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

Annual Report
1997 - 1998

DOE/BP-30423-5

October 2000

This Document should be cited as follows:

Cleary, Peter, Michael Blenden, Paul Kucera, "Emigration of Natural and Hatchery Chinook Salmon and Steelhead Smolts from the Imnaha River, Oregon", Project No. 1997-01501, 150 electronic pages, (BPA Report DOE/BP-30423-5)

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P.O. Box 3621
Portland, Oregon 97208

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

Emigration of Natural & Hatchery Chinook Salmon & Steelhead Smolts from the Imnaha River, Oregon October 14, 1997 to June 16, 1998

1998 Annual Report

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and
U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan
Program Office
1387 Vinnell Way
Boise, Idaho 83709
Cooperative Agreement 1448-1410-98-J004

Project Number: 97-015-01
Contract Number: 97AM30423
Task Order Number: 98AT00792

October 2000

ABSTRACT

The Nez Perce Tribe has conducted emigration studies in the Imnaha River for seven years and has participated in the smolt monitoring program for the fifth consecutive year. Emigration studies were conducted for the purpose of the Lower Snake River Compensation Plan's hatchery evaluation and to collect information for the Fish Passage Center's (FPC) Smolt Monitoring Program; a basin-wide effort in the Columbia and Snake rivers. Rotary screw traps were used to capture emigrating juvenile chinook salmon and steelhead smolts at two sites, at river kilometer (rkm) 74 and 7, during the fall from October 14 to December 19. Rotary screw traps were fished during the spring from February 26 to June 16 at the lower site. Fish were tagged with PIT (passive integrated transponders) tags. PIT tagged fish were detected migrating past interrogation sites in the Snake and Columbia rivers and survival was estimated with the Survival Using Proportional Hazards model (program SURPH).

Imnaha River mean discharge during the fall ranged from 4.1 cms on December 3 to 9.5 cms on October 31 and the average daily water temperature ranged from 0.2 /C on December 5 to 10.7 /C on October 18. Imnaha River mean daily discharge during spring emigration ranged from 5.6 cms on March 11 to 168.9 cms on May 26 and water temperatures ranged from 2.7 /C on February 28 to 11.4/C on May 20. The Snake River mean daily discharge ranged from 916 cms (32,300 cfs) on March 9 to 4,672 cms (165,000 cfs) on May 27 and water temperatures ranged from 5.2/C on February 28 to 15.9 /C on June 14. Begining spill dates in the Lower Snake River ranged from March 5 at Ice Harbor Dam to March 24 at Lower Granite Dam. Continuous spill at LGR occurred from April 6 to June 21.

The fall catch totaled 2,232 natural chinook salmon and 24 natural steelhead at the upper trap site and 1,156 natural chinook salmon and 123 natural steelhead at the lower trap site. The spring trap catch totaled 4,195 natural chinook salmon, 17,837 hatchery chinook salmon, 3,569 natural steelhead, and 5,141 hatchery steelhead. A total of 93,127 hatchery chinook salmon were released from the chinook acclimation facility on April 6. There were two separate releases of hatchery steelhead of 86,422 and 30,674 fish occurring on April 26 and May 19 from the Little Sheep Creek Acclimation Facility. The fall catch of natural chinook salmon peaked at the upper and lower sites on October 22 and October 24, respectively. The spring catch of natural chinook salmon, hatchery chinook salmon, natural steelhead, and hatchery steelhead peaked on March 18, April 9, April 23, and April 27, respectively. Natural chinook salmon were captured throughout the entire study period. Ninety-seven percent of the sampled hatchery chinook salmon were captured within 11 days after release and capture dates ranged from April 7 to May 22. Natural steelhead were captured from March 10 to June 11. Hatchery steelhead were captured from March 22 to June 16.

PIT tagged fish interrogated (recaptured) at rkm 7 (lower trap) during the spring emigration totaled 150 natural chinook salmon, 3,371 hatchery chinook salmon, and 20 hatchery steelhead. Estimated, in-river, post-release survival of hatchery chinook salmon smolts from release at the acclimation facility to the lower trap was 88.4% based on PIT tag recaptures. This in-river survival estimate of hatchery chinook salmon from the acclimation site to the lower trap

was the lowest recorded since 1994.

Estimated season-wide survival of natural chinook salmon from release at the upper and lower sites during the fall was 45.9% and 60.4%, respectively. Season-wide survival of natural chinook salmon, hatchery chinook salmon, natural steelhead, and hatchery steelhead, from release at the lower trap site during the spring to Lower Granite Dam was estimated as follows: 85.2%, 75.7%, 86.0%, and 82.9%, respectively. The survival estimates for natural and hatchery chinook salmon were within the range of past estimates, and the cumulative interrogation percentages of unique PIT tags at Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, and McNary Dam were also within the range of past observations. The estimated survival for hatchery steelhead was the highest observed since 1995.

Weekly survival estimates from release during the spring to Lower Monumental Dam for natural chinook salmon ranged from 71.9 to 78.1%. Weekly survival estimates from release to Lower Monumental Dam for hatchery chinook salmon were 58.4% and 72.4%. Weekly survival estimates from release to Lower Monumental Dam for natural steelhead ranged from 60.6% to 74.9%. Weekly survival estimates from release to Lower Monumental Dam for hatchery steelhead were 63.9% and 57.5%.

Arrival times of natural chinook salmon tagged in the fall at the upper and lower Imnaha River trap sites at Lower Granite Dam, ranged from March 27 to June 6. The 90% arrival time for each group was May 9 and April 24, respectively. Natural chinook salmon tagged in the spring (lower site) had arrival times ranging from April 1 to June 27 at Lower Granite Dam and 90% arrived by May 6. The range of arrival dates at Lower Granite Dam for hatchery chinook salmon, natural steelhead, and hatchery steelhead were April 15-May 22, April 2-June 12, and April 25-July 29, and 90% percent arrived at Lower Granite Dam on May 9, May 22, and May 26, respectively.

Mean weekly travel times of natural chinook to Lower Granite Dam ranged from 8 to 29 days. Hatchery chinook traveled to Lower Granite Dam in 25 days during the week of April 5 and 26 days during the week of April 12. Natural chinook had significantly faster travel times to Lower Granite Dam than hatchery chinook during the week of April 12. The range of mean weekly travel times of natural steelhead to Lower Granite Dam was 3.6 to 37.7 days. The range of mean weekly travel times of hatchery steelhead to Lower Granite Dam was 2.4 to 7.7 days. Natural steelhead released during the weeks of April 26 and May 17 had significantly faster travel times to Lower Granite Dam than hatchery steelhead.

TABLE OF CONTENTS

ABSTRACT i

TABLE OF CONTENTS iii

LIST OF TABLES v

LIST OF FIGURES vii

APPENDIX TABLES AND FIGURES x

INTRODUCTION 1

METHODS 2
- Study Area Description 2
- Equipment Description 2
- Trap Operations 5
- Trap Efficiencies 6
- Biological Characteristics 7
- PIT Tagging 7
- Smolt Yield 8
- Survival Estimation 8
- Travel Timing to Trap Site and Lower Snake River Dams 9

RESULTS AND DISCUSSION 10
- Imnaha and Snake River Discharge, Temperature and Spill 10
- Trap Operation 10
- Emigration Timing and Trends at Trap Site 12
- Biological Characteristics 22
- PIT Tag Release Groups 27
- Emigration Timing and Trends of Previously PIT Tagged Fish 31
- Smolt Yield 31
- Estimated Smolt Survival 34
- Arrival Timing 43
- Travel Times 50
- Mortality 52
- Incidental Catch 54

SUMMARY 54

ACKNOWLEDGMENTS 59

LITERATURE CITED 60

Appendix A 62

Appendix B 70

Appendix C 77

Appendix D 83

Appendix E 87

Appendix F 91

Appendix G 94

Appendix H 101

Appendix I 108

Appendix J 111

Appendix K 113

Appendix L 119

Appendix M 121

LIST OF TABLES

Table 1. The targeted positions of the Imnaha traps for staff gauge heights from February 26 to June 16, 1998.....6

Table 2. Dates the screw traps were not operated during the spring study period, February 27-28 and March 4 -June 16, 1998.....12

Table 3. Summary of the weekly catch of species caught in the Imnaha screw trap during the spring of 1998. Chinook salmon and steelhead of unknown origin (n = 47) were omitted.....13

Table 4. The number and date of hatchery chinook salmon and steelhead released into the Imnaha River, with the number PIT tagged, and type of additional external and internal marks, in 1998.....14

Table 5. Mean and range of fork length (mm), weight (g), and condition factor for natural and hatchery chinook salmon and steelhead smolts collected at the Imnaha River screw trap from October 14 to December 19, 1997 and February 26-27 and March 4 to June 16, 1998.....24

Table 6. Weekly numbers of PIT tagged natural chinook salmon released into the Imnaha River from the upper and lower Imnaha screw traps from October 15 to December 19, 1997 29

Table 7. Weekly numbers of PIT tagged fish released into the Imnaha River from the lower Imnaha screw trap from February 26 to June 16, 1998 29

Table 8. Mean and range of fork length (mm), weight (g), and condition factor for natural and hatchery chinook salmon and steelhead smolts collected and PIT tagged at the Imnaha River screw trap from February 26 to June 16, 1998.....30

Table 9. The mean trap efficiency, PIT tag interrogation percentage and estimated survival from release to trap (bootstrap and SURPH) and release to Lower Granite Dam (LGR) for hatchery chinook salmon smolts from 1994 to 1998.....34

Table 10. Season-wide survival estimates from the upper and lower traps to Lower Granite Dam (LGR), Lower Granite Dam to Little Goose Dam, (LGO), Little Goose Dam to Lower Monumental Dam (LMO), and Lower Monumental Dam to McNary Dam (MCN) for fish released from October 14 to December 16, 1997 at the upper and lower Imnaha traps and February 26 to June 16 at the lower trap.....35

Table 11. Estimated survival probabilities for salmonid smolts released from the lower Imnaha River trap from February 26 to June 16, 1998 with 95% confidence limits in parentheses. Estimates are from release to the tail race for the trap to Lower Granite Dam and tailrace to the tail race for all other sites. Abbreviations: LGR-Lower Granite Dam, LGO-Little Goose Dam, LMO-Lower Monumental Dam.....41

Table 12. Arrival timing of PIT tagged Imnaha River natural chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to1998.....44

Table 13. Arrival timing of PIT tagged Imnaha River hatchery chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary Dams from 1992 to1998.....47

Table 14. Arrival timing of PIT tagged Imnaha River natural steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary Dams from 1993 to 1998.....48

Table 15. Arrival timing of PIT tagged Imnaha River hatchery steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 1998.....49

Table 16. Mortality of chinook salmon and steelhead smolts due to trapping, handling, and PIT tagging from February 26 to June 16, 1998.....52

LIST OF FIGURES

Figure 1. Map of the Imnaha River study area. The mouth of the Imnaha River is 308 river kilometers upstream from Lower Granite Dam (not shown on map).....3

Figure 2. The Lower Imnaha trap site with two rotary screw traps operating. The traps are in position 3. Trap A is on the left and trap B is on the right.....4

Figure 3. Mean daily discharge (USGS Gauge 13292000 at Imnaha, OR) and mean daily water temperature of the Imnaha River during the spring trapping period, February 26 to June 16, 1998.....11

Figure 4. Mean daily discharge (USGS Gauge 13334300 at Anatone, WA) and mean daily water temperature of the Snake River during the spring trapping period, February 26 to June 16, 1998.....11

Figure 5. The daily catch of natural chinook salmon at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from October 14 to December 19, 1997.....16

Figure 6. The daily catch of natural chinook salmon at the lower trap and daily average temperature at rkm 7, from October 14 to December 19, 1997.....16

Figure 7. The daily catch of natural steelhead at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from October 14 to December 19, 1997. 17

Figure 8. The daily catch of natural steelhead at the lower trap and daily average temperature at rkm 7, from October 14 to December 19, 1997.....17

Figure 9. The daily catch of natural chinook salmon at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.....18

Figure 10. The daily catch of natural chinook salmon at the lower trap and daily average temperature at rkm 7, from February 26 to June 16, 1998.....18

Figure 11. The daily catch of hatchery chinook salmon at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.....19

Figure 12. The daily catch of hatchery chinook salmon at the lower trap and daily average temperature at rkm 7, from February 26 to June 16, 1998.....19

Figure 13. The daily catch of natural steelhead at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.....20

Figure 14. The daily catch of natural steelhead at the lower trap and daily average temperature at rkm 7, from February 26 to June 16, 1998 20

Figure 15. The daily catch of hatchery steelhead at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.....21

Figure 16. The daily catch of hatchery steelhead and daily average temperature at rkm 7, from February 26 to June 16, 1998.....21

Figure 17. Length frequency of natural chinook salmon trapped in the upper and lower Imnaha River traps, October 14 to December 19, 1997.....23

Figure 18. Length frequency of natural steelhead smolts (and rainbow trout) trapped in the upper and lower Imnaha River traps, October 14 to December 19, 1997.....23

Figure 19. Length frequency of natural and hatchery chinook salmon smolts trapped in the lower Imnaha River, February 26 to June 16, 1998.....25

Figure 20. Length frequency of natural and hatchery steelhead smolts trapped in the lower Imnaha River, February 26 to June 16, 1998. 25

Figure 21. Mean fork lengths and condition factors for natural chinook salmon captured in the Imnaha screw traps, February 26 to June 16, 1998.....26

Figure 22. Mean fork lengths and condition factors for hatchery chinook salmon captured in the Imnaha screw traps, February 26 to June 16, 1998.....26

Figure 23. Mean fork lengths and condition factors for natural steelhead captured in the Imnaha screw traps, February 26 to June 16, 1998.....27

Figure 24. Mean fork lengths and condition factors for hatchery steelhead captured in the Imnaha screw traps, February 26 to June 16, 1998. 28

Figure 25. The number of previously PIT tagged natural chinook salmon captured from February 26 to June 16, 1998. Dashed lines represent a departure from the scale of the x axis.....32

Figure 26. The number of previously PIT tagged hatchery chinook salmon captured from February 26 to June 16, 1998. Dashed lines represent a departure from the scale of the x axis...32

Figure 27. The arrival frequency of previously PIT tagged natural chinook salmon, released from October 15 to November 15 at the upper trap and hatchery chinook salmon, released at the acclimation facility April 6, at the lower Imnaha traps during the spring of 1998.....33

Figure 28. Season-wide survival estimates for natural chinook salmon released from the Imnaha River trap to Lower Granite Dam, from 1993 to 1998. Error bars indicate 95% confidence limits. Asterisks indicate upper confidence levels greater than 100%.....37

Figure 29. Season-wide survival estimates for hatchery chinook salmon released from the Imnaha River trap to Lower Granite Dam, from 1994 to 1998. Error bars indicate 95% confidence limits.....37

Figure 30. Season-wide survival estimates for natural steelhead released from the Imnaha River trap to Lower Granite Dam, from 1995 to 1998. Error bars indicate the 95% confidence limit.....38

Figure 31. Season-wide survival estimates for hatchery steelhead released from the Imnaha River trap to Lower Granite Dam, from 1995 to 1998. Error bars indicate the 95% confidence limit.....38

Figure 32. Estimated survival of natural and hatchery reared chinook salmon smolts released at the Imnaha River trap to Lower Monumental Dam from 1993 to 1998 and 95% confidence intervals. Confidence intervals were not available for the 1997 estimates (after Smith et al. 1998, cited in Kucera, 1998).....40

Figure 33. Estimated mortality of hatchery reared chinook salmon smolts, by stream reach, from release at the Imnaha River acclimation facility to Lower Monumental Dam from 1994 to 1998 (after Smith et al. 1998, cited in Kucera 1998).....42

Figure 34. Season-wide mortality of natural and hatchery reared chinook salmon and steelhead smolts, by stream reach, from release at the Imnaha River trap to McNary Dam in 1998.....43

Figure 35. Mean travel times of natural chinook salmon (top) and hatchery chinook salmon (bottom) weekly PIT tag release groups from the lower Imnaha trap to LGR with 95% confidence intervals, in 1998. Asterisks indicate confidence intervals greater than 42 days.....51

Figure 36. Mean travel times of natural steelhead (top) and hatchery steelhead (bottom) weekly PIT tag release groups from the lower Imnaha trap to LGR with 95% confidence intervals, in 1998.....53

APPENDIX TABLES AND FIGURES

Table A. The mean daily discharge and standard deviation estimated from provisional data collected at the USGS gauging site 13292000 at Imnaha, Oregon and the mean daily average, maximum, and minimum water temperatures at the lower site during the fall, October 14 to December 19, 1997 and spring, February 26 to May 24, 1998. 63

Table B. The mean daily discharge and standard deviation and mean, maximum and minimum water temperature estimated from provisional data collected at the USGS gauging site 13292000 at Anatone, Washington, on the Snake River, January 1 to July 1, 1998. 71

Table C. The average total discharge, average turbine discharge, and average total spill (Kcfs) for Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams from March 1 to June 30, 1998. Daily averages were calculated from midnight to midnight. 78

Table D. A summary of the daily catch of natural reared chinook salmon and steelhead captured in the upper and lower Imnaha screw traps from October 14 to December 19, 1997 84

Table E. A summary of the daily catch of natural and hatchery reared chinook salmon and steelhead captured in the Lower Imnaha River screw traps from February 26 to June 16, 1998. 88

Table F. T-test values and sample sizes (n) for seven statistical comparisons of mean fork lengths of natural and hatchery chinook salmon and steelhead in the fall of 1997 and spring of 1998 and one comparison of mean travel times of natural and hatchery chinook salmon and steelhead from the lower Imnaha River trap to Lower Granite Reservoir in 1998. 92

Table G. Daily mean fork lengths (MFL), weights, and condition factors with standard deviations (STD) for natural and hatchery chinook salmon and steelhead captured in the Imnaha River screw traps during the spring emigration of 1998. 95

Table H. A summary of individual PIT tag release group release dates, number released, and mean fork lengths and weights with standard deviations for natural and hatchery chinook salmon and steelhead released February 26 to June 16, 1998 from the lower Imnaha Trap. 102

Table I. Wilcoxon test values and sample sizes (n) for four statistical comparisons of median fork lengths of natural and hatchery chinook salmon and steelhead in the spring of 1998 and five comparisons of median travel time of natural and hatchery chinook salmon and steelhead from the lower Imnaha River trap to Lower Granite Reservoir in 1998. 109

Table J. Daily trap efficiencies conducted from April 9 to April 17, 1998, for hatchery chinook salmon released on April 6 into the Imnaha River above the lower Imnaha Trap. 112

Table K. First observations of PIT tagged natural and hatchery chinook salmon and steelhead released at the Imnaha Trap at the Snake and Columbia River Dams in 1998. Sites are abbreviated as follows: Lower Granite Dam (LGR), Little Goose Dam (LGO), Lower Monumental Dam (LMO), and McNary Dam (MCN). 114

Table L. Cumulative interrogations of spring PIT tagged Imnaha River natural and hatchery chinook salmon and steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary (MCN) dams from 1993 to 1998 and SURPH survival estimates from trap to MCN. 120

Figure M-1. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the upper site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 122

Figure M-2. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the upper site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 123

Figure M-3. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 124

Figure M-4. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 125

Figure M-5. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 126

Figure M-6. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 127

Figure M-7. Daily arrival timing frequency of hatchery chinook salmon, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 128

Figure M-8. Daily arrival timing frequency of hatchery chinook salmon, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 129

Figure M-9. Daily arrival timing frequency of natural steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 130

Figure M-10. Daily arrival timing frequency of natural steelhead, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 131

Figure M-11. Daily arrival timing frequency of hatchery-adipose-left-ventral clipped steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 132

Figure M-12. Daily arrival timing frequency of hatchery-adipose-left-ventral clipped steelhead, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 133

Figure M-13. Daily arrival timing frequency of hatchery-adipose-clipped steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 134

Figure M-14. Daily arrival timing frequency of hatchery-adipose-clipped steelhead, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. 135

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 1998 smolt migration from the Imnaha River, Oregon. These studies were designed and closely coordinated to provide information about juvenile natural and hatchery chinook salmon and steelhead 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 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 (*Oncorhynchus tshawytscha*) and steelhead smolts (*Oncorhynchus mykiss*) from the Imnaha River during the spring emigration period (March 15 - June 5) with PIT tags. Additional funds were provided by the United States Fish and Wildlife Service to compare migration timing and survival of Imnaha natural chinook salmon captured during the fall (October 14 to December 19) in the upper and lower Imnaha River. Natural chinook salmon captured during the fall in the upper Imnaha River are assumed to overwinter in the Imnaha River and natural chinook captured in the lower Imnaha River are assumed to be migrating to overwinter in the Snake River.

The completion of trapping in the spring of 1998 marked the seventh year of emigration studies on the Imnaha River and the fifth year of participation in the FPC smolt monitoring program. Monitoring and evaluation objectives were to:

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

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

3. Monitor the abundance 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 lower Imnaha River traps.

5. Estimate the post-release survival of hatchery reared chinook salmon smolts in the Imnaha River.

6. Determine arrival timing, travel time and recovery rate, or cumulative tag interrogations, (as an index of minimum smolt survival) and estimated survival of hatchery chinook salmon and natural and hatchery steelhead smolts PIT tagged from the Imnaha River traps to Snake and Columbia river dams.

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). The water diverted from Big Sheep Creek is 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 14.6 cms (515 cfs) at Imnaha, Oregon, USGS gauge 13292000. The minimum discharge, 0.5 cms (16 cfs) was observed November 22, 1931. The maximum river discharge, 572.0 cms (20,200 cfs) 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 1.5 m diameter cone, was used at the upper site in the fall.

Water temperature information for this study was collected using a constant recording

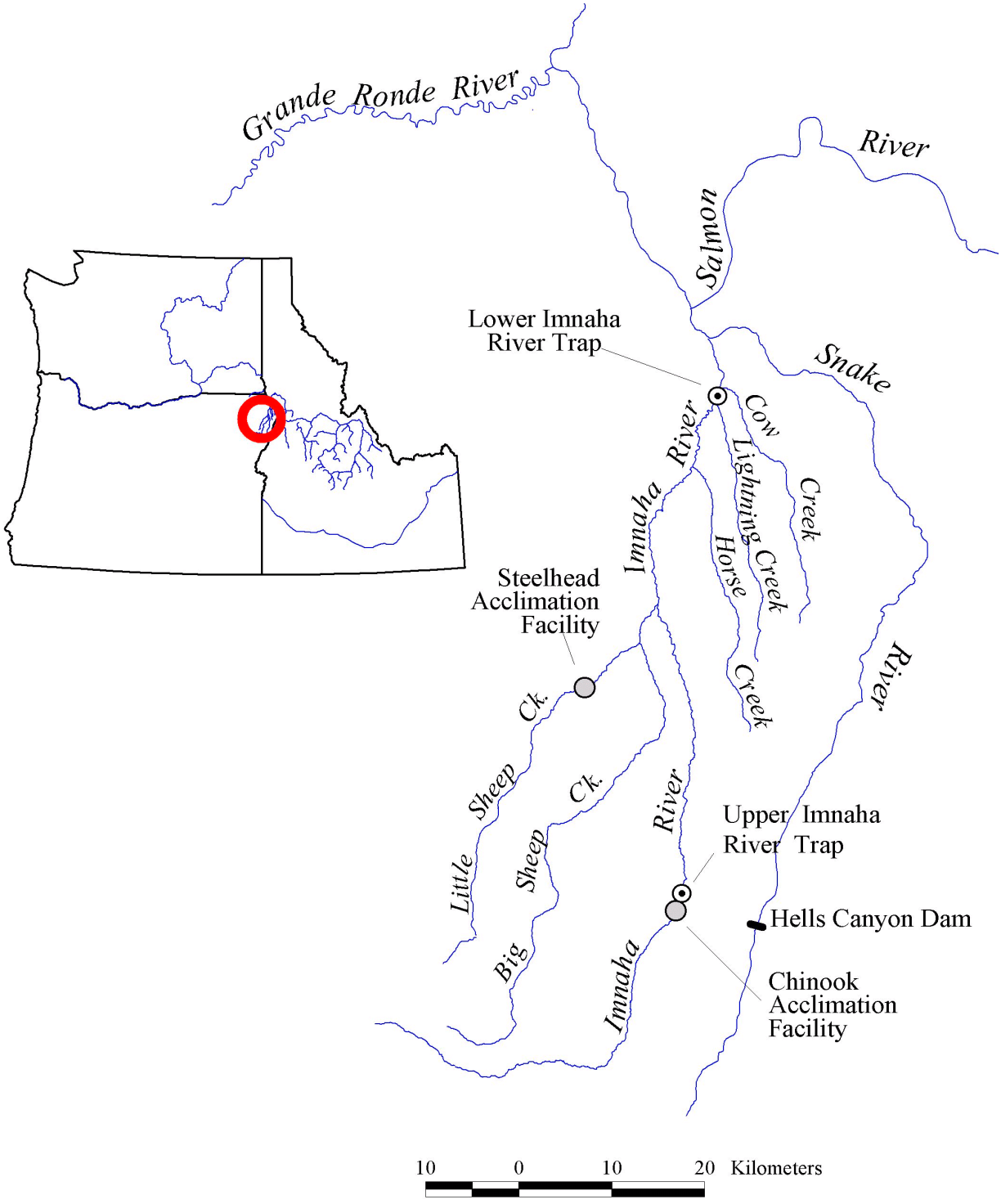

Figure 1. Map of the Imnaha study area. The mouth of the Imnaha River is 135 river kilometers upstream from Lower Granite Dam (not shown on map).

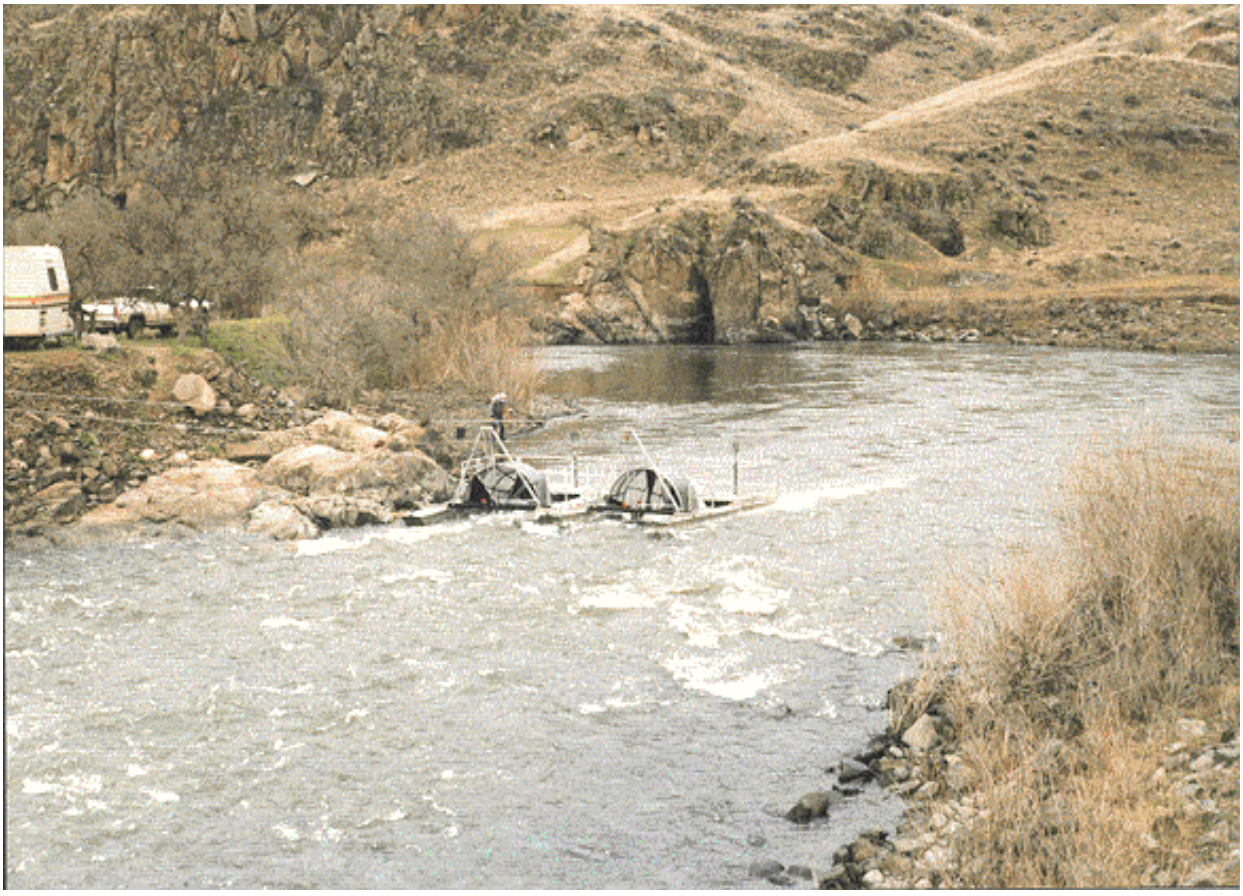

Figure 2. The lower Imnaha trap site with two rotary screw traps operating. The traps are in position 3. Trap A is on the left and trap B is on the right.

Ryan TempMentor which was located approximately 150 m upstream from the screw trap. Temperatures were collected until the end of May when the TempMentor was washed downstream and recovered in Asotin, Washington. Data from the Ryan TempMentor is valid up to May 24. Discharge information used in this report was provided by the U.S. Geological Survey, USGS gauge 13292000 at Imnaha, Oregon (rkm 32). The data is collected every half hour and was considered provisional. Water discharge and temperature information was provided by the USGS for the Anatone stream gauge, 13334300.

Data summarizing the average total discharge, average turbine discharge, and average total spill for the Snake and Columbia river dams, from January 1 to October 1 was obtained from the Fish Passage Center (H. Franzoni, personal communication). Data was summarized daily from midnight to midnight. Daily peak discharge and spills were determined from March 1 to June 30 for Lower Granite Dam (LGR), Little Goose Dam (LGO), Lower Monumental Dam (LMO), Ice Harbor (IHR) and McNary Dam (MCN). The daily averages for the total spill at each dam were summed from March 1 to June 30 to determine the total spill, at each site, for the 1998 migration. Average total spill data was summarized from March 1 to June 30 because we

expected that the majority of the Imnaha smolts would be passing though the migration corridor during that period.

Trap Operations

The upper Imnaha River trap was located at rkm 74 (0.4 rkm) downstream of the Imnaha River chinook salmon acclimation facility. This trap was fished from October 15 to November 15, 1997 (15 days). The lower Imnaha River screw trap was operated from October 14 to December 19, 1997 (43 days) and from February 26-27 and from March 4 to June 16, 1998. The SMP portion began on March 15 and was completed June 5. A second trap was deployed on March 9 for the purpose of increasing the catch of natural chinook salmon. The second trap operated until March 23. The second trap was deployed again during the following periods: April 1 to April 6, April 20 to April 23, May 11 to May 13, and May 18 to May 19. Normally, the screw traps were operated five days per week from Sunday evening through Friday morning. Exceptions occurred on several occasions when trap repair was necessary or high flows or debris load in the river prevented safe trap operation. During the release of hatchery chinook salmon one trap was operated continuously for 12 days.

The screw traps were secured on the west bank of the Imnaha River, below the Cow Creek bridge, 6.6 kilometers from the confluence with the Snake River. When two traps were fished they were positioned side by side with the trap nearest to the east bank staggered one meter downstream. Trap positions in the river were adjusted by manipulating a cable suspension system which allowed side to side and upstream/downstream movement of the traps. This allowed the trap to be backed slightly out of the main current and fished during high flows.

As in past years we attempted to position the trap according to the staff gauge height (Table 1). Heavy debris loads and high water velocities forced a change in protocol that created a fourth position a meter downstream of position 3. The trap was never fished in position 2. Stream gauge readings for positions 3 and 4 overlapped on 14 of 36 occasions. Distances between the position 1 and 4 ranged from one to three meters. 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 presumed advantage of positioning the trap upstream was increased trap efficiencies. The disadvantage, as learned from empirical knowledge, is that water velocities tend to pin small debris in the cone of the traps and sink them. The overlap in stream gauge height allowed trap personnel to safely fish the trap in a position farther downstream position during the early spring when freshets washed out debris and position traps farther upstream in late spring after the early spring freshets had cleared debris from the stream banks. The traps positions were 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. Tagging records for chinook salmon and steelhead were recorded in the same PIT tagging

Table 1. The targeted positions of the Imnaha traps for staff gauge heights from February 26 to June 16, 1998.

Staff Gauge (cm)	Position Reported to the Fish Passage Center	Distance from Position One (m)	Minimum Gauge Height of Operation (cm)	Maximum Gauge Height of Operation (cm)
> 90	1	0	36	80
	2	1	NA	NA
90 - 100	3	2	62	126
< 100	4	3	86	119

file to reduce the amount of handling and stress to the fish.

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) 300 to 100 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.

Trap Efficiencies

No trap efficiency trials were conducted at the upper or lower trap site during the fall trapping period because the goal for fall trapping was to tag 2,000 natural chinook salmon to get arrival timing and survival estimates to mainstem dams. Efficiency trials for hatchery chinook salmon were conducted nine times. 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 by clipping the distal portion of the fins. The following fin clips were used on a daily basis, Sunday through Saturday respectively: upper and lower caudal, upper caudal, lower caudal, left pelvic, right pelvic, left pectoral, and 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 the release site 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 5mm classes from 75 to 310mm. Fish were considered to be within the range of a class when it was less than or equal to the class but greater than the previous class. 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 smolt length, weight and condition factor calculations and were reported to the FPC as resident rainbow trout.

All statistics were performed with STATGRAPHICS PLUS version 2 software (Statgraphics Plus 1995). Standard skewness values were determined for each sample. Samples with standard skewness values between -2 and +2 were considered to have normal distributions. Samples with standard skewness values less than -2 or greater than +2 were considered to have non-normal distributions. A student's t-test was used to test for significant differences in fork length between various groups of fish with normal distributions (natural vs. hatchery 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 $p < 0.05$. If a samples had a non-normal distribution, the t-test was abandoned in favor of the Wilcoxon rank sum test statistic, which compared medians (Ott 1984). Differences were considered significant at $p < 0.05$.

PIT Tagging

Fish selected for passive integrated transponder (PIT) tagging were examined for previous PIT tags, descaling and general health before being tagged, measured (fork length-mm) and weighed (0.1 g). For chinook salmon, only fish greater than 65 mm were selected for tagging. Chinook salmon were not tagged if they had mortal wounds, deformations, or excessive descaling. Steelhead greater than 120 mm were targeted for tagging regardless of condition. Fish were PIT tagged using hand injector units following the general methods described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Hypodermic injector units were sterilized after each use in ethanol for at least 10 minutes prior to tagging. PIT tags were also sterilized for 10 minutes and allowed to air-dry prior to their use. Tagging was discontinued when water temperatures exceeded 15 ˚C.

Weekly PIT tagging goals for the fall targeted 500 natural chinook salmon per week at the upper and lower trap for a four week period, or 2,000 natural chinook salmon per site. We were unable to reach the tagging goal during the fall at the lower trap over ten weeks of trapping.

Weekly PIT tagging goals for the spring were a combination of FPC and LSRCP goals to meet specific objectives. These goals were modified as the season progressed based upon catch and interruptions in trapping due to equipment repairs. The combined seasonal goals of the FPC and LSRCP studies were as follows: 9,600 natural chinook salmon tagged over a 10 week period, 2,000 hatchery chinook salmon tagged over a two week period, 4,400 natural steelhead tagged

over a 7 week period, and 5,200 hatchery steelhead tagged over a 6 week period.

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 as a group after dark. The latter methodology is a standard practice employed to allow chinook salmon smolts to recover from tagging stress and increase predator avoidance and survival through night time release. Mortality due to tagging, trapping, or handling was recorded.

Tagging files were validated using the PITVAL2 software program. Tagging and interrogation files were submitted to the Pacific States Marine Fisheries Commission (PSMFC) PIT Tag Information System (PTAGIS) database via modem within a 48 hour period following tagging. PIT tag interrogation data were downloaded from the PTAGIS database.

Smolt Yield

Smolt yield was estimated by two separate methods. Interrogations of previously PIT tagged fish at the trap and Snake and Columbia River dams provide unique capture histories. These capture histories enabled us to calculate survival by the Cormack, Jolly, Seber methodology as stated in the methods for survival estimation. Smolt yield was also determined for the period using the bootstrap method (Efron and Tibshirani 1986). Daily emigration numbers were estimated by: $N = U/E$; where N is estimate of total number of emigrants, and U is number of unmarked fish and E is the trap efficiency. Bootstrap period estimates (N_p) were calculated by: $N_p=U_p/E_p$; where U_p is the total number of unmarked fish captured during the period and E_p is the mean trap efficiency for the period.

Survival Estimation

Survival was estimated by the Cormack, Jolly, and Seber methodology, also known as the "Jolly-Seber model," with the Survival Using Proportional Hazards (SURPH) program (Smith et. al., 1994). Fish were sorted into weekly release groups. Each weekly release group was treated as a single release. The SURPH model uses repeated detections of individually tagged fish through four lower Snake River dams and Columbia River dams and analysis of their capture histories provides estimates of their survival. Only weekly release groups of 200 or more fish were analyzed for survival on a weekly basis. Season-wide estimates, using a single release model, were calculated using all PIT tagged fish for each species and rearing type. Season wide estimates served as indices to compare survival between years and to cumulative interrogations.

The data files for release groups were created using the program CAPTHIST (Westhagen 1997). Capture histories identified fish which were loaded onto a barge or for which an exit point from a fish bypass facility could not be determined. Survival estimates do not include fish which had negative travel times or single coil detections. SURPH calculates standard errors for each estimate. The SURPH model can produce survival estimates which are greater than one. These estimates generally reflect an underestimation of survival in previous reaches. Estimates for multiple reaches were calculated as the product of individual reach estimates.

Travel Timing to Trap Site and Lower Snake River Dams

Emigration timing of natural and hatchery chinook salmon and steelhead smolts, at the trap sites, were determined by daily collection numbers. Arrival timing and travel time of PIT tagged hatchery chinook salmon smolts released at the Imnaha River acclimation facility and hatchery steelhead smolts released at the Little Sheep Creek acclimation facility was determined by daily collection numbers and PIT tag interrogation at the screw trap site.

Arrival timing, travel time and cumulative interrogation percentages to LGR, LGO, LMO, and 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 fish were pooled weekly to determine travel time to LGR. First time PIT tag observations, from all main interrogation sites, were used to calculate and report the cumulative interrogation percentages to LGR by species and rearing. Cumulative interrogation percentages of each species was determined by dividing the sum of first tag code observations by the total number of fish tagged and released.

Travel time estimates to LGR do not include fish captured in the Snake River trap. Differences in mean travel time, from weekly PIT tag release groups, were analyzed by means of a t-test (Statgraphics Plus 1995) as in 1997 (Blenden et al. 1998) if the standard skewness values were within ±2. Differences in means were tested and considered significant at the 0.05 level. If a sample's standard skewness values was outside the range of ±2 it was considered to have a non-normal distribution and the t-test was abandoned in favor of the Wilcoxon rank sum test statistic (Ott 1984). This test compared median travel times between hatchery reared and naturally produced smolts.

RESULTS AND DISCUSSION

Imnaha and Snake River Discharge, Temperature and Spill

During the fall 1997 trapping period, Imnaha River discharge ranged from 4.1 cms (145 cfs) on December 3 to 9.5 cms (335 cfs) on October 31. Mean daily water temperature at the lower Imnaha River trap site during the fall trapping period ranged from 0.2 /C on December 5 to 10.7 /C on October 18. Imnaha River mean daily discharge during spring emigration ranged from 5.6 cms (199 cfs) on March 11 to 168.9 cms (5,964 cfs) on May 26 at USGS gauge 13292000, Imnaha, OR (Figure 3). Mean daily water temperatures during the spring period ranged from 2.7 /C on February 28 to 11.4/C on May 20 (Figure 3). Appendix A contains the mean daily discharge readings and daily minimum, maximum and mean water temperatures during the study period. The Snake River mean daily discharge during the spring emigration ranged from 916 cms (32,300 cfs) on March 9 to 4,672 cms (165,000 cfs) on May 27 at USGS gauge13334300, Anatone, WA.(Figure 4). Mean daily water temperatures during the study period ranged from 5.2/C on February 28 to 15.9 /C on June 14. Appendix B contains the mean daily discharge readings and daily minimum, maximum and mean water temperatures during the study period for the Snake River.

IHR spill occurred March 5 through March 7, March 9, March 24 through March 29, and April 6 through June 30. The minimum amount of water spilled at IHR during spill periods was 3.74 Kcfs on March 29 and the maximum spill was 132.31 Kcfs on May 28. Spill at LMO occurred March 9, March 24 through March 27, March 31, and April 6 to June 23. The minimum amount of spill at LMO during these periods was 0.05 Kcfs on June 1 and the maximum spill was 120.48 Kcfs on May 28. LGO spilled March 15 through March 16, March 24 through March 27, and April 6 through June 20. The minimum amount of spill at LGO during these periods was 0.08 Kcfs on March 16 and the maximum spill was 98.36 Kcfs on May 27. Spill at MCN ranged from March 17 through March 19, March 21, March 24 through March 28, March 31, and April 20 to June 30. The minimum amount of spill at MCN during these periods was 2.07 Kcfs on March 24 and the maximum spill was 251.0 Kcfs on May 29. LGR was the last dam to initiate spill on March 24. Spill occurred until March 27 and continuous spill occurred April 6 through June 21. The minimum amount of spill at LGR during these periods was 0.02 Kcfs on June 21 and the maximum spill was 109.4 Kcfs on May 27. The daily average total discharge, average turbine discharge, and average total spill for the previously mentioned sites from March 1 to June 30 is presented in Appendix C.

Trap Operation

The Imnaha River screw trap was operated for 69 days during the 112 day spring emigration period. The trap was scheduled to operate 5 days per week from February 26 to June 16 except during the release of hatchery chinook salmon. Of the scheduled days, only nine were missed. One of the days missed was the result of damage to the trap and eight were the result of high flows (Table 2).

