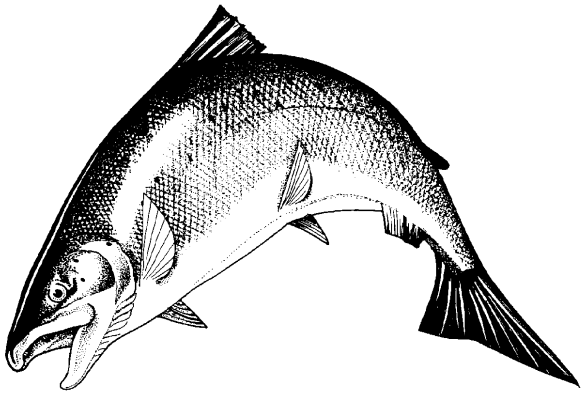
Juvenile Salmonid Production Evaluation Report

Green River and Dungeness River Chinook Monitoring Evaluations in 2007



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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: Bob Green, Josh Weinheimer 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 and a secure staging site near the trap.

Dungeness River

WDFW scientific technicians Chris Burns, Andrew Simmons and Paul Lorenz 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 Clayton Kinsel and scientific technician Bryan 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, anchorage for our trap, 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 juvenile hatchery Chinook for trap calibration tests, logistical support and storage of our office trailer and traps during the off season.

Funding

The Washington State legislature funded monitoring activities on the Green River between 2000 and 2002. Upon request from the legislature, the Washington Salmon Recovery Funding Board (SRFB) has funded smolt monitoring at Green River between 2002 and 2007, and Dungeness River from 2005 to present.

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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 listings occurred between 1997 and 1999 and impacted fisheries and land management over the entire state. In response, the Washington Department of Fish and Wildlife (WDFW) expanded its freshwater salmon production monitoring (smolt monitoring) program in order to improve understanding of the status of listed species and their production trends. During this period, monitoring projects were initiated on Lower Columbia River steelhead in Cedar Creek and Puget Sound Chinook in the Green River and the Dungeness River. The Salmon Recovery Funding Board (SRFB) has funded smolt monitoring on the Green River and Cedar Creek since 2002, and the Dungeness River since 2006. This report provides results from smolt monitoring activities that occurred on these three streams during the 2007 field season.

Green River

The Green River screw trap, located 55-km upstream of the river mouth, was operated from January 23 through July 15, 2007. The primary objective of the Green River project was to estimate the juvenile migration of Puget Sound Chinook of natural origin. A secondary objective was to estimate the migration of other salmonids produced above the screw trap.

Production estimates were made using a stratified mark-recapture approach. For each time strata, a Petersen estimator calculated juvenile migration and its variance based on catch, number of fish that were marked and released, and number of marked fish that were recaptured. Catch included estimated catch during trap outage periods. Catch data were pooled into time periods that retained variation in trap efficiency but minimized error in the production estimates caused by low recapture rates.

An estimated 120,257 ±18,118 (95% C.I.) natural-origin sub-yearling Chinook migrated during the trapping period, with an additional 1,037 Chinook estimated to have migrated after the trap ceased operation. Timing of the Chinook outmigration was bimodal. Fry migrants (40 to 45-mm FL), representing 70% of the catch, migrated between January and mid-April. Parr migrants (49 to 94-mm FL), representing 30% of the catch, outmigrated May through July. The Chinook migration estimate, which reflected production above the trap, was expanded to produce a basin-wide production estimate of 167,095 natural-origin sub-yearling Chinook. Egg-to-migrant survival of the 2006 brood of Green River Chinook was estimated to be 0.85%.

The 2007 outmigration of juvenile salmonids included 22,671 ± 7,936 (95% C.I.) natural-origin coho smolts and 2,285 natural-origin steelhead smolts. Production of chum was estimated to be 2,889,090 ± 614,765 (95% C.I.); however, a large portion of the migrants were unmarked chum fry from Keta Creek Hatchery releases.

Production of Chinook, coho, and steelhead were the lowest, or nearly the lowest, of the eight consecutive years these populations have been evaluated.

Dungeness River

The Dungeness River screw trap, located 0.5-RKm upstream of the river mouth, was operated from February 21 through August 19, 2007. The primary objective of the Dungeness River project was to estimate the juvenile migration of Puget Sound Chinook of natural origin. A secondary objective was to estimate the migration of other salmonids produced above the screw trap.

Production estimates for Chinook and chum were based on a single-trap mark-recapture design. Chinook and chum were marked and recaptured at the screw trap. Population estimates for coho and steelhead were based on a two-trap design and a simple-pooled Petersen estimation. Coho and steelhead were marked and released from a fence weir trap on Matriotti Creek and recaptured at the screw trap. The Petersen estimator calculated juvenile migration and its variance based on catch, number of fish that were marked and released, and number of marked fish that were recaptured.

An estimated 136,571 ± 37,290 (95% C.I.) natural-origin sub-yearling Chinook migrated during the trapping period. Timing of the natural-origin Chinook outmigration was bimodal. Fry migrants (40 to 45-mm FL), representing 43% of the catch, migrated between February and mid-April. Parr migrants (46 to 91-mm FL), representing 57% of the catch, migrated between May and August.

The 2007 outmigration of juvenile salmonids included 22,134 ± 2,068 (95% C.I.) natural-origin coho smolts, 11,445 ± 1,751 (95% C.I.) natural-origin steelhead smolts, and 381,781 ± 100,070 (95% C.I.) natural-origin chum fry.

Chinook juvenile migrants were the most abundant and coho juvenile migrants were the least abundant observed in the three years that juvenile migrants have been monitored on the Dungeness River. Both trends are likely due to inter-annual variation in spawner abundances.

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), and impacted 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 in order to improve understanding of the status of listed populations, environmental impacts on salmonid production, and responses to recovery efforts by ESA-listed populations.

This annual report describes the juvenile salmonid monitoring occurring on the Green River and Dungeness River during the 2007 field season. These rivers represent geographically diverse region of Western Washington. The Green River flows westward from the Cascade Mountains into southern Puget Sound. The Dungeness River flows northward from the Olympic Mountains into the Strait of Juan de Fuca. Monitoring was initiated in 2000 on the Green River, and in 2005 on the Dungeness River.

The primary objective for trapping operations is to estimate juvenile production of ESA-listed species in each river. The secondary objective is to estimate production of other salmonids in each river. Production was measured by the juvenile outmigration passing the trap site. Long-term monitoring activities on each river allow production estimates to be interpreted in terms of both historical numbers and environmental covariates.

2 Green River

2007 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 to capture downstream migrant salmonids on the Green River. The trap was located on the left bank at river kilometer (RKm) 55, approximately 975-m upstream of the Highway-18 bridge (Figure 2 - 1). This trap is fully described in Seiler *et al*. 2002.

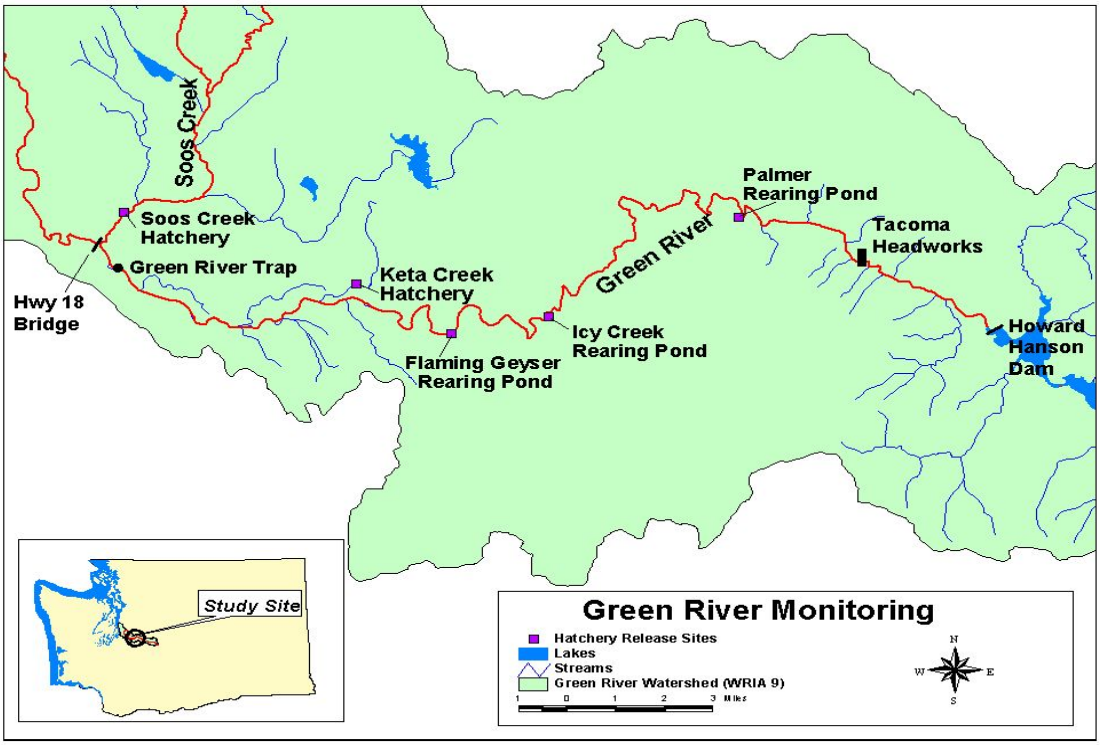

Figure 2 - 1. Map of the screw trap location relative to existing hatcheries and hydro projects on the Green River.

The Green River trap was operated between January 23 and July 15, 2007, except for periods when high flows, excessive debris and mechanical failure precluded trapping. Late in the trapping season, trap operations were also suspended during daytime periods to accommodate high recreational use of the river. Overall catches were low during this latter period. The trap was checked for fish at dawn and dusk each day and at additional times when debris loads or catches required. At the end of each trapping period, all captured fish were identified to species, measured, and enumerated. Fork length (FL) was measured from a subsample of each natural-origin salmonid species.

Juvenile salmon caught in our traps were either natural or hatchery origin. These two groups were distinguished based on the presence (natural) or absence (hatchery) of an adipose fin (ad-mark). Hatchery-origin salmonids were released from one of seven hatcheries (Table 2 - 1). Ad-

marking of hatchery fish has an associated error rate (proportion of unmarked fish), and without an ad-mark, natural-origin fish can not be distinguished from unmarked hatchery-origin fish. In 2007, however, releases of unmarked hatchery Chinook, coho, and steelhead were low (Table 2 - 1). Therefore, we disregarded hatchery marking error when estimating natural-origin and hatchery-origin production of these species. In contrast, chum migrants included a high proportion of unmarked hatchery fry, and a combined natural and hatchery-origin production estimate was derived for chum.

Table 2 - 1. Hatchery releases that could have contributed to catches in the Green River screw trap, 2007. Hatchery fish were marked with a coded-wide tag (CWT), ad-mark, or both.[a]

Species	Release Date(s)	Release Location	Brood Year	CWT Only	CWT Ad-mark	Ad-mark Only	Unmarked	Total Release
2006 Releases Above Howard Hanson Dam								
Chinook	3/16-5/3	Howard Hanson Dam	2005			467,875	24,625	467,875
2007 Releases								
Chinook	3/30-4/11	Howard Hanson Dam	2006			333,666	19,934	353,600
	5/1	Icy Creek	2005		95,779	226,941	5,950	328,670
	5/22-6/6	Soos Creek	2006		204,525	2,987,000	475	3,192,000
Coho	4/23-5/14	Keta Creek	2005	502	47,492	314,506	3,160	365,660
	4/20	Soos Creek	2005	378	89,974	412,277	1,723	504,352
Steelhead	5/1	Soos Creek Winter	2005			61,768	432	62,200
	4/16-5/8	Palmer Summer	2005			27,264		27,264
	4/16-5/8	Palmer Winter	2005			182,469		182,469
	5/1	Icy Creek Summer	2005			26,953	347	27,300
	5/1	Icy Creek Winter	2005			7,898	102	8,000
	5/5	Flaming Geyser Smr	2005			4,936	64	5,000
	5/5	Flaming Geyser Wtr	2005			1,975	25	2,000
Chum	3/17-6/1	Keta Creek	2006			98,700	2,792,300	2,891,000

[a] All release sites are upstream of the screw trap except Soos Creek. Soos Creek enters the Green River approximately 0.8 km downstream of our trap; however a few individuals from these releases have contributed to our catches in previous years (Source: Regional Mark Information System, www.rmpc.org).

Trap efficiency is the percent of the total migration sampled by the trap and is measured by recapture rates of marked juvenile salmonids released above the trap. Captured fish were anesthetized with tricaine methanesulfonate (MS-222) and marked with either Bismarck-brown dye or with a partial caudal fin clip. The position of the fin clip was periodically changed to facilitate stratification. Marked fish were allowed to recover in fresh water, transported 150-m upstream of the trap and released. Trap efficiencies are known to differ among species and between natural- and hatchery-origin fish and were therefore calculated separately for each species (Chinook fry, chum fry, coho smolts) using natural-origin fish when possible. Early in the trapping season (prior to adequate catches of natural-origin Chinook fry), ten groups of hatchery-origin Chinook from the Soos Creek Hatchery were marked and released upstream from the trap. Trap efficiencies were measured at least once each statistical week, except two weeks in late April when catches were low.

2.1.2 Production Estimate

Production estimates were made using a stratified mark-recapture approach. The Petersen method, modified by Chapman (1951), was used to estimate smolt abundance. Smolt abundance during each time period *i* is estimated by:

Equation 2 - 1

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

where,

U_i = Migration of unmarked fish passing the trap during time period *i*
u_i = Unmarked fish captured during time period *i*
M_i = Marked fish released above the trap during time period *i*
m_i = Marked fish recaptured during time period *i*

Seber (1982) provides an approximate unbiased estimate of the variance:

Equation 2 - 2

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

Total production, based on the entire smolt outmigration, is estimated as:

Equation 2 - 3

$$\hat{N} = \sum_{i=1}^{n} \hat{U}_i$$

where *n* is the total number of time intervals. Similarly, total variance ($V(\hat{N})$) is estimated from the sum of the variances for each $\hat{U}_i$. The confidence interval about *N* is:

Equation 2 - 4

$$\hat{N}_{95\%ci} = \hat{N} \pm 1.96\sqrt{V(\hat{N})}$$

The Petersen method for estimating population abundance is based on assumptions that (1) the population is geographically closed with no immigration or emigration, (2) the population is demographically closed with no births or deaths, (3) marking does not change fish behavior or vulnerability to capture, (4) marked fish mix randomly with unmarked fish, (5) no marks are lost or missed, and (6) all fish have an equal probability of capture during the fishing period (Seber 1982). The assumption of a geographically-closed population is violated at some level as all fish are emigrating; however, a temporal closure is obtained because the trap operates over the entire outmigration and outmigrants must pass a fixed point (i.e., the trap). Assumptions 2-5 were reasonably met by our study design. Assumption 6 is discussed below.

We address three additional issues in our analytical approach. First, our study design violates the assumption that marked fish and unmarked fish have the same probability of capture during each

fishing period. Second, the screw trap did not fish 24-hours a day, and trap outages periodically occurred during trap checks, high water events, and periods of high recreational use of the river. Third, low recapture rates for some time periods required pooling of recapture data across multiple time periods in order to calculate trap efficiency and produce a migration estimate. Accommodations for these issues are discussed below.

The assumption that marked fish and unmarked fish have the same probability of capture during each fish period was not necessarily met by our study. Recaptures of marked Chinook, coho, and chum salmon in the Green River occurred during a relatively short period (e.g. a few hours after release), whereas the unmarked catches they represent may occur over a longer period. Catch was also estimated for trap outage periods. In this case, total catch during a fishing period($\hat{u}_i$) is substituted for u_i in Equation 2 - 1 and Equation 2 - 2. The variance, $V(\hat{U}_i)$, is now estimated using (see 2.4 Appendix A for derivation):

Equation 2 - 5

$$V(\hat{U}_i) = Var(\hat{u}_i)\left(\frac{(M_i+1)(M_i m_i + 3M_i + 2)}{(m_i+1)^2(m_i+2)}\right) + \left(\frac{(M_i+1)(M_i - m_i)\hat{u}_i(\hat{u}_i + m_i + 1)}{(m_i+1)^2(m_i+2)}\right)$$

Because the trap did not fish continuously, total catch during each fishing period (u_i) was calculated as the sum of the enumerated catch (C_i) and the estimated catch ($\hat{C}_i$) for that fishing period. Estimated catch ($\hat{C}_i$), for trapping intervals not fished, was the mean catch rate ($\overline{R}_j$) expanded by the hours not fished (T). Mean catch rates were calculated from catch rates (R_{ij}) of fishing periods within the same diel stratum. Diel migration rates were partitioned because salmonids often migrate at different rates between day and night periods (Seiler *et al.* 1981). Night diel strata were from dusk to dawn and the day diel strata were from dawn until dusk. Catch rate for a given fishing period is defined as:

Equation 2 - 6

$$R_{ij} = \frac{C_{ij}}{T_{ij}}$$

where:

R_{ij} = Catch rate during fishing period i in diel stratum j
C_{ij} = Catch during fishing period i in diel stratum j
T_{ij} = Duration of fishing period i in diel stratum j

Variance of the mean catch rate is:

Equation 2 - 7

$$V(\overline{R}_j) = \frac{\sum_{i=1}^{i=n}(R_{ij} - \overline{R}_j)^2}{n(n-1)}$$

Variance associated with an estimated catch is:

Equation 2 - 8

$$V(\hat{C}_i) = V(\overline{R}_j)\hat{T}^2$$

Catch data used to produce population estimates were pooled into time periods that retained information reflecting trap efficiency variation and minimized error in the production estimate caused by low recapture rates. Mark groups were pooled using DARR software (Bjorkstedt 2005), which uses catch, release, and recapture information to aggregate adjacent time periods. DARR groups time periods based on four sequential criteria: 1) aggregation of time periods minimizes the number of "delayed" recaptures (i.e., those occurring outside the time period when marked fish were released), 2) aggregation of time periods ensures that at least one fish released in a time period is recaptured in that time period, 3) aggregation of time periods is necessary if the mean number of recaptures occurring in each time period is less than the ratio of the largest to the smallest number of recaptures, and 4) aggregation of time periods is necessary to eliminate strata with impossible trap efficiencies (i.e., <0 or >1) (Bjorkstedt 2005).

2.1.3 Survival

Egg to migrant survival was estimated for age 0+ Chinook. Egg-to-migrant survival was the number of migrants divided by potential egg deposition (P.E.D.) and converted to a percentage. Number of migrants were production estimates described above. Egg deposition was based on female spawning escapement above the trap site (RKm 55) and an estimated Chinook fecundity of 4,500 eggs per female. Spawning escapement data were provided by Steve Foley (WDFW Biologist, Region 4).

2.2 Results

The Green River screw trap was operated 3,611 of 4,149 possible hours, or 87% of the time, between January 23 and July 15, 2007. Trap operations were suspended four times during the season for high flows, heavy debris, and trap damage. Trap operations were also suspended during daytime hours between May 29 and the end of the trapping season (355 hours over 26 days) because recreational use of the river was high and few fish were being captured.

2.2.1 Chinook

2.2.1.1 Catch

A total of 6,421 natural-origin sub-yearling Chinook were caught over the 173-day trapping interval (2.4 Appendix B 1). One yearling Chinook was also caught. Catch of natural-origin Chinook was bimodal. The trapping season included the majority of the migration; however, some fish were already migrating on January 23 (12 migrants per day) and some continued to migrate after the trap was removed from the water on July 14 (38 migrants per day). The first peak occurred on March 16 (113 migrants per day); the second peak occurred on June 6 (200 migrants per day). Daily catches were low between the third week of April (6 migrants per day) and third week of May (13 migrants per day). Daily catches of natural-origin fish were also low by early July.

2.2.1.2 Catch Expansion

Expanded catch was estimated at 7,034 age 0+ natural-origin Chinook. This estimate included an additional 473 Chinook that should have been caught had the trap operated continuously during the season and an additional 139 Chinook that should have been caught had the trapping continued through the end of the Chinook migration. Catch estimated after trap removal was based on daily catches of natural-origin Chinook (average 33 per day) over the final four days of the season, a migration end date of July 31, and a logarithmic extrapolation.

2.2.1.3 Trap Efficiency

Trap efficiency for sub-yearling Chinook averaged 11.7% over the season. A total of 7,411 0+ Chinook were marked and released in 107 groups. Release groups ranged from 1 to 400 fish and were pooled to form 22 strata (Table 2 - 2). Release groups included both natural-origin and hatchery-produced fish. In total, 2,754 hatchery-origin Chinook were used for mark-recapture estimates; the remainder were natural-origin Chinook. Recapture rates for the 22 strata averaged 7.3% for the season (1.8 to 45.2%, Table 2 - 2). There was no apparent relationship between flow (3.3 to 177 cubic meters per second) and efficiency. Release groups were marked with Bismark Brown dye prior to May 13, and a partial caudal fin-clip after this date.

Table 2 - 2. Catch, efficiency, and production estimates of juvenile Chinook at the Green River screw trap in 2007. Release groups were pooled to form 22 strata.

