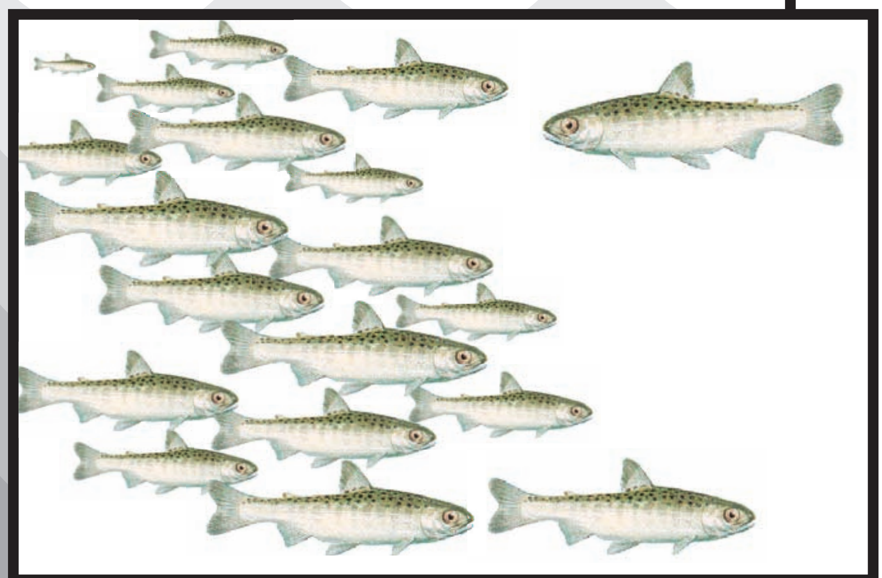
STATE OF WASHINGTON December 2006

2005 Juvenile Salmonid Production Evaluation Report

Green River, Dungeness River and Cedar Creek



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WDFW Fish Management Division

Washington Department of
FISH AND WILDLIFE
Fish Program

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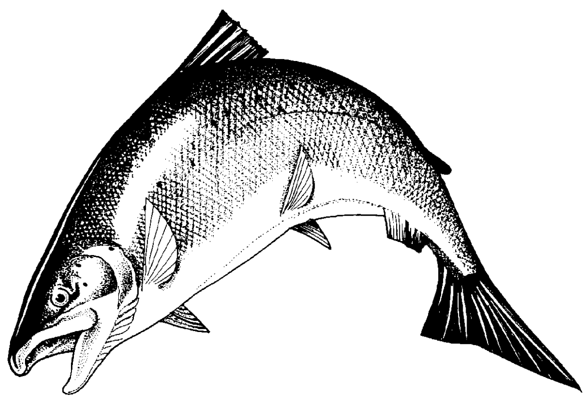

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Acknowledgements

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: Bret Brown, Bob Green, and Paul Lorenz. Logistical support was provided by Wild Salmon Production/Evaluation Unit biologist Mike Ackley.

A number of other individuals and agencies contributed to this project. For providing access to the trap site, we thank the adjacent landowner 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.

Dungeness River

WDFW scientific technicians Chris Burns, Joseph Boucher, Paul Lorenz, Dan Phinney and Scott Schuetzler worked the long hours of trap operation; their hard work and dedication was key to achieving our project goals. Wild Salmon Production Evaluation Unit biologist, Mike Ackley and scientific technician Brian Blazer provided logistical and technical support in all areas of the project.

In addition, we would like to thank the landowners of Dungeness Farms Inc., especially caretaker Matt Heins, who gave us unrestricted access to their property for trap placement and office trailer space, and provided power, water, phone, tools, and general support, and landowners Ray Gorynski and Nash Huber, who allowed us dike access to the trap site. We also thank Scott Chitwood and Rodger Mosley, employees of the Jamestown S'Klallam Tribe, for their contributions to this study, and Dan Witczak, manager of the Hurd Creek Hatchery, for providing logistical support and an office trailer.

Cedar Creek

Skip Walch, Bao Le, Christina Luzier from the USFWS provided the CWT tagging machine and screw trap for this study. Julie Grobelny, Josua Holowatz, and Scott Nelson worked the trap during the 2005 field season. Their field work was exceptional, and allowed for project goals to be achieved. Additionally field staff were responsible for data entry, which was accurate and timely. Jeff Grim analyzed the otoliths to determine the number of coho salmon smolts collected that originated from a remote site incubator (RSI). Michelle Groesbeck developed the database and supplied the queries used in this analysis. Steve VanderPloeg created the site map. Jim Scott reviewed an earlier draft of this report and his comments improved this manuscript.

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Executive Summary

Declining salmon populations in the 1980s and 1990s 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 freshwater salmon production monitoring (smolt monitoring) program. The new sites established during this period included Cedar Creek in 1998 to monitor Lower Columbia River steelhead, the Green River in 2000 and the Dungeness River in 2005 to monitor Puget Sound chinook. Funding for the Dungeness Chinook Project was made possible through short-term (one-year) reserves from the Agency General Fund monies. Continuation of this work has relied on funding by the Salmon Recovery Funding Board (SRFB). The SRFB has funded smolt monitoring on the Green River and Cedar Creek since 2002. This annual report describes the smolt monitoring activities that occurred on these three streams during the 2005 field season.

Green River

The Green River screw trap, located 55-km upstream of the mouth, was operated from January 10, earlier than in previous seasons in order to capture the start of the migration, through July 15, 2005. The focus of this project is to estimate the number of naturally-produced Puget Sound chinook originating from this river system. Over this period, 18,579 naturally-produced sub-yearling chinook were captured. As in previous years, the timing distribution of chinook out-migrants were bimodal, with the majority migrating as fry between January and mid-April. The fork lengths measured on captured fry averaged 40-mm. A smaller production component reared upstream of the trap and migrated as smolts from mid-May through the end of the season. Fork lengths measured on these later migrants averaged between 76 and 92-mm.

Thirty-three marked chinook groups were released upstream of the Green River trap to estimate the proportion of downstream migrants captured (trap efficiency). Using these efficiency rates, an estimated 465,531 naturally-produced age 0+ chinook migrated during the trapping period. The 95% confidence interval for this estimate was 393,931 to 537,131 age 0+ migrants.

Accounting for chinook spawning that occurred downstream of the trap and production from Big Soos Creek estimates the total Green River chinook production at 607,000 migrants. Based on the number of parent brood spawners, we estimate the Green River chinook egg-to-migrant survival at 2.2% for the 2004 brood.

A secondary objective for the Green River trapping project is to monitor naturally-produced coho and steelhead smolt production. Over the season, we captured 834 unmarked coho smolts and a total of 260 steelhead smolts. Unknown portions of both species were of hatchery origin, as a large proportion of hatchery coho were released unmarked, indistinguishable from naturally-produced migrants. Also, large numbers of hatchery fish were released during the period when most naturally-produced coho would be migrating past the smolt trap; trapping was suspended for extended periods after these releases to avoid mortalities due to overcrowding in the live box. As a result, we were unable to estimate natural production of coho and steelhead from the basin.

Dungeness River

The Dungeness River screw trap was operated from March 8 through August 5, located just 1.6-km upstream from the mouth of the river. The focus of this project is to monitor annual production of Dungeness chinook, which are part of the Puget Sound Chinook Evolutionarily Significant Unit (ESU). Over the trapping season, we captured a total of 9,323 naturally-produced 0+ chinook migrants. As observed at other study sites, the timing distribution of chinook out-migrants were bimodal, with and early migration as fry in March-April, and the majority migrating as smolts between May and August. Chinook fork lengths averaged less than 40-mm for the fry component, and greater than 80-mm for smolts. The season average fork length was 69.1-mm.

A total of 47 marked chinook groups were released upstream of the trap to measure trap efficiency. These groups were rearranged into 14 strata, based on flow condition, to increase confidence in our estimates. Recapture rates averaged 14.5% for the combined groups and ranged from 9.8% to 28.6%. There was no apparent relationship between trap efficiency and flow.

Over the season, we estimated 69,881 naturally-produced 0+ chinook migrated past the trap, with a 95% confidence interval of 66,754 to 73,007 chinook. Because the fry migration was well underway when trapping began, we selected a migration start date of February 15. Extrapolating the migration back to this date estimates an additional 2,232 chinook fry would have migrated before trapping began. Total production in 2005 is estimated at 72,113 naturally-produced 0+ chinook.

In addition, this project also monitors naturally-produced coho, chum and steelhead smolt production. We captured a total of 3,136 coho smolts, which includes 432 of the total 7,880 naturally-produced fin-clipped coho released by the Jamestown S'Klallam Tribe from their weir on Matriotti Creek, a tributary to the Dungeness River. We used these marked fish as the basis of our capture efficiency estimates. The resulting catch estimates the coho capture rate at 5.5%, assuming all of the marked Matriotti coho survived to pass the screw trap. Applying this efficiency to the catch results in a production estimate of 57,096 smolts, with a 95% confidence interval of 52,242 to 61,950 smolts.

We captured a total of 329 naturally-produced steelhead smolts and 587 steelhead parr, and 365 out of the 9,825 ad-marked hatchery steelhead released from the Dungeness Hatchery. Using the proportion of hatchery fish caught to estimate the steelhead capture rate (4.5%), we estimate natural-production at 9,192 smolts.

The chum migration was already underway when trapping began. We captured a total of 49,227 chum fry over the season, with an estimated missed catch of 1,669 fry. Weekly mean sizes ranged from 33-mm to 55-mm over the season, and averaged 38.4-mm. Trap efficiency for chum averaged 11.0%, resulting in a production estimate of 484,525 fry, with a 95% confidence interval of 420,220 to 548,829 fry. In addition, we estimated 13,952 chum fry migrated before trapping began, for a total basin production estimate of 498,477

Cedar Creek

The Cedar Creek screw trap was operated from March 11 through June 26, 2005. Located 4.0 km 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 1,080 steelhead trout pre-smolts and smolts were captured. Steelhead smolt fork lengths averaged 176.2-mm, with a declining trend in weekly mean sizes observed (188-mm to 156-mm) over the season. A total of 635 steelhead trout were marked by fin coloration using a Panjet inoculator and were released upstream of the trap to assess trap efficiency. Mark placement changed weekly, with 12 mark groups released. A total of 2,374 $\pm$ 420 (95% CI) steelhead trout were estimated to have migrated past the Cedar Creek trap using a pooled Peterson estimate.

In addition to steelhead, 58,921 $\pm$ 3,081 (95% CI) naturally-produced coho smolts, 9,151 $\pm$ 1,785 (95% CI) RSI-produced coho, and 5,085 $\pm$ 1,064 (95% CI) cutthroat trout were estimated to have migrated past the trap. The trap also captured a total of 15,032 chinook fry, 135 cutthroat, 73 rainbow/steelhead, and 62 coho parr over the season.

1 Introduction

Declining salmon populations in the 1980s and 1990s 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 freshwater salmon 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 River steelhead, Green River (2000) and Dungeness River (2005) to monitor Puget Sound chinook. Funding from the legislature originally established monitoring on the Green River and Cedar Creek.

The legislature requested that the Washington Salmon Recovery Funding Board (SRFB) consider funding smolt monitoring in Spring 2002. The SRFB has subsequently funded smolt monitoring on the Green River and Cedar Creek beginning in 2001/2002. Monitoring on the Dungeness River began in 2005, using short-term one-year reserves from State General Fund monies. This report describes the smolt monitoring activities that occurred during the 2005 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

2005 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 and steelhead. The trap was located at river kilometer (rkm) 55; approximately 975-m upstream of the Highway-18 bridge, on the left bank (Figure 2 - 1). This trap is fully described in Seiler *et al*. 2002.

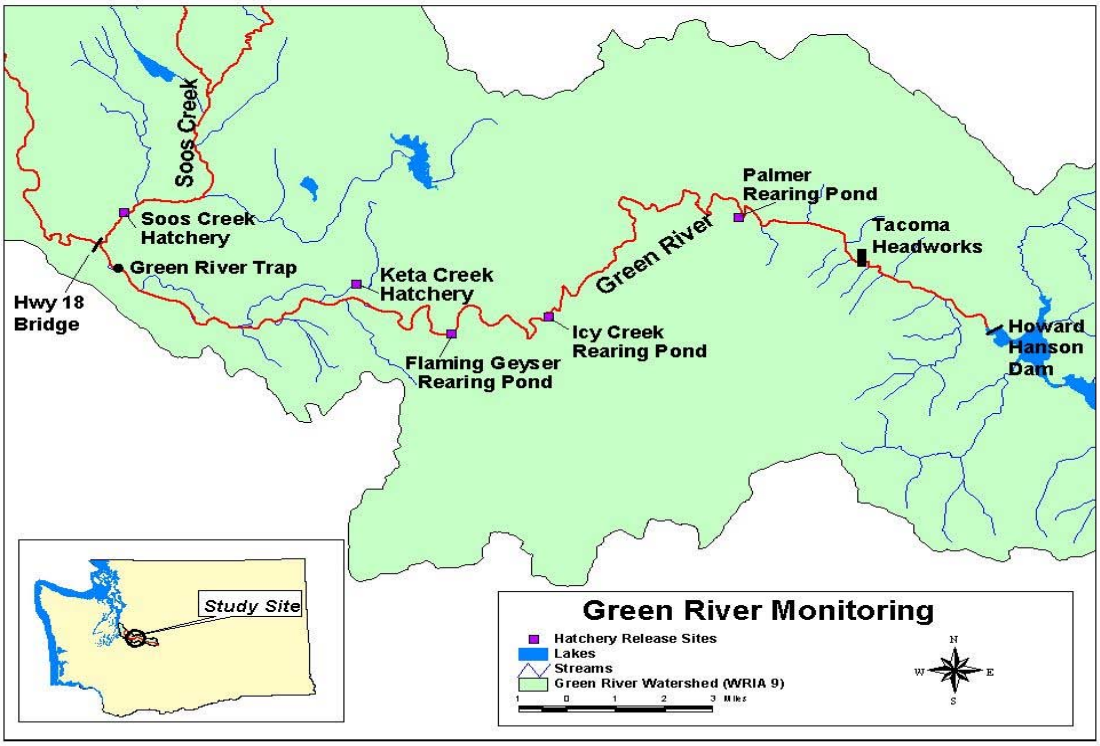

Figure 2 - 1. Map of the Green River screw trap location, relative to hatcheries and hydro projects, Middle Green River, 2005.

The Green River trap was installed and operation began on January 10, earlier than in any previous year, in order to capture a larger proportion of early-migrating chinook fry. The trap was operated until July 15, and fished continuously except for periods when debris, mechanical failure, or large numbers of hatchery fish released above our trap caused the cessation of trapping. Trap operations were 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 identified to species and enumerated. Fork length measurements were taken from a sample of the various naturally-produced salmonids captured. In addition, chinook and coho were checked for coded-wire tags (CWTs).

In order to estimate migration, groups of chinook were used to test the capture efficiency of the trap. Fish used for trap efficiency testing were anesthetized with tricaine methanesulfonate (MS-222), and marked with either Bismarck-brown dye, or with a partial caudle fin-clip. Marked fish were allowed to recover in fresh water before being placed in buckets, transported upstream, and released upstream of the trap. Capture rates were estimated by the proportion of marked fish recaptured in the trap after release.

2.1.2 Production Estimate

Estimating naturally-produced juvenile salmon production from the Green River was done in two steps. Because the trap did not operate continuously over the entire trapping period, the first step involved estimating or interpolating catch for each species for periods when the trap did not fish. The second step involved estimating the capture rate or trap efficiency.

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 fishing periods within the same diel stratum, and then expanding by the hours not fished.

Equation 2 - 1

$$\hat{R}_{fj} = \frac{C_{fj}}{T_{fj}}$$

where:

$$R_{fj} = \textit{the catch rate during fishing period } f \textit{ in diel stratum } j,$$
$$C_{fj} = \textit{catch during fishing period } f \textit{ in diel stratum } j, \textit{and}$$
$$T_{fj} = \textit{the duration of fishing period } f \textit{ in diel stratum } j.$$

The variance of the interpolated catch rate was estimated by:

Equation 2 - 2

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

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:

Equation 2 - 3

$$V\left(\hat{C}\right) = V\left(\overline{R}_{fj}\right)\hat{T}^2$$

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 groups using:

Equation 2 - 4

$$\hat{e}_i = \frac{m_i}{M_i}$$

where;

$\hat{e}_i$ = *the capture rate estimated for trap efficiency period i,*
m_i = *the number of marked or dyed migrants captured in trap efficiency period i, and*
M_i = *the number of marked or dyed migrants released in trap efficiency period i.*

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

Equation 2 - 5

$$V(\hat{e}_i) = \frac{\hat{e}_i(1-\hat{e}_i)}{M_i}$$

We conducted trap efficiency tests regularly throughout the season. For groups containing only a few individuals, we combined consecutive mark-release groups to form efficiency strata. Migration for each stratum was estimated using the following (Carlson *et al* 1998):

Equation 2 - 6

$$\hat{U}_i = \frac{u_i(M_i+1)}{m_i+1}$$

where;

U_i = *the number of unmarked fish migrating during period i, and*
u_i = *the number of unmarked fish captured during period i,*

The variance of the migration estimate was calculated using:

Equation 2 - 7

$$V(\hat{U}) = \frac{(M_i+1)(u_i+m_i+1)(M_i-m_i)u_i}{(M_i+1)^2(M_i+2)}$$

Daily migration was estimated by applying the proportion of the expanded daily catch over the estimated catch for the stratum to the migration estimate, $\hat{U}_i$.

The total season migration and variance was estimated by the sum of the estimated migrations and variance corresponding to efficiency strata.

2.2 Results

Estimating the production of naturally-produced chinook 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 2005. All the release sites with the exception of Soos Creek are located upstream of our trap site. Soos Creek enters the Green River approximately 0.8km downstream of our trap site, and a few individuals from these releases have contributed to our catches in previous years.

Table 2 - 1. Hatchery releases that could have contributed to catches in the Green River screw trap in 2005.

Species	Release		Brood Year	CWT Only	CWT Ad-mark	Ad-mark Only	Ad-mark LV	Unmarked
	Date(s)	Location						
2004 Releases Above Howard Hanson Dam								
Coho	3/31-4/2	Howard Hanson Dam	2003					497,726
Chinook	3/17-3/24	Howard Hanson Dam	2003			496,637		
2005 Releases								
Chinook	3/11-3/26	Howard Hanson Dam	2004			570,181		
	5/3-5/13	Icy Creek	2003		78,585	202,078		
	5/21-6/2	Soos Creek	2004	205,089	205,190	3,013,000		
Coho	3/23-3/26	Howard Hanson Dam	2004					546,450
	5/3-5/10	Keta Creek	2003		14,550			225,000
	4/08-4/15	Soos Creek	2003	45,500	45,500	694,100		
Steelhead	5/1	Soos Creek Winter	2003			34,500	46,000	
	5/1	Soos Creek Summer	2003			34,500		
	5/1-5/10	Palmer Winter	2003			190,918		
	5/1-5/10	Palmer Summer	2003			89,843		
	5/3-5/13	Icy Creek	2003			33,120		
Chum	3/22-4/29	Keta Creek	2004					2,415,550

2.2.1 Chinook

2.2.1.1 **Catch**

Over the 186-day season, we captured 18,579 unmarked and 57 adipose fin-clipped (ad-marked) 0+ chinook migrants (**Appendix A 1**). All hatchery 0+ chinook releases were ad-marked and/or coded-wire tagged (CWT'd); because no unmarked CWT chinook were captured, the unmarked fish captured represent naturally-produced fish. Daily catches of unmarked 0+ chinook averaged under nine fry/day through the first week of trapping. On January 17, a large storm increased the river discharge and debris loads, which suspended trapping for a period of 103 hours. We caught 263 chinook the first night the trap resumed fishing. Catches quickly declined over the following week as river flows decreased, to a daily average of 50 chinook. From this point through early March chinook catches gradually increased and peaked on March 11, with a catch of 1,011 chinook. Daily chinook catches quickly decreased to an average of 6 fish/day through most of April and early May. The smolt migration after April 15 slowly increased during May, and peaked in the third week, with peak catches of 106 and 104 zero-age chinook on May 19 and 23. Catches gradually declined from this point through the end of the trapping season.

We captured a total of 57 ad-marked 0+ chinook throughout the trapping season. Ad-marked 0+ chinook first entered catches on March 23, with 1 fish caught. We captured the last 0+ chinook on July 10. Daily catches ranged from 0 to 5 ad-marked 0+ chinook.

Over the season, we also caught 47 hatchery ad-marked/coded-wire tagged, 1+ chinook migrants. Ad-marked 1+ chinook were first caught on May 6, the reported date of the first release of marked hatchery yearlings from the Icy Creek facility. Seventy- eight percent of the catch occurred within the first six days following the release. The last hatchery 1+ chinook captured for the season occurred on the night of July 13.

2.2.1.2 Size

Naturally-produced chinook 0+ averaged 40-mm or less through the first four weeks of trapping. Starting in the middle of March and continuing through the end of the trapping season the naturally-produced chinook fry grew rapidly averaging 3.2-mm of growth per week, and by the second week of July averaged over 92-mm (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 72-mm at the end of the trapping period. We speculated that 40-mm and smaller chinook were newly emerged fry; therefore, we believe that the increase in the minimum size was an indication that incubation was completed.

Table 2 - 2. Mean fork length (mm) standard deviation, and sample size of naturally-produced 0+ chinook measured, by statistical week, Green River 2005.

