Emigration of Natural and Hatchery Chinook Salmon and Steelhead Smolts from the Imnaha River, Oregon

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Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

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Emigration of Natural and Hatchery Chinook Salmon and Steelhead Smolts from the Imnaha River, Oregon, October 20, 1999 to June 15, 2000

2000 Annual Report

Prepared by:
Peter J. Cleary
Paul A. Kucera
Michael L. Blenden
Kelly Gillogly

Nez Perce Tribe
Department of Fisheries Resources Management
Lapwai, Idaho 83540

Prepared for:
U.S. Department of Energy
Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208

and

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ABSTRACT

This report details the smolt performance of natural and hatchery chinook salmon and steelhead from the Imnaha River to the Snake River and Columbia River dams during migration year 2000. Flow conditions in the Imnaha River and Snake River were appreciably lower during May and June in 2000, compared to historic levels at gauging stations, but flow conditions in the Imnaha and Snake River were above average during April. Overall, water conditions for the entire Columbia River were characterized by the Fish Passage Center as below normal levels. Spill occurred continuously at Lower Granite Dam (LGR), Little Goose Dam (LGO), and Lower Monumental Dam (LMO) from April 5, April 10, and April 4, respectively, to June 20, and encompassed the periods of migration of Imnaha River juvenile chinook salmon and steelhead, with a few exceptions. Outflow in the tailraces of LGR, LGO, and LMO decreased in May and June while temperatures increased.

Chinook salmon and steelhead were captured using rotary screw traps at river kilometer (rkm) 74 and 7 during the fall from October 20 to November 24, 1999, and during the spring period from February 26 to June 15, 2000, at rkm 7. Spring trapping information was reported weekly to the Fish Passage Center's Smolt Monitoring Program. A portion of these fish were tagged weekly with passive integrated transponder (PIT) tags and were detected migrating past interrogation sites at Snake River and Columbia River dams. Survival of PIT tagged fish was estimated with the Survival Using Proportional Hazards model (SURPH model).

Estimated survival of fall tagged natural chinook (with ± 95% confidence intervals in parenthesis) from the upper Imnaha (rkm 74) to LGR was 29.6% (± 2.8). Natural chinook salmon tagged in the fall in the lower Imnaha River at rkm 7, which over wintered in the Snake River, had an estimated survival of 36.8% (± 2.9%) to LGR. Spring tagged natural chinook salmon from the lower site had an estimated survival of 84.8% (± 2.6%) to LGR. The season wide survival of spring tagged natural chinook salmon smolts from release in the Imnaha River to McNary Dam (MCN) was 67.9% (± 6.3%).

Post release survival of hatchery chinook salmon smolts, from release at the Imnaha River acclimation facility to the lower Imnaha River trap, was estimated at 94.7% (± 4.7%). Hatchery chinook salmon, PIT tagged and released at the lower Imnaha River trap, had an estimated survival of 75.0% (± 4.2%) to LGR. Estimated survival of hatchery chinook salmon smolts from the Imnaha River to McNary Dam (MCN) was 54.1% (± 9.7%).

Natural steelhead smolts had an estimated survival of 84.4% (± 2.7%) to LGR and a survival estimate of 49.9% (±12.2%) from the lower Imnaha River trap to MCN. The estimated survival of hatchery steelhead smolts to LGR was 85.8 (± 2.4) and the survival from release to MCN was 40.2% (±12.5%).

Survival estimates from the trap to LMO for 2000 for natural and hatchery chinook salmon were 73.2% and 54.9%, respectively, and were less than survival estimates obtained in 1998 and 1999. Natural and hatchery steelhead survival estimates to LMO were 50.9% and 57.8%, respectively, and were the lowest since 1997. The earlier migrating natural and hatchery chinook salmon had better survival rates to LMO than the later migrating natural and hatchery steelhead in 2000. No distinct trends in improved smolt survival, from the lower Imnaha River to LGR, was evident in the survival data from 1993 to 2000.

Natural juvenile chinook salmon that over wintered in the Snake River, and were PIT tagged in the lower Imnaha River in the fall of 1999, exhibited a 90% arrival timing at LGR that was 18 days earlier than spring tagged smolts. The 90% arrival time of this group at MCN on May 4, 25 days earlier than natural chinook salmon tagged in the spring. The 90% arrival timing at LGR for natural chinook salmon tagged in the fall at the upper site was May 10. Natural chinook salmon tagged in the fall at the lower site had a 90% arrival time at LGR of April 23, and natural chinook salmon tagged in the spring at the lower site had a 90% arrival time of May 11 at LGR Median arrival times for spring tagged natural chinook salmon at LGR, LGO, and LMO occurred on April 22, April 23, and April 25, respectively. These median arrival times were earlier than previous observations of median arrival made since 1993.

Hatchery chinook salmon smolt 90% arrival timing at LGR occurred on May 13. Median arrival at LGR occurred on May 3. Hatchery chinook salmon were observed at LGR, LGO, LMO, and MCN earlier than in past years (1992 to 1999), but 90% arrival was within the range of past observations with the exception of MCN where the 90% arrival timing occurred on May 27. This was three days later than past observations made from 1992 to 1999.

The 90% arrival timing of natural and hatchery steelhead smolts at LGR occurred on May 25. Median arrival timing of natural steelhead at LGR occurred on May 8. Natural steelhead median and 90% arrival timing were within the past range of observations made from 1993 to 1999 at LGR, LGO, LMO, and MCN. Median arrival timing of hatchery steelhead at LGR occurred on May 16 and was within the range of past observations of median arrival timing made from 1993 to 2000. Median arrival at LGO on May 22 and LMO on May 25 for hatchery steelhead were earlier than past observations.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX TABLES AND FIGURES

INTRODUCTION

This report summarizes the results of the Lower Snake River Compensation Plan Hatchery Evaluation Studies (LSRCP) and the Imnaha Smolt Monitoring Program (SMP) for the 2000 smolt migration from the Imnaha River, Oregon. These studies were designed and closely coordinated to provide information about juvenile natural and hatchery chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) biological characteristics, behavior and emigrant timing, survival, arrival timing and travel time to the Snake River dams and McNary Dam on the Columbia River. Data collected from these studies are shared with the Fish Passage Center (FPC). These data are essential to quantify smolt survival rates under the current passage conditions and to evaluate the future recovery strategies that seek to optimize smolt survival through the hydroelectric system. Information shared with the FPC assists with in-season shaping of flow and spill management requests in the Snake River reservoirs. The Bonneville Power Administration and the United States Fish and Wildlife Service contracted the Nez Perce Tribe (NPT) to monitor emigration timing and tag 21,200 emigrating natural and hatchery chinook salmon and steelhead smolts from the Imnaha River during the spring emigration period (March 1 - June 15) with passive integrated transponder (PIT) tags.

The completion of trapping in the spring of 2000 marked the ninth year of emigration studies on the Imnaha River and the seventh year of participating in the FPC smolt monitoring program. Monitoring and evaluation objectives were to:

1. Determine spring emigration timing of chinook salmon and steelhead smolts collected at the Imnaha River trap.

2. Evaluate effects of flow, temperature and other environmental factors on emigration timing.

3. Monitor the daily catch and biological characteristics of juvenile chinook salmon and steelhead smolts collected at the Imnaha River screw trap.

4. Determine emigration timing, travel time, and in-river survival of PIT tagged hatchery chinook salmon smolts released at the Imnaha River acclimation facility to the Imnaha River Trap.

5. Determine arrival timing, travel time and estimated survival of PIT tagged natural and hatchery chinook salmon and natural and hatchery steelhead smolts from the Imnaha River to Snake and Columbia river dams.

6. Compare emigration characteristics and survival rates of chinook salmon that may utilize the Snake River to overwinter versus overwintering in the Imnaha River.

METHODS

Study Area Description

The Imnaha River subbasin is located in northeastern Oregon (Figure 1) and encompasses an area of approximately 2,538 square kilometers. The mainstem Imnaha River flows in a northerly direction for 129 km from its headwaters in the Eagle Cap Wilderness Area to its confluence with the Snake River (James 1984; Kucera 1989). The river drains the eastern escarpment of the Wallowa mountains and part of an adjacent plateau located between the Wallowa River drainage to the west and Hells Canyon of the Snake River to the east (Kucera 1989). Elevations in the watershed vary from 3,048 m at the headwaters to about 260 m in lower elevations (Kucera 1989). There are diversions for irrigation upstream from the gauging site in the headwaters of the tributary Big Sheep Creek (rkm 32) and Little Sheep Creek. The waters diverted from Big Sheep and Little Sheep creeks are diverted to the Wallowa River Basin (Anonymous *a* 2000). Trapping sites are located at rkm 7 (lower site) and rkm 74 (upper site).

The 70 year (1929 - 1998) mean annual discharge of the Imnaha River is 515 cfs (14.6 cms) at Imnaha, Oregon, USGS gauge 13292000. The minimum discharge, 16 cfs (0.5 cms) was observed November 22, 1931. The maximum river discharge, 20,200 cfs (572.0 cms) was observed January 1, 1997 (Anonymous *a* 2000). Maximum river discharge generally occurs from April to June with minimum flows from August to February (Kucera 1989).

Equipment Description

Floating rotary screw traps manufactured by E.G. Solutions Inc., Corvallis, Oregon, were used to capture emigrating salmonid smolts (Figure 2). Similar traps have been used to capture migrating salmonid species in New York and Alaska (Kennen et al. 1994; Thedinga et al. 1994). When conditions permitted, two of these traps were fished in tandem. During hatchery releases, trap efficiency trials, high flows or periods of damage to one trap, a single trap was fished. The screw traps used in the spring and fall at the lower site consisted of a non-standard 2.1 m diameter trapping cone supported by a metal A-frame and two six meter pontoons that provided flotation. Fish entering the trapping cones move through to a custom oversize livebox (1.68 m wide x 1.25 m long x 0.55 m deep). The live box was fitted with a removable baffle to dissipate water velocity during high flows. A smaller trap, with a 0.762 m diameter cone, was used at the upper site in the fall.

Water temperature information for this study was collected using a thermograph; placed 150 m upstream from the screw trap. Discharge information was provided by the U.S. Geological Survey, USGS gauge 13292000 at Imnaha, Oregon. Water discharge and temperature information was provided by the USGS for the Anatone stream gauge, 13334300. Measurements of outflow, spill, and temperature at Lower Granite Dam (LGR), Little Goose Dam (LGO), Lower Monumental Dam (LMN) and McNary Dam (MCN), were obtained online from DART at http://www.cqs.washington.edu/dart.

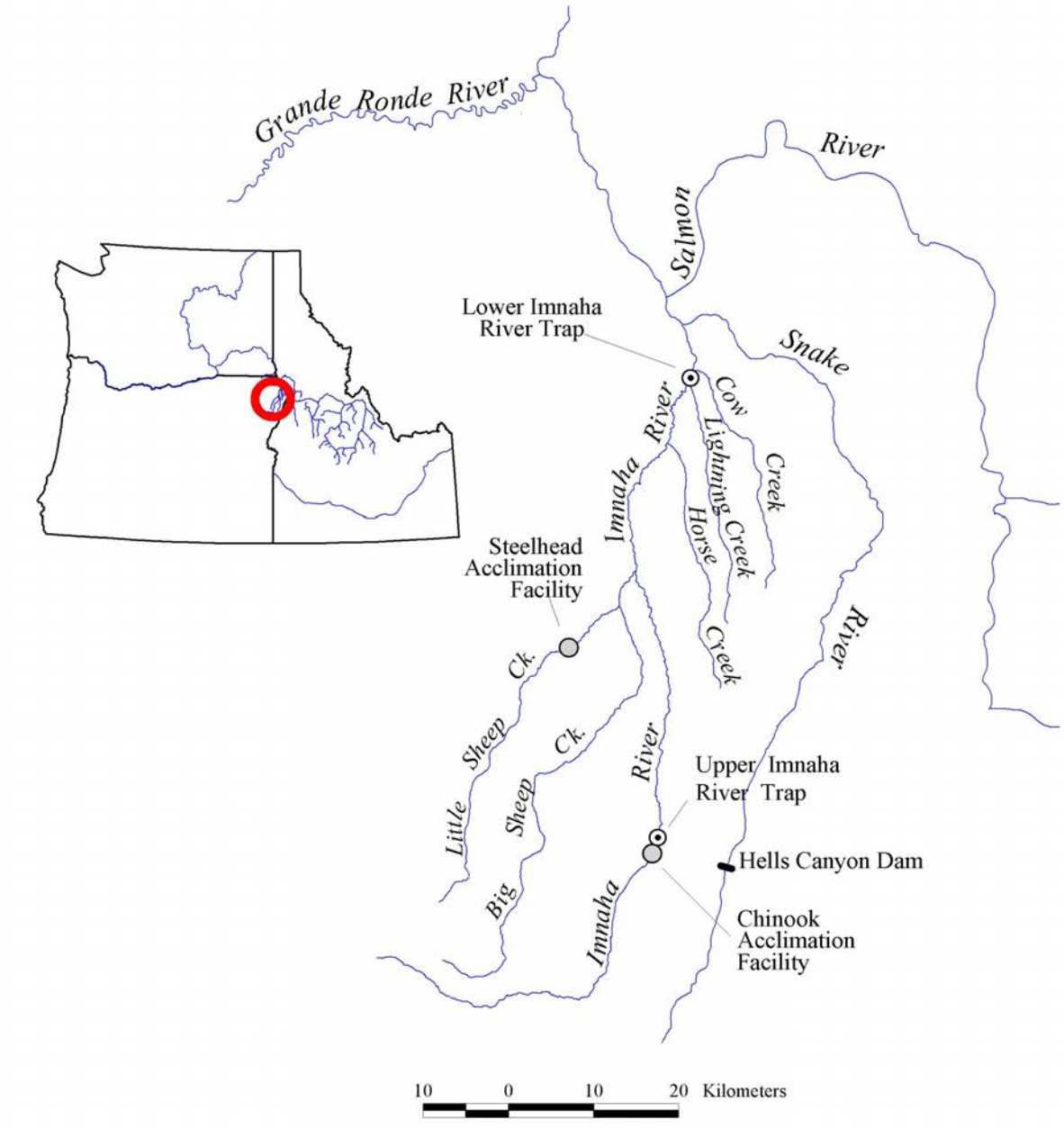

Figure 1. Map of the Imnaha River study area.

Figure 2. The Lower Imnaha trap site with two rotary screw traps operating. Trap A is on the left and trap B is on the right.

Trap Operations

The trap was operated for 23 days at the upper site during the fall of 1999, from October 20 to November 24. The upper Imnaha River trap was located at rkm 74 (~ 400 m downstream of the Imnaha River acclimation facility). The trap was operated to collect juvenile chinook salmon for a survival estimate of presmolt survival to LGR. The upper trap operated for two to six days per week over a six week period, and fished for a total of 489.0 hours during the fall season averaging 81 hours per week.

The lower trap was located 6.6 kilometers from the confluence to the Snake River. During the fall it was fished from October 20 to November 11. The lower trap was operated two to four days per week over the four week period, and fished for a total of 249.5 hours during the fall season averaging 62 hours per week fished. Spring emigrant trapping operations began February 26 and lasted until June 15, 2000. A total of 95 days were sampled. The longest consecutive number of days sampled was 63 days, from February 26 to April 29. A second trap (Trap B) was operated in tandem for a total of 22 days between April 16 and June 15. The

longest duration Trap B was operated for was four days from April 16 to April 19, and again from June 12 to June 15.

Trap position at the lower site was adjusted by manipulating a cable suspension system which allowed upstream/downstream movement of the trap. This allowed the trap to be backed slightly out of the main current and fished during high flows. Trap position at the lower site varied from 1 m (position 1) to 4 m (position 4), upstream or downstream. Ultimately, the daily position of the trap was determined by positioning the trap in the furthest upstream position where water velocities and debris would not cause the trap to sink. The position was recorded daily. The live box of the screw trap was checked at 0800 every morning and several times throughout each night and day. Non-target piscivorus fish and large numbers of other non-target fish were removed from the live box first. Non-target piscivorus fish were scanned for PIT tags and then released 30-50 meters downstream. Fish were processed as they were removed from the trap.

Daily processing procedures were similar to those used by Ashe et al. (1995) and were as follows: 1) Fish were anaesthetized in a MS-222 bath (3 mL MS-222 stock solution (100 g/L) per 19 L of water) buffered with Propolyaqua (PRO-NOVAQUA), 2) Each fish was examined for existing marks (e.g. fin clips), and PIT tag insertion scars, 3) Chinook salmon, steelhead and large piscivorus fish were scanned with a PIT tag scanner, 4) 100 to 300 hatchery chinook salmon smolts were targeted for use in daily trap efficiency trials, 5) A specified number of each species was selected for PIT tag insertion, 6) All other fish were enumerated and released 30-50 m downstream from the trap after recovering from the anaesthetic, and 7) All fish mortality was recorded.

PIT Tagging

Fish selected for passive integrated transponder (PIT) tagging were examined for previous PIT tags, descaling and general health. They were measured (FL-mm) and weighed (0.1 g). All chinook salmon selected for tagging were greater than 65 mm. Fish were PIT tagged using hand injector units following the methods described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Hypodermic injector units and PIT tags were sterilized after each use in ethanol for at least 10 minutes prior to tagging and allowed to dry. Tagging was discontinued when water temperatures exceeded 15° C. Steelhead smolts were held until fully recovered and then released as a group. Chinook salmon smolts were held in perforated aquatic containers for a minimum of 12 hours and released after dark. Mortality due to tagging was recorded.

Trap Efficiencies

Efficiency trials for hatchery salmon were conducted during the spring. The first 300 hatchery chinook salmon were targeted for trap efficiency trials. Marked fish were measured

(fork length) to the nearest mm and weighed to the nearest 0.1 g. Fish selected for trap efficiency trials were marked with PIT tags or by clipping the distal portion of the fins. The following fin clips were used on a daily basis, Sunday through Saturday respectively: 1) upper and lower caudal, 2) upper caudal, 3) lower caudal, 4) left pelvic, 5) right pelvic, 6) left pectoral, and 7) right pectoral. Fish marked for trap efficiency trials were held in perforated plastic garbage cans in the river during daytime hours (approximately 12 h) and then transported upstream approximately one km to one of two release sites during evening hours. Fish were released after dark on the day they were marked. Trap efficiency was determined by $E = R/M$; where E is estimated trap efficiency, R is number of marked fish recaptured, and M is number of fish marked and released.

Biological Characteristics

Length frequency distributions were created and condition factors calculated for each fish species and origin. Length frequencies were calculated by separating fish into 10 mm classes. Condition factors were calculated using Fulton's condition factor : $(W/L^3) \times 10^5$ (Bagenal and Tesch 1978). Natural steelhead less than 120 mm were assumed not to be smolts and therefore were not used in length, weight and condition factor calculations and were reported to the FPC as rainbow trout. Adult steelhead, and large steelhead that had the metamorphic characteristics of resident rainbow, were not reported as juvenile steelhead or used in length, weight and condition factor calculations. Weights less than 4.0 grams were not used in calculating averages or condition factors because they were not considered accurate due to the limitations of the balances used.

All statistics that compared fish captured and tagged during the spring were performed with STATGRAPHICS PLUS version 2 software (1995). A student t-test was used to test for significant differences in fork length between various groups of fish (i.e. natural versus hatchery steelhead smolts, previously PIT tagged hatchery chinook salmon smolts versus those not previously PIT tagged, hatchery chinook salmon marked and released for trap efficiency versus trap efficiency recaptures). Differences were considered significant at $p < 0.05$. When the assumption of normality or the standard skewness was violated, the t-test was abandoned in favor of the Wilcoxon rank sum test statistic (Ott 1984). Differences were considered significant at $p < 0.05$.

Survival Estimation

Survival probabilities were estimated by the Cormack, Jolly, and Seber (1964, 1965, and 1965, respectively, as cited in Smith et al. 1994) methodology with the Survival Using Proportional Hazards (SURPH) model (Smith et. al., 1994). The data files for season wide and weekly release groups were created using the program CAPTHIST (Westhagen 1997). Data for input into CAPTHIST was obtained directly from PTAGIS.

Post release survival from the acclimation facility to the lower Imnaha River trap did not include 672 PIT tagged hatchery chinook salmon interrogated in Trap B because Trap B did not operate consistently. Hatchery chinook released from the acclimation facility were treated as a single group. Season-wide and weekly release groups of natural and hatchery chinook salmon and steelhead were also treated as single release groups. Only weekly release groups of 200 or more fish were analyzed for survival on a weekly basis. The assumptions for the methodology can be found in Smith et al. 1994 and Burnham et al. 1987. When tagging chinook salmon in the fall, we assumed that fish did not migrate past LGR before PIT tag interrogation facilities became operational.

Arrival and Travel Timing to Trap Site and Lower Snake River Dams

Arrival timing to Lower Granite Dam (LGR), Little Goose Dam (LGO), Lower Monumental Dam (LMO), and McNary Dam (MCN) were determined for natural and hatchery chinook salmon and steelhead smolts. Detections and arrival timing at each dam for this report period are based on first-time observations of individual tag codes at each dam. Arrival timing estimates do not include subsequent detections of fish that were captured in the Snake River trap, held in sample rooms or raceways, had negative travel times or single coil detections. Release groups of at least 30 fish were pooled weekly to determine travel time to LGR. Travel time estimates to LGR do not include fish captured in the Snake River trap.

RESULTS AND DISCUSSION

River Discharge and Water Temperature

Imnaha River

The daily average discharge in the Imnaha River for March, May, and June, of 2000, were below the 71 year average from 1928 to 1999 (Figure 3). Monthly discharge for February was 22 cfs higher than the monthly average from 1928 to 1999, and April was 301 cfs higher than the average from 1928 to 1999. But overall, the monthly average discharge from February through June was 403 cfs less than the 71 year average (1928 to 1999). The daily average flow from 1928 to 1999 and 2000 is presented in Appendix A for the months of February, March, April, May, and June.

During the fall 1999 trapping period Imnaha River mean discharge ranged from 159 cfs (4.5 cms) on October 23 to 611 cfs (17.3 cms) on October 28. Mean daily water temperature at the lower Imnaha River trap site during the fall trapping period ranged from 4.9/C on November 2 to 9.3/C on October 26. Mean daily water temperature at the upper Imnaha River trap site during the fall trapping period ranged from 0.3/C on November 23 to 5.8/C on November 6. The daily mean discharge in the Imnaha River during the spring ranged from 253 cfs (7.2 cms) on February 22 to 1,855 cfs (55.5 cms) on April 22. The average discharge was 917 cfs (26.0 cms). Water temperature ranged from 3.3 °C on February 20 to 15.3 °C on June 5. Appendix B, Table B1 contains the mean daily discharge and water temperatures for the fall of 1999 at the upper and lower sites and Appendix B, Table B2 contains the mean daily water temperatures for the lower site during the spring of 2000.

Snake River

The monthly averages for 2000 were also lower than the 40 year monthly average (1958 to 1999) for the months of February, March, May and June for the Snake River near Anatone, Washington (Figure 4, and Appendix A). Snake River discharge ranged from 23,300 cfs (659.8 cms) on February 21 to 68,200 cfs (1,931.2 cms) on April 23. Water temperature ranged from 4.5 °C on February 20 to 16.2 °C on June 17 (Appendix B, Table B2).

The Fish Passage Center characterized the 2000 water year as “below normal” (DeHart 2001). Average outflow, measured from April 2 to September 2 in the tailrace of LGR, LGO, and LMO, ranged from 58 kcfs at LGO to 60 kcfs at LMO (Figure 5). The maximum outflow at these same sites ranged from 108 kcfs at LGO to 112 kcfs at LMO. Maximum outflow occurred April 23 and minimum outflow occurred September 2 at LGR, LGO, and LMO. Minimum outflow ranged from 15.2 at LGR to 15.6 at LGO and LMO. Outflow at McNary Dam tailrace ranged from 82 kcfs on August 27 to 359 kcfs on April 23 and averaged 203 kcfs for a five month period from April 2 to September 2.

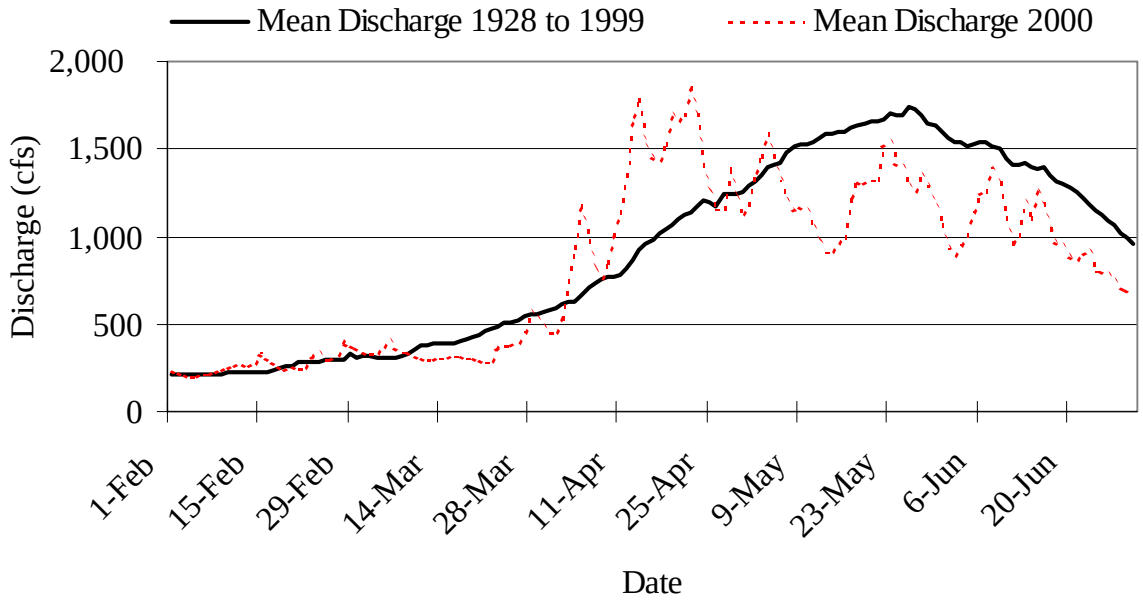

Figure 3. The mean discharge from 1928 to 1999 and the mean discharge for 2000 from February 1 to June 30, for the Imnaha River, USGS gauge 13292000.