Strata	Dates	Total Catch		Efficiency data				Migration	
		Catch	Variance	Pooled	Rate	Marked	Recaptured	Number	Variance
1	1/23-1/30	88	0.000	2	1.8%	799	14	4,746	1.58E+06
2	1/31-2/3	45	0.000	1	2.0%	400	8	2,049	4.72E+05
3	2/4-2/6	74	0.000	1	4.0%	299	12	1,730	2.34E+05
4	2/7-2/13	436	0.000	4	4.0%	480	19	10,509	5.25E+06
5	2/14-2/16	291	413.195	1	17.9%	78	14	1,537	1.37E+05
6	2/17-3/7	785	12.723	10	1.9%	1,237	24	38,922	5.88E+07
7	3/8-3/18	729	958.944	7	4.8%	396	19	14,490	1.01E+07
8	3/19-3/31	387	64.525	9	8.9%	281	25	4,207	6.40E+05
9	4/1-4/18	404	0.000	11	5.9%	320	19	6,499	1.97E+06
10	4/19-6/4	617	12.750	25	7.2%	332	24	8,231	2.50E+06
11	6/5	129	0.000	1	45.2%	42	19	279	2.26E+03
12	6/6	200	0.000	1	25.4%	130	33	773	1.47E+04
13	6/7	103	0.000	1	21.3%	197	42	478	5.67E+03
14	6/8-6/9	215	0.000	2	14.2%	204	29	1,475	6.77E+04
15	6/10-6/11	215	0.000	2	14.1%	249	35	1,499	6.02E+04
16	6/12-6/15	333	0.000	4	13.9%	280	39	2,345	1.28E+05
17	6/16	96	0.000	1	15.5%	110	17	597	1.84E+04
18	6/17-6/18	216	2.967	2	11.9%	235	28	1,765	1.03E+05
19	6/19-6/26	590	5.078	7	6.2%	534	33	9,299	2.44E+06
20	6/27-7/1	407	0.685	5	8.5%	386	33	4,643	6.06E+05
21	7/2-7/4	159	2.685	2	10.3%	116	12	1,439	1.41E+05
22	7/5-7/15	375	1.803	8	13.4%	306	41	2,747	1.68E+05
Season Total		6,894	1,475.354	107	11.7%	7,411	539	120,257	8.55E+07

2.2.1.4 Production Estimate

A total of 120,257 ±18,072 (95% C.I.) natural-origin 0+ Chinook are estimated to have passed the screw trap between January 23 and July 15, 2007 (Table 2 - 3, Figure 2 - 2). An additional 1,037 natural-origin Chinook are estimated to have passed the trap site after July 15. Post-trap estimate was based on a final strata efficiency rate of 13.40% applied to estimated missed post-season catch, (Table 2 - 3).

Table 2 - 3. Summary of natural-origin subyearling Chinook passing the Green River screw trap in 2007.

Type	Period	Catch			Migration Estimate	CV	95% CI		Migration Variance
		Actual	Estimated	Total			Low	High	
Natural-Origin									
Early	1/23-4/18	2,811	428	3,239	84,687	10.51%	67,293	102,082	7.9199E+07
Late	4/19-7/14	3,610	45	3,655	35,570	7.03%	30,668	40,472	6.2573E+06
Total Catch		**6,421**	**473**	**6,894**	**120,257**	**7.69%**	**102,185**	**138,329**	**8.5456E+07**
Post-Trap	7/15-7/31		139	139	1,037	21.28%	1,004	1,071	2.9134E+02
Total		**6,421**	**612**	**7,033**	**121,295**				

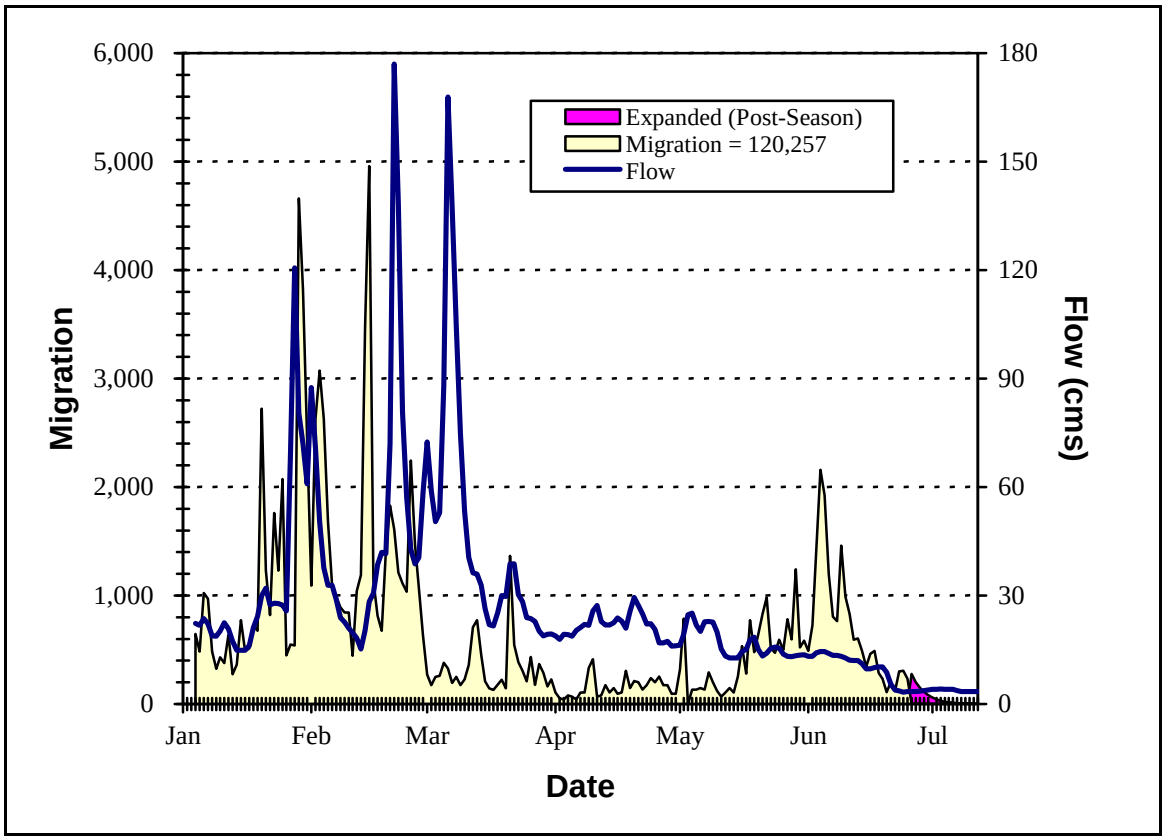

Figure 2 - 2. Daily migrations of natural-origin 0+ Chinook in the Green River screw trap and stream discharge (USGS gage# 12106700 located near Palmer, Washington) between January 23 through July 31, 2007. Daily migration estimate is the daily catch expanded by the efficiency of each pooled time strata.

2.2.1.5 Size

From statistical week 4 to 13, lengths of natural-origin 0+ Chinook consistently averaged between 40 and 43-mm fork length (FL). This period encompassed the first peak in outmigration (Strata 1-8 in Table 2 - 2). This first outmigration will hereafter be referred to as the "fry migration". Around statistical week 14 (first week in April), natural-origin 0+ Chinook were caught at larger sizes each week (average increase of 3-mm FL per week). By the peak of the second outmigration (statistical week 25), average natural-origin 0+ Chinook were larger than 89-mm FL (Table 2 - 4, Figure 2 - 3). This second outmigration will hereafter be referred to as the "parr migration".

Using statistical week 14 as the transition between the fry and parr components of the Chinook outmigration, 70% migrated as fry and 30% migrated as parr.

Table 2 - 4. Mean fork length (mm), standard deviation (s.d.), range, and sample size of natural-origin 0+ Chinook caught in the Green River screw trap in 2007.

Statistical Week			Mean	s.d.	Range		Number		Percent
No.	Begin	End			Min	Max	Sampled	Captured	Sampled
4	01/22/07	01/28/07	40.8	1.20	39	43	18	73	24.7%
5	01/29/07	02/04/07	40.7	1.40	39	43	9	81	11.1%
6	02/05/07	02/11/07	41.0	1.10	39	43	14	352	4.0%
7	02/12/07	02/18/07	41.0	1.60	39	44	12	447	2.7%
8	02/19/07	02/25/07	41.1	1.60	39	44	10	279	3.6%
9	02/26/07	03/04/07	39.7	2.10	37	43	7	124	5.6%
10	03/05/07	03/11/07	41.7	2.00	39	44	6	386	1.6%
11	03/12/07	03/18/07	40.5	1.70	38	43	13	349	3.7%
12	03/19/07	03/25/07	42.8	1.70	41	46	6	164	3.7%
13	03/26/07	04/01/07	42.6	3.40	39	51	10	200	5.0%
14	04/02/07	04/08/07	45.7	7.10	39	58	7	92	7.6%
15	04/09/07	04/15/07	44.7	5.20	38	54	14	213	6.6%
16	04/16/07	04/22/07	45.3	4.60	39	54	14	83	16.9%
17	04/23/07	04/29/07	49.3	8.00	40	64	9	86	10.5%
18	04/30/07	05/06/07	68.2	12.80	39	81	11	58	19.0%
19	05/07/07	05/13/07	78.7	12.60	56	96	10	106	9.4%
20	05/14/07	05/20/07	76.2	7.00	63	85	9	98	9.2%
21	05/21/07	05/27/07	78.4	9.40	61	88	9	122	7.4%
22	05/28/07	06/03/07	80.4	12.70	59	110	15	63	23.8%
23	06/04/07	06/10/07	90.9	11.30	70	120	18	828	2.2%
24	06/11/07	06/17/07	88.9	9.30	70	108	55	654	8.4%
25	06/18/07	06/24/07	88.9	7.40	72	108	47	518	9.1%
26	06/25/07	07/01/07	94.4	7.50	76	110	30	520	5.8%
27	07/02/07	07/08/07	90.4	6.30	79	105	25	355	7.0%
28	07/09/07	07/15/07	88.4	3.50	83	93	8	170	4.7%
Season Total			59.7	5.79	37	120	386	6,421	6.0%

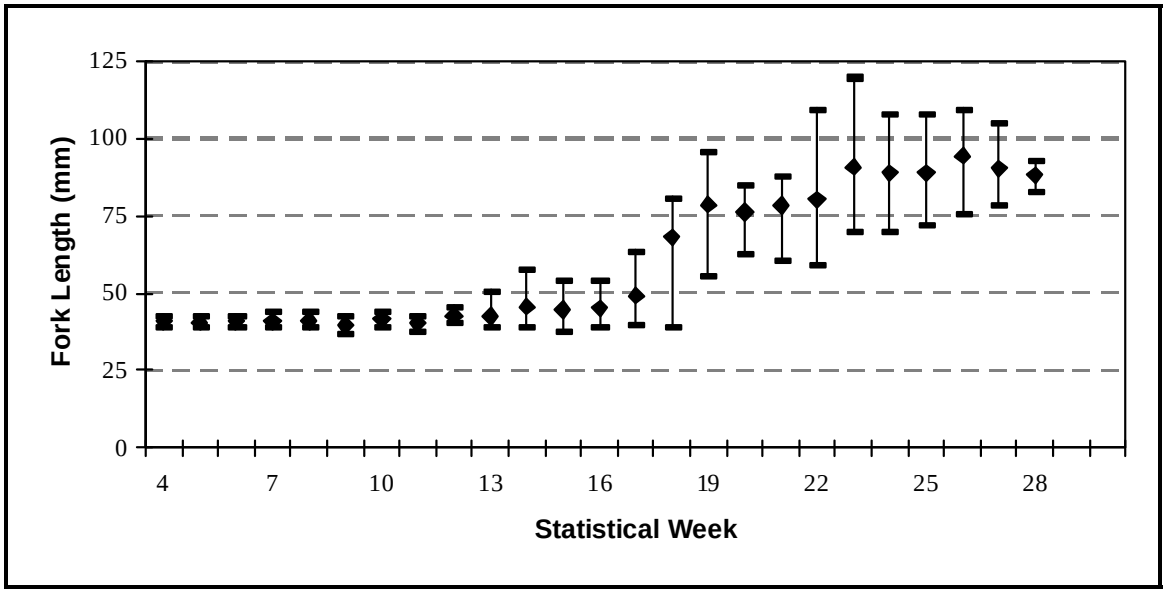

Figure 2 - 3. Fork lengths of natural-origin 0+ Chinook by statistical week at the Green River screw trap in 2007. Data are mean, minimum, and maximum values.

2.2.1.6 Survival

Egg-to-migrant survival of natural-origin 0+ Chinook (brood year 2006) was estimated at 0.85%. This calculation was based on the estimated outmigration passing the trap (121,295 natural-origin 0+ Chinook migrants) divided by the P.E.D. above the trap site (14.2-million eggs). The number of eggs above the trap site was based on an estimated 3,170 females spawning in Fall 2006 (includes Neuwaukum Creek, pers. comm. Steve Foley, WDFW Fish Biologist, Region 4).

2.2.2 Coho

2.2.2.1 Catch

A total of 957 natural-origin coho smolts were captured between January 25 and June 26, 2007 (2.4 Appendix B 2). Catches remained low through the end of March, increased in April, and peaked on May 1 (59 smolts/day). Catches remained steady through the first half of May (average 23 smolts/day) and then declined over the rest of the season.

2.2.2.2 Catch Expansion

Expanded catch was estimated at 963 natural-origin coho outmigrants, an increase of 0.6% (6 coho) over the actual catch.

2.2.2.3 Trap Efficiency

Average seasonal trap efficiency for natural-origin coho smolts was 5%. A total of 836 natural-origin coho smolts were marked and released in 98 groups (Table 2 - 5). Release groups were pooled to form six strata. No relationship existed between flow (12.7 - 177.0 cms) and trap efficiency.

Table 2 - 5. Catch, trap efficiency, and migration estimate of natural-origin coho stratified by pooled release groups for the Green River screw trap, 2007.

Strata	Dates	Estimated Catch	Efficiency data				Migration	
			Pooled	Rate	Marked	Recaptured	Number	Variance
1	1/23-4/8	78	28	6.67%	75	5	1,000	1.400E+05
2	4/9-4/27	187	16	4.29%	140	6	3,786	1.749E+06
3	4/28-5/4	222	5	4.26%	141	6	4,523	2.486E+06
4	5/5-5/13	222	9	2.30%	217	5	8,101	9.283E+06
5	5/14-6/4	155	21	3.01%	166	5	4,341	2.663E+06
6	6/5-6/27	93	19	9.28%	97	9	920	7.510E+04
Yearlings		**957**	**98**	**4.97%**	**836**	**36**	**22,671**	**1.640E+07**

2.2.2.4 Production Estimate

A total of 22,671 ± 7,936 (95% C.I.) natural-origin coho are estimated to have passed the trap between January 23 through July 15, 2007 (Table 2 - 5, Figure 2 - 4).

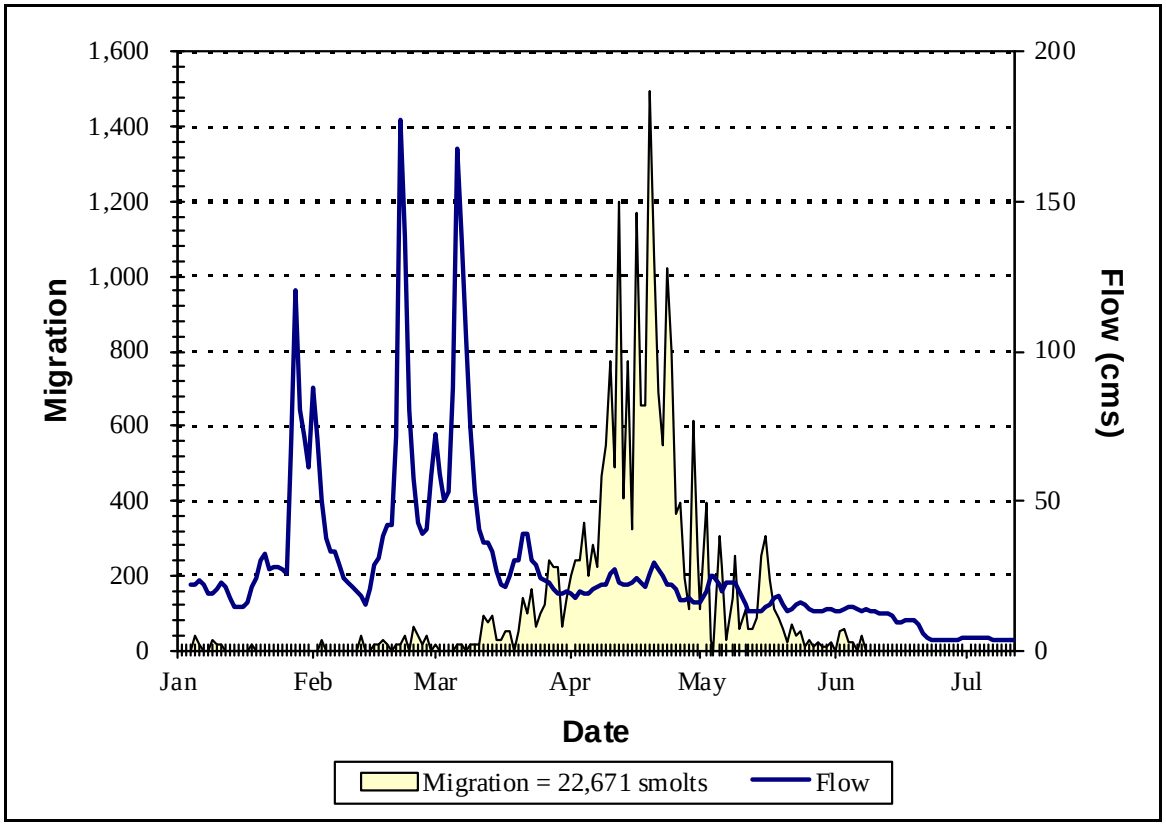

Figure 2 - 4. Daily migration of natural-origin coho yearlings passing the Green River screw trap and stream discharge near Palmer, WA (USGS gage# 12106700) between January 23 and July 15, 2007. Migration estimate is the daily catch expanded by the efficiency of each pooled time strata.

2.2.2.5 Size

Sizes of natural-origin coho yearlings ranged between 83 to 146-mm FL, had an averaged 112-mm FL (Table 2 - 6, Figure 2 - 5), and were not correlated with outmigration dates.

Table 2 - 6. Mean fork length (mm), standard deviation (s.d.), range, and sample size of natural-origin coho smolts in the Green River in 2007.

Statistical Week			Mean	s.d.	Range		Number
No.	Begin	End			Min	Max	Sampled
4	01/22/07	01/28/07	98.3	4.27	93	103	4
5	01/29/07	02/04/07	102.5	3.54	100	105	2
6	02/05/07	02/11/07	118.0		118		1
7	02/12/07	02/18/07	----	----	----	----	----
8	02/19/07	02/25/07	102.0	4.24	99	105	2
9	02/26/07	03/04/07	96.0	5.35	86	101	7
10	03/05/07	03/11/07	102.0	7.00	97	110	3
11	03/12/07	03/18/07	105.0	9.06	88	115	9
12	03/19/07	03/25/07	119.0	1.41	118	120	2
13	03/26/07	04/01/07	103.4	9.97	87	114	10
14	04/02/07	04/08/07	114.7	10.81	96	135	19
15	04/09/07	04/15/07	117.4	13.46	92	146	30
16	04/16/07	04/22/07	118.9	6.28	110	132	13
17	04/23/07	04/29/07	113.8	9.00	86	124	16
18	04/30/07	05/06/07	113.2	8.77	104	128	6
19	05/07/07	05/13/07	110.5	8.22	98	131	17
20	05/14/07	05/20/07	114.0	7.56	101	124	8
21	05/21/07	05/27/07	114.6	12.26	105	136	5
22	05/28/07	06/03/07	100.0	16.97	88	112	2
23	06/04/07	06/10/07	118.0	10.26	106	134	6
24	06/11/07	06/17/07	112.4	12.09	83	127	12
25	06/18/07	06/24/07	105.6	7.86	97	123	9
26	06/25/07	07/01/07	103.5	3.54	101	106	2
27	07/02/07	07/08/07	----	----	----	----	----
28	07/09/07	07/15/07	----	----	----	----	----
Season Total			111.6	11.34	83	146	185

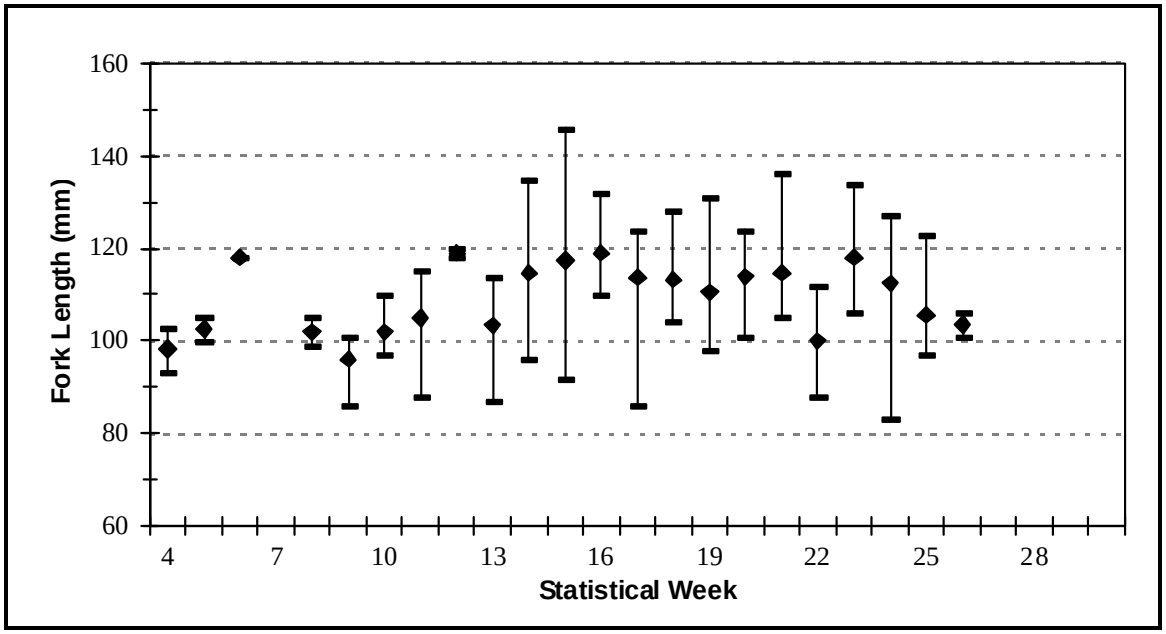

Figure 2 - 5. Fork lengths (mm) of natural-origin coho by statistical week at the Green River screw trap in 2007. Data are mean, minimum, and maximum values.

2.2.3 Steelhead

2.2.3.1 Catch

A total of 124 natural-origin juvenile steelhead were captured between January 24 and June 18, 2007 (2.4 Appendix B 2). Catches were inconsistent throughout the season. Only 6 juveniles were captured during the first two months, through mid-March. The highest daily catches occurred on March 16, March 18, and May 28. High catches during the months of March corresponded with increased river flow.

