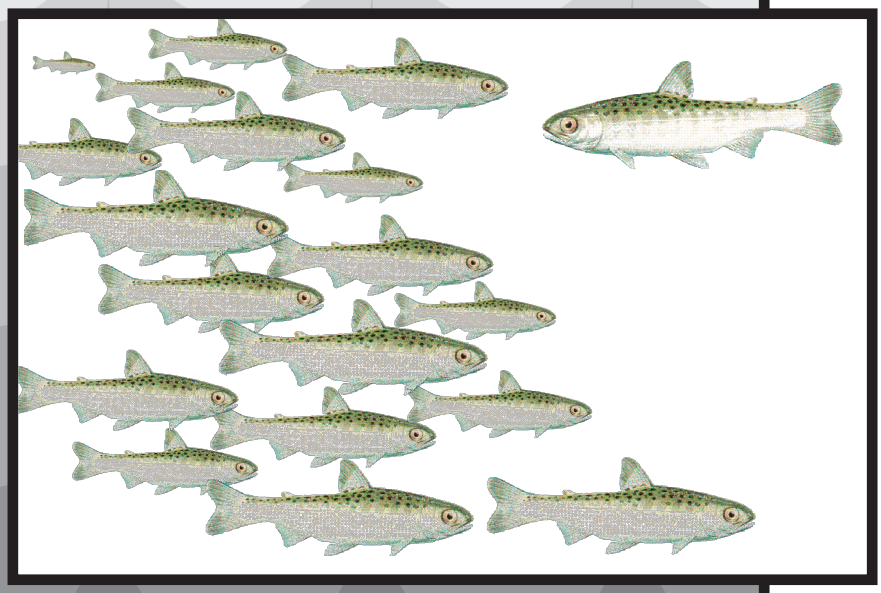
STATE OF WASHINGTON April 2006

# Evaluation of Downstream Migrant Salmon Production in 2005 from the Cedar River and Bear Creek



by Greg Volkhardt, Dave Seiler,
Lindsey Fleischer, and Kelly Kiyohara

*Washington Department of*
*FISH AND WILDLIFE*
*Fish Program*
*Science Division*
*Wild Salmon Production/Evaluation*

FPA 06-02

# Evaluation of Downstream Migrant Salmon Production in 2005 from the Cedar River and Bear Creek

Greg Volkhardt
Dave Seiler
Lindsey Fleischer
Kelly Kiyohara

Washington Department of Fish and Wildlife
Olympia, Washington 98501-1091

April 2006

Supported by:
King County Wastewater Treatment Division
City of Seattle Public Utilities

# Acknowledgements

The evaluations of downstream migrant salmon production in the Cedar River and Bear Creek in 2005 were made possible with funding from the King County Wastewater Treatment Division. In addition, the City of Seattle Public Utilities funded the evaluation of Cedar River sockeye fry production. The success of these projects relied on the hard work of a number of dedicated permanent and temporary WDFW personnel. The Hatcheries Program successfully collected adult sockeye broodstock and incubated eggs, releasing over 15.2 million sockeye fry into the Cedar River. Escapement data were collected and estimates were developed by a number of individuals representing several agencies: Steve Foley, WDFW; Mike Leslie and Brian Footen, Muckelshoot Tribe; Karl Burton, SPU; and Hans Berge, King County DNR. Scientific Technicians Paul Lorenz, Dan Estelle, and Clayton Kinsel worked long hours, usually at night, operating the traps, marking, identifying and counting fish. Biologists Mike Ackley and Pete Topping provided valuable experience and logistical support.

We also appreciate and acknowledge the contributions of the following companies and agencies to these studies:

CEDAR RIVER

The Boeing Company provided electrical power and a level of security for our fry trap.
The Renton Municipal Airport provided security for the fry trap.
The City of Renton Parks Department provided access and allowed us to attach anchor cables to their property.
The United States Geological Survey provided continuous flow monitoring.
Seattle Public Utilities communicated flow changes.

BEAR CREEK

Blockbuster Video provided electrical power.
The City of Redmond Police Department provided a measure of security for the crew and trap.
King County provided continuous flow monitoring.

# Table of Contents

# List of Tables

# List of Figures

# Executive Summary

This report provides the results of monitoring five salmonid species as downstream migrants in 2005 from the two most heavily spawned tributaries in the Lake Washington Basin: the Cedar River and Bear Creek. Monitoring sockeye fry production in the Cedar River began in 1992 to investigate the causes of low adult sockeye returns. This annual trapping program, which continued through 2005, was expanded in 1999 with the addition of a second downstream migrant trap to estimate the production of juvenile chinook salmon. With this trap, the production of coho, steelhead and cutthroat smolts were also estimated.

In addition to the Cedar River, downstream migrant production is also measured in the Sammamish basin. A trap was operated in the Sammamish River in 1997 and 1998 to estimate sockeye fry production. This monitoring program was moved to Bear Creek in 1999 to concurrently assess chinook and sockeye production. Since 1999, as in the Cedar River, this trapping operation has also estimated the populations of coho, steelhead and cutthroat smolts.

## *Cedar River*

Declining adult sockeye salmon returns in the late 1980s and early 1990s prompted an effort to investigate causes for this decline. To determine which life-stages were experiencing poor survival, an evaluation of fry production was undertaken in the Cedar River beginning in 1992. Assessing the sockeye population, at this location and life-stage, separates freshwater production into river and lake components. This report documents our evaluation during 2005, the fourteenth year of this project. The primary study goal was to estimate the season total migration of naturally produced (wild) Cedar River sockeye fry into Lake Washington. This estimate enables calculation of a survival rate for natural spawners from egg deposition to lake entry, and for production components from lake entry to subsequent life stages of smolts and adults.

Beginning in January and continuing through mid-May, a floating inclined-plane screen (fry) trap located at river mile (R.M.) 0.7 in the Cedar River was operated to capture a portion of the sockeye fry migrating into Lake Washington (Figure 1). To estimate the capture efficiency of this trap, dye-marked fry were released upstream of the trap on 45 nights during trapping season. Efficiency tests were stratified into four groups based on flow and the elevation of Lake Washington. The average of each group was used to estimate migration within each corresponding strata.

Over the season, 15.3 million hatchery produced sockeye fry were released into the Cedar River from two locations. A portion of these fry (11.6 million) was released below the fry trap at the Cedar River Trail Park. The remaining 3.6 million fry were released from Landsburg Hatchery on four nights. All hatchery fry were internally marked by slightly manipulating water temperatures in the hatchery, which produced a banding effect on the otoliths (calcified boney structures used for equilibrium). Survival of hatchery fry released at the Cedar River Trail Park was assumed to be 100%. Survival of the fry released at Landsburg was estimated based on a model developed using past year's data that correlates survival to the river discharge on the day of the release. The average survival rate from release at Landsburg to the trap site was 66%, and an estimated 2 million fry released from Landsburg survived to pass the trap.

Over the 60 nights trapped, 1.8 million wild sockeye fry were captured and this catch was expanded for intervals not fished. Application of the capture efficiency to the expanded catch estimated a total of 37 million wild sockeye fry entered Lake Washington in 2005.

Median migration timing for wild fry in 2005 was nearly three weeks earlier than average and earlier than all 13 broods measured thus far. February temperatures and flows explain most of the variation in median migration dates between years. Earlier out migration corresponded to river temperatures during incubation that were higher than normal. The median migration date for wild fry was March 2, 29 days later than that of the hatchery fry. This difference was roughly a week longer than average. Survival of wild fry from egg deposition to lake entry was estimated at 18.8%. This rate is the ratio of 37 million wild fry to an estimated deposition of 197 million eggs.

In response to the listing of the Puget Sound Chinook Evolutionary Significant Unit (ESU) under the Endangered Species Act as a threatened species, the existing sockeye fry monitoring program was expanded in 1999 to include an assessment of the natural chinook production in the Cedar River. The gear operated each year, starting in January, to assess sockeye fry production also captures chinook fry. To capture the larger, later migrating chinook smolts, a screw trap was installed at R.M. 1.1, and operated through July. Juvenile chinook production was estimated by applying the capture rate estimates to the catch data. From the start of the season in January through mid-April, we used the capture rate data generated with releases of marked sockeye to estimate fry trap efficiencies for chinook migrants. Screw trap efficiency was estimated by releasing groups of fin-marked chinook smolts above the trap.

Age 0+ chinook production from the Cedar River was estimated at 134,603 in 2005. Timing was bi-modal with fry emigrating in January through mid-April comprising approximately half of the total migration. Egg-to-migrant survival was estimated at 5.9%. Over the season, age 0+ chinook increased in size from less than 40 mm in January to 138 mm by mid-June.

Over the season, based on actual and projected catches and estimates of capture rates we estimated the migrations of coho, steelhead[1] and cutthroat smolts at 71,247, 1,098 and 3,537, respectively.

[1] We are uncertain if the downstream migrant rainbow trout referred to as steelhead follow an anadromous (saltwater rearing) or ad-fluvial (lake rearing) life history strategy. They are referred to as steelhead in this report since they appear identical to smolted juvenile steelhead from other rivers in western Washington.

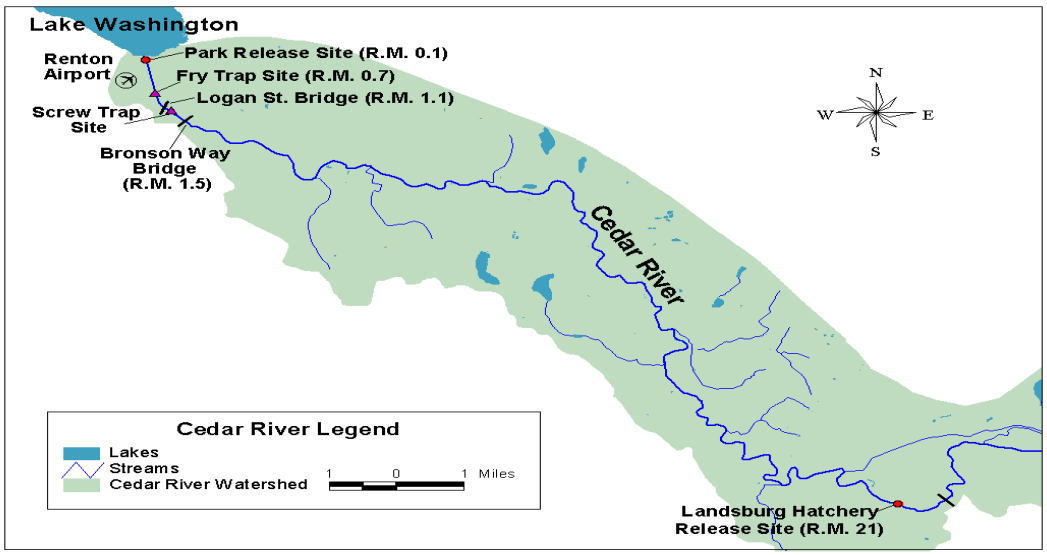



**Figure 1.** Site map of the lower Cedar River watershed depicting the fry and screw trap locations, hatchery sockeye release sites, and trap efficiency test release sites for the 2005 trapping season.

## *Bear Creek*

A fry trap was installed on Big Bear Creek 100 yards downstream of the Redmond Way Bridge and operated from February through early April. In April, it was replaced with a screw trap that fished until the middle of July. Using the approach described for the Cedar River, downstream migrant production was estimated for wild sockeye fry, age 0+ chinook, coho, steelhead, and cutthroat smolts.

Throughout the fry trapping season, seven efficiency tests were conducted using sockeye fry. Capture rates ranged from 8.7% to 28.3% and averaged 19.4%. Total sockeye production was estimated at 202,815 fry. Relating this production to the estimated deposition of 2.3 million eggs yielded a survival rate of 8.8%.

Migration of age 0+ chinook during fry trap operation was estimated using the average efficiency measured with sockeye fry. During screw trap operation efficiency tests were conducted with marked chinook smolts, similar to the Cedar River. Efficiency was estimated by using 25 efficiency tests stratified into two groups based on flow. The average of each group was used to estimate corresponding migrations. Total production of age 0+ chinook was estimated at 9,317 in 2005. Migration timing was generally unimodal, with most chinook migrating as smolts in May. Weekly chinook fork lengths averaged less than 40 mm in February, and grew to 102 mm by late June. Egg to migrant survival was estimated at 3.0%.

Coho production was estimated at 43,725 smolts and cutthroat production at 4,280 smolts. During the 2005 trapping season, only two steelhead were caught in the Bear Creek screw trap.

# Introduction

The decline of sockeye salmon returns to Lake Washington from the mid 1980s to 1991 prompted managers to begin investigating the cause(s). Although over 500,000 fish returned in 1988, by 1991 less than 100,000 sockeye returned through the Ballard Locks. In 1991, a broad-based group was formed to address this decline. Resource managers developed a program involving population monitoring in combination with an artificial production program. Information generated by these efforts, which continued through 2005, will be used to improve management of Lake Washington sockeye salmon.

At a gross-scale, sockeye life history can be partitioned into a freshwater incubation and rearing phase and a marine rearing phase. Existing management information indicated that marine survival had averaged 11%, varying eight-fold (2.6% to 21.4%), for the 1967 to 1993 broods with no apparent decline over the data set (WDFW unpublished data). In contrast, survival in freshwater, as measured by smolts per spawner rates, declined over this same period.

During the freshwater phase, the majority of sockeye production involves two freshwater habitats: the stream, where spawning, egg incubation, fry emergence, and migration to the lake occurs; and the lake, where virtually all of the juveniles rear for one year before emigrating to the ocean as smolts. Measuring survival rates in both of these habitats will help explain causes for population variation. In 1992, trapping gear and methodology were developed to estimate naturally produced (wild) and hatchery sockeye fry production from the Cedar River and monitoring began. To assess sockeye fry production on a basin scale, monitoring sockeye fry production in the Sammamish Slough began in 1997 and since 1999 has continued in Bear Creek.

The National Marine Fisheries Service listed the Puget Sound Chinook ESU under the Endangered Species Act as a threatened species in March 1999. In the Lake Washington watershed, it was evident that recovery-planning efforts would be more effective if more were known about the habitat requirements, early life history, freshwater productivity, and survival of chinook salmon. Baseline information was available on the number of spawners, but adult counts provide little insight into survival during specific life stages. Estimating the number of juvenile migrants facilitates separating survival into two components: egg-to-migrant (freshwater) and migrant-to-returning adult. In the lake Washington system, this later stage includes passage through the lake, Ship Canal, Locks, and the marine environment. This provides a more direct accounting of the role that stream habitats play in regulating salmon production (Seiler *et al.* 1981, Cramer *et al.* 1999).

The downstream migrant evaluations conducted in the Cedar River and Bear Creek in 1999 were the first in the Lake Washington Basin directed at estimating the production of wild juvenile chinook (Seiler et al. 2003). Since the chinook migration includes newly emerged fry and later, larger smolts, two different gear types were employed. The fry trap gently captures fry but larger migrants can avoid it. For the later-timed smolt migration a rotary screw trap was installed.

## *Cedar River*

Since 1992, we have operated a floating inclined plane (fry) trap in the lower Cedar River to evaluate the production of wild and hatchery sockeye fry. Production of sockeye fry at the Landsburg Hatchery on the Cedar River began with the 1991 brood. Released in 1992, this brood and all

subsequent sockeye incubated at this hatchery, have been identified with thermally-induced otolith-marks (Volk *et al.* 1990). In 1995, we evaluated the effect of flow on survival by releasing ten hatchery groups over a range of flows. Results demonstrated that in-river fry survival is largely a function of flow (Seiler and Kishimoto 1996).

We have also determined that over the twelve broods measured, survival from egg deposition to fry emigration is largely a function of the severity of peak flows in the Cedar River during the egg incubation period. Therefore, over the range of spawning population levels that have been evaluated thus far, the numbers of naturally produced sockeye fry entering Lake Washington are the product of the number of eggs deposited and the flow-affected survival rates during incubation and migration.

In the summer of 1998, the lower Cedar River was dredged to reduce the flooding potential (USACE 1997). This project lowered the streambed and created a wider and deeper channel, which reduced the velocity to near zero where the fry trap was located (R.M. 0.25). This dramatic change in the channel required moving the trap location upstream in 1999 and 2000. In addition, the trapping program was extended in 1999 to also evaluate the production of juvenile chinook (Seiler *et al.* 2003). To effectively capture larger chinook, in addition to the fry trap, a different gear type (a screw trap) was operated in faster water. Concurrent operation of the fry and screw traps assessed the capture and size biases of each trap.

## *Big Bear Creek*

In 1997 and 1998, a downstream migrant trap was operated in the Sammamish Slough at Bothell to estimate the contribution of sockeye fry to Lake Washington from the Sammamish portion of the watershed. While this operation successfully estimated sockeye fry production, velocities in the Sammamish were too low to capture migrants larger than sockeye fry. Therefore, assessing the production of chinook and other migrants required selecting a trapping location with sufficient velocity.

With sockeye escapements in excess of 50,000 adults in some years, Big Bear Creek, also referred to as Bear Creek, is the most heavily spawned tributary in the Sammamish watershed. Therefore, in 1999, the migrant trapping operation was moved downstream to the lower end of this stream where velocities were high enough to capture larger migrants. In addition to estimating chinook and sockeye production, higher velocities also enabled estimating the production of coho, steelhead and cutthroat smolts.

# Goals and Objectives

The overall goal of this project is to quantify the downstream migrant populations of sockeye, chinook and coho salmon and steelhead and cutthroat trout from the Cedar River and Bear Creek. In addition to estimating the daily migration for each species, describing their size at time and collecting additional biological data will enable accomplishing the following objectives.

**Chinook**

1. **Estimate in-river survival.** Relating total migrant production to the estimated egg deposition estimates in-river (egg-to-migrant) survival. Over time, we will correlate this rate among broods with such factors as spawner abundance, flows, and habitat condition.
2. **Estimate fry and smolt productions.** Relating the proportions of fry and smolts to brood specific factors will identify production determinants.
3. **Estimate lake/marine survival of natural production.** Relating subsequent adult returns to a brood's juvenile production will estimate survival through the lake, the Ballard Locks, and the marine environment.
4. **Tag wild chinook.** Tagging wild chinook emigrating from the Cedar River and Bear Creek with PIT tags will assess survival through the lake system.

**Sockeye**

1. **Estimate survival of natural production.** Relating the estimate of wild fry produced to the estimated egg deposition measures the overall success of natural spawning. Significant variation in this rate among broods, as a function of spawner abundance, predator populations, and flows will be evaluated to assess stream carrying capacity and the relative importance of production determinants.
2. **Estimate the season total of fry entering the lake.** Relating the combined estimate of wild and hatchery fry to the smolt production the following spring will measure rearing survival within the lake. Over time this information will help assess predation rates and the lake's carrying capacity. Relating brood year adult returns to the total fry production measures overall survival through the lake and marine environments.
3. **Estimate incidence of hatchery fry in the population at lake entry (Cedar River).** Comparing this rate with the incidence of hatchery fish in the population at later life stages (smolts and adults) will assess relative hatchery and wild survival rates.
4. **Develop migration timing of wild and hatchery fry.** Comparing the difference between wild timing and hatchery fry releases with subsequent survival to return rates will contribute to the adaptive management process guiding Cedar River Hatchery sockeye fry production.

**Coho, Steelhead[2], and Cutthroat**

Quantifying the annual production of these smolt populations will help measure the ecosystem health of the Cedar River and Bear Creek. Population levels and ratios

[2] We are uncertain if the downstream migrant rainbow trout referred to as steelhead follow an anadromous (saltwater rearing) or ad-fluvial (lake rearing) life history strategy. They are referred to as steelhead in this report since they appear identical to smolted juvenile steelhead from other rivers in western Washington.

between these species are indicative of habitat condition and performance of fisheries management.

# Methods

## *Trapping Gear and Operation*

### Cedar River

In each year since 1999, two traps were operated in the lower Cedar River during the spring out-migration period. A small floating inclined plane (fry) trap was operated in late winter through spring to capture a proportion of the migrating sockeye and chinook fry emigrating during this period. The size and placement of this trap was chosen to avoid capturing yearling migrants and to avoid predation in the trap. A floating rotary screw trap was operated during the early spring to summer months to assess the migration of chinook, coho, steelhead, and cutthroat. Because this trap was employed to capture larger migrants that would prey on sockeye fry, the live box was designed so as not to retain sockeye fry. Together, these traps enabled estimating the production of each species while minimizing mortality.

#### *Fry Trap*

The fry trap consists of a low-angle inclined-plane screen trap (3 ft wide by 2 ft deep by 9 ft long) suspended from a 40x13 ft steel pontoon barge. Fish are separated from the water via a perforated aluminum plate (33 - 1/8 in. holes per in.2). The structure resembles the larger traps we use to capture smolts in larger river systems throughout the state (Seiler *et al.* 1981). Lowered to a depth of 16 inches, the fry trap screens a cross-sectional area of 4 $ft^2$. The trap was positioned at RM 0.7, just downstream of the South Boeing Bridge in the thalweg, approximately 25 ft off the west bank.

This trap operated 60 nights from mid-January to mid-May. During each night of operation, trapping began before dusk and continued past dawn. Although most of the downstream migration occurs at night, trapping was conducted during several daylight intervals to assess daytime movement. The number of nights trapped in 2005 is substantially reduced from the 101 nights trapped in 2002 (the highest number of nights trapped over all years). This reduction was due to reduced funding for the project and the lack of variability noted in the day to day catches. For example, projecting the 2005 trapping schedule onto the 2002 catch data and interpolating catch during unfished periods estimates a total catch of 1,881,324 wild sockeye over the January 21 to May 15 period compared to the actual estimate of 1,874,392; a difference of 6,932 sockeye, or only 0.4%.

Captured fish were removed from the trap, identified by species, and counted each hour. Large sockeye fry catches were counted using an electronic counter. The electronic count was divided by an adjustment factor (95.7%) to estimate the actual catch. As in previous years, this adjustment factor was found through calibration testing. The most recent calibration tests occurred in 2003.

Over the season, 15,255,000 hatchery-produced sockeye fry were released into the Cedar River (Table 1). Seventy-six percent of this production (11,618,000) was released below the trap at the Cedar River Trail Park, and 24% (3,637,000) was released directly from the hatchery at Landsburg. Releases at Landsburg occurred on seven nights, from January 24 to February 22. Releases below the trap occurred on 24 nights, between February 3 and April 4. The group sizes released from Landsburg ranged from 90,000 to 1,331,000 fry.

### *Screw Trap*

The screw trap consisted of a 5 ft diameter screw trap supported by a 12 ft wide by 30 ft long steel pontoon barge (Seiler *et al.* 2003). As in previous seasons, the trap was positioned at RM 1.1, just upstream of the Logan Street Bridge near the right bank. This location is the lowest site with sufficient velocity to effectively operate the trap. The screw trap was operated continuously from mid-April through mid-May. The catches were enumerated at dusk and in the early morning in order to discern diel movements. From late May through July, when trapping ceased, the trap was lifted during the daylight hours to avoid any potential hazard to recreational floaters using the river. All chinook, coho, steelhead, and cutthroat smolts were enumerated by species and randomly sampled for size (fork length).