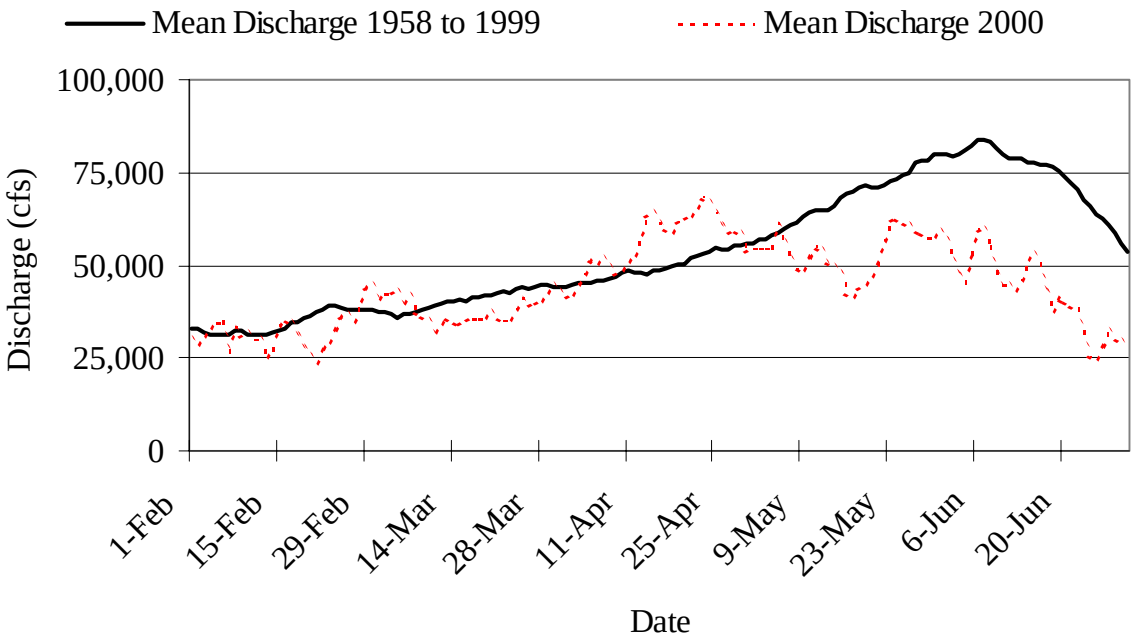

Figure 4. The mean discharge from 1958 to 1999 and the mean discharge for 2000 from February 1 to June 30, for the Snake River, USGS gauge 13334300.

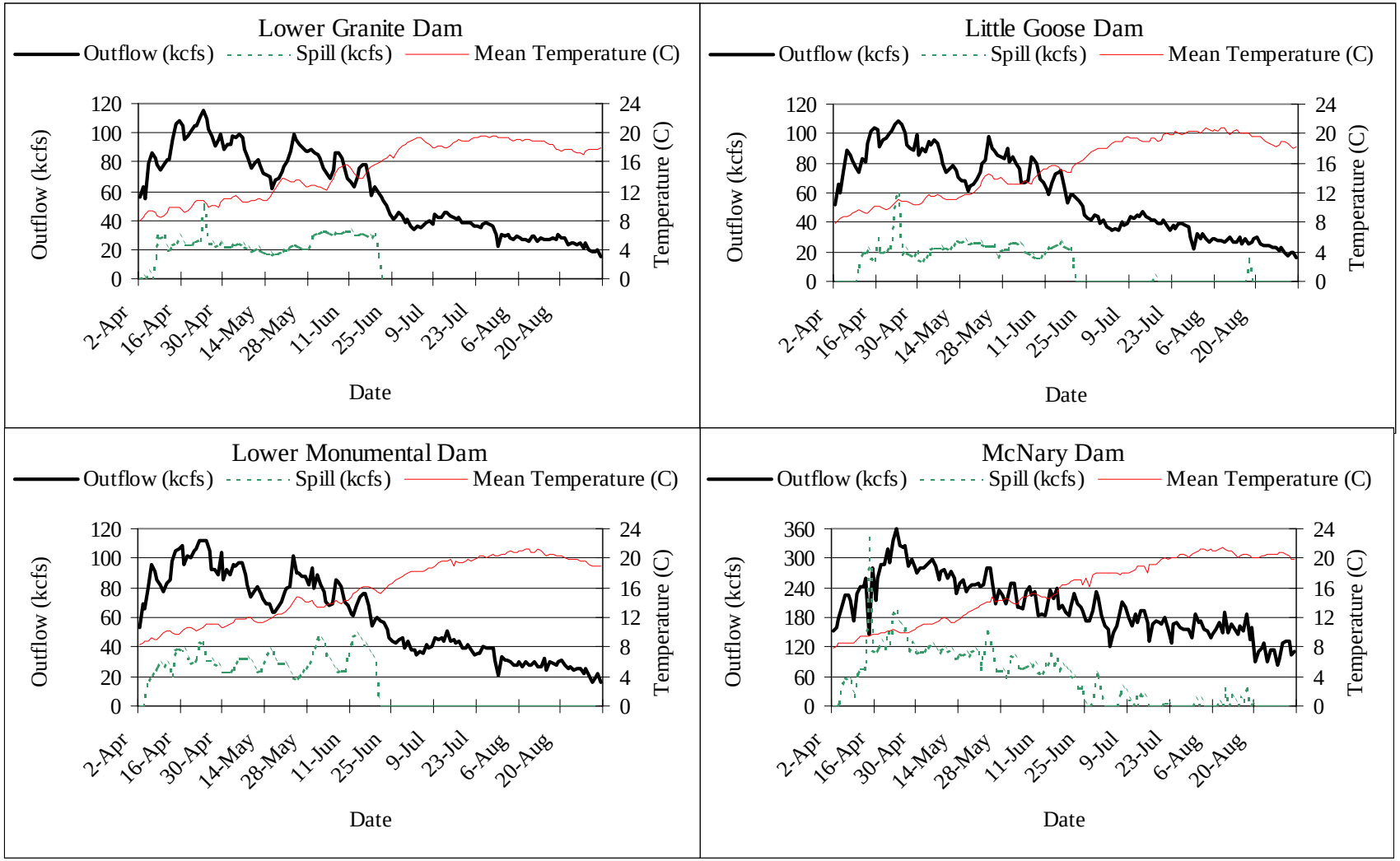

Figure 5. Measurements of outflow, spill, and mean temperature at Lower Granite Dam (top left), Little Goose Dam (top right), Lower Monumental Dam (lower left) and McNary Dam (lower right), from April 2 to September 2, 2000. Data was obtained on line at http://www.cqs.washington.edu/dart.

Maximum water temperatures recorded in the tailraces of LGR, LGO and LMO occurred after continuous spill ended on June 20. The maximum water temperature at LGR was 19.7 °C and occurred on July 25. Tailrace temperatures averaged 14.9 °C from April 2 to September 2 at LGR. At LGO, the maximum water temperature recorded in the tailrace was 20.8 °C on August 3 and tailrace temperatures averaged 15.4 °C from April 2 to September 2. LMO recorded a maximum tailrace temperature on August 8 of 21.1 °C and tailrace temperatures averaged 15.7 °C from April 2 to September 2. MCN had a maximum water temperature of 21.4 °C on August 9 and averaged 15.7 °C from April 2 to September 2. Minimum water temperatures from April 2 to September 2 were all recorded on April 2 and were as follows: LGR - 8.2 °C, LGO - 7.8 °C, LMO - 8.2 °C, and MCN - 7.8 °C. River discharge and temperature are presented because these conditions vary annually and affect migrating salmonid smolts (Berggren and Filardo 1993).

Hatchery Releases

All liberations of hatchery reared fish into the Imnaha River occurred during the spring. A total of 507, 929 hatchery reared chinook salmon and steelhead were released into the Imnaha River during the 2000 migration year (Table 1). A total of 179,716 hatchery chinook salmon were volitionally released beginning March 22 and were forced out of the ponds at the Imnaha Acclimation Facility on April 16, 17, and 18. PIT tags were used to mark 20,821 hatchery chinook salmon (11.6%). All hatchery chinook salmon were marked with coded wire tags.

Hatchery steelhead were released in three groups. The largest group, 161,582 steelhead, were force released out of the Little Sheep Creek Facility acclimation pond on April 12. All hatchery steelhead released on April 12 had adipose fin clips and coded wire tags. A portion (32.4%) were marked with left ventral clips, in addition to the adipose fin clip and coded wire tags. Only 512 hatchery steelhead (< 1%) released April 12 were marked with PIT tags. The next release of hatchery steelhead occurred from April 18 to April 20 into the lower portion of Big Sheep Creek. A total of 100,007 fish were released directly into the creek. All fish released into Big Sheep Creek had adipose fin clips. None of the hatchery steelhead released April 18 to April 20 had PIT tags. The final release of steelhead occurred May 10 from the Little Sheep Creek Acclimation Facility. A total of 66,624 adipose clipped steelhead were released. Left ventral clips and coded wire tags represented 35.4% of the 66,624 steelhead released in the third group. Less than one percent (n = 246) of the May 10 release group of hatchery steelhead were PIT tagged.

Juvenile Chinook Salmon and Steelhead Catch

Annual Catch

A total of 2,228 natural chinook salmon juveniles were captured at the upper Imnaha River trap from October 20 to November 24, 1999 (Table 2). The highest daily catch of natural chinook at the upper study site was 471 fish on October 29 (Appendix C, Table C1). A total of

Table 1. Releases of hatchery reared chinook salmon and steelhead smolts in the Imnaha River Subbasin in 2000. All fish were adipose fin clipped in addition to other marks applied unless otherwise noted (Debbie Eddy, personal communication).

Species	Numbers Released	Release Dates	Tags/Marks	Release Site
Chinook Salmon	179,716	March 22 -	172,282 Adipose Fin Clips with 20,821 PIT tags	Imnaha River
Steelhead	161,582	April 12	50,758 Adipose / Left Ventral Clips 512 PIT tags	Little Sheep Creek
Steelhead	100,007	April 18-20	Adipose Fin Clips	Big Sheep Creek
Steelhead	66,624	May 10	23,575 Adipose Left / Ventral Clips 246 PIT tags	Little Sheep Creek

Table 2. The weekly mean discharge (cfs), temperature (C) and catch of natural chinook salmon at the upper and lower Imnaha River, October 20 to November 24, 1999.

Date	Mean Discharge (cfs)	Upper Trap Mean Temperature (C)	Lower Trap Mean Temperature (C)	Upper Trap Natural Chinook	Lower Trap Natural Chinook
17-Oct	160		8.1	93	119
24-Oct	221	4.8	8.8	593	1,812
31-Oct	194	3.9	7.0	320	1,018
7-Nov	206	4.8	8.8	258	447
14-Nov		3.4		647	
21-Nov		0.8		317	
Total				2,228	3,396

3,396 natural chinook salmon were captured at the lower Imnaha River trap from October 20 to November 11, 1999 (12 days). The highest daily catch of natural chinook salmon at the lower site was 1,709 fish on October 29. The maximum daily catch of natural chinook salmon at both sites occurred the day prior to an increase in the average flow to 403 cfs at the lower study site (rkm 7). Water temperatures averaged 8.5°C on October 29. The spring target catch consisted of 5,165 natural chinook salmon, 20,670 hatchery chinook salmon, 5,041 natural steelhead, and 22,500 hatchery steelhead (Table 3). A summary of daily catch and hours fished is presented in Appendix C, Table C2).

Increases in the daily mean discharge preceded increased catch of natural chinook salmon at the upper and lower trap on October 28 and November 7. Notable points in the spring data occurred on March 29 when the peak catch of 1,236 natural chinook salmon and 5,781 hatchery chinook salmon occurred following the monthly peak discharge of 567 cfs on March 28 (Figure 6). The catch of natural steelhead peaked on May 4 with a catch of 432 fish and the peak catch of 2,113 hatchery steelhead occurred 14 days later. Although no statistically significant correlations existed between the annual catch of steelhead and discharge, the daily catch did fluctuate with daily discharge during the weeks of April 16, April 23, May 14, and May 21 (Figure 7).

Table 3. The weekly mean discharge (cfs), temperature (C) and catch of natural and hatchery chinook salmon and steelhead in the lower Imnaha River from February 26 to June 15, 2000.

Week	Mean Discharge (cfs)	Mean Temperature (C)	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
20-Feb	299	5.2	9			
27-Feb	350	6.9	80		1	
5-Mar	349	6.2	96			
12-Mar	307	6.7	193		1	
19-Mar	324	7.1	334	1,709		
26-Mar	475	7.8	2,286	13,657	8	1
2-Apr	843	8.8	624	2,870	115	3
9-Apr	1,330	9.3	261	756	109	195
16-Apr	1,614	9.5	268	959	439	2,239
23-Apr	1,266	8.8	447	453	666	1,332
30-Apr	1,404	10.4	195	168	1,376	2,079
7-May	1,100	8.9	78	57	626	2,502
14-May	1,156	12.5	62	31	1,031	5,294
21-May	1,434	12.2	71	8	429	4,143
28-May	965	10.7	60	2	101	978
4-Jun	1,267	13.7	59		104	2,832
11-Jun	1,138	13.3	42		35	902
Total			5,165	20,670	5,041	22,500

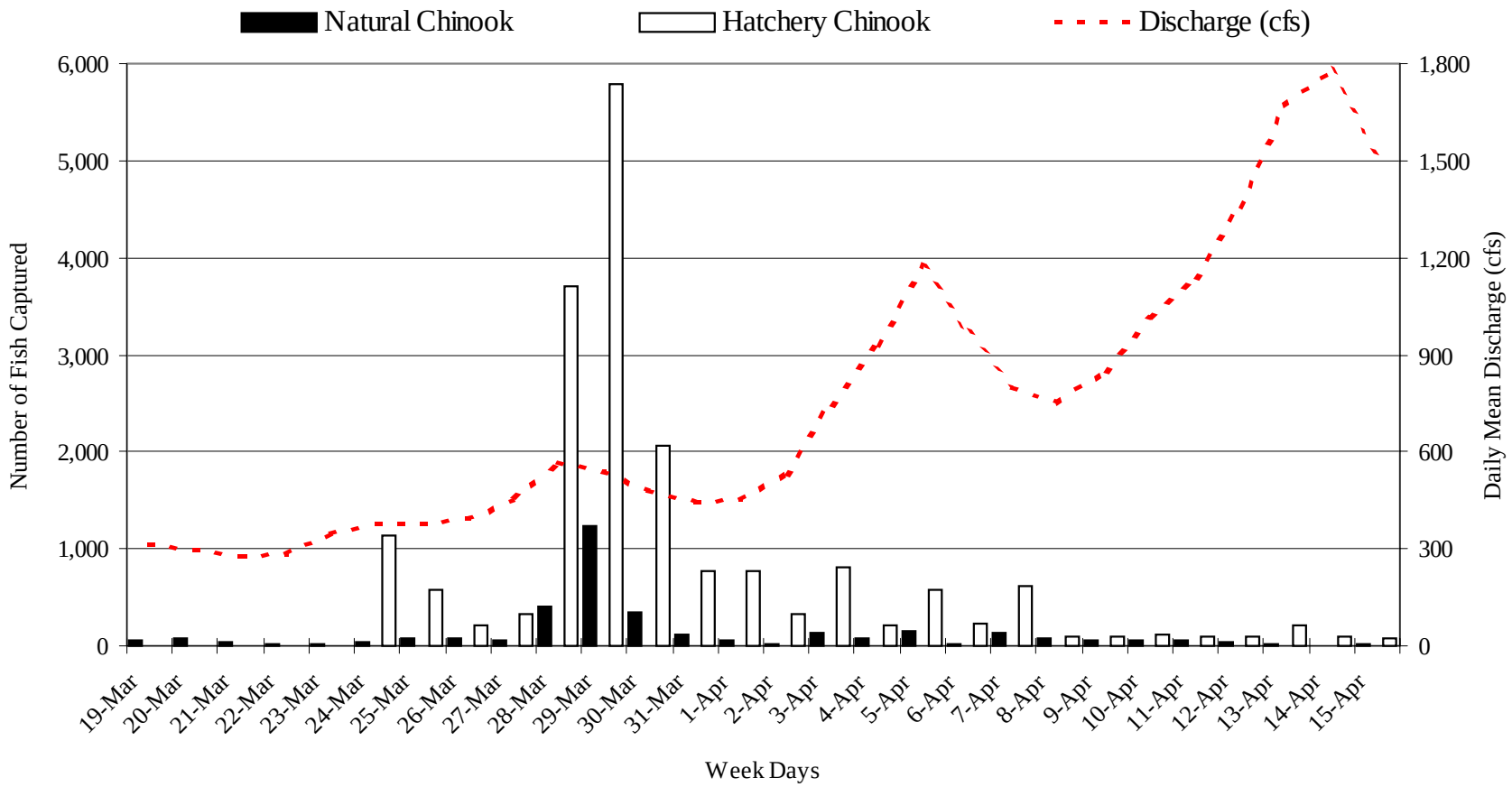

Figure 6. The daily catch of natural and hatchery chinook salmon between March 19 to April 15, 2000 at the Imnaha River screw trap and the mean daily discharge at Imnaha, Oregon (USGS Gauge 13292000). A volitional release for hatchery chinook salmon was initiated on March 22 and ended on April 18, 2000.

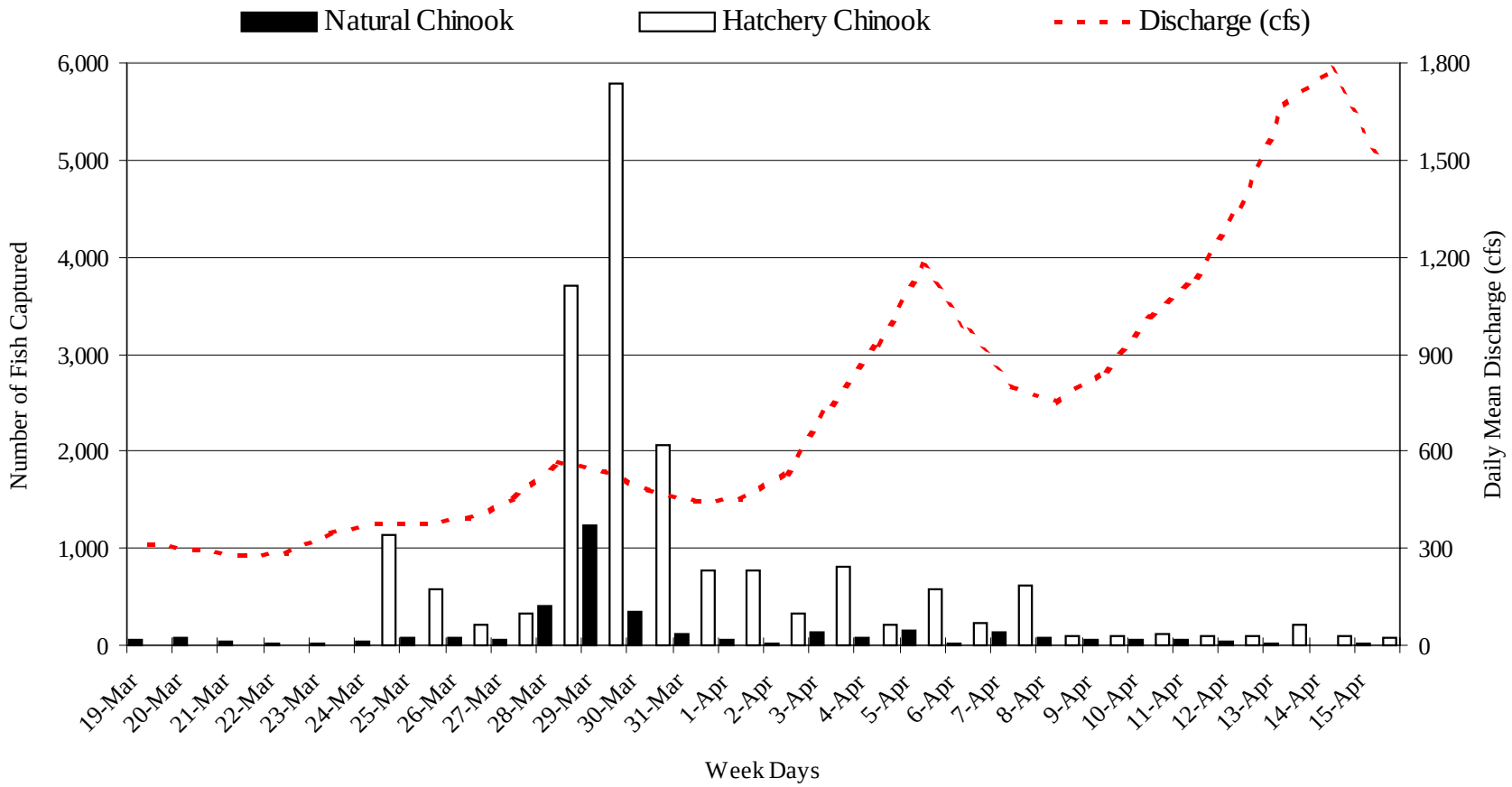

Figure 7. The daily catch of natural and hatchery steelhead between April 9 and June 15, 2000 at the Imnaha River screw trap and the mean daily discharge at Imnaha, Oregon (USGS Gauge 13292000).

PIT Tagging

Personnel at the upper and lower traps PIT tagged and released a total of 21,720 juvenile salmonids into the Imnaha River for migration year 2000 (Table 4). The fall trapping and tagging effort totaled 1,973 PIT tagged natural chinook salmon at the lower Imnaha site and 1,989 natural chinook salmon PIT tagged at the upper Imnaha site. The spring smolt PIT tagging effort at the lower site totaled 4,368 natural chinook salmon, 2,817 hatchery chinook salmon, 4,728 natural steelhead, and 5,846 hatchery steelhead (Table 4). Natural chinook were tagged throughout the spring study period with weekly release groups ranging in size from 41 fish during the week of June 11 to 1,632 fish released during the week of March 26.

Hatchery chinook salmon were tagged over a seven week period, from March 19 to May 6. Weekly PIT tag release groups of hatchery chinook salmon during the seven week period from March 19 to April 23 ranged in size from 822 fish during the week of March 26 to one fish during the week of April 30. Weekly PIT tag release groups for natural steelhead ranged from 8 fish during the week of March 26 to 1,178 fish during the week of April 30. A total of 12 weekly release groups of natural steelhead were produced during the spring of 2000. Nine weekly PIT tag release groups of hatchery steelhead were produced. Release groups of PIT tagged hatchery steelhead ranged in size from one fish during the week of March 26 to 1,044 fish during the week of April 30.

Recaptures of Previously PIT Tagged Fish

The upper and lower emigrant traps had recapture rates of previously PIT-tagged natural chinook salmon of less than 2% during the fall. Thirty natural chinook salmon were recaptured at the upper Imnaha River trap and twenty-five at the lower Imnaha study site. Twenty-one of the natural chinook salmon intercepted at the upper site had been previously PIT tagged by ODFW (Appendix C, Table C3). Twenty-one of the natural chinook salmon captured at the lower Imnaha study site were tagged as part of this investigation at the upper study site.

During the spring we recaptured 2,041 hatchery chinook salmon, 43 natural chinook salmon, and 42 hatchery steelhead at the lower Imnaha River trap. The fish had been tagged prior to the start of trapping on February 25, 2000. PIT tagged recaptured hatchery chinook salmon ranged from 100 mm to 182 mm in fork length and averaged 130 mm in fork length (Table 5). The volitional release in 2000 was the second time a volitional release was attempted in the Imnaha River for chinook salmon. Hatchery chinook salmon appeared to have moved in-mass rather than in a gradual prolonged pattern observed in 1999 (Cleary et al. 2002) (Figure 8). Ninety percent of hatchery chinook salmon recaptures occurred 22 days after the start of the volitional release. In comparison, 90% of the recaptured PIT tagged hatchery chinook salmon in 1999 were observed 38 days after the start of the volitional release. The 2000 migration was still more gradual than the 1998 forced release of hatchery chinook salmon where 90% of all PIT

Table 4. Weekly numbers of PIT tagged fish released from the upper and lower Imnaha River screw traps, October 20 to November 24, 1999 and February 26 to June 15, 2000.

Week Released	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
Upper Trap - Fall of 1999				
17-Oct	92			
24-Oct	406			
31-Oct	315			
7-Nov	256			
14-Nov	631			
21-Nov	289			
Lower Trap - Fall of 1999				
17-Oct	119			
24-Oct	918			
31-Oct	502			
7-Nov	434			
Lower Trap - Spring of 2000				
27-Feb	79			
5-Mar	93			
12-Mar	190			
19-Mar	324	594		
26-Mar	1,632	822	8	1
2-Apr	594	593	118	4
9-Apr	246	369	87	97
16-Apr	243	409	419	1,002
23-Apr	434	29	662	999
30-Apr	186	1	1,178	1,044
7-May	68		621	1,007
14-May	55		1,020	963
21-May	65		426	729
28-May	59		99	
4-Jun	58		59	
11-Jun	41		31	
Total	8,329	2,817	4,728	5,846

Table 5. Averages and ranges for fork lengths (mm), weights (g), and condition factors (K) for PIT tag recaptures of hatchery chinook salmon, natural chinook salmon, and hatchery steelhead observed at the lower Imnaha River trap from February 25 to June 13.

