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Survival Estimates of migrant Juvenile Salmonids through John Day Dam using Radio-Telemetry, 2001.

Annual Report of Research

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Table of Contents

List of Figures

List of Tables

Executive Summary

During 2001, we estimated the survival of yearling and sub-yearling Chinook salmon and steelhead trout through the juvenile bypass at John Day Dam using the paired release-recapture models of Burnham et al. (1987). Similar to the evaluations conducted at John Day Dam in 1999 and 2000, the results of Burnham tests 2 and 3, that test the assumptions that upstream or downstream detections affect downstream survival and/or detection and whether upstream capture histories affect downstream survival and/or capture, were largely incalculable. No significant differences in arrival times of treatment and control groups of yearling and sub-yearling Chinook salmon and steelhead trout were detected. No dead radio-tagged fish were detected at any of the arrays downstream of John Day Dam.

The average survival of yearling Chinook salmon released through the John Day Dam juvenile bypass during the 2001 migration season was 0.932 (± 0.042, 95% confidence interval). For releases of yearling Chinook salmon made during the day the average survival was estimated to be 0.941 (± 0.074, 95% confidence interval) and for the night releases was 0.923 (± 0.046, 95% confidence interval). No significant differences were detected between day and night survival for yearling Chinook salmon released into the juvenile bypass system. A significant relation between the survival of yearling Chinook salmon released through the John Day Dam juvenile bypass and total discharge at John Day Dam was detected.

We estimated that the average survival of steelhead through the juvenile bypass was 0.917 (± 0.040, 95% confidence interval). Average day survival was estimated to be 0.915 (± 0.054, 95% confidence interval) while night survival was 0.920 (± 0.062, 95% confidence interval). No significant difference was detected between day and night survival for steelhead trout. No significant relation between the survival of steelhead trout released through the John Day Dam juvenile bypass and total discharge at John Day Dam was detected.

The average survival of sub-yearling Chinook salmon through the John Day Dam juvenile bypass was estimated to be 0.868 (± 0.084, 95% confidence interval). Average day survival was estimated to be 0.949 (± 0.10, 95% confidence interval) while night survival was estimated to be 0.786 (± 0.11, 95% confidence interval). The difference between day and night survival was found to be statistically significant for sub-yearling Chinook salmon. The relationship between the survival of sub-yearling Chinook released through the juvenile bypass and total discharge was found to be significant.

Introduction

As anadromous juvenile salmonids migrate from freshwater rearing habitats to the ocean, they are vulnerable to a host of factors that affect their survival. Direct effects associated with dam passage (e.g., instantaneous mortality, injury, loss of equilibrium, etc.) and indirect effects (e.g., predation, disease, and physiological stress) contribute to the total mortality of seaward migrating salmonids. Many studies have been conducted to determine the effects of hydroelectric dams on the survival of salmonid migrants (Raymond 1979, Stier and Kynard 1986, Iwamato et al. 1994, Muir et al. 1995, Smith et al. 1998). Based on this research and studies examining migrant salmonid behavior at dams in the Columbia River Basin, management actions are currently being implemented to improve the survival of salmonid migrants.

A primary objective of The National Marine Fisheries Service Federal Columbia River Power System (FCRPS) Biological Opinion is to increase survival of juvenile salmonid out migrants through the federal hydrosystem (NMFS 2000). To help meet this objective, specific water management scenarios have been specified for the hydropower system in general and also, specifically for each project. Based on past research, the NMFS has determined that measures that increased juvenile fish passage through spillways should be given the highest priority, while passing fish through turbines is the least preferred route of passage. Thus, various levels and configurations of spill are used to help meet the established survival and fish passage goals. While there is a consensus that survival is greater for fish diverted from turbines, questions regarding the effectiveness of different spill patterns and other passage scenarios remain (Dawley et al. 1998, NMFS 2000). To evaluate the efficacy of specified water management strategies, the FCRPS biological opinion stresses the importance of establishing a process to monitor, evaluate, and report on the efficacy of the specified measures to improve survival of juvenile migrants. Estimating the survival of migrant juvenile salmonids through projects and reservoirs in the lower Columbia River has been specified as a necessary step in this evaluation process.

New fish marking techniques and the development and acceptance of new statistical methodologies (see Leberton et al. 1992) have led scientists to reevaluate past techniques used to assess survival of migrant salmonids in the Columbia River Basin. For instance, the development of the passive integrated transponder (PIT) tag, which allowed for the unique identification of fish (Prentice et al. 1990), offered many advantages over previous marking techniques (fin-clipping, freeze branding) used in survival studies. Consequently, PIT-tag recoveries and release-recapture models (Burnham et al. 1987, Smith et al. 1996) have been used to assess the survival of migrant salmonid smolts through various reaches of the Columbia and Snake rivers (Iwamato et al. 1994, Muir et al. 1995, Skalski et al. 1998, Smith et al. 1998, Dawley et al. 1998). However, the use of the PIT-tag technique relies on the availability of PIT-tag detectors at hydroelectric dams and these detectors are not present at all locations in the Columbia River Basin. The absence of PIT-tag detectors at certain projects (e.g., The Dalles Dam) and areas below Bonneville Dam has precluded survival estimation in some specific reaches of the Columbia River and fixed the spatial scale over which survival estimates can be made. Further, the relatively low detection probabilities associated with this technique requires that large numbers of fish be handled to obtain desired levels of precision in survival estimates (Skalski 1999b). Consequently, researchers have been motivated to examine the feasibility of using radio-telemetry to generate survival estimates (Normandeau Associates, Inc. et al. 1998, Skalski 1999a, Counihan et al. 2001).

Radio-telemetry has been used extensively to evaluate the survival of fish and wildlife populations (White 1983, Bell and Kynard 1985, Giorgi et al. 1985, Pollock et al. 1996, Normandeau Associates, Inc. et al. 1998) and to monitor the behavior of yearling and subyearling Chinook salmon *Oncorhynchus tshawytscha* and juvenile steelhead *O. mykiss* through hydroelectric projects in the Columbia River Basin (Sheer et al. 1997, Hansel et al. 1998, Holmberg et al. 1998, Hensleigh et al. 1999, Vendetti et al. 2000). During 1999, the U. S. Army Corps of Engineers, Portland District requested that the USGS examine the feasibility of extracting juvenile salmonid survival information from radio-tagged fish. The results of this evaluation suggested that radio-telemetry could be used to evaluate survival of juvenile salmonids in the lower Columbia River, but that logistic adjustments were necessary to ensure that assumptions of the survival estimation procedure were necessary (Counihan et al. 2001).

During 2001, we evaluated the survival of radio-tagged yearling and sub-yearling Chinook salmon and steelhead trout at John Day Dam. The original set of objectives planned for John Day Dam were scaled back significantly because of the low water year during 2001. For instance, certain objectives that were originally planned, such as evaluating spill survival could not be evaluated because decisions were made to not spill water at this project. Consequently, we only evaluated the survival of yearling and sub-yearling Chinook salmon and steelhead trout through the juvenile bypass at John Day Dam.

Methods

Radio-telemetry detection arrays

Radio-telemetry detection arrays were set up at John Day and The Dalles dams. Additional detection arrays were set up in Bonneville Reservoir near the town of Lyle, WA at river kilometer 286 and near the town of Hood River, OR between river kilometers 260 and 268. Release and detection schemes used during 2001 are depicted in Figure 1. The arrays at each of the dams spanned the breadth of the river channel and were set up so that passage through various routes of passage could be determined (Beeman et al. 2001a, Beeman et al. 2001b, Evans et al. 2001). The detection array in Bonneville Reservoir near Lyle, WA consisted of antennas placed on the Washington and Oregon shores.

