Preliminary evaluation of the new juvenile collection, bypass, and sampling facilities at McNary Dam, 1994

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Coastal Zone and
Estuarine Studies
Division

Northwest Fisheries
Science Center

National Marine
Fisheries Service

Seattle, Washington

by
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Gene M. Matthews

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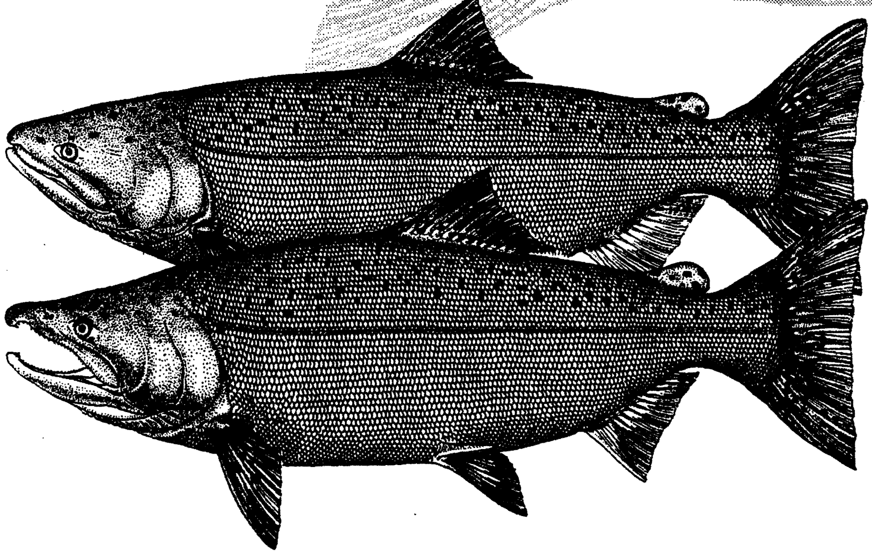

PRELIMINARY EVALUATION OF THE NEW JUVENILE COLLECTION, BYPASS, AND SAMPLING FACILITIES AT MCNARY DAM, 1994

by

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EXECUTIVE SUMMARY

We conducted research to evaluate the new juvenile fish bypass system at McNary Dam, which was completed and began operating in spring 1994.

Our evaluations at McNary Dam in 1994 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, and 3) to determine if the outfall pipe safely passed juvenile fish.

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, 2, and 3 which were accomplished in 1994.

Objective 1

Evaluate the condition and survival of yearling and subyearling chinook salmon and yearling and adult steelhead after passage through the collection/transportation facility.

We found that passage through all routes from the new collection channel to exit from the facility through either the barge, truck, or return-to-river was satisfactory for outmigrating spring chinook salmon and steelhead. After their release to the collection channel, the median passage time for the juvenile steelhead tested was 17.8 hours.

Blood analysis of outmigrating yearling spring/summer chinook salmon, juvenile steelhead, and subyearling chinook salmon showed that the fish were not overly stressed or fatigued as they passed through the facility.

To assess the effects of the system on adult fallbacks, we released 21 adult steelhead into gatewells. Adult downstream passage was not as satisfactory as that of juveniles, and we observed adults holding along the sides of the primary dewaterer. Of the 21 fish released, only 14 were observed on the separator, while 4 of the remaining 7 were found in the collection channel more than 2 months after release. The median passage time of the 14 adults recovered on the separator was 17.2 hours.

Objective 2

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

Our initial study design for this objective proved to be unsatisfactory, most likely due to the design of the separator. Utilizing a different method we were able to determine that the sampling system was effective and reliable in sampling at most sampling rates. The lone exception to this was at a 4% sample rate on the large fish flume.

Objective 3

Evaluate the bypass system outfall pipe.

Our efforts under this objective were limited to a review of video from inside the outfall pipe and the inspector's confirmation of smooth welds.

Conclusions and Recommendations

We concluded that the new collection channel, separator, flumes leading to the laboratory, and flumes leading to the raceways, barge, truck, and river, 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. Our only recommendation is to test the PIT-tag detection/diversion system at McNary Dam when it becomes operational in 1995.

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INTRODUCTION

The first McNary Dam juvenile collection and bypass facility was constructed in 1979 by the U.S. Army Corps of Engineers (COE) and the National Marine Fisheries Service (NMFS) to study juvenile salmonid transportation on the Columbia River. In 1981, this facility became part of the smolt transportation program operated by the COE (which includes similar facilities at Lower Granite, Little Goose, and Lower Monumental Dams on the Snake River). To increase fish-holding capacity and improve barge-loading facilities at McNary Dam, construction of an entirely new juvenile collection and transportation facility was initiated in 1993. The new facility was first used during the 1994 juvenile salmonid outmigration.

Because the collection channel for the old juvenile fish facility moved bypassed fish to the north (the old facility was located between the powerhouse and the spillbays), a new collection channel had to be constructed to carry bypassed fish to the new facility located downstream of the dam on the southern shore. The new collection channel was constructed within the existing ice and trash sluiceway. Fish enter this channel through 1-m-long flumes attached to the existing orifices. After entry, they move to the south end of the powerhouse, go through primary and secondary dewaterers, and enter a closed, smooth, iron pipe. This pipe transports fish and water approximately 145 m to a pneumatic switch gate, where the fish either continue on to the wet separator or are bypassed to the river through a closed corrugated pipe. The corrugated pipe transitions to a closed plastic outfall pipe approximately 110 m offshore. The outfall pipe terminates with a drop of approximately 5 m to the water surface (depending on tail-water level) (Fig. 1).

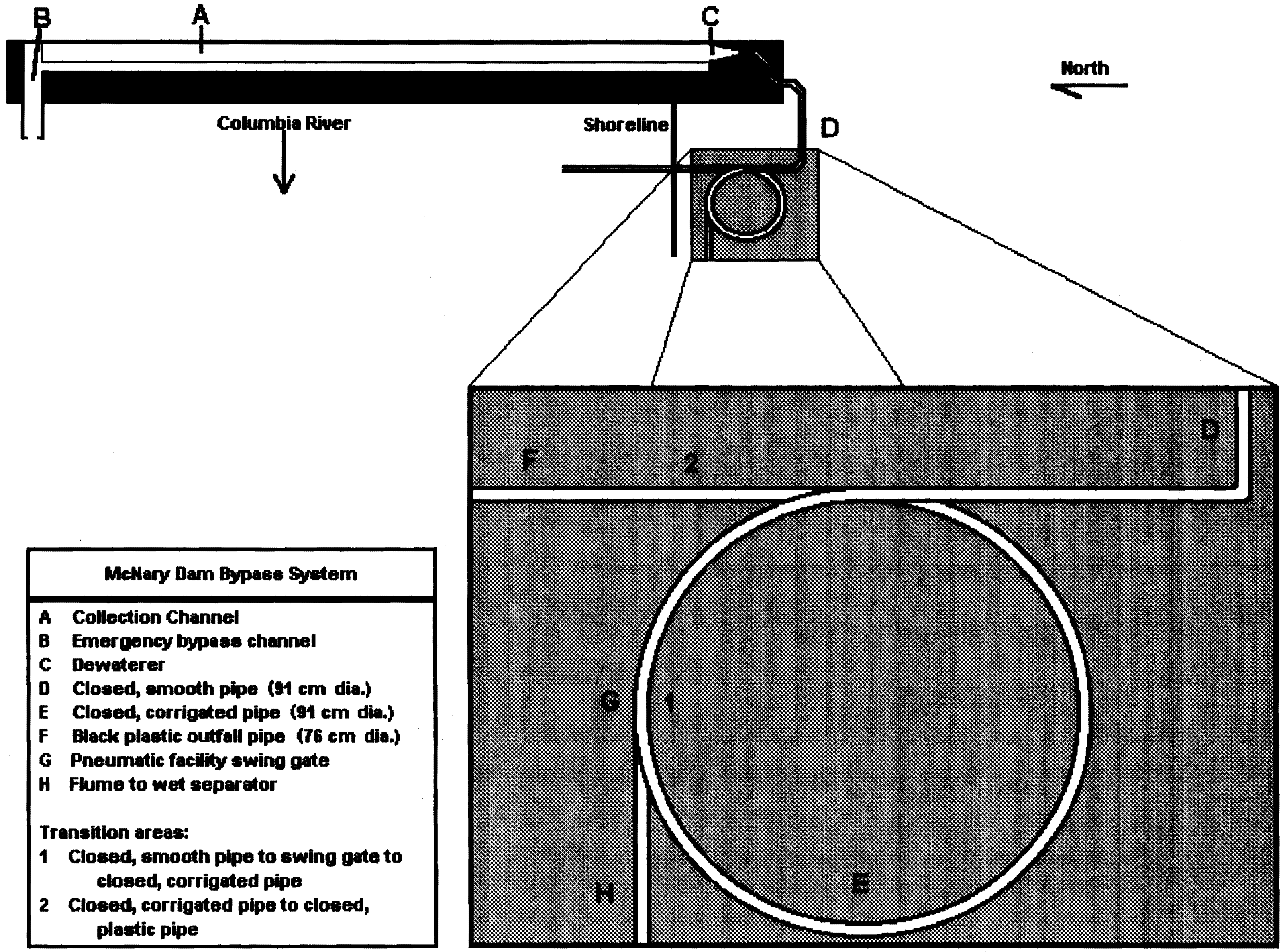

Figure 1. Schematic of the juvenile bypass system at McNary Dam.

Fish entering the wet separator are graded into two sizes; large and small fish then exit the wet separator volitionally into separate flumes. From either of these two flumes, fish may enter 1) the PIT-tag diversion system, 2) the sample holding tanks, 3) the river-return line (flume for small fish only), 4) the direct barge-loading lines or, 5) the raceways. The eight main raceways are 2.4 m wide by 20 m long and hold approximately 72,000 liters (19,000 gal) of water or 4,300 kg (9,500 lbs) of fish (at the maximum operating/holding capacity of 60g per liter (0.5 lbs per gal) of water). Fish in the raceways can be loaded onto either transport trucks (only from raceways 1-4) or barges (from all eight raceways). All of the river-return lines and barge- and truck-loading lines are made of 25-cm-diameter PVC pipe (Fig. 2).

Since 1990, new collection/bypass facilities have been constructed at Little Goose and Lower Monumental Dams. At both facilities, evaluations prior to operation revealed some areas that caused descaling and injury (Monk et al. 1992, Marsh et al. 1995). Isolating these problems prior to full-time operation of the facilities provided the opportunity to make the structural modifications and procedural changes before the start of the main collection/transport season. Similarly, it was important to conduct evaluations of the new juvenile fish facility at McNary Dam, since this facility was expected to collect and transport over seven million migrating juvenile salmonids during 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 1994 outmigration arrived at the dam.

Our study objectives in 1994 were: 1) to determine if mechanical problems existed that might affect both juvenile and adult salmonids during passage, and to determine how juveniles

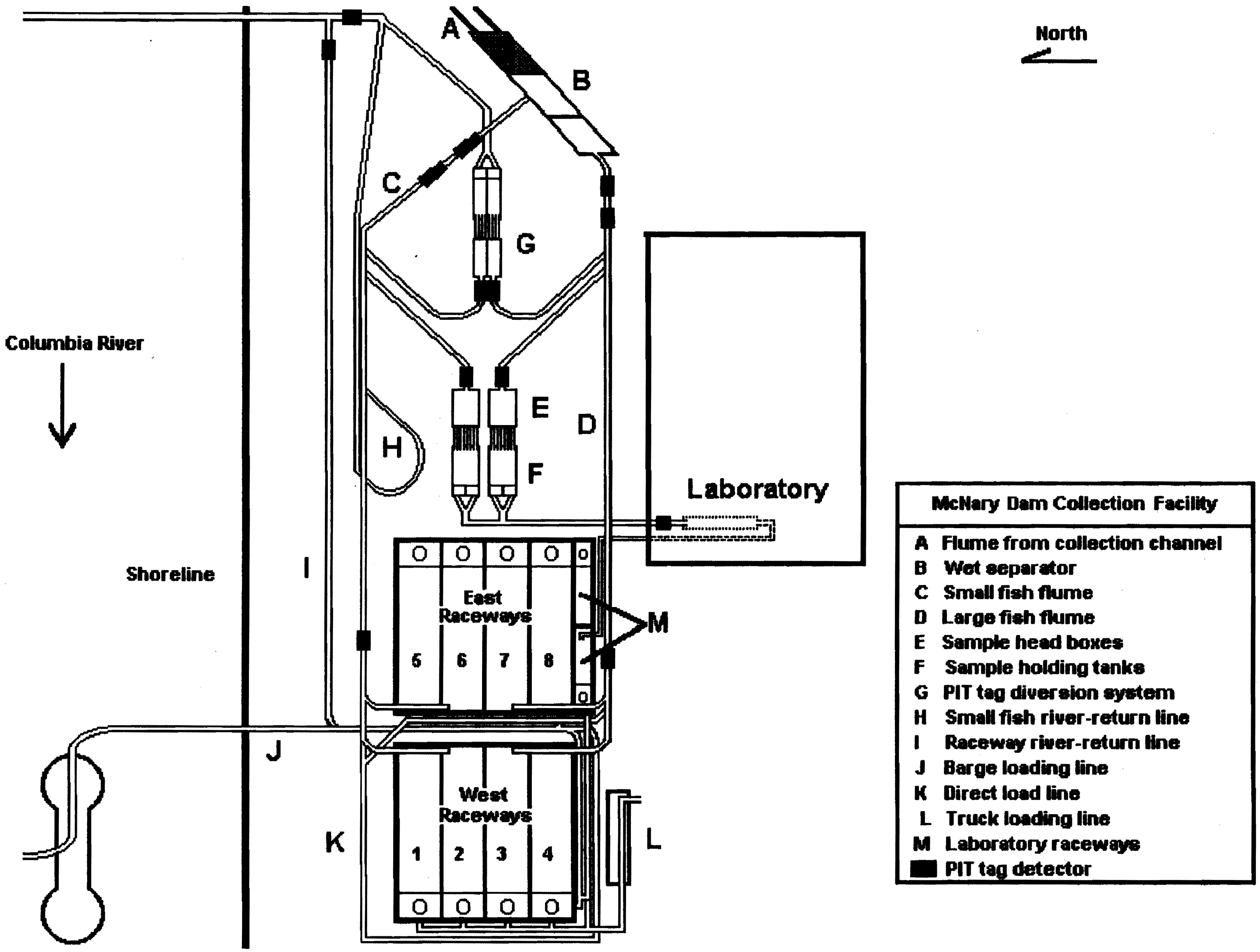

Figure 2. Schematic of the juvenile fish collection system at McNary Dam.

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 1

Evaluate the condition and survival of yearling and subyearling chinook salmon and yearling and adult steelhead after passage through the collection/transportation facility.

Approach

Descaling, Injury, and Mortality Evaluation

To determine whether mechanical problems existed within the bypass and collection facilities, hatchery fish were released into different sections of the facilities (Table 1). Fish were recaptured downstream, and the effects of each section were determined by examining the released fish for descaling, injuries, and mortalities. All test groups except Release Group 1 consisted of a test and a control group of fish marked by either an upper or lower caudal clip. Control fish for paired replicates were released directly into the collection device to isolate descaling or injury caused by the recapture or handling procedures.

All test groups consisted of yearling chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*O. mykiss*) trucked from Dworshak National Fish Hatchery. Yearling chinook salmon arrived at the dam on 9 March, and steelhead arrived in three separate loads on 9, 16, and 23 March. All fish were immediately fin-clipped upon arrival. However, because of mechanical problems and construction delays at the McNary facility, fish were held at the facility for 16 to 30 days before being released for evaluation purposes into the various sections of the facility. During the delay, fish were fed a minimum-subsistence diet. Nevertheless, when testing started,

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	Area evaluated	Release site	Collection site
1	Yr. chinook Steelhead	1) Primary dewaterer 2) Transport pipe 3) Separator 4) Sample system	Collection channel at Units 1, 17 and 14.	Sample room
2	Yr. chinook Steelhead	1) Small-fish flume 2) Raceway entrances	Small-fish exit from separator	West raceways
2	Yr. chinook Steelhead	1) Large-fish flume 2) Raceway entrances	Large-fish exit from separator	West raceways
3	Yr. chinook Steelhead	1) Raceway exits 2) Truck-loading pipes	West raceways	Net in truck
4	Yr. chinook Steelhead	1) Raceway exits 2) Barge-loading pipe	West raceways East raceways	Net in barge
5	Yr. chinook Steelhead	1) Small-fish flume 2) Barge loading pipes	Exit from separator	Net in barge
5	Yr. chinook Steelhead	1) Large-fish flume 2) Barge loading pipe	Exit from separator	Net in barge
6	Yr. chinook Steelhead	1) Small-fish return to river pipe	Small-fish flume	Floating recovery net at outfall
6	Yr. chinook Steelhead	1) Raceway exit 2) River return pipe	Raceway No. 5	Floating recovery net at outfall

the fish, especially the yearling chinook salmon, were heavily smolted with very deciduous scales, which made them as susceptible to descaling as river-run smolts.

