Emigration of Juvenile Chinook Salmon and Steelhead from the Imnaha River

Progress Report for Migration Years 2011 - 2013



Nez Perce Tribe

Department of Fisheries Resources Management

Research Division

Emigration of Juvenile Natural and Hatchery Chinook salmon (Nacó'x in Nez Perce) and Steelhead (Héeyey in Nez Perce) from the Imnaha River, Oregon

Report on Migration Years 2011 through 2013 for the Imnaha River Smolt Monitoring Project and Lower Snake River Compensation Plan Hatchery Evaluation Project

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EXECUTIVE SUMMARY

This report summarizes the Nez Perce Tribe's Imnaha River juvenile Chinook salmon (Nacó'x in Nez Perce language; *Oncorhynchus tshawytscha*) and steelhead (Héeyey in Nez Perce language; *Oncorhynchus mykiss*) emigration studies for migration years 2011 through 2013 (MY2011 through MY2013). The studies have been ongoing for the past 22 years and have contributed information to the Fish Passage Center's (FPC) Smolt Monitoring Program (SMP) for the past 20 years. The project evaluated the survival, biological characteristics, and migration performance of natural and hatchery-origin spring/summer Chinook salmon and steelhead emigrating from the Imnaha River. The study collected emigrating juveniles in the Imnaha River and used passive integrated transponder (PIT) tags to estimate survival and travel time through the Snake and Columbia River dams. Survival was analyzed from the point of release for hatchery fish to the Imnaha River trap and from the trap to Lower Granite Dam (LGR) and McNary Dam (MCN) for all release groups of natural and hatchery-origin migrants. Migration timing was analyzed from release to LGR. This report represents a compilation of 20 of the 22 years of SMP operations in addition to the MY2011 through MY2013 results.

The project's main goals are to; 1) provide real-time data from juvenile Chinook salmon and steelhead tagged with PIT tags at the Imnaha River juvenile emigrant trap for the Fish Passage Center's SMP and; 2) compare performance measure metrics between natural and hatchery Chinook salmon and steelhead as part of the Lower Snake River Compensation Program (LSRCP) hatchery evaluations project. These goals will be accomplished by completing the following five objectives. 1) Quantify life-stage specific emigrant abundance of Imnaha River juvenile Chinook salmon and steelhead; 2) Quantify and compare life-stage specific emigration timing of Imnaha River juvenile Chinook salmon and steelhead, 3) Quantify and compare life-stage specific survival of juvenile Chinook salmon and steelhead within and from the Imnaha River to Lower Granite Dam on the Snake River and McNary Dam on the Columbia River, 4) Quantify and compare smolt to adult return rate indices (SARs) for fall- and spring-tagged natural Chinook salmon and natural and hatchery steelhead smolts and, 5) Describe life-stage specific biological characteristics of Imnaha River juvenile Chinook salmon and steelhead.

Project objectives were completed with the operation of a rotary screw trap in the Imnaha River approximately 7 river kilometers (rkm) above the confluence with the Snake River. The trap was operated nearly year round in MY2011 and migration year 2012 (MY2012) capturing Chinook salmon presmolts in the fall and Chinook and steelhead smolts in the spring/summer emigration period. Trapping was discontinued in mid-July during MY2013 after data showed the benefits of late summer trapping did not justify budgetary costs and the risks of handling and tagging fish during high water temperatures.

We estimated the minimum number of natural Chinook emigrating past the trap was 96,992 (96,992 (95% C.I. 86.687 to 112,464; CV = 7.41%) in MY2011, 200,213 (95% C.I. 161,147 to 270,268; CV = 13.7%) in MY2012, and 131,909 (95% C.I. 116,728 to 141,183; CV = 6.6%) in MY2013. Fall presmolts dominated the estimate in all three years with fall presmolts comprising approximately 67% in MY2011, 81.4% in MY2012, and 70.9% in MY2013. We estimated the minimum number of steelhead passing the trap was 37,314 (95% C.I. 29,342 to 47,728; CV = 12.8%) in MY2011, 43,881 (95% C.I. 38,319 to 50,366; CF = 7.3%) in MY2012, and 54,270 (95% C.I. 48,674 to 60,708; CV = 5.8%) in MY2013.

Significant differences in emigration timing were observed between natural and hatchery Chinook and steelhead in all three years. However, despite statistical significance, patterns of natural and hatchery steelhead emigration were similar and biological differences were likely negligible.

Arrival timing at Lower Granite Dam (LGR) was significantly earlier for fall tagged natural Chinook salmon presmolts compared to spring-tagged smolts in all three years. Differences in arrival timing at LGR between natural and hatchery Chinook smolts were also significant in all three years. Natural Chinook smolts generally showed earlier first, and 10th percentile arrival dates but the contracted pattern of arrival timing for hatchery Chinook minimized differences in later arrivals. Arrival dates for all groups were similar between years but varied based on the pattern of the Snake River hydrograph. The bulk (80%) of natural Chinook smolts required 32 to 48 days to pass LGR while hatchery smolts only required 12 to 19 days. Similar to their arrival at the trap, differences in arrival timing at LGR between natural and hatchery steelhead were statistically significant but were similar overall and likely not biologically significant. During the three migration years, eighty percent of hatchery steelhead passed LGR within 11 to 40 days while natural steelhead required 17 to 30 days.

All release groups, with the exception of natural Chinook salmon fall-tagged presmolts, arrived in significant numbers after the initiation of full collections for transportation at LGR and subsequent juvenile transport dams in all years. The earlier LGR collection start date in MY2013 subjected a higher proportion of smolts to transportation than in MY2011 and MY2012. Our results suggested an average of 3.9% of Chinook presmolts, 19.6% of natural Chinook smolts, 22.5% of hatchery Chinook smolts, 25.4% of natural steelhead smolts, and 25.0% of hatchery steelhead smolts were transported at LGR during the three years. The range of juveniles transported was 3.5 – 7.2% for Chinook presmolts, 13.0 – 24.7% for natural Chinook smolts, 15.3 – 27.5% for hatchery Chinook, 21.1–27.9% for natural steelhead, and 16.2 – 31.9% for hatchery steelhead.

Given the narrow temporal range of detections at LGR for all groups, it was difficult for regression analysis to illuminate any statistically significant relationships between travel time and Snake River discharge. Only natural Chinook in MY2013 showed a significant negative relationship between travel time and Snake River discharge. However, graphical analysis suggested but hatchery juveniles were more dependent on release timing and migrated rapidly to LGR in variable environmental conditions while natural smolts generally responded to higher discharge with shorter travel times to LGR.

Survival to the trap was estimated for hatchery Chinook and steelhead. Survival of hatchery Chinook was 83% (± 3.4%) in MY2011, 99.9% (± 10.5%) in MY2012, and 93% (± 4.4%) in MY2013. Survival of hatchery steelhead was 74% (± 2.6%) in MY2011, 91% (± 3.5%) in MY2012, and 82% (± 2.2%) in MY2013. Corresponding patterns in survival between the two groups suggested environmental conditions affect hatchery steelhead and Chinook similarly and that conditions in the Imnaha River led to the highest survival in MY2012 and the lowest survival or highest residualization rates in MY2011.

We estimated survival from the Imnaha River screw trap to LGR for all natural and hatchery juvenile groups. Survival of Chinook presmolts to LGR was low in all three years and averaged 30% suggesting that overwintering in the Snake River is the largest source of mortality for presmolts after emigrating from the Imnaha River. Trap to LGR survival for natural Chinook smolts was 80% (± 2.4%) in MY2011, 72% (± 3.0%) in MY2012, and 72% (± 3.5%) in MY2013. Regression analysis showed survival to LGR for natural smolts has declined significantly with time over the 1993 – 2013 period ($p = 0.02$, $r^2 = 0.27$). Hatchery smolt survival to LGR was 71% (± 6.3%) in MY2011, 69% (± 14.1%) in MY2012, and 69% (± 10.0%) in MY2013. Hatchery Chinook survival to LGR showed a slight negative correlation with time but it was not significant. Survival of natural steelhead smolts to LGR was 81% (± 3.1%) in MY2011, 90% (± 3.1%) in MY2012, and 86% (± 3.9%) for MY2013. Survival of hatchery steelhead smolts to LGR was 96% (± 8.9%) in MY2011, 90% (±10.1%) in MY2012, and 100% (± 14.8%) in MY2013. Natural steelhead survival to LGR was not significantly correlated with time ($p = 0.32$) but hatchery steelhead showed a significant positive trend in survival over time ($p = 0.0006$, $r^2 = 0.51$).

Juvenile survival from the Imnaha River trap to McNary Dam (MCN) was estimated to compare species- and origin-specific differences in survival in the reach above LGR (screw trap to LGR) and below LGR (LGR to MCN). Chinook presmolt survival to MCN was 26% (± 3.2%) in MY2011, 26% (± 2.1%) in MY2012, and 22% (± 2.8) in MY2013. Natural Chinook smolt survival to MCN was 60% (± 3.6%) in MY2011, 74% (± 10.5%) in MY2012, and 60% (± 7.3%) in MY2013. Natural steelhead survival to MCN was 67% (± 13.3%) in MY2011, 76% (± 7.3%) in MY2012, and was low in MY2013 at 55% (± 9.9%). Hatchery steelhead survival was 66% (± 38.9%) in MY2011, 91% (± 66.6%) in MY2012, and 62% (± 13.1%) in MY2013. Smaller sample sizes of PIT tagged fish recaptured and released at the trap, low hydrosystem detection efficiencies, and removals for transportation led to wide confidence intervals for estimates of hatchery-origin survival to MCN.

We also analyzed the survival to MCN of spring emigrating juveniles in relation to changes in hydrology and the hydrosystem after the implementation of court ordered spill in 2006. Natural Chinook and natural steelhead survival to MCN were positively correlated with Snake River discharge ($p = 0.002$ and 0.011 respectively). Significant positive relationships were found between survival to MCN and spill volume and percentage were observed for natural Chinook and both steelhead origins. Hatchery Chinook survival to MCN showed no correlation with these hydrosystem variables. Overall, survival to MCN increased by 6.3% for natural Chinook, 1.3% for hatchery Chinook, 19.3% for natural steelhead, and 31.7% for hatchery steelhead in the years after court ordered spill compared to the years prior. Furthermore, the benefits of spill, especially in a low flow year, were highlighted by a comparison of survival to MCN between the low flow no spill year in 2001 and the low flow mandated spill year in 2010.

Adult returns in 2014 allowed for analyses of smolt to adult return (SAR) index rates from LGR to LGR for brood years 2006 through 2009 (BY2006 through BY2009) for Imnaha River Chinook salmon, and from MY2009 through MY2012 for steelhead. SAR index rates measured were estimated using only fish marked with a passive integrated transponder (PIT) tag that either remained in river or were bypassed back to the river when interrogated at juvenile collection facilities. Although these results did not represent the general Imnaha River run at large (as it excludes transported fish), these analyses provided important evaluations of annual survival trends and comparisons of in-river survival between conspecific groups. SARs for all Chinook groups were highest from BY2006 and declined with each successive brood year. Chinook SARs were as high as 7.46% for BY2006 presmolts and as low as 0.15% for BY2009 natural smolts. Fall presmolts had the highest Chinook geometric mean SAR (2.72%) followed by hatchery Chinook (1.32%) and natural Chinook smolts (0.88%). While overwinter mortality for fall presmolts is high, their high LGR to LGR SAR suggests a survival benefit for this life history strategy when overwinter survival is achieved. SARs were less variable for steelhead than for Chinook and hatchery steelhead showed a higher geometric mean SAR than natural steelhead (1.64% vs 1.45% respectively).

We evaluated and compared natural and hatchery-origin Chinook salmon and steelhead by fork length, weight and condition factor. Generally hatchery fish were significantly larger than natural-origin juveniles as measured by fork length and weight. The mean condition factor of naturally produced Chinook smolts was also significantly lower than that of hatchery produced Chinook smolts, while the average condition factor of natural and hatchery steelhead smolts was nearly identical. The larger size of hatchery smolts may confer survival benefits by reducing predation during the migration period and early ocean residency, and this may explain the higher SAR index rates for hatchery compared to natural steelhead. However, differences in the size and condition factor of natural and hatchery smolts should be further evaluated in terms of residualization and the age of returning adults as SAR analysis demonstrated that hatchery fish tend to return at an earlier age.

Completion of the project objectives resulted in meeting the goals indicated above. A large number of natural and hatchery Chinook salmon and steelhead were PIT-tagged and evaluated as part of the Fish Passage Center’s Smolt Monitoring Program in all three migration years and data collected provided long-term monitoring and evaluation trends for the LSRCP Imnaha River hatchery program.

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The Nez Perce Tribe appreciates the administrative support necessary to complete these projects and this report. Project funding from the United States Fish and Wildlife Service's Lower Snake River Compensation Plan program initiated the Imnaha River emigration project investigations in 1992 and the project continues today. The Bonneville Power Administration provides significant project cost share funding for the Imnaha Smolt Monitoring Project. Barbara Shields, the BPA contracting officer technical representative (COTR) for the project, provided wise budgetary council and oversight throughout the contacting periods. Furthermore, she creatively arranged for the acquisition of new and refurbished trapping equipment that would not have otherwise been available to the project.

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We also acknowledge the Oregon Department of Fish and Wildlife (ODFW) for PIT tagging under BPA program number 199602000 and for conducting the acclimation and releases of hatchery-origin Chinook and steelhead. Appreciation is also extended to Joseph Feldhaus of ODFW for providing information on rearing and releases of hatchery fish. We extend our gratitude to the United States Forest Service for allowing us the use of the Thorn Creek guard station facilities, and Scott and Vicki McClaran of McClaran Ranch Inc. for access to their land for trapping purposes. The Fish Passage Center's Data System Administrative Manager, and Senior Data Analyst, Sergei Rasskazov, Computer Specialist Chris McCarty, and Data Analyst Brandon Chockley provide software used in daily data collection, as well as assistance with server management and maintenance, and assistance with data management and analyses.

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Chapter 1: Project Background Information

Chapter Introduction

This report summarizes three years of juvenile emigration and monitoring studies by the Nez Perce Tribe (NPT) Department of Fisheries Resources Management (DFRM) for the Imnaha River Smolt Monitoring Project and the Lower Snake River Compensation Plan. This report covers the 2011, 2012, and 2013 smolt migration years (MY2011, MY2012 and MY2013) from the Imnaha River, Oregon. These studies are closely coordinated and provide information about juvenile natural and hatchery-origin spring/summer Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*) biological characteristics, survival, and emigration timing, including arrival timing at and travel time to the Snake River dams and McNary Dam on the Columbia River. These studies also provide biological information on ESA listed Chinook salmon and steelhead for the Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 2000). Co-managers in the Imnaha River subbasin have identified the need to collect information on life history, migration patterns, juvenile emigrant abundance, and reach specific smolt survival rates for both steelhead and Chinook salmon (Ecovista 2004). The studies conducted during the fall of 2010 through summer of 2013 provided information related to the majority of the high priority data needs.

This chapter provides background information pertaining to the populations of anadromous salmonids monitored by these projects. It discusses in detail the population status, project history, and specific monitoring and evaluation objectives for these projects, and also provides a description of the study area. Methods for project operations (equipment, trapping, and marking) as well as methods and approaches for data analysis that are common to all migration years covered in this report are presented here. Results and discussions are presented in unique chapters by migration year. Multi-year analyses are presented separately in chapter 5.

Population Status

The Grande Ronde-Imnaha Major Population Group (MPG) is an important contributor to the Snake River Basin Chinook salmon Evolutionarily Significant Unit (ESU) and has major cultural and social significance for tribal and non-tribal people of Northeast Oregon (Hesse et al. 2004). Historically, the Imnaha subbasin supported one of the largest runs of spring/summer Chinook salmon in Northeast Oregon (Wallowa County and Nez Perce Tribe 1993). Prior to the construction of the four lower Snake River dams, an estimated 6,700 adult wild spring/summer Chinook salmon returned to the subbasin annually (USACE 1975). Since dam construction and other major anthropogenic factors, returns of Imnaha River natural-origin adults have declined significantly and are currently part of the Snake River basin spring/summer Chinook salmon Evolutionary Significant Unit (ESU) that was listed as threatened under the United States Endangered Species Act (ESA) in 1992. The Imnaha Subbasin Management Plan maintains objectives of returning 5,740 adult Chinook (3,800 natural adults) to the Imnaha Basin annually (Ecovista 2004). The estimated adult abundance in 2011 was 1,161 natural and 4,565 hatchery spawners in the Imnaha River (Feldhaus et al. 2014a). Estimates for 2012 were 886 natural adults and 2,903 hatchery adults (Feldhaus et al. 2014b). Estimates were not available for 2013.

Imnaha River summer steelhead are one of the six MPGs that are part of the Snake River Basin Steelhead Distinct Population Segment (DPS) that was listed as threatened under the ESA in 1997. Their listing status was reaffirmed in January 2006. Listed wild fish from Little Sheep Creek were incorporated into the Little Sheep hatchery broodstock; therefore, hatchery progeny (naturally produced fish and hatchery fish with an intact adipose fin) were considered part of the DPS and were covered by Section 4(d) protective regulations in the 2006 rule (ODFW 2011). Estimates of annual adult steelhead returns to the Imnaha River may have exceeded 4,000 steelhead in the 1960's. The Imnaha Subbasin Management Plan maintains objectives of returning 4,315 adult summer steelhead (2,100 natural adults) to the basin annually (Ecovista 2004). Currently, steelhead returns are monitored in small tributaries including Camp, Cow, Lightning, Horse, Dry, Crazyman, Grouse, Gumboot, and Mahogany creeks. Redd counts in Camp Creek estimated an adult spawner abundance ranging from 2 in 1976, to 159 in 2009 (NMFS 2010). Adult weirs in Lightning, Cow and Horse creeks have estimated adult spawner escapement ranging from 30 to greater than 200 for each stream (Young and Hatch, 2013). Recent work by the Imnaha Adult Steelhead Monitoring project estimated over 1,300 returning natural fish to the upper Imnaha River in 2011 (Harbeck and Espinosa 2012).

Project History

The vision of the Nez Perce Tribe DFRM is to recover and restore all species and populations of anadromous and resident fish within the traditional lands of the Nez Perce Tribe (DFRM Strategic Plan Ad Hoc Team, 2013). The Nez Perce people have historically managed and fished throughout the Snake River basin and the mainstem Columbia River. The once abundant salmon runs were vital to supporting the Nez Perce way of life and served as a powerful cultural and social icon for the Nez Perce people. Due largely to hydroelectric power developments, habitat degradation, water quality impacts, and over-harvesting, the once robust salmon and steelhead runs have declined significantly.

The Lower Snake River Compensation Plan (LSRCP) was conceived and implemented by the United States Fish and Wildlife Service (USFWS) in 1976 to mitigate for spring, summer and fall Chinook salmon and steelhead losses to streams in the Snake River basin due to construction of the four Lower Snake River hydroelectric facilities. In 1985 the Tribe became involved in the program, and implemented the Nez Perce Tribe's Lower Snake River Compensation Plan Monitoring and Evaluation Studies (LSRCP M&E; project No. 141106J014). The LSRCP presently supports 11 hatchery programs in three states. This program is one approach to attempt to preserve and recover anadromous fish populations in the Snake River basin. One goal of the

LSRCP program is to maintain the hatchery production of 360,000 Chinook salmon smolts and 215,000 to 330,000 steelhead smolts for annual release in the Imnaha River (United States v. Oregon, 2008).

Juvenile spring/summer Chinook salmon and steelhead emigrant monitoring in the Imnaha River has been ongoing since 1992. The LSRCP funded the first two years of monitoring. In 1994, direct funding for the NPT Imnaha River Smolt Monitoring Project (IRSMP) to monitor hatchery and natural steelhead and Chinook was provided by the Bonneville Power Administration (BPA) as part of the larger Smolt Monitoring by Non-Federal Entities Project (No. 198712700) and the Fish Passage Center's Smolt Monitoring Program (SMP). These larger projects provide data on smolt emigration from major tributaries to and past hydroelectric facilities on the Snake and Columbia Rivers. Passive integrated transponder (PIT) tagged smolts are utilized to measure travel time and estimate survival through key index reaches. With the funding and support provided by BPA, FPC, and LSRCP, in-season indices of emigration strength and timing are provided to the Fish Passage Center by IRSMP for Imnaha River smolts at the Imnaha River Trap and mainstem dams. Fish quality and descaling information are recorded at the Imnaha River Trap to provide health indicators of emigrating smolts. This real-time tributary specific emigration data has been utilized in operational decisions relative to flow and spill management to improve smolt passage, and continues a collection of a time series of Chinook salmon and steelhead smolt arrival and survival information to mainstem dams. The scope of the project was further expanded in spring of 2010 with additional funding provided by the BPA to operate the trap on a year-round basis in order to better assess emigration timing and provide precise population estimates. After evaluating two seasons of year round trapping efforts, data suggested that temperatures were often too high after mid-July to tag or even handle fish and only ~2.5% of smolts emigrated from the Imnaha River during late summer (Hatch and Harbeck 2013). As a result, trap operations were discontinued in mid-July 2013. This report includes an evaluation of two years of continuous trapping efforts in 2011- 2012 and the 2013 migration year where trapping was discontinued in mid-July.

One of the aspects of the LSRCP M&E studies in the Imnaha River is to quantify and compare natural and hatchery-origin Chinook salmon and steelhead smolt performance, emigration characteristics, survival, and return rates (Kucera and Blenden 1998). A long-term monitoring effort was established to document smolt emigrant timing and post release survival within the Imnaha River, estimate smolt survival downstream to McNary Dam, compare natural and hatchery-origin smolt performance, and collect smolt to adult return information. In 2003 the studies began participation in the Separation by Code (SbyC) system. With the SbyC technology in operation at the hydrosystem bypass facilities it became possible to accurately represent non-PIT tagged fish migrating through the hydrosystem using a predetermined group of PIT tagged fish. The SbyC technology is further described in the Methods section of this report under *Smolt to Adult Return (SAR) Index Rates.* The completion of trapping in July 2013 marked NPT's 22nd year of emigration studies on the Imnaha River, and the 20th year of participating in the FPC's Smolt Monitoring Program.

Imnaha River Juvenile Emigrant Monitoring & Evaluation Objectives

The IRSMP and Imnaha River LSRCP M&E studies assess the life-stage specific status and performance of natural and hatchery-origin Chinook salmon and steelhead under a framework of M&E objectives listed below. Additionally, these studies provide near real-time data from fish PIT-tagged at the Imnaha River juvenile emigrant trap to the Fish Passage Center to inform in-season management decisions on hydrosystem operations.

M&E Objective 1: Quantify life-stage specific emigrant abundance of Imnaha River natural-origin juvenile Chinook salmon and steelhead.

Objective 1a: Quantify juvenile emigrant abundance for natural-origin Chinook salmon emigrating past the Imnaha River Trap during the presmolt and smolt emigration seasons as well as a total annual emigrant abundance estimate by migration year.

Objective 1b: Quantify juvenile emigrant abundance for natural-origin steelhead smolts emigrating past the Imnaha River Trap.

M&E Objective 2: Quantify and compare life-stage specific emigration timing of Imnaha River juvenile Chinook salmon and steelhead.

Objective 2a: Quantify and compare the arrival timing of natural and hatchery-origin Chinook salmon at the Imnaha River Trap (represents emigration timing from the Imnaha River basin) and describe the environmental parameters of discharge and temperature during peak Chinook salmon emigration periods, and periods when little to no movement is observed.

Objective 2b: Quantify and compare the arrival timing of natural and hatchery-origin steelhead smolts at the Imnaha River Trap (represents emigration timing from the Imnaha River basin) and describe the environmental parameters of discharge and temperature during peak steelhead emigration periods, and periods when little to no movement is observed.

Objective 2c: Quantify and compare the arrival timing of natural-origin Chinook salmon presmolts and smolts, hatchery-origin Chinook salmon and steelhead smolts, and natural-origin steelhead smolts from the Imnaha River Trap to Lower Granite Dam (LGR).

Objective 2d: Quantify and compare the travel time of natural and hatchery-origin juvenile Chinook salmon and steelhead from the tributary (Imnaha River Trap) to LGR.

Objective 2e: Quantify status and trends of Imnaha and Snake River discharge and evaluate effects on juvenile emigrant travel time to LGR.

M&E Objective 3: Quantify and compare life-stage specific survival of juvenile Chinook salmon and steelhead within and from the Imnaha River to Lower Granite Dam on the Snake River and McNary Dam on the Columbia River.

Objective 3a: Quantify the in-river survival (post-release survival) of PIT-tagged hatchery-origin Chinook salmon and steelhead smolts from release to the Imnaha River Trap.

Objective 3b: Quantify and compare the survival of natural-origin Chinook salmon presmolts and smolts, natural-origin steelhead smolts, and hatchery-origin Chinook salmon and steelhead smolts from the Imnaha River Trap to LGR and MCN.

Objective 3c: Quantify status and trends of Imnaha and Snake River discharge and evaluate effects on juvenile emigrant survival.

M&E Objective 4: Quantify and compare smolt to adult return (SAR) index rates for Imnaha River natural-origin Chinook salmon and steelhead.

Objective 4a: Quantify and compare annual SAR index rates for natural-origin Chinook salmon presmolts and smolts PIT tagged at the Imnaha River Trap and hatchery Chinook salmon recaptured at the trap for run-of-river release groups.

Objective 4b: Quantify and compare annual SAR index rates for natural-origin steelhead smolts PIT tagged at the Imnaha River Trap and hatchery steelhead recaptured at the trap for run-of-river release groups.

M&E Objective 5: Describe life-stage specific biological characteristics of Imnaha River juvenile Chinook salmon and steelhead.

Objective 5a: Quantify and compare the biological characteristics of fork length (mm), weight (g), and condition factor of natural-origin Chinook salmon presmolts, and natural and hatchery-origin Chinook salmon and steelhead smolts.

Description of Project Area

The Imnaha River subbasin is located in Northeastern Oregon (Figure 1.1) 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). Elevations in the watershed vary from 3,048 m at the headwaters to about 260 m in lower elevations (Kucera 1989).

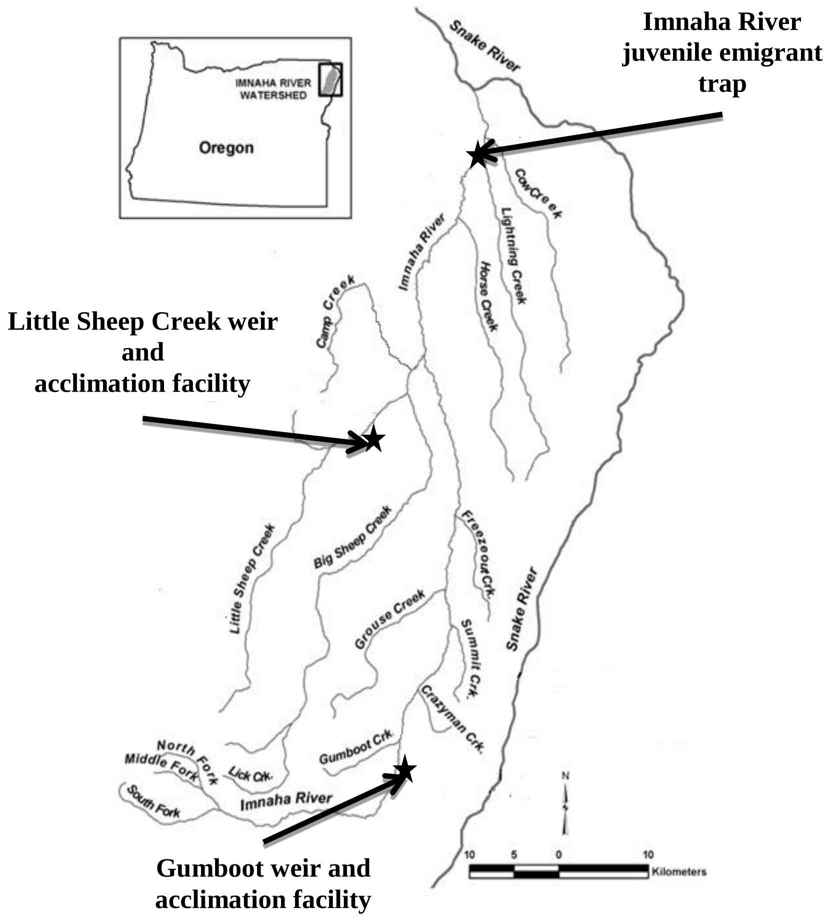

Figure 1.1. Map of the Imnaha River study area showing the location of the Imnaha River juvenile emigrant trap at N 45.76381 W 116.74802, the Gumboot Chinook salmon acclimation facility and the Little Sheep Creek steelhead acclimation facility.Map of the Imnaha River study area showing the location of the Imnaha River juvenile emigrant trap at N 45.76381 W 116.74802, the Gumboot Chinook salmon acclimation facility and the Little Sheep Creek steelhead acclimation facility.

Reservoirs encountered by emigrating Imnaha River Chinook salmon and steelhead smolts are formed by Lower Granite Dam (LGR), Little Goose Dam (LGS), Lower Monumental Dam (LMD) and Ice Harbor Dam (IHD) in the Snake River and McNary Dam (MCN), John Day Dam (JDD), The Dalles Dam (TDD), and Bonneville Dam (BON) in the Columbia River (Figure 1.2). Juvenile emigration monitoring described in this report occurs at LGR, LGS, LMD, and MCN. Juvenile emigration at Ice Harbor Dam is not monitored because IHD lacks the necessary juvenile detection facilities.

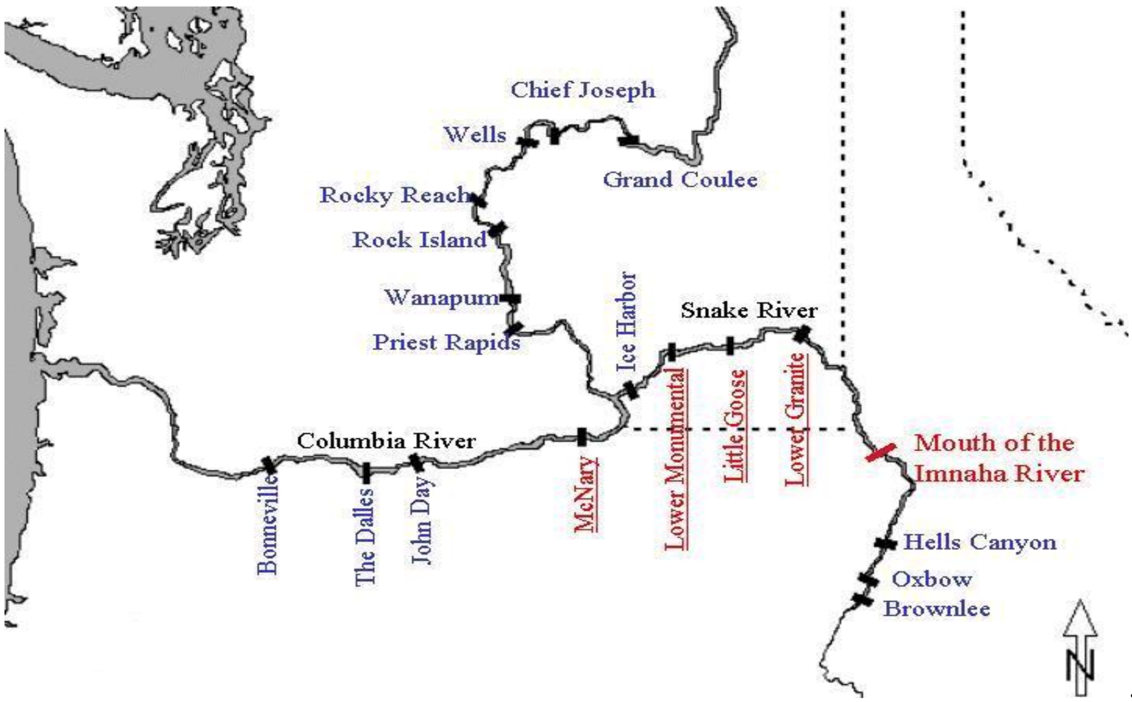

Figure 1.2. Map of the Columbia River Basin. Dams underlined indicate monitoring points for the Nez Perce Tribe Imnaha River Smolt Monitoring Project.

Trapping and Tagging Methods

Equipment Description

The primary field data collection method used to trap emigrating Chinook salmon and steelhead juveniles is the operation of a rotary screw trap. The Imnaha River juvenile emigrant trap is located at N 45.76381 W 116.74802, seven river kilometers (rkm) from the confluence with the Snake River. It is located as close to the confluence as possible while still accessible by road. Two screw traps manufactured by E.G. Solutions Inc., Corvallis, OR, are used. The trap fished during the spring season has a rotating cone that is 2.1 m in diameter and sits atop two or four (four during high spring flows) floating pontoons that are 6.7 m long, with a live box and debris drum (Figure 1.3). The trap fished during the summer and fall has cone that is 1.5 m in diameter and sits atop two 4.9 m long pontoons, with a live box and debris drum.

Figure 1.3. The Imnaha River juvenile emigrant trap rotary screw trap in operation.

Trap Operations

With the expansion of the contract beginning in fiscal year 2010, the trap was operated throughout periods when fish movement was not previously quantified in order to gain a better understanding of juvenile salmonid migration patterns in the Imnaha River. The trap fished as continuously as possible from 1 September 2010 to 18 July 2013, primarily targeting emigrating spring/summer Chinook salmon and steelhead. Trapping operations were terminated intermittently due to high flows, high stream temperatures warranting the cessation of fish handling, evacuations due to wild-land fires, and ice events. As mentioned earlier, analysis of two seasons of continuous operations suggested that trapping should be discontinued in mid-July due to environmental conditions in late summer and trapping was discontinued for the late summer in 2013 as a result.

Fish Handling

The trap was checked daily at 0800 and several times throughout each night and day, if warranted by large numbers of fish or excessive debris. Non-target piscivorous fish and large numbers of other non-target fish were removed from the live box first, then Chinook salmon and steelhead juveniles were netted into buckets and carried to the tagging tent and placed in aerated buckets. Daily processing procedures were as follows. Fish were anaesthetized in a MS-222 bath (6 ml MS-222 stock solution (100 g/L) per 19 L of water) buffered with Propolyaqua until they could be effectively handled. All fish were examined for existing marks (e.g. fin clips and external tags) and Chinook salmon, steelhead, and large piscivorous fish were scanned with a Destron Fearing FS2001F PIT tag reader (Figure 1.4 and 1.5). A target number of each species was selected for PIT tagging based on the average daily catch and all other fish were enumerated and released 30-50 m downstream from the trap after recovering from the anesthetic (Figure 1.6). Fifty randomly selected natural-origin Chinook salmon and steelhead smolts were PIT-tagged and released approximately one kilometer upstream of the trap for daily trap efficiency estimation. All other tagged fish were held in perforated recovery containers in the river and released after dark downstream of the trap. Mortality due to trapping, handling, and tagging was recorded.

Figure 1.4. A natural Chinook salmon smolt on the measuring table at the Imnaha River Trap.

Figure 1.5. A natural steelhead smolt on the measuring table at the Imnaha River Trap.

Figure 1.6. A Chinook salmon smolt about to be PIT tagged at the Imnaha River Trap.

During peak emigration periods the trap occasionally captured more smolts than can be safely processed in a reasonable time. To ensure that fish health was not compromised, two subsampling procedures were used to ensure a representative sample of juvenile fish trapped during both sampling and subsampling procedures. The first subsampling procedure was used proactively based on predictions of when large numbers of hatchery fish might hit the trap and if the rate of fish entering the trap was such that technicians could fully process a sub-sample of fish without jeopardizing fish health. Initially, a partition was placed in the trap to by-pass fish around the trap box and through a PIT tag antennae to monitor for recaptures (trap efficiency or previously tagged fish). Fish in the trap box were removed and processed as described above to get a composition of trapped fish captured prior to subsampling. After the trap box was cleared the partition was removed and fish were collected for a fixed period of time. After the set duration of trapping the partition was placed in the trap to isolate the collected fish from incoming fish and the fish in the box were processed. This was repeated until the number of fish entering the trap did not exceed the ability of the crew to process all of the fish. Abundance and composition passing the trap during the subsampling procedure was estimated by expanding the number of processed fish by an appropriate time ratio determined by the duration of the subsampling each hour. For example, if fish were collected for 15 minutes and then bypassed for 45 minutes the ratio would be 1:4. The estimated total number of fish passing would equal the total processed multiplied by four and the species, origin, and numerical composition of the handled fish would be expanded to the total abundance estimate for each species.

The second subsampling routine was used reactively when the rate of fish entering the trap entering the trap was so rapid that a sub-sample of fish could not be fully processed without jeopardizing the health of the fish remaining in the live box. Similar to above, the partition was placed in the trap box to isolate all trapped fish within the live box and divert captured fish through the PIT tag antennae. The composition of fish in the trap box was determined by subsampling and processing net-fulls of fish. This was accomplished by scooping one or more net-fulls of fish from the live box for processing then scooping equally-sized net-fulls of the remaining fish to determine the total number of net-fulls that were in the box at the time the subsampling began. All net-fulls were passed through a separate PIT tag antenna to interrogate any previously PIT-tagged fish. This estimate was expanded in a similar way to the first routine except "net-fulls" becomes the multiplier.

The PIT tag data collected were incorporated into recapture numbers and trap efficiency calculations. The expanded fish numbers were included in the number of fish handled and incidental species counts. All other pertaining calculations within this document were based on actual fish counts or PIT tags, not expanded numbers of fish handled.

<u>Hatchery Releases</u>

Hatchery-origin Chinook salmon and steelhead were released by LSRCP facilities managed by the Oregon Department of Fish and Wildlife (LSRCP 2011, 2012, 2013). In 2011, direct releases of hatchery steelhead into Big Sheep Creek were discontinued and all smolts were acclimated at

Little Sheep Creek Acclimation Facility for a period of three weeks and volitionally released from the end of March through the end of April, when all remaining smolts were forced out of the pond. Hatchery Chinook salmon smolts were volitionally released after 10-15 days of acclimation from the Gumboot Acclimation Facility beginning end of March through mid-April in 2011, 2012, and 2013. In 2012 and 2013, planned direct-stream releases of hatchery Chinook salmon occurred in addition to the volitional releases at the Gumboot Facility as part of a study comparing the two release methods conducted by Oregon Department of Fish and Wildlife (ODFW). Direct-stream releases consisted of 136,933 fish in 2012, and 166,979 fish in 2013 (ODFW, 2012 and 2013). Refer to Appendix D for a summary of hatchery release numbers, dates, and associated data.

PIT Tagging and PIT Tag Recaptures of Juvenile Natural and Hatchery-origin Chinook Salmon and Steelhead

Natural-origin Chinook salmon and steelhead juveniles selected for PIT tagging were examined for existing PIT tags, percent of descaling and general condition. All fish were measured for fork length to the nearest millimeter and weighed to the nearest 0.1gram. In 2011 and 2012, only Chinook salmon greater than 60 mm were selected for tagging. In 2013, the minimum length for PIT tagging was changed to 70 mm due to increased mortality rates observed in juveniles less than 70 mm. Fish were PIT-tagged using hand injector units following the methods described by Prentice et al. (1986 and 1990) and Matthews et al. (1990, 1992). Hypodermic injector units and PIT tags were sterilized after each use in ethanol for at least 10 minutes and allowed to dry prior to reuse. Tagging was discontinued when water temperatures exceeded 15°C, and at 20°C handling was reduced to netting, tallying by species, and returning fish to the river, no biological data was recorded. PIT-tagged fish were held in perforated recovery containers in the river and released after dark during the fall through spring trapping seasons. All previously PIT-tagged fish of either hatchery or natural-origin were recorded as recaptures at the trap, and released downstream immediately upon recovering from the anesthetic. From July through September, the trap was not staffed continuously throughout the day, but rather checked as early as possible in the morning and fish trapped since the previous morning were processed and released either upstream of the trap for efficiency trials or downstream of the trap after recovering from the anesthetic, a period of approximately 30 minutes. To reduce costs, the trap was fished on a five-day-per week basis in late summer. No trap efficiency fish were released on the last day of trapping for the week.

Performance Measure Evaluations: Methods

Juvenile Emigrant Abundance Estimates at the Imnaha River Trap

Life-stage specific estimates of natural-origin emigrant abundance

Seasonal and annual emigrant abundance of natural-origin Chinook salmon presmolts and smolts and natural-origin steelhead smolts was estimated for the Imnaha River using the weekly catch numbers expanded by the weekly trap efficiency rate. Data analysis was performed using the Gauss program (Aptech Systems Inc., Maple Valley, Washington) with a Bailey trap efficiency estimation method (Steinhorst et al. 2004). The Bailey estimate is a version of the Lincoln-Peterson method. The Gauss program utilizes a bootstrap method with 1,000 iterations to provide a distribution of population estimates, then calculates the point estimate, the 95% confidence intervals, and standard error and utilizes stratified data when appropriate. To maintain robustness for analysis, we set a lower limit of seven mark recaptures for any period when assessing trap efficiencies (Steinhorst et al. 2004). Coefficients of variation (CV) were calculated by dividing the standard error by the population estimate (point estimate) as an indicator of precision.

Daily trap efficiency (TE) trials were conducted across the entire trapping period using PIT-tagged natural-origin Chinook salmon and steelhead smolts. The daily goal was to randomly PIT tag 50 Chinook salmon and 50 steelhead. Fish marked for TE trials were held in perforated containers in the river during daylight hours (up to 12 h) and then transported upstream approximately one kilometer and released after dark, with the exception of the summer trapping period, when fish were released immediately after recovering from the anesthetic. Daily TE trials were grouped into weekly periods if at least seven marked fish were recaptured and flow conditions were relatively stable during that weekly period. Weeks with less than seven recaptures were grouped with either the preceding week or the following week depending on similarity of flow conditions. 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.

Hatchery smolt emigrant abundance estimates at the Imnaha trap

Hatchery reared Chinook salmon and steelhead smolt abundance estimates were calculated at the Imnaha River Trap by applying the estimated survival from release to the trap (post-release survival) to the total number of smolts released. Survival estimation methods are discussed in detail below. The standard error of the survival estimate to the trap was applied to the total release number (a census count with no reported standard error) to generate a standard error for the abundance estimate at the trap, which was then used to generate 95% confidence intervals (95% C.I.) around the point estimate.

<u>Juvenile Emigration Timing of Imnaha River Chinook Salmon and Steelhead</u>

Timing of juvenile emigration from the Imnaha River

Due to the proximity of the Imnaha River Trap to the confluence with the Snake River (seven river kilometers) it was assumed that juvenile emigrant arrival timing at the trap represented emigration timing from the tributary to the Snake River. Consequently, cumulative emigration timing from the Imnaha River was quantified for each group of natural and hatchery-origin Chinook salmon and steelhead juveniles. Capture timing of natural-origin Chinook salmon and steelhead was compared to the timing of recaptures of hatchery-origin fish.. Tests for differences in emigration timing using the cumulative proportion of each release group caught over time were conducted with a Kolmogorov-Smirnov (K-S) test (Steel et al. 1997 and STATGRAPHICS 1995). The PIT tag interrogation data used for these comparisons were queried from the Pacific States Marine Fisheries Commission's (PSMFC's) PIT Tag Information System database (PTAGIS). Imnaha River flows were averaged by week and discharge data was obtained from USGS gauge 13292000 at Imnaha, Oregon at http://waterdata.usgs.gov/usa/nwis/uv?site_no=13292000.

Arrival timing of Imnaha River juvenile emigrants at Lower Granite Dam in relation to juvenile transportation

Arrival timing at Lower Granite Dam (LGR) was quantified for natural and hatchery-origin Chinook salmon and steelhead using PIT tag interrogation data queried from PTAGIS and the proportion of emigrant passage over time. Detections and arrival timing for this report period were based on first-time observations of individual tag codes at the dam. The cumulative distribution of arrival times were compared using a Kolmogorov-Smirnov test (Steel et al. 1997 and STATGRAPHICS 1995) for five different release groups: fall-tagged natural-origin Chinook salmon presmolts, natural and hatchery-origin Chinook salmon smolts tagged or recaptured during the spring and summer, and natural and hatchery-origin steelhead smolts. The cumulative proportion that arrived before the initiation date of full collections for juvenile transportation at LGR was calculated for each release group by species and origin to determine the proportion of juvenile emigrants that had passed the dam before transportation was initiated, and those that were available and likely transported.

Travel time from the Imnaha River Trap to LGR in relation to Snake River flow

We calculated travel time from the trap to LGR as the number of days from release or interrogation at the trap to the first detection at LGR for PIT-tagged juveniles. Mean travel time for all fish detected at LGR by week was determined and compared for natural and hatchery-origin Chinook salmon and steelhead smolts using a two samples t-test. In addition, we determined the relationship between weekly mean travel time and Snake River flow using regression analysis. For this report, Snake River water discharge was provided by the USGS gauge 13334300 at Anatone, Washington at http://waterdata.usgs.gov/usa/nwis/uv?site_no=13334300. Measurements of outflow and spill at LGR were obtained online from Columbia River DART at http://www.cbr.washington.edu/dart/.

Proportion of juveniles likely to be transported at LGR

We calculated the proportion of juveniles likely to be transported at LGR by origin and species. This calculation is the product of the cumulative proportion of juveniles within an origin and species which passed while transportation operations occurred, the collection efficiency of that specific origin and species at the LGR juvenile bypass facility, and the proportion of collections that were transported. The collection efficiency and proportion transported of each origin and species was sourced from the annual reports of the Fish Passage Center for MY2011 through MY2013 (FPC 2012, 2013, and 2014).

Life-stage and Reach Specific Estimates of Juvenile Emigrant Survival

In-river survival (post-release survival in the tributary) was calculated for hatchery-origin Chinook salmon and steelhead smolts from their point of release to the Imnaha River juvenile emigrant trap at rkm 7. Hatchery Chinook releases occurred as acclimated volitional releases from the LSRCP Gumboot Acclimation Facility on the Imnaha River and as direct-stream releases at the Gumboot weir. Hatchery steelhead were released volitionally after an acclimation period at the LSRCP Little Sheep Creek Acclimation Facility. Survival probabilities were estimated by the Cormack, Jolly and Seber methodology (1964, and 1965, respectively, as cited in Smith et al. 1994) with the Survival Under Proportional Hazards (SURPH) model used for analysis and comparison. The data files for season- and migration year-wide release groups were created using the program PITPRO version 4.10 (Westhagen and Skalski, 2007). Data for PITPRO and SURPH was obtained directly from PTAGIS.

Survival estimates from the Imnaha River to LGR, Imnaha River to MCN, and LGR to MCN were calculated for natural and hatchery-origin Chinook salmon and steelhead smolts and natural-origin Chinook salmon presmolts. Natural-origin Chinook salmon release groups were evaluated independently by life-stage (presmolt and smolt) and also as a combined release group by migration year (cohort). Natural-origin steelhead smolts trapped during the fall are excluded from analysis due to insufficient numbers for conducting PIT-tag based survival and mark/recapture analyses. The assumptions for the methodology can be found in Smith et al. (1994) and Burnham et al. (1987). Our analysis provides estimates of survival to the Imnaha River Trap, LGR, and MCN but does not provide estimates of juvenile survival through entire Columbia River hydrosystem. See the Fish Passage Center's Comparative Survival Reports for a comprehensive analysis of juvenile survival throughout the hydrosystem (http://www.fpc.org/documents/css.html).

The estimated survival rates of all release groups to LGR are applied to the population estimates at the Imnaha River Trap, providing an estimated number of smolt equivalents at LGR by origin and life-history type. The variance and standard deviation used to estimate 95% confidence intervals for the smolt equivalent estimate are calculated using the formula where X equals the population estimate at the Imnaha River Trap and Y equals the estimated survival rate to LGR:

$$Var(X * Y) = E(X)^2 * SE(Y)^2 + E(Y)^2 * SE(X)^2 + SE(X)^2 * SE(Y)^2$$

$$SD(X * Y) = \sqrt{Var(X * Y)}$$

The relationship between juvenile survival and Imnaha or Snake River discharge provides information about the environmental conditions that maximize survival to LGR and may provide useful information important for the management of hatchery release strategies.

Survival over time to LGR and MCN in relation to hydrographic and hydrosystem variables is discussed in Chapter 5. For this analysis, discharge, spill volume, and percent of discharge spilled were averaged over the months of April and May and across the four Snake River dams for each year. Survival to LGR and to MCN was regressed vs. time over the periods of record for both reaches. Survival to MCN was regressed vs the aforementioned hydrographic and hydrosystem variables. Comparisons were made between survival to MCN before and after the implementation of court ordered spill at the four Snake River dams beginning in 2006.

Smolt to Adult Return (SAR) Index Rates

The smolt to adult return index rates quantified for this report are a measure of the number of survival mode (run-of-river) PIT tagged adults from a given brood year that return to LGR divided by the number of survival mode PIT tagged smolts which were interrogated at a juvenile facility during their outmigration. Though many juveniles were first interrogated at dams downstream of LGR, we included them with the number which passed LGR assuming they were not interrogated when they outmigrated past LGR. For LGR – LGR SAR index rates, adult PIT tag detections at LGR are totaled by their juvenile release group and brood year (Chinook salmon) or migration year (steelhead).

Smolt to adult return index rates were quantified for survival mode PIT tagged natural-origin presmolts and smolts as well as survival mode hatchery smolts recaptured at the trap for brood years 2006 through 2009 (BY2006 through BY2009). Steelhead SAR index rates were calculated for survival mode natural-origin steelhead PIT tagged at the trap for migration years 2009 through 2012. The natural steelhead PIT tagged release groups from the Imnaha River Trap include juveniles of unknown brood years, making analysis by brood year impossible for natural-origin steelhead. Hatchery-origin steelhead SAR index rates were evaluated by brood and migration year from hatchery steelhead recaptured at the trap that were marked with survival mode tags at Irrigon Hatchery.

Fish marked with PIT tags migrating downstream from the Imnaha River will travel through the hyrdrosystem in one of two predetermined designations; monitor mode or survival mode. The Separation by Code (SbyC) system allows PIT tagged fish interrogated at the hydrosystem juvenile bypass facilities to be segregated by these two actions depending on specific PIT tag codes. Survival mode fish are always bypassed back to the river in an effort to assess in-river survival of emigrating juveniles. The monitor mode group are treated as the run-at-large fish (non-PIT tagged) and barged or bypassed depending on the management actions at any given time at each hydrosystem facility. The survival mode is the default action for PIT tagged fish even when the run-at-large fish are being transported. Consequently, default action fish do not represent the non-PIT tagged fish migrating through the hydrosystem and do not accurately represent the SAR rate for the entire cohort. Therefore, the SARs presented in this report should be considered index SARs. Given sufficient numbers of monitor mode tags, in future reports we will include SARs for both survival and monitor mode tags.

Size and Condition of Juveniles at Emigration

Juvenile emigrants were evaluated for life-stage specific biological characteristics of fork length (mm), weight (g), and condition across the spring and fall emigration periods. Length frequency distributions and condition factors were calculated for each fish species by origin. Length frequencies were based on five millimeter classes. Condition factor was calculated using Fulton's condition factor: $K = 10000(W/L^3)$ (Bagenal and Tesch 1978). Natural-origin *O. mykiss* that had the morphological characteristics of resident rainbow trout (*Oncorhynchus mykiss*), rather than those of an anadromous steelhead undergoing smoltification, were assumed not to be actively migrating and therefore were not PIT tagged or used in length, weight and condition factor calculations and were reported as rainbow trout. A Student's t-test was used to test for significant differences in mean fork length, weight, and condition factor between various groups of fish. Differences were considered significant at an alpha < 0.05.

Chapter 2: Migration Year 2011

Chapter Introduction

This chapter presents the results and discussion for trapping efforts covering migration year 2011, from September 1, 2010 to August 31, 2011. The trap operated as continuously as possible targeting BY2009 spring/summer Chinook salmon and MY2011 summer steelhead. Although Chinook salmon fry and parr from BY2010 were trapped during this time period, no marking or trap efficiency trials were conducted on these fish so they are not included in population estimates or the following performance measure analyses, but their presence is noted and discussed. The performance measure results included in this chapter are specific to the BY2009 and MY2011 emigrants only, while multi-year performance measures are included in Chapter 5.

Trapping and Tagging Results and Discussion

Trap Operations

The trap operated for a total of 276 days during MY2011, from September 1, 2010 through August 31, 2011. There were a total of 44 days when the trap was not operated due to icy conditions, high flows, or heavy debris, and 10 days when the trap was not operated due to equipment repair and maintenance. The trap was not operated on the weekends during the summer trapping period or on major holidays, leaving a total of 34 days of in-operation due to scheduling. Subsampling was only utilized for one day during the fall through summer trapping period. There were also 12 sample periods that were shortened (less than 24 hours) due to equipment repair and maintenance. The trap operated for more than 75% of the 2011 migration year, extending operations beyond years previous to 2010 by 33%. Please refer to Appendix A.1. for a summary of total hours fished, and the daily catch.

Target Catch

The catch of MY2011 natural-origin Chinook salmon totaled 20,611 fish including 16,247 presmolts trapped in the fall of 2010, and 4,364 smolts trapped during spring and summer 2011 (Appendix A.1) A total of 37 BY2010 Chinook salmon fry were also caught, but were not PIT-tagged and no trap efficiency expansions were conducted for these fish so they are excluded from population estimates. A total of 4,176 natural-origin Chinook salmon presmolts were PIT tagged at the Imnaha trap during fall 2010 and 4,075 smolts were tagged during the spring of 2011 (Appendix B.1). Of the tagged fish, 1,998 fish during fall and 1,812 fish during spring were marked and released above the trap for trap efficiency trials. A total of 29 of the 1,000 natural-origin Chinook salmon that were previously PIT tagged by Oregon Department of Fish and Wildlife's (ODFW) Early Life History Program during August and September of 2010 were recaptured at the Imnaha River Trap. Please refer to Appendix C for trap date, travel time, and biological data for these fish.

The catch of MY2011 natural-origin steelhead totaled 4,396 fish including 411 trapped in fall and 3,984 trapped in spring (Appendix A.1) A total of 2,610 natural-origin steelhead were PIT tagged, of which 849 were marked and released above the trap for trap efficiency trials (Appendix B.1). Natural-origin steelhead were not tagged in the fall since the number of fish captured was typically too small to produce an accurate abundance estimate.

A total of 26,966 hatchery-origin Chinook smolts representing BY2009 were captured at the Imnaha River Trap during the MY2011 spring/summer trapping period (Appendix A.1). Hatchery-origin Chinook smolt captures were from an acclimated volitional release group totaling 252,588 smolts released from the Imnaha River Gumboot acclimation facility at rkm 74 beginning March 30, 2011 until April 14 when all remaining smolts were forced out (Feldhaus et al. 2014a). Of the 252,588 smolts released, a total of 20,757 were PIT-tagged (Appendix D). A total of 1,751 previously PIT tagged hatchery Chinook salmon were recaptured at the Imnaha juvenile emigrant trap.

A total of 10,201 hatchery-origin steelhead smolts representing BY2010 were captured at the Imnaha River Trap during the MY2011 spring/summer trapping period (Appendix A.1). Hatchery-origin steelhead captures were from a volitional release of 158,027 smolts from the LSRCP Little Sheep Creek acclimation facility beginning March 29 and ended April 26 when all remaining fish were forced out (Clarke et al. 2014). A total of 1,000 previously PIT-tagged hatchery-origin steelhead released from the Little Sheep Creek were recaptured at the Imnaha River Trap. Please refer to Appendix D for additional information on hatchery-origin steelhead.

Incidental Catch

The incidental catch during the fall, spring, and summer of MY2011 was estimated to total 2,672 fish comprising of seven families of fishes: Salmonidae, Centrarchidae, Catostomidae, Cyprinidae, Cottidae, Ictaluridae, and Petromyzontidae. The catch of Salmonidae consisted of 37 adult steelhead, 16 adult Chinook salmon, 914 rainbow trout, 110 mountain whitefish (*Prosopium williamsoni*), and 221 bull trout (*Salvelinus confluentus*). Bull trout were divided into adults 300 mm and greater (n=85), and juveniles less than 300 mm (n=136). The juvenile rainbow trout were determined to be resident fish based on morphological characteristics and were not enumerated as natural-origin steelhead juveniles in this report. The catch of Centrarchidae consisted of 36 smallmouth bass (*Micropterus dolomieui*). The catch of the Catostomidae family consisted of three bridgelip suckers (*Catostomus columbianus*) and 963 suckers of unidentified species. The catch of Cyprinidae included 24 chislemouth (*Acrocheilus alutaceus*), 125 longnose dace (*Rhinichthys cataractae*), 112 Northern pikeminnow (*Ptychocheilus oregonensis*), and 28 redside shiner (*Richardsonius balteatus*), and six peamouth chub (*Mylocheilus caurinus*). The catch of the Cottidae family consisted of 60 sculpins of unidentified species. The catch of Ictaluridae consisted of one bullhead catfish of an unidentified species (*Ameiurus sp.*) A total of 17 juvenile Pacific Lamprey (*Lampetra tridentata*) of the family Petromyzontidae were caught during MY2011. Lamprey were categorized by their developmental stage as either ammocoetes (larvae) or macropthalmia (juveniles). Please refer to Appendix E.1 for a summary table of the MY2011 Incidental Catch data and Appendix F for detailed Pacific Lamprey catch and biological data.

Trapping and Tagging Mortality

Mortalities handled at the Imnaha River Trap during the MY2011 trapping season included 98 natural and 11 hatchery Chinook salmon, and two natural and three hatchery steelhead. Sixty-three of the natural Chinook salmon mortalities occurred during the fall of 2010, accounting for 0.41% of the total Chinook salmon fall catch (Appendix G.1). Of these 66 mortalities, 46 were from trapping (including predation in the trap live box), five from handling, eight from tagging, and seven that were dead on arrival. Thirty-two natural Chinook salmon mortalities occurred during the spring: 21 due to trapping (including predation), nine from handling, one from PIT tagging and one that was dead on arrival at the Imnaha trap (Appendix G.1) The 32 mortalities accounted for 0.73% of the total natural Chinook salmon catch during the spring of 2011. Eleven hatchery Chinook salmon mortalities were recorded in the spring of 2011. Of these, five were attributed to trapping, three to handling, and three that were dead on arrival. These 11 mortalities accounted for 0.04% of the total catch of hatchery Chinook salmon in MY2011. There were two natural steelhead mortalities during the spring of 2011 (Appendix G.1), and none during the fall of 2010. Of the two mortalities in the spring, one was from trapping, and the other was dead on arrival. There were no tagging mortalities of natural steelhead. Mortality accounted for 0.05% of the total natural steelhead catch in the spring of 2011. There were three hatchery steelhead mortalities handled at the trap during MY2011: two attributed to trapping and one that was dead on arrival. These mortalities accounted for 0.03% of the total hatchery steelhead catch.

Forty-five incidental catch mortalities occurred during the MY2011 trapping season. Twenty-two of these occurred during spring trapping and twenty-three during the fall. Trapping caused the mortality of one Pacific lamprey macropthalmia, one redside shiner, eight sculpin, and 12 unidentified suckers. Handling caused the mortality of three unidentified suckers. There was a total of 20 mortalities handled that were presumably dead on arrival, including two post-spawn wild adult Chinook salmon, 12 sculpin, four unidentified suckers, one Northern pikeminnow, and one longnose dace.

Performance Measures Results and Discussion

Juvenile Emigrant Abundance Estimates at the Imnaha River Trap

Life-stage specific estimates of natural-origin Chinook salmon and steelhead emigrant abundance

Gauss population estimates generated from mark/recapture analysis of the trap efficiency fish estimated the fall juvenile emigrant abundance for natural Chinook salmon to be 64,945 presmolts, (95% C.I. 55,638 to 82,616; Table 2.1) with a CV of 10.2%. Fall 2010 trap efficiencies for natural Chinook salmon presmolts averaged 28% and individual stratum estimates ranged from 7% to 60% through the season (Table 2.1). The spring juvenile emigrant abundance estimate for natural Chinook salmon smolts was 32,047 (95% C.I. 28,069 to 37,164; Table 2.1) with a CV of 7.41%. Trap efficiencies averaged 14% and ranged from 9% to 20% through the 2011 spring season (Table 2.1). The MY2011 combined juvenile emigrant abundance estimate (fall and spring total) for natural-origin Chinook salmon was 96,992 (95% C.I. 86.687 to 112,464) with a CV of 6.72%. Our results indicate that during the trapping period 67.0% of Chinook salmon juveniles emigrated past the trap during the fall 2010 trapping period, and 33.0% during spring of 2011.

Table 2.1. Gauss population estimates and totals for natural-origin Chinook salmon captured in the Imnaha River juvenile emigrant trap during migration year 2011 (MY2011; fall 2010 and spring/summer 2011). Table includes the date range of the trap efficiency trial (Date Strata), total fish captured by the screw trap (Caught), total marked (Mark), total recaptured (Recap), trap efficiency for the period (T.E.), total population estimate (Pop. Estimate), lower 95% confidence interval (Lower C.I.), upper 95% confidence interval (Upper C.I.) and standard error (S.E.).

Date Strata	Caught	Mark	Recap	T.E.	Pop. Estimate	Lower C.I.	Upper C.I.	S.E.
9/1 - 10/16	403	154	36	23%	1688	1260	2294	267.1
10/17 - 10/23	457	181	108	60%	763	669	882	55.7
10/24 - 10/30	1089	284	94	33%	3267	2663	4071	383.1
10/31 - 11/6	1033	246	48	20%	5207	3817	7090	871.6
11/7 - 11/13	8044	289	156	54%	14858	12857	17199	1134.9
11/14 - 11/20	1601	173	71	41%	3869	3209	4689	381.2
11/21 - 11/27	247	61	18	30%	806	635	1050	106.9
11/28 - 12/4	1473	140	10	7%	18881	11160	34281	6215.6
12/5 - 12/11	841	187	19	10%	7905	5135	12447	2011.6
12/12 - 12/18	772	188	23	12%	6080	3950	9223	1393
12/19 - 12/31	287	95	16	17%	1621	1134	2411	325.4
Fall totals	**16,247**	**1,998**	**599**	**28%**	**64,945**	**55638**	**82616**	**8098.4**
1/9 - 1/22	246	121	13	11%	2,144	1,389	3,565	567.8
1/23 - 1/29	71	41	8	20%	331	216	487	67.3
1/30 - 3/12	108	47	7	15%	648	428	967	143.6
3/13 - 3/19	324	159	29	18%	1,728	1,240	2,472	326.2
3/20 - 3/26	208	127	15	12%	1,664	1,091	2,570	446.6
3/27 - 4/2	450	163	18	11%	3,884	2,526	6,417	1,014.2
4/3 - 4/9	624	262	23	9%	6,838	4,303	11,664	2,308.5
4/10 - 4/16	141	64	11	17%	764	520	1,111	157.8
4/17 - 4/23	482	169	20	12%	3,902	2,618	6,032	968.6
4/24 - 4/30	533	250	43	17%	3,041	2,166	4,454	572.2
5/1 - 8/31	1,178	409	67	16%	7,103	5,028	10,492	1,401.8
Spring totals	**4,365**	**1,812**	**254**	**14%**	**32,047**	**28,069**	**37,164**	**2,373.1**
MY 2011 Totals	**20,612**	**3,810**	**853**	**21%**	**96,992**	**86,687**	**112,464**	**6,513.9**

The 2011 spring juvenile emigration abundance estimate for natural steelhead smolts was 37,314 (95% C.I. 29,342 to 47,728; Table 2.2) with a CV of 12.8%. Trap efficiencies for natural steelhead averaged 13% and ranged from 10% to 17% (Table 2.2).

