U.S. Army Corps of Engineers
Portland District

Passage Behavior of Radio-Tagged Yearling Chinook Salmon and Steelhead at Bonneville Dam, 2004
Revised for Corrected Spill

Annual Report

Prepared by:

Rachel E. Reagan, Scott D. Evans, Lisa S. Wright, M. Jared Farley,
Noah S. Adams, and Dennis W. Rondorf
U.S. Geological Survey
Columbia River Research Laboratory
5501 A Cook-Underwood Road
Cook, Washington 98605

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U.S. Army Corps of Engineers
Portland District
Planning and Engineering Division
Environmental Resources Branch
Robert Duncan Plaza
333 S.W. 1st. Avenue
Portland, Oregon 97204-3495

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Executive Summary

Flow augmentation, spill, surface collection, and improved turbine guidance systems have been identified as potential management actions to improve passage efficiency and survival of outmigrating juvenile salmonids. The U.S. Army Corps of Engineers (USACE), along with regional, state, and federal resource agencies, has designed and implemented studies to determine which management actions would provide significant biological benefits to juvenile salmonids. From 1994 to 2004, the USACE has contracted the U.S. Geological Survey to evaluate juvenile salmonid behavior in relation to passage improvement tests at Lower Granite, John Day, The Dalles, and Bonneville Dams.

In 2004, we used radio telemetry to examine the movements and behavior of yearling Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* in the forebay of Bonneville Dam. The objectives of this research were to: 1) determine the behavior, distribution, and approach patterns of fish in the forebay areas of Bonneville Dam, 2) determine the timing and route of dam passage of fish, 3) estimate fish passage efficiency for the entire Bonneville Dam complex, fish guidance efficiency for powerhouses I and II, and efficiency and effectiveness for the spillway and corner collector, and 4) provide data to estimate survival of radio tagged fish released above and at Bonneville Dam.

From 27 April to 2 June 2004, we radio-tagged and released 6,716 yearling Chinook salmon and 4,399 yearling steelhead upstream of Bonneville Dam at John Day Dam and The Dalles Dam. At Bonneville Dam, we detected our first radio-tagged fish on 29 April 2004 and we detected our last radio-tagged fish on 7 June 2004. Mean river discharge at Bonneville Dam during the study period was 218.9 kcfs, with 35% of flow discharged at the spillway (SPI), 49% at the second powerhouse (B2), and 16% at the first powerhouse (B1). Although no spill treatments were designed into the study plan, fish were exposed to two different spill conditions throughout the study: (1) A mean discharge of 59.3 kcfs was spilled during the day and occurred for a total of 640 h over 40 d and (2) Discharge up to the total dissolved gas cap during nighttime hours occurred for a total of 320 h over 40 d with an average discharge of 112.9 kcfs. Median travel rates of radio-tagged fish from release to Bonneville Dam were 2.4 - 2.5 km/h, depending on species and release site, resulting in median travel times of 29.6 – 45.1 h. Of the fish released from John Day and The Dalles Dams, we detected 89% of yearling Chinook salmon and 91% of steelhead at Bonneville Dam. Of the fish detected downstream of Bonneville Dam, we detected 98% of yearling Chinook salmon and 99% of steelhead at Bonneville Dam. Median forebay residence time for Chinook salmon was shortest at B2 (6 min), compared to 18 min at the spillway and 54 min at B1. Median forebay residence time for steelhead was shortest at the spillway (18 min), compared to 30 min at B2 and 4.2 h at B1.

Passage routes were determined for 99.9% of Chinook salmon and 99.8% of steelhead detected at Bonneville Dam. The second powerhouse passed the most fish (59% of Chinook salmon and 66% of steelhead), followed by the spillway (33% of Chinook salmon and 25.5% of steelhead) and B1 (8% of Chinook salmon and 8.5% of steelhead). Of the fish that passed at B1, 53% of Chinook salmon and 55% of steelhead passed into the sluiceway, while 46% of Chinook salmon and 42% of steelhead passed

through the turbines (unguided). Of the Chinook salmon that passed at B2, 43% passed unguided through the turbines, 36% passed through the corner collector, and 21% were guided into the DSM. Of the steelhead that passed at B2, 74% passed through the corner collector, 16% passed unguided through the turbines, and 10% were guided into the DSM. Passage rates were higher for both species during the day than during the night at both powerhouses, except for steelhead at B2 where passage rates were similar during day and night. In contrast, at the spillway, passage rates were higher for both species at night.

Fish passage efficiency (FPE: the proportion of fish that passed the dam via non-turbine routes) at Bonneville Dam in spring 2004 was 71% (SE = 0.6) overall for Chinook salmon and 86% (SE = 0.5) for steelhead. During the day, when spill discharge averaged 78 kcfs, FPE was 70% (SE = 0.7) for Chinook salmon and 91% (SE = 0.6) for steelhead. During the night, when spill discharge averaged 130 kcfs, Chinook salmon had an FPE of 74% (SE = 1.0) and steelhead had an FPE of 76% (SE = 1.2). At B1, overall FPE was 54% (SE = 2.3) for Chinook salmon and 58% (SE = 2.7) for steelhead. At B2, overall FPE was 57% (SE = 0.8) for Chinook salmon and 84% (SE = 0.7) for steelhead. Fish guidance efficiency (FGE: the proportion of powerhouse-entrained fish that are guided by screens into the bypass system) was determined only at B2 since no guidance system operated at B1 during 2004. Overall FGE was 33% (SE = 1.0) for Chinook salmon and 40% (SE = 1.9) for steelhead. Fish Guidance Efficiency during the day was 31% (SE = 1.2) for Chinook salmon and 44% (SE = 2.7) for steelhead. During the night, FGE was 37% (SE = 1.8) for Chinook salmon and 36% (SE = 2.5) for steelhead. Chinook salmon had a spillway efficiency (proportion of fish passing all routes that passed via spill) of 33% (SE = 1.1) overall, 25% (SE = 1.3) during the day, and 51% (SE = 1.7) during the night. Spillway efficiency for steelhead was 26% (SE = 1.4) overall, 12% (1.8) during the day, and 54% (SE = 1.9) during the night. Spillway effectiveness (spillway efficiency divided by the proportion of total discharge through the spillway) for Chinook salmon was 0.9 overall, 0.9 during the day, and 1.0 during the night. Spillway effectiveness for steelhead was 0.7 overall, 0.4 during the day, and 1.1 during the night. Corner collector efficiency (CCE: the number of fish that passed through the corner collector divided by the number of fish that passed through all routes at B2) for Chinook salmon was 37% (SE = 0.8) overall, 43% (SE = 1.0) during the day, and 18% (SE = 1.3) during the night. Steelhead had a CCE of 74% (SE = 0.9) overall, 85% (SE = 0.8) during the day, and 27% (2.0) during the night. Corner collector effectiveness (CCF: corner collector efficiency divided by the proportion of discharge at B2 that went through the corner collector) for Chinook salmon was 7.0 overall, 8.7 during the day, and 2.9 during the night. Steelhead had a CCF of 14.2 overall, 17.4 during the day, and 4.5 during the night.

Like in previous years, the proportion of discharge allocated among B1, B2, and the spillway affected which dam area fish entered and passed, as well as the time fish spent in the forebay before passing. Since the greatest discharge occurred at B2, more than half of both species entered the forebay of B2 and spent the least amount of time relative to the other forebays before passing. Of the two spill conditions, spill at night (mean = 113 kcfs) was the most efficient, passing 51% (SE = 1.7) of Chinook salmon and 54% (SE = 1.9) of steelhead relative to all other passage routes. Conversely, passage through the corner collector was significantly higher during the day than during the night for both yearling Chinook salmon (43%) and steelhead (85%). Another shallow passage route, the sluiceway, was also more efficient during the day (54% for yearling Chinook salmon and 69% for steelhead) than during the night (48% for yearling Chinook salmon and 29% for steelhead).

Passage metrics for both yearling Chinook salmon and steelhead were generally lower in 2004 than in 2002. The only passage metrics that were higher in 2004 were FPE_{B2} for both species and $FPE_{project}$ for steelhead. If guidance screens had been deployed at B1 in 2004, FPE_{B1} and $FPE_{project}$ would have been higher. However, due to low discharge at B1 in 2004, relatively few fish passed there and the increase would have been minimal. Fish guidance efficiency at B2 in 2004 was the lowest of all study years. We hypothesize that low FGE_{B2} in 2004 was due to the corner collector passing the majority of the shallow fish; fish that otherwise may have been guided. Spillway efficiency decreased in 2004 because more fish passed at B2, specifically through the corner collector. The increased passage at B2 through the corner collector is reflected in increased FPE_{B2} for both species, and in the slight increase in $FPE_{project}$ for steelhead. Although the addition of the corner collector did not increase $FPE_{project}$, it did achieve $FPE_{project}$ similar to that attained in previous years, mainly through spill. Furthermore, the corner collector helped achieve similar $FPE_{project}$ with far less water than would have been used to attain the same FPE without the corner collector. The spillway discharged an average 17 times more water than the corner collector. Consequently, effectiveness of the corner collector relative to the project (8.4 for yearling Chinook salmon and 19.1 for steelhead) was far greater than effectiveness of the spillway (0.9 for yearling Chinook salmon and 0.7 for steelhead). Our results indicate that although the intake screen guidance systems at both powerhouses of Bonneville Dam have poor guidance efficiency, project FPE of 71-86%, depending on species, can be attained if sufficient numbers of fish are passed via a combination of non-turbine routes (spill, sluice, turbine guidance systems, and the corner collector). Additionally, by strategically optimizing discharge patterns at the project, passage of juvenile salmonids can be increased temporally and spatially.

1.0 Introduction

Years of research have been allocated to ensure the long-term survival of salmon and steelhead stocks in the Columbia River basin. Much of this effort has focused on the effects of dams and reservoirs on juvenile salmonids as they migrate from their natal waters to the ocean. Raymond (1968, 1979) and Park (1969) showed migration times increased after dam construction, and suggested this may be detrimental to juvenile salmonid survival.

Flow augmentation, spill, surface collection, and improved turbine intake guidance systems have been identified as potential management actions to improve juvenile salmonid passage and survival, thereby assisting the recovery of anadromous fish stocks in the Snake and Columbia rivers. Options currently being evaluated at Bonneville Dam are the improvement of turbine intake guidance systems and a new corner collector surface-flow bypass system.

In 2000, we conducted the first evaluation of species-specific FPE for the entire Bonneville Dam project and estimated that FPE was between 73% and 91%, depending on species (Evans et. al. 2001a and 2001b). The National Marine Fisheries Service Biological Opinion (2000) states, "The dam passage survival rate at Bonneville Dam is currently one of the lowest of any U.S. Army Corps of Engineers Federal Columbia River Power System (FCRPS) project, and is therefore the highest priority relative to the need for improvements," and that the Corps should "continue intake screen guidance improvement investigations and implement as warranted." The U.S. Army Corps of Engineers (USACE) addressed these concerns in 2001 by field-testing a prototype screen system at turbine unit 15 at Bonneville's second powerhouse (Monk et al. 2002). In 2002, Monk et al. (2004) evaluated intake screen modifications at turbine unit 17 and a minimum gap runner (MGR) turbine at Bonneville's first powerhouse was tested (Counihan et al. 2003). In 2004, studies of the MGR turbine continued and evaluations were also conducted for the ice and trash sluiceway at the first powerhouse and the corner collector at the second powerhouse. To determine whether these management actions are effective, it is necessary to estimate passage efficiencies and survival and compare those estimates to pre-improvement passage efficiencies and survival.

During spring 2004, we used radio telemetry to examine the movements and behavior of yearling Chinook salmon *Oncorhynchus tshawytscha* and yearling steelhead *O. mykiss* at Bonneville Dam. Our objectives were to:

- Determine the timing and route of passage for yearling Chinook salmon and steelhead at Bonneville Dam relative to spill, powerhouse operations, and corner collector tests.

- Monitor all passage routes at Bonneville Dam to determine route-specific and project survival for yearling Chinook salmon and steelhead.

- Estimate fish passage efficiency for the entire Bonneville Dam complex, fish guidance efficiency for the second powerhouse, spillway efficiency and effectiveness, corner collector efficiency and effectiveness, and sluiceway efficiency and effectiveness.

- Provide data to estimate route-specific and project survival of radio-tagged fish released above Bonneville Dam (reported by Counihan et al. 2005).

2.0 Methods

2.1 Study Area

Bonneville Dam is located on the Columbia River at rkm 233. The dam consists of two powerhouses and a single spillway, each separated by an island. The first powerhouse (B1) consists of 10 turbine units and is located at the south side of the river, spanning from the Oregon shore to Bradford Island. The second powerhouse (B2) consists of eight turbine units and is located at the north side of the river, spanning from Cascades Island to the Washington shore. The spillway lies between Cascades and Bradford islands and has 18 spill gates. A navigation lock is located at the south end of B1 (Figure 1).

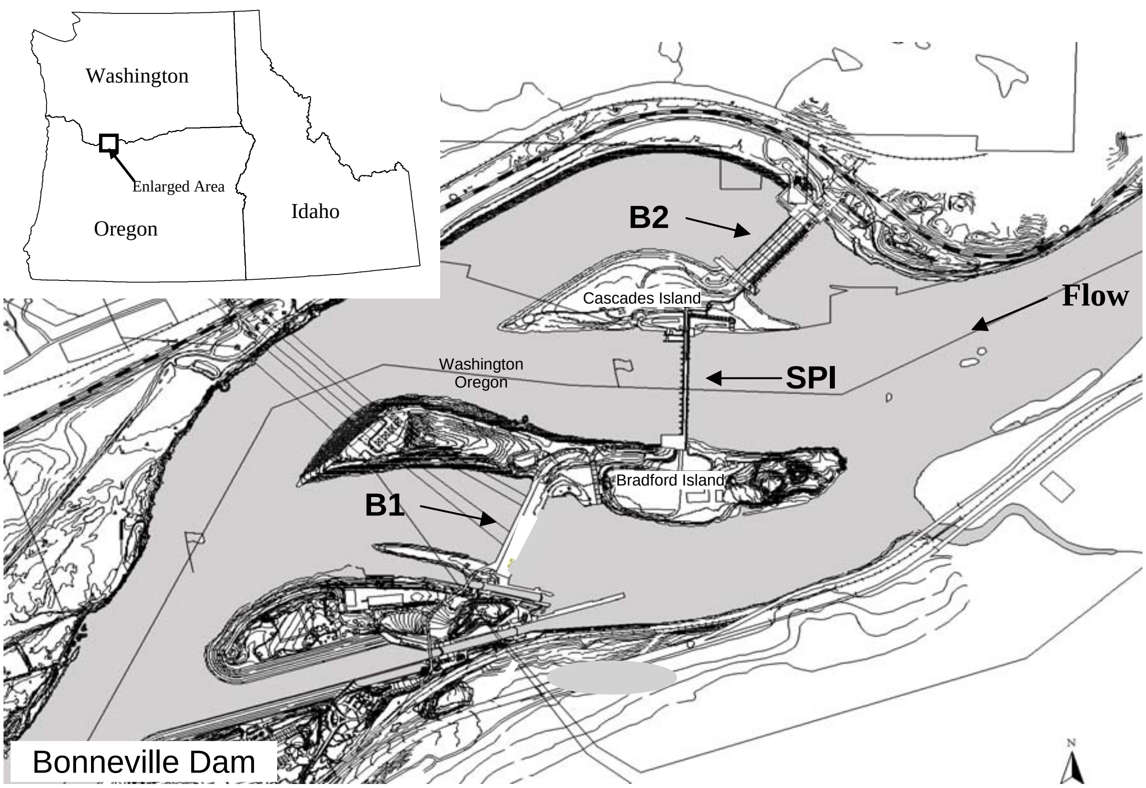

Figure 1.—Plan view of Bonneville Dam on the Columbia River showing the first powerhouse (B1), spillway (SPI), and second powerhouse (B2). Image source: U.S. Army Corps of Engineers.

2.2 Water quality

We monitored water temperature (± 0.2ºC), dissolved oxygen (DO; ± 0.2 ppm), and electrical conductivity (EC; 0.5%) throughout the study using a Stevens-Greenspan CS304 multi-parameter sensor (Stevens Water Monitoring Systems, Inc, Beaverton, Oregon). The CS304 was deployed 1.5 m below the water surface in the forebay of the Bonneville Dam spillway and was programmed to record water temperature, DO, and EC measurements every minute.

2.3 Fixed Receiving Equipment

We used four types of data acquisition equipment to monitor underwater and aerial antennas at Bonneville Dam in 2004. Ninety-seven aerial antennas, 35 stripped coax antennas, and 124 underwater dipole antennas were linked to 34 Lotek SRX-400 receivers (SRX; Lotek Engineering, Newmarket, Ontario), five Lotek DSP-500 digital spectrum processors (DSP; Lotek Engineering, Newmarket, Ontario), three Orion DSP receivers (Grant Systems Engineering, King City, Ontario, Canada), and three Multiprotocol Integrated Telemetry Acquisition Systems (MITAS; Grant Systems Engineering, King City, Ontario, Canada). Each SRX monitored a maximum of six aerial antennas. Orions, DSPs, and MITASs were used to monitor underwater antennas. Orions and DSPs were also used to monitor aerial antennas in some areas. The combination of these technologies allowed us to monitor approach behavior and passage through all routes at Bonneville Dam.

Aerial antennas were positioned in three locations: 1) along the periphery of the forebay, 2) along the tailrace shoreline, and 3) along the corner collector flume (Figure 2). Aerial antennas were located in the forebay to detect fish within 100 m of the dam, in the tailrace to confirm fish passage, and in the corner collector flume to detect fish passing through the corner collector. Aerial antennas were connected to SRX receivers programmed to monitor seventeen frequencies in random order. Two aerial antenna monitoring configurations were used depending on location: auxiliary/master switching or combined antennas. The auxiliary/master switching configuration was used in the forebay of both powerhouses and at entrance stations where signal acquisition time was longer and more spatial resolution was required. Combined antenna configurations were used in the spillway forebay and all tailraces where signal acquisition time was limited and less spatial resolution was needed. In addition to combining antennas to reduce scan time, the scan time (a function of the number of frequencies being monitored) was reduced by half by using an extra receiver at all locations. Reducing scan time is beneficial because it increases the probability of detecting transmitters. Underwater dipole and stripped coax antennas had limited ranges (about 6 m) compared to aerial antennas (100 to 300 m depending on transmitter depth, receiver gain, and number of antenna elements). Underwater antennas allowed us to obtain fine scale fish behavior information by limiting the range of signal detection.

Two SRX receivers in the B2 tailrace, two SRX receivers in the corner collector flume, and one SRX receiver at the B2 smolt monitoring facility were each coupled with DSPs. These receivers had essentially no scan time because a DSP acquires signals over

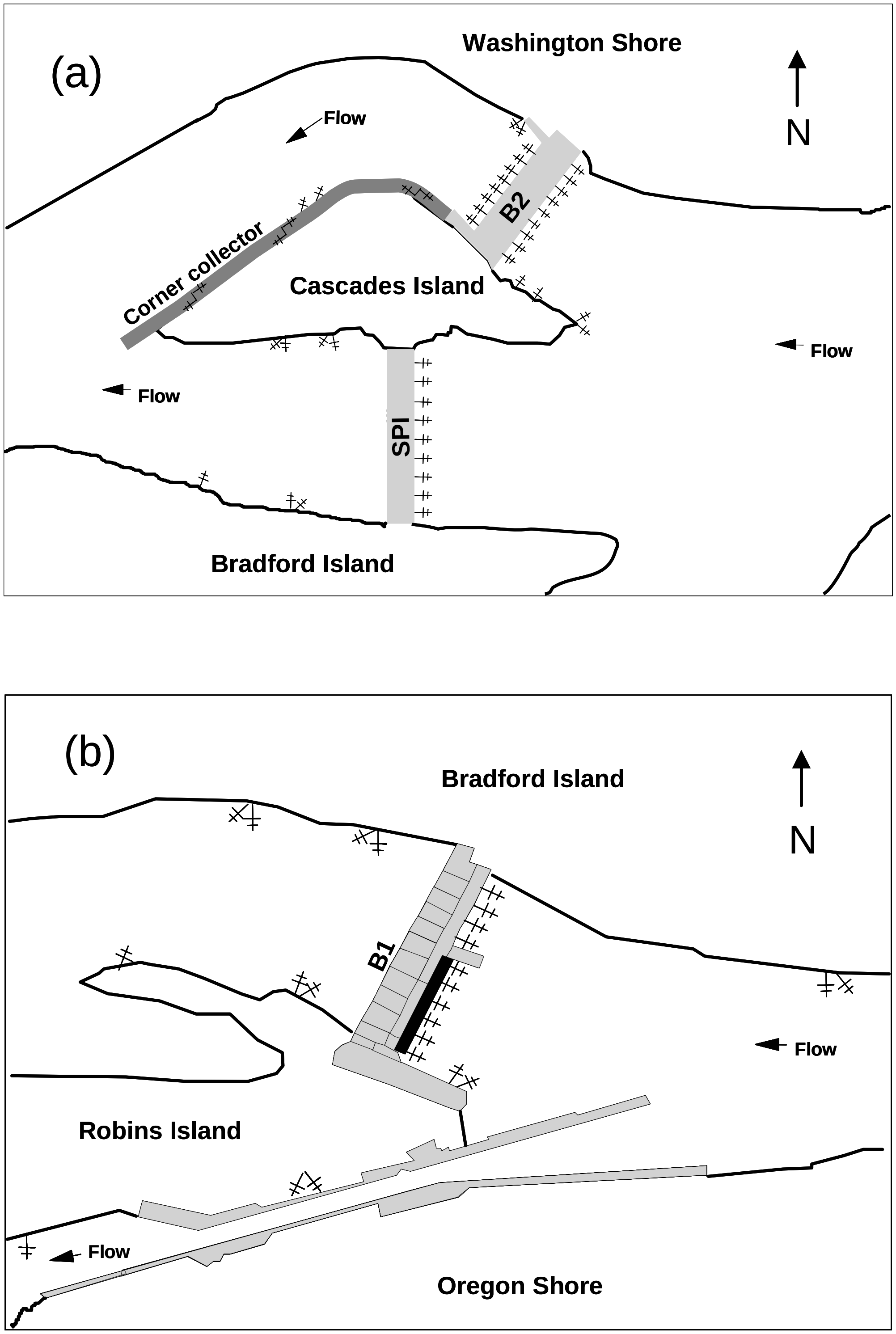

Figure 2.—Plan view of aerial antenna coverage during spring 2004 at Bonneville Dam's: (a) second powerhouse (B2) and spillway (SPI); and (b) first powerhouse (B1).

a 1 MHz bandwidth almost instantaneously. Using DSPs, rather than a stand-alone SRX, was necessary to document fish passage in high flow hydraulic environments because signal acquisition time is limited.

One Orion receiver at the B2 smolt monitoring facility and two Orion receivers in the corner collector flume were also used. Since this was the first year that Orion receivers were used, they were placed in conjunction with DSPs. All three of the Orion receivers were monitoring the same frequencies and antennas as the DSPs. The Orion receiver also has essentially no scan time because signals are acquired over a 1 MHz bandwidth.

Three MITAS systems were incorporated at B1, B2, and the spillway (Figure 3). Each MITAS was capable of simultaneously monitoring up to 50 inputs with greater multiple transmitter recognition than the SRX, DSP, or Orion. Although each MITAS was limited to a maximum of 50 inputs, each input could be a horizontal or vertical combination of multiple underwater dipole or stripped coax antennas. In addition to enhanced signal recognition, the MITAS's data displays and on-screen diagnostics allowed the user to identify problems in real-time and avoid potential data loss that otherwise would not have been apparent until post-processing.

The MITAS at B1 was composed of 22 underwater stripped coax antennas and one aerial antenna. Twenty stripped coax antennas were positioned mid-channel in the sluiceway, two at each unit, to monitor unit-specific sluiceway entrance and passage through the sluiceway. In addition, two stripped coax antennas and one aerial antenna were placed at the outfall of the sluiceway to confirm sluiceway passage.

The MITAS at B2 was composed of 61 underwater antennas. Forty-eight dipole underwater antennas attached to the submersible traveling screens monitored unguided turbine passage: Two dipole antennas were mounted to the bottom of each of three submersible traveling screens in front of each of eight turbine units. Antennas from each of three gatewell slots per unit were combined to provide turbine unit specific passage information. Nine stripped coax antennas placed within the downstream salmonids migrant channel (DSM) monitored guided fish passage. One antenna was located just downstream of each "C-slot" gatewell orifice and one additional antenna was located at the terminus of the DSM. Four dipole underwater antennas monitored approach and entrance of fish to the corner collector.

The spillway MITAS consisted of 72 underwater antennas. Seventy-two dipole underwater antennas monitored spillway passage and were attached to the forebay pier noses. Each spillbay had four antennas; two antennas on each piernose at about 4.5 m below mean pool level and 2 antennas at about 10.5 m below mean pool level. All four antennas in each spillbay were combined to one input to provide spillbay-specific passage.

Regardless of the type of monitoring technology used, a standard input signal of known value was used to determine the signal strength reaching each receiver. All aerial antennas were amplified in close proximity to the receiving antenna and transmission line amplification was used as needed to insure signal quality. Underwater antenna transmission lines were amplified as soon as they reached the deck elevation. Over-amplified signals were attenuated down to a standard level. These efforts insured that all antennas within and among arrays were equally sensitive and resulted in a balanced receiving system.

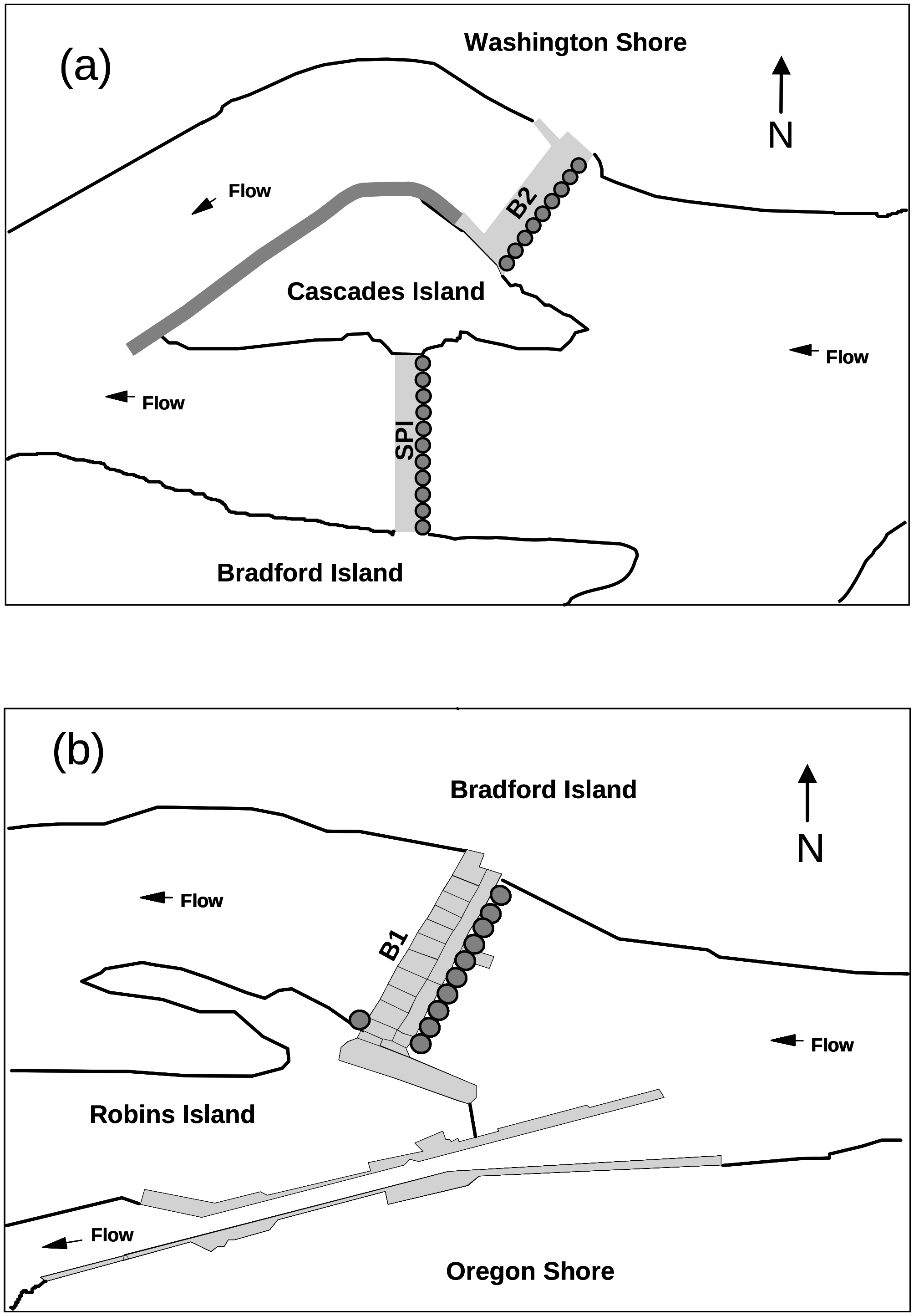

Figure 3.—Plan view of underwater antenna coverage during spring 2004 at Bonneville Dam's: (a) second powerhouse (B2) and spillway (SPI); and (b) first powerhouse (B1).