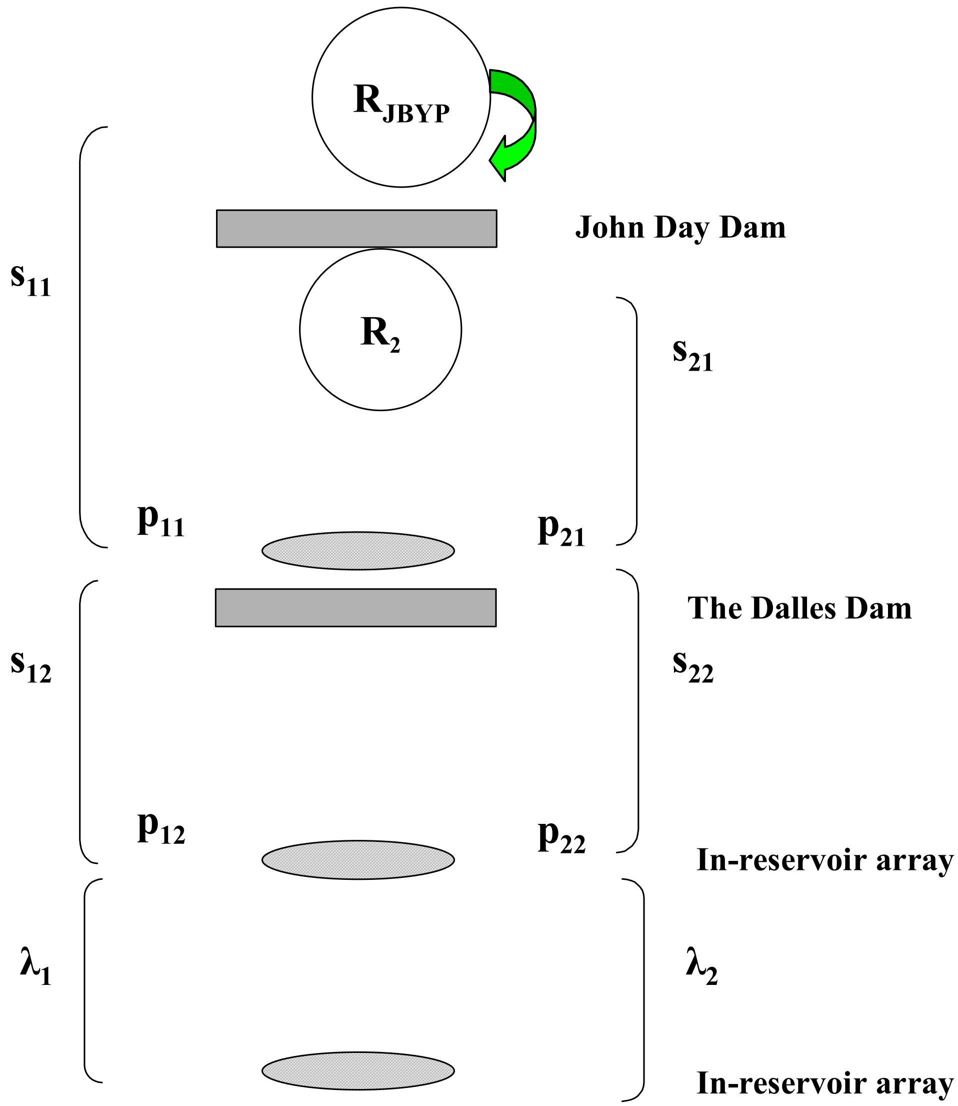

Figure 1. Schematic of estimable capture and survival probabilities (S = survival estimate, p = capture probability, and $\lambda = S \cdot p$) from releases through the John Day dam juvenile bypass and in the tailrace. Dams are represented by rectangles and ovals represent detection arrays.

Release locations

Treatment fish were released into the John Day Dam juvenile bypass system collection channel through the air vent at unit 15B. Control fish were released into the John Day Dam tailrace downstream of the dredge islands at the convergence of the two channels. The release site was positioned between the new north navigation buoy and the public boat ramp at a depth finder reading of 18.3 meters.

Collection, transport and tagging

Fish collection, transportation, tagging, holding, and release protocols are described in Beeman et. al. (2001a). The releases at the top of the John Day Dam juvenile bypass system consisted of 16 separate releases of yearling Chinook salmon that were evaluated using the single-release model and that were also grouped with 16 releases of yearling Chinook salmon made in the John Day Dam tailrace to form 16 paired releases that were evaluated using the paired release recapture models (Table 1). A total of 419 yearling Chinook salmon released into the top of the John Day Dam juvenile bypass system and 323 yearling Chinook salmon released in the John Day Dam tailrace were included in these analyses (Table 2 and Table 3). Similarly, 490 steelhead trout released into the top of the John Dam juvenile bypass system and 335 steelhead trout released in the John Day Dam tailrace were evaluated in 17 paired releases (Table 4 and Table 5).

Releases of sub-yearling Chinook salmon were also made at John Day Dam in 2001. A total of 593 sub-yearling Chinook salmon released into the top of the John Day Dam juvenile bypass system and 447 sub-yearling Chinook salmon released in the John Day Dam tailrace were evaluated in 16 paired releases (Table 6, Table 7 and Table 8).

Statistical methods

We used the paired-release recapture models of Burnham et al. (1987) to estimate the survival of juvenile yearling and sub-yearling Chinook salmon and steelhead trout through the juvenile bypass at John Day Dam. There are assumptions associated with using the single release and paired release-recapture (PR) model to estimate survival, some are biological and some pertain to the statistical models (Burnham et al. 1987, Skalski 1998, Skalski 1999a). The validity of some of the assumptions listed below can be evaluated using statistical tests and others can be met through careful consideration of fish collection, holding, tagging, and detection techniques. The assumptions are the following:

Table 1. Release dates and times of yearling Chinook salmon and juvenile steelhead for the spring 2001 releases into the John Day Dam juvenile bypass system and in the John Day Dam tailrace, spring 2001.

Paired	Juvenile Bypass System		Tailrace	
release	Release date	Release time	Release date	Release time
1	05/07/01	10:17	05/07/01	11:39
2	05/08/01	21:35	05/08/01	22:50
3	05/10/01	09:42	05/10/01	10:51
4	05/11/01	21:51	05/11/01	23:06
5	05/13/01	09:46	05/13/01	11:01
6	05/14/01	21:36	05/14/01	22:55
7	05/16/01	09:45	05/16/01	10:47
8	05/17/01	21:42	05/17/01	22:54
9	05/19/01	09:55	05/19/01	11:06
10	05/20/01	21:36	05/20/01	22:45
11	05/22/01	09:41	05/22/01	10:44
12	05/23/01	21:32	05/23/01	22:53
13	05/25/01	09:43	05/25/01	10:52
14	05/26/01	21:39	05/26/01	22:59
15	05/28/01	09:48	05/28/01	10:52
16	05/29/01	21:30	05/29/01	22:42
17	05/31/01	09:31	05/31/01	10:36

Table 2. The sample size (N), mean, standard deviation (SD), and range of fork lengths (mm) of yearling Chinook salmon released into the John Day Dam juvenile bypass system and in the John Day Dam tailrace, spring 2001.

Paired	Juvenile Bypass System				Tailrace			
Release	N	Mean	SD	Range	N	Mean	SD	Range
1	25	166	11	145-198	17	158	11	146-182
2	22	162	13	140-182	20	170	18	135-201
3	24	163	12	140-189	18	161	11	142-182
4	28	168	14	148-196	20	166	12	150-185
5	24	162	15	142-214	19	163	15	138-193
6	23	162	12	145-190	19	164	13	151-194
7	30	163	18	126-203	20	164	14	134-184
8	24	164	15	143-204	20	163	16	140-194
9	33	159	10	143-179	20	162	16	140-201
10	24	162	14	141-190	22	165	17	134-210
11	32	167	16	141-202	19	164	18	128-206
12	26	173	17	143-212	25	175	19	140-203
13	26	169	18	143-223	23	170	19	144-212
14	28	169	17	132-207	20	177	20	137-216
15	24	164	18	140-202	22	166	15	140-197
16	26	170	19	137-212	19	170	13	145-192
Overall	419	165	15	126-223	323	166	16	128-216

Table 3. The sample size (N), mean, standard deviation (SD), and range of weights (g) of yearling Chinook salmon released into the John Day Dam juvenile bypass system and in the John Day Dam tailrace, spring 2001.

Paired	Juvenile Bypass System				Tailrace			
Release	N	Mean	SD	Range	N	Mean	SD	Range
1	25	45.0	9.4	27.5-74.6	17	39.0	8.3	31.2-58.4
2	22	41.3	11.1	26.0-62.5	20	47.8	15.3	22.8-77.7
3	24	43.3	8.8	30.6-65.5	18	41.9	9.1	27.0-61.9
4	28	47.7	13.7	31.5-89.0	20	45.7	11.5	30.7-67.7
5	24	41.3	14.3	24.9-97.2	19	42.9	12.2	26.0-69.8
6	23	43.2	12.1	31.1-73.0	19	43.4	11.8	30.6-72.2
7	30	43.4	15.2	19.3-89.3	20	43.2	11.2	21.8-64.1
8	24	43.9	13.2	28.9-85.8	20	43.6	12.1	26.2-73.6
9	33	38.7	7.9	27.0-59.3	20	41.6	14.3	25.0-81.8
10	24	39.9	9.5	27.6-62.8	22	45.6	16.0	29.9-97.4
11	32	46.8	14.4	27.4-87.5	19	45.1	15.8	22.7-91.4
12	26	51.2	17.9	27.4-108.1	25	53.0	17.6	24.7-83.0
13	26	47.2	13.1	29.5-82.1	23	48.1	17.5	27.6-94.6
14	28	47.2	16.9	23.7-93.0	20	54.5	18.8	23.4-95.5
15	24	42.8	15.2	25.1-74.2	22	44.0	12.5	22.5-69.0
16	26	48.5	17.0	24.4-94.6	19	45.2	10.4	27.4-65.6
Overall	419	44.5	13.7	19.3-108.1	323	45.5	14.2	21.8-97.4

Table 4. The sample size (N), mean, standard deviation (SD), and range of fork lengths (mm) of juvenile steelhead released into the John Day Dam juvenile bypass system and in the John Day Dam tailrace, spring 2001.