Table 2.2. Gauss population estimates and totals for natural-origin steelhead captured in the Imnaha River juvenile emigrant trap during spring/summer 2011. Table includes the date range of the trap efficiency trial (Date Strata), total fish captured by the screw trap (Caught), total marked (Mark), total recaptured (Recap), trap efficiency for the period (T.E.), total population estimate (Pop. Estimate), lower 95% confidence interval (Lower C.I.), upper 95% confidence interval (Upper C.I.) and standard error (S.E.).

Date Strata	Caught	Mark	Recap	T.E.	Pop. Estimate	Lower C.I.	Upper C.I.	S.E.
1/16 - 4/9	177	82	14	17%	979	607	1722	281.4
4/10 - 4/23	188	94	9	10%	1786	966	3797	698.1
4/24 - 4/30	365	198	31	16%	2270	1411	3735	604.7
5/1 - 9/3	3255	475	47	10%	32279	17939	54830	11555.1
MY 2011 Totals	**3,985**	**849**	**101**	**13%**	**37,314**	**29,342**	**47,728**	**4,779.1**

Since the trap operated year-round during MY2011 (and MY2012-13), the estimates above may be considered annual emigrant abundance estimates for juvenile Chinook salmon and steelhead in the Imnaha River. However, they should still be considered minimum estimates, as the trap was not operated during periods of high flows, heavy debris, icy conditions, during periods of maintenance and repair, and scheduled weekends and holidays off (Appendix A.1). In addition, trap efficiency trials were limited by low marking and recapture rates during periods with few emigrating juveniles, such as the summer months of June through September. The number of juveniles that emigrated when the trap was not operational was not determined for this report period.

Based on PIT tag interrogations either downstream or upstream of the trap and the size, condition, and morphological characteristics of captured fish, the transition into the next migration year was determined to occur by August 31, with a mixture of brood years and run types moving passed the trap during the summer months. Since few fish were trapped and even fewer tagged due to high water temperatures exceeding 17^0 C during the summer months, it is difficult to determine if Chinook and steelhead trapped during the summer are emigrating from the Imnaha River to the Snake River or possibly seeking thermal refugia in the deep pools just downstream of the trap. However, juvenile Chinook tagged during mid-September 2011 were detected in the hydrosystem the following spring. While fork length, condition factor, and morphological characteristics of fish trapped during July indicated that there were still BY2009 smolts migrating downriver, data also suggested that the catch was predominately BY2010 spring/summer Chinook parr or possibly fall Chinook juveniles.

Hatchery smolt emigrant abundance estimates at the Imnaha River Trap

Refer the section on life-stage and reach specific estimates of juvenile emigrant survival below for post-release survival and corresponding hatchery smolt equivalents at the Imnaha River Trap.

Juvenile Emigration Timing of Imnaha River Chinook Salmon and Steelhead

Timing of juvenile emigration from the Imnaha River

MY2011 arrival timing at the Imnaha River Trap, assumed to represent emigration from the Imnaha River, was compared between natural and hatchery Chinook salmon and steelhead smolts using the cumulative proportion of juveniles captured over time and a K-S test (Steel et al. 1997). First, 10 percent, median, 90 percent and last arrivals for each release group by species and origin are presented in Table 2.3.

Hatchery Chinook salmon were observed at the trap in small numbers within one day of the start of the volitional release (March 30, 2011), with peak passage occurring 15-16 days after the release on April 13 and 14 when over 50% of the fish had passed the trap. By April 19 over 90% of the release group had passed the trap, and the last arrival occurred on June 19. Natural Chinook salmon smolts demonstrated significantly different emigration timing, with the first smolts arriving at the trap on January 13, reaching the 10 percentile by March 14, and median arrival occurring on April 18, by which almost 90% of the hatchery fish had already passed the trap. The 90th percentile date for natural Chinook smolts did not occur until May 6 and the last smolt arrived in late August. Results of the K-S test indicated that the maximum difference between natural and hatchery Chinook salmon emigration timing occurred on April 19, 2011 (MaxD = 0.383, $p < 0.0001$; Figure 2.1). Similar to previous years, hatchery fish demonstrated a much more contracted migration period in relation to their natural counterparts.

Arrival timing was compared between natural and hatchery steelhead. Small numbers of natural steelhead were captured at the trap as early as January 20. The 10th percentile for natural steelhead emigration occurred April 25, the median occurred May 6, and 90th percentile occurred May 11. The last natural steelhead smolt was captured August 29, 2011. The first hatchery steelhead smolt was captured March 30; one day after the beginning of the volitional release. The 10th percentile for hatchery steelhead passage occurred April 7. The last half of the hatchery steelhead emigration period mirrored natural steelhead very closely. Interestingly, median and 90th percentile passage for hatchery steelhead occurred on the same dates as for natural steelhead (May 6 and May 11 respectively). The last hatchery steelhead was captured August 1. Despite similarities in the last half of emigration timing, a K-S test found significant differences in the timing of the cumulative proportion of emigrant passage between natural and hatchery steelhead (Max D = 0.164, $p = 0.0003$; Figure 2.2) The maximum difference in hatchery and natural steelhead emigration timing occurred on May 7. The similarity in passage between steelhead groups (e.g. identical median and 90th percentile dates) likely suggest the statistically significant result may not be very biologically significant.

Table 2.3. First, 10th percentile, median, 90th percentile, and last arrival dates for natural and hatchery-origin Chinook salmon and steelhead smolt groups captured at the Imnaha River Trap during the MY2011 fall and spring calendar period.

Origin and species	First Arrival	10th percentile	Median	90th percentile	Last Arrival
Natural Chinook Salmon	13-Jan	14-Mar	18-Apr	6-May	29-Aug
Hatchery Chinook Salmon	30-Mar	9-Apr	13-Apr	19-Apr	19-Jun
Natural Steelhead	20-Jan	25-Apr	6-May	11-May	29-Aug
Hatchery Steelhead	30-Mar	7-Apr	6-May	11-May	1-Aug

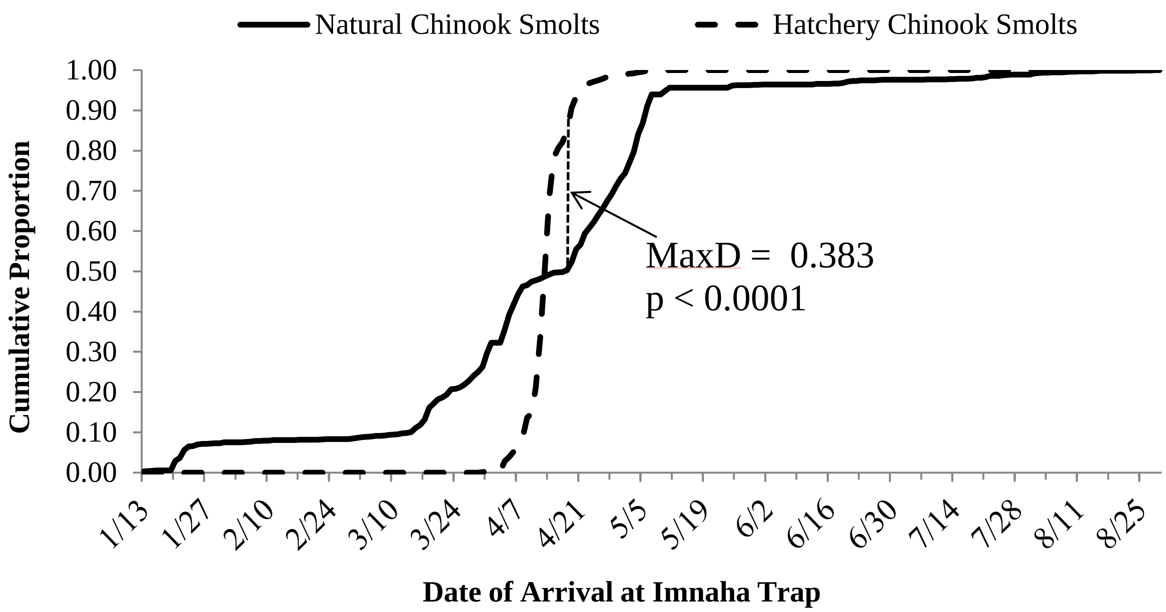

Figure 2.1. Comparison of emigration timing of natural and hatchery Chinook salmon smolts from the Imnaha River presented as the cumulative capture proportion of each origin type at the Imnaha River Trap during the spring 2011 trapping season, 1 January to 31 August. Maximum difference in emigration timing (MaxD, represented as the dashed vertical line) between the origin types occurred on April 19, 2011.

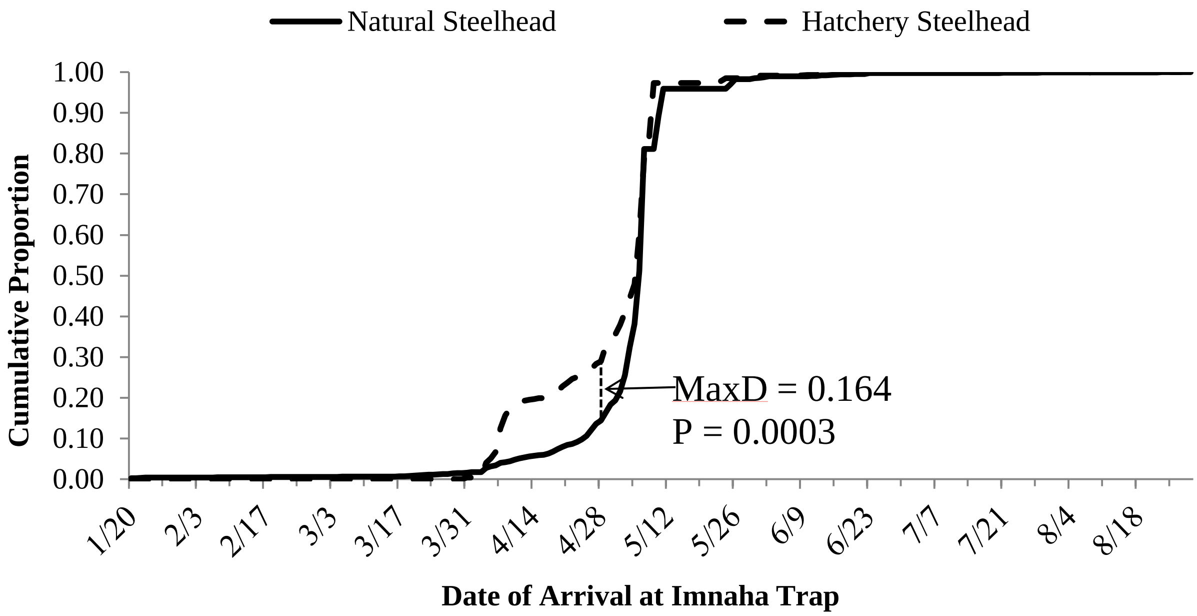

Figure 2.2. Comparison of emigration timing of natural and hatchery steelhead from the Imnaha River presented as the cumulative capture proportion of each origin type at the Imnaha River Trap during the 2011 spring and summer trapping season, 1 January to 31 August. Maximum difference in emigration timing (MaxD, represented as the dashed vertical line) between the origin types occurred on April 29, 2011.

Peak emigration timing in relation to Imnaha River discharge

Imnaha River discharge was averaged by week throughout the fall and spring emigration seasons in cubic feet per second (cfs). Chinook salmon presmolt emigration from the Imnaha River was highest from October 24 to December 18 with the peak week occurring between November 7 and November 13. Weekly average Imnaha River discharge during peak fall presmolt migration was between 139 and 230 cfs (Figure 2.3). During spring, both Chinook salmon and steelhead smolts appeared to accelerate migration during the early ascending snowmelt limb of the hydrograph with peak steelhead migration lagging about a week behind Chinook salmon migration. Natural Chinook salmon smolt emigration peaked between March 27 and May 7 with the largest number of fish migrating to the trap between May 1 and May 7 (Figure 2.4). Weekly average discharge during peak Chinook salmon outmigration was between 585 and 912 cfs. Natural steelhead smolt emigration peaked between April 24 and May 14 with largest number of fish captured between May 1 and May 7 (Figure 2.4). Weekly average discharge during peak steelhead outmigration was between 730 and 2,000 cfs. Weekly average Imnaha River discharge peaked between May 15 and May 21 at 2,650 cfs. The bulk of the Chinook salmon and steelhead emigration occurred prior to the peak of the hydrograph. However, sampling was curtailed during late May and into June because of unsafe flows and the potential catch was missed during this period.

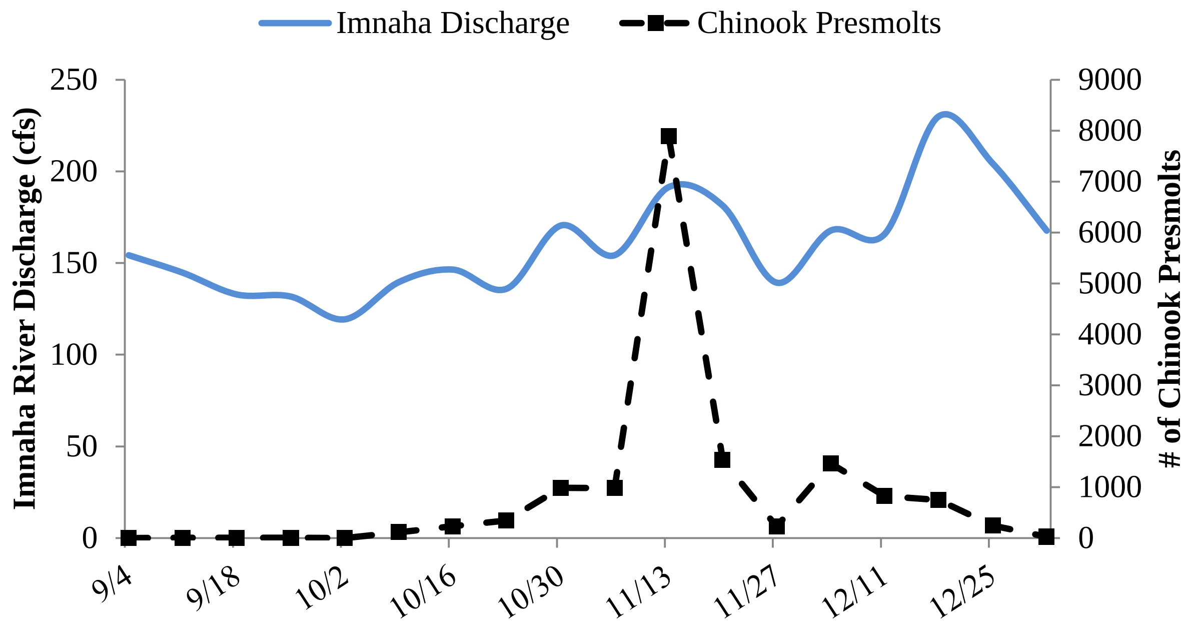

Figure 2.3. Weekly mean Imnaha River discharge and the total weekly emigration of Chinook salmon presmolts during the fall of 2010.

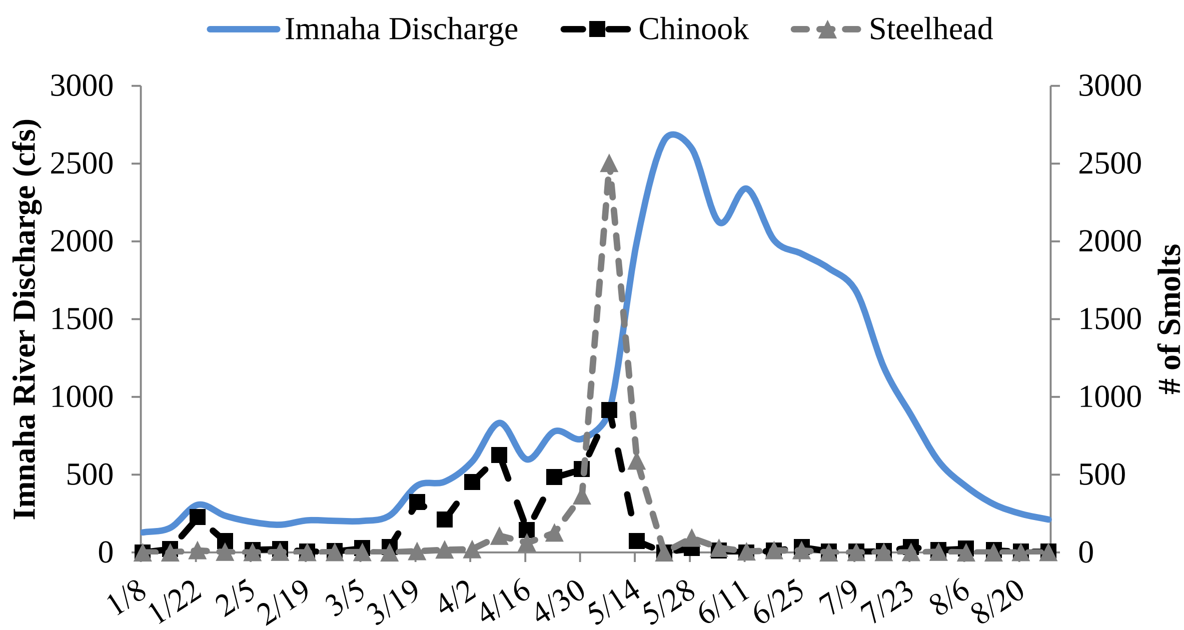

Figure 2.4. Weekly mean Imnaha River discharge and the total weekly emigration of Chinook salmon and steelhead smolts during the spring/summer trapping season in 2011. Note: Sampling was halted for much of May and June because of unsafe high flows. The potential catch was missed during this period.

Arrival Timing of Imnaha River Juvenile Emigrants at Lower Granite Dam

Arrival timing at Lower Granite Dam (LGR) was calculated for natural and hatchery juvenile emigrants. Analyses of median, 10^{th} and 90^{th} percentile, and first and last arrival dates to LGR were used to evaluate differences between natural and hatchery Chinook salmon and steelhead arrival timing as well as between natural Chinook salmon presmolts and smolts. In addition, differences in cumulative arrival timing were tested for significance using a K-S test. We also calculated the proportion of Imnaha River emigrants from each release group that had passed LGR prior to the date initiation of collections for transportation through the hydrosystem. Collections for transportation (barging/trucking) at juvenile collection facilities at LGR began on May 1, 2011. Transportation began at Little Goose Dam (LGS) on May 5, on May 8 at Lower Monumental Dam (LMN), and not until July 21 at MCN. It was assumed that fish arriving at LGR prior to May 1 were not transported, while those arriving on that date or later would be transported if collected at any of the transport dams (FPC 2011). Analyses of collection efficiencies and proportions destined for transport referenced in this report were performed by the Fish passage Center, and are available in their annual reports.

Chinook salmon arrival timing at LGR

PIT tag interrogations indicated that fall-tagged natural Chinook salmon presmolts arrived at LGR earlier than spring-tagged Chinook salmon smolts (Table 2.4).The cumulative arrival timing curves were significantly different with maximum difference in the proportion of arrivals between fall-tagged presmolts and spring-tagged smolts occurring on April 28, 2011 (MaxD = 0.514, $p = 0.001$; Figure 2.5). When collections for smolt transportation began on May 1, 90.3% of fall-tagged presmolts had already passed LGR, compared to 40.0% of spring-tagged smolts. Given collection efficiencies averaged an estimated 42% for natural Chinook; only 3.5% of presmolts emigrating from the Imnaha River in the fall were likely to be transported at LGR, compared to 21.2% of spring emigrating smolts (Table 2.5).

Table 2.4. Arrival timing for natural Chinook salmon presmolts (fall-tagged), natural Chinook salmon smolts (spring-tagged), hatchery Chinook salmon smolts, and natural and hatchery steelhead smolts determined by Passive Integrated Transponder (PIT) tag detections at Lower Granite Dam during migration year 2011. *Note: two natural steelhead tagged in spring 2011 were captured at Lower Granite dam in spring 2012 but are not shown in the table.

Origin and species	First Arrival	10th percentile	Median	90th percentile	Last Arrival
Natural Chinook presmolts	24-Mar	2-Apr	12-Apr	30-Apr	20-May
Natural Chinook smolts	26-Mar	8-Apr	5-May	14-May	30-Jul
Hatchery Chinook	9-Apr	5-May	10-May	15-May	30-May
Natural Steelhead	27-Mar	30-Apr	9-May	17-May	25-Jun*
Hatchery Steelhead	10-Apr	4-May	10-May	15-May	24-Jun

Table 2.5. Cumulative proportion of Imnaha River juvenile emigrants that passed Lower Granite Dam (LGR) by the date of initiation of full collections for transportation at LGR (May 1), the estimated proportion of emigrants destined for transportation at LGR, and collection efficiency of each origin and species at Lower Granite Dam (LGR). Proportions are based on the percentage of the total detections of Passive Integrated Transponder (PIT) tagged juveniles at LGR and the collection efficiencies at the LGR juvenile bypass facility during the 2011 migration year (FPC 2011).

Origin and Species	Proportion Passed LGR before May 1 (%)	Proportion Destined for Transportation at LGR (%)	Collection Efficiency at LGR (%)
Hatchery Chinook Smolts	3.9	27.5	34
Natural Chinook Presmolts	90.3	3.5	42
Natural Chinook Smolts	40.0	21.2	42
Hatchery Steelhead Smolts	5.0	27.0	38
Natural Steelhead Smolts	10.8	27.3	41

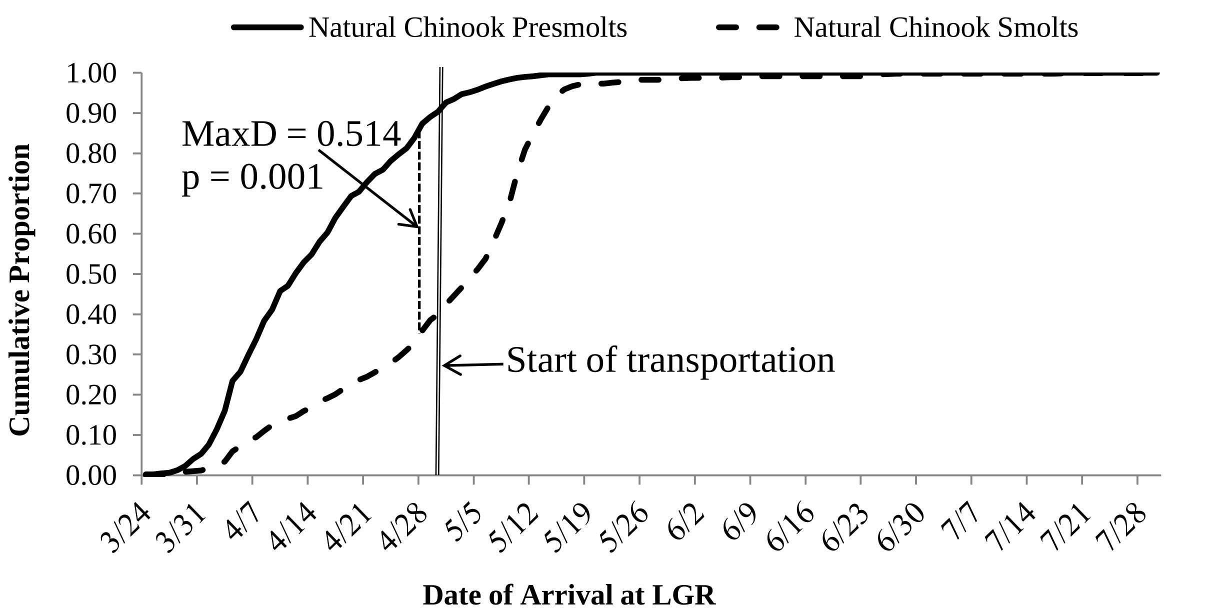

Figure 2.5. Arrival timing of natural-origin fall-tagged Chinook presmolts and spring-tagged smolts at Lower Granite Dam (LGR) during the 2011 migration year. Maximum difference (MaxD) in arrival timing between the two groups occurred on April 28, 2011 and is represented by the dashed vertical line. The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, May 1, 2011.

Natural Chinook salmon smolts demonstrated earlier arrival timing at LGR than hatchery smolts but hatchery smolts emigrated rapidly after the first week of May and surpassed cumulative natural smolt arrival timing near the end of the run. The later arrival timing at LGR of the bulk of the hatchery Chinook cohort is interesting given that median and 90th percentile emigration dates from the Imnaha River of hatchery smolts were earlier than natural smolts. Therefore, some variable(s) caused a delay in migration for hatchery Chinook in MY2011 upon entering the Snake River. In contrast, a few individuals in the tail of the natural Chinook emigration lagged behind the latest hatchery individuals. The last natural Chinook smolt arrived a full two months after the last hatchery smolt (Table 2.4). However, given the smaller size and late tagging date of several of the late arriving smolts, it is possible these smolts were fall Chinook salmon, which have been observed spawning above the juvenile trap in recent years (Adult Technical Team 2010). The significant maximum difference in arrival timing at LGR between hatchery and natural smolts occurred on May 5, 2011 (K-S test, MaxD = 0.410, $p < 0.0001$; Figure 2.6).

Less natural Chinook smolts and more hatchery Chinook smolts were transported around the hydrosystem than in 2010 (Hatch et al. 2014). Only 3.9% of the hatchery Chinook salmon group had passed the trap when transportation operations began on May 1 compared to 40.0% of the natural Chinook smolts (Table 2.5). Transport collection efficiencies were 34% for hatchery Chinook smolts and 42% for natural Chinook smolts; both greater than in 2010. Of the Chinook smolts collected, 84% of both groups were transported resulting in an estimated 21.2% of natural smolts and 27.5% of hatchery smolts being transported around the hydrosystem at LGR (Table 2.5).

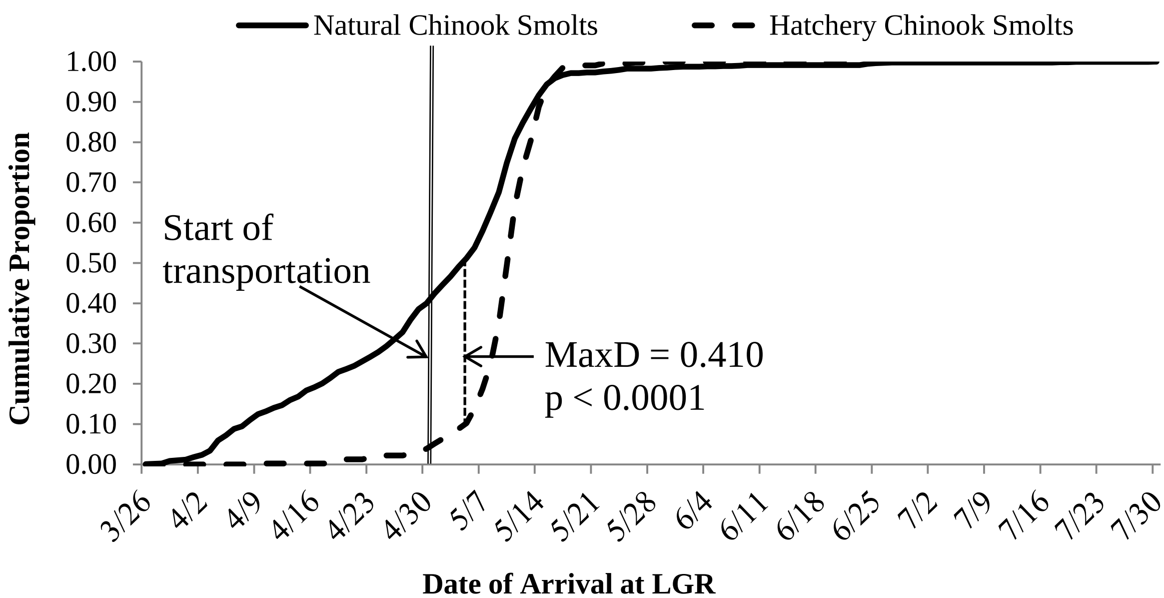

Figure 2.6. Arrival timing at Lower Granite Dam (LGR) of natural and hatchery-origin Chinook salmon smolts emigrating during the spring and summer of 2011. Maximum difference in arrival timing between the origin types occurred on May 5, 2011 (MaxD, represented by the dashed vertical line). The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, May 1, 2011.

Steelhead arrival timing at LGR

Hatchery steelhead emigration timing to LGR lagged slightly behind natural steelhead throughout most of the emigration period. This is an interesting result given the emigration timing past the Imnaha trap was nearly identical in the last half of outmigration. It suggests hatchery steelhead experienced a delay in migration from the trap to LGR similar to hatchery Chinook (Table 2.4; Figure 2.7). A K-S test revealed a significant difference in hatchery and natural steelhead emigration timing to LGR (MaxD = 0.156, $p < 0.0001$) and the maximum difference in timing occurred May 11, 2011. However, given the similarity in shape and arrival dates at LGR it is likely that the statistical difference in hatchery and natural steelhead emigration, similar to arrival at trap, may not represent a significant biological difference.

More hatchery and natural steelhead smolts were transported around the hydrosystem in 2011 than 2010 (Hatch et al. 2014). By the start of transportation efforts on May 1, 2011, only 10.8% of natural steelhead and 5.0% of hatchery steelhead had passed LGR. Given the estimated collection efficiencies of 38% for hatchery steelhead and 41% for natural steelhead; the proportion likely destined for transportation around the hydrosystem at LGR was 27.0% for hatchery steelhead and 27.3% for natural steelhead (Table 2.5).

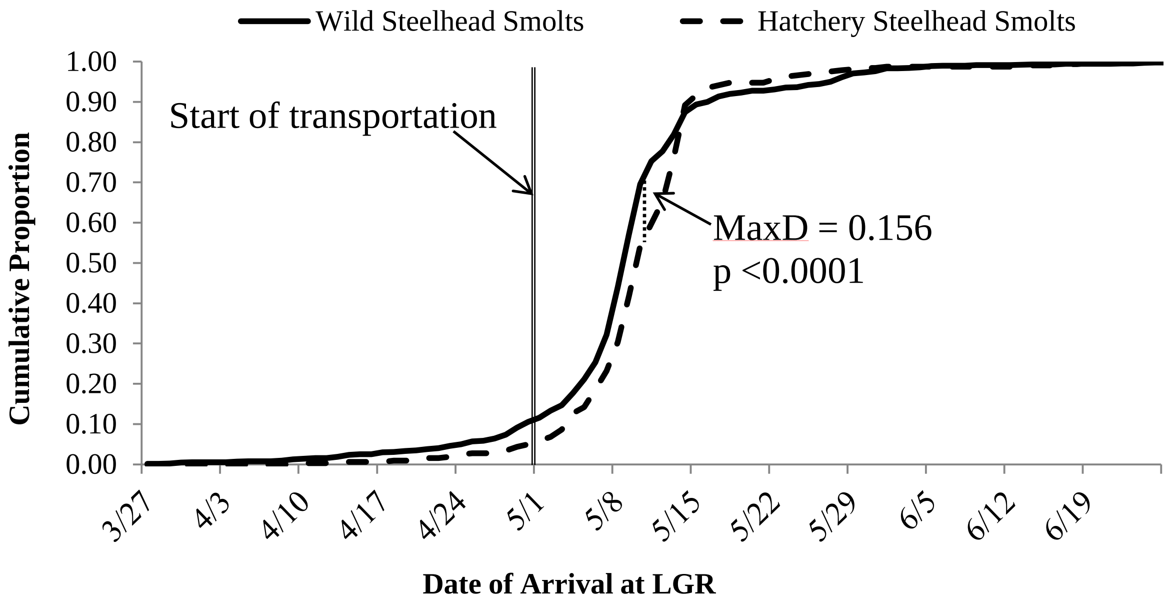

Figure 2.7. Arrival timing at Lower Granite Dam (LGR) of natural-origin steelhead and hatchery-origin steelhead smolts emigrating during the spring and summer of 2011. Maximum difference in arrival timing between the origin types occurred on May 11 (MaxD, represented by the dashed vertical line). The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, May 1, 2011. Note: two natural steelhead smolts tagged in spring 2011 were captured at LGR during spring 2012 and are not shown in this figure.

Travel Time from Imnaha River Trap to Lower Granite Dam in Relation to Snake River Flow

Chinook salmon juvenile emigrant travel time

Juvenile Chinook salmon displayed a wide range of travel times from the Imnaha River Trap to LGR. Individual travel times varied from 3 – 42 days for hatchery smolts and 2 – 121 days for spring-tagged natural smolts (Table 2.6). Generally, travel times were slightly longer for hatchery smolts than natural smolts and the difference increased as the season progressed. Mean weekly travel times for hatchery smolts were as low as seven days early in the season but lengthened to 40 days near the end of May. Mean travel times for natural smolts varied between 15 and 30 days throughout the season and were inversely related to the rising hydrograph in early May. Low numbers of Chinook of all origins were detected at LGR past mid-May. This dearth of detections late in the season limited our analysis of the relationship between travel time and Snake River discharge to a period with a narrow range of pre-snowmelt flows when biological cues and the migration benefits of higher flows would likely be limited (Figure 2.8). Given this caveat, the relation of travel time to Snake River discharge for natural Chinook spring-tagged smolts was not statistically significant (r^2 = 0.04, P = 0.54; Figure 2.9). Hatchery Chinook smolts displayed a significant positive relationship ($r^2 = 0.65$, P = 0.03). As travel time for hatchery Chinook increased with date as well as discharge, this group's results are likely an artifact of release date rather than a true positive biological relationship with Snake River Discharge.

Table 2.6. Weekly mean travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for hatchery Chinook salmon smolts and natural Chinook salmon spring-tagged smolts. The table includes LGR detection week, the number of Chinook salmon detected (count), mean travel time in days, the range of travel times for all three release groups, and mean Snake River flow in cubic feet per second (cfs). *Single detections, no range available.

LGR Detection Week	Hatchery Smolt Count	Hatchery Smolt Mean Travel Time (Days)	Hatchery Smolt Range of Travel Times	Natural Smolt Count	Natural Smolt Mean Travel Time (Days)	Natural Smolt Range of Travel Times	Snake River Flow (cfs)
3/20/11	--	--	--	1	9*	--	51,628
3/27/11	--	--	--	30	17	(4 - 70)	59,587
4/3/11	1	4*	--	134	17	(2 - 76)	72,136
4/10/11	--	--	--	89	22	(4 - 85)	63,702
4/17/11	4	7	(3 - 12)	100	28	(4 - 96)	76,953
4/24/11	9	15	(9 -24)	102	30	(4 - 101)	67,495
5/1/11	61	22	(4 - 35)	240	19	(3 - 106)	63,911
5/8/11	287	26	(4 - 40)	452	15	(3 - 121)	76,938
5/15/11	42	32	(9 - 36)	74	20	(5 - 113)	124,061
5/22/11	3	40	(38 - 42)	13	21	(15 - 39)	136,519
5/29/11	1	42*	--	7	17	(4 - 44)	114,185
6/5/11	--	--	--	4	18	(7 - 34)	129,546
6/12/11	--	--	--	--	--	--	131,443
6/19/11	--	--	--	--	--	--	120,557
6/26/11	--	--	--	2	5	(4 - 6)	117,302
7/3/11	--	--	--	--	--	--	90,100
7/10/11	--	--	--	--	--	--	63,193
7/17/11	--	--	--	2	7*	--	51,602
7/24/11	--	--	--	1	8*	--	39,342

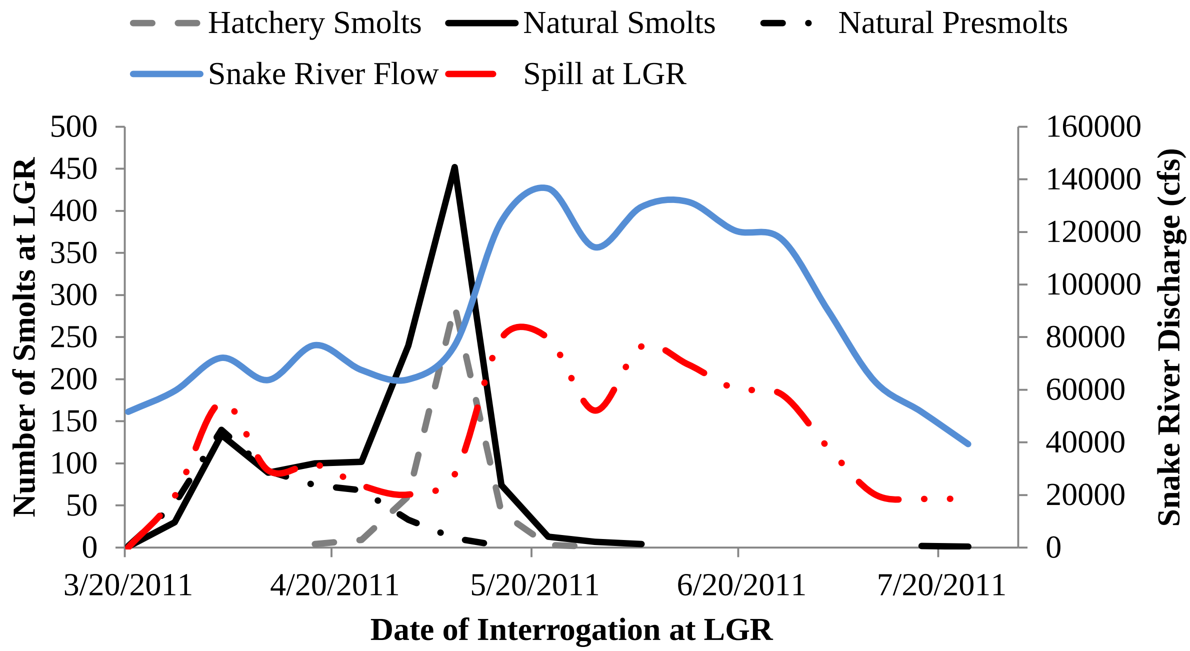

Figure 2.8. Peak passage timing at Lower Granite Dam (LGR) presented as the number of Passive Integrated Transponder (PIT) tagged Chinook salmon detections at LGR during the spring and summer of 2011 and Snake River flow and spill at LGR presented in cubic feet per second (cfs). Figure includes the date of passage of PIT-tagged fish at LGR by release group for hatchery Chinook salmon smolts, natural Chinook salmon smolts, and natural Chinook salmon presmolts.

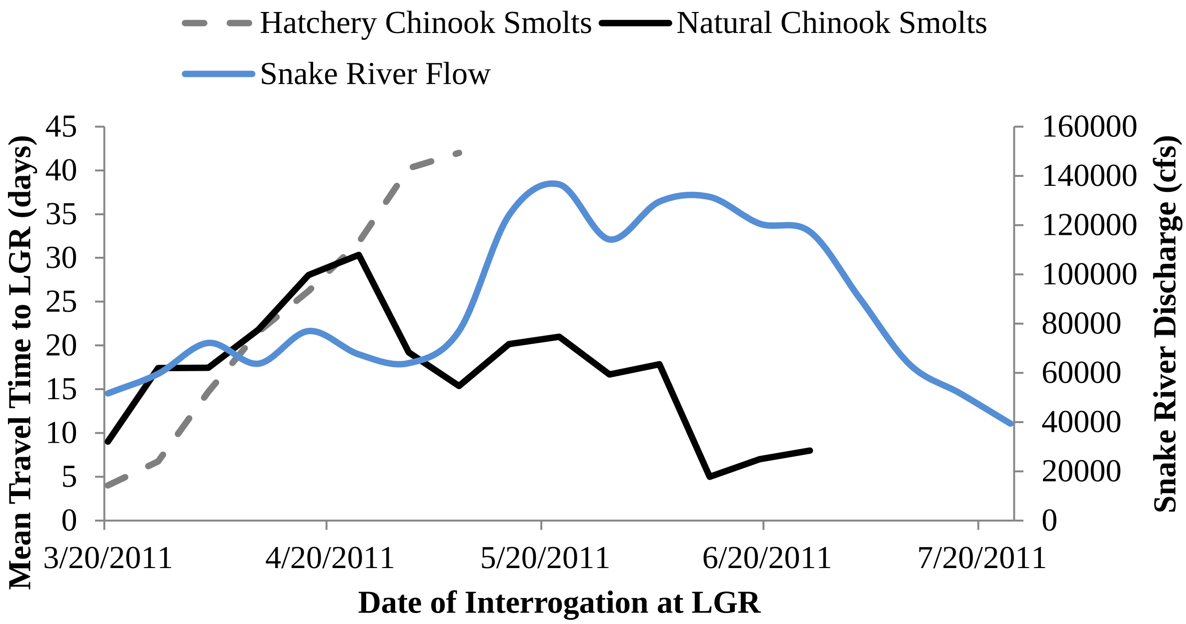

Figure 2.9. Mean weekly travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for migration year 2011 natural and hatchery Chinook salmon smolts and Snake River flow in cubic feet per second (cfs).

Steelhead juvenile emigrant travel time

Juvenile steelhead travel times from the Imnaha River Trap to LGR were shorter on average than Chinook salmon. Individuals of both natural and hatchery steelhead traveled from the Imnaha River Trap to LGR in as little as one day. Travel times for hatchery steelhead ranged from one to 44 days and from one to 130 days for natural steelhead (Table 2.7). Travel times were slightly higher for hatchery steelhead than natural steelhead until late May when hatchery steelhead rapidly emigrated past LGR. Mean weekly travel times ranged from three to 17 days for hatchery steelhead and three to six days for natural steelhead. Overall, travel times for both groups were low in April and high in early May but decreased as Snake River flows peaked in late May and June (Figure 2.10). Similar to Chinook, low numbers of detections from late May onward hampered regression analysis of the relationship between travel time and Snake River discharge because of the narrow range of flows prior to snowmelt induced ascension of the hydrograph. Given this caveat, neither hatchery nor natural steelhead showed a statistically significant relationship between travel time and Snake River discharge (both P values > 0.22).

Passage of steelhead at LGR was later than that observed for Chinook salmon and appeared to trend upward in early May, coinciding with increasing flows and spill, and peaked prior to high flows in late May and early June (Figure 2.11). Although peak flows and coinciding spill made it difficult to quantify the number of smolts passing LGR during late May and June, tagging data at the Imnaha River Trap (Appendix B.1) indicated that emigration from the Imnaha River peaked in early May and, based on a mean travel time of seven days to LGR (Table 2.7), the majority of steelhead smolts passed LGR prior to peak flows in late May and June.

Table 2.7. Weekly mean travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for hatchery and natural-origin steelhead smolts in spring and summer of 2011. The table includes LGR detection week, number of hatchery and natural steelhead smolts detected (count), mean travel time in days, the range of travel times, and mean Snake River flow in cubic feet per second (cfs).

LGR Detection Week	Hatchery Smolt Count	Hatchery Smolt Mean Travel Time (Days)	Hatchery Smolt Range of Travel Times	Natural Smolt Count	Natural Smolt Mean Travel Time (Days)	Natural Smolt Range of Travel Times	Snake River Flow (cfs)
3/27/2011	--	--	--	5	7	(3 - 14)	59,587
4/3/2011	--	--	--	6	5	(2 - 10)	72,136
4/10/2011	4	7	(5 - 10)	12	6	(2 - 11)	63,702
4/17/2011	6	6	(2 - 16)	18	8	(1 - 17)	76,953
4/24/2011	12	9	(3 - 20)	53	4	(2 - 23)	67,495
5/1/2011	73	7	(2 -33)	192	5	(2 - 50)	63,911
5/8/2011	228	9	(2 - 47)	492	7	(1 - 112)	76,938
5/15/2011	21	10	(4 - 38)	48	16	(4 - 60)	124,061
5/22/2011	11	16	(2 - 44)	30	14	(1 - 51)	136,519
5/29/2011	3	17	(6 - 26)	22	11	(1 - 130)	114,185
6/5/2011	1	6*	--	5	7	(4 - 11)	129,546
6/12/2011	2	4	(2 - 6)	3	2	(2 - 3)	131,443
6/19/2011	2	3	(1 - 4)	3	3	(1 - 6)	120,557

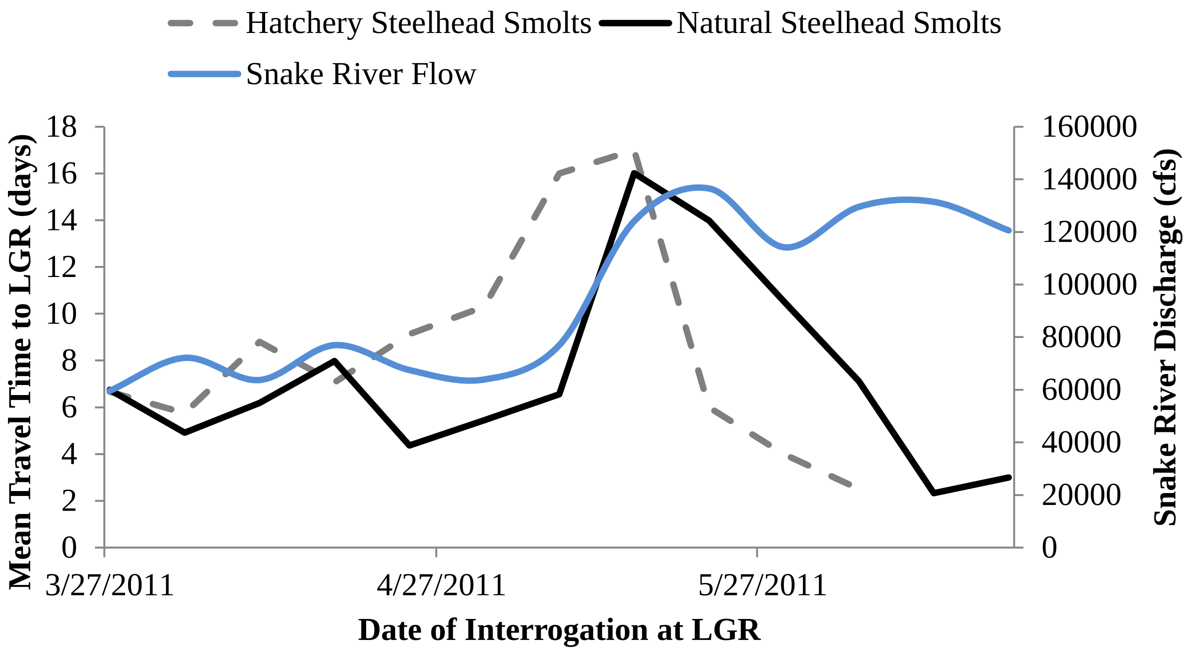

Figure 2.10. Mean weekly travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for migration year 2011 hatchery and natural-origin steelhead smolts and Snake River flow in cubic feet per second (cfs).

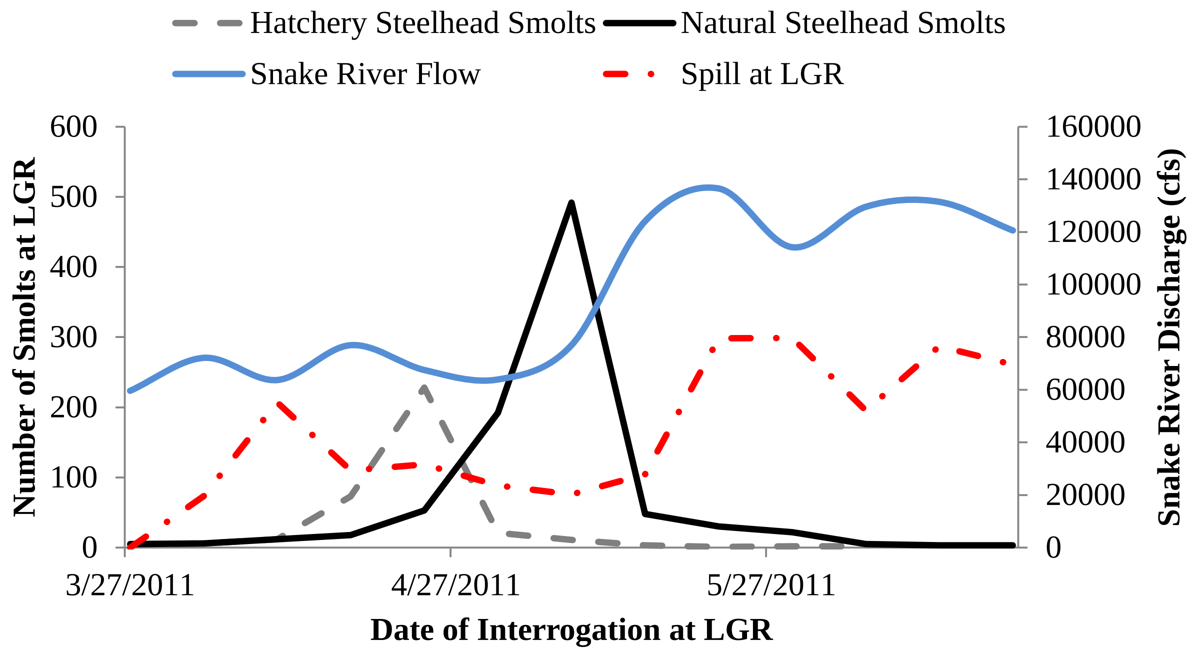

Figure 2.11. Passage timing at Lower Granite Dam (LGR) presented as the number of Passive Integrated Transponder (PIT) tagged steelhead detections at LGR during the spring and summer of 2011 and Snake River flow and spill at LGR presented in cubic feet per second (cfs). Figure includes the date of passage of PIT-tagged fish at LGR by origin type for hatchery and natural steelhead smolts.

Life-Stage and Reach Specific Estimates of Juvenile Emigrant Survival

Post-release survival of hatchery smolts

Survival of hatchery Chinook salmon smolts to the Imnaha River Trap was below average in 2011. Estimated post-release survival of acclimated hatchery Chinook from the Gumboot acclimation facility to the trap was 83% (± 3.4%) resulting in an estimated 209,480 (±7,093) hatchery Chinook salmon outmigrating past the Imnaha River Trap during spring 2011 (Table 2.8) While survival to the trap was 7% below average (90%), it was well within the observed historical range (63% to 100%)

Table 2.8. Estimated post-release survival of hatchery Chinook salmon and steelhead smolts to the Imnaha River Trap, average post-release survival from 1994 to 2011, and the number of hatchery smolts estimated to have emigrated from the Imnaha River in MY2011.

Hatchery Species	Post-Release Survival to Imnaha Trap (%)	Average survival 1994 - 2011	Estimated Outmigrating Imnaha Hatchery Smolts in 2011
Chinook Salmon	83 (± 3.4)	90 (± 4.7)	209,480 (± 7,093)
Steelhead	74 (± 2.6)	81 (± 9.2)	117,124 (± 3,079)

Survival of hatchery steelhead to the Imnaha River Trap was also below average in 2011. Estimated post-release survival of hatchery steelhead from the Little Sheep Creek acclimation facility to the trap was 74% (± 2.6%) resulting in an estimated 117,124 (± 3079) hatchery steelhead passing the trap in 2011 (Table 2.8). Similar to Chinook, survival to the trap for hatchery steelhead was 9% lower than average (81%) but still within the observed historical range (56% to 100%). Given the lower than average survival of hatchery steelhead and Chinook salmon smolts, it is likely some systemic environmental factor led to poor survival and/or high precocial parr residualization in 2011.

Survival from Imnaha River Trap to Lower Granite Dam (LGR)

Natural Chinook salmon survival from the trap to LGR was estimated for fall-tagged presmolts and spring-tagged smolts independently and collectively during MY2011 (BY2009). Estimated survival of fall-tagged presmolts was 32% (± 1.9%) compared to 80% (± 2.4%; Table 2.19) for spring-tagged smolts. Comparison of the two release groups using SURPH information revealed that there was a significantly higher proportion of spring-tagged smolts detected after release than fall-tagged presmolts ($x^2 = 1371.8$, df = 1, $p < 0.001$). Conversely, a significantly higher proportion of fall-tagged presmolts than spring-tagged smolts were first interrogated at dams below LGR ($x^2 = 16.28$, df = 1, $p < 0.001$). This result suggests many of the fall-tagged presmolts had emigrated past LGR before interrogation arrays were operational. The combined fall and spring-tagged MY2011 natural Chinook salmon survival estimate from the trap to LGR was 56% (± 1.6%). Given the proportional dominance of presmolts in the MY2011 cohort (79%) and the comparatively low survival rate of presmolts, the fall outmigrating life history type had a large negative impact on the survival of the MY2011 Imnaha River natural Chinook juvenile cohort. Survival of hatchery Chinook salmon smolts from the trap to LGR was lower than natural spring-tagged smolts and estimated to be 71% (± 6.3%). Correlated with their survival, a significantly higher proportion of natural Chinook salmon smolts were detected after release than hatchery smolts ($x^2 = 89.9$, df = 1, $p < 0.001$). See Table 2.9 for a full list of survival estimates during MY2011.

Survival of natural and hatchery steelhead was higher than for Chinook salmon. Natural steelhead smolt survival from the Imnaha River Trap to LGR for MY2011 was estimated at 81%

(± 3.1%). Unlike Chinook salmon, survival of hatchery steelhead smolts was 15% higher than their natural-origin counterparts at 96% (± 8.9%). Correlated with their survival, a significantly higher proportion of hatchery steelhead than natural steelhead were detected after release (x^2 = 7.43, df = 1, p = 0.01). In addition, a significantly higher proportion of hatchery steelhead had first detections at dams past LGR (x^2 = 7.45, df = 1, p = 0.01).

Detection efficiencies at LGR were better in 2011 than in 2010. Capture probabilities were higher for natural Chinook salmon (39%) and steelhead (42%) than for their hatchery conspecifics (33% and 34% respectively). Given the higher rates of detection and lower rates of removal for transportation, survival estimates in 2011 were more precise with narrower confidence intervals than in 2010.

Smolt equivalents at Lower Granite Dam (LGR)

The fall-tagged presmolt survival estimate of 32% produced an estimated 20,788 (± 5,222) smolts at LGR. The spring-tagged smolt survival estimate of 80% produced an estimated 25,642 (± 3,801) smolts at LGR for a natural-origin cohort total of 46,429 (± 9,023) smolts at LGR. Hatchery Chinook salmon survival of 70% produced an estimated 178,810 (±15,644) smolts at LGR. Natural steelhead survival of 81% produced an estimated 30,391(±7,719) smolts at LGR. The high 96% survival of hatchery steelhead produced an estimated 151,170 (± 13,752) smolts at LGR (Table 2.9).

Survival from Imnaha River to McNary Dam

Our analysis provides estimates of juvenile survival to the Imnaha River Trap, LGR, and MCN, but does not provide detailed results of juvenile survival through the entire hydrosystem. A more comprehensive analysis of in-river and transportation and migration route effects on juvenile survival and resulting adult returns can be found in the Fish Passage Center's Comparative Survival Study report (Comparative Survival Study 2011).

Survival of fall-tagged natural Chinook salmon presmolts from the Imnaha River Trap to MCN dam was only 26% (± 3.2%). However, survival of this group to LGR was estimated at 32% suggesting that the largest source of mortality for fall-tagged Chinook salmon is overwintering in the Snake River above LGR. Reach survival from LGR to MCN for fall-tagged presmolts was 83% (± 11.4%). Survival of spring tagged natural Chinook salmon smolts to MCN was estimated at 60% (± 3.6%) and reach survival from LGR to MCN was 76% (± 9.1%). The combined MY2011 survival of spring-tagged smolts and fall-tagged presmolts to MCN was 43% (± 1.9%); slightly higher than the MY2010 estimate of 38%. Reach survival from LGR to MCN of the combined natural-origin Chinook cohort was 78% (± 7.1%). Estimated survival of hatchery Chinook salmon smolts from the trap to MCN was 61% (± 12.5%); nearly the same as spring-tagged natural-origin smolts. Reach survival from LGR to MCN for hatchery Chinook was 80% but with wide confidence intervals (± 44.4%). Hatchery steelhead survival to MCN was 73% (± 17.2%). Hatchery steelhead reach survival from LGR to MCN was only 66% but also had wide confidence intervals similar to hatchery Chinook (± 38.9%) Natural-origin steelhead survival from the trap to MCN was estimated at 67% (± 13.3%) and reach survival from LGR to MCN was 79% (± 21.1%; Table 2.9).

Table 2.9. Estimated percent survival of natural and hatchery Chinook salmon and steelhead smolts from the Imnaha River Trap to Lower Granite Dam (LGR) and McNary Dam (MCN) and the resulting smolt equivalents at LGR during migration year 2011. Confidence intervals (95%) are presented in parentheses.

Origin and Species	Survival to LGR (%)	Survival to MCN (%)	Survival from LGR to MCN (%)	Smolt Equivalents at LGR
Natural Chinook Presmolts	32 (1.9)	26 (3.2)	83 (11.4)	20,788 (5,222)
Natural Chinook Smolts	80 (2.4)	60 (3.6)	76 (9.1)	25,642 (3,801)
Natural Chinook Cohort	56 (1.6)	43 (1.9)	78 (7.1)	54,010 (7,279)
Hatchery Chinook Smolts	71 (6.3)	61 (12.5)	80 (44.4)	178,810 (15,644)
Natural Steelhead	81 (3.1)	67 (13.3)	79 (21.1)	30,391 (7,719)
Hatchery Steelhead	96 (8.9)	73 (17.2)	66 (38.9)	151,170 (13,752)

Size and Condition of Juveniles at Emigration

The biological characteristics of fork length, weight, and condition factor at emigration were evaluated for natural and hatchery-origin juveniles for MY2011. Comparisons were made between spring-emigrating smolt groups to illustrate the differences between hatchery reared smolts and naturally produced smolts in terms of size and condition at emigration. Fall-tagged natural Chinook presmolts averaged 86 mm in length, 6.8 g in weight, and had an average condition factor of 1.03 (Table 2.10). Spring-tagged natural Chinook smolts averaged 102 mm in length, 11.6 g in weight, and had an average condition factor of 1.07. Hatchery Chinook smolts averaged 126 mm in length, 24.1 g in weight, and had an average condition factor of 1.20 (Table 2.10). Natural steelhead averaged 173 mm in length, 55 g in weight, and had and average condition factor of 1.01. Hatchery steelhead were nearly 50 mm longer (220 mm) and 56 g heavier on average (111.3 g). Hatchery fish had a significantly higher mean fork length, weight, and condition factor than spring-tagged natural smolts for both Chinook salmon and steelhead (t-test, all tests $p < 0.001$; Table 2.10; Figures 2.12 and 2.13).

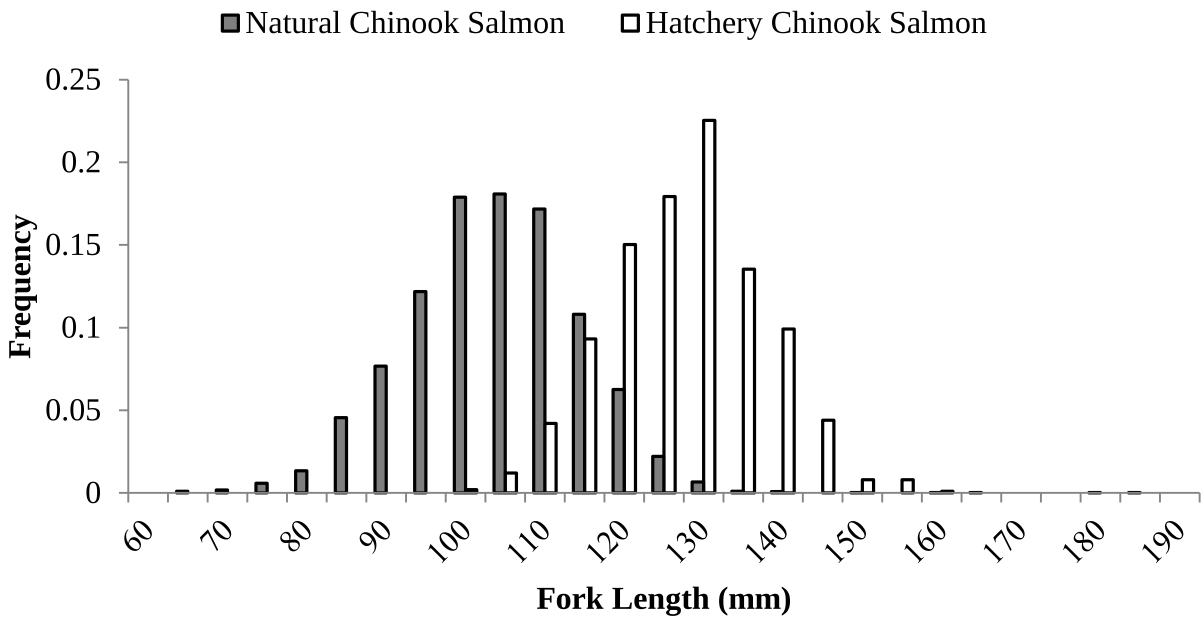

Figure 2.12. Length frequency distribution of natural and hatchery Chinook salmon smolts captured in the Imnaha River juvenile emigrant trap from January 1 to August 31, 2011.

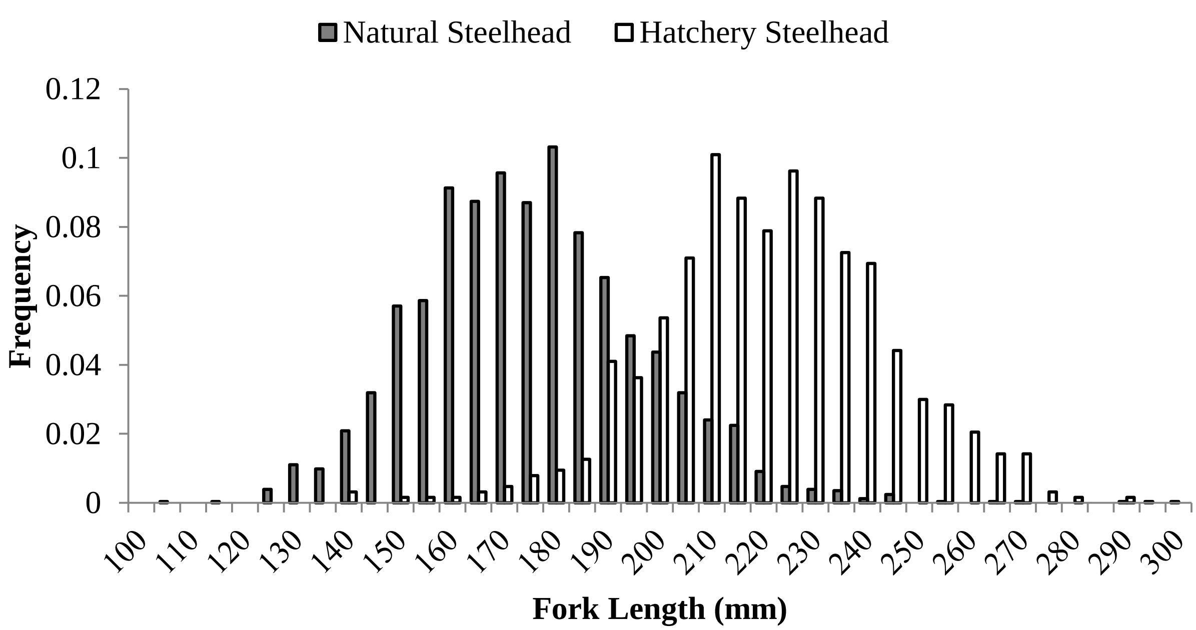

Figure 2.13. Length frequency distribution of natural and hatchery steelhead smolts captured in the Imnaha River juvenile emigrant trap from January 1 to August 31, 2011.

