2001 Green River Juvenile Salmonid Production Evaluation

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October 2004

Acknowledgments

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

A number of other individuals and agencies contributed to this project. For providing access to the trap site, we thank the adjacent landowner, Bill Mosby. We also thank Mike Wilson, Manager of the Soos Creek Hatchery, for providing logistical support, office space, and a secure staging site near the trap. And finally, we thank Fred Goetz of the United States Army Corps of Engineers for providing funding and coordination for this project.

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Executive Summary

The National Marine Fisheries Service (NMFS) listed Puget Sound chinook as threatened under the Endangered Species Act (ESA) in March 1999. This listing triggered action on the part of state and local governments to develop plans and implement actions designed to restore Puget Sound chinook runs to healthy levels. An important, but often missing, component of the plans is accurate information on wild chinook abundances and the factors that limit or impact production and productivity in key wild chinook stocks. One such key stock, Green River chinook, represents one of the largest populations of chinook within the Puget Sound Evolutionary Significant Unit (ESU). Since quantifying juvenile anadromous salmonid populations as they migrate seaward is the most direct assessment of stock performance in freshwater, a long-term wild juvenile salmon production study was initiated in the Green River to estimate and monitor the production of chinook and coho salmon, and steelhead trout.

Beyond monitoring for ESA considerations, this study provides important information for run-size forecasting and enables assessment of recovery actions in terms of change in wild salmon production. The study will also be used to evaluate a large water storage and diversion project on the Green River (Howard Hansen Dam [HHD] Additional Water Storage [AWS] Project). This report documents our investigations during 2001, the second year of this project and the second and final year of pre-construction baseline monitoring for the AWS project. Study objectives in 2001 include estimating Green River wild chinook freshwater production, migrant size, and migration timing to evaluate the condition of the stock and to help develop a better understanding of factors influencing their production and life history.

To accomplish these objectives, we operated a floating screw trap on the mainstem Green River (river mile 34.5). A portion of all downstream migrating juvenile salmonids were captured in this trap. To estimate the capture efficiency, over the season groups of dye-marked or fin-marked fish were released upstream of the trap. Nightly migration was estimated by dividing the nightly catch by the estimate of trap efficiency.

Over the 182-day January 31 to August 1 trapping period, over 56,000 juvenile chinook were captured. From this catch and our estimates of trap efficiency, we estimated a total of 728,000 age 0+ wild chinook migrated past our trap in 2001.

During both years of operation (2000 and 2001), the chinook migration followed a bi-modal timing distribution. An earlier-timed “fry” component, comprised of newly emerged fry that migrated between January and early April, was followed by a later-timed “smolt” component comprised of larger chinook smolts that migrated from May through June. We have observed this timing distribution in other rivers monitored in western Washington.

Relating our estimate of age 0+ chinook production to the number of eggs estimated to have been deposited above the trap results in an egg-to-migrant survival estimate of 5.3%.

We estimated 497,000 age 0+ chinook were produced below the trap for a total 2001 Green River age 0+ chinook natural production of 1.23-million. This estimate of lower river production was made by assuming the egg-to-migrant survival of chinook eggs deposited below the trap was equal to that measured above the trap and that the natural production from Big Soos Creek was the same as was estimated in 2000.

In addition to age 0+ chinook, we also estimated 55,000 wild and 132,000 hatchery coho smolts, and 15,000 wild and 45,000 hatchery steelhead smolts migrated past the trap. No cutthroat smolts were captured in the trap in 2001.

Since most hatchery fish released upstream of the trap were adipose-marked, we were able to estimate survival to the trap of marked chinook, coho, and steelhead. Assuming that hatchery fish are trapped at the same rate as wild fish, we estimated a 67% survival of Keta Creek coho, 15% survival of Keta Creek and Palmer Ponds steelhead, combined, and 0.22% survival of age 0+ Keta Creek chinook released upstream of Howard Hansen Dam.

Over the two years of baseline monitoring related to the AWS project, age 0+ wild chinook production upstream of the trap ranged from 535,000 in 2000 to 728,000 in 2001. Variation in the proportion of chinook migrating as fry and smolts occurred over the two years with 53% of the production migrating as fry in 2001 compared to 68% in 2000. Since more of the production migrated as fry in 2000, seasonal chinook migration timing was earlier that year. The median migration point occurred nearly a month later in 2001 compared to 2000. Results from monitoring production in other rivers suggests that production levels and migration timing measured from just two years of baseline monitoring in the Green River likely underestimates the true variability in these components of chinook life history.

Introduction and Background

The National Marine Fisheries Service (NMFS) listed Puget Sound chinook as threatened under the Endangered Species Act (ESA) in March 1999. Out of the 28 chinook stocks included in the Puget Sound Evolutionary Significant Unit (ESU), Green River chinook is one of the largest. In recent years, this stock has comprised approximately 21% of the total natural escapement for the ESU. Although an unknown level of the natural escapement has been attributed to hatchery strays from Big Soos Creek (WDFW *et al*. 1993), recent (1996 to present) escapement levels have exceeded natural escapement goals for the Green River. Consequently, Duwamish-Green River chinook are considered a healthy stock.

Under the Governor's Salmon Plan to restore salmon populations, one major objective is to determine the limiting factors for chinook salmon in priority watersheds. Necessary data for this purpose include habitat inventory, annual adult escapement estimates, and wild juvenile chinook assessment. The juvenile production evaluation is a vital link in this process because it provides a direct measure of freshwater survival.

Quantifying juvenile anadromous salmonid populations as they migrate seaward is the most direct assessment of stock performance in freshwater. It is preferred over other approaches such as run reconstruction because the error associated with partitioning brood losses into freshwater and marine environmental effects and harvest effects is excluded. Relating smolt production to parent spawners over a number of brood cycles provides an understanding of key variables for the recovery and management of the stock. For example, if adequate escapements occur, smolt production monitoring empirically measures the watershed's natural production potential. Monitoring smolts over a range of escapements also assesses watershed/stock productivity by developing the spawner-recruit function. Finally, this information enables identification of the major density-independent source(s) of inter-annual variation in freshwater survival, which is critical to improving harvest and habitat.

To accomplish these objectives, beginning in 1976 the WDFW implemented a long-term research program directed at measuring wild salmon production (smolt and adult populations) in selected watersheds. Recently, the state legislature provided additional funding to expand downstream migrant assessments throughout the state (JNRC 2000). During the scoping phase of this expansion, chinook streams throughout the Puget Sound ESU were evaluated for selection based on considerations such as feasibility and the importance of the stock to fisheries. Another important consideration was the selection of streams or sites that precluded the capture of large numbers of hatchery fish which would make wild stock monitoring difficult. In addition to these criteria, the Green River was selected for monitoring because the water capacity of Howard Hansen Dam in the upper watershed is being increased for additional storage.

Beginning in 2000, a floating juvenile migrant fish trap was operated in the mainstem Green River at river mile 34, approximately ½ mile upstream of the mouth of Big Soos Creek. Locating the trap upstream of Big Soos Creek was essential to avoid the capture of large numbers of hatchery fish produced in the Soos Creek Hatchery, located on Big Soos Creek. A second trap was also operated upstream of the hatchery in Big Soos Creek that year to assess the production of naturally-reared chinook that resulted from hatchery spawners released above the Soos Creek Hatchery rack. Chinook, coho, steelhead, and cutthroat production estimates resulting from these projects are described in Seiler *et al*. (2002[a]). This report describes the second year of operation of the mainstem trap and the findings from that effort. Operation of the Big Soos Creek trap was not continued in 2001; however, information collected from its one year of operation was used in this report to estimate total basin production of juvenile chinook salmon.

In addition to monitoring for ESA and fisheries management considerations, this project also assessed juvenile salmon production and migration to evaluate the effects of a large-scale water project that was recently approved, as well as its mitigation elements. Over the past eight years, the U.S. Army Corps of Engineers (USACE) and Tacoma Public Utilities (TPU) have worked with the U.S. Fish and Wildlife Service (USFWS), NMFS, WDFW, Washington Department of Ecology (WDOE), and the Muckleshoot Indian Tribe (MIT) to scope, conduct, and evaluate the feasibility studies for the HHD AWS Project. The project would include raising the reservoir surface elevation to 1,167 feet to increase water storage for domestic use. To accommodate this project, a wide variety of mitigation and monitoring activities were planned including a full-height fish passage facility, right abutment drainage remedies, Phase I fish and wildlife habitat restoration and mitigation, and monitoring and evaluation studies (USACE 1998). Tacoma's Second Supply Water Right (20,000 ac-ft of storage) would be stored in the spring for water supply use in the summer and fall. The final design for the project was developed between 1999 and 2001. Construction began in 2001 and is projected to continue through 2005. The project is scheduled to begin operation, storing water, and operating the fish passage facility in 2005.

Monitoring activities required for this project include the study of the in-stream migration of juvenile salmon and steelhead during the water storage and release operations at HHD. The objective of this monitoring component is to evaluate strategies designed to minimize the impact of existing and future planned operation of the AWS Project on the survival of emigrating (naturally-reared and hatchery) juvenile salmon and steelhead. Juvenile salmon emigration monitoring for the AWS project includes a two-year pre-construction baseline phase (2000 to 2001) and a five-year post-construction monitoring phase (2005 to 2009). This before and after AWS project monitoring will provide important feedback which may result in adjustment to storage and release regimes in response to observed results through an adaptive management process. This report describes our activities and findings relative to the second year of baseline monitoring.

Goals and Objectives

As part of our wild salmon monitoring activities under the State Agencies' Action Plan for the Statewide Strategy to Recover Salmon (JNRC 2000), Green River wild chinook freshwater production, migrant size, and migration timing are measured or estimated to evaluate and monitor the condition of the stock. This information will also be used to develop a better understanding of factors influencing their production and life history, and to provide direction for habitat protection. In addition, monitoring on the Green River will provide an opportunity for hatchery programs located upstream of the trap site to test strategies for improving in-river survival of their releases.

Attaining these goals and objectives will contribute to better understanding the continued production of wild chinook salmon in the Green River and the actions needed to maintain the productivity of this stock. As part of the baseline monitoring for the AWS project, the monitoring completed in 2001 documents existing characteristics of juvenile in-stream migration, such as seasonal and diel timing. In addition, it begins to document the response of different salmonid species at various life-stages to environmental changes (e.g., flow, turbidity, day length, and temperature) and their response to HHD refill and release. This information will be evaluated and used to refine an adaptive refill and release schedule for the planned AWS Project.

Trap Operations

A floating screw trap (Busack *et al.* 1991) was used on the Green River to capture downstream migrant chinook, coho, chum, and steelhead. The mainstem trap was located at river mile 34.5; approximately 3,200-ft upstream of the Highway 18 bridge, on the left bank (Figure 1). This trap is fully described in Seiler *et al*. 2002[a].

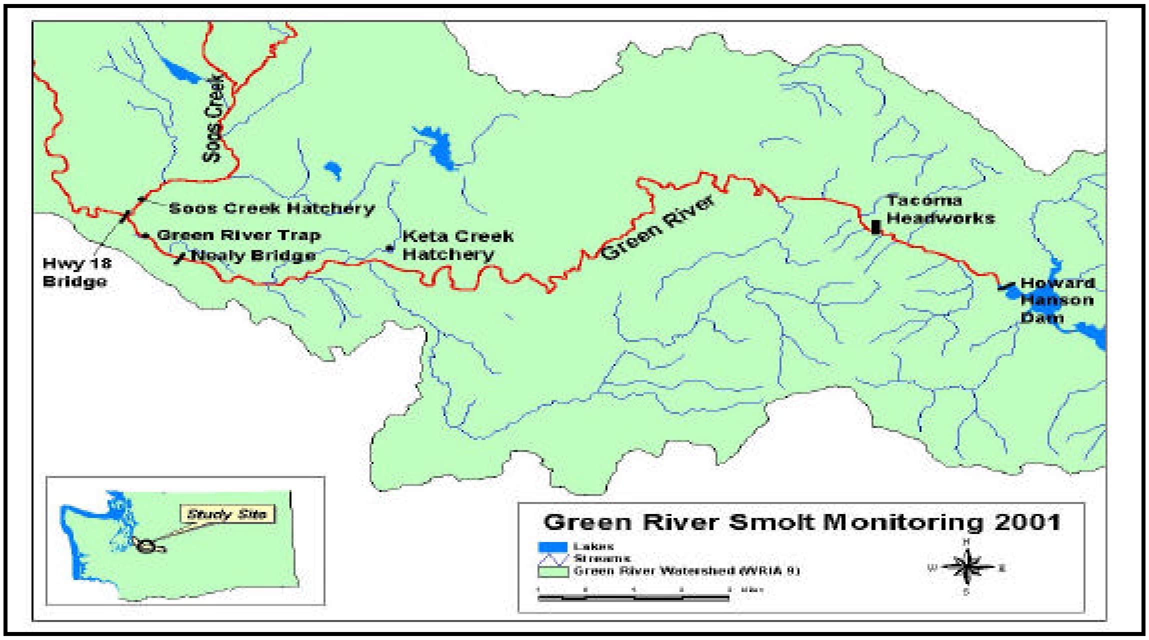

Figure 1. Location map of the Green River screw trap relative to hatcheries and hydro projects, Middle Green River 2001.