	Juvenile Bypass System				Tailrace			
Paired release	N	Mean	SD	Range	N	Mean	SD	Range
1	26	218	16	179-247	18	216	18	190-250
2	24	222	12	193-247	20	222	14	198-245
3	31	221	18	185-251	20	222	14	198-247
4	32	231	14	207-260	19	218	16	187-247
5	31	230	14	201-259	20	229	19	179-256
6	30	218	19	184-257	20	225	14	202-250
7	18	234	21	209-292	11	230	14	215-261
8	27	234	18	198-275	19	227	17	190-255
9	35	227	24	157-275	25	227	22	181-281
10	30	232	21	193-273	20	231	21	188-275
11	32	229	26	182-290	24	236	25	199-300
12	32	230	22	190-270	25	231	17	195-259
13	31	227	20	185-265	23	231	23	196-283
14	26	235	27	190-305	22	233	23	174-273
15	23	236	35	189-310	17	219	34	166-300
16	19	229	27	162-280	14	233	29	182-285
17	43	226	28	166-290	18	223	26	189-285
Overall	490	228	22	157-310	335	227	21	166-300

Table 5. The sample size (N), mean, standard deviation (SD), and range of weights (g) of juvenile steelhead released into the John Day Dam juvenile bypass system and in the John Day Dam tailrace, spring 2001.

	Juvenile Bypass System				Tailrace			
Paired release	N	Mean	SD	Range	N	Mean	SD	Range
1	26	87.0	18.1	46.7-124.7	18	85.7	22.4	56.7-130.4
2	24	88.0	16.4	60.2-130.0	20	91.6	16.7	62.1-122.8
3	31	92.7	23.7	56.2-156.3	20	89.8	16.9	65.3-120.0
4	32	101.8	19.8	68.1-140.7	19	87.1	17.9	50.4-120.6
5	31	100.4	20.8	68.3-147.8	20	102.7	25.0	46.7-146.0
6	30	80.2	21.2	47.7-131.0	20	90.8	20.5	62.2-144.2
7	18	107.1	32.6	61.5-191.2	11	98.5	17.0	78.7-135.6
8	27	106.0	26.5	62.8-186.6	19	96.8	23.6	51.4-140.9
9	35	97.0	31.1	29.7-185.6	25	97.5	30.3	45.1-178.4
10	30	102.1	30.0	56.2-169.6	20	101.0	28.3	52.7-182.8
11	32	95.4	31.4	48.9-164.2	24	106.2	32.6	63.7-203.4
12	32	98.3	30.1	52.4-170.7	25	98.2	23.2	62.2-140.5
13	31	92.1	24.9	46.6-148.4	23	97.1	29.7	55.1-172.6
14	26	102.3	38.1	50.8-206.1	22	100.3	27.2	39.1-145.5
15	23	106.3	45.4	46.8-211.1	17	84.9	39.0	36.6-176.7
16	19	97.8	31.9	29.4-168.9	14	105.3	39.5	43.9-183.7
17	43	94.9	36.3	34.8-196.1	18	90.6	35.9	53.7-172.7
Overall	490	96.7	29.3	29.4-211.1	335	95.7	27.2	36.6-203.4

Table 6. Release dates and times of sub-yearling Chinook salmon for the fall 2001 releases at John Day Dam.

Paired	Juvenile Bypass System		Tailrace	
release	Release date	Release time	Release date	Release time
1	6/20/01	09:40	6/20/01	10:44
2	6/21/01	21:47	6/21/01	22:53
3	6/23/01	09:33	6/23/01	10:34
4	6/24/01	21:46	6/24/01	22:49
5	6/26/01	09:45	6/26/01	10:43
6	6/27/01	21:49	6/27/01	22:52
7	6/29/01	09:55	6/29/01	10:51
8	6/30/01	21:51	6/30/01	23:05
9	7/02/01	10:02	7/02/01	10:58
10	7/03/01	21:52	7/03/01	22:54
11	7/05/01	09:55	7/05/01	10:52
12	7/06/01	21:48	7/06/01	22:49
13	7/08/01	09:59	7/08/01	11:16
14	7/09/01	21:38	7/09/01	22:54
15	7/12/01	09:40	7/12/01	10:43
16	7/13/01	21:42	7/13/01	22:53

Table 7. The sample size (N) , mean, standard deviation (SD), and range of fork lengths (mm) of sub-yearling Chinook salmon released into the John Day juvenile bypass system and in the John Day Dam Tailrace during fall 2001.

Paired	Juvenile Bypass System				Tailrace			
release	N	Mean	SD	Range	N	Mean	SD	Range
1	36	119.9	8.1	110-145	28	119.8	7.8	110-138
2	38	118.3	7.4	110-142	28	118.8	7.3	110-139
3	38	118.1	8.2	110-142	28	120.7	11.7	111-156
4	39	124.6	10.5	110-152	26	121.0	9.4	110-152
5	37	122.8	7.1	113-145	29	120.6	5.8	112-130
6	39	120.6	5.6	112-135	28	118.9	7.0	110-140
7	36	123.4	11.5	110-151	30	118.9	7.1	111-135
8	37	120.9	9.0	111-143	27	120.2	9.0	111-139
9	38	119.6	6.0	113-134	29	121.6	9.3	112-142
10	37	119.0	7.4	112-143	26	116.6	7.0	110-136
11	37	120.2	6.4	112-133	28	122.9	8.7	113-147
12	36	123.8	6.1	113-138	30	121.0	7.7	111-142
13	38	118.6	6.1	110-138	27	117.5	5.1	112-131
14	36	117.7	5.2	110-133	28	117.1	5.6	110-133
15	35	118.6	6.0	110-131	27	116.3	3.3	110-122
16	36	118.9	3.7	110-126	28	119.6	4.9	113-138
Overall	593	120.3	7.6	110-152	447	119.5	7.7	110-156

Table 8. The sample size (N), mean, standard deviation (SD), and range of weights (g) of sub-yearling Chinook salmon released into the John Day Juvenile Bypass and in the John Day Dam tailrace during fall 2001.

Paired release	Juvenile Bypass System N	Mean	SD	Range	Tailrace N	Mean	SD	Range
1	36	18.9	4.8	13.4-35.7	28	18.9	4.7	13.9-31.0
2	38	18.9	4.6	14.4-33.8	28	18.8	4.0	14.7-32.3
3	38	18.9	4.5	14.2-32.7	28	20.6	7.5	14.5-44.5
4	39	22.7	6.3	14.0-43.3	26	20.7	6.2	14.9-41.4
5	37	21.0	4.6	15.9-38.6	29	19.4	3.0	15.2-26.9
6	39	19.7	2.5	15.2-26.1	28	19.3	4.4	14.9-32.9
7	36	23.2	8.4	14.6-47.1	30	20.3	4.0	15.8-32.0
8	37	20.7	5.2	15.1-37.4	27	20.4	5.2	15.0-32.0
9	38	19.4	3.7	15.3-30.9	29	20.9	5.5	13.8-32.8
10	37	19.7	4.7	15.1-38.5	26	17.9	3.7	14.6-28.9
11	37	20.8	4.5	15.8-29.5	28	22.1	5.5	16.2-35.6
12	36	21.9	3.8	15.6-31.7	30	20.3	4.5	14.0-31.6
13	38	19.2	3.6	14.8-32.4	27	18.1	3.2	14.6-26.4
14	36	19.2	3.2	14.5-28.5	28	17.8	3.0	14.1-27.0
15	35	19.1	3.1	14.6-26.7	27	17.8	1.7	14.8-21.5
16	36	19.0	2.0	14.6-24.7	28	19.5	2.3	16.0-27.4
Overall	593	20.1	4.7	13.4-47.1	447	19.6	4.6	13.8-44.5

A1. Individuals marked for the study are a representative sample from the population of interest.

A2. Survival and capture probabilities are not affected by tagging or sampling (i.e., tagged animals have the same probabilities as untagged animals).

A3. All sampling events are "instantaneous" (i.e., sampling occurs over a short time relative to the length of the intervals between sampling events).

A4. The fate of each tagged individual is independent of the fate of all others.

A5. All individuals alive at a sampling location have the same probability of surviving until the end of that event.

A6. All tagged individuals alive at a sampling location have the same probability of being detected on that event.

A7. All tags are correctly identified and the status of fish (i.e., alive or dead) is correctly identified.