Table 2.10. Sample size, mean, range, and standard deviation of fork length (mm), weight (g), and condition factor (K) for natural and hatchery Chinook salmon and steelhead captured during the 2011 migration year, 1 September 2010 to 31 August 2011, at the Imnaha River juvenile emigrant trap.

		Fall 2010	Spring 2011			
Attribute	Statistic	Natural Chinook Presmolts	Natural Chinook Smolts	Hatchery Chinook Smolts	Natural Steelhead Smolts	Hatchery Steelhead Smolts
Fork Length (mm)	Sample Size (n)	4136	4037	998	2540	634
	Mean	86	102	126	173	220
	Minimum	49	63	100	105	140
	Maximum	126	181	159	297	290
	Standard Deviation	11	11	10	21	22
Weight (g)	Sample Size (n)	4136	4037	991	2540	634
	Mean	6.8	11.6	24.1	55.0	111.3
	Minimum	1.2	2.7	10.8	12.6	31.1
	Maximum	19.8	57.2	51.4	297.9	259.6
	Standard Deviation	2.8	4.0	5.6	22.0	34.2
Condition Factor (K)	Sample Size (n)	4136	4037	991	2540	634
	Mean	1.03	1.07	1.20	1.01	1.03
	Minimum	0.73	0.71	0.62	0.69	0.74
	Maximum	1.32	1.43	1.84	1.67	1.86
	Standard Deviation	0.09	0.11	0.13	0.09	0.10

Chapter 3: Migration Year 2012

Chapter Introduction

This chapter presents the results and discussion for trapping efforts covering MY2012, from September 1, 2011 to August 31, 2012. The trap operated as continuously as possible targeting BY2010 Chinook salmon and MY2012 steelhead. Although Chinook salmon fry and parr from BY2011 were trapped during this time period, no marking or trap efficiency trials were conducted on these fish and they are not included in population estimates or the following performance measure analyses. The performance measure results included in this chapter are specific to the BY2010 and MY2012 emigrants only, while multi-year performance measures are included in Chapter 5.

Trapping and Tagging Results and Discussion

Trap Operations

The trap operated for a total of 257 days during MY2012, from September 1, 2011 through August 31, 2012. There were a total of 65 days when the trap was not operated due to icy conditions, high flows, or heavy debris, including from 23 April to 28 April when a significant proportion of the target catch was likely missed. There were 26 days when the trap was not operated due to equipment repair and maintenance. The trap was not operated on the weekends during the summer trapping period or on major holidays, leaving a total of 34 days of in-operation due to scheduling. The water was too warm to handle fish for 22 days during late summer. Subsampling was not utilized on any days during the MY2012 season. There were 5 sample periods that were shortened (less than 24 hours) due to equipment repair and maintenance. The trap operated for 70% of MY2012, extending operations beyond years prior to 2010 by 27%. Please refer to Appendix A.2 for a summary of total hours fished and daily catch.

Target Catch

The catch of MY2012 natural-origin Chinook salmon totaled 18,975 fish including 15,516 presmolts trapped in the fall of 2011, and 3,459 smolts trapped during spring and summer 2012 (Appendix A.2) Only 1 BY2011 Chinook salmon fry was caught. A total of 8,866 Chinook presmolts were PIT tagged during the fall of 2011 and 2,973 smolts were tagged during spring of 2012 (Appendix B.2). Of the tagged fish, 2,702 fall-tagged presmolts and 2,288 spring-tagged smolts were marked and released above the trap for trap efficiency trials. A total of 23 of the 1,000 natural-origin Chinook salmon that were previously PIT tagged by Oregon Department of Fish and Wildlife's (ODFW) Early Life History Program during August and September of 2011 were recaptured at the Imnaha River Trap. Please refer to Appendix C.2 for trap date, travel time, and biological data for these fish.

The catch of MY2012 natural-origin steelhead totaled 5,506 fish including 157 trapped in fall and 5,349 trapped in spring (Appendix A.2) A total of 5,309 natural-origin steelhead were PIT tagged, of which 1,952 were marked and released above the trap for trap efficiency trials. Natural-origin steelhead were not tagged in the fall since the number of fish captured was typically too small to produce an accurate abundance estimate.

A total of 7,794 hatchery-origin Chinook smolts representing BY2010 were captured at the Imnaha River Trap during the MY2012 spring/summer trapping period (Appendix A). Hatchery-origin Chinook smolt captures were from an acclimated volitional release group totaling approximately 333,392 smolts released from the Imnaha River Gumboot acclimation facility at rkm 74 beginning March 30, 2012 until April 13 when all remaining smolts were forced out. There was also a direct release into the Imnaha River of 136,933 smolts on April 30. Of the 469,810 smolts released, a total of 20,914 were PIT-tagged (Appendix D). A total of 348 previously PIT tagged hatchery Chinook salmon were recaptured at the Imnaha juvenile emigrant trap.

A total of 16,252 hatchery-origin steelhead smolts representing BY2011 were captured at the Imnaha River Trap during the MY2012 spring/summer trapping period (Appendix A.2). Hatchery-origin steelhead captures were from a volitional release of 213,891 smolts from the LSRCP Little Sheep Creek acclimation facility beginning March 27 and ended April 24 when all remaining fish were forced out. A total of 1,581 previously PIT-tagged hatchery-origin steelhead released from the Little Sheep Creek facility were recaptured at the Imnaha River Trap.

Incidental Catch

The incidental catch during the fall, spring, and summer of MY2012 was estimated to total 1,645 fish comprising of seven families of fishes: Salmonidae, Centrarchidae, Catostomidae, Cyprinidae, Cottidae, Ictaluridae, and Petromyzontidae (Appendix E.2). The catch of Salmonidae consisted of 31 adult steelhead, 218 rainbow trout, 56 mountain whitefish, and 43 bull trout. Juvenile rainbow trout were determined to be resident fish based on morphological characteristics and were not enumerated as natural-origin steelhead juveniles in this report. Bull trout were divided into adults 300 mm and greater (n = 7), and juveniles less than 300 mm (n = 36). The catch of Centrarchidae consisted of 35 smallmouth bass. The catch of the Catostomidae family consisted of 348 suckers of unidentified species. The catch of Cyprinidae included 40 chislemouth, 647 longnose dace, 35 Northern pikeminnow, and 112 redside shiner. The catch of the Cottidae family consisted of 100 unidentified sculpins. The catch of Ictaluridae consisted of two bullhead catfish of an unidentified species. A total of four juvenile Pacific Lamprey of the family Petromyzontidae were caught during MY2012. Lamprey were categorized by their developmental stage as either ammocoetes (larvae), and macropthalmia (juveniles). Please refer to Appendix E for a summary table of the MY2012 Incidental Catch data and Appendix F for detailed Pacific Lamprey catch and biological data.

<u>Trapping and tagging mortality</u>

Mortalities handled at the Imnaha River Trap during the MY2012 trapping season included 95 natural and 6 hatchery Chinook salmon, and 11 natural and 22 hatchery steelhead. Sixteen of the natural Chinook salmon mortalities occurred during the fall of 2011, accounting for 0.10% of the total Chinook salmon fall catch (Appendix G.2). Of these 16 mortalities, nine were from trapping (including predation in the trap live box), three from handling, zero from tagging, and four that were dead on arrival. Twenty natural Chinook salmon mortalities occurred during the spring: 13 due to trapping (including predation), one from handling, and six from tagging Appendix G.2). The 20 mortalities accounted for 0.58% of the total natural Chinook salmon catch during the spring of 2012. Six hatchery Chinook salmon mortalities were recorded in the spring of 2012. Of these, four were attributed to trapping, one to handling, and one that was dead on arrival. These six mortalities accounted for 0.08% of the total catch of hatchery Chinook salmon in MY2012. There were 10 natural steelhead mortalities during the spring of 2012 (Appendix G.2), and one that was dead on arrival during the fall of 2011. Of the 10 spring-trapped mortalities, nine were due to trapping and the other was dead on arrival. There were no tagging mortalities of natural steelhead. Mortality accounted for 0.19% of the total natural steelhead catch in the spring of 2012. There were 22 hatchery steelhead mortalities at the trap during MY2012: 12 attributed to trapping and ten due to handling. These mortalities accounted for 0.14% of the total hatchery steelhead catch.

Only one incidental catch mortality occurred during the MY2012 trapping season. This mortality was a sculpin which died as a result of trapping.

Performance Measures Results and Discussion

<u>Juvenile Emigrant Abundance Estimates at the Imnaha River Trap</u>

Life-stage specific estimates of natural-origin Chinook salmon and steelhead emigrant abundance

Gauss population estimates generated from mark/recapture analysis of the trap efficiency fish estimated the fall juvenile emigrant abundance for natural Chinook salmon to be 163,022 presmolts, (95% C.I. 125,879 to 243,484; Table 3.1), with a CV of 18.0%. Fall 2011 trap efficiencies for natural Chinook salmon presmolts averaged 16% and ranged from 2% to 32% through the season (Table 3.1). The spring juvenile emigrant abundance estimate for natural Chinook salmon smolts was 37,191 (95% C.I. 30,251 to 50,084; Table 3.1) with a CV of 7.41%. Trap efficiencies averaged 14% and ranged from 5% to 20% through the 2012 spring season (Table 3.1). The MY2012 combined juvenile emigrant abundance estimate (fall and spring total) for natural-origin Chinook salmon was 200,213 (95% C.I. 161,147 to 270,268) with a CV of 13.7%. Our results indicate that 81.4% of Chinook salmon juveniles emigrated past the trap during the fall 2011 trapping period, and 18.6% during spring of 2012.

Table 3.1. Gauss population estimates by release group and totals for natural-origin Chinook salmon captured in the Imnaha River juvenile emigrant trap during migration year 2012 (MY2012; fall 2011 and spring/summer 2012). Table includes the date range of the trap efficiency trial (Date Strata), total fish captured by the screw trap (Caught), total marked (Mark), total recaptured (Recap), trap efficiency for the period (T.E.), total population estimate (Pop. Estimate), lower 95% confidence interval (Lower C.I.), upper 95% confidence interval (Upper C.I.) and standard error (S.E.).

Date Strata	Caught	Mark	Recap	T.E.	Pop. Estimate	Lower C.I.	Upper C.I.	S.E.
9/4 - 10/22	1,129	308	36	12%	9,429	7,002	12,712	1,468.3
10/23 - 10/29	2,272	317	48	15%	14,745	11,206	19,252	2,089.4
10/30 - 11/5	3,093	354	90	25%	12,066	9,901	14,867	1,283.5
11/6 - 11/12	2,152	353	62	18%	12,092	9,561	15,317	1,531.8
11/13 - 11/19	3,746	298	36	12%	30,272	22,446	40,914	4,690.7
11/20 - 12/3	1,912	401	9	2%	76,862	38,290	158,620	31,481.4
12/4 - 12/10	425	200	64	32%	1,314	1,089	1,549	116.1
12/11 - 12/17	370	198	23	12%	3,068	2,225	4,223	506.0
12/18 - 12/31	417	273	35	13%	3,174	2,384	4,358	514.0
Fall totals	**15,516**	**2,702**	**403**	**16%**	**163,022**	**125,879**	**243,484**	**29,320.2**
1/1 - 2/25	195	177	22	12%	1,509	985	2,278	341.7
2/26 - 3/10	54	53	7	13%	365	230	608	88.6
3/11 - 3/17	225	152	25	16%	1,324	949	1,914	241.6
3/18 - 3/24	790	213	11	5%	14,088	7,699	29,237	5,461.2
3/25 - 3/31	486	234	27	12%	4,079	2,796	6,381	902.6
4/1 -4/7	413	255	22	9%	4,597	2,987	7,423	1,240.1
4/8 - 4/14	206	203	29	14%	1,401	961	2,017	281.3
4/15 - 4/21	238	231	22	10%	2,401	1,572	3,880	598.6
4/22 - 5/5	154	143	7	5%	2,772	1,495	5,411	1,073.8
5/6 - 5/12	242	241	32	13%	1,775	1,213	2,659	383.9
5/13 -5/19	70	67	12	18%	366	249	534	74.4
5/20 - 6/2	109	105	13	12%	825	546	1,273	194.9
6/3 - 6/9	55	45	9	20%	253	170	370	51.7
6/10 - 6/16	69	57	8	14%	445	285	672	101.9
6/17 - 6/23	47	42	7	17%	253	168	388	55.9
6/24 - 8/18	107	68	9	13%	738	460	1,120	170.9
Spring totals	**3,460**	**2,286**	**262**	**13%**	**37,191**	**30,251**	**50,084**	**5,570.6**
MY2012 Totals	**18,976**	**4,988**	**665**	**14%**	**200,213**	**161,147**	**270,268**	**27,471.1**

The 2012 spring juvenile emigration abundance estimate for natural steelhead smolts was 43,881 (95% C.I. 38,319 to 50,366; Table 3.2) with a CV of 7.3%. Trap efficiencies for natural steelhead averaged 12% and ranged from 6% to 27% (Table 3.2).

Table 3.2. Gauss population estimates by release group and totals for natural-origin steelhead captured in the Imnaha River juvenile emigrant trap during spring/summer 2012. Table includes the date range of the trap efficiency trial (Date Strata), total fish captured by the screw trap (Caught), total marked (Mark), total recaptured (Recap), trap efficiency for the period (T.E.), total population estimate (Pop. Estimate), lower 95% confidence interval (Lower C.I.), upper 95% confidence interval (Upper C.I.) and standard error (S.E.).

Date Strata	Caught	Mark	Recap	T.E.	Pop. Estimate	Lower C.I.	Upper C.I.	S.E.
2/19 - 3/31	166	142	9	6%	2374	1297	4605	945.8
4/1 - 4/7	72	71	8	11%	576	336	923	160.2
4/8 - 4/14	116	115	10	9%	1223	729	2038	355.4
4/15 - 4/21	460	249	31	12%	3594	2377	5749	954.3
4/22 - 4/28	299	50	7	14%	1906	1257	2921	434.3
4/29 - 5/5	544	254	23	9%	5780	3491	10296	1782.8
5/6 - 5/12	1509	317	49	15%	9597	6556	14167	1919.7
5/13 - 5/19	1475	314	34	11%	13275	8443	20935	3225.5
5/20 - 5/26	407	247	26	11%	3738	2437	6228	986.2
5/27 - 6/2	151	150	41	27%	543	397	759	90.7
6/3 - 8/18	150	118	13	11%	1275	784	2202	367.9
MY2012 Totals	**5,349**	**2,027**	**251**	**12%**	**43,881**	**38,319**	**50,366**	**3,191.7**

Since the trap operated year-round during MY2012, the estimates above are considered annual emigrant abundance estimates for juvenile Chinook salmon and steelhead in the Imnaha River. They should still be considered minimum estimates, as the trap was not operated during periods of high flows, heavy debris, icy conditions, during periods of maintenance and repair, and scheduled weekends and holidays off (Appendix A.2). In addition, trap efficiency trials were limited by low marking and recapture rates during periods with fewer emigrating juveniles, such as the summer months of June through September and during the winter. The number of juveniles that emigrated when the trap was not operational was not determined for this report period.

Hatchery smolt emigrant abundance estimates at the Imnaha River Trap

Refer the section on life-stage and reach specific estimates of juvenile emigrant survival below for post-release survival and corresponding hatchery smolt equivalents at the Imnaha River Trap.

Juvenile Emigration Timing of Imnaha River Chinook Salmon and Steelhead

Timing of juvenile emigration from the Imnaha River

MY2012 arrival timing at the Imnaha River Trap, assumed to represent emigration from the Imnaha River, was compared between natural and hatchery Chinook salmon and steelhead smolts using the cumulative proportion of juveniles captured over time and a K-S test (Steel et al. 1997). First, 10 percent, median, 90 percent and last arrivals for each release group by species and origin are presented in Table 3.3.

Hatchery Chinook salmon emigration timing to the trap displayed a bimodal pattern. The first pulse of fish was captured at the trap beginning March 24. Given the volitional release did not begin until March 30; this group of smolts apparently escaped the Gumboot facility soon after their transfer to the acclimation ponds on March 22. A second pulse of fish arrived at the trap beginning April 3, four days after the start of the volitional release (March 30), and tapering downward by April 9. Over 50% of the hatchery Chinook smolts had passed the trap by April 4, 90% had passed by April 10, and the last capture was May 14 (Table 3.3). Natural Chinook salmon smolts demonstrated notably different emigration timing. The first smolts arrived at the trap January 4, reached the 10th percentile by March 14, and median arrival occurred March 30. The 90th percentile date for natural Chinook smolts did not occur until May 24 and the last smolt arrived August 16 (Table 3.3). Results of the K-S test indicated that the maximum difference between natural and hatchery Chinook salmon emigration timing from the Imnaha River occurred March 30, 2012 (MaxD = 0.356, $p < 0.001$; Figure 3.1). Hatchery fish rapidly emigrated from the Imnaha River demonstrating a much more contracted migration period than their natural counterparts.

Table 3.3. First, 10th percentile, median, 90th percentile, and last arrival dates for natural and hatchery-origin Chinook salmon and steelhead smolt release groups captured at the Imnaha River Trap during the 2012 spring and summer trapping period, 1 January to 31 August. *Fall-emigrating presmolts excluded from analysis.

Origin and species	First Arrival	10th percentile	Median	90th percentile	Last Arrival
Natural Chinook Salmon	4-Jan	14-Mar	30-Mar	24-May	16-Aug
Hatchery Chinook Salmon	24-Mar	25-Mar	4-Apr	10-Apr	14-May
Natural Steelhead	19-Feb	20-Apr	11-May	22-May	17-Aug
Hatchery Steelhead	28-Mar	13-Apr	16-May	13-Jun	13-Jul

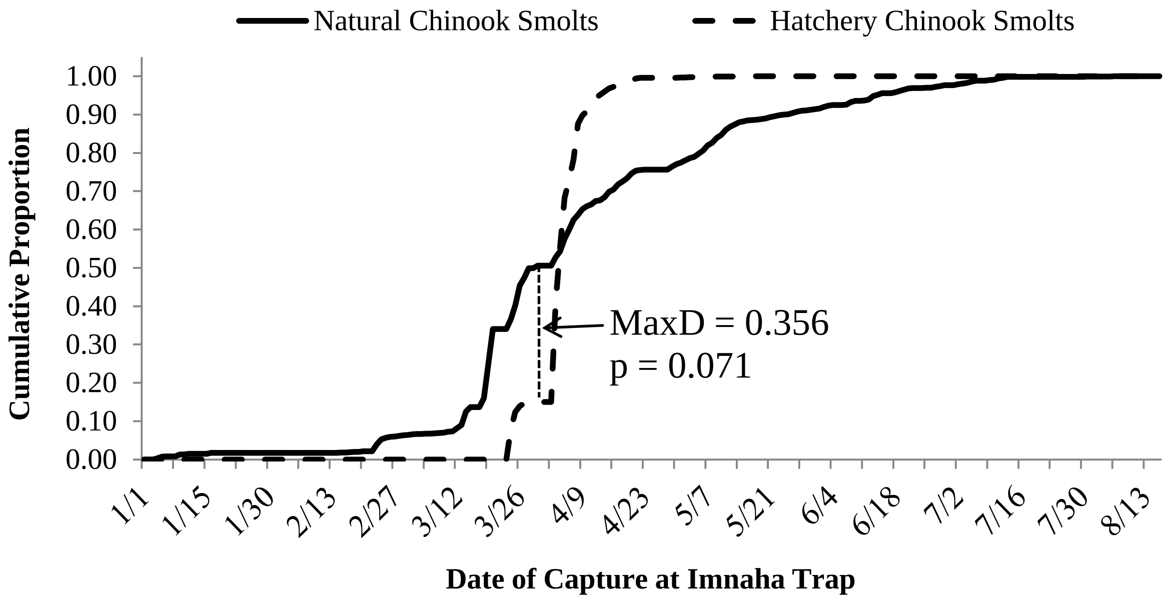

Figure 3.1. Comparison of emigration timing of natural and hatchery Chinook salmon smolts from the Imnaha River presented as the cumulative capture proportion of each origin type at the Imnaha River Trap during the spring 2012 trapping season, 1 January to 31 August. Maximum difference in emigration timing (MaxD, represented as the dashed vertical line) between the origin types occurred on March 30, 2012.

Arrival timing was compared between natural and hatchery steelhead. Small numbers of natural steelhead were captured at the trap as early as February 19. The 10th percentile for natural steelhead emigration occurred April 20, the median occurred May 11, and 90th percentile occurred May 22 (Table 3.3). The last natural steelhead smolt was captured August 17, 2012. The first hatchery steelhead smolt was captured March 28, one day after the beginning of the volitional release. The 10th percentile for hatchery steelhead passage occurred April 13, median hatchery steelhead emigration occurred May 16, the 90th percentile occurred June 13, and the last hatchery steelhead was captured July 13 (Table 3.3). The difference in the timing of the cumulative proportion of emigrant passage between natural and hatchery steelhead was nearly significant (K-S test, Max D = 0.257, p = 0.054). The maximum difference in hatchery and natural steelhead emigration timing occurred on May 7th. Though the pattern of emigration between hatchery and natural steelhead was similar and the cumulative distributions similar in shape, hatchery steelhead emigration lagged behind natural steelhead, especially in the latter half of the migration (Figure 3.2).

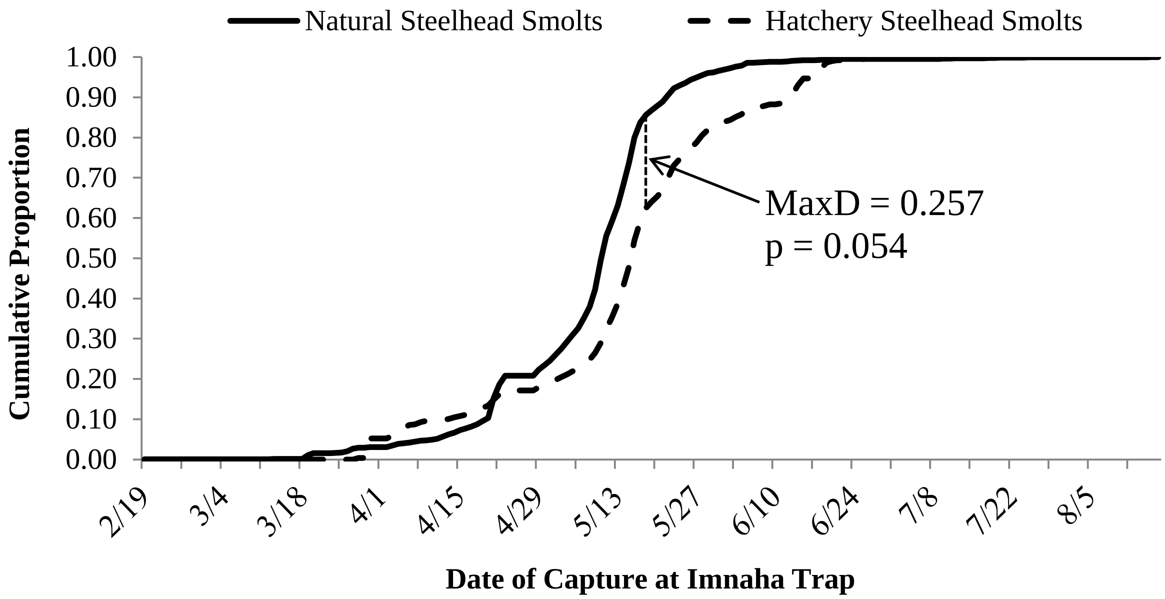

Figure 3.2. Comparison of emigration timing of natural and hatchery steelhead smolts from the Imnaha River presented as the cumulative capture proportion of each origin type at the Imnaha River Trap during the spring 2012 trapping season, 1 January to 31 August. Maximum difference in emigration timing (MaxD, represented as the dashed vertical line) between the origin types occurred on May 15, 2012.

Peak emigration timing in relation to Imnaha River discharge

Imnaha River discharge was averaged by week throughout the fall and spring emigration seasons in cfs. Fall Chinook salmon presmolt emigration from the Imnaha River was highest from October 22 to November 26 with the peak week occurring between November 13 and November 19. Weekly average Imnaha River discharge during peak fall presmolt migration fell in a narrow range between 158 and 180 cfs (Figure 3.3).

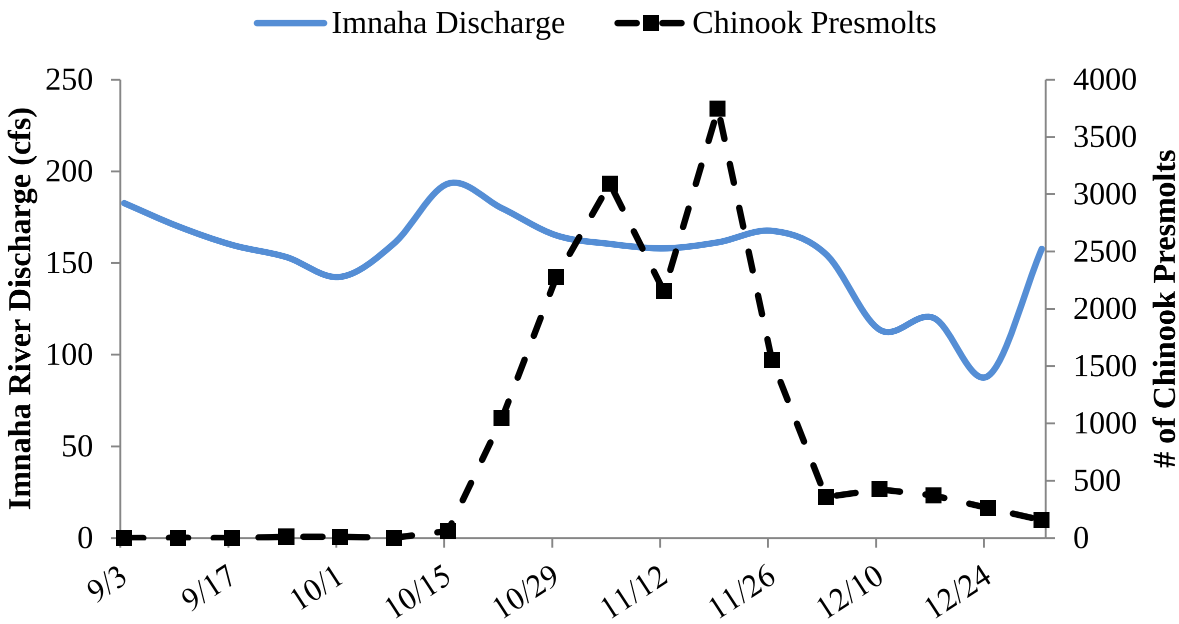

Figure 3.3. Weekly mean Imnaha River discharge and the total weekly emigration of Chinook salmon presmolts during the fall of 2011.

The apex of the hydrograph came early in 2012 with the Imnaha River reaching its highest mean flows in late April (over 2,500 cfs). The majority of natural Chinook salmon smolt emigration occurred during the hydrograph's ascending limb showing their week of highest passage from March 18 to March 24 (Figure 3.4). Daily average discharge during this time ranged from 603 to 1,341 cfs. When the Imnaha River reached its discharge climax on April 27, 75% of the natural Chinook salmon had already passed the trap. Natural steelhead smolts emigrated later than natural Chinook and were most numerous between April 15 and May 26 with the peak capture week from May 6 to May 12 (Figure 3.4). Weekly average discharge was high during peak steelhead outmigration. Discharge ranged from 1,337 cfs to a maximum of 2,699 cfs during the week of April 22 to April 28. The bulk of the Chinook salmon outmigration occurred during the ascending limb of the spring hydrograph while much of the steelhead outmigration occurred as the hydrograph descended.

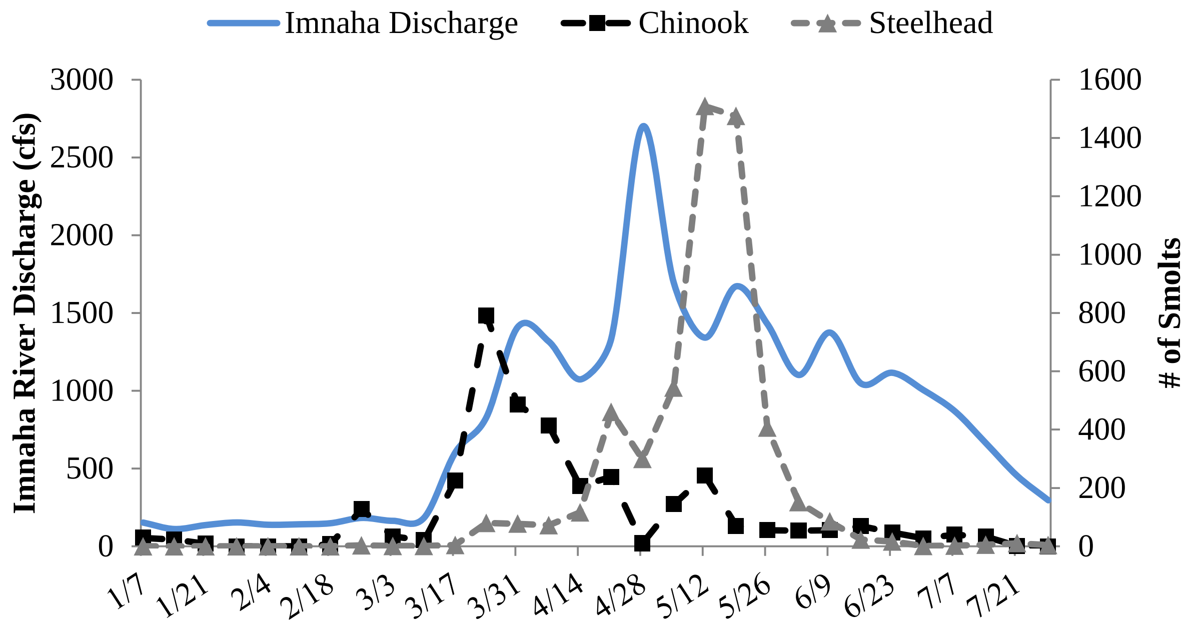

Figure 3.4. Weekly mean Imnaha River discharge and the total weekly emigration of Chinook salmon and steelhead smolts during the spring/summer trapping season in 2012.

<u>Arrival Timing of Imnaha River Juvenile Emigrants at Lower Granite Dam</u>

Arrival timing at LGR was calculated for natural and hatchery juvenile emigrants. Analyses of median, 10th and 90th percentile, and first and last arrival dates to LGR were used to evaluate differences between natural and hatchery Chinook salmon and steelhead arrival timing as well as between natural Chinook salmon presmolts and smolts. In addition, differences in cumulative arrival timing were tested for significance using a K-S test. We also calculated the proportion of Imnaha River emigrants from each release group that had passed LGR prior to the date of initiation of collections for transportation through the hydrosystem. Collections for transportation (barging/trucking) at juvenile collection facilities at LGR began on May 1, 2012. Collections for transportation began at Little Goose Dam (LGS) on May 4, on May 6 at Lower Monumental Dam (LMN), and not until August 17 at MCN. It was assumed that fish arriving at LGR prior to May 1 were not transported, while those arriving on that date or later would be transported if collected at any of the transport dams (FPC 2012). Analyses of collection efficiencies and proportions destined for transport referenced in this report were performed by the Fish passage Center, and are available in their annual reports.

Chinook salmon arrival timing at LGR

PIT tag interrogations indicated that fall-tagged natural Chinook salmon presmolts arrived at LGR earlier than spring-tagged Chinook salmon smolts (Table 3.4; Figure 3.5). The cumulative arrival timing curves were significantly different and maximum difference in the proportion of arrivals between fall-tagged presmolts and spring-tagged smolts occurring on April 22, 2012

(MaxD = 0.514, p = 0.001; Figure 3.5). The proportion of natural Chinook salmon likely to be transported in 2012 was low. When collections for smolt transportation began on May 1, 97.6% of fall-tagged presmolts had already passed LGR, compared to 45.2% of spring-tagged smolts. Given collection efficiencies averaged an estimated 38% for natural Chinook; only 0.9% of presmolts emigrating from the Imnaha River in the fall were likely to be transported at LGR, compared to 13.0% of spring emigrating smolts (Table 3.4).

Table 3.4. Arrival timing for natural Chinook salmon presmolts (fall-tagged), natural Chinook salmon smolts (spring-tagged), hatchery Chinook salmon smolts, and natural and hatchery steelhead smolts determined by Passive Integrated Transponder (PIT) tag detections at Lower Granite Dam during migration year 2012. Note: two natural and one hatchery steelhead tagged in spring 2012 were captured at Lower Granite dam in October 2012 but are not shown in this table.

Origin and Species	First Arrival	10th Percentile	Median	90th Percentile	Last Arrival
Natural Chinook Smolts	24-Mar	3-Apr	26-Apr	21-May	17-Jul
Natural Chinook Presmolts	22-Mar	27-Mar	14-Apr	25-Apr	19-May
Hatchery Chinook Smolts	14-Apr	23-Apr	3-May	12-May	18-May
Natural Steelhead Smolts	25-Mar	24-Apr	15-May	24-May	18-Jun
Hatchery Steelhead Smolts	1-Apr	26-Apr	18-May	5-Jun	9-Jul

Table 3.5. Cumulative proportion of Imnaha River juvenile emigrants that passed Lower Granite Dam (LGR) by the date of initiation of full collections for transportation at LGR (May 1), the estimated proportion of emigrants destined for transportation at LGR, and collection efficiency of each origin and species at Lower Granite Dam (LGR). Proportions are based on the percentage of the total detections of Passive Integrated Transponder (PIT) tagged juveniles at LGR and the collection efficiencies at the LGR juvenile bypass facility during the 2012 migration year (FPC 2012).

Origin and Species	Proportion Passed LGR before May 1 (%)	Proportion Destined for Transportation at LGR (%)	Collection Efficiency at LGR (%)
Hatchery Chinook Smolts	45.2	15.3	28
Natural Chinook Presmolts	97.6	0.9	20
Natural Chinook Smolts	65.9	13.0	38
Hatchery Steelhead Smolts	11.5	31.9	36
Natural Steelhead Smolts	18.0	27.9	34

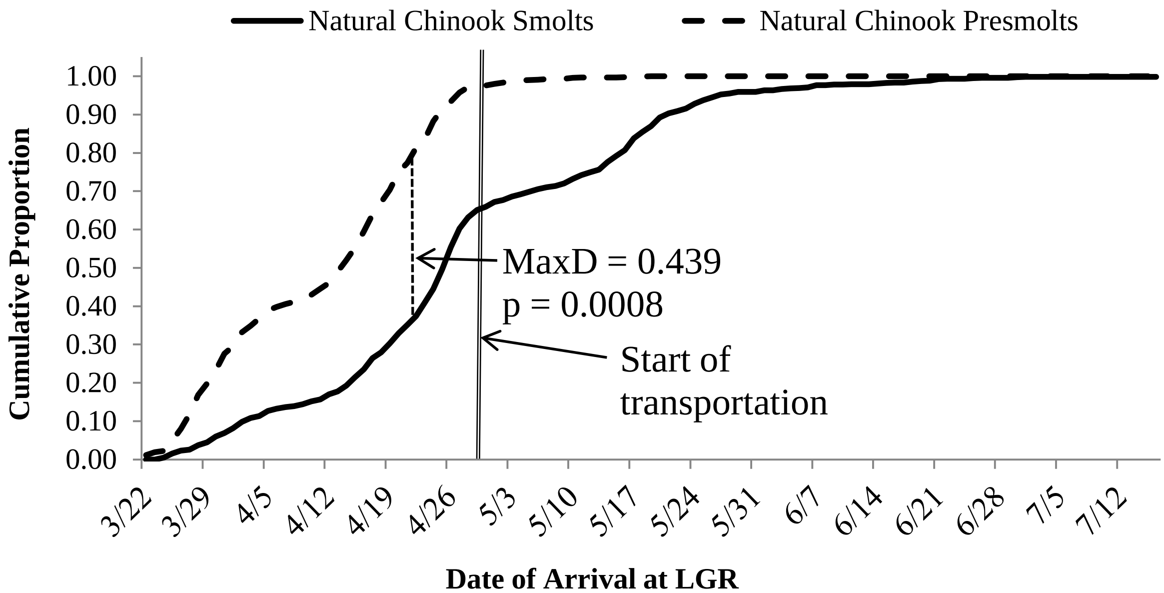

Figure 3.5. Arrival timing of natural-origin fall-tagged Chinook presmolts and spring-tagged smolts at Lower Granite Dam (LGR) during the 2012 migration year. Maximum difference (MaxD) in arrival timing between the two groups occurred on April 22, 2012 and is represented by the dashed vertical line. The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, May 1, 2012.

Natural Chinook salmon smolts demonstrated earlier arrival timing at LGR than hatchery smolts but hatchery smolts emigrated rapidly after the last week of April. Hatchery smolt arrival surpassed natural smolt arrival timing on May 8th when just over 70% of each origin type had passed LGR. The right tail of the natural Chinook emigration lagged behind the latest hatchery individuals. The 90th percentile for natural Chinook lagged nearly a month behind hatchery Chinook and the last natural smolt arrived nearly two months after the last hatchery smolt (Table 3.4). Given the smaller size (many < 90 mm at tagging) and tagging date of several of the late arriving smolts, it is possible some late emigrating smolts were fall Chinook salmon, which have been observed spawning above the juvenile trap in recent years (Adult Technical Team 2010). The significant maximum difference in arrival timing at LGR between hatchery and natural smolts occurred on April 24, 2012 (K-S test, MaxD = 0.321, p< 0.0001; Figure 3.6). However, it should be noted that only 73 hatchery Chinook, which were recaptured at the Imnaha River screw trap, were observed at LGR in 2012. This group provided a small sample size to assess arrival timing.

Similar proportions of hatchery and natural Chinook smolts were likely to be transported in 2012. More natural Chinook smolts (65.9%) than hatchery smolts (45.2%) had passed LGR prior to the start of collections (Table 3.5). However, transport collection efficiencies were higher for natural smolts (38%) than hatchery smolts (28%). The combination of these factors led to an estimated 13.0% of natural Chinook smolts being transported at LGR versus 15.3% of hatchery smolts.

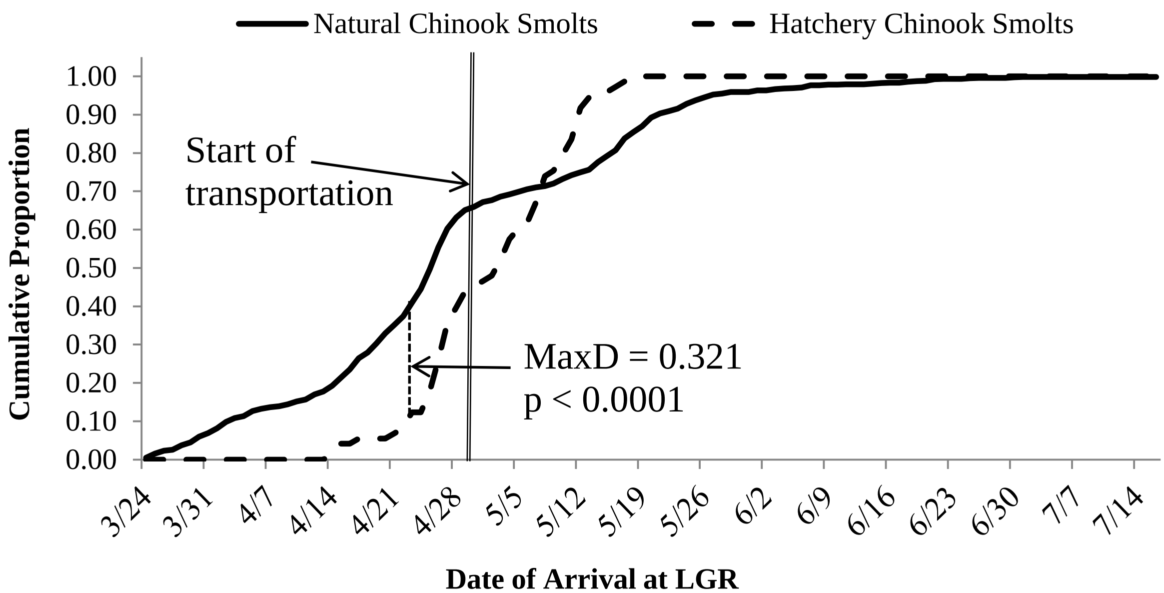

Figure 3.6. Arrival timing at Lower Granite Dam (LGR) of natural and hatchery-origin Chinook salmon smolts emigrating during the spring and summer of 2012. Maximum difference in arrival timing between the origin types occurred on April 24, 2012 (MaxD, represented by the dashed vertical line). The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, May 1, 2012.

Steelhead arrival timing at LGR

Comparable to their arrival at the trap, hatchery steelhead emigration timing to LGR lagged behind natural steelhead from several days to two weeks throughout most of their emigration period. The first natural and hatchery steelhead were seen at LGR March 25 and April 1 respectively. For natural steelhead, 10% of smolts passed LGR by April 24, 50% by May 15, and 90% by May 24. The last spring/summer emigrating natural smolt was observed at LGR June 18, 2012. For hatchery steelhead, 10% of smolts passed LGR by April 26, 50% by May 18, 90% by June 5, and the last spring/summer emigrating hatchery smolt was observed July 9 (Table 3.4). Two natural and one hatchery steelhead smolts were observed at LGR in October 2012 but are not included in our analysis. A K-S test revealed a significant difference in hatchery and natural steelhead emigration timing to LGR (MaxD = 0.211, $p < 0.0001$) and the maximum difference in timing occurred May 17, 2012. Though hatchery steelhead migration lagged behind natural steelhead, they experienced similar flow patterns during outmigration and similar numbers were likely transported around the hydrosystem (see below). Therefore the biological impacts of the difference in their arrival timing are likely limited in scope.

Similar proportions of hatchery and natural steelhead were transported around the hydrosystem in 2012. By the start of transportation collection efforts on May 1, 2012, 18.0% of natural steelhead and 11.5% of hatchery steelhead had passed LGR. Given the estimated collection efficiencies of 36% for hatchery steelhead and 34% for natural steelhead; the proportion destined for transportation around the hydrosystem at LGR was 31.9% for hatchery steelhead and 27.9% for natural steelhead (Table 3.5).

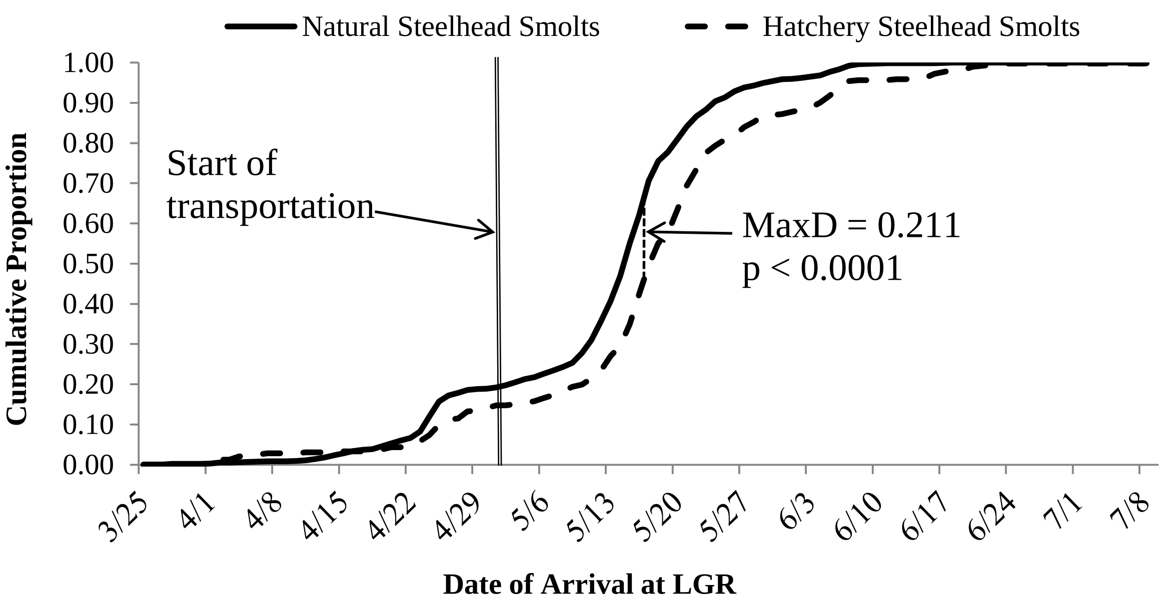

Figure 3.7. Arrival timing at Lower Granite Dam (LGR) of natural-origin steelhead and hatchery-origin steelhead smolts emigrating during the spring and summer of 2012. Maximum difference in arrival timing between the origin types occurred on May 17 (MaxD, represented by the dashed vertical line). The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, May 1, 2012. Note: two natural and one hatchery steelhead smolts tagged in spring 2012 were captured at LGR during October 2012 and are not shown in this figure.

Travel Time from Imnaha River Trap to Lower Granite Dam in Relation to Snake River Flow

Chinook salmon juvenile emigrant travel time

Juvenile Chinook salmon travel times from the Imnaha River Trap to LGR were highly variable in 2012. Individual travel times varied from 3 – 45 days for hatchery smolts and 3 – 112 days for spring-tagged natural smolts (Table 3.6). During the narrow five week period when hatchery smolts were observed at LGR, their mean travel times were initially shorter than natural smolts by several weeks but the last individuals had travel times that were several weeks longer than natural smolts observed at LGR within the same week. However, comparing hatchery to natural Chinook smolt travel time was difficult in 2012 because of few hatchery Chinook detections at LGR (n = 73). Mean weekly travel times for hatchery smolts ranged from 12 days in mid-April to 37 days in mid-May (Table 3.6; Figure 3.8). Mean travel times for natural smolts varied between seven and 28 days throughout the season. Natural smolt mean travel times started at around ten days in mid-March and rose to 28 days at the beginning of May. Natural smolt travel times then decreased to less than ten days by the middle of June as the last smolts were observed at LGR. No hatchery Chinook and few natural Chinook were detected at LGR past mid-May (Figure 3.9). The resulting paucity of data limited our analysis of the relationship between travel time and Snake River discharge to a short period with a narrow range in discharge. Given this caveat, there was no relationship between travel time and Snake River discharge for natural or hatchery Chinook. However, travel time for natural Chinook was negatively correlated with temperature at LGR, though significantly ($p = 0.03$, $r^2 = 0.31$). Because of the unseasonably early apex of the hydrograph in April of 2012, temperature may have provided a more instinctual cue than discharge to motivate the emigration of natural Chinook from the Snake River.

Table 3.6. Weekly mean travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for hatchery Chinook salmon smolts and natural Chinook salmon spring-tagged smolts. The table includes LGR detection week, the number of Chinook salmon detected (count), mean travel time in days, the range of travel times for all three release groups, and mean Snake River flow in cubic feet per second (cfs). *Single detections, no range available.

LGR Detection Week	Hatchery Smolt Count	Hatchery Smolt Mean Travel Time (Days)	Hatchery Smolt Range of Travel Times	Natural Smolt Count	Natural Smolt Mean Travel Time (Days)	Natural Smolt Range of Travel Times	Snake River Flow (cfs)
3/18/12				4	11	(11 - 12)	48,308
3/25/12				50	20	(4 - 81)	57,588
4/1/12				53	21	(6 - 88)	73,511
4/8/12	1	8*		44	25	(5 - 51)	64,288
4/15/12	4	12	(5 - 21)	124	26	(4 - 103)	60,066
4/22/12	24	22	(12 - 34)	221	25	(4 - 112)	95,673
4/29/12	15	26	(3 - 41)	52	28	(23 - 70)	84,589
5/6/12	23	34	(25 - 45)	40	24	(4 - 51)	67,570
5/13/12	6	37	(25 - 43)	94	13	(3 - 51)	74,893
5/20/12				60	18	(3 - 18)	75,147
5/27/12				14	13	(5 - 51)	55,699
6/3/12				12	13	(5 - 27)	68,577
6/10/12				4	7	(6 - 9)	51,416
6/17/12				8	8	(5 - 10)	52,930
6/24/12				3	8	(6 - 10)	49,753
7/1/12				1	16*		37,971
7/8/12							31,545
7/15/12				1	26*		27,640

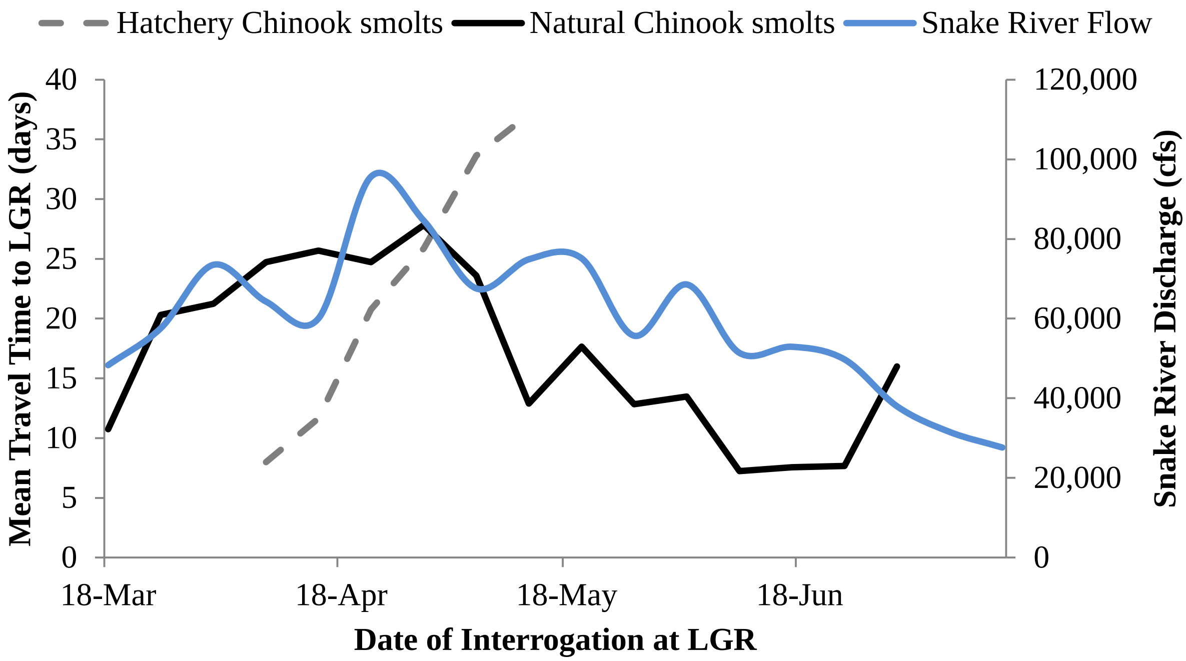

Figure 3.8. Mean weekly travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for migration year 2012 hatchery and natural Chinook salmon smolts tagged during the spring trapping period, and Snake River flow in cubic feet per second (cfs).

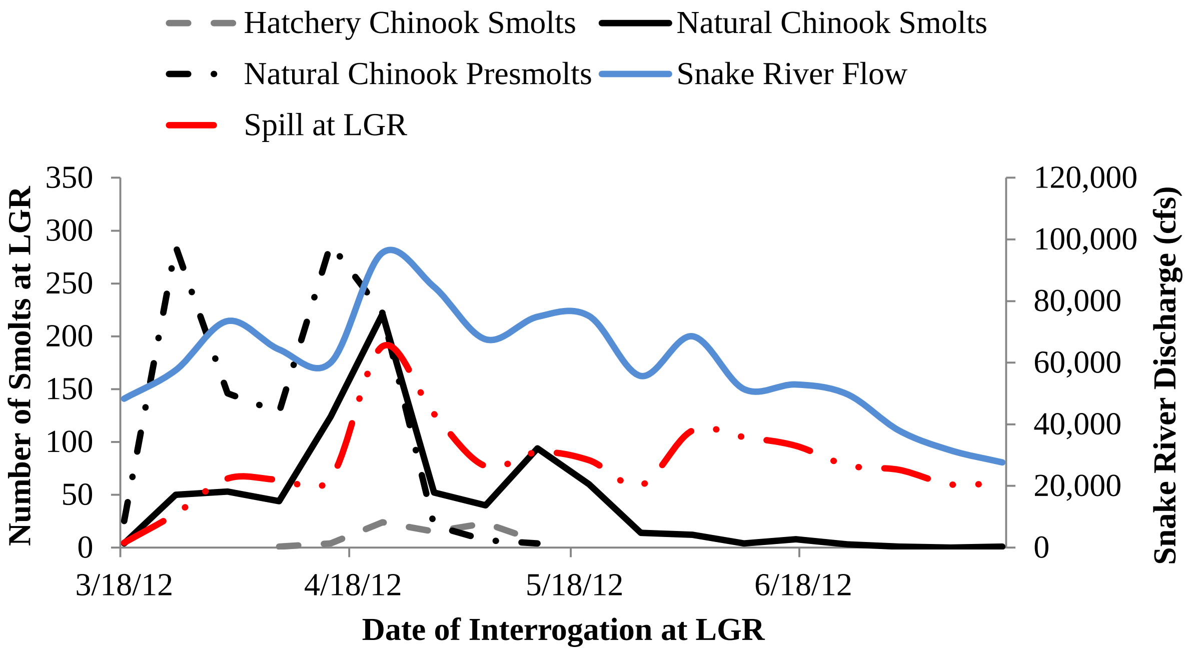

Figure 3.9. Peak passage timing at Lower Granite Dam (LGR) presented as the number of Passive Integrated Transponder (PIT) tagged Chinook salmon detections at LGR during the spring and summer of 2012 and Snake River flow and spill at LGR presented in cubic feet per second (cfs). Figure includes the date of passage of PIT-tagged fish at LGR by release group for hatchery Chinook salmon smolts, natural Chinook salmon smolts, and natural Chinook salmon presmolts.

Steelhead juvenile emigrant travel time

Juvenile steelhead travel times from the Imnaha River Trap to LGR were typically shorter on average than Chinook salmon. Individuals of both natural and hatchery steelhead traveled from the Imnaha River Trap to LGR in as little as one day; a distance of 142 km. Travel times for hatchery steelhead ranged from one to 44 days and from one to 130 days for natural steelhead (Table 3.7). Travel times were slightly higher for hatchery steelhead than natural steelhead throughout their emigration period. Mean weekly travel times ranged from four to 21 days for hatchery steelhead and four to 13 days for natural steelhead. For natural steelhead, mean travel times showed a spike in early April, but decreased to and stayed less than seven days as the Snake River hydrograph ascended in late April (Figure 3.10). Hatchery steelhead showed higher mean travel times (nine to 21 days) from March through early May despite the highest Snake River discharge occurring during this time. Thereafter, hatchery smolt mean travel times descended to between four and 10 days for the remainder of emigration through June (Figure3.10). Low numbers of detections early and late in the season for both origin types hampered regression analysis of the relationship between travel time and Snake River discharge as flows were generally high throughout the bulk of the migration in late April and May. Given this limitation, neither hatchery nor natural steelhead showed a statistically significant relationship between travel time and Snake River discharge (both P values > 0.22). Both natural and hatchery steelhead showed a negative relationship between travel time and temperature, though the relationship was not significant for either origin ($p = 0.06$ for natural steelhead and $p = 0.29$ for hatchery steelhead). Passage of steelhead at LGR was later than that observed for Chinook salmon. Most hatchery and natural steelhead detections occurred during May following the highest flows and spill at LGR (Figure 3.11).

Table 3.7. Weekly mean travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for hatchery and natural-origin steelhead smolts in spring and summer of 2012. The table includes LGR detection week, number of hatchery and natural steelhead smolts detected (count), mean travel time in days, the range of travel times, and mean Snake River flow in cubic feet per second (cfs).

LGR Detection Week	Hatchery Smolt Count	Hatchery Smolt Mean Travel Time (Days)	Hatchery Smolt Range of Travel Times	Natural Smolt Count	Natural Smolt Mean Travel Time (Days)	Natural Smolt Range of Travel Times	Snake River Flow (cfs)
03/25/12	--	--	--	3	5	(3 - 8)	57,588
04/01/12	11	5	(2 - 8)	11	8	(4 - 18)	73,511
04/08/12	2	15	(12 - 18)	26	13	(3 - 26)	64,288
04/15/12	5	9	(3 - 18)	61	8	(3 - 33)	60,066
04/22/12	35	13	(3 - 29)	213	6	(2 - 45)	95,673
04/29/12	10	21	(8 - 36)	54	6	(2 - 45)	84,589
05/06/12	30	9	(2 - 40)	235	5	(2 - 43)	67,570
05/13/12	134	6	(1 - 44)	710	5	(1 - 47)	74,893
05/20/12	95	4	(1 - 44)	255	4	(2 - 15)	75,147
05/27/12	25	5	(2 - 11)	57	5	(2 - 12)	55,699
06/03/12	29	8	(1 - 20)	59	7	(2 - 28)	68,577
06/10/12	6	10	(2 - 25)	2	4	(2 - 5)	51,416
06/17/12	10	6	(2-32)	3	4	(4 - 5)	52,930
06/24/12	0	--	--	--	--	--	49,753
07/01/12	0	--	--	--	--	--	37,971
07/08/12	1	20	--	--	--	--	31,545
07/15/12	0	--	--	--	--	--	27,640

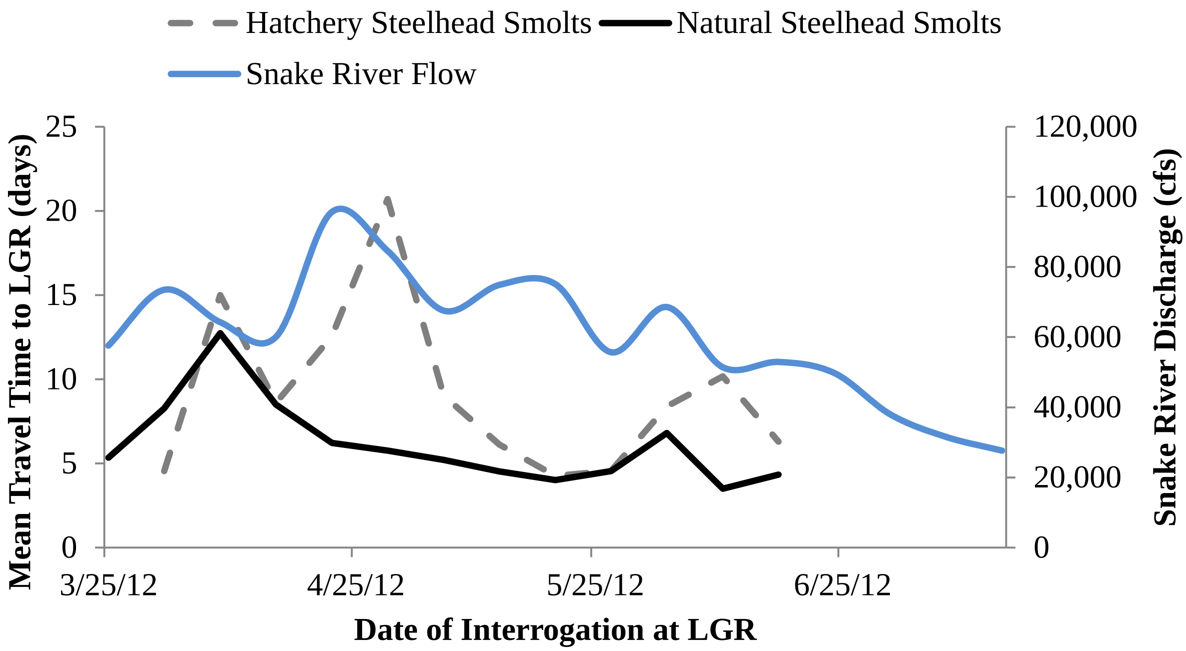

Figure 3.10. Mean weekly travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for migration year 2012 hatchery and natural-origin steelhead smolts and Snake River flow in cubic feet per second (cfs).

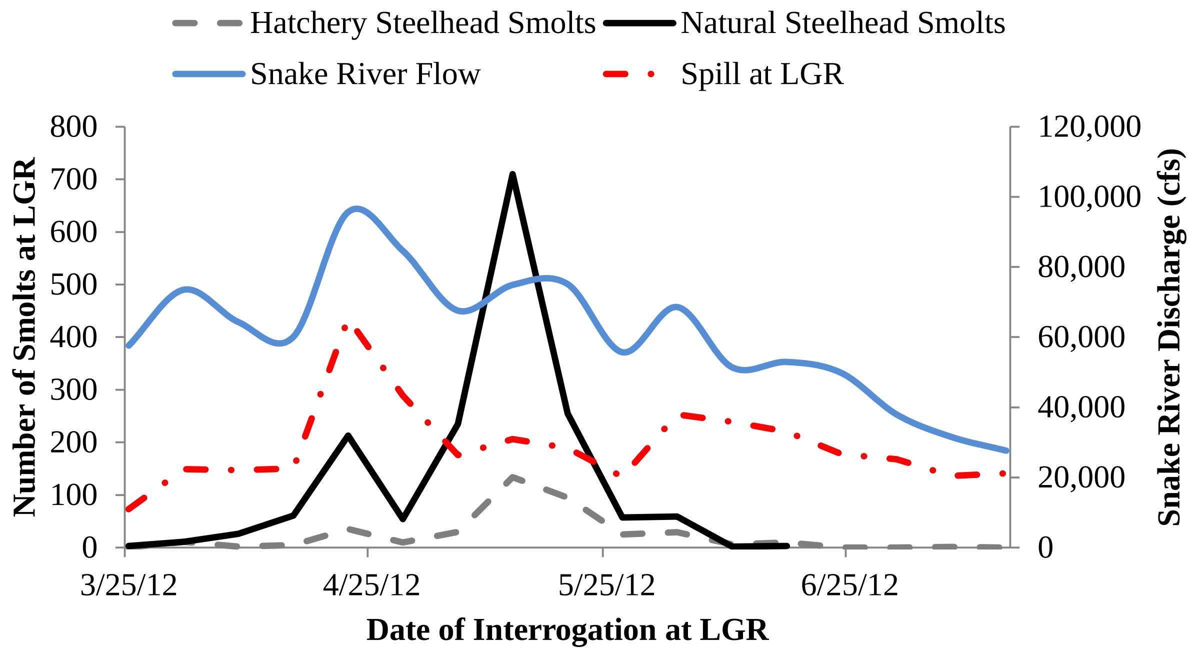

Figure 3.11. Passage timing at Lower Granite Dam (LGR) presented as the number of Passive Integrated Transponder (PIT) tagged steelhead detections at LGR during the spring and summer of 2012 and Snake River flow and spill at LGR presented in cubic feet per second (cfs). Figure includes the date of passage of PIT-tagged fish at LGR by origin type for hatchery and natural steelhead smolts.

Life-Stage and Reach Specific Estimates of Juvenile Emigrant Survival

Post-release survival of hatchery smolts

Survival of hatchery Chinook salmon smolts to the Imnaha River Trap was very high in 2012. Estimated post-release survival of acclimated hatchery Chinook from the Gumboot acclimation facility to the trap was 99.9% (± 10.5%) resulting in an estimated 333,059 (95% CI 298,460 to 333,392) hatchery Chinook salmon outmigrating past the Imnaha River Trap during spring 2012 (Table 3.8). While confidence intervals for hatchery Chinook survival were wide in 2012, even the lower bound of survival was near the average post release survival for 1994 to 2012 (91%).