**Table 1.** Hatchery-produced sockeye fry released into the Cedar River in 2005.

| Release Date | Number Released by Site | | Total Released |
|---|---|---|---|
| | Park (RM 0.1) | Landsburg (RM 22) | |
| 01/24/05 | | 90,000 | 90,000 |
| 01/25/05 | | 256,000 | 256,000 |
| 01/28/05 | | 371,000 | 371,000 |
| 02/01/05 | | 574,000 | 574,000 |
| 02/03/05 | 409,000 | 464,000 | 873,000 |
| 02/07/05 | 374,000 | | 374,000 |
| 02/10/05 | 593,000 | | 593,000 |
| 02/11/05 | 584,000 | | 584,000 |
| 02/14/05 | 630,000 | | 630,000 |
| 02/15/05 | 624,000 | | 624,000 |
| 02/16/05 | 272,000 | | 272,000 |
| 02/17/05 | 575,000 | | 575,000 |
| 02/18/05 | | 551,000 | 551,000 |
| 02/22/05 | 266,000 | 1,331,000 | 1,597,000 |
| 02/23/05 | 640,000 | | 640,000 |
| 02/24/05 | 645,000 | | 645,000 |
| 02/25/05 | 587,000 | | 587,000 |
| 02/28/05 | 586,000 | | 586,000 |
| 03/01/05 | 243,000 | | 243,000 |
| 03/03/05 | 596,000 | | 596,000 |
| 03/04/05 | 584,000 | | 584,000 |
| 03/07/05 | 596,000 | | 596,000 |
| 03/08/05 | 430,000 | | 430,000 |
| 03/11/05 | 646,000 | | 646,000 |
| 03/16/05 | 527,000 | | 527,000 |
| 03/21/05 | 646,000 | | 646,000 |
| 03/23/05 | 269,000 | | 269,000 |
| 03/28/05 | 205,000 | | 205,000 |
| 04/04/05 | 91,000 | | 91,000 |
| Total | 11,618,000 | 3,637,000 | 15,255,000 |

## Bear Creek

As with the Cedar River, out-migrating salmonids were captured using two traps in lower Bear Creek. A fry trap was used to capture sockeye and chinook fry early in the trapping season. This trap was replaced with a screw trap in early April to capture chinook, coho, steelhead, and cutthroat.

### *Fry Trap*

The fry trap used in Bear Creek was identical to that employed in the Cedar River. This gear was suspended from a 30x12 ft steel pontoon barge positioned approximately 100 yards downstream of Redmond Way, below the railroad trestle in the middle of the channel. Trapping began in early February and ended in early April. On nearly every date the trap was operated, trapping began before dusk and continued past dawn. Captured fish were removed from the trap and counted at various intervals, from hourly to several hours depending on migration rates.

### *Screw Trap*

In early April the fry trap was replaced with a 5 ft diameter screw trap. Screw trap operation began on April 8, and continued through the morning of July 29. Catches were usually enumerated at dusk and in the early morning. All chinook, coho, steelhead, and cutthroat smolts were enumerated by species and randomly sampled for size (fork length).

## *Trap Efficiency*

## Cedar River

### *Fry Trap*

The capture rate for sockeye fry in the Cedar River fry trap was estimated by marking, releasing, and recovering marked fry. Groups of approximately 2,000 marked sockeye fry were released at the Logan Street Bridge (R.M. 1.1) over 45 nights throughout the season. Fry captured the previous night or in the early hours of the night were marked in a solution of Bismarck brown dye (14 ppm for 1.5 hours). Marked fry were distributed across the middle of the channel from the bridge. Recovery rates were correlated with hourly discharge to assess the effect of flow on capture rate.

### *Screw Trap*

Capture efficiency of the screw trap was estimated for chinook and coho smolts. Groups of 30 or more smolts of each species were anesthetized in a solution of MS-222 and marked with alternating partial upper and lower caudal fin clips. Marked smolts were allowed to recover from the anesthetic during the day in perforated buckets suspended in calm river water. In the evening, the groups were released from the Bronson Way Bridge located one-half mile upstream. As the season dwindled fewer fish were available for marking and efficiency tests. Mark groups were often developed from two night's catches. During trap checks, catches were examined for marks. Recapture rates were correlated with daily discharge to assess the effect of flow on capture rate.

## Bear Creek

### *Fry Trap*

In Bear Creek, the fry trap capture rate for sockeye was estimated by releasing groups of marked sockeye fry from the Redmond Way Bridge on seven nights over the season. As in the Cedar River, fry captured the previous night or in the early hours of the night were marked in a solution of Bismarck brown dye (14 ppm for 1.5 hours). Recapture rates were correlated with mean daily discharge to assess the effect of flow on capture rate.

### *Screw Trap*

Capture efficiency for the screw trap was estimated for chinook, coho, and cutthroat smolts using the same approach described for the Cedar River screw trap. Mark groups were released from the

Redmond Way Bridge. Recapture rates were correlated with mean daily discharge to assess the effect of flow on capture rate.

# *Production Estimate*

## Cedar River

### *Fry Trap*

Estimation of total sockeye and chinook fry migrations occur in several steps. The data collected for each species every night, *i*, consisted of:

- count of total fry captured during a nighttime trapping interval - $C_i$, and
- flow - $f_i$.

Data taken less frequently included:

- count of total fry captured during a daytime trapping interval - $C_d$, and
- trap efficiency: proportion of marked fry released above the trap and subsequently retaken - $e_i$.

**Sockeye**

Sockeye fry catch was estimated for nighttime periods when trapping did not occur. Straight-line interpolation based on the catch from adjacent nights was used to estimate catch when one or more entire nights were not fished. Where the estimate was made for only a single night, the variance was estimated by the variance of the mean (i.e., the interpolated catch) (Equation 1). However if one or both nightly catches, $C_i$, used to interpolate the catch during the unfished period also were estimated then Equation 2 was used.

$$Var(\overline{C}_i) = \frac{\sum(\hat{C}_i - \overline{C}_i)^2}{n(n-1)} \qquad \textbf{Equation 1}$$

$$Var(\overline{C}_i) = \frac{\sum \hat{C}_i - \overline{C}_i)^2}{n(n-1)} + \frac{\sum Var(\hat{C}_i)}{n} \qquad \textbf{Equation 2}$$

where:

$n$ = *Number of sample nights used in the interpolation,*

$C_i$ = *Nightly catches used to estimate the un-fished interval,*

$\overline{C}_i$ = *Interpolated nightly catch estimate, and*

$\hat{C}_i$ = *Estimated nightly catch used to estimate the un-fished interval.*

Where the nightly catch estimate was interpolated for two or more consecutive nights, the variance for each interpolated catch estimate was approximated by scaling the coefficient of variation (CV) of the mean catch from the adjacent night fishing periods by the interpolated catch estimates using;

$$Var(\hat{C}_i) = \left[ \hat{C}_i \left( \frac{\sqrt{Var(\overline{C}_i)}}{\overline{C}_i} \right) \right]^2 \qquad \textbf{Equation 3}$$

Sockeye catch was also estimated when the trap was not operated continuously through the entire nighttime period. Where the trap was operated intermittently through the night, catch during the un-fished interval(s) ($\hat{C}_u$) was (were) estimated by;

$$\hat{C}_u = T_u \overline{R} \qquad \textbf{Equation 4}$$

where;

$T_u$ = *Hours during non-fishing period u, and*
$R$ = *Mean catch rate (fish/hour) from adjacent fished periods.*

The variance was estimated by;

$$Var(\hat{C}_u) = T_u^2 Var(\overline{R}) \qquad \textbf{Equation 5}$$

The total catch on night *i* was estimated by the sum of the catches from the fished periods, *f*, and un-fished periods, *u*. The variance of the nightly catch was estimated by the sum of the variances for the un-fished periods, *u*, and during night *i*.

Trapping did not occur on nights of and following hatchery releases, and, therefore, hatchery migrations were not estimated.

Daytime sockeye catches were estimated by multiplying the nighttime catch by the proportion of the 24-hour catch estimated to have been caught during the day. This proportion, ($F_d$), was found by;

$$F_d = \frac{T_d}{\frac{1}{\overline{\overline{Q}}} T_n + T_d} \qquad \textbf{Equation 6}$$

and its variance by;

$$Var(F_d) = \frac{Var(\overline{Q}) T_n^2 T_d^2}{\overline{Q}^4 \left( \frac{1}{\overline{\overline{Q}}} T_n + T_d \right)^4} \qquad \textbf{Equation 7}$$

where;

$T_n$ = *Hours of night during 24 hour period*
$T_d$ = *Hours of day during 24 hour period, and*
$\overline{Q}_d$ = *Average day/night catch ratio.*

The variance for each daytime catch was estimated using the delta method (Goodman 1960);

$$Var(\hat{C}_d) = \hat{C}_i^2 Var(F_d) + Var(\hat{C}_i)F_d^2 - Var(\hat{C}_i)Var(F_d) \quad \textbf{Equation 8}$$

Trap efficiency tests were correlated with environmental factors to evaluate for stratification. Depending on the outcomes, trap efficiency was estimated by the mean of all tests or by stratified means derived from subsets of tests;

The variances of the individual trap efficiency estimates and the mean trap efficiency estimate were found using;

$$Var(\bar{e}_i) = \frac{e_i(1-e_i)}{n} \quad \textbf{Equation 9}$$

$$Var(\bar{e}) = \frac{\sum(e_i - \bar{e}_i)^2}{n(n-1)} \quad \textbf{Equation 10}$$

Daily sockeye fry migrations were estimated by;

$$\hat{N} = \frac{(\hat{C}_i + \hat{C}_d)}{\bar{e}} \quad \textbf{Equation 11}$$

The variance of each daily migration was estimated using the delta method (Goodman 1960);

$$Var(\hat{N}) = \hat{N}^2\left(\frac{Var(\bar{e})}{\bar{e}^2} + \frac{\sum\left(Var(\hat{C}_i) + Var(\hat{C}_d)\right)}{\left(\sum(\hat{C}_i + \hat{C}_d)\right)^2}\right) \quad \textbf{Equation 12}$$

Where trap efficiency was calculated using a simple mean of all efficiency tests over the season, the total migration was the sum of the daily migrations and its variance was calculated using Equation 12, substituting the season total catch for the daily catches. When efficiency strata were used during the season, the variance for each stratum was calculated using Equation 12. The total season variance was the sum of the stratum variances.

Survival of Cedar River naturally produced sockeye fry to lake entry is the ratio of the wild fry migration estimate to an estimate of potential egg deposition (PED).

### Chinook

Procedures used to estimate the juvenile chinook migration during fry trap operation were identical to those described for sockeye fry. Trap efficiencies for chinook were calculated using the sockeye fry efficiency data.

### *Screw Trap*

**Chinook**

For nighttime intervals not fished and during nights when heavy debris decreased the fishing ability of the trap, catch was estimated for the hours missed. Where chinook nightly catch was estimated, the interpolated value was the mean of the preceding and following night's catch rates ($R_i$) expanded by the hours of the night not fished ($T_u$). Variances for these estimates were calculated by,

$$Var(\hat{C}_i) = T_u^{\,2} \frac{\sum(\hat{R}_i - \overline{R}_i)^2}{n(n-1)} \qquad \textbf{Equation 13}$$

Wild chinook catch during daytime intervals not fished were estimated in order to estimate total daily (24-hour) migrations. The estimates were made by using the average day catch rate to night catch rate ratio from trapping conducted in 2005. The catch during daytime, *d*, was estimated by;

$$\hat{C}_d = \overline{Q}\overline{R}_i T_d \qquad \textbf{Equation 14}$$

and its variance was estimated using the delta method (Goodman 1960) by;

$$Var(\hat{C}_d) = T_d^{\,2}\left(Var(\overline{R}_i)\overline{Q}^2 + Var(\overline{Q})\overline{R}_i^{\,2}\right) \qquad \textbf{Equation 15}$$

where,

$\overline{Q}$ = *Average chinook day/night catch ratio measured for scoop trap,*
$\overline{R}_i$ = *Average night catch rate preceding and following daytime interval d, and*
$T_d$ = *Hours of estimated daytime interval d.*

Where trap efficiency did not appear to correlate with environmental factors, mark-recapture tests were stratified by statistical week and applied to corresponding week's catch to estimate production using Chapman's modified version of the Peterson estimate (Chapman 1951).

$$\hat{N}_i = \left[\frac{(M_i + 1)(C_i + 1)}{(R_i + 1)}\right] - 1 \qquad \textbf{Equation 16}$$

where

$M_i$ = *Number of fish marked and released in discreet period i,*
$C_i$ = *Number of unmarked fish captured during discreet period i, and*
*Ri = Number of marked fish recaptured during discreet period i.*

and its variance calculated using;

$$V(\hat{N}_i) = \hat{N}_i^2 \frac{(C_i - R_i)}{[C_i + 1)(R_i + 2)]} \qquad \textbf{Equation 17}$$

**Other Species**

Catches of steelhead and cutthroat trout were insufficient for directly assessing capture rate via mark and recapture. Therefore, capture rates were estimated from previous studies relating steelhead capture rates to rates measured with coho smolts.

## Bear Creek

Procedures used to estimate downstream migrant production for the fry trap and screw trap were nearly identical to those used on the Cedar River. Differences applied only to estimating the daytime catch. Whereas day catches in the Cedar River were estimated using day/night catch rate ratios ($\overline{Q}$), day catches in the Bear Creek fry trap were minimal and not estimated. Day catches in the screw trap during periods not fished were estimated by interpolation. The variances of interpolated catches were estimated using Equation 1 or 2.

# *DNA and Scale Analysis*

DNA and scale samples, from both the Cedar River and Bear Creek, were collected from what visually appeared to be cutthroat trout that were captured in the fry and screw traps. These samples were taken to assess the age structure of the captured trout, expand the genetic baseline, and to assess the accuracy of trout identification by our technicians operating the traps. These samples were processed and analyzed at the WDFW genetics and scale labs in Olympia, Washington.

# Cedar River Results

## *Sockeye*

### Trap Operation

Fry trap operation began on January 21, and occurred on 60 nights through the season until the last night of trapping on May 15. Trapping did not occur during the nights of and following hatchery releases from Landsburg. Three daytime trapping intervals were fished on February 8, February 16, and March 4.

On 14 of the scheduled trapping nights, the trap did not operate continuously through the night due to excessive debris, stream flow, or catch. During those nights, the trap was operated at 5, 15, or 30-minute intervals each hour. Heavy debris and high stream flow caused this reduction on two nights. The hourly trapping intervals were reduced on the other 12 nights, between February 27 and March 21, as a result of very high catch rates.

### Catch

During the first night of trapping (January 21), 3,359 sockeye fry were caught during the five hours trapped. Nightly catches increased and peaked at 114,622 fry on March 1, which represents only 30% of the 383,000 fry we estimated would have been caught had we fished continuously that night (Appendix A). Catches decreased thereafter and on the last day of trapping, May 15, 455 fry were caught. The combined nightly catches of wild fry for the season totaled 1,803,082, and day catches totaled 1,437 fry (Appendix A). On the 14 nights that we did not fish continuously, catches were expanded to project entire nights' catch.

### Trap Efficiency

Tests to determine the capture efficiency of the trap were conducted on 45 nights from January 26 to April 24. Efficiencies among the 45 groups ranged from 7.7% to 23.7%. This variability was attributed to changes in velocity at the mouth of the trap and in the wetted channel cross section in response to the combination of changing stream flows and lake elevation. Four efficiency strata were developed from this data (Table 2, Figure 2). The four mean stratified trap efficiencies were found to be significantly different ($\alpha$=0.05) using analysis of variance.

**Table 2.** Summary of trap efficiency tests using sockeye fry separated into strata based on flows and Lake Washington elevation data, Cedar River fry trap 2005.

| Stratum | Dates | | Lk. | Flow (cfs) [1] | | Number | | Efficiency | | | | Var(e) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start | End | Elevation | Min. | Max. | Released | Recaptured | n | Min. | Max. | Avg. | |
| 1 | Jan 1 | Feb 25 | < 20.5 ft | 450 | 1,100 | 30,950 | 3,829 | 14 | 7.7% | 15.0% | 12.4% | 3.6E-05 |
| 2 | Feb 26 | Mar 14 | <20.5 ft | 335 | 352 | 12,284 | 2,564 | 8 | 18.4% | 23.7% | 20.7% | 3.7E-05 |
| 3 | Mar 15 | Mar 24 | 20.5 - 21 ft | 323 | 364 | 9,287 | 1,334 | 6 | 12.5% | 15.2% | 14.2% | 3.8E-05 |
| 4 | Mar 25 | May 15 | >21 ft | 369 | 533 | 27,851 | 3,011 | 17 | 8.0% | 12.9% | 10.5% | 1.4E-05 |

[1] Measured at hour of release.

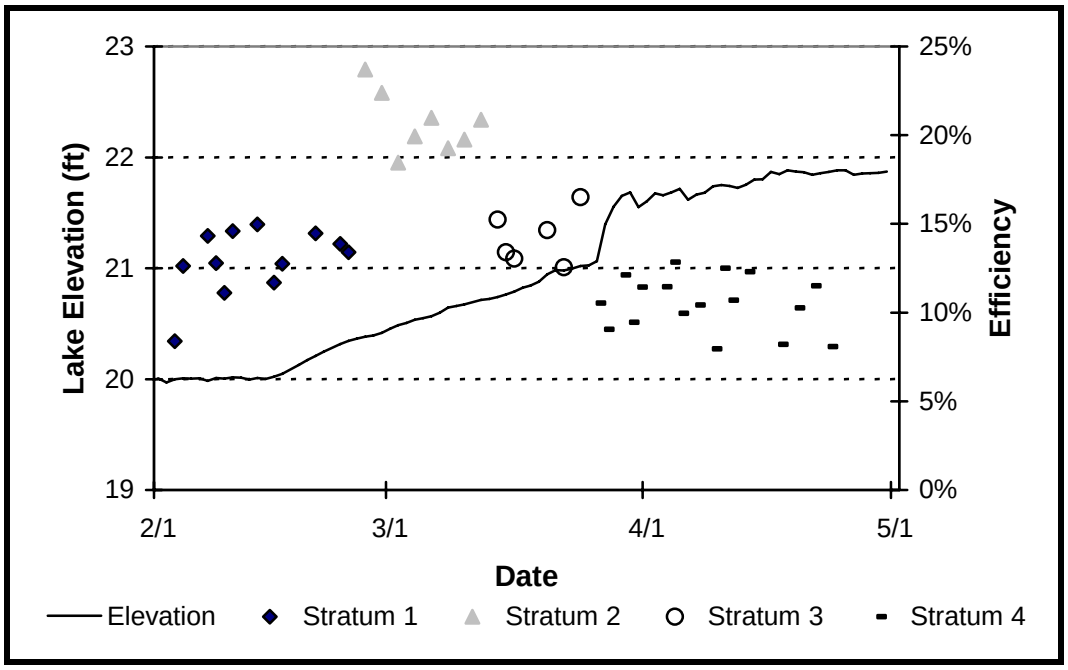



**Figure 2.** Stratified sockeye efficiency test groups related to provisional United States Army Corps of Engineers Lake Washington elevation data, 2005**.**

## Diel Migration

While the vast majority of sockeye fry migrate at night, daytime trapping indicated small numbers of fry migrating during daylight. Over the three dates that daylight intervals were trapped, the day to night catch rate ratios ranged from 0.38% to 1.04% (Table 3). The average day catch rate to night catch rate ratio (0.66%) was used to estimate daytime migrations.

**Table 3.** Day-to-night catch rate ratios of sockeye fry estimated using the night before and the night after the daytime interval, Cedar River fry trap, 2005.

| NIGHTTIME | | | | | DAYTIME | | | | DAY:NIGHT | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date Down | Time | Hours Fished | Catch | Catch/ Hour | Date Down | Time | Hours Fished | Catch | Catch/ Hour | Ratio (D/N) | Flow (cfs) |
| 02/07 | 17:00 | 14.00 | 38,174 | 2,726.7 | 02/08 | 7:00 | 10.00 | 246 | 24.60 | 1.04% | 457 |
| 02/08 | 17:00 | 14.00 | 28,057 | 2,004.1 | | | | | | | |
| | Sum | 28.00 | 66,231 | 2,365.4 | | | | | | | |
| 02/15 | 17:00 | 13.00 | 43,852 | 3,373.2 | 02/16 | 7:00 | 11.00 | 133 | 12.09 | 0.38% | 465 |
| 02/16 | 17:00 | 13.00 | 38,814 | 2,985.7 | | | | | | | |
| | | 26.00 | 82,666 | 3,179.5 | | | | | | | |
| 03/03 | 18:00 | 13.00 | 275,590 | 21,199.2 | 03/04 | 7:00 | 11.00 | 1058 | 96.18 | 0.56% | 341 |
| 03/05 | 18:00 | 13.00 | 174,314 | 13,408.8 | | | | | | | |
| | | 26.00 | 449,904 | 17,304.0 | | | | | | | |
| | | | | Average | | | | | | 0.66% | |
| | | | | Variance | | | | | | 3.9E-06 | |

## Production Estimate

An estimated 50.7 million sockeye fry entered Lake Washington from the Cedar River in 2005, (Table 4, Figure 3). The total included 37 million wild fry and 13.6 million hatchery-produced fry (Appendix A). Logarithmic extrapolation was used to estimate fry migration before trapping started, January 1 to January 20, which resulted in an additional 412,403 wild sockeye fry. Addition of this

estimate accounts for approximately 1.1% of the total wild estimate. Our estimated coefficient of variation (CV) for the wild migration of 3.3% was the third lowest measured since 1998. Therefore, while the reduced fishing schedule in 2005 affected the precision of the sockeye estimate, this effect was small. The low CV measured in 2005 was due to the lack of variability between nightly catches and within-stratum trap efficiency estimates.

**Table 4.** Estimated 2005 Cedar River wild and hatchery sockeye fry migrations entering Lake Washington with 95% confidence intervals.

| Component | Period (Release Location) | Dates | Estimated Migration | 95% CI | | CV | Prop. of Total |
|---|---|---|---|---|---|---|---|
| | | | | Low | High | | |
| Wild | Before Trapping | January 1 - 20 | 412,403 | 324,141 | 500,665 | 10.9% | 0.8% |
| | During Trapping | January 21 - May 15 | 36,615,558 | 34,967,953 | 38,922,205 | 3.3% | 72.3% |
| | | Subtotal | 37,027,961 | 34,657,170 | 39,398,752 | 3.3% | 73.1% |
| Hatchery | Landsburg | January 24 - February 22 | 2,029,787 | | | n/a | 4.0% |
| | Below Trap | February 3 - April 4 | 11,618,000 | | | n/a | 22.9% |
| | | Subtotal | 13,647,787 | | | | 26.9% |
| | | Total | 50,675,748 | | | | 100.0% |

## Wild and Hatchery Timing

Releases of hatchery-produced fry began on January 24 and continued through April 4 (Table 1). The median migration date for hatchery fry was February 1. The wild fry migration was under way when trapping began on January 21, peaked during early March, and declined through April to low levels in May when trapping stopped (Figure 3, Figure 4). Median migration dates for wild fry occurred on March 2, which is the earliest timing observed since monitoring began in 1992 (Table 5).

Stream temperatures influence the length of the incubation period. After evaluating temperature data throughout the period of fry incubation and migration, it appears February stream temperatures best explain observed variation in migration timing ($r^2 = 0.59$) (Figure 5). February stream temperatures averaged 6.9° C in 2005, higher than the past 12-year average (6.1° C). In addition, Cedar River water temperatures measured at Renton during the first two weeks of March peaked at 12.2° C. The 2001 fry migration was treated as an outlier due to extreme low flows that facilitated predation and an earthquake, which triggered a landslide that temporarily blocked flow and may have caused a significant mortality in the later-timed portion of the fry production.