We conducted statistical tests to evaluate assumptions A5 and A6 using tests developed by Burnham et al. (1987). Burnham et al. (1987) presents a series of tests of assumptions named Test 2 that examine whether upstream or downstream detections affect downstream survival and/or detection. To examine whether upstream capture histories affect downstream survival and/or capture, Burnham et al. (1987) present a series of tests called test 3.

Survival was estimated from paired releases by the expression:

$$\hat{S} = \frac{\hat{S}_{11}}{\hat{S}_{21}} \qquad (1)$$

with a variance estimate based on the Delta method (Seber 1982) of:

$$\begin{aligned} V\hat{a}r\left(\hat{S}_W\right) &\doteq \left(\frac{\hat{S}_{11}}{\hat{S}_{21}}\right)^2 \left[\frac{Var\left(\hat{S}_{11}\right)}{\hat{S}_{11}^2} + \frac{Var\left(\hat{S}_{21}\right)}{\hat{S}_{21}^2}\right] \\ &\doteq \hat{S}_W^2\left[\hat{C}V\left(\hat{S}_{11}\right)^2 + \hat{C}V\left(\hat{S}_{21}\right)^2\right] \end{aligned} \qquad (2)$$

where $\hat{S}_{11}$ = survival estimates for fish released into the juvenile bypass system and $\hat{S}_{22}$ = fish released in the John Day Dam tailrace .

and where

$$\hat{C}V\left(\hat{\theta}\right) = \frac{\sqrt{Var\left(\hat{\theta}\right)}}{\theta}$$

In order to estimate *S*, the survival S_{11} is assumed to be of the form:

$$S_{1} = S \cdot S_{21}$$

leading to the relationship

$$\frac{S_{11}}{S_{21}} = \frac{S \cdot S_{21}}{S_{21}} = S. \qquad (3)$$

The equality (3) suggests two additional assumptions for valid survival estimation using the paired release-recapture protocol.

A8. Survival in the upriver segment (*S*) is conditionally independent of survival in the lower river segment.

A9. Releases (R_1) and (R_2) have the same survival probability in the lower river segment (S_{21}).

The assumption of downstream mixing was tested at each downstream array. An R x C contingency table test of homogenous recoveries over time was performed using a table of the form:

		Release	
		R_1	R_2
Day of detections	1		
	2		
	3		
	⋮		
	D		

For each paired-release (R_1 and R_2), a chi-square test of homogeneity was performed at each downstream array. Tests were performed at $\alpha = 0.10$. Because there were multiple releases and tests across paired releases, the Type I error rates were adjusted for an overall experimental-wise error rate of $\alpha_{EW} = 0.10$ pertaining specifically to each evaluation conducted at John Day Dam.

Inferences regarding mixing will be largely based on the sequential use of likelihood ratio tests. In any given survival estimation scenario, a number of potential models will be generated and subsequently evaluated (Burnham et al. 1987, Leberton et al. 1992). Forward-sequential and reverse-sequential procedures will be used to find the most parsimonious statistical model that adequately describes the downstream survival and capture processes of the paired-release. The most efficient estimate of survival will be based on the statistical model for the paired releases that properly share all common parameters between release groups. When the sequential procedures suggested that the treatment and control groups did not share all parameters in common we used Akaike's Information Criterion (AIC, Awake 1973) to select the most parsimonious model. The treatment and control groups were then assumed to not be mixed or mixed and that some other process had differentially affected the survival and/or capture probabilities for the groups given that they were traveling downriver at approximately the same time.

A weighted average of the survival estimates from the replicated releases can be calculated according to the formula:

$$\hat{\hat{S}} = \frac{\sum_{i=1}^{k} W_i \hat{S}_i}{\sum_{i=1}^{k} W_i} \tag{1}$$

where k = number of replicate releases:

and where $\hat{S}_i$ = survival estimates from the ith release (i = 1, ..., k);

The weight W_i is calculated using the formula:

$$W_i = \frac{1}{\left(\frac{V\hat{a}r\left(\hat{S}_i\right)}{\hat{S}_i^2}\right)} = \frac{1}{CV\left(\hat{S}_i\right)^2} \tag{5}$$

with variance

$$Var\left(\hat{\hat{S}}\right) = \frac{\sum_{i=1}^{k} W_i \left(\hat{S}_i - \hat{\hat{S}}\right)^2}{(k-1)\sum_{i=1}^{k} W_i} \tag{6}$$

If the average is estimating a mean over some static process then weighting would be inversely proportional to the variance. However, in the release-recapture models,

$$Var\left(\hat{S}\right) \propto S^2 .$$

Therefore, the variance is correlated with the point estimates of survival. The weight (5) eliminates this correlation yet weights in proportion to the sampling precision (i.e., *CV*). Unfortunately, while the weighted average has been applied by others examining the survival of PIT-tagged salmonids in the Columbia River Basin, the use of this methodology for estimating mean survival using radio-tagged fish has resulted in certain estimates (e.g., those that have survival and capture probabilities near 1) having highly disproportionate weights that invariably results in estimates of survival that are very near 1 despite the fact that very few of the survival estimates reflect this value. While weighted averages are designed to weight the average by certain observations with given qualities or other derived variables or quantities and thus cannot be expected to represent the value that would exist given an un-weighted estimator, the use of a weighted estimator that always skews the evaluation to indicate that the survival of fish passing a given project or route is 1, when as researchers we know this to not be the case, is unacceptable. The high capture probabilities possible with current radio-telemetry systems and the nature of the way the SURPH software calculates the variance of the survival estimates of the individual releases (e.g., analogous to the binomial variance formula) have been identified as the cause of this result. Coordination between the USGS and the University of Washington, and subsequent efforts by University of Washington personnel have failed to resolve this matter. Consequently, we will evaluate the use of the weighted average, but will use the arithmetic mean to represent the survival of yearling Chinook salmon and steelhead trout at the various projects if it appears that the use of the weighted estimator results in estimates that are disproportionately influenced by the methodology.

We evaluated t-tests to compare the survival of yearling and sub-yearling Chinook salmon and steelhead trout released through the John Day Dam juvenile bypass during the day and night. The specific hypotheses tested were as follows:

Yearling Chinook

$$H_0 : S_{JUVENILE\ BYPASS\ DAY} = S_{JUVENILE\ BYPASS\ NIGHT}$$

$$H_0 : S_{JUVENILE\ BYPASS\ DAY} \neq S_{JUVENILE\ BYPASS\ NIGHT}$$

Steelhead trout

$$H_0 : S_{JUVENILE\ BYPASS\ DAY} = S_{JUVENILE\ BYPASS\ NIGHT}$$

$$H_0 : S_{JUVENILE\ BYPASS\ DAY} \neq S_{JUVENILE\ BYPASS\ NIGHT}$$

Sub-yearling Chinook

$$H_0 : S_{JUVENILE\ BYPASS\ DAY} = S_{JUVENILE\ BYPASS\ NIGHT}$$

$$H_0 : S_{JUVENILE\ BYPASS\ DAY} \neq S_{JUVENILE\ BYPASS\ NIGHT}$$

Bartlett's, Brown-Forsythe, and Levene's tests for equal variance were evaluated for each comparison and where suggested by the results of these tests, variance weighted t-tests were evaluated. To examine the relation of the survival of our individual paired release groups at John Day Dam to various environmental and dam operation conditions present at these projects during 2001, we evaluated linear regressions. All linear regressions were examined for outliers using regression diagnostics (e.g., studentized deleted residuals, Cook's distance, DFFITS, as per Neter et al. 1989). Outlying observations were eliminated where appropriate and the fit and significance of the resulting models were examined.

Results

Burnham Tests

The results of the Burnham Tests 2 and 3 testing assumptions A5 and A6 for the yearling Chinook released into the juvenile bypass at John Day dam and their corresponding tailrace releases were inconclusive. For Test 2, 27 of the 32 possible tests were incalculable due to the presence of all zeroes in either rows or columns in the chi-square contingency tables (Table 9). Of the tests that were calculated, goodness-of-fit was rejected for only 3 of the 32 tests ($P < 0.10$). For Test 3, similar results were obtained with 22 of the 32 tests incalculable with no tests indicating lack of fit.

The results of the Burnham Tests 2 and 3 testing assumptions A5 and A6, for steelhead trout released at Rock Creek and known to have passed the John Day Dam and releases of steelhead in the John Day Dam tailrace were also inconclusive. For Test 2, 30 of the 34 possible tests were incalculable due to the presence of all zeroes in either rows or columns in the chi-square contingency tables (Table 10). Of the tests that were calculated, goodness-of-fit was rejected for only 4 of the tests ($P < 0.10$). For Test 3, similar results were obtained with 30 of the 34 tests incalculable with no tests calculated for Test 3 indicating lack of fit.