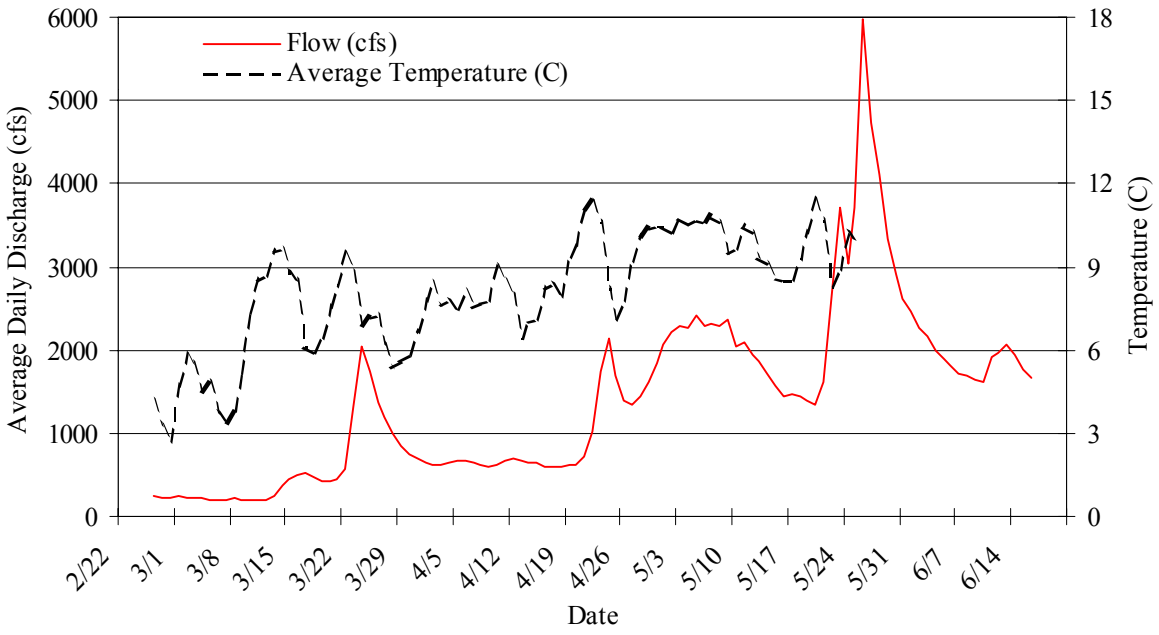

Figure 3. Mean daily discharge (USGS Gauge 13292000 at Imnaha, OR) and mean daily water temperature of the Imnaha River during the spring trapping period, February 26 to June 16, 1998.

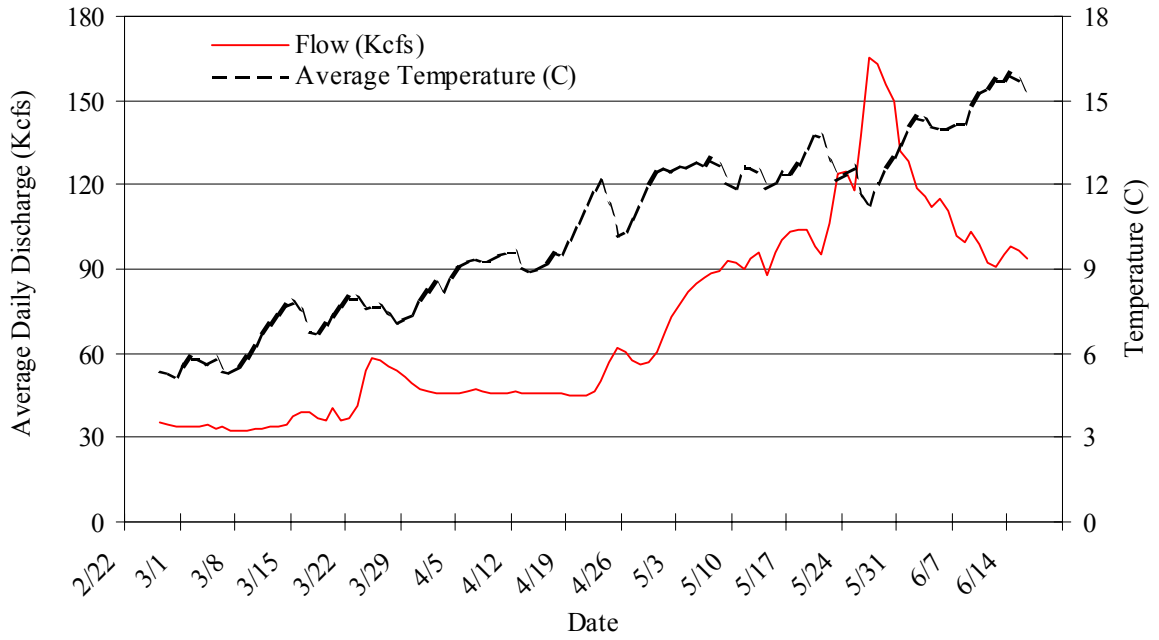

Figure 4. Mean daily discharge (USGS Gauge 13334300 at Anatone, WA) and mean daily water temperature of the Snake River during the spring trapping period, February 26 to June 16, 1998.

Table 2. Dates the screw traps were not operated during the spring study period, February 27-28 and March 4 -June 16, 1998.

Dates Not Fished	Reason Trap Not Fished	Scheduled Days Missed
02/28 - 03/03	Extended Weekend	
03/07	Weekend	
03/14	Weekend	
03/24	Trap Damage	1
03/28	Weekend	
04/04 - 04/05	Weekend	
04/18	Weekend	
04/24 - 04/25	High Flows	1
05/02 - 05/03	Weekend / High Flows	1
05/09	Weekend	
05/16	Weekend	
05/23 - 05/31	Weekend / High Flows	6
06/06	Weekend	
06/13	Weekend	

Emigration Timing and Trends at Trap Site

A total of 2,232 natural chinook salmon and 24 natural steelhead juveniles were captured at the upper Imnaha River trap from October 15 to November 15, 1997. The highest single days catch for natural chinook salmon was 361 fish on October 22. Appendix D contains daily details of the catch at the upper and lower sites from October 14 to December 19, 1997. A total of 1,516 natural chinook salmon and 123 natural steelhead juveniles were captured at the lower Imnaha River trap from October 14 to December 19, 1997. The catch of natural chinook salmon peaked twice with 108 fish sampled on October 24 and 102 fish captured on October 31. The catch of natural steelhead peaked with 40 fish on October 31, which coincided with a spike in discharge of 335 cfs and an increase in mean water temperature from 6.0°C on October 26 to 9.6°C on October 31(Appendixes A and D).

A total of 4,195 natural chinook salmon, 17,837 hatchery chinook salmon, 3,569 natural steelhead and 5,141 hatchery steelhead smolts were captured in the Imnaha River screw trap during the study period (Table 3). An additional 431 non-target fish were captured. The total

catch of target and non-target fish was 31,173 fish. Appendix E contains daily catch summaries of natural and hatchery chinook salmon and steelhead from February 26 to June 16, 1998. Natural chinook salmon were collected throughout the study period and comprised 13.5% of the total catch. The peak period of natural chinook salmon smolt collection occurred from March 15 to March 23.

Table 3. Summary of the weekly catch of species caught in the Imnaha screw trap during the spring of 1998. Chinook salmon and steelhead of unknown origin (n = 47) were omitted.

Week	Natural Chinook salmon	Hatchery Chinook salmon	Natural Steelhead	Hatchery Steelhead
02/22/98 - 02/28/98	15	0	0	0
03/01/98 - 03/07/98	14	0	0	0
03/08/98 - 03/14/98*	20	0	1	0
03/15/98 - 03/21/98*	1,789	0	61	0
03/22/98 - 03/28/98*	299	0	65	2
03/29/98 - 04/04/98*	640	0	252	0
04/05/98 - 04/11/98*	269	10,246	86	0
04/12/98 - 04/18/98	472	6,991	185	1
04/19/98 - 04/25/98*	484	521	1,093	8
04/26/98 - 05/02/98	74	57	570	2,273
05/03/98 - 05/09/98	5	7	166	178
05/10/98 - 05/16/98*	59	10	359	663
05/17/98 - 05/23/98*	49	5	717	1,835
05/24/98 - 05/30/98	-	-	-	-
05/31/98 - 06/06/98	2	0	12	48
06/07/98 - 06/13/98	2	0	2	109
06/14/98 - 06/20/98	2	0	0	24
Catch	4,195	17,837	3,569	5,141

* Two traps were fishing for one or more days.

The Oregon Department of Fish and Wildlife (ODFW) released 93,127 hatchery reared chinook salmon smolts into the Imnaha River from the Imnaha River acclimation facility (rkm 73) on April 6 (Mike Flesher, personal communication, ODFW database information). Of these, 19,827 smolts were PIT tagged prior to release (Table 4). Hatchery chinook salmon smolts comprised 57.2% of the total catch. Hatchery chinook salmon smolts were first captured on April 7, one day after the release. Approximately 97% (17,237) of the hatchery chinook salmon trapped were captured within 11 days of release. Small numbers of hatchery chinook salmon smolts were caught through mid-May (Appendix E).

Emigrating natural steelhead smolts were captured from March 10 to June 11. Natural steelhead comprised 11.4% of the total catch. Natural steelhead catch peaked on April 23 with a catch of 578 fish (Appendix E). Very few natural steelhead smolts were captured during June.

ODFW released 117,096 hatchery reared steelhead smolts into the Imnaha River subbasin, at the Little Sheep acclimation facility (rkm 45) in two groups (Table 4). Smolts released on April 26 had adipose and left ventral fin clips with coded wire tags and 867 PIT tags. The release group of May 19 were adipose fin clipped and none were PIT tagged. Thirty one percent of the hatchery reared steelhead smolts captured in the Imnaha traps occurred between May 9 and May 23 (Table 3). Hatchery steelhead comprised 16.5% of the total catch. Only 4.4% of the hatchery steelhead smolts released were captured. The low percentage of hatchery fish captured may have resulted from mean discharge greater than 2,000 cfs from May 1 to May 11 affecting the ability to efficiently operate the traps. Additionally, peak discharge from May 23 to May 31 caused us to miss six days of trapping and may have enticed the majority of the remaining hatchery reared steelhead to emigrate.

Table 4. The number and date of hatchery chinook salmon and steelhead released into the Imnaha River, with the number PIT tagged, and type of additional external and internal marks, in 1998.

Species	Date of Release	Number Released	Number PIT tagged	Mark Type
Chinook Salmon	04/06/98	93,127	19,827	AD[1], CWT[2]
Steelhead	04/26/98	86,422	867	AD[1], LV[3], CWT
Steelhead	05/19/98	30,674	0	AD[1]
Chinook Salmon Totals		93,127	19,827	
Steelhead Totals		117,096	867	

[1] adipose fin clip
[2] coded wire tag
[3] left ventral fin clip

The fall catch of natural chinook salmon at the lower site peaked on October 24, 7 days prior to the October 31 peak fall flow of 335 cfs with a catch of 108 fish (Figure 5). The second highest catch day (n = 102) occurred on October 31. Fall water temperatures during both pulses of fish were greater than 8°C (Figure 6). The fall catch of natural steelhead peaked with the October 31 increase in flow to 335 cfs and when water temperatures were greater than 8°C (Figure 7 and 8). A group of 13 natural chinook salmon were observed moving downstream on December 5 when the lowest mean daily water temperature, 0.2°C, was observed.

Observations of natural chinook salmon in the daily catch at the lower trap began to substantially increase after a slight increase in flow that occurred from March 13 from 254 to 517 cfs on March 17. The daily catch of natural chinook salmon peaked the following day when 501 fish were captured (Figure 9). Flow continued to increase and spiked to 2,033 cfs on March 24. This movement of fish occurred as mean daily water temperature increased from 2.7 °C on February 28 to 9.6 °C on March 14 (Figure 10). Another substantial movement of natural chinook salmon (n = 199) occurred on April 22 prior an increase in the average discharge from 593 cfs on April 16 to 2,148 cfs on April 24. The average daily water temperature on April 22 was 11.3 °C.

Hatchery chinook salmon were released after the mean daily discharge reached 518 cfs on March 17 and prior to the April 24 spike in the hydrograph (Figure 11). Flows were as low as 593 cfs when the majority of hatchery fish were captured. Temperature from April 6 to April 17 ranged from 6.4 to 9.0 °C (Figure 12). The catch of hatchery chinook salmon peaked on April 9 with 3,927; three days after the release. The emigration timing of hatchery chinook salmon at the lower Imnaha trap should not be correlated to flow or temperature because of the release was not volitional.

The first major catch of natural steelhead smolts was observed on April 23 with 578 fish. The stream discharge increased from 593 cfs on April 16 to 2,148 cfs on April 24 (Figure 13). The traps did not fish on April 24 and April 25 so it is unknown if the catch of natural steelhead would have coincided with the increase in discharge. However the peak in the daily catch of natural steelhead did come a day after temperatures spiked up to 11.3°C (Figure 14). The second major catch of natural steelhead was observed May 18 with 211 fish. The May 18 catch proceeded a spike in the hydrograph of 3,704 cfs on May 23 and peak flow on May 26 of 5,964 cfs. The second major movement of natural steelhead smolts coincided with an increase in water temperature from 8.5°C on May 16 to 11.4°C on May 20.

Hatchery steelhead were captured in the greatest numbers on April 27, 1998, three days after the average daily discharge reached 2,148 cfs on April 24 and a day after their release from the acclimation facility (Figure 15). As with hatchery chinook salmon, the emigration timing of hatchery steelhead at the lower Imnaha trap should not be correlated to flow or temperature because the release was not volitional. A total of 1,428 hatchery steelhead were captured from May 20 to May 22, after the May 19 release from the acclimation facility. High flows and heavy debris on May 23 forced us to stop trapping. Mean daily water temperatures from May 19 to May 22 ranged from 10.3 to 11.4°C (Figure 16).

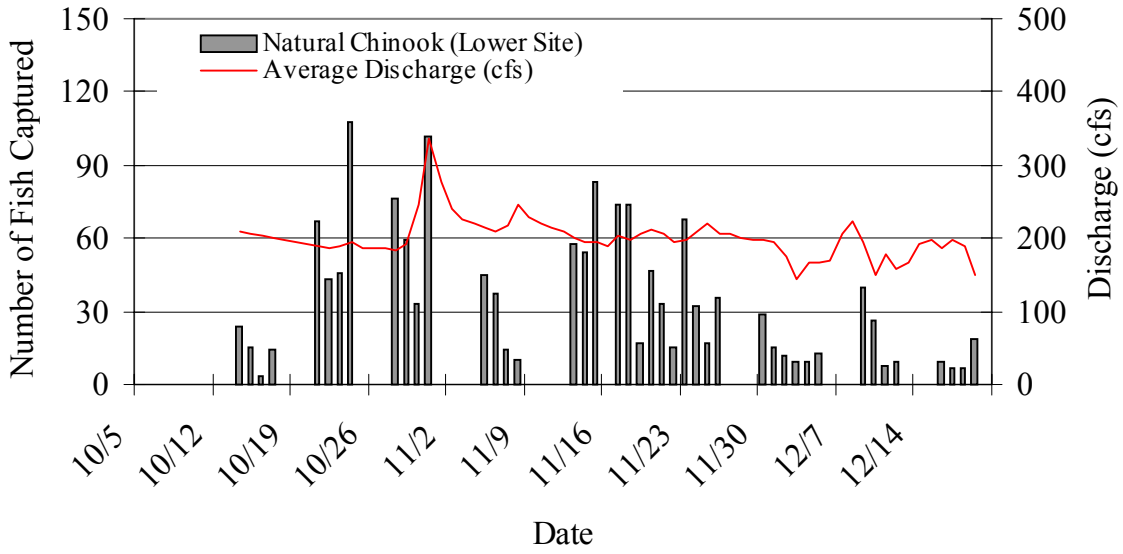

Figure 5. The daily catch of natural chinook salmon at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from October 14 to December 19, 1997.

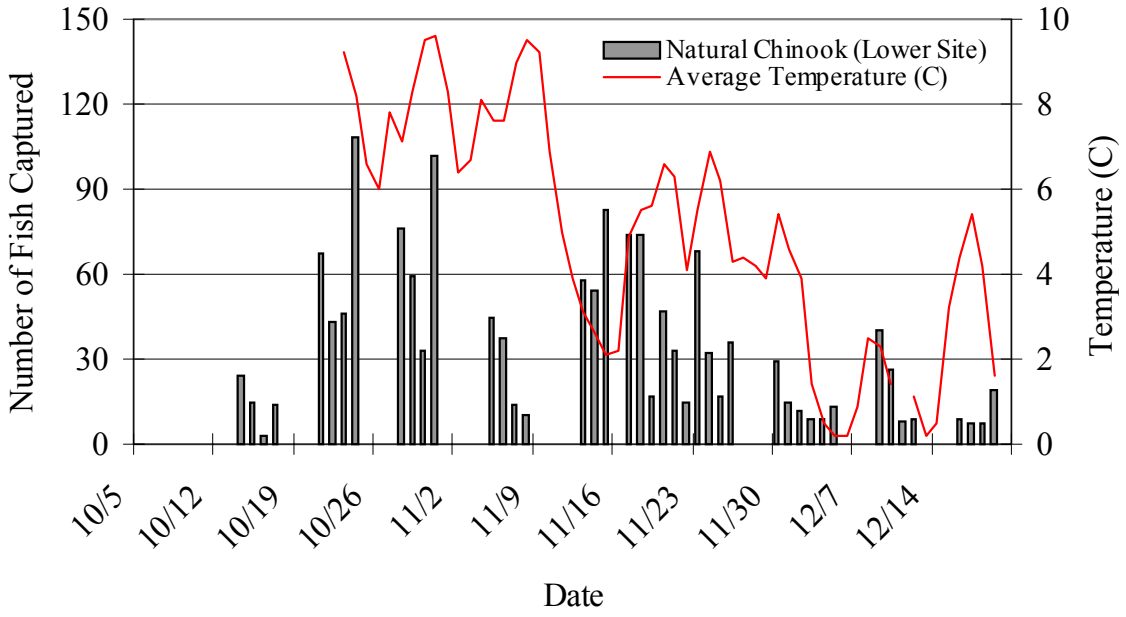

Figure 6. The daily catch of natural chinook salmon at the lower trap and daily average temperature at rkm 7, from October 14 to December 19, 1997.

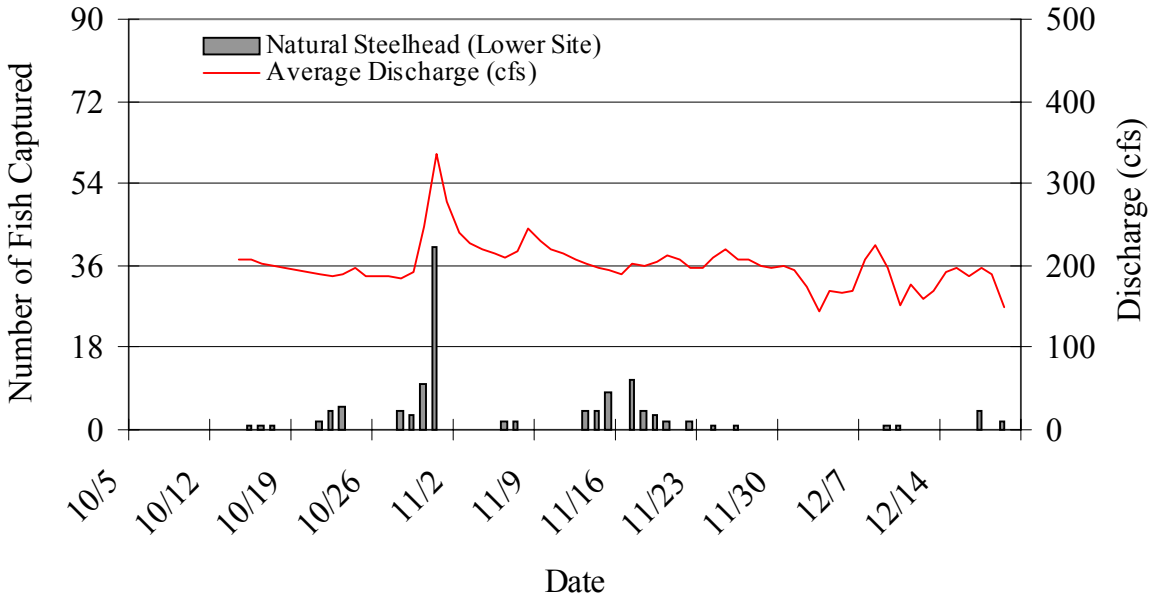

Figure 7. The daily catch of natural steelhead at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from October 14 to December 19, 1997.

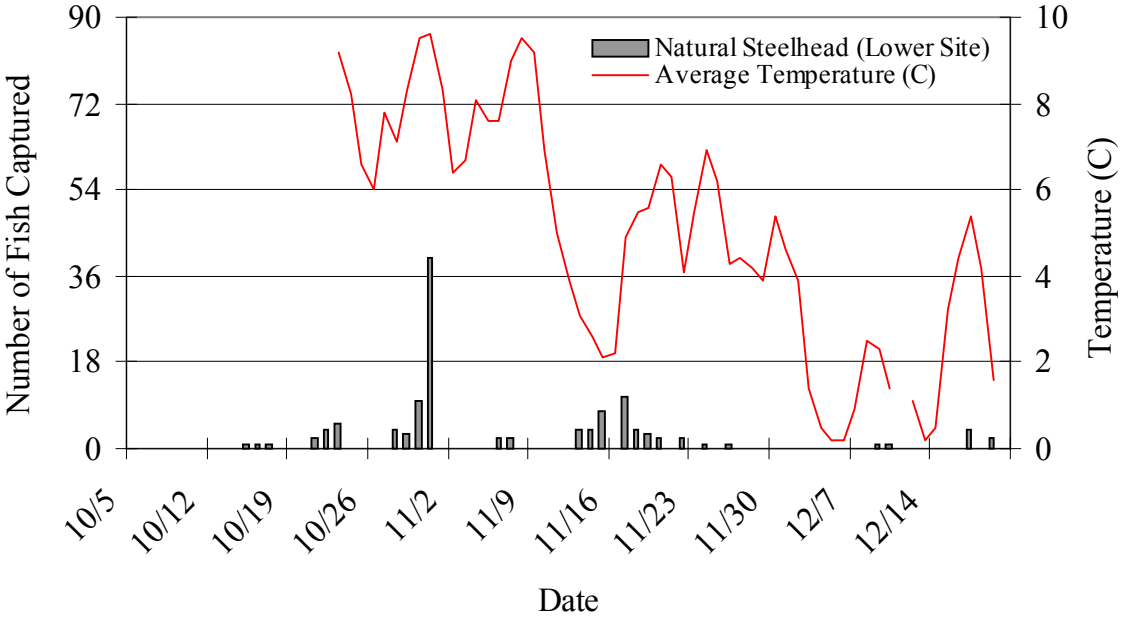

Figure 8. The daily catch of natural steelhead at the lower trap and daily average temperature at rkm 7, from October 14 to December 19, 1997.

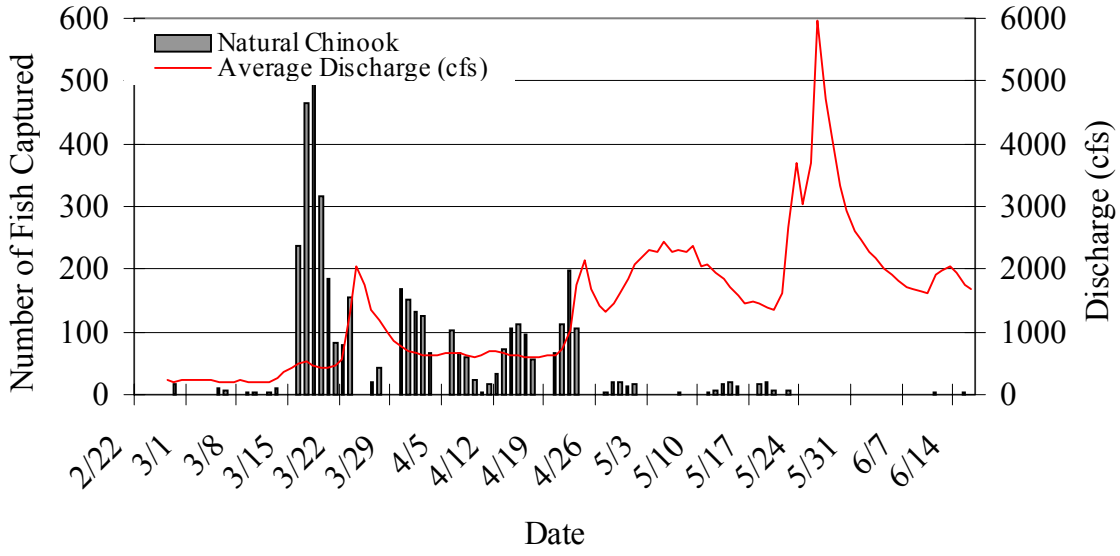

Figure 9. The daily catch of natural chinook salmon at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.

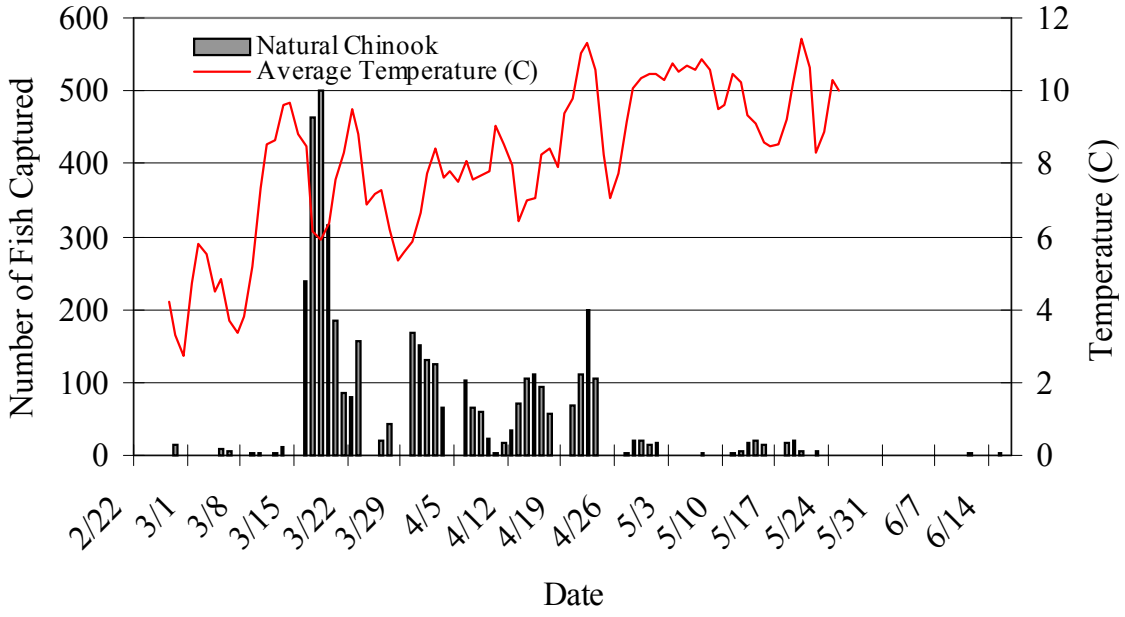

Figure 10. The daily catch of natural chinook salmon at the lower trap and daily average temperature at rkm 7, from February 26 to June 16, 1998.

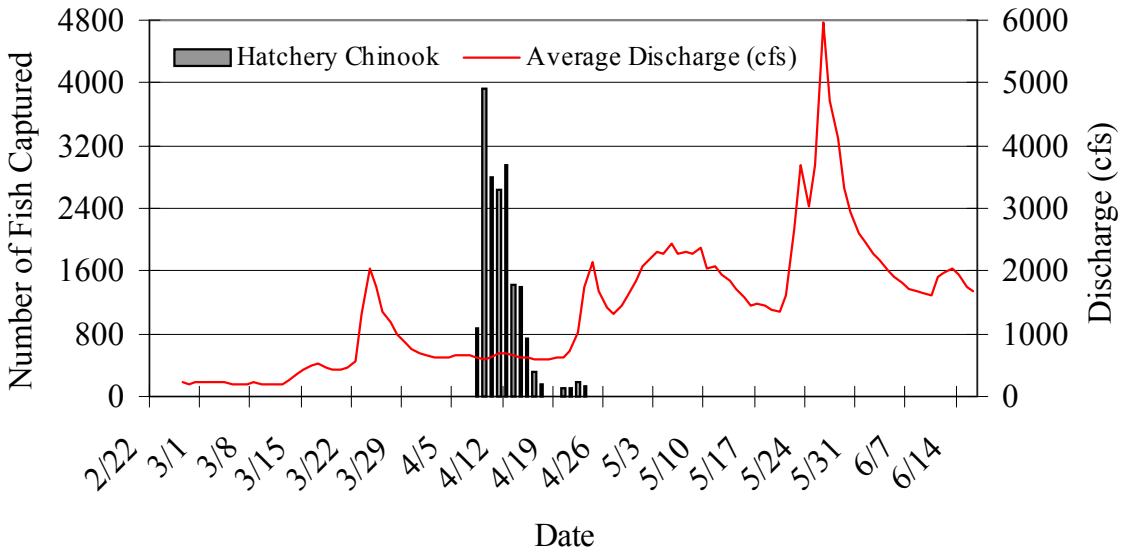

Figure 11. The daily catch of hatchery chinook salmon at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.

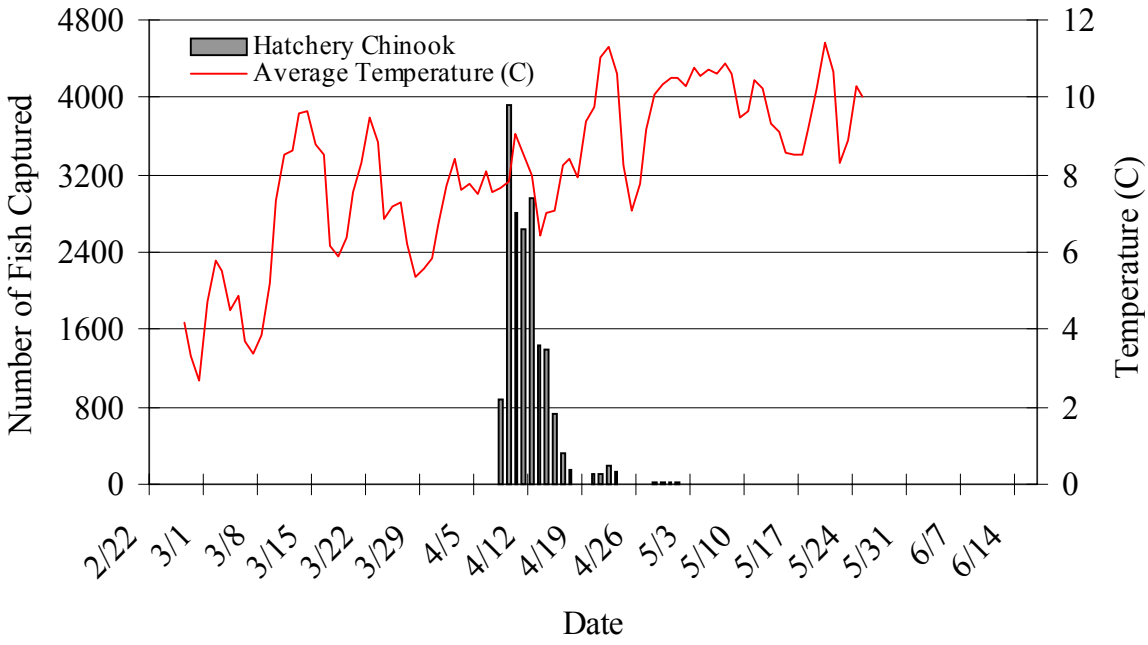

Figure 12. The daily catch of hatchery chinook salmon at the lower trap and daily average temperature at rkm 7, from February 26 to June 16, 1998.

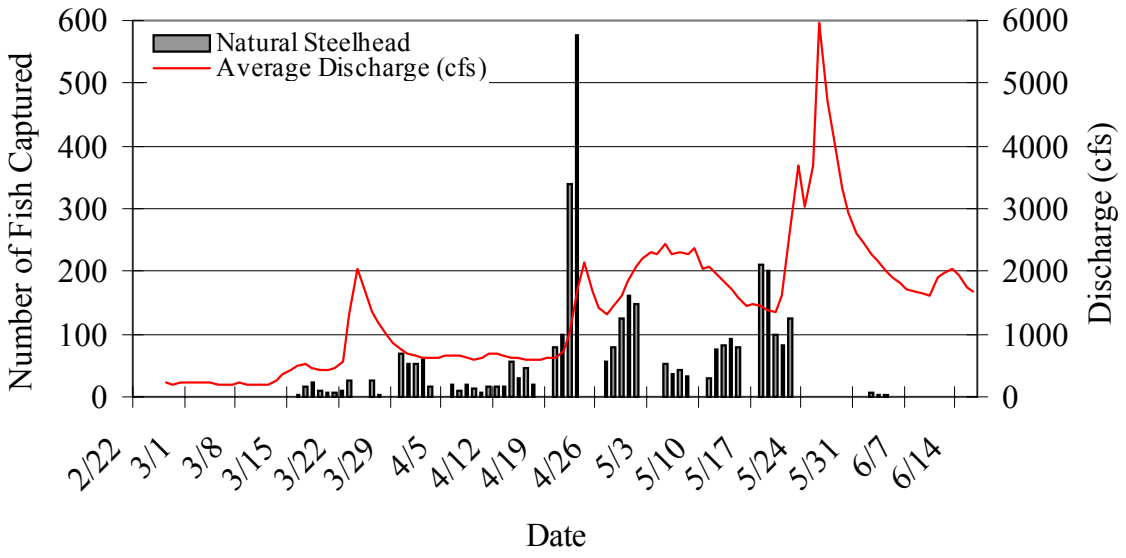

Figure 13. The daily catch of natural steelhead at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.

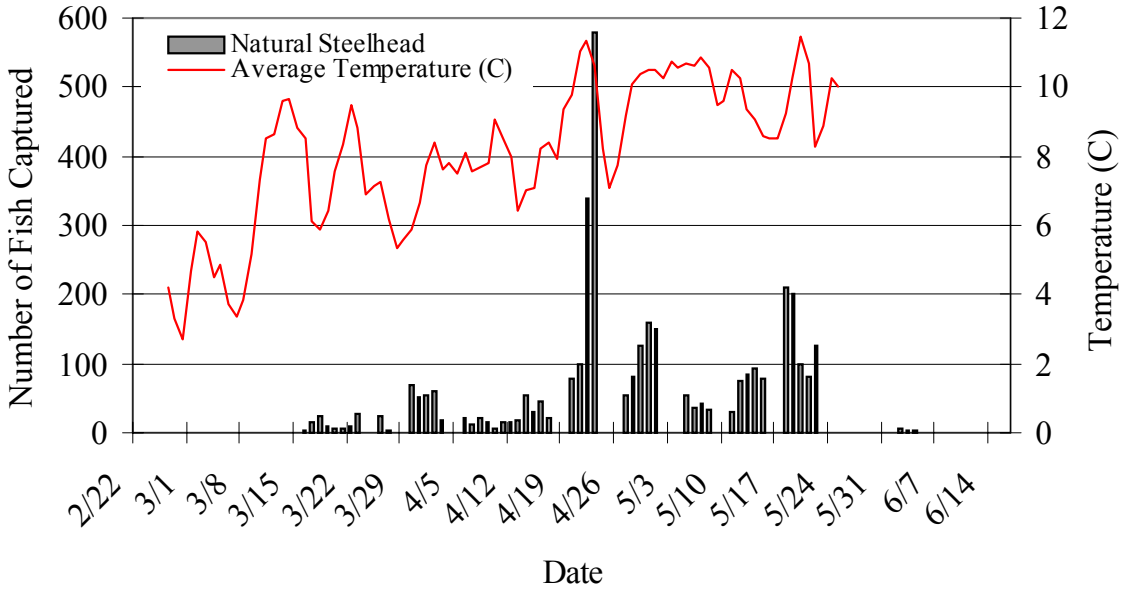

Figure 14. The daily catch of natural steelhead at the lower trap and daily average temperature at rkm 7, from February 26 to June 16, 1998.

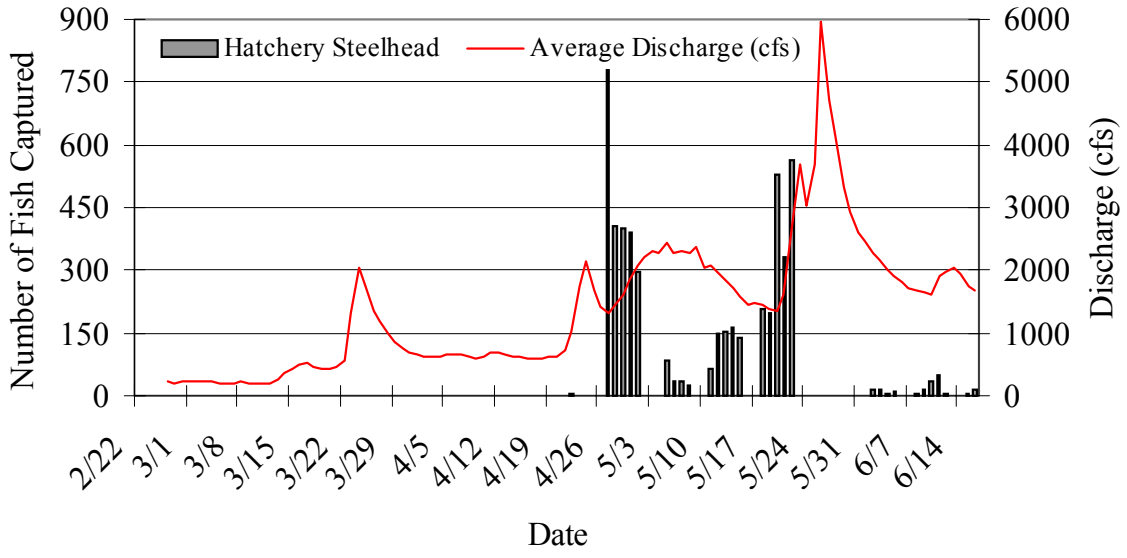

Figure 15. The daily catch of hatchery steelhead at the lower trap and daily average discharge at the Imnaha stream gauge (1329000), from February 26 to June 16, 1998.

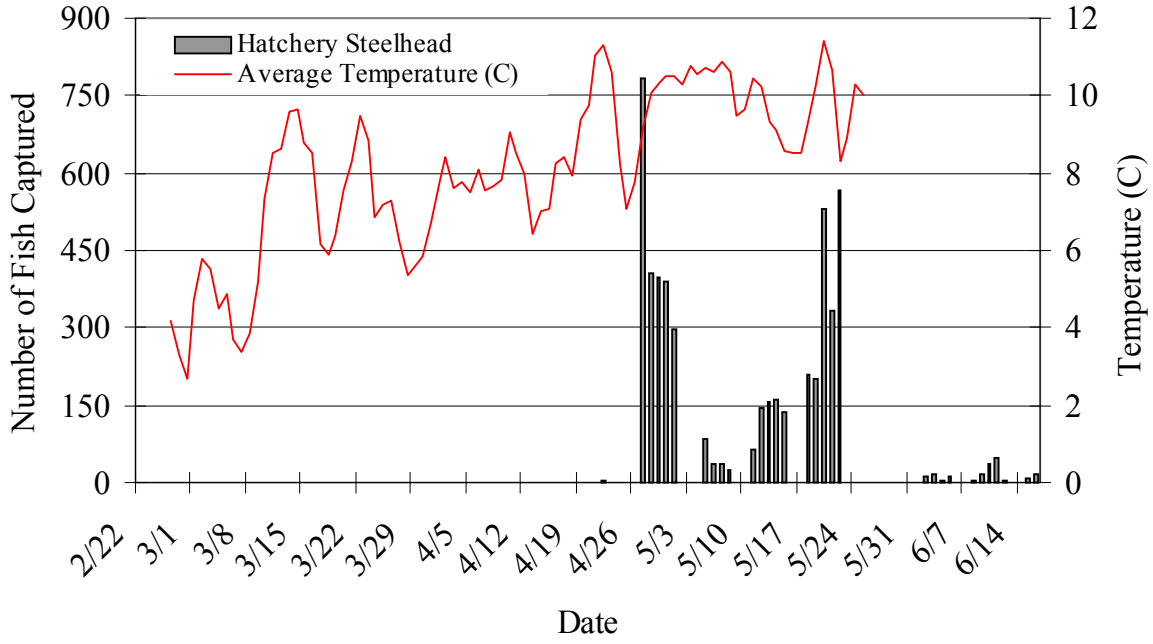

Figure 16. The daily catch of hatchery steelhead and daily average temperature at rkm 7, from February 26 to June 16, 1998.

Biological Characteristics

Natural chinook salmon caught in the fall of 1997 at the upper Imnaha River trap averaged 89 mm in fork length (n = 2,067) and ranged from 55-128 mm (Figure 17). Mean weight of natural chinook salmon was 7.9 g (n = 1,994) with a range of 1.7-24.7 g. The average condition factor was 1.1 with a range of 0.7-1.6 (Table 5). Natural steelhead caught in fall of 1997 at the upper Imnaha River trap averaged 120 mm in fork length (n = 24) and ranged from 56-225 mm (Figure 18). Mean weight of natural steelhead was 20.4 g (n = 23) with a range of 1.8-92.2 g. The average condition factor was 1.01 with a range of 0.78-1.45. Natural chinook salmon caught in the fall of 1997 at the lower Imnaha River trap site averaged 95 mm in fork length (n = 1,491) and ranged from 73-147 mm. The mean weight and condition factor was 9 g (n = 1,488) and 1.04, respectively with ranges of 3.9-32.1 g and 0.57-1.6 (Table 5). Natural chinook salmon collected at the lower trap were significantly larger in fork length ($p<0.05$) than the natural chinook salmon collected at the upper trap. T-test values for 1998 are presented in Appendix F. Natural steelhead averaged 146 mm in fork length (n = 118) and ranged from 69-221 mm. The mean weight and condition factor was 38.4 g (n = 115) and 1.04, respectively with ranges of 4.2-107.1 g and 0.80-1.34.

Based on length frequency data, the majority of chinook salmon and steelhead emigrants collected in the screw trap during the spring were age I and II, respectively (Figures 19 and 20). Hatchery reared chinook salmon smolts were significantly larger ($p<0.05$) than their natural counterparts. The size of hatchery chinook salmon has been significantly larger than their natural counter parts since 1994 (Ashe et al. 1995, Blenden et al. 1996 to 1998). Mean length of natural chinook salmon 1998 spring emigrants was 106 mm, mean weight was 12.7 g, and the mean condition factor was 1.05 (Table 5). Weekly mean lengths of natural chinook salmon throughout the spring emigration period, ranged from 102 to 110 mm and mean condition factors of natural chinook salmon ranged from 1.03 to 1.13 (Figure 21). Mean length of hatchery reared chinook salmon caught during the spring was 135 mm and mean weight was 27.2 g (Table 5). Mean condition factor for hatchery chinook salmon smolts was 1.08. Weekly mean lengths for hatchery chinook salmon smolts ranged from 139 mm to 129 mm and decreased during the four week period (Figure 22). Fish captured during the week ending April 11 averaged 138 mm in fork length. They were significantly larger ($p < 0.05$) than those captured during the week ending April 18, with an average fork length of 132 mm. Fish captured during the week ending April 25 averaged 132 mm and were significantly larger than those captured during the week ending May 2 ($p< 0.05$). Fish captured during the week ending May 2 averaged 128 mm. Weekly mean condition factors during the four week period ranged from 1.02 to 1.10.

