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ESTIMATES OF FISH AND SPILL PASSAGE EFFICIENCY OF RADIO-TAGGED JUVENILE STEELHEAD, AND YEARLING AND SUBYEARLING CHINOOK SALMON AT JOHN DAY DAM, 2000.

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Estimates of fish and spill passage efficiency of radio-tagged juvenile steelhead, and yearling and subyearling chinook salmon at John Day Dam, 2000

Final Report of Research during 2000

John W. Beeman[1], Hal C. Hansel, Philip V. Haner, Kristi Daniel and Jill Hardiman[2]

U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501 A Cook-Underwood Road
Cook, Washington 98605

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Environmental Resources Branch
Robert Duncan Plaza
333 S.W. 1st. Avenue
Portland, Oregon 97204-3495
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[1] Corresponding author: john_beeman@usgs.gov, 509-538-2299 x 257

[2] Current Address: Colorado State University, Fort Collins, Colorado 80524

Table of Contents

Executive Summary

Beginning in 1999, the U.S. Army Corps of Engineers (COE) contracted with the U.S. Geological Survey to determine spill and fish passage efficiency at John Day Dam (JDA) using radio telemetry during 12- and 24-h spill treatments. In 2000, the proposed 12-h spill treatment consisted of 0% "day" spill from 0700-1859 h and 60% "night" spill from 1900-0659 h, and the proposed 24-h spill treatment consisted of 30% day spill and 60% night spill. Spill treatments during this study were alternated every three days during four six-day blocks in the spring and again in the summer. Our specific objectives were to: 1) determine the proportion of radio-tagged juvenile steelhead (*Oncorhynchus mykiss*), yearling chinook salmon (*O. tshawytscha*), and subyearling chinook salmon (*O. tshawytscha*) passing through the spillway and powerhouse (both guided and unguided) at JDA during two different spill treatments, and 2) obtain information on the behavior of radio-tagged fish in the near-dam area prior to passage. The study was divided into spring (juvenile steelhead and yearling chinook salmon migration) and summer (subyearling chinook salmon migration) periods.

Dam Operations: The average spill levels during the spring study period from 01 May through 24 May were similar to those proposed during the day, but were slightly less than planned at night. Average hourly day spill ranged from 30.1 to 30.3% per block, with an overall average of 30.2% during the study period. The average hourly night spill ranged from 42.7 to 55.7% per block, with an overall average of 51.9%. Project discharge ranged from 171 kcfs to 360 kcfs during the spring study period. The greatest project discharge (312 kcfs) and lowest percent spill (42.7%) occurred at night during the 12-h treatment in the first block, resulting in notable differences in fish passage.

The average spill levels during the summer study period from 25 June to 24 July were similar to those proposed. The average hourly day spill was 1.2% during the 12-h treatment and 30.1% during the 24-h treatment. Average hourly night spill was 58.5% and 59.2% during the 12- and 24-h treatments, respectively. Project discharge ranged from 99.4 kcfs to 275.0 kcfs.

Number of Fish Released and Detected: From 01 May through 24 May, 487 juvenile steelhead and 484 yearling chinook salmon were radio-tagged and released 23 km above John Day Dam. Ninety-two percent of the juvenile steelhead and 96% of yearling chinook salmon released were detected at John Day Dam during the spring study period. From 30 June to 20 July, a total of 394 subyearling chinook salmon were radio-tagged and released. Telemetry detection arrays at John Day Dam detected 84% of the tagged fish during the summer study period.

Travel Time, Arrival Time, and Approach Pattern: The median travel times of juvenile steelhead and yearling chinook salmon from the Rock Creek release site to the JDA near-dam forebay during the spring were 23.1 and 15.6 h, respectively. The hour of arrival of both species was generally dispersed throughout the diel period. However, a slight peak in the arrival distribution of juvenile steelhead was evident during the night and the arrival of yearling chinook salmon was greater during the day than during the night. Similar proportions of tagged fish were first detected (i.e., approached the dam) at the powerhouse and spillway during each treatment except in Block 1, when many more yearling chinook salmon were first detected at the powerhouse during the 12-h treatment than the 24-h treatment. The median travel time of subyearling chinook salmon from the Rock Creek release site to the JDA near-dam forebay during the summer was 25.6 h. The hour of arrival was dispersed throughout the diel period. Most tagged fish were first detected near the spillway during each treatment. A slight increase in first detections at the spillway was evident over time during the 12-h treatment, but little difference during the 24-h treatment was present.

Forebay Residence Times and Approach Pattern: Median forebay residence times during the spring were influenced by the time of arrival, the percent spill during arrival, and the species. Median residence times of fish from both species arriving during the day were significantly greater than those arriving at night (range 2.4 to 14.7 h day, 0.4 to 7.7 h night). Moreover, those arriving during day-no-spill condition had longer median residence times than those of the same species arriving during the day-spill condition.

This difference was due to passage delays of both species arriving during the day conditions, as most passage was at night. However, the residence times of both species were reduced when day spill was present (a statistically significant difference only for yearling chinook salmon). As in 1999, yearling chinook salmon were more likely to pass during day-spill conditions than were juvenile steelhead.

Median forebay residence times during the summer were influenced by the time of arrival and the percent spill during arrival. Subyearling chinook salmon arriving during the 24-h treatment had shorter forebay residence times with less variability between day and night arrival periods than those arriving during the 12-h treatment.

General Time and Route of Passage: The time of day that radio-tagged fish passed JDA during the spring was affected by species-specific responses to spill conditions at the time of arrival. Most passage of both species was at night, but day passage of yearling chinook salmon was enhanced during day spill. Day passage of yearling chinook salmon increased from 14% during the 12-h treatment to 44% during the 24-h treatment. Juvenile steelhead daytime passage increased from 4 to 8% during these conditions. The spillway was the most common passage area. During the 12-h treatment, 77% of the yearling chinook salmon and 68% of the juvenile steelhead passed via the spillway (night only). During the 24-h treatment (day and night pooled), spillway passage of yearling chinook salmon and juvenile steelhead were 77 and 73%, respectively.

The time of day that radio-tagged fish passed JDA during the summer was also affected by spill conditions at the time of their arrival. Differences in the times of passage between treatments were evident, with a greater proportion of fish passing between 0900 and 1659 h during the 24-h treatment than the 12-h treatment, and the opposite trend occurring between 1700 and 2400 h. Passage of tagged fish was greatest at night during the 12-h treatment, but was greatest in the day during the 24-h treatment, indicating a passage delay of subyearling chinook salmon arriving in the day during the 12-h treatment.

The spillway was the most common passage area. During the 12-h treatment, 82% of the subyearling chinook salmon passed via the spillway (night only). During the 24-h treatment, spillway passage was 89% during the day and 82% during the night, for an overall spillway passage of 86% during the 24-h treatment. Turbine and JBS passage of the 57 tagged fish passing in the day during the 12-h treatment were 40% and 60%, respectively. Only 4 tagged fish passed the dam during the 12-h treatment of Block 4, so these data were not included in analyses.

Fish- and Spill-Passage Efficiencies: Neither juvenile steelhead nor yearling chinook salmon fish passage efficiency (FPE) differed significantly between the 12- and 24-h treatments ($P > 0.05$). Estimates of juvenile steelhead FPE were 93% during the 12-h treatment and 91% during the 24-h treatment. Estimates of yearling chinook salmon FPE were 90 and 92% during the 12- and 24-h treatments, respectively (Block 1 omitted from analysis; see Discussion).

Juvenile steelhead spill passage efficiency (SPE) did not significantly differ between treatments, but yearling chinook salmon SPE was significantly greater during the 24-h treatment than the 12-h treatment. Juvenile steelhead SPE estimates in each study block ranged from 61 to 79% during the 12-h treatment and from 64 to 83% during the 24-h treatment; significant differences between blocks prohibited an overall estimate. The overall yearling chinook salmon SPE estimates were 75 and 86% (Block 1 omitted from analysis; see Discussion).

The FPE and SPE during the 24-h treatment were significantly greater than during the 12-h treatment during the summer study period. Point estimates and 95% confidence intervals of FPE were 78.7% (71.5 to 84.9%) during the 12-h treatment and 91.1% (86.0 to 94.9%) during the 24-h treatment. Estimates of SPE during the 12- and 24-h treatments were 53.9% (45.7 to 62.0%) and 81.8% (75.0 to 87.1%), respectively.

Spill Effectiveness: As in 1999, spill effectiveness during the spring was greater during day spill than night spill and all values were greater than 1:1. The juvenile steelhead spill effectiveness in each block ranged from 2.0:1 to 2.5:1 during day spill and from 1.2:1 to 1.7:1 during night spill. The spill effectiveness of yearling chinook salmon in each block ranged from 2.9:1 to 3.1:1 during day spill and from 1.4:1 to 1.6:1 during night spill. However, it is important to note that most fish passed at night, so the day spill effectiveness results represent passage conditions of relatively few fish.

The spill effectiveness during the summer was greater during the 30% day spill condition than during the 60% night spill and all ratios were greater than 1:1. The spill effectiveness in each block ranged from 2.6:1 to 3.0:1 during day spill and from 1.1:1 to 1.6:1 during night spill.

Introduction

A Supplemental Biological Opinion issued by the National Marine Fisheries Service (NMFS) recommended that spill volumes at dams on the Columbia and Snake rivers be maximized to increase juvenile salmonid (*Oncorhynchus* spp.) survival without exceeding the current total dissolved gas (TDG) cap levels or other project-specific limitations (NMFS 1998). At John Day Dam (JDA), recent completion of spillway flow deflectors has increased the potential for greater spill volumes at this project while remaining under the TDG cap. Thus, the NMFS recommended that 24-h spill studies should be initiated at JDA in 1999 as a means of enhancing fish passage efficiency (NMFS 1998). At JDA, juvenile salmonids pass the dam via non-turbine routes through either the spillway or the juvenile-fish-bypass system (JBS) after being diverted from turbine passage by submerged traveling screens.

Generally, a 1:1 relationship is assumed between the percentage of total fish that pass through the spillway and the percentage of total river flow passing through the spillway (Whitney et al. 1997). However, studies at John Day Dam indicate the spill effectiveness is greater than 1:1. Whitney et al. (1997), based on hydroacoustic evaluations, calculated that spill volumes of 36 and 73% of total river flow were needed to achieve 80% fish passage efficiency for spring and summer migrants, respectively. Moreover, in a study based on radio telemetry at John Day Dam in 1999, Hansel et al. (2000) reported spill effectiveness values of 1.1:1 to 2.4:1, depending on species and spill treatment.

In 1999 and 2000, the U.S. Army Corps of Engineers (COE) contracted with the U.S. Geological Survey to determine fish and spill passage efficiencies (FPE, SPE) at JDA using radio telemetry during 12- and 24-h spill treatments. In 2000 the proposed 12-h spill treatment consisted of 0% “day” spill from 0700-1859 h and 60% “night” spill from 1900-0659 h, and the proposed 24-h spill treatment consisted of 30% day spill and 60% night spill. Each treatment was implemented for three consecutive days within a 6-day block and was repeated for four blocks in the spring and four blocks in the summer.

Our specific objectives were to: 1) determine the proportion of radio-tagged juvenile steelhead (*O. mykiss*) and yearling and subyearling chinook salmon (*O. tshawytscha*) passing through the spillway and powerhouse (both guided and unguided) at JDA during the two spill treatments, and 2) obtain information on the behavior of radio-tagged fish in the near-dam area prior to passage. The study was divided into spring (juvenile steelhead and yearling chinook salmon migration) and summer (subyearling chinook salmon migration) periods.

Methods

Study Site

John Day Dam is located on the Columbia River at river km 347 (Figure 1). The dam consists of a single powerhouse of 16 turbine units, 4 skeleton bays, and a single spillway of 20 tainter gates. Both powerhouse and spillway are perpendicular to river flow. A navigation lock is located at the north end of the dam. Hourly powerhouse and spillway discharge data were obtained from the COE (2000).

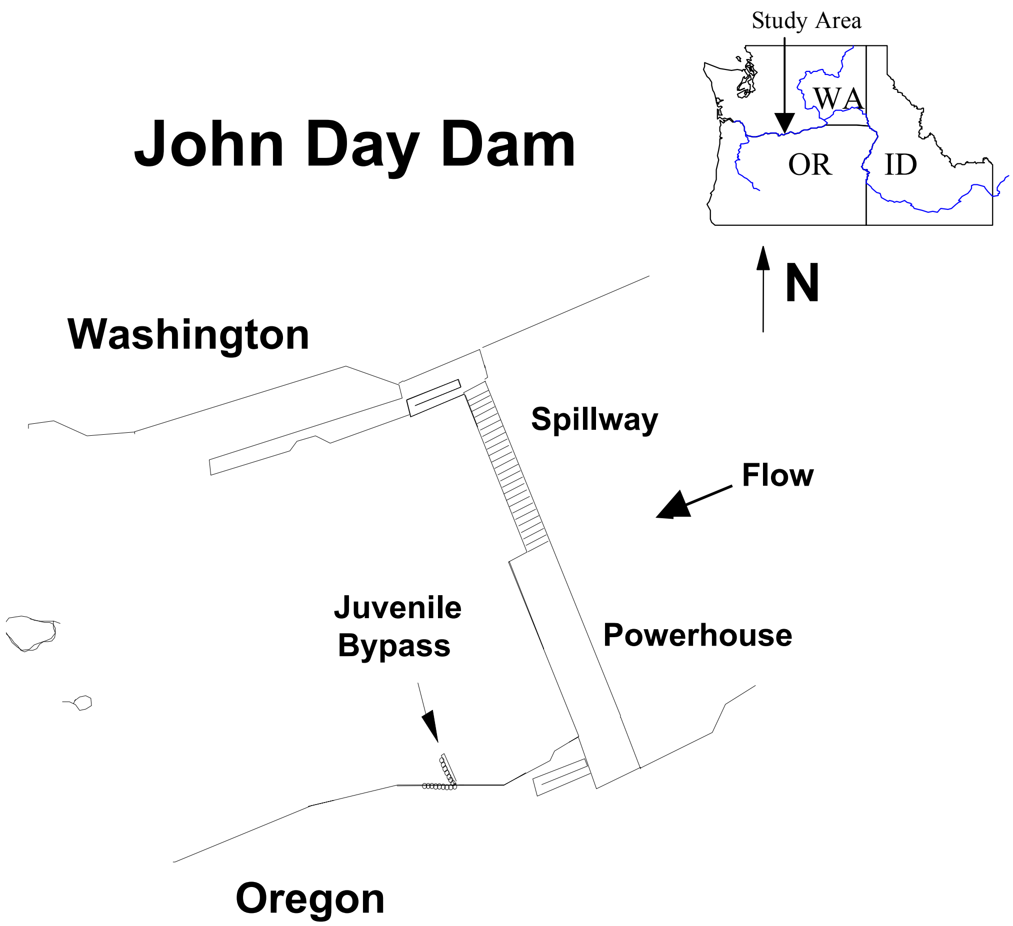

Figure 1. Drawing of the John Day Dam study site at Columbia River km 347. Juvenile steelhead and yearling chinook salmon were released 23 km upriver at Rock Creek, WA, in the north side of the river channel.

Radio Transmitters and Telemetry Receiving Equipment

Pulse-coded transmitters were gastrically implanted in juvenile steelhead and yearling and subyearling chinook salmon allowing each individual fish to be recognized. For subyearling chinook salmon, non-coded transmitters operating at frequencies between 150.320 and 150.580 MHz pulsing at rates of 30 or 50 pulses per minute were used in combination to allow each individual fish to be recognized. Three sizes of transmitters were used to accommodate the different sizes of the fish. Transmitters implanted in steelhead were 8.2 mm (diameter) x 18.9 mm and weighed 1.8 g in air and 1.0 g inwater, whereas transmitters implanted in yearling chinook salmon were 7.3 mm (diameter) x 18 mm and weighed 1.4 g in air and 0.8 g in water (Lotek Wireless, Newmarket, Ontario, Canada[1]). The transmitters used in subyearling chinook salmon were 7.0 mm (diameter) x 17.0 mm and weighed 1.0 g in air and 0.7 g in water (Advanced Telemetry Systems, Isanti, Minnesota, USA).

Four-element Yagi (aerial) antennas were positioned along the periphery of the forebay to detect fish within about 100 m of the dam face, defined as the near-dam area. Each antenna monitored an area in front of a pair of turbine units or spill bays. These antennas were connected to SRX-400 receivers (Lotek Wireless), which recorded the telemetry data, following the methods of Hensleigh et al. (1999). Additional aerial antennas were used to monitor the tailrace and area near the boundary of the forebay boat-restricted zone. The SRX-400 receivers were configured to scan all antennas combined (master antenna) until a signal was received, and then cycle through individual aerial antennas (auxiliary antennas) to determine a more precise location of the transmitter. Underwater dipole antennas were used specifically to monitor radio-tagged juvenile salmonids within about 10 m of each turbine unit or tainter gate, and within the juvenile fish bypass system (Beeman et al., In Press). Underwater dipole antennas at the powerhouse were placed at elevations 247 ft above mean sea level (MSL) and 227 ft MSL (approximately 18 ft and 28 ft deep at normal pool elevation 265 ft MSL) in the center of the "B" slot above the trash racks of each turbine unit. At the spillway, four

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1 Use of trade names does not imply endorsement by the U. S. Government

underwater dipole antennas were used to monitor passage at each spill bay. Two antennas were installed along each of the two pier noses encompassing each spill bay at elevations 227 and 247 ft MSL (as at the powerhouse); each antenna was pointed toward the center of the spill bay. Inputs from all underwater antennas, other than those at the JBS, were monitored by a single Multiprotocol Integrated Telemetry Acquisition System (MITAS; Grant Systems Engineering, King City, Ontario, Canada). The MITAS system is a PC-based monitoring system. The two underwater antennas installed in the JBS (coaxial cables with the distal 23 cm of shielding removed) were attached to a Digital Spectrum Processor (Lotek Wireless) in tandem with an SRX-400 receiver; the inputs from these antennas were combined to provide a larger detection area.

Fish Tagging, Handling, and Release

Juvenile steelhead and yearling and subyearling chinook salmon to be implanted with radio transmitters were obtained from the juvenile collection and bypass facility operated by the Pacific States Marine Fisheries Commission at JDA. Fish to be implanted were held 12 to 24 h prior to tagging. Fish were considered suitable for tagging if they were free of injuries, severe descaling, external signs of gas bubble trauma, or other abnormalities. Transmitters were gastrically implanted in both species following the methods of Martinelli et al. (1998).

Following tagging, fish were held for 20 to 28 hours in 121-L containers with three to four fish held in each container. The fish were checked for mortalities and regurgitated tags after the holding period. The containers were then loaded into a boat and the boat was towed to the boat ramp at Rock Creek, 23 km upstream of JDA. The fish were released from the boat in the northern half of the Columbia River near the mouth of Rock Creek. These releases coincided with four 6-day blocks at JDA that consisted of each spill treatment for a period of three consecutive days. Fish releases were timed to coincide with the peak passage of each species, though the proposed spill conditions continued through the spring and summer migration of juvenile salmonids. Approximately 240 fish were released per week (120 per spill treatment) with approximately equal numbers of juvenile steelhead and yearling chinook salmon in each spring release. During the summer, approximately 130 subyearling chinook were released per week (65 per spill treatment). In order to disperse the arrival of radio-tagged fish at JDA over the diel period, tagged fish were divided equally between day and night releases that occurred generally at 0800 and 2000 h.

Data Management and Analysis

Data from telemetry receivers and MITAS were typically downloaded every other day and were imported into SAS software package for personal computers (SAS 1999) for subsequent proofing and analyses. Proofing eliminated non-valid records including background noise, single records of a particular channel and code, records that were collected prior to the known release date and time, and records known to have been from fish that were consumed by avian predators. Generally, the minimum number of records required to consider detection of a radio-tagged fish valid was a combination of two master antenna detections and one auxiliary antenna detection, or three master antenna detections, within about 1 to 2 min of each other.

The location and time an individual fish was first detected by receivers on the dam face was considered the route and time of entrance into the near-dam area. Similarly, the last detection of an individual fish on the receivers on the dam face was considered the route and time of passage through the dam. However, radio-tagged fish were often detected on multiple auxiliary antennas where zones of coverage overlapped, making data reduction necessary. Fish detected by more than one aerial auxiliary antenna within a two-minute period at the time of passage were assigned to a single passage location corresponding to the antenna where the highest strength signal was recorded and all other records were excluded. A 2-minute interval was chosen because it coincided approximately with the upper boundary of time needed to complete a scan cycle if several fish were present at any given time. Manual tracking on the dams has verified that the last detection by the fixed-receiving stations is typically a good estimate of passage route (Sheer et al. 1997; Holmberg et al. 1998; Hensleigh et al. 1999). The approach and passage patterns among the various near-dam areas were compared between spill treatments using a Chi-square test. In this test and others throughout this report, results were considered statistically significant when $P \leq 0.05$.

Residence time in the near-dam area, defined as the amount of time between the first and last detections in the forebay, was calculated for each radio-tagged fish detected in the near-dam forebay area. These residence times are a minimum estimate of the actual time that radio-tagged fish spent in the near-dam area because it is possible that a fish may have been in the near-dam area for an unknown amount of time before their first detection and following their last detection. Median forebay residence times during a particular spill condition were compared statistically to those arriving under other spill conditions within and between species using Kruskal-Wallis tests.

Fish passage efficiency was determined as the proportion of the total number of radio-tagged juvenile steelhead or chinook salmon passing the dam that passed by non-turbine routes (i.e., through the spillway and the JBS) multiplied by 100%. Similarly, SPE was calculated as the proportion of the total number of radio-tagged juvenile steelhead or chinook salmon passing the dam that passed through the spillway, multiplied by 100%. Spill effectiveness is calculated as the SPE proportion divided by the proportion of total dam discharge being spilled. This index was used to help identify potential relations between spill treatments, FPE or SPE estimates, and juvenile salmonid passage behavior.

Statistical analyses comparing the passage indices calculated for each treatment were completed using logistic regression adjusted for block effects (if present). Logistic regression estimates the probability of an event (e.g., passing via a non-turbine route) after converting the dependent variable to a logit (the natural log of the event occurring or not). An “odds ratio” is calculated from the odds of the dependent variable occurring in each of the two classes (i.e., 12-h or 24-h spill), and from this, the relative importance of the independent variables in terms of the effects on the dependent variable is estimated (similar to a beta weight in a least-squares regression). For example, if the hypothetical odds ratio between FPE during 12-h and 24-h spill is 5, the probability of passing via a non-turbine route during the 12-h treatment is 5 times greater than during the 24-h treatment.

Logistic regression is not based on assumptions of linearity, normality, or homoscedasticity. The number of blocks used for analysis was determined *a-priori* by the study design (two 3-d treatments in four 6-d blocks during both the spring and summer study periods). Overdispersion was assessed within each species by examining the models' residual deviance divided by residual degrees of freedom. Ninety-five percent profile likelihood confidence intervals were calculated for the overall odds ratio. Single seasonal estimates of the passage indices with 95% profile likelihood confidence intervals based on the binomial model for each treatment were calculated when there was no evidence of overdispersion or block effects. Although little evidence of overdispersion was present in the data, the data set was small (3 degrees of freedom), making assessment of the most appropriate model (binomial vs. quasilikelihood) difficult. In small studies, the quasilikelihood model is particularly conservative due to the low degrees of freedom, whereas the confidence intervals from the binomial model are more liberal.

The detection efficiencies of the telemetry arrays at the powerhouse and spillway were calculated using a "double array" system as described by Lowther and Skalski (1997). This method is based on the number of fish detected and undetected at each of two arrays to determine the detection probability of each array, and ultimately, the combination of the two arrays (Jim Lady, University of Washington, personal communication). In a double-array system, the detection probability of one array is calculated as:

$P1 = 11/(11+01)$ Equation 1

where 11 denotes fish that were detected on both arrays and 01 denotes those not detected on the first array, but detected on the second.

The detection probability of the second array is calculated as:

$P2 = 11/(11+10)$ Equation 2

where 10 denotes those detected on the first array, but not the second. The overall detection probability of the combined arrays is calculated as:

$P12 = 1-((1-P1)(1-P2))$ Equation 3.

The numbers of fish detected at each array are then adjusted by dividing the numbers detected at an array by the results of Equation 3 prior to calculation of the passage indices. Thus, the adjusted FPE would be calculated as:

$FPE_{adj} = ((N_{sp} / P12_{spillway}) + (N_{sl} / P12_{sluiceway}))/ ((N_{ph} / P12_{powerhouse}) + (N_{sp} / P12_{spillway}) + (N_{sl} / P12_{sluiceway}))$ Equation 4,

where N_{sp} N_{sl} and N_{ph} are the numbers of fish detected passing the spillway, sluiceway and powerhouse, respectively. For the purpose of this exercise, the forebay aerial and underwater arrays at the powerhouse and spillway were each considered as a single upstream array (*P1*) for that route of passage and the aerial antennas in the tailrace of each area were considered the downstream arrays (*P2*) during the spring study period. Due to the lack of a tailrace aerial detection system during the summer study period (see Results from the Summer Study Period), the detection efficiencies were calculated with the forebay aerial arrays as *P1* and the forebay underwater arrays as *P2*. There was only one antenna system installed in the JBS (two combined inputs described above), so the detection efficiency associated with this route of passage could not be determined using this method.

Results from the Spring Study Period

Dam Operations

Data were collected during four 6-d treatment blocks between 01 May and 24 May (Appendix A). The average spill treatments were similar to those proposed during the day condition and the average spill during the night condition was slightly less than planned during the four blocks of study (Table 1; hourly discharge data are in Appendix B). During these blocks, night spill averaged 50.0% during the 12-h treatment (proposed 0% day spill, 60% night spill) and 53.8% during the 24-h treatment (proposed 30% day spill, 60% night spill) rather than the 60% as planned; the overall night spill was 51.9%. Mean percent spill during the day was near either 0 or 30% as proposed (Table 1). Throughout the remainder of this report, the two spill treatments will be referred to as the 12-h and 24-h treatments.

Mean hourly total discharge ranged from 170.9 thousand cubic feet per second (kcfs) to 359.5 kcfs during the study (Table 1). The average daytime discharges were 245.0 kcfs (range 170.9 to 298.0 kcfs) during the 12-h treatment and 272.5 kcfs (range 208.9 to 365.8 kcfs) during the 24-h treatment. Average night discharges during the 12-h and 24-h treatments were 280.7 kcfs (range 199.6 to 359.5 kcfs) and 266.6 kcfs (range 211.8 to 342.7 kcfs). Differences in day and night condition discharges between treatments within a block were generally less than 17 kcfs in blocks 2 thru 4, but there was a 65.8 kcfs difference in the day discharges of Block 4. Notable differences were also present during Block 1. In Block 1, the daytime discharge during the 24-h treatment was 36.2 kcfs greater than during the 12-h treatment and at night the trend was reversed, with the discharge during the 24-h treatment 33.1 kcfs less than during the 12-h treatment. The average night discharge during the 12-h treatment of Block 1(312.4 kcfs) was also the greatest of any 12-h period during the study. In addition, the average percent spill at night during the 12-h treatment of Block 1 was the lowest recorded during the study (42.7%). Figure 2 illustrates the project discharge for both the spring and summer study periods.

Table 1. Mean hourly percentages of total discharge spilled and mean hourly total discharge (kcfs) at John Day Dam during four 6-d blocks, 02 May through 26 May 2000. Proposed spill treatments consisted of one 3-d treatment of no "day" spill (0700– 1859 h) and 60% "night" spill (1900-0659 h; 12-h treatment) followed by a second 3-d treatment of 30% day spill and 60% night spill (24-h treatment).