2.4 Transmitters

Coded microprocessor transmitters (model MCFT-3KM) manufactured by Lotek Engineering Inc. were implanted in yearling Chinook salmon and steelhead. The transmitters were 7.3 mm (diameter) x 18 mm and weighed 1.4 g in air and 0.8 g in water. The antenna length was 30 cm and the pulse rate was 2.0 s, resulting in an estimated minimum tag life of 9 d.

2.5 Tagging, Handling, and Release of Fish

Juvenile Chinook salmon and steelhead were collected at the Smolt Monitoring Facility (SMF) at John Day Dam. Employees from the Pacific States Marine Fisheries Commission's Smolt Monitoring Program and U.S. Geological Survey employees sorted and identified study fish. Fish were weighed at the time of collection to ensure they met the minimum weight criteria of 21.5 g, keeping the tag weight to fish weight ratio below 6.5%. Fish collected at John Day Dam were tagged and released into the Columbia River at John Day Dam and at The Dalles Dam. Although fish were tagged and released at different locations, the fish handling, tagging, transport, and release methods were standardized.

Subsequent to collection, fish to be tagged and released at John Day Dam were held for 12-24 h at the SMF in 303 L circular fiberglass tanks supplied with flow-through river water at a maximum density of 100 fish per tank. Fish to be tagged and released at The Dalles Dam were collected, loaded into 265 L plastic tanks and transported to The Dalles Dam in temperature-controlled trucks. The tanks were supplied with oxygen throughout transport. Once at The Dalles Dam, the tanks were supplied with flow-through river water and fish were held for 12-24 h before tagging. The holding times for fish prior to tagging allowed the fish to attain a post-absorptive state, helping to minimize stress throughout the tagging procedure.

All fish were gastrically implanted with a radio transmitter using procedures described by Adams et al. (1998). Fish were anesthetized using tricaine methanosulfate (MS-222) at a concentration of 50 mg/L of fresh water. An equal amount of buffer solution ($NaHCO_3$) was added, along with stress coat at a concentration of 0.25 ml/L. Fish were netted from the holding tanks into the prepared anesthesia bucket with a maximum density of 5 fish in anesthesia at one time. Timers were used to ensure that no fish remained in the anesthesia for longer than 5 min. Fish were carefully observed to determine when adequate sedation occurred (evident by loss of equilibrium), then removed from anesthesia and examined for overall condition and fin clip. Fish that met criteria for size and condition were weighed, measured and tagged, then placed in an oxygenated recovery bucket for 5 min. A maximum of two fish were held in each recovery bucket and oxygen was supplied at a minimum flow rate of 50 ml/min. Following the recovery period, fish were checked for regurgitated tags or mortalities. Each bucket was then covered with a locking lid and held for 18-24 h in a 3.6 m x 1.2 m x 1.2 m aluminum tank supplied with flow-through river water to a depth of 27.5 cm. Recovery buckets were modified 19 L buckets, designed to hold 5 L of water while simultaneously allowing adequate flow-through of water through numerous drilled holes. Prior to transporting the fish to the release site, each recovery bucket was checked for mortalities, regurgitated tags and tag functionality. Releases occurred during day and night (0700 and 1900 hours at John Day Dam, 0100-0700 and 1300-1900 hours at The Dalles Dam) to enable tagged fish to mix spatially and temporally with untagged fish in the river before reaching Bonneville Dam. The upstream release locations allowed fish an average of 31 to 45 h, depending on species and release site, to adjust to temperature and hydraulic conditions in the reservoir before reaching the forebay and encountering Bonneville Dam.

2.6 Data Management and Analysis

Fixed receivers were typically downloaded every day. All data were backed up daily and imported into SAS (version 8.1, SAS Institute Inc., Cary, North Carolina, USA) for subsequent proofing and analysis. This was the first year that we implemented an automated proofing program, designed specifically for Bonneville Dam data. The automated proofing program was written in SAS and allowed us to proof and process our data with increased speed. Data were proofed to eliminate non-valid records including: environmental noise, single records of a particular channel and code, records collected prior to a known release date and time, and records suspected to be fish consumed by avian or aquatic predators. To consider a detection of a radio-tagged fish as valid, we required at least two detections within 1 min of each other. All data records for fish that fell outside of our set criteria for travel time, residence time, and geographical area were flagged and subsequently proofed manually. Additionally, a 10% sub-sample of each auto-proofed file was proofed manually as a quality assurance measure of the auto-proofing program and to ensure accurately proofed data.

Entrance into the forebay area was determined by the location and time an individual fish was first detected by aerial or underwater antennas on the dam face. Similarly, the last detection of a fish by aerial or underwater antennas on the dam face, on the traveling screens, at the corner collector, within the B2 DSM, or the B1 sluiceway, was considered to be the route and time of passage through the dam. If a fish was not detected in the forebay or within the dam, the tailrace exit stations were used to determine the passage location (DSM, corner collector, turbine, or sluiceway).

Residence time in the forebay, defined as the duration of time between the first and last detections in the forebay, was calculated for each radio-tagged fish detected in the forebay. Residence times are a minimum estimate of the actual time that radio-tagged fish spent in the forebay because of receiver limitations and detection probabilities. For example, fish may enter the forebay before they are first detected and may remain following their last detection. Additionally, fish that approach very deep may have a low probability of detection and thus pass the dam undetected.

The following are definitions of metrics used to measure passage behavior of radio-tagged fish at Bonneville Dam:

- Spillway efficiency (SPE) = $\dfrac{SP}{(B1 + SP + B2)}$

- Spillway effectiveness (SPF) = $\dfrac{SPE}{F_{SP} / F_{tot}}$

- Fish guidance efficiency (FGE) = $\frac{G_{tot}}{(G_{tot} + UG_{tot})}$

- Fish passage efficiency (FPE) = $\frac{Non-turbine\ passage}{TOT_{pass}}$

- Corner collector efficiency (CCE) = $\frac{CC}{B2}$

- Corner collector effectiveness (CCF) = $\frac{CCE}{F_{CC} / F_{B2}}$

- Sluiceway efficiency (SLE) = $\frac{SL}{B1}$

- Sluiceway effectiveness (SLF) = $\frac{SLE}{F_{SL} / F_{B1}}$

Where:

SP = Total number of fish passing spillway.
CC = Total number of fish passing through corner collector.
B1 = Total number of fish passing B1.
B2 = Total number of fish passing B2.
SL = Total number of fish passing through B1 sluiceway.
G_{tot} = Total number of guided fish.
UG_{tot} = Total number of unguided fish.
TOT_{pass} = Total number of fish passing the project (B1+SP+B2).
F_{SP} = Average discharge (kcfs) through the spillway during the study period.
F_{CC} = Average discharge (kcfs) through the corner collector during the study period.
F_{B1} = Average discharge (kcfs) through the first powerhouse during the study period.
F_{B2} = Average discharge (kcfs) through the second powerhouse during the study period.
F_{tot} = Average discharge (kcfs) through the project (B1+SP+B2) during the study period.

We calculated the standard error (SE), as described by Zar (1999), for all fish passage proportions (efficiencies) to provide a measure of precision of our estimate. We tested for equality of proportions between passage efficiencies during day and night using a chi-square test (Zar 1999).

3.0 Results

3.1 Water Quality

Water temperature in the spillway forebay increased over the course of the study, averaging 14.8 ºC, and ranging from 13.4 to 16.1 ºC. Dissolved oxygen in the spillway forebay gradually decreased over the course of the study, averaging 10.6 ppm, and ranging from 9.5 to 10.6 ppm. Electrical conductivity also decreased gradually over the course of the study, averaging 115.6 µS/cm, and ranging from 99.4 to 136.5 µS/cm (Appendix 1). Dissolved oxygen, temperature, and electrical conductivity all were higher during the day than during the night (Appendix 2).

3.2 Tagging

From 27 April to 2 June 2004, we radio-tagged and released 6,716 yearling Chinook salmon and 4,399 yearling steelhead (Appendices 3 and 4). Of the Chinook salmon, 33% (2,230 of 6,716) were released from John Day Dam and 67% (4,486 of 6,716) were released from The Dalles Dam. All 4,399 steelhead were released from The Dalles Dam. The release period coincided with the central portion of the "in river" seaward migration of yearling Chinook salmon and steelhead smolts (Figure 4). Of the fish released from John Day Dam, 50% (1,108 of 2,230) were released during the day and 50% (1,122 of 2,230) were released at night. Of the fish released from The Dalles Dam, 49% (4,352 of 8,885) were released during the day and 51% (4,533 of 8,885) were released at night. Mean fork length for Chinook salmon released from all sites was 157.1 mm and the mean weight was 38.3 g. Mean fork length for steelhead released from all sites was 223.9 mm and the mean weight was 95.1 g. The radio tag represented an average of 3.7% (1.1-6.5%) of mean Chinook salmon body weight and 1.5% (0.5-5.7%) of mean steelhead weight.

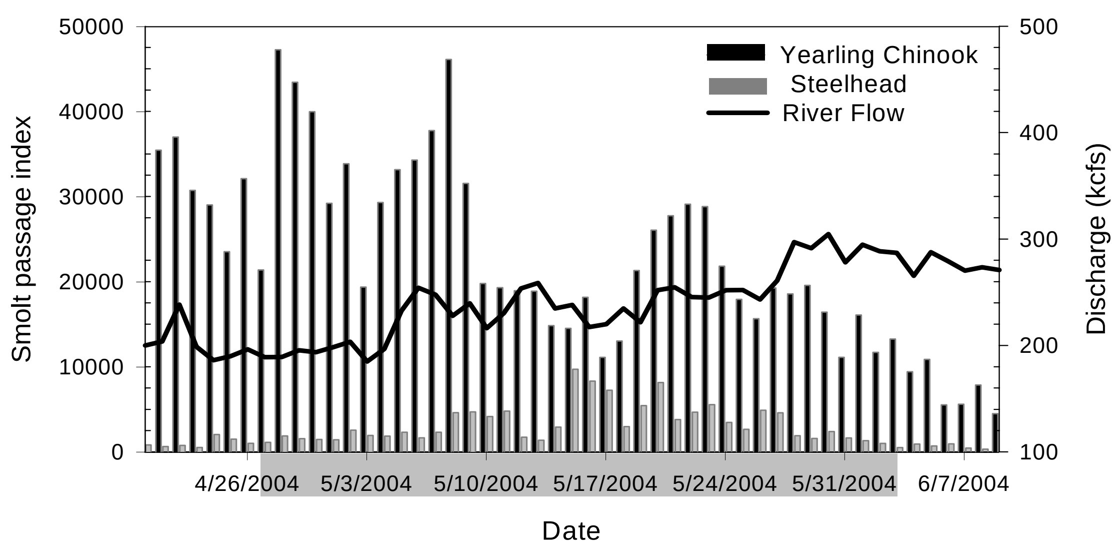

Figure 4.—Smolt passage index for yearling Chinook salmon and steelhead at Bonneville Dam's second powerhouse (B2) smolt monitoring facility during spring 2004 (Apr 20 – Jun 10). Shaded area indicates release period (Apr 27 – Jun 02). Smolt index data were acquired from the Fish Passage Center web page at www.fpc.org.

3.3 River Discharge and Project Operations

In July of 2004, the U.S. Army Corps of Engineers identified a discrepancy in the amount of water reported to be spilled at Bonneville Dam. An error in the calibration of spill gate openings installed in the early 1970's resulted in up to 30% less water discharged through the spillway than was originally reported to regional fish and water management officials. Updated spill measurements were received in June 2006 and are used in this revised report.

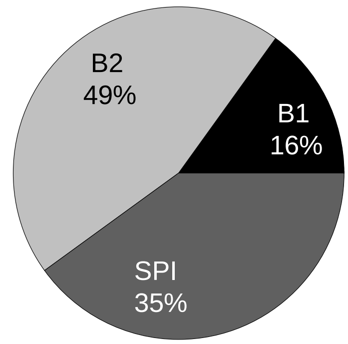

Figure 5.—Discharge allocation among dam areas at Bonneville Dam, spring 2004.

During spring 2004 (April 29 – June 7), mean river discharge at Bonneville Dam was 218.9 kcfs, and ranged from 157.1 kcfs to 283.7 kcfs. Allocation of mean river discharge among dam areas (i.e., B1, B2, and SPI) during the study period was 16% through B1, 49% through B2, and 35% through spill (Figure 5 and Table 1). Mean daily discharge at B1 (turbines 1–10) was 34.6 kcfs and ranged from 9.0 to 67.5 kcfs. Discharge at B2 averaged 107.1 kcfs, and ranged from 71.6 to 132.6 kcfs. Spill averaged 77.1 kcfs and ranged from 69.8 to 86.9 kcfs. Discharge at both powerhouses increased as the season progressed and daily discharge fluctuated more at B1 and B2 than at the spillway (Figure 6).

Two spill levels were tested in spring 2004: a discharge of 59 kcfs occurred during daytime hours (0500-2059) and a discharge up to 120% of the total dissolved gas cap occurred during nighttime hours (2100-0459). Spill during the day occurred for a total of 640 h over 40 d, averaged 59.3 kcfs, and ranged from 56.1 to 63.3 kcfs. Spill during the night occurred for a total of 320 h over 40 d, averaged 112.9 kcfs, and ranged from 92.4 to 137.6 kcfs.

Turbines 1-6 represented 76% and turbines 7-10 represented 24% of mean discharge at B1 (Figure 7). Turbines 11-14 represented 53% and turbines 15-18 represented 47% of mean discharge at B2 (Figure 8). There were considerable differences in discharge between turbine units, although fluctuations in mean daily discharge at B2 and the spillway corresponded with mean daily river discharge. Differences in daily turbine discharge were observed for multiple turbines throughout the study (Figures 9-12). We found that mean discharge at both B1 and B2 was higher during day than night (73% of B1 and 56% of B2) and mean discharge at the spillway was higher at night compared to day (66% of SPI; Table 2).

Table 1.—Descriptive statistics for discharge (kcfs) at Bonneville Dam during spring 2004. Values have been rounded to the nearest tenth and are based on daily totals. Discharges for the sluiceway and corner collector are included in discharges for the first powerhouse and second powerhouse, respectively.

Dam area	Mean	Median	Minimum	Maximum
First powerhouse	34.6	31.6	9.0	67.5
Sluiceway	1.3	1.3	1.1	1.4
Second powerhouse	107.1	110.8	71.6	132.6
Corner collector	5.6	5.6	5.3	5.8
Spillway	77.1	76.4	69.8	86.9
Total	218.9	218.5	157.1	283.7

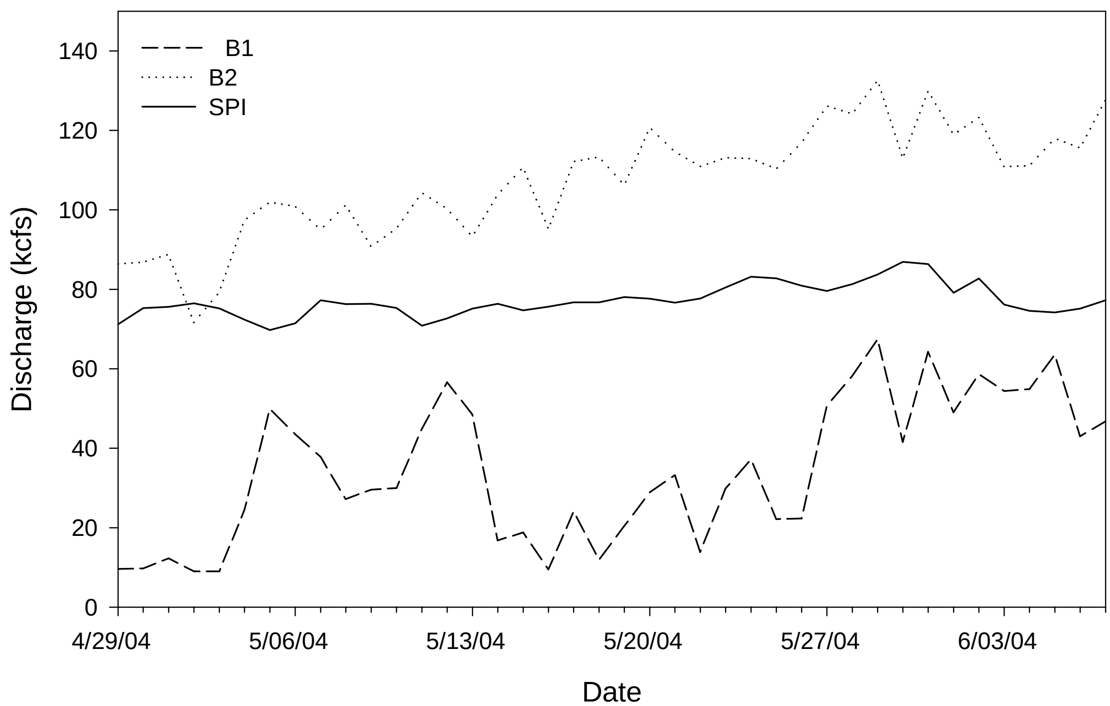

Figure 6.—Mean daily discharge by dam area at Bonneville Dam, spring 2004.

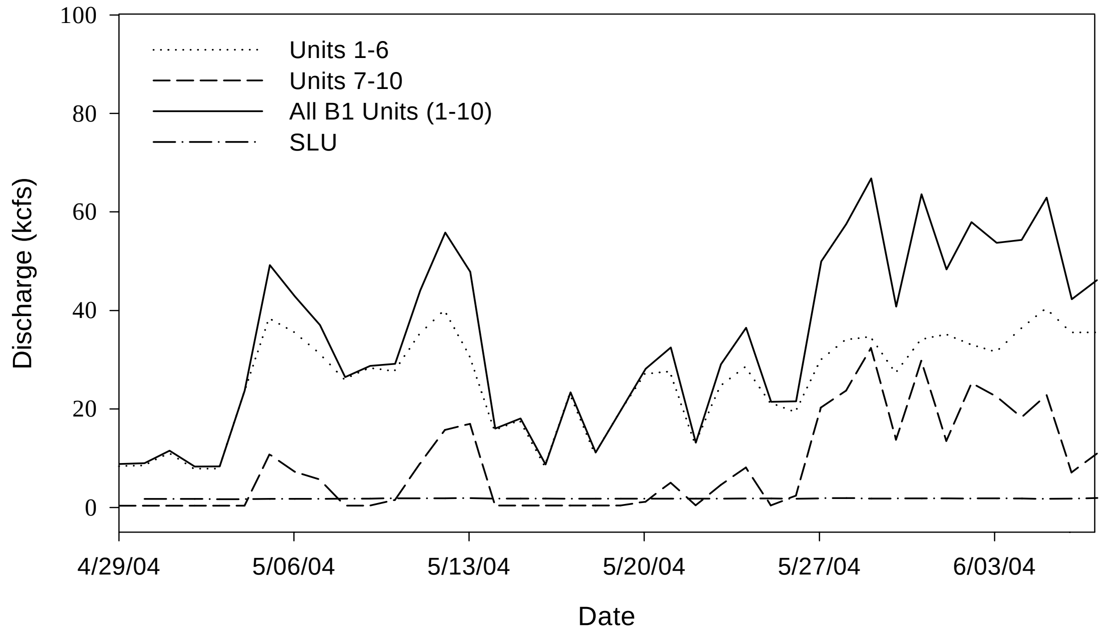

Figure 7.—Mean daily discharge through turbines 1-6, 7-10 and the sluiceway (SLU) at Bonneville Dam's first powerhouse (B1), spring 2004.

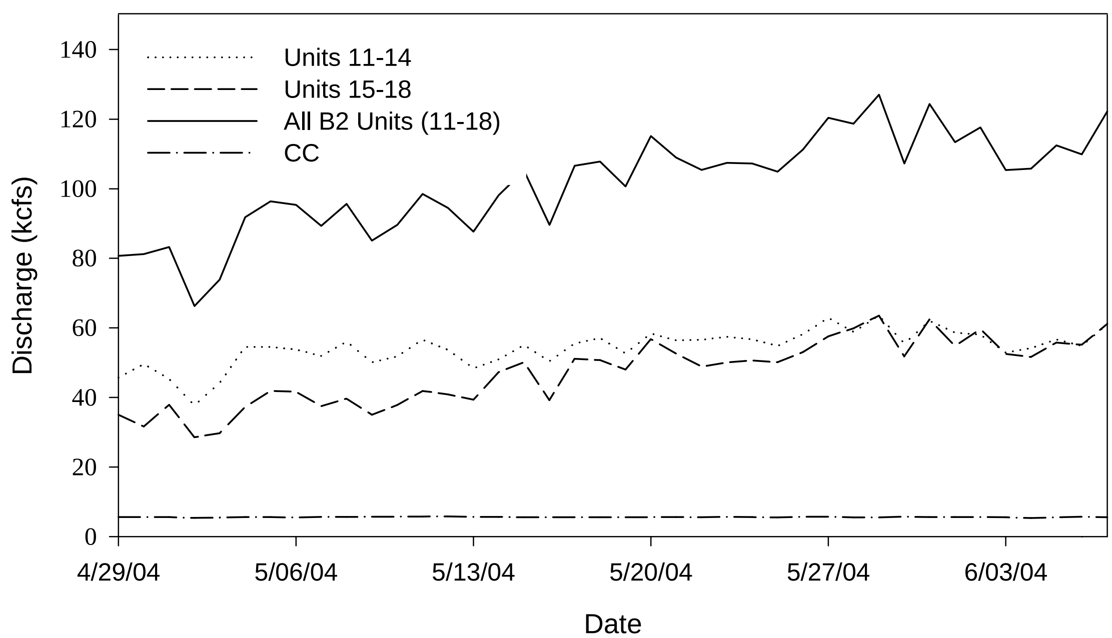

Figure 8.—Mean daily discharge through turbines 11-14, 15-18, and corner collector (CC) at Bonneville Dam's second powerhouse (B2), spring 2004.

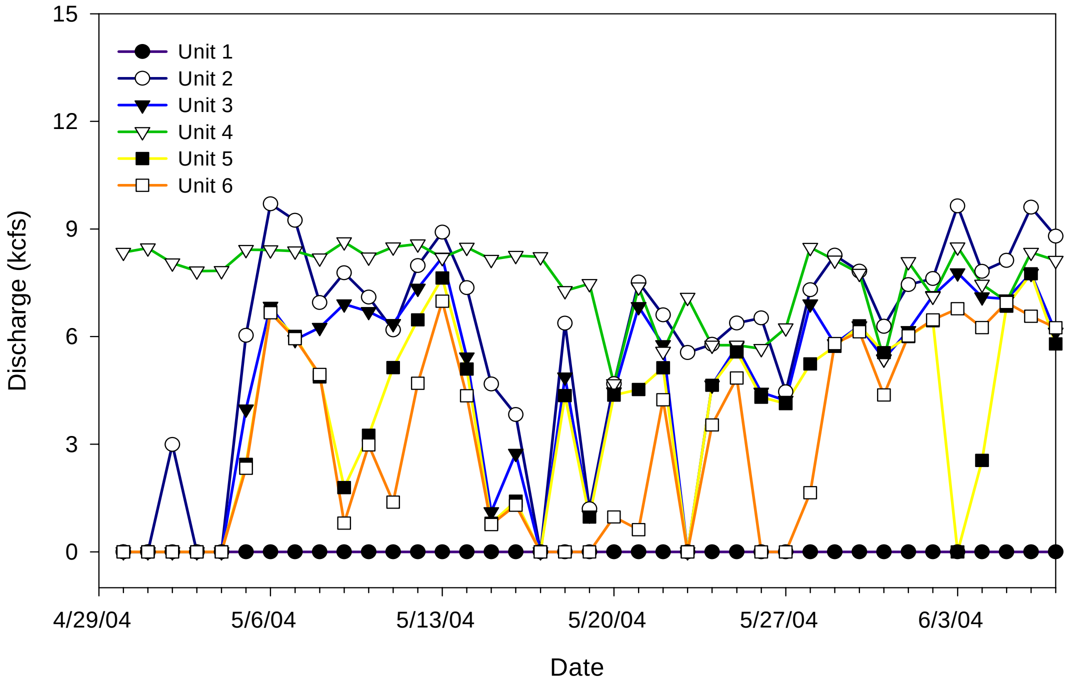

Figure 9.—Mean daily discharge by unit for turbines 1-6 at Bonneville Dam, spring 2004

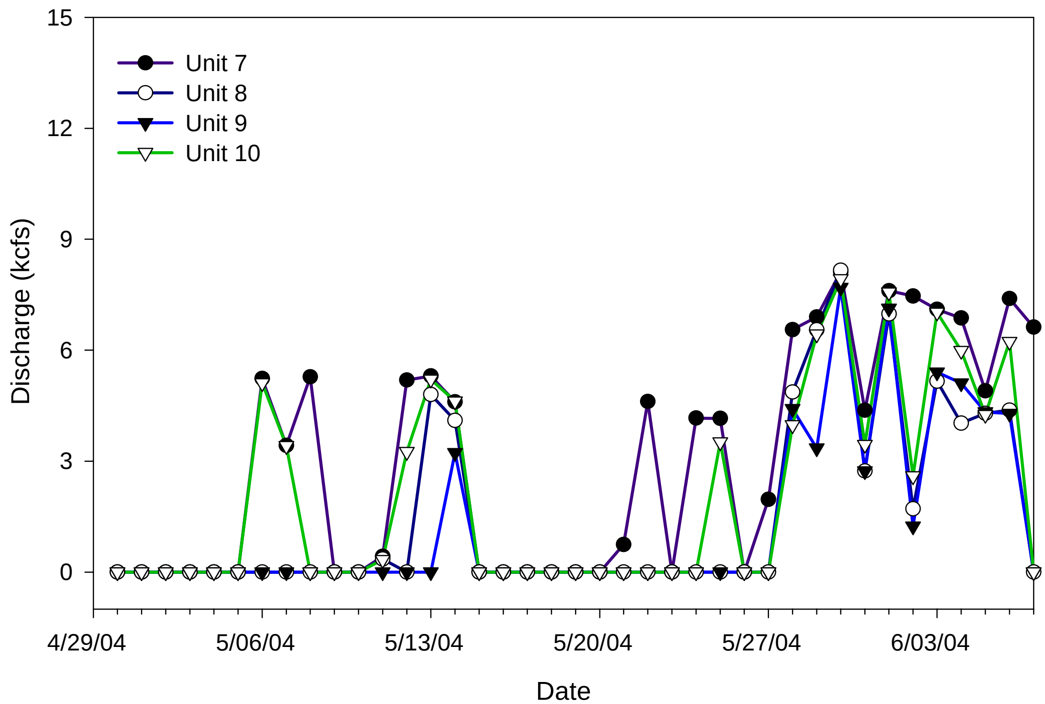

Figure 10.—Mean daily discharge by unit for turbines 7-10 at Bonneville Dam, spring 2004.

