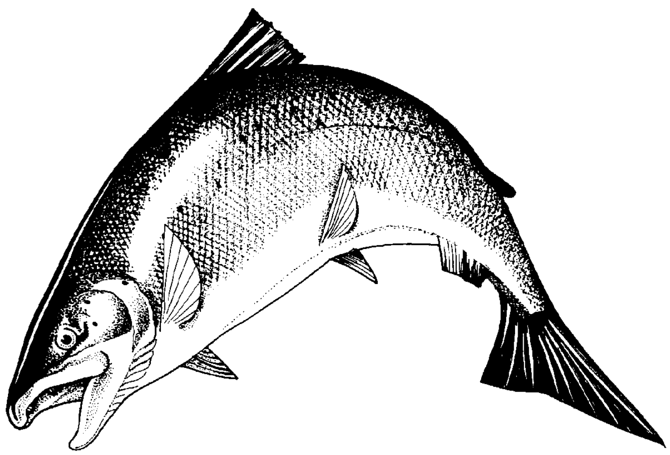
2003 Juvenile Salmonid Production Evaluation Report

Green River, Wenatchee River, and Cedar Creek



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Acknowledgments

Green River

Measuring juvenile salmon production from large river systems like the Green River involves a tremendous amount of work. Key to developing these estimates are the long hours of trap operation provided by our dedicated scientific technicians: Brett Brown, Matt Kinne, Blake Warnstadt, and Jamie Kelly. Logistical support and map development was provided by Wild Salmon Production Evaluation Unit biologists, Mike Ackley and Laurie Peterson, respectively.

A number of other individuals and agencies contributed to this project. For providing access to the trap site, we thank the adjacent land owner, Bill Mosby. We also thank Mike Wilson, manager of the Soos Creek Hatchery, for providing logistical support, office space, and a secure staging site near the trap. And finally, we thank the Salmon Recovery Funding Board for providing the funding necessary to complete this work.

Wenatchee River

We would like to thank our scientific technicians: Jay Deason, Joel Dirks, and Schuyler Zwar for all the long hours of operating and maintaining the smolt trap on the Wenatchee River. We also would like to thank the various scientific technicians from the Supplementation Research Team (SRT) in Wenatchee for assisting during times of need. We thank the Yakama Nation (YN) for the use of equipment and support. In addition, we would like to thank Chelan County Public Utility District No. 1 Central Maintenance for logistic and technical support.

Cedar Creek

Julie Grobelny, Josua Howolatz, and Scott Nelson worked the trap during the 2003 field season. Their field work was exceptional, and allowed for project goals to be achieved. They also were responsible for data entry, which was accurate and timely. Michelle Groesbeck developed the database and supplied the queries used in this analysis. Steve VanderPloeg created the site map. Charlie Cochran, Pat Frazier, Steve VanderPloeg, and Jim Scott reviewed an earlier draft of this report and their comments improved this manuscript.

Table of Contents

List of Tables

List of Figures

Executive Summary

Declining salmon populations in the 1980's and 1990's has resulted in the listing of a number of Washington State salmon populations under the Endangered Species Act (ESA). Most of these listings occurred between 1997 and 1999, impacting fisheries and land management over the entire state. To better monitor the status of these listed species and their production trends, the Washington Department of Fish and Wildlife (WDFW) expanded its salmon freshwater production monitoring (smolt monitoring) program. Among the new monitoring sites established during this period, monitoring of lower Columbia steelhead began in Cedar Creek in 1998. WDFW also began monitoring listed Puget Sound chinook in the Green River and upper Columbia spring chinook in the Wenatchee River in 2000. Continuation of this work has relied on funding provided by the Salmon Recovery Funding Board (SRFB). The SRFB has funded smolt monitoring on the Green River, Wenatchee River, and Cedar Creek since 2002. This annual report describes the smolt monitoring activities that occurred on these three streams during the 2003 field season.

Fish were captured using a rotary screw trap on all three streams. On the Green River, the trap, located 55 km upstream of the mouth, was operated from February 3 to July 13, 2003. The focus of this project was to monitor the production of naturally produced Puget Sound chinook from this river system. Over this period, 17,792 naturally produced subyearling chinook were captured. As in previous years, the timing distribution of chinook outmigrants was bimodal, with the majority migrating as fry between February and mid-April. The fork length of these fish averaged less than 45mm. A smaller production component reared upstream of the trap and migrated as smolts from late May through June. The fork lengths of these larger migrants averaged between 70 and 82mm.

Twenty releases of marked chinook were made upstream of the Green River trap to estimate the proportion of downstream migrants captured (trap efficiency). Trap efficiency averaged 12.6% when flows were between 8.3 and 57 cms, and 1.0% when flows were above 57 cms. Using these efficiency estimates at these flows resulted in an estimated 535,000 naturally produced age 0 chinook migrated during the trapping period. By extrapolating for chinook migrating outside the trapping period, we estimate the total production above the trap site at 674,000. The precision of the estimate was very poor as a result of the very low efficiencies measured at higher stream flows, which primarily occurred during the fry migration period. Precision of the smolt estimate of 14,800 migrants was much better. Accounting for chinook spawning that occurred downstream of the trap and production from Big Soos Creek estimates the total Green River chinook production at 1.36 million migrants. Based on the number of parent brood spawners, we estimate the Green River chinook egg-to-migrant survival at 4.0% for the 2002 brood.

In addition to chinook, we estimated 156,000 naturally produced coho smolts and 12,600 naturally produced steelhead smolts. A large number of unmarked hatchery produced coho were released upstream of the trap. These fish were indistinguishable from the naturally produced coho smolts, making the estimation of wild coho difficult. As a result, the precision of the estimate could not be assessed and our confidence in the coho estimate is low.

We also estimated the survival to the trap for several hatchery releases of steelhead, coho, and chinook. Survival estimates ranged from 0.1% for Keta Creek steelhead to 33.9% for the combination of Icy Creek, Palmer, and Flaming Geyser steelhead releases. We estimated Keta coho smolts survived at 21% and Icy Creek yearling chinook at 10.5%.

On the Wenatchee River, screw traps are operated in three locations. A trap on the lower Chiwawa River is used to estimate production of spring chinook from this basin. Another trap below the outlet of Lake Wenatchee estimates sockeye smolt production from the lake. Finally, a third trap is operated low in the system, near the town of Monitor to measure production from the entire Wenatchee basin. This report presents results from trapping the Monitor site, which is funded by this project.

The Monitor trap, located 9.6 kilometers upstream of the confluence with the Columbia River, was operated from February 21 to July 30. As in previous years, chinook from two broods were captured. Based on differences in life history, yearling chinook (2001 brood) were considered to be spring chinook and subyearling (2002 brood) were considered to be summer chinook. Spring run chinook from the Wenatchee River make up a portion of the endangered Upper Columbia Spring Chinook ESU. The summer run is not listed.

A total of 1,619 naturally produced yearling chinook were captured in 2003. The majority (90%) of the fish were captured by May 20. The majority of subyearlings migrated between May and June. There was some overlap in migration timing, but scale analysis confirmed that the two age classes could be differentiated by fork length which averaged over 90 mm for yearlings and nearly 50 mm for subyearlings.

A total of 30 efficiency tests (14 with yearling hatchery coho and sockeye and 16 with subyearling chinook) were conducted at the Monitor trap site over the season. Recapture rates ranged from 0.00% to 3.02% (0.79% average) for yearling fish and 0.24% to 2.73% (1.86% average) for subyearling chinook. A regression-based model using streamflow was developed to estimate trap efficiency for yearling chinook based on the result from tests conducted with yearling coho and sockeye. Two trap positions were operated during the 2003 season. Results from the 2003 efficiency tests were used to model trap efficiency for the trap position used most of the time. However, these tests along with trials from previous years were incorporated in modeling trap efficiency when the trap was fished in the "out" position.

An estimated 319,000 yearling Upper Columbia spring chinook migrated from the Wenatchee River in 2003. Due to low trap efficiency and since river discharge was outside the data range used to develop the regression model, confidence intervals were deemed too wide to be useful and not reported.

In addition to yearling spring chinook, we estimated 45 million subyearling chinook, 44,000 wild steelhead smolts, and 37,000 wild coho smolts which were recently re-introduced into the Wenatchee system. A total of 5.4 milllion sockeye smolts were estimated to have migrated past the Lake Wenatchee trap.

Trapping in a major tributary of the Wenatchee, Chiwawa River, provided some additional insight into spring chinook production and survival from the Wenatchee basin. Of the spring chinook redds created the Wenatchee system in 2001, 49% were found in the Chiwawa River subbasin. Yet the Chiwawa produced an estimated 248,000 yearling smolts or 75% of the spring chinook production from the entire Wenatchee system. Assuming the estimates of smolt production and redd distribution are accurate, the Chiwawa is extremely productive relative to other spring chinook streams such as the Icicle, Peshastin, and Ingalls subbasins. This is not surprising since habitat quality in the Chiwawa subbasin is considered much better than in these other streams.

The Cedar Creek trap was operated from March 19 to June 26, 2003. Located 4.0 kilometers upstream from its confluence with the North Fork Lewis River, this trap monitors the steelhead production from Cedar Creek. This stream's production makes up part of the listed Lower Columbia steelhead ESU. In addition to steelhead, coho and cutthroat productions are measured in the system. ESA listed Lower Columbia chinook are also present in Cedar Creek, but current funding is insufficient to monitor their production.

During the trapping period, a total of 582 steelhead pre-smolts and smolts were captured. Steelhead fork length averaged 176 mm, with a declining trend in weekly mean steelhead sizes observed (202 mm to 158 mm FL) over the season. Of the steelhead captured, 561 were marked by fin coloration using a Panjet inoculator and released upstream of the trap to assess trap efficiency. Mark placement was changed weekly and 13 groups were marked. Trap efficiency data was analyzed and population estimates were made using Stratified Population Analysis Software. A bootstrap methodology was used to estimate the variance of migration estimates. A total of 1,727 +/- 193 (95% CI) steelhead smolts migrated past the Cedar Creek trap in 2003.

In addition to steelhead, 35,095 +/- 2,481 (95% CI) naturally produced coho, 8,476 +/- 1,639 (95% CI) hatchery coho, and 2,548 +/- 321 (95% CI) cutthroat smolts are estimated to have migrated past the trap. In addition to these estimates, 361 chinook, 1,026 coho, and 65 trout fry were captured, as well as 27 cutthroat, 47 rainbow/steelhead, and 101 coho parr. Numerous non-salmonid species were also captured including western brook lamprey and Pacific lamprey.

Considerable effort was made in the Cedar Creek project to evaluate the conditions that researchers must assume to make fish population estimates using this approach. Results from these tests indicate the estimates are unbiased and were deemed to have sufficient precision for management and research use.

1 Introduction

Declining salmon populations in the 1980's and 1990's resulted in the listing of a number of Washington State salmon populations under the Endangered Species Act (ESA), impacting fisheries and land management over the entire state. With the advent of these listings, the Washington Department of Fish and Wildlife (WDFW) expanded its salmon freshwater production monitoring (smolt monitoring) program to better measure the status and trends in listed populations, determine population structure, assess habitat and environmental impacts on production, and monitor the effects of recovery measures on these listed populations. New sites established during this period included Cedar Creek (1998) to monitor Lower Columbia steelhead, Green River (2000) to monitor Puget Sound chinook, and Wenatchee River (2000) to monitor upper Columbia spring chinook. Funding from the legislature established (Green and Wenatchee Rivers) or continued (Cedar Creek) the monitoring of these listed species.

The legislature requested that the Washington Salmon Recovery Funding Board (SRFB) consider funding smolt monitoring in the spring of 2002. The SRFB agreed and has funded smolt monitoring on the Green River, Wenatchee River, and Cedar Creek over the last two years. This report describes the smolt monitoring activities that occurred during the 2003 field season. It also presents production estimates for the listed species as well as for a number of other populations rearing in these watersheds.

2 Green River

2003 Green River Juvenile Salmonid Production Evaluation

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2.1 Methods

2.1.1 Trap Operations

A floating screw trap (Busack *et al.* 1991) was used on the Green River to capture downstream migrant chinook, coho, chum, and steelhead. The 1.5-m diameter trap was located at river kilometer 55.5; approximately 1-km upstream of the Highway 18 bridge, on the left bank (Figure 2-1). This trap is fully described in Seiler *et al*. 2002[a].

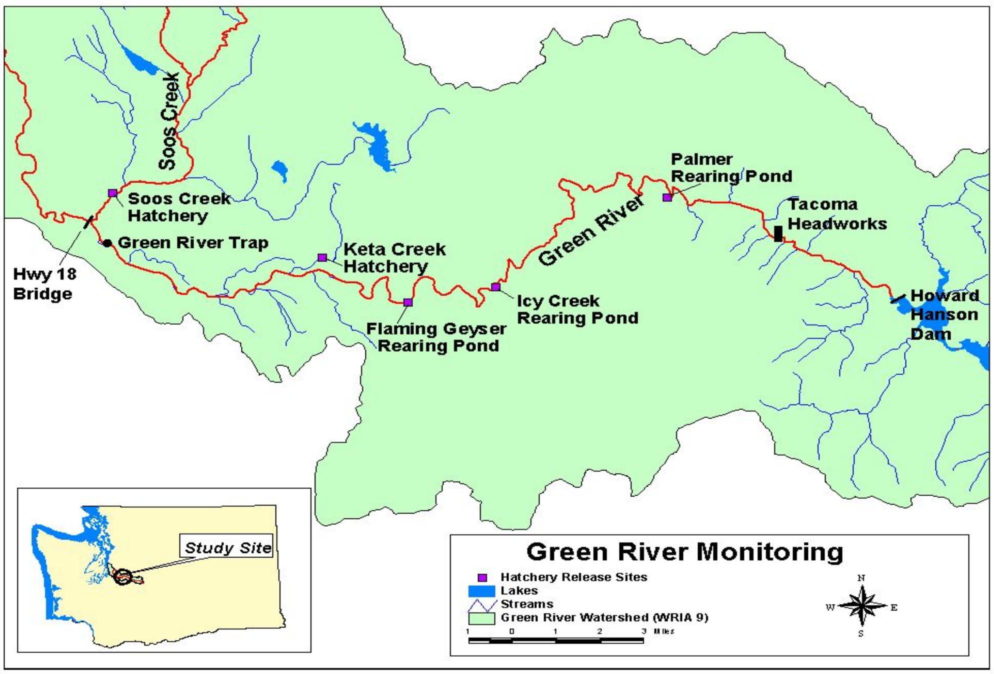

Figure 2-1. Location map of the Green River screw trap relative to hatcheries and hydro projects, Middle Green River 2003.

The trap was operated between February 3 and July 13, except for periods when debris, mechanical failure, or large catches of hatchery fry necessitated the cessation of trapping. Trapping was also suspended during daytime periods late in the trapping season, when catches were low and recreational use of the river was high. Fish were usually removed from the trap and counted at dawn and at dusk. In addition to these periods, the trap was checked at other times, as needed, based on debris loads and capture rates. At the end of each trapping period, all fish captured in the trap were enumerated by species and age. Fork length measurements were taken from a sample of the captured unmarked chinook, coho and steelhead.

To estimate migration, groups of chinook, coho, and chum were used to test the capture efficiency of the trap. Fish used for trap efficiency testing were anesthetized with tricaine methanesulfonate (MS 222), identified to species, and marked with a unique partial fin clip or with Bismark Brown dye.

Marked fish were allowed to recover in fresh water before being placed in buckets, transported upstream, and released 150 yards upstream of the trap. Capture rates were estimated by the proportion of marked fish that were recaptured in the trap after release.

2.1.2 Production Estimate

Estimating chinook, coho, and steelhead production from the Green River involved two steps. Since the trap did not operate continuously over the entire trapping period, the first step estimated catch by interpolation. The second step applied the estimated capture rate or trap efficiency to the catch to estimate migration. These methods were used to estimate the adipose-marked (ad-marked) and unmarked components of the daily catches, the trap efficiency, and migration for each species.

To interpolate catch for periods when the trap was not fishing, diel differences in migration rates were evaluated. Salmonids often migrate at different rates between day and night periods (Seiler *et al.* 1981), therefore, fishing periods were stratified into daytime, nighttime, and combined periods. The stratification was simplified by performing the trap checks near daybreak and twilight periods. Catch during trapping intervals not fished were estimated by interpolating between catch rates from the previous and following dates of the same diel stratum, and then expanding by the hours not fished. When a trapping interval was interrupted by debris, catch was either estimated for the entire night or, if available, the outage interval was estimated based on the expected number of trap rotations (RPM x fishing time) compared to the count of the revolution counter. Catch for the hours not fished was then estimated using the average catch rate from the previous and following diel stratum and the interval fished. Catch rates were estimated by;

$$\hat{R}_{fj} = \frac{C_{fj}}{T_{fj}}$$ **Equation 2-1**

where:

R_{fj} = *the catch rate during fishing period f in diel stratum j,*

C_{fj} = *catch during fishing period f in diel stratum j, and*

T_{fj} = *the duration of fishing period f in diel stratum j.*

The variance of the interpolated catch rate was estimated by;

$$V(\overline{R}_{fj}) = \frac{\sum(\hat{R}_{fj} - \overline{R}_{fj})^2}{n(n-1)}$$ **Equation 2-2**

Catch during the un-fished interval was then estimated by expanding the mean catch rate by the hours not fished (*T*). The catch variance was then estimated by;

$$V(\hat{C}) = V(\overline{R}_{fj})\hat{T}^2$$ **Equation 2-3**

When large numbers of hatchery fish were released upstream of the trap in 2003, the trap fished only for the first few hours of the evening and was then pulled for the remainder of the night interval. This occurred during consecutive nights, and interpolation of catch rates from the following and proceeding nights could not be used. Catch rates for those un-fished night intervals were estimated by averaging catch rates from the full nights fished before and after the outages (April 30 and May 9) and the catch rate during the few hours fished that night. The variance of the catch rate was calculated using Equation 2, and the variance of the catch was calculated using Equation 3.

In order to estimate the capture rate of the trap, groups of marked migrants were released upstream of the trap and subsequently recaptured. The capture rate was calculated for individual tests using;

$$\hat{e}_i = \frac{r_i}{m_i} \qquad \textbf{Equation 2-4}$$

where;

$\hat{e}_i = \textit{the capture rate estimated for trap efficiency test i,}$

$r_i = \textit{the number of marked or dyed migrants captured in trap efficiency test i, and}$

$m_i = \textit{the number of marked or dyed migrants released in trap efficiency test i.}$

The variance of each trap efficiency test was calculated using the variance of a binomial expression by;

$$V(\hat{e}_i) = \frac{\hat{e}_i(1-\hat{e}_i)}{m_i} \qquad \textbf{Equation 2-5}$$

Daily migration was estimated by dividing the estimated catch by the estimated trap efficiency. Where mean daily flow failed to show a relationship with individual trap efficiencies, the average trap efficiency was used. The variance of the average trap efficiency was calculated using Equation 2, substituting $\bar{e}$ for $\bar{R}_{fj}$ and $\hat{e}_i$ for $\hat{R}_{fj}$. Daily migration was estimated by summing daytime and nighttime catch interval to estimate 24 hour catch and dividing by the estimated efficiency. Total season migration was estimated by the sum of the daily estimated migrations, and the season migration variance for each species was estimated by;

$$V(N) = N^2\left(\frac{V(\bar{e})}{\bar{e}^2} + \frac{\sum V(\hat{C})}{C_t^{\ 2}}\right) \qquad \textbf{Equation 2-6}$$

where;

$N = \textit{the season migration estimate, and}$

$C_t = \textit{the total actual and estmimated catch during the trapping season.}$

2.2 Results

Estimating the production of chinook, coho, and steelhead migrants was complicated by the large numbers of hatchery salmonids planted into the river. Table 2-1 provides a summary of hatchery releases that could have been captured in the screw trap in 2003.

Table 2-1. Releases of hatchery salmonids that could have contributed to catches in the Green River screw trap in 2003.

Species	Release		Brood	CWT	CWT	Ad-mark	Ad-mark	Unmarked
	Date(s)	Location	Year	Only	Ad-mark	Only	LV	
2002 Releases Above Howard Hanson Dam								
Coho	5/07-5/09	Howard Hanson Dam	2001					495,700
Chinook	3/20-3/28	Howard Hanson Dam	2001			502,633		
2003 Releases								
Chinook	3/20-3/25	Howard Hanson Dam	2002			271,337		
	05/01	Icy Creek	2001			324,000		
	5/15-6/15	Soos Creek	2002	200,000	200,000	2,636,900		
Coho	4/14-4/15	Howard Hanson Dam	2002					548,240
	04/20	Soos Creek	2001	45,000	45,000	266,396		
	05/01	Keta Creek	2001	46,027	1,815			242,158
Steelhead	05/01	Keta Creek	2001				34,000	
	05/01	Palmer	2001			136,515		
	05/03	Icy Creek	2001			10,200		
	05/03	Flaming Geyser	2001			13,700		
Chum	03/17	Keta Creek	2002					270,999
	04/07	Keta Creek	2002					935,105

2.2.1 Chinook

2.2.1.1 Catch

Over the 161-day season, we captured 17,792 unmarked and 53 ad-marked age 0+ chinook migrants (Appendix A). All hatchery age 0+ chinook released upstream of the trap were ad-clipped, so the unmarked captures represent naturally produced fish. Daily unmarked age 0+ chinook catch averaged 242 migrants over the first two complete days of trapping (February 4 and 5). Daily catch of unmarked migrants increased to 1,267 on March 7 and 1,312 on March 9. After March 9, daily catches declined to approximately 20 migrants by early-April. Daily catches of unmarked age 0+ chinook migrants began to increase slightly in June when 152 migrated on June 10, before declining to less than ten migrants a day by June 22.

A total of 53 ad-marked age 0+ chinook were captured throughout the trapping season. Ad-marked age 0+ chinook first entered catches on March 23 when four were caught. The last was caught on June 17. Daily catches ranged from zero to 15 ad-marked age 0+ chinook.

Over the season, we also caught seven wild unmarked, 46 hatchery unmarked and 233 hatchery ad-marked age 1+ chinook migrants. Ad-marked age 1+ chinook were caught beginning on May 1, the reported date of the first release of marked age 1+ hatchery smolts from the Icy Creek facility. Ninety-three percent of the ad-marked catch passed the trap within eight days of release, although one was caught as late as June 10.

2.2.1.2 Size

Wild chinook 0+ averaged less than 45-mm through the first week in April. They grew rapidly afterwards, averaging over 80-mm by mid-June (Table 2-2, Figure 2-2). Migrants measuring less than 40-mm were found through the middle of April, after which, the minimum size increased to over 60-mm at the end of the trapping period. From this data, we infer that 40-mm and smaller chinook were newly emerged fry and that the increase in the minimum size was an indication that incubation was completed.

2.2.1.3 Catch Expansion

The trap was operated 3,288 hours out of 3,558 possible hours in the 161-day trapping period, or 92.4% of the time. Catch was expanded for 19 intervals when trapping was suspended due to trap repairs, screw stoppers, and large hatchery releases. Trapping was suspended for 59.5-hours during four events (February 19 and 21, March 12 through 14, and April 28) when trap repairs were needed. March 12 through 14 exhibited the second highest flows during the trapping season. During this interval, the screw trap was removed from the pontoon system by large debris moving downstream. A new screw was installed, and began operation March 14 at 1400. We estimated 562 chinook would have been caught during this interval by interpolating between catch rates for the days before and after the interval. Due to increased migration rates that typically occur with higher flows, this is likely an underestimation of the actual catch.

On two other occasions, the trap was stopped due to debris entering the screw. The catch on March 11 was estimated using interpolation of catch rates from the nights before and after. The catch during the outage on April 14 was expanding by the period not fished, which was estimated by the rotation counter mounted to the trap.