		Hourly percent spill					
		0700-1859			1900-0659		
Block	Spill Treatment	Mean	Std	Range	Mean	Std	Range
1	12 h	0.2	0.8	0.0- 4.4	42.7	5.6	34.3-55.7
	24 h	30.1	0.6	28.9-31.9	50.2	4.6	40.7-59.8
2	12 h	0.0	0.1	0.0- 0.4	51.6	6.0	38.9-60.8
	24 h	30.3	0.8	28.9-32.2	54.8	4.1	46.3-60.8
3	12 h	0.0	0.1	0.0- 0.6	53.4	11.5	7.0-72.5
	24 h	30.1	0.8	29.1-31.4	55.7	6.7	31.2-60.7
4	12 h	0.2	0.8	0.0- 4.2	52.2	12.5	4.2-64.7
	24 h	30.3	1.2	29.0-34.2	54.6	7.9	30.1-62.3

		Hourly total discharge					
		0700-1859			1900-0659		
Block	Spill Treatment	Mean	Std	Range	Mean	Std	Range
1	12 h	262.6	13.8	217.7-282.0	312.4	28.4	252.6-359.5
	24 h	298.8	32.5	256.7-365.8	279.3	27.1	226.4-342.7
2	12 h	265.1	17.1	215.8-298.0	270.9	30.9	206.4-314.6
	24 h	261.2	33.4	219.1-318.1	263.2	21.5	228.0-323.2
3	12 h	234.8	18.7	201.2-259.0	266.0	38.5	199.6-321.6
	24 h	246.9	17.3	208.9-272.9	249.2	24.5	211.8-313.4
4	12 h	217.4	25.1	170.9-278.6	273.5	28.5	218.8-314.2
	24 h	283.2	23.0	236.2-322.9	274.8	27.4	227.0-336.7

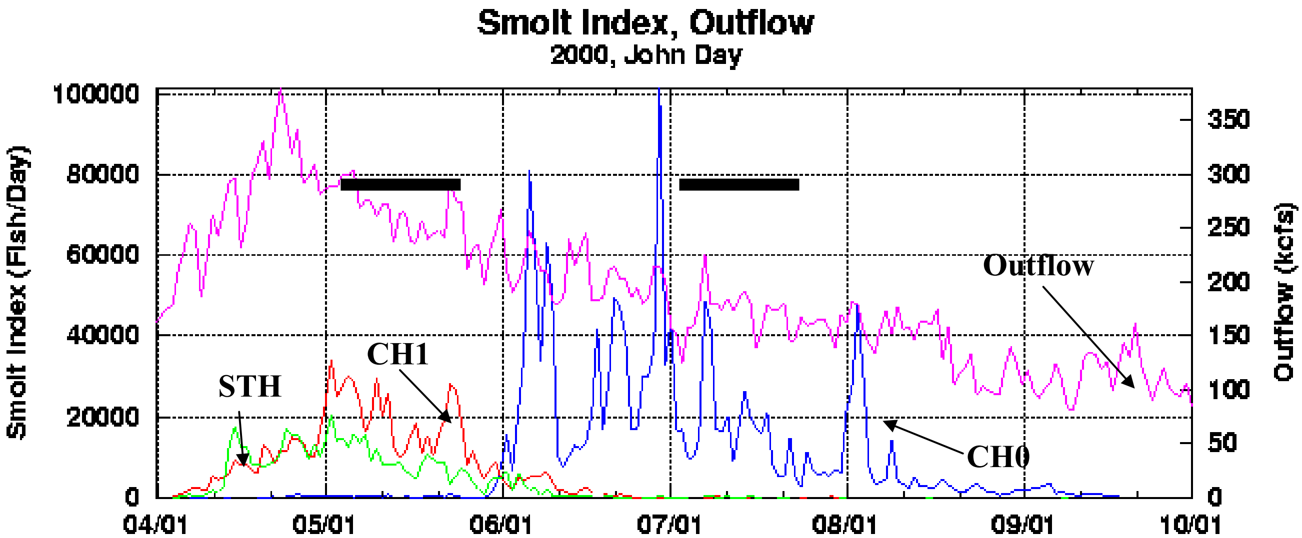

Figure 2. John Day Dam Smolt Index and project discharge (thousand cubic feet per second; kcfs) during 2000. Species depicted include wild and hatchery steelhead (STH), yearling chinook salmon (CH1) and subyearling chinook salmon (CH0). The black bars designate spring (STH and CH1) and summer (CH0) study periods. Original graphic was from the University of Washington's Data Access in Real Time web site at http://www.cqs.washington.edu/dart/pass.html.

Fish Released and Detected

From 01 May through 24 May, we radio-tagged and released 487 juvenile steelhead and 484 yearling chinook salmon 23 km above John Day Dam (Table 2; Appendices C1 and C2). The tagged juvenile steelhead had a mean fork length of 220 mm (range 103 to 285 mm) and mean weight of 89 g (range 44 to 200 g). Yearling chinook salmon selected for tagging had a mean fork length of 176 mm (range 128 to 225 mm) and a mean weight of 55 g (range 21 to 125 g). The mean fork lengths measured by the Pacific States Marine Fisheries Commission from sub samples of the fish collected in the JBS during the study period were 216 mm for juvenile steelhead and 159 mm for yearling chinook salmon. The tag-weight-to-body-weight ratios of juvenile steelhead and yearling chinook salmon were 2.0% (range 0.9 to 4.1%) and 2.5% (range 1.1 to 6.7%), respectively.

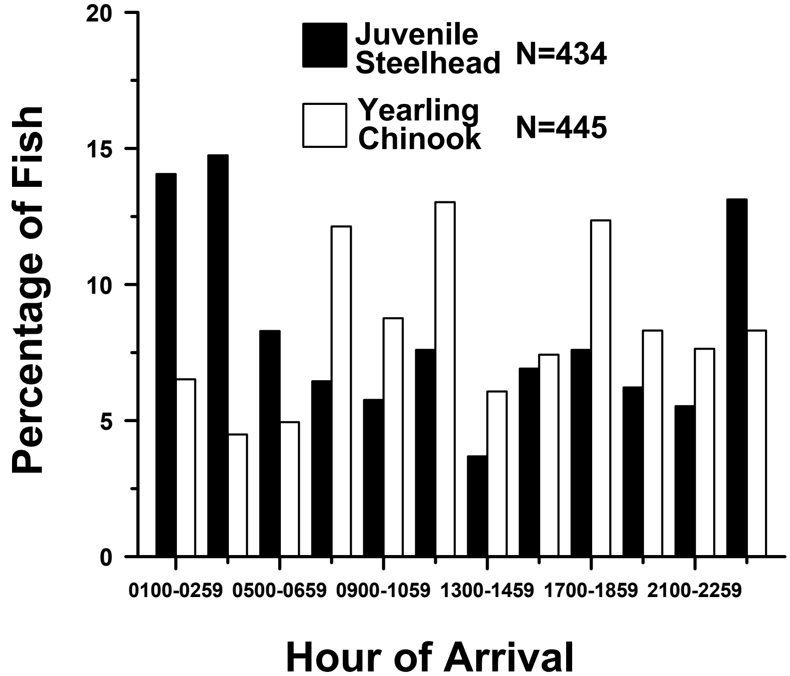

Figure 3. Hour of arrival (2-h intervals) of radio-tagged juvenile steelhead and yearling chinook salmon at John Day Dam during spring 2000.

Table 2. Number of radio-tagged juvenile steelhead and yearling chinook salmon released 23 km above John Day Dam (JDA) and the percent of fish detected by fixed receiving stations at JDA, spring 2000. Paired release dates correspond to one of two spill treatments within four blocks.

Release date	Juvenile steelhead		Yearling chinook		Total	
	Number released	Percent detected	Number released	Percent detected	Number released	Percent detected
05/01-05/03	51	92.2	55	90.9	106	91.5
05/04-05/06	58	94.8	61	96.7	119	95.8
05/07-05/09	58	94.8	53	92.5	111	93.7
05/10-05/12	68	95.6	62	96.8	130	96.2
05/13-05/15	49	87.8	66	92.4	115	90.4
05/16-05/18	71	93.0	57	94.7	128	93.8
05/19-05/21	76	86.8	57	98.2	133	90.4
05/22-05/24	56	89.3	73	100	129	95.4
Overall	487	91.8	484	95.5	971	93.6

Over the course of the study, receivers at the dam detected 87 to 96% of the juvenile steelhead and 91 to 100% of the yearling chinook salmon from each release (Table 2). Overall, 94% of all fish released were detected at the dam.

Travel Time, Arrival Time, and Approach Pattern

Median travel time from the release site to the near-dam forebay of JDA was 23.1 h for juvenile steelhead and 15.6 h for yearling chinook salmon. The hour of arrival at JDA for both species was widely dispersed throughout the diel period, but the arrival time distribution of juvenile steelhead indicates proportionally more fish arrived during the night conditions than in the day conditions and the arrival distribution of yearling chinook salmon was slightly greater during the day conditions (Figure 3).

The percentages of first detections at the spillway and powerhouse among blocks during each treatment were similar in data from juvenile steelhead, but were quite different in data from yearling chinook salmon. The percentages of yearling chinook salmon first detected (i.e., approaching the dam within approximately 100 m) at the spillway and powerhouse during each treatment were similar in blocks 2, 3 and 4, but during Block 1 many more fish were first detected at the powerhouse during the 12-h treatment than during the 24-h treatment and fewer were first detected at the spillway (Figure 4).

Behavior in the Near-Dam Forebay

The median residence times of fish arriving during the day depended on their time of arrival, but those arriving at night passed quickly regardless of their arrival time. Those that arrived shortly after the switch from night to day spill conditions had the longest residence times and those that arrived shortly before the switch from day to night spill conditions had the shortest residence times, indicating a passage of a large proportion of fish was delayed until the night. For example, juvenile steelhead arriving during the 12-h condition between 0700 and 1059 had median residence time of 14.5 h, the median residence time of those arriving between 1100 and 1459 was 11.0 h, and the median residence time of those arriving between 1500 and 1859 was 6.5 h (Table 3). This pattern was evident in data from both species and both spill treatments.

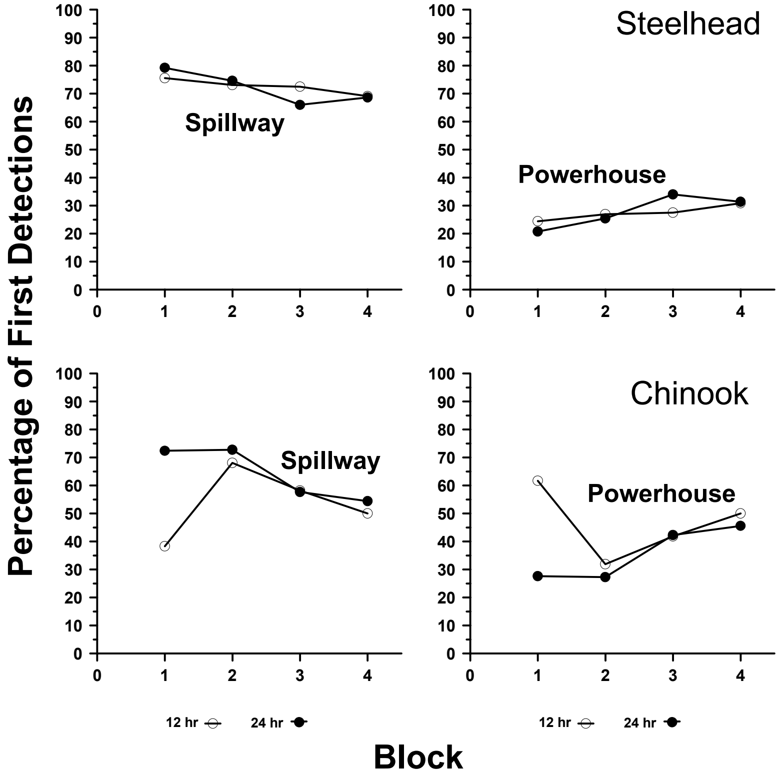

Figure 4. Distribution of first detections of juvenile steelhead and yearling chinook salmon between spillway and powerhouse radio-telemetry receivers in the John Day Dam near-dam forebay during 12-h and 24-h spill treatments, spring 2000. Blocks were four 6-d intervals from 02 May through 26 May. Sample sizes: steelhead 12 h = 40-68, 24 h = 40-63; chinook 12 h = 47-60, 24 h = 52-68.

The median travel times of fish arriving at night did not appear to be affected by their arrival time. However, the longest median residence times of fish arriving at night were of those arriving shortly before the switch from night to day spill conditions, as some did not pass before the spill was reduced to 30% or 0%, resulting in extended residence times in fish that arrived during the night. Yearling chinook salmon arriving in the day during the 24-h treatment had shorter median residence times than those arriving in the day during the 12-h treatment, but little difference was present in residence times of juvenile steelhead arriving in the day during the two treatments, because few juvenile steelhead passed the dam during the day.

Table 3. Median forebay residence times (h) of radio-tagged juvenile steelhead and yearling chinook salmon by time of arrival and spill treatment at John Day Dam, spring 2000. Sample sizes are shown in parentheses.

Time of arrival	Spill period	Juvenile steelhead Spill treatment 12 h	24 h	Yearling chinook Spill treatment 12 h	24 h
0700-1059	Day	14.5 (20)	14.7 (28)	13.2 (42)	1.7 (47)
1100-1459	Day	11.0 (23)	9.3 (24)	9.2 (39)	2.9 (45)
1500-1859	Day	6.5 (23)	4.8 (36)	4.5 (34)	2.4 (53)
1900-2259	Night	0.8 (20)	1.0 (31)	1.2 (31)	0.7 (40)
2300-0259	Night	0.4 (66)	0.4 (50)	0.4 (36)	0.3 (30)
0300-0659	Night	7.7 (50)	0.7 (44)	1.3 (23)	3.2 (17)

The forebay residence times of fish of both species arriving at night were shorter than those that arrived during the day. No significant among-block effects in residence times were evident in data from juvenile steelhead (Kruskal-Wallis test, df = 3, all *P*s > 0.2), but a significant difference among blocks was present in data from yearling chinook salmon arriving in the day condition during the 12-h treatment (Kruskal-Wallis test, df = 3, $P < 0.006$; Figure 5). The overall (all blocks pooled) median residence times of juvenile steelhead arriving during the day were 10.9 h (12-h treatment) and 9.4 h (24-h treatment), whereas those arriving at night were 0.6 and 0.7 h during the 12-h and 24-h treatments, respectively. There were no significant differences between median residence times of juvenile steelhead arriving in the day or during the night during the two treatments (Friedman's test, df = 1, day $P > 0.3$, night $P > 0.9$), though none would be expected at night since the night conditions were similar in each treatment. Median residence times of yearling chinook salmon that arrived during the 12-h treatment ranged from 4.6 to 12.3 h for those arriving during the day and from 0.3 to 1.1 h for those arriving at night. Calculating a single point estimate for all blocks of yearling chinook salmon arriving during the day was not appropriate due to the significant differences between blocks described above. The range of yearling chinook salmon median residence times during the 24-h treatment was 1.4 to 3.2 h if arriving during the day and 0.5 to 0.9 h if arriving at night. The overall (all blocks pooled) median residence times of yearling chinook salmon arriving during the night

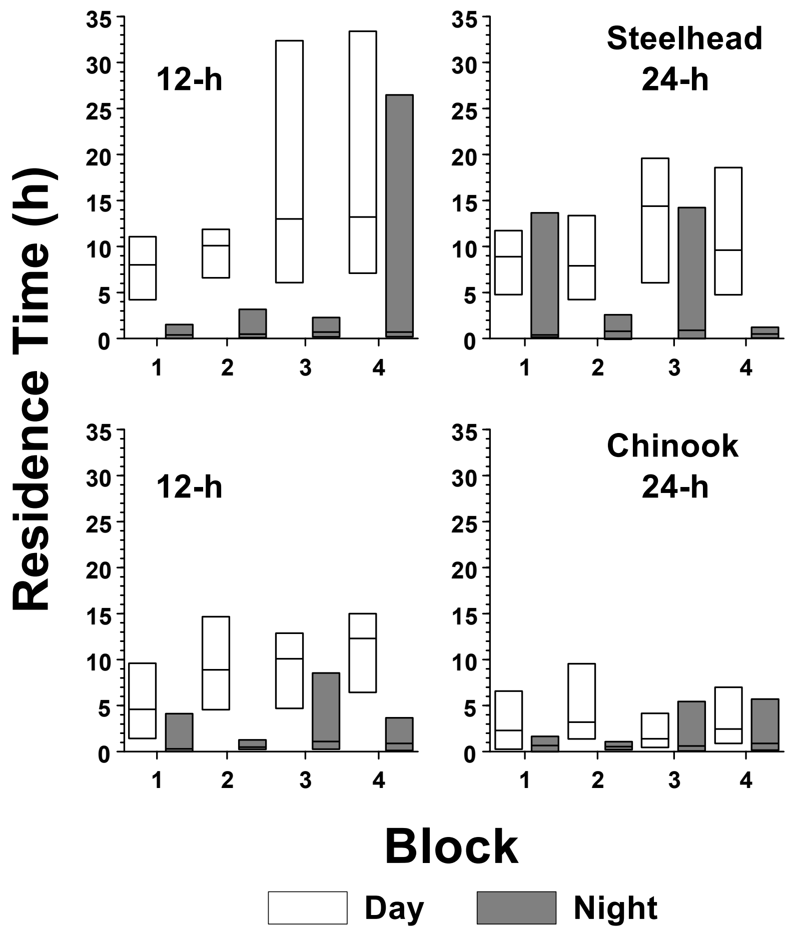

Figure 5. Twenty-fifth, 50th (median), and 75th percentiles (lower, middle, and upper horizontal lines on bars) of radio-tagged juvenile steelhead and yearling chinook salmon forebay residence times (h) by diel time of arrival during 12- and 24-h spill treatments at John Day Dam, spring 2000. Day and night refer to two, 12-h operational spill periods 0700-1859 h and 1900-0659 h. Sample sizes: steelhead day = 11-31, night = 25-46; chinook day = 22-57, night = 10-27.

were 2.4 h (12-h treatment) and 0.6 h (24-h treatment). The median residence times of yearling chinook salmon arriving during the day were significantly longer during the 12-h treatment compared to the 24-h treatment (Friedman's test, df = 1, $P < 0.0001$), but no significant differences were present between those arriving at night (Friedman's test, df = 1, $P > 0.9$).

Several species-specific differences in median residence times were evident. The difference in residence times of yearling chinook salmon arriving in the day during the two spill treatments was greater than that of juvenile steelhead and the median residence times of yearling chinook salmon were generally shorter than those of juvenile steelhead.

The residence times of radio-tagged juvenile steelhead were not related to fish size (Figure 6). Juvenile steelhead ≤ 200 mm FL (N = 12; about the size of juvenile wild steelhead at John Day Dam) passing during the day did have shorter forebay residence times (median = 4.8 h) than fish greater than 200 mm FL passing during this time (9.6 h; N = 76), but no visible trend in the data exists.

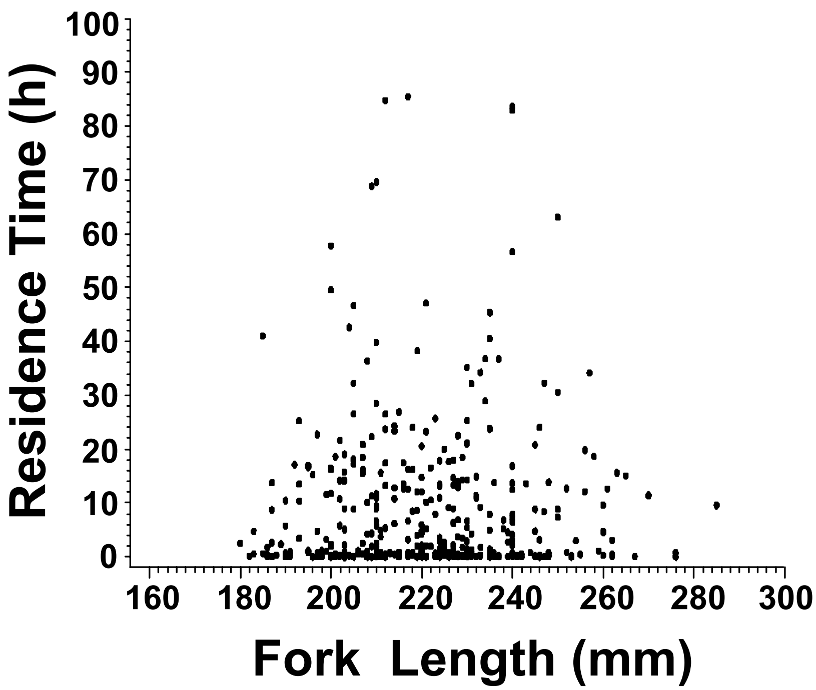

Figure 6. Forebay residence times of radio-tagged juvenile steelhead arriving at John Day Dam by fork length, 02 May through 31 May 2000.

Both juvenile steelhead and yearling chinook salmon delaying at the dam moved from one end of the dam to the other. Some fish moved out of detection range repeatedly and the amount of time fish spent out of the near-dam area varied greatly.

General Time and Route of Passage

The time of day that radio-tagged fish passed JDA was affected by release times, species-specific travel times from the release site to the dam and species-specific responses to spill conditions at the time of their arrival (Figure 7). Overall, the passage of both juvenile steelhead and yearling chinook salmon was about equally divided between the treatments, with 47% of each species passing during the 12-h treatment. Most fish of both species passed the dam at night, though daytime passage, particularly of yearling chinook salmon, was also present. Of the juvenile steelhead passing during the 12-h treatment, 4% passed during the day and 96% passed during the night. The addition of 30% day spill had little effect on day passage of juvenile steelhead; 8% of juvenile steelhead passing during the 24-h treatment passed during the day and 92% passed at night. Yearling chinook salmon passage during the day was more influenced by

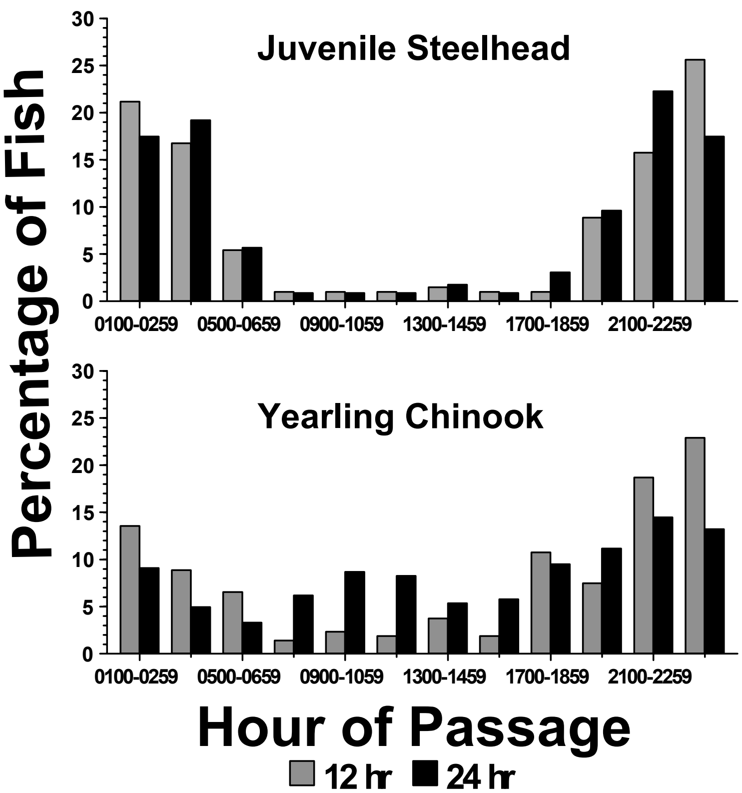

Figure 7. Hour of arrival (2-h intervals) of radio-tagged juvenile steelhead and yearling chinook salmon passage during 12-h and 24-h spill treatments at John Day Dam, 02 May through 26 May 2000. Sample size: juvenile steelhead 12 h = 203, 24 h = 229; yearling chinook 12 h = 214, 24 h = 242.

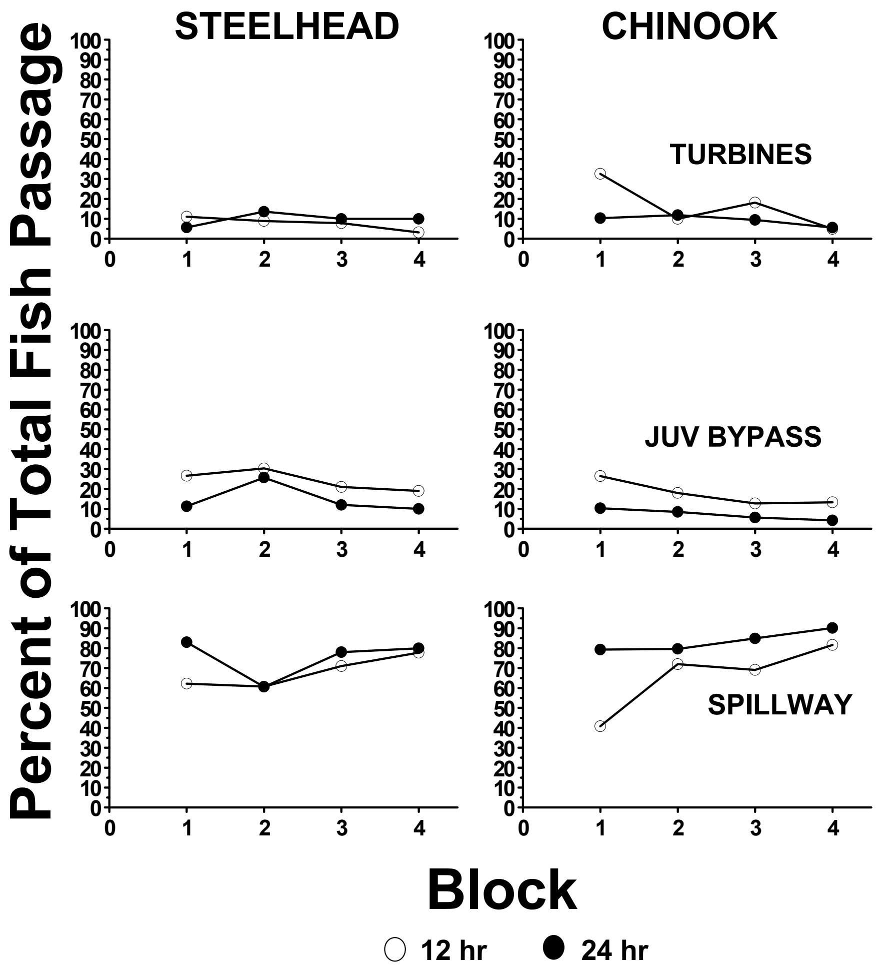

Figure 8. Percentage of radio-tagged juvenile steelhead and yearling chinook salmon passing through the turbines, juvenile fish bypass, and spillway during two spill treatments at John Day Dam, spring 2000. Blocks are four 6-day intervals from 02 May through 26 May. Spill treatments 12 hour spill, 24 hour spill. Sample sizes: steelhead 12 hour=38-63, 24 hour=53-66; chinook 12 hour= 49-60. 24 hour=53-71.

the 24-h treatment than juvenile steelhead passage. An average of 14% of the yearling chinook salmon passing during the 12-h treatment passed the dam in the day and 86% passed at night. During the 24-h treatment, 44% of the passing yearling chinook salmon did so during the day and 56% passed at night.

The proportions of juvenile steelhead passing via the turbines, juvenile bypass and spillway in each block were more consistent than the yearling chinook salmon, particularly in Block 1 (Figure 8; Appendices D and E). The differences between yearling chinook spillway passage during 12-h and 24-h treatments in Block 1 were larger than in any other block, with 41% passing via the spillway during the 12-h treatment and 79% passing the spillway during the

24-h treatment. Turbine passage of yearling chinook salmon was also unusual in Block 1, with 33% passing via this route during the 12-h treatment in this block, compared to 5 to 18% in the other blocks. Turbine passage during the 24-h treatment in Block 1 (10%) was similar to that in the other blocks, which ranged from 6 to 12%. The passage proportions of juvenile steelhead show a similar pattern of differences between the treatments during Block 1, though the magnitudes of the differences are reduced. For example, the proportion of juvenile steelhead passage via the spillway during the 12-h treatment in Block 1was 62%, and 83% passed during the 24-h treatment, a 21% difference. Differences between treatments in the other blocks ranged from 2.3 to 7.0%. The passage of juvenile steelhead and yearling chinook salmon through the turbines and JBS in periods of no day spill during the 12-h treatment were about equal, but very few fish passing during the 12-h treatment passed under this condition (9 of 202 steelhead and 29 of 214 chinook; Figure 9). Juvenile steelhead passage during day spill was mostly through the spillway (68%; 13 of 19), with 26% (N = 5) through the JBS and 5% (N = 1) through the turbines, but few juvenile steelhead passed during this condition. Most (92%; 98 of 106) yearling chinook salmon passing the dam during periods of day spill did so via the spillway, with 3% (N = 2) through the JBS and 5% (N = 5) through the turbines.

The spillway was the primary passage location of both species during the night. Spillway passage of juvenile steelhead at night was 72% (N = 139) during the 12-h treatment and 78% (N = 161) during the 24-h treatment. Their passage through the JBS and turbines at night was 23% (N = 44) and 5% (N = 10) during the 12-h treatment and 14% (N = 30) and 9% (N = 19) during the 24-h treatment. Data from yearling chinook salmon were generally similar, though turbine passage of yearling chinook salmon was greater than that of juvenile steelhead. During the 12-h treatment, 78% (N = 144), 11% (N = 20), and 11% (N = 21) of the yearling chinook salmon passing at night passed via the spillway, JBS and turbines, respectively and during the 24-h treatment 78% (N = 105), 10% (N = 14) and 12% (N = 6) passed through these routes. Night passage locations of yearling chinook salmon during the 12 and 24-h treatments were within one percent of one another. Day passage of both species during the 12-h treatment was approximately 60% through the JBS and 40% through the turbines.

Fish and Spill Passage Efficiency

No significant block effect (Chi Square test, df = 3, $P > 0.4$) or treatment effect (Chi Square test, df = 1, $P > 0.5$) was present in FPE estimates of juvenile steelhead, indicating that the FPE estimates were consistent among blocks and there was no significant difference between FPE estimates during the 12-h and 24-h treatments (Table 4; Figure 10). Point estimates (and 95% confidence intervals) of juvenile steelhead FPE (pooling blocks 1thru 4) were 93.0% (89.0 to 96.0%) during the 12-h treatment and 91.3% (87.2 to 94.5%) during the 24-h treatment.

