Technical Report 2004-3

EVALUATION OF FALLBACK OF ADULT SALMON AND STEELHEAD VIA JUVENILE BYPASS SYSTEMS AT BONNEVILLE, JOHN DAY, McNARY AND ICE HARBOR DAMS: 2000-2001

A report for Project ADS-P-0012

by

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Portland, Oregon, Walla Walla, Washington

2004

Preface

Radiotelemetry studies of adult salmon and steelhead passage through the lower Columbia River began with fish being tagged and released at Bonneville Dam in 1996. The objective was to observe salmon and steelhead behavior and assess the degree to which dams may impede passage for adult salmon and steelhead during their upstream migration. In this report, we present information on fallback behavior of adult spring, summer, and fall Chinook salmon and steelhead via juvenile bypass systems (JBS) at Bonneville, John Day, McNary, and Ice Harbor dams in 2000 and 2001. Specifically, we evaluate the number of JBS fallbacks as a proportion of the total number of fallbacks observed at each dam, estimate the residency times of fish observed in the JBS, compare reascension rates of JBS and non-JBS fallback fish, examine how JBS fallback proportion is related to spillway discharge, and present data on the fates of fish with transmitters that fell back via a JBS.

Acknowledgments

Many people assisted in the field work and data compilation for this project and the successful completion was made possible through their efforts. We thank: A. Matter, A. Pinson, C. Williams, D. Joosten, G. Naugton, J. Sandquist, K. Traylor, L. Pinson, L. Ragan, M. Feeley, M. Heinrich, M. Morasch, T. Allen, T. Dick, R. Ringe, S. McCarthy, and S. Lee. Appreciation is additionally extended to D. Clugston and M. Shutters for serving as U.S. Army Corps of Engineers (USACE) liaisons for the project. These studies were funded by USACE, Portland and Walla Walla Districts.

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Abstract

We used radiotelemetry techniques to assess the fallback behavior of adult spring, summer, and fall Chinook salmon and steelhead via juvenile bypass systems (JBS) at Bonneville, John Day, McNary, and Ice Harbor dams in 2000 and 2001. Of the 868 fallback events recorded at the four dams during the two study years, 77 (8.9%) were via a JBS; 22 by spring-summer Chinook salmon, four by fall Chinook salmon, and 51 by steelhead. Sixty-one percent of all JBS fallback events occurred in 2001. Fifty-six percent of them occurred at McNary Dam. The median JBS residency time was 10.4 h based on minimum estimates and 60.2 h based on maximum estimates.

Sixty-one percent of all JBS fallback events were followed by reascensions while 70% of all fallback events via other routes were followed by reascensions. Of those fish that did not reascend the dam after a JBS fallback, 67% (n=6) of the spring-summer Chinook salmon, 0% (n=2) of the fall Chinook salmon, and 57% (n=23) of the steelhead were recorded entering a downstream tributary or were recaptured at a downstream hatchery. We believe some JBS fallback events may have been attributed to fish that overshot their natal tributaries and returned downstream to enter them.

JBS fallback proportions for spring-summer Chinook salmon were consistently higher at all dams in 2001 than in 2000. We believe the higher JBS fallback proportions in 2001 may have been associated with low spillway discharge volumes. We discerned no pattern between JBS fallback proportion and spill when we made similar comparisons for fall Chinook salmon or steelhead and speculate this may have been because the majority of their migrations occurred during periods of relatively little or no spill in both years.

Of the 76 unique fish with transmitters that experienced a JBS fallback event at one of the four dams during the two study years, 28 (37%) were recorded passing Lower Granite or Priest Rapids Dam, 21 (27%) were last recorded entering a tributary downstream of Lower Granite or Priest Rapids Dam, two (3%) were captured in a mainstem fishery, and we could not account for 25 (33%).

Introduction

Adult Chinook salmon and steelhead must pass six to eight dams to reach spawning grounds or hatcheries in the Snake River. From 1996 to 2003, radiotelemetry studies were conducted to evaluate fish passage at the four lower Columbia River dams, the four lower Snake River dams, and some dams in the mid-Columbia River. Radio-tagged fish were released downstream from Bonneville Dam in all years and in the Bonneville forebay starting in 2000. Their upstream migrations were monitored as part of the Lower Columbia River Adult Passage Project, funded by the U.S. Army Corps of Engineers (USACE) and Bonneville Power Administration.

Adult salmon and steelhead migrating upriver and exiting the fishways of Columbia and Snake River dams will occasionally pass back downstream via dam spillways, turbine intakes, juvenile bypass systems, navigation locks or ice and trash sluiceways. This behavior is termed fallback. Fallback events have been associated with lower escapement (Bjornn et al. 2000a). Most fallback events at Columbia and Snake river dams are believed to occur via spillways (Bjornn et al. 2000b; 2000c; 2000d) but the proportions of all fallbacks occurring via the juvenile bypass systems have not been quantified. In 2000, we began monitoring the JBS at Bonneville Powerhouse II, John Day, McNary and Ice Harbor dams with the goal of estimating fallback parameters.

Methods

Tagging

Adult spring–summer Chinook salmon and steelhead were released with transmitters downstream from Bonneville Dam throughout the migration of each species each year. Fish were collected in the Adult Fish Facility adjacent to the Washington shore ladder at Bonneville Dam. During the day, a picketed lead weir was dropped into the ladder and adult migrants were unselectively diverted into the trap. Fish swam from the trap into exit chutes and were diverted into an anesthetic tank [100 mg/L tricane-methane-sulphonate (MS-222) in 2000 or 22 mg/Lclove oil in 2001] via electronically controlled guide gates. Anesthetized fish were moved to a smaller tank where lengths, and marks or injuries were recorded, and where fish were tagged. A numbered visual implant (VI) tag was injected under the clear tissue posterior to the eye in 2000. We used PIT tags in 2001 as secondary tags. A radio transmitter dipped in glycerin was inserted into the stomach through the mouth in both years. We used 3- and 7-volt transmitters developed and supplied by Lotek Wireless (Newmarket, Ont.) that emitted a digitally coded signal (containing the frequency and code of the transmitter) every 5 s. We also used some combination radio/data storage transmitters (RDST tags) in 2000 that recorded and stored temperature and pressure data, and some combination acoustic/radio transmitters (CART tags) in 2001. All transmitters were cylindrical with 43-47 cm antennas. Seven volt tags weighed 29 g in air (8.3 by 1.6 cm), RDST tags were 34 g (9.0 by 2.0 cm), and CART tags were 28 g (6.0 by 1.6 cm). Code sets allowed us to monitor up to 212 fish on each frequency. Lithium batteries powered transmitters and all but the RDST tags had a rated operating life of more than nine months. After tagging, fish were placed in an aerated transport tank where they were held until released.

In 2000 and 2001, we released some fish into the Bonneville Dam forebay to evaluate possible locations of new fishway exits. We did not use fish released in the Bonneville forebay in Bonneville Dam fallback analyses, but included them in fallback summaries at upstream dams. Additionally, we excluded fallback events by post-spawn fish (e.g. steelhead kelts) from these analyses.

Fish to be tagged were not selected at random during 2000 but because each fish entering the trap could not be tagged, there was some component of chance associated with each selection. No jack (precocious) salmon or steelhead with fork lengths < 50 cm were tagged during either year. During 2001, there was an increased effort to tag fish from known sources (identified from PIT tags received when fish were juveniles) to address questions of homing and straying. Relatively high proportions of Snake River and upper Columbia River stocks were radiotagged during 2001 as a result. In total, we tagged and released 1,626 spring Chinook salmon, 619 summer Chinook salmon, 2,110 fall Chinook salmon, 1,501 A-group steelhead (tagged before 29 August) and 808 B-group steelhead (tagged after 28 August) during the two years of study (Table 1).

Table 1. Number of adult spring, summer and fall Chinook salmon (CK) and steelhead (SH) released with transmitters at Bonneville Dam in 2000 and 2001.

		Chinook salmon			Steelhead		
Year	Release site	Spring	Summer	Fall	A-Group	B-Group	Total
2000	Downstream	728	245	745	539	305	2,562
	Forebay	73	86	373	193	123	848
	Total	801	331	1,118	732	428	3,410
2001	Downstream	574	213	561	536	266	2,150
	Forebay	251	75	431	233	114	1,104
	Total	825	288	992	769	380	3,254

Chinook salmon were assigned run status (spring, summer, fall) according to day of tagging based on date conventions accepted by USACE. For analysis purposes, all Chinook salmon maintained this designations regardless of when they passed upstream locations.

Telemetry Monitoring

We used SRX sequentially scanning receivers (Lotek Wireless) with Yagi aerial antennas to determine when fish first entered the tailrace areas of dams. Digital spectrum processors (DSP) added to SRX receivers could simultaneously monitor several frequencies and antennas. SRX/DSP receivers were connected to aerial yagi antennas or underwater antennas made of coaxial cable. All receivers used to monitor juvenile bypass systems were SRX/DSPs. All receivers recorded and stored transmitter channel and code, relative power of signal, antenna receiving the signal, date, and time. Stored information was downloaded from receivers to computers approximately once per week, but varied with the number of fish passing the dam.

Study Sites

Bonneville Dam is located at river kilometer (rkm) 235.1 (Figure 1). It is comprised of an 18-bay spillway and two powerhouses containing a total of 18 turbines. There are adult fishways on the Washington shore and on Bradford and Cascade Islands. The juvenile bypass systems (one at each powerhouse) route fish from turbine intakes into a collection gallery from which they are eventually passed to an outfall in the tailrace of the dam. For this study, we report on fallback of adult salmon and steelhead at the Bonneville Powerhouse II JBS only. We deployed two 4-element Yagi aerial antennas in the Powerhouse II JBS to monitor the movements of radiotagged adult Chinook salmon and steelhead. The upstream antenna was installed 20 m upstream from the juvenile collection channel exit, just before fish exit the collection channel and enter a 1.14 m (inside diameter) pipe. The downstream antenna was installed near the exit of the 2.9 km pipe ending on Hamilton Island, immediately before the upstream switch gate used to divert migrating fish to the monitoring facility