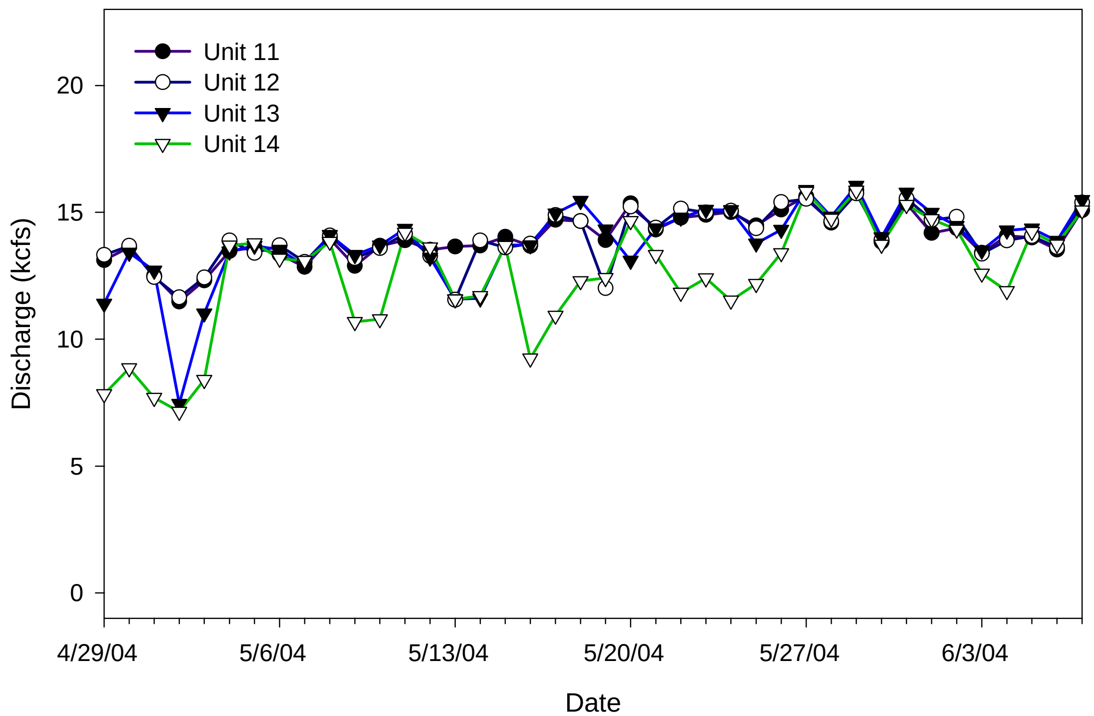

Figure 11.—Mean daily discharge by unit for turbines 11-14 at Bonneville Dam, spring 2004.

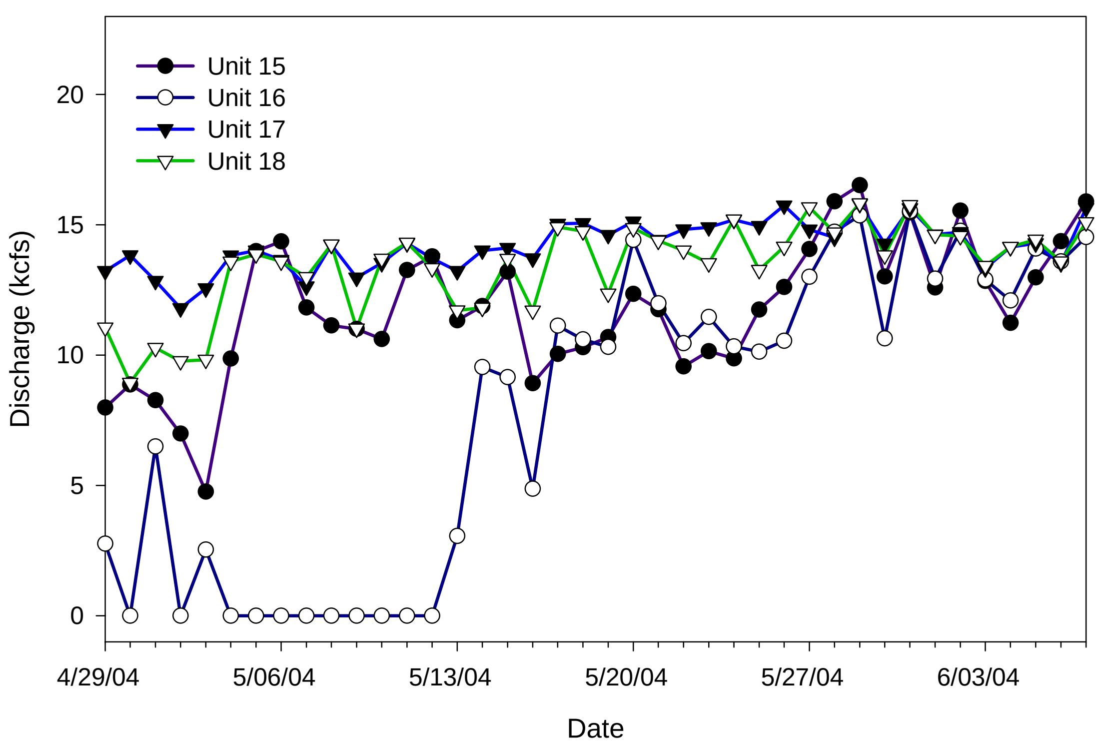

Figure 12.—Mean daily discharge by unit for turbines 15-18 at Bonneville Dam, spring 2004.

Table 2.—Mean discharge (kcfs) during day (0500-2059 hours) and night (2100-0459 hours) by dam area at Bonneville Dam, spring 2004.

Period and dam area	Percent (of period)	Mean	Median	Minimum	Maximum
Day					
First powerhouse	20%	43.9	44.7	26.0	48.8
Second powerhouse	53%	114.8	115.8	98.0	118.5
Spillway	27%	59.3	59.4	56.1	63.3
Total	100%	217.9	221.0	152.5	294.3
Night					
First powerhouse	7%	16.0	12.4	11.2	31.0
Second powerhouse	42%	91.8	89.0	87.3	108.2
Spillway	51%	112.9	110.1	92.4	137.6
Total	100%	220.7	217.9	166.3	276.7

3.4 Travel to and Arrival at Bonneville Dam

At Bonneville Dam, we detected 88% (5,961 of 6,747) of the yearling Chinook salmon and 91% (3,988 of 4,399) of the steelhead that were released from John Day Dam and The Dalles Dam. The median travel rate for Chinook salmon released from John Day Dam to first detection at Bonneville Dam was 2.5 km/h and the median travel time was 45.1 h. Chinook salmon released from The Dalles Dam had a median travel rate of 2.4 km/h and a median travel time of 30.6 h. The median travel rate for steelhead released from The Dalles Dam was 2.5 km/h and the median travel time was 29.6 h (Table 3).

Table 3.—Descriptive statistics for travel time (h) and travel rate (km/h) to Bonneville Dam for yearling Chinook salmon (CH1) and steelhead (HST), spring 2004. Travel rate statistics are represented in parentheses.

Release site	Species	N	Mean	Median	Minimum	Maximum
John Day Dam	CH1	1817	48.0 (2.4)	45.1 (2.5)	27.7 (0.7)	154.9 (4.0)
The Dalles Dam	CH1	4144	32.1 (2.4)	30.6 (2.4)	17.0 (0.7)	106.3 (4.3)
The Dalles Dam	HST	3988	30.5 (2.5)	29.6 (2.5)	17.8 (0.5)	154.2 (4.1)

Fish did not enter dam areas (i.e. B1, B2, and spillway) in equal proportions. Of the Chinook salmon detected at Bonneville Dam, 8% (482 of 5,954) first entered B1 forebay, 59% (3,507 of 5,954) first entered B2 forebay, and 33% (1,965 of 5,954) first entered the spillway forebay. Steelhead entered the forebays of Bonneville Dam in nearly identical proportions to Chinook salmon. Of the steelhead detected at Bonneville Dam, 8% (341 of 3,987) first entered B1 forebay, 66% (2,629 of 3,987) first entered B2 forebay, and 26% (1,017 of 3,987) first entered the spillway forebay. Proportions of fish approaching Bonneville Dam appeared to be strongly related to the allocation of river discharge among dam areas. Discharge allocation at B1, B2, and the spillway was 16%, 49%, and 35%, respectively. To further investigate this relation, we compared the proportion of mean daily discharge through each dam area to the daily proportion of radio-tagged fish that entered each dam area. For both species, the daily arrival of fish fluctuated with daily discharge. At all three dam areas, when discharge increased, fish arrival increased. Likewise, when discharge decreased at a dam area, the number of fish entering that dam area decreased (Figures 13 and 14).

Similarly, we compared the hourly proportion of fish entering each dam area to the hourly proportion of mean discharge through each dam area. At all three dam areas, fish entrance increased when hourly discharge increased and fish entrance decreased when hourly discharge decreased (Figures 15 and 16).

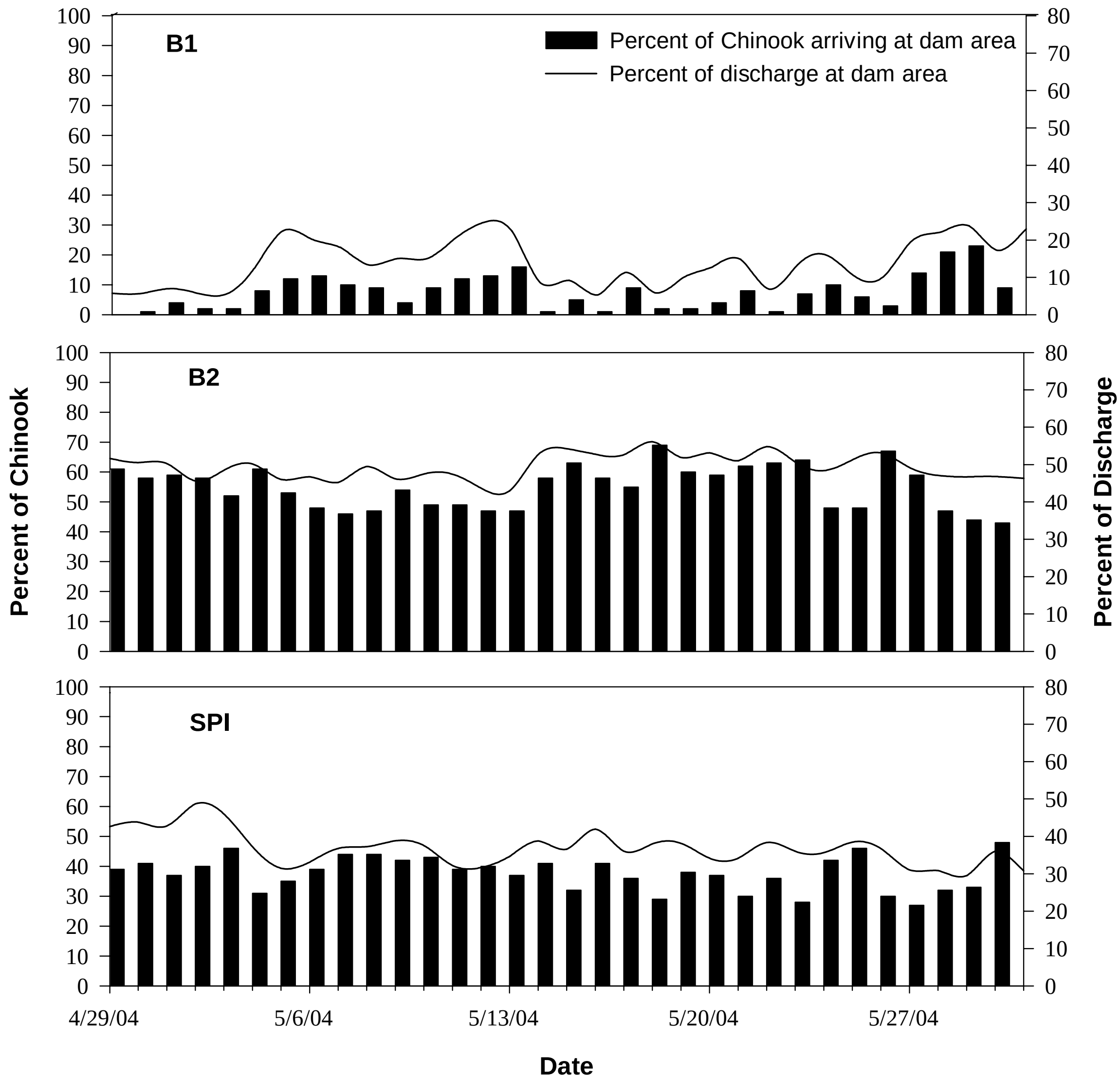

Figure 13.—The percentage of yearling Chinook salmon that entered each dam area versus the percentage of mean daily discharge at each dam area at Bonneville Dam, spring 2004.

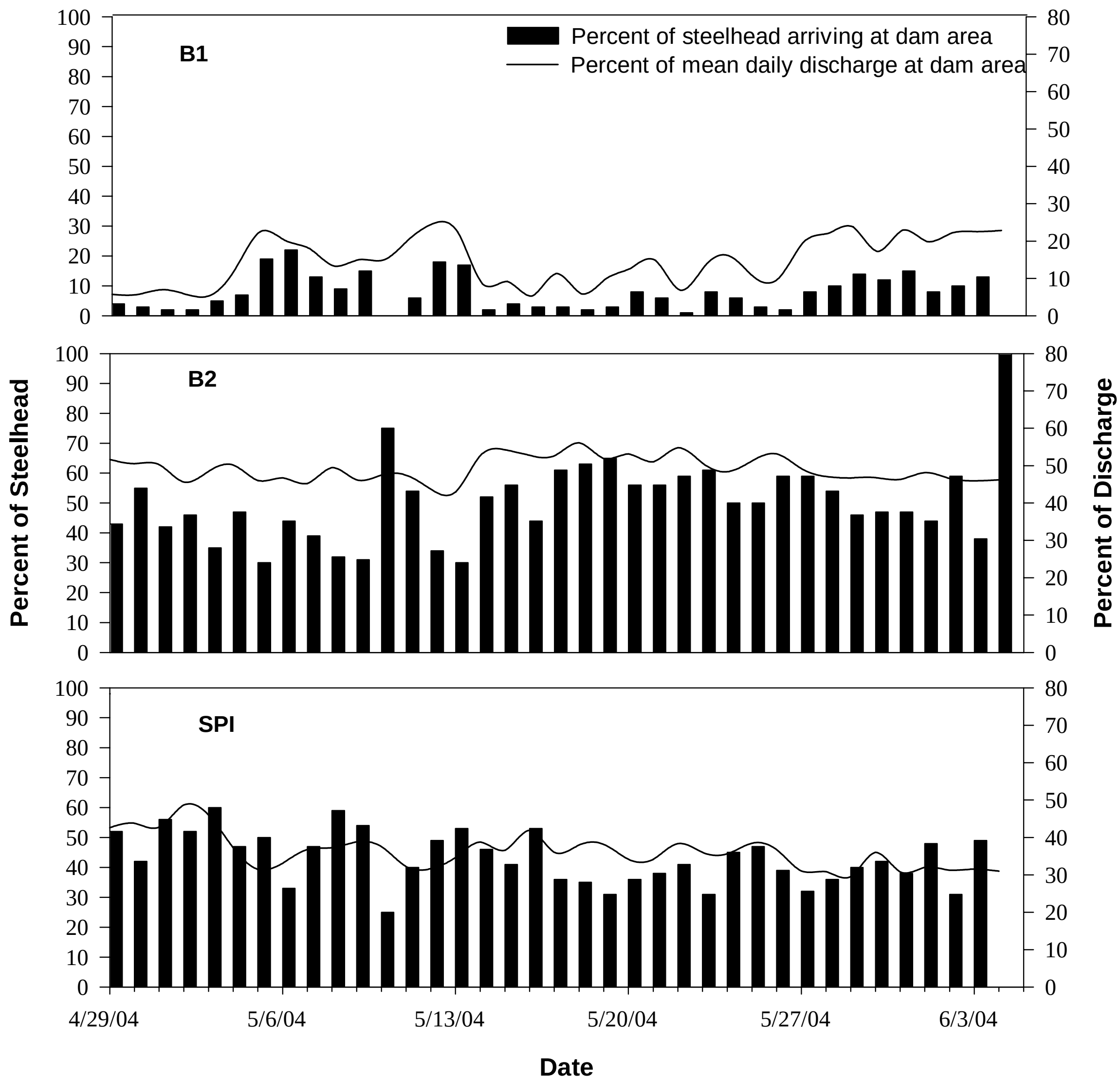

Figure 14.—The percentage of yearling steelhead that entered each dam area versus the percentage of mean daily discharge at each dam area at Bonneville Dam, spring 2004.

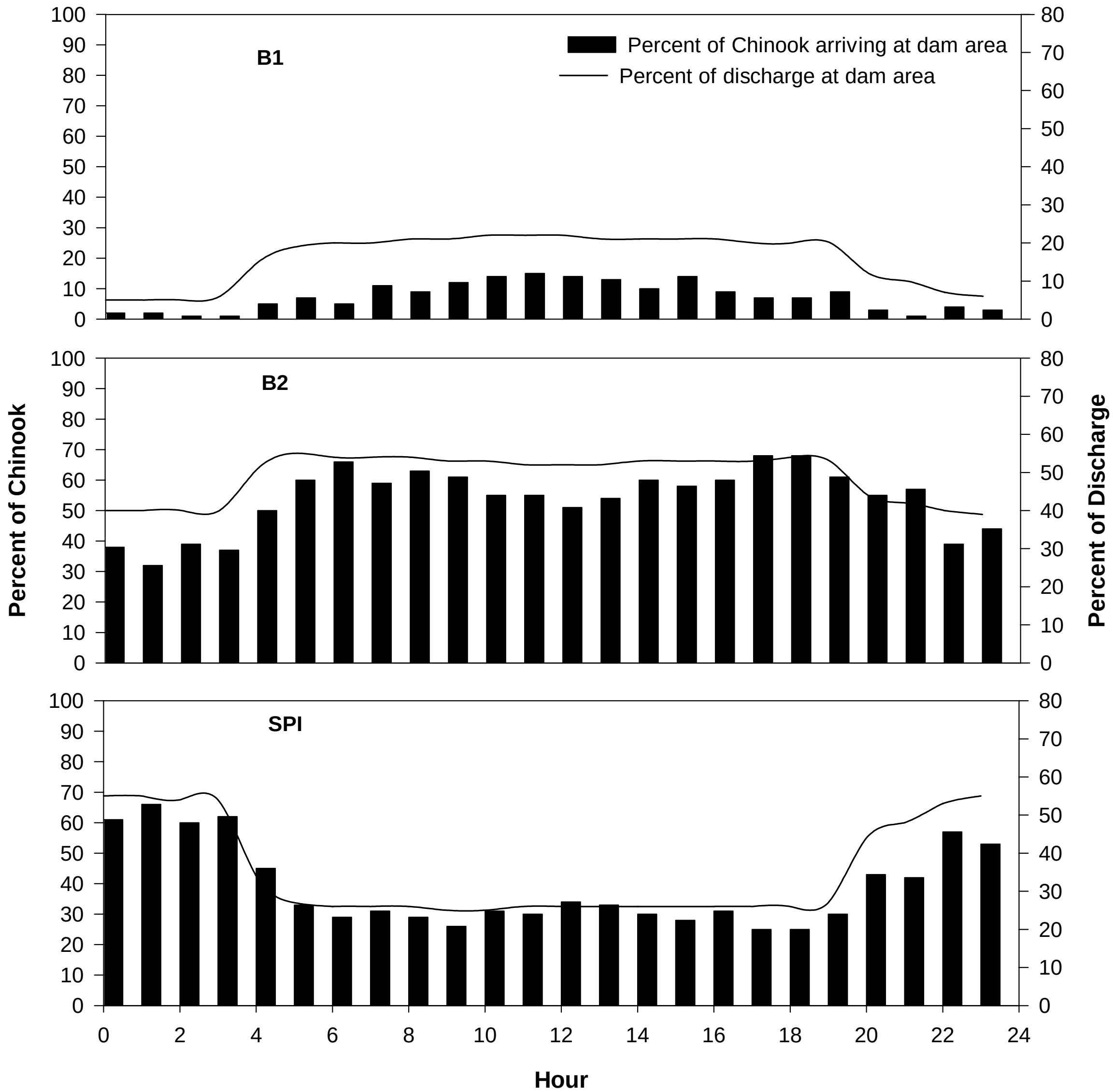

Figure 15.—The percentage of yearling Chinook salmon that entered each dam area versus the percentage of mean hourly discharge at each dam area at Bonneville Dam, spring 2004.

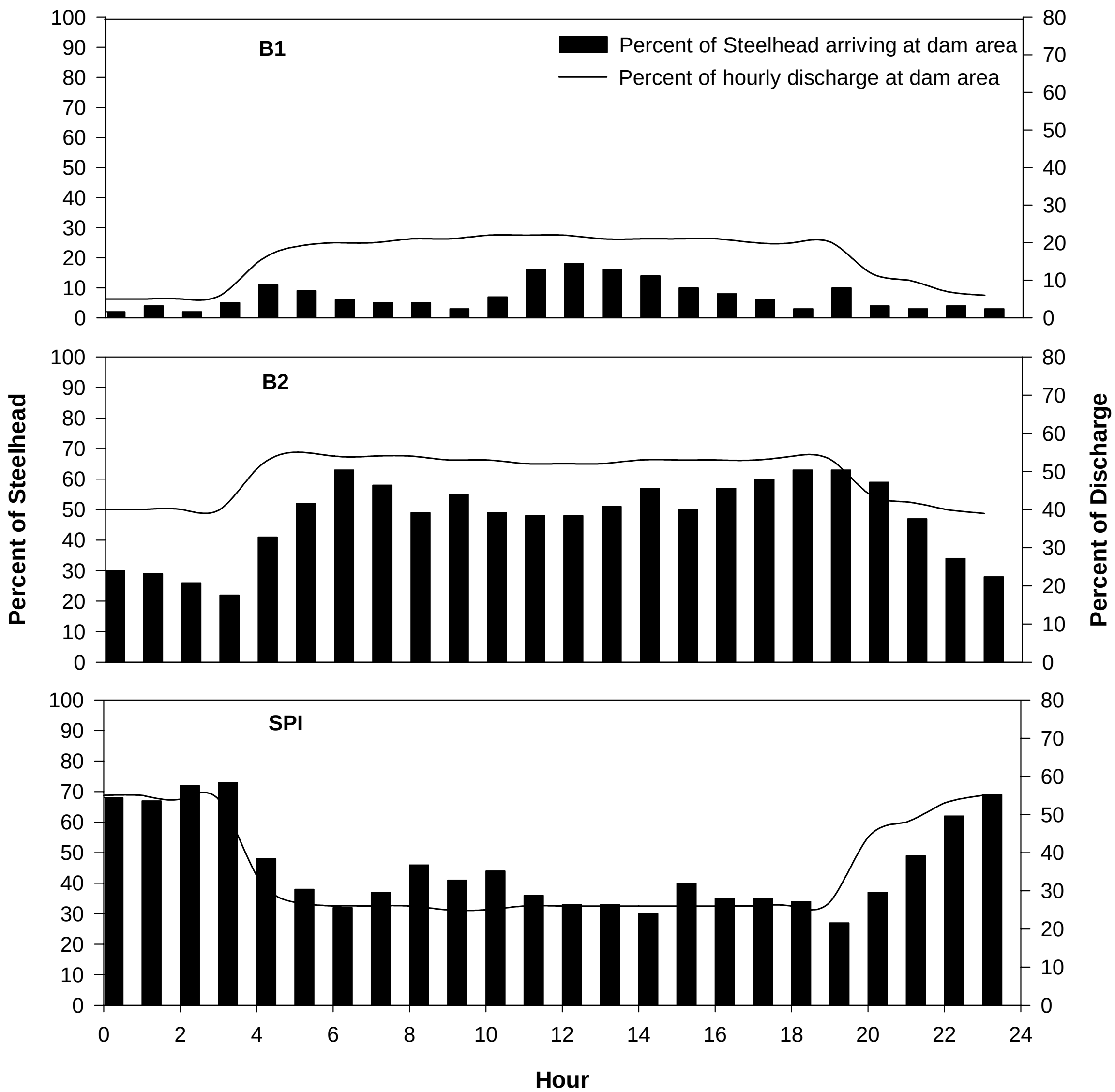

Figure 16.—The percentage of yearling steelhead that entered each dam area versus the percentage of mean hourly discharge at each dam area at Bonneville Dam, spring 2004.

3.5 Residence Time in the Forebay

Forebay residence time (time from first detection until time of passage) differed between dam areas. Yearling Chinook salmon resided considerably longer in the forebay of B1 (median = 54 min) than in the forebays of B2 (median = 6 min) or the spillway (median = 18 min). Steelhead also resided considerably longer in the forebay of B1 (median = 4.2 h) than in the forebays of B2 (median = 30 min) or the spillway (median = 18 min; Table 4). We compared median forebay residence time to mean discharge by day of passage, by hour of passage, and by hour of arrival and found that residence times generally decreased as discharge increased (Appendices 5-10).

Table 4.—Descriptive statistics of forebay residence time (h) by dam area for yearling Chinook salmon and steelhead at Bonneville Dam, spring 2004.

Species and dam area	N	Mean	Median	Minimum	Maximum
Chinook Salmon					
First powerhouse	473	4.8	0.9	0.01	127.7
Second powerhouse	2187	0.6	0.1	0.00	133.5
Spillway	1943	0.8	0.3	0.00	24.4
All Areas	4603	1.1	0.2	0.00	133.5
Steelhead					
First powerhouse	335	7.8	4.2	0.03	163.2
Second powerhouse	2448	1.7	0.5	0.00	130.1
Spillway	1002	2.8	0.3	0.00	160.5
All Areas	3785	2.6	0.5	0.00	163.2

3.6 Route and Time of Passage through Bonneville Dam

We determined the route of passage through Bonneville Dam for nearly 100% of both species (5,960 of 5,961 yearling Chinook salmon and 3,981 of 3,988 steelhead) detected at Bonneville Dam. One Chinook salmon and six steelhead were detected in the Bonneville forebay and subsequently at an upstream location but had no further downstream detections and therefore could not be assigned passage routes. One additional steelhead was suspected to have been predated in the B2 forebay. Not included in the number of fish detected at the dam are 25 Chinook salmon and eight steelhead that were detected downstream of Bonneville Dam but at no other locations. Among the three dam areas, B2 passed the most fish (59-66%, depending on species), followed by the spillway (25.5-33%) and B1 (8-8.5%; Figure 17). The distribution of passage among dam areas was identical to the distribution of approach (based on first detection of fish) among dam areas.

Passage of Chinook salmon at B1 was distributed relatively equally among the two main routes of passage. Of the 483 Chinook salmon that passed at B1, 53% (256) passed unguided through the turbines and 46% (223) passed through the sluiceway. The remaining 1% (4) passed via the navigation lock. Passage of Chinook salmon at B2 was not as equally distributed as at B1. Of the 3,512 Chinook salmon with known passage routes at B2, 43% (1,499) passed unguided through the turbines, 36% (1,283) passed through the corner collector and 21% (730) were guided into the DSM (Figure 17).

Passage of steelhead at B1 was also distributed relatively equally among the two main passage routes. Of the 341 steelhead that passed B1, 55% (187) passed through the sluiceway and 42% (143) passed unguided through the turbines. The remaining 3% (11) passed via the navigation lock. Steelhead passage at B2 was not as equally distributed as at B1. Of the 2,624 steelhead that passed at B2, 74% (1,939) passed through the corner collector, 16% (412) passed unguided through the turbines, and 10% (273) were guided into the DSM (Figure 17).

Project passage of both Chinook salmon and steelhead peaked at sunset (2100-2200 hours) and was lowest just after sunrise for steelhead (0500-0600 hours; Figure 18). Project passage was lowest for Chinook salmon between 2200 and 0100 hours. Diurnal passage distributions of Chinook salmon and steelhead were similar to overall passage distributions. During the day, more fish passed B2 (64-80%) than through the spillway (12-25%) or B1 (8-10%). At night, more fish passed through the spillway (51-54%) than through B2 (37-47%) or B1 (3-9%; Table 5). Upon comparison of the number of fish that passed each dam area during day and night, we found that a higher proportion of fish passed during day (Table 6). This was true for both Chinook salmon and steelhead at all dam areas, the only exception being at the spillway where 69% (706 of 1,016) of steelhead passed at night. However, since there was a difference in the number of hours in each diel period (16 for day, 8 for night), we also calculated passage rates (fish/hour) for each dam area and diel period. Passage rates for both species were higher during the day at B2 and higher during the night at the spillway. At B1, passage rates for Chinook salmon were higher during the day and about the same during day and night for steelhead (Table 7). Hourly passage data for each species by route of passage and by spill condition are provided in appendices 11-23.

