PRELIMINARY EVALUATION OF THE NEW JUVENILE COLLECTION, BYPASS, AND SAMPLING FACILITIES AT LOWER MONUMENTAL DAM, 1993

by

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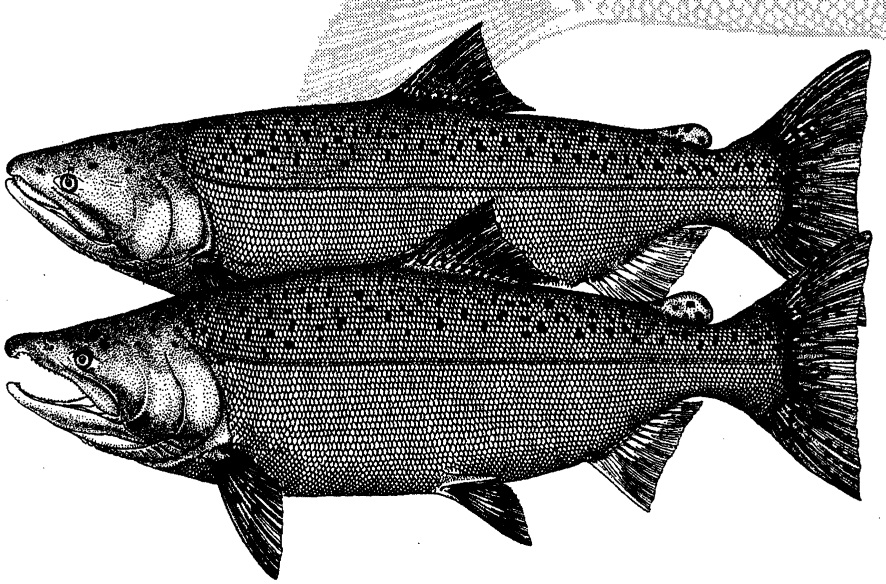

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INTRODUCTION

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 a recurrence of injuries, new bypass systems have undergone intense evaluation as soon as possible after completion. Monk et al. (1992) evaluated the new bypass system 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 design used at Little Goose Dam. Lower Monumental Dam was built without a 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 at Lower Monumental Dam became operational in 1992.

The collection channel passed out of the dam and into a bypass system that included 1) primary and secondary dewatering units; 2) a 244-m, open, corrugated flume (radius = 45 cm) extending to a junction above the collection system; 3) a 76-cm PVC pipe (the outfall pipe) extending 148 m from the junction

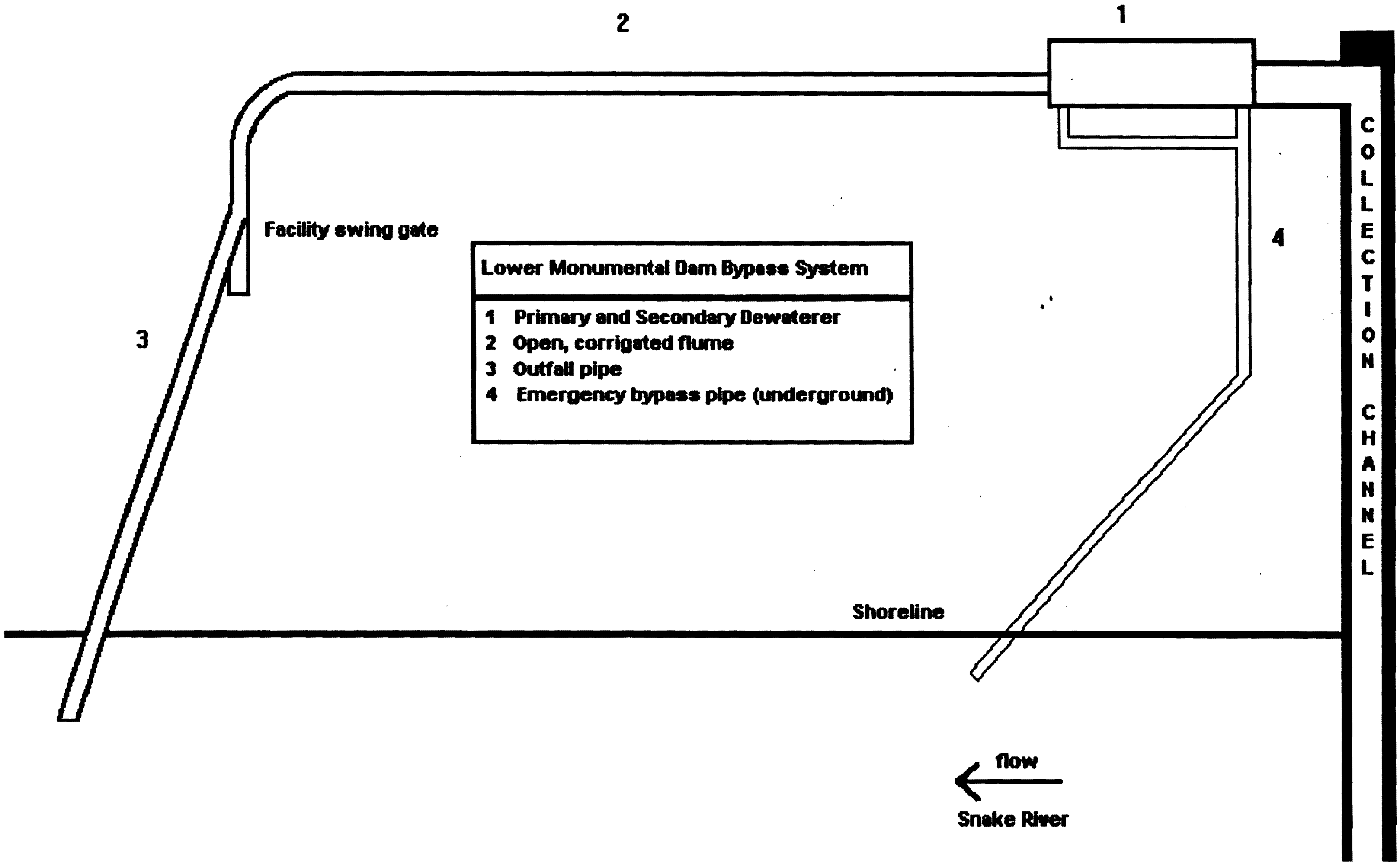

Figure 1.--Schematic of the juvenile bypass system at Lower Monumental Dam.

between the flume and the collection system to a release site approximately 20 m offshore; and 4) an emergency bypass pipe with two entrances (one above and one below the dewatering units) leading into a 76-cm-diameter pressurized pipe that continues for 73 m, converts to a 61-cm-diameter pipe, and continues another 133 m to a 6-m-deep release point 5 m offshore (Fig. 1). This bypass system differs from the one at Little Goose Dam in that a 76-cm-diameter pipe, instead of an open, corrugated flume, conveys the fish from the facility swing gate to the offshore release site.

Prior to the 1993 outmigration, a smolt collection system was added to the bypass system (Fig. 2). This system included 1) a wet separator that separates fish by size, 2) a facility sampling and holding system, 3) raceways, 4) barge and truck-loading lines, and 5) a new laboratory/office building for examination of the facility samples.

There are two major differences between the juvenile collection systems at Lower Monumental and Little Goose Dams. First, to move fish more efficiently through the collection system, the wet separator at Lower Monumental Dam was narrowed and covered with a roof. Second, there are only four raceways at Lower Monumental Dam compared with eight raceways at Little Goose Dam. However, holding capacities at the dams are the same

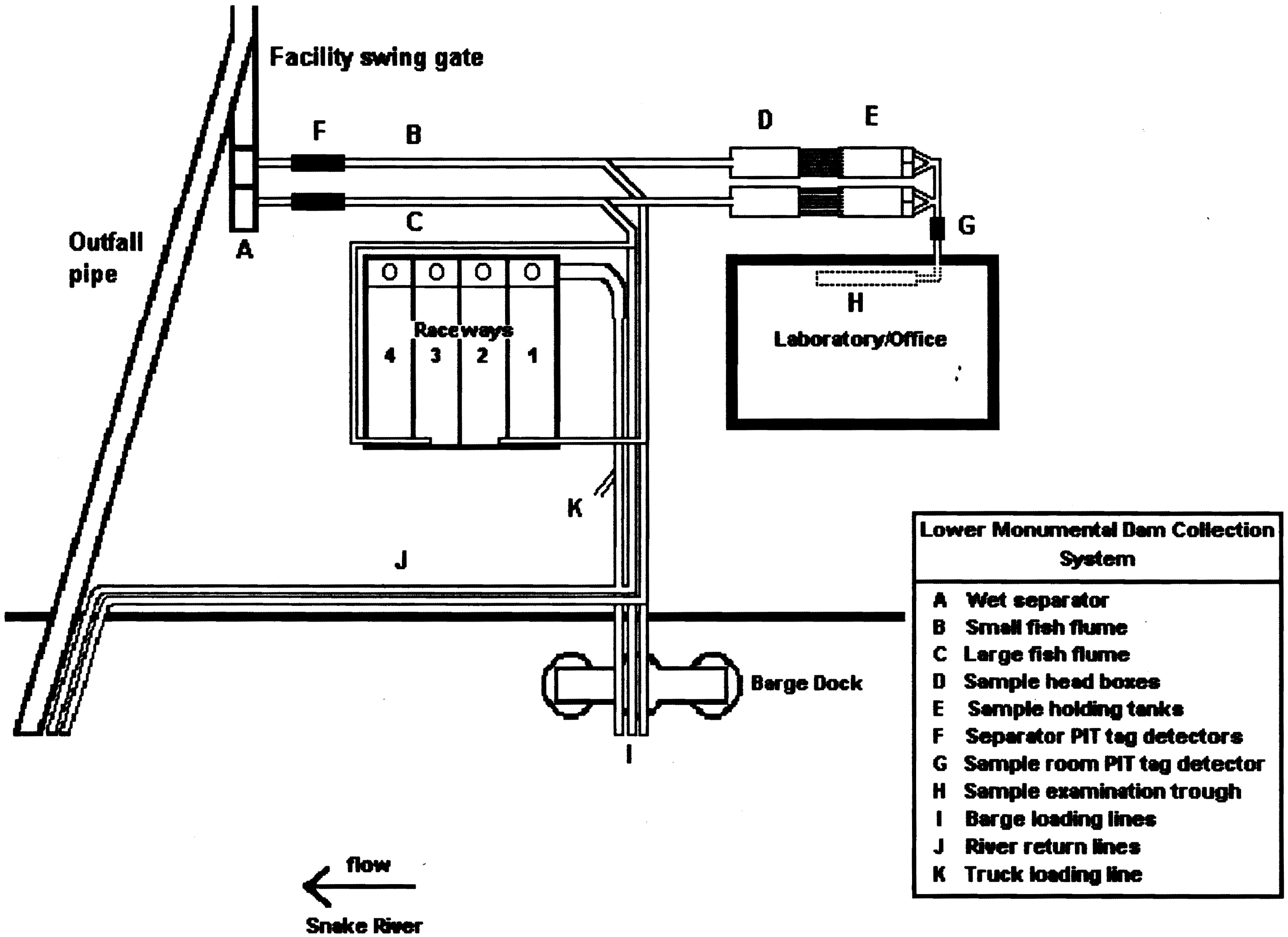

Figure 2.--Schematic of the juvenile fish collection system at Lower Monumental Dam.

because the raceways at Lower Monumental Dam are twice as wide (2.4 m vs. 1.2 m) as the raceways at Little Goose Dam.

Our study objectives in 1993 were 1) to determine if mechanical problems that might affect both juvenile and adult salmonids during passage existed 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. Because this facility was expected to collect and pass large numbers of fish over the course of the outmigration, it was critical that the facility be evaluated early in the season so any problems could be corrected before the bulk of the 1993 outmigration arrived at the dam.

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

To determine if any mechanical problems existed within the bypass and collection facilities, six groups of hatchery fish were released into different sections of the facilities. Fish were recaptured downstream, and the effects of each section were determined by examining the released fish for descaling, injuries, and mortalities.

Test fish were yearling spring/summer chinook salmon *(Oncorhynchus tshawytscha)* from Lookingglass State Fish Hatchery and yearling steelhead *(O. mykiss)* from Dworshak National Fish Hatchery. The spring/summer chinook salmon and steelhead arrived at the dam on 2 and 14 April, respectively. Fish were either fin clipped or PIT tagged, and held for at least 5 days prior to testing. Mechanical and construction problems caused testing to be delayed from 5 April until 20 April. During the delay, fish were fed a minimum-subsistence diet. When testing started, the fish, especially the spring/summer chinook salmon, were heavily smolted with very deciduous scales. This made them as susceptible to descaling as river-run smolts.

All test groups except Release Group 3 (Table 1) consisted of both a test and a control group of fish marked by either an upper or lower caudal clip. Control fish were released directly into the collection device to partition its effect. All Release groups except 3, 4, and 6 consisted of both hatchery spring/summer chinook salmon and hatchery steelhead. Release Groups 3, 4, and 6 consisted of hatchery spring/summer chinook salmon only. Protocol for testing was to release steelhead first. If steelhead were affected by conditions in the test area, we would correct the problem before releasing chinook

Table 1.--Release groups, species, area evaluated, and release and collection sites for each test under Objective 1. All fish were of hatchery origin.