For the sub-yearling Chinook salmon releases through the John Day Dam juvenile bypass and corresponding releases in the John Day Dam tailrace, the results obtained for the Burnham Tests 2 and 3 indicated that assumptions A5 and A6 were not violated. For Test 2, none of the tests evaluated indicated lack of fit with 9 of the 32 possible tests incalculable due to the presence of all zeroes in either rows or columns in the chi-square contingency tables (Table 11). Similarly, no tests evaluated for Test 3 suggested lack of fit while 15 of the 32 tests were incalculable.

Tests of the assumption of mixing of the treatment and control groups

The chi-square tests of homogeneity testing for the similarity in arrival times of paired releases of yearling Chinook salmon and steelhead trout indicated that there were no significant differences in arrival times between the two release groups for either species at The Dalles Dam (Table 12), the radio-telemetry array at river kilometer 286 in Bonneville Reservoir (Table 13), or the radio-telemetry array at river kilometer 264 in Bonneville Reservoir (Table 14). Similar results were obtained for the chi-square tests of homogeneity testing for the similarity in arrival times of paired releases of sub-yearling Chinook salmon. No significant differences were detected at any of the downstream arrays used in this evaluation (Table 15).

Table 9. Summary statistics for goodness-of-fit tests (tests 2 and 3, Burnham et al. 1987) for each of 16 paired releases of yearling Chinook salmon, spring 2001. The treatment fish were released into the John Day Dam juvenile bypass system and the control fish were released into the John Day Dam tailrace.

			Test 2			Test 3	
Release	Population	df	χ^2	P	df	χ^2	P
1	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
2	treatment	1	2.982	0.084	1	0.188	0.665
	control		[a]	[a]		[a]	[a]
3	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
4	treatment		[a]	[a]	1	0.131	0.717
	control		[a]	[a]		[a]	[a]
5	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]	1	0.017	0.896
6	treatment	1	2.982	0.084	1	0.188	0.665
	control		[a]	[a]	1	0.101	0.751
7	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
8	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
9	treatment		[a]	[a]	1	0.022	0.882
	control		[a]	[a]		[a]	[a]
10	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
11	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
12	treatment	1	4.237	0.040	1	0.055	0.815
	control	1	1.496	0.221	1	0.603	0.438
13	treatment		[a]	[a]		[a]	[a]
	control	1	0.674	0.412	1	0.208	0.648
14	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
15	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
16	treatment		[a]	[a]	1	0.098	0.755
	control		[a]	[a]		[a]	[a]

[a] - Chi-square statistic was not calculable for these tests due to the presence of all zeroes in a row or column of the contingency table.

Table 10. Summary statistics for goodness-of-fit tests (tests 2 and 3, Burnham et al. 1987) for each of 17 paired releases of juvenile steelhead trout, spring 2001. The treatment fish were released into John Day Dam juvenile bypass system and the control fish were released into the John Day Dam tailrace.

			Test 2			Test 3	
Release	Population	df	χ^2	P	df	χ^2	P
1	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
2	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
3	treatment	1	6.240	0.012		[a]	[a]
	Control		[a]	[a]		[a]	[a]
4	treatment		[a]	[a]	1	1.264	0.261
	Control		[a]	[a]		[a]	[a]
5	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
6	treatment		[a]	[a]		[a]	[a]
	Control	1	4.237	0.040	1	0.473	0.492
7	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
8	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
9	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
10	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
11	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
12	treatment	1	4.738	0.030		[a]	[a]
	Control		[a]	[a]		[a]	[a]
13	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
14	treatment		[a]	[a]	1	0.351	0.554
	Control		[a]	[a]		[a]	[a]
15	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
16	treatment		[a]	[a]		[a]	[a]
	Control		[a]	[a]		[a]	[a]
17	treatment	1	3.371	0.066	1	0.411	0.521
	Control		[a]	[a]		[a]	[a]

[a] - Chi-square statistic was not calculable for these tests due to the presence of all zeroes in a row or column of the contingency table.

Table 11. Summary statistics for goodness-of-fit tests (tests 2 and 3, Burnham et al. 1987) for each of 16 paired releases of sub-yearling Chinook salmon, fall 2001. The treatment fish were released into the John Day Dam juvenile bypass system and the control fish were released into the John Day Dam tailrace.

		Test 2			Test 3		
Release	Population	df	χ^2	P	df	χ^2	P
1	treatment	1	0.055	0.815		[a]	[a]
	control		[a]	[a]		[a]	[a]
2	treatment	1	0.002	0.964	1	1.371	0.242
	control	1	0.045	0.832	1	0.442	0.506
3	treatment	1	0.060	0.806	1	1.996	0.158
	control	1	0.042	0.838		[a]	[a]
4	treatment	1	0.217	0.641	1	2.500	0.114
	control	1	0.327	0.568		[a]	[a]
5	treatment	1	0.052	0.819	1	0.113	0.737
	control		[a]	[a]		[a]	[a]
6	treatment	1	0.010	0.922	1	0.847	0.357
	control		[a]	[a]		[a]	[a]
7	treatment	1	2.246	0.134	1	0.236	0.627
	control	1	1.746	0.186	1	0.217	0.641
8	treatment	1	0.299	0.585	1	0.339	0.560
	control		[a]	[a]		[a]	[a]
9	treatment	1	0.896	0.344	1	0.397	0.529
	control	1	0.219	0.640	1	0.600	0.439
10	treatment	1	0.847	0.357	1	0.134	0.714
	control		[a]	[a]		[a]	[a]
11	treatment		[a]	[a]		[a]	[a]
	control	1	0.000	1.000	1	0.972	0.324
12	treatment	1	0.071	0.790		[a]	[a]
	control	1	1.371	0.242	1	0.522	0.470
13	treatment	1	0.113	0.737	1	0.005	0.945
	control		[a]	[a]		[a]	[a]
14	treatment	1	0.502	0.479	1	0.381	0.537
	control	1	1.122	0.290		[a]	[a]
15	treatment		[a]	[a]		[a]	[a]
	control		[a]	[a]		[a]	[a]
16	treatment	1	1.723	0.189		[a]	[a]
	control	1	1.496	0.221	1	0.045	0.833

[a] - Chi-square statistic was not calculable for these tests due to the presence of all zeroes in a row or column of the contingency table.

Table 12. The results of chi-square tests of homogeneity testing for similarity in arrival times of paired releases of yearling Chinook salmon and steelhead trout released at John Day Dam and detected at The Dalles Dam.

Paired	Yearling Chinook salmon			Steelhead trout		
Release	DF	Chi-square	P	DF	Chi-square	P
1	3	3.67	0.299	2	6.30	0.043
2	2	1.12	0.571	2	0.90	0.639
3	1	0.39	0.533	2	3.12	0.210
4	2	6.94	0.031	1	5.17	0.023
5	1	0.92	0.336	1	1.66	0.198
6	1	1.08	0.298	2	1.47	0.479
7	0	0	[a]	1	0.76	0.383
8	1	0.89	0.345	1	0.81	0.368
9	0	0	[a]	1	0.87	0.351
10	0	0	[a]	1	1.32	0.251
11	0	0	[a]	1	4.84	0.028
12	1	1.02	0.311	1	1.02	0.312
13	0	0	[a]	0	0	[a]
14	1	0.89	0.347	0	0	[a]
15	0	0	[a]	0	0	[a]
16	0	0	[a]	1	0.97	0.326
17	[b]	[b]	[b]	1	0.87	0.352

[a] -- All fish arrived on the same day at this detection array indicting that the treatment and control groups were mixed.
[b] -- No fish released from John Day Dam

Table 13. The results of chi-square tests of homogeneity testing for similarity in arrival times of paired releases of yearling Chinook salmon and steelhead trout released at John Day Dam and detected at the radio-telemetry array at river kilometer 286 near Memaloose Island in the Bonneville Reservoir.

Paired	Yearling Chinook salmon			Steelhead trout		
Release	DF	Chi-square	P	DF	Chi-square	P
1	4	6.26	0.180	4	2.48	0.649
2	4	4.80	0.308	4	4.62	0.329
3	1	0.22	0.636	3	1.87	0.600
4	2	0.65	0.721	3	6.58	0.087
5	2	2.21	0.331	2	2.70	0.259
6	2	0.32	0.850	2	5.02	0.081
7	2	1.76	0.415	1	1.56	0.212
8	2	2.00	0.367	2	6.30	0.043
9	0	0	[a]	2	5.15	0.076
10	0	0	[a]	1	4.71	0.030
11	0	0	[a]	2	1.36	0.506
12	1	1.61	0.204	1	2.11	0.147
13	0	0	[a]	2	2.83	0.243
14	1	1.00	0.316	1	6.95	0.008
15	0	0	[a]	1	1.10	0.294
16	0	0	[a]	1	2.58	0.108
17	[b]	[b]	[b]	2	0.56	0.757

[a] -- All fish arrived on the same day at this detection array
[b] -- No fish released from John Day Dam

Table 14. The results of chi-square tests of homogeneity testing for similarity in arrival times of paired releases of yearling Chinook salmon and steelhead trout released at John Day Dam and detected at the radio-telemetry array at river kilometer 264 in the Bonneville reservoir.

