RELATIVE SURVIVAL OF JUVENILE SALMON PASSING THROUGH THE SPILLWAY AND THE ICE AND TRASH SLUICEWAY OF THE DALLES DAM, 1998

by

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Report of Research

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EXECUTIVE SUMMARY

High rates of spill are presumed to increase passage survival for juvenile salmonid migrants, because passage survival through spillways at Columbia and Snake River dams is generally higher than through turbines. However, there are two conditions at The Dalles Dam that may decrease spill-passage survival under high spill rates: 1) a short stilling basin combined with a shallow tailrace, which results in severe turbulence and lateral currents that may cause physical injury to migrant salmon; and 2) a large proportion of water passed through the spillway moves through shallows and islands downstream, and thus may substantially increase predation on salmonids by gulls (*Larus* spp.) and northern pikeminnow (*Ptychocheilus oregonensis*).

In 1997, the National Marine Fisheries Service initiated a study at The Dalles Dam to evaluate survival of juvenile Pacific salmon (*Oncorhynchus* spp.) passed through the spillway when 64% of the river flow was spilled. Results of 1997 tests suggested mortality rates of about 13% for coho salmon (*O. kisutch*) and 8% for subyearling chinook salmon (*O. tshawytscha*) passing at 64% spill. In 1998, we expanded the research to include assessment of passage survival through the spillway at high spill (64% of river flow) and moderate spill (30% of river flow) and through the ice and trash sluiceway during daytime periods at moderate spill (30% of river flow).

Test fish were collected from the juvenile bypass system at the Bonneville Dam Second Powerhouse, tagged with passive integrated transponder (PIT) tags, and transported to The Dalles Dam for release. Approximately 64,000 yearling coho salmon were tagged in April and May, and 80,000 subyearling chinook salmon were tagged in June and July. Nearly equal portions (20% each) of these fish were released through the spillway at 64% spill, the spillway at 30% spill, and the sluiceway at 30% spill; about 40% were released in the tailrace as survival reference groups.

The tailrace groups were released at a site away from turbulence and areas of suspected predation and at a time to coincide with passage of treatment groups. The spillway releases were divided into daytime and nighttime releases and apportioned as equally as possible to four quadrants of the spillway during spring tests and to three thirds of the spillway during summer tests. Spill rates were alternated daily between 30 and 64% of the river flow.

After migrating through the 75-km reservoir below The Dalles Dam, a portion of the test fish passed through the PIT-tag interrogation equipment located in the juvenile fish bypass systems at Bonneville Dam. About 12.0% of the coho salmon and 4.8% of the subyearling chinook salmon released at The Dalles Dam were interrogated in bypass systems at Bonneville Dam. An additional 4.9% of coho salmon and 1.1% of subyearling chinook salmon were interrogated in the estuary, either at Jones Beach [Columbia River Kilometer (RKm) 75] using the PIT-tag detector trawl or at the Caspian tern (*Sterna caspia*) rookery on Rice Island (RKm 35).

Relative survival for passage at 64% spill was 89% for coho salmon (CI 82-96%) and 75% for subyearling chinook salmon (CI 68-83%). These survival rates were substantially lower than survival at 30% spill, where coho salmon survived at 97% (CI 88-107%) and subyearling chinook salmon at 89% (CI 80-99%). The difference between passage survival at 64% and passage survival at 30% was insignificant for coho salmon and significant for subyearling chinook salmon. Relative survival for sluiceway passage was 96% for coho salmon (CI 87-105%) and 89% for subyearling chinook salmon (CI 81-98%), and these rates did not differ appreciably from those of spillway passage at 30% spill. Spillway passage survival of coho salmon and subyearling chinook salmon appeared to decline through the period of testing. Nighttime passage of subyearling chinook salmon produced substantially higher relative survival than daytime passage, but the difference was not significant.

Travel times to Bonneville Dam averaged 1.8 days for both spring and summer migrants, but were consistently less for tailrace reference groups than for spillway groups (0.15 days less for coho salmon and 0.08 days less for chinook salmon). Based on radiotelemetry data from 1997, we speculated that fish exiting the spillway were delayed during migration past Bridge and Basin Islands on the south side of the river downstream from the dam.

Point estimates of survival were designed to represent passage survival of mixed fish stocks throughout the migration period during daytime (adult) and nighttime (juvenile) spill patterns, through spillbays across the width of the spillway, and at ambient spill-gate openings, river flows, tailwater elevations, and water temperatures. Variation among survival estimates for individual releases was high. We compared actual detection data to a simulated binomial distribution of detection proportions for relative spillway passage survival. Based on this analysis, it appeared that variability in relative survival for coho salmon was within the expected ranges, and variability in the observed data for subyearling chinook salmon was somewhat greater than would be expected in a binomial distribution. However, we believe that the variation associated with the observed survival estimates was greater than that attributable to a binomial distribution because of the many uncontrolled variables identified above.

Tests of passage distribution homogeneity at Bonneville Dam for corresponding spillway-, sluiceway-, and tailrace-released groups of coho salmon and subyearling chinook salmon suggested that daily release groups were not mixed on 3 of 50 test dates. For these three groups, all of which were subyearling chinook salmon groups, spillway-released fish were delayed about 1 day. However, because of the rapidity with which single groups passed Bonneville Dam (average 3 and 2.4 days for 80% passage of spring and summer test fish respectively), we believe there was no systematic error imparted to the relative survival data due to temporal changes in dam operations.

Relative survival estimates calculated from PIT-tag detections at Bonneville Dam were consistently lower than those calculated from detections at Rice Island; data were combined for analyses. We have deferred evaluation of these differences until multiple years of data are available for assessment.

From the 2 years of study, results that appear important to operations at The Dalles Dam are as follows:

1) Detection rates of fish passing through the spillway at 64% spill were significantly less than those of fish released downstream from the dam.

2) Estimated spillway passage survival for juvenile salmon at 64% spill was lower than at other dams and similar to or lower than survival expected for turbine passage at The Dalles Dam (spring flows ranged from 5,099 to 14,929 m^3/second (180,000 to 527,000 ft^3/second) and summer flows ranged from 4,447 to 14,986 m^3/second (157,000 to 529,000 ft^3/second).

3) Estimated relative survival rates for fish passing at 30% spill were substantially higher than for fish passing at 64% spill.

4) Relative survival for daytime fish passage through the sluiceway at 30% spill was similar to that of daytime fish passage through the spillway at 30% spill (one year of testing).

5) Spillway passage of subyearling chinook salmon during daytime hours with adult spill patterns produced substantially lower survival than passage during nighttime hours with juvenile spill patterns.

6) Evaluation of survival in relation to tailwater elevation, spill volume, river flow, and water temperature indicated poor correlations for both spring and summer tests.

We recommend continued testing of 30 vs. 64% spill rates during spring and summer fish migrations, followed by testing of a constant rate of spill (less than 64%) with a 24-hour/day juvenile fish pattern comparing spillway vs. sluiceway releases. Additionally, recovery and evaluation of PIT tags deposited in estuarine bird rookeries should be continued so as to provide increased detection numbers, and comparisons of survival rate differences among detection sites should also be continued. To maintain sufficient detections at Bonneville Dam Second Powerhouse, we also recommend minimal use of the sluice chute.

CONTENTS

INTRODUCTION

Based on the 1995 National Marine Fisheries Service (NMFS) Biological Opinion, the U.S. Army Corps of Engineers (COE) has selected the spillway as the best passage route for juvenile salmon (*Oncorhynchus* spp.) at The Dalles Dam (NMFS 1995). Spill rates were increased to 64% of river flow to attain 80% fish passage efficiency (FPE). This high volume of spill at The Dalles Dam produces levels of total dissolved gas (TDG) which are lower than those produced at other dams with similar spill rates. High volumes of spill at The Dalles Dam during 1996 produced levels of TDG which were less than 120% of saturation, the maximum approved by the state water quality agencies. Because TDG is not a factor that limits use of spill at The Dalles Dam, implementation of other alternatives for increasing FPE, such as the use of surface collectors or turbine-intake screens with an upgraded sluiceway or bypass system, were deferred in lieu of increased spill.

However, observations at The Dalles Dam and at the COE Waterways Experiment Station (WES) model of the dam have raised concerns about passage survival of juvenile salmonids during high spill. Heavy turbulence, back eddies, and sideways flow in the spillway stilling basin may cause injury to fish, and water flows passing through the Bridge Islands downstream from the dam may cause higher-than-expected mortality due to predation (Fig. 1). Substantial predation by northern pikeminnow (*Ptychocheilus oregonensis*) and gulls (*Larus* spp.) is suspected in the reef and islands area, based upon northern pikeminnow abundance and stomach-content evaluations (Hansel et al. 1993, Ward et al. 1995) and upon observations of salmonid smolts carried off by gulls (Jones et al. 1997; John Snelling, Oregon Cooperative Fisheries Research Unit, Oregon State University, Corvallis OR 97331-1961, Pers. commun., November 1997). Balloon-tag tests conducted in 1995 (Normandeau Associates et al. 1996) corroborated concerns that heavy turbulence in the spillway stilling basin might cause higher-than-acceptable mortality.

In 1996, we began discussions with the COE on means to test the premise that high spill levels at The Dalles Dam produce high passage survival of migrating juvenile salmonids. Tags available for a comprehensive assessment of spill passage survival at The Dalles Dam were 1) balloon tags, 2) coded-wire tags, and 3) passive integrated transponder (PIT) tags. Balloon tags are appropriate to evaluate immediate and direct injury and mortality from shear currents and high-velocity collisions during dam passage, but not for evaluation of indirect mortality from predation during passage through the tailrace and downstream reservoir. Coded-wire-tag technology provides the ability to effectively evaluate both direct and indirect mortality; however, results are dependent on adult returns, and thus the number of fish necessary for the study would be unacceptably large (hundreds of thousands). Therefore, we selected PIT tags because they provided the only method to evaluate both direct and indirect mortality using feasible numbers of test fish.

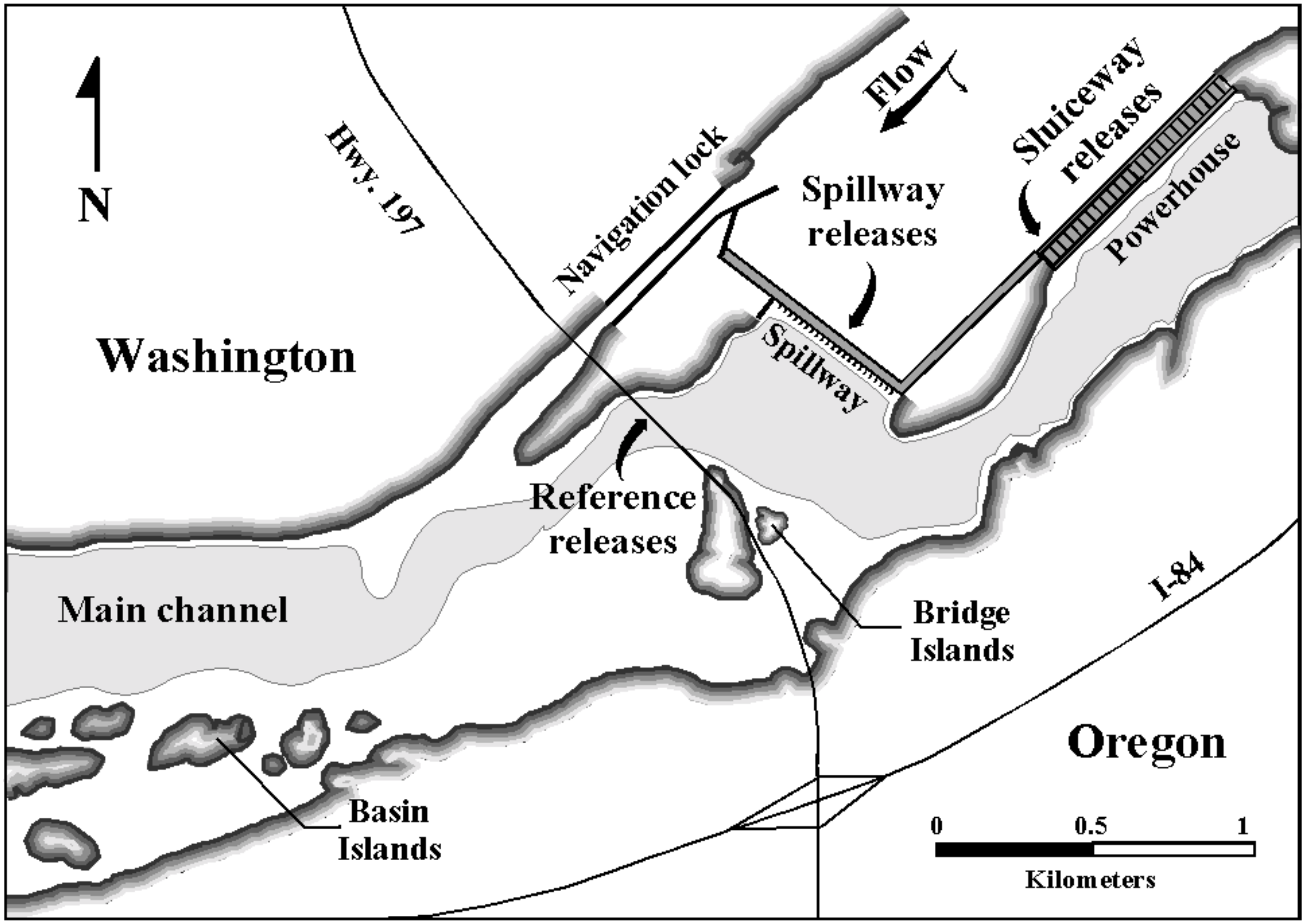

Figure 1. Overview of The Dalles Dam and tailrace area. Spillway-, sluiceway-, and reference-group release locations used in the 1998 evaluation of relative survival of juvenile coho salmon and subyearling chinook salmon are shown, as well as the position of the main channel in relation to the shallow island areas downstream from the dam.

In 1997, our study objective was to estimate the relative survival of juvenile coho salmon (*O. kisutch*) and subyearling fall chinook salmon (*O. tshawytscha*) passing through The Dalles Dam spillway when 64% of river flow passed through the spillway. Data collected in 1997 from releases of approximately 43,000 coho salmon and 53,000 subyearling chinook salmon suggested losses of about 13 and 8% respectively for passage through the spillway when spill volume was 64% of river flow (Dawley et al. 1998).

In 1998, we expanded the research to include assessment of passage survival through the spillway at high spill (64% of river flow) and moderate spill (30% of river flow) and through the ice and trash sluiceway during periods of moderate spill (30% of river flow). Point estimates of dam passage survival were calculated for juvenile salmon during the spring and summer migration periods. Estimates were based on PIT-tag detections at downstream sites, and detection percentages of treatment groups released in front of the spillway or sluiceway were compared to those of reference groups released downstream from the dam, thus providing relative survival estimates.

METHODS

We captured run-of-the-river juvenile coho and subyearling fall chinook salmon 5 to 7 days/week at the Bonneville Dam Second Powerhouse in late April/early May and late June/early July, respectively. Some subyearling chinook salmon were captured later in July at McNary Dam. We PIT tagged 300 to 5,100 fish daily and divided them proportionally among treatment and reference groups. Tagged fish were then transported to The Dalles Dam [Columbia River Kilometer (RKm) 308] and held for 1 day before release upstream from selected spillbays (treatment groups) or in the midstream area of the tailrace (reference groups). Subsequently, PIT-tag detections from the juvenile bypass systems at Bonneville Dam First and Second Powerhouses (RKm 235), from the Jones Beach PIT-tag trawl (RKm 75), and from the Rice Island tern rookery (RKm 35) were used to determine relative survival rates of the treatment groups in relation to reference groups.

Generally, juvenile salmon for each day of marking were captured during a 12- to 24-hour period from the fish bypass system at Bonneville Dam Second Powerhouse. As migrants passed out of the bypass collection channel, they slid across a dewatering screen onto horizontal bars positioned to separate juvenile salmon from larger fish and debris. Upon separation, juvenile fish and water were directed through a 25-cm (diameter) PIT-tag detector tunnel to a two-way slide gate. The gate passed PIT-tagged fish to the downwell and back to the river, but diverted non-tagged fish through a 20-cm pipe to the juvenile fish sampling room (Dawley et al. 1998). At the sampling room, fish were collected in 91-cm-wide by 5.5-m-long by 86-cm-deep raceways and held for marking.

In early July, low river flows resulted in minimized operation of the second powerhouse and insufficient collections of subyearling chinook salmon for our tests. Beginning 9 July, with the appropriate authorizations, we obtained fish for marking from the smolt monitoring facility at McNary Dam. Fish were collected in early morning hours and immediately transported by truck to Bonneville Dam for marking that day. Ice was used to maintain water temperature during transport, and water temperatures in the transport tanker never increased.

Marking commenced at about 0800 hours. After fish were anesthetized, target fish were sorted and electronically scanned for PIT tags. Individual sterile hypodermic syringes with 12-gauge needles were used to inject glass-coated, cylindrical tags, 2.1 by 10 mm, into the visceral cavity of each test fish (Prentice et al. 1990). Fish destined for treatment and reference groups were tagged in equal portions, and tagging personnel alternated between groups several times daily. Non-target fish and the occasional PIT-tagged target fish (which was not diverted back to the river at the slide gate) were allowed to recover from anesthetic and were then released into the downwell connected to the bypass egress conduit.

Tagged treatment and reference groups were placed in 800-L insulated aluminum holding tanks. After loading a maximum of 1,300 coho salmon (<40 g/L holding density; assuming 23 g average fish weight) or 1,600 subyearling chinook salmon (<25 g/L holding density; assuming 10.5 g. average fish weight), the containers were maintained with flow-through water at about 45 L/minute until transport.

Generally, holding tanks were transported by truck to The Dalles Dam in early evening. During the 1-hour transport, a small amount of oxygen was metered into tanks through air stones. When water temperatures approached 20ºC, ice was added to each tank to prevent further increases during transport. At The Dalles Dam, water was distributed to each tank at a rate of about 45 L/minute. Fish were generally held until the following morning or the following night, then released. Before release, tanks were inspected for mortalities and loose PIT tags. Tanks were then gently loaded onto trucks, supplied with oxygen, and taken to the sluiceway, spillway or tailrace.

Test Conditions

Tests were designed to evaluate passage survival at spill levels of 64 and 30% of river flow alternating daily; however, the spill rates varied $\pm$ 2% with two exceptions: one test was conducted at 61% spill, and another at 41% spill (Appendix Tables A1-A4). Passage conditions through each spillbay were different and changed through time in association with changes in river flow and hour of the day. Spill gate openings varied for each spillbay based on the established spill patterns (COE 1997) developed to maximize juvenile salmon survival during nighttime migration (juvenile spill pattern utilized from 2001 to 0500 hours; wherein spill is greatest on the north side of the spillway) without disrupting adult fish passage during the day (adult spill pattern utilized from 0500 to 2000 hours; wherein spill is less at 3 or 4 north and south end spillbays and crowned in the center bays). For these tests, flow patterns and normal operation criteria, other than percent of spill, were not altered.

Test fish releases were distributed throughout the duration of the mid-Columbia and Snake River yearling chinook salmon migration. Releases were made at the beginning and peak of the subyearling chinook migration period from above Bonneville Pool, although not at the end of the migration period due to high ambient water temperature. The experimental design called for about half the spill-passage test fish to be released during daylight and half during darkness, whereas the sluiceway-passage groups were released exclusively during daylight hours.

Release Methods, Locations, and Times

Daily releases were made during 1- to 4-hour periods from 28 April to 4 June for coho salmon and from 23 June to 24 July for subyearling chinook salmon. To allow for coincidental passage through the river downstream from the dam, sluiceway groups were released first, followed by spillway groups about 15 minutes later, and tailrace (reference) groups after an additional 10 minutes. Daily releases generally alternated between daylight and dark periods throughout both tests. All fish groups were released directly from the containers used for holding and at an elevation of about 0.5 m above the water surface; sluiceway and spillway groups were lowered by crane, and tailrace groups were released from a boat.

Over the course of testing, spillway-passage groups were released proportionally through quarters (spring tests) or thirds (summer tests) of the spillway. Daily complements of spillway groups were released at one to four locations across the spillway. From containers, fish passed through a hose positioned midway between spillbay pier-noses in front of an open spillbay, 5-9 m upstream from the spillbay gate. The hose extended to a depth of 3-4 m, where water velocities ranged from 0.4 to 1.5 m/second (Fig. 2, Appendix Table A5).

Based on visual observations of dye movements through the WES model, we believe that fish released at this general location passed through the spillbay opening without contacting the bottom edge of the gate. For both daylight and night releases, the sequence of spillway releases alternated from north to south, beginning at one end of the spillway. Generally, fish were released at one spillbay within each of one or more quarters (spring) or thirds (summer) of the spillway.

For analysis, coho salmon releases were differentiated between north Bays 1-5, middle/north Bays 6-11, middle/south Bays 12-17, and south Bays 18-23; whereas subyearling chinook salmon releases, because of lower flows and less operation of spillbays at the south end of the spillway, were differentiated between north Bays 1-6, middle Bays 7-12, and south Bays 13-23. We intended to release about half of the test fish at night and half during day; however, because of logistical, fish-distribution, and fish-handling problems, there were fewer nighttime releases (Appendix Tables A6, A7).

Sluiceway groups were released through a hose about 0.5 m under the water surface immediately downstream from the ice and trash sluiceway chain gate at Entrance 1/1 near the west end of the powerhouse. During normal operation, this gate is one of three open to pass surface-oriented juvenile salmon. Few fish utilize this passage route during the night (BioSonics 1997), thus we released all test fish during daylight hours.

Tailrace (reference fish) releases were made from a boat downstream from the dam at the proposed site for the new bypass system outfall (Fig. 1). This site is about 70 m from the Washington shore, about 0.7 km downstream from the spillway, and about 30 m downstream from the Highway-197 bridge in an area of high water velocity. At this location, released fish are thought to generally pass down the north side of the river, away from predator sanctuary areas (Snelling and Mattson 1998).

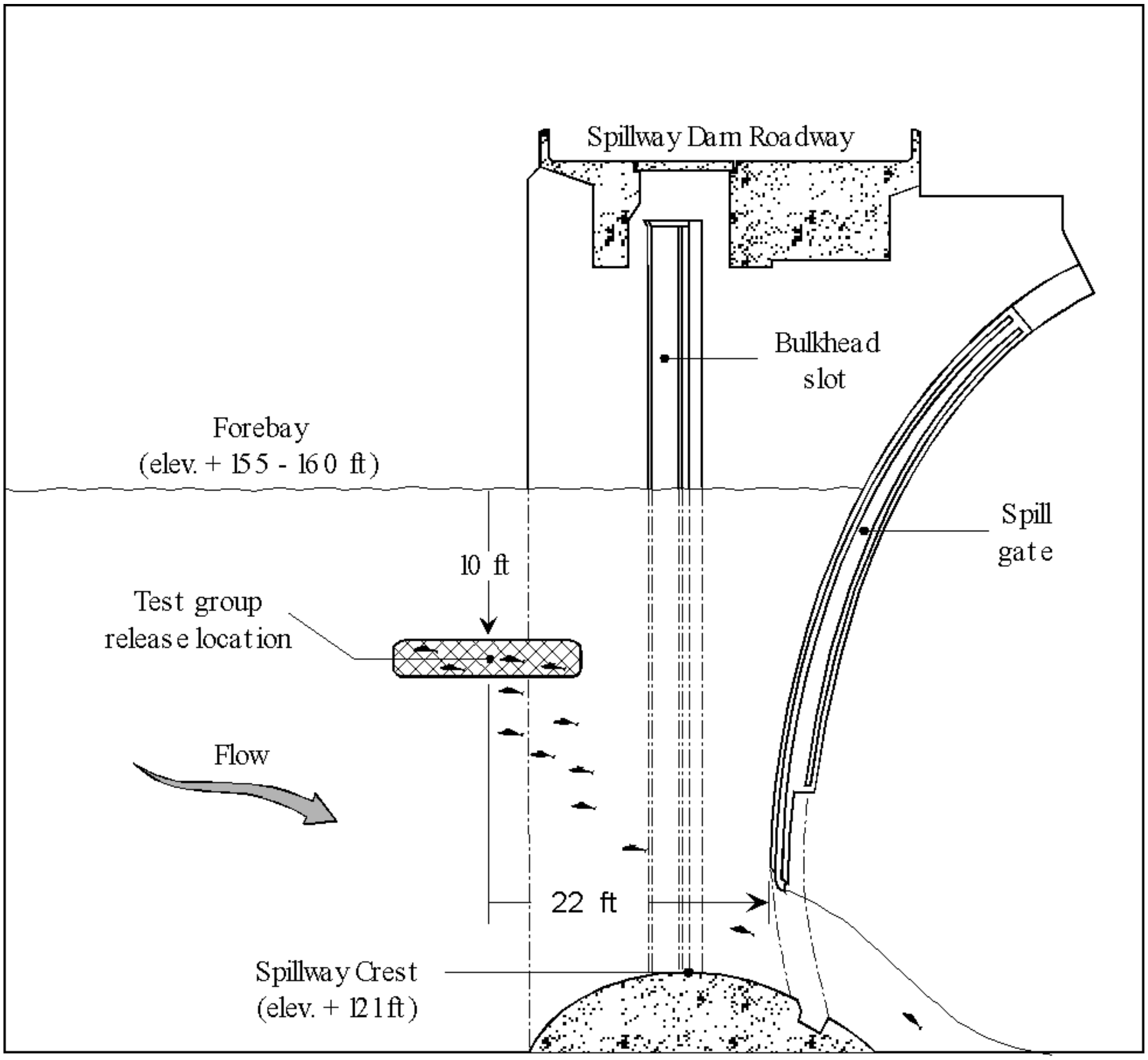

Figure 2. Spillway transverse section at The Dalles Dam, showing depth and location (relative to spillway gates) at which test groups of PIT-tagged juvenile coho salmon and subyearling chinook salmon were released during 1998.

We attempted to make all test fish releases during peak periods of daily passage for naturally migrating fish. Release times varied, but the mean daylight release time was 1122 hours for coho salmon and 1102 hours for subyearling chinook salmon, while the mean nighttime release time was 2119 hours for coho salmon and 2234 hours for subyearling chinook salmon (Appendix Tables A1-A4). The average time from the first to last release for each day was about 1 hour.