2.2.3.2 Catch expansion

Expanded catch was estimated at 130 natural-origin steelhead, an increase of 4.8% (6 steelhead) over the actual catch.

2.2.3.3 Trap Efficiency

Due to low catches, efficiency tests for were not conducted for natural-origin juvenile steelhead. A steelhead:coho capture ratio of 60% was applied to each of the corresponding coho efficiency strata, resulting in an average steelhead efficiency of 2.58%, which ranged from 1.38% to 5.57%. The steelhead:coho capture rate ratio was also used when calculating steelhead migration in 2006.

2.2.3.4 Production Estimate

A total of 2,285 natural-origin juvenile steelhead are estimated to have passed the screw trap between January 23 and July 15, 2007. No confidence intervals were developed for these estimates because capture rates were estimated rather than directly measure.

2.2.3.5 Size

Natural-origin steelhead juvenile size ranged from 101 to 221-mm FL, and averaged 149.1-mm FL (Figure 2 - 6). Ninety-five unmarked steelhead were measured, representing 77% of the total catch.

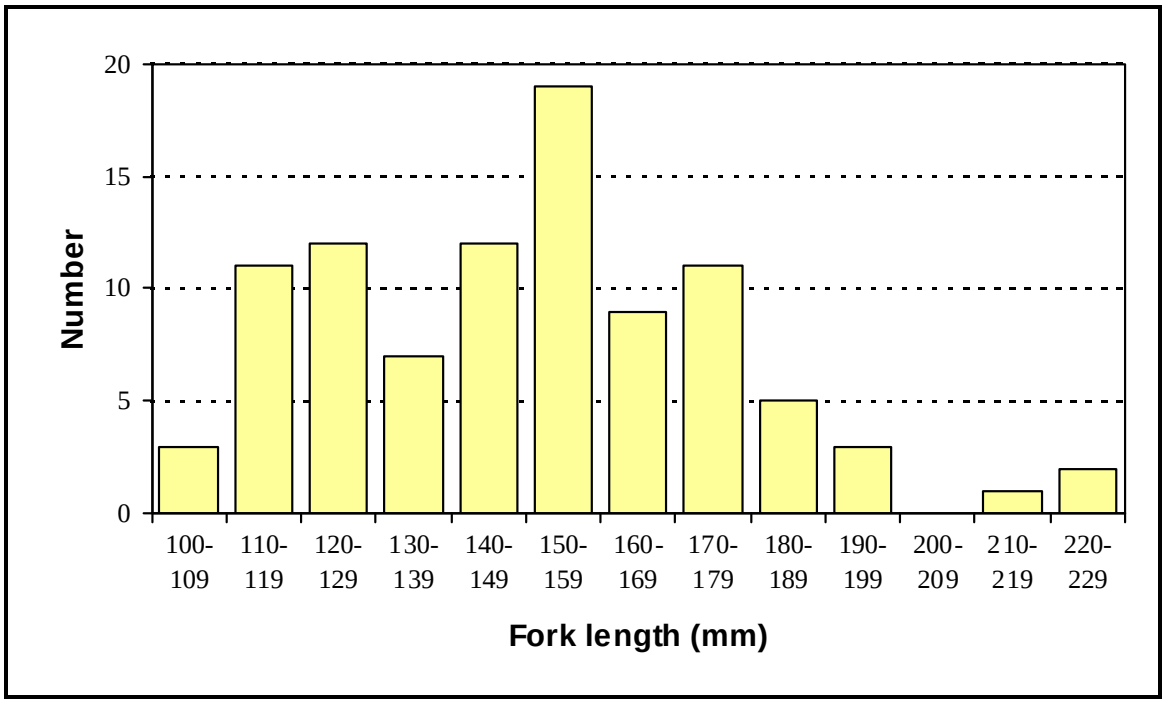

Figure 2 - 6. Fork lengths (mm) of unmarked steelhead juvenile caught in the Green River screw trap in 2007.

2.2.4 Chum

2.2.4.1 Catch

A total of 74,816 chum migrants were captured between February 24 and July 14, 2007 (2.4 Appendix B 2). Daily catches were low until March 10. A three-fold increase in daily catch occurred between March (9 fry/day) and March 11 (1,276 fry/day). Peak catch (5,590 fry/day) occurred on the night of April 28.

Natural-origin and hatchery-origin chum fry could not be distinguished in the catch because a large percentage of hatchery-origin fry had unclipped adipose fins, and natural-origin fry overlapped in size distribution with hatchery-origin fry. A total of 2.89-million hatchery chum fry were released by Keta Creek Hatchery between March 17 and June 1.

2.2.4.2 Catch expansion

Expanded catch was estimated at 77,175 chum, a 3.2% increase over actual catch. Of the expanded catch, over 2,000 fry were estimated from the missed fishing periods in March due to high flows.

2.2.4.3 Trap Efficiency

Trap efficiency for chum fry averaged 3% for the season, and ranged from 1.5 to 4.7%. A total of 5,245 chum fry in 27 groups were marked and released (Table 2 - 7). Release groups were pooled to form nine strata.

Table 2 - 7. Catch, efficiency, and migration estimates of chum fry at the Green River screw trap in 2007. Data are stratified by pooled release groups.

Strata	Dates	Estimated Catch	Efficiency data				Migration	
			Pooled	Rate	Marked	Recaptured	Number	Variance
1	1/23-4/7	16,145	1	4.04%	223	9	361,669	1.16E+10
2	4/8-4/14	10,057	2	1.52%	462	7	582,106	3.70E+10
3	4/15-4/18	4,024	4	4.18%	1,077	45	94,324	1.83E+08
4	4/19-4/24	5,974	5	2.72%	1,066	29	212,510	1.42E+09
5	4/25-5/4	19,761	4	2.76%	688	19	680,800	2.14E+10
6	5/5-5/7	6,800	3	1.48%	540	8	408,815	1.65E+10
7	5/8-5/12	5,741	3	1.71%	586	10	306,413	7.69E+09
8	5/13-5/25	5,702	3	2.82%	496	14	188,958	2.17E+09
9	5/26-7/15	2,971	2	4.67%	107	5	53,495	3.88E+08
Season Total		**77,175**	**27**	**2.88%**	**5,245**	**146**	**2,889,090**	**9.84E+10**

2.2.4.4 Production Estimate

A total of 2,889,090 ±608,910 (95% C.I.) chum fry are estimated to have passed the Green River screw trap (Table 2 - 7). Production estimates were pooled for natural-origin and hatchery-origin (released from Keta Creek Hatchery) chum because origin could not be distinguished in our catches.

2.2.5 Hatchery releases

When calculating hatchery-origin migrations passing the screw trap, catches were not expanded during periods of suspended trapping. Expansions were not necessary because trap outages did not occur during hatchery release periods. Hatchery juveniles were rarely used in efficiency tests; therefore surrogate efficiencies, described below, were used for each species.

2.2.5.1 Hatchery-origin Chinook

A total of 151 ad-marked sub-yearling Chinook migrants were captured between April 2 and July 14, 2007 (2.4 Appendix B 1). Daily catches were sporadic throughout the season. Catch peaked on April 28, with 10 hatchery Chinook captured and subsequently remained at less than 1 Chinook/day through the end of the season. A total of 254 Chinook yearling migrants (254 ad-marked) were captured between April 1 and June 10. The largest catch occurred on May 1 (72 ad-marked yearlings), coinciding with the forced release from the Icy Creek rearing facility. Daily catches quickly declined after May 1.

Efficiency measures were applied separately to sub-yearling and yearling catches of hatchery-origin Chinook. Efficiencies used for sub-yearlings were based on natural-origin sub-yearling Chinook. Efficiencies used for yearlings were based on natural-origin coho.

A total migration of 2,027 ±509 (95% C.I.) ad-marked hatchery-origin Chinook are estimated to have passed the screw trap during the trapping interval. No post-season estimate was made for hatchery Chinook.

2.2.5.2 Hatchery-origin Coho

A total of 388 ad-marked hatchery coho yearlings were captured between January 24 and June 4, 2007 (2.4 Appendix B 2). Of note, a total of 12 hatchery smolts were captured prior to the Keta Creek Hatchery release on April 23. Efficiencies for hatchery-origin coho were based on time-stratified efficiencies of natural-origin coho yearlings. A total of 13,451 ±11,200 (95% C.I.) hatchery-origin coho are estimated to have passed the trap.

2.2.5.3 Hatchery-origin Steelhead

A total of 191 hatchery-origin juvenile steelhead were captured between March 27 and July 8, 2007 (2.4 Appendix B 2). Daily catches were inconsistent through mid-May, after which point hatchery-origin steelhead were captured on a daily basis. Four hatchery-origin juveniles were captured prior to the first release from the Palmer Hatchery facility on April 16. Catches of hatchery-origin steelhead peaked on the nights of May 28 and June 5.

Efficiencies used for hatchery-origin steelhead were based on time-stratified efficiencies of natural-origin yearling coho.

Due to low catches, trap efficiency tests were not specifically conducted for hatchery-origin steelhead. A steelhead:coho capture ratio of 60%, calculated from natural-origin steelhead and coho data, was applied to catches of hatchery-origin steelhead.

A total of 4,089 hatchery juvenile steelhead are estimated to have passed the trap. No variance or confidence intervals were developed for these estimates because trap efficiencies were estimated rather than directly measured.

2.2.5.4 Survival

Estimated survivals for hatchery releases ranged from 3.67% for coho (closest release, Keta Creek Hatchery) to 0.43% for Chinook sub-yearlings (furthest release, above Howard Hansen Dam). Survival for both ad-marked Chinook yearlings and steelhead was estimated at 1.6% (Table 2 - 8).

Table 2 - 8. Survival of ad-marked hatchery releases above the Green River screw trap, 2007.

Species	Facility	Number		Estimated	
		Released	Caught	Migration	Survival
Coho[a]	Keta Creek Hatchery	365,158	388	13,390	3.67%
Steelhead[b]	Palmer/Icy/Flaming Geyser	251,495	191	4,089	1.63%
Chinook yearlings[a]	Icy Creek Hatchery	322,720	254	5,309	1.65%
Chinook fry[c]	Above Howard Hansen Dam	467,875	151	2,027	0.43%

[a] Uses natural-origin coho efficiency data.

[b] Uses 60% natural-origin coho efficiency data.

[c] Uses natural-origin Chinook fry efficiency data.

2.2.6 Other Species

In addition to species and age classes described above, 179 coho fry, 73 steelhead parr, 9 cutthroat smolts, and 2 cutthroat parr were captured during the trapping period. Smolts were distinguished from fry and parr by their size and silvery coloration. Non-salmonid species captured included sculpin (*Cottus* spp.), three-spine sticklebacks (*Gasterosteus aculeatus*), longnose dace (*Rhynichthys cataractae*), and lamprey ammocoetes.

2.3 Discussion

The Green River produces a diversity of salmonid species, with variable life history strategies. Herein, we have provided production estimates of natural-origin and hatchery-origin Chinook, coho, and steelhead as well as a combined production estimate for natural and hatchery-origin chum during the 2007 outmigration period. While these estimates apply to production above the trap site, the production estimate for natural-origin Chinook is expanded below to represent basin-wide production.

Production of Chinook, coho, and steelhead were the lowest, or nearly the lowest, observed in the eight consecutive years that we have been evaluating these populations. Below, we compare production among years and discuss a number of variables that may have contributed to low numbers in the 2007 outmigration. In addition, we discuss assumptions used to develop our migration estimates.

2.3.1 Chinook

The 2007 abundance of migrating sub-yearling Chinook was second lowest observed in the eight years that we have operated juvenile traps on the Green River (Table 2 - 9). These numbers were more likely to due low egg-to-migrant survival than to the spawner escapement in the watershed. Egg-to-migrant survival, a measure of freshwater productivity, was the lowest observed during our eight years of monitoring Chinook in the Green River (Table 2 - 10). In comparison, female spawner abundance for the 2006 brood year was intermediate in value compared to other years of this study (Table 2 - 11).

Low productivity of the 2006 brood of Chinook may have been caused by high flows during egg incubation. Freshly fertilized eggs are more fragile and more susceptible to the effects of bed scour and siltation than eggs that have developed in the gravel for a longer period. On November 8, 2006, the USGS gage near Palmer reported flows at 226 cms, the highest peak flow observed during egg incubation in the last eight years. This peak flow occurred just after the Chinook spawning period. Although high flows during the early winter months are not unusual in the Green River, the magnitude and early timing of the 2006 peak flow event may have exacerbated negative effects on Chinook egg-to-migrant survival.

Table 2 - 9. Production estimates for natural-origin sub-yearling Chinook above the Green River trap site between 2001 and 2007. Production is represented as the total migration and as the fry and parr components of the migration.

Trap Year	TOTAL		FRY			PARR		
	Migration Interval	Estimated Migration	Migration Interval	Estimated Migration	% of Total	Migration Interval	Estimated Migration	% of Total
2001	1/1-7/13	728,216	1/1-4/15	386,315	53.0%	4/16-7/13	341,901	47.0%
2002	2/7-7/11	412,460	2/7-5/1	358,313	87.0%	5/2-7/11	54,147	13.0%
2003	1/1-7/13	674,397	1/1-4/15	659,568	98.0%	4/16-7/13	14,829	2.0%
2004	1/1-7/14	270,877	1/1-4/15	171,181	63.0%	4/16-7/14	99,696	37.0%
2005	1/1-7/13	465,531	1/1-4/15	425,585	91.4%	4/16-7/13	39,946	8.6%
2006	1/24-7/16	102,728	1/24-4/23	32,195	31.3%	4/24-7/16	70,533	69.1%
2007	1/23-7/31	121,295	1/23-4/18	84,687	69.8%	4/19-7/15	36,607	30.2%

Table 2 - 10. Egg-to-migrant survival rates correlated with flow (USGS gage# 12106700, near Palmer WA) in the Green River for brood years 2000 - 2006.

Brood Year	Trap Year	# Redds/ Females	Estimated			Peak Winter Flow (cms)
			Egg deposition	Migration	Survival	
2000	2001	2,449	11,020,500	728,216	6.61%	46.2
2001	2002	2,711	12,199,500	412,460	3.38%	152.9
2002	2003	3,772	16,974,000	674,397	3.97%	172.7
2003	2004	3,124	14,058,000	270,877	1.93%	140.5
2004	2005	4,769	21,460,500	465,531	2.17%	169.1
2005	2006	1,553	6,988,500	102,728	1.47%	179.0
2006	2007	3,170	14,200,000	121,295	0.85%	226.3

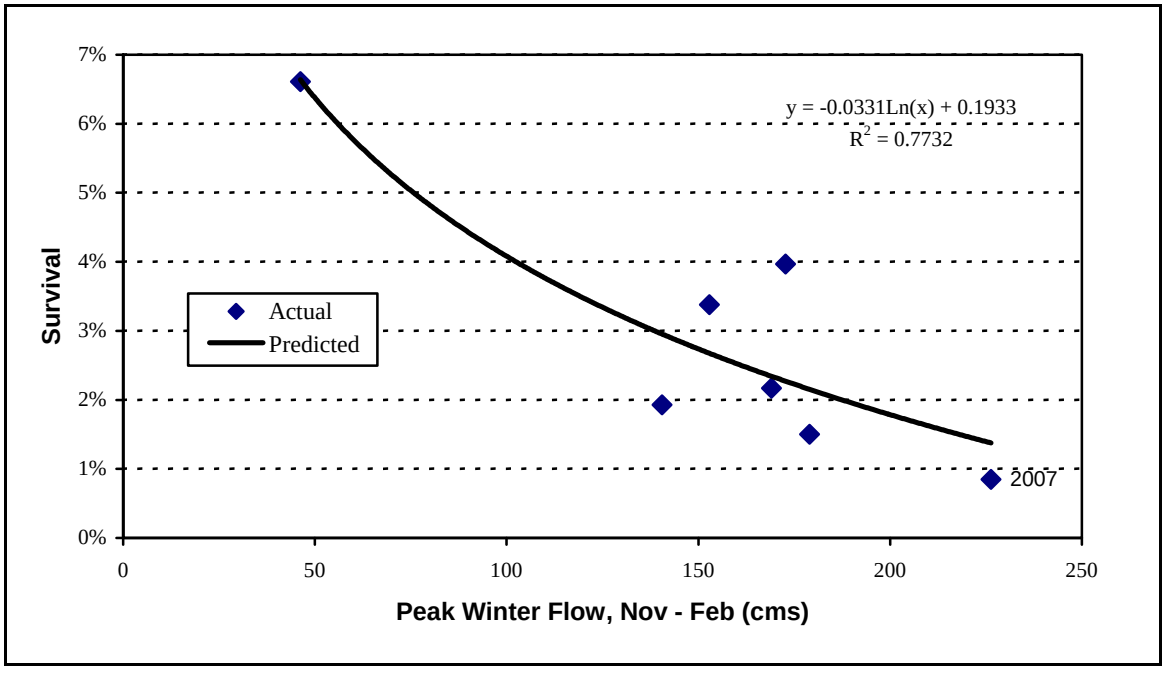

Figure 2 - 7. Natural-origin sub-yearling Chinook egg-to-migrant survival in the Green River as a function of peak winter flow (USGS gage#12106700 near Palmer) between 2001-2007 (migration years).

Using the egg-to-migrant survival calculated above the screw trap, we estimate that 167,095 natural-origin sub-yearling Chinook migrated from the entire Green River basin in 2007. This calculation includes 121,295 migrants produced above the trap, an estimated 33,800 natural-origin Chinook migrants produced from 883 females/redds downstream of the trap, and 12,000 natural-origin Chinook migrants estimated from Soos Creek (313 female Chinook passed above the weir at Big Soos Creek Hatchery in fall 2006).

Accuracy of Chinook production estimates from the Green River was partially dependent on accuracy of estimated catches during periods when the trap was not operating. As Chinook have the most extended migration of any species in our study, nonoperational trap periods need to be examined at the beginning, middle, and end of the trapping season. At the beginning of the 2007 trapping season, Chinook migration was just underway; therefore, we may have slightly underestimated total migration. Mid-season trapping operations were suspended on four occasions. Based on consistent catches before and after the outages, we assume that no major migrations occurred during the mid-season trap outages and that the estimates of missed catch are realistic. At the end of the trapping season, Chinook were still migrating from the system, an observation not surprising as this species has the most extended migration period of any species monitored in our study. July 31 was selected as an end date based on experience from previous years of fieldwork (Table 2 - 9).

2.3.2 Coho

The total estimated migration of natural-origin coho in 2007 was the lowest observed since the trapping study began in 2000 (Table 2 - 11). The 2005 coho brood was subjected to two of the three highest flows observed since the beginning of the project. The first event (179 cms) occurred in January 2006 while the eggs were still in the gravel. Bed scour during this life history stage would likely lead to egg mortality. The second event (226 cms) occurred in November 2006 during the parr life history stage. High flows during this life history stage could transport of over-wintering coho downstream of the trap site. The lack of floodplain habitat on the Green River makes it unlikely that stranding would contribute to coho parr mortality following high flow events. However, increased downstream movement during high flow events may mean that coho smolt migration at the trap site underestimated the number of coho actually produced above the trap.

Table 2 - 11. Natural-origin coho and steelhead migration estimated for the Green River, above RKm 55, trap years 2000-2007. No estimate was made in 2004 and 2005 because natural-origin coho could not be distinguished from hatchery-origin coho in these years.

Trap Year	Coho	Steelhead
2000	32,769	38,000
2001	55,113	14,529
2002	191,228	53,077
2003	156,000	12,500
2004	n/a	n/a
2005	n/a	n/a
2006	31,460	16,748
2007	22,671	2,285

The accuracy of our natural-origin coho production estimates above RKm 55 in the Green River partially relies on the accuracy of estimated catch during intervals where the trap was not operating. Trap outages occurred in March, before the peak period of coho migration. Catch was comparable before and after these outages, giving confidence to our expanded catch estimates.

2.3.3 Steelhead

The 2007 estimate of natural-origin steelhead migrants is the lowest we have observed on the Green River since trapping operations began (Table 2 - 11). As in previous years, we used a steelhead:coho ratio (60%) applied to the coho efficiency strata to estimate natural steelhead migration. As with coho, steelhead parr were subjected to a record high flow event in November 2006 and some may have experienced the high flow event in January 2006. Both events were likely to increase transportation of a large portion of the parr downstream of the trap site.

Catch expansion for steelhead was made during trap outages in March, prior to the typical migration timing of steelhead.

2.3.4 Survival of Hatchery Releases

Catch and resulting migration estimates for ad-marked hatchery fish released above the trap were surprising low. Natural-origin coho trap efficiency data was used to the estimate hatchery coho and yearling chinook migrations, and 60% of the natural-origin coho efficiency was used to estimate the hatchery steelhead migration. This approach resulted in survival estimates that ranged from 3.7% for hatchery coho smolts to 1.6% and 1.7% for steelhead and yearling chinook respectively. These survival rates were inconsistent with results from an acoustic tagging study on the Green River in 2006 and 2007 conducted by the Army Corps of Engineers (Seattle District). In 2006, Soos Creek Hatchery Steelhead were surgically implanted with acoustic tags and released from the Tacoma Diversion Dam located at RKm 98.1. In total, 79% of these smolts survived the downstream migration and were detected in the lower Duwamish River (Goetz *et al* 2008). In 2007, 64% of hatchery steelhead smolts that were acoustic tagged and released from Soos Creek Hatchery survived the migration and were detected in the estuary.

Results of the acoustic tag study on juvenile steelhead from hatchery releases are inconsistent with our survival estimates, and require further consideration. If 64% of hatchery-origin steelhead released above the trap survived to pass the trap site, our catch of 191 steelhead results in a trap efficiency of 0.12%. When this efficiency is applied to our natural-origin steelhead catch (130 fish), migration is estimated to be 108,000 natural-origin steelhead, a higher migration than estimated for any previous year. The disparity in the two estimates of natural-origin steelhead (2,285 versus 108,000) suggests that a comparison of trap efficiency between hatchery and natural-origin yearling fish should be investigated in subsequent field seasons.