Release Group 1 (released 8-9 April) was used to evaluate the components of the collection system from the collection channel into the sampling room (Table 1). Since this evaluation area terminated at the sample room, no capture nets were needed to recapture fish for examination; therefore, a control group to assess recapture injuries was not used. To isolate effects of passing through the collection channel, separate releases were made in the north (Unit 14), middle (Unit 7), and south (Unit 1) sections of the channel. The facility sample gate was opened (100% sample) for 5 days, so that fish holding in the separator would not avoid collection. After the release, fish were collected in the holding tank every 24 hours, crowded and flushed into the sample facility, anesthetized with tricane methanesulfonate (MS-222), and examined for descaling and injuries.

Release Group 2 (release made on 26 March) was used to test the flumes leading from the separator to the raceways, and the discharges into the raceways. Fish were released into both the large- and small-fish flumes just below the wet separator and collected in a raceway. The area within the raceway was reduced by moving the raceway crowder just beyond the turbulence zone at the head of the raceway. After fish had entered the raceway, the water level was dropped, and fish were dip-netted from the raceway, anesthetized (MS-222), and examined for descaling and injuries.

Release Group 3 (release made on 30 March) was used to test the raceway exits and the truck-loading lines. In order to approach the maximum raceway-loading condition of 60g of fish per liter (0.5 pounds per gallon) of water, fish were crowded into the tail section of each raceway under a full head of water. Also, by being at the tail of the raceway, the fish were exposed to the higher flows and turbulance associated with a full head of water exiting the raceway, increasing the likelihood of descaling and injury if any physical problems with the exit oriface or exit pipes existed. A large fyke net, with a sanctuary bag in the cod end, was used to line the rear compartment of a COE transport truck. Controls were released directly into this compartment prior to release of test fish from a raceway. A sanctuary dip-net was then used to capture and transport the control and test fish to a tank where they were anesthetized (MS-222) and examined for descaling and injury.

Release Group 4 (releases made on 6-7 April, 10 April and 17 April) was used to test the raceway exits and barge-loading lines from all eight raceways. The same net used to capture fish in the transport truck was draped into a compartment on the barge, and the release pipe was centered over the net approximately 1.5 m above the water surface. After capture, the procedures were the same as previously described for the other test groups.

Release Group 5 (release made on 28 April) was used to evaluate the direct barge-loading system, which included both the small- and large-fish flumes (from the separator) and the barge-loading pipes. Recapture and examination procedures used for the test and control fish were similar to those used for Release Group 4.

To evaluate the river-return lines, Release Group 6 (release made on 27 April) was divided into two releases: one to the raceway river-return line, and the other to the river- return line from the separator flume that passed small fish. The procedure for the raceway release was similar to that used for other raceway release groups. For the river-return line from the small-fish flume, fish were released into the flume just below the separator with all gates adjusted so that

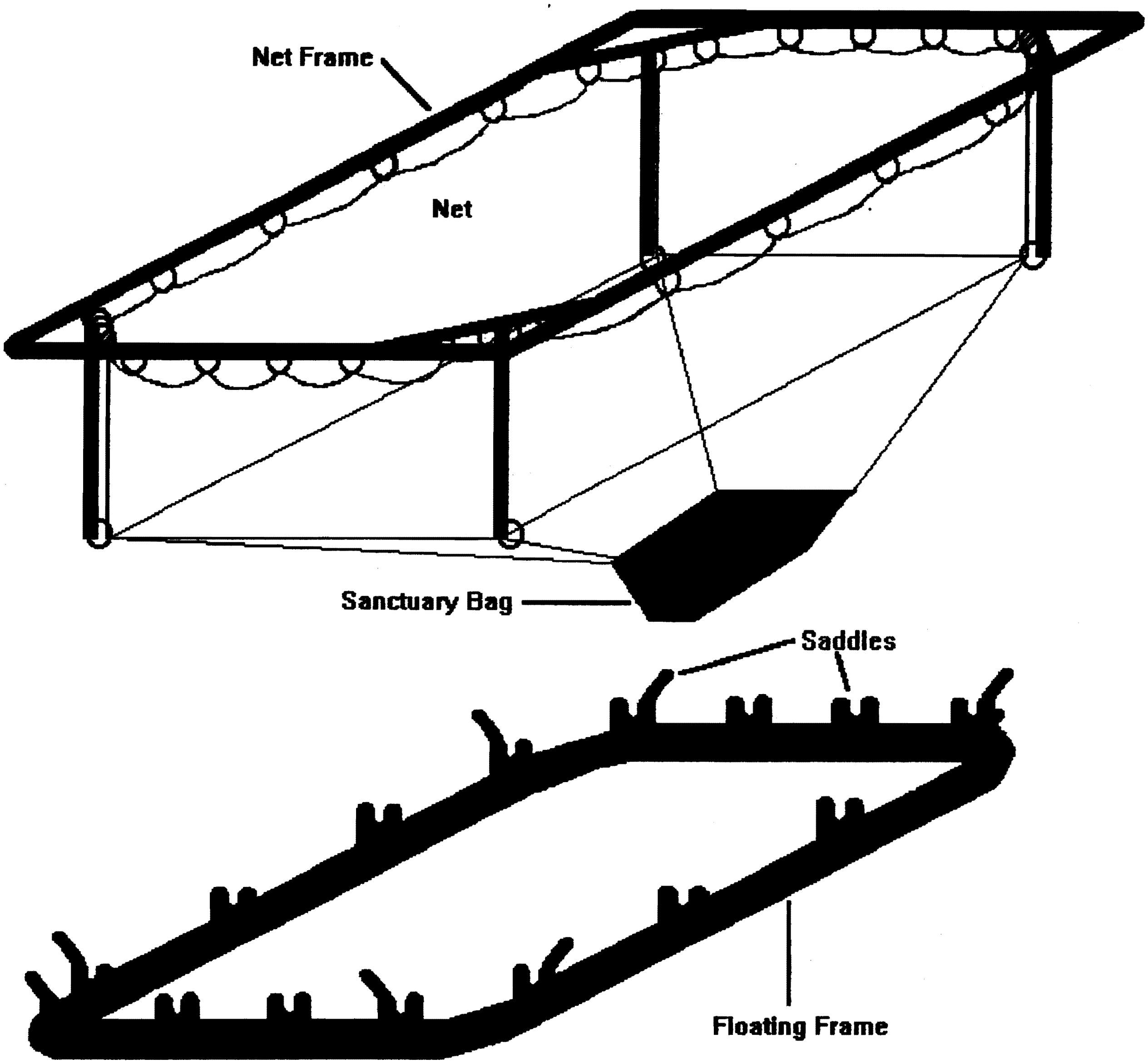

Figure 3. The floating recovery-net system used under Objective 1. The floating frame was constructed of 30-cm foam-filled polyethylene pipe. Saddles were welded onto the pipe to hold the 7.6 m x 7.6 m stainless steel net frame. The net was attached to both the top of the net frame and the legs and tapered to a sanctuary bag at the bottom.

fish continued on to the river-return line. The floating net described by Marsh et al. (1995) was used to recapture these fish at the exit of the river-return pipe (Fig. 3). The net was towed into position below the river-return pipe by skiffs, and control fish were placed into the net just prior to release of the test fish. After all fish were recaptured, the net was hauled to the tailrace of the dam, lifted by crane, and emptied into tanks on the tailrace deck. The fish were then anesthetized (MS-222) and examined for descaling and injury.

We conducted adult steelhead testing during fall 1994. Adults used were fallbacks; fish that entered a turbine intake and were guided into the juvenile collection system after they had ascended the adult ladder to the forebay. The adults were collected as they crossed the separator. Each adult steelhead was anesthetized with MS-222 and marked below the dorsal fin on the left side of its body with a uniquely numbered Floy Tag[1]. For each fish, any body marks (e.g., gillnet marks, open wounds, etc.), length, and sex were noted during tagging. After allowing recovery, groups of 2-4 fish were transported to the upper deck of the dam and released into a gatewell, with date and time of release noted for each fish. A total of 21 adult steelhead were released on 19 October, with 7 adults released into Gatewells 2B, 7B, and 14B.

Adult fish moved volitionally down to the separator, and all adult steelhead observed on the separator were checked for a tag. If a tag was found, the fish was examined for injuries. The tag was then removed and attached to a report form, and the tag number recorded along with the date, observation time, and injuries. Each fish was then released to the river through the adult river-return line. The test continued until 6 December when the collection and transport season

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

ended. Thereafter, the facility remained in bypass mode until 20 December, when it was dewatered for the year. The COE removed all remaining adults from the north sluiceway on 3 January 1995.

Passage time Evaluation

To determine the passage time of juvenile salmonids through the collection channel and separator, we PIT tagged and released 100 river-run juvenile steelhead into the collection channel. Because of Endangered Species Act constraints, we were unable to use chinook salmon for this test. The PIT-tagged steelhead were released into the upper end of the collection channel (Unit 14C), and the release date and time was recorded. Each PIT-tagged fish was recorded by PIT-tag detection units in the flumes exiting the separator. The PIT-tag detection units assigned a date and time to each observation. By comparing the collection channel release time of each steelhead with its flume observation time, we determined the passage time of each steelhead through this part of the facility.

Using the individual passage times, we developed a 95% bootstrap confidence interval (Efron 1982) around the median passage time.

Stress Evaluation

To examine the new facility in terms of physiological effects, stress and fatigue indices were measured in naturally migrating yearling chinook salmon and steelhead smolts. Four locations were sampled: 1) gatewell 7B (baseline levels), 2) primary dewaterer, 3) wet separator, and 4) the raceways. To determine the effects of raceway residence, fish were sampled at 0, 2, 4, 6, and 10 hours after raceway collection. For each species, 15 blood samples were collected from each site and time interval (raceway) on 4 separate nights and later assayed for plasma cortisol, glucose, and lactate. Yearling chinook salmon and steelhead were sampled between 9 May and 19 May, and subyearling chinook salmon were sampled from 27 June and 30 June.

Because chinook and steelhead smolts tend to move through Columbia River hydroelectric projects in the evening (Sims et al. 1981, Gessel et al. 1986), fish were sampled between 1800 and 1900 h from the first three locations. This was done to maximize the probability that fish sampled were primarily from a single population moving through the facility and not primarily from fish that remained overnight or longer in the system.

Normally, the maximum fish loading density is 60g of fish per liter of water (0.5 lb per gal) during fish holding operations at COE juvenile fish facilities. Assuming that maximum stress is more likely at higher densities, we attempted to expose fish in the raceways to higher densities to quantify the maximum stress response. However, we needed to minimize the time during which fish were collected in the raceways (prior to the start of sampling). Therefore, before any fish were collected, the raceway crowder was positioned to reduce the length of the raceway by one-half to three-quarters. Fish were then collected in the shortened raceway for 4 hours. Thus, when the sampling for blood plasma began (denoted as 0-hour), an individual fish may have been in the sample population from 0 to 4 hours and raceway densities ranged from 12-24 g of fish per liter of water (0.1 to 0.2 lb per gal). The holding densities were estimated using the hourly sample count taken by the COE, and the species composition and average weight by species were attained from the daily index sample collected by the Washington Department of Fish and Wildlife.

Fish were collected from all test areas with a standard dip net and were immediately placed in a 200-mg/L solution of MS-222. This procedure does not significantly alter any of the blood indices being measured (Black and Connor 1964, Strange and Schreck 1978). Immediately after gilling activity ceased, 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 decanted 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 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 Differences (FPLSD) multiple comparison techniques (Petersen 1985).

Results and Discussion

Descaling, Injury, and Mortality Evaluation

Little or no mortality, descaling, or eye/head injuries were observed in any of the release groups for either yearling chinook salmon or steelhead (Tables 2 and 3 and Appendix Table 1). In nearly all cases, the types of problems that were initially found at Little Goose and Lower Monumental Dams--concrete and construction debris left in flumes and dewatering sections, unsanded concrete edges, and inside edges protruding in pipe joints (Monk 1992, Marsh et al. 1995)--were nonexistent on startup of this facility.

Table 2. Mortality and descaling and injury of hatchery-reared juvenile yearling chinook salmon released into the collection and loading facilities at McNary Dam, 1994.

Location	Mortality (%)	Descaling (%)	Eye/Head Injury (%)
Release Group 1 - Collection channel to sample facility			
- Unit 1B	0.5	0.3	0.0
- Unit 7B	0.5	0.2	0.2
- Unit 14B	0.3	0.0	0.0
Release Group 2 - Separator to west raceway			
- Small fish flume	0.0	0.0	0.5
- Large fish flume	0.0	0.0	0.0
Release Group 3 - Raceways to truck			
- Raceway 1	0.0	0.0	0.0
- Raceway 2	0.0	0.0	0.0
- Raceway 3	0.0	0.0	0.0
- Raceway 4	0.0	0.0	0.0
Release Group 4 - Raceways to barge			
- Raceway 1	0.0	0.0	1.0
- Raceway 2	0.0	0.0	0.0
- Raceway 3	0.0	0.0	0.0
- Raceway 4	0.0	0.0	0.0
- Raceway 5	0.0	1.0	0.0
- Raceway 6	0.0	0.0	1.0
- Raceway 7	0.0	0.0	0.0
- Raceway 8	0.0	0.0	0.0
Release Group 5 - Separator to barge (direct loading)			
- Small fish flume	0.0	0.0	1.2
- Large fish flume	0.0	0.0	0.0
Release Group 6 - River returns			
- Small fish flume	0.0	0.0	0.5
- Raceway return line	0.5	0.5	0.0

Table 3. Mortality and descaling and injury of hatchery-reared juvenile yearling steelhead released into the collection and loading facilities at McNary Dam, 1994.

Location	Mortality (%)	Descaling (%)	Eye/Head Injury (%)
<u>Release Group 1 - Collection channel to sample facility</u>			
- Unit 1B	0.0	0.0	0.0
- Unit 7B	0.3	0.3	0.0
- Unit 14B	0.3	0.3	0.0
<u>Release Group 2 - Separator to west raceway</u>			
- Small fish flume	0.0	0.5	0.0
- Large fish flume	0.0	0.0	0.0
<u>Release Group 3 - Raceways to truck</u>			
- Raceway 1	0.0	0.0	0.0
- Raceway 2	0.0	0.0	0.0
- Raceway 3	0.0	0.0	0.0
- Raceway 4	0.0	0.0	0.0
<u>Release Group 4 - Raceways to barge</u>			
- Raceway 1	0.0	0.0	0.0
- Raceway 2	0.0	0.0	0.0
- Raceway 3	0.0	0.0	0.0
- Raceway 4	0.0	0.0	0.0
- Raceway 5	0.0	0.0	0.0
- Raceway 6	0.0	0.0	0.0
- Raceway 7	0.0	0.0	0.0
- Raceway 8	0.0	0.0	0.0
<u>Release Group 5 - Separator to barge (direct loading)</u>			
- Small fish flume	0.0	0.0	0.0
- Large fish flume	0.0	0.0	0.0
<u>Release group 6 - River returns</u>			
- Small fish flume	1.0	0.0	0.0
- Raceway return line	1.5	0.0	0.0

In the first replicates of Release Group 1, some mortalities were found from all three release locations. However, these were fish that were stranded in the fish transfer pipe between the sample holding tank and the sample room (laboratory). All of the new collection/transport facilities seem to have this problem initially, because they are designed to minimize the amount of water used to flush the fish into the lab so as not to dilute the anesthetic water. Since it is impossible to see into the transfer pipes, the amount of water used and the proper timing for flushing must be learned by trial and error. Once the proper procedures were learned for this operation, stranding in the pipe was no longer a problem, as evidenced by the mortality rates of zero for yearling chinook salmon and 0.7% (one of 136) for steelhead during the second replicates for all three locations.

There was a concern about the gates that divert fish from the main flume into the sample tanks or the east raceways because their leading edge protruded into the water flow. During the releases (Release Group 2), personnel were positioned near the gates to record any contact observed between fish and the leading edges of the gates. Neither the visual observations or the results of descaling/injury analyses (Tables 2 and 3), identified a problem with the leading edges of the gates.

The McNary Dam facility raceways are similar to those at Lower Monumental Dam. At both facilities, standard operating procedures are to remove excess water from the fish transportation flumes because if too much water is allowed in the flumes, water exiting the fish transportation flumes arcs across the raceway and contacts the opposite wall before plunging into the raceway. There was concern that fish might contact this wall and become descaled or injured. However, the water apparently acted as a buffer since no descaling or injuries were observed at this location (Tables 2 and 3).

The main concerns in both raceway releases (Release Groups 3 and 4) were the raceway exits. The raceway exits at McNary Dam differ from those at the other collection/transportation facilities in that separate exits are used for truck and barge loading. The truck-loading exits are on the raceway sides, while the barge-loading exits are on the raceway bottoms. At the Lower Monumental and Little Goose Dam facilities, descaling and injury levels were high during the initial test releases due to rough edges in the exit itself or in the exit pipe. However, this was not the case at McNary Dam, and minimal descaling was observed in both release groups of yearling chinook salmon and steelhead.

Descaling and injury were also minimal for yearling chinook salmon and steelhead in tests of the river-return line (Release Group 6). These results indicated that no problems existed in either the flumes or the pipes. However, for steelhead, the mortality rate was higher than for any other release group. Because of the handling stress involved in releasing these fish, some mortalities were removed even before the releases were made. We believe this was because they were the last groups released, and, due to construction delays, were held for 43 to 50 days.

