish with another research project that was PIT-tagging chinook salmon. We were able to mark 4,396 chinook salmon and 2,510 steelhead. Because we were unable to mark enough steelhead, tests using this species were run without controls. This decision was based on the premise that chinook salmon are more susceptible to descaling than steelhead, and therefore, the chinook replicates would sufficiently indicate whether any problems existed in the outfall pipe. Because of this, each release consisted of 300 test chinook salmon, 300 test steelhead, and 300 control chinook salmon.

Purse seining began on 6 May at 1000 hours. We were unable to shut down the powerhouse to less than 2 turbine units, so the purse-seine crew was forced to contend with currents around the outfall pipe that were much stronger than expected. During the beginning of the second seine set of the day, the large boat used to deploy and retrieve the purse seine became grounded. During our effort to free the boat, a trough used to examine fish fell overboard, tangled in the seine, and ripped approximately 100 meters of net. The seine crew repaired the net immediately, and testing resumed on 7 May.

On 7 May, while the purse seine was being pursed and retrieved after the second release, it snagged the bottom and was again damaged. The crew again repaired the net and testing continued on 8 May.

On 8 May, we released four replicates, finishing the test. The last replicate was released using all fish remaining in the tanks, but because of time constraints (turbine unit operation was about to return to normal), we were unable to count the test chinook salmon or test steelhead released. All four replicates were successfully recovered by the purse seine.

Results and Discussion

The purpose of the first round of testing (8-9 April) was to determine whether the purse seine would perform as expected. Because we were mainly interested in evaluating the feasibility of the seine as a recapture device, we avoided using river-run fish for this round of testing, and instead used hatchery fish trucked directly from the hatchery.

The results were mixed: while chinook salmon descaling and injury rates were low, recovery rates were also low (Table 3 and Appendix Table 4), averaging 35.3%, 31.8%, and 31.7% for test, control, and moribund fish, respectively. Recovery rates for the first three replicates of steelhead averaged 14.8%, 32.9% and 11.8% for test, control, and moribund fish, respectively. The fourth steelhead replicate, released concurrently with the third chinook salmon replicate, produced the highest recovery rates of all four steelhead replicates.

Overall, the recovery rates observed were well below what we had anticipated based on our fall tests (50-80% recovery rates), and below the 50% recovery rate used in the formula to determine the number of fish needed for statistical validity. However, we did not adjust the number of river-run fish used in May testing because we concluded that the low recovery rates could be attributed to the behavior of hatchery fish: these fish immediately dived to the bottom upon entering the tailrace. We believed that the recovery rates would improve when we ran the tests using river-run fish, because river-run fish tend to be surface oriented.

Table 3. Purse seine recovery rates, mortality, descaling, and injury of hatchery-reared yearling spring chinook salmon and steelhead after passing through the bypass outfall pipe at Lower Monumental Dam, 1994.

Test condition	Percent recovered	Mortality %	Descaling %	Eye/Head Injury %
Yearling chinook salmon				
Replicate #1				
- Outfall pipe	54.5	0.0	0.1	0.0
- Controls	46.0	0.0	0.0	0.1
- Moribund	41.5	0.0	0.0	0.0
Replicate #2				
- Outfall pipe	26.2	0.0	0.1	0.0
- Controls	3.5	0.0	7.1	0.0
- Moribund	32.5	0.0	0.0	0.0
Replicate #3				
- Outfall pipe	25.3	0.0	0.0	0.0
- Controls	45.8	0.0	2.2	0.0
- Moribund	21.0	0.0	0.0	0.0
Yearling steelhead				
Replicate #1				
- Outfall pipe	3.5	0.0	0.0	0.0
- Controls	49.3	0.0	0.2	0.1
- Moribund	2.5	0.0	0.0	0.0
Replicate #2				
- Outfall pipe	14.5	0.0	0.0	1.7
- Controls	27.6	0.0	1.8	1.8
- Moribund	25.0	0.0	0.0	2.0
Replicate #3				
- Outfall pipe	26.3	0.0	0.0	0.0
- Controls	21.8	0.0	0.0	1.1
- Moribund	8.0	0.0	0.0	0.0
Replicate #4				
- Outfall pipe	43.5	0.0	0.0	0.6
- Controls	53.3	0.0	0.0	0.0
- Moribund	32.0	0.0	1.6	0.0

The second round of tests (6-8 May) was hindered by high river discharge. Originally, only two powerhouse units were scheduled to operate during our testing. Instead, four powerhouse units were operated. To alleviate problems associated with higher discharges, the powerhouse load was shifted from Units 1-4 to Units 3-6. This shift provided less current along the north shoreline where the outfall pipe was located, but even with this shift, a strong current existed in the area near the terminus of the outfall pipe.

One of our original concerns with using a purse seine in that area was the presence of shallow shoals on the downstream side of the outfall pipe terminus. The purse-seine crew felt that with strong currents, they might not be able to safely maneuver the boats and net. This concern proved justified during the first 2 days of testing: on the first day, the boat deploying the purse seine ran aground; on the second day, the net snagged the river bottom during recovery.

In both incidences, the purse seine was severely damaged, necessitating several hours of repair work. Fish had not been released when the grounding occurred on the first day; however, on the second day, when the net snagged the river bottom, all three groups of fish in that replicate had been released. Therefore, the second replicate was lost.

While we were marking fish for this round of testing, low numbers of steelhead were arriving at Lower Monumental Dam. Because of this, we were only able to collect and mark half of the steelhead needed for this test. In the tests, control fish were used to isolate the recapture-net effects (descaling, injury, and mortality) on test fish. We anticipated only a 5% descaling rate for spring/summer chinook salmon, and past experience has shown that steelhead descale less easily than spring/summer chinook salmon. Therefore, we decided that releasing control fish would not be a judicious use of our limited number of fish because the effect of the purse seine on steelhead descaling would likely be negligible. In additon, we could not obtain statistically valid data if we had divided the low number of steelhead we had marked. To obtain as much observational data as possible on the effects of the outfall pipe on juvenile steelhead, we decided to release all of the marked steelhead as test fish with no controls.

When filing our Endangered Species Act (ESA) Section 10 permit, we had not requested the taking of fish to serve as moribund fish, so no moribund fish were released during the second round of testing.

Using river-run fish, the average recoveries for chinook salmon and steelhead test fish were 52.3% and 54.7%, respectively (Table 4 and Appendix Table 5). However, average recovery for river-run chinook salmon control fish was only 21.8%, which was lower than for hatchery fish.

Because the powerhouse units were shifted (from Units 1-4 to Units 3-6) for a limited period, we did not have sufficient time to count chinook salmon and steelhead test fish before the last release. The control fish had been counted earlier in the day, as they were held aboard the boat deploying the purse seine. The recapture rate for the chinook salmon control fish on that release was over twice the highest rate of any of the previous five releases.

Descaling rates for the chinook salmon ranged from 0 to 9% for the test fish, and from 0 to 23% for the controls. Steelhead test fish descaling ranged from 0% to 1%. For control fish, descaling rates were highly variable and recovery rates were low. Therefore, the data were not statistically valid. Injury and mortality rates were very low, and again because of poor control fish recovery rates, we were unable to statistically validate the data.

Table 4. Purse seine recovery rates, mortality, descaling, and injury of river-run yearling spring/summer chinook salmon and juvenile steelhead after passing through the bypass outfall pipe at Lower Monumental Dam, 1994.

Test condition	Percent recovered	Mortality %	Descaling %	Eye/Head Injury %
Yearling chinook salmon				
Replicate #1				
- Outfall pipe	69.3	1.4	7.6	0.4
- Controls	11.7	0.0	22.8	0.0
Replicate #2				
- Outfall pipe	29.0	0.0	0.0	0.0
- Controls	19.3	0.0	5.1	0.0
Replicate #3				
- Outfall pipe	47.3	0.7	9.1	0.0
- Controls	20.7	0.0	4.8	0.0
Replicate #4				
- Outfall pipe	53.7	0.0	4.9	0.6
- Controls	24.0	0.0	8.3	0.0
Replicate #5				
- Outfall pipe	62.0	0.0	1.0	0.5
- Controls	0.9	0.0	0.0	0.0
Replicate #6				
- Outfall pipe	----	---	---	---
- Controls	54.0	0.0	1.8	0.0
Juvenile steelhead				
Replicate #1				
- Outfall pipe	57.3	1.1	0.5	0.0
Replicate #2				
- Outfall pipe	59.7	0.0	0.0	0.0
Replicate #3				
- Outfall pipe	65.7	0.5	1.0	0.0
Replicate #4				
- Outfall pipe	55.7	0.0	0.5	0.0
Replicate #5				
- Outfall pipe	35.0	0.0	0.9	0.0
Replicate #6				
- Outfall pipe	----	---	---	---

In summary, although we could not statistically validate our findings on the efficacy of the outfall pipe for safely passing juvenile salmonids, we can draw a conclusion derived strictly from observation. During 2 years of testing, with over 8,000 fish released into the outfall pipe, we did not observe any descaling, injuries, or mortalities that were not attributable to the recapture and handling of the study fish. Therefore, it appears highly likely that the outfall pipe at Lower Monumental Dam is a safe passage route for juvenile salmonids.