2.3.5 Recommendations for 2007 Field Season

The following recommendations, compiled from previous years' work, are listed so we can assess the progress made during the 2007 season. These measures include actions that may be reasonably and cost-effectively implemented within the current scope and funding level of our trapping program in the Green River

1. Attempt to continue trap operation through hatchery releases, without adversely affecting the captured fish, in order to better understand hatchery/natural interactions as hatchery fish migrate through the system.
2. Install the trap by early January to intercept the start of the Chinook outmigration.
3. Continue to release as many trap efficiency groups as possible with as many species as possible throughout the trapping season.
4. Continue to explore options to estimate natural-origin steelhead smolt production.
5. Electronically sample all coho smolts.

2.3.5.1 Progress Towards Recommendations in 2007

1. **Accomplished**. We successfully operated the trap continuously through all hatchery releases in 2007.
2. **Accomplished**. The trap was installed in time to capture the start of the Chinook migration.
3. **Accomplished**. More calibration tests groups were released over the entire season in 2007 than in any previous year.
4. **Not Accomplished**. A cost-effective means was not yet found in 2007.
5. **Not Accomplished**. The number of tagged fish was small, and did not justify the cost and effort.

2.3.5.2 Recommendations for 2008

1. Catches permitting, continue to operate the trap through hatchery releases and migration periods, without adversely affecting the captured fish.
2. Continue to install the trap prior to the start of the Chinook out-migration.
3. Continue to release as many trap efficiency groups as possible with as many species as possible through the trapping season.
4. Explore options to estimate natural-origin steelhead smolt production.
5. Explore ways to better estimate hatchery fish migration numbers and produce more accurate survival estimates.

2.4 Appendices A & B

Appendix A. Variance of total unmarked smolt numbers when the number of unmarked smolts, is estimated. Variance formula was derived by Kristen Ryding, WDFW Biometrician.

The estimator for $\hat{U}_i$ is,

$$\hat{U}_i = \frac{\hat{u}_i\left(M_i+1\right)}{\left(m_i+1\right)}$$

the estimated variance of $\hat{U}_i$, $Var\left(U_i\right)$ is as follows,

$$Var\left(\hat{U}_i\right) = Var\left(\hat{u}_i\right)\left(\frac{\left(M_i+1\right)\left(M_i m_i+3M_i+2\right)}{\left(m_i+1\right)^2\left(m_i+2\right)}\right) + Var\left(\hat{U}_i\middle|E\left(\hat{u}\right)\right)$$

where

$$Var\left(\hat{U}_i\middle|E\left(\hat{u}\right)\right) = \frac{\left(M_i+1\right)\left(M_i-m_i\right)E\left(\hat{u}_i\right)\left(E\left(\hat{u}_i\right)+m_i+1\right)}{\left(m_i+1\right)^2\left(m_i+2\right)},$$

$E\left(\hat{u}_i\right)$ = the expected value of $\hat{u}_i$ either in terms of the estimator (equation for $\hat{u}_i$) or just substitute in the estimated value. $Var\left(\hat{u}_i\right)$ depends on the sampling method used to estimate $\hat{u}_i$.

Derivation:

Ignoring the subscript i for simplicity, the derivation of the variance estimator is based on the following unconditional variance expression,

$$Var\left(\hat{U}\right) = Var\left(E\left(\hat{U}\middle|u\right)\right) + E\left(Var\left(\hat{U}\middle|u\right)\right).$$

The expected value and variance $\hat{U}$ given u is as before, respectively,

$$E\left(\hat{U}_i\middle|u\right) = \frac{u_i\left(M_i+1\right)}{\left(m_i+1\right)} \text{ and,}$$

$$Var\left(\hat{U}\middle|u\right) = \frac{u\left(u+m+1\right)\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}.$$

Substituting in $\hat{u}$ for u gives the following,

$$Var\left(\hat{U}\right) = Var\left(\frac{\hat{u}\left(M+1\right)}{\left(m+1\right)}\right) + E\left[\frac{\left(M+1\right)\left(M-m\right)\hat{u}\left(\hat{u}+m+1\right)}{\left(m+1\right)^2\left(m+2\right)}\right]$$

$$Var\left(\hat{U}\right) = \left(\frac{\left(M+1\right)}{\left(m+1\right)}\right)^2 Var\left(\hat{u}\right) + \frac{\left(M+1\right)\left(M-m\right)}{\left(m+1\right)^2\left(m+2\right)}\left[E\left(\hat{u}^2\right)+E\left(\hat{u}\right)\left(m+1\right)\right]$$

Note that,

$$E\left(\hat{u}^2\right) = Var\left(\hat{u}\right) + \left(E\hat{u}\right)^2$$

Substituting in this value for $E\left(\hat{u}^2\right)$,

$$Var\left(\hat{U}\right) = \left(\frac{(M+1)}{(m+1)}\right)^2 Var\left(\hat{u}\right) + \frac{(M+1)(M-m)}{(m+1)^2(m+2)}\left[Var\left(\hat{u}\right) + \left(E\left(\hat{u}\right)\right)^2 + E\left(\hat{u}\right)(m+1)\right]$$

$$= \left(\frac{(M+1)}{(m+1)}\right)^2 Var\left(\hat{u}\right) + \frac{(M+1)(M-m)}{(m+1)^2(m+2)}\left[Var\left(\hat{u}\right) + E\left(\hat{u}\right)\left[E\left(\hat{u}\right) + m + 1\right]\right]$$

$$Var\left(\hat{U}\right) = \left(\frac{(M+1)}{(m+1)}\right)^2 Var\left(\hat{u}\right) + \frac{(M+1)(M-m)}{(m+1)^2(m+2)} Var\left(\hat{u}\right) + \frac{(M+1)(M-m)E\left(\hat{u}\right)\left[E\left(\hat{u}\right) + m + 1\right]}{(m+1)^2(m+2)}$$

$$Var\left(\hat{U}\right) = Var\left(\hat{u}\right)\left(\frac{(M+1)^2}{(m+1)^2} + \frac{(M+1)(M-m)}{(m+1)^2(m+2)}\right) + \frac{(M+1)(M-m)E\left(\hat{u}\right)\left[E\left(\hat{u}\right) + m + 1\right]}{(m+1)^2(m+2)}$$

$$Var\left(\hat{U}\right) = Var\left(\hat{u}\right)\left(\frac{(M+1)^2}{(m+1)^2} + \frac{(M+1)(M-m)}{(m+1)^2(m+2)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

$$Var\left(\hat{U}\right) = \frac{(M+1)}{(m+1)^2} Var\left(\hat{u}\right)\left(\frac{(M+1)(m+2)}{(m+2)} + \frac{(M-m)}{(m+2)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

$$Var\left(\hat{U}\right) = \frac{(M+1)}{(m+1)^2} Var\left(\hat{u}\right)\left(\frac{Mm + 2M + m + 2 + M - m}{(m+2)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

$$Var\left(\hat{U}\right) = Var\left(\hat{u}\right)\left(\frac{(M+1)(Mm + 3M + 2)}{(m+1)^2(m+2)}\right) + Var\left(\hat{U}\middle|E\left(\hat{u}\right)\right)$$

Appendix B 1. Actual and estimated daily catches and migration for natural-origin and hatchery sub-yearling Chinook migrants in the Green River, 2007. Migration estimate is based on daily catch adjusted by the trap efficiency for each pooled time strata.

Date	UNMARKED CHINOOK				AD-MARKED HATCHERY			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
1/23/07	12		12	647				
1/24/07	9		9	485				
1/25/07	19		19	1025				
1/26/07	18		18	971				
1/27/07	9		9	485				
1/28/07	6		6	324				
1/29/07	8		8	431				
1/30/07	7		7	377				
1/31/07	14		14	637				
2/1/07	6		6	273				
2/2/07	8		8	364				
2/3/07	17		17	774				
2/4/07	21		21	491				
2/5/07	22		22	514				
2/6/07	31		31	725				
2/7/07	28		28	675				
2/8/07	113		113	2724				
2/9/07	51		51	1229				
2/10/07	34		34	819				
2/11/07	73		73	1760				
2/12/07	51		51	1229				
2/13/07	86		86	2073				
2/14/07	85		85	449				
2/15/07	54	50	104	549				
2/16/07		102	102	539				
2/17/07	94		94	4661				
2/18/07	77		77	3818				
2/19/07	49		49	2430				
2/20/07	22		22	1091				
2/21/07	53		53	2628				
2/22/07	62		62	3074				
2/23/07	53		53	2628				
2/24/07	34		34	1686				
2/25/07	6	16	22	1091				
2/26/07	18	2	20	992				
2/27/07	18		18	892				
2/28/07	17		17	843				
3/1/07	17		17	843				
3/2/07	9		9	446				
3/3/07	21		21	1041				
3/4/07	24		24	1190				
3/5/07	70		70	3471				
3/6/07	100		100	4958				
3/7/07	23		23	1140				
3/8/07	41		41	815				
3/9/07	34		34	676				
3/10/07	71		71	1,411				

Table continued next page

Appendix B1. Actual and estimated daily catches and migration for natural-origin and hatchery sub-yearling Chinook migrants in the Green River, 2007. Migration estimate is based on daily catch adjusted by the trap efficiency for each pooled time strata.

Date	UNMARKED CHINOOK				AD-MARKED HATCHERY			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
3/11/07	47	45	92	1829				
3/12/07		81	81	1610				
3/13/07		61	61	1212				
3/14/07	56		56	1113				
3/15/07	52		52	1034				
3/16/07	113		113	2246				
3/17/07	74		74	1471				
3/18/07	54		54	1073				
3/19/07	58		58	631				
3/20/07	25		25	272				
3/21/07	16		16	174				
3/22/07	23		23	250				
3/23/07	24		24	261				
3/24/07	18	17	35	381				
3/25/07		30	30	326				
3/26/07		18	18	196				
3/27/07	17	6	23	250				
3/28/07	16		16	174				
3/29/07	21		21	228				
3/30/07	33		33	359				
3/31/07	65		65	707				
4/1/07	48		48	772				
4/2/07	28		28	450	5		5	82
4/3/07	13		13	209				
4/4/07	9		9	145	1		1	16
4/5/07	8		8	129				
4/6/07	11		11	177				
4/7/07	14		14	225	1		1	16
4/8/07	9		9	145				
4/9/07	85		85	1367	2		2	33
4/10/07	34		34	547	2		2	33
4/11/07	24		24	386	3		3	49
4/12/07	19		19	306	2		2	33
4/13/07	13		13	209	1		1	16
4/14/07	27		27	434	7		7	115
4/15/07	11		11	177	5		5	82
4/16/07	23		23	370	8		8	131
4/17/07	18		18	290	6		6	98
4/18/07	10		10	161	4		4	65
4/19/07	17		17	227	5		5	68
4/20/07	8		8	107				
4/21/07	4		4	53	2		2	27
4/22/07	3		3	40	2		2	27
4/23/07	6		6	80	2		2	27
4/24/07	5		5	67	5		5	68
4/25/07	3		3	40	1		1	14

Table continued next page

Appendix B1. Actual and estimated daily catches and migration for natural-origin and hatchery sub-yearling Chinook migrants in the Green River, 2007. Migration estimate is based on daily catch adjusted by the trap efficiency for each pooled time strata.

Date	UNMARKED CHINOOK				AD-MARKED HATCHERY			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
4/26/07	8		8	107	3		3	41
4/27/07	8		8	107	3		3	41
4/28/07	25		25	333	10		10	136
4/29/07	31		31	414	4		4	54
4/30/07	5		5	67				
5/1/07	6		6	80	1		1	14
5/2/07	13		13	173	1		1	14
5/3/07	8		8	107				
5/4/07	11		11	147				
5/5/07	7		7	93	2		2	27
5/6/07	8		8	107				
5/7/07	23		23	307	1		1	14
5/8/07	11		11	147				
5/9/07	16		16	213				
5/10/07	15		15	200				
5/11/07	10		10	133	2		2	27
5/12/07	13		13	173	1		1	14
5/13/07	18		18	240				
5/14/07	15		15	200				
5/15/07	19		19	253				
5/16/07	13		13	173				
5/17/07	13		13	173				
5/18/07	7		7	93				
5/19/07	7		7	93				
5/20/07	24		24	320	1		1	14
5/21/07	59		59	787	1		1	14
5/22/07								
5/23/07	10		10	133				
5/24/07	10		10	133				
5/25/07	11		11	147	1		1	14
5/26/07	10		10	133				
5/27/07	22		22	293				
5/28/07	15		15	200				
5/29/07	4	5	9	120				
5/30/07	4	1	5	67	1		1	14
5/31/07	7	1	8	107				
6/1/07	10	1	11	147				
6/2/07	6	2	8	107				
6/3/07	17	2	19	253				
6/4/07	40		40	534	1		1	14
6/5/07	129		129	279	3		3	8
6/6/07	200		200	773	1		1	7
6/7/07	103		103	478	1		1	8
6/8/07	94		94	645	1		1	10
6/9/07	121		121	830	1		1	10
6/10/07	141		141	983	1		1	8

Table continued next page

Appendix B1. Actual and estimated daily catches and migration for natural-origin and hatchery sub-yearling Chinook migrants in the Green River, 2007. Migration estimate is based on daily catch adjusted by the trap efficiency for each pooled time strata.

Date	UNMARKED CHINOOK[a]				AD-MARKED HATCHERY			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
6/11/07	74		74	516	4		4	33
6/12/07	67		67	472	2		2	16
6/13/07	84		84	592	2		2	16
6/14/07	71		71	500				
6/15/07	111		111	782	3		3	24
6/16/07	96		96	597	4		4	30
6/17/07	151	1	152	1,242				
6/18/07	63	1	64	523	4		4	40
6/19/07	35	2	37	583	2		2	34
6/20/07	29	2	31	489	2		2	34
6/21/07	46		46	725	2		2	34
6/22/07	90		90	1,418	2		2	34
6/23/07	137		137	2,159	2		2	34
6/24/07	118	4	122	1,923	2		2	34
6/25/07	71	5	76	1,198				
6/26/07	45	6	51	804	1		1	17
6/27/07	67		67	764	2		2	27
6/28/07	128		128	1,460	3		3	40
6/29/07	87		87	992				
6/30/07	71	2	73	833				
7/1/07	51	1	52	593				
7/2/07	66	1	67	606				
7/3/07	53	1	54	489	1		1	12
7/4/07	37	1	38	344	2		2	23
7/5/07	63		63	462	2		2	17
7/6/07	66	1	67	491	1		1	8
7/7/07	38	1	39	286	1		1	8
7/8/07	32		32	234				
7/9/07	15		15	110	1		1	8
7/10/07	27	1	28	205				
7/11/07	15	1	16	117				
7/12/07	40	1	41	300				
7/13/07	42		42	308				
7/14/07	31	1	32	234	1		1	8
Season Total	**6,421**	**473**	**6,894**	**120,257**	**151**		**151**	**2,027**

Appendix B 2. Daily catch for coho, steelhead, chum, and cutthroat caught in the Green River screw trap in 2007. Catch represents actual and estimated catch for a given day. Time in and out reflect time fished (in) and not fished (out) on a given day.

Date	Times		COHO Smolts		Steelhead Smolts		STHD Parr	CUTT Smolts	Chum Fry
	In	Out	Natural	Hatchery	Natural	Hatchery			
01/23/07	19.00	0.00	0	0	0	0	0	0	0
01/24/07	24.25	0.00	3	3	1	0	0	0	0
01/25/07	23.75	0.00	1	0	0	0	0	0	0
01/26/07	24.00	0.00	0	0	0	0	0	0	0
01/27/07	24.25	0.00	0	0	0	0	0	0	0
01/28/07	24.00	0.00	2	0	0	0	1	0	0
01/29/07	23.75	0.00	1	0	0	0	0	0	0
01/30/07	24.00	0.00	1	0	0	0	0	0	0
01/31/07	24.25	0.00	0	0	0	0	0	0	0
02/01/07	23.75	0.00	0	1	1	0	0	0	0
02/02/07	24.00	0.00	0	0	0	0	1	0	0
02/03/07	24.08	0.00	0	0	1	0	1	0	0
02/04/07	23.92	0.00	0	0	0	0	0	0	0
02/05/07	24.08	0.00	0	0	0	0	0	0	0
02/06/07	23.92	0.00	1	0	0	0	0	0	0
02/07/07	24.00	0.00	0	0	0	0	0	0	0
02/08/07	23.00	0.00	0	0	0	0	1	0	0
02/09/07	25.17	0.00	0	0	0	0	0	0	0
02/10/07	23.83	0.00	0	0	0	0	0	0	0
02/11/07	24.00	0.00	0	0	0	0	0	0	0
02/12/07	23.00	0.00	0	0	0	0	0	0	0
02/13/07	25.00	0.00	0	0	0	0	0	0	0
02/14/07	24.00	0.00	0	0	0	0	0	0	0
02/15/07	14.50	9.50	0	0	0	0	0	0	0
02/16/07	0.00	24.25	0	0	0	0	0	0	0
02/17/07	23.58	0.00	0	0	0	0	0	0	0
02/18/07	23.92	0.00	0	0	0	0	0	0	0
02/19/07	24.25	0.00	0	0	1	0	0	0	0
02/20/07	23.83	0.00	0	0	1	0	0	0	0
02/21/07	24.00	0.00	0	0	0	0	0	0	0
02/22/07	24.00	0.00	2	0	0	0	1	0	0
02/23/07	23.92	0.00	0	0	0	0	1	0	0
02/24/07	24.00	0.00	0	2	0	0	2	0	4
02/25/07	11.75	12.25	0	0	0	0	1	0	4
02/26/07	20.47	3.53	0	0	0	0	1	0	0
02/27/07	24.08	0.00	0	0	1	0	0	0	9
02/28/07	23.92	0.00	0	0	0	0	0	0	13
03/01/07	24.08	0.00	0	0	0	0	0	0	8
03/02/07	23.67	0.00	0	0	0	0	0	0	7
03/03/07	24.00	0.00	3	0	0	0	1	1	11
03/04/07	24.00	0.00	0	0	0	0	0	0	14
03/05/07	24.00	0.00	0	0	0	0	1	0	74
03/06/07	24.00	0.00	1	0	0	0	1	0	9
03/07/07	24.00	0.00	1	0	0	0	0	0	34
03/08/07	24.00	0.00	2	0	0	0	1	0	64
03/09/07	23.83	0.00	1	0	0	0	0	0	9
03/10/07	24.67	0.00	0	0	0	0	0	1	462
03/11/07	11.50	12.50	1	0	0	0	0	0	1,452
03/12/07	0.00	24.00	1	0	0	0	0	0	904
03/13/07	0.00	25.50	3	0	3	0	1	1	82
03/14/07	22.25	0.00	0	0	1	0	0	0	114

Table continued next page

Appendix B2. Daily catch for coho, steelhead, chum, and cutthroat caught in the Green River screw trap in 2007. Catch represents actual and estimated catch for a given day. Time in and out reflect time fished (in) and not fished (out) on a given day.

Date	Times		COHO Smolts		Steelhead Smolts		STHD Parr	CUTT Smolts	Chum Fry
	In	Out	Natural	Hatchery	Natural	Hatchery			
03/16/07	24.25	0.00	3	1	7	0	4	0	155
03/17/07	23.75	0.00	1	1	5	0	3	0	4,108
03/18/07	23.92	0.00	3	0	7	0	2	2	2,063
03/19/07	24.00	0.00	0	0	2	0	1	0	376
03/20/07	24.08	0.00	1	0	1	0	0	0	120
03/21/07	24.00	0.00	0	0	1	0	1	0	85
03/22/07	24.00	0.00	0	0	0	0	1	0	118
03/23/07	23.92	0.00	0	0	1	0	0	0	615
03/24/07	9.33	14.50	0	0	0	0	0	0	439
03/25/07	0.00	24.00	1	0	0	0	0	0	395
03/26/07	0.00	24.00	1	0	2	0	1	0	204
03/27/07	15.00	9.00	0	0	1	1	1	0	283
03/28/07	24.00	0.00	1	0	2	0	1	0	157
03/29/07	24.00	0.00	1	0	2	2	1	0	144
03/30/07	24.00	0.00	1	0	3	0	0	0	156
03/31/07	24.00	0.00	7	0	2	0	6	0	1,237
04/01/07	24.00	0.00	6	0	5	0	0	0	385
04/02/07	24.00	0.00	7	1	4	0	6	0	383
04/03/07	24.00	0.00	2	0	2	0	3	0	488
04/04/07	24.00	0.00	2	0	0	0	1	0	125
04/05/07	24.00	0.00	4	2	1	0	3	0	335
04/06/07	23.75	0.00	4	0	3	0	7	0	210
04/07/07	24.00	0.00	0	0	0	0	2	0	260
04/08/07	24.00	0.00	4	0	0	0	2	1	481
04/09/07	24.00	0.00	7	0	5	0	1	0	4,565
04/10/07	24.00	0.00	5	0	2	0	2	0	966
04/11/07	24.00	0.00	8	0	1	1	0	1	830
04/12/07	24.00	0.00	3	0	0	0	2	0	918
04/13/07	24.00	0.00	5	0	0	0	2	0	522
04/14/07	23.75	0.00	6	0	0	0	2	0	1,775
04/15/07	24.50	0.00	12	0	2	0	0	0	400
04/16/07	23.50	0.00	11	0	0	1	2	0	1,403
04/17/07	24.00	0.00	11	1	0	1	0	0	1,015
04/18/07	24.00	0.00	3	0	2	1	0	0	1,206
04/19/07	24.00	0.00	7	0	0	4	0	0	1,194
04/20/07	24.00	0.00	10	0	0	4	0	0	632
04/21/07	24.00	0.00	12	0	0	0	0	0	543
04/22/07	24.00	0.00	12	0	0	3	0	0	2,080
04/23/07	24.00	0.00	17	0	0	1	0	0	516
04/24/07	23.75	0.00	10	1	0	1	1	1	1,009
04/25/07	24.00	0.00	14	4	0	3	0	0	1,054
04/26/07	24.00	0.00	11	0	0	0	0	0	1,492
04/27/07	24.08	0.00	23	9	0	0	0	0	2,974
04/28/07	24.17	0.00	27	4	0	0	0	0	5,590
04/29/07	23.83	0.00	38	3	3	0	0	0	3,307
04/30/07	24.00	0.00	24	0	0	0	0	0	713

Table continued next page

Appendix B2. Daily catch for coho, steelhead, chum, and cutthroat caught in the Green River screw trap in 2007. Catch represents actual and estimated catch for a given day. Time in and out reflect time fished (in) and not fished (out) on a given day.