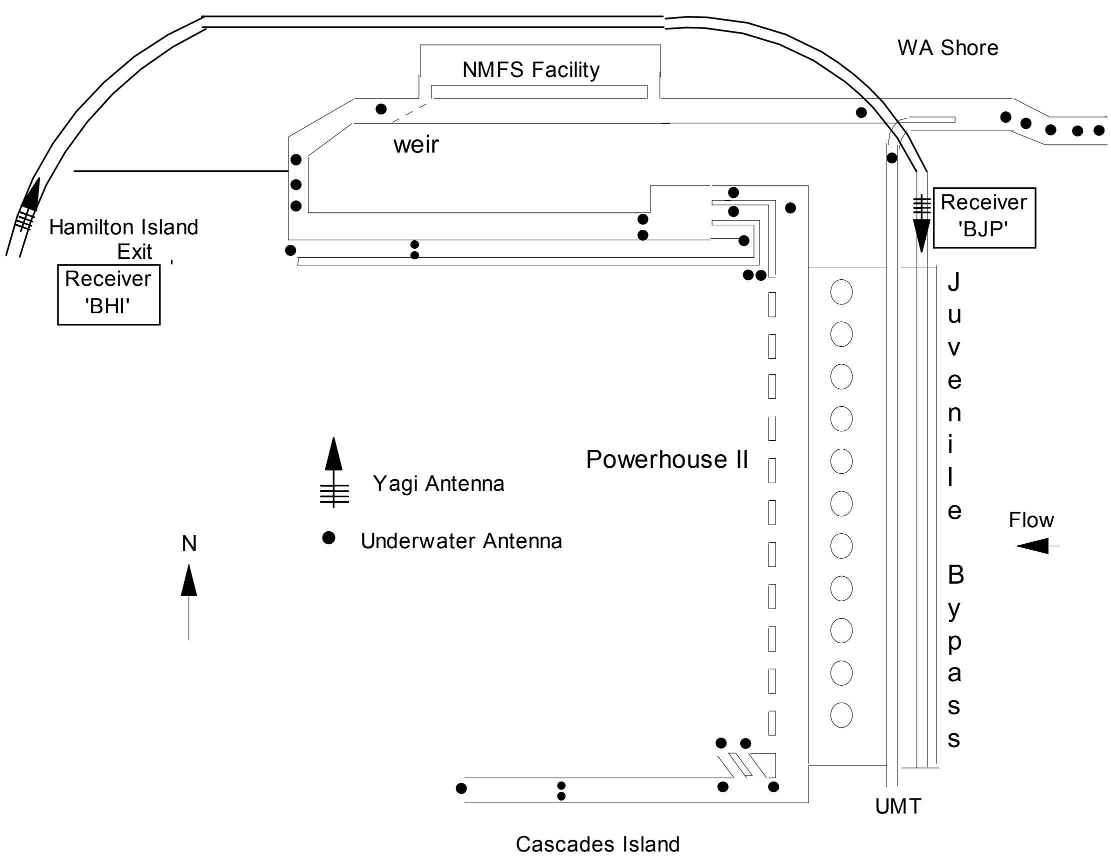

Figure 1. Location of aerial and underwater antennas at Bonneville Dam Powerhouse II in 2000 and 2001.

John Day Dam is located at rkm 346.9 and consists of a 20-bay spillway adjacent to a navigation lock on the north shore and a 16-turbine powerhouse adjacent to the south shore (Figure 2). There are two adult fishways, one along each shore. We deployed four underwater antennas in the JBS at John Day Dam. The first antenna was downstream from the hydraulic jump and the second antenna was installed at the outlet from the dewatering section. The third antenna was installed at the juvenile facility entrance pipeline before the separator and the fourth antenna was deployed at the exit of the JBS where fish are returned to the tailrace.

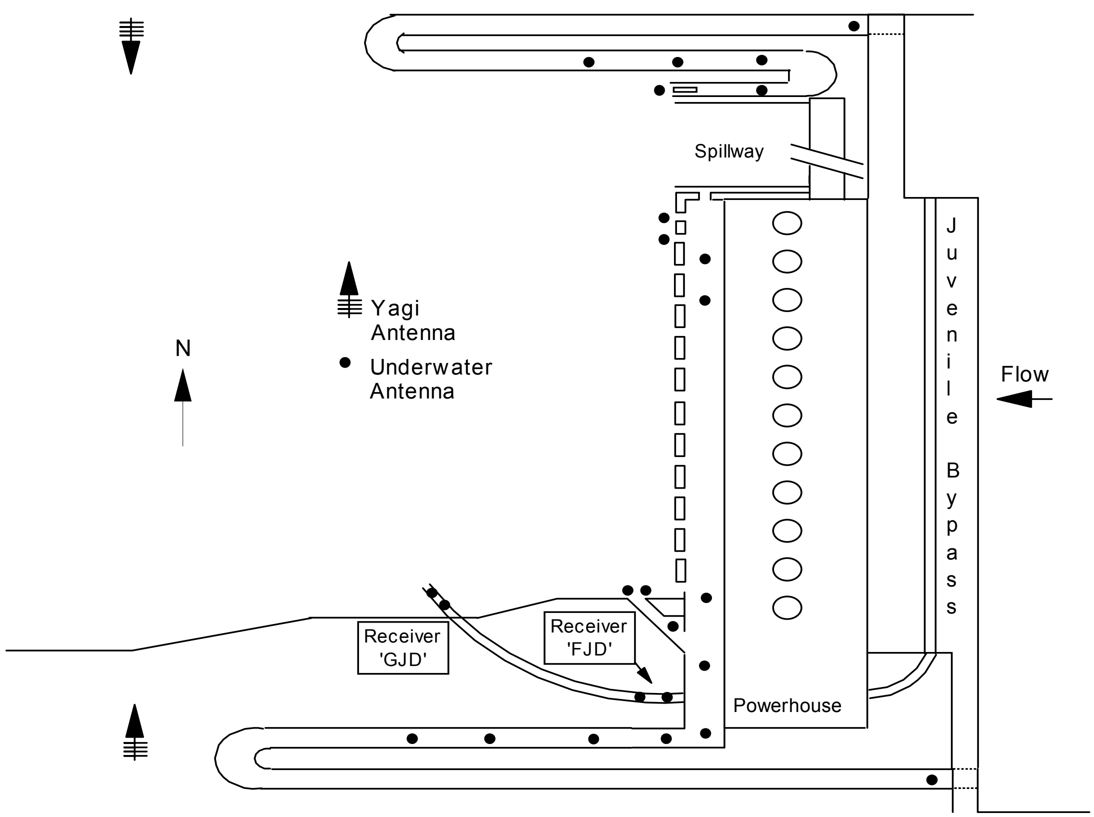

Figure 2. Location of aerial and underwater antennas at John Day Dam in 2000 and 2001.

McNary Dam is located at rkm 469.8 and consists of a 22-bay spillway adjacent to a navigation lock on the north shore and a 14-turbine powerhouse adjacent to the south shore (Figure 3). There are two fishways, one along each shore. We deployed six underwater antennas in the JBS of McNary Dam. The first was installed approximately 100 m from the north end of the juvenile collection channel and the second, third and forth antennas were deployed 200, 250 and 305 m from the north end, respectively. The fifth antenna was located near the exit of the collection channel where the channel depth decreases. The sixth antenna was deployed at the exit of the collection channel, before the site where fish are diverted to a separator/monitoring facility prior to being returned to the tailrace.

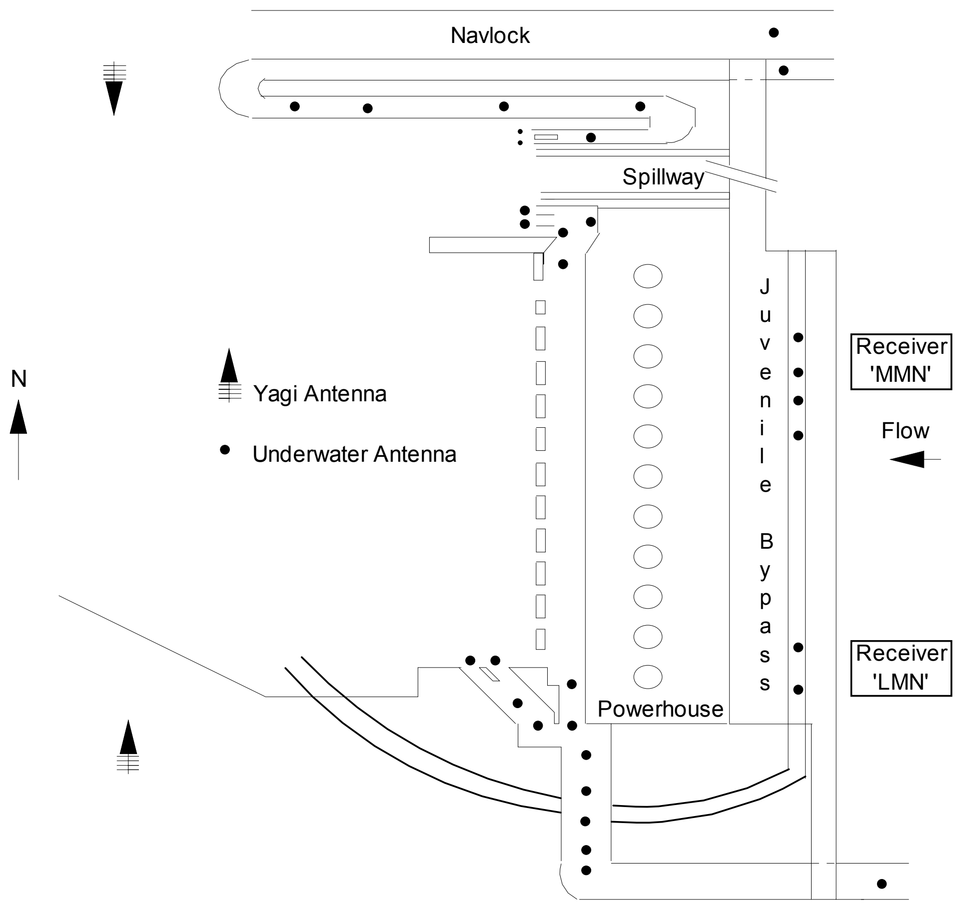

Figure 3. Location of aerial and underwater antennas at McNary Dam in 2000 and 2001.

Ice Harbor Dam is located at rkm 537.9, 16.3 rkm upstream from the confluence of the Snake and Columbia rivers. The dam consists of a 10-bay spillway adjacent to a navigation lock on the north shore and a six-turbine powerhouse adjacent to the south shore (Figure 4). There are two adult fishways, one along each shore. We deployed three underwater antennas in the JBS collection channel of Ice Harbor Dam. The first antenna was installed 111 m from the outlet of the juvenile collection channel, before the entrance to the pipe leading to the separator/monitoring facility. The second and third antennas were installed 81 and 50 m from the outlet, respectively.

Receiver Deployments and Outages

We monitored the juvenile bypass systems for radiotagged fish throughout the course of JBS operations at each dam within each year (Table 2). Most receivers at dams were removed in late November or early December for winter maintenance but receivers used to monitor tailraces and ladder exits operated throughout the year.