For these relative survival differences to exclusively relate to the effects of dam passage, it is important that treatment and reference groups migrate together (mixed) through the river downstream from The Dalles Dam. Differential timing and migration routes through a river reach could cause differences in predation and PIT-tag detection rates which are not directly attributable to dam passage.

To attain similar timing for test fish exiting the tailrace, daily treatment and reference groups were released sequentially in relation to the location and water-particle travel time to the tailrace exit. Unfortunately, the passage route taken by fish through the dam (i.e., powerhouse, sluiceway, proposed new bypass system, or spillway) affects the lateral location of fish groups at the tailrace exit, and the lateral location of a fish at the tailrace exit in turn affects its passage route and movement rate through the river downstream (Snelling and Mattson 1998). Therefore, some differences in timing from The Dalles Dam to Bonneville Dam are related to route of passage through The Dalles Dam. We believe that these variables affect naturally migrating fish and should be incorporated into measured differences of relative survival. However, different arrival timing at Bonneville Dam may also affect the comparability of detection rates because of temporal differences in river flow and Bonneville Dam operations.

PIT-tag Detections

For this study, PIT-tag detections were made at five locations. The majority of tags were detected in the smolt bypass systems at the first and second powerhouses of Bonneville Dam while fish were passing unhindered through the dam (described in Dawley et al. 1998). Supplemental detections were made at Jones Beach when fish passed through a trawl equipped with a PIT-tag detector at the cod-end (Ledgerwood et al. 1997) and at the piscivorous bird colonies on Rice Island, and gull rookeries upstream from The Dalles Dam, where tags were deposited and then detected at a later date (Ryan et al. in review).

Test Fish

Juvenile coho salmon were used as test fish to evaluate spill passage survival at The Dalles Dam during the spring migration period. Coho salmon were used as surrogates for spring chinook salmon to limit handling impacts to Snake River chinook salmon listed under the Endangered Species Act. Subyearling fall chinook salmon were used as test fish during the summer migration period.

Juvenile coho salmon for these tests were collected at Bonneville Dam. Initially, subyearling chinook salmon were collected at Bonneville Dam, but beginning 9 July, collections were made at McNary Dam because reduced operation of the Bonneville Dam Second Powerhouse precluded collection of sufficient numbers for marking.

Based on previous work, we estimated that at Bonneville Dam, detection rates of PIT-tagged fish released in The Dalles Dam tailrace would average 16.5% for coho salmon and 12.9% for subyearling chinook salmon (Dawley et al. 1997). To obtain the desired sensitivity of 8 and 9% detectable difference between treatment and reference groups for coho and subyearling chinook salmon, respectively, the calculated numbers of fish necessary for release were 66,000 coho salmon and 66,000 subyearling chinook salmon (Cochran and Cox 1957). Because of lower-than-expected detection percentages in June and July, we requested and obtained authorization from the Fish Passage Advisory Committee and the NMFS Northwest Region Protected Resources Division to increase the number of PIT-tagged subyearling chinook salmon to 81,000.

Data Analyses

The primary null hypothesis tested was

$H_{0(1)}$: Detection rates of treatment groups released to the spillway at 64% spill, the spillway at 30% spill, or the sluiceway do not differ from those of reference groups released to the tailrace of The Dalles Dam.

Secondary null hypotheses, which were not necessarily expected to be rejected with one year's data (because of limited test fish numbers) were as follows:

$H_{0(2)}$: There are no differences in relative survival between treatment groups associated with release time, (day or night), lateral release location in the spillway (north to south segments), and spill gate openings (0.3 - 3.0 m).

$H_{0(3)}$: Relative survival for groups released through the spillway is not correlated with river volume, spill volume, tailwater elevation, or water temperature.

$H_{0(4)}$: Relative survival does not differ between small and large fish size at release, wherein the threshold between small and large is defined as 125 mm for yearling fish and 110 for subyearling fish.

$H_{0(5)}$: Detection proportions at Bonneville Dam and Rice Island do not differ between treatment and reference groups.

$H_{0(6)}$: Arrival timing at Bonneville Dam does not differ between treatment and reference groups.

$H_{0(7)}$: There is no difference between the observed and expected variability in data.

Detection percentage of daily release groups passing the spillway at 64% spill and 30% spill and passing the sluiceway were compared to those of pooled reference groups (pooled by day) released in the tailrace, and means and 95% confidence intervals for the natural log of treatment-to-reference proportions were calculated.

Relative survival (detected proportion of spillway or sluiceway released fish divided by the detected proportion of tailrace-released fish) was calculated in relation to passage variables, which were categorized as follows: date and Julian date; spill percentage, indexed as 1 for 30% and 2 for 64% spill rates; spill pattern, indexed as 1 for daytime (adult spill pattern) and 2 for nighttime (juvenile spill pattern) releases; spillbay location for coho salmon, indexed as 1 for north bays (Bays 1-6), 2 for mid-north bays (Bays 7-12), 3 for mid-south bays (Bays 13-17), and 4 for south bays (Bays 18-23); spillbay location for chinook salmon, indexed as 1 for north bays (Bays 1-6), 2 for middle bays (Bays 7-12), and 3 for south bays (Bays 13-23); spill-gate opening for coho salmon, indexed as 1 for openings 0.3-1 m (1-3 ft), 2 for openings 1.2-2.1 m (4-7 ft), and 3 for openings 2.4-3.0 m (8-10 ft); and spill-gate openings for chinook salmon, indexed as 1 for openings 0.3-1 m (1-3 ft) and 2 for openings 1.2-3.0 m (4-10 ft).

Calculations were made using analysis of variance of log-transformed detection ratios (treatment/reference). Student's *t*-test distributions were used to evaluate differences between survival percentages for daytime releases (64 vs. 30% spill for spillway passage and 30% spill for spillway vs. sluiceway passage). Correlation coefficients were calculated for relative survival in relation to uncontrolled variables of tailwater elevation, river flow, spill flow, and water temperature. Data from 1997 and 1998 used for this evaluation were pooled by release period to reduce variability.

Relative survival in relation to body size at release was evaluated to provide information regarding effects of size selections for future research activities where a full range of fish sizes may not be possible. Fish were divided into two groups representing fish smaller than the size necessary for radio transmitter implantation and larger fish. The size thresholds presently utilized as minimum for tagging are 125 mm for yearling fish and 110 mm for subyearling fish (Rip Shively, USGS BRD, Columbia River Research Laboratory, Cook WA, 98605, Pers. commun., October 1998).

Student's *t*-test distributions were used to evaluate relative survival in relation to fork length. Paired *t*-tests were used for evaluating survival differences separated by site of detection (Rice Island and Bonneville Dam). We tested the assumption of mixing between treatment and reference groups (i.e., homogeneity of passage distributions at the Bonneville Dam PIT-tag detection sites) with chi-square tests for each release date, using a Monte Carlo approximation of the exact method to calculate P-values (Mehta and Patel 1992). Significance was established at $P \leq 0.05$.

We assessed variability in detection percentages among release groups to determine whether data were within expected ranges. For this analysis, we simulated a binomial distribution of detection data based on mean observed detection proportions (i.e., spillway, sluiceway, and tailrace proportions) and on actual release numbers. We compared variability (based on standard deviation and range) in the simulation with variability in the observed data to determine the expected variability of relative survival for the simulated data with the variability of the observed data. One thousand simulations were conducted for each test, and the proportion of simulated standard deviations or ranges greater than those observed constituted a P-value for the null hypothesis that observed variability was not different from expected variability for binomially distributed data.

RESULTS

Spring Migration, Coho Salmon

On test days 28 April-4 June during hours of release, river flow ranged from 5,099 to 12,946 m^3/second (180,000 to 457,000 ft^3/second). During hours of release, average spill ranged from 1,530 to 3,966 m^3/second (54,000 to 140,000 ft^3/second) for the 30% spill tests and 3,541 to 8,159 m^3/second (125,000 to 288,000 ft^3/second) for the 64% spill tests (Appendix Tables A1 and A2). Of the 63,994 PIT-tagged coho salmon released in this study, 16.2% (10,395 unique tags) were detected at one or more downstream sites (Table 1, Appendix Table A6). Of the 26,906 PIT-tagged coho salmon released as the reference group at a site downstream from the Highway-197 bridge, 17.1% (4,588 unique tags) were detected. Proportions of total PIT tags detected were 34% at Bonneville Dam First Powerhouse, 37% at Bonneville Dam Second Powerhouse, 3% at Jones Beach, and 26% at Rice Island.

The PIT-tag detection data were separated by detection site to evaluate relative survival differences between sites. We found that relative survival for 30% spill groups averaged 9% greater than for 64% spill groups as measured at Bonneville Dam (P = 0.17) and 6% greater as measured at Rice Island (P = 0.58). However, the survival estimates from detections at Bonneville Dam were lower for both 30 and 64% spill groups (96.5 and 87.9%) than those from detections at Rice Island (103.0* and 96.7%, respectively). Statistical analyses of the separated data are presented in Appendix Table B1.

Paired *t*-tests of Ln relative survival of daily releases measured at Bonneville Dam First Powerhouse vs. Second Powerhouse, Jones Beach, and Rice Island produced probabilities of P = 0.17, 0.02 and 0.85, respectively. Paired *t*-tests of Ln relative survivals of daily releases measured at Bonneville Dam Second Powerhouse vs. Jones Beach and Rice Island produced probabilities of P = 0.21, and 0.05, respectively, and a paired *t*-test of Ln relative survivals for daily releases detected at Jones Beach vs. Rice Island produced probability of P = 0.06. For all other analyses, we utilized the combined data from all recovery sites.

Survival Estimates

The point estimate (unweighted geometric mean for all release periods) of relative survival for spillway-released coho salmon was 88.6% with a 95% confidence interval (CI) of 82.1-95.5% at 64% spill and 96.9% (CI 87.6-107.0%) at 30% spill (Table 2). These point estimates represent passage survival of mixed fish stocks throughout the migration period, during day and night (adult and juvenile spill patterns), through spillbays across the width of the spillway, and at ambient spill-gate openings, river flows, tailwater elevations, and water

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* When true survival probabilities are close to 100% or when sampling variability is high, it is possible for survival probabilities to exceed 100%. For practical purposes, estimates should be considered equal to 100% in these cases (Steven G. Smith, NMFS, Pers. commun. Nov. 1998).

Table 1. Numbers and percentages of PIT-tagged fish released and detected at various locations by treatment and condition for The Dalles Dam Survival Study in 1998.

	Releases		PIT-tag detections by location					
Conditions	Site	Number	Bon PH1[a]	Bon. PH2[b]	Jones Beach	Rice Island	Total[c]	Detections (%)
			Coho salmon					
30% Spill, Daytime	Spillway	6,370	302	403	37	321	1,013	15.9
	Sluiceway	12,096	674	648	36	528	1,812	15.0
	Tailrace	10,884	596	668	40	495	1,742	16.0
30% Spill, Nighttime	Spillway	3,448	259	165	21	127	551	16.0
	Tailrace	3,577	266	192	29	164	634	17.7
64% Spill, Daytime	Spillway	9,522	449	749	46	368	1,545	16.2
	Tailrace	7,517	344	674	43	348	1,361	18.1
64% Spill, Nighttime	Spillway	5,652	378	286	36	225	885	15.7
	Tailrace	4,928	362	269	49	199	852	17.3
	Total*	63,994	3,630	4,054	337	2,775	10,395	16.2
	% of Release		5.67	6.33	0.53	4.34		
	% of Detections		34	37	3	26		
			Subyearling chinook salmon					
30% Spill, Daytime	Spillway	12,597	182	413	0	122	713	5.7
	Sluiceway	11,145	128	279	0	114	520	4.7
	Tailrace	14,514	193	512	0	169	866	6.0
30% Spill, Nighttime	Spillway	5,659	170	162	0	64	393	6.9
	Tailrace	5,403	165	161	0	57	380	7.0
64% Spill, Daytime	Spillway	8,298	176	125	0	97	394	4.7
	Sluiceway	1,618	42	26	0	21	88	5.4
	Tailrace	7,664	262	145	0	100	505	6.6
64% Spill, Nighttime	Spillway	7,210	164	187	0	93	440	6.1
	Tailrace	6,390	188	212	0	79	476	7.4
	Total	80,498	1,670	2,222	0	916	4,775	5.9
	% of Release		2.07	2.76	0.00	1.14		
	% of Detections		35	46	0	19		

a Bonneville Dam First Powerhouse.

b Bonneville Dam Second Powerhouse.

c Total observed (used for combined analysis) is the number of unique tags observed at any of the sites. Multiple observations of a tag are not counted. Numbers observed at individual sites may include tags observed at other sites, and these data were used to make the inter-site comparisons.

Table 2. Detections of PIT-tagged coho salmon released at The Dalles Dam in 1998, including relative survival percentages for daytime and nighttime passage through the spillway at 30 and 64% spill and daytime passage through the sluiceway at 30% spill.

$H_{0(1)}$: Detection rates of treatment groups released to the spillway at 64% spill, the spillway at 30% spill, or the sluiceway do not differ from those of reference groups released to the tailrace of The Dalles Dam.

	River conditions		SPILLWAY					SLUICEWAY		TAILRACE	
			Bay		Gate					Detections	
Release date	kcfs[a]	°C	No.	Location[b]	opening (ft)	Det. no.[c]	Surv. (%)[d]	Det. no.	Surv. (%)	no.	(%)
					30% Spill, daytime pattern						
4/29	196	14	22	S	2	21	111.4	20	104.0	20	19.2
5/1	238	14	2	N	3	51	117.7	33	133.8	29	16.7
5/5	308	15	15	MS	2	95	112.4	99	117.4	84	16.3
5/9	369	14	8	MN	3	110	88.9	111	89.2	128	15.1
5/15	344	14	3	N	3	69	103.5	111	96.6	115	14.2
			12	MN	3	70	106.2				
5/21	323	14	1	N	3	81	114.3	155	90.3	170	16.2
			23	S	2	114	111.4				
5/23	286	14	6	N	3	149	84.9	159	73.5	217	20.4
			21	S	2	115	72.1				
								341	90.2	209	17.4
5/27	388	14	17	MS	4	138	81.4	171	99.5	170	16.6
5/29	416	14						66	77.7	149	15.1
5/29	412	14						249	97.5	252	12.7
6/2	400	14						94	97.2	92	19.7
6/3	403	15						203	94.6	107	16.5
Total & Geometric Mean						1,013	99.2	1,812	95.9	1,742	16.5
					30% Spill, nighttime pattern						
5/7	349	15	1	N	4	102	89.4			283	19.7
			15	MS	1	132	95.8				
5/13	311	14	8	MN	5	83	90.5			215	18.8
			14	MS	2	85	92.5				
5/27	388	14	10	MN	6	149	91.6			136	12.2
Total & Geometric Mean						551	91.9			634	16.5
30% Total & Geometric Mean[e]						**1,564**	**96.5**	**1,812**	**95.9**	**2,376**	**16.5**
95% Confidence Interval							**87.6 - 107.0**				**87.4 - 105.4**

Table 2. Continued.

Release date	River Conditions kcfs[a]	River Conditions °C	SPILLWAY Bay No.	SPILLWAY Bay Location[b]	SPILLWAY Gate opening (ft)	SPILLWAY Det. no.[c]	SPILLWAY Surv. (%)[d]	SLUICEWAY Det. no.	SLUICEWAY Surv. (%)	TAILRACE Detections no.	TAILRACE Detections (%)
					64% Spill, daytime pattern						
4/28	207	14	22	S	3	54	124.7			24	18.0
5/8	353	15	8	MN	8	174	91.1			195	19.5
			23	S	4	144	74.4				
5/10	354	14	2	N	5	170	89.5			192	23.0
5/14	344	14	12	MN	8	144	82.6			98	17.7
5/20	315	14	1	N	3	92	96.9			177	17.0
			15	MS	7	70	73.8				
5/25	305	14	3	N	2	264	91.6			450	22.3
			10	MN	8	230	91.7				
5/26	310	14	17	MS	5	104	91.0			225	11.6
			21	S	4	99	86.8				
Total & Geometric Mean						1,545	89.5			1,361	18.1
					64% Spill, nighttime pattern						
4/30	227	14	2	N	7	30	68.8			44	20.1
5/6	323	15	1	N	7	150	104.1			207	14.5
			15	MS	6	76	102.9				
5/12	324	14	8	MN	10	81	85.0			197	21.5
			19	S	2	76	87.9				
5/16	317	14	3	N	9	107	78.5			137	20.9
			12	MN	8	114	82.3				
5/27[f]	388	14	3	N	10	145	90.8			150	13.4
6/4	411	15	23	S	5	106	92.2			117	19.8
Total & Geometric Mean						885	87.4			852	18.1
64% Total & Geometric Mean[e]						**2,430**	**88.6**			**2,213**	**18.1**
95% Confidence Interval							**82.1 - 95.5**				

[a] Mean daily river flow; kcfs = thousand ft^3/sec.

[b] Location of spillbay assigned to a position of north, mid-north, mid-south, or south (N, MN, MS, S) for data analysis: where bays 1-6 = N, 7-12 = MN, 13-17 = MS, and 18-23 = S.

[c] Number or percent of release which was detected at Jones Beach, Bonneville Dam, or Rice Island.

[d] Percent of treatment group detected divided by the percent of tailrace group detected times 100.

[e] Geometric mean for day and night combined; not the same as Appendix Table B1.

[f] Originally classified as 30% spill condition; however, records of dam operations indicate spill was increased to about 64%, minutes before release was made.

temperatures. Survival at 64% spill was significantly different (lower) from survival of reference fish released downstream from the dam, whereas survival at 30% spill was not. Survival at 30% spill was not significantly different from survival at 64% spill (P = 0.38, Appendix Table B1). Relative survival percentages of individual releases ranged from 68.8 to 133.8%.

Numbers of coho salmon test fish were sufficient to assess survival differences between treatment groups and reference groups at 30 and 64% spill, but were insufficient to fully evaluate survival effects related to other controlled and uncontrolled variables. However, we examined the data for survival trends related to other variables. Effects from diel period (spill pattern), spillbay location (bay index), and gate opening (gate index) on relative survival of fish passing through the spillway were not significant (P = 0.50, 0.98, and 0.30, respectively; Appendix Tables B1, B2, B3), though there did appear to be a trend of decreased survival by date through the period of testing (P = 0.19).

The point estimate (geometric mean) of relative survival for sluiceway-released coho salmon during daylight hours at 30% spill was 96.0% (CI 87.4-105.4%) (Table 2). Sluiceway passage survival appeared to be no different from daytime spillway passage survival at 30% spill (Table 3). Daytime spillway passage survival at 64% spill was lower than survival at 30% spill, but the difference was not significant (P = 0.13, Table 3, Fig. 3).

Test fish body size at release was evaluated as a variable affecting survival. We examined survival of test fish in relation to PIT-tag detection rates for daily release groups separated into two fork length categories: 125 mm or less and greater than 125 mm. Detection data from Bonneville Dam and Rice Island showed no significant differences by fish size (P = 0.42 and 0.53, respectively; Appendix Table B4).

Variability Associated With the Experimental Process

To assess differences of temporal distribution among treatment groups (mixing), we compared travel times to and daily detection distributions at Bonneville Dam for daily release groups. To assess the variability of measured survival percentages, we compared ranges and standard deviations of the actual data sets for each species to those of simulated binomial distributions of the data (1,000 simulations).

Travel times--The simplest method to evaluate whether mixing occurred among treatment groups was to assess travel time differences between treatment groups released during the same time period. Travel times through the 75-km river reach from The Dalles Dam to Bonneville Dam averaged about 1.8 days, with 80% detection in 3.0 days (Table 4). Travel time decreased substantially during the early portion of the test period (28 April-6 May), probably affected by physiological status of smolts. River flow also appeared to affect travel time (Fig. 4). Daytime releases averaged 1.9 days and nighttime releases averaged 1.5 days; the difference was not significant (P = 0.19). Tailrace-released reference groups arrived at Bonneville Dam slightly earlier than spillway-released groups (0.15 days) and sluiceway-released groups (0.08 days), but again, the differences were not significant (P = 0.22 and 0.79, respectively; Table 4).

Table 3. Relative survival comparison of coho salmon passing the spillway during the day at 30 and 64% spill vs. the sluiceway at The Dalles Dam, 1998.

Release	Spillway at 64% Daytime releases		Spillway at 30% Daytime releases		Sluiceway Daytime releases	
day	Rel. surv.	Ln	Rel. surv.	Ln	Rel. surv.	Ln
4/28	1.247	0.221				
4/29			1.114	0.108	1.040	0.039
5/1			1.177	0.163	1.338	0.291
5/5			1.124	0.117	1.174	0.160
5/8	0.911	-0.094				
5/8	0.744	-0.296				
5/9			0.889	-0.118	0.892	-0.114
5/10	0.895	-0.111				
5/14	0.826	-0.191				
5/15			1.035	0.035	0.966	-0.034
5/15			1.062	0.060		
5/20	0.969	-0.032				
5/20	0.738	-0.303				
5/21			1.143	0.133	0.903	-0.102
5/21			1.114	0.108		
5/22			0.849	-0.163	0.735	-0.308
5/22			0.721	-0.327		
5/23					0.902	-0.103
5/24	0.916	-0.088				
5/24	0.917	-0.087				
5/25	0.910	-0.094				
5/25	0.868	-0.142				
5/26			0.814	-0.206	0.995	-0.005
5/28					0.777	-0.253
5/29					0.975	-0.025
6/2					0.972	-0.029
6/3					0.946	-0.055
Geomean:	0.895	-0.111	0.992	-0.008	0.960	-0.041
SE:	0.038	0.042	0.050	0.050	0.041	0.043
95% CI:	0.815	0.984	0.887	1.109	0.874	1.054

Ratio: 64% Spillway to 30% Spillway			Ratio: 30% Spillway to Sluiceway		
Geomean:	0.903	-0.102	Geomean:	1.034	0.033
SE:	0.059	0.066	SE:	0.068	0.066
95% CI:	0.787	1.035	95% CI:	0.901	1.185
t:		-1.56	t:		0.50
df:		20	df:		22
P:		0.134	P:		0.621

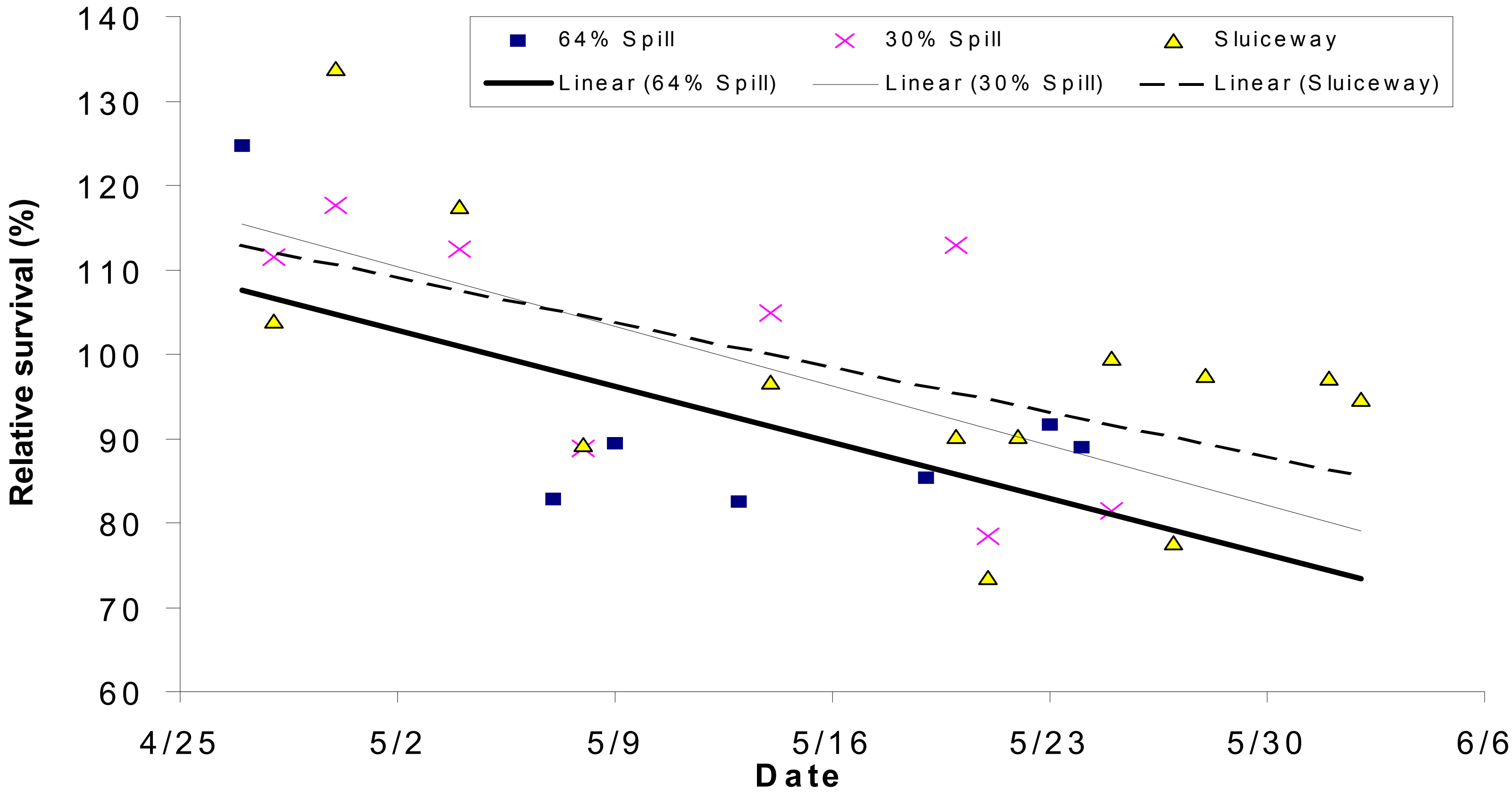

Figure 3. Daytime passage survival of coho salmon through the spillway and sluiceway at 30% spill and spillway at 64% spill at The Dalles Dam, 1998.

Table 4. Comparison of median travel time in days from The Dalles Dam to Bonneville Dam, for daily treatment groups of coho salmon, 1998.