The trap on the Green River was operated continuously between January 31 and August 1, except for periods when debris or mechanical failure caused the cessation of trapping. Trapping was also suspended during daytime periods late in the trapping season, when catches were low and recreational use of the river was high. Fish were usually removed from the trap and counted at dawn and at dusk to evaluate differences in daytime and nighttime catch rates. In addition to these periods, the trap was checked at other times, as needed, based on debris loads and capture rates. Once or twice per week, hourly trap checks were made throughout the night to assess nighttime migration timing. At the end of each trapping period, all fish captured in the trap were identified to species and enumerated. Fork length measurements were taken from a sample of the captured unmarked chinook, coho and steelhead.

In order to estimate migration, groups of chinook, coho, chum, and steelhead were used to test the capture efficiency of the trap. Fish used for trap efficiency testing were anesthetized with tricaine methanesulfonate (MS 222), identified to species, and marked with a unique partial fin clip or with Bismark Brown dye. Marked fish were allowed to recover in fresh water before being placed in buckets, transported upstream, and released within 0.5-miles upstream of the trap. Most of the mark groups were released 200 yards above the trap. Capture rates were estimated by the proportion of marked fish that were recaptured in the trap.

Production Estimates

Age 0+ Chinook

Estimating chinook production from the Green River was done in two steps. Since the trap did not operate continuously over the entire trapping period, the first step involved estimating via interpolation catch for periods when the trap did not fish. The second step involved estimating the capture rate or trap efficiency.

To interpolate catch for periods when the trap was not fishing, diel differences in migration rates were evaluated. Salmonids often migrate at different rates between day and night periods (Seiler *et al.* 1981), therefore, fishing periods were stratified into daytime, nighttime, and combined periods. The stratification was simplified by performing the trap checks near daybreak and twilight periods. A number of different approaches were used to interpolate catch depending on whether trapping was suspended for part of a day or night, the entire day or nighttime period, or for multiple days. Equations for catch interpolation and variance estimates for each of these scenarios are described in Seiler *et al*. (2002[a]).

Catches from nighttime fishing periods that spanned midnight were partitioned into before and after midnight catches. Actual and estimated catches were then summed over each 24-hour period to estimate the total daily chinook catch. Variances for the interpolated values were also summed to estimate the variances of these daily catch estimates. These methods were also used to estimate the adipose-marked (ad-marked) and unmarked components of the daily catches. Daily migration was estimated by dividing the estimated catch by the daily estimated trap efficiency. Equations used to estimate daily migration and its variance are found in Seiler *et al*. (2002[a]).

In order to estimate the trap efficiency, small groups of marked age 0+ chinook migrants were released upstream of the trap. Chinook tests were conducted using groups of chinook that were captured the previous night and marked with partial fin-clips or Bismark brown dye. Partial upper and lower caudal clips were used to mark the fish. Fish dyed in Bismark brown dye were held in a dye concentration of 14-ppm for 1.5 hours. The marked fish were transported in 5-gallon buckets and distributed at the release site. The proportion of marked fish recaptured in the trap estimated trap efficiency. The variance of each efficiency test was calculated based on a binomial relationship (Seiler *et al*. 2002[a]).

Since chinook migrants were not always available in large numbers during the trapping period, a number of additional tests were made using chum fry. These fry were usually similar in size or slightly smaller than chinook at the time they were used for testing. Capture rates resulting from the tests were stratified by species and tested for differences at a 95% significance level using analysis of variance (ANOVA). Where capture efficiencies using chum fry were not found to be significantly different from those using chinook migrants, the chum fry test results were pooled with the chinook migrant test results to provide a more robust set of efficiency data.

Linear regression analysis was used to test the effect of mean daily flow on capture rates in the Green River. Where the regression was found to be significant ($p<0.05$), the regression equation was used to estimate trap efficiency from mean daily flow found at the USGS Palmer gage station (Seiler *et al*.

2002[a]). Where regression derived relationships were not found to be significant, the mean trap efficiency from all tests was used to estimate migration.

Daily estimates of the ad-marked, unmarked, and total (ad-marked and unmarked) chinook migrations were summed across the season to estimate migration for each group over the trapping period. Daily variance estimates for these groups were also summed across the trapping period to estimate variances for the seasonal totals.

When trapping began on January 31, the chinook migration was already underway. Based on results from monitoring in other systems, we chose January 1 as the date that the wild chinook migration began (Seiler *et al.* 2002[b]). Linear extrapolation was used to estimate migration between January 1 and January 30. The extrapolation was based on the estimate of average migration from the first three days trapped (January 31 to February 2).

The ad-marked, unmarked, and total 2000 brood chinook migrations past the trap were estimated by summing the daily migration estimates from the trapped and extrapolated periods, January 1 to August 1. Summing the variance estimates for the daily migrations over the same periods generated the variances of these estimates.

Coho and Steelhead

Coho and steelhead smolt catches were expanded to account for periods not fished, as was done for chinook migrants. For coho salmon, two trap efficiency tests were conducted using hatchery fish. Only a single efficiency test was conducted for steelhead and no marked fish were recovered from this release. Results from tests for both species were not deemed adequate to estimate trap efficiency (see Results), therefore other methods were used to estimate production. Smolt trapping data collected over the last 20 years has shown that trap efficiency is inversely related to fish size (Seiler *et al.* 2002[b]). Coho smolts are larger than chinook migrants and steelhead smolts are larger than coho smolts; therefore we expect trap efficiency for coho to be lower than for chinook and for steelhead to be lower than that for coho smolts. We estimated coho trap efficiency by multiplying the chinook capture rate by the mean ratio between coho and chinook capture rates found at other sites. A similar approach was used to estimate the steelhead capture rate using the estimated rate for coho smolts. Because of the uncertainty reflected in these approaches, no attempts were made to estimate the precision of the coho and steelhead capture rates, or of the resulting migration estimates. Daily migration estimates were summed to estimate the total migrations of ad-marked and unmarked coho and steelhead.

Estimating the production of naturally-produced chinook, coho, and steelhead migrants was complicated by the large numbers of hatchery salmonids planted into the river. Table 1 provides a summary of hatchery releases that could have been captured in the screw trap in 2001.

Table 1. Hatchery releases of year 2001 migrants that occurred upstream or near the Green River screw trap.

Species	Hatchery	BY	Release Dates	Location	Ad-CWT	CWT Only	Ad-Only	Unmkd
2000 releases upstream of the Green River trap								
Coho[a]	Keta Creek	99	04/19-04/27	Above HHD	0	0	0	559,625
Fall Chinook[a]	Keta Creek	99	03/27-03/28	Above HHD	0	0	208,986	0
Winter Steelhead[b]	Keta Creek	00	08/21	Green R	0	0	0	50,281
2000 releases into Big Soos Creek[c]								
Coho[b]	Soos Creek	99	03/01	Soos Cr	0	0	0	1,000
Winter Steelhead[b]	Keta Creek	00	08/21	Soos Cr	0	0	0	10,045
2001 releases upstream of the Green River trap								
Coho	Keta Creek	99	05/01	Crisp Cr	45,582	1,100	143,748	4,570
Fall Chinook	Icy Creek	99	05/01	Green R	0	0	241,300	0
Fall Chinook	Keta Creek	00	04/02-04/06	Above HHD	0	0	537,735	49,657
Fall Chum	Keta Creek	00	04/26	Crisp Cr	0	0	0	96,540
Winter Steelhead	Keta Creek	00	05/09	Crisp Cr	0	0	104,000	0
Winter Steelhead	Palmer	00	05/01	Green R	0	0	199,578	0
2001 releases into Big Soos Creek[c]								
Coho	Soos Creek	99	04/09-04/24	Soos Cr	48,180	48,330	505,046	0
Fall Chinook	Soos Creek	00	05/18-06/11	Soos Cr	200,209	205,260	2,990,232	0

[a] Some chinook and most coho may have been retained during fill period to migrate as 1+ smolts in 2001.
[b] Fry or fingerling releases expected to migrate as smolts in 2001.
[c] Although Big Soos Creek is located 0.5-miles downstream of trap, some Soos Creek fish were caught.

Chinook

Catch

Over the 182-day season, we captured 56,554 unmarked and 71 ad-marked age 0+ chinook migrants (Appendix A). Daily unmarked age 0+ chinook catch averaged 54 migrants over the first two complete days of trapping (February 3 and 4). Daily catch of unmarked migrants increased to 3,102 on March 6 and 3,195 on March 19. After March 19, daily catches then declined to less than 20 migrants by mid-April. Daily catches of unmarked age 0+ chinook migrants began to increase again in early May, peaking on June 11 at 3,451 migrants, before declining to less than 30 migrants by the first week in July.

The only hatchery chinook releases of age 0+ fry above the trap were experimental releases above HHD. Nearly all (91.5%) of these were ad-marked. Ad-marked age 0+ chinook first entered catches on April 6, four days after the first releases occurred on April 2. The last was caught on July 10. In all, a total of just 71 ad-marked age 0+ chinook were captured from these releases. We estimated a catch of six unmarked hatchery chinook occurred along with the catch of marked fish. Subtracting this total from the unmarked catch, estimates the wild age 0+ unmarked chinook catch at 56,548 (Appendix A).

Over the season, we also caught 39 unmarked and 426 ad-marked age 1+ chinook migrants. Ad-marked age 1+ chinook were caught beginning on April 22, two days prior to the reported date of the first release of marked age 1+ hatchery smolts from the Icy Creek facility. The catch peaked on April 24 (248 smolts), the reported date of the first release, and continued through May 26. In all, we captured 426 ad-marked age 1+ chinook out of a total release of 241,300, or 0.2%. Ad-marked age 1+ chinook catches could also have resulted from releases of 0+ chinook made above HHD in 2000 that failed to migrate prior to the water storage period and held-over to migrate in 2001. This seems unlikely, however, since no ad-marked age 1+ chinook was caught prior to April 22.

Size

Wild chinook 0+ averaged around 40-mm through the first week in April. They grew rapidly afterwards, averaging over 80-mm by mid-June (Table 2, Figure 2). Migrants measuring less than 40-mm were found through the end of April, after which, the minimum size increased rapidly to over 70-mm at the end of the trapping period. The increase in the minimum size probably indicates that incubation and emergence was completed.

Catch Expansion

The trap was operated 4,003 hours out of 4,359 hours in the 182-day trapping period, or 91.8% of the time. Trapping was suspended for 22.0 hours during eight events when woody debris jammed or threatened to jam the screw. Outages from screw stoppage events were estimated based on the expected number of trap rotations (RPM x fishing time) compared to the count on the revolution counter. Trapping was also suspended on two occasions for a total of 3.7 hours when trap maintenance was required. In addition, trapping was suspended for a total of 329.9 hours late in the season during the day when recreational use of the river was high and few fish were migrating.

Expanding the actual catches for periods when trapping was suspended resulted in the addition of just 107 age 0+ wild chinook. We estimate a total of 56,655 wild chinook would have been captured if continuous trapping had occurred between January 31 and August 1 (Appendix A). Expansion did not result in the addition of hatchery chinook to the actual catch. This low rate of expansion testifies, in part, to the high level of dedication provided by our field crew in keeping the trap operational over the season. It also is a reflection of the low stream flows that occurred during the early spring 2001 migration.

Table 2. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of wild age 0+ chinook measured by statistical week, Green River, 2001.

STAT WEEK No.	Begin	End	Avg	s.d.	RANGE Min	Max	n	Captured	Percent Sampled
5	01/31	02/04	39.8	1.70	36	41	8	143	5.59%
6	02/05	02/11	39.1	1.78	35	43	48	443	10.84%
7	02/12	02/18	40.5	1.69	34	45	145	534	27.15%
8	02/19	02/25	41.4	1.79	38	45	20	488	4.10%
9	02/26	03/04	41.0	1.68	34	45	246	5,593	4.40%
10	03/05	03/11	40.9	1.86	37	58	652	9,897	6.59%
11	03/12	03/18	41.0	1.69	36	55	742	8,055	9.21%
12	03/19	03/25	41.5	2.35	36	62	714	6,280	11.37%
13	03/26	04/01	41.0	2.13	36	54	364	2,885	12.62%
14	04/02	04/08	41.5	3.03	37	62	203	1,407	14.48%
15	04/09	04/15	42.5	5.32	38	66	127	268	48.88%
16	04/16	04/22	45.0	6.76	38	65	62	130	49.23%
17	04/23	04/29	48.7	8.79	38	73	24	230	10.43%
18	04/30	05/06	59.5	8.94	47	80	26	348	7.76%
19	05/07	05/13	68.0	8.29	48	82	22	318	6.92%
20	05/14	05/20	63.3	10.16	40	83	32	2,519	1.28%
21	05/21	05/27	69.4	8.43	49	89	76	2,688	2.94%
22	05/28	06/03	75.1	8.46	48	87	37	3,480	1.06%
23	06/04	06/10			No Sample			2,028	0.00%
24	06/11	06/17	87.3	12.00	63	115	26	6,962	0.88%
25	06/18	06/24	87.5	9.63	62	123	86	813	10.58%
26	06/25	07/01	90.2	6.76	78	108	48	613	7.83%
27	07/02	07/08			No Sample			185	0.00%
28	07/09	07/15	89.0	6.58	74	100	31	130	23.85%
29	07/16	07/22						86	0.00%
30	07/23	07/29			No Sample			25	0.00%
31	07/30	08/01						6	0.00%
SEASON TOTAL			45.0	12.30	34	123	3,739	56,554	6.61%

The chinook migration exhibited a bi-modal timing distribution. The first major migration occurred in February and March, with the downstream migration of newly emerged fry. The second migration occurred in May and June, with the downstream movement of smolted chinook. Weekly day/night catch rate ratios ranged from 0.095 to 1.13 during the fry migration and from 0.0074 to 0.83 during the smolt migration (Figure 3). No discernable trend was noted among weekly day/night catch rate ratios except that after week 21 (late-May), day/night ratios were generally lower than in previous weeks.