Paired	Yearling Chinook salmon			Steelhead trout		
Release	DF	Chi-square	P	DF	Chi-square	P
1	3	5.33	0.149	3	2.28	0.517
2	3	4.10	0.251	4	4.36	0.359
3	1	3.42	0.064	3	0.97	0.807
4	2	4.56	0.102	3	2.66	0.447
5	2	5.02	0.081	2	1.21	0.546
6	2	1.08	0.584	1	1.30	0.255
7	0	0	[a]	1	2.25	0.134
8	1	0.14	0.707	1	4.94	0.026
9	0	0	[a]	1	0.01	0.929
10	1	1.05	1.306	1	1.22	0.269
11	0	0	[a]	2	0.77	0.682
12	1	0.64	0.424	1	1.88	0.170
13	1	1.18	0.277	2	4.80	0.091
14	1	0.48	0.490	1	2.17	0.141
15	0	0	[a]	1	0.82	0.366
16	0	0	[a]	1	4.49	0.034
17	[b]	[b]	[b]	3	1.59	0.661

[a] -- All fish arrived on the same day at this detection array indicating that the treatment and control groups were mixed.
[b] -- No fish released from John Day Dam

Table 15. The results of chi-square tests of homogeneity testing for similarity in arrival times of paired releases of sub-yearling Chinook salmon released at John Day Dam and detected at The Dalles Dam, the radio-telemetry array at river kilometer (rkm) 286 in the Bonneville reservoir, and the radio-telemetry array at river kilometer 264 in the Bonneville reservoir.

	The Dalles Dam			Array at rkm 286			Array at rkm 264		
Release	DF	Chi-square	P	DF	Chi-square	P	DF	Chi-square	P
1	0	0	[a]	2	1.40	0.497	4	5.77	0.217
2	1	0	1.00	2	1.53	0.464	3	4.16	0.245
3	0	0	[a]	1	0.06	0.810	2	1.35	0.508
4	1	1.17	0.280	2	0.53	0.767	4	6.05	0.196
5	0	0	[a]	1	0.78	0.377	1	2.61	0.106
6	1	0.98	0.322	2	4.47	0.107	3	1.71	0.636
7	1	0.98	0.322	4	2.38	0.666	4	3.45	0.486
8	1	0.28	0.597	3	4.32	0.230	3	2.89	0.409
9	2	1.46	0.482	3	3.25	0.355	4	5.73	0.220
10	2	1.46	0.483	3	2.27	0.519	4	4.54	0.338
11	3	3.66	0.301	2	2.33	0.311	2	1.60	0.450
12	3	2.13	0.545	2	1.32	0.516	4	1.84	0.765
13	2	2.44	0.296	4	3.30	0.509	4	2.31	0.678
14	1	0.31	0.579	1	0.40	0.525	2	0.77	0.681
15	1	1.02	0.312	2	0.88	0.645	3	1.96	0.580
16	1	0.37	0.545	2	0.88	0.645	2	1.64	0.441

[a] - All fish arrived on the same day at this detection array indicating that the treatment and control groups were mixed.

Sequential evaluation of log-likelihood tests

A sequential evaluation of log-likelihood tests testing for significant difference in the survival model parameters was also performed to further evaluate the assumption of mixing and evaluate assumption A9 (e.g., Releases R1 and R2 have the same survival probability in the lower river segment S_{21}, see Figure 1). For yearling Chinook salmon and steelhead trout released into the juvenile bypass at John Day Dam, the majority of models selected did not suggest that the survival of treatment and control groups were significantly different in the river reaches evaluated below John Day Dam (Table 16, $P > 0.10$). Similarly, the majority of models selected for the evaluation of survival of sub-yearling Chinook salmon released into the juvenile bypass at John Day Dam also did not suggest differential survival of the treatment and control groups for the river segments evaluated (Table 16, $P > 0.10$).

Releases of dead radio-tagged fish

No dead radio-tagged fish were detected at any of the radio-telemetry arrays downstream of John Day Dam.

Survival Probability Assessment

Yearling Chinook salmon

We estimated that the survival of yearling Chinook salmon released through the John Day Dam juvenile bypass ranged from 0.827 to 1.179 (Table 17). The average survival of yearling Chinook salmon released through the John Day Dam juvenile bypass during the 2001 migration season was 0.932 (± 0.042, 95% confidence interval). For releases of yearling Chinook salmon made during the day the average survival was estimated to be 0.941 (± 0.074, 95% confidence interval) and for the night releases was 0.923 (± 0.046, 95% confidence interval). No significant differences were detected between day and night survival for yearling Chinook salmon released into the juvenile bypass system ($P = 0.68$, two-tailed t-test). We detected a significant relation between the survival of yearling Chinook salmon released through the John Day Dam juvenile bypass and total discharge (Figure 2) at John Day Dam ($P = 0.005$, $r^2 = 0.47$). One observation was designated as an outlier (Studentized deleted residual = 6.69, Cook's distance = 1.25, DFFITS = 3.2085) and removed from the analysis.

Steelhead trout

The survival of steelhead trout released through the John Day Dam juvenile bypass was estimated to range from 0.789 to 1.059 (Table 18). We estimated that the average survival of steelhead through this route was 0.917 (± 0.040, 95% confidence interval). Average day survival was estimated to be 0.915 (± 0.054, 95% confidence

Table 16. Frequency of models selected as a result of evaluating log-likelihood ratio tests that test for differences in survival and capture probabilities between control and treatment groups. Model designations indicate the parameters that control and treatment groups have in common. For instance, model designation lambda p2 s2 p1 indicates that all the survival and capture probabilities were found not to be significantly different between the control and release groups. Model designation CJS refers to Cormack-Jolly-Seber (Cormack 1964, Jolly 1965, Seber 1965) model estimates that assume all parameters were different. In all cases, use of the CJS models resulted from computational constraints (e.g., variance estimates incalculable) associated with the SURPH software program and do not indicate that all parameters were tested and found to be significantly different.

	John Day Dam Juvenile Bypass System Releases		
	Frequency		
Model	Yearling Chinook salmon	Steelhead trout	Sub-Yearling Chinook salmon
Lambda p2 S2 p1	9	13	8
Lambda p2 S2	0	0	3
Lambda s2 p1	2	0	0
Lambda p2 p1	0	0	1
P2 s2 p1	1	1	1
P1 p2	0	1	3
Lambda	1	0	0
CJS	3	2	0

Table 17. Survival probabilities and associated standard errors of yearling Chinook salmon released into the John Day Dam juvenile bypass system (Treatment) and released in the John Day Dam tailrace (Control), spring 2001.

John Day Dam Juvenile Bypass				
Paired Release	Release Date	Day/Night	Survival Probability	Standard Error
1	05/07/01	Day	0.920	0.102
2	05/08/01	Night	0.861	0.098
3	05/10/01	Day	1.179	0.165
4	05/11/01	Night	0.900	0.095
5	05/13/01	Day	0.838	0.102
6	05/14/01	Night	0.884	0.105
7	05/16/01	Day	0.842	0.088
8	05/17/01	Night	0.958	0.089
9	05/19/01	Day	0.916	0.089
10	05/20/01	Night	1.001	0.092
11	05/22/01	Day	0.957	0.075
12	05/23/01	Night	1.007	0.122
13	05/25/01	Day	0.962	0.080
14	05/26/01	Night	0.827	0.092
15	05/28/01	Day	0.917	0.089
16	05/29/01	Night	0.934	0.083