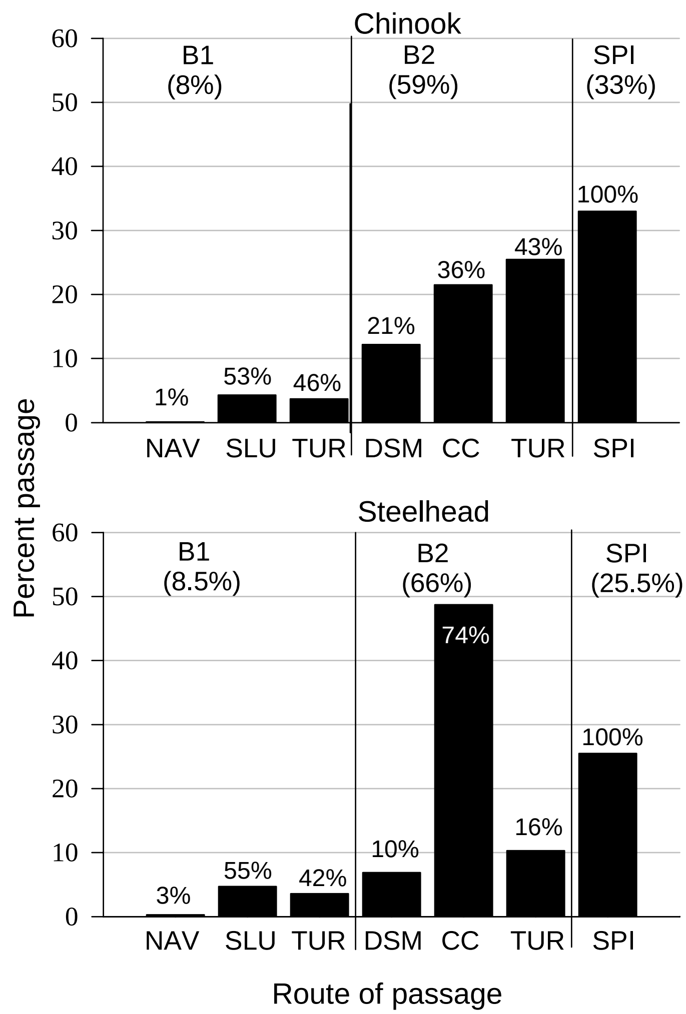

Figure 17.—Percent fish passage by dam area and route of passage for yearling Chinook salmon and steelhead at Bonneville Dam, spring 2004. B1 = first powerhouse; B2 = second powerhouse; SPI = spillway; NAV = navigation lock; SLU = sluiceway; TUR = turbine; DSM = downstream salmonid migrants channel; and CC = corner collector. Percentages in parentheses designate proportions among dam areas, percentages without parentheses designate proportions within each dam area, and the percent value of each bar represents proportions of all routes at Bonneville Dam.

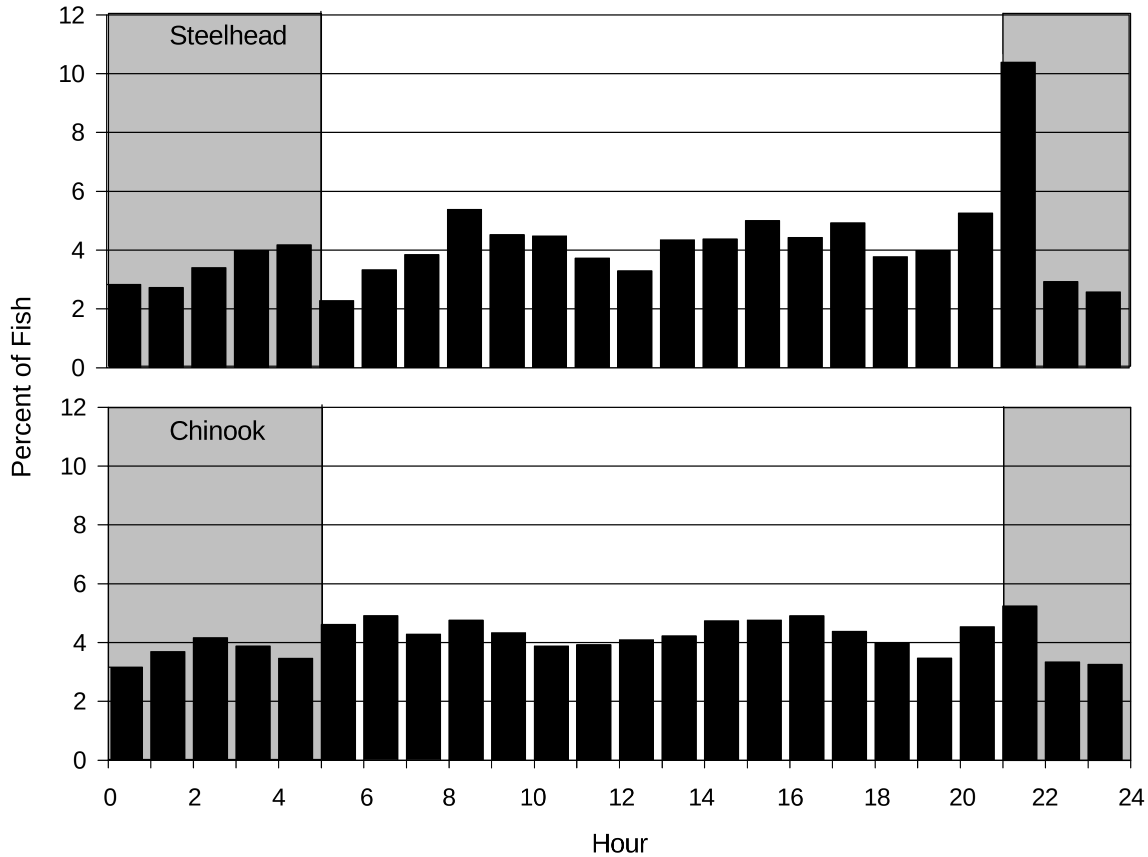

Figure 18.—Percent passage by hour during day (0500-2059 hours; unshaded) and night (2100-0459 hours; shaded) for yearling Chinook salmon and steelhead at Bonneville Dam, spring 2004.

Table 5.—Percentage of yearling Chinook salmon and steelhead that passed each area of Bonneville Dam during the day (0500-2059 hours) and night (2100-0459 hours), spring 2004. Percentages are based on the total number of fish that passed each route during each diel period. The 59 kcfs spill condition occurred during the day and spill to 120% of the TDG cap occurred during the night.

Species and period	Route of passage		
	First powerhouse	Second powerhouse	Spillway
Chinook Salmon			
Day	10% (435 of 4169)	64% (2674 of 4169)	25% (1060 of 4169)
Night	3% (48 of 1791)	47% (838 of 1791)	51% (905 of 1791)
Steelhead			
Day	8% (220 of 2663)	80% (2133 of 2663)	12% (310 of 2663)
Night	9% (121 of 1318)	37% (491 of 1318)	54% (706 of 1318)

Table 6.—Percentage of yearling Chinook salmon and steelhead that passed each area of Bonneville Dam during the day (0500-2059 hours) and night (2100-0459 hours), spring 2004. Percentages are based on the total number of fish that passed each dam area. The 59 kcfs spill condition occurred during the day and spill to 120% of the TDG cap occurred during the night.

Species and period	Route of passage		
	First powerhouse	Second powerhouse	Spillway
Chinook Salmon			
Day	90% (435 of 483)	76% (2674 of 3512)	54% (1060 of 1965)
Night	10% (48 of 483)	24% (838 of 3512)	46% (905 of 1965)
Steelhead			
Day	65% (220 of 341)	81% (2133 of 2624)	31% (310 of 1016)
Night	35% (121 of 341)	19% (491 of 2624)	69% (706 of 1016)

Table 7.—Passage rates for radio-tagged yearling Chinook salmon and steelhead that passed Bonneville Dam during the day (0500-2059 hours) and night (2100-0459 hours), spring 2004. Rates are based on 16 h per 24 h over 40 d for day passage and 8 h per 24 h over 40 d for night passage.

Species and period	Route of passage		
	First powerhouse	Second powerhouse	Spillway
Chinook Salmon			
Day	0.7 fish/h	4.2 fish/h	1.7 fish/h
Night	0.2 fish/h	2.6 fish/h	2.8 fish/h
Steelhead			
Day	0.3 fish/h	3.3 fish/h	0.5 fish/h
Night	0.4 fish/h	1.5 fish/h	2.2 fish/h

3.7 Passage Metrics

3.7.1 Spillway Efficiency

Spillway efficiency is the number of fish that passed through the spillway divided by the number of fish that passed through all routes at all dam areas (spillway, B1, and B2). Overall, 33% of Chinook salmon and 26% of steelhead passed through the spillway. Spillway efficiency was significantly higher for both yearling Chinook salmon (X^2 = 357.3, df = 1, $P < 0.0001$) and steelhead (X^2 = 815.3, df = 1, $P < 0.0001$) during the night, when spill was discharged up to the total dissolved gas cap (TDG; mean = 113 kcfs), than during the day, when an average of only 59 kcfs was discharged through the spillway (Table 8).

Table 8.—Spillway Efficiency at Bonneville Dam for yearling Chinook salmon and steelhead during spring 2004. Mean discharge spilled during each period is shown in parentheses. SE = standard error of spillway efficiency estimate. Number of fish that passed through the first powerhouse (B1), second powerhouse (B2), and the spillway (SPI) during each period are also provided.

Species and period	Spillway efficiency	SE	B1 passage	B2 passage	SPI passage
Chinook Salmon					
Overall (77 kcfs)	33%	1.1	483	3512	1965
Day (59 kcfs)	25%	1.3	435	2674	1060
Night (113 kcfs)	51%	1.7	48	838	905
Steelhead					
Overall (77 kcfs)	26%	0.8	341	2624	1016
Day (59 kcfs)	12%	1.8	220	2133	310
Night (113 kcfs)	54%	1.9	121	491	706

3.7.2 Spillway Effectiveness

Spillway effectiveness is the proportion of fish that passed through spill relative to the proportion of project discharge spilled. Chinook salmon had an overall spillway effectiveness of 0.94 and steelhead had an overall spillway effectiveness of 0.72 (Table 9). Spill during the night was more effective for both Chinook salmon (0.99) and steelhead (1.05) than during the day (0.94 and 0.43, respectively).

Table 9.—Spillway effectiveness and efficiency at Bonneville Dam for yearling Chinook salmon and steelhead during spring 2004. F_{sp} = mean spillway discharge (kcfs). F_{tot} = mean project discharge (kcfs).

Species and period	Spillway effectiveness	Spillway efficiency	F_{sp}	F_{tot}
Chinook Salmon				
Overall	0.94	33%	77.1	218.9
Day	0.94	26%	59.3	217.9
Night	0.99	51%	112.9	220.7
Steelhead				
Overall	0.72	26%	77.1	218.9
Day	0.43	12%	59.3	217.9
Night	1.05	54%	112.9	220.7

3.7.3 Fish Guidance Efficiency

Fish guidance efficiency at B2 (FGE; proportion of fish entering turbine intakes that were guided by turbine intake screens) overall was 33% for Chinook salmon and 40% for steelhead. Since no guidance screens were deployed at B1 in 2004 we could not calculate FGE at B1. Fish guidance efficiency at B2 was significantly higher (X^2 = 6.3, df = 1, P = 0.01) for Chinook salmon during the night (37%) compared to day (31%). Conversely, FGE at B2 was significantly higher (X^2 = 5.0, df = 1, P = 0.03) for steelhead during the day (44%) compared to night (36%; Table 10). Turbine unit 11 was the most efficient (42%) at guiding Chinook salmon and turbine unit 16 was the most efficient (54%) at guiding steelhead (Table 11). Over twice as many fish of both species passed at the southern half of B2, at units 11-14, compared to the northern half, at units 15-18. Unit 18 passed the least amount of fish and had the lowest guidance. Units 12-17 had similar FGE for Chinook salmon, ranging from 32-36%. Units 11-15 had similar FGE for steelhead, ranging from 41-45%. Unit 13, although it didn't have the highest FGE, guided the most fish.

Table 10.—Estimates of fish guidance efficiency (FGE) and corresponding standard error at Bonneville Dam's second powerhouse for yearling Chinook salmon and steelhead during spring 2004. Mean discharge spilled during each period and numbers of fish guided of total guided and unguided are shown in parentheses.

Species and period	Second powerhouse	Standard error
Chinook salmon		
Overall (77 kcfs)	33% (730 of 2,229)	1.0
Day (59 kcfs)	31% (478 of 1,538)	1.2
Night (113 kcfs)	37% (252 of 691)	1.8
Steelhead		
Overall (77 kcfs)	40% (273 of 685)	1.9
Day (59 kcfs)	44% (145 of 328)	2.7
Night (113 kcfs)	40% (128 of 357)	2.5

Table 11.—Estimates of fish guidance efficiency (FGE) by turbine unit at Bonneville Dam's second powerhouse for yearling Chinook salmon (CH1) and steelhead (HST), spring 2004. These estimates do not include 75 unguided and 1 guided CH1 and 35 unguided and 1 guided HST that passed through unknown units at B2.

Turbine unit	FGE	
	Chinook salmon	Steelhead
11	42% (109 of 259)	41% (41 of 100)
12	34% (94 of 277)	44% (48 of 108)
13	34% (167 of 489)	42% (57 of 135)
14	33% (132 of 397)	45% (41 of 91)
15	34% (99 of 290)	41% (29 of 70)
16	36% (48 of 135)	54% (26 of 48)
17	32% (57 of 177)	33% (19 of 57)
18	23% (20 of 87)	29% (9 of 31)

3.7.4 Fish Passage Efficiency

Fish passage efficiency (FPE: the proportion of fish that passed the dam via non-turbine routes) at Bonneville Dam was 71% (SE = 0.6) overall for Chinook salmon and 86% (SE = 0.5) overall for steelhead (Table 12). Fish passage efficiency was highest during the night for Chinook salmon (74%) and during the day for steelhead (91%). Differences in FPE between day and night were significant for both yearling Chinook salmon (X^2 = 11.5, df = 1, P = 0.0007) and steelhead (X^2 = 152.9, df = 1, P < 0.0001).

Table 12.—Fish passage efficiency (FPE) at Bonneville Dam for yearling Chinook salmon and steelhead during spring 2004. Passage numbers shown that were used to calculate FPE do not include five Chinook salmon and 11 steelhead that passed through the navigation lock. However, those fish were included in calculations of FPE. B1 = first powerhouse and B2 = second powerhouse.

Species and period	FPE	Sluiceway	B2 guided	Corner collector	Spillway	B1 unguided	B2 unguided
Chinook Salmon							
Overall	71%	256	730	1283	1965	223	1499
Day	70%	233	478	1136	1060	199	1060
Night	74%	23	252	147	905	24	439
Steelhead							
Overall	86%	187	273	1939	1016	143	412
Day	91%	152	145	1805	310	57	183
Night	76%	35	128	134	706	86	229

3.7.5 Corner Collector Efficiency

Corner collector efficiency (CCE) is the number of fish that passed through the corner collector divided by the number of fish that passed through all routes at B2. Overall, about one-third of Chinook salmon and three-quarters of steelhead that passed at B2 went through the corner collector. Passage through the corner collector was significantly higher during the day than during the night for both yearling Chinook salmon (X^2 = 171.2, df = 1, P < 0.0001) and steelhead (X^2 = 680.1, df = 1, P < 0.0001; Table 13).

Table 13.—Corner collector efficiency (CCE) and effectiveness (CCF) at Bonneville Dam for yearling Chinook salmon and steelhead during spring 2004. SE = standard error of corner collector efficiency estimate. F_{cc} = mean corner collector discharge (kcfs). F_{B2} = mean discharge (kcfs) at second powerhouse (B2).

Species and period	CCE	SE	CCF	F_{cc}	F_{B2}
Chinook Salmon					
Overall	37%	0.8	7.0	5.58	107.12
Day	43%	1.0	8.7	5.58	114.81
Night	18%	1.3	2.9	5.58	91.76
Steelhead					
Overall	74%	0.9	14.2	5.58	107.12
Day	85%	0.8	17.4	5.58	114.81
Night	27%	2.0	4.5	5.58	91.76

3.7.6 Corner Collector Effectiveness

Corner collector effectiveness (CCF) is the proportion of fish that passed through the corner collector relative to the proportion of discharge at B2 that went through the corner collector. Chinook salmon had an overall effectiveness of 7.0 and steelhead had an overall effectiveness of 14.2 (Table 13).

3.7.7 Sluiceway Efficiency

Sluiceway efficiency is the number of fish that passed through the B1 sluiceway divided by the number of fish that passed through all routes at B1. Overall, just over half of both species that passed at B1 passed through the sluiceway. For steelhead, passage through the sluiceway was significantly (X^2 = 50.9, df = 1, P < 0.0001) higher during the day than during the night. For yearling Chinook salmon, differences in passage through the sluiceway during day and night were not significant (X^2 = 0.55, df = 1, P = 0.46; Table 14).

Table 14.—Sluiceway efficiency (SLE) and effectiveness (SLF) at Bonneville Dam for yearling Chinook salmon and steelhead during spring 2004. SE = standard error of sluiceway efficiency estimate. F_{SL} = mean sluiceway (SL) discharge (kcfs). F_{B1} = mean discharge (kcfs) at first powerhouse (B1).

Species and period	SLE	SE	SLF	F_{SL}	F_{B1}
Chinook Salmon					
Overall	53%	2.3	14.6	1.26	34.59
Day	54%	2.4	18.6	1.26	43.87
Night	48%	7.2	6.1	1.26	16.04
Steelhead					
Overall	55%	2.7	15.1	1.26	34.59
Day	69%	3.1	24.1	1.26	43.87
Night	29%	4.1	3.7	1.26	16.04

3.7.8 Sluiceway Effectiveness

Sluiceway effectiveness (SLF) is the proportion of fish that passed through the B1 sluiceway relative to the proportion of discharge at B1 that went through the sluiceway. Chinook salmon had an overall sluiceway effectiveness of 14.6 and steelhead had an overall effectiveness of 15.1 (Table 14).

3.8 Comparison of Passage Performance Metrics as Measured by Radio Telemetry and Hydroacoustics

In addition to the radio telemetry evaluation we conducted, Pacific Northwest National Laboratory (PNNL) used fixed hydroacoustics to monitor fish passage and estimate passage performance metrics for the run-at-large. The spring monitoring period for hydroacoustics (April 15 – May 31) was slightly different than it was for our radio telemetry study (April 29 – June 7). We therefore calculated passage metrics during the overlapping period of April 29 – May 31 to directly compare estimates and minimize the effects of variables such as discharge that may have differed during non-overlapping time periods. Because PNNL's estimates were based on the run-at-large and incorporated both yearling Chinook salmon and steelhead, we also weighted our passage estimates based on the passage index (Fish Passage Center, 2004). The passage index from April 29 through May 31, 2004 was 800,515 (87%) yearling Chinook salmon and 120,346 (13%) steelhead. Rather than simply adding passage numbers for each species to get a combined total from which to calculate passage metrics, we multiplied passage proportions for each species by the index proportions: 87% for yearling Chinook salmon and 13% for steelhead. We then added the adjusted proportions to get a combined estimate for the run-at-large. Differences in passage performance metrics, as estimated by radio telemetry and hydroacoustics, ranged from 1-27%. Estimates of $FPE_{Project}$, FPE_{B2}, and sluiceway $efficiency_{Project}$ differed by 4% or less and spillway efficiency and corner collector efficiency were within 8% (Table 15). Estimates with the greatest disparity were sluiceway $efficiency_{B1}$ and FPE_{B1}. Estimates of FGE by unit at B2 were most similar for the southern units and differed considerably at the northern units (Table 16). Although sample sizes for radio telemetry estimates of FGE by unit were relatively small compared to those for hydroacoustics, standard errors of radio telemetry passage metric estimates ranged from only 0.2% to 1.7%. Standard errors for FGE by unit ranged from 1.9-3.9%.

Table 15.—Comparison of passage performance metrics for yearling Chinook salmon and steelhead combined, as measured by radio telemetry (RT), and the run-at-large, as measured by hydroacoustics (HA) during the overlapping period of April 29-May 31, 2004, at Bonneville Dam. Radio telemetry estimates are weighted by the proportion of run size for each species based on the equation: RT estimate = (RT $estimate_{CH1}$ x proportion of run_{CH1}) + (RT $estimate_{STH}$ x proportion of run_{STH}). Powerhouse one = B1 and Powerhouse two = B2. Hydroacoustic data were provided by Gene Ploskey, Pacific Northwest National Laboratory (January 20, 2005).

Passage metric	RT estimate	HA estimate	Difference
Corner collector $efficiency_{B2}$	42%	35%	7%
Corner collector $effectiveness_{B2}$	7.8	6.5	1.3
Corner collector $efficiency_{Project}$	25%	14%	11%
Corner collector $effectiveness_{Project}$	9.6	5.2	4.4
Spillway efficiency	32%	41%	9
Spillway effectiveness	0.88	1.13	0.25
Sluiceway $efficiency_{B1}$	53%	28%	25%
Sluiceway $effectiveness_{B1}$	13.0	8.0	5.0
Sluiceway $efficiency_{Project}$	4%	6%	2%
Sluiceway $effectiveness_{Project}$	7.3	10.3	3.0
FGE_{B2}	33%	47%	14%
$FPE_{Project}$	73%	72%	1%
FPE_{B1}	55%	28%	27%
FPE_{B2}	61%	65%	4%

Table 16.—Estimates of Fish Guidance Efficiency (FGE), by turbine unit, at Bonneville Dam's second powerhouse (B2) for yearling Chinook salmon and steelhead combined, as measured by radio telemetry (RT), and for the run-at-large, as measured by hydroacoustics (HA) from April 29-May 31, 2004. Radio telemetry estimates are weighted by the proportion of run size for each species based on the equation: RT FGE = (RT FGE_{CH1} x proportion of run_{CH1}) + (RT FGE_{STH} x proportion of run_{STH}). Hydroacoustic data were provided by Gene Ploskey, Pacific Northwest National Laboratory (January 20, 2005).

Location	RT FGE	HA FGE	Difference
Unit 11	42%	42%	0%
Unit 12	36%	46%	10%
Unit 13	35%	45%	10%
Unit 14	35%	39%	4%
Unit 15	35%	61%	26%
Unit 16	37%	55%	18%
Unit 17	32%	55%	23%
Unit 18	24%	41%	17%

3.9 Residence Times at Areas of Potential Delay

According to new survey data gathered by the USACE early in 2002, the second powerhouse's Juvenile Bypass System (B2 JBS) conveyance pipe had become out-of-round (exceeded the maximum allowable ovality of 8.5%) in two locations and there was concern that these areas may cause delay in travel times of fish. The B2 JBS conveyance pipe transported juvenile salmonids rather quickly in 1999-2001 (Holmberg et al. 2001a, 2001b; Evans et al. 2001a, 2001b) and again in 2002, after the discovery of the ovality issue. Travel times of juvenile salmonids through the conveyance pipe were monitored again in 2004. The median travel time of guided fish through the B2 JBS conveyance pipe in 2004 was slightly less than travel times through the pipe in 1999-2002, indicating that fish were not delayed in the pipe (Table 17).

Table 17.—Median travel times (min) for yearling Chinook salmon and steelhead passing through Bonneville Dam's second powerhouse juvenile bypass system conveyance pipe during spring study periods of 2000-2004.

	1999	2000	2001	2002	2004
Chinook Salmon	50.3[a]	41.3	37.9	37.0	36.4
Steelhead	56.6[a]	47.7	No data	38.2	37.0

[a]Residence times in 1999 were based on travel from the top of the pipe to the outfall. Residence times in 2000-2004 were based on travel from the top of the pipe to the fish sampling facility, which was not yet completed in 1999.

4.0 Discussion

The proportion of discharge allocated to each dam area was likely the determining factor for which forebay fish entered, and subsequently passed. Based on our analysis of percent discharge per dam area by day related to percent of fish that entered each dam area, fish appeared to follow the bulk flow, entering the dam area with the highest proportion of discharge. Since B2 discharged the greatest amount of water during the study (49%), most fish entered the B2 forebay (55% of Chinook salmon and 50% of steelhead). Since flows were lowest at B1 (16% of project discharge), only 8% of both Chinook salmon and steelhead entered that dam area.

Forebay residence times were also affected by discharge. Both Chinook salmon and steelhead spent the least amount of time (6 min and 30 min, respectively) in the forebay of B2, the structure with the highest project discharge. Residence times were longest in the forebay of B1, which had the lowest project discharge. No relation was apparent between daily discharge patterns, hour of arrival, or hour of passage and residence time. Therefore, total discharge per dam area seemed to be the primary factor affecting residence times of yearling Chinook salmon and steelhead. These observations indicate that project operations and the resulting discharge per dam area influence approach paths of migrating yearling Chinook salmon and steelhead and consequently determine which dam area smolts enter and pass. Likewise, discharge per dam area affected how long fish resided in the forebay of Bonneville Dam before passing.

At B1, the proportions of radio-tagged fish that passed through specific routes indicated that fish were generally shallow in the water column. The largest percentage of both species (53% of Chinook salmon and 55% of steelhead) passed through the shallow, weir-type entrances of the sluiceway, followed by the deeper turbine intakes (46% of Chinook salmon and 42% of steelhead). Likewise, at B2, steelhead preferred the corner collector (74%), which had a surface-oriented entrance. However, yearling Chinook salmon passed more readily through the deeper turbine intakes (43% unguided, 21% guided) than through the corner collector (36%). Similarly, at the spillway, where fish must descend about 15 m to pass, yearling Chinook salmon had a higher passage distribution than steelhead. These data indicate that yearling Chinook salmon were likely distributed deeper in the water column than steelhead.

Passage distributions fluctuated with diurnal periods but were confounded because discharge also varied diurnally. Passage distributions were greatest for both species at B2 during the day and at the spillway during the night. However, discharge was also greatest (53% of project flow) at B2 during the day and at the spillway during the night (51% of project flow). Thus, it is difficult to determine whether diurnal periods or discharge were most responsible for fluctuating passage distributions. During spring 2002, when discharge was similar during day and night for all dam areas and when the only passage route through B2 was through the turbines or bypass system, fish passage increased during the night at both the spillway and B2, and increased during the day at B1 (Evans et al. 2003a). Therefore, past and present research at Bonneville Dam shows that fish passage increases at night through deep routes of passage like the turbines and spillway, and increases during the day through shallow routes of passage like the sluiceway and corner collector. These findings concur with the findings of numerous studies regarding juvenile salmonid behavior at hydroelectric projects. Coutant and Whitney (2000) reported in a review of literature on fish behavior relative to passage of fish through hydropower turbines, that emigrating salmonids descend, mostly at night, to pass the dam through the turbines or turbine intake bypass system. Surface-oriented passage of juvenile salmonids has been shown to increase during the day at Bonneville Dam (Willis and Uremovich 1981; Magne et al.1987; Evans et al. 2001a) as well as at other Columbia River Basin projects (Nichols et al. 1978; Raymond and Sims 1980; Ransom and Ouellette 1991). These data suggest that, regardless of whether discharge or diurnal period affects fish passage the most, since fish tend to both follow flow and pass in a diurnal pattern, if discharge is varied in the right area at the right time, discharge and diurnal period can have a synergistic effect on fish passage.

Passage metrics for both yearling Chinook salmon and steelhead were generally lower in 2004 than in 2002 (Table 18). The only passage metrics that were higher in 2004 were FPE_{B2} for both species and $FPE_{project}$ for steelhead. If guidance screens had been deployed at B1 in 2004, FPE_{B1} and $FPE_{project}$ would have been higher. However, due to low discharge at B1 in 2004, relatively few fish passed there and the increase would have been minimal. Fish guidance efficiency at B2 in 2004 was the lowest of all study years. We hypothesize that low FGE_{B2} in 2004 was due to the corner collector passing the majority of the shallow fish; fish that may otherwise have been guided. Spillway efficiency decreased in 2004 because more fish passed at B2, specifically through the corner collector. The increased passage at B2 through the corner collector is reflected in increased FPE_{B2} for both species, and in the slight increase in $FPE_{project}$ for steelhead. Although the addition of the corner collector did not increase $FPE_{project}$, it did achieve $FPE_{project}$ similar to that attained in previous years, mainly through spill. Furthermore, the corner collector helped achieve similar $FPE_{project}$ with far less water than would have been used to attain the same FPE without the corner collector. The spillway discharged an average 14 times more water than the corner collector. Consequently, effectiveness of the corner collector relative to the project (8.4 for yearling Chinook salmon and 19.1 for steelhead) was far greater than effectiveness of the spillway (0.9 for yearling Chinook salmon and 0.7 for steelhead). Our results indicate that although the intake screen guidance systems at Bonneville Dam have poor guidance efficiency, project FPE of 71-86%, depending on species, can be attained if sufficient numbers of fish are passed via a combination of non-turbine routes (spill, sluice, turbine guidance systems, and the corner collector). Additionally, by strategically optimizing discharge patterns at the project, passage of juvenile salmonids can be increased temporally and spatially.