Inconsistencies in the FPE estimates of yearling chinook salmon among blocks affected the statistical analyses used to compare the FPE estimates of the two treatments. The yearling chinook salmon FPE during the 12-h treatment in Block 1 (67%) was much lower than the estimates in the other blocks (range 84 to 95%), suggesting that Block 1 data should perhaps be omitted from this analysis (Figure 10). If the data from Block 1 are omitted, no significant block or treatment effects are present in FPE estimates of yearling chinook salmon (block effect Chi Square test df = 3, P > 0.09; treatment effect Chi Square test df = 1, P > 0.4; Table 4). The point estimates (and 95% confidence intervals) of FPE from this analysis (pooling blocks 2 thru 4) were 89.7% (84.4 to 93.7%) during the 12-h treatment and 91.8% (87.2 to 95.2%) during the 24-h treatment. The outcome of tests comparing FPE with all blocks included is also presented in Table 4. It indicates a statistically significant block effect (Chi Square test, df = 3, $P < 0.01$) and a significant treatment effect after controlling for the block effect (Chi Square test, df = 1, $P < 0.02$). Point estimates (and 95% confidence intervals) of FPE with the four blocks pooled were 84.6% (74.8 to 91.8%) during the 12-h treatment and 91.3% (83.7 to 96.2%) during the 24-h treatment. No significant evidence of overdispersion was present in analyses with or without Block 1 included.

Table 4. Juvenile steelhead (STH) and yearling chinook (CH1) fish passage efficiency (FPE) during two spill treatments at John Day Dam, 02 May through 26 May 2000. N=sample size. Odds=FPE/(100-FPE). Odds ratio=12 h_{odds} / 24 h_{odds}. LRCI = likelihood ratio confidence interval. Test hypotheses of no overall differences in FPE between spill treatments (odds ratio=1) were evaluated using logistic regression after adjusting for blocks. Differences between spill treatments are significant (*) where P ≤ 0.05.

		Spill treatment						
		12 h			24 h			Observed
	Block	FPE	N	Odds	FPE	N	Odds	Odds Ratio
STH	1	88.9	45	8.009	94.3	53	16.544	2.066
	2	91.1	56	10.236	89.4	66	8.434	0.824
	3	92.1	38	11.658	90.0	50	9.000	0.772
	4	98.4	63	61.500	91.7	60	11.048	0.180
	Overall odds ratio adjusted for blocks 1-4 (95% LRCI)							0.792 (0.381-1.607)
	Test HO: odds ratio = 1 (no treatment effect), P>0.52							
CH1	1	67.3	49	2.058	89.6	58	8.615	4.186
	2	90.0	50	9.000	88.1	59	7.403	0.823
	3	83.6	55	5.098	92.4	53	12.158	2.385
	4	95.0	60	19.000	94.4	71	16.857	0.887
	Overall odds ratio adjusted for blocks 2-4 (95% LRCI)							1.342 (0.650-2.805)
	Test HO: odds ratio = 1 (no treatment effect), P>0.42							
	Overall odds ratio adjusted for blocks 1-4 (95% LRCI)							2.015 (1.128-3.676)
	Test HO: odds ratio = 1 (no treatment effect), P<0.02*							

As with FPE of yearling chinook salmon, inconsistencies in the SPE of each species affected statistical analyses comparing the SPE between treatments. In data from juvenile steelhead, the SPE estimates of the two treatments in Block 1 were 21% apart and those of the other blocks were no more than 8% apart, indicating the data from Block 1 was anomalous and should perhaps be omitted from comparisons of juvenile steelhead SPE (Figure 11, Table 5). Analysis of juvenile steelhead using only blocks 2 thru 4 indicates a significant block effect (Chi

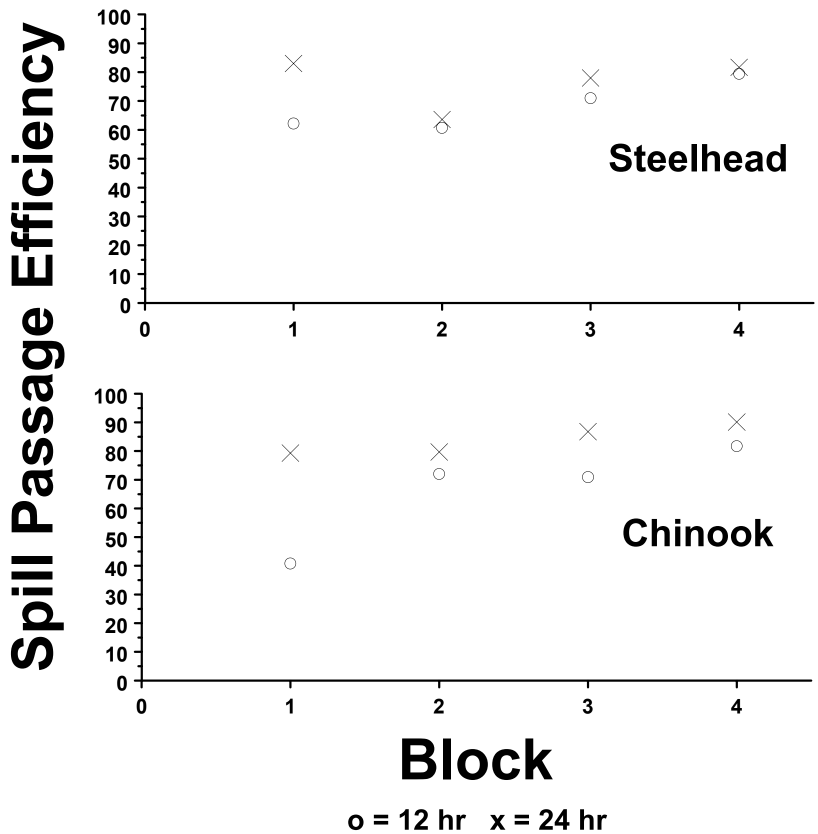

Figure 11. Juvenile steelhead and yearling chinook salmon spill passage efficiency during 12-h and 24-h spill treatments at John Day Dam, spring 2000. Blocks represent four 6-day intervals from 02 May through 26 May. Sample sizes are given in Table 5.

Square test, df = 3, $P < 0.01$) and no significant treatment effect after controlling for the block effect (Chi Square test, df = 1, $P > 0.4$; Table 5). Results of analyses based on all blocks were similar, indicating a significant block effect (Chi Square test, df = 3, $P < 0.01$) and no significant treatment effect after controlling for the block effect (Chi Square test, df = 1, $P = 0.07$), though the treatment effect was nearly significant at the $\alpha = 0.05$ level. Point estimates (and 95% confidence intervals) of SPE pooling the four blocks were 68.8% (58.6 to 77.9%) during the 12-h treatment and 76.0% (67.0 to 83.7%) during the 24-h treatment. The SPE estimates of the four blocks ranged from 60.7 to 79.4% during the 12-h treatment and 63.6 to 83.0% during the 24-h treatment (Table 5). No significant evidence of overdispersion was present in analyses with or without Block 1 included.

A large treatment difference between yearling chinook salmon SPE estimates in Block 1 resulted in concerns similar to those in the juvenile steelhead SPE analysis. The difference in SPE between treatments in Block 1 was 38%, whereas the differences in blocks 2, 3 and 4 were 8, 16 and 8%, respectively. Analysis omitting data from Block 1 indicates no significant block effect (Chi Square test, df = 3, $P > 0.1$), but a significant treatment effect (Chi Square test, df = 1, $P < 0.02$). Point estimates (and 95% confidence intervals) of yearling chinook salmon SPE pooling blocks 2 thru 4 are 75.1% (68.2 to 81.3%) for the 12-h treatment and 85.8% (80.2 to 90.3%) for the 24-h treatment. Analysis using all blocks indicates significant effects in blocks (Chi Square test, df = 3, $P < 0.0001$) and treatments after controlling for the block effect (Chi Square test, df = 1, $P = 0.0001$; Table 5). Point estimates (and 95% confidence intervals) of SPE with the four blocks pooled were 67.3% (53.6 to 79.2%) during the 12-h treatment and 84.2% (73.3 to 92.1%) during the 24-h treatment. No significant evidence of overdispersion was present in analyses with or without Block 1 included.

Spill Effectiveness

The spill effectiveness of each species was greater during the 30% day spill than during the night spill condition (mean night spills were 50.0% during the 12-h treatment and 53.8% during the 24-h treatment). Spill effectiveness of juvenile steelhead in each block ranged from 2.0:1 to 2.5:1 during day spill and 1.2:1 to 1.7:1 at night during the 12 h and 24-h treatments; the spill effectiveness at night was similar between treatments (Table 6). Spill effectiveness of yearling chinook salmon was greater than that of juvenile steelhead, ranging from 2.9:1 to 3.2:1 during day spill and 1.4:1 to 1.6:1 during night spill; the largest differences between the species were during day spill.

Table 5. Juvenile steelhead (STH) and yearling chinook (CH1) spill passage efficiency (SPE) during two spill treatments at John Day Dam, 02 May through 26 May 2000. N=sample size. Odds=SPE/(100-SPE). Odds ratio=12 h_{odds} / 12 h_{odds}. LRCI = likelihood ratio confidence interval. Test hypotheses of no overall differences in SPE between spill treatments (odds ratio=1) were evaluated using logistic regression after adjusting for blocks. Differences between spill treatments are significant (*) where P<=0.05.

		Spill treatment						
		12 h			24 h			Observed
	Block	SPE	N	Odds	SPE	N	Odds	Odds Ratio
STH	1	62.2	45	1.646	83.0	53	4.882	2.967
	2	60.7	56	1.545	63.6	66	1.747	1.131
	3	71.0	38	2.448	78.0	50	3.545	1.448
	4	79.4	63	3.854	81.7	60	4.464	1.158
	Overall odds ratio adjusted for blocks 2-4 (95% LRCI)							1.213(0.743-1.983)
	Test HO: odds ratio = 1 (no treatment effect), P>0.44							
	Overall odds ratio adjusted for blocks 1-4 (95% LRCI)							1.482(0.963-2.287)
	Test HO: odds ratio = 1 (no treatment effect), P>0.07							
CH1	1	40.8	49	0.689	79.3	58	3.831	5.559
	2	72.0	50	2.571	79.7	59	3.926	1.527
	3	70.9	55	2.436	86.8	53	6.576	2.699
	4	81.7	60	4.464	90.1	71	9.101	2.039
	Overall odds ratio adjusted for blocks 2-4 (95% LRCI)							1.999(1.165-3.495)
	Test HO: odds ratio = 1 (no treatment effect), P<0.01*							
	Overall odds ratio adjusted for blocks 1-4 (95% LRCI)							2.752 (1.743-4.407)
	Test HO: odds ratio = 1 (no treatment effect), P<0.0001*							

Table 6. Spill effectiveness of juvenile steelhead (STH) and yearling chinook salmon (CH1) passing the John Day Dam spillway during 12-h and 24-h spill treatments (trt) in spring 2000. Values represent the percent of fish passing the dam via the spillway divided by the percent spill during each category.

Species	Block	12-h trt night	24-h trt day	24-h trt night
STH	1	1.46	2.49	1.67
	2	1.29	1.98	1.17
	3	1.37	2.49	1.40
	4	1.60	2.20	1.52
CH1	1	1.51	2.92	1.45
	2	1.52	2.93	1.38
	3	1.46	3.16	1.46
	4	1.62	3.14	1.52

Detection Efficiencies

The detection efficiencies of the spillway and powerhouse arrays during the two treatments ranged from 0.86 to 1.00, with efficiencies generally highest at the spillway (Table 7). The highest detection efficiency (1.00) was of juvenile steelhead at the powerhouse during the 12–h treatment, but the numbers of fish this estimate was based on was the lowest of any group (N = 14), suggesting it may not be as robust as some of the other estimates. The lowest detection efficiency estimate was of juvenile steelhead at the powerhouse during the 24-h treatment (0.86, N = 20). A detection efficiency of 1.00 was assumed for the JBS, because we did not have a double array in that route of passage with which to calculate the estimate. Differences between FPE and SPE based on the detection efficiencies of the various arrays were all within 1.4% of each other, indicating little bias in the estimates due to differences in detection efficiencies of the arrays (Table 8). Differences between raw and adjusted FPE estimates were within ± 1.0% in 81% of the cases (13 of 16 times) and differences between SPE estimates were within this range in 94% of the cases (15 of 16 times).

Table 7. Diel capture histories and detection probabilities of telemetry detection arrays at the powerhouse and spillway at John Day Dam, spring 2000. See text for capture history and detection probability definitions.

Capture History	Steelhead				Chinook Salmon			
	Powerhouse		Spillway		Powerhouse		Spillway	
	12 h	24 h	12 h	24 h	12 h	24 h	12 h	24 h
01	0	4	4	4	2	5	3	3
10	11	7	30	32	12	2	34	42
11	3	9	112	126	17	14	107	153
Total	14	20	146	162	31	21	144	198
Detection Probabilities								
P1	1.00	0.69	0.96	0.97	0.89	0.74	0.97	0.98
P2	0.21	0.56	0.79	0.80	0.59	0.88	0.76	0.78
P12	1.00	0.86	0.99	0.99	0.96	0.97	0.99	0.99

Table 8. Fish and spill passage efficiency estimates (FPE, SPE) of juvenile steelhead (STH) and yearling chinook salmon (CH1) based on raw numbers of fish detected (Raw), after adjustments based on detection probabilities of each detection array (Adj) and the resulting difference (Diff). All numbers are percents.

Species	Estimate	Block	12-h treatment			24-h treatment		
			Raw	Adj	Diff	Raw	Adj	Diff
STH	FPE	1	88.9	90.0	0.0	94.3	93.5	-0.8
		2	91.1	91.1	0.0	89.4	88.0	1.4
		3	92.1	92.2	-0.1	90.0	88.6	1.4
		4	98.4	98.4	0.0	91.7	90.5	1.2
	SPE	1	62.2	62.5	-0.3	83.0	82.4	-0.6
		2	60.7	60.9	-0.2	63.6	62.8	0.8
		3	71.0	71.2	-0.2	78.0	76.9	1.1
		4	79.4	79.5	-0.1	81.7	80.7	1.0
CH1	FPE	1	67.3	66.6	0.7	89.6	89.4	0.2
		2	90.0	89.7	0.3	88.1	87.9	0.2
		3	83.6	83.2	0.4	92.4	92.3	0.1
		4	95.0	94.8	0.2	94.4	94.2	0.2
	SPE	1	40.8	40.5	0.3	79.3	79.2	0.1
		2	72.0	71.9	0.1	79.7	79.5	0.2
		3	70.9	70.6	0.3	86.8	86.7	0.1
		4	81.7	81.6	0.1	90.1	90.1	0.0

Results from the Summer Study Period

Dam Operations

Data were collected during four 6-d treatment blocks between 30 June and 20 July (Appendix F). The average spill during these blocks was similar to proposed levels (Table 9; hourly discharge data are in Appendix G). During these blocks, night spill averaged 58.5% during the 12-h treatment (proposed 0% day spill, 60% night spill) and 59.2% during the 24-h treatment (proposed 30% day spill, 60% night spill); the overall night spill was 58.8%. Mean percent spill during the day was 1.2 % during the 12-h treatment and 30.1% during the 24-h treatment (Table 9).

Mean hourly total discharge ranged from 99.4 kcfs to 275.0 kcfs during the summer study period (Table 9). The average daytime discharges were 177.6 kcfs (range 102.4 to 145.9 kcfs) during the 12-h treatment and 171.4 kcfs (range 99.4 to 275.0 kcfs) during the 24-h treatment. Average night discharges during the 12-h and 24-h treatments were 161.0 kcfs (range 114.8 to 244.75 kcfs) and 164.1 kcfs (range 113.4 to 268.3 kcfs). Differences in mean discharges between treatments within a block were +5.1 kcfs in Block 1 (12-h treatment minus 24-h treatment), –1.8 kcfs in Block 2, +27.1 kcfs in Block 3 and –22.3 kcfs in Block 4.

Fish Released and Detected

From 30 June through 20 July, we radio-tagged and released 395 subyearling chinook salmon 23 km above John Day Dam (Figure 2, Table 10). The subyearling chinook salmon selected for tagging had a mean fork length of 118.5 mm (range 110 to 152 mm) and a mean weight of 19.2 g (range 13.6 to 42.6 g; Appendix H). The mean fork lengths of subyearling chinook salmon measured by the Pacific States Marine Fisheries Commission from subsamples of the fish collected in the JBS during the study period was 107.6 mm (range 78 to 156 mm; fish were not weighed). The tag-weight-to-body-weight ratio of subyearling chinook salmon was 5.2% (range 2.3 to 7.4%).

Table 9. Mean hourly percentages of total discharge spilled and mean hourly total discharge (KCFS) at John Day Dam during four 6-d blocks, 01 July through 25 July 2000. Proposed spill treatments consisted of one 3-d treatment of no day spill discharge (0700– 1859 h) and 60% night discharge (1900-0659 h; 12-h treatment) followed by a second 3-d treatment of 30% day spill discharge and 60% night discharge (24-h treatment).

		Hourly percent spill					
	Spill	0700-1859			1900-0659		
Block	treatment	Mean	Std	Range	Mean	Std	Range
1	12 h	1.2	1.1	0.7-6.1	59.2	2.1	53.1-62.1
	24 h	30.2	0.9	29.2-34.4	59.1	1.5	53.3-61.2
2	12 h	1.0	0.7	0.0- 4.5	57.8	2.1	50.1-60.4
	24 h	30.2	2.0	27.9-40.7	59.4	1.2	56.7-62.7
3	12 h	1.0	0.7	0.6- 3.9	58.3	6.7	21.7-61.4
	24 h	29.8	1.0	27.6-32.1	59.1	1.3	55.7-61.9
4	12 h	1.4	1.6	0.0- 10.1	58.6	2.2	51.8-61.1
	24 h	30.1	0.9	28.8-32.4	59.3	3.4	44.3-63.5

		Hourly total discharge					
	Spill	0700-1859			1900-0659		
Block	treatment	Mean	Std	Range	Mean	Std	Range
1	12 h	167.0	25.4	103.7-211.5	162.9	24.3	115.3-206.9
	24 h	140.7	24.1	99.4-180.8	149.0	12.5	128.2-178.5
2	12 h	187.6	22.4	119.7-216.0	163.6	42.5	114.8-244.7
	24 h	200.8	33.6	144.0-275.0	188.0	27.4	159.9-268.3
3	12 h	199.9	22.1	145.9-234.2	168.1	33.4	134.1-227.8
	24 h	158.3	29.2	115.3-239.0	155.5	30.5	132.4-226.1
4	12 h	155.7	29.9	102.4-214.0	149.4	26.1	127.3-237.2
	24 h	185.9	26.6	135.7-228.8	164.0	32.3	113.4-215.1

Over the course of the study, receivers at the dam detected 61 to 97% of the tagged subyearling chinook salmon released (Table 10). Overall, 84% of all fish released were detected at the dam.

Travel Time, Arrival Time, and Approach Pattern

Median travel time from the release site to the near-dam forebay of JDA was 25.6 h (range 4.9 to 171.5 h). The hour of arrival at JDA was widely dispersed throughout the diel period, but the arrival distribution was lower during the 1700 to 1859 h and 2100 to 2259 h intervals than during the rest of the diel period (Figure 12).

The percentages of first detections at the spillway and powerhouse were similar among blocks during the 24-h treatment, but a decrease in powerhouse approach and increase in spillway approach was evident over time during the 12-h treatment (Figure 13). The mean proportions of arriving fish first detected at the powerhouse during the 12-h treatment

Table 10. Number of radio-tagged subyearling chinook salmon released 23 Km above the John Day Dam at Rock Creek during summer 2000 and the percent of fish detected by radio-telemetry receivers at John Day Dam.

Release Date	Release Time	Number Released	Percent Detected
30 June	20:00	32	96.9
02 July	08:00	19	84.2
03 July	20:00	24	95.8
05 July	08:00	33	97.0
06 July	20:00	32	90.6
08 July	08:00	32	90.6
09 July	20:00	32	71.9
11 July	08:00	29	82.8
12 July	20:00	34	79.4
14 July	08:00	32	87.5
16 July	20:00	33	87.9
17 July	09:00	31	65.6
20 July	20:00	31	61.3
Overall		394	83.8

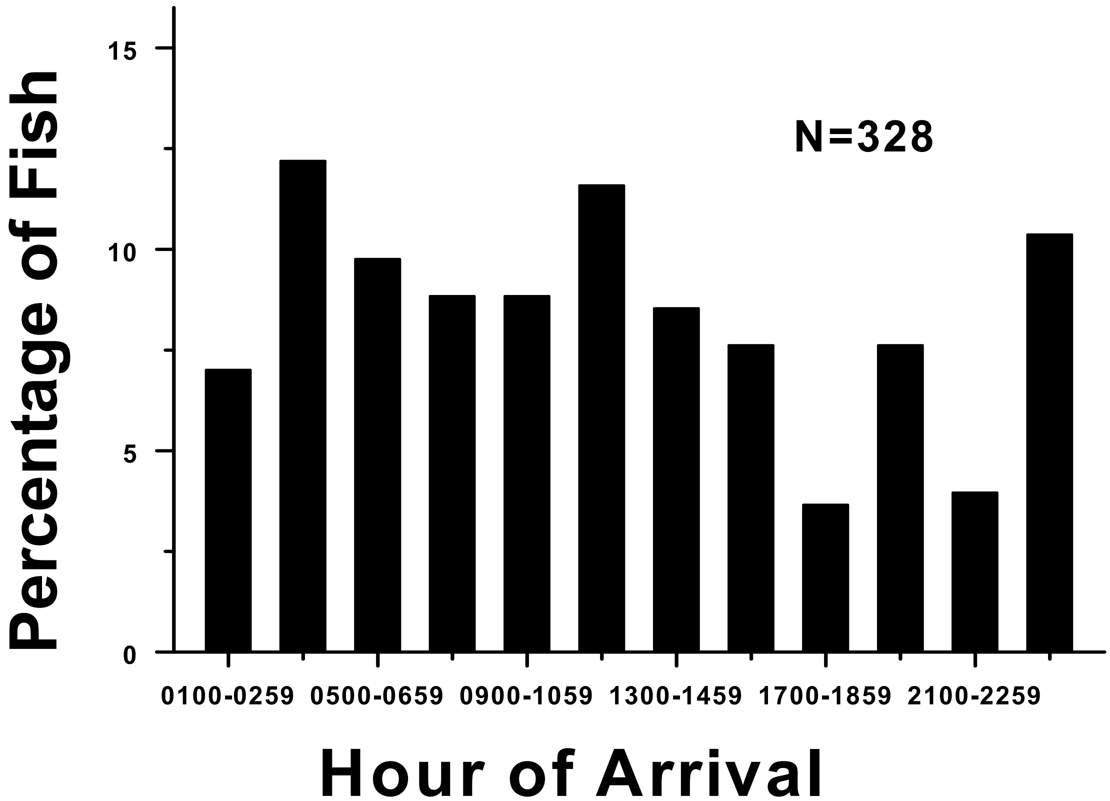

Figure 12. Hour of arrival (2-h intervals) of radio-tagged subyearling chinook salmon at John Dam, 01 July through 25 July 2000

decreased from 45.6% during Block 1 to 20.0% during Block 4. Since the powerhouse and spillway are the only main areas of approach at JDA, the reduction in first detections at the powerhouse was accompanied by an increase in first detections at the spillway, which were 54.9, 61.5, 61.3, and 80% in blocks 1 through 4, respectively (N = 5 fish arrived during the 12-h treatment of Block 4).

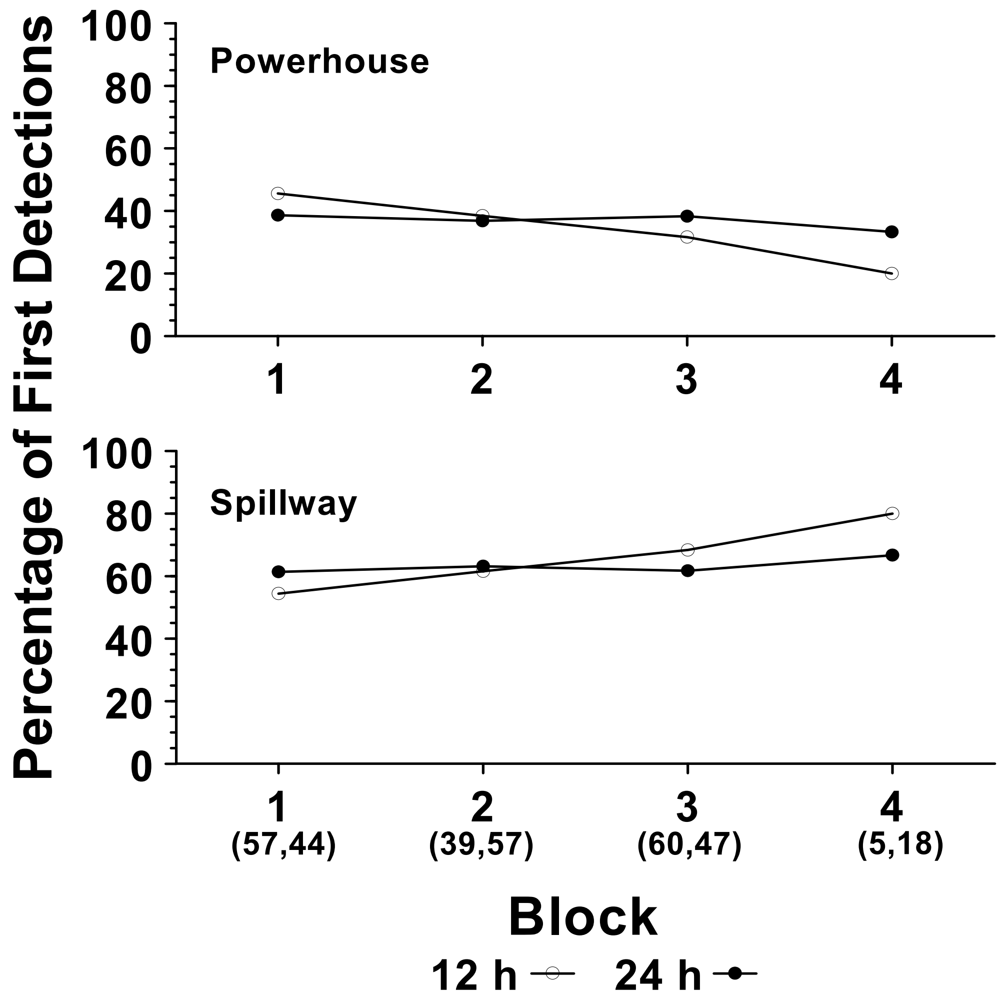

Figure 13. Distribution of first detections of subyearling chinook salmon between spillway and powerhouse radio-telemetry receivers in the John Day Dam near-dam forebay during 12- and 24-h spill treatments, spring 2000. Blocks were 6-d intervals from 01 July through 25 July. Sample sizes are in parentheses (12h, 24h).

Behavior in the Near-Dam Forebay

Median residence times of subyearling chinook salmon were affected by the time of day they arrived at the dam and the spill treatment in use at that time. Fish arriving near the end of the spill period, or during the no-spill period of the 12-h treatment, had the longest forebay residence times. Fish that arrived more than several hours before the end of a spill period had the shortest residence times. The result of these trends was high variability in forebay residence times during the 12-h treatment in fish arriving during the day as well as those arriving at night

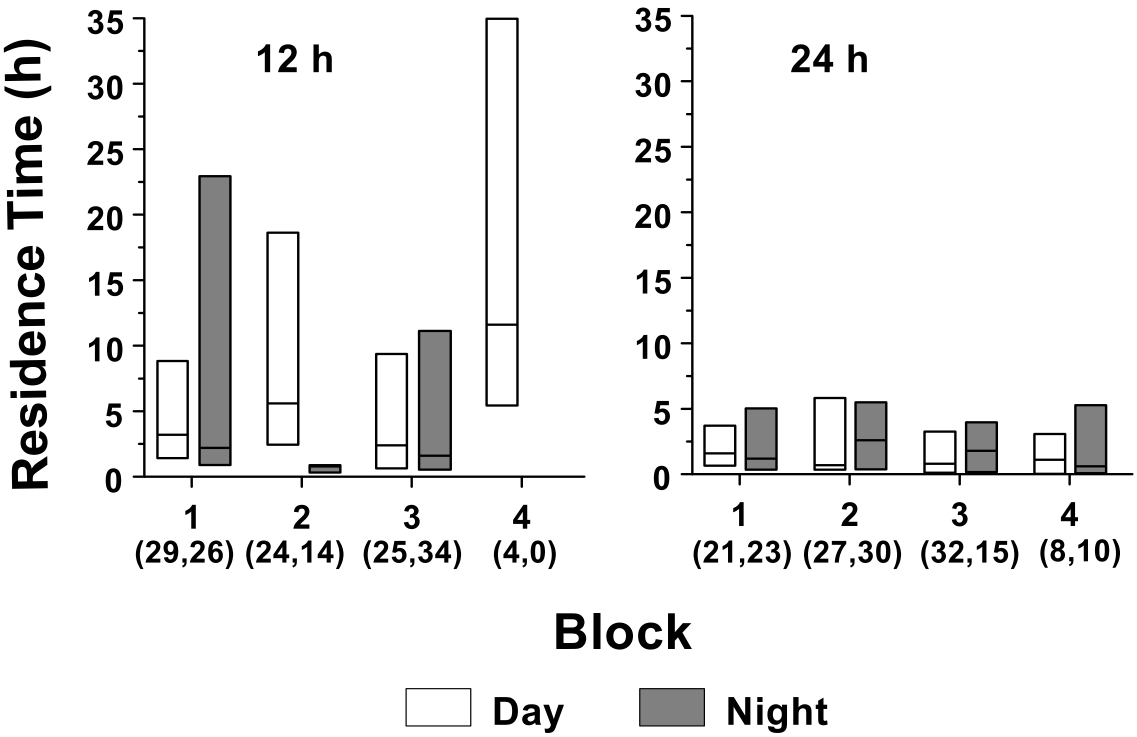

Figure 14. Twenty-fifth, 50th (median), and 75th percentiles (lower, middle, and upper horizontal lines on bars) of radio-tagged subyearling chinook salmon forebay residence times (h) by diel time of arrival during 12- and 24-h spill treatments at John Day Dam, 01 July through 25 July. Day and night refer to two, 12-h operational spill periods 0700-1859 h and 1900-0659 h. Sample sizes are shown in parentheses.