Statistical Week			Average	s.d.	Range		Number		Percent
No.	Begin	End			Min	Max	Sampled	Captured	Sample
3	01/10/05	01/16/05	39.1	1.10	37	40	10	37	27.0%
4	01/17/05	01/23/05	39.1	1.07	37	41	20	819	2.4%
5	01/24/05	01/30/05	40.3	2.21	36	44	13	316	4.1%
6	01/31/05	02/06/05	39.3	1.21	37	42	20	1,406	1.4%
7	02/07/05	02/13/05	----	----	----	----	0	908	0.0%
8	02/14/05	02/20/05	41.0	2.12	37	48	89	1,820	4.9%
9	02/21/05	02/27/05	41.2	1.71	38	49	164	1,391	11.8%
10	02/28/05	03/06/05	40.9	1.71	38	48	87	1,503	5.8%
11	03/07/05	03/13/05	41.4	2.66	38	54	222	4,856	4.6%
12	03/14/05	03/20/05	41.1	2.19	37	55	187	1,536	12.2%
13	03/21/05	03/27/05	43.3	3.85	38	56	98	1,566	6.3%
14	03/28/05	04/03/05	47.1	5.74	38	70	122	344	35.5%
15	04/04/05	04/10/05	48.7	6.60	39	59	21	45	46.7%
16	04/11/05	04/17/05	53.6	7.31	39	67	17	55	30.9%
17	04/18/05	04/24/05	58.2	7.92	45	71	14	15	93.3%
18	04/25/05	05/01/05	62.0	8.17	41	74	22	34	64.7%
19	05/02/05	05/08/05	63.5	9.19	50	81	25	27	92.6%
20	05/09/05	05/15/05	73.8	9.48	55	96	70	123	56.9%
21	05/16/05	05/22/05	76.7	9.10	49	91	71	530	13.4%
22	05/23/05	05/29/05	85.1	7.60	66	102	62	309	20.1%
23	05/30/05	06/05/05	81.7	9.97	57	98	59	276	21.4%
24	06/06/05	06/12/05	84.5	10.89	55	104	21	186	11.3%
25	06/13/05	06/19/05	86.9	6.05	72	97	43	175	24.6%
26	06/20/05	06/26/05	92.2	6.87	76	104	13	128	10.2%
27	06/27/05	07/03/05	90.6	5.74	75	97	15	106	14.2%
28	07/04/05	07/10/05	92.2	8.42	74	104	13	41	31.7%
29	07/11/05	07/17/05	----	----	----	----	0	27	0.0%
Season Total			**52.7**	**18.11**	**36**	**104**	**1,498**	**18,579**	**8.1%**

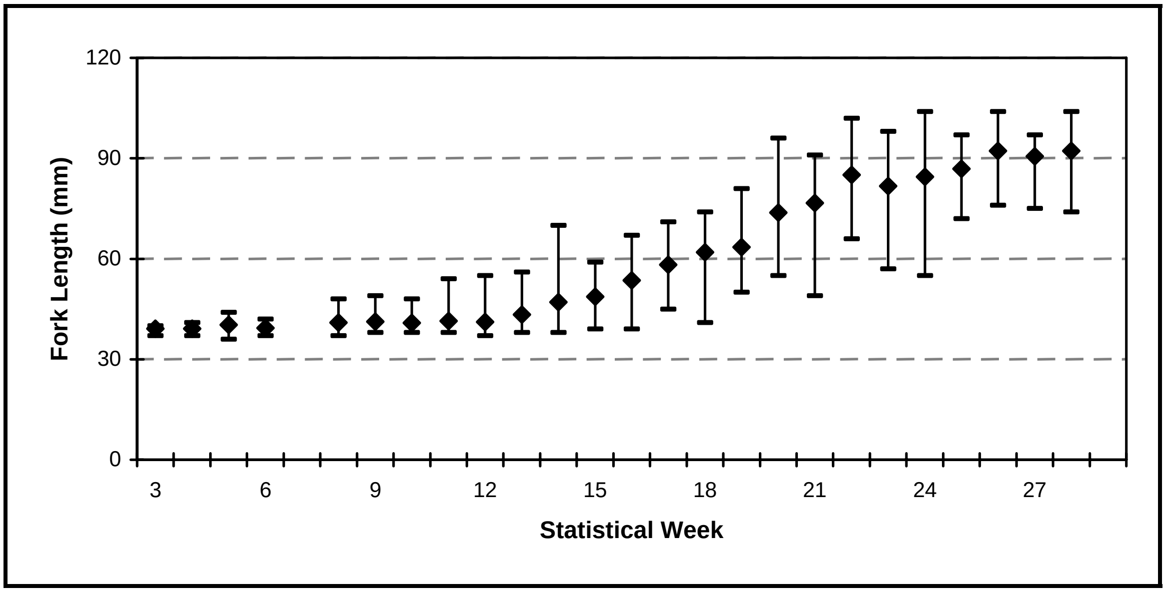

Figure 2 - 2. Range of 0+ chinook fork lengths (mm) measured at the Green River screw trap, by week, in 2005.

2.2.1.3 Catch Expansion

The trap was operated 4,033.0 hours out of 4,460.5 possible hours in the 186-day trapping period, or 90.4% of the time. The trap was removed from fishing only once during the season for high flows and heavy debris for a total of 103 hours. Using linear interpolations, we estimated we would have captured 1,394 chinook had we been able to fish. In May, trapping was suspended for six nighttime periods (66 hours) to avoid large numbers of hatchery fish migrating downstream. We estimated we would have captured 24 chinook during these outages. Trapping was suspended for a three-day period on the Fourth of July weekend, during which we estimated we would have caught 36 chinook. The trap was pulled during daylight hours beginning on June 20. Trapping was suspended for a total of 173.4 hours during the daytime when recreational use of the river was high and few fish were caught. By interpolating between the daylight periods sampled each week, we estimate that we would have captured ten additional naturally-produced chinook during those intervals.

Trapping was interrupted by debris four times during the season for a total of 4.1 hours, with all but 12 minutes occurring during the day when catch rates are low. We estimated we would have captured 2 chinook had the trap not stopped fishing during these intervals. 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.

In total we estimate we would have captured an additional 1,466 naturally-produced chinook had we fished the entire time. Addition of these estimated fish to our actual catch, results in a total of 20,045 naturally-produced chinook captured if we had trapped continuously from January 10 and July 15 (Appendix A 1). This represents a 7.9% increase over the actual catch of naturally-produced migrants. We estimated an additional 8 hatchery 0+ chinook, a 10.4% increase over the actual catch. Very few fish were caught at the beginning and end of the trapping season, indicating that we sampled the entire migration. Thus, we did not estimate any migration before and after the trapping period.

Throughout the trapping season, catch expansion for period not fished resulted in the addition of 103 ad-marked hatchery yearling chinook to the actual catch of 47 yearlings. No naturally-produced 1+ chinook were captured over the entire trapping season.

2.2.1.4 Trap Efficiency

A total of 6,813 naturally-produced 0+ chinook migrants in 33 groups were marked and released 150-meters upstream of the trap. The number of fish released in each group ranged from 26 to 736 chinook. Recapture rates for these 33 groups averaged 4.54%, for the season, and ranged from 0.0% to 12.8%. Flows ranged from 8.2 to 50.4 cubic meters per second (cms) during the chinook trap efficiency tests. There was no apparent relationship between flow and efficiency. The releases were combined into 15 efficiency strata in order to achieve at least five to ten recoveries in each stratum; recapture rates for these strata ranged from 1.7% to 12.1%, and averaged 5.14%. From the start of the season through June 8, the chinook used for the efficiency groups were marked with Bismarck Brown dye. From June 9 through the end of the season, we used a partial caudal fin-clip. Because of the low chinook catches, we fin-marked nearly all the unmarked chinook captured after June 9, and released them above the trap the same day they were captured. The caudal mark was changed every few days to facilitate stratification.

Table 2 - 3. Zero-age chinook trap efficiency strata for the Green River screw trap, 2005.

Test Dates		Number		Percent	Flow
Start	**End**	**Released**	**Recovered**	**Recovered**	**(cfs)**
01/27/05	02/06/05	515	19	3.69%	1,383
02/07/05	02/11/05	688	37	5.38%	968
02/12/05	02/15/05	528	14	2.65%	743
02/16/05	03/02/05	1,541	69	4.48%	563
03/03/05	03/05/05	445	24	5.39%	464
03/06/05	03/07/05	191	15	7.85%	407
03/08/05	03/09/05	406	11	2.71%	389
03/10/05	03/18/05	462	22	4.76%	496
03/19/05	03/24/05	300	25	8.33%	319
03/25/05	03/26/05	83	10	12.05%	289
03/27/05	03/30/05	598	10	1.67%	1,072
05/21/05	05/26/05	319	22	6.90%	1,150
05/31/05	06/08/05	180	7	3.89%	731
06/09/05	06/27/05	395	12	3.04%	790
06/28/05	07/14/05	162	7	4.32%	528
Season Total		**6,813**	**304**	**5.14%**	

2.2.1.5 Production Estimate

We estimated 491,048 naturally-produced 0+ chinook migrants passed the screw trap between January 10 through July 15, with a coefficient of variation of 7.93% and 95% confidence interval of 414,711 to 567,386 fish (Appendix A 1, Appendix A 2 and Figure 2 - 3). We believe this estimate represents the entire migration because of the early start to the season, and the small catches seen at the start and end of the season. In addition to the naturally-produced fish, we estimate 1,919 ad-marked hatchery 0+ chinook migrated during the January 10 through July 15 trapping period (Appendix A 1).

No unmarked yearling chinook were captured during the 2005 trapping season. In total 47 ad-marked yearling chinook were caught; all of these fish were captured after the reported release date from Icy Creek. Because of the large amount of missed fishing time during the peak of the migration, no estimate was made for the number of fish that passed the trap.

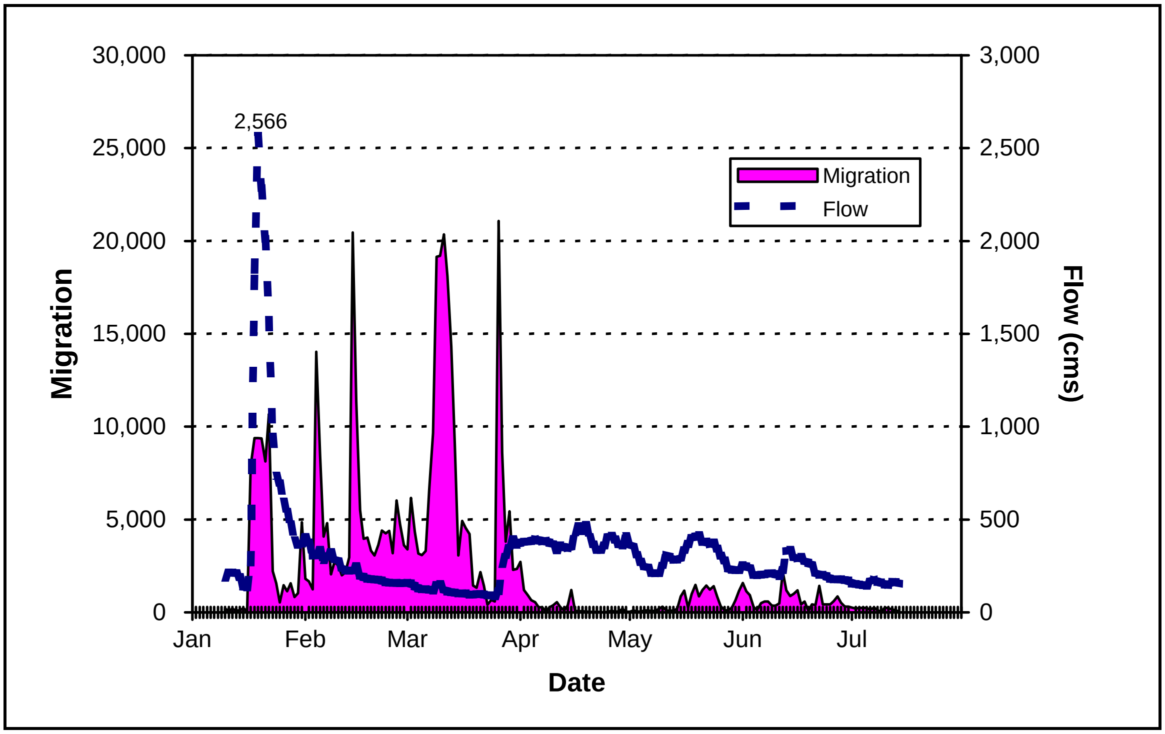

Figure 2 - 3. Daily migration of naturally-produced age 0+ chinook in the Green River screw trap, relative to stream discharge at USGS gage# 1211300, January 10 through July 15, 2005.

2.2.2 Coho

2.2.2.1 Catch

We began capturing coho pre-smolts/smolts on the first night of trapping. Catch rates were low, generally less than 3 fish/day through early May, when Keta Creek released their unmarked hatchery coho. The only exception occurred in January, when we had two days where we captured 27 and 28 yearlings, and several other days with catches in the teens. The total estimated catch in January was 225 unmarked naturally-produced yearlings. The probable explanation for this winter movement of yearling coho is the increased flow during January, which likely caused in-basin movement prior to smoltification. Prior to the Keta Creek Hatchery release of 239,550 unmarked coho smolts in early May, there were only minor increases in the daily catch of unmarked coho. For the season we captured 900 (834 unmarked, 58 ad-marked, and 8 ad-marked/coded-wire tagged) coho pre-smolts/smolts.

Ad-marked hatchery coho yearlings appeared in the catch early in the season. The first individual was captured on the night of January 15, well before any planned releases of hatchery fish. Hatchery smolt yearlings continued sporadically through the early part of the season, and by April 20, the date Soos Creek Hatchery fish were released, we had already captured 17 admk-only coho. All of the ad-marked fish released from Keta Creek contained coded-wire tags

(CWTs), and therefore these fish had likely escaped from Soos Creek Hatchery. Over the entire season, we captured 58 admk-only coho.

The total coho production from the Green River was not estimated in 2005. Factors contributing to this decision include:

1) Suspension of nightly trapping for six nights between May 2 and May 9 during peak migration period for naturally-produced smolts;
2) The presence of large numbers of unmarked hatchery fish in the catch; and
3) No directed trap efficiency tests were conducted for coho.

2.2.2.2 Size

Weekly average fork lengths for unmarked naturally-produced coho ranged from between 85.5-mm to 138-mm over the trapping season (Table 2 - 4, Figure 2 - 4). The individual smolts ranged in size from 73-mm to 157-mm over the trapping season, and averaged 106.8 mm.

Table 2 - 4. Mean fork length (mm) standard deviation, and sample size of naturally-produced coho smolts measured, by statistical week, Green River 2005.

Statistical Week			Average	s.d.	Range		Number		Percent
No.	Begin	End			Min	Max	Sampled	Captured	Sample
3	01/10/05	01/16/05	85.6	7.70	73	96	11	35	31.4%
4	01/17/05	01/23/05	92.0	8.70	75	103	8	54	14.8%
5	01/24/05	01/30/05	95.5	4.32	87	98	6	73	8.2%
6	01/31/05	02/06/05	94.3	1.15	93	95	3	30	10.0%
7	02/07/05	02/13/05	----	----	----	----	0	13	0.0%
8	02/14/05	02/20/05	88.3	5.69	82	93	3	5	60.0%
9	02/21/05	02/27/05	85.5	14.85	75	96	2	2	100.0%
10	02/28/05	03/06/05	----	----	----	----	0	0	0.0%
11	03/07/05	03/13/05	92.0	----	92	95	1	4	25.0%
12	03/14/05	03/20/05	87.0	----	87	87	1	1	100.0%
13	03/21/05	03/27/05	90.8	6.72	82	98	5	8	62.5%
14	03/28/05	04/03/05	88.0	7.07	83	93	2	3	66.7%
15	04/04/05	04/10/05	97.5	13.10	89	117	4	5	80.0%
16	04/11/05	04/17/05	95.6	6.43	85	103	7	10	70.0%
17	04/18/05	04/24/05	107.2	10.22	87	126	18	25	72.0%
18	04/25/05	05/01/05	112.7	9.92	98	132	17	40	42.5%
19	05/02/05	05/08/05	117.9	12.68	98	150	17	191	8.9%
20	05/09/05	05/15/05	102.8	12.54	87	128	12	115	10.4%
21	05/16/05	05/22/05	113.7	9.77	94	135	40	135	29.6%
22	05/23/05	05/29/05	116.3	11.58	98	135	20	70	28.6%
23	05/30/05	06/05/05	117.7	14.07	98	131	6	6	100.0%
24	06/06/05	06/12/05	138.0	----	138	138	1	3	33.3%
25	06/13/05	06/19/05	129.0	39.60	101	157	2	3	66.7%
26	06/20/05	06/26/05	101.0	----	101	101	1	0	0.0%
27	06/27/05	07/03/05	97.0	----	97	97	1	1	100.0%
28	07/04/05	07/10/05	103.0	1.41	102	104	2	2	100.0%
29	07/11/05	07/17/05	----	----	----	----	0	0	0.0%
Season Total			**106.8**	**14.93**	**73**	**157**	**190**	**834**	**22.8%**

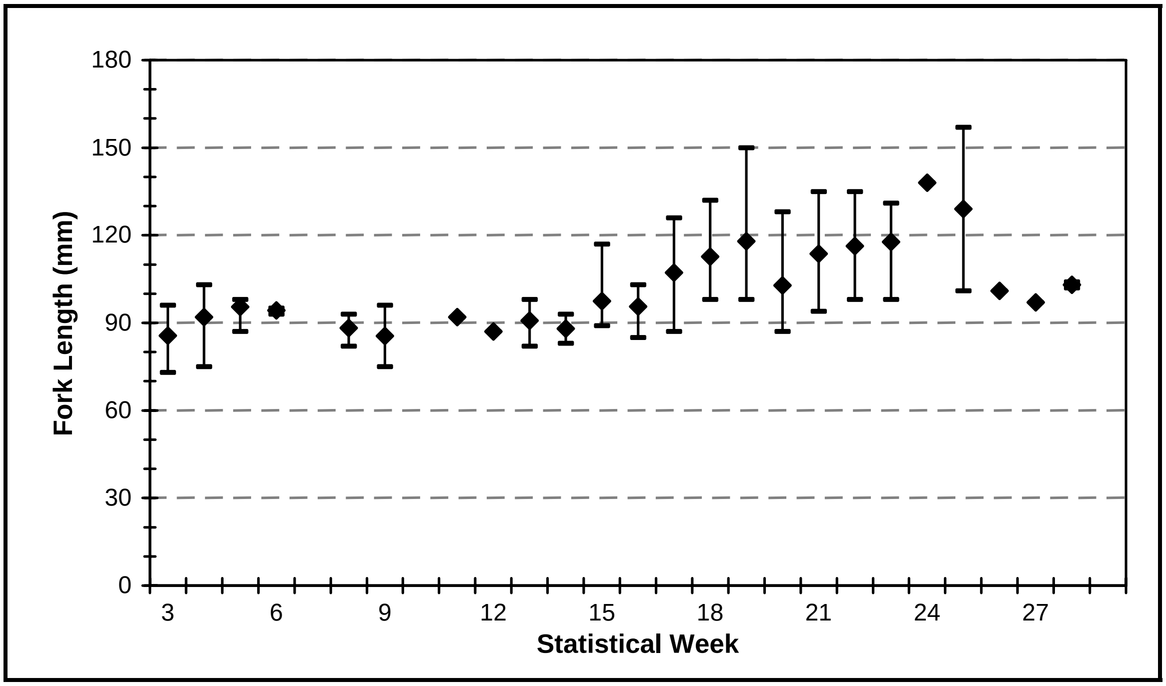

Figure 2 - 4. Range of unmarked coho smolt fork lengths (mm) measured at the Green River screw trap, by week, in 2005.

2.2.3 2.2.3 Steelhead

2.2.3.1 Catch

Over the trapping period, we caught 260 steelhead (181 ad-marked, 79 unmarked). We captured 50 unmarked naturally-produced steelhead in January, 63% of the seasons total. This early movement was likely due to the high flow event (8,400 cfs) on January 19. However, we have observed similar migration patterns during previous years of this study, and this may be a regular part of their migration. Daily catches of naturally-produced pre-smolts/smolts declined to nearly zero in February, and remained low through the remainder of the season. The exception occurred in May, when we captured a total of 19 unmarked naturally-produced smolts, with a one -day peak catch of 4 unmarked smolts on May 17. The last unmarked steelhead smolt was captured on May 31.

The total steelhead production from the Green River was not estimated in 2005. Factors contributing to this decision include:

1) Suspension of nightly trapping for six nights, between May 2 and May 9, during peak migration period for naturally-produced smolts; and
2) No directed trap efficiency tests were conducted for steelhead.

2.2.3.2 Size

We measured a total of 29 unmarked steelhead (fork length) during the trapping season, 37% of the total catch. Individuals ranged from 120 to 195 mm, and averaged 153.3 mm for the season (Figure 2 - 5).

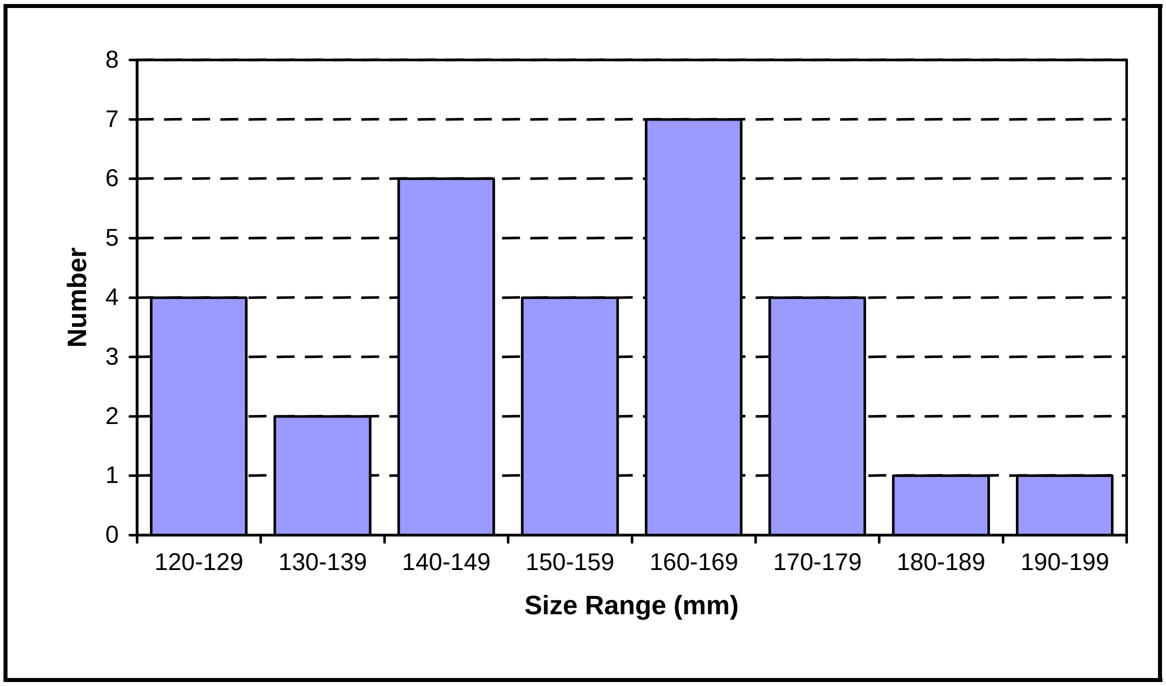

Figure 2 - 5. Length frequency of unmarked steelhead smolt fork lengths (mm) measured at the Green River screw trap, 2005.

