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

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Emigration of Natural and Hatchery Chinook Salmon and Steelhead Smolts from the Imnaha River, Oregon, October 19, 1998 to June 24, 1999

1999 Annual Report

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ABSTRACT

The Nez Perce Tribe has conducted emigration studies in the Imnaha River for eight years and has participated in the smolt monitoring program for a sixth 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. Rotary screw traps were used to capture emigrating juvenile chinook salmon and steelhead smolts at river kilometer (rkm) 74 and 7 during the fall from October 19 to November 13, and during the spring from March 1 to June 24 at rkm 7. Fish were tagged with PIT (passive integrated transponders) tags. PIT tagged fish were detected migrating past interrogation sites in the Snake River and Columbia River and survival was estimated with the Survival Using Proportional Hazards model (SURPH).

A volitional release strategy of 184,567 hatchery chinook salmon smolts from the Imnaha River Acclimation Facility (rkm 74) began on March 16 and continued until fish were forced out of the pond on April 15. This was the first volitional chinook salmon smolt release in the Imnaha River. Estimated inriver survival of the hatchery chinook salmon smolts from release at the acclimation facility to the lower Imnaha River trap in 1999 was 93.7%.

The fall catch totaled 2,444 natural chinook salmon and 20 natural steelhead at the upper trap, and 2,341 natural chinook salmon and 321 natural steelhead at the lower trap. The spring target catch totaled 5,715 natural chinook salmon, 12,856 hatchery chinook salmon, 2,748 natural steelhead, and 8,858 hatchery steelhead. The spring catch of chinook salmon peaked on April 18 for natural chinook salmon and April 18 for hatchery chinook salmon. The peak catch of chinook salmon occurred two days prior to a spike in the average daily flow of 2,066 cfs in the Imnaha River and during a period where the mean water temperature reached 9.3°C. Natural steelhead were captured in the greatest numbers on May 13. Flow in the Imnaha River increased from 1,209 cfs on May 11 to 1,454 cfs on May 13. The peak catch of hatchery steelhead occurred May 19 as a result of the forced release on May 18.

The 90% arrival timing of all PIT tagged hatchery chinook salmon at the lower Imnaha River trap occurred 34 days after release. During the past two years, when acclimated-forced releases were used, 90% of the fish were captured at the trap in 10 to 11 days. The volitional release allowed a more prolonged migration for hatchery chinook salmon and mimicked their naturally reared cohorts. Hatchery chinook salmon and steelhead were statistically larger ($p < 0.05$) than natural fish. This observation is consistent with past results since 1992. There were no significant or noticeable weekly trends in the fork lengths or condition factors of natural or hatchery chinook salmon or steelhead captured in 1999. Comparison of the weekly median travel time between natural and hatchery chinook salmon and steelhead showed that natural fish emigrated significantly faster ($p < 0.05$) to Lower Granite Dam than their hatchery reared cohorts.

Season-wide survival of natural chinook salmon released during the fall at the upper site to Lower Granite Dam was 24.6%, while juvenile chinook salmon released during the fall at the

lower site had a survival of 41.5% to Lower Granite Dam. Natural chinook salmon released during the spring at the lower site had a survival of 88.5% to Lower Granite Dam. Estimated season-wide survival for other anadromous smolts to Lower Granite Dam was as follows: 71.6% - hatchery chinook salmon, 87.7% - natural steelhead, and 85.4% - hatchery steelhead. All seasonal estimates for fish released in the spring were within the range of the 1999 weekly survival estimates for each species and rearing type. Some season-wide and weekly estimates between Lower Granite Dam and Little Goose Dam, and between Little Goose Dam and Lower Monumental Dam, were over estimated (greater than 100%). This may indicate that survival to Lower Granite Dam was underestimated in these instances. There are no apparent trends in the season-wide survival from the Imnaha River to Lower Granite Dam of natural or hatchery chinook salmon or natural steelhead from 1993 to 1999. The season-wide survival of hatchery steelhead has been slightly increasing since 1996.

Season-wide survival of PIT tagged fish released in the spring at Imnaha River trap site to McNary Dam was as follows: 68.5% - natural chinook salmon, 53.8% - hatchery chinook salmon, 71.6% - natural steelhead, and 58.8% - hatchery steelhead.

Operation of Lower Granite Dam's interrogation facilities began on March 25, three days prior to the first detection of an Imnaha River chinook salmon smolt. More natural and hatchery chinook salmon and natural steelhead were detected at Little Goose Dam than at Lower Granite Dam in 1999. However median and 90% arrival times for natural chinook salmon at Lower Granite Dam were no later than past years. A possible explanation is that Little Goose Dam's interrogation system may have a higher probability of detecting a PIT tag than at Lower Granite Dam.

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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 1999 smolt migration from the Imnaha River, Oregon. These studies were designed and closely coordinated to provide information about juvenile natural and hatchery chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) biological characteristics, behavior and emigrant timing, survival, arrival timing and travel time to the Snake River dams and McNary Dam on the Columbia River. Data collected from these studies are shared with the Fish Passage Center (FPC). These data are essential to quantify smolt survival rates under the current passage conditions and to evaluate the future recovery strategies that seek to optimize smolt survival through the hydroelectric system. Information shared with the FPC assists with in-season shaping of flow and spill management requests in the Snake River reservoirs. The Bonneville Power Administration and the United States Fish and Wildlife Service contracted the Nez Perce Tribe (NPT) to monitor emigration timing and tag 21,200 emigrating natural and hatchery chinook salmon and steelhead smolts from the Imnaha River during the spring emigration period (March 1 - June 15) with passive integrated transponder (PIT) tags.

The completion of trapping in the spring of 1999 marked the eighth year of emigration studies on the Imnaha River and the sixth year of participating in the FPC smolt monitoring program. Monitoring and evaluation objectives were to:

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

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

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

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

5. Determine arrival timing, travel time and estimated survival of PIT tagged hatchery and natural chinook salmon and natural and hatchery steelhead smolts from the Imnaha River 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) and Little Sheep Creek. The waters diverted from Big Sheep and Little Sheep creeks are diverted to the Wallowa River Basin (Anonymous *a* 2000). Trapping sites are located at rkm 7 (lower site) and rkm 74 (upper site).

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

Equipment Description

Floating rotary screw traps manufactured by E.G. Solutions Inc., Corvallis, Oregon, were used to capture emigrating salmonid smolts (Figure 2). Similar traps have been used to capture migrating salmonid species in New York and Alaska (Kennen et al. 1994; Thedinga et al. 1994). When conditions permitted, two of these traps were fished in tandem. During hatchery releases, trap efficiency trials, high flows or periods of damage to one trap, a single trap was fished.

The screw traps used in the spring and fall at the lower site consisted of a non-standard 2.1 m diameter trapping cone supported by a metal A-frame and two six meter pontoons that provided flotation. Fish entering the trapping cones move through to a custom oversize livebox (1.68 m wide x 1.25 m long x 0.55 m deep). The live box was fitted with a removable baffle to dissipate water velocity during high flows. A smaller trap, with a 0.762 m diameter cone, was used at the upper site in the fall.

Water temperature information for this study was collected using a constant recording Ryan TempMentor which was located approximately 150 m upstream from the screw trap. 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.

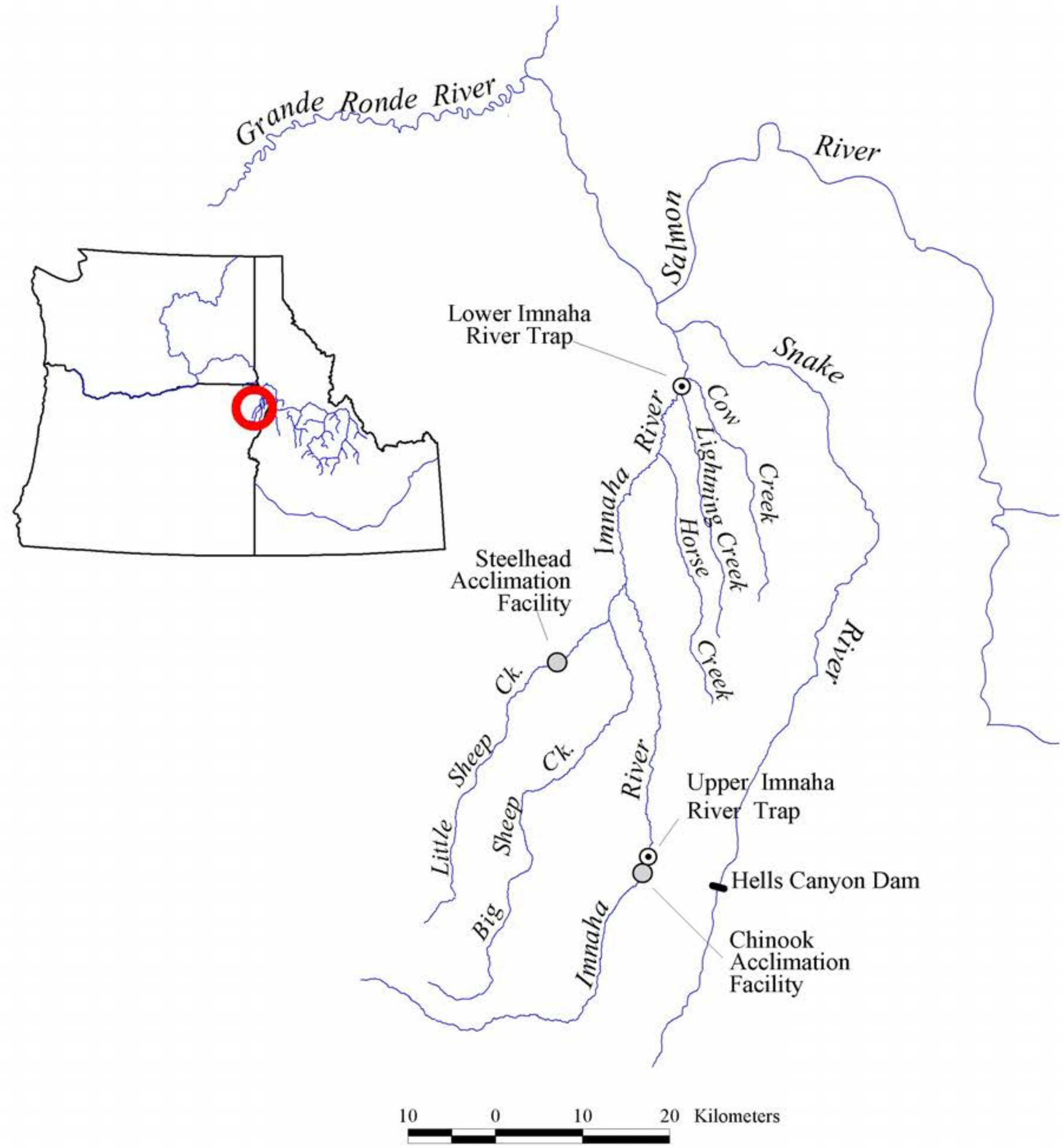

Figure 1. Map of the Imnaha River study area.

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

Trap Operations

The upper Imnaha River trap was located at rkm 74 (~400 m downstream of the Imnaha River chinook salmon acclimation facility). This trap was fished from October 19 to November 13, 1998. The lower Imnaha River screw trap was operated from October 19 to November 10, 1998 and from March 1 to June 24, 1999. The SMP portion began on March 15 and was completed June 5. A second trap was deployed whenever conditions permitted for the purpose of increasing the catch of natural chinook salmon. Normally, the screw traps were operated five days per week from Sunday evening through Friday morning during this period. Exceptions to this occurred on several occasions when trap repair was necessary or high flows or debris load in the river prevented safe trap operation.

The screw traps were secured on the west bank of the Imnaha River, below the Cow Creek bridge, 7 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 1998 we positioned the trap according to the staff gauge height with four possible positions (Table 1). 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 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) 100 to 300 hatchery chinook salmon smolts were targeted for use in daily trap efficiency trials, 5) A specified number of each species was selected for PIT tag insertion, 6) All other fish were enumerated and released 30-50 m downstream from the trap after recovering from the anaesthetic, and 7) All fish mortality was recorded.

Table 1. The targeted positions of the Imnaha traps for staff gauge heights from the week of February 28 to June 26, 1999.

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	44	100
90-95	2	1	46	105
95 - 100	3	2	70	99
< 100	4	3	78	125

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 main-stem dams. Efficiency trials for hatchery salmon were conducted. 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: 1) upper and lower caudal, 2) upper caudal, 3) lower caudal, 4) left pelvic, 5) right pelvic, 6) left pectoral, and 7) right pectoral.

Fish marked for trap efficiency trials were held in perforated 33 gallon containers in the river during daytime hours (approximately 12 h) and then transported upstream approximately one km (± 75m) to one of two release sites during evening hours. Release sites alternated between the east and west bank. 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 equal to or less than the class but greater than the previous class (i.e. 76 to 80 mm, 81 to 85 mm). 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. Adult steelhead and large steelhead that had the metamorphic characteristics of resident rainbow were not reported as juvenile steelhead or used in smolt length, weight and condition factor calculations. Weights less than 4.0 grams were not used in calculating averages or condition factors because they were not considered accurate due to the limitations of the balances used.

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

PIT Tagging

Fish selected for passive integrated transponder (PIT) tagging were examined for previous PIT tags, descaling and general health before being tagged, measured (FL-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 were tagged 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 both the upper and lower trap for a four week period. Weekly PIT tagging goals for the spring were a combination of FPC and LSRCP goals to meet separate 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, 3,000 hatchery chinook salmon tagged over a three 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. Natural 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 was recorded.

Tagging files were created with PITTAG.EXE and validated separately using the PITVAL2 software program until May 3. After May 3, tagging files were created and validated with PITTAG2.exe software. The validation process with PITTAG2.EXE included verifying that individual tag codes of newly tagged fish were contained in the current clip files in use to prevent submitting files with duplicated tag codes to the PIT Tag Information System database (PTAGIS). Files created prior to May 3 were corrrected for duplicated tag codes by periodically reviewing the data files “tag_dup_data.txt” and “true_dup_data.txt” that were posted by the Pacific States Marine Fisheries Commission (PSMFC) at http://www.psmfc.org/pittag/Data and Reports/db data files . Tagging release files were also checked for the presence of orphans. Orphans are defined here as PIT tag recaptured fishes who’s tag identification is not contained in any tagging release records by PTAGIS. Occasionally, newly tagged fish were mis-identified as PIT tag recaptures in the tagging file. This created an instant orphan. Orphans were identified by obtaining a master list of all orphans that were currently residing in PITAGIS (n = 30,416) and comparing individual tag identifications to tag identifications contained in the original clip files obtained with each clip of tags from PTAGIS and used during the spring. We identified 104 orphans who’s tag identifications matched tag identifications contained in clip files used during the spring.

Corrections were submitted for 18 of 104 the individual tag codes that were believed to have been misidentified as recaptured PIT tagged fish. The remaining orphans were assumed to have been fish that were double tagged. Tagging and interrogation files were submitted to PTAGIS 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 calculating the survival of PIT tagged fish released at the acclimation site using the Cormack, Jolly, and Seber (1964, 1965, and 1965, respectively, as cited in Smith et. al, 1994) methodology with the Survival Using Proportional Hazards (SURPH) model (Smith et. al., 1994). 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. Three survival estimates were obtained for the following groups of fish released at the acclimation facility: acclimated volitional released fish tagged in the fall, acclimated volitional released fish tagged in the spring, and direct stream released fish tagged in the fall. A weighted average survival estimate ($\overline{S}$), and variance $Var(\overline{S})$, were calculated for releases from the acclimation facilty to the trap as:

$$\overline{S} = \sum_{i=1}^{n} w_i S_i \Big/ \sum w_i \ , \quad \text{and} \quad Var\left(\overline{S}\right) = \sum_{i=1}^{n} w_i \left(S_i - \overline{S}\right)^2 \Big/ \left[\sum_{i=1}^{n} w_i\right](n-1)$$

where w_i = the number of fish released (Burnham et al. 1987). The yield was calculated by multiplying the number of fish released by the average survival rate.

Survival Estimation

Survival was estimated by the Cormack, Jolly, and Seber (1964, 1965, and 1965, respectively, as cited in Smith et al. 1994) methodology with the Survival Using Proportional Hazards (SURPH) model (Smith et. al., 1994). The assumptions for the methodology can be found in Smith et al. 1994 and Burnham et al. 1987. When tagging pre-smolt chinook salmon in the fall, we assumed that fish did not migrate past LGR before PIT tag interrogation facilities become operational, and pre-smolts migrated the following spring (i.e. residual fish or delayed migration does not occur).

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.

The data files for weekly release groups were created using the program CAPTHIST (Westhagen 1997). 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 1. These estimates generally reflect an underestimation of survival in previous reaches.

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

During the fall 1998 trapping period Imnaha River mean discharge ranged from 172 cfs (4.9 cms) on October 31 to 192 cfs (5.4 cms) on November 8. Mean daily water temperature at the lower Imnaha River trap site during the fall trapping period ranged from 5.0 /C on November 10 to 9.8 /C on October 23 and 28. Imnaha River mean daily discharge during spring emigration ranged from 274 cfs (7.8 cms) on March 12 to 3,311 cfs (93.8 cms) on May 26. Mean daily water temperatures during the spring period ranged from 4.4 /C on March 9 and 10 to 13.4/C on June 15 (Figure 3). Appendix A contains the mean daily discharge readings and daily minimum, maximum and mean water temperatures during the study period.

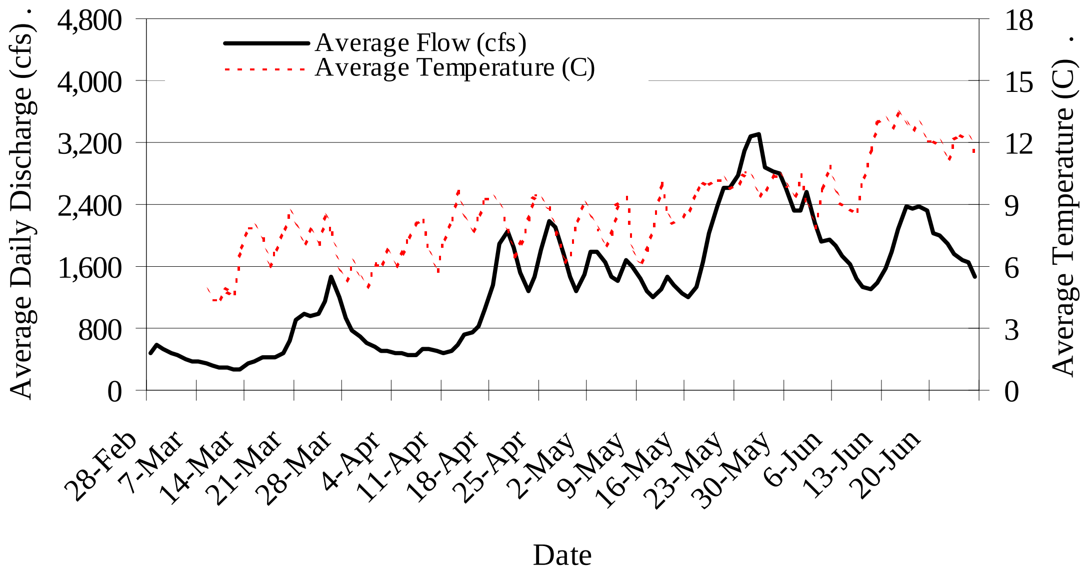

Figure 3. Mean daily discharge (USGS Gauge 13292000 at Imnaha, OR) and mean daily water temperature of the Imnaha River during the spring, February 28 to June 26, 1999.

The Snake River mean daily discharge during the spring emigration ranged from 51,300 cfs (1,453 cms) on March 8 to 132,000 cfs (3,738 cms) on May 31 at USGS gauge 13334300, Anatone, WA (Figure 4). Mean daily water temperatures during the study period ranged from 4.3 /C on February 28 to 15.3 /C on June 24. Appendix B contains the mean daily discharge readings and daily minimum, maximum and mean water temperatures during the study period.

Continuous spill began March 21 at LGR and continued until March 30. Spill resumed on April 2 and lasted until July 2. The minimum amount spilled was 0.7 Kcfs on March 30 and the maximum amount spilled was 84.6 Kcfs on May 27 (Table 2). Maximum spill occurred at all dams on either May 26 or May 27. LGO initiated spill earlier than LGR on March 11 and continued spilling until March 30. Spill resumed again on April 2 and continued until June 26. The minimum amount spilled was 0.4 Kcfs and the maximum spilled was 73.6 Kcfs. The minimum and maximum spill occurred on June 25 and May 26, respectively. LMO began spilling later than any of the other three dams on the Snake River or McNary Dam. Spill occurred from March 23 to March 30 and again from April 2 to June 24. The minimum amount, 0.4 Kcfs, was spilled on March 30 and the maximum amount , 66.1 Kcfs, was spilled on May 27. IHR began spilling on March 11 and continued to spill until September 1. The spill ranged from 0.3 Kcfs on September 1 to 125.9 Kcfs on May 27. Spill at MCN occurred from March 9 to August 21. The spill ranged from 3.3 Kcfs on March 14 to 218.9 Kcfs on May 27. However, the

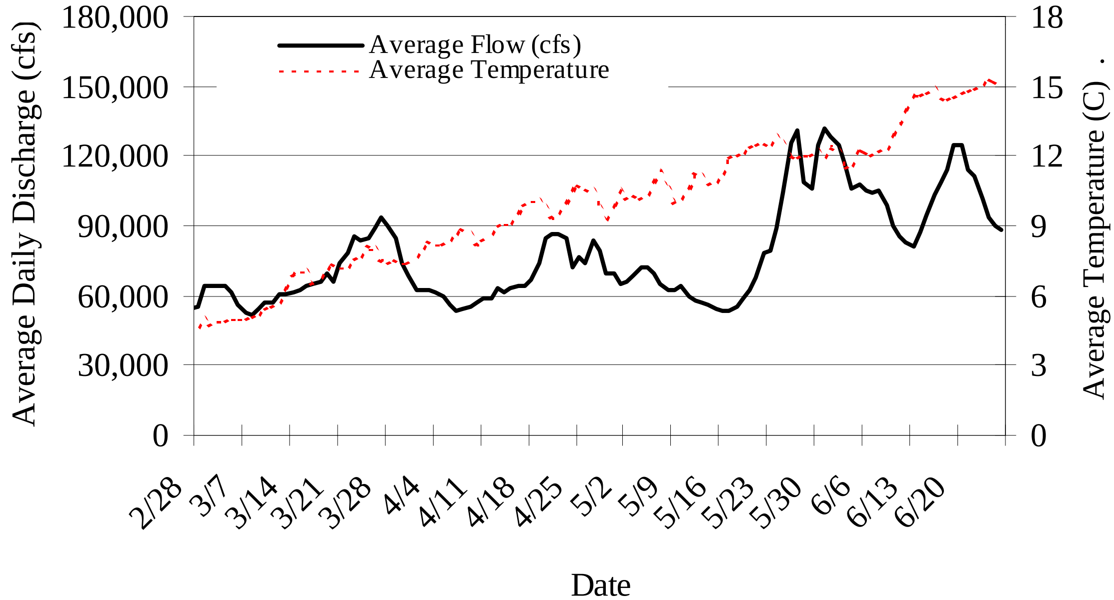

Figure 4. Mean daily discharge (USGS Gauge 13334300 at Anatone, WA) and mean daily water temperature of the Snake River during the spring trapping period, February 28 to June 26, 1999.

minimum spill that occurred between March 26 and August 21, when fish would have been migrating past MCN, was 9.6 Kcfs. The minimum spill between March 26 and August 21 occurred on April 19 (Appendix C).

Trap Operation

The operation during the fall occurred on weekdays from October 19 to November 13. The Imnaha River screw trap was operated for 87 nights out of the 115 day spring emigration period. The trap was scheduled to operate 5 days per week from March 1 to June 25, 1999, except during the release of hatchery chinook salmon. During the release of hatchery chinook salmon the traps were scheduled to operate continuously. Eight days of scheduled trapping were missed due to high flows (Figure 5). The trapping effort ranged from four days (March 1 to March 5 and June 20 to June 24) to 34 days (March 27 to April 30).

Emigration Timing and Trends at Trap Site

A total of 2,444 natural chinook salmon and 20 natural steelhead juveniles were captured at the upper Imnaha River trap from October 19 to November 13, 1998. The highest single days

Table 2. A summary of spill events at the Snake and Columbia river hydroelectric projects located at distances of 695 river kilometers (rkm) to 470 rkm from the mouth of the Columbia River during 1999. Data was obtained from the Fish Passage Center.

Dam (rkm)	Periods of Spill	Minimum Spill Date	Minimum Spill Amount (Kcfs)	Maximum Spill Date	Maximum Spill Amount (Kcfs)
Lower Granite (695)	March 21 to March 30 April 2 to July 2	03/30/99	0.7	05/27/99	84.6
Little Goose (635)	March 11 to March 30 April 2 to June 26	06/25/99	0.4	05/26/99	73.6
Lower Monumental (589)	March 23 to March 30 April 2 to June 24	03/30/99	0.4	05/27/99	66.1
Ice Harbor (538)	March 11 to Sept 1	09/01/99	0.3	05/27/99	125.9
McNary (470)	March 9 to August 21	3/14/1999*	3.3	05/27/99	218.9

* The minimum date and spill from March 26 to August 21 was 9.57 Kcfs and it occurred on April 19.

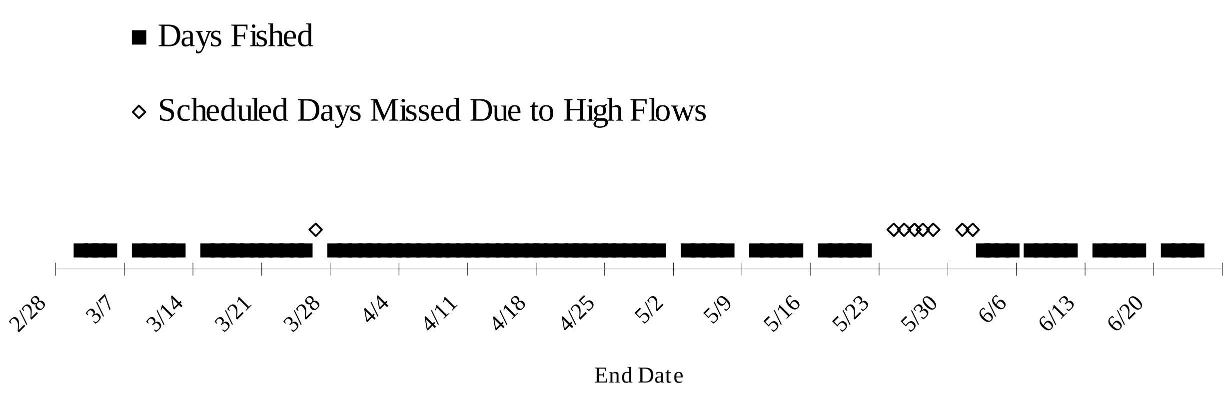

Figure 5. A time line of the days fished and scheduled days missed due to high flows for the lower Imnaha River trap, March 1 to June 24, 1999.

catch for natural chinook salmon was 607 fish on November 10. The daily catch of natural steelhead ranged from one to three fish (Appendix D). A total of 2,341 natural chinook salmon and 321 natural steelhead juveniles were captured at the lower Imnaha River trap from October 19 to November 13, 1998. The highest single days catch for natural chinook salmon was 947 fish on November 10 while for natural steelhead it was 113 fish on November 10 (Appendix D). The peak movement at the lower site occurred two days after average flows peaked at 191.8 cfs.

Natural chinook salmon at the upper trap site during the fall comprised 96.3 % of the catch and natural steelhead comprised 0.8 % of the catch. Natural chinook salmon at the lower trap site during the fall comprised 76.1 % of the catch and natural steelhead comprised 10.4 % of the catch. The remainder of the catch at each site was comprised of non-target species.

A total of 5,715 natural chinook salmon, 12,856 hatchery reared chinook salmon, 2,748 natural steelhead and 8,858 hatchery reared steelhead smolts were captured in the Imnaha River screw trap during the spring study period (Table 3). An additional 1,004 incidental species were captured. The total catch of target and incidental species was 31,181 fish. Appendix E contains daily catch summaries of natural and hatchery chinook salmon and steelhead from March 1 to June 24, 1998. Natural chinook salmon were collected throughout the study period and comprised 18.3% of the total catch. Natural chinook salmon were captured from March 2 to June 23. The peak daily catch of natural chinook salmon occurred on April 18, two days prior to a spike in the average flow of 2,066 cfs. Water temperatures averaged 9.3°C on April 18. Appendix F contains figures of the daily catch of fish at the lower trap site in the fall and spring and the daily mean flow and water temperature.

The Oregon Department of Fish and Wildlife (ODFW) initiated a volitional release of 184,567 hatchery reared chinook salmon smolts into the Imnaha River from the Imnaha River acclimation facility (rkm 73) on March 16 (Pat Keniry, personal communication, ODFW database) after acclimating the fish for a period of 15 days. An additional 10,242 were direct stream released on April 5. A total of 22,927 hatchery chinook salmon were PIT tagged prior to the March 16 release (Table 4). A group of 498 hatchery chinook salmon, considered to be at a high risk for bacterial kidney disease, were PIT tagged prior to the April 5 release. All hatchery fish released had adipose fin clips and were coded wire tagged. Hatchery chinook salmon released April 5 were considered to be a high risk group for bacterial kidney disease. Hatchery chinook salmon smolts comprised 41.2% of the total catch. Hatchery chinook salmon smolts were first captured on March 8, eight days prior to the start of the volitional release. This pre-release observation may have been the result of the weather conditions. Icy conditions at the acclimation facility forced hatchery personnel to temporarily pull dam boards and or screens on several occasions for an unspecified amount of time (Rick Zollman, personal communication, NPT) .

Only 12.2% (1,569) of the hatchery chinook salmon trapped were captured 14 days after the start of the volitional release. The cumulative catch reached ninety percent on April 19 (n =

Table 3. Summary of the weekly catch of target species caught in the lower Imnaha screw trap during the spring of 1999.

End Dates	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
2/28/1999 - 3/6/1999*	366		9	
3/7/1999 - 3/13/1999	129	4	4	1
3/14/1999 - 3/20/1999	243	511	2	
3/21/1999 - 3/27/1999*	252	879	11	
3/28/1999 - 4/3/1999*	1128	491	36	
4/4/1999 - 4/10/1999*	783	3449	11	
4/11/1999 - 4/17/1999	1193	3578	44	1871
4/18/1999 - 4/24/1999	757	3397	245	774
4/25/1999 - 5/1/1999	139	134	162	186
5/2/1999 - 5/8/1999	167	153	261	197
5/9/1999 - 5/15/1999*	367	207	1075	1154
5/16/1999 - 5/22/1999*	47	47	718	3028
5/30/1999 - 6/5/1999	26	4	54	242
6/6/1999 - 6/12/1999*	87	2	89	761
6/13/1999 - 6/19/1999*	23		25	525
6/20/1999 - 6/26/1999	8		2	119
Grand Total	5,715	12,856	2,748	8,858

* Two traps were fishing for one or more days.

11,929). This was 34 days after the initial volitional release began and four days after the remaining fish in the acclimation facility were pushed out. The prolonged movement of hatchery chinook salmon was the result of the volitional release strategy. It was assumed that the hatchery chinook salmon would begin moving when they attained a sufficient level of smoltification and if acclimation allowed hatchery chinook salmon to sense the right environmental clues. The peak movement of hatchery chinook salmon during the spring coincided with the peak movement of natural chinook salmon on April 18. Hatchery chinook salmon smolts were captured until June 10 (Appendix E).

Emigrating natural steelhead smolts were captured from March 3 to June 23. Natural steelhead comprised 8.8% of the total catch. Natural steelhead catch peaked on May 13 with a catch of 398 fish (Appendix E). The peak catch coincided with a spike in the hydro-graph of 1,454 cfs (Appendix F). The previous catch of 245 and 398 fish on May 12 and May 13 followed an increase in the daily average temperature of 2°C on May 11 (Appendix F). A second peak in the catch of natural steelhead occurred May 19 after the average flow increased from 1,649 cfs on May 18 to 2,034 cfs on May 19.

ODFW released 334,672 acclimated hatchery reared steelhead smolts into the Imnaha River subbasin, at the Little Sheep acclimation facility (rkm 45) in two groups. Both releases were

Table 4. A summary of the volitional and direct stream releases of hatchery chinook salmon and steelhead from the Gumboot and Little Sheep Creek Acclimation Facilities, respectively, with the number PIT tagged and types of marks, in 1999.

Species	Strategy	Date Release Began	Date Release Ended	Number Released	Number PIT Tagged	Marks (percent marked)
Chinook	Acclimated/ Volitional	March 16	April 15	184,567	22,927[1]	Adipose clip and Coded Wire (100%)
Chinook	Stream / Direct	April 5		10,242[2]	498	Adipose clip and Coded Wire(100%)
Steelhead	Acclimated/ Forced	April 13		215,294	509	Adipose clip (75%) Adipose& left ventral clips, coded wire (24%)
Steelhead	Acclimated/ Forced	May 18		119,378	252	Adipose clip (78%) Adipose& left ventral clips, coded wire (21%)
		Chinook Release Totals		194,809	23,425	
		Steelhead Release Totals		334,672	761	

[1] A total of 14,948 were tagged in the spring and 7,979 were tagged in the fall.
[2] High risk bacterial kidney disease release group.

forced and occurred on April 13 and May 18 (Table 4). The majority of smolts released April 13 had only adipose fin clips (75%). Twenty four percent had an adipose and left ventral fin clip with coded wire tags. A total of 509 fish from the first release were PIT tagged. The majority of the smolts from the second release had only adipose fin clips (78%) and the remaining fish had an adipose and left ventral fin clip with coded wire tags (21%). Two steelhead were captured before the April 13 release on March 9 and April 12. Fourteen fish were captured April 14. The catch from the first release peaked on April 17 with a catch of 838 fish. The peak catch coincided with the second largest catch of natural chinook salmon observed at the lower Imnaha River trap during 1999. The average flow and temperature for April 17 was 1,052 cfs and 9.3°C respectively. This was one day earlier than the peak movement of natural and hatchery chinook salmon and three days prior to a major increase in discharge to 2,066 cfs. The peak catch of hatchery steelhead, for the spring of 1999, was 1,340 fish captured on May 19. This catch was most likely the result of the forced release on May 18.

Biological Characteristics

Natural chinook salmon caught and PIT tagged in the fall of 1998 at the upper Imnaha River trap averaged 86 mm in fork length (n=2,012) with standard deviation of 8.7. The mean weight of natural chinook salmon was 6.3g with a standard deviation of 2.1. The average condition factor was 0.99 with a standard deviation of 0.10 (Table 5). Average lengths, weights and condition factors for steelhead/rainbow trout captured at the upper site were not calculated due to a low number of valid fork lengths collected (n = 6). Natural chinook salmon caught and PIT tagged in the fall of 1998 at the lower Imnaha River trap averaged 94 mm in fork length (n=2,020) with standard deviation of 12.8. The mean weight of natural chinook salmon was 9.0 g with a standard deviation of 4.06. The average condition factor was 1.01 with a standard deviation of 0.11. Natural steelhead caught in the fall of 1998 at the lower Imnaha River trap averaged 186 mm in fork length (n=186) with standard deviation of 21.0. The mean weight of natural steelhead was 67.5 g with a standard deviation of 22.5. The average condition factor was 1.02 with a standard deviation of 0.10 (Table 5).

The mean fork length of chinook salmon sampled at the lower site were statistically significantly larger and more varied than those sampled at the upper site ($p < 0.05$). A total of 173, or 7.4%, of the natural chinook salmon captured at the lower site had fork lengths greater than or equal to 115 mm. Natural chinook salmon greater than or equal to 115 mm captured at the upper site totaled 5 fish, or 3.0% of all natural chinook salmon captured at the upper site. Scale samples were collected from individual natural chinook greater than 115 mm, but no protocols were in place to measure age composition by scale analysis.