Few adult steelhead fallbacks were observed during spring 1994. However, we were able to conduct the test the following fall when adult steelhead fallbacks were more numerous. Since water temperatures remained in the 16-20° C range, we theorized that passage time would not differ between spring and fall. Of the 21 adults released, 14 were subsequently observed on the separator: 5 from the gatewell 2B release, 4 from the gatewell 7B release, and 5 from the gatewell 14B release (Table 4 and Appendix Table 3). Of the 14 fish observed, 2 from the

Table 4. Passage time (days), mortality, and descaling and injury for adult steelhead released into the gatewells and recovered on the separator at McNary Dam in 1994.

Location	Number released	Number observed	Median passage time (days)	Mortality		Descaling		Injury	
				N	(%)	N	(%)	N	(%)
Gatewell									
- 1B	7	5	1.8	0	0.0	0	0.0	2	40.0
- 7B	7	4	0.1	0	0.0	0	0.0	1	25.0
- 14B	7	5	0.8	0	0.0	0	0.0	1	20.0
Totals	21	14	0.7	0	0.0	0	0.0	4	28.6

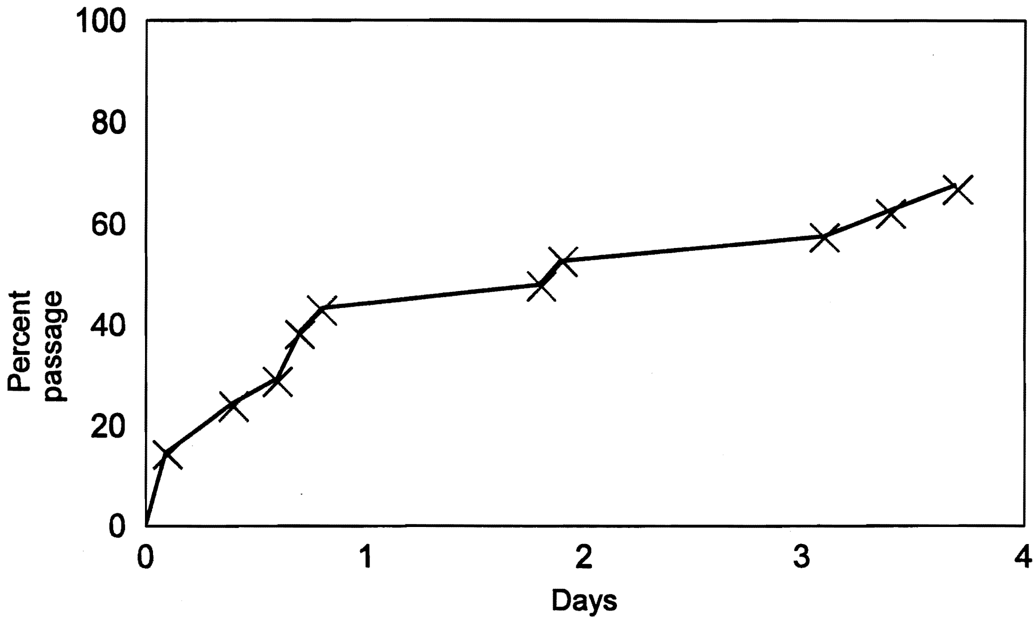

Figure 4. Percent passage of 21 adult steelhead released into gatewells 1B, 7B, and 14B (seven per gatewell), and recaptured on the fish/debris separator at McNary Dam, October 1994. (After release, four fish were subsequently observed during system dewatering, and three fish were never observed again.)

gatewell 2B release, and 1 each from the gatewell 7B and 14B releases showed signs of minor injuries. Median passage time was 17.2 hours (Fig. 4). During testing at Little Goose Dam in spring 1990, a similar median passage time of approximately 13 hours was observed (Monk et al. 1992). However, testing at Lower Monumental Dam in fall 1994 (Marsh et al. 1996) showed a median passage time of 84 hours, nearly five times longer than the time required at Little Goose or McNary Dams.

The McNary Dam facility was placed in bypass mode on 6 December, ending collection for the year. When the facility was later dewatered on 20 December, three of the tagged adult steelhead were observed in the collection channel. On 3 January 1995, the COE removed the remaining in-river fish from the north sluiceway and found another tagged adult. Three tagged adults were never found. Water temperatures began dropping in November, which probably induced the adults to hold in the collection channel after that time.

Passage Time Evaluation

The median passage time for juvenile steelhead was 17.8 hours, with a 95% confidence interval between 14.4 and 22.3 hours. This passage time was over seven times longer than that observed for juvenile steelhead at Lower Monumental Dam (Marsh et al. 1996). Although steelhead were released at different times at the two dams (1030 at McNary Dam and 1800 at Lower Monumental Dam), observation of the data indicated that this was probably not the reason for the difference in steelhead passage times between the two dams. At Lower Monumental Dam, 98% of the fish were detected within 24 hours of release, while at McNary dam, only 60% of the fish were detected within the first 24 hours, and 10% remained undetected after 48 hours.

A more likely explanation was the effect of low-water velocity areas within the collection channel and dewaterer at McNary Dam. The collection channel drains 84 orifices. Depending upon orifice operations, eddies develop within the channel, particularly at the upper end. Another low water-velocity area occurs where the dewaterer transitions to the pipe that transfers fish to the collection facility. The water velocity in this area is sufficiently low to allow fish to hold with little effort. During blood sampling for this objective, large numbers of fish were consistently observed holding in this area.

Stress evaluation

Plasma cortisol, lactate, and glucose levels showed no significant changes as yearling spring/summer chinook salmon passed from the gatewell into the raceways (Fig. 5 and Appendix Tables 4, 5, 6 and 10). In contrast, similar testing at Little Goose (Monk et al. 1992) and Lower Monumental Dams (Marsh et al. 1995) showed significant changes in the levels of these blood indices as the fish moved through each of these facilities. The levels of all three plasma indices were either lower than, or in the mid-range of, the results obtained from Little Goose and Lower Monumental Dams.

For yearling spring/summer chinook salmon, the highest average cortisol level observed (102.4 ng/ml in the separator sample) was below the range measured for this species above and below the wet separator at Lower Granite Dam (160-210 ng/ml) by Congleton et al. (1984). 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 and lactate showed no significant changes as juvenile steelhead passed from the gatewell into the raceways (Fig. 6 and Appendix Tables 4, 5, 6 and 11). In contrast,

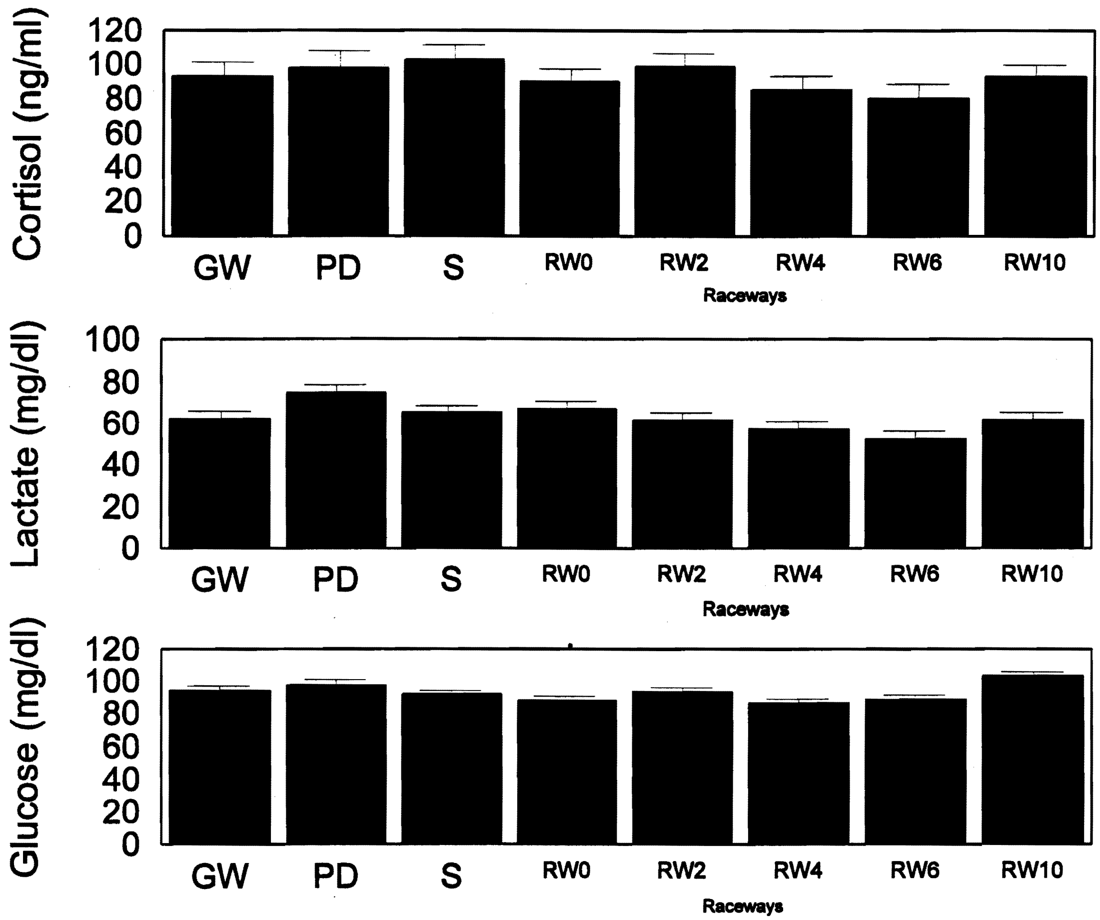

Figure 5. Mean concentrations (+ S.E., n = 4, n = 3 for PD) of plasma cortisol, lactate, and glucose for yearling spring/summer chinook salmon at four locations (fish in the raceway were sampled at five different times) in the collection and transportation facility at McNary Dam, 1994. No significant differences were seen for any of the parameters. Abbreviations used are: GW = gatewell; PD = post-dewaterer; and S = separator.

similar testing conducted at Little Goose Dam (Monk et al. 1992) and at Lower Monumental Dam (Marsh et al. 1995) showed significant changes in the levels of these blood parameters as fish moved through each of these facilities.

Plasma glucose showed a significant decrease as juvenile steelhead moved from the gatewell to the dewaterer ($P < 0.05$). This decrease was maintained in the separator sample, but had returned to the gatewell level in the 0-hour raceway sample. At Little Goose Dam, although no samples were significantly different, plasma glucose levels also decreased successively from the gatewell to the separator samples. However, levels did not return to gatewell levels until the 2-hour raceway sample (Monk et al. 1992). At Lower Monumental Dam, the plasma glucose levels increased significantly between the gatewell and the 0-hour raceway sample (Marsh et al. 1995). Overall at McNary Dam, plasma cortisol levels were lower for steelhead than the levels observed at Little Goose and Lower Monumental Dams, while levels of plasma lactate and glucose were similar at all three dams.

Plasma cortisol and glucose showed no significant changes as subyearling chinook salmon passed from the gatewell into the raceways (Fig. 7 and Appendix Tables 7, 8, 9, and 12). Plasma lactate levels decreased significantly between the gatewell and the dewaterer, and remained low through the separator. Levels then rose significantly, back to gatewell levels, at the 0-hour raceway sample. The plasma lactate levels again dropped significantly between the 0-hour and the 2-hour raceway samples. Thereafter, levels remained low through the 10-hour raceway sample.

These results suggested that the physiological effects on yearling spring/summer chinook salmon and steelhead smolts, and subyearling chinook salmon passing through the juvenile

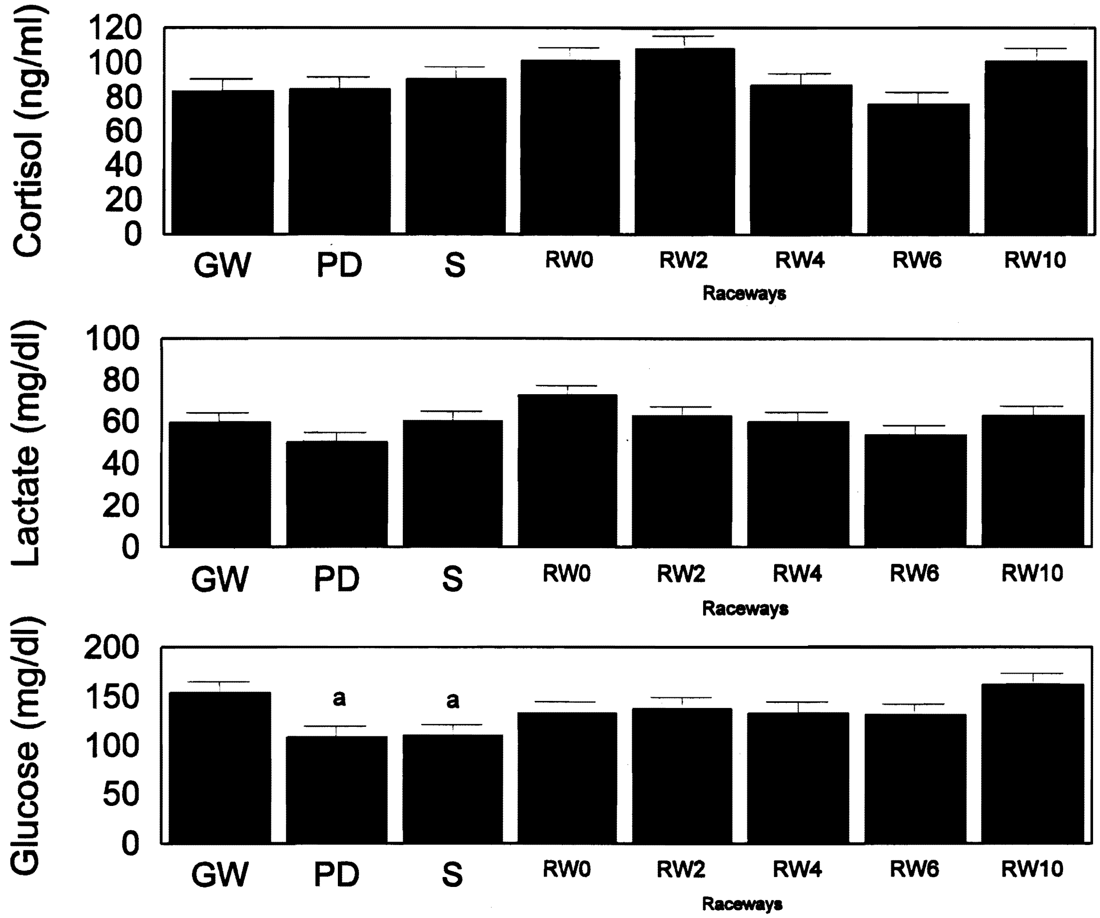

Figure 6. Mean concentrations (+ S.E., n = 4) of plasma cortisol, lactate, and glucose for juvenile steelhead at four locations (fish in the raceway were sampled at five different times) in the collection and transportation facility at McNary Dam, 1994. Bars marked (a) are significantly lower than gatewell levels. Abbreviations used are: GW = gatewell; PD = post-dewaterer; and S = separator.

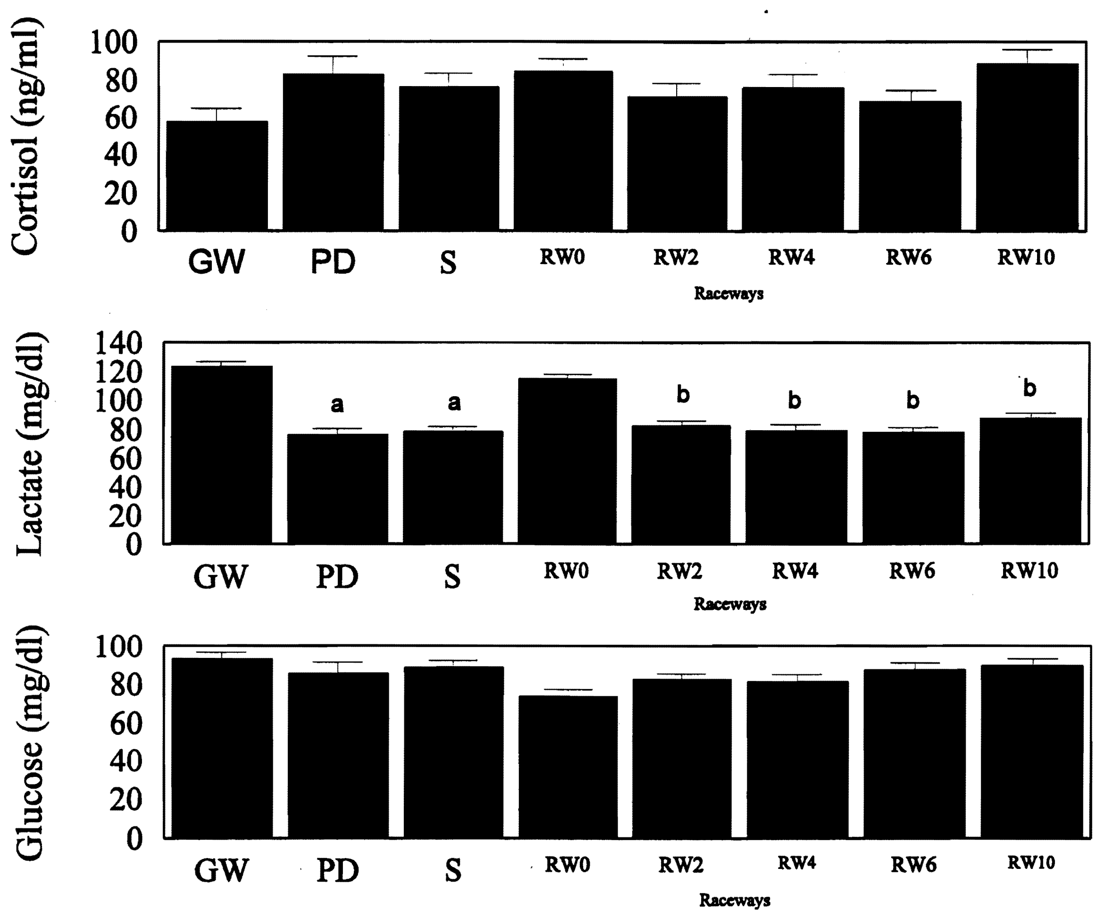

Figure 7. Mean concentrations (+ S.E., n = 4; n = 2 for PD) of plasma cortisol, lactate, and glucose for subyearling chinook salmon at four locations (fish in the raceway were sampled at five different times) in the collection and transportation facility at McNary Dam, 1994. Bars marked (a) are significantly lower than gatewell levels, and bars marked (b) are significantly lower than the 0-hour raceway sample. Abbreviations used are: GW = gatewell; PD = post-dewaterer; and S = separator.

collection facility at McNary Dam are nominal. For the most part, blood indicator levels of stress and fatigue did not change significantly during passage through the facility. Overall, plasma cortisol, lactate, and glucose levels observed at McNary Dam were low to moderate compared to similar testing at other facilities.