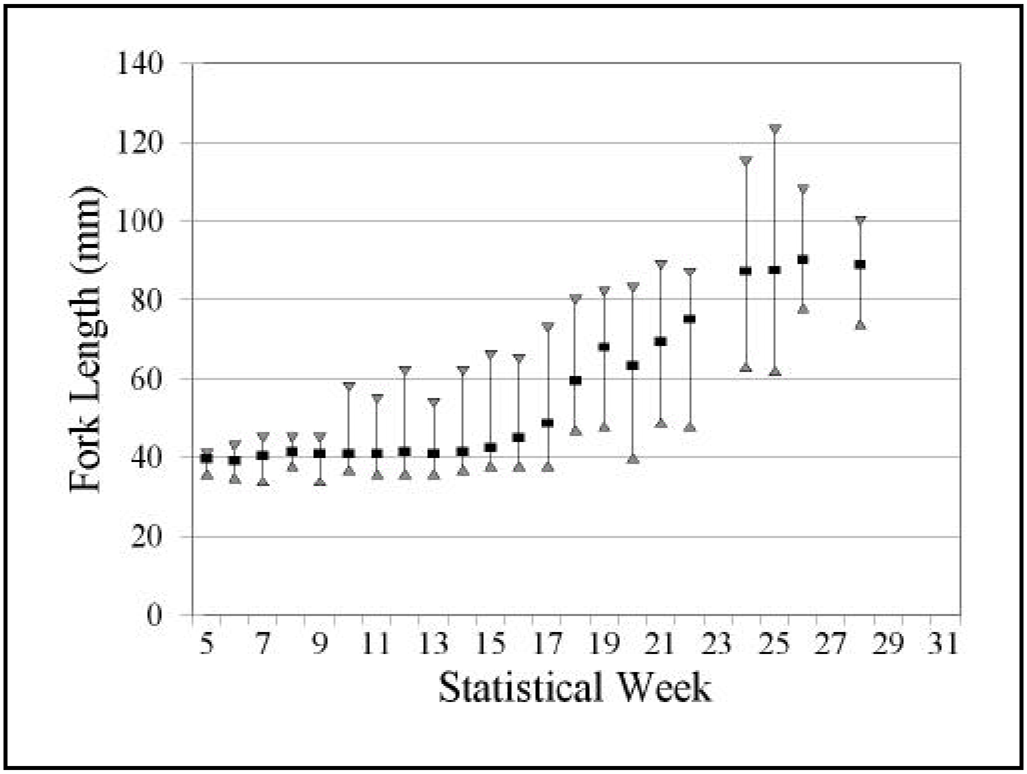

Figure 2. Weekly average, minimum, and maximum 0+ chinook fork lengths (mm) measured at the Green River screw trap, 2001.

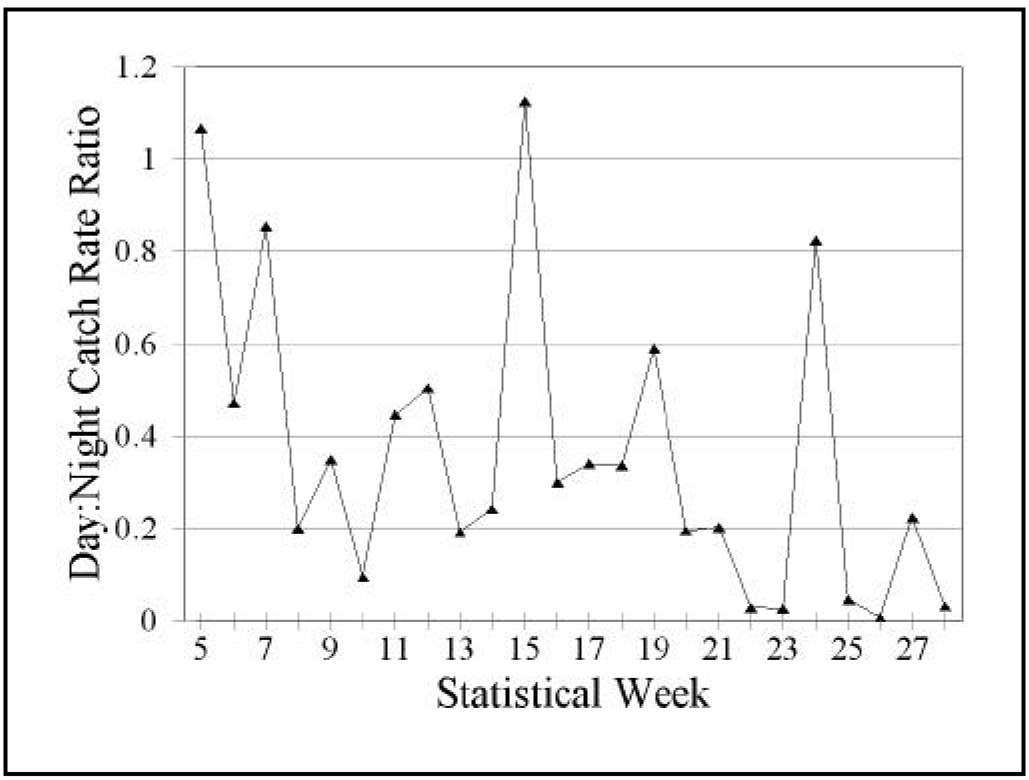

Figure 3. Weekly ratio of day/night chinook catch rates from the Green River screw trap, 2001.

Trap Efficiency

As the trap was positioned at two different locations over the 2001 season, we stratified trap efficiency by position. Between January 31 and March 11, the trap operated in the thalweg of the channel at position 1. Trap efficiencies as high as 36% were measured while the trap operated in this position. Such high capture rates would result in large catches that would greatly increase the work load, complicate the care of the fish, and put many fish at risk in the event of a debris jam. Therefore, we moved the trap several feet toward the right bank. Chinook capture rates at this second position averaged 6%.

A total of 2,231 age 0+ wild chinook migrants in 18 groups were marked and released from 100-yards to a half-mile upstream of the trap (Table 3). Three groups were released while the trap operated in position 1, and 15 groups were released while the trap was in position 2. The number of fish released in each group ranged from 48 to 300 chinook. Recapture rates averaged 22.3% and ranged from 9% to 36% while the trap operated in position 1. In position 2, recapture rates averaged 5.9% and ranged from 1% to 12%.

In addition to the chinook releases, 791 marked chum were released in seven groups. Only one chum test was performed while the trap operated in position 1, which resulted in a capture rate of 32%. Chum recapture rates averaged 6.3% and ranged from 2% to 16% while the trap operated in position 2. Analysis of Variance was used to test for differences between the distributions and means of the tests using chinook and chum while the trap operated in position 2. Differences were not significant at the 95% significance level. ANOVA comparing the mean of the chinook tests with the single chum test (Sokal and Rohlf 1981) while the trap operated in position 1 also failed to detect a difference at the 95% significance level.

The four trap efficiency tests using chinook and chum salmon were conducted over a 5-day interval while the trap operated in position 1 (Table 3). Stream flow was essentially constant over this period; therefore, no analysis of flow effects on trap efficiency was conducted. Flows ranged from 225 to 1,320 cubic feet per second (cfs) during the trap efficiency tests conducted while the trap operated in position 2. However, no relationship between flow and trap efficiencies was found while the trap operated in this position.

Using both the chinook and chum data, trap efficiency averaged 24.75% while the trap operated in position 1 and 6.03% while it operated in position 2 (Table 3). These values were used to estimate daily chinook migration.

Table 3. Estimated chinook migrant capture rates from chinook and chum trap efficiency tests conducted on the Green River screw trap, 2001.

Date	Number Released	Number Recaptured	Recapture Rate	V(ς)
Position 1				
Chinook Tests				
03/06	300	108	36.00%	0.000771
03/08	100	9	9.00%	0.000827
03/10	100	22	22.00%	0.001733
Chum Tests				
03/07	100	32	32.00%	0.002198
Sum	600	171		
		Average	24.75%	
		V(ς)	0.033989	
		n	6	
Position 2				
Chinook Tests				
03/11	200	17	8.50%	0.000391
03/12	100	7	7.00%	0.000658
03/14	200	5	2.50%	0.000122
03/16	100	9	9.00%	0.000827
03/21	100	7	7.00%	0.000658
03/23	200	8	4.00%	0.000193
03/26	100	12	12.00%	0.001067
03/28	48	3	6.25%	0.001247
04/01	100	6	6.00%	0.000570
05/19	100	1	1.00%	0.000100
05/23	100	7	7.00%	0.000658
05/28	100	5	5.00%	0.000480
06/07	100	1	1.00%	0.000100
06/15	100	9	9.00%	0.000827
06/28	83	3	3.61%	0.000425
Chum Tests				
04/10	100	4	4.00%	0.000388
04/15	99	5	5.05%	0.000489
04/21	99	16	16.16%	0.001383
04/25	100	2	2.00%	0.000198
04/27	93	7	7.53%	0.000757
04/29	200	6	3.00%	0.000146
Sum	2,422	140		
		Average	6.03%	
		V(ς)	0.000621	
		n	21	

Chinook Production

From January 31 through August 1 we estimate 726,801 wild age 0+ chinook migrants passed the screw trap (Table 4). Extrapolation of the migration back to January 1, the date we selected to approximate the start of the chinook migration, resulted in an additional 1,415 wild 0+ migrants for a total wild migration of 728,216 (Figure 4). In addition to the wild fish, we estimate 1,179 ad-marked and 120 unmarked hatchery age 0+ chinook migrated by the trap during the January 31 through August 1 trapping period. Since there were no marked age 0+ hatchery migrants captured prior to the first release of hatchery chinook on April 2, this estimate includes the entire hatchery migration.

Table 4. Estimated age 0+ wild and hatchery chinook migration past the Green River screw trap, 2001.

Period	Actual Catch	Expanded Catch	Estimated Migration	CV	95% CI Low	95% CI High
Wild 0+ Chinook Migrants						
Jan 1 – Jan 30	N/A	N/A	1,415	[a]14.61%	[a]1,010	[a]1,820
Jan 31 – Aug 1	56,548	56,655	726,801	4.64%	660,685	792,917
Total	56,548	56,655	728,216	4.63%	662,099	794,333
Ad-marked Hatchery 0+ Chinook Migrants						
Jan 1 – Jan 30	N/A	N/A	0	N/A	N/A	N/A
Jan 31 – Aug 1	71	71	1,179	7.53%	1,005	1,353
Total	71	71	1,179	7.53%	1,005	1,353
Unmarked Hatchery 0+ Chinook Migrants						
Jan 1 – Jan 30	N/A	N/A	0	N/A	N/A	N/A
Jan 31 – Aug 1	6	6	120	6.19%	106	139
Total	6	6	120	6.19%	106	139
All Chinook 0+ Migrants						
Jan 1 – Jan 30	N/A	N/A	1,415	14.61%	1,010	1,820
Jan 31 – Aug 1	56,625	56,733	728,100	4.64%	661,909	794,292
Total	56,625	56,733	729,515	4.63%	663,323	795,708

[a] The CV and confidence interval about this estimate reflect variability around the slope of the extrapolation line only (Figure 4), and does not include uncertainty associated with the shape of the extrapolation line or the January 1 migration start date.