Release		Sluiceway		Spillway		Tailrace		Daily groups combined*			Treatment groups combined		River flow
Date	Period	n	Days	n	Days	n	Days	Sluiceway Days	Spillway Days	Tailrace Days	n	Days	(kcfs)
4/28	Day			45	4.39	21	3.62		4.39	3.62	66	4.38	207
4/29	Day	16	2.54	16	3.49	15	3.36	2.54	3.49	3.36	47	3.43	196
4/30	Night			26	2.58	35	2.19		2.58	2.19	61	2.29	227
5/1	Day	29	3.14	42	2.65	23	2.93	3.14	2.65	2.93	94	2.86	238
5/5	Day	85	2.11	66	2.37	61	1.74	2.11	2.37	1.74	212	2.09	308
5/6	Night			120	1.19	120	1.16		1.24	1.20	504	2.19	323
5/6	Night			56	1.36	35	1.32						
5/7	Night			110	2.39	111	2.26		2.38	2.25	240	1.18	349
5/7	Night			83	2.38	109	2.24						
5/8	Day			121	1.21	152	0.95		1.13	0.95	407	1.03	353
5/8	Day			134	1.05								
5/9	Day	82	1.80	72	1.79	82	1.61	1.80	1.79	1.61	236	1.70	369
5/10	Day			130	1.54	148	1.58		1.54	1.58	278	1.55	354
5/12	Night			60	1.28	161	1.43		1.58	1.43	279	1.46	324
5/12	Night			58	1.88								
5/13	Night			64	1.18	159	1.10		1.20	1.10	294	1.14	311
5/13	Night			71	1.22								
5/14	Day			104	1.58	39	1.52		1.58	1.54	176	1.57	344
5/14	Day					33	1.57						
5/15	Day	77	1.78	53	1.60	89	1.81	1.78	1.67	1.81	263	1.76	344
5/15	Day			44	1.75								
5/16	Night			83	1.46	101	1.88		1.71	1.88	276	1.90	317
5/16	Night			92	1.93								

Table 4. Continued.

Release		Sluiceway		Spillway		Tailrace		Daily groups combined*			Treatment groups combined		River flow
								Sluiceway	Spillway	Tailrace			
Date	Period	n	Days	n	Days	n	Days	Days	Days	Days	n	Days	(kcfs)
5/20	Day			51	1.77	123	1.50		1.63	1.50	238	1.53	315
5/20	Day			64	1.52								
5/21	Day	106	2.04	57	2.40	116	2.25	2.04	2.23	2.25	364	2.16	323
5/21	Day			85	2.12								
5/23	Day	121	1.48	92	1.51	158	1.93	1.48	1.52	1.93	843	1.66	286
5/23	Day			79	1.52								
5/23	Day	120	1.63			139	1.52	1.60		1.52			286
5/23	Day	134	1.58										
5/25	Day			216	1.45	141	1.44		1.46	1.72	751	1.59	305
5/25	Day			185	1.46	209	1.91						
5/26	Day			68	1.44	73	1.47		1.47	1.68	291	1.55	310
5/26	Day			75	1.50	75	1.89						
5/27	Day	121	1.42	98	1.39	126	1.14	1.42	1.39	1.14			388
5/27	Night			90	1.13	88	1.08		1.15	1.11	696	1.18	388
5/27	Night			95	1.18	78	1.13						
5/29	Day	46	1.47			114	1.49	1.80		1.72	508	1.85	412
5/29	Day	75	1.91			100	1.85						
5/29	Day	88	1.87			85	1.87						
6/2	Day	77	1.01			71	1.15	1.01		1.15	148	1.05	400
6/3	Day	72	0.94			83	0.91	1.03		0.91	227	0.97	403
6/3	Day	72	1.12										
6/4	Night			78	0.98	91	0.97		0.98	0.97	169	0.98	416
				Mean				1.81	1.88	1.73		1.80	

* *t*-test that travel time of sluiceway fish is not different from tailrace fish; P = 0.79.
t-test that travel time of spillway fish is not different from tailrace fish; P = 0.22.
t-test that travel time of sluiceway fish is not different from spillway fish; P = 0.50.
Correlation evaluation of combined travel time to river flow indicated a strong inverse relationship; r = -0.80.
Correlation evaluation of combined travel time to Julian date indicated a moderate inverse relationship; r = -0.65.

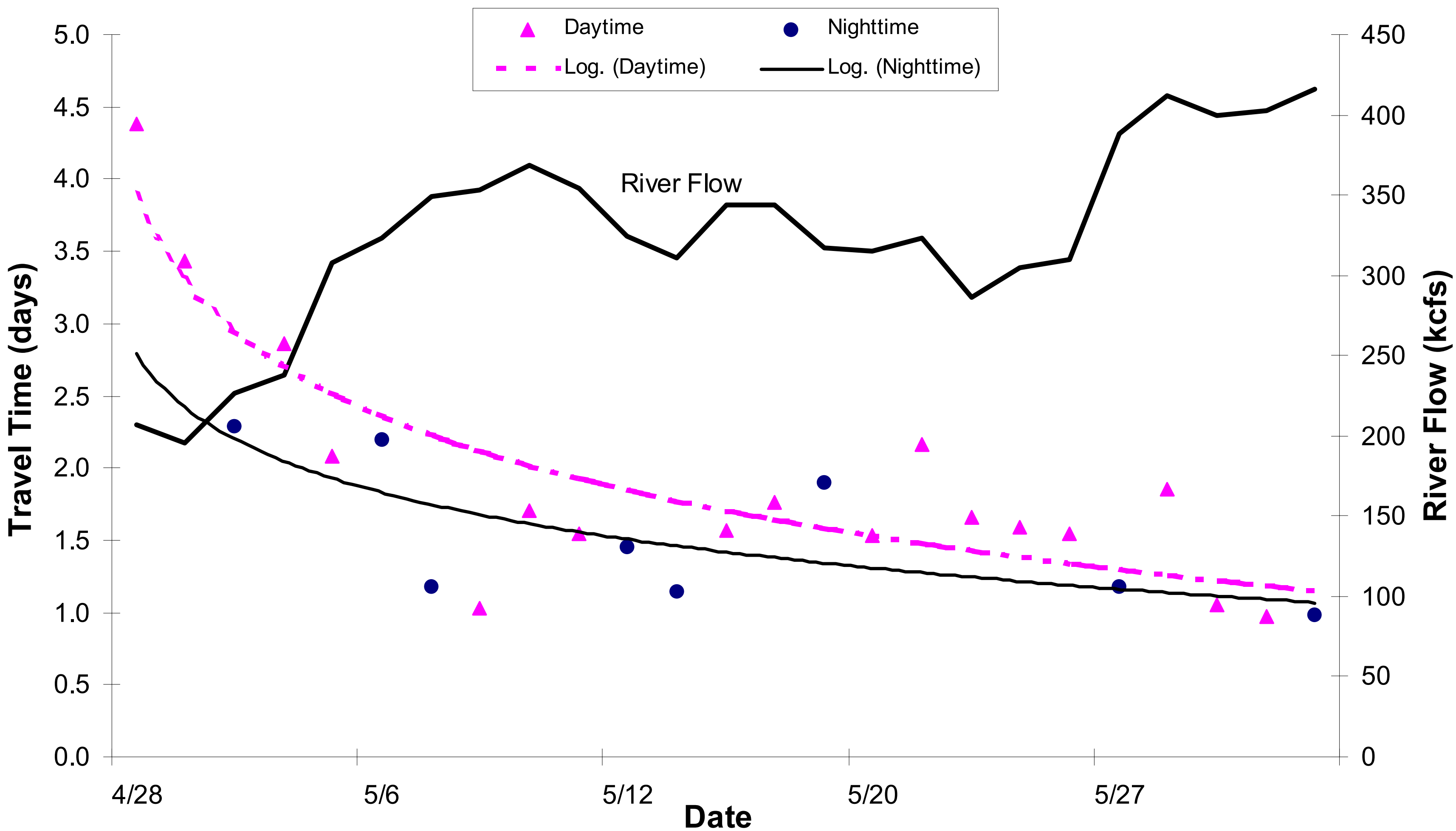

Figure 4. Travel time of coho salmon from The Dalles Dam to Bonneville Dam compared to river flow, 1998.

Temporal detection distributions--The homogeneity of passage distributions at Bonneville Dam (detection through time) for corresponding spillway-, sluiceway-, and tailrace-released groups of coho salmon suggested no violation of the mixing assumption. Using a chi-square test of the homogeneity of passage distributions for the 28 release periods, we found no significant differences between spillway and tailrace release groups in arrival timing at Bonneville Dam (Table 5).

Variability by date--We assessed the variability in detection percentages among release groups to determine whether data were within expected ranges. The analysis compared actual data to a simulated binomial distribution of the data for detection proportions by tag day and by combinations of tag day, spill pattern, and spillbay for relative spillway-passage survival. The observed SDs were 14.5 and 13.3%, whereas the simulated SDs were 12.1 and 12.3% ($P = 0.24$ and 0.33), respectively. The observed ranges were 55.9 and 55.8%, whereas the simulated ranges were 52.9 and 57.9% ($P = 0.44$ and 0.55), respectively (Table 6). Based on this analysis, the observed variability in detection percentages by date was not different from the expected variability for binomially distributed data.

Comparison with 1997 Results and Trends for Combined Data

The point estimate for passage survival at 64% spill in 1998 was similar to that in 1997. Survival trend lines (linear) showed a slight decrease through time with the exception of the last release in 1998, which occurred at much increased river flow and about 7 days later than any other release (Fig. 5). The trend line for spill passage survival at 30% (for 1998) also decreased through the test period, but was higher than trend lines at 64% spill passage.

Point estimates of survival for daytime releases were similar to those of nighttime releases, and combined 1997/1998 data, including all daily estimates at 30 and 64% spill, showed no significant difference ($P = 0.80$, Appendix Table B5).

In both 1997 and 1998, travel times for daily groups showed differences between tailrace groups and dam passage groups, wherein tailrace groups traveled slightly faster. However, evaluation of those differences indicated no statistical significance ($P = 0.36$ and 0.22 for 1997 and 1998, respectively).

Evaluation of survival in relation to water temperature, spill flow, river flow, and tailwater elevation showed poor correlation, $r = 0.18, -0.22, -0.19$, and -0.12 respectively for springtime tests using coho salmon (Fig. 6a, and 6b; Appendix Table B6).

Table 5. Tests of homogeneity of Bonneville Dam passage distributions for groups of PIT-tagged coho salmon and subyearling chinook salmon released into spillway, sluiceway, or tailrace at The Dalles Dam, 1998.

$H_{0(6)}$: Arrival timing at Bonneville Dam does not differ between treatment and reference groups.

Coho salmon					Subyearling chinook salmon				
Tag day	Release sites[a]	X^2	df	P[b]	Tag day	Release sites[a]	X^2	df	P[b]
4/27	SP, T	15.30	13	0.27	6/22	SP, SL, T	19.98	18	0.30
4/28	SP, SL, T	20.95	20	0.40	6/23	SP, SL, T	10.96	14	0.76
4/29	SP, T	6.85	7	0.47	6/24	SP, T	16.31	9	**0.02**
4/30	SP, SL, T	19.01	22	0.76	6/25	SP, T	10.11	7	0.15
5/4	SP, SL, T	31.23	36	0.83	6/26	SL, T	3.94	6	0.76
5/5	SP, T	12.60	17	0.85	6/29	SP, SL, T	15.42	16	0.52
5/6	SP, T	19.17	19	0.46	6/30	SP, T	9.39	8	0.29
5/7	SP, T	24.72	21	0.23	7/1	SP, T	8.72	7	0.25
5/8	SP, SL, T	30.45	42	0.97	7/2	SP, T	9.06	10	0.60
5/9	SP, T	11.48	18	0.94	7/7	SP, SL, T	15.93	12	0.17
5/11	SP, T	11.10	12	0.56	7/8	SP, T	8.59	8	0.43
5/12	SP, T	13.15	15	0.67	7/9	SP, T	12.96	5	**0.01**
5/13	SP, T	7.51	13	0.95	7/10	SL, T	11.06	10	0.34
5/14	SP, SL, T	15.25	28	0.99	7/13	SP, SL, T	7.71	8	0.48
5/15	SP, T	14.09	14	0.46	7/14	SP, T	7.16	6	0.29
5/19	SP, T	11.08	12	0.57	7/15	SP, T	2.67	2	0.31
5/20	SP, SL, T	26.34	28	0.58	7/16	SP, T	4.37	6	0.74
5/21	SP, SL, T	23.46	26	0.63	7/17	SL, T	1.80	3	0.73
5/22	SL, T	9.63	11	0.58	7/20	SP, T	3.54	2	0.15
5/23	SP, T	11.53	11	0.39	7/21	SP, SL, T	2.75	4	0.64
5/24	SP, T	10.50	10	0.40	7/22	SP, T	16.72	6	**0.00**
5/25	SP, SL, T	19.86	18	0.31	7/23	SP, SL, T	12.68	12	0.38
5/26	SP, T	7.83	11	0.82					
5/27	SL, T	9.11	8	0.32					
5/28	SL, T	9.45	11	0.66					
6/1	SL, T	7.20	7	0.44					
6/2	SL, T	5.19	5	0.38					
6/3	SP, T	1.81	2	0.41					

[a] Comparing dates of arrival at Bonneville Dam among treatment groups, i.e., fish from different release sites where: SP = spillway, SL = sluiceway, and T = tailrace.

[b] Probability values were calculated using a Monte Carlo approximation of the exact method.

Table 6. Comparison of actual and simulated data for standard deviations and ranges of relative survival for juvenile salmon passing The Dalles Dam via the spillway, 1998.

$H_{0(7)}$: There is no difference between the observed and expected variability in data.						
Pooling factor	Standard deviation			Range		
	Observed	Simulated*	P	Observed	Simulated	P
Coho salmon						
Tag day	14.5%	12.1%	0.24	55.9%	52.9%	0.44
Tag day/spill pattern/ spillbay index combination	13.3%	12.3%	0.33	55.8%	57.9%	0.55
Subyearling chinook salmon						
Tag day	16.7%	12.0%	0.04	52.9%	45.6%	0.25
Tag day/spill pattern/ spillbay index combination	21.4%	15.7%	0.01	99.7%	69.6%	0.05
Without outlier (31% survival)						
Tag day/spill pattern/ spillbay index combination	19.8%	15.9%	0.07	76.0%	70.7%	0.37

* Results of 1,000 simulations. Median simulated standard deviations and ranges.

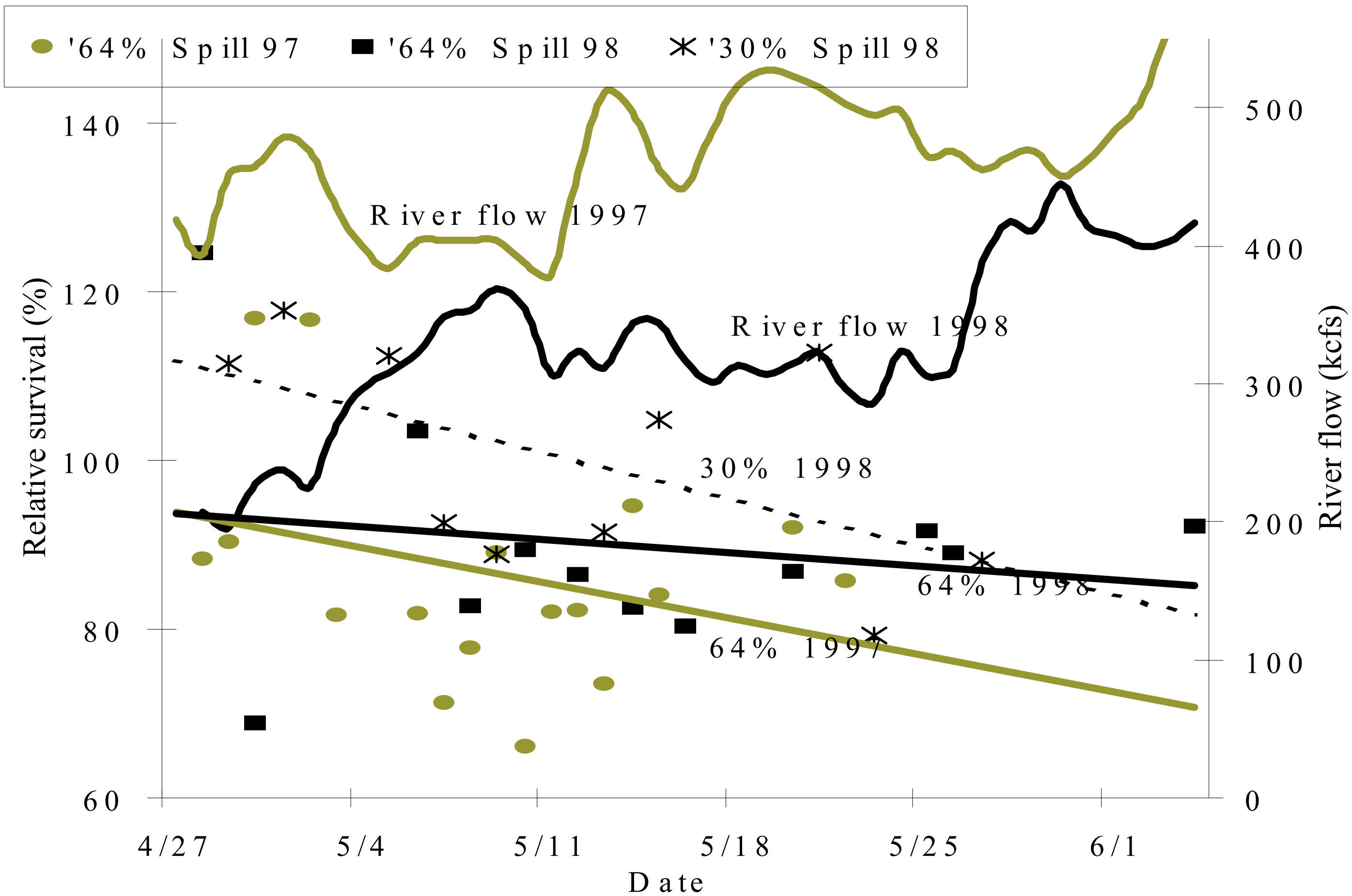

Figure 5. Relative spill passage survival of coho salmon and river flow through time at The Dalles Dam, 1997 and 1998.

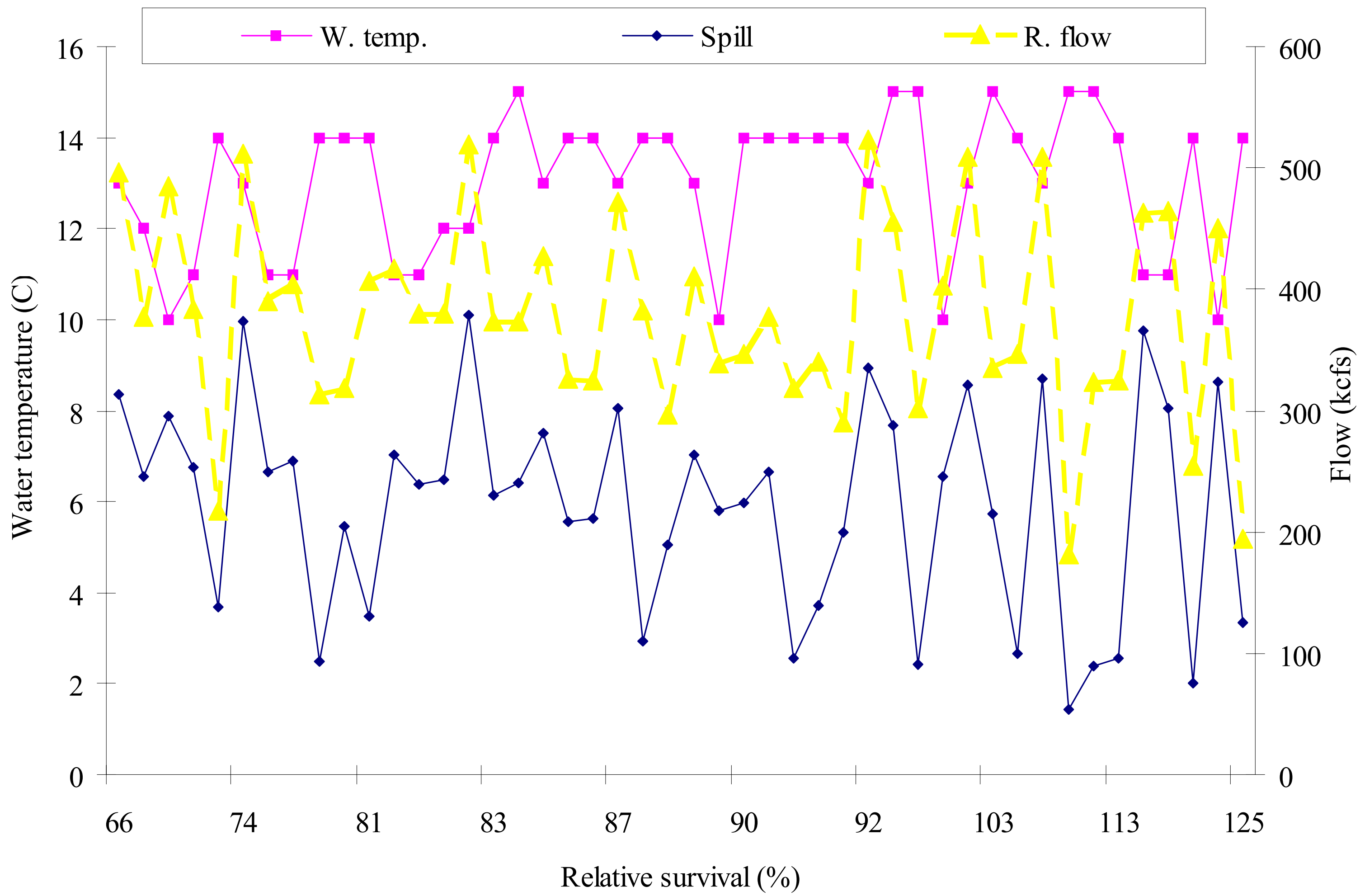

Figure 6a. Spill passage survival of coho salmon compared with water temperature, spill volume, and river flow at The Dalles Dam, 1997 and 1998.

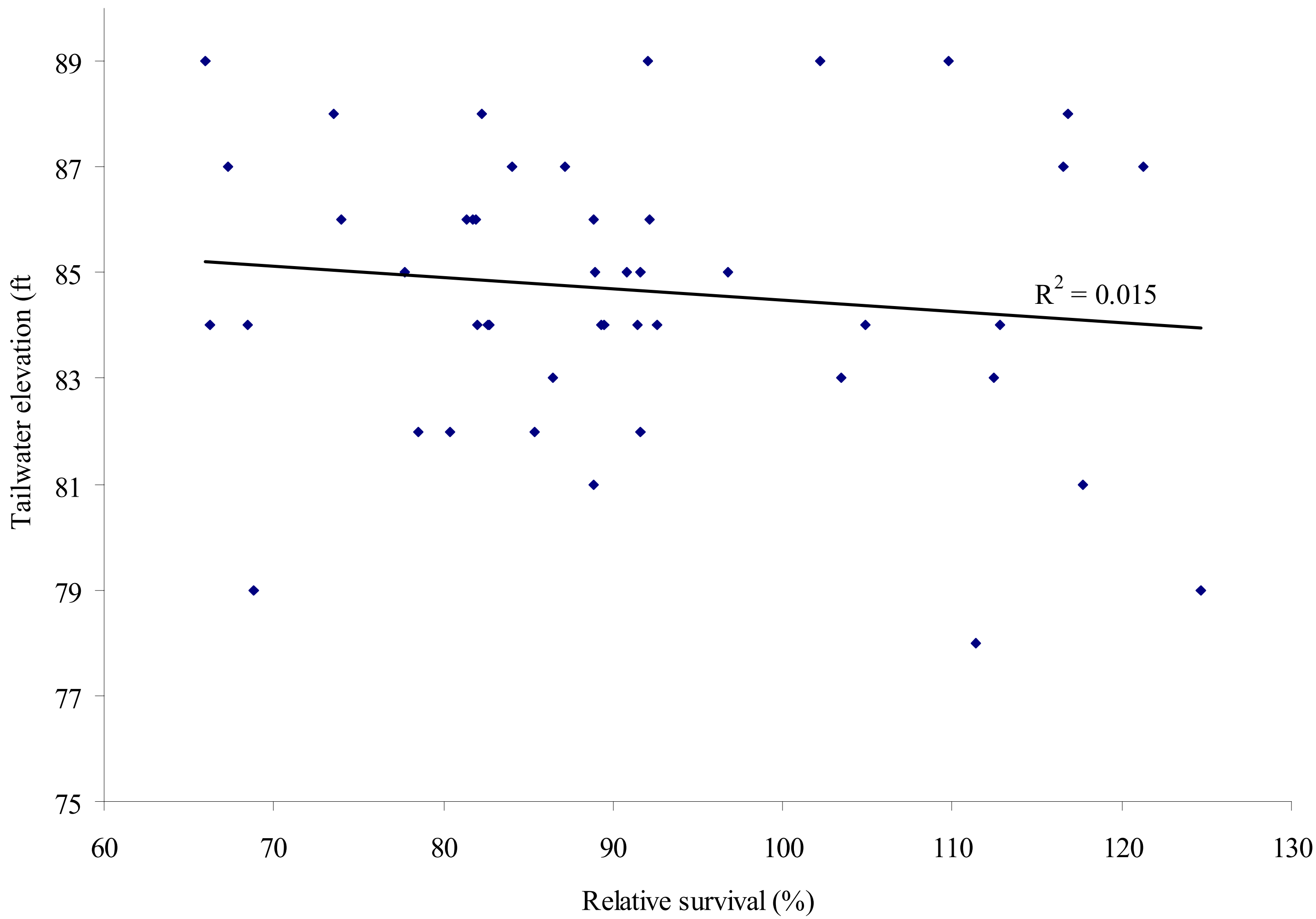

Figure 6b. Spill passage survival of coho salmon compared to tailwater elevation at The Dalles Dam, 1997 and 1998.

We noted with interest that PIT-tag surveys on gull rookeries upstream from The Dalles Dam detected approximately 0.2% of all spring-released tags in 1997 and in 1998, and that spillway released tags comprised 90% of the detected tags (Brad Ryan, NMFS, Northwest Fisheries Science Center, P.O. Box 155 Hammond, OR, 97121, Pers. commun., December 1999).