2.2.4 Other Species

We caught and enumerated a number of other salmonid age classes, as well as other fish species. Over the trapping period, our fry catches totaled 43,087 chum, 13 pink, 2 sockeye and 1,402 coho. We also captured 72 steelhead parr, and 5 cutthroat smolts. Non-salmonid species captured included sculpin (*Cottus* spp.), three-spine sticklebacks (*Gasterosteus aculeatus*), longnose dace (*Rhynichthys cataractae*), and lamprey ammocoetes.

2.3 Discussion

We developed estimates of migration past the trap for Green River naturally-produced and hatchery 0+ chinook. A number of assumptions used to develop these estimates are discussed below. In addition, the estimates for naturally-produced chinook migrants are expanded to represent total basin production. The coho and steelhead smolt catches during the trapping season provide valuable information on migration timing and relative abundance for these species. While our inability to estimate production for coho and steelhead smolts was disappointing, we were able to successfully accomplish our primary objective: to monitor the natural production of listed Puget Sound chinook emigrating from the Green River.

2.3.1 Chinook

The accuracy of the naturally-produced 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. The accuracy is also dependent on the accuracy of capture efficiency estimates. One week after the trapping season began, river flows increased ten-fold, from around 800 cfs to around 8,400 cfs. During this high-flow event, we could not safely operate the trap for a period of 103 hours. Catches prior to this outage averaged 5 fish/day, and averaged 365 fish/day for the first two days after the trapping resumed. Therefore, to estimate missed catch during the period when we were not operating the trap, we used the catch rate for the two-day period following the outage. This was the best available data to estimate fish movement during this period, but it likely underestimates the true migration that occurred during the peak of the high-water event.

Egg-to-migrant survival is a measure of freshwater productivity for naturally-reared salmon. The estimated migration of 465,531 naturally-produced 0+ chinook migrants divided by the estimated egg deposition above the trap site of 21,460,500 eggs, results in an egg-to-migrant survival of 2.2%. The estimated egg deposition was derived by multiplying the 4,769 estimated number of chinook redds above the trap site (T. Cropp pers. comm.) by an estimated chinook fecundity of 4,500 eggs/ female.

The naturally-produced age 0+ chinook production estimate made at the Green River trap site only represents the production that occurred upstream of the trap. An additional 827 redds were estimated for the main river downstream of the trap. Assuming the same egg-to-migrant survival, we estimated the total Green River production downstream of the trap at 80,729 naturally-produced chinook. A total of 623 female chinook spawners were passed above the weir on Big Soos Creek; assuming they all spawned and had similar egg-to-migrant survival, we estimate 60,815 0+ chinook were produced from Soos Creek. This results in a total basin production estimate of 607,074 naturally-produced 0+ chinook migrants.

The naturally-produced 0+ chinook migration for the Green River assumed a bi-modal timing distribution. The earliest component, composed of newly emerged chinook fry, migrated past the trap from January through mid April, and peaked in the second week of March. This was followed by a smolt component that migrated from mid April through June, and peaked in late

May/early June. The fry component in 2005 made up 91% of the production above the Green River trap. High river flows early in the trapping season may have transported more fry downstream past the trap site than would have had the flows remained moderate.

2.3.2 Recommendations

For the past three years, the majority of the hatchery coho smolts released from Keta Creek Hatchery have been unmarked. This makes it impossible to differentiate between the hatchery and natural-origin coho smolts captured in the trap. For this reason, we have chosen to remove the trap from fishing for several days during the peak of the hatchery smolt migration. Beginning in 2006, the hatchery coho smolts released from Keta Creek will be mass-marked with an adipose fin-clip, justifying continuous trapping through the hatchery releases. This will enable us to distinguish between the hatchery and natural-origin migrants and make a wild coho production estimate possible.

2.4 References

2.4.1 Literature Cited

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2.4.2 Personal Communications

Cropp, Tom. WDFW - District Fish & Wildlife Biologist. 2-15

2.5 Appendix A

Daily Actual and Estimated Catches and Migration Estimates
for Age 0+ Chinook Migrants, Green River 2005

Appendix A 1. Daily actual and estimated catches and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2005.

Period	Date Down	Wild				Hatchery			
		Actual	Estimated	Total	Migration	Actual	Estimated	Total	Migration
Period 1	01/10/05	7		7	189				
	01/11/05	4		4	108				
	01/12/05	7		7	189				
	01/13/05	4		4	108				
	01/14/05	4		4	108				
	01/15/05	9		9	243				
	01/16/05	2	1	3	81				
	01/17/05	4	302	306	8,259				
	01/18/05		364	364	9,824				
	01/19/05		364	364	9,824				
	01/20/05		363	363	9,797				
	01/21/05	315		315	8,502				
	01/22/05	414		414	11,174				
	01/23/05	86		86	2,321				
	01/24/05	61		61	1,646				
	01/25/05	21		21	567				
	01/26/05	57		57	1,538				
	01/27/05	44		44	1,188				
	01/28/05	61		61	1,646				
	01/29/05	32		32	864				
	01/30/05	40		40	1,080				
	01/31/05	188		188	5,074				
	02/01/05	70		70	1,889				
	02/02/05	65		65	1,754				
	02/03/05	48		48	1,295				
	02/04/05	544		544	14,682				
	02/05/05	328		328	8,852				
	02/06/05	163		163	4,399				
Period 2	02/07/05	265		265	4,940				
	02/08/05	113		113	2,107				
	02/09/05	150		150	2,797				
	02/10/05	139		139	2,591				
	02/11/05	96		96	1,790				
Period 3	02/12/05	61		61	2,251				
	02/13/05	84		84	3,099				
	02/14/05	580		580	21,401				
	02/15/05	337		337	12,434				
Period 4	02/16/05	250		250	5,553				
	02/17/05	180		180	3,998				
	02/18/05	183		183	4,064				
	02/19/05	151		151	3,354				
	02/20/05	139		139	3,087				
	02/21/05	165		165	3,665				
	02/22/05	200		200	4,442				
	02/23/05	193		193	4,287				
	02/24/05	199		199	4,420				
	02/25/05	145		145	3,220				
	02/26/05	274		274	6,086				
	02/27/05	215		215	4,775				
	02/28/05	164		164	3,642				

Table continued next page

Appendix A.1. Daily actual and estimated catches and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2005 (cont'd)

Period	Date Down	Wild				Hatchery			
		Actual	Est'd	Total	Migration	Actual	Est'd	Total	Migration
Per. 4 cont	03/01/05	154		154	3,420				
	03/02/05	290		290	6,441				
Period 5	03/03/05	243		243	4,324				
	03/04/05	178		178	3,167				
	03/05/05	199		199	3,541				
Per. 6	03/06/05	275		275	3,454				
	03/07/05	391		391	4,911				
Per. 7	03/08/05	285		285	10,389				
	03/09/05	605		605	22,054				
Period 8	03/10/05	954		954	20,289				
	03/11/05	1,011		1,011	21,501				
	03/12/05	899		899	19,119				
	03/13/05	711		711	15,121				
	03/14/05	448		448	9,528				
	03/15/05	152		152	3,233				
	03/16/05	245		245	5,210				
	03/17/05	226		226	4,806				
	03/18/05	225		225	4,785				
Period 9	03/19/05	125		125	1,462				
	03/20/05	115		115	1,345				
	03/21/05	187		187	2,186				
	03/22/05	124		124	1,450				
	03/23/05	36		36	421	1		1	12
	03/24/05	76		76	889				
Per. 10	03/25/05	77		77	478				
	03/26/05	908		908	5,639				
Period 11	03/27/05	158		158	14,260				
	03/28/05	70		70	6,318				
	03/29/05	100		100	9,025	2		2	120
	03/30/05	42		42	3,791	1		1	60
	03/31/05	43		43	3,881	2		2	120
	04/01/05	50		50	4,513	1		1	60
	04/02/05	22		22	1,986	1		1	60
	04/03/05	17		17	1,534	2		2	120
	04/04/05	12		12	1,083	2		2	120
	04/05/05	10		10	903	2		2	120
	04/06/05	5		5	451				
	04/07/05	5		5	451				
	04/08/05	1		1	90				
	04/09/05	5		5	451	2		2	120
	04/10/05	7		7	632				
	04/11/05	10		10	903				
	04/12/05	5		5	451	2		2	120
	04/13/05	2		2	181				
	04/14/05	7		7	632				
	04/15/05	21	1	22	1,986	2		2	120

Table continued next page

Appendix A.1. Daily actual and estimated catches and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2005 (cont'd)

Period	Date Down	Wild				Hatchery			
		Actual	Est'd	Total	Migration	Actual	Est'd	Total	Migration
Period 12	04/16/05	5		5	72	4		4	58
	04/17/05	5		5	72				
	04/18/05	4		4	58	2		2	29
	04/19/05	4		4	58				
	04/20/05	3		3	43				
	04/21/05	1		1	14				
	04/22/05	2		2	29				
	04/23/05	1		1	14				
	04/24/05	0		0	0				
	04/25/05	2		2	29	3		3	44
	04/26/05	6		6	87	1		1	15
	04/27/05	2		2	29	1		1	15
	04/28/05	4		4	58				
	04/29/05	14		14	203	5		5	73
	04/30/05	3		3	43				
	05/01/05	3		3	43				
	05/02/05	4	3	7	101		1	1	15
	05/03/05	1	3	4	58		1	1	15
	05/04/05	0	3	3	43	1	1	2	29
	05/05/05	5	3	8	116		1	1	15
	05/06/05	6	2	8	116		1	1	15
	05/07/05	5		5	72	2		2	29
	05/08/05	6		6	87	1		1	15
	05/09/05	4	10	14	203	2	1	3	44
	05/10/05	22		22	319				
	05/11/05	8		8	116				
	05/12/05	6		6	87				
	05/13/05	7		7	101				
	05/14/05	14		14	203				
	05/15/05	62		62	898				
	05/16/05	84		84	1,217				
	05/17/05	18	1	19	275				
	05/18/05	70		70	1,014				
	05/19/05	106		106	1,536				
	05/20/05	62		62	898	3		3	44
	05/21/05	86		86	1,246	2		2	29
	05/22/05	104		104	1,507				
	05/23/05	88		88	1,275				
	05/24/05	102		102	1,478				
	05/25/05	61		61	884				
	05/26/05	24		24	348				
	05/27/05	9		9	130				
	05/28/05	7		7	101				
	05/29/05	18		18	261				
	05/30/05	47		47	681	2		2	29

Table continued next page

Appendix A.1. Daily actual and estimated catches and migration estimates for wild and hatchery age 0+ chinook migrants, Green River 2005 (cont'd)

Period	Date Down	Wild				Hatchery			
		Actual	Est'd	Total	Migration	Actual	Est'd	Total	Migration
Period 13	05/31/05	51		51	1,316				
	06/01/05	70		70	1,806				
	06/02/05	50		50	1,290	1		1	26
	06/03/05	40	1	41	1,058				
	06/04/05	12		12	310				
	06/05/05	6		6	155				
	06/06/05	22		22	568				
	06/07/05	26		26	671				
	06/08/05	26		26	671				
Period 14	06/09/05	12		12	395				
	06/10/05	12		12	395				
	06/11/05	16		16	527				
	06/12/05	72		72	2,370	1		1	33
	06/13/05	39		39	1,284				
	06/14/05	29		29	955				
	06/15/05	33		33	1,086				
	06/16/05	39		39	1,284				
	06/17/05	14		14	461				
	06/18/05	19		19	625				
	06/19/05	2	1	3	99				
	06/20/05	12	2	14	461				
	06/21/05	13		13	428				
	06/22/05	45	2	47	1,547	1		1	33
	06/23/05	13	1	14	461				
	06/24/05	13	1	14	461				
	06/25/05	12	2	14	461	1		1	33
	06/26/05	20		20	658				
	06/27/05	28		28	922				
Period 15	06/28/05	25	25	0	509	0		0	0
	06/29/05	15	15	0	306	0		0	0
	06/30/05	15	15	0	306	1	1	0	20
	07/01/05	13	13	0	265	0		0	0
	07/02/05	10	10	0	204	1	1	0	20
	07/03/05	12		12	245	0		0	0
	07/04/05	12		12	245	0		0	0
	07/05/05	12		12	245	1		1	20
	07/06/05	7	7	0	143	0		0	0
	07/07/05	13	13		265	1	1		20
	07/08/05	6	6	0	122	1		1	20
	07/09/05	2	2		41				0
	07/10/05	13	13		265	1	1		20
	07/11/05	11	11	0	224	0		0	0
	07/12/05	8	8	0	163	0		0	0
	07/13/05	6	6	0	122	0		0	0
	07/14/05	2	2		41				0
Season Total		**18,579**	**1,466**	**20,045**	**491,048**	**57**	**8**	**65**	**1,919**

Appendix A 2. **Summary of actual and estimated catches and migration estimates for wild and hatchery age 0+ chinook migrants, by trap efficiency strata, Green River 2005.**

Strata	Wild				Hatchery			
	Actual	Est'd	Total	Migration	Actual	Est'd	Total	Migration
1	2,578	1,394	3,972	107,201				
2	763		763	14,225				
3	1,062		1,062	39,185				
4	2,902		2,902	64,454				
5	620		620	11,032				
6	666		666	8,366				
7	890		890	32,443				
8	4,871		4,871	103,593				
9	663		663	7,752	1		1	12
10	985		985	6,117				
11	592	1	593	53,521	19		19	1,136
12	1,095	25	1,120	16,226	29	6	35	508
13	303	1	304	7,843	1		1	26
14	443	9	452	14,878	3		3	99
15	146	36	182	4,212	4	2	6	139
Season Total	**18,579**	**1,466**	**20,045**	**491,048**	**57**	**8**	**65**	**1,920**

3 Dungeness River

2005 Dungeness River
Juvenile Salmonid Production Evaluation

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3.1 Methods

3.1.1 Trap Operations

A floating five-foot diameter screw trap (Busack *et al.* 1991) was used on the Dungeness River to capture downstream migrant salmonids. The trap was located at River Kilometer (rkm) 0.5, just above tidal influence (Figure 3 - 1). This trap is identical to that used on the Green River (Chapter 2.1.1).

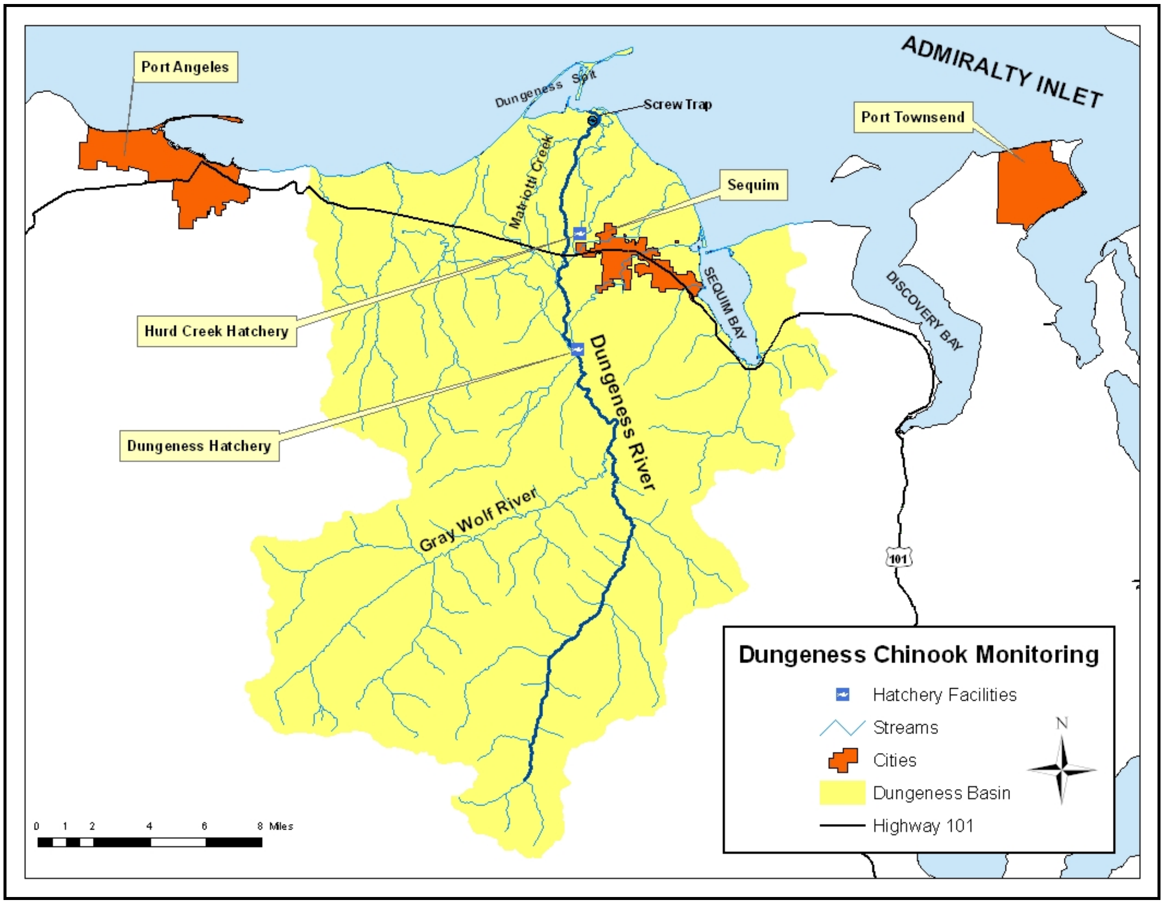

Figure 3 - 1. Map of the Dungeness River watershed with the location of the screw trap, Matriotti Creek and hatcheries.

The screw trap was operated continuously between March 8 and August 5, except for periods when mechanical failure, or large numbers of hatchery fish released above the trap prevented its operation. Trapping was also suspended during daytime periods late in the trapping season, when catches were low and the potential for 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, as needed, based on debris loads and capture rates. At the end of each trapping period, all fish captured in the trap were identified to species, checked for marks, CWTS, and enumerated. Fork length measurements were taken from a sample of the various wild salmonids captured.

To estimate migration, groups of naturally-produced chinook and chum migrants capture in the trap were marked with either a unique fin-clip or by staining with Bismarck Brown dye. The fish were marked in the morning and held in a perforated bucket placed in the trap live-box during the day. Each group of marked fish was released 150-meters upstream of the trap just before dark. Trap efficiency was estimated by the proportion of marked fish recaptured in the trap.

Coho smolt trap efficiency was estimated by the proportion of marked fish released by the Jamestown S'Klallam Tribe from a smolt fence-trap they operated on Matriotti Creek, which were subsequently captured in our screw trap. The Matriotti Creek trap was located just upstream from the mouth, which enters the Dungeness River at rkm 3.1. Coho smolts captured in the Matriotti Creek trap were marked with a partial caudal fin-clip and released daily.

3.1.2 Chinook and Chum Production Estimate

Estimating naturally-produced juvenile salmon production from the Dungeness River was done in two steps. Because the trap did not operate continuously over the entire trapping period, the first step involved estimating or interpolating catch for each species for periods when the trap did not fish. The second step involved estimating the capture rate or trap efficiency.

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 fishing periods within the same diel stratum, and then expanding by the hours not fished. Catch rates were defined using:

Equation 3 - 1

$$\hat{R}_{fj} = \frac{C_{fj}}{T_{fj}}$$

where:

$$R_{fj} = \text{the catch rate during fishing period } f \text{ in diel stratum } j,$$
$$C_{fj} = \text{catch during fishing period } f \text{ in diel stratum } j, \text{and}$$
$$T_{fj} = \text{the duration of fishing period } f \text{ in diel stratum } j.$$

The variance of the mean catch rate was estimated by:

Equation 3 - 2

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

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:

Equation 3 - 3

$$V\left(\hat{C}\right)=V\left(\overline{R}_{fj}\right)\hat{T}^2$$

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 groups using:

Equation 3 - 4

$$\hat{e}_i=\frac{m_i}{M_i}$$

where;

$\hat{e}_i$ = *the capture rate estimated for trap efficiency period i,*
m_i = *the number of marked or dyed migrants captured in trap efficiency period i, and*
M_i = *the number of marked or dyed migrants released in trap efficiency period i.*

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

Equation 3 - 5

$$V\left(\hat{e}_i\right)=\frac{\hat{e}_i\left(1-\hat{e}_i\right)}{M_i}$$

We conducted trap efficiency tests regularly throughout the season. For groups containing only a few individuals, we combined consecutive mark-release groups to form efficiency strata, in order to achieve at least five recaptures per stratum, as recommended by Schwartz and Taylor 1998. Chinook and chum migration for each stratum was estimated using the following stratified mark-recapture equation (Carlson *et al* 1998):

Equation 3 - 6

$$\hat{U}_i=\frac{u_i(M_i+1)}{m_i+1}$$

where;

U_i = *the number of unmarked fish migrating during period i, and*
u_i = *the number of unmarked fish captured during period i,*

The variance of the migration estimate was calculated using:

Equation 3 - 7

$$V(\hat{U}) = \frac{(M_i + 1)(u_i + m_i + 1)(M_i - m_i)u_i}{(m_i + 1)^2 (m_i + 2)}$$

Daily migration was estimated by applying the proportion of the expanded daily catch over the estimated catch for the stratum to the migration estimate $\hat{U}_i$.