Natural steelhead spring smolts mean length was 177 mm, mean weight was 56.8 g, and mean condition factor was 0.99 (Table 5). Weekly mean lengths and condition factor for natural steelhead smolts ranged from 143 to 186 mm and 0.90 to 1.01, respectively (Figure 23). Hatchery steelhead were significantly larger ($p<0.05$), with a mean length of 218 mm and a mean weight of 102.0 g. The mean condition factor for hatchery steelhead was 0.96. The size of hatchery steelhead has been significantly larger than their natural counterparts since 1994 (Ashe et al.

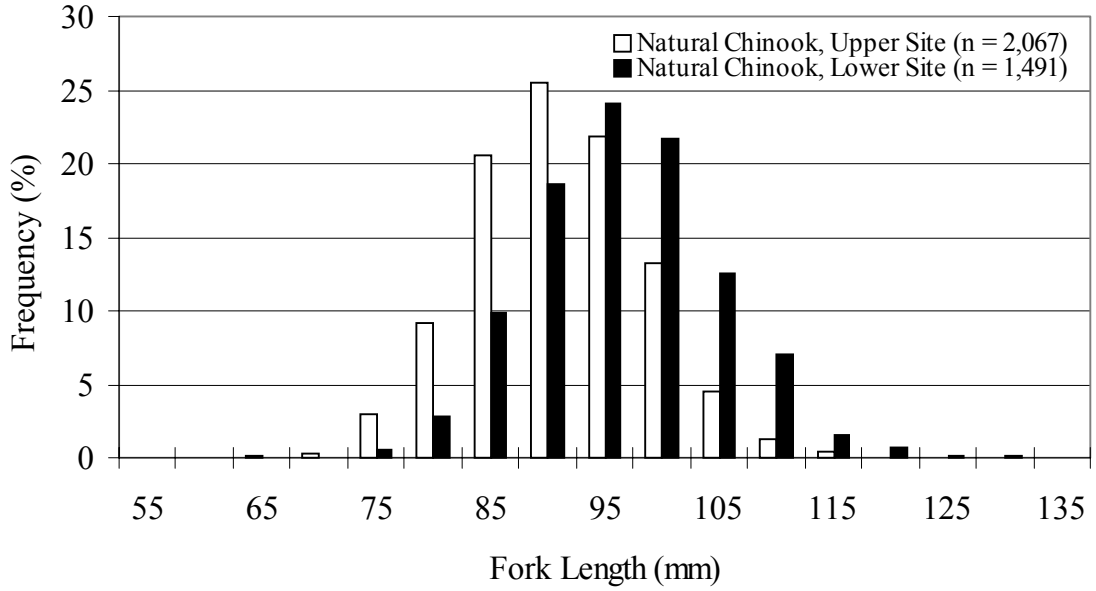

Figure 17. Length frequency of natural chinook salmon trapped in the upper and lower Imnaha River traps, October 14 to December 19, 1997.

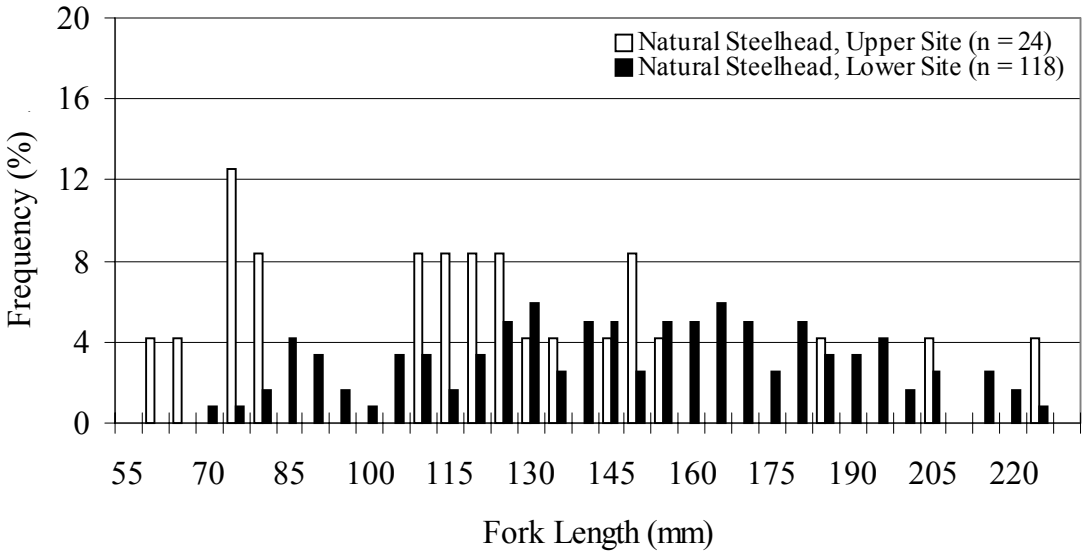

Figure 18. Length frequency of natural steelhead (and rainbow trout) trapped in the upper and lower Imnaha River traps, October 14 to December 19, 1997.

Table 5. Mean and range of fork length (mm), weight (g), and condition factor for natural and hatchery chinook salmon and steelhead smolts collected at the Imnaha River screw trap from October 14 to December 19, 1997 and February 26-27 and March 4 to June 16, 1998.

	Chinook salmon		Steelhead	
	Natural	Hatchery	Natural	Hatchery
Fall, (Upper Trap)				
Sample Size	2,067	NA	24	NA
Mean Fork Length	89		120	
Range	55 - 128		56 - 225	
Standard Deviation	7.6		37.6	
Sample Size	1,994	NA	23	NA
Mean Weight	7.9		20.4	
Range	1.7 - 24.7		1.8 - 92.2	
Standard Deviation	2.1		25.7	
Sample Size	1,994	NA	23	NA
Mean K	1.1		1.01	
Range	0.7 - 1.6		0.78 - 1.45	
Standard Deviation	0.10		1.0	
Fall, (Lower Trap)				
Sample Size	1,491	NA	118	NA
Mean Fork Length	95		146	
Range	73 - 147		69 - 221	
Standard Deviation	8.3		43.1	
Sample Size	1,488	NA	115	NA
Mean Weight	9.0		38.4	
Range	3.9 - 32.1		4.2 - 107.1	
Standard Deviation	2.5		20.9	
Sample Size	1,488	NA	115	NA
Mean K	1.04		1.04	
Range	0.57 - 1.6		0.80 - 1.34	
Standard Deviation	0.09		0.13	
Spring, (Lower Trap)				
Sample Size	3,969	3,098	2,843	3,890
Mean Fork Length	106	135	177	218
Range	75 - 133	103 - 220	120 - 260	137 - 294
Standard Deviation	7.9	11.1	20.7	20.0
Sample Size	3,951	2,269	2,842	1,665
Mean Weight	12.7	27.2	56.8	102.0
Range	4.4 - 44.1	10.5 - 190.0	16.7 - 184.0	39.6 - 228.7
Standard Deviation	3.2	8.4	20.7	30.4
Sample Size	3,951	2,269	2,842	1,665
Mean K	1.05	1.08	0.99	0.96
Range	0.73 - 1.78	0.61 - 1.78	0.67 - 1.59	0.65 - 1.33
Standard Deviation	0.09	0.10	0.07	0.07

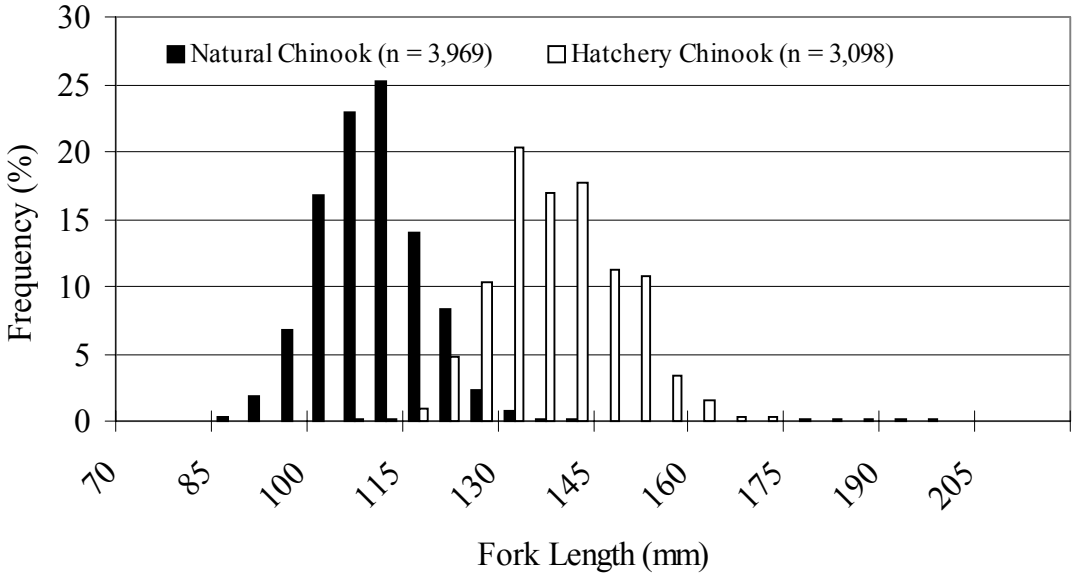

Figure 19. Length frequency of natural and hatchery chinook salmon smolts trapped in the lower Imnaha River, February 26 to June 16, 1998.

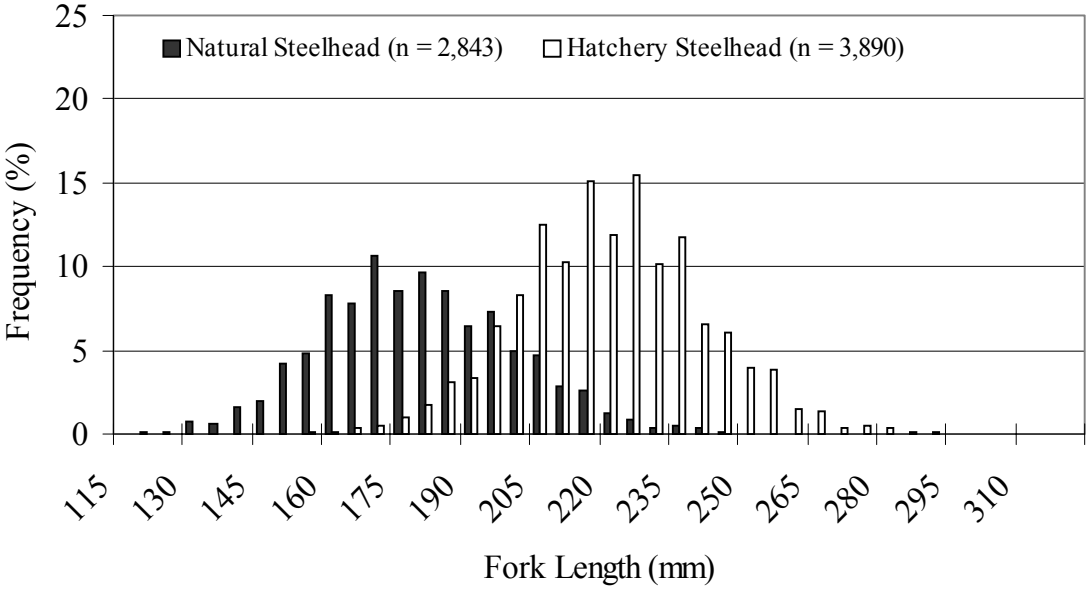

Figure 20. Length frequency of natural and hatchery steelhead smolts trapped in the lower Imnaha River, February 26 to June 16, 1998.

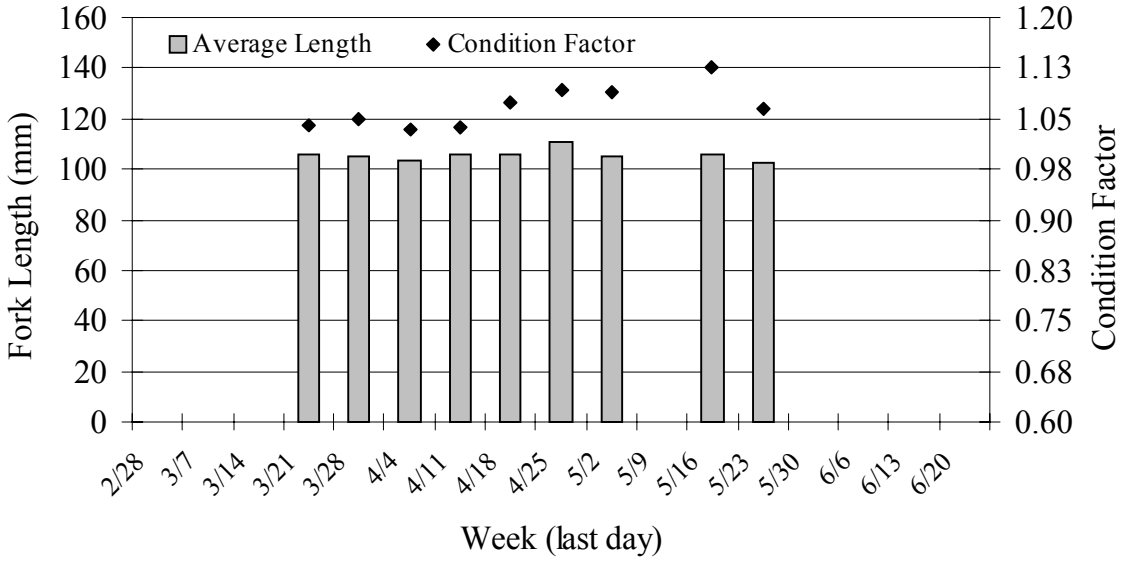

Figure 21. Mean fork lengths and condition factors for natural chinook salmon captured in the Imnaha screw traps, February 26 to June 16, 1998.

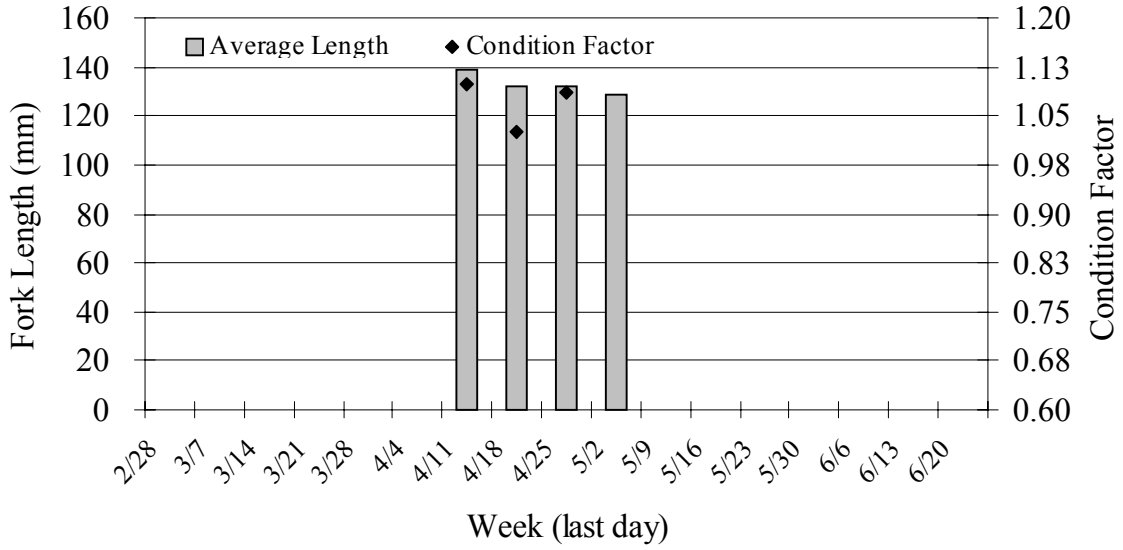

Figure 22. Mean fork lengths and condition factors for hatchery chinook salmon captured in the Imnaha screw traps, February 26 to June 16, 1998.

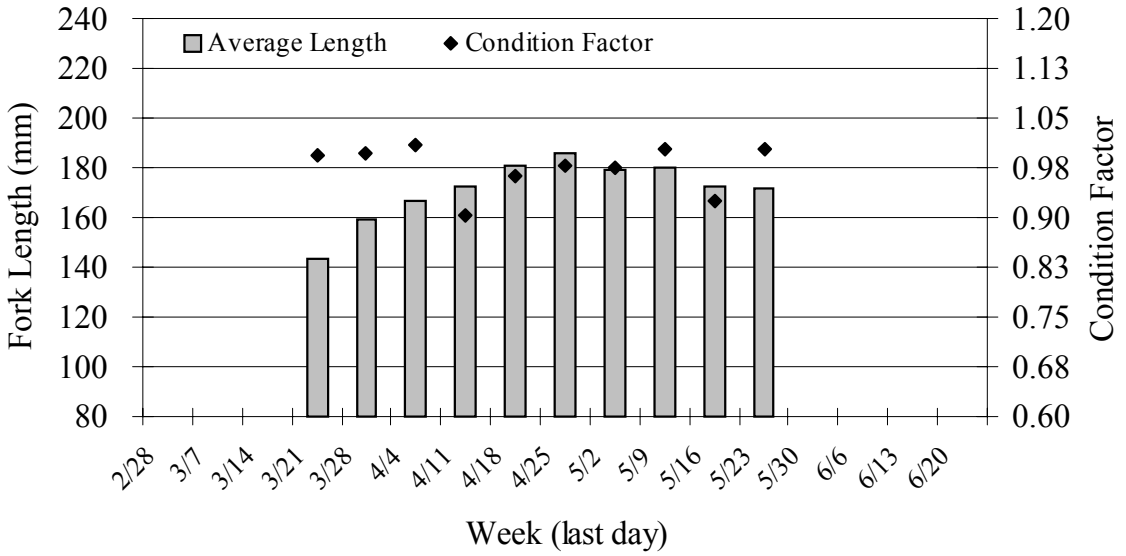

Figure 23. Mean fork lengths and condition factors for natural steelhead captured in the Imnaha screw traps, February 26 to June 16, 1998.

1995, Blenden et al. 1996 to 1998). Weekly mean lengths and condition factor for hatchery steelhead smolts ranged from 213 to 223 mm and 0.93 to 1.00, respectively (Figure 24). Appendix G contains mean daily length, weight and condition factors for captured natural and hatchery chinook salmon and steelhead smolts.

PIT Tag Release Groups

A total of 1,996 natural chinook salmon were PIT tagged at the upper Imnaha River trap between October 15 and November 15, 1997 (Table 6). Average fork length and weight was 89 mm and 7.9 g. Mean condition factor was 1.09. Weekly release group sample sizes ranged from 90 to 742 with the majority of the fish being tagged the week ending October 25. Average weekly fork lengths ranged from 88 to 92 mm. Average weekly weight and condition factors ranged from 7.6 to 8.2 g and 0.98 to 1.12, respectively. At the lower Imnaha River trap we PIT tagged and released 1,454 natural chinook salmon between October 16 and December 19, 1997 (Table 6). Average fork length was 95 mm with an average weight and condition factor of 9.0 g and 1.04, respectively. Natural chinook salmon tagged at the lower trap were significantly larger ($p < 0.05$) than those tagged at the upper trap. Sample sizes of weekly release groups ranged from 32 to 264. Mean weekly fork lengths ranged from 93 to 97 mm with mean weekly weights ranging from 8.5 to 10.5 g. Mean weekly condition factors ranged from 0.96 to 1.22.

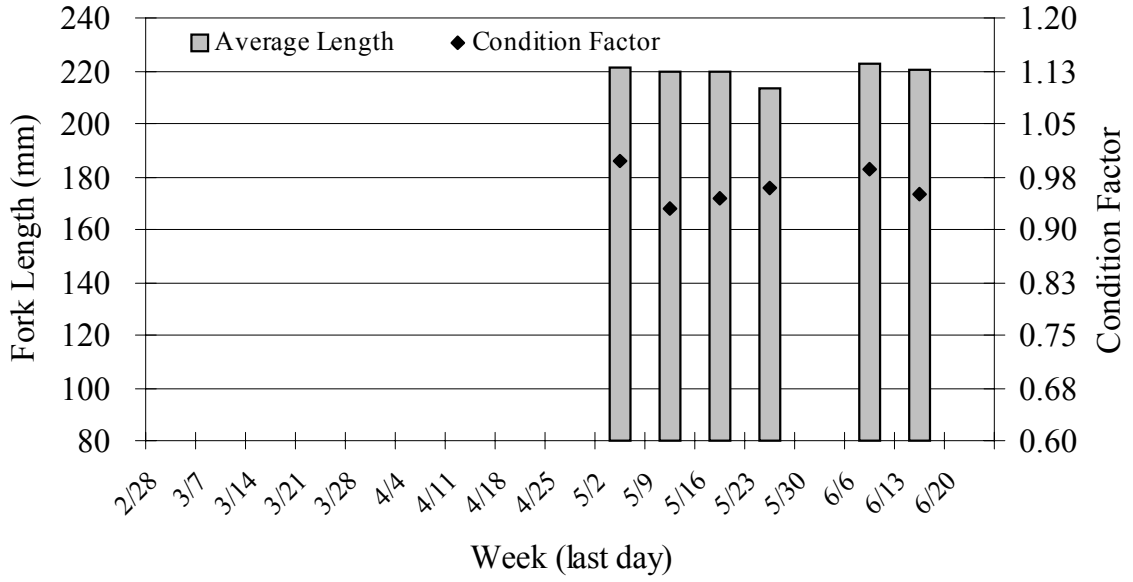

Figure 24. Mean fork lengths and condition factors for hatchery steelhead captured in the Imnaha screw traps, February 26 to June 16, 1998.

We PIT tagged and released 3,956 natural chinook salmon, 2,000 hatchery chinook salmon, 3,106 natural steelhead, and 3,859 hatchery steelhead from February 26 to June 16, 1998 (Table 7). Tagging goals were met for hatchery chinook salmon but were not accomplished for natural chinook salmon and natural and hatchery steelhead. The majority of natural chinook salmon (45%) were tagged during the week of March 15. The majority of hatchery chinook salmon (50%) were tagged during the week of April 5. The majority of natural and hatchery steelhead (23% and 38%) were tagged during the weeks of April 19 and April 26 respectively. Information on PIT tag release groups are listed in Appendix H.

Spring PIT tagged natural chinook salmon averaged 106 mm in fork length and had an average weight of 12.7 g. Natural chinook salmon had an average condition factor of 1.05. Spring PIT tagged hatchery chinook salmon averaged 136 mm in fork length and had an average weight of 27.5 g. Hatchery chinook salmon averaged a condition factor of 1.07. Spring PIT tagged natural steelhead averaged 177 mm in fork length and had an average weight of 57.2 g. Natural steelhead had an average condition factor of 0.99. Spring PIT tagged hatchery steelhead averaged 218 mm in fork length and had an average weight of 101.8 g. Hatchery steelhead had an average condition factor of 0.96 (Table 8).

The standard skewness value for the fork lengths of PIT tagged natural chinook salmon was 4.13, indicating a significant departure from normality. The fork lengths of PIT tagged

Table 6. Weekly numbers of PIT tagged natural chinook salmon released into the Imnaha River from the upper and lower Imnaha screw traps from October 15 to December 19, 1997 .

Week	Upper Trap	Lower Trap
10/12/97-10/16/97	249	32
10/19/97-10/25/97	742	259
10/26/97-11/1/97	497	264
11/2/97-11/8/97	418	102
11/9/97-11/15/97	90	188
11/16/97-11/22/97		250
11/23/97-11/29/97		150
11/30/97-12/6/97		85
12/7/97-12/13/97		83
12/14/97-12/20/97		41
Totals	1,996	1,454

Table 7. Weekly numbers of PIT tagged fish released into the Imnaha River from the lower Imnaha screw trap from February 26 to June 16, 1998.

Week	Natural Chinook salmon	Hatchery Chinook salmon	Natural Steelhead	Hatchery Steelhead
2/22/98 - 2/28/98	14			
3/1/98 - 3/7/98				
3/8/98 - 3/14/98	19		1	
3/15/98 - 3/21/98	1,698		41	
3/22/98 - 3/28/98	280		28	
3/29/98 - 4/4/98	611		247	
4/5/98 - 4/11/98	218	1,007	83	
4/12/98 - 4/18/98	457	987	180	
4/19/98 - 4/25/98	491	6	714	8
4/26/98 - 5/2/98	70		567	1,449
5/3/98 - 5/9/98	2		164	174
5/10/98 - 5/16/98	51		357	661
5/17/98 - 5/23/98	41		712	1,402
5/24/98 - 5/30/98				
5/31/98 - 6/6/98	2		10	42
6/7/98 - 6/13/98			2	100
6/14/98 - 6/20/98	2			23
Totals	3,956	2,000	3,106	3,859

Table 8. Mean and range of fork length (mm), weight (g), and condition factor for natural and hatchery chinook salmon and steelhead smolts collected and PIT tagged at the Imnaha River screw trap from February 26 to June 16, 1998.

	Chinook salmon		Steelhead	
Statistic	Natural	Hatchery	Natural	Hatchery
Sample Size	3,933	1,987	2,768	3,847
Mean Fork Length	106	136	177	218
Range	75 - 133	103 - 201	120 - 260	137 - 304
Standard Deviation	7.9	11.4	20.3	20.0
Sample Size	3,912	1,161	2,768	1,621
Mean Weight	12.7	27.5	57.2	101.8
Range	4.4 - 44.1	10.6 - 87.5	16.7 - 184.0	30.2
Standard Deviation	3.2	7.9	20.5	39.6 - 228.7
Sample Size	3,912	1,159	2,767	1,621
Mean K	1.05	.61 - 1.69	0.99	0.96
Range	0.73 - 1.78	1.07	0.67 - 1.59	0.65 - 1.33
Standard Deviation	0.1	0.1	0.1	0.1

hatchery chinook, natural steelhead, and hatchery steelhead also had standard skewness values outside of the range of ±2, or non-normal distributions. Therefore, medians were compared using the Wilcoxon test instead of a students t-test to compare the means. Wilcoxon test values for 1998 are presented in Appendix I. There were no significant differences between the median fork lengths of tagged and non-tagged natural chinook salmon, and tagged and non-tagged hatchery steelhead ($p > 0.05$). Tagged natural chinook salmon represented 94.3% of all natural chinook salmon captured. Tagged hatchery steelhead represented 75.1% of all hatchery steelhead captured. There were statistically significant differences between fork lengths of tagged and non-tagged hatchery chinook salmon, and tagged and non-tagged natural steelhead. These differences were not considered biologically significant for hatchery chinook salmon. The average fork length of PIT tagged hatchery chinook salmon was 136 mm and the median was 135 mm (n = 1,987). The average length of non-PIT tagged hatchery chinook salmon was 134 mm and the median was 133 (n = 1,111).

The average fork length of PIT tagged natural steelhead was 177 mm (n = 2,768). The average fork length of non-PIT tagged natural steelhead was 160 mm (n = 74). These averages do not include the lengths of 31 non-PIT tagged natural steelhead between 75 and 119 mm and 14 PIT tagged natural steelhead less than 120 mm. The reason for the exclusion of these small fish was that steelhead greater than 120 mm were selected for PIT tagging and fish less than 120 mm were reported as rainbow trout. PIT tagged natural steelhead represented 87% of all fish captured in the trap. Therefore, we feel that the PIT tagged portion was representative of Imnaha natural

steelhead captured in the trap.

There were nine weekly release groups of natural steelhead of 30 or more individuals, ranging from 41 to 714 fish during the spring (Table 7). These nine groups represent 98.7% of all PIT tagged natural steelhead and 85.9% of all natural steelhead captured. Mean weekly fork lengths ranged from 149 to 186 mm. Weekly condition factors ranged from 0.93 to 1.00. Six of the nine weekly release groups of natural steelhead contained 200 or more individuals. There were six weekly release groups of hatchery steelhead of 30 or more individuals ranging from 42 to 1,402 fish during the spring (Table 7). These six groups represent 99.2% of all PIT tagged hatchery steelhead or 74.5% of all hatchery steelhead captured. Mean weekly fork lengths ranged from 214 to 223 mm. Weekly condition factors ranged from 0.93 to 0.98. Three of the nine weekly release groups of hatchery steelhead contained 200 or more individuals.

Emigration Timing and Trends of Previously PIT Tagged Fish

NPT released 1,996 PIT tagged natural chinook salmon between October 15 and November 15, 1997 and ODFW released 1,010 PIT tagged natural chinook salmon on September 8 and 9, 1997 in the upper Imnaha River. We recaptured 124 (6.2%) and 26 (2.6%) of these fish, respectively, at the lower trap from February 27 to May 19. The peak catch of previously PIT tagged natural chinook salmon (n = 22) occurred on March 17 (Figure 25). The following day the peak catch of non-PIT tagged natural chinook salmon occurred. There were a total of 3,371 hatchery chinook salmon recaptured (17%) from the release of 19,827 PIT tagged fish. The peak catch of previously PIT tagged hatchery chinook salmon (n = 933) occurred on April 9 (Figure 26). This was the same day as the peak catch of non-PIT tagged fish. Recapture dates ranged from April 6 to May 12. Mean travel time for hatchery chinook salmon smolts from the acclimation facility to the Imnaha River screw trap was four days. The median arrival date of natural chinook salmon, tagged in the fall by NPT, occurred on March 20 and 90 % arrival occurred on April 22 (Figure 27). Hatchery chinook salmon's median arrival date occurred on April 10 and 90% arrival occurred on April 14 (Figure 27).

The traps may not have captured the majority of the PIT tagged hatchery steelhead. There were a total of 20 hatchery steelhead recaptured from the release of 867 PIT tagged fish from the acclimation facility. Recapture dates ranged from April 26 to May 22. Half of the hatchery steelhead arrived by May 2 and 90% arrived on May 19. Flows greater than 2,000 cfs during the week of May 3 and May 24 may have decreased our ability to trap hatchery steelhead effectively.

Smolt Yield

The SURPH model was used to estimate post-release survival and smolt yield of hatchery chinook salmon smolts from the acclimation facility release to the lower Imnaha River trap site as in 1997. Trap efficiency trials were conducted as in past years but we placed no confidence in the resulting bootstrap estimate (Table 9). Future Bootstrap population estimates for hatchery chinook salmon should be carefully examined and trap efficiency trial methods tested for biases.

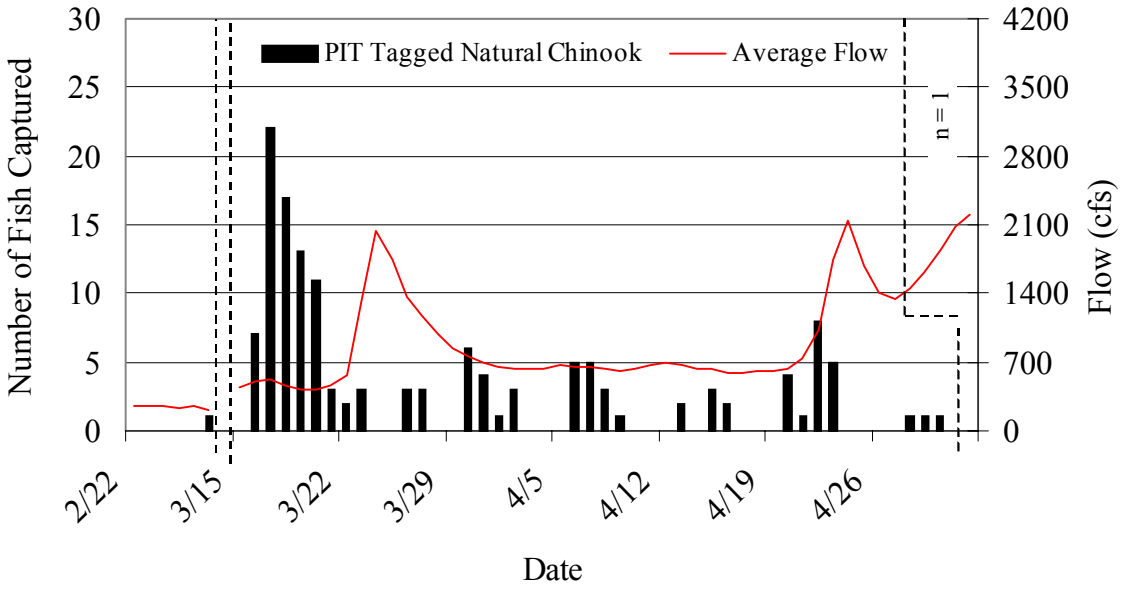

Figure 25. The number of previously PIT tagged natural chinook salmon captured from February 26 to June 16, 1998. Dashed lines represent a departure from the scale of the x axis.

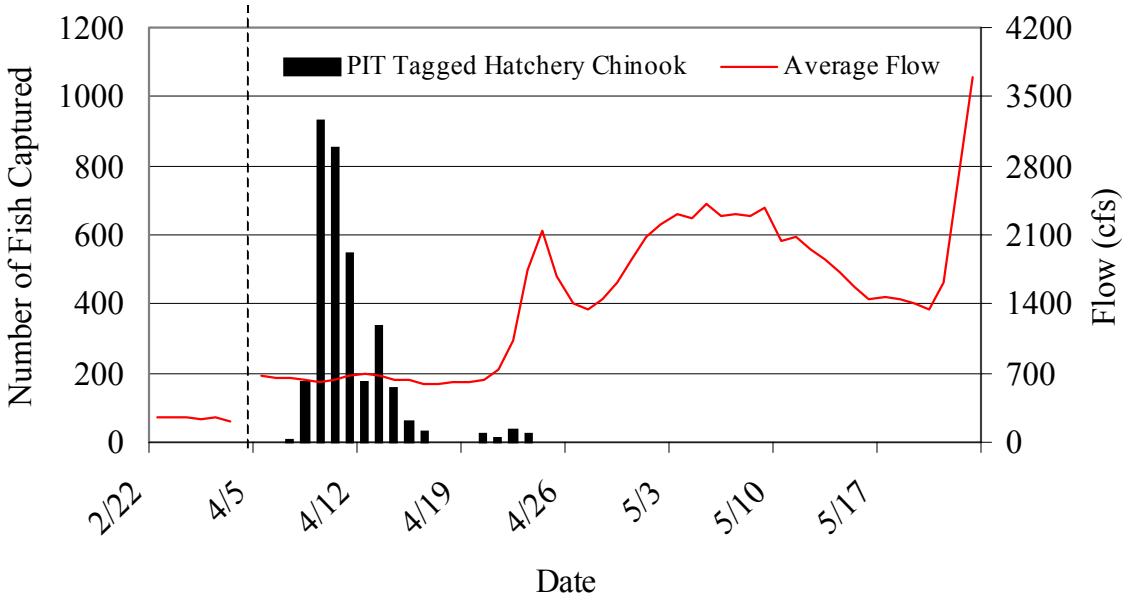

Figure 26. The number of previously PIT tagged hatchery chinook salmon captured from February 26 to June 16, 1998. Dashed lines represent a departure from the scale of the x axis.

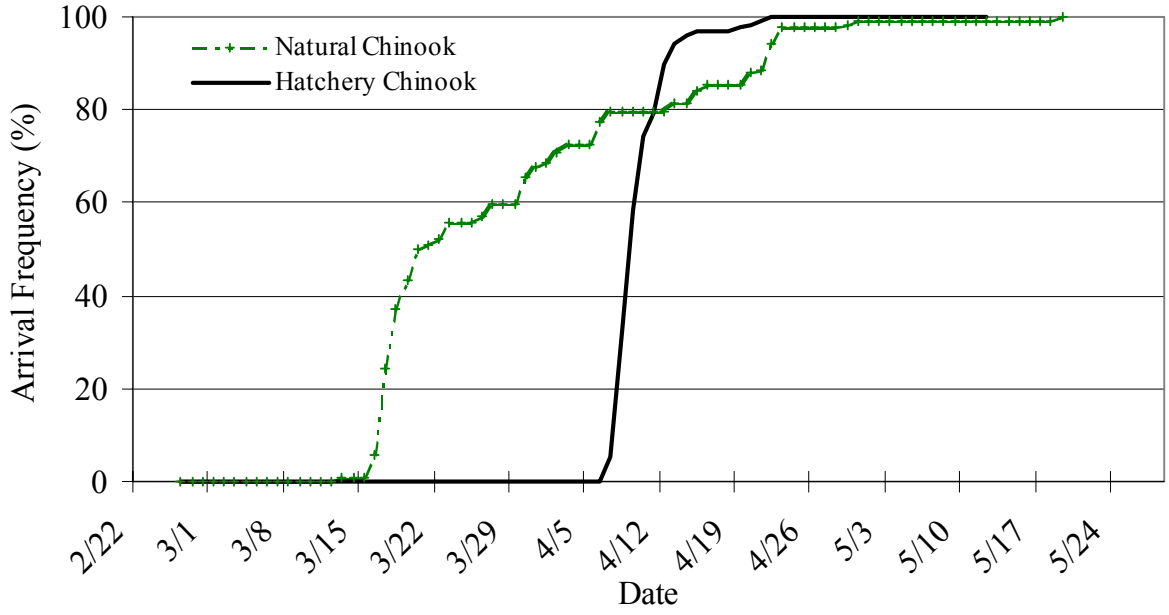

Figure 27. The arrival frequency of previously PIT tagged natural chinook salmon, released from October 15 to November 15 at the upper trap and hatchery chinook salmon, released at the acclimation facility April 6, at the lower Imnaha traps during the spring of 1998.

Survival for PIT tagged hatchery chinook salmon smolts, from release at the Imnaha River acclimation facility to the screw trap, was estimated at 88.4% using the SURPH based Jolly-Seber Cormack method (Table 9). The 95% confidence interval around the point estimate was 1.0%. This estimate was based on 3,371 interrogations of PIT tagged fish at the Imnaha River trap site and subsequent interrogations at downstream interrogation sites. The interrogations at the Imnaha River trap represents 17% of all PIT tagged hatchery chinook salmon released and the SURPH estimate represented a smolt yield of 82,324 fish at the screw trap.

Trap efficiency trials were conducted from April 8 to April 16 (Appendix J). The average daily flows during this period ranged from 598.4 to 698.5 cfs. The mean trap efficiency was estimated at 29.4% in 1998, based on 2,683 marked fish and nine trials. This was higher than observations from 1994 to 1996. The resulting bootstrap estimate, based on the mean trap efficiency, was 60,252 fish. The 95% confidence interval around this point estimate was ±3,599. The estimate accounted for 65% of the hatchery chinook salmon released. After April 17 an additional 600 fish were captured. Using the season trap efficiency average of 29% for the following five weeks of operation results in an additional yield of 2,070 fish ±183. The addition of these fish results in a survival estimate, from release at the acclimation facility to the Imnaha trap site, of 67% . The 95% confidence intervals around this point estimate is 6.0%. We feel that this estimate is low because the SURPH program estimated survival, from release at the acclimation facilty to the lower trap, at 0.884 (95% confidence interval of 0.010) and survival from the trap to LGR at 0.773 (95% confidence interval of 0.011). The product of the estimates for these two reaches would be 68.3%. The 95% confidence of the bootstrap point estimate to the

Table 9. The mean trap efficiency, PIT tag interrogation percentage and estimated survival from release to trap (bootstrap and SURPH) and release to Lower Granite Dam (LGR) for hatchery chinook salmon smolts from 1994 to 1998.

Year	Mean Trap Efficiency (%)	PIT Tag Interrogations at Screw Trap (%)	Estimated Survival		
			Release to Trap SURPH (%)	Bootstrap (%)	Release to LGR[5] (%)
1998	29.4[1]	17.0	88.4	66.9[2]	68.3
1997	45.9[1]	19.6	89.2	44[2]	61.6
1996	11.6	10.6	95	101.7	56.8
1995[3]	---	10.8	92.6	---	61.8
1994	13.8[4]	6.2	100.9	88.1	68.5

[1] Over-estimate of trap efficiency.
[2] Under-estimate of smolt yield based on the bootstrap method.
[3] Based on one trap efficiency trial.
[4] Data for HxW crossed chinook salmon smolts released on March 28.
[5] SURPH based estimate after Blenden et al. 1998.

lower trap overlaps the SURPH point estimate from the acclimation facility to LGR. There may be no significant differences between the estimates, but survival from the acclimation facility to the trap should not be higher than survival from acclimation facility to LGR.

There appears to have been a statistical size related bias in trapping of hatchery reared chinook salmon smolts used in trap efficiency trails. Mean fork length of hatchery chinook salmon smolts marked and released for trap efficiency trials was 132.9 mm (n=1,071). This was significantly different ($p<0.05$) than the mean fork length of 135.2 mm for recaptured hatchery chinook salmon used in trap efficiency trials (n=667). However, the 2.3 mm may not be biologically significant. Similar differences were observed during a previous study with natural chinook salmon marked and recaptured in the upper Imnaha River (Gaumer 1968). Gaumer reported significant differences in two of seven trials. Mean fork lengths were 3.9 and 2.7 mm greater for recaptured fish in a ditch diversion trap. The difference in the recaptured fork length was attributed to differential mortality by size of fish at marking or predators, smaller fish passing over the rotary screen, or poor detection of marks (Gaumer 1968).

Estimated Smolt Survival

Estimated survival of 1997 fall tagged natural chinook salmon from the upper trap site to LGR, using the program SURPH, was 45.9%, with 95% confidence interval of 3.1%(Table 10). This survival rate was approximately twice as much as the estimated survival in 1993 (22.4%) and

1995 (0.257) from the upper trap. Some estimates in Table 10 are greater than one. This is possible when survival to the previous site was underestimated. Minimum survival to LGR, using cumulative detections of unique PIT tags at LGR, LGO, LMO, and MCN, was 39.8%. Fall tagged chinook salmon from release at the upper trap to LMO had an estimated survival of 0.393. Appendix K contains details of first observations of PIT tag detections at LGR, LGO, LMO, and MCN for daily release groups of natural and hatchery chinook salmon and steelhead.

Natural chinook salmon trapped at the lower trap site in 1997 had a seasonal survival estimate of 0.604, with a confidence interval of 0.043, from the trap to LGR. This survival estimate nearly doubled earlier estimates from 1993 to 1995. This estimate is 0.145 higher than fall tagged natural chinook salmon released at the upper site. However, this is considered a minimum survival estimate because it is unknown if fall PIT tagged chinook salmon continue to migrate downstream through the dams during fall and winter before PIT tag interrogation systems are operational in the spring. Cumulative detections of fall PIT tagged natural chinook salmon from the lower site at LGR, LGO, LMO, and MCN totaled 707 fish, or 48.6%. Fall tagged chinook salmon, from release at the lower trap to LMO, had an estimated survival of 0.497.