OBJECTIVE 4

Evaluate the new PIT-tag detection/diversion system.

Approach

From 1989 to 1991, a Passive Integrated Transponder (PIT) tag detection/diversion system was developed and tested at Lower Granite Dam (Matthews et al. 1990, 1992; Achord et al. 1992). A similar system was incorporated into the new juvenile bypass system at Little Goose Dam in spring 1992. This system was tested in spring 1993 and determined to be fully functional (Harmon et al. 1995).

In spring 1994, testing was conducted on the newly installed PIT-tag detection/diversion system in the juvenile bypass, collection, and transportation facility at Lower Monumental Dam. As at Little Goose, (but not Lower Granite Dam) fish are sorted by size at the Lower Monumental Dam separator and passed to small- or large-fish flumes. Therefore, the two flumes exiting the separator were tested independently.

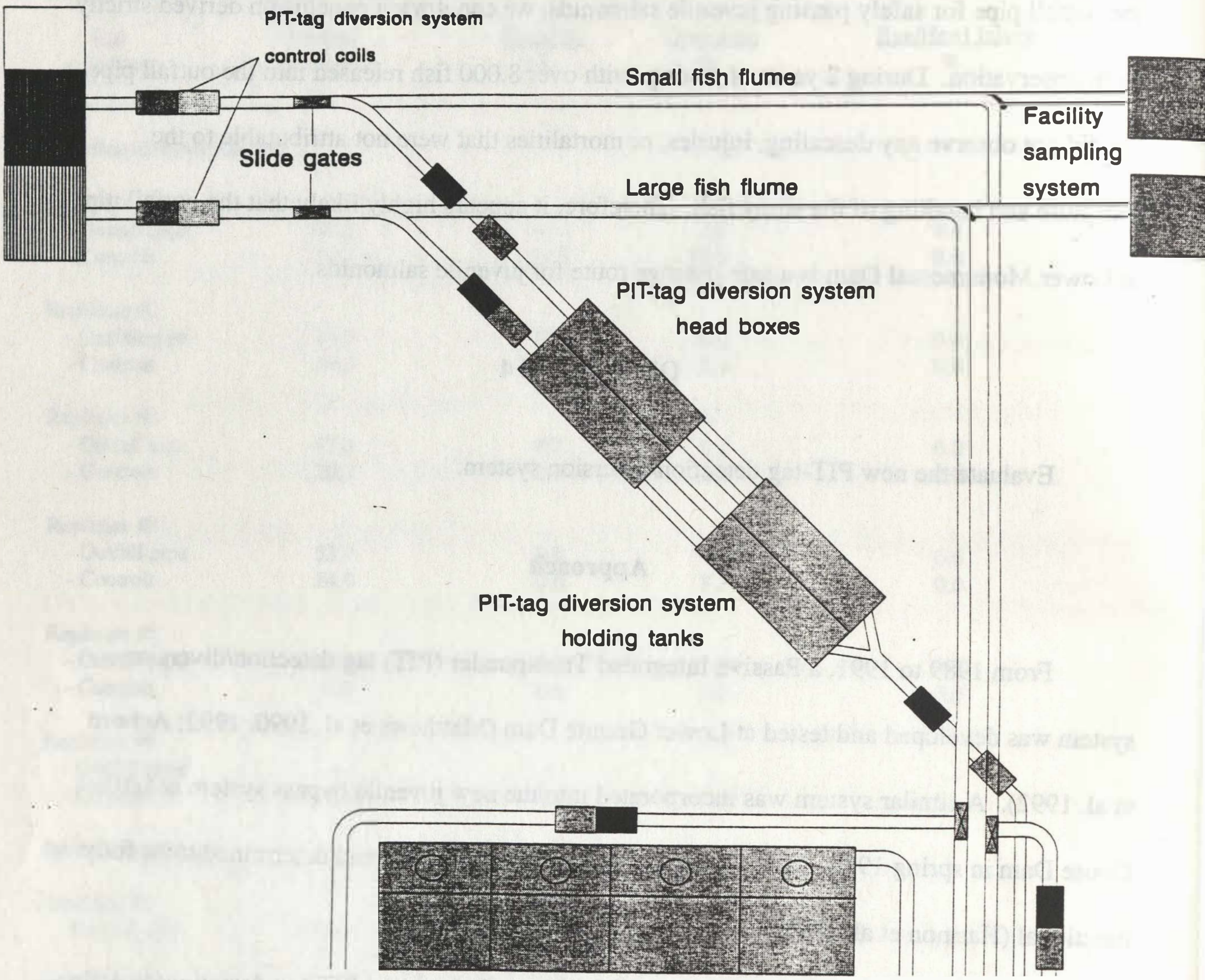

Figure 3. Schematic of the Lower Monumental Dam PIT-tag detection/diversion system, 1994.

At Lower Monumental Dam, after fish exit the fish and debris separator, they pass through four PIT-tag detection coils (Fig. 3). The last two coils control the diversion gate (slide gate) in the bottom of each flume. PIT-tagged fish detected by the last two coils are diverted by the slide gate to a head box. The fish then pass into a holding tank via two 10-cm lines for later release to the river. Untagged fish and undetected PIT-tagged fish pass over the slide gate and continue to the facility sample, to the raceways for possible transport, or are bypassed to the river.

During testing in 1994, we followed procedures established during similar testing at Lower Granite Dam (Matthews et al. 1990, 1992; Achord et al. 1992) and at Little Goose Dam (Harmon et al. 1995). Because high concentrations of PIT-tagged salmonids were passing the dam, hourly tests were planned for non-peak passage hours to decrease the number of endangered or threatened species handled. However, the hourly count of fish passing through the facility (facility count) and the number of slide-gate cycles were not known until after each hourly test was completed. Therefore, peak and non-peak fish passage periods were estimated by using the previous day's facility hourly counts. Testing was also coordinated with National Marine Fisheries Service (NMFS) survival study requirements.

Because the diversion holding tanks were long, narrow, and deep, net-pens (constructed of a PVC-pipe frame with netting attached) were placed in the holding tanks to expedite fish removal and minimize injuries and descaling. A PVC-pipe insert was set into the net-pen to keep the netting taut, and the net-pens were covered to keep fish from jumping out.

Electronic fish counters were located between each head box and the holding tank. To enable electronic fish counters to work, high water levels had to be maintained in the head box and holding tank. On the first day of testing, we observed heavy descaling rates. We attributed this descaling to the large volume of water entering the relatively small net-pen. By plugging one of the two 10-cm lines exiting the head box and lowering the water level in the head box, we significantly decreased descaling.

At the end of each hourly test, fish were crowded out of the head box, the lines were closed, and the PVC-pipe insert was lifted out. The net-pen was then pushed to the rear of the tank, and the empty pen with the insert placed inside was positioned under the line for the next test. The fish were then dipped from the net pens with sanctuary dipnets. They were anesthetized, identified by species, counted, scanned for PIT-tags, and any descaling or injuries were noted for each fish. All PIT-tagged fish were measured (fork length), and weights were recorded for wild, PIT-tagged fish. All fish were placed in the recovery section of the holding tank and held until testing was completed. When they had recovered sufficiently, these fish were released back to the river.

The efficiency of the Lower Monumental Dam PIT-tag detection/diversion system was defined in two ways. The first was the ratio of untagged fish diverted per PIT-tag diversion cycle, as defined during previous tests at Lower Granite and Little Goose Dams. This ratio is a function of the cycle time (the length of time the slide gate is open) and the rate of fish passage through each flume (number of fish per hour); therefore, an expected value for this ratio was estimated. Since there was a mechanical separation of fish passing through the separator, an estimate was made for each flume. The formulas used to estimate the expected values were:

$$\text{Expected value of small fish flume} = \sum_{i=1}^{n} \frac{H_{ai}\,(T_{ai})}{3600n}$$

$$\text{Expected value of large fish flume} = \sum_{i=1}^{n} \frac{H_{bi}\,(T_{bi})}{3600n}$$

where:

n = the number of tests in each grouping

i = 1,...,n

H_{ai} = the expanded hourly facility count for test i for the small-fish flume

H_{bi} = the expanded hourly facility count for test i for the large-fish flume

T_{ai} = the cycle time for small-fish flume

T_{bi} = the cycle time for large-fish flume

These formulas show a linear relationship between the facility count and the expected value. As the facility count increases, the expected values increase proportionally (Achord et al. 1992).