The total season migration and variance was estimated by the sum of the estimated migrations and variance corresponding to efficiency strata.

3.1.3 Coho Smolt Production Estimate

Coho smolt production was estimated using a simple Peterson estimate (modified by Chapman 1951):

Equation 3 - 8

$$\hat{N} = \frac{(m+1)(c+1)}{(r+1)} - 1$$

Where:
$\hat{N}$ = total wild coho smolt population estimate in the Dungeness River;
m = the number of wild coho smolts left ventral fin-marked and released at the tributary trap (Matriotti Creek);
c = the number of wild coho smolts captured in the mainstem traps; and
r = the number of marked fish recaptured in the mainstem trap.

The variance of the coho production estimate was found using:

Equation 3 - 9

$$Var(\hat{N}) = \frac{(m+1)(c+1)(m-r)(c-r)}{(r+1)^2 (r+2)}$$

3.2 Results

Estimating the production of naturally-produced chinook migrants was complicated by the large numbers of hatchery salmonids planted into the river. Table 3 - 1 provides a summary of hatchery releases that could have been captured in the screw trap in 2005.

Table 3 - 1. Hatchery releases upstream of the Dungeness River screw trap, 2005.

Species	Release		Brood Year	CWT Only	Ad-mark Only	Unmarked
	Date(s)	Location				
Chinook	April 06	Dungeness Hatchery	2003	45,036		2,824
Coho	May 02	Dungeness Hatchery	2003		512,450	
	Volitional[a]	Dungeness Hatchery	2003	5,682		1,931
Steelhead	April 27	Dungeness Hatchery	2003		9,825	

[a] This experimental group was part of a naturalized rearing project conducted by the University of Idaho.

3.2.1 Chinook

3.2.1.1 Catch

Over the 150-day season, we captured 9,323 unmarked naturally-produced 0+ chinook migrants (Appendix B 1). The chinook fry migration was already in progress when trapping began on March 8. On the first complete day of trapping, we captured 86 newly-emerged chinook fry.

The chinook migration showed two distinct peaks, indicating fry (early) and smolt (later) migration trends; the later migration peak consisted of fish that had reared in the river and began their smoltification process before migrating. Daily catches generally increased over the first week of trapping to peak on March 16, at 205 chinook fry. Catches quickly declined to an average of less than 10 fish/day at the end of March, and remained low through April, averaging just 5 fish/day. Chinook catches gradually increased thereafter, ranging from 7 to 94 fish/day and averaged 40 fish/day during May. The second peak occurred on June 8, with 371 smolts captured. Catches gradually declined through the remainder of the season, and averaged just 6 fish/day by the end of the trapping. Using April 15 as a transition date between the fry and smolt component of the migration, we estimate that 24% of the production migrated as fry and 76% migrated as smolts.

3.2.1.2 Size

We measured a total of 1,365 zero-age chinook over the entire run. Chinook fork lengths averaged 38-mm over the first two weeks of trapping. The fish began to grow rapidly in late March and averaged 2.5-mm of growth per week through the rest of the trapping season. By the end of the season the chinook averaged 89.3-mm, with individuals as large as 104 mm. (Table 3 - 2, Figure 3 - 2). Migrants measuring less than 40-mm were caught through the middle of April, after which, the minimum size increased to over 78-mm at the end of the trapping season.

Individuals 40-mm and smaller were assumed to be newly emerged fry; therefore, we believe that incubation and emergence was complete by the middle of April.

Table 3 - 2. Mean fork length (mm), standard deviation, range, and sample size of wild age 0+ chinook measured by statistical week, Dungeness River 2005.

Statistical Week			Average	s.d.	Range		Number		Percent
No.	Begin	End			Min	Max	Sampled	Captured	Sample
11	03/07/05	03/14/05	38.6	1.54	35	42	109	517	21.1%
12	03/14/05	03/20/05	38.7	1.54	35	45	89	954	9.3%
13	03/21/05	03/27/05	43.6	6.79	38	59	11	231	4.8%
14	03/28/05	04/03/05	42.4	2.89	37	49	22	85	25.9%
15	04/04/05	04/10/05	47.9	4.45	42	53	7	12	58.3%
16	04/11/05	04/17/05	51.0	12.53	38	68	5	17	29.4%
17	04/18/05	04/24/05	55.8	5.15	50	64	6	33	18.2%
18	04/25/05	05/01/05	58.5	10.80	43	79	14	71	19.7%
19	05/02/05	05/08/05	60.0	5.77	53	67	4	38	10.5%
20	05/09/05	05/15/05	62.5	7.82	52	85	60	266	22.6%
21	05/16/05	05/22/05	68.6	7.31	52	89	82	307	26.7%
22	05/23/05	05/29/05	71.3	5.81	59	87	76	396	19.2%
23	05/30/05	06/05/05	73.1	5.60	55	91	204	1,217	16.8%
24	06/06/05	06/12/05	73.9	4.76	63	86	113	1,471	7.7%
25	06/13/05	06/19/05	76.4	6.10	61	100	163	928	17.6%
26	06/20/05	06/26/05	78.3	5.44	60	90	160	847	18.9%
27	06/27/05	07/03/05	81.2	5.57	65	92	43	831	5.2%
28	07/04/05	07/10/05	81.2	5.32	70	92	70	587	11.9%
29	07/11/05	07/17/05	85.0	6.39	68	103	60	276	21.7%
30	07/18/05	07/24/05	87.6	3.77	80	94	19	135	14.1%
31	07/25/05	07/31/05	88.4	6.44	78	104	34	90	37.8%
32	08/01/05	08/07/05	89.3	5.48	78	95	14	14	100.0%
Season Total			**69.1**	**15.86**	**35**	**104**	**1,365**	**9,323**	**14.6%**

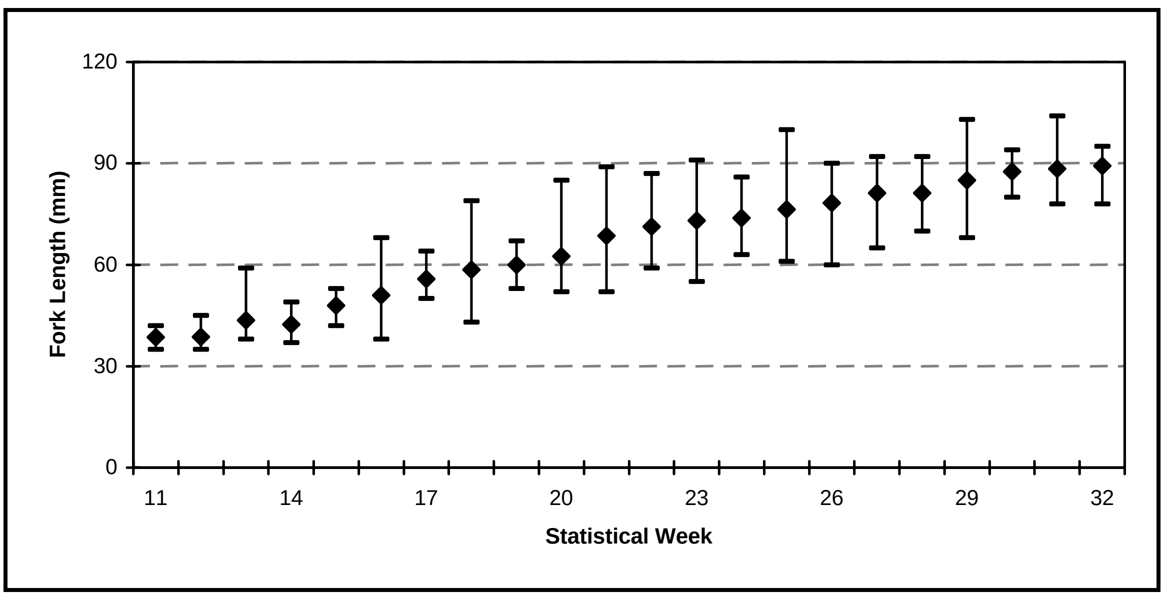

Figure 3 - 2. Weekly average, minimum, and maximum 0+ chinook fork lengths (mm) measured at the Dungeness River screw trap, 2005.

3.2.1.3 Catch Expansion

The trap was operated 3,203 hours out of 3,590 possible hours in the 150-day trapping period, or 89.2% of the time. Over the course of the season trapping was suspended three times for a total of 3.93 hours for maintenance and debris removal; we estimated 7 chinook would have been caught during this period. Trapping was also suspended to avoid large numbers of hatchery fish for a total of 123.08 hours (49.93 hours daytime, and 73.15 hours nighttime). We estimated a catch of 119 chinook would have occurred during this period. Late in the season, we discontinued trapping for 259 hours on 20 occasions (246.75 hours daytime, and 12.25 hours nighttime), and estimated a missed catch of 24 chinook for these outage periods. In total, we estimate that we could have captured 150 additional naturally-produced 0+ chinook (1.6% over the actual catch) had we been able to fish throughout entire season, for a total expanded catch of 9,473 naturally-produced chinook estimated between March 8 and August 5 (Appendix B 1).

3.2.1.4 Trap Efficiency

A total of 2,147 age 0+ naturally-produced chinook migrants in 47 groups were marked and released from the east bank of the river approximately 150-yards upstream of the trap. All of the fish that were marked and released were individuals that had been captured in the trap. Release groups ranged from 1 to 143 fish. Because many of the groups contained very few individuals we arranged them into 14 strata made up of contiguous test release groups that shared similar flow conditions (Table 3 - 3). Recapture rates averaged 14.46%, for the combined groups, and ranged from 9.76% to 28.57%.

Table 3 - 3. Trap efficiency strata for 0+ chinook, Dungeness River screw trap, 2005.

Efficiency	Dates		Number				Percent	Variance
Strata	Rel/Recap	Period Applied	Marked	Morts	Released	Recov'd	Recov'd	
1	03/09-03/10	03/01-03/17	103	0	103	13	12.62%	7.81E-04
2	03/18-04/14	03/18-04/15	191	3	188	21	11.17%	1.13E-02
3	05/12-05/19	04/16-05/21	145	3	142	17	11.97%	2.69E-03
4	05/22-05/24	05/22-05/29	102	2	99	18	18.18%	3.77E-04
5	05/30-06/02	05/30-06/03	117	5	112	32	28.57%	3.31E-02
6	06/04-06/07	06/04-06/10	201		201	32	15.92%	8.39E-05
7	06/11-06/17	06/11-06/17	188	1	187	24	12.83%	4.22E-03
8	06/18-06/25	06/18-06/26	189		189	28	14.81%	5.31E-03
9	06/27-06/30	06/27-07/01	262	5	257	30	11.67%	1.78E-04
10	07/02-07/07	07/02-07/08	248	2	246	24	9.76%	7.76E-04
11	07/09-07/11	07/09-07/13	153		153	20	13.07%	3.21E-03
12	07/14-07/19	07/14-07/22	131		131	17	12.98%	1.69E-04
13	07/23-07/26	07/23-07/26	72	1	71	8	11.27%	6.58E-04
14	07/27-08/04	07/27-08/04	68		68	12	17.65%	1.03E-03
Season Total			**2,170**	**22**	**2,147**	**296**	**14.46**	**6.39E-02**

Flows ranged from 3.36 to 16.7 cubic meters per second (cms) during the chinook trap efficiency tests. There was no apparent relationship between flow and efficiency, probably because flows in the Dungeness never reached the magnitude necessary to substantially alter the river cross-section at the trap site. (Figure 3 - 3).

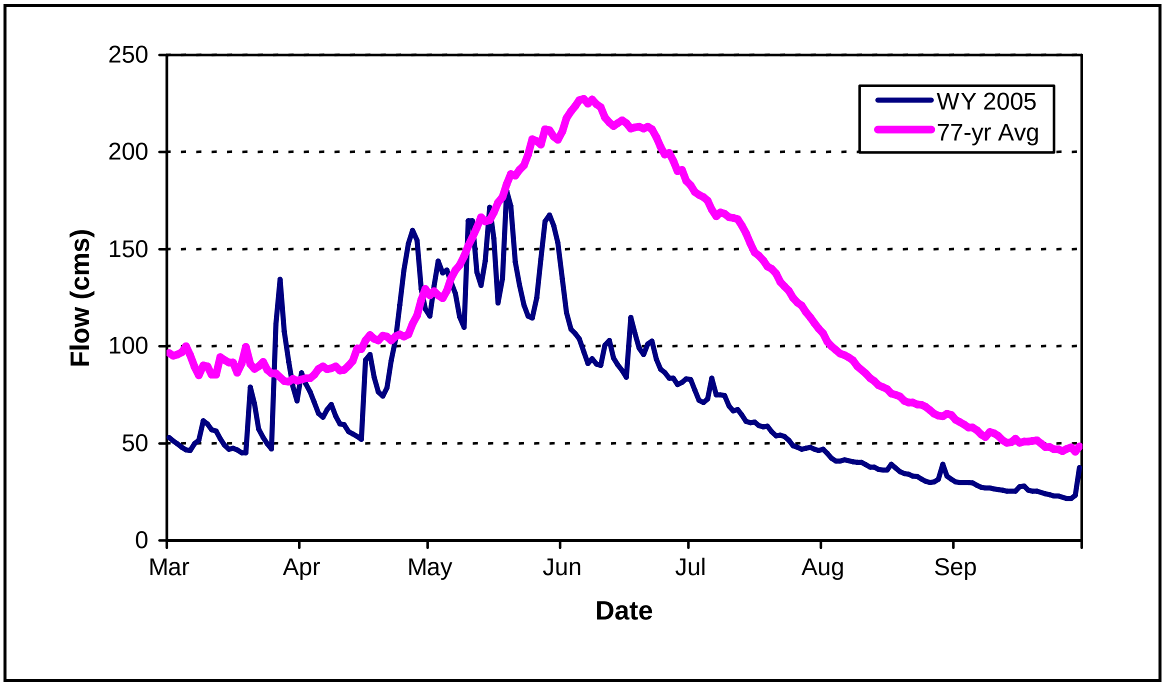

Figure 3 - 3. Daily mean flow in 2005 and 77-year average daily flow (1923-2005), Dungeness River (USGS gage# 12048000).

3.2.1.5 Production Estimate

Over the trapping season (March 8 through August 5), we estimated 67,160 naturally-produced 0+ chinook migrants passed the screw trap, with a coefficient of variation of 6.08% and 95% confidence intervals of 59,156 to 75,163 chinook. The migration was well underway when trapping began, with initial catches of 86 chinook on our first complete day of fishing. Using February 15 as the assumed migration start date (Witczak pers. comm.), logarithmic extrapolation estimates 2,232 0+ chinook migrated before trapping began. Because of low catches at the end of the season, we assumed the migration was over and did not estimate migration after the trap was removed (Figure 3 - 4). No variance or confidence intervals were developed for the pre-trapping migration estimate. Total production for the Dungeness River in 2005 was estimated at 69,392 naturally-produced 0+ chinook (Appendix B 1).

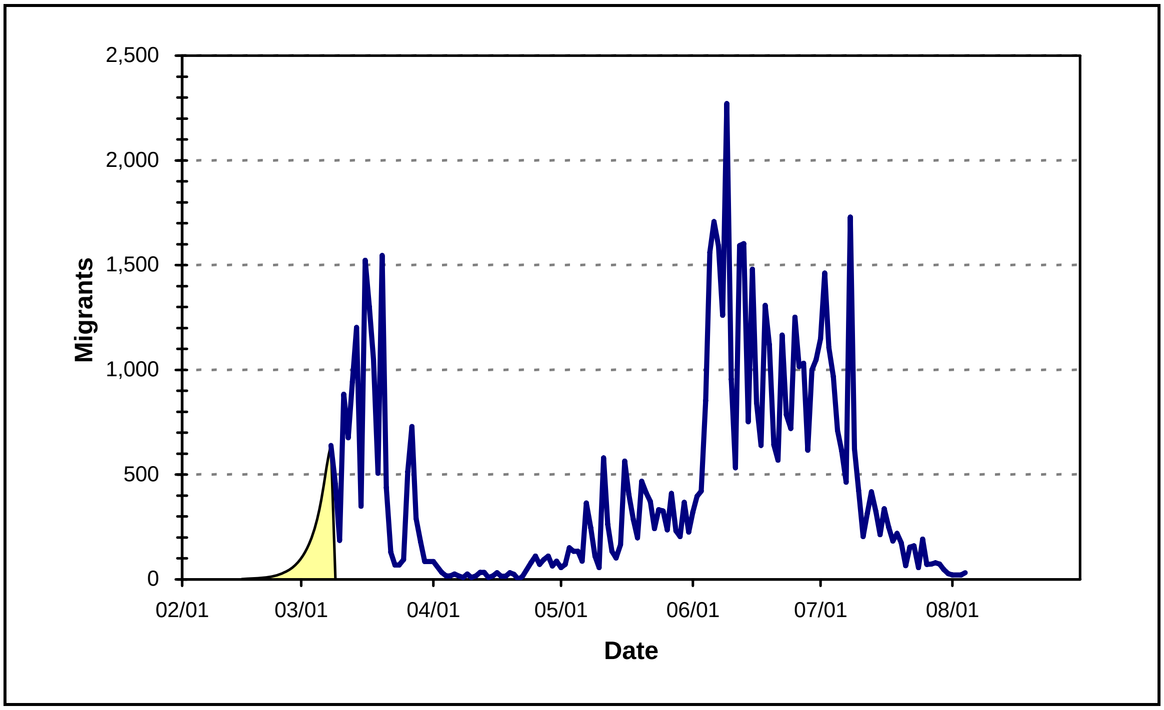

Figure 3 - 4. Estimated daily migration of naturally-produced 0+ chinook past the Dungeness River screw trap, 2005.

3.2.1.6 Yearling Chinook

Over the season, we caught 1,850 yearling chinook smolts. This catch consisted of 1,842 coded-wire tagged (CWT'd) hatchery fish and 8 untagged fish. The untagged fish were visually indistinguishable from the tagged fish and were most likely just untagged hatchery fish. No yearling chinook where captured until April 6, the day following the volitional release of 47,860 fish from the Dungeness Hatchery. When the fish reached the trap, catches increased to 1,267 fish in the first seven hours; trapping was suspended for the following 39 hours to avoid catching thousands more. We estimated that 99% of the hatchery fish migrated past the trap site over five days. We estimate 3,666 yearling chinook would have been captured, had we fished continuously throughout the entire season. Applying the estimated catch to the number released estimates a trapping efficiency of 7.7%, assuming 100% survival past the trap.

3.2.2 Coho

3.2.2.1 Catch

The first naturally-produced coho was captured on March 14. Catches remained low until the third week of April when catches rapidly increased. The naturally produced coho catch peaked on the night of May 7, with a one-night catch of 165 smolts. Nightly catches remained at consistently high levels through mid-June, and then quickly declined to near zero by the end of June. With the exception of a small push of fish in early July, the catches remained low through the end of the season.

Over the season, we caught 3,136 naturally-produced coho smolts. This catch includes 432 fish that were previously marked with a partial caudal fin-clip and released from a trap operated by the Jamestown S'Klallam Tribe on Matriotti Creek (R.M. 1.9) **(**Table 3 - 4). The Tribe used a partial upper caudal fin-clip (UC) from April 26 through May 26, and a partial lower caudal fin-clip (LC) from May 27 through June 28. The UC-marked coho first appeared in our catches on April 27, only one day following the first release. We captured our first LC-marked coho the same day they changed to that mark.

Two groups of hatchery coho were released from the Dungeness hatchery: the larger production group of 512,450 ad-marked fish was an experimental group released on May 2; the second group of 7,613 smolts (1,931unmarked and 5,682 CWT-only) was reared in a "Nature's Study" (naturalized rearing) pond and allowed to migrate volitionally. The ad-marked hatchery coho reached the trap in large numbers on the evening of May 3, resulting in a catch of 1,053 smolt in the first five hours. We suspended trap operation for the next 50 hours to avoid excessive handling and other adverse impacts, including overcrowding in the live box. The three days following the trap outage we only operated during daylight hours, when coho catch rates where low. Full-time trapping resumed on the evening of May 10.

We caught and detected only 5 CWT-only nature-study hatchery fish over the season. The reason for the low catch of these fish was not apparent. The first CWT fish was detected on July 3, well after the majority of the ad-marked coho had migrated past the trap.

Table 3 - 4. Summary of caudal fin-clipped coho smolts released at Matriotti Creek weir and recaptured in the mainstem screw trap, by statistical week, Dungeness River 2005.

Statistical Week			Number Released		Number Recaptured		Pecent Recapture	
No.	**Begin**	**End**	**UC**	**LC**	**UC**	**LC**	**UC**	**LC**
18	04/25/05	05/01/05	161		26		16.15%	
19	05/02/05	05/08/05	894		8		0.89%	
20	05/09/05	05/15/05	2,193		116		5.29%	
21	05/16/05	05/22/05	1,344		91		6.77%	
22	05/23/05	05/29/05	322	1,735	35	77	12.73%	4.44%
23	05/30/05	06/05/05		147	1	9		6.12%
24	06/06/05	06/12/05		712		41		5.76%
25	06/13/05	06/19/05		311		21		6.75%
26	06/20/05	06/26/05		61	5	1		
27	06/27/05	07/03/05				1		
Season Total			**4,914**	**2,966**	**282**	**150**	**5.74%**	**5.06%**
			7,880		**432**		**5.48%**	

3.2.2.2 Size

Over the season, we measured (fork length) a total of 496 unmarked naturally-produced coho. Sizes ranged from 80 to 171-mm, and averaged 108.8-mm. In addition, we measured 45 caudal fin-marked naturally-produced coho released from the Matriotti Creek weir. The Matriotti coho were over 7-mm larger than the coho emigrating from the rest of the Dungeness system. No significant differences were observed between the size of the Matriotti fish marked at the weir and the ones recovered in the trap, indicating that there is little or no size selectivity associated with the screw trap (Table 3 - 5, Figure 3 - 5).