Similar to Chinook, survival of hatchery steelhead to the Imnaha River Trap was above average in 2012. Estimated post-release survival of acclimated hatchery steelhead from the Little Sheep Creek acclimation facility to the trap was 91% (± 3.5%) resulting in an estimated 216,540 (95% CI 209,018 to 224,062) hatchery steelhead passing the trap in 2012 (Table 3.8). Survival to the trap for hatchery steelhead was nearly 10% higher than average (82%). Given the higher than average survival of both hatchery steelhead and Chinook salmon smolts, it appears conditions in the Imnaha River were conducive to low mortality and residualization for both species in 2012.

Table 3.8. Estimated post-release survival of hatchery Chinook salmon and steelhead smolts to the Imnaha River Trap, average post-release survival from 1994 to 2012, and the number of hatchery smolts estimated to have emigrated from the Imnaha River in MY2012.

Hatchery Species	Post-Release Survival to Imnaha Trap (%)	Average survival 1994 - 2012	Estimated Outmigrating Imnaha Hatchery Smolts in 2012
Chinook Salmon	99.9 (±10.5)	91 (± 5.0)	333,059 (298,460, 333,392)
Steelhead	91 (± 3.5)	82 (± 8.9)	216,540 (CI 209,018, 224,062)

Survival from Imnaha River Trap to Lower Granite Dam

Natural Chinook salmon survival from the trap to LGR was estimated for fall-tagged presmolts and spring-tagged smolts independently and collectively during MY2012 (BY2010). Estimated survival of fall-tagged presmolts was 31% (± 1.3%) compared to 72% (± 3.0%; Table 3.9) for spring-tagged smolts. As in 2011, comparison of the two release groups using SURPH information revealed that there was a significantly higher proportion of spring-tagged smolts detected after release than fall-tagged presmolts (x^2 = 1243.0, df = 1, p < 0.001). Conversely, a significantly higher proportion of fall-tagged presmolts than spring-tagged smolts were first interrogated at dams below LGR (x^2 = 13.25, df = 1, p < 0.001). This result suggests many of the fall-tagged presmolts emigrated past LGR early in the season before interrogation arrays were operational. As in 2011, the proportional dominance of presmolts (82%) and the comparatively low survival rate of presmolts produced a low overall survival rate for the MY2012 cohort to LGR. The combined MY2012 natural Chinook salmon cohort survival estimate from the trap to LGR was 41% (± 1.3%). Survival of hatchery Chinook salmon smolts from the trap to LGR was slightly lower than natural spring-tagged smolts and estimated to be 69% (± 14.1%; Table 3.9). Tag detections throughout the hydrosystem for hatchery Chinook recaptured at the Imnaha River Trap were very low in 2012 (n = 170) which led to the wide confidence intervals surrounding their survival estimate. Further analysis showed a significantly higher proportion of natural Chinook salmon smolts were detected after release than hatchery smolts (x^2 = 13.3, df = 1, p < 0.001), which would be expected given the low number of overall hatchery Chinook detections.

Survival to LGR was very similar for natural and hatchery steelhead in 2012. Natural steelhead smolt survival from the Imnaha River Trap to LGR for MY2012 was estimated at 90% (± 3.1%). Hatchery steelhead survival was also estimated at 90% (±10.1%; Table 3.9). Opposite from 2011, a significantly higher proportion of natural steelhead than hatchery steelhead were detected after release (x^2 = 34.06, df = 1, p <0.001). However, a significantly higher proportion of hatchery steelhead than natural steelhead had first detections at dams past LGR (x^2 = 8.08, df = 1, p < 0.01).

Detection efficiencies at LGR were low in 2012, due mainly to the high flows observed (FPC 2012). Capture probabilities for natural Chinook salmon (39%) and steelhead (35%) were higher than for their hatchery conspecifics (31% and 27% respectively). The low detection efficiencies and relatively low numbers of tagged hatchery fish recaptured and released at the Imnaha River Trap led to less precise survival estimates and wider confidence intervals for both species of hatchery fish in 2012 than in 2011.

Smolt equivalents at Lower Granite Dam (LGR)

The fall-tagged presmolt survival estimate of 31% produced an estimated 50,391 (± 17,896) smolts at LGR. The spring-tagged smolt survival estimate of 72% produced an estimated 26,889 (± 7,974) smolts at LGR for a natural-origin cohort estimate of 77,280 (± 25,870) smolts at LGR. Hatchery Chinook salmon survival of 69% produced an estimated 229,529 (± 44,565) smolts at LGR. Natural steelhead survival of 90% produced an estimated 39,273 (± 7,719) smolts at LGR. The estimated 90% survival of hatchery steelhead produced an estimated 214,146 (± 23,473) smolts at LGR (Table 3.9).

Survival from Imnaha River to McNary Dam

Our analysis provides estimates of juvenile survival to the Imnaha River Trap, LGR, and MCN, but does not provide detailed results of juvenile survival through the entire hydrosystem. A more comprehensive analysis of in-river and transportation and migration route effects on juvenile survival and resulting adult returns can be found in the Fish Passage Center's Comparative Survival Study report (Comparative Survival Study 2012).

Survival of fall-tagged natural Chinook salmon presmolts from the Imnaha River Trap to MCN dam was the same as in 2011 and only 26% (± 2.1%). Survival of this group to LGR was estimated at 31% suggesting that the largest source of mortality for fall-tagged Chinook salmon is overwintering in the Snake River above LGR. Reach survival from LGR to MCN for fall-tagged presmolts was high at 83% (± 10.9%). Survival of spring tagged natural Chinook salmon smolts to MCN was estimated at 74% (± 10.5%) and reach survival from LGR to MCN was very high at 97% (± 17.7%). The combined MY2012 survival of spring-tagged smolts and fall-tagged presmolts to MCN was 37% (± 2.9%). Reach survival from LGR to MCN of the combined natural-origin Chinook cohort was 88% (± 9.3%; Table 3.9). Hatchery Chinook smolts experienced high mortality from the trap to MCN in 2012. Estimated survival of hatchery Chinook salmon smolts from the trap to MCN was 42% (± 10.8%). Reach survival from LGR to MCN for hatchery Chinook was 76% but a paucity of detections generated very wide confidence intervals (± 46.9%). Hatchery steelhead survival to MCN was 88% (± 23.1%). Hatchery steelhead reach survival from LGR to MCN was 91% but, similar to hatchery Chinook, exceptionally wide confidence intervals surrounded the estimate (± 66.6%). Natural-origin steelhead survival from the trap to MCN was estimated at 76% (± 7.3%) and reach survival from LGR to MCN was 82% (± 18.7%; Table 3.9).

Table 3.9. Estimated percent survival of natural and hatchery Chinook salmon and steelhead smolts from the Imnaha River Trap to Lower Granite Dam (LGR) and McNary Dam (MCN) and the resulting smolt equivalents at LGR during migration year 2012. Confidence intervals (95%) are presented in parentheses.

Origin and Species	Survival to LGR (%)	Survival to MCN (%)	Survival from LGR to MCN (%)	Smolt Equivalents at LGR
Natural Chinook Presmolts	31 (1.3)	26 (2.1)	83 (10.9)	50,391 (17,896)
Natural Chinook Smolts	72 (3.0)	74 (10.5)	97 (17.7)	26,889 (7,974)
Natural Chinook Cohort	41 (1.3)	37 (2.9)	88 (9.3)	82,788 (22,413)
Hatchery Chinook Smolts	69 (14.1)	42 (10.8)	76 (46.9)	229,529 (44,565)
Natural Steelhead	90 (3.1)	76 (7.3)	82 (18.7)	39,273 (7,719)
Hatchery Steelhead	90 (10.1)	88 (23.1)	91 (66.6)	214,146 (23,473)

Size and Condition of Juveniles at Emigration

The biological characteristics of length, weight, and condition factor at emigration were evaluated for natural and hatchery-origin juveniles for MY2012. Comparisons were made between spring-emigrating smolt groups to illustrate the differences between hatchery reared smolts and naturally produced smolts in terms of size and condition at emigration. Fall-tagged natural Chinook presmolts averaged 78 mm in length, 5.4 g in weight, and had an average condition factor of 1.11. Spring tagged natural Chinook smolts had an average fork length of 95 mm, an average weight of 9.6 g, and a mean condition factor of 1.10. Hatchery Chinook recaptured at the trap averaged 120 mm in length, 20.0 g, and had a condition factor of 1.15 (Table 3.10). Natural steelhead smolts showed a mean fork length of 170 mm, a mean weight of 50.9 g, and a mean condition factor of 1.01. Hatchery fish had a significantly higher mean fork length, weight, and condition factor than spring-tagged natural smolts for both Chinook salmon and steelhead (t-test, all tests $p < 0.001$; Table 3.10; Figures 3.12 and 3.13)

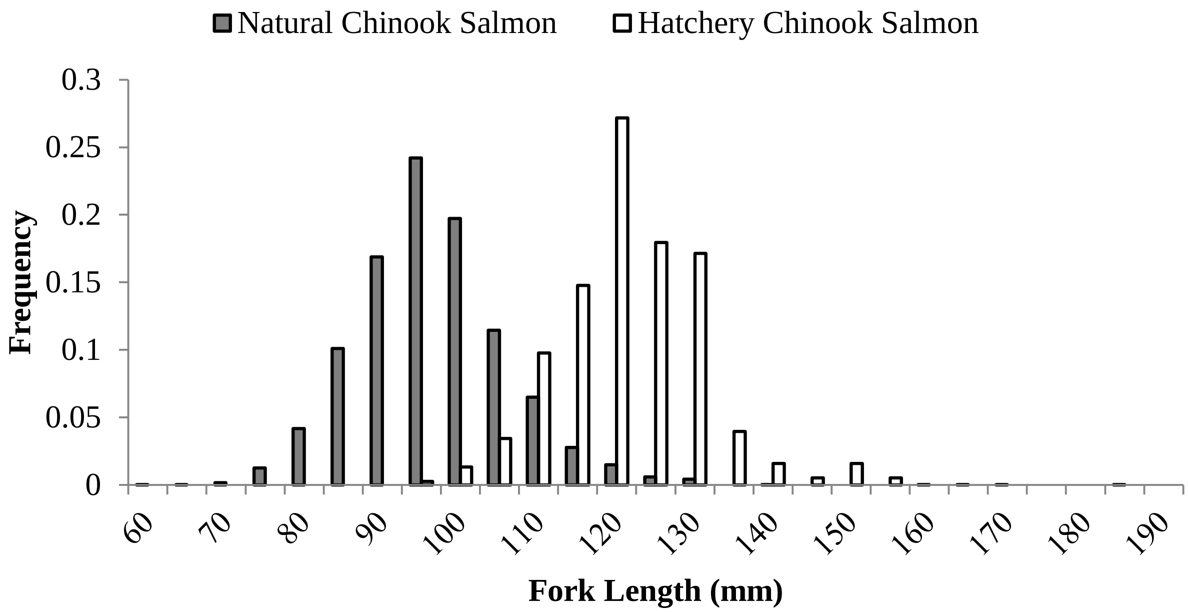

Figure 3.12. Length frequency distribution of natural and hatchery Chinook salmon smolts captured in the Imnaha River juvenile emigrant trap from January 1 to August 31, 2012.

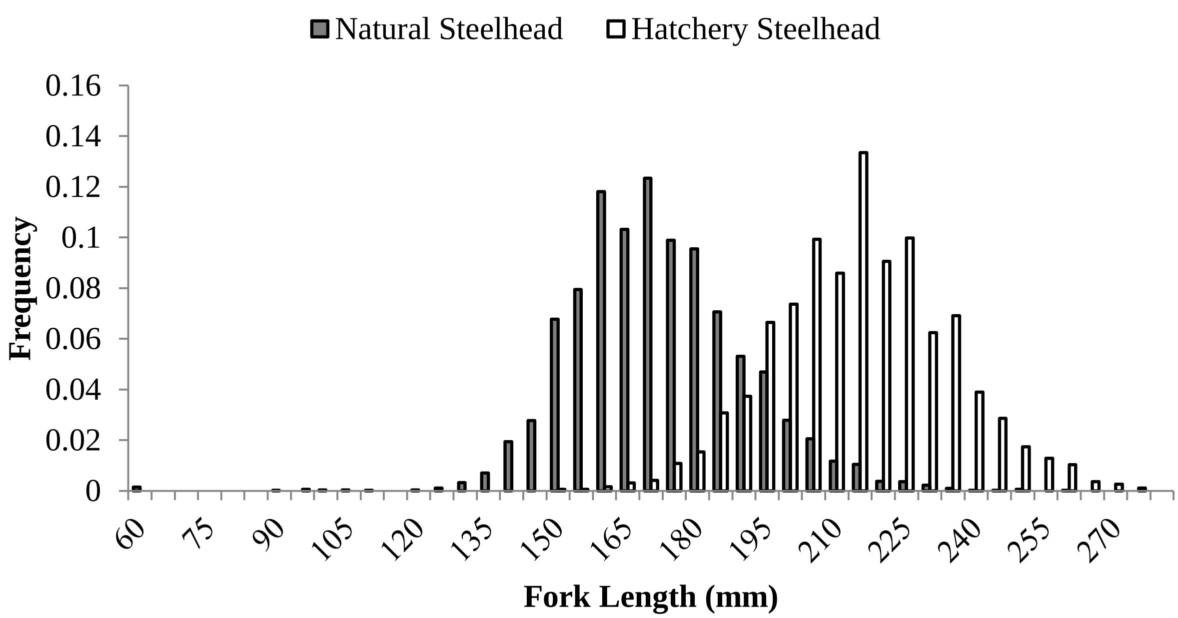

Figure 3.13. Length frequency distribution of natural and hatchery steelhead smolts captured in the Imnaha River juvenile emigrant trap from January 1 to August 31, 2012.

Table 3.10. Sample size, mean, range, and standard deviation of fork length (mm), weight (g), and condition factor (K) for natural and hatchery Chinook salmon and steelhead captured during the 2012 migration year, September 1, 2011 to August 31, 2012, at the Imnaha River juvenile emigrant trap.

		Fall 2011	Spring 2012			
Attribute	Statistic	Natural Chinook Presmolts	Natural Chinook Smolts	Hatchery Chinook Smolts	Natural Steelhead Smolts	Hatchery Steelhead Smolts
Fork Length (mm)	Sample Size (n)	9,120	3,002	379	5,304	1,955
	Mean	78	95	120	170	213
	Minimum	43	58	94	87	91
	Maximum	114	184	154	260	274
	Standard Deviation	10	10	9	18	19
Weight (g)	Sample Size (n)	9,067	2,999	380	5,299	1,906
	Mean	5.4	9.6	20.0	50.9	95.9
	Minimum	1.1	2.3	10.0	8.2	7.9
	Maximum	16.0	53.5	40.1	176.7	220.4
	Standard Deviation	2.1	3.3	4.9	16.2	26.1
Condition Factor (K)	Sample Size (n)	9,067	2,998	378	5,299	1,906
	Mean	1.11	1.10	1.15	1.01	0.97
	Minimum	0.56	0.66	0.59	0.71	0.73
	Maximum	1.95	1.79	2.03	1.79	1.29
	Standard Deviation	0.11	0.11	0.13	0.08	0.07

Chapter 4: Migration Year 2013

Chapter Introduction

This chapter presents the results and discussion for trapping efforts covering MY2013, from September 1, 2012 to August 31, 2013. The trap operated from late September 2012 to mid-July 2013 (see trap operations) targeting BY2011 Chinook salmon and MY2013 steelhead. Although Chinook salmon fry and parr from BY2012 were trapped during this time period, no marking or trap efficiency trials were conducted on these fish and they are not included in population estimates or the following performance measure analyses. The performance measure results included in this chapter are specific to the BY2011 and MY2013 emigrants only, while multi-year performance measures are included in Chapter 5.

Trapping and Tagging Results and Discussion

Trap Operations

The trap operated for a total of 233 days during MY2013. Trapping began September 23, 2012 and ceased July 17, 2013. Analysis of the previous two years of extended trapping suggested that high temperatures and low migration rates negated the need and effectiveness of late summer trapping (Hatch and Harbeck 2013). There were a total of 53 days when the trap was not operated due to icy conditions, high flows, or heavy debris, and nine days when the trap was not operated due to equipment repair and maintenance. The trap was not operated on the weekends during the summer trapping period, during the Nez Perce Tribe's general council meetings, or on major holidays, leaving a total of four days of in-operation due to scheduling. Subsampling occurred on seven days during the MY2012 season on days with high passage rates of hatchery fish. There were 55 sample periods that were shortened (less than 24 hours) due to equipment repair and maintenance. The trap operated for 64% of MY2013, extending operations beyond years prior to 2010 by 21%. Please refer to Appendix A.3. for a summary of total hours fished and the daily catch.

Target Catch

The catch of MY2013 natural-origin Chinook salmon totaled 13,659 fish including 7,371 presmolts trapped in the fall of 2012, a further 4,970 smolts trapped during spring and summer 2013, and 1,318 smolts estimated to have passed during bypass procedures (Appendix A.3). Forty five BY2012 Chinook salmon fry < 60mm were caught. During the fall of 2012, 6,264 Chinook presmolts were PIT tagged at the trap and 4,633 Chinook smolts were PIT tagged during the spring trapping season of 2013 (Appendix B.3). Of the tagged fish, 2,433 fall-tagged presmolts and 2,868 spring-tagged smolts were marked and released above the trap for trap efficiency trials. A total of 21 of the 1,000 natural-origin Chinook salmon that were previously PIT tagged by Oregon Department of Fish and Wildlife's (ODFW) Early Life History Program during August and September of 2012 were recaptured at the Imnaha River Trap. Please refer to Appendix C.3 for trap date, travel time, and biological data for these fish.

The catch of MY2013 natural-origin steelhead totaled 8,776 fish including 217 trapped in fall, 7,246 trapped in spring, which included 1,313 estimated to have passed the trap during bypass procedures (Appendix A.3) A total of 6997 natural-origin steelhead were PIT tagged during spring (Appendix B.3), of which 2,504 were marked and released above the trap for trap efficiency trials. Natural-origin steelhead were not tagged in the fall since the number of fish captured was too small to produce an accurate abundance estimate.

A total of 14,128 hatchery-origin Chinook smolts representing BY2011 were captured at the Imnaha River Trap during the MY2013 spring/summer trapping period (Appendix A). A further 35,333 hatchery Chinook smolts were estimated to have passed during bypass procedures for a total of 49,461 individuals. Hatchery-origin Chinook smolt captures were from an acclimated volitional release group totaling approximately 223,716 smolts released from the Imnaha River Gumboot acclimation facility at rkm 74 beginning March 30, 2013 until April 5 when all remaining smolts were forced out. There was also a direct release into the Imnaha River of 166,979 smolts on March 30. Of the 390,695 smolts released, a total of 20,852 were PIT-tagged (Appendix D). A total of 1,973 previously PIT tagged hatchery Chinook salmon were recaptured at the Imnaha juvenile emigrant trap.

A total of 32,273 hatchery-origin steelhead smolts representing BY2012 were captured at the Imnaha River Trap during the MY2013 spring/summer trapping period. This included 5,219 smolts estimated to have passed during bypass procedures (Appendix A.3). Hatchery-origin steelhead captures were from a volitional release of 237,149 smolts from the LSRCP Little Sheep Creek acclimation facility beginning March 26 and ended April 23 when all remaining fish were forced out. A total of 2,681 previously PIT-tagged hatchery-origin steelhead released from the Little Sheep Creek facility were recaptured at the Imnaha River Trap. Please refer to Appendix D for additional information on hatchery-origin steelhead.

Incidental Catch

The incidental catch during the fall, spring, and summer of MY2013 was estimated to total 3,104 fish comprising of six families of fishes: Salmonidae, Centrarchidae, Catostomidae, Cyprinidae, Cottidae, and Petromyzontidae (Appendix E.3) The catch of Salmonidae consisted of 19 adult steelhead, 1,511 rainbow trout, 12 mountain whitefish, and 57 bull trout. Bull trout were divided into adults 300 mm and greater (n = 24), and juveniles less than 300 mm (n = 33). Juvenile rainbow trout were determined to be resident fish based on morphological characteristics and were not enumerated as natural-origin steelhead juveniles in this report. The catch of Centrarchidae consisted of 30 smallmouth bass. The catch of the Catostomidae family consisted of 576 suckers of unidentified species and five bridgelip suckers. The catch of Cyprinidae included 34 chislemouth, 634 longnose dace, 50 Northern pikeminnow, 14 redside shiner, and 8 peamouth. The catch of the Cottidae family consisted of 149 sculpins of unidentified species. Only one juvenile pacific lampreyof the family Petromyzontidae was caught during MY2013 (Appendix F).

<u>Trapping and Tagging Mortality</u>

Mortalities handled at the Imnaha River Trap during the MY2013 trapping season included 191 natural and 15 hatchery Chinook salmon, and 58 natural and 39 hatchery steelhead. Thirty seven of the natural Chinook salmon mortalities occurred during the fall of 2012, accounting for 0.50% of the total Chinook salmon fall catch (Appendix G.3). Of these 37 mortalities, 16 were from trapping (including predation in the trap live box), one from handling, 19 from tagging, and one that was dead on arrival. One hundred fifty four natural Chinook salmon mortalities occurred during the spring: 79 due to trapping (including predation), 55 from handling, 16 from tagging, and four that were dead on arrival (Appendix G.3). The 154 mortalities accounted for 2.45% of the total natural Chinook salmon catch during the spring of 2013. Most of the trapping mortalities were due to instances of trap equipment failure. Fifteen hatchery Chinook salmon mortalities were recorded in the spring of 2013. Of these, seven were attributed to trapping, five to handling, and three were dead on arrival. These 15 mortalities accounted for 0.03% of the total catch of hatchery Chinook salmon in MY2013. There were 58 natural steelhead mortalities during the spring of 2013 (Appendix G.3). Of these 58 mortalities, 13 were due to trapping and 45 were as a result of handling. There were no tagging mortalities of natural steelhead. Mortality accounted for 0.68% of the total natural steelhead catch in the spring of 2013. There were 39 hatchery steelhead mortalities at the trap during MY2013: 33 attributed to trapping, four due to handling, and two that were dead on arrival. These mortalities accounted for 0.75% of the total hatchery steelhead catch.

There were 56 incidental catch mortalities during the MY2013 trapping season. One juvenile bull trout died as a result of trapping. Four longnose dace died as a result of trapping and one was dead on arrival. There were seven rainbow trout mortalities: four attributed to trapping, one attributed to handling, and two were dead on arrival. Thirty one sculpin died as a result of trapping, and six were dead on arrival. Lastly, five unidentified suckers died as a result of trapping and one was dead on arrival.

Performance Measures Results and Discussion

<u>Juvenile Emigrant Abundance Estimates at the Imnaha River Trap</u>

Life-stage specific estimates of natural-origin Chinook salmon and steelhead emigrant abundance

Gauss population estimates generated from mark/recapture analysis of the trap efficiency fish estimated the fall juvenile emigrant abundance for natural Chinook salmon to be 93,469 presmolts, (95% C.I. 79,479 to 114,109; Table 4.1), with a CV of 9.26%. Fall 2012 trap efficiencies for natural Chinook salmon presmolts averaged 8% and ranged from 5% to 13% through the season (Table 4.1). The spring juvenile emigrant abundance estimate for natural Chinook salmon smolts was 38,440 (95% C.I. 33,837 to 44,049; Table 4.1) with a CV of 6.53%. Trap efficiencies averaged 19% and ranged from 11% to 42% through the 2013 spring season (Table 4.1). The MY2013 combined juvenile emigrant abundance estimate (fall and spring total) for natural-origin Chinook salmon was 131,909 (95% C.I. 116,728 to 141,183) with a CV of 6.6%. Our results indicate that 70.9% of Chinook salmon juveniles emigrated past the trap during the fall 2012 trapping period, and 29.1% during spring of 2013.

Table 4.1. Gauss population estimates by release group and totals for natural-origin Chinook salmon captured in the Imnaha River juvenile emigrant trap during migration year 2013 (MY2013; fall 2012 and spring/summer 2013). Table includes the date range of the trap efficiency trial (Date Strata), total fish captured by the screw trap (Caught), total marked (Mark), total recaptured (Recap), trap efficiency for the period (T.E.), total population estimate (Pop. Estimate), lower 95% confidence interval (Lower C.I.), upper 95% confidence interval (Upper C.I.) and standard error (S.E.).

Date Strata	Caught	Mark	Recap	T.E.	Pop. Estimate	Lower C.I.	Upper C.I.	S.E.
9/23 - 10/13	175	143	7	5%	3,150	1,548	6,300	1,295.2
10/14 - 10/20	516	291	24	8%	6,027	3,650	11,160	1,910.6
10/21- 10/27	853	345	31	9%	9,223	5,580	15,804	2,776.4
10/28 - 11/3	1,080	261	34	13%	8,085	5,369	12,163	1,779.1
11/4 - 11/10	1,691	303	21	7%	23,367	13,344	39,936	7,352.7
11/11 - 11/17	1,041	331	35	11%	9,600	6,154	15,523	2,525.6
11/18 - 11/24	1,110	209	12	6%	17,931	9,738	37,440	7,018.3
11/25 - 12/29	905	550	30	5%	16,086	8,527	29,952	5,952.3
Fall totals	**7,371**	**2,433**	**194**	**8%**	**93,469**	**79,479**	**114,109**	**8,654.2**
1/27 - 3/16	277	95	19	20%	1330	893	1994	276.9
3/17 - 3/23	819	326	56	17%	4699	3045	7469	1127.6
3/24 - 3/30	230	210	42	20%	1129	747	1744	254.9
3/31 - 4/6	1698	235	33	14%	11786	7479	19452	3140.5
4/7 - 4/13	420	298	33	11%	3694	2181	6624	1193.2
4/14 - 4/20	462	325	84	26%	1772	1286	2558	330
4/21 - 4/27	366	329	67	20%	1776	1227	2747	407.8
4/28 - 5/4	1005	355	54	15%	6505	4186	10635	1727.2
5/5 - 5/11	402	263	48	18%	2166	1421	3404	506.7
5/12 - 5/25	141	134	28	21%	656	435	1022	150.8
5/26 - 6/15	212	151	16	11%	1896	1061	3328	641.5
6/16 - 6/22	147	116	21	18%	782	511	1232	191.8
6/23 - 7/20	109	31	13	42%	249	190	321	34
Spring totals	**6,288**	**2,868**	**514**	**19%**	**38,440**	**33,837**	**44,049**	**2,511.1**
MY 2013 Totals	**13,659**	**5,301**	**708**	**15%**	**131,909**	**116,728**	**141,183**	**8,698.8**

The 2013 spring juvenile emigration abundance estimate for natural steelhead smolts was 54,270 (95% C.I. 48,674 to 60,708; Table 4.2) with a CV of 5.8%. Trap efficiencies for natural steelhead averaged 18% and ranged from 9% to 53% (Table 4.2).

Table 4.2. Gauss population estimates by release group and totals for natural-origin steelhead captured in the Imnaha River juvenile emigrant trap during spring/summer 2013. Table includes the date range of the trap efficiency trial (Date Strata), total fish captured by the screw trap (Caught), total marked (Mark), total recaptured (Recap), trap efficiency for the period (T.E.), total population estimate (Pop. Estimate), lower 95% confidence interval (Lower C.I.), upper 95% confidence interval (Upper C.I.) and standard error (S.E.).

Date Strata	Caught	Mark	Recap	T.E.	Pop. Estimate	Lower C.I.	Upper C.I.	S.E.
3/10 - 3/23	77	76	10	13%	539	295	975	183.0
3/24 - 3/30	19	15	8	53%	34	22	48	6.5
3/31 - 4/6	287	153	32	21%	1,339	882	2,023	309.1
4/7 - 4/13	242	197	18	9%	2,522	1,351	5,467	995.0
4/14 - 4/20	182	181	25	14%	1,274	728	2,259	385.0
4/21 - 4/27	365	316	29	9%	3,857	2,041	8,162	1,493.2
4/28 - 5/4	2,068	363	46	13%	16,016	9,226	31,046	5,263.2
5/5 - 5/11	3,319	351	74	21%	15,577	10,016	23,317	3,613.8
5/12 - 5/18	911	217	33	15%	5,841	3,519	9,559	1,656.1
5/19 - 5/25	746	349	51	15%	5,021	3,023	8,239	1,345.4
5/26 - 6/1	127	102	14	14%	872	504	1,540	270.8
6/2 - 6/29	216	184	28	15%	1,378	851	2,497	424.6
MY 2013 Totals	**8,559**	**2,504**	**368**	**18%**	**54,270**	**48,674**	**60,708**	**3,164.7**

The Imnaha River Trap did not operate during late summer, periods of high flows, heavy debris, icy conditions, during periods of maintenance and repair, or scheduled weekends and holidays off (Appendix A.3). During periods when the trap was not operating the number of juveniles passing the trap was not estimated. Therefore, the estimates of natural-origin juvenile emigrant abundance presented above for the Imnaha River during MY2013 should be considered minimum estimates (Tables 4.1 and 4.2).

Hatchery smolt emigrant abundance estimates at the Imnaha River Trap

See post-release survival of hatchery smolts below.

<u>Juvenile Emigration Timing of Imnaha River Chinook Salmon and Steelhead</u>

Timing of juvenile emigration from the Imnaha River

MY2013 arrival timing at the Imnaha River Trap, assumed to represent emigration from the Imnaha River, was compared between natural and hatchery Chinook salmon and steelhead smolts using the cumulative proportion of juveniles captured over time and a K-S test (Steel et al. 1997). First, 10 percent, median, 90 percent and last arrivals for each release group by species and origin are presented in Table 4.3.

Hatchery Chinook salmon rapidly emigrated past the trap in a unimodal pulse of fish. The first hatchery Chinook smolt was captured March 31st and over 90% of the catch was seen by April 2; only two days later (Table 4.3). The last hatchery Chinook salmon smolt was captured July 11 but only 1% of the hatchery smolt catch occurred after April 23. Natural Chinook salmon smolt emigration was highly protracted compared to hatchery Chinook salmon smolts. The first smolts arrived at the trap January 31, reached the 10th percentile by March 18, and median arrival occurred April 9. The 90th percentile date for natural Chinook salmon smolts did not occur until May 10 and the last smolt arrived July 17 (Table 4.3). Results of the K-S test indicated that the maximum difference between natural and hatchery Chinook salmon emigration timing from the Imnaha River occurred April 4, 2013 (MaxD = 0.504, $p < 0.001$; Figure 4.1).

Table 4.3. First, 10th percentile, median, 90th percentile, and last arrival dates for natural and hatchery-origin Chinook salmon and steelhead smolt release groups captured at the Imnaha River Trap during the 2013 spring and summer trapping period, January 1 to July 17. *Fall-emigrating presmolts excluded from analysis.

Origin and species	First Arrival	10th percentile	Median	90th percentile	Last Arrival
Natural Chinook Salmon	31-Jan	18-Mar	9-Apr	10-May	17-Jul
Hatchery Chinook Salmon	31-Mar	31-Mar	1-Apr	2-Apr	11-Jul
Natural Steelhead	15-Mar	21-Apr	7-May	20-May	25-Jun
Hatchery Steelhead	28-Mar	4-Apr	1-May	18-May	10-Jul

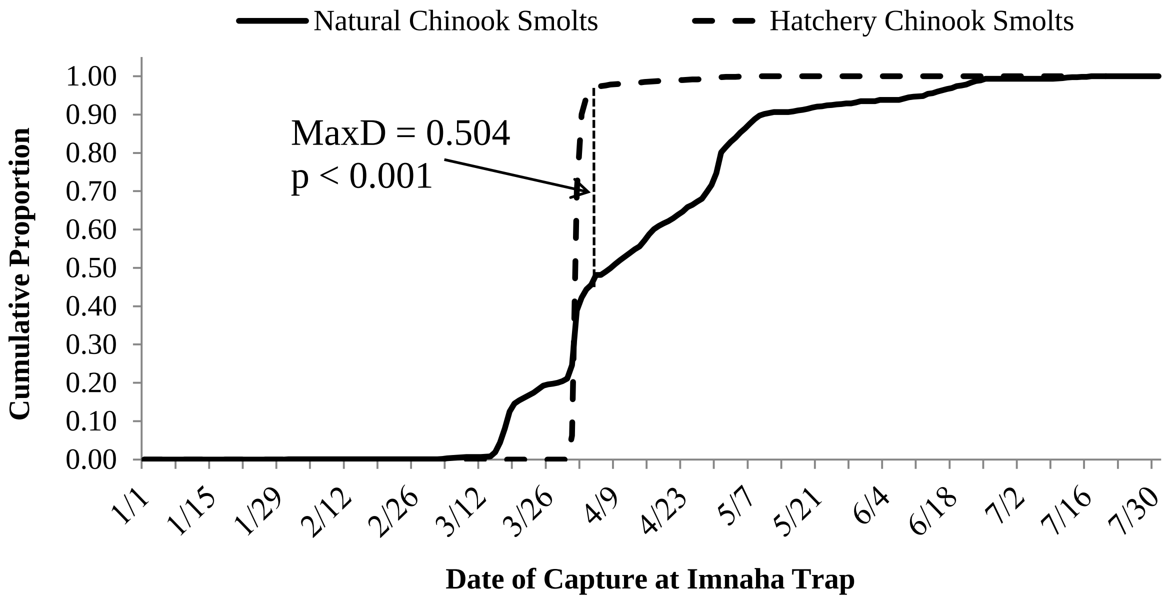

Figure 4.1. Comparison of emigration timing of natural and hatchery Chinook salmon smolts from the Imnaha River presented as the cumulative capture proportion of each origin type at the Imnaha River Trap during the spring 2013 trapping season, January 1 to July 17. Maximum difference in emigration timing (MaxD, represented as the dashed vertical line) between the origin types occurred on April 4, 2013.

Arrival timing was compared between natural and hatchery steelhead. The first steelhead was not captured at the trap until March 15, 2013. The 10th percentile for natural steelhead emigration occurred April 21, the median occurred May 7, and 90th percentile occurred May 20 (Table 4.3). The last natural steelhead smolt was captured June 25, 2013. The first hatchery steelhead smolt was captured March 28, two days after the beginning of the volitional release. The 10th percentile for hatchery steelhead passage occurred April 4, median hatchery steelhead emigration occurred May 1, the 90th percentile occurred May 18, and the last hatchery steelhead was captured July 10 (Table 4.3). The difference in the timing of the cumulative proportion of emigrant passage between natural and hatchery steelhead was significant (K-S test, Max D = 0.202, $p < 0.001$). The maximum difference in hatchery and natural steelhead emigration timing occurred on May 3. Though statistically different, the pattern of emigration between hatchery and natural steelhead was similar and the cumulative distributions similar in shape. Natural steelhead emigration lagged slightly behind hatchery steelhead, especially in the first half of the cohort (Figure 4.2). However, the lag in emigration timing was less than seven days so it is difficult to speculate as to the biological significance of the difference between natural and hatchery steelhead emigration timing during spring 2013.

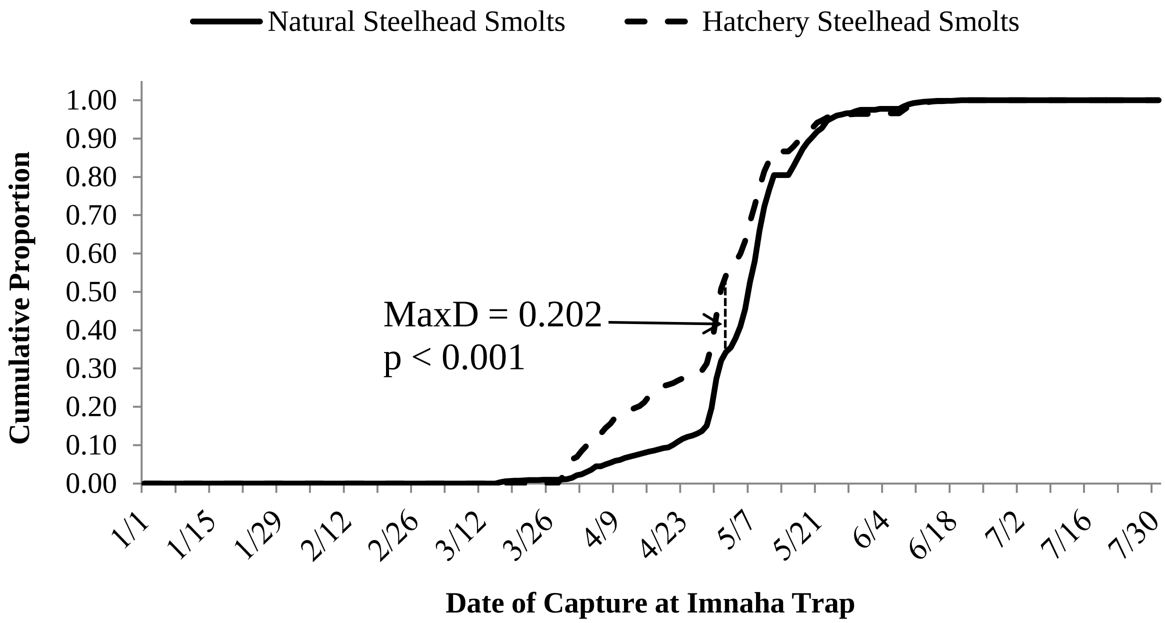

Figure 4.2. Comparison of emigration timing of natural and hatchery steelhead smolts from the Imnaha River presented as the cumulative capture proportion of each origin type at the Imnaha River Trap during the spring 2013 trapping season, January 1 to July 17. Maximum difference in emigration timing (MaxD, represented as the dashed vertical line) between the origin types occurred on May 3, 2013.

Peak emigration timing in relation to Imnaha River discharge

Imnaha River discharge was averaged by week throughout the fall and spring emigration MY2013 seasons in cfs. Fall Chinook salmon presmolt emigration from the Imnaha River was highest from October 20 to December 1 with the peak week occurring between November 3 and November 10. Weekly average Imnaha River discharge during peak fall presmolt migration fell between 100 – 200 cfs from September 1 to November 17. Thereafter, late fall rains produced a large spike in flows and the river reached a weekly mean of 1,106 cfs during the first week of December (Figure 4.3). The bulk of the fall presmolt catch (93%) occurred prior to this unseasonable flow pulse. However, the trap was not operated from December 1 to December 8 due to high flows and debris. Therefore, the potential catch during much of the flow pulse was missed.

During spring of 2013, the hydrograph displayed a bimodal pattern with a flow pulse in early April and a longer and higher pulse in mid-May. Much of the natural Chinook salmon smolt emigration occurred in response to these flow pulses. The week of highest natural Chinook catch occurred as the first flow pulse was ascending from March 31 to April 6. Average Imnaha River discharge during this week was 1,140 cfs. Another smaller but still numerous group of natural Chinook smolts was captured as the second flow pulse ascended from April 28 to May 4 when the weekly average discharge was 849 cfs (Figure 4.4). Natural steelhead catch remained fairly low throughout early spring and the first flow pulse but rose dramatically with the ascending limb of the second pulse (Figure 4.4). Steelhead catch was highest from May 5 to May 11 when 3,319 smolts were caught and the average discharge was 1,153 cfs. Eighty percent of the spring steelhead catch occurred between April 28 and May 25. During the apex of the pulse the trap was not operated from May 12 to May 15 due to unsafe flows and high debris loads. It is possible that a significant portion of the natural steelhead catch was missed during these four days. However, natural Chinook catch had declined significantly prior to the missed days of operation and therefore it is likely a much smaller proportion of natural Chinook was missed.

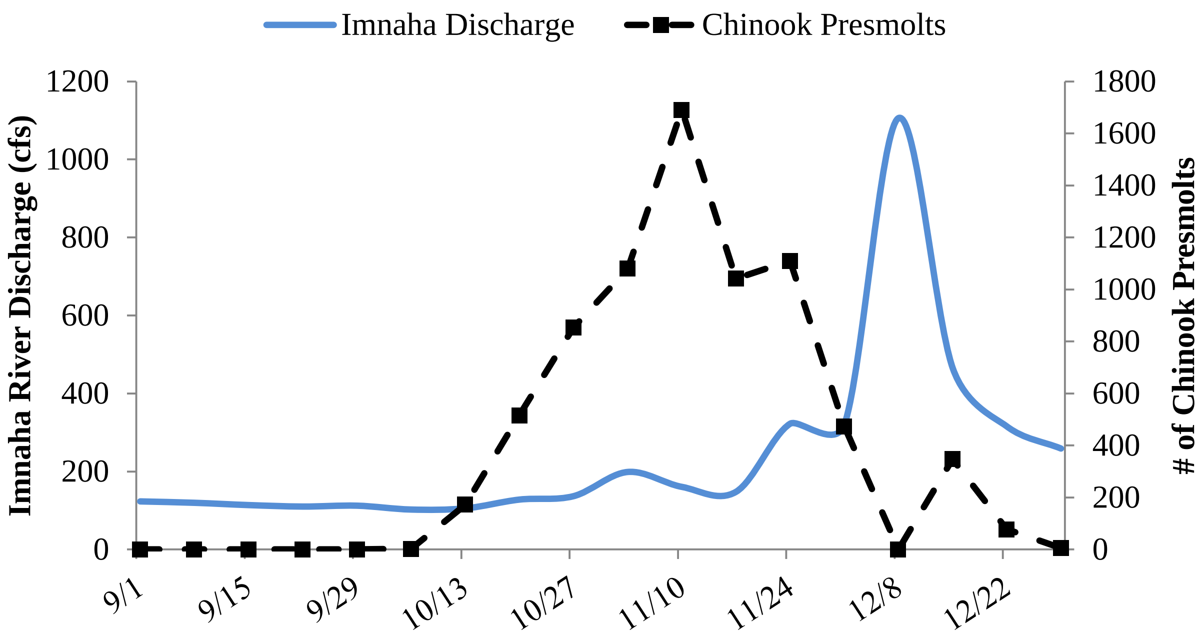

Figure 4.3. Weekly mean Imnaha River discharge and the total weekly emigration of Chinook salmon presmolts during the fall of 2012.

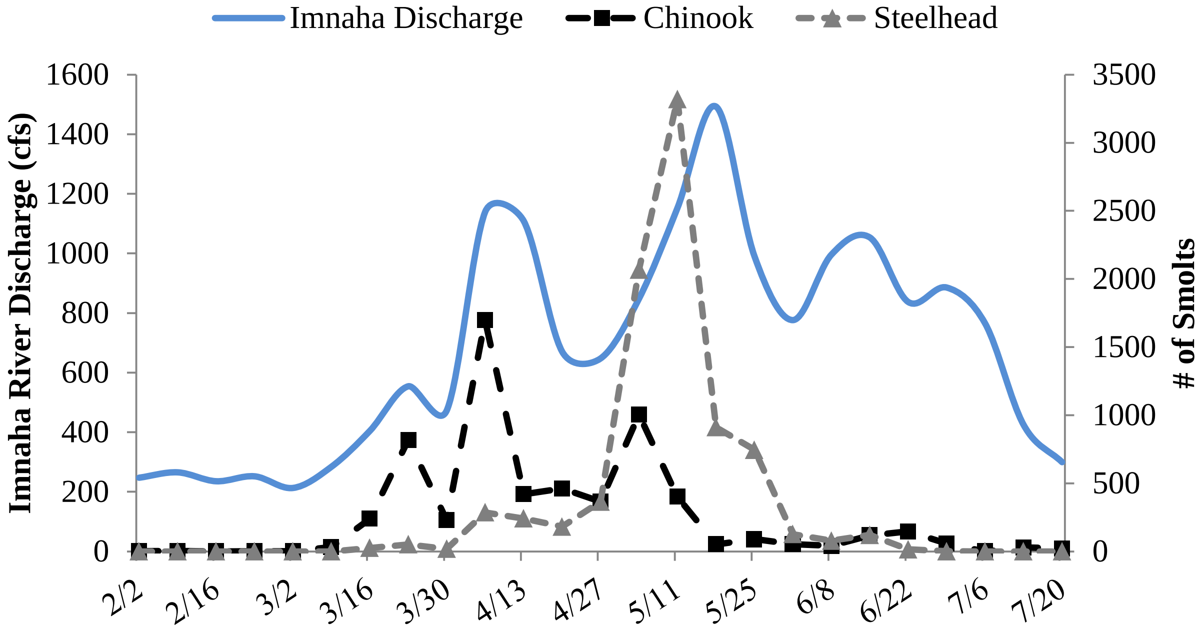

Figure 4.4. Weekly mean Imnaha River discharge and the total weekly emigration of Chinook salmon and steelhead smolts from February through the end of July 2013. Note: the trap was not operated from May 12 to May 15 due to high flows and debris loads and potential catch was missed during those days.

Arrival Timing of Imnaha River Juvenile Emigrants at Lower Granite Dam

Arrival timing at LGR was calculated for natural and hatchery juvenile emigrants. Analyses of median, 10th and 90th percentile, and first and last arrival dates to LGR were used to evaluate differences between natural and hatchery Chinook salmon and steelhead arrival timing as well as between natural Chinook salmon presmolts and smolts. In addition, differences in cumulative arrival timing were tested for significance using a K-S test. We also calculated the proportion of Imnaha River emigrants from each release group that had passed LGR prior to the date of initiation of collections for transportation through the hydrosystem. Collections for transportation (barging/trucking) at juvenile collection facilities at LGR began on April 28, 2013, at Little Goose Dam (LGS) on May 2, and on May 7 at Lower Monumental Dam (LMN). Collections for transportation at McNary dam were discontinued beginning spring 2013. It was assumed that fish arriving at LGR prior to April 28 were not transported, while those arriving on that date or later would be transported if collected at any of the transport dams (FPC 2014). Analyses of collection efficiencies and proportions destined for transport referenced in this report were performed by the Fish passage Center, and are available in their annual reports.

Chinook salmon arrival timing at LGR

As in 2011 and 2012, PIT tag interrogations indicated that fall-tagged natural Chinook salmon presmolts arrived at LGR earlier than spring-tagged Chinook salmon smolts (Table 4.4; Figure

4.5). The cumulative arrival timing curves were significantly different and maximum difference in the proportion of LGR arrivals between fall-tagged presmolts and spring-tagged smolts occurred on May 1, 2013 (MaxD = 0.583, p = 0.001; Figure 4.5). The earlier start to transportation collections subjected more Chinook salmon to transportation than in 2011 and 2012. When collections for smolt transportation began on 28 April, 77.6% of fall-tagged presmolts had passed LGR, compared to 22.9% of spring-tagged smolts. Given collection efficiencies averaged an estimated 32% for natural Chinook salmon; only 7.2% of presmolts emigrating from the Imnaha River in the fall were likely to be transported at LGR, compared to 24.7% of spring emigrating smolts (Table 4.5).

Table 4.4. Arrival timing for natural Chinook salmon presmolts (fall-tagged), natural Chinook salmon smolts (spring-tagged), hatchery Chinook salmon smolts, and natural and hatchery steelhead smolts determined by Passive Integrated Transponder (PIT) tag detections at Lower Granite Dam during migration year 2013.

Origin and Species	First Arrival	10th Percentile	Median	90th Percentile	Last Arrival
Natural Chinook Smolts	25-Mar	12-Apr	9-May	14-May	14-Jul
Natural Chinook Presmolts	24-Mar	2-Apr	13-Apr	3-May	14-May
Hatchery Chinook Smolts	8-Apr	29-Apr	7-May	11-May	14-May
Natural Steelhead Smolts	15-Mar	23-Apr	9-May	18-May	15-Jun
Hatchery Steelhead Smolts	4-Apr	28-Apr	10-May	21-May	25-Jun

Table 4.5. Cumulative proportion of Imnaha River juvenile emigrants that passed Lower Granite Dam (LGR) by the date of initiation of full collections for transportation at LGR (April 28), the estimated proportion of emigrants destined for transportation at LGR, and the collection efficiency of each origin and species at Lower Granite Dam (LGR). Proportions are based on the percentage of the total detections of Passive Integrated Transponder (PIT) tagged juveniles at LGR and the collection efficiencies at the LGR juvenile bypass facility during the 2013 migration year (FPC 2014).

Origin and Species	Proportion Passed LGR before May 1 (%)	Proportion Destined for Transportation at LGR (%)	Collection Efficiency at LGR (%)
Hatchery Chinook Smolts	5.0	24.7	26
Natural Chinook Presmolts	77.6	5.6	25
Natural Chinook Smolts	22.9	24.7	32
Hatchery Steelhead Smolts	9.8	16.2	18
Natural Steelhead Smolts	12.0	21.1	24

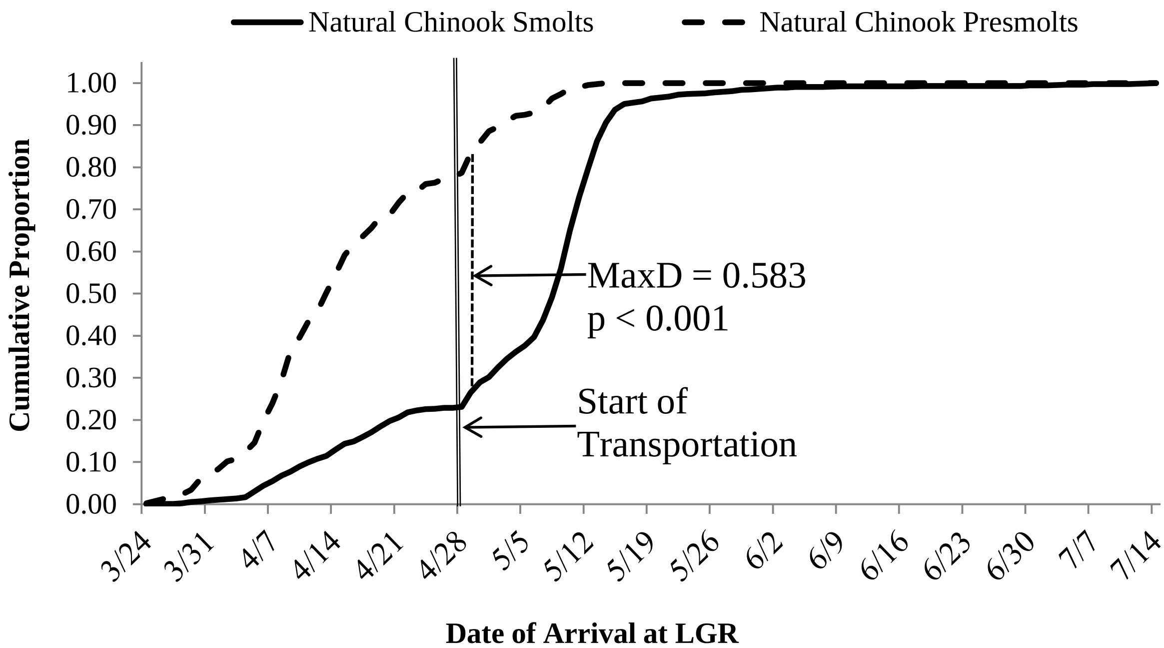

Figure 4.5. Arrival timing of natural-origin fall-tagged Chinook presmolts and spring-tagged smolts at Lower Granite Dam (LGR) during the 2013 migration year. Maximum difference (MaxD) in arrival timing between the two groups occurred on May 1, 2013 and is represented by the dashed vertical line. The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, April 28, 2013.

The differences between hatchery and natural Chinook salmon in arrival timing and cumulative distribution curves were less apparent at LGR than to the Imnaha River Trap. Cumulative hatchery smolt arrival surpassed natural smolt arrival timing on May 4 when 36% of natural smolts and 37% of hatchery smolts had passed LGR. The right tail of the natural Chinook salmon emigration lagged slightly behind the latest hatchery individuals. The 90th percentile for natural Chinook salmon occurred only three days after hatchery Chinook salmon but the last natural smolt arrived nearly two months after the last hatchery smolt (Table 4.4). Given the smaller size ($n = 411 < 90$ mm), it is possible some smolts emigrating from the Imnaha River from May onward were fall Chinook salmon, which have been observed spawning above the juvenile trap in recent years (Adult Technical Team 2010). The significant maximum difference in arrival timing at LGR between hatchery and natural smolts occurred on May 9, 2013 (K-S test, MaxD = 0.229, $p < 0.001$; Figure 4.6). Though the difference in cumulative arrival timing between natural and hatchery Chinook salmon smolts in 2013 was significant, the timing of cumulative arrival was only several days apart for much of the emigration and the biological significance of the difference may be slight.

Identical proportions of hatchery and spring-tagged natural Chinook salmon smolts were likely to be transported in 2013. More natural Chinook salmon smolts (22.9%) than hatchery smolts (5.0%) had passed LGR prior to the start of collections (Table 4.5). However, transport collection efficiencies were higher for natural smolts (32%) than hatchery smolts (26%). The combination of these factors led to the estimate that 24.7% of both natural and hatchery Chinook salmon smolts were likely to be transported in spring 2013.

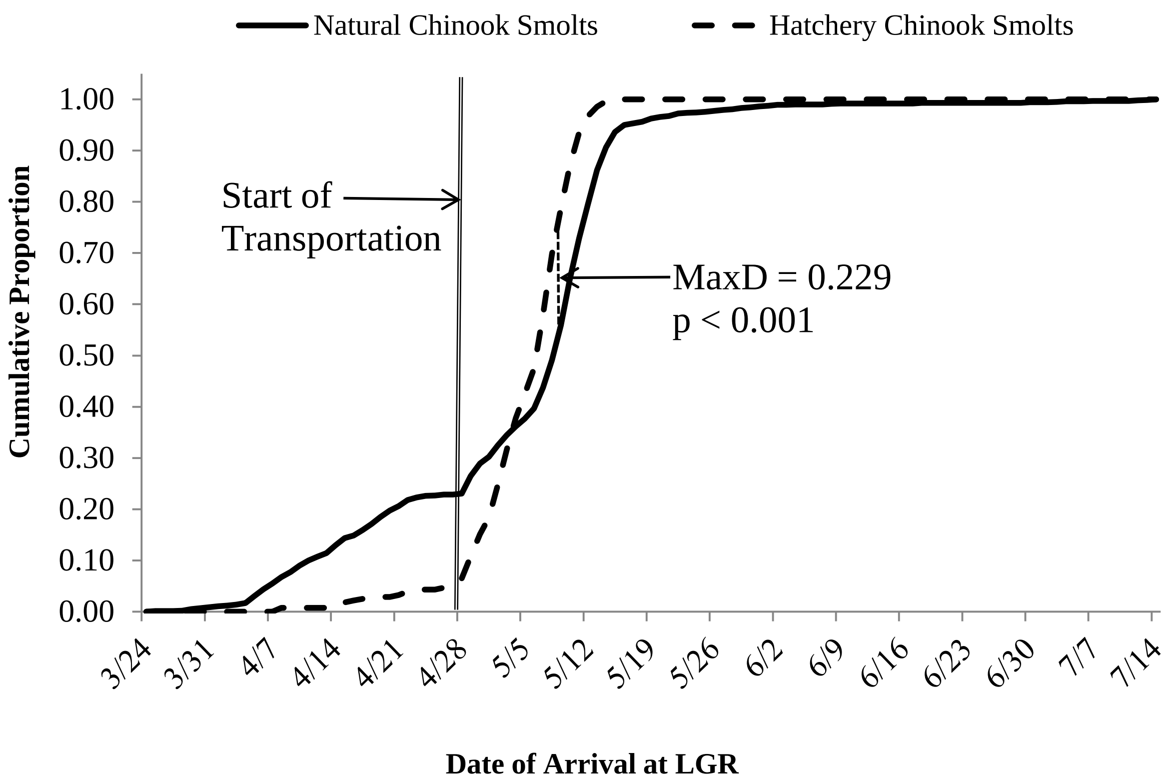

Figure 4.6. Arrival timing of natural-origin fall-tagged Chinook salmon presmolts and spring-tagged smolts at Lower Granite Dam (LGR) during the 2013 migration year. Maximum difference (MaxD) in arrival timing between the two groups occurred on May 1, 2013 and is represented by the dashed vertical line. The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, April 28, 2013.

Steelhead arrival timing at LGR

Comparable to their arrival at the trap, hatchery steelhead emigration timing to LGR lagged behind natural steelhead from several days to two weeks throughout most of their emigration period. The first natural and hatchery steelhead were seen at LGR March 15 and April 4 respectively. Ten percent of natural steelhead smolts passed LGR by April 23, 50% by May 9, and 90% by May 18. The last MY2013 spring/summer emigrating natural smolt was observed at

LGR June 15, 2013. Ten percent of hatchery smolts passed LGR by April 26, 50% by May 10, 90% by May 21, and the last spring/summer emigrating hatchery smolt was observed June 25 (Table 4.4). A K-S test revealed a significant difference in hatchery and natural steelhead emigration timing to LGR, which occurred on May 10, 2013 (MaxD = 0.148, $p < 0.001$; Figure 4.7). Though hatchery steelhead arrival at LGR lagged behind natural steelhead, the difference was minor and it is likely the biological implications were limited.

More natural than hatchery Imnaha River steelhead were likely to be transported around the hydrosystem in 2013. By the start of transportation collection efforts on April 28, 2013, 12.0% of natural steelhead and 9.8% of hatchery steelhead had passed LGR. Given the poor estimated collection efficiencies of 18% for hatchery steelhead and 24% for natural steelhead in 2013; the estimated proportion destined for transportation around the hydrosystem at LGR was 16.2% for hatchery steelhead and 21.1% for natural steelhead (Table 4.5).

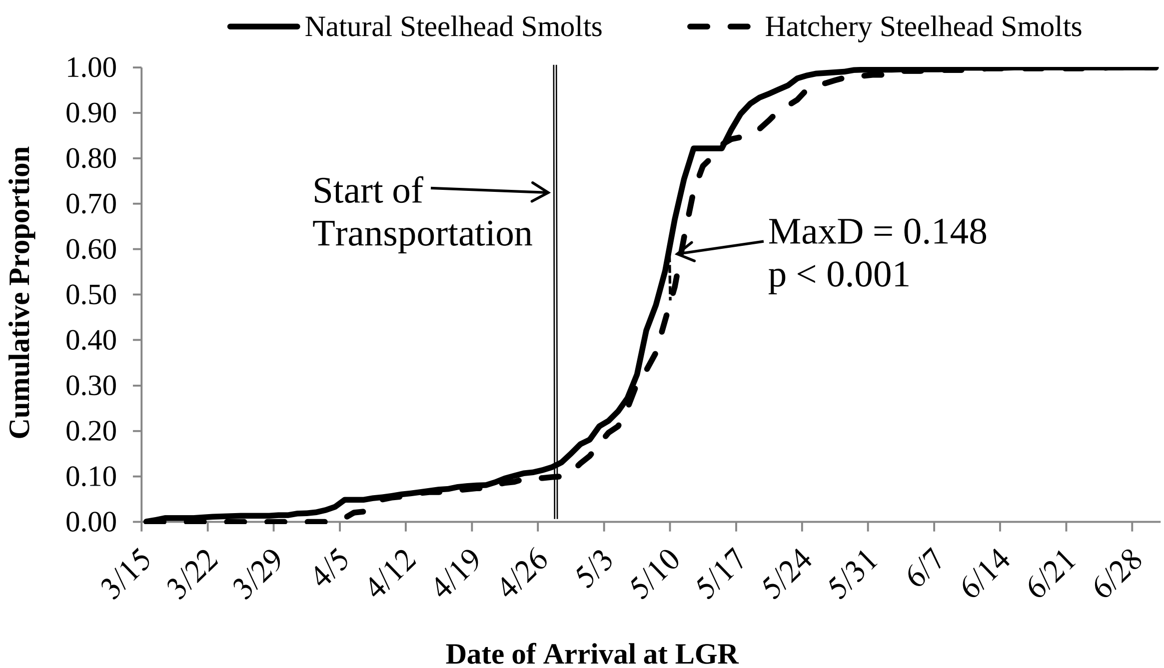

Figure 4.7. Arrival timing at Lower Granite Dam (LGR) of natural-origin steelhead and hatchery-origin steelhead smolts emigrating during the spring and summer of 2013. Maximum difference in arrival timing between the origin types occurred on May 10 (MaxD, represented by the dashed vertical line). The double vertical line indicates the initiation date of full collections for juvenile transportation at LGR, April 28, 2013.

Travel Time from Imnaha River Trap to Lower Granite Dam in Relation to Snake River Flow

Chinook salmon juvenile emigrant travel time

Juvenile Chinook salmon travel times from the Imnaha River Trap to LGR were calculated in 2013. Individual travel times varied from 4 - 44 days for hatchery smolts and 3 – 58 days for spring-tagged natural smolts (Table 4.6). During the limited six week period when hatchery smolts were observed at LGR, their mean travel times were shorter than natural smolts during the first three weeks and longer in the last three weeks when the bulk of the hatchery Chinook salmon smolts were observed (264 out of 278 total observations; Figure 4.8). Mean weekly travel times for hatchery smolts ranged from six days in mid-April to 35 days at the end of their LGR passage in mid-May. Mean travel times for natural smolts varied between six and 24 days throughout the season (Table 4.6; Figure 4.8). The negative relationship between natural Chinook salmon smolt travel time and Snake River discharge was significant ($p = 0.002$; $r^2 = 0.49$). No hatchery Chinook salmon were detected at LGR past mid-May (Figure 4.9), which provided a limited range of dates to investigate the relationship between discharge and travel time. Given this caveat, there was not a significant relationship between hatchery smolt travel time and Snake River discharge. Hatchery travel time seemed to be more a product of release date than environmental cues since travel time increased steadily throughout the short period they were detected at LGR (Figure 4.8).

Table 4.6. Weekly mean travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for hatchery Chinook salmon smolts, natural Chinook salmon spring-tagged smolts, and natural Chinook salmon fall-tagged presmolts during spring 2013. The table includes LGR detection week, the number of Chinook salmon detected (count), mean travel time in days, the range of travel times for all three release groups, and mean Snake River flow in cubic feet per second (cfs). *Single detections, no range available.