Statistic	Hatchery Chinook Salmon	Natural Chinook Salmon	Hatchery Steelhead
Sample Size	1,149	42	38
Average Length	130	109	219
Standard Deviation	8.2	9.4	17.4
Range	100 - 182	86 - 127	172 - 251
Sample Size	998	40	30
Average Weight	26.0	14.6	96.7
Standard Deviation	5.52	3.73	22.92
Range	10.0 - 72.9	6.5 - 22.2	53.7 -141.3
Sample Size	992	40	30
Average Condition Factor	1.17	1.10	0.89
Standard Deviation	0.08	0.09	0.06
Range	0.84 - 1.43	0.94 - 1.28	0.75 - 1.04

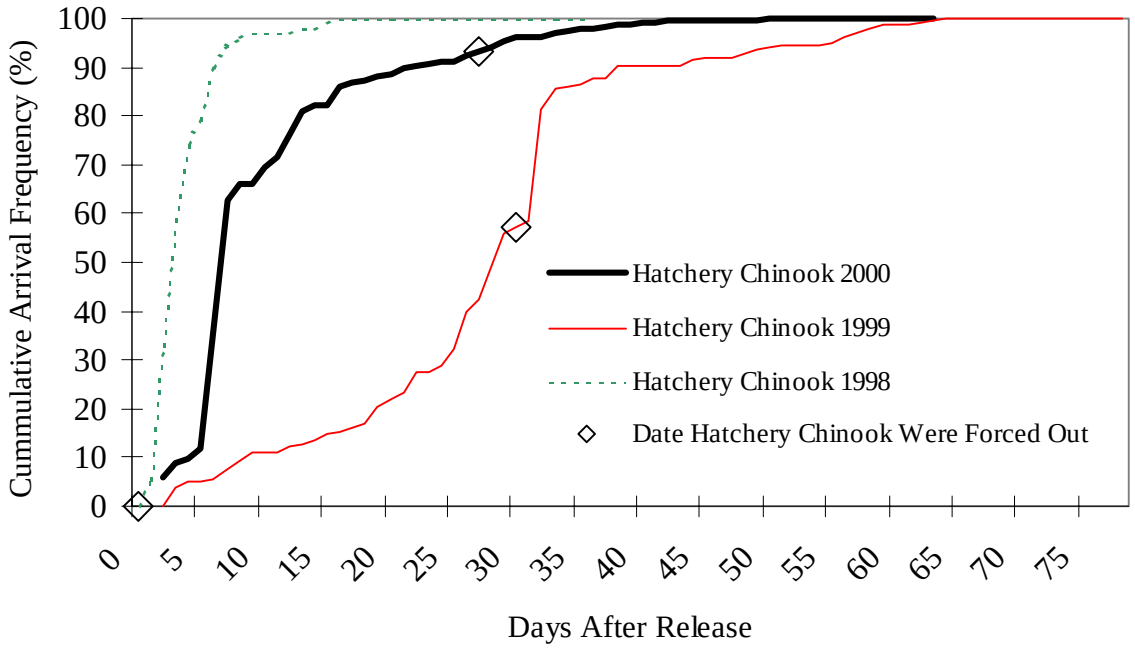

Figure 8. The arrival frequency of previously PIT tagged hatchery chinook salmon smolts released from the acclimation facility and captured in the lower Imnaha River trap during the spring of 1998, 1999, and 2000. The release strategy in 1998 was a forced release and the release strategies in 1999 and 2000 were volitional releases.

tag recaptures occurred eight days after they were forced out of the ponds (Cleary et al. 2000). Hatchery chinook salmon may have been acclimated long enough for the physiological processes of smoltification to trigger a mass movement and allowed the hatchery chinook salmon to take advantage of higher than average flows in April. Hatchery chinook salmon arrived at LGR five days earlier than previous observations made from 1992 to 1999 (Ashe et al. 1995, Blenden et al. 1996, Blenden et al. 1997, Blenden et al. 1998, Cleary et al. 2000, Cleary et al. 2002). The survival rate to Lower Granite Dam was slightly higher than 1999.

Biological Characteristics

Chinook Salmon

The mean fork lengths of natural chinook salmon sampled at the lower site during the fall of 1999 were significantly larger and more varied than those at the upper site ($P<0.01$). However, we do not consider the 3 mm difference to be biologically significant (Figure 9). Natural chinook salmon caught in the fall of 1999 at the upper Imnaha River trap averaged 89 mm in fork length, 7.7g in weight with a condition factor of 1.04. Natural chinook salmon captured in the fall of 1999 at the lower Imnaha River trap averaged 92 mm in fork length (n=1,960) with a mean weight of 8.6 g, and average condition factor of 1.04 (Table 6).

Natural chinook salmon captured during the spring averaged 110 mm in fork length, 14.1 g, with a condition factor of 1.05 (Table 7). Median fork lengths for natural and hatchery chinook salmon were compared because fork length distributions had standard skewness values outside of the normal ± 2 range. Median fork lengths for natural chinook salmon (109 mm) were significantly smaller ($p < 0.05$) than median fork lengths for hatchery chinook salmon (131 mm). Hatchery chinook salmon averaged 132 mm in fork length and weighed an average of 26.7 g, with a condition factor of 1.14. Weekly fork lengths, weights, and condition factors are presented in Table 8.

Steelhead

Median fork lengths for natural and hatchery steelhead were compared because fork length distributions had standard skewness values outside of the normal ± 2 range. The median fork length for natural steelhead captured was 182 mm (Table 6). Hatchery steelhead had a statistically significantly larger median fork length of 223 mm ($p < 0.05$). Mean fork lengths for natural and hatchery steelhead were 184 mm and 224 mm, respectively. Mean weight for natural steelhead was 62 g. Hatchery steelhead weighed an average of 106.8 g. Although statistically smaller, natural steelhead had a mean condition factor (0.95) similar to their hatchery cohorts (0.93). Differences in the fork lengths of natural and hatchery produced fish are visible in length frequency distributions (Figure 10 and 11).

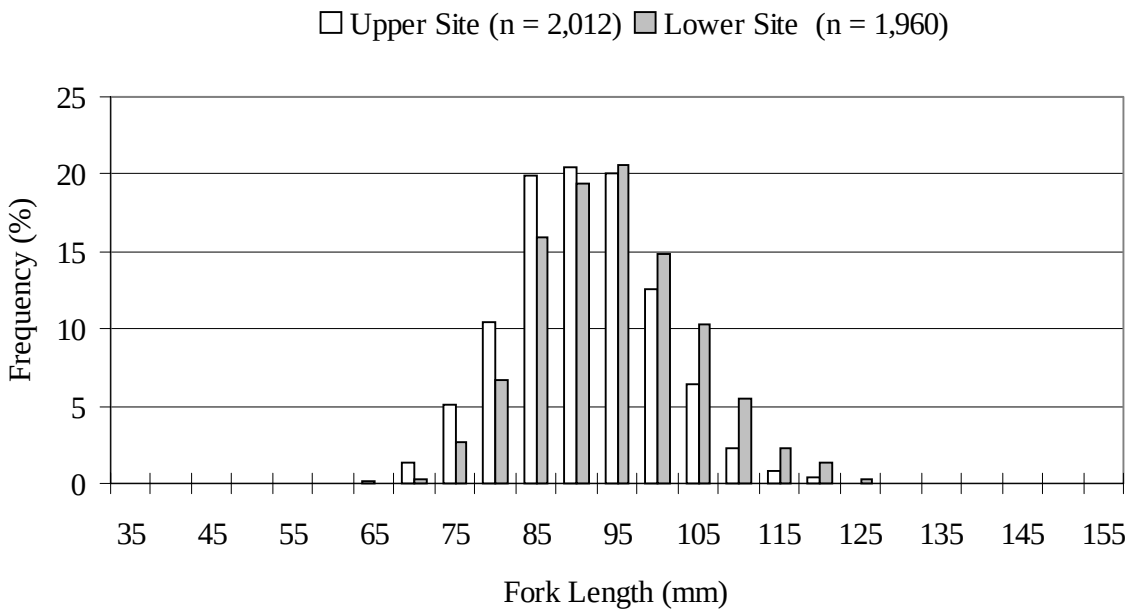

Figure 9. Length frequency of natural chinook salmon trapped in the upper and lower Imnaha River traps from October 21 to November 24, 1999.

Table 6. Mean lengths, weights, and condition factors of natural chinook salmon captured from October 21,1999 to November 24, 1999 at the upper and lower sites on the Imnaha River.

Statistic	Upper Trap	Lower Trap
Sample Size	2,032	1,960
Mean Fork Length	89	92
Range	61 - 150	30 - 150
Standard Deviation	9.1	9.8
Sample Size	1,912	1,759
Mean Weight	7.7	8.6
Range	4.0 -30.3	4.0 - 22.2
Standard Deviation	2.38	2.71
Sample Size	1899	1744
Mean K	1.04	1.04
Range	0.64 - 1.48	0.72 - 1.35
Standard Deviation	0.08	0.09

Table 7. A summary of the biological characteristics of natural and hatchery chinook salmon and steelhead from the Imnaha River trap from February 26 to June 15, 2000.

	Chinook Salmon		Steelhead	
Statistic	Natural	Hatchery	Natural	Hatchery
Mean Fork Length (mm)	110	132	184	224
Sample Size	4,330	2,399	4,668	5,751
Range	69 - 150	101 - 219	120 - 272	126 - 303
Standard Deviation	9.5	9.6	21.0	18.4
Mean Weight (g)	14.1	26.7	62	106.8
Sample Size	4,065	1,989	4,287	4,262
Range	4.1 - 35.3	10.8 - 94.1	17.0 - 196.9	21.9 - 226.3
Standard Deviation	3.83	6.8	22.16	27.07
Mean Condition Factor (K)	1.05	1.15	0.95	0.93
Sample Size	4,042	1,976	4,244	4,227
Range	0.71 - 1.69	0.63 - 1.69	0.74 - 1.24	0.70 - 1.34
Standard Deviation	0.08	0.07	0.06	0.07

Table 8. Weekly mean fork lengths and condition factors (K) for natural and hatchery chinook salmon and steelhead captured at the Imnaha River trap during the spring of 2000. All weekly groups represent 30 or more fish.

	Natural Chinook		Hatchery Chinook		Natural Steelhead		Hatchery Steelhead	
Week	Average Length (mm)	Average K	Average Length (mm)	Average K	Average Length (mm)	Average K	Average Length (mm)	Average K
27-Feb	106	0.97						
5-Mar	109	0.98						
12-Mar	115	1.00						
19-Mar	113	1.04	132	1.15				
26-Mar	110	1.05	131	1.17				
2-Apr	110	1.07	131	1.16	192	0.97		
9-Apr	110	1.05	133	1.13	186	0.98	224	1.00
16-Apr	109	1.08	133	1.13	193	0.97	219	0.98
23-Apr	108	1.03			183	0.94	222	0.93
30-Apr	107	1.02			184	0.95	229	0.92
7-May	106	1.04			184	0.96	226	0.92
14-May	108	1.02			181	0.92	225	0.88
21-May	104				183	0.98	221	
28-May	102	1.10			181	1.01		
4-Jun	106	1.10			178	1.02		
11-Jun	101	1.10			186	1.00		

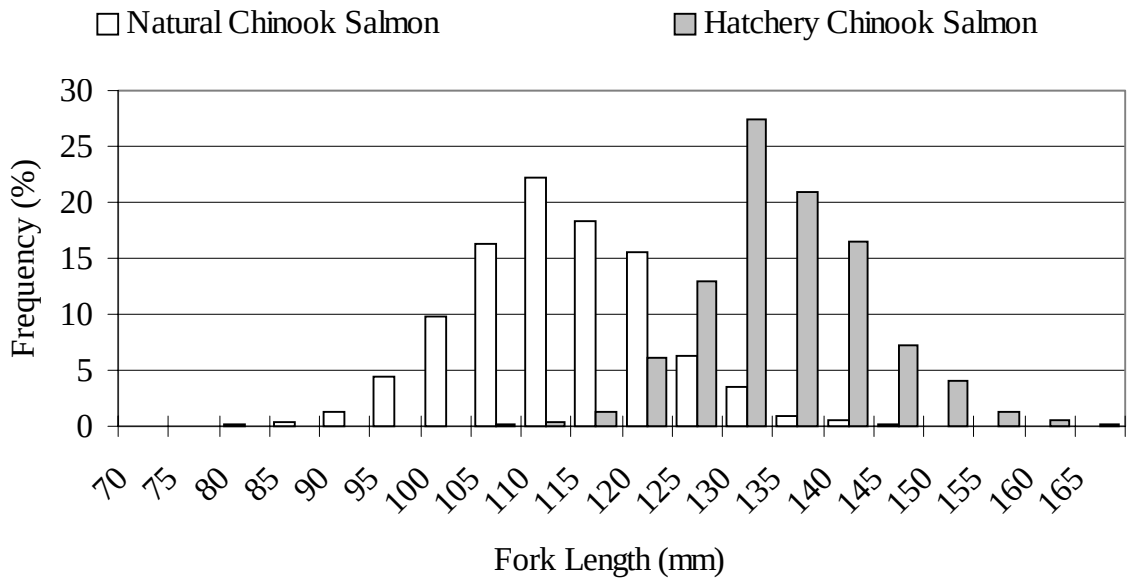

Figure 10. Length frequency distribution of natural and hatchery chinook salmon captured in the lower Imnaha River trap, from February 26 to June 15, 2000.

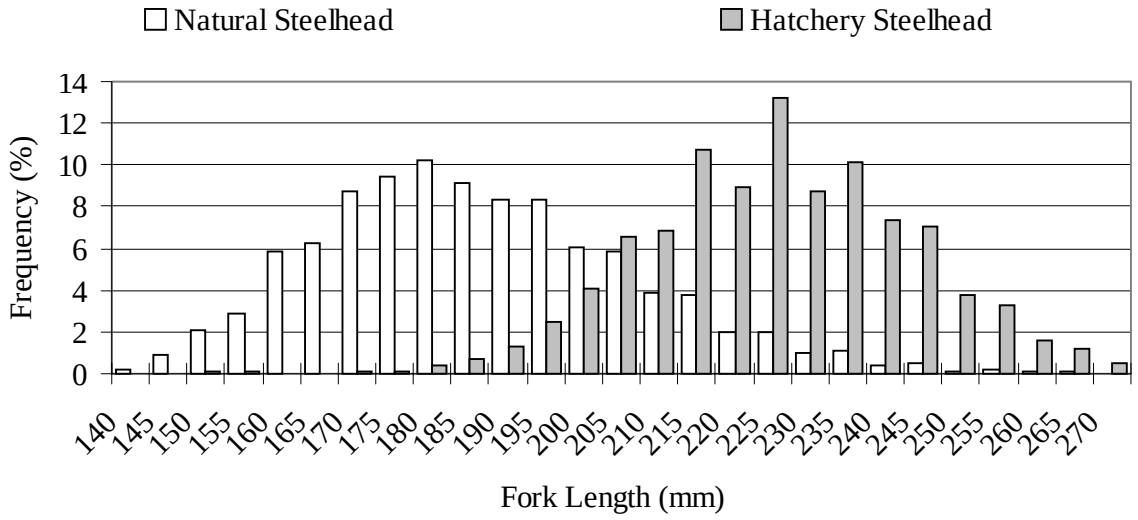

Figure 11. Length frequency distribution of natural and hatchery steelhead captured in the lower Imnaha River trap, from February 26 to June 15, 2000.

Survival of PIT Tagged Smolts

Hatchery Chinook Salmon Post Release Survival

The post release survival of PIT tagged hatchery chinook released from the acclimation facility to the lower trap was 94.7% (95% C.I. ± 4.7%). Post release survival of hatchery chinook salmon smolts, in the 66 km stream reach from the acclimation facility to the lower trap site, has been estimated since 1994 (Figure 12). Smolt release practices were changed from acclimation or direct stream releases, to volitional releases in 1999. Although smolts are released volitionally, the Imnaha River chinook salmon acclimation facility was not designed or constructed for volitional releases. Smolts are volitionally released by removing the screen at the end of a raceway that is designed as a holding pond for adult fish. Water in the raceway spills over the top of dam boards placed at the end of the raceway and down into the adult fish ladder. Smolts must swim over the top of the dam boards, down the adult fish ladder, and into the Imnaha River, to move out of the concrete acclimation facility. Estimated smolt survival in the 67 rkm stream reach has ranged from 88.4% to 95% from 1995 to 1998 when smolt acclimation and forced release methods were utilized. Estimated post release survival of volitionally released smolts ranged from 93.7% to 94.7% in 1999 and 2000. No clear improvement in post release survival has been observed between forced release and volitional released smolts within the Imnaha River; although volitional release survival estimates have been consistent at 93.7% to 94.7%.

The 2000 Cormack Jolly-Seber survival estimate would imply that 170,191 (95% C.I. ± 8,447) hatchery chinook salmon passed by the lower Imnaha River trap during the spring of 2000. We used SURPH to estimate the population of hatchery chinook migrating past the Imnaha River trap instead of the Bootstrap method used in Ashe et al. (1995) because SURPH has produced more accurate and reasonable results since 1995.

Trap efficiencies and the percentage of PIT tags interrogated vary annually (Figure 13). Trap efficiencies have ranged from 11.6 % in 1996 to 45.9% in 1997 while PIT tag interrogations have ranged from 4.5% in 1999 (Cleary et al. 2002) to 19.6% in 1997 (Blenden et al. 1998). Annual variation in trap efficiency estimates may be due to annual flow and temperature conditions, and operation of the trap. PIT tag interrogation have an additional variable of mortality in the 67 rkm reach between the acclimation facility and the lower trap. Although we attempt to be consistent each year, mechanical breakdowns have rendered the trap inoperable for periods of time each spring. During inoperable time periods we can not quantify the number of migrating chinook salmon or accurately estimate migrating populations using the Bootstrap method. However, observations of unobserved PIT tagged hatchery chinook salmon at Snake and Columbia river interrogation sites allow us to accurately estimate post release survival to the trap using SURPH. Bootstrap estimates and trap efficiencies for 1994 to 2000 are presented and discussed in Appendix D.

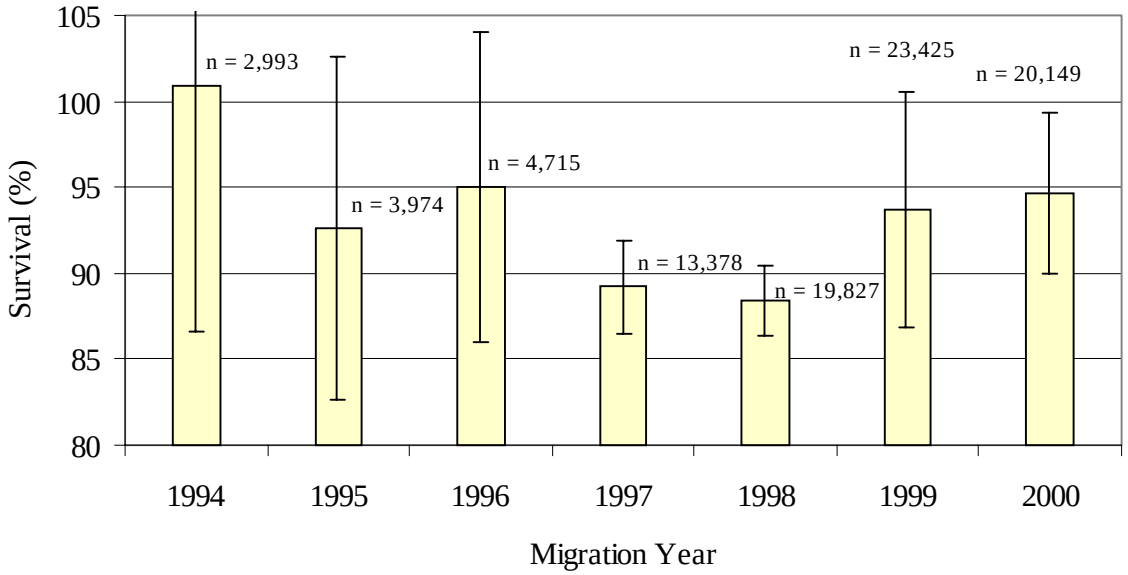

Figure 12. Annual survival of hatchery chinook salmon from the Imnaha River acclimation facility to the lower Imnaha River trap from 1994 to 2000. The size of annual PIT tag release groups are shown above for each year and error bars indicate the 95% C.I..

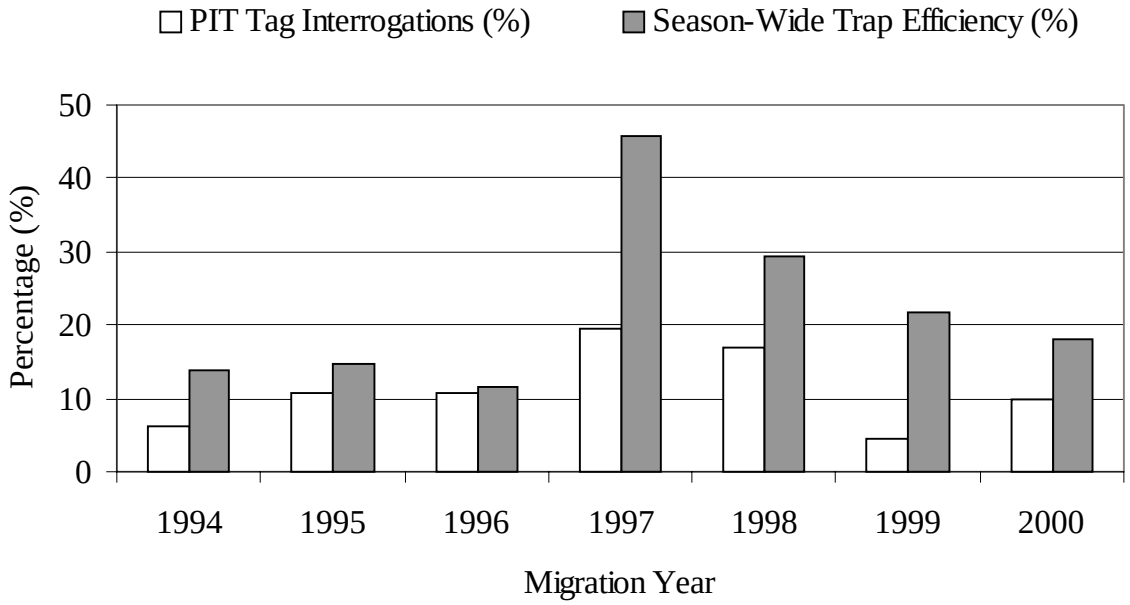

Figure 13. The percentage of hatchery chinook salmon PIT tags interrogated each year and the annual season-wide trap efficiency estimated from mark-recapture experiments at the lower Imnaha River trap from 1994 to 2000.

Estimated Season-Wide Smolt Survival

The season-wide survival of pre-smolt chinook salmon PIT tagged in the fall at the upper trap to LGR was 29.6% with 95% confidence intervals of ±2.8% (Figure 14). Fish tagged during the same period at the lower trap had a higher season-wide survival to LGR of 36.8% with a ±2.9% 95% confidence interval. Survival estimates of fall tagged chinook salmon from the upper trap to LGR have ranged from 22.4% (1994) to 45.9% (1998) for migration years 1994 to 2000. The lower trap survival estimates for fall tagged fish have ranged from 25.6% (1995) to 60.4% (1998) from migration years 1994 to 2000 (Cleary et. al 2000, and Cleary et. al 2002).

The lowest survival estimate for fish released at the upper trap to LGR was 22.4% and occurred in migration year 1994 and the highest survival estimate to LGR was 45.9% and occurred in migration year 1998. No sampling occurred at the upper site in migration year 1995 or 1997. The lower trap operated each fall from 1993 to 1999. The lowest survival estimate (25.6%) for natural chinook salmon pre-smolts tagged in the fall at the lower trap occurred in migration year 1995 and the highest survival estimate (60.4%) to LGR occurred in migration year 1998. Survival between the upper and lower site had differed from 5.9% in migration year 1996 to 16.9% in migration year 1999. Survival between the upper and lower trap in 2000 differed by 7.2%.

The season-wide release of 4,368 natural chinook salmon during the spring at the lower trap resulted in a survival estimate of 84.8% at LGR (95% C.I. ± 2.6%). The same release group had an estimated survival of 73.2% from the trap to LMO and 67.9% from the trap to MCN (Table 9). The 2,817 hatchery chinook salmon that were released at the trap during the spring had lower survival estimates at LGR (75.0%), LMO (54.9 %), and MCN (54.1%). Natural steelhead were estimated to have a survival estimate of 84.4% (± 2.7 95% C.I.) from the trap to LGR. The season-wide estimate for natural steelhead was not noticeably different from the 85.8% (± 2.4 95% C.I.) survival estimate for hatchery steelhead.

Season-wide survival from the trap to LGR fell within the range of past season-wide estimates for natural chinook salmon, hatchery chinook salmon, and natural steelhead. Natural chinook salmon survival estimates since 1993 have ranged from 76.2% in 1994 to 90.9% in 1995 (Figure 15). Since 1994 survival estimates from the lower trap to LGR for hatchery chinook salmon have ranged from 67.1% (± 10.2%) in 1994 to 80.4% in 1997 (Figure 16).

Natural steelhead survival estimates have ranged from 83.7% in 1995 to 90.1% in 1997 (Figure 17). Hatchery steelhead survival from the trap to LGR increased for the fifth consecutive year. The lowest season-wide survival estimate from the trap to LGR for hatchery steelhead was 64.6% and it occurred in 1996 (Figure 18).