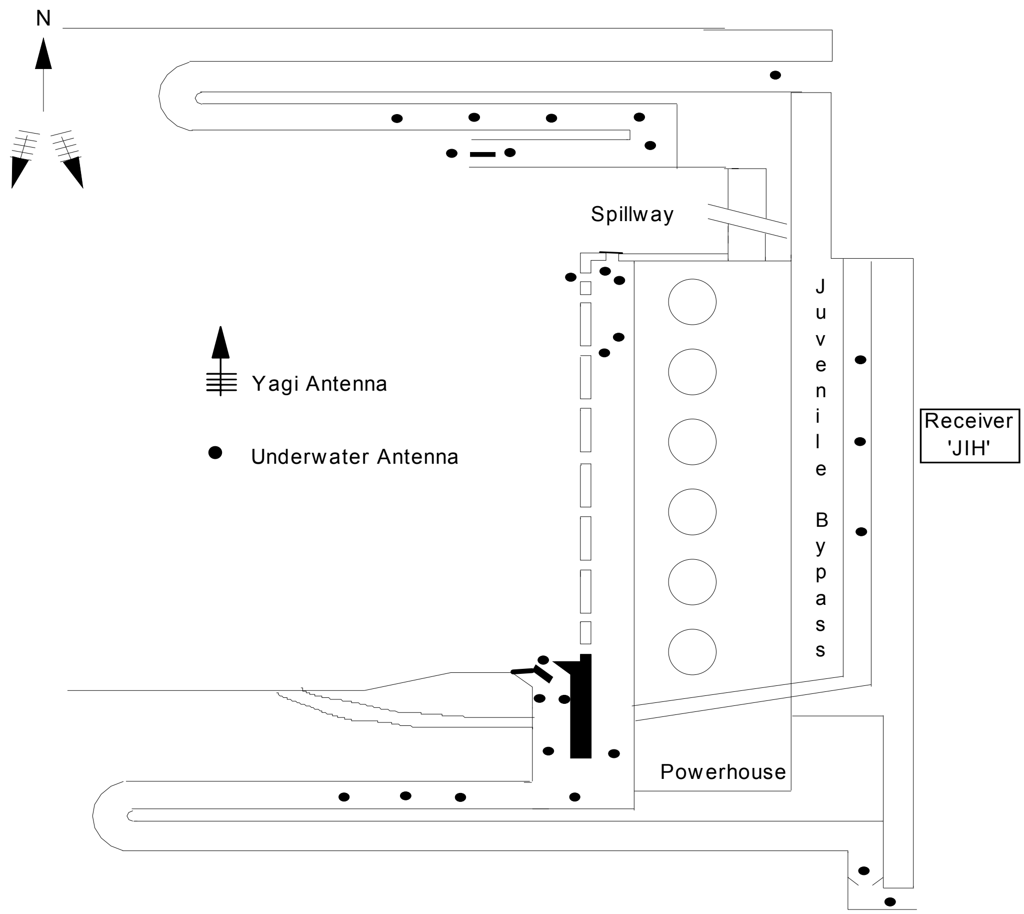

Figure 4. Location of aerial and underwater antennas at Ice Harbor Dam in 2000 and 2001.

Table 2. Dates of deployments and deactivations of JBS receivers at Bonneville, John Day, McNary, and Ice Harbor dams, 2000-2001.

Dam	Receiver	Deployment Date (m/d/y)	Deactivation Date (m/d/y)	Deployment Date (m/d/y)	Deactivation Date (m/d/y)
Bonneville	BHI	4/2/20000	11//27/2000	4/9/2001	12/19/2001
	BJP	4/3/2000	11//27/2000	3/29/2001	3/20/2002
John Day	FJD	4/5/2000	10/6/2000	3/21/2001	9/19/2001
	GJD	4/5/2000	10/6/2000	4/2/2001	9/19/2001
McNary	MMN	4/6/2000	12/8/2000	4/9/2001	12/4/2001
	LMN	4/22/2000	12/8/2000	4/9/2001	12/4/2001
Ice Harbor	JIH	4/6/2000	12/20/2000	4/10/2001	12/13/2001

During 2000 and 2001, receivers and antennas installed to monitor juvenile bypass systems operated satisfactorily 94.7% to >99.9% of the time they were deployed (Tables 3-4). Receiver outages occurred because of power loss, receiver malfunction, and full memory banks. In a few additional cases, receivers were operating but were not accurately recording data (i.e., entries of values in hex files known not to be within the range of meaningful values) or were recording data incompletely. Cut or damaged antenna wires, malfunctioning receivers, or downloading errors accounted for other data gaps (Table 5).

Table 3. JBS receiver power outages and hours of operation in 2000. Operation percentages do not measure data collection gaps that occurred for reasons other than power outages.

Receiver site	Total possible operation hours	Actual operation hours	Total outage hours	Percent in operation
Bonneville Dam				
BJP	5,712	5,541	171	97.0
BHI	5,734	5,698	36	99.4
John Day Dam				
FJD	4,414	4,404	10	99.8
GJD	4,414	4,403	11	99.8
McNary Dam				
LMN	5,511	5,492	19	99.7
MMN	5,901	5,651	250	95.7
Ice Harbor Dam				
JIH	6,183	6,152	31	99.5

Data Analysis

Downloaded data files were electronically transferred to the NOAA Fisheries office in Seattle, WA for initial processing. Each file was screened and obvious errors and records produced from electronic background noise were removed. Screened files were then transferred to the University of Idaho for coding. Coding involved inspection of all records for each fish and assigning a code to appropriate records that defined behavior of those fish (e.g. first passage of the tailrace receiver, entrance or exit from a fishway). Coding was facilitated by using a semi-automated program developed with ArcView software package (Version 2.0 for Windows). Coded data were used to identify and summarize movements of radiotagged fish.

Table 4. JBS receiver power outages and hours of operation in 2001. Operation percentages do not measure data collection gaps that occurred for reasons other than power outages.

Receiver site	Total possible operation hours	Actual operation hours	Total outage hours	Percent in operation
Bonneville Dam				
BJP	8,541	8,433	108	98.7
BHI	6,101	6,066	35	99.4
John Day Dam				
FJD	4,360	4,190	170	96.1
GJD	4,076	4,070	6	99.8
McNary Dam				
LMN	5,732	5,430	302	94.7
MMN	5,732	5,559	173	97.0
Ice Harbor Dam				
JIH	5,928	5,898	30	99.5

Table 5. Dates, duration (days) and explanation for significant gaps in data collection in 2000 and 2001 by JBS receivers and antennas.

Location	Start date	End date	Duration	Explanation
Bonneville Dam				
BJP	11-Apr-00	17-Apr-00	6	Memory Full
BJP	10-Aug-01	13-Aug-01	3	Memory Full
John Day Dam				
FJD	12-Jul-01	19-Jul-01	7	Breaker tripped
McNary Dam				
LMN	06-May-00	10-May-00	4	Memory Full
LMN	11-May-00	17-May-00	6	Memory Full
LMN	20-May-00	23-May-00	3	Memory Full
LMN	03-Jun-00	05-Jun-00	2	Data lost – Hard Drive Error
LMN	07-Jun-00	08-Jun-00	1	Memory Full
MMN	30-Jun-00	02-Jul-00	2	Unexplained – unplugged?
MMN	27-Sep-00	28-Sep-00	1	Cord unplugged
MMN	27-Oct-00	02-Nov-00	5	Outlet removed
LMN	19-Aug-01	23-Aug-01	4	Receiver locked up
LMN	10-Sep-01	13-Sep-01	3	Breaker tripped
MMN	16-Oct-01	22-Oct-01	6	Breaker tripped
Ice Harbor Dam	No outages			

We used Chi-square analyses to compare reascension rates of JBS and non-JBS fallback fish and Fisher's Exact Test to compare JBS fallback proportions between years because cell counts in many contingency tables were less than five. By using these tests, we were assuming the independent behavior of individual fish. The telemetry monitoring of juvenile bypass systems was not designed to experimentally test hypotheses. Our analyses related to this monitoring effort were retrospective and strict statistical criteria were not met for any comparisons. Our objectives with these 'ad hoc' statistical analyses were to identify general relationships between reascension rates of JBS and non-JBS fallback fish and between JBS fallback proportions and years with different volumes/patterns of spillway discharge.

We obtained 2000-2001 adult fish passage counts at the four dams from USACE, compiled by University of Washington at http://www.cqs.washington.edu/dart/dart.html.

River Conditions

Columbia and Snake River discharge during the two study years varied markedly. River discharge was near average in 2000 while 2001 was one of the lowest discharge years on record. Spillway discharge at all dams was considerably less in 2001 as a result (Figure 5). Water temperatures had similar trends in both years with peaks generally occurring in mid-August and nadirs in mid-February.

Results

Passage, Fallback and JBS Fallback Events by Species, Dam and Year

Spring–summer Chinook salmon, 2000 -- A total of five JBS fallback events were recorded for spring–summer Chinook salmon between 1 April and 31 July, 2000, two at Bonneville Dam and three at John Day Dam (Table 6). None fell back via the JBS at McNary or Ice Harbor dams. JBS fallback percentages, the total number of JBS fallback events divided by the total number of fallback events at a dam (multiplied by 100), were 1.2% at Bonneville Dam and 6.8% at John Day Dam. JBS fallback rates, the total number of JBS fallback events divided by the number of unique fish that passed a dam (multiplied by 100), were 0.2% at Bonneville Dam and 0.4% at John Day Dam.

Spring–summer Chinook salmon, 2001 -- A total of 19 JBS fallback events were recorded for spring–summer Chinook salmon between 1 April and 31 July, 2001 (Table 7). JBS fallback percentages were 5.0% at Bonneville Dam, 16.1% at John Day Dam, 58.3% at McNary Dam and 28.6% at Ice Harbor Dam. JBS fallback rates were between 0.4 and 0.8% at all four dams. One salmon fell back via the JBS at McNary Dam twice.

Fall Chinook salmon, 2000 -- Only one fall Chinook salmon fell back through a JBS between 1 August and 8 December, 2000, at McNary Dam (Table 8). The single fallback was one of nine total fallback events recorded at McNary Dam, resulting in a JBS fallback percentage of 11.1%. The JBS fallback rate was 0.2%.