LGR Detection Week	Hatchery Smolt Count	Hatchery Smolt Mean Travel Time (Days)	Hatchery Smolt Range of Travel Times	Natural Smolt Count	Natural Smolt Mean Travel Time (Days)	Natural Smolt Range of Travel Times	Snake River Flow (cfs)
3/24/2013	--	--	--	7	13	(9 - 22)	24,984
3/31/2013	--	--	--	38	18	(8 - 23)	33,205
4/7/2013	2	6	(5 - 7)	72	19	(5 - 62)	37,706
4/14/2013	6	15	(12 - 18)	85	24	(9 - 44)	30,192
4/21/2013	6	21	(21 - 25)	32	24	(11 - 38)	28,460
4/28/2013	91	30	(14 - 33)	136	24	(5 - 50)	33,072
5/5/2013	155	35	(4 - 41)	376	16	(3 - 56)	45,278
5/12/2013	18	35	(12 - 44)	232	14	(3 - 58)	69,843
5/19/2013	--	--	--	20	14	(5 - 35)	49,557
5/26/2013	--	--	--	12	12	(5 - 30)	43,359
6/2/2013	--	--	--	4	11	(9 - 12)	42,393
6/9/2013	--	--	--	1	6*	--	40,101
6/16/2013	--	--	--	1	19*	--	32,059
6/23/2013	--	--	--	--	--	--	31,628
6/30/2013	--	--	--	3	20	(15 - 25)	29,184
7/7/2013	--	--	--	3	19	(15 - 22)	22,911
7/14/2013	--	--	--	1	21*	--	19,379

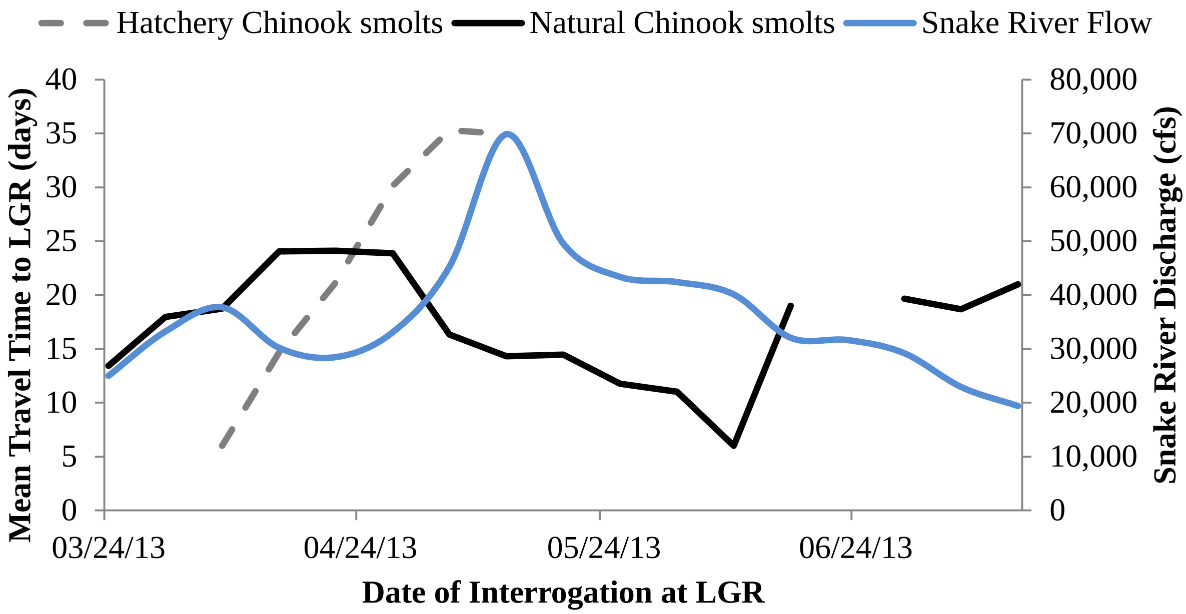

Figure 4.8. Mean weekly travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for migration year 2013 hatchery and natural Chinook salmon smolts tagged during the spring trapping period, and Snake River flow in cubic feet per second (cfs).

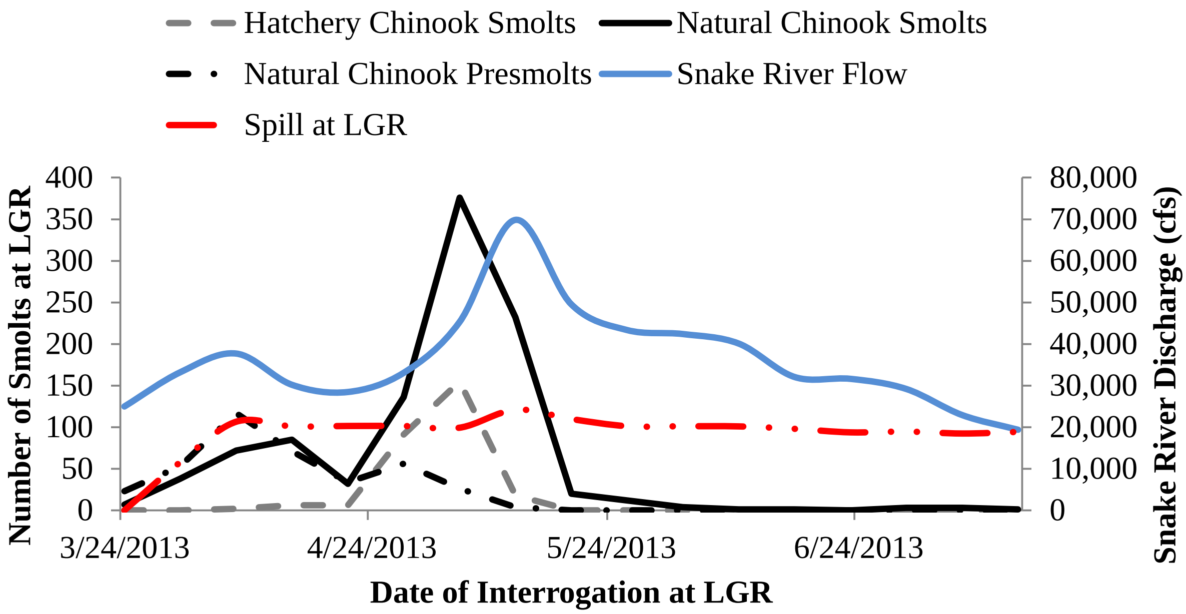

Figure 4.9. Peak passage timing at Lower Granite Dam (LGR) presented as the number of Passive Integrated Transponder (PIT) tagged Chinook salmon detections at LGR during the spring and summer of 2013 and Snake River flow and spill at LGR presented in cubic feet per second (cfs). Figure includes the date of passage of PIT-tagged fish at LGR by release group for hatchery Chinook salmon smolts, natural Chinook salmon smolts, and natural Chinook salmon presmolts.

Steelhead juvenile emigrant travel time

Overall, juvenile steelhead travel times from the Imnaha River Trap to LGR were shorter on average than Chinook salmon. Individuals of both natural and hatchery steelhead traveled from the Imnaha River Trap to LGR in as little as one day. Travel times for hatchery steelhead ranged from one to 56 days and from one to 67 days for natural steelhead (Table 4.7). Travel times were slightly higher for hatchery steelhead than natural steelhead through much of their emigration period. Mean weekly travel times ranged from four to 13 days for hatchery steelhead and four to 16 days for natural steelhead. For natural steelhead, mean travel times were higher in March and April but decreased to less than seven days as the Snake River hydrograph peaked in mid-May. Travel times then vacillated widely as the hydrograph receded. Hatchery steelhead followed a similar pattern but with travel times that were consistently one to three days longer than natural steelhead until after mid-May (Figure 4.10). LGR passage for both origin types was largely limited to 4 – 5 weeks between the end of April and the beginning of June 2013 (Figure 4.11). This narrow range of dates limited the temporal range for regression analysis of potential correlation between travel time and Snake River discharge. Given this limitation, neither hatchery nor natural steelhead showed a statistically significant relationship between travel time and Snake River discharge (both P values > 0.21).

Table 4.7. Weekly mean travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for hatchery and natural steelhead smolts in 2013. The table includes LGR detection week, the number of steelhead detected (count), mean travel time in days, the range of travel times for all three release groups, and mean Snake River flow in cubic feet per second (cfs). *Single detections, no range available.

LGR Detection Week	Hatchery Smolt Count	Hatchery Smolt Mean Travel Time (Days)	Hatchery Smolt Range of Travel Times	Natural Smolt Count	Natural Smolt Mean Travel Time (Days)	Natural Smolt Range of Travel Times	Snake River Flow (cfs)
3/17/2013	--	--	--	1	5*	--	26,347
3/24/2013	--	--	--	1	14*	--	24,984
3/31/2013	10	5	(3 - 8)	1	11*	--	33,205
4/7/2013	21	7	(3 - 13)	30	5	(4 - 8)	37,706
4/14/2013	5	10	(4 - 16)	14	8	(4 - 24)	30,192
4/21/2013	12	10	(4 - 24)	14	7	(4 - 15)	28,460
4/28/2013	55	13	(3 - 34)	89	10	(3 - 48)	33,072
5/5/2013	203	8	(1 - 42)	608	6	(1 - 54)	45,278
5/12/2013	111	6	(1 - 47)	648	5	(1 - 58)	69,843
5/19/2013	53	4	(2 -14)	194	4	(2 - 42)	49,557
5/26/2013	11	10	(3 - 56)	85	8	(3 - 53)	43,359
6/2/2013	5	8	(3 - 16)	27	16	(4 - 67)	42,393
6/9/2013	3	4	(3 -4)	3	4	(3 - 6)	40,101
6/16/2013	--	--	--	4	9	(6 - 11)	32,059
6/23/2013	1	5*	--	--	--	--	31,628

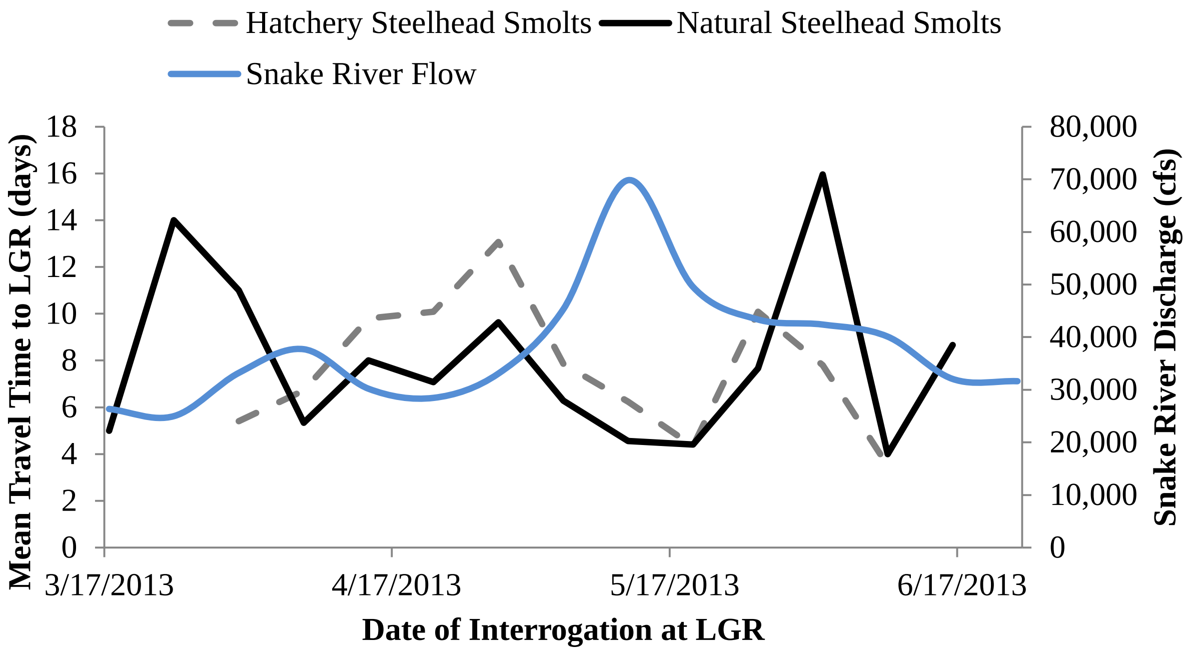

Figure 4.10. Mean weekly travel time from the Imnaha River Trap to Lower Granite Dam (LGR) for migration year 2013 hatchery and natural-origin steelhead smolts and Snake River flow in cubic feet per second (cfs).

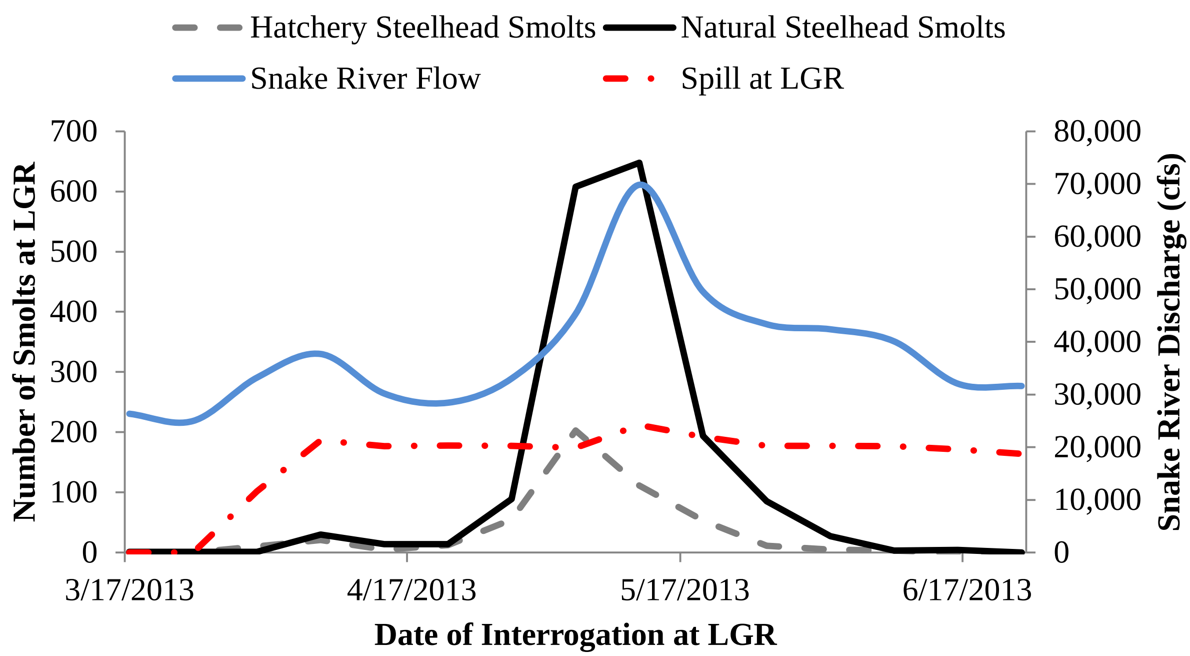

Figure 4.11. Passage timing at Lower Granite Dam (LGR) presented as the number of Passive Integrated Transponder (PIT) tagged steelhead detections at LGR during the spring and summer of 2013 and Snake River flow and spill at LGR presented in cubic feet per second (cfs). Figure includes the date of passage of PIT-tagged fish at LGR by origin type for hatchery and natural steelhead smolts.

Life-Stage and Reach Specific Estimates of Juvenile Emigrant Survival

Post-release Survival of Hatchery Smolts

Survival of hatchery Chinook salmon smolts to the Imnaha River Trap was slightly higher than average in 2013. Estimated post-release survival of acclimated hatchery Chinook salmon from the Gumboot acclimation facility to the Imnaha River Trap was 93% (± 4.4%) resulting in an estimated 364,388 (95% CI 348,531 to 380,245) hatchery Chinook salmon outmigrating past the Imnaha River Trap during spring 2013 (Table 4.8).

Table 4.8. Estimated post-release survival of hatchery Chinook salmon and steelhead smolts to the Imnaha River Trap, average post-release survival from 1994 to 2013, and the number of hatchery smolts estimated to have emigrated from the Imnaha River in migration year 2013.

Hatchery Stocks	Post-Release Survival to Imnaha Trap (%)	Average survival 1994 - 2013	Estimated Outmigrating Imnaha Hatchery Smolts in 2013
Chinook salmon	93 (± 4.4)	91 (± 5.0)	364,388 (348,531, 380,245)
Steelhead	82 (± 2.2)	82 (± 8.6)	193,821 (189,523, 198,120)

Estimated survival of hatchery steelhead to the Imnaha River Trap was exactly average when compared to the project's period of record in 2013 (82% ± 2.2%). This resulted in an estimated 193,821 (95% CI 189,523 to 198,120) hatchery steelhead passing the trap in 2013 (Table 4.8).

Survival from Imnaha River Trap to Lower Granite Dam

Natural Chinook salmon survival from the trap to LGR was estimated for fall-tagged presmolts and spring-tagged smolts independently and collectively during MY2013 (BY2011). Estimated survival of fall-tagged presmolts was 28% (± 2.5%) compared to 72% (± 3.5%; Table 4.9) for spring-tagged smolts. As in 2011 and 2012, comparison of the two release groups using SURPH information revealed that there was a significantly higher proportion of spring-tagged smolts detected after release than fall-tagged presmolts (x^2 = 1459.7, df = 1, p < 0.001). The combined MY2013 natural Chinook salmon cohort survival estimate from the trap to LGR was 46% (± 2.06%). Survival of hatchery Chinook salmon smolts from the trap to LGR was slightly lower than natural spring-tagged smolts and estimated to be 69% (± 10.0%; Table 4.9). Concurrent with their survival, SURPH analysis showed a significantly higher proportion of natural Chinook salmon smolts were detected after release than hatchery smolts (x^2 = 41.54, df = 1, p < 0.001).

Survival to LGR was very high for hatchery steelhead and near average for natural steelhead in 2013. Natural steelhead smolt survival from the Imnaha River Trap to LGR for MY2013 was estimated at 86% (± 3.9%). Estimated hatchery steelhead survival was 100% though the confidence intervals for the estimate were wide (± 14.8; Table 4.9). As in 2011, a significantly higher proportion of hatchery steelhead than natural steelhead were detected after release (x^2 = 10.85, df = 1, p <0.001). While both origin types of steelhead were first detected in higher proportions at dams downstream of LGR, the proportion of hatchery steelhead first detected past LGR was significantly higher than that of natural steelhead (x^2 = 75.59, df = 1, p < 0.001).

Detection efficiencies at LGR were very low again in 2013. Capture probabilities for natural Chinook salmon smolts (31%) and steelhead (28%) were higher than for their hatchery conspecifics (21% and 16% respectively). The low detection efficiencies and relatively low numbers of tagged hatchery smolts recaptured and released at the Imnaha River Trap led to less precise survival estimates and wide confidence intervals for hatchery smolts compared to natural smolts.

Smolt equivalents at Lower Granite Dam (LGR)

The fall-tagged presmolt survival estimate of 28% produced an estimated 25,878 (± 5,229) smolts at LGR. The spring-tagged survival estimate of 72% produced an estimated 27,505 (± 3,767) smolts at LGR for a natural-origin cohort total of 53,383 (± 8,996) smolts at LGR. Hatchery Chinook salmon survival of 69% produced an estimated 268,281 (± 37,905) smolts at LGR. Natural steelhead survival of 86% produced an estimated 46,845 (± 5,751) smolts at LGR. The estimated 99.9% survival of hatchery steelhead produced an estimated 236,912 (± 34,489) smolts at LGR (Table 4.9).

Survival from Imnaha River to McNary Dam

Our analysis provides estimates of juvenile survival to the Imnaha River Trap, LGR, and MCN, but does not provide detailed results of juvenile survival through the entire hydrosystem. A more comprehensive analysis of in-river, transportation and migration route effects on juvenile survival and resulting adult returns can be found in the Fish Passage Center's Comparative Survival Study report (Comparative Survival Study 2013).

Overall survival of natural Chinook salmon juveniles to MCN was low in MY2013. Survival of fall-tagged natural Chinook salmon presmolts from the Imnaha River Trap to MCN dam was only an estimated 22% (± 2.8). Survival of this group to LGR was estimated at 28% suggesting, as in 2011 and 2012, the largest source of mortality for fall-tagged Chinook salmon is overwintering in the Snake River above LGR. However, mortality between LGR and MCN was still significant. Survival in the reach from LGR to MCN for fall-tagged presmolts was 75% (± 13.6%). Survival of spring tagged natural Chinook salmon smolts to MCN was estimated at 60% (± 7.3%) and reach survival from LGR to MCN was low in 2013 at 70% (± 11.9%). The combined MY2013 survival of spring-tagged smolts and fall-tagged presmolts to MCN was 38% (± 3.5%). Reach survival from LGR to MCN of the combined natural-origin Chinook salmon cohort was 71% (± 8.8%).

Hatchery Chinook salmon smolts also experienced high mortality from the trap to MCN in 2013. Estimated survival of hatchery Chinook salmon smolts from the trap to MCN was 56% (± 8.0%). Reach survival from LGR to MCN for hatchery Chinook was 81% but with a wide confidence interval of ± 27.7%. Hatchery steelhead survival to MCN was estimated at 62% (± 13.1%). Estimated hatchery steelhead reach survival from LGR to MCN was low at 50% the estimate also generated a wide confidence interval (± 22.4%). Natural-origin steelhead survival from the trap to MCN was estimated at 55% (± 9.9%) and reach survival from LGR to MCN was 67% (± 15.5%; Table 4.9).

Table 4.9. Estimated percent survival of natural and hatchery Chinook salmon and steelhead smolts from the Imnaha River Trap to Lower Granite Dam (LGR) and McNary Dam (MCN) and the resulting smolt equivalents at LGR during migration year 2013. Confidence intervals (95%) are presented in parentheses.

Origin and Species	Survival to LGR (%)	Survival to MCN (%)	Survival from LGR to MCN (%)	Smolt Equivalents at LGR
Natural Chinook Salmon Presmolts	28 (2.5)	22 (2.8)	75 (13.6)	25,878 (5,229)
Natural Chinook Salmon Smolts	72 (3.5)	60 (7.3)	70 (11.9)	27,505 (3,767)
Natural Chinook Salmon Cohort	46 (2.1)	38 (3.5)	71 (8.8)	60,952 (8,335)
Hatchery Chinook Salmon Smolts	69 (10.0)	57 (8.0)	81 (27.7)	268,281 (37,905)
Natural Steelhead	86 (3.9)	55 (9.9)	67 (15.5)	46,845 (5,751)
Hatchery Steelhead	99.9 (14.8)	62 (13.1)	50 (22.4)	236,912 (34,489)

Size and Condition of Juveniles at Emigration

The morphometic measures of fork length and weight were used to calculate condition factor at emigration and were evaluated for natural and hatchery-origin juveniles for MY2013. Comparisons were made between spring-emigrating smolt groups to illustrate the differences between hatchery reared smolts and naturally produced smolts in terms of size and condition at emigration. Fall-tagged natural Chinook salmon presmolts averaged 77 mm in length, 5.2 g in weight, and had an average condition factor of 1.09 (Table 4.10; Appendix H). Spring tagged natural Chinook salmon smolts had an average fork length of 99 mm, an average weight of 10.6 g, and a mean condition factor of 1.07. Hatchery Chinook salmon recaptured at the trap averaged 128 mm in length, 22.7 g in weight, and had a condition factor of 1.08 (Table 4.10; Appendix H). Natural steelhead smolts showed a mean fork length of 169 mm, a mean weight of 51.4 g, and a mean condition factor of 1.03. Hatchery steelhead smolts had a mean fork length of 205 mm, a mean weight of 90.2 g, and a mean condition factor of 1.01 (Table 4.10; Appendix I). Hatchery Chinook salmon had a significantly higher mean fork length, weight, and condition factor than natural Chinook salmon (t-test, all p values < 0.004) though differences in condition factor were marginal if still statistically significant (Figure 4.12; Table 4.10). Hatchery steelhead had significantly higher mean length and weight (t-test, $p < 0.001$) than natural steelhead. Conversely, hatchery steelhead had a significantly lower mean condition factor than natural steelhead ($p < 0.001$) though the difference was slight and may not be biologically significant.

Table 4.10. Sample size, mean, range, and standard deviation of fork length (mm), weight (g), and condition factor (K) for natural and hatchery Chinook salmon and steelhead captured during the 2013 migration year, September 23, 2012 to July 17, 2013, at the Imnaha River Juvenile Emigrant Trap.

		Fall 2012	Spring 2013			
Attribute	Statistic	Natural Chinook Presmolts	Natural Chinook Smolts	Hatchery Chinook Smolts	Natural Steelhead Smolts	Hatchery Steelhead Smolts
Fork Length (mm)	Sample Size (n)	7029	4721	1048	7013	2163
	Mean	77	99	128	169	205
	Minimum	47	28	87	93	122
	Maximum	130	162	214	277	267
	Standard Deviation	9	11	9	21	19
Weight (g)	Sample Size (n)	7029	4714	1030	6993	1859
	Mean	5.2	10.6	22.7	51.4	90.2
	Minimum	1.2	1.0	6.5	9.5	23.8
	Maximum	24.0	37.4	97.9	217.1	206.8
	Standard Deviation	1.9	3.5	5.7	20.1	23.9
Condition Factor (K)	Sample Size (n)	7029	4714	1027	6993	1859
	Mean	1.09	1.07	1.08	1.03	1.01
	Minimum	0.57	0.28	0.50	0.68	0.75
	Maximum	1.80	1.99	1.70	1.68	1.59
	Standard Deviation	0.11	0.14	0.10	0.11	0.09

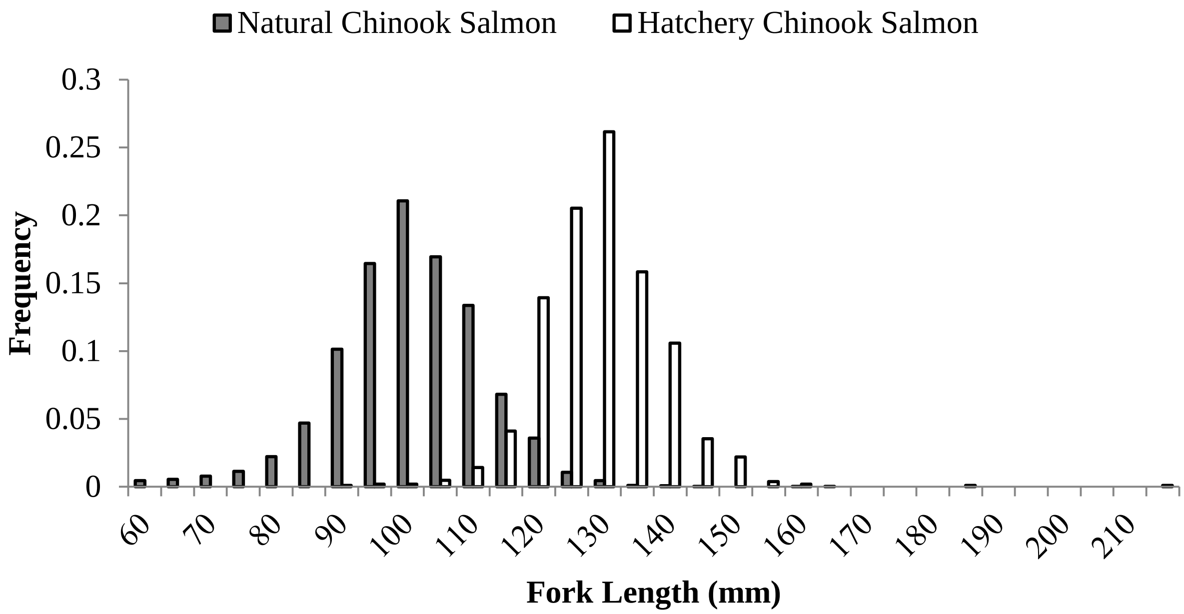

Figure 4.12. Fork length frequency distribution of natural and hatchery Chinook salmon smolts captured in the Imnaha River juvenile emigrant trap from January 1 to July 17, 2013.

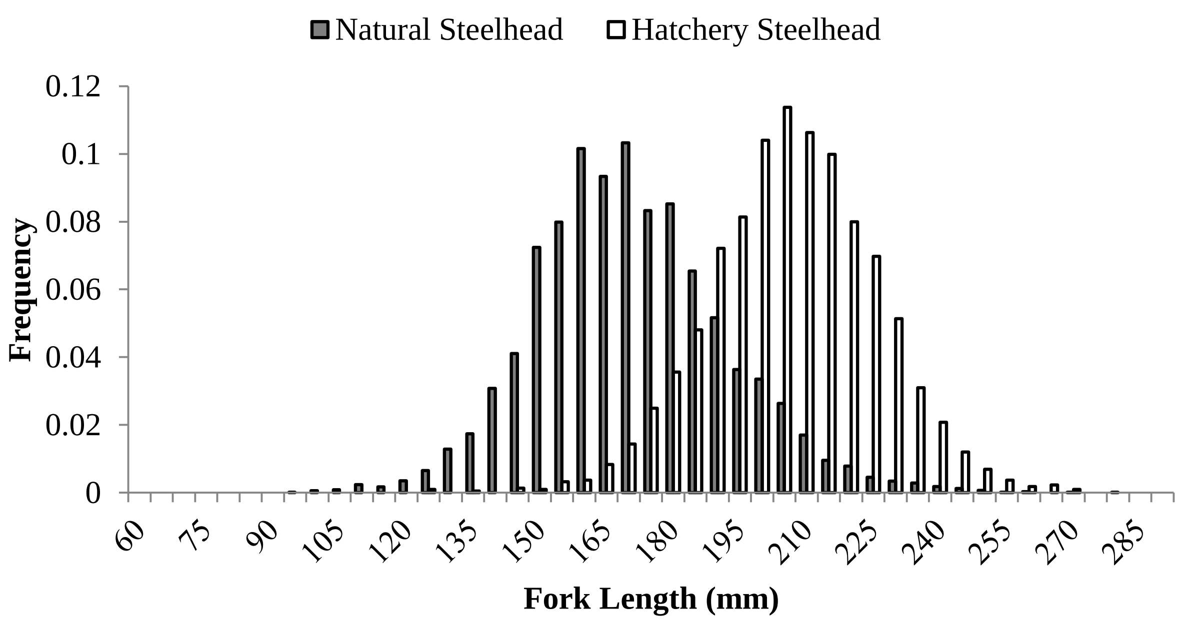

Figure 4.13. Fork length frequency distribution of natural and hatchery steelhead smolts captured in the Imnaha River juvenile emigrant trap from January 1 to July 17, 2013.

Chapter 5: Performance Measures Over Multiple Years

Chapter Introduction

This chapter combines the results of the MY2011 through MY2013 trapping seasons and discusses possible trends over time in the performance measures of Chinook salmon and steelhead emigrating from the Imnaha River. Production, survival, and biological characteristics were analyzed and reported over the available years of data from previous IRSMP reports. Emigration timing from the Imnaha River and arrival timing at LGR were analyzed and reported for MY2011 through MY2013.

<u>Imnaha River Natural Salmon and Steelhead Production Over Time</u>

The Imnaha River juvenile screw trap has been operating since MY1992. However, trap efficiency tests have only been conducted since MY2007. This operational limitation restricted the estimates of Chinook salmon and steelhead outmigrants from the Imnaha River in the following paragraphs to MY2007 through MY2013.

Natural Chinook Salmon Production

The estimated number of Chinook salmon emigrating from the Imnaha River has vacillated widely in the seven available years of population estimates. Estimated natural production has ranged from a low of 73,384 combined presmolts and smolts in MY2008 to a high of 200,213 in MY2012 (Figure 5.1; Table 5.1). The mean production of natural Chinook from 2007 – 2013 was 130,314 individuals with a CV of 35.2%. The migration years 2011, 2012, and 2013 represent the fifth, first, and third highest of seven years of production respectively. The proportion of Chinook salmon emigrating from the Imnaha River as presmolts was greater than 50% in five of the seven years of population estimation. The proportion of presmolts tends to be positively correlated with the production estimate and years with high production usually are dominated by presmolts. MY2011 seems to be the only exception to this pattern as production was below average in MY2011 but nearly 70% of Chinook emigrated as presmolts (Figure 5.2). The high proportion of presmolts during these years is possibly a result of the densities of juveniles exceeding the production capacity of available upriver rearing habitat. With a high density of juveniles, a higher proportion may choose to leave the Imnaha River in search of more profitable and less crowded rearing habitat in the Snake River. However, a recent study of density dependence in Clearwater and Salmon River tributaries showed no relationship between the number of adult spawners and the proportion of migrants that emigrate as presmolts vs. smolts (Walters et al. 2013). However, the screw traps in the Walters et al. study were largely located within or just below spawning habitat while the Imnaha River trap is well below spawning and rearing habitat for spring/summer Chinook salmon. It is possible that fish in those tributaries overwinter below the screw traps in downstream rearing habitat but do not necessarily migrate to mainstem sites as presmolts. Therefore, it is difficult to ascertain whether Imnaha River Chinook salmon would show a similar lack of relationship between seasonal migration and density dependence. Unfortunately, while the Snake River may offer productive rearing habitat for presmolts, overwintering survival is low and consequently the survival to LGR of Chinook salmon emigrating as fall presmolts is also low. However, we do not have an overwinter estimate of survival for spring emigrating smolts and it is possible that overwinter survival of presmolts in the Snake River is actually higher than overwinter survival in the Imnaha River for spring emigrating smolts. For example, while we have not generated a survival estimate from tagging to the Imnaha River Trap for Chinook salmon juveniles marked by ODFW's Early Life History Program, we generally only capture ~25 of the 1,000 juveniles marked by this project as spring emigrating smolts. Employing a trap efficiency of 15% and assuming these fish are not emigrating as presmolts, a rough Imnaha River overwinter survival estimate of around 15 – 20% is reached. If Imnaha River overwinter survival is near this estimate, then the presmolt life history strategy may be reinforced by natural selection within the Imnaha River Chinook salmon population.

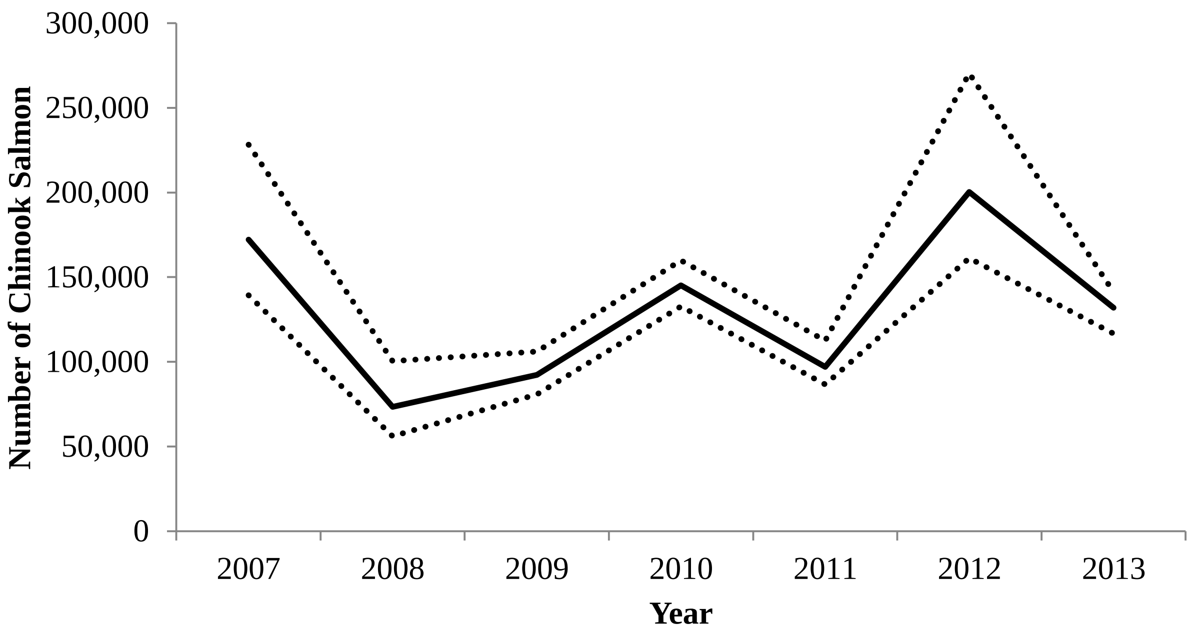

Figure 5.1. Estimated production of natural-origin Chinook salmon emigrating from the Imnaha River between the migration years 2007 and 2013. The solid line represents the annual estimate with the dashed lines as upper and lower 95% confidence intervals. The estimate is generated based on catch and trap efficiencies from the Imnaha River screw trap at Cow Creek and is a combination of individuals emigrating as presmolts in the fall or as smolts in the spring.

Table 5.1. The estimated number of natural-origin Chinook salmon and steelhead individuals emigrating from the Imnaha River from 2007 - 2013.

	Natural-origin Chinook Salmon			Natural-origin Steelhead		
Migration Year	Population Estimate	Lower 95% C.I.	Upper 95% C.I.	Population Estimate	Lower 95% C.I.	Upper 95% C.I.
2007	172,145	139,357	228,282	59,504	54,695	65,001
2008	73,384	56,000	100,325	50,311	39,688	64,576
2009	92,373	80,823	106,105	56,298	45,378	71,595
2010	145,179	132,673	159,930	57,051	47,627	71,530
2011	96,992	86,687	112,464	37,314	29,342	47,728
2012	200,213	161,147	270,268	43,881	38,319	50,366
2013	131,909	116,728	141,183	54,270	48,674	60,708
Mean	130,314	110,488	159,794	51,233	43,389	61,643
SD	45,917	37,297	65,702	8,018	8,311	9,472
CV	35.2	33.8	41.1	15.7	19.2	15.4

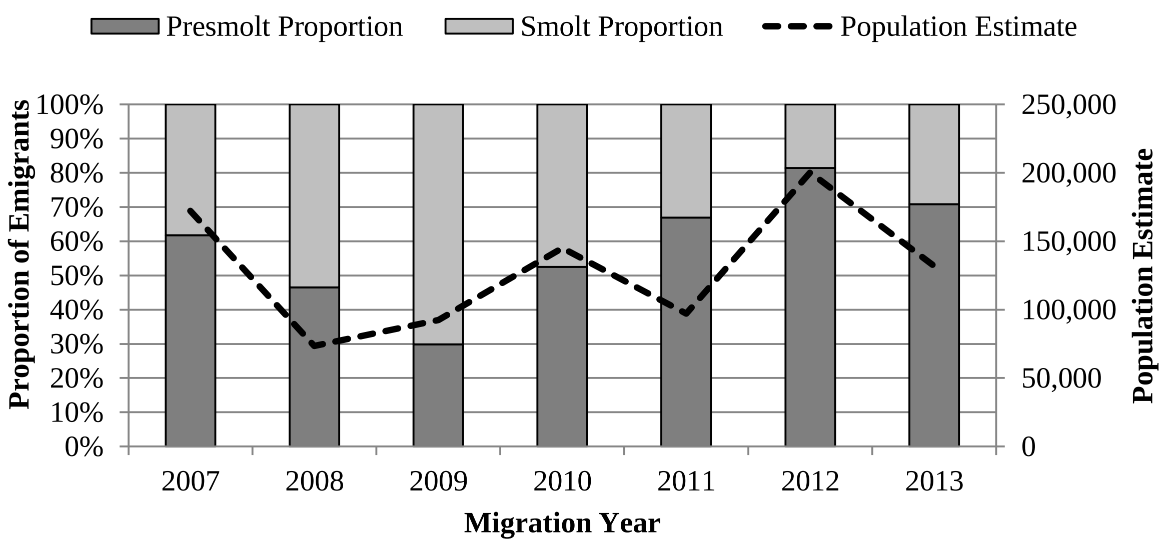

Figure 5.2. The proportions of natural-origin Chinook salmon emigrating from the Imnaha River as fall presmolts and spring smolts and the total estimate of outmigrating presmolt and smolt individuals combined.

Natural Steelhead Production

Imnaha River natural steelhead production has been less variable than natural Chinook production from MY2007 to MY2013. Estimated production during these years ranged from a low of 37,314 individuals to a high of 59,504 (Figure5.3; Table 5.2). The mean number of steelhead emigrants was 51,233 with a CV of 15.7%. The migration years 2011, 2012, and 2013 represent the lowest, second lowest, and median estimate of natural steelhead production respectively. As mentioned earlier, these estimates are of spring emigrating smolts only as the catch of fall emigrating steelhead is generally too low to generate trap efficiency estimates so fall emigrants are not PIT tagged. Steelhead and Chinook salmon total population estimates appear to be fairly independent during the period of population estimation (Figure 5.4). However, the estimate of spring emigrating smolts of both species follows a similar trend (Figure 5.5) and a Pearson correlation statistic value of 0.81 showed the production of natural-origin spring emigrating steelhead and Chinook salmon to be highly correlated. Though this relationship may be cautionary given the short period of analysis, it suggests that environmental pressures affect the overwinter survival and production of juvenile steelhead and Chinook salmon in the Imnaha River in a similar manner. Alternatively, seasonal trap bias or out of basin factors, such as ocean conditions that commonly impact adults of each species, effectively equalize productivity potential or the detection thereof for Chinook salmon and steelhead in the Imnaha River.

Figure 5.3. Estimated production of natural-origin steelhead emigrating from the Imnaha River during the spring/summer trapping season between 2007 and 2013. The solid line represents the annual estimate with the dashed lines as upper and lower 95% confidence intervals. The estimate is generated based on catch and trap efficiencies from the Imnaha River Trap.

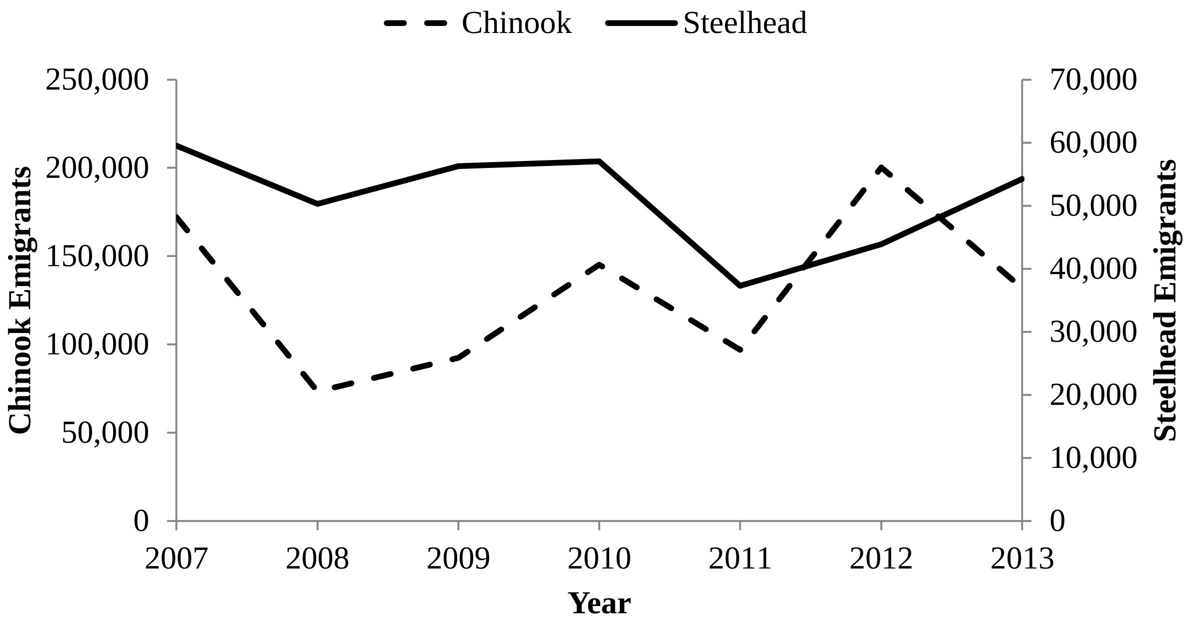

Figure 5.4. The estimated number of Chinook salmon and steelhead emigrating from the Imnaha River during the migration years 2007 to 2013. Chinook salmon are represented by the dashed line and steelhead by the solid line. Note the separate y axis for steelhead emigrants.

Figure 5.5. The estimated number of Chinook salmon and steelhead smolts emigrating from the Imnaha River during spring in migration years 2007 to 2013. Chinook salmon are represented by the dashed line and steelhead by the solid line.

Emigration Timing of Imnaha River Chinook Salmon and Steelhead MY2011 – MY2013

Comparisons within and between origins and species were made for arrival at the Imnaha River Trap of spring emigrating smolts (emigration from the Imnaha River) in MY2011 through MY2013. Please refer to the juvenile emigration timing sections within chapters two, three, and four for comparisons between origins within each year.

Chinook Salmon Emigration Timing

Similar overall patterns in emigration timing were observed between years. Natural Chinook arrived at the trap as early as January 4 when the trap was operating during an ice free period in MY2012. The tenth percentile for natural Chinook salmon emigration occurred between March 14 and March 18 in all years (Table 5.2). Median arrivals occurred on April 18 in 2011, March 30 in 2012, and April 9 in 2013. The 90th percentile of emigration timing occurred as early as May 6 in 2011 and as late as May 24 in 2012. The last arrivals were as late as July 29 in 2011, when trapping occurred throughout the summer. Later emigrants may have been missed in 2013 after the trap ceased operations on July 17. The bulk of natural smolts (80%) passed in a 53 day span in 2011 and 2013 and a 71 day span in 2012 (Table 5.3).

Hatchery Chinook salmon rapidly emigrated past the trap in the three migration years for this reporting period. Emigration was most rapid in MY2013 and least rapid in MY2011, though differences between years were fairly slight and largely determined by release date (Figure 5.7). First arrivals occurred within a day of the beginning of volitional releases in MY2011 and MY2013. The first arrival occurred six days before the release began in MY2012 as a result of a temporary malfunction at the acclimation facility which allowed some hatchery smolts to escape early. Tenth percentiles of emigration occurred as early as March 25 in 2012 and as late April 9 in 2011. Median arrivals occurred April 1 in 2013, April 4 in 2012, and April 13 in 2011 (Table 5.2). Ninety percent of hatchery smolts passed by April 2 in 2013, April 10 in 2012, and April 19 in 2011. Last arrivals were as early as May 14 in 2012 and as late as July 11 in 2013 (Table 5.2). Eighty percent of hatchery smolts passed during 10 days in 2011, 16 days in 2012, and a very quick two days in 2013 (Table 5.3). On average, the emigration period for natural Chinook salmon was protracted and distributed over time more evenly when compared to hatchery Chinook salmon (Figure 5.8; Table 5.3).

Table 5.2. First, 10th percentile, median, 90th percentile, and last arrival at the Imnaha River Trap for natural and hatchery Chinook salmon and steelhead during the spring trapping period in migration years 2011, 2012, and 2013.

Year	Species and Origin	First Arrival	10th Percentile	Median	90th Percentile	Last Arrival
2011	Natural Chinook Salmon	1/13	3/14	4/18	5/6	7/29
2012	Natural Chinook Salmon	1/4	3/14	3/30	5/24	7/16
2013	Natural Chinook Salmon	1/31	3/18	4/9	5/10	7/17
2011	Hatchery Chinook Salmon	3/30	4/9	4/13	4/19	6/19
2012	Hatchery Chinook Salmon	3/24	3/25	4/4	4/10	5/14
2013	Hatchery Chinook Salmon	3/31	3/31	4/1	4/2	7/11
2011	Natural Steelhead	1/20	4/25	5/6	5/11	7/29
2012	Natural Steelhead	2/19	4/20	5/11	5/22	7/17
2013	Natural Steelhead	3/15	4/21	5/7	5/20	6/25
2011	Hatchery Steelhead	3/30	4/7	5/6	5/11	7/1
2012	Hatchery Steelhead	3/28	4/13	5/16	6/13	7/13
2013	Hatchery Steelhead	3/28	4/4	5/1	5/18	7/10

Table 5.3. The number of days passed between statistical metrics of the cumulative distribution of emigration from the Imnaha River for natural and hatchery Chinook salmon and steelhead in migration years 2011, 2012, and 2013.

Year	Species and Origin	First arrival to 10th Percentile	10th Percentile to Median	Median to 90th Percentile	90th Percentile to Last arrival	First Arrival to Last Arrival	10th Percentile to 90th Percentile
2011	Natural Chinook Salmon	60	35	18	84	197	53
2012	Natural Chinook Salmon	69	16	55	53	193	71
2013	Natural Chinook Salmon	46	22	31	68	167	53
2011	Hatchery Chinook Salmon	10	4	6	61	81	10
2012	Hatchery Chinook Salmon	1	10	6	34	51	16
2013	Hatchery Chinook Salmon	0	1	1	100	102	2
2011	Natural Steelhead	95	11	5	79	190	16
2012	Natural Steelhead	60	21	11	56	148	32
2013	Natural Steelhead	37	16	13	36	102	29
2011	Hatchery Steelhead	8	29	5	51	93	34
2012	Hatchery Steelhead	16	33	28	30	107	61
2013	Hatchery Steelhead	7	27	17	53	104	44

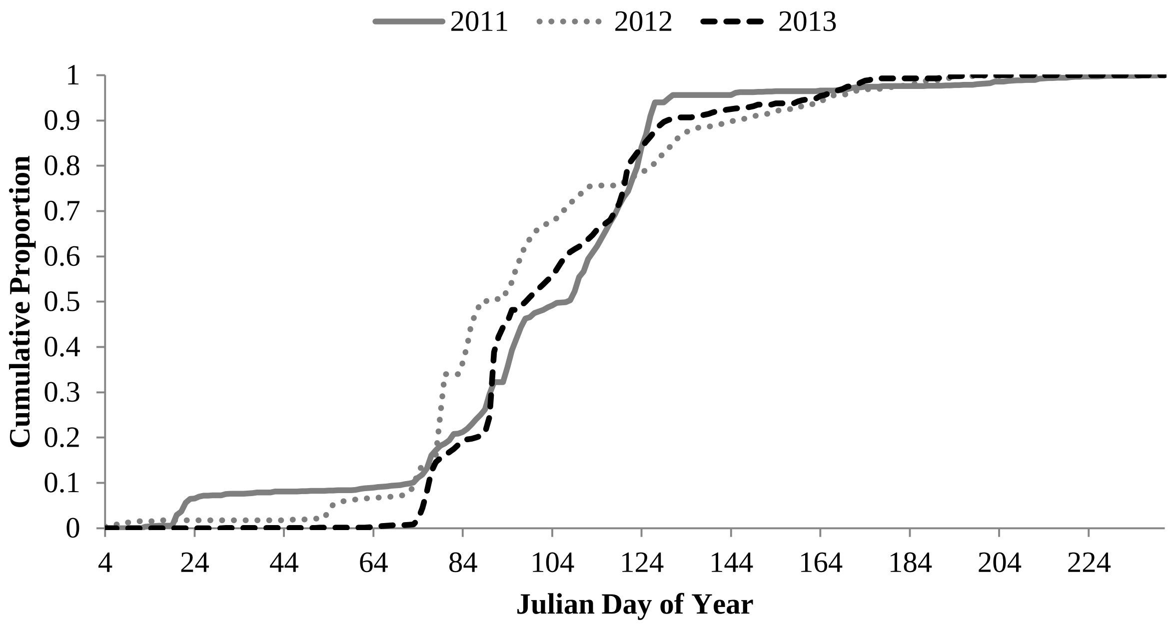

Figure 5.6. Cumulative emigration timing of natural Chinook salmon smolts from the Imnaha River in migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

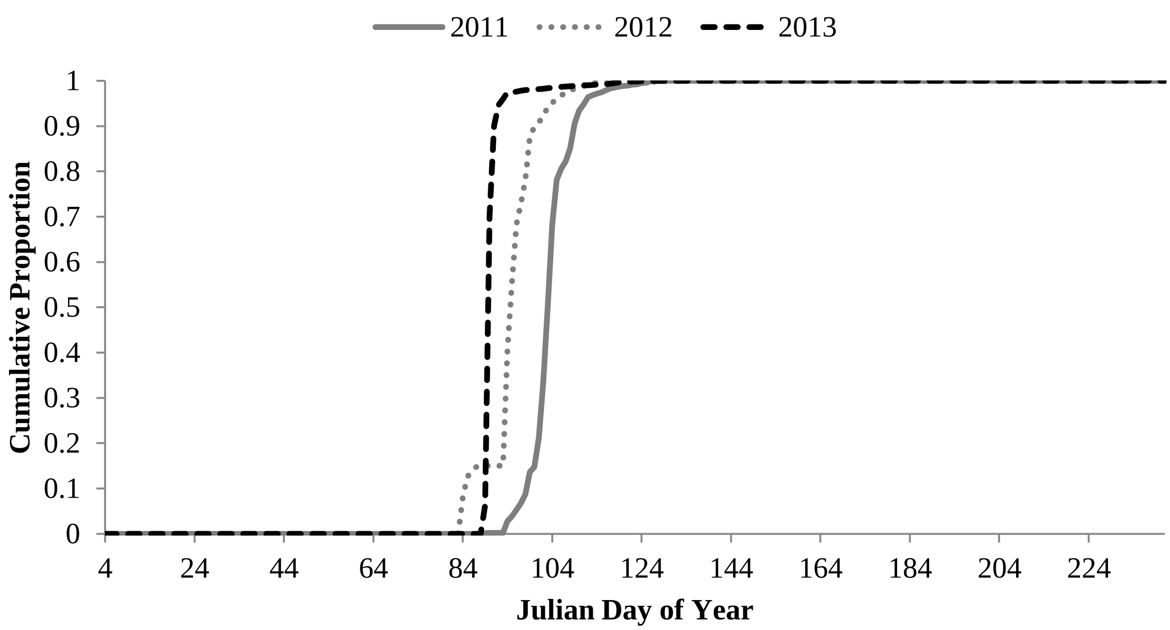

Figure 5.7. Cumulative emigration timing of hatchery Chinook salmon smolts from the Imnaha River in migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

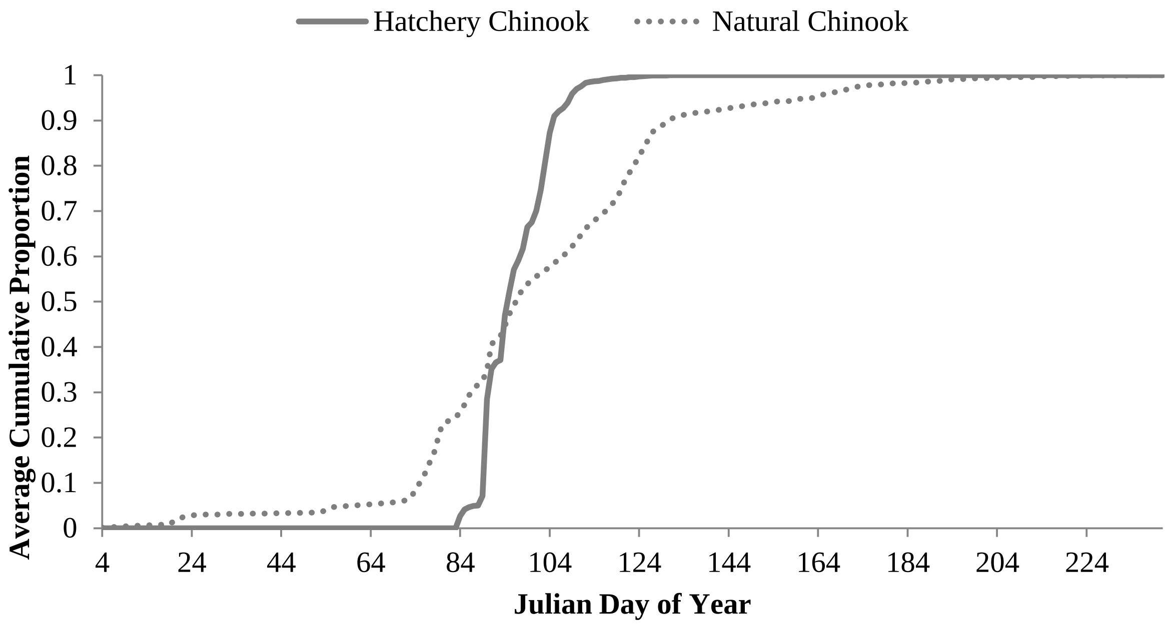

Figure 5.8. Cumulative emigration timing from the Imnaha River of natural and hatchery Chinook salmon averaged over the migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

Steelhead Emigration Timing

As with Chinook salmon, similar overall patterns in emigration timing for natural steelhead were observed between years. Natural steelhead arrived at the trap as early as January 20 in 2011 but not until February 19 in 2012 and March 15 in 2013. Migration in all three years accelerated rapidly when around 10% of natural steelhead smolts had passed. The tenth percentile for natural Steelhead emigration occurred between April 20 and April 25 in all years (Table 5.2). Median arrivals occurred on May 6 in 2011, May 11 in 2012, and May 7 in 2013. The 90th percentile of emigration timing occurred as early as May 11 in 2011 and as late as May 22 in 2012 (Table 5.2). Last arrivals were as late as July 29 in 2011, when trapping occurred throughout the summer. Later emigrants may have been missed in 2013 after the trap ceased operations on July 17. However, the last steelhead was captured on June 25 in 2013 so it is likely that few individuals were missed (Table 5.2). The bulk of natural steelhead smolts (80%) passed in a 16 day span in 2011 (25 April to 11 May), a 32 day span in 2012 (20 April to 22 May), and a 29 day span in 2013 (21 April to 20 May; Table 5.3). Overall, natural steelhead migration from the Imnaha River tends to start later and be shorter in duration than the migration period of natural Chinook. This pattern is displayed by the steeper slope of the average steelhead cumulative distribution curve combined with later median arrival dates than natural Chinook salmon but similar 90th percentile arrival dates (Figure 5.10; Table 5.2)

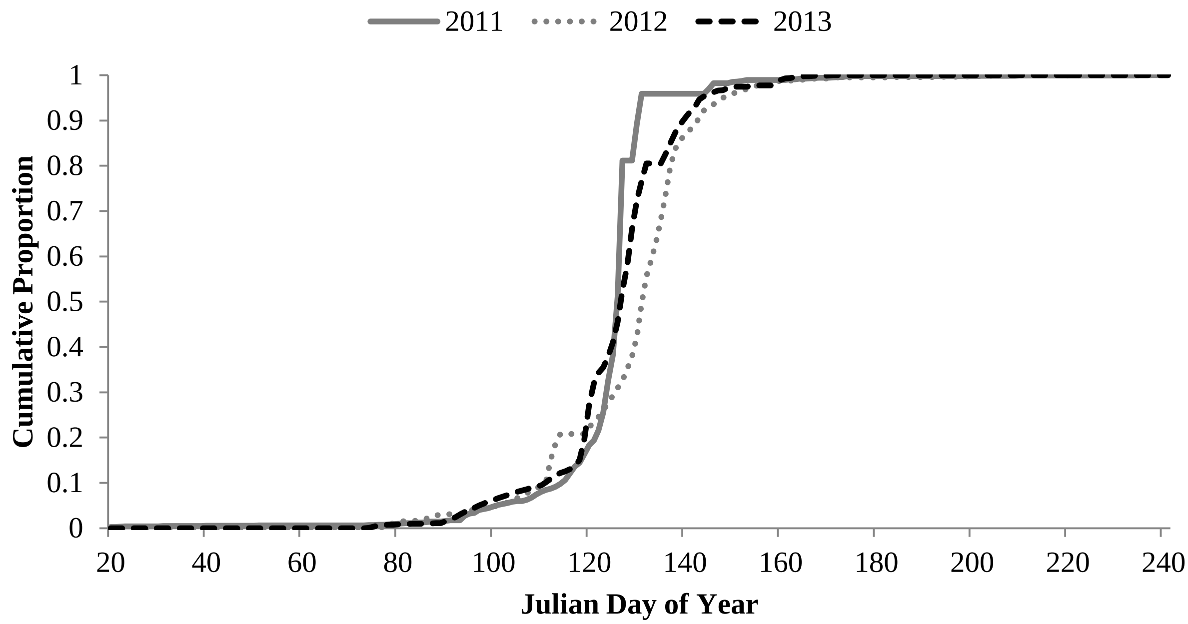

Figure 5.9. Cumulative emigration timing of natural steelhead smolts from the Imnaha River in migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

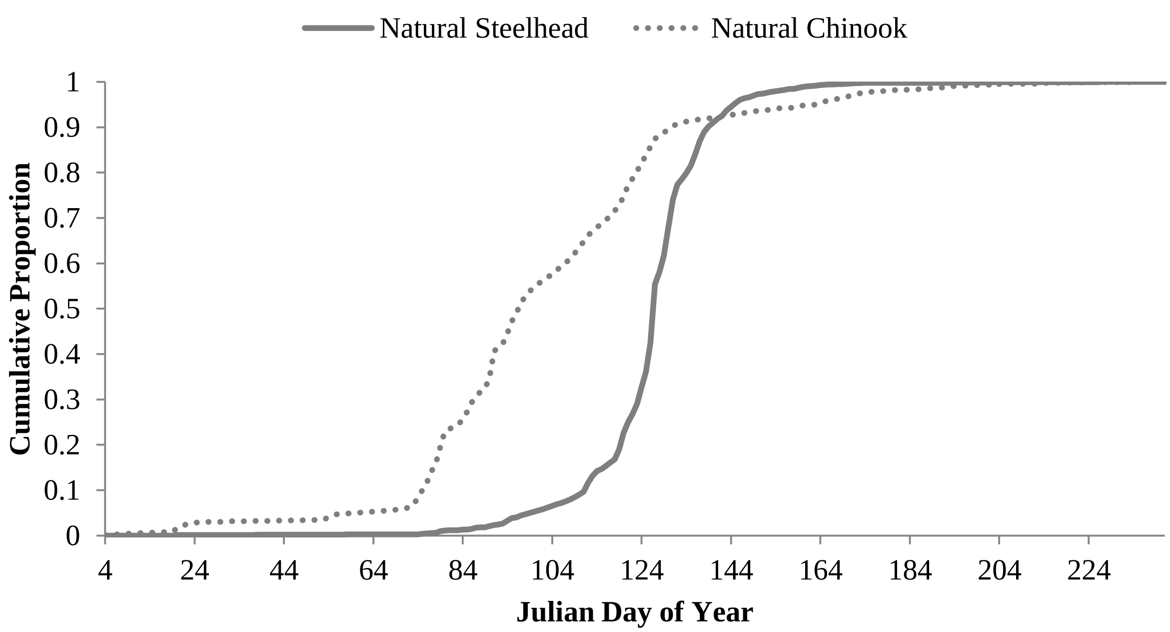

Figure 5.10. Cumulative emigration timing of natural Chinook salmon and steelhead averaged over the migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

Hatchery steelhead migration mirrored natural steelhead much more closely than hatchery and natural Chinook salmon. First arrivals occurred within one day of the beginning of volitional releases in 2011 and 2012 and two days after the beginning of volitional releases in 2013. The tenth percentile of emigration occurred as early as April 4 in 2013 and as late April 13 in 2012. Median arrivals occurred May 1 in 2013, May 6 in 2011, and May 16 in 2012 (Table 5.2). Ninety percent of hatchery smolts passed by May 11 in 2011, May 18 in 2013, and not until June 13 in 2012. Last arrivals were between July 1 and July 13 in all years (Table 5.2). Eighty percent of hatchery smolts passed during 34 days in 2011, 61 days in 2012, and 44 days in 2013 (Table 5.3). Overall, migration patterns of natural and hatchery steelhead were quite similar (Figure 5.12). Though K-S tests revealed differences between emigration timing of natural and hatchery-origin steelhead within years (see juvenile emigration timing in chapters 2, 3, and 4) it is likely that both origins experienced similar in river conditions and differences in survival would likely be mostly due to other factors than emigration timing.