Summer Migration, Subyearling Chinook Salmon

On test days 23 June to 24 July during hours of release, river flow ranged from 4,447 to 8,555 m^3/second (157,000 to 302 ,000 ft^3/second). During hours of release, average spill ranged from 1,275 to 2,550 m^3/second (45,000 to 90,000 ft^3/second) for the 30% spill tests and 2,833 to 5,439 m^3/second (100,000 to 192,000 ft^3/second) for the 64% spill tests (Appendix Tables A3-A4). Of the 80,498 PIT-tagged subyearling chinook salmon released in this study, 5.9% (4,775 unique tags) were detected at one or more downstream sites (Table 1, Appendix Table A7). Of 33,971 PIT-tagged subyearling chinook salmon released at the reference location, just downstream from the Highway-197 bridge, 6.6% (2,227 unique tags) were detected. Of the 4,775 total detected PIT tags, 35% were detected at Bonneville Dam First Powerhouse, 46% were detected at Bonneville Dam Second Powerhouse, and 19% were detected at Rice Island.

The PIT-tag detection data were separated by detection site to evaluate relative survival differences between sites. We found that relative survival for 30% spill groups averaged 16% greater than for 64% spill groups as measured at Bonneville Dam ($P = 0.03$) and 7% greater as measured at Rice Island ($P = 0.68$). However, the survival estimates from detections at Bonneville Dam for both 30 and 64% spill groups (86.8 and 70.7%) were lower than those from detections at Rice Island (97.2 and 90.0%), respectively. Statistical analyses of the separated data are presented in Appendix Table B7. Paired *t*-tests of Ln relative survivals for daily releases measured at Bonneville Dam First Powerhouse vs. those measured at the Second Powerhouse and at Rice Island were not significantly different ($P = 0.66$ and 0.41, respectively). Paired *t*-tests of Ln relative survivals for daily releases measured at Bonneville Dam Second Powerhouse vs. those measured at Rice Island were not significantly different ($P = 0.15$). For all other analyses, we utilized the combined data from all recovery sites.

Survival Estimates

The point estimate (unweighted geometric mean for all release periods) of relative survival for spillway-released subyearling chinook salmon was 75.2% (CI 68.0-83.3%) at 64% spill and 89.1% (CI 80.0-99.4%) at 30% spill (Table 7). These point estimates represent passage survival of mixed fish stocks throughout the migration period during day and night, through spillbays across the width of the spillway, and at ambient spill-gate openings, river flows, tailwater elevations, and water temperatures.

Survival of fish released at 64% spill was significantly lower than survival of reference fish released downstream from the dam, whereas survival at 30% spill was not significantly different from that of reference fish. Survival at 64% spill was significantly lower than survival

Table 7. Detections of PIT-tagged subyearling chinook salmon released at The Dalles Dam in 1998, including relative survival percentages for daytime and nighttime passage through the spillway at 30 and 64% spill and daytime passage through the sluiceway at 30% spill.

	River		Spillway					Sluiceway		Tailrace Detections	
			Bay		Open	Det.	Surv.	Det	Surv.		
Release date	kcfs[a]	°C	no.	Loc.[b]	(ft)	no.[c]	(%)[d]	no.[c]	(%)[d]	no.	(%)[c]
30% Spill, Daytime Pattern											
6/24	263	17	1	N	3	60	110.4	49	90.5	54[e]	5.4
			14	S	2	53	97.7				
6/27	270	17						152	79.5	197	9.9
6/30	240	18	6	N	2	74	93.0	190	96.6	201	11.5
			23	S	3	76	68.1				
7/8	217	18	2	N	3	24	117.4	62	117.8	52	3.1
			8	M	3	32	104.9				
7/10	196	20	2	N	3	24	81.8			58	3.0
			8	M	3	30	103.2				
7/11	169	19						65	87.6	74	3.8
7/14	204	19	17, 20	S	1, 2	47	59.6[f]	62	78.4	79	8.0
7/18	196	21						37	87.7	41	4.2
7/22	195	21	10, 12	M	2, 2	34	57.0[f]	46	75.3	61	4.1
7/24	174	21	4	N	1	37	77.4	50	93.3	49	6.8
			19	S	1	29	60.0				
Total & Geometric Mean						520	83.3	713	88.9	866	5.4
30% Spill, Nighttime Pattern											
6/26	266	17	1	N	4	96	96.1			198	10.1
			14	S	2	99	98.9				
7/2	242	18	6	N	5	53	116.6			84[e]	4.7
			14	S	2	35	75.3				
7/16	209	21	4	N	4	36	106.5			65	6.9
			12	M	3	34	86.2				
7/24	174	21	10	M	3	40	131.1			33	4.7
Total & Geometric Mean						393	100.1			380	6.3
30% Total & Geometric Mean[g]						**913**	**89.1**	**713**	**88.9**	**1,246**	**5.8**
95% Confidence Interval							**80.0 - 99.4**		**80.6 - 98.0**		

Table 7. Continued.

	River		Spillway					Sluiceway		Tailrace Detections	
Release date	kcfs[a]	°C	Bay no.	Loc.[b]	Open (ft)	Det. no.[c]	Surv. (%)[d]	Det. no.	Surv. (%)[d]	no.	(%)[c]
					64% Spill, Daytime Pattern						
6/23	212	17	1	N	3	44	100.0	88[h]	86.4[h]	87	6.3
			14	S	4	37	86.9				
7/3	193	18	6	N	3	43	103.1			84[e]	4.2
			23	S	3	36	85.9				
7/9	214	19	2	N	3	14	71.2			19	4.0
			8	M	5	16	80.7				
7/15	214	21	8	M	5	53	63.4			70	9.1
7/17	186	21	17, 22	S	4, 3	35	55.1[f]			58	7.7
7/23	174	21	4	N	3	60	103.4			187	8.2
			12	M	3	19	31.4				
			19	S	3	37	60.3				
Total & Geometric Mean						394	72.8	88[h]	86.4[h]	505	6.3
					64% Spill, Nighttime Pattern						
6/25	275	17	1	N	7	97	107.3			181	9.1
			14	S	3	81	91.3				
7/1	258	18	6	N	10	23	69.5			38[f]	4.5
			18	S	2	26	83.1				
7/15	214	21	12	M	5	56	67.9			83	10.5
7/17	186	21	2	N	8	17	62.2			50	6.9
			8	M	7	15	59.1				
7/21	191	21	10	M	6	79	98.0			124	6.1
			14	S	3	46	80.8				
Total & Geometric Mean						440	78.4			476	7.1
64% Total & Geometric Mean[g]						**440**	**75.2**	**88[h]**	**86.4[h]**	**981**	**6.7**
95% Confidence Interval							**68.0 - 83.3**				

[a] Mean daily river flow; kcfs = thousand ft^3/sec.

[b] L = Location of spillbay assigned to a position of north, middle or south (N, M, S) for data analysis where bays 1-6 = N, 7-12 = M, and 13-23 = S.

[c] Number or percent of release which was detected at Bonneville Dam.

[d] Percent of treatment group detected divided by the percent of tailrace released fish detected times 100.

[e] Intermittent operation of the Bonneville Second Powerhouse ice and trash chute caused decreased detection rates. The ice and trash chute was not operated after 7/6/98.

[f] Within-day releases were combined for data analysis because index characterizations were identical.

[g] Geometric mean for day and night combined; not the same as Appendix Table B5.

[h] Unintentional release at 64% spill conditions.

at 30% spill ($P = 0.02$, Appendix Table B7). Relative survival of fish passing though the spillway decreased through time ($P < 0.01$). Relative survival percentages calculated for each test release ranged from 31.4 to 131.1%.

Numbers of subyearling chinook salmon test fish were sufficient to assess survival differences between treatment and reference groups at 30 and 64% spill, but were insufficient to fully evaluate survival effects related to other controlled and uncontrolled variables. However, we examined the data for survival trends related to other variables (Appendix Table B8).

Relative survival decreased significantly through the test period; $P < 0.01$. Relative survival differences among spill patterns (diel periods) and spillbay locations were significant at $P = 0.08$ and $P = 0.14$, respectively (Appendix Table B7). Interaction between spillbay location and both spill percent and diel release period appeared to be substantial, though not significant ($P = 0.07$ and 0.12, respectively). Means of relative survival for releases through the southern bays were generally low, but means through the northern bays were generally high (Appendix Table B7). Survival appeared unrelated to spill-gate opening (height of gate opening dictates the volume of spill, $P = 0.91$, Appendix Table B9).

The point estimate (geometric mean) for relative survival of sluiceway-released subyearling chinook salmon during daylight hours at 30% spill was 88.9% (CI 80.6-98.0%, Table 7). Sluiceway survival appeared to be no different from daytime spillway passage survival at 30% spill (Table 8, Fig. 7). In contrast, mean daytime passage survival at 64% spill was about 11% less than mean survival at 30% spill, but the difference was not significant.

Test fish body size at release was also evaluated as a variable affecting survival. We examined survival of test fish in relation to PIT-tag detection rates of daily release groups separated into two fork length categories: 110 mm or less and greater than 110 mm. Detection data from Bonneville Dam and Rice Island showed no significant differences in survival by fish size ($P = 0.35$ and 0.85, respectively; Appendix Table B10).

Variability Associated With the Experimental Process

To assess differences of temporal distribution among treatment groups (mixing), we compared travel times to and daily detection distributions at Bonneville Dam for daily release groups. To assess the variability of measured survival percentages, we compared ranges and standard deviations of the annual data sets for each species to those of simulated, binomially distributed data (1,000 simulations).

Travel times--The simplest method to evaluate whether mixing occurred among treatment groups was an assessment of travel time differences between treatment groups released during the same time period. Travel times through the 75-km river reach from The Dalles Dam to Bonneville Dam averaged about 1.8 days, with 80% detected in 2.4 days (Table 9). Travel time showed no change through the test period ($r = 0.10$) and was not correlated with river flow

Table 8. Relative survival comparison of subyearling chinook salmon passing the spillway during the day at 30 and 64% spill vs. the sluiceway at The Dalles Dam, 1998.

Tag day	Spillway at 64% daytime releases		Spillway at 30% daytime releases		Sluiceway daytime releases	
	Relative survival	Ln	Relative survival	Ln	Relative survival	Ln
6/22	1.000	0.000				
6/22	0.869	-0.140				
6/23			1.104	0.099	0.905	-0.100
6/23			0.977	-0.024		
6/26					0.795	-0.229
6/29			0.930	-0.072	0.966	-0.034
6/29			0.681	-0.385		
7/2	1.031	0.031				
7/2	0.859	-0.152				
7/7			1.174	0.160	1.178	0.164
7/7			1.049	0.048		
7/8	0.712	-0.340				
7/8	0.807	-0.214				
7/9			0.818	-0.201		
7/9			1.032	0.032		
7/10					0.876	-0.133
7/13			0.629	-0.464	0.784	-0.243
7/14	0.634	-0.456				
7/16	0.551	-0.596				
7/17					0.877	-0.131
7/21			0.594	-0.521	0.753	-0.284
7/22	1.034	0.033				
7/22	0.314	-1.158				
7/22	0.603	-0.506				
7/23			0.774	-0.256	0.933	-0.070
7/23			0.600	-0.511		
Geomean:	0.728	-0.318	0.840	-0.174	0.889	-0.118
SE:	0.078	0.107	0.060	0.072	0.040	0.045
95% CI:	0.574	0.923	0.717	0.984	0.801	0.986

Ratio: 64% spill to 30% spill			Ratio: 30% spill to sluice		
Geomean:	0.866	-0.144	Geomean:	0.945	-0.057
SE:	0.111	0.129	SE:	0.080	0.085
95% CI:	0.663	1.132	95% CI:	0.791	1.128
t:		-1.12	t:		-0.67
df:		21	df:		19
P:		0.2771	P:		0.5109

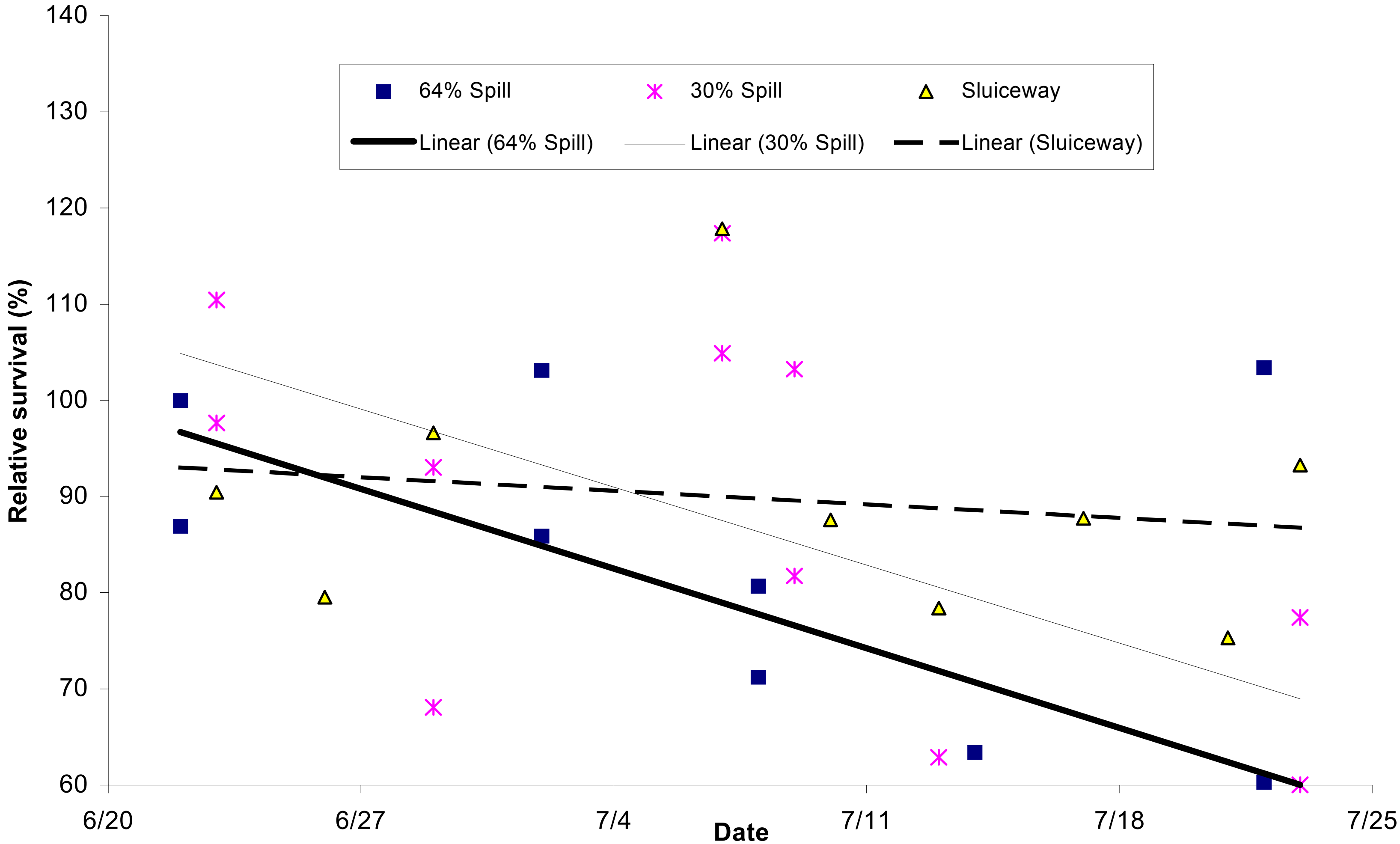

Figure 7. Daytime passage survival of subyearling chinook salmon through the spillway and sluiceway at 30% spill and spillway at 64% spill; The Dalles Dam, 1998.

Table 9. Comparison of median travel time in days from The Dalles Dam to Bonneville Dam, for daily treatment groups of subyearling chinook salmon, 1998.

Release		Sluiceway		Spillway		Tailrace		Daily groups combined*			Treatment groups combined		River flow
								Sluiceway	Spillway	Tailrace			
Date	Period	n	Days	n	Days	n	Days	Days	Days	Days	n	Days	(kcfs)
6/23	Day	68	1.99	40	2.23	76	2.24	1.99	2.28	2.24	210	2.17	211
	Day			26	2.35								
6/24	Day	40	1.47	47	1.41	47	1.74	1.47	1.70	1.74	175	1.66	263
	Day			41	2.04								
6/25	Night			92	1.66	83	1.34		1.68	1.22	329	1.45	275
	Night			70	1.70	84	1.10						
6/26	Night			91	1.66	96	1.47		1.70	1.45	362	1.58	266
	Night			94	1.75	81	1.43						
6/27	Day	68	1.52			93	1.45	1.51		1.47	316	1.49	270
	Day	70	1.51			85	1.49						
6/30	Day	94	1.50	71	1.49	99	1.46	1.50	1.49	1.46	496	1.55	242
	Day	80	1.46	67	1.46	85	1.92	1.46	1.46	1.92			
7/1	Night			13	2.70	21	2.04		2.06	2.07	56	2.07	258
	Night			18	1.60	4	2.25						
7/2	Night			36	1.94	29	1.42		1.94	1.42	127	1.74	242
	Night			26	1.90	36	1.67		1.90	1.67			
7/3	Day			26	1.58	32	1.51		1.53	1.48	118	1.50	193
	Day			32	1.49	28	1.45						
7/8	Day	25	1.48	27	1.67	14	1.43	1.81	1.81	1.71	124	1.78	239
	Day	21	2.21	14	2.08	23	1.89						
7/9	Day			11	1.72	12	2.02		1.76	2.02	31	1.86	214
	Day			8	1.83								
7/10	Day			20	2.79	18	2.69		3.03	2.71	75	2.86	196
	Day			16	3.33	21	2.73						
7/11	Day	28	2.39			29	2.81	2.41		2.48	105	2.45	169
	Day	20	2.43			28	2.15						
7/14	Day	50	1.48	9	1.45	57	1.44	1.48	1.46	1.44	136	1.46	204
	Day			20	1.46								
7/15	Day			45	1.51	60	1.51		1.51	1.51	105	1.51	214
7/15	Night			43	2.01	68	1.97		2.01	1.97	111	1.97	214
7/16	Night			22	1.97	30	1.82		1.87	1.86	111	1.87	209
	Night			28	1.80	31	1.91						
7/17	Day			12	1.48	42	1.47		1.49	1.71	101	1.66	186
	Day			10	1.51	37	1.98						
7/17	Night			9	1.98				1.95		18	1.95	186
	Night			9	1.92								

Table 9. Continued.

Release		Sluiceway		Spillway		Tailrace		Daily groups combined*			Treatment groups combined		River flow
								Sluiceway	Spillway	Tailrace			
Date	Period	n	Days	n	Days	n	Days	Days	Days	Days	n	Days	(kcfs)
7/18	Day	9	1.75			12	1.61	1.65		1.65	51	1.65	196
	Day	15	1.59			15	1.69						
7/21	Night			35	1.72	50	1.49		1.69	1.51	200	1.59	191
	Night			62	1.66	53	1.52						
7/22	Day	15	1.45	11	1.37	20	1.89	1.46	2.03	1.62	96	1.67	195
	Day	17	1.47	13	2.59	20	1.36						
7/23	Day			30	2.31	65	1.32		1.78	1.35	248	1.57	174
	Day			45	1.43	51	1.39						
	Day			16	1.41	41	1.86						
7/24	Day	43	1.50	20	1.45	39	1.44	1.50	1.44	1.44	133	1.46	174
	Day			31	1.44								
7/24	Night			35	1.76	23	1.93		1.76	1.93	58	1.83	174
Mean								1.66	1.81	1.73		1.77	

* *t*-test that travel time of sluiceway fish is not different from tailrace fish; P = 0.15.
t-test that travel time of spillway fish is not different from tailrace fish; P = 0.11.
t-test that travel time of sluiceway fish is not different from spillway fish; P = 0.15.
Correlation evaluation of combined travel time to river flow indicated little relationship; r = -0.23.
Correlation evaluation of combined travel time to Julian date indicated little relationship; r = 0.10.

(r = -0.23; Fig. 8). Mean travel times of daytime- and nighttime-released groups were identical. Tailrace-released reference groups arrived at Bonneville Dam slightly earlier than spillway groups (0.08 days, P = 0.11) and later than sluiceway groups (0.07 days, P = 0.15), but the differences were not significant (Table 9).

Temporal detection distributions--The homogeneity of passage distributions at Bonneville Dam (PIT-tag detections through time) for corresponding spillway-, sluiceway-, and tailrace-released groups of subyearling chinook salmon was evaluated. Based on a chi-square test, spillway and tailrace groups did not arrive at Bonneville Dam at the same time for 3 of 22 release periods (Table 5); however, even with complete mixing, we would expect about 1 violation in 20 tests in relation to 95% probability testing. Evaluation of release groups failing the mixing test showed that spillway groups passed Bonneville Dam about 1 day later than tailrace groups (Appendix Table B11). Although these data present limited evidence that mixing did not occur on three test dates, we would not expect to see large survival differences between groups associated with a travel-time difference of 1 day.

Variability by date--We assessed variability in detection percentages among release groups to determine whether data were within expected ranges. The analysis compared actual to a simulated binomial distribution of detection proportions by tag day and by combinations of tag day, spill pattern, and spillbay index for relative spillway passage survival. The SDs and ranges of the observed data were significantly larger than those of the simulated data (tag-day range was not significant; P = 0.25). When an outlier (31%) was extracted, the probabilities for no difference between the observed and simulated SD and range for tag day, spill pattern, and spillbay indices increased to 0.07 and 0.37 respectively (Table 6). Extracting the outlier changed the overall mean less than 2%. Based on this analysis, it appears that relative survival data variability was somewhat greater than would be expected for binomial data. However, the variation associated with the observed data was expected to be greater than that of a binomial distribution because of the many uncontrolled variables discussed above.

Comparison with 1997 Results and Trends for Combined Data

The point estimate for passage survival at 64% spill in 1998 was much lower than in 1997. We evaluated fish-handling differences as much as possible and have no reason to suspect that the differences are from testing procedures. However, variation in survival between years could be related to differences in fish stocks and their physical condition, and/or interactions between river volumes and spill percentage or predator abundance. Survival trends for both years of data showed a decrease through the test period (Fig. 9).

Point estimates of survival for daytime releases ranged from 6 to 17% less than those for nighttime releases. Because variability was high, differences in combined 1997 and 1998 data were not significant (P = 0.07, Appendix Table B5).

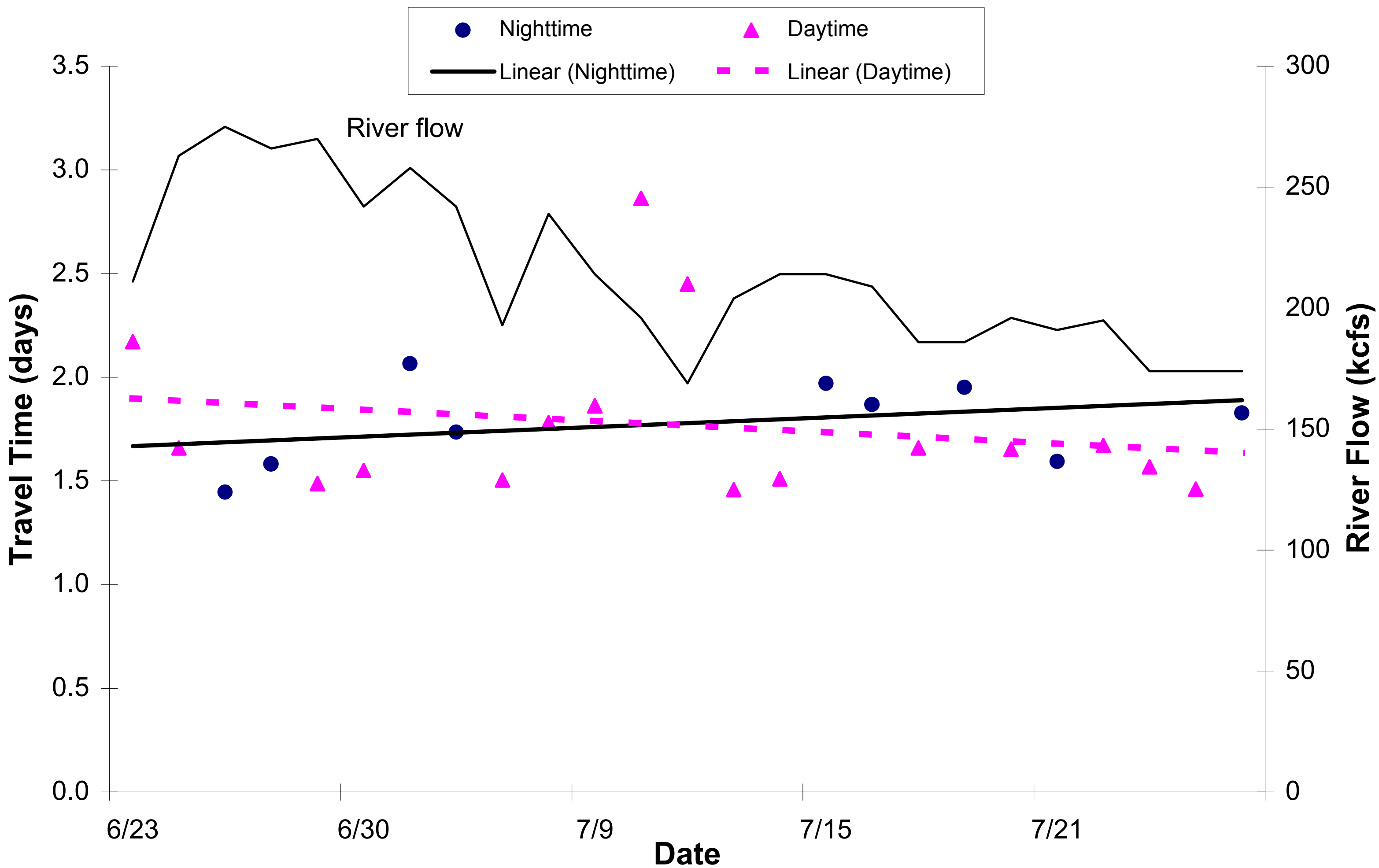

Figure 8. Travel time of subyearling chinook salmon from The Dalles Dam to Bonneville Dam compared to river flow, 1998.