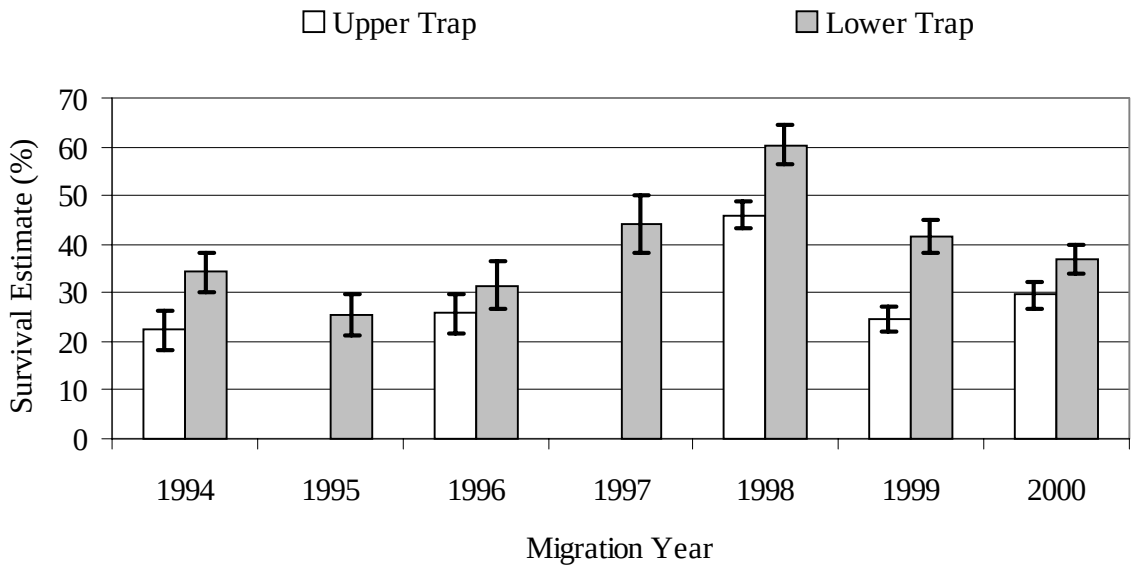

Figure 14. The annual survival of natural chinook salmon, PIT tagged in the fall and released at the upper and lower Imnaha River traps, to Lower Granite Dam, from 1993 to 1999, with 95% confidence intervals.

Table 9. Estimated survival probabilities for season-wide PIT tag release groups of natural and hatchery chinook salmon smolts released from the lower Imnaha River trap from February 26 to June 15, 2000 with 95% confidence intervals in parentheses. Abbreviations: LGR -Lower Granite Dam, LGO - Little Goose Dam, LMO - Lower Monumental Dam, MCN -McNary Dam.

Release Group	Number Released	Trap to LGR (%)	LGR to LGO (%)	LGO to LMO (%)	LMO to MCN (%)	Trap to LMO (%)	Trap to MCN (%)
Natural Chinook Salmon							
	4,368	84.8 (2.6)	92.4 (3.7)	93.4 (6.1)	92.7 (10.0)	73.2 (4.3)	67.9 (6.3)
Hatchery Chinook Salmon							
	2,817	75.0 (4.2)	81.5 (6.9)	89.8 (13.3)	98.6 (22.0)	54.9 (7.5)	54.1 (9.7)
Natural Steelhead							
	4,728	84.4 (2.7)	71.6 (4.7)	84.2 (8.8)	98.1 (25.4)	50.9 (4.7)	49.9 (12.2)
Hatchery Steelhead							
	5,846	85.8 (2.4)	79.4 (7.3)	84.8 (13.7)	69.7 (23.5)	57.8 (7.8)	40.2 (12.5)

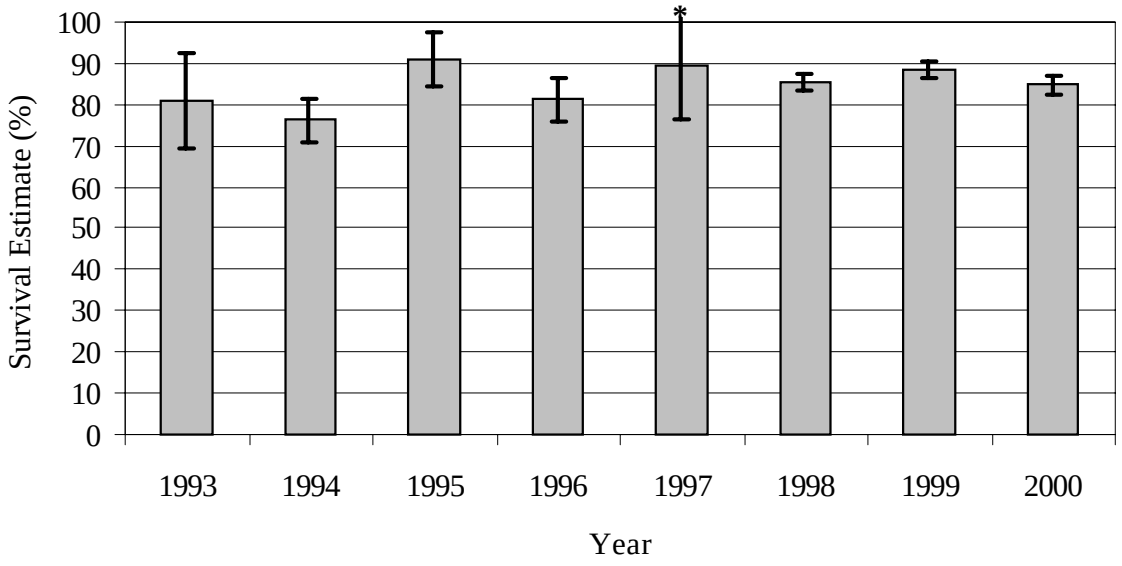

Figure 15. Season-wide survival estimates for natural chinook salmon released from the lower Imnaha River trap to Lower Granite Dam, from 1993 to 2000. Error bars indicate 95% confidence limits. The asterisk indicates upper confidence limit exceeds 100%.

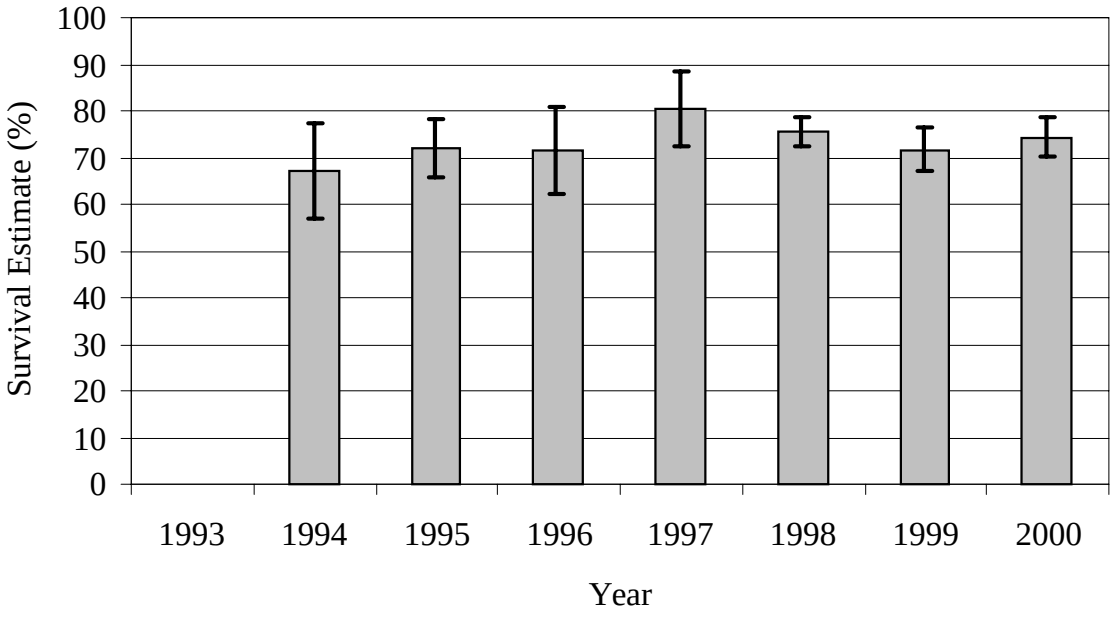

Figure 16. Season-wide survival estimates for hatchery chinook salmon released from the lower Imnaha River trap to Lower Granite Dam, from 1994 to 2000. Error bars indicate 95% confidence limits.

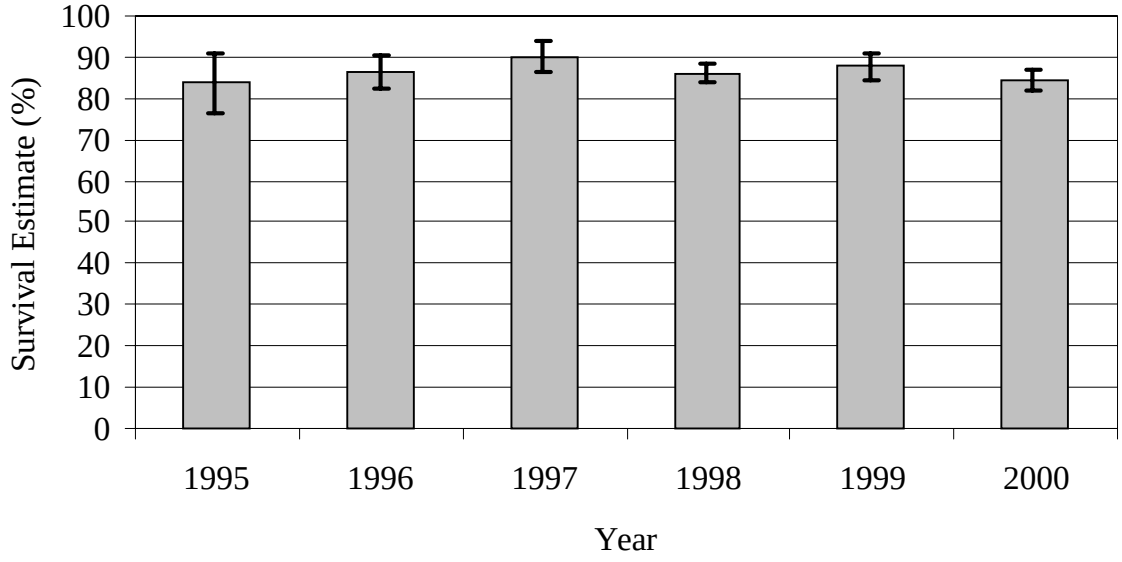

Figure 17. Season-wide survival estimates for natural steelhead released from the lower Imnaha River trap to Lower Granite Dam, from 1995 to 2000. Error bars indicate 95% confidence limits.

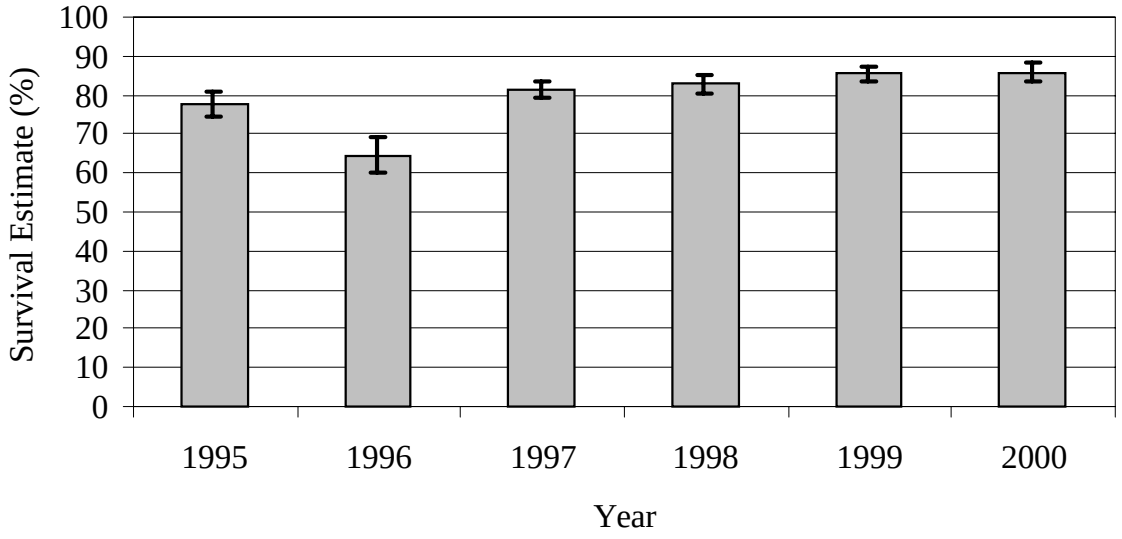

Figure 18. Season-wide survival estimates for hatchery steelhead released from the lower Imnaha River trap to Lower Granite Dam, from 1995 to 2000. Error bars indicate 95% confidence limits.

Estimated season-wide survival of natural chinook salmon from the trap to LMO for fish released in the spring has ranged from a low of 73.2% in 2000 to a high of 78.3% in 1999 (Table 10). The lowest survival estimate (54.9%) for hatchery chinook salmon from release to LMO was also noted in 2000. The lowest survival estimates for natural and hatchery steelhead from 1997 to 2000 was 50.9% for natural steelhead and 57.8% for hatchery steelhead. Both low estimates for steelhead occurred in 2000. The highest estimates of season-wide survival from the trap to LMO for natural and hatchery steelhead was 75.1% for natural steelhead (1999), and 73.9% for hatchery steelhead (1999).

Table 10. Season-wide estimates of survival from the lower Imnaha River trap to Lower Monumental Dam from 1997 to 2000. Ninety-five percent confidence intervals are shown in parentheses.

Migration Year	Natural Chinook Salmon Survival (%)	Hatchery Chinook Salmon Survival (%)	Natural Steelhead Survival (%)	Hatchery Steelhead Survival (%)
1997			73.0 (12.0)	64.0 (6.5)
1998	75.3 (4.7)	64.5 (6.7)	67.0 (5.7)	63.2 (4.9)
1999	78.3 (2.4)	61.1 (5.9)	75.1 (4.6)	73.9 (3.3)
2000	73.2 (4.3)	54.9 (7.5)	50.9 (4.7)	57.8 (7.8)

Estimated Weekly Smolt Survival

Estimated survival of natural chinook salmon weekly PIT tag release groups from the Imnaha River lower trap to LGR ranged from 78.9% to 89.2% from the week of March 19 to the week of April 23 (Table 11). No trend was apparent in survival over the six week period that natural chinook salmon smolts were released. The estimated season wide survival for natural chinook smolts to LGR of 84.8% (Table 9), fell within the range and confidence intervals of the weekly release groups survival estimates. Hatchery chinook salmon weekly survival ranged from 64.1% to 83.8% from the week of March 19 to the week of April 16. Weekly estimates slightly increased from the week of March 10 to the week of April 9 but confidence intervals overlapped from week to week. The confidence intervals around the season wide estimate for hatchery chinook salmon presented in Table 11 encompassed all the range of weekly survival estimates for hatchery chinook salmon.

Survival for release groups of natural steelhead from the week of April 16 to the week of May 21 ranged from 95.0% during the week of April 16 to 72.9% during the week of May 7. The survival estimates to LGR for natural steelhead released during the weeks of April 16 and May 7 were outside of the season wide 95% confidence limits of 81.7% to 87.1% for natural steelhead. Weekly release groups of hatchery steelhead had estimated survivals ranging from

81.1% from the week of May 14 to 92.6% for the week of May 21. Confidence intervals for season wide and weekly estimates overlapped for all weekly release groups of hatchery steelhead.

Table 11. Estimated survival probabilities for weekly PIT tagged release groups of natural and hatchery chinook salmon and steelhead smolts released from the lower Imnaha River trap to Lower Granite Dam from February 26 to June 15, 2000 with 95% confidence limits in parentheses.

Species and Rearing	Week of Release	Number Released	Trap to LGR (95% C.I.)
Natural Chinook Salmon			
	19-Mar	324	78.9 (8.1)
	26-Mar	1,632	88.0 (4.0)
	2-Apr	594	86.7 (5.4)
	9-Apr	246	80.1 (8.7)
	16-Apr	243	89.2 (11.9)
	23-Apr	434	84.5 (8.6)
Hatchery Chinook Salmon			
	19-Mar	594	64.1 (7.4)
	26-Mar	451	71.9 (7.7)
	2-Apr	593	78.8 (9.0)
	9-Apr	369	83.8 (13.7)
	16-Apr	409	78.4 (10.5)
Natural Steelhead			
	16-Apr	419	95.0 (5.8)
	23-Apr	662	87.6 (5.0)
	30-Apr	1,178	87.4 (5.2)
	7-May	621	72.9 (8.6)
	14-May	1,020	90.1 (7.7)
	21-May	426	80.4 (11.5)
Hatchery Steelhead			
	16-Apr	1,002	84.7 (4.9)
	23-Apr	999	83.2 (5.7)
	30-Apr	1,044	83.5 (5.4)
	7-May	1,007	88.1 (6.8)
	14-May	963	81.1 (6.0)
	21-May	729	92.6 (7.8)

Arrival Timing at Dams

Natural and Hatchery Chinook Salmon Arrival Timing

Natural chinook salmon were analyzed as three separate groups; fish tagged in the fall at the upper site, fish tagged in the fall at the lower site, and fish tagged in the spring at the lower site. It is assumed that fish tagged in the fall at the lower trap overwinter in the Snake River. It is unknown when the fish tagged in the fall at the lower site begin migrating towards LGR. The arrival timing data suggest this group arrives earlier than fish from the upper site or fish tagged in the spring at the lower site. The range of arrival times, median arrival dates, and 90% arrival dates for natural and hatchery chinook salmon and steelhead, from 1992 to 2000 are presented in Appendix E.

Comparison of the three natural chinook salmon PIT tag groups indicated that natural chinook salmon from the lower trap exhibited earlier arrival timing at LGR (Figure 19) and other dams. This group of fish arrived at LGR on April 4. This was two days later than natural chinook salmon tagged in the spring, but four days earlier than the April 8 arrival of natural chinook salmon tagged in the fall at the upper site. Natural chinook salmon tagged in the fall at the lower site had a median arrival time of April 14. This was 17 days earlier than fish tagged in the fall at the upper site (May 1) and 8 days earlier than fish from the lower site (April 22). The 90% arrival timing for natural chinook salmon tagged in the fall at the lower site occurred on April 23, 17 days and 18 days earlier than the natural chinook salmon fall upper tag group, and spring lower tag group, respectively.

The range of arrival dates for natural chinook salmon tagged and released in the fall at the upper site at LGO, LMO, and MCN fell within the range of past observations made in 1994, 1996, and from 1998 to 2000. Natural chinook salmon arrival timing for fall release groups from the lower site at LGO, LMO, and MCN also fell withing the range of past observations made from 1994 to 2000. Median arrival timing for fish tagged and released in the fall at the upper site has ranged from April 24 to May 1 at LGR, April 28 to May 4 at LGO, April 27 to May 7 at LMO, and April 30 to May 17 at MCN. Median arrival timing for fish tagged in the fall at the lower site has ranged from April 13 to April 21 at LGR, April 17 to April 26 at LGO, April 19 to April 29 at LMO, and April 21 to May 8 at MCN. Median arrival timing for the fall upper and lower release groups fell within the range of past observations at LGR, LGO, LMO and MCN. The 90% arrival dates for natural chinook tagged in the fall at the upper and lower sites also fell within the range of past observations with the exception of the arrival of natural chinook salmon from the upper trap at LGO. This 90% arrival date (May 11) was four days earlier than previous observations. The range of 90% arrival timing from 1994, 1996, and 1998 to 2000 for natural chinook salmon tagged in the fall at the upper site is as follows: May 9 to May 17 at LGR, May 11 to May 19 at LGO, May 19 to May 24 at LMO, and May 18 to May 25 at MCN. The range of 90% arrival timing from 1994 to 200 for natural chinook salmon tagged in the fall at the lower site is as follows: April 21 to April 25 at LGR, April 24 to May 2 at LGO, April 25 to May 9 at LMO, and April 28 to May 18 at MCN.

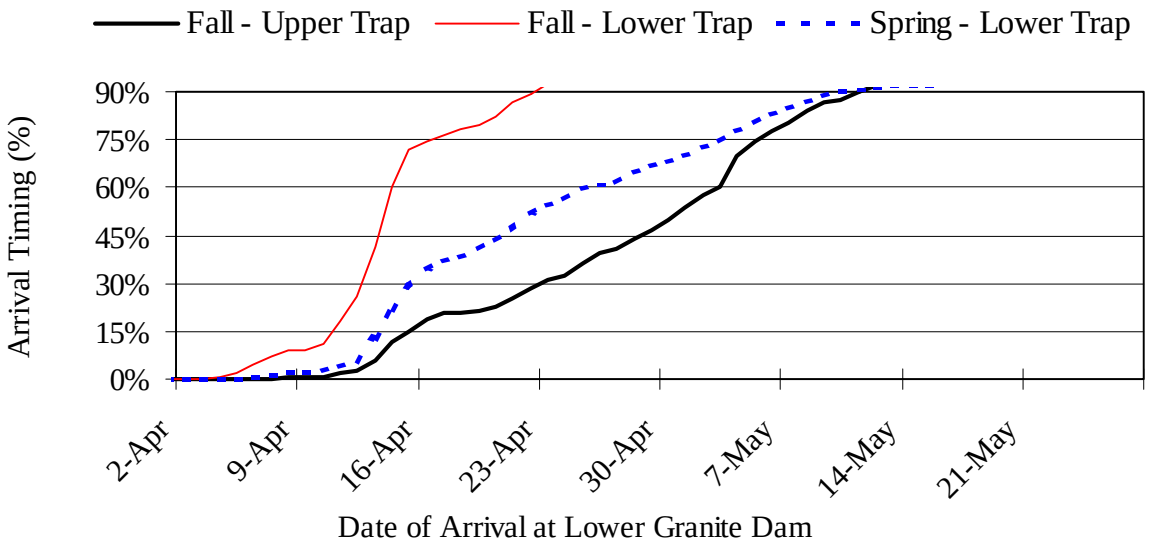

Figure 19. The arrival timing of PIT tagged natural chinook salmon tagged in the fall at the upper and lower sites, and tagged in the spring at the lower site at Lower Granite Dam for the 2000 migration year.

Natural chinook salmon tagged in the spring at the lower site first arrived at LGR on April 2 and the last observation was made on August 8, 2000. The median and 90% arrival dates for spring emigrating smolts at LGR was April 22 and May 11, respectively. Median arrival dates at LGR for Imnaha River natural chinook salmon have ranged from April 22 to May 4 from 1993 to 2000. The 90% arrival timing at LGR has ranged over a 16 day period from May 6 to May 22 over the same time period. Arrival timing at LGO occurred from April 11 to July 14, 2000, with median and 90% arrival dates of April 23 to May 7 (1993 to 2000). Arrival timing of Imnaha River chinook salmon smolts at LMO ranged from April 13 to July 12 in the 2000 migration year. The median arrival date at LMO occurred from April 25 to May 10 from 1993 to 2000 and the 90% arrival of the PIT tagged smolts arrived between May 11 and June 4 (1993 to 2000). Arrival timing at MCN in 2000 occurred between April 18 and July 4, with median and 90% arrival timing occurring on May 7 and May 29, respectively.

Hatchery chinook salmon first arrived at LGR on April 7 and were last observed on May 24. This first observation of a hatchery chinook salmon was the earliest this study had observed since 1992. Prior to 2000, arrival timing for hatchery chinook salmon at LGR ranged from April 12 (1992) to June 6 (1992). The median time of arrival for hatchery chinook salmon in 2000 was May 3 and was within the range of past observations of April 21 (1992) to May 12 (1993) from 1993 to 1999. The 90% arrival timing occurred on May 13. Observations of 90% arrival timing at LGR made from 1993 to 2000 have ranged from May 6 (1992) to May 16 (1996).

A hatchery chinook salmon was observed at LGO on April 14, two days earlier than past observations. The last observation of a chinook salmon at LGO occurred on May 24. First arrivals of hatchery chinook salmon at LGO occurred from April 16 (1999) to April 28 (1994) from 1992 to 1999. Median and 90% arrival timing occurred on May 3 and May 13. The range of median arrival dates at LGO from 1992 to 2000 ranged from April 27 to May 14 and the range of 90% arrival dates at LGO from 1992 to 2000 ranged from May 5 (1992) to May 23 (1995). At LMO the first arrival on April 19 was the earliest observed since 1992. Hatchery chinook salmon were last observed on May 26. Arrival timing from 1992 to 1999 ranged from April 23 (1996) to June 10 (1995). Early arrival timing was also observed at MCN where an April 24 arrival was the earliest observed since 1992. Arrival timing at MCN from 1992 to1999 had ranged from April 27 (1992) to June 9 (1995). Earlier arrival at LMO did equate to earlier median arrival timing on May 5; the earliest median arrival timing observed at LMO for hatchery chinook salmon since 1992. The 90% arrival timing at LMO occurred on May 22 and was within the range of 90% arrival timing from 1993 to 1999 of May 15 (1998) to May 26 (1995). Prior to 2000, median arrival ranged from May 8 (1998) to May 26 (1995). The early arrival of a hatchery chinook salmon at MCN did not equate to early median arrival. Median arrival at MCN was observed on May 13. Median arrival at MCN from 1992 to 2000 has ranged from May 8 (1992) to May 21 (1994). The 90% arrival timing on May 27 at MCN occurred three days later than observations of 90% arrival timing made from 1992 to 1999. The earliest observation of 90% arrival timing at MCN occurred on May 17 (1992).

The earlier median arrival timing of natural and hatchery chinook salmon at LMO accompanied season-wide survival estimates from the trap to LMO of 73.2 (95% C.I. of ± 4.3%) for natural chinook salmon and 54.9% (95% C.I. of ± 7.5%) for hatchery chinook salmon (Table 10). Confidence intervals for these estimates are within the range of past estimates obtained in 1998 and 1999.