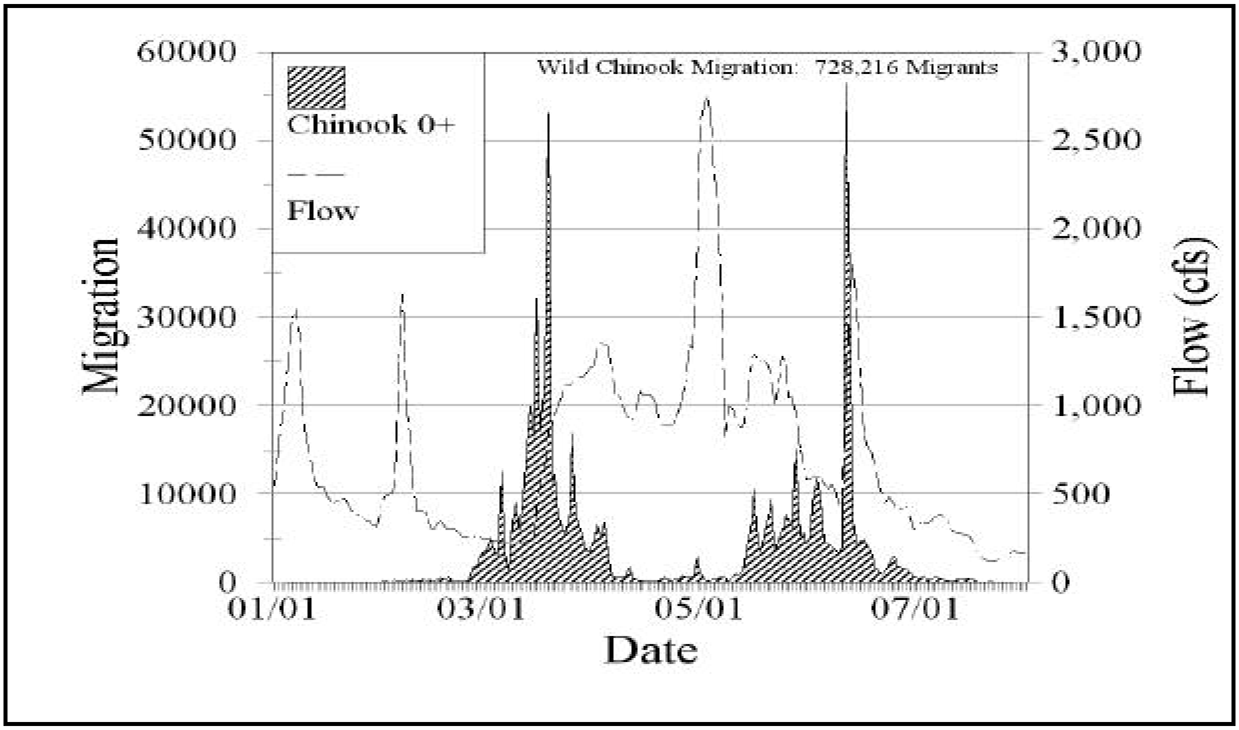

Figure 4. Daily migration of wild age 0+ chinook past the Green River screw trap, 2001.

Coho

Catch

Yearling coho salmon were captured on the first night of trapping, January 31. However, catch rates were low, generally less than five per day through the third week in April. Migration past the trap during this period may have largely been the result of within-basin movement prior to smoltification. In the fourth week of April, daily catches of age 1+ coho increased; peaking at 2,010 smolts on May 8. Of these, 1,962 were ad-marked and 48 were unmarked. Daily catches of unmarked coho smolts peaked at 238 on May 14. Daily catches declined thereafter to near zero by June 18. Over the 182-day trapping period, a total of 8,534 coho were captured, of which 5,778 were ad-marked and 2,756 were unmarked.

Ad-marked hatchery coho smolts began to show up in the catch in low numbers on February 1. Between February 1 and April 8, 13 ad-marked coho were caught. This period was prior to any known yearling hatchery coho releases in 2001. Therefore, these fish had likely escaped from Soos Creek and/or Keta Creek Hatcheries. An additional 27 ad-marked coho smolts were captured between April 9 and May 6. This period was after the Soos Creek Hatchery coho release, but prior to the Keta Creek Hatchery release. The mouth of Big Soos Creek is located about a half-mile downstream of the smolt trap; therefore, we assumed that these ad-marked coho were smolts that had swum upstream from Big Soos Creek to the trap. Following the May 7 release of ad-marked coho smolts from Keta Creek Hatchery, located about six miles upstream of the trap, we captured 5,738 ad-marked coho smolts. Both the releases from Soos Creek Hatchery and Keta Creek Hatchery had unmarked components. Therefore in order to estimate migration, we assumed all 40 ad-marked coho smolts captured prior to May 7 were Soos Creek Hatchery coho that had swum upstream. We further assumed that all marked coho captured on or after May 7 were Keta Creek coho. Based on these assumptions, we estimated 2,595 wild coho smolts, 5,778 ad-marked hatchery smolts, and 161 unmarked hatchery smolts were captured over the season.

Size

Unmarked coho fork lengths averaged between 106-mm and 122-mm for the weeks where at least two smolts were sampled (Table 5, Figure 5). The sizes of individual age 1+ migrants ranged from 90-mm to 173-mm over the trapping season.

Table 5. Mean fork lengths (mm), standard deviations, ranges, and sample sizes of unmarked coho smolts measured by statistical week, Green River 2001.

Statistical Week			Average	Standard	Range		n	Captured	Percent
Number	Begin	End		Deviation	Minimum	Maximum			Sampled
5	01/31	02/04	90.0	n/a	90	90	1	15	5.56%
6	02/05	02/11						14	0.00%
7	02/12	02/18						14	0.00%
8	02/19	02/25						10	0.00%
9	02/26	03/04						2	0.00%
10	03/05	03/11			No Sample			4	0.00%
11	03/12	03/18						5	0.00%
12	03/19	03/25						11	0.00%
13	03/26	04/01						16	0.00%
14	04/02	04/08						24	0.00%
15	04/09	04/15						29	0.00%
16	04/16	04/22	105.8	9.91	93	115	4	14	28.57%
17	04/23	04/29	122.1	23.96	97	173	10	69	14.49%
18	04/30	05/06	112.4	10.69	95	156	32	180	17.78%
19	05/07	05/13	116.0	11.89	103	140	8	445	1.77%
20	05/14	05/20	116.1	10.69	99	142	11	834	1.32%
21	05/21	05/27			No sample			451	0.00%
22	05/28	06/03	114.8	11.98	95	147	32	371	8.63%
23	06/04	06/10			No sample			189	0.00%
24	06/11	06/17	143.0	n/a	143	143	1	41	2.44%
25	06/18	06/24	92.0	n/a	92	92	1	4	25.00%
26	06/25	07/01			No sample			5	0.00%
27	07/02	07/08						1	0.00%
28	0709	07/15	105.5	13.44	96	115	2	3	66.67%
29	07/16	07/22			No sample			1	0.00%
Season Total			114.3	13.68	90	173	102	2,756	3.69%

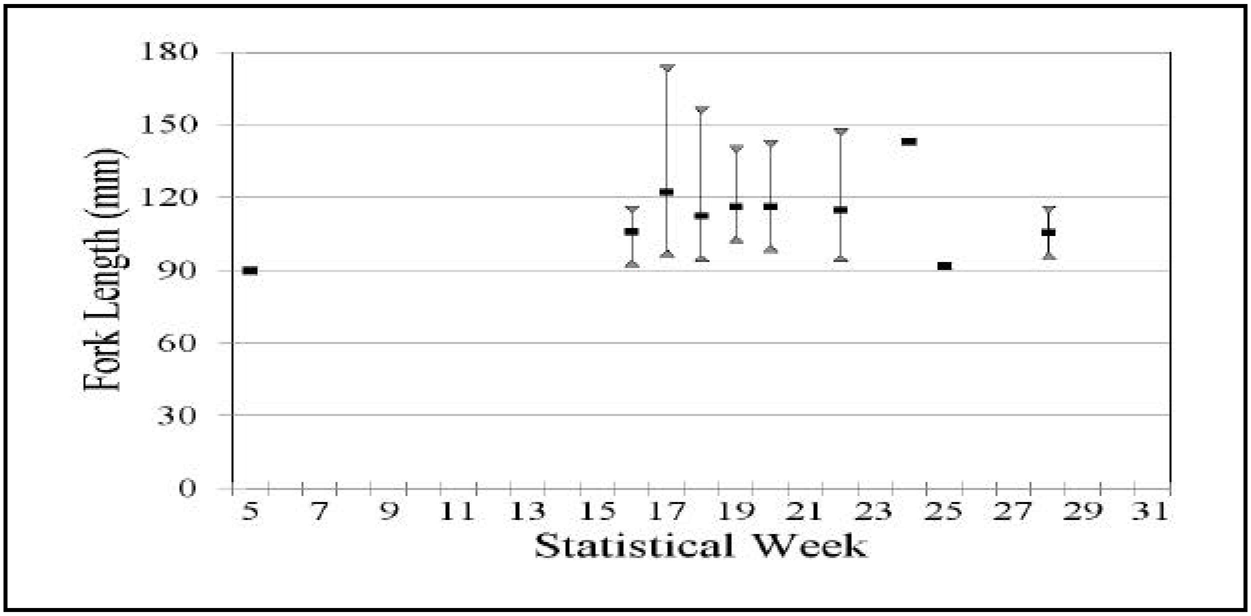

Figure 5. Weekly average, minimum, and maximum unmarked yearling coho fork lengths measured at the Green River screw trap, 2001.

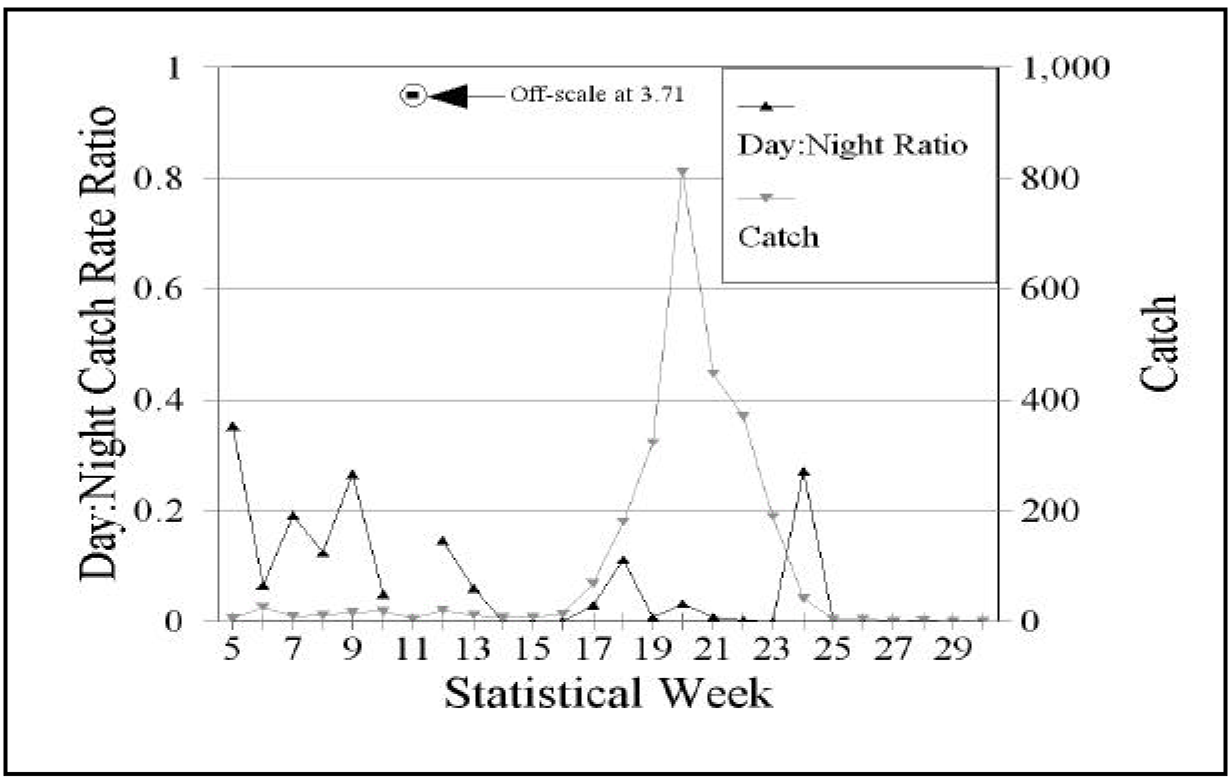

Figure 6. Weekly ratios of day/night coho catch rates relative to migration timing as described by catch, Green River screw trap 2001.

Catch Expansion

Although trapping operations were suspended for a total of 356 hours over the course of the trapping period, almost all of the non-fished periods occurred outside the time of coho migration (at night from April through mid-June). If we assume that the proportions of coho migrants caught during day and night fishing periods were the same, then the weekly day/night catch rate ratios for coho indicated that during the peak migration period generally less than one smolt in ten migrated during the day (Figure 6). As a result, catch expansion resulted in the addition of only 136 smolts: 124 ad-marked hatchery smolts and 12 unmarked smolts. Of these 12, we estimate eight were wild. These were added to the estimated actual wild catch of 2,595 smolts.

Trap Efficiency

A total of 253 yearling coho were acquired from the Keta Creek Hatchery, marked and released in two trap efficiency tests during the 2001 trapping period. Both tests were conducted while the trap operated in position 2. Trap efficiency results from these two tests were; 0.65% for the test conducted on April 20 and 6.06% for the test conducted on May 13, nearly a 10-fold difference (Table 6). Uncertainty existed around how well tests employing hatchery yearling coho represented the capture rate for actively migrating wild smolts. Since these fish were removed from the hatchery, uncertainty also existed regarding their willingness to migrate. This is particularly evident with the first release group that exhibited a very low recovery rate. Given these uncertainties, we opted to base the coho efficiency rate on that measured for chinook.