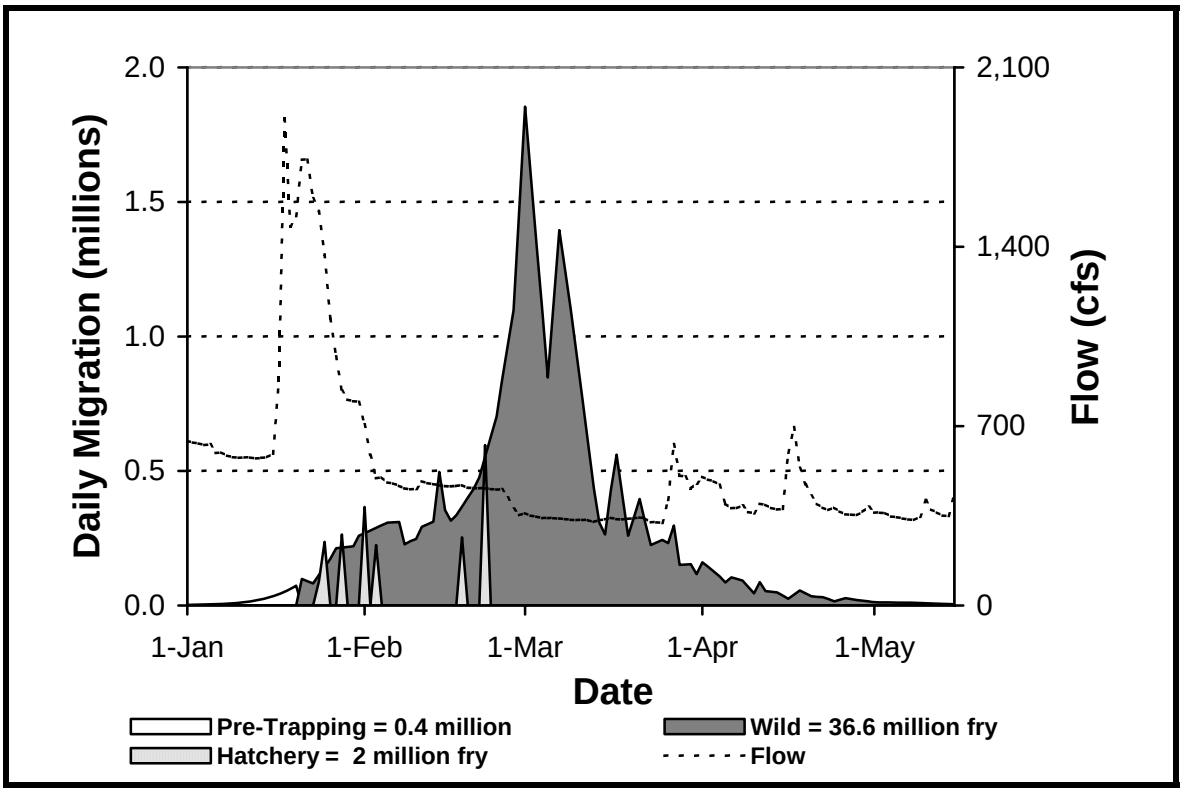



**Figure 3.** Estimated daily migration of wild and hatchery Cedar River sockeye fry into Lake Washington and daily average flow, 2005.

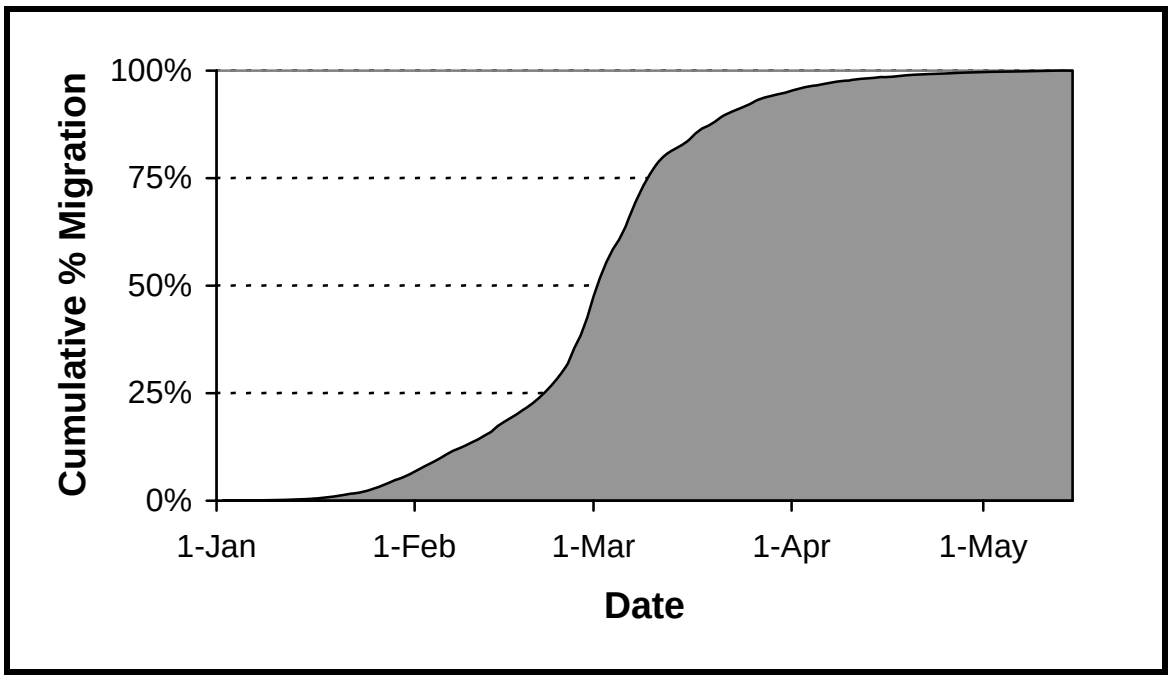



**Figure 4.** Cumulative wild sockeye fry migration timing, Cedar River 2005.

**Table 5.** Median migration dates of wild, hatchery, and total (combined) sockeye fry populations, Cedar River.

| Brood Year i | Trap Year i+1 | Median Migration Date Wild | Hatchery | Combined | Difference (days) W-H |
|---|---|---|---|---|---|
| 1991 | 1992 | 03/18 | 02/28 | 03/12 | 19 |
| 1992 | 1993 | 03/27 | 03/07 | 03/25 | 20 |
| 1993 | 1994 | 03/29 | 03/21 | 03/26 | 8 |
| 1994 | 1995 | 04/05 | 03/17 | 03/29 | 19 |
| 1995 | 1996 | 04/07 | 02/26 | 02/28 | 41 |
| 1996 | 1997 | 04/07 | 02/20 | 03/16 | 46 |
| 1997 | 1998 | 03/11 | 02/23 | 03/06 | 16 |
| 1998 | 1999 | 03/30 | 03/03 | 03/15 | 27 |
| 1999 | 2000 | 03/27 | 02/23 | 03/20 | 32 |
| 2000 | 2001 | 03/10 | 02/23 | 03/08 | 15 |
| 2001 | 2002 | 03/25 | 03/04 | 03/19 | 21 |
| 2002 | 2003 | 03/08 | 02/24 | 03/03 | 12 |
| 2003 | 2004 | 03/21 | 02/23 | 03/15 | 26 |
| 2004 | 2005 | 03/02 | 02/01 | 02/28 | 29 |
| | Average | 03/22 | 02/27 | 03/13 | 23 |

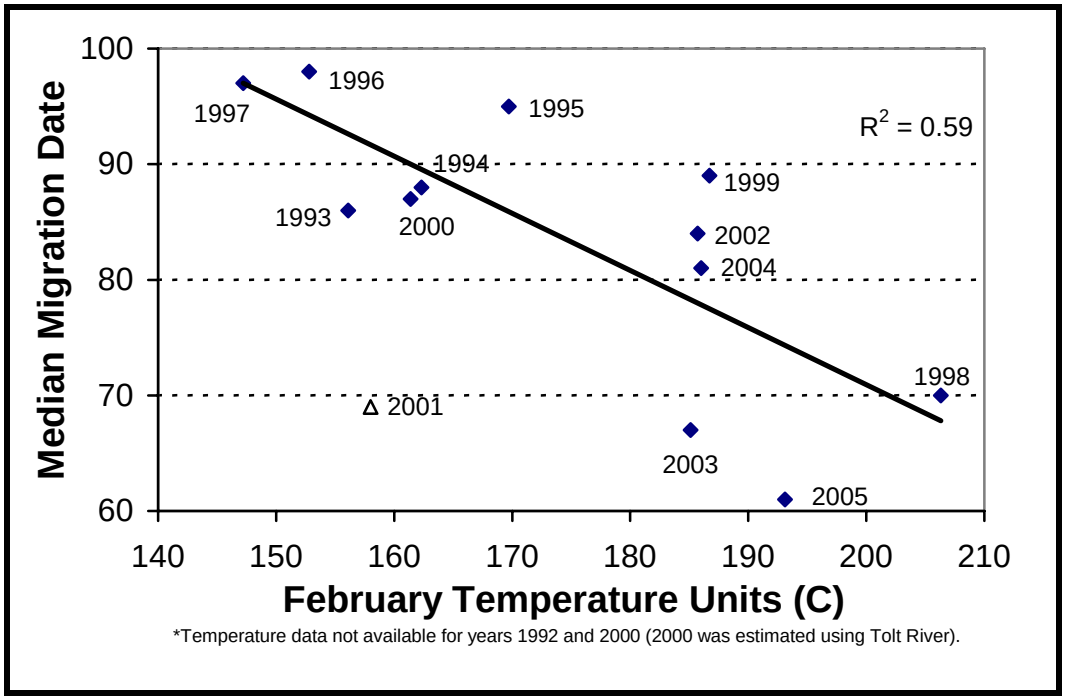



**Figure 5.** Linear regression of median migration Julian Calendar date for wild Cedar River sockeye fry as a function of the sum of daily average temperatures from February 1-28 (USGS Renton Gaging Station #12119000) for migration years 1993-2005, with 2001 as an outlier.

## Survival of Hatchery Release Groups

Survival rates estimated for the groups of fry released at Landsburg Hatchery ranged from 45% to 98%. Over these release groups, we estimated 66.3% of hatchery fry survived to pass the trap (Table 6). As in 2004, no otolith samples were collected at the trap and used to estimate the survival of hatchery release groups. Instead, survival of Landsburg releases were estimated using a regression-based model that correlated survival with stream discharge at release. The model used otolith estimated survival rates and flow data from 1995 and 2001 through 2003 trapping years. All but

three releases, those who's estimates were over 120%, were combined to predict survival based on daily average flow (Figure 6). Survival of hatchery releases below the trap were assumed to be 100%.

Confidence intervals and percent standard errors of these survival estimates were not estimated.

**Table 6.** In-river survival estimates of hatchery sockeye fry released from Landsburg Hatchery, Cedar River 2005.

| Release Date | Sockeye Released | Daily Avg. Flow | Estimated Daily Migration | Survival |
|---|---|---|---|---|
| 01/24 | 90,000 | 1,540 | 87,801 | 97.56% |
| 01/25 | 256,000 | 1,370 | 236,746 | 92.48% |
| 01/28 | 371,000 | 839 | 264,130 | 71.19% |
| 02/01 | 574,000 | 708 | 366,356 | 63.83% |
| 02/03 | 464,000 | 496 | 224,473 | 48.38% |
| 02/18 | 551,000 | 470 | 253,684 | 46.04% |
| 02/22 | 1,331,000 | 457 | 596,597 | 44.82% |
| Sum | 3,637,000 | | 2,029,787 | |
| Average | | | | 66.3% |

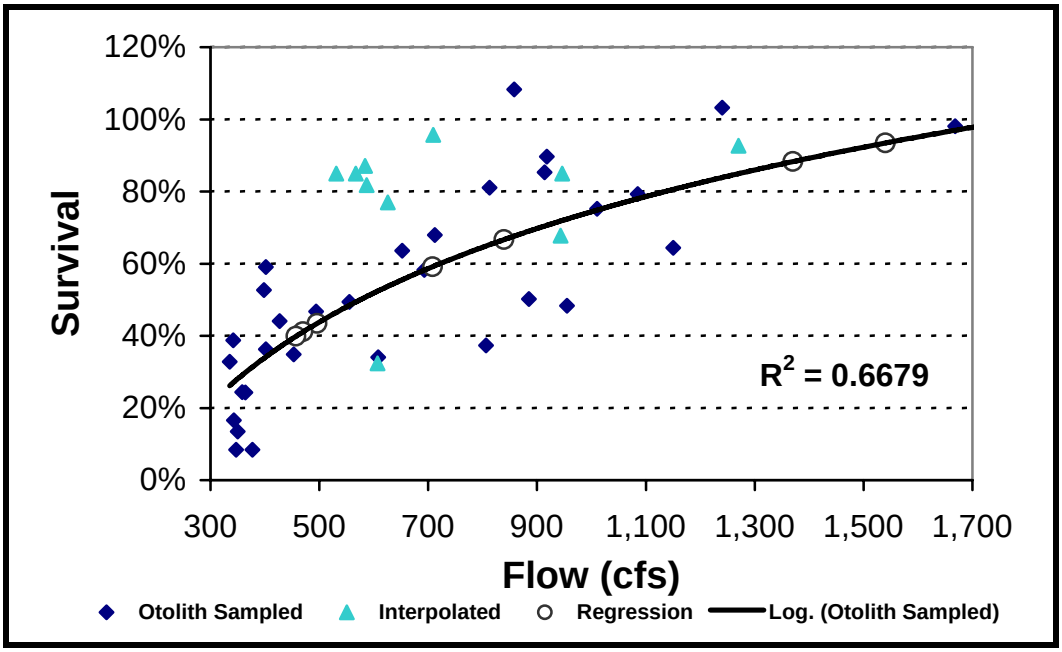



**Figure 6.** Survival of hatchery fry released from Landsburg as a function of daily mean flow using data collected from the Cedar River in 1995, and 2001 - 2003. Also shown are survival rates estimated in 2004 (interpolated) and in 2005 (regression).

## Egg-to-Migrant Survival of Naturally Produced Fry

The veracity of egg-to-migrant survival rates depends on the estimates of parent spawners and fry production. For the 1991 through 1998 broods, fry production estimates were related to potential egg deposition based on estimates of spawners generated with area under the curve (AUC) methodology. While analyzing egg-to-migrant survival for the 1999 brood, it appeared that the AUC based escapement of 22,000 sockeye may have underestimated escapement. Consequently, beginning with the 1999 brood and including previous broods through 1991, we generated Cedar River sockeye

spawning estimates with the number of sockeye passing through the Ballard Locks. This procedure involved subtracting the following estimates:

1. sockeye harvested in recreational and tribal fisheries,
2. sockeye estimated spawning on beaches and in all other tributaries,
3. pre-spawning mortality rate of 5%, and
4. sockeye removed from the Cedar River for brood stock.

In most years, the Locks based estimates were somewhat larger than the AUC. In 2004, this discrepancy was approximately 200,000 sockeye, nearly two times the AUC based estimate. Therefore, we elected to revert back to utilizing the AUC based estimates until another methodology produces a more accurate estimate. This decision results in shifting egg-to-migrant survivals somewhat higher than were estimated previously.

Overall egg-to-migrant survival of the 2004 brood sockeye was estimated at 19.3 %. This rate is the ratio of 37 million wild fry to an estimated potential egg deposition (PED) of 192 million eggs. This PED is based on a spawning escapement estimate of 116,978, an assumed even sex ratio and an average fecundity of 3,276 (Table 7). Of these three values, the estimate of fecundity may be the most accurate since it is the average number of eggs per female estimated during broodstock collection (Antipa pers. comm.).

Regressing the survival estimates on peak brood year incubation flow resulted in a correlation coefficient of 61% (Figure 7). The best fit for this data series was derived from fitting the data to an exponential equation ($y = ba^x$). This function generally describes an exponential decay in egg-to-migrant survival with increasing peak stream flow during the incubation period. As additional data are generated, we will continue to assess this model and others, to increase our understanding of the factors affecting natural sockeye fry production from the Cedar River.

**Table 7.** Estimated egg-to-migrant survival of naturally-produced sockeye fry (using the AUC method to estimate spawners) in the Cedar River relative to peak mean daily flows during the incubation period as measured at the USGS Renton gage, brood years 1991-2004.

| Brood Year | Spawners | Females (@50%) | Fecundity | PED | Fry Production | Survival Rate | Peak Incubation Flow (cfs) | Peak Incubation Flow Date |
|---|---|---|---|---|---|---|---|---|
| 1991 | 77,000 | 38,500 | 3,282 | 126,357,000 | 9,800,000 | 7.8% | 2,060 | 01/28/1992 |
| 1992 | 100,000 | 50,000 | 3,470 | 173,500,000 | 27,100,000 | 15.6% | 1,570 | 01/26/1993 |
| 1993 | 76,000 | 38,000 | 3,094 | 117,572,000 | 18,100,000 | 15.4% | 927 | 01/14/1994 |
| 1994 | 109,000 | 54,500 | 3,176 | 173,092,000 | 8,700,000 | 5.0% | 2,730 | 12/27/1994 |
| 1995 | 22,000 | 11,000 | 3,466 | 38,126,000 | 730,000 | 1.9% | 7,310 | 11/30/1995 |
| 1996 | 230,000 | 115,000 | 3,298 | 379,270,000 | 24,390,000 | 6.4% | 2,830 | 01/02/1997 |
| 1997 | 104,000 | 52,000 | 3,292 | 171,184,000 | 25,350,000 | 14.8% | 1,790 | 01/23/1998 |
| 1998 | 49,588 | 24,794 | 3,176 | 78,745,744 | 9,500,000 | 12.1% | 2,720 | 01/01/1999 |
| 1999 | 22,138 | 11,069 | 3,591 | 39,748,779 | 8,058,909 | 20.3% | 2,680 | 12/18/1999 |
| 2000 | 148,225 | 74,113 | 3,451 | 255,762,238 | 38,447,878 | 15.0% | 627 | 01/05/2001 |
| 2001 | 119,000 | 59,500 | 3,568 | 212,296,000 | 31,673,029 | 14.9% | 1,930 | 11/23/2001 |
| 2002 | 194,640 | 97,320 | 3,395 | 330,401,400 | 27,859,466 | 8.4% | 1,410 | 02/04/2003 |
| 2003 | 110,404 | 55,202 | 3,412 | 188,349,224 | 38,686,899 | 20.5% | 2,039 | 01/30/2004 |
| 2004 | 116,978 | 58,489 | 3,276 | 191,609,964 | 37,027,961 | 19.3% | 1,900 | 01/18/2005 |

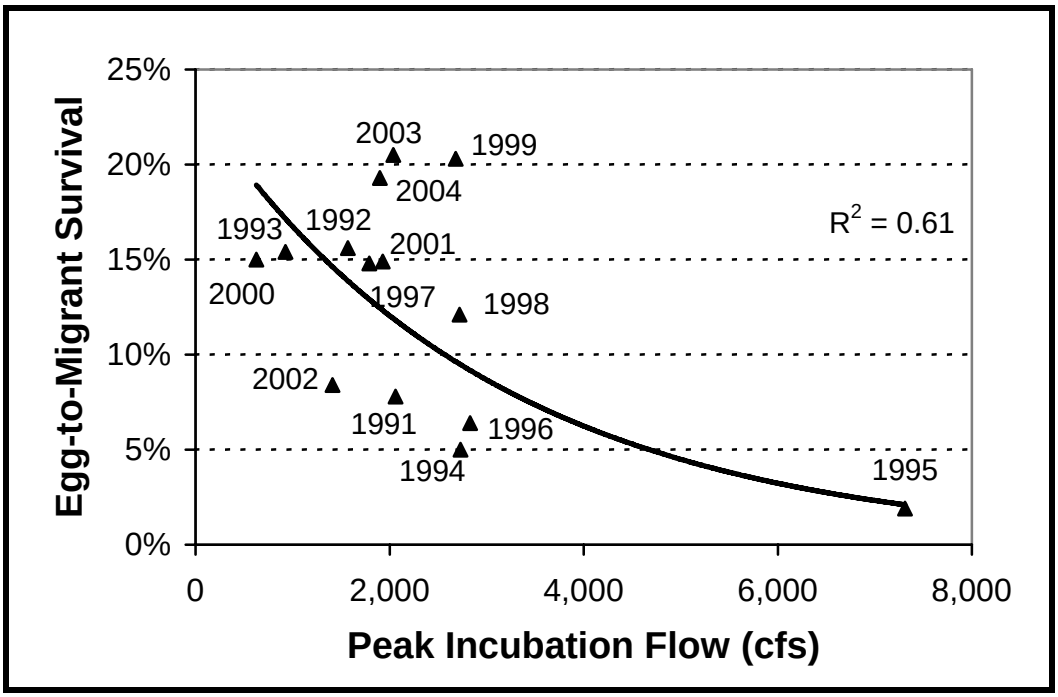



**Figure 7.** Exponential regression of wild sockeye egg-to-migrant survival from brood years 1991 to 2004 as a function of peak flow during the winter egg incubation period, Cedar River.

# *Chinook*

## Catch

### *Fry Trap*

On the first night of fry trap operation (January 21), 51 chinook fry were caught. Nightly catches peaked at 662 fry on February 14. Through February, a total of 4,147 chinook fry were caught during the 22 nights fished, 90% of the season total catch. During the 38 nights fished, from March 1 through May 15, only 449 juvenile chinook were caught. Three daytime intervals were fished throughout the season. Day to night catch rate ratios ranged from 7% to 12% (Table 8). Over the season, a total of 4,640 chinook were captured in the fry trap.

### *Screw Trap*

Over the 109-day interval that the screw trap was operated (April 11 through July 28), 4,267 unmarked wild and 257 hatchery adipose-marked chinook were caught. From the first night of trapping to April 30, nightly catches ranged from zero to 180 chinook and comprised 14% of the total wild chinook catch. During May and June, 3,580 wild chinook smolts, 84% of the season total, were caught. Nightly catch peaked on May 9 with 223 chinook smolts caught.

**Table 8.** Day to night catch rate ratios of chinook fry estimated at the Cedar River fry trap, 2005.

| Nighttime | | | | | Daytime | | | | | D:N | Flow |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Start Date | Time | Hours | Catch | Catch/Hr | Start Date | Time | Hours | Catch | Catch/Hr | Ratio | (cfs) |
| 02/07 | 17:00 | 14.00 | 205 | 14.6 | 02/08 | 7:00 | 10.00 | 14 | 1.40 | 12.10% | 457 |
| 02/08 | 17:00 | 14.00 | 119 | 8.5 | | | | | | | |
| | Sum | 28.00 | 324 | 11.6 | | | | | | | |
| 02/15 | 17:00 | 13.00 | 571 | 43.9 | 02/16 | 7:00 | 11.00 | 25 | 2.27 | 6.85% | 465 |
| 02/16 | 17:00 | 13.00 | 292 | 22.5 | | | | | | | |
| | | 26.00 | 863 | 33.2 | | | | | | | |
| 03/03 | 18:00 | 13.00 | 84 | 6.5 | 03/04 | 7:00 | 11.00 | 5 | 0.45 | 12.44% | 341 |
| 03/05 | 18:00 | 13.00 | 11 | 0.8 | | | | | | | |
| | | 26.00 | 95 | 3.7 | | | | | | | |
| Average | | | | | | | | | | 10.55% | |
| Variance | | | | | | | | | | 3.0E-04 | |

## Catch Expansion

### *Fry Trap*

An estimate was made for the number of chinook that may have been caught for the day and night periods not fished. Daytime migration was estimated by using the average (10.6%) ratio of day/night catch rates measured during operation of the fry trap. Due to high flows and large catches of sockeye fry, partial catches were expanded on 14 nights. Had the trap fished continuously (day and night) from January 21 through May 15, we estimate an additional 4,403 fry would have been caught. With the addition of these fish to the actual catches, season catch total is projected at 9,043 chinook in the fry trap (Appendix B).

### *Screw Trap*

Catch data was expanded to estimate the numbers of chinook smolts that would have been caught in the screw trap had it fished continuously from the evening of April 11 through the morning of July 29 (Appendix B). Expansion resulted in the addition of 156 chinook to the wild catch. This increase represented 3.5% of the total catch estimate. The catch expansion includes daytime and nighttime migration estimates when the trap did not fish, and five trapping intervals when the screw trap was stopped by debris. Daytime migrations during June and July were estimated using the average of day catch rate to night catch rate ratios measured during May (1.4%).

## Size

From January through March, the weekly mean fork lengths of chinook fry caught in the fry trap increased 7.5 mm from 39.2 mm to 46.7 mm, and averaged 42 mm (Table 9, Figure 8). The weekly average increased to over 60 mm by early April. The smallest chinook fry captured each week was consistently less than 40mm through March, but increased afterwards indicating the end of the incubation period.

Chinook caught in the screw trap increased in size from a weekly average fork length of 61.9 mm in mid-April to 116 mm near the end of trapping (Table 9, Figure 8). Over the season, sizes ranged from 42 mm to 138 mm and averaged 95.7 mm.