Natural and Hatchery Steelhead Arrival Timing

The first arrival of natural steelhead at LGR occurred on April 6 and the last arrival occurred on August 3. The range of observations from 1993 to 2000 has been from April 2 (1998) to August 20 (1994). Median and 90% arrival dates, of May 8 and May 25 respectively, for natural steelhead at LGR also fell within the range of past observations from 1993 to 2000 of May 2 (1995) to May 26 (1993) for median arrival timing, and May 9 (1995) to June 8 (1993) for 90% arrival timing at LGR. The range of arrival for the 2000 migration at LGO occurred from April 11 to June 26. Median and 90% arrival at LGO occurred on May 8 and May 29 respectively. Historically, the past ranges of arrival times from 1993 to 2000 have been observed: range of arrivals from April 8 (1999) to July 29 (1994), median arrival from May 7 (1995) to May 24 (1993), and 90% arrival from May 12 (1995) to June 7 (1993). At LMO the earliest and latest arrival since 1993 of a natural steelhead from the Imnaha River was observed on April 12 and August 12. Prior to the 2000 migration year, the range of arrival dates for natural steelhead at LMO was April 16 (1998) to August 8 (1994). The median arrival time of May 14, and the 90% arrival time of May 30 was within the range of past median arrival

observations of May 9 (1995) to May 30 (1993) and past 90% arrival observations of May 14 (1995) to July 10 (1994). An earlier than usual natural steelhead arrival at MCN was observed on April 15, two days earlier than previous observations made since 1993. The last observation of a natural steelhead at MCN occurred on June 16, 9 days earlier than the latest observation made in 1994. The median arrival timing of natural steelhead at MCN on May 24 was within past observations of median arrival timing of May 7 (1998) to May 25 (1993, 1999). Ninety percent arrival timing at MCN was also within the past range of observations of 90% arrival timing at MCN of May 17 (1995) to June 9 (1994).

Arrivals of PIT tagged hatchery steelhead occurred earlier than previously observed with hatchery steelhead being observed during the following times at the following dams: LGR - April 8 to July 24, LGO - April 13 to July 22, LMO - April 16 to August 18. The range of arrivals from 1993 to 1999 occurred from April 18 (1999) to August 21 (1994) at LGR, April 20 (1999) to August 23 (1997) at LGO, and April 21 (1999) to August 24 (1994) at LMO. At MCN, 2000 migration year arrivals of hatchery steelhead from May 3 to July 30 fit into the past range of arrival observations (1993 to 1999) from April 23 (1997) to August 12 (1997). The median arrival time of May 16 at LGR was within the range of past observations from 1993 to 1999 of May 15 (1998) to May 31 (1995). Median arrival timing at LGO (May 22) and LMO (May 25) were earlier than the range of past median observations of May 25 (1994, 1996, 1999) to June 3 (1995) at LGO, and May 26 (1993, 1998, 1999) to June 18 (1994) at LMO. But at MCN the median arrival on July 2 was the latest observed since 1993. The past range of observed 90% arrival timing at MCN from 1993 to 1999 for hatchery steelhead has been from May 19 (1993) to June 17 (1994). The 90% arrival timing at LGR, LGO, and LMO occurred on May 25, July 1, and July 3. The 90% arrival timing range at these sites from 1993 to 2000 is as follows: May 26 (1998) to July 15 (1994) at LGR, May 30 (1998) to July 17 (1994) at LGO, and June 3 (1998) to July 21 (1994) at LMO. The 90% hatchery steelhead arrival timing at MCN on July 17 was the latest 90% arrival time observed since 1993. The past range of 90% arrival times of hatchery steelhead at MCN was from May 30 (1993) to July 10 (1994).

Natural steelhead arrived earlier than usual at LMO and MCN and their survival from the trap to LMO (50.9% ± 4.7%) was outside of the range of past estimates obtained for 1997 to 2000 (Table 10). Hatchery steelhead had earlier median arrival timing at LGR, LGO, and MCN and their survival from the trap to LMO was low (57.8% ± 7.8%), but still within the confidence intervals obtained for 1997 and 1998 (Table 10).

Smolt Arrival Frequencies and Spill at Dams

The arrival timing range, median arrival, and 90% arrival timing at LGR, LGO, LMO, and MCN was presented in the previous section and in Appendix E, but the arrival of smolts at dams has not been discussed in relation to the spill that occurred at LGR, LGO, LMO, and MCN. Continuous spill began at LGR, LGO, and LMO on April 5, April 10, and April 4, respectively, and ended June 20 at all Snake River dams. The spill at MCN began on April 4 and lasted until June 24. Spill at LGR, LGO, LMO, and MCN encompassed the entire period of observations of Imnaha River PIT tagged fish with a few exceptions. Daily arrival frequencies of less than 1% occurred for spring tagged natural chinook salmon at LGR after June 20. Daily arrival frequencies of less than 1% for natural steelhead occurred at LGO and LMO after June 20. And daily arrival frequencies of 1% occurred at LMO on June 27 and 28.

Fall tagged natural chinook salmon from the upper trap had a May 10 90% arrival time at LGR that occurred during a spill of 20.1 kcfs (Figure 20). The 90% arrival time that occurred at LGO on May 11 coincided with a spill of 24.3 kcfs (Figure 21). Daily arrival frequencies never exceeded 6% and our sample size (n = 128) may not be sufficient to accurately represent daily arrival frequency, but we decided to include this data to allow readers to compare the arrival of natural chinook salmon tagged in the fall at the upper site and lower site, and during the spring at the lower site. Natural chinook salmon tagged in the fall at the lower site had a 90% arrival time at LGR of April 23 during a spill of 49.7 kcfs and the largest movement (19%) occurred on April 14 during a spill of 25.0 kcfs (Figure 22). The 90% arrival at LGO for natural chinook salmon tagged in the fall at the lower site occurred during a spill of 30.7 kcfs on April 24 (Figure 23).

Natural chinook salmon tagged in the spring at the lower site had the same 90% arrival time at LGR and LGO (May 11). The spill at LGR was 20.4 kcfs and the spill at LGO was 24.3 kcfs (Figures 24 and 25). The 90% arrival time at LMO occurred one day later during a spill of 24.2 kcfs (Figure 26). At MCN, the 90% arrival timing didn't occur until May 29 but it was accompanied by a spill of 60.5 kcfs (Figure 27).

Detections of hatchery chinook salmon were only sufficient to estimate daily arrival frequencies at LGR and LGO. The first arrival of a hatchery chinook salmon at LGR in 2000 (and the earliest since 1992) happened on April 7 during a spill of 15.1 kcfs. Daily arrival frequencies greater than 1% at LGR occurred intermittently from April 11 during a spill of 20.1 kcfs to May 22 during spill of 22.0 kcfs. A spill of 18.6 kcfs occurred on May 13 when 90% of hatchery chinook salmon arrived at LGR (Figure 28). At LGO the first Imnaha River hatchery chinook salmon arrived on April 14 during a spill of 16.1 kcfs and 90% arrived during a spill of 27.4 kcfs on May 13 (Figure 29).

There were sufficient detections of natural and hatchery steelhead at LGR, LGO, and LMO to estimate daily arrival frequencies. Daily arrival frequencies for natural steelhead ranged from 0% to 2% at LGR during the month of April (Figure 30). Ninety percent arrival at LGR occurred on May 25 during a spill of 21.6 kcfs and on May 29 at LGO during a spill of 22.2 kcfs (Figure 31). A larger spill of 38.8 kcfs on May 30 at LMO coincided with the 90% arrival of

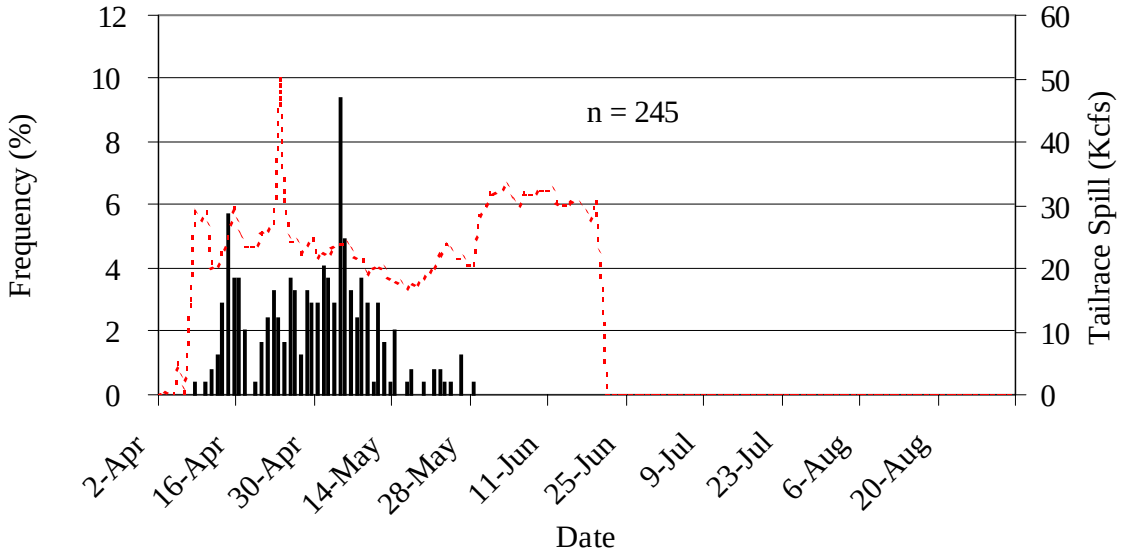

Figure 20. The daily arrival frequency of natural chinook salmon, tagged at the upper Imnaha River trap during the fall, at Lower Granite Dam in 2000.

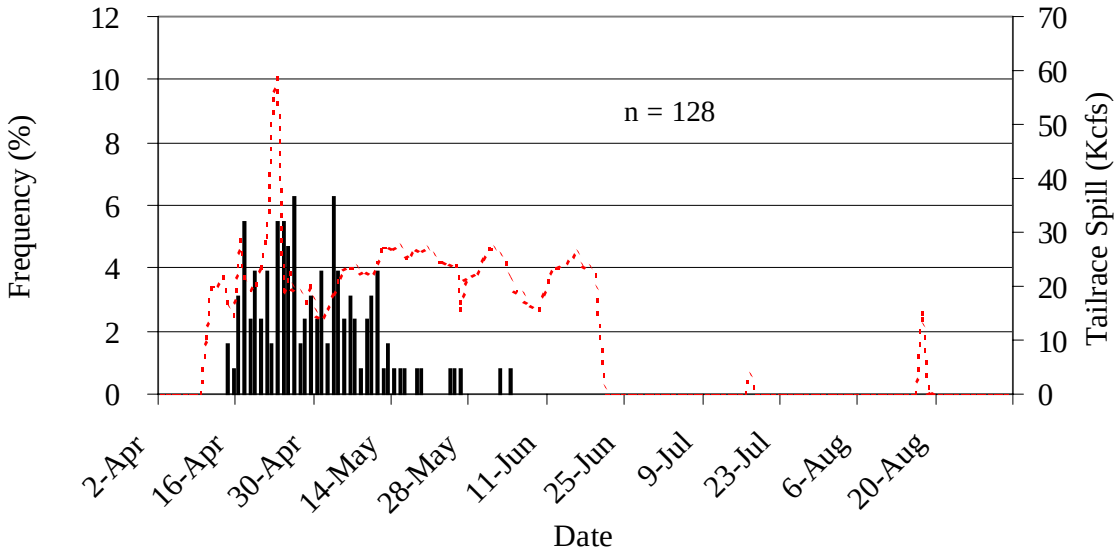

Figure 21. The daily arrival frequency of natural chinook salmon, tagged at the upper Imnaha River trap during the fall, at Little Goose Dam in 2000.

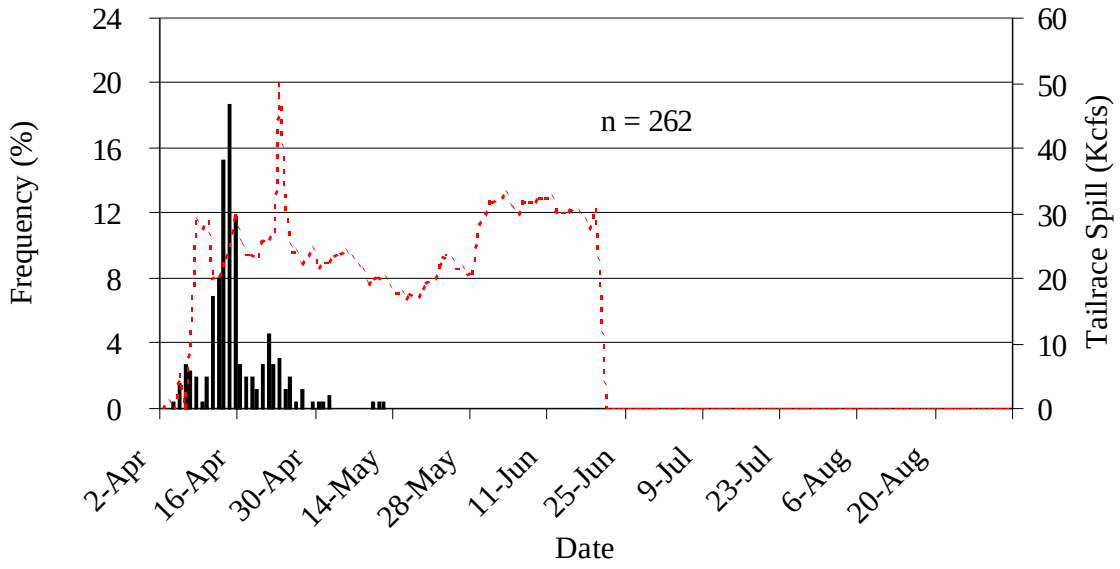

Figure 22. The daily arrival frequency of natural chinook salmon, tagged at the lower Imnaha River trap during the fall, at Lower Granite Dam in 2000.

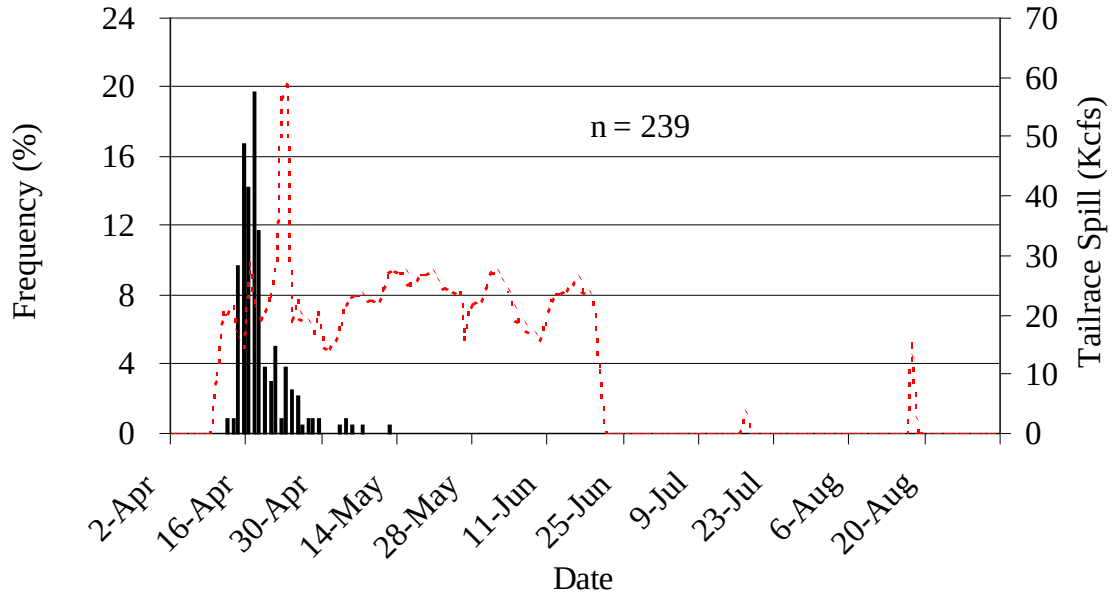

Figure 23. The daily arrival frequency of natural chinook salmon, tagged at the lower Imnaha River trap during the fall, at Little Goose Dam in 2000.

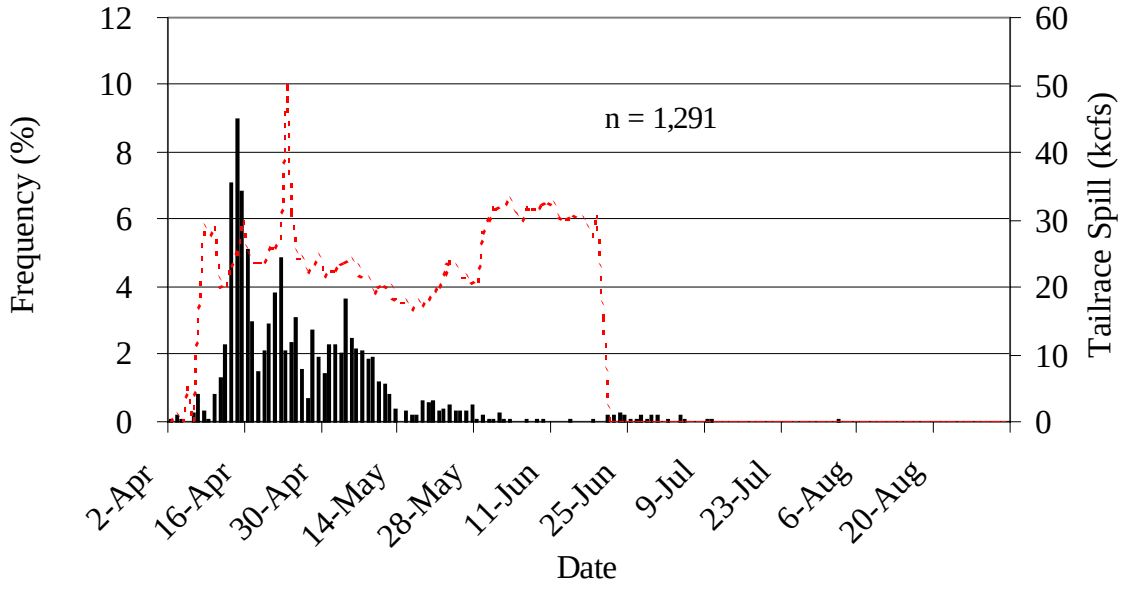

Figure 24. The daily arrival frequency of natural chinook salmon, tagged at the lower Imnaha River trap during the spring, at Lower Granite Dam in 2000.

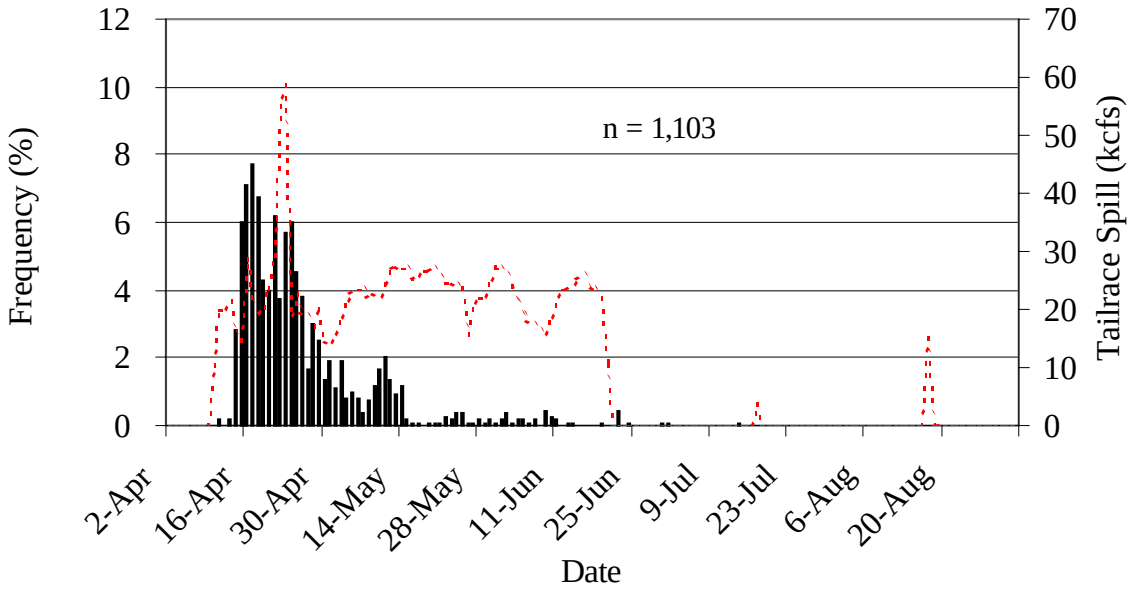

Figure 25. The daily arrival frequency of natural chinook salmon, tagged at the lower Imnaha River trap during the spring, at Little Goose Dam in 2000.

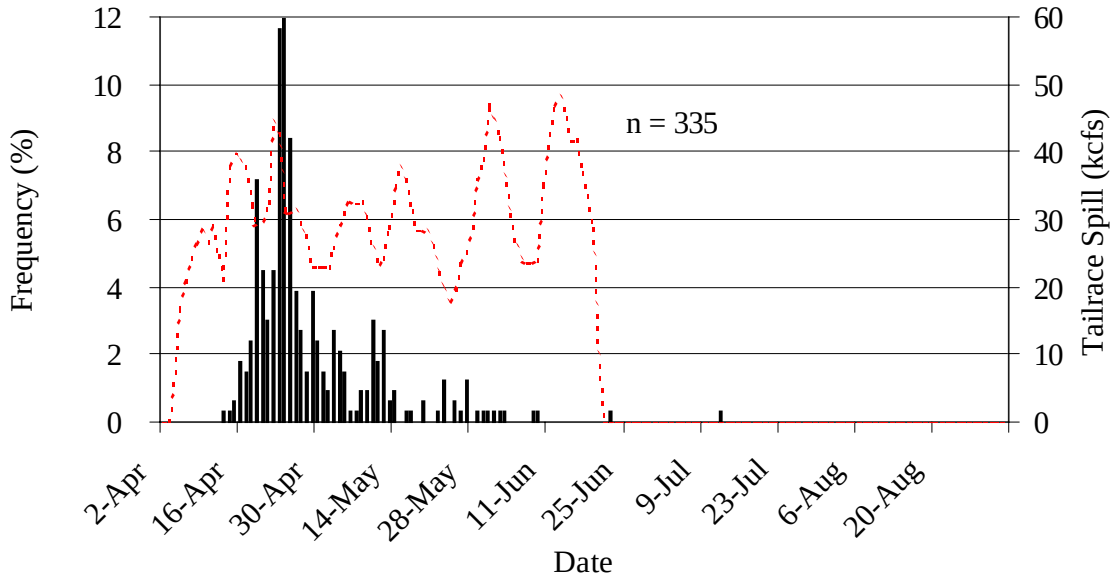

Figure 26. The daily arrival frequency of natural chinook salmon, tagged at the lower Imnaha River trap during the spring, at Lower Monumental Dam in 2000.

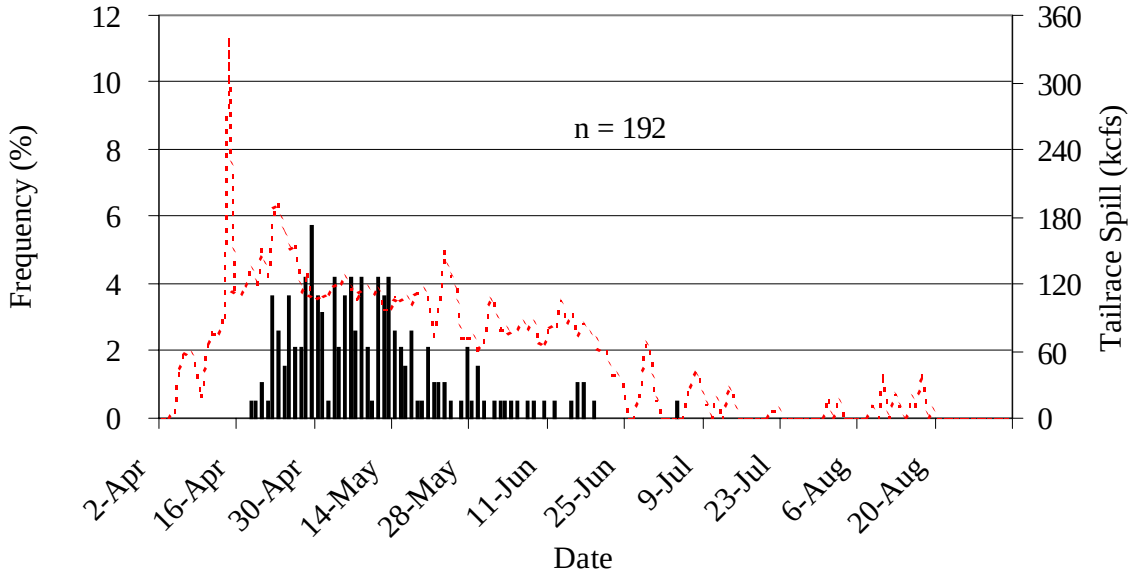

Figure 27. The daily arrival frequency of natural chinook salmon, tagged at the lower Imnaha River trap during the spring, at McNary Dam in 2000.

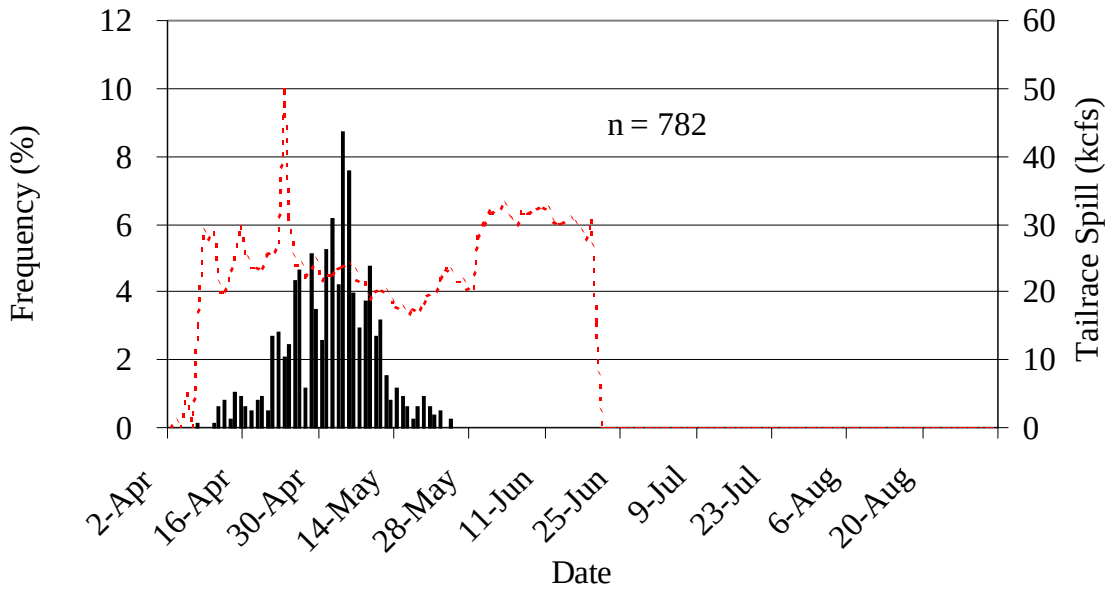

Figure 28. The daily arrival frequency of hatchery chinook salmon, tagged at the lower Imnaha River trap during the spring, at Lower Granite Dam in 2000.