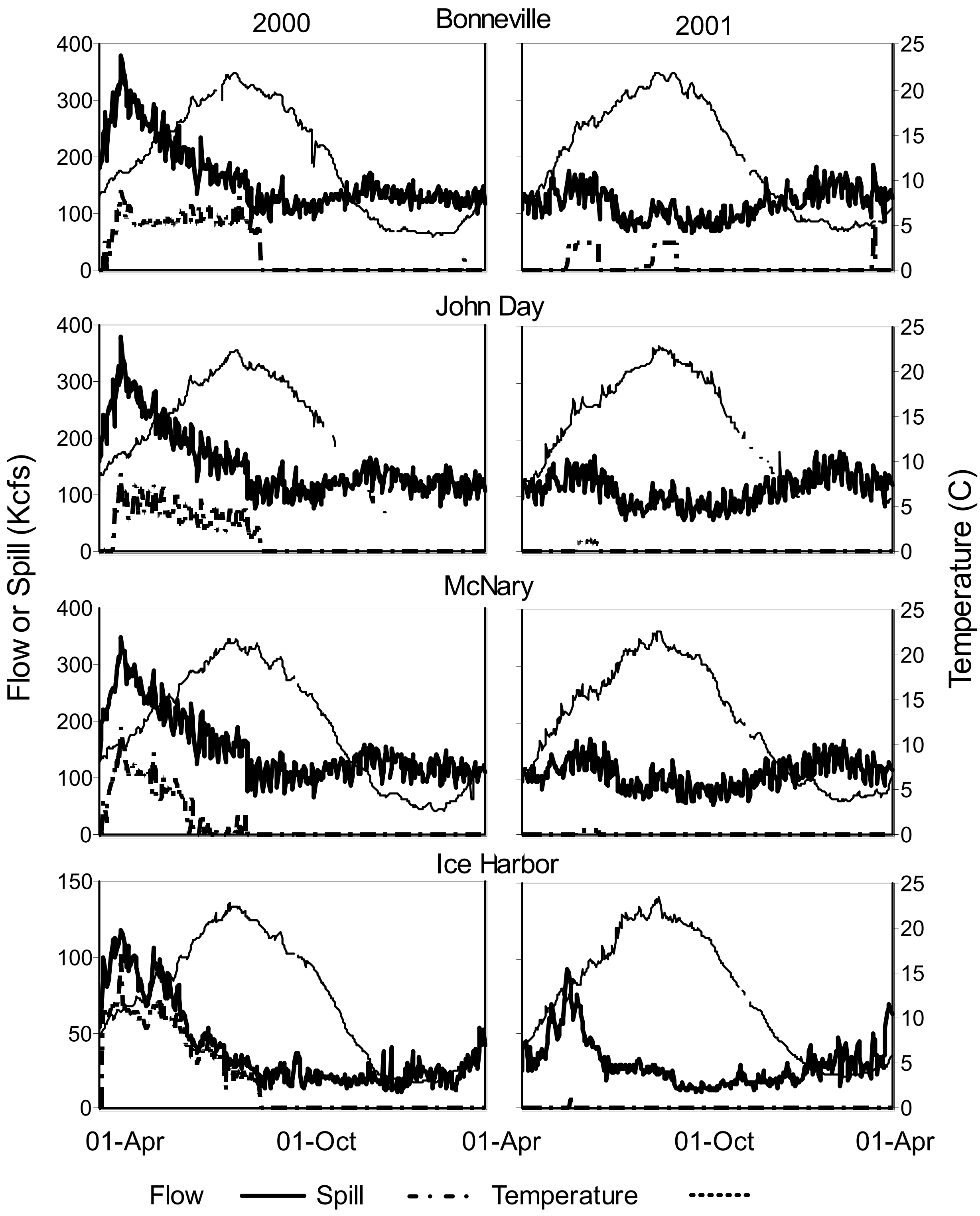

Figure 5. Mean daily flow, spillway discharge, and water temperature at Bonneville, John Day, McNary, and Ice Harbor dams in 2000 and 2001.

Table 6. Number of passage and fallback events by unique spring and summer Chinook salmon (CK) with transmitters, the number that fell back via the juvenile bypass system (JBS), the JBS fallback percentage (total JBS fallback events/total fallback events x 100) and JBS fallback rate (total JBS fallback events/unique fish past dam x100) in 2000 at Bonneville, John Day, McNary and Ice Harbor dams.

2000 Spring–summer Chinook	Bonneville	John Day	McNary	Ice Harbor
Total passage events	1,104	711	648	274
Unique fish past dam	952	681	627	249
Total fallback events	160	44	34	34
Unique fish that fell back	124	41	27	24
Total JBS fallback events	2	3	0	0
JBS fallback percentage	1.2	6.8	0.0	0.0
JBS fallback rate	0.2	0.4	0.0	0.0

Fall Chinook salmon, 2001 -- Three fall Chinook salmon fell back through the JBS between 1 August and 19 December, 2001, two at Bonneville Dam, and one at McNary Dam (Table 9). JBS fallback percentages were 5.5% and 5.2% at the two dams; JBS fallback rates were 0.4 and 0.2%.

Steelhead, 2000 -- Twenty four fallback events were recorded through the JBS for steelhead between 1 June and 20 December, 2000, with 19 (79%) of the events occurring at McNary Dam (Table 10). JBS fallback percentages were 0.0% at Bonneville, 8.8% at John Day, 29.2% at McNary and 9.1% at Ice Harbor dams. JBS fallback rates were 0.4% at John Day and Ice Harbor dams and 2.9% at McNary Dam.

Steelhead, 2001 -- Twenty seven fallback events were recorded through the JBS for steelhead between 1 June and 19 December, 2001, and 10-16 April, 2002, with 15 (56%) of the events at McNary Dam (Table 11). JBS fallback percentages were 11.4% at Bonneville, 10.2% at John Day, 25.9% at McNary and 13.6% at Ice Harbor dams. JBS fallback rates were 0.5 to 0.6% at Bonneville, John Day and Ice Harbor dams and 1.9% at McNary Dam.

Table 7. Number of passage and fallback events by unique spring and summer Chinook salmon with transmitters, the number that fell back via the JBS, the JBS fallback percentage and JBS fallback rate in 2001 at Bonneville, John Day, McNary, and Ice Harbor dams.

2001 Spring–summer Chinook	Bonneville	John Day	McNary	Ice Harbor
Total passage events	819	921	856	506
Unique fish past dam	774	902	848	504
Total fallback events	60	31	12	7
Unique fish that fell back	37	28	10	7
Total JBS fallback events	3	5	7	2
JBS fallback percentage	5.0	16.1	58.3	28.6
JBS fallback rate	0.4	0.6	0.8	0.4

Table 8. Number of passage and fallback events by unique fall Chinook salmon with transmitters, the number that fell back via the JBS, the JBS fallback percentage and JBS fallback rate in 2000 at Bonneville, John Day, McNary, and Ice Harbor dams.

2000 Fall Chinook	Bonneville	John Day	McNary	Ice Harbor
Total passage events	680	571	458	33
Unique fish past dam	659	570	456	33
Total fallback events	34	15	9	1
Unique fish that fell back	26	15	9	1
Total JBS fallback events	0	0	1	0
JBS fallback percentage	0.0	0.0	11.1	0.0
JBS fallback rate	0.0	0.0	0.2	0.0

Table 9. Number of passage and fallback events by unique fall Chinook salmon with transmitters, the number that fell back via the JBS, the JBS fallback percentage and JBS fallback rate in 2001 at Bonneville, John Day, McNary, and Ice Harbor dams.

2001 Fall Chinook	Bonneville	John Day	McNary	Ice Harbor
Total passage events	547	583	489	95
Unique fish past dam	521	580	482	93
Total fallback events	36	16	19	11
Unique fish that fell back	25	15	17	11
Total JBS fallback events	2	0	1	0
JBS fallback percentage	5.5	0.0	5.2	0.0
JBS fallback rate	0.4	0.0	0.2	0.0

Table 10. Number of passage and fallback events by unique steelhead with transmitters, the number that fell back via the JBS, the JBS fallback percentages and JBS fallback rate in 2000 at Bonneville, John Day, McNary, and Ice Harbor dams.

2000 Steelhead	Bonneville	John Day	McNary	Ice Harbor
Total passage events	870	770	676	500
Unique fish past dam	814	748	645	487
Total fallback events	60	34	65	22
Unique fish that fell back	56	32	63	20
Total JBS fallback events	0	3	19	2
JBS fallback percentage	0.0	8.8	29.2	9.1
JBS fallback rate	0.0	0.4	2.9	0.4

Table 11. Number of passage and fallback events by unique steelhead with transmitters, the number that fell back via the JBS, the JBS fallback percentage and JBS fallback rate in 2001 at Bonneville, John Day, McNary, and Ice Harbor dams.

2001 Steelhead	Bonneville	John Day	McNary	Ice Harbor
Total passage events	803	908	828	502
Unique fish past dam	775	869	790	489
Total fallback events	35	49	58	22
Unique fish that fell back	33	46	54	18
Total JBS fallback events	4	5	15	3
JBS fallback percentage	11.4	10.2	25.9	13.6
JBS fallback rate	0.5	0.6	1.9	0.6

JBS Residency Times

We calculated both minimum and maximum estimates of JBS residency time because we believed fish could reside in sections of the JBS undetected by our radio receivers/antennas. The minimum estimate was calculated as the difference in time between the first and last observations on JBS antennas. We defined the maximum estimate as the interval between the last observation before the first record on a JBS antenna and the first observation after the last record on a JBS antenna. We found marked differences between minimum and maximum estimates at some dams and believe it was related to differences in antenna configurations in the forebays of those dams. Specifically, Bonneville Dam had the greatest number of antennas in its forebay and the smallest median residency time based on maximum estimates. A listing of minimum and maximum residency time estimates for individual fish and the dates of their first and last JBS detections are provided in Appendix A and B, respectively.

With the four dams and both years combined, the median residency time, based on both minimum and maximum estimates, was lowest for fall Chinook salmon and highest for steelhead (Table 12). Both minimum and maximum estimates of mean residency time were lowest for fall Chinook salmon. Spring-summer Chinook salmon had the highest mean residency time using minimum estimates, while steelhead had the highest mean residency time based on maximum estimates. Standard deviations of the mean and ranges were lowest for fall Chinook salmon, intermediate for spring-summer Chinook salmon, and highest for steelhead (Table 12).

Sixty-eight percent of spring–summer Chinook salmon resided in a JBS < 24 h and 77% of them resided < 48 h, based on minimum estimates (Figure 6). Fourteen percent of spring–summer Chinook salmon resided in a JBS > 144 h based on both minimum and maximum estimates. All four of the fall Chinook salmon resided in the JBS < 24 h based on minimum estimates and three of them resided there < 24 h based on maximum estimates. Two-thirds of all steelhead resided in a JBS < 24 h and 86% of them < 48 h based on minimum estimates. Thirty five percent of all steelhead resided in a JBS > 144 h based on maximum estimates.

Table 12. Medians, means, standard deviation (S.D.) of the mean, range and sample sizes (N) of minimum and maximum estimates of JBS residency time for spring-summer Chinook salmon, fall Chinook salmon and steelhead at Bonneville, John Day, McNary, and Ice Harbor dams.

	Spring-summer Chinook		Fall Chinook		Steelhead	
	Min. (h)	Max. (h)	Min. (h)	Max. (h)	Min. (h)	Max. (h)
Median	13.7	25.3	3.3	13.4	11.5	89.7
Mean	73.0	91.3	3.6	20.4	72.1	209.9
S.D.	154.3	150.0	3.9	21.8	297.2	341.5
Range	<0.1 - 527.2	6.8 - 529.1	0.1 - 7.6	2.8 - 52.1	<0.1 - 2,072.3	0.2 - 2,076.6
N	22	22	4	4	51	51

With all species and years combined, median JBS residency times ranged from 9.9 h at John Day Dam to 13.6 h at McNary Dam based on minimum estimates and from 15.0 h at Bonneville Dam to 75.1 h at Ice Harbor Dam based on maximum estimates (Table 13). Ice Harbor Dam had the lowest, and John Day Dam had the highest mean JBS residency time based on minimum estimates while Bonneville Dam had the lowest, and McNary had the highest mean residency time based on maximum estimates. The median residency time associated with all recorded JBS fallback events was 10.4 h based on minimum estimates and 60.2 h based on maximum estimates (n=77).

With all species, years, and dams combined, 69% of the JBS fish resided in a JBS < 24 h and 85% of them resided there < 48 h based on minimum estimates (Figure 7). Based on maximum estimates, 32% of JBS fish resided in a JBS < 24 h and 43% of them resided there < 48 h. Twenty seven percent of the JBS fish resided there >144 h based on maximum estimates.