OBJECTIVE 2

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

Approach

To evaluate the reliability and efficiency of the collection facility sampling system, we released PIT-tagged fish upstream from the separator and monitored their passage through the small- and large-fish distribution flumes. We PIT tagged 8,382 yearling chinook salmon and 21,028 steelhead delivered from Dworshak National Fish Hatchery. The yearling chinook salmon were used to test the small-fish flume sampling system, while the steelhead were used to test the large-fish flume sampling system. Because the fish were not placed directly into the small- or large-fish side of the separator, we anticipated that some hatchery chinook salmon would pass through the large-fish flume and some hatchery steelhead would pass through the small-fish flume. In order to make use of this, the two flumes were tested concurrently.

Two sample rates per flume were tested, and both rates chosen for testing were within the range of sample rates used at McNary Dam under normal fish collection operations. For the small-fish flume, the test sample rates were 10 and 5% of all the fish passing into the collection facility; for the large-fish flume, these rates were set at 5 and 2%. For the 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, the test was 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% sample rate and the large-fish flume 5% sample rate tests were run concurrently, as were tests of the small-fish flume at 5% and the large-fish flume at 2%.

We relied upon the results of similar tests conducted at Lower Monumental Dam in spring 1993 (Marsh et al. 1995) to determine the numbers of fish required for precision. Based upon these results , we used the following formulas to estimate the numbers of tests and fish needed:

$$n = 4S^2/W^2$$

$$x = ny$$

where: n = number of tests needed

S^2 = variance of the measured sample rate

W = half-width of the confidence interval

x = number of fish needed

y = number of fish in system during one test

Before the start of each set of tests, the sample gates in each flume were set at the rates to be tested. Sample rates of 5% on the small-fish flume and 2% on the large-fish flume were tested first, and sample rates of 10% on the small-fish flume and 5% on the large-fish flume were tested last.

The first set of tests began at 1000 hours on 13 April, with the last release being made at 1730 hours on 16 April. We released totals of 4,000 PIT-tagged yearling chinook salmon and 16,000 PIT-tagged steelhead for these tests. Of these totals, 50 yearling chinook salmon and 100 steelhead were released every half-hour during the first 40 hours. During the last 40 hours, 100 steelhead were released every half-hour.

The second set of tests began at 0800 hours on 18 April, with the last release occurring at 2330 hours on 19 April. We released totals of 4,000 PIT-tagged yearling chinook salmon and 4,000 PIT-tagged steelhead for these tests. Of these totals, 50 yearling chinook salmon and 50 steelhead were released every half-hour for 40 hours.

To make a release, test fish were counted into a 114-L plastic container at ground level. The container was then placed into a sling and power hoisted the 14 m up to the flume platform for release into the flume approximately 10 m upstream from the separator. To obtain an accurate measure of the sample rate, the tests required that fish leave the separator randomly over time. Therefore, fish were not released directly into the separator because we believed that this release procedure would affect the behavior of fish already in the separator.

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

Results and Discussion

The tests of the sampling system were compromised by an unexpected development. While visiting the PIT-tag equipment room at the facility, we noticed that whenever fish were released into the flume, an unusually large number of PIT-tag detections occurred immediately, particularly in the large-fish flume. An examination of the observation records at the end of the tests revealed that twice during each hour, large numbers of detections occurred within 1-2 minutes. Based on these observations, and since we were releasing test fish every half-hour on the half-hour, we speculated that introduction of the test fish to the flume was inducing large numbers of fish to exit the separator.

Although the exact time of each half-hour release was not recorded, we believed it safe to assume that the majority of the releases occurred within the first fifteen minutes of each half-hour. Using the observation records of the 2% large-fish flume test, we ran a t-test (Table 5) comparing the mean number of fish observed during the first fifteen minutes of each half-hour with the mean number of fish observed during the second fifteen minutes of each half-hour. We found that nearly 70% ($P \leq 0.001$) more fish exited the separator during the first than the second fifteen minutes of each half-hour (Table 5).

The experimental design required that test fish exit the separator volitionally, and most importantly, at random over the course of each hour. We concluded that this requirement was not met, thus invalidating the test.

During the 1994 outmigration, large numbers of fish were PIT tagged in the Snake River by various researchers. At each Snake River collector dam, these PIT-tagged fish were diverted

Table 5. Number of PIT tags observed each hour, by 15-minute intervals

Minutes of each hour	Number of PIT tags observed	t-value	P
0-14	4,048	8.206	<0.001
15-29	2,346		
30-44	4,435		
45-59	2,713		

back to the river by the PIT-tag diversion system. Subsequently, many of these fish were collected at McNary Dam throughout the spring.

We analyzed the observation records for McNary Dam from 13 April to 1 July 1994, removing records gathered on the days that we conducted our formal tests under this Objective (13-16 and 18-20 April). We also removed records from dates when the facility did not operate for a full 24 hours, and dates when the expected value for fish in the sample was less than one. The daily sample rate for each of the dates in the analysis was provided by the Washington Department of Fish and Wildlife. Each day represented one replicate.

Over the course of this period, 18,822 PIT-tagged fish passed through the small-fish flume, and 34,068 PIT-tagged fish passed through the large-fish flume. Based on our analysis, all of the electronic (pre-set) sample rates (2%, 3%, 4%, 5%, and 16.67%) fell within the 95% confidence interval of the observed sample rate for the small-fish flume (Table 6). For the large-fish flume, the pre-set sample rates of 2%, 3%, and 5% fell within the 95% confidence interval of the observed sample rate, while the pre-set sample rate of 4% fell outside of the 95% confidence interval for its observed sample rate. While all but one of the sample rates tested were within the confidence interval of the observed sample rates, the width of some of the confidence intervals indicates the variability of the data.

Table 6. Results from Objective 2, using river-run PIT-tagged fish passing through the McNary Dam bypass/collection facility and recovered in the sampling system, 1994.

Pre-set sample rate (%)	Number of days	Observed sample rate	95% Confidence interval
Small-fish flume			
2	23	2.06	(1.64, 2.48)
3	3	1.97	(0.19, 3.75)
4	7	2.81	(1.39, 4.23)
5	13	4.28	(2.06, 6.50)
16.67	4	18.75	(7.47, 30.03)
Large-fish flume			
2	24	1.80	(1.58, 2.02)
3	7	1.89	(0.27, 3.51)
*4	8	2.43	(1.73, 3.13)
5	19	4.78	(3.70, 5.86)

* Indicates that the pre-set sample rate was outside the 95% confidence interval

OBJECTIVE 3

Evaluate the bypass system outfall pipe.

Approach

The outfall pipe design at McNary Dam juvenile fish facility was based on the design used at Lower Monumental Dam. It is a 76-cm-diameter, black PVC pipe that terminates approximately 110 m offshore, immediately downstream from the turbine boil near the center of the powerhouse. Flow and plunge conditions at the pipe terminus were similar to conditions at Lower Monumental Dam, and turbulence in the tailrace was greater than at Lower Monumental Dam. Therefore, we ruled out the use of a floating recovery-net similar to the one used at Lower Monumental Dam in 1993 (Marsh et al. 1995): these conditions had previously caused such instability that precise placement of the net was not feasible.

During October 1993, we examined the feasibility of using a purse seine to recapture test fish for this objective. Turbine units were operated selectively in an attempt to create acceptable conditions for purse-seine deployment. After several failed attempts, we concluded that the only operating conditions that would allow use of the purse seine in this area would be a complete shutdown of all 14 turbine units with no spill. However, it was virtually impossible to operate the dam with total shutdown of all units and spill for the 8-16 hours required to complete the testing.

The fisheries agencies and tribes agreed that a visual inspection of the pipe, combined with further testing of the outfall pipe at Lower Monumental Dam in 1994 (Marsh et al.1996) would suffice as a surrogate evaluation of the McNary Dam outfall pipe, at least for the 1994 outmigration. When we attempted to coordinate a visual inspection of the pipe with the COE, we were advised that under the Occupational Safety and Health Administration's (OSHA) regulations, the pipe was considered an "enclosed space" and was therefore subject to a strict set of safety requirements. Unfortunately, it was impossible to meet all of the safety requirements in the limited amount of time available between completion of the pipe and opening of the facility. Therefore, we were unable to visually inspect the pipe.

During construction, some videos of the internal welds had been made. We obtained these videos (approximately 2-3 minutes in length) along with a statement from the chief inspector of the pipe regarding his inspections of the welds in order to meet this objective. Neither of these two pieces of information indicated any problems with the outfall pipe.

Results and Discussion

The 1994 evaluation of the Lower Monumental Dam outfall pipe produced no statistically reliable results. However, based on observations from 2 years of evaluation, we are confident that the Lower Monumental Dam outfall pipe safely passes migrating juvenile salmonids (Marsh et al. 1996). These observations, together with information on the McNary Dam outfall pipe, are the extent of the McNary Dam outfall pipe evaluation for 1994.

CONCLUSIONS AND RECOMMENDATIONS

1. Based on the tests conducted, the new bypass, collection, and transportation facility at McNary Dam appears to safely pass fish around the dam.

2. The sample rates set electronically (2, 3, 4, 5, and 16.67%) for the small-fish flume and most (2, 3, and 5%) set for the large-fish flume provided samples that were relatively accurate.

3. The complete PIT-tag detection/diversion system was not operational in 1994. This system should be evaluated when it becomes operational in 1995.

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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 McNary Dam, 1993 (Objective 1).

Location	Number of fish				
	Released	Collected	Mortalities	Descaled	Injured
Release Group 1 - Collection channel to sample facility					
Yearling chinook salmon					
- Unit 1	400	386	2	1	0
- Unit 7	400	404	2	1	1
- Unit 14	400	394	1	0	0
Yearling steelhead					
- Unit 1	400	309	0	0	0
- Unit 7	400	312	1	1	0
- Unit 14	400	289	1	0	0
Release Group 2 - Separator to raceway					
Yearling chinook salmon					
- Small-fish flume					
- Test	200	197	0	0	1
- Control	100	100	0	0	0
- Large-fish flume					
- Test	200	191	0	0	0
- Controls	100	100	0	0	0
Yearling steelhead					
- Small-fish flume					
- Test	200	198	0	1	1
- Controls	100	101	0	0	0
- Large-fish flume					
- Test	200	198	0	0	0
- Controls	100	100	0	0	0
Release Group 3 - Raceways to truck					
Yearling chinook salmon					
- Raceway 1	100	102	0	0	0
- Raceway 2	100	93	0	0	0
- Control (1&2)	100	99	0	0	0
- Raceway 3	100	99	0	0	0
- Raceway 4	100	100	0	0	0
- Control (3&4)	100	99	0	0	2
Yearling steelhead					
- Raceway 1	100	100	0	0	0
- Raceway 2	100	97	0	0	0
- Control (1&2)	100	100	0	0	0
- Raceway 3	100	97	0	0	0
- Raceway 4	100	101	0	0	0
- Control (3&4)	100	99	0	0	0

Appendix Table 1. Continued.

Location	Number of fish: Released	Collected	Mortalities	Descaled	Injured
Release Group 4 - Raceways to barge					
Yearling Chinook salmon					
- Raceway 1	100	101	0	0	1
- Raceway 2	100	100	0	0	0
- Control (1&2)	100	95	0	2	0
- Raceway 3	100	101	0	0	0
- Raceway 4	100	101	0	4	0
- Control (3&4)	100	99	0	8	0
- Raceway 5	100	104	0	1	0
- Raceway 6	100	108	0	0	1
- Control (5&6)	100	97	0	0	0
- Raceway 7	100	97	0	2	0
- Raceway 8	100	99	0	0	0
_ Control (7&8)	100	92	0	2	0
Steelhead					
- Raceway 1	100	98	0	1	0
- Raceway 2	100	101	0	0	0
- Control (1&2)	100	97	0	1	0
- Raceway 3	100	99	0	0	0
- Raceway 4	100	100	0	0	0
- Control (3&4)	100	100	0	0	0
- Raceway 5	100	100	0	0	0
- Raceway 6	100	100	0	0	0
- Control (5&6)	100	103	0	0	0
- Raceway 7	100	107	0	0	0
- Raceway 8	100	95	0	0	0
_ Control (7&8)	100	99	0	0	0
Release Group 5 - Separator to barge (direct loading)					
Yearling chinook salmon					
- Small fish flume	100	83	0	0	1
- Large fish flume	100	92	0	0	0
- Controls	100	107	0	0	0
Yearling steelhead					
- Small fish flume	100	83	0	0	0
- Large fish flume	100	96	0	0	0
- Controls	100	103	0	1	0
Release Group 6 - River return lines					
Yearling chinook salmon					
- Small fish flume	200	199	0	0	1
- Raceway return	200	202	1	1	0
- Control	200	205	0	1	0
Steelhead					
- Small fish flume	200	196	2	0	0
- Raceway return	200	197	3	0	0
- Control	200	201	0	0	0

Appendix Table 2. Passage times for river-run juvenile steelhead marked and released at McNary Dam, 1994.

PIT-tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
7F7F531A45	05/14	8:30	05/14	8:35	0.003
7F7F773229	05/14	9:30	05/14	10:14	0.031
7F7F530807	05/14	9:30	05/14	10:33	0.044
7F7F413756	05/14	8:30	05/14	9:35	0.045
7F7F513A7E	05/14	9:30	05/14	11:04	0.065
7F7F756E04	05/14	9:30	05/14	11:36	0.087
7F7F760F47	05/14	9:30	05/14	11:39	0.090
7F7F585627	05/14	8:30	05/14	11:03	0.106
7F7F4B7351	05/14	8:30	05/14	11:16	0.115
7F7F3E741A	05/14	9:30	05/14	12:45	0.135
7F7F535566	05/14	8:30	05/14	11:55	0.142
7F7F757104	05/14	9:30	05/14	13:35	0.170
7F7F530120	05/14	8:30	05/14	13:21	0.202
7F7F513D67	05/14	8:30	05/14	13:26	0.206
7F7F4D7147	05/14	8:30	05/14	13:43	0.217
7F7F785B39	05/14	9:30	05/14	15:10	0.236
7F7F53151F	05/14	8:30	05/14	14:34	0.253
7F7F4F471E	05/14	8:30	05/14	14:49	0.263
7F7F526A75	05/14	9:30	05/14	15:57	0.269
7F7F54191A	05/14	9:30	05/14	16:21	0.285
7F7F505839	05/14	8:30	05/14	16:50	0.347
7F7F742151	05/14	9:30	05/14	17:51	0.348
7F7F581161	05/14	9:30	05/14	19:06	0.400
7F7F510656	05/14	9:30	05/14	19:18	0.408
7F7F760D03	05/14	8:30	05/14	18:41	0.424
7F7F58222B	05/14	8:30	05/14	19:12	0.446
7F7F59460F	05/14	8:30	05/14	19:44	0.468
7F7F3C2569	05/14	8:30	05/14	19:47	0.470
7F7F530E1F	05/14	8:30	05/14	19:51	0.473
7F7F51444C	05/14	8:30	05/14	22:04	0.565
7F7F4D4840	05/14	9:30	05/14	23:12	0.571
7F7F56147C	05/14	9:30	05/15	0:31	0.626
7F7F4D7C31	05/14	9:30	05/15	1:03	0.648
7F7F412C01	05/14	9:30	05/15	1:17	0.658
7F7F595252	05/14	9:30	05/15	1:18	0.658
7F7F557E3C	05/14	9:30	05/15	1:57	0.685
7F7F4A7E43	05/14	9:30	05/15	3:13	0.738
7F7F4E005F	05/14	9:30	05/15	3:20	0.743
7F7F561415	05/14	8:30	05/15	2:33	0.752
7F7F510A1D	05/14	8:30	05/15	2:42	0.758

Appendix Table 2. Continued.