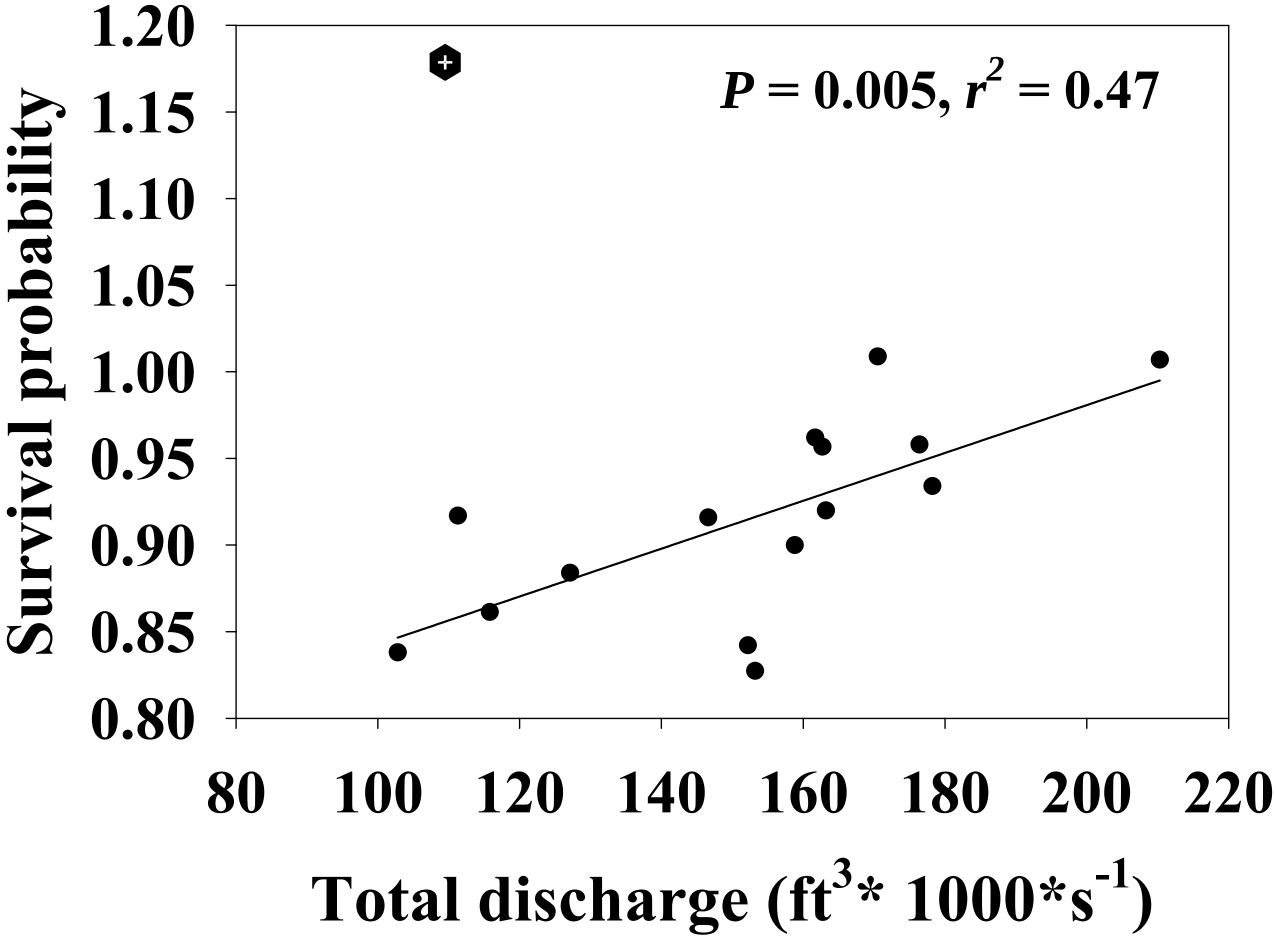

Figure 2. The relation of the survival of yearling Chinook salmon released through the John Day Dam juvenile bypass system and total discharge.

Table 18. Survival probabilities and associated standard errors of juvenile steelhead trout released into the John Day Dam juvenile bypass system (Treatment) and released in the John Day Dam tailrace (Control), spring 2001.

John Day Juvenile Bypass System				
Paired Release	Release Date	Day/Night	Survival Probability	Standard Error
1	05/07/01	Day	0.923	0.098
2	05/08/01	Night	0.958	0.089
3	05/10/01	Day	0.936	0.089
4	05/11/01	Night	0.969	0.089
5	05/13/01	Day	0.815	0.089
6	05/14/01	Night	0.901	0.092
7	05/16/01	Day	0.833	0.141
8	05/17/01	Night	0.889	0.097
9	05/19/01	Day	0.838	0.092
10	05/20/01	Night	1.059	0.119
11	05/22/01	Day	1.044	0.072
12	05/23/01	Night	0.816	0.096
13	05/25/01	Day	0.935	0.081
14	05/26/01	Night	0.979	0.116
15	05/28/01	Day	0.878	0.099
16	05/29/01	Night	0.789	0.128
17	05/31/01	Day	1.033	0.126

interval) while night survival was 0.920 (± 0.062, 95% confidence interval). No significant difference was detected between day and night survival (P = 0.91, two-tailed t-test) for steelhead trout. No significant relation between the survival of steelhead trout released through the John Day Dam juvenile bypass and total discharge at John Day Dam was detected (Figure 3, P = 0.68, r^2 = 0.01).

Sub-yearling Chinook salmon

For sub-yearling Chinook salmon released through the John Day Dam juvenile bypass, the estimated survival ranged from 0.458 to 1.23 (Table 19). The average survival of sub-yearling Chinook salmon was estimated to be 0.868 (± 0.084, 95% confidence interval). Average day survival was estimated to be 0.949 (± 0.10, 95% confidence interval) while night survival was estimated to be 0.786 (± 0.11, 95% confidence interval). The difference between day and night survival was found to be statistically significant (P = 0.048, two-tailed t-test) for sub-yearling Chinook salmon. The relationship between the survival of sub-yearling Chinook released through the juvenile bypass and total discharge was found to be significant (P= 0.08, r^2 = 0.20; Figure 4).

Discussion

As was true for releases made during 1999 and 2000 (Counihan et al. 2002), the majority of the Burnham Tests 2 and 3 that test the assumption that upstream or downstream detections do not affect downstream survival and/or detection were incalculable for releases of yearling Chinook salmon and steelhead trout at John Day Dam. The majority of tests were calculable for sub-yearling Chinook salmon; perhaps reflecting the lower capture probabilities associated with the releases of these fish. While we will continue to evaluate Burnham tests 2 and 3 in future years, the utility of these tests to discern whether assumptions A5 and A6 have been met is limited by the high capture probabilities now possible with the radio-telemetry detection arrays. Since we have constructed detection arrays that span the entire river channel, the possibility that this assumption could be violated if downstream detections were influenced by upstream passage routes is minimized (Skalski 1999a). Also, the lack of handling following initial release of radio-tagged fish also minimizes the risk that upstream detections affect survival (Skalski 1999a).

Releases of yearling Chinook salmon and steelhead trout near Rock Creek, WA were not conducted during 2001. Consequently, past difficulties in matching up the passage time of the treatment groups with releases of control groups in the tailrace of John Day Dam, to satisfy the assumption of mixing of the treatment and control groups particularly for steelhead, were not experienced during the 2001 evaluation. Thus, the assumption of mixing of the treatment and control groups was satisfied during 2001 for all species evaluated at John Day Dam. Releases of dead radio-tagged yearling and

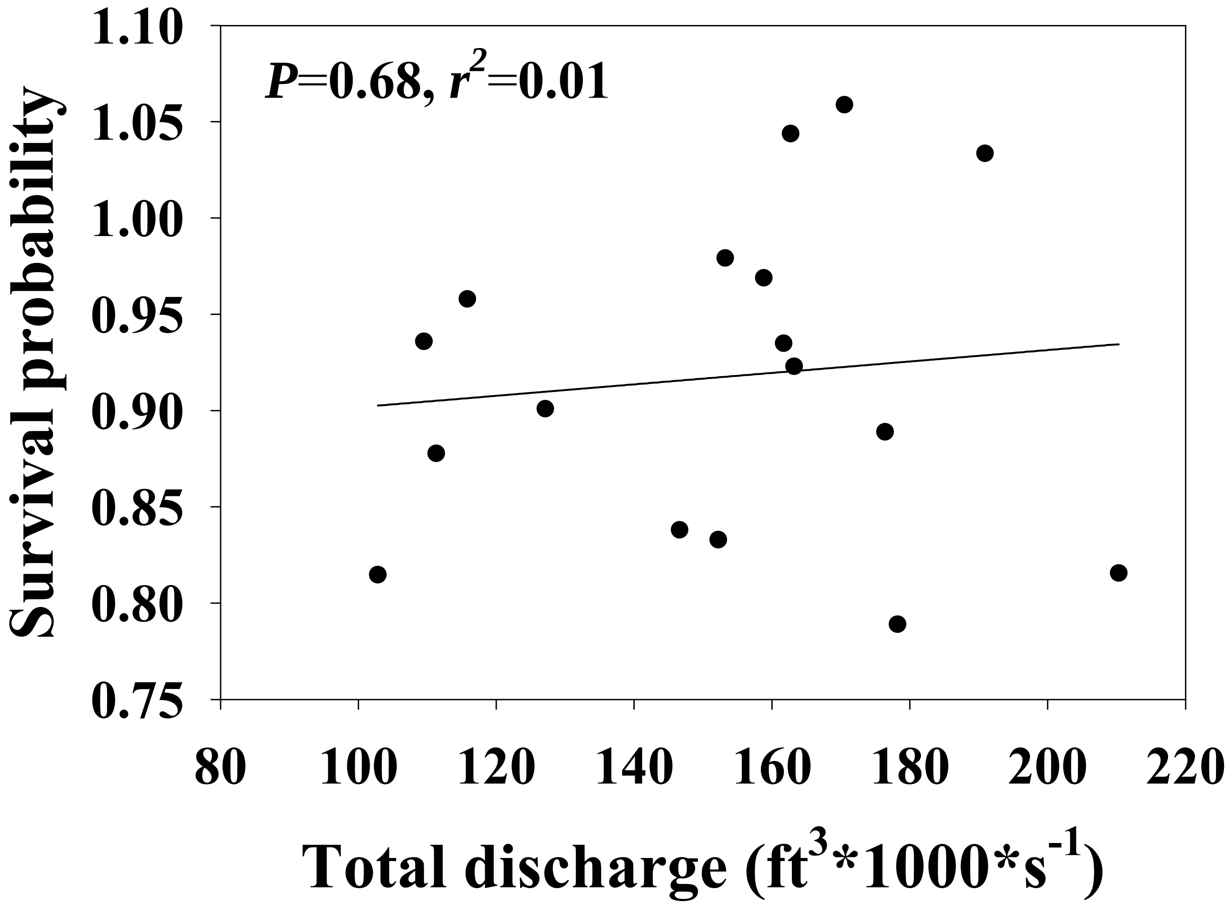

Figure 3. The relation of the survival of juvenile steelhead trout released through the John Day Dam juvenile bypass system and total discharge.