Date	Times		COHO Smolts		Steelhead Smolts		STHD Parr	CUTT Parr	Chum Fry
	In	Out	Natural	Hatchery	Natural	Hatchery			
05/01/07	24.00	0.00	59	0	1	5	0	0	1,090
05/02/07	24.17	0.00	20	0	0	0	0	0	2,602
05/03/07	24.00	0.00	38	0	0	2	0	0	453
05/04/07	23.83	0.00	16	1	0	6	0	0	486
05/05/07	23.67	0.00	32	45	0	0	0	0	2,350
05/06/07	24.00	0.00	18	159	1	4	0	0	600
05/07/07	24.00	0.00	18	65	0	3	1	0	3,850
05/08/07	24.00	0.00	41	33	2	6	0	0	1,449
05/09/07	24.00	0.00	29	10	1	1	1	0	2,572
05/10/07	24.00	0.00	19	4	0	1	0	0	707
05/11/07	24.00	0.00	15	4	0	2	0	0	473
05/12/07	24.00	0.00	28	13	0	3	0	0	540
05/13/07	24.00	0.00	22	5	2	7	0	0	950
05/14/07	24.00	0.00	13	5	0	2	0	0	620
05/15/07	24.00	0.00	14	4	0	1	0	0	233
05/16/07	24.00	0.00	7	3	0	1	0	0	489
05/17/07	24.00	0.00	4	0	0	1	0	0	733
05/18/07	24.00	0.00	22	0	1	1	0	0	282
05/19/07	24.00	0.00	9	0	1	0	0	0	520
05/20/07	24.00	0.00	4	1	0	1	0	0	230
05/21/07	24.00	0.00	14	0	0	6	0	0	1,060
05/22/07	24.00	0.00	1	1	0	0	0	0	180
05/23/07	24.00	0.00	0	0	0	0	0	0	80
05/24/07	24.00	0.00	11	0	2	3	0	0	32
05/25/07	24.00	0.00	8	0	0	0	0	0	293
05/26/07	24.00	0.00	1	1	0	2	0	0	107
05/27/07	24.00	0.00	5	0	1	1	0	0	114
05/28/07	24.00	0.00	9	0	6	9	0	0	86
05/29/07	9.50	14.50	2	0	1	3	0	0	51
05/30/07	9.00	14.50	4	0	3	5	0	0	51
05/31/07	9.50	15.00	2	0	2	4	0	0	59
06/01/07	9.50	14.50	2	0	0	5	0	0	73
06/02/07	9.50	14.50	3	0	0	3	0	0	113
06/03/07	9.50	14.50	9	0	2	4	0	0	108
06/04/07	24.00	0.00	11	1	2	5	0	0	160
06/05/07	24.00	0.00	19	0	2	10	0	0	280
06/06/07	24.00	0.00	11	0	2	6	0	0	424
06/07/07	24.00	0.00	9	0	0	2	0	0	225
06/08/07	24.00	0.00	6	0	4	8	0	0	129
06/09/07	24.00	0.00	2	0	2	6	0	0	164
06/10/07	24.00	0.00	7	0	2	3	0	0	266
06/11/07	24.00	0.00	4	0	3	2	0	0	112
06/12/07	24.00	0.00	5	0	0	0	0	0	45
06/13/07	24.00	0.00	1	0	0	4	0	0	58
06/14/07	24.00	0.00	3	0	2	5	0	0	44
06/15/07	24.00	0.00	1	0	3	3	0	0	33

Table continued next page

Appendix B2. Daily catch for coho, steelhead, chum, and cutthroat caught in the Green River screw trap in 2007. Catch represents actual and estimated catch for a given day. Time in and out reflect time fished (in) and not fished (out) on a given day.

Date	Times		COHO Smolts		Steelhead Smolts		STHD Parr	CUTT Smolts	Chum Fry
	In	Out	Natural	Hatchery	Natural	Hatchery			
06/16/07	27.50	0.00	2	0	0	5	0	0	42
06/17/07	11.50	11.00	1	0	1	4	0	0	56
06/18/07	9.50	12.50	1	0	1	1	0	0	22
06/19/07	9.50	14.50	2	0	0	4	0	0	17
06/20/07	9.50	14.50	0	0	0	1	0	0	14
06/21/07	24.00	0.00	5	0	0	0	0	0	10
06/22/07	24.00	0.00	6	0	0	1	0	0	10
06/23/07	27.00	0.00	2	0	0	1	0	0	15
06/24/07	12.00	11.50	2	0	0	0	0	0	23
06/25/07	9.50	12.00	0	0	0	0	0	0	7
06/26/07	9.50	14.50	4	0	0	0	0	0	10
06/27/07	24.00	0.00	0	0	0	1	0	0	8
06/28/07	24.00	0.00	0	0	0	1	0	0	7
06/29/07	24.00	0.00	0	0	0	0	0	0	6
06/30/07	12.00	14.50	0	0	0	0	0	0	3
07/01/07	12.50	12.00	0	0	0	0	0	0	1
07/02/07	9.00	12.00	0	0	0	1	0	0	4
07/03/07	9.50	14.50	0	0	0	0	0	0	2
07/04/07	9.50	14.50	0	0	0	1	0	0	2
07/05/07	24.00	0.00	0	0	0	0	0	0	2
07/06/07	9.50	14.55	0	0	0	0	0	0	1
07/07/07	13.50	14.50	0	0	0	0	0	0	2
07/08/07	12.00	11.00	0	0	0	1	0	0	0
07/09/07	9.50	11.50	0	0	0	0	0	0	0
07/10/07	9.50	14.50	0	0	0	0	0	0	1
07/11/07	9.50	14.50	0	0	0	0	0	0	3
07/12/07	9.50	14.50	0	0	0	0	0	0	1
07/13/07	24.00	0.00	0	0	0	0	0	0	0
07/14/07	13.00	14.50	0	0	0	0	0	0	1
Total	3,610.97	538.08	957	388	130	191	76	10	77,176

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3 Dungeness River

2007 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 to capture outmigrating salmonids on the Dungeness River. The trap was located at river kilometer (RKm) 0.5, just above tidal influence (Figure 3 - 1).

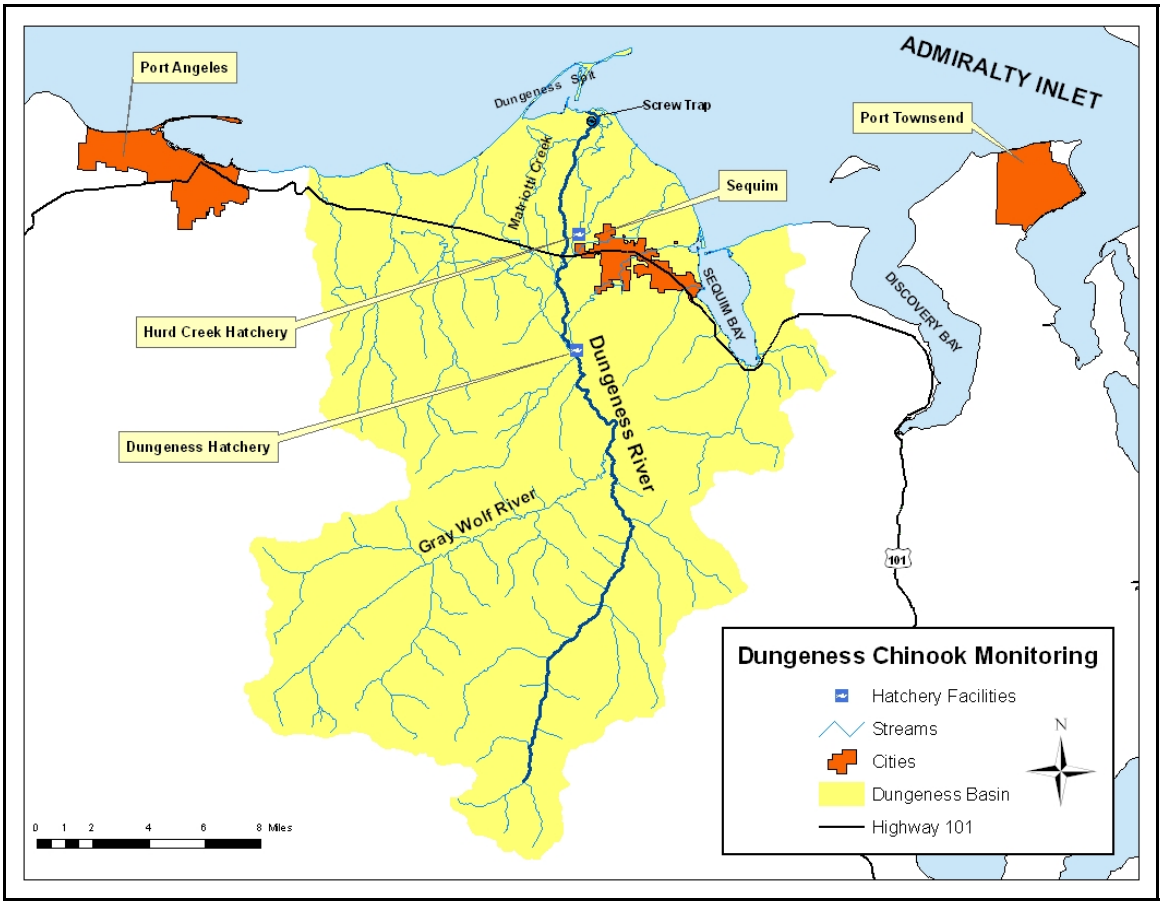

Figure 3 - 1. Map of the Dungeness River watershed with the location of the screw trap, Matriotti Creek and hatcheries.

The Dungeness screw trap operated continuously between February 21 and August 19, 2007, except for periods when operation was prevented by high stream flows, heavy debris, mechanical failure, and large releases of hatchery smolts. Fish were removed from the trap and counted at dawn and at dusk and at additional times based on debris loads and capture rates. At the end of each trapping period, all captured fish were identified to species, measured, and checked for coded-wire tags (CWT) and adipose-fin clips. Fork length (FL) measurements were taken from a sample of the various natural-origin salmonids captured.

Juvenile salmon caught in our traps were either of natural or hatchery origin. Hatchery-origin fish were released from one of two hatcheries upstream of the trap (Table 3 - 1). Juvenile salmonids of hatchery origin were identified based on the absence of an adipose fin (ad-marked) or the presence of a coded-wire tag (CWT). Ad-marking hatchery fish has an associated error rate (i.e., unmarked fish); without an adipose mark, natural-origin fish can not be distinguished from unmarked hatchery-origin fish. In 2007, however, releases of unmarked hatchery Chinook, coho, and steelhead were low (< 2.9%). Therefore, captured fish with no ad-mark and no CWT (non-marked/untagged) were considered to be of natural-origin for the purpose of estimating juvenile migrations.

Table 3 - 1. Hatchery releases upstream of the Dungeness River screw trap in 2007. Hatchery fish were labeled with an adipose fin clip (ad-mark), a coded-wire-tag (CWT), or both.

Species	Release Dates	Release Location	Brood Year	CWT Only	Ad-mark Only	Ad-mark CWT	Unmarked
Chinook	5/18-5/20	Grey Wolf Ponds	2006	50,235			765
	6/13-6/19	Grey Wolf Ponds	2006	50,045			1,495
	4/3	Hurd Creek Hatchery	2005	53,331			1,033
	4/2	Dungeness Hatchery	2005	63,119			381
Coho	6/1-6/10	Dungeness Hatchery	2005	174	466,157	37,790	6,979
Steelhead	6/1-6/2	Dungeness Hatchery	2006		10,518		182

Trap efficiency is the percentage of the total migration sampled by the trap and is measured by recapture rates of marked juvenile salmonids released above the trap. Recapture rates were measured separately for each species and for hatchery- and natural-origin fish. Chinook and chum caught in our trap were marked in the morning, held in a perforated bucket in the trap live-box, and released at dusk 150-m upstream of the trap. Chinook and chum migrants were marked with a unique fin-clip or by staining with Bismarck Brown dye. In addition, coho and steelhead smolts were captured, marked, and released from a smolt fence weir on Matriotti Creek that is operated by the Jamestown S'Klallam Tribe. Smolts captured in the Matriotti Creek trap were marked with a partial caudal fin-clip and released daily. The Matriotti Creek trap was located upstream of its confluence with the Dungeness River at RKm 3.1 (Figure 3 - 1), approximately 2.5-km upstream of our screw trap.

3.1.2 Chinook and Chum Salmon Production Estimate

Production estimates for Chinook and chum were made using a stratified mark-recapture approach. The Petersen estimate, modified by Chapman (1951), is often used to estimate smolt abundance. Smolt abundance during time period *i* is estimated by:

Equation 3 - 1

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

where;

U_i = Migration of unmarked fish passing trap during time period *i*,

u_i = Unmarked fish captured during time period *i*,

M_i = Marked fish released above the trap during time period *i*, and

m_i = Marked fish recaptured during time period *i.*

Seber (1982) provides and approximate unbiased estimate of the variance:

Equation 3 - 2

$$V(\hat{U}_i) = \frac{(M+1)(u+1)(M-m)(u-m)}{(m+1)^2(m+2)}$$

Total production, based on the entire smolt outmigration, is estimated by:

Equation 3 - 3

$$\hat{N} = \sum_{i=1}^{n} \hat{U}_i$$

where *n* is the total number of time intervals. Similarly, total variance ($V(\hat{N})$) is estimated from the sum of the variances for each $\hat{U}_i$. The confidence interval about *N* is:

Equation 3 - 4

$$\hat{N}_{95\%ci} = \hat{N} \pm 1.96\sqrt{V(\hat{N})}$$

The Petersen method for making a population estimate is based on assumptions that:

1) The population is geographically closed with no immigration or emigration;
2) The population is demographically closed with no births or deaths;
3) Marking does not change fish behavior or vulnerability to capture;
4) Marked fish mix at random with unmarked fish;
5) No marks are lost or missed; and
6) All fish have an equal probability of capture during the fishing period (Seber 1982).

The geographically closed population assumption is violated at some level as all fish are emigrating; however, a temporal closure is obtained because the trap operates over the entire outmigration and outmigrants must pass a fixed point (i.e., the trap). Assumptions 2-5 were reasonably met by our study design; assumption 6 is discussed below.

We address three additional issues in our analytical approach. First, our study design violates the assumption that marked fish and unmarked fish have the same probability of capture during each fishing period. Second, the screw trap did not fish 24-hours a day; trap outages periodically occurred during trap checks and high water events. Third, low recapture rates for some time periods required pooling of efficiency data across multiple time periods in order to produce a migration estimate.

The assumption that marked fish and unmarked fish have the same probability of capture during each fish period was not necessarily met by our study. Recaptures of marked Chinook and chum

in the Dungeness River occurred during a relatively short period (e.g., a few hours after release), whereas the unmarked catches they represent may occur over a longer period. In addition, catch of unmarked fish must be estimated during trap outages. In this case, total catch for a fishing period ($\hat{u}_i$) is substituted for u_i in Equation 3 - 1. The variance, $V(\hat{U}_i)$, is now estimated as (see 2.4 Appendix A for derivation):

Equation 3 - 5

$$V(\hat{U}_i) = Var(\hat{u}_i)\left(\frac{(M_i+1)(M_i m_i + 3M_i + 2)}{(m_i+1)^2(m_i+2)}\right) + \left(\frac{(M_i+1)(M_i - m_i)\hat{u}_i(\hat{u}_i + m_i + 1)}{(m_i+1)^2(m_i+2)}\right)$$

Because the trap did not fish continuously, total catch for each fishing period was ($\hat{u}_i$) was the sum of enumerated (C_i) and estimated catch ($\hat{C}_i$) for that fishing period. Catch ($\hat{C}_i$) estimated for trapping intervals not fished was the mean catch rate ($\overline{R}_j$) expanded by the hours not fished (T). Mean catch rates were calculated from catch rates (R_{ij}) of fishing periods within the same diel stratum. Diel migration rates were partitioned because salmonids often migrate at different rates between day and night periods (Seiler *et al.* 1981). Night diel strata ranged from dusk to dawn and the day diel strata ranged from dawn until dusk.
Catch rate for a given fishing period is defined as:

Equation 3 - 6

$$R_{ij} = \frac{C_{ij}}{T_{ij}}$$

where:

R_{ij} = Catch rate during fishing period i in diel stratum j
C_{ij} = Catch during fishing period i in diel stratum j
T_{ij} = Duration of fishing period f in diel stratum j

Variance of the mean catch rate is:

Equation 3 - 7

$$V(\overline{R}_{ij}) = \frac{\sum_{i=1}^{i=n}(R_{ij} - \overline{R}_j)^2}{n(n-1)}$$

Variance associated with an estimated catch is:

Equation 3 - 8

$$V(\hat{U}_i) = V(\overline{R}_{ij})T^2$$

Catch data used to produce migration estimates were pooled into time periods that retained information reflecting trap efficiency variation and minimized error in the production estimate caused by low recapture rates. Mark groups were pooled using DARR software (Bjorkstedt

2005). DARR software uses information on marked-released fish and marked-recaptured fish to aggregate adjacent time periods based on four sequential criteria:

1) Aggregation of time periods minimizes the number of "delayed" recaptures (i.e., those occurring outside the time period when marked fish were released);
2) Aggregation of time periods ensures that at least one fish released in a time period is recaptured in that time period;
3) Aggregation of time periods is necessary if the mean number of recaptures occurring in each time period is less than the ratio of the largest to the smallest number of recaptures; and
4) Aggregation of time periods is necessary to eliminate strata with impossible trap efficiencies (i.e., <0 or >1) (Bjorkstedt 2005).

3.1.3 Coho and Steelhead Smolt Production Estimate

Coho and steelhead smolt production was estimated using a "total-capture trap and partial-capture trap" sample design (Volkhardt et al. 2007). This approach uses a simple pooled Petersen estimator (modified by Chapman 1951):

Equation 3 - 9

$$\hat{N} = \frac{(n+1)(M+1)}{(m+1)} - 1$$

Where: $\hat{N}$ = Total natural-origin coho smolt estimate for the Dungeness River
n = Number of natural-origin coho smolts captured in the partial-capture mainstem trap
M = Number of natural-origin coho smolts that were marked and released at the total-capture tributary trap (Matriotti Creek)
m = Number of marked fish recaptured in the partial-capture mainstem trap

Variance of the coho and steelhead production estimate (Seber 1982) is:

Equation 3 - 10

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

The normal confidence interval about N is shown in Equation 2 - 4.

3.1.4 Survival

Survival was estimated for 0+ Chinook of natural and hatchery origin. Hatchery-origin Chinook survival was the number of migrants divided by the number released. Egg-to-migrant survival,

estimated for natural-origin Chinook, was the number of migrants divided by the estimated egg deposition. Number of migrants was based on production estimates described above. Egg deposition was based on female spawning escapement and an estimated Chinook fecundity of 5,192 eggs per female. This represented an average fecundity observed for the Dungeness River in the Captive Brood Chinook Enhancement Project. Spawner data were provided by Randy Cooper (WDFW Biologist, Region 6).

3.2 Results

The screw trap operated 4,148 hours of 4,319 possible hours (96% of the time) between February 21 and August 17, 2007. Trap operations were suspended on two occasions (early April and early June) to avoid large numbers of hatchery fish released above the trap. In addition, the trap was removed from fishing or stopped due to high water and heavy debris for a total of 3.18 hours on four different occasions.

3.2.1 Chinook 0+

3.2.1.1 Catch

A total of 12,117 natural-origin sub-yearling Chinook were captured over the 176-day season (3.4 Appendix C1). Catches averaged 1 fry per day for the first seven days of trapping. As observed at other trap sites, the Dungeness River natural-origin Chinook migration was bimodal. The first peak catch occurred on March 11, when 194 natural-origin sub-yearling Chinook were captured. Catches declined to an average 1.5 fish per day the last week of April. The second peak catch occurred in late June, with 361 and 358 natural-origin sub-yearling Chinook caught on June 14 and 28 respectively. Five parr were captured on the last day of trapping.

A total of 15,570 CWT hatchery sub-yearling Chinook migrants were also caught.

3.2.1.2 Catch Expansion

Expanded catch was 12,312 natural-origin sub-yearling Chinook, representing an increase of 1.6% over the actual catch (3.4 Appendix C1).

Expanded catch for hatchery-origin Chinook was estimated at 15,588 fish. This estimate included an additional 18 hatchery Chinook that should have been captured had the trap operated continuously (3.4 Appendix C1).

3.2.1.3 Trap Efficiency

Trap efficiencies of natural-origin sub-yearling Chinook averaged 12.7% over the season, and ranged from 1.7% to 31.3%. Forty efficiency groups were released and included a total of 2,468 natural-origin Chinook. Release groups were pooled into 18 strata (Table 3 - 2).

Trap efficiencies of hatchery-origin sub-yearling Chinook averaged 19% for the season, ranging from 5% to 31%. Ten releases were performed using a total of 574 hatchery Chinook. Release groups were pooled into 8 strata (Table 3 - 3).

Table 3 - 2. Catch, efficiency, and production estimates of natural-origin sub-yearling Chinook captured in the Dungeness River screw trap in 2007. Release groups were pooled to form 18 strata.