Reascension Rates and Downstream Tributary use of JBS Fallback Fish

Sixteen of the 22 (73%) fallback events via a JBS by spring–summer Chinook salmon in the two years were followed by reascensions of the dam where the fallback occurred (Figure 8). In comparison, 286 of the 360 (79%) non-JBS fallback events by spring–summer Chinook salmon at the four dams were followed by reascensions. The lone spring Chinook salmon that fell back via the McNary Dam JBS twice reascended the dam after each of its two JBS fallback events. In 2000, five of five (100%) JBS fallback events by spring–summer Chinook salmon were followed by reascensions while 12 of 17 (71%) were followed by reascensions in 2001.

Two of the four (50%) fall Chinook salmon that fell back via JBS fallback reascended the dam over which they fell back while 60 of 137 (44%) non-JBS fallbacks by fall Chinook salmon were followed by reascensions. In 2000, the one JBS fallback event by a fall Chinook salmon did not result in a reascension (0%) while two of three (67%) in 2001 were followed by reascensions.

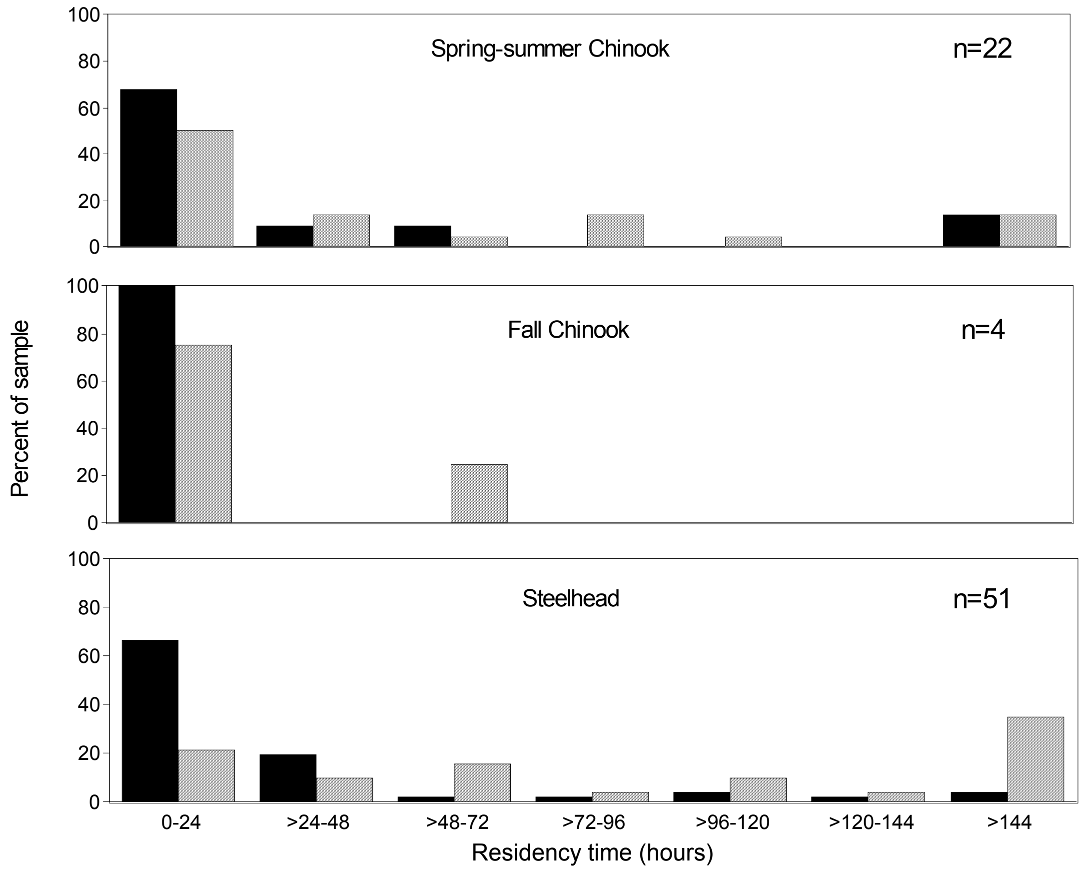

Figure 6. Frequency distributions of minimum (solid bars) and maximum (striped bars) JBS residency time estimates for spring-summer Chinook salmon, fall Chinook salmon, and steelhead.

Table 13. Median, mean, standard deviation (S.D.) of the mean, range and sample sizes (N) of minimum and maximum estimates of JBS residency time for spring-summer Chinook salmon, fall Chinook salmon and steelhead at Bonneville John Day, McNary, and Ice Harbor dams: 2000-2001.

	Bonneville		John Day		McNary		Ice Harbor	
	Min. (h)	Max. (h)	Min. (h)	Max. (h)	Min. (h)	Max. (h)	Min. (h)	Max. (h)
Median	11.6	15.0	9.9	57.6	13.6	35.0	10.2	75.1
Mean	37.8	56.8	81.6	120.3	80.6	216.6	16.5	133.0
S.D.	92.7	94.0	167.8	175.0	323.2	360.9	17.4	227.6
Range	0.5 - 316.4	2.8 – 322.5	<0.1 – 527.2	4.0 – 529.1	<0.1 – 2,072.3	0.2 – 2,076.6	0.3 – 47.2	16.8 – 646.4
N	11	11	7	7	43	43	16	16

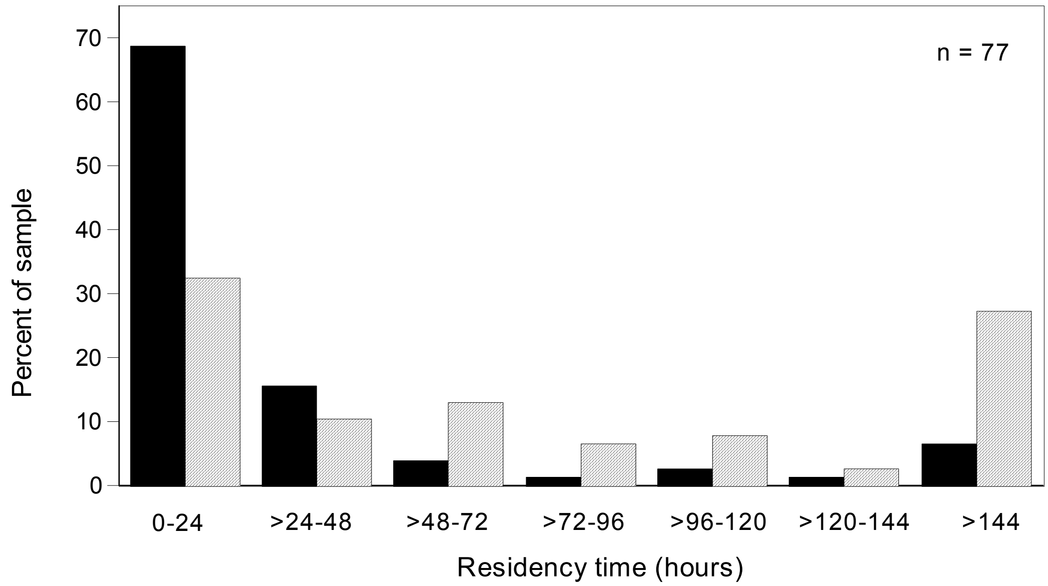

Figure 7. Frequency distribution of minimum (solid bars) and maximum (striped bars) estimates of residency time in JBS for adult Chinook salmon and steelhead: 2000-2001.

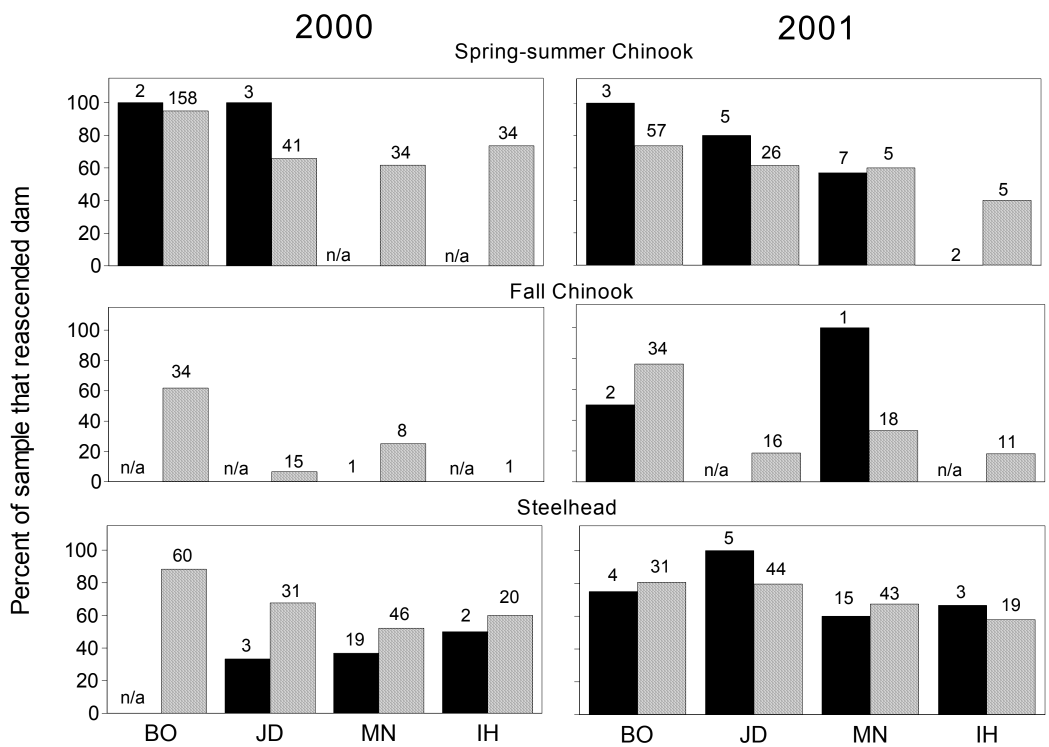

Figure 8. Comparison of reascension rates of JBS fallback fish (solid bars) with fish that fell back via other routes (striped bars) at Bonneville (BO), John Day (JD), McNary (MN), and Ice Harbor (IH) dams in 2000 and 2001. Sample sizes are listed above the bars.

Of the 51 JBS fallback events by steelhead at the four dams in both years, 28 (55%) were followed by reascensions. In contrast, 210 of 294 (71%) non-JBS fallbacks by steelhead resulted in reascensions, a significantly higher proportion (P = 0.019, Chi-square test). With the four dams combined, the reascension rate for non-JBS fallbacks by steelhead in 2000 (110/157) was not significantly different from the reascension rate for non-JBS fallbacks by steelhead in 2001 (100/137) (P=0.58, Chi-square test). However, a significantly lower proportion of JBS fallback events by steelhead were followed by reascensions in 2000 (37.5%; 9/24) than in 2001 (70.4%; 19/27) (P=0.018, Chi-square test) .