Table 3 - 5. Mean fork length (mm), standard deviation, range, and sample size of naturally-produced coho smolts measured by statistical week, Dungeness River 2005.

Statistical Week			Average	s.d.	Range		Number		Percent
No.	Begin	End			Min	Max	Sampled	Captured	Sample
11	03/08/06	03/13/06	----	----	----	----	0	0	0.0%
12	03/14/06	03/20/06	----	----	----	----	0	5	0.0%
13	03/21/06	03/27/06	----	----	----	----	0	6	0.0%
14	03/28/06	04/03/06	108.5	9.19	102	115	2	13	15.4%
15	04/04/06	04/10/06	112.67	10.97	104	125	3	20	15.0%
16	04/11/06	04/17/06	142.7	19.23	117	166	6	39	15.4%
17	04/18/06	04/24/06	125.6	21.83	109	171	7	104	6.7%
18	04/25/06	05/01/06	111.85	10.37	89	133	20	304	6.6%
19	05/02/06	05/08/06	----	----	----	----	0	722	0.0%
20	05/09/06	05/15/06	105.4	10.44	83	123	44	512	8.6%
21	05/16/06	05/22/06	106.7	9.78	81	125	74	395	18.7%
22	05/23/06	05/29/06	106.8	11.09	80	139	92	502	18.3%
23	05/30/06	06/05/06	102.6	10.28	91	140	40	166	24.1%
24	06/06/06	06/12/06	105.5	10.99	84	147	107	181	59.1%
25	06/13/06	06/19/06	112.0	12.72	80	136	29	83	34.9%
26	06/20/06	06/26/06	115.5	12.72	97	133	8	30	26.7%
27	06/27/06	07/03/06	119.1	10.46	104	157	37	167	22.2%
28	07/04/06	07/10/06	117.4	10.11	105	138	12	36	33.3%
29	07/11/06	07/17/06	116.2	12.71	97	138	9	9	100.0%
30	07/18/06	07/24/06	114.0	14.93	97	125	3	7	42.9%
31	07/25/06	07/31/06	105.0	13.75	90	117	3	3	100.0%
Season Total			**108.8**	**12.62**	**80**	**171**	**496**	**3,304**	**15.0%**
Matriotti Coho Captured			**116.24**	**9.15**	**100**	**136**	**45**	**531**	**8.5%**
Matriotti Coho at Release			**116.41**	**10.75**	**91**	**195**	**511**	**9,045**	**5.7%**

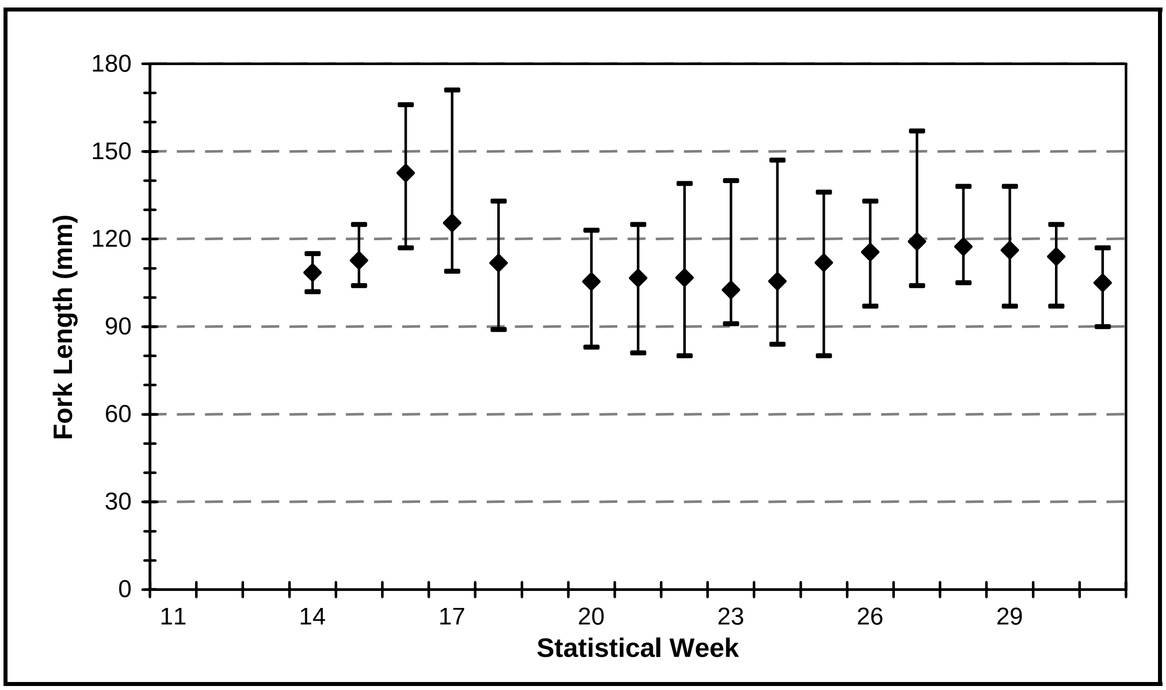

Figure 3 - 5. Weekly average, minimum, and maximum naturally-produced coho fork lengths measured at the Dungeness River screw trap, 2005.

3.2.2.3 Catch Expansion

Trapping operations were suspended for a total of 386.47 hours (see **Chapter 3.2.1.3**). We captured 3,136 naturally-produced coho smolts, and estimated 699 additional naturally-produced smolts during the period the trap did not fish, for a total expanded catch of 3,835 naturally-produced coho smolts (3,304 unmarked, 381 UC, and 150 LC). The expansion represents an 18.2% increase to the actual naturally-produced coho catch.

We also captured 7,845 ad-marked hatchery smolts, and estimated 15,779 additional fish would have been captured, for a total expanded catch of 23,624 hatchery coho. The expansion represents an increase of 67% over the actual catch of ad-marked coho. No additional CWT hatchery fish were estimated for the periods during which trapping was suspended.

3.2.2.4 Trap Efficiency

In total, the Jamestown S'Klallam tribe marked and released 7,880 naturally-produced coho from their weir trap on Matriotti Creek. Over the season, 4,914 smolts were marked with a partial UC fin-clip (April 26 through May 26), and 2,966 were marked with a partial LC fin-clip (May 27 through June 28) (Table 3 - 4). We captured 432 fin-marked coho (282 UC and 150 LC) in our screw trap. Applying the number of marked coho captured in the screw trap to the number released estimates that we recaptured 5.7% (282/4,914) of the UC-marks and 5.1% (150/2,966) of the LC-marks. The difference in between these proportions was tested using a Z-test. Because the difference was not found to be significantly different ($\alpha = 0.05$), the two groups were pooled, resulting in an estimated trapping efficiency of 5.5% (432/7,880). This catch rate assumes that all the marked fish released from the weir survived and migrated past the trap during the trapping season.

3.2.2.5 Production Estimate

The smolts marked and released from the Matriotti Creek weir provided the basis for our smolt production estimate. Application of the Chapman's modification of a Peterson Population estimate yielded a production estimate of 57,095 smolts, with a coefficient of variation of 4.34% and a 95% confidence interval of 52,242 to 61,950 (Figure 3 - 6, Table 3 - 6).

The Dungeness Hatchery reported releasing 512,450 ad-marked coho, of which we captured an estimated 23,624 smolts (7,845 actual, 15,779 estimated), 4.7% of the release. Assuming trap efficiency for the hatchery fish was the same as that of naturally-produced smolts, we estimate 431,095 ad-marked hatchery fish passed the trap. This estimates that 84% of the hatchery-released smolts survived to migrate past the trap. Variance and confidence intervals were not developed for the hatchery fish migration estimate.

Nature Study hatchery fish were not captured in sufficient numbers to make an estimate of the number that survived to migrate past the trap.

Table 3 - 6. Estimation of naturally-produced coho smolt production, Dungeness River 2005.

	Number	Formula
Total screw trap catches	10,986	
Hatchery coho	-7,850	
Wild coho captured (c)	**3,136**	
Marks recaptured (r)	432	N = (m+1)(c+1)
Marks released (m)	7,880	(r+1)
Total production (N)	**57,095**	
Variance (Var)	6.12E+06	Var = (m+1)(c+1)(m-r)(c-r)
Standard Deviation (sd)	2,474	$(r+1)^2(r+2)$
Coefficient of Var (CV)	4.33%	CV = sd/N
Confidence Interval (CI) +/-	4,848	CI = +/- 1.96(sd)
Estimated coho production		
Dungeness River	57,095	
Upper CI (95%)	61,944	
Lower CI (95%)	52,247	

Notes: Total mainstem catch includes Matriotti Creek smolts (432 total recaptured).
Dungeness Hatchery (ad-marked and CWT only) counts are by visual identification and tag detection at the mainstem traps.

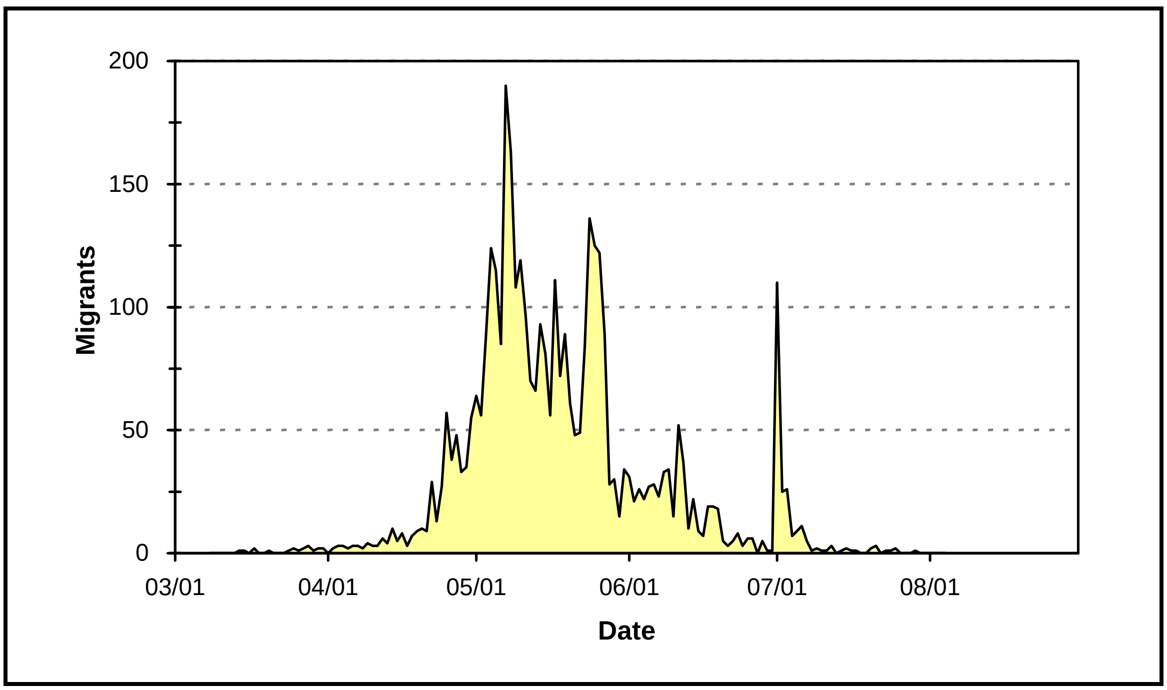

Figure 3 - 6. Estimated daily migration of coho smolts past the Dungeness River screw trap, 2005.

3.2.3 Steelhead

3.2.3.1 Catch

The first naturally-produced steelhead smolt was captured on March 25. Catches remained sporadic until late April, when nightly catches began to increase. The naturally-produced steelhead catches peaked on the night of May 7, at 22 smolts, then slowly declined through the end of the trapping season. Over the season, we captured a total of 329 naturally-produced steelhead smolts. In addition, we trapped an estimated 587 naturally-produced steelhead parr, and 167 trout parr that were not identified to species.

We captured a total of 365 ad-marked hatchery steelhead smolts, one of which was also right ventral fin-marked. Two ad-marked hatchery fish were captured in mid-April, prior to the release of 9,825 hatchery fish on April 27; these may have been either escapees or holdovers from the previous year's release. We observed the first significant catch of ad-marked fish on the morning of April 28, and captured approximately 89% of our total catch of hatchery fish over the following week.

3.2.3.2 Size

Over the season, we measured (fork length) a total of 61 unmarked steelhead smolts. Sizes ranged from 109-mm to 215-mm, and averaged 169.8-mm (Figure 3 - 7). We also measured a total of 79 steelhead parr, which ranged in size from 65-mm to 131-mm, and averaged 96.3-mm over the season.

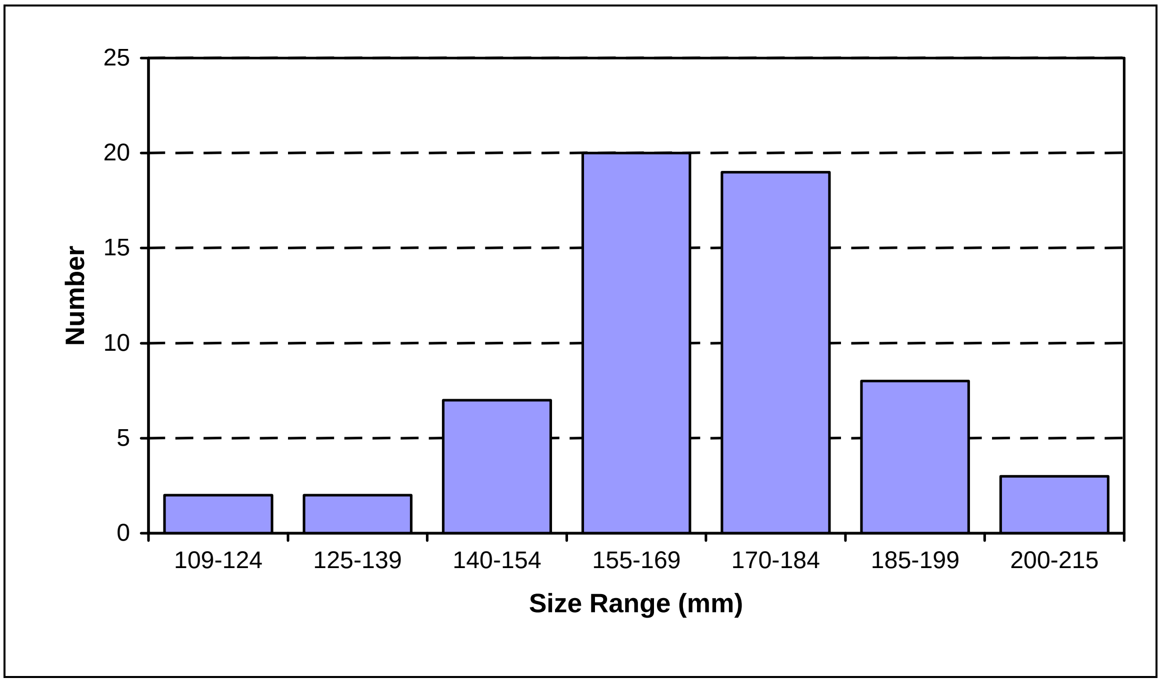

Figure 3 - 7. Length frequency of unmarked steelhead smolt fork lengths (mm) measured at the Dungeness River screw trap, 2005.

3.2.3.3 Catch Expansion

We estimated an additional 92 naturally-produced and 85 hatchery steelhead smolts would have been captured had we fished throughout the entire trapping season. This expanded catch represents an increase of 22% and 19% over actual catches of natural- and hatchery-origin fish, respectively. The total estimated catch for the season was 871 (421 naturally-produced and 450 hatchery fish).

3.2.3.4 Trap Efficiency

No trapping efficiency tests were conducted for steelhead. Trap efficiency for naturally-produced steelhead was estimated by the capture rate observed for the hatchery fish. Applying our season estimated hatchery steelhead catch to the 9,825 smolts released estimates a capture rate for hatchery fish of 4.58% (450/9,825).

3.2.3.5 Production Estimate

Applying the 4.58% capture rate calculated for the hatchery fish, to the estimated 421 smolts captured, estimates production at 9,192 naturally-produced steelhead smolts. Because trapping encompassed the entire steelhead migration, this estimate represents the total steelhead production from the system in 2005. No variance or confidence intervals were developed for this estimate.

3.2.4 Chum

3.2.4.1 Catch

The chum migration was well under way when trapping began, as indicated by a first-day catch of 467 fry. Catches increased quickly and peaked on March 29, at 2,747 fry. Fry catches remained high through the mid April, and then quickly declined to just a few fish per day by early May. Over the season we captured 49,227 chum fry.

3.2.4.2 Size

Over the season, we measured (fork length) a total of 217 chum fry. Weekly mean sizes showed little variation, averaging 38.4-mm, and ranged from 33 to 50-mm over the season (Table 3 - 7).

Table 3 - 7. Mean fork lengths (mm), standard deviations, ranges, and sample sizes, of unmarked naturally-produced chum, measured by statistical week, Dungeness River, 2005.

Statistical Week			Average	s.d.	Range		Total
Number	Begin	End			Min	Max	Sampled
11	03/07/05	03/14/05	38.5	1.01	37	40	30
12	03/14/05	03/20/05	37.6	2.18	33	45	57
13	03/21/05	03/27/05	38.1	2.36	34	46	30
14	03/28/05	04/03/05	38.0	1.83	34	44	58
15	04/04/05	04/10/05	39.1	1.56	36	42	17
16	04/11/05	04/17/05	42.6	3.73	37	50	12
17	04/18/05	04/24/05	39.5	3.71	36	49	13
Season Total			**38.4**	**2.43**	**33**	**50**	**217**

3.2.4.3 Catch Expansion

Over the season, we suspended trap operations for a total of 386.47 hours (see **Chapter 3.2.1.3**). During this period, we estimated an additional 1,669 fry would have been captured when the trap was not fishing, for a total estimated season catch of 50,896 chum fry. The estimated catch represents an increase of 3.3% over the actual catches.

3.2.4.4 Trap Efficiency

A total of 13 trap efficiency tests were conducted during trapping season. The number of individuals in each release group ranged from 50 to 410. Adjacent tests were combined to achieve at least five recoveries in each stratum (Schwartz and Taylor 1998); in all, ten strata were formed (Table 3 - 8). The proportion that was recovered in each stratum ranged from 4.2% to 25.0% and averaged 12.4%.

Table 3 - 8. Trap efficiency strata for chum, Dungeness River screw trap, 2005

Eff	Dates		Efficiency Test Data				Catch Data		
Strata	Rel/Recap	Per Applied	Released	Recap	% Recov'd	Var	Est catch	Migration	Var
	Pre trapping estimate							13,952	
1	03/10-03/18	03/8-03/19	417	71	17.03%	3.39E-04	11,818	68,610	5.37E+07
2	03/21	03/20-03/22	410	44	10.73%	2.34E-04	3,737	34,131	2.28E+07
3	03/24	03/23-03/25	384	96	25.00%	4.88E-04	3,142	12,471	1.22E+06
4	03/27-03/29	03/26-03/31	362	37	10.22%	2.53E-04	7,605	72,648	1.22E+08
5	04/02	04/01-04/03	302	17	5.63%	1.76E-04	4,576	77,029	2.95E+08
6	04/05	04/04-04/08	338	60	17.75%	4.32E-04	4,965	27,592	1.02E+07
7	04/11	04/09-04/12	203	21	10.34%	4.57E-04	4,796	44,472	7.71E+07
8	04/14	04/13-04/17	237	29	12.24%	4.53E-04	4,429	35,137	3.50E+07
9	04/19	04/18-04/20	297	33	11.11%	3.33E-04	1,441	12,630	4.13E+06
10	04/22-04/25	04/21-end	454	19	4.19%	8.83E-05	4,387	99,804	4.56E+08
In-Season Total			**3,404**	**427**	**12.42%**	**3.25E-03**	**50,896**	**484,525**	**1.08E+09**
Total								**498,477**	

3.2.4.5 Production Estimate

We used the same stratified mark-recapture approach for estimating chum production as was used for chinook. During the trapping period (March 8 through August 5) we estimated 484,525 chum fry migrated past the screw trap, with a coefficient of variation of 6.77% and 95% confidence intervals of 420,220 to 548,829 fry.

To estimate total production, a migration starting date of February 15 was chosen. Extrapolating from this date, we estimate 13,952 chum fry migrated before trapping began. No variance or confidence intervals were developed for the pre-trapping migration estimate. The last chum was captured on June 20, well before the end of the trapping season, so no estimate was made for migration after the trap was removed. The total estimated chum production was estimated at 411,229 fry (Figure 3 - 8).

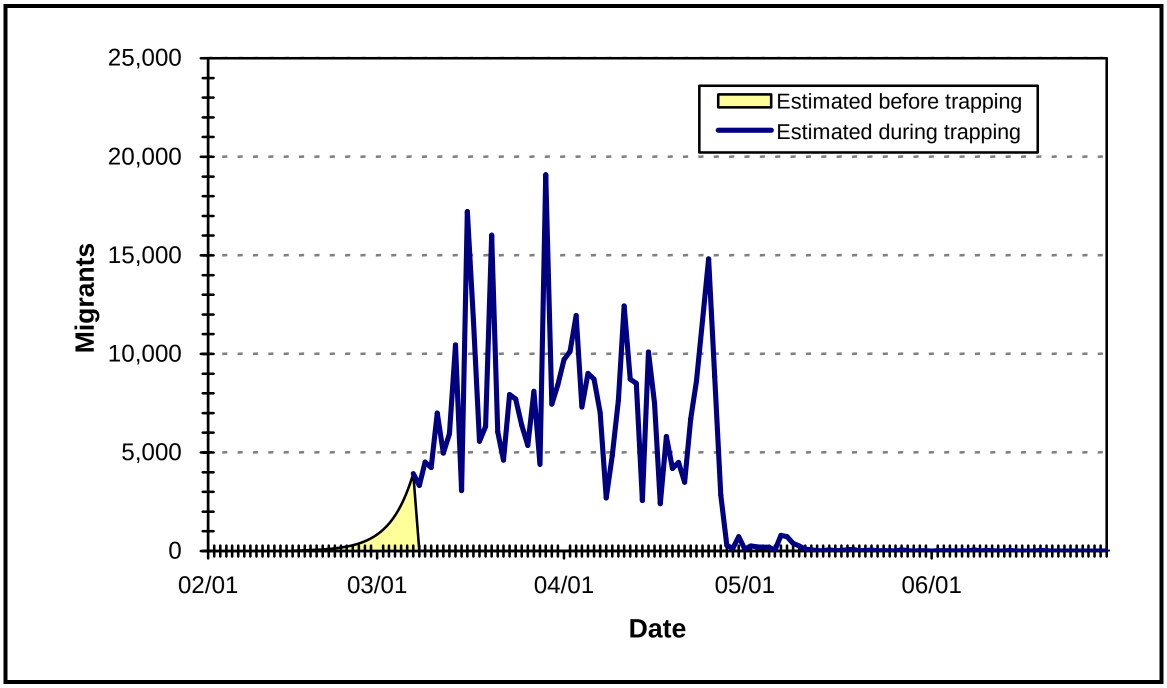

Figure 3 - 8. Estimated daily migration of chum fry past the Dungeness River screw trap, 2005.