**Table 9.** Mean chinook fork length (mm), standard deviation, range, sample size, and catches in the Cedar River fry and screw traps, 2005.

| Statistical Week | | | FRY TRAP | | | | | | SCREW TRAP | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Begin | End | No. | Avg. | s.d. | Range Min | Range Max | n | Catch | Avg. | s.d. | Range Min | Range Max | n | Catch |
| 01/17 | 01/23 | 4 | 39.2 | 1.47 | 36 | 41 | 28 | 95 | | | | | | |
| 01/24 | 01/30 | 5 | 39.8 | 1.55 | 36 | 42 | 26 | 381 | | | | | | |
| 01/31 | 02/06 | 6 | 39.6 | 1.46 | 37 | 43 | 57 | 226 | | | | | | |
| 02/07 | 02/13 | 7 | 40.4 | 1.83 | 36 | 44 | 45 | 967 | | | | | | |
| 02/14 | 02/20 | 8 | 41.3 | 2.82 | 37 | 50 | 47 | 2,051 | | | | | | |
| 02/21 | 02/27 | 9 | 40.7 | 2.32 | 37 | 48 | 35 | 466 | | | | | | |
| 02/28 | 03/06 | 10 | 42.9 | 4.03 | 38 | 53 | 20 | 47 | | | | | | |
| 03/07 | 03/13 | 11 | 43.9 | 6.50 | 38 | 61 | 22 | 95 | | | | | | |
| 03/14 | 03/20 | 12 | 49.1 | 15.32 | 39 | 110 | 24 | 49 | | | | | | |
| 03/21 | 03/27 | 13 | 46.7 | 8.46 | 38 | 65 | 47 | 157 | | | | | | |
| 03/28 | 04/03 | 14 | 57.5 | 10.38 | 41 | 74 | 17 | 23 | | | | | | |
| 04/04 | 04/10 | 15 | 61.5 | 5.61 | 50 | 69 | 11 | 15 | | | | | | |
| 04/11 | 04/17 | 16 | 57.7 | 5.70 | 47 | 75 | 27 | 51 | 61.9 | 8.10 | 48 | 79 | 72 | 333 |
| 04/18 | 04/24 | 17 | 59.5 | 6.70 | 51 | 70 | 8 | 8 | 69.5 | 8.94 | 42 | 85 | 46 | 65 |
| 04/25 | 05/01 | 18 | | | | | 0 | 2 | 77.6 | 9.24 | 56 | 94 | 58 | 271 |
| 05/02 | 05/08 | 19 | 76.0 | | | | 1 | 1 | 84.3 | 6.60 | 68 | 101 | 325 | 692 |
| 05/09 | 05/15 | 20 | 72.0 | | | | 1 | 6 | 84.9 | 5.90 | 67 | 106 | 503 | 717 |
| 05/16 | 05/22 | 21 | | | | | | | 86.1 | 7.30 | 71 | 111 | 186 | 481 |
| 05/23 | 05/29 | 22 | | | | | | | 92.8 | 6.90 | 73 | 108 | 328 | 400 |
| 05/30 | 06/05 | 23 | | | | | | | 95.5 | 6.20 | 75 | 114 | 320 | 491 |
| 06/06 | 06/12 | 24 | | | | | | | 97.4 | 7.30 | 80 | 138 | 235 | 483 |
| 06/13 | 06/19 | 25 | | | | | | | 96.5 | 6.30 | 80 | 110 | 48 | 281 |
| 06/20 | 06/26 | 26 | | | | | | | 100.6 | 6.20 | 88 | 119 | 88 | 176 |
| 06/27 | 07/03 | 27 | | | | | | | 104.6 | 8.40 | 90 | 138 | 33 | 72 |
| 07/04 | 07/10 | 28 | | | | | | | 106.9 | 4.20 | 101 | 114 | 10 | 38 |
| 07/11 | 07/17 | 29 | | | | | | | 97.5 | 14.50 | 84 | 118 | 4 | 19 |
| 07/18 | 07/24 | 30 | | | | | | | 116.0 | 6.40 | 107 | 122 | 4 | 5 |
| Season Totals | | | 44.7 | 9.00 | 36 | 110 | 416 | 4,640 | 95.7 | 10.80 | 42 | 138 | 2,260 | 4,524 |

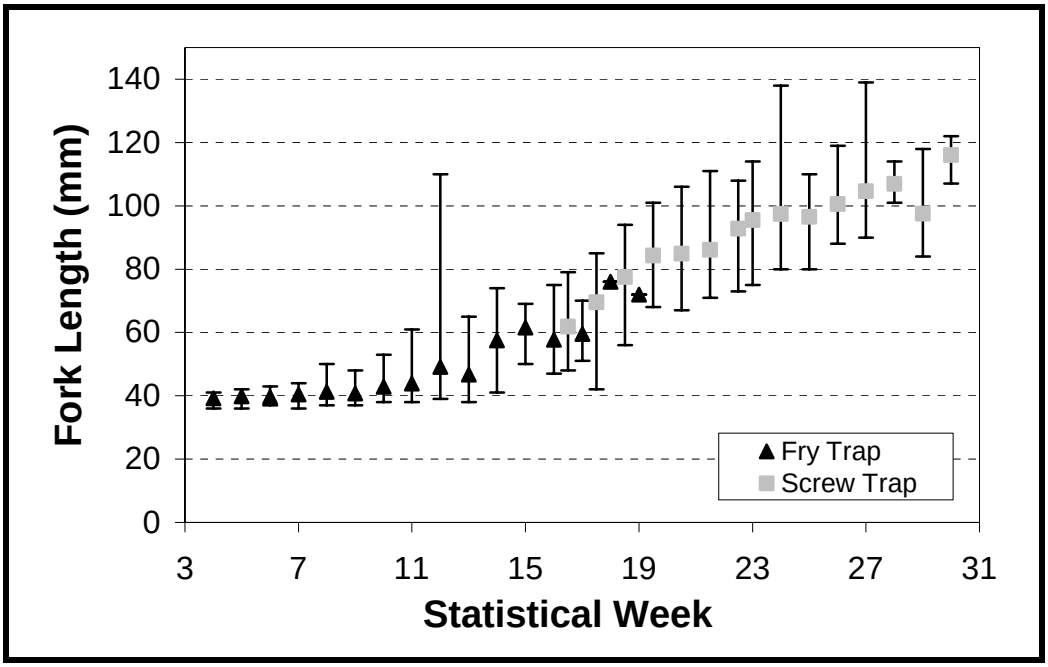



**Figure 8.** Average and range of fork lengths of chinook sampled from the Cedar River, 2005.

## Trap Efficiency

### *Fry Trap*

Capture rates for chinook fry were assumed to be equivalent to that of marked sockeye fry released upstream of the trap. We believe that the combination of decreasing flows and rising lake elevation resulted in the lower capture rates. Therefore, we applied the same strata to chinook as was used with the sockeye fry trap efficiency (Table 2).

### *Screw Trap*

Capture rates of chinook in the screw trap were estimated by releasing 24 mark-recapture groups between April 17 and July 4. Capture rates ranged from 0% to 28%, and release group sizes ranged from 16 to 100 chinook. Hourly flows during releases ranged from 240 to 696 cfs, and did not significantly explain the variation among individual trap efficiency tests. Trap efficiency tests were grouped by statistical week due to small sizes of some release groups and low recapture numbers. Weeks with only one efficiency test were grouped with previous or following weeks to create a larger group (Table 10). Chapman's modification of the Peterson estimate was used to estimate migration.

**Table 10.** Estimated chinook smolt recapture rates from grouped screw trap efficiency tests, Cedar River 2005.

| Statistical Week | Average Flow (cfs) | NUMBER Released | NUMBER Recaptured | Recapture Rate | Catch | Peterson Estimate | Variance |
|---|---|---|---|---|---|---|---|
| 16 | 696 | 100 | 10 | 10.0% | 333 | 3,066 | 1.29E+06 |
| 17, 18 | 362 | 50 | 7 | 14.0% | 336 | 2,147 | 9.92E+05 |
| 19 | 335 | 150 | 22 | 14.7% | 692 | 4,549 | 1.11E+07 |
| 20 | 351 | 49 | 9 | 18.4% | 717 | 3,589 | 5.58E+06 |
| 21 | 523 | 243 | 35 | 14.4% | 507 | 3,442 | 8.84E+06 |
| 22 | 358 | 164 | 18 | 11.0% | 401 | 3,490 | 3.06E+06 |
| 23 | 330 | 91 | 4 | 4.4% | 558 | 10,285 | 1.85E+06 |
| 24 | 315 | 210 | 4 | 1.9% | 450 | 19,031 | 1.20E+06 |
| 25 | 299 | 89 | 2 | 2.2% | 188 | 5,669 | 1.39E+05 |
| 26-31 | 266 | 75 | 2 | 2.7% | 241 | 6,130 | 2.29E+05 |
| Total | | 1,221 | 113 | | 4,423 | 61,397 | |
| Average | | | | 9.4% | | | |
| Variance | | | | | | | 3.43E+07 |

## Production Estimate

The fry trap and screw trap ran concurrently between April 11 and May 15, which provided independent daily estimates of chinook migration. Daily estimates from each trap were summed by week and tested for equality using a Z-test. Differences were significant in three of the five weeks tested ($\alpha = 0.05$) (Table 11). After week 17, weekly migration estimates based on fry trapping declined to low levels relative to screw trap-based estimates. Over the same period, weekly migrations estimated with the screw trap increased with the exception of just one week. As chinook grew in April, larger chinook were able to avoid the fry trap. Therefore, we used the screw trap estimates from April 11 through the end of the migration.

Combining the chinook production estimated from the fry trap for January 21 through April 10, with the estimate from the screw trap for April 11 through July 29, yielded a total migration over this interval of 129,471 age 0+ chinook (Table 12, Figure 9, Appendix B). Migration prior to fry trap

operation was estimated by logarithmic extrapolation from January 1 to 20, adding 5,132 migrants for a total migration of 134,603 chinook.

**Table 11.** Independent weekly estimates of chinook migration, $N_w$, from the fry and screw traps with results from a Z-test comparison of the weekly estimates, Cedar River 2005**.**

| Statistical Week | | | Fry Trap | | Screw Trap | | Significant Difference? (Yes/No) |
|---|---|---|---|---|---|---|---|
| Begin | End | Number | Estimated Migration ($N_w$) | $V(N_w)$ | Estimated Migration ($N_w$) | $V(N_w)$ | |
| 04/11 | 04/17 | 16 | 1,027 | 15,533 | 3,066 | 327,980 | No |
| 04/18 | 04/24 | 17 | 134 | 1,189 | 415 | 3,305 | No |
| 04/25 | 05/01 | 18 | 39 | 57 | 1,732 | 36,198 | Yes |
| 05/02 | 05/08 | 19 | 70 | 0 | 4,549 | 70,680 | Yes |
| 05/09 | 05/15 | 20 | 211 | 340 | 3,589 | 175,055 | Yes |

**Table 12.** 2005 Cedar River juvenile chinook production estimate and confidence intervals.

| Gear | Period | Estimated | | 95% CI | | CV |
|---|---|---|---|---|---|---|
| | | Catch | Migration | Low | High | |
| Pre-Trapping | January 1 - 20 | | 5,132 | 556 | 9,708 | 45.5% |
| Fry Trap | January 21- April 10 | 8,888 | 68,074 | 39,016 | 97,132 | 21.8% |
| Screw Trap | April 11 - July 29 | 4,423 | 61,397 | 42,921 | 72,874 | 9.5% |
| | Season Total | 13,311 | 134,603 | 91,691 | 177,515 | 16.3% |

As in the previous five seasons, emigration timing was clearly bi-modal (Figure 9). We estimate that the migration was 25%, 50%, and 75% complete by February 12, March 10, and June 3, respectively (Figure 10). Juvenile chinook emigrated in nearly equal proportions of fry and smolts during the 2004 brood out-migration. Relative to the patterns observed over the previous five broods, the 2004 brood fry to smolt ratio is similar to 2003, with a larger smolt portion than most other years (Table 13). This timing pattern of nearly equal smolt and fry proportions may be a result of density and flows during the rearing period. Brood year 2000 was notable because it experienced extremely low stable flows throughout the winter and also had the lowest number of parent spawners.

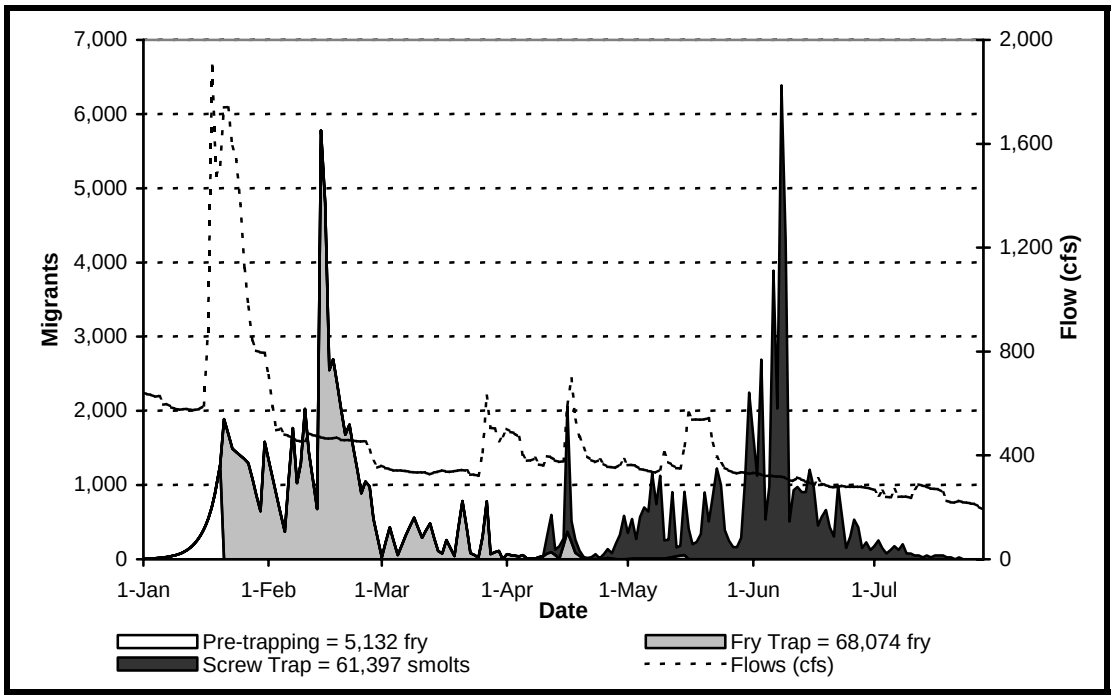



**Figure 9.** Estimated daily Cedar River chinook migration from fry and screw trap estimates and flow (USGS Renton Gage), 2005.

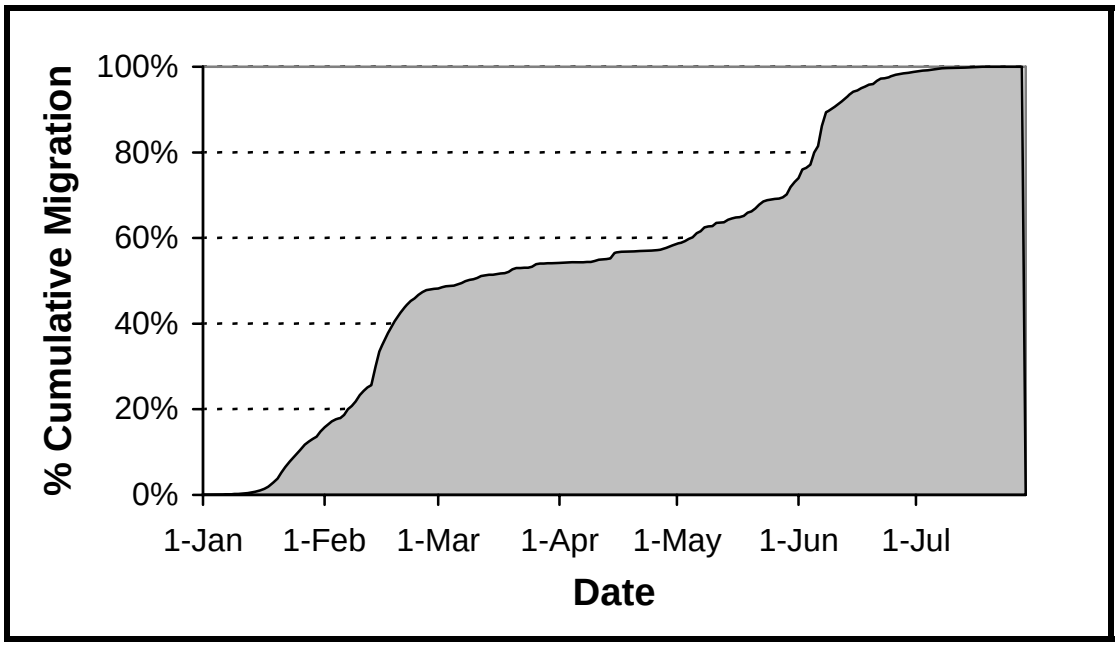



**Figure 10.** Cumulative percent migration of age 0+ chinook, Cedar River 2005.

**Table 13.** Comparison of fry and smolt components between brood years for wild chinook production, standardized by assuming a January 1 to July 13 migration period, Cedar River broods 1998 to 2004.

| Brood Year | Migration | | | % Migration | |
|---|---|---|---|---|---|
| | Fry Jan 1-Apr 15 | Smolt Apr 16-Jul 13 | Total Jan 1-Jul 13 | Fry Jan 1-Apr 15 | Smolt Apr 16-Jul 13 |
| 1998 | 67,293 | 12,811 | 80,104 | 84% | 16% |
| 1999 | 45,906 | 18,817 | 64,723 | 71% | 29% |
| 2000 | 10,994 | 21,157 | 32,151 | 34% | 66% |
| 2001 | 79,813 | 39,326 | 119,139 | 67% | 33% |
| 2002 | 194,135 | 41,262 | 235,397 | 82% | 18% |
| 2003 | 65,875 | 54,929 | 120,804 | 55% | 45% |
| 2004 | 74,292 | 60,569 | 134,861 | 55% | 45% |

## Egg-to-Migrant Survival

Relating juvenile chinook production from the Cedar River to estimates of annual egg deposition yields brood year egg-to-migrant survival rates. For the 2004 brood, the wild chinook egg-to-migrant survival rate was estimated at 5.9% based on an escapement of 511 females (Burton *et al.* 2005) and an assumed fecundity of 4,500 eggs per female. Although the 2004 brood had the largest number of spawners, it produced the lowest survival rate in the seven-year data set (Table 14). Following an anomalous winter with very little snowfall in the watershed, flows during winter through spring 2005 were notably low and stable. Continued monitoring and subsequent analysis will identify and quantify the importance of factors such as flow and spawner density on fresh water chinook production.

**Table 14.** Wild age 0+ chinook egg-to-migrant survival estimates for brood years 1998-2004, Cedar River.

| Brood Year | Estimated Migration | Est. Females | Potential Egg Deposition | Production/ Female | Survival Rates |
|---|---|---|---|---|---|
| 1998 | 80,932 | 173 | 778,500 | 468 | 10.4% |
| 1999 | 64,723 | 180 | 810,000 | 360 | 8.0% |
| 2000 | 32,249 | 53 | 238,500 | 608 | 13.5% |
| 2001 | 119,674 | 398 | 1,791,000 | 301 | 6.7% |
| 2002 | 235,397 | 281 | 1,264,500 | 838 | 18.6% |
| 2003 | 120,876 | 337 | 1,516,500 | 359 | 8.0% |
| 2004 | 134,604 | 511 | 2,299,500 | 263 | 5.9% |

# *Coho*

## Catch

A total of 2,899 wild coho smolts were caught in the screw trap between April 11 and July 29. Approximately 74% of the catch occurred during May. Catch distribution was uni-modal with the peak catch of 174 smolts occurring on May 15.

## Catch Expansion

Expansion of the actual catch to represent the number of coho that would have been caught if the screw trap had fished continuously resulted in the addition of only 29 coho. This addition represented less than 1% of the catch. These expansions account for additions made for three fishing

intervals when debris stopped the screw from turning (screw stoppers). Although two other screw stoppers occurred, catch was not expanded on those dates due to catches of zero for previous and following intervals.

## Size

Over the season, weekly coho smolt fork lengths averaged 110 mm and ranged from 84 mm to 158 mm (Figure 11, Table 15). There was little variation in weekly mean size over the season.

**Table 15.** Weekly mean fork length (mm), standard deviation, range, sample size and catches for coho smolts from the Cedar River screw trap, 2005.

| Statistical Week | | | Avg. | s.d. | Range | | n | Catch |
|---|---|---|---|---|---|---|---|---|
| Begin | End | No. | | | Min | Max | | |
| 04/11 | 04/17 | 16 | 112.5 | 12.1 | 92.0 | 145 | 52 | 201 |
| 04/18 | 04/24 | 17 | 112.5 | 11.3 | 90.0 | 158 | 65 | 112 |
| 04/25 | 05/01 | 18 | 111.8 | 9.9 | 91.0 | 139 | 66 | 443 |
| 05/02 | 05/08 | 19 | 112.5 | 10.2 | 84.0 | 157 | 498 | 748 |
| 05/09 | 05/15 | 20 | 108.7 | 8.9 | 85.0 | 114 | 400 | 701 |
| 05/16 | 05/22 | 21 | 105.8 | 9.1 | 84.0 | 128 | 215 | 369 |
| 05/23 | 05/29 | 22 | 111.9 | 10.5 | 87.0 | 138 | 84 | 192 |
| 05/30 | 06/05 | 23 | 109.1 | 8.0 | 93.0 | 126 | 38 | 76 |
| 06/06 | 06/12 | 24 | 112.6 | 11.1 | 101.0 | 142 | 12 | 42 |
| 06/13 | 07/31 | 25-31 | | | | | | 15 |
| Season Totals | | | 110.0 | 9.9 | 84 | 158 | 1,430 | 2,899 |

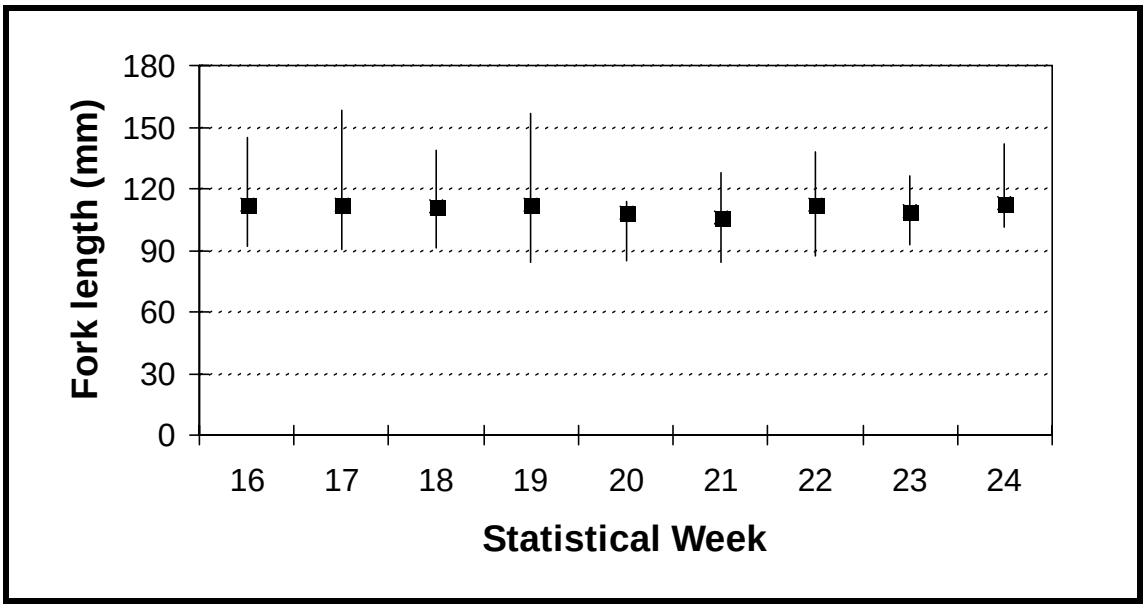



**Figure 11.** Weekly ranges and mean fork lengths for coho smolts captured in the Cedar River screw trap, 2005.

## Trap Efficiency

Thirteen mark-recapture tests were conducted to measure trap efficiency for coho. Recapture rates for individual release groups ranged from 0% to 8.8% (Table 16). No environmental or flow effects

explained the observed variation in efficiency. Therefore, the average rate (4.1%) was used to estimate daily migration and season production.