Table 18.—Passage performance metrics for yearling Chinook salmon and steelhead at Bonneville Dam during spring study periods of 2000, 2001, 2002, and 2004. B1 = first powerhouse and B2 = second powerhouse.

Passage metric	Chinook salmon				Steelhead			
	2000	2001	2002	2004	2000	2001[a]	2002	2004
Spillway efficiency	44%	16%	57%	33%	33%	-----	55%	26%
Spillway effectiveness	1.3	0.7	1.2	0.9	1.0	-----	1.2	0.7
FGE_{B1}[c]	50%	45%	50%	-----	59%	-----	75%	-----
FGE_{B2}	39%	46%	37%	33%	55%	-----	59%	40%
Sluiceway $efficiency_{B1}$	29%	77%	35%	53%	44%	-----	65%	55%
Sluiceway $effectiveness_{B1}$[b]	-----	-----	18.6	14.6	-----	-----	34.1	15.1
Corner collector $efficiency_{B2}$	-----	-----	-----	37%	-----	-----	-----	74%
Corner collector $effectiveness_{B2}$	-----	-----	-----	7.0	-----	-----	-----	14.2
Corner collector $efficiency_{Project}$	-----	-----	-----	22%	-----	-----	-----	49%
Corner collector $effectiveness_{Project}$	-----	-----	-----	8.4	-----	-----	-----	19.1
$FPE_{Project}$	73%	56%	76%	71%	78%	-----	84%	86%
FPE_{B1}	65%	87%	69%	54%	77%	-----	91%	58%
FPE_{B2}	40%	46%	37%	57%	55%	-----	59%	84%

[a] Steelhead were not evaluated in 2001.

[b] Sluiceway discharge data was not provided in 2000 and 2001 so sluiceway effectiveness could not be calculated.

[c] In 2004, FGE_{B1} could not be estimated due to the absence of guidance screens.

The comparison of our estimates of passage metrics with those obtained with hydroacoustics demonstrates the importance of having more than one independent estimate of passage performance. Although each research tool has its strengths, each tool also has its weaknesses. Radio telemetry is useful because it enables the investigator to obtain information on a species-specific basis and it has a relatively wide range of spatial resolution in terms of coverage area. However, radio telemetry sample size is often restricted by costs of tags and the number of radio-tagged fish that can be tracked concurrently. Hydroacoustic sampling is an effective means of obtaining information on numerous fish, but deciphering fish species or obtaining information on individual fish is not currently possible. Therefore it can be advantageous to utilize both technologies to overcome the limitations of each method. We do not have a clear explanation of why differences in passage metric estimates for radio telemetry and hydroacoustics were, in some instances, so great (up to 27%). The smaller sample sizes utilized by radio telemetry may have contributed to these differences. However, standard errors for radio telemetry estimates were very low, never exceeding 1.7%. Equally plausible is that, because hydroacoustics sampled the run-at-large, passage estimates may have been based on a mixture of species with different passage behavior than yearling Chinook salmon or steelhead.

5.0 Acknowledgements

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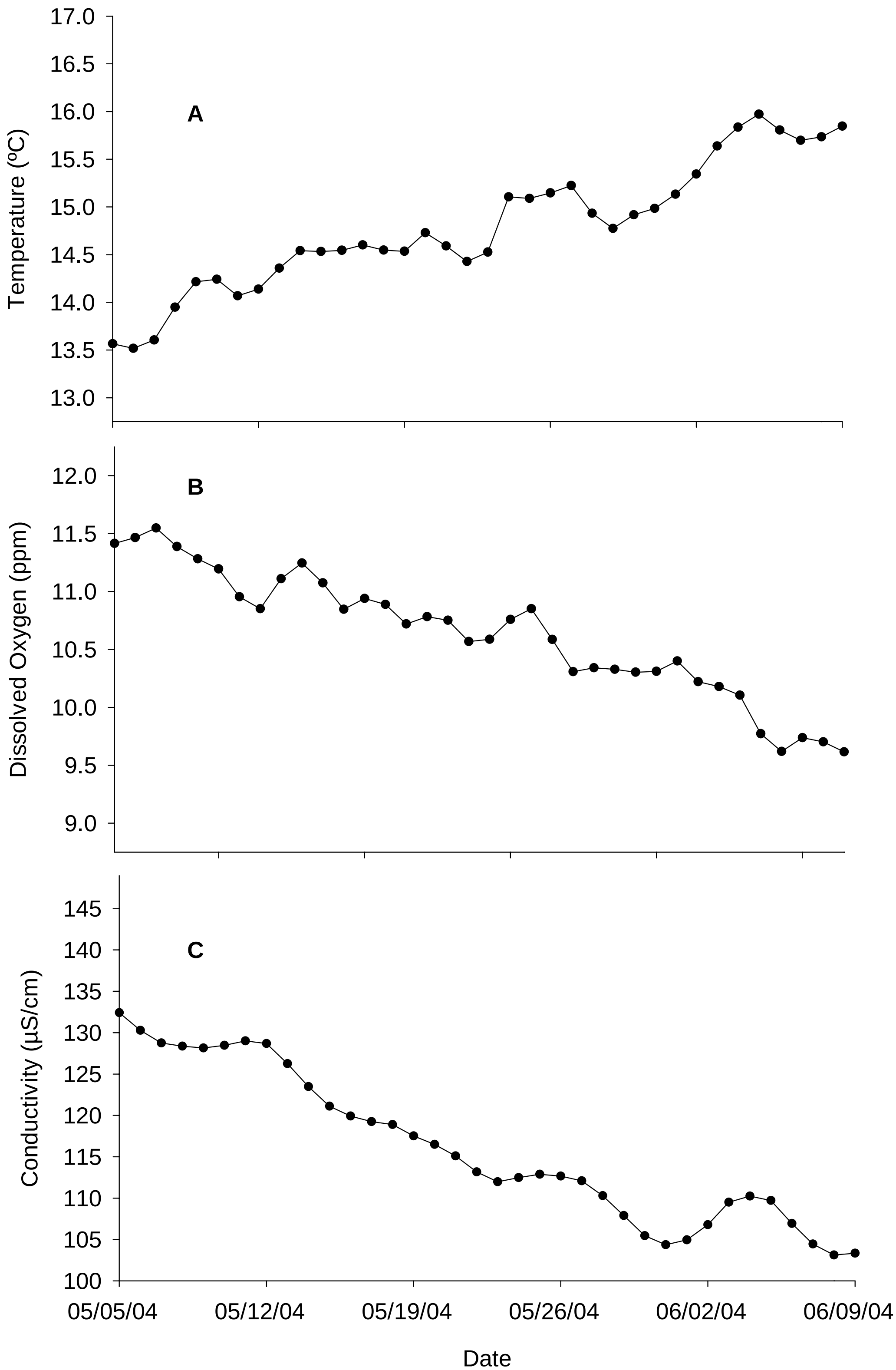
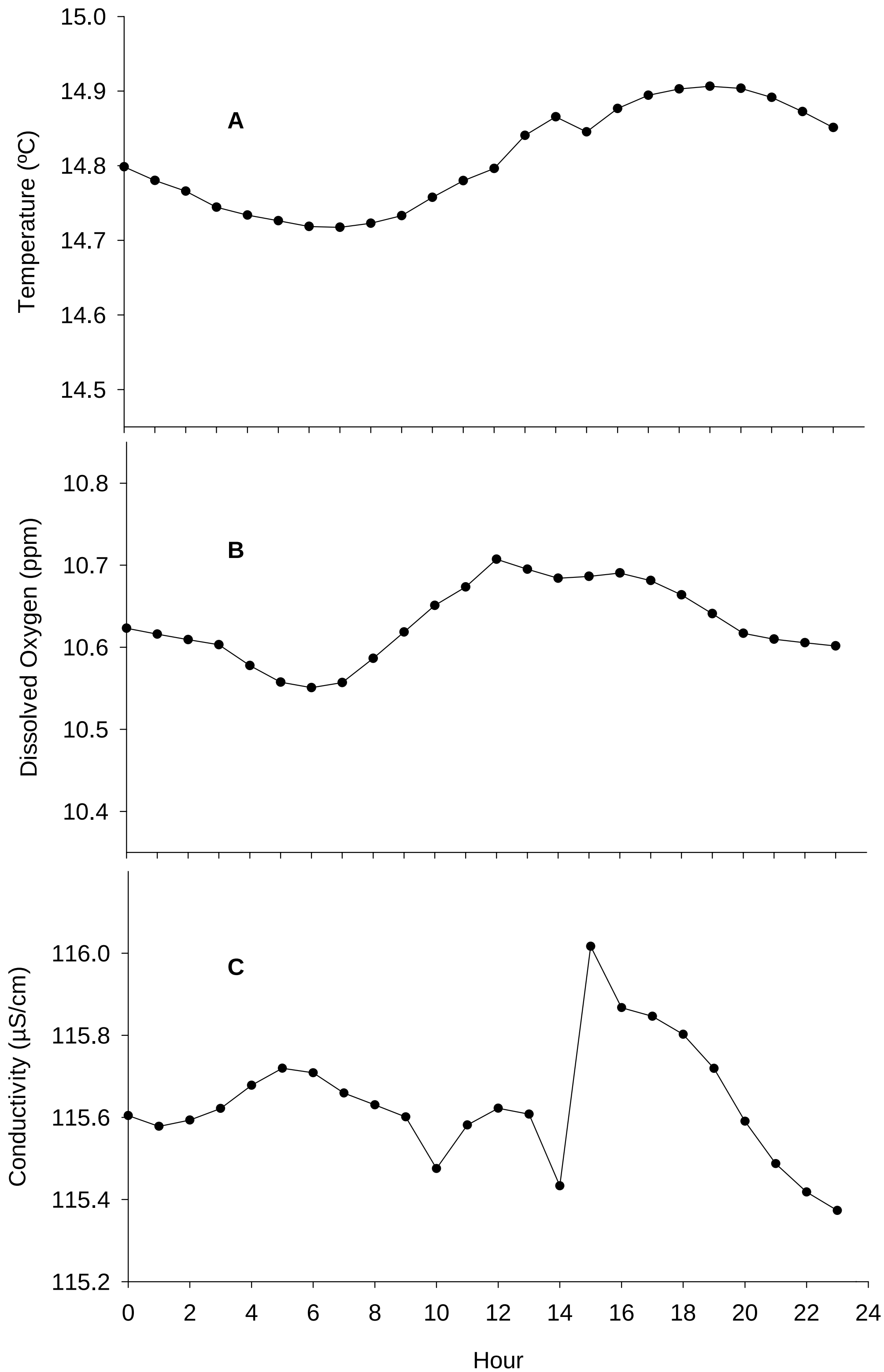
7.0 Appendices



Appendix 1. —Mean daily temperature (A), dissolved oxygen (B), and conductivity (C) at Bonneville Dam 1.5 m below water surface in the forebay of the spillway from 5 May to 9 June 2004.



Appendix 2. —Mean hourly temperature (A), dissolved oxygen (B), and conductivity (C) at Bonneville Dam 1.5 m below water surface in the forebay of the spillway from 5 May to 9 June 2004.

Appendix 3.—Mean weight and fork length, and their associated standard deviations (SD), for yearling Chinook salmon released from The Dalles Dam (TDA) and John Day Dam (JDA), spring 2004.

Release Date	Dam	Release Time	N	Weight Mean (g)	Weight SD	Fork length Mean (mm)	Fork length SD
4/27/2004	JDA	7:00	30	31.7	6.2	149	10
4/27/2004	JDA	19:00	34	35.0	7.9	151	10
4/28/2004	JDA	7:00	34	34.0	7.1	150	10
4/28/2004	JDA	19:00	34	34.0	6.0	150	8
4/28/2004	TDA	1:00	41	34.8	9.2	148	11
4/28/2004	TDA	13:00	77	34.5	6.0	154	8
4/29/2004	JDA	7:00	35	34.7	7.2	153	9
4/29/2004	JDA	19:00	38	38.8	8.7	158	11
4/29/2004	TDA	1:00	40	36.7	9.0	155	12
4/29/2004	TDA	13:00	44	38.2	9.3	156	13
4/29/2004	TDA	19:00	44	36.1	6.5	154	9
4/30/2004	JDA	7:00	34	37.6	8.1	145	10
4/30/2004	JDA	19:00	36	35.7	7.9	151	10
4/30/2004	TDA	1:00	38	35.1	8.0	152	10
4/30/2004	TDA	13:00	47	35.1	5.6	153	8
5/1/2004	JDA	7:00	36	34.6	6.7	142	10
5/1/2004	JDA	19:00	36	35.8	6.8	152	9
5/1/2004	TDA	1:00	91	34.2	6.5	152	9
5/1/2004	TDA	7:00	42	33.8	6.6	151	10
5/1/2004	TDA	13:00	45	35.5	7.4	153	10
5/2/2004	JDA	7:00	35	35.6	8.5	152	11
5/2/2004	JDA	19:00	38	35.2	6.6	154	9
5/2/2004	TDA	1:00	47	33.0	5.6	149	8
5/2/2004	TDA	13:00	90	33.9	7.2	147	12
5/3/2004	JDA	7:00	36	36.4	8.0	154	11
5/3/2004	JDA	19:00	34	36.1	7.5	153	11
5/3/2004	TDA	1:00	46	34.9	7.7	153	11
5/3/2004	TDA	7:00	47	33.7	7.9	147	11
5/3/2004	TDA	13:00	45	36.2	10.8	150	14
5/4/2004	JDA	7:00	35	33.8	8.3	150	13
5/4/2004	JDA	19:00	35	35.8	8.7	152	12
5/4/2004	TDA	1:00	44	33.0	6.4	149	9
5/4/2004	TDA	13:00	47	32.5	6.5	150	10
5/5/2004	JDA	7:00	35	31.9	6.2	147	9
5/5/2004	JDA	19:00	34	32.7	7.0	148	10
5/5/2004	TDA	1:00	94	31.9	8.4	148	11
5/5/2004	TDA	13:00	47	31.6	7.1	149	11
5/5/2004	TDA	19:00	46	30.6	6.9	147	10
5/6/2004	JDA	7:00	35	29.2	6.5	145	9
5/6/2004	JDA	19:00	34	35.8	11.4	152	15
5/6/2004	TDA	1:00	47	35.4	10.3	154	14
5/6/2004	TDA	7:00	47	33.5	9.9	151	14
5/6/2004	TDA	13:00	46	34.0	8.5	152	12

Appendix 3 (continued).—Mean weight and fork length, and their associated standard deviations (SD), for yearling Chinook salmon released from The Dalles Dam (TDA) and John Day Dam (JDA), spring 2004.

Release Date	Dam	Release Time	N	Weight Mean (g)	Weight SD	Fork length Mean (mm)	Fork length SD
5/7/2004	JDA	7:00	31	36.6	8.3	155	12
5/7/2004	JDA	19:00	35	37.3	8.7	155	12
5/7/2004	TDA	1:00	41	35.5	8.0	149	12
5/7/2004	TDA	13:00	45	34.6	10.2	152	14
5/8/2004	JDA	7:00	35	34.9	8.8	153	12
5/8/2004	JDA	19:00	35	39.5	11.5	151	14
5/8/2004	TDA	1:00	92	41.0	9.9	156	12
5/8/2004	TDA	13:00	43	36.0	7.2	156	11
5/8/2004	TDA	19:00	43	35.6	11.1	152	15
5/9/2004	JDA	7:00	35	37.1	10.4	155	14
5/9/2004	JDA	19:00	35	36.6	9.2	148	14
5/9/2004	TDA	1:00	47	31.8	10.5	147	13
5/9/2004	TDA	13:00	95	31.0	8.6	148	11
5/10/2004	JDA	7:00	35	36.4	12.9	154	16
5/10/2004	JDA	19:00	36	39.7	9.7	157	13
5/10/2004	TDA	1:00	48	37.5	9.8	157	13
5/10/2004	TDA	13:00	47	35.9	9.3	154	12
5/10/2004	TDA	19:00	47	35.0	13.6	152	15
5/11/2004	JDA	7:00	34	35.0	11.4	152	15
5/11/2004	JDA	19:00	36	42.9	14.6	162	18
5/11/2004	TDA	1:00	48	32.2	8.5	149	12
5/11/2004	TDA	13:00	95	31.7	11.7	149	15
5/12/2004	JDA	7:00	37	35.8	11.1	155	16
5/12/2004	JDA	19:00	36	38.6	12.8	158	16
5/12/2004	TDA	1:00	46	39.4	13.5	159	18
5/12/2004	TDA	7:00	48	37.6	13.6	156	17
5/12/2004	TDA	13:00	45	39.2	10.7	159	15
5/13/2004	JDA	7:00	35	41.7	12.5	163	16
5/13/2004	JDA	19:00	36	45.7	15.2	165	18
5/13/2004	TDA	1:00	48	36.2	12.4	154	17
5/13/2004	TDA	13:00	48	42.3	13.8	163	17
5/14/2004	JDA	7:00	35	43.2	14.8	162	19
5/14/2004	JDA	19:00	36	38.6	11.2	158	15
5/14/2004	TDA	1:00	92	37.9	12.9	157	17
5/14/2004	TDA	13:00	48	38.4	12.4	159	18
5/15/2004	JDA	7:00	33	45.1	18.7	167	19
5/15/2004	JDA	19:00	37	41.9	13.0	162	16
5/15/2004	TDA	1:00	95	42.9	16.2	163	19
5/15/2004	TDA	7:00	46	41.8	18.1	161	21
5/15/2004	TDA	13:00	47	40.8	14.8	161	18
5/16/2004	JDA	7:00	36	44.8	15.2	166	19
5/16/2004	JDA	19:00	34	44.0	16.4	164	20
5/16/2004	TDA	1:00	47	39.7	14.7	160	19

Appendix 3 (continued).—Mean weight and fork length, and their associated standard deviations (SD), for yearling Chinook salmon released from The Dalles Dam (TDA) and John Day Dam (JDA), spring 2004.

Release Date	Dam	Release Time	N	Weight Mean (g)	Weight SD	Fork length Mean (mm)	Fork length SD
5/16/2004	TDA	13:00	47	38.7	14.6	159	19
5/16/2004	TDA	19:00	46	39.4	13.5	160	18
5/17/2004	JDA	7:00	35	39.7	12.0	159	15
5/17/2004	JDA	19:00	35	41.5	12.6	162	15
5/17/2004	TDA	1:00	45	41.0	13.7	161	18
5/17/2004	TDA	13:00	96	41.1	13.9	162	16
5/18/2004	JDA	7:00	35	47.2	14.9	168	17
5/18/2004	JDA	19:00	36	40.6	9.6	162	14
5/18/2004	TDA	1:00	46	40.0	14.3	160	18
5/18/2004	TDA	13:00	43	42.7	13.9	165	18
5/19/2004	JDA	7:00	35	42.0	13.9	162	18
5/19/2004	JDA	19:00	33	42.7	12.0	163	15
5/19/2004	TDA	1:00	95	37.2	11.2	157	16
5/19/2004	TDA	13:00	94	36.5	10.4	157	15
5/20/2004	JDA	7:00	34	43.5	12.0	166	17
5/20/2004	JDA	19:00	35	36.1	10.8	156	15
5/20/2004	TDA	1:00	53	39.9	11.7	160	16
5/20/2004	TDA	7:00	54	42.1	11.2	165	15
5/20/2004	TDA	13:00	51	41.5	11.4	163	15
5/21/2004	JDA	7:00	35	37.5	12.2	157	17
5/21/2004	JDA	19:00	35	41.3	15.4	162	17
5/21/2004	TDA	1:00	52	39.7	11.1	160	15
5/21/2004	TDA	13:00	53	37.1	10.5	158	15
5/21/2004	TDA	19:00	54	36.7	11.3	156	16
5/22/2004	JDA	7:00	35	35.3	12.6	155	17
5/22/2004	JDA	19:00	33	44.5	12.5	168	15
5/22/2004	TDA	1:00	53	39.3	11.7	160	15
5/22/2004	TDA	13:00	107	38.4	11.0	160	14
5/23/2004	JDA	7:00	35	42.9	15.5	162	19
5/23/2004	JDA	19:00	34	36.1	9.1	158	13
5/23/2004	TDA	1:00	51	40.2	11.8	162	15
5/23/2004	TDA	13:00	53	40.0	9.9	161	14
5/23/2004	TDA	19:00	53	38.0	9.4	160	13
5/24/2004	JDA	7:00	34	40.8	13.8	162	17
5/24/2004	JDA	19:00	34	41.0	13.0	162	16
5/24/2004	TDA	1:00	52	40.0	11.6	162	14
5/24/2004	TDA	13:00	48	39.0	11.5	160	16
5/25/2004	JDA	7:00	34	47.5	17.8	170	19
5/25/2004	JDA	19:00	34	39.9	14.2	160	18
5/25/2004	TDA	1:00	103	40.4	14.4	162	17
5/25/2004	TDA	7:00	55	42.7	12.5	164	15
5/25/2004	TDA	13:00	51	42.5	16.0	162	19

Appendix 3 (continued).—Mean weight and fork length, and their associated standard deviations (SD), for yearling Chinook salmon released from The Dalles Dam (TDA) and John Day Dam (JDA), spring 2004.

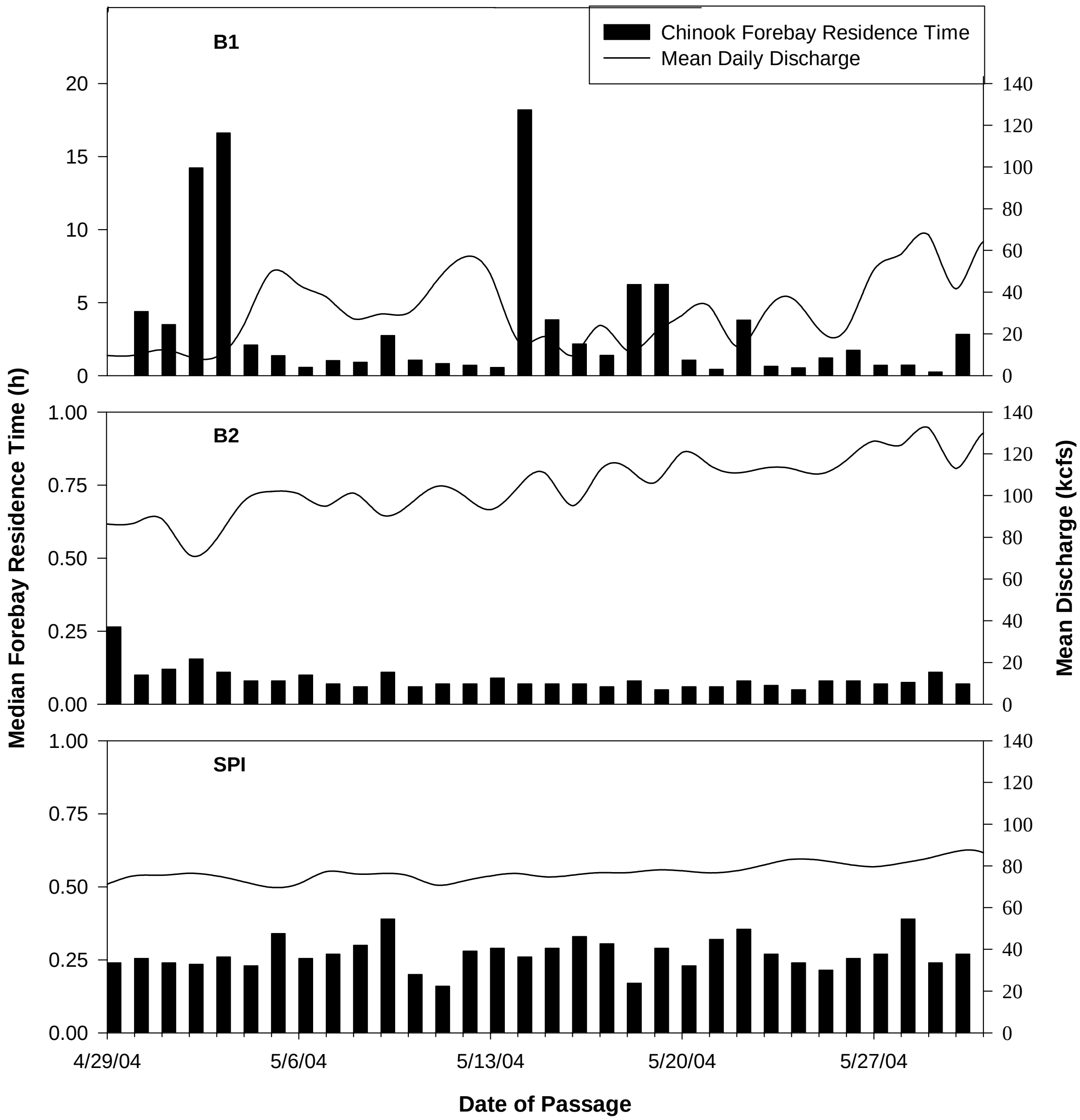
Release Date	Dam	Release Time	N	Weight Mean (g)	Weight SD	Fork length Mean (mm)	Fork length SD
5/26/2004	JDA	7:00	34	38.9	12.9	158	16
5/26/2004	JDA	19:00	35	47.0	15.3	167	18
5/26/2004	TDA	1:00	51	41.0	16.7	162	18
5/26/2004	TDA	13:00	52	41.1	14.9	161	17
5/27/2004	JDA	7:00	35	51.0	19.9	172	22
5/27/2004	JDA	19:00	35	48.7	17.8	170	19
5/27/2004	TDA	1:00	105	43.0	17.1	164	19
5/27/2004	TDA	13:00	106	43.8	16.3	164	18
5/28/2004	JDA	7:00	36	47.0	16.0	167	18
5/28/2004	JDA	19:00	35	46.1	16.4	167	18
5/28/2004	TDA	1:00	44	48.8	19.5	168	21
5/28/2004	TDA	7:00	45	40.4	16.4	161	18
5/28/2004	TDA	13:00	47	48.5	20.9	169	22
5/29/2004	TDA	1:00	28	46.5	18.9	166	21
5/29/2004	TDA	13:00	29	47.1	19.1	169	19
5/29/2004	TDA	19:00	20	46.3	18.2	166	20

Appendix 4.—Mean weight and fork length, and their associated standard deviations (SD), for yearling steelhead released from The Dalles Dam (TDA) and John Day Dam (JDA), spring 2004.