With all species, years, and dams combined, reascension rates for JBS fallback fish (61%, n=77) were approximately 9% less than rates for fish that fell back via other routes (70.0%, n=791; Boggs et al. 2004). These proportions were not significantly different (P=0.09, Chi-square test).

Some fallback events are associated with fish swimming upstream farther than their natal tributaries and having to swim back downstream to enter them, an event termed overshoot behavior. No overshoot behavior was observed for spring–summer Chinook salmon that had fallen back via a JBS during 2000 (Figure 9). In 2001, three spring–summer Chinook salmon fell back via the JBS at Bonneville Dam and all reascended the dam; one salmon fell back via the JBS at John Day Dam and was last observed in the John Day Dam tailrace. There were three non-reascending, JBS fallback salmon at McNary Dam in 2001 and two of them (67%) were observed in downstream tributaries, one each in the John Day and Deschutes rivers. There were two non-reascending, JBS fallback fish at Ice Harbor Dam in 2001 and both were subsequently recaptured in

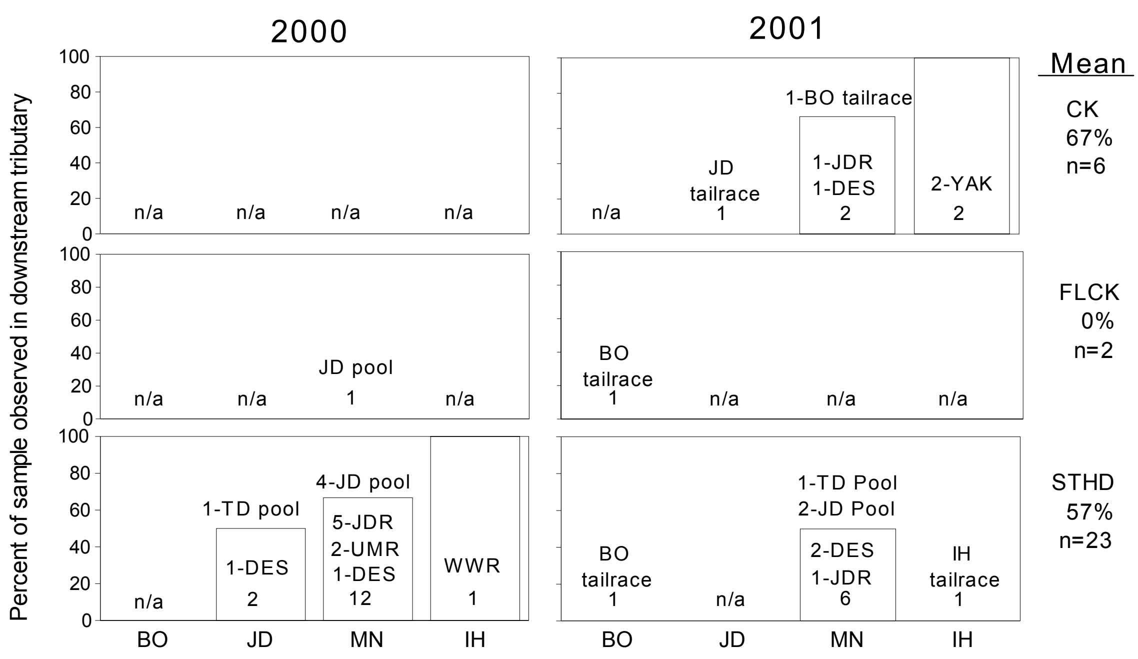

Figure 9. Percentages of non-reascending JBS fallback fish recorded in downstream tributaries. Sample sizes and frequencies of individual fates are listed inside and above the bars. Species and species means are listed to the right.

the Yakima River at Roza Dam. Overall, four of the six (67%) non-reascending, JBS fallback spring–summer Chinook salmon were last observed in downstream tributaries.

The two fall Chinook salmon that fell back via juvenile bypass systems and did not reascend in 2000 and 2001 did not appear to be overshoot fallbacks. One fell back via the JBS at McNary Dam in 2000 and was last observed in the John Day Dam pool. The other fell back via the JBS at Bonneville Dam in 2001 and was last observed in the Bonneville Dam tailrace.

There were two non-reascending, JBS fallback steelhead at John Day Dam in 2000. One was last observed in the Deschutes River and the other was last observed in The Dalles Dam pool. There were twelve non-reascending, JBS fallback steelhead at McNary Dam in 2000. Eight (67%) were last observed in downstream tributaries: five in the John Day River, two in the Umatilla River and one in the Deschutes River. There was one non-reascending, JBS fallback steelhead at Ice Harbor Dam in 2000 and it was observed entering the Walla Walla River in November, 2000, before the transmitter was found in the McNary Dam separator in April, 2001. The lone non-reascending, JBS fallback steelhead at Bonneville Dam in 2001 was last observed in the Bonneville Dam tailrace. All five steelhead that fell back via the John Day Dam JBS in 2001, reascended the dam. Of the six non-reascending JBS fallback steelhead at McNary Dam in 2001, three (50%) were last observed in downstream tributaries: one in the John Day River and two in the Deschutes River. The lone non-reascending, JBS fallback steelhead at Ice Harbor Dam in 2001 was last observed in the Ice Harbor Dam tailrace. Overall, 57% (n=23) of the steelhead that fell back via the JBS and did not reascend, were last observed in downstream tributaries.

JBS Fallback Proportions in Relation to Spillway Discharge

The JBS fallback proportions for all species at Bonneville Dam were higher in 2001, the year with less spill, although the difference was statistically significant for steelhead only (Table 13). At John Day Dam, JBS fallback proportions were higher or constant for all species in 2001 as compared to 2000 but no differences were statistically significant. For spring-summer Chinook salmon, the JBS fallback proportion at McNary Dam was significantly higher in 2001 while for fall Chinook salmon, it was not. There were a relatively high number of JBS fallback events by steelhead at McNary Dam in both years but there was no significant difference between their JBS proportions. The JBS fallback proportion for spring-summer Chinook salmon at Ice Harbor Dam was signficantly higher in the year with less spill while those for fall Chinook salmon were constant in both years. There was no significant difference between the two years for JBS fallback proportions by steelhead at Ice Harbor Dam.

Last Recorded Observations of JBS Fallback Fish

Of the 76 unique fish with transmitters that experienced a JBS fallback event at one of the four dams during the two study years, 28 (36.8%) were last observed upstream of Lower Granite or Priest Rapids Dam, 21 (27.6%) were recorded entering a tributary downstream of Lower Granite or Priest Rapids Dam, two (2.7%) were captured in a

Table 14. Ratio of JBS to non-JBS fallback events for spring-summer, and fall Chinook salmon and steelhead at Bonneville, John Day, McNary, and Ice Harbor dams 2000-2001, and P-values resulting from Fisher's Exact Tests.

Dam	Species	2000 JBS/non-JBS FB Events	2001 JBS/non-JBS FB Events	Fisher's Exact Prob. > χ
Bonneville	Sp-Su Chinook	2/158	3/57	0.106
	Fall Chinook	0/34	2/34	0.261
	Steelhead	0/60	4/31	0.016
John Day	Sp-Su Chinook	3/41	5/26	0.133
	Fall Chinook	0/15	0/16	n/a
	Steelhead	3/31	5/44	0.289
McNary	Sp-Su Chinook	0/34	7/5	<0.001
	Fall Chinook	1/8	1/18	0.452
	Steelhead	19/46	15/43	0.147
Ice Harbor	Sp-Su Chinook	0/34	2/5	0.026
	Fall Chinook	0/1	0/11	n/a
	Steelhead	2/20	3/19	0.327

mainstem fishery, resulting in 25 (32.9%) fish for which we had no accounting (Figure 10). The lone spring Chinook salmon that experienced two JBS fallback events was last recorded in the Columbia River upstream from Rocky Reach Dam.

In comparison, we recorded 968 radio-tagged fish that fell back at one of the lower Columbia or Snake River dams via a route not known to be a JBS during the two years (Boggs et al. 2004). Of these, 364 (30%) were recorded passing Lower Granite or Priest Rapids dam, 290 (30%) were recorded entering a tributary downstream of Lower Granite or Priest Rapids Dam, 98 (10.1%) were captured in a mainstem fishery, resulting in 216 (22.3%) fish for which we had no accounting.

Generally, radio-tagged fish that did not fall back at any dam passed Lower Granite or Priest Rapids Dam in higher proportions than fish that did. Specifically, 2,284 (42.3%) of the 5,405 fish with transmitters that did not fall back passed Lower Granite or Priest Rapids Dam. Of the 5,405 radio-tagged fish without a recorded fallback event, 1,660 (30.7%) were recorded entering a tributary downstream of Lower Granite or Priest Rapids Dam, 923 (17.1%) were captured in a mainstem fishery, and 538 (10.0%) had no accounting.

Overall, the unaccounted for proportion of radio-tagged fish recorded falling back via a JBS was three times higher than the unaccounted for proportion of radio-tagged fish without a fallback. In comparison, the unaccounted for proportion of radio-tagged fish that fell back via a route not known to be a JBS was two times higher than the unaccounted for proportion of radio-tagged fish without a fallback. Fish that were