(since those arriving near the end of the spill period often did not pass until the next spill period; Figure 14).

Subyearling chinook salmon arriving during the 24-h treatment had shorter forebay residence times with less variability between day and night arrival periods than those arriving during the 12-h treatment. Subyearling chinook salmon arriving during the 12-h treatment in the day had a median forebay residence time of 4.8 h (range 2.4 to 6.6 h) in Blocks 1 thru 3 and those arriving at night had median forebay residence times ranging from 0.8 to 4.2 h in those blocks (Table 11; data from Block 4 excluded due to low sample size). Calculating a single point estimate for all blocks of subyearling chinook salmon arriving at night during the 12-h treatment was not appropriate due to significant differences between the first three blocks (Kruskal-Wallis Test, P = 0.0143; data from Block 4 omitted due to low sample size).

Table 11. Twenty-fifth, 50th (median), and 75th percentiles of radio-tagged subyearling chinook salmon forebay residence times (h) by diel time of arrival during 12- and 24-h spill treatments at John Day Dam, 01 July through 25 July. Day and night refer to two, 12-h operational spill periods 0700-1859 h and 1900-0659 h. N=sample size.

	12-h spill treatment							
	Day				Night			
Block	N	Median	25th	75th	N	Median	25th	75th
1	29	3.2	1.5	8.8	26	4.2	1.0	22.9
2	24	6.6	2.5	18.6	14	0.8	0.5	0.9
3	25	2.4	0.7	9.3	34	1.6	0.6	11.1
4	4	11.6	5.5	43.0	-	-	-	-
	24-h spill treatment							
Block	Day				Night			
	N	Median	25th	75th	N	Median	25th	75th
1	21	1.6	0.7	3.7	23	1.2	0.4	5.0
2	27	0.7	0.4	5.8	30	2.6	0.4	5.4
3	32	0.8	0.2	3.2	15	1.8	0.3	3.9
4	8	1.1	0.1	3.1	10	0.6	0.0	5.2

The median residence times of subyearling chinook salmon during the 24-h treatment was 1.0 h (range 0.7 to 1.6 h) if arriving during the day and 1.6 h (range 1.2 to 2.6 h) if arriving at night (excluding data from Block 4 due to low sample size).

General Time and Route of Passage

The time of day that radio-tagged subyearling chinook salmon passed JDA was affected by release times, travel time from the release site to the dam and response to spill conditions at the time of their arrival (Figure 15). Differences in the time of passage between treatments were evident, with a greater proportion of fish passing between 0900 and 1659 h during the 24-h treatment than the 12-h treatment, and the opposite trend occurring between 1700 and 2400 h.

This indicates a passage delay of subyearling chinook salmon arriving during the day during the 12-h treatment.

The proportions of subyearling chinook salmon passing via the turbines, juvenile bypass and spillway were relatively consistent between blocks (Figure 16; Appendix I). Passage via the turbines and JBS was greater during the 12-h treatment than during the 24-h treatment. These trends were accompanied by greater spillway passage during the 24-h treatment than the 12-h treatment.

The differences in passage proportions between treatments at the turbines, JBS and spillway were largely due to the increase in passage via daytime spill during the 24-h treatment (Figure 17). Most fish passed during the night during the 12-h treatment, but the greatest passage was during the day during the 24-h treatment. Of the total number of tagged subyearling chinook salmon that passed the dam during each treatment, 39.3% (57 of 145) passed in the day

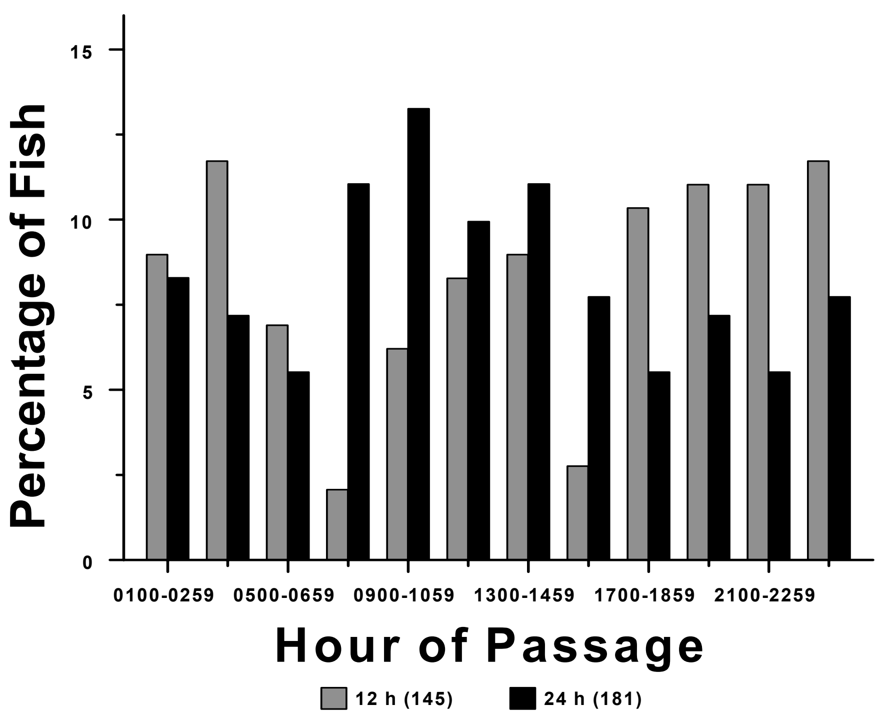

Figure 15. Hour of passage (2-h intervals) of radio-tagged subyearling chinook salmon during 12- and 24-h spill treatments at John Day Dam, 01 July through 25 July 2000. Sample sizes are in parentheses.

during the 12-h treatment and 63.1% (113 of 179) passed in the day during the 24-h treatment. Average turbine passage (pooling day and night passage) was 20.7% during the 12-h treatment

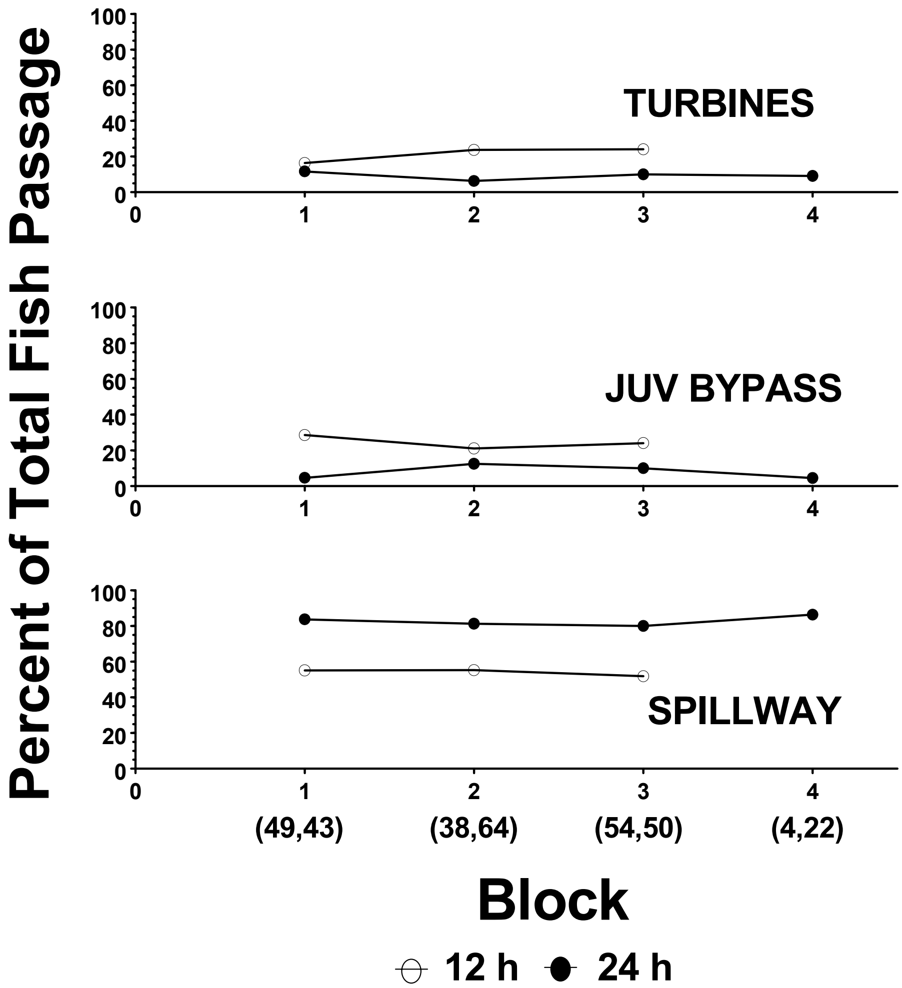

Figure 16. Percentage of radio-tagged subyearling chinook salmon passing through the turbines, juvenile fish bypass, and spillway during 12- and 24-h spill treatments at John Day Dam, summer 2000. Blocks are four 6-d intervals from 01 July through 25 July. Sample sizes are shown in parentheses. Percentages during 12-h spill discharge for block 4 are not shown due to small sample size (12h, 24h).

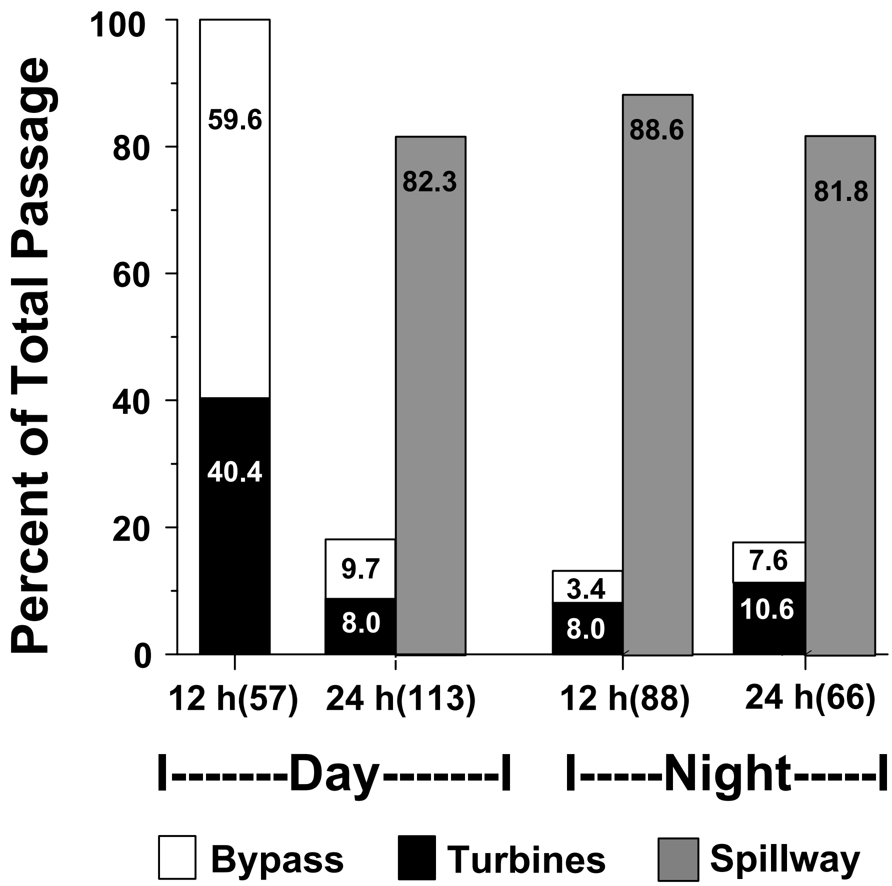

Figure 17. Percentage of radio-tagged subyearling chinook salmon passing through the juvenile fish bypass (Bypass), turbines, and spillway at John Day Dam during 12- and 24-h spill treatments, 01 July through 25 July 2000. Passage percentages for each area and spill condition are shown on each bar. Day and night refer to two operational spill periods 0700-1859 h and 1900-0659 h. Sample sizes are in parentheses.

and 8.9% during the 24-h treatment. Average JBS passage proportions during the 12-h and 24-h treatments (pooling day and night passage) were 27.0% and 8.9%, respectively. Day passage during the 12-h treatment was 60% through the JBS and 40% through the turbines.

Fish and Spill Passage Efficiency

No statistically significant block effect in FPE or SPE was present (Chi Square test, df = 1, FPE $P > 0.77$, SPE $P > 0.86$), but there was a statistically significant treatment effect in both FPE and SPE (Chi Square test, df = 2, FPE $P < .004$, SPE $P < 0.0001$; Table 12). The FPE and SPE were significantly greater during the 24-h treatment than in the 12-h treatment (Figure 18).

Point estimates (and 95% confidence intervals) of subyearling chinook salmon FPE (pooling blocks 1thru 3 only, as only 4 fish passed in Block 4 during the 12-h treatment) were 78.7% (71.5 to 84.9%) during the 12-h treatment and 91.1% (86.0 to 94.9%) during the 24-h treatment (Table 13). Point estimates of SPE during these blocks were 53.9% (45.7 to 62.0%) during the 12-h treatment and 81.8% (75.0 to 87.1%) during the 24-h treatment.

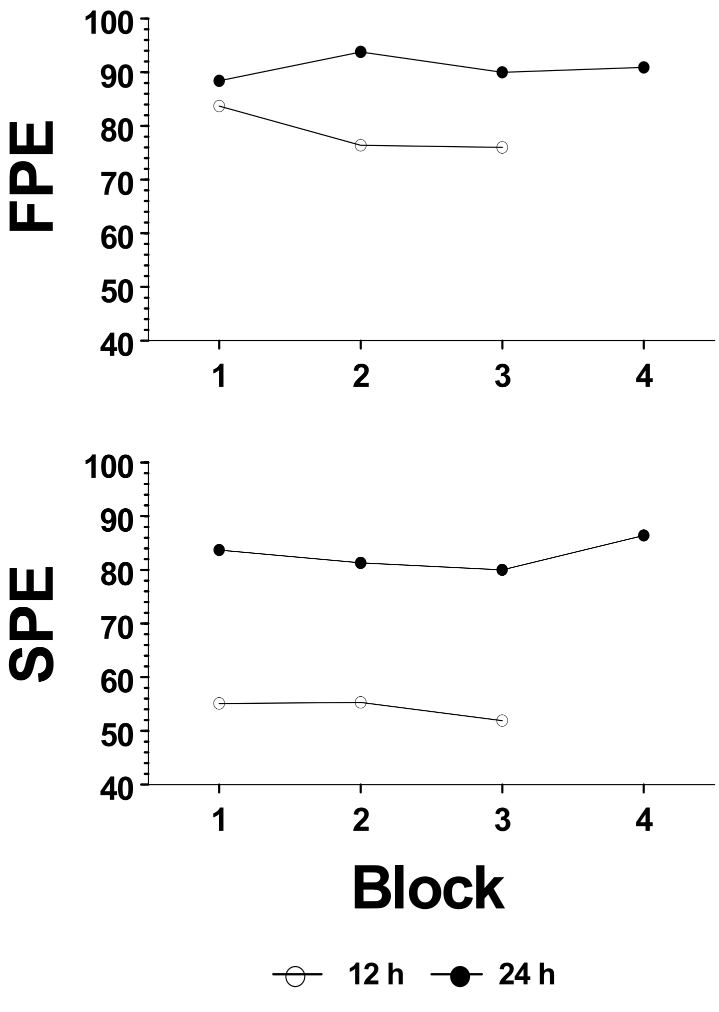

Figure 18. Subyearling chinook salmon fish passage efficiency (FPE) and spill passage efficiency (SPE) during 12- and 24-h spill treatments at John Day Dam, summer 2000. Blocks represent four 6-d intervals from 01 July through 25 July 2000. Sample sizes are given in Table 5.

Table 12. Estimates (Est) of subyearling chinook salmon fish passage efficiency (FPE) and spill passage efficiency (SPE) during 12- and 24-h spill treatments at John Day Dam, 01 July through 25 July 2000. N=sample size. Odds=Est/(100-Est). Odds ratio=24 h_{odds} / 12 h_{odds}. LRCI = likelihood ratio confidence interval. Test hypotheses of no overall differences in FPE between spill treatments (odds ratio=1) were evaluated using logistic regression after adjusting for blocks. Differences between spill treatments are significant (*) where P ≤ 0.05. Data from Block 4 were omitted from analysis due to low sample size during the 12-h treatment (N = 4).

		Spill treatment						
		12 h			24 h			Observed
	Block	Est	N	Odds	Est	N	Odds	Odds Ratio
FPE	1	83.7	49	5.135	88.4	43	7.621	1.484
	2	76.3	38	3.219	93.7	64	14.873	4.620
	3	75.9	54	3.149	90.0	50	9.000	2.858
	Overall odds ratio adjusted for blocks 1-3 (95% LRCI)							2.732 (1.397-5.579)
	Test HO: odds ratio = 1 (no treatment effect), P=0.0031*							
SPE	1	55.1	49	1.227	83.7	43	5.135	4.185
	2	55.3	50	1.237	81.2	64	4.319	3.491
	3	51.8	54	1.075	80.0	50	4.000	3.721
	Overall odds ratio adjusted for blocks 1-3 (95% LRCI)							3.771 (2.245-6.461)
	Test HO: odds ratio = 1 (no treatment effect), P<0.0001*							

Table 13. Estimates (Est) of subyearling chinook salmon fish passage efficiency (FPE), spill passage efficiency (SPE) during 12- and 24-h spill treatments at John Day Dam, 01 July through 25 July 2000. N=sample size. LRCI = likelihood ratio confidence interval. Test hypotheses of no overall spill treatment effect on fish passage for each passage index were evaluated using logistic regression after adjusting for blocks (Table 5). Point estimates represent data from blocks 1 thru 3; data from Block 4 were omitted due to low sample size in the 12-h treatment group (N = 4).

Passage efficiency	Spill treatment					
	12 h			24 h		
	Est	95%LRCI	N	Est	95%LRCI	N
FPE	78.7	71.5 – 84.9	141	91.1	86.0 – 94.9	157
SPE	53.9	45.7 – 62.0	141	81.5	75.0 – 87.1	157

Spill Effectiveness

The spill effectiveness was greater during the 30% day spill than during the night spill condition. Spill effectiveness in each block ranged from 2.57:1 to 3.01:1 during day spill, 1.14:1 to 1.58:1 at night during the 12 h treatment and from 1.29:1 to 1.56:1 at night during the 24-h treatment (Table 14).

Detection Efficiencies

There were differences in the detection efficiencies at the spillway and powerhouse arrays. The lowest detection efficiencies were at the powerhouse, where they were 0.52 during the day and 0.66 at night (Table 15). Detection efficiencies at the spillway were 0.99 during the day and night. Most changes in the estimated FPE's and SPE's due to differences in detection efficiencies were less than 7%, but the reduction in FPE for day passage during the 12-h treatment was 16.1% (from 59.6 to 43.5%; Table 16).

Table 14. Spill effectiveness of subyearling chinook salmon passing the John Day spillway during 12- and 24-h spill treatments (trt) in summer 2000. Values represent the percent of fish passing the dam via the spillway divided by the percent spill during each category. The numbers of fish passing through the spillway are shown in parentheses.

Block	12-h trt night	24-h trt day	24-h trt night
1	1.58 (27)	3.01 (20)	1.29 (16)
2	1.45 (21)	2.72 (32)	1.35 (20)
3	1.55 (28)	2.57 (28)	1.56 (12)
4	1.14 (2)	2.88 (13)	1.44 (6)

Table 15. Diel capture histories and detection probabilities of telemetry detection arrays at the powerhouse and spillway at John Day Dam, summer 2000. See text for capture history and detection probability definitions.

Capture History	Powerhouse		Spillway	
	Day	Night	Day	Night
01	39	2	3	11
10	20	18	14	16
11	12	3	71	114
Total	71	23	88	141
	Detection Probabilities			
P1	0.24	0.60	0.96	0.91
P2	0.38	0.14	0.84	0.88
P12	0.52	0.66	0.99	0.99

Table 16. Fish and spill passage efficiency estimates (FPE, SPE) of subyearling chinook salmon based on raw numbers of fish detected (Raw), after adjustments based on detection probabilities of each detection array (Adj) and the resulting difference (Diff). All numbers are percents. NA = not applicable.

Estimate	Time	12-h treatment			24-h treatment		
		Raw	Adj	Diff	Raw	Adj	Diff
FPE	Day	59.6	43.5	16.1	92.0	85.8	6.8
	Night	92.0	88.5	3.5	89.4	84.9	4.5
SPE	Day	NA	NA	NA	82.3	76.8	5.5
	Night	88.6	85.3	3.3	81.8	77.8	4.0

Discussion

The 24-h spill treatment used in 2000 was effective in increasing the proportion of yearling chinook salmon passing John Day Dam via the spillway during the day, but did not significantly change FPE from that achieved during the 12-h spill treatment. Though day passage of yearling chinook salmon increased by 30% (from 14% during 12-h treatment to 44% during 24-h treatment), a similar proportion of fish would have passed via non-turbine routes at night had they not passed during the day, resulting in no significant change in FPE. The FPE of juvenile steelhead was unaffected because few juvenile steelhead passed during the day during either treatment condition (4% during 12-h treatment and 8% during 24-h treatment). The spill effectiveness was greater during day spill than night spill, however, spill effectiveness can be misleading, because it is not related to the numbers of fish passing the dam. Spill effectiveness values must be viewed in relation to the proportion of fish passing during each condition: 44% of yearling chinook salmon passed during day spill, but only 8% of juvenile steelhead did. Thus, while the greater spill effectiveness during the day indicates day spill is more effective at passing fish via the spillway than night spill, this finding has little meaning in terms of overall juvenile steelhead passage under the current operation at John Day Dam, because very few juvenile steelhead passed during the day. It does have meaning in terms of the passage of yearling chinook salmon. An additional benefit of day spill was a statistically significant reduction in forebay residence times of tagged yearling chinook salmon arriving during the day. The median residence times of juvenile steelhead arriving during the day were also reduced, though not significantly (10.9 h vs. 9.4 h).

The use of the 24-h treatment resulted in significant improvements in passage of subyearling chinook salmon compared to passage during the 12-h treatment during 2000. Turbine passage was reduced by 12%, decreasing from 21% during the 12-h treatment to 9% during the 24-h treatment. This decrease was largely due to an increase in spill passage during the 30% day spill of the 24-h treatment, resulting in a statistically significant increase in SPE from 54% during the 12-h treatment to 82% in the 24-h treatment. The FPE was also significantly greater during the 24-h treatment (91.1%) than the 12-h treatment (78.7%).

The changes in turbine and JBS passage of subyearling chinook salmon were greater than those of yearling spring chinook salmon and juvenile steelhead during the spring of 2000 under similar operating conditions, indicating that the 24-h spill treatment was more beneficial to the subyearling chinook salmon than either of the spring species. In the spring, yearling chinook salmon spillway passage was greater during the 24-h treatment than during the 12-h treatment, but very few juvenile steelhead passed in the day during either treatment. The FPE's of the spring species were not changed significantly and only the SPE of yearling chinook salmon was changed significantly during the tests. During the summer, FPE and SPE of subyearling chinook salmon were both significantly greater during the 24-h treatment than in the 12-h treatment and the fish passed readily through day spill. The spillway passage of subyearling chinook salmon during the 30% day spill condition was actually slightly greater than night passage during the 60% spill of the same treatment.

The FPE and SPE estimates of yearling chinook salmon from Block 1 were considerably lower than those of the other Blocks (Tables 4 and 5). The most likely explanations of this are differences in project discharge and percent spill between the two treatments during Block 1. The greatest mean project discharge (312.4 kcfs) and the lowest mean percent spill (42.7%) observed during the spring study period occurred at night during the 12-h treatment of Block 1. This is quite different than the nighttime mean project discharge (279.3 kcfs) and mean percent spill (50.2%) during the 24-h treatment in this block. An increased project discharge and reduced spill proportion can be expected to result in greater approach and passage at the powerhouse. The influence of these differences in Block 1 was apparent in approach patterns, area of passage, FPE and SPE of yearling chinook salmon and to a lesser degree in spillway passage and SPE of juvenile steelhead. We chose to omit data from block 1 in FPE and SPE statistical analyses due to the differences in project operations noted above, but some results would have been different if the analyses had been conducted using all four blocks. The conclusions from juvenile steelhead FPE analyses would not have changed (no significant change in either estimate), though the SPE treatment effect using all blocks, while not significant at the $\alpha = 0.5$ level of significance, would be at the $\alpha = 0.1$ level ($P = 0.0735$) and may have indicated a possible biological significance to the changes in SPE of this species. The yearling chinook salmon FPE and SPE tests would have indicated significant block and treatment effects if all blocks were included in these analyses, whereas neither effect was significant in tests of FPE and only the treatment effect was significant in tests of SPE with Block 1 excluded. These differences in outcomes were influenced primarily by the low yearling chinook salmon FPE and SPE during the 12-h treatment relative to the estimates during the 24-h treatment in Block 1 (12 h FPE 67% vs. 24 h FPE 90%; 12 h SPE 41% vs. 24 h SPE 79%). As previously noted, we believe these unusually large differences between treatments were due to the different operating conditions present during the treatments in Block 1 rather than differences in fish passage during standard study conditions and prefer to omit this data from statistical comparisons. However, results of both analyses are presented in Tables 4 and 5.

The results of the spring portion of this study were similar to those obtained under similar conditions in 1999 (Hansel et al. 2000). The dam operating conditions were closer to those proposed in 2000 than in 1999, resulting in a greater mean percent spill at night in 2000 (52.9%) than in 1999 (45.2%). As may be expected from this difference, the SPE values were greater (approximately 20%) in 2000 than in 1999. The increased spill in 2000 had little effect on FPE. Spill effectiveness during the spring was slightly greater in 2000 than in 1999. Spill effectiveness values of juvenile steelhead in 1999 and 2000 were 1.7:1 and 2.2:1 during day spill and 1.2:1 and 1.6:1 during night spill (Hansel et al. 2000). Yearling chinook salmon values were 2.5:1 and 3.1:1 during day spill and 1.4:1 and 1.6:1 during night spill in 1999 and 2000, respectively. The results between the summer study and a similar telemetry study of fish passage conducted in 1999 are difficult to compare, due to low sample sizes and varied project operation during the 1999 study period.

The FPE, SPE and spill effectiveness estimates from this study during the summer period were similar to estimates based on fixed hydroacoustics. The FPE estimates from the hydroacoustic study were 0.72 during the 12-h treatment and 0.91 during the 24-h treatment; our estimates were 0.79 and 0.91 (Moursund et al. 2001; our results are presented as FPE *100% elsewhere in this report). The SPE estimates based on hydroacoustics were 0.61 and 0.87, compared to 0.54 and 0.82 from this study for the 12-h and 24-h treatments, respectively. Spill effectiveness values in each block from Moursund et al. (2001) ranged from 1.2 to 1.5:1 at night during the 12-h treatment, from 2.6 to 3.3:1 in the day during the 24-h treatment and from 1.2 to

1.5:1 at night during the 24-h treatment. The estimates in our study blocks were similar in each case. Moursund et al. (2001) also calculated spill effectiveness during the 0% spill condition of the 12-h treatment (range 33.9 to 59.3:1), but too few radio-tagged fish passed during this condition to estimate spill effectiveness during this condition in our study. There was little overlap in time between the two studies. The results of Moursund et al. (2001) are based on data collected from 07 June to 07 July, whereas our data was based on fish passage between 01 July and 25 July. The only overlap between studies was during the 6-d block between 01 July and 06 July, which was the last block in the hydroacoustic study and the first block in our study. Some difference in study dates is expected, because we typically need to wait until subyearling chinook salmon are large enough to accept the radio transmitter (generally 110 mm FL and 13 g weight), but in 2000 the difference was primarily due to the delay caused by the last-minute change in transmitter manufacturers. The coded transmitter type originally planned for use in this study were used in some studies at The Dalles Dam and they released their first group on 20 June, whereas the first release of beeper tags at Rock Creek was on 30 June. No hydroacoustic assessment of fish passage was conducted at John Day Dam during the spring of 2000.