Release Group	Species	Areas evaluated	Release site	Collection site
1	Yr. chin. salmon Steelhead	1) Flume from separator to raceways	Small-fish exit from separator	Raceway 3
1	Yr. chin. salmon Steelhead	1) Flume from separator to raceways	Large-fish exit from separator	Raceway 4
2	Yr. chin. salmon Steelhead	1) Raceway exits 2) Barge-loading lines	Raceway 4	Floating recovery net in barge-loading area
3	Yr. chin. salmon	1) Raceway exits 2) Barge-loading lines	Raceway 3 and manifold/flume transition area	Floating recovery net in barge-loading area
4	Yr. chin. salmon	1) Raceway exits 2) Truck-loading lines	Raceways 1-4	Transport truck
5	Yr. chin. salmon Steelhead	1) Flume from separator to barge	Small-fish exit from separator	Floating recovery net in barge-loading area
5	Yr. chin. salmon Steelhead	1) Flume from separator to barge	Large-fish exit from separator	Floating recovery net in barge-loading area
6	Yr. chin. salmon	1) Return flume from separator to river	Small-fish exit from separator	Floating recovery net at outfall
6	Yr. chin. salmon	1) Return flume from separator to river	Large-fish exit from separator	Floating recovery net at outfall

salmon (steelhead are less susceptible to descaling or injury than chinook salmon).

Fish groups were released into both the large- and small-fish flumes below the separator to check the effects of the flumes and pipes leading to the raceways, barge, and river (Release Groups 1, 5, & 6, respectively). Fish were also released into raceways to check the flumes and pipes leading to the barge and truck (Release Groups 2, 3, & 4, respectively).

Release Group 1 was used to test the flumes leading from below the separator to the raceways, as well as the raceway entry. Fish were released into both the large- and small-fish flumes just below the wet separator and collected in a shortened raceway. At Little Goose Dam, fish enter the centers of raceways by dropping vertically through a pipe. At Lower Monumental Dam, water exits the flumes at 0.2 cubic meters per second (cms) and arcs across the raceways, contacting the opposite sidewalls as it enters the raceways. There was concern that fish would be injured or descaled when entering the raceways under these conditions.

To test these conditions, the raceway crowder was moved to a location just beyond the turbulence zone at the head of a raceway. Control fish were released directly into this turbulence zone. After fish had entered the raceway, the water level was dropped, and fish were dipnetted from the raceway into a solution of the anesthetic, tricaine methanesulfonate (MS-222). After anesthesia, fish were examined for descaling and injuries.

Release Group 2 was used to test the barge-loading line from the raceways. Raceway 4 was chosen as the release site for this test because fish exiting that raceway must traverse the entire length of the raceway release line. At the end of the barge-loading line, a floating recovery net was placed in the river to collect the fish. The recovery net was held in position by a barge and crane, while test fish were released into the end of Raceway 4. Control fish were released directly into the recovery net. After the test, the recovery net was lifted from the river, and fish were collected in a sanctuary bag at the bottom of the net. The bag was emptied into a sorting trough where the fish were anesthetized with MS-222 and examined for descaling and injuries.

Release Group 3 was divided into two subgroups and used to identify the source of descaling observed in Release Group 2. No controls were used. Instead, releases were made at two points along the barge-loading line in an attempt to determine what part of the line was causing the problem. The first release point was at the end of a raceway, and the second was immediately downstream from where a fiberglass manifold drains the raceways into an aluminum flume.

Release Group 4 was used to test the truck-loading line, as well as corrective measures taken in the problem area identified with Release Group 3. Fish were released into the end of each raceway and collected in a net draped into the rear compartment of a U.S. Army Corps of Engineers (COE) fish transport tanker truck. Controls were released directly into the tank compartment as test fish were collected. The net was then removed, and captured fish were placed in a sorting trough containing MS-222 and examined for descaling and injuries.

Release Group 5 was used to test the direct barge-loading lines. Fish were released into both the large- and small-fish flumes just below the separator and again collected in the floating recovery net. Control fish were released directly into the recovery net. After the test, the recovery net was lifted with a crane, and fish were collected in the sanctuary bag at the bottom of the net. The bag was emptied into a sorting trough where fish were anesthetized with MS-222 and examined for descaling and injuries.

Release Group 6 was used to test the river-return lines from the separator. Because we planned to run this test concurrent with the outfall pipe test, the ventral fins of hatchery spring/summer chinook salmon and steelhead for Release Group 6 were clipped to distinguish them from caudal-clipped fish used in the outfall pipe test. These fish were released just below the separator into both the large- and small-fish flumes and collected with the floating recovery net. Controls were released directly into the recovery net. After the test, the recovery net was lifted from the river, and fish were collected in the sanctuary bag at the bottom of the net. The bag was emptied into a sorting trough where fish were anesthetized with MS-222 and examined for descaling and injuries. When the test was conducted using steelhead, we observed that all river-run hatchery steelhead were vent-clipped, and this rendered our mark meaningless.

Prior to each test, the required numbers of fish were dipnetted out of the holding pens in groups of two to five fish, and placed into release containers. 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.

We had proposed using 20 adult steelhead from Lyons Ferry Hatchery to evaluate the effects of the facility on adults. These fish were held at the hatchery until we were ready to use them. However, due to the delay in opening the facility, we were unable to conduct these tests before all adults being held for this purpose died.

Stress Evaluation

To examine the physiological effects of the new facility, stress and fatigue indices were measured in naturally migrating spring/summer chinook salmon and steelhead smolts. For each species, 15 blood samples were collected on 4 consecutive nights from 4 locations within the facility. The blood samples were assayed for plasma cortisol, glucose, and lactate. The following four locations were sampled: 1) gatewell 1C (baseline levels), 2) just downstream from the secondary dewatering unit (designated the post-dewaterer), 3) just upstream from the wet separator (designated the pre-separator), and 4) the raceways. To determine the effects of residing in the raceways, fish were sampled at 0, 2, 4, 6, and 10 hours after being collected in a raceway. Sample dates for spring/summer chinook salmon were May 10-14, and for steelhead, May 17-21.

Because most juvenile chinook salmon and steelhead tend to move through Columbia River Basin hydroelectric projects during evenings (Sims et al. 1981, Gessel et al. 1986), we anticipated beginning the serial collection of fish at 1800 hours (h). However, because of the work schedule of COE crane operators, we had to initiate serial collections at 1600 h.

At 1600 h, the COE began collecting fish in a shortened raceway. To shorten the raceway, the crowder was moved to the head of the raceway until it was just downstream from the turbulence zone created by water entering the raceway from the flume. At COE juvenile fish facilities, the maximum raceway loading density is 60 grams of fish per liter of water. We had hoped to achieve this loading density, but not enough fish passed during the collection time, and we were unable to achieve more than 12 grams per liter.

Loading density was determined from the COE hourly sample count for the time period fish were collected and from the daily index sample for species composition and average weight by species, obtained by the Washington Department of Fisheries. At the end of 4 hours, raceway collection was stopped and the 0-hour raceway samples were taken. At this time, fish had been in the raceway from 0 to 4 hours. Samples were then taken at 2, 4, 6, and 10 hours after collection had stopped.

Fish were collected from all test areas (except the gatewell) with a standard dip net and were immediately placed in a 200-mg/L solution of MS-222. This concentration has been shown not to alter plasma cortisol, glucose, or lactate values significantly (Black and Conner 1964, Strange and Schreck 1978). Immediately after each fish ceased gilling activity, the caudal peduncle was severed, and blood was collected with a 0.25-ml ammonium-heparinized capillary tube. Blood samples were then centrifuged, and the plasma was drawn off and frozen immediately on dry ice. Plasma cortisol, glucose, and lactate were assayed at Oregon State University. Thawed plasma was assayed for cortisol using a radioimmunoassay, for glucose using the σ-toluidine method, and for lactate using a fluorimetric enzyme reaction (Barton et al. 1986, Barton and Schreck 1987).

Mean stress indices of the 32 samples (8 locations/times X 4 replicates) were analyzed by Randomized Block Analysis of Variance (RBANOVA). Significant changes between locations and raceway times were then examined with Fisher's Protected Least Significant Difference (FPLSD) multiple comparisons technique (Peterson 1985). Compared samples with a P-value less than 0.05 were considered significantly different.

Results and Discussion

Descaling, Injury, and Mortality Evaluation

Our testing demonstrated that juvenile salmonids passed through the facility with little or no negative effects (Table 2 and Appendix Table 1). Test fish from releases originating below the separator and ending at the raceways, barge, or river (Release Groups 1, 5, and 6, respectively) showed little or no descaling or injuries. The little descaling that we observed was patternless and likely caused by handling.

Hatchery chinook salmon from the first raceway test (Release Group 2) showed a low descaling incidence of 6.8%. The majority of these descaled fish were completely descaled on both sides,

Table 2--Mortality, descaling, and injury for hatchery-reared juvenile spring chinook salmon and steelhead released into the collection and loading facilities at Lower Monumental Dam in 1993 (Objective 1).

Test location and species	Mortality (%)	Descaling (%)	Eye/Head Injury (%)
	<u>Release Group 1</u> - Separator to Raceway		
Yearling chinook salmon			
- Small-fish flume	0.0	0.0	0.5
- Large-fish flume	0.0	0.0	0.5
Yearling steelhead			
- Small-fish flume	0.0	0.0	0.0
- Large-fish flume	0.0	0.0	0.5
	<u>Release Group 2</u> - Raceway 4 to barge		
Yearling chinook salmon	0.0	6.8	0.3
Yearling steelhead	0.7	0.5	0.0
	<u>Release Group 3</u> - Raceways to barge (performed to isolate descaling problem)		
Yearling chinook salmon			
- From Raceway 3	0.0	4.0	1.0
- From junction of manifold and flume	0.0	0.0	0.0
	<u>Release Group 4</u> - Raceways to truck		
Yearling chinook salmon			
- From Raceway 1	0.0	1.0	0.0
- From Raceway 2	0.0	0.0	0.0
- From Raceway 3	0.0	0.0	1.0
- From Raceway 4	0.0	1.0	1.0
	<u>Release Group 5</u> - Separator to barge (direct loading)		
Yearling chinook salmon	0.0	2.1	0.0
Yearling steelhead	0.0	0.0	0.3
	<u>Release Group 6</u> - Separator to river		
Yearling chinook salmon	0.0	0.0	0.0

from the opercle to the caudal fin. After the test we examined the flume, beginning our inspection at the transition from the fiberglass manifold that drains the raceways, and ending it at the transition from the flume to a 25-cm PVC pipe.

Our inspection revealed that the hatch covering the truck-loading system was raised approximately 13-mm above the floor of the flume, exposing its front edge to fish as they moved down the flume. While this may have caused complete descaling on one side of the fish, it could not have caused descaling on both sides. However, we also noticed that one of the two finger holds used to remove the hatch was set such that it opened with the flow. Water moving through the flume could have caused it to pop up into the water column and become a serious obstacle to fish moving down the flume.

We informed the COE of these problems, and they corrected them immediately. They padded the hatch so that it could not rise into the water column and turned the finger hold around so that it opened against the flow. We also found several large screw heads protruding into the flume, as well as metal shavings and small pieces of concrete lodged in the bar screens used to de-water the flume. These problems were also remedied quickly by COE personnel.

Since we could not inspect the fiberglass manifold that drains fish from the raceways, COE personnel ran a video camera through the manifold. They found and removed several large pieces of concrete from the floor of the manifold.

To determine if these adjustments had remedied the descaling problem, and to further isolate the problem if it still existed, we made another test release (Release Group 3). Because COE personnel were unable to immediately remove a piece of concrete from the raceway release line under Raceway 4 (the concrete was eventually removed), we moved the first release site to Raceway 3. The second release site was at the transition from the fiberglass manifold to the aluminum flume. Descaling results from this test showed that there was no problem below the transition area, but that a problem still existed somewhere in the raceway-release line.

Based on these results, COE personnel methodically removed all debris from the raceways and the raceway release line. The drain system was examined with a video camera to confirm that all debris had been removed. After consulting with the contractors, COE staff discovered that concrete orifices in the floor of the raceways had never been sanded, so we delayed testing until the orifices were sanded.

As mentioned above, the truck-loading line is accessed by removing a hatch from the bottom of the barge-loading line. This hatch is approximately halfway down the line, between the fiberglass manifold that drains the raceways and the 25-cm PVC pipe at the end of the flume. Because the results from Release Group 3 showed that this area had no adverse effect on fish, and to conserve fish, we decided to conduct the retest of the raceway release line with fish from the truck-loading line test (Release Group 4). The results from this retest verified that the raceway problem had been corrected, and that the truck-loading system had no detrimental effect on fish.

The only mortalities observed during all of the tests occurred in Release Group 2, the first raceway-to-barge system test. However, it was a procedural error, not a mechanical problem, that caused these mortalities.

For this test, we used the floating recovery net to recapture fish at the end of the barge-loading line. After we recaptured the steelhead, we emptied the recovery net into the sorting troughs and reset the net. We then made the chinook salmon release while finishing our examination of the steelhead. When we counted the steelhead after examining them, we found we were missing 70 of the test fish (all of the control fish were present).