The second efficiency estimate, the system efficiency, was actually composed of two parts, the separation efficiency and the detection efficiency, as shown in the following formulas:

$$\text{Separation Efficency } (E_{SEP}) = \frac{n_D}{n_S}$$

$$\text{System Efficiency } (E_{SYS}) = E_{SEP} \times E_D$$

where: n_D = the number of individual PIT tags detected at the diversion-control coils

n_S = the number of individual PIT tags detected at the diversion-control coils that were subsequently detected on a diversion-system coil

E_D = the detection efficiency of the diversion-control and diversion-system coils; i.e., the ability of the coils to detect a PIT tag passing through them

Results and Discussion

From 28 April to 25 May, 88 and 79 successful hourly tests were performed on the small-fish and large-fish flumes, respectively (Tables 5 and 6, and Appendix Tables 6-9). A few tests were aborted due to electrical and/or mechanical problems. Facility counts for the hours when testing occurred were as high as 7,600 for the small-fish flume and 5,500 for the large-fish flume.

The average number of untagged fish diverted per slide-gate cycle for the small-fish and large-fish flumes was 0.49 and 0.33, respectively (Table 5). The small-fish flume was 97.7% efficient and the large-fish flume was 97.9% efficient at separating detected PIT-tagged fish (Table 6). The small-fish flume had a 94.4% overall efficiency of detecting and separating PIT-tagged fish, while the large-fish flume had a 93.3% overall efficiency for this task (Table 6). Overall, a minimum of 93.0% of all PIT-tagged fish passing through the juvenile bypass system at Lower Monumental Dam were detected and separated by the PIT-tag detection/diversion system.

Descaling rates for the small-fish and large-fish flumes were 20.0% and 13.9%, respectively. The descaling rate for the facility sample was 6.1% for the small-fish flume and

Table 5. Summary of the PIT-tag detection/diversion system test results at Lower Monumental Dam, 1994.

Hourly fish counts	Number of tests	Untagged fish per cycle	Standard error	Expected value
Small-fish flume				
≤ 500	56	0.45	0.06	0.08
501 - 1,000	21	0.44	0.07	0.20
1,001 - 1,500	3	0.34	0.13	0.37
1,501 - 2,000	3	0.54	0.14	0.49
2,001 - 2,500	1	1.00	0.00	0.58
2,501 - 3,000	1	0.89	0.00	0.78
3,001 - 3,500[1]	0	--	--	--
3,501 - 4,000	2	0.53	0.00	1.10
4,001 - 5,000[1]	0	--	--	--
5,001 - 8,000	1	0.43	0.00	2.11
Totals and averages	88	0.49	0.04	0.19
Large-fish flume				
≤ 500	56	0.16	0.03	0.07
501 - 1,000	19	0.44	0.17	0.20
1,001 - 1,500	3	1.18	1.33	0.31
1,501 - 4,000[1]	0	--	--	--
4,001 - 6,000	1	0.52	0.00	1.53
Totals and averages	79	0.33	0.07	0.13

[1] No tests were conducted in this range of hourly counts

Table 6. Efficiencies of the PIT-tag detection/diversion system at Lower Monumental Dam, 1994.

	Total number detected	Total number detected and separated	Percent efficiency
Separation efficiency - separation of a detected fish			
Small-fish flume	1,679	1,641	97.7
Large-fish flume	1,013	992	97.9
System efficiency - detection and separation of a fish			
Small-fish flume	1,679	1,585	94.4
Large-fish flume	1,013	945	93.3

5.3% for the large-fish flume. Though descaling rates were higher in the PIT-tag detection/diversion system samples than in the facility samples, they were comparable to rates observed at Little Goose Dam in 1993 (Harmon et al. 1995) and at Lower Granite in 1991 (Achord et al. 1992). The higher rates were probably caused by fish having passed two upstream hydroelectric dams, handling during testing, and handling from other research projects upstream. No direct slide-gate-induced injuries or mortalities were observed.

Few electronic, mechanical, or procedural problems were encountered during testing. Of those that did occur, all were corrected prior to the end of testing. The Corps of Engineers biologist was notified of these problems and corrections.

Overall results of the PIT-tag detection/diversion system tests indicated that the system operated with a high level of efficiency. These results were comparable to the 1991 testing at Lower Granite Dam and the 1993 testing at Little Goose Dam. The Lower Monumental Dam system is ready for use in research or monitoring programs.

CONCLUSIONS

1. Based on the tests conducted, the new bypass, collection, and transportation facility at Lower Monumental Dam appears to safely pass fish around the dam.
2. The PIT-tag detection/diversion system at Lower Monumental Dam is ready for use in monitoring or research programs.

RECOMMENDATIONS

1. All elements of this evaluation have been addressed and there is no need for additional testing.

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APPENDIX

Data Tables

Appendix Table 1. Recoveries, descaling, injuries, and mortality of hatchery yearling spring chinook salmon and steelhead released into the collection and sampling facilities at Lower Monumental Dam, 1994 (Objective 1).

Location	Number of fish				
	Released	Collected	Mortalities	Descaled	Injured
Release Group 1 - Collection channel to laboratory					
Yearling chinook salmon					
- Unit 1B					
- Replicate 1	200				
- 24 hours		156	0	0	0
- 48 hours		18	0	1	0
- 72 hours		9	0	0	0
- 96 hours		0	0	0	0
- 120 hours		1	0	0	0
- Replicate 2	200				
- 24 hours		125	2	0	0
- 48 hours		68	0	0	0
- Unit 3B					
- Replicate 1	200				
- 24 hours		122	0	0	0
- 48 hours		25	0	0	0
- 72 hours		8	0	0	1
- Replicate 2	200				
- 24 hours		117	1	0	0
- 48 hours		70	0	0	0
- 72 hours		3	0	0	0
- Unit 6C					
- Replicate 1	200				
- 24 hours		106	0	0	1
- 48 hours		43	0	2	0
- 72 hours		41	0	0	0
- 96 hours		9	0	0	0
- 120 hours		1	0	0	0
- 144 hours		2	0	0	0
- 168 hours		1	0	0	0
- Replicate 2	200				
- 24 hours		115	1	0	0
- 48 hours		87	0	0	0
- 72 hours		11	0	0	0
- 96 hours		3	0	0	0
- 120 hours		4	0	0	0
- 144 hours		2	0	0	0

Appendix Table 1. Continued.

Location	Released	Collected	Mortalities	Descaled	Injured
		Number of fish			
Yearling steelhead					
- Unit 1B					
- Replicate 1	200				
- 24 hours		169	1	0	0
- 48 hours		34	1	0	0
- 72 hours		41	0	0	2
- 96 hours		12	0	0	0
- 120 hours		1	0	0	0
- 144 hours		12	0	0	0
- 168 hours		6	0	0	0
- Replicate 2	200				
- 24 hours		123	1	0	0
- 48 hours		71	0	0	0
- 72 hours		25	0	0	0
- 96 hours		3	0	0	0
- 120 hours		10	0	0	0
- 144 hours		2	0	0	0
- Unit 3B					
- Replicate 1	200				
- 24 hours		143	0	0	0
- 48 hours		47	1	0	0
- 72 hours		26	0	0	1
- 96 hours		11	0	0	0
- 120 hours		3	0	0	0
- 144 hours		11	0	0	0
- 168 hours		2	0	0	0
- 192 hours		1	0	0	0
- Replicate 2	200				
- 24 hours		96	0	0	0
- 48 hours		47	0	0	0
- 72 hours		27	0	0	0
- 96 hours		7	0	0	0
- 120 hours		16	0	0	0
- 144 hours		8	0	0	0
- Unit 6C					
- Replicate 1	200				
- 24 hours		146	1	0	0
- 48 hours		32	0	0	0
- 72 hours		25	0	0	0
- 96 hours		12	0	0	0
- 120 hours		4	0	0	0
- 144 hours		7	0	0	0
- 168 hours		7	0	0	0
- 192 hours		0	0	0	0
- 216 hours		1	0	0	0

Appendix Table 1. Continued.