In addition to the repairs and screw stoppers, the trap was also pulled during ten intervals to avoid large catches of hatchery-produced salmonids. Trapping was suspended for 45.0 hours from April 7 to April 9 due to hatchery releases. Chinook migration rates were low during this period and using interpolation we estimated that we missed catching only 26 chinook. The trap was also pulled during the nights of May 1 through May 8 for a total of 79.3 hours. During each of those nine nights, the trap fished for approximately one to four hours. In total, we estimated 67 unmarked chinook would have been caught had we been trapping continuously through those nights.

The trap was pulled during daylight hours beginning on June 5. Trapping was suspended for a total of 376.5-hours during the daytime when recreational use of the river was high and few fish were caught. By interpolating between the daylight periods fished weekly, we estimate that ten chinook in total would have been caught during these un-fished intervals.

Table 2-2. Mean fork length (mm), standard deviation, range, and sample size of wild age 0+ chinook measured by statistical week, Green River 2003.

Statistical Week			Average	s.d.	Range		Number		Percent
#	Begin	End			Min	Max	Sampled	Caught	Sampled
6	02/03	02/09	40.8	1.3	37	45	102	1,256	8.1%
7	02/10	02/16	41.2	1.5	38	48	231	854	27.0%
8	02/17	02/23	40.4	2.2	37	54	150	2,671	5.6%
9	02/24	03/02	41.7	1.9	38	51	207	2,099	9.9%
10	03/03	03/09	42.3	2.8	38	65	194	4,877	4.0%
11	03/10	03/16	41.5	1.6	38	48	155	2,375	6.5%
12	03/17	03/23	42.3	3.9	38	66	124	1,109	11.2%
13	03/24	03/30	44.2	5.2	38	69	83	464	17.9%
14	03/31	04/06	44.4	4.3	40	54	19	102	18.6%
15	04/07	04/13	44.9	6.0	38	68	57	136	41.9%
16	04/14	04/20	50.1	9.2	38	68	36	127	28.3%
17	04/21	04/27	56.5	7.1	42	69	26	85	30.6%
18	04/28	05/04	61.3	5.8	54	75	11	78	14.1%
19	05/05	05/11	60.4	6.7	42	76	33	80	41.3%
20	05/12	05/18	66.6	9.4	49	81	13	90	14.4%
21	05/19	05/25	73.7	8.3	57	91	22	65	33.8%
22	05/26	06/01	70.0	10.3	42	87	62	255	24.3%
23	06/02	06/08	74.8	9.4	48	95	48	262	18.3%
24	06/09	06/15	81.8	4.6	73	92	18	491	3.7%
25	06/16	06/22	81.9	6.8	67	94	30	257	11.7%
26	06/23	06/29	78.3	8.1	67	90	7	37	18.9%
27	06/30	07/06	85.7	12.1	62	98	7	17	41.2%
28	07/07	07/13	79.2	14.0	59	97	5	5	100.0%
Season Total			47.1	12.4	37	98	1,640	17,792	9.2%

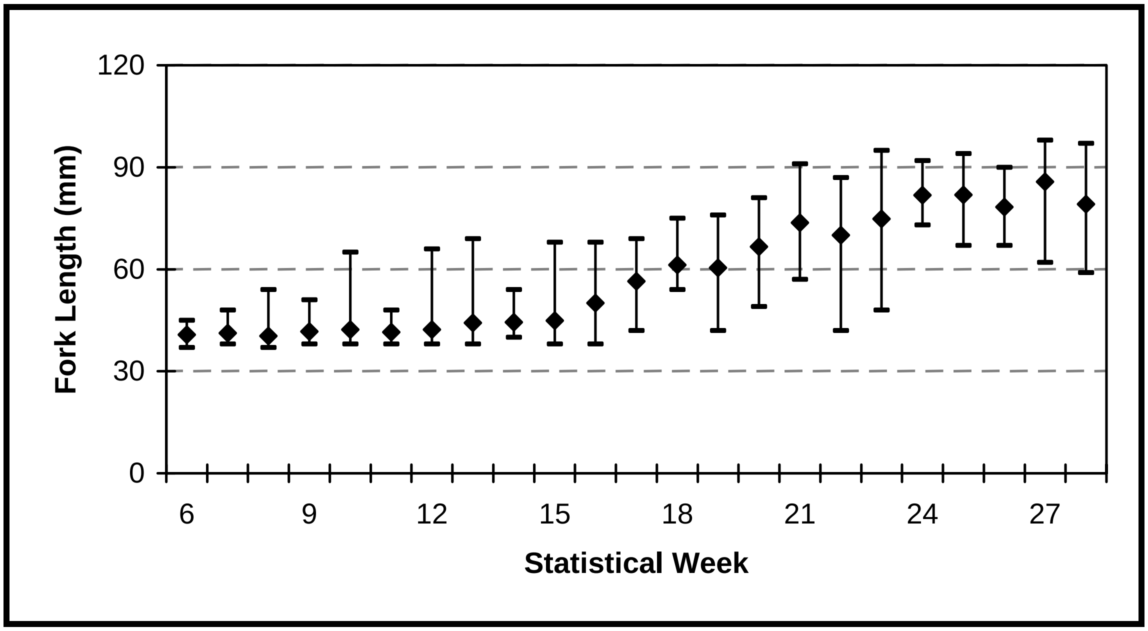

Figure 2-2. Weekly average, minimum, and maximum 0+ chinook fork lengths (mm) measured at the Green River screw trap, 2003.

Expanding the actual catches for periods when trapping was suspended resulted in the addition of 1,189 age 0+ wild chinook (Appendix A). We estimate a total of 18,981 wild chinook would have been captured if continuous trapping had occurred between February 3 and July 13. This represents a 6.7% increase over the actual catch of wild migrants. Expansion also resulted in the addition of four hatchery age 0+ chinook.

Throughout the trapping season, catch expansion also resulted in the addition of four wild age 1+ and 1,680 hatchery age 1+ chinook to the actual catch. Hatchery catch expansions were estimated from May 1 to May 9 when the trap was only operated for a few hours each night due to large hatchery releases of yearling chinook, coho, and steelhead (Table 2-1). The hatchery catch was estimated by applying the catch rate measured during the first few hours of the night to the hours not fished during that night.

2.2.1.4 Trap Efficiency

A total of 1,719 age 0+ wild chinook migrants in 20 groups were marked and released from 150-yards upstream of the trap. The number of fish released in each group ranged from 14 to 200 chinook. The last two releases of the season were combined in order to increase our confidence due to the low numbers of chinook in those releases. Recapture rates averaged 10.2% and ranged from 0% to 28% for the combined groups (Table 2-3).

Flows ranged from 6.4 to 73.1 cubic meters per second (cms) during the chinook trap efficiency tests. Although the relationship between flow and efficiency was not statistically significant (α=0.05), trap efficiencies decreased with increased flow, as is evident in many other river systems. The distribution of trap efficiency results with flow suggested partitioning the efficiencies into two flow strata. The efficiency distributions were found to be significantly different between strata (Wilcoxin two-sample test (α=0.05). The first stratum is the flow range of 0 to 57 cms, which the chinook efficiency tests conducted during that range averaged 12.6% (Table 2-3). The second stratum is the flow range above 57 cms, which the chinook efficiency tests conducted during that range averaged 1.0%. These values along with catch estimates were used to estimate daily migration.

In addition to the chinook releases, 1,995 marked chum were released in 12 groups. Chum recapture rates averaged 6.5% and ranged from 0% to 17%. We initially intended to use these tests to represent chinook trap efficiency. The distribution of the chum efficiency results were not significantly different from chinook (Wilcoxin two-sample test, α=0.05). Nevertheless, we did not use the chum data to estimate trap efficiency for chinook since we were able to conduct sufficient chinook efficiency tests.

2.2.1.5 Production Estimate

From February 3 through July 13 we estimated 535,471 wild age 0+ chinook migrants passed the screw trap with a coefficient of variation of 55.6% and 95% confidence interval of 0 to 1,118,632 chinook. The migration was well underway when trapping began. To estimate total chinook production, we extrapolated the migration back to a January 1 start date. The extrapolation was accomplished using the chinook migration timing measured in the Cedar River. It is estimated that 20.6% of the Cedar River chinook migrated prior to February 3. This approach was used because the largest freshet of the spring occurred a few days before trapping began and simple extrapolation would have underestimated the migration that would have occurred during this flow event. Expanding the Green River migration by this proportion resulted in an additional 138,926 wild 0+ migrants for a total wild migration of 674,397 (Figure 2-3). In addition to the wild fish, we estimate 821 ad-marked hatchery age 0+ chinook migrated during the February 3 through July 13 trapping period.

Chinook yearling migration was estimated by applying the coho trap efficiency estimate to the expanded catch. Total wild production was estimated at 192 yearlings with a coefficient of variation of 44%, and hatchery production was estimated at 34,149 yearlings. Since the trap was fished for only 1 to 4 hours per night between May 1 and May 9, when nearly all of these fish passed the trap, substantial error may exist in this estimate.

Table 2-3. Chinook 0+ trap efficiency tests conducted on the Green River screw trap and separated by flow strata, 2003.

Strata	Date	Flow (cfs)	# Marked Released	# Marked Recaptured	Trap Efficiency
FLOWS: 0 - 2,000 cfs	02/10	1,020	105	8	7.6%
	02/16	679	103	4	3.9%
	02/19	630	200	12	6.0%
	02/25	1,420	100	5	5.0%
	03/01	644	100	11	11.0%
	03/03	630	100	28	28.0%
	03/05	553	100	21	21.0%
	03/07	636	100	15	15.0%
	03/09	905	100	8	8.0%
	03/28	1,520	100	14	14.0%
	05/29	918	50	8	16.0%
	05/31	784	50	13	26.0%
	06/02	713	50	8	16.0%
	06/12	415	55	1	1.8%
	06/16-6/18	293-316	31	3	9.7%
	Total		1,344	159	
	Average				12.6%
	Var				4.1E-04
	n				15
FLOWS: 2,000+	03/11	2,150	100	0	0
	03/24	2,210	75	0	0
	03/14	3,200	100	3	0.03
	02/23	3,350	100	1	0.01
	Total		375	4	
	Average				1.0%
	Var				5.0E-05
	n				4

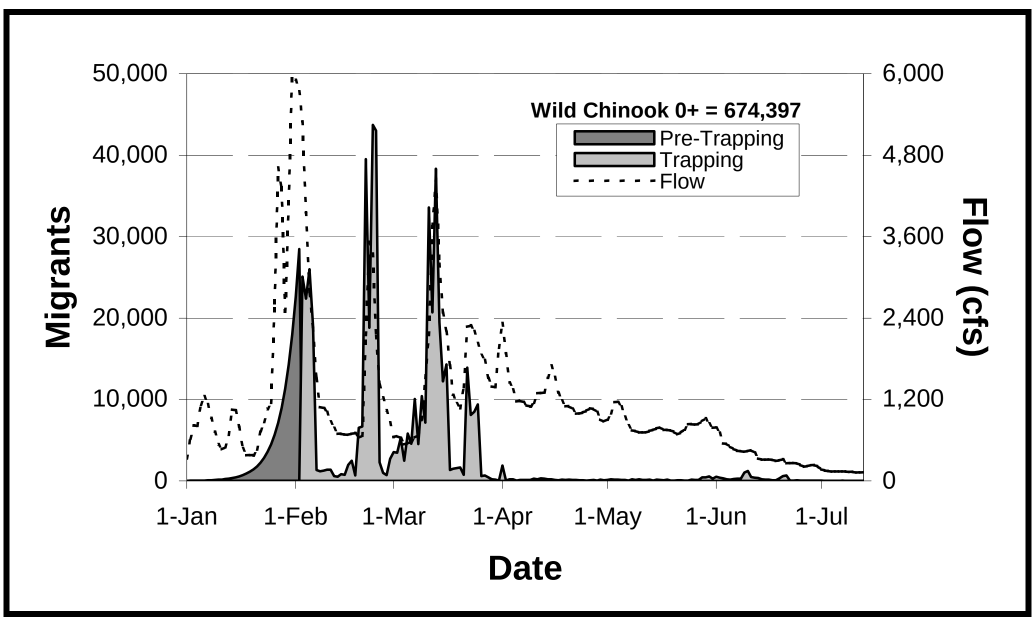

Figure 2-3. Daily migration of wild age 0+ chinook past the Green River screw trap, 2003.

2.2.2 Coho

2.2.2.1 Catch

Yearling coho salmon were captured on the first night of trapping, February 3. However, catch rates were low, generally less than 50 per day during the peak flows in early February. Catches from mid-February to mid-April averaged only five per day. After the peak flows, migration past the trap during this period may have largely been the result of within-basin movement prior to smoltification. In the fourth week of April, daily catches of age 1+ coho increased and peaked at 888 smolts on April 30. The majority of this catch was assumed to be hatchery smolts since Keta Creek hatchery reported a release of 290,000 smolts by volition on May 1, one day later. Of this release, only 1,815 were ad-marked and CWT and 46,027 were CWT only. Daily catches after the hatchery releases declined thereafter to near zero by mid-June. Over the 161-day trapping period, a total of 6,817 coho were captured: 31 were hatchery ad-marked, 371 were hatchery CWT, and 6,415 were unmarked.

Ad-marked hatchery coho smolts began to show up in the catch in low numbers on February 12. Between February 12 and April 25, 18 ad-marked coho were caught. This period was prior to any known yearling hatchery coho release in 2003. Therefore, these fish had likely escaped from Soos Creek Hatchery.

2.2.2.2 Size

Unmarked coho fork lengths averaged between 90-mm and 121-mm throughout the trapping season (Table 2-4, Figure 2-4). The sizes of individual age 1+ migrants ranged from 60-mm to 142-mm over the trapping season, and averaged 104 mm.

2.2.2.3 Catch Expansion

Trapping operations were suspended for a total of 270 hours over the course of the trapping period (see Section 2.2.1.3). As a result of pulling the trap during coho smolt hatchery releases, catch expansion resulted in the addition of 5,699 smolts: four ad-marked hatchery smolts, 210 CWT hatchery smolts, and 5,485 unmarked smolts. These were added to the estimated actual catch of 6,817 smolts. The expansion represents an 84% increase to the actual catch of coho smolts.

2.2.2.4 Trap Efficiency

A total of 353 yearling coho were marked and released in six trap efficiency tests during the 2003 trapping period. Trap efficiencies from these tests ranged from 0% 10.8%, and averaged 5.7% (Table 2-5). Linear regression analysis failed to find a correlation between trap efficiency and daily mean flow. Due to the small number of release groups, we chose to use the average efficiency to estimate daily migration.

Table 2-4. Mean fork length (mm), standard deviation, range, and sample size of unmarked coho smolts measured by statistical week, Green River 2003.

Statistical Week #	Begin	End	Average	s.d.	Range Min	Range Max	Number Sampled	Number Caught	Percent Sampled
6	02/03	02/09	94.2	16.9	60	124	15	166	9.0%
7	02/10	02/16	92.3	13.6	71	112	7	114	6.1%
8	02/17	02/23	113.2	14.6	88	129	6	33	18.2%
9	02/24	03/02	89.8	7.8	79	103	6	64	9.4%
10	03/03	03/09	106.0	26.4	73	141	8	40	20.0%
11	03/10	03/16	95.4	11.8	79	111	8	32	25.0%
12	03/17	03/23	94.4	17.7	75	120	7	19	36.8%
13	03/24	03/30					0	11	0.0%
14	03/31	04/06					0	10	0.0%
15	04/07	04/13	104.1	13.8	89	132	7	20	35.0%
16	04/14	04/20	101.1	7.3	85	113	24	64	37.5%
17	04/21	04/27	104.8	8.5	94	130	18	237	7.6%
18	04/28	05/04	109.1	10.0	92	140	51	2,593	2.0%
19	05/05	05/11					0	781	0.0%
20	05/12	05/18	103.3	7.1	87	118	32	1,185	2.7%
21	05/19	05/25	109.2	8.6	93	129	29	442	6.6%
22	05/26	06/01					0	207	0.0%
23	06/02	06/08					0	50	0.0%
24	06/09	06/15	106.6	12.3	93	122	5	25	20.0%
25	06/16	06/22	120.8	14.9	103	142	6	9	66.7%
26	06/23	06/29						0	
27	06/30	07/06	105.0	n/a	105	105	1	1	100.0%
28	07/07	07/13						0	
Season Total			104.3	12.4	60	142	235	6,103	3.85%

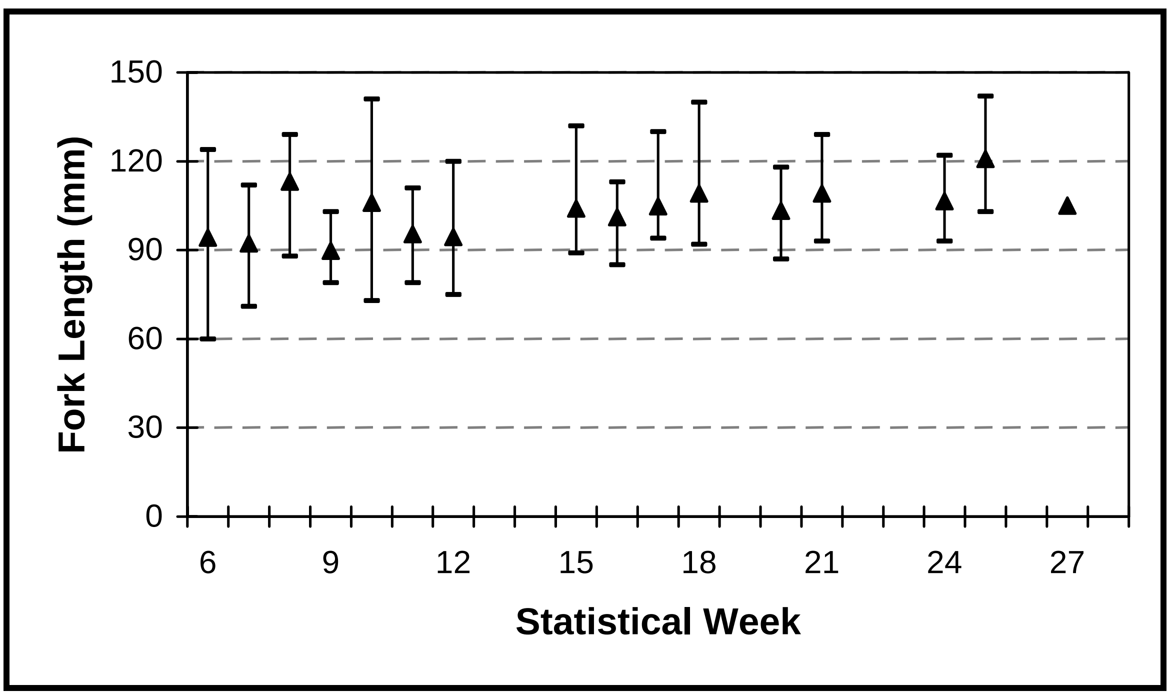

Figure 2-4. Weekly average, minimum, and maximum unmarked yearling coho fork lengths measured at the Green River screw trap, 2003.

Table 2-5. Estimated coho recapture rates from efficiency tests, Green River screw trap 2003.

Date	Flow (cfs)	Number Released	Number Recaptured	Trap Efficiency	Variance
04/27	1,060	50	4	8.0%	0.00174
04/30	872	50	3	6.0%	0.00128
05/10	712	50	4	8.0%	0.00174
05/13	733	60	1	1.7%	0.00028
05/15	772	93	10	10.8%	0.00130
05/19	746	50	0	0.0%	0.00000
	Total	353	22		
	Average			5.7%	
	Var			2.8E-04	
	n			6	

2.2.2.5 Production Estimate

Applying our average coho capture rate estimate to the expanded catch estimates yields a total coho migration estimate of 218,173 coho smolts (Table 2-6, Figure 2-5). This estimate was comprised of 207,442 unmarked, 605 ad-marked, and 10,126 hatchery CWT coho smolts. The low number of trap efficiency release groups and the large proportion of estimated catch resulted in low confidence of our coho smolt estimates. Although the coefficient of variation is high, we believe this to be the best estimate of coho migration past the Green River screw trap in 2003.

Table 2-6. Actual catch, missed catch estimated during un-fished periods, total (actual and missed) estimated catch and the estimated migration past the trap site of marked and unmarked coho smolts, Green River screw trap 2003.

Origin	Catch Actual	Catch Estimated	Catch Total	Migration Estimate	CV	95% CI Low	95% CI High
Unmarked	6,415	5,485	11,900	207,442	34.4%	67,404	347,480
Hatchery Ad-mk	31	4	35	605	31.3%	234	976
Hatchery CWT	371	210	581	10,126	34.0%	3,377	16,875
TOTAL	6,817	5,699	12,516	218,173	34.0%	72,805	363,541

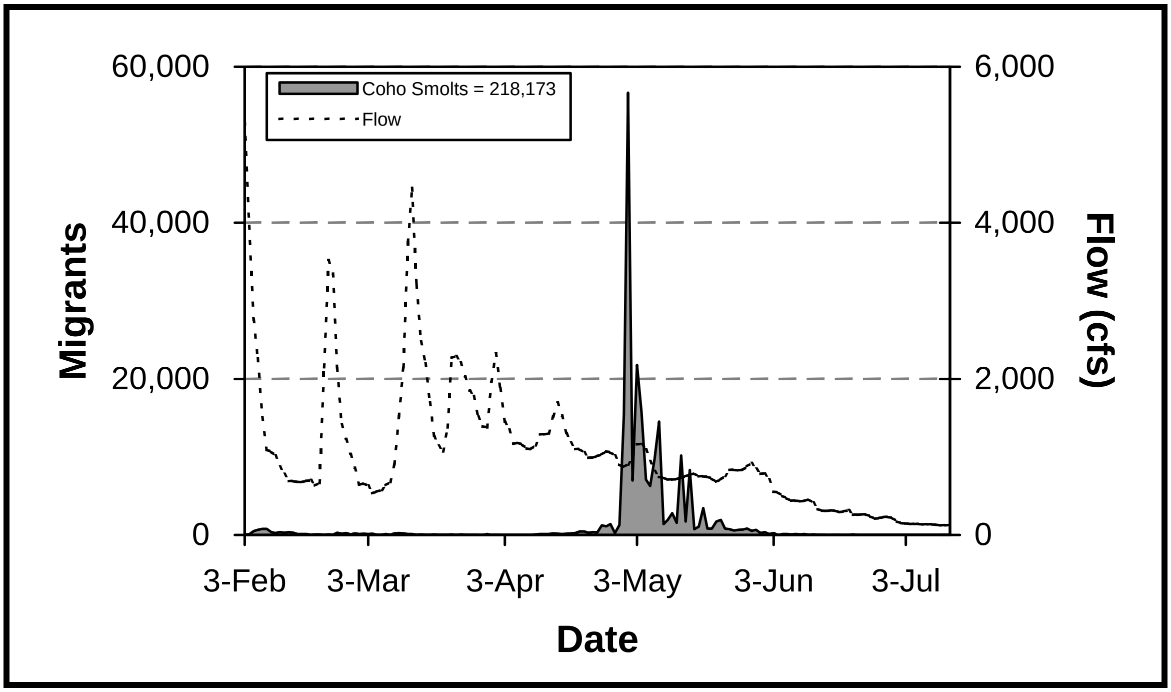

Figure 2-5. Daily migration of total, wild and hatchery, coho smolts in the Green River screw trap relative to stream discharge (USGS Gage #12113000), 2003.

The unmarked migration estimate includes both hatchery and wild coho smolts. The Keta Creek coho hatchery release consisted of over 240,000 unmarked smolts. During their migration downstream, most were indistinguishable from their wild counterparts. In order to estimate the number of wild smolts within the un-marked catch, we estimated wild migration using an additional two steps. First we divided the marked catch by the ratio of marked/unmarked smolts (16.5%) to estimate total hatchery catch, and the second step was to subtract the estimated hatchery catch from the total unmarked catch. The sum of the daily catches estimated a total wild coho production of 156,259 smolts (Table 2-7). No variances or confidence intervals were developed for these estimates.