Strata	Dates	Total Catch		Efficiency data				Migration	
		Catch	Var	#Pooled	Marked	Recaptured	Rate	Number	Variance
1	2/21-3/19	937	61.994	5	301	5	1.7%	47,212	3.14E+08
2	3/20-3/23	323	0.000	1	122	9	7.4%	3,984	1.36E+06
3	3/24-4/18	333	56.364	7	144	6	4.2%	6,918	5.81E+06
4	4/19-5/14	237	0.000	5	107	12	11.2%	1,976	2.57E+05
5	5/15-6/4	823	1,144.655	5	198	19	9.6%	8,198	3.06E+06
6	6/5	84	0.000	1	111	12	10.8%	731	3.82E+04
7	6/6-6/7	318	0.000	1	104	17	16.3%	1,860	1.59E+05
8	6/8-6/14	1,333	0.000	3	315	18	5.7%	22,186	2.34E+07
9	6/15-6/16	543	0.000	1	100	26	26.0%	2,034	1.13E+05
10	6/17-6/21	992	0.000	2	224	25	11.2%	8,592	2.48E+06
11	6/22-6/29	2,225	0.000	2	150	21	14.0%	15,277	8.75E+06
12	6/30-7/5	1,085	0.000	1	99	25	25.3%	4,176	4.89E+05
13	7/6-7/12	871	0.000	1	100	15	15.0%	5,504	1.52E+06
14	7/13-7/19	976	0.000	1	100	28	28.0%	3,402	2.83E+05
15	7/20-7/24	624	0.000	1	93	25	26.9%	2,259	1.42E+05
16	7/25-7/31	300	0.000	1	68	17	25.0%	1,153	5.45E+04
17	8/1-8/9	191	0.000	1	67	21	31.3%	592	1.14E+04
18	8/10-8/19	117	0.000	1	65	14	21.5%	518	1.44E+04
Season Total		**12,312**	**1,263.014**	**40**	**2,468**	**315**	**16.2%**	**136,571**	**3.62E+08**

Table 3 - 3. Catch, efficiency, and production estimates of hatchery sub-yearling Chinook captured in the Dungeness River screw trap in 2007. Release groups were pooled to form 8 strata.

Strata	Dates	Total Catch		Efficiency data				Migration	
		Catch	Var	#Pooled	Marked	Recaptured	Rate	Number	Variance
1	2/21-5/18	10	0.000	1	100	5	5.0%	184	6.09E+03
2	5/19-5/22	4,281	0.000	1	112	35	31.3%	13,440	3.35E+06
3	5/23-5/26	421	0.000	1	56	4	7.1%	4,810	3.54E+06
4	5/27-5/29	199	0.000	1	50	14	28.0%	679	2.17E+04
5	5/30-6/5	121	36.000	3	64	8	12.5%	880	7.27E+04
6	6/6-6/13	289	0.000	1	25	6	24.0%	1,076	1.08E+05
7	6/14-6/24	8,902	0.000	1	117	34	29.1%	30,015	1.77E+07
8	6/25-8/19	1,365	0.009	1	50	4	8.0%	13,932	2.92E+07
Season Total		**15,588**	**36.009**	**10**	**574**	**110**	**18.1%**	**65,016**	**5.40E+07**

3.2.1.4 Production Estimate

A total of 136,571 ±37,253 (95% C.I.) natural-origin sub-yearling Chinook (CV = 13.9%) is estimated to have passed the screw trap. We assume our trapping operation covered the majority of the migration based on low catches at the beginning and end of the trapping season (Figure 3 - 2, 3.4 Appendix C1).

A total migration of 65,016 ±14,406 (95% C.I.) hatchery sub-yearling Chinook (CV = 11.3%) is estimated to have passed the screw trap.

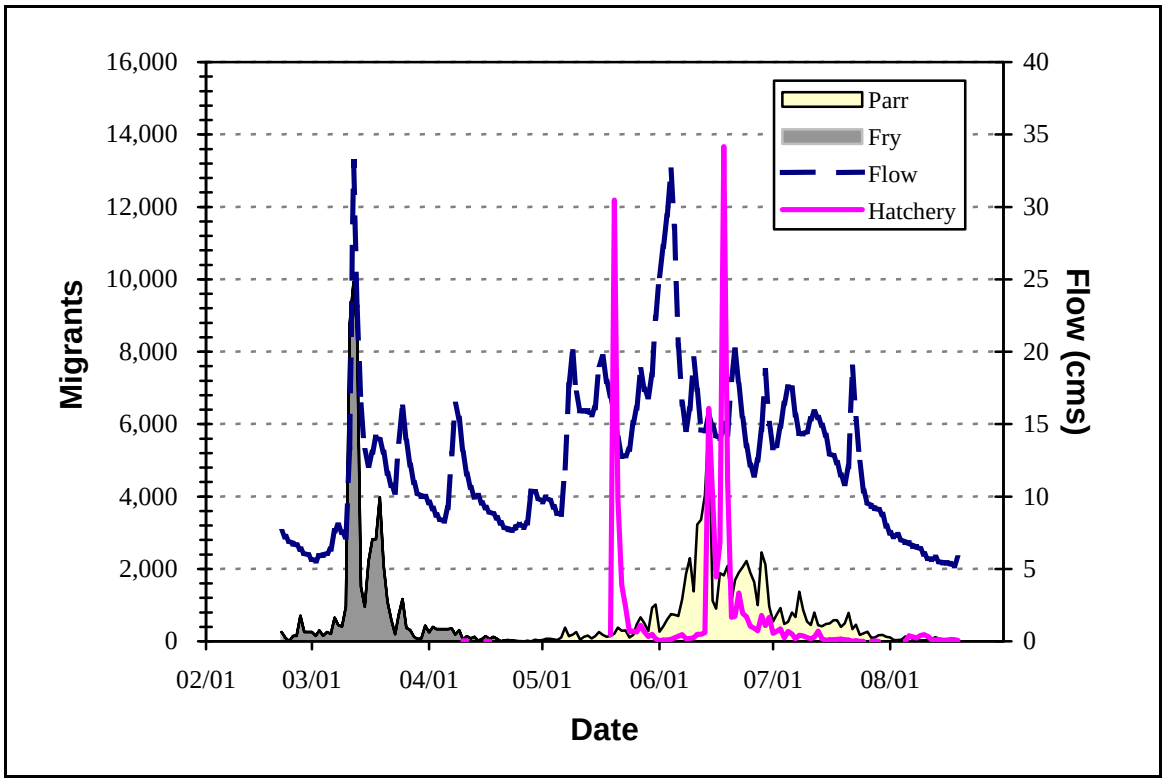

Figure 3 - 2. Daily migration of natural-origin 0+ Chinook passing the Dungeness River screw trap relative to stream discharge measured at USGS Gage #12048000 in 2007. Daily migration estimate is the daily catch expanded by the efficiency of each pooled time strata.

3.2.1.5 Size

Lengths of natural-origin 0+ Chinook averaged 43-mm FL between statistical week 8 and 16. This period encompassed the first peak in outmigration (strata 1-3 in Table 3 - 1), hereafter referred to as the "fry migration". Catch of natural-origin sub-yearling Chinook increased in body size each week after statistical week 16 (mid April). By the peak of the second outmigration (statistical week 18), average natural-origin sub-yearling Chinook were larger than 60-mm FL (Table 3 - 4, Figure 3 - 3). By mid-August, Chinook averaged 91-mm FL, with some individuals as large as 116-mm FL. This second outmigration will hereafter be referred to as the "parr migration".

Using April 26 as a transition date between the fry and parr components of the Chinook sub-yearling migration, 43% of the production migrated as fry and 57% migrated as parr.

Table 3 - 4. Mean fork length (mm), standard deviation (s.d.), range, and sample size of natural-origin 0+ Chinook caught in the Dungeness River in 2007.

Statistical Week			Mean	s.d.	Range		Number		Percent
No.	Begin	End			Min	Max	Sampled	Captured	Sample
8	02/19/07	02/25/07	40.0	1.91	37	43	7	13	53.8%
9	02/26/07	03/04/07	40.5	1.47	39	44	21	41	51.2%
10	03/05/07	03/11/07	40.1	2.04	37	46	43	252	17.1%
11	03/12/07	03/18/07	40.0	2.80	36	51	99	544	18.2%
12	03/19/07	03/25/07	38.7	1.72	35	45	68	492	13.8%
13	03/26/07	04/01/07	44.3	6.59	38	57	19	79	24.1%
14	04/02/07	04/08/07	----	----	----	----	----	26	0.0%
15	04/09/07	04/15/07	45.3	7.97	36	60	19	38	50.0%
16	04/16/07	04/22/07	52.4	9.46	37	65	21	31	67.7%
17	04/23/07	04/29/07	60.0	n/a	60		1	10	10.0%
18	04/30/07	05/06/07	60.3	8.51	46	79	28	47	59.6%
19	05/07/07	05/13/07	60.5	8.54	37	80	36	155	23.2%
20	05/14/07	05/20/07	64.4	8.08	42	89	54	116	46.6%
21	05/21/07	05/27/07	68.4	9.27	46	90	126	240	52.5%
22	05/28/07	06/03/07	67.4	7.54	46	88	98	301	32.6%
23	06/04/07	06/10/07	69.1	6.08	54	88	210	810	25.9%
24	06/11/07	06/17/07	75.2	9.25	51	103	213	1,760	12.1%
25	06/18/07	06/24/07	76.7	7.32	54	99	130	1,674	7.8%
26	06/25/07	07/01/07	----	----	----	----	----	1,719	0.0%
27	07/02/07	07/08/07	79.1	7.30	66	100	70	1,139	6.1%
28	07/09/07	07/15/07	81.6	6.77	62	101	104	807	12.9%
29	07/16/07	07/22/07	----	----	----	----	----	1,038	0.0%
30	07/23/07	07/29/07	----	----	----	----	----	400	0.0%
31	07/30/07	08/05/07	----	----	----	----	----	188	0.0%
32	08/06/07	08/12/07	91.1	8.03	77	116	60	107	56.1%
33	08/13/07	08/19/07	----	----	----	----	----	90	0.0%
Season Total			**66.48**	**16.16**	**35**	**116**	**1,427**	**12,117**	**11.78%**

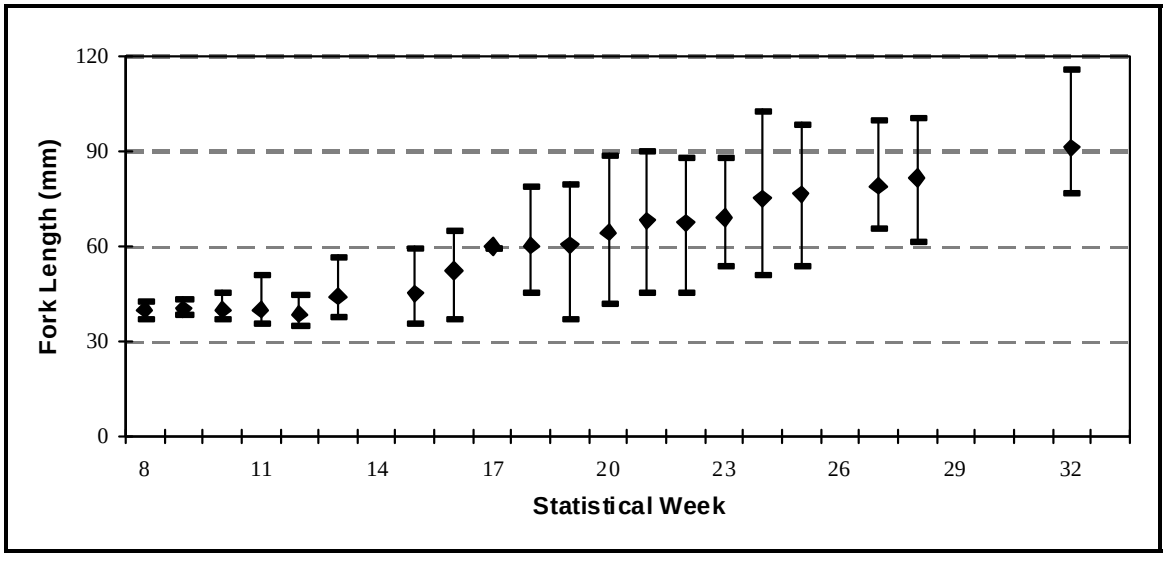

Figure 3 - 3. Fork lengths (mm) of natural-origin 0+ Chinook at the Dungeness River screw trap in 2007. Data are mean, minimum, and maximum values for each statistical week.

3.2.1.6 Survival

Egg-to-migrant survival of outmigrating natural-origin 0+ Chinook (2006 brood year) was 4.7%. This calculation was based on the outmigration estimate (136,571 natural-origin sub-yearling Chinook) divided by the estimated egg deposition above the trap site (2.9-million eggs). Egg deposition was calculated based on 562 female spawners (pers. comm. Randy Cooper).

An estimated 65% of hatchery-origin 0+ Chinook survived from the release site (Grey Wolf acclimation ponds) to the screw trap. Hatchery Chinook appeared in the trap the day after their release; peak catches were on the second day following the first release, and five days following the second release (Figure 3 - 2).

3.2.1.7 Yearling Chinook

Hatchery and natural-origin yearling Chinook were not enumerated separately because unmarked/untagged hatchery yearlings could not be distinguished from natural-origin yearlings. Total migration and survival was not estimated for yearling Chinook because of the extensive 124-hour period of suspended trapping during the peak of the hatchery migration.

A total of 471 yearling Chinook were captured in our trap (332 CWT and 139 unmarked/untagged fish). The first yearling Chinook was captured on March 18. Eighteen unmarked/untagged yearlings were captured prior to the release of the hatchery fish on April 2 and 3. A total of 52 unmarked/untagged yearling Chinook were measured; sizes ranged from 83 to 153-mm FL, and averaged 102-mm FL. The measured sample was a mix of natural-origin and hatchery fish. Smaller fish in the measured sample looked different than the CWT hatchery smolts and were obviously natural-origin migrants.

The Dungeness and Hurd Creek Hatcheries reported a total release of 117,864 yearling Chinook (116,450 CWT-only and 1,414 untagged). Most of the hatchery fish passed the screw trap during the outage period. When trap operations resumed, 453 Chinook were captured (332 CWTs and 121 untagged) over the remaining season.

3.2.2 Coho

3.2.2.1 Catch

A total of 2,221 natural-origin coho smolts were captured between February 27 and August 1, 2007. Catches remained low through the end of March. Peak catches occurred on May 1 (n = 109) and May 28 (n = 116), then slowly declined through June and July (3.4 Appendix C2).

An additional 336 natural-origin coho smolts, marked with an upper caudal fin clip (UC-mark) at the Matriotti Creek weir trap, were recaptured at the mainstem screw trap between April 26 and June 20, 2007.

A total of 4,699 ad-marked coho smolts were captured between the evening of June 1 (the first day of hatchery release) and July 17.

3.2.2.2 Trap Efficiency

Of the 2,915 natural-origin coho smolts that were marked and released from the Matriotti Creek weir trap, 11.5% (n = 336)recaptured at the screw trap.

3.2.2.3 Production Estimate

A total of 22,134 ± 2,068 (95% C.I.) natural-origin coho (CV = 4.8%) are estimated to have passed the screw trap in 2007 (Figure 3 - 4, 3.4 Appendix C3).

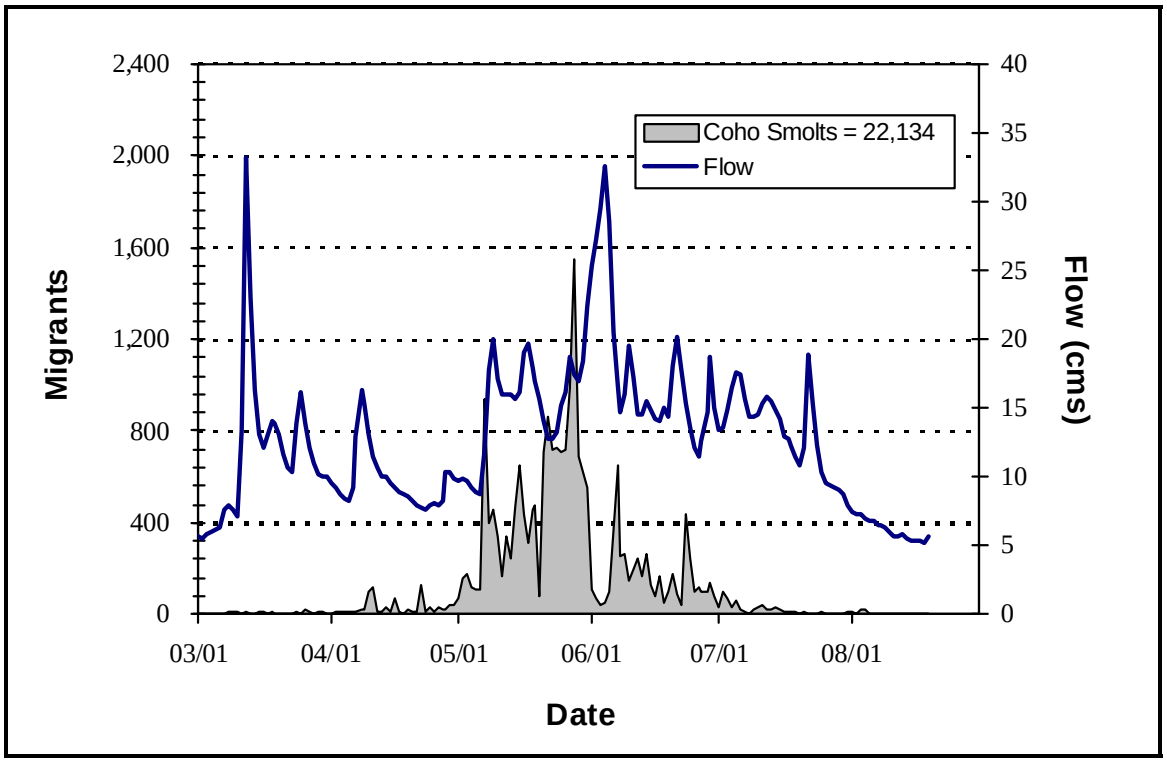

Figure 3 - 4. Daily migration of coho smolts passing the Dungeness River screw trap in 2007 relative to stream discharge measured at USGS Gage #12048000. Daily migration estimate is daily catch expanded by trap efficiency.

3.2.2.4 Size

Lengths of unmarked coho ranged from 61 to 146-mm FL, and averaged 104.3-mm FL. Matriotti Creek coho lengths ranged from 91 to 152-mm FL, and averaged 119.9-mm FL (Figure 3 - 5).

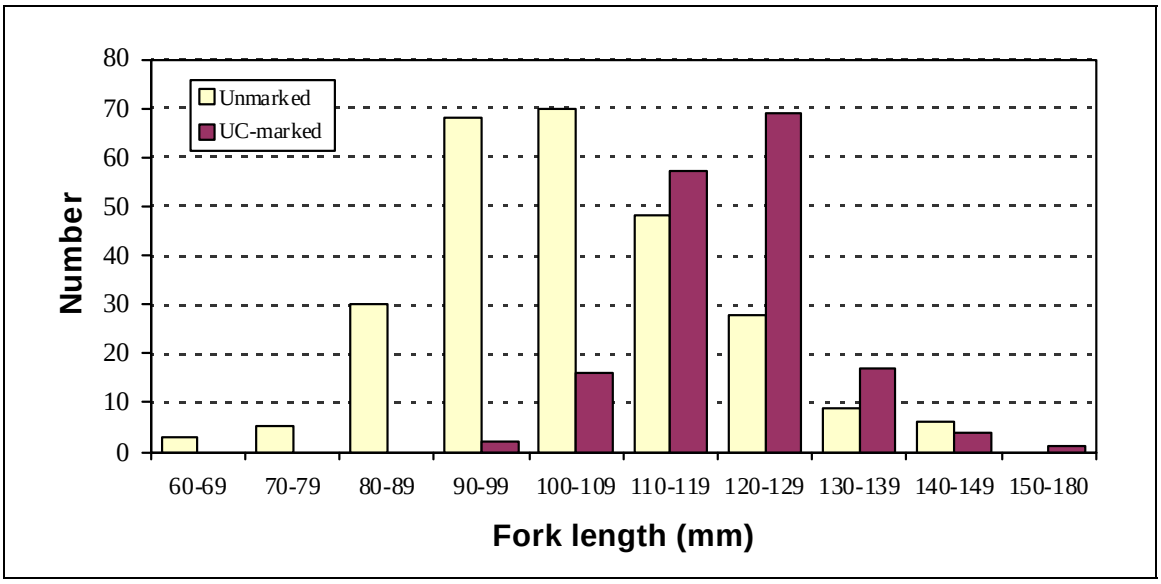

Figure 3 - 5. Fork lengths of natural-origin coho smolts caught in the Dungeness River screw trap in 2007. Unmarked fish were captured at the screw trap only. UC-marked fish were released from the Matriotti Creek weir and recaptured at the screw trap.

3.2.3 Steelhead

3.2.3.1 Catch

A total of 818 natural-origin steelhead smolts were caught at the screw trap between March 22 and July 30, 2007 (3.4 Appendix C2). Peak catch (n = 58) occurred on the night of May 7.

An additional 128 natural-origin steelhead smolts, marked with an upper caudal fin clip at the Matriotti Creek weir trap, were recaptured in the main stem screw trap.

A total of 460 ad-marked hatchery steelhead smolts were caught. Four ad-marked hatchery smolts were captured prior to the reported release from the Dungeness Hatchery on June 1. Hatchery smolt outmigration occurred over a 16-day period following release; the last hatchery steelhead was captured on June 18.

3.2.3.2 Trap Efficiency

Of the 1,558 natural-origin steelhead smolts that were marked and released from the Matriotti Creek weir trap, 8.2% (n = 128) were recaptured at the mainstem screw trap.

3.2.3.3 Production Estimate

A total of 11,445 ± 1,751 (95% C.I.) natural-origin steelhead (CV = 7.8%) are estimated to have passed the screw trap in 2007 (Figure 3 - 6, 3.4 Appendix C3). Qualifications on this estimate are provided in the Discussion.