Typically, coho are captured at a lower rate than chinook due to their larger size (Seiler *et al*. 2002[b]). Coho-to-chinook capture rate ratios ranged from 60.0% to 100.7% for screw traps operating in the Cedar River, Bear Creek, and Issaquah Creek in the Lake Washington watershed in 1999 and 2000 (Table 7). We applied the mean ratio, 76%, to the average position 1 and position 2 chinook trap efficiencies of 24.75% and 6.03%, respectively, to estimate position 1 coho trap efficiency at 18.8% and position 2 efficiency at 4.6%. The resulting position 2 estimated trap efficiency is within the range of values measured for position 2 using hatchery yearling coho.

Table 6. Estimated coho smolt capture rates from efficiency tests using hatchery coho yearlings, Green River screw trap 2001.

Date	Number Released	Number Recaptured	Recapture Rate	V(ç)
April 20	154	1	0.65%	0.000042
May 13	99	6	6.06%	0.000581
Sum	253	7		
		Average	3.36%	
		V(ç)	0.001044	
		n	2	

Table 7. Estimated 2001 Green River coho smolt capture rates derived from the mean coho:chinook capture rate ratio found from traps operated in Lake Washington tributaries.

Stream/Year	Trap Efficiency Rates Coho	Trap Efficiency Rates Chinook	Coho:Chinook Ratio
Cedar River			
1999	14.43%	24.07%	60%
2000	9.01%	8.95%	101%
Bear Creek			
1999	32.6%	45.62%	71%
2000	27.5%	40.14%	68%
Issaquah Creek			
2000	15.3%	18.72%	82%
		Average	76%
		Measured 2001 Green River Chinook Rates	
		Position 1	24.75%
		Position 2	6.03%
		Estimated 2001 Green River Coho Rates	
		Position 1	18.8%
		Position 2	4.6%

Note: 2001 Green River coho capture rates were estimated by multiplying the corresponding chinook rates by the average coho:chinook capture rate ratio.

Coho Production

Applying our coho capture rate estimates to the expanded position 1 and position 2 catch estimates yields a total coho migration estimate of 186,751 coho smolts. Of these, we estimated 131,638 hatchery smolts, ad-marked and unmarked, migrated past the trap by expanding the estimated migration of ad-marked hatchery smolts by the ratio of unmarked to ad-marked hatchery smolts released from the two hatcheries. Total wild migration was therefore estimated at 55,113 smolts, the difference between the total migration and hatchery migration estimates (Table 8, Figure 7). As a result of the assumptions that went into the trap efficiency estimates, we did not attempt to calculate variances or confidence intervals about these estimates.

Table 8. Estimated wild and hatchery coho smolt migration past the Green River screw trap, 2001.

Group	Dates	Catch	Expanded Catch	Migration
Hatchery Ad-Marked	Jan 31 – Apr 8	13	16	119
	Apr 9 – May 6	27	27	587
	May 7 – Aug 1	5,738	5,859	127,364
Hatchery Unmarked	Jan 31 – Apr 8	0	1	4
	Apr 9 – May 6	1	1	30
	May 7 – Aug 1	159	163	2,199
Hatchery Total	Jan 31 – Aug 1	5,939	6,067	131,638
Wild Smolts	Jan 31 – Aug 1	2,595	2,603	55,113
Total Smolts	Jan 31 – Aug 1	8,534	8,670	186,751

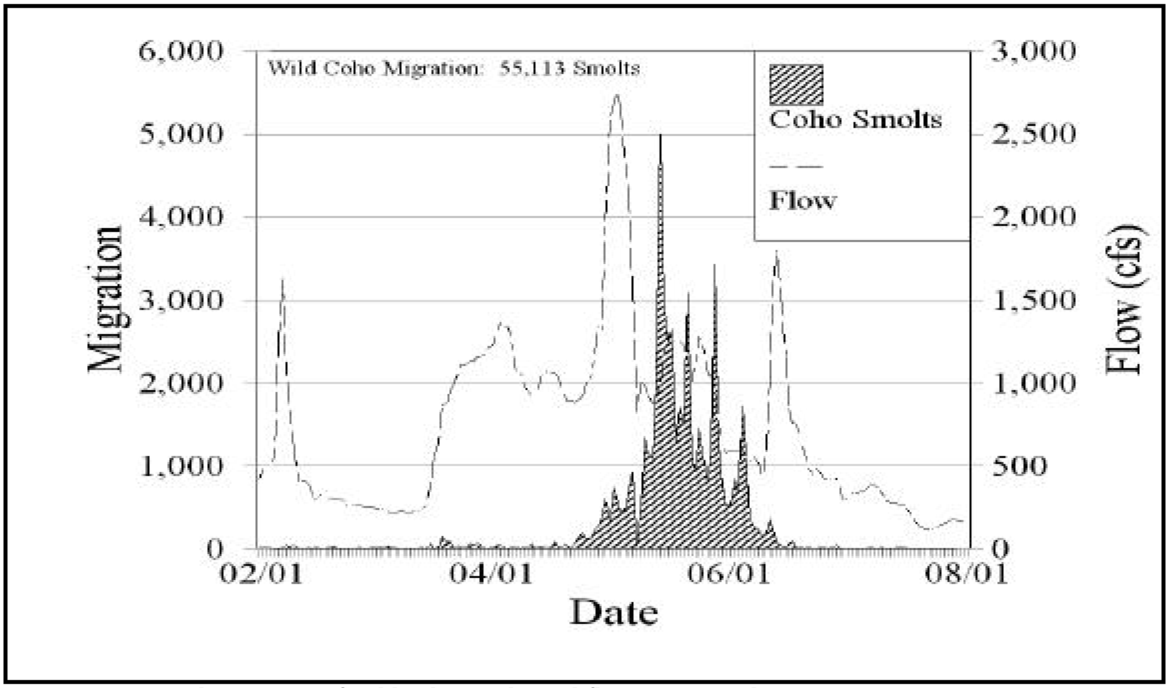

Figure 7. Estimated migration of wild coho smolts and flow (USGS Palmer Gage), Green River screw trap 2001.

Steelhead

Catch

Over the trapping season, we caught 2,024 steelhead smolts. Of these, 1,522 were adipose marked and 502 were unmarked. The ad-marked steelhead resulted from releases at Keta Creek Hatchery and the Palmer Ponds. All hatchery steelhead smolts released in 2001 were ad-marked. The 502 unmarked smolts captured in the trap were likely comprised primarily of wild smolts. Releases of 50,281 unmarked steelhead fingerlings upstream of the trap occurred in 2000. These fish originated at the Keta Creek Hatchery and some portion may have migrated past the trap as smolts in 2001. The proportion of the unmarked smolts captured in the trap that were from these releases is unknown.

The migration of both ad-marked and unmarked steelhead occurred between mid-April and the end of May. Outside of this period, total catches of ad-marked and unmarked steelhead were generally less than five per day. The catch of unmarked wild smolts peaked on May 19 with a catch of 28 smolts. The catch of ad-marked fish peaked on May 11, with a catch of 345 smolts.

Size

Only 24 unmarked steelhead were measured from April 21 to May 20. Fork lengths ranged from 138-mm to 235-mm and averaged 176.6-mm (S.D. = 20.2).

Catch Expansion

As was the case with coho salmon, most of the suspended trapping periods and outages occurred during times when few steelhead were migrating. Catch expansion resulted in the addition of only 25 steelhead smolts. Of these, we estimated that one was unmarked and 24 were ad-marked.

Trap Efficiency

In any migrant trapping operation, trap efficiency is influenced by a number of variables such as the channel configuration, the size/swimming ability of the captured fish, the velocity of water entering the trap, the position in the channel/water column preferred by the migrant, and the design of the trap itself. Steelhead smolts average approximately 1.5 times the size of coho smolts and are, therefore, generally captured at a lower rate. In 2001, one trap efficiency test was attempted for steelhead using yearling steelhead provided by the Keta Creek Hatchery. None of these fish were recovered. Therefore, to estimate trap efficiency for steelhead, we used the same approach applied in the 2000 report of multiplying a steelhead:coho capture rate ratio to the coho trap efficiency to estimate steelhead trap efficiency (Seiler *et al*. 2002[a]). A steelhead:coho capture rate ratio of 75% was applied to the coho rate which resulted in a steelhead trap efficiency of 14.1% while the trap operated in position 1 and 3.45% while the trap operated in position 2. No variance estimates were made for these rates.

Steelhead Smolt Production

Application of the steelhead trap efficiency estimates to the expanded catch, estimated the migration of 14,529 unmarked steelhead smolts and 44,790 ad-marked hatchery steelhead smolts during the period of trap operation. The trapping interval encompassed the entire steelhead migration; therefore, expansion of the production estimates beyond the trapping period was unnecessary (Figure 8). No variances or confidence intervals were developed for these estimates.

Other Species

A number of other fish species and other salmonid age classes were captured and enumerated. Over the trapping period, a total of 56,952 chum fry, 7,503 age 0+ coho fry, 3 pink fry, 2 sockeye fry, 339 age 0+ trout, 465 age 1+ chinook, and 1 adult cutthroat were captured in the trap. No cutthroat smolts were captured in 2001. Of the 465 age 1+ chinook caught, 426 were ad-marked. As discussed earlier, we believe all, or nearly all, of these fish were from a yearling chinook release from Icy Creek Hatchery.

Non-salmonids caught in the trap included 176 dace, 201 sculpin, 999 lamprey ammocoetes, 2 northern pikeminnow, 13 whitefish, 24 suckers, 31 sticklebacks, and 1 yellow perch.

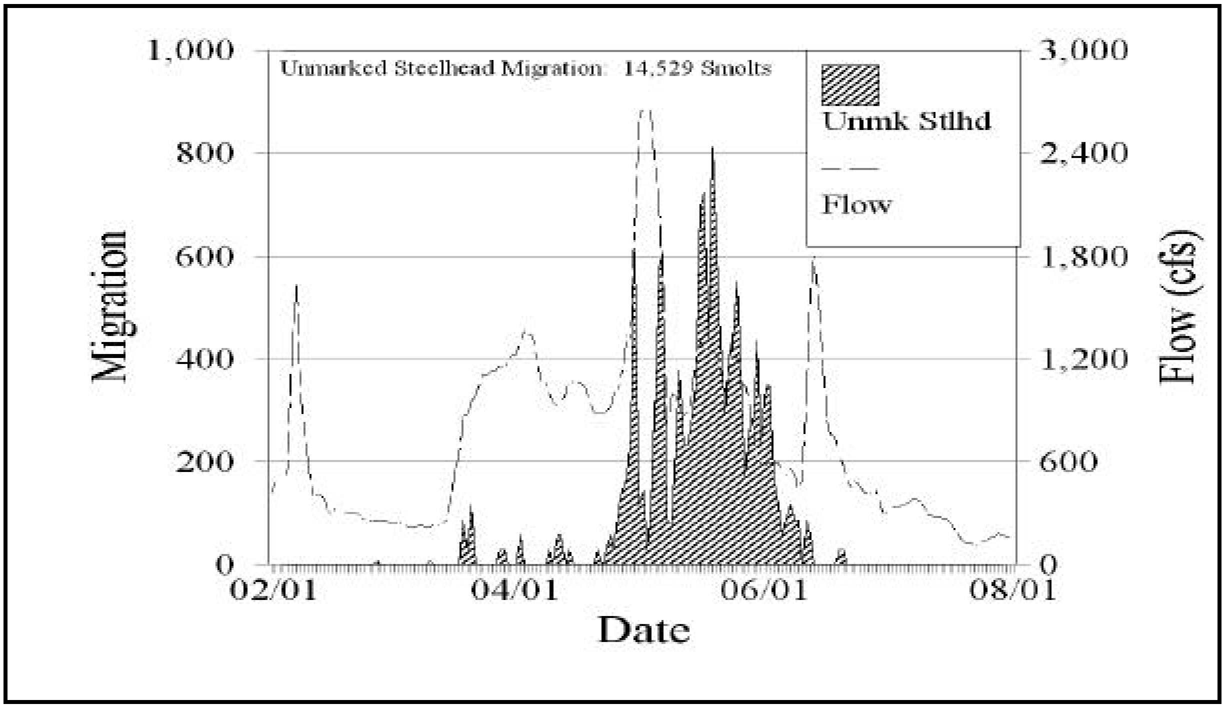

Figure 8. Estimated migration of unmarked steelhead smolts and flow (USGS Palmer Gage), Green River screw trap 2001.

Discussion

Estimates of migration past the trap were developed for Green River wild and hatchery age 0+ chinook, wild and hatchery yearling coho, and wild and hatchery steelhead smolts. A number of assumptions used to develop these estimates are discussed below. In addition, the estimates for wild chinook migrants are expanded to represent total basin production. As an aid to managers of the Keta Creek Hatchery, Icy Creek Hatchery, and Palmer Ponds we attempt to estimate survival of release groups to the smolt trap and explain the assumptions that went into those estimates. This section also discusses the diel migration timing of juvenile salmonids and compares and contrasts production over the first two years of baseline monitoring for the AWS project.