Table 2-7. Estimated hatchery and wild coho smolt migration past the Green River screw trap, 2003.

Origin	Estimated Catch			Migration Estimate
	CWT	Ad-mk	Un-mk	
Soos Creek Hatchery		35		605
Keta Creek Hatchery	581		2,936	61,312
Wild			8,964	156,259
TOTAL	581	35	11,900	218,176

2.2.3 Steelhead

2.2.3.1 Catch

Over the trapping period, we caught 468 unmarked wild steelhead and nine unmarked cutthroat smolts. We also captured 857 ad-marked hatchery steelhead smolts, and two hatchery adipose and left-ventral fin clips. The first ad-marked steelhead was caught in the trap on February 11, two and a half months before the first reported hatchery release. A total of 27 hatchery ad-marked steelhead were caught before the first release from Keta Creek on April 30. These smolts were either escapees from the hatchery, or may have been possibly released the previous year.

2.2.3.2 Size

A total of 75 unmarked steelhead fork lengths were recorded throughout the trapping season; 16% of the total catch. Fork lengths ranged from 147 to 231 mm, and averaged 174 for the season (Table 2-8).

2.2.3.3 Catch Expansion

The trap was pulled during the migration of high numbers of hatchery smolts, which included steelhead. Although wild smolts were migrating during this interval, the catches were low. We estimated an additional 74 wild smolts would have been caught had we fished continuously throughout the trapping season. This represents an increase of 16% to the wild catch. We also estimated an additional 1,481 hatchery ad-marked steelhead smolts would have been caught. Hatchery steelhead smolts during the night intervals of May 1 through May 9 were estimated by applying the catch rate measured in the first few hours of the evening to the hours not fished that night. The expanded catch represents an increase of 173% to the actual catch.

2.2.3.4 Trap Efficiency

In any migrant trapping operation, trap efficiency is influenced by a number of variables such as channel configuration, the size/swimming ability of the captured fish, the velocity of water entering the trap, the position in the channel/water column preferred by the migrant, and the design of the trap itself. Steelhead smolts average approximately 1.5 times the size of coho smolts and are, therefore, generally captured at a lower rate. Trap efficiency was not measured for steelhead during this study. Therefore, to estimate trap efficiency for steelhead, we used the same approach applied in the 2002 report of multiplying a steelhead:coho capture rate ratio to the coho trap efficiency to estimate steelhead trap efficiency (Seiler *et al*. 2002[a]). A steelhead:coho capture rate ratio of 75% was applied to the coho rate which resulted in a steelhead trap efficiency of 4.3%. No variance estimates were made for these rates.

2.2.3.5 Production Estimate

Application of the steelhead trap efficiency estimate to the expanded catch resulted in an estimated migration of 12,612 unmarked steelhead smolts and 54,419 ad-marked hatchery steelhead smolts, of these, 47 were left-ventral fin clipped. The trapping interval typically encompasses the entire steelhead migration. However in 2003, substantial numbers of steelhead migrated at the beginning of trapping. Since this occurred at the highest flows of the spring emigration period, we believe few steelhead migrated before trapping began. Therefore, expansion of the production estimates beyond the trapping period was not deemed necessary (Figure 2-6). Variances and confidence intervals were not developed for these estimates.

Table 2-8. Mean fork length (mm), standard deviation, range, and sample size of unmarked steelhead smolts measured by statistical week, Green River 2003.

Statistical Week			Average	s.d.	Range		Number		Percent
#	Begin	End			Min	Max	Sampled	Caught	Sampled
6	02/03	02/09	168.0	19.3	147	226	20	136	14.7%
7	02/10	02/16					0	50	0.0%
8	02/17	02/23					0	10	0.0%
9	02/24	03/02	147.0	n/a	147	147	1	9	11.1%
10	03/03	03/09					0	1	0.0%
11	03/10	03/16	171.0	n/a	171	171	1	5	20.0%
12	03/17	03/23	179.5	30.4	158	201	2	3	66.7%
13	03/24	03/30					0	0	0.0%
14	03/31	04/06	175.0	24.6	152	201	3	8	37.5%
15	04/07	04/13	149.0	n/a	149	149	1	3	33.3%
16	04/14	04/20	180.3	24.0	157	218	7	11	63.6%
17	04/21	04/27					0	16	0.0%
18	04/28	05/04	181.1	15.5	152	203	12	24	50.0%
19	05/05	05/11	184.4	29.2	150	231	7	25	28.0%
20	05/12	05/18	157.3	3.9	153	161	4	84	4.8%
21	05/19	05/25	180.1	24.5	148	214	7	46	15.2%
22	05/26	06/01	169.2	12.8	154	184	9	23	39.1%
23	06/02	06/08					0	12	0.0%
24	06/09	06/15					0	3	0.0%
25	06/16	06/22	186.0	n/a	186	186	1	1	100.0%
26	06/23	06/29						0	
27	06/30	07/06						0	
28	07/07	07/13						0	
Season Total			173.8	20.4	147	231	75	470	16.0%

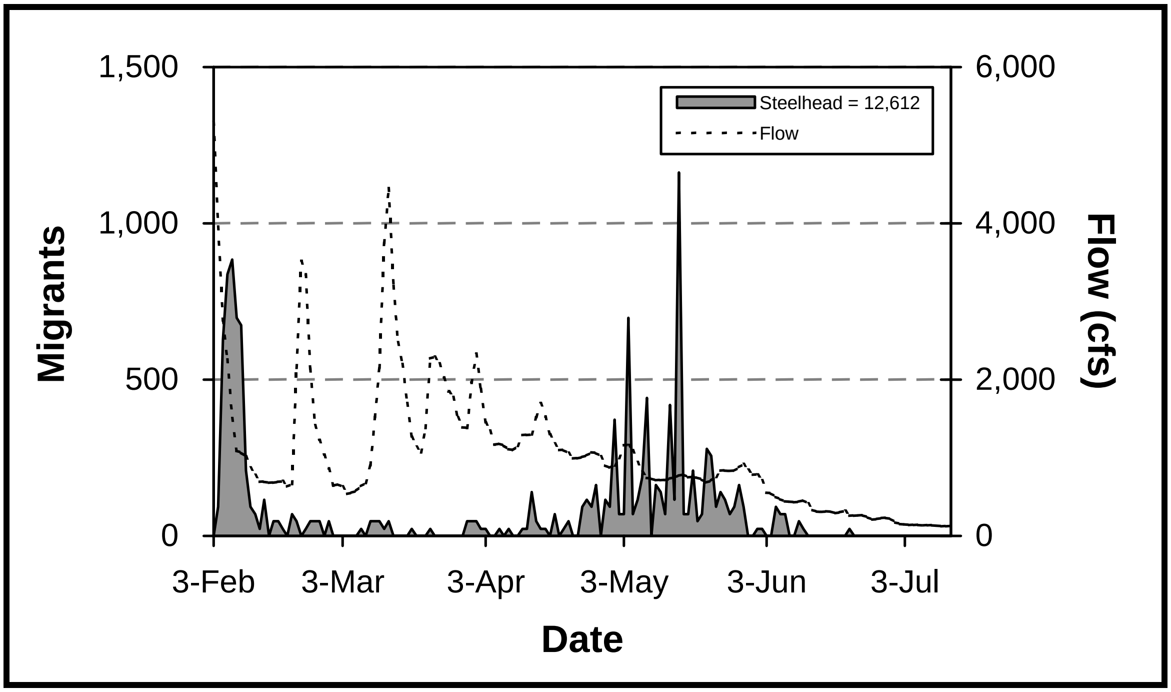

Figure 2-6. Daily migration of wild steelhead smolts in the Green River screw trap relative to stream discharge measured at USGS Gage #12113000, 2003.

2.2.4 Other Species

A number of other fish species and other salmonid age classes were captured and enumerated in the catch. Over the trapping period, a total of 46,222 chum, 689 age 0+ coho fry, and 11 age 2+ coho. We also captured 650 trout parr, nine cutthroat smolts, and one cutthroat adult. In addition to salmonids, a number of other species were captured: sculpin, three-spine sticklebacks, longnose dace, and lamprey ammocoetes.

2.3 Discussion

Estimates of migration past the trap were developed for Green River wild and hatchery age 0+ chinook, wild and hatchery yearling coho, and wild and hatchery steelhead smolts. A number of assumptions used to develop these estimates are discussed below. In addition, the estimates for wild chinook migrants are expanded to represent total basin production. As an aid to managers of the Keta Creek Hatchery, Icy Creek Hatchery, and Palmer Ponds we attempt to estimate survival of release groups to the smolt trap and explain the assumptions that went into those estimates.

2.3.1 Chinook

The accuracy of the wild age 0+ chinook production estimate for the Green River is partially dependent on the veracity of the estimated catch that was missed during the periods when the trap was not fishing. We believe the highest proportion of this missed catch (47%) occurred between March 12 and 13 when the trap was damaged by high flows and heavy debris. Because debris also made the trap inoperable the night before this outage, the catch rates from previous and following nights used to estimate catch occurred on flows that were half that during March 13. Due to large numbers of fry migrating at this time and high flows, which typically increase migration rates, we believe the estimated migration is biased low.

The accuracy of the wild age 0+ chinook production is also dependent on the veracity of our estimated capture efficiency. It is evident that in this system trap efficiency decreases with increased flow. However, due to the variability of trap efficiency tests conducted at low to mid flows, that relationship could not be used to estimate daily trap efficiency. It was observed that at flows of approximately 57 cms, the river flow covered a gravel bar on the right bank and substantially widened the channel, giving the fish an alternate path downstream. This effect of channel morphology on trap efficiency was demonstrated by the results of the four efficiency tests conducted at flows above 57 cms. Use of two flow strata (above and below 57 cms) to estimate trap efficiency instead of the annual mean efficiency undoubtedly resulted in a more accurate season total chinook estimate.

The chinook migration was well underway when trapping began February 3. Flows were decreasing from the peak of the season, and an unknown portion of the migration moved downstream before trapping began. In order to estimate migration prior to the trapping season, we chose to use chinook migration timing from the Cedar River as a best estimate. The assumption that the same proportion of the production migrated during the same January interval for two different watersheds may be erroneous, however, we believe that it represents the most accurate estimate available. Due to high flows and warmer temperatures, migration timing in 2003 was earlier in the season compared to previous years for both rivers (Seiler *et al.* 2002[b]).

Egg-to-migrant survival is a measure of freshwater productivity for naturally-reared salmon. The estimated migration of 674,397 wild age 0+ chinook migrants divided by the estimated egg-deposition above the trap resulted in an egg-to-migrant survival of 4.0%. The estimated egg deposition was derived using an above the trap escapement estimate of 3,772 chinook redds above the trap (Cropp pers. comm.). Egg deposition was estimated using an average fecundity of 4,500 eggs per female.

The wild age 0+ chinook production estimate made at the Green River trap only represents the production that occurred upstream of the trap. An additional 2,314 females were estimated to have spawned downstream of the trap. Assuming the same egg-to-migrant survival, we estimated the total Green River production downstream of the trap at 413,721 wild chinook migrants. Assuming similar naturally-produced chinook production levels for Big Soos Creek as was observed in 2000, 275,000 migrants (Seiler *et al.* 2002[a]), results in a total basin production estimate of 1,363,118 naturally-produced age 0+ chinook migrants. We believe this assumption is valid since Big Soos Creek received sufficient hatchery spawners in both 1999 and 2002 to fully seed the habitat available to them.

The wild age 0+ chinook migration for the Green River exhibited a bi-modal timing distribution. The earliest component was composed of chinook fry that migrated past the trap in January through March, which was followed by a smolt component that migrated from May through June. The fry component in 2003 made up 98% of the production above the Green River trap, or 659,568 fry. This is a larger proportion than has been seen in previous years, and was in response to extreme flow events early in the migration. Although the majority of chinook migrated as fry, these fish would have survived at a lower rate compared to smolts due to their smaller size.

The precision of the 2003 migration estimate is low as indicated by its coefficient of variation (55.6%). The lack of precision resulted from:

1. Non-operation of the trap during periods of extensive potential migrations, and
2. Variability in trap efficiency.

The confidence in our smolt estimate is much higher due to lower flows, few trap outages, and less variable trap efficiency tests as a result of these flows. The smolt component in 2003 (April 16 through July 13) was estimated to be 14,829 migrants, with a coefficient of variation of 14% and a 95% confidence interval of 10,134 to 19,524 smolts.

2.3.2 Coho

The accuracy of the wild coho production estimate is dependent on the accuracy of both the estimated catch and the ratio of tagged to unmarked hatchery smolts released. Of the wild coho that we estimated would have been caught during un-fished periods, nearly all (99%) were estimated for periods between May 1 and May 9 when the trap was fished for only a few hours each night to avoid most of the large numbers of hatchery coho smolts migrating downstream. These releases were by volition and began on May 1 from Keta Creek Hatchery. Of the 290,000 smolts released, 16.5% were coded wire tagged and the rest were unmarked. The large numbers of unmarked hatchery smolts captured were indistinguishable from their wild counterparts and required estimating the wild catch using the CWT:unmarked/untagged ratio for the hatchery release. This is an added step that is not necessary where only wild fish are present or where all hatchery fish are externally identifiable. Use of this tag rate adds an additional variance component to the wild coho migration estimate. Since the precision of this estimate was unknown, we could not calculate a variance for the wild coho production estimate.

2.3.3 Steelhead

The accuracy of our steelhead migration estimates for the Green River are reliant on the accuracy of our catch estimates during intervals not fished and of our assumption relating trap efficiency for steelhead to coho salmon. Catches of wild steelhead were less variable than those of hatchery smolts between days, therefore, we believe the wild steelhead catch estimates are more accurate. The estimation of hatchery smolts during the nights not fished between May 1 and May 9 is of particular concern. The catch estimates found using interpolation between nights before and after the outages (April 30 and May 10) and the few hours fished the night of the outage were deemed too low. In order to more accurately estimate hatchery catch during those nights, we estimated nightly catch by extrapolating the catch rate measured during the first few hours of the hours not fished. This method increased the number of hatchery smolts estimated, but may still underestimate actual migration past the trap. Catch rates for each night were estimated from hours fished from approximately 1800 to 2100 hours before the trap was pulled. During the 2001 trapping season, it was estimated that 16% of the wild steelhead migration occurred during the 2100 hour during the month of May (Seiler *et al. in press*). Also measured in 2001 were four nights in May when nightly catches were separated into before and after the 2300 hour, an average of 33% of the hatchery catch occurred before 2300 (WDFW unpub.). Comparing this proportion to the estimated catch for hatchery steelhead in 2003, our methods may have still underestimated nightly catch because the fished intervals in 2003 mostly ended prior to the 2300 hour.

In previous years and other river systems, wild steelhead migration is usually uni-modal. In 2003, in response to high flows, there was an early migration of steelhead in February. Although it is possible that part of the steelhead production migrated prior to trap operation, we believe it is unlikely, or relatively low since on the first night of trap operation no steelhead were caught.

2.3.4 Survival of Hatchery Releases

Most of the steelhead and chinook yearlings released from hatcheries upstream of the trap were marked by adipose or ventral fin clips. Due to the lack of mass-marking of hatchery coho smolts released from Keta Creek Hatchery, survival was estimated, however, the veracity of this estimate is unknown. The hatchery coho smolt migration was estimated by dividing the tagged catch estimate by the known tag rate of 16.5%. This approach estimates a total migration of 61,312 hatchery coho smolts passed the trap. This estimate was made assuming that hatchery and wild migrants were similarly distributed across the channel and equally susceptible to capture by the screw trap. The chinook yearling estimate was based on the assumption that they were captured in the trap at the same rate as coho smolts, which are similar in size. As in 2002, we did not conduct trap efficiency tests using chinook yearlings. Estimated survival of hatchery release groups ranged from 0.1% to 34% (Table 2-9). The survival of hatchery steelhead smolts released from Icy Creek Hatchery, Flaming Geyser Hatchery, and Palmer Ponds were combined since we had no way of differentiating smolts from these facilities.

Table 2-9. Estimated survival of hatchery salmonid release groups above the Green River screw trap, 2003.

Species	Facility	Released	Estimated	Survival
Coho Smolts	Keta Creek	290,000	61,312	21.1%
Steelhead Smolts	Keta Creek	34,000	47	0.1%
	Icy, Palmer, & Flaming Geyser	160,415	54,372	33.9%
Chinook 1+	Icy Creek	324,000	34,149	10.5%

2.3.5 Recommendations

Precision of the age 0 chinook production estimates would increase if we began trapping two to three weeks earlier, in early to mid-January, to intercept a larger portion of the early migrants.

We estimated approximately 20% of the chinook migration occurred prior to the beginning of trap operation in 2003. While the large freshets in late January and early February certainly triggered a large part of this early migration, the movement of these fish indicates a substantial presence of fry in the river prior to installation of the trap. By moving the start date back to early-mid January, we will be in position to trap these early migrants should they head downstream.

This recommendation is currently unfunded. We will attempt to locate funding in order to implement these recommendations for the 2005 trapping season.

While moving the start date for trap operations back to early/mid January will increase the precision of the chinook estimate, it will not address that part of the imprecision that is attributed to hatchery practices. Continued releases of large numbers of hatchery fish upstream of the trap over a short time period will necessitate continued intermittent trapping and the estimation of missed catch while these fish move downstream. Furthermore, our ability to estimate the production of naturally produced coho and the precision of this estimate will continue to suffer while releases of unmarked hatchery coho above the trap persists.

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2.5 Appendix A

Daily Actual and Estimated Catches and Migration Estimates
for Age 0+ Chinook Migrants, Green River 2003.

Appendix A. Daily average flow (USGS Gage #12113000), actual catches, estimated missed catch during un-fished periods, and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2003.

Date	Daily Average Flow	Wild Chinook			Hatchery Chinook		
		Catch		Migration	Catch		Migration
		Actual	Estimated		Actual	Estimated	
02/03	5,300	251		25,100	0		0
02/04	3,960	224		22,400	0		0
02/05	2,760	260		26,000	0		0
02/06	2,260	191		19,100	0		0
02/07	1,510	167		1,325	0		0
02/08	1,090	150		1,190	0		0
02/09	1,070	157		1,246	0		0
02/10	1,020	171		1,357	0		0
02/11	874	173		1,373	0		0
02/12	779	73		579	0		0
02/13	691	64		508	0		0
02/14	691	105		833	0		0
02/15	682	94		746	0		0
02/16	679	248		1,968	0		0
02/17	692	311		2,468	0		0
02/18	700	86		683	0		0
02/19	630	811	12	6,532	0	0	0
02/20	665	841		6,675	0		0
02/21	2,150	118	277	39,500	0	0	0
02/22	3,520	188		18,800	0		0
02/23	3,350	437		43,700	0		0
02/24	2,140	430		43,000	0		0
02/25	1,420	288		2,286	0		0
02/26	1,230	123		976	0		0
02/27	1,040	87		690	0		0
02/28	863	343		2,722	0		0
03/01	644	445		3,532	0		0
03/02	661	436		3,460	0		0
03/03	630	661		5,246	0		0
03/04	535	314		2,492	0		0
03/05	553	731		5,802	0		0
03/06	577	573		4,548	0		0
03/07	636	1,267		10,056	0		0
03/08	676	568		4,508	0		0
03/09	905	1,312		10,413	0		0
03/10	1,520	901		7,151	0		0
03/11	2,150	118	218	33,600	0	0	0
03/12	3,750	28	179	20,682	0	0	0
03/13	4,450		383	38,318		0	0
03/14	3,200	195		19,500	0		0
03/15	2,480	122		12,200	0		0
03/16	2,200	143		14,300	0		0
03/17	1,700	166		1,317	0		0
03/18	1,270	187		1,484	0		0
03/19	1,140	200		1,587	0		0

Appendix A. Daily average flow (USGS Gage #12113000), actual catches, estimated missed catch during un-fished periods, and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2003 (cont'd.).

Date	Daily Average Flow	Wild Chinook			Hatchery Chinook		
		Catch		Migration	Catch		Migration
		Actual	Estimated		Actual	Estimated	
03/20	1,070	206		1,635	0		0
03/21	1,380	92		730	0		0
03/22	2,270	139		13,900	0		0
03/23	2,290	81		8,100	0		0
03/24	2,210	85		8,500	0		0
03/25	2,030	94		9,400	4		400
03/26	1,850	73		579	0		0
03/27	1,780	82		651	9		71
03/28	1,520	53		421	15		119
03/29	1,390	27		214	0		0
03/30	1,380	21		167	0		0
03/31	1,960	5		40	0		0
04/01	2,330	19		1,900	0		0
04/02	1,880	6		48	0		0
04/03	1,450	27		214	1		8
04/04	1,350	26		206	0		0
04/05	1,170	5		40	0		0
04/06	1,180	16		127	0		0
04/07	1,160	3	12	122	0	0	0
04/08	1,110		14	108		0	0
04/09	1,100	14		111	0		0
04/10	1,150	37		294	1		8
04/11	1,290	24		190	1		8
04/12	1,290	39		310	0		0
04/13	1,300	35		278	0		0
04/14	1,520	15	12	214	0	0	0
04/15	1,700	24		190	0		0
04/16	1,530	13		103	0		0
04/17	1,300	12		95	0		0
04/18	1,180	18		143	0		0
04/19	1,100	14		111	1		8
04/20	1,100	18		143	1		8
04/21	1,060	15		119	0		0
04/22	991	17		135	0		0
04/23	990	9		71	0		0
04/24	1,010	8		63	0		0
04/25	1,030	7		56	0		0
04/26	1,070	8		63	0		0
04/27	1,060	14		111	0		0
04/28	1,020	1	3	32	0	0	0
04/29	903	19		151	1		8
04/30	872	8		63	0		0
05/01	905	11	5	127	0	0	0
05/02	996	18	9	214	0	0	0
05/03	1,160	13	6	151	0	0	0

Appendix A. Daily average flow (USGS Gage #12113000), actual catches, estimated missed catch during un-fished periods, and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2003 (cont'd.).

Date	Daily Average Flow	Wild Chinook Catch Actual	Wild Chinook Catch Estimated	Wild Chinook Migration	Hatchery Chinook Catch Actual	Hatchery Chinook Catch Estimated	Hatchery Chinook Migration
05/04	1,160	4	18	175	0	0	0
05/05	1,100	6	8	111	0	0	0
05/06	948	7	7	111	5	4	71
05/07	817	2	4	48	0	0	0
05/08	743	16	10	206	0	0	0
05/09	733	16		127	0		0
05/10	712	26		206	1		8
05/11	712	14		111	1		8
05/12	713	17		135	0		0
05/13	733	18		143	0		0
05/14	751	7		56	1		8
05/15	772	17	2	151	3	0	24
05/16	787	13		103	1		8
05/17	750	11		87	0		0
05/18	749	22		175	0		0
05/19	746	7		56	0		0
05/20	723	7		56	0		0
05/21	683	10		79	0		0
05/22	710	8		63	0		0
05/23	760	6		48	0		0
05/24	835	4		32	0		0
05/25	835	18		143	0		0
05/26	831	14		111	0		0
05/27	834	14		111	0		0
05/28	877	52		413	0		0
05/29	918	53		421	0		0
05/30	845	71		563	0		0
05/31	784	34		270	0		0
06/01	783	66		524	0		0
06/02	713	48		381	0		0
06/03	553	41		325	0		0
06/04	545	23		183	0		0
06/05	502	21	0	167	0	0	0
06/06	473	29	0	230	0	0	0
06/07	441	34	0	270	0	0	0
06/08	440	34	0	270	0	0	0
06/09	430	131		1,040	1		8
06/10	437	152	2	1,222	3	0	24
06/11	454	55	2	452	0	0	0
06/12	415	46	2	381	1	0	8
06/13	332	47		373	0		0
06/14	310	26		206	0		0
06/15	309	17	2	151	0	0	0
06/16	316	18	2	159	0	0	0
06/17	310	12		95	2		16

Appendix A. Daily average flow (USGS Gage #12113000), actual catches, estimated missed catch during un-fished periods, and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2003 (cont'd.).