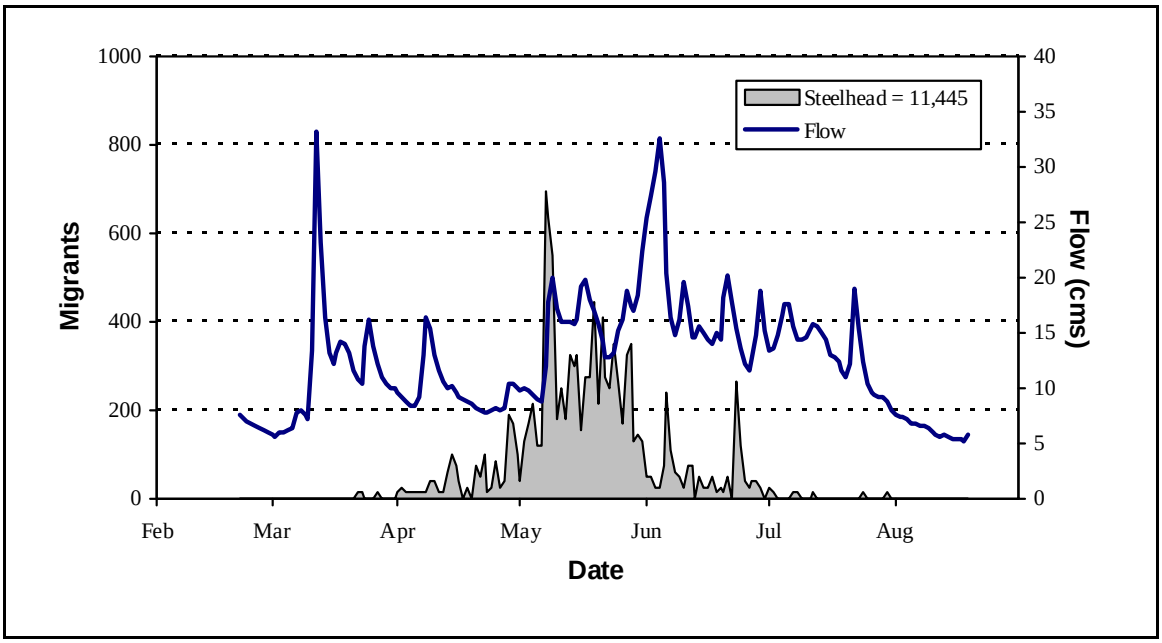

Figure 3 - 6. Daily migration of natural-origin steelhead smolts passing the Dungeness River screw trap relative to stream discharge measured at USGS Gage #12048000, 2007. Daily migration estimate is daily catch expanded by trap efficiency.

3.2.3.4 Size

Lengths of unmarked steelhead averaged 165.5-mm FL (range 85 to 230-mm FL). Lengths of recaptured Matriotti steelhead averaged 168.0-mm FL and ranged from 98-mm to 221-mm FL. Steelhead captured at the Matriotti Creek trap averaged 180.0-m FL, and ranged from 115-mm to 220-mm FL (Figure 3 - 7).

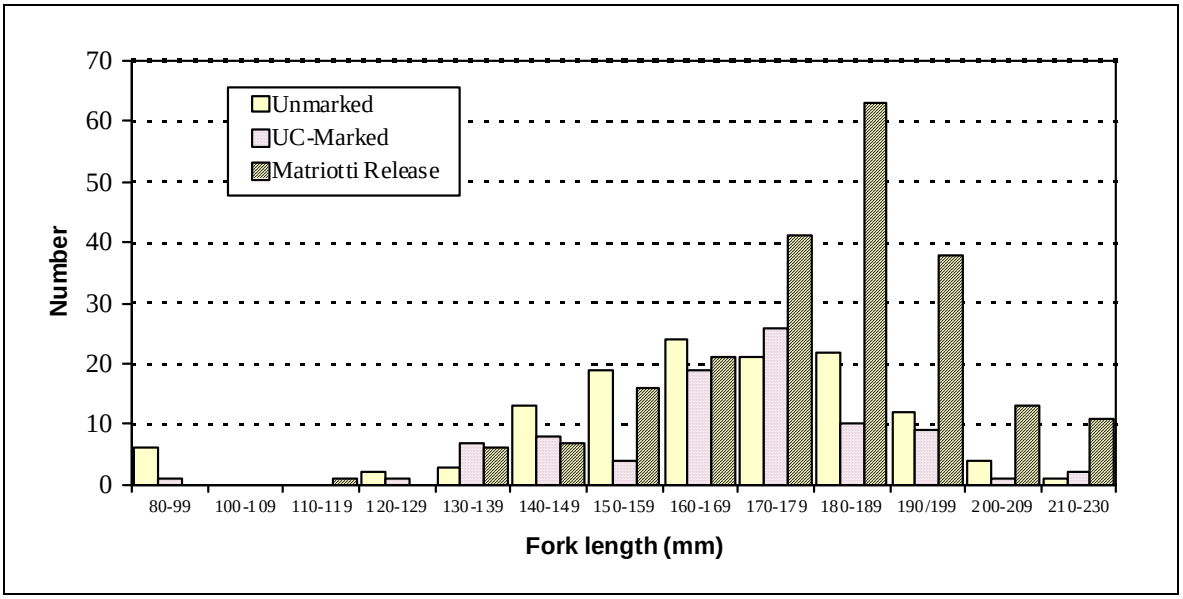

Figure 3 - 7. Fork lengths of natural-origin steelhead smolts caught in the Dungeness River screw trap in 2007. Unmarked fish were caught at the screw trap only. UC-marked steelhead were marked and released in Matriotti Creek and recaptured in the main stem screw trap. Matriotti Release steelhead were all steelhead measured and released from the Matriotti Creek weir.

3.2.4 Chum

3.2.4.1 Catch

A total of 18,389 chum fry were captured between February 28 and July 17, 2007 (3.4 Appendix C2). Daily catches of chum migration increased on March 10 (11 fry), corresponding with increased flow, and peaked on April 14, with 1,074 fry captured. Catches of chum declined to single digits by June 1.

3.2.4.2 Catch Expansion

Expanded catch was 22,189 chum fry, a 17.1% increase (n = 3,800 chum) over the actual catch (3.4 Appendix C2).

3.2.4.3 Trap Efficiency

Trap efficiency for chum fry averaged 6%, ranging from 2.5% to 11.5%. Nineteen efficiency groups were released and included a total of 1,650 chum. Release groups were pooled into ten strata (Table 3 - 5).

Table 3 - 5. Catch, efficiency, and migration estimates for chum fry caught in the Dungeness River screw trap in 2007. Data were pooled to form 10 strata.

Strata	Dates	Total Catch		Efficiency data				Migration	
		Catch	Var	#Pooled	Marked	Recaptured	Rate	Number	Variance
1	2/21-3/22	1,493	3.94E+00	5	311	16	5.14%	27,418	3.99E+07
2	3/23-3/28	761	8.24E+01	2	237	6	2.53%	25,907	8.21E+07
3	3/29-3/30	995	0.00E+00	1	97	9	9.28%	9,760	7.84E+06
4	3/31-4/5	4,038	1.52E+05	1	97	8	8.25%	43,979	1.96E+08
5	4/6-4/10	3,604	3.98E+03	1	94	3	3.19%	85,618	1.41E+09
6	4/11-4/15	2,547	0.00E+00	2	199	11	5.53%	42,466	1.31E+08
7	4/16-4/18	1,689	0.00E+00	1	96	11	11.46%	13,660	1.27E+07
8	4/19-4/25	2,054	0.00E+00	2	192	11	5.73%	33,050	7.92E+07
9	4/26-4/28	776	0.00E+00	1	114	8	7.02%	9,927	9.17E+06
10	4/29-8/20	4,625	5.82E+01	3	213	10	4.69%	89,996	6.42E+08
Season Total		**22,189**	**1.56E+05**	**19**	**1,650**	**93**	**5.64%**	**381,781**	**2.61E+09**

3.2.4.4 Production Estimate

A total of 381,781 ±100,070 chum fry (CV = 13.37%) are estimated to have passed the screw trap in 2007 (Figure 3 - 8, Appendix C3).

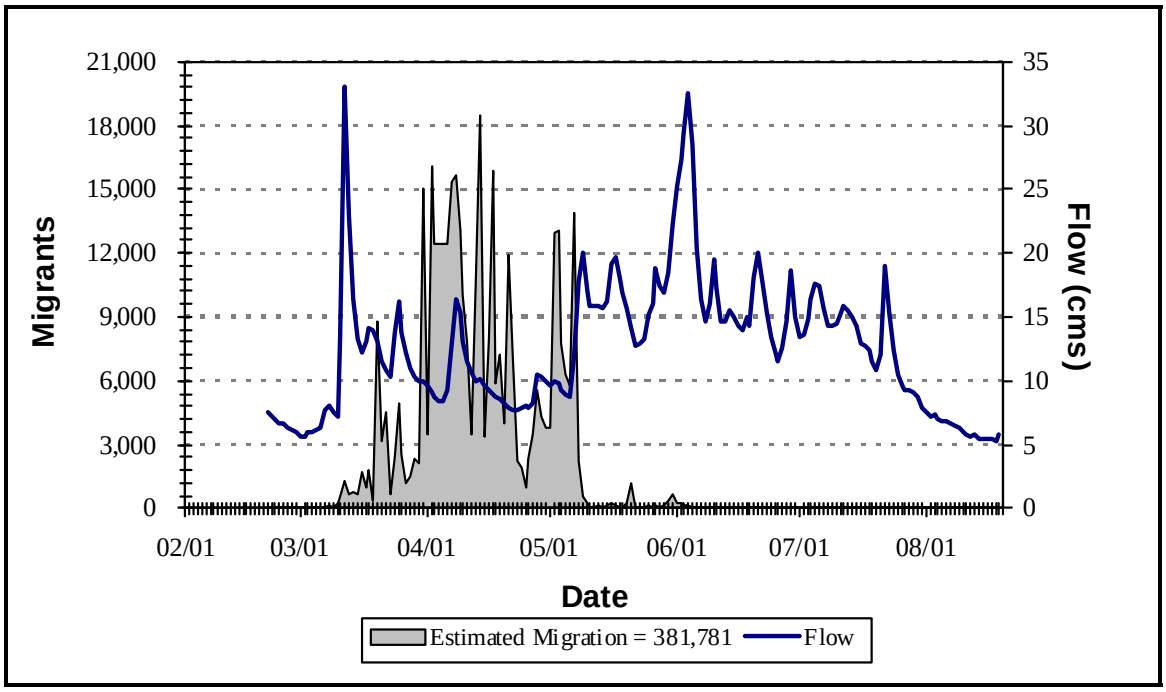

Figure 3 - 8. Daily migration of chum fry passing the Dungeness River screw trap relative to stream discharge measured at USGS Gage #12048000 in 2007. Daily migration is daily catch expanded by pooled efficiency of each time strata.

3.2.4.5 Size

Chum lengths ranged from 34-mm to 62-mm FL, and averaged 40.0-mm FL (Table 3 - 6). Weekly mean lengths were consistent until early April, when catches began to include larger individuals.

Table 3 - 6. Mean fork lengths (mm), standard deviation, range, and sample size of unmarked natural-origin chum fry caught in the Dungeness River, 2007.

Statistical Week			Mean	s.d.	Range		Total		Percent
Number	Begin	End			Min	Max	Sampled	Catch	Sampled
8	02/19/07	02/25/07	----	----	----	----	----	0	0.00%
9	02/26/07	03/04/07	----	----	----	----	----	3	0.00%
10	03/05/07	03/11/07	38.8	1.71	37	41	4	57	7.02%
11	03/12/07	03/18/07	38.3	1.38	35	42	63	458	13.76%
12	03/19/07	03/25/07	39.3	1.82	36	44	60	1,426	4.21%
13	03/26/07	04/01/07	40.1	2.75	36	47	31	1,627	1.91%
14	04/02/07	04/08/07	----	----	----	----	----	1,876	0.00%
15	04/09/07	04/15/07	39.6	3.25	35	52	45	3,889	1.16%
16	04/16/07	04/22/07	40.1	3.00	36	54	90	3,487	2.58%
17	04/23/07	04/29/07	43.3	5.42	38	56	30	1,208	2.48%
18	04/30/07	05/06/07	39.6	4.69	35	56	62	3,107	2.00%
19	05/07/07	05/13/07	39.7	5.04	36	54	11	998	1.10%
20	05/14/07	05/20/07	50.0	n\a	50		1	52	1.92%
21	05/21/07	05/27/07	42.2	8.17	34	62	34	86	39.53%
22-33	05/28/07	08/20/07	----	----	----	----	----	115	0.00%
Season Total			**40.0**	**4.12**	**34**	**62**	**431**	**18,389**	**2.34%**

3.2.5 Other Species

In addition to the species listed above, 44 coho fry, 69 cutthroat smolts, and 43 bull trout smolts were caught in the screw trap (3.4 Appendix C2). Of the 1,131 trout parr captured, 77 steelhead and 2 cutthroat were positively identified. Other species included sculpin (*Cottus spp*), three-spine stickleback (*Gasterosteus aculeatus*), lamprey ammocoetes (*Lampetra spp*), long-nose dace (*Rhinichthys cataractae*), and starry flounder (*Platichthys stellatus*).

3.3 Discussion

At least six salmonid species migrated from the Dungeness River in 2007, including Chinook, chum, and coho salmon, as well as steelhead, cutthroat, and bull trout. Pink salmon were not observed; this species returns to the Dungeness on even-year cycles. Both Chinook and coho exhibit multiple life history strategies with respect to outmigration timing. Migration of sub-yearling Chinook was bimodal, with an early peak of fry migrants and a late peak of parr migrants. Catches of yearling Chinook were minimal, yet present in our collection. Coho migration consisted mostly of smolts; however, a number of fry migrants were also observed. Herein, we have provided production estimates of natural-origin and hatchery-origin Chinook, coho, and steelhead as well as a production estimate for natural-origin chum during the 2007 outmigration period.

Chinook sub-yearling migrants were the highest and coho smolt migrants were the lowest abundances observed over three years of trapping on the Dungeness. Both results were likely due to spawner abundances contributing to each outmigration. Trends in salmonid production and the assumptions used to make production estimates are discussed below.

3.3.1 Chinook

The 2007 outmigration of natural-origin 0+ Chinook was the most abundant and had the second highest proportion of parr migrants (57%) observed in the three years of this study. High production was due to a greater number of spawners than observed in previous years, rather than higher survival of the 2006 brood year. The 562 redds observed in 2006 were the highest observed in 10 years of surveys, and were over twice the ten-year average of 210 redds (pers. comm. Randy Cooper, WDFW Region 6 Fish Biologist). In comparison, the 4.7% survival rate estimated for the 2006 brood-year Chinook falls between the 3.6% survival estimated for the 2004 brood and the 6.3% estimated for the 2005 brood.

The accuracy of the natural-origin sub-yearling Chinook production estimate for the Dungeness River is dependent on our trap efficiencies and on the accuracy of the estimated catch during periods of suspended trap operation. Efficiency estimates were improved by operating the trap in the same position throughout the season; as a result, all 40 efficiency-group releases evaluated the same fishing location. Total catch was considered fairly accurate because estimated catch represented a low proportion (1.6%) of actual catch.

Survival rates of hatchery sub-yearling Chinook migrations have ranged from 1.6%, observed for one release in 1996 (Marlowe *et al.* 2001), to 64.8%, observed in 2007 (Table 3 - 7).

Table 3 - 7. Estimated survival from release site to the screw trap for hatchery sub-yearling Chinook caught in the Dungeness River in 1996, 1997, 2006 and 2007.

Year	Hatchery Mark	Number Released	Estimated Migration	Estimated Survival	CV	95% $CI_{survival}$ Low	95% $CI_{survival}$ High
1996	Admk	4,018	1,267	31.5%	6.27%	37.66%	35.42%
	AdRV	1,115	203	18.2%	6.27%	15.97%	20.45%
	AdLV	7,880	127	1.6%	6.27%	1.41%	1.61%
	Total	**13,013**	**1,597**	**12.3%**	**5.07%**	**11.05%**	**13.49%**
1997	Admk	590,050	136,347	23.1%	3.46%	21.54%	24.68%
	AdCWT	415,452	87,768	21.1%	4.21%	19.39%	22.87%
	Blank wire	769,034	160,260	20.8%	3.08%	19.58%	22.10%
	Total	**1,774,536**	**384,375**	**21.7%**	**2.02%**	**20.80%**	**22.52%**
2006	**CWT only**	**108,500**	**41,297**	**38.1%**	**23.00%**	**n/a**	**n/a**
2007	**CWT only**	**100,280**	**65,000**	**64.8%**	**11.30%**	**49.36%**	**77.45%**

3.3.2 Coho

Production of natural-origin coho in 2007 (22,134 smolts) was less than half that observed in 2005 (58,000 smolts) and 2006 (44,000 smolts). Low coho production in 2007 may be explained by low spawner abundance in 2005. Although adult coho escapement is not enumerated in the Dungeness River, inter-annual variation in the numbers of natural-origin spawners should be correlated with numbers of adult coho returning to the Dungeness Hatchery. Hatchery returns for the 2005 brood year were low compared to the 2003 and 2004 brood years; similarly, natural-origin production associated with the 2005 brood year was low compared to the 2003 and 2004 brood years (Table 3 - 8).

Table 3 - 8. Adult coho return to Dungeness Hatchery and estimated natural-origin smolt production associated with each brood year.

Brood Year	Hatchery Return	Smolt Outmigration	Estimated Production
2003	13,185	2005	58,000
2004	2,756	2006	44,000
2005	1,776	2007	21,000

Production estimate for natural-origin coho was based on the recovery of UC-marked coho that had been captured, marked, and released from Matriotti Creek. The weir remained fish tight, and the Jamestown S'Klallam Tribe marked and released virtually all coho (and steelhead) smolts captured over the entire migration. Matriotti Creek enters the Dungeness River at RKm 3.05. The creek is approximately 13-km long, lies along the valley floor, and differs from the main stem Dungeness, which flows directly out of the Olympic Mountains. Matriotti Creek experiences warmer water temperatures and higher productivity than the main stem Dungeness. Thus, fish migrating from Matriotti Creek, including coho and steelhead, are larger than their mainstem cohort (Figure 3 - 5, Figure 3 - 7).

Use of a total-capture trap/partial-capture trap sampling method for coho (and steelhead) eliminated the need to expand screw trap catches for periods of suspended operation. The production estimate was based on a couple of key assumptions:

1. All marked fish released from Matriotti survived to pass the trap;
2. All marked fish released have the same probability of recapture at the mainstem trap.

Analysis of length data collected from the UC-marked coho at release and recapture indicates a violation of the second assumption. Marked coho lengths averaged 123.5-mm FL at release, but averaged 119.9-mm FL at recapture. Assuming that length samples were taken randomly the size discrepancy between release and recapture indicates a possible size bias in our screw trap capture rate. If the discrepancy is truly due to size-biased capture, a predicted 34 UC-marked coho should have been captured at the mainstem screw trap. An adjusted total of 170 UC-marked coho produces an estimated production of 20,105 coho smolts, a number within the confidence intervals of the original estimate. We therefore believe the original estimate is robust.

3.3.3 Steelhead

A comparison of steelhead length data at Matriotti Creek compared to that at the mainstem screw trap indicated that screw trap efficiency for steelhead declines with increased lengths. Steelhead marked and released at Matriotti (average = 180-mm FL) were larger than those collected at the mainstem screw trap (average = 168 mm). When released from Matriotti Creek, 68% of the steelhead measured longer than 175-mm FL; when recaptured at the mainstem trap, 31% of the Matriotti steelhead were longer than 175-mm.

The size-biased trap efficiency means fewer steelhead were recaptured than would have been if the trap were unbiased with respect to size. In order to adjust for the size bias, we estimated the number of additional, "larger," fish that should have been recaptured in a non size-biased trap, yielding a recapture of 175 UC-marked Matriotti steelhead (128 actual + 47 estimated).

The recapture estimate, adjusted for size-biased trap efficiency, results in a total production estimate of 8,400 steelhead smolts. This production estimate is 26.6% less than the 11,445 steelhead estimated using actual recaptures of steelhead. True production is likely between these two estimates because the entire population of migrating steelhead is comprised of mainstem smolts as well as those from Matriotti Creek. Lengths of mainstem Dungeness smolts are smaller, minimizing impact of an efficiency estimate biased against larger fish.

3.3.4 Recommendations

The following recommendations, compiled from previous years' work, are listed in order to assess progress during the 2007 season. These measures include actions that may be reasonably and cost-effectively be implemented within the current scope and funding level of our trapping program in the Dungeness River.

1. Increase the accuracy of the production estimates made for species that are captured at the screw trap, marked and released above the trap (i.e., Chinook, chum, and pink salmon).

2. Reduce the number of periods of suspended trapping due to high flow events and hatchery releases.
3. Increase the number of trap calibration test groups released for chum (and pinks in even-numbered years).
4. Evaluate size selectivity of the trap by measuring all fish recaptured from Matriotti Creek releases and comparing them to the size at release from Matriotti.

3.3.4.1 Progress Towards Recommendations in 2007

1. **Accomplished**. In 2007 the trap was operated in the same location throughout the season.
2. **Accomplished**. In 2006, the trap operated through 89% of the season; in 2007, trap operation time increased to 96%.
3. **Accomplished**. Chum calibration releases were increased from 12 groups in 2006 to 19 groups in 2007.
4. **Accomplished**. Virtually all Matriotti Creek marked coho and steelhead were measured upon recapture at the screw trap in 2007.

3.4 Appendix C

Appendix C1. Actual and estimated daily catches and migration for sub-yearling Chinook caught in the Dungeness River screw trap in 2007.

Date	NATURAL-ORIGIN CHINOOK				HATCHERY-ORIGIN CHINOOK			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
02/21/07	5		5	252				
02/22/07	2		2	101				
02/23/07								
02/24/07	3		3	151				
02/25/07	3		3	151				
02/26/07	14		14	705				
02/27/07	5		5	252				
02/28/07	5		5	252				
03/01/07	5		5	252				
03/02/07	3		3	151				
03/03/07	6		6	302				
03/04/07	3		3	151				
03/05/07	5		5	252				
03/06/07	4		4	202				
03/07/07	13		13	655				
03/08/07	9		9	453				
03/09/07	8		8	403				
03/10/07	19		19	957				
03/11/07	166	8	174	8,767				
03/12/07	197		197	9,926				
03/13/07	170		170	8,566				
03/14/07	30		30	1,512				
03/15/07	19		19	957				
03/16/07	44		44	2,217				
03/17/07	56		56	2,822				
03/18/07	56		56	2,822				
03/19/07	79		79	3,980				
03/20/07	170		170	2,097				
03/21/07	89		89	1,098				
03/22/07	48		48	592				
03/23/07	16		16	197				
03/24/07	34	1	35	727				
03/25/07	56		56	1,163				
03/26/07	18		18	374				
03/27/07	15		15	312				
03/28/07	6		6	125				
03/29/07	3		3	62				
03/30/07	4		4	83				
03/31/07	21		21	436				

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Appendix C1. Actual and estimated daily catches and migration for sub-yearling Chinook caught in the Dungeness River screw trap in 2007.