3.2.5 Other Species

We captured and enumerated salmonids of other age classes, as well as a number of other fish species. Over the trapping period, a total of 787 pink fry, and 41 coho fry were caught. We also captured 553 steelhead parr, one steelhead adult, 72 cutthroat (35 smolts, 30 parr and 7 adults), and 5 bull trout (1 smolt and 4 adults). Other species captured included starry flounders (*Platichthys stellatus*), three-spine sticklebacks (*Gasterosteus aculeatus*), and American shad adults (*Alosa sapidissima*), and unidentified species of sculpin (*Cottus spp*), and lamprey (*Lampetra spp*).

3.3 Discussion

We developed estimates of migration past the trap for Dungeness River natural-origin 0+ chinook, coho smolts, steelhead smolts, and chum fry. The assumptions used to develop these estimates follow below.

3.3.1 Chinook

The accuracy of the naturally-produced 0+ chinook production estimate for the Dungeness River is partially dependent on the accuracy of the estimated catch during the periods trap operations were suspended. The trap was operated throughout the periods when chinook migration rates were high. Missed catches occurred when migration rates were relatively low; therefore we only estimate a missed catch of 150 chinook fry for the entire trapping period, an increase of only 1.6% over the actual catch.

The trap was installed and began fishing on March 8, after the chinook migration had already started. To accurately estimate total chinook production, we needed to select a reasonably accurate start date from which to extrapolate our pre-trapping migration estimate. Because this was our first year of trapping, we were unfamiliar with this system's chinook migration timing. Upon consulting with Dan Witczak from the Hurd Creek Hatchery, we selected a migration start date of February 15.

The accuracy of the production estimates also depends on the veracity of our estimated capture efficiency. We conducted 47 trap efficiency tests over the entire migration, using chinook captured in our trap. During periods of low migration the numbers of fish in each efficiency test became quite small. We therefore chose to create 14 strata, combining contiguous test groups with such similar environmental conditions as river flow. Stratification was necessary to avoid errors associated with small sample sizes. Based on recommendations by Schwartz and Taylor (1998), we sought to achieve at least five to ten recoveries in each efficiency stratum.

Egg-to-migrant survival is a measure of freshwater productivity for naturally-reared salmon. The estimated migration of 72,113 naturally-produced 0+ chinook divided by the estimated deposition of 1,978,152 eggs results in a survival rate of 3.6%. The estimated egg deposition was derived using a female escapement estimate (redd count) of 381 chinook females made in 2004 (Randy Cooper, pers. comm..) and an average fecundity of 5,192 eggs/female (the average fecundity of the females collected from the Dungeness River for the Captive Brood Chinook Enhancement Project). The 3.6% survival rate estimated for the Dungeness chinook is within the range of survival rates observed over six years of trapping on the Green River.

Winter 2004-05 was a dry, and resulted in a very little snow pack. The lack of snowmelt in late spring and early summer during the peak chinook migration period allowed for continuous trapping, which ultimately improved our production estimate. The lack of snow melt also allowed the river temperatures to increase earlier in the summer, and likely triggered the chinook smolts to migrate from the river earlier than normal.

The naturally-produced 0+ chinook migration from the Dungeness River exhibited a bi-modal timing distribution. The earliest component, composed of newly-emerged chinook fry, migrated past the trap from early February through mid April, and peaked on March 16. This was followed by the smolt component, which migrated from mid April through early August, and peaked on June 9. In 2005, the fry component made up just 24% of the total production, compared to a smolt component of 76%. Proportions of fry and smolt out-migrants are influenced by escapement levels (density effects), the magnitude of high flow events, and the availability of flow refugia (unpublished WDFW data). The river flows remained below normal for most of the time the juvenile fish were in the river (Figure 3 - 3), enabling a higher percentage of fry to remain in the river. This would allow them to grow prior to migrating as smolts in late spring, and ultimately increasing survival potential during their marine phase.

3.3.2 Coho

The naturally-produced coho production estimate was greatly simplified by the release of marked fish from the Matriotti Creek trap. The Matriotti trap remained fish tight and released marked coho over the entire migration in proportion to their migration timing. This eliminated the need to expand the screw trap catches for periods when trap operations were suspended. This was especially helpful during the 82-hour trap outage during the hatchery coho migration, which coincides with the peak naturally-produced smolt migration. With a coefficient of variation of only 4.34%, we feel confident that our estimated production of 58,000 smolts accurately reflects the coho production in 2005.

3.3.3 Steelhead

In any trapping operation, capture rates are affected by many factors such as channel configuration, fish size, water velocity, and trap position. Typically, the larger the fish, the lower the efficiency. Steelhead smolts are large, strong swimmers, a therefore a challenge for trap efficiency-based production estimates.

We did not directly measure trap efficiency for steelhead during this study. Instead, efficiency was estimated by the proportion of hatchery steelhead captured in the trap. While we believe this is an accurate estimate of efficiency, the hatchery steelhead migration occurred over a brief period of time and may not represent catch rates over the entire season. Seiler (2002) estimated steelhead efficiency for the Green River trap by applying an average steelhead:coho capture rate ratio to the coho capture rate measured for the Green River. This ratio (75%) is based on ratios from a number of streams previously trapped. Applying this ratio to our Dungeness coho efficiency of 5.5% estimates steelhead efficiency at 4.1%, which is only slightly less than the 4.6% measured using hatchery steelhead.

3.3.4 Recommendations

Monitoring in 2005 was the first year we attempted to estimate chinook production from the Dungeness system. Migration timing is later than we've measured in other Puget Sound streams, most likely due to colder water temperatures resulting from the north-facing aspect of the watershed and the relatively steep, incised basin topology that limits solar heating. In anticipation of this later migration timing, trapping was not initiated until March 8. It was apparent that trapping needed to have started earlier in order to sample the entire out-migration. The earlier-than-anticipated migration timing observed in 2005 may have been the result of higher-than-average water temperatures resulting from the low stream-flows and light snowpack. Nevertheless, we recommend starting trapping near mid-February in future years to better sample the entire chinook out-migration.

Trap efficiency was not estimated for naturally-produced steelhead in 2005. Given the relatively low catches and capture rates observed, mark-recapture using fish caught in the screw trap would result in too few recoveries to provide a stratified mark-recapture approach. In 2006, we recommend exploring the use of a simple mark-recapture approach, as was used for coho salmon, using steelhead captured in the Matriotti Creek trap by the Jamestown S'Klallam Tribe.

3.4 References

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3.5 Appendix B

Daily Actual and Estimated Catches and Migration Estimates
for Age 0+ Chinook Migrants, Dungeness River 2005

Appendix B 1. Daily actual and estimated catches and migration estimates for wild 0+ chinook migrants, Dungeness River 2005.

Date	Catch			Migration
	Actual	Estimated	Total	
02/15-03/07		2,232	2,232	2,232
03/08/05	86		86	639
03/09/05	61		61	453
03/10/05	25		25	186
03/11/05	119		119	884
03/12/05	91		91	676
03/13/05	127		127	943
03/14/05	162		162	1,203
03/15/05	47		47	349
03/16/05	205		205	1,523
03/17/05	175		175	1,300
03/18/05	122		122	1,048
03/19/05	59		59	507
03/20/05	180		180	1,546
03/21/05	51		51	438
03/22/05	15		15	129
03/23/05	8		8	69
03/24/05	8		8	69
03/25/05	11		11	95
03/26/05	53	7	60	515
03/27/05	85		85	730
03/28/05	34		34	292
03/29/05	21		21	180
03/30/05	10		10	86
03/31/05	10		10	86
04/01/05	10		10	86
04/02/05	7		7	60
04/03/05	4		4	34
04/04/05	2		2	17
04/05/05	2		2	17
04/06/05	3		3	26
04/07/05	0	2	2	17
04/08/05	0	1	1	9
04/09/05	3		3	26
04/10/05	1		1	9
04/11/05	2		2	17
04/12/05	4		4	34
04/13/05	4		4	34
04/14/05	1		1	9
04/15/05	2		2	17

Table continued next page

Appendix B 1. Daily actual and estimated catches and migration estimates for wild 0+ chinook migrants, Dungeness River 2005 (cont'd).

Date	Catch Actual	Catch Estimated	Catch Total	Migration
04/16/05	4		4	32
04/17/05	2		2	16
04/18/05	2		2	16
04/19/05	4		4	32
04/20/05	3		3	24
04/21/05	0		0	0
04/22/05	2		2	16
04/23/05	6		6	48
04/24/05	10		10	79
04/25/05	14		14	111
04/26/05	9		9	72
04/27/05	12		12	95
04/28/05	14		14	111
04/29/05	8		8	64
04/30/05	11		11	87
05/01/05	7		7	56
05/02/05	9		9	72
05/03/05	17	2	19	151
05/04/05	0	17	17	135
05/05/05	0	17	17	135
05/06/05	3	8	11	87
05/07/05	11	35	46	365
05/08/05	0	31	31	246
05/09/05	18	3	21	111
05/10/05	70	3	73	56
05/11/05	33		33	580
05/12/05	17		17	262
05/13/05	13		13	135
05/14/05	21		21	103
05/15/05	71		71	167
05/16/05	51		51	564
05/17/05	36		36	405
05/18/05	25		25	286
05/19/05	59		59	199
05/20/05	52		52	469
05/21/05	47		47	413
05/22/05	46		46	373
05/23/05	63		63	242
05/24/05	62		62	332
05/25/05	45		45	326
05/26/05	78		78	237
05/27/05	44		44	411
05/28/05	39		39	232
05/29/05	70		70	205
05/30/05	66		66	368
05/31/05	94		94	226

Table continued next page

Appendix B 1. Daily actual and estimated catches and migration estimates for wild 0+ chinook migrants, Dungeness River 2005 (cont'd).

Date	Catch			Migration
	Actual	Estimated	Total	
06/01/05	116		116	322
06/02/05	123		123	397
06/03/05	249		249	421
06/04/05	255		255	853
06/05/05	279		279	1,561
06/06/05	260		260	1,708
06/07/05	206		206	1,592
06/08/05	371		371	1,261
06/09/05	156		156	2,271
06/10/05	87		87	955
06/11/05	212		212	533
06/12/05	213		213	1,594
06/13/05	100		100	1,602
06/14/05	197		197	752
06/15/05	112		112	1,481
06/16/05	85		85	842
06/17/05	174		174	639
06/18/05	171		171	1,308
06/19/05	98		98	1,120
06/20/05	87		87	642
06/21/05	89		89	570
06/22/05	89		89	1,166
06/23/05	120		120	786
06/24/05	110		110	721
06/25/05	191		191	1,251
06/26/05	155		155	1,016
06/27/05	124		124	1,032
06/28/05	74		74	616
06/29/05	120		120	999
06/30/05	126		126	1,049
07/01/05	138		138	1,149
07/02/05	148		148	1,462
07/03/05	108	4	112	1,107
07/04/05	94	4	98	968
07/05/05	72		72	711
07/06/05	58	4	62	613
07/07/05	47		47	464
07/08/05	175		175	1,729
07/09/05	85		85	623
07/10/05	53	5	58	425
07/11/05	28		28	205
07/12/05	43		43	315
07/13/05	57		57	418
07/14/05	44		44	323
07/15/05	29		29	213

Table continued next page

Appendix B 1. Daily actual and estimated catches and migration estimates for wild 0+ chinook migrants, Dungeness River 2005 (cont'd).

Date	**Catch**			**Migration**
	Actual	**Estimated**	**Total**	
07/16/05	45	1	46	337
07/17/05	33	1	34	249
07/18/05	24	1	25	183
07/19/05	30		30	220
07/20/05	24		24	176
07/21/05	9		9	66
07/22/05	21		21	154
07/23/05	20		20	160
07/24/05	7		7	56
07/25/05	24		24	192
07/26/05	9		9	72
07/27/05	14		14	74
07/28/05	15		15	80
07/29/05	14		14	74
07/30/05	9		9	48
07/31/05	5		5	27
08/01/05	0	4	4	21
08/02/05	4		4	21
08/03/05	4		4	21
08/04/05	6		6	32
TOTAL	**9,323**	**150**	**9,473**	**67,160**

4 Cedar Creek

2005 Cedar Creek
Juvenile Salmonid Production Evaluation

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4.1 Introduction

4.1.1 Monitoring History

The Washington Department of Fish and Wildlife (WDFW) began adult steelhead monitoring in the Cedar Creek watershed during February 1998 after the installation of an adult trap in the Cedar Creek fishway (RKm 4.0). This occurred after the National Marine Fisheries Service (NMFS) status review indicated populations of wild steelhead in the Lower Columbia River were at risk (Busby et al. 1996). The original intention was to monitor adult steelhead escapement and maintain the genetic diversity of wild steelhead in this basin by limiting the number of out of ESU hatchery steelhead spawning in the upper watershed. Later that year the adult monitoring program was expanded to include Chinook salmon, coho salmon, and sea-run cutthroat trout. In March 1998, a rotary screw was installed to estimate steelhead, coho salmon, and sea-run cutthroat smolt production in this watershed. Smolt monitoring has continued through 2005 and has been funded by the Salmon Recovery Funding (SRF) Board. Sufficient funding was not available to begin juvenile trapping prior to the start of the fall chinook outmigration in late January; therefore, population estimates were not made for this species.

4.1.2 Study Site

Cedar Creek is a third order tributary to the Lewis 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 R.KM. 24.9 on the Lewis River. The Cedar Creek basin, which drains approximately 88.6 square kilometers, is a low gradient system with elevations ranging from 10 to 565 meters. The anadromous salmonid species identified in Cedar Creek include Chinook salmon, chum salmon, 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. The hatchery influence on fall Chinook escapement in Cedar Creek is 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 1950s, a fish ladder was constructed by the Washington Department of Fisheries (WDF) to ensure salmon and steelhead passage at this location. This site, which is owned by WDFW, is located below most of the coho salmon, steelhead, and sea-run cutthroat trout spawning. The constricted river allows for acceptable trap efficiencies. These characteristics and properties make this site ideal for juvenile trapping.

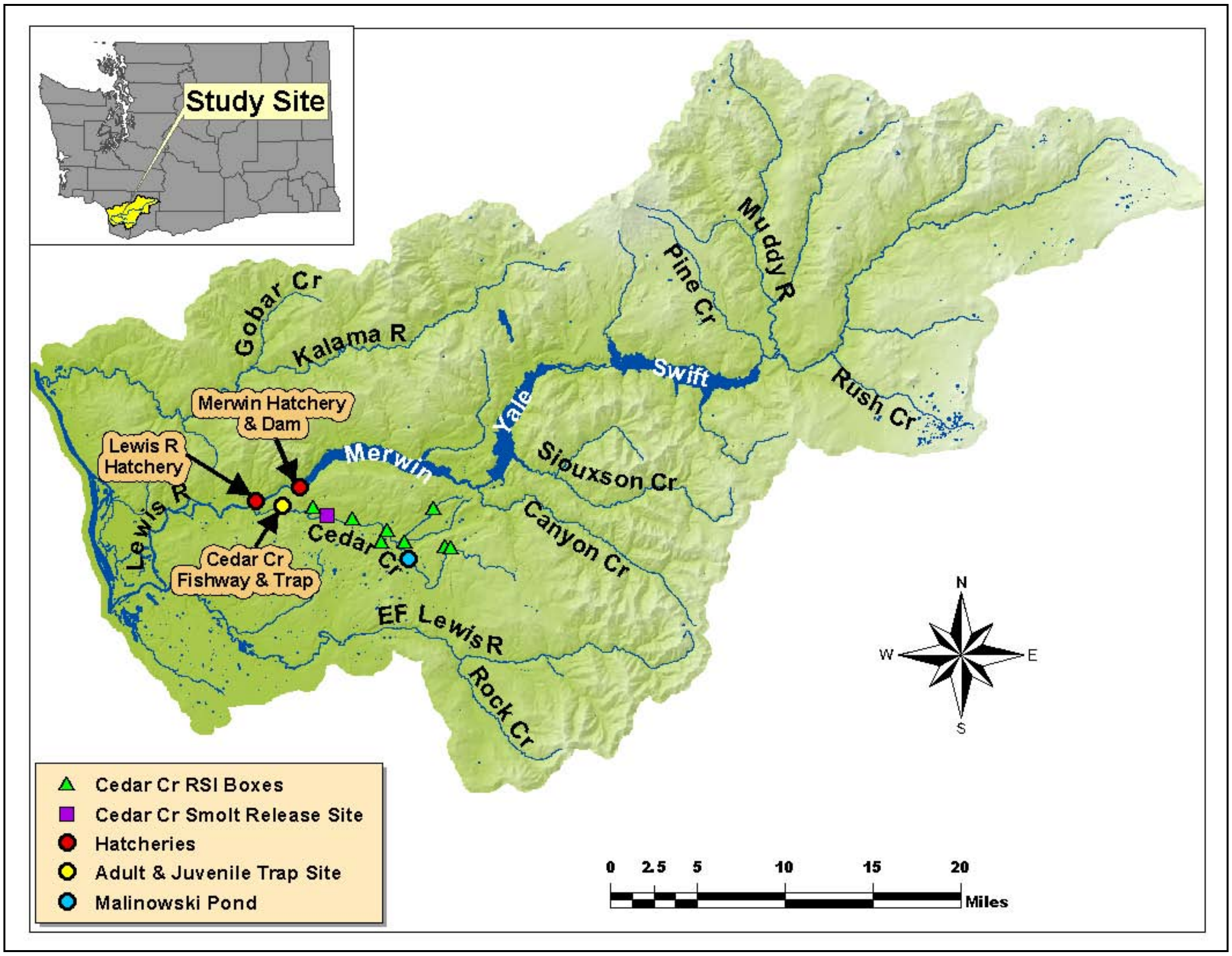

Figure 4 - 1. Lewis River subbasin map with the Lewis River hatcheries and dam, Cedar Creek trap, acclimation, remote site incubator sites.

4.2 Methods

4.2.1 Trap Operations

On March 11, 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 et al. 2004). The trap was fished until the end of the smolt migration on June 26, 2005. 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 installed in the downstream section of the riffle and later during this same week it was moved upstream and remained at this site for the remainder of the season. The trap was adjusted on March 1, 8, and 25, April 11 and 25, and May 2. 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.

The trap was fished 24 hours/day throughout the smolt outmigration period. A total of 8 days, between March 26 and April 3, were lost due to high flow and debris. Since this followed a trap efficiency release of salmon and steelhead smolts in early March, this release was not used for the trap efficiency. There was no estimate to correct for these days and therefore the reported population estimates are biased low. The trap was 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 140 Rkm 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 5.9 R.KM. above the trap site. Since steelhead and sea-run cutthroat abundance is 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. All marked fish were enumerated by species, life stage and fork lengths (mm). 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).

4.2.2 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, Thedinga et al. 1994, Carlson et al. 1998, Plante et al. 1998). Captured juvenile salmonids were marked with a Panjet inoculator (Hart and Pitcher 1969, Thedinga and Johnson 1995). 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 was analyzed by recovery week and statistical weeks in this report were from Monday through Sunday. To achieve the desired level of precision all maiden steelhead and cutthroat were marked and released 5.9 km upstream while up to 40 maiden coho smolts per day were marked and released upstream to develop trap efficiency estimates.

Smolt abundance estimates in 1998 and 1999 were based on a temporal stratification design. Initial estimates used BOOTN software as presented in Thedinga et al. 1994 and further described in Murphy et al. (1996) to estimate smolt yield. This software uses Bailey (1951) estimate for trap efficiency (e) = (R+1)/(M+1), where M is the number of marked fish released upstream of the trap, and R is the number of marked fish recaptured. The number of migrants (N) = U/e, where U is the total unmarked catch, and e is the trap efficiency. Variance for each N was determined by a bootstrapping method (Efron and Tibshirani 1986) with 1,000 iterations from a Fortran program (Murphy et al. 1996). The 95% confidence interval (95% CI) = 1.96 */V where V is the variance determined from bootstrapping. From 2000 to 2003, 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). Trap efficiencies, population estimates, and standard error (SE) are estimated using standard likelihood methods using equations. SPAS computes a pooled Petersen (Chapman 1951), a Darroch Moment estimate, and a ML Darroch estimate for non-square arrays. The partially pooled ML Darroch estimate was used to estimate smolt yield during this period (Rawding et al. 2004).