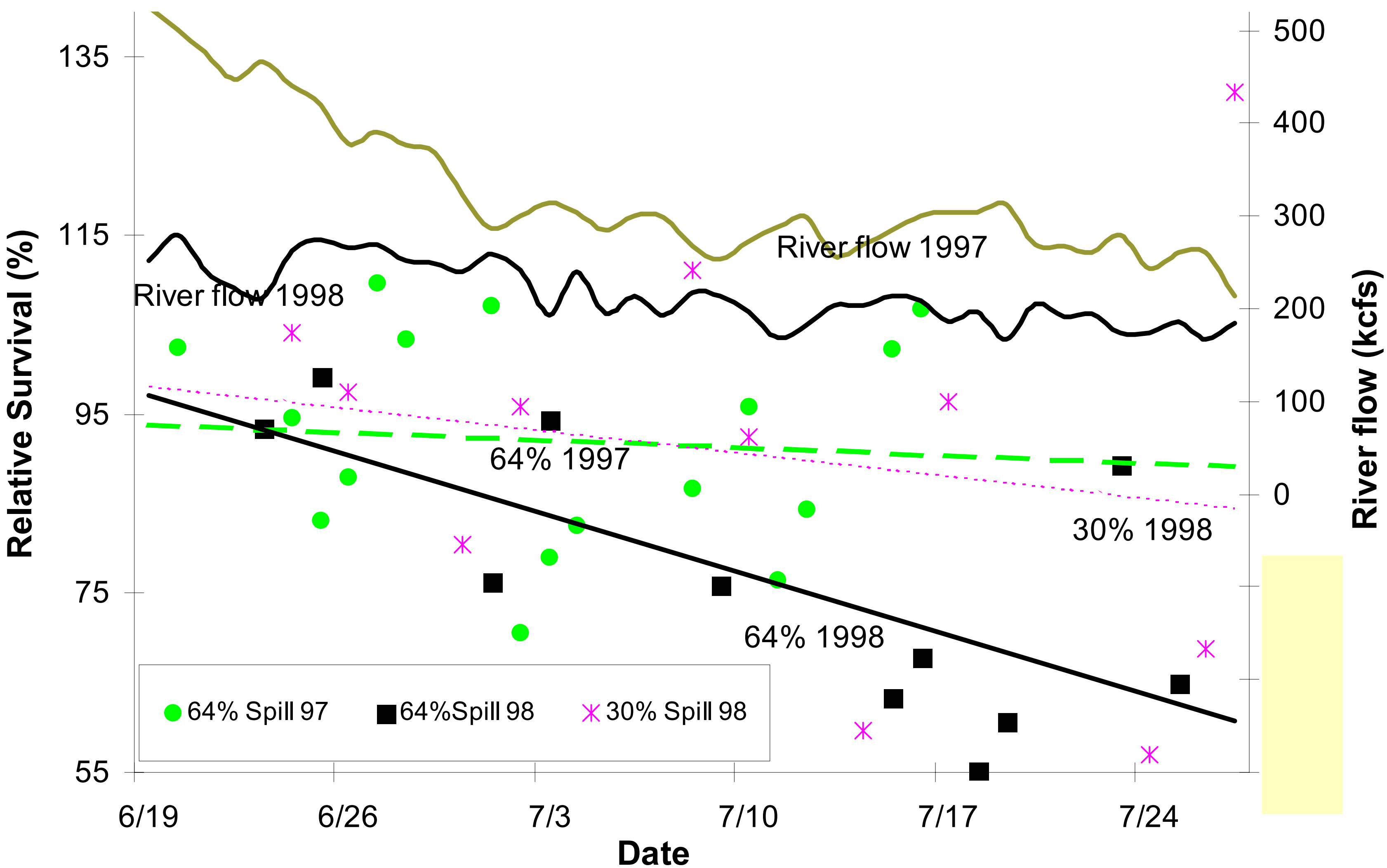

Figure 9. Relative spill passage survival of subyearling chinook salmon and river flow through time at The Dalles Dam, 1997 and 1998.

In both 1997 and 1998, travel times for daily groups of tailrace-released subyearling chinook salmon groups were slightly less (0.3 and 0.1 days, respectively) than those of spillway-released fish groups.

Evaluation of survival in relation to water temperature, spill levels, river flow, and tailwater elevation showed poor correlation, r = -0.44, 0.30, 0.41, and 0.43, respectively, for summer tests using subyearling chinook salmon (Fig. 10, Appendix Table B6).

We noted with interest that PIT-tag surveys on gull rookeries upstream from The Dalles Dam detected approximately 0.05% of all spring released tags in 1997 and in 1998 (Brad Ryan, NMFS, Northwest Fisheries Science Center, P.O. Box 155, Hammond, OR 97121, Pers. commun., December 1999). Spillway-released fish comprised 90% of these detections.

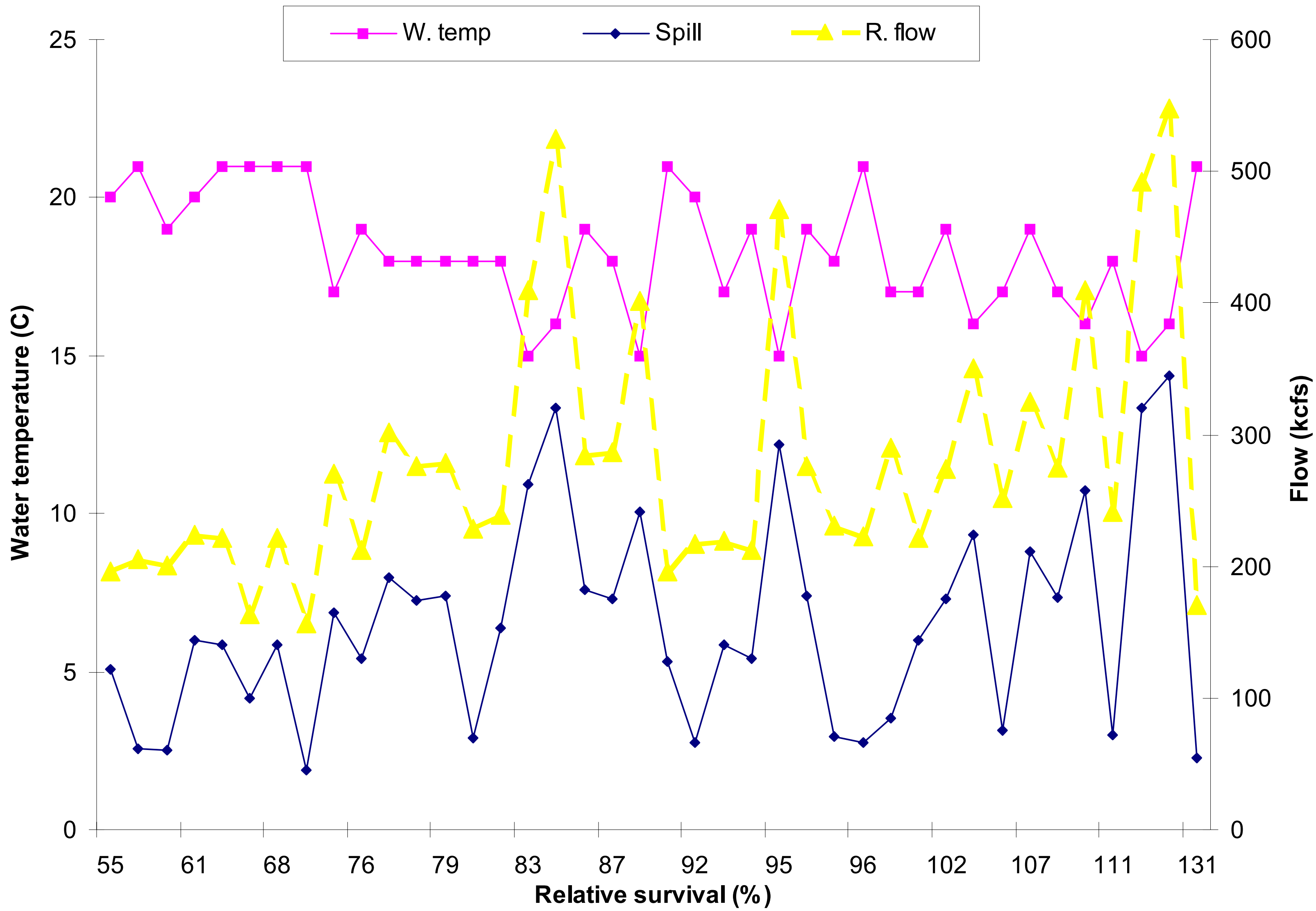

Figure 10a. Spill passage survival of subyearling chinook salmon compared with water temperature spill volume, and river flow at The Dalles Dam, 1997 and 1998.

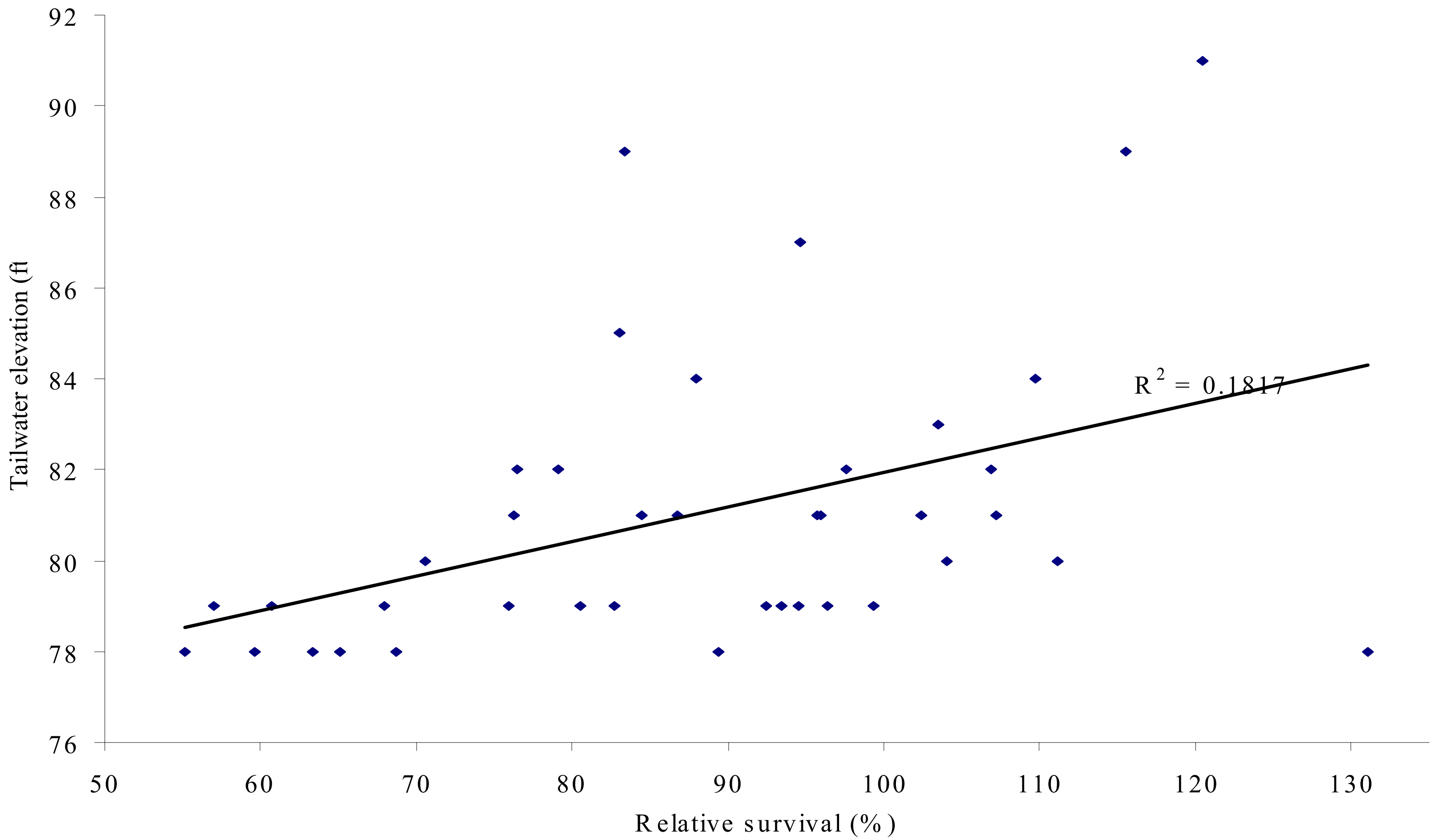

Figure 10b. Spill passage survival of subyearling chinook salmon compared with tailwater elevation at The Dalles Dam, 1997 and 1998.

DISCUSSION

We noted differences in the average survival estimates based on whether detections at Bonneville Dam, Jones Beach, or the piscivorous bird colonies in the estuary were used in the analyses. It is not surprising that we observe differences between the various PIT tag recovery sites. This is because Bonneville Dam, the Jones Beach pair-trawl, and bird colonies on estuarine islands each utilize different sample mechanisms (guidance screen, towed trawl net, and bird feeding behavior) and each is subject to sampling bias associated with that mechanism.

We speculate that differences in detection probabilities at Bonneville Dam could be related to poor spacial mixing of reference and treatment fish groups, with fish staying oriented to the side of the river on which they were released. For example, survival estimates would be lower at Bonneville Second Powerhouse and higher at the First Powerhouse, as was observed in 1998, if reference fish detections were more likely at Bonneville Second Powerhouse and treatment group detections were more likely at Bonneville First Powerhouse. Diel changes in test fish depth distribution at Bonneville Dam coupled with arrival time differences may have caused differences in detection rate probability between reference and treatment groups. Survival estimates based on PIT tag detections on bird colonies are influenced by whether the treatment and reference groups are completely mixed (pass the islands at the same time and at the same depth) and the foraging behavior of the avian predators.

In summary, the estimates based on detections at Bonneville Dam were generally lower than those based on detections from the other sites. However, in estimates based on detections at all sites combined, the differences between 30 and 64% spill and day and night releases generally trended in the same direction, with 30% spill and nighttime releases producing the highest estimates of relative survival. Based on a cursory evaluation, we believe that hourly operations at Bonneville Dam did not systematically affect the estimates. Based on consistent trends through the 2 years of study we are confident that combining data from all detection sites provides a data set that reasonably represents relative fish survival differences between test conditions. In 1999 we will analyze PIT-tag detections and water flow operations at Bonneville Dam for1997, 1998, and 1999 to test for bias in detections from this site.

From the two years of study, the results that appear important to operations at The Dalles Dam are as follows:

1) Detection rates of fish passing through the spillway at 64% spill were significantly less than for fish released downstream from the dam.

2) Estimated spillway passage survival for juvenile salmon at 64% spill was lower than at other dams and similar to or lower than survival expected for turbine passage (NMFS 1999). During testing, spring flows ranged from 5,099 to 14,929 m^3/second (180,000 to 527,000 ft^3/second) and summer flows ranged from 4,447 to 14,986 m^3/second (157,000 to 529,000 ft^3/second).

3) The estimated relative survival rates for fish passing at 64% spill were substantially lower than for fish passing at 30% spill; significantly for subyearling chinook salmon.

4) Relative survivals for daytime fish passage through the sluiceway were similar to those of daytime fish passage through the spillway at 30% spill (1998 testing only).

5) Spillway passage of subyearling chinook salmon during daytime hours with adult spill patterns produced substantially lower survival than passage during nighttime hours with juvenile spill patterns.

6) Evaluations of survival in relation to tailwater elevation, spill volume, river flow, and water temperature indicated weak correlations for both spring and summer tests.

Although the study was designed to produce a point estimate of survival for each passage condition (spillway passage at 64% spill and 30% spill and daytime sluiceway passage at 30% spill), we also evaluated survival percentages among individual releases. In so doing, it appeared that variation among survival estimates of individual release groups was extraordinarily high. However, we believe this variation is not beyond the expected range because of the dynamics of test conditions and the low PIT-tag detection rate.

We expected rates of injury and predation to change through time in association with passage conditions and predation. Predation by northern pikeminnow (*Ptychocheilus oregonensis*) generally increases through time because of increased water temperature and changes in location due to predator migration and variation in prey availability (Hansel et al. 1993). Avian predation may also have changed through time for similar reasons (Jones et al. 1997). Certainly, conditions at the tailrace changed with river flow and dam operations, and a major premise of this study was that some passage conditions produce diminished survival. We believe that these uncontrolled variables resulted in high variation within and between years.

Based on radiotelemetry data from 1997 (Snelling and Mattson 1998), we speculated that longer travel times to Bonneville Dam for spillway-released fish over those of tailrace-released fish were caused by delays during migration through the Bridge Islands and the Basin Islands on the south side of the river downstream from the dam. We designed the study with the belief that it was more important for the various treatment groups to enter the tailrace downstream from The Dalles Dam at the same time than to arrive at Bonneville Dam at the same time. Because of the rapidity with which single groups passed Bonneville Dam (average 3 and 2.4 days for 80% passage of spring and summer test fish, respectively), we believe there were no systematic errors imparted to the relative survival data due to temporal changes in dam operations.

RECOMMENDATIONS

1) In 1999, tests should repeat the relative survival evaluation for 30 and 64% spill conditions during the spring and summer fish migrations. Additionally, the sluiceway assessment should be eliminated to allow an increase in statistical sensitivity of further spill tests by maximizing test fish numbers.

2) In 2000, tests should evaluate a constant spill rate at less than 64% with juvenile spill patterns in effect 24 hours/day; these tests should include evaluation of sluiceway survival. Maximum fish numbers should be used to obtain the highest possible statistical sensitivity.

3) Evaluations of PIT tags deposited in estuarine bird rookeries and from the PIT-tag detector trawl off Jones Beach should be continued to provide increased detection numbers.

4) Assessment of differences between detection sites and evaluation of combined data from 1997, 1998, and future years should be continued.

5) Operation of the sluice chute during testing compromised PIT-tag detection rates for this study. Therefore, operation of the sluice chute at Bonneville Dam Second Powerhouse should be minimized during future testing in order to maximize the number of PIT-tags detected at Bonneville Dam.

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APPENDICES

Appendix A: Release Numbers, Dates, Times, Locations, and Conditions for Juvenile Coho and Subyearling Chinook Salmon at The Dalles Dam in 1998

Appendix Table A1. Times, dates, and conditions during daylight releases of juvenile coho salmon at The Dalles Dam, 1998.

Date	4/28	4/29	5/1	5/5	5/8	5/9	5/10	5/14	5/15	5/20
Start time	1300	1120	1040	1035	1045	1030	1015	1030	1025	1035
End time	1320	1147	1121	1113	1130	1130	1035	1040	1125	1058
Median time	1310	1133	1100	1054	1107	1100	1025	1035	1055	1046
Turbine low[a]	63	121	174	226	126	266	117	137	228	112
Turbine high[a]	63	121	174	229	130	267	117	137	254	112
Turbine mean[a]	63	121	174	228	128	267	117	137	241	112
Spill low[a]	125	54	75	90	240	109	224	230	100	208
Spill high[a]	125	54	75	90	240	110	224	230	100	208
Spill mean[a]	125	54	75	90	240	110	224	230	100	208
Spill %[b]	64	30	29	28	64	29	65	62	29	64
Temp. °C[c]	14	15	14	15	15	14	14	14	14	14
Elev. forebay[d]	158	158	159	158	159	159	159	159	159	159
Elev. tailwater[d]	79	78	81	83	84	86	84	84	84	82

Gate openings at release (feet)

Site[e]	4/28	4/29	5/1	5/5	5/8	5/9	5/10	5/14	5/15	5/20	Location
Bay 1										3	
Bay 2			3				5				
Bay 3									3		North
Bay 4											
Bay 5											
Bay 6											
Bay 7											
Bay 8					8	3					
Bay 9											Mid-North
Bay 10											
Bay 11											
Bay 12								8	3		
Bay 13											
Bay 14											
Bay 15				2						7	Mid-South
Bay 16											
Bay 17											
Bay 18											
Bay 19											
Bay 20											South
Bay 21											
Bay 22	3	2									
Bay 23					3						

Appendix Table A1. Continued.

Date	5/21	5/23	5/23	5/25	5/26	5/27	5/29	5/29	6/2	6/3
Start time	1149	1055	1320	1102	1115	1035	1036	1202	1020	1030
End time	1245	1205	1350	1222	1205	1120	1050	1230	1040	1055
Median time	1217	1130	1335	1142	1140	1057	1043	1216	1030	1042
Turbine low[a]	222	211	214	93	102	261	297	301	257	239
Turbine high[a]	223	216	214	93	102	281	297	301	257	239
Turbine mean[a]	223	214	214	93	102	271	297	301	257	239
Spill low[a]	96	94	94	200	189	130	125	125	111	110
Spill high[a]	96	94	94	200	189	130	125	125	111	110
Spill mean[a]	96	94	94	200	189	130	125	125	111	110
Spill %[b]	30	30	30	69	64	32	29	29	30	31
Temp. °C[c]	14	14	14	14	14	14	14	14	14	15
Elev. forebay[d]	158	160	159	158	158	158	158	158	158	159
Elev. tailwater[d]	84	82	82	82	81	86	87	87	86	84

Gate openings at release (feet)

Site[e]	5/21	5/23	5/23	5/25	5/26	5/27	5/29	5/29	6/2	6/3	Location
Bay 1	3										
Bay 2											
Bay 3				2							North
Bay 4											
Bay 5											
Bay 6		3									
Bay 7											
Bay 8											
Bay 9											Mid-North
Bay 10				8							
Bay 11											
Bay 12			Sluiceway Only				Sluiceway Only	Sluiceway Only	Sluiceway Only	Sluiceway Only	
Bay 13											
Bay 14											
Bay 15											Mid-South
Bay 16											
Bay 17					5	4					
Bay 18											
Bay 19											
Bay 20											South
Bay 21		2			4						
Bay 22											
Bay 23	2										

a Thousand cubic feet per second (kcfs); English units by COE convention.
b Percent of river flow in kcfs.
c Temperature during holding.
d Units in feet; English units by COE convention.
e Bay 1 is to the north and Bay 23 to the south.

Appendix Table A2. Times, dates, and conditions during nighttime releases of juvenile coho salmon at The Dalles Dam, 1998.

Date	4/30	5/6	5/7	5/12	5/13	5/16	5/27	5/27	6/4
Start time	2220	2225	2220	2235	2240	2235	2255	2320	2240
End time	2225	0020	2355	2310	2320	2320	2255	2320	2255
Median time	2223	2323	2307	2252	2300	2257	2255	2320	2247
Turbine low[a]	75	109	191	95	201	107	194	121	161
Turbine high[a]	75	121	219	122	233	107	194	121	161
Turbine mean[a]	75	115	205	109	217	107	194	121	161
Spill low[a]	138	209	83	197	87	205	140	250	288
Spill high[a]	138	220	98	224	104	205	140	250	288
Spill mean[a]	138	215	91	211	96	205	140	250	288
Spill % [b]	63	64	30	65	30	64	41	66	63
Temp. °C[c]	14	15	15	14	14	14	14	14	15
Elev. forebay[d]	158	158	159	158	157	159	158	158	157
Elev. tailwater[d]	79	83	84	83	84	82	85	84	86

Gate openings at release (feet)

Site[e]	4/30	5/6	5/7	5/12	5/13	5/16	5/27	5/27	6/4	Location
Bay 1		7	4							
Bay 2	7									North
Bay 3						9		10		
Bays 4-6										
Bay 7										
Bay 8				10	5					
Bay 9										
Bay 10							6			Mid-North
Bay 11										
Bay 12						8				
Bay 13										
Bay 14					2					
Bay 15		6	1							Mid-South
Bays 16, 17										
Bay 18										
Bay 19				2						
Bays 20-22										South
Bay 23									5	

a Thousand cubic feet per second (kcfs); English units by COE convention.
b Percent of river flow in kcfs.
c Temperature during holding.
d Units in feet; English units by COE convention.
e Bay 1 is to the north and Bay 23 to the south.

Appendix Table A3. Times, dates, and conditions during daylight releases of subyearling chinook salmon at The Dalles Dam, 1998.

Date	6/23	6/24	6/27	6/30	7/3	7/8	7/9	7/10	7/11
Start time	1137	1047	1052	1014	1028	1115	1010	1025	1015
End time	1240	1147	1118	1206	1100	1251	1020	1105	1039
Median time	1208	1117	1105	1110	1044	1203	1015	1045	1027
Turbine low[a]	73	169	169	135	76	163	76	144	130
Turbine high[a]	73	172	173	171	76	164	76	146	130
Turbine mean[a]	73	171	171	153	76	164	76	145	130
Spill low[a]	140	75	77	60	130	72	130	66	58
Spill high[a]	140	75	77	80	130	72	130	66	58
Spill mean[a]	140	75	77	70	130	72	130	66	58
Spill % [b]	64	30	30	31	61	30	61	30	30
Temp. °C[c]	17	17	17	18	18.5	18	19	20	19
Elev. forebay[d]	157	159	159	159	159	159	157	158	159
Elev. tailwater[d]	79	80	81	80	79	80	79	79	79

Gate openings at release (feet)

Site[e]	6/23	6/24	6/27	6/30	7/3	7/8	7/9	7/10	7/11	Location
Bay 1	3	3								
Bay 2						3	3	3		
Bay 3										North
Bay 4										
Bay 5										
Bay 6				2	3					
Bay 7										
Bay 8						3	5	3		
Bay 9										Middle
Bay 10										
Bay 11										
Bay 12			Sluiceway Only						Sluiceway Only	
Bay 13										
Bay 14	4	2								
Bay 15										
Bay 16										
Bay 17										
Bay 18										South
Bay 19										
Bay 20										
Bay 21										
Bay 22										
Bay 23				3	3					

Appendix Table A3. Continued.