Date	NATURAL-ORIGIN CHINOOK				HATCHERY-ORIGIN CHINOOK			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
04/01/07	12		12	249				
04/02/07	7	12	19	395				
04/03/07		16	16	332				
04/04/07		16	16	332				
04/05/07		16	16	332				
04/06/07		16	16	332				
04/07/07	10	7	17	353				
04/08/07	9		9	187				
04/09/07	15		15	312				
04/10/07	2		2	42	5		5	21
04/11/07	7		7	145	3		3	13
04/12/07	4		4	83				
04/13/07	6		6	125				
04/14/07	1		1	21				
04/15/07	3		3	62				
04/16/07	7		7	145	1		1	4
04/17/07	3		3	62	1		1	4
04/18/07	6		6	125				
04/19/07	8		8	67				
04/20/07								
04/21/07	3		3	25				
04/22/07	4		4	33				
04/23/07	2		2	17				
04/24/07	1		1	8				
04/25/07								
04/26/07								
04/27/07	2		2	17				
04/28/07								
04/29/07	5		5	42				
04/30/07	3		3	25				
05/01/07	4		4	33				
05/02/07	8		8	67				
05/03/07	9		9	75				
05/04/07	6		6	50				
05/05/07	4		4	33				
05/06/07	13		13	108				
05/07/07	46		46	384				
05/08/07	17		17	142				
05/09/07	22		22	183				
05/10/07	31		31	258				
05/11/07	5		5	42				
05/12/07	15		15	125				
05/13/07	19		19	158				
05/14/07	10		10	83				
05/15/07	14		14	139				

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Appendix C1. Actual and estimated daily catches and migration for sub-yearling Chinook caught in the Dungeness River screw trap in 2007.

Date	NATURAL-ORIGIN CHINOOK				HATCHERY-ORIGIN CHINOOK			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
05/16/07	26		26	259				
05/17/07	18		18	179				
05/18/07	12		12	120				
05/19/07	15		15	149	42		42	175
05/20/07	21		21	209	2,922		2,922	12,187
05/21/07	38		38	379	945		945	3,941
05/22/07	29		29	289	372		372	1,552
05/23/07	30		30	299	229		229	955
05/24/07	11		11	110	63		63	263
05/25/07	18		18	179	68		68	284
05/26/07	47		47	468	61		61	254
05/27/07	67		67	667	105		105	438
05/28/07	50		50	498	62		62	259
05/29/07	28		28	279	32		32	133
05/30/07	93		93	926	47		47	196
05/31/07	102		102	1,016	16		16	67
06/01/07	27		27	269	5		5	21
06/02/07	1	41	42	418	1	8	9	38
06/03/07		60	60	598		9	9	38
06/04/07	75		75	747	12		12	50
06/05/07	84		84	731	23		23	96
06/06/07	119		119	696	34		34	142
06/07/07	199		199	1,164	45		45	188
06/08/07	112		112	1,864	18		18	75
06/09/07	138		138	2,297	20		20	83
06/10/07	83		83	1,381	23		23	96
06/11/07	194		194	3,229	46		46	192
06/12/07	202		202	3,362	46		46	192
06/13/07	243		243	4,044	57		57	238
06/14/07	361		361	6,008	1,542		1,542	6,432
06/15/07	301		301	1,127	956		956	3,987
06/16/07	242		242	906	427		427	1,781
06/17/07	217		217	1,880	650		650	2,711
06/18/07	210		210	1,819	3,276		3,276	13,664
06/19/07	241		241	2,087	1,056		1,056	4,404
06/20/07	129		129	1,117	160		160	667
06/21/07	195		195	1,689	166		166	692
06/22/07	277		277	1,902	321		321	1,339
06/23/07	299		299	2,053	184		184	767
06/24/07	323		323	2,218	164		164	684
06/25/07	275		275	1,888	99		99	413
06/26/07	238		238	1,634	87		87	363
06/27/07	146		146	1,002	69		69	288
06/28/07	358		358	2,458	171		171	713
06/29/07	309		309	2,122	104		104	434

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Appendix C1. Actual and estimated daily catches and migration for sub-yearling Chinook caught in the Dungeness River screw trap in 2007.

Date	NATURAL-ORIGIN CHINOOK				HATCHERY-ORIGIN CHINOOK			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
07/01/07	143		143	550	54		54	225
07/02/07	190		190	731	64	1	65	271
07/03/07	236	2	238	916	82		82	342
07/04/07	124		124	477	23		23	96
07/05/07	140		140	539	65		65	271
07/06/07	126		126	796	49		49	204
07/07/07	106		106	670	18		18	75
07/08/07	217		217	1,371	41		41	171
07/09/07	137		137	866	35		35	146
07/10/07	87		87	550	26		26	108
07/11/07	72		72	455	18		18	75
07/12/07	126		126	796	27		27	113
07/13/07	127		127	443	68		68	284
07/14/07	120		120	418	16		16	67
07/15/07	138		138	481	7		7	29
07/16/07	142		142	495	11		11	46
07/17/07	167		167	582	11		11	46
07/18/07	167		167	582	13		13	54
07/19/07	115		115	401	14		14	58
07/20/07	136		136	492	11		11	46
07/21/07	218		218	789	8		8	33
07/22/07	93		93	337	1		1	4
07/23/07	127		127	460	5		5	21
07/24/07	50		50	181	1		1	4
07/25/07	58		58	223	1		1	4
07/26/07	68		68	261				
07/27/07	26		26	100	1		1	4
07/28/07	27		27	104	2		2	8
07/29/07	44		44	169	1		1	4
07/30/07	45		45	173				
07/31/07	32		32	123				

Table continued next page

Appendix C1. Actual and estimated daily catches and migration for sub-yearling Chinook caught in the Dungeness River screw trap in 2007.

Date	NATURAL-ORIGIN CHINOOK				HATCHERY-ORIGIN CHINOOK			
	Catch			Migration	Catch			Migration
	Actual	Estimated	Total		Actual	Estimated	Total	
08/01/07	34		34	105				
08/02/07	10		10	31				
08/03/07	10		10	31				
08/04/07	14		14	43				
08/05/07	43		43	133	1		1	4
08/06/07	39		39	121				
08/07/07	20		20	62				
08/08/07	13		13	40				
08/09/07	8		8	25				
08/10/07	6		6	27				
08/11/07	7		7	31				
08/12/07	14		14	62				
08/13/07	25		25	111				
08/14/07	16		16	71				
08/15/07	14		14	62				
08/16/07	14		14	62				
08/17/07	11		11	49				
08/18/07	5		5	22				
08/19/07	5		5	22				
Total	**12,117**	**195**	**12,312**	**136,571**	**15,570**	**18**	**15,588**	**65,016**

Appendix C2. Daily catches of Dungeness River coho, chum, steelhead, cutthroat, unspecified trout, pink, and bull trout (Dolly Varden), 2007.

Date	Times		COHO		CHUM	STHD	CUTTHROAT		TROUT	PINK	DOLLYV
	In	Out	Smolts	Fry	Fry	Smolts	Smolt	Adult	Parr	Fry	Smolt
02/21/07	20.80								2		
02/22/07	24.83								1		
02/23/07	22.70								3		
02/24/07	24.07								2		
02/25/07	24.43								2		
02/26/07	23.75								3		
02/27/07	24.55		1	1					1		
02/28/07	23.90				1				3		
03/01/07	23.52				1				1		
03/02/07	24.25								1		
03/03/07	23.67								3		
03/04/07	24.33				1				1		
03/05/07	23.98				1				4	1	
03/06/07	24.02									1	
03/07/07	24.05										
03/08/07	24.45		1		5				1		
03/09/07	23.25		1		3				2	1	
03/10/07	24.75		1		11				1	5	
03/11/07	22.78	0.63	1		37					6	
03/12/07	25.42				67				8	8	
03/13/07	25.83				41				5	1	
03/14/07	21.33				46				9	3	
03/15/07	24.25		1		41				1		
03/16/07	24.00		1		99				2	2	
03/17/07	24.25				59				2	5	
03/18/07	23.25		1		105				2	1	
03/19/07	24.25				22				2		
03/20/07	23.50				508				3	5	
03/21/07	24.33				181				3	2	
03/22/07	23.92				262	1			1	5	
03/23/07	22.63				37	1			2		
03/24/07	25.12	1.00	1		132				6	1	
03/25/07	22.50				284				4		
03/26/07	25.00		3		146				6		
03/27/07	23.58		2		66	1			8		
03/28/07	24.17				87				2		
03/29/07	24.08		2		137				11		
03/30/07	23.92		1		122				6		
03/31/07	24.25				873				13		
04/01/07	23.20	1.30			196	1			8		
04/02/07	9.00	14.50			206				1		
04/03/07		24.00									
04/04/07		24.00									
04/05/07		24.00									
04/06/07		24.00									
04/07/07	10.42	13.42	2		759	1	2		13		
04/08/07	24.25		3		911	1	1		7		
04/09/07	23.67		3		759	3			15	1	
04/10/07	24.58		12		583	3	1		4	1	

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Appendix C2. Daily catches of Dungeness River coho, chum, steelhead, cutthroat, unspecified trout, pink, and bull trout (Dolly Varden), 2007.

Date	Times		COHO		CHUM	STHD	CUTTHROAT		TROUT	PINK	DOLLYV
	In	Out	Smolts	Fry	Fry	Smolts	Smolt	Adult	Parr	Fry	Smolt
04/11/07	24.17		14	1	458	1			6		
04/12/07	23.00		2		203	1			2		
04/13/07	24.25		2		617	5			1		
04/14/07	24.00		4		1,074	8			1		
04/15/07	24.00		1		195	6			10		
04/16/07	23.58		8		464	3			8		
04/17/07	25.23		1		923				8		
04/18/07	24.27				344	2			6		
04/19/07	23.50		3		422		1		7		
04/20/07	23.42		2		234	6	1		6		
04/21/07	24.25		2		693	4			6		
04/22/07	23.83		15		407	8			12		
04/23/07	22.58		1		128	1			6		
04/24/07	25.50		4		111	2	1		12		
04/25/07	23.75		2		59	7			6		
04/26/07	24.08		4		134	2	1		15		
04/27/07	24.50		3		205	3	2		13		
04/28/07	23.75		3		323	16	1		12		
04/29/07	24.25		5		248	14			13		2
04/30/07	23.92		5		220	8			10		
05/01/07	23.58		8		219	3			6		
05/02/07	24.75		18		755	11	2		10		1
05/03/07	24.50		21		762	14	1		11		
05/04/07	22.25		14		447	18	2		13		
05/05/07	23.25		13		367	10			11		
05/06/07	24.88		13		337	10			15		
05/07/07	24.82		109		808	58			39		1
05/08/07	23.80		47		131	53	2		18		
05/09/07	24.00		53		32	46			20		
05/10/07	24.75		40		15	15	2		22		
05/11/07	23.75		20		2	21			16		
05/12/07	23.00		40		2	15			10		
05/13/07	24.60		28		8	27			13		
05/14/07	23.90		54		3	25			10		
05/15/07	23.75		76		6	27			11		
05/16/07	23.83		51		17	13			6		
05/17/07	24.17		36		10	23			7		
05/18/07	24.75		53		1	23	1		1		
05/19/07	23.25		55		1	37	2		9		1
05/20/07	25.92		9		14	18			7		1
05/21/07	20.08		82		70	34	1		5		
05/22/07	26.00		100	1	2	23	2		16		1
05/23/07	24.25		84		2	21			29		
05/24/07	24.00		85		1	29			14		
05/25/07	24.00		82		5	22			10		1
05/26/07	24.83		84		1	14			14		
05/27/07	24.42		115		5	27			16		
05/28/07	24.25		180		4	29			13		
05/29/07	23.25		80		10	11			1		
05/30/07	23.75		72		21	12	2		5		

Table continued next page

Appendix C2. Daily catches of Dungeness River coho, chum, steelhead, cutthroat, unspecified trout, pink, and bull trout (Dolly Varden), 2007.

Date	Times		COHO		CHUM	STHD	CUTTHROAT		TROUT	PINK	DOLLYV
	In	Out	Smolts	Fry	Fry	Smolts	Smolt	Adult	Parr	Fry	Smolt
05/31/07	23.75		64		36	11			2		
06/01/07	27.82		13		17	4					
06/02/07	0.60	20.09			2						
06/03/07	0.92	23.08									
06/04/07	24.50		6		5	2					1
06/05/07	24.50		11		1	6					
06/06/07	24.25		43	1		20	1		12		
06/07/07	22.00		76			9			6		1
06/08/07	24.25		30			5			14		
06/09/07	24.33		31		3	4			23		1
06/10/07	23.92		17			2			5		
06/11/07	23.05		23			6			4		1
06/12/07	25.45		28		1	6			14		
06/13/07	24.75		20		1				15		
06/14/07	27.00		31	1	2	4	1		18		1
06/15/07	19.50		15		1	2			18		
06/16/07	23.75		9			2	1		16		1
06/17/07	24.00		19		1	4			4		2
06/18/07	23.50		6			1	1		4		1
06/19/07	24.17		11			2	3				
06/20/07	24.83		21	5	1	1	2		11		
06/21/07	24.50		10			4			13		3
06/22/07	23.17		5	2			1		4		2
06/23/07	24.33		51	5		22	9		17		
06/24/07	24.75		28	8	1	10	3		8		2
06/25/07	23.50		12	4	1	3	1		2		1
06/26/07	23.75		14			2	1		6		
06/27/07	24.08		12			3	1		22		
06/28/07	23.92		11	2	3	3	2		22		
06/29/07	24.25		16	2		2	3		19		
06/30/07	24.00		9		1		1		6		
07/01/07	24.25		4			2					
07/02/07	23.75	0.25	11		1	1	2		9		
07/03/07	23.75		8	1					6		
07/04/07	24.25		4						4		1
07/05/07	20.00		7						3		
07/06/07	27.75		3						5		
07/07/07	23.25		2	1		1			4		1
07/08/07	25.08			2		1			6		
07/09/07	22.42		3				1		3		
07/10/07	24.50		4	2	1		1		4		2
07/11/07	24.75		5						3		1
07/12/07	23.75		3	4		1			4		1
07/13/07	22.58		3	1					6		3
07/14/07	25.17		4						3		1
07/15/07	25.25		3						4		

Table continued next page

Appendix C2. Daily catches of Dungeness River coho, chum, steelhead, cutthroat, unspecified trout, pink, and bull trout (Dolly Varden), 2007.

Date	Times		COHO		CHUM	STHD	CUTTHROAT		TROUT	PINK	DOLLYV
	In	Out	Smolts	Fry	Fry	Smolts	Smolt	Adult	Parr	Fry	Smolt
07/16/07	23.50		2						4		
07/17/07	23.75		2				1				1
07/18/07	23.42		2		1		1		1		
07/19/07	25.08		1						2		
07/20/07	24.00								5		
07/21/07	24.75		1						5		
07/22/07	23.17								2		
07/23/07	21.67								4		1
07/24/07	26.00					1			5		1
07/25/07	24.67		1				1		4		
07/26/07	24.50						2	1	4		2
07/27/07	22.67								3		
07/28/07	24.83							1	1		1
07/29/07	23.42								8		1
07/30/07	23.17					1					
07/31/07	25.17		1						1		1
08/01/07	22.50		1						7		
08/02/07	24.75								2		
08/03/07	25.25								1		
08/04/07	22.50								2		
08/05/07	25.08										
08/06/07	23.67								1		
08/07/07	23.75								2		
08/08/07	27.08								2		
08/09/07	20.67								1		
08/10/07	24.75										
08/11/07	22.75										
08/12/07	25.00										
08/13/07	23.92								1		
08/14/07	24.17						1				
08/15/07	23.75										
08/16/07	23.50										
08/17/07	25.42										
08/18/07	23.42								1		
08/19/07	24.58										
Total	4148.78	170.27	2,557	44	18,389	946	69	2	1,131	49	43

Appendix C3. Daily migration estimates for juvenile coho, steelhead and chum salmon, Dungeness River 2007. Daily migration calculated from daily catches and associated trap efficiency.

Date	COHO Smolts	STEELHEAD Smolts	Chum CHUM
02/21/07			
02/22/07			
02/23/07			
02/24/07			
02/25/07			
02/26/07			
02/27/07	9		
02/28/07			17
03/01/07			17
03/02/07			
03/03/07			
03/04/07			17
03/05/07			17
03/06/07			
03/07/07			
03/08/07	9		86
03/09/07	9		52
03/10/07	9		189
03/11/07			551
03/12/07	9		1,273
03/13/07			705
03/14/07			791
03/15/07	9		705
03/16/07	9		1,703
03/17/07			1,015
03/18/07	9		1,807
03/19/07			379
03/20/07			8,741
03/21/07			3,114
03/22/07		12	4,508
03/23/07		12	637
03/24/07	9		2,426
03/25/07			4,886
03/26/07	26		2,512
03/27/07	17	12	1,136
03/28/07			1,497
03/29/07	17		2,357
03/30/07	9		2,099
03/31/07			15,021
04/01/07		12	3,458
04/02/07	17	24	16,122
04/03/07	9	12	12,474
04/04/07	9	12	12,474
04/05/07	9	12	12,474

Table continued next page

Appendix C3. Daily migration estimates for juvenile coho, steelhead and chum salmon, Dungeness River 2007. Daily migration calculated from daily catches and associated trap efficiency.

Date	Coho Smolts	Steelhead Smolts	Chum Fry
04/06/07	9	12	12,474
04/07/07	17	12	15,365
04/08/07	26	12	15,675
04/09/07	26	36	13,059
04/10/07	103	36	10,031
04/11/07	120	12	7,880
04/12/07	17	12	3,493
04/13/07	17	60	10,616
04/14/07	34	96	18,479
04/15/07	9	72	3,355
04/16/07	69	36	7,984
04/17/07	9		15,881
04/18/07		24	5,919
04/19/07	26		7,261
04/20/07	17	72	4,026
04/21/07	17	48	11,924
04/22/07	129	96	7,003
04/23/07	9	12	2,202
04/24/07	34	24	1,910
04/25/07	17	84	1,015
04/26/07	34	24	2,306
04/27/07	26	36	3,527
04/28/07	26	191	5,557
04/29/07	43	167	4,267
04/30/07	43	96	3,785
05/01/07	69	36	3,768
05/02/07	155	131	12,990
05/03/07	180	167	13,111
05/04/07	120	215	7,691
05/05/07	112	119	6,315
05/06/07	112	119	5,798
05/07/07	937	693	13,902
05/08/07	404	633	2,254
05/09/07	455	550	551
05/10/07	344	179	258
05/11/07	172	251	34
05/12/07	344	179	34
05/13/07	241	323	138
05/14/07	464	299	52
05/15/07	653	323	103
05/16/07	438	155	292
05/17/07	309	275	172
05/18/07	455	275	17
05/19/07	473	442	17
05/20/07	77	215	241

Table continued next page

Appendix C3. Daily migration estimates for juvenile coho, steelhead and chum salmon, Dungeness River 2007. Daily migration calculated from daily catches and associated trap efficiency.

Date	Coho Smolts	Steelhead Smolts	Chum Fry
05/21/07	705	406	1,204
05/22/07	859	275	34
05/23/07	722	251	34
05/24/07	730	346	17
05/25/07	705	263	86
05/26/07	722	167	17
05/27/07	988	323	86
05/28/07	1,547	346	69
05/29/07	687	131	172
05/30/07	619	143	361
05/31/07	550	131	619
06/01/07	112	48	292
06/02/07	69	48	206
06/03/07	43	24	155
06/04/07	52	24	86
06/05/07	95	72	17
06/06/07	369	239	
06/07/07	653	108	
06/08/07	258	60	
06/09/07	266	48	52
06/10/07	146	24	
06/11/07	198	72	
06/12/07	241	72	17
06/13/07	172		17
06/14/07	266	48	34
06/15/07	129	24	17
06/16/07	77	24	
06/17/07	163	48	17
06/18/07	52	12	
06/19/07	95	24	
06/20/07	180	12	17
06/21/07	86	48	
06/22/07	43		
06/23/07	438	263	
06/24/07	241	119	17
06/25/07	103	36	17
06/26/07	120	24	
06/27/07	103	36	
06/28/07	95	36	52
06/29/07	137	24	
06/30/07	77		17
07/01/07	34	24	
07/02/07	95	12	17
07/03/07	69		
07/04/07	34		
07/05/07	60		

Table continued next page

Appendix C3. Daily migration estimates for juvenile coho, steelhead and chum salmon, Dungeness River 2007. Daily migration calculated from daily catches and associated trap efficiency.

Date	Coho Smolts	Steelhead Smolts	Chum Fry
07/06/07	26		
07/07/07	17	12	
07/08/07		12	
07/09/07	26		
07/10/07	34		17
07/11/07	43		
07/12/07	26	12	
07/13/07	26		
07/14/07	34		
07/15/07	26		
07/16/07	17		
07/17/07	17		
07/18/07	17		17
07/19/07	9		
07/20/07			
07/21/07	9		
07/22/07			
07/23/07			
07/24/07		12	
07/25/07	9		
07/26/07			
07/27/07			
07/28/07			
07/29/07			
07/30/07		12	
07/31/07	9		
08/01/07	9		
08/02/07			
08/03/07			
08/04/07			
08/05/07			
08/06/07			
08/07/07			
08/08/07			
08/09/07			
08/10/07			
08/11/07			
08/12/07			
08/13/07			
08/14/07			
08/15/07			
08/16/07			
08/17/07			
08/18/07			
08/19/07			
Total	22,134	11,445	381,781

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