Date	Daily Average Flow	Wild Chinook			Hatchery Chinook		
		Catch		Migration	Catch		Migration
		Actual	Estimated		Actual	Estimated	
06/18	293	12	0	95	0	0	0
06/19	304	38		302	0		0
06/20	318	76	0	603	0	0	0
06/21	259	84	0	667	0	0	0
06/22	259	4	0	32	0	0	0
06/23	263	5	0	40	0	0	0
06/24	261	8	0	63	0	0	0
06/25	236	3	0	24	0	0	0
06/26	209	7	0	56	0	0	0
06/27	216	6	0	48	0	0	0
06/28	230	4	0	32	0	0	0
06/29	231	3	0	24	0	0	0
06/30	216	5	0	40	0	0	0
07/01	172	4	0	32	0	0	0
07/02	153	1		8	0		0
07/03	148	2	0	16	0	0	0
07/04	138	0	0	0	0	0	0
07/05	138	2	0	16	0	0	0
07/06	138	2	0	16	0	0	0
07/07	137	3	0	24	0	0	0
07/08	137	0	0	0	0	0	0
07/09	134	0	0	0	0	0	0
07/10	130	0		0	0		0
07/11	123	0	0	0	0	0	0
07/12	124	0	0	0	0	0	0
07/13	126	0	0	0	0	0	0
Season Totals		17,792	1,189	535,471	53	4	821

3 Wenatchee River

2003 Wenatchee River Basin Juvenile Salmonid Production

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3.1 Methods

3.1.1 Trap Operations

An 2.4-meter diameter floating screw trap was operated on the Wenatchee River to capture downstream migrant chinook, coho, and steelhead. The trap was located immediately downstream of the West Monitor Bridge (rkm 9.6) on the right bank (Figure 3-1).

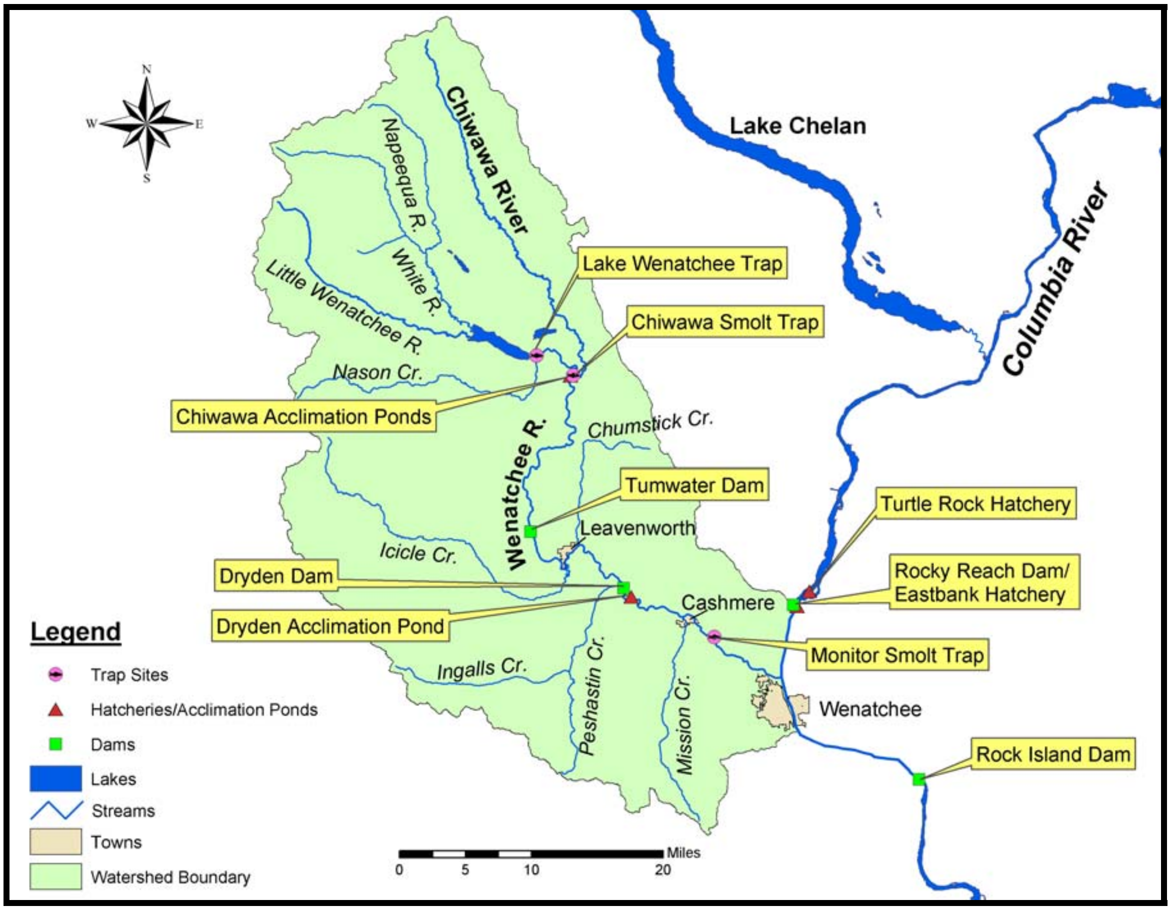

Figure 3-1. Location of the Monitor smolt trap, Wenatchee River Basin.

The trap on the Wenatchee River was operated between 21 February and 30 July during night time hours only. Trap operation started one half hour prior to sun down and ended at one half hour after sun up. However, during periods of high discharge, debris, hatchery releases, or mechanical failures trapping did not occur. During breaks in trapping we estimated the number of fish captured from the mean of the two days prior and two days after the break. All fish captured were removed from the livebox in 1 to 3 h intervals throughout the night and placed in an anesthetic solution of MS-222. Fish were identified to species and enumerated. Hatchery origin salmonids were identified by adipose fin clips or by the presence of coded wire tags, passive integrated transponder tags, elastomer tags, and fin erosion. All yearling chinook and steelhead captured had length and weight recorded. A sub-sample of subyearling chinook and coho had length and weight recorded. Fish were allowed to recover in freshwater, and subsequently released below the trap. This area allowed fish to hold in current or disperse quickly.

Any fish that were captured and retained for trap efficiency trials (used when estimating emigration) were held in a 984 liter recirculating tank on shore. Yearling salmon were marked with a unique caudal fin clip and subyearlings were marked with Bismark Brown dye. All marked fish were transported upstream approximately 19.6 rkm and released with equal numbers on the right and left bank to ensure adequate dispersal within the water column with nonmarked fish.

3.1.2 Production Estimate

Emigration estimates were calculated using an estimated daily trap efficiency derived from the regression formula using trap efficiency (dependent variable) and river discharge (independent variable). Trap efficiency was calculated using the following formula:

Equation 3-1

$$E_i = R_i / M_i$$

Where E_i is the trap efficiency during time period i; M_i is the number of marked fish released during time period i; and R_i is the number of marked fish recaptured during time period i. The number of fish captured was expanded by the estimated daily trap efficiency (e) to estimate the daily number of fish migrating past the trap (N_i) using the following formula:

Equation 3-2

$$\hat{N}_i = C_i / \hat{e}_i$$

Where N_i is the estimated number of fish passing the trap during time period i; C_i is the number of unmarked fish captured during time period i; and e_i is the estimated trap efficiency for time period i based on the regression equation. The variance for the total daily number of fish migrating past the trap was calculated using the following formulas:

Equation 3-3

$$\mathrm{var}\left[\hat{N}_i\right] = \hat{N}_i^2 \frac{\mathrm{MSE}\left(1 + \frac{1}{n} + \frac{\left(X_i - \overline{X}\right)^2}{(n-1)s_X^2}\right)}{\hat{e}_i^2}$$

where X_i is the discharge for time period *i*, and *n* is the sample size. If a relationship between discharge and trap efficiency was not present (i.e. $P < 0.05$; r^2 . 0.5), a pooled trap efficiency was used to estimate daily emigration:

Equation 3-4

$$E_p = \sum R / \sum M$$

The daily emigration estimate was calculated using the formula:

Equation 3-5

$$\hat{N}_i = C_i / E_p$$

The variance for daily emigration estimates using the pooled trap efficiency was calculated using the formula:

Equation 3-6

$$\mathrm{var}\left[\hat{N}_i\right] = \hat{N}_i^2 \frac{E_p(1 - E_p) / \sum M}{E_p^2}$$

The total emigration estimate and confidence interval were calculated using the following formulas:

Equation 3-7

$$\hat{N} = \sum \hat{N}_i$$

Equation 3-8

$$\hat{N} \pm 1.96 \times \sqrt{\sum \mathrm{var}\left[\hat{N}_i\right]}$$

A valid estimate would require the following assumptions to be true concerning the trap efficiency trials:

1) All marked fish migrated downstream past the trap site in the time period in which they were released.

2) The probability of capturing a marked or unmarked fish is equal.

3) All marked fish recaptured were identified.

4) Marks were not lost between the time of release and recapture.

Estimates for salmon and steelhead were calculated using efficiency trials conducted with subyearling chinook, sockeye, and hatchery coho. Mark/recapture trials were conducted when river discharge changed between 14 and 28 m^3/s (cms) or the trap position had changed. The preferable minimum mark group size is greater than 300. Most groups were closer to 500 fish. No other species were used in mark/recapture trials because too few fish were captured.

3.2 Results

All production estimates were calculated using separate regression models (independent variable = river discharge) for each trap position. In some cases, efficiency trials from multiple years (i.e., 2001-2003) were used in the regression model. Because the abundance of wild yearling Chinook, wild coho, and steelhead is too low to perform effective species-specific efficiency trials, surrogate species (e.g., subyearling chinook, yearling hatchery chinook, yearling hatchery coho, and wild sockeye) will be utilized.

3.2.1 Chinook

3.2.1.1 Catch

Chinook salmon were captured from two brood years, subyearlings (2002 brood) and yearlings (2001 brood). The separation of brood years was based on size and emigration timing. Many of the 2002 brood were alevins and easily identifiable as subyearlings. Subyearling and yearling salmon captured were considered summer and spring chinook, respectively. This differentiation was based on the analysis of scales sampled from adult summer and spring chinook, which showed a distinct separation in emigration timing.

During the season, a total of 1,619 wild yearling chinook and 20,939 hatchery yearling chinook were trapped (Figure 3-2). A total of 110,528 subyearling chinook were also captured comprising 74% of the total salmon (i.e. chinook, coho, and sockeye) captured in 2003.

Cumulative passage dates for chinook in 2003 were 50% passage by 17 April and 90% passage by 20 May for yearling chinook (Appendix A). The peak daily total capture for yearling chinook was 88 on 2 April. The dates for 50% and 90% passage for subyearling chinook were 24 May and 24 June, respectively. The peak daily total capture for subyearlings was 15,421 on 25 May.

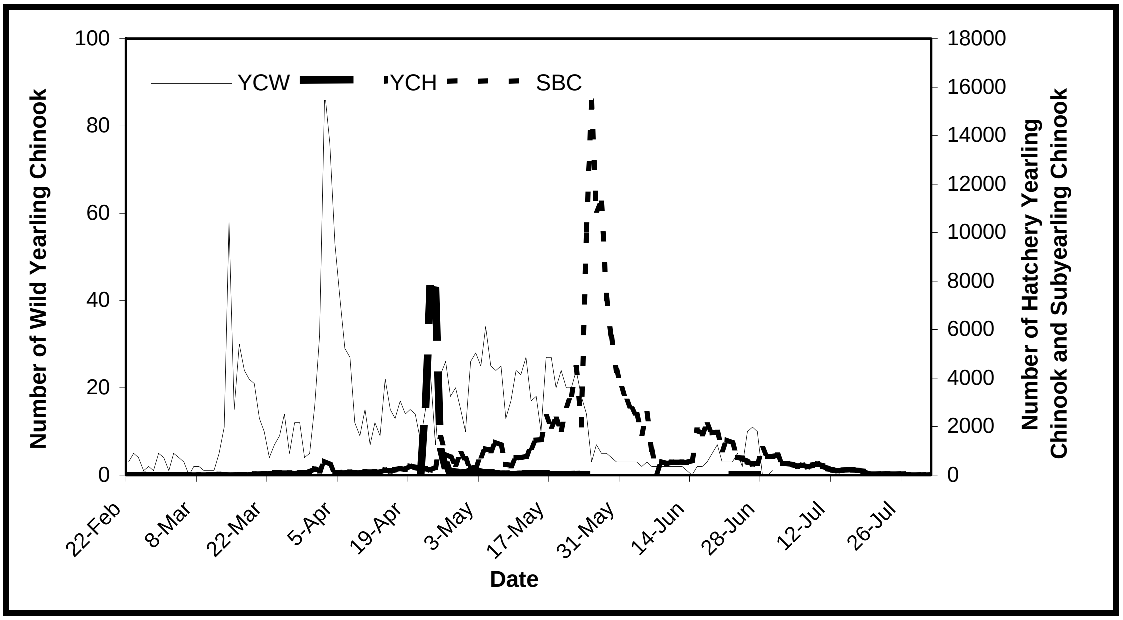

Figure 3-2. The daily number of wild yearling (YCW), subyearling (SBC), and hatchery yearling chinook (YCH) captured in the Wenatchee River trap in 2003.

3.2.1.2 Size

Fork lengths for yearling chinook averaged 91.7 mm the first three months of trapping through April. May and June fork lengths averaged 98 mm (Table 3-1, Figure 3-3). To ensure that subyearlings were not incorporated into the sample, scale samples were taken from fish that could not be discernable to age from size. Results of the scale samples indicated that a combination of size and morphological characteristics, such as the presence of parr marks, accurately differentiated age classes for the month of June when size overlap existed between yearlings and subyearlings.

Table 3-1. Average fork length (mm), standard deviation, range, sample size, and sample percentage of yearling chinook, Wenatchee River 2003.

Month	Average	SD	Range		Number		Percent Sampled
			Min	Max	Sampled	Caught	
Feb	89.24	7.61	72	105	21	21	100.00
Mar	93.01	8.27	70	120	321	321	100.00
Apr	93.30	8.74	73	133	499	664	75.15
May	99.71	9.05	73	136	535	538	99.44
Jun	97.37	11.78	81	135	74	75	98.67
Jul	--	--	--	--	0	0	--
Total	95.73	9.4	70	136	1450	1619	89.56

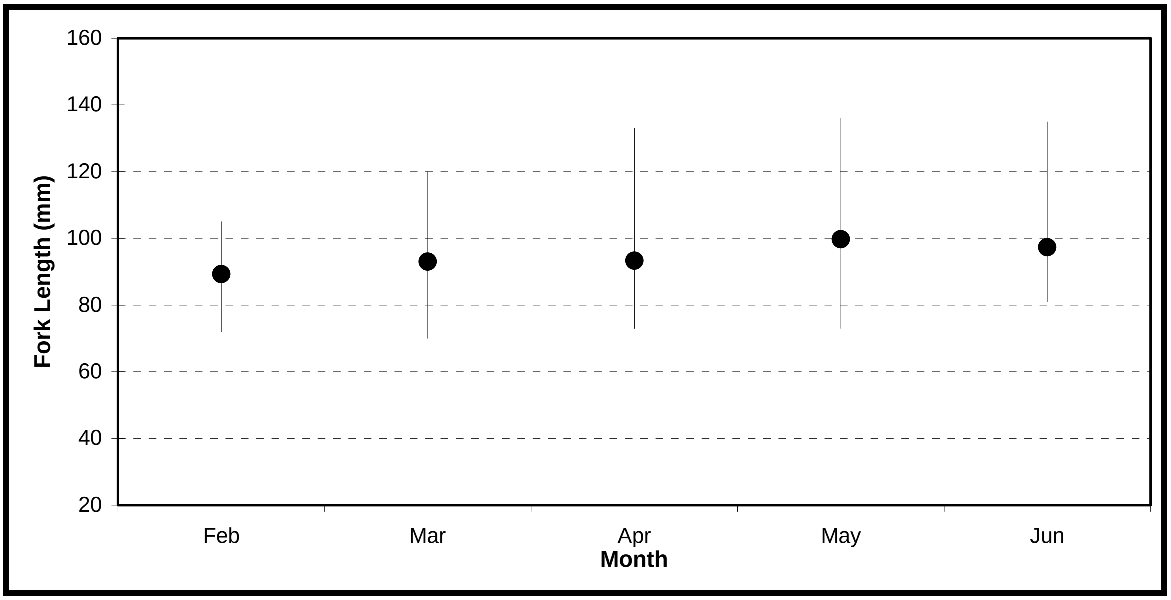

Figure 3-3. Monthly average, minimum, and maximum yearling chinook fork lengths (mm) measured at the Wenatchee River screw trap, 2003.

Subyearling chinook fork lengths averaged 31.6 mm through May. June and July fork lengths averaged 56.9 mm. The average fork length for the season was 46.7 mm (Table 3-2, Figure 3-4).

Table 3-2. Average fork length (mm), standard deviation, range, sample size, and sample percentage of subyearling chinook, Wenatchee River 2003.

Month	Average	SD	Range		Number		Percent
			Min	Max	Sampled	Caught	Sampled
Feb	37.52	2.49	33	42	71	90	78.89
Mar	38.97	2.27	33	50	419	1423	29.44
Apr	38.87	2.84	28	52	500	10039	4.98
May	39.95	2.86	31	72	378	67378	0.56
Jun	50.77	14.28	36	109	311	25014	1.24
Jul	63.16	14.70	36	115	514	6584	7.81
Total	46.71	13.8	36	115	2193	110528	1.98

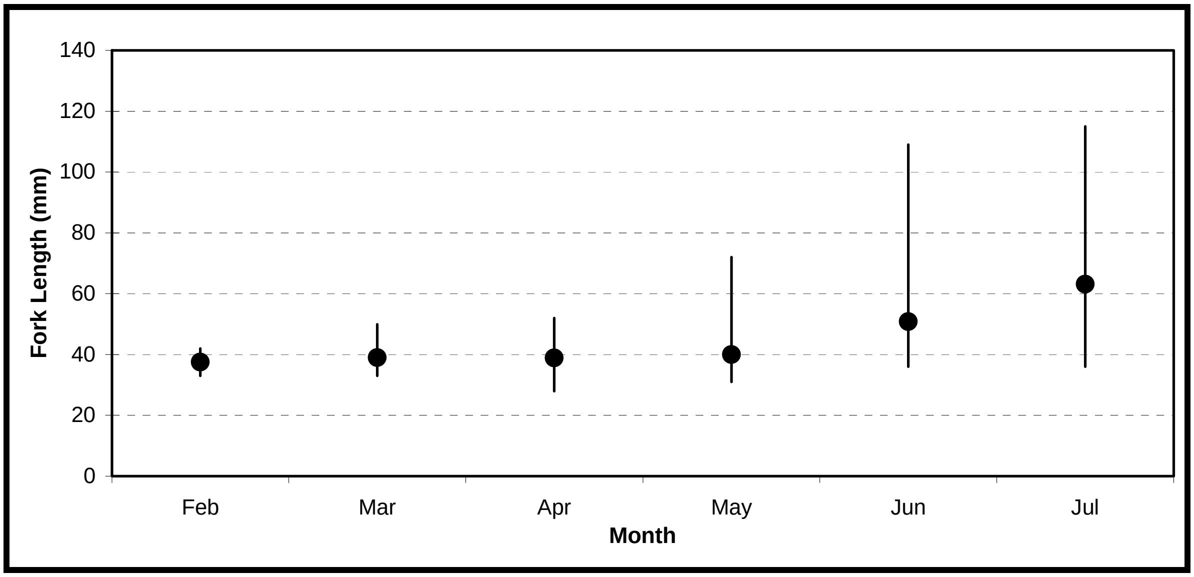

Figure 3-4. Monthly average, minimum, and maximum subyearling chinook fork lengths (mm) measured at the Wenatchee River screw trap, 2003.

3.2.1.3 Catch Expansion

The catch of the trap must be expanded for the time it was not in operation to estimate production. Table 3-3 provides a summary of trapping during 2003. During the 160-day trapping season, the trap operated 92.5% (148 d) of the time. Catch was expanded for a total of 12 days when the trap was non-operational due to river discharge, heavy debris, hatchery releases, and trap repairs. During the breaks in trapping, the estimated capture for subyearling chinook was 47,243. Based on the positive relationship between discharge and capture of subyearling chinook, this is likely a conservative estimate of the total capture. The estimate of 58 yearling chinook is likely representative of the true capture because most breaks in trapping occurred during little to no movement of yearling chinook.

Table 3-3. Summary of trapping days (sunset to sunrise) for the lower Wenatchee River smolt trap at Monitor, 2003.

Date		Number of days	
Set	Pulled	Trapped	Missed
21 Feb	25 May	92	1
25 May	27 May	0	2
27 May	28 May	1	0
28 May	01 Jun	0	4
01 Jun	07 Jun	6	0
07 Jun	12 Jun	0	5
12 Jun	31 Jul	49	0
Total (percent)		148 (92.5)	12 (7.5)

3.2.1.4 Trap Efficiency

A total of 36 efficiency trial groups were released at Dryden Dam. The number of fish released in each group ranged from 146 to 1,201. Efficiency trials were conducted in two trap positions based on river discharge. Subyearling recapture rates averaged 1.86% and efficiency trials ranged from 0.24% to 2.73%. Yearling recapture rates averaged 0.79% and trials ranged from 0.00% to 3.02% (Table 3-4).

River discharge during efficiency trials ranged from 84.8 to 267.6 cms. Because of variability between efficiency trials among hatchery coho and wild sockeye, trials of yearling salmon (hatchery coho and wild sockeye) were combined to increase correlation between efficiency and discharge. We felt that combining the trials would ultimately strengthen relationships between trials. However, we did find a correlation between efficiency and discharge with the subyearling groups. When the trap was operated at a third position (out) we combined trials of previous years (2001-2003) to estimate efficiency. This position is typically used for less than 14 days early in migration and trials are conducted only when fish numbers allow. The regression models derived from yearling salmon (i.e., hatchery coho and wild sockeye) and subyearling chinook groups were used to estimate daily emigration.

3.2.1.5 Production Estimate

An estimated 318,595 yearling chinook emigrated from the Wenatchee River from 22 February to 30 June. In the same time frame, we estimated 45,356,403 subyearling chinook emigrated the Wenatchee River (Appendix B). The precision of these estimates is very low due to the low trap efficiencies, averaging less than 1% for yearling and 2% for sub-yearling chinook. The resulting confidence intervals about these estimates are too wide to be useful and are, therefore, not reported. This problem is addressed in our recommendations (see Section 3.3) and we anticipate developing more precise estimates in 2005.

3.2.2 Steelhead

3.2.2.1 Catch

Juvenile steelhead were also captured during the spring emigration. All steelhead were enumerated and scale samples were taken from smolts for freshwater age analysis. Fish sampled were visually examined to determine their degree of smoltification. Steelhead were classified as either smolt, transitional, parr, or fry. Fry was determined to be a fish less than 50 mm.

During trapping in 2003, we captured 334 wild steelhead smolts. A total of 2,175 hatchery steelhead smolts were also captured (Figure 3-5, Appendix A). The first wild steelhead smolt was captured 16 March with the peak catch of 52 on 13 May. The first hatchery steelhead was captured shortly after hatchery releases began on 30 April. The peak capture of 255 fish was 13 May. Cumulative passage dates for wild steelhead were 50% passage on 12 May and 90% passage on 21 May. (Appendix C).

Table 3-4. Subyearling chinook, coho, and sockeye trap efficiency trials conducted for moderate-flow (In) and high-flow (flood) trap positions on the lower Wenatchee River, 2003.