**Table 16.** Estimated coho smolt recapture rates from screw trap efficiency tests, Cedar River 2005.

| Date(s) | Flow(s) (cfs) | NUMBER Released | Recaptured | Recapture Rate | Variance |
|---|---|---|---|---|---|
| 4/17 | 696 | 101 | 3 | 3.0% | 2.9E-04 |
| 4/28 | 352 | 35 | 1 | 2.9% | 7.9E-04 |
| 4/29 | 366 | 60 | 1 | 1.7% | 2.7E-04 |
| 5/01 | 362 | 100 | 4 | 4.0% | 3.8E-04 |
| 5/07 | 336 | 50 | 2 | 4.0% | 7.7E-04 |
| 5/08 | 334 | 100 | 4 | 4.0% | 3.8E-04 |
| 5/11 | 375 | 100 | 0 | 0.0% | 0.0E+00 |
| 5/14 | 350 | 34 | 3 | 8.8% | 2.4E-03 |
| 5/16 | 563 | 50 | 4 | 8.0% | 1.5E-03 |
| 5/17 | 537 | 50 | 4 | 8.0% | 1.5E-03 |
| 5/21 | 543 | 100 | 1 | 1.0% | 9.9E-05 |
| 5/27 | 335 | 37 | 3 | 8.1% | 2.0E-03 |
| 5/29 | 335 | 65 | 0 | 0.0% | 0.0E+00 |
| Total | | 882 | 30 | | |
| Average | | | | 4.11% | |
| Variance | | | | 7.74E-05 | |
| n | | | | 13 | |

## Production Estimate

Coho production was estimated at 71,247 smolts during the trapping season. Using linear extrapolation to a starting migration date of April 1, an estimated 1,396 additional smolts migrated before trapping began on April 11. Total coho production was estimated at 72,643 smolts with a coefficient of variation of 21.4% and a 95% confidence interval of 42,725 to 102,561 smolts (Figure 12, Appendix B).

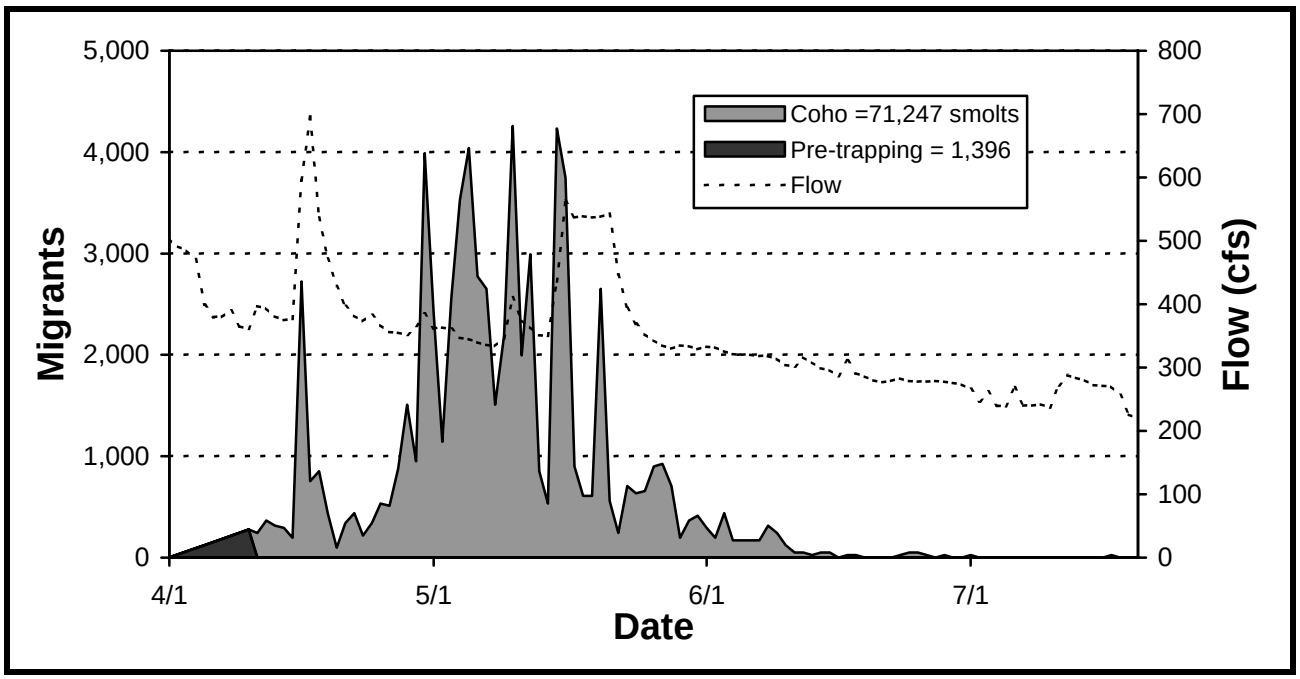



**Figure 12.** Estimate of daily coho smolt migration and daily average flow, Cedar River screw trap 2005.

# *Trout*

## DNA and Scale Analysis

Over the season, 50 juvenile cutthroat samples were collected for DNA analysis. Only one sample was collected during fry trap operation and 49 during screw trap operation in April and May. These samples were collected and analyzed to assess the accuracy of species identification and increase the genetic baseline. Thirty-five scale samples were collected from the cutthroat sampled for DNA. Scale analysis indicated that ages 1+, 2+, and 3+ trout were captured in the traps. Fork lengths ranged from 127 mm to 237 mm (Table 17), and varied considerably within and between age classes. Fork lengths between the three age groups were found to be significantly different ($\alpha = 0.05$) using single classification analysis of variance. Tukey's pairwise comparison was used to evaluate fork length differences between individual age classes. Fork lengths from age 1 and 2 trout were found to be significantly different from age 3 fork lengths ($\alpha = 0.05$), but not from each other.

Genotypic identification indicated our ability to identify cutthroat trout was fairly accurate (88%). The six trout that were incorrectly identified as cutthroat were actually *Oncorhynchus mykiss/Oncorhynchus clarki* hybrids (Marshall et al., *in prep*). These hybrids ranged in size from 124 mm to 182 mm and were age 2+ or 3+ fish.

**Table 17.** Size and age of cutthroat sampled for DNA, Cedar River 2005**.**

| Age | n | Length Range (mm) Min | Max | Average |
|---|---|---|---|---|
| 1 | 5 | 142 | 152 | 145.8 |
| 2 | 19[a] | 127 | 195 | 156.6 |
| 3 | 11[b] | 157 | 237 | 192.9 |
| Total | 35 | 127 | 237 | 163 |

Note: 15 of the cutthroat sampled for DNA were not sampled for scales .

[a] Includes two hybrids.

[b] Includes one hybrid.

The variety of life history strategies used by trout in the Cedar River may include anadromous, ad-fluvial, and resident forms. For simplicity, the catches and estimates reported herein are for trout that were visually identified in the field as either cutthroat or steelhead. We acknowledge that cutthroat-rainbow hybrids are included in the reported cutthroat numbers. Furthermore, we are uncertain whether the reported steelhead were truly the anadromous life-form; yet we reported these separately from the resident rainbows described in the Incidental Catch section, below, since they appeared smolted.

## Catch

Beginning in mid April and lasting through the end of May, 27 steelhead migrants were trapped sporadically.

A total of 86 cutthroat trout were captured in the screw trap between April 11 and July 28. Due to the low catches, there was no definable timing pattern. Only one cutthroat was estimated to have migrated past the trap during intervals when debris stopped the screw.

## Size

Steelhead fork lengths ranged from 132 to 205 mm, and averaged 176.5 mm. Cutthroat trout fork lengths averaged 161.9 mm, and ranged from 106 to 237 mm throughout the trapping season (Table 18).

## Trap Efficiency

Because catches of steelhead and cutthroat migrants were too low on any one day to mark a group for calibrating the trap, estimates of trap efficiency for these species were approximated from other studies.

During evaluation of downstream migrant passage in the Toutle, Green, and White Salmon Rivers, we captured steelhead smolts at rates that were 79%, 54%, and 47%, respectively, of the rates that marked coho were recaptured (Seiler and Neuhauser 1985, Seiler *et al.* 1992). The average of these rates (60%) indicates a steelhead-to-coho capture rate. Applying this rate to our average coho smolt catch rate (4.1%) estimates a steelhead capture rate in the Cedar River screw trap of 2.5%. Although the trapping operations on the Toutle, Green, and White Salmon Rivers employed scoop traps, from which steelhead can more easily escape, Bear Creek screw trap data corroborates the 60% rate. In 2004, the capture rates in Bear Creek for coho and cutthroat averaged 43.2% and 25.6%, resulting in a cutthroat-to-coho capture rate of 59%. As cutthroat migrants in the Cedar River averaged 161.9 mm, similar in size to steelhead migrants, we consider them an acceptable surrogate.

**Table 18.** Weekly mean cutthroat fork length (mm), standard deviation, range, sample size and catches, Cedar River screw trap 2005.

| Statistical Week | | | Avg. | s.d. | Range | | n | Catch |
|---|---|---|---|---|---|---|---|---|
| Begin | End | No. | | | Min | Max | | |
| 04/11 | 04/17 | 16 | 162.3 | 28.8 | 106 | 237 | 23 | 29 |
| 04/18 | 04/24 | 17 | 144.9 | 13.3 | 127 | 167 | 8 | 6 |
| 04/25 | 05/01 | 18 | 165.0 | 31.4 | 143 | 201 | 3 | 3 |
| 05/02 | 05/08 | 19 | 155.3 | 18.1 | 134 | 181 | 6 | 6 |
| 05/09 | 05/15 | 20 | 163.8 | 16.0 | 143 | 184 | 6 | 4 |
| 05/16 | 05/22 | 21 | | | | | | 1 |
| 05/23 | 05/29 | 22 | 197.3 | 27.4 | 181 | 229 | 3 | 4 |
| 05/30 | 06/05 | 23 | 184.0 | 4.2 | 181 | 187 | 2 | 4 |
| 06/06 | 06/12 | 24 | 169.0 | 1.4 | 168 | 170 | 2 | 6 |
| 06/13 | 07/31 | 25-31 | | | | | | 23 |
| Season Total | | | 161.9 | 25.2 | 106 | 237 | 53 | 86 |

## Production Estimate

Application of a capture rate of 2.5% to the catch of 27 steelhead estimates a total migration of 1,098 migrants. Applying this rate to the expanded catch of 87 cutthroat estimates the total cutthroat migration during the trapping period at 3,537 cutthroat (Appendix B). No confidence intervals were developed for these estimates, which apply only to the period of screw trap operation (April 11 through July 29). While cutthroat migration likely occurred before and after this interval, no migration timing trends were evident from the catch data, which would help to define the start or end of this migration. Therefore, there was no expansion of the cutthroat estimate beyond the trapping period. The estimate of cutthroat migration during the trapping season represents an unknown portion of the total production of downstream migrant cutthroat from the Cedar River.

Based on limited sampling, Marshall et al. (*in press*) estimated 12% of the field identified cutthroat were, in fact, cutthroat/rainbow hybrids. Applying this rate estimates that approximately 3,113 cutthroat and 424 hybrid trout passed the traps.

## PIT Tagging

To support the ongoing, multi-agency evaluation of salmonid survival within the Lake Washington basin, we began tagging chinook with passive integrated transponder (PIT) tags on May 2 and tagged almost daily through the beginning of June when fish were abundant. As migration slowed in June, tagging occurred roughly every two days and ended July 12. Chinook were held from the previous day in order to increase the number tagged per day. Over the season a total of 2,075 wild and 63 hatchery chinook smolts were tagged (Table 19). This tag group comprised 1.5% of the chinook smolt production from the Cedar River in 2005. In addition, 1,265 coho were also PIT tagged.

**Table 19.** Wild chinook smolts PIT tagged and released from the Cedar River screw trap, 2005.

| Stat Week | | | Chinook | Length | | | Chinook | Length | | | Portion of |
|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Start | End | Wild | Avg | Min | Max | Hatchery | Avg | Min | Max | Migration Tagged |
| 19 | 05/02 | 05/08 | 325 | 84.3 | 68 | 101 | 0 | | | | 7.1% |
| 20 | 05/09 | 05/15 | 503 | 84.9 | 67 | 106 | 0 | | | | 14.0% |
| 21 | 05/16 | 05/22 | 186 | 84.1 | 71 | 111 | 0 | | | | 5.4% |
| 22 | 05/23 | 05/29 | 328 | 92.8 | 73 | 108 | 0 | | | | 9.4% |
| 23 | 05/30 | 06/05 | 318 | 95.3 | 75 | 114 | 0 | | | | 3.1% |
| 24 | 06/06 | 06/12 | 235 | 97.4 | 80 | 138 | 0 | | | | 1.2% |
| 25 | 06/13 | 06/19 | 48 | 96.5 | 80 | 110 | 29 | 115 | 99 | 131 | 0.8% |
| 26 | 06/20 | 06/26 | 88 | 100.6 | 88 | 119 | 26 | 122 | 111 | 134 | 2.7% |
| 27 | 06/27 | 07/03 | 33 | 104.4 | 90 | 139 | 6 | 124 | 115 | 132 | 1.7% |
| 28 | 07/04 | 07/10 | 10 | 106.9 | 101 | 114 | 1 | 136 | 136 | 136 | 1.2% |
| 29 | 07/11 | 07/24 | 1 | 118 | 118 | 118 | 1 | 130 | 130 | 130 | 0.3% |
| Total | | | 2,075 | 90.6 | 67 | 139 | 63 | 119 | 9 | 136 | 1.5% |

## Mortality

Over the season, one chinook fry died in the fry trap in January.

Three coho and 19 chinook smolts were found dead in the screw trap throughout the season.

## Incidental Species

Additional catch in the fry trap, other than sockeye and chinook fry, included 51 coho smolts, five chum fry, three cutthroat smolts, two chinook smolts, and two trout parr. Other species caught included three-spine stickleback, sculpin, lamprey, large scale sucker fry, dace, and long-fin smelt.

Other salmonids caught in the screw trap include 4 coho fry, 161 sockeye fry, 15 cutthroat adult, 17 resident rainbow trout, one sockeye smolt, and 257 ad-marked chinook smolts. Other species caught included three-spine stickleback, sculpin, lamprey, pumpkinseed, large scale suckers (adult and fry), peamouth, and one northern pike minnow.

# Bear Creek Results

## *Sockeye*

### Catch

On the first night of trapping, February 1, 45 sockeye fry were caught in the fry trap. Thereafter, through the night of April 7, the trap fished two to four nights a week for a total of 34 nights. Catches peaked during the night of March 16 when 5,202 fry were caught. When trapping concluded on the morning of April 7, catches totaled 19,903 sockeye fry.

Expanding catches for the 32 nights not fished estimates that there would have been an additional 19,150 sockeye fry caught during those nights. Should the trap have fished continuously from February 1 to April 7, a total of 39,053 fry would have been caught. In previous years no sockeye fry were caught during daylight intervals fished. Therefore, migration during daylight hours was considered minimal and not estimated.

### Trap Efficiency

Over the season, seven groups of marked sockeye fry were released upstream of the fry trap. Capture rates ranged from 8.7% to 28.3% (Table 20). The mean of these rates (19.4%) was used to estimate daily efficiency.

**Table 20.** Sockeye fry trap efficiency tests by date, Bear Creek 2005.

| Date | Flow (cfs) | Released | Recaptured | Trap Efficiency | Variance |
|---|---|---|---|---|---|
| 02/28 | 45 | 300 | 26 | 8.7% | 2.6E-04 |
| 03/02 | 45 | 300 | 85 | 28.3% | 6.8E-04 |
| 03/04 | 43 | 298 | 79 | 26.5% | 6.5E-04 |
| 03/07 | 40 | 299 | 72 | 24.1% | 6.1E-04 |
| 03/08 | 39 | 300 | 75 | 25.0% | 6.3E-04 |
| 03/29 | 152 | 197 | 18 | 9.1% | 4.2E-04 |
| 04/05 | 100 | 272 | 38 | 14.0% | 4.4E-04 |
| Total | | 1,966 | 393 | | |
| Average | | | | 19.4% | |
| Variance | | | | 1.0E-03 | |
| n | | | | 7 | |

### Production Estimate

During the period of fry trap operation (February 1 through April 7), we estimate 201,456 sockeye fry passed the trap. The sockeye fry migration was still underway when the screw trap replaced the fry trap on April 7. Rather than attempting to calibrate the screw trap, the tail end of the migration was estimated using logarithmic extrapolation. Migration from April 8 to April 15 was estimated at 1,359 fry. A total of 202,815 sockeye fry was estimated to have migrated from Bear Creek in 2005 (Table 21, Figure 13, Appendix C).

Egg-to-migrant survival of the 2004 brood was estimated at 8.8% (Table 22). This rate is the ratio of 202,815 fry to an estimate of 2.3 million eggs potentially deposited. Egg deposition is based on an estimated 1,449 sockeye adults in Bear Creek (Foley[a] pers. comm.), an even sex ratio, and an assumed fecundity of 3,200 eggs per female.

**Table 21.** Estimated 2005 Bear Creek sockeye fry migration entering Lake Washington with 95% confidence intervals.

| Period | Dates | Est. Migration | CV | 95% CI | |
|---|---|---|---|---|---|
| | | | | Low | High |
| Fry Trap | February 1 - April 7 | 201,456 | 16.6% | 136,008 | 266,904 |
| Post-Trapping | April 8 - April 15 | 1,359 | 17.6% | 891 | 1,827 |
| | Season Totals | 202,815 | 16.5% | 137,365 | 268,265 |

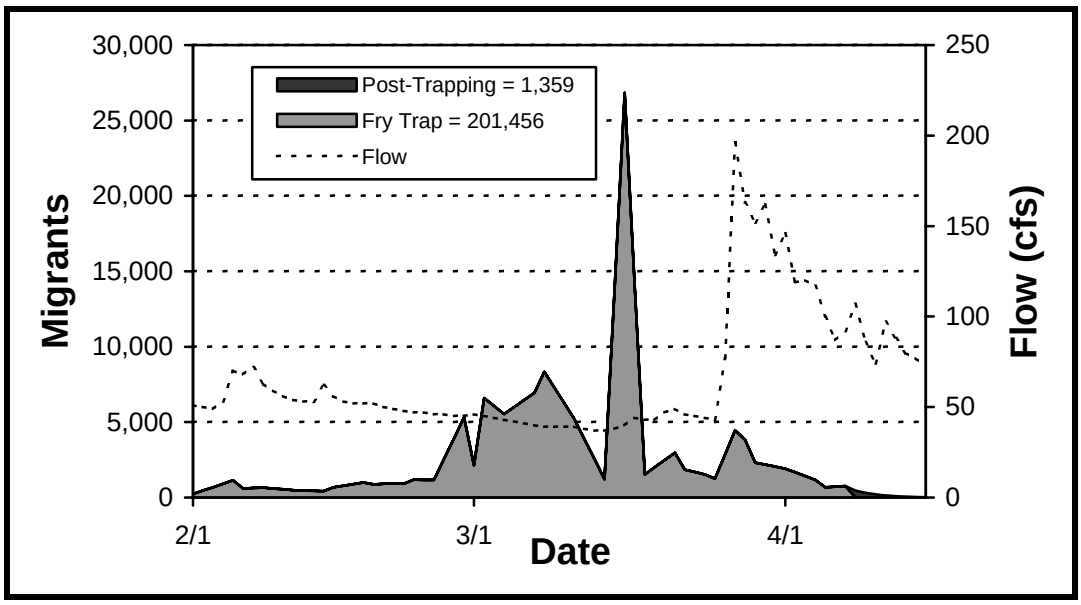



**Figure 13.** Estimated daily migration of sockeye fry from Bear Creek and daily average flow, 2005.

**Table 22. Sockeye egg-to-migrant survival rates by brood year, Bear Creek.**

| Brood Year | Spawners | Females (@50%) | Fecundity | PED | Fry Production | Survival Rate | Peak Incubation Flow (cfs) | Peak Incubation Flow Date |
|---|---|---|---|---|---|---|---|---|
| 1998 | 8,300 | 4,150 | 3,200 | 13,280,000 | 1,523,208 | 11.47% | 515 | 11/26/1998 |
| 1999 | 1,600 | 800 | 3,200 | 2,560,000 | 189,571 | 7.42% | 458 | 11/13/1999 |
| 2000 | 43,000 | 21,500 | 3,200 | 68,800,000 | 2,235,514 | 3.20% | 188 | 11/27/2000 |
| 2001 | 8,378 | 4,189 | 3,200 | 13,404,800 | 2,659,782 | 19.84% | 626 | 11/23/2001 |
| 2002 | 34,700 | 17,350 | 3,200 | 55,520,000 | 1,995,294 | 3.59% | 222 | 01/23/2003 |
| 2003 | 1,765 | 883 | 3,200 | 2,824,000 | 177,801 | 6.30% | 660 | 01/30/2004 |
| 2004 | 1,449 | 725 | 3,200 | 2,318,400 | 202,815 | 8.75% | 495 | 12/12/2004 |

# *Chinook*

## Catch

### *Fry Trap*

The first night of trapping, February 1 no chinook fry were caught. Catches peaked on the night of February 5 when 20 fry were caught. In total, 102 chinook fry were caught in the fry trap by the time trapping ended on the morning of April 7.

Catch expansion for the 32 nights not fished resulted in an additional estimated catch of 127 chinook fry, bringing the total to 229 chinook fry caught in the fry trap.

### *Screw Trap*

The fry trap was replaced with the screw trap on April 7, and it fished continuously through July 14. On the first night of trapping, only one chinook was caught. Catches began to increase by late April, and peaked on May 5 when 325 chinook were caught. Catches then declined to less than 20 per day by June 11. A total of 4,612 chinook were caught over the 98 days trapped. Catch was estimated for one night when the trap was stopped due to debris, adding an additional eight fish.

## Size

From early February through early April, the sizes of chinook fry captured in the fry trap ranged from only 38 mm to 47 mm, and averaged 40.6 mm (Figure 14).

Weekly average fork lengths during screw trap operation increased throughout the season. Chinook averaged 54 mm in mid April, and grew to average 84 mm by mid June (Table 23). Fork lengths over the season ranged from 40 mm to 102 mm (Figure 14).