Date	7/14	7/15	7/17	7/18	7/22	7/23	7/24
Start time	1032	1015	1040	1012	1035	1036	1008
End time	1140	1015	1110	1040	1222	1237	1138
Median time	1106	1015	1055	1026	1128	1136	1053
Turbine low[a]	134	75	68	126	137	58	106
Turbine high[a]	135	75	68	126	139	58	106
Turbine mean[a]	135	75	68	126	138	58	106
Spill low[a]	60	141	122	59	61	100	45
Spill high[a]	60	141	122	59	61	100	45
Spill mean[a]	60	141	122	59	61	100	45
Spill %[b]	30	63	62	31	30	61	29
Temp. ^{o}C[c]	19	21	20	21	21	21	21.5
Elev. forebay[d]	159	159	158	158	159	158	158
Elev. tailwater[d]	78	79	78	79	79	78	78

Gate openings at release (feet)

Site[e]	7/14	7/15	7/17	7/18	7/22	7/23	7/24	Location
Bay 1								
Bay 2								
Bay 3								
Bay 4						3	1	North
Bay 5								
Bay 6								
Bay 7								
Bay 8		5						
Bay 9								
Bay 10					2			Middle
Bay 11								
Bay 12				Sluiceway Only	2	3		
Bay 13								
Bay 14								
Bay 15								
Bay 16								
Bay 17	1		4					
Bay 18								South
Bay 19						3	1	
Bay 20								
Bay 21								
Bay 22	2		3					
Bay 23								

a Thousand cubic feet per second (kcfs); English units by COE convention.
b Percent of river flow in kcfs.
c Temperature during holding.
d Units in feet; English units by COE convention.
e Bay 1 is to the north and Bay 23 to the south.

Appendix Table A4. Times, dates, and conditions during nighttime releases of subyearling chinook salmon at The Dalles Dam, 1998.

Date	6/25	6/26	7/1	7/2	7/15	7/16	7/17	7/21	7/24
Start time	2227	2244	2218	2230	2155	2210	2232	2230	2205
End time	2255	2315	2250	2305	2205	2250	2245	2319	2223
Median time	2241	2259	2234	2247	2200	2230	2238	2254	2214
Turbine low[a]	72	186	104	132	75	151	74	60	111
Turbine high[a]	72	213	104	177	75	151	74	65	111
Turbine mean[a]	72	200	104	155	75	151	74	63	111
Spill low[a]	144	80	192	60	140	66	144	128	54
Spill high[a]	144	90	192	81	140	66	144	128	54
Spill mean[a]	144	85	192	71	140	66	144	128	54
Spill %[b]	65	29	64	30	63	30	64	65	32
Temp. °C[c]	17	17	18	18	21	21	21	21	21
Elev. forebay[d]	160	158	159	158	159	157	158	159	158
Elev. tailwater[d]	79	82	81	81	79	79	79	78	78

Gate openings at release (feet)

Site[e]	6/25	6/26	7/1	7/2	7/15	7/16	7/17	7/21	7/24	Location
Bay 1	7	4								
Bay 2							8			
Bay 3										
Bay 4						4				North
Bay 5										
Bay 6			10	5						
Bay 7										
Bay 8							7			
Bay 9										
Bay 10								6	3	Middle
Bay 11										
Bay 12					5	3				
Bay 13										
Bay 14	3	2		2				3		
Bay 15										
Bay 16										South
Bay 17										
Bay 18			2							
Bays 19-23										

a Thousand cubic feet per second (kcfs); English units by COE convention.
b Percent of river flow in kcfs.
c Temperature during holding.
d Units in feet; English units by COE convention.
e Bay 1 is to the north and Bay 23 to the south.

Appendix Table A5. Water velocities at the location of fish releases at The Dalles Dam spillway, 1998. Release sites were between pier-noses of each spill bay, about 7 m upstream from the gate and 3- to 4-m deep, depending on the gate opening.

		Water velocity at designated depth	
Gate opening (ft)	Flow* (ft^3/second)	1-m depth (m/second)	5-m depth (m/second)
3	4,500	0.3	0.4
4	6,800	0.5	0.5
5	7,500	0.6	0.7
6	9,000	0.9	0.9
8	12,000	1.0	1.1
10	15,000	1.2	1.4
12	18,000	1.5	1.5

* Units of measure in English units by COE convention.

Appendix Table A6. Releases, detections, proportions, and survival percentages for coho salmon at each site, separated by passage conditions during release at The Dalles Dam, 1998.

Tag date	Rel[a] date	Rel no.	Bonneville 1 Det[c]	Bonneville 1 Prop[d]	Bonneville 2 Det	Bonneville 2 Prop	Jones Beach Det	Jones Beach Prop	Rice Island Det	Rice Island Prop	Total[b] Det	Total[b] Prop
Tailrace, daytime 30% spill condition												
4/28	4/29	104	7	0.067	8	0.077	0		4	0.038	20	0.192
4/30	5/1	174	11	0.063	12	0.069	4	0.023	4	0.023	29	0.167
5/4	5/5	516	26	0.050	35	0.068	9	0.017	15	0.029	84	0.163
5/8	5/9	850	63	0.074	19	0.022	13	0.015	38	0.045	128	0.151
5/14	5/15	811	46	0.057	43	0.053	4	0.005	25	0.031	115	0.142
5/14	5/15											
5/20	5/21	1,048	48	0.046	68	0.065	0		59	0.056	170	0.162
5/20	5/21											
5/21	5/23	1,065	40	0.038	120	0.113	3	0.003	61	0.057	217	0.204
5/21	5/23											
5/22	5/23	1,199	36	0.030	103	0.086	4	0.003	79	0.066	209	0.174
5/22	5/23											
5/25	5/27	1,027	38	0.037	88	0.086	0		48	0.047	170	0.166
5/27	5/29	989	69	0.070	45	0.046	0		40	0.040	149	0.151
5/28	5/29	990	49	0.049	51	0.052	1	0.001	38	0.038	133	0.134
5/28	5/29	995	37	0.037	48	0.048	1	0.001	35	0.035	119	0.120
6/1	6/2	468	63	0.135	8	0.017	0		22	0.047	92	0.197
6/2	6/3	648	63	0.097	20	0.031	1	0.002	27	0.042	107	0.165
6/2	6/3											
Total/mean[e]		10,884	596	0.056	668	0.053	40	0.004	495	0.041	1,742	0.162
Tailrace, nighttime 30% spill condition												
5/6	5/7	721	68	0.094	43	0.060	11	0.015	24	0.033	143	0.198
5/6	5/7	713	67	0.094	43	0.060	9	0.013	24	0.034	140	0.196
5/12	5/13	1,146	83	0.072	76	0.066	9	0.008	55	0.048	215	0.188
5/12	5/13											
5/26	5/27	997	48	0.048	30	0.030	0		61	0.061	136	0.136
Total/mean		3,577	266	0.075	192	0.052	29	0.011	164	0.043	634	0.178

Appendix Table 6. Continued.

Tag date	Rel date	Rel no.	Bonneville 1 Det	Bonneville 1 Prop	Bonneville 2 Det	Bonneville 2 Prop	Jones Beach Det	Jones Beach Prop	Rice Island Det	Rice Island Prop	Total Det	Total Prop
Tailrace, daytime 64% spill condition												
4/27	4/28	133	12	0.090	9	0.068	0		3	0.023	24	0.180
5/7	5/8	1,000	69	0.069	87	0.087	12	0.012	35	0.035	195	0.195
5/7	5/8											
5/9	5/10	836	72	0.086	76	0.091	8	0.010	46	0.055	192	0.230
5/13	5/14	274	17	0.062	22	0.080	1	0.004	12	0.044	51	0.186
5/13	5/14	279	11	0.039	22	0.079	2	0.007	14	0.050	47	0.168
5/19	5/20	1,040	44	0.042	79	0.076	10	0.010	52	0.050	177	0.170
5/19	5/20											
5/23	5/25	791	24	0.030	117	0.148	3	0.004	38	0.048	178	0.225
5/23	5/25	1,223	45	0.037	164	0.134	2	0.002	71	0.058	272	0.222
5/24	5/26	953	24	0.025	49	0.051	1	0.001	37	0.039	108	0.113
5/24	5/26	988	26	0.026	49	0.050	4	0.004	40	0.040	117	0.118
Total/mean		7,517	344	0.046	674	0.082	43	0.005	348	0.043	1,361	0.176
Tailrace, nighttime 64% spill condition												
4/29	4/30	219	13	0.059	22	0.100	3	0.014	6	0.027	44	0.201
5/5	5/6	1,083	83	0.077	37	0.034	25	0.023	21	0.019	157	0.145
5/5	5/6	343	24	0.070	11	0.032	6	0.017	10	0.029	50	0.146
5/11	5/12	918	106	0.115	55	0.060	6	0.007	33	0.036	197	0.215
5/11	5/12											
5/15	5/16	655	55	0.084	46	0.070	9	0.014	33	0.050	137	0.209
5/15	5/16											
5/26	5/27	1,120	53	0.047	35	0.031	0		68	0.061	150	0.134
6/3	6/4	590	28	0.047	63	0.107	0		28	0.047	117	0.198
Total/mean		4,928	362	0.068	269	0.055	49	0.014	199	0.036	852	0.175

Appendix Table A6. Continued.

Tag date	Release date	Release no.	Release loc	Bonneville 1 Det	Bonneville 1 S (%)[f]	Bonneville 2 Det	Bonneville 2 S (%)	Jones Beach Det	Jones Beach S (%)	Rice Island Det	Rice Island S (%)	Total Det	Total S (%)
Spillway, daytime 30% spill condition													
4/28	4/29	98	S	8	121.3	8	106.1	0		7	185.7	21	111.4
4/30	5/1	260	N	20	121.7	22	122.7	3	50.2	11	184.0	51	117.7
5/4	5/5	519	MS	22	84.1	45	127.8	10	110.5	20	132.6	95	112.4
5/8	5/9	822	MN	51	83.7	21	114.3	12	95.5	29	78.9	110	88.9
5/14	5/15	470	N	33	123.8	20	80.3	3	129.4	17	117.3	69	103.5
5/14	5/15	465	MN	26	98.6	18	73.0	2	87.2	25	174.4	70	106.2
5/20	5/21	437	N	24	119.9	33	116.4	0		31	126.0	81	114.3
5/20	5/21	631	S	35	121.1	50	122.1	1		36	101.3	114	111.4
5/21	5/23	861	N	29	89.7	63	64.9	3	123.7	61	123.7	149	84.9
5/21	5/23	783	S	24	81.6	55	62.3	3	136.0	39	87.0	115	72.1
5/22	5/23												
5/22	5/23												
5/25	5/27	1,024	MS	30	79.2	68	77.5	0		45	94.0	138	81.4
5/27	5/29												
5/28	5/29												
5/28	5/29												
6/1	6/2												
6/2	6/3												
6/2	6/3												
Total/mean		6,370		302	100.6	403	93.8	37	100.1	321	122.7	1,013	99.2
Spillway, nighttime 30% spill condition													
5/6	5/7	578	N	54	99.2	30	86.5	8	99.2	16	82.7	102	89.4
5/6	5/7	698	MS	69	105.0	41	97.9	8	82.2	18	77.0	132	95.8
5/12	5/13	489	MN	33	93.2	31	95.6	3	78.1	19	81.0	83	90.5
5/12	5/13	490	MS	48	135.3	23	70.8			16	68.0	85	92.5
5/26	5/27	1,193	MN	55	95.8	40	111.4	2		58	79.5	149	91.6
Total/mean		3,448		259	104.7	165	91.4	21	86.0	127	77.5	551	91.9

Appendix Table A6. Continued.

Tag date	Release date	Release no.	Release loc	Bonneville 1 Det	Bonneville 1 S (%)[f]	Bonneville 2 Det	Bonneville 2 S (%)	Jones Beach Det	Jones Beach S (%)	Rice Island Det	Rice Island S (%)	Total Det	Total S (%)
Spillway, daytime 64% spill condition													
4/27	4/28	240	S	15	69.3	30	184.7	1	---	8	147.8	54	124.7
5/7	5/8	980	MN	74	109.4	61	71.5	10	85.0	38	110.8	174	91.1
5/7	5/8	993	S	70	102.2	51	59.0	9	75.5	23	66.2	144	74.4
5/9	5/10	827	N	71	99.7	59	78.5	7	88.5	39	85.7	170	89.5
5/13	5/14	984	MN	52	104.4	53	67.7	5	93.7	43	92.9	144	82.6
5/13	5/14												
5/19	5/20	558	N	28	118.6	36	84.9	1	18.6	32	114.7	92	96.9
5/19	5/20	557	MS	19	80.6	32	75.6	3	56.0	19	68.2	70	73.8
5/23	5/25	1,290	N	43	97.3	175	97.2	4	124.9	51	73.0	264	91.6
5/23	5/25	1,123	MN	32	83.2	154	98.3	4	143.5	53	87.2	230	91.7
5/24	5/26	986	MS	18	70.9	50	100.4	1	39.4	37	94.6	104	91.0
5/24	5/26	984	S	27	106.5	48	96.6	1	39.5	25	64.0	99	86.8
Total/mean		9,522		449	93.4	749	88.1	46	65.9	368	90.7	1,545	89.5
Spillway, nighttime 64% spill condition													
4/29	4/30	217	N	10	77.6	16	73.4	1	33.6	3	50.5	30	68.8
5/5	5/6	993	N	74	99.3	46	137.6	13	60.2	27	125.1	150	104.1
5/5	5/6	509	MS	38	99.5	18	105.1	7	63.3	16	144.6	76	102.9
5/11	5/12	444	MN	37	72.2	24	90.2	1	34.5	23	144.1	81	85.0
5/11	5/12	403	S	33	70.9	25	103.5	4	151.9	19	131.2	76	87.9
5/15	5/16	652	N	46	84.0	37	80.8	5	55.8	24	73.1	107	78.5
5/15	5/16	662	MN	54	97.1	38	81.7	5	55.0	25	75.0	114	82.3
5/26	5/27	1,192	N	51	90.4	39	104.7	0		57	78.8	145	90.8
6/3	6/4	580	S	35	127.2	43	69.4	0		31	112.6	106	92.2
Total/mean		5,652		378	89.5	286	92.1	36	57.4	225	98.1	885	87.4

Appendix Table A6. Continued.

Sluiceway, daytime 30% spill condition												
Tag	Rel	Rel	Bonneville 1		Bonneville 2		Jones Beach		Rice Island		Total	
date	date	no.	Det	S (%)	Det	S (%)	Det	S (%)	Det	S (%)	Det	S (%)
4/28	4/29	100	7	104.0	9	117.0	1		4	104.0	20	104.0
4/30	5/1	148	6	64.1	23	225.3	0		5	147.0	33	133.8
5/4	5/5	518	41	157.1	44	125.2	5	55.3	12	79.7	99	117.4
5/8	5/9	826	62	101.3	20	108.3	10	79.2	28	75.8	111	89.2
5/14	5/15	810	38	82.7	40	93.1	5	125.2	29	116.1	111	96.6
5/14	5/15											
5/20	5/21	1,058	56	115.6	50	72.8	0		57	95.7	155	90.3
5/20	5/21											
5/21	5/23	1,062	38	95.3	83	69.4	3	100.3	43	70.7	159	73.5
5/21	5/23											
5/22	5/23	1,054	38	120.1	82	90.6	6	170.6	46	66.2	163	88.7
5/22	5/23	1,115	50	149.4	84	87.7	3	80.7	47	64.0	178	91.6
5/25	5/27	1,038	35	91.1	86	96.7	0		56	115.4	171	99.5
5/27	5/29	564	31	78.8	15	58.5	0		22	96.4	66	77.7
5/28	5/29	997	37	85.7	38	76.4	1	99.5	42	114.5	115	90.9
5/28	5/29	1,015	53	120.5	35	69.1	2	195.6	50	133.9	134	104.0
6/1	6/2	492	73	110.2	4	47.6	0		21	90.8	94	97.2
6/2	6/3	650	57	90.2	15	74.8	0		34	125.5	105	97.8
6/2	6/3	649	52	82.4	20	99.8	0		32	118.3	98	91.4
Total/mean		12,096	674	100.3	648	88.5	36	105.0	528	97.9	1,812	95.5

[a] Rel = Release

[b] Total (used for combined analysis) is the number of unique tags observed at any of the sites. Multiple observations of a tag are not counted. Numbers observed at individual sites may include tags observed at other sites, and these data are used to make the inter-site comparisons.

[c] Det = Detected (number of fish detected).

[d] Prop = Proportion detected (number of fish detected ÷ number of fish released).

[e] mean is geometric mean

[f] S(%) = Survival percentage (detected proportion of spillway- or sluiceway-released fish ÷ detected proportion of tailrace-released fish x 100).

Appendix Table A7. Releases, detections, proportions, and survival percentages for chinook salmon at each site, separated by passage conditions during release at The Dalles Dam, 1998.

Tag date	Release date	Number released	Bonneville 1 Det[b]	Bonneville 1 Prop[c]	Bonneville 2 Det	Bonneville 2 Prop	Rice Island Det	Rice Island Prop	Total[a] Det	Total[a] Prop
Tailrace, daytime 30% spill condition										
6/23	6/24	993	15	0.015	32	0.032	8	0.008	54	0.054
6/23	6/24									
6/26	6/27	991	15	0.015	78	0.079	9	0.009	102	0.103
6/26	6/27	992	14	0.014	71	0.072	11	0.011	95	0.096
6/29	6/30	978	13	0.013	86	0.088	9	0.009	107	0.109
6/29	6/30	763	15	0.020	70	0.092	10	0.013	94	0.123
7/7	7/8	706	3	0.004	11	0.016	10	0.014	23	0.033
7/7	7/8	985	7	0.007	16	0.016	6	0.006	29	0.029
7/9	7/10	966	11	0.011	7	0.007	8	0.008	26	0.027
7/9	7/10	982	14	0.014	7	0.007	11	0.011	32	0.033
7/10	7/11	989	13	0.013	16	0.016	12	0.012	41	0.041
7/10	7/11	979	15	0.015	13	0.013	6	0.006	33	0.034
7/13	7/14	988	13	0.013	44	0.045	22	0.022	79	0.080
7/13	7/14									
7/17	7/18	485	6	0.012	6	0.012	8	0.016	19	0.039
7/17	7/18	491	7	0.014	8	0.016	7	0.014	22	0.045
7/21	7/22	735	8	0.011	12	0.016	9	0.012	29	0.039
7/21	7/22	769	4	0.005	16	0.021	12	0.016	32	0.042
7/23	7/24	722	20	0.028	19	0.026	11	0.015	49	0.068
7/23	7/24									
Total/mean[d]		14,514	193	0.012	512	0.024	169	0.011	866	0.052
Tailrace, nighttime 30% spill condition										
6/25	6/26	991	29	0.029	67	0.068	11	0.011	106	0.107
6/25	6/26	964	30	0.031	51	0.053	11	0.011	92	0.095
7/1	7/2	964	18	0.019	11	0.011	14	0.015	43	0.045
7/1	7/2	836	22	0.026	14	0.017	5	0.006	41	0.049
7/15	7/16	476	20	0.042	10	0.021	3	0.006	33	0.069
7/15	7/16	470	23	0.049	8	0.017	2	0.004	32	0.068
7/23	7/24	702	23	0.033	0		11	0.016	33	0.047
Total/mean		5,403	165	0.031	161	0.025	57	0.009	380	0.065

Appendix Table A7. Continued.

Tag date	Release date	Number released	Bonneville 1 Det	Bonneville 1 Prop	Bonneville 2 Det	Bonneville 2 Prop	Rice Island Det	Rice Island Prop	Total Det	Total Prop.
Tailrace, daytime 64% spill condition										
6/22	6/23	1,382	46	0.033	30	0.022	11	0.008	87	0.063
6/22	6/23									
7/2	7/3	990	19	0.019	13	0.013	15	0.015	47	0.047
7/2	7/3	1,004	18	0.018	10	0.010	9	0.009	37	0.037
7/8	7/9	478	5	0.010	7	0.015	7	0.015	19	0.040
7/8	7/9									
7/14	7/15	771	24	0.031	36	0.047	10	0.013	70	0.091
7/16	7/17	755	28	0.037	14	0.019	16	0.021	58	0.077
7/16	7/17									
7/22	7/23	788	47	0.060	18	0.023	13	0.016	77	0.098
7/22	7/23	749	43	0.057	8	0.011	6	0.008	57	0.076
7/22	7/23	747	32	0.043	9	0.012	13	0.017	53	0.071
Total/mean		7,664	262	0.030	145	0.017	100	0.013	505	0.063
Tailrace, nighttime 64% spill condition										
6/24	6/25	997	25	0.025	58	0.058	8	0.008	91	0.091
6/24	6/25	999	27	0.027	57	0.057	6	0.006	90	0.090
6/30	7/1	721	13	0.018	8	0.011	9	0.012	30	0.042
6/30	7/1	119	2	0.017	2	0.017	5	0.042	8	0.067
7/14	7/15	787	46	0.058	22	0.028	17	0.022	83	0.105
7/16	7/17	725	17	0.023	20	0.028	13	0.018	50	0.069
7/16	7/17									
7/20	7/21	953	28	0.029	22	0.023	12	0.013	62	0.065
7/20	7/21	1,089	30	0.028	23	0.021	9	0.008	62	0.057
Total/mean		6,390	188	0.026	212	0.026	79	0.013	476	0.071

Appendix Table A7. Continued.

Tag date	Release date	Release no	Release loc	Bonneville 1 Det	Bonneville 1 S (%)[e]	Bonneville 2 Det	Bonneville 2 S (%)	Rice Island Det	Rice Island S (%)	Total Det	Total S (%)
Spillway, daytime 30% spill condition											
6/23	6/24	999	N	17	112.7	30	93.2	13	161.5	60	110.4
6/23	6/24	998	S	10	66.3	31	96.4	12	149.2	53	97.7
6/26	6/27										
6/26	6/27										
6/29	6/30	689	N	13	117.3	54	87.5	8	106.4	74	93.0
6/29	6/30	967	S	13	83.6	58	66.9	5	47.4	76	68.1
7/7	7/8	665	N	6	152.6	8	75.3	10	158.9	24	117.4
7/7	7/8	992	M	9	153.4	18	113.6	5	53.3	32	104.9
7/9	7/10	986	N	6	47.4	10	141.1	8	83.2	24	81.8
7/9	7/10	976	M	11	87.8	9	128.3	10	105.0	30	103.2
7/10	7/11										
7/10	7/11										
7/13	7/14	494	S	4	61.5	5	22.7	9	81.8	18	45.6
7/13	7/14	492	S	7	108.1	13	59.3	9	82.2	29	73.7
7/17	7/18										
7/17	7/18										
7/21	7/22	757	M	1	16.6	10	71.0	3	28.4	14	45.6
7/21	7/22	714	M	5	87.8	8	60.2	7	70.2	20	69.1
7/23	7/24	704	N	15	76.9	16	86.4	6	55.9	37	77.4
7/23	7/24	712	S	11	55.8	9	48.0	9	83.0	29	60.0
Total/mean		11,145		128	77.8	279	75.5	114	81.4	520	78.7
Spillway, nighttime 30% spill condition											
6/25	6/26	986	N	28	94.1	63	105.9	5	45.1	96	96.1
6/25	6/26	988	S	35	117.4	59	98.9	6	54.0	99	98.9
7/1	7/2	974	N	23	106.3	13	96.1	17	165.4	53	116.6
7/1	7/2	996	S	14	63.3	12	86.7	9	85.6	35	75.3
7/15	7/16	492	N	22	98.4	6	64.1	9	346.1	36	106.5
7/15	7/16	574	M	17	65.2	5	45.8	12	395.5	34	86.2
7/23	7/24	649	M	31	145.8	4	---	6	59.0	40	131.1
Total/mean		5,659		170	94.9	162	79.7	64	115.7	393	100.1

Appendix Table A7. Continued.

Tag date	Release date	Release no	Release loc	Bonneville 1 Det	Bonneville 1 S (%)[e]	Bonneville 2 Det	Bonneville 2 S (%)	Rice Island Det	Rice Island S (%)	Total Det	Total S (%)
Spillway, daytime 64% spill condition											
6/22	6/23	699	N	26	111.7	14	92.3	6	107.8	44	100.0
6/22	6/23	676	S	13	57.8	13	88.6	12	223.0	37	86.9
7/2	7/3	990	N	17	92.5	15	131.4	11	92.3	43	103.1
7/2	7/3	995	S	13	70.4	13	113.3	10	83.5	36	85.9
7/8	7/9	495	N	7	135.2	1	13.8	6	82.8	14	71.2
7/8	7/9	499	M	7	134.1	4	54.7	5	68.4	16	80.7
7/14	7/15	921	M	15	52.3	30	69.8	8	67.0	53	63.4
7/16	7/17	356	S	5	37.9	7	106.0	6	79.5	18	65.8
7/16	7/17	471	S	5	28.6	5	57.2	7	70.1	17	47.0
7/22	7/23	709	N	36	95.1	9	82.8	16	161.1	60	103.4
7/22	7/23	738	M	10	25.4	6	53.1	3	29.0	19	31.4
7/22	7/23	749	S	22	55.0	8	69.7	7	66.7	37	60.3
Total/mean		8,298		176	65.0	125	69.1	97	83.9	394	71.2
Tailrace, Nighttime 64% spill condition											
6/24	6/25	997	N	36	138.6	56	97.5	5	71.5	97	107.3
6/24	6/25	978	S	30	117.7	40	71.0	13	189.5	81	91.3
6/30	7/1	732	N	11	84.2	7	80.3	6	49.2	23	69.5
6/30	7/1	692	S	7	56.6	6	72.8	13	112.7	26	83.1
7/14	7/15	782	M	30	65.6	13	59.5	13	77.0	56	67.9
7/16	7/17	396	N	2	21.5	7	64.1	8	112.7	17	62.2
7/16	7/17	368	M	5	57.9	4	39.4	6	90.9	15	59.1
7/20	7/21	1,327	M	26	69.0	36	123.1	18	131.9	79	98.0
7/20	7/21	938	S	17	63.8	18	87.1	11	114.0	46	80.8
Total/mean		7,210		164	67.2	187	73.8	93	98.7	440	78.4

Appendix Table A7. Continued.