Table 10. Season-wide survival estimates from the upper and lower traps to Lower Granite Dam (LGR), Lower Granite Dam to Little Goose Dam, (LGO), Little Goose Dam to Lower Monumental Dam (LMO), and Lower Monumental Dam to McNary Dam (MCN) for fish released from October 14 to December 16, 1997 at the upper and lower Imnaha traps and February 26 to June 16 at the lower trap. Ninety-five percent confidence intervals (C.I.) are shown to the right in parentheses.

Season, Site Rearing Species	Number Released	Trap to LGR (95% C.I.)		LGR to LGO (95% C.I.)		LGO to LMO (95% C.I.)		LMO to MCN (95% C.I.)	
Fall, Upper Site Natural Chinook salmon	1,996	0.459	(0.031)	1.010	(0.038)	0.848	(0.110)	1.077	(0.402)
Fall, Lower Site Natural Chinook salmon	1,453	0.604	(0.043)	1.052	(0.071)	0.782	(0.147)	0.873	(0.269)
Spring, Lower Site Natural Chinook salmon	3,956	0.852	(0.020)	1.034	(0.041)	0.849	(0.059)	1.050	(0.186)
Spring, Lower Site Hatchery Chinook salmon	2,000	0.757	(0.031)	1.002	(0.063)	0.848	(0.098)	0.845	(0.257)
Spring, Lower Site Natural Steelhead	3,106	0.860	(0.022)	0.996	(0.051)	0.795	(0.071)	0.939	(0.298)
Spring, Lower Site Hatchery Steelhead	3,859	0.829	(0.024)	0.930	(0.047)	0.824	(0.071)	1.004	(0.331)

The season-wide estimate for natural chinook salmon released from the Imnaha River trap to LGR, March 15 to April 25, was 0.852 with a 95% confidence interval of 0.020 (Table 10). This estimate is 0.248 higher than natural chinook salmon released from the same point in the fall. However, as previously mentioned, it is unknown if fall PIT tagged chinook salmon continue to migrate downstream through the dams during fall and winter before PIT tag interrogation systems are operational in the spring. The cumulative percentage of unique PIT tags interrogated at LGR, LGO, LMO, and MCN was 74.4% (n = 3,956). Appendix L contains the cumulative interrogation percentages from 1993 to 1998. Survival estimates from 1993 to 1998 have ranged from 0.762 in 1994 to 0.909 in 1995. The 95% confidence intervals were 0.053 and 0.067, respectively (Figure 28). Seasonal survival estimates prior to 1998 in this report for natural and hatchery chinook salmon and steelhead represent the latest calculations by NPT and preceded estimations presented in previous annual reports. The smaller confidence interval for 1998 reflects the largest release group of natural chinook salmon from the Imnaha river. Sample sizes for estimates prior to 1998 ranged from 238 to 1,310. There are no apparent trends in survival of Imnaha River natural chinook salmon, from 1993 to 1998.

Hatchery chinook salmon, released from the Imnaha River trap to LGR, had a season-wide survival estimate of 0.757 with a 95% confidence interval of 0.031. This was within the range of estimates from 1994 to 1997 (Figure 29). The lowest survival estimate to LGR was 67.1%, occurring in 1994, and the highest estimate was 0.804, occurring in 1997. PIT tag release groups, used in estimates from 1994 to 1997, ranged from 662 to 999 fish. The cumulative percentage of unique PIT tags interrogated in 1998 at LGR, LGO, LMO, and MCN was 64.2% (n = 2,000). This is the highest cumulative interrogation rate since 1992. No PIT tagged hatchery chinook salmon smolts were released from the Imnaha River screw trap in 1993. In 1992, cumulative interrogation percentages did not include LMO as it was not yet an interrogation site.

Season wide survival for natural steelhead released from the Imnaha River trap to LGR was 0.860 (Table 10). The 95% confidence interval was 0.022. This is the lowest seasonal estimate reported since 1995 (Figure 30). Natural steelhead have had fairly consistent survival estimates that ranged from 0.837 in 1995 to 0.901 in 1997. The 95% confidence intervals were 0.071 and 0.039. The cumulative percentage of unique PIT tags interrogated at LGR, LGO, LMO, and MCN in 1998 was 71.5% (n = 3,106). This currently represents the largest group of natural steelhead released into the Imnaha River. PIT tag release groups, used for cumulative interrogations prior to 1998, have ranged from 227 to 1,502 fish.

The estimated season-wide survival for hatchery steelhead released from the Imnaha River trap to LGR was 0.829 with a 95% confidence interval of 0.024. This was the highest estimated survival since 1995 (Figure 31). Estimated season-wide survival from the lower trap to LGR for 1995 was 0.775, with a 95% confidence interval of 0.031. However, the 1998 estimate is only slightly higher than the estimate for 1997 of 0.814 with a 95% confidence interval of 0.020 and the 1998 95% confidence interval overlaps 95% confidence intervals for 1997 and 1995. The lowest seasonal survival estimate to LGR was 0.646, occurring in 1996 with a 95% confidence interval of 0.047. The cumulative percentage of unique PIT tags interrogated at LGR, LGO, LMO, and MCN in 1998 was 65.4% (n = 3,859). Survival estimates and cumulative interrogation rates for 1993 and

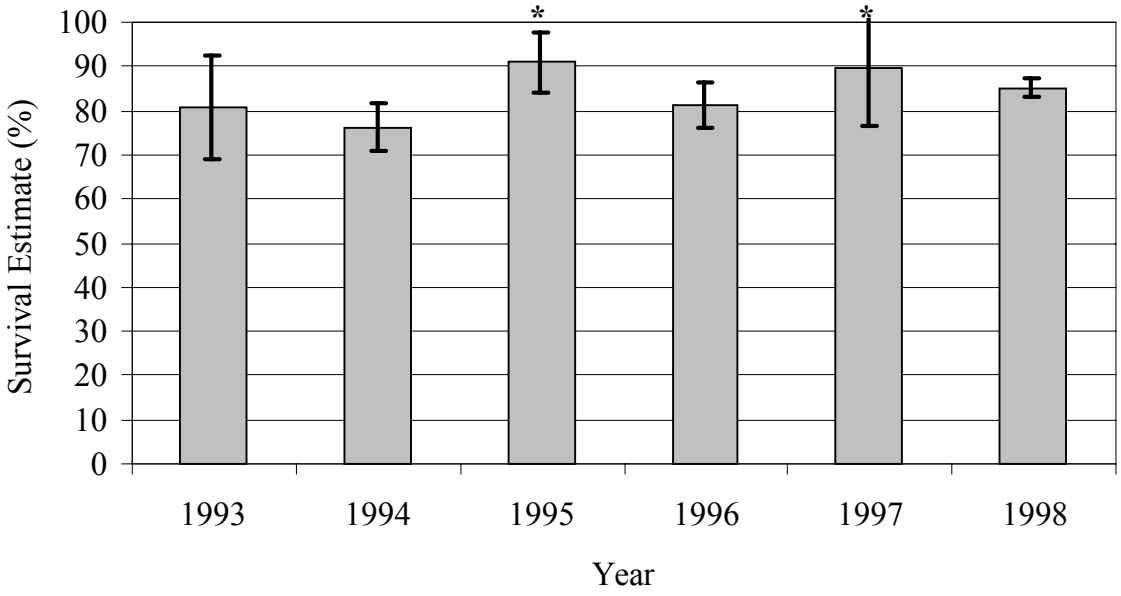

Figure 28. Season-wide survival estimates for natural chinook salmon released from the Imnaha River trap to Lower Granite Dam, from 1993 to 1998. Error bars indicate 95% confidence limits. Asterisks indicate upper confidence levels greater than 100%.

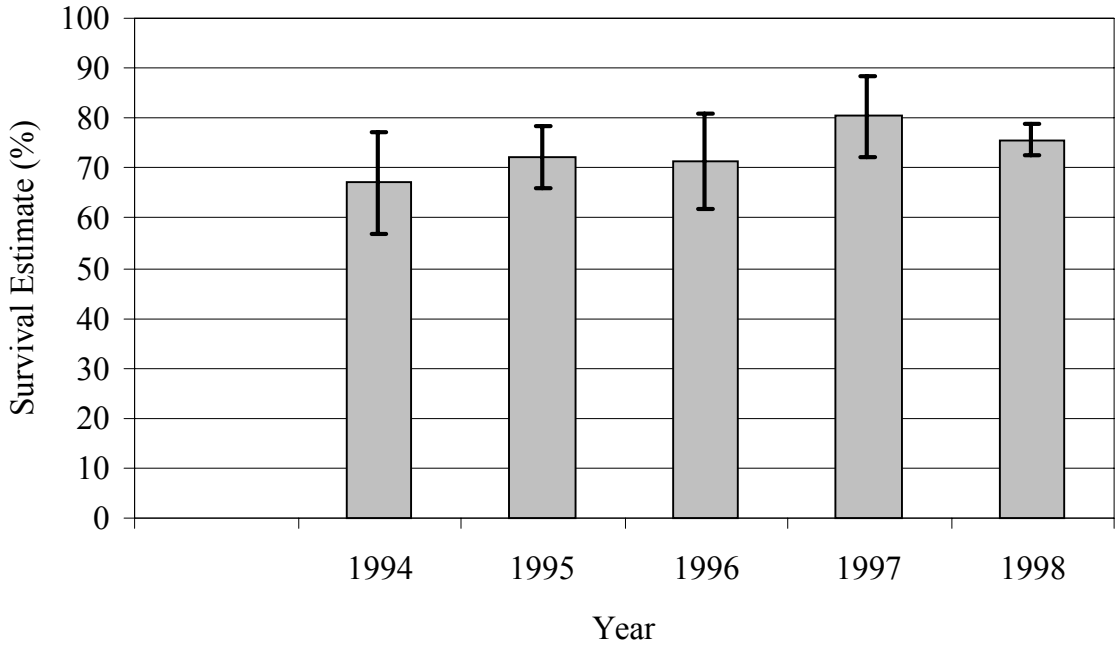

Figure 29. Season-wide survival estimates for hatchery chinook salmon released from the Imnaha River trap to Lower Granite Dam, from 1994 to 1998. Error bars indicate 95% confidence limits.

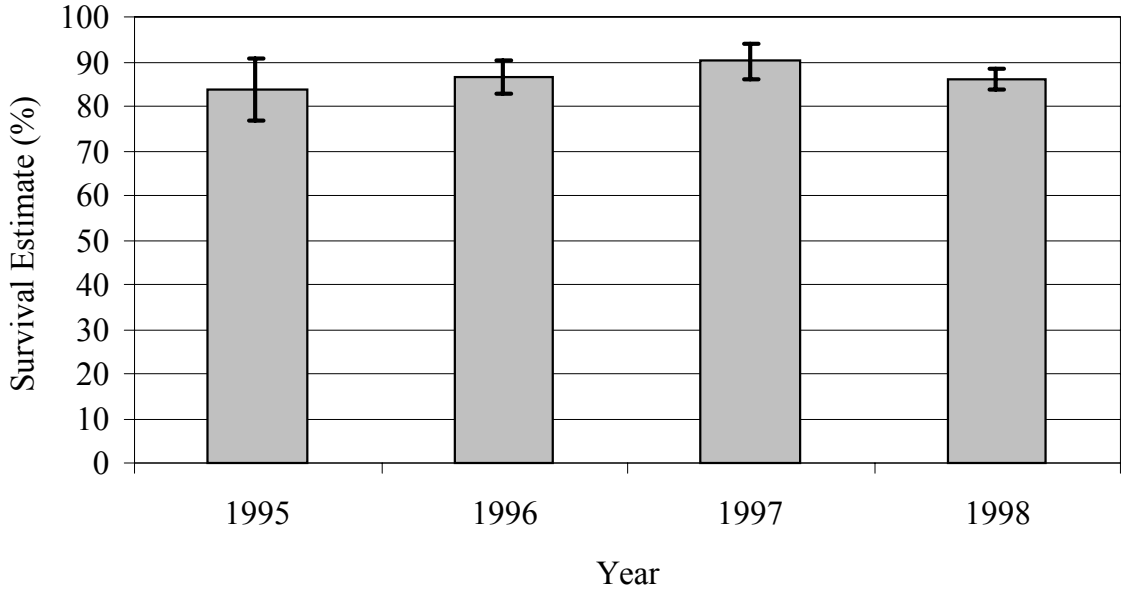

Figure 30. Season-wide survival estimates for natural steelhead released from the Imnaha River trap to Lower Granite Dam, from 1995 to 1998. Error bars indicate the 95% confidence limit.

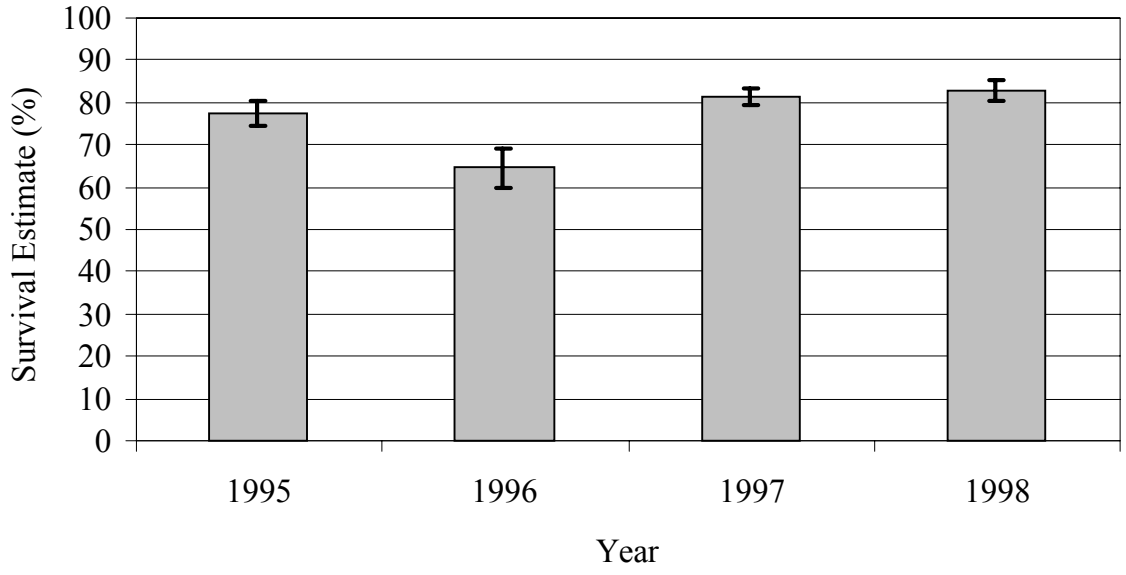

Figure 31. Season-wide survival estimates for hatchery steelhead released from the Imnaha River trap to Lower Granite Dam, from 1995 to 1998. Error bars indicate the 95% confidence limit.

1994 were not presented because handling procedures may have caused excessive stress to the fish.

The seasonal estimate for the release of 19,827 PIT tagged hatchery chinook salmon from the acclimation facility to Lower Monumental Dam was higher than previous estimates from 1993 to 1997 (Figure 32). Survival of these fish was estimated to be 0.572. The 95% confidence interval was 0.010. The previous high estimate was 0.519, occurring in 1995, and the low estimate is 0.463, occurring in 1996. The 95% confidence intervals were 0.029 and 0.028 respectively.

Seasonal survival estimates from the trap to MCN for natural and hatchery chinook salmon and steelhead were not as accurate as those to LMO. Although sample sizes of PIT tagged smolts released at the trap ranged from 2,000 to 3,956 the 95% confidence intervals were generally robust. Estimated survival of each species and rearing type from the trap to MCN were as follows, with 95% confidence intervals in parentheses: natural chinook salmon - 0.787 (0.133), hatchery chinook salmon - 0.543 (0.157), natural steelhead - 0.640 (0.198), and hatchery steelhead - 0.638 (0.206). The survival estimate for natural chinook salmon and hatchery steelhead from release to MCN were higher than from release to LMO because the model estimated suvival from LMO to MCN to be greater than one for each estimate.

Estimated survival for 1998 spring weekly release groups of natural chinook salmon from the Imnaha River trap to LGR ranged from 0.838 to 0.904 (Table 11). The 95% confidence intervals were 0.049 and 0.043, respectively. Estimated survival for spring weekly release groups of natural chinook salmon from LGR to LGO ranged from 0.946 to 1.112, with confidence intervals of 0.078 and 0.082, respectively. Estimates greater than one indicate that survival to the previous site may have been underestimated. Estimated survival, from LGO to LMO, ranged from 0.811 to 0.893. The 95% confidence intervals were 0.099 and 0.131, respectively. Estimates from release to LMO ranged from 0.719 to 0.781. The 95% confidence intervals were 0.163 and 0.143.

Confidence intervals for weekly estimates from LMO to MCN were greater than 21% for natural and hatchery chinook salmon and natural and hatchery steelhead. Therefore, they are not presented here. If more precise estimates are to be obtained for LMO then larger release groups will be needed to increase detections past MCN. This may not be possible given the environmental conditions and current emigrant trapping constraints at the Imnaha River trap site.

Estimated survival for the two 1998 weekly release groups of PIT tagged hatchery chinook salmon from the Imnaha River trap to LGR were 0.746 and 0.765 (Table 11). The 95% confidence intervals were 0.043 and 0.045, respectively. These estimates are 0.123 and 0.120 lower than natural salmon released during the same weeks. Estimated survival of weekly release groups of hatchery chinook salmon from LGR to LGO were 1.050 and 0.960, with 95% confidence intervals of 0.09 and 0.08, respectively. Survival estimates from LGO to LMO were 0.745 and 0.986, with 95% confidence intervals of 0.111 and .168, respectively. Estimates from release to LMO were 0.584 and 0.724. The 95% confidence intervals were .078 and .120, respectively.

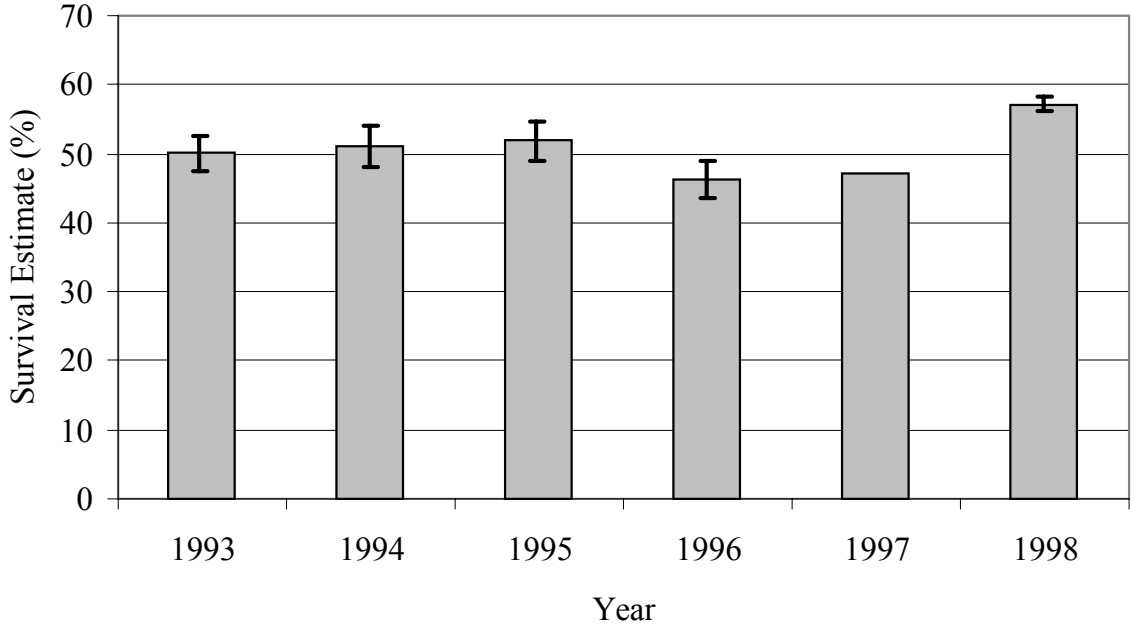

Figure 32. Estimated survival of hatchery reared chinook salmon smolts released at the Imnaha River acclimation facility to Lower Monumental Dam from 1993 to 1998 and 95% confidence intervals. Confidence intervals were not available for the 1997 estimates (after Smith et al. 1998, cited in Kucera, 1998).

Natural steelhead survival, from the Imnaha River trap to LGR, ranged from 0.798 to 0.889 for weekly release groups (Table 11). The 95% confidence intervals were 0.056 and 0.050, respectively. Survival from LGR to LGO ranged from 0.863 to 1.072. The 95% confidence intervals were 0.154 and 0.143. Estimated survival from LGO to LMO ranged from 0.636 to 0.843, with 95% confidence intervals of 0.135 and 0.107, respectively. Estimates from release to LMO ranged from 0.606 to 0.749. The 95% confidence intervals were 0.102 and 0.084, respectively.

Weekly release groups of hatchery steelhead, from the Imnaha River trap to LGR, had survival estimates ranging from 0.774 to 0.869. The 95% confidence intervals were 0.068 and 0.027 (Table 11). Estimated survival for spring weekly release groups of hatchery steelhead from LGR to LGO ranged from 0.824 to 0.920. The 95% confidence intervals were 0.127 and 0.060, respectively. The survival of hatchery steelhead from LGO to LMO released during the week of April 26 and May 24 were estimated to have survival rates of 0.796 and 0.775, with 95% confidence intervals of 0.082 and 0.119, respectively. No survival estimate was presented for hatchery steelhead released during the week of May 10 because confidence intervals were greater than 0.200 (Table 11). Survival estimates for weekly release groups of hatchery steelhead during

Table 11. Estimated survival probabilities for salmonid smolts released from the lower Imnaha River trap from February 26 to June 16, 1998 with 95% confidence limits in parentheses. Estimates are from release to the tail race for the trap to Lower Granite Dam and tailrace to the tail race for all other sites. Abbreviations: LGR-Lower Granite Dam, LGO-Little Goose Dam, LMO-Lower Monumental Dam.

Week of Release	Number Released	Trap to LGR (95% C.I.)		LGR to LGO (95% C.I.)		LGO to LMO (95% C.I.)		Trap to LMO (95% C.I.)	
Natural Chinook salmon									
3/15	1,698	0.849	(0.033)	1.112	(0.082)	0.811	(0.099)	0.766	(0.078)
3/22	280	0.849	(0.094)	1.019	(0.178)				
3/29	611	0.838	(0.049)	1.059	(0.099)	0.880	(0.172)	0.781	(0.143)
4/5	218	0.867	(0.070)	0.986	(0.105)	0.842	(0.196)	0.719	(0.163)
4/12	457	0.886	(0.051)	0.941	(0.080)	0.900	(0.141)	0.750	(0.110)
4/19	491	0.904	(0.043)	0.989	(0.072)	0.807	(0.107)	0.721	(0.090)
Hatchery Chinook salmon									
4/5	1,007	0.746	(0.043)	1.050	(0.090)	0.745	(0.111)	0.584	(0.078)
4/12	987	0.765	(0.045)	0.960	(0.080)	0.986	(0.168)	0.724	(0.120)
Natural Steelhead									
3/29	247	0.838	(0.082)	0.863	(0.154)				
4/19	714	0.889	(0.050)	1.072	(0.143)	0.636	(0.135)	0.606	(0.102)
4/26	567	0.880	(0.039)	1.010	(0.084)	0.843	(0.107)	0.749	(0.084)
5/10	357	0.798	(0.056)	0.982	(0.121)	0.802	(0.192)	0.629	(0.141)
5/24	712	0.849	(0.074)	0.966	(0.145)				
Hatchery Steelhead									
4/26	1,449	0.869	(0.027)	0.920	(0.060)	0.796	(0.082)	0.636	(0.061)
5/10	661	0.774	(0.068)	0.824	(0.127)				
5/24	1,402	0.838	(0.054)	0.886	(0.096)	0.775	(0.119)	0.575	(0.074)

the week of April 26 and May 24, from the Imnaha River trap to LMO, were 0.636 and 0.575, with confidence intervals of 0.061 and 0.074, respectively.

Kucera and Blenden (1998) reported that Imnaha River hatchery chinook salmon smolts released at the acclimation facility experienced the highest reach specific mortality from the Imnaha River trap to LGR. Our results for 1998 are consistent (Figure 33). Mortality between the Imnaha trap and LGR was estimated to be 22.7 (±2.1%), for hatchery chinook salmon released from the acclimation facility. This is the lowest estimated mortality for this reach since 1994. The highest estimated was 38.6% in 1996. Mortality for hatchery chinook salmon released from the acclimation facility to the Imnaha trap was 11.6%. This is the highest in river post-release mortality estimated since 1994 (Kucera and Blenden 1998). Prior to 1998, estimated survival for hatchery chinook released from the acclimation facility to the lower Imnaha trap had ranged from 0% in 1994 to 10.8% in 1997.

The values in Table 10 indicate that hatchery chinook and steelhead experienced the highest reach specific mortality from the Imnaha River trap to LGR (Figure 34). Mortality in this section was 24.3% for hatchery chinook salmon and 17.1% for hatchery steelhead. Natural chinook and steelhead released during the spring had 14.8 and 14.0% mortality between the Imnaha river trap and LGR, but had higher mortality estimates between LGO and LMO of 15.1 and 20.5%, respectively. Values in Table 10 indicate that least amount of mortality occurred

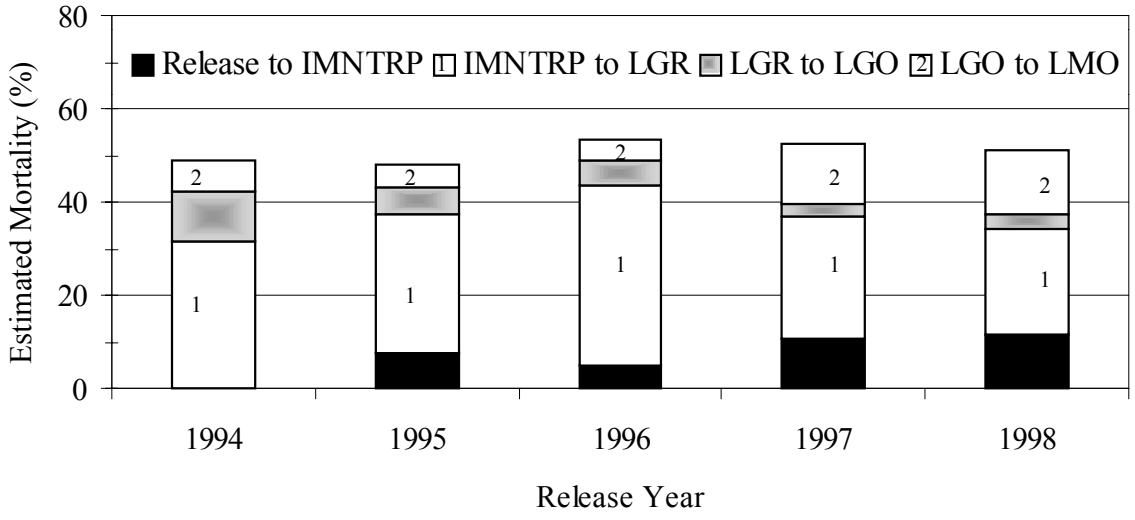

Figure 33. Estimated mortality of hatchery reared chinook salmon smolts, by stream reach, from release at the Imnaha River acclimation facility to Lower Monumental Dam from 1994 to 1998 (after Smith et al. 1998, cited in Kucera 1998).

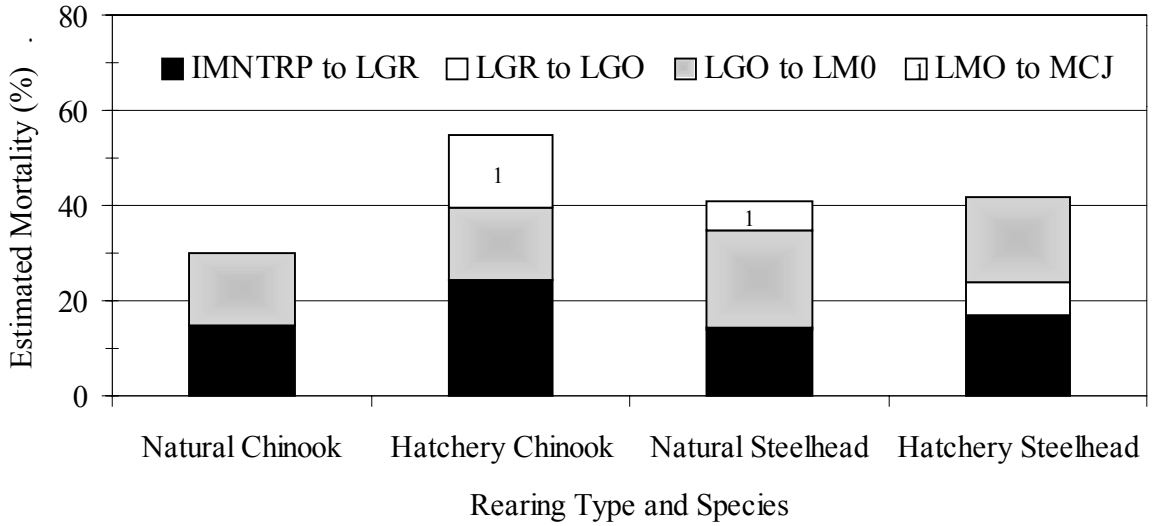

Figure 34. Season-wide mortality of natural and hatchery reared chinook salmon and steelhead smolts, by stream reach, from release at the Imnaha River trap to McNary Dam in 1998.

between LGR and LGO and limited mortality occurred between LMO and MCN. However, four of the 6 estimates presented in Table 10 for the area between LGR and LGO are greater than one and three of the 6 estimates presented in Table 10 for the area between LMO and MCN are greater than one. Estimates greater than one are not possible because the number of PIT tagged fish detected at LGR and released back into the river can not exceed the number of PIT tagged fish detected downstream at LGO unless the number of fish detected at LGR and released back into the river were underestimated. This may have occurred if a significant portion of the PIT tagged fish were not detected at LGR or if handling protocols at LGR were breached (e.g. fish were detected in route to a barge and removed from the study and subsequent release group at LGR, but were actually released into the river). Overestimation in a single reach should not invalidate the overall survival estimate because there are multiple recapture events where a fish can be detected but it does make assessing the mortality in these reaches problematic. Therefore, we recommend that readers view the data as an overall estimate of the season-wide mortality and bear in mind the problems with using this data to assess reach specific mortality.

Arrival Timing

Natural chinook salmon PIT tagged in the fall of 1997, at the upper trap, arrived at LGR from April 3 to June 5 (n=454) with median and 90% arrival on April 27 and May 9 (Table 12). April 3 arrivals were represented by three fish. Arrival at LGO occurred from April 14 to May 28

Table 12. Arrival timing of PIT tagged Imnaha River natural chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 1998.

Dam	Year	Sample Size(n)	Arrival Timing		
			Date Range	Median	90%
Lower Granite	**1998[a]**	**454**	**April 3 - June 5**	**April 27**	**May 9**
	1998[b]	**428**	**March 27 - May 12**	**April 14**	**April 24**
	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	**1998[a]**	**410**	**April 14 - May 28**	**May 4**	**May 15**
	1998[b]	**228**	**April 11 - May 12**	**April 25**	**May 2**
	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	**1998[a]**	**304**	**April 15 - May 29**	**May 7**	**May 19**
	1998[b]	**202**	**April 19 - May 19**	**April 25**	**May 4**
	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	**1998[a]**	**195**	**April 18 - June 4**	**May 4**	**May 18**
	1998[b]	**236**	**April 20 - May 23**	**April 30**	**May 4**
	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

[a] Tagged and released during the fall of 1997 from the upper trap site.
[b] Tagged and released during the fall of 1997 from the lower trap site.

(n=410). Median and 90% arrival to LGO occurred on May 4 and May 15, respectively. Natural chinook salmon emigrated past LMO between April 15 and May 29 (n=304), with median and 90% passage dates of May 7 and May 19. Natural chinook salmon arrival at MCN ranged from April 18 to June 4 (n=195). Median and 90% arrival at MCN occurred on May 4 and May 18. These fish, assumed to overwinter in the Imnaha River, had similar arrival timing at all dams to natural chinook salmon tagged at the lower trap during the spring, with 90% arrival timings being three to eight days later.

Fall PIT tag release groups of natural chinook salmon from the lower trap arrived at LGR from March 27 to May 12 (n=428), with median and 90% arrival on April 14 and April 24 (Table 12). March 27 arrivals were represented by 2 fish. Arrival at LGO occurred from April 11 to May 12 (n=228). Median and 90% arrival to LGO occurred on April 25 and May 2, respectively. Natural chinook salmon emigrated past LMO between April 19 and May 19 (n=202) with median and 90% passage dates of April 25 and May 4. Natural chinook salmon arrival at MCN ranged from April 20 to May 23 (n=236). Median and 90% arrival at MCN occurred on April 30 and May 4. Peak arrival occurred at LGR from early to mid-April and occurred in late April at Little Goose, Lower Monumental and MCN (Appendix M).

Imnaha River natural chinook salmon smolts PIT tagged and released during the spring arrived at LGR from April 1 to June 27 with median and 90% passage dates of April 25 and May 6, respectively (Table 12). April 1 arrivals were represented by 5 fish. Arrival timing at LGR, LGO, LMO, and MCN for natural chinook salmon is represented by 1,630, 837, 289, and 187 fish, respectively. Median arrival dates at LGR have ranged between April 22 and May 4 from 1993 to 1998. The 90% arrival dates for natural chinook salmon released in the spring for the years 1993-1997 have all fallen within a one week period from May 11-18 at LGR. In 1998 the 90% arrival occurred earlier, May 6. Natural chinook salmon smolts emigrated past LGO between April 14 and June 25, 1998. The median passage date at LGO was May 3 and 90% of natural chinook salmon smolt passage occurred by May 12. The 90% passage date at LGO (1993-1998) has occurred over a two week period from May 7 to May 20. Natural chinook salmon released in the spring of 1998, from the lower trap, moved past LMO and MCN occurred between April 19 to June 8 and April 19 to June 2, respectively. Passage of 90% of natural chinook salmon smolts at LMO in 1998 occurred on May 11, two days earlier than previously observed from 1993 to 1997. The latest passage date for 90% of natural chinook at LMO, since 1993, has been June 4. Timing of 90% passage at MCN was observed from May 12 to May 28 (1993-1998).

PIT tag interrogation systems at LGR may not have covered the whole emigration period. The fish tagged at the lower trap during the fall, and assumed to overwinter in the Snake River, had earlier arrival timings than the natural chinook salmon smolts tagged at the lower trap during the spring or the upper trap during the fall. March 27 was the first day of sampling at LGR. Two of the Imnaha fish, from the fall release group at the lower trap, arrived on March 27. The daily index of passage at LGR on March 27 was 44 wild yearling chinook salmon (Anonymous *b* 1998). The fall tagged natural chinook salmon released from the lower trap had a 90% arrival timing 12 days earlier than spring tagged fish at LGR. The 90% arrival timing of fall tagged natural chinook salmon, from the lower trap, was 10 days earlier at LGO, 7 days earlier at LMO, and 9 days earlier

at MCN, than natural chinook salmon smolts tagged at the lower trap during the spring. The earlier arrival timing of Imnaha natural chinook salmon released during the fall at LGR suggests that the cumulative interrogation rate of 48.6% for natural chinook salmon released in the fall from the lower trap may not be accurate due to the lack of interrogation data. Earlier operation of the PIT tag interrogation system would be beneficial for evaluating different life history strategies of chinook salmon.

Arrival timing of spring PIT tagged Imnaha River hatchery chinook salmon smolts occurred between April 15 and May 22 at LGR, April 25 and May 26 at LGO, April 23 and May 26 at LMO, and between May 2 and May 30 at MCN. Arrival timing at LGR, LGO, LMO, and MCN for hatchery chinook salmon is represented by 696, 391, 143, and 53 fish, respectively. Median arrival dates of hatchery chinook salmon at LGR, LGO, LMO, and MCN occurred on May 2, May 7, May 8, and May 11, respectively (Table 13). Ninety percent of the fish had passed by LGR, LGO, LMO, and MCN by May 9, May 14, May 15, and May 19 respectively. For the migratory years 1994-1998 the median and 90% arrival dates at LGR ranged from May 2-12 and May 9-16. respectively. The 90% passage date at LGO (1994-1998) has occurred over a 9 day period from May 14-23. The 90% arrival dates (1994-1998) at LMO occurred over a nine day period (May 15-26).

Natural steelhead smolts PIT tagged and released in the spring from the Imnaha River arrived at LGR from April 2 to June 12, at LGO from April 14 to June 19, at LMO from April 16 to June 11, and at MCN from April 20 to June 4 (Table 14). Arrival timing at LGR, LGO, LMO, and MCN for natural steelhead is represented by 1,474, 481, 213, and 53 fish, respectively. Median and 90% arrival dates of natural steelhead occurred on May 3 and May 22 at LGR, May 8 and May 26 at LGO, May 10 and May 27 at LMO, and May 7 and May 28 at MCN. May 2 to May 26 is the median arrival date range at LGR for natural steelhead from 1993 to 1998. The 90% arrival date range for 1993 to 1998 is May 9 to June 8. Natural steelhead 90% arrival timing at LGO has occurred between May 12 and June 7 (1993-1998). LMO 90% arrival timing of natural steelhead smolts has occurred from May 14 to July 10, from 1993 to 1998. Ninety percent arrival timing at MCN (1994 and 1996-1998) occurred between the dates of May 18 and June 9. Handling procedures in 1994 may have caused a lower than average cumulative interrogation rate and may have affected arrival timing as well (Ashe et. al. 1995).

Imnaha River hatchery steelhead smolt dam arrival timing was more prolonged than their natural counterparts because of the two release dates. Arrival timing occurred between April 25 and July 29 at LGR, May 3 to July 10 at LGO, May 5 to July 15 at LMO, and May 13 to July 2 at MCN (Table 15). PIT tagging and differential fin clips made it possible to distinguish between the April 26 and May 19 release groups. However, the point of release for all PIT tagged steelhead used in this analysis was from the lower trap. Therefore, hatchery steelhead were treated as one entire group for summarizing arrival timing data.

Arrival timing of spring PIT tagged Imnaha River hatchery steelhead smolts occurred between April 25 and July 29 at LGR, May 3 and July 10 at LGO, May 5 and July 15 at LMO, and

Table 13. Arrival timing of PIT tagged Imnaha River hatchery chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary Dams from 1992 to 1998.

Dam	Year	Sample Size (n)	Arrival Timing		
			Date Range	Median	90%
Lower Granite	**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	**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	**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	**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 the Nez Perce Tribe and released at dark.
[2] HXH crossed chinook salmon smolts PIT tagged for the Fish Passage Center 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.

Overall, for the years 1993-1998, the median and 90% arrival date ranges for hatchery steelhead at LGR were May 5 to May 31, and May 26 to July 15, respectively. Handling procedures in 1994 may have caused a lower than average cumulative interrogation rates and may have affected arrival timing as well (Blenden et al. 1997). At LGO the median and 90% arrival timing for 1993 to 1998 was May 25 to June 3, and May 30 to July 17, respectively. Median and

Table 14 . Arrival timing of PIT tagged Imnaha River natural steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary Dams from 1993 to 1998.

Dam	Year	Sample Size (n)	Arrival Timing		
			Date Range	Median	90%
Lower Granite	**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-August 15	May 8	June 1
	1994[2]	207	May 3-August 20	May 9	May 30
	1993	101	May 3-June 13	May 26	June 8
Little Goose	**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	**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	**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

90% arrival timing at LMO for 1993 to 1998 was May 26 to June 18, and June 3 to July 21. At MCN the median and 90% arrival date ranges for 1993 to 1998 was May 23 to June 17, and May 30 to July 10, respectively. between May 13 and July 2 at MCN. Arrival timing at LGR, LGO, LMO, and MCN for hatchery steelhead is represented by 1, 683, 555, 253, and 31 fish, respectively. Median arrival dates of hatchery steelhead at LGR, LGO, LMO, and MCN occurred on May 15, May 25, May 26, and June 1, respectively (Table 14). Ninety percent of the fish had

Table 15. Arrival timing of PIT tagged Imnaha River hatchery steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 1998.

Dam	Year	Sample Size (n)	Arrival Timing		
			Date Range	Median	90%
Lower Granite	**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	**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	**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	**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
[2] - FPC PIT tagged fish released after recovery

passed by LGR, LGO, LMO, and MCN by May 26, May 30, June 3, and June 19, respectively.

Spill occurred at all dams during the Imnaha River smolt emigration, the majority of the smolts arrived at the dams before the peak in the average spill occurred. The 90% arrival timing of Imnaha River natural chinook salmon, released in the fall at the upper trap preceded the peak in the average total spill at LGR by 18 days. At LGO, LMO, and MCN 90% arrival of natural chinook salmon released in the fall at the upper trap preceded the peak in the average total spill by 12, 9,

and 11 days. Natural chinook salmon released at the lower trap during the fall had ninety percent arrival times that preceded the peak average total spills at LGR, LGO, LMO and MCN by 33, 22, 24, and 25 days, respectively. However, differences between 90% arrival of natural chinook salmon released in the fall at the lower trap and the peak average total spills may be greater if early arrivals at dams went undetected. Spring releases of natural chinook had 90% arrival times at LGR, LGO, LMO, and MCN that preceded the peak average total spills at LGR, LGO, LMO, and MCN by 21, 15, 17 and 14 days, respectively. A group of PIT tagged wild spring/summer chinook salmon from multiple streams in Idaho in 1995 were also observed to have arrived before peak flows occurred in 1995 (Achord et al. 1996). Peak passage of fish from multiple streams in Idaho at LGR coincided with an increasing flow period, but prior to peak flows. Additionally, peak passage occurred prior to peak flows at LGO, LMO, and MCN, but coincided with moderate to high river flows (Achord et al. 1996).

Hatchery Chinook arrived at LGR, LGO, LMO, and MCN 18, 13, 13, and 10 days, respectively, prior to the peaks in the average total spill. Differences between 90% arrival timing and the peak in the average total spill were less for Imnaha River steelhead. Natural steelhead arrived at LGR five days earlyer than the peak in the average total spill at LGR and only one day difference at LGO, LMO, and MCN. At LGR, 90% arrival of hatchery steelhead occurred a day prior to the peak in the average total spill and 90% arrival at LGO, LMO, and MCN occurred 3, 6, and 21 days, respectively, after the peaks in the total average spill occurred at each dam. Appendix M contains figures of the arrival timing frequency, the average total discharge, and the average total turbine discharge for LGR, LGO, LMO, and MCN for all fish released in the fall and spring from the Imnaha River.