Table 19. Survival probabilities and associated standard errors of sub-yearling Chinook salmon released into the John Day Dam juvenile bypass system (Treatment) and released in the John Day Dam tailrace (Control), fall 2001.

John Day Juvenile Bypass System to The Dalles Dam				
Paired Release	Release Date	Day/Night	Survival Probability	Standard Error
1	6/20/01	Day	0.845	0.120
2	6/21/01	Night	0.771	0.128
3	6/23/01	Day	1.087	0.146
4	6/24/01	Night	0.758	0.099
5	6/26/01	Day	1.230	0.185
6	6/27/01	Night	0.797	0.104
7	6/29/01	Day	0.861	0.072
8	6/30/01	Night	0.792	0.097
9	7/02/01	Day	0.959	0.101
10	7/03/01	Night	0.992	0.186
11	7/05/01	Day	0.904	0.130
12	7/06/01	Night	0.833	0.144
13	7/08/01	Day	0.936	0.161
14	7/09/01	Night	0.891	0.168
15	7/12/01	Day	0.771	0.112
16	7/13/01	Night	0.458	0.112

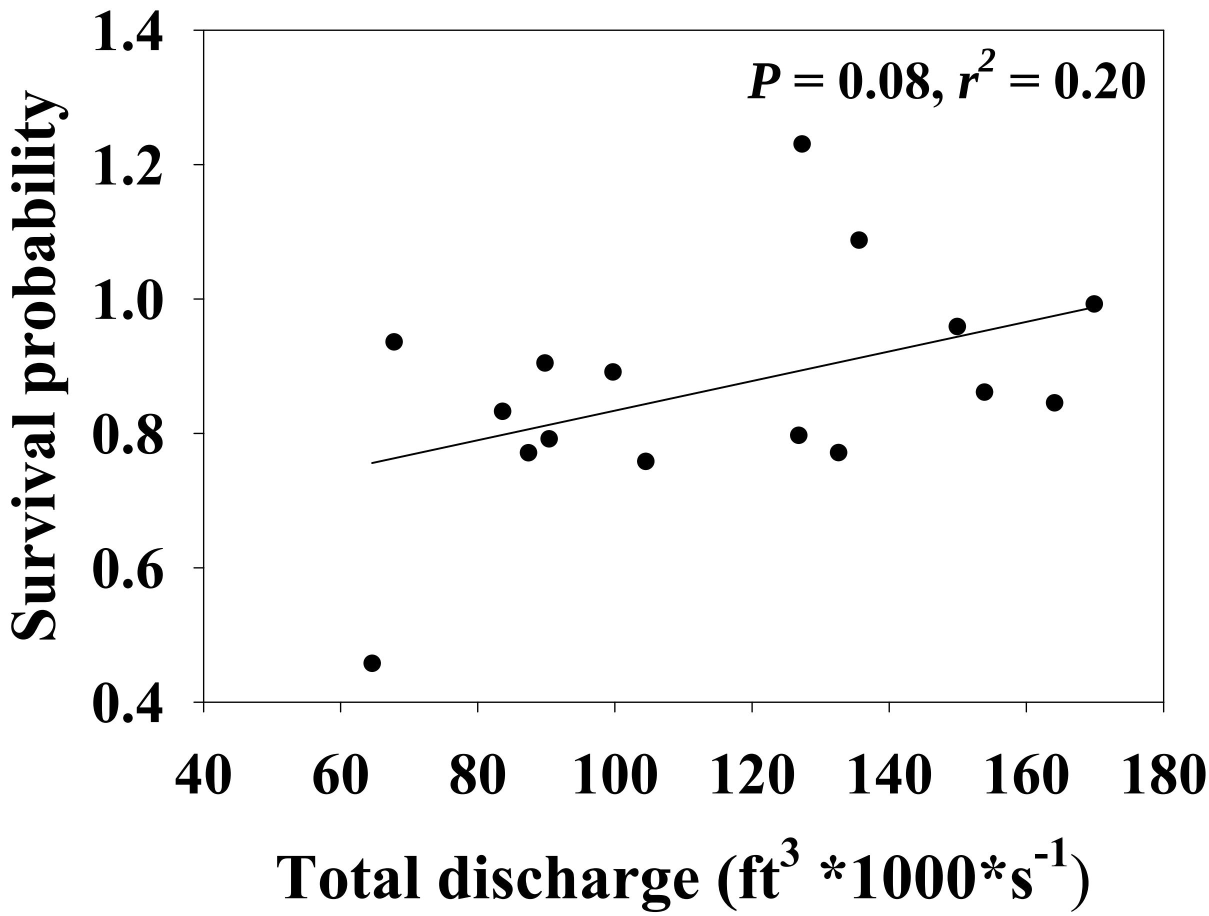

Figure 4. The relation of the survival of sub-yearling Chinook salmon released through the John Day Dam juvenile bypass system and total discharge.

sub-yearling Chinook salmon and steelhead trout at John Day Dam indicated that there was no evidence at these projects that dead radio-tagged fish drifted downstream and were detected and thus, assumed to be alive when in fact they were dead.

Evaluations of the survival of yearling and sub-yearling Chinook salmon and steelhead trout during 2001 were only made through the John Day Dam juvenile bypass and thus, comparisons of the survival through this route cannot be placed in the context of the survival through other passage routes at John Day Dam during 2001. Further, evaluations of the survival of juvenile salmonids passing through the juvenile bypass were initiated during 2001 and thus, comparisons to survival through this route in other years is not possible.

No significant differences were detected between day and night survival for yearling Chinook salmon and steelhead trout. However, the survival of sub-yearling Chinook salmon during day and night releases was found to be significantly different. Differences between total discharge through John Day during times when releases were made offer a possible explanation for the magnitude of differences between day and night survival among the species. For both yearling Chinook and steelhead, the average total discharge during night releases (release times ranged from 2130 to 2306 h) were higher than for day releases (release times ranged from 0931 to 1139 h) (Table 12). For sub-yearling Chinook salmon, however, average total discharge was higher during the day (release times ranged from 0940 to 1116 h) then night releases (release times ranged from 2138 to 2305 h) (Table 12). In a manuscript summarizing research conducted on the distribution of northern pikeminnow in the tailrace areas of The Dalles and John Day dams, Hansel et al. (In preparation) found significant correlations between the use of the tailrace area of John Day Dam by northern pikeminnow and decreased total discharge and increased spill discharge. Altered hydraulics in the tailrace area may also promote egress through areas with high predator densities during times of low discharge. Differences in average total discharge did exist for day and night releases of yearling Chinook and steelhead but were small for steelhead and somewhat greater for yearling Chinook (Table 12). Differences in total discharge that did not result in significant differences in day and night survival for yearling Chinook and steelhead may be a function of the relative magnitude of the discharge (i.e., average total discharge was much lower during releases of sub-yearling Chinook salmon).

No significant relation between total discharge and the survival of steelhead were detected. However, significant relations between the survival of yearling and sub-yearling Chinook salmon and total discharge through John Day Dam were detected. Potential causal mechanisms for the differences in the observed relationships are similar to those stated for differences in the day and night survival estimates.

Table 12. The average total discharge ($ft^3 \cdot s^{-1} \cdot 1000$) through John Day Dam during releases of radio-tagged yearling and sub-yearling Chinook salmon and steelhead trout during 2001.

	Average total discharge ($ft^3 \cdot s^{-1} \cdot 1000$)		
Day/Night	Yearling Chinook	Steelhead trout	Sub-yearling Chinook
Day	146.7	151.1	122.0
Night	154.3	154.3	109.0

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