Location	Number of fish: Released	Collected	Mortalities	Descaled	Injured
- Unit 6C (continued)					
- Replicate 2	200				
- 24 hours		106	1	0	0
- 48 hours		70	1	0	0
- 72 hours		44	0	0	0
- 96 hours		13	0	0	0
- 120 hours		27	0	0	0
- 144 hours		24	0	0	0
- 168 hours		1	0	0	0
- 192 hours		1	0	0	0

Appendix Table 2. Passage times, descaling, injuries and mortalities for adult steelhead released and recovered at Lower Monumental Dam, 1994.

Tag code	Length (cm)	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)	Descaling	Injury	Mortality
L-PY	60.5	10/24	11:30	--	--	--	-	-	-
L-BLY	64	10/24	11:30	--	--	--	-	-	-
L-YN	66	10/24	11:43	10/29	3:20	4.65	N	N	N
L-OY	60	10/24	11:43	10/28	23:28	4.49	N	N	N
L-RY	63	10/24	11:55	--	--	--	-	-	-
L-WY	69.5	10/24	14:18	10/25	7:15	0.71	N	N	N
L-GNY	65	10/24	14:18	10/26	23:40	2.39	N	N	N
L-BRN	60.5	10/24	14:28	10/28	14:25	4.00	N	N	N
L-ON	59	10/24	14:28	10/28	2:45	3.51	N	N	N
L-YY	62	10/24	14:39	10/30	7:50	5.72	N	N	N
R-OY	64.5	10/25	10:45	10/28	5:20	2.77	N	N	N
R-PN	60.5	10/25	10:45	10/27	17:06	2.26	N	N	N
R-YY	60	10/25	11:01	10/29	0:20	3.55	N	N	N
R-WY	61	10/25	11:01	10/31	14:00	6.12	N	N	N
R-BLN	66.5	10/25	11:12	--	--	--	-	-	-
R-RN	62	10/25	11:12	11/01	7:10	6.83	N	N	N
R-PY	62	10/25	13:02	10/29	0:05	3.46	Y	Y	N
R-GYY	63	10/25	13:02	10/27	9:05	1.84	N	N	N
R-GYN	58	10/25	13:14	10/28	4:15	2.63	N	N	N
R-WN	58	10/25	13:14	10/28	7:45	2.77	N	N	N

Appendix Table 3. Passage times for river-run yearling spring/summer chinook salmon and juvenile steelhead marked and released at Lower Monumental Dam, 1994.

PIT tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
Yearling spring/summer chinook salmon:					
7F7F4A5F4B	05/06	16:52	05/06	17:02	0.007
7F7F564735	05/06	16:52	05/06	17:02	0.007
7F7F595725	05/06	16:52	05/06	17:03	0.008
7F7F506B40	05/06	16:52	05/06	17:03	0.008
7F7F534B7F	05/06	16:52	05/06	17:03	0.008
7F7F535632	05/06	16:52	05/06	17:04	0.008
7F7F3E7B29	05/06	16:52	05/06	17:04	0.008
7F7F564758	05/06	16:52	05/06	17:04	0.008
7F7F506D27	05/06	16:52	05/06	17:05	0.009
7F7F534459	05/06	16:52	05/06	17:05	0.009
7F7F494924	05/06	16:52	05/06	17:06	0.010
7F7F594D59	05/06	16:52	05/06	17:08	0.011
7F7F56557B	05/06	16:52	05/06	17:10	0.012
7F7F493C3D	05/06	16:52	05/06	17:11	0.013
7F7F564672	05/06	16:52	05/06	17:14	0.015
7F7F494058	05/06	16:52	05/06	17:15	0.016
7F7F56546A	05/06	16:52	05/06	17:15	0.016
7F7F56412A	05/06	16:52	05/06	17:17	0.017
7F7F493A7D	05/06	16:52	05/06	17:21	0.020
7F7F552121	05/06	16:52	05/06	17:21	0.020
7F7F564C62	05/06	16:52	05/06	17:21	0.020
7F7F530F28	05/06	16:52	05/06	17:23	0.022
7F7F493B52	05/06	16:52	05/06	17:23	0.022
7F7F595926	05/06	16:52	05/06	17:24	0.022
7F7F542554	05/06	16:52	05/06	17:25	0.023
7F7F527B34	05/06	16:52	05/06	17:25	0.023
7F7F505F55	05/06	16:52	05/06	17:25	0.023
7F7F564922	05/06	16:52	05/06	17:26	0.024
7F7F53154E	05/06	16:52	05/06	17:26	0.024
7F7F526659	05/06	16:52	05/06	17:26	0.024
7F7F565932	05/06	16:52	05/06	17:27	0.024
7F7F595C28	05/06	16:52	05/06	17:28	0.025
7F7F494772	05/06	16:52	05/06	17:29	0.026
7F7F575118	05/06	16:52	05/06	17:29	0.026

Appendix Table 3. Continued.

PIT tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
7F7F526E0E	05/06	16:52	05/06	17:29	0.026
7F7F564319	05/06	16:52	05/06	17:29	0.026
7F7F3E7D2E	05/06	16:52	05/06	17:29	0.026
7F7F565652	05/06	16:52	05/06	17:29	0.026
7F7F564673	05/06	16:52	05/06	17:34	0.029
7F7F492C1D	05/06	16:52	05/06	17:35	0.030
7F7F50594A	05/06	16:52	05/06	17:36	0.031
7F7F56471B	05/06	16:52	05/06	17:40	0.033
7F7F595276	05/06	16:52	05/06	17:42	0.035
7F7F4E041F	05/06	16:52	05/06	17:46	0.037
7F7F594028	05/06	16:52	05/06	17:47	0.038
7F7F53024B	05/06	16:52	05/06	17:48	0.039
7F7F596E5D	05/06	16:52	05/06	17:48	0.039
7F7F565E6F	05/06	16:52	05/06	17:56	0.044
7F7F541136	05/06	16:52	05/06	18:02	0.049
7F7F526E2C	05/06	16:52	05/06	18:02	0.049
7F7F506727	05/06	16:52	05/06	18:03	0.049
7F7F58113B	05/06	16:52	05/06	18:04	0.050
7F7F506B75	05/06	16:52	05/06	18:05	0.051
7F7F54123F	05/06	16:52	05/06	18:06	0.051
7F7F492678	05/06	16:52	05/06	18:07	0.052
7F7F56423F	05/06	16:52	05/06	18:08	0.053
7F7F527672	05/06	16:52	05/06	18:16	0.058
7F7F597279	05/06	16:52	05/06	18:21	0.062
7F7F493C14	05/06	16:52	05/06	18:31	0.069
7F7F506E36	05/06	16:52	05/06	18:44	0.078
7F7F504D5D	05/06	16:52	05/06	18:46	0.079
7F7F596E11	05/06	16:52	05/06	18:53	0.084
7F7F535606	05/06	16:52	05/06	19:00	0.089
7F7F50636D	05/06	16:52	05/06	19:10	0.096
7F7F560936	05/06	16:52	05/06	19:19	0.102
7F7F594A1C	05/06	16:52	05/06	19:38	0.115
7F7F565A72	05/06	16:52	05/06	19:43	0.119
7F7F54263A	05/06	16:52	05/06	19:44	0.119
7F7F59407F	05/06	16:52	05/06	19:47	0.122
7F7F3F011A	05/06	16:52	05/06	20:12	0.139
7F7F595875	05/06	16:52	05/06	20:16	0.142
7F7F4B2A42	05/06	16:52	05/06	21:29	0.192
7F7F4B1B3B	05/06	16:52	05/06	21:41	0.201

Appendix Table 3. Continued.