			Sluiceway, daytime 30% spill condition							
Tag date	Release date	Number released	Bonneville 1 Det	Bonneville 1 S (%)	Bonneville 2 Det	Bonneville 2 S (%)	Rice Island Det	Rice Island S (%)	Total Det	Total S (%)
6/23	6/24	996	8	53.2	32	99.7	10	124.6	49	90.5
6/23	6/24									
6/26	6/27	968	19	134.1	49	67.2	10	101.4	77	80.0
6/26	6/27	956	15	107.2	55	76.4	5	51.3	75	78.9
6/29	6/30	935	19	121.7	75	89.5	9	85.5	103	95.1
6/29	6/30	768	17	132.5	63	91.5	7	81.0	87	97.8
7/7	7/8	729	7	153.6	18	154.6	9	110.9	34	151.3
7/7	7/8	982	10	162.9	11	70.1	7	64.0	28	92.5
7/9	7/10									
7/9	7/10									
7/10	7/11	993	14	98.5	14	94.8	11	109.3	39	103.4
7/10	7/11	981	9	64.1	11	75.4	6	60.4	26	69.7
7/13	7/14	989	16	123.0	34	77.2	13	59.0	62	78.4
7/13	7/14									
7/17	7/18	530	3	42.3	6	77.5	5	61.1	14	62.6
7/17	7/18	474	6	94.6	9	129.9	8	109.2	23	115.0
7/21	7/22	770	6	86.7	9	61.9	7	64.2	21	67.2
7/21	7/22	736	7	105.8	10	71.9	8	76.7	25	83.7
7/23	7/24	790	26	118.8	17	81.8	7	58.2	50	93.3
7/23	7/24									
Total/mean		12,597	182	100.3	413	85.3	122	77.9	713	88.7
			Sluiceway, daytime 64% spill condition							
6/22	6/23	1,618	42	78.0	26	74.0	21	163.1	88	86.4
Total/mean		1,618	42	86.2	26	95.7	21	100.5	88	86.0

[a] Total (used for combined analysis) is the number of unique tags observed at any of the sites. Multiple observations of a tag are not counted. Numbers observed at individual sites may include tags observed at other sites, and these data are used to make the inter-site comparisons.
[b] Det = Detected (number of fish detected).
[c] Prop = Proportion detected (number of fish detected ÷ number of fish released).
[d] mean is geometric mean
[e] S = Survival percentage (detected proportion of spillway- or sluiceway-released fish ÷ detected proportion of tailrace-released fish x 100).

Appendix B Statistical Analyses of Pit-Tag Interrogation Data, Fork Length Data, and Passage Condition Data in Relation to Relative Survival for The Dalles Dam Juvenile Passage Survival Study

Appendix Table B1. Analysis of variance for log-transformed relative survival proportions derived for coho salmon passing through the spillway and sluiceway at The Dalles Dam, 1998.

All recoveries

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.05183	0.04150	0.04150	1.82	0.191
Diel	1	0.03247	0.01081	0.01081	0.47	0.499
Spill (%)	1	0.05142	0.01824	0.01824	0.80	0.381
Bay index	3	0.00816	0.00312	0.00104	0.05	0.987
Diel × Spill (%)	1	0.00238	0.00680	0.00680	0.30	0.591
Diel × Bay index	3	0.04909	0.04156	0.01385	0.61	0.618
Spill (%) × Bay index	3	0.00539	0.00539	0.00180	0.08	0.971
Error	22	0.50251	0.50251	0.02284		
Total	35	0.70327				

Term	Coef	SE	T	P
Constant	0.4787	0.4225	1.13	0.269
Julian day	-0.004214	0.003126	-1.35	0.191

Least Squares Means* for Ln (Spill Survival)

	Mean	SE	Back transformed Mean	Back transformed SE	95% CI
Diel					
1 (Daytime)	-0.0639	0.0332	0.9381	0.0311	0.8758 to 1.0049
2 (Nighttime)	-0.1054	0.0502	0.9000	0.0452	0.8110 to 0.9987
Spill (%)					
1 (30%)	-0.0575	0.0482	0.9441	0.0455	0.8544 to 1.0433
2 (64%)	-0.1118	0.0363	0.8942	0.0324	0.8294 to 0.9641
Bay index					
1 (North)	-0.0856	0.04781	0.9180	0.0438	0.8314 to 1.0135
2 (N. Mid)	-0.1015	0.05111	0.9035	0.0461	0.8127 to 1.0044
3 (S. Mid)	-0.0803	0.05891	0.9228	0.0544	0.8167 to 1.0428
4 (South)	-0.0713	0.0775	0.9312	0.0722	0.7929 to 1.0936

The regression equation is: Ln (Sluice Survival) = 1.04 - 0.00779 × (Julian day)

Term	Coef	SD	T	P
Constant	1.0374	0.4419	2.35	0.039
Julian day	-0.007788	0.003195	-2.44	0.033

R^2 (adj) = 29.2%

Appendix Table B1. Continued.

Bonneville and Jones Beach Recoveries Only

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.03152	0.02824	0.02824	1.02	0.323
Diel	1	0.01014	0.00050	0.00050	0.02	0.894
Spill (%)	1	0.06914	0.05606	0.05606	2.03	0.168
Bay index	3	0.01474	0.01002	0.00334	0.12	0.947
Diel × Spill (%)	1	0.02193	0.01244	0.01244	0.45	0.509
Diel × Bay index	3	0.02775	0.02728	0.00909	0.33	0.804
Spill (%) × Bayindex	3	0.00056	0.00056	0.00019	0.01	0.999
Error	22	0.60667	0.60667	0.02758		
Total	35	0.78246				

Term	Coef	SE	T	P
Constant	0.3965	0.4795	0.83	0.417
Julian day	-0.003583	0.003540	-1.01	0.323

Least Squares Means* for Ln (Spill Survival)

			Back transformed	
Diel	Mean	SE	Mean	SE
1 (Daytime)	-0.0781	0.03639	0.9249	0.0337
2 (Nighttime)	-0.0868	0.05311	0.9169	0.0487
Spill (%)				
1 (30%)	-0.0361	0.05071	0.9645	0.0489
2 (64%)	-0.1289	0.0403	0.8791	0.0354
Bay index				
1 (North)	-0.0833	0.049	0.9201	0.0451
2 (N. MID)	-0.1083	0.0561	0.8974	0.0503
3 (S. MID)	-0.0914	0.06478	0.9127	0.0591
4 (South)	-0.0469	0.08591	0.9542	0.0820

The regression equation is: Ln (Sluice Surv.) = 1.47 - 0.0109 × (Julian day)

Term	Coef	SE	T	P
Constant	1.4729	0.4508	3.27	0.008
Julian day	-0.010920	0.003259	-3.35	0.006

R^2 (adj) = 46.0%

Appendix Table B1. Continued.

Rice Island Recoveries Only

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.28250	0.42829	0.42829	5.22	0.032
Diel	1	0.20481	0.03615	0.03615	0.44	0.514
Spill (%)	1	0.08812	0.02554	0.02554	0.31	0.582
Bay index	3	0.06130	0.14967	0.04989	0.61	0.617
Diel × Spill (%)	1	0.59561	0.24001	0.24001	2.93	0.101
Diel × bay index	3	0.40731	0.37512	0.12504	1.53	0.236
Spill (%) × bay index	3	0.20613	0.20613	0.06871	0.84	0.487
Error	22	1.80371	1.80371	0.08199		
Total	35	3.64950				

Term	Coef	SE	T	P
Constant	1.8632	0.8267	2.25	0.035
Julian day	-0.013952	0.006104	-2.29	0.032

Least Squares Means* for Ln (Spill Survival)

Diel		Mean	SE	Back transformed Mean	Back transformed SE
1	(Day)	0.03472	0.06275	1.0353	0.0650
2	(Night)	-0.0389	0.09157	0.9618	0.0881
Spill (%)					
1	(30%)	0.02924	0.08744	1.0297	0.0900
2	(64%)	-0.03342	0.06949	0.9671	0.0672
Bay index					
1	(North)	-0.08421	0.08449	0.9192	0.0777
2	(N. MID.)	-0.0036	0.09672	0.9964	0.0964
3	(S. MID.)	-0.05654	0.1117	0.9450	0.1056
4	(South)	0.136	0.14813	1.1457	0.1697

The regression equation is: Ln (Sluice Surv) = 0.030 - 0.00041 × (Julian day)

Term	Coef	SE	T	P
Constant	0.0303	0.8539	0.04	0.972
Julian day	-0.000409	0.006173	-0.07	0.948

R^2 (adj) = 0.0%

* Least square means are not equal to the raw data means due to an unbalanced experimental design.

Appendix Table B2. Analysis of variance for log-transformed relative survival proportions derived for coho salmon passing through the spillway at various spillway gate openings, The Dalles Dam, 1998.

SPILL GATE OPENINGS--All Recoveries

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.05872	0.02498	0.02498	1.42	0.245
Diel	1	0.03520	0.00490	0.00490	0.28	0.602
Spill (%)	1	0.06647	0.00700	0.00700	0.40	0.534
Gate index	2	0.06503	0.04422	0.02211	1.26	0.302
Diel × Spill (%)	1	0.00018	0.00179	0.00179	0.10	0.753
Diel × gate index	2	0.05390	0.05225	0.02613	1.49	0.246
Spill (%) × gate index	2	0.00649	0.00649	0.00325	0.18	0.833
Error	25	0.43961	0.43961	0.01758		
Total	35	0.72560				

Term	Coef	SE	T	P
Constant	0.3276	0.3637	0.90	0.376
Julian day	-0.003165	0.002656	-1.19	0.245

Least Squares Means* for Ln (Spill Survival)

			Back transformed	
Diel	Mean	SE	Mean	SE
1 (Day)	-0.080	0.053	0.923	0.049
2 (Night)	-0.111	0.040	0.895	0.036
Spill (%)				
1 (30%)	-0.074	0.062	0.928	0.058
2 (64%)	-0.117	0.034	0.890	0.030
Gate index				
1 (1-3 ft)	-0.041	0.046	0.960	0.044
2 (4-7 ft)	-0.141	0.043	0.868	0.038
3 (8-10 ft)	-0.104	0.085	0.901	0.077
Diel × gate index				
1 (Day) × 1 (1-3 ft)	0.019	0.043	1.019	0.044
1 (Day) × 2 (4-7 ft)	-0.184	0.070	0.832	0.058
1 (Day) × 3 (8-10 ft)	-0.075	0.128	0.927	0.118
2 (Night) × 1 (1-3 ft)	-0.101	0.080	0.904	0.072
2 (Night) × 2 (4-7 ft)	-0.099	0.051	0.906	0.046
2 (Night) × 3 (8-10 ft)	-0.133	0.078	0.876	0.069

* Least square means are not equal to the raw data means due to an unbalanced experimental design.

Appendix Table B3. Relative passage survival for coho salmon in relation to controlled and uncontrolled variables.

Tag day	Julian day	Diel[a]	Spill[b] (%)	Bay index[c]	Gate index[d]	Spillway Relative survival	Spillway Ln transformed	Sluiceway Relative survival	Sluiceway Ln transformed
4/27	117	1	2	4	1	1.247	0.2206		
4/28	118	1	1	4	1	1.114	0.1082	1.04	0.0392
4/29	119	2	2	1	2	0.688	-0.3738		
4/30	120	1	1	1	1	1.177	0.1629	1.34	0.2911
5/4	124	1	1	3	1	1.124	0.1173	1.17	0.1604
5/5	125	2	2	1	2	1.041	0.0398		
5/5	125	2	2	3	2	1.029	0.0282		
5/6	126	2	1	1	2	0.894	-0.1118		
5/6	126	2	1	3	1	0.958	-0.0426		
5/7	127	1	2	2	3	0.911	-0.0937		
5/7	127	1	2	4	2	0.744	-0.2962		
5/8	128	1	1	2	1	0.889	-0.1181	0.89	-0.1139
5/9	129	1	2	1	2	0.895	-0.1109		
5/11	131	2	2	2	3	0.850	-0.1624		
5/11	131	2	2	4	1	0.879	-0.1292		
5/12	132	2	1	2	2	0.905	-0.1001		
5/12	132	2	1	3	1	0.925	-0.0784		
5/13	133	1	2	2	3	0.826	-0.1914		
5/14	134	1	1	1	1	1.035	0.0347	0.97	-0.0342
5/14	134	1	1	2	1	1.062	0.0598		
5/15	135	2	2	1	3	0.785	-0.2426		
5/15	135	2	2	2	3	0.823	-0.1944		
5/19	139	1	2	1	1	0.969	-0.0317		
5/19	139	1	2	3	2	0.738	-0.3032		
5/20	140	1	1	1	1	1.143	0.1334	0.90	-0.1019
5/20	140	1	1	4	1	1.114	0.1077		
5/21	141	1	1	1	1	0.849	-0.1633	0.73	-0.3082
5/21	141	1	1	4	1	0.721	-0.3274		
5/22	142	1	1					0.90	-0.1032
5/23	143	1	2	1	1	0.916	-0.0878		
5/23	143	1	2	2	3	0.917	-0.0870		
5/24	144	1	2	3	2	0.910	-0.0944		
5/24	144	1	2	4	2	0.868	-0.1416		
5/25	145	1	1	3	2	0.814	-0.2056	1.00	-0.0048
5/26	146	2	1	2	2	0.916	-0.0882		
5/26	146	2	2	1	3	0.908	-0.0962		
5/27	147	1	1					0.78	-0.2527
5/28	148	1	1					0.97	-0.0255
6/1	152	1	1					0.97	-0.0285
6/2	153	1	1					0.95	-0.0551
6/3	154	2	2	4	2	0.922	-0.0816		
					Geomean:	0.922	-0.082	0.960	-0.041
					SE:	0.022	0.024	0.041	0.043
					95% CI:	0.879	0.966	0.87	1.05

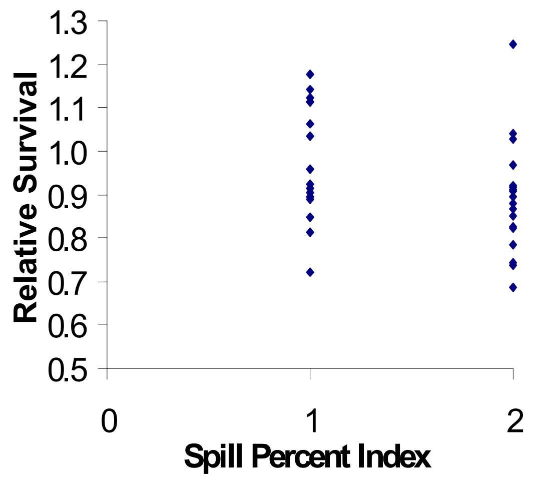
a Diel: 1 for daytime, 2 for nighttime.

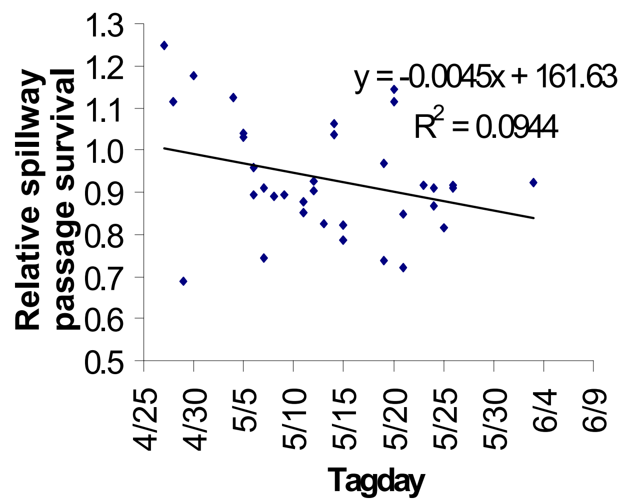
b Spill (%): 1 for 30% and 2 for 64%.

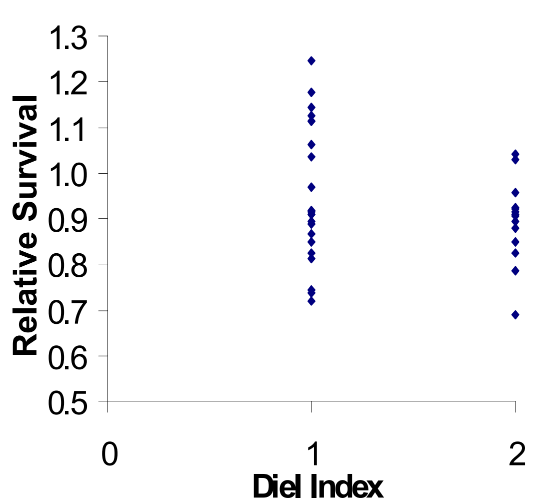
c Bay index: 1 for north Bays 1-6, 2 for mid-north Bays 7-12, 3 for mid-south Bays 13-17, and 4 for south Bays 18-23.

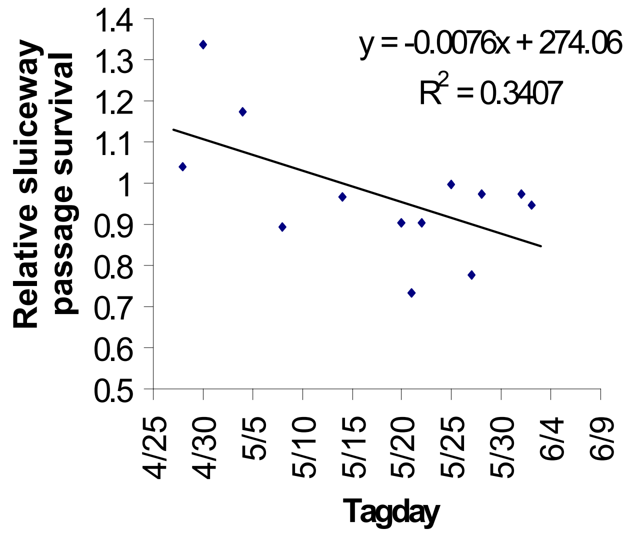
d Gate index: 1 for 1-3 ft, 2 for 4-7 ft, and 3 for 8-10 ft gate openings.

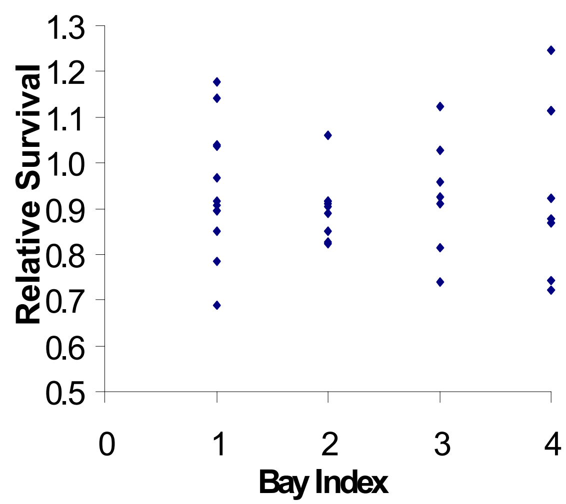
Addendum to Appendix Table B3.

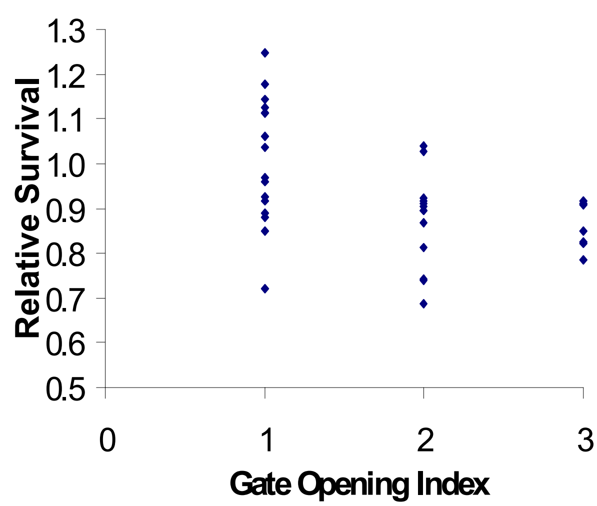












Appendix Table B4. PIT-tag detections in relation to size at release comparing proportions above and below the critical size for radio telemetry evaluations; coho salmon from The Dalles Survival Study, 1998.

	Fork length <=125 mm					Fork length >125 mm				
		Detected PIT tags[a]					Detected PIT tags[a]			
		Bonneville[b]		Rice Island			Bonneville[b]		Rice Island	
Tag date	Release no.[c]	no.	Prop[d]	no.	Prop[d]	Release no.[c]	no.	Prop[d]	no.	Prop[d]
4/27	5	0		1		51	9		1	
4/28	3	1		0		82	14		7	
4/29	14	1		1		202	34		5	
4/30	5	1		0		140	28		5	
5/4	93	13	0.133	3	0.042	463	53	0.147	13	0.033
5/5	105	13	0.124	7	0.067	588	67	0.114	13	0.022
5/6	67	12	0.179	4		450	54	0.120	11	
5/7	81	12	0.148	1		680	83	0.122	18	
5/8	41	4		1		224	14		9	
5/9	32	4	0.110	0	0.027	233	38	0.114	12	0.032
5/11	60	7	0.117	5		338	60	0.178	8	
5/12	48	7	0.146	1		463	69	0.149	22	
5/13	55	8	0.145	1		517	64	0.124	25	
5/14	40	3		0		222	28		16	
5/15	23	6	0.143	1	0.035	363	56	0.144	16	0.046
5/19	136	17	0.125	6		917	106	0.116	45	
5/20	45	7	0.156	3	0.050	363	43	0.118	24	0.054
5/21-27	0	0		0		0	0		0	
5/28	3	1		0		37	5		1	
6/1-3	0	0		0		0	0		0	
Total	856	117	0.137	35	0.041	6,333	825	0.130	251	0.040

Bonneville ratio: <=125 to >125mm		Ln	Rice I. ratio: <=125 to >125mm		Ln
Geomean:	1.056	0.055	Geomean:	1.19	0.170
SE:	0.064	0.061	SE:	0.248	0.217
95% CI:	0.930 to 1.200		95% CI:	0.585 to 2.056	
t:		0.90	t:	0.001	0.78
df:		20	df:		8
P:		0.38	P:		0.46

a In instances where detections/recoveries were few, proportions were based on cumulative data for several release days. For analysis, the minimum detection was five fish for the size category with the least number.

b Detections from Bonneville Dam or Jones Beach.

c All release sites combined by day.

d Prop = Proportion detected (number of fish detected ÷ number of fish released).

Appendix Table B5. Relative survival of daytime vs. nighttime passage for coho and chinook salmon at The Dalles Dam spillway, 1997 and 1998.

Springtime migration--Coho salmon											
1997 block 1				1998 block 2				1998 block 3			
Day 64% spill		Night 64% spill		Day 30% spill		Night 30% spill		Day 64% spill		Night 64% spill	
Prop.	Ln	Prop.	Ln	Prop.	Ln	Prop.	Ln	Prop.	Ln	Prop.	Ln
0.986	-0.014	0.843	-0.171	1.114	0.108	0.894	-0.112	1.247	0.221	0.688	-0.374
0.922	-0.081	0.805	-0.217	1.177	0.163	0.958	-0.043	0.911	-0.094	1.041	0.040
0.871	-0.138	0.798	-0.226	1.124	0.117	0.905	-0.100	0.744	-0.296	1.029	0.028
0.798	-0.226	0.804	-0.218	0.889	-0.118	0.925	-0.078	0.895	-0.111	0.850	-0.162
0.864	-0.146	0.921	-0.082	1.035	0.035	0.900	-0.105	0.826	-0.191	0.879	-0.129
0.483	-0.728	0.976	-0.024	1.062	0.060	0.924	-0.079	0.969	-0.032	0.785	-0.243
0.813	-0.207	0.582	-0.541	1.143	0.133			0.738	-0.303	0.823	-0.194
0.731	-0.313	0.898	-0.108	1.114	0.108			0.916	-0.088	0.922	-0.082
1.162	0.150	0.848	-0.165	0.849	-0.163			0.917	-0.087		
0.610	-0.494	0.915	-0.089	0.721	-0.327			0.910	-0.094		
		1.010	0.010	0.814	-0.206			0.868	-0.142		
Geometric means											
0.803	-0.220	0.847	-0.166	0.992	-0.008	0.918	-0.086	0.895	-0.111	0.870	-0.140

Analysis of Variance for Ln (surv)

Source	df	Seq SS	Adj SS	Adj MS	F	P
DayNight	1	0.012	0.004	0.004	0.160	0.691
Block	2	0.219	0.19	0.095	3.520	0.037
DayNight*Block	2	0.041	0.041	0.02	0.750	0.478
Error	51	1.378	1.378	0.027		
Total	56	1.649				

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DayNight	Ln Mean	Ln SE	Back transformed Mean	Back transformed SE
1 (Day)	-0.113	0.0291	0.89	0.03
2 (Nite)	-0.131	0.0339	0.88	0.03

Appendix Table B5. Continued.

Summertime migration–Subyearling chinook salmon											
1997 block 1				1998 block 2				1998 block 3			
Day 64% spill		Night 64% spill		Day 30% spill		Night 30% spill		Day 64% spill		Night 64% spill	
Prop.	Ln	Prop.	Ln	Prop.	Ln	Prop.	Ln	Prop.	Ln	Prop.	Ln
0.80	-0.23	0.67	-0.40	1.10	0.10	0.96	-0.04	1.00	0.00	1.07	0.07
0.89	-0.12	1.03	0.03	0.98	-0.02	0.99	-0.01	0.87	-0.14	0.91	-0.09
1.10	0.10	0.87	-0.14	0.93	-0.07	1.17	0.15	1.03	0.03	0.69	-0.36
0.77	-0.26	1.00	0.00	0.68	-0.38	0.75	-0.28	0.86	-0.15	0.83	-0.19
0.77	-0.26	0.97	-0.03	1.17	0.16	1.06	0.06	0.71	-0.34	0.68	-0.39
1.00	0.00	1.18	0.16	1.05	0.05	0.86	-0.15	0.81	-0.21	0.62	-0.47
0.72	-0.33	0.81	-0.21	0.82	-0.20	1.31	0.27	0.63	-0.46	0.59	-0.53
0.86	-0.15	1.04	0.04	1.03	0.03			0.55	-0.60	0.98	-0.02
0.98	-0.02	0.93	-0.07	0.60	-0.52			1.03	0.03	0.81	-0.21
0.73	-0.31	1.01	0.01	0.57	-0.56			0.31	-1.16		
1.00	0.00	0.94	-0.06	0.77	-0.26			0.60	-0.51		
				0.60	-0.51						
Geometric Means											
0.87	-0.14	0.97	-0.03	0.81	-0.21	1.01	0.01	0.70	-0.35	0.75	-0.28

Analysis of Variance for Ln (surv)						
Source	DF	Seq SS	Adj SS	Adj MS	F	P
DayNight	1	0.177	0.191	0.191	3.54	0.07
Block	2	0.424	0.447	0.223	4.13	0.02
DayNight*Block	2	0.034	0.034	0.017	0.31	0.73
Error	55	2.973	2.973	0.054		
Total	60	3.608				

Where: Block

DayNight	Ln Mean	Ln SE	Back transformed Mean	Back transformed SE
1 (Day)	-0.215	0.040	0.81	0.03
2 (Nite)	-0.101	0.046	0.90	0.04

Appendix Table B6. Spill passage survival in relation to water temperature, spill volume, river flow, and tailwater elevation; The Dalles Dam, 1997 and 1998.