Travel Times

Mean travel time of natural chinook salmon, for release groups of 30 or more fish, to LGR ranged from 8 to 29 days between March 15 and May 23 and mean travel times during the weeks of April 5 and 12 were 21 and 16 days, respectively (Figure 35). The fastest mean travel time resulted from the releases during the week of May 10 and the slowest mean travel time resulted from the releases during the week of March 15. Mean travel times of natural chinook salmon decreased with an increase in the calendar date. Natural chinook salmon tagged in March and early April did not have the benefit of the increased discharge from the Imnaha River and Snake River and may not have been as smoltified as natural chinook salmon tagged in late April. The mean travel time of hatchery chinook salmon to LGR was 26 and 25 days for the releases during the weeks of April 5 and April 12 (Figure 35).

Individual travel times of natural and hatchery chinook salmon were compared for releases occurring during the weeks of April 5 and April 12. There was not a significant difference in the travel times of natural and hatchery chinook salmon from the Imnaha River trap to LGR during the week of April 5 ($p > 0.05$). T-test values for 1998 are presented in Appendix F. Natural chinook salmon released during the following week had significantly faster travel times to LGR than hatchery chinook salmon ($p < 0.05$).

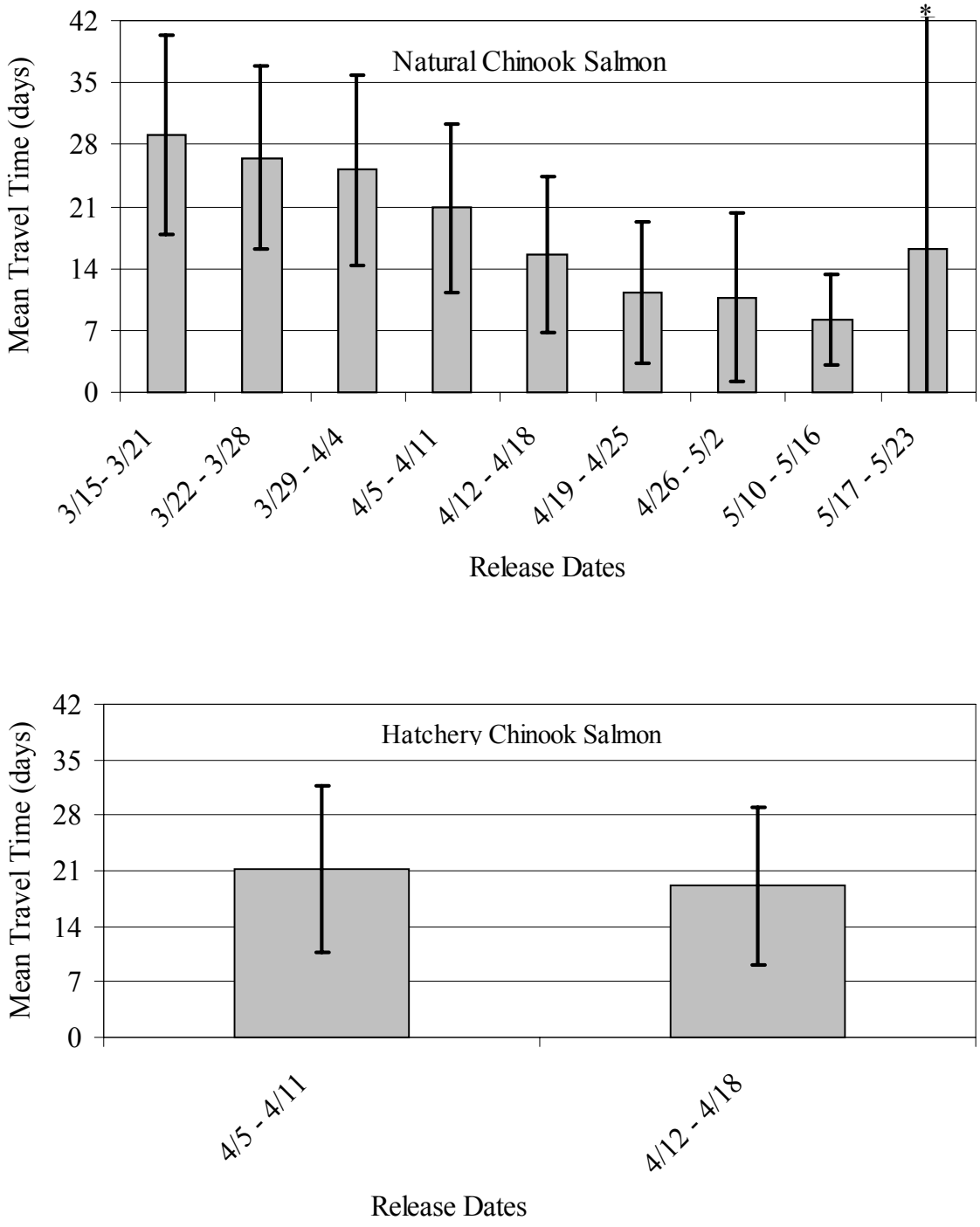

Figure 35. Mean travel times of natural chinook salmon (top) and hatchery chinook salmon (bottom) weekly PIT tag release groups, from the lower Imnaha trap to LGR, with 95% confidence intervals, in 1998. Asterisks indicate confidence intervals greater than 42 days.

Travel time of natural steelhead to LGR ranged from 4 to 38 days (Figure 36). Natural steehead smolt travel time decreased over time as the spring emigration proceeded until the weekof April 19. Mean travel time from the May 17 weekly PIT tag releases was the fastest and the slowest mean travel time was the result of the March 15 weekly releases. Hatchery Steelhead mean travel time to LGR ranged from 5 to 8 days (Figure 36). The slowest travel times were the result of the releases during the week of April 26 and the fastest travel times were the result of the releases during the week of June 7. Median travel times of natural and hatchery steelhead smolts were compared for releases occurring from April 26 to May 17. Median travel times of natural steelhead (4 days) were significantly faster than hatchery steelhead (6 days) to LGR during the week of April 26 and May 17 ($p < 0.05$). Wilcoxon test values for 1998 are presented in Appendix I.

Mortality

Mortality was tallied for each anadromous salmonid species of natural and hatchery origin to determine the effects of trapping, handling and tagging on the fish during the fall and spring. The only mortality experienced during the fall was a trapping related mortality (0.07%) at the lower trap.

Handling was the principal cause of mortality during the spring in natural and hatchery chinook salmon (0.12 and 0.03%), while trapping caused the most mortalities in natural and hatchery steelhead (0.03 and 0.10%). PIT tagging was not a cause of mortality for natural chinook salmon and steelhead. PIT tagging caused minimal mortalities for hatchery chinook salmon and hatchery steelhead (0.01 and 0.06%) (Table 16). Total mortality due to trapping, handling, and PIT tagging did not exceed 0.17% for natural chinook salmon, 0.04 for hatchery chinook salmon, 0.03 for natural steelhead, and 0.18 for hatchery steelhead during the spring emigration trapping.

Table 16. Mortality of chinook salmon and steelhead smolts due to trapping, handling, and PIT tagging from February 26 to June 16, 1998.

	Chinook salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Number Captured	4163		17,926		3,560		5,141	
Mortality Source	n	%	n	%	n	%	n	%
Trapping	2	0.05	1	0.01	1	0.03	5	0.10
Handling	5	0.12	5	0.03	0	0.00	1	0.02
PIT Tagging	0	0.00	2	0.01	0	0.00	3	0.06
Total	7	0.17	8	0.04	1	0.03	9	0.18

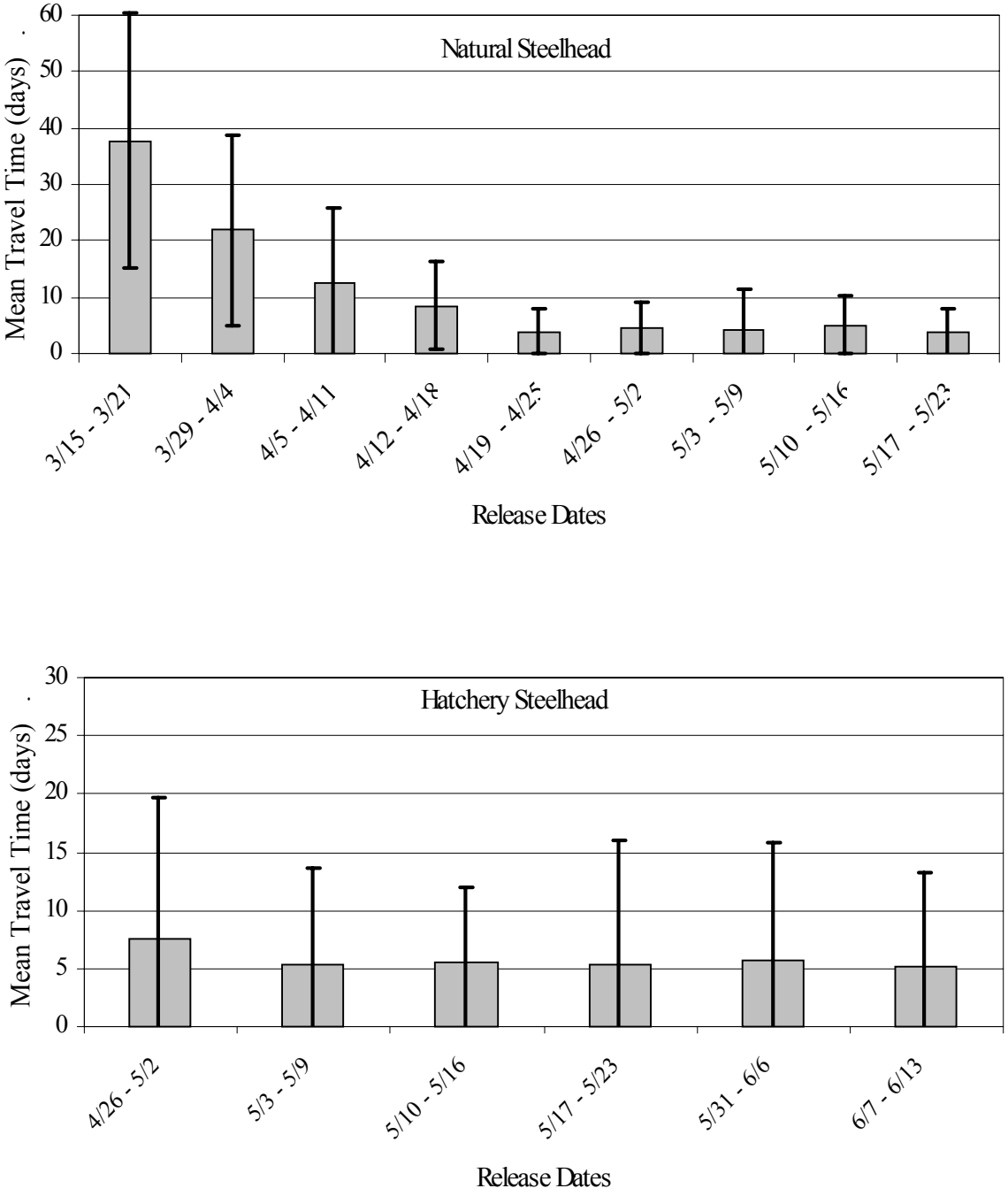

Figure 36. Mean travel times of natural steelhead (top) and hatchery steelhead (bottom) weekly PIT tag release groups, from the lower Imnaha trap to LGR, with 95% confidence intervals, in 1998.

Incidental Catch

Four non-target game fish species were incidentally captured during our investigation. They were mountain whitefish (*Prosopium williamsoni*), rainbow trout and adult steelhead (*Onchorhyncus mykiss*), bull trout (*Salvelinus confluentus*) and smallmouth bass (*Micropterus dolomieui*). The upper Imnaha River trap collected 198 mountain whitefish and seven bull trout during the fall trapping period. Seven mountain whitefish, five bull trout and one smallmouth bass were collected in the lower Imnaha River trap during the fall trapping period. A total of 36 mountain whitefish, 32 rainbow trout, 12 adult steelhead, and one bull trout were captured during the spring trapping period.

Other non-target fish collected during the spring include longnose dace (*Rhinichthys cataractae*), bridgelip suckers (*Catostomus columbianus*), sculpin (*Cottus sp.*), northern pike minnow (*Ptychocheilus oregonensis*) and redside shiner (*Richardsonius balteatus*). A total of 184, 147, 12, two and one were captured, respectively, during the spring trapping period. Additionally, four unidentified suckers were captured (*Catostomus sp.*). Three longnose dace and one sculpin were caught during the fall at the upper Imnaha River trap. The lower Imnaha River trap collected two longnose dace, seven bridgelip suckers, one sculpin, and eight northern pike minnow during fall trapping.

SUMMARY

Rotary screw traps were used to capture emigrating juvenile chinook salmon and steelhead in the Imnaha River at two sites, rkm 7 and 74, during the fall of 1997 and the spring of 1998. The fall sampling period ranged from October 14 to December 19. The spring sampling period ranged from Feburary 26 to June 16. Trapping only occurred at the lower site during the spring. High flows and debris kept the traps from fishing for 9 days during the spring trapping period in 1998.

Fall emigrants captured at the upper site totaled 2,232 natural chinook salmon and 24 natural steelhead. Fall emigrants captured at the lower site totaled 1,516 natural chinook salmon and 123 natural steelhead. A total of 4,195 natural chinook salmon, 17,837 hatchery chinook salmon, 3,569 natural steelhead, and 5,141 hatchery steelhead were sampled during the spring emigrant trapping at the lower site. The spring catch composition was 57.2% hatchery chinook salmon, 16.5% hatchery steelhead, 13.5% natural chinook salmon, 11.4% natural steelhead and 1.4% incidental species.

The mean length and weight of fall emigrating natural chinook salmon captured at the upper site was 89 mm and 7.9 g with a condition factor of 1.1. Mean fork length and weight of fall emigrating natural chinook salmon captured at the lower site was 95 mm and 9.0 g with a condition factor of 1.04. Fall emigrating chinook salmon captured at the lower site were significantly larger in fork length than chinook salmon at the upper site ($p < 0.05$). The mean length and weight of spring emigrating natural chinook salmon captured was 106 mm and 12.7 g with a condition factor of 1.05. There were no discerning size trends in mean weekly fork length or condition factor of emigrating natural chinook salmon. The mean length and weight of hatchery

chinook salmon captured was 135 mm and 27.2 g with a condition factor of 1.08. Hatchery chinook salmon were significantly larger in fork length than there natural counterparts in the spring ($p < 0.05$). The fork lengths of hatchery chinook salmon captured in the trap significantly decreased from April 5 to May 2.

The mean length and weight of fall emigrating natural steelhead captured at the upper site was 120 mm and 20.4 g with a condition factor of 1.01. Average length and weight of fall emigrating natural steelhead captured at the lower site was 146 mm and 38.4 g with a condition factor of 1.04. The mean length and weight of spring emigrating natural steelhead captured was 177 mm and 56.8 g with a condition factor of 0.99. Mean length and weight of spring emigrating hatchery steelhead captured was 218 mm and 102.2 g with a condition factor of 0.96. Hatchery steelhead were significantly larger than there natural counterparts in the spring.

Spring releases of hatchery chinook salmon by ODFW from the chinook salmon acclimation facility occurred on April 6 and totaled 93,123 smolts. All fish were marked with adipose fin clips and coded wire tags. A total of 19,827, of the 93,123 hatchery chinook salmon smolts released, were marked with PIT tags as well. Hatchery steelhead were released from the Little Sheep Creek Acclimation Facility on April 26 and May 19 and totaled 117,096 fish. Hatchery steelhead released April 26 had adipose, left ventral clips, and coded wire tags and totaled 86,422 fish. Hatchery steelhead released May 19 had only adipose clips and totaled 30,674 fish. Only the April 26 release group included a group of hatchery steelhead with 867 PIT tags.

The peak catch of natural chinook salmon totaled 501 smolts and occurred on March 18. Emigration timing of hatchery chinook salmon in the Imnaha River peaked April 9, with the catch of 3,927 fish, three days after their release. Approximately 97% of the hatchery chinook salmon were captured within 11 days of their release. Previously PIT tagged natural chinook salmon were captured in the greatest numbers on March 17 and the peak catch of previously PIT tagged hatchery chinook were captured on April 9. Mean travel time of PIT tagged hatchery chinook salmon to the trap was four days. Future volitional releases should be considered to produce earlier emigration timing that is synchronized with the movement of natural chinook salmon. Evaluation of emigration timing for hatchery chinook salmon can be accomplished by continuing to release groups of PIT tagged smolts.

The catch of natural steelhead did increase with increasing flows on April 25, but there was no noticeable trend throughout the season with migration responses, as measured by the daily catch, to fluctuations in flow or temperature. However, the daily catch does not account for factors such as changes in the trap efficiency, the number of traps operating, or the amount of time the traps were fished during the day. Hatchery steelhead also lacked noticeable responses to increases or fluctuations in flow or temperature. Emigration timing, as with hatchery chinook salmon, was the result of release timing.

We tagged a total of 7,406 natural chinook salmon in three distinct PIT tag release groups. The PIT tag release groups of natural chinook salmon tagged at the upper and lower site in the fall, and the lower site in the spring produced survival estimates, arrival timing, and mean travel time to LGR. A total of 2,000 hatchery chinook, 3,106 natural steelhead, and 3,859 hatchery steelhead

were PIT tagged as well. There was no significant differences between the fork lengths of tagged versus non-tagged natural chinook salmon, or tagged and non-tagged hatchery steelhead. There was a statistical difference between the fork lengths of tagged and non-tagged hatchery chinook salmon, but the 2 mm difference was not considered biologically significant. The majority of the natural steelhead captured (87%) were PIT tagged, released, and determined to be representative of the natural steelhead captured in the Imnaha trap in 1998.

The release of 19,827 PIT tagged hatchery chinook salmon from the acclimation site allowed us to estimate survival using the SURPH model. We interrogated 3,371 PIT tagged hatchery chinook salmon at the trap site in the spring and estimated survival to the trap at 88.4%. As in past years, daily trap efficiencies were conducted for the purpose of estimating survival using the Bootstrap method. However, overestimated trap efficiencies produced a bootstrap survival estimate from the acclimation facility to the lower Imnaha River trap that was slightly lower than a SURPH survival estimate from the acclimation facility to LGR.

Season-wide survival estimates from release to LGR of natural chinook salmon, released during the fall at the upper and lower trap, were 45.9 and 60.4%. Estimated season-wide survival of natural chinook salmon from release to LMO for fall releases at the upper and lower trap, were 39.3 and 49.7%. Survival estimates from release at the Imnaha trap to LGR, for weekly release groups of natural chinook salmon released from March 15 to April 19, ranged from 83.8 to 90.4%. Survival estimates from release at the Imnaha trap to LMO, ranged from 71.9 to 78.1%. Survival estimates from release at the Imnaha trap to LGR, for two weekly release groups of hatchery chinook salmon were 74.6 and 76.5%. Survival estimates from release at the Imnaha trap to LMO, were 58.4 and 72.4%. Natural chinook salmon smolts had higher survival rates to LGR and LMO for the weeks of April 5 and April 12, despite being significantly smaller than their hatchery counterparts.

Survival estimates from release at the Imnaha trap to LGR, for weekly release groups of natural steelhead released from March 29 to May 24, ranged from 79.8% to 88.9%. Survival estimates from release at the Imnaha trap to LMO for weekly release groups of natural steelhead ranged from 60.6% to 74.9%. Survival estimates from release at the Imnaha trap to LGR, for weekly release groups of hatchery steelhead released from April 26 to May 24, ranged from 77.4% to 86.9%. Survival estimates from release at the Imnaha trap to LMO, for weekly release groups of hatchery steelhead released from April 26 and May 24, were from 63.9 and 57.5%, respectively.

The season survival estimates for natural and hatchery chinook salmon, from release at the lower trap to LGR, were within the ranges observed from 1993 to 1997. Ranges for these two groups are 76.2 to 90.9%, and 67.1 to 80.4%, respectively. There appears to be no definite yearly trends in survival for natural or hatchery chinook salmon. Estimated season-wide survival from release at the lower trap to LGR, for natural steelhead (86.0%) was the lowest observed since 1995. Hatchery steelhead season-wide survival from release at the lower trap to LGR (82.9%) was the highest observed since 1995. Season-wide survival estimates from the lower trap to LGR for natural and hatchery steelhead have ranged from 83.7 to 90.1%, and 64.6 to 82.1%, respectively, since 1995.

Hatchery chinook salmon, released from the acclimation facility to LMO, appear to have sustained the highest mortality between the lower Imnaha trap and LGR. Mortality within this reach, has been higher than other reaches since 1994. Reach specific mortality for hatchery steelhead in 1998, from release at the lower trap to LMO, was also the highest between the Imnaha trap and LGR (17.9%). Natural chinook salmon and steelhead in 1998, released during the spring from the lower Imnaha trap to LMO, had the highest reach specific mortality between LGO and LMO. Mortality estimates should be used cautiously and only as indicators of reaches that are potential problems for passage because they are the result of survival estimates and survival between LGR and LGO may have been overestimated.

PIT tag interrogation systems at LGR may not have covered the whole emigration period. The passage index at LGR indicated that 44 wild (natural) chinook salmon yearlings passed during their first day of operations on March 27. Two Imnaha River fish, tagged during the fall at the lower trap, were interrogated on March 27 at LGR. An additional 8 PIT tagged natural chinook from the Imnaha River were interrogated between April 1 and April 3. Natural chinook salmon tagged in the fall at the lower site had median and 90% arrival dates 9 and 12 days earlier than natural chinook salmon tagged in the fall at the upper site or natural chinook salmon tagged in the spring at the lower site. Earlier operation of interrogation facilities at LGR would improve PIT tag based estimates of natural chinook released from the Imnaha River to LGR. Knowledge of early arrival timing of natural chinook at LGR could be beneficial for planning spills for smolt monitoring programs in the spring.

Median arrival timing for natural chinook salmon released during the spring of 1998 occurred on April 25 at LGR and has ranged from April 22 to May 4, from 1993 to 1998. The 90% arrival time range at LGR for spring released natural chinook salmon in 1998 occurred on May 6 and has ranged from May 6 to May 18, from 1993 to 1998. Hatchery chinook arrival timing at LGR occurred later than natural chinook salmon. Median and 90% arrival occurred on May 2 and May 9, respectively. Median and 90% arrival dates of hatchery chinook salmon from the Imnaha river to LGR have ranged from April 21 to May 12, and May 6 to May 16, respectively, from 1993 to 1998.

Natural steelhead arrived at LGR from April 2 to June 12. Median arrival occurred on May 3 and 90% arrival occurred on May 22. Median arrival dates of natural steelhead smolts have ranged from May 2 to May 26, from 1993 to 1998. Ninety percent arrival dates of natural steelhead smolts have ranged from May 9 to June 8, from 1993 to 1998. Arrival timing of hatchery steelhead at LGR occurred from April 25 to July 29. This was later than their natural counterparts and interrogations of hatchery steelhead smolts lasted 24 days longer at LGR than interrogations of natural steelhead. We attribute the differences in arrival timing of natural and hatchery steelhead to the release timing of hatchery steelhead on April 26 and May 19.

Natural chinook salmon had significantly faster travel times from the Imnaha River to LGR than hatchery chinook salmon during the week of April 12. Travel times of natural chinook salmon from the trap to LGR decreased as the season progressed. Mean travel times of natural chinook from the trap to LGR ranged from 8 to 29 days and mean travel times of hatchery chinook from the trap to LGR ranged from 25 to 26 days. Slow travel times of natural chinook may have

been influence by the release of PIT tagged fish during March and early April. These fish would not have had the benefit of discharge from the Imnaha and Snake rivers. Natural steelhead had significantly faster travel times to LGR than hatchery steelhead during the weeks of April 26 and May 17. Mean travel times of natural steelhead to LGR ranged from 4 to 38 days. Mean travel times of hatchery steelhead to LGR ranged from 5 to 8 days. Mean travel times of natural steelhead decreased as the season progressed but travel times of hatchery steelhead remain fairly consistent.

Trapping caused one mortality during the fall at the lower site. There were a total of 25 deaths of target species in the spring of the 30,742 target fish captured. Trapping caused the death of two chinook salmon and handling accounted for another five deaths. Eight hatchery chinook deaths were due to a combination of trapping, handling, and PIT tagging, with the majority of deaths due to handling (n = 5). The only death of natural steelhead was due to trapping. Nine hatchery steelhead deaths were attributed to a combination of trapping, handling, and PIT tagging. Most of the deaths of hatchery steelhead were due to trapping.

In conclusion, hatchery production has produced hatchery chinook salmon and steelhead smolts that are larger than natural fish. Arrival timing of natural fish has differed from hatchery fish in past years. Natural chinook salmon arrived at LGR on March 27, the same day sampling began at LGR. Earlier operation of the LGR interrogation facility would be beneficial for eliminating the uncertainty in arrival timing and survival estimates of early migrating Imnaha River chinook salmon. Survival of hatchery chinook salmon, from release at the lower Imnaha River trap to LGR, was not better than the survival of natural chinook, during the weeks of April 5 and April 12. Additionally, natural chinook had significantly faster travel times than hatchery steelhead, from the trap to LGR, during the week of April 12. However, differences in smoltification or behavior could have had an effect on the survival of natural and hatchery chinook salmon from the Imnaha River and future emigration studies should investigate how these variables affect survival.

ACKNOWLEDGMENTS

The Nez Perce Tribe extends the administrative support necessary to complete these projects and this report. Project funding from the U.S. Fish and Wildlife Service's Lower Snake River Compensation Plan program initiated the Imnaha River emigration project investigations in 1992 and continues today. Project cost share funding is also provided by the Bonneville Power Administration though the Imnaha Smolt Monitoring Program. We wish to thank Joe McCormack, for his expertise in operating, maintaining, and repairing the trapping equipment and PIT tagging fish and Glenda Claire, for her expertise in PIT tagging fish and contributions with data entry, validation, and summary of the PIT tag data. We also thank Glenn Szerlong for assisting with PIT tagging, data entry, and summary of PIT tag groups. Department Aides Olicutt Watters and Neil Miller also deserves our gratitude for their efforts and dedication in operating the traps and recording data. We extend our gratitude to the United States Forest Service for allowing us the use of the Thorn Creek guard station facilities, and Jack McClaren for allowing us access to his land for trapping purposes. The Fish Passage Center's Data System Administrative Manager, Henry Franzoni, deserves our gratitude for providing the software and technical support for communicating data to the Fish Passage Center and biometrician, Tom Berggren for assisting with the necessary PIT tagging schedule. Thank you's are also due to Carter Stein and Dave Marvin of the Pacific States Marine Fisheries Commission for providing the technical support and identifying duplicate tag codes in the PIT tag data. Finally, we would like to extend our thanks Jay Hesse, for technical advice pertaining to this report and data collection.

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Appendix A

The mean daily discharge and standard deviation estimated from provisional data collected at the USGS gauging site 13292000 at Imnaha, Oregon and the mean daily average, maximum, and minimum water temperatures at the lower site during the fall, October 14 to December 19, 1997 and spring, February 26 to May 24, 1998.

Table A. The mean daily discharge and standard deviation estimated from provisional data collected at the USGS gauging site 13292000 at Imnaha, Oregon and the mean daily average, maximum, and minimum water temperatures at the lower site during the fall, October 14 to December 19, 1997 and spring, February 26 to May 24, 1998. NA = data not available.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (°C)	Maximum Water Temperature (°C)	Minimum Water Temperature (°C)
Fall (Lower Site)					
10/14/97	208		10.5	15.8	7.9
10/15/97	206		9.9	16.4	6.9
10/16/97	202		9.6	17.4	6.2
10/17/97	200		9.8	16.8	6.2
10/18/97	197		10.7	15.3	8.0
10/19/97	194		10.4	15.9	7.9
10/20/97	192		8.5	14.2	5.2
10/21/97	189		7.5	14.7	4.3
10/22/97	187		8.1	10.0	5.9
10/23/97	189		9.2	9.8	8.5
10/24/97	196		8.2	9.8	7.4
10/25/97	186		6.6	8.0	5.2
10/26/97	186		6.0	7.1	4.7
10/27/97	186		7.8	9.5	6.7
10/28/97	184		7.1	7.8	6.4
10/29/97	192		8.3	9.5	7.1
10/30/97	247		9.5	10.3	8.8
10/31/97	335		9.6	10.3	9.0
11/1/97	277		8.3	9.4	7.4
11/2/97	240		6.4	7.4	5.2
11/3/97	227		6.7	7.8	5.7

Table A. Continued.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (ºC)	Maximum Water Temperature (ºC)	Minimum Water Temperature (ºC)
11/4/97	220		8.1	9.2	7.3
11/5/97	214		7.6	8.9	6.4
11/6/97	209		7.6	8.9	6.4
11/7/97	218		9.0	9.2	8.7
11/8/97	245		9.5	10.2	8.8
11/9/97	230		9.2	10.1	8.2
11/10/97	220		6.9	8.1	6.2
11/11/97	215		5.0	6.0	4.2
11/12/97	208		3.9	4.8	2.9
11/13/97	201		3.1	4.2	2.1
11/14/97	196		2.6	3.7	1.6
11/15/97	194		2.1	3.2	1.2
11/16/97	190		2.2	3.7	0.9
11/17/97	203		4.9	6.0	4.0
11/18/97	199		5.5	6.4	4.7
11/19/97	205		5.6	6.4	4.9
11/20/97	211		6.6	7.4	6.1
11/21/97	207		6.3	7.1	5.3
11/22/97	196		4.1	5.2	3.2
11/23/97	197		5.5	7.1	3.8
11/24/97	210		6.9	7.3	6.4
11/25/97	220		6.2	7.1	5.3
11/26/97	207		4.3	5.1	3.7
11/27/97	207		4.4	5.1	3.5

Table A. Continued.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (ºC)	Maximum Water Temperature (ºC)	Minimum Water Temperature (ºC)
11/28/97	200		4.2	4.9	3.4
11/29/97	197		3.9	4.4	3.2
11/30/97	199		5.4	6.0	4.6
12/1/97	194		4.6	5.3	4.2
12/2/97	174		3.9	4.8	2.7
12/3/97	145		1.4	2.5	0.6
12/4/97	168		0.5	1.1	0.0
12/5/97	167		0.2	0.6	0.0
12/6/97	169		0.2	0.4	0.0
12/7/97	207		0.9	1.7	0.2
12/8/97	224		2.5	3.2	1.9
12/9/97	196		2.3	3.3	1.7
12/10/97	151		1.4	1.9	1.1
12/11/97	178		NA	NA	NA
12/12/97	158		1.1	1.9	0.4
12/13/97	168		0.2	0.4	0.0
12/14/97	193		0.5	2.0	0.0
12/15/97	198		3.2	3.7	2.4
12/16/97	187		4.4	5.1	3.3
12/17/97	198		5.4	5.7	5.1
12/18/97	189		4.2	5.1	3.5
12/19/97	149		1.6	3.2	0.7
Spring (Lower Site)					
2/26/98	246	11.5	4.2	4.9	3.5
2/27/98	212	21.9	3.3	4.4	1.7

Table A. Continued.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (ºC)	Maximum Water Temperature (ºC)	Minimum Water Temperature (ºC)
2/28/98	227	20.7	2.7	3.8	1.6
3/1/98	237	15.0	4.7	6.4	3.5
3/2/98	225	7.6	5.8	6.7	5.1
3/3/98	234	10.1	5.5	6.4	4.7
3/4/98	215	5.3	4.5	6.1	3.2
3/5/98	208	11.8	4.9	6.1	3.6
3/6/98	202	15.8	3.7	5.3	2.2
3/7/98	202	18.2	3.4	5.6	1.6
3/8/98	217	13.6	3.8	4.8	2.9
3/9/98	206	5.6	5.2	7.3	3.7
3/10/98	201	2.6	7.3	9.0	6.0
3/11/98	199	2.5	8.5	10.8	6.7
3/12/98	206	4.0	8.6	11.1	6.4
3/13/98	254	24.5	9.6	12.1	7.7
3/14/98	370	37.3	9.6	10.9	7.9
3/15/98	445	18.7	8.8	9.8	7.8
3/16/98	504	16.8	8.5	9.2	7.8
3/17/98	518	9.9	6.1	7.6	5.6
3/18/98	469	17.2	5.9	8.1	4.0
3/19/98	430	8.8	6.4	8.5	3.0
3/20/98	424	1.9	7.6	9.5	5.7
3/21/98	458	12.0	8.3	9.8	6.8
3/22/98	572	92.5	9.5	10.8	8.4
3/23/98	1,330	418.8	8.8	10.1	8.1
3/24/98	2,033	168.8	6.9	7.8	5.6
3/25/98	1,745	48.6	7.2	7.8	6.4
3/26/98	1,361	33.0	7.3	7.4	6.9
3/27/98	1,184	73.8	6.2	7.0	5.4
3/28/98	985	45.7	5.4	6.6	3.8
3/29/98	847	37.9	5.6	7.7	3.8
3/30/98	747	23.2	5.9	7.7	3.9
3/31/98	686	18.7	6.7	8.1	5.3
4/1/98	645	13.3	7.7	9.6	6.0

Table A. Continued.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (ºC)	Maximum Water Temperature (ºC)	Minimum Water Temperature (ºC)
4/2/98	625	9.6	8.4	9.3	7.7
4/3/98	626	5.9	7.6	8.5	6.4
4/4/98	639	5.4	7.8	8.3	7.4
4/5/98	675	6.4	7.5	7.9	7.1
4/6/98	661	13.8	8.1	9.8	6.8
4/7/98	650	5.5	7.5	8.6	7.0
4/8/98	622	10.3	7.7	9.5	6.0
4/9/98	608	3.9	7.8	9.0	6.6
4/10/98	628	12.3	9.0	11.2	7.5
4/11/98	678	6.7	8.5	9.5	7.7
4/12/98	693	9.5	8.0	8.9	7.0
4/13/98	666	11.5	6.4	7.7	5.3
4/14/98	636	10.8	7.0	8.2	6.0
4/15/98	636	7.6	7.1	8.3	6.0
4/16/98	593	11.5	8.2	10.6	6.4
4/17/98	597	4.9	8.4	10.5	6.6
4/18/98	603	5.5	7.9	9.5	6.0
4/19/98	614	3.2	9.4	10.9	8.1
4/20/98	629	6.9	9.8	12.3	7.5
4/21/98	728	29.2	11.0	13.4	8.9
4/22/98	1,019	98.2	11.3	12.9	9.9
4/23/98	1,743	177.9	10.6	12.3	9.8
4/24/98	2,148	139.0	8.3	9.7	7.3
4/25/98	1,683	122.0	7.1	8.0	6.0
4/26/98	1,405	68.7	7.8	9.8	6.0
4/27/98	1,334	53.2	9.2	11.1	7.4
4/28/98	1,439	53.3	10.1	11.6	8.5
4/29/98	1,611	74.3	10.4	11.8	8.8
4/30/98	1,853	89.9	10.5	11.7	8.9
5/1/98	2,079	89.0	10.5	11.7	8.9
5/2/98	2,212	109.9	10.3	11.3	8.5
5/3/98	2,302	112.2	10.8	11.8	9.5
5/4/98	2,259	85.7	10.5	12.0	8.9

Table A. Continued.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (ºC)	Maximum Water Temperature (ºC)	Minimum Water Temperature (ºC)
5/5/98	2,425	156.7	10.7	11.7	9.2
5/6/98	2,287	99.5	10.6	12.1	9.2
5/7/98	2,314	120.5	10.9	11.8	9.5
5/8/98	2,279	108.2	10.6	11.7	9.4
5/9/98	2,377	134.6	9.5	10.7	8.8
5/10/98	2,041	73.4	9.6	11.2	8.8
5/11/98	2,086	99.1	10.5	11.1	10.0
5/12/98	1,944	69.3	10.2	11.2	9.5
5/13/98	1,858	45.8	9.3	10.1	8.9
5/14/98	1,717	54.0	9.1	9.6	8.5
5/15/98	1,569	50.3	8.6	9.7	7.5
5/16/98	1,455	22.5	8.5	8.9	7.8
5/17/98	1,470	20.7	8.5	9.2	8.0
5/18/98	1,443	19.9	9.2	11.2	7.6
5/19/98	1,401	27.7	10.3	11.9	8.9
5/20/98	1,353	32.2	11.4	13.5	9.9
5/21/98	1,616	223.5	10.7	12.3	8.5
5/22/98	2,662	410.6	8.3	8.9	7.7
5/23/98	3,704	176.1	8.9	9.8	8.3
5/24/98	3,042	236.7	10.3	12.0	8.9
5/25/98	3,706	1,233	NA	NA	NA
5/26/98	5,964	190	NA	NA	NA
5/27/98	4,730	191	NA	NA	NA
5/28/98	4,118	366	NA	NA	NA
5/29/98	3,346	146	NA	NA	NA
5/30/98	2,922	164	NA	NA	NA
5/31/98	2,613	121	NA	NA	NA
6/1/98	2,468	73	NA	NA	NA
6/2/98	2,274	112	NA	NA	NA
6/3/98	2,161	80	NA	NA	NA
6/4/98	2,002	119	NA	NA	NA
6/5/98	1,902	60	NA	NA	NA
6/6/98	1,815	70	NA	NA	NA

Table A. Continued.

Season & Site Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (ºC)	Maximum Water Temperature (ºC)	Minimum Water Temperature (ºC)
6/7/98	1,721	46	NA	NA	NA
6/8/98	1,693	47	NA	NA	NA
6/9/98	1,637	68	NA	NA	NA
6/10/98	1,622	52	NA	NA	NA
6/11/98	1,927	109	NA	NA	NA
6/12/98	1,975	81	NA	NA	NA
6/13/98	2,060	95	NA	NA	NA
6/14/98	1,930	117	NA	NA	NA
6/15/98	1,757	61	NA	NA	NA
6/16/98	1,668	88	NA	NA	NA

Appendix B

The mean daily discharge and standard deviation and mean, maximum and minimum water temperature estimated from provisional data collected at the USGS gauging site 13292000 at Anatone, Washington, on the Snake River, January 1 to July 1, 1998.

Table B. The mean daily discharge and standard deviation and mean, maximum and minimum water temperature estimated from provisional data collected at the USGS gauging site 13292000 at Anatone, Washington, on the Snake River, January 1 to July 1, 1998.