We continued the tests, and later, while sorting through the chinook salmon, we found 61 of the missing steelhead. A construction worker informed us that some fish were trapped in the transition area between the manifold and the flume. When we searched the flume and manifold, we found six live and three dead steelhead.

In discussions with COE personnel, we discovered that the 5-cm flushing line had not been used to flush fish from the raceway to the barge. This line was intended for flushing the manifold after all the raceway drains have been closed. Correct usage of this line will preclude any further stranding of fish in the manifold.

Stress Evaluation

Plasma cortisol and glucose levels increased significantly ($P = 0.0125$ and $P < 0.0001$, respectively), while lactate levels decreased significantly ($P < 0.0001$), for yearling spring/summer chinook salmon as they passed from the gatewell into the raceways (Appendix Tables 2-6).

Cortisol levels in yearling spring/summer chinook salmon increased rapidly, but not significantly, as fish moved through the collection system from the gatewell to the separator (Fig. 3). Cortisol levels of fish in the 0-hour sample from the raceway were significantly higher than those of fish in the gatewell; however, contrary to the findings of Maule et al. (1988) at McNary Dam and Monk et al. (1992) at Little Goose Dam, fish cortisol levels were already declining in the 2-hour raceway sample, and were significantly lower in the 6-hour sample. The 6-hour raceway samples had lower levels than the gatewell

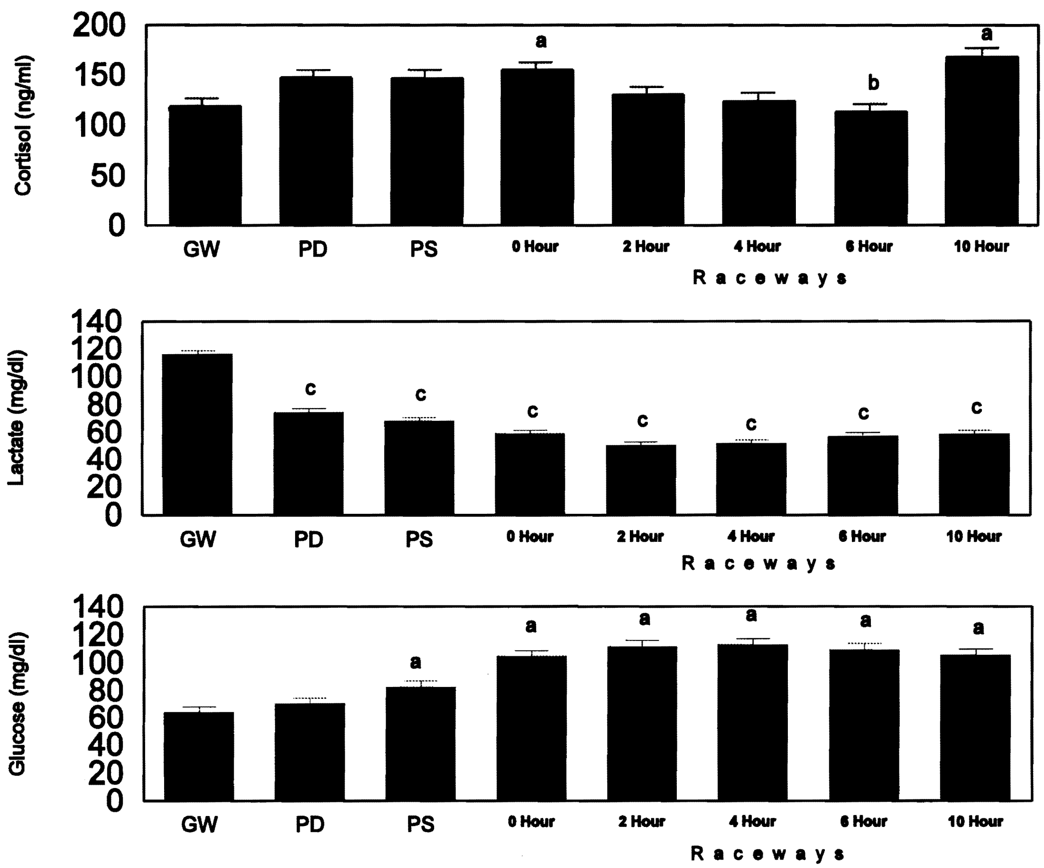

Figure 3.--Mean concentrations (+ S.E., n = 4) of plasma cortisol, lactate, and glucose for spring/summer chinook salmon at four locations (fish in the raceway were sampled at five different times) in the collection and transportation facility at Lower Monumental Dam, 1993. Bars marked (a) are significantly higher than gatewell levels, bars marked (b) are significantly lower than 0-hour raceway levels, and bars marked (c) are significantly lower than gatewell levels. Abbreviations used are: GW = gatewell; PD = post-dewaterer; and PS = pre-separator.

samples, but the difference was not significant. Cortisol levels in the final (10-hour) raceway sample were significantly higher than those in the 6-hour sample, and surpassed even those in the 0-hour sample.

Plasma glucose levels in yearling spring/summer chinook also increased as the fish moved through the collection facility. A significant increase over the gatewell levels was observed as the fish were entering the separator (Fig. 3). Glucose levels for the 0-hour sample in the raceway were significantly higher than levels for the pre-separator sample, increased slightly through the 2-hour and 4-hour samples, and then decreased slightly in all remaining samples. This pattern was similar to that observed at Little Goose Dam by Monk et al. (1992).

For yearling spring/summer chinook salmon, lactate levels decreased as fish moved through the collection system. By the time fish had passed the secondary dewaterer (Fig. 3), their lactate levels were significantly lower than those of fish sampled in gatewell. Levels continued to decrease through the 2-hour raceway sample, and then began to rise again slowly. Except for the gatewell levels, this pattern was again similar to that observed at Little Goose Dam by Monk et al. (1992).

Delays at the beginning of the season, combined with river conditions when chinook salmon were being sampled, may have affected the results of our gatewell samples. By the time sampling began, the majority of chinook salmon outmigrants had passed Lower Monumental Dam. River conditions at the time decreased the number of chinook salmon collected: at the time of our collections, Lower Monumental Dam was spilling an average of 2.5 to 31.0 kcfs per day. Spill allows fish to pass the dam without entering the fish guidance system; thus collections in the bypass and collection facility are decreased. In addition, the steelhead outmigration was beginning to peak during this period.

These three conditions resulted in very small numbers of chinook salmon and large numbers of steelhead being collected in the gatewell dip basket. Because of the large ratio of steelhead to chinook salmon, and the fact that 22-27 spring/summer chinook salmon were needed to obtain the 15 samples for each replicate, 1-3 minutes were required to search through all the steelhead to find the few chinook salmon in the dip basket. While exposed to this highly stressful situation, the fish were very active. This likely resulted in gatewell samples having artificially high cortisol and lactate levels, and lower plasma glucose levels.

In summary, plasma cortisol, glucose, and lactate levels changed as spring/summer chinook salmon passed through the collection system, with cortisol and glucose levels increasing and lactate levels decreasing. The highest average cortisol level observed for yearling spring/summer chinook salmon (166.6

ng/ml in the 10-hour raceway sample) was near the low end of the range measured by Congleton et al. (1984) for this species above and below the wet separator at Lower Granite Dam (160-210 ng/ml). This value was also well below the values measured by Matthews et al. (1987) for yearling chinook salmon after marking at Lower Granite Dam.

Plasma cortisol, glucose, and lactate levels increased significantly ($P < 0.0001$, $P = 0.0021$, and $P = 0.0060$, respectively) as juvenile steelhead passed through the collection system (Fig. 4). Cortisol levels nearly doubled as fish passed from the gatewell to below the dewaterer, and they continued to rise as steelhead entered the separator. Cortisol levels from the 0-hour raceway sample were significantly lower than those from the pre-separator, but levels increased to pre-separator levels in the 2-hour sample. The 4-hour and 6-hour raceway samples were significantly lower than the 2-hour sample, with the 4-hour levels being lower than the gatewell levels (but not significantly). The cortisol levels then increased significantly in the 10-hour sample, where levels were as high as those observed at the 2-hour raceway sample. With the exception of the 2-hour raceway sample, this pattern followed the results observed at Little Goose Dam by Monk et al. (1992).

Plasma glucose levels increased slightly through the separator, were significantly higher at the 0-hour raceway

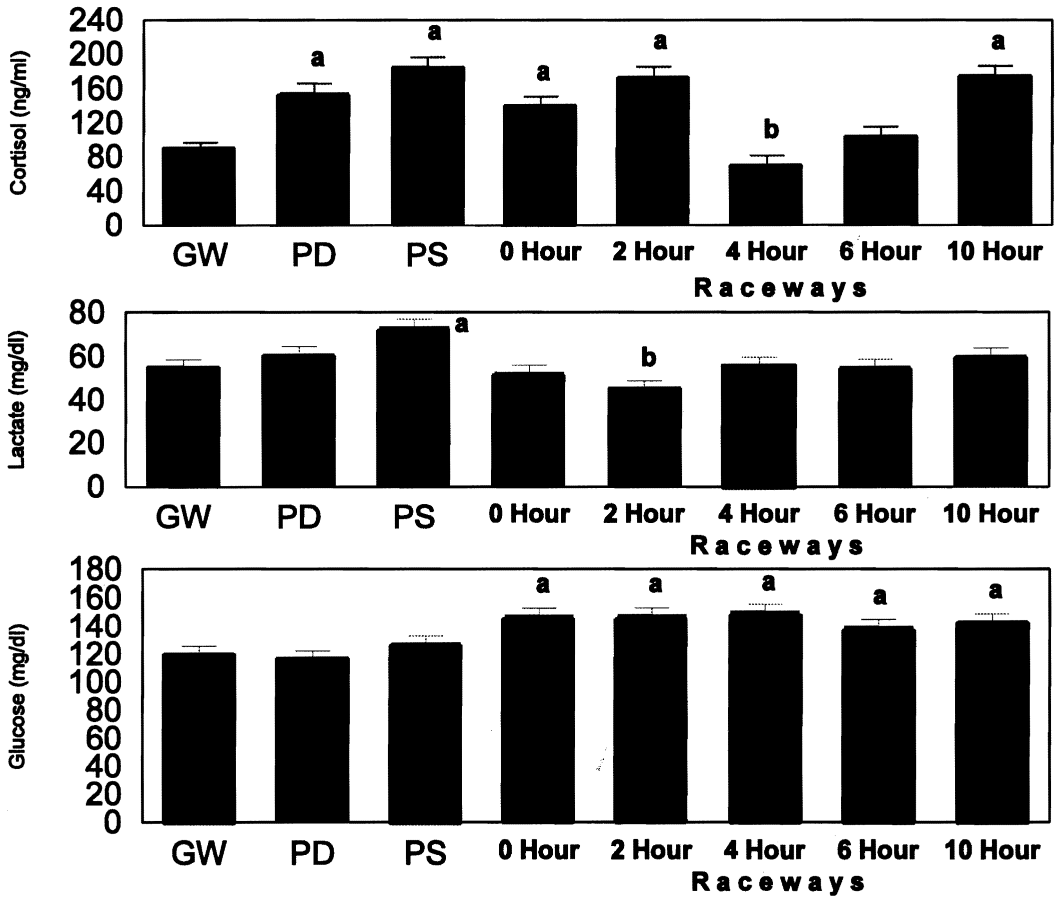

Figure 4.--Mean concentrations (+ S.E., n = 4) of plasma cortisol, lactate, and glucose for steelhead at four locations (fish in the raceway were sampled at five different times) in the collection and transportation facility at Lower Monumental Dam, 1993. Bars marked (a) are significantly higher than gatewell levels, and bars marked (b) are significantly lower than 0-hour raceway levels. Abbreviations used are: GW = gatewell; PD = post-dewaterer; and PS = pre-separator.

sample, held fairly steady through the 4-hour raceway sample, and then decreased slightly. This pattern differed from the observation of Monk et al. (1992) at Little Goose Dam. In that study, plasma glucose levels declined from the gatewell sample to the 0-hour raceway sample. Levels increased in the 2-hour raceway sample and decreased slowly through the 6-hour raceway sample; then they increased again in the 9-hour raceway sample. None of the differences were significant.

Lactate levels increased as steelhead passed from the gatewell through the dewaterer and into the separator. Levels from the separator sample were significantly higher than those from the gatewell. Lactate levels then decreased significantly in the 0-hour raceway sample, and continued to decrease in the 2-hour sample (which was lower than the gatewell levels, but not significantly). Lactate levels increased slowly in all the remaining samples. This pattern followed that observed at Little Goose Dam by Monk et al. (1992).

The results suggested that both yearling spring/summer chinook salmon and steelhead smolts were holding in the dewaterer (this was supported by NMFS and COE observations). It also appeared that steelhead attempted to hold in the corrugated flume between the dewaterer and the separator, thus increasing their fatigue level. Both species recovered through their first 6 hours in the raceways, while their 10-hour samples showed elevated levels of cortisol with small changes in lactate and glucose. However, diel passage patterns at other dams have indicated that fish movement is highest during crepuscular periods. Therefore, as the 10-hour raceway sample occurred at 0600 hours, this change in plasma chemistry would be expected, regardless of the collection system.