PIT-tag number	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)
7F7F510147	05/14	9:30	05/15	4:04	0.774
7F7F4C1522	05/14	9:30	05/15	4:36	0.796
7F7F785A55	05/14	9:30	05/15	5:06	0.817
7F7F510219	05/14	8:30	05/15	4:13	0.822
7F7F757D30	05/14	8:30	05/15	4:27	0.831
7F7F3E6C02	05/14	9:30	05/15	6:19	0.867
7F7F413616	05/14	8:30	05/15	5:35	0.878
7F7F593E3B	05/14	8:30	05/15	6:32	0.918
7F7F4D4F7C	05/14	8:30	05/15	7:00	0.938
7F7F4C127F	05/14	9:30	05/15	9:40	1.007
7F7F49380E	05/14	9:30	05/15	10:29	1.041
7F7F513560	05/14	9:30	05/15	10:30	1.042
7F7F4B7D7D	05/14	8:30	05/15	10:19	1.076
7F7F3E7665	05/14	8:30	05/15	10:21	1.077
7F7F493B03	05/14	9:30	05/15	12:56	1.143
7F7F594E3E	05/14	9:30	05/15	13:00	1.146
7F7F4B4C6C	05/14	9:30	05/15	13:12	1.154
7F7F594000	05/14	8:30	05/15	12:21	1.160
7F7F560A2D	05/14	8:30	05/15	12:41	1.174
7F7F527F06	05/14	9:30	05/15	14:01	1.188
7F7F75322D	05/14	8:30	05/15	13:19	1.201
7F7F4D4A15	05/14	8:30	05/15	13:50	1.222
7F7F49496F	05/14	9:30	05/15	14:53	1.224
7F7F4D4A4A	05/14	8:30	05/15	15:05	1.274
7F7F506317	05/14	9:30	05/15	16:35	1.295
7F7F581B53	05/14	8:30	05/15	16:16	1.324
7F7F534538	05/14	8:30	05/15	16:53	1.349
7F7F755420	05/14	8:30	05/15	19:00	1.438
7F7F4A6770	05/14	8:30	05/15	19:00	1.438
7F7F4B3B35	05/14	9:30	05/16	0:33	1.627
7F7F510011	05/14	9:30	05/16	5:18	1.825
7F7F413F75	05/14	8:30	05/16	7:14	1.947
7F7F4B7610	05/14	9:30	05/16	11:53	2.099
7F7F785F28	05/14	9:30	05/16	13:30	2.167
7F7F576727	05/14	8:30	05/16	16:00	2.313
7F7F533F5C	05/14	8:30	05/16	23:30	2.625
7F7F531856	05/14	9:30	05/17	7:19	2.909
7F7F510F47	05/14	9:30	05/17	10:06	3.025
7F7F773B43	05/14	9:30	05/17	10:10	3.028
7F7F533E12	05/14	8:30	05/18	1:18	3.700

Appendix Table 3. Passage times, descaling, injuries and mortalities for adult steelhead released and recovered at McNary Dam, 1994.

Tag code	Sex	Length (cm)	Release gatewell	Release Date	Release Time	Detection Date	Detection Time	Passage time (days)	Descaling	Injury	Mortality
07951	M	70	2B	10/19	08:08	10/21	04:00	1.83	N	N	N
07952	F	83	2B	10/19	08:08	10/19	17:05	0.37	N	N	N
07953	M	58	2B	10/19	08:08						
07954	F	79	2B	10/19	09:37	10/23	03:15	3.73	N	Y	N
07955	F	57	2B	10/19	09:38	(found 1/3/95 in sluiceway, after dewatering)					
07956	M	64	2B	10/19	09:38	10/20	03:34	0.75	N	Y	N
07957	F	63	2B	10/19	09:37	10/22	20:20	3.45	N	N	N
07958	M	80	7B	10/19	10:23	10/19	10:30	<0.01	N	N	N
07959	M	68	7B	10/19	10:23						
07960	F	55	7B	10/19	10:23	(found 12/20 in channel, after dewatering)					
07961	F	73	7B	10/19	10:23	10/19	10:25	<0.01	N	N	N
07962	M	62	7B	10/19	11:27	10/20	03:55	0.69	N	N	N
07963	F	57	7B	10/19	11:25	10/19	11:45	0.01	N	Y	N
07964	F	61	7B	10/19	11:27	(found 12/20 in channel, after dewatering)					
07965	F	64	14B	10/19	12:50	10/22	14:55	3.09	N	Y	N
07966	F	79	14B	10/19	12:50	10/19	21:14	0.35	N	N	N
07967	M	61	14B	10/19	12:50	(found 12/20 in channel, after dewatering)					
07968	M	58	14B	10/19	13:49						
07969	F	55	14B	10/19	13:49	10/20	03:09	0.56	N	N	N
07970	F	75	14B	10/19	14:54	10/20	10:05	0.80	N	N	N
07971	M	73	14B	10/19	14:54	10/21	12:30	1.90	N	N	N

Appendix Table 4. Means of plasma cortisol values (ng/ml), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for yearling chinook salmon and juvenile steelhead sampled at various locations and times at McNary Dam, May 1994.

		Yearling chinook		Steelhead	
Sample	Location/(Time)	Mean	S.E.	Mean	S.E.
1	Gatewell 7B	92.5	8.1	83.2	7.2
2	Post-Dewaterer	97.5	9.3	84.4	7.2
4	Separator	102.4	8.1	90.5	7.2
5	Raceway (0-hour)	89.5	8.1	101.2	7.2
6	Raceway (2-hour)	98.4	8.1	108.0	7.2
7	Raceway (4-hour)	84.7	8.1	86.9	7.2
8	Raceway (6-hour)	79.8	8.1	75.8	7.2
9	Raceway (10-hour)	92.3	8.1	100.9	7.2

Yearling spring/summer chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	528.8	176.3		
Location/Time	7	1492.8	213.3	0.8	0.5865
Error	20	5240.5	262.0		
Total	30	7296.7			

FPLSD = N/A

Juvenile steelhead (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	3668.1	1222.7		
Location/Time	7	3377.8	482.5	2.36	0.0606
Error	21	4299.1	204.7		
Total	31	11344.9			

FPLSD = N/A

Appendix Table 5. Means of plasma lactate values (mg/dl), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for yearling chinook salmon and juvenile steelhead sampled at various locations and times at McNary Dam, May 1994.

		Yearling chinook		Steelhead	
Sample	Location/(Time)	Mean	S.E.	Mean	S.E.
1	Gatewell 7B	62.1	3.7	59.3	4.7
2	Post-Dewaterer	74.8	4.2	49.9	4.7
4	Separator	65.3	3.7	59.9	4.7
5	Raceway (0-hour)	66.9	3.7	72.4	4.7
6	Raceway (2-hour)	61.5	3.7	62.4	4.7
7	Raceway (4-hour)	57.1	3.7	59.6	4.7
8	Raceway (6-hour)	52.3	3.7	53.4	4.7
9	Raceway (10-hour)	61.7	3.7	62.6	4.7

Yearling spring/summer chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	503.4	167.8		
Location/Time	7	928.2	132.6	2.5	0.0544
Error	20	1080.1	54.0		
Total	30	2687.3			

FPLSD = N/A

Juvenile steelhead (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	279.8	93.3		
Location/Time	7	1259.7	180.0	2.01	0.1014
Error	21	1876.1	89.3		
Total	31	3415.7			

FPLSD = N/A

Appendix Table 6. Means of plasma glucose values (mg/dl), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for yearling chinook salmon and juvenile steelhead sampled at various locations and times at McNary Dam, May 1994.

		Yearling chinook		Steelhead	
Sample	Location/(Time)	Mean	S.E.	Mean	S.E.
1	Gatewell 7B	93.9	3.9	153.3	11.5
2	Post-Dewaterer	97.1	4.5	108.2	11.5
4	Separator	91.6	3.9	109.7	11.5
5	Raceway (0-hour)	87.7	3.9	132.7	11.5
6	Raceway (2-hour)	93.1	3.9	137.3	11.5
7	Raceway (4-hour)	86.2	3.9	132.7	11.5
8	Raceway (6-hour)	88.3	3.9	131.2	11.5
9	Raceway (10-hour)	103.2	3.9	161.5	11.5

Yearling spring/summer chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	466.4	155.5		
Location/Time	7	900.9	128.7	2.1	0.0919
Error	20	1227.8	61.4		
Total	30	2550.5			

FPLSD = N/A

Juvenile steelhead (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	1484.5	494.8		
Location/Time	7	9655.0	1379.3	2.62	0.0413
Error	21	11061.2	526.7		
Total	31	22200.6			

FPLSD = 33.8

Appendix Table 7. Means of plasma cortisol values (ng/ml), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for subyearling chinook salmon sampled at various locations and times at McNary Dam, June 1994.

Sample	Location/(Time)	Subyearling chinook Mean	S.E.
1	Gatewell 7B	57.2	7.4
2	Post-Dewaterer	82.6	10.4
4	Separator	75.9	7.4
5	Raceway (0-hour)	84.4	7.4
6	Raceway (2-hour)	70.8	7.4
7	Raceway (4-hour)	75.6	7.4
8	Raceway (6-hour)	68.1	7.4
9	Raceway (10-hour)	88.3	7.4

Subyearling chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	561.8	187.3		
Location/Time	7	2621.2	374.5	1.73	0.1618
Error	19	4114.4	216.5		
Total	29	7392.3			

FPLSD = N/A

Appendix Table 8. Means of plasma lactate values (mg/dl), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for subyearling chinook salmon sampled at various locations and times at McNary Dam, June 1994.

Sample	Location/(Time)	Subyearling chinook Mean	S.E.
1	Gatewell 7B	122.8	3.6
2	Post-Dewaterer	75.5	5.0
4	Separator	77.7	3.6
5	Raceway (0-hour)	114.2	3.6
6	Raceway (2-hour)	82.0	3.6
7	Raceway (4-hour)	78.4	3.6
8	Raceway (6-hour)	77.3	3.6
9	Raceway (10-hour)	87.0	3.6

Subyearling chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	999.1	333.0		
Location/Time	7	9153.0	1307.6	25.83	<0.0001
Error	19	961.8	50.6		
Total	29	11089.8			

FPLSD = 13.2, = 18.7 for PD

Appendix Table 9. Means of plasma glucose values (mg/dl), standard errors, RBANOVAs, and Fisher's Protected Least Significant Difference (FPLSD) for subyearling chinook salmon sampled at various locations and times at McNary Dam, June 1994.

		Subyearling chinook	
Sample	Location/(Time)	Mean	S.E.
1	Gatewell 7B	92.7	3.9
2	Post-Dewaterer	85.1	5.5
4	Separator	88.2	3.9
5	Raceway (0-hour)	73.1	3.9
6	Raceway (2-hour)	82.0	3.9
7	Raceway (4-hour)	80.9	3.9
8	Raceway (6-hour)	87.0	3.9
9	Raceway (10-hour)	89.2	3.9

Subyearling chinook salmon (RBANOVA):

Source	df	Sum of Squares	Mean Square	F	P
Block	3	831.2	277.1		
Location/Time	7	1041.4	148.8	2.46	0.0563
Error	19	1149.5	60.5		
Total	29	3014.2			

FPLSD = N/A

Appendix Table 10. Fork lengths, plasma cortisol, lactate, and glucose values for migrating yearling spring/summer chinook salmon collected from various locations and times at McNary Dam's collection facility, 1994.

Sample date: **05/9/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Gatewell 7B			
158	82.9	56.0	73.3
(Not taken)	173.8	44.0	89.2
158	67.4	68.2	86.9
140	49.1	48.7	59.2
152	310.9	32.3	75.6
160	56.0	52.9	103.0
147	102.5	62.1	65.6
158	47.9	51.4	123.5
161	16.4	97.7	128.5
156	57.6	79.3	74.4
140,144	68.6	55.1	63.2
140	117.0	75.7	78.2
144	186.0	64.4	39.9
149	43.9	78.6	74.9
152,145	23.8	81.9	77.8
Separator			
162	188.2	72.5	294.8
170	67.4	37.0	117.5
166	177.8	54.7	98.8
150	34.6	50.8	112.4
146,133	320.5	41.1	79.7
146	183.5	72.4	109.9
144	178.3	93.0	117.0
159	222.6	50.5	65.4
158	14.2	52.7	64.3
132	117.0	75.8	79.1
141,142	137.8	105.0	65.6
155	55.7	65.4	67.9
133	106.3	33.5	61.3
132,131	83.8	28.2	81.0
130	43.2	32.6	100.4
Raceway 2-hour			
125,127	46.9	30.6	116.6
164	99.3	37.0	81.3
133,136	37.9	36.1	110.7
153	174.4	30.5	78.6
127,133	131.7	48.5	142.5
124,126	120.3	66.8	143.6
137	37.9	51.0	61.3
150	226.6	60.8	94.5
161,115	25.4	62.4	115.7
140,132	30.0	50.4	64.6
136,129	47.0	85.6	68.2
158	66.6	40.9	121.8
128,130	160.7	55.7	100.8
145	157.7	32.4	87.5
Raceway 6-hour			
153	44.1	38.0	80.1
137	142.1	33.5	100.4
171	31.5	23.9	83.3
145	23.8	21.3	82.1
135,122	32.6	34.6	79.6
144	42.7	34.7	119.2
150	--	41.7	84.8
136,118	23.3	34.1	98.2
153,146	77.7	51.2	82.7
155	99.8	50.4	110.5
166	123.8	58.9	96.7
126.130,127	88.9	57.1	62.9
149,130	11.6	56.3	56.9
155,149,135	--	74.8	67.3
149	42.2	67.1	78.1

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
(No samples were taken at this site)			
Raceway 0-hour			
139	38.4	22.8	126.8
136	20.4	22.7	92.9
145	176.1	36.9	80.1
145	108.9	19.5	80.2
168	157.9	63.3	81.3
138	20.2	40.5	104.0
140,127	100.2	53.7	160.0
140	14.8	39.9	104.4
156	86.3	47.8	99.6
168	7.1	73.3	115.0
159	142.8	58.1	67.4
141,131,139	7.2	42.6	77.2
130,130	60.8	65.9	71.3
139	43.0	25.2	106.5
144	17.1	44.0	122.9
Raceway 4-hour			
142	110.8	49.8	117.0
133	20.6	27.6	79.8
146	67.8	36.4	72.9
127,117	268.2	41.4	162.8
130,155	38.9	41.2	90.9
140	89.5	44.1	138.1
172	42.1	51.0	100.3
152,129	80.0	80.5	106.4
153	31.9	57.4	85.1
164	54.4	59.0	85.8
137,118	53.6	98.1	72.0
150	60.6	65.3	71.8
142,123	71.1	111.8	39.3
142	52.2	79.5	53.9
Raceway 10-hour			
126,130	48.9	32.4	111.6
163	21.5	47.6	120.7
148	69.9	22.8	109.6
132	12.6	--	--
175	62.5	44.9	114.8
144,110	334.4	86.2	455.5
139	61.9	48.4	84.8
181	174.0	44.3	100.8
135,147	127.2	57.7	100.8
130,141	144.0	65.0	74.6
130,132	30.0	63.0	69.0
169	74.9	56.8	83.0
140	67.8	65.7	84.9
128,132	158.4	80.2	75.7
141,132	47.7	78.6	77.4

Appendix Table 10. Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/11/94**			
Gatewell 7B			
162	47.6	41.5	175.7
145	121.7	30.4	97.0
140	113.2	37.9	76.1
139	287.0	39.5	78.8
136	9.6	35.0	85.3
123,151	105.2	48.4	102.5
140	89.1	93.4	98.0
151	23.3	57.3	100.2
180	12.4	58.3	81.9
171	58.1	69.2	116.4
125,154	142.0	59.3	118.3
135	43.9	63.6	81.3
142,135	36.2	91.5	63.6
140	33.7	66.7	34.2
145,156	172.1	-0.9	--
Separator			
144	--	35.8	118.7
151	167.0	65.2	134.9
138,128	158.4	55.5	93.1
139	90.2	69.8	51.4
139	124.9	77.0	124.9
133	67.8	55.4	91.3
157	158.4	64.1	144.3
154	119.6	48.0	121.2
150	182.7	67.9	76.3
160	40.7	120.0	70.2
147	67.3	85.7	38.3
145,133	187.2	67.7	85.3
145	12.5	51.4	34.8
155	138.6	93.6	56.1
147	62.8	119.3	86.9
Raceway 2-hour			
139	21.5	39.4	134.2
147	24.2	28.5	58.9
156	14.3	73.3	58.5
176	16.3	41.5	99.6
150,155	174.1	53.9	150.7
132,131	282.3	44.3	139.3
135,124	120.4	49.1	87.1
148	22.8	49.7	131.1
136,138	56.0	68.4	56.7
140,144	82.1	74.1	60.2
135,130	123.8	80.2	63.1
140,125	120.5	81.1	121.4
129,138	133.3	88.3	82.7
138,147	58.6	83.7	71.3
136,139	162.1	112.5	82.2
Raceway 6-hour			
161	106.6	30.6	73.1
151,121	88.8	--	--
161	228.4	36.8	104.7
154	148.8	40.9	108.2
144	28.8	35.1	153.2
142	88.5	37.3	76.9
135	76.5	37.5	112.1
137,142	81.6	50.1	72.0
152	33.2	40.4	87.6
139,131,128	56.3	93.5	61.9
157	42.6	75.0	94.9
172	55.8	70.0	101.6
144,129	20.9	54.6	95.4
138,134,135	61.5	83.0	73.1
125,119,150	85.3	78.3	66.0