Position	Species	Date	Flow (cms)	# Marked		Trap Efficiency
				Released	Recaptured	
In	Chinook	03/27	84.8	256	7	2.73%
		03/31	147.2	430	10	2.33%
		04/06	98.7	146	3	2.05%
		04/11	93.2	314	6	1.91%
		04/15	117.1	280	5	1.79%
		05/09	117.4	349	1	0.29%
		05/11	125.9	448	5	1.12%
		05/19	117.9	843	11	1.30%
	Coho	05/08	120.2	287	3	1.05%
		05/11	125.9	496	15	3.02%
		05/18	127.6	345	4	1.16%
		05/20	112.2	677	4	0.59%
	Sockeye	04/07	91.1	183	1	0.55%
		04/10	92.6	314	1	0.32%
		04/14	120.0	362	1	0.28%
		04/30	133.6	368	2	0.54%
Flood	Chinook	04/02	139.8	690	17	2.46%
		04/24	163.9	414	1	0.24%
		04/27	135.4	1,003	16	1.60%
		04/30	133.6	909	8	0.88%
		05/02	155.7	475	4	0.84%
		05/03	160.5	651	2	0.31%
		05/06	164.0	526	3	0.57%
		05/13	149.0	847	14	1.65%
		05/15	172.2	782	5	0.64%
		06/04	267.6	1,201	17	1.42%
		06/13	240.5	442	3	0.68%
		06/14	212.2	517	6	1.16%
		06/17	185.1	1,130	21	1.86%
		06/19	200.6	857	16	1.87%
	Coho	05/05	145.1	418	5	1.20%
		05/13	149.0	433	5	1.15%
		05/15	172.2	479	2	0.42%
	Sockeye	04/24	163.9	600	5	0.83%
		04/28	130.1	310	0	0.00%
		05/02	155.7	396	0	0.00%

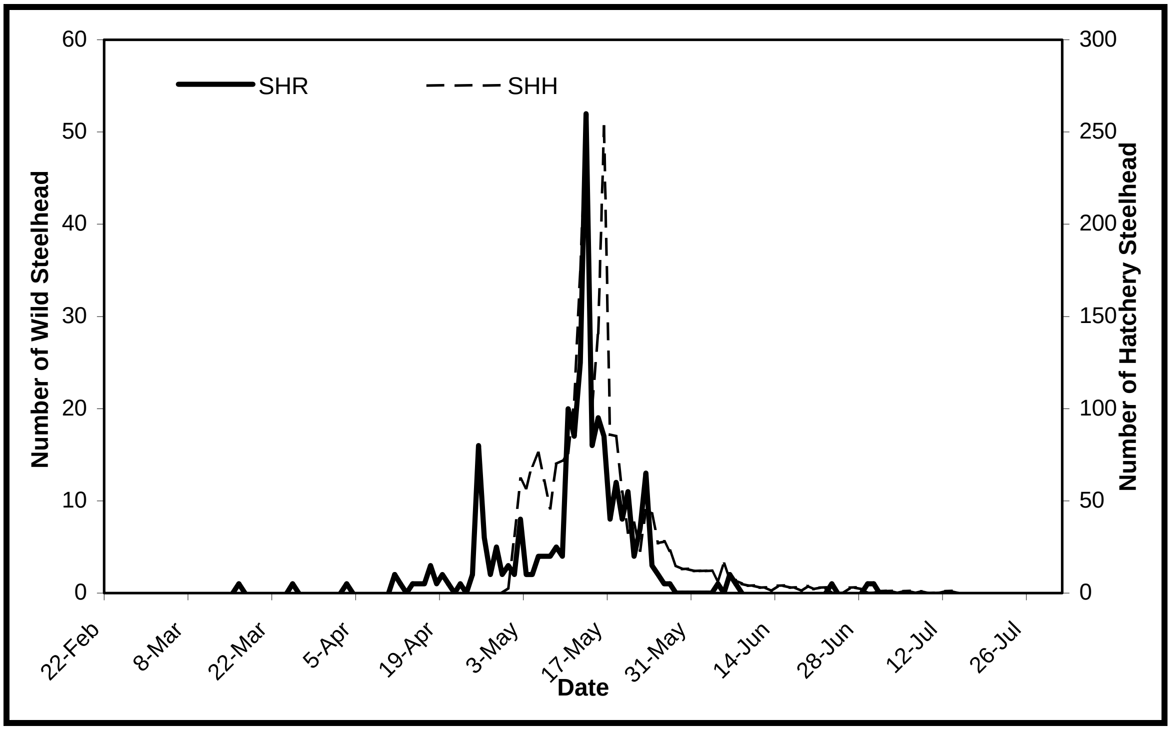

Figure 3-5. The daily number of wild and hatchery steelhead captured in the Wenatchee River trap in 2003.

3.2.2.2 Size

A total of 334 wild steelhead smolts had fork length and weight recorded. Fork lengths ranged from 96 mm to 244 mm, and averaged 166 mm throughout the season (Table 3-5, Figure 3-6). Age-2 fish fork lengths averaged 180.6 mm and made up 81.5% of the total estimated steelhead to emigrate the Wenatchee.

Table 3-5. Average fork length (mm), standard deviation, range, sample size, and sample percentage of wild steelhead at Monitor, 2003.

Month	Average	SD	Range		Number		Percent Sampled
			Min	Max	Sampled	Caught	
Feb	--	--	--	--	0	0	--
Mar	153.00	--	--	--	1	2	50.00
Apr	180.56	20.74	134	244	52	52	100.00
May	183.16	18.87	128	240	268	270	99.26
Jun	147.67	31.90	96	172	6	10	60.00
Jul	--	--	--	--	0	0	--
Total	170.46	23.84	96	244	327	334	97.90

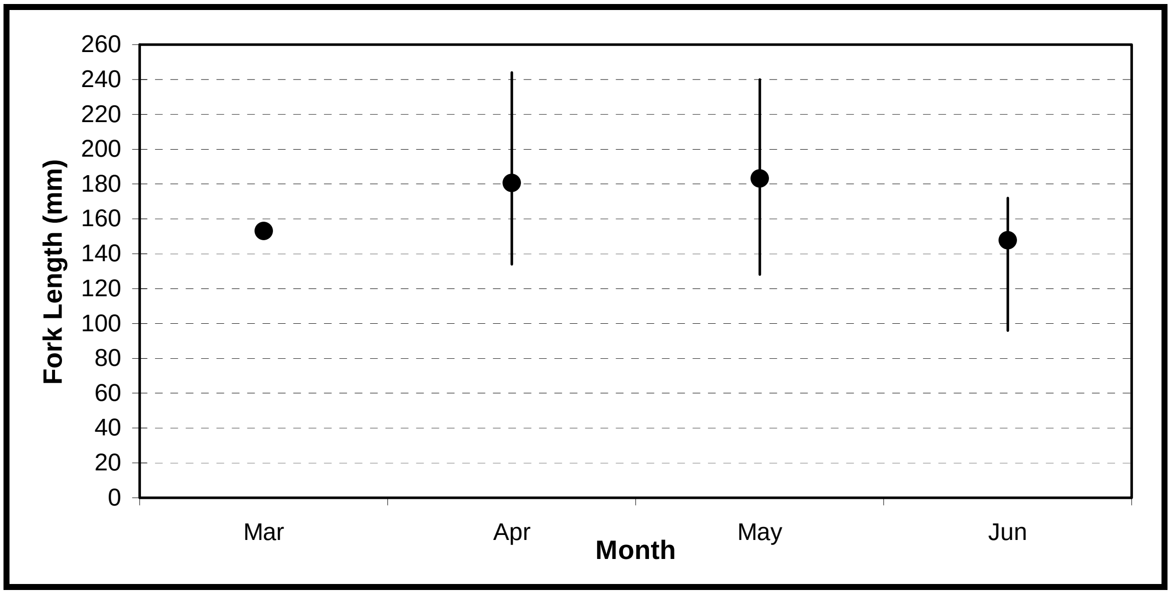

Figure 3-6. Monthly average, minimum, and maximum steelhead smolt fork lengths (mm) measured at the Wenatchee River screw trap, 2003.

3.2.2.3 Catch Expansion

Because most breaks in trapping occurred after steelhead passage was greater than 90%. The estimated capture of steelhead was only 4 additional steelhead smolts that would have been trapped if the trap operated without interruption.

3.2.2.4 Trap Efficiency

Because the relative capture rates of wild steelhead smolts were small, no efficiency trials were attempted with steelhead. Without adequate numbers of steelhead captured for efficiency trials, we utilized hatchery coho and wild sockeye as surrogates for steelhead.

3.2.2.5 Production Estimate

After applying the calculated regression to the daily and expanded catch of steelhead smolts, an estimate of 44,204 wild steelhead smolts emigrated from 16 March through 30 June (Appendix C). A confidence interval is not reported because trap efficiency for steelhead was not estimated.

3.2.3 Coho

3.2.3.1 Catch

During trapping in 2003, we captured 199 wild and 8,036 hatchery coho smolts (Figure 3-7, Appendix A). The first wild coho smolt was captured on 22 March with the peak catch of 6 fish on 4 May. Cumulative passage dates for wild coho were 50% passage on 24 April and 90% passage on 18 May. (Appendix C). We captured the first hatchery coho 14 March. The peak capture of hatchery coho totaled 1,021 fish on 17 May.

Coho fry/parr were also captured during the trapping season. A total of 29 fry were trapped from 26 February through 21 July. It was assumed that coho fry/parr were captured during redistribution after emerging in the spring for rearing purposes.

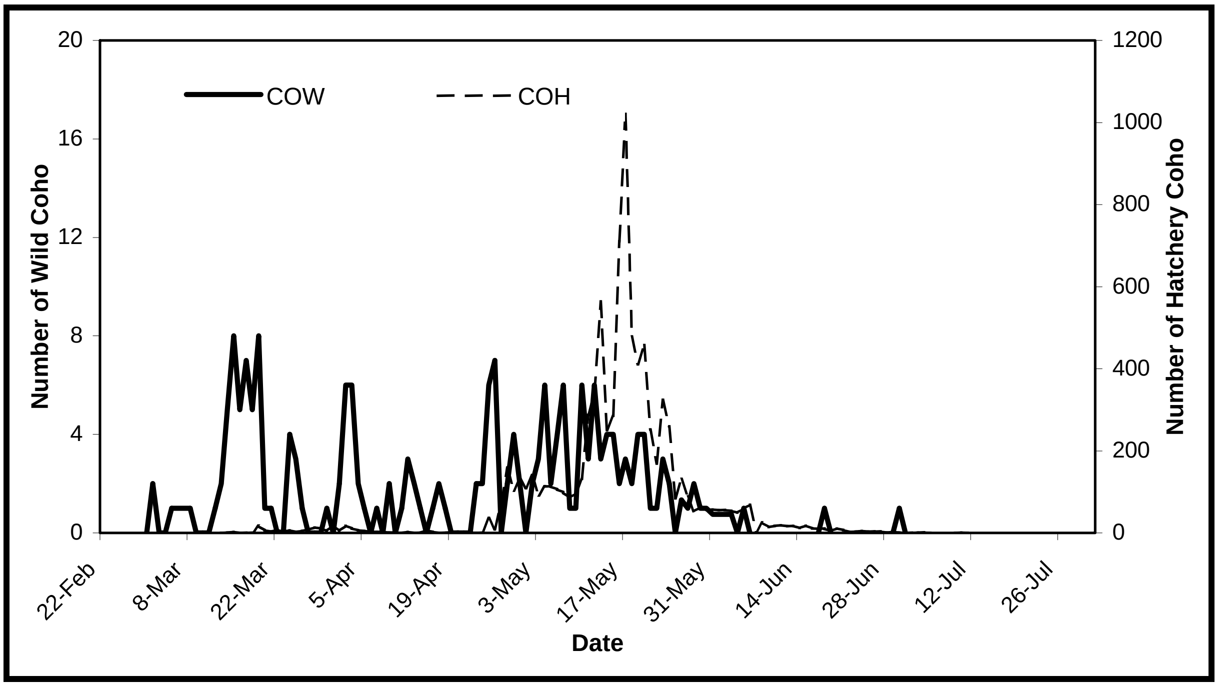

Figure 3-7. The daily number of wild and hatchery coho captured in the Wenatchee River trap in 2003.

3.2.3.2 Size

Wild yearling coho fork lengths averaged between 90 and 113 mm throughout the trapping season (Table 3-6, Figure 3-8). The minimum and maximum sizes ranged from 76 to 150 mm during the trapping season.

Table 3-6. Average fork length (mm), standard deviation, range, sample size, and sample percentage of wild yearling Coho Wenatchee River screw trap, 2003.

Month	Average	SD	Range		Number		Percent
			Min	Max	Sampled	Caught	Sampled
Feb	90.17	4.62	84	98	6	6	1.00
Mar	92.83	9.69	76	118	59	59	100.00
Apr	105.81	13.61	76	149	55	56	98.21
May	113.47	9.70	90	150	74	75	98.67
Jun	105.33	3.51	102	109	3	3	100.00
Jul	--	--	--	--	0	0	--
Total	104.26	13.91	76	150	197	199	98.99

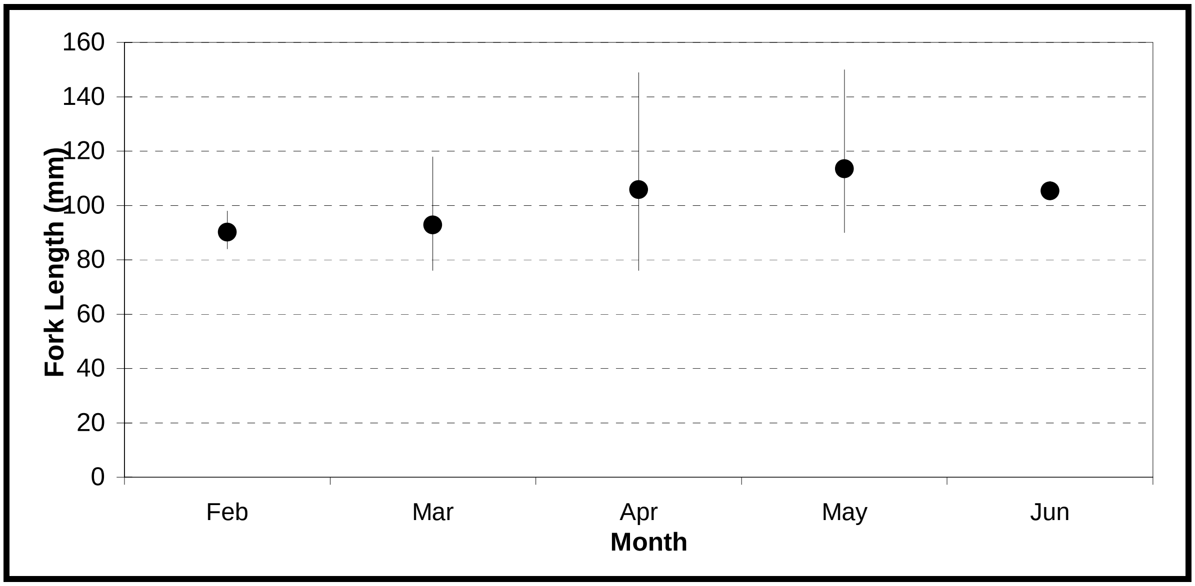

Figure 3-8. Monthly average, minimum, and maximum coho smolt fork lengths (mm) measured at the Wenatchee River screw trap, 2003.

3.2.3.3 Catch Expansion

The expanded catch for the 12 evenings the trap was non-operational resulted in a total of 8 wild coho smolts to be included to the actual fish captured.

3.2.3.4 Trap Efficiency

Returning coho adults began spawning in the Wenatchee Basin in 2001, a result of YN's (Yakama Nation) re-introduction of coho in 1999. Smolts produced from the returning adults provided capture rates too small to try efficiency trials. Again, not having adequate numbers of wild coho for trials resulted in the utilization of hatchery coho and wild sockeye in trials as surrogates for wild coho smolts. The relationship between efficiency and river discharge found for surrogates is thought to be similar for wild coho smolts. It was felt that using a yearling salmon surrogate for efficiency trials was a conservative approach to attaining an estimate.

3.2.3.5 Production Estimate

The estimated production of 36,679 wild coho smolts was calculated during the emigration period from 2 March through 30 June after applying the calculated regression to the daily and expanded catch. A confidence interval is not reported because trap efficiency for wild coho was not estimated.

3.2.4 Other Species

Several other species of fish were captured and enumerated during the trapping season. Throughout the trapping season no bull trout were captured. In addition, 7,544 wild sockeye and 271 hatchery sockeye were also captured. Sockeye production estimates were calculated at the Lake Wenatchee trap site. The estimated production for Lake Wenatchee sockeye was 5,439,659 (Miller 2004). We also captured a significant number of lamprey ammocoetes. Pacific lamprey catch totaled 922 with a peak of 390 for the month of June. The monthly totals of all fish captured are listed in Appendix A

3.3 Discussion

The efficiency of the trap in 2003 was lower and more variable than needed to provide precise estimates of production. In 2005, we plan to have two smolt traps operating at this location to satisfy our efficiency shortcomings. We expect the increase in trap efficiency to be sufficient for calculating confidence intervals as well as reasonable production estimates. We also need to perform efficiency trials at the minimum and maximum river discharge to further increase the utility of our regression models.

3.3.1 Chinook

3.3.1.1 Subyearling

Even though a significant relationship between efficiency and river discharge (r^2=0.94, P<0.001 (Flood); r^2=0.82, P<0.001 (In)) was evident, not all observed discharges were included in the model. For the days when river discharge was outside of the efficiency trials used in calculating our regression, we used the minimum and maximum discharge from our trials. This could cause some considerable over/under estimation of our production estimate.

The subyearling chinook estimate of 45,356,403 seems high when compared to egg deposition. Egg deposition may be under estimated when using peak redd counts that Chelan County Fish and Wildlife crews perform. The totals for the Wenatchee Basin in 2002 were 5,419 redds (Grassell 2003). When using peak counts to estimate maximum egg deposition (i.e. 5,000 eggs/redd), an estimate of 27,095,000 eggs were deposited. Several potential explanations exist for why the estimated submigrant production could exceed the estimated egg deposition:

1. Trap efficiency was under estimated,
2. Redds were under estimated,
3. Wild fish were misidentified as hatchery migrants, and
4. Species were misclassified.

3.3.1.2 Yearling

The yearling chinook production estimate in the Wenatchee basin was 318,595. Spring chinook redd counts for the Wenatchee Basin in 2001 was 2,139 redds (Mosey and Murphy 2002). Assuming an average fecundity of 5,000 eggs/redd or female yields an estimated egg-to-yearling smolt production of 3%. Redd counts in the Chiwawa River accounted for 48.9% (N=1,046) of the total Wenatchee River Basin redd counts. The Chiwawa River production estimate of 247,670 smolts (Miller 2004) is 77.8% of the estimated population in the basin. The Chiwawa basin has an overall higher quality of habitat than other streams in the Wenatchee Basin, and as a result the over-winter survival is high in the Chiwawa River (74.8%; Miller 2004). Furthermore, assuming that redds produced in streams such as the Icicle, Peshastin, and Ingalls had very low egg-to-emigrant survival (i.e., very poor habitat), we feel that the Wenatchee basin production estimate is accurate.

3.3.2 Steelhead

The use of surrogate species to estimate trap efficiency (i.e., coho and sockeye) for steelhead likely introduces error in the steelhead production estimate. Catch efficiencies of hatchery coho and wild sockeye are probably higher than the larger steelhead smolt. Knowing that the actual steelhead catch efficiency may be lower, the production estimate calculated may be conservative. An additional trap in 2005 may increase trap efficiency to allow steelhead efficiency trials in the future.

3.3.3 Coho

The coho estimate of 36,679 wild smolts was dependent on the ability to differentiate between hatchery coho among the wild coho. The hatchery coho in the Wenatchee were CWT marked but not adipose fin clipped. Each coho was scanned for tags and separated. All non-tagged coho were visually scanned for "hatchery fins" and for morphological traits to identify the coho as wild or hatchery. Questionable fish had scales sampled to ensure greater accuracy. A total of 135 coho were scaled and 134 were considered wild yearlings. One fish was considered an age-2 migrant.

Redd production in 2001 was the first good year of returns since the recent re-introduction of coho. A total of 154 redds were counted by YN personnel in the Icicle River and Nason Creek. Redds were not counted in the Wenatchee River and the total of 154 is considered a minimum (K. Murdoch, YN Biologist, personal communication). When comparing egg deposition to emigrants an 8.7% egg to smolt survival rate was calculated. This survival rate is similar to other rates reported for stream type salmon (Miller 2004).

3.4 References

3.4.1 Literature Cited

Grassel, A. 2003. 2002 Wenatchee River Basin Spring and Summer Chinook Spawning Ground Surveys. Chelan County PUD, Wenatchee, WA.

Miller, T. 2004. 2003 Chiwawa and Wenatchee River Smolt Estimates. Washington Department of Fish and Wildlife, Science Division, Mid-Columbia Field Office, Wenatchee, WA.

Mosey, T.R. and L.J. Murphy. 2002. Spring and summer chinook spawning ground surveys in the Wenatchee River Basin, 2001. Chelan County PUD, Wenatchee, WA.

Murdoch A., K. Petersen, T. Miller, M. Tonseth, and T. Randolph. 2001. Freshwater Production and Emigration of Juvenile Spring Chinook from the Chiwawa River in 2000. Washington Department of Fish and Wildlife, Science Division, Mid-Columbia Field Office, Wenatchee, WA.

3.4.2 Personal Communication

Murdoch, Keely. Fisheries Biologist. Yakama Nation. 18 May, 2004. Phone conversation.

3.5 Appendix A

Yearly and Monthly Total Juvenile Capture Information for the Wenatchee River Trap

Appendix A. Yearly and monthly total juvenile capture information for the Wenatchee River trap.

2003											
Species/Origin	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
Chinook											
Wild yearling	21	321	664	538	75	0	-	-	-	-	1619
Wild subyearling	90	1423	10039	67378	25014	6584	-	-	-	-	110528
Hatchery yearling	0	0	19952	984	3	0	-	-	-	-	20939
Steelhead											
Wild	5	15	81	275	29	1	-	-	-	-	406
Smolt	0	2	52	270	10	0	-	-	-	-	334
Parr	5	13	29	4	19	1	-	-	-	-	71
Hatchery	0	0	3	2098	66	8	-	-	-	-	2175
Sockeye											
Wild	0	14	6747	782	1	0	-	-	-	-	7544
Hatchery	0	0	150	72	27	22	-	-	-	-	271
Coho											
Wild yearling	6	59	56	75	3	0	-	-	-	-	199
Wild subyearling	2	0	1	12	9	5	-	-	-	-	29
Hatchery yearling	0	109	582	7036	304	3	-	-	-	-	8034
Bull trout											
Juvenile	0	0	0	0	0	0	-	-	-	-	0
Adult	0	0	0	0	0	0	-	-	-	-	0
Cutthroat	0	0	0	0	0	0	-	-	-	-	0
White fish	0	2	5	65	15	28	-	-	-	-	115
Northern pikeminnow	1	2	4	12	2	0	-	-	-	-	21
Longnose dace	1	44	104	124	126	89	-	-	-	-	488
Speckled dace	1	2	1	0	0	0	-	-	-	-	4
Umatilla dace	0	0	0	0	0	1	-	-	-	-	1
Sucker spp.	1	17	59	53	30	12	-	-	-	-	172
Peamouth	0	0	0	0	0	0	-	-	-	-	0
Chiselmouth	0	0	0	0	0	2	-	-	-	-	2
Redside shiner	0	0	4	0	3	7	-	-	-	-	14
Yellow bullhead	0	0	0	0	0	0	-	-	-	-	0
Pacific lamprey	6	67	257	168	390	34	-	-	-	-	922
River lamprey	0	0	0	1	0	0	-	-	-	-	1
Sculpin spp.	0	10	17	17	12	15	-	-	-	-	71
Stickleback (3 spined)	0	0	2	6	6	4	-	-	-	-	18

3.6 Appendix B

Actual Daily and Estimated Captures and Emigration Estimates for Wild Subyearling and Yearling Chinook, Wenatchee River 2003

Appendix B. Actual daily and estimated captures and emigration estimates for wild subyearling and yearling chinook, Wenatchee River 2003.