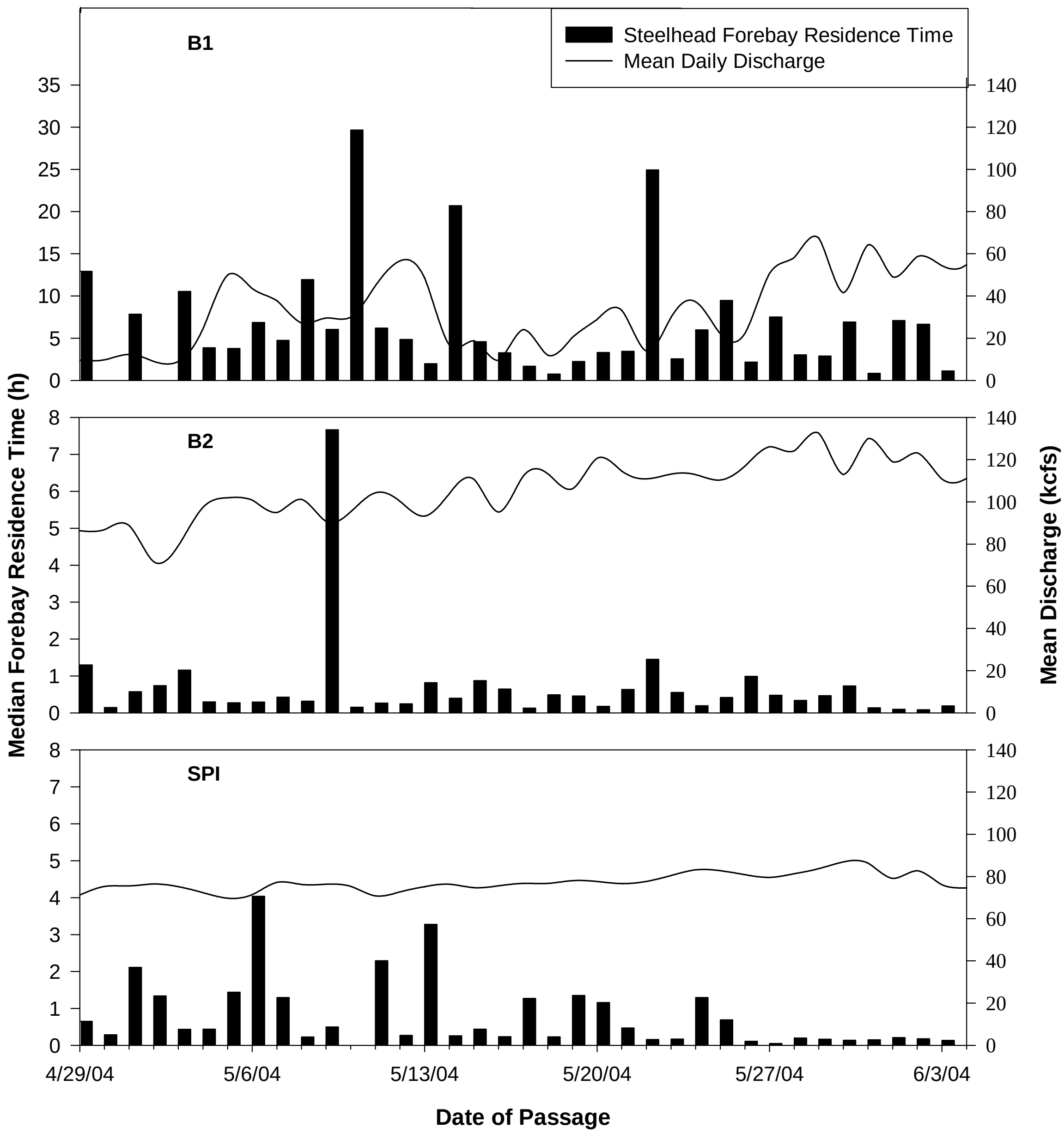
Release Date	Dam	Release Time	N	Weight Mean (g)	Weight SD	Fork length Mean (mm)	Fork length SD
4/28/2004	TDA	1:00	21	86.0	20.6	216	18
4/28/2004	TDA	13:00	17	80.3	12.6	218	17
4/29/2004	TDA	1:00	30	88.9	23.0	225	19
4/29/2004	TDA	13:00	27	90.7	23.9	227	21
4/30/2004	TDA	1:00	33	103.0	23.6	228	20
4/30/2004	TDA	13:00	40	83.6	24.0	221	22
5/1/2004	TDA	1:00	67	76.1	18.6	218	19
5/1/2004	TDA	13:00	34	91.7	24.8	227	17
5/2/2004	TDA	1:00	62	107.3	22.9	232	16
5/2/2004	TDA	13:00	56	99.3	24.1	216	22
5/3/2004	TDA	1:00	70	103.1	24.9	228	23
5/3/2004	TDA	13:00	64	101.7	24.0	218	22
5/4/2004	TDA	1:00	66	97.6	21.8	226	19
5/4/2004	TDA	13:00	35	93.1	21.4	223	17
5/5/2004	TDA	1:00	25	100.5	30.1	227	24
5/5/2004	TDA	13:00	28	90.7	22.2	220	17
5/6/2004	TDA	1:00	38	97.6	23.3	227	18
5/6/2004	TDA	13:00	40	98.8	26.5	226	17
5/7/2004	TDA	1:00	65	98.2	26.1	218	22
5/7/2004	TDA	13:00	61	101.0	22.3	228	16
5/8/2004	TDA	1:00	70	100.0	28.6	223	23
5/10/2004	TDA	1:00	41	99.6	24.3	225	23
5/10/2004	TDA	13:00	41	99.7	24.2	231	19

Appendix 4 (continued).—Mean weight and fork length, and their associated standard deviations (SD), for yearling steelhead released from The Dalles Dam (TDA) and John Day Dam (JDA), spring 2004.

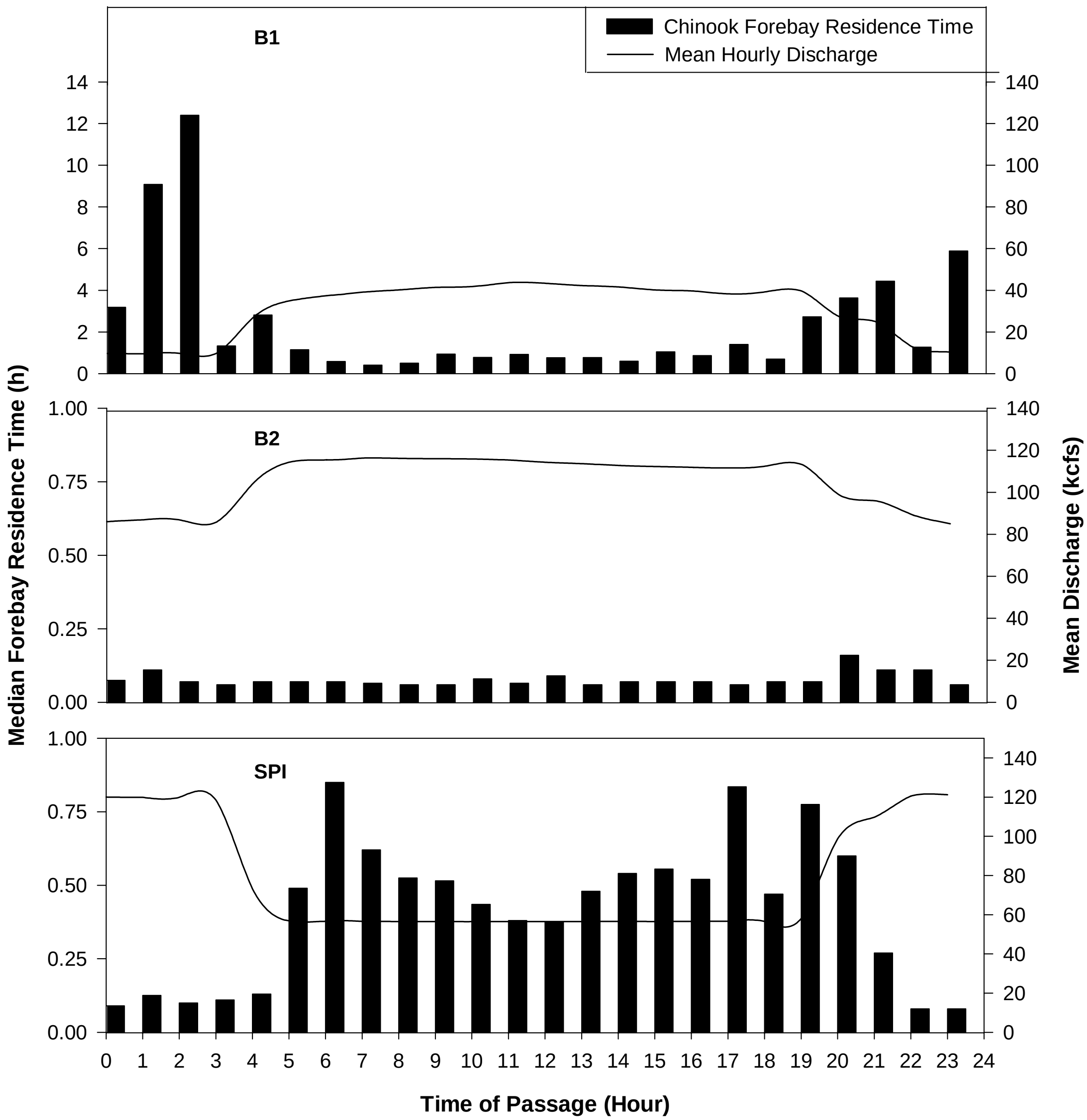
Release		Release		Weight		Fork length	
Date	Dam	Time	N	Mean (g)	SD	Mean (mm)	SD
5/11/2004	TDA	1:00	70	100.5	27.8	230	19
5/11/2004	TDA	13:00	68	102.3	29.7	232	20
5/12/2004	TDA	1:00	71	98.6	25.0	228	18
5/12/2004	TDA	13:00	67	95.7	26.6	226	19
5/13/2004	TDA	1:00	72	99.0	29.4	230	21
5/13/2004	TDA	13:00	67	95.7	27.9	226	19
5/14/2004	TDA	1:00	78	97.1	27.3	224	22
5/14/2004	TDA	13:00	75	89.5	23.2	223	19
5/15/2004	TDA	1:00	76	100.7	29.7	229	22
5/15/2004	TDA	13:00	79	98.9	25.7	229	19
5/16/2004	TDA	1:00	77	97.5	24.9	228	22
5/16/2004	TDA	13:00	80	103.2	32.4	232	23
5/17/2004	TDA	1:00	78	98.4	25.9	229	20
5/17/2004	TDA	13:00	70	90.1	23.1	221	22
5/18/2004	TDA	1:00	80	90.5	27.5	220	20
5/18/2004	TDA	13:00	80	91.3	27.7	220	22
5/19/2004	TDA	1:00	74	93.0	29.8	221	23
5/19/2004	TDA	13:00	81	91.1	29.2	221	22
5/20/2004	TDA	1:00	81	101.2	31.8	229	24
5/20/2004	TDA	13:00	77	91.9	26.6	219	22
5/21/2004	TDA	1:00	81	91.0	30.3	219	24
5/21/2004	TDA	13:00	77	94.5	36.0	221	25
5/22/2004	TDA	1:00	77	84.3	31.4	214	26
5/22/2004	TDA	13:00	79	81.1	22.8	213	20
5/23/2004	TDA	1:00	80	90.2	33.4	218	26
5/23/2004	TDA	13:00	77	90.5	34.4	217	25
5/24/2004	TDA	1:00	77	85.6	28.7	217	24
5/24/2004	TDA	13:00	80	88.6	29.8	219	25
5/25/2004	TDA	1:00	80	85.7	29.3	218	24
5/25/2004	TDA	13:00	81	88.1	31.5	218	26
5/26/2004	TDA	1:00	39	94.9	36.6	226	28
5/26/2004	TDA	13:00	44	90.3	27.8	222	22
5/27/2004	TDA	1:00	79	99.7	28.6	229	25
5/27/2004	TDA	13:00	80	95.6	26.7	227	22
5/28/2004	TDA	1:00	80	106.3	28.4	234	21
5/28/2004	TDA	13:00	79	95.1	34.7	224	26
5/29/2004	TDA	1:00	71	95.8	27.5	223	25
5/29/2004	TDA	13:00	75	84.8	30.5	216	23
5/30/2004	TDA	1:00	78	91.0	37.1	220	25
5/30/2004	TDA	13:00	74	95.6	30.8	225	21
5/31/2004	TDA	1:00	75	101.7	38.0	228	26
5/31/2004	TDA	13:00	78	105.5	41.4	230	24
6/1/2004	TDA	1:00	77	99.5	33.4	228	24
6/1/2004	TDA	13:00	78	105.0	37.5	231	24
6/2/2004	TDA	1:00	71	97.0	35.2	227	27



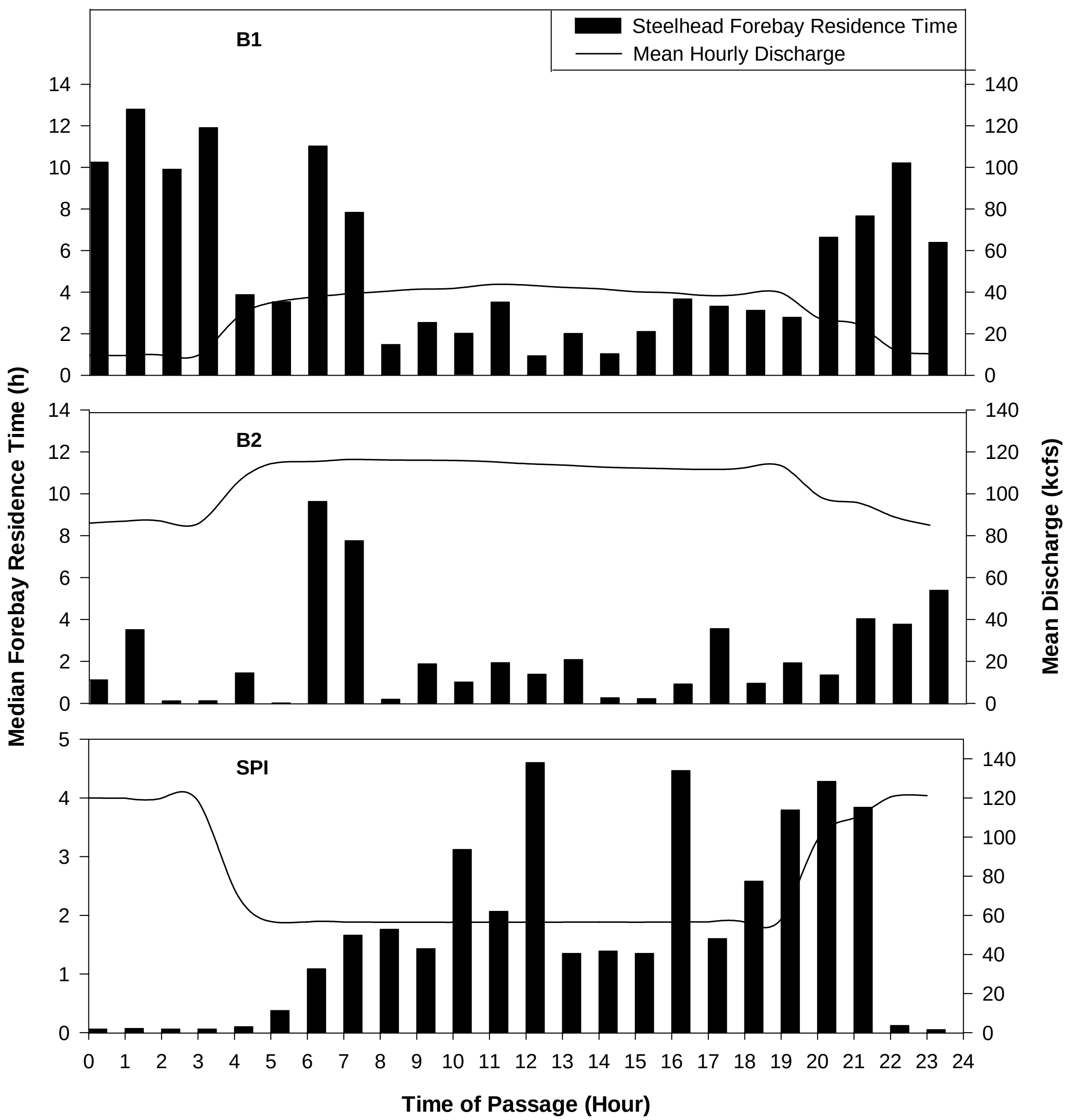
Appendix 5.—Median forebay residence time by day of passage versus mean discharge by dam area for yearling Chinook salmon at Bonneville Dam, spring 2004. Scale of y-axis for first powerhouse graph differs from graphs for second powerhouse and spillway for visual clarity of residence time data.



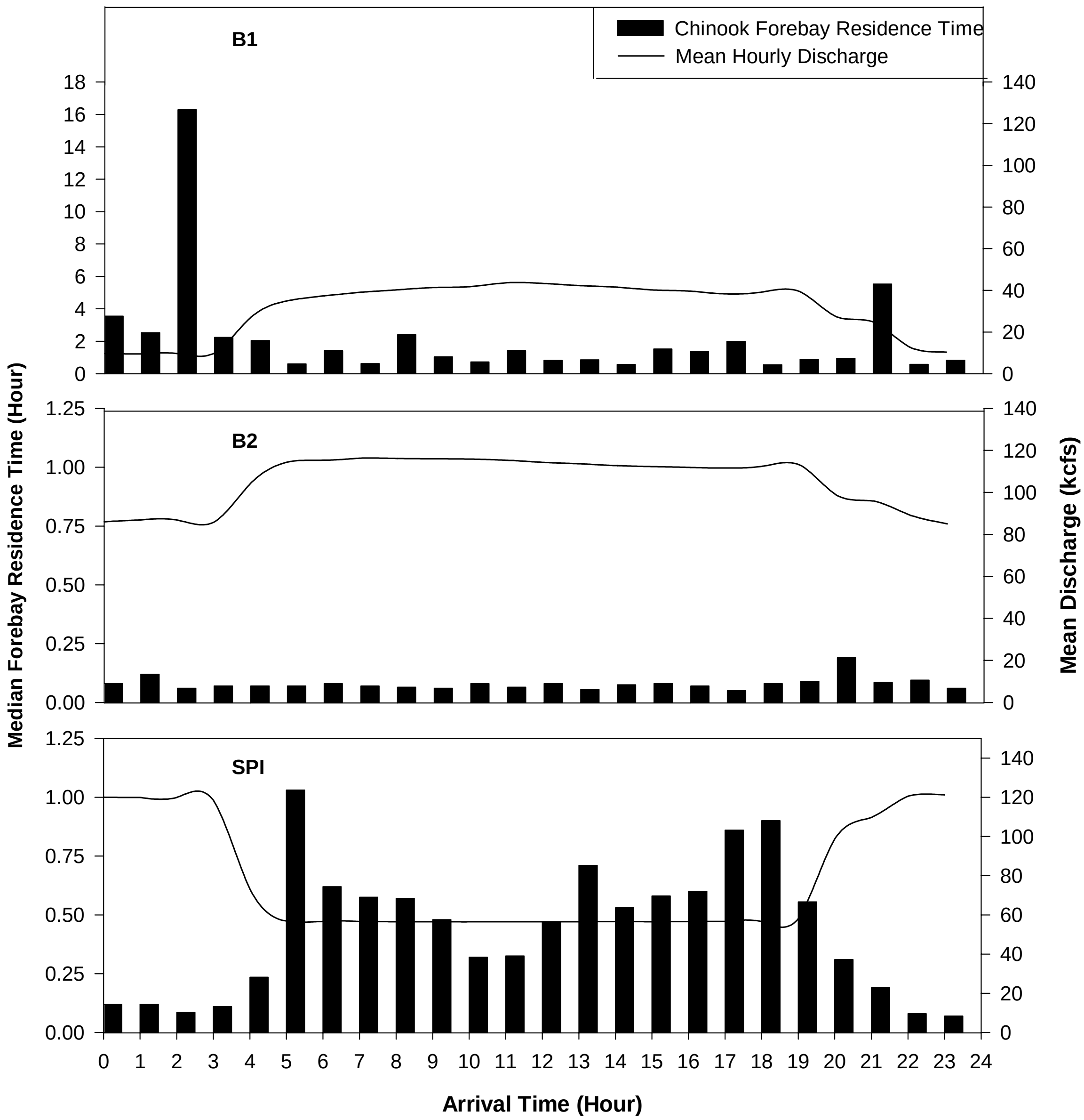
Appendix 6.—Median forebay residence time by day of passage versus mean discharge by dam area for yearling steelhead at Bonneville Dam, spring 2004. Scale of y-axis for first powerhouse graph differs from graphs for second powerhouse and spillway for visual clarity of residence time data.



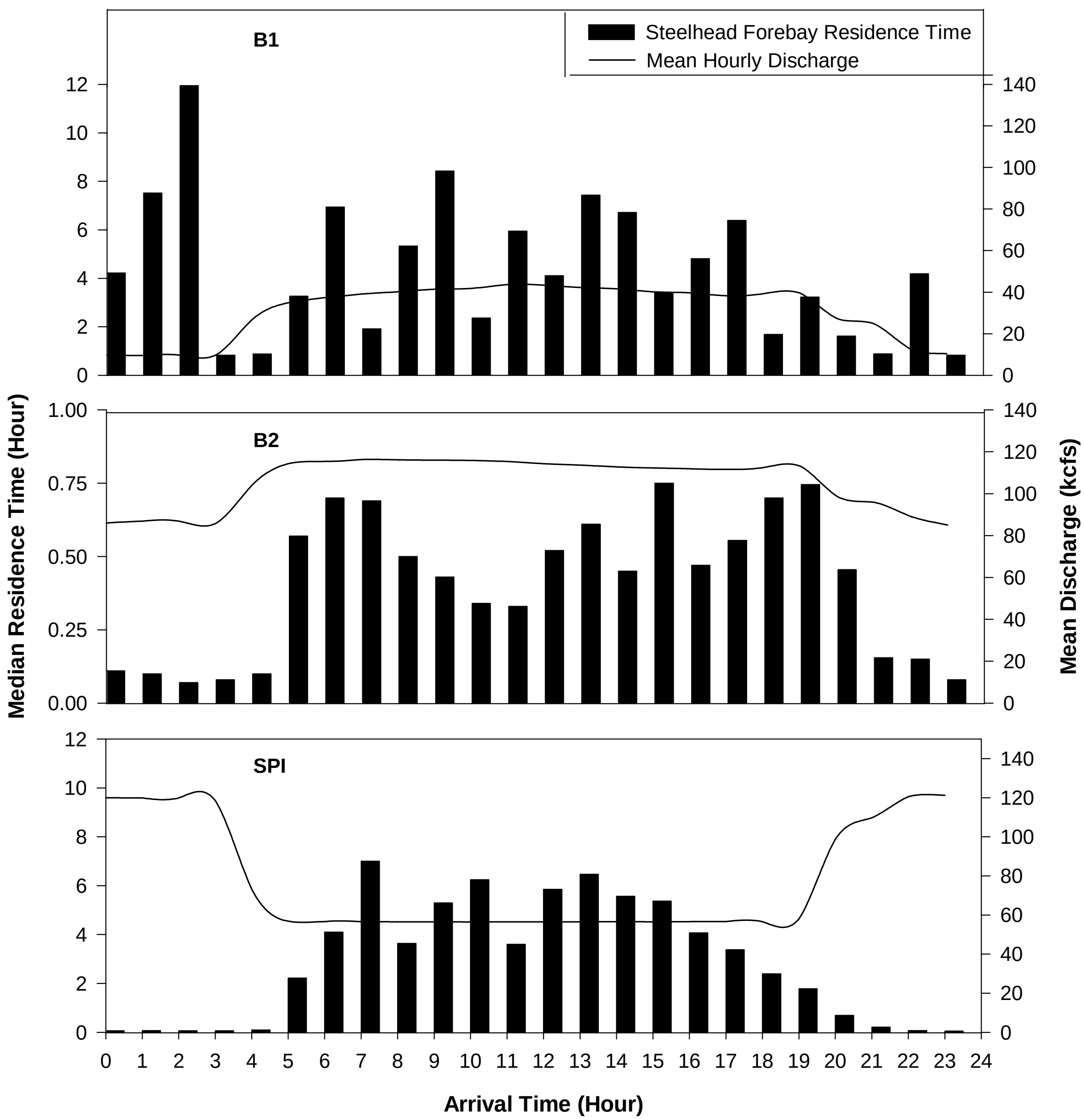
Appendix 7.—Median forebay residence time by hour of passage versus mean discharge by dam area for yearling Chinook salmon at Bonneville Dam, spring 2004. Scale of y-axis for first powerhouse graph differs from graphs for second powerhouse and spillway for visual clarity of residence time data.



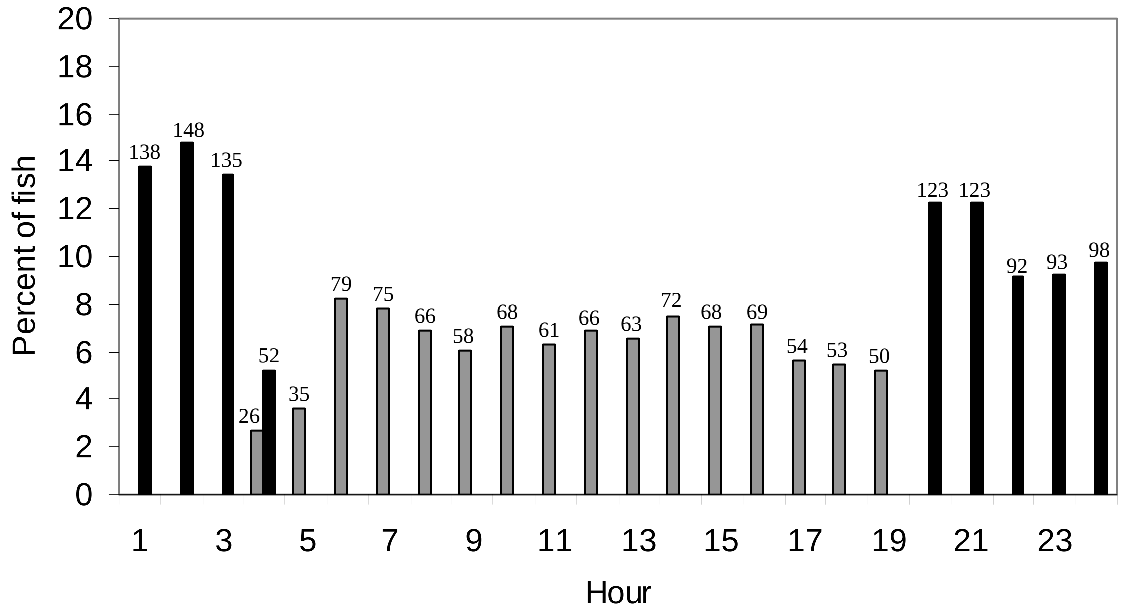
Appendix 8.—Median forebay residence time by hour of passage versus mean discharge by dam area for yearling steelhead at Bonneville Dam, spring 2004. Scale of y-axis for spillway graph differs from graphs for first powerhouse and second powerhouse for visual clarity of residence time data.



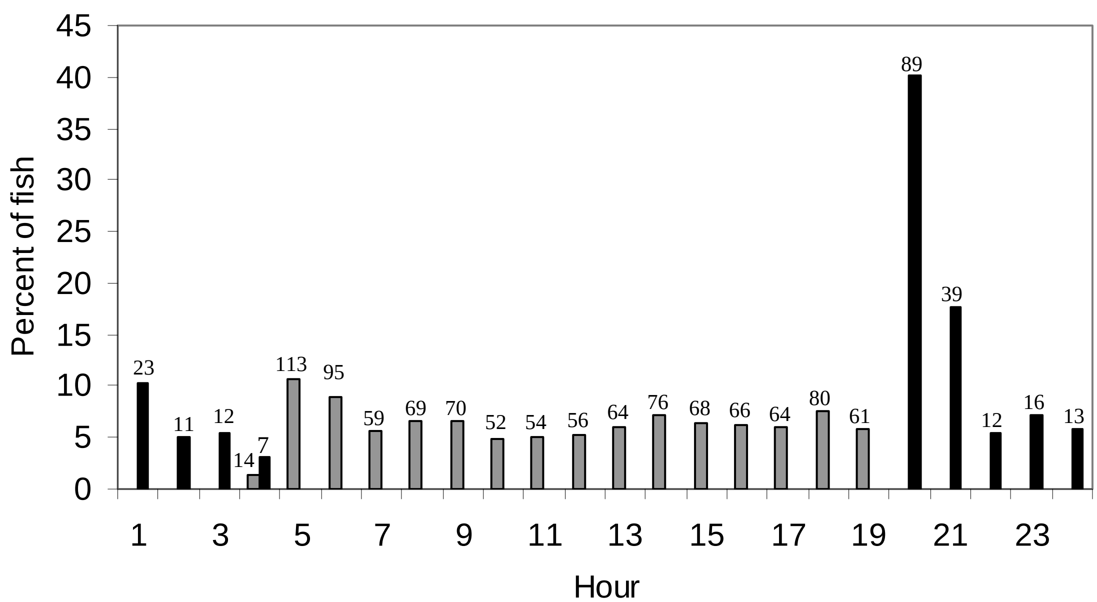
Appendix 9.—Median forebay residence time by hour of arrival versus mean discharge by dam area for yearling Chinook salmon at Bonneville Dam, spring 2004. Scale of y-axis for first powerhouse graph differs from graphs for second powerhouse and spillway for visual clarity of residence time data.