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
152	97.6	112.5	35.4
153	85.3	56.6	180.7
161	77.7	40.3	105.3
166	68.1	60.4	44.2
128,140	131.7	73.6	81.0
160	14.4	64.6	98.1
148,138	122.9	77.0	37.2
141	35.2	63.1	150.2
149	45.3	60.3	76.2
169	336.6	53.3	72.0
139,136	63.5	89.8	52.9
156	--	79.7	73.8
162	39.9	62.6	55.6
129,133	99.6	123.5	110.8
154	147.1	108.0	145.0
Raceway 0-hour			
131	38.3	46.6	92.7
124,130	78.8	44.6	69.2
133,133	25.2	46.2	173.8
130,128	110.7	53.2	98.2
157,132	81.7	54.0	69.8
158	50.7	43.7	63.1
154	102.4	103.9	65.8
137	51.6	65.6	45.3
124,154	57.6	137.2	108.1
127,134	51.0	75.6	80.8
145,124	114.2	64.4	65.6
145,134,137	124.5	99.2	33.6
132,129	40.9	87.1	65.5
141	38.0	90.0	41.1
Raceway 4-hour			
149	70.8	29.8	56.0
124,131	259.2	27.5	89.9
136	120.4	48.1	109.0
143	115.4	46.6	82.1
137,140	60.1	38.6	80.3
132	106.5	39.1	71.9
167	35.2	54.0	89.9
148,129	31.8	46.9	72.2
165	112.7	57.5	85.1
149,146	--	95.5	101.6
130,136	96.1	57.2	84.6
160	32.7	52.3	59.0
151	71.6	92.6	78.9
151,130,139	29.4	72.0	50.1
136,145	165.7	67.1	77.7
Raceway 10-hour			
144	62.4	34.5	64.9
141	18.6	57.8	186.6
175	218.7	68.7	111.4
134,123	74.1	48.6	96.9
140	203.5	52.4	82.1
131	37.2	50.4	107.0
146	236.2	46.5	114.8
146	30.1	47.1	76.6
129,155	20.2	102.4	88.1
142	28.9	53.5	66.8
134,112	35.0	74.7	48.3
133,138	58.4	70.1	82.7
141,131	15.5	79.6	73.6
120,132	23.0	--	--
148,131	26.4	118.6	53.3

Appendix Table 10. 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: **05/16/94**							
Gatewell 7B				Post Dewaterer			
136	92.2	85.1	93.1	144	37.1	30.3	75.7
181	183.0	54.4	95.7	142	31.1	36.0	85.1
163	149.9	52.8	91.7	159	63.8	65.6	116.4
150	60.7	93.2	110.5	138,140	143.1	39.9	87.5
131,131	49.0	65.3	97.6	171	224.4	51.7	102.9
144,144	39.0	60.1	77.2	153	159.5	--	--
156	161.9	54.1	112.9	143,140	38.6	52.5	96.6
161	30.2	81.6	73.1	147,140,134	74.9	85.1	81.4
149,144	142.9	63.0	88.3	163	35.6	65.9	155.8
165	64.5	71.9	114.3	155	51.0	77.4	133.6
156	261.6	99.7	135.9	149,138	51.9	101.5	113.7
158,141	114.1	73.6	129.1	164	34.3	100.9	171.3
165	54.4	68.6	124.7	142,140	208.3	88.0	48.9
144,153	85.1	94.3	118.2	129,140	83.5	85.8	80.1
146,152	120.5	79.2	83.7	136,125	204.2	88.5	52.2
Separator				Raceway 0-hour			
148	72.9	49.1	55.5	174	59.8	51.9	103.6
135	64.5	31.2	75.1	155	49.0	92.5	126.7
182	20.0	75.3	117.0	162	90.6	58.8	154.0
135,145	118.6	31.8	81.3	120,129	47.7	54.2	114.3
147	76.1	92.4	123.3	156	113.5	33.5	71.6
150	62.3	68.8	118.8	147	9.3	64.2	132.3
170	16.9	66.7	118.7	143	54.6	52.8	--
156,137	--	69.2	53.7	170	208.9	106.0	56.9
149	175.9	114.3	101.6	155	180.8	67.1	86.3
135,141	92.4	64.4	40.6	154	26.3	70.3	105.3
147	44.9	69.3	79.6	139,123	56.4	64.4	64.9
135	52.3	77.9	59.6	148	80.4	68.0	87.7
129,138	41.4	81.6	76.5	143	298.0	79.9	55.4
156	143.0	51.0	120.6	145,141,132	79.4	102.2	65.9
155	199.4	74.1	90.2	143,138,141	128.2	108.2	66.2
Raceway 2-hour				Raceway 4-hour			
145	107.1	30.3	114.7	156	98.2	24.9	106.4
144,135	36.2	41.7	110.3	132,115	19.9	42.3	65.4
153	133.7	57.3	127.7	165	52.3	42.4	192.9
146	47.4	56.8	168.3	119,124	227.6	63.3	98.6
132	44.3	52.7	58.4	126,111	19.9	42.6	98.5
134,132	101.2	--	--	152,134	37.0	70.1	123.2
132,129	126.9	65.9	115.9	148,134	42.4	47.4	80.1
157	102.3	48.5	118.8	143,142	63.1	55.0	120.0
141,144	68.6	64.7	92.4	139,128	87.4	61.2	56.7
140,134,140	199.4	67.0	84.8	149,129	55.5	59.1	77.3
144	135.6	69.3	70.8	146,147	29.8	61.6	57.9
149	66.6	64.1	56.7	146,149,141	33.5	73.3	79.9
145,139	81.3	90.3	59.7	140,134	103.5	80.2	67.8
				146,134,130	171.7	80.7	92.4
				152	69.7	96.0	55.8
Raceway 6-hour				Raceway 10-hour			
142	60.6	31.2	81.9	160	281.4	51.7	139.3
137,127	82.8	40.3	109.9	122,139	196.1	45.4	97.9
153	183.5	28.3	93.1	148	108.8	42.4	396.3
139	65.6	33.4	103.0	184	13.8	48.0	107.7
137,136	34.6	45.6	117.8	153	34.8	36.2	90.0
138,150	45.5	38.7	98.8	145	83.1	51.8	94.7
144	166.4	36.5	109.4	153	47.1	48.6	69.2
141,135	64.9	54.8	72.5	137,121	94.3	64.9	77.3
140,136	43.0	54.8	110.5	138,133	122.3	57.0	71.8
143	84.9	56.4	78.5	134,130	163.8	60.3	81.0
144,152	47.9	61.9	62.0	143,133	68.1	79.1	59.7
137,140	48.5	74.7	72.6	144,122,134	32.0	87.2	77.8
141,136,111	128.8	81.5	54.6	145,144	75.6	78.3	96.6
147,150	43.5	74.9	66.8	138,141	40.8	86.0	59.7
148,147	104.2	81.6	62.5	136,133	152.3	112.3	54.9

Appendix Table 10. Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **05/18/94**			
Gatewell 7B			
134	172.6	36.5	69.2
165	150.3	46.3	180.5
146	74.5	60.2	111.9
132	51.8	52.2	93.9
145	154.2	41.3	109.0
155	35.2	46.6	79.2
150	90.3	60.6	126.2
149	76.1	115.5	87.6
152	12.6	57.3	91.0
150	30.3	51.1	112.4
157	76.1	56.0	128.0
148,148	78.1	52.5	65.8
155	99.0	72.5	108.7
146	65.6	77.7	113.6
154,130	69.7	62.7	86.9
Separator			
164	199.4	55.5	53.9
150,162	93.4	77.0	129.7
145	--	56.5	40.9
136	191.3	59.3	129.2
136,130	81.1	76.4	101.4
152	69.6	62.4	133.4
135,142	15.9	88.2	70.3
130,153	146.5	52.9	116.1
137,136	31.8	89.2	64.0
142,131	45.1	72.2	47.6
131,138	39.6	83.3	95.8
154,127	29.0	75.0	82.7
154	30.4	40.7	101.3
136	114.7	4.2	84.5
Raceway 2-hour			
140,132	172.4	36.3	114.1
136	--	62.7	99.2
134	50.5	69.8	49.0
150,126	25.3	87.9	58.0
143,125	120.1	57.1	101.4
142	17.2	76.6	78.1
141,140	58.7	64.1	60.7
164	44.1	57.3	104.3
151	48.9	72.2	145.0
166	478.6	63.8	88.5
138,148	66.4	71.6	87.5
132,144	80.6	95.2	89.8
178	131.3	97.8	42.4
136,127	130.8	91.1	45.2
146	56.7	91.8	63.1
Raceway 6-hour			
146	124.7	26.5	94.5
149	178.2	43.5	85.7
141	129.0	52.1	126.9
140,139	133.3	42.8	105.9
160	166.8	39.4	92.3
141	24.4	41.4	86.6
143,138	29.8	49.1	96.5
147	145.3	50.4	101.0
143	36.6	63.0	69.9
138,132	48.9	68.2	80.7
142	76.9	53.7	49.9
138,140	108.8	67.2	107.1
133,140	85.8	84.1	134.6
140,138	83.1	93.3	58.3
139,122	--	67.9	58.4

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
170	118.7	59.0	90.6
157	167.0	116.8	148.6
144,136	200.2	53.5	131.0
133	30.5	81.4	125.9
134,133	117.3	83.7	149.9
148	89.7	60.5	99.2
153	139.3	92.9	149.3
155,137	26.8	74.9	107.5
135,141	37.9	77.8	88.1
151	55.0	67.6	71.3
141	107.4	94.3	76.9
147	65.9	78.0	97.9
145,143	170.0	85.7	67.2
223	108.8	76.0	79.8
132,139	47.7	97.8	63.7
Raceway 0-hour			
152,138	--	47.5	112.5
143,146	47.7	102.4	193.1
143	148.2	35.2	82.5
144	158.4	104.5	85.7
133,136	250.7	73.4	37.4
140,124	18.6	67.8	138.6
132,137	181.8	81.4	94.3
160	--	53.9	58.5
128,135	20.6	68.6	73.3
151	115.4	66.8	73.0
161	155.0	83.0	52.8
155	18.3	86.3	106.5
134,127	134.5	102.9	64.6
136,132,129	230.9	142.7	67.6
Raceway 4-hour			
147	256.3	--	--
140	31.5	29.1	107.2
147	97.1	35.9	82.5
134	16.8	35.6	108.2
153	76.7	40.6	115.1
129,138	125.4	51.2	125.7
165	155.9	--	--
155	61.5	42.1	121.3
143,130	237.5	57.9	97.7
149	14.7	61.8	87.4
140,140	108.8	114.6	43.3
146,134	67.4	57.6	70.5
156	33.8	58.0	91.1
144,138	121.3	73.0	39.7
130,135	45.8	84.5	66.5
Raceway 10-hour			
138	135.6	46.3	144.1
143	86.1	27.8	72.0
159	35.9	50.0	118.3
137	229.4	35.9	93.4
148	141.2	60.4	153.2
124,143	57.5	64.1	133.2
154	133.8	76.6	157.5
139	85.4	52.1	103.4
132,119	91.2	78.7	95.5
142,127	187.4	60.3	71.3
138,139	79.2	69.0	88.8
143,139	50.5	60.7	70.2
135,127	94.9	79.1	43.4
140,133	37.0	76.6	63.5
143,134	50.4	89.4	83.2

Appendix Table 11. Fork lengths, plasma cortisol, lactate, and glucose values for migrating juvenile steelhead collected from various locations and times at McNary Dam's collection facility, 1994.

Sample date: **05/10/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Gatewell 7B			
199	105.2	43.3	210.3
232	22.9	39.5	93.1
240	160.7	56.3	133.2
227	14.2	50.1	167.4
215	158.4	58.6	99.5
231	112.5	62.2	124.0
213	13.6	39.9	74.6
210	--	54.6	76.9
203	46.9	67.2	123.0
208	87.6	85.3	125.0
221	181.5	75.3	113.2
203	118.1	68.5	105.0
173	81.5	64.2	106.1
196	99.5	72.8	76.2
218	32.4	79.1	123.7
Separator			
222	170.5	38.0	105.9
206	83.2	37.7	118.5
237	92.2	34.4	106.3
253	16.1	53.8	127.5
247	123.5	39.3	184.8
243	126.4	39.4	134.0
240	25.2	26.1	87.5
248	68.4	48.0	170.3
204	21.5	75.5	121.9
228	--	41.1	96.3
231	154.0	75.0	88.0
223	30.1	52.8	47.3
225	158.6	97.0	86.4
179	105.3	58.5	90.1
221	17.4	99.4	53.3
Raceway 2-hour			
216	66.2	38.8	155.2
213	89.4	46.3	114.1
224	141.2	107.6	64.2
232	200.4	42.6	122.9
238	34.3	65.0	79.0
215	104.4	115.4	190.1
253	48.5	73.1	178.4
265	89.3	97.2	82.6
218	39.6	49.3	93.7
236	55.2	44.6	76.7
218	94.5	73.1	98.0
196	73.2	79.8	83.8
195	260.2	91.7	144.0
189	77.1	83.7	154.6
190	255.0	90.7	383.0
Raceway 6-hour			
194	144.3	32.0	115.3
208	55.0	43.4	95.4
235	88.6	31.4	386.2
205	42.7	65.7	165.6
210	71.6	45.2	175.5
204	74.3	39.7	123.3
222	35.2	58.1	182.7
228	107.2	46.9	244.7
198	226.1	70.0	151.6
235	37.5	40.3	94.8
208	92.7	107.4	118.2
187	55.3	47.4	138.6
205	29.4	52.2	161.6
206	120.5	76.4	144.0
200	14.9	76.1	127.6

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
201	136.1	46.5	79.4
217	55.6	26.5	64.6
183	136.1	66.8	112.1
201	--	30.2	85.7
224	92.0	54.7	150.7
237	19.7	72.6	105.3
220	42.6	37.9	121.8
219	45.6	46.9	83.6
231	48.7	59.8	144.9
236	130.9	182.1	115.8
280	112.5	63.6	83.1
214	83.3	62.2	55.8
253	42.6	54.4	112.0
205	256.0	48.0	64.3
234	23.6	58.1	62.2
Raceway 0-hour			
232	155.0	28.0	546.5
213	150.8	81.3	518.6
234	79.1	85.1	103.0
208	116.8	96.5	88.5
248	176.6	57.1	117.1
227	84.7	48.3	93.1
220	200.7	46.6	115.3
220	180.1	53.1	90.8
241	70.3	106.1	62.5
228	76.8	69.2	113.6
227	111.6	82.7	80.1
216	43.9	44.6	106.4
200	210.5	75.7	100.2
238	46.3	77.6	152.6
Raceway 4-hour			
245	38.1	30.3	106.0
252	167.1	78.4	93.0
255	250.0	73.7	376.1
200	27.7	49.3	171.1
231	156.2	41.3	110.8
221	39.4	36.1	88.0
220	73.8	22.1	83.2
256	64.3	77.1	142.3
214	16.0	48.4	176.9
266	15.0	52.4	101.6
226	15.9	81.3	141.3
222	40.2	43.3	91.7
233	28.3	47.5	93.7
250	198.1	52.4	132.2
208,195	19.8	--	--
Raceway 10-hour			
214	13.5	55.4	146.5
240	72.3	51.9	130.7
188	196.0	97.1	128.6
205	21.2	31.0	90.9
196	169.1	75.8	138.5
210	19.9	74.6	57.2
267	42.2	49.2	115.6
223	131.7	79.3	178.9
220	28.4	72.6	143.7
247	176.4	61.8	128.0
231	129.0	64.4	96.0
219	117.0	69.3	105.3
234	96.2	67.9	83.3
223	121.0	54.2	93.0
196	108.3	61.8	80.8

Appendix Table 11. Continued.