Average length, weight, and conditions factor of 1999 spring emigrating natural chinook salmon was 104 mm, 12.4 g, and 1.08, respectively (Table 6). Weekly average lengths of natural chinook salmon throughout the spring emigration period, ranged from 100 to 107 mm and average condition factors ranged from 0.99 to 1.16 (Figure 6). Average length, weight, and condition factor of hatchery reared chinook salmon caught during the spring was 134 mm, 26.8 g, and 1.12. Weekly average lengths for hatchery chinook salmon smolts ranged from 128 mm to 137 mm (Figure 7). Weekly average condition factors ranged from 0.99 to 1.15. There were no apparent trends in the average weekly fork length or condition factor of natural or hatchery reared chinook salmon.

Average length, weight, and condition factor of 1999 spring emigrating natural steelhead was 184 mm, 62.3 g, and 0.97, respectively (Table 6). Weekly average lengths of natural steelhead throughout the spring emigration period , ranged from 172 to 190 mm and average condition factors ranged from 0.94 to 1.02 (Figure 8). Average length, weight, and condition factors of hatchery reared steelhead caught during the spring was 216 mm, 98.3 g, and 0.95. Weekly average lengths for hatchery steelhead smolts ranged from 207 mm to 223 mm (Figure 9). Weekly average condition factors ranged from 0.88 to 1.05. Mean fork lengths of weekly groups of natural steelhead were not compared because the standard skewness values were outside of the range of $\pm$ 2. There was a statistically significant difference between the median fork lengths of

Table 5. Descriptive statistics of PIT-tagged natural-reared chinook salmon collected at emigrant traps in the upper and lower Imnaha River, October 19 to November 13, 1998.

Site & Statistic	Natural Chinook Salmon	Natural Steelhead
Upper Trap		
Sample Size	2,012	6
Average Fork Length (mm)	86	NA
Standard Deviation	8.7	
Average Weight (g)	6.3	NA
Standard Deviation	2.1	
Average Condition Factor	0.99	NA
Standard Deviation	0.1	
Lower Trap		
Sample Size	2,020	186
Average Fork Length (mm)	94	186
Standard Deviation	12.8	21.0
Average Weight (g)	9.0	67.5
Standard Deviation	4.1	22.5
Average Condition Factor	1.01	1.02
Standard Deviation	0.1	0.1

natural steelhead captured from May 9 to May 22 and natural steelhead captured from May 30 and June 12 ($p < 0.05$). The larger fork lengths from May 9 to May 22 may be due to the differences in sample size ($n_1 = 1,489$ vs. $n_2 = 142$). The largest weekly average fork lengths were observed from May 2 to May 22. Average fork lengths of hatchery steelhead sampled during the weeks of May 2, May 9, and May 16 were 221, 223, and 219 mm, respectively ($n_1 = 192$, $n_2 = 1,146$, and $n_3 = 1,854$) and represented 4,379 (49.4%) of the 8,858 hatchery steelhead captured.

Table 6. Averages and ranges of the fork lengths (mm), weights (g), and condition factors for natural and hatchery chinook salmon and steelhead smolts collected at the Imnaha River screw trap from March 1 to June 24, 1999.

	Chinook Salmon		Steelhead	
Statistic	Natural	Hatchery	Natural	Hatchery
Mean Fork Length	104	134	184	216
Sample Size	5,422	6,838	2,517	6,444
Range	70 - 178	90 - 213	131 - 258	113 - 288
Standard Deviation	9.8	11.3	18.7	18.0
Mean Weight	12.4	26.8	62.3	98.3
Sample Size	5,274	5,193	2,335	5,976
Range	4.1 - 53.4	7.0 - 91.4	19.0 - 165.8	27.4 - 250.4
Standard Deviation	3.54	7.56	19.83	0.95
Mean Condition Factor	1.08	1.12	0.97	0.95
Sample Size	5,274	5,193	2,337	5,976
Range	0.70 - 1.66	0.71 - 1.66	0.75 - 1.29	0.71 - 1.56
Standard Deviation	0.12	0.10	0.07	0.08

A plot of the length frequency distribution of natural and hatchery chinook salmon and steelhead fork length showed a definite separation in their length (Figure 10 and 11). The distribution of fork lengths for natural and hatchery chinook salmon and steelhead had standard skewness values outside of the range stated in the methods so median fork lengths were compared instead. The median fork lengths of natural and hatchery chinook salmon captured during the spring were 104 and 134 mm, respectively. Natural and hatchery steelhead had significantly different median fork lengths ($p < 0.05$). The median fork lengths of natural and hatchery steelhead captured during the spring were 184 and 216 mm, respectively. Appendix G contains mean daily length, weight and condition factors for natural and hatchery chinook salmon and steelhead smolts. Values for statistical comparisons are presented in Appendix H.

Emigration Timing and Trends of Previously PIT Tagged Fish

We released 2,001 PIT tagged natural chinook salmon between October 20 and November 11, 1998 at rkm 74 and ODFW released 1,009 natural chinook salmon between August 24 and August 26, 1998 above rkm 7. We recaptured 11 of the fish we tagged and six of the fish ODFW released above rkm 7. Natural chinook salmon PIT tagged during the fall of 1998 were recaptured from March 10 to April 23, 1998.

There were a total of 1,058 hatchery chinook salmon recaptured from the 23,425 PIT tagged fish included in the volitional release of 184,567 chinook salmon from the acclimation facility at rkm 74. PIT tagged fish were transported with non-PIT tagged fish and allowed to mix

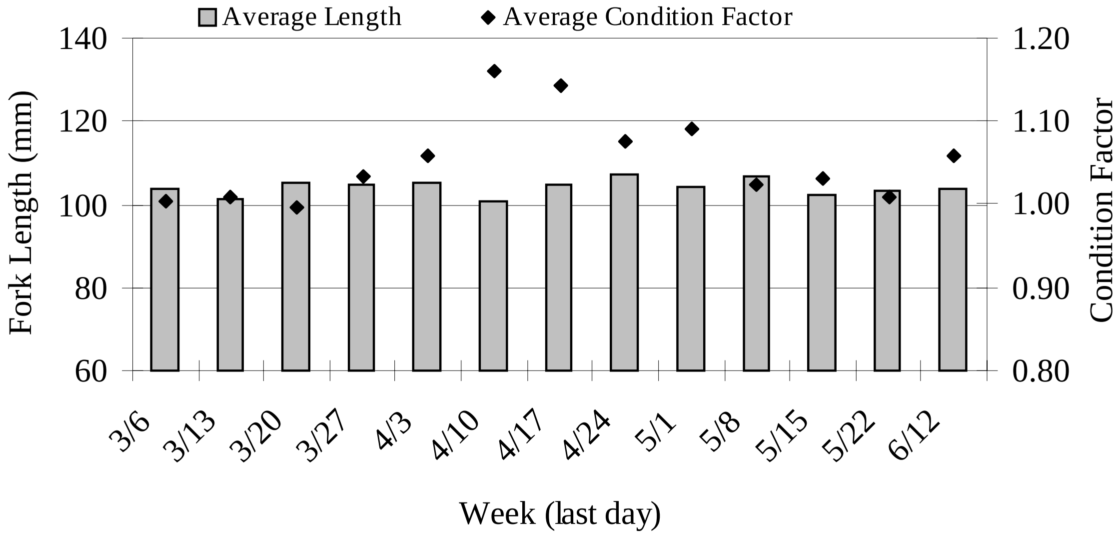

Figure 6. Average fork lengths and condition factors for natural chinook salmon captured in the Imnaha River screw traps, March 1 to June 24, 1999.

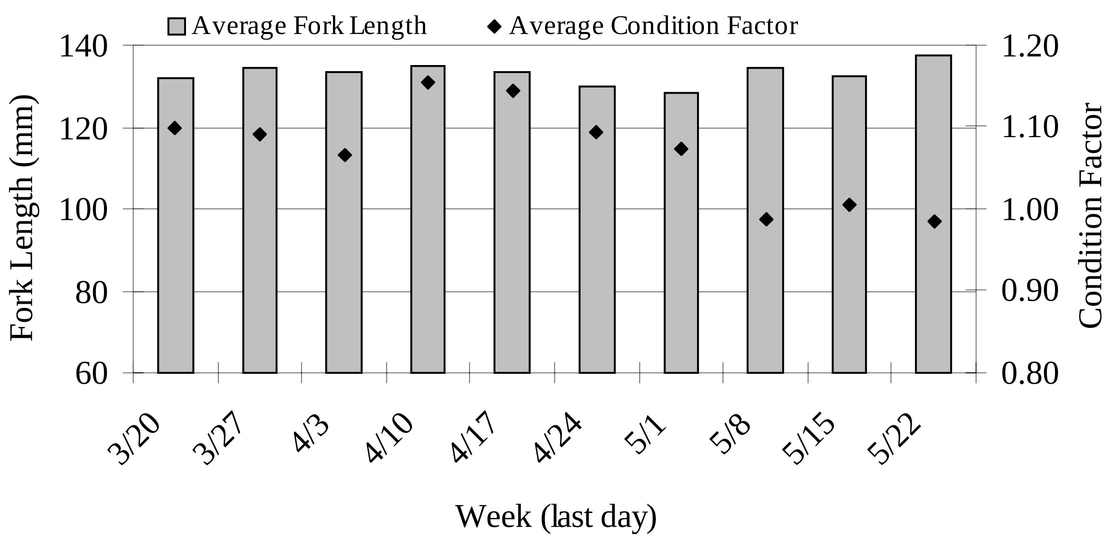

Figure 7. Average fork lengths and condition factors for hatchery chinook salmon captured in the Imnaha River screw traps, March 1 to June 24, 1999.

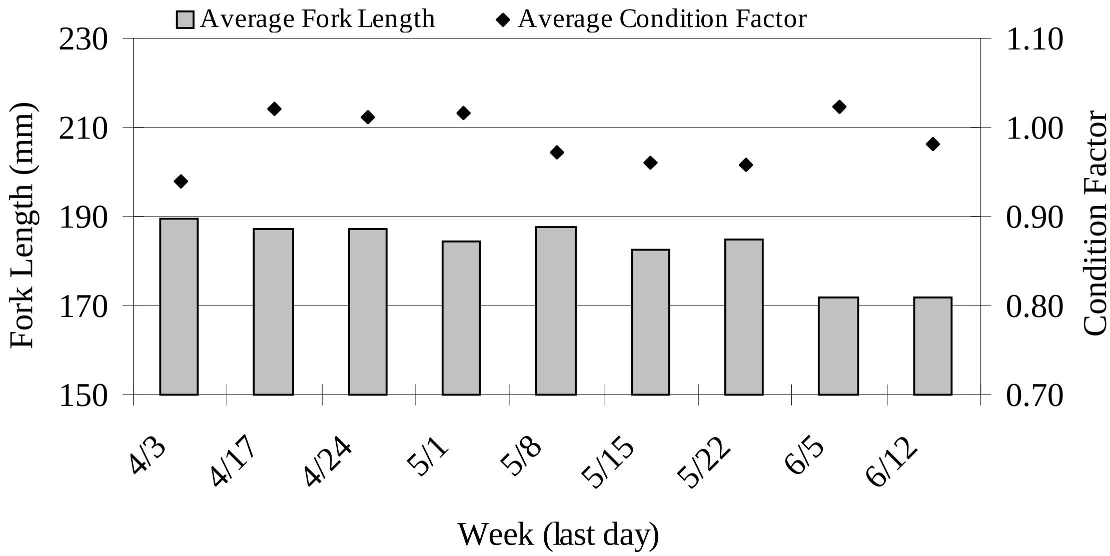

Figure 8. Average fork lengths and condition factors for natural steelhead captured in the Imnaha River screw traps, March 1 to June 24, 1999.

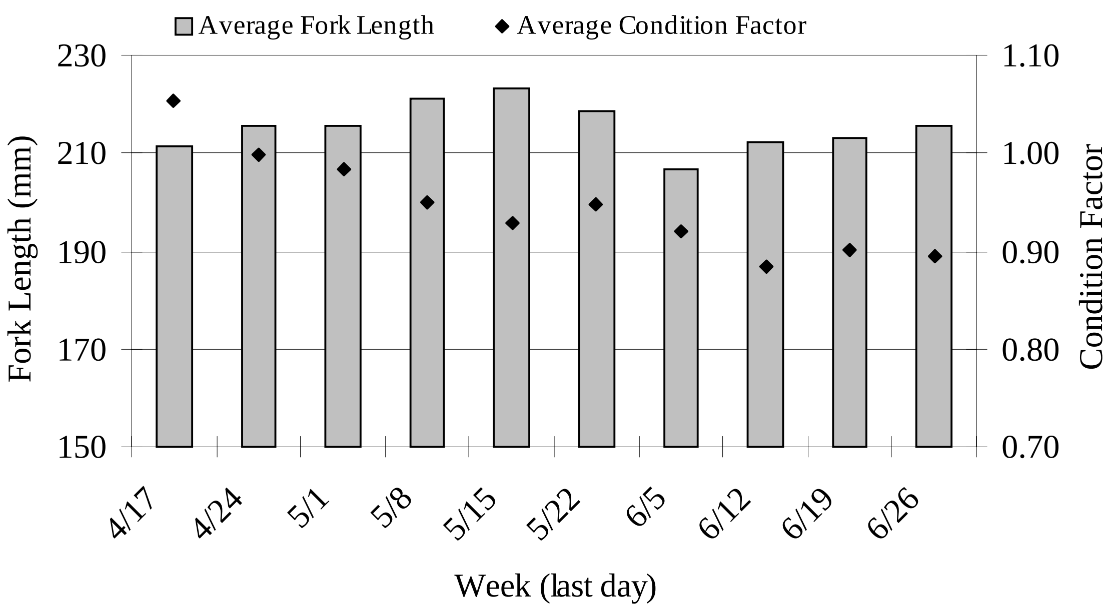

Figure 9. Average fork lengths and condition factors for hatchery steelhead captured in the Imnaha River screw traps, March 1 to June 24, 1999.

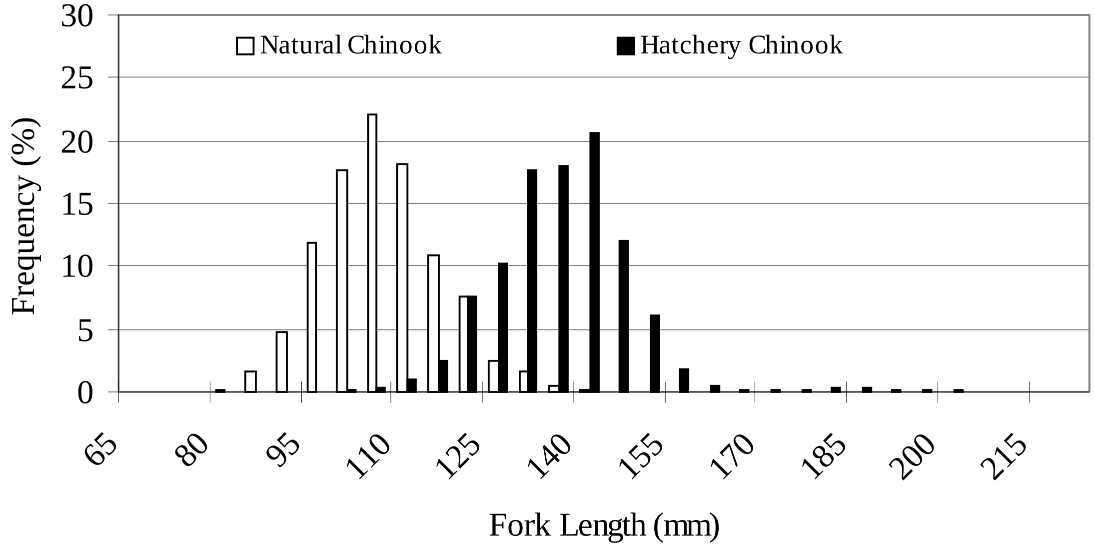

Figure 10. Length frequency of natural and hatchery chinook salmon smolts trapped in the lower Imnaha River, March 1 to June 24, 1999.

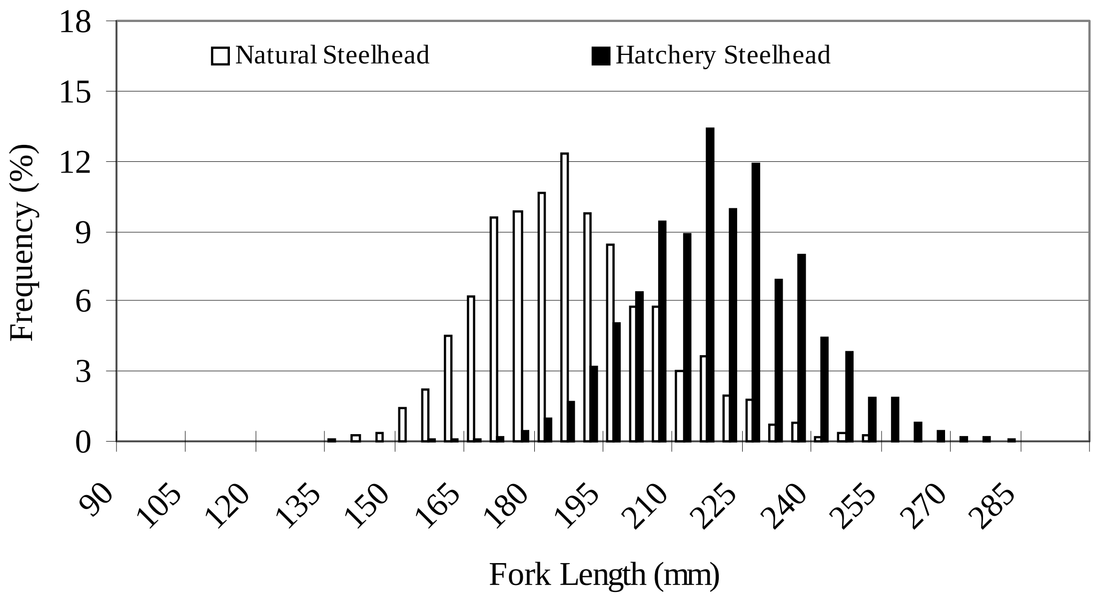

Figure 11. Length frequency of natural and hatchery steelhead smolts trapped in the lower Imnaha River, March 1 to June 24, 1999.

with the population in the acclimation facility. The peak catch of previously PIT tagged hatchery chinook salmon occurred on April 17 (n = 240). This was a day prior to the peak catch of all hatchery chinook salmon captured (n = 2,611) and two days after the end of the volitional release. Recapture dates ranged from March 18 to June 2 (Figure 12). Mean travel time for hatchery chinook salmon smolts to the Imnaha River screw trap is not presented because it was not known when the fish left the facility during the volitional release. Half of the hatchery chinook salmon arrived by April 14. This was one day prior to the end of the volitional release and forcing the remainder of the fish out of the acclimation ponds. Ninety percent of the previously PIT tagged fish arrived by April 23 (Figure 13). This was four days later than the 90% arrival timing of all hatchery chinook salmon captured in the Imnaha traps. It took 36 days for 90% of the hatchery chinook salmon to arrive at the trap in 1999 after the volitional release. Additionally, the emigration was more prolonged than in 1998 when 90% of the PIT tagged fish arrived at the trap eight days after a forced release from the chinook salmon acclimation facility.

A total of eight hatchery steelhead were recaptured from 761 PIT tagged fish released from the steelhead acclimation facility. Six fish were from the April 13 release and two were from the May 18 release. Recapture dates for the April 13 release group ranged from April 21 to June 15 and recapture dates for the May 18 release group occurred on May 18 and May 20.

Smolt Yield

Survival for PIT tagged hatchery chinook salmon smolts, from release at the Imnaha River acclimation facility to the screw trap, was estimated at 93.7% (Table 7). The 95% confidence interval (CI) for this estimate is ± 6.8%. Only 4.5% of all PIT tagged hatchery chinook salmon released were interrogated at the Imnaha River trap site. The SURPH estimate represented a smolt yield of 182,536 hatchery chinook salmon at the screw trap. The survival estimate from the acclimation facility to the trap is within the range of past estimates from 1995 to 1998. However, the percent of tags detected at the trap was lowest since 1995, despite efforts to fish two traps. The lower interrogation rate did not affect the SURPH based survival estimate because PIT tags were interrogated later at downstream sites.

Trap efficiencies were conducted as in past years and the average trap efficiency was calculated at 20.1% during periods when one trap was operating and 26.3% when two traps were operating. Overall, the trapping efficiency was 21.8%. There were no significant differences between trials where fish were released on the east bank or where fish were released on the west bank. Appendix I contains a summary of the trap efficiency trials.

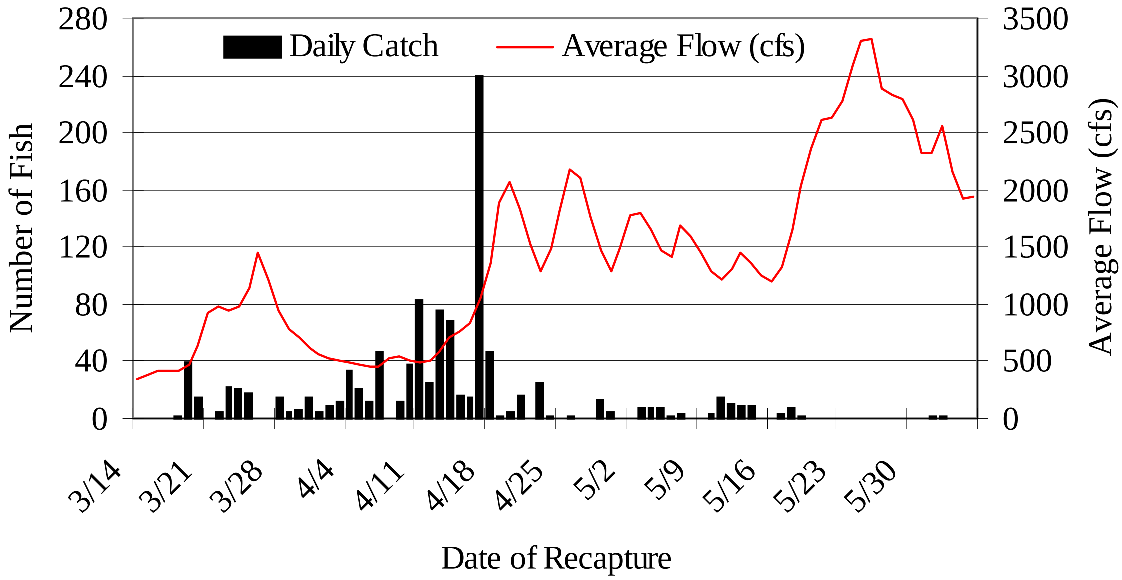

Figure 12. The catch of previously PIT tagged hatchery chinook salmon interrogated and the average flow from March 1 to June 24, 1999.

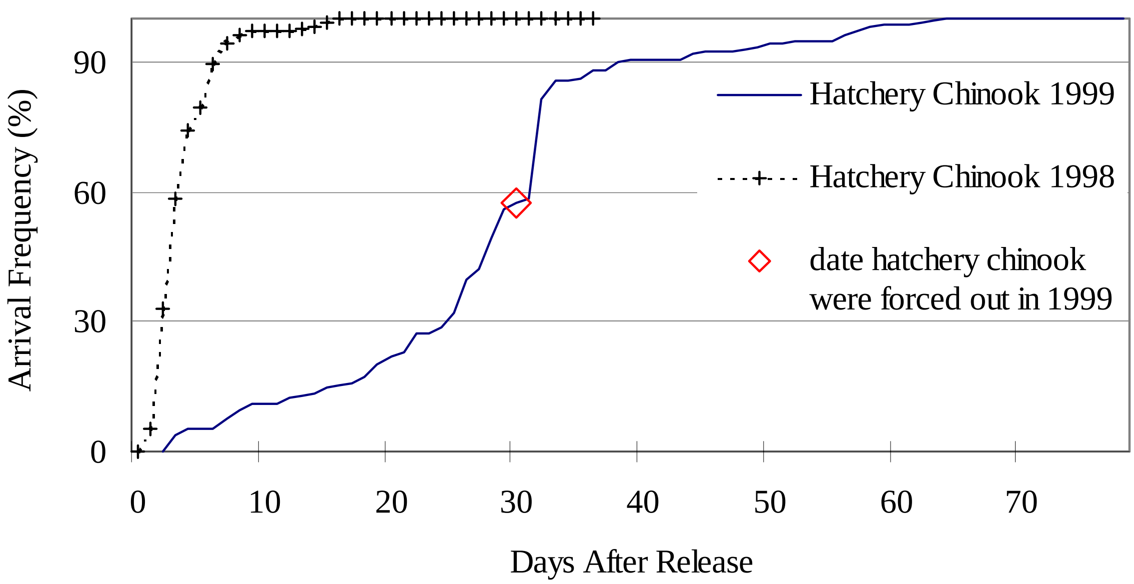

Figure 13. The arrival frequency of previously PIT tagged hatchery chinook salmon captured in the Imnaha traps during the spring of 1998 and 1999 after a forced release in 1998 and a volitional release in 1999.

Table 7. The number of PIT tagged fish released and percent of PIT tagged fish interrogated at the Lower Imnaha River trap and estimated survival from the release at the acclimation facility to trap (SURPH) and release at the acclimation facility to Lower Granite Dam (LGR) for hatchery chinook salmon smolts from 1995 to 1999.

Year	Number Released	PIT Tag Interrogations (%)	Release to Trap (%)	Release to LGR(%)
1999	23,425	4.5	93.7	73.1
1998	19,827	17.0	88.4	77.3
1997	13,378	19.6	89.2	61.6
1996	4,715	10.6	95	56.8
1995	3,974	10.8	92.6	61.8

PIT Tag Release Groups

A total of 2,001 natural chinook salmon were PIT tagged at the upper Imnaha River trap between October 20 and November 11, 1998. Weekly release group sample sizes were as follows for the four week period: 500, 468, 489, and 544. At the lower Imnaha River trap, a total of 2,000 natural chinook salmon were PIT tagged between October 20 and November 13. Weekly release groups sample sizes were as follows: 412, 297, 417, and 874 fish.

A total of 5,306 natural chinook salmon, 1,450 hatchery chinook salmon, 2,431 natural steelhead, and 6,339 hatchery steelhead were PIT tagged, from March 1 to June 24, 1999 (Table 8). Natural chinook salmon were tagged throughout the study and weekly release groups ranged from 7 to 1,162 fish. Hatchery chinook salmon weekly release groups ranged from one to 664 fish and 91% of the hatchery chinook salmon were PIT tagged from April 4 to April 17. Natural steelhead weekly release groups ranged from one to 1,053 fish and 77% of the natural steelhead were PIT tagged during a three week period from May 2 to May 22. Hatchery steelhead were PIT tagged and released from the week of April 11 to the week of June 20 and release groups ranged from 116 to 1,836 fish. The proportion of hatchery steelhead we PIT tagged that represented the acclimated forced release on April 13 and May 18 is unknown because both groups were marked with adipose fin clips. Information on spring PIT tag release groups are listed in Appendix J.

Spring PIT tagged natural chinook salmon averaged 104 mm in fork length and had an average weight of 12.4 g (Table 9). Natural chinook salmon had an average condition factor of 1.08. Spring PIT tagged hatchery chinook salmon averaged 135 mm in fork length and had an average weight of 28.3 g. Hatchery chinook salmon had an average condition factor of 1.14. Spring PIT tagged natural steelhead averaged 184 mm in fork length and had an average weight of 62.2 g. Natural steelhead had an average condition factor of 0.97. Spring PIT tagged hatchery steelhead averaged 216 mm in fork length and had an average weight of 98.3g. Hatchery steelhead

Table 8. Weekly numbers of PIT tagged fish released from the lower Imnaha River screw trap from the week of February 28 to June 26, 1999.

Week	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
2/28/1999 - 3/6/1999	363			
3/7/1999 - 3/13/1999	123	2		
3/14/1999 - 3/20/1999	230	55		
3/21/1999 - 3/27/1999	251	1	1	
3/28/1999 - 4/3/1999	1,118	2	21	
4/4/1999 - 4/10/1999	741	653	6	
4/11/1999 - 4/17/1999	1,162	664	40	999
4/18/1999 - 4/24/1999	484	67	155	422
4/25/1999 - 5/1/1999	133		151	167
5/2/1999 - 5/8/1999	165		261	189
5/9/1999 - 5/15/1999	352	6	1,053	1,125
5/16/1999 - 5/22/1999	46		574	1,836
5/30/1999 - 6/5/1999	26		54	239
6/6/1999 - 6/12/1999	86		88	740
6/13/1999 - 6/19/1999	19		25	506
6/20/1999 - 6/26/1999	7		2	116
Total	5,306	1,450	2,431	6,339

Table 9. 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 March 1 to June 24, 1999.

	Chinook Salmon		Steelhead	
Statistic	Natural	Hatchery	Natural	Hatchery
Sample Size	5,302	1,443	2,428	6,311
Mean Fork Length	104	135	184	216
Range	70 - 178	96 - 192	94 - 258	113 - 288
Standard Deviation	10.3	10.1	18.9	17.9
Sample Size	5,158	1,290	2,251	5,865
Mean Weight	12.4	28.3	62.2	98.3
Range	4.1 - 53.4	7.0 - 77.9	8.8 - 165.8	27.4 - 174.5
Standard Deviation	3.53	6.79	19.9	25.5
Sample Size	5,158	1,286	2,251	5,865
Mean K	1.08	1.14	0.97	0.95
Range	0.70 - 1.66	0.77 - 1.52	0.75 - 1.29	0.75 - 1.35
Standard Deviation	0.12	0.08	0.07	0.08

had an average condition factor of 0.95.

There were no significant differences between the median fork lengths of tagged and non-tagged natural chinook salmon, natural steelhead and hatchery steelhead (Wilcoxon $p > 0.05$). The fork lengths of PIT tagged and non-PIT tagged fish captured during the spring had standard skewness values outside of the normal range (-2 to +2).

There was a statistically significant difference between median fork lengths of tagged (n = 1,443) and non-tagged hatchery chinook salmon (n = 4,334). The median fork length for tagged hatchery chinook salmon was 136 mm and the median fork length for non-tagged hatchery chinook salmon was 135 mm. However, the one millimeter difference is not considered biologically significant. The average fork lengths of PIT tagged and non-PIT tagged hatchery chinook salmon was the same, 135 mm, and not tested for significant differences.

<u>Estimated Season-Wide Smolt Survival</u>

Estimated survival of 1998 fall tagged natural chinook salmon from the upper trap site to LGR was 24.6%, with a 95% CI of 2.4%. This survival rate is similar to previous estimates from 1993 (22.4%) and 1995 (25.7%) but much lower than 1997 (45.9%). Natural chinook salmon trapped at the lower trap site in 1998 had a seasonal survival estimate of 41.5%, with a 95% CI of 3.3%, from the trap to LGR. Estimates of survival from the lower trap site to LGR have ranged from 25.6% (± 4.3%) in 1994 to 60.4% (± 4.1%) in 1997 for fall tagged natural chinook salmon released (Appendix K).

The season-wide survival estimate for the 5,306 natural chinook salmon released from the Imnaha River trap during the spring to LGR was 88.5% with a 95% CI of 2.0% (Table 10). This estimate is 47.0% higher than natural chinook salmon released from the same point in the fall. Survival estimates for the same group of fish to LMO and MCN were 78.3 (± 2.4%) and 68.5% (± 4.3%). Survival estimates from 1993 to 1998 to LGR have ranged from 76.2% in 1994 to 90.9% in 1995. The 95% confidence intervals were 5.3 and 6.7%, respectively (Figure 14). Sample sizes have ranged from 238 in 1997 to 5,306 in 1999.

Hatchery chinook salmon, released from the Imnaha River trap to LGR, had a season-wide survival estimate of 71.6% with a 95% CI of 4.7%. This was within the range of estimates from 1994 to 1997 (Figure 15). The lowest recorded survival estimate to LGR was 67.1% in 1994, and the highest estimate was 80.4%, occurring in 1997. PIT tag release groups ranged from 662 fish in 1994 to 2,000 fish in 1998. No PIT tagged hatchery chinook salmon smolts were released from the Imnaha River screw trap in 1993. The 1999 season-wide survival estimates for this same group of fish to LMO was 61.1 %(± 5.9%) and 53.8% (± 9.8%) to MCN.

Season-wide survival for natural steelhead released from the Imnaha River trap to LGR was

Table 10. Estimated survival probabilities for season-wide PIT tag release groups of natural and hatchery chinook salmon and steelhead smolts released from the lower Imnaha River trap from March 1 to June 24, 1999 with 95% confidence intervals in parentheses. Estimates are from release to the tail race for the trap to Lower Granite Dam and tail race to tail race for all other sites. Abbreviations: LGR -Lower Granite Dam, LGO - Little Goose Dam, LMO - Lower Monumental Dam, MCN -McNary Dam.

Release Group	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.	Trap to LMO (%) (95%) C.I.	Trap to MCN (%) (95%) C.I.
Natural Chinook Salmon							
	5,306	88.5 (2.0)	97.0 (2.4)	91.1 (2.7)	87.5 (5.9)	78.3 (2.4)	68.5 (4.3)
Hatchery Chinook Salmon							
	1,450	71.6 (4.7)	91.2 (6.9)	93.6 (9.2)	88.0 (17.6)	61.1 (5.9)	53.8 (9.8)
Natural Steelhead							
	2,432	87.7 (3.1)	98.4 (4.7)	87.0 (5.9)	95.3 (16.7)	75.1 (4.6)	71.6 (12.0)
Hatchery Steelhead							
	6,339	85.4 (2.0)	94.4 (2.9)	91.7 (4.5)	79.7 (10.8)	73.9 (3.3)	58.8 (7.6)

87.7% (Table 10). The 95% CI was 3.1%. Natural steelhead have had fairly consistent survival estimates from the trap to LGR that ranged from 83.7% in 1995 to 90.1% in 1997 (Figure 16). PIT tag release groups have ranged from 227 in 1995 to 2,597 fish in 1998. The season-wide survival estimates for natural steelhead released from the Imnaha River trap to LMO and MCN were 75.1% (± 4.6%) and 71.6% (± 12.0%).

The estimated season-wide survival for hatchery steelhead released from the Imnaha River trap to LGR was 85.4% with a 95% confidence interval of 2.0%. This was the highest estimated survival since 1995 (Figure 17). Annual season-wide survival estimates from the trap to LGR have increased for hatchery steelhead since 1996. The lowest seasonal survival estimate to LGR was 64.6%, occurring in 1996 with a 95% confidence interval of 4.7%. Survival estimates for 1993 and 1994 were not presented because handling procedures may have caused excessive stress to the fish. The season-wide survival of the 1999 hatchery steelhead from the Imnaha River trap to LMO was 73.9% (± 3.3%) and to MCN was 58.8% (± 7.6%).

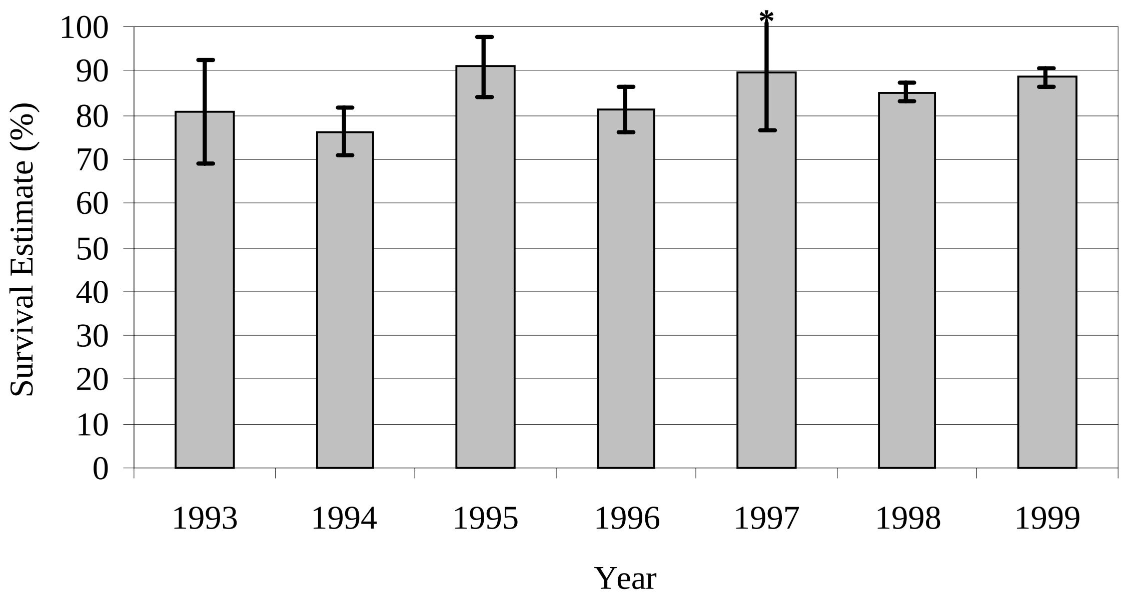

Figure 14. Season-wide survival estimates for natural chinook salmon released from the Imnaha River trap to Lower Granite Dam, from 1993 to 1999. Error bars indicate 95% confidence limits. Asterisks indicate upper confidence levels greater than 100%.