The overall measure of success of the 24-h spill program is an increase in FPE, without a distinction in whether the increased non-turbine passage is via the spillway or JBS; however, recent survival evidence suggests that such a distinction may be warranted. Results of a relative survival study of fish passed through the JBS in 2001 (Tim Counihan, USGS, 2001 Anadromous Fish Evaluation Program presentation, Walla Walla, Washington, November 15, 2001) indicated the relative survival and 95% confidence interval of subyearling chinook salmon passing through the JBS was 86.8 ± 8.2% in 2001 (no estimates were made in 2000). The confidence interval around this estimate is large and there was no estimate of relative survival associated with spill passage to compare this with (due to the low water year and the planned lack of spill), but this low relative survival associated with passage via the JBS suggests that it would be prudent to evaluate the 24-h spill program not only in terms of overall FPE, but also in terms of the proportion of fish that pass each non-turbine route, as they will likely have different survival probabilities associated with them. This also affirms the need to determine fish passage routes and route-specific survival together to determine the proportions of fish passing via each route as well as assess the survival probabilities of each route of passage.

Reducing daytime passage delay at dams is often overlooked as an important factor in juvenile salmonid passage. This may, in part, be due to the lack of information about the migration behavior of juvenile salmonids within Columbia and Snake river reservoirs compared to the amount of attention that has been focused on passage time distributions at dams. It is generally understood that peaks in dam passage occur at night (Brege et al. 1996; Monk et al. 1997; Hansel et al. 2000; Beeman and Maule 2001). However, this is not the natural migration pattern of these species. Beeman and Maule (In Press) found that, though nighttime migration rates of juvenile steelhead and yearling chinook salmon are slower than those during the day, they generally migrated during all times of the day and night. For example, in a study based on mobile tracking radio-tagged juvenile steelhead and yearling chinook salmon 24-h per day between Ice Harbor and McNary dams, they found that mean migration rates of juvenile steelhead were 1.60 km/h during the day and 1.33 km/h at night. Results of a similar study using subyearling chinook salmon in the Snake River indicate that this race of chinook salmon also migrate at all times of the day and night, though they did stop migrating for brief periods (D. Venditti, Idaho Department of Fish and Game, personal communication). Thus, prolonged residence times of fish arriving during the day represent a delay in dam passage. Such delays could result in mortality due to increased exposure to predatory fish (Poe et al. 1991; Reiman et al. 1991). Petersen (1994), in an analysis of the spatial pattern of predation in John Day reservoir, calculated that approximately 10 to 15% of the predation on juvenile salmonids by northern pikeminnow (*Ptychocheilus oregonensis*) in the entire reservoir (estimated at 1.4 million salmonids annually) occurred in the area of the John Day Dam forebay. Reiman et al. (1991) estimated that the walleye (*Stizostedion vitreum*) and smallmouth bass (*Micropterus dolomieu*) collectively account for an additional 22% of the total predation on juvenile salmonids in John Day reservoir. Delays in dam passage can also extend the exposure to elevated water temperatures (primarily a concern with summer migrants) and have a cumulative effect resulting in delaying the time of seawater entry beyond the optimum state of physiological readiness or food availability.

Differences in detection efficiencies between the spillway and powerhouse arrays during the spring study period had little effect on the FPE or SPE estimates, but they did have an important effect during the summer. During the spring, the detection efficiencies at the powerhouse and spillway were always within 13% and were most often within 1% of one another. However, differences in detection efficiencies during the summer were sufficient to result in a 16.1% reduction in the FPE estimate from day passage during the 12-h treatment. The estimate during this condition was affected by the low daytime detection efficiency at the powerhouse (0.52) more than during the other study conditions because no fish passed via the spillway in the day during the 12-h treatment, making the powerhouse passage component more influential than in the other conditions. The large differences between spillway detection efficiencies (0.99 day and night) and powerhouse detection efficiencies (0.52 day and 0.66 night) were due to the differences in the coverage of each route of passage by our telemetry systems. Aerial antennas monitor spillway passage in conjunction with four underwater antennas mounted on the pier noses between bays, which result in an almost complete coverage of the passage route. The powerhouse is monitored by a similar aerial array, but the underwater array is much less robust than at the spillway. Underwater antennas at the powerhouse are mounted above the trash racks of the center ("B") slot of each unit at approximately 5.5 m and 8.5 m below the water surface. This does not result in complete coverage along the face of the powerhouse. Four factors affected the overall detection efficiencies at the powerhouse: 1) the incomplete coverage of the underwater array, 2) the low overall efficiency of the forebay aerial array at the powerhouse during the summer (24 to 60%), 3) the lack of tailrace aerial antennas due to the switch to beeper tags, and 4) the low radiated power of the small beeper tags. The addition of underwater antennas to the turbine intake screens would likely improve detection efficiencies at the powerhouse.

The summer study was conducted using non-pulse-coded transmitters, which contributed to the low overall detection efficiencies. We had planned to pulse-coded transmitters and a proprietary code set with 170 unique codes per channel (i.e., frequency), but production problems at the manufacturer prevented their delivery. The non-coded transmitters we used in their place were purchased from another firm (without such a coding scheme) at two pulse rates per channel, which allowed two transmitters per channel rather than 170, resulting in a greater number of channels and repetitions than planned. The disadvantage of having fewer unique codes per channel is that it can result in increases in conflicts between signals of transmitters near the detection arrays at the same time (i.e., "collisions") and increased scan times on aerial receivers (aerial receivers typically scan channels individually on a repeating cycle and the total scan time is affected by the numbers of channels used). To accommodate the switch to the non-coded transmitters we reduced the number of tags released and removed aerial telemetry receivers from all tailrace arrays and used them in conjunction with those in forebay aerial arrays to reduce overall scan times; each receiver scanned ½ the channels, which reduced scan time by a factor of 2. The results of this were lower sample sizes and reductions in scan times on forebay aerial arrays at the cost of the abandonment of the tailrace aerial arrays. Doubling the receiver numbers at the forebay aerial arrays should have the net effect of increasing the detection efficiencies of the forebay aerial arrays over what they would have been if the tailrace receivers were not moved to the forebay, but likely resulted in reduced overall detection efficiencies from those expected if the coded transmitters were used.

As in 1999, the forebay residence times of juvenile steelhead appeared to be affected by fish size, but further analysis indicated this was not the case. When examined as fish smaller than 200 mm FL and those larger than that size, roughly the cutoff between wild and hatchery steelhead at John Day Dam, the small size group had lower median residence times. The median residence times of the small size group were similar to those of yearling chinook salmon. However, there were few juvenile steelhead less than 200 mm to examine (N = 8 during 0% spill conditions, N = 12 during 30% spill conditions), and a scatter plot of fork length and residence time of juvenile steelhead indicate no relation between these variables. Thus, the differences in residence times of juvenile steelhead in the two size groups is an artifact of the small sample size, rather than representing a true difference based on fish length. If information about passage of wild steelhead at John Day Dam is important to regional managers, we suggest experiments using these fish be conducted.

In summary, the results of the spring study were similar to those from a similar study in 1999 (Hansel et al. 2000). The results from both years indicate that the use of the 24-h spill treatment at John Day Dam decreases forebay residence times of fish arriving during the day, increases SPE of yearling chinook salmon, but does not significantly alter FPE from values obtained during the 12-h spill treatment. No hydroacoustic assessment of fish passage was conducted at John Day Dam during the spring of 2000. The results from the summer study were similar to those from the hydroacoustic assessment of subyearling chinook salmon passage of Moursund et al. (2001) and similar in general to the radio telemetry study of passage from 1999 (Hansel et al. 2000). Turbine passage was 12% lower, JBS passage was 17% lower and forebay residence times were shorter and less variable during the 24-h treatment than in the 12-h treatment. These reductions are considerably greater than reductions in the passage metrics of yearling chinook salmon and juvenile steelhead during the spring tests), suggesting greater benefits of the 24-h treatment to subyearling chinook salmon than to the spring migrants. Though not a primary goal of the 24-h spill evaluation, the reduction in JBS passage associated with the increased spill passage during 24-h spill may be beneficial, as a recent estimate of the relative survival of subyearling chinook salmon passing through the JBS indicated survival through this route was only 87%. This information suggests that evaluations of the routes of fish passage should be coupled with route-specific survival estimates to allow a more complete assessment of the overall effects of changes in fish passage routes based on changes in project operations or physical modifications. Expanding underwater antenna coverage at the powerhouse, adding a second detection array to the JBS, and continuing to use telemetry monitoring systems capable of detecting beeper and coded transmitters types will improve future telemetry studies of fish passage at John Day Dam.

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Appendices

Appendix A. – Spring spill treatments (DAY%/NIGHT%) for evaluating juvenile passage at John Day Dam in 2000. Three-day treatments alternate between the 0% to 30% daytime spill with 60% nighttime spill for both treatments.

Date	Block	Spill Level
02-May	1	0/60
03-May	1	0/60
04-May	1	0/60
05-May	1	30/60
06-May	1	30/60
07-May	1	30/60
08-May	2	0/60
09-May	2	0/60
10-May	2	0/60
11-May	2	30/60
12-May	2	30/60
13-May	2	30/60
14-May	3	0/60
15-May	3	0/60
16-May	3	0/60
17-May	3	30/60
18-May	3	30/60
19-May	3	30/60
20-May	4	0/60
21-May	4	0/60
22-May	4	0/60
23-May	4	30/60
24-May	4	30/60
25-May	4	30/60

Appendix B. Hourly spill discharge (SPILL), total discharge (TOTQ), and percent spill (SPILL_PCT) at John Day Dam (thousand cubic feet per second), 01 May through 31 May 2000.

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/01/00	0:00:00	117.7	383.0	30.7
05/01/00	1:00:00	115.3	278.2	41.4
05/01/00	2:00:00	115.2	239.3	48.1
05/01/00	3:00:00	117.4	205.2	57.2
05/01/00	4:00:00	115.2	199.3	57.8
05/01/00	5:00:00	115.3	200.4	57.5
05/01/00	6:00:00	96.3	210.4	45.8
05/01/00	7:00:00	0.0	258.2	0.0
05/01/00	8:00:00	0.0	269.9	0.0
05/01/00	9:00:00	0.0	275.1	0.0
05/01/00	10:00:00	0.0	269.1	0.0
05/01/00	11:00:00	0.0	270.1	0.0
05/01/00	12:00:00	0.0	268.1	0.0
05/01/00	13:00:00	0.0	269.8	0.0
05/01/00	14:00:00	0.0	270.0	0.0
05/01/00	15:00:00	0.0	275.5	0.0
05/01/00	16:00:00	0.0	269.7	0.0
05/01/00	17:00:00	0.0	268.5	0.0
05/01/00	18:00:00	5.3	269.6	2.0
05/01/00	19:00:00	119.7	364.7	32.8
05/01/00	20:00:00	119.0	383.1	31.1
05/01/00	21:00:00	120.8	390.3	31.0
05/01/00	22:00:00	118.9	387.1	30.7
05/01/00	23:00:00	118.5	384.1	30.9
05/02/00	0:00:00	124.6	287.4	43.4
05/02/00	1:00:00	118.7	339.7	34.9
05/02/00	2:00:00	118.4	297.7	39.8
05/02/00	3:00:00	118.2	296.5	39.9
05/02/00	4:00:00	120.2	301.8	39.8
05/02/00	5:00:00	118.2	299.3	39.5
05/02/00	6:00:00	108.8	297.1	36.6
05/02/00	7:00:00	0.0	269.2	0.0
05/02/00	8:00:00	0.0	268.5	0.0
05/02/00	9:00:00	0.0	268.8	0.0
05/02/00	10:00:00	0.0	272.4	0.0
05/02/00	11:00:00	0.0	279.0	0.0
05/02/00	12:00:00	0.0	270.5	0.0
05/02/00	13:00:00	0.0	270.4	0.0
05/02/00	14:00:00	0.0	217.7	0.0
05/02/00	15:00:00	0.0	270.3	0.0
05/02/00	16:00:00	0.0	267.9	0.0

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/02/00	17:00:00	0.0	265.5	0.0
05/02/00	18:00:00	3.7	273.6	1.4
05/02/00	19:00:00	126.1	324.8	38.8
05/02/00	20:00:00	124.5	316.5	39.3
05/02/00	21:00:00	124.5	316.2	39.4
05/02/00	22:00:00	124.5	314.3	39.6
05/02/00	23:00:00	124.4	287.2	43.3
05/03/00	0:00:00	133.0	323.6	41.1
05/03/00	1:00:00	124.5	288.2	43.2
05/03/00	2:00:00	124.6	301.1	41.4
05/03/00	3:00:00	126.8	320.7	39.5
05/03/00	4:00:00	124.4	330.8	37.6
05/03/00	5:00:00	124.4	359.5	34.6
05/03/00	6:00:00	112.3	327.7	34.3
05/03/00	7:00:00	1.6	249.0	0.6
05/03/00	8:00:00	0.1	246.3	0.0
05/03/00	9:00:00	0.0	264.4	0.0
05/03/00	10:00:00	0.0	281.3	0.0
05/03/00	11:00:00	0.0	282.0	0.0
05/03/00	12:00:00	0.0	260.5	0.0
05/03/00	13:00:00	0.0	249.4	0.0
05/03/00	14:00:00	0.0	247.7	0.0
05/03/00	15:00:00	0.0	243.7	0.0
05/03/00	16:00:00	0.0	243.2	0.0
05/03/00	17:00:00	0.0	243.6	0.0
05/03/00	18:00:00	11.4	258.4	4.4
05/03/00	19:00:00	133.4	297.5	44.8
05/03/00	20:00:00	134.0	336.6	39.8
05/03/00	21:00:00	133.3	311.6	42.8
05/03/00	22:00:00	132.6	309.8	42.8
05/03/00	23:00:00	132.7	311.4	42.6
05/04/00	0:00:00	139.8	307.1	45.5
05/04/00	1:00:00	135.3	331.8	40.8
05/04/00	2:00:00	133.2	326.1	40.8
05/04/00	3:00:00	133.4	326.0	40.9
05/04/00	4:00:00	132.9	326.8	40.7
05/04/00	5:00:00	133.1	353.7	37.6
05/04/00	6:00:00	122.9	349.5	35.2
05/04/00	7:00:00	0.0	271.8	0.0
05/04/00	8:00:00	0.0	273.3	0.0
05/04/00	9:00:00	0.0	269.5	0.0

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/04/00	10:00:00	0.0	270.3	0.0
05/04/00	11:00:00	0.0	274.0	0.0
05/04/00	12:00:00	0.0	270.5	0.0
05/04/00	13:00:00	0.0	248.3	0.0
05/04/00	14:00:00	0.0	243.6	0.0
05/04/00	15:00:00	0.0	267.1	0.0
05/04/00	16:00:00	0.0	270.1	0.0
05/04/00	17:00:00	0.0	268.7	0.0
05/04/00	18:00:00	0.0	264.8	0.0
05/04/00	19:00:00	138.3	324.5	42.6
05/04/00	20:00:00	141.7	339.7	41.7
05/04/00	21:00:00	139.2	348.6	39.9
05/04/00	22:00:00	139.2	339.8	41.0
05/04/00	23:00:00	139.4	327.8	42.5
05/05/00	0:00:00	142.5	286.2	49.8
05/05/00	1:00:00	140.0	275.6	50.8
05/05/00	2:00:00	139.8	254.5	54.9
05/05/00	3:00:00	141.8	254.6	55.7
05/05/00	4:00:00	139.3	252.6	55.1
05/05/00	5:00:00	139.4	269.8	51.7
05/05/00	6:00:00	137.5	274.1	50.2
05/05/00	7:00:00	94.9	297.9	31.9
05/05/00	8:00:00	101.2	347.3	29.1
05/05/00	9:00:00	102.0	352.9	28.9
05/05/00	10:00:00	101.5	340.3	29.8
05/05/00	11:00:00	95.3	317.1	30.1
05/05/00	12:00:00	109.2	365.8	29.9
05/05/00	13:00:00	106.2	349.4	30.4
05/05/00	14:00:00	89.9	299.7	30.0
05/05/00	15:00:00	90.0	296.4	30.4
05/05/00	16:00:00	83.4	279.5	29.8
05/05/00	17:00:00	88.6	299.2	29.6
05/05/00	18:00:00	89.7	293.7	30.5
05/05/00	19:00:00	140.7	291.2	48.3
05/05/00	20:00:00	140.2	288.2	48.6
05/05/00	21:00:00	139.9	288.6	48.5
05/05/00	22:00:00	139.7	295.0	47.4
05/05/00	23:00:00	140.1	297.0	47.2
05/06/00	0:00:00	139.3	283.4	49.2
05/06/00	1:00:00	139.9	281.0	49.8
05/06/00	2:00:00	140.1	276.7	50.6
05/06/00	3:00:00	140.1	273.4	51.2

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/06/00	4:00:00	140.1	273.2	51.3
05/06/00	5:00:00	140.1	275.5	50.9
05/06/00	6:00:00	140.0	273.3	51.2
05/06/00	7:00:00	91.3	296.5	30.8
05/06/00	8:00:00	84.4	290.2	29.1
05/06/00	9:00:00	84.7	280.1	30.2
05/06/00	10:00:00	90.0	299.4	30.1
05/06/00	11:00:00	96.4	321.0	30.0
05/06/00	12:00:00	96.1	320.3	30.0
05/06/00	13:00:00	95.7	320.6	29.9
05/06/00	14:00:00	98.1	329.7	29.8
05/06/00	15:00:00	101.3	340.0	29.8
05/06/00	16:00:00	89.8	298.5	30.1
05/06/00	17:00:00	90.3	299.0	30.2
05/06/00	18:00:00	106.5	343.8	31.0
05/06/00	19:00:00	139.5	342.7	40.7
05/06/00	20:00:00	139.4	321.6	43.3
05/06/00	21:00:00	139.5	321.9	43.3
05/06/00	22:00:00	141.8	340.1	41.7
05/06/00	23:00:00	139.2	304.1	45.8
05/07/00	0:00:00	135.0	226.4	59.6
05/07/00	1:00:00	139.4	283.4	49.2
05/07/00	2:00:00	139.4	265.2	52.6
05/07/00	3:00:00	139.2	263.7	52.8
05/07/00	4:00:00	141.9	272.0	52.2
05/07/00	5:00:00	139.4	264.7	52.7
05/07/00	6:00:00	137.9	265.9	51.9
05/07/00	7:00:00	78.6	258.0	30.5
05/07/00	8:00:00	77.6	256.8	30.2
05/07/00	9:00:00	77.7	256.7	30.3
05/07/00	10:00:00	77.4	263.8	29.3
05/07/00	11:00:00	78.8	261.7	30.1
05/07/00	12:00:00	77.4	257.0	30.1
05/07/00	13:00:00	77.4	258.9	29.9
05/07/00	14:00:00	77.5	257.1	30.1
05/07/00	15:00:00	85.9	292.1	29.4
05/07/00	16:00:00	86.0	291.6	29.5
05/07/00	17:00:00	80.3	264.6	30.3
05/07/00	18:00:00	82.0	259.0	31.7
05/07/00	19:00:00	139.0	265.3	52.4
05/07/00	20:00:00	139.0	274.3	50.7
05/07/00	21:00:00	138.9	304.1	45.7

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/07/00	22:00:00	139.1	276.7	50.3
05/07/00	23:00:00	138.4	273.7	50.6
05/08/00	0:00:00	139.2	304.3	45.7
05/08/00	1:00:00	137.4	229.6	59.8
05/08/00	2:00:00	135.4	226.4	59.8
05/08/00	3:00:00	138.6	245.9	56.4
05/08/00	4:00:00	138.5	248.8	55.7
05/08/00	5:00:00	138.7	270.3	51.3
05/08/00	6:00:00	127.1	266.5	47.7
05/08/00	7:00:00	0.0	277.2	0.0
05/08/00	8:00:00	0.0	298.0	0.0
05/08/00	9:00:00	0.0	295.8	0.0
05/08/00	10:00:00	0.0	292.3	0.0
05/08/00	11:00:00	0.0	268.2	0.0
05/08/00	12:00:00	0.0	271.8	0.0
05/08/00	13:00:00	0.0	274.2	0.0
05/08/00	14:00:00	0.0	281.4	0.0
05/08/00	15:00:00	0.0	273.8	0.0
05/08/00	16:00:00	0.0	261.8	0.0
05/08/00	17:00:00	0.0	257.6	0.0
05/08/00	18:00:00	0.0	259.4	0.0
05/08/00	19:00:00	108.9	279.8	38.9
05/08/00	20:00:00	138.9	304.0	45.7
05/08/00	21:00:00	141.5	310.1	45.6
05/08/00	22:00:00	139.1	304.2	45.7
05/08/00	23:00:00	139.5	302.2	46.2
05/09/00	0:00:00	139.4	246.2	56.6
05/09/00	1:00:00	139.1	303.9	45.8
05/09/00	2:00:00	139.2	302.3	46.0
05/09/00	3:00:00	139.2	302.1	46.1
05/09/00	4:00:00	141.7	308.5	45.9
05/09/00	5:00:00	139.2	305.9	45.5
05/09/00	6:00:00	128.8	314.4	41.0
05/09/00	7:00:00	0.0	286.0	0.0
05/09/00	8:00:00	0.0	285.0	0.0
05/09/00	9:00:00	0.0	285.0	0.0
05/09/00	10:00:00	0.0	278.7	0.0
05/09/00	11:00:00	0.0	257.3	0.0
05/09/00	12:00:00	0.0	259.4	0.0
05/09/00	13:00:00	0.0	257.4	0.0
05/09/00	14:00:00	0.0	255.2	0.0
05/09/00	15:00:00	0.0	250.6	0.0

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/09/00	16:00:00	0.0	244.1	0.0
05/09/00	17:00:00	0.0	234.9	0.0
05/09/00	18:00:00	0.8	215.8	0.4
05/09/00	19:00:00	134.0	273.6	49.0
05/09/00	20:00:00	138.4	314.6	44.0
05/09/00	21:00:00	138.6	312.5	44.4
05/09/00	22:00:00	139.2	251.2	55.4
05/09/00	23:00:00	139.3	245.7	56.7
05/10/00	0:00:00	147.2	256.9	57.3
05/10/00	1:00:00	139.3	245.7	56.7
05/10/00	2:00:00	139.3	247.4	56.3
05/10/00	3:00:00	141.9	252.1	56.3
05/10/00	4:00:00	139.4	248.2	56.2
05/10/00	5:00:00	139.3	246.4	56.5
05/10/00	6:00:00	127.4	246.5	51.7
05/10/00	7:00:00	0.0	247.9	0.0
05/10/00	8:00:00	0.0	272.9	0.0
05/10/00	9:00:00	0.0	275.0	0.0
05/10/00	10:00:00	0.0	271.5	0.0
05/10/00	11:00:00	0.0	260.0	0.0
05/10/00	12:00:00	0.0	259.2	0.0
05/10/00	13:00:00	0.0	259.9	0.0
05/10/00	14:00:00	0.0	256.1	0.0
05/10/00	15:00:00	0.0	253.9	0.0
05/10/00	16:00:00	0.0	260.2	0.0
05/10/00	17:00:00	0.0	256.5	0.0
05/10/00	18:00:00	1.1	251.0	0.4
05/10/00	19:00:00	141.1	280.3	50.3
05/10/00	20:00:00	144.9	277.2	52.3
05/10/00	21:00:00	145.0	284.5	51.0
05/10/00	22:00:00	144.8	273.3	53.0
05/10/00	23:00:00	144.6	270.6	53.4
05/11/00	0:00:00	144.6	254.8	56.8
05/11/00	1:00:00	144.5	251.2	57.5
05/11/00	2:00:00	144.5	251.8	57.4
05/11/00	3:00:00	132.6	223.1	59.4
05/11/00	4:00:00	125.4	206.4	60.8
05/11/00	5:00:00	126.9	208.8	60.8
05/11/00	6:00:00	140.4	245.6	57.2
05/11/00	7:00:00	88.1	286.6	30.7
05/11/00	8:00:00	86.2	283.3	30.4
05/11/00	9:00:00	87.0	298.3	29.2

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/11/00	10:00:00	95.0	318.1	29.9
05/11/00	11:00:00	95.0	316.0	30.1
05/11/00	12:00:00	95.0	316.0	30.1
05/11/00	13:00:00	87.0	299.1	29.1
05/11/00	14:00:00	80.0	276.8	28.9
05/11/00	15:00:00	80.0	270.3	29.6
05/11/00	16:00:00	80.0	258.3	31.0
05/11/00	17:00:00	74.8	252.0	29.7
05/11/00	18:00:00	74.2	236.7	31.3
05/11/00	19:00:00	138.1	285.2	48.4
05/11/00	20:00:00	143.6	299.6	47.9
05/11/00	21:00:00	149.7	323.2	46.3
05/11/00	22:00:00	146.2	300.2	48.7
05/11/00	23:00:00	144.6	254.6	56.8
05/12/00	0:00:00	144.3	270.5	53.3
05/12/00	1:00:00	144.5	253.0	57.1
05/12/00	2:00:00	144.6	252.3	57.3
05/12/00	3:00:00	144.5	251.0	57.6
05/12/00	4:00:00	147.2	256.5	57.4
05/12/00	5:00:00	144.6	253.4	57.1
05/12/00	6:00:00	139.0	282.8	49.2
05/12/00	7:00:00	89.2	299.3	29.8
05/12/00	8:00:00	88.6	301.6	29.4
05/12/00	9:00:00	88.6	300.9	29.4
05/12/00	10:00:00	88.6	292.9	30.2
05/12/00	11:00:00	90.0	295.4	30.5
05/12/00	12:00:00	79.8	268.4	29.7
05/12/00	13:00:00	79.2	266.5	29.7
05/12/00	14:00:00	79.4	268.9	29.5
05/12/00	15:00:00	79.2	266.3	29.7
05/12/00	16:00:00	79.2	248.6	31.9
05/12/00	17:00:00	79.3	245.9	32.2
05/12/00	18:00:00	80.7	250.3	32.2
05/12/00	19:00:00	134.4	281.8	47.7
05/12/00	20:00:00	144.1	291.3	49.5
05/12/00	21:00:00	144.4	287.5	50.2
05/12/00	22:00:00	144.3	284.8	50.7
05/12/00	23:00:00	144.4	271.8	53.1
05/13/00	0:00:00	144.6	254.5	56.8
05/13/00	1:00:00	146.9	264.0	55.6
05/13/00	2:00:00	144.4	245.0	58.9
05/13/00	3:00:00	144.3	242.0	59.6

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/13/00	4:00:00	144.0	236.9	60.8
05/13/00	5:00:00	137.6	230.1	59.8
05/13/00	6:00:00	136.8	228.0	60.0
05/13/00	7:00:00	70.6	222.1	31.8
05/13/00	8:00:00	68.6	228.3	30.0
05/13/00	9:00:00	67.4	221.9	30.4
05/13/00	10:00:00	67.2	220.8	30.4
05/13/00	11:00:00	67.1	220.2	30.5
05/13/00	12:00:00	67.2	221.6	30.3
05/13/00	13:00:00	67.2	219.9	30.6
05/13/00	14:00:00	67.1	219.7	30.5
05/13/00	15:00:00	68.3	225.1	30.3
05/13/00	16:00:00	67.1	219.1	30.6
05/13/00	17:00:00	67.8	223.7	30.3
05/13/00	18:00:00	73.5	243.5	30.2
05/13/00	19:00:00	139.9	253.1	55.3
05/13/00	20:00:00	144.5	252.9	57.1
05/13/00	21:00:00	147.1	257.5	57.1
05/13/00	22:00:00	144.7	253.1	57.2
05/13/00	23:00:00	144.5	252.4	57.3
05/14/00	0:00:00	144.4	294.4	49.0
05/14/00	1:00:00	144.5	252.7	57.2
05/14/00	2:00:00	144.6	252.6	57.2
05/14/00	3:00:00	144.6	252.5	57.3
05/14/00	4:00:00	147.2	257.2	57.2
05/14/00	5:00:00	144.5	254.3	56.8
05/14/00	6:00:00	134.6	244.4	55.1
05/14/00	7:00:00	0.1	223.3	0.0
05/14/00	8:00:00	0.0	255.3	0.0
05/14/00	9:00:00	0.0	256.3	0.0
05/14/00	10:00:00	0.0	254.1	0.0
05/14/00	11:00:00	0.0	259.0	0.0
05/14/00	12:00:00	0.0	252.1	0.0
05/14/00	13:00:00	0.0	253.1	0.0
05/14/00	14:00:00	0.0	251.1	0.0
05/14/00	15:00:00	0.0	250.7	0.0
05/14/00	16:00:00	0.0	230.5	0.0
05/14/00	17:00:00	0.0	231.9	0.0
05/14/00	18:00:00	0.0	231.7	0.0
05/14/00	19:00:00	127.9	294.8	43.4
05/14/00	20:00:00	144.2	310.2	46.5
05/14/00	21:00:00	144.3	309.6	46.6