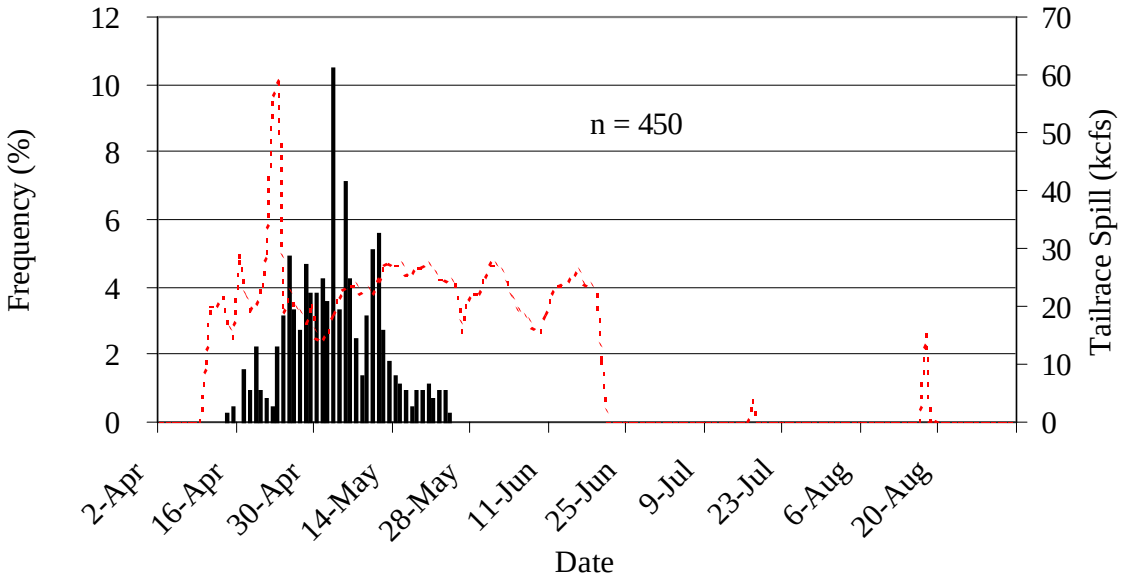

Figure 29. The daily arrival frequency of hatchery chinook salmon, tagged at the lower Imnaha River trap during the spring, at Little Goose Dam in 2000.

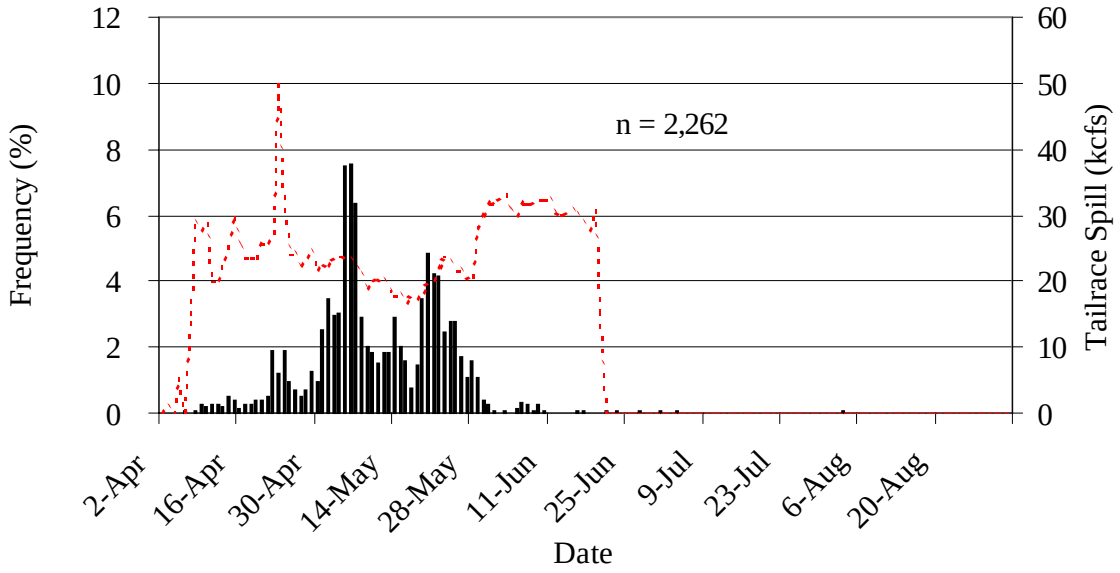

Figure 30. The daily arrival frequency of natural steelhead, tagged at the lower Imnaha River trap during the spring, at Lower Granite Dam in 2000.

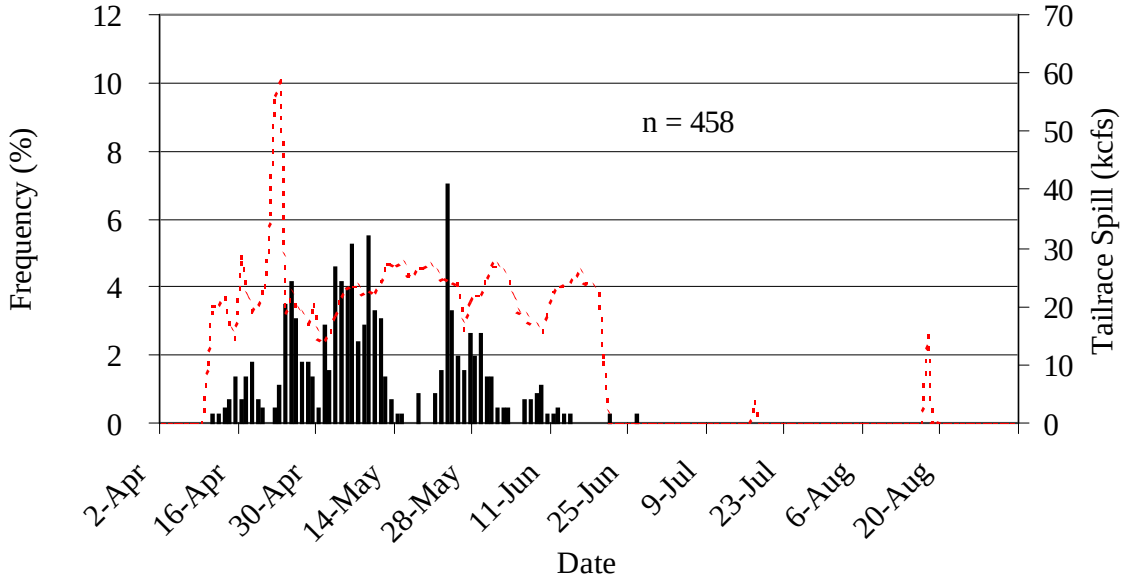

Figure 31. The daily arrival frequency of natural steelhead, tagged at the lower Imnaha River trap during the spring, at Little Goose Dam in 2000.

natural steelhead (Figure 32). The first arrival of an Imnaha River natural steelhead at LMO during a spill of 24.4 kcfs on April 12. The last observation of an Imnaha River natural steelhead at LMO occurred on August 12 when no spill was occurring. As stated in the previous section, this was the latest observation of a natural steelhead from the Imnaha River at LMO since 1992.

Hatchery steelhead daily arrival frequencies at LGR ranged from 0% to 8% during the period of spill and did not increase above 2% until May 5 with a spill of 24.0 kcfs (Figure 33). The first, and earliest arrival since 1992, of an Imnaha River hatchery chinook salmon at LGR occurred on April 8 during a spill of 29.0 kcfs and the 90% arrival timing at LGR occurred on May 25 during a spill of 21.6 kfcs. Downstream at LGO, a spill of 21.4 kcfs occurred on April 13 when the first Imnaha River hatchery steelhead arrived (Figure 34). The earlier median arrival time at LGO on May 22 accompanied a spill of 24.5 kcfs and the 90% arrival time coincided with a spill of 27.1% on July 1. Further downstream at LMO, a spill of 38.5 kcfs occurred when the first hatchery steelhead was detected. The median arrival time on May 25 coincided with a spill of 19.6 kcfs and the July 3 90% arrival time occurred during a spill of 35.1 kcfs (Figure 35).

The arrival data for natural and hatchery chinook salmon shows that the majority of the movement past LGR occurred during the month of April and the first week of May, respectively. These fish had the benefit of the higher than average flows in the Snake River in April, and spill at Snake River dams. The majority of natural and hatchery chinook salmon (~ 90%) were past LMO before tailrace temperatures increased to 12 °C and above. The earlier arrival timing of natural and hatchery chinook salmon, as compared to natural and hatchery steelhead, may be a factor in the difference in the survival estimates from the trap to LMO as presented in Table 9.

Spill occurring continuously during the majority of April and all of May at LGR, LGO, and LMO tailraces and remained relatively constant. Outflow remained above 60 kcfs for most of April and May, as shown in Figure 5. Tailrace temperatures at LGR, LGO, and LMO all increased above 12 °C after May 18. There is substantial evidence that increased flow will increase travel time (Raymond 1979, Berggren and Filardo 1993). A faster travel time would decrease exposure to predators.

Travel Time to Lower Granite Dam

The arrival data in Appendix E shows the following numbers of spring tagged fish were detected at LGR for the first time: 1,291 natural chinook salmon, 782 hatchery chinook salmon, 2,262 natural steelhead, and 3,249 hatchery steelhead. Natural chinook salmon PIT tagged from February 26 to June 15, 2000, had weekly mean travel times to LGR ranging from 10 days to 30 days. Weekly mean travel times for hatchery chinook salmon ranged from 13 to 31 days. Natural steelhead weekly mean travel times ranged from 4 to10 days and hatchery steelhead weekly mean travel times ranged from 3 to 19 days (Appendix F).

Weekly mean travel times for natural and hatchery chinook salmon and steelhead all showed a decreasing trend from the weeks of March 12 to May 27. Weekly mean travel times for natural chinook salmon and steelhead were less than weekly mean travel times for hatchery

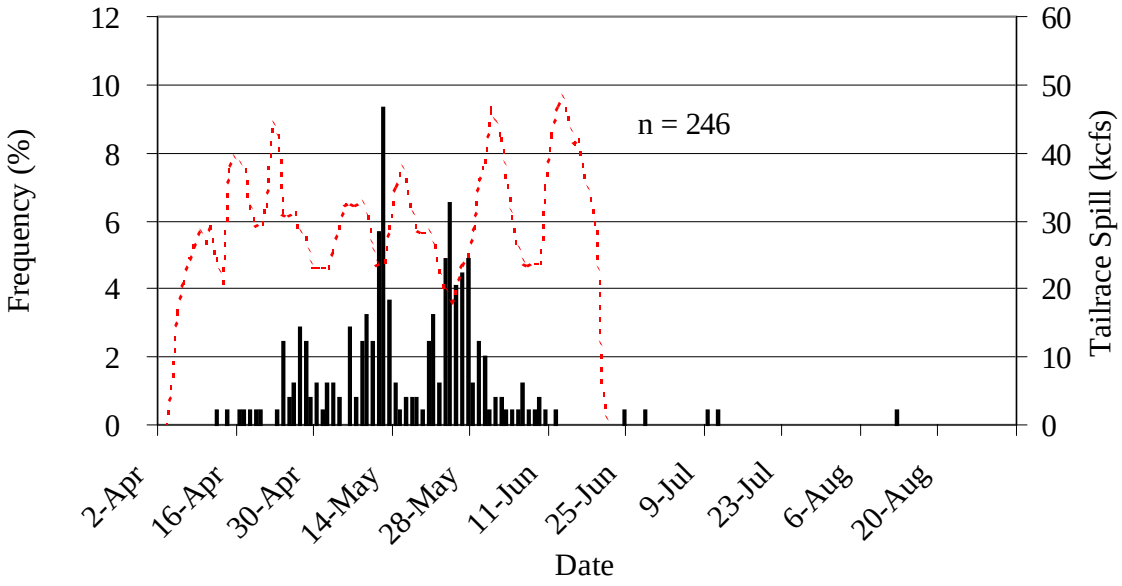

Figure 32. The daily arrival frequency of natural steelhead, tagged at the lower Imnaha River trap during the spring, at Lower Monumental Dam in 2000.

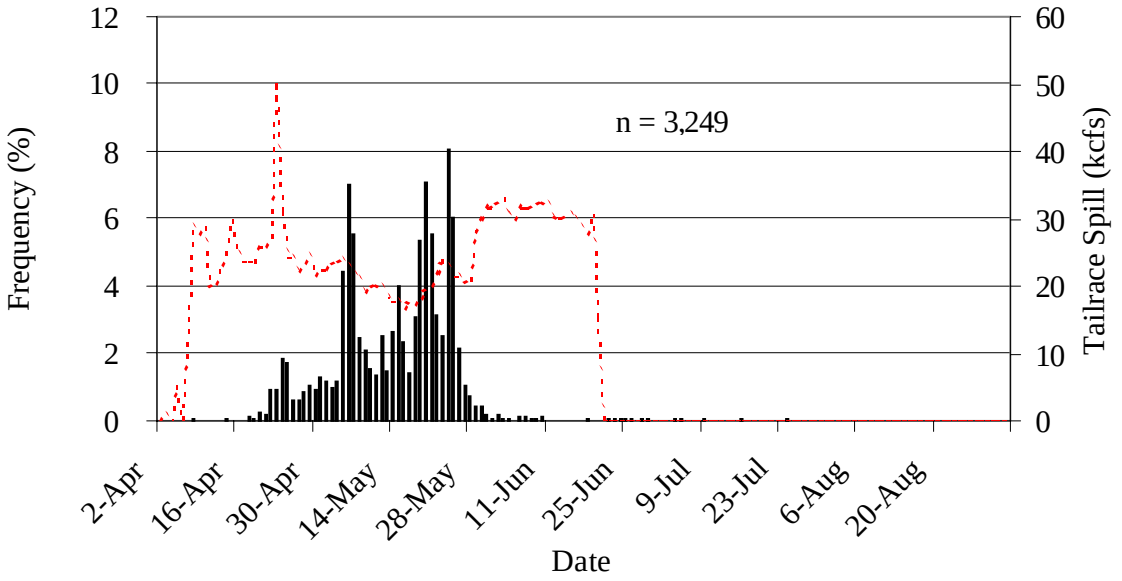

Figure 33. The daily arrival frequency of hatchery steelhead, tagged at the lower Imnaha River trap during the spring, at Lower Granite Dam in 2000.

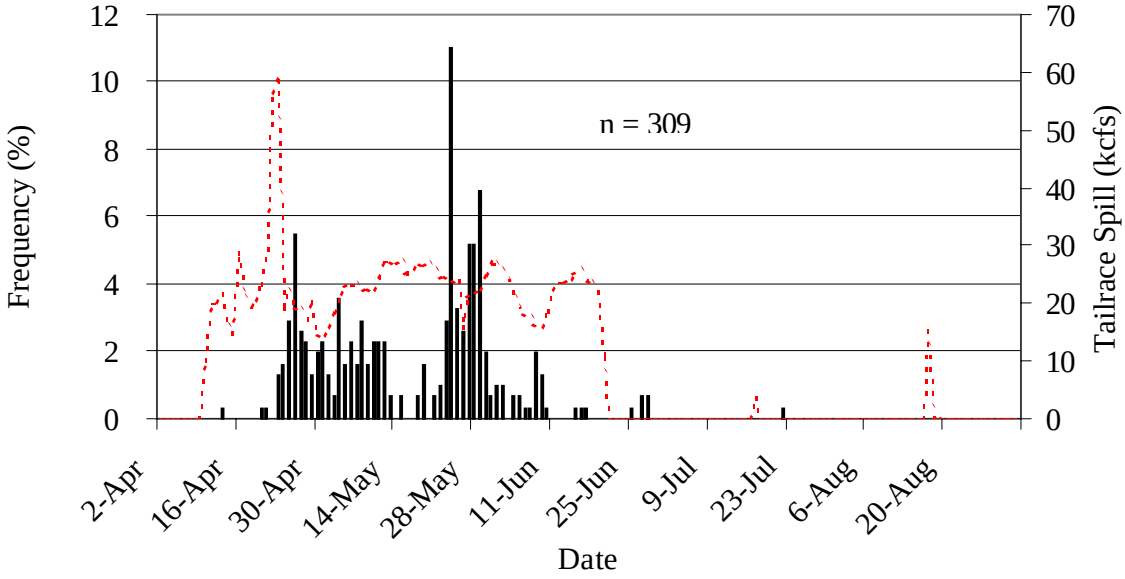

Figure 34. The daily arrival frequency of hatchery steelhead, tagged at the lower Imnaha River trap during the spring, at Little Goose Dam in 2000.

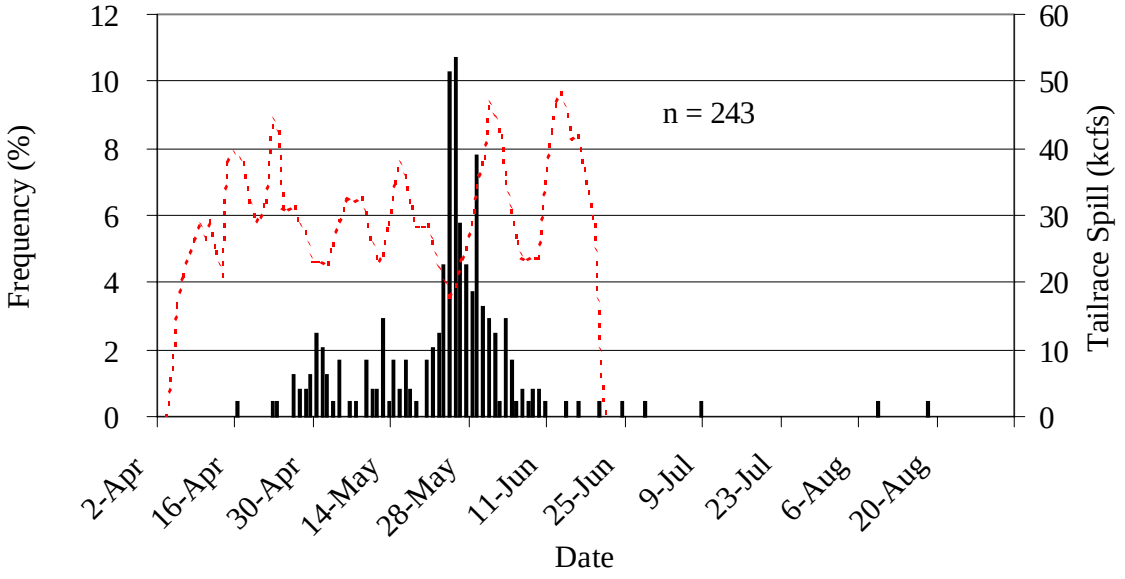

Figure 35. The daily arrival frequency of hatchery steelhead, tagged at the lower Imnaha River trap during the spring, at Lower Monumental Dam in 2000.

chinook salmon and steelhead. Due to the large variation and non-normal distributions in weekly travel times of natural and hatchery chinook salmon and steelhead, medians were compared to test for significant differences (Table 12). The median travel times of hatchery chinook salmon were significantly larger ($p < 0.05$) than the median travel times of natural chinook salmon for groups released during the week of May 19 to the week of April 16. The median travel times of hatchery steelhead were also significantly larger ($p < 0.05$) than their natural cohorts for fish released during the weeks of April 9 to May 14. However, the 0.9 day difference during the week of April 30 and the 0.5 day difference during the week of May 14 is not biologically significant.

Weekly travel time results are consistent with Berggren and Filardo (1993) and were most likely affected by the degree of smoltification and river discharge. An increase in the day time hours and water temperatures would have aided the physiological process of smoltification (Hoar 1976, 1988, and Wedemeyer et al. 1980). Berggren and Filardo (1993) used water temperature, date of entry into an index reach, race, and prior travel time, as indirect variables of smoltification. These variables explained 74% of the variation in travel time for yearling chinook salmon and 90% of the variation in travel time for steelhead, from LGR to MCN and from the mouth of the Methow River to MCN.

Mortality

Mortalities during the fall only affected the 2,228 and 3,396 natural chinook salmon captured at the upper and lower trap respectively. Six mortalities occurred at the upper study site: three due to trapping and three due to tagging. Four mortalities occurred at the lower study site; three due to trapping and one due to handling mortality. The total mortality during the fall was 0.27% at the upper trap and 0.12% at the lower trap.

Natural and hatchery chinook salmon and steelhead mortalities during the spring accounted for less than one percent of the catch for any one species and rearing type. A total of 33 natural chinook salmon mortalities occurred; 10 due to handling (0.19%), 11 due to trapping (0.21%), and 12 due to PIT tagging (0.23%). Trapping caused 118 hatchery chinook salmon mortalities (0.57%), while only 29 were caused by handling (0.14%) and two more resulted from PIT tagging (0.01%). Trapping was also the leading cause of mortality for natural and hatchery steelhead and resulted in 27 natural steelhead deaths (0.54%) and 94 hatchery steelhead deaths (0.42%). Handling and PIT tagging of natural steelhead caused only four and one mortality, or 0.08% and 0.02% respectively. Five hatchery steelhead mortalities occurred as a result of handling (0.02%) and PIT tagging caused no mortalities for hatchery steelhead. Daily mortalities are presented in Appendix G.

Table 12. A summary of average and median annual and weekly travel times of natural and hatchery chinook salmon and steelhead released from the lower Imnaha screw trap, February 26 to June 15, 2000, at Lower Granite Dam (LGR). Weeks with less than 30 interrogations at Lower Granite Dam were not presented. Wilcoxon rank sum statistical test values represent a comparison of median natural and hatchery smolt travel times.

Species	Week Released	Number Interrogated		Average Travel Time (days)		Median Travel Time (days)		Wilcoxon W Value	$p < 0.05$
		Natural	Hatchery	Natural	Hatchery	Natural	Hatchery		
Chinook Salmon	3/12	46		30		29.1		NA	NA
	3/19	75	131	24	31	24.1	31.1	2,155	1.07^{-11}
	3/26	450	211	19	30	17.7	31.8	8,156	0.0
	4/2	206	173	16	27	15.4	28.3	4,463	0.0
	4/9	81	113	14	22	13.2	23.3	1,445	0.0
	4/16	100	143	13	20	12.5	20.1	2,955	0.0
	4/23	105		10		9.7		NA	NA
Steelhead	4/2	52		10		6.7			
	4/9	42	48	8	19	4.8	20.2	433	0.0
	4/16	210	531	7	16	5.4	12.8	33,127	0.0
	4/23	374	548	6	16	4.7	12.4	29,252	0.0
	4/30	629	609	5	7	3.9	4.8	143,854	0.0
	5/7	264	550	6	8	5.0	7.1	46,636	0.0
	5/14	473	520	5	6	4.4	4.9	92,233	4.85^{-12}
	5/21	190	441	4	3	3.4	2.7	58,781	1.0

[1] PIT Tagged and released between February 26 and June 12, 2000

Incidental Catch

The incidental catch during the fall and spring total 2,516 fish. It was comprised of five families of fishes: Salmonidae, Centrarchidae, Catostomidae, Cyprinidae, and Cottidae (Appendix H). The catch of Salmonidae consisted of 404 juvenile rainbow trout/steelhead, 36 adult natural and hatchery steelhead, 328 mountain whitefish (*Prosopium williamsoni*), and 62 bull trout (*Salvelinus confluentus*). Only one Centrarchidae was captured, a smallmouth bass (*Micropterus dolomieui*). A total of 739 bridgelip suckers (*Catostomus columbianus*), 175 largescale suckers (*Catostomus macrocheilus*), and 5 unidentified sucker species represented the family Catostomidae. The catch of Cyprinidae was as follows: 595 longnose dace (*Rhinichthys cataractae*), 56 redsided shiner (*Richardsonius balteatus*), 33 northern pike minnow (*Ptychocheilus oregonensis*), 26 chislemouth (*Acrocheilus alutaceus*), and 4 speckled dace (*Rhinichthys osculus*). A total of 52 *Cottus* species (sculpins) of the family Cottidae were captured during the spring study period.

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APPENDIX A

IMNAHA AND SNAKE RIVER DISCHARGE

Appendix A. Table A1. The mean daily discharge for the Imnaha River gauge 13292000 and the mean daily discharge for the Snake River gauge 13334300, from 1928 to 1999 and 2000 for the month of February.