OBJECTIVE 2:

Evaluate the reliability and efficiency of the sampling system at the collection facility.

Approach

To determine the reliability and efficiency of the sampling system at the collection facility, we released PIT-tagged fish into the separator and monitored their passage through the facility.

We PIT tagged 5,600 of the hatchery chinook salmon and 5,400 of the hatchery steelhead delivered from Dworshak National Fish Hatchery to Lower Monumental Dam. Chinook salmon were used to test the small-fish flume sampling system, while steelhead were used to test the large-fish flume sampling system. Because tests were conducted while the facility was collecting migrating fish, we anticipated that some of our hatchery chinook salmon would be passing through the large-fish flume and some of our hatchery steelhead passing through the small-fish flume. In order to take advantage of this cross-over, two tests were run concurrently, one of each flume.

Two sample rates were also tested for each flume. These rates were determined by examining the range of sample rates used at Little Goose Dam, the dam immediately upstream from Lower Monumental Dam. For the small-fish flume, the sample rates tested were 10 and 5%. For the large-fish flume, the sample rates tested were 5 and 2%. For 10 and 5% rates, tests were designed to determine if the measured sample rate was within one percentage point of either side of the set sample rate (i.e., 9 to 11% for the 10% sample rate). For the 2% rate, tests were designed to determine if the measured sample rate was within one-half a percentage point of either side of the set sample rate (i.e., 1.5 to 2.5%). The small-fish flume 10% test was run concurrently with the large-fish flume 5% test, and the small-fish flume 5% test was run with the large-fish flume 2% test.

The number of fish needed for each test was based on the width of the confidence interval and the sample rate being tested, according to the following formula:

$$n = \frac{4[p(1-p)]}{w^2}$$

where p = sample rate being tested

w = one-half the confidence interval

n = number of fish needed for the test

Based on this formula, the number of fish needed for each sample-rate test was:

Sample Rate	Number of fish needed
10%	3,600
5%	1,800
2%	3,200

At the start of each set of tests, the sample gates were set at the sample rate to be tested. Testing started at 0700 hours, and sample rates were not changed until 1600 hours the following day (a total of 33 hours).

Every half-hour we released 200 fish above the separator until all the fish for one set of tests were released. The first set of tests was at the 10% level for the small-fish flume and the 5% level for the large-fish flume. This required the release of 3,600 chinook salmon and 1,800 steelhead. Groups of 200 fish were released every half-hour, and were comprised of 133 chinook salmon and 67 steelhead. This set of tests required 27 releases over 13 hours. The second set of tests was at the 5% level for the small-fish flume and the 2% level for the large-fish flume. This required the release of 1,800 chinook salmon and 3,200 steelhead. The 200-fish groups, released every half-hour, were comprised of 72 chinook salmon and 128 steelhead. This set of tests required 25 releases over 12 hours.

Each flume leaving the separator was equipped with PIT-tag detectors that recorded the date and time that each PIT-tagged fish departed from the separator. Another detector recorded PIT-tagged fish that were captured by the sampling system. By comparing detections at each set of detectors, a measured sample rate could be determined (e.g., if 100 PIT-tagged fish were recorded leaving the separator during 1 hour, and 9 of these were seen by the sample detector, the measured sample rate for that hour was 9%).

Results and Discussion

Two problems were encountered during these tests. The first affected the interpretation of the results from the first set of tests, while the second problem was related to PIT-tag detectors on the pipe leading into the sample-room.

We began releasing fish for the first set of tests at 0700 hours. At 1000 hours, the COE biologist found a weld that was about to fail in one of the dewatering units. Repairing the weld required complete drainage of the separator. After 1,200 fish (out of 5,400) had been released, the test was terminated to drain the separator. Due to mechanical problems with a valve, testing was delayed for 1 week. When the test was restarted, we were short the 1,200 fish previously released, and this shortage decreased the sensitivity of the first set of tests.

The second problem concerned the PIT-tag detector system that recorded the PIT tags of fish captured by the sampling system. We decided to pass the fish caught during the aborted part of the first set of tests through the PIT-tag detector on the pipe leading into the sample room. When a fish is PIT tagged, the scar where the tag was inserted can be seen for several weeks after tagging. While looking at the fish entering the sample room, we counted the number of PIT-tag scars to approximate the number of PIT-tagged fish that had passed through the detector. By comparing the number of scars to the number of detections made by the detector, we determined that the PIT-tag detector had missed over half of the PIT tags. Because the PIT-tag detector could not be repaired before we resumed testing, we had no alternative but to hand-scan every fish captured by the sampling system.

Test results showed a much higher variability than we had anticipated (Table 4). This variability, combined with the small sample sizes, produced results which were not significantly different from the sample rate tested.

In an attempt to decrease variability and increase sample sizes, we investigated the possibility of including river-run fish that were being sampled during our testing. We found that although the sample sizes did increase, the variability also increased because actively migrating fish were sampled at a lower rate at all settings.

Low separator efficiency for PIT-tagged chinook salmon also decreased the sensitivity of the tests conducted on the small-fish flume. Nearly half of the chinook salmon passed through the large-fish flume, while less than 15% of the steelhead passed through the small-fish flume. These efficiency rates were sufficient to meet the study design for both tests involving the large-fish flume, but were insufficient to meet the study design for both tests involving the small-fish flume.

As mentioned under Objective 1 above, we were unable to test the system from the collection channel to the separator. However, because we were forced to hand-scan every fish captured in the sample, we were able to observe how passage from immediately above the separator to the laboratory affected the fish. Most of the fish appeared to be unaffected by this part of the facility. We did observe, however, semicircular rings of descaling on either side of some fish.

It appeared that these fish had been forced against the end of a half-section of pipe. We noticed that the diameter of the descaling rings was the same as the diameter of pipes used to make the fish-separating bars in the wet separator. When we observed fish entering the wet separator, we found that a portion

Table 4.--The number and percentages of PIT-tagged hatchery-reared juvenile spring chinook salmon and steelhead released into the separator and recovered in the sampling system

Pre-set sample rate (%)	Number of fish in system	Number of fish in sample	Number of hours in test	Measured sample rate	95% Confidence interval
Small-fish flume					
10	1,682	165	12	9.7	(7.9, 11.5)
5	1,092	52	15	4.8	(2.6, 6.9)
Large-fish flume					
5	1,983	86	11	4.4	(2.9, 5.9)
2	3,224	58	17	2.0	(0.9, 3.1)

were falling into a gap between the porosity control screens and the small-fish screen at the front of the separator. Water surging over the separator forced fish against the end of the small-fish screen. Since only half of each pipe end was covered by the metal frame of the small-fish screen, the fish contacted the exposed portion of the pipe ends. To prevent fish from falling into the gap, COE personnel filled the gap between the porosity control screens and the small-fish screen with a piece of PVC pipe.

The fish-return pipe from the laboratory to the raceway was another area of concern. The slope of the pipe was insufficient, despite the fact that at the laboratory sorting trough, the pipe was over 6 feet above the floor. Steelhead and large chinook were capable of swimming against the flow with little effort; on one occasion, live fish entered a dry raceway 24 hours after being placed in the pipe. The COE plans to increase the slope of the pipe, both in the laboratory and as it enters the raceway.

OBJECTIVE 3:

Evaluate the bypass system outfall pipe.

Approach

The fisheries agencies and tribes were concerned that passage through the 76-cm diameter outfall pipe used to carry fish from the facility swing gate to the offshore release site might be detrimental to juvenile salmonids. 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. In actuality, the flume discharged at 1.02 m^3/s. Another concern was high water velocities in the pipe and at its terminus. Water velocities were estimated at 10.7 meters per second (mps) in the steepest section, 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 pipe. To accomplish this, the COE provided a floating frame and net system (Fig. 5). The floating frame was constructed of 30-cm-diameter foam-filled polyethylene pipe. To hold the net frame, the floating frame had polyethylene saddles welded to it. The net frame was 7.6 by 7.6 m and was constructed of stainless steel pipe. Attached at each corner of the net frame was a 2.4-m stainless steel leg which was used to secure each corner of the net.

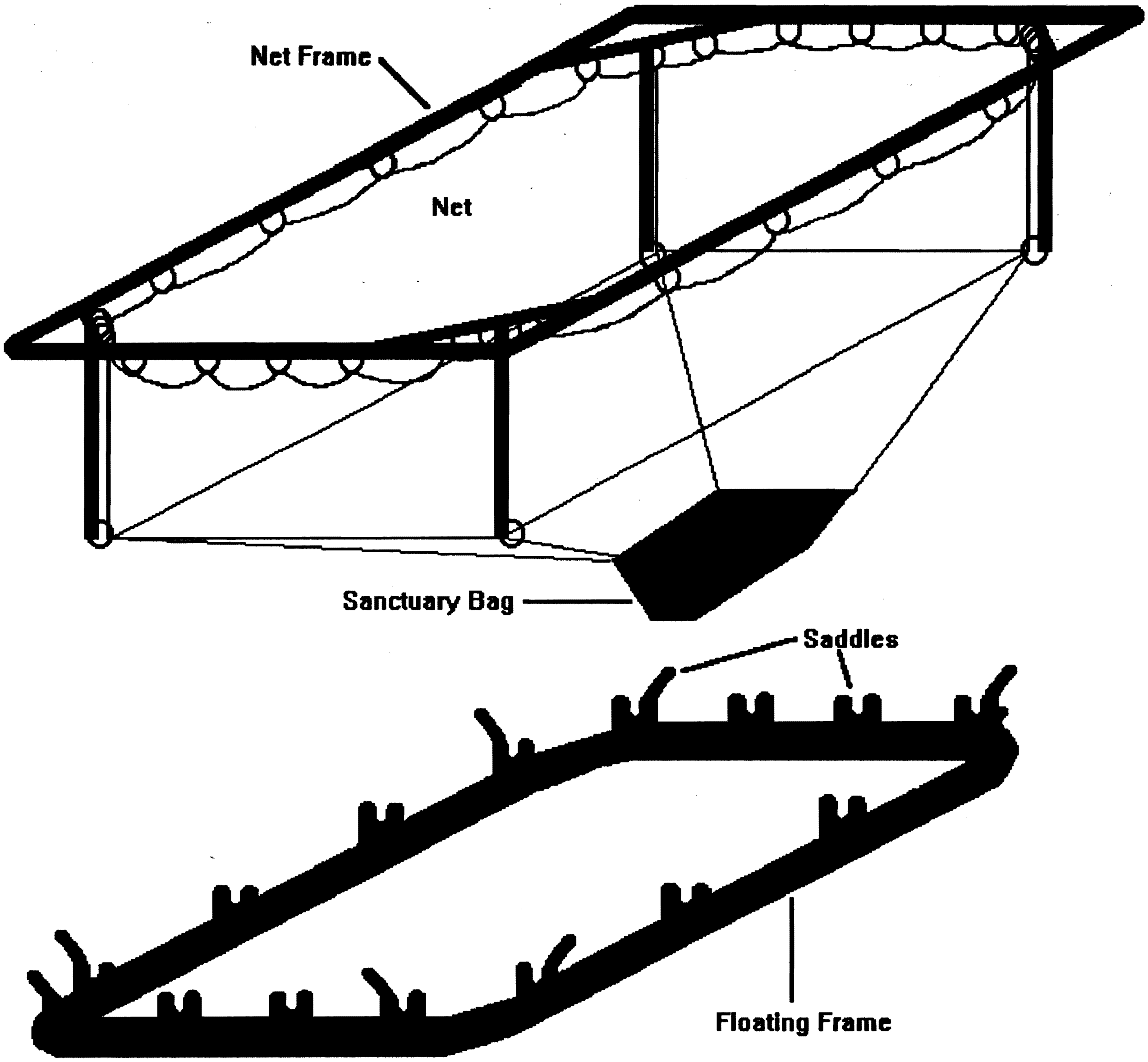

Figure 5--The floating recovery-net system designed by the U.S. Army Corps of Engineers. The floating frame was constructed of 30 cm foam-filled polyethylene pipe. Saddles were welded onto the pipe to hold the 7.6 m x 7.6 m stainless steel net frame. The net was attached to both the top of the net frame and the legs. The net tapered to a sanctuary bag at the bottom.

The net was constructed of 5-mm knotless mesh, and was 7.6 by 7.6 m square and 2.4 m deep along the sides. The net tapered 0.9 m to a 246-L sanctuary bag at the bottom center. A lead line was sewn around the top of the sanctuary bag to overcome its buoyancy. The top of the net was attached to the net frame, and the side corners of the net were attached to the net frame legs.

A combination barge and crane was used to manipulate the recovery net and floating frame. The barge/crane picked up and set the net and frame and held the system in place during testing. Because the area lacked a fixed anchoring site, the barge/crane maintained position in the river between four temporary anchors set by the barge/crane operators. The barge/crane was positioned just upstream from the net and was equipped with a flow-blocking device on its downstream end to decrease the amount of flow entering the upstream face of the net.