**Table 23.** Chinook and coho smolt mean fork lengths (mm), standard deviations, ranges, sample sizes, and catches in the Bear Creek fry and screw traps, 2005.

| | Statistical Week | | | CHINOOK | | | | | | COHO | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Begin | End | No. | Avg. | s.d. | Range Min | Range Max | n | Catch | Avg. | s.d. | Range Min | Range Max | n | Catch |
| Fry Trap | 01/31 | 02/06 | 6 | 40.0 | 1.9 | 38 | 42 | 5 | 30 | | | | | | |
| | 02/07 | 02/13 | 7 | 38.5 | 1.2 | 38 | 41 | 6 | 23 | | | | | | |
| | 02/14 | 02/20 | 8 | 39.0 | 1.4 | 38 | 40 | 2 | 7 | | | | | | |
| | 02/21 | 02/27 | 9 | 39.7 | 1.0 | 38 | 41 | 6 | 8 | | | | | | |
| | 02/28 | 03/06 | 10 | 41.0 | 0.8 | 40 | 42 | 7 | 7 | | | | | | |
| | 03/07 | 03/13 | 11 | 41.5 | 1.5 | 40 | 44 | 6 | 6 | | | | | | |
| | 03/14 | 03/20 | 12 | 43.3 | 2.3 | 42 | 46 | 3 | 3 | | | | | | |
| | 03/21 | 03/27 | 13 | 46.5 | 0.7 | 46 | 47 | 2 | 2 | | | | | | |
| | 03/28 | 04/03 | 14 | 38.0 | 0.0 | 38 | 38 | 4 | 10 | | | | | | |
| | 04/04 | 04/10 | 15 | 42.0 | 1.4 | 40 | 44 | 5 | 6 | | | | | | |
| | | | Totals | 40.6 | 2.3 | 38 | 47 | 46 | 102 | | | | | | |
| Screw Trap | 04/08 | 04/10 | 15 | 62.0 | 4.2 | 59 | 65 | 2 | 2 | 120.6 | 9.8 | 106 | 138 | 11 | 11 |
| | 04/11 | 04/17 | 16 | 53.7 | 7.5 | 40 | 65 | 9 | 20 | 129.0 | 24.9 | 100 | 220 | 26 | 76 |
| | 04/18 | 04/24 | 17 | 66.6 | 5.8 | 54 | 74 | 19 | 47 | 114.5 | 13.2 | 87 | 156 | 114 | 1,032 |
| | 04/25 | 05/01 | 18 | 69.9 | 8.2 | 51 | 86 | 69 | 471 | 110.0 | 10.7 | 90 | 146 | 179 | 6,028 |
| | 05/02 | 05/08 | 19 | 77.3 | 5.7 | 60 | 94 | 600 | 1,565 | 107.0 | 11.0 | 81 | 183 | 609 | 6,342 |
| | 05/09 | 05/15 | 20 | 78.6 | 5.7 | 63 | 93 | 214 | 490 | 113.5 | 11.5 | 91 | 190 | 459 | 1,811 |
| | 05/16 | 05/22 | 21 | 79.6 | 6.1 | 68 | 97 | 208 | 321 | 110.9 | 11.4 | 86 | 148 | 219 | 494 |
| | 05/23 | 05/29 | 22 | 80.3 | 5.5 | 68 | 95 | 203 | 857 | 112.3 | 10.4 | 89 | 146 | 104 | 310 |
| | 05/30 | 06/05 | 23 | 83.0 | 6.1 | 69 | 99 | 198 | 382 | 109.5 | 12.1 | 91 | 134 | 22 | 52 |
| | 06/06 | 06/12 | 24 | 84.1 | 7.1 | 65 | 102 | 137 | 278 | 112.8 | 15.7 | 100 | 134 | 4 | 23 |
| | 06/13 | 06/19 | 25 | 76.8 | 6.7 | 62 | 97 | 60 | 101 | 111.5 | 15.8 | 96 | 131 | 6 | 10 |
| | 06/20 | 06/26 | 26 | 77.5 | 5.4 | 64 | 86 | 46 | 38 | | | | | | 2 |
| | 06/27 | 07/03 | 27 | 80.3 | 6.0 | 74 | 86 | 3 | 19 | | | | | | 0 |
| | 07/04 | 07/10 | 28 | 78.0 | | 78 | 78 | 1 | 18 | | | | | | 0 |
| | 07/11 | 07/17 | 29 | 83.0 | | 83 | 83 | 1 | 3 | | | | | | 0 |
| | | | Totals | 78.7 | 7.1 | 40 | 102 | 1,770 | 4,612 | 110.9 | 12.1 | 81 | 220 | 1,753 | 16,191 |

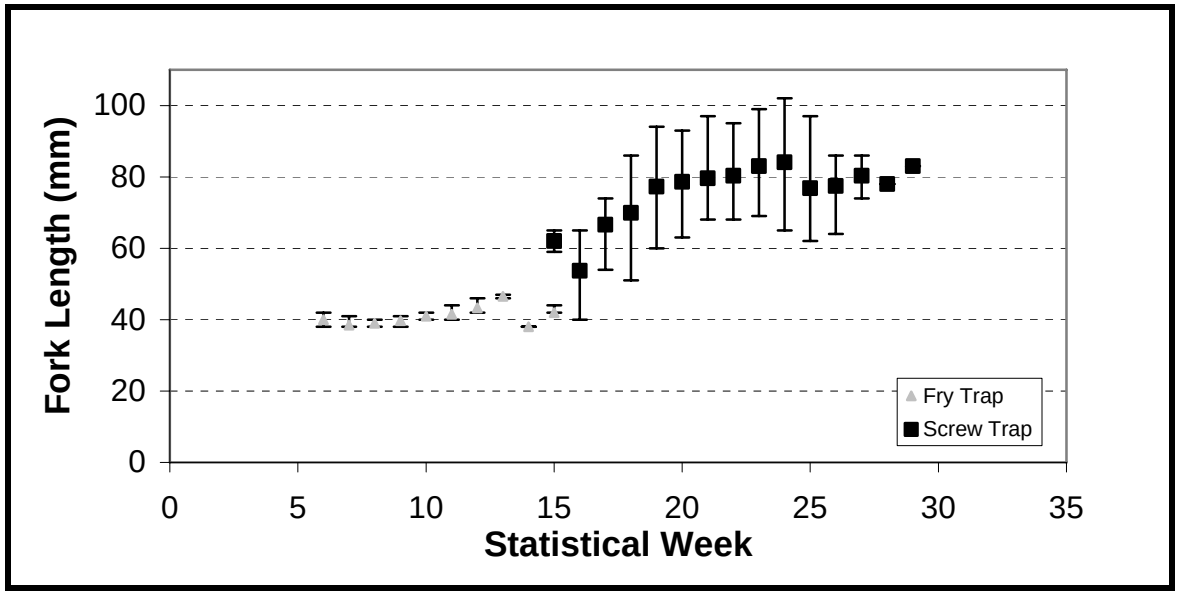



**Figure 14.** Average and range of chinook 0+ fork lengths sampled from Bear Creek, 2005.

## Trap Efficiency

Sockeye fry were used to estimate fry trap efficiency because inadequate numbers of chinook fry were available to conduct efficiency tests. Capture efficiency was estimated at 19.4%, the average of all individual tests (Table 20).

Tests to estimate the capture rate of the screw trap efficiency tests were conducted on 19 days from May 1 to June 17. Efficiency rates ranged from 9.8% to 96.2% and averaged 58.1% (Table 24). Daily average flows ranged from 34 to 111 cfs during the tests, similar to the flow range during trapping season (26 to 156 cfs). Lower capture rates were associated with flows greater than 60 cfs, therefore we stratified the data into two groups: efficiency test conducted with flows below 60 cfs and those conducted with flows of 60 cfs or greater. Efficiency ranged from 38% to 96.2% with flows below 60 cfs and average 66.5%. With flows 60 cfs or greater, efficiency ranged from 9.8% to 81% and averaged 34.6%. The average efficiency of each stratum was used to estimate migration.

**Table 24.** Chinook 0+ trap efficiency test results stratified by flow, Bear Creek 2005.

| | Date | NUMBER Released | NUMBER Recaptured | Efficiency Rate | Variance | Flow (cfs) |
|---|---|---|---|---|---|---|
| Flows < 60 cfs | 05/01 | 50 | 21 | 42.0% | 4.9E-03 | 41 |
| | 05/03 | 50 | 19 | 38.0% | 4.7E-03 | 44 |
| | 05/04 | 50 | 34 | 68.0% | 4.4E-03 | 42 |
| | 05/06 | 50 | 39 | 78.0% | 3.4E-03 | 40 |
| | 05/07 | 50 | 34 | 68.0% | 4.4E-03 | 36 |
| | 05/08 | 50 | 26 | 52.0% | 5.0E-03 | 34 |
| | 05/14 | 26 | 25 | 96.2% | 1.4E-03 | 47 |
| | 05/27 | 73 | 60 | 82.2% | 2.0E-03 | 45 |
| | 05/28 | 74 | 59 | 79.7% | 2.2E-03 | 40 |
| | 05/29 | 50 | 37 | 74.0% | 3.8E-03 | 35 |
| | 05/30 | 50 | 39 | 78.0% | 3.4E-03 | 34 |
| | 06/08 | 23 | 14 | 60.9% | 1.0E-02 | 58 |
| | 06/16 | 25 | 13 | 52.0% | 1.0E-02 | 39 |
| | 06/17 | 16 | 10 | 62.5% | 1.5E-02 | 51 |
| | Average | 637 | 430 | 66.5% | | |
| | Variance | | | 1.9E-03 | | |
| | n | | | 14 | | |
| Flows = or > 60 cfs | 05/18 | 19 | 8 | 42.1% | 1.3E-02 | 75 |
| | 05/21 | 41 | 4 | 9.8% | 2.1E-03 | 111 |
| | 05/23 | 60 | 12 | 20.0% | 2.7E-03 | 82 |
| | 06/10 | 53 | 43 | 81.1% | 2.9E-03 | 62 |
| | 06/06 | 50 | 10 | 20.0% | 3.2E-03 | 60 |
| | Average | 223 | 77 | 34.6% | | |
| | Variance | | | 1.6E-02 | | |
| | n | | | 5 | | |

## Production Estimate

From February 1 to April 7, an estimate of 1,175 chinook fry passed the fry trap. During screw trap operation (April 8 through July 15) an estimated 8,142 chinook passed the trap. Daily migrations in April averaged less than 30 chinook. Migration increased by late-April and averaged over 200 chinook per day for the month of May. Thereafter, migration declined to average less than 25 chinook per day through the remainder of trapping season.

Combining the fry and screw trap chinook production estimates a total juvenile production of 9,317 chinook with a coefficient of variation of 10.2% and a 95% confidence interval of 7,452 to 11,183 juveniles (Figure 15, Appendix C).

Egg-to-migrant survival of the 2004 brood was estimated at 3.0% (Table 25). This rate is the ratio of 9,317 chinook to an estimate of 306,000 eggs potentially deposited. Egg deposition is based on 68 spawning females in Bear Creek (Foley[a] pers. comm.) and an assumed fecundity of 4,500 eggs per female. This is the lowest spawning escapement observed since monitoring downstream migrants began with the 1998 brood. In addition, based on carcass recovery, hatchery produced chinook comprised 63.8% of the spawners (Foley[b] pers comm.).

**Table 25.** Age 0+ chinook production and egg-to-migrant survival estimates for Bear Creek broods 1998 to 2004.

| Brood Year | Estimated Migration | Estimated Females | Potential Egg Deposition | Production/ Female | Survival Rates |
|---|---|---|---|---|---|
| 1998 | 15,002 | 159 | 715,500 | 94.4 | 2.1% |
| 1999 | 32,220 | 293 | 1,318,500 | 110.0 | 2.4% |
| 2000 | 10,588 | 133 | 598,500 | 79.6 | 1.8% |
| 2001 | 21,454 | 276 | 1,242,000 | 77.7 | 1.7% |
| 2002 | 17,313 | 144 | 648,000 | 120.2 | 2.7% |
| 2003 | 23,647 | 105 | 472,500 | 225.2 | 5.0% |
| 2004 | 9,317 | 68 | 306,000 | 137.0 | 3.0% |

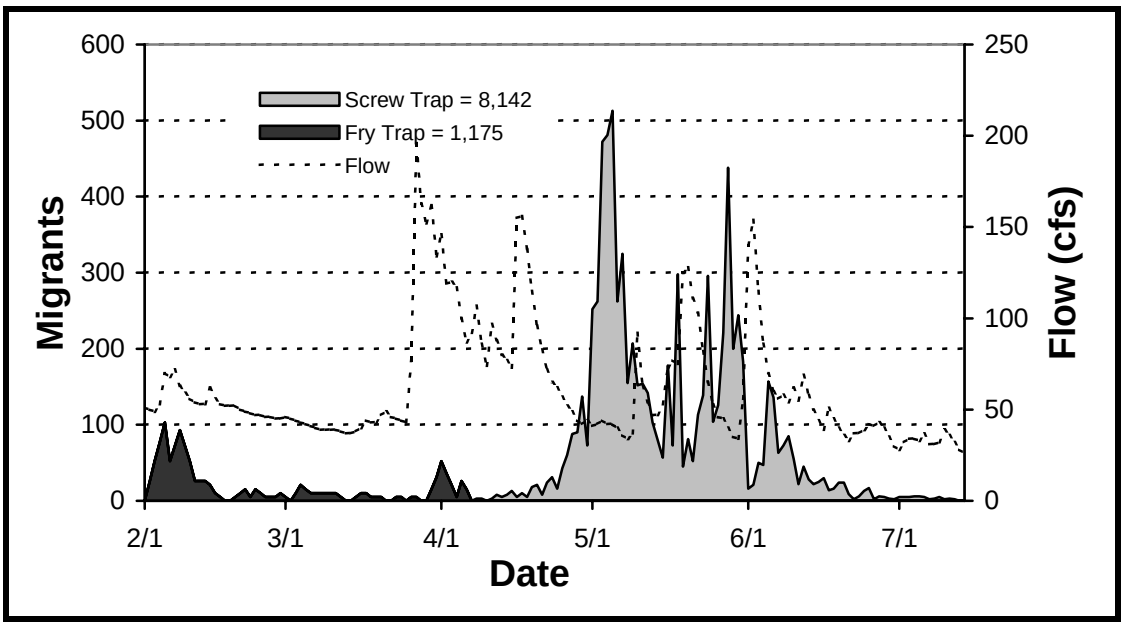



**Figure 15.** Estimated daily chinook 0+ migration and daily average flow from Bear Creek, 2005.

# *Coho*

## Catch

Two coho smolts were caught on the first night, April 8, of screw trap operation. After this night, catches steadily increased and peaked at 1,602 smolts on May 3. Catches declined thereafter, and by early June daily catches averaged less than five smolts per day. Over the entire 98-day trapping season, ending on the morning of July 15, a total of 16,191 coho smolts were caught.

## Size

Over the trapping period, fork lengths ranged from 81 mm to 220 mm and averaged 110.9 mm (Table 23). Weekly mean size ranged from 107mm to 129 mm over the season (Figure 16).

## Trap Efficiency

A total of 1,244 marked coho were released in 25 groups upstream of the trap between April 21 and May 28. Trap efficiencies ranged from 5.4% to 72% and averaged 37.3% (Table 26). Tests conducted when flows were less than 70 cfs resulted in higher efficiencies ($\bar{e} = 41.3\%$) compared to those conducted at higher flows ($\bar{e} = 16.8\%$). These mean efficiencies were found to be significantly different ($\alpha = 0.05$) using analysis of variance. Therefore the catch data was stratified by streamflow and the mean efficiency for each stratum was used to estimate migration.

## Production Estimate

Coho production was estimated at 43,725 smolts with a coefficient of variation of 0.1% and a 95% confidence interval of 43,638 to 43,813 smolts (Figure 17, Appendix C).

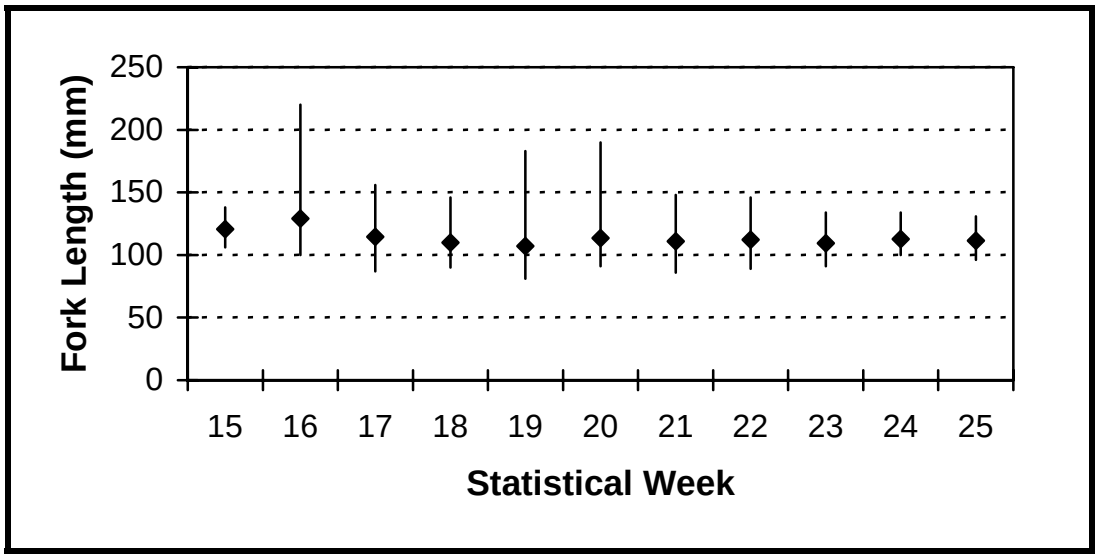



**Figure 16.** Average and range of fork lengths from coho smolts sampled from Bear Creek, 2005.

**Table 26.** Estimated coho smolt recapture rates from screw trap efficiency tests, Bear Creek 2005.

| | Date | Flow (cfs) | Efficiency Tests | | Efficiency Rate | Variance |
|---|---|---|---|---|---|---|
| | | | Released | Recaptured | | |
| Flows < 70 cfs | 04/23 | 83 | 50 | 17 | 34.0% | 4.49E-03 |
| | 04/24 | 65 | 50 | 16 | 32.0% | 4.35E-03 |
| | 04/25 | 62 | 50 | 19 | 38.0% | 4.71E-03 |
| | 04/26 | 57 | 50 | 22 | 44.0% | 4.93E-03 |
| | 04/27 | 52 | 50 | 23 | 46.0% | 4.97E-03 |
| | 04/28 | 49 | 50 | 25 | 50.0% | 5.00E-03 |
| | 04/29 | 44 | 50 | 22 | 44.0% | 4.93E-03 |
| | 05/01 | 42 | 50 | 21 | 42.0% | 4.87E-03 |
| | 05/02 | 41 | 50 | 20 | 40.0% | 4.80E-03 |
| | 05/03 | 42 | 50 | 21 | 42.0% | 4.87E-03 |
| | 05/06 | 44 | 50 | 25 | 50.0% | 5.00E-03 |
| | 05/07 | 40 | 50 | 28 | 56.0% | 4.93E-03 |
| | 05/08 | 36 | 50 | 36 | 72.0% | 4.03E-03 |
| | 05/11 | 34 | 50 | 30 | 60.0% | 4.80E-03 |
| | 05/12 | 63 | 50 | 10 | 20.0% | 3.20E-03 |
| | 05/14 | 54 | 50 | 20 | 40.0% | 4.80E-03 |
| | 05/15 | 47 | 50 | 12 | 24.0% | 3.65E-03 |
| | 05/15 | 53 | 50 | 16 | 32.0% | 4.35E-03 |
| | 05/25 | 53 | 49 | 7 | 14.3% | 2.50E-03 |
| | 05/27 | 75 | 47 | 21 | 44.7% | 5.26E-03 |
| | 05/28 | 111 | 41 | 17 | 41.5% | 5.92E-03 |
| | Average | | | | 41.3% | |
| | Variance | | | | 2.61E-08 | |
| | n | | | | 21 | |
| Flows = or > 70 cfs | 04/21 | 82 | 50 | 20 | 40.0% | 4.80E-03 |
| | 05/18 | 53 | 50 | 3 | 6.0% | 1.13E-03 |
| | 05/21 | 45 | 37 | 2 | 5.4% | 1.38E-03 |
| | 05/23 | 40 | 70 | 11 | 15.7% | 1.89E-03 |
| | Average | | | | 16.8% | |
| | Variance | | | | 7.2E-07 | |
| | n | | | | 4 | |

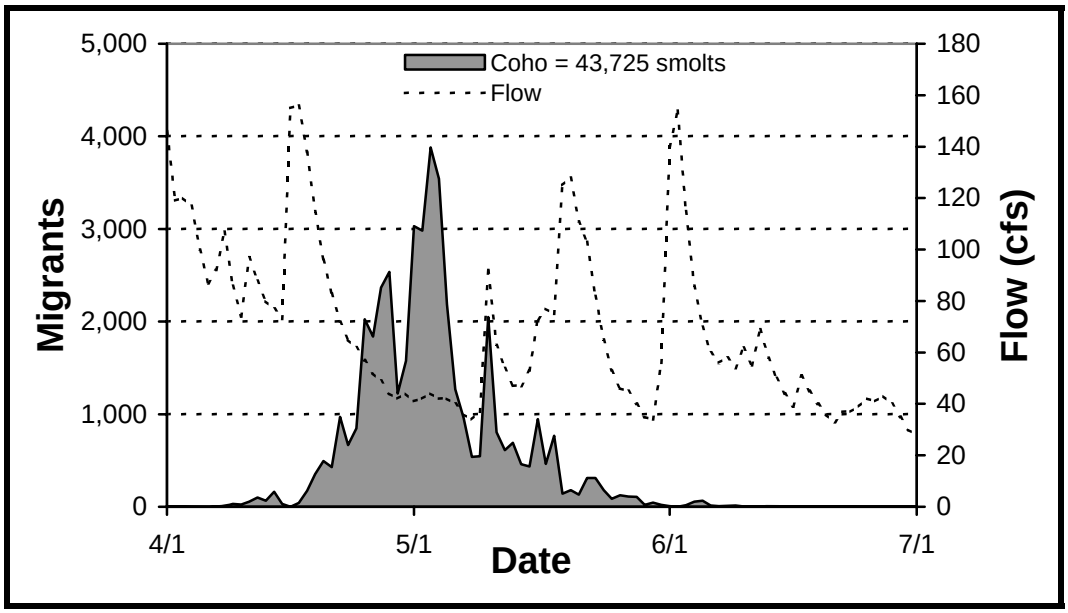



**Figure 17.** Estimated daily coho smolt migration, Bear Creek screw trap 2005.

# *Trout*

## DNA and Scale Analysis

A total of 47 trout were sampled from two traps, 15 adult cutthroat tissue samples were collected during fry trap operation, and 32 juvenile cutthroat samples were collected during screw trap operation. Scales were collected and aged from 37 of the DNA sampled fish (Table 27). The cutthroat sampled ranged in size from 119mm to 595 mm, and from one to seven years of age, some with numerous spawning checks. Fork length analysis was conducted to determine whether differences existed between the DNA sampled fish. Age 5, 6, and 7 trout were not included in this analysis since only a single fish from each of these age classes was sampled. Fork lengths between the age 1 through 4 trout were found to be significantly different ($\alpha = 0.05$) using single classification analysis of variance. Tukey's pairwise comparison was used to evaluate fork length differences between individual age classes. Fork length differences were not significant between the age 1 and 2 trout ($\alpha = 0.05$), but were among all other pairings. The mature fish appeared to migrated earlier in the season than the juvenile migrants. In comparing the DNA results with our visual identification, only *O. mykiss*/*O. clarki* hybrids were identified incorrectly. These accounted for 8.5% (four fish) of those sampled (Marshall et al. *in prep*). The sampled hybrids ranged in size from 162 mm to 595 mm and ranged in age from one to seven years.

The identification of trout in Bear Creek poses the same difficulties as was discussed earlier in the Cedar River section. For these reasons, we refer to trout as cutthroat trout or steelhead out migrants, based on visual identification.

**Table 27.** Age and length of cutthroat sampled for DNA, Bear Creek 2005**.**

| Lifestage Timing | Age | n | Length Range (mm) Min | Length Range (mm) Max | Average |
|---|---|---|---|---|---|
| Adult (February-March) | 3 | 3 | 375 | 420 | 403 |
| | 4 | 7 | 370 | 470 | 406 |
| | 5 | 1 | 520 | 520 | 520 |
| | 6 | 1 | 425 | 425 | 425 |
| | 7 | 1[a] | 595 | 595 | 595 |
| Juveniles (April-June) | 1 | 6[b] | 119 | 179 | 150 |
| | 2 | 11[c] | 158 | 225 | 189 |
| | 3 | 7[d] | 181 | 328 | 217 |
| Total | | 37 | 119 | 595 | 272 |

Note: Fourteen scales samples were not taken on cutthroat that were sampled for DNA.
[a-d] Include one hybrid

## Catch and Production Estimate

There were two steelhead captured throughout the 2005 trapping season in Bear Creek.

A total of 1,238 cutthroat trout were captured in the screw trap. Migration was mostly uni-modal with daily catch peaking April 25 and May 2 when 153 cutthroat were caught on each day. Cutthroat trout fork lengths averaged 172.2 mm, and varied from 90 mm to 328 mm throughout the trapping season (Table 28). Six efficiency tests were conducted in late April and early May when catches were high. Capture rates ranged from 20% to 30.2% and averaged 27.9% (Table 29). Cutthroat production was estimated at 4,441 cutthroat, with a coefficient of variation of 5.9% and a 95% confidence interval of 3,928 to 4,954 smolts (Figure 18, Appendix C). This estimate applies only to the interval trapped (April 8 through July 14). During the 2000 season, when the screw trap operated from January through June, 35% of the cutthroat migration occurred prior to April 5. Applying this timing to the cutthroat estimated during the 2005 trapping season estimates that a total of 7,328 cutthroat migrated from Bear Creek.

Based on limited sampling, Marshall et al. (*in press*) estimated 8.5% of the field identified cutthroat were, in fact, cutthroat/rainbow hybrids. Applying this rate estimates that approximately 6,705 cutthroat and 623 hybrid trout passed the traps.