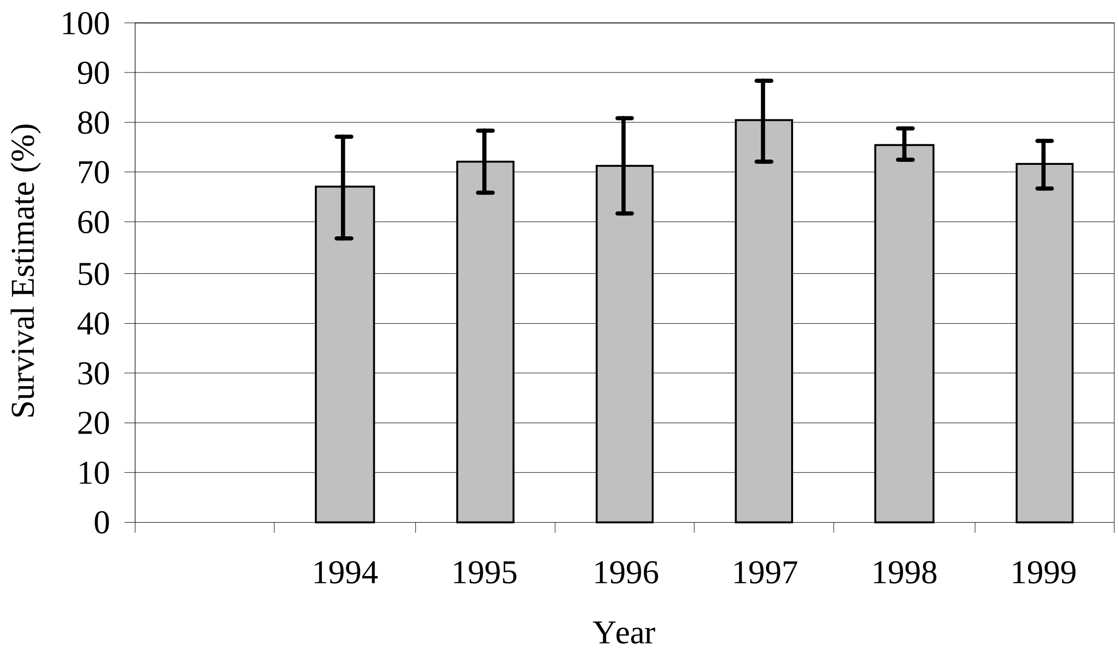

Figure 15. Season-wide survival estimates for hatchery chinook salmon released from the Imnaha River trap to Lower Granite Dam, from 1994 to 1999. Error bars indicate 95% confidence limits.

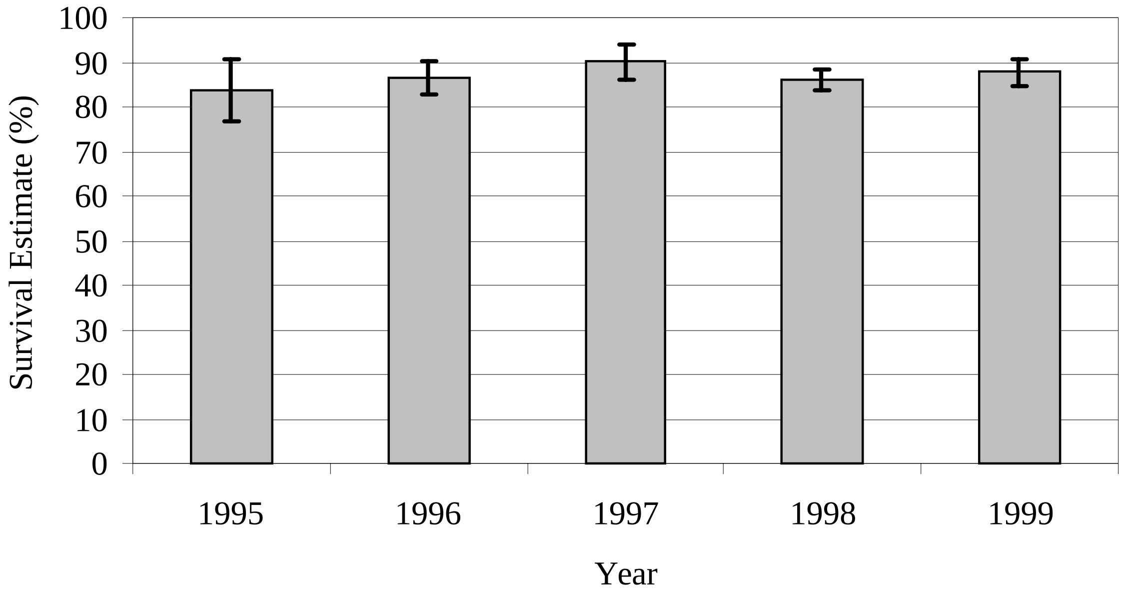

Figure 16. Season-wide survival estimates for natural steelhead released from the Imnaha River trap to Lower Granite Dam, from 1995 to 1999. Error bars indicate the 95% confidence limit.

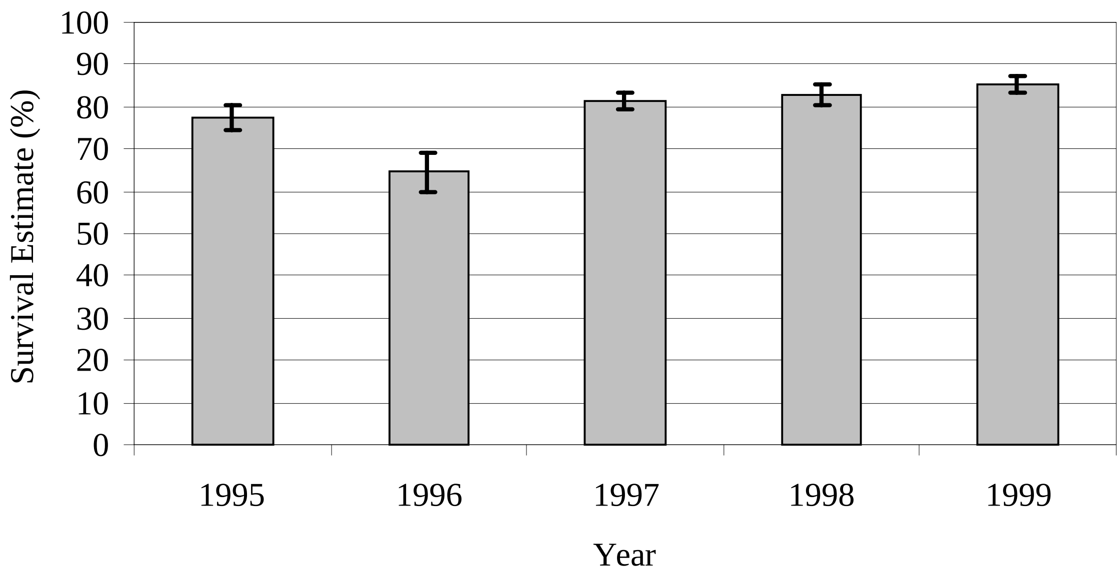

Figure 17. Season-wide survival estimates for hatchery steelhead released from the Imnaha River trap to Lower Granite Dam, from 1995 to 1999. Error bars indicate the 95% confidence limit.

Season-wide survival estimates, from the acclimation facility to LGR and from the acclimation facility to LMO, were calculated for each group of hatchery PIT tagged chinook salmon released. The season-wide survival of the14,948 hatchery chinook salmon PIT tagged in the spring and released volitionally was 72.6% (± 5.1%) to LGR and 57.5% (± 2.4%) to LMO. Hatchery chinook tagged in the fall and released volitionally after acclimation (n = 7,979) had a season-wide survival estimate of 75.5% (± 9.0%) to LGR and 59.6% (± 4.8) to LMO. Season-wide survival of the direct stream released hatchery chinook salmon (n = 498) was 50.0% (±15.2%) to LGR and 48.0% (± 16.3%). Survival estimates for hatchery chinook salmon released at the acclimation facility to Lower Monumental Dam from 1993 to 1999 are presented in Appendix L.

Estimated Weekly Smolt Survival

Estimated survival for 1999 spring weekly release groups of natural chinook salmon from the Imnaha River trap to LGR ranged from 84.9 to 91.8% (Table 11). Estimates greater than one indicate that survival to the previous site may have been underestimated. The 95% CI were 9.8 and 11.6%, respectively. Estimated survival for spring weekly release groups of natural chinook salmon from LGR to LGO ranged from 79.8 to 102.8%, with CI of 14.7 and 6.7%, respectively. Estimated survival, from LGO to LMO, ranged from 88.5% to 100.0%. The 95% confidence intervals were 12.2 and 11.2%, respectively.

Estimated survival for the two 1999 weekly release groups of PIT tagged hatchery chinook salmon from the Imnaha River trap to LGR were 71.0% and 71.7% (Table 11). The 95% confidence intervals were 6.9 and 7.1%, respectively. These estimates are 19.4 and 19.8% lower than natural chinook salmon released during the same weeks. Estimated survival of weekly release groups of hatchery chinook salmon from LGR to LGO were 89.8 and 90.0% (95% CI of 10.0% and 10.0%). Survival estimates from LGO to LMO were 92.8 and 96.1% (95% CI of 6.5% and 14.7%).

Natural steelhead weekly smolt survival, from the Imnaha River trap to LGR for the weeks of May 2, 9, and 16 ranged from 83.0 to 91.2% (Table 11). Survival estimates from LGR to LGO were very similar, ranging from 99.1% to 99.8%. Estimated survival from LGO to LMO ranged from 81.6 to 87.3, with 95% CI ranging from10.6% to 17.8%.

Weekly survival estimates for hatchery steelhead, from the Imnaha River trap to LGR, ranged from 80.5 to 94.8%. The 95% confidence intervals were 5.5 and 6.5% (Table 11). Estimated survival of hatchery steelhead from LGR to LGO ranged from 84.0 to 102.6%. The range of survival estimates of hatchery steelhead from LGO to LMO were 82.8 to 109.4%, with 95% confidence intervals of 10.2 and 23.1%, respectively (Table 11).

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. The results for 1999 are consistent (Figure 18). Mortality for smolts tagged in the spring and released volitionally after acclimation (n = 14,948) was 27.4% (± 5.5)

Table 11. Estimated survival probabilities for weekly PIT tagged release groups of natural and hatchery chinook salmon smolts released from the lower Imnaha River trap from the week of February 28 to June 26, 1999 with 95% confidence limits in parentheses. Estimates are from release to the tail race for the trap to Lower Granite Dam and tail race to 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					
2/28	363	88.1 (14.9)	79.8 (14.7)	100.0[1] (11.2)	70.5 (8.4)
3/14	230	84.9 (9.8)	98.6 (12.2)	94.4 (13.1)	79.1 (10.8)
3/21	251	91.8 (11.6)	90.6 (13.5)	88.5 (12.2)	73.7 (9.4)
3/28	1,118	88.4 (4.1)	96.4 (5.1)	91.9 (5.5)	78.4 (4.7)
4/4	741	90.4 (5.1)	97.6 (6.5)	89.3 (7.4)	78.8 (6.1)
4/11	1,162	91.5 (3.3)	98.1 (4.1)	91.8 (5.3)	82.4 (4.5)
4/18	484	88.3 (4.9)	102.8[1] (6.7)	90.7 (10.0)	82.4 (8.4)
5/9	352	90.4 (10.8)	90.8 (12.9)	93.6 (18.4)	76.9 (14.3)
Hatchery Chinook Salmon					
4/4	653	71.0 (6.9)	89.8 (10.0)	92.8 (6.5)	59.2 (8.0)
4/11	664	71.7 (7.1)	90.0 (10.0)	96.1 (14.7)	62.7 (9.4)
Natural Steelhead					
5/2	261	83.0 (8.8)	99.3 (14.5)	81.6 (17.8)	67.3 (13.1)
5/9	1,053	88.2 (7.2)	99.8 (10.6)	86.2 (10.4)	76.0 (7.6)
5/16	574	91.2 (5.7)	99.1 (8.4)	87.3 (10.6)	78.9 (8.2)
Hatchery Steelhead					
4/11	998	83.9 (4.5)	93.6 (7.3)	83.2 (9.2)	67.2 (6.7)
4/18	423	81.9 (7.1)	96.9 (11.0)	91.3 (16.5)	72.5 (12.3)
5/9	1,125	84.8 (7.1)	94.9 (10.2)	82.8 (10.2)	66.7 (7.1)
5/16	1,836	85.6 (3.1)	102.6[1] (5.5)	88.9 (7.4)	78.0 (5.7)
5/30	239	91.3 (6.7)	89.8 (9.4)	109.2[1] (30.4)	89.5 (24.9)
6/6	740	94.8 (6.5)	84.0 (8.0)	86.0 (13.3)	68.5 (10.2)
6/13	506	80.5 (5.5)	84.7 (7.3)	109.4[1] (23.1)	74.7 (16.1)

[1] Estimates greater than 100% indicate that survival to previous reach may have been underestimated.

between the trap and LGR. Fall tagged smolts released volitionally after acclimation experience similar mortality of 24.5% (± 9.0) between the trap and LGR and the direct release of smolts (n = 498) resulted in a mortality of 50.0% (± 15.2%). Mortality between the Imnaha trap and LGR for all PIT tagged hatchery chinook salmon released (n = 23,425) was estimated to be 26.9 (±11.2%). Overall mortality in this 142 km reach from 1994 to present has ranged from 22.7% in 1998 to 38.6% in 1996. Mortality for hatchery chinook salmon released from the acclimation facility to the lower Imnaha River trap in 1999 was 7.9%. This was within the range of estimates from 1994 (0.0%) to 1998 (11.6%).

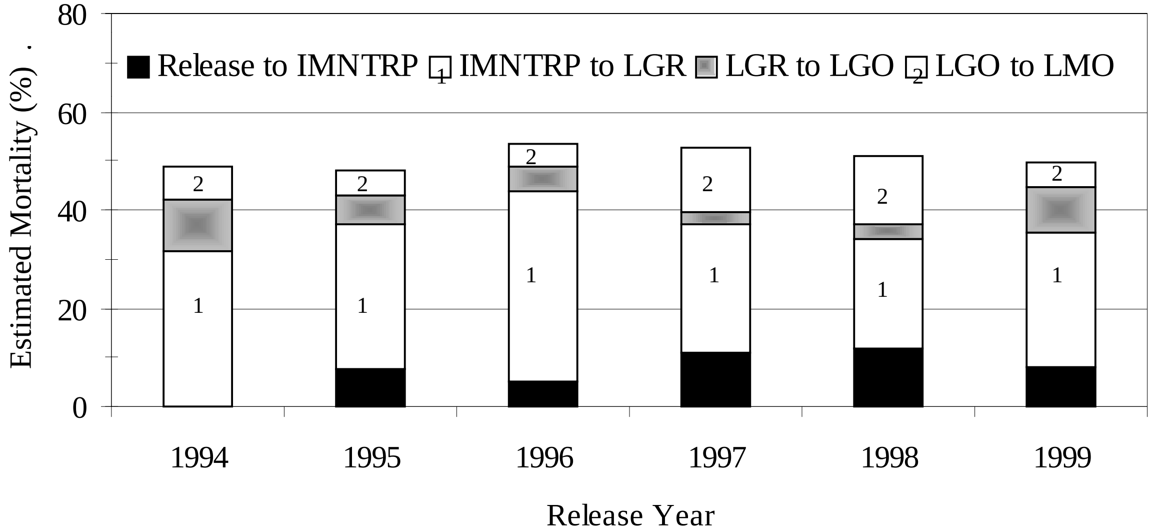

Figure 18. Estimated mortality of hatchery reared chinook salmon smolts, by stream reach, from release at the Imnaha River acclimation facility to Lower Monumental Dam from 1994 to 1999 (after Smith et al. 1998, cited in Kucera and Blenden 1998).

Arrival Timing

Natural chinook salmon PIT tagged in the fall of 1998, at the upper trap, arrived at LGR from April 8 to May 27 (n = 128) with median and 90% arrival on May 1 and May 17. Median and 90% arrival dates were four and seven days later than the previous year, respectively (Table 12). Arrival at LGO occurred from April 10 to June 21 (n = 220). Median and 90% arrival to LGO occurred on April 30 and May 18, respectively. Natural chinook salmon emigrated past LMO between April 13 and May 28 (n = 80), with median and 90% passage dates of May 2 and May 20. Natural chinook salmon arrival at MCN ranged from April 18 to May 30 (n = 18). Median and 90% arrival at MCN occurred on May 9 and May 25. 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 within one to 5 days.

Fall PIT tag release groups of natural chinook salmon from the lower trap arrived at LGR from April 3 to May 2 (n = 103), with median and 90% arrival on April 19 and April 25 (Table 12). Arrival at LGO occurred from April 8 to May 9 (n = 364). Median and 90% arrival to LGO occurred on April 19 and April 25, respectively. Natural chinook salmon emigrated past LMO between April 10 and May 21 (n = 144) with median and 90% passage dates of April 19 and April 25. Natural chinook salmon arrival at MCN ranged from April 10 to May 10 (n = 64). Median and

Table 12. Arrival timing of PIT tagged Imnaha River natural chinook salmon smolts, tagged and released in the fall at the upper trap site and the lower trap site at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1998 to 1999.

Trap Site and Dam	Year	Sample Size (n)	Date Range	Arrival Timing Median	Arrival Timing 90%
Upper Trap					
Lower Granite	1999	128	April 8 - May 27	May 1	May 17
	1998	454	April 3 - June 5	April 27	May 9
Little Goose	1999	220	April 10 - June 21	April 30	May 18
	1998	410	April 14 - May 28	May 4	May 15
Lower Monumental	1999	80	April 13 - May 28	May 2	May 20
	1998	304	April 15 - May 29	May 7	May 19
McNary	1999	18	April 18 - May 30	May 9	May 25
	1998	195	April 18 - June 4	May 4	May 18
Lower Trap					
Lower Granite	1999	103	April 3 May 2	April 19	April 25
	1998	428	March - May 12	April 14	April 24
Little Goose	1999	364	April 8 - May 9	April 19	April 25
	1998	228	April 11 - May 12	April 25	May 2
Lower Monumental	1999	144	April 10 - May 21	April 19	April 25
	1998	202	April 19 - May 19	Apr 25	May 4
McNary	1999	64	April 10 - May 10	April 21	April 28
	1998	236	April 20 - May 23	April 30	May 4

90% arrival at MCN occurred on April 21 and April 28. Fall PIT tagged fish released at the lower site were assumed to overwinter in the Snake River. Median and 90% arrival times were, at all dams, within one to nine days of the previous year and are approximately 15 days ahead of fall PIT tagged fish from the upper trap and spring tagged fish.

Imnaha River natural chinook salmon smolts PIT tagged and released during the spring arrived at LGR from March 28 to July 15 with median and 90% passage dates of April 27 and May 22, respectively (Table 13). The greater number of observations at LGO (n = 2,099) as compared to LGR (n = 1,218) may indicate that PIT tagged natural chinook salmon have a higher probability of being detected at LGO than at LGR.

Table 13. Arrival timing of spring PIT tagged Imnaha River natural chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 1999.

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

Another possible explanation may be that Imnaha River fish are migrating past LGR before the PIT tag interrogation facilities are operational. As noted in the Fish Passage Center's weekly report "the bypass/collection facility at Lower Granite Dam became operational the morning of March 25" (Anonymous *b* 2000). However, if Imnaha natural chinook salmon arrived before LGR interrogation facilities were operational then the median and 90% arrival times would be even earlier than reported. The observed median arrival dates for 1999 at LGR was within the range of observations from 1993 to 1998. The observed 90% arrival time was 3 days later than the latest 90% arrival date observed from 1993 to 1998. Unless LGR routinely misses detections of natural chinook salmon smolts because of late start up times on an annual basis, the first explanation of differing detection probabilities between LGR and LGO seems to be the best explanation for the higher number of detections at LGO.

Arrival timing at LGR, LGO, LMO, and MCN for natural chinook salmon tagged and released in the spring was represented by 1,218, 2,099, 688, and 152 fish, respectively. The 90% arrival date at LGR occurred on May 22. This was four days later than the previous latest date observed from 1993 to 1998. Median arrival dates at LGR have ranged between April 22 and May 4 from 1993 to 1999. Natural chinook salmon smolts emigrated past LGO between April 9 and August 1, 1999. The median passage date at LGO was April 29 and 90% of natural chinook salmon smolt passage occurred by May 22. The median arrival date fell within the range of past observations of median arrivals from 1993 to 1998. However, the 90% arrival time at LGO occured two days later than the previous latest date observed from 1993 to 1998. Natural chinook salmon released in the spring of 1999, from the lower trap, were observed at LMO and MCN between April 9 to August 4 and April 18 to June 27, respectively. The observation of an Imnaha River natural chinook salmon at LMO on April 9 was the also earliest observed since 1993 for spring tagged natural chinook salmon. The observation of an Imnaha River natural chinook salmon at MCN on April 18 was the earliest observed since 1993. Median and 90% arrival at LMO and MCN fell within the range of past observations from 1993 to 1998.

Arrival timing of spring PIT tagged Imnaha River hatchery chinook salmon smolts at the trap occurred between April 18 and May 25 at LGR, April 16 and June 6 at LGO, April 23 and May 25 at LMO, and between May 2 and May 26 at MCN. Arrival timing at LGR, LGO, LMO, and MCN for hatchery chinook salmon is represented by 267, 387, 124, and 56 fish, respectively. All first arrival dates of Imnaha River hatchery chinook salmon fell within the range of past observations of first arrival dates from 1992 to 1998 except at LGO. The observation of an Imnaha River hatchery chinook salmon at LGO on April 16 was one day earlier than previous observations from 1992 to 1998. Last arrivals of hatchery chinook salmon at LGR, LGO were within the range of last arrival dates from 1992 to 1998. The last arrival of hatchery chinook salmon at LMO and MCN occurred a day earlier than the previous latest date observed since 1992. Median arrival dates of hatchery chinook salmon at LGR, LGO, LMO, and MCN occurred on May 5, May 10, May 11, and May 19, respectively (Table 14). All median arrival dates for hatchery chinook salmon observed during 1999 were within the past ranges observed since 1992. Ninety percent of the fish had passed by LGR, LGO, LMO, and MCN by May 14, May 19, May 20, and May 24, respectively. For the migratory years 1992-1999 the 90% arrival dates at LGR ranged from May 6 to May 16. The 90% passage date at LGO (1992-1999) has occurred over an 18 day period from

Table 14. Arrival timing of PIT tagged Imnaha River hatchery chinook salmon smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1992 to 1999.

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

[1] HxW crossed chinook salmon smolts PIT tagged for NPT and released at dark.
[2] HxW crossed chinook salmon smolts PIT tagged for the FPC and released one hour after tagging and recovery.
[3] Hatchery chinook salmon smolts PIT tagged and released in 1992 were over a two day period only for survival estimation.

May 5-23. The 90% arrival dates (1992-1999) at LMO occurred over an 11 day period (May 15 to May 26) and over a 9 day period (May 17 to May 26) at MCN from 1992 to 1999.

Natural steelhead smolts PIT tagged and released in the spring from the Imnaha River arrived at LGR from April 19 to June 26, at LGO from April 8 to June 24, at LMO from April 19 to June 21, and at MCN from April 17 to May 31 (Table 15). The April 8 arrival at LGO and the April 17 arrival at MCN are the earliest recorded arrivals since 1993. Arrival timing at LGR, LGO, LMO, and MCN for natural steelhead was represented by 649, 717, 342, and 55 fish, respectively. Median and 90% arrival dates of natural steelhead occurred on May 18 and June 5 at LGR, May 21 and May 25 at LGO, May 23 and May 27 at LMO, and May 25 and May 27 at MCN. May 2 to May 26 is the median arrival date range at LGR for natural steelhead from 1993 to 1999. The 90% arrival date range for 1993 to 1999 at LGR 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 1999. Ninety percent arrival timing at MCN (1993 to1999) occurred between the dates of May 17 and June 9. However, handling procedures in 1994 may have caused a lower than average cumulative interrogation rate and may have affected arrival timing (Ashe et. al. 1995).

Arrival timing of spring PIT tagged Imnaha River hatchery steelhead smolts occurred between April 18 and August 5 at LGR, April 20 and August 22 at LGO, April 21 and July 20 at LMO, and April 27 and July 8 at MCN (Table 16). The range of arrivals may have been affected by the tagging effort. Over half of the hatchery steelhead were tagged after May 16. The first arrivals at LGR, LGO, and LMO were the earliest observed since 1993. Overall, for the years 1993-1999, the median and 90% arrival date ranges for hatchery steelhead at LGR were May 15 to May 31, and May 26 to July 15, respectively. However, 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 1999 was May 25 to June 3, and May 30 to July 17, respectively. Median and 90% percent arrival timing at LMO for 1993 to 1999 was May 26 to June 18, and June 3 to July 21. At MCN the median and 90% arrival date ranges for 1993 to 1999 was May 23 to June 17, and May 30 to July 10, respectively. Arrival timing at LGR, LGO, LMO, and MCN for hatchery steelhead is represented by 1,973, 1,593, 790, and 79 fish, respectively. Median arrival dates of hatchery steelhead at LGR, LGO, LMO, and MCN occurred on May 24, May 25, May 26, and May 28, respectively (Table 16). Ninety percent of the fish had passed by LGR, LGO, LMO, and MCN by June 18, June 18, June 19, and May 31, respectively.

The frequencies of arrival, and the average total discharge and the average turbine discharge at LGR, LGO, LMO, and MCN, were plotted against the day of the year for each dam and the results are presented in Appendix M. Median and 90% arrival timing of natural and hatchery chinook salmon released during the spring at the lower site preceded maximum spill events at LGR, LGO, and LMO, by five to 30 days. Median arrival times of Imnaha natural steelhead at LGR, LGO, and LMO, preceded maximum spill events by four to 9 days. These observations of arrival are similar to last years (Cleary et. al 2000). However, these observations

Table 15 . Arrival timing of PIT tagged Imnaha River natural steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 1999.

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

[1] NPT PIT tagged fish
[2] FPC PIT tagged fish

Table 16. Arrival timing of PIT tagged Imnaha River hatchery steelhead smolts at Lower Granite, Little Goose, Lower Monumental, and McNary dams from 1993 to 1999.

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

[1] NPT PIT tagged fish released at dark

[1] FPC PIT tagged fish released after recovery

are subjective because it is unknown how many chinook salmon and steelhead avoided the interrogation facilities by passing over the dam during the spill events.

Another noticeable trend visible in appendix Figures M-11, M-12, and M-13 is the arrival frequency of hatchery steelhead peaking at LGR, LGO, and LMO close to the occurrence of maximum spill events. At LGR two spikes in the arrival frequency of hatchery steelhead are visible on May 23, and June 17. When arrival frequencies peaked on May 23 spill was increasing and peaked on May 27 at 85 Kcfs. At LGO the arrival of 14.8% of the hatchery steelhead on May 24 occurred during a spill of 26 Kcfs. A peak in the arrival frequency of 17.6% of the hatchery steelhead at LMO occurred on May 26 during a spill of 62 Kcfs.

Travel Times

Mean travel time of natural chinook salmon, for weekly release groups of 30 or more fish, to LGR ranged from 11 (±5.9) to 47 (±16.8) days between the weeks of February 28 and May 9 (Figure 19). The fastest mean travel time resulted from the releases during the week of May 9 and the slowest mean travel time resulted from the releases during the week of February 28.

Mean travel times of natural chinook salmon decreased with an increase in the calendar date as observed in 1998 (Cleary et al. 2000). 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 (±10.7) and 24 (±13.0) days for the releases during the weeks of April 4 and April 11 (Figure 19).

Individual travel times of natural and hatchery chinook salmon were compared for releases occurring during the weeks of April 4 and April 11. There was a significant difference ($p < 0.05$) in the median travel times of natural and hatchery chinook salmon from the Imnaha River trap to LGR during both weeks (Table 17). Travel time of natural steelhead to LGR from the week of April 18 to May 16 ranged from 4 to 6 days (Figure 20). Hatchery steelhead smolt mean travel time to LGR ranged from 3 to 20 days (Figure 20). The slowest travel times were the result of the releases during the week of April 11 and the fastest travel times were the result of the releases during the week of June 13. Median travel times of natural and hatchery steelhead smolts were compared for releases occurring from April 16 to May 16. Median travel times of natural steelhead were significantly faster than hatchery steelhead to LGR for each of the five weeks examined (Table 17).

Mortality

Trapping caused seven mortalities at the lower trap site during the fall. No other mortalities occurred at the lower or upper site during the fall. All seven mortalities were natural chinook salmon and occurred on November 13, 1998. A trap malfunction was believed to have caused the mortalities.

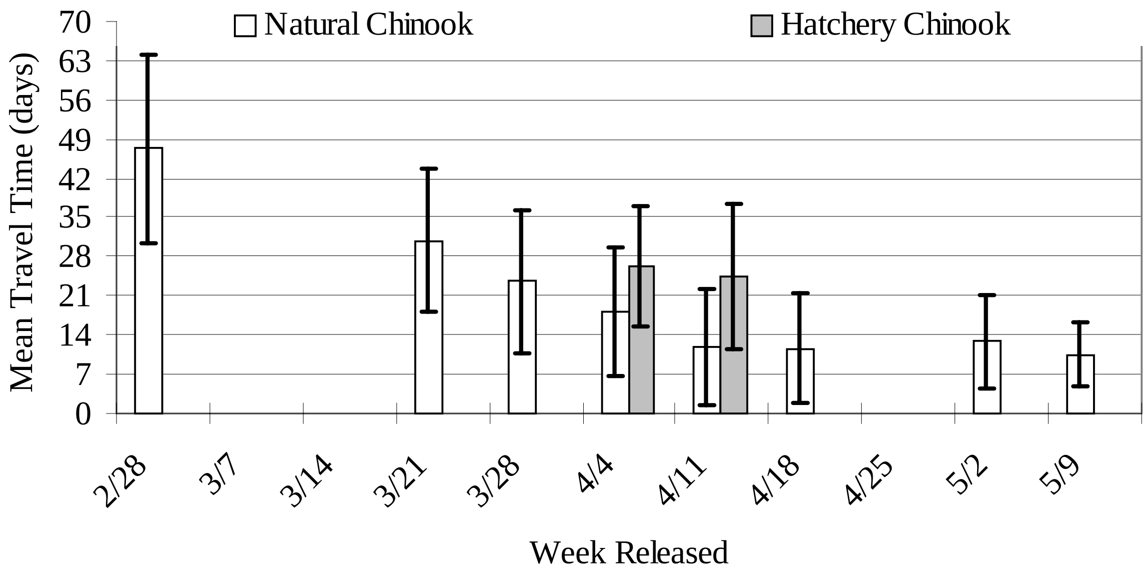

Figure 19. Mean travel times of natural and hatchery chinook salmon weekly PIT tag release groups from the lower Imnaha River trap to Lower Granite Dam with 95% confidence intervals, in 1999.

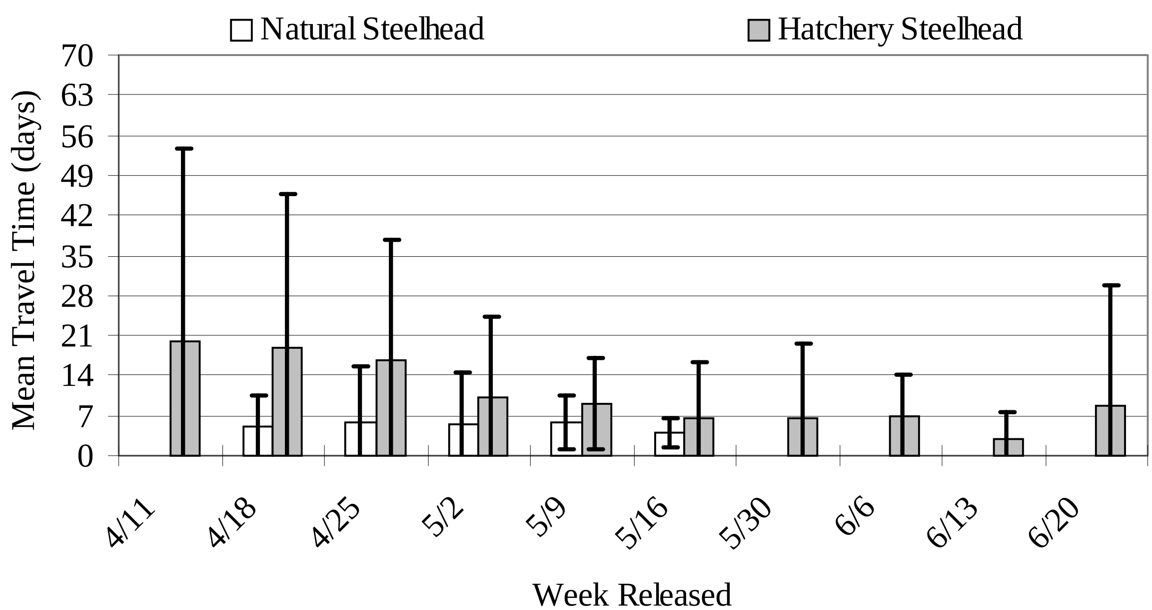

Figure 20. Mean travel times of natural and hatchery steelhead weekly PIT tag release groups from the lower Imnaha River trap to Lower Granite Dam with 95% confidence intervals, in 1999.

Table 17. A comparison of median travel times between weekly PIT tag release groups of natural and hatchery chinook salmon and steelhead smolts released between February 28 and June 26, 1999 at the lower Imnaha River trap.

Species	Week Released	Sample Size Natural	Sample Size Hatchery	Median Travel Time (days) Natural	Median Travel Time (days) Hatchery	Wilcoxon Value	Significance
Chinook Salmon	4/4/1999	174	126	17.3	25.7	3,244.0	$p < 0.05$
	4/11/1999	343	123	11.1	24.7	3,436.5	$p < 0.05$
Steelhead	4/18/1999	72	124	4.4	19.5	2,241.0	$p < 0.05$
	4/25/1999	54	54	4.6	21.0	629.0	$p < 0.05$
	5/2/1999	82	40	3.9	6.5	1,044.0	$p < 0.05$
	5/9/1999	178	208	5.3	8.9	8,887.0	$p < 0.05$
	5/16/1999	176	571	3.5	4.8	30,439.5	$p < 0.05$

The following mortalities occurred in the spring: 18 - natural chinook salmon, 27 - hatchery chinook salmon, 15 - natural steelhead, and 33 - hatchery steelhead. The principle cause of mortality during the spring was trapping for natural and hatchery chinook salmon and steelhead. A total of 72 mortalities were caused by trapping: 10 - natural chinook salmon, 22 - hatchery chinook salmon, 10 - natural steelhead, and 30 - hatchery steelhead. The second major cause of mortality was PIT tagging which accounted for 12 mortalities. Handling caused nine mortalities. As a percentage of the catch, mortality was low. It comprised 0.31% of the catch of natural chinook salmon, 0.21% of the catch of hatchery chinook salmon, 0.55% of the catch of natural steelhead, and 0.37% of the catch of hatchery steelhead (Table 18).

Incidental Catch

Four game fish species were incidentally captured during our investigation. They were mountain whitefish (*Prosopium williamsoni*), rainbow trout and adult steelhead, bull trout (*Salvelinus confluentus*) and smallmouth bass (*Micropterus dolomieui*). The upper Imnaha River trap collected 47 mountain whitefish and 10 bull trout during the fall trapping period. Thirty-four mountain whitefish, 38 bull trout and one smallmouth bass were collected in the lower Imnaha River trap during the fall trapping period. A total of four mountain whitefish, 12 rainbow trout, 14 adult steelhead, nine bull trout, and four smallmouth bass were captured during the spring trapping period.