PIT tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
7F7F504F24	05/06	16:52	05/06	21:53	0.209
7F7F594154	05/06	16:52	05/06	22:26	0.232
7F7F594169	05/06	16:52	05/07	11:01	0.756
7F7F4B3634	05/06	16:52	05/07	14:26	0.899
<u>Juvenile steelhead:</u>					
7F7F541C05	05/06	17:07	05/06	16:59	-0.006
7F7F596C61	05/06	17:07	05/06	17:11	0.003
7F7F565A1A	05/06	17:07	05/06	17:12	0.003
7F7F54107D	05/06	17:07	05/06	17:13	0.004
7F7F50537E	05/06	17:07	05/06	17:14	0.005
7F7F541A33	05/06	17:07	05/06	17:15	0.006
7F7F59754E	05/06	17:07	05/06	17:28	0.015
7F7F582D60	05/06	17:07	05/06	17:29	0.015
7F7F531818	05/06	17:07	05/06	17:34	0.019
7F7F50672A	05/06	17:07	05/06	17:35	0.019
7F7F506D15	05/06	17:07	05/06	17:36	0.020
7F7F565A6F	05/06	17:07	05/06	17:38	0.022
7F7F507068	05/06	17:07	05/06	17:39	0.022
7F7F4C2633	05/06	17:07	05/06	17:43	0.025
7F7F54216D	05/06	17:07	05/06	17:44	0.026
7F7F4A6B7E	05/06	17:07	05/06	17:44	0.026
7F7F4D6D5B	05/06	17:07	05/06	17:45	0.026
7F7F493A2B	05/06	17:07	05/06	17:49	0.029
7F7F596B7A	05/06	17:07	05/06	17:49	0.029
7F7F59461A	05/06	17:07	05/06	17:51	0.031
7F7F54220A	05/06	17:07	05/06	17:52	0.031
7F7F59722D	05/06	17:07	05/06	17:53	0.032
7F7F4B0D3D	05/06	17:07	05/06	17:57	0.035
7F7F541F09	05/06	17:07	05/06	18:00	0.037
7F7F564168	05/06	17:07	05/06	18:00	0.037
7F7F56481E	05/06	17:07	05/06	18:01	0.038
7F7F504E35	05/06	17:07	05/06	18:01	0.038
7F7F50736D	05/06	17:07	05/06	18:02	0.038
7F7F50694D	05/06	17:07	05/06	18:03	0.039
7F7F56596D	05/06	17:07	05/06	18:05	0.040
7F7F493427	05/06	17:07	05/06	18:08	0.042
7F7F542A50	05/06	17:07	05/06	18:13	0.046

Appendix Table 3. Continued.

PIT tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
7F7F506873	05/06	17:07	05/06	18:29	0.057
7F7F43743A	05/06	17:07	05/06	18:29	0.057
7F7F56581B	05/06	17:07	05/06	18:30	0.058
7F7F494548	05/06	17:07	05/06	18:36	0.062
7F7F54146E	05/06	17:07	05/06	18:40	0.065
7F7F564E50	05/06	17:07	05/06	18:46	0.069
7F7F505F4D	05/06	17:07	05/06	18:47	0.069
7F7F4B1540	05/06	17:07	05/06	18:49	0.071
7F7F50730F	05/06	17:07	05/06	18:54	0.074
7F7F493A22	05/06	17:07	05/06	19:00	0.078
7F7F535963	05/06	17:07	05/06	19:04	0.081
7F7F582F7F	05/06	17:07	05/06	19:09	0.085
7F7F541412	05/06	17:07	05/06	19:11	0.086
7F7F59755D	05/06	17:07	05/06	19:15	0.089
7F7F49471D	05/06	17:07	05/06	19:23	0.094
7F7F4B302B	05/06	17:07	05/06	19:23	0.094
7F7F540B29	05/06	17:07	05/06	19:27	0.097
7F7F49406F	05/06	17:07	05/06	19:35	0.103
7F7F540778	05/06	17:07	05/06	19:36	0.103
7F7F49270B	05/06	17:07	05/06	19:50	0.113
7F7F506322	05/06	17:07	05/06	19:51	0.114
7F7F493F19	05/06	17:07	05/06	19:51	0.114
7F7F4F3B5A	05/06	17:07	05/06	19:54	0.116
7F7F553334	05/06	17:07	05/06	19:55	0.117
7F7F526F1B	05/06	17:07	05/06	19:55	0.117
7F7F551F3E	05/06	17:07	05/06	19:59	0.119
7F7F54170C	05/06	17:07	05/06	20:04	0.123
7F7F530D2E	05/06	17:07	05/06	20:04	0.123
7F7F535C6C	05/06	17:07	05/06	20:05	0.124
7F7F59564F	05/06	17:07	05/06	20:07	0.125
7F7F506765	05/06	17:07	05/06	20:08	0.126
7F7F50597A	05/06	17:07	05/06	20:08	0.126
7F7F540811	05/06	17:07	05/06	20:14	0.130
7F7F49333A	05/06	17:07	05/06	20:15	0.131
7F7F3E7E46	05/06	17:07	05/06	20:24	0.137
7F7F4B584F	05/06	17:07	05/06	20:36	0.145
7F7F526D52	05/06	17:07	05/06	21:03	0.164
7F7F527824	05/06	17:07	05/06	21:04	0.165
7F7F597439	05/06	17:07	05/06	21:31	0.183

Appendix Table 3. Continued.

PIT tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
7F7F595729	05/06	17:07	05/06	21:31	0.183
7F7F492B1A	05/06	17:07	05/06	21:43	0.192
7F7F527A1A	05/06	17:07	05/06	22:06	0.208
7F7F505D6A	05/06	17:07	05/06	22:14	0.213
7F7F596C6F	05/06	17:07	05/06	22:21	0.218
7F7F582D0C	05/06	17:07	05/06	22:25	0.221
7F7F504F48	05/06	17:07	05/06	22:25	0.221
7F7F4C1B04	05/06	17:07	05/06	22:44	0.234
7F7F564872	05/06	17:07	05/06	23:18	0.258
7F7F494777	05/06	17:07	05/07	0:17	0.299
7F7F564C17	05/06	17:07	05/07	0:52	0.323
7F7F493652	05/06	17:07	05/07	2:57	0.410
7F7F593D29	05/06	17:07	05/07	3:04	0.415
7F7F565C19	05/06	17:07	05/07	3:16	0.423
7F7F56585A	05/06	17:07	05/07	3:38	0.438
7F7F50736C	05/06	17:07	05/07	3:52	0.448
7F7F56467C	05/06	17:07	05/07	4:31	0.475
7F7F530057	05/06	17:07	05/07	5:02	0.497
7F7F56412C	05/06	17:07	05/07	5:04	0.498
7F7F505419	05/06	17:07	05/07	8:01	0.621
7F7F542B19	05/06	17:07	05/07	9:52	0.698
7F7F565B09	05/06	17:07	05/07	12:27	0.806
7F7F493823	05/06	17:07	05/07	13:26	0.847
7F7F506B41	05/06	17:07	05/07	15:28	0.931
7F7F506B2C	05/06	17:07	05/07	15:40	0.940
7F7F54247D	05/06	17:07	05/07	23:16	1.256
7F7F565412	05/06	17:07	05/08	6:04	1.540

Appendix Table 4. Release and recovery numbers, and descaling, injuries, and mortalities from the purse-seine testing of the Lower Monumental Dam outfall pipe, using hatchery-reared yearling spring chinook salmon and steelhead, 1994.

Test cond.	Number released	Number recovered	Mortality N	Mortality %	Descaling N	Descaling %	Eye/Head injury N	Eye/Head injury %
Yearling chinook salmon								
Outfall Pipe:								
Rep. #1	400	218	0	0.0	2	0.1	0	0.0
Rep. #2	400	105	0	0.0	1	0.1	0	0.0
Rep. #3	400	101	0	0.0	0	0.1	0	0.0
Controls:								
Rep. #1	400	184	0	0.0	0	0.0	1	0.1
Rep. #2	400	14	0	0.0	1	7.1	0	0.0
Rep. #3	400	183	0	0.0	4	2.2	0	0.0
Moribund (released through outfall pipe):								
Rep. #1	200	83	0	0.0	0	0.0	0	0.0
Rep. #2	200	65	0	0.0	0	0.0	0	0.0
Rep. #3	200	42	0	0.0	0	0.0	0	0.0
Yearling steelhead								
Outfall Pipe:								
Rep. #1	394	14	0	0.0	0	0.0	0	0.0
Rep. #2	400	58	0	0.0	0	0.0	1	1.7
Rep. #3	400	105	0	0.0	0	0.0	0	0.0
Rep. #4	400	174	0	0.0	0	0.0	1	0.6
Controls:								
Rep. #1	400	184	0	0.0	3	1.5	1	0.5
Rep. #2	399	14	0	0.0	2	1.8	2	1.8
Rep. #3	400	183	0	0.0	0	0.0	1	1.1
Rep. #4	379	202	0	0.0	0	0.0	0	0.0
Moribund (released through outfall pipe):								
Rep. #1	200	83	0	0.0	0	0.0	0	0.0
Rep. #2	200	65	0	0.0	0	0.0	1	2.0
Rep. #3	200	42	0	0.0	0	0.0	0	0.0
Rep. #4	200	64	0	0.0	1	1.6	0	0.0

Appendix Table 5. Release and recovery numbers, and descaling, injuries, and mortalities from the purse-seine testing of the Lower Monumental Dam outfall pipe, using river-run yearling spring chinook salmon and juvenile steelhead, 1994.