**Table 28.** Mean cutthroat fork length (mm), standard deviation, range, sample size, and catch by statistical week, Bear Creek screw trap 2005.

| Statistical Week | | | Avg. | s.d. | Range | | n | Catch |
|---|---|---|---|---|---|---|---|---|
| Begin | End | No. | | | Min | Max | | |
| 04/04 | 04/10 | 15 | 180.4 | 28.2 | 134 | 219 | 7 | 7 |
| 04/11 | 04/17 | 16 | 189.6 | 41.3 | 129 | 328 | 20 | 55 |
| 04/18 | 04/24 | 17 | 178.5 | 27.3 | 122 | 298 | 94 | 272 |
| 04/25 | 05/01 | 18 | 131.1 | 29.8 | 90 | 208 | 55 | 354 |
| 05/02 | 05/08 | 19 | 164.6 | 21.3 | 130 | 210 | 34 | 417 |
| 05/09 | 05/15 | 20 | 161.6 | 23.9 | 114 | 210 | 16 | 79 |
| 05/16 | 05/22 | 21 | 139.5 | 29.0 | 119 | 160 | 2 | 9 |
| 05/23 | 05/29 | 22 | 241.0 | | 241 | 241 | 1 | 25 |
| 05/30 | 06/05 | 23 | 151.5 | 5.0 | 148 | 155 | 2 | 9 |
| 06/06 | 06/12 | 24 | 173.0 | 24.0 | 156 | 190 | 2 | 3 |
| 06/13 | 07/03 | 25-27 | | | | | | 8 |
| Season Totals | | | 172.2 | 26.0 | 90 | 328 | 233 | 1,238 |

**Table 29.** Cutthroat capture rates measured at Bear Creek screw trap, 2005.

| Date | Flow (cfs) | Released | Recaptured | Efficiency | Variance |
|---|---|---|---|---|---|
| 04/23 | 65 | 43 | 13 | 30.2% | 4.9E-03 |
| 04/24 | 62 | 62 | 17 | 27.4% | 3.2E-03 |
| 04/25 | 57 | 50 | 15 | 30.0% | 4.2E-03 |
| 04/26 | 52 | 50 | 15 | 30.0% | 4.2E-03 |
| 05/02 | 42 | 50 | 15 | 30.0% | 4.2E-03 |
| 05/03 | 44 | 50 | 10 | 20.0% | 3.2E-03 |
| Total | | 305 | 85 | | |
| Average | | | | 27.9% | |
| Variance | | | | 2.7E-04 | |

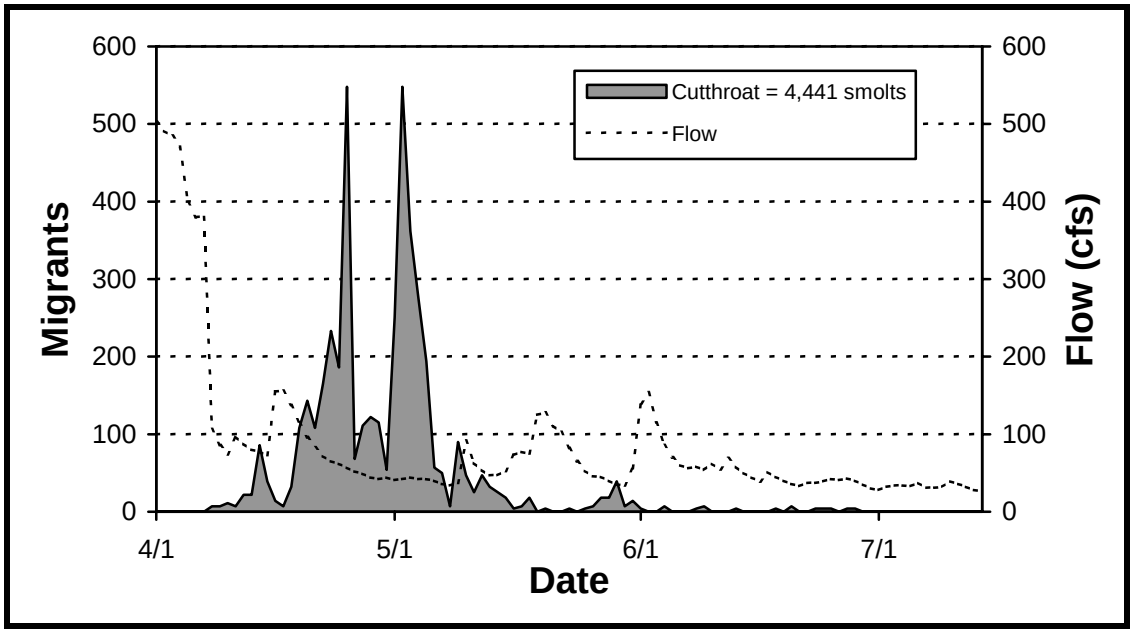



**Figure 18.** Daily estimated migration of cutthroat trout and flow, Bear Creek screw trap 2005.

## PIT Tagging

Tagging chinook began on May 2 and continued for four to five days a week for three weeks. As catch dwindled, chinook were held from the previous days in order to increase the number tagged per day and resulted in tagging only once or twice a week for the remainder of the season. Throughout the trapping season, 1,424 chinook smolts were PIT tagged (Table 30). We tagged 15.3% of the total chinook production from Bear Creek in 2005. In addition, we also tagged 1,207 coho smolts.

**Table 30.** Wild chinook PIT tagged and released from the Bear Creek screw trap, 2005.

| Statistical Week | | | Number | Length | | | Proportion of |
|---|---|---|---|---|---|---|---|
| # | Start | End | Tagged | Average | Min | Max | Migration Tagged |
| 19 | 05/02 | 05/08 | 499 | 78 | 66 | 94 | 20.2% |
| 20 | 05/09 | 05/15 | 195 | 79 | 66 | 93 | 21.8% |
| 21 | 05/16 | 05/22 | 197 | 80 | 68 | 97 | 23.5% |
| 22 | 05/23 | 05/29 | 173 | 80 | 70 | 95 | 11.3% |
| 23 | 05/30 | 06/05 | 194 | 83 | 69 | 99 | 27.0% |
| 24 | 06/06 | 06/12 | 119 | 84 | 69 | 102 | 24.9% |
| 25 | 06/13 | 06/19 | 21 | 82 | 74 | 97 | 13.2% |
| 26 | 06/20 | 06/26 | 26 | 78 | 71 | 86 | 35.8% |
| | | Total | 1,424 | 80 | 66 | 102 | 15.3% |

## Mortality

During the fry trapping season, two chinook died in the trap. In the screw trap, 14 chinook and seven coho smolts died over the trapping season.

## Incidental Species

In addition to sockeye and chinook fry caught in the fry trap, two coho fry, six coho smolts, 13 cutthroat smolts, and 16 cutthroat adults were also caught. Other species included lamprey, sculpin, three-spine sticklebacks, pumpkinseed, whitefish, dace, and Northern Pike Minnow. In addition to the species estimated for the screw trap, we also caught sockeye fry, one sockeye smolt, 19 coho fry, four two-year old coho smolts, one ad-marked resident rainbow trout, 16 wild resident rainbow trout, and six cutthroat adults. Other species caught included lamprey, large-scale suckers, three-spine stickleback, sculpin, pumpkinseed, small-mouth bass, peamouth, dace, catfish, and Northern Pike Minnow.

# Citations

## *Literature Cited*


Burton, K., L. Lowe, and H. Berge. 2005 Cedar River Chinook Salmon (*Oncorhynchus tshawytscha)* Redd and Carcass Surveys: Annual Report 2004. Seattle Public Utilities. Seattle.

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with applications to zoological samle censuses. University of California Publications in Statistics. 1:131-160.

Cramer, S.P., J. Norris, P.R. Mundy, G. Grette, K.P. O'Neal, J.S. Hogle, C. Steward, and P. Bahls. 1999. Status of chinook salmon and their habitat in Puget Sound. Volume 2, Final Report. Prepared for Coalition of Puget Sound Businesses. S.P. Cramer & Associates, Inc. Gresham, OR.

Goodman, L.A. 1960. On the exact variance of products. Journal of the American Statistical Association. 55: 708-713.

Marshall, A., M. Small, and S. Foley. In prep. Genetic relationships among anadromous and non-anadromous *Oncorhynchus mykiss* in Cedar River and Lake Wasington – implications for steelhead recovery planning. WA Dept of Fish & Wildlife.

Seiler, D., S. Neuhauser, and M. Ackley. 1981. Upstream/Downstream Salmonid Project 1977-1980. WA Dept. of Fish. Prog. Rpt. No. 144. 195 p.

Seiler, D. and S. Neuhauser. 1985. Evaluation of downstream migrant passage at two dams: Condit Dam, Big White River, 1983 & 1984; Howard Hanson Dam, Green River, 1984. Wash. Dept. Fish. Prog. Rep. No. 235: 94 p.

Seiler, D., S. Wolthausen, and L.E. Kishimoto. 1992. Evaluation of downstream migrant passage through the sediment retention structure, North Fork Toutle River, 1991. WA Dept. Fish, Prog. Rep. No. 297. 45 p.

Seiler, D. and L. Kishimoto. 1996. Annual report: 1995 Cedar River sockeye salmon fry production evaluation program. WA Dept. Fish & Wildlife. Olympia. 28 p.

Seiler, D., G. Volkhardt, and L. Kishimoto. 2003. Evaluation of downstream migrant salmon production in 1999 and 2000 from three Lake Washington tributaries: Cedar River, Bear Creek, and Issaquah Creek. WA Dept. Fish & Wildlife. Olympia, WA. 199 p.

U.S. Army Corps of Engineers, Seattle District. 1997. Cedar River Section 205 flood damage reduction study. Final Environmental Impact Statement.

Volk, E.C., S.L. Schroder, and K.L. Fresh. 1990. Inducement of unique otolith banding patterns as a practical means to mass-mark juvenile Pacific Salmon. Am. Fish. Soc. Symposium 7: 203-215.

## *Personal Communication*

Antipa, Brodie. Hatchery Manager-Rainier Complex. Washington Department of Fish and Wildlife, Puyallup. Electronic mail on June 17, 2005.

Foley, Steve[a]. Fish and Wildlife Biologist. Washington Department of Fish and Wildlife, Mill Creek. Electronic mail on September 6, 2005.

Foley, Steve[b]. Fish and Wildlife Biologist. Washington Department of Fish and Wildlife, Mill Creek. December 27, 2005.

# Appendix A: Daily Estimated Cedar River Wild Sockeye Fry Migration into Lake Washington, 2005.

**Appendix A.** Daily estimated Cedar River wild sockeye fry migration into Lake Washington, 2005.

| Date | Flow (cfs) | Nightly Catch | | Estimated Daily Catch [a] | Trap Efficiency | Daily Wild Migration |
|---|---|---|---|---|---|---|
| | | Actual | Estimate | | | |
| 01/01 | 641 | | | | | 1,854 |
| 01/02 | 636 | | | | | 2,252 |
| 01/03 | 633 | | | | | 2,735 |
| 01/04 | 626 | | | | | 3,321 |
| 01/05 | 629 | | | | | 4,033 |
| 01/06 | 595 | | | | | 4,898 |
| 01/07 | 598 | | | | | 5,949 |
| 01/08 | 585 | | | | | 7,224 |
| 01/09 | 579 | | | | | 8,773 |
| 01/10 | 576 | | | | | 10,654 |
| 01/11 | 578 | | | | | 12,939 |
| 01/12 | 578 | | | | | 15,714 |
| 01/13 | 574 | | | | | 19,083 |
| 01/14 | 576 | | | | | 23,175 |
| 01/15 | 579 | | | | | 28,144 |
| 01/16 | 593 | | | | | 34,179 |
| 01/17 | 878 | | | | | 41,508 |
| 01/18 | 1,900 | | | | | 50,408 |
| 01/19 | 1,480 | | | | | 61,217 |
| 01/20 | 1,520 | | | | | 74,343 |
| 01/21 | 1,740 | 3,359 | 8,836 | 12,246 | 12.4% | 98,849 |
| 01/22 | 1,740 | | | 11,185 | 12.4% | 90,284 |
| 01/23 | 1,590 | 2,574 | 7,505 | 10,124 | 12.4% | 81,720 |
| 01/24 | 1,540 | | | 13,945 | 12.4% | 112,563 |
| 01/25 | 1,370 | | | 17,766 | 12.4% | 143,406 |
| 01/26 | 1,120 | 21,486 | | 21,587 | 12.4% | 174,249 |
| 01/27 | 972 | 26,262 | | 26,385 | 12.4% | 212,978 |
| 01/28 | 839 | | | 26,703 | 12.4% | 215,545 |
| 01/29 | 804 | | | 27,021 | 12.4% | 218,111 |
| 01/30 | 797 | 27,212 | | 27,339 | 12.4% | 220,678 |
| 01/31 | 795 | 31,940 | | 32,096 | 12.4% | 259,076 |
| 02/01 | 708 | | | 33,325 | 12.4% | 268,997 |
| 02/02 | 587 | | | 34,556 | 12.4% | 278,933 |
| 02/03 | 496 | | | 35,787 | 12.4% | 288,870 |
| 02/04 | 501 | | | 37,018 | 12.4% | 298,806 |
| 02/05 | 480 | 38,085 | | 38,249 | 12.4% | 308,743 |
| 02/06 | 476 | | | 38,335 | 12.4% | 309,437 |
| 02/07 | 468 | 38,174 | | 38,420 | 12.4% | 310,123 |
| 02/08 | 457 | 28,057 | | 28,188 | 12.4% | 227,531 |
| 02/09 | 454 | 29,440 | | 29,590 | 12.4% | 238,848 |
| 02/10 | 456 | 30,605 | | 30,748 | 12.4% | 248,195 |
| 02/11 | 485 | 36,073 | | 36,242 | 12.4% | 292,543 |
| 02/12 | 478 | | | 37,454 | 12.4% | 302,326 |
| 02/13 | 474 | 38,453 | | 38,666 | 12.4% | 312,109 |
| 02/14 | 469 | 61,235 | | 61,574 | 12.4% | 497,021 |
| 02/15 | 466 | 43,852 | | 43,985 | 12.4% | 355,044 |

**Appendix A.** Daily estimated Cedar River wild sockeye fry migration into Lake Washington, 2005 (cont'd.).

| Date | Flow (cfs) | Nightly Catch | | Estimated Daily Catch [a] | Trap Efficiency | Daily Wild Migration |
|---|---|---|---|---|---|---|
| | | Actual | Estimate | | | |
| 02/16 | 465 | 38,814 | | 39,029 | 12.4% | 315,039 |
| 02/17 | 466 | 41,375 | | 41,604 | 12.4% | 335,824 |
| 02/18 | 470 | | | 45,639 | 12.4% | 368,394 |
| 02/19 | 460 | | | 49,672 | 12.4% | 400,949 |
| 02/20 | 459 | 53,409 | | 53,705 | 12.4% | 433,503 |
| 02/21 | 458 | 58,730 | | 59,056 | 12.4% | 476,695 |
| 02/22 | 457 | | | 68,376 | 12.4% | 551,926 |
| 02/23 | 455 | | | 77,694 | 12.4% | 627,140 |
| 02/24 | 453 | 86,532 | | 87,012 | 12.4% | 702,354 |
| 02/25 | 454 | 103,108 | | 103,680 | 12.4% | 836,897 |
| 02/26 | 421 | | | 165,263 | 12.4% | 1,333,990 |
| 02/27 | 377 | 86,628 | 138,967 | 226,845 | 20.7% | 1,097,745 |
| 02/28 | 352 | | | 305,021 | 20.7% | 1,476,053 |
| 03/01 | 361 | 114,622 | 266,462 | 383,196 | 20.7% | 1,854,356 |
| 03/02 | 351 | | | 329,922 | 20.7% | 1,596,553 |
| 03/03 | 347 | 78,091 | 197,499 | 276,648 | 20.7% | 1,338,751 |
| 03/04 | 341 | | | 225,964 | 20.7% | 1,093,481 |
| 03/05 | 341 | 53,094 | 121,220 | 175,280 | 20.7% | 848,212 |
| 03/06 | 341 | | | 231,824 | 20.7% | 1,121,839 |
| 03/07 | 340 | 83,455 | 203,185 | 288,367 | 20.7% | 1,395,461 |
| 03/08 | 337 | | | 257,771 | 20.7% | 1,247,401 |
| 03/09 | 335 | 50,332 | 175,482 | 227,174 | 20.7% | 1,099,337 |
| 03/10 | 334 | | | 193,112 | 20.7% | 934,505 |
| 03/11 | 334 | 35,880 | 122,217 | 159,049 | 20.7% | 769,667 |
| 03/12 | 334 | | | 124,577 | 20.7% | 602,851 |
| 03/13 | 326 | 27,366 | 62,153 | 90,105 | 20.7% | 436,035 |
| 03/14 | 334 | | | 63,837 | 20.7% | 308,919 |
| 03/15 | 336 | 37,324 | | 37,568 | 14.2% | 263,931 |
| 03/16 | 343 | 34,108 | 26,508 | 61,013 | 14.2% | 428,642 |
| 03/17 | 338 | 52,074 | 27,206 | 79,799 | 14.2% | 560,622 |
| 03/18 | 336 | | | 58,365 | 14.2% | 410,039 |
| 03/19 | 339 | 19,863 | 16,784 | 36,930 | 14.2% | 259,449 |
| 03/20 | 341 | | | 46,643 | 14.2% | 327,687 |
| 03/21 | 344 | 41,923 | 14,033 | 56,354 | 14.2% | 395,911 |
| 03/22 | 341 | | | 44,200 | 14.2% | 310,524 |
| 03/23 | 325 | 31,837 | | 32,045 | 14.2% | 225,130 |
| 03/24 | 325 | | | 33,401 | 14.2% | 234,656 |
| 03/25 | 322 | 34,530 | | 34,756 | 14.2% | 244,176 |
| 03/26 | 413 | | | 33,056 | 14.2% | 232,233 |
| 03/27 | 630 | 31,116 | | 31,356 | 10.5% | 298,107 |
| 03/28 | 506 | 15,769 | | 15,891 | 10.5% | 151,078 |
| 03/29 | 504 | | | 16,010 | 10.5% | 152,210 |
| 03/30 | 456 | 16,015 | | 16,129 | 10.5% | 153,341 |
| 03/31 | 476 | 12,209 | | 12,296 | 10.5% | 116,900 |

**Appendix A.** Daily estimated Cedar River wild sockeye fry migration into Lake Washington, 2005 (cont'd.).

| Date | Flow (cfs) | Nightly Catch | | Estimated Daily Catch [a] | Trap Efficiency | Daily Wild Migration |
|---|---|---|---|---|---|---|
| | | Actual | Estimate | | | |
| 04/01 | 503 | 16,801 | | 16,931 | 10.5% | 160,966 |
| 04/02 | 491 | | | 15,102 | 10.5% | 143,577 |
| 04/03 | 485 | | | 13,273 | 10.5% | 126,189 |
| 04/04 | 471 | 11,363 | | 11,444 | 10.5% | 108,800 |
| 04/05 | 399 | 8,981 | | 9,050 | 10.5% | 86,040 |
| 04/06 | 380 | 10,907 | | 10,991 | 10.5% | 104,493 |
| 04/07 | 380 | | | 10,406 | 10.5% | 98,932 |
| 04/08 | 390 | 9,744 | | 9,819 | 10.5% | 93,351 |
| 04/09 | 365 | | | 7,309 | 10.5% | 69,488 |
| 04/10 | 361 | 4,758 | | 4,798 | 10.5% | 45,615 |
| 04/11 | 397 | 9,098 | | 9,168 | 10.5% | 87,162 |
| 04/12 | 394 | 5,650 | | 5,697 | 10.5% | 54,162 |
| 04/13 | 381 | | | 5,430 | 10.5% | 51,624 |
| 04/14 | 375 | 5,115 | | 5,162 | 10.5% | 49,076 |
| 04/15 | 377 | | | 3,876 | 10.5% | 36,850 |
| 04/16 | 596 | 2,558 | | 2,588 | 10.5% | 24,605 |
| 04/17 | 696 | | | 4,216 | 10.5% | 40,082 |
| 04/18 | 537 | 5,789 | | 5,842 | 10.5% | 55,541 |
| 04/19 | 472 | | | 4,726 | 10.5% | 44,931 |
| 04/20 | 429 | 3,571 | | 3,610 | 10.5% | 34,321 |
| 04/21 | 397 | | | 3,426 | 10.5% | 32,572 |
| 04/22 | 382 | 3,206 | | 3,241 | 10.5% | 30,813 |
| 04/23 | 373 | | | 2,458 | 10.5% | 23,369 |
| 04/24 | 383 | 1,655 | | 1,673 | 10.5% | 15,905 |
| 04/25 | 367 | | | 2,283 | 10.5% | 21,705 |
| 04/26 | 356 | 2,860 | | 2,891 | 10.5% | 27,485 |
| 04/27 | 355 | | | 2,527 | 10.5% | 24,025 |
| 04/28 | 352 | 2,137 | | 2,162 | 10.5% | 20,554 |
| 04/29 | 366 | | | 1,872 | 10.5% | 17,797 |
| 04/30 | 385 | | | 1,583 | 10.5% | 15,050 |
| 05/01 | 362 | 1,279 | | 1,294 | 10.5% | 12,302 |
| 05/02 | 363 | | | 1,244 | 10.5% | 11,827 |
| 05/03 | 361 | | | 1,193 | 10.5% | 11,342 |
| 05/04 | 347 | 1,129 | | 1,142 | 10.5% | 10,857 |
| 05/05 | 345 | | | 1,119 | 10.5% | 10,639 |
| 05/06 | 340 | | | 1,096 | 10.5% | 10,420 |
| 05/07 | 336 | | | 1,073 | 10.5% | 10,201 |
| 05/08 | 334 | | | 1,050 | 10.5% | 9,983 |
| 05/09 | 346 | 1,015 | | 1,027 | 10.5% | 9,764 |
| 05/10 | 411 | | | 930 | 10.5% | 8,842 |
| 05/11 | 375 | | | 836 | 10.5% | 7,948 |
| 05/12 | 364 | | | 742 | 10.5% | 7,054 |
| 05/13 | 351 | | | 648 | 10.5% | 6,161 |
| 05/14 | 350 | | | 554 | 10.5% | 5,267 |
| 05/15 | 436 | 455 | | 460 | 10.5% | 4,373 |
| Season Total | | 1,803,082 | 1,388,057 | 5,981,730 | | 37,027,961 |

Notes: Shaded values represent pre-trapping migration estimated through extrapolation.

[a] Includes both actual and estimated nightly catch as well as estimated daytime catch.