Chinook

Stream flows throughout the late fall and winter of 2000 and early spring of 2001 were anomalously low and consistently well below normal. We refer to this year as the "winter without rain". Not only did these conditions have a profound effect on fish migrating and rearing in streams, but they also resulted in relatively benign trapping conditions. Near continuous operation of the trap required little expansion of the catch for periods of suspended trap operation. In addition, multiple groups of marked chinook and chum salmon were released upstream of the trap while it operated in each position which provided fairly good estimates of trap efficiency over a variety of conditions. These conditions resulted in what we believe are very good estimates of wild age 0+ chinook migration in 2001.

Egg-to-migrant survival is a measure of freshwater productivity for naturally-reared salmon. The estimated migration of 728,216 wild age 0+ chinook migrants divided by the estimated egg deposition above the trap site results in an egg-to-migrant survival of 5.3%. The estimated egg deposition was derived using an above-the-trap escapement estimate of 3,064 chinook females. This estimate was derived from a Green River (less Big Soos Creek) female escapement estimate of 4,129, developed from a mark-recapture study occurring in the lower Green River (Hahn pers. comm.). To account for a small number of unsampled fish that entered Big Soos Creek and pre-spawning mortalities, the female escapement into Green River was reduced to 4,000 females. We estimated 3,064 females spawned above the trap site based on available spawning distribution data (Malcolm 2002). Egg deposition was estimated using an average fecundity of 4,500 eggs per female (Wilson pers. comm.).

The egg-to-migrant survival estimate of 5.3% is not comparable to the 7.3% survival estimated for the 1999 brood (Seiler et al. 2002a). While the 2000 escapement was based on a mark-recapture study, previous escapement estimates relied on the less accurate expansions of redd counts in index reaches. The redd count expansion approach estimated a total Green River (less Big Soos Creek) female escapement of 2, 449 from an estimate of 2,449 redds in 2000 (Hahn pers. comm.). Using the same spawner distribution and fecundity estimates used with the mark-recapture-based escapement estimate, the 2000 brood egg-to-migrant survival would have been estimated at 8.63% using the redd-count expansion approach. Using equivalent methods to estimate escapement suggests that egg-to-migrant survival for the 2000 brood increased by 1% over that estimated for the 1999 brood.

The wild age 0+ chinook production estimate made with the Green River trap only represents the production that occurred upstream of it. We estimated an additional 936 females (not including Big

Soos Creek) spawned downstream of the trap (4,000 female spawners minus 3,064 spawning upstream of the trap). Assuming the same egg-to-migrant survival, we estimated the total Green River production at 950,610 wild chinook migrants. Assuming similar naturally-produced chinook production levels for Big Soos Creek as was observed in 2000, 275,000 migrants (Seiler *et al.* 2002[a]), results in a total basin production estimate of 1,225,610 naturally-produced age 0+ chinook migrants (Table 9). We believe this assumption is valid since Big Soos Creek received sufficient hatchery spawners in both 1999 and 2000 to fully seed the habitat available to them.

Our work in the Green River has resulted in estimates of naturally-produced chinook production and egg-to-migrant survival; however at this point, we don't have a good understanding of the comparability of these estimates from year to year. The wild age 0+ chinook migration from the Green River was a bi-modal timing distribution. The earliest component was composed of chinook "fry" that migrated past the trap in January through March, which was followed by a "smolt" component that migrated from May through June. The fry component made up 53% of the production above the Green River trap, or 386,315 migrants (Table 9). If we assume that the production resulting from mainstem spawners below the trap migrated as fry at this same rate and that Soos Creek natural chinook production and fry/smolt proportions were the same as in 2000, total basin production of migrant fry was 775,994 or 63.3%. Because of their smaller size, these fish would likely have survived at a lower rate compared to smolt size fish.

Table 9. Fry and smolt component size and production estimates for naturally-produced juvenile chinook, Green River 2001.

Component	Migration Interval	Average Fork Length (mm)	Migration Past Trap	Percentage Production	Total Migration
Above Green River Trap					
Fry	Jan 1 - Apr 15	41	386,315	53.0%	386,315
Smolt	Apr 16 - Jul 13	72	341,901	47.0%	341,901
Below Green River Trap					
Fry	Jan 1 - Apr 15	NA		53.0%	117,979
Smolt	Apr 16 - Jul 13	NA		47.0%	104,415
Big Soos Creek					
Fry	Jan 1 - Apr 15	NA		98.8%	271,700
Smolt	Apr 16 - Jul 13	NA		1.2%	3,300
Total Basin Production					
Fry	Jan 1 - Apr 15	NA		63.3%	775,994
Smolt	Apr 16 - Jul 13	NA		36.7%	449,616
Total					1,225,610

Note: Big Soos Creek natural chinook production level and fry/smolt proportions are assumed to be equal to the levels measured in 2000.

Coho

Two efficiency tests using hatchery coho were conducted over the trapping period. The first test, conducted on April 20, resulted in a recovery rate of only 0.65%. Since April 20 is at the very leading edge of the coho out-migration, we believe this low rate resulted from using fish that were not ready to migrate at the time of the experiment. This left only the results from the remaining test conducted on May 13. This test resulted in a position 2 efficiency of 6.06%. Since we typically observe considerable variability among trap efficiency test results, we were uncomfortable basing the entire migration estimate on one small test. Therefore, we opted to adjust the chinook trap efficiency estimates by the average coho:chinook capture rate ratio found during our Lake Washington studies (Seiler *et al*. 2002[b]), which resulted in a position 2 efficiency of 4.6%.

Water velocities at the entrance to the trap are higher in the Green River than at any of the Lake Washington streams monitored; therefore, the difference in efficiency between chinook and coho may be less than observed in Lake Washington. If this were the case, then the migration estimates for coho may be biased high. If we assumed coho trap efficiency was equal to the 6.06% measured in the single test using hatchery coho, our estimate of 55,113 wild coho migrating past the trap would be reduced to 42,956. These two estimates represent a range that is likely within or near to the actual migration. To estimate the wild migration, we assume all ad-marked recoveries that occurred on or after May 7 were Keta Creek Hatchery smolts and those occurring before that date were Soos Creek Hatchery smolts. Violation of this assumption would have a small effect on the accuracy of the wild coho migration estimate since these two hatcheries had different proportions of unmarked hatchery fish associated with their ad-marked releases. Because so few marked coho were captured prior to May 7 and because we expect that few Soos Creek Hatchery fish migrated upstream to the trap site, this potential bias is expected to be small.

Approximately 560,000 unmarked coho fry were planted, primarily upstream of the HHD, in 2000. The rate that these contributed to the estimated wild coho migration past the trap of 55,113 smolts is unknown.

Steelhead

The accuracy of our steelhead migration estimates for the Green River are predicated on the accuracy of our assumption relating trap efficiency for steelhead to that of coho salmon. The estimated production above the trap of 14,529 steelhead smolts is well below the 35,701 to 40,801 smolts that were estimated to have migrated in 2000. Stream flows were much lower in 2001 compared to 2000, which made it more difficult to catch strong swimmers such as steelhead smolts. Therefore, using our simple assumptions of an average steelhead/coho capture rate ratio, we may have over-estimated their capture rate. If this occurred, then the 2001 steelhead production estimate would be biased low.

Diel Migration Timing

The downstream migrations of all species occurred primarily at night. Weekly ratios of day catch rates to night catch rates were highly variable between weeks for both chinook and coho. Over the season, weekly day/night catch rate ratios averaged 36% for wild chinook and 27% for coho; however, coho averaged only 3% during the period when the majority of coho migrated (April 30 to June 17). Chinook day/night catch rate ratios averaged 46% during the January to March fry migration period and 25% during the May to June smolt migration period.

Since the nighttime period was of particular importance for migration, hourly trap checks were made throughout at least one night each week between February 9 and June 5 to evaluate timing. Percent nightly migration was calculated for each hour during the night and averaged for each month. Results of this analysis indicated the majority of chinook migrate in the first few hours after darkness. On average, at least 70% of the nightly migration of chinook occurred before 1:00 AM in all months except April where only 50% migrated by 1:00 AM (Figure 9). We have less confidence in the April data, however, because than 6% of the total wild chinook 0+ migration occurred during this month.

Nightly migration timing was similar for coho salmon and steelhead during the months when their nightly migrations were sufficient to evaluate timing. Nearly 70% of their nightly migrations occurred prior to 1:00 AM for both species (Figures 10 and 11).

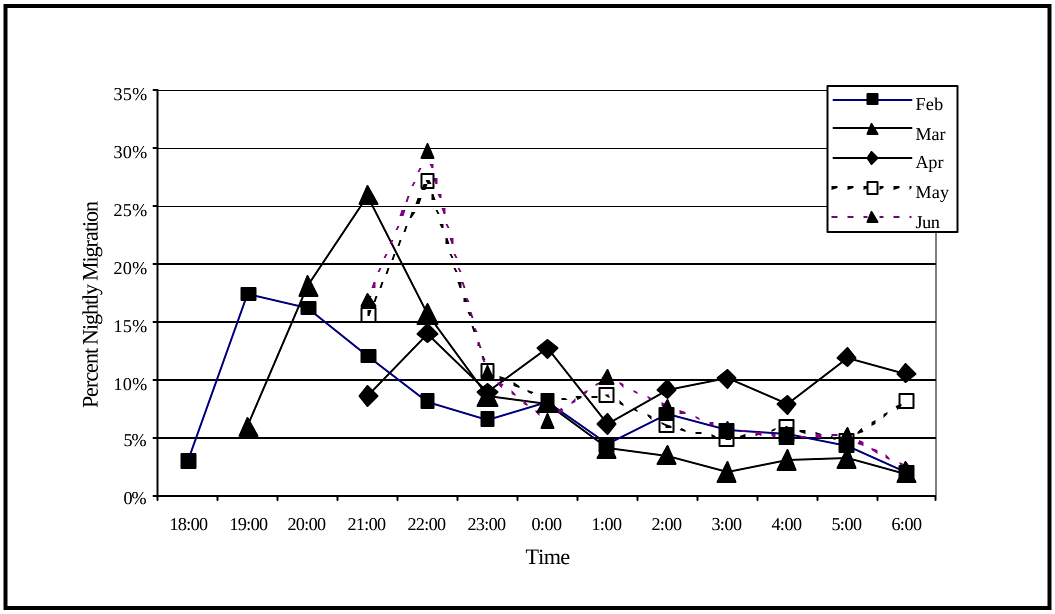

Figure 9. Average nightly wild age 0+ chinook migration timing, Green River 2001**.**

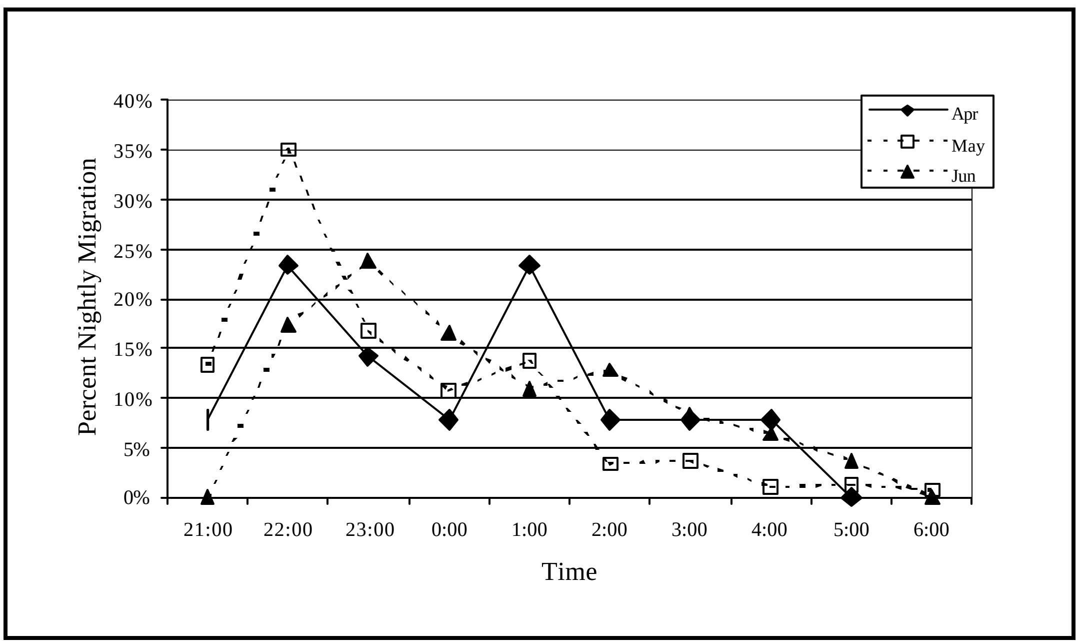

Figure 10. Average nightly wild coho smolt migration timing, Green River 2001**.**

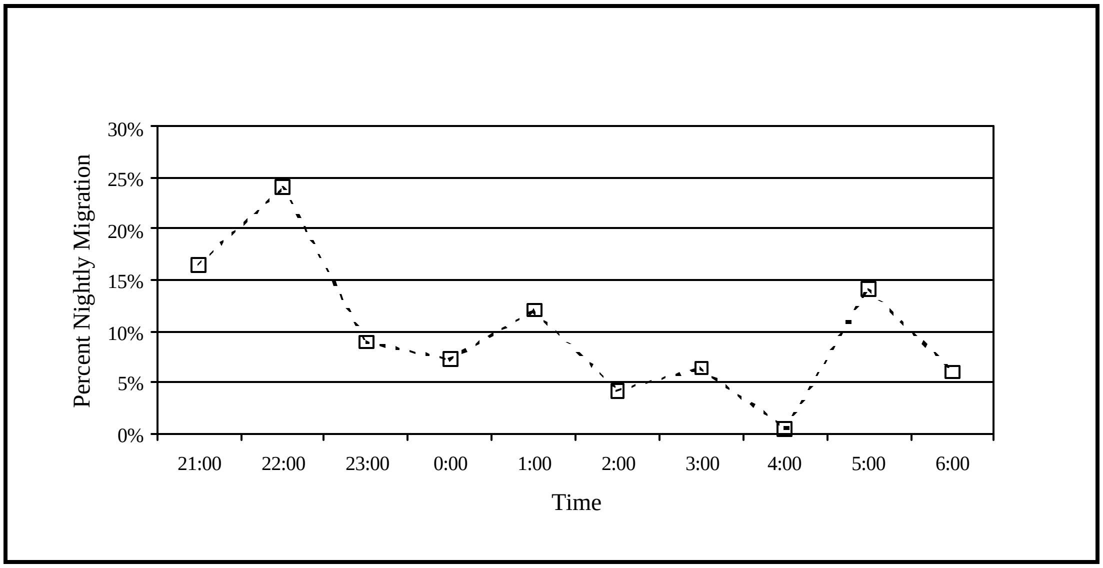

Figure 11. Average nightly wild steelhead smolt migration timing in May, Green River 2001.