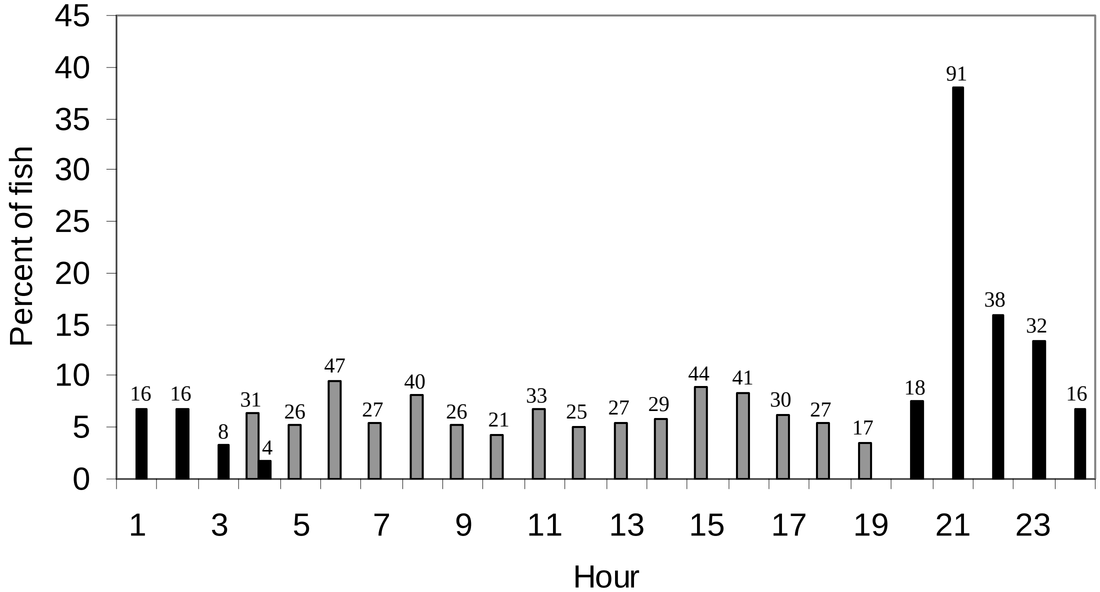
Appendix 10.—Median forebay residence time by hour of arrival versus mean discharge by dam area for yearling steelhead at Bonneville Dam, spring 2004. Scale of y-axis for second powerhouse graph differs from graphs for first powerhouse and spillway for visual clarity of residence time data.



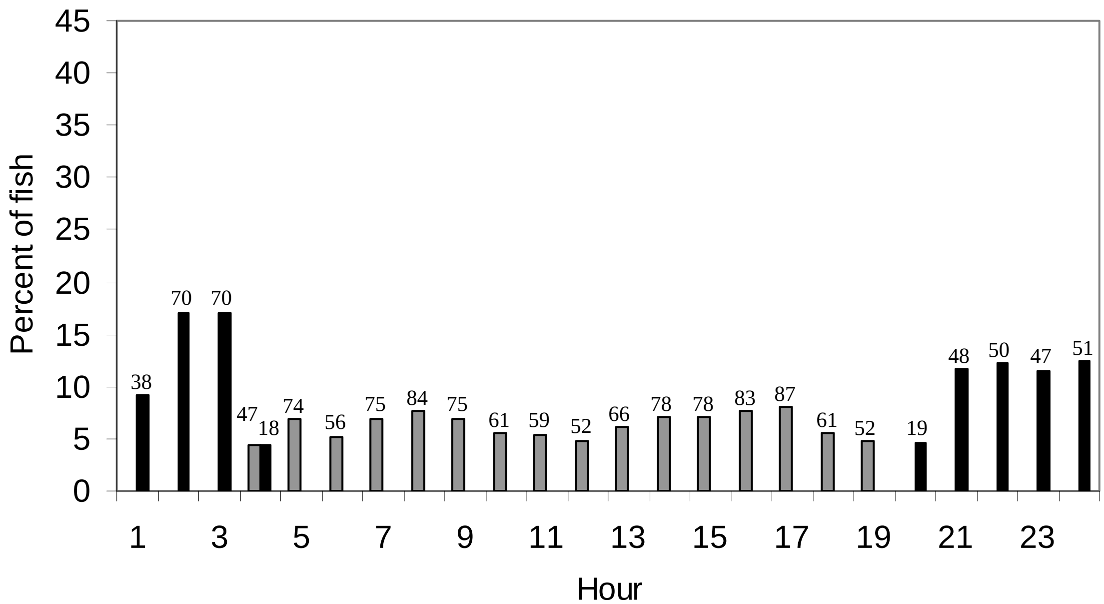
Appendix 11.—Hourly spillway passage of yearling Chinook salmon at Bonneville Dam during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



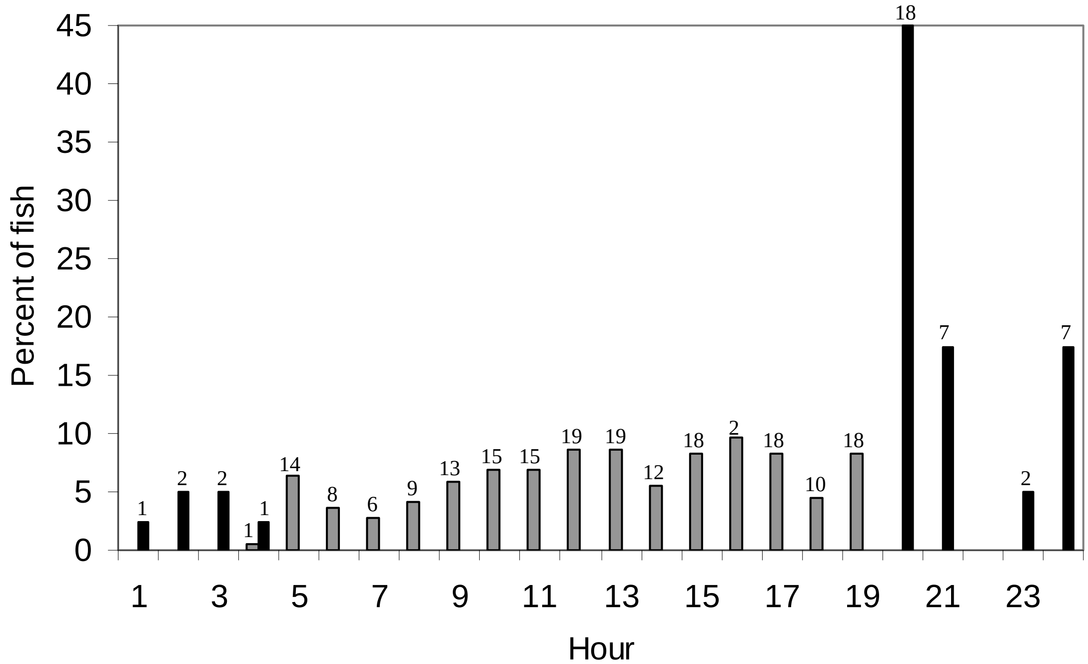
Appendix 12.—Hourly corner collector passage of yearling Chinook salmon at Bonneville Dam's second powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



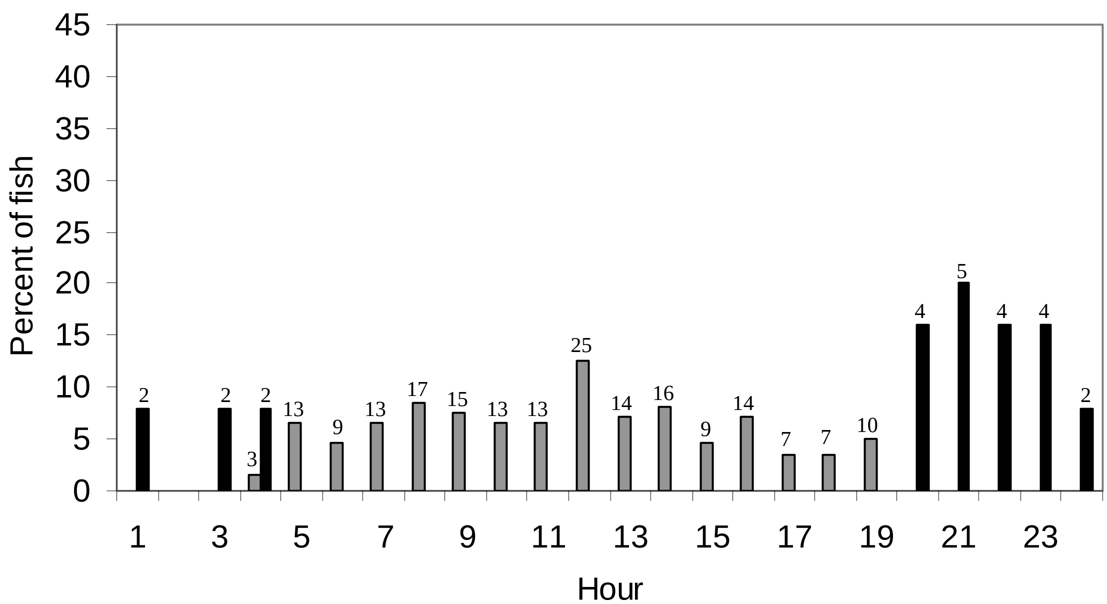
Appendix 13.—Hourly guided passage of yearling Chinook salmon at the Bonneville Dam's second powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



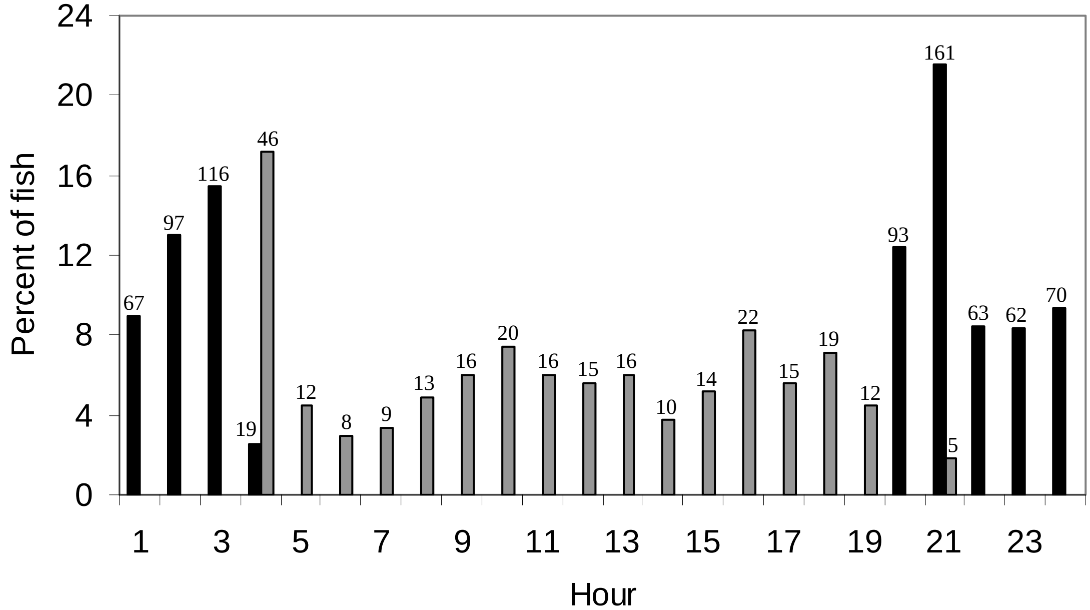
Appendix 14.—Hourly unguided passage of yearling Chinook salmon at the Bonneville Dam's second powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



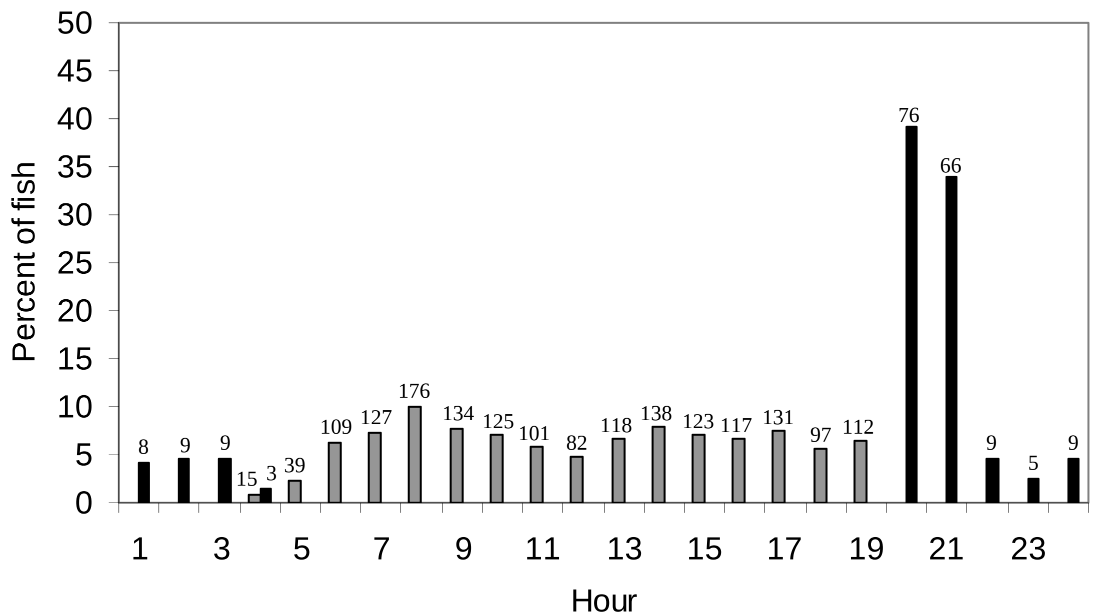
Appendix 15.—Hourly sluiceway passage of yearling Chinook salmon at Bonneville Dam's first powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



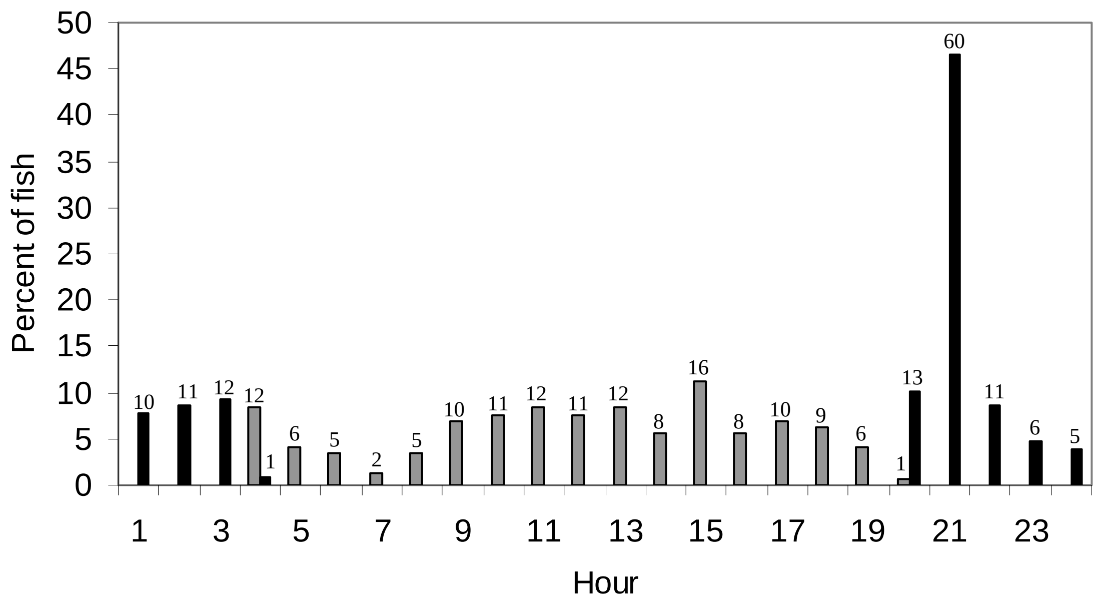
Appendix 16.—Hourly unguided passage of yearling Chinook salmon at Bonneville Dam's first powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



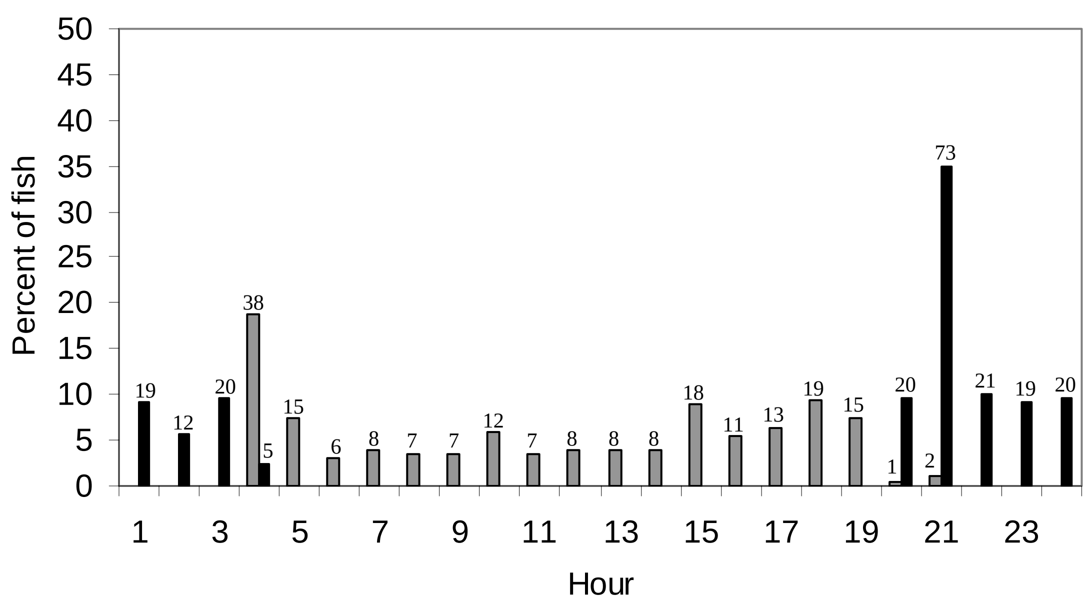
Appendix 17.—Hourly spillway passage of yearling steelhead during 59 kcfs spill (light bars) and TDG Cap spill (dark bars) at Bonneville Dam during spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



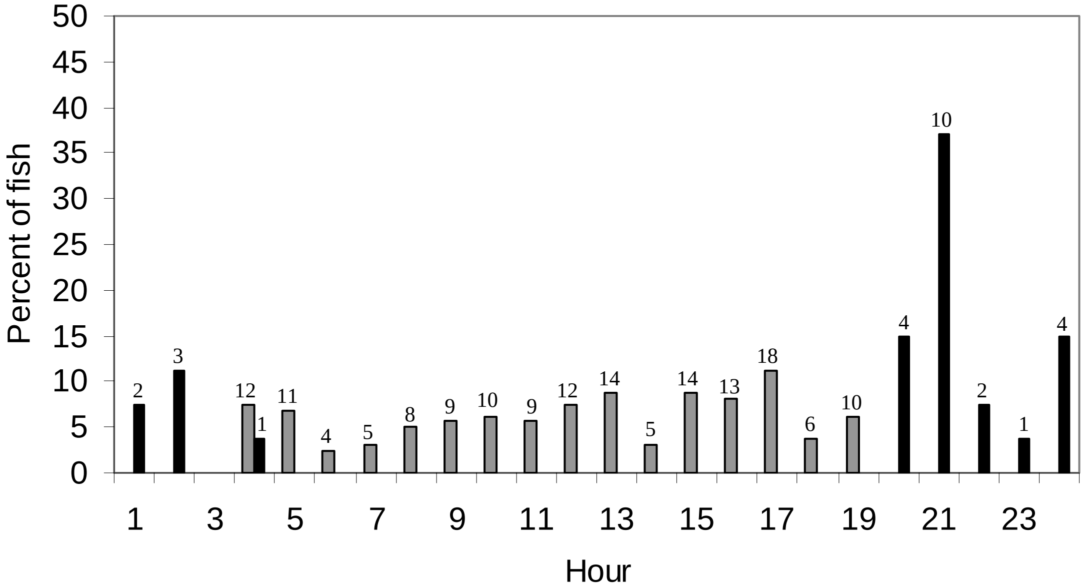
Appendix 18.—Hourly corner collector passage of yearling steelhead at Bonneville Dam's second powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



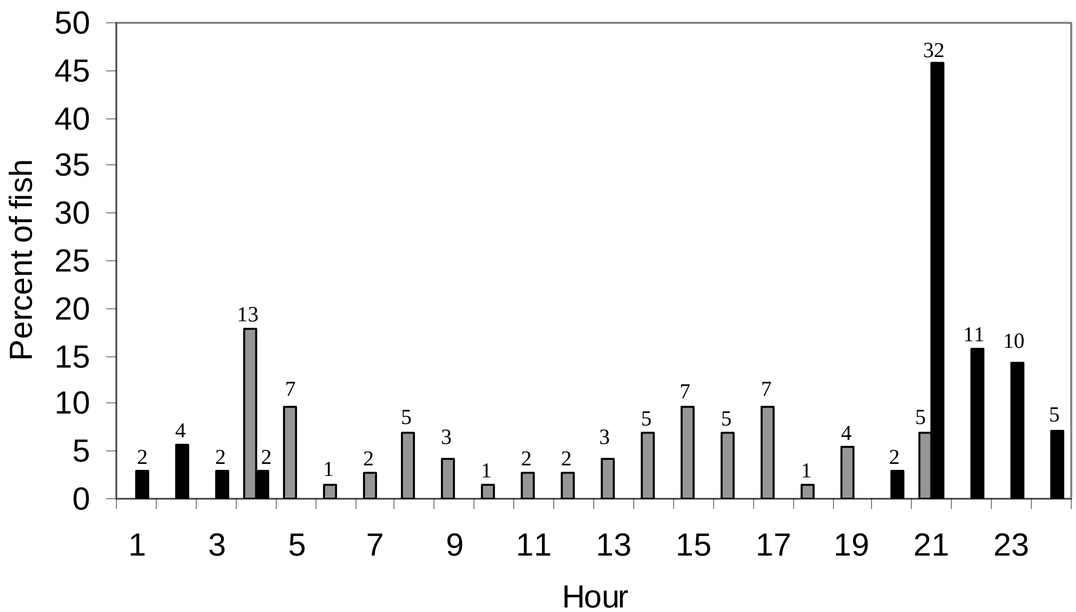
Appendix 19.—Hourly guided passage of yearling steelhead at Bonneville Dam’s second powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



Appendix 20.—Hourly unguided passage of yearling steelhead at Bonneville Dam’s second powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



Appendix 21.—Hourly sluiceway passage of yearling steelhead at Bonneville Dam's first powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.



Appendix 22.—Hourly unguided passage of yearling steelhead at Bonneville Dam's first powerhouse during 59 kcfs spill (light bars) and TDG Cap spill (dark bars), spring 2004. Percentages are based on the number of fish that passed during each spill condition. Numbers above the bars represent number of fish that passed during that hour.

Appendix 23.—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	DAY_CAP_59	SPILL	1	0
CH1	DAY_CAP_59	SPILL	2	0
CH1	DAY_CAP_59	SPILL	3	0
CH1	DAY_CAP_59	SPILL	4	26
CH1	DAY_CAP_59	SPILL	5	35
CH1	DAY_CAP_59	SPILL	6	79
CH1	DAY_CAP_59	SPILL	7	75
CH1	DAY_CAP_59	SPILL	8	66
CH1	DAY_CAP_59	SPILL	9	58
CH1	DAY_CAP_59	SPILL	10	68
CH1	DAY_CAP_59	SPILL	11	61
CH1	DAY_CAP_59	SPILL	12	66
CH1	DAY_CAP_59	SPILL	13	63
CH1	DAY_CAP_59	SPILL	14	72
CH1	DAY_CAP_59	SPILL	15	68
CH1	DAY_CAP_59	SPILL	16	69
CH1	DAY_CAP_59	SPILL	17	54
CH1	DAY_CAP_59	SPILL	18	53
CH1	DAY_CAP_59	SPILL	19	50
CH1	DAY_CAP_59	SPILL	20	0
CH1	DAY_CAP_59	SPILL	21	0
CH1	DAY_CAP_59	SPILL	22	0
CH1	DAY_CAP_59	SPILL	23	0
CH1	DAY_CAP_59	SPILL	24	0
CH1	TDG_NIGHT	SPILL	1	138
CH1	TDG_NIGHT	SPILL	2	148
CH1	TDG_NIGHT	SPILL	3	135
CH1	TDG_NIGHT	SPILL	4	52
CH1	TDG_NIGHT	SPILL	5	0
CH1	TDG_NIGHT	SPILL	6	0
CH1	TDG_NIGHT	SPILL	7	0
CH1	TDG_NIGHT	SPILL	8	0
CH1	TDG_NIGHT	SPILL	9	0
CH1	TDG_NIGHT	SPILL	10	0
CH1	TDG_NIGHT	SPILL	11	0
CH1	TDG_NIGHT	SPILL	12	0
CH1	TDG_NIGHT	SPILL	13	0
CH1	TDG_NIGHT	SPILL	14	0
CH1	TDG_NIGHT	SPILL	15	0
CH1	TDG_NIGHT	SPILL	16	0
CH1	TDG_NIGHT	SPILL	17	0
CH1	TDG_NIGHT	SPILL	18	0
CH1	TDG_NIGHT	SPILL	19	0
CH1	TDG_NIGHT	SPILL	20	123
CH1	TDG_NIGHT	SPILL	21	123

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	TDG_NIGHT	SPILL	22	92
CH1	TDG_NIGHT	SPILL	23	93
CH1	TDG_NIGHT	SPILL	24	98
CH1	DAY_CAP_59	B2B2CC	1	0
CH1	DAY_CAP_59	B2B2CC	2	0
CH1	DAY_CAP_59	B2B2CC	3	0
CH1	DAY_CAP_59	B2B2CC	4	14
CH1	DAY_CAP_59	B2B2CC	5	113
CH1	DAY_CAP_59	B2B2CC	6	95
CH1	DAY_CAP_59	B2B2CC	7	59
CH1	DAY_CAP_59	B2B2CC	8	69
CH1	DAY_CAP_59	B2B2CC	9	70
CH1	DAY_CAP_59	B2B2CC	10	52
CH1	DAY_CAP_59	B2B2CC	11	54
CH1	DAY_CAP_59	B2B2CC	12	56
CH1	DAY_CAP_59	B2B2CC	13	64
CH1	DAY_CAP_59	B2B2CC	14	76
CH1	DAY_CAP_59	B2B2CC	15	68
CH1	DAY_CAP_59	B2B2CC	16	66
CH1	DAY_CAP_59	B2B2CC	17	64
CH1	DAY_CAP_59	B2B2CC	18	80
CH1	DAY_CAP_59	B2B2CC	19	61
CH1	DAY_CAP_59	B2B2CC	20	0
CH1	DAY_CAP_59	B2B2CC	21	0
CH1	DAY_CAP_59	B2B2CC	22	0
CH1	DAY_CAP_59	B2B2CC	23	0
CH1	DAY_CAP_59	B2B2CC	24	0
CH1	DAY_CAP_59	B2B2DSM	1	0
CH1	DAY_CAP_59	B2B2DSM	2	0
CH1	DAY_CAP_59	B2B2DSM	3	0
CH1	DAY_CAP_59	B2B2DSM	4	31
CH1	DAY_CAP_59	B2B2DSM	5	26
CH1	DAY_CAP_59	B2B2DSM	6	47
CH1	DAY_CAP_59	B2B2DSM	7	27
CH1	DAY_CAP_59	B2B2DSM	8	40
CH1	DAY_CAP_59	B2B2DSM	9	26
CH1	DAY_CAP_59	B2B2DSM	10	21
CH1	DAY_CAP_59	B2B2DSM	11	33
CH1	DAY_CAP_59	B2B2DSM	12	25
CH1	DAY_CAP_59	B2B2DSM	13	27
CH1	DAY_CAP_59	B2B2DSM	14	29
CH1	DAY_CAP_59	B2B2DSM	15	44
CH1	DAY_CAP_59	B2B2DSM	16	41
CH1	DAY_CAP_59	B2B2DSM	17	30
CH1	DAY_CAP_59	B2B2DSM	18	27