	Imnaha River Gauge 13292000		Snake River Gauge 13334300	
Date	Mean Daily Discharge 1928 to 1999	Mean Daily Discharge 2000	Mean Daily Discharge 1958 to 1999	Mean Daily Discharge 2000
1-Feb	214	231	33,032	30,100
2-Feb	217	222	32,744	28,300
3-Feb	219	211	32,015	30,900
4-Feb	210	202	31,432	32,900
5-Feb	208	205	31,190	34,700
6-Feb	211	209	31,234	34,700
7-Feb	214	215	31,507	26,800
8-Feb	217	226	32,200	32,700
9-Feb	218	242	32,366	31,000
10-Feb	220	251	31,349	31,600
11-Feb	224	262	31,263	30,100
12-Feb	226	267	31,254	30,200
13-Feb	229	263	31,346	25,300
14-Feb	228	275	31,739	27,500
15-Feb	227	331	32,249	33,700
16-Feb	229	308	33,080	35,300
17-Feb	237	281	34,493	34,800
18-Feb	244	255	34,702	31,500
19-Feb	256	242	35,493	28,200
20-Feb	266	258	36,156	25,700
21-Feb	281	254	37,688	23,300
22-Feb	280	253	37,880	27,200
23-Feb	278	309	39,305	28,800
24-Feb	285	337	38,907	32,200
25-Feb	302	295	38,444	36,000
26-Feb	302	299	37,922	36,600
27-Feb	292	325	37,727	34,600
28-Feb	295	390	37,880	40,000
29-Feb	333	381	38,230	43,500
Monthly Average	247	269	34,304	31,662

Appendix A. Table A2. The mean daily discharge for the Imnaha River gauge 13292000 and the mean daily discharge for the Snake River gauge 13334300, from 1928 to 1999 and 2000 for the month of March.

	Imnaha River Gauge 13292000		Snake River Gauge 13334300	
Date	Mean Daily Discharge 1928 to 1999	Mean Daily Discharge 2000	Mean Daily Discharge 1958 to 1999	Mean Daily Discharge 2000
1-Mar	312	361	38,024	44,700
2-Mar	319	339	37,159	40,700
3-Mar	315	326	37,402	42,200
4-Mar	306	326	36,998	42,300
5-Mar	306	365	35,629	42,900
6-Mar	307	398	36,768	39,700
7-Mar	311	369	37,066	41,900
8-Mar	320	344	37,441	37,400
9-Mar	326	341	38,098	36,100
10-Mar	356	315	38,610	35,000
11-Mar	383	309	38,876	31,800
12-Mar	376	295	39,756	34,200
13-Mar	386	297	39,966	35,800
14-Mar	389	304	40,222	34,900
15-Mar	386	312	40,661	34,200
16-Mar	394	320	40,176	35,200
17-Mar	407	319	41,415	35,500
18-Mar	416	305	41,615	35,500
19-Mar	425	310	42,007	36,000
20-Mar	440	292	42,127	37,600
21-Mar	461	280	42,556	35,900
22-Mar	468	283	42,834	35,000
23-Mar	485	350	42,471	35,000
24-Mar	505	374	43,576	38,100
25-Mar	505	378	43,883	40,700
26-Mar	520	391	43,656	39,200
27-Mar	539	450	44,100	39,600
28-Mar	554	567	44,902	40,300
29-Mar	556	538	44,707	42,200
30-Mar	566	482	44,107	44,600
31-Mar	578	447	44,159	42,900
Monthly Average	417	358	40,676	38,294

Appendix A. Table A3. The mean daily discharge for the Imnaha River gauge 13292000 and the mean daily discharge for the Snake River gauge 13334300, from 1928 to 1999 and 2000 for the month of April.

	Imnaha River Gauge 13292000		Snake River Gauge 13334300	
Date	Mean Daily Discharge 1928 to 1999	Mean Daily Discharge 2000	Mean Daily Discharge 1958 to 1999	Mean Daily Discharge 2000
1-Apr	595	454	44,273	41,200
2-Apr	613	534	44,898	42,000
3-Apr	624	749	45,332	44,500
4-Apr	628	937	45,132	47,600
5-Apr	658	1,170	45,271	51,400
6-Apr	705	967	45,727	50,500
7-Apr	736	799	45,863	51,700
8-Apr	753	754	46,122	49,600
9-Apr	764	852	47,015	47,600
10-Apr	772	1,010	48,132	48,700
11-Apr	781	1,140	48,676	50,700
12-Apr	819	1,350	47,885	52,300
13-Apr	866	1,680	48,100	57,900
14-Apr	922	1,770	47,749	63,200
15-Apr	954	1,510	48,337	64,500
16-Apr	977	1,450	48,461	61,300
17-Apr	1,013	1,430	49,322	59,600
18-Apr	1,046	1,530	49,893	58,800
19-Apr	1,070	1,690	50,380	61,300
20-Apr	1,106	1,660	50,444	62,500
21-Apr	1,121	1,690	52,085	63,400
22-Apr	1,134	1,850	52,485	65,600
23-Apr	1,168	1,690	52,873	68,200
24-Apr	1,212	1,410	53,698	67,200
25-Apr	1,193	1,260	54,612	64,100
26-Apr	1,170	1,160	54,068	61,000
27-Apr	1,238	1,160	53,927	58,500
28-Apr	1,247	1,390	55,115	59,100
29-Apr	1,246	1,220	55,237	58,800
30-Apr	1,259	1,130	55,754	53,400
Monthly Average	946	1,247	49,562	56,207

Appendix A. Table A4. The mean daily discharge for the Imnaha River gauge 13292000 and the mean daily discharge for the Snake River gauge 13334300, from 1928 to 1999 and 2000 for the month of May.

	Imnaha River Gauge 13292000		Snake River Gauge 13334300	
Date	Mean Daily Discharge 1928 to 1999	Mean Daily Discharge 2000	Mean Daily Discharge 1958 to 1999	Mean Daily Discharge 2000
1-May	1,291	1,180	55,995	54,900
2-May	1,316	1,360	56,856	54,800
3-May	1,348	1,460	57,134	54,600
4-May	1,396	1,580	57,912	55,000
5-May	1,403	1,450	58,588	61,100
6-May	1,419	1,320	59,632	56,400
7-May	1,482	1,210	60,907	51,800
8-May	1,514	1,150	61,646	49,300
9-May	1,524	1,170	63,137	48,600
10-May	1,524	1,150	64,415	52,100
11-May	1,536	1,050	64,680	54,800
12-May	1,559	975	64,673	54,200
13-May	1,581	915	64,790	51,100
14-May	1,584	914	66,095	49,800
15-May	1,602	954	67,888	48,100
16-May	1,602	1,000	69,176	42,300
17-May	1,619	1,220	69,885	41,500
18-May	1,628	1,310	70,939	43,500
19-May	1,645	1,300	71,663	44,900
20-May	1,662	1,320	71,159	46,900
21-May	1,662	1,330	71,095	50,100
22-May	1,663	1,510	71,690	56,400
23-May	1,703	1,540	72,485	62,200
24-May	1,698	1,420	72,976	62,400
25-May	1,688	1,400	74,093	61,600
26-May	1,741	1,290	75,051	60,800
27-May	1,730	1,250	77,380	59,400
28-May	1,687	1,350	78,041	58,900
29-May	1,650	1,290	78,312	57,600
30-May	1,630	1,170	80,124	57,300
31-May	1,594	1,070	80,044	59,100
Monthly Average	1,570	1,245	68,015	53,597

Appendix A. Table A5. The mean daily discharge for the Imnaha River gauge 13292000 and the mean daily discharge for the Snake River gauge 13334300, from 1928 to 1999 and 2000 for the month of June.

	Imnaha River Gauge 13292000		Snake River Gauge 13334300	
Date	Mean Daily Discharge 1928 to 1999	Mean Daily Discharge 2000	Mean Daily Discharge 1958 to 1999	Mean Daily Discharge 2000
1-Jun	1,567	937	79,883	57,100
2-Jun	1,544	890	79,498	51,400
3-Jun	1,543	943	79,863	47,500
4-Jun	1,516	1,010	80,800	45,200
5-Jun	1,523	1,140	82,324	53,000
6-Jun	1,540	1,240	84,000	59,400
7-Jun	1,538	1,260	83,712	60,000
8-Jun	1,517	1,390	83,020	54,800
9-Jun	1,498	1,300	81,717	47,900
10-Jun	1,446	1,100	80,149	44,900
11-Jun	1,408	961	78,829	44,600
12-Jun	1,411	1,010	78,663	43,200
13-Jun	1,414	1,200	78,717	45,800
14-Jun	1,392	1,100	77,807	51,400
15-Jun	1,386	1,260	77,420	53,100
16-Jun	1,397	1,180	77,193	50,100
17-Jun	1,355	1,040	77,190	43,200
18-Jun	1,319	967	76,456	37,600
19-Jun	1,304	946	75,341	40,900
20-Jun	1,284	886	73,993	40,200
21-Jun	1,253	869	72,120	39,000
22-Jun	1,224	905	70,193	38,200
23-Jun	1,184	910	67,676	31,900
24-Jun	1,148	809	65,844	25,600
25-Jun	1,120	809	63,790	24,600
26-Jun	1,093	780	62,346	27,700
27-Jun	1,059	741	60,866	32,500
28-Jun	1,016	714	58,573	30,300
29-Jun	990	696	55,993	29,600
30-Jun	955	678	53,529	27,900
Monthly Average	1,331	989	73,917	42,620

APPENDIX B

IMNAHA RIVER DISCHARGE, FALL OF 1999, AND IMNAHA AND SNAKE RIVER TEMPERATURES

Appendix B. Table B1. The daily mean discharge at the lower site (cfs), and temperature (C) at the upper and lower Imnaha River, October 20 to November 24, 1999.

	Upper Trap	Lower Trap	
Date	Mean Temperature (C)	Mean Discharge (cfs)	Mean Temperature (C)
21-Oct		160	7.8
22-Oct		160	8.2
23-Oct		159	8.2
24-Oct		159	9.3
25-Oct		160	9.1
26-Oct		171	9.3
27-Oct	5.0	182	8.0
28-Oct	5.3	403	8.6
29-Oct	4.6	264	8.5
30-Oct	4.2	211	8.8
31-Oct	3.9	194	9.0
1-Nov	2.3	183	6.2
2-Nov	2.5	179	5.0
3-Nov	3.5	177	5.9
4-Nov	4.5	178	8.1
5-Nov	4.7	179	6.8
6-Nov	5.8	271	7.9
7-Nov	4.8	247	9.0
8-Nov	5.0	199	8.8
9-Nov	4.4	195	8.5
10-Nov	5.0	190	8.9
11-Nov	5.1	201	8.8
12-Nov	4.7		
13-Nov	4.4		
14-Nov	3.7		
15-Nov	3.2		
16-Nov	3.9		
17-Nov	4.2		
18-Nov	3.0		
19-Nov	2.8		
20-Nov	3.0		
21-Nov	1.5		
22-Nov	0.8		
23-Nov	0.3		
24-Nov	0.7		

Appendix B. Table B2. The daily mean temperature for the Imnaha and Snake rivers. Temperature for the Snake river was collected at USGS Gauge 13334300. Temperature for the Imnaha River was collected at river kilometer 7.

Date	Imnaha River Average Temperature (C)	Snake River Average Temperature (C)
20-Feb	3.3	4.5
21-Feb	6.0	5.2
22-Feb	6.8	5.7
23-Feb	6.6	5.8
24-Feb	4.9	5.5
25-Feb	3.9	5.2
26-Feb	5.2	5.4
27-Feb	6.4	6.0
28-Feb	6.4	6.1
29-Feb	5.7	6.0
1-Mar	6.8	6.2
2-Mar	6.9	6.4
3-Mar	8.1	6.8
4-Mar	8.1	7.1
5-Mar	7.6	7.1
6-Mar	6.2	6.5
7-Mar	6.3	6.3
8-Mar	5.5	6.6
9-Mar	5.1	6.6
10-Mar	6.2	6.7
11-Mar	6.6	7.2
12-Mar	5.5	6.8
13-Mar	7.2	7.2
14-Mar	8.5	7.8
15-Mar	7.7	7.6
16-Mar	6.5	7.2
17-Mar	5.5	6.8
18-Mar	5.7	6.8
19-Mar	6.4	7.0
20-Mar	5.9	6.8
21-Mar	6.5	7.1
22-Mar	8.3	7.9
23-Mar	8.6	8.2

Appendix B. Table B2 Continued.

Date	Imnaha River Average Temperature (C)	Snake River Average Temperature (C)
24-Mar	7.0	7.5
25-Mar	7.1	7.6
26-Mar	8.5	8.0
27-Mar	8.9	8.5
28-Mar	7.8	8.4
29-Mar	6.7	7.8
30-Mar	6.9	7.9
31-Mar	7.4	8.3
1-Apr	8.5	8.9
2-Apr	10.3	9.5
3-Apr	9.8	9.6
4-Apr	9.9	9.7
5-Apr	8.0	9.1
6-Apr	7.1	8.6
7-Apr	7.9	8.7
8-Apr	8.7	9.5
9-Apr	10.1	10.3
10-Apr	9.7	10.7
11-Apr	9.4	10.6
12-Apr	10.4	10.9
13-Apr	9.3	10.9
14-Apr	7.9	10.0
15-Apr	8.2	9.9
16-Apr	8.3	10.1
17-Apr	8.9	10.5
18-Apr	10.0	11.3
19-Apr	10.4	11.6
20-Apr	9.4	11.7
21-Apr	10.1	12.0
22-Apr	9.1	12.0
23-Apr	7.4	10.9
24-Apr	7.8	10.8
25-Apr	8.1	10.8
26-Apr	8.9	10.8
27-Apr	10.2	11.8
28-Apr		12.2

Appendix B. Table B2 Continued.

	Imnaha River	Snake River
Date	Average Temperature (C)	Average Temperature (C)
29-Apr		11.8
30-Apr	10.5	12.0
1-May	11.4	12.7
2-May	11.5	13.1
3-May	10.5	12.6
4-May	9.5	11.7
5-May	9.3	11.5
6-May	9.0	11.4
7-May	9.6	11.6
8-May	10.0	12.0
9-May	10.1	12.1
10-May	8.3	11.6
11-May	7.3	11.2
12-May	8.7	11.4
13-May	10.2	11.8
14-May	11.4	12.6
15-May	12.3	13.5
16-May	12.8	13.9
17-May	12.8	14.3
18-May	12.6	14.0
19-May	12.1	14.0
20-May	12.1	13.6
21-May	13.4	14.1
22-May	13.8	14.5
23-May	12.2	14.2
24-May	11.6	13.5
25-May	11.6	13.3
26-May	12.0	13.1
27-May	11.7	13.4
28-May	12.1	13.3
29-May	12.1	13.2
30-May	10.1	12.8
31-May	8.3	12.0
1-Jun	10.6	12.3
2-Jun	13.3	13.7
3-Jun	14.6	14.4

Appendix B. Table B2 Continued.

	Imnaha River	Snake River
Date	Average Temperature (C)	Average Temperature (C)
4-Jun	15.1	15.4
5-Jun	15.3	16.1
6-Jun	14.4	16.1
7-Jun	14.7	16.1
8-Jun	13.1	15.8
9-Jun	11.1	14.5
10-Jun	10.6	14.1
11-Jun	10.4	13.8
12-Jun	11.3	13.8
13-Jun	12.7	14.2
14-Jun	14.5	15.2
15-Jun	14.6	15.9
16-Jun	13.5	16.0
17-Jun	13.9	16.2

APPENDIX C

DAILY MEAN TEMPERATURE, DISCHARGE, AND CATCH OF CHINOOK SALMON AND STEELHEAD

Appendix C. Table C1. The daily mean discharge at the lower site (cfs), and temperature (C) and catch of natural chinook salmon at the upper and lower Imnaha River, October 20 to November 24, 1999.

	Upper Trap		Lower Trap		
Date	Mean Temperature (cfs)	Natural Chinook	Mean Discharge (cfs)	Mean Temperature (C)	Natural Chinook
21-Oct		83	160	7.8	87
22-Oct		10	160	8.2	32
23-Oct			159	8.2	
24-Oct			159	9.3	
25-Oct			160	9.1	
26-Oct		2	171	9.3	5
27-Oct	5.0	64	182	8.0	33
28-Oct	5.3	56	403	8.6	65
29-Oct	4.6	471	264	8.5	1,709
30-Oct	4.2		211	8.8	
31-Oct	3.9		194	9.0	
1-Nov	2.3		183	6.2	
2-Nov	2.5	50	179	5.0	614
3-Nov	3.5	153	177	5.9	404
4-Nov	4.5	98	178	8.1	
5-Nov	4.7	19	179	6.8	
6-Nov	5.8		271	7.9	
7-Nov	4.8		247	9.0	
8-Nov	5.0	101	199	8.8	106
9-Nov	4.4	38	195	8.5	60
10-Nov	5.0	53	190	8.9	147
11-Nov	5.1	66	201	8.8	134
12-Nov	4.7				
13-Nov	4.4				
14-Nov	3.7	56			
15-Nov	3.2	75			
16-Nov	3.9	190			
17-Nov	4.2	166			
18-Nov	3.0	106			
19-Nov	2.8	54			
20-Nov	3.0				
21-Nov	1.5				
22-Nov	0.8	72			
23-Nov	0.3	93			
24-Nov	0.7	152			

Appendix C. Table C2. The catch of natural and hatchery chinook salmon and steelhead at the Imnaha River traps, A and B, from February 26 to June 15, 2000. The hours fished represent when trap A, or trap A and B, began fishing to when their live boxes where cleared of all fish (daily samples may exceed 24 hours if sampling continued into the following day).

		Trap A				Trap B			
Date	Hours Fished	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
Feb 26	19.0	9							
Feb 27	25.0	5							
Feb 28	24.0	10							
Feb 29	24.0	14							
Mar 1	24.0	16							
Mar 2	23.0	14		1					
Mar 3	23.5	10							
Mar 4	24.0	11							
Mar 5	24.0	11							
Mar 6	24.0	18							
Mar 7	23.0	24							
Mar 8	24.0	11							
Mar 9	24.5	12							
Mar 10	24.5	13							
Mar 11	24.0	7							
Mar 12	23.5	6							
Mar 13	24.0	7							
Mar 14	22.5	19							
Mar 15	24.0	50		1					
Mar 16	24.0	12							
Mar 17	24.0	27							

Appendix C. Table C2. Continued.

		Trap A				Trap B			
Date	Hours Fished	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
Mar 18	25.0	72							
Mar 19	24.0	56							
Mar 20	23.0	71							
Mar 21	24.0	33							
Mar 22	23.5	28							
Mar 23	23.5	18							
Mar 24	27.0	44	1,131						
Mar 25	19.5	84	578						
Mar 26	23.5	73	216						
Mar 27	29.0	55	335						
Mar 28	27.0	209	1,606	1		189	2,105		1
Mar 29	22.5	772	2,734	2		464	3,047	1	
Mar 30	22.5	169	1,116	2		181	955	1	
Mar 31	25.0	120	763	1					
Apr 1	22.5	54	780						
Apr 2	25.0	15	324						
Apr 3	25.5	82	358			57	446		
Apr 4	20.0	84	221	2					
Apr 5	22.0	150	562	55	3	1	9		
Apr 6	9.5	26	224	18					
Apr 7	12.0	134	625	24					
Apr 8	22.0	75	101	16					

Appendix C. Table C2. Continued.

		Trap A				Trap B			
Date	Hours Fished	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
Apr 9	15.8	53	96	7					
Apr 10	13.8	35	24	8		26	86		
Apr 11	13.5	20	34	13	1	42	62	3	
Apr 12	15.5	43	63	8		5	29	7	
Apr 13	9.8	20	203	31	112				
Apr 14	4.3	2	88	11	16				
Apr 15	8.0	15	71	21	66				
Apr 16	9.5	22	116					25	71
Apr 17	29.0	32	173	54	161	46	62	29	63
Apr 18	10.5	19	63	38	13	34	48	22	10
Apr 19	9.0	18	61	53	37		14	6	11
Apr 20	10.0	7	105	51	262				
Apr 21	21.8	52	202	88	925				
Apr 22	23.0	38	115	73	686				
Apr 24	16.5	57	147	79	507				
Apr 25	23.3	50	86	58	201				
Apr 26	24.0	58	49	50	149				
Apr 27	22.4	54	39	58	70				
Apr 28	30.0	104	53	176	107	27	7	43	32
Apr 29	25.0	97	72	202	266				
May 1	4.3	44	66	136	162				
May 2	23.0	47	18	221	206	17	24	120	1

Appendix C. Table C2. Continued.

		Trap A				Trap B			
Date	Hours Fished	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
May 3	27.5	45	24	328	598	0	1	80	135
May 4	17.5	28	24	432	830				
May 5	9.5	14	11	59	147				
May 8	12.0	18	7	93	293				
May 9	25.5	16	9	127	411				
May 10	11.5	12	11	179	710				
May 11	24.5	25	28	223	1,081				
May 12	13.0	7	2	4	7				
May 15	22.5	11	1	161	686				
May 16	15.0	10	4	235	891				
May 17	24.0	15	7	221	1,148				
May 18	24.0	22	13	349	2,113				
May 19	11.0	4	6	65	456				
May 22	19.0	31	3	173	1,533				
May 23	7.5	12	3	86	1,158				
May 24	8.5	8	1	70	630				
May 25	12.0	14		58	428				
May 26	13.0	6	1	42	394				
May 31	12.5	16	1	52	430				
Jun 1	24.0	30	1	39	376				
Jun 2	23.0	14		10	172				
Jun 5	13.5	15		15	348	15		9	142

Appendix C. Table C2. Continued.

		Trap A				Trap B			
Date	Hours Fished	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
Jun 6	14.5	10		18	546	2		6	244
Jun 7	14.5	8		12	399	2		9	207
Jun 8	12.5	3		12	366	2		9	207
Jun 9	14.5	4		23	580				
Jun 12	13.0	5		2	105	6		6	42
Jun 13	23.5	11		5	214	1		7	121
Jun 14	12.0	3		7	157	9		2	80
Jun 15	9.0	4		6	130	3			53
Totals	1,840	4,038	13,775	4,665	21,287	1,127	6,895	376	1,213

Appendix C. Table C3. PIT tagged fish recaptured in the upper Imnaha River trap from October 20 to November 24, 1999.

Agency	Recapture File	Tag ID	Date Tagged	Date Recaptured	Recapture Length	Recapture Weight	Travel Time
ODFW	JAH99323.NP1	3D9.1BF0DF9F89	8/23/99	11/19/99	84	6.1	87 days 18 hrs 9 mins
ODFW	JAH99322.NP1	3D9.1BF0DFBD28	8/23/99	11/18/99	90	7.4	86 days 18 hrs 24 mins
ODFW	JAH99301.NP1	3D9.1BF0DFFA38	8/23/99	10/28/99	85	6.7	65 days 17 hrs 50 mins
ODFW	JAH99322.NP1	3D9.1BF0E02EC1	8/23/99	11/18/99	85	6.1	86 days 18 hrs 24 mins
ODFW	JAH99327.NP1	3D9.1BF0E12604	8/23/99	11/23/99	74		91 days 18 hrs 13 mins
ODFW	JAH99312.NP1	3D9.1BF0DF5771	8/24/99	11/8/99	83	5.1	75 days 16 hrs 18 mins
ODFW	JAH99327.NP1	3D9.1BF0E0F36E	8/24/99	11/23/99	80	4.9	90 days 18 hrs 13 mins
ODFW	JAH99323.NP1	3D9.1BF0E10AC2	8/24/99	11/19/99	85	6.5	86 days 18 hrs 9 mins
ODFW	JAH99328.NP1	3D9.1BF0E110D2	8/24/99	11/24/99	83	5.8	91 days 18 hrs 3 mins
ODFW	JAH99315.NP1	3D9.1BF0E1162F	8/24/99	11/11/99	83	6	78 days 20 hrs 57 mins
ODFW	JAH99302.NP1	3D9.1BF0E11C9E	8/24/99	10/29/99	94	9.1	65 days 16 hrs 39 mins
ODFW	JAH99302.NP1	3D9.1BF0E120E3	8/24/99	10/29/99	77	5.1	65 days 16 hrs 39 mins
ODFW	JAH99302.NP1	3D9.1BF0E12953	8/24/99	10/29/99	98	9.8	65 days 16 hrs 39 mins
ODFW	JAH99294.NP1	3D9.1BF0DF3D26	8/24/99	10/21/99	84	6.3	57 days 16 hrs 51 mins
ODFW	JAH99326.NP1	3D9.1BF0DF3D9A	8/24/99	11/22/99	83	5.3	89 days 18 hrs 8 mins
ODFW	JAH99307.NP1	3D9.1BF0DF3E04	8/24/99	11/3/99	78		70 days 15 hrs 57 mins
ODFW	JAH99328.NP1	3D9.1BF0DF4B39	8/24/99	11/24/99	83	5.4	91 days 16 hrs 48 mins
ODFW	JAH99328.NP1	3D9.1BF0DFF16E	8/24/99	11/24/99	87	6.1	91 days 16 hrs 48 mins
ODFW	JAH99327.NP1	3D9.1BF0E10E44	8/24/99	11/23/99	84	5.1	90 days 16 hrs 58 mins
ODFW	JAH99322.NP1	3D9.1BF0E11524	8/24/99	11/18/99	75		85 days 17 hrs 9 mins
ODFW	JAH99322.NP1	3D9.1BF0E125B4	8/24/99	11/18/99	91	6.9	85 days 17 hrs 9 mins
NPT	JAH99307.NP1	3D9.1BF0DED771	11/2/99	11/3/99	89	7.8	14 hrs 12 mins
NPT	JAH99308.NT1	3D9.1BF0E04CCE	11/3/99	11/4/99	94	8	14 hrs 5 mins
NPT	JAH99320.NP1	3D9.1BF0DED05B	11/15/99	11/16/99	109	14.2	14 hrs 38 mins
NPT	JAH99321.NP1	3D9.1BF0E0395F	11/16/99	11/17/99	95	7.7	14 hrs 53 mins
NPT	JAH99323.NP1	3D9.1BF0E03FE9	11/18/99	11/19/99	84	5.8	15 hrs 9 mins
NPT	JAH99323.NP1	3D9.1BF0E04457	11/18/99	11/19/99	105	12.7	15 hrs 9 mins
NPT	JAH99323.NP1	3D9.1BF0E0493D	11/18/99	11/19/99	103	11.4	15 hrs 9 mins
NPT	JAH99323.NP1	3D9.1BF0E0533A	11/18/99	11/19/99	86	7.2	15 hrs 9 mins
NPT	JAH99328.NP1	3D9.1BF0DEE492	11/23/99	11/24/99	97	9	15 hrs 3 mins

Appendix C. Table C3. PIT tagged fish recaptured in the lower Imnaha River trap from October 20 to November 24, 1999.