Sample date: **05/12/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Gatewell 7B			
214	120.8	34.5	110.9
208	41.4	56.7	92.9
220	89.1	50.0	118.4
246	29.5	35.3	96.9
201	52.1	65.2	254.7
229	28.8	35.7	125.1
236	18.4	59.6	245.2
220	161.9	95.8	509.0
222	63.6	57.6	151.1
244	40.5	65.4	134.8
203	88.5	72.7	213.1
224	83.1	61.0	93.7
213	93.7	73.6	118.1
240	46.3	46.2	134.9
212	20.0	64.6	227.3
Separator			
235	125.6	92.7	44.0
246	37.5	23.9	69.0
248	79.0	51.5	110.8
239	229.8	34.5	143.5
222	20.8	42.9	157.3
229	111.0	101.4	104.8
253	23.0	71.6	121.5
208	57.4	57.4	75.7
262	25.8	46.6	47.6
220	110.3	48.8	115.1
215	47.1	67.0	127.0
223	86.4	116.6	134.2
220	29.9	90.6	129.2
217	59.6	63.8	170.5
221	180.6	52.2	80.2
Raceway 2-hour			
243	151.6	52.2	161.6
249	167.6	63.6	135.2
287	89.7	36.8	97.2
220	77.4	32.9	91.7
201	79.7	78.2	203.8
243	142.5	30.7	79.7
230	130.9	59.6	94.8
220	129.5	47.2	61.9
226	43.9	57.0	143.0
240	218.7	51.8	134.1
240	144.9	61.8	127.9
220	75.3	64.4	125.9
177	12.3	86.9	55.5
208	179.2	63.0	85.7
234	88.1	81.1	236.7
Raceway 6-hour			
243	24.2	29.2	89.4
210	89.7	23.1	102.2
213	154.8	54.6	132.0
228	36.6	40.0	93.0
256	8.2	28.7	125.0
273	60.7	26.4	133.0
205	51.3	52.4	135.2
216	133.2	42.8	112.0
220	39.7	42.5	97.0
229	8.9	33.3	111.7
224	45.1	53.8	108.3
208	60.1	50.8	153.4
221	32.0	50.3	158.5
190	59.0	61.2	123.1
208	17.2	53.6	61.4

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
270	103.8	46.5	158.1
210	140.8	59.9	73.7
223	44.7	55.4	176.6
216	66.3	34.1	98.6
213	83.4	31.4	65.8
244	44.2	30.1	120.8
202	9.1	30.4	101.1
256	12.4	35.0	81.5
253	85.3	90.9	141.9
232	--	117.4	107.8
232	42.3	25.0	95.3
218	35.2	50.7	114.3
251	11.1	78.7	105.9
218	--	65.6	96.9
211	12.0	32.3	83.2
Raceway 0-hour			
239	213.1	42.9	129.5
233	123.4	98.8	367.3
236	117.5	110.6	215.9
214	29.6	86.6	103.4
185	142.3	36.7	88.5
255	35.0	33.9	140.9
191	87.5	107.0	136.8
216	92.5	79.5	110.0
258	108.2	46.6	161.2
231	79.5	69.3	87.5
232	189.4	62.2	57.8
253	69.9	72.8	118.3
236	35.2	55.9	91.9
256	56.9	43.3	90.5
214	93.9	53.2	87.7
Raceway 4-hour			
204	75.6	42.1	98.6
255	5.5	29.4	187.7
244	85.4	43.5	160.2
235	14.9	28.8	90.0
254	--	37.7	76.7
282	13.4	36.2	98.4
240	117.9	50.7	92.7
218	86.8	40.0	100.5
233	--	44.5	97.7
210	25.5	35.3	146.5
213	34.6	51.9	185.3
232	140.2	44.9	106.9
270	17.5	48.7	126.8
214	21.2	97.4	108.1
213	--	66.8	83.9
Raceway 10-hour			
209	54.8	65.7	352.6
203	150.9	76.4	96.9
232	31.1	69.5	391.4
222	77.6	40.2	117.1
188	109.8	50.5	231.8
235	5.5	34.0	105.4
288	109.5	55.7	104.8
222	129.5	51.9	144.3
208	37.5	61.0	134.0
213	23.2	46.2	71.8
226	97.6	47.7	111.6
222	20.9	54.2	243.6
209	52.9	73.9	105.4

Appendix Table 11. 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: **05/17/94**							
Gatewell 7B				Post Dewaterer			
244	--	73.4	162.4	199	171.7	39.4	79.4
254	86.2	47.5	137.7	188	37.6	52.3	92.4
218	275.1	49.1	269.4	239	122.6	24.3	90.4
241	160.6	44.8	212.6	215	59.5	54.3	83.8
224	--	42.5	135.0	230	81.3	30.4	101.0
188	35.7	75.8	113.3	260	63.0	36.8	115.3
227	155.9	52.9	103.0	247	52.7	29.7	111.4
189	43.3	57.9	166.2	224	55.5	31.2	114.2
228	50.7	150.5	386.0	235	49.5	43.2	113.1
194	171.3	67.8	139.9	207	131.6	42.7	77.9
212	44.8	122.6	216.9	255	206.9	123.9	218.5
179	25.5	62.1	95.6	268	102.5	39.7	79.1
221	39.6	77.4	117.7	217	34.9	77.2	102.9
189	51.0	76.8	125.9	224	43.8	36.6	78.9
270	20.9	69.4	153.8	261	64.1	48.1	100.6
Separator				Raceway 0-hour			
223	174.7	79.9	66.2	238	133.3	42.6	137.6
246	126.2	26.1	96.0	258	79.5	77.3	79.6
242	92.1	40.6	72.4	214	136.5	61.6	77.2
193	60.2	32.9	103.6	209	228.7	177.1	130.7
216	62.6	42.4	128.6	213	46.0	42.0	140.7
236	36.6	86.3	109.0	233	212.3	152.3	83.2
164	192.2	32.9	72.7	250	99.5	63.3	110.8
266	33.8	87.1	125.3	207	78.1	79.6	68.6
228	76.9	72.5	109.3	214	46.2	66.6	63.8
234	49.2	76.3	75.6	238	78.5	88.6	91.3
214	109.6	46.3	131.6	205	145.9	83.7	161.7
236	95.8	91.8	138.9	203	58.9	76.7	74.9
206	57.1	41.1	83.1	237	46.6	94.3	88.8
198	109.5	59.1	80.9	240	--	70.1	168.6
222	69.7	159.6	115.9	226	72.2	116.6	136.5
Raceway 2-hour				Raceway 4-hour			
255	38.2	43.0	196.8	261	111.5	41.0	159.9
223	103.2	90.6	161.7	185	103.4	51.0	147.8
248	20.8	43.3	123.8	195	17.3	7.6	40.4
220	133.1	25.6	107.5	280	--	41.0	167.3
240	121.3	84.5	363.1	238	114.2	57.0	114.3
210	43.3	23.3	88.3	188	106.1	59.9	107.6
228	16.8	50.7	146.1	217	188.4	48.2	147.6
203	25.5	40.2	109.2	217	212.6	80.4	155.0
222	292.1	100.7	109.5	208	47.2	46.2	138.6
213	55.7	56.6	137.1	215	167.0	33.7	133.6
230	25.4	79.3	129.8	206	45.4	46.2	78.8
186	118.3	93.7	135.2	220	83.1	67.3	148.8
249	322.4	91.2	62.7	182	227.2	95.8	536.0
187	104.4	106.1	80.7	209	14.7	51.3	112.0
244	11.3	64.4	91.9	195	59.3	86.9	99.1
Raceway 6-hour				Raceway 10-hour			
227	155.0	54.0	40.3	201	223.3	69.2	132.4
188	110.1	41.1	149.9	224	25.8	81.0	356.0
214	130.6	67.1	122.5	263	79.3	83.5	71.9
204	40.8	52.1	93.1	265	120.0	41.4	108.9
253	129.6	49.3	66.8	218	187.4	46.1	274.2
246	52.6	59.5	134.2	236	242.5	120.4	426.2
258	109.6	59.5	117.0	220	--	51.1	110.2
253	12.6	59.5	129.3	225	122.2	57.0	82.7
185	147.6	81.0	126.8	227	59.5	89.2	119.4
218	63.5	39.5	125.6	180	84.8	75.1	108.7
246	121.9	43.4	132.3	215	33.3	53.4	225.2
223	53.6	71.0	109.4	195	77.4	52.8	114.2
214	70.9	57.4	82.1	226	37.8	-4.9	11.9
187	25.3	98.0	149.9	203	163.7	40.9	97.0
260	87.5	50.8	91.3	211	106.7	65.4	156.7

Appendix Table 11. Continued.

Sample date: **05/19/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Gatewell 7B			
223	207.2	22.4	96.5
179	15.6	58.9	401.0
219	49.1	32.5	105.4
198	119.3	40.9	251.2
176	50.2	57.8	202.0
187	36.0	41.3	104.7
206	51.3	53.8	184.1
210	149.2	51.2	273.5
232	114.0	50.4	121.8
178	154.7	49.9	135.4
233	33.0	53.1	108.9
174	256.3	41.2	89.0
216	51.6	58.9	115.6
219	126.9	72.8	286.0
222	62.8	62.4	113.5
Separator			
200	217.6	55.9	76.0
248	59.7	30.4	137.2
215	157.5	27.4	153.6
291	178.8	35.0	165.2
245	29.5	57.8	115.1
199	99.4	22.0	82.1
226	110.3	127.1	153.8
214	109.7	53.6	171.5
202	68.4	95.6	75.0
185	88.1	60.3	123.7
265	87.9	66.8	127.6
210	57.6	36.9	100.4
211	--	78.2	96.7
189	99.5	31.2	89.7
212	151.0	25.7	94.2
Raceway 2-hour			
225	51.9	43.5	116.1
207	249.1	63.3	313.0
247	130.6	84.5	115.8
232	216.3	76.3	604.5
213	--	28.9	93.5
234	54.5	26.7	115.9
219	46.8	51.0	129.3
213	75.0	35.9	253.4
254	30.0	41.5	131.6
245	58.7	90.4	85.6
205	147.5	75.5	108.6
250	182.5	44.9	79.1
184	71.5	54.5	81.3
227,194	88.1	84.6	79.6
Raceway 6-hour			
203	35.4	45.1	105.9
212	90.9	35.0	118.9
187	72.3	39.8	93.8
220	43.9	44.5	172.9
286	273.4	33.5	125.9
255	67.3	48.1	159.6
235	114.2	59.9	88.6
238	46.9	50.0	85.2
201	186.5	77.3	142.5
226	118.5	38.3	102.2
244	15.0	57.2	71.6
218	16.6	70.4	107.5
208	12.4	61.9	161.6
239	178.8	52.4	176.3
221	13.9	55.4	80.8

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
187	67.5	38.0	126.4
232	13.3	35.5	146.9
223	--	38.7	115.4
231	116.6	18.3	157.6
224	135.6	50.4	291.8
234	57.9	18.9	80.7
230	85.9	24.5	115.9
209	163.7	48.9	152.5
214	125.1	19.3	85.2
219	118.6	42.4	85.2
215	176.1	73.0	88.9
235	65.9	38.9	72.0
194	190.3	55.5	165.5
226	44.1	25.3	86.3
206	144.3	27.9	113.7
Raceway 0-hour			
233	78.6	40.3	57.9
213	42.9	57.1	165.1
222	72.2	34.8	110.7
220	164.5	61.0	100.1
206	52.3	50.0	99.2
270	238.7	61.8	116.3
191	78.6	68.1	92.9
199	70.6	47.8	128.0
232	78.1	53.0	26.2
208	79.1	64.5	140.3
271	68.6	131.7	139.0
220	98.3	36.5	143.1
235	41.8	81.6	98.6
247	100.4	141.8	102.0
230	141.6	106.9	196.4
Raceway 4-hour			
217	137.8	34.5	143.1
235	33.1	96.1	84.5
214	230.6	93.3	151.9
175,196	117.7	74.5	89.9
229	71.1	64.9	104.3
280	63.1	71.7	192.5
252	256.3	119.0	128.5
203	71.2	50.3	206.3
227	79.2	78.2	122.4
240	49.2	79.8	151.3
199	27.4	109.5	76.7
215	51.9	99.1	119.3
Raceway 10-hour			
232	220.2	94.6	71.6
210	184.9	73.2	288.1
253	64.1	96.3	390.7
201	68.0	48.1	367.1
245	46.4	57.3	211.0
257	171.1	81.4	292.6
255	50.8	96.5	480.6
203	101.1	58.7	160.3
210	171.1	54.3	231.1
223	156.2	79.5	105.9
175	111.7	96.1	168.2
166	212.9	67.0	58.5
236	98.2	56.3	100.3
246	122.0	69.1	176.5
236	43.5	90.6	122.1

Appendix Table 12. Fork lengths, plasma cortisol, lactate, and glucose values for migrating subyearling chinook salmon collected from various locations and times at McNary Dam's collection facility, 1994.

Sample date: **06/27/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Gatewell 7B			
111,103	51.0	84.8	124.9
84,107,105	51.1	78.9	98.1
99,105	54.6	97.6	87.0
110,116	84.9	89.8	85.8
101,103,99	11.3	103.7	80.6
100,118,99	14.2	77.8	99.8
98,111,110	17.2	140.7	101.0
101,108,108	71.5	180.3	109.2
109,109	26.0	120.9	122.5
104,83,107	41.2	163.8	102.0
105,96,100	147.0	176.5	63.0
Separator			
102,104	45.7	50.2	120.7
106,106	93.9	54.2	79.9
100,104	40.0	82.9	80.0
95,102,97	129.0	63.7	93.6
103,108	54.0	92.8	74.7
104,106,105	45.2	97.1	78.1
110,105	65.6	90.2	84.2
102,104,108,103	32.2	97.1	56.4
105,111	53.6	130.2	62.4
104,110,108	64.0	141.9	36.0
98,106,102,104	20.0	129.0	58.9
109,100	34.9	107.2	59.6
101,108,104	59.8	136.8	47.7
Raceway 2-hour			
99,101,100	48.7	42.2	151.8
109,100,104	118.6	38.2	118.8
104,108,104	54.1	114.5	52.7
107,112,104	46.9	54.2	47.6
96,110,102	--	71.5	126.0
105,103,108	147.8	67.3	57.6
105,105,100,97	10.2	105.1	50.3
105,106,101	56.7	94.9	53.3
106,108,101	36.0	108.5	84.3
106,107,102	103.7	96.0	43.0
110,107,102	163.6	98.1	50.4
111,91,108	49.2	144.1	38.5
Raceway 6-hour			
105,107,106	59.0	42.2	125.8
104,104,104	125.9	41.4	117.6
103,105,108	35.0	48.9	112.8
108,98,111	43.0	52.5	105.8
101,99,112, 89	46.0	--	--
97,99,103	72.3	73.1	57.0
101,100,98,102	77.3	88.3	79.8
105,108,108	88.7	83.3	87.0
107,103,101	133.5	114.6	54.6
111,108,109	76.3	102.3	45.8
108,99,97	21.0	111.4	54.6
103,101	65.1	105.7	54.4

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
112,111	133.8	39.6	69.6
111,107,92	151.3	64.4	94.2
108,103	88.7	95.4	74.7
102,110,109	18.5	71.2	45.8
104,108	36.0	81.8	62.6
107,101	126.8	81.7	55.8
112,105,93,108	64.3	84.2	74.7
108,107,102	36.5	114.2	87.4
89,96,81,112	68.4	95.4	71.9
102,107,108	117.7	54.3	67.2
109,100	96.5	75.0	61.9
108,103,102	47.4	77.8	64.8
105,110,96	81.7	87.2	61.2
Raceway 0-hour			
103,103	155.4	141.1	99.6
102,101,107	48.4	90.5	150.4
114,104	55.7	101.4	101.6
112,104,101,95	147.1	91.3	59.6
108,108	54.5	99.9	116.5
101,111,115	48.5	181.1	59.5
97,109,114	67.9	131.3	91.8
103,100,108	67.9	86.8	36.9
108,106,106	131.5	136.2	41.4
103,103,102,98	133.8	154.0	34.8
105,98,101	88.3	126.9	48.6
102,108,101	18.2	142.1	24.9
104,96,99,94	87.0	139.9	35.4
Raceway 4-hour			
108,98,101	79.7	44.5	96.0
99,115	81.8	44.0	92.4
95,109,103	55.1	58.8	120.1
113,109	168.2	49.4	109.2
99,101,109,105	63.6	75.5	88.4
106,99,104,104	40.5	64.4	126.0
109,120	50.4	101.1	82.3
102,104,103,112	75.3	93.6	55.8
100,106,106,110	167.7	90.9	57.6
114,110,95	50.0	102.9	52.0
105,111,107	55.7	118.4	50.6
104,101,107	25.2	124.5	41.6
112,112,89	27.7	123.9	29.2
102,93,99,100	50.5	120.3	54.0
112,105,94,92	35.8	128.6	40.4
Raceway 10-hour			
107,109	78.1	50.7	117.1
105,106,106	114.7	49.9	91.3
111,112	194.8	68.4	130.2
105,93,110	101.3	71.2	84.7
100,108,111	140.7	75.1	81.0
112,101,110,98	176.9	73.1	74.4
113,100,105	--	--	--
106,101,114	--	70.9	101.6
102,104,104,109	37.1	122.2	88.6
106,101,107,108	37.5	114.7	67.8
103,91,109	92.5	106.3	44.0
114,97,111	200.8	129.2	57.6
99,105,105	146.3	121.5	42.6

Appendix Table 12. Continued.