For this objective, 1,520 hatchery fish of each species were caudal-fin-clipped: 760 at the upper lobe for use as test fish, and 760 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 3%:

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

where n = number of fish needed

d = expected detection level

p_1 = net-descaling rate

p_2 = $p_1 + d$

To conduct the tests, the outfall pipe was shut off while the floating recovery-net system was moved into position under the pipe. With the floating recovery net in place, the outfall pipe was opened, and the flow allowed to stabilize. Test fish were released just above the facility swing gate, and control fish were released from a boat into the floating recovery net. The steelhead test was conducted the first day, followed the next day by the chinook salmon test. Each test involved two replicate releases of 380 fish each.

After the fish were allowed sufficient time to traverse its length, the outfall pipe was shut off. The crane then lifted the recovery net from the floating frame and positioned it over the barge. The sanctuary bag was unzipped, emptying the fish into sorting troughs. The crane set the recovery net back on the floating frame, and the second release was made. The recovery net was left in place on the floating frame while fish from the first replicate were anesthetized with MS-222, examined for descaling and injuries, sorted, and counted.

Prior to its use for this objective, the floating recovery-net system was used for barge-loading and river-return testing under Objective 1. After the first release under Objective 1, we attempted to keep net descaling low by lifting the recovery net slowly, allowing the fish an opportunity to swim down into the sanctuary bag instead of rolling down the sides of the net.

However, we found that the sanctuary bag floated to the surface as the recovery net was retrieved from the water. This resulted in little water remaining in the sanctuary bag when the recovery net was fully raised. After the first test, we raised the recovery net more quickly to avoid allowing the sanctuary bag to float to the surface. The speed with which the recovery net was raised did not appear to affect net-descaling rates because all tests conducted under Objective 1 showed no descaling attributable to the net.

Results and Discussion

Unlike the tests conducted under Objective 1, major descaling caused by the floating recovery-net system precluded accomplishment of Objective 3. Net-descaling rates exceeded 20%, overshadowing any effect of the outfall pipe.

Several problems likely contributed to this result. The floating recovery net was designed by the COE, with review by outside consultants (Summit Technology, NMFS, and the Fish Facility Design Review Subcommittee). Based on their calculations, the floating recovery net should have been large enough to dissipate the plume of water from the outfall pipe. However, during the test, we observed that the water plume exiting the pipe caused a turbulent, high-velocity zone extending 2-3 m beyond one side of the floating recovery net. Water plunging through that side of the floating recovery net would pin fish against it and cause severe descaling.

Some of the net descaling problem was due to the inability of the barge/crane to precisely maintain the net position under the pipe. Had the barge/crane been able to precisely maintain the net position, net descaling would probably have been lower than observed, but may have still been unacceptably high. Because of the location of the outfall pipe, the downstream, inside anchor had to be placed in shallow water close to the barge/crane. During the first replicate release, this anchor was displaced, decreasing the ability of the barge to maintain position. For later releases, ropes were run from the barge/crane to the concrete outfall pipe supports and back to the floating frame in an attempt to maintain position. The barge/crane also attempted to tie off to the outside pipe support, but this was not very effective because the support was not designed to withstand a lateral pull. Even the crane was used in an attempt to maintain net position. However, being on the barge, it was subject to the same instabilities that affected the barge.

The steelhead test was plagued with other problems as well. As with all previous tests, steelhead were tested first. Because the river-return lines from the separator terminate at the same release point as the outfall pipe, we planned to run both tests simultaneously. This required positioning the floating recovery net so that both sets of pipes would enter it. After the first replicate was released, we realized that this setup was unsatisfactory: the outfall pipe was too close to the side of the floating recovery net for the plume to dissipate before reaching that side.

A second problem involved the inadvertent release of two adult steelhead from the separator by a COE biological technician. Adult steelhead, confined in a relatively small sanctuary bag with 500-600 juveniles, have been shown to inflate juvenile descaling rates. Finally, a water hose used to maintain the control fish stopped functioning, resulting in the loss of 190 control fish because of oxygen deprivation. This was not noticed until after the fish had been released into the floating recovery net.

Because of these and other problems encountered during the steelhead tests, the net-descaling problem was not noticed until we began conducting the chinook salmon tests. During the initial tests, chinook salmon test fish showed a descaling rate of 25.2% (Table 5), while the controls showed a descaling rate of only 2%. The pattern of descaling was consistent among fish, with both sides of the body completely descaled.

As a precaution, we recommended that the outfall pipe not be used until the data were further analyzed, and that all the fish be bypassed through the collection facility by way of the river-return lines.

To determine if the floating recovery net was causing the descaling problem, we conducted another test using hatchery chinook salmon. The COE cut a hole in the top of the outfall pipe 6 m from its terminus at the river. Upon entering the floating recovery net, fish released from this point would be subjected to the same forces as the test fish released at the top of the pipe.

Table 5.--Mortality, descaling, and injury of hatchery-reared spring chinook salmon after passing through the outfall bypass pipe at Lower Monumental Dam.

Date	Mortality (%)	Descaling (%)	Eye/Head Injury (%)
<u>Yearling chinook salmon</u>			
04/25/93	0.0	25.2	0.0
05/05/93 - (an attempt to verify if descaling was due to the recovery net)			
Released into pipe			
- 6 m from end	0.0	24.1	0.0
- 46 m from end	0.0	22.7	0.0

Water velocity near the end of the pipe was approximately 5 mps and allowed fish only 1 second to distribute and orient themselves in the water column before plunging into the river. Because the fish might not be able to distribute themselves in the water column in such a short time, a second release point was chosen at an observation window 46 m upstream from the pipe terminus. Both release points were located on the relatively flat section of the outfall pipe (3% slope).

Results of this test demonstrated that the net was the descaling agent. Both release sites showed descaling rates (24.1% and 22.7% for the 6-m and 46-m sites, respectively) that were similar to the descaling rate observed during the initial chinook salmon test. Therefore, we concluded that the test could not be conducted properly with the available equipment.

At the end of May, we discussed the possibility of conducting the test using a purse seine to recover test fish. However, by this time the number of fish collected at the dam had dropped considerably, and the percentage of wild fish in the population was increasing to approximately 50%. Therefore, this strategy was aborted.

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. Some minor descaling problems detected at the raceway exits were easily corrected.

2) Levels of plasma cortisol and glucose in both species, and levels of lactate in steelhead, increased significantly during passage through the facility, receded during the first 6 hours in the raceways, and increased again after 10 hours in the raceways. For chinook salmon, levels of plasma lactate decreased during passage through the facility but increased in the raceways. These results (and other observations) indicated that both species were holding in the secondary dewaterer and that steelhead appeared to be holding in the corrugated flume between the secondary dewaterer and the separator.

4) Based on t-test analyses, no significant differences were detected between the COE electronically-set sample rate and the measured PIT-tag sample rate for fish exiting the separator through either the small-fish or large-fish flume. However, we observed that river-run fish passing through the separator during our tests showed a slightly, but not significantly, lower sample rate than our test fish.

RECOMMENDATIONS

1) Because the facility opening was delayed, testing above the wet separator for effects on both juvenile and adult salmonids was not accomplished in 1993. These tests should be conducted as early as possible next season.

2) Equipment design problems precluded the proper conduct of Objective 3 in 1993. This objective should be pursued further, utilizing other types of equipment (e.g., a purse seine) in 1994.

3) A complete PIT-tag detection/diversion system was not installed prior to 1993. This equipment should be evaluated as soon as it is operational in 1994.

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APPENDIX

Data Tables

Appendix Table 1.--Recoveries, descaling, injuries, and mortality of hatchery yearling spring chinook salmon released into the collection and loading facilities at Lower Monumental Dam, 1993 (Objective 1).

Location	Number of fish				
	Released	Collected	Mortalities	Descaled	Injured
<u>Release Group 1</u> - Separator to Raceway					
Yearling chinook salmon					
- Small-fish flume					
- Test	200	203	0	1	1
- Controls	100	93	0	1	0
- Large-fish flume					
- Test	200	207	0	0	1
- Controls	100	99	0	1	0
Yearling steelhead					
- Small-fish flume					
- Test	200	190	0	0	0
- Controls	100	114	0	0	0
- Large-fish flume					
- Test	200	184	0	0	1
- Controls	100	100	0	0	0
<u>Release Group 2</u> - Raceway 4 to barge					
Yearling chinook salmon					
- Test	400	399	0	27	1
- Controls	200	205	0	0	0
Yearling steelhead					
- Test	400	405	3	2	0
- Controls	200	193	0	0	0
<u>Release Group 3</u> - Raceways to barge (performed to isolate descaling problem)					
Yearling chinook salmon					
- From Raceway 3	200	200	0	8	2
- From junction of manifold and flume	200	200	0	0	0
<u>Release Group 4</u> - Raceways to truck					
Yearling chinook salmon					
- From Raceway 1	100	100	0	1	0
- From Raceway 2	100	101	0	0	0
- Controls (1&2)	50	46	0	0	0
- From Raceway 3	100	98	0	0	1
- From Raceway 4	100	101	0	1	1
- Controls (3&4)	50	51	0	0	1

Appendix Table 1.--Continued.

Location	Number of fish Released	Collected	Mortalities	Descaled	Injured
Release Group 5 - Separator to barge (direct loading)					
Yearling chinook salmon					
- Test	200	194	0	4	0
- Controls	100	100	0	0	0
Yearling steelhead					
- Test	294	293	0	0	0
- Controls	100	100	0	0	0
Release Group 6 - Separator to river					
Yearling chinook salmon					
- Test	400	400	0	0	0
- Controls	100	100	0	0	0

Appendix Table 2.--Means of plasma cortisol values (ng/ml), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for yearling chinook salmon and steelhead sampled at various locations and times at Lower Monumental Dam, 1993.

		Yearling chinook		Steelhead	
Sample	Location/(Time)	Mean	S.E.	Mean	S.E.
1	Gatewell 1C	115.7	10.5	84.4	12.4
2	Post-Dewaterer	144.6	10.5	154.2	12.4
4	Pre-Separator	144.7	10.5	184.0	12.4
5	Raceway (0-hour)	152.3	10.5	138.6	12.4
6	Raceway (2-hour)	127.2	10.5	173.1	12.4
7	Raceway (4-hour)	121.4	10.5	69.3	12.4
8	Raceway (6-hour)	110.3	10.5	103.2	12.4
9	Raceway (10-hour)	166.6	10.5	174.1	12.4

Yearling spring/summer chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	357.7	119.2		
Location/Time	7	10818.5	1545.5	3.5	0.0125
Error	21	9341.6	444.8		
Total	31	20517.8			

FPLSD = 31.0

Juvenile steelhead (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	2599.1	866.4		
Location/Time	7	54540.7	7791.5	12.6	<0.0001
Error	21	12968.8	617.6		
Total	31	70108.6			

FPLSD = 36.6

Appendix Table 3.--Means of plasma lactate values (mg/dl), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for yearling chinook salmon and steelhead sampled at various locations and times at Lower Monumental Dam, 1993.

		Yearling chinook		Steelhead	
Sample	Location/(Time)	Mean	S.E.	Mean	S.E.
1	Gatewell 1C	114.5	3.9	54.6	4.0
2	Post-Dewaterer	73.4	3.9	60.6	4.0
4	Pre-Separator	66.8	3.9	72.7	4.0
5	Raceway (0-hour)	57.9	3.9	52.1	4.0
6	Raceway (2-hour)	49.0	3.9	44.9	4.0
7	Raceway (4-hour)	50.4	3.9	55.7	4.0
8	Raceway (6-hour)	55.9	3.9	54.8	4.0
9	Raceway (10-hour)	57.5	3.9	59.8	4.0

Yearling spring/summer chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	152.0	50.7		
Location/Time	7	12859.3	1837.0	30.1	<0.0001
Error	21	1280.0	61.0		
Total	31	14291.3			

FPLSD = 11.5

Juvenile steelhead (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	228.6	76.2		
Location/Time	7	1796.8	256.7	4.0	0.0060
Error	21	1338.4	63.7		
Total	31	3363.8			

FPLSD = 11.7

Appendix Table 4.--Means of plasma glucose values (mg/dl), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for yearling chinook salmon and steelhead sampled at various locations and times at Lower Monumental Dam, 1993.