Test cond.	Number released	Number recovered	Mortality N	Mortality %	Descaling N	Descaling %	Eye/Head injury N	Eye/Head injury %
<u>Yearling chinook salmon</u>								
Outfall pipe:								
Rep. #1	300	208	3	1.4	16	7.6	1	0.4
Rep. #2	300	87	0	0.0	0	0.0	0	0.0
Rep. #3	300	142	1	0.7	13	9.1	0	0.0
Rep. #4	300	161	0	0.0	8	4.9	1	0.6
Rep. #5	300	186	0	0.0	2	1.0	1	0.5
Rep. #6	---	33	0	0.0	0	0.0	0	0.0
Totals		817	4	0.5	39	4.8	3	0.4
Controls:								
Rep. #1	300	35	0	0.0	8	22.8	0	0.0
Rep. #2	300	58	0	0.0	3	5.1	0	0.0
Rep. #3	300	62	0	0.0	3	4.8	0	0.0
Rep. #4	300	72	0	0.0	6	8.3	0	0.0
Rep. #5	327	3	0	0.0	0	0.0	0	0.0
Rep. #6	---	162	0	0.0	3	1.8	0	0.0
Totals		392	0	0.0	23	5.9	0	0.0
<u>Yearling steelhead</u>								
Outfall Pipe:								
Rep. #1	300	172	2	1.1	1	0.5	0	0.0
Rep. #2	300	179	0	0.0	0	0.0	0	0.0
Rep. #3	300	197	1	0.5	2	1.0	0	0.0
Rep. #4	300	167	0	0.0	1	0.5	0	0.0
Rep. #5	300	105	0	0.0	1	0.9	0	0.0
Rep. #6	---	224	1	0.4	0	0.0	0	0.0
Totals		1,044	4	0.4	5	0.5	0	0.0

Appendix Table 6. Numbers of PIT-tagged and nontagged fish diverted per hourly test of the small-fish flume PIT-tag detection/diversion system at Lower Monumental Dam, 1994.

Test date	Test time	Tagged chinook	Tagged steelhead	Total tagged	Untagged chinook	Untagged steelhead	Total untagged	Number of cycles	Untagged per cycle
28 APR	0800	11	2	13	7	1	8	7	1.14
28 APR	0900	4	1	5	9	1	10	10	1.00
28 APR	1000	22	3	25	2	0	2	18	0.11
28 APR	1100	10	3	13	7	2	9	15	0.60
28 APR	1200	11	1	12	7	0	7	5	1.40
28 APR	1300	8	1	9	9	3	12	11	1.09
29 APR	1200	9	3	12	4	2	6	13	0.46
29 APR	1300	6	0	6	0	1	1	5	0.20
30 APR	0800	7	2	9	0	1	1	9	0.11
30 APR	0900	8	3	11	4	0	4	12	0.33
30 APR	1000	14	7	21	15	0	15	21	0.71
30 APR	1100	14	11	25	10	1	11	25	0.44
30 APR	1200	9	1	10	6	1	7	10	0.70
30 APR	1300	9	1	10	14	3	17	12	1.42
02 MAY	0800	13	4	17	1	1	2	16	0.13
02 MAY	0900	8	6	14	2	1	3	15	0.20
02 MAY	1000	11	8	19	9	2	11	18	0.61
02 MAY	1100	9	6	15	2	2	4	15	0.27
02 MAY	1200	10	2	12	2	1	3	12	0.25
02 MAY	1300	8	1	9	2	2	4	9	0.44
03 MAY	1300	9	0	9	2	0	2	9	0.22
03 MAY	1400	3	2	5	0	1	1	4	0.25
03 MAY	1500	6	4	10	1	2	3	12	0.25
03 MAY	1600	9	0	9	3	1	4	9	0.44
03 MAY	1700	6	0	6	1	0	1	5	0.20
03 MAY	1800	3	1	4	1	0	1	4	0.25
04 MAY	1300	5	6	11	0	0	0	11	0.00
04 MAY	1400	5	3	8	3	2	5	9	0.56
04 MAY	1500	9	3	12	1	1	2	11	0.18
04 MAY	1600	5	0	5	0	0	0	5	0.00
04 MAY	1700	7	8	15	6	0	6	16	0.38
04 MAY	1800	12	9	21	5	5	10	23	0.43
05 MAY	1300	18	10	28	7	3	10	29	0.34
05 MAY	1400	21	4	25	7	4	11	25	0.44
05 MAY	1500	13	9	22	6	4	10	21	0.48
05 MAY	1600	7	6	13	2	1	3	13	0.23
05 MAY	1700	12	4	16	7	3	10	17	0.59
05 MAY	1800	7	0	7	2	0	2	8	0.25
06 MAY	1500	8	5	13	2	0	2	14	0.14
06 MAY	1600	33	4	37	8	6	14	36	0.39
06 MAY	1700	32	15	47	13	0	13	49	0.27
06 MAY	1800	15	9	24	6	2	8	23	0.35
06 MAY	1900	9	8	17	8	1	9	22	0.41
06 MAY	2000	38	7	45	29	4	33	46	0.72
07 MAY	1500	21	5	26	53	10	63	25	2.52
07 MAY	1600	6	1	7	1	0	1	8	0.13
07 MAY	1700	6	4	10	1	0	1	10	0.10
07 MAY	1800	3	0	3	0	0	0	2	0.00
07 MAY	1900	5	0	5	3	0	3	8	0.38
07 MAY	2000	13	3	16	3	0	3	17	0.18
08 MAY	1500	41	0	41	12	4	16	41	0.39
08 MAY	1600	30	7	37	15	2	17	36	0.47
08 MAY	1700	31	2	33	6	2	8	33	0.24
08 MAY	1800	16	2	18	2	0	2	19	0.11
08 MAY	1900	27	3	30	9	1	10	33	0.30
08 MAY	2000	31	3	34	13	2	15	38	0.39
09 MAY	1500	27	7	34	10	5	15	35	0.43
09 MAY	1600	30	6	36	17	2	19	38	0.50
09 MAY	1700	16	2	18	7	0	7	21	0.33

Appendix Table 6. Continued.

Test date	Test time	Tagged chinook	Tagged steelhead	Total tagged	Untagged chinook	Untagged steelhead	Total untagged	Number of cycles	Untagged per cycle
09 MAY	1800	20	6	26	4	0	4	22	0.18
09 MAY	1900	14	2	16	4	4	8	17	0.47
09 MAY	2000	33	4	37	10	0	10	38	0.26
10 MAY	1000	41	12	53	26	6	32	54	0.59
10 MAY	1100	26	21	47	15	6	21	47	0.45
10 MAY	1200	23	20	43	21	18	39	44	0.89
10 MAY	1400	26	14	40	42	16	58	41	1.14
10 MAY	1500	44	6	50	18	4	22	51	0.43
11 MAY	0900	27	15	42	13	6	19	43	0.44
11 MAY	1000	53	26	79	67	14	81	81	1.00
11 MAY	1200	28	19	47	25	9	34	49	0.69
23 MAY	0900	1	4	5	0	0	0	5	0.00
23 MAY	1000	3	5	8	1	0	1	9	0.11
23 MAY	1100	4	9	13	1	0	1	12	0.08
23 MAY	1200	2	7	9	0	0	0	8	0.00
23 MAY	1300	1	3	4	0	0	0	5	0.00
23 MAY	1400	3	4	7	1	0	1	8	0.13
24 MAY	0800	2	9	11	1	0	1	10	0.10
24 MAY	0900	0	10	10	0	0	0	12	0.00
24 MAY	1000	2	8	10	0	0	0	10	0.00
24 MAY	1100	1	9	10	0	1	1	10	0.10
24 MAY	1200	0	11	11	2	2	4	11	0.36
24 MAY	1300	0	2	2	0	0	0	3	0.00
25 MAY	0800	2	3	5	0	0	0	5	0.00
25 MAY	0900	0	9	9	0	0	0	9	0.00
25 MAY	1000	1	1	2	0	0	0	4	0.00
25 MAY	1100	3	7	10	0	1	1	10	0.10
25 MAY	1200	2	10	12	0	1	1	11	0.09
25 MAY	1300	1	6	7	0	0	0	7	0.00
Totals		1,159	490	1,649	635	181	816	1,679	
Average/test		13	5	18	7	2	9	19	0.49

Appendix Table 7. Numbers of PIT-tagged and nontagged fish diverted per hourly test of the large-fish flume PIT-tag detection/diversion system at Lower Monumental Dam, 1994.