Non-game fish species collected during the fall at the upper trap included 14 longnose dace

(*Rhinichthys cataractae*), two bridgelip suckers (*Catostomus columbianus*), and one sculpin (*Cottus sp.*), The catch of non-game fish at the lower trap consisted of the following: 44 bridgelip suckers, 260 longnose dace, one pumpkinseed (*Lepomis gibbosus*), 34 redside shiners (*Richardsonius balteatus*), one sculpin, and one northern pike minnow (*Ptychocheilus oregonensis*). Non-game fish collected during the spring include 175 longnose dace, one specked dace (*Rhinichthys osculus*), 673 bridgelip suckers, 55 largescale suckers (*Catostomus macrocheilus*), 26 sculpin, 55 northern pike minnow, five redside shiners and one chislemouth (*Acrocheilus alutaceus*).

Table 18. Mortality of chinook salmon and steelhead smolts due to trapping, handling, and PIT tagging from the week of February 28 to June 26, 1999.

	Chinook salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Number Captured	5,715		12,856		2,748		8,858	
Mortality								
Source	n	(%)	n	(%)	n	(%)	n	(%)
Trapping	10		22		10		30	
Handling	3		4		0		2	
PIT Tagging	5		1		5		1	
Total	18	(0.31)	27	(0.21)	15	(0.55)	33	(0.37)

SUMMARY

The monitoring and evaluation efforts for the 1999 migration year allowed for the observation and documentation of the first acclimated volitional release of hatchery chinook salmon from the Imnaha River acclimation facility into the Imnaha River. We documented a statistically significant difference between the fork lengths of natural and hatchery chinook salmon and steelhead and we were able to estimate survival for hatchery chinook salmon from the acclimation facility to the lower Imnaha River trap (rkm 7). Additionally, survival and arrival timing to LGR, LGO, LMO, and MCN was calculated.

No significant correlation was observed between any environmental factors and emigration timing. However, we graphically described fish movement as it related to daily mean flow and temperature in the Imnaha River. Continued collection of daily emigration timing, and daily mean flow and temperature data may allow for a multi-year analysis evaluating the effects of flow and temperature on emigration timing.

The peak catch of hatchery chinook salmon at the Imnaha River trap occurred on the same day as the peak catch of natural chinook salmon, April 18. Although effort and environmental conditions vary between years it is worth noting that a difference was observed in the cumulative catch of hatchery chinook salmon. The arrival of 90% of the hatchery chinook salmon at the lower Imnaha River trap was more prolonged than in past years. It took 34 days to achieve a 90% cumulative catch of hatchery chinook salmon at the lower trap after the initial volitional release began. A cumulative catch of 12.4% was achieved 14 days after the initial volitional release began. In contrast, it took eleven days to capture 97% of the hatchery chinook salmon in 1998 and 10 days to capture 99% of the hatchery chinook salmon in 1997. The peak catch of natural and hatchery chinook salmon occurred two days prior to a spike of 2,066 cfs in the daily mean discharge of the Imnaha River and during a period when water temperatures increased to 9.3°C. While it is unclear whether the movement of Imnaha River chinook salmon should be attributed to the end of the volitional release, increasing discharge, increasing water temperatures, or other environmental factors, it is apparent that a majority of both natural and hatchery fish migrated past the Imnaha River trap at the same time. The acclimated volitional release may have allowed hatchery chinook salmon to physiologically respond to the same environmental clues as their natural cohorts. The data suggests that the acclimated volitional release produced a more natural pattern of migration for hatchery chinook salmon.

Hatchery chinook salmon were significantly larger (fork length) than natural chinook salmon ($p < 0.05$) as were hatchery steelhead compared with natural steelhead. Mean fork lengths for hatchery chinook salmon were 30 mm longer than natural chinook salmon and mean fork lengths for hatchery steelhead were 32 mm longer than natural steelhead. The difference in size is attributed to the advantages of a hatchery environment has over a natural environment, such as constant water temperatures and feed.

The survival of hatchery chinook salmon was estimated to 93.7% from the acclimation facility to the Imnaha River trap. This percent of survival was within the range of estimates from 1994 to 1998. Predators such as bull trout, rainbow trout, kingfishers, blue heron, and otters are commonly observed between the acclimation facility and the lower Imnaha River Trap.

Season-wide survival estimates of natural and hatchery chinook salmon and steelhead were calculated from the trap to as far downstream as MCN when detections of fish permitted estimates with 95% confidence intervals of less than 20%. There were no apparent trends for survival estimates from the lower trap to LGR for natural and hatchery chinook salmon or natural steelhead from 1993 to 1999. However, the survival of hatchery steelhead from the trap to LGR has slightly increased each year since 1996. The 90% arrival times for hatchery steelhead were later than the natural and hatchery chinook salmon and natural steelhead and occurred closer to peak spill events at LGR, LGO, LMO, and MCN. Season-wide survival estimates of natural chinook salmon to LGR, LMO, and MCN were, respectively, 16.9%, 17.2%, and 14.7% higher than the season-wide estimates of hatchery chinook salmon. In addition to the documented differences in rearing and size between the natural and hatchery chinook salmon, hatchery chinook salmon had later median arrival times at LGR, LGO, LMO, and MCN and median travel times were 8 and 14 days slower during the weeks of April 4 and April 11, respectively.

There were no noticeable trends in the weekly survival estimates of natural and hatchery chinook salmon or steelhead from the Imnaha River trap to LGR or the overall estimate of survival from the trap to LMO. Survival between LGR and LGO, and between LGO and LMO may have been overestimated in some cases. Survival in these reaches sometimes exceeded 100%. This indicates that survival to the previous detection point, LGR and LGO, was probably underestimated. This may have been caused by lack of detections at the interrogation facility or diversion of fish from a route inside the dam known to go to a barge, but instead are diverted back to the river. The program used to create the capture histories for SURPH, CAPTHIST, treats barged fish as removals from the study. Overestimation in a single reach should not invalidate the overall estimate of survival because of the use of multiple detection sites.

Median and 90% arrival of natural chinook salmon tagged and released in the spring occurred four to 7 days later than in 1998. A higher number of detections of natural chinook salmon occurred at LGO than at LGR but the first interrogation of a natural chinook salmon at LGR occurred on March 28, three days after the LGR interrogation system became operational. More hatchery chinook salmon and natural steelhead were interrogated at LGO than at LGR, as well. A conservative conclusion is that natural and hatchery chinook salmon and natural steelhead had a higher probability of being detected at LGO than at LGR during the 1999 migration year. If this conclusion is correct than researches seeking to model survival in 1999 need to model the capture probability at LGR differently than at LGO.

In conclusion, the acclimated volitional release of hatchery chinook salmon has merit and the practice should continue in the future. It appeared to produce a more natural migration of hatchery chinook salmon in the Imnaha River. Hatchery production continued to produce chinook salmon and steelhead smolts that were larger than natural fish. The survival estimates for the larger hatchery fish to LGR during the weeks of April 4 (71.0%) and April 11 (71.7%) were not better than the estimated survival of natural fish to LGR during the weeks of April 4 (90.4%) and April 11 (91.5%). Differences in smoltification or behavior may have had an effect on the survival of natural and hatchery chinook salmon and future emigration studies should investigate how these variables affect emigration and survival. The lack of data from the LGR interrogation facility in the winter and early spring leave this research with a void in knowledge of whether fish continue to move downstream or if they overwinter in the Snake River. If a significant number of fish are detected during the winter months at LGR it would be valuable information to researchers in the Snake River basin.

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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, minimum, and maximum water temperatures at the upper and lower site during the fall, October 19 to November 13, 1998 and spring, March 1 to June 24, 1999.

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, minimum, and maximum water temperatures at the upper and lower site during the fall, October 19 to November 13, 1998 and spring, March 1 to June 24, 1999.

Season, Site, & Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
1998 Fall (Upper Site)					
21-Oct			4.4	2.3	6.1
22-Oct			5.0	3.2	6.4
23-Oct			6.1	4.4	7.6
24-Oct			5.6	4.2	6.8
25-Oct			6.6	6.0	7.6
26-Oct			5.6	3.8	7.0
27-Oct			5.4	3.8	6.9
28-Oct			5.7	5.0	6.5
29-Oct			4.3	3.2	5.6
30-Oct			2.3	0.9	3.7
31-Oct			2.6	1.3	3.7
1-Nov			3.8	2.9	4.6
2-Nov			4.3	3.2	5.3
3-Nov			2.6	1.0	3.7
4-Nov			3.9	3.0	4.8
5-Nov			4.1	3.5	4.6
6-Nov			3.6	3.0	4.4
7-Nov			2.6	1.9	3.3
8-Nov			2.3	1.6	3.0
9-Nov			2.1	1.2	2.7
10-Nov			1.1	-0.1	1.9
11-Nov			2.4	1.6	3.3
12-Nov			3.0	2.4	3.7
1998 Fall (Lower Site)					
19-Oct	184		8.9	7.4	10.2
20-Oct	181		8.0	6.3	9.5
21-Oct	181		7.9	6.3	9.5
22-Oct	178		7.8	6.7	8.6
23-Oct	178		8.9	7.3	10.7
24-Oct			9.3	8.2	10.0
25-Oct	177		9.8	9.2	10.5
26-Oct	177		9.5	8.3	11.0
27-Oct	176		9.2	7.9	10.6
28-Oct	178		9.8	9.0	11.0

Table A. Continued.

Season, Site, & Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
29-Oct	177		8.5	7.4	9.8
30-Oct	173		6.4	5.0	7.6
31-Oct	172		6.2	5.1	7.1
1-Nov	175		7.3	6.6	8.1
2-Nov	176		7.9	7.4	8.6
3-Nov	174		6.3	5.2	7.4
4-Nov	174		6.6	6.0	7.5
5-Nov	179		7.4	7.0	8.1
6-Nov	189		7.1	6.5	7.9
7-Nov	176		5.7	4.8	6.7
8-Nov	192		6.2	5.8	6.7
9-Nov	186		6.0	5.5	6.4
10-Nov	172		5.0	3.9	5.9
11-Nov	179		5.4	4.8	6.4
12-Nov	176		5.4	4.6	6.4
13-Nov	174		7.0	6.3	7.6
1999 Spring (Lower Site)					
28-Feb	474	133.2			
1-Mar	598	29.4			
2-Mar	535	16.6			
3-Mar	493	16.9			
4-Mar	448	15.4			
5-Mar	391	23.9			
6-Mar	369	24.1			
7-Mar	362	14.4			
8-Mar	336	6.4	4.8	4.2	5.1
9-Mar	326	3.8	4.4	3.5	5.3
10-Mar	303	8.7	4.4	2.6	6
11-Mar	289	5.1	4.9	2.7	7.1
12-Mar	274	7.9	4.7	2.9	5.9
13-Mar	280	13.1	6.9	4.8	9
14-Mar	336	53.1	7.9	6.6	9.2
15-Mar	384	30.0	7.9	5.7	9.6
16-Mar	424	6.3	7.3	6	8.7
17-Mar	418	3.8	6.0	4	7.7
18-Mar	426	8.0	6.8	5.2	8.5
19-Mar	476	22.7	7.8	5.7	10.1

Table A. Continued.

Season, Site, & Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
20-Mar	634	55.6	8.6	6.7	10
21-Mar	919	69.3	7.9	7	9
22-Mar	985	21.5	7.1	5.1	8.9
23-Mar	951	22.7	7.7	6.3	9.4
24-Mar	985	21.6	7.1	6.1	8.5
25-Mar	1,148	39.8	8.4	7.3	9.3
26-Mar	1,458	56.4	7.6	6.6	9.2
27-Mar	1,213	98.7	5.7	4.8	6.7
28-Mar	936	63.9	5.3	4.2	6.9
29-Mar	785	29.0	6.2	5.7	6.7
30-Mar	701	23.3	5.4	4.7	6.3
31-Mar	616	18.2	5.0	3.6	7
1-Apr	558	17.0	6.1	4.2	8.1
2-Apr	519	11.1	6.1	3.7	8.4
3-Apr	509	3.4	6.7	5.3	8.1
4-Apr	492	7.5	6.0	5.2	7
5-Apr	477	7.5	6.6	5.2	8.2
6-Apr	452	9.2	7.4	5.6	9.5
7-Apr	448	4.5	8.1	5.7	10.6
8-Apr	525	30.3	8.2	7.5	9.2
9-Apr	535	15.8	6.6	5.7	7.6
10-Apr	499	11.1	5.8	3.6	8
11-Apr	484	7.7	7.3	4.8	10
12-Apr	503	8.0	8.3	6.4	9.8
13-Apr	576	22.5	9.6	7.8	11.8
14-Apr	711	24.0	8.3	6.4	9.8
15-Apr	755	10.1	7.7	5.6	9.8
16-Apr	834	25.0	8.5	6.4	10.7
17-Apr	1,052	48.1	9.3	7.6	11
18-Apr	1,367	90.4	9.3	8.1	10.2
19-Apr	1,885	65.2	8.9	8	10
20-Apr	2,066	51.8	7.7	6.7	8.6
21-Apr	1,827	122.6	6.5	5.3	7.4
22-Apr	1,524	83.6	7.1	6	8.4
23-Apr	1,289	57.9	8.3	6	10.8

Table A. Continued.

Season, Site, & Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
24-Apr	1,479	74.0	9.4	7.6	11.1
25-Apr	1,812	85.8	9.2	7.4	10.2
26-Apr	2,183	50.3	8.8	7.7	10
27-Apr	2,107	116.0	7.6	6.7	8.4
28-Apr	1,761	105.5	6.2	5.6	7.4
29-Apr	1,465	69.6	6.6	5.9	7.4
30-Apr	1,287	43.1	8.2	6.2	10.5
1-May	1,493	41.9	9.0	8.2	9.5
2-May	1,783	36.6	8.3	7.6	8.9
3-May	1,789	27.5	7.8	7.2	8.5
4-May	1,651	56.3	7.1	6.2	7.8
5-May	1,471	50.0	7.6	5.7	9.8
6-May	1,415	53.2	9.0	6.9	11.5
7-May	1,683	37.0	9.3	7.8	10.9
8-May	1,598	38.5	6.6	5.5	7.6
9-May	1,448	47.0	6.2	5.5	6.7
10-May	1,293	44.0	6.8	5.1	8.5
11-May	1,209	31.8	8.0	6	10.1
12-May	1,301	28.2	10.0	9.2	11.5
13-May	1,454	34.1	8.4	7.8	9.7
14-May	1,353	28.3	8.1	6.8	9.9
15-May	1,260	34.2	8.4	7.4	9.3
16-May	1,192	27.8	8.7	6.7	10.8
17-May	1,328	29.0	9.7	9.2	10.3
18-May	1,649	99.7	10.1	9.2	11.4
19-May	2,034	103.2	10.0	8.5	11.5
20-May	2,367	142.9	10.2	8.5	11.3
21-May	2,620	183.9	10.2	8.9	11.2
22-May	2,624	202.4	9.8	8	11.1
23-May	2,782	211.0	10.0	8.1	11.8
24-May	3,085	237.3	10.5	8.5	11.9
25-May	3,292	237.8	10.3	8.5	11.6
26-May	3,311	316.3	9.4	7.5	10.8
27-May	2,889	176.5	9.7	7.8	11.2
28-May	2,822	132.1	10.4	8.9	11.4

Table A. Continued.

Season, Site, & Day	Mean Discharge (cfs)	Standard Deviation of the Discharge	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
29-May	2,799	131.1	10.4	9	11.2
30-May	2,608	139.1	9.9	8.8	10.9
31-May	2,321	119.1	9.4	8.5	10.1
1-Jun	2,318	77.5	10.4	9.7	11.4
2-Jun	2,554	100.1	9.0	8	10.5
3-Jun	2,165	102.2	7.9	7.8	8.2
4-Jun	1,921	64.3	9.8	7.8	12
5-Jun	1,949	90.5	10.8	10.1	11.8
6-Jun	1,868	45.6	9.5	9	10
7-Jun	1,721	70.6	9.1	7.8	10.2
8-Jun	1,625	30.3	8.8	7.7	9.3
9-Jun	1,443	50.1	8.7	6.4	11.3
10-Jun	1,327	42.8	10.3	8.7	11.8
11-Jun	1,298	33.7	11.7	10.3	13.2
12-Jun	1,378	41.3	13.0	11.1	15
13-Jun	1,582	44.6	13.1	12.6	13.8
14-Jun	1,788	75.4	12.7	11.6	14
15-Jun	2,083	104.8	13.4	12.1	14.8
16-Jun	2,365	131.6	12.9	11.9	14.4
17-Jun	2,339	94.0	12.6	11.5	14
18-Jun	2,363	162.9	12.9	11.3	13.7
19-Jun	2,313	201.6	12.1	10.7	13.3
20-Jun	2,020	119.8	12.1	10.9	13.1
21-Jun	2,011	35.7	12.0	11.1	12.9
22-Jun	1,892	110.1	11.2	10.3	12.1
23-Jun	1,767	110.8	12.2	11.1	13.4
24-Jun	1,678	82.4	12.5	11.8	12.9

Appendix B

The mean daily discharge and mean, minimum, and maximum water temperature estimated from provisional data collected at the USGS gauging site at Anatone, Washington, on the Snake River, February 28 to June 24, 1999.

Table B. The mean daily discharge and mean, minimum, and maximum water temperature estimated from provisional data collected at the USGS gauging site at Anatone, Washington, on the Snake River, February 28 to June 24, 1999.

Day	Mean Discharge (cfs)	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
2/28/1999	55,300	4.6	4.3	5.0
3/1/1999	63,800	5.0	4.6	5.3
3/2/1999	64,000	4.7	4.4	5.0
3/3/1999	64,500	4.9	4.5	5.4
3/4/1999	64,100	4.9	4.6	5.2
3/5/1999	61,300	5.0	4.6	5.4
3/6/1999	55,700	5.0	4.6	5.2
3/7/1999	52,300	5.0	4.6	5.3
3/8/1999	51,300	5.1	4.9	5.3
3/9/1999	54,400	5.2	4.9	5.4
3/10/1999	57,100	5.4	5.0	5.7
3/11/1999	56,600	5.5	5.2	5.9
3/12/1999	60,300	5.7	5.4	6.1
3/13/1999	60,500	6.3	5.8	6.9
3/14/1999	61,200	6.9	6.4	7.2
3/15/1999	62,600	7.0	6.6	7.4
3/16/1999	64,200	7.0	6.4	7.4
3/17/1999	64,700	6.5	5.9	6.9
3/18/1999	65,900	6.8	6.3	7.2
3/19/1999	69,800	7.1	6.6	7.5
3/20/1999	65,500	7.4	6.9	7.7
3/21/1999	74,000	7.2	6.8	7.6
3/22/1999	78,800	7.2	6.7	7.8
3/23/1999	85,400	7.6	7.2	8.0
3/24/1999	84,200	7.7	7.2	8.1
3/25/1999	85,000	8.0	7.7	8.4
3/26/1999	89,100	8.0	7.4	8.5
3/27/1999	93,600	7.6	7.3	8.0
3/28/1999	89,800	7.4	7.0	7.8
3/29/1999	84,700	7.6	7.5	7.8
3/30/1999	73,600	7.4	7.3	7.6
3/31/1999	68,500	7.4	7.0	7.8
4/1/1999	62,800	7.7	7.1	8.2
4/2/1999	62,700	8.0	7.4	8.6
4/3/1999	62,000	8.4	8.0	8.9

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
4/4/1999	61,400	8.2	7.9	8.7
4/5/1999	59,500	8.2	7.8	8.6
4/6/1999	55,800	8.4	8.0	8.9
4/7/1999	53,900	8.6	8.1	9.2
4/8/1999	54,100	8.9	8.5	9.2
4/9/1999	55,000	8.6	8.3	8.9
4/10/1999	57,400	8.2	7.8	8.6
4/11/1999	59,000	8.4	7.9	9.1
4/12/1999	58,400	8.6	8.3	9.0
4/13/1999	63,400	9.0	8.3	9.5
4/14/1999	61,700	9.1	8.6	9.5
4/15/1999	63,100	9.1	8.4	9.7
4/16/1999	64,100	9.5	8.8	10.1
4/17/1999	64,100	9.9	9.3	10.4
4/18/1999	66,900	10.1	9.6	10.4
4/19/1999	74,100	10.1	9.8	10.3
4/20/1999	84,300	9.8	9.5	10.1
4/21/1999	86,700	9.4	8.9	9.9
4/22/1999	86,200	9.5	9.1	10.0
4/23/1999	84,900	10.0	9.3	10.6
4/24/1999	71,900	10.5	9.8	11.1
4/25/1999	76,700	10.8	10.5	11.2
4/26/1999	73,900	10.6	10.4	10.9
4/27/1999	83,400	10.5	10.2	10.8
4/28/1999	79,600	9.8	9.2	10.6
4/29/1999	69,600	9.3	9.0	9.7
4/30/1999	69,300	9.9	9.2	10.7
5/1/1999	65,400	10.5	10.1	10.7
5/2/1999	65,500	10.2	9.9	10.6
5/3/1999	68,300	10.3	9.8	10.9
5/4/1999	72,100	10.2	9.7	10.6
5/5/1999	72,200	10.3	9.6	11.0
5/6/1999	69,400	10.9	10.3	11.6
5/7/1999	64,900	11.3	10.8	11.7
5/8/1999	62,600	10.6	10.2	11.3
5/9/1999	62,300	10.0	9.8	10.4

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
5/10/1999	64,100	10.2	9.5	11.0
5/11/1999	59,900	10.6	9.9	11.3
5/12/1999	57,700	11.3	10.9	12.0
5/13/1999	57,400	11.1	10.8	11.6
5/14/1999	56,200	10.8	10.2	11.3
5/15/1999	54,500	10.9	10.5	11.3
5/16/1999	53,400	11.2	10.4	12.0
5/17/1999	53,600	11.9	11.5	12.2
5/18/1999	55,000	12.0	11.6	12.6
5/19/1999	59,000	12.1	11.5	12.7
5/20/1999	62,700	12.4	11.9	12.8
5/21/1999	67,700	12.5	11.8	13.1
5/22/1999	78,100	12.6	12.1	13.1
5/23/1999	79,300	12.5	12.1	13.0
5/24/1999	89,000	12.8	12.4	13.2
5/25/1999	104,000	12.6	12.4	12.9
5/26/1999	126,000	12.0	11.6	12.4
5/27/1999	131,000	11.9	11.4	12.2
5/28/1999	109,000	12.0	11.6	12.4
5/29/1999	106,000	12.0	11.5	12.4
5/30/1999	125,000	12.2	11.8	12.6
5/31/1999	132,000	11.9	11.6	12.3
6/1/1999	128,000	12.4	11.8	13.0
6/2/1999	125,000	12.2	11.6	12.7
6/3/1999	116,000	11.5	11.2	11.6
6/4/1999	106,000	11.6	11.0	12.2
6/5/1999	108,000	12.3	12.0	12.7
6/6/1999	105,000	12.2	11.8	12.6
6/7/1999	104,000	12.0	11.5	12.5
6/8/1999	105,000	12.2	11.8	12.5
6/9/1999	98,900	12.3	11.7	13.0
6/10/1999	90,400	12.9	12.4	13.4
6/11/1999	85,400	13.4	12.8	14.1
6/12/1999	82,800	14.0	13.5	14.8
6/13/1999	80,900	14.6	14.2	14.9
6/14/1999	87,700	14.6	14.0	15.0

Table B. Continued.

Day	Mean Discharge (cfs)	Mean Water Temperature (°C)	Minimum Water Temperature (°C)	Maximum Water Temperature (°C)
6/15/1999	94,400	14.7	14.1	15.4
6/16/1999	103,000	14.9	14.6	15.3
6/17/1999	109,000	14.5	14.1	15.0
6/18/1999	114,000	14.4	14.0	14.9
6/19/1999	125,000	14.5	14.1	15.0
6/20/1999	125,000	14.7	14.1	15.3
6/21/1999	114,000	14.8	14.4	15.1
6/22/1999	111,000	14.9	14.5	15.5
6/23/1999	102,000	15.1	14.6	15.6
6/24/1999	93,900	15.3	14.9	15.7

Appendix 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 February 28 to June 24, 1999. Daily averages were calculated from midnight to midnight.

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 February 28 to June 24, 1999. Daily averages were calculated from midnight to midnight. Abbreviations: Discharge = Dschrg., Average = Avg.

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill
02/28	80.65	80.55	0.00	81.46	81.26	0.00	91.95	91.65	0.00	91.75	58.81	32.63	188.20	184.20	0.00
03/01	95.27	95.17	0.00	92.13	91.93	0.00	105.07	104.77	0.00	109.97	57.19	52.47	181.97	176.73	1.25
03/02	93.39	93.29	0.00	98.14	97.94	0.00	113.58	113.28	0.00	111.52	62.45	48.78	266.25	201.04	61.21
03/03	88.19	88.09	0.00	86.88	86.68	0.00	92.36	92.06	0.00	91.45	68.13	23.02	229.60	205.40	20.20
03/04	86.46	86.36	0.00	86.93	86.73	0.00	99.47	98.48	0.69	100.16	77.78	22.09	254.18	207.94	42.24
03/05	81.16	81.06	0.00	80.84	80.64	0.00	84.20	83.90	0.00	81.26	80.33	0.63	269.48	209.95	55.53
03/06	77.04	76.94	0.00	73.58	73.38	0.00	78.86	78.56	0.00	79.04	78.74	0.00	239.30	214.37	20.94
03/07	72.17	72.07	0.00	70.12	69.92	0.00	77.16	76.86	0.00	80.08	79.78	0.00	218.37	214.37	0.00
03/08	71.94	71.72	0.12	73.25	73.05	0.00	78.27	77.97	0.00	74.30	74.00	0.00	214.04	210.04	0.00
03/09	73.72	73.62	0.00	75.45	75.25	0.00	81.95	81.65	0.00	78.90	78.60	0.00	223.28	206.09	13.19
03/10	75.49	75.39	0.00	81.05	80.85	0.00	84.71	84.28	0.00	82.15	81.85	0.00	255.05	210.41	40.64
03/11	71.25	71.15	0.00	64.98	64.78	0.00	71.35	70.93	0.00	70.26	69.05	0.91	230.84	212.65	14.18
03/12	79.74	79.64	0.00	74.48	74.28	0.00	79.06	78.70	0.00	74.00	66.08	7.56	224.50	213.42	7.08
03/13	74.65	74.55	0.00	74.54	74.28	0.00	80.31	79.95	0.00	84.40	69.87	14.24	237.76	203.48	29.91
03/14	74.73	74.06	0.00	75.87	75.29	0.00	81.82	81.21	0.00	80.67	61.94	17.94	222.64	215.36	3.25
03/15	89.00	88.55	0.00	89.81	88.67	0.00	94.22	93.55	0.00	93.64	59.82	33.07	213.75	163.65	46.10
03/16	85.75	84.99	0.00	87.04	85.53	0.00	94.53	93.79	0.00	95.93	70.93	24.07	260.15	163.65	92.49
03/17	83.40	82.96	0.00	80.09	79.58	0.00	83.73	83.05	0.00	88.84	69.67	18.18	223.77	165.35	54.27
03/18	87.03	86.59	0.00	89.20	76.63	12.05	93.98	93.43	0.00	88.89	67.73	20.35	234.05	164.35	65.71
03/19	85.78	85.33	0.00	85.31	84.10	0.83	92.30	91.94	0.00	100.65	70.15	29.74	237.79	162.58	71.23
03/20	86.52	86.08	0.00	87.30	83.73	3.31	88.86	88.43	0.00	84.91	68.59	15.57	215.44	168.09	43.35
03/21	103.84	101.89	1.58	105.63	84.24	21.06	115.85	115.43	0.00	118.78	69.90	48.01	215.48	172.84	38.65
03/22	113.04	87.16	25.29	111.15	78.65	32.16	115.75	115.14	0.00	115.21	71.70	42.63	223.37	163.98	55.56
03/23	118.33	90.52	27.15	123.54	69.36	52.99	130.79	110.85	19.20	130.65	75.21	54.55	249.94	167.61	78.37
03/24	111.94	107.23	3.99	111.24	70.66	40.03	116.16	98.88	16.38	120.29	76.17	43.23	255.05	165.16	85.89
03/25	111.70	94.19	16.98	116.02	68.62	46.93	123.74	121.74	1.15	122.88	84.33	37.65	239.55	169.42	66.13
03/26	123.38	105.35	17.38	121.27	69.27	51.58	128.40	122.73	4.95	129.42	89.38	39.48	264.39	171.46	88.93
03/27	127.85	86.41	41.08	124.70	84.22	40.00	133.21	121.95	10.48	136.51	89.32	46.39	285.78	173.08	108.70

Table C. Continued.

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill
03/29	112.89	110.51	1.58	114.03	78.55	35.00	121.69	120.05	0.85	122.32	84.68	36.90	292.40	167.70	120.70
03/30	99.36	97.97	0.73	106.55	64.63	41.25	113.62	112.29	0.41	113.78	84.05	28.86	277.23	167.39	105.83
03/31	95.46	95.09	0.00	103.64	79.35	23.73	112.30	111.51	0.00	122.48	90.19	31.49	290.90	172.70	114.20
04/01	85.25	84.80	0.00	85.12	84.53	0.00	92.60	91.81	0.00	88.49	87.43	0.37	239.15	172.08	63.07
04/02	86.27	72.19	13.72	86.71	73.89	12.35	90.86	81.78	8.49	92.59	90.58	1.32	260.26	176.19	80.07
04/03	89.21	61.40	27.50	92.98	67.70	24.82	100.34	82.42	17.14	101.29	74.25	26.35	239.65	175.55	60.10
04/04	83.53	55.32	27.65	80.32	57.91	21.83	86.14	68.82	16.46	92.06	30.30	61.03	223.07	174.13	44.94
04/05	79.65	48.48	30.60	76.53	51.79	24.02	81.86	64.27	16.88	85.92	25.45	59.70	226.25	172.14	50.11
04/06	76.95	46.24	29.79	72.06	46.84	24.57	75.41	57.67	16.85	77.90	19.91	57.05	247.39	171.92	71.47
04/07	75.70	43.53	31.80	71.62	45.73	25.18	74.18	55.07	18.15	77.70	19.18	57.46	240.40	168.77	67.64
04/08	74.48	41.54	32.37	72.08	43.23	28.26	76.55	57.90	17.90	80.46	20.51	59.34	249.54	170.99	74.55
04/09	75.00	42.94	31.68	70.51	45.45	24.40	74.17	54.06	19.30	78.81	17.38	60.55	207.59	173.72	30.25
04/10	76.41	42.87	33.25	72.09	46.73	24.72	76.87	57.05	19.09	82.12	22.03	59.38	188.49	174.93	9.57
04/11	72.84	38.85	33.55	68.71	43.46	24.48	71.74	52.18	18.70	76.41	19.01	56.51	184.30	152.43	27.87
04/12	75.29	40.60	34.25	73.10	44.45	27.99	71.98	52.30	18.82	75.98	23.45	51.73	194.05	138.65	51.40
04/13	79.58	43.64	35.15	77.35	51.20	25.12	82.03	62.07	19.11	82.73	19.07	62.73	208.37	150.91	53.46
04/14	81.73	46.13	35.23	78.62	52.43	24.79	81.75	62.24	18.60	86.00	22.82	62.29	240.91	153.88	83.03
04/15	80.16	44.43	35.29	76.59	49.83	26.09	81.64	61.61	19.30	86.85	22.51	63.67	211.23	156.13	51.10
04/16	83.20	47.77	35.13	79.18	53.82	24.71	83.05	64.57	17.55	87.96	23.42	63.67	195.49	140.39	51.10
04/17	85.15	49.21	35.36	81.65	56.61	24.45	85.70	65.94	19.05	88.75	25.42	62.59	182.10	127.00	51.10
04/18	90.95	55.28	35.16	85.30	60.10	24.49	88.50	70.13	17.60	92.41	28.76	62.84	207.14	152.04	51.10
04/19	98.33	63.92	33.83	95.68	71.38	23.65	101.20	82.59	17.63	104.52	38.50	65.08	204.97	149.63	51.33
04/20	118.70	84.60	33.39	113.64	88.68	23.63	121.16	99.19	20.93	126.48	57.66	67.87	267.07	148.87	114.20
04/21	126.29	93.10	32.59	123.01	89.55	32.75	130.08	109.50	19.74	130.84	58.23	71.48	255.40	132.30	119.11
04/22	122.44	89.56	32.50	117.95	98.05	19.10	124.65	110.61	13.13	127.05	54.10	72.20	274.30	154.29	116.01
04/23	118.66	84.69	33.32	112.83	93.95	18.29	119.32	104.48	14.04	123.32	51.15	71.48	323.34	162.77	156.57
04/24	103.93	69.07	34.36	101.68	83.44	17.65	107.31	92.38	14.08	112.98	42.59	69.58	286.70	159.52	123.18
04/25	110.71	58.42	51.27	104.29	88.85	14.65	107.85	93.03	13.91	110.42	39.58	69.91	292.60	157.62	131.05
04/26	113.70	68.03	45.11	109.57	93.68	14.73	114.84	101.71	12.26	116.88	46.21	69.79	284.28	161.55	118.73

Table C. Continued.

	Lower Granite Dam			Little Goose Dam			Lower Monumental Dam			Ice Harbor Dam			McNary Dam		
Date	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill	Avg. Total Dschrg.	Avg. Turbine Dschrg.	Avg. Total Spill
04/27	123.21	73.58	48.88	117.45	100.85	15.19	124.29	109.77	13.49	127.60	54.59	72.15	291.80	161.74	126.07
04/28	122.00	74.15	47.40	118.98	90.50	27.57	126.73	109.08	16.73	130.25	56.42	72.95	321.08	156.22	160.85
04/30	100.17	65.96	33.49	97.17	76.08	20.51	102.11	84.69	16.64	104.33	37.83	65.69	309.82	162.82	143.00
05/01	98.70	63.83	34.49	95.37	75.21	19.32	97.36	78.90	17.55	100.11	33.00	66.17	282.53	149.42	129.11
05/02	102.21	67.40	34.42	101.24	82.98	17.48	106.01	88.31	16.91	108.43	34.94	72.60	298.90	154.00	140.90
05/03	103.83	68.40	34.50	99.50	81.44	17.22	102.33	85.78	15.58	107.05	36.40	69.53	304.56	161.66	138.90
05/04	109.08	74.27	34.23	106.50	87.09	18.54	113.75	97.15	15.68	116.38	44.46	71.29	298.89	160.09	134.80
05/05	100.67	65.91	34.16	94.54	73.44	20.33	98.10	81.90	15.30	103.39	31.18	71.39	294.68	155.36	135.32
05/06	98.19	63.18	34.64	94.54	72.74	21.09	102.08	81.79	19.38	105.38	32.51	72.06	286.20	159.64	122.56
05/07	91.99	57.13	34.48	88.31	67.08	20.83	88.81	69.83	18.25	93.72	28.15	64.68	270.17	162.19	103.98
05/08	95.70	60.74	34.51	92.94	72.58	19.75	97.90	79.10	18.08	101.71	27.69	73.20	263.12	148.31	110.81
05/09	93.38	58.27	34.71	89.34	68.66	20.02	91.99	73.50	17.64	94.43	23.79	69.97	254.43	142.24	108.20
05/10	95.78	61.76	33.50	93.00	71.59	20.69	95.86	75.98	18.98	99.55	27.82	70.79	283.54	150.85	128.69
05/11	88.42	54.14	33.63	84.74	63.07	21.08	89.79	71.35	17.64	93.72	26.98	65.93	245.62	129.39	112.23
05/12	86.96	51.30	35.28	82.35	59.31	22.34	86.20	66.60	18.61	90.07	24.35	64.75	244.24	125.08	115.17
05/13	86.50	50.85	35.31	81.53	58.82	22.05	83.67	64.95	17.92	87.60	29.57	57.29	239.24	128.50	106.74
05/14	86.64	50.78	35.35	83.05	60.08	22.45	85.94	66.23	18.92	90.99	28.40	61.78	262.39	144.13	114.27
05/15	83.08	47.42	35.15	80.80	57.53	22.86	83.24	64.50	18.00	86.42	23.68	61.92	261.15	147.29	109.86
05/16	81.13	44.49	36.05	78.20	52.94	24.80	80.43	58.92	20.48	86.89	26.39	59.69	248.33	139.78	104.55
05/17	82.66	46.85	35.30	78.82	55.65	22.50	81.57	61.59	19.07	85.90	25.59	59.48	264.38	145.50	114.89
05/18	82.26	46.73	34.95	78.21	54.80	22.71	78.59	58.23	19.46	84.30	26.78	56.78	251.59	138.94	108.65
05/19	88.74	53.20	35.23	84.06	60.87	22.10	88.24	68.67	18.60	89.84	27.08	61.78	262.39	147.89	110.50
05/20	88.87	52.95	35.35	86.45	63.76	21.99	88.88	69.00	19.10	94.27	22.92	70.65	270.69	143.14	123.38
05/21	94.36	59.10	34.76	89.81	67.40	21.90	91.39	73.09	17.60	98.28	30.79	65.81	273.96	148.05	121.92
05/22	113.63	68.70	44.29	107.48	84.64	22.17	113.33	92.64	19.78	117.38	50.24	66.08	248.98	136.36	108.62
05/23	115.75	80.26	34.99	111.51	88.26	22.66	115.50	94.74	19.86	116.42	45.65	70.02	252.38	137.33	111.04
05/24	131.41	88.51	42.31	124.85	97.85	26.46	131.02	111.04	19.19	132.20	58.43	72.89	237.76	137.06	96.70
05/25	154.76	97.86	56.17	144.46	106.41	37.41	150.89	115.62	34.42	157.12	76.13	80.24	302.34	163.64	134.70
05/26	181.25	102.12	78.77	172.81	98.52	73.64	184.48	121.18	62.44	178.55	70.70	106.96	310.16	161.63	144.53

Table C. Continued.