		Yearling chinook		Steelhead	
Sample	Location/(Time)	Mean	S.E.	Mean	S.E.
1	Gatewell 1C	62.5	5.5	119.8	6.0
2	Post-Dewaterer	68.9	5.5	116.3	6.0
4	Pre-Separator	81.5	5.5	127.0	6.0
5	Raceway (0-hour)	103.1	5.5	147.0	6.0
6	Raceway (2-hour)	110.4	5.5	147.2	6.0
7	Raceway (4-hour)	111.7	5.5	149.7	6.0
8	Raceway (6-hour)	108.3	5.5	139.0	6.0
9	Raceway (10-hour)	104.3	5.5	142.8	6.0

Yearling spring/summer chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	578.7	192.9		
Location/Time	7	11008.6	1572.7	12.8	<0.0001
Error	21	2575.6	122.6		
Total	31	14162.9			

FPLSD = 16.3

Juvenile steelhead (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	328.2	109.4		
Location/Time	7	4897.1	699.6	4.9	0.0021
Error	21	3002.5	143.0		
Total	31	8227.8			

FPLSD = 17.6

Appendix Table 5.--Fork lengths, plasma cortisol, lactate, and glucose values for migrating spring/summer chinook salmon collected from various locations and times at Lower Monumental Dam's collection facility, 1993.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/10/93**							
Gatewell 1C				Post Dewaterer			
125	85.4	106.4	39.2	130,128	129.2	59.5	35.8
112,120	170.8	50.4	94.9	140	239.6	85.1	77.6
150	179.9	35.0	59.6	141	132.4	87.3	32.7
147	79.6	126.7	14.7	160	151.1	61.0	60.3
130	92.3	166.4	17.5	135,130	248.7	123.3	141.5
127,126	90.7	159.4	30.6	128,134	128.8	77.8	52.8
134	155.4	199.3	21.4	129,130	145.2	61.3	81.9
131	108.8	87.3	--	129	236.8	61.4	68.5
				116,128,125,129	157.5	70.3	53.1
				130	159.5	67.1	49.9
				135	90.7	46.6	58.3
				135	96.0	64.3	63.5
				118	115.0	58.6	52.5
				134	99.4	56.3	70.7
				139	194.9	61.4	63.0
Pre-Separator				Raceway 0-hour			
125	205.3	63.8	96.4	130,135	247.8	74.2	161.6
14	111.1	76.1	46.0	129	159.6	27.9	98.1
140	150.4	65.0	52.1	143	242.0	50.7	122.5
129,103	213.8	71.3	72.1	130	81.7	13.6	140.1
138	239.4	69.2	87.1	140	267.0	43.7	110.8
141	121.3	119.1	146.4	145,125	204.4	80.7	117.7
128	123.3	63.1	78.6	125,118	229.9	60.7	86.1
126	12.8	54.5	74.3	122,120	114.1	53.9	79.9
123	213.5	44.5	75.8	127,123	268.2	51.1	97.6
139,127	177.7	63.1	98.7	125,122	169.1	56.8	89.6
132,116	156.8	86.9	58.7	129	148.8	52.5	70.5
148	121.5	69.6	65.8	129,130	159.4	35.8	60.1
149,135	91.0	73.3	71.2	129	104.0	20.9	96.8
108,112,129	194.2	79.0	49.3	131	138.6	38.9	90.8
143	105.6	37.6	56.3	140	149.5	57.1	140.0
Raceway 2-hour				Raceway 4-hour			
114,121	167.7	72.4	103.0	120,120	124.5	33.4	141.1
130,121	256.0	39.6	128.7	141,140	33.0	39.3	91.1
132,140	190.6	27.5	142.7	125,126	49.6	36.5	86.3
130,134,140	131.0	48.3	124.0	134,104	40.0	36.5	79.2
134	102.4	37.3	68.8	136,137	98.0	44.5	137.5
133	29.6	35.2	70.9	132,131	65.6	45.0	138.7
120,130	66.2	43.6	114.2	134,125	15.4	53.8	106.4
129	41.9	45.3	126.5	140	70.9	53.0	95.4
130,129	71.3	44.3	--	147	17.7	72.3	157.3
135,110	222.8	69.8	149.3	123,126,129	36.4	44.5	68.4
136	32.9	63.4	287.2	126	7.8	23.0	50.8
123,128	77.0	56.0	54.7	128,115	91.9	39.1	99.7
120,131	39.1	24.2	53.9	118,133	159.7	27.1	64.3
129	131.8	18.1	64.3	128,125	157.2	60.6	112.9
133	160.0	30.7	63.3	137	62.0	36.7	74.5
Raceway 6-hour				Raceway 10-hour			
123,111	66.7	36.7	67.6	128,126	348.3	58.6	307.6
135	338.3	51.0	250.8	124,120,138	115.5	48.0	98.3
138	119.2	63.8	50.6	134,140	192.7	54.5	162.8
146	21.9	33.7	81.0	123,125	118.1	56.5	103.9
136	25.1	52.8	115.7	122,124	105.8	65.1	75.3
134,134	55.2	46.3	126.6	136,124	159.1	61.4	46.6
128,123	30.2	48.9	83.8	121,130	106.5	63.3	59.5
130,141	198.9	61.6	123.3	125,116	99.3	85.9	45.2
126,119	58.0	57.7	111.5	116,134	147.5	64.2	268.1
123,125	19.3	58.0	77.6	121,126	242.5	55.7	137.6
130,131,137	251.3	88.2	176.1	120,130	197.7	47.7	133.6
128,108	49.5	63.3	64.1	132,132	171.4	54.5	102.4
113,119	45.4	30.9	126.6	128,136	77.1	56.9	91.4
118,135	235.8	42.3	73.1	134,109	113.3	69.8	89.4
125,122	251.5	71.4	167.1	135,143	63.4	37.0	53.9

Appendix Table 5.-- Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/11/93**							
<u>Gatewell 1C</u>				<u>Post Dewaterer</u>			
135	14.7	56.7	57.6	124,140	117.0	99.4	43.8
141	55.2	79.0	57.2	126	124.4	39.1	62.7
137	109.6	100.8	95.8	139	193.5	44.5	52.3
134	179.8	101.8	21.4	149	197.7	65.8	52.3
131,123	75.0	119.5	102.7	140	35.7	34.1	52.8
139	202.7	117.5	50.8	135,136	135.8	90.5	65.7
135,126	169.4	137.4	51.5	138	215.3	60.3	72.7
134	90.7	127.0	52.3	150,138	100.0	90.9	52.3
134	64.5	138.9	75.3	143	193.0	120.9	80.7
133,124	156.4	140.3	48.6	180	78.1	134.6	42.9
144	28.4	125.8	175.3	138	109.5	86.1	36.1
132,133	70.6	143.4	37.5	150,146	192.8	127.9	36.5
128,128	100.2	170.8	35.4	125,135,131	119.6	64.2	41.5
132,129	88.0	159.3	32.0	135,131	103.6	71.4	74.5
129,130,141	77.1	191.8	58.0	125,131	118.4	99.1	55.3
<u>Pre-Separator</u>				<u>Raceway 0-hour</u>			
125,122	205.4	66.8	92.0	116,140	121.7	31.7	101.1
138	235.8	67.6	132.3	135	123.6	53.5	98.3
152	180.7	82.7	53.9	129,111	160.5	88.3	100.8
135	219.4	48.6	60.3	125	166.3	32.8	60.7
138	148.3	82.0	74.4	144,125	330.6	74.9	97.3
131	69.1	48.9	129.9	137	155.4	49.7	121.1
135,125	108.9	70.1	78.7	132,132	336.3	95.7	262.1
149	187.9	61.2	137.8	148	101.7	42.0	76.9
130,128	123.6	80.4	91.5	130,110	159.6	30.9	71.6
138,126	83.0	82.3	67.5	130,128	151.5	66.0	66.7
141,120	121.3	91.1	58.7	128,136	56.9	56.8	113.8
135,129	131.6	97.0	106.9	120,120	166.5	33.7	106.7
128,133	178.8	45.3	55.5	151	187.3	36.1	221.8
129	92.3	52.7	44.3	143	--	--	--
133	188.4	53.6	93.0	137	174.5	74.2	87.1
<u>Raceway 2-hour</u>				<u>Raceway 4-hour</u>			
125,108	63.2	30.1	71.1	147	48.9	40.5	41.5
135	51.4	37.8	133.1	128	127.5	47.6	78.1
146	145.7	28.1	99.5	138,140	88.6	39.8	112.7
138	254.5	46.3	159.6	130,120	216.3	71.1	239.0
131,124	92.9	36.4	94.9	134,100	31.5	49.9	65.9
129,121	251.7	46.6	116.5	133,130	45.4	59.7	67.6
137	14.3	38.2	92.1	138,125,128,117	183.2	56.2	91.2
131,122	146.6	45.4	145.9	131,123	113.3	39.9	107.7
127,114	73.0	58.5	120.8	143,128	268.9	57.1	293.4
130,120	98.3	31.6	70.5	140,134	280.3	54.5	170.6
138,128	51.3	48.4	98.3	143,130	173.7	48.3	117.5
132,105,126	80.1	74.3	80.0	150	81.2	57.5	88.3
133,129	75.7	70.4	93.4	135,122,127	54.4	57.4	82.9
122,131	163.9	55.1	53.9	138,140	28.2	70.7	58.9
135	412.2	74.9	300.4	130	140.8	66.3	69.8
<u>Raceway 6-hour</u>				<u>Raceway 10-hour</u>			
142,120	71.0	46.0	85.1	130,122	108.5	39.9	95.3
120,112	129.9	37.3	110.8	135	246.1	33.5	71.0
130,116	88.3	41.0	100.5	125,117	215.7	69.0	164.4
135,112	49.7	48.3	87.9	143	104.3	50.7	103.8
134,117	58.9	48.1	97.1	120,121	187.6	58.0	127.1
138,121	93.5	70.5	159.6	130,127	100.7	41.9	89.3
128,126,121	200.2	76.2	210.3	138,131	134.7	55.0	86.1
123,112,121,132	144.6	76.9	105.1	150,130	138.8	49.0	100.3
141	63.4	47.2	89.2	132,127	141.5	76.9	80.6
138	98.9	58.4	91.4	120,124,121,128	132.3	62.4	118.8
130,129	68.5	49.5	74.4	135,135	237.9	59.7	197.5
150	36.8	50.5	88.3	130,129	311.2	95.9	151.2
130,144	67.7	66.3	89.1	140	214.2	66.8	120.8
146,131	141.7	103.7	110.7	140	172.2	52.0	81.1
				147	173.6	43.3	76.3

Appendix Table 5.-- Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/12/93**							
Gatewell 1C				Post Dewaterer			
131	170.2	61.0	29.9	140	163.8	78.9	56.4
135	136.0	72.2	75.3	132,130	278.5	116.9	162.6
149	152.8	139.0	120.8	134,134	282.2	56.0	57.7
134	56.6	76.0	53.1	125,120	148.9	55.0	65.0
151	66.7	75.7	66.1	156	102.4	57.2	41.1
139,125	93.0	83.9	44.5	130	63.4	68.9	49.4
134,128	153.9	102.9	88.3	152	162.5	151.5	24.4
140,131	237.0	121.7	91.4	122,125	156.2	56.7	39.9
175	73.0	115.9	103.7	155	154.5	163.7	71.1
137,130	46.4	142.2	77.3	135,130	115.1	84.6	50.9
154	112.1	150.3	75.8	125,126	180.2	55.6	55.8
136,136	25.5	124.1	47.6	131	112.7	46.3	67.5
152,102,132	135.6	151.8	24.9	127,125	203.8	75.4	79.5
137,128	111.6	144.1	35.4	137	177.8	52.1	108.1
127,125,124	177.5	155.6	44.6	134	64.0	81.8	79.1
Pre-Separator				Raceway 0-hour			
150	134.5	51.0	70.5	132,122	107.7	76.5	127.5
130,99	108.2	61.5	111.5	119	137.3	52.9	73.9
130	104.8	45.9	60.7	141	69.9	68.0	74.3
141	88.7	74.8	88.6	141,129	277.4	57.6	246.0
130,129	74.3	60.5	37.4	143	67.1	40.5	76.9
141	64.4	113.3	159.3	131,122	158.6	60.4	51.5
142	207.4	53.2	60.9	139,115	238.1	105.6	137.6
144	137.2	78.0	92.9	150	112.7	53.0	95.3
159	126.3	46.8	66.6	148	244.6	66.1	69.9
140	162.4	78.8	41.6	139	135.7	45.2	71.1
143	197.4	63.7	60.1	131,122	133.0	69.9	59.9
128,120,125	220.4	84.8	181.3	135,136	85.8	64.7	94.6
129,123	102.9	93.6	64.4	140	156.5	104.4	95.9
137	89.5	63.8	78.4	138,117	103.8	109.7	43.5
134	92.8	56.7	84.3	126,110,116	153.5	65.0	52.8
Raceway 2-hour				Raceway 4-hour			
140	137.0	31.3	111.2	144	174.6	30.9	84.4
123,123	204.6	36.5	105.1	129,126	148.9	32.5	79.0
124,126,121	226.3	48.4	196.3	133,134	39.9	49.8	115.4
143	51.6	25.6	73.0	140	130.5	54.4	69.9
121,133	97.0	41.9	77.3	130,135	214.9	60.7	87.1
136	136.7	49.0	130.7	135,130	110.3	74.6	186.8
135	51.8	47.2	92.4	132,125	158.9	45.7	87.4
125,137	163.9	57.1	112.3	135	128.9	24.1	78.4
141	166.8	44.5	108.1	142	160.4	42.8	128.6
137	59.4	80.4	140.8	125,132	110.4	36.3	91.6
129	86.3	63.9	47.6	135,126	258.2	62.5	195.6
133,122	159.8	67.8	79.7	134,128	161.8	58.8	83.3
140,118	74.3	60.6	84.3	130,130,121,132	86.4	31.1	75.3
110,120	159.9	34.6	70.7	140,125	94.1	53.0	60.9
132	143.6	42.5	46.0	143,119	200.4	42.1	143.8
Raceway 6-hour				Raceway 10-hour			
142	133.5	55.7	213.2	136	165.6	54.2	76.9
143	141.6	52.8	215.3	144	217.7	30.9	94.2
139	55.7	38.6	77.6	132	179.4	51.7	100.3
140,127	78.0	41.9	66.8	140	184.3	40.3	91.8
139,127	80.9	53.6	143.7				
136,137	99.7	59.8	142.8				
127	32.3	58.5	98.0				
128,140	90.7	36.1	92.9				
135	135.4	32.6	132.8				
119,114,116	197.0	57.8	117.1				
140,128	128.2	55.9	136.5				
135,118	26.6	52.6	66.8				
128,128	129.9	56.9	93.5				
135,130	151.8	48.6	65.0				
130	313.2	26.2	33.5				