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/14/00	22:00:00	144.4	319.0	45.3
05/14/00	23:00:00	144.4	321.6	44.9
05/15/00	0:00:00	145.7	293.9	49.6
05/15/00	1:00:00	144.4	296.1	48.8
05/15/00	2:00:00	146.9	301.0	48.8
05/15/00	3:00:00	144.2	292.3	49.3
05/15/00	4:00:00	144.3	254.4	56.7
05/15/00	5:00:00	144.2	256.4	56.2
05/15/00	6:00:00	140.3	288.4	48.6
05/15/00	7:00:00	1.6	252.9	0.6
05/15/00	8:00:00	0.0	252.8	0.0
05/15/00	9:00:00	0.0	251.1	0.0
05/15/00	10:00:00	0.0	253.7	0.0
05/15/00	11:00:00	0.0	227.2	0.0
05/15/00	12:00:00	0.0	226.3	0.0
05/15/00	13:00:00	0.0	232.1	0.0
05/15/00	14:00:00	0.0	249.7	0.0
05/15/00	15:00:00	0.0	252.9	0.0
05/15/00	16:00:00	0.0	224.5	0.0
05/15/00	17:00:00	0.0	201.2	0.0
05/15/00	18:00:00	0.0	207.3	0.0
05/15/00	19:00:00	143.6	310.5	46.2
05/15/00	20:00:00	144.9	310.9	46.6
05/15/00	21:00:00	145.0	311.2	46.6
05/15/00	22:00:00	145.4	308.5	47.1
05/15/00	23:00:00	145.5	295.9	49.2
05/16/00	0:00:00	145.8	227.1	64.2
05/16/00	1:00:00	145.7	274.3	53.1
05/16/00	2:00:00	145.7	273.3	53.3
05/16/00	3:00:00	148.2	258.4	57.4
05/16/00	4:00:00	145.6	253.2	57.5
05/16/00	5:00:00	145.3	265.7	54.7
05/16/00	6:00:00	137.5	263.0	52.3
05/16/00	7:00:00	0.0	229.5	0.0
05/16/00	8:00:00	0.0	243.9	0.0
05/16/00	9:00:00	0.0	249.1	0.0
05/16/00	10:00:00	0.0	247.3	0.0
05/16/00	11:00:00	0.0	227.7	0.0
05/16/00	12:00:00	0.0	227.3	0.0
05/16/00	13:00:00	0.0	221.5	0.0
05/16/00	14:00:00	0.0	214.3	0.0
05/16/00	15:00:00	0.0	203.4	0.0

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/16/00	16:00:00	0.0	203.6	0.0
05/16/00	17:00:00	0.0	203.3	0.0
05/16/00	18:00:00	0.0	202.4	0.0
05/16/00	19:00:00	15.6	222.4	7.0
05/16/00	20:00:00	147.6	251.0	58.8
05/16/00	21:00:00	145.2	243.3	59.7
05/16/00	22:00:00	145.6	243.9	59.7
05/16/00	23:00:00	145.7	245.0	59.5
05/17/00	0:00:00	145.9	251.9	57.9
05/17/00	1:00:00	145.7	201.5	72.3
05/17/00	2:00:00	145.8	201.2	72.5
05/17/00	3:00:00	145.8	201.3	72.4
05/17/00	4:00:00	142.9	199.6	71.6
05/17/00	5:00:00	123.7	206.2	60.0
05/17/00	6:00:00	129.2	220.0	58.7
05/17/00	7:00:00	74.9	249.7	30.0
05/17/00	8:00:00	74.5	252.5	29.5
05/17/00	9:00:00	74.5	250.0	29.8
05/17/00	10:00:00	74.4	251.7	29.6
05/17/00	11:00:00	73.6	252.2	29.2
05/17/00	12:00:00	68.2	233.5	29.2
05/17/00	13:00:00	69.4	234.0	29.7
05/17/00	14:00:00	68.2	230.3	29.6
05/17/00	15:00:00	68.1	233.3	29.2
05/17/00	16:00:00	68.2	230.1	29.6
05/17/00	17:00:00	68.2	230.1	29.6
05/17/00	18:00:00	68.6	229.2	29.9
05/17/00	19:00:00	79.4	254.4	31.2
05/17/00	20:00:00	146.2	263.8	55.4
05/17/00	21:00:00	149.1	268.2	55.6
05/17/00	22:00:00	146.4	260.2	56.3
05/17/00	23:00:00	146.5	251.6	58.2
05/18/00	0:00:00	142.7	239.2	59.7
05/18/00	1:00:00	142.9	244.8	58.4
05/18/00	2:00:00	126.3	217.1	58.2
05/18/00	3:00:00	142.6	245.6	58.1
05/18/00	4:00:00	144.4	247.3	58.4
05/18/00	5:00:00	146.9	251.2	58.5
05/18/00	6:00:00	135.9	239.5	56.7
05/18/00	7:00:00	65.4	217.3	30.1
05/18/00	8:00:00	75.7	240.8	31.4
05/18/00	9:00:00	76.3	244.9	31.2

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/18/00	10:00:00	76.3	245.1	31.1
05/18/00	11:00:00	76.5	245.2	31.2
05/18/00	12:00:00	79.3	263.1	30.1
05/18/00	13:00:00	80.7	267.8	30.1
05/18/00	14:00:00	79.3	272.7	29.1
05/18/00	15:00:00	79.4	271.4	29.3
05/18/00	16:00:00	79.4	270.2	29.4
05/18/00	17:00:00	79.5	272.9	29.1
05/18/00	18:00:00	79.4	270.7	29.3
05/18/00	19:00:00	140.8	283.6	49.6
05/18/00	20:00:00	148.1	288.1	51.4
05/18/00	21:00:00	144.8	281.7	51.4
05/18/00	22:00:00	144.0	280.4	51.4
05/18/00	23:00:00	143.9	276.1	52.1
05/19/00	0:00:00	145.0	238.9	60.7
05/19/00	1:00:00	128.8	216.3	59.5
05/19/00	2:00:00	126.6	211.9	59.7
05/19/00	3:00:00	126.5	211.8	59.7
05/19/00	4:00:00	126.5	213.7	59.2
05/19/00	5:00:00	126.5	211.8	59.7
05/19/00	6:00:00	124.5	216.6	57.5
05/19/00	7:00:00	65.6	208.9	31.4
05/19/00	8:00:00	66.0	211.5	31.2
05/19/00	9:00:00	70.8	230.3	30.7
05/19/00	10:00:00	74.8	238.8	31.3
05/19/00	11:00:00	76.2	251.1	30.3
05/19/00	12:00:00	75.2	240.2	31.3
05/19/00	13:00:00	78.0	253.5	30.8
05/19/00	14:00:00	78.0	263.5	29.6
05/19/00	15:00:00	77.9	263.9	29.5
05/19/00	16:00:00	77.9	257.1	30.3
05/19/00	17:00:00	79.3	257.9	30.7
05/19/00	18:00:00	77.9	253.1	30.8
05/19/00	19:00:00	84.1	255.2	33.0
05/19/00	20:00:00	149.4	260.5	57.4
05/19/00	21:00:00	149.3	268.5	55.6
05/19/00	22:00:00	152.0	272.7	55.7
05/19/00	23:00:00	149.5	256.7	58.2
05/20/00	0:00:00	150.4	313.4	48.0
05/20/00	1:00:00	144.2	238.9	60.4
05/20/00	2:00:00	144.0	237.7	60.6
05/20/00	3:00:00	144.1	237.8	60.6

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/20/00	4:00:00	144.4	239.9	60.2
05/20/00	5:00:00	144.3	239.4	60.3
05/20/00	6:00:00	141.6	238.6	59.3
05/20/00	7:00:00	5.4	189.3	2.9
05/20/00	8:00:00	0.0	204.9	0.0
05/20/00	9:00:00	0.0	206.3	0.0
05/20/00	10:00:00	0.0	212.4	0.0
05/20/00	11:00:00	0.0	213.2	0.0
05/20/00	12:00:00	0.0	221.7	0.0
05/20/00	13:00:00	0.0	232.8	0.0
05/20/00	14:00:00	0.0	233.4	0.0
05/20/00	15:00:00	0.0	235.7	0.0
05/20/00	16:00:00	0.0	232.9	0.0
05/20/00	17:00:00	0.0	231.5	0.0
05/20/00	18:00:00	10.0	237.4	4.2
05/20/00	19:00:00	150.4	291.2	51.6
05/20/00	20:00:00	150.4	292.4	51.4
05/20/00	21:00:00	150.4	290.4	51.8
05/20/00	22:00:00	150.5	290.1	51.9
05/20/00	23:00:00	153.3	299.6	51.2
05/21/00	0:00:00	151.1	281.6	53.7
05/21/00	1:00:00	150.6	314.2	47.9
05/21/00	2:00:00	150.5	313.6	48.0
05/21/00	3:00:00	150.6	306.3	49.2
05/21/00	4:00:00	150.5	305.8	49.2
05/21/00	5:00:00	150.7	304.7	49.5
05/21/00	6:00:00	144.8	301.9	48.0
05/21/00	7:00:00	2.2	278.6	0.8
05/21/00	8:00:00	0.0	260.4	0.0
05/21/00	9:00:00	0.0	262.6	0.0
05/21/00	10:00:00	0.0	221.9	0.0
05/21/00	11:00:00	0.0	214.1	0.0
05/21/00	12:00:00	0.0	170.9	0.0
05/21/00	13:00:00	0.0	184.1	0.0
05/21/00	14:00:00	0.0	210.0	0.0
05/21/00	15:00:00	0.0	188.9	0.0
05/21/00	16:00:00	0.0	175.7	0.0
05/21/00	17:00:00	0.0	175.7	0.0
05/21/00	18:00:00	0.0	184.9	0.0
05/21/00	19:00:00	13.4	222.6	6.0
05/21/00	20:00:00	150.2	256.2	58.6
05/21/00	21:00:00	150.6	264.6	56.9

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/21/00	22:00:00	151.1	269.9	56.0
05/21/00	23:00:00	151.0	280.1	53.9
05/22/00	0:00:00	155.4	290.6	53.5
05/22/00	1:00:00	153.8	276.5	55.6
05/22/00	2:00:00	151.2	257.0	58.8
05/22/00	3:00:00	150.0	243.8	61.5
05/22/00	4:00:00	134.7	222.5	60.5
05/22/00	5:00:00	134.7	222.5	60.5
05/22/00	6:00:00	126.9	218.8	58.0
05/22/00	7:00:00	0.9	214.8	0.4
05/22/00	8:00:00	0.0	193.1	0.0
05/22/00	9:00:00	0.0	203.4	0.0
05/22/00	10:00:00	0.0	217.6	0.0
05/22/00	11:00:00	0.0	212.8	0.0
05/22/00	12:00:00	0.0	212.4	0.0
05/22/00	13:00:00	0.0	212.8	0.0
05/22/00	14:00:00	0.0	219.2	0.0
05/22/00	15:00:00	0.0	237.6	0.0
05/22/00	16:00:00	0.0	239.0	0.0
05/22/00	17:00:00	0.0	245.1	0.0
05/22/00	18:00:00	0.0	237.9	0.0
05/22/00	19:00:00	10.1	242.0	4.2
05/22/00	20:00:00	155.3	280.1	55.4
05/22/00	21:00:00	155.4	296.5	52.4
05/22/00	22:00:00	155.4	289.1	53.8
05/22/00	23:00:00	155.3	289.4	53.7
05/23/00	0:00:00	160.0	268.0	59.7
05/23/00	1:00:00	158.1	295.7	53.5
05/23/00	2:00:00	155.3	290.0	53.6
05/23/00	3:00:00	155.3	261.9	59.3
05/23/00	4:00:00	155.4	240.0	64.8
05/23/00	5:00:00	155.4	240.0	64.8
05/23/00	6:00:00	149.4	237.5	62.9
05/23/00	7:00:00	72.6	236.2	30.7
05/23/00	8:00:00	78.7	262.8	29.9
05/23/00	9:00:00	80.2	273.3	29.3
05/23/00	10:00:00	90.0	305.6	29.5
05/23/00	11:00:00	96.7	320.8	30.1
05/23/00	12:00:00	96.7	317.7	30.4
05/23/00	13:00:00	96.7	320.8	30.1
05/23/00	14:00:00	96.4	319.4	30.2
05/23/00	15:00:00	96.5	320.4	30.1

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/23/00	16:00:00	96.5	322.9	29.9
05/23/00	17:00:00	96.5	320.5	30.1
05/23/00	18:00:00	96.5	320.5	30.1
05/23/00	19:00:00	96.5	320.5	30.1
05/23/00	20:00:00	128.5	336.7	38.2
05/23/00	21:00:00	160.0	317.8	50.3
05/23/00	22:00:00	160.0	311.5	51.4
05/23/00	23:00:00	160.0	301.3	53.1
05/24/00	0:00:00	160.0	313.9	51.0
05/24/00	1:00:00	159.9	268.3	59.6
05/24/00	2:00:00	159.9	268.3	59.6
05/24/00	3:00:00	159.9	268.3	59.6
05/24/00	4:00:00	150.9	249.9	60.4
05/24/00	5:00:00	150.9	259.3	58.2
05/24/00	6:00:00	136.7	250.2	54.6
05/24/00	7:00:00	80.0	248.1	32.2
05/24/00	8:00:00	80.0	268.8	29.8
05/24/00	9:00:00	80.0	272.0	29.4
05/24/00	10:00:00	80.0	275.4	29.0
05/24/00	11:00:00	80.0	275.4	29.0
05/24/00	12:00:00	80.1	275.5	29.1
05/24/00	13:00:00	80.0	273.6	29.2
05/24/00	14:00:00	80.0	273.6	29.2
05/24/00	15:00:00	80.0	273.3	29.3
05/24/00	16:00:00	80.0	272.6	29.3
05/24/00	17:00:00	80.0	272.6	29.3
05/24/00	18:00:00	80.0	272.9	29.3
05/24/00	19:00:00	95.0	282.5	33.6
05/24/00	20:00:00	160.0	297.9	53.7
05/24/00	21:00:00	160.0	294.8	54.3
05/24/00	22:00:00	160.0	294.8	54.3
05/24/00	23:00:00	160.0	292.5	54.7
05/25/00	0:00:00	146.8	246.5	59.6
05/25/00	1:00:00	160.0	272.7	58.7
05/25/00	2:00:00	160.0	270.9	59.1
05/25/00	3:00:00	160.0	270.9	59.1
05/25/00	4:00:00	160.0	272.7	58.7
05/25/00	5:00:00	160.0	272.7	58.7
05/25/00	6:00:00	160.0	269.7	59.3
05/25/00	7:00:00	78.4	265.1	29.6
05/25/00	8:00:00	78.0	262.9	29.7
05/25/00	9:00:00	78.0	261.6	29.8

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/25/00	10:00:00	85.0	270.8	31.4
05/25/00	11:00:00	85.0	289.2	29.4
05/25/00	12:00:00	90.0	285.6	31.5
05/25/00	13:00:00	90.0	280.7	32.1
05/25/00	14:00:00	90.0	263.3	34.2
05/25/00	15:00:00	90.0	278.9	32.3
05/25/00	16:00:00	90.0	281.5	32.0
05/25/00	17:00:00	90.7	280.8	32.3
05/25/00	18:00:00	90.8	281.9	32.2
05/25/00	19:00:00	95.4	272.4	35.0
05/25/00	20:00:00	158.9	295.0	53.9
05/25/00	21:00:00	162.8	299.0	54.4
05/25/00	22:00:00	160.2	293.3	54.6
05/25/00	23:00:00	144.8	237.7	60.9
05/26/00	0:00:00	141.5	227.0	62.3
05/26/00	1:00:00	144.1	242.4	59.4
05/26/00	2:00:00	143.8	242.1	59.4
05/26/00	3:00:00	143.7	242.9	59.2
05/26/00	4:00:00	143.9	242.4	59.4
05/26/00	5:00:00	146.6	248.2	59.1
05/26/00	6:00:00	140.0	245.8	57.0
05/26/00	7:00:00	0.3	226.4	0.1
05/26/00	8:00:00	0.0	227.3	0.0
05/26/00	9:00:00	0.0	231.3	0.0
05/26/00	10:00:00	0.0	229.1	0.0
05/26/00	11:00:00	0.0	201.8	0.0
05/26/00	12:00:00	0.0	197.4	0.0
05/26/00	13:00:00	0.0	199.5	0.0
05/26/00	14:00:00	0.0	187.3	0.0
05/26/00	15:00:00	0.0	188.0	0.0
05/26/00	16:00:00	0.0	190.6	0.0
05/26/00	17:00:00	0.0	187.3	0.0
05/26/00	18:00:00	0.0	190.5	0.0
05/26/00	19:00:00	2.4	163.9	1.5
05/26/00	20:00:00	100.4	176.1	57.0
05/26/00	21:00:00	116.4	182.8	63.7
05/26/00	22:00:00	116.4	190.7	61.0
05/26/00	23:00:00	132.3	204.9	64.6
05/27/00	0:00:00	152.3	254.4	59.9
05/27/00	1:00:00	143.7	239.7	59.9
05/27/00	2:00:00	144.0	242.3	59.4
05/27/00	3:00:00	144.0	238.8	60.3

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/27/00	4:00:00	144.3	240.2	60.1
05/27/00	5:00:00	146.7	243.7	60.2
05/27/00	6:00:00	141.3	239.3	59.0
05/27/00	7:00:00	0.0	235.1	0.0
05/27/00	8:00:00	0.0	244.6	0.0
05/27/00	9:00:00	0.0	248.2	0.0
05/27/00	10:00:00	0.0	250.2	0.0
05/27/00	11:00:00	0.0	252.2	0.0
05/27/00	12:00:00	0.0	229.9	0.0
05/27/00	13:00:00	0.0	230.4	0.0
05/27/00	14:00:00	0.0	229.4	0.0
05/27/00	15:00:00	0.0	232.6	0.0
05/27/00	16:00:00	0.0	228.6	0.0
05/27/00	17:00:00	0.0	229.3	0.0
05/27/00	18:00:00	0.0	189.5	0.0
05/27/00	19:00:00	0.0	182.4	0.0
05/27/00	20:00:00	108.5	193.6	56.0
05/27/00	21:00:00	120.7	202.3	59.7
05/27/00	22:00:00	135.5	226.7	59.8
05/27/00	23:00:00	149.5	251.2	59.5
05/28/00	0:00:00	144.8	242.4	59.7
05/28/00	1:00:00	149.8	251.1	59.7
05/28/00	2:00:00	149.6	251.1	59.6
05/28/00	3:00:00	149.5	252.7	59.2
05/28/00	4:00:00	149.5	251.0	59.6
05/28/00	5:00:00	149.6	250.7	59.7
05/28/00	6:00:00	120.5	215.3	56.0
05/28/00	7:00:00	0.0	199.6	0.0
05/28/00	8:00:00	0.0	218.6	0.0
05/28/00	9:00:00	0.0	247.8	0.0
05/28/00	10:00:00	0.0	245.4	0.0
05/28/00	11:00:00	0.0	229.8	0.0
05/28/00	12:00:00	0.0	211.0	0.0
05/28/00	13:00:00	0.0	216.1	0.0
05/28/00	14:00:00	0.0	228.5	0.0
05/28/00	15:00:00	0.0	234.2	0.0
05/28/00	16:00:00	0.0	223.0	0.0
05/28/00	17:00:00	0.0	222.6	0.0
05/28/00	18:00:00	0.0	225.6	0.0
05/28/00	19:00:00	6.4	233.4	2.7
05/28/00	20:00:00	141.3	243.4	58.1
05/28/00	21:00:00	143.6	240.4	59.7

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/28/00	22:00:00	144.5	241.6	59.8
05/28/00	23:00:00	147.3	245.9	59.9
05/29/00	0:00:00	120.2	199.1	60.4
05/29/00	1:00:00	144.8	241.3	60.0
05/29/00	2:00:00	133.8	217.1	61.6
05/29/00	3:00:00	119.3	199.1	59.9
05/29/00	4:00:00	119.2	197.4	60.4
05/29/00	5:00:00	119.2	197.5	60.4
05/29/00	6:00:00	115.6	195.5	59.1
05/29/00	7:00:00	51.6	168.1	30.7
05/29/00	8:00:00	54.6	179.2	30.5
05/29/00	9:00:00	54.6	177.4	30.8
05/29/00	10:00:00	54.5	178.0	30.6
05/29/00	11:00:00	54.2	178.3	30.4
05/29/00	12:00:00	54.3	178.5	30.4
05/29/00	13:00:00	59.1	195.3	30.3
05/29/00	14:00:00	60.2	198.2	30.4
05/29/00	15:00:00	59.1	196.3	30.1
05/29/00	16:00:00	59.1	194.6	30.4
05/29/00	17:00:00	59.1	198.0	29.8
05/29/00	18:00:00	59.4	198.0	30.0
05/29/00	19:00:00	66.7	213.7	31.2
05/29/00	20:00:00	118.6	198.7	59.7
05/29/00	21:00:00	119.3	199.3	59.9
05/29/00	22:00:00	122.2	203.2	60.1
05/29/00	23:00:00	120.1	200.3	60.0
05/30/00	0:00:00	156.0	265.3	58.8
05/30/00	1:00:00	120.2	200.2	60.0
05/30/00	2:00:00	137.7	226.6	60.8
05/30/00	3:00:00	140.3	230.0	61.0
05/30/00	4:00:00	140.2	229.4	61.1
05/30/00	5:00:00	140.3	229.4	61.2
05/30/00	6:00:00	142.8	238.5	59.9
05/30/00	7:00:00	76.9	234.9	32.7
05/30/00	8:00:00	69.6	230.3	30.2
05/30/00	9:00:00	69.4	234.6	29.6
05/30/00	10:00:00	69.4	237.5	29.2
05/30/00	11:00:00	69.8	242.0	28.8
05/30/00	12:00:00	69.8	231.6	30.1
05/30/00	13:00:00	69.8	215.8	32.3
05/30/00	14:00:00	69.8	201.0	34.7
05/30/00	15:00:00	69.8	200.9	34.7

Appendix B continued

DATE	HOUR	SPILL	TOTQ	SPILL_ PCT
05/30/00	16:00:00	71.0	201.0	35.3
05/30/00	17:00:00	68.5	193.9	35.3
05/30/00	18:00:00	71.3	196.9	36.2
05/30/00	19:00:00	71.9	196.6	36.6
05/30/00	20:00:00	152.1	262.8	57.9
05/30/00	21:00:00	155.3	264.5	58.7
05/30/00	22:00:00	155.8	265.0	58.8
05/30/00	23:00:00	155.9	264.8	58.9
05/31/00	0:00:00	170.0	280.1	60.7
05/31/00	1:00:00	156.6	254.4	61.6
05/31/00	2:00:00	122.9	207.0	59.4
05/31/00	3:00:00	119.1	201.5	59.1
05/31/00	4:00:00	122.5	206.9	59.2
05/31/00	5:00:00	124.7	207.1	60.2
05/31/00	6:00:00	122.7	210.8	58.2
05/31/00	7:00:00	73.1	241.2	30.3
05/31/00	8:00:00	71.2	240.5	29.6
05/31/00	9:00:00	77.2	258.5	29.9
05/31/00	10:00:00	78.2	257.6	30.4
05/31/00	11:00:00	73.2	242.1	30.2
05/31/00	12:00:00	72.6	240.6	30.2
05/31/00	13:00:00	72.6	242.0	30.0
05/31/00	14:00:00	75.1	242.4	31.0
05/31/00	15:00:00	77.3	247.0	31.3
05/31/00	16:00:00	77.5	245.4	31.6
05/31/00	17:00:00	77.4	261.0	29.7
05/31/00	18:00:00	78.7	265.6	29.6
05/31/00	19:00:00	85.2	263.8	32.3
05/31/00	20:00:00	155.4	260.3	59.7
05/31/00	21:00:00	155.3	257.9	60.2
05/31/00	22:00:00	158.0	260.1	60.7
05/31/00	23:00:00	169.9	279.3	60.8

Appendix C1. Summary of the number of radio-tagged juvenile steelhead released (N) at Rock Creek, Washington, during spring 2000, and the mean, standard deviation (SD), and range of the fork length (mm) and weight (g).

Release date	Release time	N	Fork length (mm)			Weight (g)		
			Mean	SD	Range	Mean	SD	Range
5/01/00	20:00	11	227	43	121-285	116.	41.9	69.7-200.5
5/02/00	08:00	13	220	14	191-253	89.3	15.4	62.1-127.5
5/03/00	08:00	13	222	15	195-245	91.2	18.8	62.0-127.2
5/03/00	20:00	14	223	19	185-254	93.6	24.4	54.5-136.9
5/04/00	20:00	13	221	18	195-265	88.5	23.6	61.7-147.0
5/05/00	08:00	14	229	16	194-258	104.	24.1	56.4-155.1
5/06/00	08:00	15	219	20	180-250	88.8	25.3	45.6-148.5
5/06/00	20:00	16	224	21	197-262	93.6	29.1	60.5-162.2
5/07/00	20:00	15	218	18	187-260	83.8	22.3	48.1-138.5
5/08/00	08:00	15	222	16	197-252	90.7	23.0	58.0-125.3
5/09/00	08:00	13	220	16	187-246	92.2	19.7	57.5-125.7
5/09/00	20:00	15	222	24	186-262	95.8	35.0	49.9-163.0
5/10/00	20:00	14	216	18	191-252	85.2	20.8	55.4-121.3
5/11/00	08:00	19	223	15	200-261	94.7	21.9	63.5-158.7
5/12/00	08:00	15	226	20	205-270	96.5	27.7	67.2-170.6
5/12/00	20:00	20	224	22	188-262	94.4	29.6	54.4-166.4
5/13/00	20:00	14	231	18	199-263	99.2	18.8	68.8-132.6
5/14/00	08:00	13	218	17	187-248	90.9	22.4	50.6-132.2
5/15/00	08:00	11	221	20	182-247	92.2	23.1	52.9-126.1
5/15/00	20:00	10	213	20	185-246	83.4	25.4	49.7-128.3
5/16/00	20:00	20	215	19	185-247	83.7	23.0	52.0-125.5
5/17/00	08:00	15	213	18	191-256	83.2	26.6	56.9-161.4
5/18/00	08:00	16	226	20	200-276	95.8	28.5	63.6-175.0
5/18/00	20:00	20	224	14	202-258	93.0	18.5	70.2-144.8
5/19/00	20:00	20	212	14	193-253	74.9	19.0	56.6-144.4
5/20/00	08:00	20	216	19	189-267	83.7	22.3	47.5-148.0
5/21/00	08:00	20	209	31	103-257	82.3	29.0	51.3-164.0
5/21/00	20:00	16	216	15	189-246	74.5	18.4	46.4-122.0
5/22/00	20:00	14	229	20	195-260	80.7	25.0	44.5-127.5
5/23/00	08:00	14	226	21	197-257	65.5	17.4	43.5-98.4
5/24/00	08:00	16	218	22	183-276	84.4	34.1	46.4-197.7
5/24/00	20:00	12	215	21	183-250	83.9	26.8	46.6-128.7
Overall		487	220	20	103-285	88.7	25.7	43.5-200.5

Appendix C2. Summary of the number of radio-tagged yearling chinook salmon released (N) at Rock Creek, Washington, during spring 2000, and mean, standard deviation (SD) and range of fork length (mm) and weight (g).