Test date	Test time	Tagged chinook	Tagged steelhead	Total tagged	Untagged chinook	Untagged steelhead	Total untagged	Number of cycles	Untagged per cycle
28 APR	0800	10	0	10	0	0	0	4	0.00
28 APR	0900	7	3	10	1	0	1	7	0.14
28 APR	1000	9	1	10	5	5	10	13	0.77
28 APR	1100	9	3	12	2	2	4	10	0.40
28 APR	1200	2	1	3	0	0	0	5	0.00
28 APR	1300	5	1	6	3	0	3	2	1.50
29 APR	1200	8	2	10	1	2	3	9	0.33
29 APR	1300	2	3	5	4	1	5	5	1.00
30 APR	0800	13	3	16	37	39	76	18	4.22
30 APR	0900	4	0	4	0	0	0	5	0.00
30 APR	1000	7	2	9	0	1	1	8	0.13
30 APR	1100	8	2	10	1	3	4	13	0.31
30 APR	1200	2	4	6	0	1	1	5	0.20
30 APR	1300	6	2	8	1	1	2	11	0.18
02 MAY	0800	3	3	6	1	2	3	16	0.19
02 MAY	0900	10	4	14	5	1	6	17	0.35
02 MAY	1000	13	4	17	2	5	7	20	0.35
02 MAY	1100	7	2	9	2	2	4	12	0.33
02 MAY	1200	4	1	5	0	0	0	10	0.00
02 MAY	1300	5	0	5	0	0	0	7	0.00
03 MAY	1300	1	4	5	2	0	2	7	0.29
03 MAY	1400	4	2	6	1	1	2	12	0.17
03 MAY	1500	2	2	4	0	1	1	12	0.08
03 MAY	1600	2	1	3	0	0	0	3	0.00
03 MAY	1700	4	2	6	1	0	1	9	0.11
03 MAY	1800	3	2	5	1	0	1	9	0.11
04 MAY	1300	1	4	5	1	0	1	7	0.14
05 MAY	1300	6	5	11	2	2	4	11	0.36
05 MAY	1400	4	5	9	0	0	0	7	0.00
05 MAY	1500	5	8	13	2	2	4	17	0.24
05 MAY	1600	6	4	10	0	1	1	8	0.13
05 MAY	1700	4	5	9	5	21	26	8	3.25
05 MAY	1800	1	0	1	0	1	1	3	0.33
06 MAY	1500	3	1	4	0	1	1	5	0.20
06 MAY	1600	10	2	12	0	2	2	10	0.20
06 MAY	1700	12	13	25	1	0	1	30	0.03
06 MAY	1800	10	9	19	0	1	1	20	0.05
06 MAY	1900	7	8	15	0	0	0	15	0.00
06 MAY	2000	20	7	27	8	3	11	29	0.38
07 MAY	1500	16	8	24	24	6	30	26	1.15
07 MAY	1600	4	2	6	1	0	1	4	0.25
07 MAY	1700	0	1	1	0	0	0	3	0.00
07 MAY	1800	4	0	4	0	1	1	4	0.25
07 MAY	1900	3	5	8	3	2	5	8	0.63
07 MAY	2000	14	5	19	1	2	3	23	0.13
08 MAY	1500	9	3	12	3	1	4	14	0.29
08 MAY	1600	7	3	10	1	1	2	9	0.22
08 MAY	1700	13	4	17	1	1	2	15	0.13
08 MAY	1800	3	5	8	0	1	1	10	0.10
08 MAY	1900	6	1	7	1	0	1	10	0.10
08 MAY	2000	28	8	36	8	3	11	42	0.26
09 MAY	1500	3	5	8	1	3	4	8	0.50
09 MAY	1600	4	3	7	0	0	0	8	0.00
09 MAY	1700	2	2	4	0	1	1	4	0.25
09 MAY	1800	3	3	6	1	0	1	5	0.20
09 MAY	1900[1]	3	2	5	0	0	0	7	0.00
09 MAY	2000	13	4	17	5	1	6	17	0.35
10 MAY	1000	5	11	16	2	1	3	17	0.18

Appendix Table 7. Continued.

Test date	Test time	Tagged chinook	Tagged steelhead	Total tagged	Untagged chinook	Untagged steelhead	Total untagged	Number of cycles	Untagged per cycle
10 MAY	1100	14	14	28	4	11	15	26	0.58
10 MAY	1200	1	4	5	2	1	3	5	0.60
10 MAY	1400	5	6	11	0	1	1	11	0.09
10 MAY	1500	2	9	11	0	0	0	11	0.00
11 MAY	0900	10	24	34	1	2	3	33	0.09
11 MAY	1000	4	19	23	3	10	13	25	0.52
11 MAY	1200	11	19	30	4	3	7	32	0.22
23 MAY	0900	0	7	7	0	0	0	7	0.00
23 MAY	1000*	0	8	8	0	1	1	9	0.11
23 MAY	1100*	2	7	9	1	0	1	9	0.11
23 MAY	1200	2	4	6	1	0	1	7	0.14
23 MAY	1300*	1	11	12	1	0	1	11	0.09
23 MAY	1400	2	8	10	1	0	1	11	0.09
24 MAY	0800	1	17	18	0	2	2	18	0.11
24 MAY	0900	1	15	16	1	0	1	21	0.05
24 MAY	1000	2	15	17	0	2	2	16	0.13
24 MAY	1100	4	26	30	0	0	0	29	0.00
24 MAY	1200	3	17	20	0	3	3	18	0.17
24 MAY	1300	3	11	14	0	0	0	15	0.00
25 MAY	0800	1	10	11	1	0	1	11	0.09
25 MAY	0900	2	12	14	2	1	3	13	0.23
25 MAY	1000	1	16	17	0	5	5	20	0.25
25 MAY	1100	1	19	20	0	2	2	17	0.12
25 MAY	1200	1	8	9	0	1	1	11	0.09
25 MAY	1300	1	9	10	0	2	2	10	0.20
Totals		448	487	935	161	170	331	1,013	
Average/test		5	6	11	1	2	3	12	0.33

* Not included in the final analysis due to facility counts being lower than the total number of fish diverted.

Appendix Table 8. Descaling data for hourly tests of the small-fish flume PIT-tag detection/diversion system at Lower Monumental Dam, 1994.

Test date	Test time	Chinook Not descaled	Chinook Descaled	Steelhead Not descaled	Steelhead Descaled	Total descaled	Total fish	Percent descaled
29 APR	1200	13	0	5	0	0	18	0.0
29 APR	1300	6	0	1	0	0	7	0.0
30 APR	0800	5	2	3	0	2	10	20.0
30 APR	0900	11	1	3	0	1	15	6.7
30 APR	1000	23	6	7	0	6	36	16.7
30 APR	1100	17	7	12	0	7	36	19.4
30 APR	1200	13	2	1	1	3	17	17.6
30 APR	1300	18	5	4	0	5	27	18.5
02 MAY	0800	10	4	4	1	5	19	26.3
02 MAY	0900	7	3	7	0	3	17	17.6
02 MAY	1000	16	4	10	0	4	30	13.3
02 MAY	1100	9	2	7	1	3	19	15.8
02 MAY	1200	8	4	3	0	4	15	26.7
02 MAY	1300	9	1	3	0	1	13	7.7
03 MAY	1300	10	1	0	0	1	11	9.1
03 MAY	1400	3	0	3	0	0	6	0.0
03 MAY	1500	7	0	6	0	0	13	0.0
03 MAY	1600	9	3	1	0	3	13	23.1
03 MAY	1700	6	1	0	0	1	7	14.3
03 MAY	1800	3	1	1	0	1	5	20.0
04 MAY	1300	4	1	6	0	1	11	9.1
04 MAY	1400	7	1	5	0	1	13	7.7
04 MAY	1500	9	1	4	0	1	14	7.1
04 MAY	1600	5	0	0	0	0	5	0.0
04 MAY	1700	10	3	8	0	3	21	14.3
04 MAY	1800	10	7	13	1	8	31	25.8
05 MAY	1300	21	4	13	0	4	38	10.5
05 MAY	1400	23	5	7	1	6	36	16.7
05 MAY	1500	18	1	12	1	2	32	6.2
05 MAY	1600	7	2	5	2	4	16	25.0
05 MAY	1700	16	3	7	0	3	26	11.5
05 MAY	1800	6	3	0	0	3	9	33.3
06 MAY	1500	7	3	4	1	4	15	26.7
06 MAY	1700	36	9	14	1	10	60	16.7
06 MAY	1800	17	4	10	1	5	32	15.6
06 MAY	1900	17	0	8	1	1	26	3.8
06 MAY	2000	52	15	11	0	15	78	19.2
07 MAY	1500	49	25	13	2	27	89	30.3
07 MAY	1600	6	1	1	0	1	8	12.5
07 MAY	1700	7	0	4	0	0	11	0.0
07 MAY	1800	3	0	0	0	0	3	0.0
07 MAY	1900	3	5	0	0	5	8	62.5
07 MAY	2000	13	3	3	0	3	19	15.8
08 MAY	1500	34	19	4	0	19	57	33.3
08 MAY	1600	31	14	8	1	15	54	27.8
08 MAY	1700	21	16	4	0	16	41	39.0
08 MAY	1800	16	2	2	0	2	20	10.0
08 MAY	1900	29	7	4	0	7	40	17.5
08 MAY	2000	38	6	5	0	6	49	12.2
09 MAY	1500	15	22	11	1	23	49	46.9
09 MAY	1600	36	11	7	1	12	55	21.8