Date	Lower Granite Dam Avg. Total Dschrg.	Lower Granite Dam Avg. Turbine Dschrg.	Lower Granite Dam Avg. Total Spill	Little Goose Dam Avg. Total Dschrg.	Little Goose Dam Avg. Turbine Dschrg.	Little Goose Dam Avg. Total Spill	Lower Monumental Dam Avg. Total Dschrg.	Lower Monumental Dam Avg. Turbine Dschrg.	Lower Monumental Dam Avg. Total Spill	Ice Harbor Dam Avg. Total Dschrg.	Ice Harbor Dam Avg. Turbine Dschrg.	Ice Harbor Dam Avg. Total Spill	McNary Dam Avg. Total Dschrg.	McNary Dam Avg. Turbine Dschrg.	McNary Dam Avg. Total Spill
05/27	187.52	102.39	84.61	178.54	114.69	63.28	186.12	119.19	66.07	195.91	68.88	125.93	388.58	165.70	218.88
05/28	161.37	101.88	58.84	153.95	113.51	39.46	150.68	113.86	35.78	162.10	70.01	91.14	352.77	165.58	183.18
05/29	157.77	99.40	57.93	149.76	111.60	37.45	156.86	120.73	35.09	159.95	76.81	82.02	321.22	162.50	167.23
05/30	172.07	99.99	71.58	164.06	113.36	49.93	172.51	121.71	49.75	174.28	81.13	92.20	328.63	149.63	175.00
06/01	169.23	102.99	65.60	160.37	116.06	43.71	168.50	122.52	45.25	171.24	81.34	89.15	336.36	163.40	168.97
06/02	174.28	103.57	70.40	165.50	118.46	46.33	176.63	122.59	53.17	178.60	75.02	102.18	360.92	163.28	193.43
06/03	161.73	100.82	60.26	155.55	112.78	42.05	164.37	120.36	43.16	168.55	73.44	94.30	359.30	164.31	190.98
06/04	152.54	93.00	58.98	148.13	108.15	39.31	153.96	115.43	37.62	156.18	59.34	95.91	351.21	166.25	180.96
06/05	151.73	94.99	56.44	143.15	105.56	37.08	149.20	110.91	37.52	153.76	68.72	84.30	369.40	164.71	200.70
06/06	146.45	95.12	51.03	139.11	109.12	29.46	145.08	115.77	28.59	148.58	72.55	75.34	349.78	165.88	179.90
06/07	138.35	93.43	44.48	131.46	108.90	21.92	138.09	118.60	18.58	141.28	70.25	70.33	338.90	165.11	169.78
06/08	137.75	77.60	59.48	132.51	107.20	24.73	138.96	117.33	20.83	142.45	71.38	70.24	332.92	159.69	169.35
06/09	129.84	86.56	42.79	125.09	90.90	33.49	129.73	103.88	24.94	131.44	56.63	74.00	355.82	161.74	190.10
06/10	118.30	81.23	36.70	113.88	93.15	20.20	120.83	104.91	15.18	124.79	56.17	68.00	323.09	165.94	153.11
06/11	108.84	76.21	31.96	105.85	85.65	19.73	110.18	94.48	14.93	114.08	45.58	67.81	296.99	163.55	129.44
06/12	107.65	71.59	35.49	105.95	85.18	20.20	109.43	93.28	15.30	113.88	44.70	68.10	315.25	162.60	148.65
06/13	108.16	74.50	33.07	104.73	83.13	20.96	108.48	89.77	17.87	110.49	42.81	66.75	299.78	158.88	136.90
06/14	118.84	82.11	36.14	112.60	89.14	22.75	119.14	101.56	16.79	121.93	54.60	66.70	299.53	159.23	136.45
06/15	131.40	89.77	41.18	125.26	100.33	24.28	132.52	114.07	17.60	135.35	70.29	64.24	321.03	145.97	171.06
06/16	147.70	95.47	51.87	141.25	111.25	29.28	147.43	115.52	30.92	149.11	75.96	72.28	334.33	156.71	173.63
06/17	156.04	99.55	56.00	146.69	104.83	41.41	153.54	121.35	31.45	158.21	89.07	68.52	360.75	160.41	196.31
06/18	157.41	97.48	59.28	152.47	115.48	36.36	159.23	119.38	39.01	160.81	88.72	71.29	343.62	157.67	181.95
06/19	165.77	101.54	63.71	159.12	116.87	41.72	165.43	118.47	46.10	166.25	87.18	78.14	336.04	160.50	171.54
06/20	162.56	100.90	61.01	156.12	120.50	35.00	166.48	122.05	43.51	173.19	87.31	84.89	336.88	160.03	172.85
06/21	150.59	101.15	48.87	146.65	116.53	29.55	151.40	121.49	29.12	153.52	75.77	77.00	326.47	154.99	167.48
06/22	144.97	94.53	49.87	139.43	112.65	25.88	143.28	120.63	21.69	148.85	78.13	69.89	314.60	160.51	150.09
06/23	133.64	87.22	45.99	131.84	112.32	18.93	135.86	120.81	14.19	138.70	72.24	65.65	352.26	153.06	195.20
06/24	121.54	77.47	43.61	116.10	112.29	3.28	120.98	118.78	1.42	124.73	60.73	63.29	339.68	160.75	174.93

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 19 to November 13, 1998.

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 20 to November 13, 1998.

	Upper Trap Site		Lower Trap Site	
Date	Natural Chinook	Natural Steelhead	Natural Chinook	Natural Steelhead
10/20/1998	163	2	140	31
10/21/1998	315	3	91	17
10/22/1998	235		82	20
10/23/1998	158	3	100	15
10/27/1998			37	
10/28/1998	171	1	79	1
10/29/1998	131	2	71	2
10/30/1998	172	2	115	6
11/2/1998	59			
11/3/1998	109	1	52	13
11/4/1998	20	1	15	2
11/5/1998	25	2	33	42
11/6/1998	279	1	321	55
11/10/1998	607	2	947	113
11/13/1998			258	4
Total	2,444	20	2,341	321

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 March 1 to June 24, 1999.

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 March 1 to June 24, 1999.

	Natural Chinook		Hatchery Chinook		Natural Steelhead		Hatchery Steelhead	
Date	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B
1-Mar								
2-Mar	60							
3-Mar	142				8			
4-Mar	86							
5-Mar	51	27			1			
6-Mar								
7-Mar								
8-Mar	32		1					
9-Mar	29		1		3		1	
10-Mar	27		2					
11-Mar	22							
12-Mar	19				1			
13-Mar								
14-Mar								
15-Mar	21				1			
16-Mar	30		2					
17-Mar	37				1			
18-Mar	58		34					
19-Mar	42		335					
20-Mar	55		140					
21-Mar								
22-Mar	19		71		1			
23-Mar	51	32	216	109	2			
24-Mar	74	29	247	98	4			
25-Mar	47		138		4			
26-Mar								
27-Mar								
28-Mar	224		134		16			
29-Mar	75		45					
30-Mar	52		20					
31-Mar	107	91	49	7	4	2		
1-Apr	124	134	28	25	5	3		
2-Apr	215		86		3			
3-Apr	76	30	71	26	3			

Appendix E. Continued.

	Natural Chinook		Hatchery Chinook		Natural Steelhead		Hatchery Steelhead	
Date	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B
4-Apr	57	44	173	161	2			
5-Apr	37	36	90	83	1			
6-Apr	79	63	47	44	1			
7-Apr	94	58	967	841	1	1		
8-Apr	29		293		1			
9-Apr	71		240		2			
10-Apr	215		510		2			
11-Apr	161		715		2			
12-Apr	88		166		4		1	
13-Apr	57		1,001		3			
14-Apr	97		315		3		14	
15-Apr	191		555		7		461	
16-Apr	222		287		8		557	
17-Apr	377		539		17		838	
18-Apr	393		2,611		59		176	
19-Apr	134		410		53		236	
20-Apr	16		21		12		53	
21-Apr	20		45		25		64	
22-Apr	38		133		29		124	
23-Apr	118		146		42		112	
24-Apr	38		31		25		9	
25-Apr	3		5		1		1	
26-Apr								
27-Apr	12		21		44		41	
28-Apr	5		9		28		41	
29-Apr	48		53		50		55	
30-Apr	71		46		39		48	
1-May								
2-May								
3-May	31		35		42		33	
4-May	43		38		62		49	
5-May	32		36		27		55	
6-May	29		26		54		26	
7-May	32		18		76		34	
8-May								
9-May								

Appendix E. Continued.

	Natural Chinook		Hatchery Chinook		Natural Steelhead		Hatchery Steelhead	
Date	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B
10-May	41		22		66		79	
11-May	58	52	29	40	104	157	175	184
12-May	39	41	23	24	118	127	137	92
13-May	65	40	19	22	208	190	173	170
14-May	31		28		105		144	
15-May								
16-May								
17-May	23		15		157		172	
18-May	9	2	12	5	164	29	253	61
19-May	5		11			262		1,340
20-May	4		4		86		860	
21-May	4				20		342	
22-May								
23-May								
24-May								
25-May								
26-May								
27-May								
28-May								
29-May								
30-May								
31-May								
1-Jun								
2-Jun	10		2		11		73	
3-Jun	6		1		15		61	
4-Jun	5				15		79	
5-Jun	5		1		13		29	
6-Jun								
7-Jun	19		1		19		156	
8-Jun		16				16	3	147
9-Jun	5	12			17	15	102	145
10-Jun	6	2	1		8	4	55	66
11-Jun	27				10		87	
12-Jun								
13-Jun								
14-Jun	4	7			3	4	24	48

Appendix E. Continued.

Date	Natural Chinook Trap A	Natural Chinook Trap B	Hatchery Chinook Trap A	Hatchery Chinook Trap B	Natural Steelhead Trap A	Natural Steelhead Trap B	Hatchery Steelhead Trap A	Hatchery Steelhead Trap B
15-Jun	1	4			7	7	104	164
16-Jun	3				3		67	
17-Jun	4				1		69	
18-Jun							49	
19-Jun								
20-Jun								
21-Jun	1						40	
22-Jun	3						36	
23-Jun	4				2		22	
24-Jun							21	
Total per Trap:	4,995	720	11,371	1,485	1,931	817	6,441	2,417
Total per rearing and species:		5,715		12,856		2,748		8,858

Appendix F

The daily catch at the upper and lower Imnaha River traps during the fall and spring versus the average daily flow and temperature. The upper Imnaha River trap was operated from October 19 to November 13. The lower Imnaha River trap was operated from October 19 to November 13 and March 1 to June 24, 1999.

Appendix F. The daily catch at the upper and lower Imnaha River traps during the fall and spring versus the average daily flow and temperature. The upper Imnaha River trap was operated from October 19 to November 13. The lower Imnaha River trap was operated from October 19 to November 13 and March 1 to June 24, 1999.

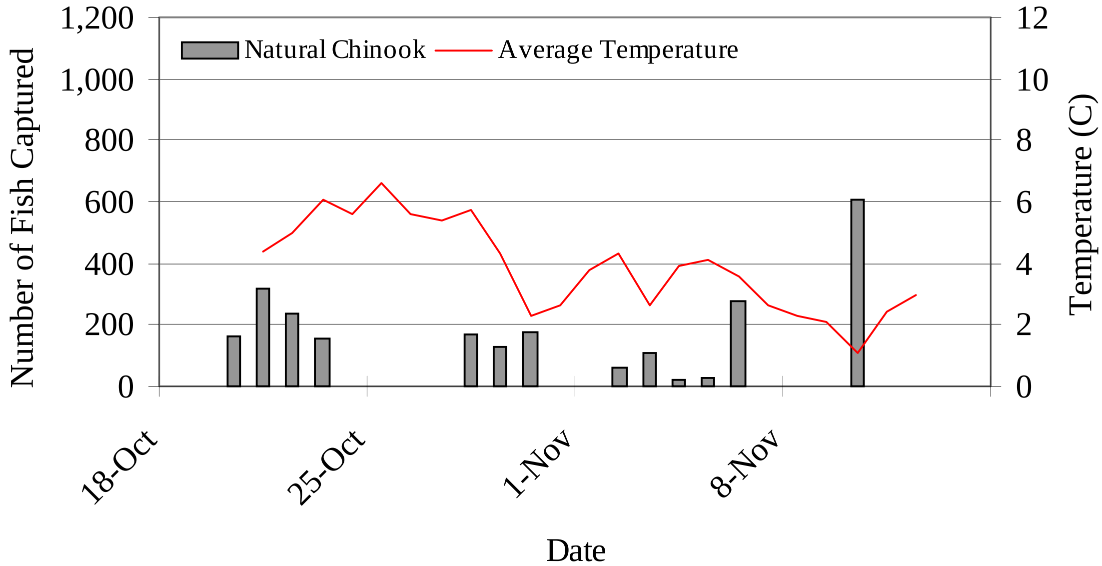


Figure F-1. The daily catch of natural chinook salmon at the upper trap and the daily average temperature at rkm 74, from October 19 to November 13, 1998.

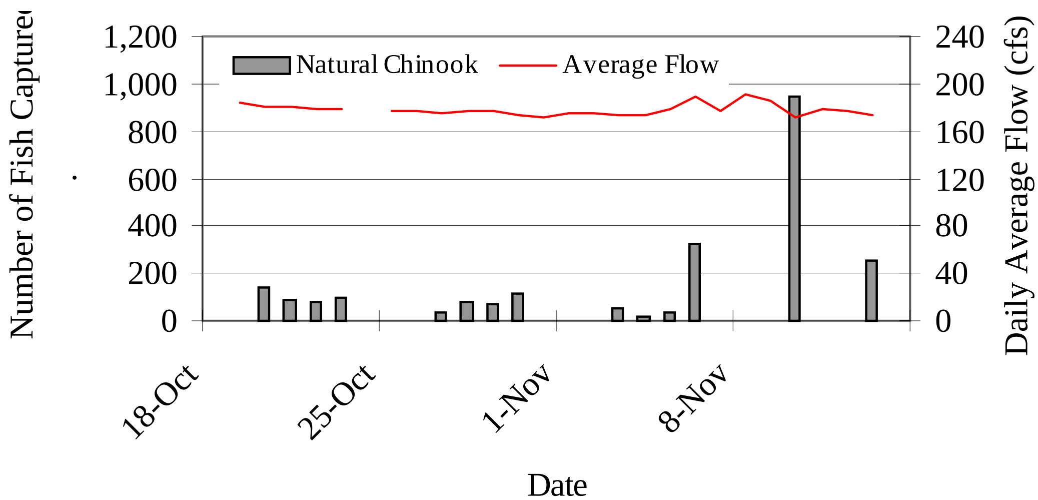


Figure F-2. The daily catch of natural chinook salmon at the lower trap and the daily average flow at the Imnaha stream gauge (1329000), from October 19 to November 13, 1998.

Appendix F. Continued.

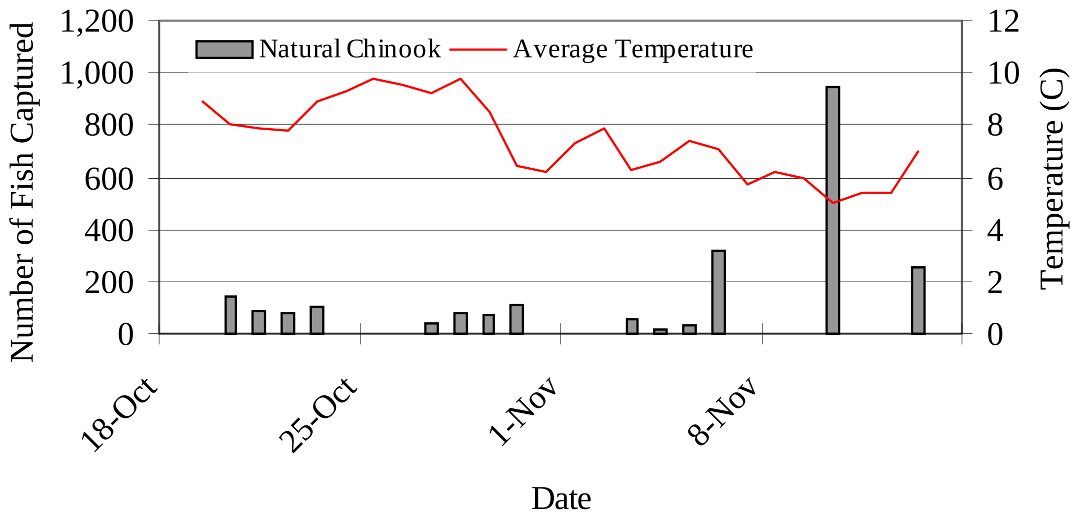


Figure F-3. The daily catch of natural chinook salmon at the lower Imnaha trap and the daily average temperature at rkm 7, from October 19 to November 13, 1998.

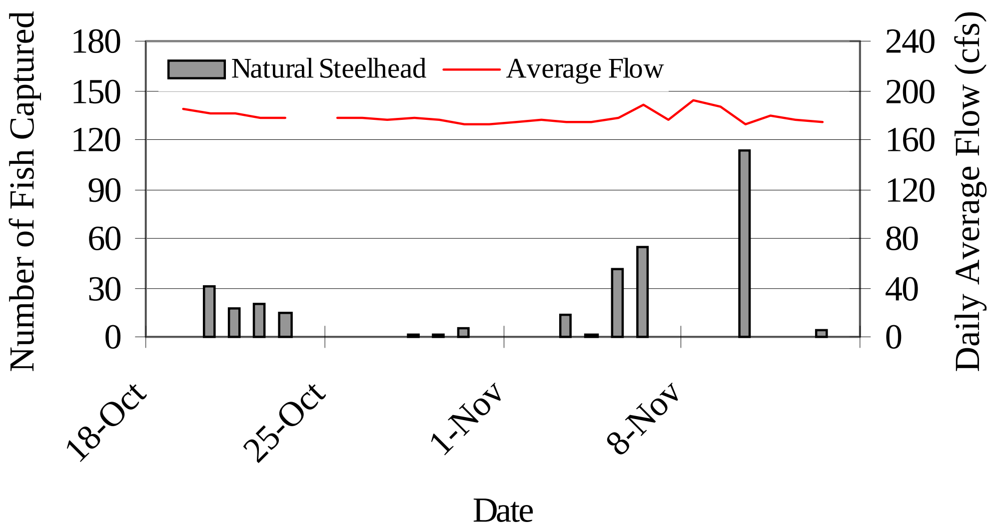


Figure F-4. The daily catch of natural steelhead at the lower trap and the daily average flow at the Imnaha stream gauge (1329000), from October 19 to November 13, 1998.

Appendix F. Continued.

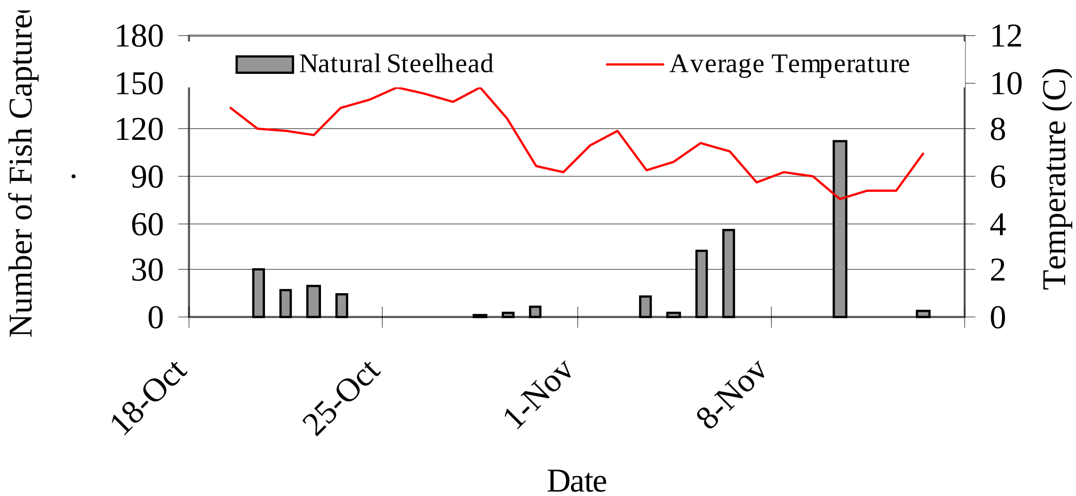


Figure F-5. The daily catch of natural steelhead at the lower Imnaha trap and the daily average temperature at rkm 7, from October 19 to November 13, 1998.

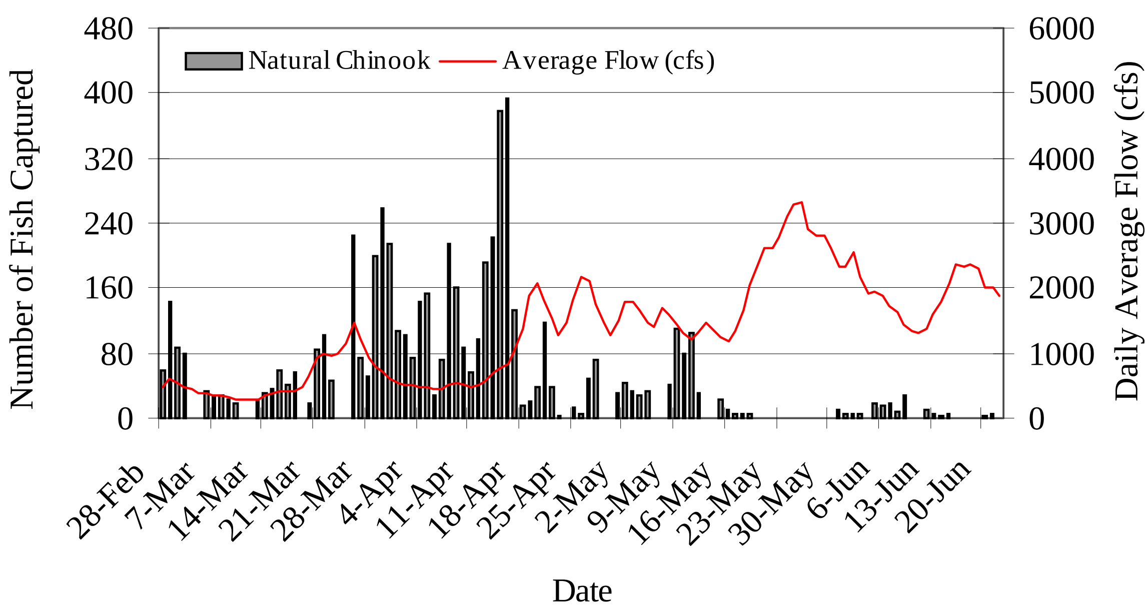


Figure F-6. The daily catch of natural chinook salmon at the lower trap and the daily average flow at the Imnaha stream gauge (1329000), from March 1 to June 24, 1999.

Appendix F. Continued.

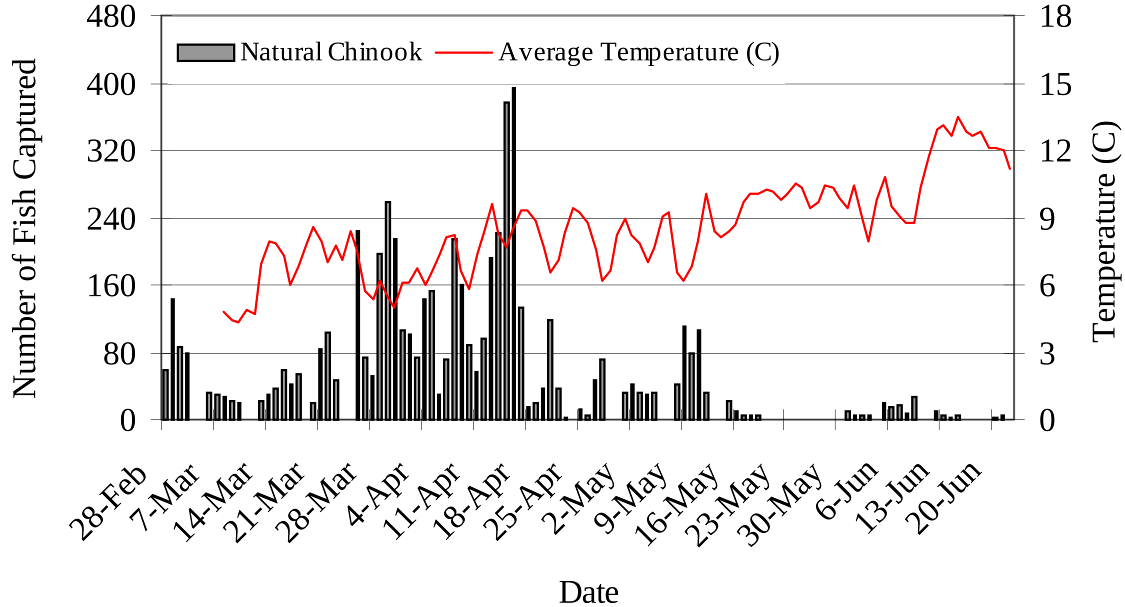


Figure F-7. The daily catch of natural chinook salmon at the lower Imnaha trap and the daily average temperature at rkm 7, from March 1 to June 24, 1999.

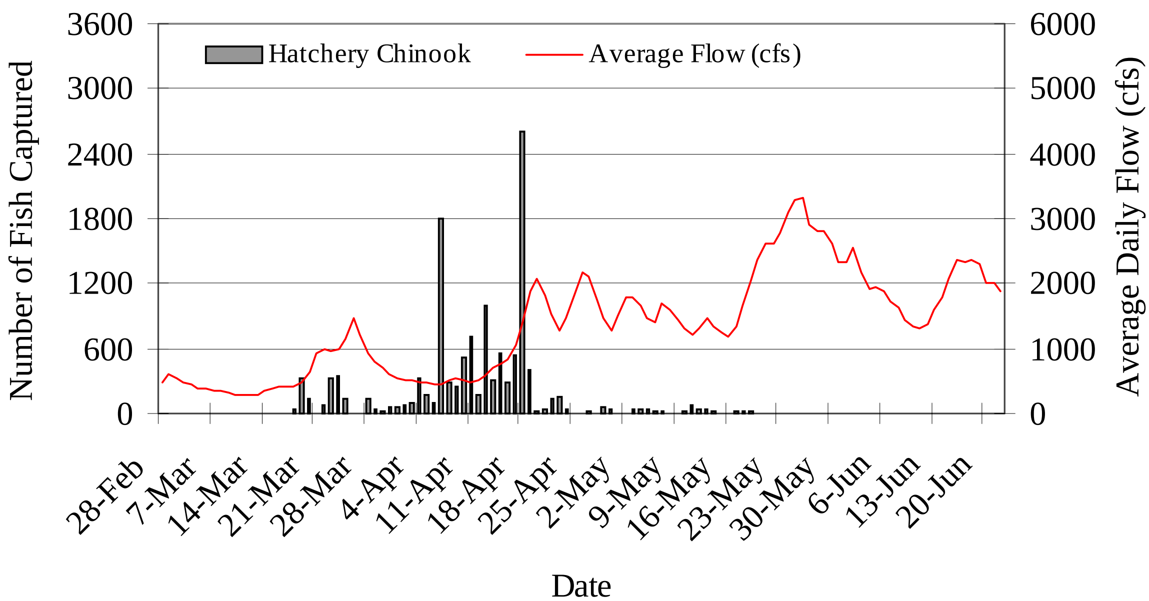


Figure F-8. The daily catch of hatchery chinook salmon at the lower trap and the daily average flow at the Imnaha stream gauge (1329000), from March 1 to June 24, 1999.

Appendix F. Continued.

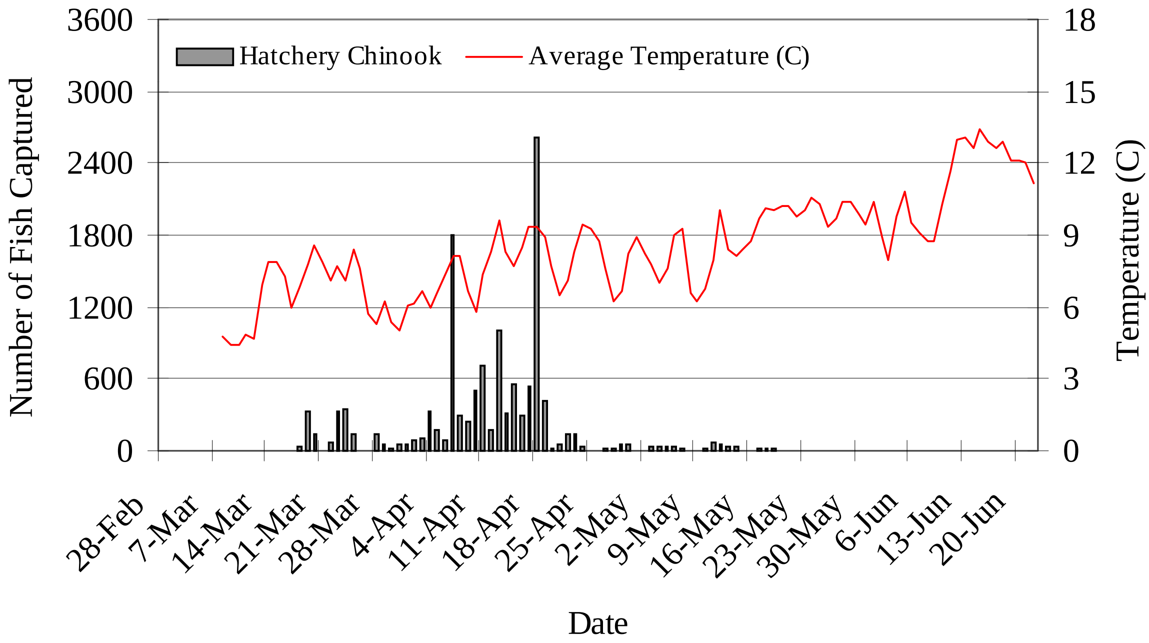


Figure F-9. The daily catch of hatchery chinook salmon at the lower Imnaha trap and the daily average temperature at rkm 7, from March 1 to June 24, 1999.

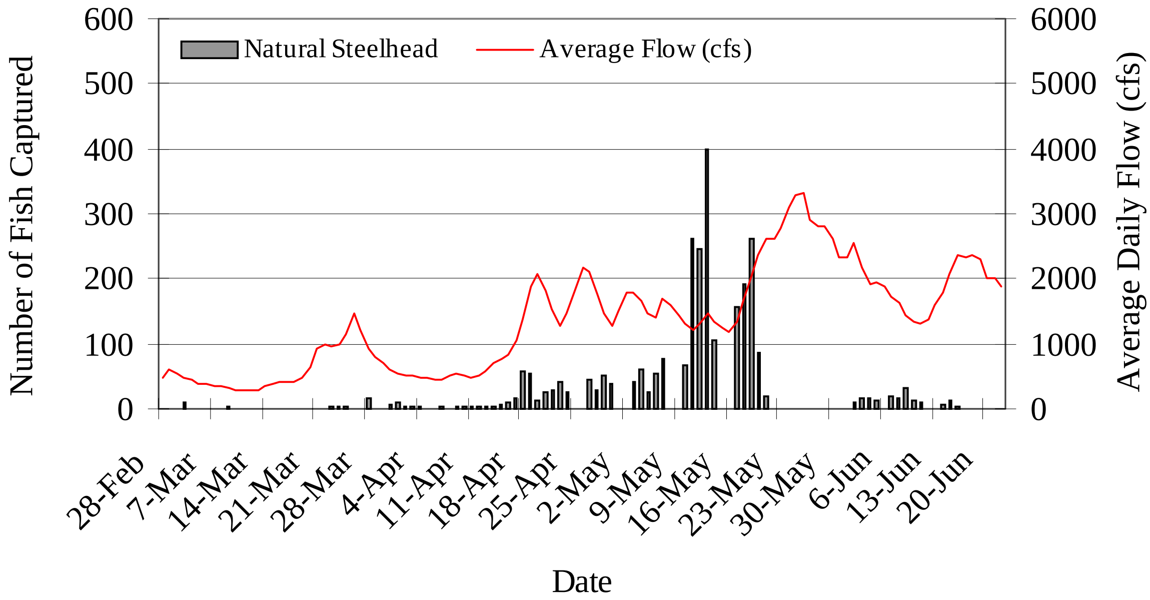


Figure F-10. The daily catch of natural steelhead at the lower trap and the daily average flow at the Imnaha stream gauge (1329000), from March 1 to June 24, 1999.

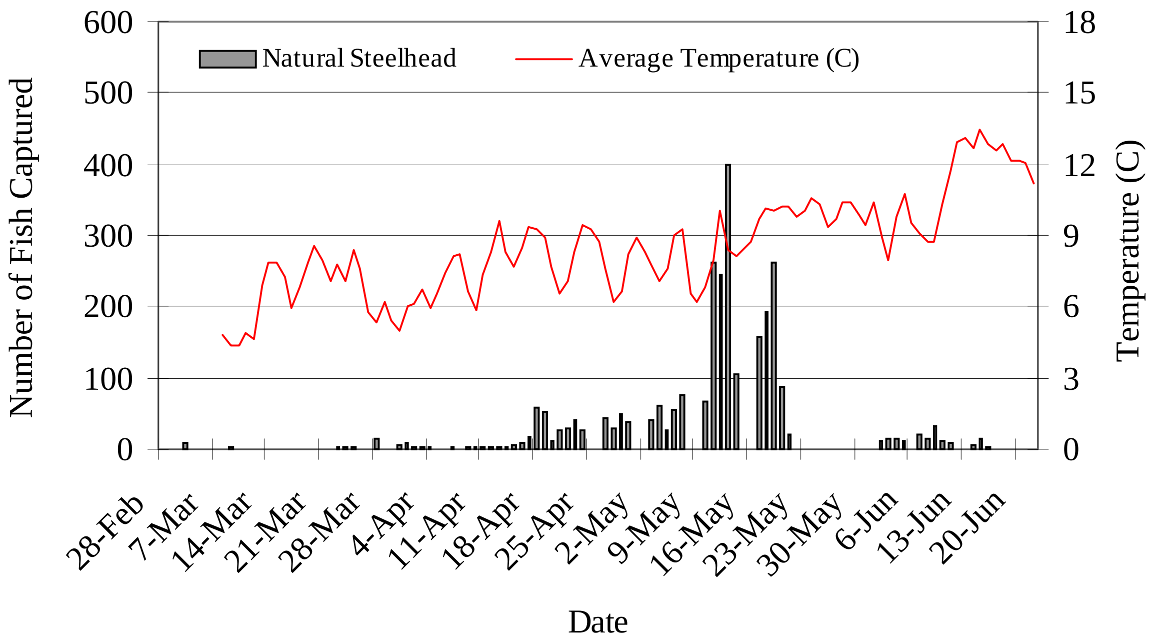


Figure F-11. The daily catch of natural steelhead at the lower Imnaha trap and the daily average temperature at rkm 7, from March 1 to June 24, 1999.