Day	Mean Discharge (cfs)	Mean Water Temperature (ᴮC)	Maximum Water Temperature (ᴮC)	Minimum Water Temperature (ᴮC)
1/1/98	22,800	3.9	4.1	3.8
1/2/98	19,500	4	4.2	3.7
1/3/98	21,700	4.1	4.2	3.9
1/4/98	21,100	3.9	4.1	3.7
1/5/98	22,400	3.7	4.1	3.5
1/6/98	25,400	4	4.1	3.8
1/7/98	25,700	4.1	4.2	3.9
1/8/98	27,200	4.2	4.3	3.9
1/9/98	30,700	3.9	4.1	3.7
1/10/98	31,500	3.5	3.9	3.4
1/11/98	27,900	3.1	3.6	2.3
1/12/98	24,300	2.3	2.7	1.9
1/13/98	26,400	2.5	2.7	2.4
1/14/98	25,500	2.7	2.9	2.4
1/15/98	28,100	2.8	2.9	2.6
1/16/98	27,400	2.6	2.7	2.4
1/17/98	26,800	2.9	3.2	2.7
1/18/98	24,400	3.1	3.4	2.9
1/19/98	24,900	3.3	3.5	3.1
1/20/98	29,000	3.3	3.5	3.1
1/21/98	30,100	3.4	3.6	3.2
1/22/98	32,000	3.3	3.5	3.2
1/23/98	29,900	3.4	3.5	3.2
1/24/98	30,200	3.6	3.8	3.4
1/25/98	33,600	3.6	3.8	3.5
1/26/98	32,500	3.7	4	3.5
1/27/98	33,000	3.9	4	3.7
1/28/98	33,900	4	4.4	3.9
1/29/98	36,500	3.7	4	3.6
1/30/98	34,200	3.7	4.1	3.6
1/31/98	34,600	3.5	3.7	3.3

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (ᴮC)	Maximum Water Temperature (ᴮC)	Minimum Water Temperature (ᴮC)
2/1/98	34,100	3.3	3.5	3.2
2/2/98	32,500	3.5	3.9	3.2
2/3/98	33,500	3.7	3.8	3.5
2/4/98	33,900	3.9	4.1	3.6
2/5/98	35,000	4	4.2	3.8
2/6/98	34,700	3.8	4	3.6
2/7/98	35,000	3.9	4.3	3.6
2/8/98	35,200	4.2	4.3	4
2/9/98	36,800	4.2	4.5	4
2/10/98	35,900	3.8	4.1	3.6
2/11/98	36,400	4	4.4	3.6
2/12/98	36,400	4.1	4.2	4.1
2/13/98	36,600	4.4	4.6	4.2
2/14/98	35,800	4.4	4.5	4.3
2/15/98	37,000	4.6	4.7	4.4
2/16/98	36,800	4.8	5.1	4.5
2/17/98	35,100	4.7	4.9	4.6
2/18/98	36,100	4.9	5.3	4.7
2/19/98	35,400	5.1	5.4	4.9
2/20/98	35,500	5.4	5.7	5
2/21/98	34,200	5.6	5.7	5.5
2/22/98	35,600	5.5	5.8	5.3
2/23/98	35,200	5.6	5.9	5.4
2/24/98	34,500	5.5	5.8	5.3
2/25/98	35,200	5.3	5.5	5.1
2/26/98	35,600	5.4	5.6	5.2
2/27/98	34,700	5.3	5.7	5
2/28/98	34,100	5.2	5.3	5
3/1/98	33,900	5.5	5.7	5.3
3/2/98	33,600	5.8	6	5.6
3/3/98	34,200	5.8	6.1	5.6
3/4/98	34,600	5.6	5.9	5.3
3/5/98	32,900	5.8	6.1	5.5

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (ᴮC)	Maximum Water Temperature (ᴮC)	Minimum Water Temperature (ᴮC)
3/6/98	33,800	5.4	5.7	5.2
3/7/98	32,500	5.3	5.8	5
3/8/98	32,700	5.5	5.7	5.3
3/9/98	32,300	5.8	6.3	5.4
3/10/98	32,900	6.3	6.6	5.9
3/11/98	33,400	6.7	7.2	6.4
3/12/98	34,200	7	7.4	6.6
3/13/98	34,100	7.4	7.9	7
3/14/98	34,800	7.7	8.1	7.4
3/15/98	37,500	7.8	8	7.6
3/16/98	39,300	7.5	7.8	7.1
3/17/98	39,000	6.8	7.2	6.4
3/18/98	36,900	6.7	7.3	6.2
3/19/98	36,400	7	7.3	6.6
3/20/98	40,600	7.3	7.6	7
3/21/98	36,400	7.7	7.8	7.5
3/22/98	36,600	8	8.2	7.8
3/23/98	41,200	8	8.2	7.8
3/24/98	54,100	7.6	8	7.1
3/25/98	58,300	7.7	8.1	7.4
3/26/98	57,900	7.7	7.9	7.5
3/27/98	55,200	7.4	7.7	6.9
3/28/98	54,100	7.1	7.6	6.7
3/29/98	51,400	7.2	7.8	6.5
3/30/98	49,100	7.4	8	6.9
3/31/98	47,400	7.9	8.3	7.5
4/1/98	46,400	8.2	8.8	7.8
4/2/98	45,800	8.5	8.9	8.2
4/3/98	45,400	8.2	8.5	7.8
4/4/98	45,400	8.7	9	8.4
4/5/98	45,900	9.1	9.3	8.9
4/6/98	46,500	9.3	9.8	8.8
4/7/98	46,900	9.4	9.7	9.2

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (ᴮC)	Maximum Water Temperature (ᴮC)	Minimum Water Temperature (ᴮC)
4/8/98	46,700	9.3	9.7	8.9
4/9/98	46,100	9.3	9.6	9
4/10/98	46,000	9.5	9.9	9.2
4/11/98	46,000	9.6	9.8	9.3
4/12/98	46,200	9.6	9.8	9.2
4/13/98	45,900	9.1	9.6	8.9
4/14/98	45,700	8.9	9.1	8.6
4/15/98	46,000	9	9.2	8.7
4/16/98	46,000	9.2	9.6	8.7
4/17/98	45,800	9.6	10	9.2
4/18/98	45,500	9.5	9.8	9.2
4/19/98	45,100	10	10.6	9.6
4/20/98	44,900	10.6	11.2	10
4/21/98	45,300	11.3	11.9	10.7
4/22/98	46,700	11.8	12.2	11.5
4/23/98	50,500	12.1	12.4	11.6
4/24/98	56,800	11.3	12.1	10.5
4/25/98	61,900	10.2	10.7	9.7
4/26/98	60,800	10.3	10.9	9.7
4/27/98	57,700	10.8	11.5	10.2
4/28/98	55,900	11.4	12.3	10.7
4/29/98	56,800	12	12.8	11.4
4/30/98	60,700	12.5	13.2	11.8
5/1/98	67,700	12.6	13.3	12
5/2/98	72,700	12.5	12.9	12.1
5/3/98	77,800	12.7	13.3	12.2
5/4/98	81,800	12.6	13.1	12.1
5/5/98	84,800	12.8	13.3	12.4
5/6/98	86,800	12.7	13.2	12.4
5/7/98	88,200	12.9	13.3	12.5
5/8/98	89,400	12.7	13.1	12.4
5/9/98	92,600	12.1	12.5	11.7
5/10/98	91,900	11.9	12.6	11.4

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (ᴮC)	Maximum Water Temperature (ᴮC)	Minimum Water Temperature (ᴮC)
5/11/98	90,100	12.6	13.1	12.2
5/12/98	93,800	12.6	13	12
5/13/98	96,100	12.5	12.9	12.1
5/14/98	88,000	11.9	12.2	11.6
5/15/98	95,700	12.1	12.5	11.7
5/16/98	100,000	12.4	12.8	11.9
5/17/98	103,000	12.4	12.7	12.1
5/18/98	104,000	12.7	13.3	12.2
5/19/98	104,000	13.3	13.9	12.8
5/20/98	98,000	13.8	14.3	13.3
5/21/98	95,100	13.7	14.1	13.2
5/22/98	106,000	12.8	13.2	12.3
5/23/98	124,000	12.2	12.4	12
5/24/98	125,000	12.4	13	12
5/25/98	118,000	12.6	12.9	12.2
5/26/98	137,000	11.6	12.3	11
5/27/98	165,000	11.3	11.8	10.9
5/28/98	163,000	12	12.7	11.5
5/29/98	156,000	12.6	13	12.2
5/30/98	150,000	13	13.4	12.6
5/31/98	132,000	13.4	14.2	12.9
6/1/98	128,000	14.1	14.7	13.5
6/2/98	119,000	14.4	14.8	13.9
6/3/98	116,000	14.3	14.7	13.9
6/4/98	112,000	14.1	14.7	13.5
6/5/98	115,000	14	14.6	13.7
6/6/98	111,000	14	14.7	13.5
6/7/98	102,000	14.2	14.6	13.8
6/8/98	99,400	14.2	14.9	13.6
6/9/98	103,000	14.8	15.3	14.2
6/10/98	99,100	15.3	15.8	14.7
6/11/98	92,200	15.4	15.8	14.9
6/12/98	90,900	15.7	16.1	15.1

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (ᴮC)	Maximum Water Temperature (ᴮC)	Minimum Water Temperature (ᴮC)
6/13/98	95,500	15.7	16.1	15.2
6/14/98	97,800	15.9	16.4	15.5
6/15/98	96,400	15.7	16.1	15.3
6/16/98	93,900	15.2	15.8	14.8
6/17/98	88,100	14.7	15.4	14.1
6/18/98	79,500	15.4	16.1	14.9
6/19/98	73,900	15.5	16	15.1
6/20/98	73,000	15.3	16	14.7
6/21/98	73,400	16.1	16.7	15.6
6/22/98	70,700	16.3	16.6	15.8
6/23/98	67,600	16.7	17.3	16.3
6/24/98	66,800	16.8	17	16.6
6/25/98	64,100	16.3	16.7	16
6/26/98	71,300	15.8	16.2	15.5
6/27/98	79,100	15.7	16.3	15.1
6/28/98	75,200	16.2	16.9	15.7
6/29/98	68,400	17	17.7	16.5
6/30/98	68,000	18	18.6	17.6
7/1/98	63,400	18.7	19.2	18.2

Appendix C

The average total discharge, average turbine discharge, and average total (Kcfs) spill for Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams from March 1 to June 30, 1998. Daily averages were calculated from midnight to midnight. This data is a subset of data obtained from the Fish Passage Center.

Table C. The average total discharge, average turbine discharge, and average total spill (Kcfs) for Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary dams from March 1 to June 30, 1998. Daily averages were calculated from midnight to midnight. This data is a subset of data obtained from the Fish Passage Center. Abbreviations: Discharge = Dschrg., Average = Avg.

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill
03/01	47.95	47.85	0.00	42.18	41.98	0.00	46.75	46.55	0.00	48.02	47.82	0.00	154.92	150.92	0.00
03/02	35.85	35.68	0.00	35.84	35.58	0.00	38.11	37.88	0.00	35.88	35.68	0.00	156.42	152.42	0.00
03/03	35.13	35.03	0.00	33.33	33.13	0.00	35.59	35.29	0.00	33.33	33.13	0.00	182.84	178.88	0.00
03/04	34.65	34.55	0.00	31.23	30.97	0.00	31.22	30.92	0.00	30.52	30.32	0.00	183.11	179.11	0.00
03/05	48.10	48.00	0.00	53.28	53.08	0.00	60.77	60.41	0.00	65.35	41.10	24.07	196.13	192.13	0.00
03/06	36.38	36.28	0.00	36.47	36.27	0.00	37.79	37.49	0.00	35.21	10.80	23.49	161.85	157.43	0.00
03/07	35.57	35.47	0.00	34.98	34.78	0.00	35.38	35.08	0.00	39.36	15.53	23.60	156.45	152.46	0.00
03/08	33.32	33.22	0.00	30.01	29.81	0.00	31.44	31.14	0.00	28.57	28.31	0.00	140.01	136.01	0.00
03/09	46.23	46.13	0.00	66.90	66.70	0.00	76.10	70.56	5.17	80.76	52.46	27.90	154.90	150.90	0.00
03/10	35.36	35.26	0.00	29.40	29.20	0.00	28.23	27.87	0.00	27.52	27.25	0.00	155.59	151.59	0.00
03/11	36.57	36.47	0.00	32.76	32.56	0.00	38.06	37.76	0.00	37.65	37.45	0.00	164.17	160.17	0.00
03/12	37.93	37.83	0.00	41.43	41.16	0.00	41.94	41.39	0.00	43.63	43.43	0.00	157.46	153.46	0.00
03/13	38.01	37.78	0.00	32.38	32.18	0.00	33.85	33.55	0.00	32.43	32.23	0.00	166.68	162.68	0.00
03/14	39.43	39.26	0.00	38.06	37.73	0.00	40.22	39.67	0.00	39.28	39.08	0.00	150.20	146.20	0.00
03/15	41.29	41.19	0.00	40.23	38.59	1.44	41.97	41.67	0.00	42.33	42.01	0.00	127.54	123.54	0.00
03/16	47.74	47.43	0.00	48.30	47.71	0.08	49.31	48.70	0.00	47.43	46.73	0.00	159.43	155.43	0.00
03/17	44.02	43.36	0.00	44.22	43.83	0.00	49.65	49.17	0.00	50.15	49.58	0.00	179.23	160.55	14.69
03/18	42.88	42.36	0.00	42.80	42.41	0.00	44.48	43.99	0.00	41.54	41.09	0.00	195.41	170.94	20.00
03/19	46.34	45.55	0.00	44.67	44.34	0.00	45.60	45.05	0.00	48.47	48.02	0.00	180.86	168.13	7.63
03/20	47.06	46.62	0.00	49.09	48.70	0.00	51.77	51.28	0.00	48.26	47.87	0.00	176.25	171.64	0.00
03/21	41.69	41.25	0.00	43.20	42.87	0.00	45.96	45.48	0.00	43.57	43.12	0.00	164.61	153.39	6.52
03/22	44.38	43.93	0.00	47.77	47.38	0.00	51.05	50.62	0.00	53.27	52.88	0.00	130.37	125.67	0.00
03/23	50.10	49.52	0.00	52.00	51.61	0.00	54.40	53.83	0.00	55.55	55.16	0.00	156.10	151.40	0.00
03/24	65.47	64.23	0.59	62.81	60.75	1.39	65.29	62.83	1.74	58.75	52.75	5.61	172.14	165.37	2.07

Table C. Continued

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill
03/25	74.12	66.17	7.57	72.89	61.18	11.30	78.09	56.23	21.47	81.82	56.43	24.88	197.51	145.29	47.56
03/26	75.38	68.47	6.18	75.24	66.55	8.04	78.00	68.70	8.52	79.85	56.65	22.68	253.31	165.34	83.45
03/27	83.23	69.50	13.37	84.50	77.63	6.21	89.88	75.57	13.47	92.99	58.76	33.82	241.15	173.70	62.74
03/28	63.45	63.00	0.00	63.64	63.18	0.00	68.36	67.63	0.00	72.55	62.05	9.82	215.28	169.61	40.98
03/29	60.50	59.91	0.00	60.66	60.13	0.00	68.12	67.33	0.00	66.23	61.87	3.74	159.58	154.88	0.00
03/30	57.74	57.09	0.00	57.07	56.35	0.00	57.85	56.93	0.00	58.73	57.91	0.00	164.64	159.94	0.00
03/31	61.09	60.36	0.00	62.11	61.34	0.00	65.71	64.38	0.49	60.37	59.62	0.00	192.88	162.11	26.07
04/01	43.99	43.62	0.00	44.87	44.28	0.00	49.75	48.90	0.00	52.46	51.65	0.00	153.69	148.99	0.00
04/02	53.39	52.95	0.00	54.66	54.14	0.00	58.01	57.35	0.00	57.43	56.80	0.00	147.63	142.93	0.00
04/03	53.78	53.41	0.00	56.38	55.80	0.00	59.12	58.39	0.00	60.08	59.39	0.00	137.00	132.32	0.00
04/04	55.63	55.33	0.00	57.05	56.59	0.00	60.15	59.43	0.00	58.84	58.15	0.00	138.76	134.06	0.00
04/05	55.87	55.43	0.00	59.65	59.13	0.00	62.43	61.51	0.00	57.18	56.43	0.00	131.28	126.58	0.00
04/06	64.40	56.46	7.30	70.95	55.39	14.98	76.97	66.46	9.78	76.45	64.15	11.49	148.14	143.44	0.00
04/07	68.70	39.21	29.05	74.45	43.98	29.76	78.73	58.15	19.73	83.29	37.37	45.05	149.89	145.19	0.00
04/08	63.02	33.74	28.86	57.79	28.84	28.35	63.13	42.17	20.13	66.06	17.95	47.43	137.45	132.75	0.00
04/09	61.28	31.92	28.88	57.40	32.33	24.55	61.43	41.00	19.71	67.25	11.20	55.25	129.85	125.15	0.00
04/10	60.23	31.70	28.17	55.98	32.35	23.04	58.49	37.99	19.63	63.43	7.73	55.00	130.78	126.08	0.00
04/11	60.66	35.20	25.15	59.49	35.95	22.94	61.93	42.82	18.45	66.58	13.10	52.79	135.97	131.27	0.00
04/12	58.38	32.82	25.12	54.75	33.28	20.83	55.61	36.98	17.78	59.87	12.82	46.31	128.94	124.24	0.00
04/13	58.43	42.46	15.52	54.49	30.79	23.10	57.53	37.64	19.23	63.03	9.33	53.02	133.57	129.06	0.00
04/14	55.48	49.17	5.73	57.57	33.78	23.07	58.18	38.27	19.06	61.72	9.39	51.45	125.56	121.01	0.00
04/15	57.31	50.95	5.91	55.62	35.20	19.73	58.97	39.51	18.61	62.63	8.83	52.99	132.95	128.25	0.00
04/16	55.85	49.46	6.01	55.63	33.05	22.04	56.92	36.41	19.67	62.12	10.81	50.62	144.66	140.04	0.00
04/17	55.37	48.77	6.02	56.72	33.48	22.59	58.62	39.85	18.05	58.61	10.93	46.91	137.88	133.18	0.00
04/18	53.52	46.93	6.01	54.16	35.43	18.15	55.70	35.89	19.10	58.20	6.65	50.52	129.29	124.59	0.00
04/19	52.83	46.23	6.02	51.55	33.97	16.99	53.35	36.99	15.51	57.96	11.36	45.72	141.75	137.05	0.00

Table C. Continued

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill
04/20	58.23	51.77	6.01	58.14	37.98	19.57	60.27	40.55	19.00	63.90	12.17	51.01	145.63	91.44	49.49
04/21	64.66	54.58	9.50	65.93	42.53	22.57	69.79	50.70	18.20	75.78	17.13	57.83	155.63	100.35	50.63
04/22	62.46	55.28	6.73	61.68	38.04	23.05	62.25	41.66	19.69	64.83	10.46	53.42	154.95	91.86	58.38
04/23	71.39	64.32	6.51	69.10	45.55	22.89	70.34	51.55	18.00	76.37	15.95	59.48	202.82	123.40	74.72
04/24	85.95	66.61	18.98	84.70	61.08	23.05	88.74	68.38	19.58	90.38	29.26	60.51	194.05	114.10	75.28
04/25	98.56	66.18	32.06	94.41	70.98	22.86	101.23	82.50	18.06	103.48	36.81	65.80	180.33	105.72	69.90
04/26	93.64	66.48	26.75	87.65	64.70	22.35	91.40	72.18	18.38	95.63	29.20	65.62	184.57	109.79	70.08
04/27	84.11	66.19	17.34	80.39	55.31	22.98	81.70	63.41	17.50	86.81	26.16	59.79	200.13	125.50	69.93
04/28	82.13	66.01	15.37	81.79	58.10	22.98	87.63	68.37	18.35	89.85	28.08	60.95	198.49	123.77	70.03
04/29	83.64	66.20	16.84	81.13	57.65	22.83	84.23	65.32	17.93	87.67	24.23	62.38	196.89	122.19	70.00
04/30	90.82	66.10	24.00	86.00	62.28	22.99	89.10	71.35	16.90	93.80	28.24	64.82	217.23	148.50	64.03
05/01	100.85	66.38	34.03	94.70	71.20	22.85	98.60	80.50	17.26	103.19	36.86	65.40	230.62	156.07	69.85
05/02	102.19	70.49	31.34	97.00	73.65	22.77	101.05	83.08	17.19	105.70	39.30	65.40	225.36	145.81	74.85
05/03	111.75	84.52	26.70	106.89	78.23	27.89	113.16	89.43	22.91	114.10	42.55	70.61	278.82	154.01	120.10
05/04	119.34	87.50	31.32	114.24	86.14	27.37	118.56	92.74	24.98	125.31	55.38	69.06	279.08	155.20	119.18
05/05	124.45	92.92	30.95	119.65	86.85	31.80	121.88	92.46	28.53	126.63	53.00	72.51	295.98	160.41	130.89
05/06	126.67	93.20	32.95	120.82	88.71	31.33	125.21	97.71	26.59	127.92	55.58	71.35	328.08	159.14	164.25
05/07	126.55	94.71	31.33	122.25	91.43	30.22	125.75	99.84	25.05	129.72	60.76	68.14	337.82	169.58	163.54
05/08	128.91	96.05	32.51	125.28	93.02	31.67	128.04	100.13	27.11	132.86	56.12	75.85	339.72	169.42	165.60
05/09	131.33	96.20	34.75	126.81	91.33	34.83	134.62	100.35	33.35	139.65	59.48	79.05	360.50	169.90	185.91
05/10	129.85	96.21	33.11	124.83	91.52	32.53	128.86	99.22	28.73	131.48	56.93	73.61	329.26	167.13	157.43
05/11	123.73	93.88	29.20	118.11	74.76	42.64	124.08	98.75	24.55	128.83	61.41	66.61	300.39	160.58	135.11
05/12	122.50	92.57	29.20	116.61	88.43	26.84	118.67	95.66	22.04	124.23	56.59	66.70	309.62	165.63	139.30
05/13	125.43	95.75	29.29	124.10	89.75	33.46	129.00	100.55	27.53	132.59	63.04	68.75	326.50	169.65	152.15
05/14	117.32	87.65	29.21	112.29	86.41	25.10	115.14	93.88	20.47	118.48	51.92	65.75	327.35	175.42	147.24
05/15	126.96	94.13	32.39	120.80	86.84	33.38	125.67	95.54	29.28	129.23	61.10	67.38	333.35	174.72	153.94

Table C. Continued

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill
05/16	123.69	94.07	29.25	120.29	89.72	29.98	125.11	96.87	27.40	130.48	63.63	65.85	317.63	173.71	139.22
05/17	126.02	96.36	29.21	120.20	84.25	35.25	125.23	100.64	23.61	128.35	61.91	65.45	296.94	171.67	120.57
05/18	127.91	90.78	36.52	125.07	91.45	32.83	128.84	101.32	26.59	133.53	66.28	66.51	293.58	163.98	124.90
05/19	127.45	96.33	30.45	122.25	88.26	33.03	125.05	97.40	26.75	127.69	61.64	65.19	315.17	160.57	149.90
05/20	125.55	92.86	32.34	121.30	83.30	37.19	128.43	95.52	32.07	134.93	68.08	65.65	308.15	157.30	146.08
05/21	122.60	90.12	31.92	115.94	82.80	32.38	118.40	89.95	27.35	121.98	55.57	65.35	312.50	165.25	142.55
05/22	143.55	100.93	42.03	138.47	94.22	43.56	143.10	100.07	42.06	145.73	71.13	73.59	293.09	154.74	133.65
05/23	172.62	103.79	68.42	162.54	99.90	61.86	172.06	100.57	70.53	173.15	83.54	88.56	284.41	146.92	132.79
05/24	173.52	104.01	68.85	166.23	99.98	65.56	179.32	100.08	78.20	183.34	75.64	106.77	317.34	156.38	156.25
05/25	161.45	103.78	57.07	155.40	99.98	54.73	166.21	101.82	63.49	167.39	82.01	84.40	287.05	140.09	142.26
05/26	177.99	103.72	73.40	167.68	98.71	68.32	179.42	99.70	79.02	180.59	85.51	94.33	306.10	154.14	147.25
05/27	213.28	103.30	109.40	200.40	101.35	98.36	211.45	100.62	109.99	212.39	86.93	124.60	379.64	168.13	206.82
05/28	208.98	102.85	105.75	197.82	98.84	98.26	221.30	100.03	120.48	218.59	85.40	132.31	400.13	157.19	238.25
05/29	191.89	103.14	88.15	183.07	97.35	85.20	191.80	98.61	92.35	189.61	84.29	104.33	408.97	153.27	251.00
05/30	189.52	100.22	88.78	179.83	92.26	86.91	198.00	96.38	100.89	200.01	91.34	107.81	414.28	165.51	244.08
05/31	167.49	101.98	64.85	163.09	91.57	70.89	174.79	86.30	87.59	176.49	87.15	88.46	394.40	163.48	226.22
06/01	162.64	102.16	59.71	152.76	86.32	65.73	160.20	94.67	64.63	164.29	84.40	79.13	366.78	166.68	195.40
06/02	149.04	98.68	49.80	144.06	74.68	68.56	153.03	85.83	66.17	156.20	72.90	82.21	384.97	150.27	230.00
06/03	150.65	92.36	57.99	146.01	79.28	66.13	155.69	90.83	64.00	157.22	72.59	83.76	405.38	163.38	237.30
06/04	142.04	98.35	43.37	138.98	86.40	51.98	144.10	93.64	49.62	149.31	72.88	75.67	390.75	162.86	223.19
06/05	144.14	87.48	56.37	138.66	83.18	55.02	147.32	95.22	51.43	151.39	75.04	75.53	353.51	168.00	180.81
06/06	139.22	85.79	53.13	131.38	86.13	44.78	138.78	98.16	39.88	140.50	71.73	67.95	373.29	166.12	202.48
06/07	131.15	72.82	58.03	124.37	77.78	46.12	130.28	92.69	36.79	133.51	57.78	74.90	316.82	152.12	160.00
06/08	125.65	82.20	42.89	119.45	81.68	37.19	123.10	91.90	30.40	127.83	61.20	65.90	322.76	163.44	154.93
06/09	126.60	86.64	39.31	123.53	83.78	39.17	128.20	94.18	33.10	134.39	64.84	68.80	337.04	168.22	164.12

Appendix C. Continued.

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill	Average Total Dschrg.	Average Turbine Dschrg.	Avg. Total Spill
06/10	121.06	71.28	49.27	115.28	77.16	37.34	119.28	90.05	28.45	122.54	56.28	65.31	315.17	159.58	150.88
06/11	117.24	82.85	33.74	112.94	75.78	36.44	118.58	94.43	23.36	123.48	55.30	67.07	310.78	164.49	141.59
06/12	114.62	79.81	34.43	109.16	73.71	34.74	112.61	93.62	18.09	115.02	49.03	65.05	296.52	164.93	126.89
06/13	120.40	79.75	40.15	116.41	70.23	45.59	122.83	101.70	20.31	122.95	56.56	65.55	304.28	162.48	137.10
06/14	122.68	84.05	38.12	116.45	73.74	42.05	120.32	102.59	17.00	126.27	59.70	65.70	290.83	174.81	111.32
06/15	119.41	90.67	28.16	117.64	63.46	53.58	122.16	104.28	17.15	123.94	57.69	65.50	273.74	158.31	110.73
06/16	116.64	90.58	25.26	112.90	77.68	34.58	116.95	98.27	17.83	117.90	52.65	64.50	213.86	135.47	73.78
06/17	115.23	87.54	27.25	108.94	79.13	29.23	114.41	95.18	18.39	118.23	55.12	62.24	252.14	152.18	95.28
06/18	97.61	69.92	27.18	100.38	71.26	28.55	104.23	86.28	17.15	108.38	45.12	62.57	253.33	153.78	94.85
06/19	94.27	66.45	27.38	89.68	64.58	24.53	94.58	72.33	21.40	98.66	36.41	61.45	254.25	142.65	106.89
06/20	99.64	71.91	27.08	96.78	71.25	24.81	100.37	73.38	26.21	105.20	43.18	61.02	276.35	150.09	121.55
06/21	91.51	91.05	0.02	90.28	89.63	0.00	96.59	95.76	0.05	99.36	37.57	60.86	230.93	154.05	72.18
06/22	88.95	88.37	0.00	88.95	88.43	0.00	94.34	93.49	0.06	96.49	33.43	62.20	208.34	131.19	72.45
06/23	84.24	83.65	0.00	85.05	84.15	0.00	91.43	90.38	0.25	93.75	35.23	57.77	214.58	137.30	72.58
06/24	86.04	85.67	0.00	85.65	84.94	0.00	90.35	89.50	0.00	91.41	33.35	57.05	284.06	162.93	116.45
06/25	83.13	77.35	5.35	81.83	81.37	0.00	86.12	85.45	0.00	86.43	25.88	59.93	267.72	167.33	95.69
06/26	90.68	90.30	0.00	89.98	89.52	0.00	94.69	94.03	0.00	100.40	38.55	61.19	258.79	160.92	93.18
06/27	101.31	100.80	0.00	99.99	99.47	0.00	109.25	108.53	0.00	109.67	47.94	61.05	275.76	165.55	105.52
06/28	97.96	97.38	0.00	99.33	98.81	0.00	106.52	105.73	0.00	110.30	48.46	61.14	250.81	168.39	77.73
06/29	88.07	87.63	0.00	89.73	89.15	0.00	96.70	95.79	0.00	97.61	35.98	61.00	242.27	161.55	76.02
06/30	85.09	84.58	0.00	83.75	82.98	0.00	87.84	87.05	0.00	91.33	34.53	56.07	235.25	146.32	84.23
Sum of the Daily Avg. Spill			2,680.2			2,841.8			2,552.5			5,949.1			9,700.3

Appendix D

A summary of the daily catch of natural reared chinook salmon and steelhead captured in the upper and lower Imnaha screw traps from October 14 to December 19, 1997.

Table D. A summary of the daily catch of natural chinook salmon and steelhead captured in the upper and lower Imnaha screw traps from October 14 to December 19, 1997.

Date	Lower Trap Site		Upper Trap Site	
	Natural Chinook Salmon	Natural Steelhead	Natural Chinook Salmon	Natural Steelhead
10/14/98	24	0	--	--
10/15/98	15	1	143	1
10/16/98	3	1	229	2
10/17/98	14	1	--	--
10/18/98	--	--	--	--
10/19/98	--	--	--	--
10/20/98	--	--	--	--
10/21/98	67	2	192	0
10/22/98	43	4	362	0
10/23/98	46	5	243	0
10/24/98	108	0	--	--
10/25/98	--	--	--	--
10/26/98	--	--	--	--
10/27/98	--	--	--	--
10/28/98	76	4	141	1
10/29/98	59	3	137	0
10/30/98	33	10	227	5
10/31/98	102	40	--	--
11/1/98	--	--	--	--
11/2/98	--	--	--	--
11/3/98	--	--	--	--
11/4/98	--	--	75	3
11/5/98	45	0	97	2

Table D. Continued.

Date	Lower Trap Site		Upper Trap Site	
	Natural Chinook Salmon	Natural Steelhead	Natural Chinook Salmon	Natural Steelhead
11/6/98	37	2	96	6
11/7/98	14	2	73	0
11/8/98	10	0	85	1
11/9/98	--	--	37	3
11/10/98	--	--	--	--
11/11/98	--	--	--	--
11/12/98	--	--	--	--
11/13/98	58	4	--	--
11/14/98	54	4	--	--
11/15/98	83	8	95	0
11/16/98	--	--	--	--
11/17/98	74	11	--	--
11/18/98	74	4	--	--
11/19/98	17	3	--	--
11/20/98	47	2	--	--
11/21/98	33	0	--	--
11/22/98	15	2	--	--
11/23/98	68	0	--	--
11/24/98	32	1	--	--
11/25/98	17	0	--	--
11/26/98	36	1	--	--
11/27/98	--	--	--	--
11/28/98	--	--	--	--

Table D. Continued.

Date	Lower Trap Site		Upper Trap Site	
	Natural Chinook Salmon	Natural Steelhead	Natural Chinook Salmon	Natural Steelhead
11/29/98	--	--	--	--
11/30/98	29	0	--	--
12/1/98	15	0	--	--
12/2/98	12	0	--	--
12/3/98	9	0	--	--
12/4/98	9	0	--	--
12/5/98	13	0	--	--
12/6/98	--	--	--	--
12/7/98	--	--	--	--
12/8/98	--	--	--	--
12/9/98	40	1	--	--
12/10/98	26	1	--	--
12/11/98	8	0	--	--
12/12/98	9	0	--	--
12/13/98	--	--	--	--
12/14/98	--	--	--	--
12/15/98	--	--	--	--
12/16/98	9	0	--	--
12/17/98	7	4	--	--
12/18/98	7	0	--	--
12/19/98	19	2	--	--

Appendix E

A summary of the daily catch of natural and hatchery reared chinook salmon and steelhead captured in the lower Imnaha River screw traps from February 26 to June 16, 1998.

Table E. A summary of the daily catch of natural and hatchery reared chinook salmon and steelhead captured in the Lower Imnaha River screw traps from February 26 to June 16, 1998.

Date	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
2/27/98	15	0	0	0
3/5/98	9	0	0	0
3/6/98	5	0	0	0
3/9/98*	4	0	0	0
3/10/98*	2	0	1	0
3/11/98*	0	0	0	0
3/12/98*	4	0	0	0
3/13/98*	10	0	0	0
3/16/98*	239	0	3	0
3/17/98*	464	0	15	0
3/18/98*	501	0	24	0
3/19/98*	317	0	9	0
3/20/98*	184	0	5	0
3/21/98*	84	0	5	0
3/22/98*	79	0	9	1
3/23/98*	155	0	28	1
3/24/98	-	-	-	-
3/25/98	-	-	-	-
3/26/98	21	0	25	0
3/27/98	44	0	3	0
3/30/98	167	0	68	0
3/31/98	152	0	52	0
4/1/98*	131	0	54	0
4/2/98*	125	0	60	0
4/3/98*	65	0	18	0
4/6/98*	101	0	20	0
4/7/98	65	8	11	0
4/8/98	59	870	20	0
4/9/98	23	3,927	14	0
4/10/98	3	2,805	6	0
4/11/98	18	2,636	15	0
4/12/98	34	2,956	16	0

Table E. Continued.

Date	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
4/13/98	72	1,426	17	1
4/14/98	104	1,390	55	0
4/15/98	111	733	31	0
4/16/98	94	327	45	0
4/17/98	57	159	21	0
4/20/98*	67	110	78	0
4/21/98*	112	100	99	1
4/22/98*	199	186	338	5
4/23/98*	106	125	578	2
4/24/98	0	0	0	0
4/27/98	4	9	55	782
4/28/98	21	11	80	405
4/29/98	19	13	125	399
4/30/98	14	12	160	391
5/1/98	16	12	150	296
5/4/98	0	0	0	0
5/5/98	1	3	54	83
5/6/98	1	2	36	35
5/7/98	3	2	42	35
5/8/98	0	0	34	25
5/11/98*	2	0	29	65
5/12/98*	6	5	75	146
5/13/98*	18	4	84	155
5/14/98	20	0	93	161
5/15/98	13	1	78	136
5/18/98*	18	1	211	207
5/19/98*	19	0	200	200
5/20/98	6	2	100	531
5/21/98	1	0	81	332
5/22/98	5	2	125	565
5/25/98	0	0	0	0
5/26/98	0	0	0	0

Table E. Continued.

Date	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
5/27/98	0	0	0	0
5/28/98	0	0	0	0
5/29/98	0	0	0	0
6/1/98	0	0	0	0
6/2/98	1	0	6	14
6/3/98	1	0	4	16
6/4/98	0	0	2	6
6/5/98	0	0	0	12
6/8/98	0	0	0	5
6/9/98	0	0	1	15
6/10/98	0	0	0	35
6/11/98	2	0	1	50
6/12/98	0	0	0	4
6/15/98	2	0	0	7
6/16/98	0	0	0	17
Total	4,195	17,837	3,569	5,141

* The asterisk notes days when two traps were fishing.

Appendix F

T-test values and sample sizes (n) for seven statistical comparisons of mean fork lengths of natural and hatchery chinook salmon and steelhead in the fall of 1997 and spring of 1998 and one comparison of mean travel times of natural and hatchery chinook salmon and steelhead from the lower Imnaha River trap to Lower Granite Reservoir in 1998.

Table F. T-test values and sample sizes (n) for seven statistical comparisons of mean fork lengths of natural and hatchery chinook salmon and steelhead in the fall of 1997 and spring of 1998 and one statistical comparison of the mean travel times of natural and hatchery chinook salmon and steelhead from the lower Imnaha River trap to Lower Granite Reservoir in 1998. Abbreviations: L - Lower, U - Upper, N - Natural, H - Hatchery, CHS - Chinook, and STT - Steelhead.

	Group One						Group Two						Statistical Values	
Test Item	Time Period	Site	Rearing	Species	Sample Size	Mean	Time Period	Site	Rearing	Species	Sample Size	Mean	P	T
Fork Lengths	Fall	L	N	CHS	1,491	95 mm	Fall	U	N	CHS	2,067	89 mm	0.00	20.601
Fork Lengths	Spring	L	H	CHS	3,098	135 mm	Spring	L	N	CHS	3,969	106 mm	0.00	125.832
Fork Lengths	4/5 to 4/11	L	H	CHS	1,694	138 mm	4/12 to 4/18	L	H	CHS	2,506	132 mm	0.00	18.629
Fork Lengths	4/19 to 4/25	L	H	CHS	239	132 mm	4/26 to 5/2	L	H	CHS	51	128 mm	0.00	2.796
Fork Lengths	Spring	L	H	STT	3,809	218 mm	Spring	L	N	STT	2,843	177 mm	0.00	81.830
Fork Lengths	Fall	L	N	CHS[1]	1,454	95 mm	Fall	U	N	CHS[1]	1,996	89 mm	0.00	-20.400

[1] Natural chinook salmon that were PIT tagged and Released.

Table F. Continued.

	Group One						Group Two						Statistical Values	
Test Item	Time Period	Site	Rearing	Species	Sample Size	Mean	Time Period	Site	Rearing	Species	Sample Size	Mean	P	T
Fork Lengths	Spring	L	H	CHS[2]	1,071	133 mm	Spring	L	H	CHS[3]	667	135 mm	0.00	-4.286
Travel Times	4/5 to 4/11	L	N	CHS	100	20.8 days	4/5 to 4/11	L	H	CHS	357	21.3 days	0.61	-0.557

[2] Hatchery chinook salmon that were marked and released for trap efficiency trials.

[3] Hatchery chinook salmon that were marked, released for trap efficiency trials and then recaptured.

Appendix G

Daily mean fork lengths (MFL), weights, and condition factors with standard deviations (STD) for natural and hatchery chinook salmon and steelhead captured in the Imnaha River screw traps during the spring emigration of 1998.

Table G. Daily mean fork lengths (MFL), weights, and condition factors with standard deviations (STD) for natural and hatchery chinook salmon and steelhead captured in the Imnaha River screw traps during the spring emigration of 1998.

Species/ Date	MFL	MFL (STD)	Mean Weight	Mean Weight (STD)	Mean Condition Factor	Mean Condition Factor (STD)
Natural Chinook salmon						
02/27/98	106	7.7	12.6	3.03	1.04	0.048
03/10/98	110	5.2	13.2	2.21	0.94	0.029
03/12/98	106	9.1	13.5	3.01	1.15	0.282
03/13/98	108	6.7	13.3	2.89	1.03	0.050
03/16/98	108	7.7	13.3	2.73	1.05	0.084
03/17/98	107	7.6	13.0	2.79	1.05	0.077
03/18/98	105	7.4	12.3	2.81	1.04	0.083
03/19/98	105	7.4	11.8	2.60	1.00	0.070
03/20/98	103	7.8	12.2	3.32	1.09	0.160
03/21/98	103	6.4	11.5	2.33	1.03	0.059
03/22/98	104	8.4	12.0	3.09	1.05	0.078
03/23/98	106	8.1	12.5	3.08	1.03	0.066
03/26/98	102	5.3	11.7	2.09	1.11	0.069
03/27/98	107	7.1	13.3	2.85	1.07	0.070
03/30/98	103	8.6	11.6	3.63	1.03	0.068
03/31/98	104	11.8	12.1	6.25	1.03	0.078
04/01/98	102	7.3	11.3	2.47	1.05	0.065
04/02/98	103	7.6	11.5	2.74	1.04	0.063
04/03/98	104	7.5	11.6	2.69	1.02	0.059
04/06/98	105	6.7	12.0	2.42	1.02	0.062
04/07/98	106	7.2	13.0	2.85	1.07	0.071
04/08/98	106	8.6	12.5	3.42	1.02	0.103
04/09/98	103	8.0	12.6	2.19	1.17	0.163
04/10/98	115	26.7	17.7	18.26	0.99	0.084
04/11/98	106	7.1	12.2	2.73	0.99	0.075
04/12/98	109	5.2	13.9	2.57	1.05	0.078
04/13/98	105	8.1	12.4	2.97	1.04	0.128
04/14/98	105	7.4	13.2	2.92	1.12	0.125
04/15/98	107	11.4	13.5	4.84	1.07	0.083

Table G. Continued.

Species/ Date	MFL	MFL (STD)	Mean Weight	Mean Weight (STD)	Mean Condition Factor	Mean Condition Factor (STD)
Natural Chinook Salmon						
04/16/98	108	7.4	13.6	3.01	1.07	0.094
04/17/98	112	0.0	15.5	0.00	1.10	0.000
04/20/98	107	8.3	13.8	3.30	1.11	0.089
04/21/98	108	7.7	14.2	3.24	1.10	0.092
04/22/98	113	10.5	16.1	5.32	1.10	0.089
04/23/98	111	8.0	14.6	3.12	1.05	0.071
04/26/98	100	5.7	11.1	3.03	1.12	0.108
04/27/98	101	6.1	12.0	2.37	1.14	0.091
04/28/98	105	8.5	12.5	3.41	1.06	0.111
04/29/98	112	23.6	17.1	15.23	1.08	0.066
04/30/98	106	8.2	13.0	3.57	1.06	0.075
05/05/98	116	0.0	14.0	0.00	0.90	0.000
05/06/98	113	0.0				
05/07/98	104	10.7	13.4	3.78	1.17	0.022
05/12/98	105	6.2	13.2	2.03	1.14	0.128
05/13/98	103	6.9	12.4	2.32	1.11	0.066
05/14/98	107	6.6	13.9	2.72	1.13	0.070
05/15/98	107	6.7	13.9	2.33	1.13	0.082
05/18/98	102	8.4				
05/19/98	102	9.3	11.8	2.90	1.06	0.148
05/20/98	102	12.6	11.9	5.44	1.05	0.065
05/22/98	107	10.1	13.7	3.54	1.10	0.054
06/02/98	98	0.0	11.3	0.00	1.20	0.000
06/03/98	95	0.0	10.7	0.00	1.25	0.000
06/11/98	98	3.0	11.2	0.85	1.18	0.020
06/15/98	89	3.5	7.9	0.30	1.16	0.180
Hatchery Chinook Salmon						
04/07/98	138	0.0	30.0	0.0	1.14	0.000
04/08/98	141	11.4	31.7	8.7	1.11	0.070
04/09/98	136	10.5	29.0	6.2	1.11	0.096
04/10/98	139	11.7	30.8	15.0	1.13	0.744

Table G. Continued.

Species/ Date	MFL	MFL (STD)	Mean Weight	Mean Weight (STD)	Mean Condition Factor	Mean Condition Factor (STD)
Hatchery Chinook Salmon						
04/11/98	137	12.4	27.6	10.0	1.04	0.085
04/12/98	135	9.1	25.8	5.9	1.04	0.102
04/13/98	133	10.6	25.2	6.2	1.07	0.107
04/14/98	151	52.6	25.3	7.3	0.51	0.471
04/15/98	129	12.6	26.7	10.6	1.43	1.399
04/16/98	131	9.2	24.0	5.6	1.03	0.070
04/20/98	123	0.0	22.8	0.0	1.23	0.000
04/21/98	131	8.8	24.5	5.5	1.09	0.107
04/22/98	133	10.7	26.0	6.8	1.08	0.119
04/23/98	157	0.0	38.9	0.0	1.01	0.000
04/27/98	128	5.8				
04/28/98	123	8.0				
04/29/98	131	7.6				
04/30/98	133	6.7				
05/01/98	128	5.9				
05/05/98	132	5.6				
05/06/98	135	4.0				
05/12/98	130	6.8				
05/13/98	138	8.3	26.3	6.0	0.99	0.068
05/14/98	131	0.5	23.3	1.0	1.05	0.055
05/15/98	130	0.0	27.8	0.0	1.27	0.000
05/18/98	138	0.0				
05/20/98	119	0.0				
05/22/98	127	0.0	22.5	0.0	1.10	0.000
Natural Steelhead						
03/16/98	135	36.2	30.6	24.48	1.05	0.112
03/17/98	158	12.0	38.2	8.83	0.96	0.052
03/18/98	143	18.3	29.4	12.63	0.97	0.076
03/19/98	137	21.4	27.3	10.52	0.98	0.051
03/20/98	145	14.9	32.2	9.88	1.04	0.082
03/21/98	125	20.9	23.1	11.87	1.07	0.053

Table G. Continued.

Species/ Date	MFL	MFL (STD)	Mean Weight	Mean Weight (STD)	Mean Condition Factor	Mean Condition Factor (STD)
Natural Steelhead						
03/22/98	140	14.1	29.2	7.42	1.04	0.060
03/23/98	151	34.6	38.1	26.96	0.96	0.118
03/26/98	176	18.7	57.2	20.85	1.01	0.213
03/27/98	154	29.9	42.7	23.41	1.04	0.148
03/30/98	176	22.2	55.7	18.97	0.97	0.057
03/31/98	170	28.5	50.7	21.00	0.97	0.106
04/01/98	163	19.6	43.8	15.73	0.97	0.057
04/02/98	160	17.3	42.6	13.98	1.00	0.079
04/03/98	151	29.6	40.0	21.91	1.36	1.791
04/06/98	167	24.4	46.8	21.08	0.95	0.079
04/07/98	170	10.5	47.3	8.15	0.96	0.040
04/08/98	168	25.7	47.1	21.88	0.90	0.205
04/09/98	171	29.3	51.9	23.08	0.97	0.104
04/10/98	186	17.6	54.9	27.80	0.81	0.296
04/11/98	173	15.5	42.7	17.46	0.83	0.252
04/12/98	174	11.9	53.5	13.47	0.99	0.081
04/13/98	187	18.5	65.0	19.00	0.97	0.069
04/14/98	174	18.8	53.8	18.38	0.98	0.058
04/15/98	178	18.9	56.7	17.69	0.97	0.053
04/16/98	184	19.1	58.6	24.09	0.90	0.226
04/17/98	96	0.0	9.3	0.00	1.05	0.000
04/20/98	176	21.2	54.2	20.50	0.96	0.068
04/21/98	179	22.4	58.1	19.44	1.02	0.490
04/22/98	188	22.5	66.7	24.02	0.97	0.063
04/23/98	191	22.6	71.9	27.13	0.98	0.090
04/26/98	180	17.7	45.3	28.68	0.77	0.434
04/27/98	179	16.2	59.9	17.41	1.02	0.065
04/28/98	179	17.5	56.7	19.95	0.97	0.188
04/29/98	179	20.4	59.2	21.30	1.00	0.128
04/30/98	179	19.9	60.0	20.01	1.01	0.057
05/01/98	178	0.0	52.8	0.00	0.94	0.000

Table G. Continued.