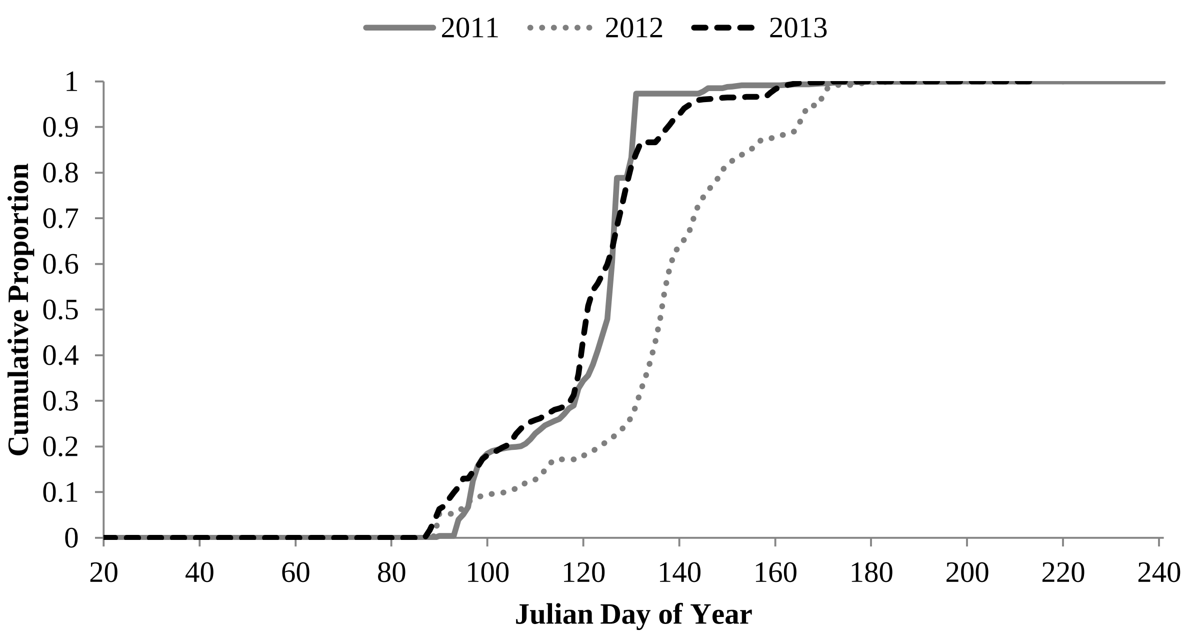

Figure 5.11. Cumulative emigration timing of hatchery steelhead smolts from the Imnaha River in migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

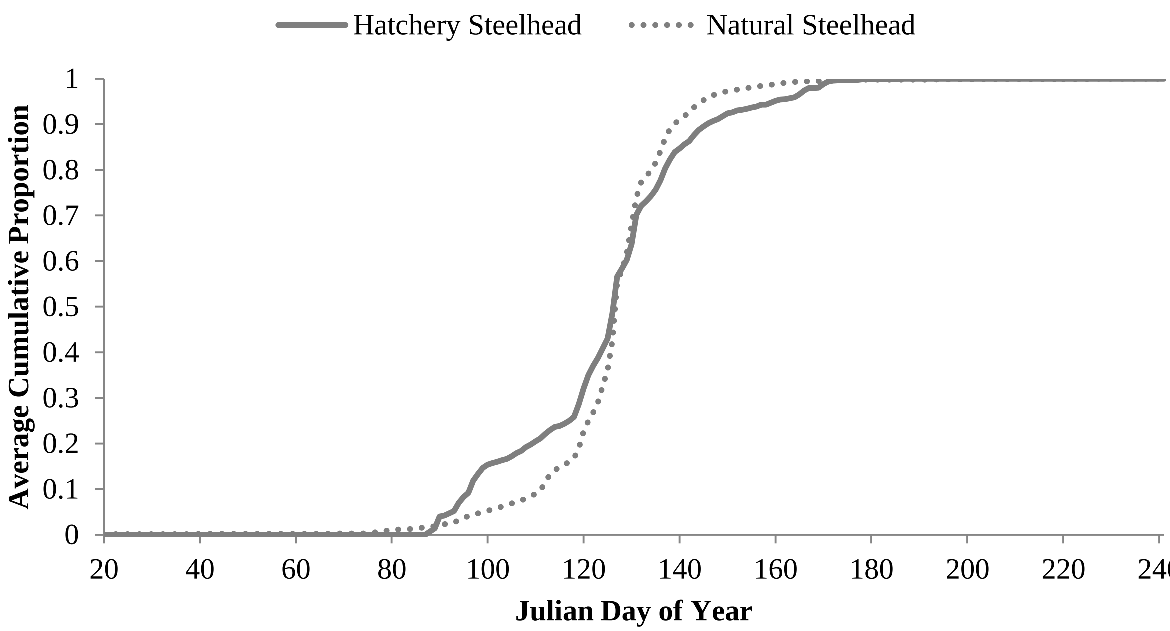

Figure 5.12. Cumulative emigration timing of natural and hatchery steelhead averaged over the migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

Arrival Timing of Imnaha River Juvenile Emigrants at Lower Granite Dam MY2011 – MY2013

Comparisons within and between origins and species were made for arrival at LGR between MY2011 andMY2013. Please refer to the arrival timing sections within chapters 2, 3, and 4 for comparisons between origins within each year.

Chinook salmon arrival at LGR

Comparisons of arrival at LGR were made for natural Chinook salmon fall emigrating presmolts, natural Chinook salmon spring emigrating smolts, and hatchery Chinook salmon smolts. It is important to note that the PIT tag arrays at LGR were not operated before March 23 in 2011, March 22 in 2012, and March 18 in 2013. Natural Chinook salmon arriving before this date would have passed LGR undetected and not contributed to the cumulative arrival timing distributions reported here. Presmolt arrival timing was very similar throughout migration years 2011 through 2013 (Figure 5.13). Natural Chinook salmon presmolts showed earlier arrivals at LGR than Chinook salmon smolts. This pattern should be expected given their proximity to LGR while overwintering in the Snake River above the dam. Ten percent of natural presmolts passed LGR by March 27 in 2012 and April 2 in 2011 and 2013. Median arrivals occurred 10 to 18 days later in mid-April (Tables 5.4 and 5.5) Ninety percent of presmolts passed LGR by April 25 in 2012, April 30 in 2011, and May 3 in 2013. The last arrival at LGR in any year for a presmolt was May 20 (Table 5.4). The bulk (80%) of the presmolt migration passed LGR in about a month's time (28 – 31 days) in all three years. The average 10th percentile passage date was 2 April and the average 90th percentile passage date was 13 May.

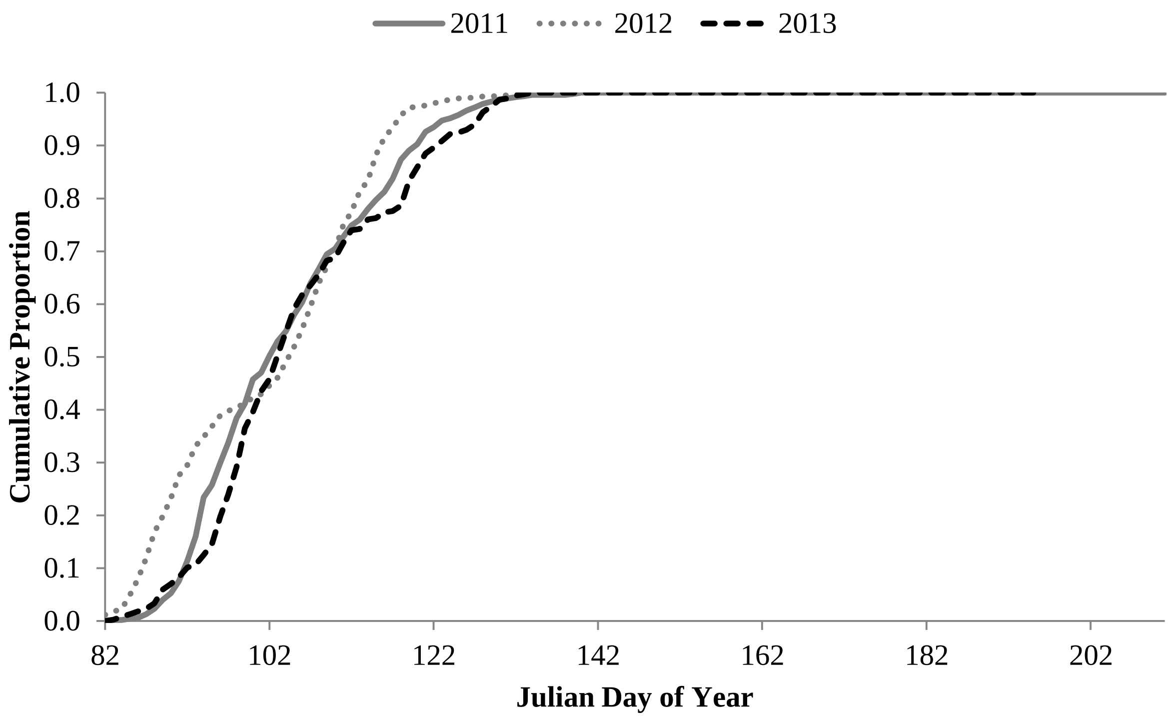

Figure 5.13. Cumulative arrival timing of natural Chinook salmon presmolts from the Imnaha River at Lower Granite Dam during migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

Table 5.4. First, 10th percentile, median, 90th percentile, and last arrival at Lower Granite Dam (LGR) for natural and hatchery Chinook salmon and steelhead during the spring trapping period in migration years 2011, 2012, and 2013.*Note: one natural steelhead captured at the Imnaha River Trap in migration year2011 was detected at LGR April 27, 2012, two natural steelhead captured in migration year 2012 were detected at LGR on October 17 and 18, 2012, and one hatchery steelhead captured in migration year 2012 was detected at LGR on October 13, 2012.

Year	Species and Origin	First Arrival	10th Percentile	Median	90th Percentile	Last Arrival
2011	Natural Chinook Salmon Smolts	3/26	4/8	5/5	5/14	6/30
2012	Natural Chinook Salmon Smolts	3/24	4/3	4/26	5/21	7/17
2013	Natural Chinook Salmon Smolts	3/25	4/12	5/9	5/14	7/14
2011	Natural Chinook Salmon Presmolts	3/24	4/2	4/12	4/30	5/20
2012	Natural Chinook Salmon Presmolts	3/22	3/27	4/14	4/25	5/19
2013	Natural Chinook Salmon Presmolts	3/24	4/2	4/13	5/3	5/14
2011	Natural Chinook Salmon Cohort	3/24	4/4	4/29	5/13	7/30
2012	Natural Chinook Salmon Cohort	3/22	3/28	4/18	5/14	7/17
2013	Natural Chinook Salmon Cohort	3/24	4/7	5/4	5/14	7/14
2011	Hatchery Chinook Salmon	4/9	5/5	5/10	5/15	5/30
2012	Hatchery Chinook Salmon	4/14	4/23	5/3	5/12	5/18
2013	Hatchery Chinook Salmon	4/8	4/29	5/7	5/11	5/14
2011	Natural Steelhead	3/27	4/30	5/9	5/17	6/25*
2012	Natural Steelhead	3/25	4/24	5/15	5/24	6/18*
2013	Natural Steelhead	3/15	4/26	5/9	5/18	6/15
2011	Hatchery Steelhead	4/10	5/4	5/10	5/15	6/24
2012	Hatchery Steelhead	4/1	4/26	5/18	6/5	7/9*
2013	Hatchery Steelhead	4/4	4/28	5/10	5/21	6/25

Table 5.5. The number of days passed between statistical metrics of the cumulative distribution of arrival at Lower Granite Dam for natural and hatchery Chinook salmon and steelhead in migration years 2011, 2012, and 2013.

Year	Species and Origin	First arrival to 10th Percentile	10th Percentile to Median	Median to 90th Percentile	90th Percentile to Last arrival	First Arrival to Last Arrival	10th Percentile to 90th Percentile
2011	Natural Chinook Salmon Smolts	13	27	9	47	96	36
2012	Natural Chinook Salmon Smolts	10	23	25	57	115	48
2013	Natural Chinook Salmon Smolts	18	27	5	61	111	32
2011	Natural Chinook Salmon Presmolts	9	10	18	20	57	28
2012	Natural Chinook Salmon Presmolts	5	18	11	24	58	29
2013	Natural Chinook Salmon Presmolts	9	11	20	11	51	31
2011	Natural Chinook Salmon Cohort	11	25	14	78	128	39
2012	Natural Chinook Salmon Cohort	6	21	26	64	117	47
2013	Natural Chinook Salmon Cohort	14	27	10	61	112	37
2011	Hatchery Chinook Salmon	26	5	5	15	51	10
2012	Hatchery Chinook Salmon	9	10	9	6	34	19
2013	Hatchery Chinook Salmon	21	8	4	3	36	12
2011	Natural Steelhead	34	9	8	39	90	17
2012	Natural Steelhead	30	21	9	25	85	30
2013	Natural Steelhead	42	13	9	28	92	22

Migration years 2011 and 2013 were very similar for natural Chinook salmon smolts but an early Imnaha and Snake River freshet quickened their arrival at LGR in 2012 for the first 70% of the migration (Figure 5.14). In all years, the tenth percentile of LGR passage for smolts occurred a week to ten days later than for presmolts and spanned from April 3 in 2012 to April 12 in 2013 (Table 5.4). Median arrivals occurred 23 to 27 days later (Table 5.5) and spanned from April 26 in 2012 to May 9 in 2013. Ninety percent of Chinook smolts passed by May 14 in 2011 and 2013 Ninetieth percentile arrival timing was delayed to May 21 following the spring freshet in 2012. Eighty percent of smolts passed within a 32 to 48 day window from early April to mid or late May during the three migration years (Table 5.5). The last arrival in any year was July 17 in 2012 (Table 5.4).

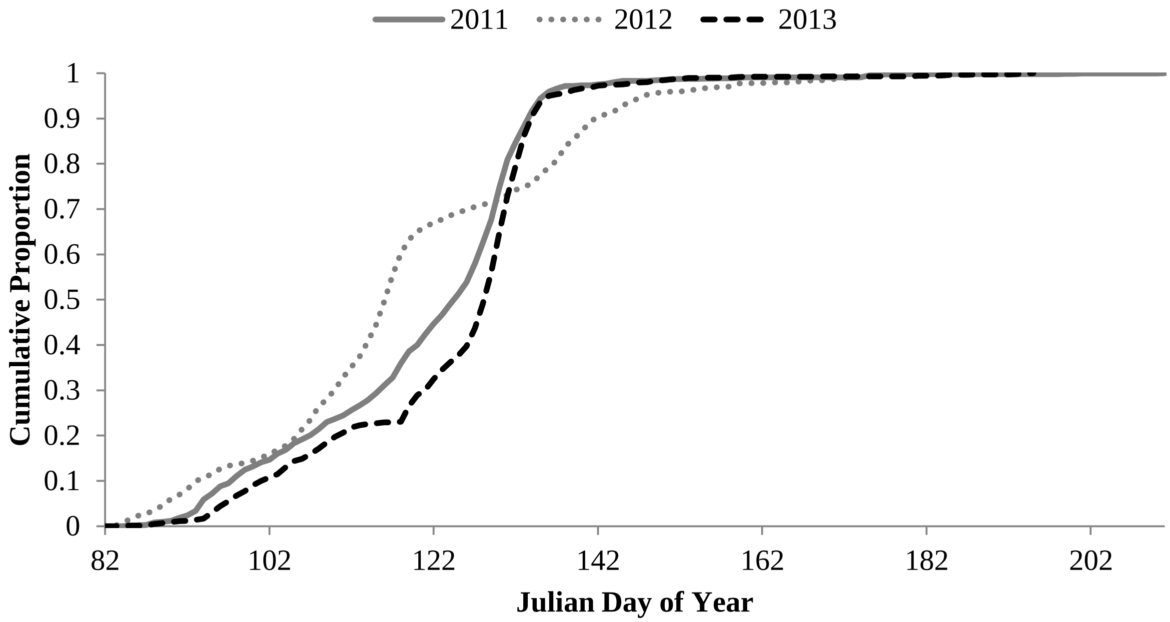

Figure 5.14. Cumulative arrival timing of natural Chinook salmon smolts from the Imnaha River at Lower Granite Dam during migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

Similar to their emigration from the Imnaha River, hatchery Chinook salmon smolts passed LGR rapidly in all three years. The first hatchery smolts arrived at LGR as early as April 8 in 2013 (Table 5.4). Ten percent of hatchery smolts passed LGR by April 23 in 2012, April 29 in 2013, and May 5 in 2011. Median hatchery Chinook salmon smolt arrivals occurred on May 3 in 2012, May 7 in 2013, and May 10 in 2011 (Table 5.4). Ninetieth percentile arrival dates occurred five to nine days later (May 11 to May 15; Table 5.5). The latest arrival date in any year was May 30 in 2011. The total LGR passage period (first to last arrival) for hatchery Chinook salmon lasted 34 to 51 days. However, 80% of hatchery smolts passed each year in a period between 12 and 19 days compared to a 32 to 48 day span for natural smolts (Table 5.5).

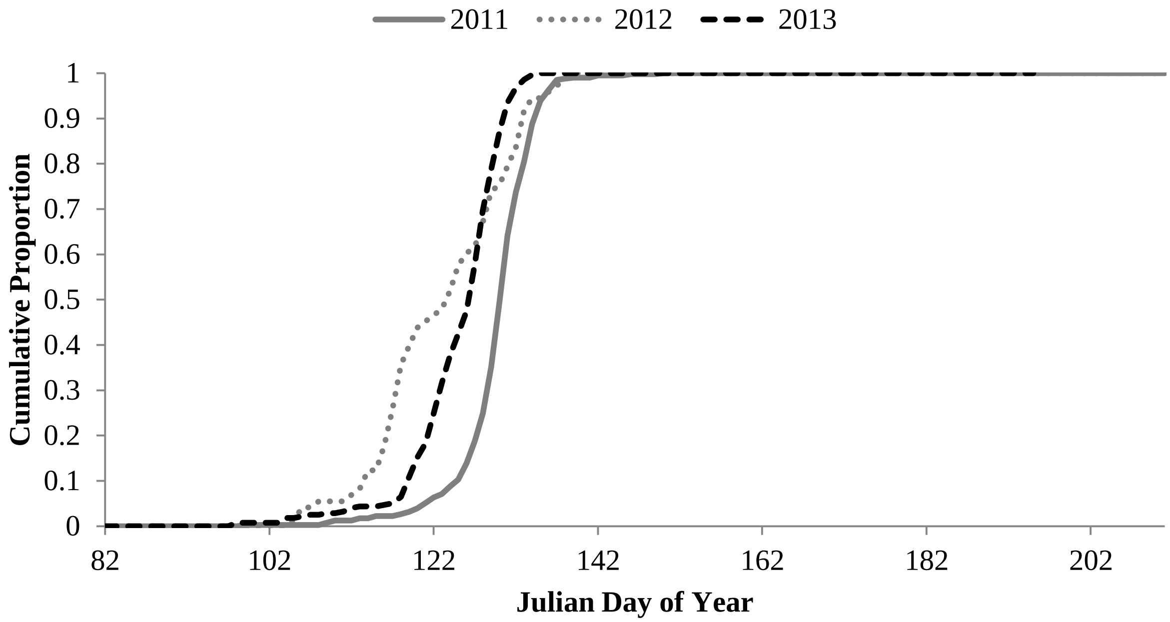

Figure 5.15. Cumulative arrival timing of hatchery Chinook salmon smolts from the Imnaha River at Lower Granite Dam during migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

Steelhead arrival at LGR

Natural steelhead smolts passed LGR in a rapid pattern similar to hatchery Chinook salmon. All three years of migration displayed nearly symmetrical cumulative migration curves with the bulk of the migration being nearly identical in 2011 and 2013 and slightly later in 2012 (Figure 5.16). First arrivals at LGR occurred as early as March 15 in 2013 and as late as March 27 in 2011 (Table 5.4). The tenth percentile of LGR passage for natural steelhead occurred on April 30 in 2011, April 24 in 2012, and April 26 in 2013; about a month after first arrivals. Median arrivals occurred on May 9 in 2011 and 2013 and on May 15 in 2012. Ninety percent of natural steelhead passed LGR by May 17 in 2011, May 24 in 2012, and May 18 in 2013 (Table 5.4). Eighty percent of natural steelhead passed in a period of 17 to 30 days from late April till mid to late May (Table 5.5). Last arrivals in spring of the year of capture were June 25 in 2011, June 18 in 2012, and June 15 in 2013. The total time span from first to last spring arrival at LGR was a period of 85 – 92 days (Table 5.5). However, one natural steelhead smolt captured at the Imnaha River Trap in spring 2011 passed LGR in April 2012 and two smolts captured in spring 2012 passed LGR in October 2012.

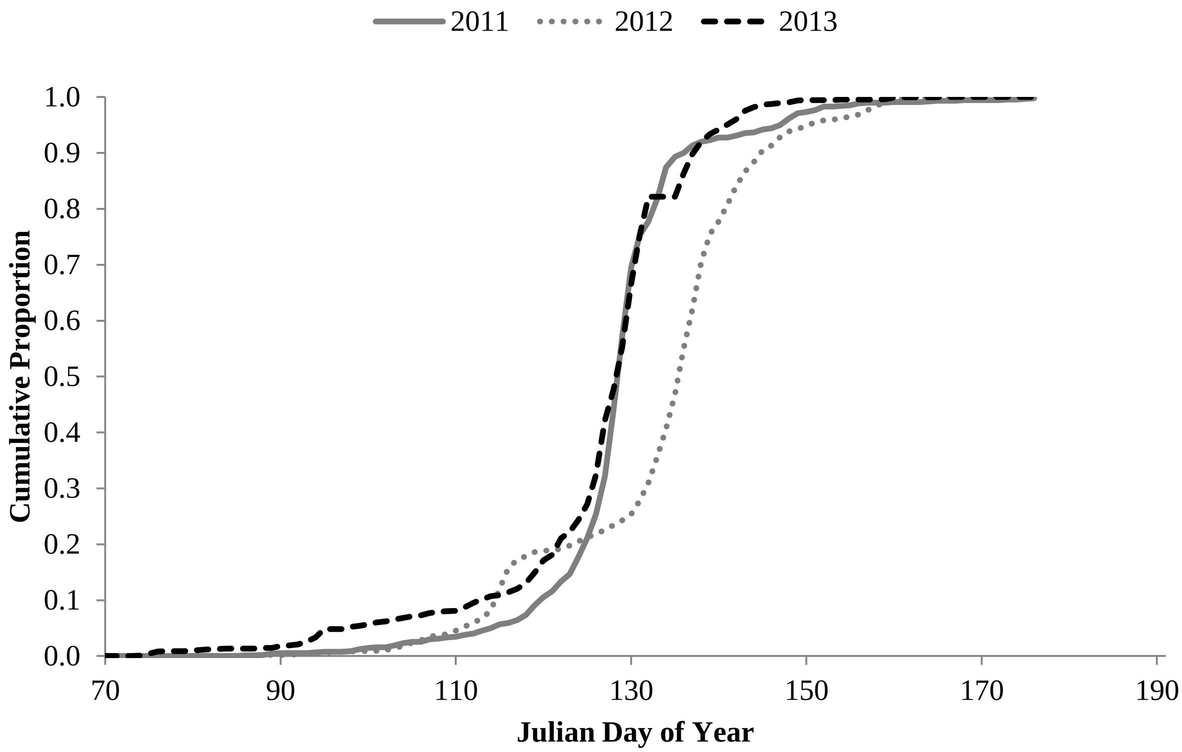

Figure 5.16. Cumulative arrival timing of natural steelhead smolts from the Imnaha River at Lower Granite Dam (LGR) during migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012. Note: one smolt captured at the Imnaha River Trap in spring 2011 passed LGR in April 2012 and two smolts captured in spring 2012 passed LGR in October 2012. These fish were omitted from the cumulative distribution curves.

Hatchery steelhead migration timing at LGR was a near mirror image of natural steelhead but occurred several days later on average (Figure 5.17). Similar to natural steelhead, the cumulative arrival curves for 2011 and 2013 were nearly identical but 2012 lagged behind by several days. First arrivals of hatchery steelhead at LGR occurred as early as April 1 in 2012 and as late as April 10 in 2011 (Table 5.4). Tenth percentiles for arrival of hatchery steelhead at LGR occurred on May 4 in 2011, April 26 in 2012, and April 28 in 2013. Median arrival occurred on May 10 in 2011 and 2013 and on May 18 in 2012 (Table 5.4). Ninetieth percentiles occurred on May 15 in 2011, June 5 in 2012, and May 21 in 2013. The time required for eighty percent of hatchery steelhead to pass LGR was 11 – 40 days and the total migration period from first to last arrival was 85 – 92 days (Table 5.5). However, one hatchery steelhead captured in spring 2012 passed LGR in October 2012 and was omitted from the analysis.

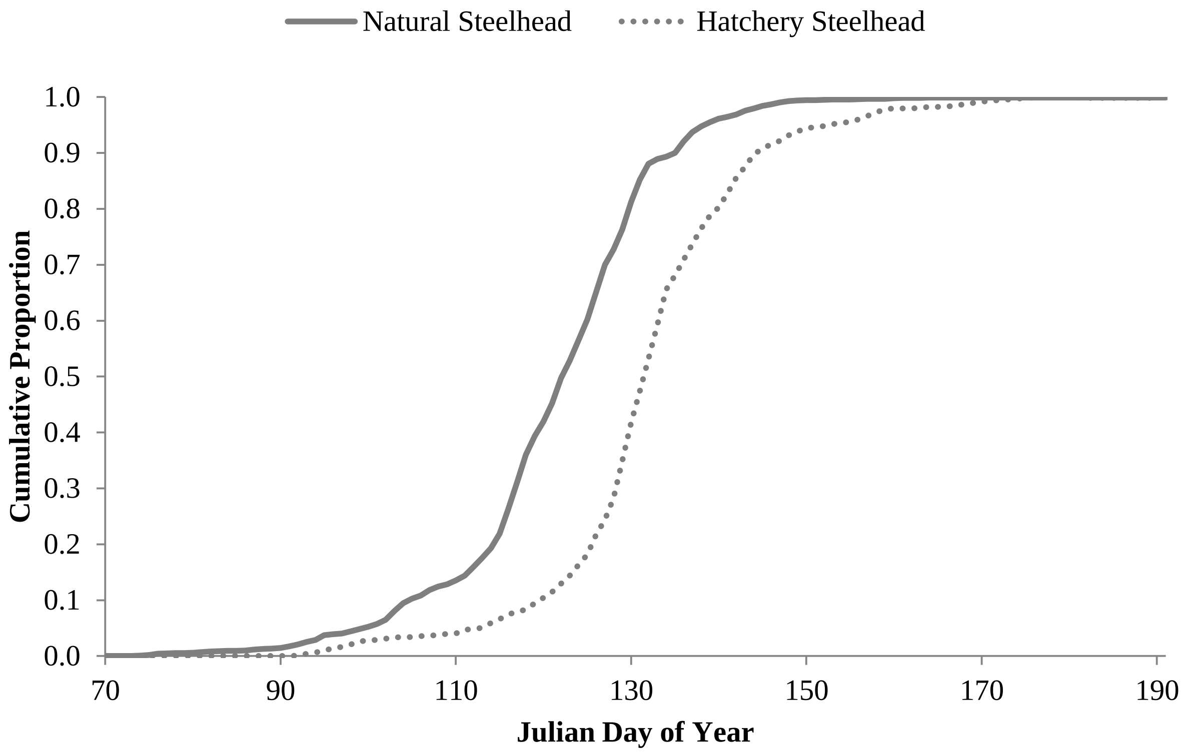

Figure 5.17. Cumulative arrival timing of natural and hatchery steelhead smolts from the Imnaha River at Lower Granite Dam (LGR) averaged over migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012.

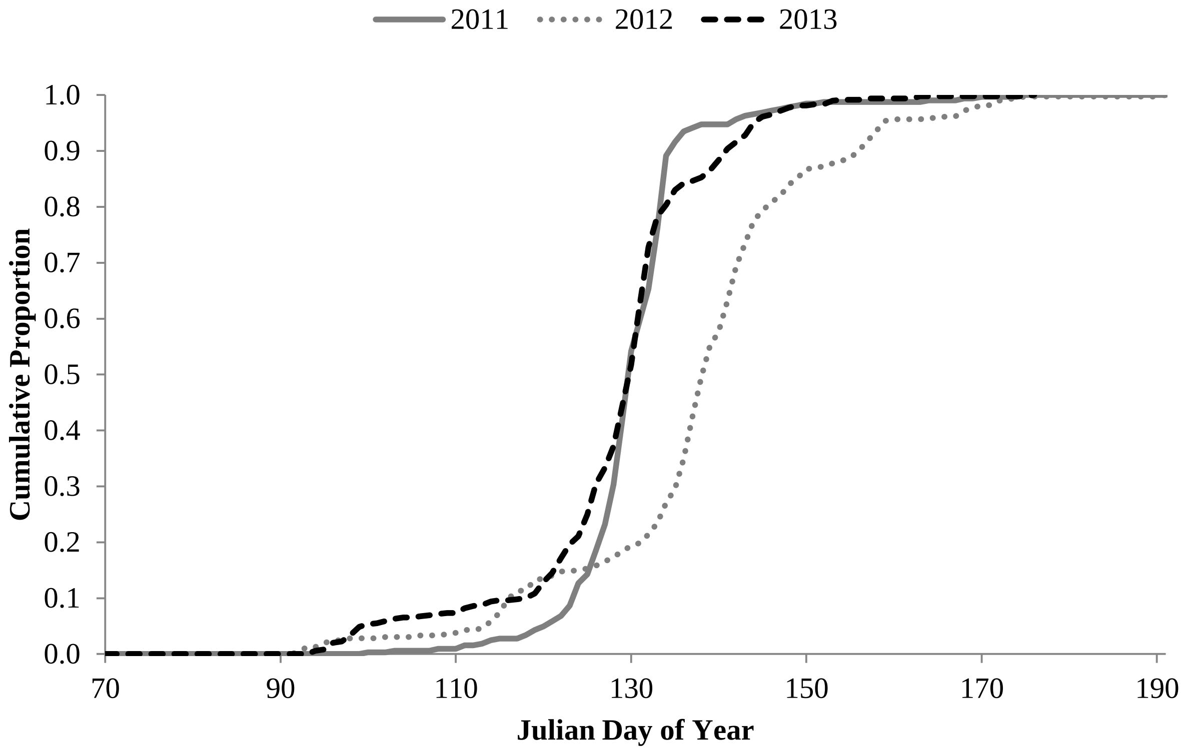

Figure 5.18. Cumulative arrival timing of hatchery steelhead smolts from the Imnaha River at Lower Granite Dam (LGR) during migration years 2011, 2012, and 2013. The x axis is presented as the Julian day of the year because of the leap year in 2012. Note: one smolt captured at the Imnaha River Trap in spring 2012 passed LGR in October 2012. This fish was omitted from the cumulative distribution curves.

Transport Proportions at LGR

Depending upon the origin and species, the proportion likely to be transported ranged from 0.9 – 31.9 % from MY2011-MY2013. On average 3.9% of natural Chinook salmon presmolts, 19.6% of natural Chinook salmon smolts, 22.5% of hatchery Chinook salmon, 25.4% of natural steelhead, and 25% of hatchery steelhead were likely to be transported (Table 5.6). Despite having higher collection efficiencies at LGR, natural Chinook salmon of both origins were less likely to be transported because of earlier arrival timing at LGR. Steelhead of both origins were more likely to be transported because of their later arrival timing (Figure 5.6). The average proportion of juveniles that passed LGR before the start of collections was 88.5% for natural Chinook salmon presmolts, 42.9% for natural Chinook smolts, 18.0% for hatchery Chinook salmon, 13.6% for natural steelhead, and 8.7% for hatchery steelhead. Collection efficiencies were highest in 2011 and lowest in 2013 for all juvenile groups and varied between 18% and 42% (Table 5.6). MY2011 would have shown the highest rates of transportation of the three years but 13 – 25% of the collected juveniles were bypassed back to the river whereas all collections were transported in 2012 and 2013 (Table 5.6). Natural and hatchery smolts of both species were generally transported at a similar rate and consequently experience similar emigration conditions through the hydrosystem. In contrast, Chinook salmon presmolts were significantly less likely to be transported and therefore experience significantly different emigration conditions. These results may assist in our understanding of the effects of different emigration conditions, such as timing and transportation, on adult survival

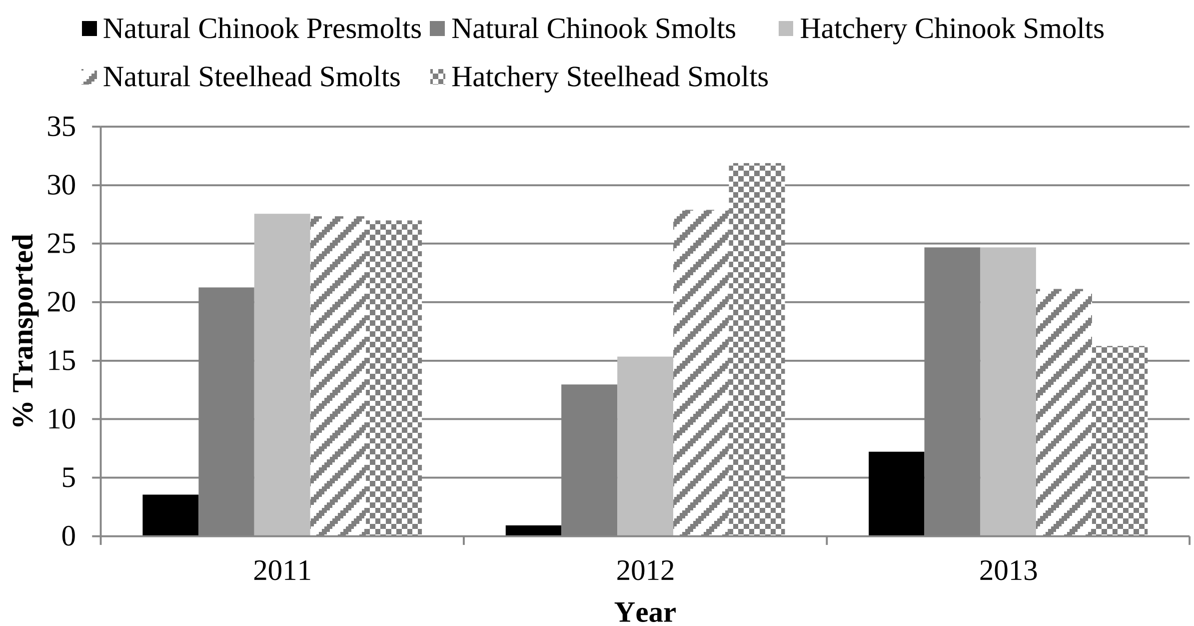

Figure 5.19. The proportion of juveniles likely transported by origin and species during migration years 2011 through 2013.

Table 5.6. The proportion of juveniles, by origin and species, likely transported at Lower Granite Dam (LGR) during migration years 2011 through 2013 along with the proportion of each group which passed LGR before transportation operations began, the collection efficiency at the LGR juvenile bypass facility, and the proportion of juveniles collected which were transported in each year. The origin and species abbreviations are as follows: 12W = natural Chinook salmon, 12H = hatchery Chinook salmon, 32W = natural steelhead, and 32H = hatchery steelhead.

Migration Year	Origin and Species	% Passed Before Transportation	% Likely Transported	Collection Efficiency at LGR (%)	% of Collections Transported
2011	12W Presmolts	90.3	3.5	42	86.9
2012	12W Presmolts	97.6	0.9	38	100
2013	12W Presmolts	77.6	7.2	32	100
	Mean	88.5	3.9	37.3	95.6
2011	12W Smolts	40.0	21.2	42	84.3
2012	12W Smolts	65.9	13.0	38	100
2013	12W Smolts	22.9	24.7	32	100
	Mean	42.9	19.6	37.3	94.8
2011	12H Smolts	3.9	27.5	34	84.30
2012	12H Smolts	45.2	15.3	28	100
2013	12H Smolts	5.0	24.7	26	100
	Mean	18.0	22.5	29.3	94.8
2011	32W Smolts	10.8	27.3	41	74.7
2012	32W Smolts	18.0	27.9	34	100
2013	32W Smolts	12.0	21.1	24	100
	Mean	13.6	25.4	33.0	91.6
2011	32H Smolts	5.0	27.0	38	74.7
2012	32H Smolts	11.5	31.9	36	100
2013	32H Smolts	9.8	16.2	18	100
	Mean	8.7	25.0	30.7	91.6

Travel Time from the Imnaha River Trap to LGR MY2011 – MY2013

See chapters two, three, and four for travel time within individual migration years and its relationship with Snake River discharge.

Chinook salmon showed similar patterns in travel time to LGR across migration years. For natural Chinook salmon smolts, travel times were generally low during the beginning of migration in late March but increased to migration year maxes by mid to late April. Thereafter natural Chinook salmon smolt travel times generally decreased until smolt detections became intermittent in mid-June (Figure 5.20). Interannual variability between migration years was greater from May through June and may be tied to differences in flow or temperature between years.

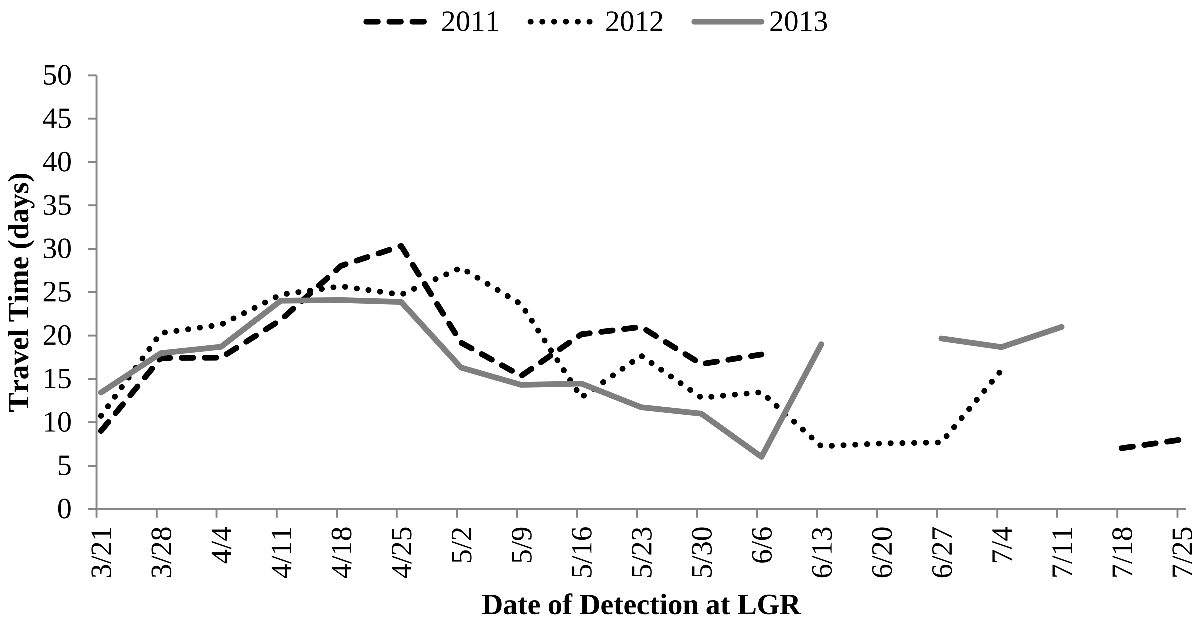

Figure 5.20. Average travel time by week to Lower Granite Dam (LGR) for natural Chinook smolts during migration years 2011, 2012, and 2013.

Hatchery Chinook salmon smolts displayed very similar trends in travel time between years but very different patterns from natural Chinook salmon. Weekly averaged travel times to LGR started at just above five days and ascended to over 35 days in all three years (Figure 5.21). Because hatchery smolts passed the trap rapidly in all three years, their patterns in travel time to LGR appear to be simply a case of some smolts continuing downstream migration immediately upon entering the Snake River while others are delayed as the cohort spreads out downstream.

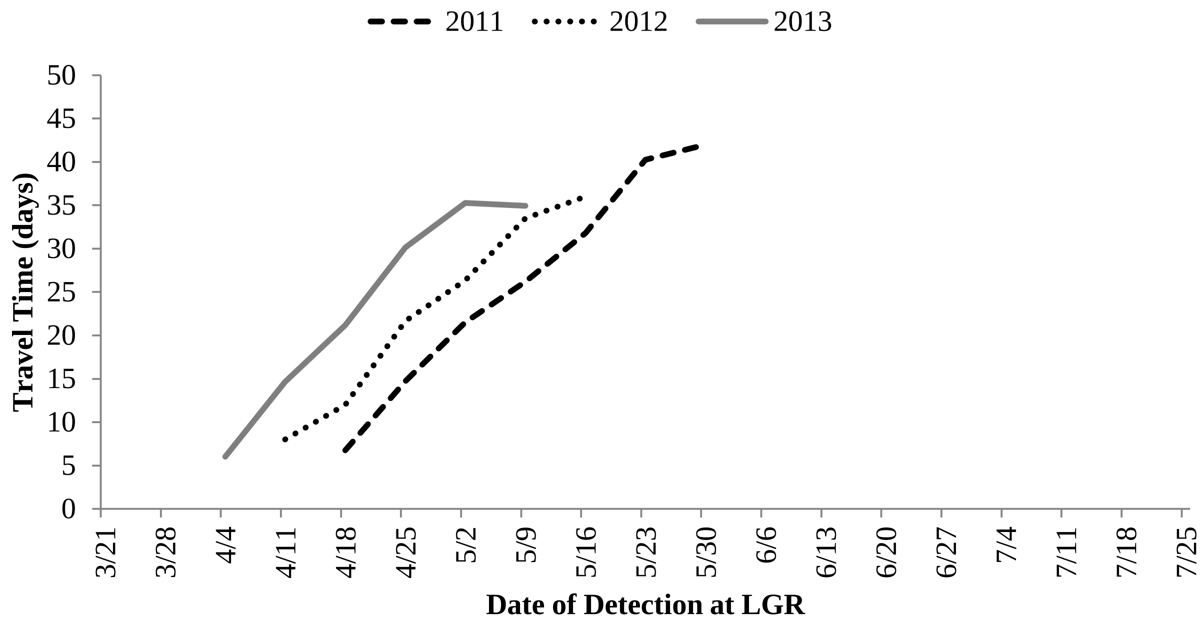

Figure 5.21. Average weekly travel time to Lower Granite Dam (LGR) for hatchery Chinook smolts during migration years 2011, 2012, and 2013.

Unlike Chinook salmon, natural steelhead travel times were variable between years with no “typical” pattern. Weekly averaged natural steelhead travel times varied from less than five to 16 days in all three years (Figure 5.22). Hatchery steelhead also displayed no seasonal patterns across years. Their travel times did not lengthen as the season progressed like hatchery Chinook salmon but vacillated between less than five to 21 days with some years showing higher travel times early in the season and later in the season in others (Figure 5.23). When averaged across the three migration years, steelhead showed travel times that were generally shorter than for Chinook salmon. Averaging across years also highlighted the similarity in travel times and patterns between steelhead groups and the disparity between Chinook salmon groups (Figure 5.24).

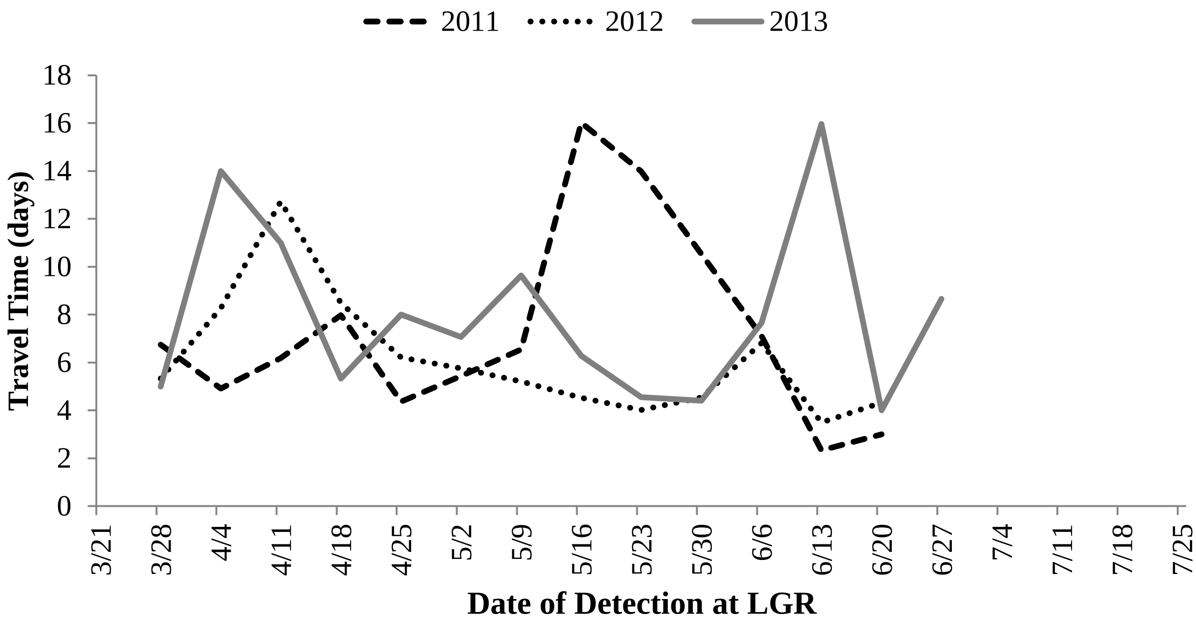

Figure 5.22. Average weekly travel time to Lower Granite Dam (LGR) for natural steelhead smolts during migration years 2011, 2012, and 2013.

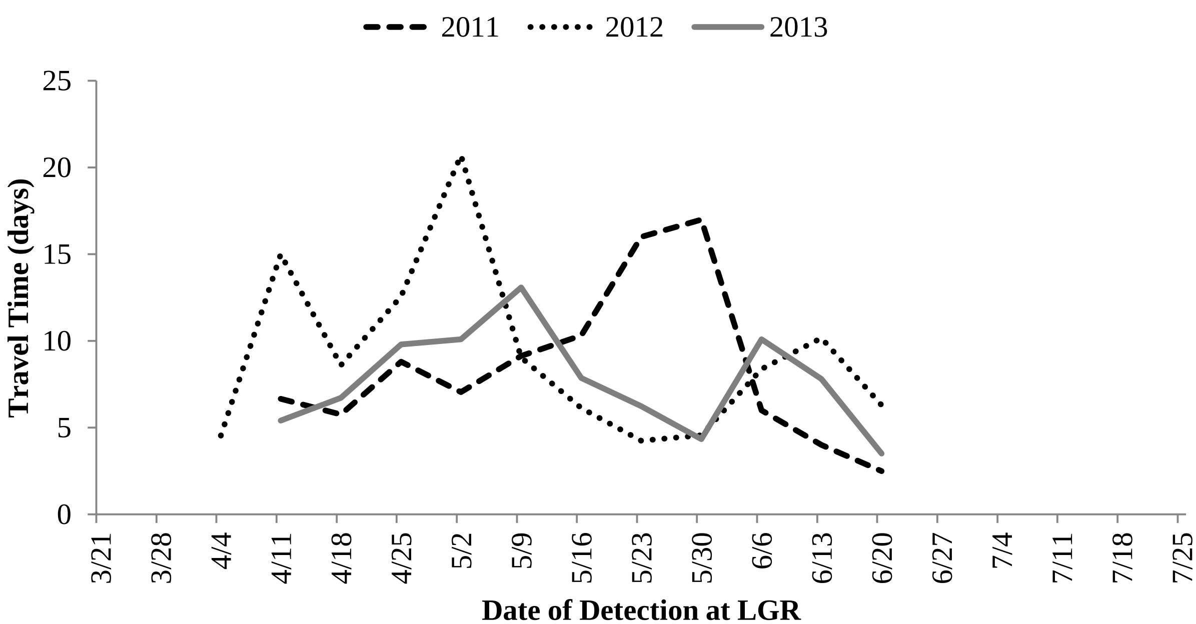

Figure 5.23. Average weekly travel time to Lower Granite Dam (LGR) for hatchery steelhead smolts during migration years 2011, 2012, and 2013.

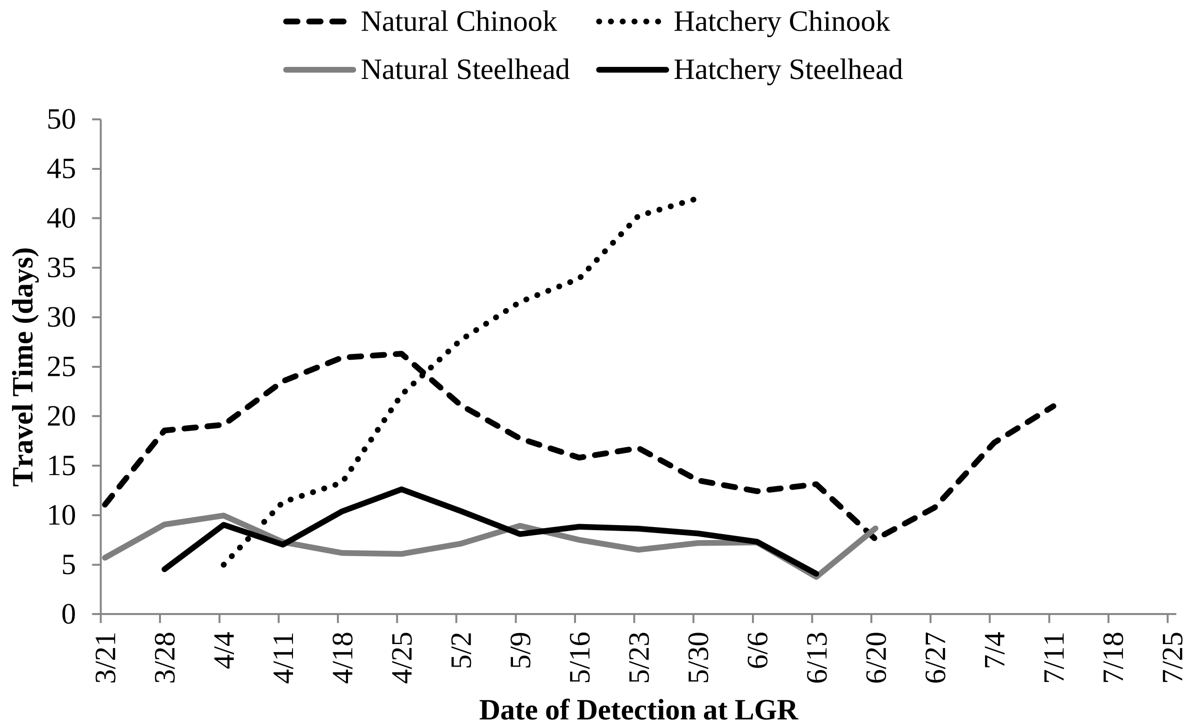

Figure 5.24. Travel time to Lower Granite Dam (LGR) for natural and hatchery Chinook salmon and steelhead smolts during migration years 2011, 2012, and 2013.

Trends in Juvenile Survival MY1993 to MY2013

The following sections investigate trends in survival for all species and origin types over the duration of the Imnaha River Smolt Monitoring Project. Estimates were generated from release to the Imnaha River Trap for hatchery smolts as well as from the Imnaha River Trap to LGR and MCN for natural and hatchery smolts. Some estimates are unavailable during the earliest years of the project. Methods for estimation of survival in each migration year can be found in the corresponding annual report in the Nez Perce Tribe Department of Fisheries Resource Management publications library at http://www.nptfisheries.org/PublicationLibrary.aspx.

Post-release survival of hatchery smolts

Estimates of survival from release to the Imnaha River Trap were available for hatchery Chinook salmon from MY1994 to MY2013. Survival was high over most years and averaged 91% (SD ± 8.0%). Estimated post-release survival ranged from 63% (95% CI = 2.3%) in 2006 to 99.9% in 1994 and 2012 (95% CI = 14.3 and 10.5% respectively). No positive or negative trend in survival over time or between shorter spans is evident (Figure 5.25).

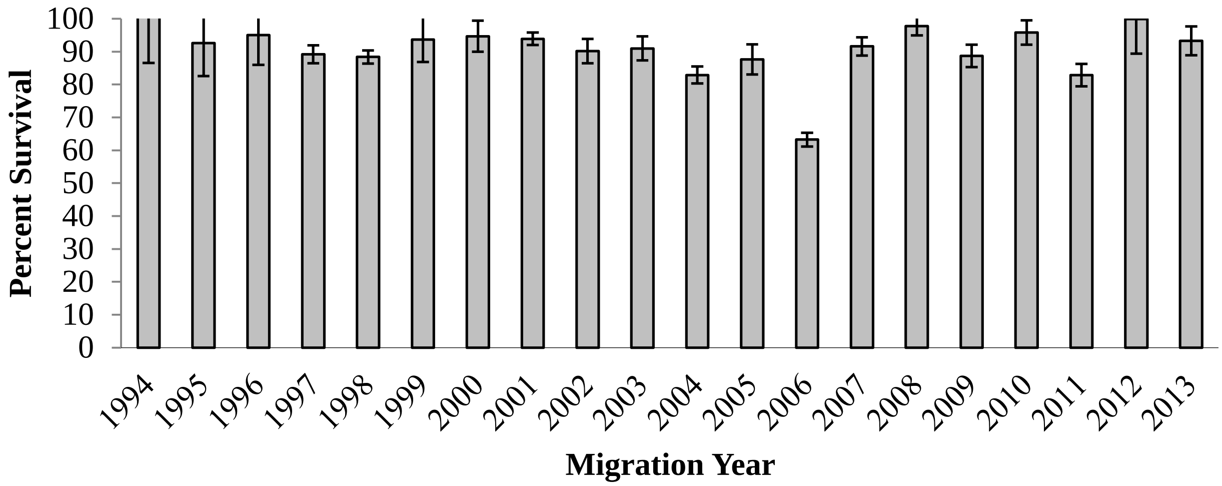

Figure 5.25. Estimated survival of hatchery Chinook salmon smolts from release to the Imnaha River Trap during the migration years 1994 to 2013. Error bars represent 95% confidence intervals.

Estimates of post-release survival to the Imnaha River Trap for hatchery steelhead from MY1994 to MY2013 were lower and more variable than for Chinook salmon. As with Chinook salmon, there was no discernible trend in survival over the period of estimation. Estimates ranged from 56% (95% CI = 8.0%) in 1994 to 99.9% (95% CI = 9.2 %) in 2003 (Figure 5.26). The average estimated hatchery steelhead post release survival was 82% (SD ± 11.2%); nine percent lower than for hatchery Chinook salmon. Some of the difference in survival may be attributed to higher smolt residualization rates of hatchery steelhead than hatchery Chinook salmon.

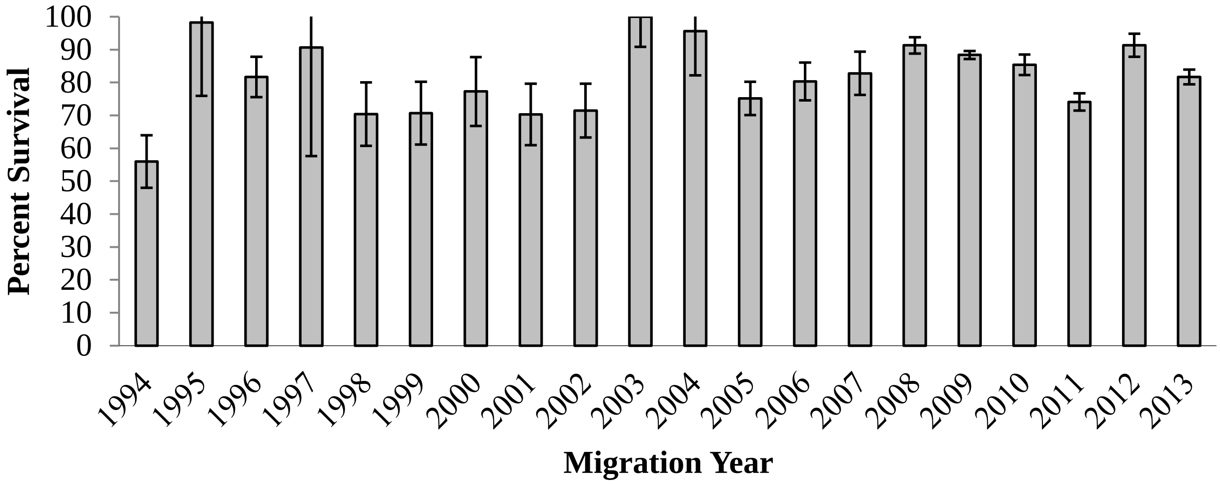

Figure 5.26. Estimated survival of hatchery steelhead smolts from release to the Imnaha River Trap during the migration years 1994 to 2013. Error bars represent 95% confidence intervals.

Survival from the Imnaha River to Lower Granite Dam (LGR)

Chinook Salmon Survival to LGR

Juvenile natural Chinook salmon survival from the Imnaha River Trap to LGR was estimated from MY1993 - MY2013 for natural-origin smolts and from MY1994 – MY2013 for hatchery-origin smolts. Natural-origin survival to LGR averaged 81% (SD ± 5.9%) and ranged from 72% to 91%. Generally, survival was above average during the mid to late 1990's and below average from MY2003 to MY2008. Survival in MY2011 to MY2013 was below average in all three years and MY2012 and MY2013 were the lowest years of estimated survival to LGR on record (Figure 5.27). Regression showed a significant negative trend in survival of natural Chinook salmon to LGR over time ($p = 0.02$, $r^2 = 0.27$).

Hatchery Chinook salmon survival to LGR mirrored the survival of natural Chinook salmon but was generally lower. Average survival of hatchery Chinook salmon to LGR from MY1994 – MY2013 was 72% (SD ± 5.3%) and ranged from 61% to 80% (Figure 5.27). Though survival did show a slight negative trend over time for hatchery Chinook salmon, the trend was not statistically significant ($p = 0.28$). Survival to LGR of hatchery Chinook salmon was highly correlated with survival of natural Chinook salmon ($p = 0.0003$, $r^2 = 0.52$). This suggests that factors affecting the survival of natural Chinook salmon, during their migration to LGR, have similar impacts on the survival of hatchery Chinook salmon.

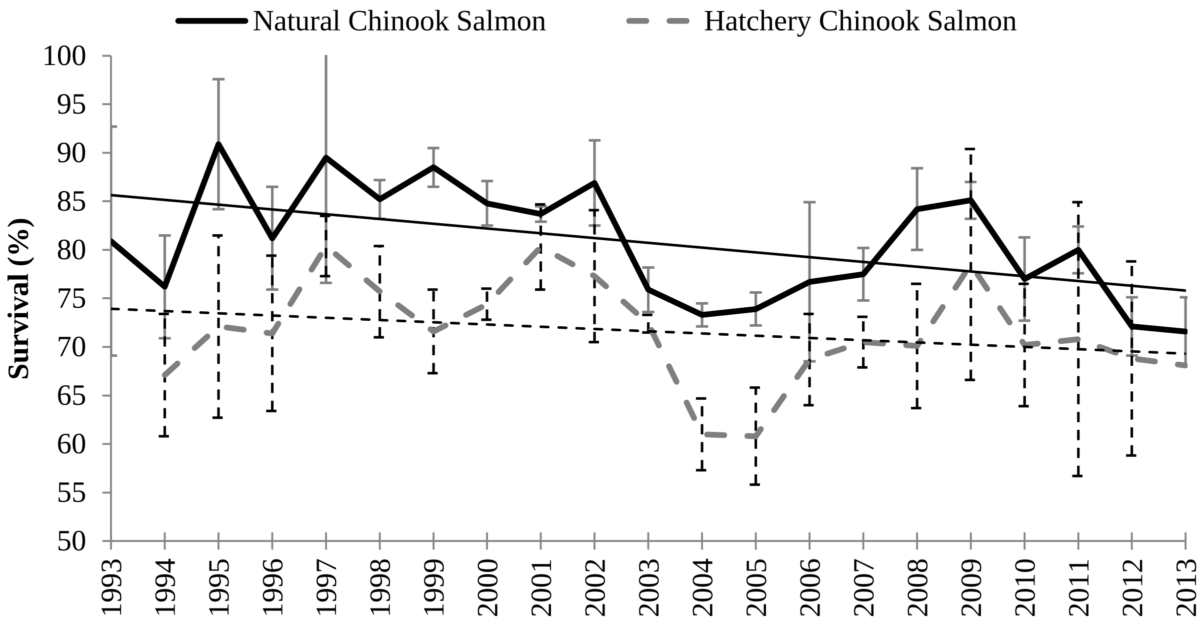

Figure 5.27. Estimated survival and associated trend lines for natural and hatchery Chinook salmon smolts from the Imnaha River Trap to Lower Granite Dam during the migration years 1993 to 2013. Error bars represent 95% confidence intervals. The negative trend in survival of hatchery Chinook over time was not significant.

Steelhead Survival to LGR

Juvenile steelhead survival from the Imnaha River Trap to LGR was estimated from MY1994 – MY2013 for natural and hatchery-origin smolts. Natural steelhead survival averaged 86% (SD ± 5.1) and ranged from 79% to 99.9% (Figure 5.28). There was not a significant trend in survival over time for natural steelhead ($p = 0.32$). Average survival was slightly higher over the last half of the record but with considerable interannual variation (Figure 5.28). Migration year 2011 showed below average survival to LGR but MY2012 and MY2013 were both above average with MY2013 having the highest estimated survival on record.

Hatchery steelhead survival to LGR was nearly identical to natural steelhead on average but varied considerably from natural steelhead within years. Hatchery steelhead survival also averaged 86% (SD ± 7.8%) and ranged from 65% to 99.9% (Figure 5.28). Unlike natural steelhead, there was a significant positive trend in survival over time for hatchery steelhead ($p = 0.0006$, $r^2 = 0.51$). Survival was 10% above average in MY2011 and 6% above average in 2012. Survival in MY2013 was just above average (0.5%). Unlike Chinook salmon, there was no relationship between survival of natural and hatchery-origin steelhead ($p = 0.67$; Figure 5.28). Therefore, factors that lead to increased mortality or residualization of natural steelhead smolts do not necessarily have the same effects on hatchery steelhead smolts.

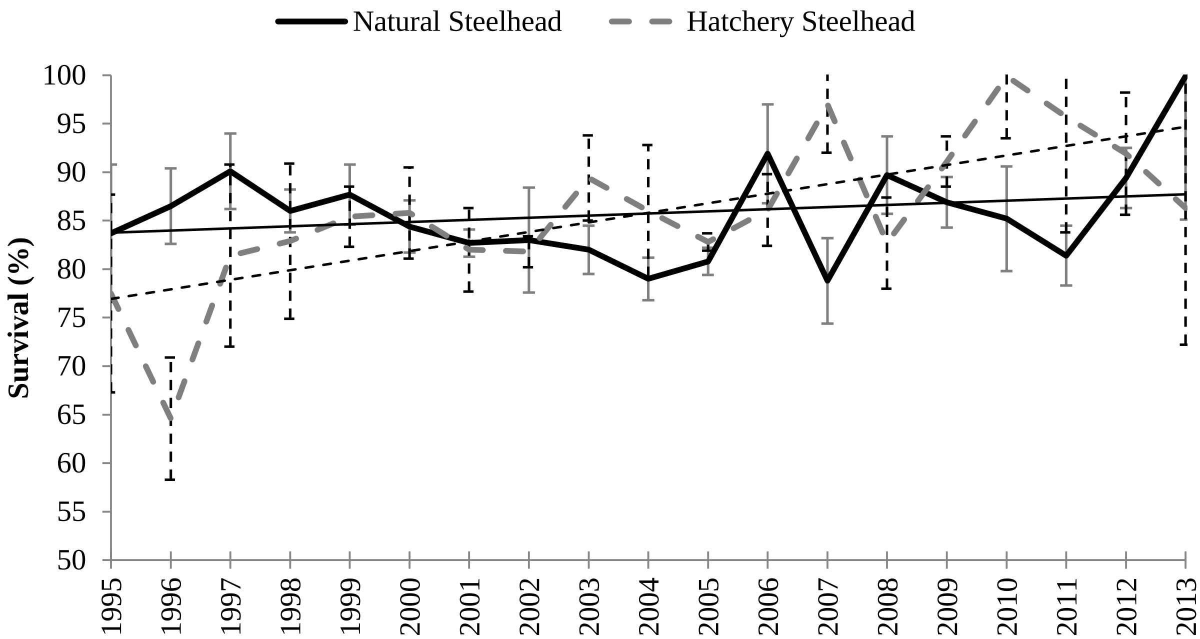

Figure 5.28. Estimated survival and associated trend lines for natural and hatchery-origin steelhead smolts from the Imnaha River Trap to Lower Granite Dam during the migration years 1995 to 2013. Error bars represent 95% confidence intervals. Natural steelhead survival was not significantly correlated with time ($p = 0.32$) but hatchery steelhead showed a significant positive trend in survival over time ($p = 0.0006$, $r^2 = 0.51$).