Agency	Recapture File	Tag ID	Date Tagged	Date Recaptured	Recapture Length	Recapture Weight	Travel Time
ODFW	JAH99302.NT1	3D9.1BF0DF9B68	8/23/99	10/29/99			66 days 16 hrs 18 mins
ODFW	JAH99302.NT1	3D9.1BF0E129EC	8/24/99	10/29/99	71		65 days 16 hrs 18 mins
ODFW	JAH99306.NT1	3D9.1BF0DFF57F	8/25/99	11/2/99			68 days 22 hrs 48 mins
NPT	JAH99302.NT1	3D9.1BF0DEBC85	10/21/99	10/29/99	88	6.9	7 days 13 hrs 18 mins
NPT	JAH99302.NT1	3D9.1BF0DEC314	10/21/99	10/29/99			7 days 13 hrs 18 mins
NPT	JAH99302.NT1	3D9.1BF0E04B72	10/21/99	10/29/99	84	6	7 days 13 hrs 18 mins
NPT	JAH99306.NT1	3D9.1BF0DEC4B2	10/21/99	11/2/99	95	8.9	11 days 16 hrs 18 mins
NPT	JAH99302.NT1	3D9.1BF0DED9DC	10/22/99	10/29/99	88		6 days 20 hrs 18 mins
NPT	JAH99306.NT1	3D9.1BF0DEC460	10/28/99	11/2/99	89	7.3	4 days 16 hrs 18 mins
NPT	JAH99306.NT1	3D9.1BF0DEEFF4	10/28/99	11/2/99	101	10.5	4 days 16 hrs 18 mins
NPT	JAH99307.NT1	3D9.1BF0DED390	10/28/99	11/3/99			5 days 15 hrs 23 mins
NPT	JAH99314.NT1	3D9.1BF0DEEB76	10/28/99	11/10/99	82	5.6	12 days 15 hrs 34 mins
NPT	JAH99306.NT1	3D9.1BF0DEC832	10/29/99	11/2/99	101	11.2	4 days 10 hrs 18 mins
NPT	JAH99307.NT1	3D9.1BF0DEBCE2	11/2/99	11/3/99	87		14 hrs 53 mins
NPT	JAH99307.NT1	3D9.1BF0DEC03B	10/29/99	11/3/99			5 days 9 hrs 23 mins
NPT	JAH99307.NT1	3D9.1BF0DEF0E5	10/29/99	11/3/99			5 days 9 hrs 23 mins
NPT	JAH99312.NT1	3D9.1BF0DEBB35	10/29/99	11/8/99	95	9.2	10 days 10 hrs 3 mins
NPT	JAH99312.NT1	3D9.1BF0DEC114	10/29/99	11/8/99	86	6.9	10 days 10 hrs 3 mins
NPT	JAH99312.NT1	3D9.1BF0DECA34	10/29/99	11/8/99		6.3	10 days 10 hrs 3 mins
NPT	JAH99313.NT1	3D9.1BF0DED94D	10/29/99	11/9/99	100	11.7	11 days 9 hrs 11 mins
NPT	JAH99314.NT1	3D9.1BF0DEE7DE	10/29/99	11/10/99	86	6.4	12 days 9 hrs 34 mins
NPT	JAH99313.NT1	3D9.1BF0DED771	11/2/99	11/9/99	91	7.7	6 days 15 hrs 11 mins
NPT	JAH99314.NT1	3D9.1BF0DEC103	11/2/99	11/10/99	99		7 days 15 hrs 34 mins
NPT	JAH99313.NT1	3D9.1BF0DEE493	11/3/99	11/9/99	92	9.4	5 days 15 hrs 11 mins
NPT	JAH99315.NT1	3D9.1BF0DEBCEC	11/4/99	11/11/99	80	5.4	6 days 14 hrs 10 mins

APPENDIX D

IMNAHA RIVER JUVENILE HATCHERY CHINOOK SALMON TRAP EFFICIENCIES AND POST RELEASE SURVIVAL ESTIMATES FROM 1994 TO 2000

Appendix D. Table D1. The mean trap efficiency, PIT tag interrogation percentage and estimated survival of hatchery chinook salmon from release at the Imnaha River Acclimation Facility at river kilometer 74 to the Imnaha River trap at river kilometer 7, and from release to Lower Granite Dam from 1994 to 2000.

				Estimated Survival		
				Release to Trap		Release to Lower Granite Dam (%)[1]
Year	Number of Trials	Mean Trap Efficiency (%)	PIT Tag Interrogations at the Screw Trap (%)	SURPH (%)	Bootstrap (%)	
2000	11	18.1	9.8	94.7	66.9	68.7
1999	51	21.8	4.5	93.7	45.9	68.5
1998	9	29.4	17.0	88.4	66.9	68.3
1997	6	45.9	19.6	89.2	44	61.6
1996	9	11.6	10.6	95.0	101.7	56.8
1995	7	14.8	10.8	92.6	68	61.8
1994	1	13.8	6.2	100.9	88.1	68.5

[1] Estimated as the product of the SURPH Survival estimates from release to the Imnaha River trap, and from the trap to Lower Granite Dam.

Appendix D. Table D2. Daily trap efficiency trials of hatchery chinook salmon marked with fin clips and PIT tags released and recaptured in the lower Imnaha River trap during the spring of 2000 migration.

Date Released	Mark Applied	Number	Number	Percent
March 24	Fin Clip	100	18	18.0
March 30	Fin Clip	300	70	23.3
March 30	PIT Tag	371	57	15.4
March 31	Fin Clip	301	47	15.6
April 2	Fin Clip	281	97	34.5
April 17	Fin Clip	190	17	8.9
April 25	Fin Clip	73	1	1.4
April 26	Fin Clip	40	7	17.5
April 27	Fin Clip	35	1	2.9
April 28	Fin Clip	53	2	3.8
April 28	PIT Tag	27	4	14.8

APPENDIX E

ARRIVAL TIMING AT SNAKE RIVER AND COLUMBIA RIVER DAMS

Appendix E. Table E1. Arrival timing of PIT tagged Imnaha River natural chinook salmon smolts, tagged and released in the fall of 1993 to 1999 at the upper trap site at Lower Granite, Little Goose, Lower Monumental, and McNary dams for migration years 1994 to 2000.

Dam	Migration Year	Sample Size (n)	Date Range	Arrival Timing Median	Arrival Timing 90%
Lower Granite	2000	245	April 8 - May 28	May 1	May 10
	1999	128	April 8 - May 27	May 1	May 17
	1998	454	April 3 - June 5	April 27	May 9
	1996	108	April 11 - May 19	April 24	May 14
	1994	68	April 20 - July 12	April 25	May 11
Little Goose	2000	128	April 14 - June 4	April 28	May 11
	1999	220	April 10 - June 21	April 30	May 18
	1998	410	April 14 - May 28	May 4	May 15
	1996	87	April 14 - May 26	April 26	May 16
	1994	43	April 22 - June 25	May 1	May 19
Lower Monumental	2000	40	April 17 - May 30	April 29	May 21
	1999	80	April 13 - May 28	May 2	May 20
	1998	304	April 15 - May 29	May 7	May 19
	1996	92	April 19 - May 31	April 27	May 19
	1994	43	April 27 - July 18	May 6	May 24
McNary	2000	42	April 26 - May 31	May 10	May 21
	1999	18	April 18 - May 30	May 9	May 25
	1998	195	April 18 - June 4	May 4	May 18
	1996	40	April 25 - May 26	April 30	May 21
	1994	63	May 1 - June 1	May 17	May 24

Appendix E. Table E2. Arrival timing of PIT tagged Imnaha River natural chinook salmon smolts, tagged and released in the fall of 1993 to 1999 at the lower trap site at Lower Granite, Little Goose, Lower Monumental, and McNary dams for migration years 1994 to 2000.

Dam	Migration Year	Sample Size (n)	Date Range	Arrival Timing Median	Arrival Timing 90%
Lower Granite	2000	262	April 4 - May 12	April 14	April 23
	1999	103	April 3 May 2	April 19	April 25
	1998	428	March 27 - May 12	April 14	April 24
	1997	101	March 31 - April 24	April 13	April 21
	1996	98	April 8 - April 28	April 19	April 23
	1995	106	April 3 - May 9	April 14	April 25
	1994	145	April 2 - May 6	April 21	April 25
Little Goose					
	2000	239	April 12 - May 12	April 17	April 24
	1999	364	April 8 - May 9	April 19	April 25
	1998	228	April 11 - May 12	April 25	May 2
	1997	92	April 12 - April 30	April 21	April 24
	1996	146	April 12 - May 17	April 23	April 26
	1995	54	April 11 - May 14	April 18	May 2
	1994	80	April 22 - May 8	April 26	April 30
Lower Monumental					
	2000	62	April 13 - May 6	April 21	April 26
	1999	144	April 10 - May 21	April 19	April 25
	1998	202	April 19 - May 19	Apr 25	May 4
	1997	61	April 8 - April 29	April 22	April 26
	1996	87	April 13 - May 18	April 24	April 27
	1995	50	April 13 - May 16	April 22	May 3
	1994	93	April 24 - May 18	April 29	May 9
McNary					
	2000	35	April 18 - May 6	April 27	May 4
	1999	64	April 10 - May 10	April 21	April 28
	1998	236	April 20 - May 23	April 30	May 4
	1997	25	April 12 - April 29	April 25	April 28
	1996	48	April 18 - May 12	April 27	May 3
	1995	42	April 23 - May 16	April 30	May 10
	1994	90	April 29 - June 15	May 8	May 18

Appendix E. Table E3. Arrival timing of spring PIT tagged Imnaha River natural chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 2000.

Dam	Migration Year	Sample Size (n)	Date Range	Arrival Timing Median	Arrival Timing 90%
Lower Granite	2000	1,291	April 2 - August 8	April 22	May 11
	1999	1,218	March 28 - July 15	April 27	May 22
	1998	1,630	April 1 - June 27	April 25	May 6
	1997	74	April 6 - May 18	April 22	May 11
	1996	421	April 6 - June 12	April 30	May 18
	1995	184	April 11 - July 11	May 1	May 11
	1994	348	April 14 - June 23	April 24	May 11
	1993	109	April 21 - June 12	May 4	May 14
Little Goose	2000	1,103	April 11 - July 14	April 23	May 11
	1999	2,099	April 9 - August 1	April 29	May 22
	1998	837	April 14 - June 25	May 3	May 12
	1997	70	April 15 - May 22	April 26	May 11
	1996	358	April 12 - June 16	April 27	May 20
	1995	144	April 15 - July 15	May 7	May 20
	1994	194	April 23 - June 17	April 28	May 7
	1993	46	April 27 - June 2	May 3	May 16
Lower Monumental	2000	335	April 13 - July 12	April 25	May 12
	1999	688	April 9 - August 4	May 1	May 23
	1998	289	April 19 - June 8	April 30	May 11
	1997	74	April 20 - June 1	April 30	May 14
	1996	359	April 13 - June 15	May 10	May 22
	1995	142	April 19 - August 4	May 8	June 4
	1994	215	April 25 - July 26	May 1	May 24
	1993	37	May 3 - June 2	May 8	May 13
McNary	2000	192	April 18 - July 4	May 7	May 29
	1999	152	April 18 - June 27	May 6	May 21
	1998	187	April 19 - June 2	May 1	May 15
	1997	24	April 22 - May 19	May 1	May 12
	1996	148	April 19 - June 8	May 14	May 24
	1995	89	April 28 - July 9	May 12	May 21
	1994	229	April 29 - July 16	May 12	May 28
	1993	20	May 3 - June 15	May 9	May 21

Appendix E. Table E4. Arrival timing of PIT tagged Imnaha River hatchery chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1992 to 2000.

				Arrival Timing	
Dam	Year	Sample Size (n)	Date Range	Median	90%
Lower Granite	2000	782	April 7 - May 24	May 3	May 13
	1999	267	April 18 - May 25	May 5	May 14
	1998	696	April 15 - May 22	May 2	May 9
	1997	227	April 16 - May 22	May 5	May 14
	1996	169	April 13 - May 26	May 7	May 16
	1995[1]	128	April 13 - June 7	May 2	May 13
	1995[2]	83	April 16 - May 22	May 8	May 15
	1994	129	April 24 - May 18	May 12	May 12
	1992[3]	273	April 12 - June 6	April 21	May 6
Little Goose	2000	450	April 14 - May 24	May 3	May 13
	1999	387	April 16 - June 6	May 10	May 19
	1998	391	April 25 - May 26	May 7	May 14
	1997	267	April 20 - May 27	May 9	May 18
	1996	131	April 23 - June 6	May 13	May 20
	1995[1]	114	April 26 - June 11	May 10	May 20
	1995[2]	67	April 27 - June 7	May 12	May 23
	1994	65	April 28 - June 2	May 14	May 21
	1992[3]	116	April 17 - May 22	April 27	May 5
Lower Monumental	2000	107	April 19 - May 26	May 5	May 22
	1999	124	April 23 - May 25	May 11	May 20
	1998	143	April 23 - May 26	May 8	May 15
	1997	199	April 25 - June 3	May 10	May 19
	1996	136	April 23 - May 29	May 15	May 23
	1995[1]	106	April 27 - June 10	May 12	May 21
	1995[2]	71	April 29 - June 9	May 17	May 26
	1994	73	April 30 - June 7	May 14	May 20
McNary	2000	99	April 24 - May 30	May 13	May 27
	1999	56	May 2 - May 26	May 19	May 24
	1998	53	May 2 - May 30	May 11	May 19
	1997	61	May 1 - June 1	May 10	May 19
	1996	55	May 1 - May 27	May 16	May 23
	1995[1]	67	April 29 - June 9	May 16	May 23
	1995[2]	36	May 3 - May 30	May 16	May 22
	1994	119	May 6 - June 17	May 21	May 26
	1992[3]	61	April 27 - June 1	May 8	May 17

[1] HxW crossed chinook salmon smolts PIT tagged for NPT and released at dark.

[2] HxW crossed chinook salmon smolts PIT tagged for the FPC and released one hour after tagging and recovery.

[3] Hatchery chinook salmon smolts PIT tagged and released in 1992 were over a two day period only for survival estimation.

Appendix E. Table E5. Arrival timing of PIT tagged Imnaha River natural steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 2000.

Dam	Year	Sample Size (n)	Date Range	Arrival Timing Median	Arrival Timing 90%
Lower Granite	2000	2,262	April 6 - August 3	May 8	May 25
	1999	649	April 19 - June 26	May 18	June 5
	1998	1,474	April 2 - June 12	May 3	May 22
	1997	368	April 20 - July 10	May 8	May 24
	1996	537	April 19 - June 10	May 6	June 4
	1995	128	April 28 - June 19	May 2	May 9
	1994[1]	332	April 25 - Aug 15	May 8	June 1
	1994[2]	207	May 3 - Aug 20	May 9	May 30
	1993	101	May 3 - June 13	May 26	June 8
Little Goose	2000	458	April 11 - June 26	May 8	May 29
	1999	717	April 8 - June 24	May 21	May 25
	1998	481	April 14 - June 19	May 8	May 26
	1997	319	April 20 - June 19	May 10	May 26
	1996	365	April 20 - June 14	May 9	May 28
	1995	70	May 1 - June 23	May 7	May 12
	1994[1]	159	April 29 - July 29	May 12	May 31
	1994[2]	121	May 6 - July 26	May 15	June 1
	1993	48	May 6 - June 11	May 24	June 7
Lower Monumental	2000	246	April 12 - August 12	May 14	May 30
	1999	342	April 19 - June 21	May 23	May 27
	1998	213	April 16 - June 11	May 10	May 27
	1997	264	April 21 - June 6	May 11	May 25
	1996	397	April 22 - June 15	May 14	May 29
	1995	81	May 3 - May 17	May 9	May 14
	1994[1]	148	May 1 - August 8	May 12	July 8
	1994[2]	91	May 9 - July 31	May 15	July 10
	1993	43	May 6 - June 15	May 30	June 11
McNary	2000	58	April 15 - June 16	May 24	June 7
	1999	55	April 17 - May 31	May 25	May 27
	1998	53	April 20 - June 4	May 7	May 28
	1997	62	April 24 - June 5	May 13	May 18
	1996	157	April 25 - June 11	May 11	May 21
	1995	35	May 5 - May 27	May 11	May 17
	1994[1]	66	May 5 - June 22	May 18	June 9
	1994[2]	42	May 13 - June 25	May 18	June 6
	1993	17	May 11 - June 13	May 25	May 31

[1] NPT PIT tagged fish

[2] FPC PIT tagged fish

Appendix E. Table E6. Arrival timing of PIT tagged Imnaha River hatchery steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 2000.

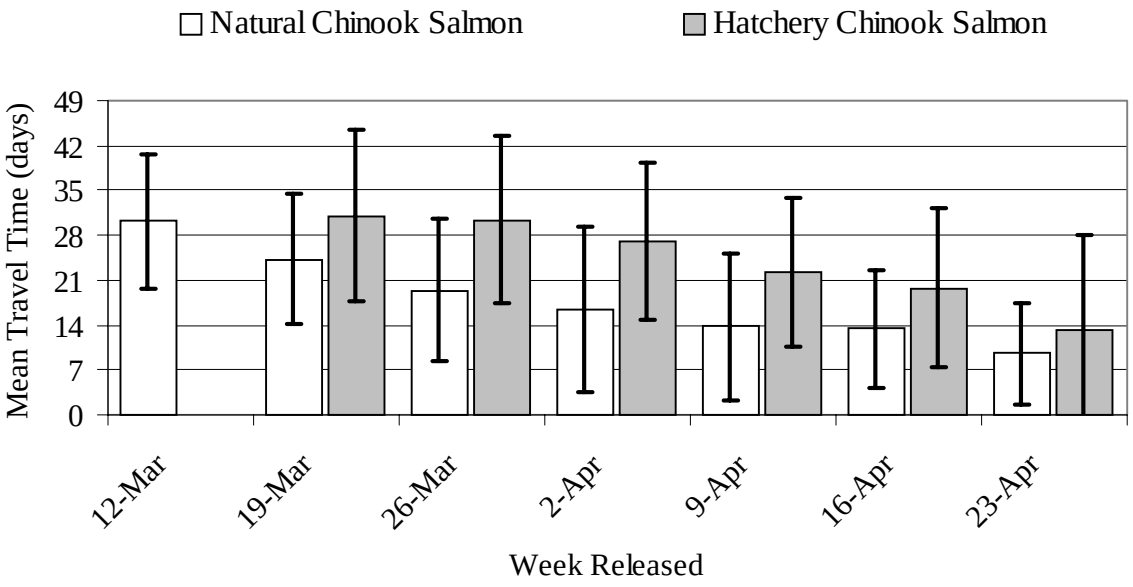
Dam	Year	Sample Size (n)	Date Range	Arrival Timing Median	Arrival Timing 90%
Lower Granite	2000	3,249	April 8 - July 24	May 16	May 25
	1999	1,973	April 18 - August 5	May 24	June 18
	1998	1,683	April 25 - July 29	May 15	May 26
	1997	2,346	April 19 - July 24	May 23	June 13
	1996	440	April 23 - July 14	May 28	June 14
	1995	661	May 6 - July 12	May 31	June 16
	1994[1]	164	April 29 - August 20	May 29	July 15
	1994[2]	306	May 6 - August 21	May 25	June 23
	1993	224	May 3 - June 28	May 17	May 31
Little Goose	2000	309	April 13 - July 22	May 22	July 1
	1999	1,593	April 20 - August 22	May 25	June 18
	1998	555	May 3 - July 10	May 25	May 30
	1997	1,844	April 21 - August 23	May 26	June 13
	1996	261	April 24 - July 11	May 25	June 16
	1995	409	May 8 - July 13	June 3	June 20
	1994[1]	86	May 2 - July 30	May 31	July 17
	1994[2]	165	May 10 - August 12	May 27	July 9
	1993	106	May 5 - July 8	May 25	June 2
Lower Monumental	2000	243	April 16 - August 18	May 25	July 3
	1999	790	April 21 - July 20	May 26	June 19
	1998	253	May 5 - July 15	May 26	June 3
	1997	1,432	April 22 - August 6	May 27	June 15
	1996	232	May 6 - July 7	May 27	June 15
	1995	410	May 9 - July 13	June 6	June 16
	1994[1]	30	May 5 - August 5	June 3	July 17
	1994[2]	75	May 11 - August 24	June 18	July 21
	1993	92	May 7 - June 14	May 26	June 5
McNary	2000	58	May 3 - July 30	July 2	July 17
	1999	79	April 27 - July 8	May 28	May 31
	1998	31	May 13 - July 2	June 1	June 19
	1997	245	April 23 - August 12	May 27	June 18
	1996	30	April 27 - July 3	May 23	June 7
	1995	69	May 15 - July 17	June 5	June 27
	1994[1]	22	May 17 - July 14	June 5	July 10
	1994[2]	56	May 20 - July 11	June 17	July 8
	1993	7	May 11 - June 5	May 19	May 30

[1] NPT PIT tagged fish released at dark

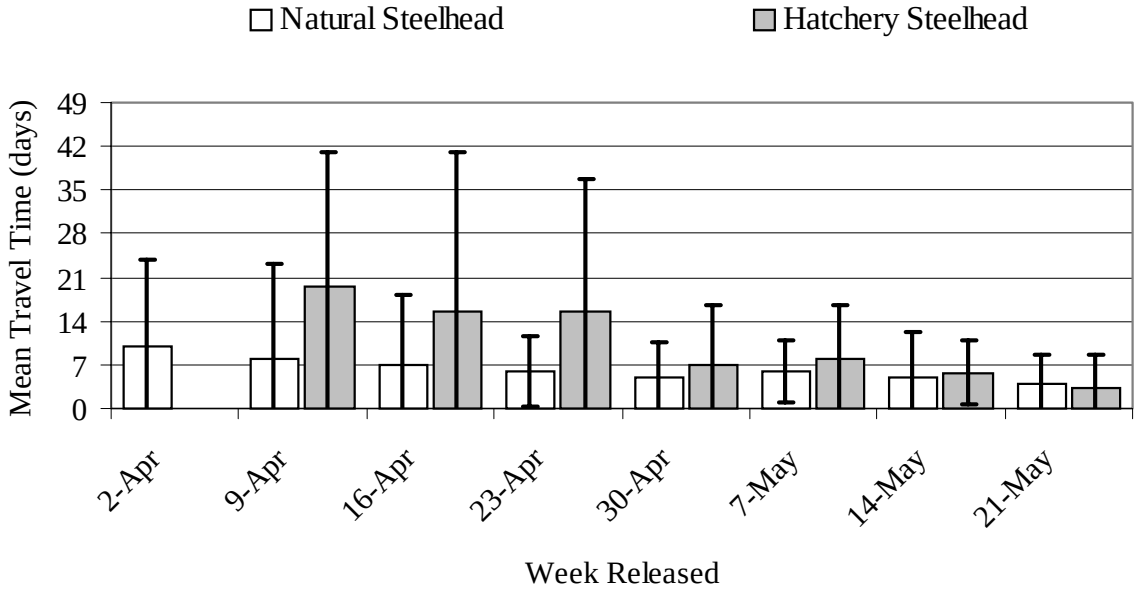
[1] FPC PIT tagged fish released after recovery

APPENDIX F

AVERAGE WEEKLY TRAVEL TIMES FOR NATURAL AND HATCHERY CHINOOK SALMON AND STEELHEAD



Appendix F. Figure F1. Mean travel times of natural and hatchery chinook salmon weekly PIT tag release groups from the lower Imnaha River trap to Lower Granite Dam, with 95% C.I., for 2000.



Appendix F. Figure F2. Mean travel times of natural and hatchery steelhead weekly PIT tag release groups from the lower Imnaha River trap to Lower Granite Dam, with 95% C.I., for 2000.

APPENDIX G

MORTALITY, FEBRUARY 26 TO JUNE 15

Appendix G. Table G1. The mortality at the Imnaha River juvenile fish trap, from February 26 to June 15, 2000. Mortality was due to either handling, trapping, or PIT tagging.

	Handling				Trapping				Tagging			
Date	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
24-Mar		2										
5-Apr	1	17										
13-Apr					7	102	20	90				
14-Apr						1						
18-Apr						6						
20-Apr					1							
22-Apr	1							1	1			
23-Apr									1	2		
25-Apr									1			
26-Apr						2						
27-Apr						1						
28-Apr												
29-Apr		1							1			
2-May	2	1		1								
3-May	2	7	4	4	1	2						
4-May												
5-May		1				4	3	2	1			
8-May									1			
10-May							1					
11-May									1			
16-May							1	1				
18-May									1		1	
19-May					1		2					
22-May									4			
25-May					1							
2-Jun	1											
5-Jun	3											
Totals	10	29	4	5	11	118	27	94	12	2	1	0

APPENDIX H

INCIDENTAL CATCH, MIGRATION YEAR 2000

Appendix H. Table H1. The catch of incidental fish during the fall, October 20 to November 24, and the spring, February 26 to June 15, at the upper and lower Imnaha River juvenile fish traps for the 2000 migration year.

Family	Common Name	Fall - Upper Trap	Fall - Lower Trap	Spring -Lower Trap	Total Catch
Salmonidae	Rainbow Trout / Steelhead	140	247	17	404
	Adult Steelhead (natural and hatchery)			36	36
	Mountain Whitefish	71	251	6	328
	Bulltrout	16	44	2	62
Centrarchidae	Smallmouth Bass		1		1
Catostomidae	Bridgelip Sucker		378	361	739
	Largescale Sucker			175	175
	Sucker (unidentified species)			5	5
Cyprinidae	Longnose Dace	4	4	587	595
	Specked Dace		1	3	4
	Chislemouth		1	25	26
	Redsided Shiner		43	13	56
	Northern Pikeminnow		21	12	33
Cottidae	Sculpin Species	5	16	31	52
	Total Catch	236	1,007	1,273	2,516