Species/ Date	MFL	MFL (STD)	Mean Weight	Mean Weight (STD)	Mean Condition Factor	Mean Condition Factor (STD)
Natural Steelhead						
05/05/98	177	15.1	52.3	13.71	0.92	0.053
05/06/98	187	21.1	0.0	0.00	0.00	0.000
05/07/98	178	16.2	59.0	17.36	1.01	0.058
05/08/98	177	15.1	56.4	15.39	1.00	0.062
05/11/98	181	23.6	0.0	0.00	0.00	0.000
05/12/98	173	15.2	52.4	14.50	0.99	0.054
05/13/98	171	13.8	51.0	12.79	1.00	0.060
05/14/98	174	15.7	54.8	17.11	1.02	0.199
05/15/98	170	16.2	51.0	15.16	1.02	0.058
05/18/98	175	16.6	0.0	0.00	0.00	0.000
05/19/98	171	15.4	50.7	16.47	0.99	0.157
05/20/98	170	16.8	49.4	17.45	0.97	0.158
05/21/98	169	17.0	46.7	18.26	0.96	0.159
05/22/98	171	16.4	52.2	15.75	1.01	0.067
06/02/98	158	23.7	46.3	15.21	1.11	0.066
06/03/98	172	19.9	56.7	14.22	1.10	0.102
06/09/98	161	0.0	38.3	0.00	0.92	0.000
06/10/98	90	0.0	7.9	0.00	1.08	0.000
06/11/98	219	0.0	99.6	0.00	0.95	0.000
06/12/98	157	0.0	44.4	0.00	1.15	0.000
06/15/98	106	0.0	10.6	0.00	0.89	0.000
Hatchery Steelhead						
03/22/98	234	0.0	113.8	0.00	0.89	0.000
03/23/98	263	0.0	155.2	0.00	0.85	0.000
04/14/98	288	0.0	117.8	0.00	0.49	0.000
04/21/98	281	0.0	203.9	0.00	0.92	0.000
04/22/98	262	24.1	172.2	63.25	0.92	0.062
04/23/98	260	7.5	178.3	7.65	1.02	0.045
04/26/98	221	17.4	108.2	29.57	0.98	0.060
04/27/98	225	19.0	119.4	36.27	1.01	0.060
04/28/98	219	18.8	102.7	26.53	0.99	0.064

Table G. Continued.

Species/ Date	MFL	MFL (STD)	Mean Weight	Mean Weight (STD)	Mean Condition Factor	Mean Condition Factor (STD)
Hatchery Steelhead						
04/29/98	219	19.2	101.9	27.31	0.99	0.060
05/05/98	222	18.4	101.5	29.13	0.90	0.057
05/06/98	223	19.8				
05/07/98	212	18.9	93.9	29.45	0.95	0.064
05/08/98	219	18.5	105.2	28.03	0.98	0.043
05/11/98	219	16.4				
05/12/98	221	18.5	95.7	22.61	0.93	0.051
05/13/98	218	20.0	101.5	27.48	0.95	0.054
05/14/98	221	19.4	103.2	28.59	0.94	0.049
05/15/98	218	18.2	101.2	26.59	0.95	0.055
05/18/98	221	21.3				
05/19/98	221	18.3	103.2	26.30	0.93	0.051
05/20/98	211	19.9	93.2	29.37	0.97	0.065
05/21/98	212	20.8	97.6	31.98	0.97	0.124
05/22/98	208	19.0	87.8	0.00	1.05	0.000
06/02/98	224	19.3	115.9	33.66	1.00	0.072
06/03/98	221	22.8	109.4	33.53	0.99	0.086
06/05/98	224	16.1	108.8	25.27	0.96	0.058
06/09/98	220	24.3	104.9	41.08	0.94	0.091
06/10/98	224	23.8	109.4	38.95	0.93	0.071
06/11/98	215	20.9	99.0	33.34	0.96	0.060
06/12/98	245	8.6	151.0	21.93	1.02	0.045
06/15/98	219	30.7	104.7	42.90	0.94	0.058
06/16/98	225	19.7	105.5	31.80	0.91	0.044

Appendix H

A summary of individual PIT tag release group release dates and times, number released, and mean fork lengths and weights with standard deviations for natural and hatchery chinook salmon and steelhead released February 26 to June 16, 1998 from the lower Imnaha Trap.

Table H. A summary of individual PIT tag release group release dates, number released, and mean fork lengths and weights with standard deviations for natural and hatchery chinook salmon and steelhead released February 26 to June 16, 1998 from the lower Imnaha Trap.

Rearing and Species	PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight
Natural Chinook salmon							
	PAK98058.NT1	2/27/98	14	106	8.0	12.6	3.1
	PAK98069.NT1	3/10/98	4	112	6.2	13.2	2.6
	PAK98069.NT2	3/10/98	2	107	4.2	0.0	0.0
	PAK98071.NT1	3/12/98	2	99	5.0	12.4	2.1
	PAK98071.NT3	3/12/98	2	114	9.2	14.5	5.2
	PAK98072.NT1	3/13/98	9	108	7.1	13.3	3.1
	PAK98075.NT1	3/16/98	230	108	7.7	13.3	2.7
	PAK98076.NT1	3/17/98	432	107	7.7	13.0	2.9
	PAK98077.NT1	3/18/98	413	105	7.4	12.2	2.9
	PAK98078.NT1	3/19/98	305	105	9.7	11.6	2.9
	PAK98078.NT2	3/19/98	69	106	6.6	11.8	2.2
	PAK98079.NT1	3/20/98	168	103	7.9	12.2	3.3
	PAK98080.NT2	3/21/98	81	103	6.4	11.5	2.3
	PAK98081.NT1	3/22/98	77	104	8.4	12.0	3.1
	PAK98082.NT2	3/23/98	146	106	8.2	12.5	3.1
	PAK98085.NT1	3/26/98	16	102	5.4	11.7	2.2
	PAK98086.NT1	3/27/98	41	107	7.2	13.3	2.9
	PAK98089.NT4	3/30/98	48	104	11.0	11.9	5.2
	PAK98089.NT5	3/30/98	109	103	7.4	11.5	2.7
	PAK98090.NT1	3/31/98	40	103	6.1	11.9	2.3
	PAK98090.NT3	3/31/98	105	105	13.4	12.2	7.2
	PAK98091.NT1	4/1/98	128	103	6.7	11.4	2.4
	PAK98092.NT1	4/2/98	121	103	7.3	11.6	2.7
	PAK98093.NT2	4/3/98	60	104	7.6	11.6	2.7
	PAK98096.NT1	4/6/98	95	105	6.8	12.0	2.4
	PAK98097.NT1	4/7/98	39	105	7.7	12.8	3.1
	PAK98097.NT5	4/8/98	21	108	6.1	13.4	2.5
	PAK98098.NT2	4/8/98	27	106	8.7	12.5	3.5
	PAK98099.NTA	4/9/98	20	103	8.4	12.7	2.2
	PAK98099.NTC	4/9/98	1	85		60.9	
	PAK98099.NTP	4/9/98	1	102		10.4	

Table H. Continued.

Rearing and Species	PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight
Natural Chinook salmon							
	PAK98100.NTC	4/10/98	2	107	14.8	13.3	4.7
	PAK98100.NTE	4/11/98	12	117	29.5	18.4	20.5
	PAK98101.NTA	4/12/98	33	106	7.2	11.8	3.5
	PAK98102.NTB	4/13/98	19	110	5.4	14.1	2.6
	PAK98103.NT1	4/13/98	33	105	8.2	12.7	3.9
	PAK98103.NTA	4/13/98	19	108	8.9	12.9	4.0
	PAK98103.NTB	4/14/98	2	115	13.4	15.1	6.2
	PAK98103.NTD	4/14/98	99	105	7.8	12.1	3.1
	PAK98104.NT1	4/15/98	109	105	7.3	13.2	3.0
	PAK98105.NT1	4/16/98	90	113	34.5	13.4	4.7
	PAK98106.NT1	4/17/98	3	106	1.0	12.6	0.3
	PAK98106.NT4	4/17/98	50	108	7.7	13.7	3.1
	PAK98110.NT1	4/20/98	94	107	8.2	13.8	3.3
	PAK98111.NT1	4/21/98	107	108	7.3	14.2	3.1
	PAK98112.NT1	4/22/98	4	107	3.2	16.9	4.2
	PAK98112.NT2	4/22/98	91	113	12.1	16.5	6.6
	PAK98112.NT3	4/22/98	94	112	8.8	15.8	3.8
	PAK98113.NT1	4/23/98	101	111	8.0	14.6	3.1
	PAK98116.NT2	4/27/98	4	100	6.6	8.4	6.3
	PAK98117.NT1	4/28/98	21	101	6.3	12.0	2.4
	PAK98118.NT1	4/29/98	18	105	8.7	12.5	3.5
	PAK98119.NT1	4/30/98	12	112	24.6	17.1	15.9
	PAK98120.NT1	5/1/98	15	106	8.5	13.0	3.7
	PAK98125.NT1	5/5/98	1	116		14.0	
	PAK98126.NT1	5/6/98	1	113		0.0	
	PAK98133.NT1	5/13/98	18	103	7.1	12.4	2.4
	PAK98134.NT1	5/14/98	20	107	6.9	13.9	2.8
	PAK98135.NT1	5/15/98	13	107	7.0	13.9	2.4
	PAK98138.NT1	5/18/98	17	102	8.7	0.0	0.0
	PAK98139.NT1	5/19/98	18	102	9.6	11.2	4.0
	PAK98140.NT1	5/20/98	6	102	13.8	11.9	6.0
	PAK98153.NT1	6/2/98	1	98		11.3	

Table H. Continued.

Rearing and Species	PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight
Natural Chinook salmon							
	PAK98154.NT1	6/3/98	1	95		10.7	
	PAK98166.NT1	6/15/98	2	89	5.0	7.9	0.4
	Total Number Released		3,956				
Hatchery Chinook salmon							
	PAK98097.NT5	4/8/98	1	138		30.0	
	PAK98098.NT2	4/8/98	382	141	11.9	31.3	8.9
	PAK98099.NT1	4/9/98	623	136	10.4	29.2	6.2
	PAK98099.NTP	4/9/98	1	180		34.1	
	PAK98103.NT1	4/13/98	749	133	13.2	25.1	6.2
	PAK98103.NTA	4/13/98	62	136	13.2		
	PAK98103.NTD	4/14/98	176	136	11.0	26.5	6.2
	PAK98110.NT1	4/20/98	1	123		22.8	
	PAK98111.NT1	4/21/98	1	118		16.6	
	PAK98112.NT3	4/22/98	3	201	21.0	80.2	37.7
	PAK98113.NT1	4/23/98	1	157		38.9	
	Total Number Released		2,000				
Natural Steelhead							
	PAK98069.FP1	3/10/98	1	110		16.6	
	PAK98075.NT1	3/16/98	2	137	3.5	26.5	2.0
	PAK98076.NT1	3/17/98	16	154	18.6	36.5	11.2
	PAK98077.NT1	3/18/98	23	143	18.9	29.3	13.0
	PAK98085.NT1	3/26/98	25	176	19.1	57.2	21.3
	PAK98086.NT1	3/27/98	3	177	15.0	59.5	17.2
	PAK98089.NT4	3/30/98	10	165	23.2	46.7	16.8
	PAK98089.NT5	3/30/98	58	177	23.3	56.5	19.8
	PAK98090.NT1	3/31/98	4	141	14.9	29.8	9.3
	PAK98090.NT3	3/31/98	48	177	21.5	55.0	18.5
	PAK98091.NT1	4/1/98	52	163	19.9	43.8	15.9
	PAK98092.FP2	4/2/98	59	160	17.5	42.6	14.1
	PAK98093.FPA	4/3/98	16	158	21.2	39.6	20.0

Table H. Continued.

Rearing and Species	PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight
Natural Steelhead							
	PAK98096.FP1	4/6/98	19	168	21.5	45.4	18.0
	PAK98097.FP1	4/7/98	11	165	18.5	44.6	12.0
	PAK98098.FP1	4/9/98	6	183	21.1	59.8	20.0
	PAK98098.NT2	4/8/98	14	166	23.9	43.1	21.5
	PAK98099.NTA	4/9/98	14	173	27.0	53.6	23.1
	PAK98099.NTP	4/9/98	1	202		64.7	
	PAK98100.NTC	4/10/98	4	192	25.6	60.8	46.8
	PAK98100.NTE	4/11/98	14	185	16.2	53.2	23.5
	PAK98101.NTA	4/12/98	14	173	15.5	40.3	19.8
	PAK98102.NTB	4/13/98	3	174	14.6	53.5	16.5
	PAK98103.NT1	4/13/98	9	174	15.3	54.6	15.0
	PAK98103.NTA	4/13/98	6	169	24.3	48.1	21.1
	PAK98103.NTB	4/14/98	3	174	7.9	51.9	9.8
	PAK98103.NTD	4/14/98	51	192	16.5	69.6	18.1
	PAK98104.NT1	4/15/98	30	174	19.1	53.8	18.7
	PAK98105.NT1	4/16/98	43	178	19.4	56.6	18.1
	PAK98106.NT4	4/17/98	21	185	19.2	55.9	27.1
	PAK98110.NT1	4/20/98	76	176	20.0	54.7	20.4
	PAK98111.NT1	4/21/98	95	181	19.7	59.0	19.1
	PAK98112.NT1	4/22/98	19	182	22.2	55.6	29.2
	PAK98112.NT2	4/22/98	194	190	21.2	68.6	24.4
	PAK98112.NT3	4/22/98	102	186	21.9	64.6	22.2
	PAK98113.NT1	4/23/98	228	192	22.6	69.9	29.0
	PAK98116.NT2	4/27/98	55	180	17.8	45.3	28.9
	PAK98117.NT1	4/28/98	80	177	25.8	59.6	17.7
	PAK98118.NT1	4/29/98	125	178	23.7	56.1	20.5
	PAK98119.NT1	4/30/98	158	178	24.3	59.1	21.2
	PAK98120.NT1	5/1/98	149	178	24.8	60.0	20.0
	PAK98125.NT1	5/5/98	53	177	15.3	52.2	14.0
	PAK98126.NT1	5/6/98	36	187	21.4	0.0	0.0
	PAK98127.NT1	5/7/98	41	178	16.5	59.0	17.6
	PAK98128.NT1	5/8/98	34	177	15.3	56.4	15.6

Table H. Continued.

Rearing and Species	PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight
Natural Steelhead							
	PAK98131.NT1	5/11/98	29	181	24.0	0.0	0.0
	PAK98132.NT1	5/12/98	75	173	15.3	52.4	14.6
	PAK98133.NT1	5/13/98	82	171	13.9	50.8	12.9
	PAK98134.NT1	5/14/98	93	174	15.8	54.8	17.2
	PAK98135.NT1	5/15/98	78	170	16.3	51.0	15.3
	PAK98138.NT1	5/18/98	209	175	16.7	0.0	0.0
	PAK98139.NT1	5/19/98	199	171	15.5	50.7	16.5
	PAK98140.NT1	5/20/98	99	168	23.4	49.0	17.8
	PAK98140.NT2	5/21/98	81	170	18.7	50.2	18.3
	PAK98141.NT1	5/22/98	44	169	17.2	46.7	18.5
	PAK98142.NT2	5/22/98	80	171	16.5	52.2	15.9
	PAK98153.NT1	6/2/98	6	167	11.1	51.6	9.2
	PAK98154.NT1	6/3/98	4	172	23.0	56.7	16.4
	PAK98160.NT1	6/9/98	1	161		38.3	
	PAK98162.NT2	6/11/98	1	219		99.6	
	Total Number Released		3,106				
Hatchery Steelhead							
	PAK98111.NT1	4/21/98	1	281		203.9	
	PAK98112.NT1	4/22/98	1	304		290.4	
	PAK98112.NT2	4/22/98	3	246	14.0	132.0	24.4
	PAK98112.NT3	4/22/98	1	265		174.4	
	PAK98113.NT1	4/23/98	2	260	10.6	178.3	10.8
	PAK98116.NT2	4/27/98	289	220	21.7	14.2	38.2
	PAK98117.NT1	4/28/98	387	221	33.6	30.6	55.2
	PAK98118.NT1	4/29/98	394	219	18.9	21.4	43.5
	PAK98119.NT1	4/30/98	379	219	19.2	22.6	44.3
	PAK98125.NT1	5/5/98	82	219	30.6	100.6	31.2
	PAK98126.NT1	5/6/98	32	223	20.1	0.0	0.0
	PAK98127.NT1	5/7/98	35	206	40.6	93.5	29.5
	PAK98128.NT1	5/8/98	25	219	18.9	105.2	28.6
	PAK98131.NT1	5/11/98	65	219	16.6	0.0	0.0

Table H. Continued.

Rearing and Species	PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight
Hatchery Steelhead							
	PAK98132.NT1	5/12/98	145	221	18.5	14.5	35.6
	PAK98133.NT1	5/13/98	155	218	20.0	98.2	32.5
	PAK98134.NT1	5/14/98	161	221	19.4	98.7	35.1
	PAK98135.NT1	5/15/98	135	218	18.3	100.5	28.0
	PAK98138.NT1	5/18/98	201	221	21.4	0.0	0.0
	PAK98139.NT1	5/19/98	196	222	18.1	101.3	31.0
	PAK98140.NT1	5/20/98	531	211	19.7	33.1	47.1
	PAK98140.NT2	5/21/98	211	209	20.6	38.7	51.9
	PAK98141.NT1	5/22/98	132	209	18.8	55.2	47.6
	PAK98142.NT2	5/22/98	131	206	26.3	0.7	7.7
	PAK98153.NT1	6/2/98	14	224	20.0	115.9	34.9
	PAK98154.NT1	6/3/98	16	221	23.5	109.4	34.6
	PAK98156.NT1	6/5/98	12	224	16.8	108.8	26.4
	PAK98160.NT1	6/9/98	19	220	25.0	104.9	42.2
	PAK98161.NT1	6/10/98	34	224	24.1	109.4	39.5
	PAK98162.NT2	6/11/98	43	215	21.4	99.2	34.1
	PAK98163.NT1	6/12/98	4	245	9.9	151.0	25.3
	PAK98166.NT1	6/15/98	7	219	33.2	104.7	46.3
	PAK98167.NT1	6/16/98	16	225	20.3	105.5	32.8
	Total Number Released		3,859				

Appendix I

Wilcoxon test values and sample sizes (n) for four statistical comparisons of median fork lengths of natural and hatchery chinook salmon and steelhead in the spring of 1998 and five statistical comparison of the median travel time of natural and hatchery chinook salmon and steelhead from the lower Imnaha River trap to Lower Granite Reservoir in 1998**.**

Table I. Wilcoxon test values and sample sizes (n) for four statistical comparisons of median fork lengths of natural and hatchery chinook salmon and steelhead in the spring of 1998 and five statistical comparison of the median travel time of natural and hatchery chinook salmon and steelhead from the lower Imnaha River trap to Lower Granite Reservoir in 1998. Abbreviations: L - Lower, U - Upper, N - Natural, H - Hatchery, CHS - Chinook, and STT - Steelhead.

	Group One						Group Two						Statistical Values	
Test Item	Time Period	Site	Rearing	Species	Sample Size	Median	Time Period	Site	Rearing	Species	Sample Size	Median	P	W
Fork Lengths	Spring	L	N	CHS[1]	3,933	106 mm	Spring	L	N	CHS[2]	36	105 mm	0.30	63,675
Fork Lengths	Spring	L	H	STT[1]	3,846	218 mm	Spring	L	H	STT[2]	44	226 mm	0.08	97,562
Fork Lengths	Spring	L	H	CHS[1]	1,987	135 mm	Spring	L	H	CHS[2]	1,111	133 mm	0.00	$1.18*10^6$
Fork Lengths	Spring	L	N	STT[1]	2,768	176 mm	Spring	L	N	STT[2]	74	157 mm	0.00	60,102
Travel Times	4/12 to 4/18	L	N	CHS	204	15.5 days	4/26 to 4/18	L	H	CHS	339	19.1 days	0.00	6,009
Travel Times	4/26 to 5/2	L	N	STT	325	3.8 days	4/26 to 5/2	L	H	STT	839	5.6 days	0.0	188,827

[1] PIT Tagged
[2] Non-PIT Tagged

Table I. Continued.

	Group One						Group Two						Statistical Values	
Test Item	Time Period	Site	Rearing	Species	Sample Size	Mean	Time Period	Site	Rearing	Species	Sample Size	Mean	P	W
Travel Times	5/3 to 5/9	L	N	STT	93	3.3 days	5/3 to 5/9	L	H	STT	86	3.8 days	0.07	4,616
Travel Times	5/10 to 5/16	L	N	STT	188	4.4 days	5/10 to 5/16	L	H	STT	253	4.0 days	0.74	24,229
Travel Times	5/17 to 5/23	L	N	STT	236	3.3	5/17 to 5/23	L	H	STT	448	3.7	0.00	64,609

Appendix J

Daily trap efficiencies conducted from April 9 to April 17, 1998, for hatchery chinook salmon released on April 6 into the Imnaha River above the lower Imnaha Trap.

Table J. Daily trap efficiencies conducted from April 9 to April 17, 1998, for hatchery chinook salmon released on April 6 into the Imnaha River above the lower Imnaha Trap.

Trial	Trial End Date	Daily Average Discharge (cfs)	Number Released	Number Recaptured	Daily Efficiency Estimate
1	4/08/98	609	300	84	.28
2	4/09/98	612	300	78	.26
3	4/10/98	665	303	73	.24
4	4/11/98	698	301	108	.36
5	4/12/98	679	302	85	.28
6	4/13/98	654	304	60	.20
7	4/14/98	636	305	102	.33
8	4/15/98	613	304	87	.29
9	4/16/98	598	264	109	.41
	Totals and Average		2,683	786	29.4%

Appendix K

First observations of PIT tagged natural and hatchery chinook salmon and steelhead released at the Imnaha Trap at the Snake and Columbia river dams in 1998.

Table K. First observations of PIT tagged natural and hatchery chinook salmon and steelhead released at the Imnaha Trap at the Snake and Columbia River Dams in 1998. Sites are abbreviated as follows: Lower Granite Dam (LGR), Little Goose Dam (LGO), Lower Monumental Dam (LMO), and McNary Dam (MCN).

Date Released	Number Released	Number of First Observations at Main Sites				
		LGR	LGO	LMO	MCN	Total
Natural Chinook Salmon						
2/27/98	14	5	3	0	0	8
3/10/98	6	3	0	0	1	4
3/12/98	4	0	1	1	0	2
3/13/98	9	5	1	0	0	6
3/16/98	230	88	34	25	20	167
3/17/98	432	171	79	34	30	314
3/18/98	413	155	85	39	26	305
3/19/98	374	140	58	29	30	257
3/20/98	168	68	28	12	12	120
3/21/98	81	35	17	4	5	61
3/22/98	77	25	14	4	7	50
3/23/98	146	47	30	17	11	105
3/26/98	16	3	7	1	0	11
3/27/98	41	17	10	0	4	31
3/30/98	157	65	32	14	7	118
3/31/98	145	53	37	11	4	105
4/1/98	128	68	23	2	5	98
4/2/98	121	50	26	9	3	88
4/3/98	60	23	16	4	1	44
4/6/98	95	39	29	3	2	73
4/7/98	39	18	14	0	0	32
4/8/98	48	26	9	3	0	38
4/9/98	22	11	7	0	1	19
4/10/98	2	1	0	0	0	1
4/11/98	12	5	4	1	0	10
4/12/98	33	11	12	0	0	23
4/13/98	71	34	17	5	3	59
4/14/98	101	35	24	13	1	73

Table K. Continued.

Date Released	Number Released	Number of First Observations at Main Sites				
		LGR	LGO	LMO	MCN	Total
Natural Chinook Salmon						
4/15/98	109	51	30	8	1	90
4/16/98	90	48	22	4	1	75
4/17/98	53	25	17	4	0	46
4/20/98	94	45	29	8	1	83
4/21/98	107	50	23	7	2	82
4/22/98	189	100	39	9	5	153
4/23/98	101	49	29	7	2	87
4/27/98	4	1	2	0	0	3
4/28/98	21	11	6	1	0	18
4/29/98	18	8	2	0	0	10
4/30/98	12	4	2	1	0	7
5/1/98	15	8	4	1	0	13
5/5/98	1	0	1	0	0	1
5/6/98	1	1	0	0	0	1
5/13/98	18	8	5	1	0	14
5/14/98	20	8	3	1	0	12
5/15/98	13	3	2	0	0	5
5/18/98	17	4	1	3	0	8
5/19/98	18	4	2	2	2	10
5/20/98	6	0	1	1	0	2
6/2/98	1	1	0	0	0	1
6/4/98	1	0	0	0	0	0
6/15/98	2	0	0	0	0	0
Total	3,956	1,630	837	289	187	2,943
Hatchery Chinook Salmon						
4/8/98	383	144	73	28	10	255
4/9/98	624	215	117	51	13	396
4/13/98	811	289	161	47	21	518
4/14/98	176	51	39	17	8	115

Table K. Continued.

Date Released	Number Released	Number of First Observations at Main Sites				
		LGR	LGO	LMO	MCN	Total
Hatchery Chinook salmon						
4/20/98	1	0	1	0	0	1
4/21/98	1	0	0	0	0	0
4/22/98	3	1	0	0	0	1
4/23/98	1	0	0	0	1	1
Total	2,000	700	391	143	53	1,287
Natural Steelhead						
3/16/98	1	1	0	0	0	1
3/17/98	2	8	0	1	1	10
3/18/98	16	12	4	1	0	17
3/26/98	23	11	3	3	1	18
3/27/98	25	2	0	0	0	2
3/30/98	13	35	10	7	1	53
3/31/98	62	26	2	2	3	33
4/1/98	48	25	2	5	3	35
4/2/98	52	31	6	2	2	41
4/3/98	59	6	4	1	1	12
4/6/98	16	8	4	0	0	12
4/7/98	19	6	0	2	0	8
4/8/98	6	9	3	0	1	13
4/9/98	39	12	1	1	0	14
4/10/98	1	3	0	0	1	4
4/11/98	4	7	1	1	1	10
4/12/98	14	6	2	0	0	8
4/13/98	26	12	1	2	0	15
4/14/98	9	27	8	2	2	39
4/15/98	51	13	4	2	0	19
4/16/98	30	24	8	2	1	35
4/17/98	43	9	6	1	1	17
4/20/98	21	33	14	4	0	51

Table K. Continued.

Date Released	Number Released	Number of First Observations at Main Sites				
		LGR	LGO	LMO	MCN	Total
Natural Steelhead						
4/21/98	76	41	11	10	2	64
4/22/98	308	152	58	17	4	231
4/23/98	102	116	32	20	5	173
4/27/98	228	29	6	5	1	41
4/28/98	55	43	11	5	1	60
4/29/98	80	68	18	11	1	98
4/30/98	125	92	23	14	3	132
5/1/98	158	93	19	8	2	122
5/5/98	149	27	11	8	1	47
5/6/98	53	20	7	5	0	32
5/7/98	36	25	7	3	0	35
5/8/98	41	21	6	3	0	30
5/11/98	34	18	8	1	0	27
5/12/98	29	42	15	4	0	61
5/13/98	75	43	10	2	1	56
5/14/98	82	39	11	4	2	56
5/15/98	93	46	5	6	0	57
5/18/98	78	82	34	7	4	127
5/19/98	209	71	28	12	4	115
5/20/98	199	32	15	5	1	53
5/21/98	99	18	16	14	0	48
5/22/98	125	33	47	8	2	90
6/2/98	80	2	0	1	0	3
6/3/98	6	0	1	1	0	2
6/9/98	4	0	0	0	0	0
6/11/98	1	0	0	0	0	0
Total	3,105	1,479	482	213	53	2,227
Hatchery Steelhead						
4/21/98	1	0	0	0	0	0

Table K. Continued.

Date Released	Number Released	Number of First Observations at Main Sites				
		LGR	LGO	LMO	MCN	Total
Hatchery Steelhead						
4/22/98	5	2	0	1	0	3
4/23/98	2	1	0	0	0	1
4/27/98	289	166	40	9	1	216
4/28/98	387	216	48	33	0	297
4/29/98	394	241	48	23	1	313
4/30/98	379	216	46	22	2	286
5/5/98	82	41	9	3	0	53
5/6/98	32	15	3	2	0	20
5/7/98	35	16	7	5	0	28
5/8/98	25	14	3	4	0	21
5/11/98	65	29	11	6	0	46
5/12/98	145	76	18	9	2	105
5/13/98	155	56	23	8	0	87
5/14/98	161	52	11	5	2	70
5/15/98	135	40	20	8	0	68
5/18/98	201	71	20	10	1	102
5/19/98	196	67	17	18	1	103
5/20/98	531	163	103	43	11	320
5/21/98	211	67	39	14	1	121
5/22/98	263	80	64	23	3	170
6/2/98	14	6	0	0	0	6
6/3/98	16	3	2	1	2	8
6/5/98	12	5	4	1	1	11
6/9/98	19	4	4	2	1	11
6/10/98	34	17	3	1	0	21
6/11/98	43	12	4	2	1	19
6/12/98	4	0	1	0	1	2
6/15/98	7	4	2	1	0	7
6/16/98	16	2	5	0	0	7
Total	3,859	1,682	555	254	31	2,522

Appendix L

Cumulative interrogations of spring PIT tagged Imnaha River natural and hatchery chinook salmon and steelhead smolts at Lower Granite, Little Goose, Lower Monumental and McNary (MCN) dams from 1993 to 1998 and SURPH survival estimates to MCN.

Table L. Cumulative interrogations of spring PIT tagged Imnaha River natural and hatchery chinook salmon and steelhead smolts at Lower Granite, Little Goose, Lower Monumental and McNary Dams from 1993 to 1998 and survival estimates to MCN.

Species	Migration Year	Number Released	Cumulative Interrogations	Cumulative Interrogations (%)	Survival Estimate To MCN (%)
Natural Chinook salmon					
	1998	3,956	2,943	74.4	78.3 (±13.7)
	1997	238	160	67.2	
	1996	1,311	819	62.5	
	1995	421	330	78.4	
	1994	956	595	62.2	
	1993	249	160	64.3	
Hatchery Chinook salmon					
	1998	2,000	1,283	64.2	57.9 (±18.6)
	1997	1,000	538	53.8	
	1996	698	335	48.0	
	1995[a]	445	262	58.9	
	1995[b]	302	171	56.6	
	1994	662	299	45.2	
	1992[c]	928	450	48.5	
Natural Steelhead					
	1998	3,106	2,222	71.5	56.5 (±17.1)
	1997	782	588	75.2	
	1996	1,503	1,065	70.9	
	1995	227	173	76.2	
	1994[d]	846	443	52.4	
	1994	604	292	48.3	
	1993	183	131	71.6	
Hatchery Steelhead					
	1998	3,859	2,522	65.4	60.5 (±20.4)
	1997	6,117	3,794	62.0	
	1996	1,346	671	49.9	
	1995	1,289	897	69.6	
	1994[d]	1,076	216	20.1	
	1994	1,237	479	38.7	
	1993	526	279	53.0	

[a] HXW crossed chinook salmon smolts PIT tagged for the Nez Perce Tribe and released at dark.

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

[c] Lower Monumental Dam was not an interrogation site.

[d] NPT PIT tagged fish.

[e] FPC PIT tagged fish.

Appendix M

Daily arrival timing frequencies of PIT tagged Imnaha River fish to Lower Granite, Little Goose, Lower Monumental, and McNary dams during the 1998 spring migration.

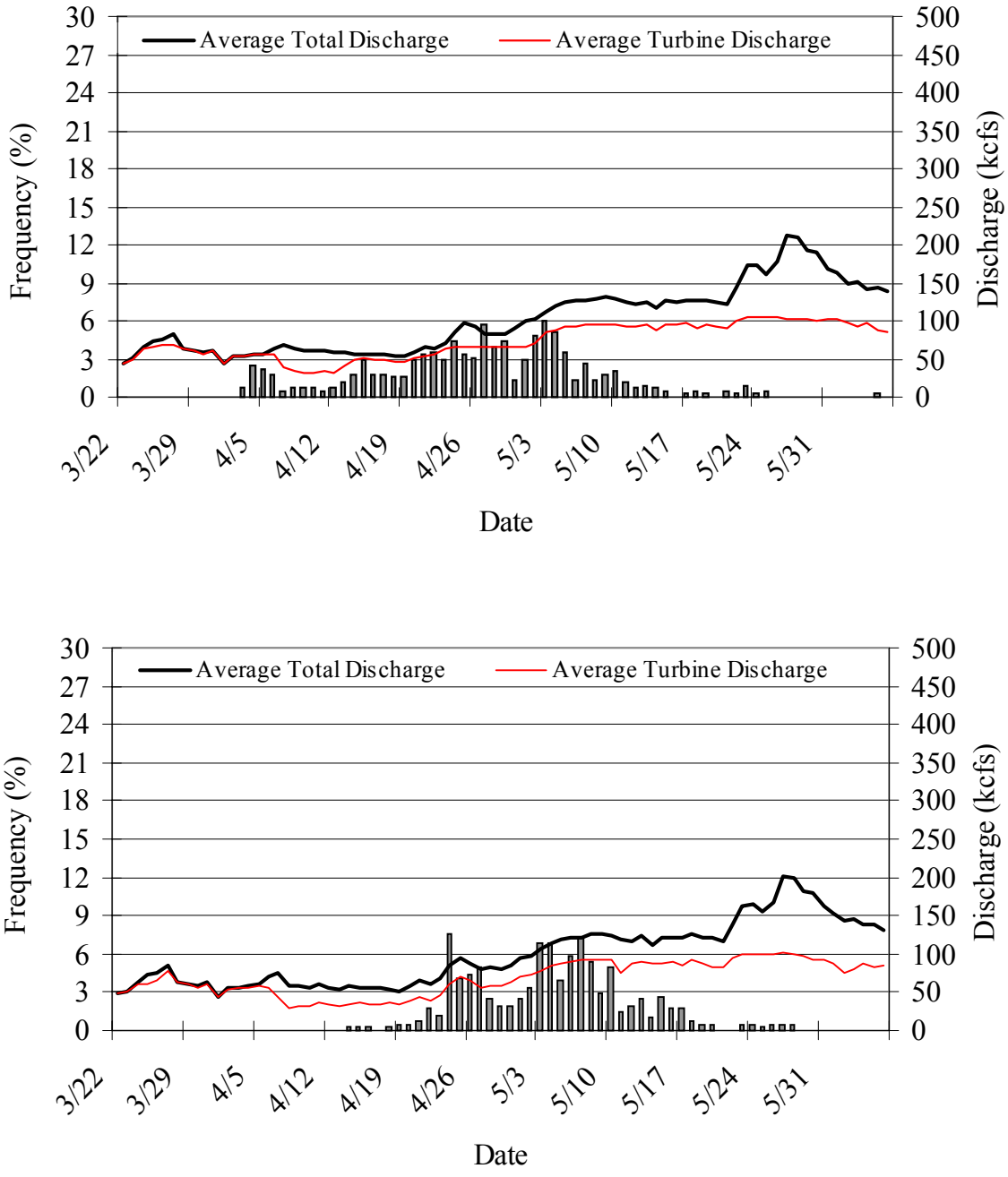

Figure M-1. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the upper site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

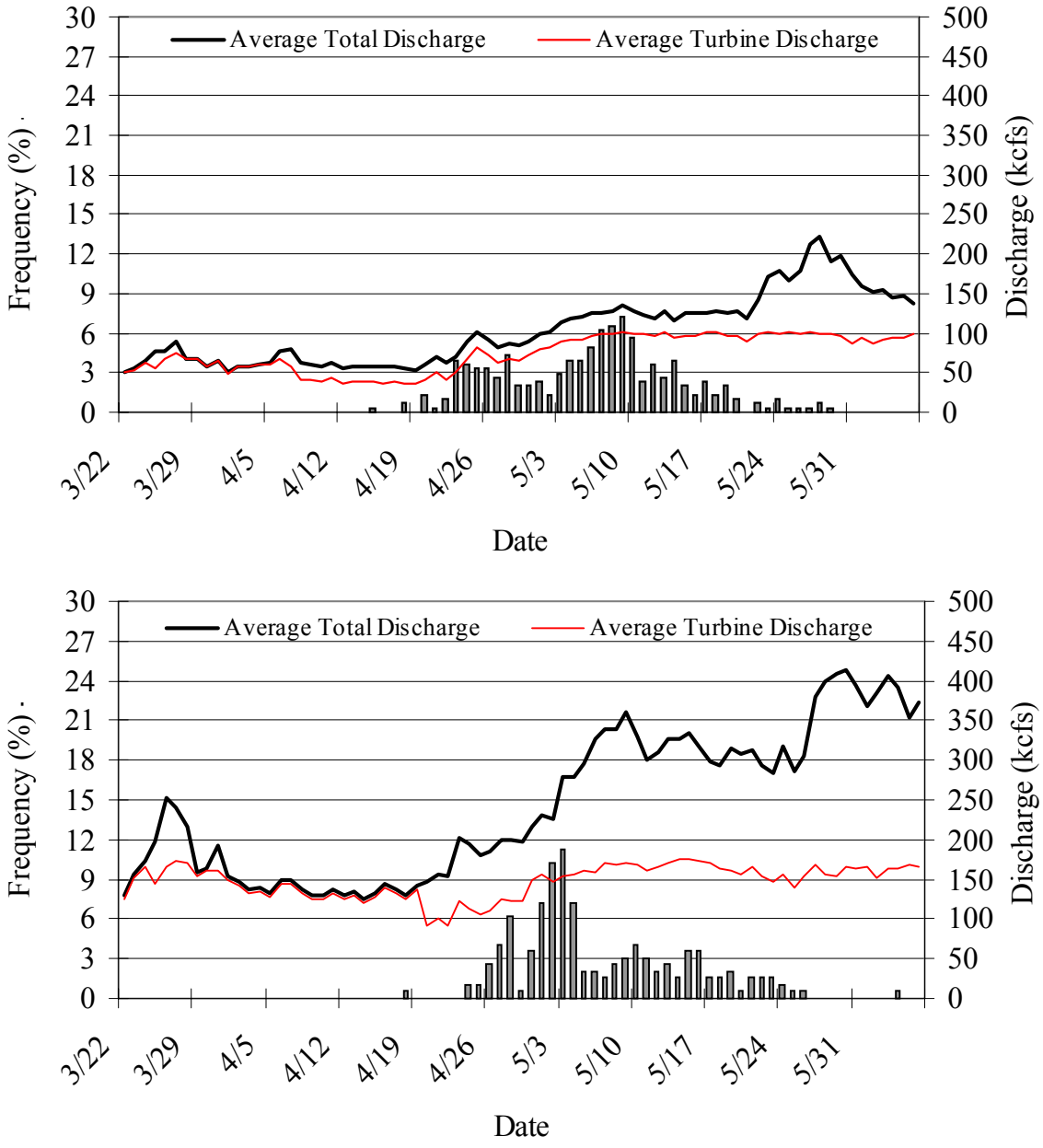

Figure M-2. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the upper site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