Appendix Table 8. Continued.

Test date	Test time	Chinook Not descaled	Chinook Descaled	Steelhead Not descaled	Steelhead Descaled	Total descaled	Total fish	Percent descaled
09 MAY	1700	16	7	2	0	7	25	28.0
09 MAY	1800	16	8	6	0	8	30	26.7
09 MAY	1900	16	2	6	0	2	24	8.3
09 MAY	2000	40	3	4	0	3	47	6.4
10 MAY	1000	53	14	17	1	15	85	17.6
10 MAY	1100	36	5	26	1	6	68	8.8
10 MAY	1200	24	20	37	1	21	82	25.6
10 MAY	1400	45	23	28	2	25	98	25.5
10 MAY	1500	44	18	8	2	20	72	27.8
11 MAY	0900	21	19	21	0	19	61	31.1
11 MAY	1000	96	24	36	4	28	160	17.5
11 MAY	1200	27	26	25	3	29	81	35.8
23 MAY	0900	0	1	4	0	1	5	20.0
23 MAY	1000	4	0	4	1	1	9	11.1
23 MAY	1100	1	4	9	0	4	14	28.6
23 MAY	1200	2	0	6	1	1	9	11.1
23 MAY	1300	1	0	3	0	0	4	0.0
23 MAY	1400	1	3	4	0	3	8	37.5
24 MAY	0800	2	1	9	0	1	12	8.3
24 MAY	0900	0	0	10	0	0	10	0.0
24 MAY	1000	2	0	8	0	0	10	0.0
24 MAY	1100	1	0	9	1	1	11	9.1
24 MAY	1200	1	1	13	0	1	15	6.7
24 MAY	1300	0	0	2	0	0	2	0.0
25 MAY	0800	0	2	3	0	2	5	40.0
25 MAY	0900	0	0	9	0	0	9	0.0
25 MAY	1000	1	0	1	0	0	2	0.0
25 MAY	1100	3	0	8	0	0	11	0.0
25 MAY	1200	1	1	11	0	1	13	7.7
25 MAY	1300	0	1	6	0	1	7	14.3
Totals		1,223	423	609	34	457	2,289	
Average								20.0

Appendix Table 9. Descaling data for hourly tests of the large-fish flume PIT-tag detection/diversion system at Lower Monumental Dam, 1994.

Test date	Test time	Chinook Not descaled	Chinook Descaled	Steelhead Not descaled	Steelhead Descaled	Total descaled	Total fish	Percent descaled
29 APR	1200	8	1	4	0	1	13	7.7
29 APR	1300	5	1	3	1	2	10	20.0
30 APR	0800	38	12	42	1	13	92	14.1
30 APR	0900	2	2	0	0	2	4	50.0
30 APR	1000	7	0	3	0	0	10	0.0
30 APR	1100	8	1	5	0	1	14	7.1
30 APR	1200	2	0	5	0	0	7	0.0
30 APR	1300	6	1	3	0	1	10	10.0
02 MAY	0800	1	3	4	1	4	9	44.4
02 MAY	0900	11	4	5	0	4	20	20.0
02 MAY	1000	9	6	6	3	9	24	37.5
02 MAY	1100	9	0	4	0	0	13	0.0
02 MAY	1200	3	1	1	0	1	5	20.0
02 MAY	1300	5	0	0	0	0	5	0.0
03 MAY	1300	3	0	4	0	0	7	0.0
03 MAY	1400	5	0	2	1	1	8	12.5
03 MAY	1500	2	0	3	0	0	5	0.0
03 MAY	1600	2	0	1	0	0	3	0.0
03 MAY	1700	4	1	1	1	2	7	28.6
03 MAY	1800	3	1	2	0	1	6	16.7
04 MAY	1300	2	0	4	0	0	6	0.0
05 MAY	1300	7	1	7	0	1	15	6.7
05 MAY	1400	2	2	5	0	2	9	22.2
05 MAY	1500	6	1	9	1	2	17	11.8
05 MAY	1600	5	1	5	0	1	11	9.1
05 MAY	1700	5	4	24	2	6	35	17.1
05 MAY	1800	1	0	1	0	0	2	0.0
06 MAY	1500	1	2	2	0	2	5	40.0
06 MAY	1700	12	1	11	2	3	26	11.5
06 MAY	1800	10	0	9	1	1	20	5.0
06 MAY	1900	7	0	8	0	0	15	0.0
06 MAY	2000	16	12	9	1	13	38	34.2
07 MAY	1500	34	6	13	1	7	54	13.0
07 MAY	1600	5	0	2	0	0	7	0.0
07 MAY	1700	0	0	1	0	0	1	0.0
07 MAY	1800	3	1	1	0	1	5	20.0
07 MAY	1900	6	0	6	1	1	13	7.7
07 MAY	2000	13	2	6	1	3	22	13.6
08 MAY	1500	10	2	2	1	3	15	20.0
08 MAY	1600	6	2	4	0	2	12	16.7
08 MAY	1700	13	1	4	1	2	19	10.5
08 MAY	1800	3	0	6	0	0	9	0.0
08 MAY	1900	6	1	1	0	1	8	12.5
08 MAY	2000	33	3	11	0	3	47	6.4
09 MAY	1500	1	3	8	0	3	12	25.0
09 MAY	1600	3	1	3	0	1	7	14.3
09 MAY	1700	1	1	3	0	1	5	20.0
09 MAY	1800	3	1	3	0	1	7	14.3
09 MAY	2000	14	4	5	0	4	23	17.4
10 MAY	1000	6	1	12	0	1	19	5.3
10 MAY	1100	13	5	24	1	6	43	13.9

Appendix Table 9. Continued.

Test date	Test time	Chinook Not descaled	Chinook Descaled	Steelhead Not descaled	Steelhead Descaled	Total descaled	Total fish	Percent descaled
10 MAY	1200	2	1	5	0	1	8	12.5
10 MAY	1400	4	1	6	1	2	12	16.7
10 MAY	1500	2	0	8	1	1	11	9.1
11 MAY	0900	9	2	20	6	8	37	21.6
11 MAY	1000	4	3	25	4	7	36	19.4
11 MAY	1200	12	3	21	1	4	37	10.8
23 MAY	0900	0	0	7	0	0	7	0.0
23 MAY	1200	3	0	4	0	0	7	0.0
23 MAY	1400	2	1	8	0	1	11	9.1
24 MAY	0800	0	1	18	1	2	20	10.0
24 MAY	0900	2	0	13	2	2	17	11.8
24 MAY	1000	2	0	15	2	2	19	10.5
24 MAY	1100	2	2	23	3	5	30	16.7
24 MAY	1200	2	1	18	2	3	23	13.0
24 MAY	1300	3	0	11	0	0	14	0.0
25 MAY	0800	1	1	8	2	3	12	25.0
25 MAY	0900	3	1	10	3	4	17	23.5
25 MAY	1000	1	0	17	4	4	22	18.2
25 MAY	1100	1	0	20	1	1	22	4.5
25 MAY	1200	1	0	9	0	0	10	0.0
25 MAY	1300	0	1	11	0	1	12	8.3
Totals		436	110	583	54	164	1,183	
Average								13.9