Release date	Release time	N	Fork length (mm)			Weight (g)		
			Mean	SD	Range	Mean	SD	Range
5/01/00	20:00	14	156	20	128-187	40.1	16.1	21.8-71.5
5/02/00	08:00	14	172	21	142-205	52.1	19.1	30.2-84.3
5/03/00	08:00	12	163	19	142-196	44.1	16.3	25.4-71.7
5/03/00	20:00	15	165	18	143-195	45.3	17.6	27.0-76.5
5/04/00	20:00	15	162	20	138-212	42.9	21.4	25.1-104.2
5/05/00	08:00	16	162	19	137-198	43.8	15.3	25.1-78.3
5/06/00	08:00	15	160	15	141-194	41.6	14.4	28.8-80.0
5/06/00	20:00	15	164	20	140-198	44.7	16.7	25.0-75.8
5/07/00	20:00	14	176	19	131-197	56.5	17.4	22.3-81.2
5/08/00	08:00	16	160	17	131-189	42.5	13.1	22.8-66.4
5/09/00	08:00	13	169	17	145-197	50.2	15.9	33.2-76.1
5/09/00	20:00	10	167	16	143-192	49.3	14.0	28.9-72.9
5/10/00	20:00	15	176	16	155-208	56.0	17.4	36.4-98.8
5/11/00	08:00	15	166	20	131-203	48.3	18.5	22.3-92.5
5/12/00	08:00	18	188	15	166-214	67.9	17.8	37.7-102.8
5/12/00	20:00	14	191	17	165-225	72.5	21.8	45.2-125.1
5/13/00	20:00	17	186	19	140-215	65.3	19.4	24.0-103.5
5/14/00	08:00	16	184	18	143-218	65.3	19.7	26.7-99.1
5/15/00	08:00	17	183	18	130-204	62.3	17.8	21.4-87.8
5/15/00	20:00	16	173	16	138-197	54.5	16.2	27.9-91.8
5/16/00	20:00	16	177	18	142-202	57.2	17.9	25.6-89.3
5/17/00	08:00	6	177	22	144-198	54.7	20.1	26.8-77.4
5/18/00	08:00	19	185	11	164-200	63.3	12.3	41.0-85.5
5/18/00	20:00	16	183	13	153-205	62.7	13.8	34.1-86.5
5/19/00	20:00	13	184	14	158-204	60.1	12.1	42.7-79.9
5/20/00	08:00	14	185	10	165-201	64.4	11.7	44.2-86.4
5/21/00	08:00	15	189	14	165-218	63.4	13.7	42.8-89.9
5/21/00	20:00	15	188	12	165-210	54.7	9.4	37.1-73.8
5/22/00	20:00	15	179	14	153-198	48.0	11.2	30.4-61.6
5/23/00	08:00	16	184	17	148-206	42.8	10.2	21.2-57.5
5/24/00	08:00	18	190	10	161-204	66.7	9.7	40.3-77.6
5/24/00	20:00	24	183	17	140-210	60.2	15.7	24.6-93.7
Overall		484	176	19	128-225	55.0	18.0	21.2-125.1

Appendix D. Number of juvenile steelhead (STH) and yearling Chinook salmon (CH1) passing John Day Dam through the juvenile fish bypass, powerhouse, and spillway locations during 12 and 24-h spill treatments, spring 2000. Day = 0700-1859, Night = 1900-0659.

Block	Treatment	Spill Period	Species	Location	Frequency
1	12	Day	CH1	JUVBYPAS	10
1	12	Day	CH1	POWERHOU	8
1	12	Day	CH1	SPILLWAY	0
1	12	Day	STH	JUVBYPAS	0
1	12	Day	STH	POWERHOU	0
1	12	Day	STH	SPILLWAY	0
1	12	Night	CH1	JUVBYPAS	3
1	12	Night	CH1	POWERHOU	8
1	12	Night	CH1	SPILLWAY	20
1	12	Night	STH	JUVBYPAS	12
1	12	Night	STH	POWERHOU	5
1	12	Night	STH	SPILLWAY	28
1	24	Day	CH1	JUVBYPAS	2
1	24	Day	CH1	POWERHOU	1
1	24	Day	CH1	SPILLWAY	22
1	24	Day	STH	JUVBYPAS	1
1	24	Day	STH	POWERHOU	0
1	24	Day	STH	SPILLWAY	3
1	24	Night	CH1	JUVBYPAS	4
1	24	Night	CH1	POWERHOU	5
1	24	Night	CH1	SPILLWAY	24
1	24	Night	STH	JUVBYPAS	5
1	24	Night	STH	POWERHOU	3
1	24	Night	STH	SPILLWAY	41
2	12	Day	CH1	JUVBYPAS	3
2	12	Day	CH1	POWERHOU	1
2	12	Day	CH1	SPILLWAY	0
2	12	Day	STH	JUVBYPAS	3
2	12	Day	STH	POWERHOU	2
2	12	Day	STH	SPILLWAY	0
2	12	Night	CH1	JUVBYPAS	6
2	12	Night	CH1	POWERHOU	4
2	12	Night	CH1	SPILLWAY	36
2	12	Night	STH	JUVBYPAS	14
2	12	Night	STH	POWERHOU	3
2	12	Night	STH	SPILLWAY	34
2	24	Day	CH1	JUVBYPAS	0
2	24	Day	CH1	POWERHOU	2
2	24	Day	CH1	SPILLWAY	16
2	24	Day	STH	JUVBYPAS	2

Appendix D continued

Block	Treatment	Spill Period	Species	Location	Frequency
2	24	Day	STH	POWERHOU	0
2	24	Day	STH	SPILLWAY	3
2	24	Night	CH1	JUVBYPAS	5
2	24	Night	CH1	POWERHOU	5
2	24	Night	CH1	SPILLWAY	31
2	24	Night	STH	JUVBYPAS	15
2	24	Night	STH	POWERHOU	7
2	24	Night	STH	SPILLWAY	39
3	12	Day	CH1	JUVBYPAS	2
3	12	Day	CH1	POWERHOU	3
3	12	Day	CH1	SPILLWAY	0
3	12	Day	STH	JUVBYPAS	0
3	12	Day	STH	POWERHOU	1
3	12	Day	STH	SPILLWAY	0
3	12	Night	CH1	JUVBYPAS	5
3	12	Night	CH1	POWERHOU	6
3	12	Night	CH1	SPILLWAY	39
3	12	Night	STH	JUVBYPAS	8
3	12	Night	STH	POWERHOU	2
3	12	Night	STH	SPILLWAY	27
3	24	Day	CH1	JUVBYPAS	0
3	24	Day	CH1	POWERHOU	1
3	24	Day	CH1	SPILLWAY	20
3	24	Day	STH	JUVBYPAS	0
3	24	Day	STH	POWERHOU	1
3	24	Day	STH	SPILLWAY	3
3	24	Night	CH1	JUVBYPAS	3
3	24	Night	CH1	POWERHOU	3
3	24	Night	CH1	SPILLWAY	26
3	24	Night	STH	JUVBYPAS	6
3	24	Night	STH	POWERHOU	4
3	24	Night	STH	SPILLWAY	36
4	12	Day	CH1	JUVBYPAS	2
4	12	Day	CH1	POWERHOU	0
4	12	Day	CH1	SPILLWAY	0
4	12	Day	STH	JUVBYPAS	2
4	12	Day	STH	POWERHOU	1
4	12	Day	STH	SPILLWAY	0
4	12	Night	CH1	JUVBYPAS	6
4	12	Night	CH1	POWERHOU	3
4	12	Night	CH1	SPILLWAY	49
4	12	Night	STH	JUVBYPAS	10

Appendix D continued

Block	Treatment	Spill Period	Species	Location	Frequency
4	12	Night	STH	POWERHOU	0
4	12	Night	STH	SPILLWAY	50
4	24	Day	CH1	JUVBYPAS	1
4	24	Day	CH1	POWERHOU	1
4	24	Day	CH1	SPILLWAY	40
4	24	Day	STH	JUVBYPAS	2
4	24	Day	STH	POWERHOU	0
4	24	Day	STH	SPILLWAY	4
4	24	Night	CH1	JUVBYPAS	2
4	24	Night	CH1	POWERHOU	3
4	24	Night	CH1	SPILLWAY	24
4	24	Night	STH	JUVBYPAS	4
4	24	Night	STH	POWERHOU	5
4	24	Night	STH	SPILLWAY	45

Appendix E. Percent of radio–tagged juvenile steelhead (STH) and yearling chinook salmon (CH1) passage via the turbines, spillway and juvenile bypass of John Day Dam during 12-h and 24-h spill treatments (Trt) used during spring 2000. Sample sizes are shown in parentheses.

Species	Block	Trt	Turbines	Spillway	Juvenile Bypass
STH	1	12-h	11.1 (5)	62.2 (28)	26.7 (12)
	1	24-h	5.7 (3)	83.0 (44)	11.3 (6)
	2	12-h	8.9 (5)	60.7 (34)	30.4 (17)
	2	24-h	10.6 (7)	63.6 (42)	25.8 (17)
	3	12-h	7.9 (3)	71.0 (27)	21.0 (8)
	3	24-h	10.0 (5)	78.0 (39)	12.0 (6)
	4	12-h	1.6 (1)	79.4 (50)	19.0 (12)
	4	24-h	8.3 (5)	81.7 (49)	10.0 (6)
CH1	1	12-h	32.6 (16)	40.8 (20)	26.5 (13)
	1	24-h	10.3 (6)	79.3 (46)	10.3 (6)
	2	12-h	10.0 (5)	72.0 (36)	18.0 (9)
	2	24-h	11.9 (7)	79.7 (47)	8.5 (5)
	3	12-h	16.4 (9)	70.9 (39)	12.7 (7)
	3	24-h	7.6 (4)	86.8 (46)	5.7 (3)
	4	12-h	5.0 (3)	81.7 (49)	13.3 (8)
	4	24-h	5.6 (4)	90.1 (64)	4.2 (3)

Appendix F. – Summer spill treatments (DAY%/NIGHT%) for evaluating juvenile passage at John Day Dam in 2000. Three-day treatments alternate between the 0% to 30% daytime spill with 60% nighttime spill for both treatments.

Date	Block	Spill Level
01-Jul	1	30/60
02-Jul	1	30/60
03-Jul	1	30/60
04-Jul	1	0/60
05-Jul	1	0/60
06-Jul	1	0/60
07-Jul	2	30/60
08-Jul	2	30/60
09-Jul	2	30/60
10-Jul	2	0/60
11-Jul	2	0/60
12-Jul	2	0/60
13-Jul	3	0/60
14-Jul	3	0/60
15-Jul	3	0/60
16-Jul	3	30/60
17-Jul	3	30/60
18-Jul	3	30/60
19-Jul	4	30/60
20-Jul	4	30/60
21-Jul	4	30/60
22-Jul	4	0/60
23-Jul	4	0/60
24-Jul	4	0/60

Appendix G. Hourly spill discharge (thousand cubic feet per second), total discharge, and percent spill at John Day Dam, 01 July through 31 July 2000.

Date	Hour	Spill	Tot Q	Percent spill
07/01/00	01:00:00	106.4	178.5	59.6
07/01/00	02:00:00	92.0	157.2	58.5
07/01/00	03:00:00	92.7	157.7	58.8
07/01/00	04:00:00	92.8	157.9	58.8
07/01/00	05:00:00	92.7	157.8	58.7
07/01/00	06:00:00	81.3	152.5	53.3
07/01/00	07:00:00	45.4	148.8	30.5
07/01/00	08:00:00	45.4	151.9	29.9
07/01/00	09:00:00	45.4	150.5	30.2
07/01/00	10:00:00	45.4	149.7	30.3
07/01/00	11:00:00	45.3	149.6	30.3
07/01/00	12:00:00	45.3	150.4	30.1
07/01/00	13:00:00	45.3	150.2	30.2
07/01/00	14:00:00	47.7	161.8	29.5
07/01/00	15:00:00	46.9	157.9	29.7
07/01/00	16:00:00	46.9	157.1	29.9
07/01/00	17:00:00	46.9	160.1	29.3
07/01/00	18:00:00	46.9	160.0	29.3
07/01/00	19:00:00	50.9	159.3	32.0
07/01/00	20:00:00	98.3	168.9	58.2
07/01/00	21:00:00	102.3	170.8	59.9
07/01/00	22:00:00	102.3	168.9	60.6
07/01/00	23:00:00	99.2	164.5	60.3
07/02/00	00:00:00	84.6	141.4	59.8
07/02/00	01:00:00	84.6	140.8	60.1
07/02/00	02:00:00	84.6	140.5	60.2
07/02/00	03:00:00	84.6	138.6	61.0
07/02/00	04:00:00	86.1	140.7	61.2
07/02/00	05:00:00	84.5	140.7	60.1
07/02/00	06:00:00	79.1	138.7	57.0
07/02/00	07:00:00	42.2	136.4	30.9
07/02/00	08:00:00	42.1	140.8	29.9
07/02/00	09:00:00	42.1	138.8	30.3
07/02/00	10:00:00	42.1	140.6	29.9
07/02/00	11:00:00	42.9	140.5	30.5
07/02/00	12:00:00	48.0	158.8	30.2
07/02/00	13:00:00	54.1	177.9	30.4
07/02/00	14:00:00	54.1	180.8	29.9
07/02/00	15:00:00	53.3	176.0	30.3

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent Spill
07/02/00	16:00:00	49.4	160.1	30.9
07/02/00	17:00:00	50.3	162.8	30.9
07/02/00	18:00:00	50.3	162.8	30.9
07/02/00	19:00:00	55.9	162.6	34.4
07/02/00	20:00:00	90.0	154.0	58.4
07/02/00	21:00:00	89.9	150.8	59.6
07/02/00	22:00:00	89.9	151.2	59.5
07/02/00	23:00:00	89.8	151.1	59.4
07/03/00	00:00:00	88.2	150.9	58.4
07/03/00	01:00:00	78.6	134.8	58.3
07/03/00	02:00:00	78.5	132.2	59.4
07/03/00	03:00:00	78.5	134.0	58.6
07/03/00	04:00:00	78.5	132.4	59.3
07/03/00	05:00:00	78.5	132.6	59.2
07/03/00	06:00:00	71.9	128.2	56.1
07/03/00	07:00:00	35.9	119.0	30.2
07/03/00	08:00:00	35.6	121.2	29.4
07/03/00	09:00:00	35.5	119.1	29.8
07/03/00	10:00:00	35.4	121.2	29.2
07/03/00	11:00:00	35.7	119.6	29.8
07/03/00	12:00:00	35.9	119.3	30.1
07/03/00	13:00:00	35.9	119.3	30.1
07/03/00	14:00:00	29.9	100.2	29.8
07/03/00	15:00:00	29.6	100.9	29.3
07/03/00	16:00:00	29.6	99.5	29.7
07/03/00	17:00:00	29.6	99.4	29.8
07/03/00	18:00:00	29.6	99.5	29.7
07/03/00	19:00:00	30.1	101.0	29.8
07/03/00	20:00:00	85.7	146.0	58.7
07/03/00	21:00:00	90.0	150.0	60.0
07/03/00	22:00:00	90.0	151.7	59.3
07/03/00	23:00:00	90.1	149.9	60.1
07/04/00	00:00:00	90.1	149.6	60.2
07/04/00	01:00:00	90.0	151.2	59.5
07/04/00	02:00:00	90.0	149.7	60.1
07/04/00	03:00:00	89.2	148.4	60.1
07/04/00	04:00:00	79.7	134.3	59.3
07/04/00	05:00:00	79.7	134.2	59.4
07/04/00	06:00:00	71.6	132.4	54.1
07/04/00	07:00:00	1.5	143.8	1.0

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
07/04/00	08:00:00	1.5	152.3	1.0
07/04/00	09:00:00	1.5	176.1	0.9
07/04/00	10:00:00	1.5	178.5	0.8
07/04/00	11:00:00	1.5	170.2	0.9
07/04/00	12:00:00	1.5	169.1	0.9
07/04/00	13:00:00	1.5	168.5	0.9
07/04/00	14:00:00	1.5	162.8	0.9
07/04/00	15:00:00	1.5	164.4	0.9
07/04/00	16:00:00	1.5	160.9	0.9
07/04/00	17:00:00	1.5	162.5	0.9
07/04/00	18:00:00	1.5	175.1	0.9
07/04/00	19:00:00	7.8	177.4	4.4
07/04/00	20:00:00	89.4	161.1	55.5
07/04/00	21:00:00	91.5	159.3	57.4
07/04/00	22:00:00	90.0	148.3	60.7
07/04/00	23:00:00	90.0	144.9	62.1
07/05/00	00:00:00	90.0	156.4	57.5
07/05/00	01:00:00	89.9	150.7	59.7
07/05/00	02:00:00	90.1	148.3	60.8
07/05/00	03:00:00	88.5	146.6	60.4
07/05/00	04:00:00	78.3	131.9	59.4
07/05/00	05:00:00	78.2	130.7	59.8
07/05/00	06:00:00	61.2	115.3	53.1
07/05/00	07:00:00	1.5	103.7	1.4
07/05/00	08:00:00	1.5	124.2	1.2
07/05/00	09:00:00	1.5	127.5	1.2
07/05/00	10:00:00	1.5	134.4	1.1
07/05/00	11:00:00	1.5	129.4	1.2
07/05/00	12:00:00	1.5	131.0	1.1
07/05/00	13:00:00	1.5	142.0	1.1
07/05/00	14:00:00	1.5	153.3	1.0
07/05/00	15:00:00	1.5	192.4	0.8
07/05/00	16:00:00	1.5	185.5	0.8
07/05/00	17:00:00	1.5	193.4	0.8
07/05/00	18:00:00	1.5	195.7	0.8
07/05/00	19:00:00	12.5	203.9	6.1
07/05/00	20:00:00	120.7	205.4	58.8
07/05/00	21:00:00	120.6	200.7	60.1
07/05/00	22:00:00	120.6	202.6	59.5
07/05/00	23:00:00	116.8	197.1	59.3

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
07/06/00	00:00:00	102.6	170.0	60.4
07/06/00	01:00:00	102.5	167.4	61.2
07/06/00	02:00:00	102.5	167.3	61.3
07/06/00	03:00:00	102.5	169.7	60.4
07/06/00	04:00:00	102.5	170.1	60.3
07/06/00	05:00:00	104.4	174.1	60.0
07/06/00	06:00:00	87.8	161.9	54.2
07/06/00	07:00:00	1.6	137.5	1.2
07/06/00	08:00:00	1.5	156.7	1.0
07/06/00	09:00:00	1.5	169.4	0.9
07/06/00	10:00:00	1.5	175.2	0.9
07/06/00	11:00:00	1.5	171.9	0.9
07/06/00	12:00:00	1.5	172.5	0.9
07/06/00	13:00:00	1.5	171.3	0.9
07/06/00	14:00:00	1.5	171.2	0.9
07/06/00	15:00:00	1.5	198.9	0.8
07/06/00	16:00:00	1.5	194.2	0.8
07/06/00	17:00:00	1.5	197.2	0.8
07/06/00	18:00:00	1.5	208.3	0.7
07/06/00	19:00:00	8.1	211.5	3.8
07/06/00	20:00:00	120.6	206.9	58.3
07/06/00	21:00:00	117.6	197.8	59.5
07/06/00	22:00:00	108.6	182.9	59.4
07/06/00	23:00:00	108.6	178.0	61.0
07/07/00	00:00:00	108.5	180.2	60.2
07/07/00	01:00:00	108.5	181.8	59.7
07/07/00	02:00:00	108.5	183.6	59.1
07/07/00	03:00:00	108.6	180.8	60.1
07/07/00	04:00:00	110.5	183.3	60.3
07/07/00	05:00:00	108.5	180.0	60.3
07/07/00	06:00:00	104.3	181.5	57.5
07/07/00	07:00:00	69.0	169.4	40.7
07/07/00	08:00:00	60.6	205.7	29.5
07/07/00	09:00:00	60.8	218.3	27.9
07/07/00	10:00:00	69.1	240.2	28.8
07/07/00	11:00:00	72.6	257.5	28.2
07/07/00	12:00:00	72.7	243.0	29.9
07/07/00	13:00:00	72.6	247.2	29.4
07/07/00	14:00:00	72.6	249.1	29.1
07/07/00	15:00:00	72.7	254.4	28.6

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
07/07/00	16:00:00	72.7	250.4	29.0
07/07/00	17:00:00	72.8	245.5	29.7
07/07/00	18:00:00	75.9	258.7	29.3
07/07/00	19:00:00	88.2	275.0	32.1
07/07/00	20:00:00	154.5	268.3	57.6
07/07/00	21:00:00	154.7	259.8	59.5
07/07/00	22:00:00	147.0	250.7	58.6
07/07/00	23:00:00	136.7	241.1	56.7
07/08/00	00:00:00	119.9	200.7	59.7
07/08/00	01:00:00	119.7	190.9	62.7
07/08/00	02:00:00	105.2	172.5	61.0
07/08/00	03:00:00	99.9	166.7	59.9
07/08/00	04:00:00	99.8	166.0	60.1
07/08/00	05:00:00	101.6	168.3	60.4
07/08/00	06:00:00	94.6	159.9	59.2
07/08/00	07:00:00	50.0	144.0	34.7
07/08/00	08:00:00	50.0	162.8	30.7
07/08/00	09:00:00	49.9	162.7	30.7
07/08/00	10:00:00	49.9	164.6	30.3
07/08/00	11:00:00	49.9	164.8	30.3
07/08/00	12:00:00	50.5	165.9	30.4
07/08/00	13:00:00	54.3	179.3	30.3
07/08/00	14:00:00	54.2	180.8	30.0
07/08/00	15:00:00	59.8	197.8	30.2
07/08/00	16:00:00	60.2	199.4	30.2
07/08/00	17:00:00	60.1	199.4	30.1
07/08/00	18:00:00	60.1	199.1	30.2
07/08/00	19:00:00	62.0	201.4	30.8
07/08/00	20:00:00	118.0	202.4	58.3
07/08/00	21:00:00	117.9	199.2	59.2
07/08/00	22:00:00	107.4	184.8	58.1
07/08/00	23:00:00	107.3	179.6	59.7
07/09/00	00:00:00	107.3	179.5	59.8
07/09/00	01:00:00	107.3	179.3	59.8
07/09/00	02:00:00	104.8	174.7	60.0
07/09/00	03:00:00	112.5	190.1	59.2
07/09/00	04:00:00	107.2	179.3	59.8
07/09/00	05:00:00	101.5	168.9	60.1
07/09/00	06:00:00	96.9	167.0	58.0
07/09/00	07:00:00	54.8	186.3	29.4

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
07/09/00	08:00:00	54.8	185.3	29.6
07/09/00	09:00:00	54.8	187.3	29.3
07/09/00	10:00:00	54.8	185.5	29.5
07/09/00	11:00:00	54.8	185.1	29.6
07/09/00	12:00:00	54.8	185.1	29.6
07/09/00	13:00:00	54.8	182.4	30.0
07/09/00	14:00:00	54.8	180.3	30.4
07/09/00	15:00:00	54.8	182.6	30.0
07/09/00	16:00:00	54.9	183.7	29.9
07/09/00	17:00:00	54.6	183.9	29.7
07/09/00	18:00:00	54.6	187.0	29.2
07/09/00	19:00:00	54.7	181.9	30.1
07/09/00	20:00:00	101.7	176.6	57.6
07/09/00	21:00:00	102.5	172.2	59.5
07/09/00	22:00:00	102.6	173.5	59.1
07/09/00	23:00:00	104.3	173.7	60.0
07/10/00	00:00:00	99.7	166.7	59.8
07/10/00	01:00:00	68.7	123.4	55.7
07/10/00	02:00:00	68.7	122.5	56.1
07/10/00	03:00:00	68.7	122.3	56.2
07/10/00	04:00:00	68.8	124.3	55.3
07/10/00	05:00:00	68.8	124.5	55.3
07/10/00	06:00:00	57.5	114.8	50.1
07/10/00	07:00:00	1.5	139.5	1.1
07/10/00	08:00:00	1.5	158.5	0.9
07/10/00	09:00:00	1.5	174.3	0.9
7/10/00	10:00:00	1.5	186.8	0.8
7/10/00	11:00:00	1.5	207.8	0.7
7/10/00	12:00:00	1.5	198.7	0.8
7/10/00	13:00:00	1.1	191.4	0.6
7/10/00	14:00:00	0.0	190.5	0.0
7/10/00	15:00:00	0.7	197.9	0.4
7/10/00	16:00:00	1.5	213.1	0.7
7/10/00	17:00:00	1.5	212.4	0.7
7/10/00	18:00:00	1.6	216.0	0.7
7/10/00	19:00:00	2.6	208.0	1.3
7/10/00	20:00:00	117.6	213.5	55.1
7/10/00	21:00:00	127.6	218.6	58.4
7/10/00	22:00:00	120.5	202.4	59.5
7/10/00	23:00:00	99.6	170.9	58.3

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/11/00	00:00:00	83.1	142.2	58.4
7/11/00	01:00:00	70.1	124.6	56.3
7/11/00	02:00:00	83.9	138.8	60.4
7/11/00	03:00:00	84.6	140.5	60.2
7/11/00	04:00:00	84.6	143.7	58.9
7/11/00	05:00:00	85.6	144.9	59.1
7/11/00	06:00:00	87.2	156.7	55.6
7/11/00	07:00:00	2.1	147.5	1.4
7/11/00	08:00:00	1.5	173.2	0.9
7/11/00	09:00:00	1.5	166.3	0.9
7/11/00	10:00:00	1.5	169.7	0.9
7/11/00	11:00:00	1.5	190.2	0.8
7/11/00	12:00:00	1.5	192.8	0.8
7/11/00	13:00:00	1.5	191.2	0.8
7/11/00	14:00:00	1.5	197.9	0.8
7/11/00	15:00:00	1.5	201.1	0.7
7/11/00	16:00:00	1.5	199.7	0.8
7/11/00	17:00:00	1.5	209.4	0.7
7/11/00	18:00:00	1.5	213.8	0.7
7/11/00	19:00:00	5.2	210.2	2.5
7/11/00	20:00:00	134.6	240.7	55.9
7/11/00	21:00:00	139.7	237.8	58.7
7/11/00	22:00:00	142.1	244.7	58.1
7/11/00	23:00:00	137.9	235.8	58.5
7/12/00	00:00:00	95.4	162.1	58.9
7/12/00	01:00:00	80.0	133.7	59.8
7/12/00	02:00:00	79.7	132.8	60.0
7/12/00	03:00:00	79.6	133.2	59.8
7/12/00	04:00:00	79.6	136.3	58.4
7/12/00	05:00:00	79.6	135.8	58.6
7/12/00	06:00:00	78.0	134.3	58.1
7/12/00	07:00:00	1.8	119.7	1.5
7/12/00	08:00:00	1.5	152.1	1.0
7/12/00	09:00:00	1.5	159.4	0.9
7/12/00	10:00:00	1.5	175.3	0.9
7/12/00	11:00:00	1.5	181.0	0.8
7/12/00	12:00:00	1.5	188.2	0.8
7/12/00	13:00:00	1.5	186.7	0.8
7/12/00	14:00:00	1.5	187.6	0.8
7/12/00	15:00:00	1.5	201.1	0.7

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/12/00	16:00:00	1.5	205.5	0.7
7/12/00	17:00:00	1.5	204.4	0.7
7/12/00	18:00:00	1.5	198.2	0.8
7/12/00	19:00:00	9.0	198.4	4.5
7/12/00	20:00:00	131.1	227.7	57.6
7/12/00	21:00:00	128.4	217.6	59.0
7/12/00	22:00:00	111.2	190.0	58.5
7/12/00	23:00:00	97.6	164.0	59.5
7/13/00	00:00:00	87.3	144.6	60.4
7/13/00	01:00:00	86.5	142.1	60.9
7/13/00	02:00:00	83.8	139.4	60.1
7/13/00	03:00:00	83.8	138.1	60.7
7/13/00	04:00:00	83.8	140.8	59.5
7/13/00	05:00:00	83.8	139.8	59.9
7/13/00	06:00:00	79.6	142.3	55.9
7/13/00	07:00:00	2.7	155.2	1.7
7/13/00	08:00:00	1.5	170.0	0.9
7/13/00	09:00:00	1.5	175.0	0.9
7/13/00	10:00:00	1.5	173.7	0.9
7/13/00	11:00:00	1.5	186.6	0.8
7/13/00	12:00:00	1.5	187.3	0.8
7/13/00	13:00:00	1.5	201.5	0.7
7/13/00	14:00:00	1.5	202.6	0.7
7/13/00	15:00:00	1.5	203.6	0.7
7/13/00	16:00:00	1.5	208.3	0.7
7/13/00	17:00:00	1.5	229.8	0.7
7/13/00	18:00:00	1.5	216.7	0.7
7/13/00	19:00:00	8.1	223.2	3.6
7/13/00	20:00:00	128.4	222.1	57.8
7/13/00	21:00:00	129.8	217.9	59.6
7/13/00	22:00:00	129.4	218.0	59.4
7/13/00	23:00:00	115.0	192.8	59.6
7/14/00	00:00:00	114.8	189.4	60.6
7/14/00	01:00:00	112.8	189.0	59.7
7/14/00	02:00:00	95.0	161.7	58.8
7/14/00	03:00:00	87.4	144.6	60.4
7/14/00	04:00:00	87.3	145.3	60.1
7/14/00	05:00:00	87.4	145.2	60.2
7/14/00	06:00:00	79.6	142.1	56.0
7/14/00	07:00:00	1.6	145.9	1.1