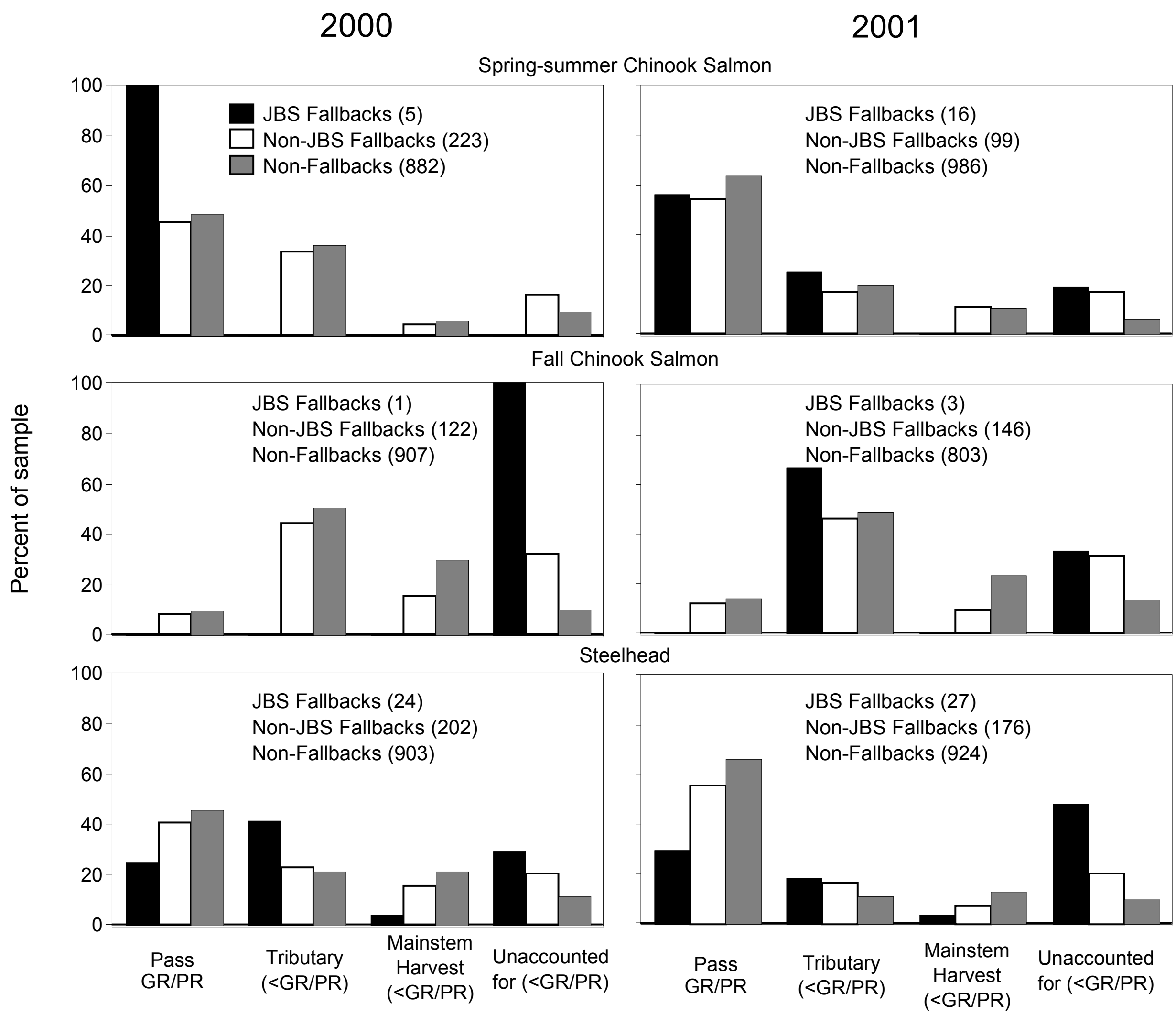

Figure 10. Comparison of our best estimate of the fates of radio-tagged JBS fallback fish with radio-tagged fish that fell back via a route not known to be a JBS and radio-tagged fish that did not fall back; categories include fish that passed Lower Granite or Priest Rapids dams, fish recorded entering a tributary downstream of Lower Granite or Priest Rapids dams, fish captured in a mainstem fishery, or fish whose fate was unaccounted for. Sample sizes are in parentheses within each panel.

unaccounted for may have been harvested but not reported to us, may have regurgitated tags that were not recovered, may have entered tributaries undetected, or may have been mortalities with unrecoverable transmitters.

Discussion

Fallback of adult salmon and steelhead through the juvenile bypass systems of Bonneville, John Day, McNary and Ice Harbor dams during 2000 and 2001 comprised a relatively low percentage (8.9%) of the total 868 fallbacks events by fish with transmitters. JBS fallback percentages were less than 17% for eight of twelve species/dam/year combinations. The remaining four groups were spring–summer Chinook salmon at McNary (58.3%, *n*=12) and Ice Harbor dams (28.5%, *n*=7) in 2001, and steelhead at McNary Dam in 2000 (29.2%, *n*=65) and 2001 (25.9%, *n*=58). The relatively large JBS fallback percentages for the spring–summer Chinook salmon may be accounted for in part, by the relatively low overall fallback rates observed at McNary and Ice Harbor dams in 2001 (the contribution of any given JBS fallback to the JBS fallback percentage is inversely proportional to the total number of fallback events). Conversely, JBS fallback percentages for steelhead may be underestimates because our JBS monitoring efforts were not continuous through the winter and kelt fallback events were not included in analyses.

During periods of spill, most fallback events are believed to occur via spillways (Bjornn et al., 2000a, b, c, Boggs et al., 2004). It follows that fallback events via other routes should increase in periods of low to no spill, if they are to occur. While the pattern of increasing JBS fallback percentage with low to no spill appeared to occur for spring-summer Chinook salmon, it was not discernable for fall Chinook salmon and steelhead. This was most likely because most fall Chinook salmon and steelhead migrated during periods of relatively little or no spill during both years.

It is unclear why the JBS fallback proportions for steelhead at McNary Dam were relatively high in both years. A possible explanation may relate to overshoot behavior (particularly for steelhead). The percentage of steelhead that fell back via the McNary Dam JBS and did not reascend, but were observed in downstream tributaries, was 67% (*n*=12) in 2000 and 50% (*n*=6) in 2001. Fallbacks of fish that subsequently entered tributaries downstream from the dam where they fell back were likely caused by fish migrating upstream past their natal streams and then returning downstream. Alternately, they may have been destined for other streams and permanently strayed into the tributary where they were last observed.

JBS fallback rates were < 3% for all dam/species/year groups and typically were < 1%. If the ratio of JBS fallback events to passage events by radio-tagged fish is used to estimate the frequency of JBS fallback events from dam- and year-specific counting window data (uncorrected for bias from fallbacks), approximately 8,321 spring-summer Chinook salmon fell back via juvenile bypass systems during the course of approximately 1.75 million passage events at the four dams in both years. Similarly, a total of 1,838 JBS fallback events was estimated from 1.01 million passage events by fall Chinook salmon and 24,041 JBS fallback events from approximately 3.09 million passage events by steelhead.

While JBS fallback events by adult salmonids may have been relatively few in number, protracted residency times may be of particular concern for Chinook salmon, which have shorter migration periods than steelhead. Estimates of JBS residency times could likely be made more precise with increased antenna deployments in forebays and juvenile bypass systems of dams.

An additional concern involves the greater proportion of JBS fallback fish with unaccounted for fates than fish without a fallback, or fish known to have fallen back via a non-JBS route. This suggests there is higher mortality rates associated with falling back via juvenile bypass systems as compared to other routes or not falling back at all.

In summary, the probability of adult salmonids falling back via a JBS as opposed to another route is relatively low. Based on our comparison of only two years, the probability may increase slightly during periods of low to no spillway discharge. Residency times for fish falling back via a JBS ranged markedly, from minutes to months. There does not seem to be a great difference between falling back via a JBS or another route for Chinook salmon based on reascension rates alone. A significantly lower percentage of steelhead reascended the dam after a JBS fallback event as compared to steelhead falling back via other routes, although some of the non-reascensions were likely attributed to overshoot behavior.

Literature Cited

Bjornn, T.C., Keefer, M.L., Ringe, R.R., Tolotti, K.R., and Stuehrenberg, L.C. 2000a. Migration of adult spring and summer chinook salmon past Columbia and Snake river dams, through reservoirs and distribution into tributaries, 1996. Idaho Cooperative Fish and Wildlife Research Unit and National Marine Fisheries Service. Technical Report 2000-5

Bjornn, T.C. and M.L. Keefer, C.A. Peery, K.R. Tolotti, R. R. Ringe and L.S. Stuehrenberg. 2000b. Adult Chinook and sockey salmon, and steelhead fallback rates at Bonneville Dam - 1996-1998. Idaho Cooperative Fish and Wildlife Research Unit and National Marine Fisheries Service. Technical Report 2000-1.

Bjornn, T.C. and M.L. Keefer, C.A. Peery, M. A. Jepson, K.R. Tolotti, R. R. Ringe and L.S. Stuehrenberg. 2000c. Adult Chinook and sockey salmon, and steelhead fallback rates at The Dalles Dam - 1996, 1997, and1998. Idaho Cooperative Fish and Wildlife Research Unit and National Marine Fisheries Service. Technical Report 2000-2.

Bjornn, T.C. and M.L. Keefer, C.A. Peery, M.A. Jepson, K.R. Tolotti, R. R. Ringe and L.S. Stuehrenberg. 2000d. Adult Chinook and sockey salmon, and steelhead fallback rates at John Day Dam - 1996, 1997, and1998. Idaho Cooperative Fish and Wildlife Research Unit and National Marine Fisheries Service. Technical Report 2000-3.

Boggs, C.T., M.L. Keefer and C.A. Peery. 2004. Adult Chinook salmon and steelhead fallback at Bonneville Dam, 2000-2001. Technical Report 2004-4. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, for the U.S. Army Corps of Engineers, Portland and Walla Walla Districts, Portland, Oregon.

Appendix A. List of JBS fallback events by spring-summer, and fall Chinook salmon and steelhead at Bonneville, John Day, McNary and Ice Harbor dams 2000-2001, minimum and maximum estimates of JBS residency time (hours), reascension data, and final recorded observation.

					Residency time		Reascend?	
					Min.	Max.	0 = no	
Year	Species	Chan	Code	Dam	hours	hours	1 = yes	Final Recorded Obs. / (rkm)
2000	SCK	16	28	BO	12.8	13.2	1	Mobile Track - Salmon R. (912.0)
2000	SCK	24	277	BO	316.4	322.5	1	RCP - Lochsa R. Weir (1015.5)
2000	SCK	15	152	JD	479.1	484.0	1	Grande Ronde R. (794.7)
2000	SCK	15	274	JD	0.4	15.8	1	RCP - S. Fork Salmon R. (1148.3)
2000	SCK	24	296	JD	527.2	529.1	1	RCP - N. Fork Clearwater (813.5)
2001	SCK	13	365	BO	14.6	15.0	1	RCP-Clearwater R. (869.8)
2001	SCK	13	381	BO	17.5	17.7	1	RCP-Rapid R. (980.5)
2001	SCK	14	61	BO	26.7	26.9	1	Bonneville Dam tailrace (232.3)
2001	SCK	11	39	JD	17.2	23.7	1	Priest Rapids Dam TOL (638.9)
2001	SCK	11	475	JD	6.1	17.9	1	RCP-Middle Fork Salmon R. (1224.6)
2001	SCK	13	34	JD	1.5	6.8	0	John Day Dam tailrace (345)
2001	SCK	13	456	JD	14.6	17.7	1	RCP-Clearwater R. (869.6)
2001	SCK	14	116	JD	60.6	67.5	1	MBT- S. Fork Salmon R. (1147.7)
2001	SCK	13	30	MN	24.3	75.1	0	John Day R. (355.7)
2001	SCK	13	193	MN	57.3	103.9	0	RCP – Columbia R. (106.5)
2001	SCK	13	365	MN	10.4	36.7	1	RCP - Clearwater R. (869.8)
2001	SCK	14	132	MN	10.2	28.3	1	MBT - S. Fork Salmon R. (1132.4)
2001	SCK	14	184	MN	2.5	22.9	1	MBT - Columbia R. (762.3)
2001	SCK	14	184	MN	0.1	74.1	1	“
2001	SCK	15	111	MN	0.03	21.0	0	MBT- Deschutes R. (347.9)
2001	SCK	11	405	IH	0.3	72.1	0	RCP - Yakima R. - Roza Dam (745.1)
2001	SCK	13	451	IH	5.2	16.8	0	RCP - Yakima R.- Roza Dam (745.1)
2000	FLCK	23	120	MN	0.05	15.6	0	Alderdale fixed site / Col. R. (415.1)
2001	FLCK	20	151	BO	0.5	2.8	1	MBT-White Salmon R. (270.8)
2001	FLCK	23	59	BO	6.2	11.3	0	Bonneville Dam tailrace (232.3)
2001	FLCK	11	106	MN	7.6	52.1	1	RCP - Lyons Ferry Hatchery (615.9)
2000	STHD	9	127	JD	1.0	4.0	0	MBT-Columbia R. (338.7)
2000	STHD	21	19	JD	125.6	135.0	0	Deschutes River (328.9)
2000	STHD	24	163	JD	<0.1	362.2	1	RCP-Columbia R. (453.7)

Abbreviations: RCP = recapture, MBT = Mobile Track, TOL = top of ladder.