Sample date: **06/28/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Gatewell 7B			
112,108	211.6	160.4	83.4
114,109	34.9	87.7	120.1
95,110	29.4	67.5	95.4
114,105,97	45.7	116.7	99.3
108,96,96	51.7	141.1	178.9
108,114,98	42.8	90.2	95.5
95,105,102,116	157.9	183.1	97.8
110,100,113	19.8	144.1	99.8
100,107,104	15.9	116.8	75.0
78,112,111	64.2	113.2	65.7
100,108,103	44.6	101.3	134.4
101,103,105	40.7	138.5	81.6
105,94,99	29.4	128.2	110.3
Separator			
106,106	115.3	43.7	92.4
117,109	50.6	57.0	124.3
104,97	81.0	60.3	86.1
106,102	117.0	66.6	67.6
103,101,98	53.0	106.5	115.2
98,106	99.8	66.3	71.9
110,107	153.0	52.9	94.2
104,100	124.4	73.9	82.8
98,104	67.0	111.9	111.5
99,103,102	54.9	71.8	70.9
103,102,105	78.4	74.1	81.3
110,100	135.2	47.7	97.8
105,107,101	51.8	70.4	86.8
106,106	--	--	--
119,110	184.2	87.8	112.2
Raceway 2-hour			
106,103	58.2	36.0	123.7
112,102	40.5	41.1	92.3
106,103,101	43.3	52.4	115.2
105,97,109,101	138.4	51.4	77.6
104,117,99	132.8	81.6	77.1
106,107,112	95.1	92.2	109.4
105,114,101	49.0	112.5	58.9
105,106,104	173.9	88.3	56.4
108,113,98	76.7	91.1	53.4
109,104,99	45.4	99.0	108.2
101,101,106	92.8	103.1	44.4
105,100,104	12.5	104.8	34.8
Raceway 6-hour			
109,103,105	44.7	41.9	117.1
109,102,101,100	39.3	39.6	106.8
113,113,110	137.9	54.3	114.0
104,105,102	94.5	66.4	85.8
108,106,105	48.7	63.8	81.8
108,105,109,108	--	--	--
99,110,102	87.9	75.8	67.1
104,105,105,104	46.6	104.2	69.0
101,110,100,100,110	27.9	111.4	54.0
109,104,98	38.3	110.5	58.3

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
112,113,96	121.2	97.1	107.4
115,100	73.3	58.7	123.0
93,102,104	66.0	68.1	113.0
104,103	40.5	117.8	54.1
105,110	161.8	52.0	105.6
106,100,116	121.6	62.3	79.9
108,104,108	69.3	69.5	89.9
106,107,105	89.8	45.3	86.1
106,105	41.0	74.6	129.6
104,103	45.8	78.0	126.0
Raceway 0-hour			
104,109	71.6	96.3	144.3
91,100,102,114	94.7	56.3	85.2
109 109	110.8	66.1	109.2
103,105,101,98	172.0	69.0	70.8
102,108,105	42.2	125.5	136.7
107,105,107,106	108.1	122.6	58.8
106,105,100	119.2	116.1	60.0
105,100,103	204.5	124.1	34.2
102,110,99	61.1	114.1	78.5
97,102,94	31.3	174.9	32.9
102,96,104	81.4	129.3	39.7
Raceway 4-hour			
108,108	68.0	27.8	99.0
111,101,101	38.6	53.3	100.4
110,113	224.8	41.7	97.8
104,106,99	41.9	54.7	88.0
106,106,107	57.2	55.4	94.1
111,109,106	38.8	68.4	101.1
103,110,103,105	215.7	81.4	81.6
75,102,114,95	27.9	84.0	96.3
104,104,112	34.5	88.0	53.3
93,106,103,94	70.3	92.8	79.0
106,114,105	105.9	111.4	57.0
97,92,86	127.4	117.4	63.0
Raceway 10-hour			
107,107	121.6	51.4	141.9
97,118,98	56.7	48.7	118.3
116,114	46.3	53.9	125.8
100,111,104,108	38.8	57.6	138.5
112,102,112	31.9	54.2	91.1
95,97,94,108,106	30.1	84.6	88.0
108,100,105	119.7	75.9	76.2
109,101,110,98	135.9	92.4	87.6
104,103,100	72.5	100.7	66.6
110,114	76.8	88.2	65.7
107,101,101,108	175.4	117.7	54.0
107,108,108	32.0	120.8	54.6

Appendix Table 12. Continued.

Sample date: **06/29/94**

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
<u>Gatewell 7B</u>			
133	21.7	59.8	79.7
113,105,101	46.5	79.8	93.6
97,104,108	143.3	81.4	86.4
98,106,114,100,96	50.1	109.7	78.0
108,107,98,105,100	39.1	130.2	66.7
101,104,101,97,110	53.7	141.3	87.4
103,86,101,106,97	40.2	134.4	51.0
110,103,102	8.8	133.9	94.8
105,102,107,93,105	20.4	137.9	61.5
<u>Separator</u>			
100,103,119	47.6	48.2	112.1
102,97,111,104	50.4	58.7	109.7
114,102	104.7	81.1	97.8
106,101,102	131.5	76.8	99.6
103,106,105,111	121.2	105.2	90.8
100,105,109	61.9	66.4	100.5
112,101	105.6	52.8	104.5
112,109,108	69.9	52.5	107.8
101,108,97	109.0	51.7	81.8
113,107	79.2	64.0	89.4
103,109,97	85.8	53.5	81.6
105,113,100	25.4	76.3	74.9
<u>Raceway 2-hour</u>			
104,106,105	80.3	44.8	127.8
99,98,105,104	40.5	49.9	148.0
108,113	64.0	72.1	120.8
114,105,104	190.8	74.5	100.2
109,108,101	24.4	61.3	82.1
99,106,109,100	118.3	88.3	72.6
119,113	57.9	82.6	63.9
109,108,109	60.1	91.9	100.5
106,104,111,106	65.1	104.4	91.6
109,110,106	133.5	105.9	52.2
104,98,106,104,107	45.5	105.4	49.6
<u>Raceway 6-hour</u>			
109,101	64.0	44.2	107.2
103,102,108	56.7	45.9	111.5
112,108,109	35.6	59.0	141.8
110,109,99,108	97.3	63.2	103.6
108,113,100,115	40.1	70.7	85.5
102,108,91,114	85.0	71.5	68.6
110,120,108	31.8	84.8	40.4
100,92,110,105,100,118	21.1	96.6	55.8
105,111,110	62.8	96.2	47.3

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
<u>Post Dewaterer</u>			
(No samples were taken at this site)			
<u>Raceway 0-hour</u>			
101,98,102	199.5	62.9	95.1
99,97,105	108.1	79.4	97.8
111,117	30.0	88.6	99.8
104,106,105,110	51.3	69.2	62.0
107,111,115	101.3	140.5	68.1
107,107,106	149.4	80.6	45.0
113,119,115	20.5	143.3	76.9
106,108,105	81.0	142.0	69.0
104,99,103,115	85.4	135.1	70.5
106,106,95,105	118.3	149.4	61.9
105,113,101	29.5	151.5	34.0
<u>Raceway 4-hour</u>			
112,117	58.4	33.7	137.3
101,103,115	45.8	36.0	94.5
112,99	109.3	41.0	93.6
99,104,107,104	52.0	54.4	94.8
109,109,112	--	--	--
110,100,105,100	143.7	75.4	72.0
105,110,114	15.8	92.3	60.8
106,97	19.2	88.0	57.7
104,98,104,106	126.8	83.9	66.2
107,106,100,107,99	35.0	111.1	68.8
94,96,96,106	124.7	98.1	46.8
<u>Raceway 10-hour</u>			
105,110,113	114.2	37.3	120.0
102,109,101,102	125.0	44.8	111.0
107,109,109	77.4	51.7	109.3
105,107,112	80.9	62.0	86.1
118,105,102	39.3	78.0	79.1
101,101,100,101,106,104	40.7	92.9	64.5
107,105,104,107	88.5	94.2	77.1
107,106,106	101.1	99.6	72.6
104,102,109,103,98	47.1	109.7	65.1
112,109	62.4	97.4	44.9

Appendix Table 12. Continued.

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Sample date: **06/30/94**			
Gatewell 7B			
108,109,104	114.1	68.1	93.6
109,101,101	108.2	52.5	97.4
112,109	75.3	150.2	83.2
98,104,110	115.4	155.5	107.8
113,95,103	70.7	172.2	93.0
115,93,104,97	54.7	104.6	87.0
109,105,107,100	42.3	165.0	70.9
105,115,113,107,100	36.4	164.9	88.0
107,107,115	28.0	195.9	131.4
103,100,104,100,91	44.0	141.7	71.9
Separator			
107,100,103	115.7	58.8	97.4
99,99,103,99	84.6	71.2	84.2
98,103,110	37.0	104.2	79.1
108,95,103,94	47.1	100.3	104.1
105,98,92,94	75.6	122.1	77.1
107,106	80.4	64.4	110.3
105,101,103	77.2	59.8	105.3
107,109,105	35.9	63.0	76.7
103,102	49.2	58.1	83.2
110,97	77.2	63.5	101.0
112,108,104	70.7	88.5	113.0
103,102	48.7	62.7	80.3
Raceway 2-hour			
110,105	75.4	43.6	148.0
105,103,102	26.1	44.5	39.8
107,117	50.4	49.6	120.1
106,109,92,106	36.0	49.3	69.0
109,105,112,112	112.6	82.0	81.6
105,109,110,109	71.6	81.9	72.3
106,114,100,98	40.8	97.4	99.8
97,118,104,108	16.9	119.1	67.0
114,106	25.9	94.3	66.3
107,106,97	23.9	111.8	89.8
98,115,90	41.0	127.5	69.6
Raceway 6-hour			
110,111	49.9	48.2	123.9
105,106,109	167.7	48.0	119.4
109,104,108	46.9	52.4	127.6
106,101,107,110	38.2	61.0	98.1
109,111,103	134.0	77.8	83.2
102,112,106,113	56.7	96.9	104.1
102,114,107	120.8	111.7	119.4
113,108,106	66.0	99.1	48.2
105,105,108,102	31.0	114.7	105.8
106,109,100,106	172.0	115.7	77.4
103,104,108	40.9	121.3	70.7

Fork Length (mm)	Cortisol (ng/ml)	Lact. (mg/dl)	Gluc. (mg/dl)
Post Dewaterer			
(No samples were taken at this site)			
Raceway 0-hour			
105,115	29.0	92.6	81.8
107,94,102,104	112.9	86.7	101.2
100,111,107	81.8	75.4	104.4
122,114,99	37.8	73.5	88.0
121,110	142.2	75.7	66.6
104,101,105,104	53.9	126.7	63.3
107,103,104,101	30.3	90.6	69.4
102,114	28.1	101.4	38.5
102,105,106,105	76.0	130.4	56.4
115,108,111	30.1	154.9	86.1
123,102,109	50.4	164.9	99.1
98,108,99	95.5	151.4	40.8
Raceway 4-hour			
104,110	53.3	40.2	84.4
101,108,104,112	140.0	44.2	91.8
108,115,110	85.4	55.7	114.0
115,99,111,102	109.9	59.4	89.9
106,110	75.7	71.0	78.0
111,113,114	140.7	74.8	89.4
108,115,97,107	62.1	107.4	71.9
104,102,110,108	34.6	97.1	73.1
109,111,108,108	40.3	95.1	62.4
108,117,109	27.5	116.1	92.2
104,105,107,95	32.9	116.7	108.2
Raceway 10-hour			
108,106,105,120	55.5	66.1	185.2
100,97,111,110,111	148.4	84.2	98.4
106,112,115,113,95	50.4	105.1	102.9
108,109,115,101,102	90.7	104.9	79.0
101,102,112,107,99,107	125.6	109.9	81.6
116,96,96,98,87,100	36.5	135.4	68.1
101,106,104,107,109	33.9	125.8	81.5

Appendix Table 13. The number of PIT-tagged fish passing through the flume, the number caught in the sampling system, the measured sample rate, the facility sample rate, and the expected number of fish caught in the sample for each day at McNary Dam, 1994 (Objective 2).

Date	Total number detected	Total in sample	Measured sample rate	Daily sample rate	Expected value
Small-fish flume:					
04/17/94	134	5	3.73	5	6.70
04/30/94	24	2	8.33	5	1.20
05/01/94	72	3	4.17	5	3.60
05/02/94	165	11	6.67	5	8.25
05/03/94	254	9	3.54	5	12.70
05/04/94	269	3	1.12	3	8.07
05/05/94	272	4	1.47	2	5.44
05/06/94	405	9	2.22	2	8.10
05/07/94	358	5	1.40	2	7.16
05/08/94	349	9	2.58	2	6.98
05/09/94	581	15	2.58	2	11.62
05/10/94	680	13	1.91	2	13.60
05/11/94	1000	17	1.70	2	20.00
05/12/94	697	20	2.87	2	13.94
05/13/94	1258	25	1.99	2	25.16
05/14/94	1150	17	1.48	2	23.00
05/15/94	1121	21	1.87	2	22.42
05/16/94	856	18	2.10	2	17.12
05/17/94	1586	28	1.77	2	31.72
05/18/94	1633	56	3.43	2	32.66
05/19/94	758	5	0.66	2	15.16
05/22/94	900	16	1.78	2	18.00
05/23/94	614	8	1.30	2	12.28
05/24/94	554	17	3.07	2	11.08
05/25/94	386	6	1.55	2	7.72
05/26/94	239	1	0.42	2	4.78
05/27/94	584	11	1.88	2	11.68
05/28/94	249	5	2.01	2	4.98
05/31/94	148	2	1.35	2	2.96
06/01/94	156	2	1.28	3	4.68
06/02/94	195	8	4.10	3	5.85
06/03/94	119	4	3.36	4	4.76
06/04/94	70	1	1.43	4	2.80
06/05/94	48	1	2.08	4	1.92
06/06/94	38	3	7.89	4	1.52
06/09/94	199	8	4.02	4	7.96
06/10/94	58	1	1.72	4	2.32
06/11/94	67	3	4.48	4	2.68
06/12/94	26	0	0.00	5	1.30
06/13/94	34	4	11.76	5	1.70
06/14/94	34	6	17.65	5	1.70
06/15/94	97	2	2.06	5	4.85

Appendix Table 13. Continued.

Date	Total number detected	Total in sample	Measured sample rate	Daily sample rate	Expected value
06/16/94	68	2	2.94	5	3.40
06/17/94	42	0	0.00	5	2.10
06/18/94	33	2	6.06	5	1.65
06/19/94	25	3	12.00	5	1.25
06/21/94	13	3	23.08	16.67	2.17
06/22/94	11	3	27.27	16.67	1.84
06/23/94	12	2	16.67	16.67	2.00
06/24/94	25	1	4.00	16.67	4.17
<u>Large-fish flume:</u>					
04/17/94	185	4	2.16	2	3.70
04/29/94	36	1	2.78	5	1.80
04/30/94	64	3	4.69	5	3.20
05/01/94	156	10	6.41	5	7.80
05/02/94	355	15	4.23	5	17.75
05/03/94	453	14	3.09	5	22.65
05/04/94	508	8	1.57	3	15.24
05/05/94	678	13	1.92	2	13.56
05/06/94	621	9	1.45	2	12.42
05/07/94	625	6	0.96	2	12.50
05/08/94	855	20	2.34	2	17.10
05/09/94	948	18	1.90	2	18.96
05/10/94	1177	25	2.12	2	23.54
05/11/94	1632	23	1.41	2	32.64
05/12/94	1323	23	1.74	2	26.46
05/13/94	1507	20	1.33	2	30.14
05/14/94	1306	24	1.84	2	26.12
05/15/94	1123	21	1.87	2	22.46
05/16/94	1195	17	1.42	2	23.90
05/17/94	2372	48	2.02	2	47.44
05/18/94	2368	49	2.07	2	47.36
05/19/94	1087	23	2.12	2	21.74
05/22/94	1517	19	1.25	2	30.34
05/23/94	1624	26	1.60	2	32.48
05/24/94	1904	34	1.79	2	38.08
05/25/94	1478	20	1.35	2	29.56
05/26/94	678	8	1.18	2	13.56
05/27/94	1191	24	2.02	2	23.82
05/28/94	424	3	0.71	2	8.48
05/31/94	515	19	3.69	2	10.30
06/01/94	535	17	3.18	3	16.05
06/02/94	442	12	2.71	3	13.26
06/03/94	434	11	2.53	4	17.36
06/04/94	283	7	2.47	4	11.32
06/05/94	161	6	3.73	4	6.44
06/06/94	213	6	2.82	4	8.52

Appendix Table 13. Continued.

Date	Total number detected	Total in sample	Measured sample rate	Daily sample rate	Expected value
06/07/94	118	1	0.85	4	4.72
06/09/94	253	8	3.16	4	10.12
06/10/94	141	4	2.84	4	5.64
06/11/94	108	3	2.78	4	4.32
06/12/94	91	3	3.30	5	4.55
06/13/94	98	10	10.20	5	4.90
06/14/94	63	2	3.17	5	3.15
06/15/94	112	5	4.46	5	5.60
06/16/94	50	4	8.00	5	2.50
06/17/94	75	5	6.67	5	3.75
06/18/94	87	6	6.90	5	4.35
06/19/94	66	3	4.55	5	3.30
06/20/94	177	8	4.52	5	8.85
06/21/94	144	5	3.47	5	7.20
06/22/94	107	7	6.54	5	5.35
06/23/94	70	1	1.43	5	3.50
06/24/94	63	1	1.59	5	3.15
06/25/94	62	1	1.61	5	3.10
06/26/94	42	0	0.00	3	1.26
06/28/94	58	1	1.72	3	1.74
06/29/94	46	1	2.17	3	1.38
06/30/94	34	0	0.00	3	1.02