The Chapman's modification to the Lincoln-Petersen estimate is often used to estimate smolt abundance. When stratified estimates are pooled this is referred to as the pooled Petersen and is:

Equation 4 - 1

$$N = \frac{(C+1)(M+1)}{(R+1)} - 1$$

where N is the population estimate, M is the total fish that are marked and released, C is the total of fish captured, and R is the number of marked fish that are recaptured. Seber (1982) provides and approximate unbiased estimate of the variance:

Equation 4 - 2

$$Var = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}$$

and normal confidence intervals were calculated from the equation:

Equation 4 - 3

$$95\% CI = 1.96 * \sqrt{Var}$$

Since trap efficiencies may change with flow or temperature (Seiler et al.1997, Schwartz and Dempson 1994, and Mantyniemi and Romakkaniemi 2002, Cheng and Gallinat 2004), the pooled Petersen estimate may not always be valid and in this case a stratified estimate is more appropriate (Darroch 1961, Seber 1982, Warren and Dempson 1995, Bannehaka et al. 1997, Miyakoshi and Kudo 1999). Outmigration data was analyzed using the maximum likelihood estimator for stratified populations developed by Darroch (1961) as illustrated by Seber (1982). This is a standard analysis for salmonid smolt populations (Dempson and Stansbury 1991). The software used in this analysis is a program called DARR (Darroch Analysis with Rank Reduction) developed by Bjorkstedt (2000). DARR 2.0 was used in this analysis and is an improved version of the original program (Bjorkstedt 2005). In a temporally stratified study design fish are marked and released in *s* tagging strata, and tagged and untagged fish are recovered in *t* recovery strata. The number of smolts captured in recovery stratum j is u_j , m_i is the number of marked individuals released in tagging stratum *i*, and r_{ij} is the number of marked fish released in tagging stratum *i* that are recaptured in recovery stratum *j*. The probability that a fish tagged in the i^{th} period, will be captured in the j^{th} period, is the joint probability (π_{ij}) that an individual released in period *i* will resume migration and is susceptible to capture during period *j* (migration probability θ_{ij}) and is captured during period *j* (capture probability p_j). The joint probability is $\pi_{ij} = \theta_{ij}\, p_j$. Darroch (1961) provided a maximum likelihood estimator for obtaining n_j where $s = t$ and the rows of $\mathbf{R}$,$\{r_i\}$, are mutually independent and

$$r_i \sim \text{multinomial}\,(m_i\,,\ \pi_{ij})$$
$$u_j \sim \text{binomial}\,(n_j\,,\ p_j)$$

where i = 1,2,3,….s, and j = 1,2,3,…t.

Data are arranged in matrices as:

$$u = \begin{pmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{pmatrix},\quad m = \begin{pmatrix} m_1 \\ m_2 \\ m_3 \\ m_4 \end{pmatrix},\quad \mathbf{R} = \begin{pmatrix} r_{11} & r_{12} & \dots & r_{1\,t} \\ 0 & r_{22} & \dots & r_{2\,t} \\ \dots & \dots & \dots & \dots \\ 0 & \dots & 0 & r_{s\,t} \end{pmatrix}$$

The capture probability or the trap efficiency for each period is estimated as the proportion of marked fish that are recaptured from the matrices:

Equation 4 - 4

$$P = p^{-1}$$

Counts of smolts are expanded to estimates of abundance:

Equation 4 - 5

$$n = D_u P$$

where $\mathbf{p} = \mathbf{R}^{-1}\,\mathbf{m}$, $\mathbf{R}^{-1}$ is the inverse of the recapture matrix, n_j are the estimated number of smolts migrating past the trap in the j^{th} recovery period, $\mathbf{D_u}$ is a matrix with elements **u** arranged along the diagonal with zeros elsewhere, and **u** is the number of unmarked fish passing the trap during recovery stratum. The total abundance is estimated by summing the estimated number of unmarked individuals.

Equation 4 - 6

$$N = \sum n_j$$

The variance-covariance matrix for **n** is approximated by:

Equation 4 - 7

$$\operatorname{cov}(n) \sim D_n \theta^{-1} D_u D_m^{-1} (\theta')^{-1} D_n + D_n (D_n - I)$$

where D is the diagonal matrix, **I** is an identity matrix, elements of the vector **u** are calculated $u_i = \Sigma_j (\theta_{ij} / p_j) - 1$, and $\theta = \mathbf{D_m^{-1}\,R\,D_p}$. The estimated variance for the total population estimate is obtained by summing the elements of the variance-covariance matrix for the stratum estimates. Normal confidence limits were calculated from Equation 4 - 7.

Initial data inputs to DARR consisted of a matrix of marks released, recaptures, and captures by week. DARR 2.0 applies a series of algorithms to aggregate data to yield an admissible estimate of abundance while preserving as much of the data structure as possible (Bjorkstedt 2005). To increase the precision of the smolt estimate, the partial pooling option in DARR was implemented. Guidance on appropriate methods of pooling mark and recovery strata are not always clear (Schwarz and Taylor 1998). Two diagnostic chi-square tests were used to determine if pooling adjacent strata was valid (Darroch 1961, Arnason et al. 1996, Schwarz and Taylor 1998). The equal proportions test determines if the ratio of marked to unmarked fish is constant across all strata and the complete mixing test determines if recovery probabilities are constant across all strata. If either test yields P-values greater than 0.05, strata can be pooled. Therefore, 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. Schwarz and Taylor (1998) indicated that recovery strata may be arbitrarily pooled without affecting the consistency of the Petersen estimate. Since the Darroch estimate is only valid when the numbers of tagging and recovery strata are equal, a DARR algorithm pools the recovery strata to match the tagging strata. The purpose of this pooling was to develop homogeneous periods for the population estimate and to increase the precision of the seasonal migration estimate. This the same pooling procedure used for the 1998-2003 smolt estimates.

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. 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 is considered be met in this study except for 9 days from March 26 to April 4 when the trap was not fished due to high water and debris load.

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 Chi-square 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, 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, Carlson et al. 1996, 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).

4.2.3 Contribution of Remote Site Incubator (RSI) to Coho Salmon Smolt Production

Fish First, a local fishing and conservation group implemented habitat restoration projects in the Cedar Creek watershed to increase juvenile salmon and steelhead productivity and capacity. Eggs were collected from adult coho salmon returning in the fall and winter of 2002. Eggs were incubated at Lewis River hatchery and transferred to Washougal Hatchery for otolith marking. Thermal marks were created by manipulating water temperature between the eyed egg and yolk absorption stages. Each time the water temperature is dropped by two to four degrees centigrade, a distinctive black band is deposited in the microstructure of the developing otolith. Exposure to chilled water for periods of 8 to 48 hours will create "bar" codes on the otolith that can be read (Figure 4 - 2). Voucher samples were taken to determine mark quality and form. Otoliths collected from sampling coho salmon smolts were analyzed by WDFW, Science Division, Otolith Laboratory. A total of 420,000 thermally marked eggs for use in remote site incubators (RSI) were given to Fish First (Josua Holowatz, WDFW personal communication).

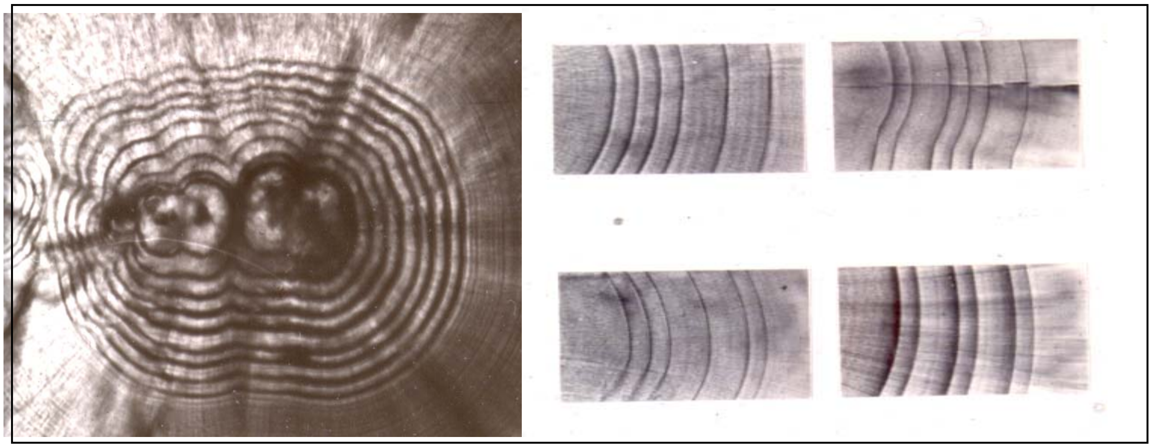

Figure 4 - 2. Thermally marked otolith. (Photo courtesy of Eric Volk, WDFW).

The origin of naturally produced coho salmon smolts were classified as RSI or wild. The proportion of coho salmon smolts in each category was estimated as:

Equation 4 - 8

$$p_k = \frac{n_k}{n_t}$$

Where n_k = the number of wild or RSI otoliths from examined coho salmon smolts, and n_t = the number of analyzed otoliths. The variance of the proportion was estimates as:

Equation 4 - 9

$$V(p_k) = \frac{(p_k(1-p_k))}{(n_t - 1)}$$

Abundance by origin was estimated as:

Equation 4 - 10

$$N * P(Var) = V(N)p_k^2 + V(p_k)N^2 + V(N)V(p_k)$$

where N = coho smolt estimate from natural production and V(N) = the variance of the coho salmon smolt estimate from natural production.

4.3 Results

4.3.1 Assumptions

Assumptions 2 and 3 address equal catchability. In mark-recapture studies, population estimates are made 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. 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.

For steelhead and sea-run cutthroat trout, lengths were grouped by 10mm intervals from 140 to 240mm. If fish were less than 140mm or greater than 240mm, they were assigned to the smallest or largest group to ensure few intervals had less than 5 fish (Quinn and Keogh 2002). Since coho salmon smolts were more smaller and more numerous, intervals ranged from 85 to 160mm based on 5mm increments. Chi-square tests were not significant for sea-run cutthroat (P-value = 0.957, df=10, $\chi 2$ =3.755), steelhead (P-value = 0.394, df=10, $\chi 2$ =10.550), and coho salmon smolts (P-value = 0.827, df=15, $\chi 2$ =9.885) (Figure 4 - 3).

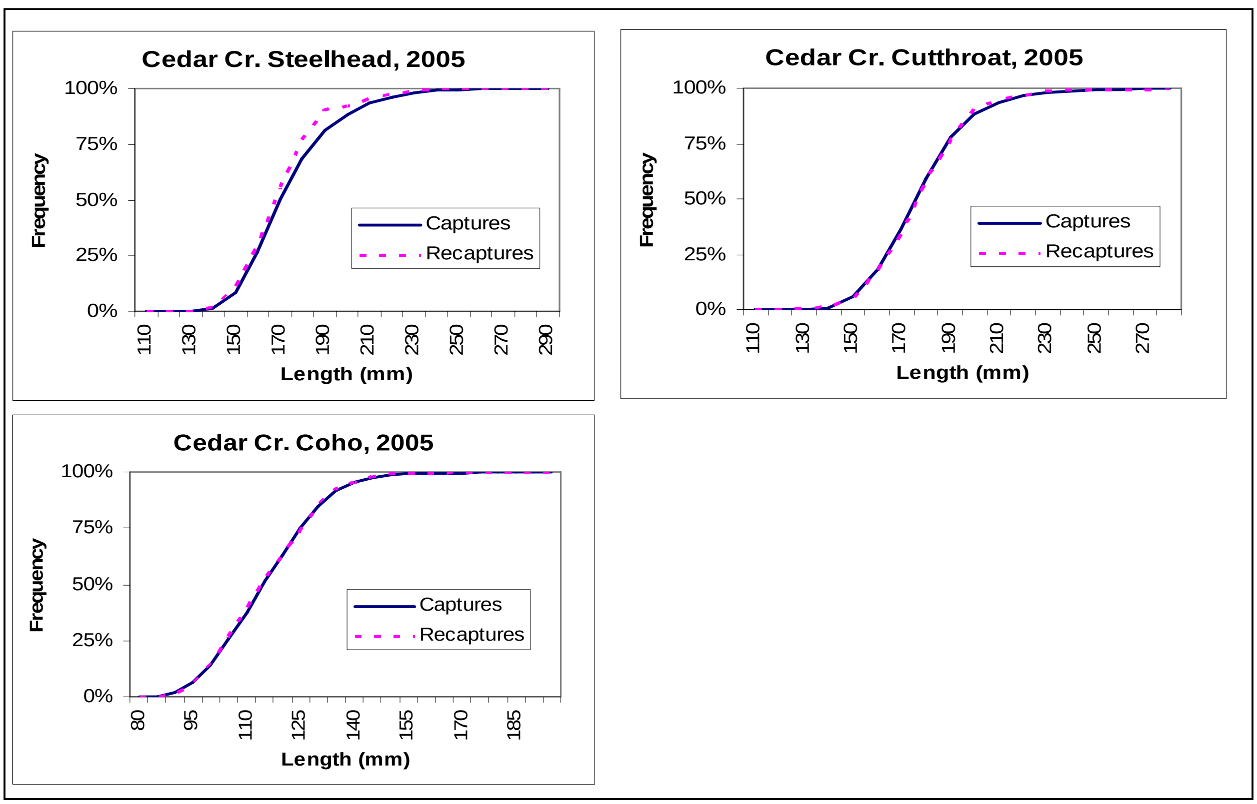

Figure 4 - 3. Comparison of first time captures and recaptures of naturally-produced coho salmon, naturally-produced steelhead, and naturally-produced sea-run cutthroat trout smolts at the Cedar Creek trap in 2005. The solid line indicates maiden captures and the dashed line indicates recaptures.

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. From March 23 to June 12, a total of 105 coho salmon were marked and tagged, and held in a live box for a period of 24 hours after being trapped and marked. Panjet mark retention and survival were 100% indicating the tag loss and mortality assumptions were met. Coded-wire-tag (CWT) retention was 100%.

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 staff did not identify 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 are not significantly biased.

4.3.2 Cutthroat

A total of 914 cutthroat trout classified as pre-smolts and smolts were captured during the trapping period. The mean size for naturally-produced sea-run cutthroat smolts was 178.0mm with a SE of 20.06 (Table 4 - 1). Over the season the weekly mean size declined from 210 to 159 mm between weeks 12 and 24 (Table 4 - 1 and Figure 4 - 4).

Table 4 - 1. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of naturally-produced sea-run cutthroat trout smolts measured by statistical week in Cedar Creek, 2005.

Statistical Week			Mean	s.d.	RANGE		Number	Total	Percent
No.	Begin	End			Min	Max	Sampled	Catch	Sampled
10	03/02/05	03/12/05	154.0	0.00	154	154	1	1	100.0%
11	03/13/05	03/19/05	178.8	40.31	137	242	5	5	100.0%
12	03/20/05	03/26/05	210.3	16.64	189	224	4	4	100.0%
13	03/27/05	04/02/05					0	0	0.0%
14	04/03/05	04/09/05	179.1	18.24	134	225	36	36	100.0%
15	04/10/05	04/16/05	192.2	34.12	137	274	21	22	95.5%
16	04/17/05	04/23/05	189.9	22.54	145	237	78	78	100.0%
17	04/24/05	04/30/05	186.9	24.50	144	274	82	83	98.8%
18	05/01/05	05/07/05	179.8	20.54	120	262	183	188	97.3%
19	05/08/05	05/14/05	175.0	16.20	130	218	246	246	100.0%
20	05/15/05	05/21/05	170.9	14.24	137	221	148	149	99.3%
21	05/22/05	05/28/05	173.8	14.86	146	225	67	67	100.0%
22	05/29/05	06/04/05	167.4	14.28	144	194	17	17	100.0%
23	06/05/05	06/11/05	167.7	9.86	150	187	15	15	100.0%
24	06/12/05	06/18/05	158.7	14.64	143	172	2	3	66.7%
Season Total			178.0	20.06	120	274	905	914	99.0%

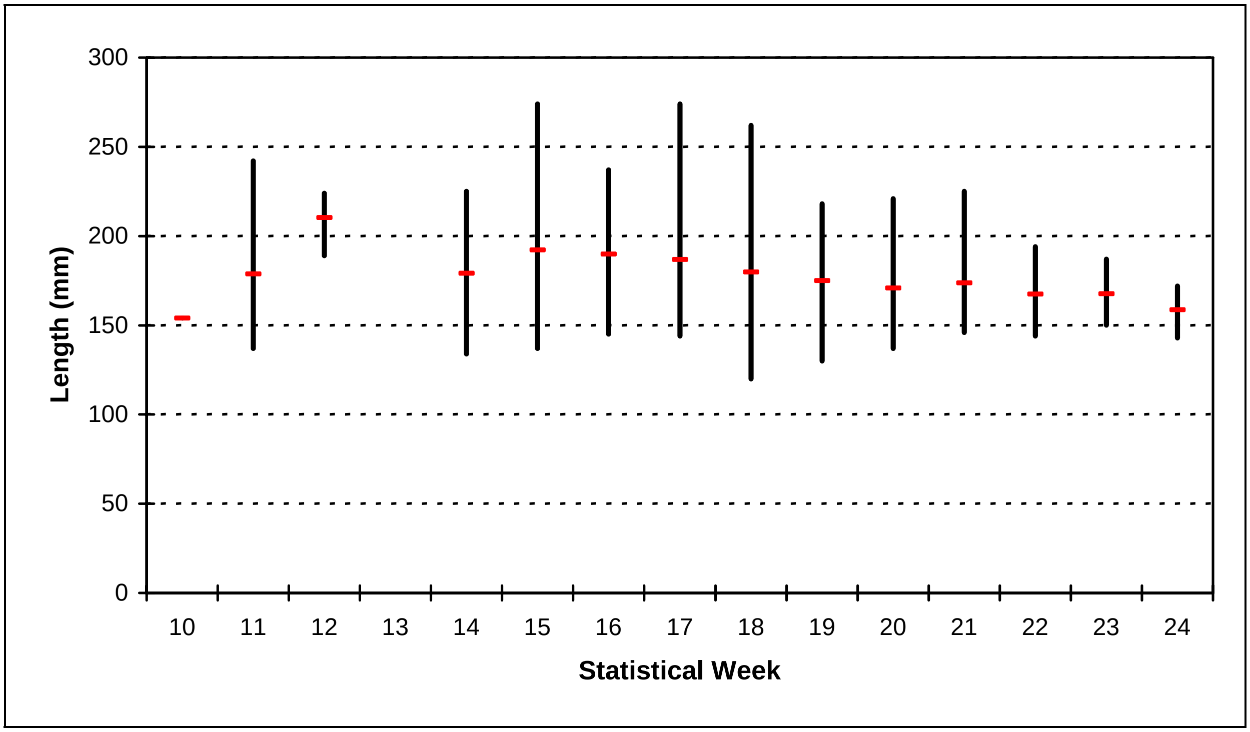

Figure 4 - 4. Weekly average, minimum, and maximum sea-run cutthroat trout smolt fork lengths measured at the Cedar Creek screw trap, 2005.

A total of 921 cutthroat trout were marked for 14 different release groups. The chi-square diagnostic complete mixing and equal proportions tests yielded P-values of 0.027 and 0.043, respectively. Since neither of these P-values exceeded 0.05, the pooled Petersen estimate was not valid. An admissible estimate (5,221, SE = 587) was obtained from DARR when release groups were reduced to six groups. However, chi-square diagnostic tests yielded P-values greater than 0.05 when partial pooling of weeks 10-16 and 17-24 was implemented. The final stratum estimate based on these two periods was 5,085 with a 95% CI from 4,021 to 6,249 for sea-run cutthroat trout smolts (Table 4 - 2). Trap efficiency for naturally-produced sea-run cutthroat smolts was ~9% through week 16 and ~23% from week 17-24. The different trap efficiencies were not unexpected. From week 17 onward the trap was fished at a relatively consistent site at the head of the pool but prior to this trap was located further downstream where it is less efficient at capturing smolts due to lower velocities and sampling a smaller cross-section of the creek. Weekly trap catches increased from statistical week 10 (March 11-12) to week 19, and steadily declined through week 24 (Figure 4 - 5). Peak outmigration occurred during week 19, which corresponds to the period between May 8 and May 14.

Table 4 - 2. Catch and population estimates for sea-run cutthroat trout smolts emigrating past the Cedar Creek Trap during 2005.

Peterson Estimate	Periods	Catch	Smolt Yield	SE	95% CI		CV
					Lower	Upper	
Pooled	1	921	4,410	279.15	3,863	4,957	6.33%
Initial Strata	6	921	5,221	587.85	4,069	6,373	11.26%
Final Strata	2	921	5,085	542.88	4,021	6,149	10.68%

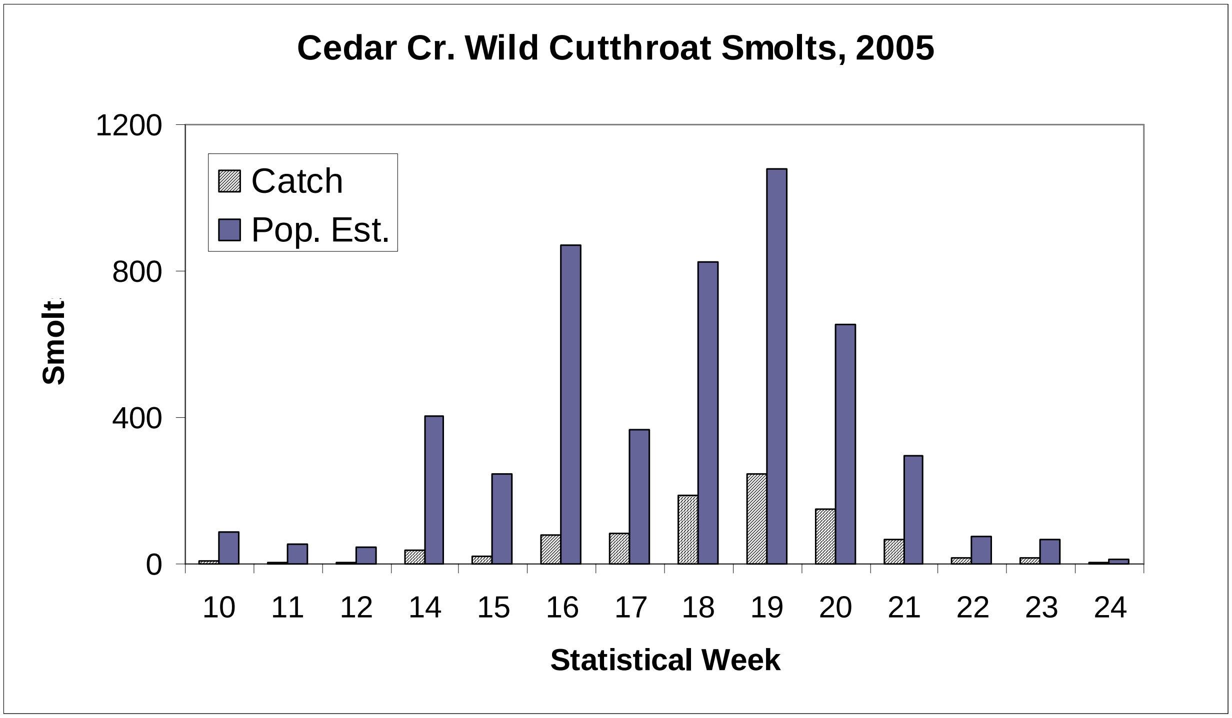

Figure 4 - 5. Weekly catch and population estimates for sea-run cutthroat trout smolts migrating past the Cedar Creek trap in 2005.