Date	Average Trapping Flow (M^3/S)	Wild Subyearling Chinook			Wild Yearling Chinook		
		Catch		Migration	Catch		Migration
		Actual	Estimated		Actual	Estimated	
22-Feb	58.1	7		2069	3		887
23-Feb	54.3	10		2956	5		1478
24-Feb	49.4	22		6503	4		1182
25-Feb	46.9	25		7390	1		296
26-Feb	46.5	9		2660	2		591
27-Feb	44.8	8		2365	1		296
28-Feb	43.1	9		2660	5		1478
1-Mar	41.3	11		3251	4		1182
2-Mar	40.3	16		4729	1		296
3-Mar	39.3	17		5025	5		1478
4-Mar	38.5	11		3251	4		1182
5-Mar	39.7	10		2956	3		887
6-Mar	42.6	17		5025	0		0
7-Mar	42.8	4		1182	2		591
8-Mar	40.7	13		3843	2		591
9-Mar	40.6	5		1478	1		296
10-Mar	40.2	8		2365	1		296
11-Mar	47.9	16		4729	1		296
12-Mar	73.3	38		3239	5		426
13-Mar	117.0	28		1924	11		1133
14-Mar	134.7	0		0	58		5065
15-Mar	139.9	3		259	15		1339
16-Mar	130.6	12		1035	30		3494
17-Mar	117.9	15		1053	24		4021
18-Mar	107.7	4		227	22		5904
19-Mar	98.5	56		2717	21		9968
20-Mar	92.9	35		1559	13		8761
21-Mar	93.2	61		2730	10		3098
22-Mar	111.4	41		2505	4		650
23-Mar	110.1	110		6549	7		1587
24-Mar	101.2	89		4509	9		3374
25-Mar	94.5	77		3512	14		9019
26-Mar	89.7	87		3700	5		3221
27-Mar	84.8	63		2509	12		7730
28-Mar	80.4	97		3862	12		7730
29-Mar	79.6	95		3783	4		2577
30-Mar	94.1	113		5118	5		3221
31-Mar	147.2	271		58708	16		2318
1-Apr	153.2	174		14326	32		3889
2-Apr	139.8	594		24664	88		10694
3-Apr	126.1	426		36739	76		7357
4-Apr	114.7	99		6472	53		6984
5-Apr	105.7	99		5428	41		7580
6-Apr	98.7	84		4089	29		7782
7-Apr	91.1	129		5596	27		17393
8-Apr	89.0	105		4426	12		7730
9-Apr	91.8	82		3596	9		5798
10-Apr	92.6	140		6209	15		9678
11-Apr	93.2	117		5232	7		4509
12-Apr	97.8	147		7057	12		5869

13-Apr	112.6	108		6764	9		2337
14-Apr	120.0	230		16989	22		3130
15-Apr	117.1	161		11096	15		2061
16-Apr	114.1	219		14132	13		1972
17-Apr	111.6	280		17155	17		2818
18-Apr	107.1	219		12316	14		2649
19-Apr	102.6	379		19671	15		3499
20-Apr	101.4	323		16425	14		3955
21-Apr	106.8	255		14253	8		1951
22-Apr	118.9		277	19899		15	2539
23-Apr	125.6	192		16409	24		2945
24-Apr	163.9	336		129427	7		851
25-Apr	156.3	1543		165487	23		2795
26-Apr	146.8	885		49739	26		3160
27-Apr	135.4	722		62266	18		1468
28-Apr	130.1	443		18402	20		2431
29-Apr	131.4	868		36056	15		1823
30-Apr	133.6	654		56402	10		974
1-May	141.8	269		23199	26		2347
2-May	155.7	349		35408	28		3403
3-May	160.5	808		143969	25		3038
4-May	153.3	1095		91281	34		4132
5-May	145.1	1012		52388	25		3038
6-May	135.7	1377		57199	24		2917
7-May	127.5	1231		106163	25		2465
8-May	120.2	449		33310	13		1548
9-May	117.4	397		27558	17		2356
10-May	120.2	710		52598	24		3298
11-May	125.9	707		60990	23		2801
12-May	138.9	775		32193	27		3281
13-May	149.0	1148		72458	17		2066
14-May	165.2	1437		582324	18		2187
15-May	172.2	1466		594075	10		1215
16-May	157.5	2407		290761	27		3281
17-May	141.7	2034		90664	27		3281
18-May	127.6	2295		197923	20		1836
19-May	117.2	1891		130660	24		2968
20-May	112.2	2859		177569	20		3092
21-May	112.4	3327		207434	20		3459
22-May	126.6	4431		389581	24		3326
23-May	170.9	2071		839243	18		2187
24-May	280.2	10111		4097338	14		1701
25-May	334.2	15421		6249139	3		365
26-May	299.2		10944	4434899		7	851
27-May	288.3		11222	4547554		5	608
28-May	333.7	7301		2958625	5		608
29-May	346.2		5694	2307412		4	486
30-May	334.2		4312	1747376		3	365
31-May	335.6		3565	1444665		3	365
1-Jun	323.2		3032	1228674		3	365
2-Jun	293.8		2713	1099404		3	365
3-Jun	271.8		1064	431171		3	365
4-Jun	267.6	1717		695790	2		243
5-Jun	292.3	2537		1028083	3		365
6-Jun	338.1	1009		408883	2		243

7-Jun	377.8		1166	472505		2	243
8-Jun	392.4		823	333509		2	243
9-Jun	376.1		776	314463		2	243
10-Jun	333.6		679	275155		2	243
11-Jun	281.7		643	260567		2	243
12-Jun	256.0		610	247194		2	243
13-Jun	240.5	515		208696	1		122
14-Jun	212.2	601		243547	0		0
15-Jun	189.2	1857		752523	2		243
16-Jun	180.4	1717		695790	2		243
17-Jun	185.1	2053		831949	3		365
18-Jun	208.1	1741		705515	5		608
19-Jun	200.6	1771		717672	7		851
20-Jun	171.3	1045		423471	3		365
21-Jun	145.3	1466		76268	3		365
22-Jun	125.3	1321		112018	3		419
23-Jun	110.8	721		43484	5		1031
24-Jun	105.1	694		37618	2		407
25-Jun	110.0	549		32622	10		1860
26-Jun	126.9	451		38895	11		1551
27-Jun	156.6	484		53016	10		1215
28-Jun	156.9	1080		122797	0		0
29-Jun	149.1	768		48766	0		0
30-Jun	143.3	771		36742	1		122
1-Jul	126.4	821		70804	0		0
2-Jul	109.1	476		27780	0		0
3-Jul	99.0	475		23207	0		0
4-Jul	94.8	441		20187	0		0
5-Jul	96.1	361		16870	0		0
6-Jul	95.1	424		19500	0		0
7-Jul	92.0	336		14770	0		0
8-Jul	87.0	406		16642	0		0
9-Jul	78.6	478		19034	0		0
10-Jul	75.6	373		14853	0		0
11-Jul	76.7	258		10273	0		0
12-Jul	79.5	210		8362	0		0
13-Jul	77.1	171		6809	0		0
14-Jul	69.4	205		8163	0		0
15-Jul	64.1	207		8243	0		0
16-Jul	60.8	209		8322	0		0
17-Jul	56.3	199		7924	0		0
18-Jul	52.6	157		6252	0		0
19-Jul	51.3	57		2270	0		0
20-Jul	49.1	43		1712	0		0
21-Jul	48.3	38		1513	0		0
22-Jul	47.2	35		1394	0		0
23-Jul	45.8	54		2150	0		0
24-Jul	43.7	43		1712	0		0
25-Jul	40.2	41		1633	0		0
26-Jul	37.9	36		1433	0		0
27-Jul	36.7	14		557	0		0
28-Jul	35.5	6		239	0		0
29-Jul	34.0	1		40	0		0
30-Jul	32.9	6		239	0		0
31-Jul	32.6	3		119	0		0
	Season Totals	**110356**	**47520**	**45356404**	**1626**	**58**	**318595**

3.7 Appendix C

Actual Daily and Estimated Captures and Emigration Estimates for Wild Steelhead and Wild Coho, Wenatchee River 2003

Appendix C. Actual daily and estimated captures and emigration estimates for wild steelhead and wild coho, Wenatchee River 2003.

Date	Average Trapping Flow (M^3/S)	Wild Steelhead			Wild Coho		
		Catch		Migration	Catch		Migration
		Actual	Estimated		Actual	Estimated	
22-Feb	58.1	0		0	0		0
23-Feb	54.3	0		0	0		0
24-Feb	49.4	0		0	0		0
25-Feb	46.9	0		0	0		0
26-Feb	46.5	0		0	0		0
27-Feb	44.8	0		0	0		0
28-Feb	43.1	0		0	0		0
1-Mar	41.3	0		0	0		0
2-Mar	40.3	0		0	2		591
3-Mar	39.3	0		0	0		0
4-Mar	38.5	0		0	0		0
5-Mar	39.7	0		0	1		296
6-Mar	42.6	0		0	1		296
7-Mar	42.8	0		0	1		296
8-Mar	40.7	0		0	1		296
9-Mar	40.6	0		0	0		0
10-Mar	40.2	0		0	0		0
11-Mar	47.9	0		0	0		0
12-Mar	73.3	0		0	1		85
13-Mar	117.0	0		0	2		206
14-Mar	134.7	0		0	5		437
15-Mar	139.9	0		0	8		714
16-Mar	130.6	1		116	5		582
17-Mar	117.9	0		0	7		1173
18-Mar	107.7	0		0	5		1342
19-Mar	98.5	0		0	8		3797
20-Mar	92.9	0		0	1		674
21-Mar	93.2	0		0	1		310
22-Mar	111.4	0		0	0		0
23-Mar	110.1	0		0	0		0
24-Mar	101.2	0		0	4		1500
25-Mar	94.5	1		644	3		1933
26-Mar	89.7	0		0	1		644
27-Mar	84.8	0		0	0		0
28-Mar	80.4	0		0	0		0
29-Mar	79.6	0		0	0		0
30-Mar	94.1	0		0	1		644
31-Mar	147.2	0		0	0		0
1-Apr	153.2	0		0	2		243
2-Apr	139.8	0		0	6		729
3-Apr	126.1	1		97	6		581
4-Apr	114.7	0		0	2		264
5-Apr	105.7	0		0	1		185
6-Apr	98.7	0		0	0		0
7-Apr	91.1	0		0	1		644

8-Apr	89.0	0		0	0		0
9-Apr	91.8	0		0	2		1288
10-Apr	92.6	0		0	0		0
11-Apr	93.2	2		1288	1		644
12-Apr	97.8	1		489	3		1467
13-Apr	112.6	0		0	2		519
14-Apr	120.0	1		142	1		142
15-Apr	117.1	1		137	0		0
16-Apr	114.1	1		152	1		152
17-Apr	111.6	3		497	2		332
18-Apr	107.1	1		189	1		189
19-Apr	102.6	2		466	0		0
20-Apr	101.4	1		283	0		0
21-Apr	106.8	1		244	0		0
22-Apr	118.9		1	169		0	0
23-Apr	125.6	0		0	2		245
24-Apr	163.9	2		243	2		243
25-Apr	156.3	16		1944	6		729
26-Apr	146.8	6		729	7		851
27-Apr	135.4	2		163	0		0
28-Apr	130.1	5		608	2		243
29-Apr	131.4	2		243	4		486
30-Apr	133.6	3		292	2		195
1-May	141.8	2		181	0		0
2-May	155.7	8		972	2		243
3-May	160.5	2		243	3		365
4-May	153.3	1		122	6		729
5-May	145.1	4		486	2		243
6-May	135.7	4		486	4		486
7-May	127.5	4		394	6		592
8-May	120.2	5		595	1		119
9-May	117.4	5		693	1		139
10-May	120.2	20		2748	6		824
11-May	125.9	17		2070	3		365
12-May	138.9	25		3038	6		729
13-May	149.0	52		6319	3		365
14-May	165.2	15		1823	4		486
15-May	172.2	20		2431	4		486
16-May	157.5	17		2066	2		243
17-May	141.7	8		972	3		365
18-May	127.6	12		1102	2		184
19-May	117.2	8		989	4		495
20-May	112.2	11		1701	4		618
21-May	112.4	4		692	1		173
22-May	126.6	7		970	1		139
23-May	170.9	14		1701	3		365
24-May	280.2	3		365	2		243
25-May	334.2	2		243	0		0
26-May	299.2		1	122		1	162
27-May	288.3		1	122		1	122
28-May	333.7	0		0	2		243

29-May	346.2		0	0		1	122
30-May	334.2		0	0		1	122
31-May	335.6		0	0		1	91
1-Jun	323.2		0	0		1	91
2-Jun	293.8		0	0		1	91
3-Jun	271.8		0	0		1	91
4-Jun	267.6	1		122	0		0
5-Jun	292.3	4		486	1		122
6-Jun	338.1	2		243	0		0
7-Jun	377.8		1	122		0	0
8-Jun	392.4		0	0		0	0
9-Jun	376.1		0	0		0	0
10-Jun	333.6		0	0		0	0
11-Jun	281.7		0	0		0	0
12-Jun	256.0		0	0		0	0
13-Jun	240.5	0		0	0		0
14-Jun	212.2	0		0	0		0
15-Jun	189.2	0		0	0		0
16-Jun	180.4	0		0	0		0
17-Jun	185.1	0		0	0		0
18-Jun	208.1	0		0	1		122
19-Jun	200.6	0		0	0		0
20-Jun	171.3	0		0	0		0
21-Jun	145.3	0		0	0		0
22-Jun	125.3	0		0	0		0
23-Jun	110.8	1		206	0		0
24-Jun	105.1	0		0	0		0
25-Jun	110.0	0		0	0		0
26-Jun	126.9	0		0	0		0
27-Jun	156.6	0		0	0		0
28-Jun	156.9	0		0	0		0
29-Jun	149.1	1		122	0		0
30-Jun	143.3	1		122	1		122
1-Jul	126.4	0		0	0		0
2-Jul	109.1	0		0	0		0
3-Jul	99.0	0		0	0		0
4-Jul	94.8	0		0	0		0
5-Jul	96.1	0		0	0		0
6-Jul	95.1	0		0	0		0
7-Jul	92.0	0		0	0		0
8-Jul	87.0	0		0	0		0
9-Jul	78.6	0		0	0		0
10-Jul	75.6	0		0	0		0
11-Jul	76.7	0		0	0		0
12-Jul	79.5	0		0	0		0
13-Jul	77.1	0		0	0		0
14-Jul	69.4	0		0	0		0
15-Jul	64.1	0		0	0		0
16-Jul	60.8	0		0	0		0
17-Jul	56.3	0		0	0		0
18-Jul	52.6	0		0	0		0

9-Jul	51.3	0		0	0		0
20-Jul	49.1	0		0	0		0
21-Jul	48.3	0		0	0		0
22-Jul	47.2	0		0	0		0
23-Jul	45.8	0		0	0		0
24-Jul	43.7	0		0	0		0
25-Jul	40.2	0		0	0		0
26-Jul	37.9	0		0	0		0
27-Jul	36.7	0		0	0		0
28-Jul	35.5	0		0	0		0
29-Jul	34.0	0		0	0		0
30-Jul	32.9	0		0	0		0
31-Jul	32.6	0		0	0		0
Season Totals		**333**	**4**	**44204**	**192**	**8**	**36679**

4 Cedar Creek

2003 Cedar Creek Juvenile Salmonid Production Evaluation

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4.1 METHODS

4.1.1 Study Site

Cedar Creek is a third order tributary to the Columbia River and located in Clark County, WA (Figure 4-1). The mouth of Cedar Creek is located across from the Lewis River Salmon Hatchery at river kilometer (Rkm) 25 on the Lewis River. The Cedar Creek basin is a low gradient system with elevation ranging from 10 meters to 565 meters; this basin drains approximately 88.6 square kilometers. The anadromous salmonid species identified in Cedar Creek include chinook, chum, and coho salmon, cutthroat trout, and steelhead. Hatchery smolt releases of steelhead, coho and spring chinook into the Lewis River strongly influence the escapement of these species in Cedar Creek. Whereas these escapements of these species are influenced by in-basin releases, fall chinook escapements in Cedar Creek are strongly influenced by hatchery strays from outside the Lewis River basin. A natural fall exists at Rkm 4.0, which restricts salmon and steelhead passage at some flows. In the 1950's, a fish ladder was constructed by the Washington Department of Fisheries (WDF) to ensure salmon and steelhead passage at this location. This site is located below most of the coho salmon, steelhead, and sea-run cutthroat trout spawning, the property is owned by WDFW, and the constricted river allows for acceptable trap efficiencies. These characteristics and properties make this site ideal for juvenile trapping.

4.1.2 Trap Operation

On March 17, prior to the start of the smolt outmigration, a 1.5 meter rotary screw trap was installed just above the fish ladder at Rkm 4.0 (Rawding and VanderPloeg 2001)(Figure 4-1). The trap was fished until the end of the smolt migration on June 25. The trap was located near the head of a pool, just below a narrow section of fast turbulent flowing water. The trap was positioned so that stream flow entered in a straight line. Water velocities at this site were generally greater than 1.5 meter/second producing cone revolutions of between 3 and 12 revolutions per minute (rpm). It is difficult to trap at this location over the range of flows without moving the trap. The trap was initially fished in the middle part of the pool, then during weeks 17, 19 and 20 it was moved upstream. The upstream sites are narrower and have higher water velocities. Trap efficiency is usually higher in these conditions, since the trap fishes a higher cross sectional area when the stream width is narrower and trap avoidance is lower in faster more turbulent water.

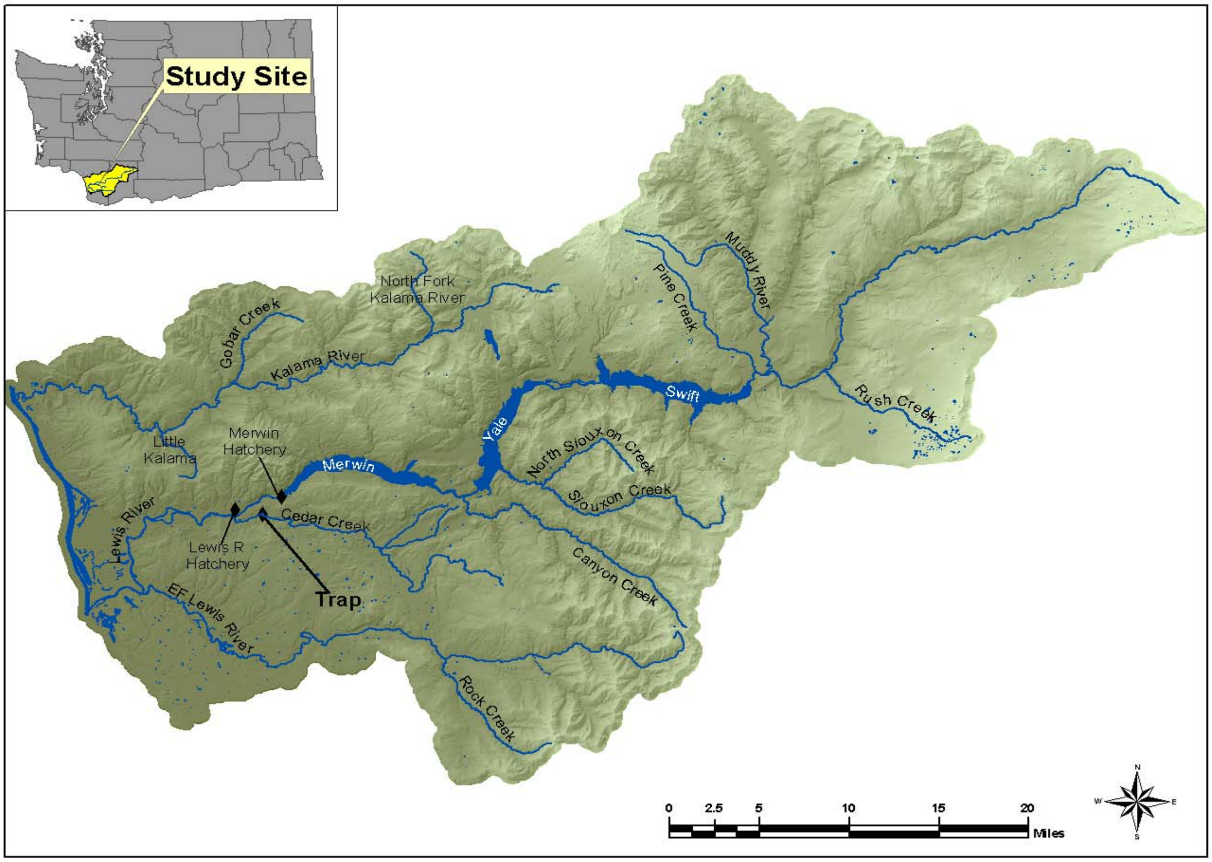

Figure 4-1. Location map of the Lewis River subbasin and the Cedar Creek juvenile trap site.

The trap was fished 24 hours/day throughout the smolt outmigration period. Trapping was suspended 5 days between March 21 and 27 due to high flow and debris. Since this is prior to the start of significant migration, we assumed no fish passed during these 5 days. Traps were checked daily in the morning; fish were removed from the live well and placed into aerated coolers. Salmonid juveniles were sorted by species composition and life history stage. Wild salmonids were classified as fry, parr, pre-smolt, or smolt (Rawding et al. 1999). The criteria for parr included well-developed parr marks and heavy spotting across the dorsal surface. Pre-smolts were those fish that had faint parr marks, less prominent dorsal spotting, silvery appearance, and no dark caudal fin margin. Smolts consisted of those salmonids with deciduous scales, silver appearance, and a dark band on the outer margin of the caudal fin. Since smoltification is a process that salmon, steelhead, and cutthroat undergo along their downstream migration, and these salmonids are more than 90 miles from the ocean, we felt it was more accurate to classify fish as pre-smolts and smolts. However, both groups were combined for the outmigration analysis.

In all cases, captured juveniles were anesthetized with MS-222 (~ 40 mg/l) before handling, sampled as quickly as possible and were allowed to recover fully before being released into the river. The release occurred at the next available public access approximately 4.8 km above the trap site. Since steelhead and sea-run cutthroat abundance was low, all steelhead and sea-run cutthroat smolts were marked and released upstream to increase the precision of the trap efficiency estimate. Wild coho salmon were more numerous, and up to 40 per day were released for trap efficiency tests with the remainder being released below the trap to continue their outmigration. Since we were less concerned with estimating hatchery coho salmon because the release number is known, approximately 40 hatchery coho salmon smolts were marked each week to validate our hatchery estimate by comparing it to the release of hatchery coho salmon. Trap efficiency was not estimated for juvenile chinook in this study since current funding levels enabled only trapping an undetermined portion of the chinook out-migration.

Species were enumerated by life stage, and fork lengths (mm) were obtained on marked fish. Water temperatures were recorded by the United States Fish and Wildlife Service (USFWS) and stream discharge was measured and recorded by the Washington State Department of Ecology (DOE).

4.1.3 Juvenile Production Estimates

The number of juvenile outmigrants was estimated by using a trap efficiency method of releasing marked fish upstream of the trap (Dempson and Stansbury 1991, and Thedinga et al. 1994). Captured juvenile salmonids were marked with a Panjet inoculator (Hart and Pitcher 1969). Our marking schedule rotated every week and used different fin combinations to distinguish between weeks. Since the marking schedule was Sunday through Saturday, marks were recovered Monday through Sunday. Data is analyzed by recovery week and statistical weeks in this report are from Monday through Sunday. To achieve the desired level of precision, each day all maiden steelhead and cutthroat, and up to 40 maiden coho smolts, were marked and released 6 kilometers upstream to develop trap efficiency estimates.