Appendix Table 5.-- Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/13/93**							
Gatewell 1C				Post Dewaterer			
158	131.5	52.1	103.7	111,127	176.2	68.2	103.5
154	84.0	104.6	64.5	131	109.0	52.5	79.1
136	167.7	86.4	105.2	131	135.9	63.0	65.9
137,140	147.8	98.8	64.3	129	112.5	41.0	63.7
145,114	115.1	82.1	79.9	128	68.8	44.0	72.0
163	156.0	120.7	69.1	126	264.1	40.7	34.0
133,136	199.9	36.1	63.3	131	139.8	49.9	98.7
154	88.3	92.1	70.7	140,126	164.0	67.1	140.3
138,132	167.2	85.7	111.5	119,130	204.7	64.3	116.5
166	39.8	120.4	93.1	139,135	108.6	54.7	83.5
150,123	181.3	113.0	86.7	155	76.9	36.9	77.3
160,135	90.7	115.1	119.8	126,144	124.1	72.0	67.1
148	121.6	141.9	83.8	129,136	67.1	94.2	85.9
142,131	130.4	115.4	89.1	120,129	135.5	96.9	105.1
142,140	85.2	133.2	21.6	146	60.8	87.7	148.2
Pre-Separator				Raceway 0-hour			
140	189.3	50.2	69.1	135	170.3	28.9	123.6
155	71.8	42.5	71.5	130	111.6	34.9	97.1
138	180.1	51.9	104.4	130	217.0	74.4	188.0
130	163.4	46.3	47.8	128	55.1	24.9	77.9
142	109.5	62.7	97.6	138	33.4	42.5	84.6
136	136.3	37.6	65.9	138	228.9	59.7	50.7
139	127.3	60.6	85.9	146	50.9	70.8	115.4
134	140.3	79.3	85.9	153	207.3	82.5	147.5
127	248.4	92.0	61.8	134	15.6	59.4	44.3
131	104.4	65.2	96.0	136,127	85.1	64.1	156.3
125	106.3	109.7	42.7	152	82.3	53.0	96.8
132	139.6	54.8	73.9	135	42.8	73.7	133.1
153	182.5	42.5	96.9	134	150.8	61.5	84.3
143	175.7	49.2	81.8	131,130	108.7	73.7	83.5
132	182.7	69.1	147.5	126,130	145.8	91.7	70.7
Raceway 2-hour				Raceway 4-hour			
128	67.5	38.1	104.7	110,120	246.4	48.9	183.2
131	349.3	92.4	320.2	138,135	235.0	49.1	193.1
126	237.6	53.0	44.5	135	105.7	37.5	118.8
122	77.7	28.2	84.3	138,130	74.4	52.7	86.9
127,121	69.8	34.6	93.7	115,136	65.5	46.3	94.7
130,127	142.1	49.4	92.3	127,126	62.8	95.7	67.5
142	97.6	72.3	108.4	114,135	215.5	62.1	191.6
138	172.0	53.0	94.6	128,115	240.8	72.1	172.9
119,120	179.5	37.0	110.7	140	86.6	41.0	117.9
122	105.3	39.8	91.6	138,125,119	158.6	53.0	149.9
135,131	67.9	54.8	127.5	142	99.8	55.0	130.1
129,122	90.6	59.5	79.9	136	277.8	93.2	220.3
143	140.3	64.4	128.5	132,135	105.5	68.9	64.3
147	110.8	56.0	148.3	115,132	95.5	53.6	56.3
133,121	106.5	98.3	127.9	130	125.1	33.1	100.7
Raceway 6-hour				Raceway 10-hour			
135	--	--	--	145	219.8	42.9	124.4
125,135	63.5	38.5	70.3	133	175.4	47.5	103.5
132,113	27.5	55.7	125.9	116,120	125.3	53.5	104.3
140	50.7	58.2	97.1	152	140.7	55.5	121.1
143,117,130	147.9	47.2	76.9	132,130	137.0	46.3	110.5
120,130	69.2	57.9	76.3	142,128	165.9	60.3	54.7
140,135	247.1	66.4	69.2	144	156.4	62.4	85.1
132,130	36.9	97.3	118.5	143,127	168.1	80.5	90.7
135,123	45.0	113.1	49.1	139,132	115.5	62.4	58.7
139	83.0	36.9	131.6	133,127	210.1	57.2	53.2
145,124	164.6	69.3	83.8	140,130	151.8	113.2	76.7
145	161.3	53.9	101.3	137,130	107.2	106.7	133.1
136	94.6	48.3	98.0	141,121	101.4	49.6	141.9
134	260.0	83.1	156.5	133,134	189.1	44.3	102.4
110,127	151.3	53.8	154.7	135	150.6	51.7	96.3

Appendix Table 6.--Fork lengths, plasma cortisol, lactate, and glucose values for migrating steelhead collected from various locations and times at Lower Monumental Dam's collection facility, 1993.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/17/93**							
<u>Gatewell 1C</u>				<u>Post Dewaterer</u>			
182	114.2	35.8	98.7	170	197.9	26.0	121.1
218	210.1	40.3	151.2	200	197.8	43.1	69.4
201	142.6	39.5	135.4	251	172.6	68.4	150.1
249	163.4	37.8	91.4	229	124.8	72.4	116.5
219	212.6	90.2	108.4	204	122.5	68.8	153.9
232	124.4	54.5	84.7	218	249.9	84.3	274.2
215	117.7	60.9	104.2	159	171.4	35.5	122.0
214	68.3	46.0	96.8	212	211.1	49.8	132.8
182	82.1	47.9	81.6	225	176.6	148.3	146.7
213	29.8	59.7	96.9	224	130.2	50.7	151.6
233	57.5	53.9	103.1	166	125.6	38.4	86.3
210	122.4	52.8	105.9	206	222.7	46.9	106.9
221	83.6	80.6	188.4	152	103.6	32.9	109.7
209	155.0	56.2	108.4	193	156.9	29.5	131.3
181	95.8	80.1	79.9	222	154.0	56.0	177.3
<u>Pre-Separator</u>				<u>Raceway 0-hour</u>			
200	65.4	55.0	113.1	165	200.6	22.7	141.9
214	182.8	60.0	96.4	259	202.9	51.2	302.0
159	162.6	68.1	121.6	122	58.1	81.6	104.2
163	95.2	56.9	93.0	195	137.2	22.7	157.0
205	197.1	95.6	109.5	192	96.3	27.4	95.4
218	107.1	62.9	103.9	203	13.4	39.3	115.2
243	363.8	57.4	81.6	265	200.4	54.5	187.1
199	164.3	66.4	165.6	223	87.9	41.0	193.1
179	215.3	74.2	103.9	252	114.4	43.1	112.9
157	184.0	42.0	98.3	232	28.5	47.4	116.9
214	110.1	42.5	113.5	163	64.8	40.3	110.8
190	129.7	131.1	73.7	220	89.8	39.9	149.7
217	180.8	63.5	103.9	175	26.3	43.9	125.1
185	163.0	50.7	128.1	182	109.1	48.0	105.5
172	178.9	57.7	113.7	234	174.2	40.4	109.9
<u>Raceway 2-hour</u>				<u>Raceway 4-hour</u>			
214	220.1	31.4	101.5	204	13.3	22.4	181.9
223	216.6	19.1	94.5	218	16.5	30.6	84.4
200	62.6	23.0	210.3	231	33.3	38.7	140.0
180	201.7	39.6	112.9	183	74.4	45.1	141.6
210	155.7	33.7	114.7	194	63.0	39.0	100.5
250	126.3	34.8	155.6	249	139.6	76.5	349.2
165	109.0	40.7	101.5	185	44.1	39.0	132.5
261	210.4	46.0	103.8	206	22.1	58.1	103.1
217	86.0	41.5	176.1	221	33.1	43.1	131.6
186	258.1	50.1	130.3	211	77.9	51.8	111.5
226	121.3	60.4	222.1	210	87.6	74.4	239.4
225	199.3	63.5	114.6	189	58.3	76.6	125.7
180	256.8	58.4	201.2	182	52.9	110.9	155.6
213	161.7	47.1	150.7	197	103.3	72.2	103.6
216	133.1	105.8	196.4	226	31.6	71.9	125.1
<u>Raceway 6-hour</u>				<u>Raceway 10-hour</u>			
215	57.1	39.1	129.4	193	200.4	34.2	186.1
191	88.5	42.4	216.5	201	175.2	37.3	166.6
200	57.7	32.3	154.7	224	249.9	28.4	58.7
190	353.3	76.2	216.4	232	203.3	77.6	376.5
205	67.0	54.4	99.0	206	148.1	40.5	107.5
165	156.4	48.6	210.8	235	115.5	51.6	133.6
180	63.6	68.8	191.9	245	90.8	50.1	112.3
227	14.6	53.9	101.5	265	120.8	60.9	145.5
230	166.0	45.2	135.5	196	81.2	53.2	103.0
225	25.7	56.5	173.0	208	149.9	75.9	167.5
209	65.8	71.0	84.5	210	147.5	112.7	109.5
223	36.9	67.3	106.0	200	87.3	69.9	114.7
231	48.1	84.2	97.7	195	168.9	67.2	76.5
222	48.7	85.6	79.9	242	183.9	76.9	125.7
217	34.6	85.7	168.1	280	96.1	70.5	128.7

Appendix Table 6.-- Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/18/93**							
Gatewell 1C				Post Dewaterer			
203	119.7	54.7	93.8	171	342.2	52.7	88.3
233	119.2	46.0	114.7	200	157.4	33.5	100.5
206	29.3	42.2	155.2	215	226.6	77.9	69.1
193	70.6	47.1	89.5	171	58.5	46.0	120.8
180	106.0	52.1	113.1	188	195.3	86.9	178.1
208	174.5	112.4	136.9	223	307.1	80.8	66.6
214	48.8	47.4	99.7	202	145.0	57.2	87.6
204	99.3	44.9	99.4	170	51.9	44.5	89.9
211	97.5	66.3	109.2	197	80.0	54.7	91.5
178	107.9	96.2	122.3	189	252.7	85.5	112.3
194	56.4	63.8	99.4	161,194	84.1	84.5	166.8
219	113.7	61.8	140.3	214	31.7	62.1	115.2
194	89.8	78.1	141.5	225	190.6	98.1	220.4
257	49.9	51.9	97.6	212	119.0	69.6	106.2
182	90.5	71.0	133.9	217	63.0	90.4	45.1
Pre-Separator				Raceway 0-hour			
151	187.3	72.4	105.2	231	89.3	20.9	120.9
224	226.8	103.7	111.5	196	182.7	105.3	121.5
229	100.6	69.6	89.5	176	115.0	52.0	123.2
213	67.6	127.2	112.9	176	200.2	54.8	90.8
191	183.5	67.0	124.4	232	81.4	35.1	135.4
235	241.1	98.7	214.0	226	211.1	39.9	206.8
192	154.3	45.4	130.1	204	186.7	55.1	204.9
175	159.0	92.4	170.8	217	66.3	79.0	147.8
199	215.1	130.5	150.7	201	258.6	57.2	147.0
166	44.0	73.1	57.1	200	43.7	36.5	133.6
200	96.6	66.6	77.5	222	142.8	46.2	270.8
200	130.2	48.0	140.1	160	182.1	121.5	163.3
161	121.0	79.4	78.7	178	197.8	85.2	100.7
197	185.6	149.6	117.0	168	151.7	52.0	108.3
167	239.0	70.1	124.9	215	163.8	43.0	115.4
Raceway 2-hour				Raceway 4-hour			
184	67.1	36.3	133.9	237	45.6	18.4	153.5
196	234.8	47.4	281.9	181	31.7	28.7	201.2
193	186.2	22.4	95.4	205	19.3	22.5	98.7
190	142.7	28.8	114.0	215	178.2	34.6	157.4
207	95.6	50.3	118.2	212	102.1	40.7	175.5
233	379.1	41.5	218.7	173	30.2	33.8	187.9
200	111.2	28.2	111.5	211	25.2	39.9	114.6
188	177.0	41.0	179.6	208	45.5	41.9	127.0
205	181.4	36.9	170.1	191	40.6	52.3	205.6
182	148.9	35.2	179.9	173	40.9	49.3	108.3
208	120.4	40.5	128.2	217	106.1	49.9	172.4
207	257.0	48.6	113.1	176,163	30.6	48.5	150.5
205	79.2	54.4	192.2	205	53.9	56.6	227.6
233	180.5	93.2	112.3	234	62.9	54.9	130.7
192	114.5	49.3	124.8	203	185.4	26.0	157.2
Raceway 6-hour				Raceway 10-hour			
216	65.9	26.8	112.9	225	244.7	31.9	114.4
192	14.1	29.1	135.5	232	199.1	65.7	333.8
185	6.6	39.2	93.1	232	119.6	36.6	107.7
187	52.4	43.1	152.2	219	100.8	43.9	188.0
180	119.8	38.2	92.1	215	128.5	41.6	97.6
207	22.7	36.8	128.1	195	191.7	38.6	161.2
215	24.4	48.2	118.2	225	164.7	51.1	104.2
210	15.2	39.0	114.7	242	180.8	51.5	113.7
170	38.4	61.0	77.1	235	229.7	65.1	125.5
206	83.3	53.9	133.9	230	222.3	50.7	101.3
235	18.9	52.1	117.3	196	170.8	75.2	158.0
205	22.6	51.2	94.2	220	174.8	67.2	233.4
215	21.8	73.2	176.1	221	165.8	58.2	124.3
220	40.6	81.9	91.2	200	149.3	66.6	117.0
240	130.5	68.0	101.1	217	168.2	66.7	155.1