4.3.3 Steelhead

A total of 1,080 steelhead trout classified as pre-smolts and smolts were captured during the trapping period. The mean size for naturally-produced steelhead smolts was 176.2 mm (SE = 23.72). As with sea-run cutthroat trout, the mean weekly size declined from 188 mm to 156 mm during the trapping period (Table 4 - 3 and Figure 4 - 6).

Table 4 - 3. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of naturally-produced steelhead smolts measured by statistical week, Cedar Creek, 2005.

Statistical Week			Mean	s.d.	RANGE		Number	Total	Percent
No.	Begin	End			Min	Max	Sampled	Catch	Sampled
10	03/02/05	03/12/05	188.5	14.46	170	200	1	4	25.0%
11	03/13/05	03/19/05	212.3	36.37	182	258	4	4	100.0%
12	03/20/05	03/26/05	176.0	25.65	152	204	7	7	100.0%
13	03/27/05	04/02/05							0.0%
14	04/03/05	04/09/05	193.4	35.93	128	261	36	40	90.0%
15	04/10/05	04/16/05	193.8	29.11	143	260	48	54	88.9%
16	04/17/05	04/23/05	184.3	23.72	138	287	116	116	100.0%
17	04/24/05	04/30/05	177.1	20.63	119	231	99	99	100.0%
18	05/01/05	05/07/05	167.7	15.79	137	247	199	202	98.5%
19	05/08/05	05/14/05	167.0	18.48	124	257	104	108	96.3%
20	05/15/05	05/21/05	168.1	13.25	144	198	15	17	88.2%
21	05/22/05	05/28/05	173.8	22.81	145	198	3	4	75.0%
22	05/29/05	06/04/05	156.0	0.00	156	256	0	1	0.0%
		Season Total	176.2	20.06	119	287	632	656	96.3%

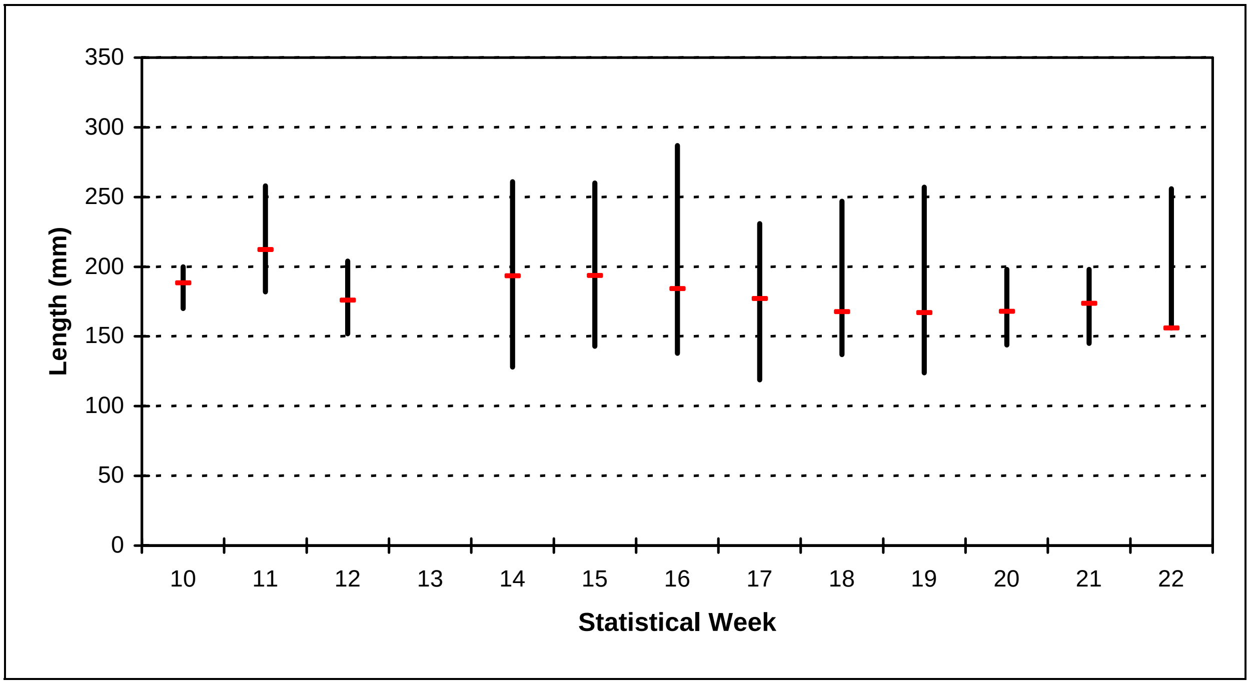

Figure 4 - 6. Weekly average, minimum, and maximum yearling steelhead fork lengths measured at the Cedar Creek screw trap, 2004.

A total of 635 steelhead trout were marked for 12 different release groups (Table 4 - 4). The chi-square diagnostic for complete mixing and equal proportions tests yielded P-values less than 0.001 for each group. The initial estimates from DARR for seven periods was 2,440 with a SE of 233.98. As with the sea-run cutthroat smolts, Chi-square diagnostic tests indicated partial pooling for weeks 10-16, and 17-24 was acceptable yielding a final estimate of 2,372 (SE = 214.10). Since trapping was initiated prior to the smolt outmigration period, no expansion of the estimate was required to obtain a total smolt outmigration estimate. Weekly trap catches increased from statistical week 10 to week 18, and steadily declined through week 21 (Figure 4 - 7). Peak steelhead emigration occurred during week 16 (April 17 – 23), which is 3 weeks earlier than the peak in sea-run cutthroat outmigration,

Table 4 - 4. Catch and population estimates for steelhead smolts emigrating past the Cedar Creek Trap during 2005.

Peterson Estimate	Periods	Catch	Smolt Yield	SE	95% CI		CV
					Lower	Upper	
Pooled	1	635	1,980	109.17	1,766	2,194	5.51%
Initial Strata	7	635	2,440	233.98	1,981	2,899	9.59%
Final Strata	2	635	2,374	214.10	1,954	2,794	9.02%

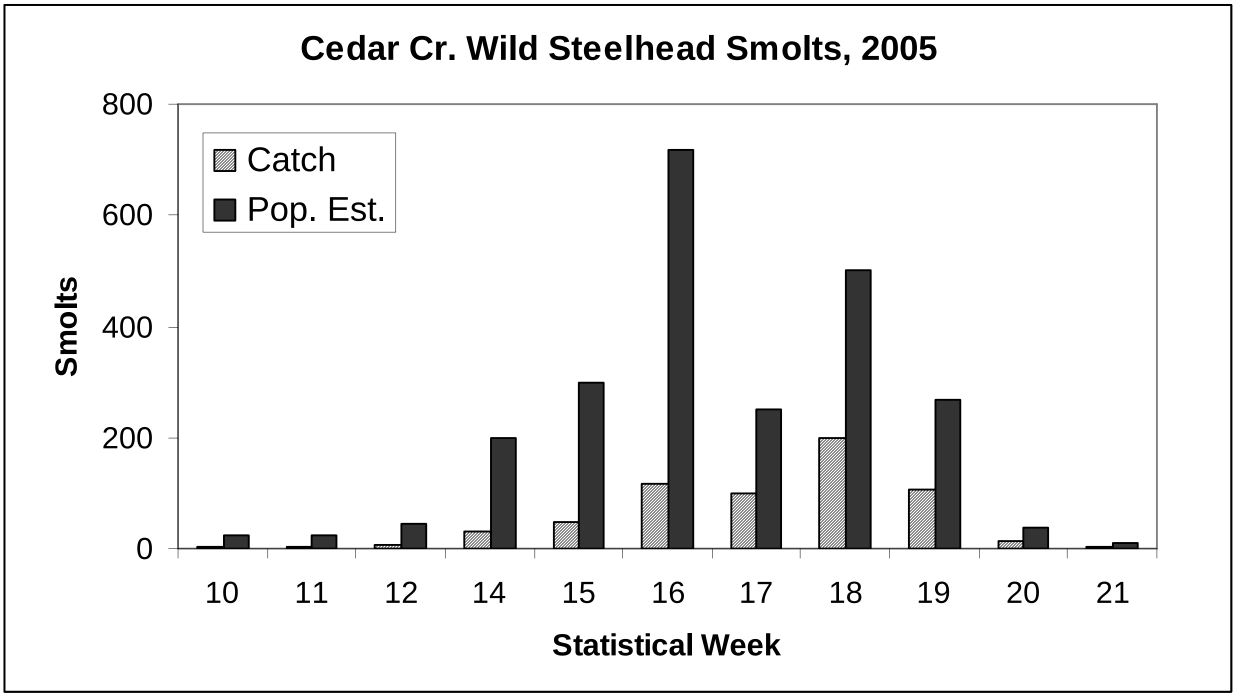

Figure 4 - 7. Weekly catch and population estimates for steelhead smolts migrating past the Cedar Creek trap in 2005.

4.3.4 Coho

Both hatchery and naturally produced coho salmon smolts were found in Cedar Creek. A supplementation program for coho salmon was initiated for Cedar Creek coho salmon to ensure fish could utilize habitat where restoration projects improved access and habitat. Hatchery coho salmon smolt program was discontinued in 2004 but a RSI program is ongoing. A total of 27,337 natural coho salmon classified as pre-smolts and smolts were captured during the trapping period. The mean size for natural coho salmon smolts was 116.2 mm (Table 4 - 5). Over the season the mean weekly size of naturally-produced coho salmon decreased from 126 mm to 97 mm during the trapping period (Figure 4 - 8).

A total of 3,242 natural coho salmon were marked for 15 different release groups. The chi-square diagnostic complete mixing and equal proportions tests yielded P-values of less than 0.001 for both tests, which indicated the pooled Petersen estimate is not valid. An admissible estimate of 58,174 naturally-produced coho salmon smolts was obtained from DARR without pooling. 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 seven periods and population estimates were calculated for these periods separately. The final seven period stratification estimate of the outmigration was 58,921 (SE = 1,572). The 95% CI for the final estimated ranged from 55,840 to 62,002 smolts (Table 4 - 6). Since trapping was initiated prior to the smolt outmigration no expansion of the estimate was required to obtain a total smolt outmigration estimate.

Table 4 - 5. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of naturally produced coho salmon smolts measured by statistical week, Cedar Creek, 2005.

Statistical Week No.	Begin	End	Mean	s.d.	RANGE Min	Max	Number Sampled	Total Catch	Percent Sampled
10	03/02/05	03/12/05	127.3	11.24	115	137	3	3	100.0%
11	03/13/05	03/19/05	122.3	23.10	105	173	2	27	7.4%
12	03/20/05	03/26/05	120.8	17.17	95	184	26	36	72.2%
13	03/27/05	04/02/05					0	0	0.0%
14	04/03/05	04/09/05	125.4	14.67	97	189	215	343	62.7%
15	04/10/05	04/16/05	124.9	12.67	99	178	274	348	78.7%
16	04/17/05	04/23/05	126.6	10.99	93	190	320	1,288	24.8%
17	04/24/05	04/30/05	126.1	10.13	102	157	279	2,642	10.6%
18	05/01/05	05/07/05	122.6	10.43	93	164	320	7,169	4.5%
19	05/08/05	05/14/05	116.5	10.62	85	179	320	7,348	4.4%
20	05/15/05	05/21/05	113.5	12.65	87	195	318	4,946	6.4%
21	05/22/05	05/28/05	109.6	9.67	88	171	320	1,010	31.7%
22	05/29/05	06/04/05	105.5	10.00	85	220	281	1,066	26.4%
23	06/05/05	06/11/05	102.7	9.69	84	158	263	445	59.1%
24	06/12/05	06/18/05	98.8	7.81	84	135	210	304	69.1%
25	06/19/05	06/25/05	96.9	7.64	85	125	40	190	21.1%
		Season Total	116.2	14.32	84	220	3,191	27,165	11.7%

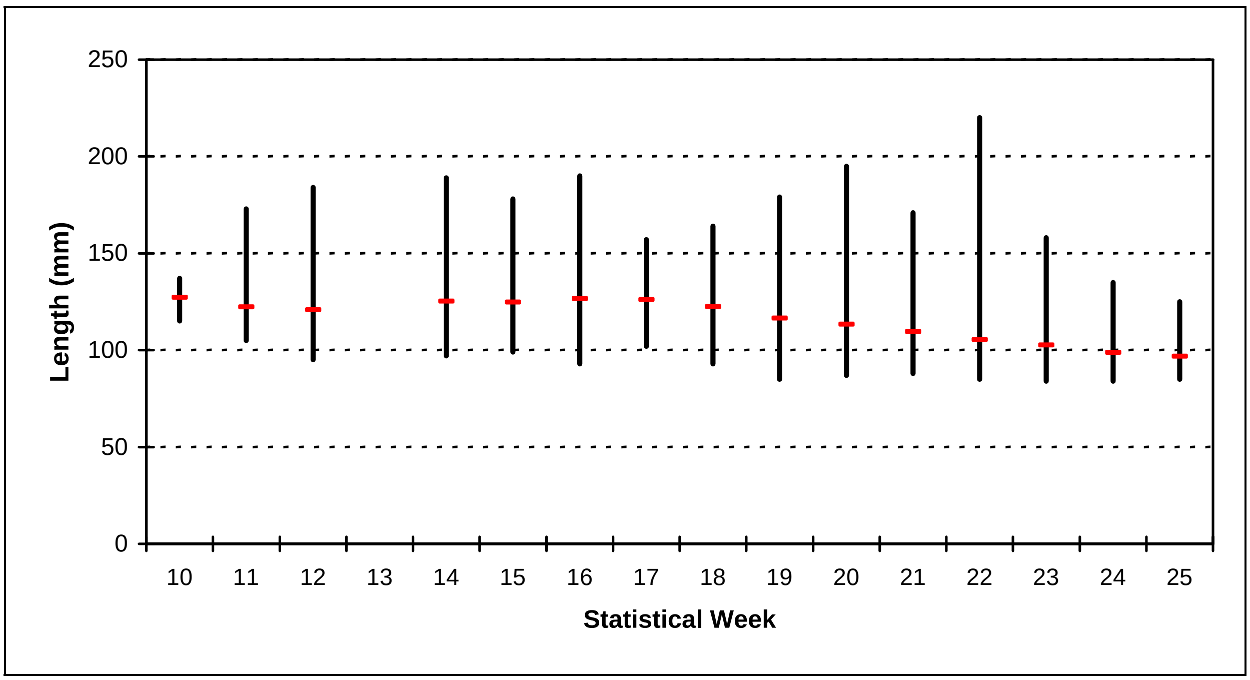

Figure 4 - 8. Weekly average, minimum, and maximum yearling naturally-produced coho salmon fork lengths measured at the Cedar Creek screw trap, 2005.

Coho salmon smolts were collected from May 2 through June 22 using a systematic sampling rate of ~ 1:40. A total of 629 fish were sacrificed for otolith collection and 627 otoliths were analyzed. The results indicate that 524 were collected from adults that spawned in the river and 103 were collected from smolts originating from an RSIs. The estimated natural production was 49,770 smolts with a 95% CI of 45,932 to 53,608 smolts. Production from RSIs totaled 9,151 smolts with a 95% CI from 7,366 to 10,937 smolts. Based on a total of 420,000 thermally marked eggs, the estimated egg to smolt survival was 2.2% with a 95% CI from 1.8% to 2.6%. The peak coho salmon emigration occurred during week 20 (May 15-21) (Figure 4 - 9), which is 4 weeks later than the steelhead outmigration and 1 week later than the cutthroat outmigration.

Table 4 - 6. Catch and population estimates for naturally-produced coho salmon smolts emigrating past the Cedar Creek Trap during 2005.

Peterson Estimate	Periods	Catch	Smolt Yield	SE	95% CI Lower	95% CI Upper	CV
Pooled	1	27,337	59,721	1127.33	57,511	61,931	1.89%
Initial Strata	14	27,337	58,174	1613.20	55,012	61,336	2.77%
Final Strata	7	27,337	58,921	1571.73	55,840	62,002	2.67%

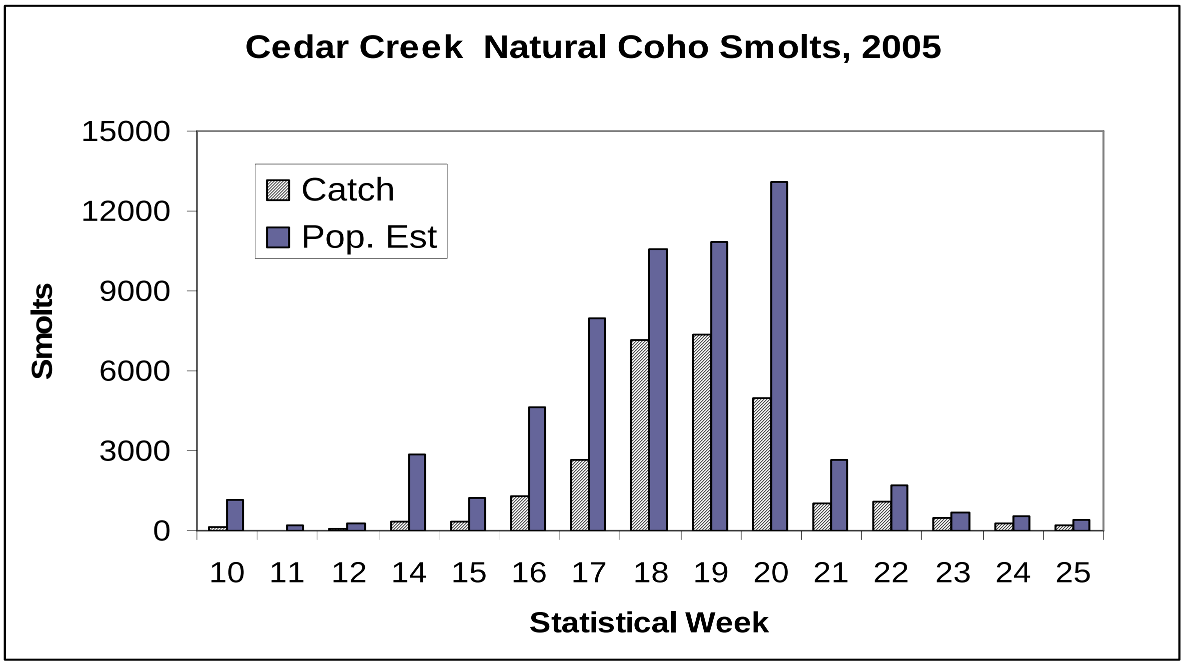

Figure 4 - 9. Weekly catch and population estimates for naturally-produced coho salmon smolts migrating past the Cedar Creek trap in 2005.

4.3.5 Other Species and Life Stages

A total of 15,032 chinook fry were captured at the Cedar Creek trap during its operation period. An additional 135 cutthroat, 73 rainbow/steelhead, and 62 coho salmon parr were trapped. Largemouth bass, bluegill, pumpkinseed, brown bullhead, crappie, sculpins, mountain whitefish, large scale sucker, three-spine stickleback, western brook lamprey, Pacific lamprey, adult steelhead, adult cutthroat, and adult spring chinook were also identified by the sampling crew.

4.4 Discussion

Since the assumptions of the Petersen estimate were met, it's likely the population estimates are relatively unbiased. During the eight trapping days that were missed from March 26 to April 3 and an unknown number of fish passed during this period. Since this is prior to significant migration, the number of fish passing during this time is likely insignificant.

In previous years, the estimated number of hatchery coho salmon smolts 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 entire migration period (Rawding et al. 2004, Rawding and Groesbeck 2005).

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 naturally-produced populations. For naturally-produced cutthroat, steelhead, and coho salmon smolts the CV were 10.7%, 9.0%, and 2.7%, respectively. The precision of population estimates is directly tied to the number of recoveries, and for small populations like sea-run cutthroat and steelhead trout there are no easy solutions to increasing the level of precision other than marking all fish and choosing efficient sites to fish. In 2005, all steelhead and cutthroat smolts were marked and transported upstream. 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 CV was 10.7 and 9.0% compared to the goal of 5%.

Based on simulations (Dan Rawding - WDFW, unpublished), it was estimated that up to 40 coho salmon smolts per day should be used for trap efficiency tests. Catch above this level were tagged with a CWT and released below the trap. The CV for naturally-produced coho salmon was 2.7% and exceeded our precision target of a CV less than 5%.

A total of 26,493 naturally-produced coho salmon smolts were tagged with a 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 naturally-produced Lower Columbia River coho salmon, which are listed as "threatened" 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 after the 2006 adult return.

4.4.1 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 also in the area above the trap. Funding should be provided to estimate the fall chinook outmigration. 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 population estimates could be obtained in Cedar Creek, thereby increasing the value of the juvenile dataset.

3) 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 potentially develop estimates that are less biased and more precise (Schwarz and Dempson 1994, Mantyniemi and Romakkaniemi 2002, Cheng and Gallinat 2004).

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