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	DAY_CAP_59	B2B2DSM	19	17
CH1	DAY_CAP_59	B2B2DSM	20	0
CH1	DAY_CAP_59	B2B2DSM	21	0
CH1	DAY_CAP_59	B2B2DSM	22	0
CH1	DAY_CAP_59	B2B2DSM	23	0
CH1	DAY_CAP_59	B2B2DSM	24	0
CH1	DAY_CAP_59	B2TUR	1	0
CH1	DAY_CAP_59	B2TUR	2	0
CH1	DAY_CAP_59	B2TUR	3	0
CH1	DAY_CAP_59	B2TUR	4	47
CH1	DAY_CAP_59	B2TUR	5	74
CH1	DAY_CAP_59	B2TUR	6	56
CH1	DAY_CAP_59	B2TUR	7	75
CH1	DAY_CAP_59	B2TUR	8	84
CH1	DAY_CAP_59	B2TUR	9	75
CH1	DAY_CAP_59	B2TUR	10	61
CH1	DAY_CAP_59	B2TUR	11	59
CH1	DAY_CAP_59	B2TUR	12	52
CH1	DAY_CAP_59	B2TUR	13	66
CH1	DAY_CAP_59	B2TUR	14	78
CH1	DAY_CAP_59	B2TUR	15	78
CH1	DAY_CAP_59	B2TUR	16	83
CH1	DAY_CAP_59	B2TUR	17	87
CH1	DAY_CAP_59	B2TUR	18	61
CH1	DAY_CAP_59	B2TUR	19	52
CH1	DAY_CAP_59	B2TUR	20	0
CH1	DAY_CAP_59	B2TUR	21	0
CH1	DAY_CAP_59	B2TUR	22	0
CH1	DAY_CAP_59	B2TUR	23	0
CH1	DAY_CAP_59	B2TUR	24	0
CH1	TDG_NIGHT	B2B2CC	1	23
CH1	TDG_NIGHT	B2B2CC	2	11
CH1	TDG_NIGHT	B2B2CC	3	12
CH1	TDG_NIGHT	B2B2CC	4	7
CH1	TDG_NIGHT	B2B2CC	5	0
CH1	TDG_NIGHT	B2B2CC	6	0
CH1	TDG_NIGHT	B2B2CC	7	0
CH1	TDG_NIGHT	B2B2CC	8	0
CH1	TDG_NIGHT	B2B2CC	9	0
CH1	TDG_NIGHT	B2B2CC	10	0
CH1	TDG_NIGHT	B2B2CC	11	0
CH1	TDG_NIGHT	B2B2CC	12	0
CH1	TDG_NIGHT	B2B2CC	13	0
CH1	TDG_NIGHT	B2B2CC	14	0
CH1	TDG_NIGHT	B2B2CC	15	0
CH1	TDG_NIGHT	B2B2CC	16	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	TDG_NIGHT	B2B2CC	17	0
CH1	TDG_NIGHT	B2B2CC	18	0
CH1	TDG_NIGHT	B2B2CC	19	0
CH1	TDG_NIGHT	B2B2CC	20	89
CH1	TDG_NIGHT	B2B2CC	21	39
CH1	TDG_NIGHT	B2B2CC	22	12
CH1	TDG_NIGHT	B2B2CC	23	16
CH1	TDG_NIGHT	B2B2CC	24	13
CH1	TDG_NIGHT	B2B2DSM	1	16
CH1	TDG_NIGHT	B2B2DSM	2	16
CH1	TDG_NIGHT	B2B2DSM	3	8
CH1	TDG_NIGHT	B2B2DSM	4	4
CH1	TDG_NIGHT	B2B2DSM	5	0
CH1	TDG_NIGHT	B2B2DSM	6	0
CH1	TDG_NIGHT	B2B2DSM	7	0
CH1	TDG_NIGHT	B2B2DSM	8	0
CH1	TDG_NIGHT	B2B2DSM	9	0
CH1	TDG_NIGHT	B2B2DSM	10	0
CH1	TDG_NIGHT	B2B2DSM	11	0
CH1	TDG_NIGHT	B2B2DSM	12	0
CH1	TDG_NIGHT	B2B2DSM	13	0
CH1	TDG_NIGHT	B2B2DSM	14	0
CH1	TDG_NIGHT	B2B2DSM	15	0
CH1	TDG_NIGHT	B2B2DSM	16	0
CH1	TDG_NIGHT	B2B2DSM	17	0
CH1	TDG_NIGHT	B2B2DSM	18	0
CH1	TDG_NIGHT	B2B2DSM	19	0
CH1	TDG_NIGHT	B2B2DSM	20	18
CH1	TDG_NIGHT	B2B2DSM	21	91
CH1	TDG_NIGHT	B2B2DSM	22	38
CH1	TDG_NIGHT	B2B2DSM	23	32
CH1	TDG_NIGHT	B2B2DSM	24	16
CH1	TDG_NIGHT	B2TUR	1	38
CH1	TDG_NIGHT	B2TUR	2	70
CH1	TDG_NIGHT	B2TUR	3	70
CH1	TDG_NIGHT	B2TUR	4	18
CH1	TDG_NIGHT	B2TUR	5	0
CH1	TDG_NIGHT	B2TUR	6	0
CH1	TDG_NIGHT	B2TUR	7	0
CH1	TDG_NIGHT	B2TUR	8	0
CH1	TDG_NIGHT	B2TUR	9	0
CH1	TDG_NIGHT	B2TUR	10	0
CH1	TDG_NIGHT	B2TUR	11	0
CH1	TDG_NIGHT	B2TUR	12	0
CH1	TDG_NIGHT	B2TUR	13	0
CH1	TDG_NIGHT	B2TUR	14	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	TDG_NIGHT	B2TUR	15	0
CH1	TDG_NIGHT	B2TUR	16	0
CH1	TDG_NIGHT	B2TUR	17	0
CH1	TDG_NIGHT	B2TUR	18	0
CH1	TDG_NIGHT	B2TUR	19	0
CH1	TDG_NIGHT	B2TUR	20	19
CH1	TDG_NIGHT	B2TUR	21	48
CH1	TDG_NIGHT	B2TUR	22	50
CH1	TDG_NIGHT	B2TUR	23	47
CH1	TDG_NIGHT	B2TUR	24	51
CH1	TDG_NIGHT	B2UPS	24	1
CH1	DAY_CAP_59	B1NAV	9	1
CH1	DAY_CAP_59	B1NAV	12	1
CH1	DAY_CAP_59	B1NAV	18	1
CH1	DAY_CAP_59	B1SLU	1	0
CH1	DAY_CAP_59	B1SLU	2	0
CH1	DAY_CAP_59	B1SLU	3	0
CH1	DAY_CAP_59	B1SLU	4	1
CH1	DAY_CAP_59	B1SLU	5	14
CH1	DAY_CAP_59	B1SLU	6	8
CH1	DAY_CAP_59	B1SLU	7	6
CH1	DAY_CAP_59	B1SLU	8	9
CH1	DAY_CAP_59	B1SLU	9	13
CH1	DAY_CAP_59	B1SLU	10	15
CH1	DAY_CAP_59	B1SLU	11	15
CH1	DAY_CAP_59	B1SLU	12	19
CH1	DAY_CAP_59	B1SLU	13	19
CH1	DAY_CAP_59	B1SLU	14	12
CH1	DAY_CAP_59	B1SLU	15	18
CH1	DAY_CAP_59	B1SLU	16	21
CH1	DAY_CAP_59	B1SLU	17	18
CH1	DAY_CAP_59	B1SLU	18	10
CH1	DAY_CAP_59	B1SLU	19	18
CH1	DAY_CAP_59	B1SLU	20	0
CH1	DAY_CAP_59	B1SLU	21	0
CH1	DAY_CAP_59	B1SLU	22	0
CH1	DAY_CAP_59	B1SLU	23	0
CH1	DAY_CAP_59	B1SLU	24	0
CH1	DAY_CAP_59	B1TUR	1	0
CH1	DAY_CAP_59	B1TUR	2	0
CH1	DAY_CAP_59	B1TUR	3	0
CH1	DAY_CAP_59	B1TUR	4	3
CH1	DAY_CAP_59	B1TUR	5	13
CH1	DAY_CAP_59	B1TUR	6	9
CH1	DAY_CAP_59	B1TUR	7	13
CH1	DAY_CAP_59	B1TUR	8	17

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	DAY_CAP_59	B1TUR	9	15
CH1	DAY_CAP_59	B1TUR	10	13
CH1	DAY_CAP_59	B1TUR	11	13
CH1	DAY_CAP_59	B1TUR	12	25
CH1	DAY_CAP_59	B1TUR	13	14
CH1	DAY_CAP_59	B1TUR	14	16
CH1	DAY_CAP_59	B1TUR	15	9
CH1	DAY_CAP_59	B1TUR	16	14
CH1	DAY_CAP_59	B1TUR	17	7
CH1	DAY_CAP_59	B1TUR	18	7
CH1	DAY_CAP_59	B1TUR	19	10
CH1	DAY_CAP_59	B1TUR	20	0
CH1	DAY_CAP_59	B1TUR	21	0
CH1	DAY_CAP_59	B1TUR	22	0
CH1	DAY_CAP_59	B1TUR	23	0
CH1	DAY_CAP_59	B1TUR	24	0
CH1	TDG_NIGHT	NAV	3	1
CH1	TDG_NIGHT	B1SLU	1	1
CH1	TDG_NIGHT	B1SLU	2	2
CH1	TDG_NIGHT	B1SLU	3	2
CH1	TDG_NIGHT	B1SLU	4	1
CH1	TDG_NIGHT	B1SLU	5	0
CH1	TDG_NIGHT	B1SLU	6	0
CH1	TDG_NIGHT	B1SLU	7	0
CH1	TDG_NIGHT	B1SLU	8	0
CH1	TDG_NIGHT	B1SLU	9	0
CH1	TDG_NIGHT	B1SLU	10	0
CH1	TDG_NIGHT	B1SLU	11	0
CH1	TDG_NIGHT	B1SLU	12	0
CH1	TDG_NIGHT	B1SLU	13	0
CH1	TDG_NIGHT	B1SLU	14	0
CH1	TDG_NIGHT	B1SLU	15	0
CH1	TDG_NIGHT	B1SLU	16	0
CH1	TDG_NIGHT	B1SLU	17	0
CH1	TDG_NIGHT	B1SLU	18	0
CH1	TDG_NIGHT	B1SLU	19	0
CH1	TDG_NIGHT	B1SLU	20	18
CH1	TDG_NIGHT	B1SLU	21	7
CH1	TDG_NIGHT	B1SLU	22	0
CH1	TDG_NIGHT	B1SLU	23	2
CH1	TDG_NIGHT	B1SLU	24	7
CH1	TDG_NIGHT	B1TUR	1	2
CH1	TDG_NIGHT	B1TUR	2	0
CH1	TDG_NIGHT	B1TUR	3	2
CH1	TDG_NIGHT	B1TUR	4	2
CH1	TDG_NIGHT	B1TUR	5	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
CH1	TDG_NIGHT	B1TUR	6	0
CH1	TDG_NIGHT	B1TUR	7	0
CH1	TDG_NIGHT	B1TUR	8	0
CH1	TDG_NIGHT	B1TUR	9	0
CH1	TDG_NIGHT	B1TUR	10	0
CH1	TDG_NIGHT	B1TUR	11	0
CH1	TDG_NIGHT	B1TUR	12	0
CH1	TDG_NIGHT	B1TUR	13	0
CH1	TDG_NIGHT	B1TUR	14	0
CH1	TDG_NIGHT	B1TUR	15	0
CH1	TDG_NIGHT	B1TUR	16	0
CH1	TDG_NIGHT	B1TUR	17	0
CH1	TDG_NIGHT	B1TUR	18	0
CH1	TDG_NIGHT	B1TUR	19	0
CH1	TDG_NIGHT	B1TUR	20	4
CH1	TDG_NIGHT	B1TUR	21	5
CH1	TDG_NIGHT	B1TUR	22	4
CH1	TDG_NIGHT	B1TUR	23	4
CH1	TDG_NIGHT	B1TUR	24	2
STH	DAY_CAP_59	SPILL	1	0
STH	DAY_CAP_59	SPILL	2	0
STH	DAY_CAP_59	SPILL	3	0
STH	DAY_CAP_59	SPILL	4	46
STH	DAY_CAP_59	SPILL	5	12
STH	DAY_CAP_59	SPILL	6	8
STH	DAY_CAP_59	SPILL	7	9
STH	DAY_CAP_59	SPILL	8	13
STH	DAY_CAP_59	SPILL	9	16
STH	DAY_CAP_59	SPILL	10	20
STH	DAY_CAP_59	SPILL	11	16
STH	DAY_CAP_59	SPILL	12	15
STH	DAY_CAP_59	SPILL	13	16
STH	DAY_CAP_59	SPILL	14	10
STH	DAY_CAP_59	SPILL	15	14
STH	DAY_CAP_59	SPILL	16	22
STH	DAY_CAP_59	SPILL	17	15
STH	DAY_CAP_59	SPILL	18	19
STH	DAY_CAP_59	SPILL	19	12
STH	DAY_CAP_59	SPILL	20	0
STH	DAY_CAP_59	SPILL	21	5
STH	DAY_CAP_59	SPILL	22	0
STH	DAY_CAP_59	SPILL	23	0
STH	DAY_CAP_59	SPILL	24	0
STH	TDG_NIGHT	SPILL	1	67
STH	TDG_NIGHT	SPILL	2	97
STH	TDG_NIGHT	SPILL	3	116

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
STH	TDG_NIGHT	SPILL	4	19
STH	TDG_NIGHT	SPILL	5	0
STH	TDG_NIGHT	SPILL	6	0
STH	TDG_NIGHT	SPILL	7	0
STH	TDG_NIGHT	SPILL	8	0
STH	TDG_NIGHT	SPILL	9	0
STH	TDG_NIGHT	SPILL	10	0
STH	TDG_NIGHT	SPILL	11	0
STH	TDG_NIGHT	SPILL	12	0
STH	TDG_NIGHT	SPILL	13	0
STH	TDG_NIGHT	SPILL	14	0
STH	TDG_NIGHT	SPILL	15	0
STH	TDG_NIGHT	SPILL	16	0
STH	TDG_NIGHT	SPILL	17	0
STH	TDG_NIGHT	SPILL	18	0
STH	TDG_NIGHT	SPILL	19	0
STH	TDG_NIGHT	SPILL	20	93
STH	TDG_NIGHT	SPILL	21	161
STH	TDG_NIGHT	SPILL	22	63
STH	TDG_NIGHT	SPILL	23	62
STH	TDG_NIGHT	SPILL	24	70
STH	DAY_CAP_59	B2CC	1	0
STH	DAY_CAP_59	B2CC	2	0
STH	DAY_CAP_59	B2CC	3	0
STH	DAY_CAP_59	B2CC	4	15
STH	DAY_CAP_59	B2CC	5	39
STH	DAY_CAP_59	B2CC	6	109
STH	DAY_CAP_59	B2CC	7	127
STH	DAY_CAP_59	B2CC	8	176
STH	DAY_CAP_59	B2CC	9	134
STH	DAY_CAP_59	B2CC	10	125
STH	DAY_CAP_59	B2CC	11	101
STH	DAY_CAP_59	B2CC	12	82
STH	DAY_CAP_59	B2CC	13	118
STH	DAY_CAP_59	B2CC	14	138
STH	DAY_CAP_59	B2CC	15	123
STH	DAY_CAP_59	B2CC	16	117
STH	DAY_CAP_59	B2CC	17	131
STH	DAY_CAP_59	B2CC	18	97
STH	DAY_CAP_59	B2CC	19	112
STH	DAY_CAP_59	B2CC	20	0
STH	DAY_CAP_59	B2CC	21	1
STH	DAY_CAP_59	B2CC	22	0
STH	DAY_CAP_59	B2CC	23	0
STH	DAY_CAP_59	B2CC	24	0
STH	DAY_CAP_59	B2DSM	1	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
STH	DAY_CAP_59	B2DSM	2	0
STH	DAY_CAP_59	B2DSM	3	0
STH	DAY_CAP_59	B2DSM	4	12
STH	DAY_CAP_59	B2DSM	5	6
STH	DAY_CAP_59	B2DSM	6	5
STH	DAY_CAP_59	B2DSM	7	2
STH	DAY_CAP_59	B2DSM	8	5
STH	DAY_CAP_59	B2DSM	9	10
STH	DAY_CAP_59	B2DSM	10	11
STH	DAY_CAP_59	B2DSM	11	12
STH	DAY_CAP_59	B2DSM	12	11
STH	DAY_CAP_59	B2DSM	13	12
STH	DAY_CAP_59	B2DSM	14	8
STH	DAY_CAP_59	B2DSM	15	16
STH	DAY_CAP_59	B2DSM	16	8
STH	DAY_CAP_59	B2DSM	17	10
STH	DAY_CAP_59	B2DSM	18	9
STH	DAY_CAP_59	B2DSM	19	6
STH	DAY_CAP_59	B2DSM	20	1
STH	DAY_CAP_59	B2DSM	21	0
STH	DAY_CAP_59	B2DSM	22	0
STH	DAY_CAP_59	B2DSM	23	0
STH	DAY_CAP_59	B2DSM	24	0
STH	DAY_CAP_59	B2TUR	1	0
STH	DAY_CAP_59	B2TUR	2	0
STH	DAY_CAP_59	B2TUR	3	0
STH	DAY_CAP_59	B2TUR	4	38
STH	DAY_CAP_59	B2TUR	5	15
STH	DAY_CAP_59	B2TUR	6	6
STH	DAY_CAP_59	B2TUR	7	8
STH	DAY_CAP_59	B2TUR	8	7
STH	DAY_CAP_59	B2TUR	9	7
STH	DAY_CAP_59	B2TUR	10	12
STH	DAY_CAP_59	B2TUR	11	7
STH	DAY_CAP_59	B2TUR	12	8
STH	DAY_CAP_59	B2TUR	13	8
STH	DAY_CAP_59	B2TUR	14	8
STH	DAY_CAP_59	B2TUR	15	18
STH	DAY_CAP_59	B2TUR	16	11
STH	DAY_CAP_59	B2TUR	17	13
STH	DAY_CAP_59	B2TUR	18	19
STH	DAY_CAP_59	B2TUR	19	15
STH	DAY_CAP_59	B2TUR	20	1
STH	DAY_CAP_59	B2TUR	21	2
STH	DAY_CAP_59	B2TUR	22	0
STH	DAY_CAP_59	B2TUR	23	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
STH	DAY_CAP_59	B2TUR	24	0
STH	DAY_CAP_59	B2UPS	8	1
STH	DAY_CAP_59	B2UPS	9	1
STH	DAY_CAP_59	B2UPS	12	1
STH	DAY_CAP_59	B2UPS	15	1
STH	DAY_CAP_59	B2UPS	16	1
STH	DAY_CAP_59	B2UPS	17	1
STH	TDG_NIGHT	B2CC	1	8
STH	TDG_NIGHT	B2CC	2	9
STH	TDG_NIGHT	B2CC	3	9
STH	TDG_NIGHT	B2CC	4	3
STH	TDG_NIGHT	B2CC	5	0
STH	TDG_NIGHT	B2CC	6	0
STH	TDG_NIGHT	B2CC	7	0
STH	TDG_NIGHT	B2CC	8	0
STH	TDG_NIGHT	B2CC	9	0
STH	TDG_NIGHT	B2CC	10	0
STH	TDG_NIGHT	B2CC	11	0
STH	TDG_NIGHT	B2CC	12	0
STH	TDG_NIGHT	B2CC	13	0
STH	TDG_NIGHT	B2CC	14	0
STH	TDG_NIGHT	B2CC	15	0
STH	TDG_NIGHT	B2CC	16	0
STH	TDG_NIGHT	B2CC	17	0
STH	TDG_NIGHT	B2CC	18	0
STH	TDG_NIGHT	B2CC	19	0
STH	TDG_NIGHT	B2CC	20	76
STH	TDG_NIGHT	B2CC	21	66
STH	TDG_NIGHT	B2CC	22	9
STH	TDG_NIGHT	B2CC	23	5
STH	TDG_NIGHT	B2CC	24	9
STH	TDG_NIGHT	B2DSM	1	10
STH	TDG_NIGHT	B2DSM	2	11
STH	TDG_NIGHT	B2DSM	3	12
STH	TDG_NIGHT	B2DSM	4	1
STH	TDG_NIGHT	B2DSM	5	0
STH	TDG_NIGHT	B2DSM	6	0
STH	TDG_NIGHT	B2DSM	7	0
STH	TDG_NIGHT	B2DSM	8	0
STH	TDG_NIGHT	B2DSM	9	0
STH	TDG_NIGHT	B2DSM	10	0
STH	TDG_NIGHT	B2DSM	11	0
STH	TDG_NIGHT	B2DSM	12	0
STH	TDG_NIGHT	B2DSM	13	0
STH	TDG_NIGHT	B2DSM	14	0
STH	TDG_NIGHT	B2DSM	15	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
STH	TDG_NIGHT	B2DSM	16	0
STH	TDG_NIGHT	B2DSM	17	0
STH	TDG_NIGHT	B2DSM	18	0
STH	TDG_NIGHT	B2DSM	19	0
STH	TDG_NIGHT	B2DSM	20	13
STH	TDG_NIGHT	B2DSM	21	60
STH	TDG_NIGHT	B2DSM	22	11
STH	TDG_NIGHT	B2DSM	23	6
STH	TDG_NIGHT	B2DSM	24	5
STH	TDG_NIGHT	B2EAT	1	1
STH	TDG_NIGHT	B2TUR	1	19
STH	TDG_NIGHT	B2TUR	2	12
STH	TDG_NIGHT	B2TUR	3	20
STH	TDG_NIGHT	B2TUR	4	5
STH	TDG_NIGHT	B2TUR	5	0
STH	TDG_NIGHT	B2TUR	6	0
STH	TDG_NIGHT	B2TUR	7	0
STH	TDG_NIGHT	B2TUR	8	0
STH	TDG_NIGHT	B2TUR	9	0
STH	TDG_NIGHT	B2TUR	10	0
STH	TDG_NIGHT	B2TUR	11	0
STH	TDG_NIGHT	B2TUR	12	0
STH	TDG_NIGHT	B2TUR	13	0
STH	TDG_NIGHT	B2TUR	14	0
STH	TDG_NIGHT	B2TUR	15	0
STH	TDG_NIGHT	B2TUR	16	0
STH	TDG_NIGHT	B2TUR	17	0
STH	TDG_NIGHT	B2TUR	18	0
STH	TDG_NIGHT	B2TUR	19	0
STH	TDG_NIGHT	B2TUR	20	20
STH	TDG_NIGHT	B2TUR	21	73
STH	TDG_NIGHT	B2TUR	22	21
STH	TDG_NIGHT	B2TUR	23	19
STH	TDG_NIGHT	B2TUR	24	20
STH	DAY_CAP_59	B1NAV	7	1
STH	DAY_CAP_59	B1NAV	11	1
STH	DAY_CAP_59	B1NAV	13	1
STH	DAY_CAP_59	B1NAV	15	7
STH	DAY_CAP_59	B1NAV	17	1
STH	DAY_CAP_59	B1SLU	1	0
STH	DAY_CAP_59	B1SLU	2	0
STH	DAY_CAP_59	B1SLU	3	0
STH	DAY_CAP_59	B1SLU	4	12
STH	DAY_CAP_59	B1SLU	5	11
STH	DAY_CAP_59	B1SLU	6	4
STH	DAY_CAP_59	B1SLU	7	5

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
STH	DAY_CAP_59	B1SLU	8	8
STH	DAY_CAP_59	B1SLU	9	9
STH	DAY_CAP_59	B1SLU	10	10
STH	DAY_CAP_59	B1SLU	11	9
STH	DAY_CAP_59	B1SLU	12	12
STH	DAY_CAP_59	B1SLU	13	14
STH	DAY_CAP_59	B1SLU	14	5
STH	DAY_CAP_59	B1SLU	15	14
STH	DAY_CAP_59	B1SLU	16	13
STH	DAY_CAP_59	B1SLU	17	18
STH	DAY_CAP_59	B1SLU	18	6
STH	DAY_CAP_59	B1SLU	19	10
STH	DAY_CAP_59	B1SLU	20	0
STH	DAY_CAP_59	B1SLU	21	0
STH	DAY_CAP_59	B1SLU	22	0
STH	DAY_CAP_59	B1SLU	23	0
STH	DAY_CAP_59	B1SLU	24	0
STH	DAY_CAP_59	B1TUR	1	0
STH	DAY_CAP_59	B1TUR	2	0
STH	DAY_CAP_59	B1TUR	3	0
STH	DAY_CAP_59	B1TUR	4	13
STH	DAY_CAP_59	B1TUR	5	7
STH	DAY_CAP_59	B1TUR	6	1
STH	DAY_CAP_59	B1TUR	7	2
STH	DAY_CAP_59	B1TUR	8	5
STH	DAY_CAP_59	B1TUR	9	3
STH	DAY_CAP_59	B1TUR	10	1
STH	DAY_CAP_59	B1TUR	11	2
STH	DAY_CAP_59	B1TUR	12	2
STH	DAY_CAP_59	B1TUR	13	3
STH	DAY_CAP_59	B1TUR	14	5
STH	DAY_CAP_59	B1TUR	15	7
STH	DAY_CAP_59	B1TUR	16	5
STH	DAY_CAP_59	B1TUR	17	7
STH	DAY_CAP_59	B1TUR	18	1
STH	DAY_CAP_59	B1TUR	19	4
STH	DAY_CAP_59	B1TUR	20	0
STH	DAY_CAP_59	B1TUR	21	5
STH	DAY_CAP_59	B1TUR	22	0
STH	DAY_CAP_59	B1TUR	23	0
STH	DAY_CAP_59	B1TUR	24	0
STH	TDG_NIGHT	B1SLU	1	2
STH	TDG_NIGHT	B1SLU	2	3
STH	TDG_NIGHT	B1SLU	3	0
STH	TDG_NIGHT	B1SLU	4	1
STH	TDG_NIGHT	B1SLU	5	0

Appendix 23 (continued).—Numbers of yearling Chinook salmon (CH1) and yearling steelhead (STH) that passed Bonneville Dam by spill condition, passage route, and hour of passage during spring, 2004.

Species	Spill Condition	Passage Route	Hour of Passage	Number Passed
STH	TDG_NIGHT	B1SLU	6	0
STH	TDG_NIGHT	B1SLU	7	0
STH	TDG_NIGHT	B1SLU	8	0
STH	TDG_NIGHT	B1SLU	9	0
STH	TDG_NIGHT	B1SLU	10	0
STH	TDG_NIGHT	B1SLU	11	0
STH	TDG_NIGHT	B1SLU	12	0
STH	TDG_NIGHT	B1SLU	13	0
STH	TDG_NIGHT	B1SLU	14	0
STH	TDG_NIGHT	B1SLU	15	0
STH	TDG_NIGHT	B1SLU	16	0
STH	TDG_NIGHT	B1SLU	17	0
STH	TDG_NIGHT	B1SLU	18	0
STH	TDG_NIGHT	B1SLU	19	0
STH	TDG_NIGHT	B1SLU	20	4
STH	TDG_NIGHT	B1SLU	21	10
STH	TDG_NIGHT	B1SLU	22	2
STH	TDG_NIGHT	B1SLU	23	1
STH	TDG_NIGHT	B1SLU	24	4
STH	TDG_NIGHT	B1TUR	1	2
STH	TDG_NIGHT	B1TUR	2	4
STH	TDG_NIGHT	B1TUR	3	2
STH	TDG_NIGHT	B1TUR	4	2
STH	TDG_NIGHT	B1TUR	5	0
STH	TDG_NIGHT	B1TUR	6	0
STH	TDG_NIGHT	B1TUR	7	0
STH	TDG_NIGHT	B1TUR	8	0
STH	TDG_NIGHT	B1TUR	9	0
STH	TDG_NIGHT	B1TUR	10	0
STH	TDG_NIGHT	B1TUR	11	0
STH	TDG_NIGHT	B1TUR	12	0
STH	TDG_NIGHT	B1TUR	13	0
STH	TDG_NIGHT	B1TUR	14	0
STH	TDG_NIGHT	B1TUR	15	0
STH	TDG_NIGHT	B1TUR	16	0
STH	TDG_NIGHT	B1TUR	17	0
STH	TDG_NIGHT	B1TUR	18	0
STH	TDG_NIGHT	B1TUR	19	0
STH	TDG_NIGHT	B1TUR	20	2
STH	TDG_NIGHT	B1TUR	21	32
STH	TDG_NIGHT	B1TUR	22	11
STH	TDG_NIGHT	B1TUR	23	10
STH	TDG_NIGHT	B1TUR	24	5