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/14/00	08:00:00	1.6	181.0	0.9
7/14/00	09:00:00	1.5	189.8	0.8
7/14/00	10:00:00	1.5	208.2	0.7
7/14/00	11:00:00	1.5	209.8	0.7
7/14/00	12:00:00	1.5	208.2	0.7
7/14/00	13:00:00	1.5	215.6	0.7
7/14/00	14:00:00	1.5	219.2	0.7
7/14/00	15:00:00	1.5	214.4	0.7
7/14/00	16:00:00	1.5	213.5	0.7
7/14/00	17:00:00	1.5	216.4	0.7
7/14/00	18:00:00	1.5	209.2	0.7
7/14/00	19:00:00	7.9	202.9	3.9
7/14/00	20:00:00	133.9	227.8	58.8
7/14/00	21:00:00	134.6	226.1	59.5
7/14/00	22:00:00	131.1	223.7	58.6
7/14/00	23:00:00	113.1	191.7	59.0
7/15/00	00:00:00	97.9	163.4	59.9
7/15/00	01:00:00	84.3	139.4	60.5
7/15/00	02:00:00	83.6	139.4	60.0
7/15/00	03:00:00	83.7	139.5	60.0
7/15/00	04:00:00	83.6	139.1	60.1
7/15/00	05:00:00	83.6	139.0	60.1
7/15/00	06:00:00	74.9	134.1	55.9
7/15/00	07:00:00	3.1	155.7	2.0
7/15/00	08:00:00	2.2	174.2	1.3
7/15/00	09:00:00	1.5	174.2	0.9
7/15/00	10:00:00	1.5	180.7	0.8
7/15/00	11:00:00	1.5	204.7	0.7
7/15/00	12:00:00	1.5	207.4	0.7
7/15/00	13:00:00	1.5	209.8	0.7
7/15/00	14:00:00	1.5	206.7	0.7
7/15/00	15:00:00	1.5	207.4	0.7
7/15/00	16:00:00	1.5	231.3	0.6
7/15/00	17:00:00	1.5	234.2	0.6
7/15/00	18:00:00	1.5	231.1	0.6
7/15/00	19:00:00	1.5	212.2	0.7
7/15/00	20:00:00	44.8	206.1	21.7
7/15/00	21:00:00	118.8	200.9	59.1
7/15/00	22:00:00	99.5	165.1	60.3
7/15/00	23:00:00	98.4	162.9	60.4

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/16/00	00:00:00	84.6	137.8	61.4
7/16/00	01:00:00	84.2	136.0	61.9
7/16/00	02:00:00	84.3	137.4	61.4
7/16/00	03:00:00	84.3	138.6	60.8
7/16/00	04:00:00	84.3	146.6	57.5
7/16/00	05:00:00	84.3	142.4	59.2
7/16/00	06:00:00	79.2	136.7	57.9
7/16/00	07:00:00	31.8	115.3	27.6
7/16/00	08:00:00	42.1	140.2	30.0
7/16/00	09:00:00	42.1	134.2	31.4
7/16/00	10:00:00	42.1	136.5	30.8
7/16/00	11:00:00	42.1	137.9	30.5
7/16/00	12:00:00	42.1	136.6	30.8
7/16/00	13:00:00	42.6	134.2	31.7
7/16/00	14:00:00	47.1	162.0	29.1
7/16/00	15:00:00	47.1	161.7	29.1
7/16/00	16:00:00	45.6	157.0	29.0
7/16/00	17:00:00	38.5	133.1	28.9
7/16/00	18:00:00	36.2	123.4	29.3
7/16/00	19:00:00	39.6	124.5	31.8
7/16/00	20:00:00	78.7	135.6	58.0
7/16/00	21:00:00	79.0	133.3	59.3
7/16/00	22:00:00	79.0	134.6	58.7
7/16/00	23:00:00	79.0	132.6	59.6
7/17/00	00:00:00	79.0	132.4	59.7
7/17/00	01:00:00	79.0	132.7	59.5
7/17/00	02:00:00	79.0	134.1	58.9
7/17/00	03:00:00	78.9	132.7	59.5
7/17/00	04:00:00	79.0	133.1	59.4
7/17/00	05:00:00	79.0	133.9	59.0
7/17/00	06:00:00	77.1	133.2	57.9
7/17/00	07:00:00	40.8	130.5	31.3
7/17/00	08:00:00	38.9	131.2	29.6
7/17/00	09:00:00	39.5	133.6	29.6
7/17/00	10:00:00	38.8	131.2	29.6
7/17/00	11:00:00	38.8	130.1	29.8
7/17/00	12:00:00	39.9	132.2	30.2
7/17/00	13:00:00	45.1	145.4	31.0
7/17/00	14:00:00	45.1	148.4	30.4
7/17/00	15:00:00	45.1	151.5	29.8

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/17/00	16:00:00	45.1	154.1	29.3
7/17/00	17:00:00	56.8	197.3	28.8
7/17/00	18:00:00	57.2	192.1	29.8
7/17/00	19:00:00	59.7	189.9	31.4
7/17/00	20:00:00	120.6	204.8	58.9
7/17/00	21:00:00	120.5	202.1	59.6
7/17/00	22:00:00	119.1	200.4	59.4
7/17/00	23:00:00	108.1	179.3	60.3
7/18/00	00:00:00	101.3	169.2	59.9
7/18/00	01:00:00	85.9	148.7	57.8
7/18/00	02:00:00	84.0	140.2	59.9
7/18/00	03:00:00	85.5	144.8	59.0
7/18/00	04:00:00	84.0	140.7	59.7
7/18/00	05:00:00	84.0	141.9	59.2
7/18/00	06:00:00	78.1	138.1	56.6
7/18/00	07:00:00	48.0	161.4	29.7
7/18/00	08:00:00	48.0	163.9	29.3
7/18/00	09:00:00	48.0	162.4	29.6
7/18/00	10:00:00	47.9	162.6	29.5
7/18/00	11:00:00	48.0	165.1	29.1
7/18/00	12:00:00	49.2	172.2	28.6
7/18/00	13:00:00	56.3	184.5	30.5
7/18/00	14:00:00	56.2	188.6	29.8
7/18/00	15:00:00	56.3	195.7	28.8
7/18/00	16:00:00	56.8	196.5	28.9
7/18/00	17:00:00	59.2	203.5	29.1
7/18/00	18:00:00	60.9	213.7	28.5
7/18/00	19:00:00	76.7	239.0	32.1
7/18/00	20:00:00	131.4	226.1	58.1
7/18/00	21:00:00	131.6	218.3	60.3
7/18/00	22:00:00	130.4	217.8	59.9
7/18/00	23:00:00	111.7	193.9	57.6
7/19/00	00:00:00	89.0	159.9	55.7
7/19/00	01:00:00	58.5	113.4	51.6
7/19/00	02:00:00	80.4	134.2	59.9
7/19/00	03:00:00	82.0	135.5	60.5
7/19/00	04:00:00	80.6	133.0	60.6
7/19/00	05:00:00	83.1	138.0	60.2
7/19/00	06:00:00	75.4	137.3	54.9
7/19/00	07:00:00	50.0	155.7	32.1

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/19/00	08:00:00	50.7	161.5	31.4
7/19/00	09:00:00	51.3	165.1	31.1
7/19/00	10:00:00	51.3	169.3	30.3
7/19/00	11:00:00	51.4	171.9	29.9
7/19/00	12:00:00	51.3	172.9	29.7
7/19/00	13:00:00	51.3	175.9	29.2
7/19/00	14:00:00	51.3	176.7	29.0
7/19/00	15:00:00	51.3	176.1	29.1
7/19/00	16:00:00	56.6	193.0	29.3
7/19/00	17:00:00	62.6	204.6	30.6
7/19/00	18:00:00	63.6	206.6	30.8
7/19/00	19:00:00	69.1	213.4	32.4
7/19/00	20:00:00	126.2	213.1	59.2
7/19/00	21:00:00	126.3	210.8	59.9
7/19/00	22:00:00	128.6	212.3	60.6
7/19/00	23:00:00	126.3	207.2	61.0
7/20/00	00:00:00	110.5	183.8	60.1
7/20/00	01:00:00	93.0	146.5	63.5
7/20/00	02:00:00	84.4	138.4	61.0
7/20/00	03:00:00	84.4	139.0	60.7
7/20/00	04:00:00	84.5	137.0	61.7
7/20/00	05:00:00	84.5	139.0	60.8
7/20/00	06:00:00	74.8	135.3	55.3
7/20/00	07:00:00	42.3	137.2	30.8
7/20/00	08:00:00	43.5	148.1	29.4
7/20/00	09:00:00	49.9	166.4	30.0
7/20/00	10:00:00	49.9	167.7	29.8
7/20/00	11:00:00	50.0	168.6	29.7
7/20/00	12:00:00	51.4	172.3	29.8
7/20/00	13:00:00	57.4	194.5	29.5
7/20/00	14:00:00	57.4	199.2	28.8
7/20/00	15:00:00	57.5	197.2	29.2
7/20/00	16:00:00	57.6	199.2	28.9
7/20/00	17:00:00	63.5	215.6	29.5
7/20/00	18:00:00	63.4	213.7	29.7
7/20/00	19:00:00	68.8	219.3	31.4
7/20/00	20:00:00	123.8	215.1	57.6
7/20/00	21:00:00	109.6	181.9	60.3
7/20/00	22:00:00	111.4	185.2	60.2
7/20/00	23:00:00	109.3	180.6	60.5

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/21/00	00:00:00	104.6	174.4	60.0
7/21/00	01:00:00	95.1	156.7	60.7
7/21/00	02:00:00	81.5	135.1	60.3
7/21/00	03:00:00	81.3	134.7	60.4
7/21/00	04:00:00	85.0	140.2	60.6
7/21/00	05:00:00	86.0	141.3	60.9
7/21/00	06:00:00	81.3	139.7	58.2
7/21/00	07:00:00	40.7	135.7	30.0
7/21/00	08:00:00	41.4	139.0	29.8
7/21/00	09:00:00	51.1	166.2	30.7
7/21/00	10:00:00	51.3	169.5	30.3
7/21/00	11:00:00	52.4	169.6	30.9
7/21/00	12:00:00	60.3	195.0	30.9
7/21/00	13:00:00	61.0	198.3	30.8
7/21/00	14:00:00	66.0	217.0	30.4
7/21/00	15:00:00	66.1	223.6	29.6
7/21/00	16:00:00	66.1	222.6	29.7
7/21/00	17:00:00	66.0	221.9	29.7
7/21/00	18:00:00	66.1	222.3	29.7
7/21/00	19:00:00	69.9	228.8	30.6
7/21/00	20:00:00	72.8	164.2	44.3
7/21/00	21:00:00	120.2	204.0	58.9
7/21/00	22:00:00	129.4	213.1	60.7
7/21/00	23:00:00	129.8	212.5	61.1
7/22/00	00:00:00	106.3	177.9	59.8
7/22/00	01:00:00	91.1	151.0	60.3
7/22/00	02:00:00	86.6	144.5	59.9
7/22/00	03:00:00	86.9	143.9	60.4
7/22/00	04:00:00	86.8	149.9	57.9
7/22/00	05:00:00	86.7	142.0	61.1
7/22/00	06:00:00	87.3	150.1	58.2
7/22/00	07:00:00	2.9	120.2	2.4
7/22/00	08:00:00	1.5	118.8	1.3
7/22/00	09:00:00	1.5	119.4	1.3
7/22/00	10:00:00	1.6	120.0	1.3
7/22/00	11:00:00	1.6	132.4	1.2
7/22/00	12:00:00	1.6	162.2	1.0
7/22/00	13:00:00	1.6	177.3	0.9
7/22/00	14:00:00	1.5	176.1	0.9
7/22/00	15:00:00	1.5	175.8	0.9

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/22/00	16:00:00	1.5	153.8	1.0
7/22/00	17:00:00	1.5	150.2	1.0
7/22/00	18:00:00	1.5	152.4	1.0
7/22/00	19:00:00	5.4	149.0	3.6
7/22/00	20:00:00	87.1	151.9	57.3
7/22/00	21:00:00	80.5	135.1	59.6
7/22/00	22:00:00	80.8	136.1	59.4
7/22/00	23:00:00	80.7	135.8	59.4
7/23/00	00:00:00	80.7	132.8	60.8
7/23/00	01:00:00	84.7	139.7	60.6
7/23/00	02:00:00	91.9	151.2	60.8
7/23/00	03:00:00	91.9	152.1	60.4
7/23/00	04:00:00	91.9	153.5	59.9
7/23/00	05:00:00	88.2	148.4	59.4
7/23/00	06:00:00	76.6	133.5	57.4
7/23/00	07:00:00	4.7	131.4	3.6
7/23/00	08:00:00	1.7	117.4	1.4
7/23/00	09:00:00	1.5	122.7	1.2
7/23/00	10:00:00	1.5	133.4	1.1
7/23/00	11:00:00	1.5	135.5	1.1
7/23/00	12:00:00	1.5	149.0	1.0
7/23/00	13:00:00	1.5	172.5	0.9
7/23/00	14:00:00	1.5	173.0	0.9
7/23/00	15:00:00	1.5	168.4	0.9
7/23/00	16:00:00	1.6	165.5	1.0
7/23/00	17:00:00	1.5	163.0	0.9
7/23/00	18:00:00	1.5	156.7	1.0
7/23/00	19:00:00	3.3	148.9	2.2
7/23/00	20:00:00	75.9	146.5	51.8
7/23/00	21:00:00	79.8	144.5	55.2
7/23/00	22:00:00	79.1	144.9	54.6
7/23/00	23:00:00	75.2	128.3	58.6
7/24/00	00:00:00	75.1	128.1	58.6
7/24/00	01:00:00	75.1	127.7	58.8
7/24/00	02:00:00	75.1	129.5	58.0
7/24/00	03:00:00	75.2	127.9	58.8
7/24/00	04:00:00	75.1	127.3	59.0
7/24/00	05:00:00	75.1	129.2	58.1
7/24/00	06:00:00	74.6	128.6	58.0
7/24/00	07:00:00	10.9	108.2	10.1

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/24/00	08:00:00	1.5	102.4	1.5
7/24/00	09:00:00	1.5	122.8	1.2
7/24/00	10:00:00	1.5	151.5	1.0
7/24/00	11:00:00	1.5	164.2	0.9
7/24/00	12:00:00	1.5	171.5	0.9
7/24/00	13:00:00	0.4	179.0	0.2
7/24/00	14:00:00	0.0	202.1	0.0
7/24/00	15:00:00	0.0	201.7	0.0
7/24/00	16:00:00	0.0	201.6	0.0
7/24/00	17:00:00	1.5	206.5	0.7
7/24/00	18:00:00	1.5	203.6	0.7
7/24/00	19:00:00	2.8	214.0	1.3
7/24/00	20:00:00	126.0	237.2	53.1
7/24/00	21:00:00	127.4	211.8	60.2
7/24/00	22:00:00	119.0	199.9	59.5
7/24/00	23:00:00	117.9	197.4	59.7
7/25/00	00:00:00	102.1	170.8	59.8
7/25/00	01:00:00	89.5	149.1	60.0
7/25/00	02:00:00	83.1	134.8	61.6
7/25/00	03:00:00	75.3	126.9	59.3
7/25/00	04:00:00	75.4	127.3	59.2
7/25/00	05:00:00	75.3	127.3	59.2
7/25/00	06:00:00	75.3	128.8	58.5
7/25/00	07:00:00	42.3	139.1	30.4
7/25/00	08:00:00	42.1	145.2	29.0
7/25/00	09:00:00	43.1	148.0	29.1
7/25/00	10:00:00	50.3	164.6	30.6
7/25/00	11:00:00	50.3	168.9	29.8
7/25/00	12:00:00	50.3	168.8	29.8
7/25/00	13:00:00	51.3	176.8	29.0
7/25/00	14:00:00	55.2	185.9	29.7
7/25/00	15:00:00	55.2	187.0	29.5
7/25/00	16:00:00	55.2	186.5	29.6
7/25/00	17:00:00	55.1	190.4	28.9
7/25/00	18:00:00	55.2	183.9	30.0
7/25/00	19:00:00	57.0	183.7	31.0
7/25/00	20:00:00	99.0	168.5	58.8
7/25/00	21:00:00	99.4	166.0	59.9
7/25/00	22:00:00	99.5	163.8	60.7
7/25/00	23:00:00	97.5	165.4	58.9

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/26/00	00:00:00	88.0	145.6	60.4
7/26/00	01:00:00	75.6	127.6	59.2
7/26/00	02:00:00	75.6	127.7	59.2
7/26/00	03:00:00	76.9	129.8	59.2
7/26/00	04:00:00	75.5	127.6	59.2
7/26/00	05:00:00	75.5	127.5	59.2
7/26/00	06:00:00	71.9	127.7	56.3
7/26/00	07:00:00	45.3	144.3	31.4
7/26/00	08:00:00	45.1	152.5	29.6
7/26/00	09:00:00	45.1	150.9	29.9
7/26/00	10:00:00	45.1	149.3	30.2
7/26/00	11:00:00	45.1	151.7	29.7
7/26/00	12:00:00	45.6	151.5	30.1
7/26/00	13:00:00	51.3	172.5	29.7
7/26/00	14:00:00	51.3	173.1	29.6
7/26/00	15:00:00	56.9	190.7	29.8
7/26/00	16:00:00	57.1	185.0	30.9
7/26/00	17:00:00	57.2	193.0	29.6
7/26/00	18:00:00	57.2	188.5	30.3
7/26/00	19:00:00	58.7	186.5	31.5
7/26/00	20:00:00	110.4	190.1	58.1
7/26/00	21:00:00	114.2	189.5	60.3
7/26/00	22:00:00	114.1	189.2	60.3
7/26/00	23:00:00	111.0	184.5	60.2
7/27/00	00:00:00	93.1	156.6	59.5
7/27/00	01:00:00	75.7	129.2	58.6
7/27/00	02:00:00	74.3	126.1	58.9
7/27/00	03:00:00	74.4	128.0	58.1
7/27/00	04:00:00	74.3	126.2	58.9
7/27/00	05:00:00	74.3	125.9	59.0
7/27/00	06:00:00	69.2	122.8	56.4
7/27/00	07:00:00	45.4	146.2	31.1
7/27/00	08:00:00	45.3	147.1	30.8
7/27/00	09:00:00	45.3	149.2	30.4
7/27/00	10:00:00	45.3	147.7	30.7
7/27/00	11:00:00	45.3	147.7	30.7
7/27/00	12:00:00	46.2	149.2	31.0
7/27/00	13:00:00	53.2	179.0	29.7
7/27/00	14:00:00	62.5	209.5	29.8
7/27/00	15:00:00	62.6	208.8	30.0

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/27/00	16:00:00	62.6	211.3	29.6
7/27/00	17:00:00	62.6	210.1	29.8
7/27/00	18:00:00	62.6	209.7	29.9
7/27/00	19:00:00	64.2	210.6	30.5
7/27/00	20:00:00	118.7	204.9	57.9
7/27/00	21:00:00	118.3	198.8	59.5
7/27/00	22:00:00	102.8	174.1	59.0
7/27/00	23:00:00	89.8	151.1	59.4
7/28/00	00:00:00	86.7	148.8	58.3
7/28/00	01:00:00	73.5	128.5	57.2
7/28/00	02:00:00	74.8	128.5	58.2
7/28/00	03:00:00	73.6	128.3	57.4
7/28/00	04:00:00	73.6	128.2	57.4
7/28/00	05:00:00	73.5	126.3	58.2
7/28/00	06:00:00	65.7	121.5	54.1
7/28/00	07:00:00	1.6	133.2	1.2
7/28/00	08:00:00	1.6	137.7	1.2
7/28/00	09:00:00	1.5	137.6	1.1
7/28/00	10:00:00	1.5	137.3	1.1
7/28/00	11:00:00	1.5	137.4	1.1
7/28/00	12:00:00	1.5	137.8	1.1
7/28/00	13:00:00	1.5	138.7	1.1
7/28/00	14:00:00	1.5	152.3	1.0
7/28/00	15:00:00	1.5	197.2	0.8
7/28/00	16:00:00	1.5	193.2	0.8
7/28/00	17:00:00	1.5	211.5	0.7
7/28/00	18:00:00	1.5	223.0	0.7
7/28/00	19:00:00	13.2	240.5	5.5
7/28/00	20:00:00	138.2	265.8	52.0
7/28/00	21:00:00	135.8	233.7	58.1
7/28/00	22:00:00	113.5	196.4	57.8
7/28/00	23:00:00	98.7	167.1	59.1
7/29/00	00:00:00	97.9	162.9	60.1
7/29/00	01:00:00	86.6	153.2	56.5
7/29/00	02:00:00	84.4	139.5	60.5
7/29/00	03:00:00	84.4	137.5	61.4
7/29/00	04:00:00	84.5	139.6	60.5
7/29/00	05:00:00	84.4	137.9	61.2
7/29/00	06:00:00	80.8	136.8	59.1
7/29/00	07:00:00	2.3	109.5	2.1

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/29/00	08:00:00	1.5	111.1	1.4
7/29/00	09:00:00	1.5	149.9	1.0
7/29/00	10:00:00	1.5	170.5	0.9
7/29/00	11:00:00	1.5	162.8	0.9
7/29/00	12:00:00	1.5	155.7	1.0
7/29/00	13:00:00	1.5	199.4	0.8
7/29/00	14:00:00	1.5	202.6	0.7
7/29/00	15:00:00	1.5	189.0	0.8
7/29/00	16:00:00	1.5	158.4	0.9
7/29/00	17:00:00	1.5	148.0	1.0
7/29/00	18:00:00	1.5	155.6	1.0
7/29/00	19:00:00	13.7	167.7	8.2
7/29/00	20:00:00	130.5	217.7	59.9
7/29/00	21:00:00	99.1	167.2	59.3
7/29/00	22:00:00	90.2	149.1	60.5
7/29/00	23:00:00	89.8	144.8	62.0
7/30/00	00:00:00	88.9	142.1	62.6
7/30/00	01:00:00	84.2	137.1	61.4
7/30/00	02:00:00	84.2	137.2	61.4
7/30/00	03:00:00	84.3	139.4	60.5
7/30/00	04:00:00	84.3	140.2	60.1
7/30/00	05:00:00	84.3	138.4	60.9
7/30/00	06:00:00	76.1	138.9	54.8
7/30/00	07:00:00	2.8	155.2	1.8
7/30/00	08:00:00	1.6	133.3	1.2
7/30/00	09:00:00	1.6	135.4	1.2
7/30/00	10:00:00	1.6	144.4	1.1
7/30/00	11:00:00	1.6	132.2	1.2
7/30/00	12:00:00	1.6	131.0	1.2
7/30/00	13:00:00	1.6	116.4	1.4
7/30/00	14:00:00	1.6	125.9	1.3
7/30/00	15:00:00	1.6	131.9	1.2
7/30/00	16:00:00	1.6	137.1	1.2
7/30/00	17:00:00	1.6	139.1	1.2
7/30/00	18:00:00	1.6	171.0	0.9
7/30/00	19:00:00	1.6	155.0	1.0
7/30/00	20:00:00	80.7	156.5	51.6
7/30/00	21:00:00	84.4	144.1	58.6
7/30/00	22:00:00	84.1	140.5	59.9
7/30/00	23:00:00	72.7	126.7	57.4

Appendix G. cont.

Date	Hour	Spill	Tot Q	Percent spill
7/31/00	00:00:00	41.2	94.7	43.5
7/31/00	01:00:00	40.6	93.6	43.4
7/31/00	02:00:00	40.6	95.6	42.5
7/31/00	03:00:00	41.3	95.4	43.3
7/31/00	04:00:00	40.6	95.6	42.5
7/31/00	05:00:00	40.6	93.9	43.2
7/31/00	06:00:00	37.7	94.7	39.8
7/31/00	07:00:00	1.6	100.9	1.6
7/31/00	08:00:00	1.6	133.3	1.2
7/31/00	09:00:00	1.6	142.9	1.1
7/31/00	10:00:00	1.6	170.2	0.9
7/31/00	11:00:00	1.6	189.6	0.8
7/31/00	12:00:00	1.6	205.3	0.8
7/31/00	13:00:00	1.6	210.1	0.8
7/31/00	14:00:00	1.6	224.4	0.7
7/31/00	15:00:00	1.6	224.7	0.7
7/31/00	16:00:00	1.6	226.6	0.7
7/31/00	17:00:00	1.6	210.2	0.8
7/31/00	18:00:00	1.6	197.9	0.8
7/31/00	19:00:00	1.6	183.9	0.9
7/31/00	20:00:00	128.8	246.4	52.3
7/31/00	21:00:00	140.1	254.6	55.0
7/31/00	22:00:00	136.8	241.0	56.8
7/31/00	23:00:00	119.4	198.8	60.1

Appendix H. Fork lengths and weights of subyearling chinook salmon released at Rock Creek, summer 2000.

Release Date	Release time	N	Fork length (mm)			Weight (g)		
			Mean	SD	Range	Mean	SD	Range
6/30/00	20:00	32	118.9	5.0	112-132	19.0	2.7	15.1-28.5
7/02/00	08:00	19	115.5	3.4	110-122	17.7	1.8	13.8-20.0
7/03/00	20:00	24	117.4	5.9	112-132	18.9	3.2	15.8-26.8
7/05/00	08:00	33	120.5	7.3	111-146	20.9	4.3	14.7-35.6
7/06/00	20:00	32	116.8	7.1	110-137	18.8	4.1	14.2-30.3
7/08/00	08:00	32	118.1	5.2	111-131	18.6	3.1	14.5-28.1
7/09/00	20:00	32	117.5	5.8	111-135	18.9	3.2	14.9-29.3
7/11/00	08:00	29	121.6	10.0	112-152	21.8	6.4	13.8-42.6
7/12/00	20:00	34	117.3	6.7	110-142	17.9	2.7	13.6-25.0
7/14/00	08:00	32	117.2	4.7	111-127	18.3	2.7	14.4-24.6
7/16/00	20:00	33	123.2	6.3	115-139	21.0	3.2	16.3-28.7
7/17/00	08:00	31	118.4	6.2	111-137	18.3	3.2	14.4-28.8
7/20/00	08:00	31	116.6	4.0	111-128	19.0	2.3	15.9-26.7
Overall		394	118.5	6.5	110-152	19.2	3.7	13.6-42.6

Appendix I. Number subyearling chinook salmon (CH0) passing John Day Dam through the juvenile fish bypass, powerhouse, and spillway during 12 and 24-h spill treatments, summer 2000. Day = 0700-1859, Night = 1900-0659.

Block	Treatment	Spill Period	Species	Location	Frequency
1	12	Day	CH0	JUVBYPAS	13
1	12	Day	CH0	POWERHOU	7
1	12	Day	CH0	SPILLWAY	0
1	12	Night	CH0	JUVBYPAS	1
1	12	Night	CH0	POWERHOU	1
1	12	Night	CH0	SPILLWAY	27
1	24	Day	CH0	JUVBYPAS	1
1	24	Day	CH0	POWERHOU	1
1	24	Day	CH0	SPILLWAY	20
1	24	Night	CH0	JUVBYPAS	1
1	24	Night	CH0	POWERHOU	4
1	24	Night	CH0	SPILLWAY	16
2	12	Day	CH0	JUVBYPAS	7
2	12	Day	CH0	POWERHOU	6
2	12	Day	CH0	SPILLWAY	0
2	12	Night	CH0	JUVBYPAS	1
2	12	Night	CH0	POWERHOU	3
2	12	Night	CH0	SPILLWAY	21
2	24	Day	CH0	JUVBYPAS	5
2	24	Day	CH0	POWERHOU	2
2	24	Day	CH0	SPILLWAY	32
2	24	Night	CH0	JUVBYPAS	3
2	24	Night	CH0	POWERHOU	2
2	24	Night	CH0	SPILLWAY	20
3	12	Day	CH0	JUVBYPAS	13
3	12	Day	CH0	POWERHOU	10
3	12	Day	CH0	SPILLWAY	0
3	12	Night	CH0	JUVBYPAS	0
3	12	Night	CH0	POWERHOU	3
3	12	Night	CH0	SPILLWAY	28
3	24	Day	CH0	JUVBYPAS	5
3	24	Day	CH0	POWERHOU	4
3	24	Day	CH0	SPILLWAY	28
3	24	Night	CH0	JUVBYPAS	0
3	24	Night	CH0	POWERHOU	1
3	24	Night	CH0	SPILLWAY	12
4	12	Day	CH0	JUVBYPAS	1
4	12	Day	CH0	POWERHOU	0
4	12	Day	CH0	SPILLWAY	0

Appendix I. cont.

Block	Treatment	Spill Period	Species	Location	Frequency
4	12	Night	CH0	JUVBYPAS	1
4	12	Night	CH0	POWERHOU	0
4	12	Night	CH0	SPILLWAY	2
4	24	Day	CH0	JUVBYPAS	0
4	24	Day	CH0	POWERHOU	2
4	24	Day	CH0	SPILLWAY	13
4	24	Night	CH0	JUVBYPAS	1
4	24	Night	CH0	POWERHOU	0
4	24	Night	CH0	SPILLWAY	6

Appendix J. Percent of radio–tagged subyearling chinook salmon (CH0) passage via the turbines, spillway and juvenile bypass of John Day Dam during 12-h and 24-h spill treatments (Trt) used during summer 2000. Sample sizes are shown in parentheses.

Species	Block	Trt	Turbines	Spillway	Juvenile Bypass
CH0	1	12-h	16.3 (8)	55.1 (27)	28.6 (14)
	1	24-h	11.6 (5)	83.7 (36)	4.7 (2)
	2	12-h	23.7 (9)	55.3 (21)	21.0 (8)
	2	24-h	6.3 (4)	81.2 (52)	12.5 (8)
	3	12-h	24.1 (13)	51.8 (28)	24.1 (13)
	3	24-h	10.0 (5)	80.0 (40)	10.0 (5)
	4	12-h	0.0 (0)	50.0 (2)	50.0 (2)
	4	24-h	9.1 (2)	86.4 (19)	4.5 (1)