Survival of Hatchery Releases

Most or all of the production from hatcheries located upstream of the trap were adipose marked, which enabled us to estimate survival of the total hatchery production by species to the trap. Our estimates of migration past the trap were made assuming that hatchery and wild migrants were similarly distributed across the channel and equally susceptible to capture by the screw trap. Survival of marked releases ranged from 0.22% for age 0+ chinook released above HHD to 67% for coho smolts released from Keta Creek Hatchery (Table 10). We estimated the coho survival by assuming that all of the marked smolts captured on or after May 7 were from the Keta Creek Hatchery release. It is possible that a few marked coho captured after May 7 were Soos Creek Hatchery fish that swam upstream to the trap. If this occurred, the survival rate may be biased slightly high. Steelhead survival was estimated at 15%, about the same as was observed in 2000. This survival rate was calculated for the combined releases from Keta Creek Hatchery and the Palmer Ponds since we had no way of differentiating smolts from these facilities.

Table 10. Survival of ad-marked hatchery salmonid release groups to the Green River screw trap, 2001.

Species	Facility	Ad-marked Hatchery Release Above Trap	Estimated Migration of Ad-marks Past Trap	Survival of Release
Age 0+ Chinook[a]	Keta Creek	537,735	1,179	0.22%
Coho Smolts	Keta Creek	189,330	[b]127,364	67.27%
Steelhead Smolts[c]	Keta Creek Palmer Ponds	303,578	44,790	14.75%

[a] Released above Howard Hansen Dam.
[b] Only ad-marked coho captured on and after May 7 are included.
[c] Includes releases from both facilities, as we were not able to identify fish from separate release sites.

Disposition of Chinook Released above HHD

We estimated that 1,179 ad-marked age 0+ chinook migrated past the trap in 2001 out of a release of 537,735. This represents an age 0+ migration of just 0.22% of the number released. This survival rate is much lower than the 3.7% measured for similar releases that occurred in 2000. The difference in survival probably results from the much lower flows that occurred in 2001. This assumes the condition of the released fish were similar between years. In the 2000 report, it was hypothesized that some of the chinook fry released in 2000 may have been retained behind HHD to migrate in 2001 as yearling smolts. The failure to capture any yearling migrants prior to the release of hatchery yearlings from the Icy Creek Hatchery suggests that few if any of these chinook survived to migrate as yearlings.

AWS Baseline Monitoring

Downstream migrant trapping in 2001 represents the second and final year of baseline monitoring funded by the AWS project. Post-project monitoring is scheduled to start in 2005. During the two years of monitoring, age 0+ wild chinook production upstream of the trap ranged from 535,000 migrants in 2000 to 728,000 migrants in 2001. Two years of monitoring is not sufficient to evaluate the true range of chinook production that occurs in the Green River. For example, nearly a 4-fold variation in annual age 0+ chinook production occurred in the Skagit River between 1997 and 2001 (Seiler *et al*. 2002[c]).

Moderate variation in the proportions of wild chinook fry and smolt migrants occurred between the two years. A total of 53% of the production migrated as fry in 2001 compared to 68% in 2000. Additional variation in these proportions is expected over a longer period of time. For instance, the proportion of age 0+ chinook that migrated as fry in the Skagit River ranged from 39% to 85% between 1997 and 2001 (WDFW unpublished data).

Because of the proportionately larger migration of chinook fry in 2000, the median migration date (the date when 50% of the wild production had passed the trap) occurred nearly a month earlier in 2000 (March 7) compared to 2001 (April 2) (Figure 12). A bi-modal migration timing pattern developed in both years. Between migration peaks of fry in March and smolts in May/June, little migration occurred in April during both years.

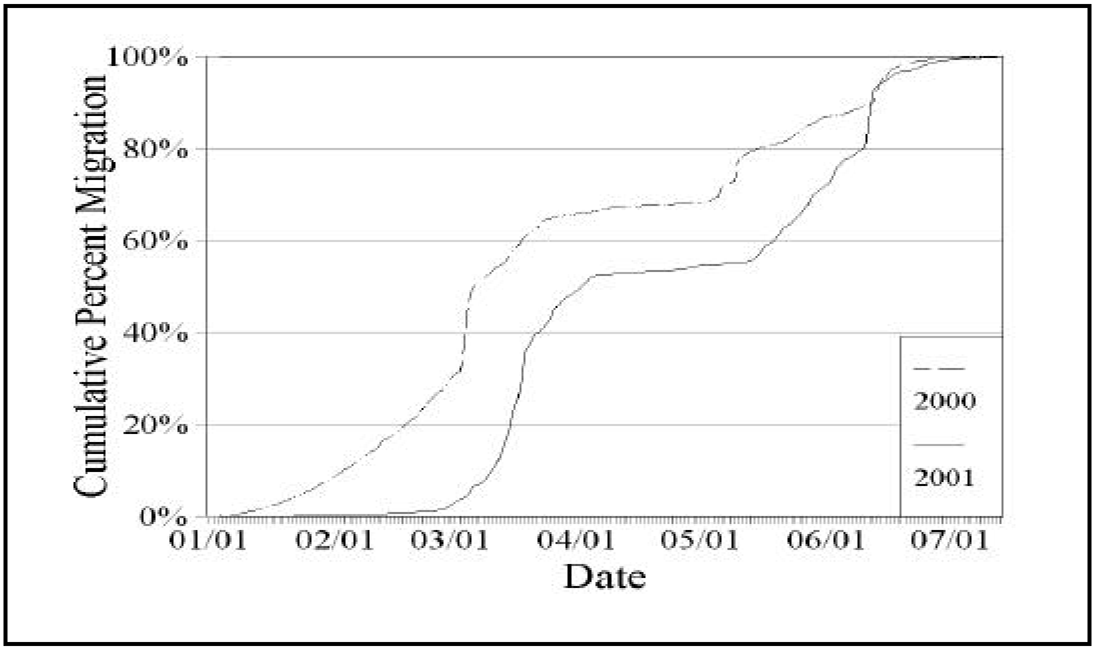

Figure 12. Comparison of wild age 0+ chinook timing distributions for 2000 and 2001 age 0+ chinook, Green River.

References

Literature Cited

Busack, C., Knudsen, A., Marshall, A., Phelps, S., and D. Seiler. 1991. Yakima Hatchery experimental design. Wash. Dept. Fish. Annual Progress Report prepared for BPA Division of Fish and Wildlife. Olympia, WA.

Joint Natural Resources Cabinet. 2000. State agencies action plan for the statewide strategy to recover salmon: 1999-2001 biennium. Governor's Salmon Recovery Office. Olympia, WA.

Malcolm, R. 2002. Draft: Annual variation (1997-2000) in the distribution of spawning chinook in the mainstem Green River (WRIA 09.001), King County, Washington. Ecocline Fisheries Habitat Consulting Ltd. Burnaby, BC Canada.

Seiler, D., S. Neuhauser, and M. Ackley. 1981. Upstream/downstream salmonid trapping project 1977-1980. Wash. Dep. Fish. Prog. Rpt. No. 144: 113pp.

Seiler, D., Volkhardt, G., Kishimoto, L., and P. Topping. 2002[a]. 2000 Green River juvenile salmonid production evaluation. Washington Department of Fish and Wildlife. Olympia, WA.

Seiler, D., Volkhardt, G., and L. Kishimoto. 2002[b]. Evaluation of downstream migrant salmon production in 1999 and 2000 from three Lake Washington tributaries: Cedar River, Bear Creek, and Issaquah Creek. Washington Department of Fish and Wildlife. Olympia, WA.

Seiler, D., Neuhauser, S., and L. Kishimoto. 2002[c]. Annual project report: 2001 Skagit River wild 0+ chinook production evaluation. Washington Department of Fish and Wildlife. Olympia, WA.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. 2nd ed. W. H. Freeman and Company. San Francisco, CA.

U.S. Army Corps of Engineers. 1998. Additional Water Storage Project draft feasibility report and EIS: Howard Hansen Dam, Green River, Washington. USACE - Seattle District. Seattle, WA.

Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory. Olympia, WA.

Personal Communications

Hahn, Pete. WDFW biometrician. October 25, 2002. Conversation.

Wilson, Michael. Soos Creek Hatchery. May 16, 2001 and October 2, 2001. Telephone Conversations.

Appendix A

Daily Catch, Expanded Catch, and Migration Estimates for Age 0+ Chinook Migrants, Green River 2001

Appendix A. Daily catches, expanded catches, and migration estimates for age 0+ chinook migrants, Green River 2001.													
Date	**Hours Fished**	**Catch**					**Expanded Catch**			**Migration**		
		Total	**Unmarked**	**Ad-Marked**	**Wild**	**Hatchery**	**Total**	**Wild**	**Hatchery**	**Total**	**Wild**	**Hatchery**
01/31	6.00	3	3	0	3	0	12	12	0	50	50	0
02/01	20.01	20	20	0	20	0	28	28	0	113	113	0
02/02	15.17	12	12	0	12	0	30	30	0	120	120	0
02/03	24.00	11	11	0	11	0	11	11	0	44	44	0
02/04	24.00	97	97	0	97	0	97	97	0	392	392	0
02/05	24.00	65	65	0	65	0	65	65	0	263	263	0
02/06	21.55	45	45	0	45	0	36	36	0	145	145	0
02/07	24.00	101	101	0	101	0	101	101	0	408	408	0
02/08	24.00	38	38	0	38	0	38	38	0	154	154	0
02/09	24.00	78	78	0	78	0	78	78	0	315	315	0
02/10	23.33	51	51	0	51	0	55	55	0	222	222	0
02/11	24.00	65	65	0	65	0	65	65	0	263	263	0
02/12	24.00	76	76	0	76	0	76	76	0	307	307	0
02/13	24.00	57	57	0	57	0	57	57	0	230	230	0
02/14	24.00	77	77	0	77	0	77	77	0	311	311	0
02/15	24.00	35	35	0	35	0	35	35	0	141	141	0
02/16	24.00	91	91	0	91	0	91	91	0	368	368	0
02/17	24.00	126	126	0	126	0	126	126	0	509	509	0
02/18	24.00	72	72	0	72	0	72	72	0	291	291	0
02/19	24.00	157	157	0	157	0	157	157	0	634	634	0
02/20	24.00	99	99	0	99	0	99	99	0	400	400	0
02/21	24.00	45	45	0	45	0	45	45	0	182	182	0
02/22	24.00	26	26	0	26	0	26	26	0	105	105	0
02/23	24.00	25	25	0	25	0	25	25	0	101	101	0
02/24	24.00	39	39	0	39	0	39	39	0	158	158	0
02/25	24.00	97	97	0	97	0	97	97	0	392	392	0
02/26	24.00	441	441	0	441	0	441	441	0	1,782	1,782	0
02/27	24.00	452	452	0	452	0	452	452	0	1,826	1,826	0
02/28	24.00	746	746	0	746	0	746	746	0	3,014	3,014	0
03/01	24.00	881	881	0	881	0	881	881	0	3,560	3,560	0
03/02	24.00	919	919	0	919	0	919	919	0	3,713	3,713	0
03/03	24.00	1,253	1,253	0	1,253	0	1,253	1,253	0	5,063	5,063	0
03/04	24.00	901	901	0	901	0	901	901	0	3,640	3,640	0
03/05	24.00	771	771	0	771	0	771	771	0	3,115	3,115	0
03/06	24.00	3,102	3,102	0	3,102	0	3,102	3,102	0	12,533	12,533	0
03/07	24.00	825	825	0	825	0	825	825	0	3,333	3,333	0
03/08	24.00	293	293	0	293	0	293	293	0	1,184	1,184	0
03/09	24.00	1,687	1,687	0	1,687	0	1,687	1,687	0	6,816	6,816	0
03/10	24.00	2,241	2,241	0	2,241	0	2,241	2,241	0	9,055	9,055	0
03/11	24.00	978	978	0	978	0	978	978	0	5,909	5,909	0
03/12	24.00	581	581	0	581	0	581	581	0	9,637	9,637	0
03/13	24.00	929	929	0	929	0	929	929	0	15,410	15,410	0
03/14	24.00	1,199	1,199	0	1,199	0	1,199	1,199	0	19,888	19,888	0
03/15	24.00	998	998	0	998	0	998	998	0	16,554	16,554	0
03/16	24.00	1,938	1,938	0	1,938	0	1,938	1,938	0	32,146	32,146	0
03/17	24.00	1,032	1,032	0	1,032	0	1,032	1,032	0	17,118	17,118	0