Appendix Table 6.-- Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/19/93**							
Gatewell 1C				Post Dewaterer			
195	83.4	41.1	157.3	195	182.1	34.9	119.0
203	195.1	40.2	70.1	184	104.0	43.3	73.1
212	104.6	46.9	134.1	195	182.4	39.4	91.3
238	143.4	40.2	131.6	227	144.8	46.8	102.1
224	30.1	39.0	157.4	260	166.1	24.8	120.1
214	61.3	28.8	79.1	211	106.7	36.1	124.9
191	25.0	48.0	94.2	195	27.2	49.8	154.8
207	120.0	37.6	103.0	205	157.3	26.9	115.4
214	27.8	37.6	129.9	191	104.7	52.4	125.9
195	42.1	46.8	87.5	208	190.4	43.1	74.6
224	26.0	56.3	159.5	192	132.5	68.3	129.5
256	13.2	47.4	114.8	210	53.5	41.7	128.2
193	65.3	61.4	129.9	234	223.5	71.1	178.1
177	58.2	79.2	109.5	252	119.9	61.0	86.8
193	24.2	67.7	115.7	233	226.5	74.7	131.3
Pre-Separator				Raceway 0-hour			
168	204.9	45.7	137.0	184	87.6	29.8	72.2
203	247.8	68.4	186.4	179	106.9	37.5	203.4
203	211.3	87.3	99.0	214	123.5	46.6	123.5
180	193.2	48.2	152.2	192	19.6	30.5	94.6
200	115.4	81.6	99.0	229	168.2	39.4	201.2
167	231.5	68.6	118.0	212	133.3	41.4	218.0
157	246.7	50.0	202.3	214	190.2	35.5	196.4
168	420.3	56.3	153.9	189	134.7	41.2	103.6
231	164.5	81.8	112.9	208	279.0	47.5	257.6
204	138.4	48.9	96.1	236	178.2	76.8	109.2
158	150.0	60.1	148.2	214	123.6	54.4	166.3
189	267.1	79.3	96.6	182	38.1	26.6	134.1
214	57.7	54.2	63.0	192	186.9	46.8	150.1
189	229.0	47.4	242.7	193	229.7	140.5	96.4
179	293.5	46.2	63.5	158	39.8	47.8	139.3
Raceway 2-hour				Raceway 4-hour			
218	176.9	30.1	88.3	195	161.4	47.2	64.8
169	176.0	52.5	144.8	212	40.4	36.0	96.4
211	131.2	63.9	140.3	206	21.3	47.5	133.3
251	201.3	32.6	177.1	192	29.7	39.9	115.6
198	176.5	63.3	158.0	195	23.6	37.0	119.0
202	168.2	31.7	75.4	176	24.9	51.0	71.6
270	116.2	42.9	152.8	228	53.6	52.4	141.5
214	162.0	58.5	169.6	213	132.9	63.6	189.5
170	134.6	38.5	117.0	208	64.5	56.8	124.8
227	333.8	59.1	339.2	210	80.3	73.6	199.5
199	105.5	44.5	145.5	195	84.0	71.1	96.4
171	82.0	47.4	82.2	209	88.2	99.4	145.6
179	98.8	44.9	145.3	109,220	68.8	85.8	234.3
205	185.7	53.6	104.6	245	79.3	61.3	139.9
189	188.1	69.2	161.7	200	164.8	36.2	108.4
Raceway 6-hour				Raceway 10-hour			
200	282.0	32.6	185.6	205	189.8	37.6	157.2
208	131.0	23.0	131.0	183	223.3	32.3	101.4
172	225.3	50.0	293.1	216	189.8	30.8	90.6
171	28.0	32.6	113.9	195	200.7	54.2	144.0
225	225.5	44.8	177.6	205	124.9	54.1	96.4
204	101.0	63.0	130.7	210	225.5	48.2	217.5
201	195.4	48.9	146.8	205	226.5	65.2	138.2
215	197.8	61.2	82.4	215	199.8	47.8	78.1
198	160.8	61.4	132.4	220	165.4	82.7	316.3
220	151.8	73.3	112.7	224	135.9	98.0	125.5
184	97.1	64.8	156.6	221	163.0	61.3	148.3
205	174.9	68.4	--	205	177.3	60.4	85.1
260	127.4	71.1	189.2	235	170.0	80.8	91.2
248	119.1	53.6	114.2	213	82.6	81.0	128.5
241	127.2	66.5	94.6	231	155.2	72.1	134.6

Appendix Table 6.-- Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)	Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/20/93**							
Gatewell 1C				Post Dewaterer			
220	156.2	36.4	141.9	189	156.5	49.5	96.3
218	30.9	56.0	254.8	186	104.1	107.1	120.8
235	118.0	45.1	102.2	184	174.1	37.6	32.3
192	48.3	49.4	94.7	205	358.5	54.5	160.4
182	18.2	48.6	149.3	200	154.5	99.1	124.3
165	110.8	57.6	106.4	229	188.7	45.0	89.9
222	56.7	48.7	100.3	177	131.8	87.4	143.2
200	15.7	45.0	133.6	206	48.8	73.6	112.7
194	66.0	44.1	123.6	199	171.3	56.4	144.2
197	96.4	48.1	106.1	216	173.4	73.4	92.6
175	23.8	59.3	102.2	193	142.3	48.9	79.1
205	46.5	55.6	153.5	237	95.8	55.3	133.9
216	41.1	68.1	122.4	184	99.7	69.8	57.2
182	46.9	64.0	189.2	185	209.2	99.4	71.0
218	19.1	58.2	151.8	181	98.4	88.9	54.2
Pre-Separator				Raceway 0-hour			
206	225.2	81.7	271.4	198	174.2	48.1	134.6
210	237.3	52.1	211.6	190	224.8	91.3	167.8
190	249.3	66.4	117.5	192	279.1	71.8	198.9
195	136.7	74.7	114.4	232	240.3	51.2	180.1
203	343.5	103.5	107.6	206	130.2	29.3	96.0
232	182.8	42.2	119.9	220	111.1	45.7	115.0
210	174.9	56.5	99.4	210	36.7	33.7	110.8
195	242.0	126.3	186.1	221	111.4	43.2	161.2
225	165.6	86.9	188.0	227	224.6	57.4	235.2
208	153.2	82.7	144.3	212	286.5	131.5	204.9
208	194.0	94.9	156.3	208	98.9	46.0	165.3
203	60.8	34.9	80.3	197	74.0	42.9	98.3
155	261.6	117.1	87.1	200	206.9	69.6	136.2
165	114.7	67.1	156.5	206	29.3	39.4	104.3
170	272.7	72.5	185.6	200	171.4	55.7	128.1
Raceway 2-hour				Raceway 4-hour			
229	264.3	25.4	194.7	225	51.6	44.2	150.1
205	278.5	18.8	157.4	190	69.1	45.4	419.0
193	258.6	29.7	108.4	203	76.3	58.2	167.8
200	222.4	40.1	141.6	200	176.5	140.3	361.7
194	183.2	47.9	114.7	237	46.8	47.9	174.8
195	93.6	110.4	96.4	220	99.6	41.1	75.5
215	98.9	22.1	133.9	235	30.6	47.4	110.7
215	205.1	44.8	282.6	225	81.8	75.8	177.6
254	327.1	37.2	199.4	221	58.3	55.7	93.1
243	164.4	36.1	135.6	237	46.4	67.9	117.1
188	215.1	42.3	180.4	235	42.3	78.3	107.5
180	183.7	39.9	148.2	243	86.3	103.2	55.1
198	157.8	32.8	87.4	205	150.7	63.6	128.6
196	112.6	43.0	75.5	245	59.0	83.6	150.7
197	187.6	43.3	115.5	194,165	118.7	83.3	119.7
Raceway 6-hour				Raceway 10-hour			
210	27.8	32.2	169.6	182	201.2	37.8	149.3
193	225.3	32.8	140.5	196	209.3	34.0	133.0
215	174.6	42.8	170.1	195	135.9	42.5	69.4
207	102.6	39.6	162.8	175	172.5	51.0	218.9
197	47.0	41.2	106.0	182	259.0	76.6	357.2
212	96.8	42.9	102.9	193	217.8	44.5	98.0
195	116.6	43.9	113.1	196	251.4	80.7	189.4
195	140.0	51.7	89.4	213	237.7	54.2	122.7
197	114.0	53.8	148.1	197	180.1	63.1	76.1
205	129.6	78.9	232.0	220	224.5	94.4	52.8
237	154.8	72.6	281.6	210	155.5	78.0	117.3
220,222	143.0	70.8	157.4	200	130.1	56.9	139.0
202	136.8	62.8	122.1	212	150.2	56.9	96.6
230	152.3	74.4	119.0	228	161.5	89.3	112.3
227	125.8	76.5	117.0	260	302.7	105.6	236.7

Appendix Table 7.--The facility sample rate, the number of PIT-tagged test fish passing through the fish flume, the number of test fish caught by the sampling system, and the measured sampling rate for each hour of testing at Lower Monumental Dam, 1993 (Objective 2).

Test Date	Pre-set Sample Rate	Time (PST)	Number of fish in flume	Number of fish in sample	Measured sample rate
<u>Large-fish flume:</u>					
5/4/93	5%	0600	78	3	3.85
		0700	244	8	3.28
		0800	149	11	7.38
		0900	193	2	1.04
		1000	180	11	6.11
		1100	181	10	5.52
		1200	187	8	4.28
		1300	217	3	1.38
		1400	188	15	7.98
		1500	227	11	4.85
		1600	139	4	2.88
		1700	8	0	< 10 Fish
		1800	4	0	< 10 Fish
		1900	5	0	< 10 Fish
		2000	5	0	< 10 Fish
		2100	5	0	< 10 Fish
		2200	2	0	< 10 Fish
		2300	0	0	< 10 Fish
5/6/93	2%	0600	85	5	5.88
		0700	190	0	0.00
		0800	198	3	1.52
		0900	316	9	2.85
		1000	290	3	1.03
		1100	254	9	3.54
		1200	281	4	1.42
		1300	249	3	1.20
		1400	249	3	1.20
		1500	215	6	2.79
		1600	274	1	0.36
		1700	240	6	2.50
		1800	216	2	0.93
		1900	129	1	0.78
		2000	38	3	7.89
		2100	19	0	0.00
		2200	9	0	< 10 Fish
		2300	13	0	0.00

Appendix Table 7.--Continued.

Test Date	Pre-set Sample Rate	Time (PST)	Number of fish in flume	Number of fish in sample	Measured sample rate
<u>Small-fish flume:</u>					
5/4/93	10%	0600	64	8	12.50
		0700	144	9	6.25
		0800	130	17	13.08
		0900	172	19	11.05
		1000	209	19	9.09
		1100	175	21	12.00
		1200	164	16	9.76
		1300	138	7	5.07
		1400	149	17	11.41
		1500	152	19	12.50
		1600	156	11	7.05
		1700	29	2	6.90
		1800	4	0	< 10 fish
		1900	1	0	< 10 fish
		2000	8	1	< 10 fish
5/6/93	5%	600	22	3	13.64
		700	67	3	4.48
		800	56	3	5.36
		900	74	9	12.16
		1000	73	3	4.11
		1100	60	2	3.33
		1200	77	3	3.90
		1300	121	3	2.48
		1400	122	9	7.38
		1500	77	1	1.30
		1600	91	3	3.30
		1700	104	6	5.77
		1800	87	4	4.60
		1900	34	0	0.00
		2000	27	0	0.00
		2100	7	0	< 10 fish
		2200	4	0	< 10 fish
		2300	7	0	< 10 fish

Appendix Table 8.--Recoveries, descaling, injuries, and mortality of hatchery yearling spring chinook salmon released into the bypass pipe at Lower Monumental Dam, 1993 (Objective 3).

Location	Number of fish				
	Released	Collected	Mortalities	Descaled	Injured
Release Group #1 - Outfall pipe from facility switch gate					
Yearling chinook salmon					
- Test	760	754	0	190	0
- Controls	760	761	0	15	1
Release Group #2 - To determine if the capture net was the cause of the descaling					
Yearling chinook salmon					
- Distance from end of pipe					
- 6 m	200	203	0	49	0
- 46 m	200	198	0	45	0