Population and trap efficiency estimates were calculated using Stratified Population Analysis Software (SPAS) developed by Arnason et al. (1996), which is based on the maximum likelihood estimator developed by Plante (1990). Standard likelihood methods were used to estimate trap efficiencies, population estimates, and variance using the following equations:

Trap Efficiency: Bailey's modification to the Petersen estimate (Bailey 1951):

$$\hat{e} = \frac{(R+1)}{(M+1)}$$ **Equation 4-1**

Population (Production):

$$\hat{N} = \frac{U}{\hat{e}}$$ **Equation 4-2**

Variance/Confidence Limits: Variance for each N was estimated with SPAS using the variance of the Peterson estimate (Seber 1982). Ninety five percent confidence limits were found by:

$$CL_{95\%} = \hat{N} \pm 1.96 \times \sqrt{V(\hat{N})}$$ **Equation 4-3**

Where:

$\hat{e}$ = the estimated trap efficiency,

M = the number of marked fish released upstream of the trap,

R = the number of marked fish recaptured in the trap,

$\hat{N}$ = the estimated migration past the trap,

U = the total unmarked catch,

$CL_{(95\%)}$ = the 95% confidence limit about the estimated migration, and

$V(\hat{N})$ = the variance of the estimated migration past the trap.

SPAS computed the pooled Petersen (Chapman 1951) and stratified Petersen estimates (Darroch 1961). Using this software, we conducted two diagnostic chi-square tests to determine if the pooled Petersen estimate was valid. The equal proportions test was used to determine if the ratio of marked to unmarked fish was constant across all strata and complete mixing tests determined if recovery probabilities were constant across all strata. If either test yielded P values above 0.05, then the pooled Petersen estimate was considered valid. Since trap efficiencies may change with flow (Seiler et al. 1997), the pooled Petersen estimate may not always be valid and in this case a stratified estimate was used (Seber 1982, Warren and Dempson 1995, Miyakoshi and Kudo 1999). Initial data inputs to SPAS consisted of a matrix of marks released, recaptures, and captures by week. The MLE estimated for the stratified estimate often failed to converge due to numeric problems, such as small sample size and linear dependency. The original matrix was reduced usually by combining weeks late in the study where few fish were caught, and weeks when the least squares estimate initially provided negative numbers. Guidance on appropriate methods of pooling mark and recovery strata were not always clear (Schwarz and Taylor 1998). After the initial stratified estimate, a chi-square test was used to compare marked and unmarked smolts per release group to formally test pooling (Murphy et al. 1996). The first two weeks were tested for a significant difference (P value <0.05). If not significant, then additional weeks were added until a significant difference was detected. This process was repeated beginning with the week that caused the P value to drop below 0.05. The purpose of this pooling was to develop homogeneous periods for population estimate and to increase the precision of the seasonal migration estimate.

Murphy et al. (1996) listed the standard assumptions of the Petersen method that apply in trap efficiency experiments: (1) the population is closed; (2) all fish have the same probability of capture in the first sample; (3) the second sample is either a simple random sample, or if the second sample is systematic, marked and unmarked fish mix randomly; (4) marking does not affect catchability; (5) fish do not lose their marks; and (6) all recaptured marks are recognized. During the smolt trapping season, we took steps to reduce the possibility that these assumptions were violated. Assumption 1 is that of closure, which assumes that no fish leave or enter between sampling occasions. Since smolts are actively emigrating this assumption cannot be met. However, the Petersen estimate is still consistent if the loss rate of tagged and untagged smolts is the same (Arnason et al. 1996). Therefore, the closure assumption was met in this study.

To the extent possible, we conducted experiments to determine the bias caused by violations of other assumptions and develop correction factors. Assumptions 2 and 3 were addressed by estimating populations by species, origin and life stage. A Kolmogorov-Smirnov (KS) test was used to test for differences in recovery rates by length. Although Seber (1982) recommends a comparison of recaptured fish with those captured not seen again with a KS test, this is not possible with the batch mark we used for smolt trapping. For batch marked fish, we followed the recommendation of Thedinga et al. (1994) and compared recaptured fish with all marked fish. Assumptions 4 and 5 were estimated by holding marked fish to assess tag loss and handling mortality (Thedinga et al. 1994, Rawding et al 1999). When properly applied the panjet mark is easily observed, and retention consistently exceeded the three week period required for this study (Thedinga and Johnson 1995, Rawding and Cochran 2001).

4.2 RESULTS

4.2.1 Assumptions

Assumptions 2 and 3 address equal catchability. In mark-recapture studies, most biologists try to estimate population size for homogeneous groups because they are likely to have the same capture and recapture probabilities. In this study design, separate estimates were made for different species and hatchery coho salmon were estimated separately from wild fish. Furthermore, estimates were only made for the pre-smolt/smolt life stage. Parr or fry are smaller than smolts and may not be actively migrating. Therefore, parr and fry were identified and enumerated separately. In addition, trap efficiency and ultimately population estimates may be affected by fish size or length. KS tests were not significant for sea-run cutthroat, steelhead, and wild coho smolts, with P values of 0.16, 0.17, and 0.17, respectively (Figure 4-2). This analysis indicates trapping was not selective by size for wild smolts. For hatchery coho salmon smolts it appears that recaptured smolts were smaller, than all smolts caught. The KS test for hatchery coho salmon was significant (P value = 0.00) indicating that trap efficiency and population estimates may be biased. It is unclear why the difference occurred for this hatchery group.

Assumptions 4, 5, and 6 address tag induced mortality, tag loss, and tag recognition. A secondary experiment was conducted to assess tag loss and handling mortality. A total of 130 coho and cutthroat trout were tagged and held in a live box for a period of 24 hours after being trapped and marked. Panjet mark retention, CWT retention, and survival were 100% indicating the tag loss and mortality assumptions were met. We did not specifically assess if field staff properly identified marked or tagged fish. However, these experienced staff knew the importance of carefully sampling fish and the need to identify all tagged fish. The likelihood that they missed tags in this study is believed to be low. Based on this information, no serious violation of the assumptions required for unbiased population estimates occurred and it is believed that the smolt population estimates for sea-run cutthroat trout, steelhead, and coho salmon were not significantly biased.

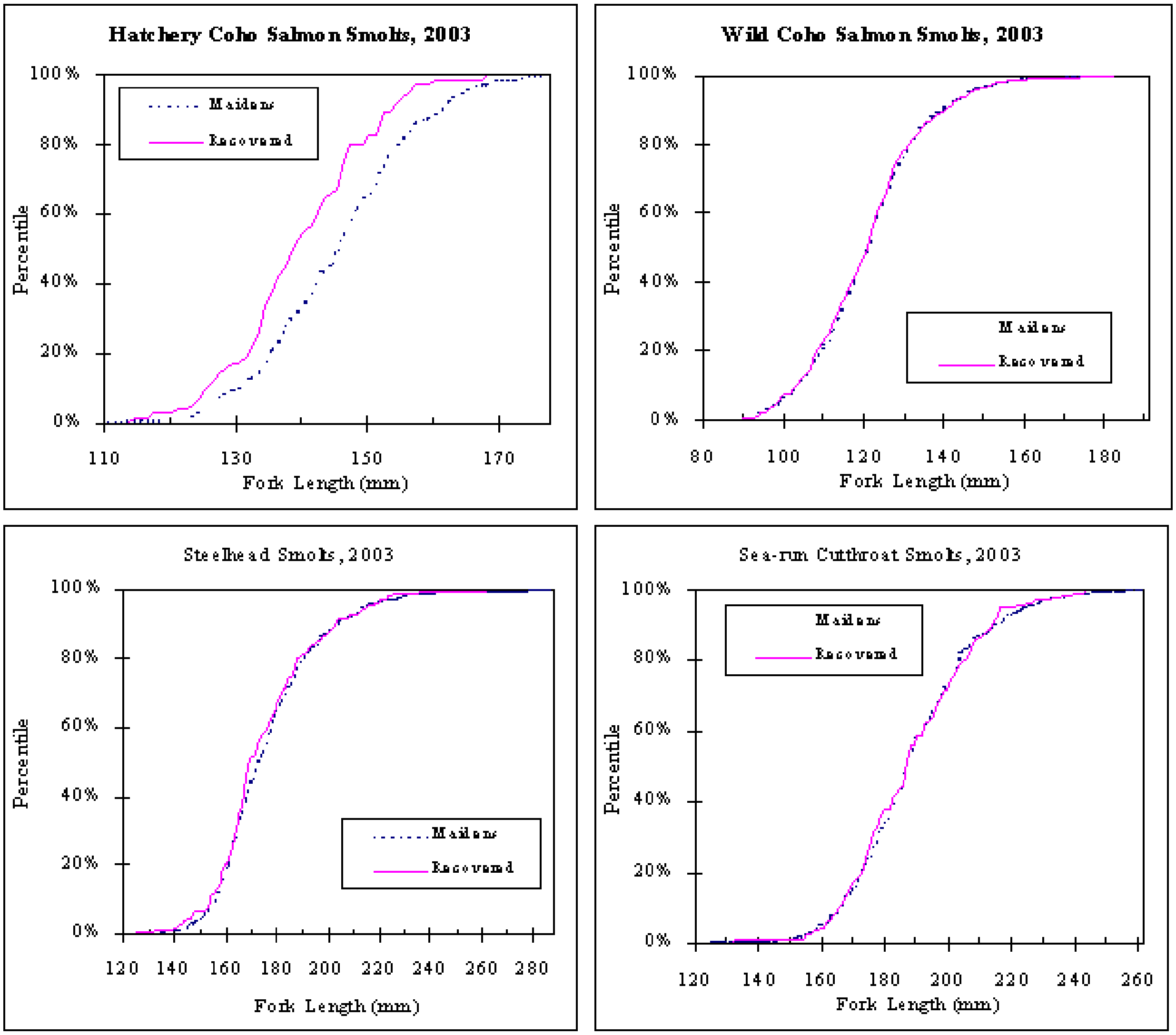

Figure 4-2. KS tests for hatchery coho salmon, wild coho salmon, wild steelhead, and wild sea-run cutthroat trout smolts captured at the Cedar Creek trap in 2003.

4.2.2 Cutthroat

A total of 622 cutthroat trout classified as pre-smolts and smolts were captured during the trapping period. The mean size for wild sea-run cutthroat smolts was 188.7 mm with a SE of 19.67 (Table 4-1). Over the season the weekly mean size declined from 201 mm to 149mm (Table 4-1 and Figure 4-3).

Table 4-1. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of wild sea-run cutthroat trout smolts measured by statistical week, Cedar Creek, 2003.

Statistical Week				Std	Range		Number	Total	Percent
No.	Begin	End	Mean	Dev	Min	Max	Sampled	Catch	Sampled
14	03/30	04/06	201.2	20.98	155	237	20	25	80.0%
15	04/07	04/12	210.5	17.57	179	245	20	20	100.0%
16	04/13	04/19	191.3	17.74	139	224	17	18	94.4%
17	04/20	04/26	203.6	21.18	152	256	33	34	97.1%
18	04/27	05/03	196.9	22.78	124	271	82	82	100.0%
19	05/04	05/10	182.7	17.15	124	232	69	70	98.6%
20	05/11	05/19	188.6	16.87	154	240	96	97	99.0%
21	05/18	05/25	185.2	15.47	147	237	159	176	90.3%
22	05/26	05/31	175.6	13.73	149	208	49	59	83.1%
23	06/01	06/07	174.8	16.32	145	234	23	33	69.7%
24	06/08	06/14	172.5	10.03	162	187	6	6	100.0%
25	06/15	06/21	149.0	0.00	149	149	1	1	100.0%
26	06/22	06/24	149.0	0.00	149	149	1	1	100.0%
		Season Total	188.7	19.67	124	271	576	622	92.6%

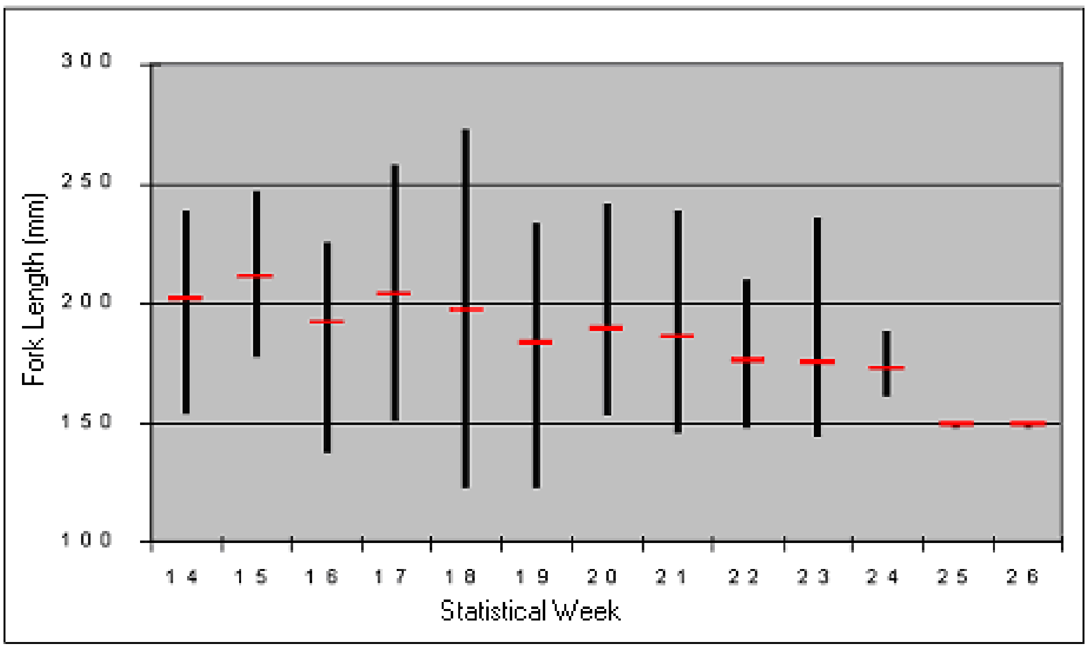

Figure 4-3. Weekly average, minimum, and maximum sea-run cutthroat trout smolt fork lengths measured at the Cedar Creek screw trap, 2003.

A total of 576 cutthroat trout were marked for 13 different release groups. The chi-square diagnostic complete mixing and equal proportions tests yielded P values of 0.54 and 0.07, respectively. Since one of these P values exceeded 0.05, the pooled Petersen estimate is valid. From March 17 to June 25, the wild cutthroat smolt outmigration estimate (SE) was 2,548 (164). Since the diagnostic tests indicated the pooled Petersen estimate met the assumption it was used as the final estimate. The 95% confidence interval ranged from 2,227 to 2,869 for sea-run cutthroat trout smolts (Table 4-2). Trap efficiency (SE) for wild sea-run cutthroat smolts was 24.84% (1.4%). Since trapping was initiated before the smolt outmigration period started and only a few days were not trapped at the beginning of the season, no expansion of the estimate was required.

Table 4-2. Catch and population estimates for sea-run cutthroat trout smolts emigrating past the Cedar Creek Trap during 2003.

Petersen Estimate	Periods	Catch	Migration Estimate	SE	Lower 95% CI	Upper 95% CI	CV
Pooled	1	633	2,548.44	163.58	2,228	2,869	6.42%
Init. Strat.	9	633	2,712.09	288.66	2,146	3,278	10.64%
Final Strat.	1	633	2,548.44	163.58	2,228	2,869	6.42%

Weekly trap catches increased from statistical week 14 (March 30- April 2) to week 21, and declined to few fish after week 23 (Figure 4-4). Weekly population estimates were approximated by dividing the stratum estimate by the proportion of the total captures that occurred during that week.

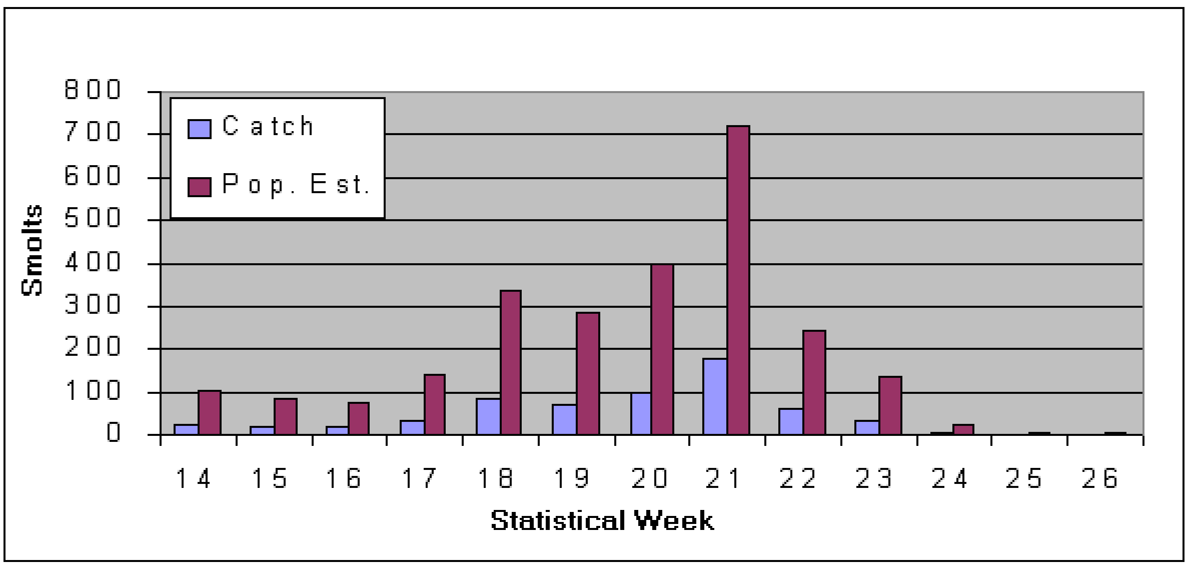

Figure 4-4. Weekly catch and population estimates for sea-run cutthroat trout smolts migrating past the Cedar Creek trap in 2003.

4.2.3 Steelhead

A total of 582 steelhead trout classified as pre-smolts and smolts were captured during the trapping period. The mean size for wild steelhead smolts was 176.5 mm. As with sea-run cutthroat trout, the mean weekly size declined from 202.5 mm to 149 mm during the trapping period (Table 4-3 and Figure 4-5).

Table 4-3. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of wild steelhead smolts measured by statistical week, Cedar Creek, 2003.

Statistical Week				Std	Range		Number	Total	Percent
No.	Begin	End	Mean	Dev	Min	Max	Sampled	Catch	Sampled
14	03/30	04/06	202.5	29.68	159	262	28	28	100.0%
15	04/07	04/12	186.6	28.37	144	278	34	35	97.1%
16	04/13	04/19	189.6	20.29	134	242	41	41	100.0%
17	04/20	04/26	183.4	25.26	139	287	66	66	100.0%
18	04/27	05/03	176.9	18.53	143	231	109	109	100.0%
19	05/04	05/10	169.6	17.25	131	212	71	75	97.7%
20	05/11	05/19	169.0	13.01	137	206	103	105	98.1%
21	05/18	05/25	170.5	13.16	147	211	89	98	90.8%
22	05/26	05/31	169.0	13.35	157	207	15	18	83.3%
23	06/01	06/07	158.3	9.29	150	171	3	4	75.0%
24	06/08	06/14	---	---	---	---	0	0	---
25	06/15	06/21	158.0	2.83	156	160	2	2	100.0%
26	06/22	06/24	---	---	---	---	0	0	---
Season Total			176.5	20.53	131	287	561	581	96.6%

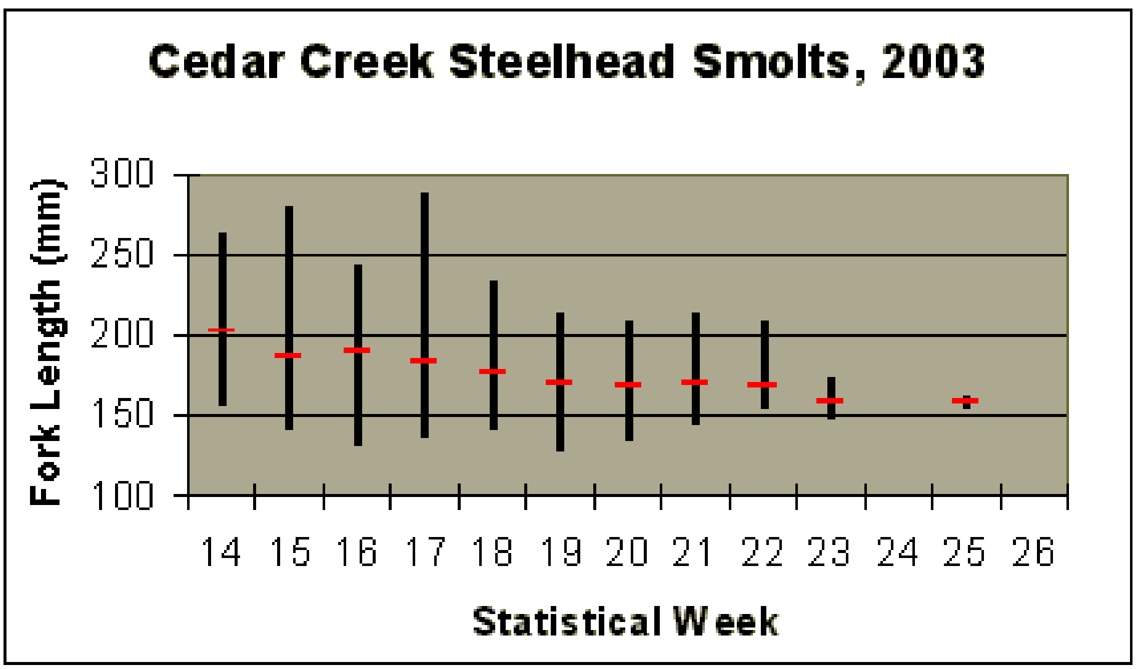

Figure 4-5. Weekly average, minimum, and maximum yearling steelhead fork lengths measured at the Cedar Creek screw trap, 2003.

A total of 561 steelhead trout were marked for 13 different release groups. The chi-square diagnostic complete mixing and equal proportions tests yielded P values of 0.00 for both tests, which indicated the pooled Petersen estimate is not valid. Since few fish were available for marking, steelhead in statistical weeks 23-26 were combined into one release group, yielding 10 release groups for the season. Further pooling of marking and recovery strata for weeks 15 &

16, produced 9 x 9 matrix with admissible population estimates. A chi-square test was used to compare marked and unmarked steelhead per release group to formally test pooling. The results indicated trap efficiencies were significantly different for two periods and population estimates were calculated for these two periods separately. For weeks 14 to 19, the trap efficiency was estimated to be 28% while it was estimated to be 50% for weeks 20 to 26. The difference in trap efficiencies for the two periods coincides with repositioning of the trap during weeks 19 and 20 to increase trap efficiency.

From March 17 to June 25, the wild steelhead smolt outmigration using the pooled Petersen estimate (SE) was estimated at 1,582 (70), using the stratified Petersen estimate it was estimated at 1,798 (122), and using the final two period stratification the outmigration was estimated to be 1,727 (98). The 95% confidence interval for the final estimated ranged from 1,534 to 1,919 smolts (Table 4-4). Since trapping was initiated prior to the smolt outmigration period and only a few days were not trapped at the beginning of the season, no expansion of the estimate was required to obtain a total smolt outmigration estimate.

Table 4-4. Catch and population estimates for steelhead smolts emigrating past the Cedar Creek Trap during 2003.