Appendix A. Daily catches, expanded catches, and migration estimates for age 0+ chinook migrants, Green River 2001.												
Date	**Hours Fished**	**Catch**					**Expanded Catch**			**Migration**		
		Total	**Unmarked**	**Ad-Marked**	**Wild**	**Hatchery**	**Total**	**Wild**	**Hatchery**	**Total**	**Wild**	**Hatchery**
03/18	24.00	1,378	1,378	0	1,378	0	1,378	1,378	0	22,857	22,857	0
03/19	24.00	3,195	3,195	0	3,195	0	3,195	3,195	0	52,996	52,996	0
03/20	24.00	678	678	0	678	0	678	678	0	11,246	11,246	0
03/21	24.00	741	741	0	741	0	741	741	0	12,291	12,291	0
03/22	24.00	457	457	0	457	0	457	457	0	7,580	7,580	0
03/23	24.00	392	392	0	392	0	392	392	0	6,502	6,502	0
03/24	24.00	334	334	0	334	0	334	334	0	5,540	5,540	0
03/25	24.00	483	483	0	483	0	483	483	0	8,012	8,012	0
03/26	24.00	1,014	1,014	0	1,014	0	1,014	1,014	0	16,819	16,819	0
03/27	24.00	459	459	0	459	0	459	459	0	7,614	7,614	0
03/28	24.00	387	387	0	387	0	387	387	0	6,419	6,419	0
03/29	24.00	303	303	0	303	0	303	303	0	5,026	5,026	0
03/30	24.00	218	218	0	218	0	218	218	0	3,616	3,616	0
03/31	24.00	215	215	0	215	0	215	215	0	3,566	3,566	0
04/01	24.00	289	289	0	289	0	289	289	0	4,794	4,794	0
04/02	24.00	397	397	0	397	0	397	397	0	6,585	6,585	0
04/03	24.00	299	299	0	299	0	299	299	0	4,960	4,960	0
04/04	24.00	406	406	0	406	0	406	406	0	6,734	6,734	0
04/05	20.31	196	196	0	196	0	216	216	0	3,586	3,586	0
04/06	24.00	39	38	1	38	1	39	38	1	647	629	18
04/07	24.00	41	40	1	40	1	41	40	1	680	662	18
04/08	24.00	31	31	0	31	0	31	31	0	514	514	0
04/09	24.00	41	41	0	41	0	41	41	0	680	680	0
04/10	24.00	42	42	0	42	0	42	42	0	697	697	0
04/11	24.00	103	103	0	103	0	103	103	0	1,708	1,708	0
04/12	24.00	32	31	1	31	1	32	31	1	531	513	18
04/13	24.00	26	24	2	24	2	26	24	2	431	395	36
04/14	24.00	17	16	1	16	1	17	16	1	282	264	18
04/15	24.00	12	11	1	11	1	12	11	1	199	181	18
04/16	24.00	8	8	0	8	0	8	8	0	133	133	0
04/17	24.00	13	13	0	13	0	13	13	0	216	216	0
04/18	24.00	10	9	1	9	1	10	9	1	166	151	15
04/19	24.00	17	16	1	16	1	17	16	1	282	264	18
04/20	24.00	24	24	0	24	0	24	24	0	398	398	0
04/21	24.00	36	36	0	36	0	36	36	0	597	597	0
04/22	24.00	24	24	0	24	0	24	24	0	398	398	0
04/23	24.00	17	17	0	17	0	17	17	0	282	282	0
04/24	24.00	22	22	0	22	0	22	22	0	365	365	0
04/25	24.00	29	29	0	29	0	29	29	0	481	481	0
04/26	24.00	46	46	0	46	0	46	46	0	763	763	0
04/27	24.00	44	44	0	44	0	44	44	0	730	730	0
04/28	24.00	44	44	0	44	0	44	44	0	730	730	0
04/29	24.00	29	28	1	28	1	29	28	1	481	463	18
04/30	24.00	175	172	3	172	3	175	172	3	2,903	2,849	54
05/01	24.00	66	66	0	66	0	66	66	0	1,095	1,095	0
05/02	24.00	33	33	0	33	0	33	33	0	547	547	0
05/03	24.00	13	13	0	13	0	13	13	0	216	216	0
05/04	24.00	17	17	0	17	0	17	17	0	282	282	0

Appendix A. Daily catches, expanded catches, and migration estimates for age 0+ chinook migrants, Green River 2001.

Date	Hours Fished	Catch					Expanded Catch			Migration		
		Total	Unmarked	Ad-Marked	Wild	Hatchery	Total	Wild	Hatchery	Total	Wild	Hatchery
05/05	24.00	21	21	0	21	0	21	21	0	348	348	0
05/06	24.00	26	26	0	26	0	26	26	0	431	431	0
05/07	24.00	32	32	0	32	0	32	32	0	531	531	0
05/08	24.00	35	35	0	35	0	35	35	0	581	581	0
05/09	22.75	12	12	0	12	0	13	13	0	211	211	0
05/10	24.00	35	35	0	35	0	35	35	0	581	581	0
05/11	24.00	61	61	0	61	0	61	61	0	1,012	1,012	0
05/12	24.00	54	54	0	54	0	54	54	0	896	896	0
05/13	24.00	89	89	0	89	0	89	89	0	1,476	1,476	0
05/14	24.00	245	244	1	244	1	245	244	1	4,064	4,046	18
05/15	24.00	343	343	0	343	0	343	343	0	5,689	5,689	0
05/16	24.00	635	635	0	635	0	635	635	0	10,533	10,533	0
05/17	24.00	280	280	0	280	0	280	280	0	4,644	4,644	0
05/18	24.00	214	214	0	214	0	214	214	0	3,550	3,550	0
05/19	24.00	362	361	1	361	1	362	361	1	6,005	5,987	18
05/20	24.00	442	442	0	442	0	442	442	0	7,332	7,332	0
05/21	24.00	566	566	0	566	0	566	566	0	9,388	9,388	0
05/22	24.00	218	217	1	217	1	218	217	1	3,616	3,598	18
05/23	24.00	301	299	2	299	2	301	299	2	4,993	4,957	36
05/24	24.00	360	360	0	360	0	360	360	0	5,971	5,971	0
05/25	19.24	439	439	0	439	0	465	465	0	7,705	7,705	0
05/26	24.00	430	430	0	430	0	430	430	0	7,133	7,133	0
05/27	24.00	377	377	0	377	0	377	377	0	6,253	6,253	0
05/28	24.00	910	910	0	910	0	910	910	0	15,094	15,094	0
05/29	24.00	320	319	1	319	1	320	319	1	5,308	5,290	18
05/30	24.00	339	339	0	339	0	339	339	0	5,623	5,623	0
05/31	24.00	270	270	0	270	0	270	270	0	4,479	4,479	0
06/01	24.00	318	318	0	318	0	318	318	0	5,275	5,275	0
06/02	24.00	623	621	2	621	2	623	621	2	10,334	10,298	36
06/03	24.00	704	703	1	703	1	704	703	1	11,677	11,659	18
06/04	24.00	561	560	1	560	1	561	560	1	9,305	9,287	18
06/05	24.00	283	282	1	282	1	283	282	1	4,694	4,676	18
06/06	24.00	266	266	0	266	0	266	266	0	4,412	4,412	0
06/07	24.00	247	246	1	246	1	247	246	1	4,097	4,079	18
06/08	24.00	223	223	0	223	0	223	223	0	3,699	3,699	0
06/09	24.00	198	197	1	197	1	198	197	1	3,284	3,266	18
06/10	24.00	255	254	1	254	1	255	254	1	4,230	4,212	18
06/11	24.00	3,457	3,451	6	3,450	7	3,457	3,450	7	57,342	57,234	108
06/12	24.00	2,016	2,014	2	2,014	2	2,016	2,014	2	33,440	33,404	36
06/13	24.00	428	423	5	423	5	428	423	5	7,099	7,009	90
06/14	24.00	249	247	2	247	2	249	247	2	4,130	4,094	36
06/15	24.00	290	285	5	285	5	290	285	5	4,810	4,720	90
06/16	24.00	302	297	5	297	5	302	297	5	5,009	4,919	90
06/17	24.00	250	245	5	245	5	250	245	5	4,147	4,057	90
06/18	24.00	221	219	2	219	2	221	219	2	3,666	3,630	36
06/19	24.00	104	102	2	102	2	104	102	2	1,725	1,689	36
06/20	24.00	85	83	2	83	2	85	83	2	1,410	1,374	36
06/21	24.00	53	52	1	52	1	53	52	1	879	861	18

Appendix A. Daily catches, expanded catches, and migration estimates for age 0+ chinook migrants, Green River 2001.

Date	Hours Fished	Catch					Expanded Catch			Migration		
		Total	Unmarked	Ad-Marked	Wild	Hatchery	Total	Wild	Hatchery	Total	Wild	Hatchery
06/22	12.00	70	69	1	69	1	73	72	1	1,214	1,196	18
06/23	13.25	127	126	1	126	1	132	131	1	2,185	2,167	18
06/24	14.00	162	162	0	162	0	167	167	0	2,775	2,775	0
06/25	24.00	179	179	0	179	0	179	179	0	2,969	2,969	0
06/26	24.00	108	107	1	107	1	108	107	1	1,791	1,773	18
06/27	16.00	97	97	0	97	0	97	97	0	1,615	1,615	0
06/28	17.50	90	90	0	90	0	90	90	0	1,497	1,497	0
06/29	16.50	65	65	0	65	0	65	65	0	1,082	1,082	0
06/30	14.50	42	42	0	42	0	42	42	0	700	700	0
07/01	15.00	33	33	0	33	0	33	33	0	550	550	0
07/02	24.00	28	27	1	27	1	28	27	1	464	446	18
07/03	24.00	37	37	0	37	0	37	37	0	614	614	0
07/04	15.25	18	18	0	18	0	20	20	0	337	333	4
07/05	15.00	19	19	0	19	0	22	21	0	358	354	4
07/06	16.00	28	28	0	28	0	31	31	0	517	512	5
07/07	15.75	29	29	0	29	0	32	32	0	538	532	6
07/08	15.50	27	27	0	27	0	30	30	0	503	498	5
07/09	24.00	20	18	2	18	2	20	18	2	332	296	36
07/10	24.00	18	17	1	17	1	18	17	1	299	281	18
07/11	12.50	12	12	0	12	0	12	12	0	205	205	0
07/12	16.25	20	20	0	20	0	20	20	0	337	337	0
07/13	14.17	19	19	0	19	0	19	19	0	322	322	0
07/14	12.25	18	18	0	18	0	19	19	0	308	308	0
07/15	12.25	26	26	0	26	0	27	27	0	444	444	0
07/16	24.00	30	30	0	30	0	30	30	0	498	498	0
07/17	14.00	20	20	0	20	0	20	20	0	332	332	0
07/18	14.75	11	11	0	11	0	11	11	0	182	182	0
07/19	14.50	6	6	0	6	0	6	6	0	100	100	0
07/20	10.50	4	4	0	4	0	4	4	0	66	66	0
07/21	13.08	6	6	0	6	0	6	6	0	100	100	0
07/22	13.50	9	9	0	9	0	9	9	0	149	149	0
07/23	13.25	6	6	0	6	0	6	6	0	100	100	0
07/24	11.75	3	3	0	3	0	3	3	0	50	50	0
07/25	13.50	2	2	0	2	0	2	2	0	33	33	0
07/26	15.00	3	3	0	3	0	3	3	0	50	50	0
07/27	14.08	3	3	0	3	0	3	3	0	50	50	0
07/28	12.00	4	4	0	4	0	4	4	0	66	66	0
07/29	12.25	4	4	0	4	0	4	4	0	66	66	0
07/30	12.50	2	2	0	2	0	2	2	0	33	33	0
07/31	13.75	3	3	0	3	0	3	3	0	50	50	0
08/01	8.75	1	1	0	1	0	1	1	0	17	17	0
Total	4,003.18	56,625	56,554	71	56,548	77	56,733	56,655	78	728,099	726,801	1,299