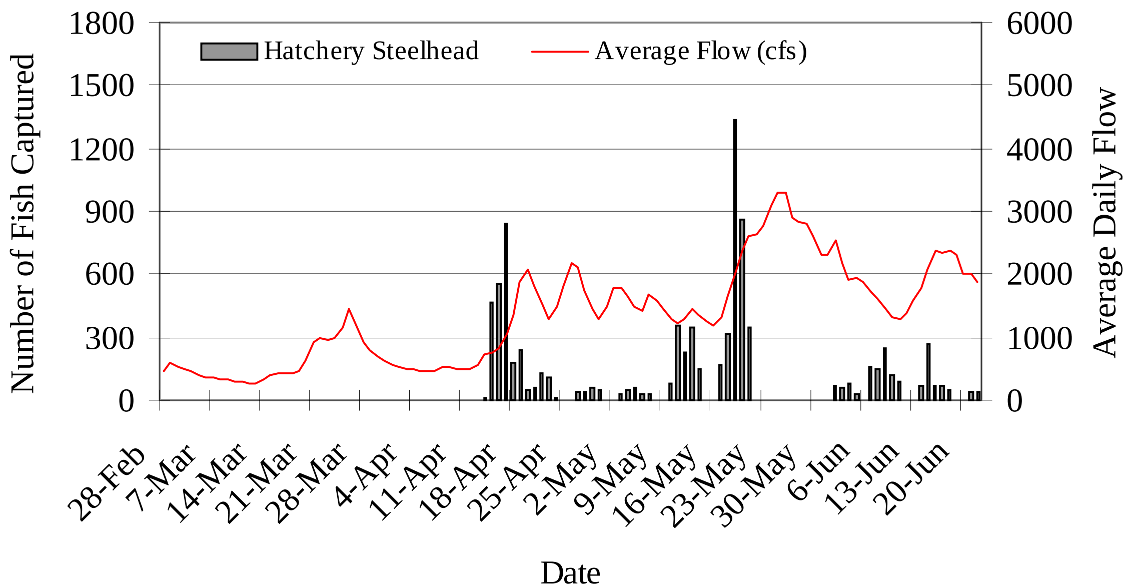


Figure F-12. The daily catch of hatchery steelhead at the lower trap and the daily average flow at the Imnaha stream gauge (1329000), from March 1 to June 24, 1999.

Appendix F. Continued.

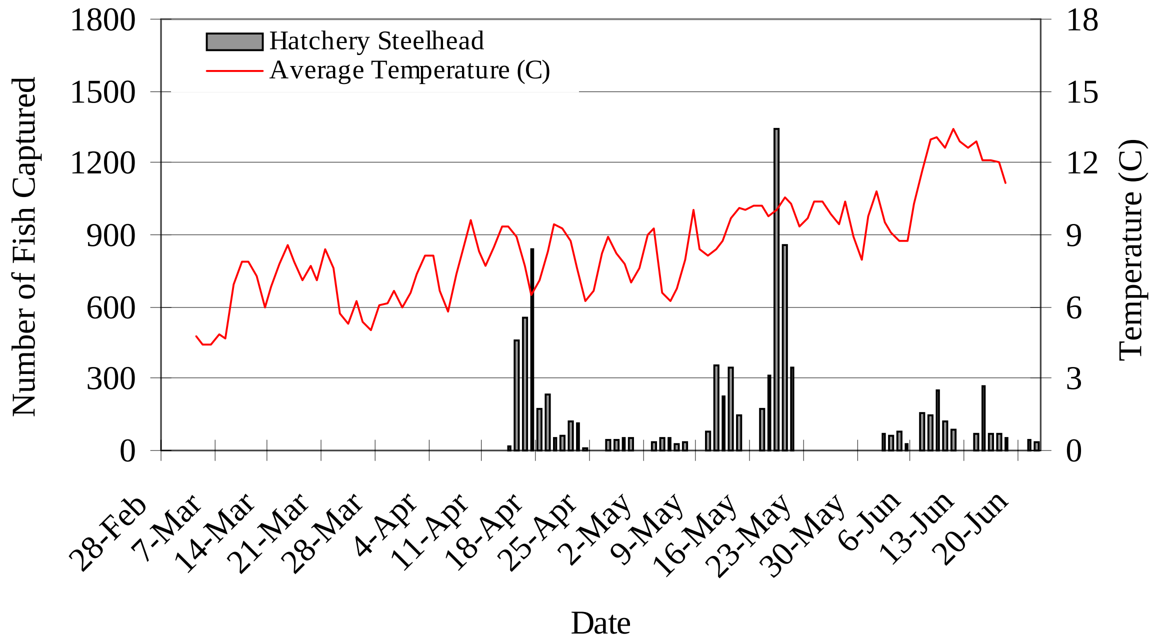


Figure F-13. The daily catch of hatchery steelhead at the lower Imnaha trap and the daily average temperature at rkm 7, from March 1 to June 24, 1999.

Appendix G

Daily mean fork lengths, weights, and condition factors with standard deviations for natural and hatchery chinook salmon and steelhead captured in the Imnaha River screw traps during the spring emigration of 1999.

Table G. Daily mean fork lengths, weights, and condition factors with standard deviations for natural and hatchery chinook salmon and steelhead captured in the Imnaha River screw traps during the spring emigration of 1999.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
Natural Chinook Salmon						
2-Mar	106	11.2	12.9	4.48	1.04	0.085
3-Mar	104	10.9	11.6	3.56	0.99	0.060
4-Mar	104	10.4	11.5	3.41	0.99	0.055
5-Mar	99	9.9	10.3	3.02	1.02	0.063
8-Mar	102	9.4	10.9	3.10	1.02	0.079
9-Mar	101	9.1	10.6	3.05	0.99	0.049
10-Mar	102	10.2	11.3	3.12	1.03	0.067
11-Mar	100	9.1	10.2	2.92	1.01	0.056
12-Mar	102	6.2	10.7	2.14	1.00	0.058
15-Mar	104	8.7	13.4	4.38	1.16	0.227
16-Mar	107	10.6	12.3	4.03	0.98	0.063
17-Mar	106	9.5	12.1	3.14	0.98	0.090
18-Mar	106	10.2	11.7	3.57	0.97	0.067
19-Mar	103	9.2	11.0	2.80	1.01	0.078
20-Mar	106	9.6	12.1	3.71	0.99	0.071
22-Mar	105	6.6	11.8	2.21	1.00	0.079
23-Mar	107	10.1	13.0	3.88	1.03	0.073
24-Mar	103	9.8	11.5	3.45	1.04	0.068
25-Mar	103	8.5	11.6	3.02	1.02	0.066
28-Mar	116	8.1	13.2	2.93	0.82	0.047
29-Mar	106	8.0	12.6	3.22	1.04	0.072
30-Mar	106	10.0	12.6	3.97	1.04	0.048
31-Mar	105	7.1	12.2	2.50	1.04	0.058
1-Apr	102	8.2	12.0	3.01	1.12	0.066
2-Apr	99	8.2	11.6	2.86	1.17	0.110
3-Apr	101	9.4	12.8	3.22	1.20	0.124
4-Apr	100	8.3	12.1	3.09	1.19	0.069
5-Apr	101	7.5	12.3	2.84	1.18	0.069
6-Apr	99	8.9	11.7	3.53	1.18	0.073
7-Apr	101	7.8	12.0	2.91	1.14	0.082
8-Apr	102	8.8	12.7	3.44	1.17	0.098
9-Apr	103	7.9	11.7	2.91	1.05	0.063

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
10-Apr	101	8.3	12.4	3.20	1.18	0.101
11-Apr	101	9.0	11.5	2.48	1.18	0.084
12-Apr	105	9.9	12.8	3.92	1.06	0.100
13-Apr	102	8.2	12.3	3.29	1.12	0.069
14-Apr	104	10.3	13.3	4.35	1.13	0.082
15-Apr	106	8.9	14.1	3.65	1.15	0.089
16-Apr	104	9.3	13.3	3.67	1.15	0.089
17-Apr	106	9.1	13.8	3.70	1.15	0.078
18-Apr	108	10.7	14.2	4.72	1.11	0.070
19-Apr	114	9.6	13.8	3.35	0.94	0.136
20-Apr	109	9.4	15.0	3.93	1.13	0.061
21-Apr	109	11.2	15.4	4.24	1.16	0.131
22-Apr	107	7.6	13.6	3.02	1.10	0.075
23-Apr	106	9.2	12.5	3.45	1.02	0.076
24-Apr	102	9.2	11.8	3.31	1.07	0.074
25-Apr	111	6.1				
27-Apr	103	5.5	12.3	2.09	1.13	0.073
28-Apr	104	7.4	12.0	2.89	1.05	0.066
29-Apr	104	9.2	12.7	3.17	1.11	0.083
30-Apr	104	7.3	12.3	2.86	1.07	0.075
3-May	112	8.9	11.5	2.98	0.79	0.046
4-May	105	7.9	12.2	3.12	1.03	0.077
5-May	106	13.8	13.7	7.00	1.10	0.123
6-May	106	8.6	12.6	3.15	1.04	0.059
7-May	106	8.8	13.5	3.59	1.13	0.076
10-May	100	13.3	11.6	5.75	1.10	0.100
11-May	105	10.4	11.8	3.35	0.99	0.120
12-May	101	8.1	11.1	2.59	1.05	0.087
13-May	101	8.5	10.9	2.77	1.03	0.096
14-May	98	10.7	9.7	2.54	1.06	0.099
17-May	100	10.3	10.3	3.36	1.01	0.072
18-May	107	8.5	12.7	3.07	1.02	0.064
19-May	110	13.9	13.3	4.41	0.97	0.138
20-May	103	8.0	11.4	3.10	1.01	0.047
21-May	104	8.1	11.6	2.71	1.02	0.007

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
2-Jun	107	6.2	13.9	3.03	1.11	0.065
3-Jun	103	8.2	13.1	3.15	1.18	0.067
4-Jun	101	7.0	11.9	2.75	1.14	0.070
5-Jun	106	6.5	13.0	2.19	1.10	0.102
7-Jun	102	7.8	11.1	2.58	1.04	0.054
8-Jun	103	9.4	11.8	3.14	1.06	0.086
9-Jun	107	8.7	12.7	3.29	1.03	0.059
10-Jun	103	8.6	11.8	2.68	1.08	0.036
11-Jun	104	7.7	12.2	2.69	1.09	0.069
14-Jun	104	6.9	12.6	0.95	1.04	0.043
15-Jun	109	2.9	13.5	2.19	1.04	0.165
16-Jun	89	26.2	13.7	NA	1.12	NA
17-Jun	105	10.4	13.2	5.66	1.09	0.132
21-Jun	105	NA	9.7	NA	0.84	NA
22-Jun	100	4.0	10.5	1.05	1.03	0.024
23-Jun	109	2.3	12.1	1.24	0.94	0.039
Hatchery Chinook Salmon						
8-Mar	138	NA	28.8	NA	1.10	NA
9-Mar	133	NA	23.8	NA	1.01	NA
10-Mar	136	4.9	27.9	2.55	1.12	0.020
16-Mar	129	4.2	22.6	4.67	1.05	0.114
18-Mar	141	14.2	32.2	12.27	1.13	0.105
19-Mar	130	12.4	24.6	8.69	1.09	0.076
20-Mar	130	9.6	23.9	5.75	1.09	0.070
22-Mar	133	10.2	26.1	6.82	1.08	0.081
23-Mar	136	11.0	28.1	5.66	1.09	0.063
24-Mar	133	11.9	26.5	7.92	1.11	0.079
25-Mar	136	15.4	27.9	11.77	1.07	0.082
28-Mar	143	13.1	26.8	9.00	0.88	0.085
29-Mar	134	13.3	26.7	8.96	1.07	0.113
30-Mar	133	15.9	25.8	9.84	1.05	0.062
31-Mar	133	18.5	26.3	14.21	1.06	0.068
1-Apr	128	9.8	23.7	5.62	1.10	0.053
2-Apr	127	10.7	25.2	5.96	1.21	0.098

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
3-Apr	128	10.7	25.0	6.78	1.17	0.086
4-Apr	131	10.9	27.6	7.83	1.21	0.083
5-Apr	132	11.9	27.3	8.34	1.17	0.070
6-Apr	129	11.6	25.3	6.02	1.19	0.090
7-Apr	138	7.6	30.0	5.16	1.13	0.068
8-Apr	138	8.9	30.3	6.92	1.14	0.073
9-Apr	137	9.7	29.0	6.61	1.12	0.065
10-Apr	132	9.8	26.9	6.76	1.15	0.075
11-Apr	129	10.2	26.4	6.62	1.20	0.067
12-Apr	131	9.8	26.0	6.92	1.13	0.074
13-Apr	136	10.6	28.5	7.07	1.12	0.080
14-Apr	130	12.2	26.2	7.55	1.15	0.064
15-Apr	134	14.7	23.5	9.26	1.13	0.103
16-Apr	134	12.7	22.5	5.62	1.13	0.144
17-Apr	132	10.4	22.4	4.40	1.15	0.082
18-Apr	128	8.8	22.7	4.26	1.14	0.085
19-Apr	134	9.0	23.2	4.00	0.97	0.163
20-Apr	131	9.1	25.4	5.56	1.14	0.070
21-Apr	131	9.3	25.9	6.12	1.14	0.102
22-Apr	132	10.1	25.2	6.02	1.09	0.079
23-Apr	132	10.0	24.6	6.62	1.04	0.084
24-Apr	127	11.0	21.7	5.74	1.03	0.068
25-Apr	130	7.3				
27-Apr	131	8.0	24.8	3.87	1.09	0.073
28-Apr	130	6.8	23.2	3.82	1.06	0.061
29-Apr	126	7.5	21.2	3.65	1.06	0.061
30-Apr	132	10.1	25.2	6.61	1.09	0.087
3-May	140	8.7	22.5	4.55	0.81	0.045
4-May	133	11.5	24.6	6.77	1.01	0.048
5-May	132	11.7	25.8	7.73	1.08	0.074
6-May	134	13.7	24.9	9.00	1.00	0.069
7-May	130	8.2	23.4	4.46	1.07	0.076
10-May	134	13.8	26.4	8.98	1.05	0.066
11-May	131	11.1	22.3	6.73	0.97	0.082
12-May	132	14.6	24.8	8.98	1.03	0.102

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
13-May	134	9.8	24.5	5.96	1.02	0.080
14-May	132	14.0	21.6	11.17	1.01	0.084
17-May	152	33.9	38.0	26.60	0.97	0.058
18-May	135	10.6	24.3	6.54	0.99	0.054
19-May	126	11.1	20.5	5.94	0.99	0.060
20-May	121	3.6	18.0	1.32	1.01	0.107
2-Jun	126	19.1	22.9	12.87	1.09	0.148
3-Jun	133	NA	23.5	NA	1.00	NA
5-Jun						
7-Jun	126	NA	18.1	NA	0.90	NA
10-Jun	130	NA	21.7	NA	0.99	NA
Natural Steelhead						
3-Mar	183	24.2	64.0	26.15	1.00	0.041
5-Mar	161	NA	38.8	NA	0.93	NA
9-Mar	189	10.6	64.6	10.12	0.95	0.049
12-Mar	206	NA	80.2	NA	0.92	NA
15-Mar	203	NA	83.0	NA	0.99	NA
17-Mar	178	NA	64.5	NA	1.14	NA
22-Mar	213	NA	88.9	NA	0.92	NA
23-Mar	190	4.2	69.5	3.04	1.02	0.112
24-Mar	132	NA	41.3	23.06	0.98	0.114
25-Mar	168	23.8	51.8	18.10	1.08	0.092
28-Mar	201	19.6	70.0	20.35	0.84	0.064
31-Mar	174	19.4	51.9	19.22	0.96	0.012
1-Apr	177	20.7	59.9	19.98	1.03	0.045
2-Apr	196	50.0	89.9	63.63	1.06	0.030
3-Apr	191	15.9	68.2	14.96	0.98	0.062
4-Apr	187	34.6	66.4	38.04	0.96	0.045
5-Apr	223	NA	126.1	NA	1.14	NA
6-Apr	187	NA	66.2	NA	1.01	NA
7-Apr	171	12.7	52.4	10.68	1.04	0.019
8-Apr						
9-Apr	175	4.2	51.3	2.90	0.96	0.015
10-Apr	186	31.1	67.3	31.75	1.01	0.013

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
11-Apr	191	2.1	67.5	11.38	0.97	0.132
12-Apr	173	29.8	42.1	16.37	0.98	0.022
13-Apr	194	26.8	78.8	37.98	1.02	0.069
14-Apr	194	27.0	78.0	32.27	1.03	0.059
15-Apr	183	12.5	64.2	16.60	1.04	0.049
16-Apr	194	25.6	77.7	32.92	1.01	0.072
17-Apr	186	20.3	67.7	22.29	1.03	0.049
18-Apr	173	24.6	56.6	26.34	1.05	0.042
19-Apr	194	17.2	69.2	17.96	0.93	0.094
20-Apr	192	22.4	78.3	28.57	1.06	0.091
21-Apr	188	19.6	73.1	22.12	1.07	0.063
22-Apr	184	20.5	68.2	21.77	1.04	0.084
23-Apr	190	18.1	69.6	18.78	1.00	0.072
24-Apr	181	17.3	59.9	20.78	0.98	0.071
25-Apr	178	NA				
27-Apr	183	15.6	64.6	16.56	1.03	0.055
28-Apr	185	14.2	65.5	15.02	1.02	0.033
29-Apr	189	21.7	71.1	23.42	1.01	0.063
30-Apr	180	20.8	60.8	18.81	1.01	0.063
3-May	197	17.1	65.9	18.99	0.85	0.047
4-May	188	18.1	66.6	20.81	0.97	0.056
5-May	181	20.3	61.0	15.82	1.00	0.057
6-May	188	20.6	67.6	24.32	1.00	0.061
7-May	185	19.6	66.6	23.22	1.01	0.057
10-May	184	16.9	62.8	17.52	0.98	0.059
11-May	184	17.5	60.8	18.41	0.96	0.064
12-May	183	17.8	59.8	19.06	0.96	0.061
13-May	182	17.6	59.4	17.05	0.96	0.059
14-May	182	20.5	57.0	15.44	0.98	0.054
17-May	NA	NA	64.9	21.29	0.95	0.052
18-May	189	18.5	65.4	21.74	0.95	0.055
19-May	186	19.1	64.1	20.89	0.96	0.064
20-May	181	18.0	58.7	17.64	0.98	0.061
21-May	170	19.6	52.4	16.56	1.01	0.087
2-Jun	169	8.0	49.2	7.73	1.01	0.061

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
3-Jun	171	15.6	53.6	14.12	1.06	0.062
4-Jun	176	15.9	55.7	14.20	1.01	0.050
5-Jun	170	19.6	51.3	17.87	1.01	0.063
7-Jun	174	14.6	52.4	14.56	0.97	0.043
8-Jun	175	11.2	53.7	10.33	0.99	0.064
9-Jun	171	11.7	48.5	11.43	0.95	0.050
10-Jun	170	16.3	50.8	13.86	1.01	0.047
11-Jun	165	6.9	46.9	6.20	1.04	0.074
14-Jun	170	10.2	50.7	9.10	0.99	0.084
15-Jun	185	16.2	62.4	15.30	0.98	0.064
16-Jun	168	4.2	48.7	1.82	1.03	0.041
17-Jun	163	NA	42.6	NA	0.98	NA
23-Jun	171	9.2	47.5	5.73	0.96	0.039
Hatchery Steelhead						
9-Mar	189	NA	68.7	NA	1.02	NA
12-Apr	215	NA	78.5	NA	0.79	NA
14-Apr	214	21.8	103.6	34.06	1.03	0.093
15-Apr	210	15.0	98.6	20.99	1.06	0.064
16-Apr	212	14.6	102.4	21.38	1.06	0.056
17-Apr	212	16.4	101.0	22.82	1.04	0.055
18-Apr	200	NA	79.4	NA	0.99	NA
19-Apr	222	14.1	102.5	18.98	0.93	0.075
20-Apr	216	13.4	105.7	21.12	1.03	0.052
21-Apr	212	14.8	100.0	22.33	1.03	0.062
22-Apr	214	15.5	100.9	22.15	1.02	0.063
23-Apr	216	15.0	100.3	21.18	0.99	0.063
24-Apr	217	21.5	101.7	37.59	0.99	0.051
25-Apr	203	NA				
27-Apr	212	21.7	99.8	19.98	0.99	0.049
28-Apr	217	16.4	102.2	23.04	0.98	0.056
29-Apr	218	12.9	102.6	19.23	0.98	0.046
30-Apr	215	12.1	97.6	16.95	0.97	0.054
3-May	226	19.1	101.1	30.39	0.85	0.061
4-May	219	14.1	101.2	22.23	0.94	0.050

Table G. Continued.

Species/Date	Mean Fork Length (mm)	Standard Deviation of Fork Length	Mean Weight (g)	Standard Deviation of Weight	Mean Condition Factor	Standard Deviation of Condition Factor
5-May	218	17.3	104.7	23.17	0.98	0.067
6-May	222	14.4	110.8	24.38	1.00	0.070
7-May	223	17.3	110.1	28.17	0.98	0.063
10-May	223	14.9	107.5	22.25	0.96	0.056
11-May	223	15.7	103.4	23.36	0.91	0.056
12-May	222	17.3	104.8	25.29	0.93	0.062
13-May	224	18.7	107.7	27.18	0.94	0.051
14-May	222	18.2	105.9	26.72	0.95	0.055
17-May	223	16.9	104.9	23.98	0.92	0.048
18-May	226	16.6	106.3	25.98	0.91	0.051
19-May	218	17.7	102.1	26.12	0.97	0.073
20-May	215	19.4	97.9	28.28	0.95	0.060
21-May						
2-Jun	206	17.2	83.1	22.27	0.92	0.057
3-Jun	204	15.1	79.2	19.38	0.91	0.055
4-Jun	209	21.5	88.7	28.33	0.93	0.052
5-Jun	205	21.0	80.7	27.47	0.91	0.043
7-Jun	210	17.5	83.1	21.80	0.89	0.051
8-Jun	211	18.0	84.4	22.34	0.87	0.042
9-Jun	214	18.9	87.4	25.14	0.87	0.049
10-Jun	214	18.2	89.7	24.35	0.90	0.057
11-Jun	212	18.0	88.3	22.21	0.90	0.049
14-Jun	214	20.3	87.2	26.75	0.90	0.037
15-Jun	215	17.8	90.6	24.93	0.89	0.059
16-Jun	208	18.4	85.9	22.64	0.93	0.058
17-Jun	210	19.1	86.7	25.44	0.92	0.049
18-Jun	211	18.0	85.2	23.45	0.89	0.044
21-Jun	213	20.5	87.6	27.96	0.88	0.060
22-Jun	220	18.8	99.5	28.81	0.90	0.050
23-Jun	219	10.3	92.2	17.05	0.87	0.075
24-Jun	210	15.8	88.4	20.14	0.95	0.053

Appendix H

Wilcoxon test values and sample sizes (n) for statistical comparisons of median fork lengths of natural and hatchery chinook salmon and steelhead migrating in 1999.

Table H. Wilcoxon test values and sample sizes (n) for statistical comparisons of median fork lengths of natural and hatchery chinook salmon and steelhead captured during the spring at the lower site in 1999. Abbreviations: N - Natural, H - Hatchery, CHS - Chinook, and STT - Steelhead.

Group One				vs.	Group Two				Statistical Values	
Rearing	Species	Sample Size	Median		Rearing	Species	Sample Size	Median	P	W
N	CHS[a]	5,297	104		N	CHS[b]	75	140	0.732	203,201
N	STT[a]	2,427	182		N	STT[b]	63	187	0.329	81,954
H	CHS[a]	1,443	136		H	CHS[b]	4,334	135	0.000	$2.94 \cdot 10^6$
H	STT[a]	6,311	216		H	STT[b]	57	214	0.068	159,247
N	CHS[c]	5,422	104		H	CHS[d]	6,838	134	0.000	$3.62 \cdot 10^7$
N	STT	1,654	182		N	STT	142	170	0.000	68,321
N	STT	2,519	182		H	STT	6,444	216	0.000	$1.45 \cdot 10^7$

[a] PIT tagged
[b] Non-PIT tagged
[c] Released from May 9 to May 22, 1999
[d] Released from May 30 to June 12, 1999

Appendix I

A summary of the trap efficiency trials for 1999 conducted at the lower Imnaha River trap during the spring, March 8 to June 16.

Table I. A summary of the trap efficiency trials for 1999 conducted at the lower Imnaha River trap during the spring, March 8 to June 16.

Beginning Date	Ending Date	Number of Trials	Number of Traps	Marked Fish Released	Mean Trap Efficiency
3/8/1999	3/20/1999	7	1	296	0.162
3/24/1999	3/25/1999	2	2	603	0.229
3/28/1999	3/30/1999	3	1	41	0.098
3/31/1999	4/7/1999	8	2	707	0.294
4/8/1999	4/16/1999	9	1	1,551	0.198
4/17/1999	4/27/1999	10	1	200	0.100
4/28/1999	4/30/1999	3	1	40	0.225
5/3/1999	5/10/1999	6	1	87	0.069
5/11/1999	5/13/1999	3	1	87	0.333

Appendix J

A summary of individual PIT tag release group release dates and times, number released, and mean fork lengths, weights, and condition factors with standard deviations for natural and hatchery chinook salmon and steelhead released March 1 to June 24, 1999 at the lower site.

Table J. A summary of individual PIT tag release group release dates and times, number released, and mean fork lengths, weights, and condition factors with standard deviations for natural and hatchery chinook salmon and steelhead released March 1 to June 24, 1999 at the lower site. Abbreviation: Condition Factor - C.F.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
Natural Chinook Salmon								
JAH99061.NT1	3/2/99	60	106	11.2	12.9	4.5	1.04	0.085
JAH99062.NT1	3/3/99	142	104	10.9	11.6	3.6	0.99	0.060
JAH99063.NT1	3/4/99	84	104	10.4	11.5	3.4	0.99	0.056
JAH99064.NT1	3/5/99	77	99	10.0	10.3	3.0	1.02	0.062
JAH99067.NT2	3/8/99	32	102	9.7	11.4	4.1	1.04	0.132
JAH99068.NT1	3/10/99	29	101	9.1	10.6	3.0	0.99	0.049
JAH99069.NT1	3/10/99	24	102	10.4	11.1	3.2	1.02	0.066
JAH99070.NT1	3/12/99	20	100	9.1	10.2	2.9	1.01	0.056
JAH99071.NT1	3/12/99	18	101	4.9	10.4	1.8	1.00	0.058
JAH99074.NT1	3/15/99	20	104	8.8	12.9	4.1	1.13	0.219
JAH99075.NT1	3/16/99	29	106	10.7	12.2	4.1	0.98	0.065
JAH99076.NT1	3/17/99	37	106	9.5	12.1	3.1	0.98	0.090
JAH99077.NT1	3/18/99	58	106	10.2	11.7	3.6	0.97	0.067
JAH99078.NT1	3/19/99	42	103	9.2	11.0	2.8	1.01	0.078
JAH99079.NT2	3/20/99	44	106	9.3	12.1	3.7	0.99	0.071
JAH99081.NT1	3/22/99	19	105	6.6	11.8	2.2	1.00	0.079
JAH99082.NT1	3/23/99	58	107	9.2	12.9	3.1	1.04	0.081
JAH99082.NT2	3/23/99	24	107	8.5	12.5	2.9	1.02	0.052
JAH99083.NT1	3/24/99	103	103	9.8	11.5	3.4	1.04	0.068
JAH99084.NT1	3/25/99	47	103	8.5	11.6	3.0	1.02	0.066
JAH99087.NT1	3/28/99	220	116	8.1	13.2	2.9	0.82	0.047
JAH99088.NTA	3/29/99	70	106	7.7	12.5	3.0	1.03	0.074
JAH99089.NT1	3/30/99	52	106	10.0	12.6	4.0	1.04	0.048
JAH99090.NT1	3/31/99	198	105	7.1	12.2	2.5	1.04	0.058
JAH99091.NT2	4/1/99	258	102	8.2	12.0	3.0	1.12	0.066
JAH99092.NT1	4/2/99	215	99	8.2	11.6	2.9	1.17	0.110
JAH99093.NT1	4/3/99	75	102	10.0	13.0	3.4	1.22	0.149
JAH99093.NT2	4/3/99	30	101	7.8	12.1	2.9	1.16	0.062
JAH99094.NT1	4/4/99	100	100	8.1	12.0	3.0	1.19	0.070
JAH99095.NT1	4/5/99	73	101	7.5	12.3	2.8	1.18	0.069
JAH99096.NT1	4/6/99	140	99	9.0	11.7	3.6	1.18	0.073
JAH99097.NT1	4/7/99	150	101	7.9	12.0	2.9	1.14	0.082
JAH99099.NTI	4/9/99	68	103	7.4	11.6	2.6	1.05	0.063
JAH99100.NT2	4/10/99	84	103	8.1	13.6	3.3	1.22	0.097
JAH99100.NTI	4/10/99	126	100	8.0	11.5	2.7	1.14	0.090
JAH99101.NT1	4/11/99	155	101	9.1	11.7	3.3	1.18	0.085
JAH99102.NTI	4/12/99	86	105	9.9	12.7	3.9	1.06	0.100
JAH99103.NT1	4/13/99	49	102	7.8	12.1	2.9	1.13	0.065
JAH99103.NTA	4/13/99	4	99	6.6	10.5	2.1	1.06	0.051

Table J. Continued.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
JAH99104.NT1	4/14/99	95	104	10.4	13.2	4.4	1.13	0.082
JAH99104.NT2	4/15/99	126	108	9.1	14.4	3.8	1.13	0.084
JAH99106.CT2	4/16/99	79	103	9.2	13.4	3.8	1.18	0.094
JAH99106.CT3	4/16/99	25	105	10.5	13.1	4.1	1.10	0.068
JAH99106.NT1	4/17/99	153	106	9.3	14.4	3.9	1.17	0.069
JAH99107.NT1	4/18/99	227	107	10.7	14.2	4.7	1.11	0.071
JAH99108.NT1	4/19/99	22	118	8.6	13.9	3.4	0.84	0.060
JAH99110.FP1	4/21/99	18	108	11.4	15.1	4.3	1.17	0.132
JAH99111.FP1	4/22/99	37	107	7.1	13.7	2.9	1.11	0.075
JAH99114.NT1	4/24/99	38	102	9.2	11.8	3.3	1.07	0.074
JAH99117.FP1	4/28/99	5	104	7.4	12.0	2.9	1.05	0.066
JAH99119.NT1	4/29/99	48	104	9.2	12.7	3.2	1.11	0.083
JAH99123.FP2	5/3/99	31	112	8.9	11.5	3.0	0.79	0.046
JAH99124.FP2	5/4/99	43	105	7.9	12.2	3.1	1.03	0.077
JAH99125.NT1	5/5/99	32	106	13.8	13.7	7.0	1.10	0.123
JAH99155.NT1	6/5/99	5	106	6.5	13.0	2.2	1.10	0.102
PJC99105.NT1	4/15/99	62	104	7.9	13.5	3.2	1.19	0.085
PJC99105.NT2	4/16/99	115	105	9.1	13.4	3.5	1.14	0.083
PJC99107.FP1	4/17/99	213	105	8.9	13.4	3.5	1.13	0.077
PJC99108.NTA	4/18/99	13	107	8.0	13.5	3.5	1.08	0.092
PJC99109.NT1	4/20/99	15	109	9.7	15.0	3.9	1.13	0.061
PJC99113.FP1	4/23/99	114	106	8.7	12.4	3.2	1.02	0.076
PJC99116.NT1	4/27/99	10	103	5.8	12.4	2.3	1.13	0.076
PJC99120.NT1	4/30/99	70	104	7.3	12.3	2.9	1.07	0.075
PJC99126.FP1	5/6/99	28	106	8.4	12.5	3.1	1.04	0.059
PJC99127.NT1	5/7/99	31	106	9.0	13.5	3.6	1.13	0.076
PJC99130.NT1	5/10/99	40	100	13.5	11.6	5.8	1.10	0.098
PJC99131.FP1	5/11/99	50	101	8.8	11.2	2.8	1.07	0.095
PJC99131.FP2	5/11/99	56	109	10.4	12.3	3.7	0.91	0.084
PJC99131.FP3	5/11/99	2	100	3.5	10.9	0.8	1.10	0.038
PJC99132.FP1	5/12/99	41	101	7.1	11.4	2.4	1.10	0.096
PJC99132.FP3	5/12/99	36	102	9.2	10.9	2.8	1.01	0.042
PJC99133.FP1	5/13/99	63	101	8.5	10.9	2.7	1.05	0.097
PJC99133.FPA	5/13/99	34	101	8.0	10.4	2.7	0.99	0.080
PJC99134.FP1	5/14/99	30	97	10.9	9.7	2.5	1.06	0.099
PJC99137.FP1	5/17/99	23	100	10.3	10.3	3.4	1.01	0.072
PJC99138.FP1	5/18/99	2	107	9.2	12.3	3.7	1.00	0.044
PJC99138.FP3	5/18/99	8	107	9.0	12.8	3.2	1.03	0.070
PJC99138.FP4	5/19/99	4	115	10.3	14.9	2.9	0.99	0.152

Table J. Continued.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
PJC99138.FPB	5/19/99	1	91	NA	6.8	NA	0.90	NA
PJC99139.FP1	5/20/99	4	103	8.0	11.4	3.1	1.01	0.047
PJC99140.FP3	5/20/99	4	104	8.1	11.6	2.7	1.02	0.007
PJC99152.FP1	6/2/99	10	107	6.2	13.9	3.0	1.11	0.065
PJC99153.FP1	6/3/99	6	103	8.2	13.1	3.2	1.18	0.067
PJC99154.NT1	6/4/99	5	101	7.0	11.9	2.8	1.14	0.070
PJC99158.FP1	6/7/99	19	102	7.8	11.1	2.6	1.04	0.054
PJC99159.FP1	6/8/99	15	103	9.4	11.8	3.1	1.06	0.086
PJC99160.FP1	6/9/99	17	107	8.7	12.7	3.3	1.03	0.059
PJC99161.FP1	6/10/99	8	103	8.6	11.8	2.7	1.08	0.036
PJC99162.NP1	6/11/99	27	104	7.7	12.2	2.7	1.09	0.069
PJC99165.FP1	6/14/99	11	104	6.9	12.6	0.9	1.04	0.043
PJC99166.FP1	6/15/99	5	109	2.9	13.5	2.2	1.04	0.165
PJC99168.FP1	6/17/99	3	109	9.0	14.7	5.9	1.11	0.159
PJC99172.NT1	6/21/99	1	105	NA	9.7	NA	0.84	NA
PJC99173.NT1	6/22/99	3	100	4.0	10.5	1.1	1.03	0.024
PJC99174.FP1	6/23/99	3	109	2.3	12.1	1.2	0.94	0.039
total number released		5,306						
Hatchery Chinook Salmon								
JAH99067.NT2	3/8/99	1	138	NA	28.8	NA	1.10	NA
JAH99068.NT1	3/10/99	1	133	NA	23.8	NA	1.01	NA
JAH99075.NT1	3/16/99	2	129	4.2	22.6	4.7	1.05	0.114
JAH99079.NT2	3/20/99	53	131	9.9	24.5	5.6	1.10	0.066
JAH99083.NT1	3/24/99	1	116	NA	15.5	NA	0.99	NA
JAH99087.NT1	3/28/99	1	132	NA	17.9	NA	0.78	NA
JAH99088.NTA	3/29/99	1	116	NA	16.1	NA	1.03	NA
JAH99097.NT1	4/7/99	492	138	7.7	29.9	5.3	1.13	0.063
JAH99100.NT2	4/10/99	130	133	9.4	27.6	6.2	1.17	0.068
JAH99100.NTI	4/10/99	31	135	9.4	28.1	6.4	1.12	0.048
JAH99101.NT1	4/11/99	286	131	10.0	27.1	6.7	1.20	0.066
JAH99102.NTI	4/12/99	6	127	10.4	21.6	5.5	1.03	0.070
JAH99103.NT1	4/13/99	243	136	9.9	28.8	6.2	1.13	0.076
JAH99103.NTA	4/13/99	126	139	12.6	30.2	9.2	1.09	0.062
JAH99104.NT2	4/15/99	2	147	45.3	40.8	33.0	1.13	0.023
JAH99110.FP1	4/21/99	41	132	9.2	26.5	6.1	1.14	0.105
JAH99111.FP1	4/22/99	1	148	NA	31.2	NA	0.96	NA
JAH99114.NT1	4/24/99	25	127	11.7	21.9	6.0	1.03	0.069
PJC99107.FP1	4/17/99	1	148	NA	33.0	NA	1.02	NA