Smolt Survival from the Imnaha River to McNary Dam (MCN)

Recent alterations in management of the hydrosystem since 2005 have systematically changed the proportion and/or volume of water that is spilled over the four Snake River dams. To investigate whether survival has changed in response to the altered spill regime, in the following section we report survival to MCN over time, survival in relation to Snake River discharge, survival in relation to spill volume, and survival in relation to the percent of discharge that is spilled. The metrics of discharge, spill volume, and spill % were averaged over April and May and over the four Snake River Dams to encompass most of the migration span within each year. Survival estimates were available from MY1998 to MY2013. Data for discharge and spill at each of the dams during these years was obtained from Columbia River DART at http://www.cbr.washington.edu/dart.

Chinook Salmon Survival to MCN

Natural Chinook salmon had the highest survival to MCN of the four origins and species of salmon and steelhead. Natural Chinook salmon survival to MCN averaged 64% (SD ± 8.9%) with a minimum of 47% in the drought year of 2001 and a maximum of 79% in 1998. The migration years of 2011 and 2013 were nearly four percent below average survival to MCN while MY2012 was almost 10% above average (Figure 5.29)

Hatchery Chinook salmon displayed lower survival than natural-origin Chinook salmon to MCN as they did to LGR (Figure 5.29). Hatchery Chinook salmon survival averaged 56% (SD ± 7.4%) to MCN and ranged from 42% in 2012 to 67% in 2009. Hatchery Chinook salmon survival to MCN in MY2011 was 5% above average, 13% below average in MY2012, and MY2013 was 1% above average. Unlike survival to LGR, survival to MCN was not correlated for natural and hatchery Chinook salmon ($p = 0.30$).

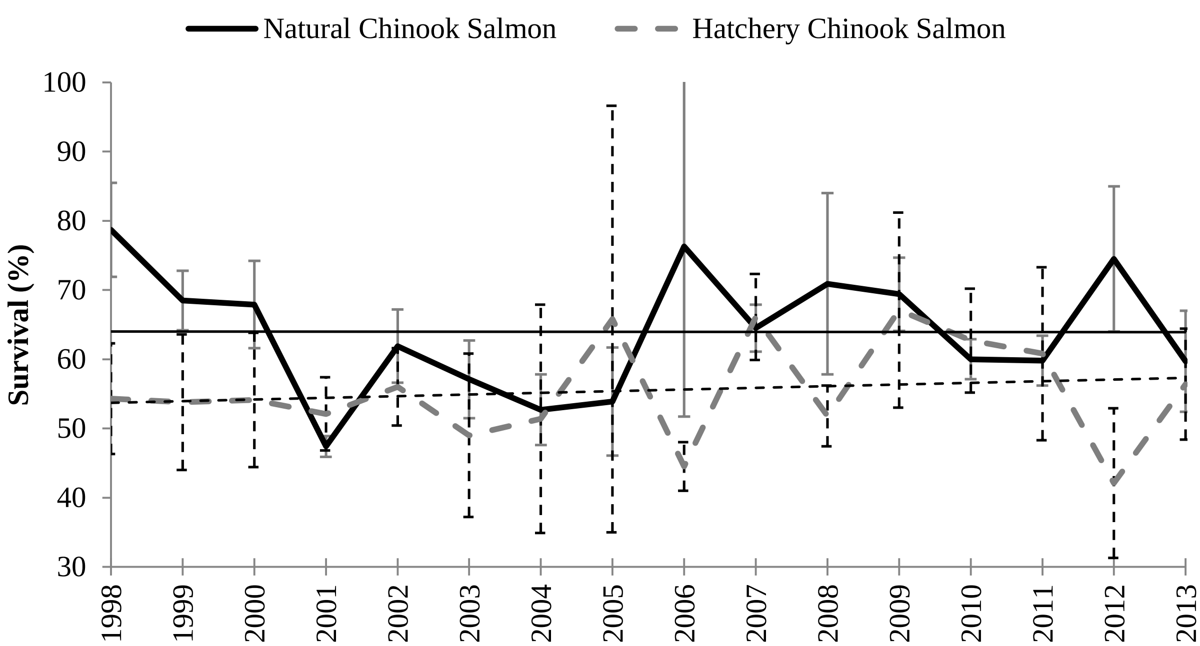

Figure 5.29. Estimated survival and associated trend lines for natural and hatchery Chinook salmon smolts from the Imnaha River Trap to McNary Dam during the migration years 1998 to 2013. Error bars represent 95% confidence intervals. There was no significant trend in survival over time for either origin of Chinook salmon.

Steelhead Survival to MCN

Juvenile natural steelhead survival to MCN was almost 10% lower on average than natural Chinook salmon and was more variable. Natural steelhead survival averaged 55% (SD ± 14.7%) and ranged from a paltry 18% during the drought of 2001 to a maximum of 76% in MY2012 (Figure 5.30). Natural steelhead survival to MCN in MY2011 was 12% above average, 21% above average in MY2012, and MY2013 matched the average survival over the course of the study.

Hatchery steelhead survival to MCN was slightly higher on average than natural steelhead (Figure 5.30). Average hatchery steelhead survival to MCN was 60% (SD ± 20.4%). Survival to MCN ranged from 14% during drought conditions in MY2001 to 89% in MY2012. Hatchery steelhead survival in MY2011 was 13% above average, 29% above average in MY2012, and MY2013 was 15% above average.

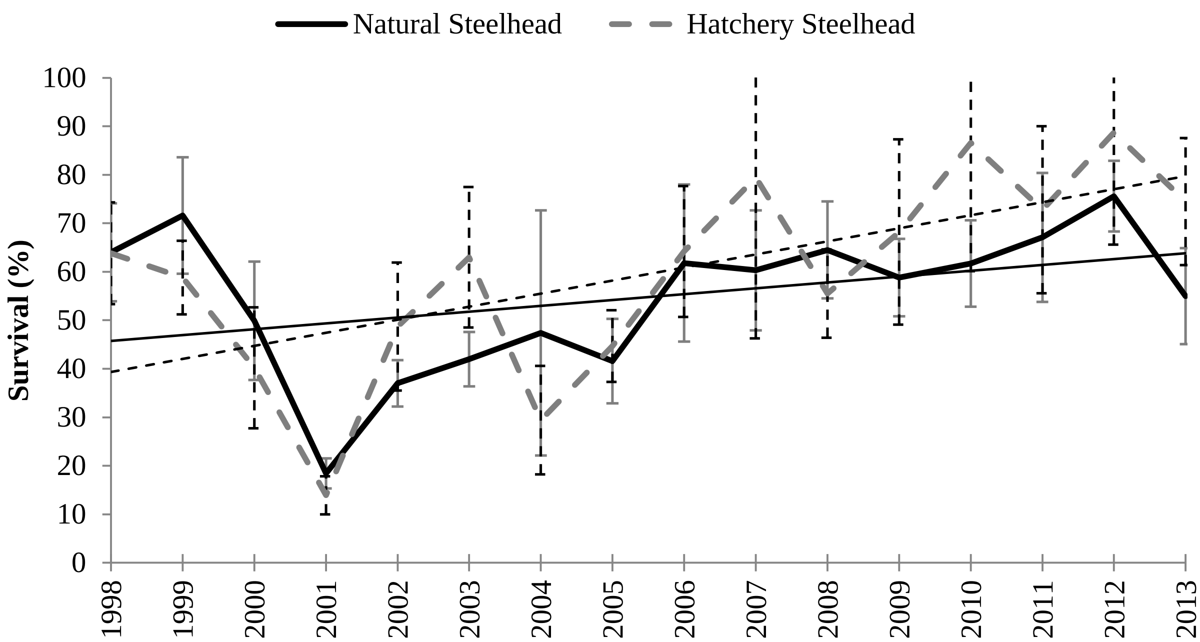

Figure 5.30. Estimated survival and associated trend lines for natural and hatchery steelhead smolts from the Imnaha River Trap to McNary Dam during the migration years 1998 to 2013. Error bars represent 95% confidence intervals. The positive correlation between survival and time was not significant for natural-origin steelhead ($p = 0.135$) but was significant for hatchery steelhead ($p = 0.009$)

Juvenile survival to MCN versus time and hydrographic and hydrosystem variables

Survival over time was analyzed for natural and hatchery-origin salmon and steelhead. Natural Chinook salmon showed no discernible trend in survival over time ($p = 0.992$; Table 5.7) in contrast to the significant negative trend over time they displayed in survival to LGR. Hatchery Chinook salmon and natural steelhead displayed a positive trend in survival over time but neither trend was statistically significant (p values of 0.57 and 0.14 respectively). Hatchery steelhead showed a strong significant positive trend in survival over time with the slope of the line fitting a 2.7% annual increase in survival ($p = 0.009$, $r^2 = 0.40$; Table 5.7; Figure 5.30).

Regressions of survival to MCN showed multiple significant positive responses to environmental variables as smolts passed through the hydrosystem. Natural Chinook salmon and natural steelhead showed significantly improved survival with increases in Snake River discharge ($p = 0.002$ and 0.011 respectively; Table 5.7). The slope of the line predicted a 0.26% increase in survival for natural Chinook salmon and a 0.38% increase for steelhead with each 1,000 cfs increase in Snake River discharge. Hatchery steelhead displayed a positive trend in survival with Snake River discharge but this relationship was not significant ($p = 0.18$; Table 5.7). Interestingly, hatchery Chinook salmon showed a negative trend in survival with Snake River discharge though this relationship was not significant ($p = 0.178$).

Positive relationships with spill volume and percentage were evident for most smolt groups. Survival significantly increased with spill volume for natural Chinook salmon, natural steelhead, and hatchery steelhead ($p = 0.001$, 0.000, and 0.013 respectively; Table 5.7). Trend line slopes predicted survival increases of 0.94% for hatchery steelhead, 0.88% for natural steelhead, and 0.51% for natural Chinook salmon with each 1000 cfs increase in average spill at the four Snake River Dams. In contrast, hatchery Chinook salmon showed a non-significant negative trend in survival vs. spill volume ($p = 0.415$; Table 5.7). As with spill volume, natural Chinook salmon, natural steelhead, and hatchery steelhead had significant increases in survival with increases in percentage spilled at the four Snake River dams ($p = 0.020$, 0.001, and 0.000 respectively; Table 5.7). Line slopes indicated survival increases of 1.45% for hatchery steelhead, 1.00% for natural steelhead, and 0.46% for natural Chinook salmon with each 1% increase in spill percentage. Hatchery Chinook salmon showed a very slight positive trend in survival with spill % but the trend was far from significant ($p = 0.812$; Table 5.7).

Table 5.7. Results of survival to McNary Dam regressed versus time, discharge, spill volume, and spill percentage for natural and hatchery juveniles from migration years 1998 – 2013. Discharge and spill were averaged across April and May and across the four Snake River Dams for each year. Significant regressions are italicized. All significant regressions showed a positive trend.

	Survival vs. Time		Survival vs. Discharge		Survival vs. Spill Volume		Survival vs. Spill %	
Origin and Species	P Value	r^2	P Value	r^2	P Value	r^2	P Value	r^2
Natural Chinook	0.992	0.00	*0.002*	0.50	*0.001*	0.55	*0.020*	0.33
Hatchery Chinook	0.569	0.02	0.178	0.13	0.415	0.05	0.812	0.00
Natural Steelhead	0.135	0.15	*0.011*	0.38	*0.000*	0.63	*0.001*	0.58
Hatchery Steelhead	*0.009*	0.40	0.180	0.12	*0.013*	0.37	*0.000*	0.63

Natural and anthropogenic differences existed in the Snake River above and through the hydrosystem over the period of survival to MCN estimation (MY1998 – MY2013). Average discharge was 16% higher in April and May on average during the years after the implementation of court ordered spill in 2006 (Table 5.8; Figure 5.31). This change in the hydrograph is a combination of natural upriver patterns in precipitation and the management of releases from upstream reservoirs. This increase in discharge would be expected to increase survival for natural-origin juveniles given their positive relationship with discharge reported above. Average spill volume across the four Snake River dams in April and May before 2006 was 24,231 cfs and increased to 35,755 cfs from 2006 – 2013; a rise of 48% (Table 5.8; Figure 5.31). Correspondingly, the average spill percentage rose from 27% before 2006 to 39% afterward. The largest sources for the change in spill volume and percentage arose from Little Goose and Lower Monumental dams, which averaged 20% and 14% spill in April and May before court ordered spill. Average (geometric mean) survival to LGR decreased for natural and hatchery Chinook (-3.4% and -0.7% respectively) and increased for natural and hatchery steelhead (4.5% and 6.7% respectively) in the years after the court ordered spill. In contrast, survival to MCN increased for all juvenile groups after 2006 and the increases were dramatic for steelhead but may be just as significant for Chinook given the change from a negative trend to LGR to a positive trend to MCN after 2006 (Table 5.9).

Table 5.8. Discharge, spill, and spill percentage averaged across the four Snake River dams in April and May from 1998 to 2013. Values are separated before and after the implementation of court ordered spill in 2005.

Time Period	Average Discharge at Snake River Dams (cfs)	Average Spill at Snake River Dams (cfs)	Average Spill % at Snake River Dams
1998 - 2005	80,210	24,231	27
2006 - 2013	92,626	35,755	39
Difference	12,416	7,409	12

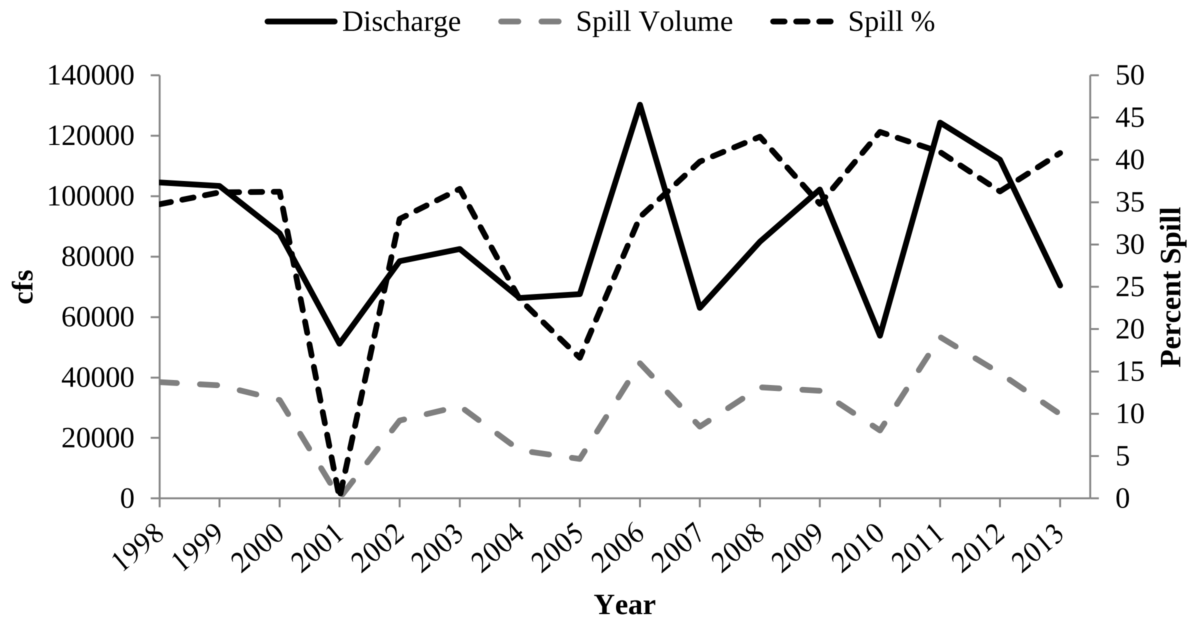

Figure 5.31. Average discharge, spill volume, and spill percentage across the four Snake River dams during April and May from 1998 – 2013. Court ordered spill was implemented beginning in 2006. Note that spill % is on a secondary y-axis.

Table 5.9 Average (geometric mean) survival of Imnaha River origin juvenile Chinook salmon and steelhead. Values are separated into the period prior to and after court ordered summer spill began at the four Snake River dams in 2006.

	Time Period	Natural Chinook Salmon	Hatchery Chinook Salmon	Natural Steelhead	Hatchery Steelhead
Survival to LGR	1998 - 2005	81.3	71.4	83.2	84.5
	2006 - 2013	77.9	70.6	87.7	91.2
	Difference	-3.4	-0.7	4.5	6.7
Survival to MCN	1998 - 2005	60.3	54.4	43.5	41.3
	2006 - 2013	66.6	55.7	62.8	73.0
	Difference	6.3	1.3	19.3	31.7

Our results show that survival has improved to MCN in the years after compared to the years prior to court ordered spill. Causality cannot be determined from our results and in a large heteroscedastic system such as the Snake River, a host of confounding natural and anthropogenic factors likely lead to changes in survival before and after the implementation of court ordered spill. Given this caveat, the change in direction from lower survival for Chinook salmon to LGR to a higher survival to MCN in the post-spill years suggests that alterations in management of the hydrosystem are likely a source of increased survival. If this were not the case, then increases in survival might be expected for to LGR as well as to MCN. Furthermore, the magnitude of the increase in survival after 2006 for natural and hatchery-origin steelhead reinforces the assumption that changes in spill are positively affecting survival. A comparison of survival in two low flow years provides an example of the possible benefits of spill. The years of 2001 and 2010 showed the lowest average discharge through the Snake River hydrosystem in April and May from 1998 – 2013 (51,181 cfs in 2001 and 53,867 cfs in 2010). There was essentially no spill (0.05% average) during April and May in 2001 while the same span in 2010 had an average of 43% spill across the Snake River dams. While the proportion of spill in 2010 was high, the actual volume of spill was low and only three years showed lower spill volume than 2010 between 1998 and 2013. Survival to MCN was poor across all groups of Imnaha River juvenile emigrants in 2001 and the poorest on record for natural Chinook and natural and hatchery steelhead. Contrastingly, survival to MCN in 2010 was slightly below average for natural Chinook but was above average for hatchery Chinook and well above average for both steelhead groups. In fact survival to MCN for 2010 was the second highest estimate recorded for natural steelhead (86.6%). Our results discussed above support the survival findings of the Comparative Survival Study (CSS). In the post spill years the CSS has found a dramatic reduction in travel time through the hydrosystem and a concomitant increase in survival (CSS 2014).

Smolt to adult return index rates

Smolt to adult return index rates for Chinook salmon

Adult returns in 2014 allowed for the estimation of smolt to adult return (SAR) index rates for BY2006 through BY2009 for Chinook salmon and MY2009 through MY2012 for steelhead. SARs for BY1995 – BY2005 for Chinook salmon and MY2000 – MY2008 can be found in the IRSMP annual report for MY2010 (Hatch et al. 2014). SAR index rates for survival mode tags only were calculated from LGR to LGR. These should be considered SAR index rates because they were not representative of the entire brood year population and only fully represent juveniles that were collected at a transportation bypass facility but shunted back to the river. They do not represent monitor mode tags that were transported if collected at a juvenile facility, nor do they fully represent segments of the population which were spilled over one or more dams. However, they were useful as a means to analyze and compare annual variation and the origin effects on survival to the adult life stage.

Adult detections in 2014 completed the estimation of SAR index rates for BY2009 Chinook salmon. Relying on PIT tag interrogations resulted in small sample sizes (few adult PIT tag detections) during some years. Due to low numbers of survival tags recaptured at IMNTRP for hatchery Chinook salmon and low overwinter survival for natural fall tagged presmolts, the number of survival tags for SAR estimation for these two groups was only about one quarter of the number available for natural smolts (Table 5.10). Therefore, our confidence in the accuracy of SARs for natural spring smolts is higher than for fall presmolts or hatchery smolts and it is difficult to conclusively determine the validity of differences in SARs between the three groups of Chinook salmon.

SARs were highest from BY2006 for natural and hatchery-origin Chinook salmon and dropped successively each year through BY2009. SARs for fall-tagged presmolts were as high as 7.46% from BY2006 and dropped to 1.01% from BY2009. Fall presmolts showed a geometric mean SAR from LGR to LGR of 2.72%, which was the highest of the three Chinook salmon groups (Table 5.10). Therefore, the higher rate of return as adults for fall presmolts may eliminate some of the deficit in survival to LGR that this group shows compared to spring-tagged natural smolts. Hatchery Chinook salmon had the next highest geometric mean SAR at 1.32%. Hatchery Chinook salmon SARs ranged from a BY2006 high of 4.06% to a low of 0.36% from BY2009 (Table 5.10). Natural spring-tagged Chinook had the lowest geometric mean SAR of 0.88%. Natural smolt SARs ranged from 2.63% from BY2006 to 0.15% from BY2009 (Table 5.10).

Hatchery Chinook salmon smolts and fall presmolts tended to return at earlier ages than natural smolts. Three percent of hatchery smolts returned as age two minijacks, 50% at age three, 47% at age four, and 3% at age five. Five percent of presmolts returned as age two minijacks, 42% at age three, 47% at age four, and 5% at age five. One percent of natural smolts returned as age two minijacks, 10% at age three, 71% at age four, and 17% at age five (Table 5.10).

Table 5.10. Smolt to adult return (SAR) index rates from Lower Granite Dam (LGR) to LGR for passive integrated transponder (PIT) tagged, survival mode (in-river migration) Imnaha River Chinook salmon for brood years 2006 to 2009. Brood year included fish tagged in the fall of one year and spring of the following year (i.e. Brood year 2006 were tagged in migration year 2008 during the fall of 2007 and spring of 2008). Hatchery Chinook were recaptured but not tagged at the Imnaha River Trap. Geomean = geometric mean.

Brood Year	PIT - tags at Imnaha Trap	PIT - tagged Smolts at LGR	Adult Detections at LGR	Age at Return				SAR Index LGR to LGR (%)
Hatchery Chinook Salmon				II	III	IV	V	
2006	911	493	20	1	12	8	--	4.06
2007	537	303	4	--	--	4	--	1.32
2008	966	310	5	--	2	2	1	1.61
2009	523	281	1	--	1	--	--	0.36
Geometric Mean								1.32
Fall Presmolts								
2006	1,198	362	27	1	17	7	2	7.46
2007	1,336	463	14	--	2	11	1	3.02
2008	3,177	455	11	--	4	7	--	2.42
2009	1,037	297	3	2	--	1	--	1.01
Geometric Mean								2.72
Spring Smolts								
2006	1,642	1,103	29	--	1	21	7	2.63
2007	3,076	2,251	40	--	5	29	6	1.78
2008	3,962	1,812	16	--	3	11	2	0.88
2009	2,069	1,378	2	1	--	1	--	0.15
Geometric Mean								0.88

Smolt to adult return index rates for steelhead

Juvenile natural steelhead emigrate at variable ages and thus it was impossible to analyze their brood year SAR index rates. For this analysis we evaluated migration year SAR index rates assuming that these largely represented a single cohort as they passed the trap. Analysis for brood year and migration year are presented for hatchery steelhead. As with Chinook salmon, tagged steelhead were segregated into “survival” or run-of-river mode and “monitor-only” mode groups for survival analysis through the hydrosystem.

Adult returns in 2014 completed the MY2012 SAR index rate analyses for natural steelhead. As with Chinook salmon, the sample size of hatchery steelhead survival mode tags at LGR was less than 25% of natural steelhead tags. Therefore, our confidence in the accuracy of SARs is higher for natural steelhead than for hatchery steelhead.

Steelhead SARs did not demonstrate successive annual decreases as did Chinook salmon SARs. Natural steelhead SARs were highest from MY2010 (1.93%) and lowest from MY2011 (1.10%). Natural steelhead showed a geometric mean SAR of 1.45% (Table 5.11). Hatchery steelhead SARs were highest from MY2012 (2.03%) and lowest from MY2011 (0.98%). The geometric mean SAR for hatchery steelhead was slightly higher than for natural steelhead (1.64% vs. 1.45%).

Hatchery steelhead tended to return at a younger age than natural steelhead. Fifty six percent of natural steelhead returned as one salt adults, 42% as two salt adults, and 2% as three salt adults. Seventy three percent of hatchery steelhead returned as one salt adults, 27% as two salt adults, and none returned as three salt adults (Table 5.11).

Table 5.11. Smolt to adult return (SAR) index rates from Lower Granite Dam (LGR) to LGR for passive integrated transponder (PIT) tagged, survival mode (in-river juvenile migration) Imnaha River steelhead for migration years 2009 to 2012. Natural steelhead were tagged and hatchery steelhead were recaptured at the Imnaha River Trap. Geomean = geometric mean.

Brood Year	Migration Year	PIT - tags at Imnaha Trap	PIT - tagged Smolts at LGR	Adult Detections at LGR	Ocean Age at Return			SAR Index LGR to LGR (%)
Hatchery Steelhead					I	II	III	
2008	2009	608	429	8	8	--	--	1.86
2009	2010	566	304	6	5	1	--	1.97
2010	2011	288	204	2	1	1	--	0.98
2011	2012	511	296	6	2	4	--	2.03
Geometric Mean								1.64
Natural Steelhead								
	2009	2,598	1,812	32	18	14	--	1.77
	2010	3,070	1,452	28	14	13	1	1.93
	2011	1,418	908	10	4	5	1	1.10
	2012	2,309	1,518	18	13	5	--	1.19
Geometric Mean								1.45

Size and Condition of Juveniles at Emigration Over Time

Size and condition of juvenile emigrants has been evaluated at the Imnaha River Trap from 1994 - 2013. In the following sections we report patterns on the metrics of length, weight, and condition factor and their possible impact on the survival of juveniles through their migration to the Columbia River estuary. Refer to chapters 2, 3, and 4 for statistical tests of differences between origins within MY2011, MY2012, and MY2013.

Chinook Salmon size and condition

Natural Chinook smolt fork length has been somewhat variable over the IRSMP history. The long term average fork length for natural Chinook smolts was 102 mm (SD ± 4). From 1994 to 2003, mean natural Chinook smolt fork length vacillated between 99 and 110 mm. From 2004 to 2010 mean fork length was fairly stable between 98 and 100 mm. Fork length vacillated again between 95 and 102 mm from MY2011 to MY2013 (Figure 5.32; Appendix H). The 95 mm average fork length in MY2012 was the lowest average for natural Chinook smolts on record. Fork length for hatchery Chinook smolts was well above that of natural Chinook smolts for all years. Hatchery fish showed an average fork length of 120 mm (SD ± 7 mm); 26 mm larger than for natural Chinook salmon smolts. Hatchery Chinook salmon had a more variable pattern of fork length with fork length rising from 126 mm in MY1994 to 142 mm in MY2001 (Figure 5.32; Appendix H). Hatchery fork length dropped sharply in 2004 to 118 mm and has increased somewhat but stayed fairly stable since.

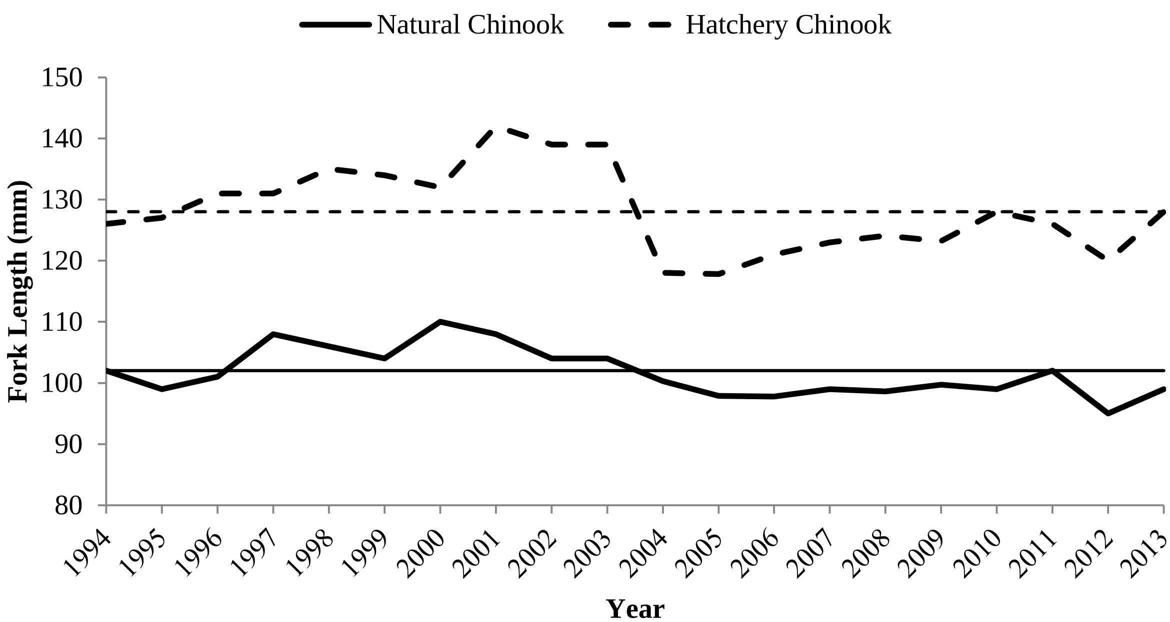

Figure 5.32. Average fork length (mm) over the spring trapping season for natural and hatchery Chinook salmon smolts from 1994 to 2013. The horizontal lines represent the average fork length for each origin.

Patterns in weight have generally mirrored fork length for natural and hatchery Chinook salmon from 1994 - 2013. Average smolt weight was 11.7 g (SD ± 1.1) for natural Chinook salmon and 24.0 g (SD ± 3.5) for hatchery Chinook salmon. Weight was at or slightly below average for both origins during MY2011 – MY2013 (Figure 5.33).

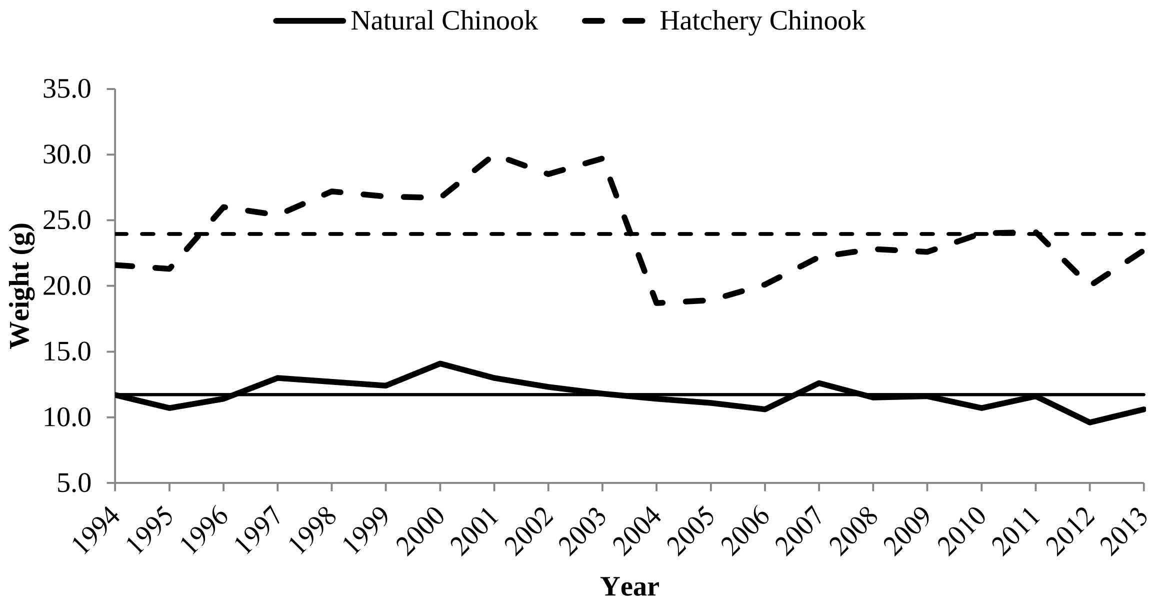

Figure 5.33. Average weight (g) over the spring trapping season for natural and hatchery Chinook salmon smolts from 1994 to 2013. The horizontal lines represent the average weight for each origin.

Condition factor (K) was very similar for natural and hatchery Chinook salmon. Average K from 1994 – 2013 was 1.11 for natural Chinook salmon and ranged from 1.03 in 1997 to 1.30 in 2007. Average K was 1.13 for hatchery Chinook and ranged from 1.04 to 1.21 (Figure 5.34; Appendix H). Condition factor for both origins has been higher after than prior to 2005.

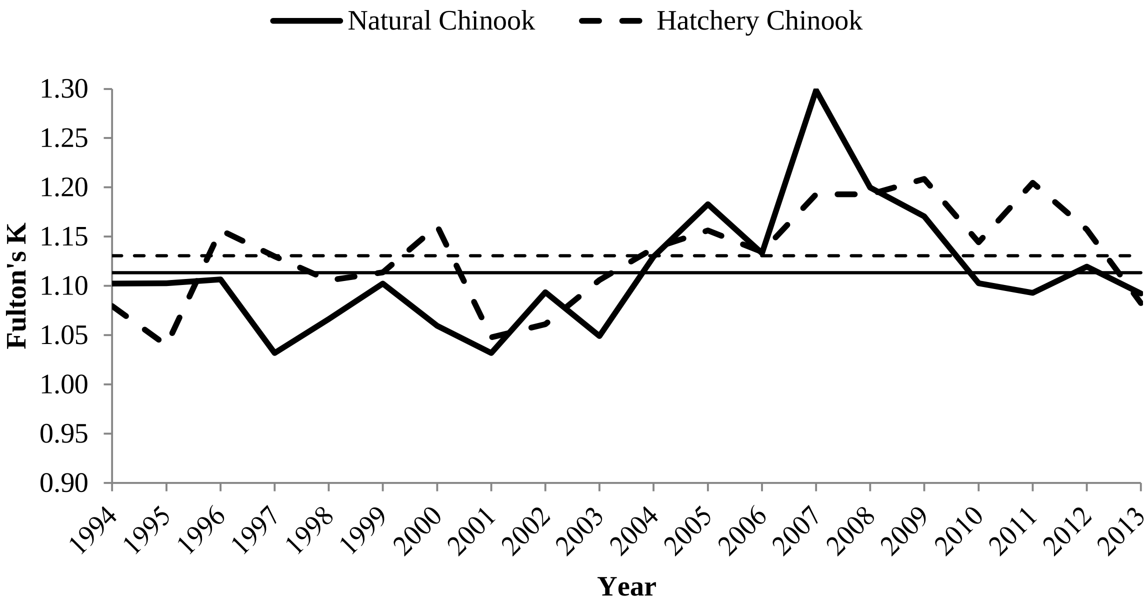

Figure 5.34. Average condition factor (Fulton's K) over the spring trapping season for natural and hatchery Chinook salmon smolts from 1994 to 2013. The horizontal lines represent the average condition factor for each origin.

Steelhead size and condition

Natural and hatchery steelhead showed consistently different fork length over the project's history. The average fork length for natural steelhead smolts was 173 mm (SD ± 5). Length was generally above average through 2001 and at or below average afterward. Fork length was average in MY2011, three mm below average in MY2012, and four mm below average in MY2013 (Figure 5.35; Appendix I). Fork length for hatchery steelhead smolts was well above that of natural smolts for all years. Hatchery fish showed an average fork length of 214 mm (SD ± 6 mm); 41 mm larger than for natural steelhead smolts. Hatchery steelhead fork length was below average before 1998 and in 2012 – 2013. Length was generally above average from 1998 to 2011. (Figure 5.35; Appendix I).

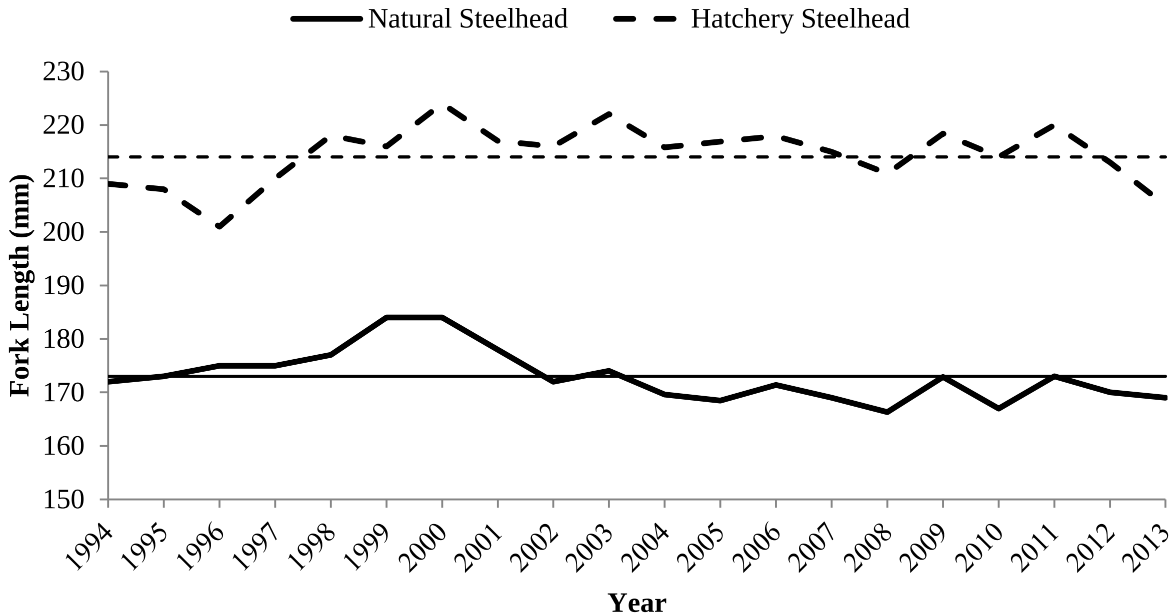

Figure 5.35. Average fork length (mm) over the spring trapping season for natural and hatchery steelhead smolts from 1994 to 2013. The horizontal lines represent the average fork length for each origin.

As with Chinook salmon, patterns in weight generally mirrored fork length for natural and hatchery steelhead. Average smolt weight was 53.9 g (SD ± 3.8) for natural steelhead and 99.7 g (SD ± 8.9) for hatchery Chinook salmon. Weight was at or slightly below average for natural steelhead during MY2011 – MY2013. Weight was above average in MY2011 and below average in MY2012 and MY2013 for hatchery steelhead (Figure 5.36; Appendix I).

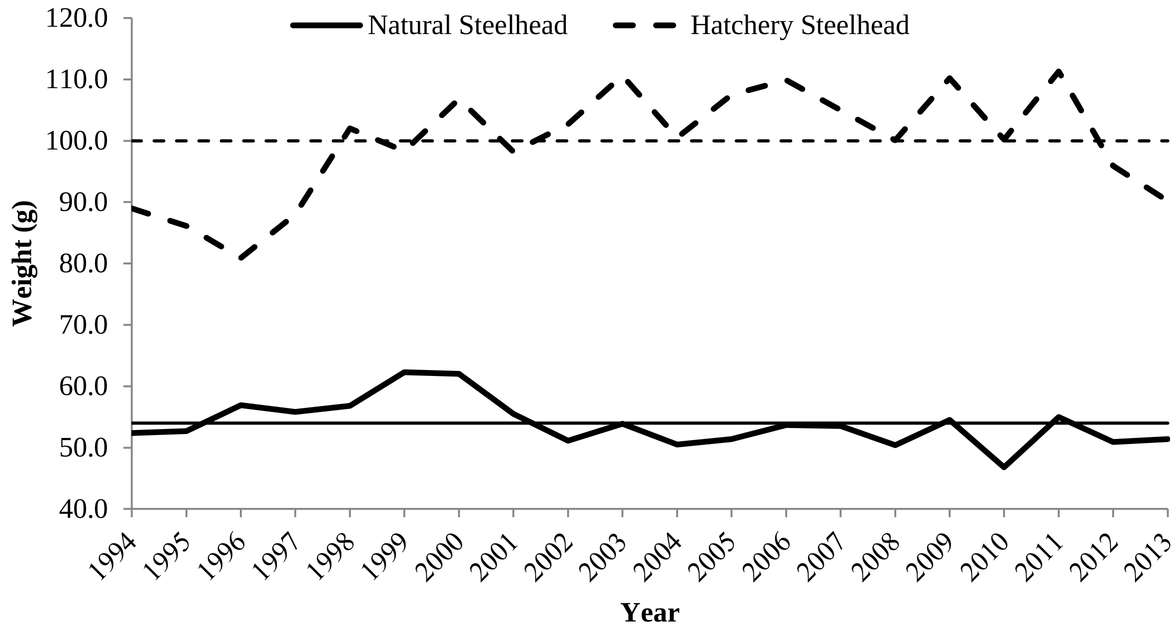

Figure 5.36. Average weight (g) over the spring trapping season for natural and hatchery steelhead smolts from 1994 to 2013. The horizontal lines represent the average weight for each origin.

Condition factor was lower for steelhead of both origins than for Chinook salmon. Average condition factor was 1.04 (SD ± 0.03) for natural steelhead and 1.01 (SD ± 0.04) hatchery steelhead (Figure 5.37). Interestingly, condition factor for both origins followed a similar general pattern despite vastly different rearing histories.

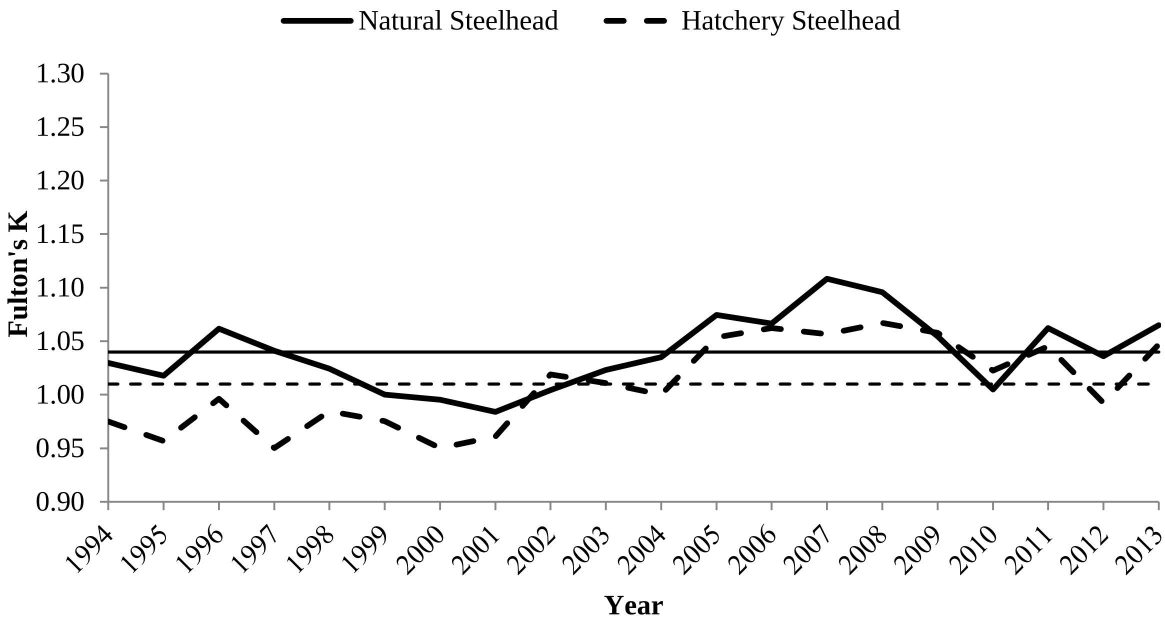

Figure 5.37. Average condition factor (Fulton’s K) over the spring trapping season for natural and hatchery steelhead smolts from 1994 to 2013. The horizontal lines represent the average for each origin.

Relationship Between Juvenile Survival and size

The data collected by the Imnaha River Smolt Monitoring Project from 1994 – 2013 indicated that LSRCP hatchery programs produced significantly larger smolts than those reared naturally in the Imnaha River. Predation through the migration corridor and in the estuary, especially from Northern Pikeminnow (Rieman et al. 1991, Zimmerman 1999), is likely a large source of mortality for Imnaha River emigrants, as it is for other Columbia Basin anadromous fish. Size has been shown to be inversely related to mortality in freshwater and marine habitat (Neilson and Geen 1986, Holtby et al. 1990, Muir et al. 2006, Bond et al. 2008, Claiborne et al. 2011). Larger fish are more likely to have the locomotive capacity to escape predators. In addition a larger body size will exceed the gape limitations of smaller predatory fish and cause increased handling time upon capture. Research has shown predation in the Columbia River estuary is higher on juveniles smaller than 150 mm in total length (Muir et al. 2006). However, less than one percent of hatchery and natural Chinook salmon smolts left the Imnaha River in MY2011 through MY2013 with a length longer than 150 mm. Therefore, though hatchery Chinook salmon were consistently larger, their larger size likely did not provide a survival benefit compared to natural smolts unless sufficient growth was added during migration to be beneficial in the estuary. This assumption is supported by Feldhaus et al. (2015) who found no differences in survival or SARs between paired experimental releases of large and small Imnaha River hatchery Chinook salmon. Natural Chinook salmon which emigrated during the fall as presmolts would likely have a larger body size than individuals leaving the Imnaha River as smolts in the spring due to overwintering in the warmer and more productive Snake River above LGR. In contrast, 99% of hatchery steelhead and 85% of natural steelhead emigrated from the Imnaha River with a length greater than 150 mm from MY2011 through MY2013. Consequently, most steelhead would be at a lower risk of predation based on size regardless of origin.

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Appendices

Appendix A.1 The number of hours sampled and the catch, including subsample estimates, of natural-origin and hatchery-origin Chinook salmon and steelhead at the Imnaha River juvenile emigrant trap from September 1, 2010 to August 31, 2011. Sampling periods exceeded 24 hours when trapping continued past the hour the trap was started from the previous day (e.g. 0800 on October 17 to 0845 on October 18). N/O indicates the trap was not operated on that date.

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
9/1/2010	24	1	0	0	0
9/2/2010	24	0	0	0	0
9/3/2010	24	0	0	1	0
9/4/2010	0	N/O	N/O	N/O	N/O
9/5/2010	0	N/O	N/O	N/O	N/O
9/6/2010	0	N/O	N/O	N/O	N/O
9/7/2010	14	3	0	0	0
9/8/2010	28	0	0	0	0
9/9/2010	21	2	0	1	0
9/10/2010	24	0	0	2	0
9/11/2010	0	N/O	N/O	N/O	N/O
9/12/2010	0	N/O	N/O	N/O	N/O
9/13/2010	12	0	0	1	0
9/14/2010	26	0	0	1	0
9/15/2010	22.5	0	0	0	0
9/16/2010	26	2	0	0	0
9/17/2010	23	0	0	0	0
9/18/2010	0	N/O	N/O	N/O	N/O
9/19/2010	0	N/O	N/O	N/O	N/O
9/20/2010	24	0	0	0	0
9/21/2010	19.5	0	0	1	0
9/22/2010	24.5	0	0	0	0
9/23/2010	23.5	0	0	0	0
9/24/2010	24	3	0	0	0
9/25/2010	0	N/O	N/O	N/O	N/O
9/26/2010	0	N/O	N/O	N/O	N/O
9/27/2010	18	0	0	0	0
9/28/2010	24	0	0	0	0
9/29/2010	24	0	0	0	0
9/30/2010	25	0	0	0	0
10/1/2010	24	0	0	0	0
10/2/2010	25	0	0	0	0
10/3/2010	23	2	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
10/4/2010	23	1	0	0	0
10/5/2010	25	25	0	0	0
10/6/2010	23.5	21	0	0	0
10/7/2010	24	22	0	10	0
10/8/2010	24	30	0	11	0
10/9/2010	24	25	0	3	0
10/10/2010	24	18	0	0	0
10/11/2010	23	13	0	1	0
10/12/2010	24	26	0	3	0
10/13/2010	24	31	0	4	0
10/14/2010	25	83	0	13	0
10/15/2010	24	41	0	16	0
10/16/2010	24	54	0	0	0
10/17/2010	24	39	0	0	0
10/18/2010	24	83	0	0	0
10/19/2010	24	80	0	0	0
10/20/2010	24	82	0	0	0
10/21/2010	23	104	0	28	0
10/22/2010	24	44	0	31	0
10/23/2010	24	25	0	24	0
10/24/2010	24	4	0	33	0
10/25/2010	24	42	0	1	0
10/26/2010	27.5	253	0	35	0
10/27/2010	21.5	179	0	8	0
10/28/2010	25	198	0	0	0
10/29/2010	23	133	0	0	0
10/30/2010	24	280	0	0	0
10/31/2010	24	273	0	0	0
11/1/2010	25	300	0	0	0
11/2/2010	24	110	0	0	0
11/3/2010	24	68	0	0	0
11/4/2010	24	58	0	0	0
11/5/2010	23.5	51	0	0	0
11/6/2010	24	173	0	3	0
11/7/2010	25	195	0	3	0
11/8/2010	24	605	0	8	0
11/9/2010	27.5	3015	0	60	0
11/10/2010	21.5	1591	0	31	0
11/11/2010	27	2167	0	0	0
11/12/2010	22	150	0	0	0
11/13/2010	23	321	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
11/14/2010	24	394	0	0	0
11/15/2010	24	251	0	0	0
11/16/2010	24	195	0	0	0
11/17/2010	24	245	0	0	0
11/18/2010	23.5	198	0	27	0
11/19/2010	24	211	0	7	0
11/20/2010	23.5	107	0	11	0
11/21/2010	24	153	0	7	0
11/22/2010	24	50	0	6	0
11/23/2010	24	33	0	1	0
11/24/2010	24	11	0	0	0
11/25/2010	0	N/O	N/O	N/O	N/O
11/26/2010	0	N/O	N/O	N/O	N/O
11/27/2010	0	N/O	N/O	N/O	N/O
11/28/2010	0	N/O	N/O	N/O	N/O
11/29/2010	17	309	0	0	0
11/30/2010	23	296	0	0	0
12/1/2010	23.5	205	0	0	0
12/2/2010	23.5	317	0	4	0
12/3/2010	24	197	0	5	0
12/4/2010	24	149	0	0	0
12/5/2010	24	109	0	1	0
12/6/2010	24	101	0	3	0
12/7/2010	24	148	0	0	0
12/8/2010	24	173	0	0	0
12/9/2010	25	136	0	0	0
12/10/2010	23.5	131	0	0	0
12/11/2010	24	43	0	0	0
12/12/2010	24	50	0	0	0
12/13/2010	24	67	0	0	0
12/14/2010	24	54	0	0	0
12/15/2010	25	366	0	0	0
12/16/2010	23	53	0	1	0
12/17/2010	24	103	0	1	0
12/18/2010	24	79	0	0	0
12/19/2010	24	102	0	2	0
12/20/2010	24	23	0	0	0
12/21/2010	24	53	0	0	0
12/22/2010	23.5	42	0	0	0
12/23/2010	24.5	41	0	1	0
12/24/2010	0	1	0	0	0
12/25/2010	0	0	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
12/26/2010	0	0	0	0	0
12/27/2010	15.5	5	0	0	0
12/28/2010	24	6	0	0	0
12/29/2010	24	3	0	0	0
12/30/2010	24	3	0	1	0
12/31/2010	24	8	0	0	0
1/1/2011	0	N/O	N/O	N/O	N/O
1/2/2011	0	N/O	N/O	N/O	N/O
1/3/2011	0	N/O	N/O	N/O	N/O
1/4/2011	0	N/O	N/O	N/O	N/O
1/5/2011	0	N/O	N/O	N/O	N/O
1/6/2011	0	N/O	N/O	N/O	N/O
1/7/2011	0	N/O	N/O	N/O	N/O
1/8/2011	0	N/O	N/O	N/O	N/O
1/9/2011	0	N/O	N/O	N/O	N/O
1/10/2011	0	N/O	N/O	N/O	N/O
1/11/2011	0	N/O	N/O	N/O	N/O
1/12/2011	0	N/O	N/O	N/O	N/O
1/13/2011	18	13	0		0
1/14/2011	23.5	3	0		0
1/15/2011	25	5	0		0
1/16/2011	23.5	1	0		0
1/17/2011	24	0	0		0
1/18/2011	13	1	0		0
1/19/2011	0	N/O	N/O	N/O	N/O
1/20/2011	15	106	0	9	0
1/21/2011	13	29	0	2	0
1/22/2011	17	88	0	2	0
1/23/2011	24	36	0	3	0
1/24/2011	24	4	0	0	0
1/25/2011	25	18	0	0	0
1/26/2011	23	8	0	0	0
1/27/2011	24	0	0	0	0
1/28/2011	24	3	0	0	0
1/29/2011	24	2	0	0	0
1/30/2011	24	0	0	0	0
1/31/2011	24	10	0	1	0
2/1/2011	24	3	0	0	0
2/2/2011	9.5	0	0	0	0
2/3/2011	0	N/O	N/O	N/O	N/O
2/4/2011	0	N/O	N/O	N/O	N/O
2/5/2011	15.5	3	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
2/6/2011	24	4	0	0	0
2/7/2011	24	5	0	1	0
2/8/2011	24	1	0	1	0
2/9/2011	24	2	0	1	0
2/10/2011	27	0	0	0	0
2/11/2011	21	7	0	0	0
2/12/2011	24	1	0	0	0
2/13/2011	24	1	0	0	0
2/14/2011	24	0	0	0	0
2/15/2011	24	0	0	0	0
2/16/2011	23.5	0	0	0	0
2/17/2011	14.5	2	0	0	0
2/18/2011	24	1	0	1	0
2/19/2011	24	1	0	0	0
2/20/2011	24	0	0	2	0
2/21/2011	24	0	0	0	0
2/22/2011	24	2	0	0	0
2/23/2011	24	2	0	0	0
2/24/2011	24	1	0	0	0
2/25/2011	24	1	0	0	0
2/26/2011	19.5	1	0	0	0
2/27/2011	0	N/O	N/O	N/O	N/O
2/28/2011	0	N/O	N/O	N/O	N/O
3/1/2011	23.25	4	0	0	0
3/2/2011	24	8	0	0	0
3/3/2011	24	6	0	1	0
3/4/2011	24	3	0	0	0
3/5/2011	24	4	0	1	0
3/6/2011	24	7	0	0	0
3/7/2011	24	1	0	0	0
3/8/2011	24	5	0	0	0
3/9/2011	24	5	0	0	0
3/10/2011	23.5	3	0	0	0
3/11/2011	24.75	3	0	0	0
3/12/2011	24	11	0	0	0
3/13/2011	25	5	0	0	0
3/14/2011	22.5	10	0	0	0
3/15/2011	24.5	45	0	1	0
3/16/2011	23	30	0	0	0
3/17/2011	12.25	60	0	3	0
3/18/2011	24.75	127	0	0	0
3/19/2011	23	47	0	4	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
3/20/2011	24.25	43	0	3	0
3/21/2011	24	22	0	1	0
3/22/2011	24	33	0	4	0
3/23/2011	24	59	0	2	0
3/24/2011	24	3	0	2	0
3/25/2011	23.75	18	0	4	0
3/26/2011	24	30	0	1	0
3/27/2011	24	42	0	2	0
3/28/2011	24	51	0	6	0
3/29/2011	24	42	0	1	0
3/30/2011	23.5	54	31	0	1
3/31/2011	26.5	145	18	3	41
4/1/2011	15	116	8	8	2
4/2/2011	0	N/O	N/O	N/O	N/O
4/3/2011	0	N/O	N/O	N/O	N/O
4/4/2011	15.5	144	701	39	365
4/5/2011	24.75	163	289	18	115
4/6/2011	22.5	110	362	7	161
4/7/2011	26.5	113	401	26	591
4/8/2011	20.25	83	542	7	326
4/9/2011	16.5	11	1332	10	175
4/10/2011	23.75	41	280	14	103
4/11/2011	15.75	14	1729	13	59
4/12/2011	24	16	3365	9	28
4/13/2011	22.75	24	4516	9	25
4/14/2011	14.5	21	4834	9	16
4/15/2011	20	22	2683	6	20
4/16/2011	23.25	3	643	2	7
4/17/2011	26	3	441	11	11
4/18/2011	22.5	20	764	19	55
4/19/2011	23.75	87	1497	27	104
4/20/2011	24	138	763	22	126
4/21/2011	26	52	352	19	88
4/22/2011	27.25	121	446	10	94
4/23/2011	21.5	61	104	18	48
4/24/2011	23.25	63	99	24	51
4/25/2011	24	76	88	35	41
4/26/2011	24.25	70	108	58	111
4/27/2011	23	84	115	60	128
4/28/2011	25	71	52	32	61
4/29/2011	14.5	92	54	78	388
4/30/2011	20.75	77	34	78	172

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
5/1/2011	25	59	27	43	115
5/2/2011	23	119	54	87	245
5/3/2011	25	112	30	158	313
5/4/2011	24.25	195	61	275	350
5/5/2011	24	118	34	228	353
5/6/2011	23.75	184	67	516	1273
5/7/2011	18.25	127	28	1196	1884
5/8/2011	11.25	1	0	0	0
5/9/2011	0	N/O	N/O	N/O	N/O
5/10/2011	22.5	38	5	322	449
5/11/2011	23.5	33	7	267	1432
5/12/2011	0	N/O	N/O	N/O	N/O
5/13/2011	0	N/O	N/O	N/O	N/O
5/14/2011	0	N/O	N/O	N/O	N/O
5/15/2011	0	N/O	N/O	N/O	N/O
5/16/2011	0	N/O	N/O	N/O	N/O
5/17/2011	0	N/O	N/O	N/O	N/O
5/18/2011	0	N/O	N/O	N/O	N/O
5/19/2011	0	N/O	N/O	N/O	N/O
5/20/2011	0	N/O	N/O	N/O	N/O
5/21/2011	0	N/O	N/O	N/O	N/O
5/22/2011	0	N/O	N/O	N/O	N/O
5/23/2011	0	N/O	N/O	N/O	N/O
5/24/2011	0	N/O	N/O	N/O	N/O
5/25/2011	10	20	1	43	48
5/26/2011	9.5	7	0	50	74
5/27/2011	0	N/O	N/O	N/O	N/O
5/28/2011	0	N/O	N/O	N/O	N/O
5/29/2011	0	N/O	N/O	N/O	N/O
5/30/2011	9.5	4	0	10	33
5/31/2011	9.5	0	0	3	6
6/1/2011	24.5	4	0	7	12
6/2/2011	24.75	0	0	8	13
6/3/2011	24	1	0	0	4
6/4/2011	0	N/O	N/O	N/O	N/O
6/5/2011	0	N/O	N/O	N/O	N/O
6/6/2011	0	N/O	N/O	N/O	N/O
6/7/2011	0	N/O	N/O	N/O	N/O
6/8/2011	0	N/O	N/O	N/O	N/O
6/9/2011	0	N/O	N/O	N/O	N/O
6/10/2011	0	N/O	N/O	N/O	N/O
6/11/2011	11	0	0	6	6

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
6/12/2011	11.5	1	0	0	5
6/13/2011	16	5	0	6	5
6/14/2011	23	0	0	0	0
6/15/2011	11	0	0	1	2
6/16/2011	12	0	0	3	2
6/17/2011	13.5	3	0	3	8
6/18/2011	14.5	1	0	0	6
6/19/2011	24	8	1	1	3
6/20/2011	12.5	14	0	3	5
6/21/2011	24.5	5	0	1	10
6/22/2011	23	2	0	1	5
6/23/2011	22	5	0	7	9
6/24/2011	0	N/O	N/O	N/O	N/O
6/25/2011	0	0	0	0	0
6/26/2011	0	0	0	0	0
6/27/2011	10	5	0	0	6
6/28/2011	25.5	1	0	0	2
6/29/2011	25	0	0	0	2
6/30/2011	0	N/O	N/O	N/O	N/O
7/1/2011	0	N/O	N/O	N/O	N/O
7/2/2011	0	N/O	N/O	N/O	N/O
7/3/2011	0	N/O	N/O	N/O	N/O
7/4/2011	0	N/O	N/O	N/O	N/O
7/5/2011	0	N/O	N/O	N/O	N/O
7/6/2011	12.5	1	0	0	0
7/7/2011	24	2	0	0	1
7/8/2011	24	1	0	1	2
7/9/2011	0	N/O	N/O	N/O	N/O
7/10/2011	0	N/O	N/O	N/O	N/O
7/11/2011	11	1	0	0	0
7/12/2011	27	N/O	N/O	N/O	N/O
7/13/2011	23.5	3	0	0	0
7/14/2011	23.5	2	0	0	0
7/15/2011	24	1	0	0	0
7/16/2011	0	N/O	N/O	N/O	N/O
7/17/2011	0	N/O	N/O	N/O	N/O
7/18/2011	13.5	6	0	0	2
7/19/2011	24	4	0	0	1
7/20/2011	23	3	0	0	0
7/21/2011	24	5	0	1	0
7/22/2011	24.5	14	0	0	0
7/23/2011	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
7/24/2011	0	N/O	N/O	N/O	N/O
7/25/2011	11.25	7	0	0	0
7/26/2011	24	2	0	0	0
7/27/2011	23.5	4	0	0	0
7/28/2011	26	0	0	2	0
7/29/2011	24	1	0	2	1
7/30/2011	0	N/O	N/O	N/O	N/O
7/31/2011	0	N/O	N/O	N/O	N/O
8/1/2011	13	13	0	0	1
8/2/2011	25	4	0	0	0
8/3/2011	24	4	0	0	0
8/4/2011	24	0	0	0	0
8/5/2011	24	2	0	0	0
8/6/2011	0	N/O	N/O	N/O	N/O
8/7/2011	0	N/O	N/O	N/O	N/O
8/8/2011	15.5	6	0	0	0
8/9/2011	24.5	2	0	0	0
8/10/2011	24	1	0	0	0
8/11/2011	23	2	0	0	0
8/12/2011	24	2	0	0	0
8/13/2011	0	N/O	N/O	N/O	N/O
8/14/2011	0	N/O	N/O	N/O	N/O
8/15/2011	19	2	0	0	0
8/16/2011	23.5	2	0	0	0
8/17/2011	24	0	0	0	0
8/18/2011	25	0	0	0	0
8/19/2011	23.45	1	0	1	0
8/20/2011	0	N/O	N/O	N/O	N/O
8/21/2011	0	N/O	N/O	N/O	N/O
8/22/2011	19	2	0	0	0
8/23/2011	23	0	0	1	0
8/24/2011	24	1	0	0	0
8/25/2011	24	1	0	0	0
8/26/2011	0	N/O	N/O	N/O	N/O
8/27/2011	0	N/O	N/O	N/O	N/O
8/28/2011	23.5	2	0	0	0
8/29/2011	24	1	0	1	0
8/30/2011	24.5	0	0	0	0
8/31/2011	23.5	0	0	0	0
Fall Total	2,499	16,247	0	411	0
Spring Total	3,790	4,364	26,966	3,984	10,201
MY Total	6,289	20,611	26,966	4,395	10,201

Appendix A.2 The number of hours sampled and the catch, including subsample estimates, of natural-origin and hatchery-origin Chinook salmon and steelhead at the Imnaha River juvenile emigrant trap from September 5, 2011 to August 17, 2012. Sampling periods exceeded 24 hours when trapping continued past the hour the trap was started from the previous day (e.g. 0800 on October 17 to 0845 on October 18). N/O indicates the trap was not operated on that date.