Petersen Estimate	Periods	Catch	Migration Estimate	SE	Lower 95% CI	Upper 95% CI	CV
Pooled	1	582	1,581.83	70.05	1,445	1,719	4.43%
Init. Strat.	9	582	1,797.61	122.09	1,558	2,037	6.79%
Final Strat.	2	582	1,726.71	98.18	1,534	1,919	5.69%

Weekly trap catches increased from statistical week 14 to week 18, and declined to few fish after week 22 (Figure 4-6). Weekly population estimates were approximated by dividing the stratum estimate by the proportion of the total captures that occurred during that week.

4.2.4 Coho Salmon

Both hatchery and wild coho salmon smolts are found in Cedar Creek. A small supplementation program was initiated for Cedar Creek coho salmon to ensure fish could utilize habitat where restoration projects improved access and habitat. Hatchery coho salmon smolts were acclimated from January 8 to April 4 at an acclimation pond located approximately 4 miles above the trap site. On April 4, screens were removed and hatchery smolts could begin their emigration. On April 30, the remaining hatchery coho salmon smolts were forced from the pond into the river, so they could continue their emigration.

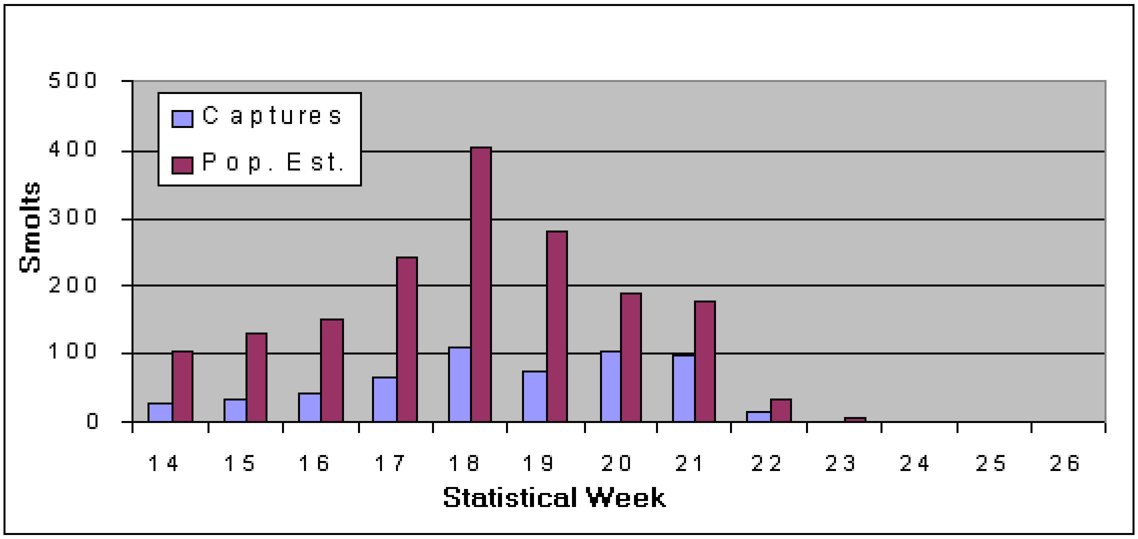

Figure 4-6. Weekly catch and population estimates for steelhead smolts migrating past the Cedar Creek trap in 2003.

A total of 14,286 wild and 2,487 hatchery coho salmon classified as pre-smolts and smolts were captured during the trapping period. The mean size for wild and hatchery coho salmon smolts were 121.2 mm and 145.4 mm, respectively (Table 4-5 and Table 4-6). Over the season the mean weekly size of wild coho salmon declined from 116 mm to 100 mm during the trapping period (Figure 4-7). Hatchery coho salmon, although larger, exhibited the same decline in size from 150 mm to 136 mm (Figure 4-8).

Table 4-5. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of wild coho salmon smolts measured by statistical week, Cedar Creek, 2003.

Statistical Week				Std	Range		Number	Total	Percent
No.	Begin	End	Mean	Dev	Min	Max	Sampled	Catch	Sampled
14	03/30	04/06	116.2	12.85	98	157	29	88	33.0%
15	04/07	04/12	130.0	16.90	104	182	67	79	84.8%
16	04/13	04/19	135.4	15.05	103	172	58	75	77.3%
17	04/20	04/26	135.2	13.21	108	171	213	463	46.0%
18	04/27	05/03	128.6	10.38	99	161	217	1,156	18.8%
19	05/04	05/10	126.8	12.34	97	191	277	1,666	16.6%
20	05/11	05/19	127.1	11.15	104	198	280	1,763	15.9%
21	05/18	05/25	125.4	10.81	105	189	280	3,850	7.3%
22	05/26	05/31	119.4	8.41	101	179	200	2,712	7.4%
23	06/01	06/07	115.1	7.43	93	142	240	1,706	14.1%
24	06/08	06/14	108.3	8.07	91	134	260	403	64.5%
25	06/15	06/21	103.8	8.36	90	132	214	263	81.4%
26	06/22	06/24	100.3	7.55	90	123	42	62	67.7%
Season Total			121.2	14.00	90	198	2,377	14,286	16.6%

Table 4-6. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of hatchery coho salmon smolts measured by statistical week, Cedar Creek, 2003.

Statistical Week			Mean	Stnd	Range		Number	Total	Percent
No.	Begin	End		Dev	Min	Max	Sampled	Catch	Sampled
14	03/28	04/06	149.7	16.65	126	224	36	152	23.7%
15	04/07	04/12	157.3	17.83	132	217	47	89	52.8%
16	04/13	04/19	148.3	12.33	124	187	22	41	53.7%
17	04/20	04/26	155.9	18.14	134	240	52	137	38.0%
18	04/27	05/03	149.5	12.77	125	195	46	217	21.2%
19	05/04	05/10	169.6	17.25	131	212	37	291	12.7%
20	05/11	05/17	144.1	9.96	123	172	40	645	6.2%
21	05/18	05/25	143.7	10.23	124	162	40	766	5.2%
22	05/26	05/31	134.9	7.84	122	153	48	120	40.0%
23	06/01	06/07	136.3	12.15	113	149	13	29	44.8%
Season Total			**145.4**	**11.47**	**113**	**240**	**381**	**2,487**	15.3%

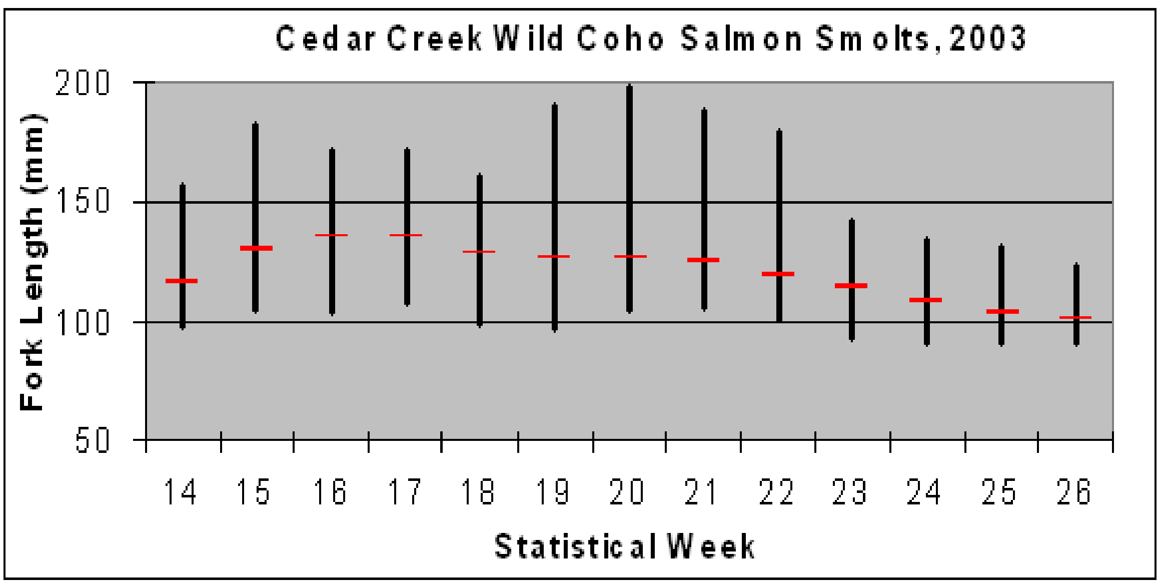

Figure 4-7. Weekly average, minimum, and maximum yearling wild coho salmon fork lengths measured at the Cedar Creek screw trap, 2003.

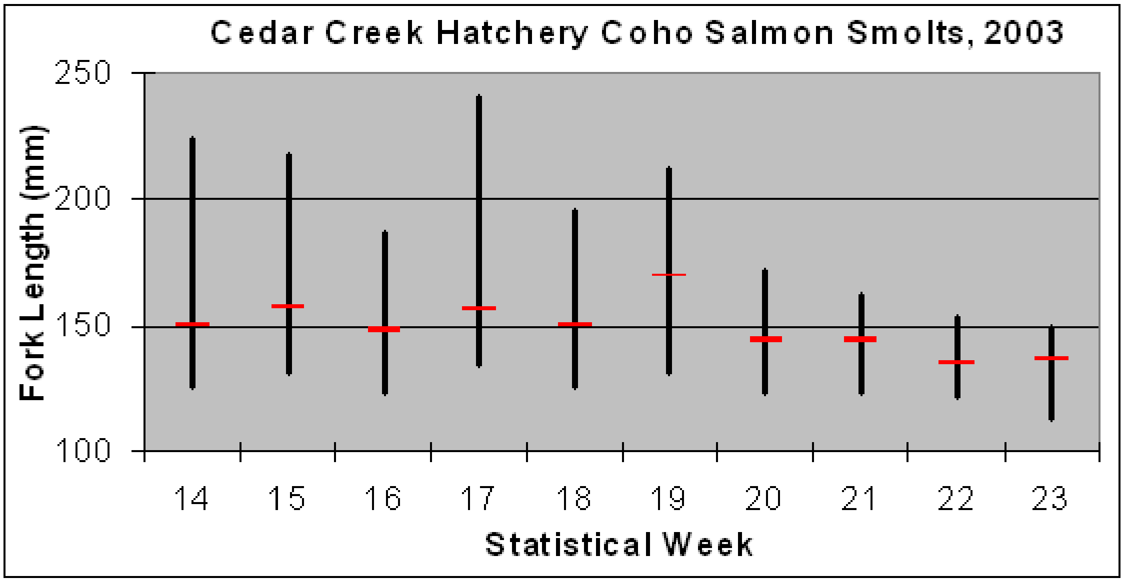

Figure 4-8. Weekly average, minimum, and maximum yearling hatchery coho salmon fork lengths measured at the Cedar Creek screw trap, 2003.

A total of 2,377 wild coho salmon were marked in 13 different release groups. The chi-square diagnostic complete mixing and equal proportions tests yielded P values of 0.00 for both tests, which indicated the pooled Petersen estimate was not valid. Pooling of marking and recovery strata for weeks 17 & 18, 19 & 20, and 25 & 26, produced 10 x 10 matrix with admissible population estimates. A chi-square test was used to compare marked and unmarked coho salmon smolts by release groups to formally test pooling. The results indicated trap efficiencies were significantly different for three periods and population estimates were calculated for these periods separately. For weeks 14 to 16, the trap efficiency was estimated to be 7% while it was estimated to be 34% for weeks 17 to 20, and 52% for weeks 21 through 26. This difference coincides with repositioning of the trap during weeks 17, 19, and 20.

From March 17 to June 25, the wild coho salmon smolt outmigration using the pooled Petersen estimate (SE) was estimated to be 33,145 (752), using the stratified Petersen estimate it was estimated to be 36,049 (2,687), and using the final three period stratification the outmigration was estimated to be 35,096 (1,266). The 95% confidence interval for the final estimated ranged from 32,614 to 37,575 smolts (Table 4-7). Since trapping was initiated prior to the smolt outmigration period and only a few days were not trapped at the beginning of the season, no expansion of the estimate was required to obtain a total smolt outmigration estimate.

A total of 381 hatchery coho salmon smolts were marked in 10 different release groups to develop trap efficiency estimates. The chi-square diagnostic complete mixing and equal proportions tests yielded P values of 0.00 for both tests, which indicated the pooled Petersen estimate is not valid. Pooling of marking and recovery strata for weeks 14 to 16, produced 8 x 8 matrix with admissible population estimates. A chi-square test was used to compare marked and unmarked coho salmon smolts by release groups to formally test pooling. The results indicated trap efficiencies were significantly different for three periods and population estimates were calculated for these periods separately. For weeks 14 to 17, the trap efficiency was estimated to be 13% while it was estimated to be 39% for weeks 18 to 21, and 59% for weeks 22 through 23. This difference coincides with repositioning of the trap during weeks17 and 20. The trap efficiency for hatchery and wild coho salmon smolts was similar during periods and increased during the course of the season.

Table 4-7. Catch and population estimates for wild coho salmon smolts emigrating past the Cedar Creek Trap during 2003.

Petersen Estimate	Periods	Catch	Population Estimate	SE	Lower 95% CI	Upper 95% CI	CV
Pooled	1	14,286	33,144.84	752.03	31,671	34,619	2.27%
Init. Strat.	10	14,286	36,048.55	2,686.52	30,783	41,314	7.45%
Final Strat.	3	14,286	35,094.74	1,265.65	32,614	37,575	3.61%

From March 17 to June 25, the hatchery coho salmon smolt outmigration using the pooled Petersen estimate (SE) was estimated to be 7,602 (541), using the stratified Petersen estimate it was estimated to be 8,471 (949), and using the final three period stratification the outmigration was estimated to be 8476 (836). The 95% confidence interval for the final estimated ranged from 6,837 to 10,115 smolts (Table 4-8). Since trapping was initiated prior to the smolt outmigration period and only a few days were not trapped at the beginning of the season, no expansion of the estimate was required to obtain a total smolt outmigration estimate.

Table 4-8. Catch and population estimates for hatchery coho salmon smolts emigrating past the Cedar Creek Trap during 2003.

Petersen Estimate	Periods	Catch	Population Estimate	SE	Lower 95% CI	Upper 95% CI	CV
Pooled	1	2,487	7,602.33	541.45	6,541	8,664	7.12%
Init. Strat.	8	2,487	8,470.82	948.96	6,611	10,331	11.20%
Final Strat.	3	2,487	8,475.82	836.23	6,837	10,115	9.87%

Similar to the sea-run cutthroat trout, the weekly trap catches and population estimates for wild coho salmon smolts increased from week 14 to a peak in week 21, and declined to a few fish by the last week of the season (Figure 4-9 and Figure 4-10). Unlike wild salmonids, which followed a normal distribution, weekly hatchery coho salmon catches and population estimates were highly variable, with significant movement in weeks 14, 17, 20, and 21. Hatchery and wild coho salmon catch and population estimate both peaked in week 21.

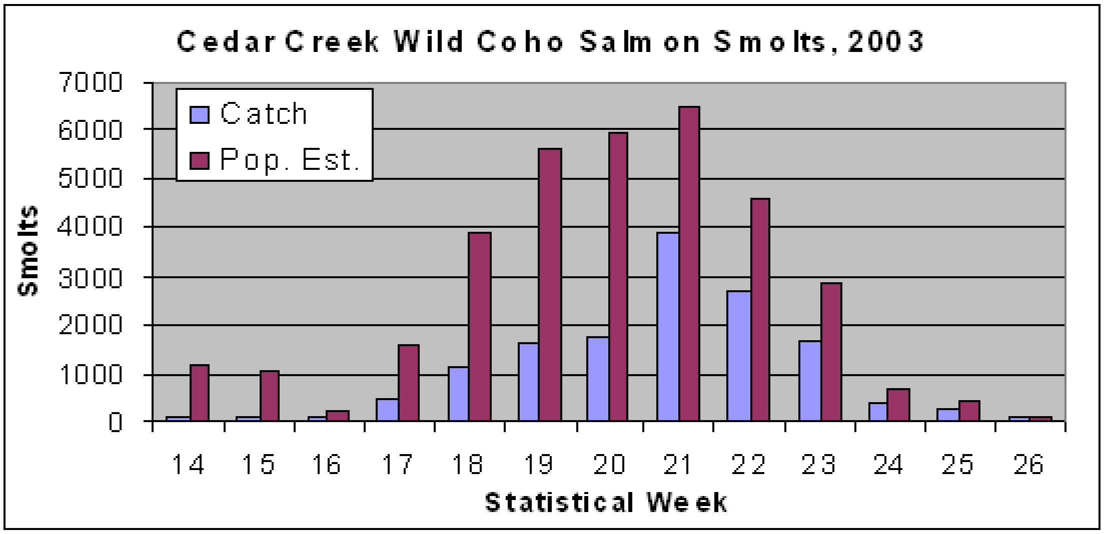

Figure 4-9. Weekly catch and population estimates for wild coho salmon smolts migrating past the Cedar Creek trap in 2003.

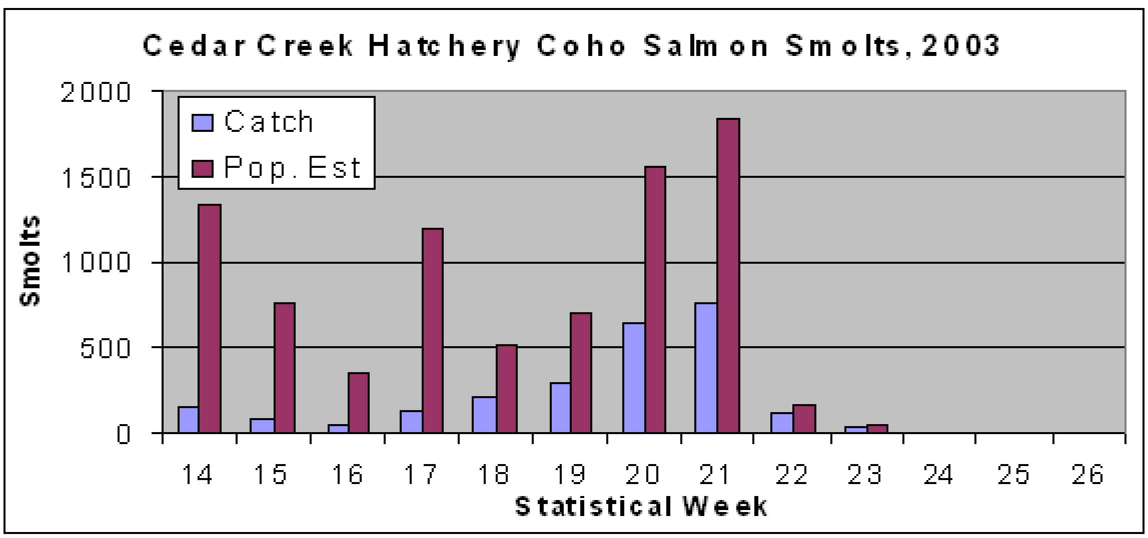

Figure 4-10. Weekly catch and population estimates for hatchery coho salmon smolts migrating past the Cedar Creek trap in 2003.

4.2.5 Other species and life stages

A total of 1,026 coho fry, 361 chinook fry, and 65 trout fry were captured in the Cedar Creek trap during its operation period. An additional 27 cutthroat, 47 rainbow/steelhead, and 101 coho salmon parr were also trapped. Largemouth bass, bluegill, pumpkinseed, brown bullhead, crappie, sculpins, mountain whitefish, largescale suckers, redside shiner, western brook lamprey, Pacific lamprey, adult steelhead, adult cutthroat, and adult spring chinook were identified by the sampling crew.

4.3 DISCUSSION

Since the assumptions of the Petersen estimate were met, it's likely the population estimates are unbiased. In previous years, the comparison of the estimated hatchery coho salmon population migrating past the trap was not significantly different from the number of hatchery coho salmon smolts released into Cedar Creek as long as the trap was operated throughout the migration period (WDFW unpublished). In January 2003, a total of 15,193 coho smolts were released into an acclimation facility on Cedar Creek. After the release it was estimated that 5,000 hatchery coho smolts had emigrated from the acclimation facility since screen designed to keep the smolts in place were not functioning properly. Given the flushing flows that occurred between January and March, it is likely that few of the 5,000 smolts remained in Cedar Creek. This left approximately 10,000 smolts to migrate during the trapping period. The estimated hatchery smolt outmigration, which was between 6,837 to 10,115 smolts, falls within the 95% CI for the hatchery coho salmon smolt migration estimate.

Robson and Reiger (1964) suggested that the precision of population estimates be scaled to the use of the estimate. For management, they recommended the 95% CI of the population estimate be less than 25% and for research they recommended 10% or less. This equates to a coefficient of variation (CV) of 12.7% and 5.1%, respectively. Since this monitoring project goes beyond management, project goals were for CV of 5% or less for wild populations. For wild cutthroat, steelhead, and coho salmon smolts the CV were 6.4%, 5.7%, and 3.6%, respectively. The precision of population estimates is directly tied to the number of recoveries, and for small populations like steelhead and sea-run cutthroat trout there are no easy solutions to increasing the level of precision other than marking all fish and choosing efficient sites to fish. In 2003, all steelhead and cutthroat smolts were marked and transported upstream, and the trap efficiency was 34% and 25% respectively. As long as abundance levels for steelhead and cutthroat smolts remain less than 3,000 smolts, it will be difficult to achieve the precision goals for these species. However, it should be noted despite this difficulty, the precision estimate was only 1% higher than the goal.

Based on simulations (Dan Rawding - WDFW, unpublished), it was estimated that up to 40 smolts per day should be used for trap efficiency tests. Catch above this level were coded-wire-tagged (CWT) and released below the trap. The CV for wild coho salmon was 3.6% and exceeded our precision target of a CV less than 5%. Since the number of hatchery coho salmon smolts is known, there is no precision goal for this group. Approximately, 40 smolts are marked weekly and the CV for hatchery coho salmon smolts was 9.9% in 2003. Improving the precision of this estimate is possible but would require marking additional hatchery smolts. Given the other wild salmonid priorities in the study this is not likely to occur without additional funding.

A total of 13,888 wild coho salmon smolts were CWT. This tagging serves two purposes, the first is to provide marks for a coho salmon smolt estimate obtained from adults (Seiler et al. 1997) and the second is to provide information about the ocean and Columbia River fisheries interception of wild Lower Columbia River coho salmon, which are listed as a candidate species under the Endangered Species Act (ESA). Since, adult coho salmon typically return after two summers in the ocean, an independent smolt estimate from adult returns and harvest information will be available in 2006 to 2007.

4.3.1 Recommendations

1) Funding for this trapping operation covers a field season from late March to late June, which coincides with the migration of yearling coho salmon, steelhead, and sea-run cutthroat smolts. Fall chinook salmon are listed for protection under the ESA, and these fish spawn in the area above the trap. If funding can be provided the fall chinook outmigration should be estimated. This would necessitate initiating trapping by mid to late January.
2) An adult trap currently is operated by WDFW in a fish ladder adjacent to the juvenile trapping site. Currently, WDFW maintains a count of adult salmon, cutthroat, and steelhead. With additional funding, fish caught in the trap could be tagged and carcass surveys, snorkeling, or an upstream trap could be used to obtain recoveries. Using mark-recapture, accurate and precise populations estimates could be obtained in Cedar Creek, increasing the value of the juvenile dataset.
3) Hatchery fish were marked with a green elastomer in the fatty tissue adjacent to the eye. Tag retention for this mark was poor. Therefore, a portion of the hatchery fish had no mark and field staff used other characteristics to identify these fish. Circumstantial evidence, such as, outmigration estimate not being significantly different than the released estimate and the wild population estimate being within the observed range, indicate these estimates are reasonable but mark retention should be improved for hatchery releases.
4) Population estimates were obtained from standard mark-recapture methods. Since temperature and flow are known to influence smolt migration (Seiler et al 1997 and Rawding et al. 1999), flow and temperature data could be incorporated as co-variates to a population estimate to develop accurate but potentially more precise estimates (Schwarz and Dempson 1994).

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