Table J. Continued.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
PJC99130.NT1	5/10/99	1	115	NA	15.8	NA	1.04	NA
PJC99131.FP2	5/11/99	1	109	NA	11.4	NA	0.88	NA
PJC99132.FP1	5/12/99	1	96	NA	10.6	NA	1.20	NA
PJC99133.FPA	5/13/99	1	129	NA	21.5	NA	1.00	NA
PJC99134.FP1	5/14/99	2	117	NA	7.0	NA		
total number released		1,450						
Natural Steelhead								
JAH99083.NT1	3/24/99	1	132	NA	19.0	NA	0.83	NA
JAH99100.NT2	4/10/99	1	208	NA	89.7	NA	1.00	NA
JAH99100.NTI	4/10/99	1	164	NA	44.8	NA	1.02	NA
JAH99101.NT1	4/11/99	1	192	NA	75.5	NA	1.07	NA
JAH99102.NTI	4/12/99	3	161	22.1	42.1	16.4	0.98	0.022
JAH99103.NT1	4/13/99	2	207	23.3	93.8	39.2	1.03	0.093
JAH99104.NT1	4/14/99	3	194	27.0	78.0	32.3	1.03	0.059
JAH99104.NT2	4/15/99	4	188	13.6	72.3	20.0	1.06	0.041
JAH99106.CT2	4/16/99	4	177	10.5	56.5	11.7	1.01	0.036
JAH99106.NT1	4/17/99	8	193	17.7	75.8	18.3	1.04	0.060
JAH99107.NT1	4/18/99	4	173	24.6	56.6	26.3	1.05	0.042
JAH99108.NT1	4/19/99	12	203	16.9	73.6	19.4	0.86	0.046
JAH99110.FP1	4/21/99	25	188	19.6	73.1	22.1	1.07	0.063
JAH99111.FP1	4/22/99	29	184	20.5	68.2	21.8	1.04	0.084
JAH99113.NT1	4/23/99	13	192	13.8	72.8	14.3	1.02	0.045
JAH99117.FP1	4/28/99	28	185	14.2	65.5	15.0	1.02	0.033
JAH99119.NT1	4/29/99	50	189	21.7	71.1	23.4	1.01	0.063
JAH99123.FP2	5/3/99	42	197	17.1	65.9	19.0	0.85	0.047
JAH99124.FP2	5/4/99	62	188	18.1	66.6	20.8	0.97	0.056
JAH99125.NT1	5/5/99	27	181	20.3	61.0	15.8	1.00	0.057
JAH99155.NT1	6/5/99	13	170	19.6	51.3	17.9	1.01	0.063
PJC99089.NT1	3/30/99	1	222	NA	103.2	NA	0.94	NA
PJC99090.NT1	3/31/99	6	174	19.4	51.9	19.2	0.96	0.012
PJC99091.NT1	4/1/99	8	177	20.7	59.9	20.0	1.03	0.045
PJC99092.NT1	4/2/99	3	196	50.0	89.9	63.6	1.06	0.030
PJC99093.NT1	4/3/99	3	191	15.9	68.2	15.0	0.98	0.062
PJC99094.NT1	4/4/99	2	187	34.6	66.4	38.0	0.96	0.045
PJC99095.NT1	4/5/99	1	223	NA	126.1	NA	1.14	NA
PJC99096.NT1	4/6/99	1	187	NA	66.2	NA	1.01	NA
PJC99105.NT1	4/15/99	2	180	0.0	61.2	3.5	1.05	0.061
PJC99105.NT2	4/16/99	4	212	24.8	99.0	34.5	1.01	0.104

Table J. Continued.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
PJC99107.FP1	4/17/99	9	180	21.3	59.6	24.1	1.02	0.036
PJC99108.NTA	4/18/99	11	185	12.3	64.4	15.7	1.00	0.078
PJC99109.NT1	4/20/99	11	192	23.5	78.5	30.0	1.07	0.095
PJC99113.FP1	4/23/99	26	190	20.8	68.7	21.6	0.99	0.086
PJC99114.FP1	4/24/99	24	179	16.1	57.6	17.9	0.97	0.063
PJC99116.NT1	4/27/99	35	182	14.9	63.6	16.0	1.03	0.056
PJC99120.NT1	4/30/99	38	180	21.1	60.6	19.0	1.00	0.061
PJC99126.FP1	5/6/99	54	188	20.6	67.6	24.3	1.00	0.061
PJC99127.NT1	5/7/99	76	185	19.6	66.6	23.2	1.01	0.057
PJC99130.NT1	5/10/99	66	184	16.9	62.8	17.5	0.98	0.059
PJC99131.FP1	5/11/99	156	182	17.0	60.2	17.2	0.98	0.057
PJC99131.FP2	5/11/99	96	187	17.0	61.8	19.4	0.92	0.055
PJC99131.FP3	5/11/99	7	173	12.8	51.5	10.5	0.99	0.037
PJC99132.FP1	5/12/99	125	183	19.1	61.4	20.7	0.98	0.062
PJC99132.FP3	5/12/99	114	183	16.6	58.3	17.3	0.94	0.051
PJC99133.FP1	5/13/99	205	180	17.0	57.4	16.4	0.96	0.056
PJC99133.FPA	5/13/99	179	185	18.2	63.0	17.9	0.95	0.062
PJC99134.FP1	5/14/99	105	182	20.5	57.0	15.4	0.98	0.054
PJC99137.FP1	5/17/99	157	188	18.7	64.9	21.3	0.95	0.052
PJC99138.FP1	5/18/99	57	187	21.2	66.2	24.3	0.97	0.059
PJC99138.FP3	5/18/99	134	189	18.4	65.3	20.7	0.94	0.049
PJC99138.FP4	5/19/99	64	189	20.3	66.3	22.1	0.96	0.062
PJC99138.FPB	5/19/99	62	184	18.2	62.4	19.8	0.97	0.066
PJC99139.FP1	5/20/99	78	181	17.7	58.8	17.5	0.97	0.063
PJC99140.FP3	5/20/99	18	170	20.3	52.6	17.4	1.01	0.090
PJC99140.FPA	5/20/99	4	178	32.0	57.7	29.6	0.97	0.050
PJC99152.FP1	6/2/99	11	169	8.0	49.2	7.7	1.01	0.061
PJC99153.FP1	6/3/99	15	171	15.6	53.6	14.1	1.06	0.062
PJC99154.NT1	6/4/99	15	176	15.9	55.7	14.2	1.01	0.050
PJC99158.FP1	6/7/99	19	174	14.6	52.4	14.6	0.97	0.043
PJC99159.FP1	6/8/99	16	175	11.2	53.7	10.3	0.99	0.064
PJC99160.FP1	6/9/99	31	172	11.6	48.9	11.5	0.95	0.051
PJC99161.FP1	6/10/99	12	170	16.3	50.8	13.9	1.01	0.047
PJC99162.NP1	6/11/99	10	165	6.9	46.9	6.2	1.04	0.074
PJC99165.FP1	6/14/99	7	170	10.2	50.7	9.1	0.99	0.084
PJC99166.FP1	6/15/99	14	185	16.2	62.4	15.3	0.98	0.064

Table J. Continued.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
PJC99167.NT1	6/16/99	3	168	4.2	48.7	1.8	1.03	0.041
PJC99168.FP1	6/17/99	1	163	NA	42.6	NA	0.98	NA
PJC99174.FP1	6/23/99	2	171	9.2	47.5	5.7	0.96	0.039
total number released		2,431						
Hatchery Steelhead								
JAH99104.NT2	4/15/99	100	211	14.0	98.6	18.5	1.06	0.058
JAH99106.CT2	4/16/99	316	212	14.6	102.7	21.4	1.07	0.055
JAH99106.CT3	4/16/99	3	207	15.0	95.0	19.5	1.06	0.048
JAH99106.NT1	4/17/99	94	210	16.7	100.8	20.3	1.05	0.059
JAH99107.NT1	4/18/99	1	200	NA	79.4	NA	0.99	NA
JAH99108.NT1	4/19/99	40	226	13.4	103.1	18.8	0.88	0.049
JAH99110.FP1	4/21/99	64	212	14.8	100.0	22.3	1.03	0.062
JAH99111.FP1	4/22/99	120	214	15.6	100.8	22.3	1.02	0.064
JAH99113.NT1	4/23/99	40	216	14.2	100.3	18.6	1.00	0.072
JAH99117.FP1	4/28/99	40	216	15.9	101.2	22.4	0.99	0.056
JAH99119.NT1	4/29/99	55	218	12.9	102.6	19.2	0.98	0.046
JAH99123.FP2	5/3/99	32	226	19.1	101.1	30.4	0.85	0.061
JAH99124.FP2	5/4/99	47	220	14.1	101.8	22.4	0.94	0.051
JAH99125.NT1	5/5/99	53	219	16.0	104.7	23.2	0.98	0.067
JAH99155.NT1	6/5/99	29	205	21.0	80.7	27.5	0.91	0.043
PJC99105.NT1	4/15/99	190	210	15.6	98.6	22.0	1.06	0.065
PJC99105.NT2	4/16/99	44	213	14.3	101.8	21.4	1.04	0.062
PJC99107.FP1	4/17/99	251	213	15.4	101.6	23.2	1.03	0.051
PJC99108.NTA	4/18/99	26	216	13.4	101.8	20.0	0.99	0.053
PJC99109.NT1	4/20/99	52	217	13.0	106.5	20.6	1.03	0.052
PJC99113.FP1	4/23/99	71	216	15.2	100.6	22.7	0.98	0.048
PJC99114.FP1	4/24/99	9	215	21.2	103.0	35.0	1.01	0.074
PJC99116.NT1	4/27/99	25	216	11.1	99.0	15.7	0.98	0.036
PJC99120.NT1	4/30/99	47	215	12.3	97.8	17.1	0.97	0.053
PJC99126.FP1	5/6/99	26	222	14.4	110.8	24.4	1.00	0.070
PJC99127.NT1	5/7/99	31	223	17.3	110.1	28.2	0.98	0.063
PJC99130.NT1	5/10/99	77	222	14.4	106.9	21.1	0.96	0.056
PJC99131.FP1	5/11/99	179	221	15.4	102.1	23.0	0.94	0.051
PJC99131.FP2	5/11/99	170	226	15.8	104.8	24.0	0.89	0.052
PJC99131.FP3	5/11/99	4	226	11.3	103.4	14.2	0.90	0.037
PJC99132.FP1	5/12/99	90	220	14.6	103.7	22.7	0.96	0.065
PJC99132.FP3	5/12/99	135	225	18.8	106.1	27.1	0.91	0.050

Table J. Continued.

Species & Rearing/ PIT Tag Group	Release Date	Number Released	Mean Fork Length (mm)	Standard Deviation of Length	Mean Weight (g)	Standard Deviation of Weight	Mean C.F.	Standard Deviation of C.F.
PJC99133.FP1	5/13/99	169	223	18.1	106.7	27.1	0.94	0.051
PJC99133.FPA	5/13/99	159	226	19.6	110.7	27.3	0.92	0.048
PJC99134.FP1	5/14/99	142	222	18.2	105.8	26.7	0.95	0.055
PJC99137.FP1	5/17/99	172	223	16.9	104.9	24.0	0.92	0.048
PJC99138.FP1	5/18/99	90	223	16.8	106.2	27.0	0.94	0.047
PJC99138.FP3	5/18/99	220	227	16.2	106.8	25.6	0.90	0.047
PJC99138.FP4	5/19/99	292	217	19.1	102.6	28.1	0.97	0.065
PJC99138.FPB	5/19/99	348	218	16.6	101.1	23.4	0.96	0.061
PJC99139.FP1	5/20/99	629	215	19.3	97.5	28.2	0.95	0.058
PJC99140.FPA	5/20/99	85	215	20.3	98.6	29.3	0.96	0.069
PJC99152.FP1	6/2/99	73	206	17.2	83.1	22.3	0.92	0.057
PJC99153.FP1	6/3/99	61	204	15.1	79.2	19.4	0.91	0.055
PJC99154.NT1	6/4/99	76	209	21.7	88.1	28.7	0.93	0.053
PJC99158.FP1	6/7/99	153	209	16.8	82.5	20.9	0.89	0.051
PJC99159.FP1	6/8/99	148	211	17.7	84.8	22.2	0.88	0.042
PJC99160.FP1	6/9/99	241	213	19.0	87.1	25.2	0.87	0.046
PJC99161.FP1	6/10/99	116	214	18.4	89.6	24.3	0.90	0.056
PJC99162.NP1	6/11/99	82	212	18.2	88.1	22.5	0.91	0.050
PJC99165.FP1	6/14/99	67	213	19.2	87.2	26.8	0.90	0.037
PJC99166.FP1	6/15/99	263	215	17.9	90.5	25.0	0.89	0.059
PJC99167.NT1	6/16/99	64	209	18.2	86.6	22.4	0.93	0.059
PJC99168.FP1	6/17/99	66	210	19.2	86.7	25.4	0.92	0.049
PJC99169.FP1	6/18/99	46	210	18.2	84.9	23.9	0.89	0.042
PJC99172.NT1	6/21/99	40	213	20.5	87.6	28.0	0.88	0.060
PJC99173.NT1	6/22/99	35	219	18.2	98.0	28.0	0.90	0.051
PJC99174.FP1	6/23/99	21	219	10.3	92.2	17.1	0.87	0.075
PJC99175.FP1	6/24/99	20	210	15.8	88.4	20.1	0.95	0.053
total number released		6,339						

Appendix K

Survival estimates of natural chinook salmon released at the upper and lower Imnaha River trap, during the fall from 1993 to 1998, to Lower Granite Dam.

Table K. Season-wide survival estimates of natural chinook salmon released at the upper and lower Imnaha River trap, during the fall from 1993 to 1998, to Lower Granite Dam (LGR) and from release at the upper and lower Imnaha River trap to Lower Monumental Dam (LMO).

Release Site	Year	Number Released	Survival to LGR (%) (95% Confidence Interval)		Survival to LMO (%) (95% Confidence Interval)	
Upper Trap	1998	2,001	24.6	(2.4)	23.2	(2.7)
	1997	1,996	45.9	(2.7)	39.4	(4.9)
	1996					
	1995	998	25.7	(3.9)	31.1	(12.1)
	1994					
	1993	688	22.4	(4.1)	17.1	(4.1)
Lower Trap	1998	2,000	41.5	(3.3)	40.8	(4.1)
	1997	1,453	60.4	(4.1)	49.7	(7.3)
	1996	442	44.0	(5.9)	36.8	(13.3)
	1995	998	31.6	(4.7)	35.8	(15.7)
	1994	760	25.6	(4.3)	18.7	(5.3)
	1993	749	34.2	(4.1)	23.7	(3.9)

Appendix L

Estimated survival of hatchery reared chinook salmon smolts released at the Imnaha River Acclimation Facility to Lower Monumental Dam from 1993 to 1999 and 95% confidence intervals.

Table L. Estimated survival of hatchery reared chinook salmon smolts released at the Imnaha River Acclimation Facility to Lower Monumental Dam from 1993 to 1999 and 95% confidence intervals.

Migration Year	Survival (%)	95% Confidence Interval	Number Released
1993	50.7	2.5	1,991
1994	51.1	2.9	2,973
1995	51.9	2.9	2,494
1996	46.3	2.8	4,714
1997	47.1	(NA)	13,378
1998	57.2	1	19,827
1999[1]	57.5	2.4	14,948
1999[2]	59.6	4.8	7,979
1999[3]	48.0	16.3	498

[1] PIT tagged in the spring, acclimated, and released volitionally.
[2] PIT tagged in the fall, acclimated, and released volitionally.
[3] PIT tagged in the fall and released directly into the Imnaha River.

Appendix M

Daily arrival frequencies of PIT tagged Imnaha River fish to Lower Granite, Little Goose, Lower Monumental, and McNary dams during the 1999 spring migration.

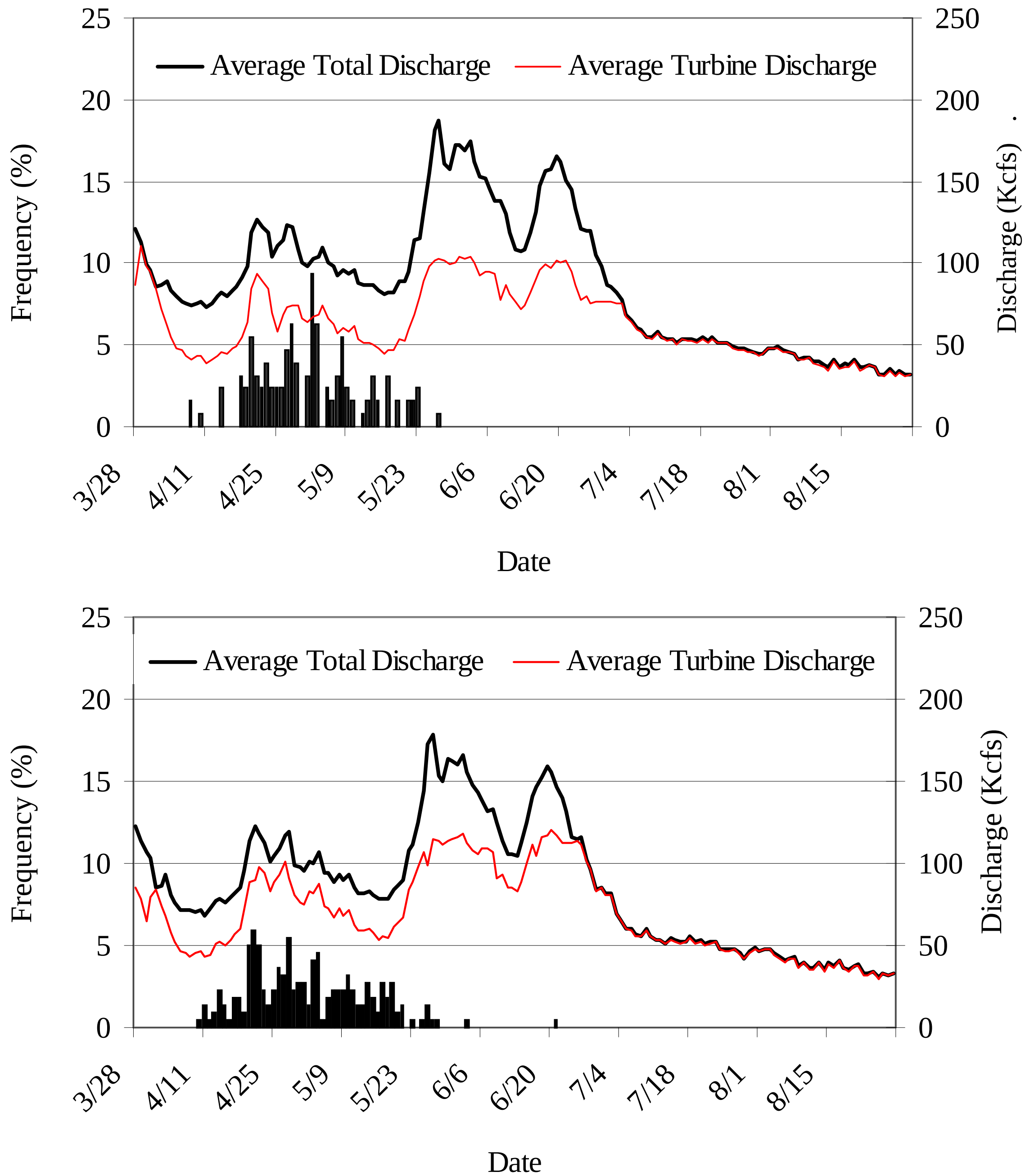
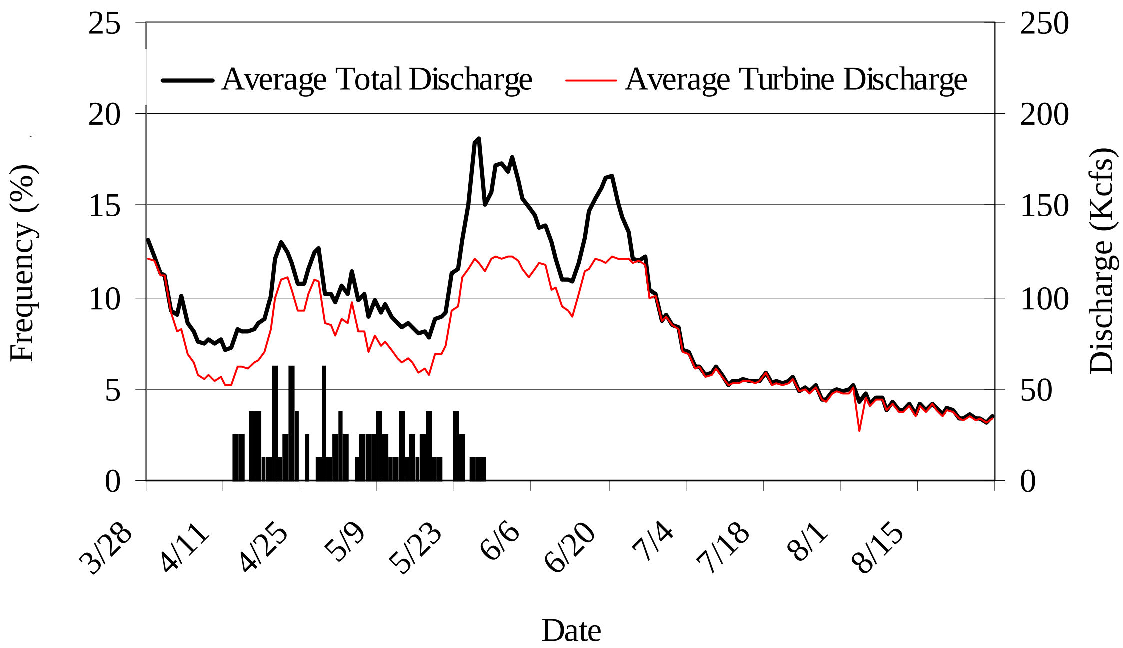


Figure M-1. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the upper site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



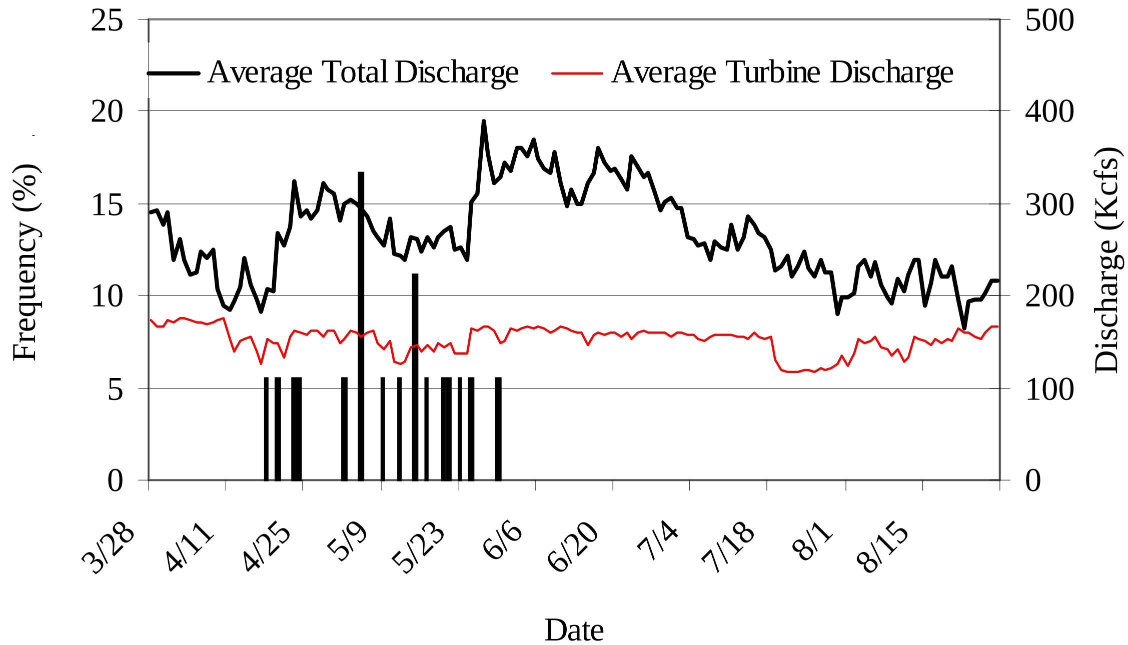
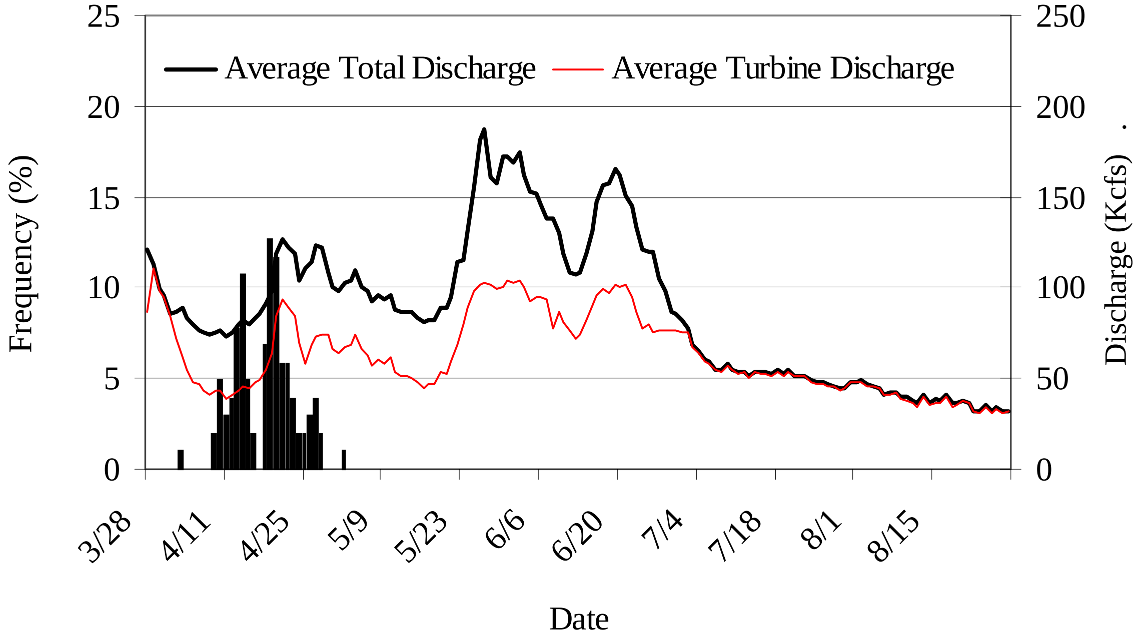


Figure M-2. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the upper site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



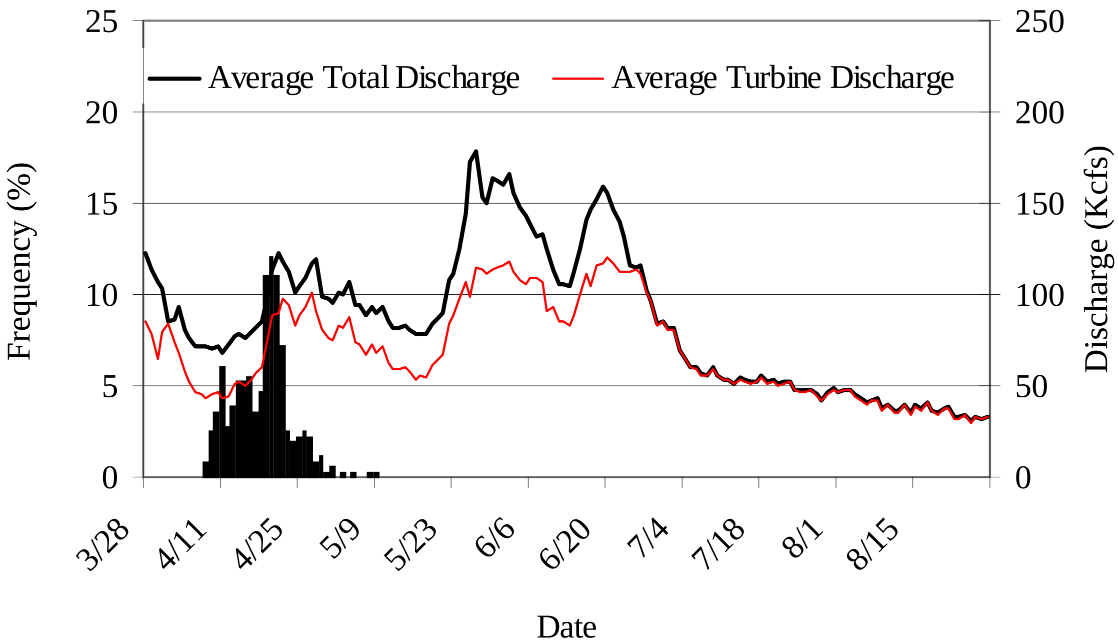
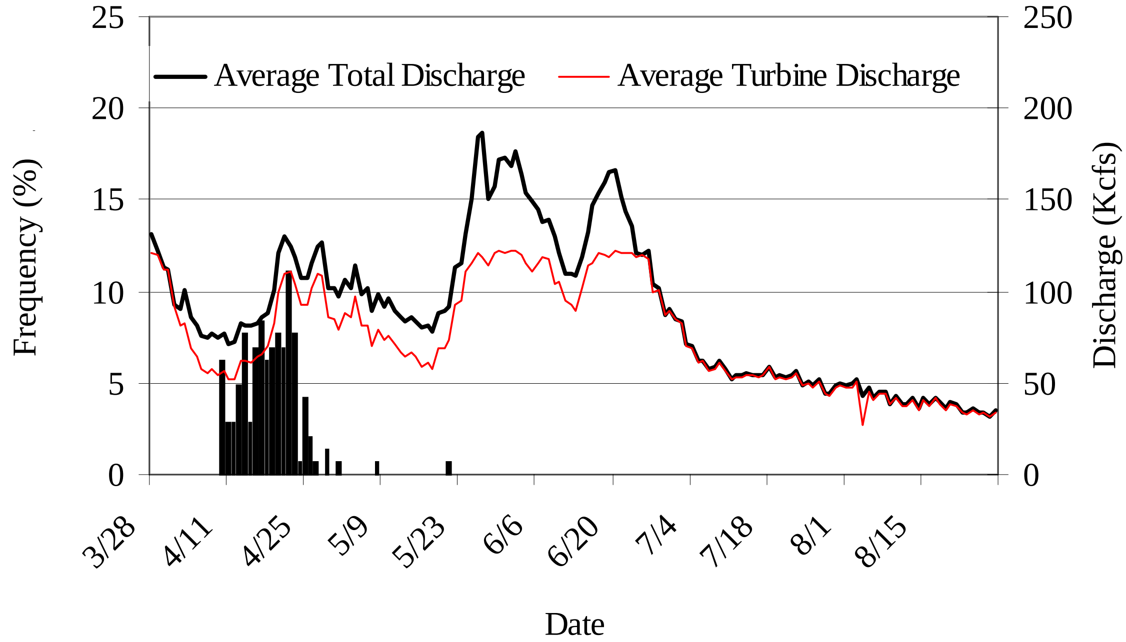


Figure M-3. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



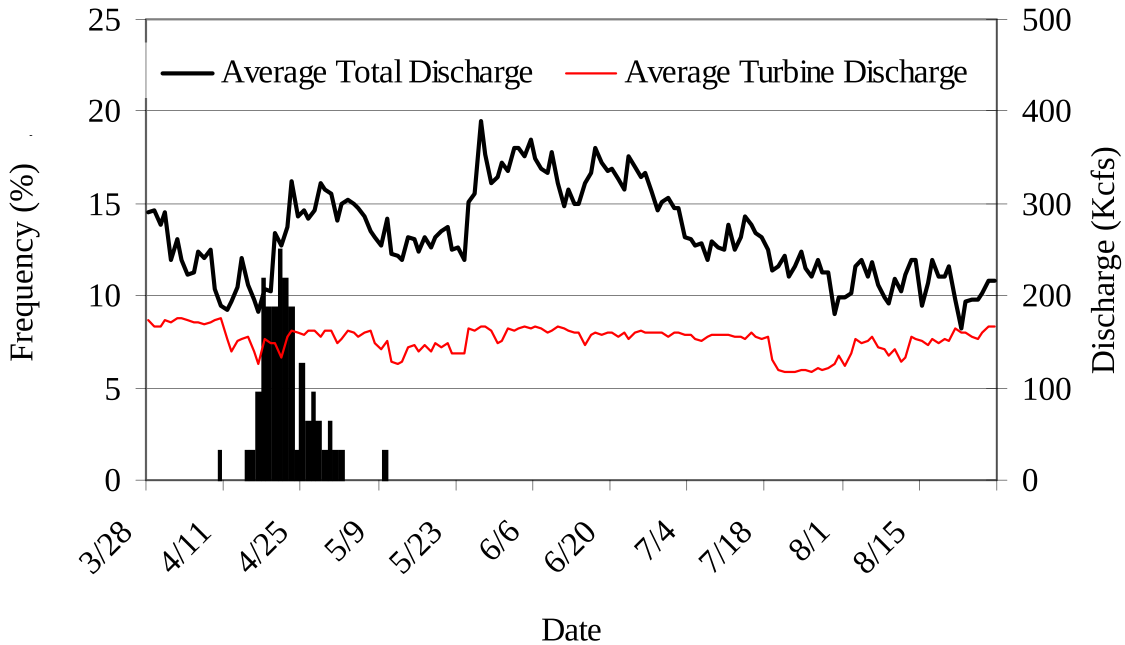
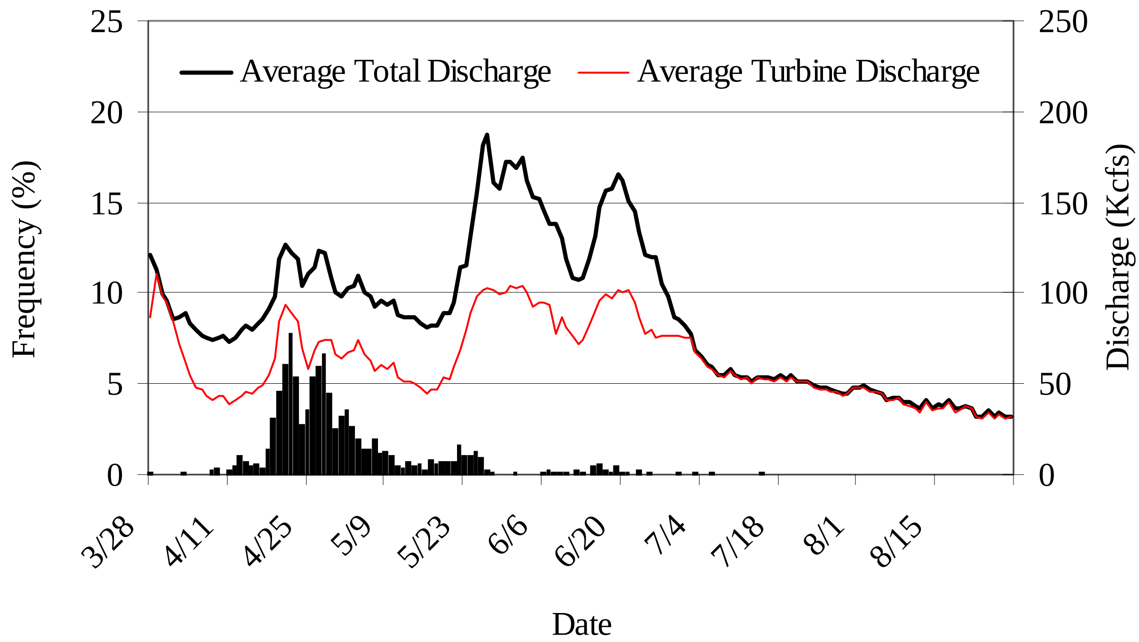