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
9/5/2011	24	0	0	0	0
9/6/2011	24	0	0	0	0
9/7/2011	24	0	0	0	0
9/8/2011	24	1	0	1	0
9/9/2011	0	N/O	N/O	N/O	N/O
9/10/2011	0	N/O	N/O	N/O	N/O
9/11/2011	0	N/O	N/O	N/O	N/O
9/12/2011	16.5	0	0	0	0
9/13/2011	24	0	0	0	0
9/14/2011	24	0	0	0	0
9/15/2011	24	0	0	0	0
9/16/2011	23.5	0	0	0	0
9/17/2011	0	N/O	N/O	N/O	N/O
9/18/2011	0	N/O	N/O	N/O	N/O
9/19/2011	20.5	0	0	0	0
9/20/2011	24.5	3	0	0	0
9/21/2011	23.5	6	0	0	0
9/22/2011	24	1	0	0	0
9/23/2011	25	1	0	0	0
9/24/2011	0	N/O	N/O	N/O	N/O
9/25/2011	0	N/O	N/O	N/O	N/O
9/26/2011	17	1	0	1	0
9/27/2011	24	3	0	0	0
9/28/2011	24	3	0	0	0
9/29/2011	24.5	3	0	0	0
9/30/2011	24	0	0	0	0
10/1/2011	0	N/O	N/O	N/O	N/O
10/2/2011	0	N/O	N/O	N/O	N/O
10/3/2011	24	0	0	0	0
10/4/2011	19	0	0	0	0
10/5/2011	24	0	0	0	0
10/6/2011	24.5	1	0	0	0
10/7/2011	23	1	0	0	0
10/8/2011	0	N/O	N/O	N/O	N/O
10/9/2011	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
10/10/2011	11.5	0	0	0	0
10/11/2011	25.5	2	0	0	0
10/12/2011	28	19	0	0	0
10/13/2011	16	24	0	0	0
10/14/2011	24.5	2	0	1	0
10/15/2011	24	13	0	0	0
10/16/2011	24.5	3	0	0	0
10/17/2011	24	174	0	0	0
10/18/2011	24	191	0	0	0
10/19/2011	23.5	364	0	0	0
10/20/2011	26	138	0	1	0
10/21/2011	23.5	122	0	0	0
10/22/2011	23	53	0	1	0
10/23/2011	25	67	0	0	0
10/24/2011	24	313	0	0	0
10/25/2011	23.5	77	0	0	0
10/26/2011	24	151	0	2	0
10/27/2011	29.5	483	0	7	0
10/28/2011	22.25	425	0	13	0
10/29/2011	24.25	756	0	13	0
10/30/2011	23	505	0	4	0
10/31/2011	22	343	0	6	0
11/1/2011	20.5	226	0	4	0
11/2/2011	26.5	364	0	6	0
11/3/2011	27.5	564	0	17	0
11/4/2011	23.5	454	0	28	0
11/5/2011	24	637	0	13	0
11/6/2011	24	712	0	13	0
11/7/2011	27.75	445	0	8	0
11/8/2011	18.75	204	0	2	0
11/9/2011	22	271	0	2	0
11/10/2011	24	208	0	0	0
11/11/2011	24.5	237	0	0	0
11/12/2011	24	75	0	0	0
11/13/2011	24	220	0	0	0
11/14/2011	24	611	0	0	0
11/15/2011	24	298	0	0	0
11/16/2011	25	930	0	0	0
11/17/2011	25.5	438	0	0	0
11/18/2011	24.5	934	0	0	0
11/19/2011	22.5	315	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
11/20/2011	25	324	0	0	0
11/21/2011	23.5	370	0	0	0
11/22/2011	27	506	0	0	0
11/23/2011	21	281	0	0	0
11/24/2011	0	N/O	N/O	N/O	N/O
11/25/2011	0	N/O	N/O	N/O	N/O
11/26/2011	15	75	0	0	0
11/27/2011	23.5	92	0	0	0
11/28/2011	24.5	80	0	0	0
11/29/2011	23.5	51	0	0	0
11/30/2011	24	25	0	0	0
12/1/2011	26	7	0	0	0
12/2/2011	23.5	60	0	0	0
12/3/2011	22	41	0	0	0
12/4/2011	25.25	25	0	0	0
12/5/2011	24	0	0	0	0
12/6/2011	23.75	20	0	0	0
12/7/2011	23	162	0	1	0
12/8/2011	24	156	0	0	0
12/9/2011	28	62	0	0	0
12/10/2011	0	N/O	N/O	N/O	N/O
12/11/2011	0	N/O	N/O	N/O	N/O
12/12/2011	0	N/O	N/O	N/O	N/O
12/13/2011	0	N/O	N/O	N/O	N/O
12/14/2011	18.5	128	0	4	0
12/15/2011	28.5	60	0	2	0
12/16/2011	20	95	0	2	0
12/17/2011	24	87	0	2	0
12/18/2011	24	77	0	0	0
12/19/2011	24.5	50	0	1	0
12/20/2011	24.5	55	0	0	0
12/21/2011	23	54	0	0	0
12/22/2011	20	25	0	0	0
12/23/2011	0	N/O	N/O	N/O	N/O
12/24/2011	0	N/O	N/O	N/O	N/O
12/25/2011	0	N/O	N/O	N/O	N/O
12/26/2011	0	N/O	N/O	N/O	N/O
12/27/2011	0	N/O	N/O	N/O	N/O
12/28/2011	0	N/O	N/O	N/O	N/O
12/29/2011	18	112	0	0	0
12/30/2011	23.5	44	0	2	0
12/31/2011	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
1/1/2012	0	N/O	N/O	N/O	N/O
1/2/2012	0	N/O	N/O	N/O	N/O
1/3/2012	0	N/O	N/O	N/O	N/O
1/4/2012	14	12	0	0	0
1/5/2012	23.5	12	0	0	0
1/6/2012	24	3	0	0	0
1/7/2012	24	2	0	0	0
1/8/2012	24	0	0	0	0
1/9/2012	24	15	0	0	0
1/10/2012	24	1	0	0	0
1/11/2012	24	7	0	0	0
1/12/2012	18	0	0	0	0
1/13/2012	0	N/O	N/O	N/O	N/O
1/14/2012	0	N/O	N/O	N/O	N/O
1/15/2012	0	N/O	N/O	N/O	N/O
1/16/2012	15.5	8	0	0	0
1/17/2012	0	N/O	N/O	N/O	N/O
1/18/2012	10	N/O	0	0	0
1/19/2012	0	N/O	N/O	N/O	N/O
1/20/2012	0	N/O	N/O	N/O	N/O
1/21/2012	0	N/O	N/O	N/O	N/O
1/22/2012	0	N/O	N/O	N/O	N/O
1/23/2012	0	N/O	N/O	N/O	N/O
1/24/2012	0	N/O	N/O	N/O	N/O
1/25/2012	0	N/O	N/O	N/O	N/O
1/26/2012	0	N/O	N/O	N/O	N/O
1/27/2012	0	N/O	N/O	N/O	N/O
1/28/2012	0	N/O	N/O	N/O	N/O
1/29/2012	0	N/O	N/O	N/O	N/O
1/30/2012	0	N/O	N/O	N/O	N/O
1/31/2012	0	N/O	N/O	N/O	N/O
2/1/2012	0	N/O	N/O	N/O	N/O
2/2/2012	0	N/O	N/O	N/O	N/O
2/3/2012	0	N/O	N/O	N/O	N/O
2/4/2012	0	N/O	N/O	N/O	N/O
2/5/2012	0	N/O	N/O	N/O	N/O
2/6/2012	0	N/O	N/O	N/O	N/O
2/7/2012	0	N/O	N/O	N/O	N/O
2/8/2012	0	N/O	N/O	N/O	N/O
2/9/2012	0	N/O	N/O	N/O	N/O
2/10/2012	0	N/O	N/O	N/O	N/O
2/11/2012	19	0	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
2/12/2012	22	0	0	0	0
2/13/2012	24	0	0	0	0
2/14/2012	24	0	0	0	0
2/15/2012	24	3	0	0	0
2/16/2012	24	0	0	0	0
2/17/2012	24	1	0	0	0
2/18/2012	24	3	0	0	0
2/19/2012	24	1	0	1	0
2/20/2012	22.5	4	0	0	0
2/21/2012	26.5	2	0	0	0
2/22/2012	22	0	0	1	0
2/23/2012	24.5	61	0	1	0
2/24/2012	24.5	44	0	0	0
2/25/2012	26.5	15	0	0	0
2/26/2012	21.5	9	0	0	0
2/27/2012	24	4	0	1	0
2/28/2012	24	6	0	0	0
2/29/2012	24	4	0	0	0
3/1/2012	24	3	0	0	0
3/2/2012	24	6	0	0	0
3/3/2012	24	2	0	0	0
3/4/2012	24	2	0	0	0
3/5/2012	23.5	2	0	0	0
3/6/2012	24.5	0	0	0	0
3/7/2012	23.5	3	0	0	0
3/8/2012	24.5	4	0	0	0
3/9/2012	24	3	0	1	0
3/10/2012	23	6	0	0	0
3/11/2012	25	3	0	0	0
3/12/2012	24	30	0	0	0
3/13/2012	25	29	0	1	0
3/14/2012	24	122	0	3	0
3/15/2012	24	41	0	0	0
3/16/2012	0	N/O	N/O	N/O	N/O
3/17/2012	0	N/O	N/O	N/O	N/O
3/18/2012	1	81	0	0	0
3/19/2012	18	310	0	50	0
3/20/2012	22	312	0	23	0
3/21/2012	0	N/O	N/O	N/O	N/O
3/22/2012	0	N/O	N/O	N/O	N/O
3/23/2012	0	N/O	N/O	N/O	N/O
3/24/2012	12.5	87	614	7	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
3/25/2012	25.75	129	356	5	0
3/26/2012	24	179	114	17	0
3/27/2012	22.25	69	61	31	0
3/28/2012	24	87	22	12	58
3/29/2012	0	N/O	N/O	N/O	N/O
3/30/2012	12	22	4	12	795
3/31/2012	0	N/O	N/O	N/O	N/O
4/1/2012	0	N/O	N/O	N/O	N/O
4/2/2012	0	N/O	N/O	N/O	N/O
4/3/2012	13	76	2001	21	108
4/4/2012	24.5	54	1145	21	113
4/5/2012	15.5	112	1007	9	191
4/6/2012	23.5	81	359	9	130
4/7/2012	23.5	90	418	12	28
4/8/2012	25	47	728	10	88
4/9/2012	22.5	51	173	8	43
4/10/2012	23.5	26	81	6	4
4/11/2012	24	16	89	14	11
4/12/2012	12.5	30	181	28	28
4/13/2012	12	7	63	32	46
4/14/2012	23.25	29	68	18	53
4/15/2012	25.25	48	64	34	61
4/16/2012	12.75	20	31	24	48
4/17/2012	23.75	47	43	26	161
4/18/2012	11.75	26	37	30	35
4/19/2012	24.75	28	24	40	78
4/20/2012	24	43	19	43	95
4/21/2012	26	26	49	263	238
4/22/2012	12.5	8	9	186	220
4/23/2012	10.25	2	1	113	155
4/24/2012	0	N/O	N/O	N/O	N/O
4/25/2012	0	N/O	N/O	N/O	N/O
4/26/2012	0	N/O	N/O	N/O	N/O
4/27/2012	0	N/O	N/O	N/O	N/O
4/28/2012	0	N/O	N/O	N/O	N/O
4/29/2012	11.75	25	2	80	136
4/30/2012	10	24	2	62	99
5/1/2012	10.5	14	4	59	63
5/2/2012	10.75	21	1	78	128
5/3/2012	13.75	21	4	83	117
5/4/2012	21.75	11	3	90	104
5/5/2012	25	28	0	92	126

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
5/6/2012	24	28	1	85	141
5/7/2012	23.5	48	2	137	158
5/8/2012	24.75	23	4	149	169
5/9/2012	23.25	42	2	230	266
5/10/2012	14.5	27	2	394	414
5/11/2012	23.75	47	1	321	546
5/12/2012	14	27	1	193	497
5/13/2012	22.75	22	1	211	556
5/14/2012	23	18	3	266	675
5/15/2012	11.25	10	0	297	806
5/16/2012	11.75	8	0	337	1057
5/17/2012	13.5	2	0	199	763
5/18/2012	22	4	0	103	548
5/19/2012	26.25	6	0	62	238
5/20/2012	22.75	6	0	60	226
5/21/2012	24	10	0	53	251
5/22/2012	25	11	0	94	520
5/23/2012	22.5	8	0	84	481
5/24/2012	10.5	6	0	41	263
5/25/2012	24	1	0	32	242
5/26/2012	23.5	13	0	43	200
5/27/2012	24.5	12	0	31	222
5/28/2012	24	8	0	30	288
5/29/2012	23.75	4	0	26	219
5/30/2012	23.83	5	0	10	121
5/31/2012	24.25	7	0	21	160
6/1/2012	24.75	5	0	19	55
6/2/2012	22.5	13	0	14	72
6/3/2012	25	13	0	25	129
6/4/2012	11.75	5	0	12	101
6/5/2012	24	0	0	38	223
6/6/2012	0	N/O	N/O	N/O	N/O
6/7/2012	11	4	0	4	59
6/8/2012	24	23	0	3	57
6/9/2012	24.25	10	0	3	59
6/10/2012	0	N/O	N/O	N/O	N/O
6/11/2012	10.25	5	0	1	41
6/12/2012	26.25	7	0	4	83
6/13/2012	24.5	33	0	9	266
6/14/2012	25	10	0	6	380
6/15/2012	23.75	14	0	3	283
6/16/2012	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
6/17/2012	0	N/O	N/O	N/O	N/O
6/18/2012	11	11	0	5	359
6/19/2012	23	9	0	8	267
6/20/2012	23	13	0	2	68
6/21/2012	24	10	0	0	36
6/22/2012	23.25	4	0	1	3
6/23/2012	0	N/O	N/O	N/O	N/O
6/24/2012	0	N/O	N/O	N/O	N/O
6/25/2012	9.75	2	0	0	24
6/26/2012	26.75	2	0	0	33
6/27/2012	24	7	0	0	29
6/28/2012	25	6	0	1	12
6/29/2012	21	10	0	0	4
6/30/2012	0	N/O	N/O	N/O	N/O
7/1/2012	0	N/O	N/O	N/O	N/O
7/2/2012	17	8	0	1	5
7/3/2012	24	6	0	0	4
7/4/2012	24.5	5	0	0	7
7/5/2012	23.75	13	0	0	3
7/6/2012	24.75	8	0	1	0
7/7/2012	0	N/O	N/O	N/O	N/O
7/8/2012	0	N/O	N/O	N/O	N/O
7/9/2012	12	6	0	0	1
7/10/2012	24	3	0	1	0
7/11/2012	23.75	10	0	2	0
7/12/2012	25.25	8	0	2	1
7/13/2012	23	6	0	0	1
7/14/2012	0	N/O	N/O	N/O	N/O
7/15/2012	0	N/O	N/O	N/O	N/O
7/16/2012	12	0	0	1	0
7/17/2012	26.5	0	0	0	0
7/18/2012	24.5	1	0	4	0
7/19/2012	23.33	0	0	3	0
7/20/2012	24.42	0	0	2	0
7/21/2012	0	N/O	N/O	N/O	N/O
7/22/2012	0	N/O	N/O	N/O	N/O
7/23/2012	12	0	0	0	0
7/24/2012	24.5	0	0	2	0
7/25/2012	23.25	0	0	2	0
7/26/2012	25	0	0	0	0
7/27/2012	23.5	0	0	0	0
7/28/2012	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
7/29/2012	0	N/O	N/O	N/O	N/O
7/30/2012	10	1	0	0	0
7/31/2012	24	2	0	0	0
8/1/2012	23	0	0	0	0
8/2/2012	24.75	0	0	0	0
8/3/2012	24	1	0	0	0
8/4/2012	0	N/O	N/O	N/O	N/O
8/5/2012	0	N/O	N/O	N/O	N/O
8/6/2012	12	1	0	0	0
8/7/2012	24	0	0	0	0
8/8/2012	25	0	0	0	0
8/9/2012	23	0	0	0	0
8/10/2012	0	N/O	N/O	N/O	N/O
8/11/2012	0	N/O	N/O	N/O	N/O
8/12/2012	0	N/O	N/O	N/O	N/O
8/13/2012	22	0	0	1	0
8/14/2012	24	0	0	1	0
8/15/2012	24.25	0	0	0	0
8/16/2012	24	1	0	1	0
8/17/2012	25.25	0	0	1	0
Fall Total	2,201	15,516	0	157	0
Spring Total	3,503	3,459	7,794	5,349	16,252
MY Total	5,703	18,975	7,794	5,506	16,252

Appendix A.3 The number of hours sampled and the catch, including subsample estimates, of natural-origin and hatchery-origin Chinook salmon and steelhead at the Imnaha River juvenile emigrant trap from September 24, 2012 to July 18, 2013. Sampling periods exceeded 24 hours when trapping continued past the hour the trap was started from the previous day (e.g. 0800 on October 17 to 0845 on October 18). N/O indicates the trap was not operated on that date.

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
9/24/2012	19	0	0	0	0
9/25/2012	23	0	0	0	0
9/26/2012	23.5	0	0	0	0
9/27/2012	0	N/O	N/O	N/O	N/O
9/28/2012	0	N/O	N/O	N/O	N/O
9/29/2012	0	N/O	N/O	N/O	N/O
9/30/2012	0	N/O	N/O	N/O	N/O
10/1/2012	19	0	0	0	0
10/2/2012	23	0	0	0	0
10/3/2012	23	0	0	0	0
10/4/2012	24.25	1	0	0	0
10/5/2012	21.5	0	0	0	0
10/6/2012	28	2	0	0	0
10/7/2012	21.25	9	0	0	0
10/8/2012	24.75	30	0	1	0
10/9/2012	24	31	0	0	0
10/10/2012	23	26	0	1	0
10/11/2012	23.75	27	0	0	0
10/12/2012	24	21	0	0	0
10/13/2012	24.25	28	0	0	0
10/14/2012	24	34	0	0	0
10/15/2012	25.25	34	0	0	0
10/16/2012	23	38	0	0	0
10/17/2012	24	44	0	1	0
10/18/2012	24	106	0	0	0
10/19/2012	23.75	114	0	0	0
10/20/2012	24	146	0	1	0
10/21/2012	24.5	183	0	0	0
10/22/2012	24.5	106	0	2	0
10/23/2012	23	114	0	0	0
10/24/2012	23.25	127	0	0	0
10/25/2012	25.25	103	0	0	0
10/26/2012	23.5	161	0	0	0
10/27/2012	24.5	59	0	0	0
10/28/2012	25	37	0	18	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
10/29/2012	22.5	20	0	44	0
10/30/2012	26.5	548	0	116	0
10/31/2012	21.5	186	0	2	0
11/1/2012	24.25	172	0	0	0
11/2/2012	24.25	104	0	0	0
11/3/2012	23.5	13	0	0	0
11/4/2012	24	5	0	0	0
11/5/2012	27.25	382	0	0	0
11/6/2012	23	270	0	0	0
11/7/2012	21.75	67	0	0	0
11/8/2012	24.75	102	0	0	0
11/9/2012	24	255	0	1	0
11/10/2012	25.5	610	0	0	0
11/11/2012	25.75	220	0	4	0
11/12/2012	23.25	218	0	2	0
11/13/2012	23.5	137	0	1	0
11/14/2012	24	111	0	2	0
11/15/2012	24.25	103	0	0	0
11/16/2012	14	45	0	1	0
11/17/2012	25.5	207	0	1	0
11/18/2012	23	143	0	1	0
11/19/2012	27.5	288	0	9	0
11/20/2012	20.5	158	0	2	0
11/21/2012	23	388	0	1	0
11/22/2012	0	N/O	N/O	N/O	N/O
11/23/2012	0	N/O	N/O	N/O	N/O
11/24/2012	15.75	133	0	0	0
11/25/2012	23.5	89	0	0	0
11/26/2012	23.75	42	0	0	0
11/27/2012	24.25	119	0	0	0
11/28/2012	23.75	65	0	0	0
11/29/2012	24.75	15	0	0	0
11/30/2012	23.75	65	0	0	0
12/1/2012	16.25	78	0	5	0
12/2/2012	0	N/O	N/O	N/O	N/O
12/3/2012	0	N/O	N/O	N/O	N/O
12/4/2012	0	N/O	N/O	N/O	N/O
12/5/2012	0	N/O	N/O	N/O	N/O
12/6/2012	0	N/O	N/O	N/O	N/O
12/7/2012	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
12/8/2012	0	N/O	N/O	N/O	N/O
12/9/2012	18	75	0	0	0
12/10/2012	24	82	0	0	0
12/11/2012	24	80	0	0	0
12/12/2012	23.75	59	0	0	0
12/13/2012	24.5	17	0	0	0
12/14/2012	22.5	21	0	0	0
12/15/2012	26.5	14	0	0	0
12/16/2012	22.75	16	0	0	0
12/17/2012	23.25	15	0	0	0
12/18/2012	24.75	14	0	1	0
12/19/2012	0	N/O	N/O	N/O	N/O
12/20/2012	21.75	0	0	0	0
12/21/2012	24	16	0	0	0
12/22/2012	24.25	17	0	0	0
12/23/2012	0	N/O	N/O	N/O	N/O
12/24/2012	0	N/O	N/O	N/O	N/O
12/25/2012	0	N/O	N/O	N/O	N/O
12/26/2012	0	N/O	N/O	N/O	N/O
12/27/2012	14.5	1	0	0	0
12/28/2012	24.25	4	0	0	0
12/29/2012	24.25	1	0	0	0
12/30/2012	0	N/O	N/O	N/O	N/O
12/31/2012	0	N/O	N/O	N/O	N/O
1/1/2013	0	N/O	N/O	N/O	N/O
1/2/2013	0	N/O	N/O	N/O	N/O
1/3/2013	0	N/O	N/O	N/O	N/O
1/4/2013	0	N/O	N/O	N/O	N/O
1/5/2013	0	N/O	N/O	N/O	N/O
1/6/2013	0	N/O	N/O	N/O	N/O
1/7/2013	0	N/O	N/O	N/O	N/O
1/8/2013	0	N/O	N/O	N/O	N/O
1/9/2013	0	N/O	N/O	N/O	N/O
1/10/2013	0	N/O	N/O	N/O	N/O
1/11/2013	0	N/O	N/O	N/O	N/O
1/12/2013	0	N/O	N/O	N/O	N/O
1/13/2013	0	N/O	N/O	N/O	N/O
1/14/2013	0	N/O	N/O	N/O	N/O
1/15/2013	0	N/O	N/O	N/O	N/O

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
1/16/2013	0	N/O	N/O	N/O	N/O
1/17/2013	0	N/O	N/O	N/O	N/O
1/18/2013	0	N/O	N/O	N/O	N/O
1/19/2013	0	N/O	N/O	N/O	N/O
1/20/2013	0	N/O	N/O	N/O	N/O
1/21/2013	0	N/O	N/O	N/O	N/O
1/22/2013	0	N/O	N/O	N/O	N/O
1/23/2013	0	N/O	N/O	N/O	N/O
1/24/2013	0	N/O	N/O	N/O	N/O
1/25/2013	0	N/O	N/O	N/O	N/O
1/26/2013	0	N/O	N/O	N/O	N/O
1/27/2013	0	N/O	N/O	N/O	N/O
1/28/2013	0	N/O	N/O	N/O	N/O
1/29/2013	0	N/O	N/O	N/O	N/O
1/30/2013	0	N/O	N/O	N/O	N/O
1/31/2013	14.5	1	0	0	0
2/1/2013	23.75	0	0	0	0
2/2/2013	25.25	0	0	0	0
2/3/2013	21.5	0	0	0	0
2/4/2013	26	2	0	0	0
2/5/2013	23.5	1	0	0	0
2/6/2013	23.75	0	0	0	0
2/7/2013	23.75	0	0	0	0
2/8/2013	24	0	0	0	0
2/9/2013	25	0	0	0	0
2/10/2013	24.5	0	0	0	0
2/11/2013	23.75	0	0	0	0
2/12/2013	23.5	0	0	0	0
2/13/2013	24	0	0	0	0
2/14/2013	23.75	0	0	0	0
2/15/2013	24	0	0	0	0
2/16/2013	24	0	0	0	0
2/17/2013	24	0	0	0	0
2/18/2013	24	0	0	0	0
2/19/2013	24	0	0	0	0
2/20/2013	24	0	0	0	0
2/21/2013	24.5	1	0	0	0
2/22/2013	24	0	0	0	0

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
2/23/2013	24.25	0	0	0	0
2/24/2013	24	0	0	0	0
2/25/2013	24	1	0	0	0
2/26/2013	24	0	0	0	0
2/27/2013	24.25	0	0	0	0
2/28/2013	26.5	0	0	0	0
3/1/2013	20	0	0	0	0
3/2/2013	24.5	0	0	0	0
3/3/2013	24	0	0	0	0
3/4/2013	24	3	0	0	0
3/5/2013	24	8	0	0	0
3/6/2013	24	7	0	0	0
3/7/2013	23.25	4	0	0	0
3/8/2013	25	5	0	0	0
3/9/2013	25	5	0	0	0
3/10/2013	23.5	2	0	0	0
3/11/2013	23.25	1	0	0	0
3/12/2013	22.5	0	0	0	0
3/13/2013	10.5	4	0	0	0
3/14/2013	22.75	5	0	0	0
3/15/2013	27	67	0	1	0
3/16/2013	21.5	160	0	25	0
3/17/2013	24.25	232	0	23	0
3/18/2013	24.25	275	0	8	0
3/19/2013	20.75	130	0	6	0
3/20/2013	16	55	0	2	0
3/21/2013	24.25	40	0	5	0
3/22/2013	24	46	0	3	0
3/23/2013	24.25	41	0	4	0
3/24/2013	23.5	58	0	2	0
3/25/2013	26	55	0	1	0
3/26/2013	21.75	22	0	1	0
3/27/2013	23.75	8	0	1	0
3/28/2013	24	16	0	3	13
3/29/2013	25	26	0	7	529
3/30/2013	24	45	0	4	682
3/31/2013	27	221	3094	32	809
4/1/2013	19.5	893	31624	52	202

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
4/2/2013	23	212	9821	24	494
4/3/2013	25	135	2253	53	454
4/4/2013	14.5	77	692	47	412
4/5/2013	23.75	160	712	79	590
4/6/2013	0	N/O	N/O	N/O	N/O
4/7/2013	12.75	55	82	44	496
4/8/2013	14	57	94	35	354
4/9/2013	13	68	69	41	524
4/10/2013	9.25	61	49	24	288
4/11/2013	13	56	42	39	162
4/12/2013	24	58	30	30	159
4/13/2013	24.5	65	36	29	186
4/14/2013	23.5	49	40	27	156
4/15/2013	24.5	95	66	34	326
4/16/2013	24	100	58	27	531
4/17/2013	23.5	85	43	24	362
4/18/2013	24	54	36	28	313
4/19/2013	23.25	41	29	23	164
4/20/2013	24.25	38	27	19	122
4/21/2013	27.25	47	25	58	126
4/22/2013	24.25	55	32	68	222
4/23/2013	22.25	56	24	63	179
4/24/2013	21.5	73	36	44	205
4/25/2013	24.25	38	19	31	95
4/26/2013	24.75	52	29	41	135
4/27/2013	23.75	45	23	60	221
4/28/2013	25.5	111	61	118	582
4/29/2013	24	115	62	394	1508
4/30/2013	21	196	90	652	2522
5/1/2013	24	339	61	406	2270
5/2/2013	12.5	88	11	190	1120
5/3/2013	23.5	83	10	103	456
5/4/2013	24.75	73	17	205	659
5/5/2013	25.75	80	22	267	704
5/6/2013	21.75	71	13	389	1086
5/7/2013	22.5	79	14	596	1601
5/8/2013	24	71	6	473	1391
5/9/2013	8.92	57	3	689	1522

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
5/10/2013	9.5	26	2	535	1355
5/11/2013	8.75	18	0	370	888
5/12/2013	27.5	15	0	330	801
5/13/2013	0	N/O	N/O	N/O	N/O
5/14/2013	0	N/O	N/O	N/O	N/O
5/15/2013	0	N/O	N/O	N/O	N/O
5/16/2013	10.25	13	1	185	374
5/17/2013	10.5	11	1	201	447
5/18/2013	10.5	12	0	195	407
5/19/2013	9.75	16	0	151	459
5/20/2013	9.5	20	0	119	272
5/21/2013	9.75	18	0	120	444
5/22/2013	9	3	0	80	207
5/23/2013	11.5	16	0	160	247
5/24/2013	22.5	8	0	62	119
5/25/2013	24.75	9	0	54	52
5/26/2013	24.25	4	0	24	21
5/27/2013	23.75	10	0	28	32
5/28/2013	23.5	4	0	8	19
5/29/2013	23	13	0	42	40
5/30/2013	25.5	23	0	25	12
5/31/2013	0	N/O	N/O	N/O	N/O
6/1/2013	0	N/O	N/O	N/O	N/O
6/2/2013	0	N/O	N/O	N/O	N/O
6/3/2013	7	18	0	24	55
6/4/2013	0	N/O	N/O	N/O	N/O
6/5/2013	0	N/O	N/O	N/O	N/O
6/6/2013	0	N/O	N/O	N/O	N/O
6/7/2013	0	N/O	N/O	N/O	N/O
6/8/2013	17.75	23	0	55	287
6/9/2013	13.5	20	0	47	263
6/10/2013	11.5	10	0	27	156
6/11/2013	10.5	4	0	11	81
6/12/2013	11.25	7	0	16	78
6/13/2013	26.25	38	0	7	60
6/14/2013	22.25	11	0	9	60
6/15/2013	26	27	0	4	28
6/16/2013	22.5	18	0	1	6

Sample End Date	Hours Fished	Natural Chinook	Hatchery Chinook	Natural Steelhead	Hatchery Steelhead
6/17/2013	23.75	20	1	2	6
6/18/2013	23.25	18	0	2	3
6/19/2013	24.25	31	0	2	14
6/20/2013	13	11	0	6	35
6/21/2013	23.5	13	0	2	5
6/22/2013	24	36	0	0	5
6/23/2013	23	25	0	0	2
6/24/2013	23.5	10	0	0	0
6/25/2013	25.75	23	0	1	0
6/26/2013	0	N/O	N/O	N/O	N/O
6/27/2013	0	N/O	N/O	N/O	N/O
6/28/2013	0	N/O	N/O	N/O	N/O
6/29/2013	0	N/O	N/O	N/O	N/O
6/30/2013	0	N/O	N/O	N/O	N/O
7/1/2013	0	N/O	N/O	N/O	N/O
7/2/2013	0	N/O	N/O	N/O	N/O
7/3/2013	0	N/O	N/O	N/O	N/O
7/4/2013	0	N/O	N/O	N/O	N/O
7/5/2013	0	N/O	N/O	N/O	N/O
7/6/2013	0	N/O	N/O	N/O	N/O
7/7/2013	0	N/O	N/O	N/O	N/O
7/8/2013	0	N/O	N/O	N/O	N/O
7/9/2013	0	N/O	N/O	N/O	N/O
7/10/2013	24.75	7	0	0	1
7/11/2013	22	8	1	0	0
7/12/2013	22.5	9	0	0	0
7/13/2013	23.5	5	0	0	0
7/14/2013	0	N/O	N/O	N/O	N/O
7/15/2013	13	4	0	0	0
7/16/2013	24.25	3	0	0	0
7/17/2013	23.5	8	0	0	0
7/18/2013	24	7	0	0	0
Fall Total	1,841	7,371	0	217	0
Spring Total	3,061	6,288	49,461	8,559	32,273
MY Total	4,901	13,659	49,461	8,776	32,273

Appendix B.1. The number of natural-origin Chinook salmon and steelhead administered passive integrated transponder tags (PIT) weekly at the Imnaha River juvenile emigrant trap from during migration year 2011.

Week	Chinook Salmon PIT-tagged	Steelhead PIT-tagged
9/1/2010	1	0
9/5/2010	4	0
9/12/2010	2	0
9/19/2010	3	0
9/26/2010	0	0
10/3/2010	104	0
10/10/2010	218	0
10/17/2010	338	0
10/24/2010	704	0
10/31/2010	492	0
11/7/2010	652	0
11/14/2010	347	0
11/21/2010	121	0
11/28/2010	301	0
12/5/2010	336	0
12/12/2010	331	0
12/19/2010	198	0
12/26/2010	24	0
1/2/2011	0	0
1/9/2011	21	0
1/16/2011	221	13
1/23/2011	71	3
1/30/2011	15	1
2/6/2011	19	2
2/13/2011	5	1
2/20/2011	7	2
2/27/2011	25	1
3/6/2011	34	0
3/13/2011	323	8
3/20/2011	205	17
3/27/2011	441	18
4/3/2011	616	107
4/10/2011	140	62
4/17/2011	362	116
4/24/2011	526	365

Week	Chinook Salmon PIT-tagged	Steelhead PIT-tagged
5/1/2011	888	1398
5/8/2011	40	341
5/15/2011	0	0
5/22/2011	16	92
5/29/2011	8	28
6/5/2011	0	6
6/12/2011	10	13
6/19/2011	33	13
6/26/2011	6	0
7/3/2011	2	1
7/10/2011	5	1
7/17/2011	29	1
7/24/2011	5	0
7/31/2011	0	0
8/7/2011	0	0
8/14/2011	2	0
8/21/2011	0	0
8/28/2011	0	0
Fall Total	4176	0
Spring Total	4075	2610
MY Total	8251	2610

Appendix B.2. The number of natural-origin Chinook salmon and steelhead administered passive integrated transponder tags (PIT) weekly at the Imnaha River juvenile emigrant trap from during migration year 2012.

Week	Chinook Salmon PIT-tagged	Steelhead PIT-tagged
9/4/2011	0	0
9/11/2011	0	0
9/18/2011	5	0
9/25/2011	6	0
10/2/2011	0	0
10/9/2011	52	0
10/16/2011	854	0
10/23/2011	1456	0
10/30/2011	2024	0
11/6/2011	1528	0
11/13/2011	1328	0
11/20/2011	372	0
11/27/2011	334	0
12/4/2011	331	0
12/11/2011	260	0
12/18/2011	223	0
12/25/2011	93	0
1/1/2012	28	0
1/8/2012	22	0
1/15/2012	8	0
1/22/2012	0	0
1/29/2012	0	0
2/5/2012	0	0
2/12/2012	7	0
2/19/2012	127	3
2/26/2012	33	1
3/4/2012	20	1
3/11/2012	222	4
3/18/2012	365	80
3/25/2012	486	77
4/1/2012	410	71
4/8/2012	206	115
4/15/2012	232	459
4/22/2012	9	299
4/29/2012	136	537

Week	Chinook Salmon PIT-tagged	Steelhead PIT-tagged
5/6/2012	242	1506
5/13/2012	70	1474
5/20/2012	52	407
5/27/2012	53	150
6/3/2012	55	84
6/10/2012	69	23
6/17/2012	46	16
6/24/2012	26	1
7/1/2012	40	1
7/8/2012	9	0
7/15/2012	0	0
7/22/2012	0	0
7/29/2012	0	0
8/5/2012	0	0
8/12/2012	0	0
8/19/2012	0	0
8/26/2012	0	0
Fall Total	8866	0
Spring Total	2973	5309
MY Total	11839	5309

Appendix B.3. The number of natural-origin Chinook salmon and steelhead administered passive integrated transponder tags (PIT) weekly at the Imnaha River juvenile emigrant trap from during migration year 2013.

Week	Chinook Salmon PIT-tagged	Steelhead PIT-tagged
9/23/2012	0	0
9/30/2012	3	0
10/7/2012	145	0
10/14/2012	446	0
10/21/2012	699	0
10/28/2012	738	0
11/4/2012	1506	0
11/11/2012	906	0
11/18/2012	984	0
11/25/2012	435	0
12/2/2012	0	0
12/9/2012	324	0
12/16/2012	72	0
12/23/2012	5	0
12/30/2012	0	0
1/6/2013	0	0
1/13/2013	0	0
1/20/2013	0	0
1/27/2013	1	0
2/3/2013	3	0
2/10/2013	0	0
2/17/2013	1	0
2/24/2013	1	0
3/3/2013	29	0
3/10/2013	236	26
3/17/2013	750	51
3/24/2013	224	19
3/31/2013	734	232
4/7/2013	354	241
4/14/2013	456	182
4/21/2013	365	364
4/28/2013	639	1169
5/5/2013	355	2797
5/12/2013	45	900
5/19/2013	89	738

Week	Chinook Salmon PIT-tagged	Steelhead PIT-tagged
5/26/2013	53	122
6/2/2013	28	66
6/9/2013	98	121
6/16/2013	116	13
6/23/2013	48	1
6/30/2013	0	0
7/7/2013	5	0
7/14/2013	3	0
Fall Total	6263	0
Spring Total	4633	7042
MY Total	10896	7042

Appendix C.1 Recaptures of passive integrated transponder tagged natural-origin Chinook salmon, tagged by the Oregon Department of Fish and Wildlife Early Life History Program, at the Imnaha River juvenile emigrant trap during migration year 2011. Fork length is reported in millimeters (mm) and weight to the nearest 0.1 gram (g).

Migration Year	PIT Tag ID	Date Tagged	Date Recaptured	Travel Time (Days)	Recapture Fork Length (mm)	Recapture Weight (g)	Recapture Condition Factor
2011	3D9.1C67C4E564	8/26/2010	10/6/2010	41	91	7.1	0.94
2011	3D9.1C67C5313C	8/23/2010	10/31/2010	69	62	4.8	2.01
2011	3D9.1C67C47444	8/24/2010	11/8/2010	76	83	6.0	1.05
2011	3D9.1C67C4D40F	8/26/2010	11/8/2010	74	86	6.8	1.07
2011	3D9.1C67C4D4E7	8/26/2010	11/8/2010	74	103	11.1	1.02
2011	3D9.1C67C47354	8/24/2010	11/9/2010	77	78	4.8	1.01
2011	3D9.1C67C52F74	8/23/2010	11/9/2010	78	83	7.5	1.31
2011	3D9.1C67C472CC	8/23/2010	11/11/2010	80	106	12.8	1.07
2011	3D9.1C67C47C41	8/24/2010	11/12/2010	80	73	5.0	1.29
2011	3D9.1C67C4E0E8	8/23/2010	11/12/2010	81	94	8.8	1.06
2011	3D9.1C67C4E39F	8/23/2010	11/12/2010	81	78	4.8	1.01
2011	3D9.1C67C54B8C	8/26/2010	11/12/2010	78	92	7.5	0.96
2011	3D9.1C67C47BE3	8/26/2010	11/17/2010	83	80	6.5	1.27
2011	3D9.1C67C56083	8/26/2010	12/8/2010	104	92	7.5	0.96
2011	3D9.1C67C54C6D	8/26/2010	12/15/2010	111	99	8.8	0.91
2011	3D9.1C67C527EA	8/26/2010	12/18/2010	114	115	14.8	0.97
2011	3D9.1C67C52848	8/26/2010	12/18/2010	114	89	7.1	1.01
2011	3D9.1C67C5018B	8/23/2010	12/21/2010	120	92	7.3	0.94
2011	3D9.1C67C45B06	8/26/2010	4/28/2011	245	109	15.0	1.16
2011	3D9.1C67C4698F	8/26/2010	5/6/2011	253	119	18.8	1.12
2011	3D9.1C67C47550	8/24/2010	4/6/2011	225	93	8.4	1.04
2011	3D9.1C67C47C34	8/24/2010	5/5/2011	254	75	4.3	1.02
2011	3D9.1C67C4E163	8/26/2010	1/22/2011	149	104	10.9	0.97
2011	3D9.1C67C4E5EB	8/26/2010	3/23/2011	209	104	11.2	1.00
2011	3D9.1C67C547A3	8/26/2010	4/4/2011	221	103	11.2	1.02
2011	3D9.1C67C54938	8/26/2010	3/23/2011	209	98	11.6	1.23
2011	3D9.1C67C54983	8/24/2010	4/30/2011	249	105	14.4	1.24
2011	3D9.1C67C55492	8/26/2010	4/25/2011	242	106	22.6	1.90
2011	3D9.1C67C56229	8/24/2010	5/1/2011	250	105	13.2	1.14

Appendix C.2 Recaptures of passive integrated transponder tagged natural-origin Chinook salmon, tagged by the Oregon Department of Fish and Wildlife Early Life History Program, at the Imnaha River juvenile emigrant trap during the migration year 2012. Fork length is reported in millimeters (mm) and weight to the nearest 0.1 gram (g).

Migration Year	PIT Tag ID	Date Tagged	Date Recaptured	Travel Time (Days)	Recapture Fork Length (mm)	Recapture Weight (g)	Recapture Condition Factor
2012	3D9.1C2D9E85F8	8/24/2011	10/18/2011	55	64	2.5	0.95
2012	3D9.1C2D9BD6BF	8/24/2011	10/28/2011	65	75	5.0	1.19
2012	3D9.1C2D9BE87F	8/24/2011	10/31/2011	68	67	3.5	1.16
2012	3D9.1C2D9C49C7	8/24/2011	11/1/2011	69	72	3.9	1.04
2012	3D9.1C2D9EF244	8/22/2011	11/7/2011	77	76	5.2	1.18
2012	3D9.1C2D9CAC7B	8/25/2011	11/11/2011	78	71	4.3	1.20
2012	3D9.1C2D9C7CC9	8/23/2011	11/15/2011	84	68	3.8	1.21
2012	3D9.1C2D9F5CF0	8/25/2011	11/16/2011	83	82	6.9	1.25
2012	3D9.1C2D9BD0A2	8/22/2011	11/18/2011	88	78	3.6	0.76
2012	3D9.1C2D9BFEEB	8/24/2011	11/18/2011	86	76	4.6	1.05
2012	3D9.1C2D9CACEA	8/22/2011	11/18/2011	88	84	4.4	0.74
2012	3D9.1C2D9EF272	8/23/2011	11/18/2011	87	82	5.3	0.96
2012	3D9.1C2D9EFEBD	8/24/2011	11/18/2011	86	72	4.1	1.10
2012	3D9.1C2D9E5F43	8/23/2011	11/20/2011	89	85	5.9	0.96
2012	3D9.1C2D9C7CBB	8/24/2011	11/21/2011	89	79	5.6	1.14
2012	3D9.1C2D9F0C47	8/25/2011	11/21/2011	88	64	3.3	1.26
2012	3D9.1C2D9F0EC3	8/24/2011	11/21/2011	89	92	8.4	1.08
2012	3D9.1C2D9C34C1	8/24/2011	3/13/2012	245	91	9.0	1.19
2012	3D9.1C2D9E77C2	8/23/2011	3/19/2012	149	90	8.0	1.10
2012	3D9.1C2D9CC36A	8/24/2011	4/4/2012	225	89	7.6	1.08
2012	3D9.1C2D9E7163	8/23/2011	4/15/2012	254	96	9.6	1.09
2012	3D9.1C2D9ECE21	8/23/2011	5/1/2012	209	97	10.7	1.17
2012	3D9.1C2D9C358F	8/24/2011	5/2/2012	253	95	10.6	1.24

Appendix C.3 Recaptures of passive integrated transponder tagged natural-origin Chinook salmon, tagged by the Oregon Department of Fish and Wildlife Early Life History Program, at the Imnaha River juvenile emigrant trap during the fall of 2012 and spring 2013. Fork length is reported in millimeters (mm) and weight to the nearest 0.1 gram (g).

Migration Year	PIT Tag ID	Date Tagged	Date Recaptured	Travel Time (Days)	Recapture Fork Length (mm)	Recapture Weight (g)	Recapture Condition Factor
2013	3D9.1C2D9E441E	8/15/2012	10/21/2012	67	71	3.8	1.06
2013	3D9.1C2D9BD0F8	8/13/2012	11/5/2012	84	67	3.9	1.30
2013	3D9.1C2D9BF35A	8/14/2012	11/5/2012	83	75	4.3	1.02
2013	3D9.1C2D9C5EB9	9/5/2012	11/9/2012	65	87	8.2	1.25
2013	3D9.1C2D9E9887	9/5/2012	11/9/2012	65	75	6.4	1.52
2013	3D9.1C2D9C5CEB	9/5/2012	11/24/2012	80	74	4.8	1.18
2013	3D9.1C2D9EE889	8/14/2012	11/25/2012	103	77	4.3	0.94
2013	3D9.1C2D9BE3B8	8/25/2011	11/28/2012	461	95	9.5	1.11
2013	3D9.1C2D9E66A6	8/15/2012	12/1/2012	108	82	4.9	0.89
2013	3D9.1C2D9E8980	9/5/2012	12/1/2012	87	74	3.4	0.84
2013	3D9.1C2D9BF918	8/14/2012	3/17/2013	215	100	9.5	0.95
2013	3D9.1C2D9E6359	8/15/2012	3/18/2013	215	101	10.6	1.03
2013	3D9.1C2D9ECFD5	8/15/2012	3/18/2013	215	89	7.0	0.99
2013	3D9.1C2D9C0E24	8/15/2012	4/1/2013	229	--	--	--
2013	3D9.1C2D9C8AC3	8/15/2012	4/1/2013	229	--	--	--
2013	3D9.1C2D9E4901	9/5/2012	4/12/2013	219	93	8.9	1.11
2013	3D9.1C2D9F2645	9/5/2012	4/15/2013	222	105	12.4	1.07
2013	3D9.1C2D9C19D2	8/15/2012	4/29/2013	257	128	24.6	1.17
2013	3D9.1C2D9BE5AF	9/5/2012	4/30/2013	237	--	--	--
2013	3D9.1C2D9C0015	8/15/2012	5/3/2013	261	115	15.3	1.01
2013	3D9.1C2D9EA542	8/15/2012	5/4/2013	262	91	9.6	1.27

Appendix D. Releases of hatchery-origin Chinook salmon and steelhead smolts to the Imnaha River subbasin and the number of smolts released with a passive integrated transponder (PIT) tag during migration years 2011 - 2013.

Release Year	Species	Arrival Date at Acclimation Site	Number Released	Release Dates	Total PIT Tags Released	Release Site
2011	Chinook Salmon	4/9 - 4/10	252,588	3/30 - 4/14	20,757	Imnaha River (Gumboot)
2011	Steelhead	4/6	158,027		21,895	Little Sheep Creek
2012	Chinook Salmon	3/22	333,392	3/30 - 4/13	20,914*	Imnaha River (Gumboot)
2012	Chinook Salmon	Direct Release	136,933	4/30		Imnaha River (Gumboot)
2012	Steelhead	3/1	213,891		21,937	Little Sheep Creek
2013	Chinook Salmon	3/20	223,716	3/30 - 4/05	20,852*	Imnaha River (Gumboot)
2013	Chinook Salmon	Direct Release	166,979	3/30		Imnaha River (Gumboot)
2013	Steelhead	2/28	237,149		21,882	Little Sheep Creek

*The number of PIT tags released in the direct release group versus the volitional release group is unknown.

Appendix E.1. The catch of incidental fish during the 2011 migration year. Catch totals include sub sampling estimates.

Family	Common Name	Fall 2010	Spring 2011
Salmonidae	Adult Chinook Salmon	10	0
	Jack Chinook Salmon	6	0
	Adult Steelhead	0	37
	Adult Bull Trout	83	2
	Bull Trout	134	2
	Rainbow Trout	805	109
	Mountain Whitefish	104	6
Centrarchidae	Smallmouth Bass	33	3
Catostomidae	Bridgelip Sucker	3	0
	Largescale Sucker	0	0
	Sucker (unidentified species)	794	169
Cyprinidae	Chiselmouth	3	21
	Longnose Dace	18	107
	Northern Pikeminnow	95	17
	Redside Shiner	6	22
	Peamouth	6	0
Cottidae	Sculpin (unidentified species)	27	33
Petromyzontidae	Pacific Lamprey macropthalmia	1	1
	Pacific Lamprey ammocoetes	0	15
	Total Catch	**2128**	**544**

Appendix E.2. The catch of incidental fish during the 2012 migration year. Catch totals include sub sampling estimates.

Family	Common Name	Fall 2011	Spring 2012
Salmonidae	Adult Steelhead	1	30
	Adult Bull Trout	5	2
	Bull Trout	29	7
	Rainbow Trout	65	153
	Mountain Whitefish	54	2
Centrarchidae	Smallmouth Bass	1	34
Catostomidae	Sucker (unidentified species)	76	272
Cyprinidae	Chiselmouth	3	37
	Longnose Dace	3	644
	Northern Pikeminnow	8	27
	Redside Shiner	83	29
	Speckled Dace	0	1
Cottidae	Sculpin (unidentified species)	5	95
Ictaluridae	Bullhead Catfish	0	2
Petromyzontidae	Pacific Lamprey macropthalmia	0	0
	Pacific Lamprey ammocoetes	0	0
	Unidentified Lamprey	0	4
	Other unidentifed species	0	3
	Total Catch	**333**	**1342**

Appendix E.3. The catch of incidental fish during the 2013 migration year. Catch totals include sub sampling estimates.

Family	Common Name	Fall 2012	Spring 2013
Salmonidae	Adult Chinook Salmon	3	0
	Adult Steelhead	1	18
	Adult Bull Trout	17	7
	Bull Trout	30	3
	Rainbow Trout	433	1078
	Mountain Whitefish	12	0
Centrarchidae	Smallmouth Bass	21	9
Catostomidae	Bridgelip Sucker	0	5
	Sucker (unidentified species)	309	267
Cyprinidae	Chiselmouth	4	30
	Longnose Dace	2	632
	Northern Pikeminnow	11	39
	Redside Shiner	5	9
	Peamouth	0	8
Cottidae	Sculpin (unidentified species)	45	104
Petromyzontidae	Unidentified Lamprey	1	0
	Other unidentifed species	1	0
	Total Catch	**895**	**2209**

Appendix F. Pacific Lamprey (*Lampetra tridentate*), caught during the migration years 2011 – 2013. Table includes the trap date, developmental stage, total length in millimeters (mm), and weight in grams (g).

Trap Date	Developmental Stage	Length (mm)	Weight (g)	Count
12/13/2010	Macropthalmia	153		1
4/4/2011	Ammocoete	166	6.2	1
5/6/2011	Macropthalmia	140	5.2	1
5/7/2011	Macropthalmia	162	5.7	1
5/7/2011	Macropthalmia	158	7.3	1
5/7/2011	Macropthalmia	152	7.2	1
5/7/2011	Macropthalmia	150	5.8	1
5/7/2011	Macropthalmia			6
5/10/2011	Macropthalmia	155	7	1
5/10/2011	Macropthalmia	150	5.5	1
5/10/2011	Macropthalmia	149	9.5	1
5/26/2011	Macropthalmia	160	8.3	1
2/23/2012	Macropthalmia	155	6.7	1
2/23/2012	Macropthalmia	142	4.5	1
1/30/2012	Macropthalmia	146	9.3	1
5/29/2012	Macropthalmia	175		1
12/9/2013	Macropthalmia			1

Appendix G.1. Mortality of Chinook salmon and steelhead smolts due to trapping, handling, PIT tagging and those that were dead on arrival (DOA) at the Imnaha River juvenile emigrant trap in the fall and spring trapping seasons of migration year 2011.

Fall 2010

	Chinook Salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Source of Mortality	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped
Trapping	46	0.28	0	0.00	0	0.00	0	0.00
Handling	5	0.03	0	0.00	0	0.00	0	0.00
Tagging	8	0.05	0	0.00	0	0.00	0	0.00
DOA	7	0.04	0	0.00	0	0.00	0	0.00
Total Mortality	66	0.41	0	0.00	0	0.00	0	0.00
Number Captured	16,247		0		411		0	

Spring 2011

	Chinook Salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Source of Mortality	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped
Trapping	21	0.48	5	0.02	1	0.03	2	0.02
Handling	9	0.21	3	0.01	0	0.00	0	0.00
Tagging	1	0.02	0	0.00	0	0.00	0	0.00
DOA	1	0.02	3	0.01	1	0.03	1	0.01
Total Mortality	32	0.73	11	0.04	2	0.05	3	0.03
Number Captured	4,364		26,966		3,984		10,201	

Appendix G.2. Mortality of Chinook salmon and steelhead smolts due to trapping, handling, PIT tagging and those that were dead on arrival (DOA) at the Imnaha River juvenile emigrant trap in the fall and spring trapping seasons of migration year 2012.

Fall 2011

	Chinook Salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Source of Mortality	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped
Trapping	9	0.06	0	0.00	0	0.00	0	0.00
Handling	3	0.02	0	0.00	0	0.00	0	0.00
Tagging	0	0.00	0	0.00	0	0.00	0	0.00
DOA	4	0.03	0	0.00	1	0.64	0	0.00
Total Mortality	16	0.10	0	0.00	1	0.64	0	0.00
Number Captured	15,516		0		157		0	

Spring 2012

	Chinook Salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Source of Mortality	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped
Trapping	13	0.38	4	0.05	9	0.17	12	0.07
Handling	1	0.03	1	0.01	0	0.00	10	0.06
Tagging	6	0.17	0	0.00	0	0.00	0	0
DOA	0	0.00	1	0.01	1	0.02	0	0
Total Mortality	20	0.58	6	0.08	10	0.19	22	0.14
Number Captured	3,459		7,794		5,349		16,252	

Appendix G.3. Mortality of Chinook salmon and steelhead smolts due to trapping, handling, PIT tagging and those that were dead on arrival (DOA) at the Imnaha River juvenile emigrant trap in the fall and spring trapping seasons of migration year 2013.

Fall 2012

	Chinook Salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Source of Mortality	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped
Trapping	16	0.22	0	0.00	0	0.00	0	0.00
Handling	1	0.01	0	0.00	0	0.00	0	0.00
Tagging	19	0.26	0	0.00	0	0.00	0	0.00
DOA	1	0.01	0	0.00	0	0.00	0	0.00
Total Mortality	37	0.50	0	0.00	0	0.00	0	0.00
Number Captured	7371		0		217		0	

Spring 2013

	Chinook Salmon				Steelhead			
	Natural		Hatchery		Natural		Hatchery	
Source of Mortality	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped	N	Percent of Total Trapped
Trapping	79	1.26	7	0.01	13	0.15	33	0.10
Handling	55	0.87	5	0.01	45	0.53	4	0.01
Tagging	16	0.25	0	0.00	0	0.00	0	0.00
DOA	4	0.06	3	0.01	0	0.00	2	0.01
Total Mortality	154	2.45	15	0.03	58	0.68	39	0.12
Number Captured	6,288		49,461		8,559		32,273	

Appendix H. Natural and hatchery Chinook salmon smolt size at the Imnaha River juvenile emigrant trap and estimated survival from the trap to Lower Granite Dam (LGR) from migration year 1994 through 2013. mm = millimeters, g = grams, S.D. = standard deviation.

Migration Year	Origin	Mean Fork Length	S.D. Fork Length	Weight (g)	S.D. Weight	Fulton's K	Sample Size at Trap	Fish Per Pound	Survival Trap to LGR	S.D. Survival
1994	Natural	102	9	11.7	3.4	1.10	3,190	38.77	76.2	5.3
1995	Natural	99	10	10.7	3.4	1.10	1,003	42.39	80.9	6.7
1996	Natural	101	8	11.4	3.0	1.11	1,797	39.79	81.2	5.3
1997	Natural	108	9	13.0	3.6	1.03	270	34.89	89.5	12.9
1998	Natural	106	8	12.7	3.2	1.07	3,969	35.72	85.2	2.0
1999	Natural	104	10	12.4	3.5	1.10	5,422	36.58	88.5	2.0
2000	Natural	110	10	14.1	3.8	1.06	4,330	32.17	84.8	2.3
2001	Natural	108	10	13.0	3.9	1.03	9,956	34.89	83.7	0.8
2002	Natural	104	11	12.3	5.4	1.09	2,333	36.88	86.9	4.4
2003	Natural	104	9	11.8	3.6	1.05	4,841	38.44	75.9	2.3
2004	Natural	100	10	11.4	3.2	1.13	9,847	39.79	73.3	1.2
2005	Natural	98	10	11.1	3.4	1.18	3,472	40.86	73.9	1.7
2006	Natural	98	10	10.6	3.4	1.13	1,158	42.79	76.7	8.2
2007	Natural	99	12	12.6	4.1	1.30	7,547	36.00	77.5	2.7
2008	Natural	99	10	11.5	3.3	1.20	3,269	39.44	84.2	4.2
2009	Natural	100	10	11.6	3.5	1.17	6,115	39.10	85.1	1.9
2010	Natural	99	10	10.7	3.2	1.10	8,020	42.39	77.0	4.3
2011	Natural	102	11	11.6	4.0	1.09	4,037	39.10	80.0	0.8
2012	Natural	95	10	9.6	3.3	1.12	2,999	47.25	72.1	0.8
2013	Natural	99	11	10.6	3.5	1.09	4,714	42.79	71.6	0.7
1994	Hatchery	126	13	21.6	4.8	1.08	9,034	21.00	67.1	10.2
1995	Hatchery	127	8	21.3	4.5	1.04	391	21.30	72.1	6.3
1996	Hatchery	131	9	26.0	6.1	1.16	11,896	17.45	71.4	9.4
1997	Hatchery	131	11	25.4	7.2	1.13	10,616	17.86	80.4	8.0
1998	Hatchery	135	11	27.2	8.4	1.11	3,098	16.68	75.7	3.1
1999	Hatchery	134	11	26.8	7.6	1.11	6,839	16.93	71.6	4.7
2000	Hatchery	132	10	26.7	6.8	1.16	2,399	16.99	74.4	4.3
2001	Hatchery	142	12	30.0	7.5	1.05	7,107	15.12	80.3	1.6
2002	Hatchery	139	17	28.5	11.9	1.06	3,918	15.92	77.3	4.4
2003	Hatchery	139	16	29.7	11.4	1.11	1,743	15.27	72.4	6.8
2004	Hatchery	118	10	18.7	5.3	1.14	2,694	24.26	61.0	0.9
2005	Hatchery	118	8	18.9	4.4	1.16	2,418	24.00	60.8	3.7
2006	Hatchery	121	10	20.1	5.0	1.13	1,462	22.57	68.7	5.0

Migration Year	Origin	Mean Fork Length	S.D. Fork Length	Weight (g)	S.D. Weight	Fulton's K	Sample Size at Trap	Fish Per Pound	Survival Trap to LGR	S.D. Survival
2007	Hatchery	123	11	22.2	6.2	1.19	1,084	20.43	70.5	4.7
2008	Hatchery	124	11	22.8	6.6	1.19	1,754	19.89	70.1	2.6
2009	Hatchery	123	8	22.6	4.5	1.21	1,957	20.07	78.5	6.4
2010	Hatchery	128	8	24.0	4.9	1.14	2,442	18.90	70.2	11.9
2011	Hatchery	126	10	24.1	5.6	1.20	991	18.82	68.8	1.0
2012	Hatchery	120	9	20.0	4.9	1.16	379	22.68	68.1	1.3
2013	Hatchery	128	9	22.7	5.7	1.08	1,030	19.98	75.0	1.5

Appendix I. Natural and hatchery steelhead smolt size at the Imnaha River juvenile emigrant trap and estimated survival from the trap to Lower Granite Dam (LGR) from migration year 1994 through 2013. mm = millimeters, g = grams, S.D. = standard deviation.

Migration Year	Origin	Mean Fork Length	S.D. Fork Length	Weight (g)	S.D. Weight	Fulton's K	Sample Size at Trap	Fish Per Pound	Survival Trap to LGR	S.D. Survival
1994	Natural	172	19	52.4	17.0	1.03	2,228	8.66		
1995	Natural	173	20	52.7	18.2	1.02	568	8.61	83.7	7.1
1996	Natural	175	19	56.9	17.8	1.06	3,786	7.97	86.5	3.9
1997	Natural	175	20	55.8	18.9	1.04	864	8.13	90.1	3.9
1998	Natural	177	21	56.8	20.7	1.02	2,843	7.99	86.0	2.2
1999	Natural	184	19	62.3	19.8	1.00	2,517	7.28	87.7	3.1
2000	Natural	184	21	62.0	22.2	1.00	4,668	7.32	84.4	2.7
2001	Natural	178	24	55.5	24.3	0.98	3,733	8.17	82.7	1.4
2002	Natural	172	20	51.1	17.3	1.00	4,738	8.88	83.0	5.4
2003	Natural	174	23	53.9	20.7	1.02	5,961	8.42	82.0	2.5
2004	Natural	170	21	50.5	19.6	1.04	5,652	8.98	79.0	2.2
2005	Natural	169	19	51.4	17.1	1.07	4,541	8.82	80.8	1.4
2006	Natural	171	20	53.7	18.0	1.07	2,298	8.45	91.9	5.1
2007	Natural	169	19	53.5	18.5	1.11	7,195	8.48	78.8	4.4
2008	Natural	166	19	50.4	17.4	1.10	2,524	9.00	89.7	4.0
2009	Natural	173	18	54.5	16.9	1.05	5,163	8.32	86.9	2.6
2010	Natural	167	19	46.8	16.7	1.00	6,159	9.69	85.2	5.4
2011	Natural	173	21	55.0	22.0	1.06	2,540	8.25	81.4	0.8
2012	Natural	170	18	50.9	16.2	1.04	5,299	8.91	89.4	1.1
2013	Natural	169	21	51.4	20.1	1.06	6,993	8.82	99.9	1.7
1994	Hatchery	209	19	89.0	27.8	0.97	3,229	5.10		
1995	Hatchery	208	19	86.1	25.6	0.96	1,537	5.27	77.5	3.1
1996	Hatchery	201	18	80.9	24.0	1.00	31,094	5.61	64.6	4.7
1997	Hatchery	210	20	88.0	26.1	0.95	7,345	5.15	81.4	2.0
1998	Hatchery	218	20	102.0	30.4	0.98	3,890	4.45	82.9	2.4
1999	Hatchery	216	18	98.3	1.0	0.98	6,444	4.61	85.4	2.0
2000	Hatchery	224	18	106.8	27.1	0.95	5,751	4.25	85.8	2.4
2001	Hatchery	217	23	98.2	31.6	0.96	4,365	4.62	82.0	1.6
2002	Hatchery	216	21	102.7	31.4	1.02	2,428	4.42	81.8	3.5
2003	Hatchery	222	23	110.6	34.0	1.01	5,397	4.10	89.4	3.3
2004	Hatchery	216	22	100.5	31.8	1.00	4,498	4.51	86.0	1.3
2005	Hatchery	217	22	107.5	35.5	1.05	6,596	4.22	82.8	1.2
2006	Hatchery	218	22	109.9	35.0	1.06	1,993	4.13	86.1	3.8

Migration Year	Origin	Mean Fork Length	S.D. Fork Length	Weight (g)	S.D. Weight	Fulton's K	Sample Size at Trap	Fish Per Pound	Survival Trap to LGR	S.D. Survival
2007	Hatchery	215	24	105.0	37.9	1.06	2,360	4.32	97.0	8.8
2008	Hatchery	211	21	100.1	31.0	1.07	1,030	4.53	82.7	4.9
2009	Hatchery	218	23	110.2	38.6	1.06	1,923	4.12	91.1	4.7
2010	Hatchery	214	25	100.2	39.1	1.02	2,124	4.53	99.9	14.7
2011	Hatchery	220	22	111.3	34.2	1.05	634	4.08	95.7	1.1
2012	Hatchery	213	19	95.9	26.1	0.99	1,906	4.73	91.9	2.2
2013	Hatchery	205	19	90.2	23.9	1.05	1,859	5.03	86.3	3.2