Coho 1997							Subyearling chinook 1997						
Rel. Date	Temp. (ºC)	Spill kcfs	Spill (%)	R. flow kcfs	Tai w. El. (ft)	Survival (%)	Rel. Date	Temp. ºC	Spill kcfs	Spill (%)	R. flow kcfs	Tailw. El. (ft)	Survival (%)
4/27	10	246	61	403	85	96.8	6/19	16	345	63	548	91	120.5
4/28	10	217	64	339	84	89.3	6/20	16	320	61	525	89	83.4
4/29	10	296	61	485	87	67.3	6/21	15	320	65	492	89	115.5
4/29	10	324	72	450	87	121.3	6/24	15	292	62	471	87	94.6
4/30	11	302	65	465	88	116.8	6/25	15	262	64	409	85	83.1
5/2	11	366	79	463	87	116.6	6/26	15	241	60	402	84	88.0
5/3	11	263	63	417	86	81.7	6/27	16	258	63	410	84	109.7
5/6	11	239	63	379	86	81.9	6/28	16	224	64	350	83	103.5
5/7	11	253	66	383	84	68.5	7/1	17	176	64	275	81	107.2
5/7	11	250	64	391	86	74.0	7/2	17	165	61	270	80	70.6
5/8	11	259	64	405	85	77.7	7/3	18	178	64	278	82	79.1
5/9	13	263	64	411	85	89.0	7/4	18	153	64	239	79	82.7
5/10	12	245	65	377	84	66.2	7/8	18	175	61	287	81	86.8
5/11	12	243	64	380	84	82.0	7/10	19	177	64	277	81	95.8
5/12	12	379	73	519	88	82.3	7/11	18	174	63	276	82	76.5
5/13	13	374	73	512	88	73.5	7/12	19	182	64	284	81	84.4
5/14	13	302	64	472	87	87.2	7/15	19	175	64	273	81	102.4
5/14	13	321	63	510	89	102.2	7/16	19	211	65	325	82	106.9
5/15	13	282	66	427	87	84.0							
5/20	13	335	64	523	89	92.1							
5/21	13	326	64	509	89	109.8							
5/22	13	313	63	497	89	66.0							

Appendix Table B6. Continued.

Coho 1998							Subyearling chinook 1998						
Rel. Date	Temp (ºC)	Spill kcfs	Spill (%)	R. flow kcfs	Tailw. El. (ft)	Survival (%)	Rel. Date	Temp. ºC	Spill kcfs	Spill (%)	R. flow kcfs	Tailw. El. (ft)	Survival (%)
4/28	14	125	64	194	79	124.7	6/23	17	140	64	219	79	93.5
4/29	15	54	30	181	78	111.4	6/24	17	75	30	252	80	104.1
4/30	14	138	64	218	79	68.8	6/25	17	144	65	222	79	99.3
5/1	14	75	29	255	81	117.7	6/26	17	85	29	291	82	97.5
5/5	15	90	28	324	83	112.4	6/30	18	70	31	229	79	80.6
5/6	15	215	64	336	83	103.5	7/1	18	192	64	302	81	76.3
5/7	15	91	30	302	84	92.6	7/2	18	71	30	231	81	96.0
5/8	15	240	64	374	84	82.7	7/3	19	130	61	212	79	94.5
5/9	14	110	29	382	86	88.9	7/8	18	72	30	242	80	111.1
5/10	14	224	65	347	84	89.5	7/9	19	130	61	212	79	75.9
5/12	14	211	65	325	83	86.4	7/10	20	66	30	217	79	92.5
5/13	14	96	30	319	84	91.5	7/14	19	60	30	201	78	59.6
5/14	14	230	62	373	84	82.6	7/15	21	141	63	222	78	63.4
5/15	14	100	29	347	84	104.8	7/15	21	140	63	221	79	67.9
5/16	14	205	64	318	82	80.4	7/16	21	66	30	223	79	96.3
5/20	14	208	64	326	82	85.4	7/17	20	122	62	196	78	55.1
5/21	14	96	30	325	84	112.8	7/17	20	144	64	224	79	60.7
5/23	14	94	30	314	82	78.5	7/21	21	128	65	197	78	89.4
5/25	14	200	69	290	82	91.6	7/22	21	61	30	205	79	57.0
5/26	14	189	64	297	81	88.9	7/23	21	100	61	164	78	65.0
5/27	14	130	32	407	86	81.4	7/24	21	45	29	157	78	68.7
5/27	14	140	41	340	85	91.6	7/24	21	54	32	171	78	131.1
5/27	14	250	66	377	85	90.8							
6/4	15	288	63	455	86	92.2							

Appendix Table B7. Analysis of variance for Ln transformed relative survival percentages derived for subyearling chinook salmon passing through the spillway and sluiceway at The Dalles Dam,1998.

All Recoveries

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.56146	0.45785	0.45785	9.59	0.004
Diel	1	0.09096	0.15295	0.15295	3.20	0.084
Spill (%)	1	0.26275	0.29537	0.29537	6.18	0.019
Bay index	2	0.23946	0.20391	0.10195	2.13	0.137
Diel × Spill (%)	1	0.02130	0.02197	0.02197	0.46	0.503
Diel × Bay index	2	0.19915	0.22172	0.11086	2.32	0.117
Spill (%) × Bay index	2	0.28620	0.28620	0.14310	3.00	0.066
Error	28	1.33720	1.33720	0.04776		
Total	38	2.99847				

Term	Coef	SE	T	P
Constant	2.0511	0.7262	2.82	0.009
Julian day	-0.011864	0.003832	-3.10	0.004

Least Squares Means* for Ln (Spill Survival)

			Back transformed		
Diel	Mean	SE	Mean	SE	95% CI
1 (Day)	-0.2568	0.0464	0.7735	0.0359	0.7033 to 0.8507
2 (Night)	-0.1273	0.0555	0.8805	0.0489	0.7859 to 0.9865
Spill (%)					
1 (30%)	-0.1020	0.0529	0.9030	0.0478	0.8102 to 1.0064
2 (64%)	-0.2821	0.0494	0.7542	0.0372	0.6817 to 0.8344
Spill (%) × Bay index					
1 (30%) × 1 (N)	-0.0470	0.0800	0.9541	0.0763	0.8099 to 1.1240
1 (30%) × 2 (M)	0.0468	0.1028	1.0479	0.1078	0.8489 to 1.2936
1 (30%) × 3 (S)	0.3060	0.0946	0.7364	0.0697	0.6066 to 0.8939
2 (64%) × 1 (N)	-0.1955	0.0842	0.8224	0.0692	0.6921 to 0.9772
2 (64%) × 2 (M)	-0.3700	0.0938	0.6907	0.0648	0.5699 to 0.8371
2 (64%) × 3 (S)	-0.2808	0.0835	0.7552	0.0631	0.6364 to 0.8961
Diel × Bay index					
1 (Day) × 1 (N)	-0.0896	0.0736	0.9143	0.0673	0.7864 to 1.0630
1 (Day) × 2 (M)	-0.3207	0.0916	0.7256	0.0665	0.6015 to 0.8754
1 (Day) × 3 (S)	-0.3602	0.0773	0.6975	0.0539	0.5954 to 0.8172
2 (Night) × 1 (N)	-0.1528	0.0909	0.8583	0.0780	0.7125 to 1.0340
2 (Night) × 2 (M)	-0.0025	0.1054	0.9975	0.1051	0.8038 to 1.2379
2 (Night) × 3 (S)	-0.2266	0.1019	0.7972	0.0812	0.6470 to 0.9823

The regression equation is: Ln (Sluice Survival) = 49 - 0.00136 Tag day

Term	Coef	SE	T	P	
Constant	48.6	137.4	0.35	0.733	
Tag day	-0.001355	0.003820	-0.35	0.732	R^2 (adj) = 0.0%

Appendix Table B7. Continued.

Bonneville Recoveries Only

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.66848	0.62540	0.62540	8.23	0.008
Diel	1	0.02873	0.05843	0.05843	0.77	0.388
Spill (%)	1	0.32489	0.38328	0.38328	5.05	0.033
Bay index	2	0.38730	0.34806	0.17403	2.29	0.120
Diel × Spill (%)	1	0.04296	0.04233	0.04233	0.56	0.462
Diel × Bay index	2	0.13668	0.14575	0.07288	0.96	0.395
Spill (%) × Bay index	2	0.30290	0.30290	0.15145	1.99	0.155
Error	28	2.12656	2.12656	0.07595		
Total	38	4.01850				

Term	Coef	SE	T	P
Constant	2.3774	0.9158	2.60	0.015
Julian day	-0.013866	0.004832	-2.87	0.008

Least Squares Means* for Ln (Spill Survival)

			Back transformed	
Diel	Mean	SE	Mean	SE
1 (Day)	-0.2843	0.05856	0.7525	0.0441
2 (Night)	-0.2042	0.06997	0.8153	0.0570
Spill (%)				
1 (30%)	-0.1417	0.06675	0.8679	0.0579
2 (64%)	-0.3468	0.06225	0.7069	0.0440
Bay index				
1 (North)	-0.1818	0.07447	0.8338	0.0621
2 (Mid.)	-0.1647	0.09139	0.8481	0.0775
3 (South)	-0.3862	0.08092	0.6796	0.0550
Spill (%) × Bay index				
1 (30%) × 1 (North)	-0.1203	0.10088	0.8867	0.0894
1 (30%) × 2 (Mid.)	0.0676	0.12969	1.0699	0.1388
1 (30%) × 3 (South)	-0.3723	0.11935	0.6891	0.0822
2 (64%) × 1 (North)	-0.2433	0.10617	0.7840	0.0832
2 (64%) × 2 (Mid.)	-0.397	0.11833	0.6723	0.0796
2 (64%) × 3 (South)	-0.4001	0.10533	0.6703	0.0706

The regression equation is Ln (Sluice Survival) = -100 + 0.00279 Tag day

Term	Coef	SD	T	P
Constant	-100.4	152.0	-0.66	0.527
Tag day	0.002787	0.004224	0.66	0.528

R^2 (adj) = 0.0%

Appendix Table B7. Continued.

Rice Island Recoveries Only						
Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests						
Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.2389	0.1665	0.1665	0.54	0.468
Diel	1	0.3994	0.6014	0.6014	1.96	0.173
Spill (%)	1	0.0403	0.0534	0.0534	0.17	0.680
Bay index	2	0.3223	0.0927	0.0464	0.15	0.861
Diel × Spill (%)	1	0.0418	0.0451	0.0451	0.15	0.704
Diel × Bay index	2	1.0610	1.1636	0.5818	1.90	0.169
Spill (%) × Bay index	2	0.9113	0.9113	0.4557	1.48	0.244
Error	28	8.5960	8.5960		0.3070	
Total	38	11.6111				

Term	Coef	SE	T	P
Constant	1.286	1.841	0.70	0.491
Julian day	-0.007155	0.009715	-0.74	0.468

Least Squares Means* for Ln (Spill Survival)

			Back transformed	
Diel	Mean	SE	Mean	SE
1 (Day)	-0.1954	0.1177	0.8225	0.0968
2 (Night)	0.0614	0.1407	1.0633	0.1496
Spill (%)				
1 (30%)	-0.0287	0.1342	0.9717	0.1304
2 (64%)	-0.1053	0.1251	0.9001	0.1126
Bay index				
1 (North)	0.0023	0.1497	1.0023	0.1500
2 (Mid.)	-0.1259	0.1837	0.8817	0.1620
3 (South)	-0.0775	0.1627	0.9254	0.1506
Spill (%) × Bay index				
1 (30%) × 1 (North)	0.129	0.2028	1.1377	0.2307
1 (30%) × 2 (Mid.)	0.0436	0.2607	1.0446	0.2723
1 (30%) × 3 (South)	-0.2588	0.2399	0.7720	0.1852
2 (64%) × 1 (North)	-0.1244	0.2135	0.8830	0.1885
2 (64%) × 2 (Mid.)	-0.2953	0.2379	0.7443	0.1771
2 (64%) × 3 (South)	0.1038	0.2118	1.1094	0.2350

The regression equation is Ln (Sluice Survival) = 739 -0.0205 Tag day

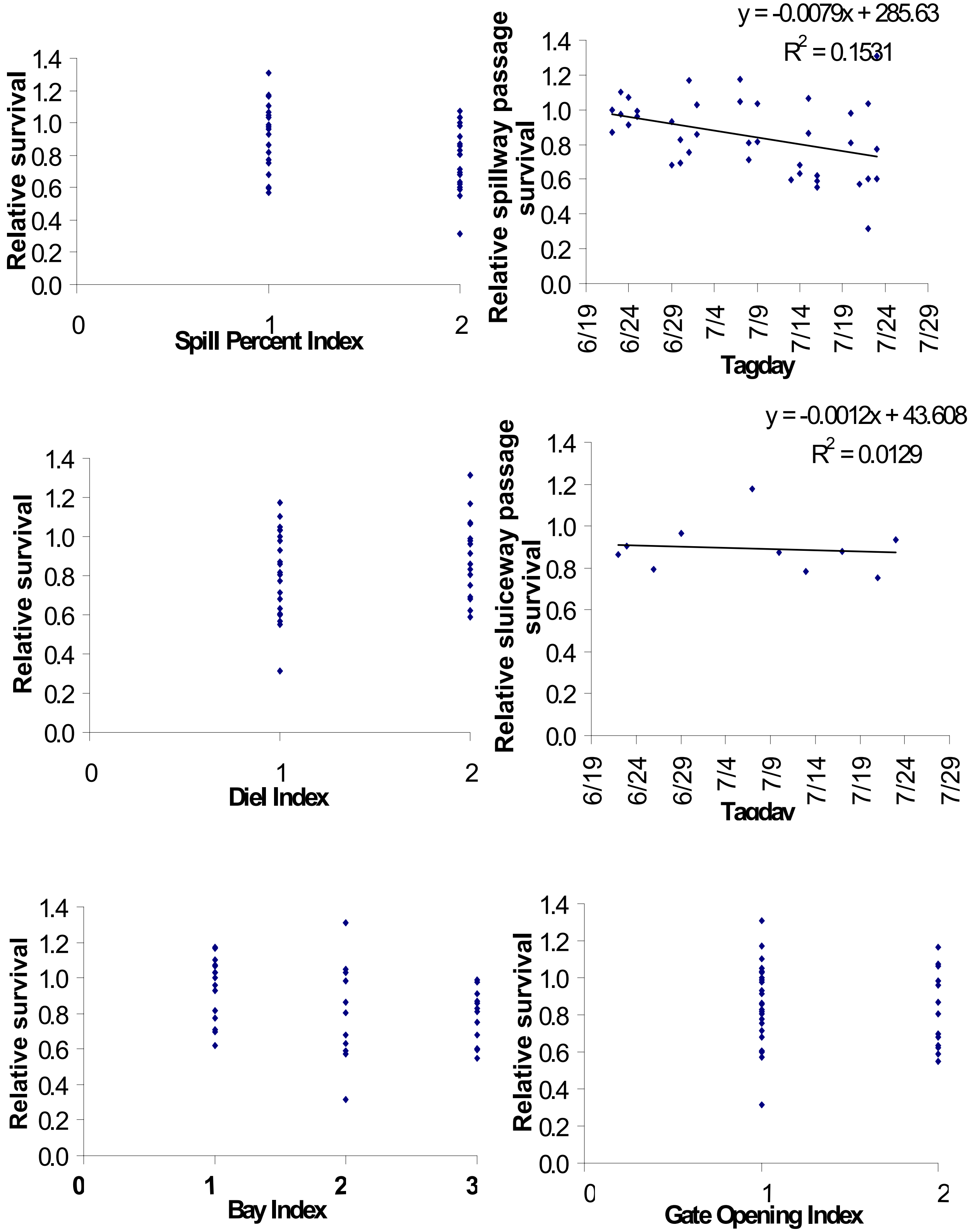
Term	Coef	SDE	T	P	
Constant	738.6	234.9	3.14	0.014	R^2 (adj) = 49.7%
Tag day	-0.020530	0.006528	-3.14	0.014	

* Least square means are not equal to the raw data means due to an unbalanced experimental design.

Appendix Table B8. Data of relative passage survival in relation to controlled and uncontrolled variables for subyearling chinook salmon at The Dalles Dam, 1998.

Tag day	Julian day	Diel[a]	Spill[b] (%)	Bay index[c]	Gate index[d]	Spillway relative surv.	Ln	Sluiceway relative surv.	Ln
6/22	173	1	2	1	1	1.00	-0.0001	0.86	-0.15
6/22	173	1	2	3	2	0.87	-0.1399		
6/23	174	1	1	1	1	1.10	0.0993	0.90	-0.10
6/23	174	1	1	3	1	0.98	-0.0237		
6/24	175	2	2	1	2	1.07	0.0704		
6/24	175	2	2	3	1	0.91	-0.0907		
6/25	176	2	1	1	2	0.96	-0.0394		
6/25	176	2	1	3	1	0.99	-0.0107		
6/26	177	1	1					0.80	-0.23
6/29	180	1	1	1	1	0.93	-0.0723	0.97	-0.03
6/29	180	1	1	3	1	0.68	-0.3846		
6/30	181	2	2	1	2	0.69	-0.3645		
6/30	181	2	2	3	1	0.83	-0.1857		
7/1	182	2	1	1	2	1.17	0.1536		
7/1	182	2	1	3	1	0.75	-0.2837		
7/2	183	1	2	1	1	1.03	0.0306		
7/2	183	1	2	3	1	0.86	-0.1521		
7/7	188	1	1	1	1	1.17	0.1601	1.18	0.16
7/7	188	1	1	2	1	1.05	0.0478		
7/8	189	1	2	1	1	0.71	-0.3403		
7/8	189	1	2	2	2	0.81	-0.2148		
7/9	190	1	1	1	1	0.82	-0.2015		
7/9	190	1	1	2	1	1.03	0.0319		
7/10	191	1	1					0.88	-0.13
7/13	194	1	1	3	1	0.60	-0.5147	0.78	-0.24
7/14	195	1	2	2	2	0.63	-0.4560		
7/14	195	2	2	2	2	0.68	-0.3871		
7/15	196	2	1	1	2	1.06	0.0629		
7/15	196	2	1	2	1	0.86	-0.1484		
7/16	197	1	2	3	2	0.55	-0.5960		
7/16	197	2	2	1	2	0.62	-0.4741		
7/16	197	2	2	2	2	0.59	-0.5259		
7/17	198	1	1					0.88	-0.13
7/20	201	2	2	2	2	0.98	-0.0198		
7/20	201	2	2	3	1	0.81	-0.2137		
7/21	202	1	1	2	1	0.57	-0.5621	0.75	-0.28
7/22	203	1	2	1	1	1.03	0.0331		
7/22	203	1	2	2	1	0.31	-1.1569		
7/22	203	1	2	3	1	0.60	-0.5052		
7/23	204	1	1	1	1	0.77	-0.2557	0.93	-0.07
7/23	204	1	1	3	1	0.60	-0.5106		
7/23	204	2	1	2	1	1.31	0.2709		
					Geomean:	0.817	-0.202	0.886	-0.121
					SE:	0.037	0.045	0.036	0.040
					95% CI:	0.747	0.894	0.81	0.97

a Diel: 1 for daytime, 2 for nighttime.
b Spill (%): 1 for 30% and 2 for 64%
c Bay index: 1 for north Bays 1-6, 2 for middle Bays 7-12, and 3 for south Bays 13-23.
d Gate index: 1 for 1-3 ft, and 2 for 4-10 ft gate openings.


Relative survival
Spill Percent Index
y = -0.0079x + 285.63
R^2 = 0.1531
Relative spillway passage survival
Tagday
Relative survival
Diel Index
y = -0.0012x + 43.608
R^2 = 0.0129
Relative sluiceway passage survival
Tagday
Relative survival
Bay Index
Relative survival
Gate Opening Index

Appendix Table B9. Analysis of variance for Ln transformed relative survival proportions derived for subyearling chinook salmon passing through the spillway at various spillway gate openings, The Dalles Dam, 1998.

SPILLWAY GATE OPENINGS--All Recoveries

Analysis of Variance for Ln (Spill Survival), using Adjusted SS for Tests

Source	df	Seq SS	SS (adj)	MS (adj)	F	P
Julian day	1	0.56185	0.45819	0.45819	6.99	0.013
Diel	1	0.09120	0.07613	0.07613	1.16	0.290
Spill (%)	1	0.26232	0.18518	0.18518	2.82	0.103
Gate index	1	0.00724	0.00081	0.00081	0.01	0.912
Diel × Spill (%)	1	0.02606	0.00527	0.00527	0.08	0.779
Diel × Gate index	1	0.00724	0.00026	0.00026	0.00	0.950
Spill (%) × Gate index	1	0.01191	0.01191	0.01191	0.18	0.673
Error	31	2.03258	2.03258	0.06557		
Total	38	3.00041				

Term	Coef	SE	T	P
Constant	1.8121	0.7486	2.42	0.022
Julian day	-0.010547	0.003990	-2.64	0.013

Least Squares Means* for Ln (Spill Survival)

			Back transformed	
Diel	Mean	SE	Mean	SE
1 (Day)	-0.2418	0.1002	0.7852	0.0787
2 (Night)	-0.1221	0.0669	0.8851	0.0592
Spill (%)				
1 (30%)	-0.0892	0.1038	0.9147	0.0949
2 (64%)	-0.2747	0.0605	0.7598	0.0460
Gate index				
1 (1-3 ft)	-0.1749	0.0576	0.8395	0.0484
2 (4-10 ft)	-0.1890	0.1146	0.8278	0.0948
Diel × gate index				
1 (Day) × 1 (1-3 ft)	-0.2308	0.0610	0.7939	0.0484
1 (Day) × 2 (4-10 ft)	-0.2528	0.1964	0.7766	0.1525
2 (Night) × 1 (1-3 ft)	-0.1189	0.0980	0.8879	0.0870
2 (Night) × 2 (4-10 ft)	-0.1253	0.0907	0.8822	0.0800

* Least square means are not equal to the raw data means due to an unbalanced experimental design.

Appendix Table B10. PIT-tag detections in relation to size at release comparing proportions above and below the critical size for radio telemetry evaluations; subyearling chinook salmon from The Dalles Survival Study, 1998.

	Fork length <=110 mm					Fork length >110 mm				
		Detections[a]					Detections[a]			
Tag	Release	Bonneville [b]		Rice Island		Release	Bonneville [c]		Rice Island	
date	no. [c]	no.	Prop[d]	no.	Prop[d]	no. [a]	no.	Prop[d]	no.	Prop[D]
6/22	1,622	78	0.048	22		112	4	0.036	2	
6/23	1,678	69	0.041	20		106	5	0.047	1	
6/24	1,093	83	0.076	13		150	13	0.087	1	
6/25	496	39	0.079	6		56	7	0.125	0	
6/26	749	68	0.091	8	0.012	105	9	0.086	0	0.008
6/29	586	54	0.092	4		120	14	0.117	2	
6/30	695	23	0.033	5	0.007	228	6	0.026	4	0.017
7/1	838	26	0.031	9		247	11	0.045	5	
7/2	1,017	28	0.028	19	0.015	424	9	0.021	4	0.013
7/7	1,359	33		15		508	14		4	
7/8	200	2		4		35	0		1	
7/9	974	23		11		119	1		0	
7/10	521	14	0.024	5	0.011	43	0	0.021	1	0.009
7/13	269	7		6		13	0		0	
7/14	119	14		1		8	0		0	
7/15	337	15		3		54	2		1	
7/16	825	39		19		135	4		6	
7/17	934	28	0.041	18	0.019	192	1	0.017	0	0.017
7/20	347	21		2		122	2		1	
7/21	588	22		6		226	2		3	
7/22	175	10	0.048	0		85	5	0.021	3	
7/23	300	12	0.040	5	0.009	193	7	0.036	1	0.013
Total	15,722	708	0.045	201	0.013	3,281	116	0.035	40	0.012

Bonneville ratio: <=110 to >110mm	
Geomean:	1.191
SE:	0.137
95% CI:	0.929 to 1.527
t:	0.851
df:	24
P:	0.40

Rice Island Ratio:<=110 to >110mm	
Geomean:	1.025
SE:	0.198
95% CI:	0.624 to 1.685
t:	0.835
df:	10
P:	0.42

a In instances where detections/recoveries were few, proportions were based on cumulative data for several release days. For analysis, the minimum detection was five fish for the size category with the least number.
b Detections from Bonneville Dam or Jones Beach.
c All release sites combined by day.
d Prop = Proportion detected (number of fish detected ÷ number of fish released).

Appendix Table B11. PIT-tags detected by treatment by date for the three days which failed the chi-square test of no difference in temporal distribution for subyearling chinook salmon at Bonneville Dam, 1998.

Release		Days after release											
Date	Treatment	1	2	3	4	5	6	7	8	9	10	11	19
		Number of fish detected at Bonneville Dam											
6/25	Spillway	27	85	34	11	2	2	0	0	0	1	0	0
6/25	Tailrace	53	79	22	8	1	1	1	1	0	0	0	1
		Percent of total detected											
6/25	Spillway	17	52	21	6.8	1.2	1.2	0	0	0	0.6	0	0
6/25	Tailrace	32	47	13	4.8	0.6	0.6	0.6	0.6	0	0	0	0.6
		Number of fish detected at Bonneville Dam											
7/10	Spillway	12	11	8	4	1	0	0	0				
7/10	Tailrace	15	21	2	0	0	0	0	1				
		Percent of total detected											
7/10	Spillway	33	31	22	11	2.8	0	0	0				
7/10	Tailrace	38	54	5.1	0	0	0	0	2.6				
		Number of fish detected at Bonneville Dam											
7/23	Spillway	51	29	8	1	0	1	1					
7/23	Tailrace	113	41	2	0	1	0	0					
		Percent of total detected											
7/23	Spillway	56	32	8.8	1.1	0	1.1	1.1					
7/23	Tailrace	72	26	1.3	0	0.6	0	0					