Figure M-4. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the fall at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



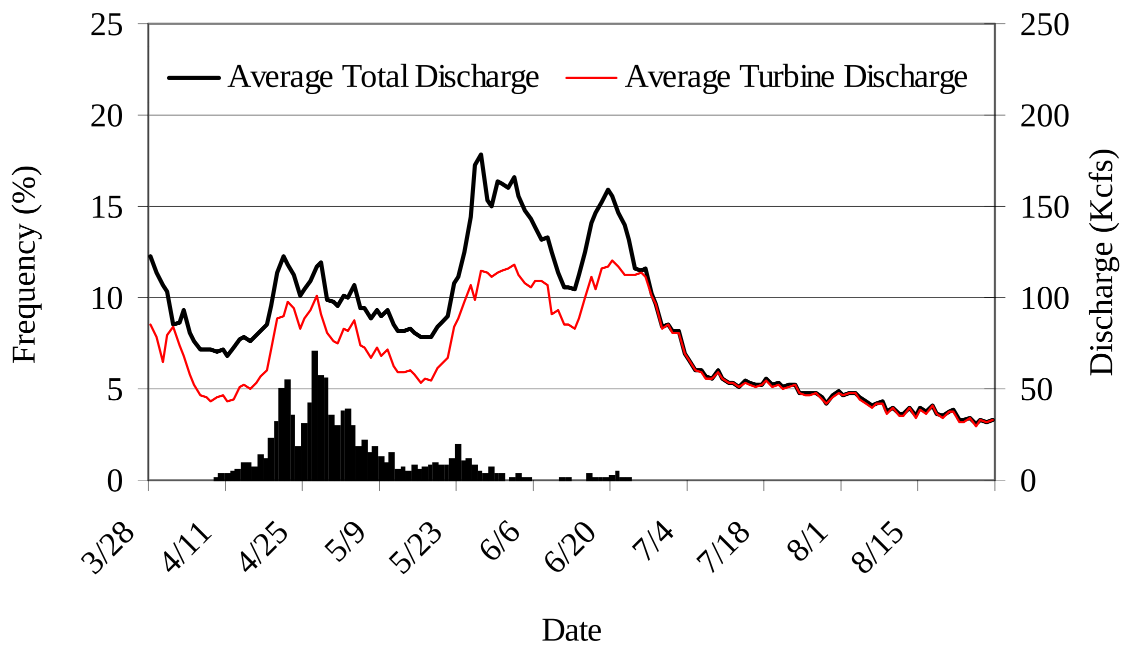
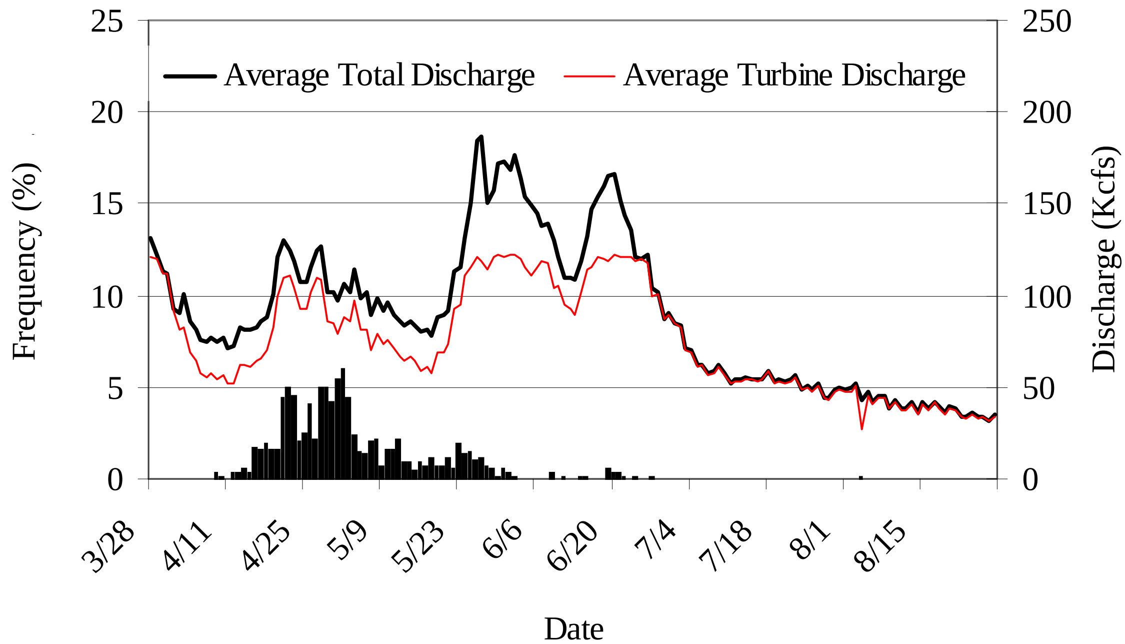


Figure M-5. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



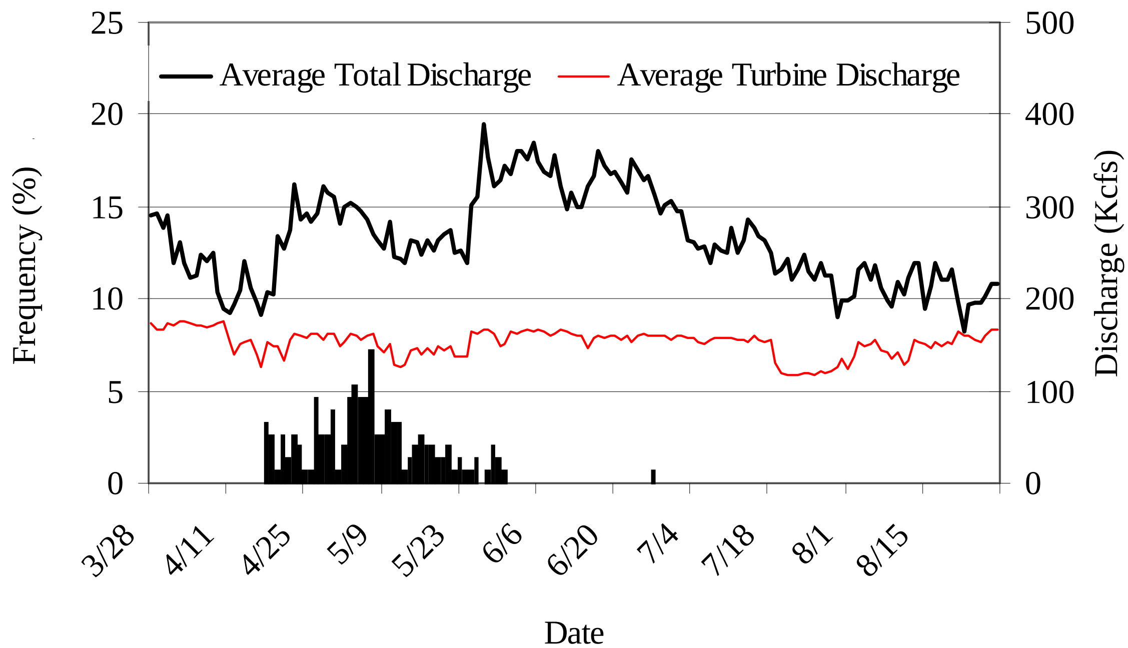
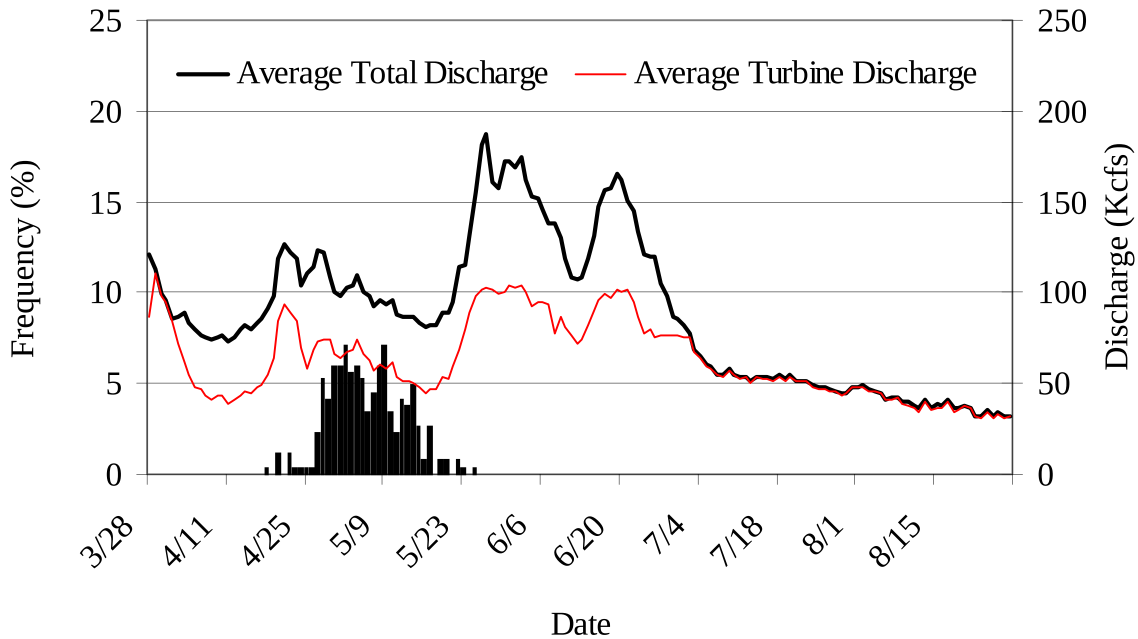


Figure M-6. Daily arrival timing frequency of natural chinook salmon, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



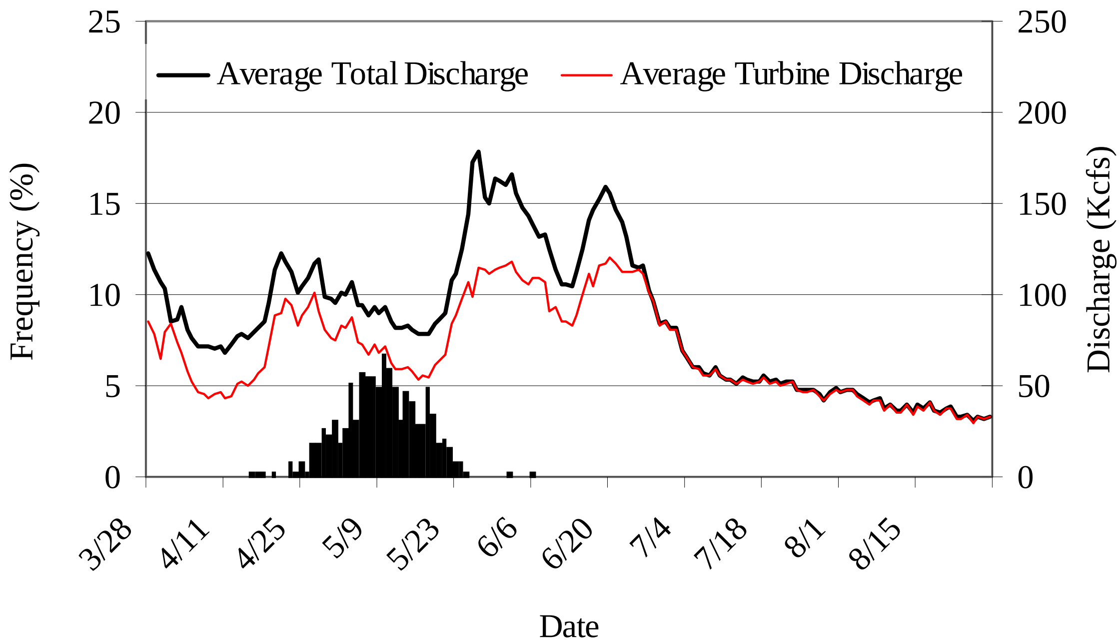
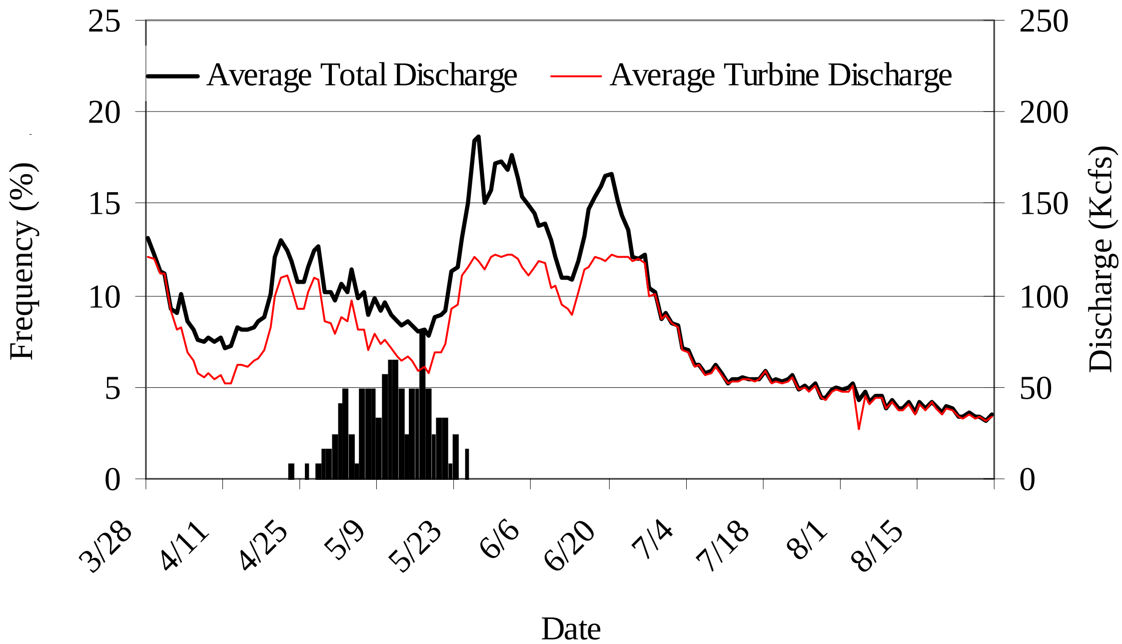


Figure M-7. Daily arrival timing frequency of hatchery chinook salmon, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



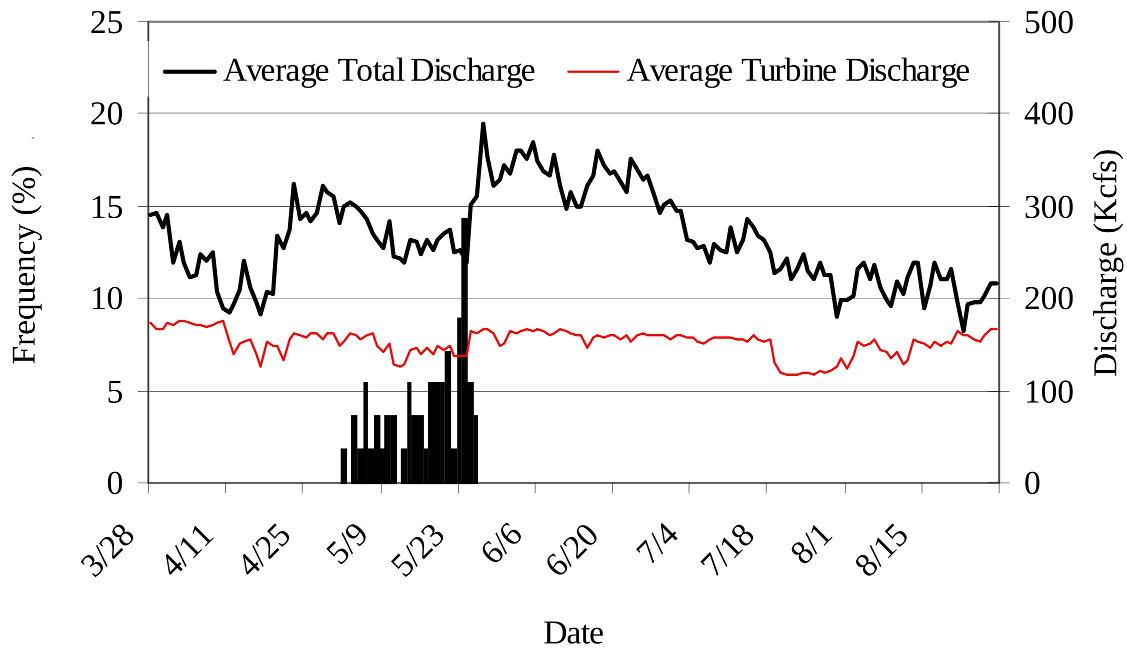
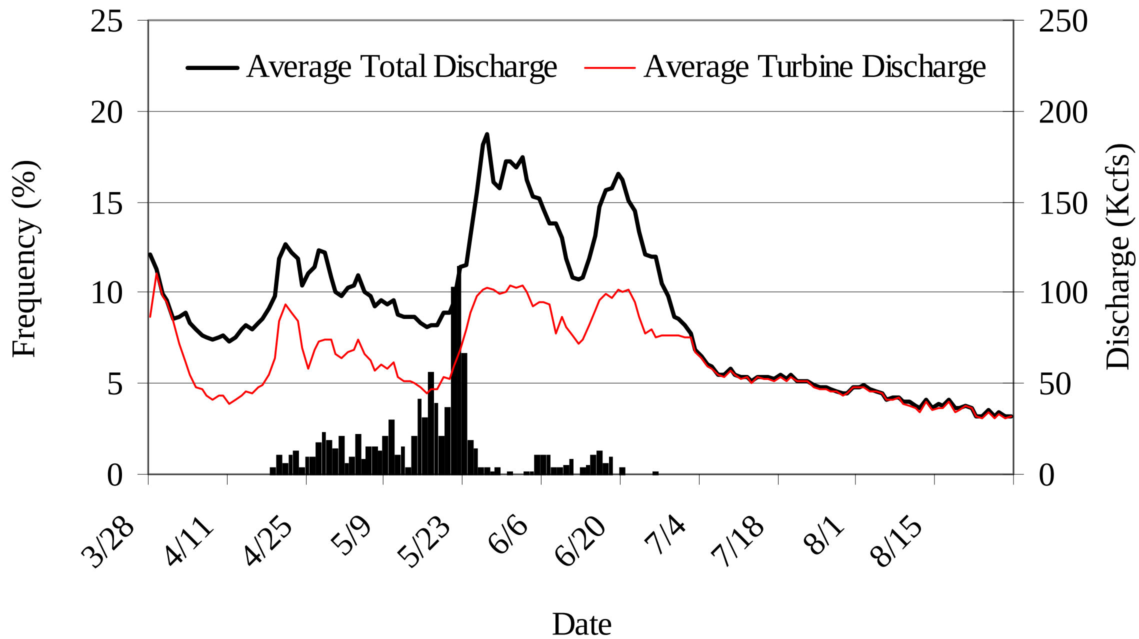


Figure M-8. Daily arrival timing frequency of hatchery chinook salmon, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



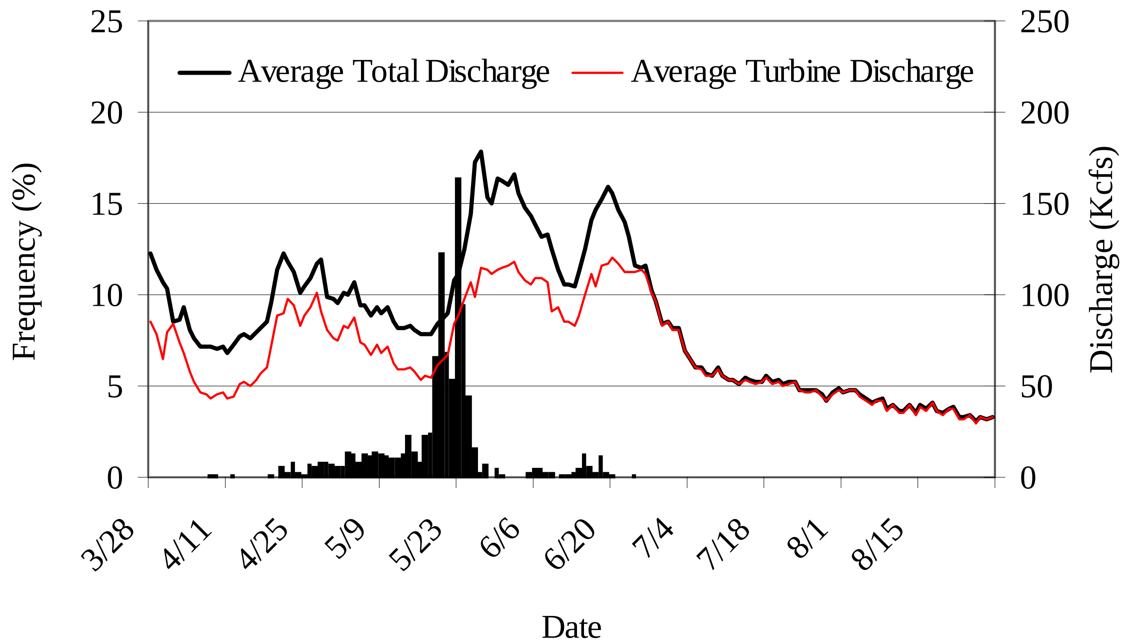
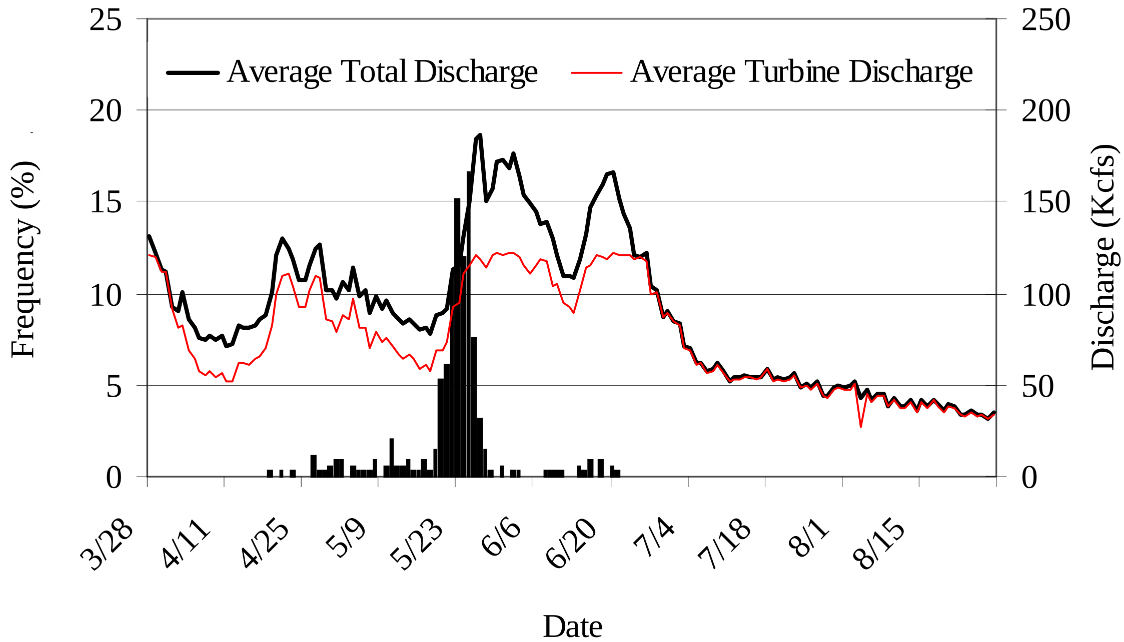


Figure M-9. Daily arrival timing frequency of natural steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



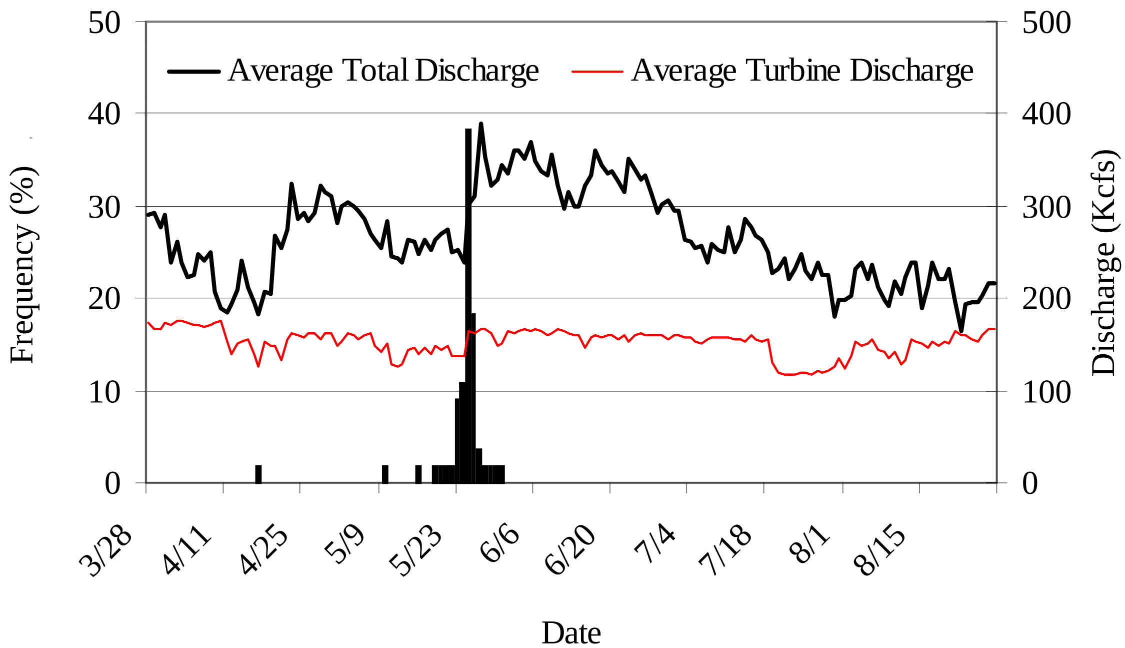
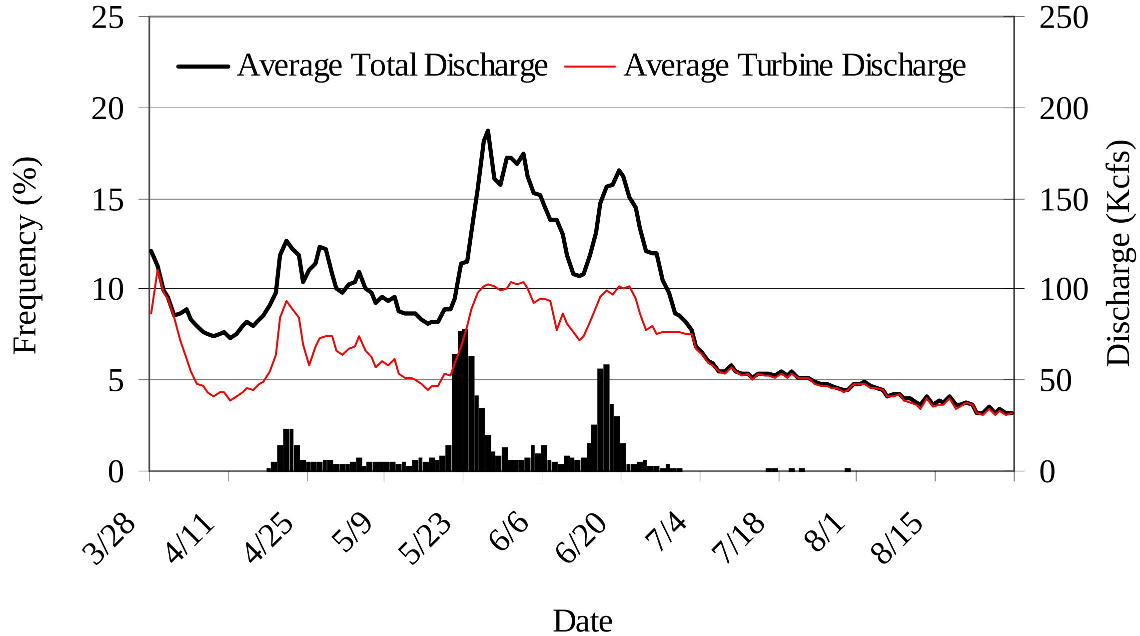


Figure M-10. Daily arrival timing frequency of natural steelhead, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



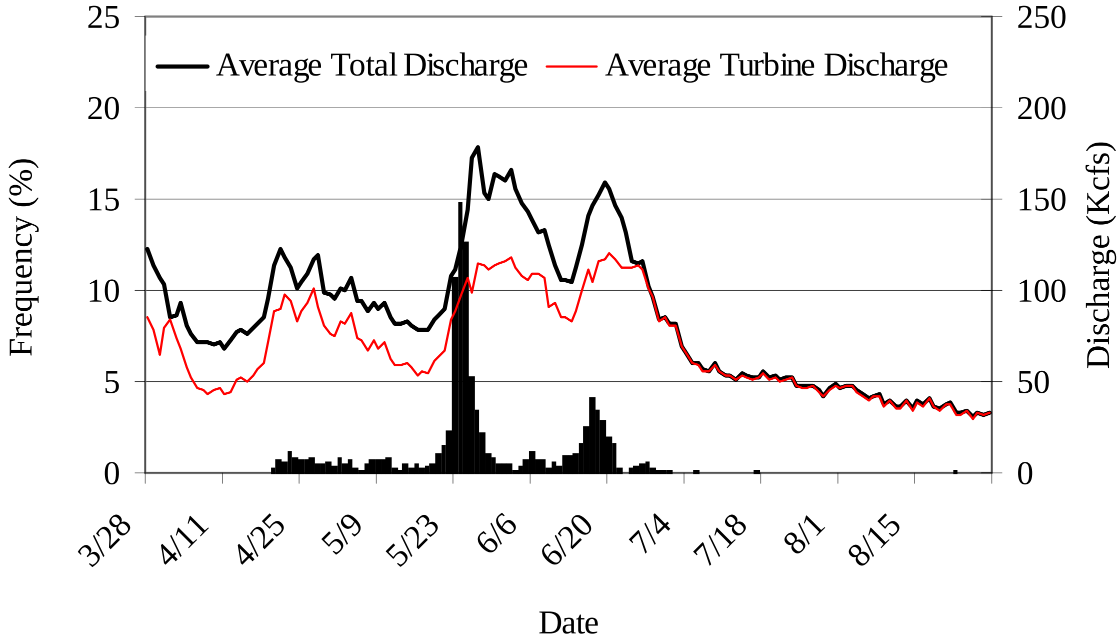
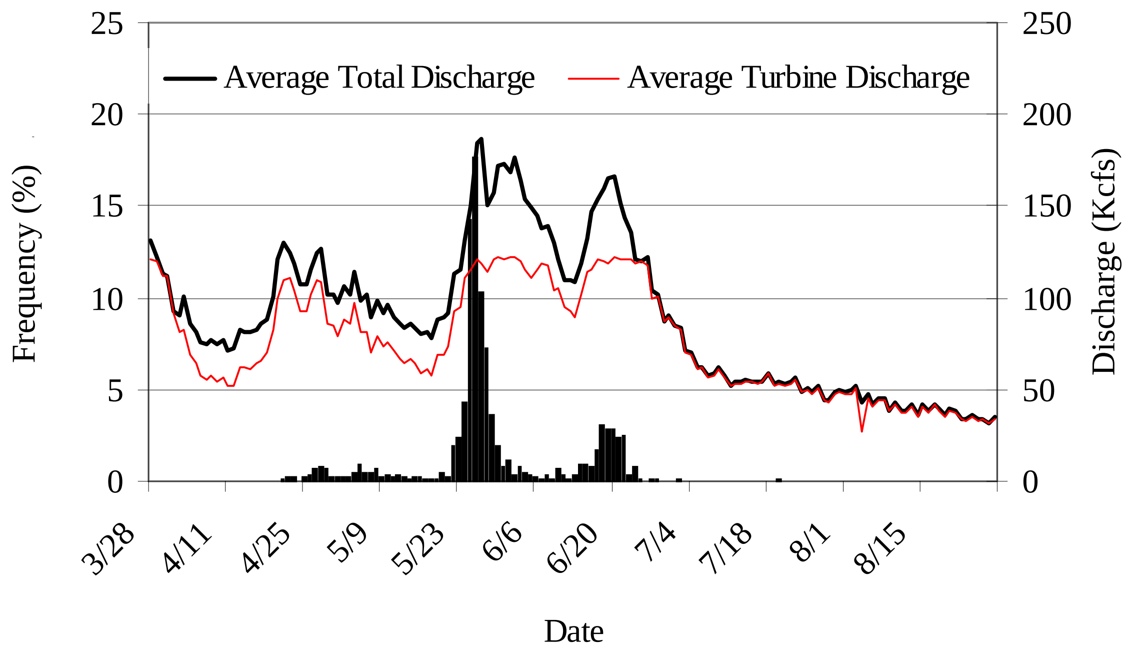


Figure M-11. Daily arrival timing frequency of hatchery steelhead, PIT tagged in the spring at the lower site, at Lower Granite Dam (top graph) and Little Goose Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.



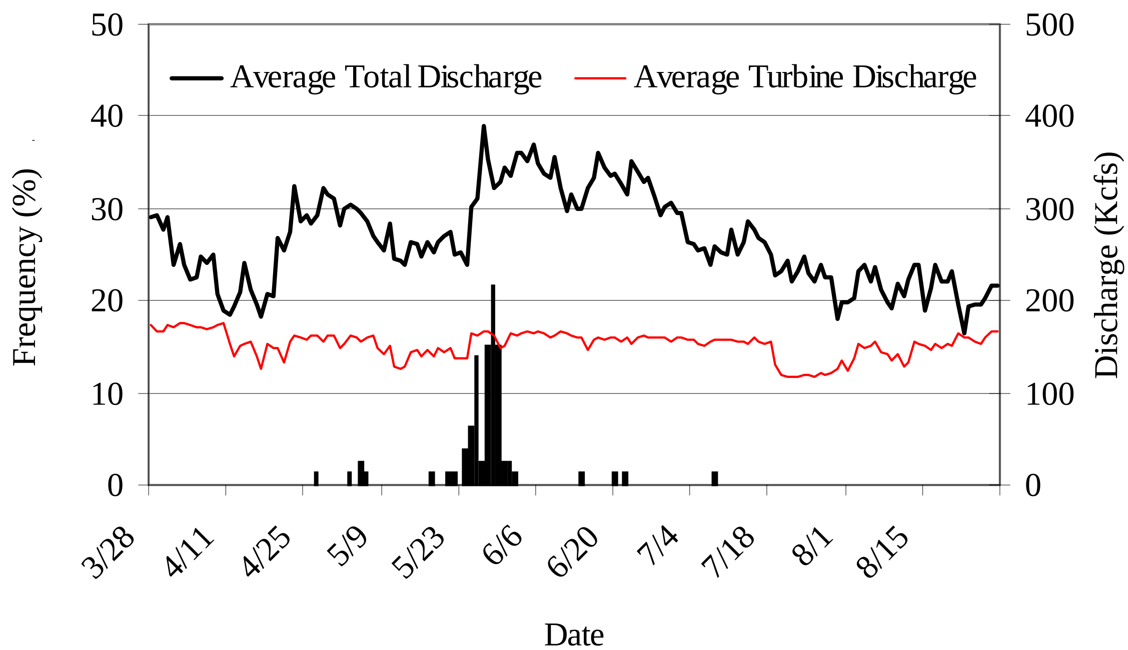


Figure M-12. Daily arrival timing frequency of hatchery steelhead, PIT tagged in the spring at the lower site, at Lower Monumental Dam (top graph) and McNary Dam (bottom graph), March 28 to August 28, 1999. The average total project discharge is represented by the top line and the average turbine discharge is represented by the lower line. Spill is represented by the area between the average total project discharge and the average turbine discharge.