Appendix A (continued). List of JBS fallback events by spring-summer, and fall Chinook salmon and steelhead at Bonneville, John Day, McNary and Ice Harbor dams 2000-2001, minimum and maximum estimates of JBS residency time (hours), reascension data, and final recorded observation

					Residency time		Reascend?	
					Min.	Max.	0 = no	
Year	Species	Chan	Code	Dam	hours	hours	1 = yes	Final Recorded Obs. / (rkm)
2000	STHD	9	87	MN	21.5	178.4	1	Found Tag – Salmon R. (731.9)
2000	STHD	9	245	MN	0.4	67.5	1	RCP - Grande Ronde R. (825.5)
2000	STHD	10	23	MN	92.4	106.3	1	Rocky Reach Dam TOL (762.2)
2000	STHD	10	35	MN	7.3	50.1	0	MBT- John Day R. (414.6)
2000	STHD	10	70	MN	44.6	548.5	0	John Day R. (355.7)
2000	STHD	10	84	MN	0.2	215.5	0	MBT- Umatilla R. (465.0)
2000	STHD	10	96	MN	2,072	2,076	0	McNary Dam tailrace (469.8)
2000	STHD	10	109	MN	40.4	52.9	1	MBT - Snake R. (765.4)
2000	STHD	10	131	MN	2.2	587.6	0	John Day R. (355.7)
2000	STHD	11	18	MN	28.2	96.3	1	RCP - Walla Walla R. (580.2)
2000	STHD	11	102	MN	19.7	581.3	1	RCP – Columbia R. (470)
2000	STHD	11	137	MN	47.0	210.1	0	John Day R. (355.7)
2000	STHD	11	159	MN	569.4	613.4	0	McNary Dam tailrace (467.3)
2000	STHD	12	14	MN	5.5	69.3	0	MBT – Columbia R. (323.4)
2000	STHD	12	21	MN	13.3	211.9	0	RCP – Umatilla R. Weir (469.8)
2000	STHD	12	39	MN	28.6	162.8	0	John Day R. Boat Launch (350.8)
2000	STHD	15	161	MN	20.6	173.9	1	RCP – DNFH Clearwater R. (811.1)
2000	STHD	21	15	MN	31.0	217.1	0	John Day Dam forebay (347)
2000	STHD	21	19	MN	0.2	116.2	0	Deschutes R. (328.9)
2000	STHD	11	127	IH	18.7	21.6	1	Salmon R. (963.2)
2000	STHD	11	135	IH	2.54	78.0	0	Walla Walla R. (525.7)
2001	STHD	16	112	BO	0.8	89.7	1	Bonneville Dam forebay (235.1)
2001	STHD	16	155	BO	8.7	13.1	1	John Day R. boat launch (350.8)
2001	STHD	16	212	BO	11.6	12.9	1	Clearwater R. (753.3)
2001	STHD	18	177	BO	0.7	99.7	0	Bonneville Dam tailrace (232.8)
2001	STHD	16	193	JD	2.4	128.1	1	Lyons Ferry Hatchery (615.9)
2001	STHD	16	462	JD	5.4	42.7	1	RCP- Columbia R. (388.2)
2001	STHD	17	69	JD	22.0	33.9	1	Priest Rapids Dam - TOL (638.9)
2001	STHD	19	212	JD	12.7	20.3	1	Priest Rapids - TOL (638.9)
2001	STHD	21	168	JD	29.6	36.2	1	McNary Dam tailrace (467.3)
2001	STHD	16	46	MN	<0.1	0.2	0	Deschutes R. (328.9)
2001	STHD	16	56	MN	<0.1	39.7	1	Grande Ronde R. (794.7)
2001	STHD	16	160	MN	0.3	1.7	1	RCP– Walla Walla R. (548.5)
2001	STHD	17	42	MN	25.3	902.6	0	MBT – Columbia R. (468.2)
2001	STHD	17	73	MN	0.01	679.4	0	MBT– Columbia R. (330.8)
2001	STHD	17	150	MN	0.24	304.5	0	McNary Dam tailrace (467.3)
2001	STHD	17	153	MN	0.8	3.8	0	Deschutes R. (328.9)
2001	STHD	18	1	MN	103.6	269.3	1	Little Goose Dam – TOL (634.8)
2001	STHD	18	5	MN	0.3	0.5	1	McNary tailrace (467.3)
2001	STHD	18	9	MN	50.0	58.9	1	Priest Rapids – TOL (638.9)
2001	STHD	18	108	MN	6.0	23.1	1	Lower Granite Dam tailrace (693.8)
2001	STHD	19	190	MN	14.1	70.4	1	Clearwater R. (753.3)
2001	STHD	21	4	MN	0.4	21.1	1	Ice Harbor Dam – TOL (537.7)
2001	STHD	21	109	MN	97.7	113.6	1	RCP – Snake R. (792.3)
2001	STHD	16	474	IH	31.8	38.6	1	RCP – Clearwater R. (751.7)
2001	STHD	18	44	IH	47.2	57.6	1	L. Granite Dam tailrace (693.8)
2001	STHD	19	84	IH	9.9	646.4	0	MBT – Columbia R. (469.8)

Abbreviations: RCP = recapture, MBT = Mobile Track, TOL = top of ladder.

Appendix B. List of first and last JBS detection dates (mm/dd/yy) by spring-summer, and fall Chinook salmon and steelhead at Bonneville, John Day, McNary and Ice Harbor dams 2000-2001.

Year	Species	Chan	Code	Dam	First JBS record	Last JBS record
2000	SCK	16	28	BO	4/25/00	4/26/00
2000	SCK	24	277	BO	5/6/00	5/19/00
2000	SCK	15	152	JD	6/2/00	6/22/00
2000	SCK	15	274	JD	5/31/00	5/31/00
2000	SCK	24	296	JD	4/27/00	5/19/00
2001	SCK	13	365	BO	5/13/01	5/13/01
2001	SCK	13	381	BO	5/2/01	5/3/01
2001	SCK	14	61	BO	5/10/01	5/11/01
2001	SCK	11	39	JD	4/22/01	4/23/01
2001	SCK	11	475	JD	5/17/01	5/17/01
2001	SCK	13	34	JD	4/30/01	4/30/01
2001	SCK	13	456	JD	4/27/01	4/28/01
2001	SCK	14	116	JD	5/14/01	5/17/01
2001	SCK	13	30	MN	5/8/01	5/9/01
2001	SCK	13	193	MN	4/23/01	4/26/01
2001	SCK	13	365	MN	5/28/01	5/29/01
2001	SCK	14	132	MN	5/27/01	5/28/01
2001	SCK	14	184	MN	5/15/01	5/15/01
2001	SCK	14	184	MN	5/26/01	5/26/01
2001	SCK	15	111	MN		
2001	SCK	11	405	IH	6/23/01	6/23/01
2001	SCK	13	451	IH	5/13/01	5/13/01
2000	FLCK	23	120	MN	11/25/00	11/25/00
2001	FLCK	20	151	BO	11/18/01	11/18/01
2001	FLCK	23	59	BO	10/26/01	10/26/01
2001	FLCK	11	106	MN	9/16/01	9/16/01
2000	STHD	9	127	JD	9/4/00	9/4/00
2000	STHD	21	19	JD	8/5/00	8/10/00
2000	STHD	24	163	JD	9/4/00	9/4/00

Appendix B (continued). List of first and last JBS detection dates (mm/dd/yy) by spring-summer, and fall Chinook salmon and steelhead at Bonneville, John Day, McNary and Ice Harbor dams 2000-2001.

Year	Species	Chan	Code	Dam	First JBS record	Last JBS record
2000	STHD	9	87	MN	9/19/00	9/20/00
2000	STHD	9	245	MN	9/14/00	9/14/00
2000	STHD	10	23	MN	9/16/00	9/19/00
2000	STHD	10	35	MN	9/29/00	9/29/00
2000	STHD	10	70	MN	10/11/00	10/13/00
2000	STHD	10	84	MN	9/27/00	9/27/00
2000	STHD	10	96	MN	9/10/00	12/6/00
2000	STHD	10	109	MN	8/25/00	8/26/00
2000	STHD	10	131	MN	11/13/00	11/14/00
2000	STHD	11	18	MN	10/19/00	10/20/00
2000	STHD	11	102	MN	10/10/00	10/11/00
2000	STHD	11	137	MN	10/5/00	10/7/00
2000	STHD	11	159	MN	10/16/00	11/8/00
2000	STHD	12	14	MN	10/6/00	10/6/00
2000	STHD	12	21	MN	10/9/00	10/10/00
2000	STHD	12	39	MN	9/17/00	9/18/00
2000	STHD	15	161	MN	10/18/00	10/19/00
2000	STHD	21	15	MN	9/30/00	10/2/00
2000	STHD	21	19	MN	7/31/00	7/31/00
2000	STHD	11	127	IH	9/20/00	9/21/00
2000	STHD	11	135	IH	10/18/00	10/18/00
2001	STHD	16	112	BO	4/7/02	4/7/02
2001	STHD	16	155	BO	10/27/01	10/27/01
2001	STHD	16	212	BO	11/15/01	11/16/01
2001	STHD	18	177	BO	12/17/01	12/17/01
2001	STHD	16	193	JD	8/15/01	8/15/01
2001	STHD	16	462	JD	7/3/01	7/3/01
2001	STHD	17	69	JD	9/14/01	9/15/01
2001	STHD	19	212	JD	9/12/01	9/13/01
2001	STHD	21	168	JD	9/11/01	9/13/01
2001	STHD	16	46	MN	10/2/01	10/2/01
2001	STHD	16	56	MN	4/10/02	4/10/02
2001	STHD	16	160	MN	10/5/01	10/5/01
2001	STHD	17	42	MN	11/29/01	11/30/01
2001	STHD	17	73	MN	4/16/02	4/16/02
2001	STHD	17	150	MN	11/7/01	11/7/01
2001	STHD	17	153	MN	10/10/01	10/11/01
2001	STHD	18	1	MN	11/5/01	11/9/01
2001	STHD	18	5	MN	9/27/01	9/27/01
2001	STHD	18	9	MN	8/7/01	8/9/01
2001	STHD	18	108	MN	10/17/01	10/17/01
2001	STHD	19	190	MN	10/22/01	10/23/01
2001	STHD	21	4	MN	11/3/01	11/3/01
2001	STHD	21	109	MN	10/27/01	10/31/01
2001	STHD	16	474	IH	8/13/01	8/14/01
2001	STHD	18	44	IH	6/23/01	6/25/01
2001	STHD	19	84	IH	11/23/01	11/23/01