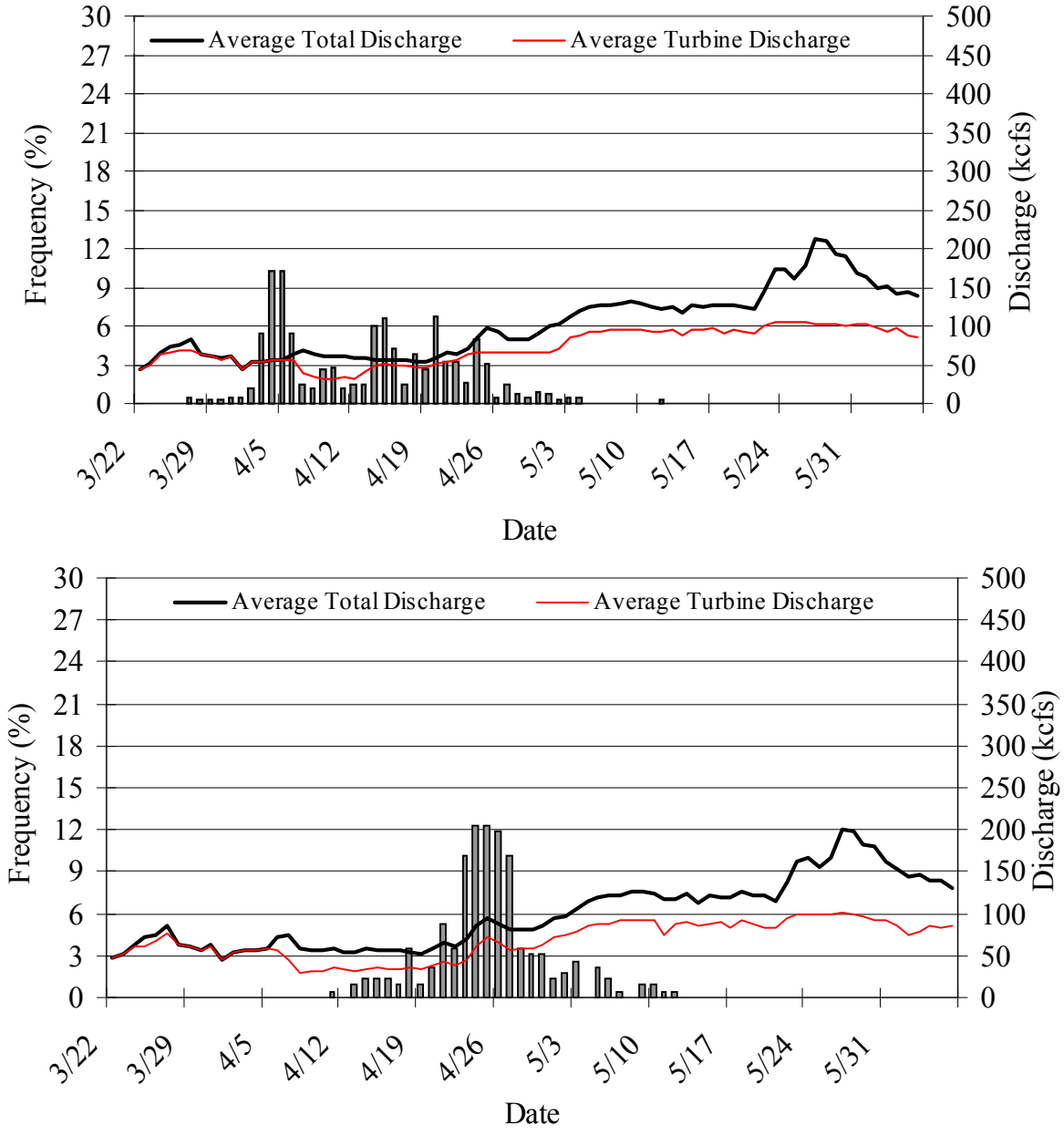

Figure M-3. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

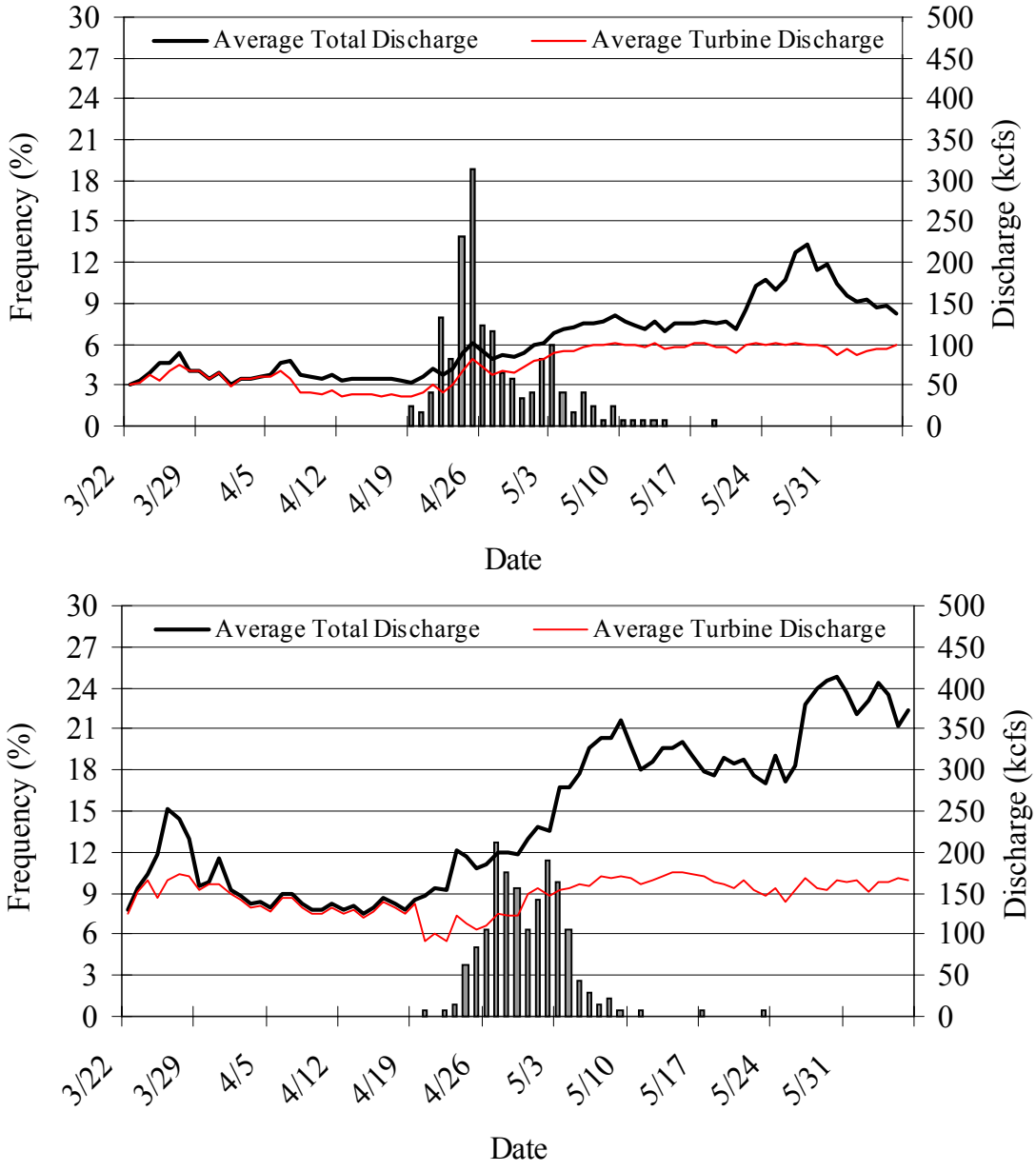

Figure M-4. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 22 to June 6, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

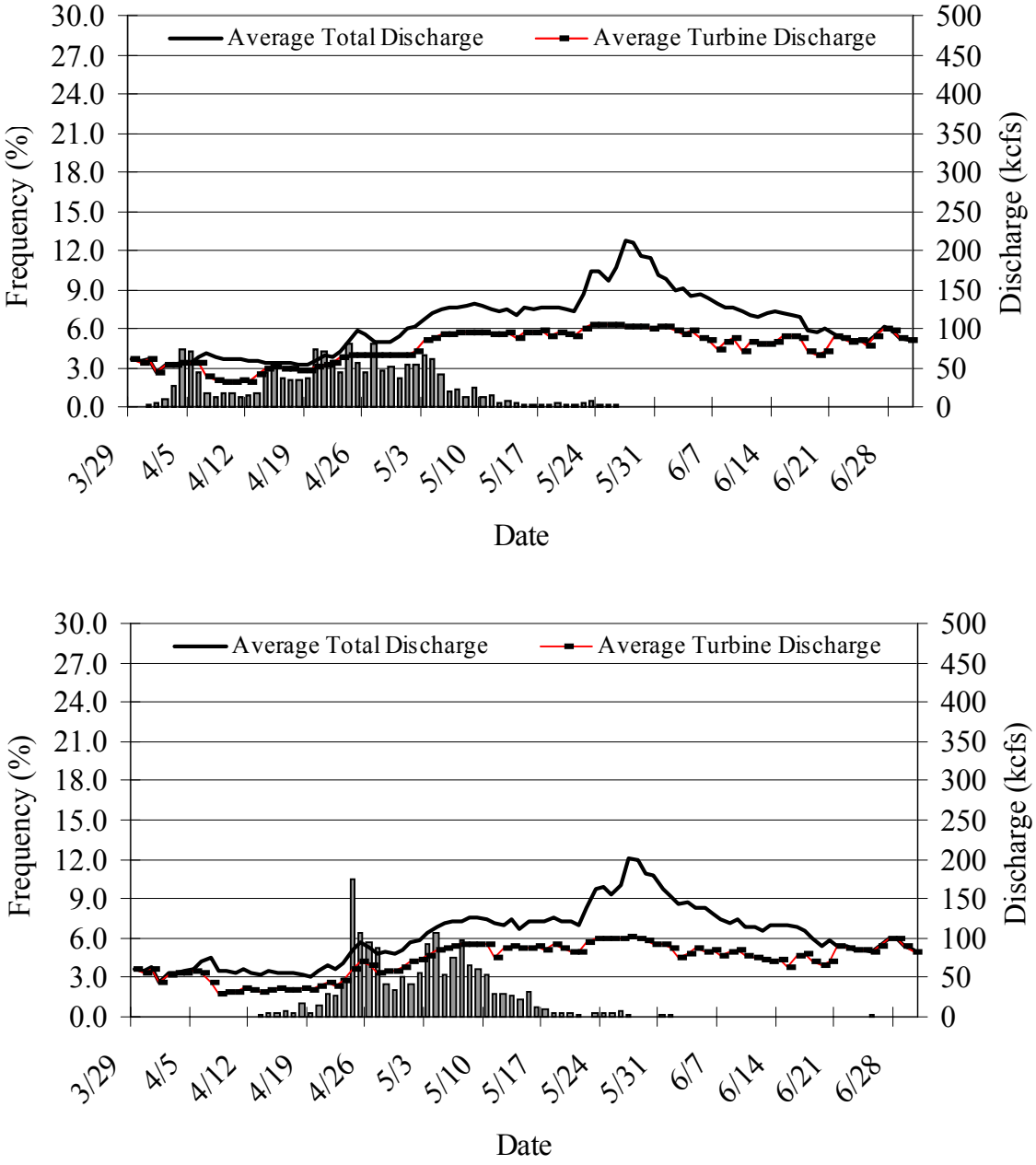

Figure M-5. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

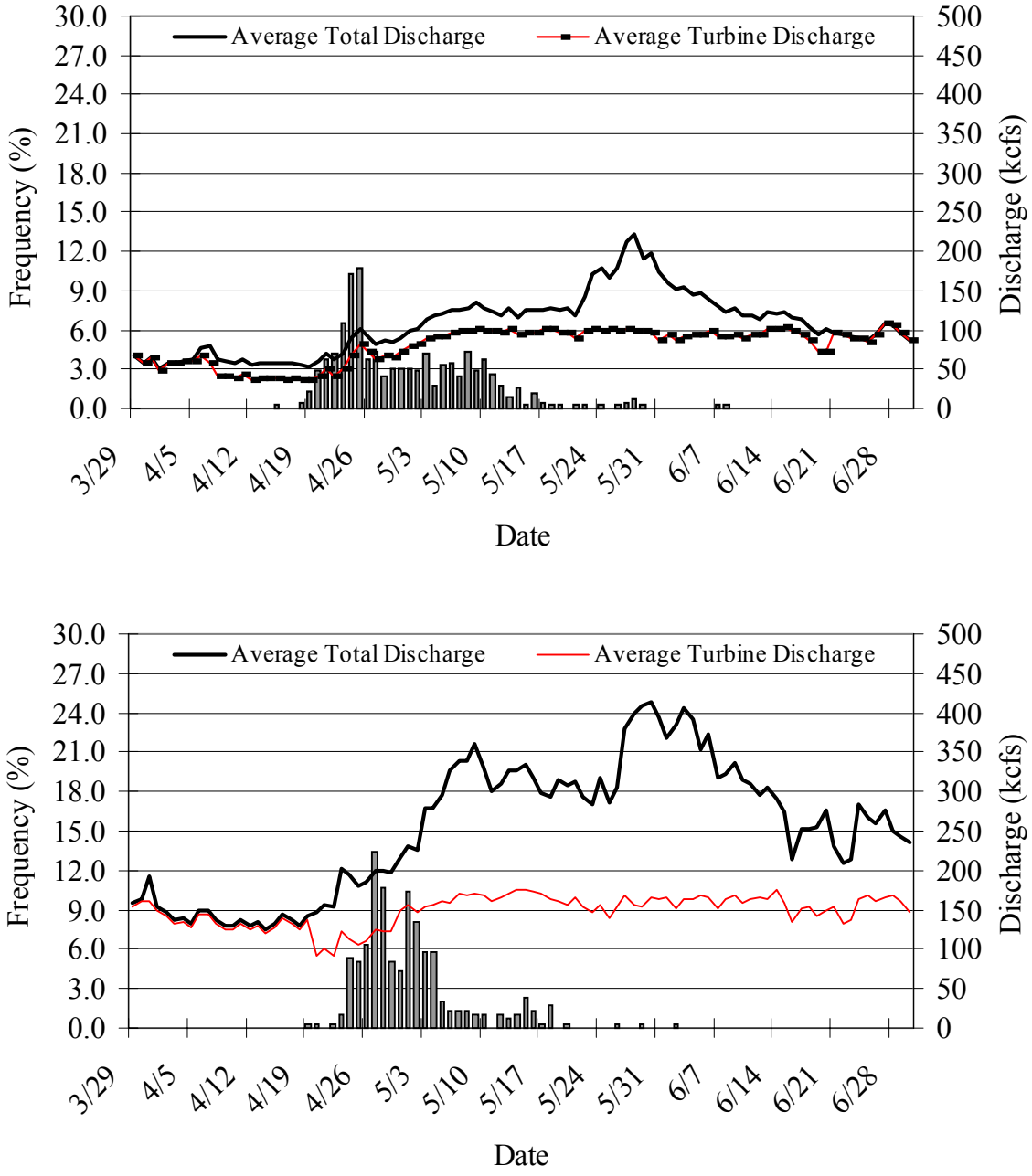

Figure M-6. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

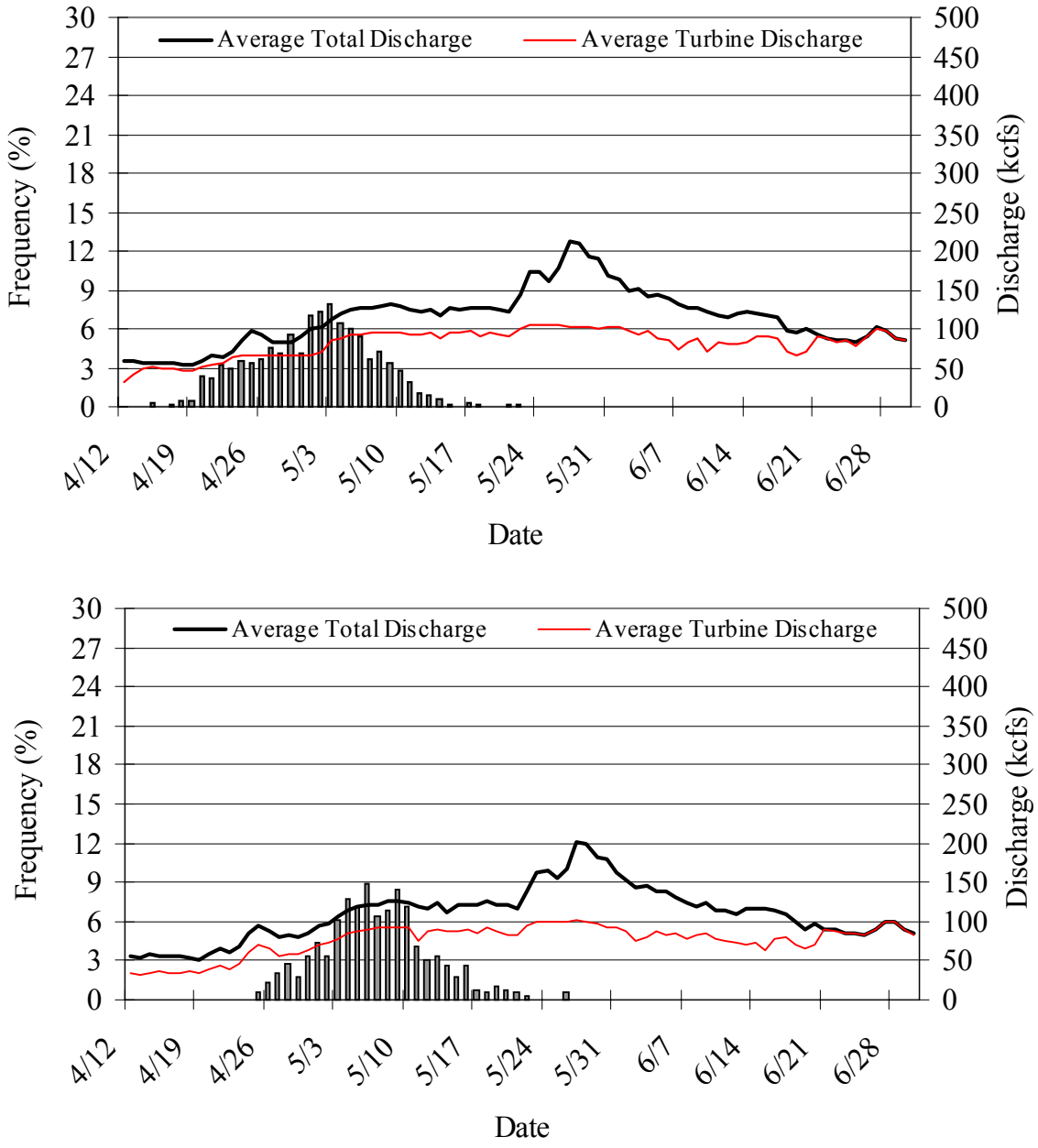

Figure M-7. Daily arrival timing frequency of hatchery chinook salmon, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), April 12 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix K. Continued.

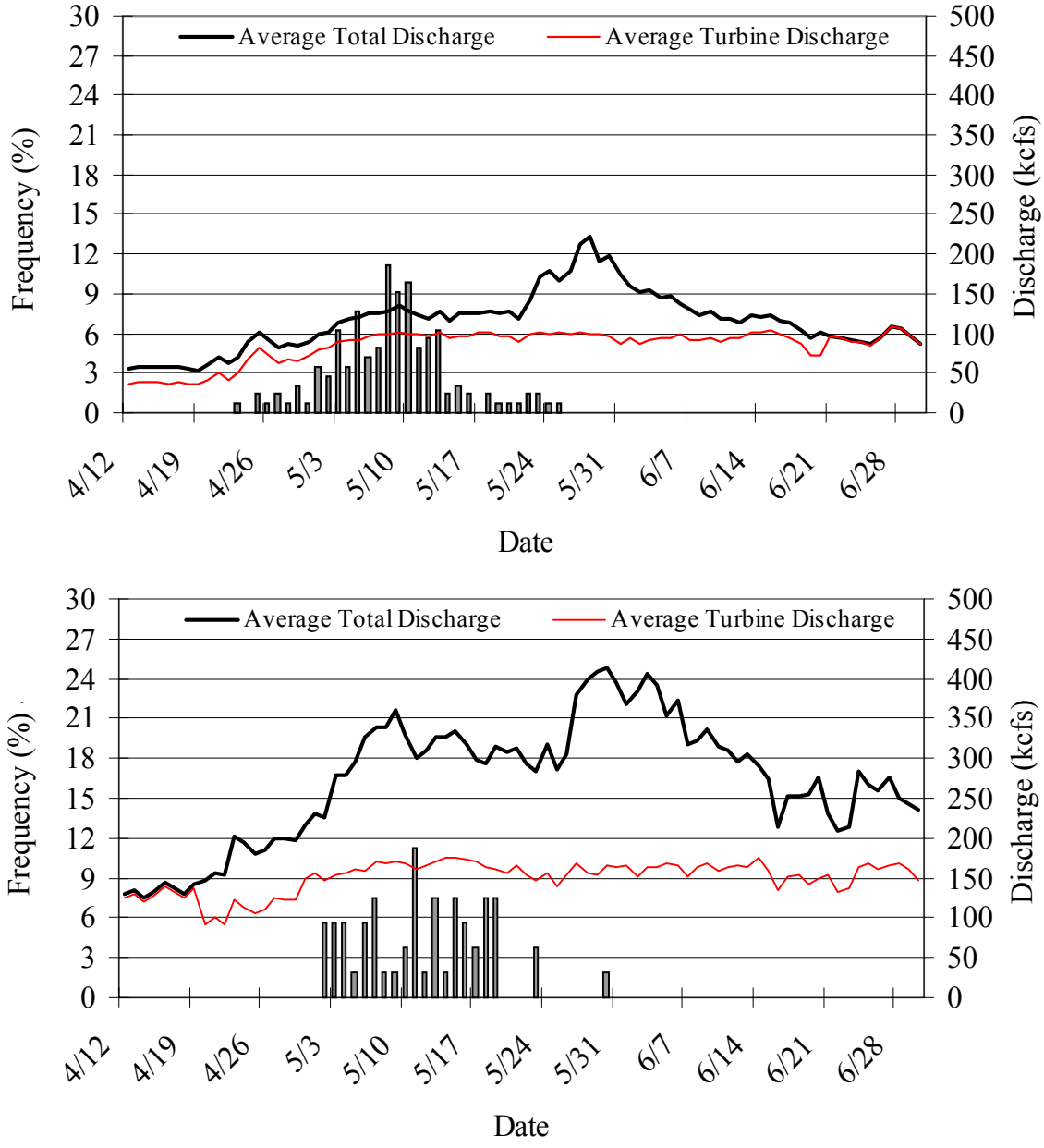

Figure M-8. Daily arrival timing frequency of hatchery chinook salmon, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

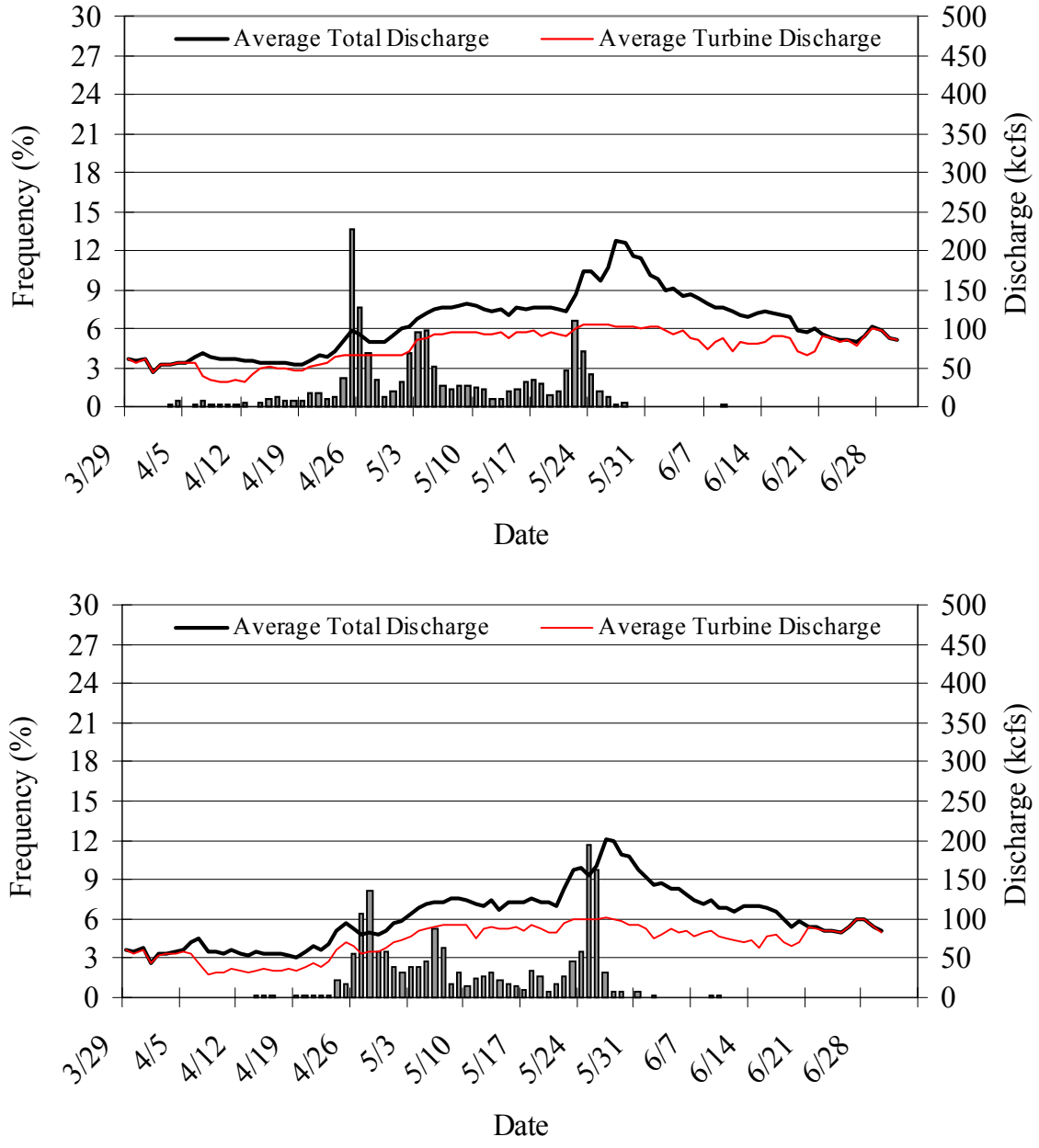

Figure M-9. Daily arrival timing frequency of natural steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

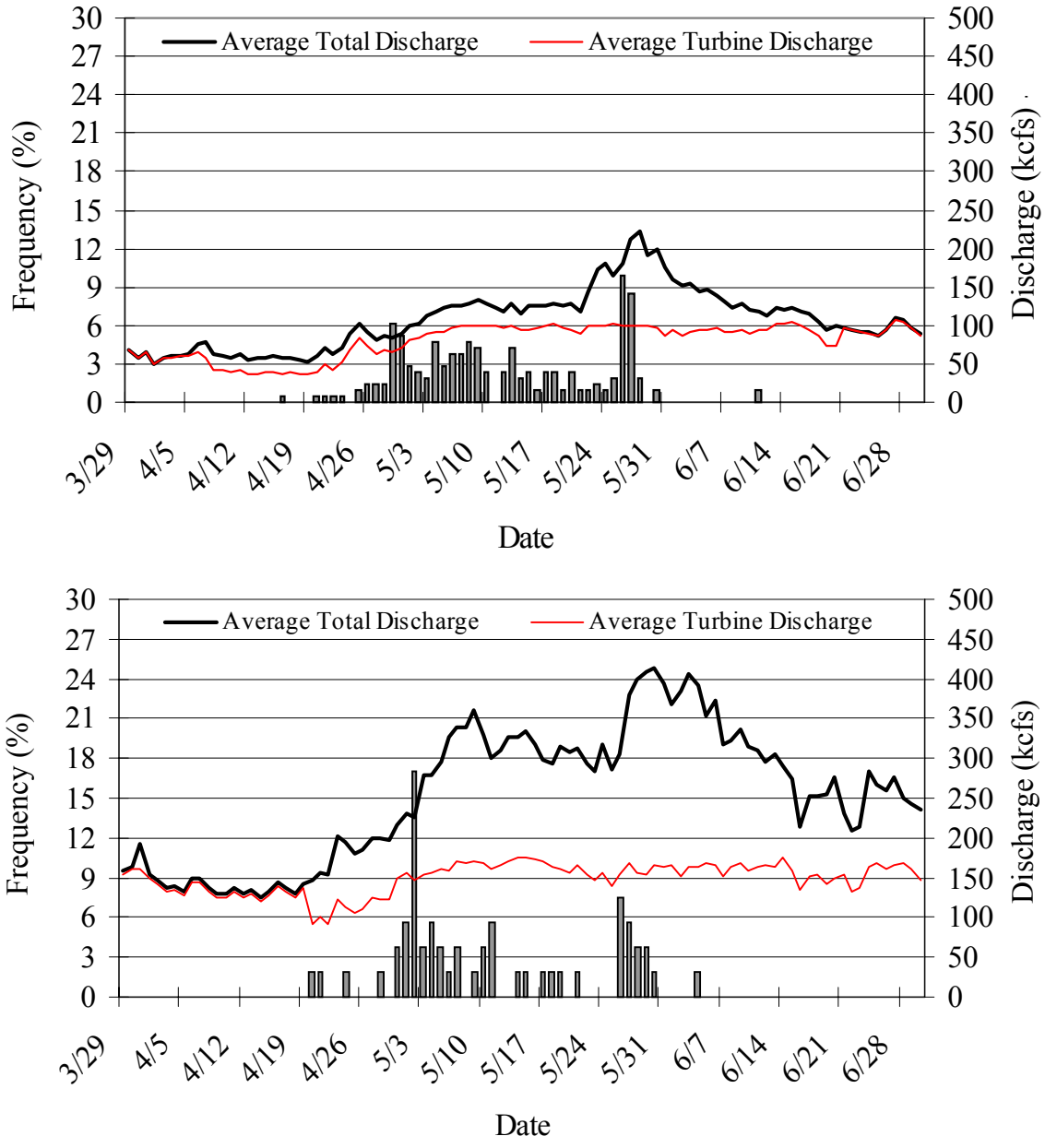

Figure M-10. Daily arrival timing frequency of natural steelhead, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 29 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

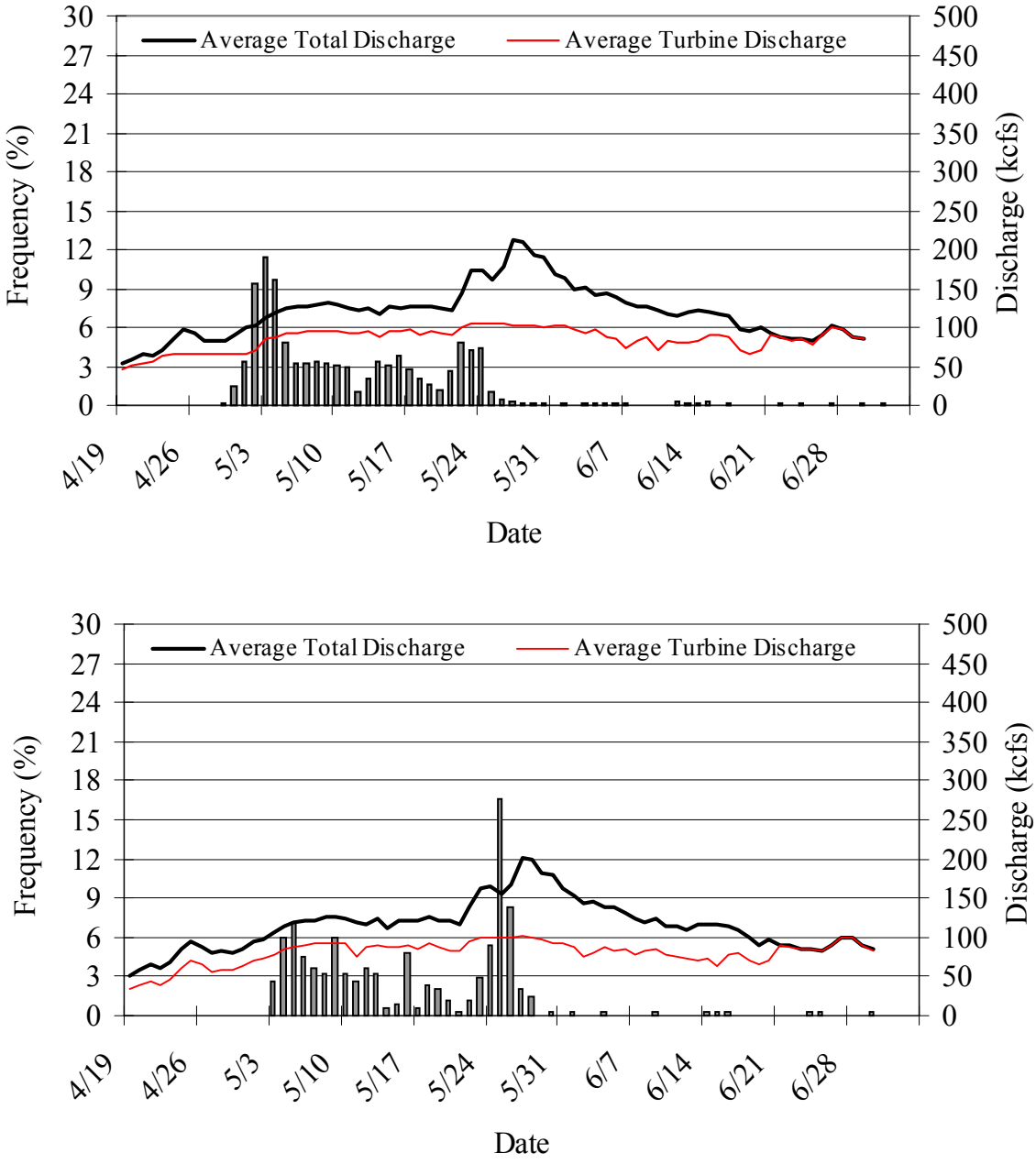

Figure M-11. Daily arrival timing frequency of hatchery-adipose-left-ventral clipped steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), April 19 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M Continued.

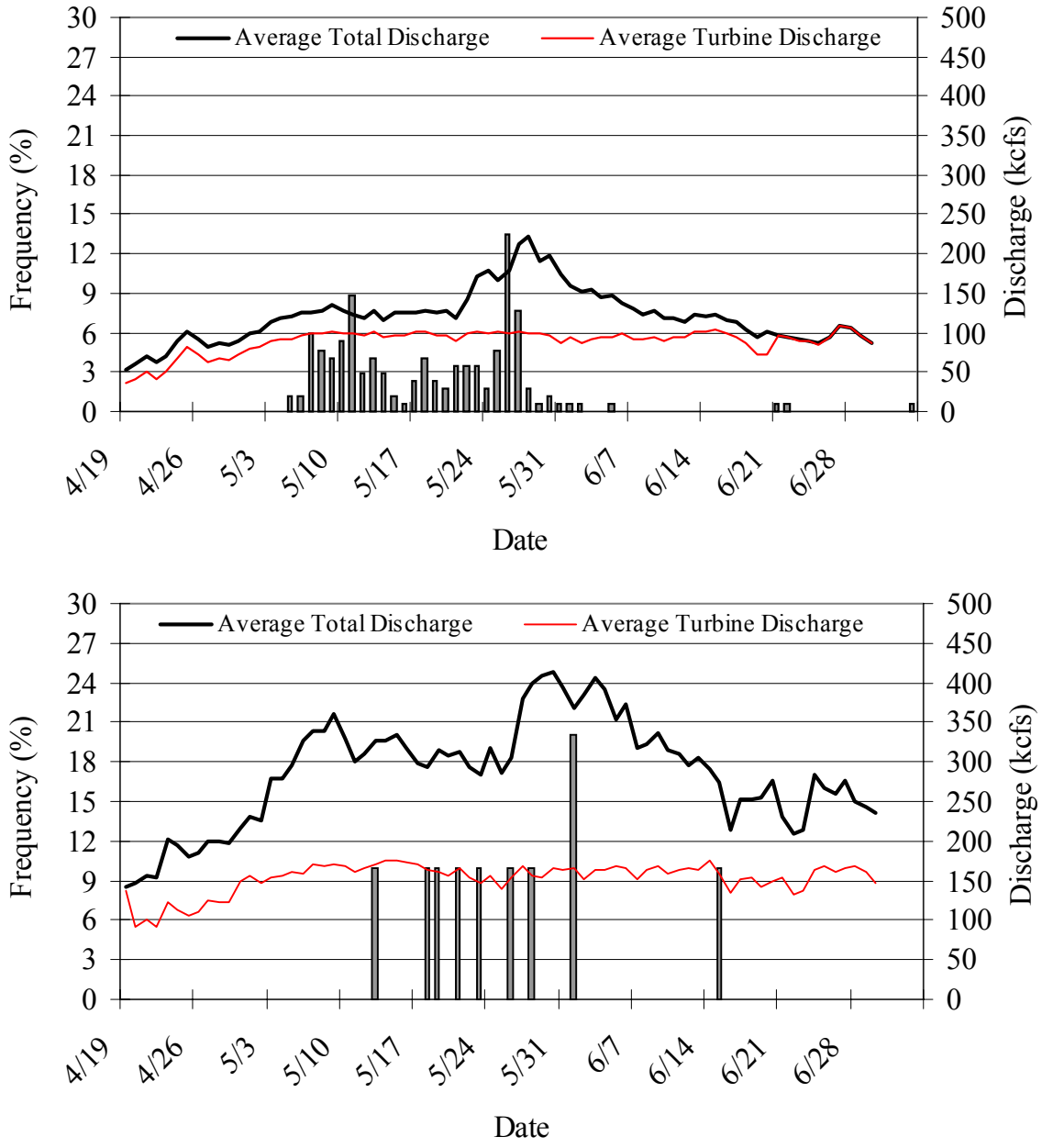

Figure M-12. Daily arrival timing frequency of hatchery-adipose-left-ventral clipped steelhead, PIT tagged in the spring at the lower site, at Lower Monumental (top graph) and McNary Dam (bottom graph), April 19 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

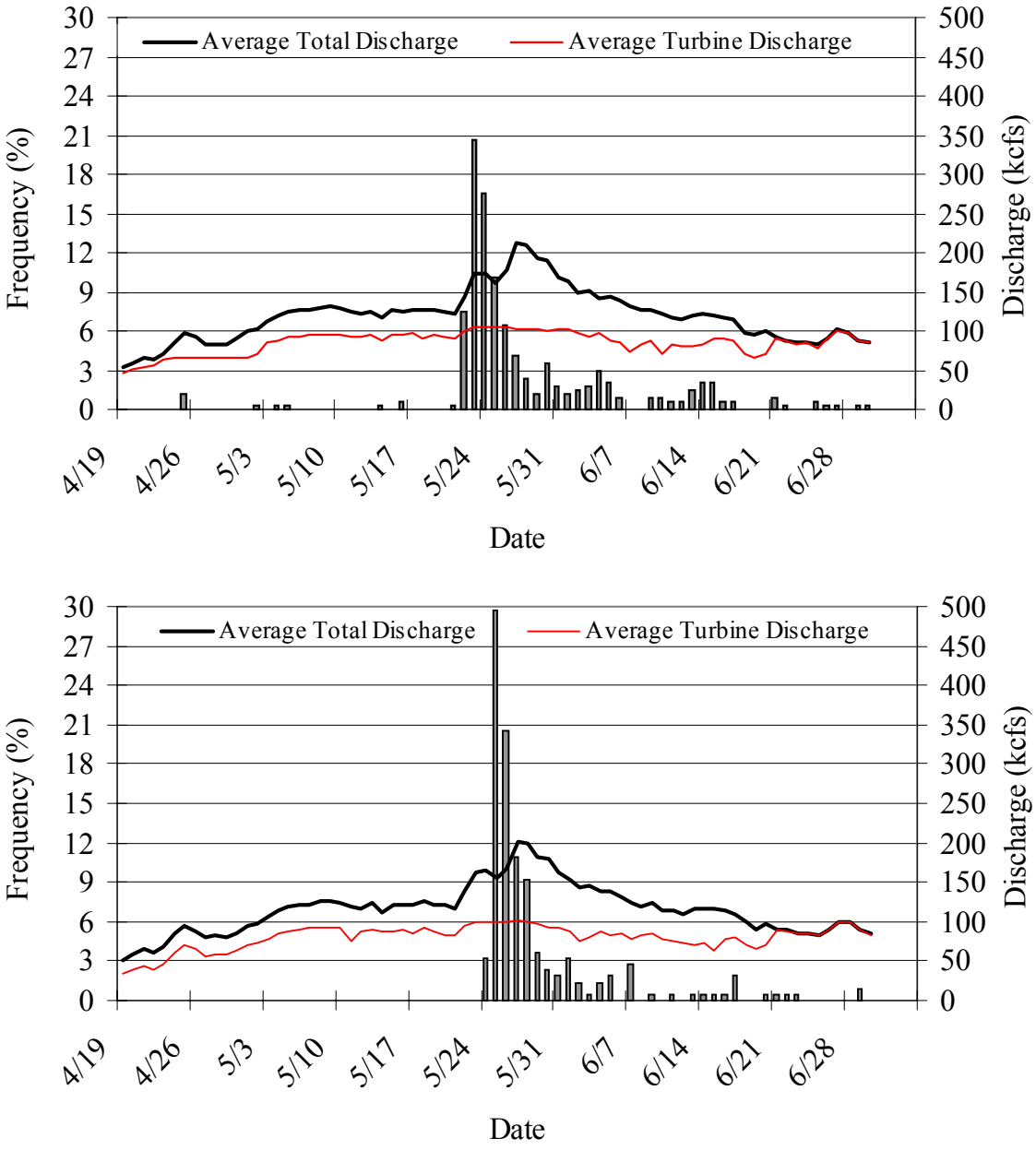

Figure M-13. Daily arrival timing frequency of hatchery-adipose clipped steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), April 19 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.

Appendix M. Continued.

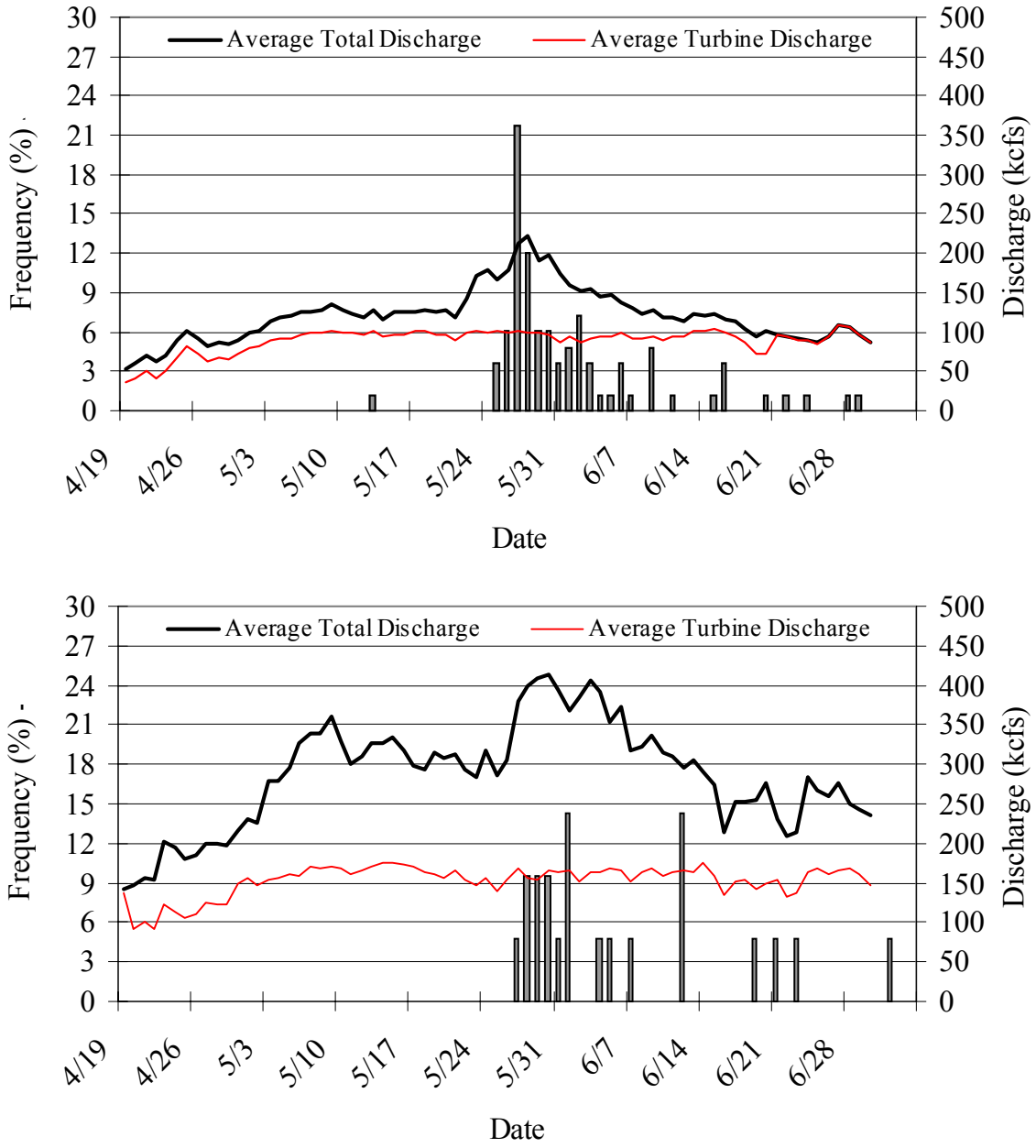

Figure M-14. Daily arrival timing frequency of hatchery-adipose clipped steelhead, PIT tagged in the spring at the lower site, at Lower Monumental (top graph) and McNary Dam (bottom graph), April 19 to July 4, 1998. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line.