# Appendix B: Estimated Chinook, Coho, and Cutthroat Daily Migration, Cedar River, 2005.

**Appendix B.** Estimated chinook, coho, and cutthroat daily migrations, Cedar River 2005.

| Date | Flow (cfs) | Est. Chinook Catch | | Chinook Migration | Coho Migration | Cutthroat Migration |
|---|---|---|---|---|---|---|
| | | Fry | Screw | | | |
| 01/01 | 641 | | | 6 | | |
| 01/02 | 636 | | | 8 | | |
| 01/03 | 633 | | | 10 | | |
| 01/04 | 626 | | | 14 | | |
| 01/05 | 629 | | | 18 | | |
| 01/06 | 595 | | | 24 | | |
| 01/07 | 598 | | | 32 | | |
| 01/08 | 585 | | | 42 | | |
| 01/09 | 579 | | | 56 | | |
| 01/10 | 576 | | | 74 | | |
| 01/11 | 578 | | | 99 | | |
| 01/12 | 578 | | | 131 | | |
| 01/13 | 574 | | | 174 | | |
| 01/14 | 576 | | | 232 | | |
| 01/15 | 579 | | | 308 | | |
| 01/16 | 593 | | | 409 | | |
| 01/17 | 878 | | | 543 | | |
| 01/18 | 1,900 | | | 721 | | |
| 01/19 | 1,480 | | | 958 | | |
| 01/20 | 1,520 | | | 1,273 | | |
| 01/21 | 1,740 | 234 | | 1,889 | | |
| 01/22 | 1,740 | 210 | | 1,695 | | |
| 01/23 | 1,590 | 185 | | 1,493 | | |
| 01/24 | 1,540 | 179 | | 1,445 | | |
| 01/25 | 1,370 | 173 | | 1,396 | | |
| 01/26 | 1,120 | 167 | | 1,348 | | |
| 01/27 | 972 | 161 | | 1,292 | | |
| 01/28 | 839 | 134 | | 1,082 | | |
| 01/29 | 804 | 107 | | 864 | | |
| 01/30 | 797 | 80 | | 646 | | |
| 01/31 | 795 | 196 | | 1,582 | | |
| 02/01 | 708 | 166 | | 1,340 | | |
| 02/02 | 587 | 136 | | 1,098 | | |
| 02/03 | 496 | 106 | | 856 | | |
| 02/04 | 501 | 76 | | 613 | | |
| 02/05 | 480 | 46 | | 371 | | |
| 02/06 | 476 | 133 | | 1,074 | | |
| 02/07 | 468 | 219 | | 1,768 | | |
| 02/08 | 457 | 127 | | 1,025 | | |
| 02/09 | 454 | 160 | | 1,292 | | |
| 02/10 | 456 | 251 | | 2,026 | | |
| 02/11 | 485 | 179 | | 1,445 | | |
| 02/12 | 478 | 132 | | 1,065 | | |
| 02/13 | 474 | 84 | | 678 | | |
| 02/14 | 469 | 716 | | 5,779 | | |
| 02/15 | 466 | 596 | | 4,811 | | |

**Appendix B.** Estimated chinook, coho, and cutthroat daily migrations, Cedar River 2005 (cont'd.).

| Date | Flow (cfs) | Est. Chinook Catch | | Chinook Migration | Coho Migration | Cutthroat Migration |
|---|---|---|---|---|---|---|
| | | Fry | Screw | | | |
| 02/16 | 465 | 316 | | 2,551 | | |
| 02/17 | 466 | 334 | | 2,696 | | |
| 02/18 | 470 | 292 | | 2,357 | | |
| 02/19 | 460 | 250 | | 2,018 | | |
| 02/20 | 459 | 208 | | 1,679 | | |
| 02/21 | 458 | 225 | | 1,816 | | |
| 02/22 | 457 | 186 | | 1,501 | | |
| 02/23 | 455 | 148 | | 1,195 | | |
| 02/24 | 453 | 110 | | 888 | | |
| 02/25 | 454 | 130 | | 1,049 | | |
| 02/26 | 421 | 122 | | 977 | | |
| 02/27 | 377 | 113 | | 542 | | |
| 02/28 | 352 | 59 | | 286 | | |
| 03/01 | 361 | 5 | | 24 | | |
| 03/02 | 351 | 47 | | 227 | | |
| 03/03 | 347 | 89 | | 431 | | |
| 03/04 | 341 | 51 | | 247 | | |
| 03/05 | 341 | 12 | | 58 | | |
| 03/06 | 341 | 40 | | 194 | | |
| 03/07 | 340 | 67 | | 324 | | |
| 03/08 | 337 | 92 | | 445 | | |
| 03/09 | 335 | 116 | | 561 | | |
| 03/10 | 334 | 88 | | 426 | | |
| 03/11 | 334 | 60 | | 290 | | |
| 03/12 | 334 | 80 | | 387 | | |
| 03/13 | 326 | 100 | | 484 | | |
| 03/14 | 334 | 58 | | 281 | | |
| 03/15 | 336 | 16 | | 112 | | |
| 03/16 | 343 | 11 | | 77 | | |
| 03/17 | 338 | 37 | | 260 | | |
| 03/18 | 336 | 22 | | 155 | | |
| 03/19 | 339 | 6 | | 42 | | |
| 03/20 | 341 | 59 | | 415 | | |
| 03/21 | 344 | 112 | | 787 | | |
| 03/22 | 341 | 62 | | 436 | | |
| 03/23 | 325 | 12 | | 84 | | |
| 03/24 | 325 | 8 | | 56 | | |
| 03/25 | 322 | 3 | | 21 | | |
| 03/26 | 413 | 43 | | 302 | | |
| 03/27 | 630 | 82 | | 780 | | |
| 03/28 | 506 | 7 | | 67 | | |
| 03/29 | 504 | 10 | | 95 | | |
| 03/30 | 456 | 12 | | 114 | | |
| 03/31 | 476 | 0 | | 0 | | |

**Appendix B.** Estimated chinook, coho, and cutthroat daily migrations, Cedar River 2005 (cont'd.).

| Date | Flow (cfs) | Est. Chinook Catch | | Chinook Migration | Coho Migration | Cutthroat Migration |
|---|---|---|---|---|---|---|
| | | Fry | Screw | | | |
| 04/01 | 503 | 7 | | 67 | 3 | |
| 04/02 | 491 | 6 | | 57 | 33 | |
| 04/03 | 485 | 5 | | 48 | 64 | |
| 04/03 | 485 | 5 | | 48 | 64 | |
| 04/04 | 471 | 4 | | 38 | 94 | |
| 04/05 | 399 | 6 | | 57 | 87 | |
| 04/06 | 380 | 1 | | 10 | 104 | |
| 04/07 | 380 | 1 | | 10 | 122 | |
| 04/08 | 390 | 1 | | 10 | 139 | |
| 04/09 | 365 | 3 | | 29 | 156 | |
| 04/10 | 361 | 4 | | 38 | 174 | |
| 04/11 | 397 | 8 | 27 | 249 | 191 | 203 |
| 04/12 | 394 | 10 | 55 | 506 | 209 | 81 |
| 04/13 | 381 | 6 | 8 | 74 | 226 | 81 |
| 04/14 | 375 | 1 | 18 | 166 | 292 | 81 |
| 04/15 | 377 | 20 | 10 | 92 | 195 | 122 |
| 04/16 | 596 | 39 | 184 | 1,694 | 2725 | 407 |
| 04/17 | 696 | 24 | 31 | 285 | 754 | 203 |
| 04/18 | 537 | 9 | 28 | 179 | 852 | 122 |
| 04/19 | 472 | 5 | 11 | 70 | 438 | 0 |
| 04/20 | 429 | 0 | 5 | 32 | 97 | 41 |
| 04/21 | 397 | 0 | 3 | 19 | 341 | 81 |
| 04/22 | 382 | 0 | 5 | 32 | 438 | 0 |
| 04/23 | 373 | 0 | 11 | 70 | 219 | 0 |
| 04/24 | 383 | 0 | 2 | 13 | 341 | 0 |
| 04/25 | 367 | 1 | 9 | 58 | 535 | 0 |
| 04/26 | 356 | 2 | 19 | 121 | 511 | 41 |
| 04/27 | 355 | 1 | 11 | 70 | 876 | 0 |
| 04/28 | 352 | 0 | 34 | 217 | 1509 | 0 |
| 04/29 | 366 | 0 | 51 | 326 | 949 | 0 |
| 04/30 | 385 | 0 | 92 | 588 | 3991 | 0 |
| 05/01 | 362 | 0 | 55 | 352 | 2409 | 81 |
| 05/02 | 363 | 1 | 81 | 532 | 1144 | 0 |
| 05/03 | 361 | 1 | 40 | 263 | 2555 | 122 |
| 05/04 | 347 | 1 | 85 | 559 | 3528 | 0 |
| 05/05 | 345 | 1 | 105 | 690 | 4039 | 41 |
| 05/06 | 340 | 1 | 96 | 631 | 2774 | 81 |
| 05/07 | 336 | 1 | 174 | 1,144 | 2652 | 0 |
| 05/08 | 334 | 1 | 111 | 730 | 1509 | 0 |
| 05/09 | 346 | 1 | 223 | 1,116 | 2190 | 0 |
| 05/10 | 411 | 1 | 49 | 245 | 4258 | 41 |
| 05/11 | 375 | 2 | 49 | 245 | 1995 | 41 |
| 05/12 | 364 | 3 | 175 | 876 | 2993 | 0 |
| 05/13 | 351 | 4 | 24 | 120 | 852 | 81 |
| 05/14 | 350 | 5 | 27 | 135 | 535 | 0 |
| 05/15 | 436 | 6 | 170 | 851 | 4234 | 0 |

**Appendix B.** Estimated chinook, coho, and cutthroat daily migrations, Cedar River 2005 (cont'd.).

| Date | Flow (cfs) | Est. Chinook Catch | | Chinook Migration | Coho Migration | Cutthroat Migration |
|---|---|---|---|---|---|---|
| | | Fry | Screw | | | |
| 05/16 | 563 | | 61 | 414 | 3747 | 0 |
| 05/17 | 537 | | 30 | 204 | 900 | 0 |
| 05/18 | 539 | | 34 | 231 | 608 | 0 |
| 05/19 | 537 | | 50 | 339 | 608 | 0 |
| 05/20 | 538 | | 133 | 903 | 2652 | 41 |
| 05/21 | 543 | | 75 | 509 | 560 | 0 |
| 05/22 | 447 | | 124 | 842 | 243 | 0 |
| 05/23 | 394 | | 141 | 1,227 | 706 | 0 |
| 05/24 | 369 | | 115 | 1,001 | 633 | 41 |
| 05/25 | 353 | | 45 | 392 | 657 | 81 |
| 05/26 | 343 | | 29 | 252 | 900 | 41 |
| 05/27 | 335 | | 19 | 165 | 925 | 0 |
| 05/28 | 330 | | 19 | 165 | 706 | 0 |
| 05/29 | 335 | | 33 | 287 | 195 | 0 |
| 05/30 | 334 | | 57 | 1,051 | 365 | 0 |
| 05/31 | 329 | | 122 | 2,249 | 414 | 41 |
| 06/01 | 333 | | 90 | 1,659 | 292 | 41 |
| 06/02 | 332 | | 61 | 1,124 | 195 | 41 |
| 06/03 | 326 | | 146 | 2,691 | 438 | 0 |
| 06/04 | 321 | | 29 | 535 | 170 | 0 |
| 06/05 | 320 | | 53 | 977 | 170 | 81 |
| 06/06 | 320 | | 92 | 3,891 | 170 | 81 |
| 06/07 | 318 | | 48 | 2,030 | 170 | 41 |
| 06/08 | 318 | | 151 | 6,386 | 316 | 0 |
| 06/09 | 314 | | 102 | 4,314 | 243 | 41 |
| 06/10 | 304 | | 12 | 507 | 122 | 0 |
| 06/11 | 302 | | 22 | 930 | 49 | 41 |
| 06/12 | 316 | | 23 | 973 | 49 | 41 |
| 06/13 | 308 | | 30 | 905 | 24 | 0 |
| 06/14 | 299 | | 30 | 905 | 49 | 0 |
| 06/15 | 296 | | 40 | 1,206 | 49 | 0 |
| 06/16 | 287 | | 32 | 965 | 0 | 0 |
| 06/17 | 311 | | 15 | 452 | 24 | 0 |
| 06/18 | 291 | | 19 | 573 | 24 | 0 |
| 06/19 | 286 | | 22 | 663 | 0 | 0 |
| 06/20 | 280 | | 17 | 432 | 0 | 41 |
| 06/21 | 277 | | 12 | 305 | 0 | 0 |
| 06/22 | 279 | | 39 | 992 | 0 | 41 |
| 06/23 | 283 | | 23 | 585 | 24 | 0 |
| 06/24 | 279 | | 6 | 153 | 49 | 0 |
| 06/25 | 278 | | 12 | 305 | 49 | 81 |
| 06/26 | 278 | | 21 | 534 | 24 | 41 |
| 06/27 | 279 | | 17 | 432 | 0 | 0 |
| 06/28 | 278 | | 6 | 153 | 24 | 81 |
| 06/29 | 276 | | 9 | 229 | 0 | 81 |
| 06/30 | 273 | | 5 | 127 | 0 | 0 |

**Appendix B.** Estimated chinook, coho, and cutthroat daily migrations, Cedar River 2005 (cont'd.).

| Date | Flow (cfs) | Est. Chinook Catch | | Chinook Migration | Coho Migration | Cutthroat Migration |
|---|---|---|---|---|---|---|
| | | Fry | Screw | | | |
| 07/01 | 266 | | 7 | 178 | 24 | 0 |
| 07/02 | 247 | | 10 | 254 | 0 | 0 |
| 07/03 | 262 | | 6 | 153 | 0 | 41 |
| 07/04 | 240 | | 3 | 76 | 0 | 41 |
| 07/05 | 239 | | 5 | 127 | 0 | 0 |
| 07/06 | 269 | | 7 | 178 | 0 | 122 |
| 07/07 | 240 | | 5 | 127 | 0 | 81 |
| 07/08 | 240 | | 8 | 203 | 0 | 41 |
| 07/09 | 242 | | 3 | 76 | 0 | 41 |
| 07/10 | 237 | | 3 | 76 | 0 | 0 |
| 07/11 | 272 | | 2 | 51 | 0 | 41 |
| 07/12 | 288 | | 2 | 51 | 0 | 0 |
| 07/13 | 284 | | 1 | 25 | 0 | 0 |
| 07/14 | 280 | | 2 | 51 | 0 | 0 |
| 07/15 | 272 | | 1 | 25 | 0 | 0 |
| 07/16 | 271 | | 2 | 51 | 0 | 41 |
| 07/17 | 270 | | 2 | 51 | 24 | 41 |
| 07/18 | 257 | | 2 | 51 | 0 | 0 |
| 07/19 | 226 | | 1 | 25 | 0 | 0 |
| 07/20 | 219 | | 1 | 25 | 0 | 0 |
| 07/21 | 218 | | 0 | 0 | 0 | 0 |
| 07/22 | 225 | | 1 | 25 | 0 | 41 |
| 07/23 | 219 | | 0 | 0 | 0 | 0 |
| 07/24 | 218 | | 0 | 0 | 0 | 0 |
| 07/25 | 215 | | 0 | 0 | 0 | 0 |
| 07/26 | 213 | | 0 | 0 | 0 | 0 |
| 07/27 | 202 | | 0 | 0 | 0 | 41 |
| 07/28 | 190 | | 0 | 0 | 0 | 0 |
| Season Totals | | 9,043 | 4,423 | 134,603 | 72643 | 3,542 |

Note: Shade values represent pre-trapping migration estimated through extrapolation.

# Appendix C: Estimated Sockeye, Chinook, Coho, and Cutthroat Daily Migrations, Bear Creek 2005.

**Appendix C.** Estimated sockeye, chinook, coho, and cutthroat migrations, Bear Creek 2005.

| Date | Flow (cfs) | Sockeye | Chinook | Coho | Cutthroat |
|---|---|---|---|---|---|
| 02/01 | 51 | 232 | 0 | | |
| 02/02 | 50 | 459 | 26 | | |
| 02/03 | 49 | 686 | 52 | | |
| 02/04 | 53 | 913 | 77 | | |
| 02/05 | 70 | 1,145 | 103 | | |
| 02/06 | 68 | 604 | 52 | | |
| 02/07 | 72 | 634 | 72 | | |
| 02/08 | 63 | 660 | 93 | | |
| 02/09 | 59 | 604 | 72 | | |
| 02/10 | 56 | 547 | 52 | | |
| 02/11 | 54 | 490 | 26 | | |
| 02/12 | 53 | 469 | 26 | | |
| 02/13 | 53 | 449 | 26 | | |
| 02/14 | 62 | 428 | 21 | | |
| 02/15 | 56 | 686 | 10 | | |
| 02/16 | 53 | 789 | 5 | | |
| 02/17 | 52 | 892 | 0 | | |
| 02/18 | 52 | 996 | 0 | | |
| 02/19 | 52 | 872 | 5 | | |
| 02/20 | 50 | 903 | 10 | | |
| 02/21 | 49 | 929 | 15 | | |
| 02/22 | 48 | 903 | 5 | | |
| 02/23 | 47 | 1,186 | 15 | | |
| 02/24 | 47 | 1,176 | 10 | | |
| 02/25 | 46 | 1,166 | 5 | | |
| 02/26 | 46 | 2,548 | 5 | | |
| 02/27 | 45 | 3,931 | 5 | | |
| 02/28 | 45 | 5,318 | 10 | | |
| 03/01 | 46 | 2,151 | 5 | | |
| 03/02 | 45 | 6,598 | 0 | | |
| 03/03 | 44 | 6,066 | 10 | | |
| 03/04 | 43 | 5,535 | 21 | | |
| 03/05 | 42 | 6,005 | 15 | | |
| 03/06 | 41 | 6,474 | 10 | | |
| 03/07 | 40 | 6,938 | 10 | | |
| 03/08 | 39 | 8,331 | 10 | | |
| 03/09 | 39 | 7,289 | 10 | | |
| 03/10 | 39 | 6,247 | 10 | | |
| 03/11 | 39 | 5,200 | 10 | | |
| 03/12 | 38 | 3,874 | 5 | | |
| 03/13 | 37 | 2,548 | 0 | | |
| 03/14 | 37 | 1,217 | 0 | | |
| 03/15 | 38 | 14,026 | 5 | | |

**Appendix C.** Estimated sockeye, chinook, coho, and cutthroat migrations, Bear Creek 2005 (cont'd.).

| Date | Flow (cfs) | Sockeye | Chinook | Coho | Cutthroat |
|---|---|---|---|---|---|
| 03/16 | 40 | 26,835 | 10 | | |
| 03/17 | 44 | 14,181 | 10 | | |
| 03/18 | 43 | 1,522 | 5 | | |
| 03/19 | 43 | 2,007 | 5 | | |
| 03/20 | 47 | 2,492 | 5 | | |
| 03/21 | 49 | 2,971 | 0 | | |
| 03/22 | 46 | 1,842 | 0 | | |
| 03/23 | 45 | 1,692 | 5 | | |
| 03/24 | 44 | 1,537 | 5 | | |
| 03/25 | 43 | 1,259 | 0 | | |
| 03/26 | 77 | 2,863 | 5 | | |
| 03/27 | 196 | 4,462 | 5 | | |
| 03/28 | 163 | 3,833 | 0 | | |
| 03/29 | 152 | 2,306 | 0 | | |
| 03/30 | 162 | 2,177 | 15 | | |
| 03/31 | 134 | 2,048 | 31 | | |
| 04/01 | 146 | 1,919 | 52 | | |
| 04/02 | 119 | 1,666 | 36 | | |
| 04/03 | 120 | 1,413 | 21 | | |
| 04/04 | 117 | 1,166 | 5 | | |
| 04/05 | 100 | 676 | 26 | | |
| 04/06 | 87 | 717 | 15 | | |
| 04/07 | 92 | 758 | 0 | | |
| 04/08 | 107 | 476 | 3 | 12 | 7 |
| 04/09 | 86 | 315 | 3 | 30 | 7 |
| 04/10 | 74 | 209 | 0 | 24 | 11 |
| 04/11 | 97 | 139 | 3 | 54 | 7 |
| 04/12 | 88 | 92 | 8 | 101 | 22 |
| 04/13 | 80 | 61 | 5 | 65 | 22 |
| 04/14 | 77 | 40 | 8 | 161 | 86 |
| 04/15 | 73 | 27 | 13 | 30 | 39 |
| 04/16 | 155 | | 5 | 0 | 14 |
| 04/17 | 156 | | 10 | 42 | 7 |
| 04/18 | 138 | | 5 | 173 | 32 |
| 04/19 | 115 | | 18 | 351 | 108 |
| 04/20 | 96 | | 21 | 494 | 143 |
| 04/21 | 83 | | 8 | 429 | 108 |
| 04/22 | 72 | | 24 | 970 | 165 |
| 04/23 | 65 | | 31 | 668 | 233 |
| 04/24 | 62 | | 16 | 847 | 186 |
| 04/25 | 57 | | 43 | 2,024 | 548 |
| 04/26 | 52 | | 60 | 1,840 | 68 |
| 04/27 | 49 | | 88 | 2,368 | 111 |
| 04/28 | 44 | | 90 | 2,535 | 122 |
| 04/29 | 42 | | 137 | 1,223 | 115 |
| 04/30 | 44 | | 73 | 1,574 | 54 |

**Appendix C.** Estimated sockeye, chinook, coho, and cutthroat migrations, Bear Creek 2005 (cont'd.).

| Date | Flow (cfs) | Sockeye | Chinook | Coho | Cutthroat |
|---|---|---|---|---|---|
| 05/01 | 41 | | 252 | 3,031 | 251 |
| 05/02 | 42 | | 262 | 2,981 | 548 |
| 05/03 | 44 | | 472 | 3,879 | 362 |
| 05/04 | 42 | | 481 | 3,542 | 276 |
| 05/05 | 42 | | 513 | 2,186 | 194 |
| 05/06 | 40 | | 262 | 1,269 | 57 |
| 05/07 | 36 | | 325 | 959 | 50 |
| 05/08 | 34 | | 155 | 540 | 7 |
| 05/09 | 37 | | 207 | 547 | 90 |
| 05/10 | 92 | | 152 | 2,048 | 47 |
| 05/11 | 63 | | 154 | 806 | 25 |
| 05/12 | 54 | | 142 | 613 | 47 |
| 05/13 | 47 | | 103 | 692 | 32 |
| 05/14 | 47 | | 80 | 458 | 25 |
| 05/15 | 53 | | 57 | 436 | 18 |
| 05/16 | 73 | | 178 | 946 | 4 |
| 05/17 | 77 | | 73 | 464 | 7 |
| 05/18 | 75 | | 298 | 768 | 18 |
| 05/19 | 125 | | 45 | 143 | 0 |
| 05/20 | 128 | | 81 | 179 | 4 |
| 05/21 | 111 | | 52 | 131 | 0 |
| 05/22 | 103 | | 113 | 310 | 0 |
| 05/23 | 82 | | 139 | 310 | 4 |
| 05/24 | 65 | | 296 | 179 | 0 |
| 05/25 | 53 | | 104 | 85 | 4 |
| 05/26 | 46 | | 126 | 123 | 7 |
| 05/27 | 45 | | 221 | 109 | 18 |
| 05/28 | 40 | | 438 | 107 | 18 |
| 05/29 | 35 | | 200 | 22 | 39 |
| 05/30 | 34 | | 244 | 46 | 7 |
| 05/31 | 56 | | 183 | 22 | 14 |
| 06/01 | 140 | | 16 | 6 | 4 |
| 06/02 | 154 | | 21 | 0 | 0 |
| 06/03 | 115 | | 50 | 18 | 0 |
| 06/04 | 86 | | 47 | 54 | 7 |
| 06/05 | 70 | | 157 | 65 | 0 |
| 06/06 | 60 | | 136 | 15 | 0 |
| 06/07 | 56 | | 63 | 7 | 0 |
| 06/08 | 58 | | 73 | 10 | 4 |
| 06/09 | 54 | | 85 | 15 | 7 |
| 06/10 | 62 | | 55 | 2 | 0 |
| 06/11 | 55 | | 22 | 2 | 0 |
| 06/12 | 69 | | 45 | 5 | 0 |
| 06/13 | 58 | | 28 | 5 | 4 |
| 06/14 | 50 | | 22 | 7 | 0 |
| 06/15 | 44 | | 25 | 7 | 0 |

**Appendix C.** Estimated sockeye, chinook, coho, and cutthroat migrations, Bear Creek 2005 (cont'd.).

| Date | Flow (cfs) | Sockeye | Chinook | Coho | Cutthroat |
|---|---|---|---|---|---|
| 06/16 | 39 | | 30 | 0 | 0 |
| 06/17 | 51 | | 14 | 0 | 0 |
| 06/18 | 45 | | 16 | 2 | 4 |
| 06/19 | 40 | | 24 | 2 | 0 |
| 06/20 | 36 | | 24 | 2 | 7 |
| 06/21 | 33 | | 9 | 2 | 0 |
| 06/22 | 37 | | 2 | 0 | 0 |
| 06/23 | 37 | | 6 | 0 | 4 |
| 06/24 | 39 | | 13 | 0 | 4 |
| 06/25 | 42 | | 17 | 0 | 4 |
| 06/26 | 41 | | 2 | 0 | 0 |
| 06/27 | 43 | | 6 | 0 | 4 |
| 06/28 | 40 | | 5 | 0 | 4 |
| 06/29 | 35 | | 3 | 0 | 0 |
| 06/30 | 30 | | 2 | 0 | 0 |
| 07/01 | 28 | | 5 | 0 | 0 |
| 07/02 | 32 | | 5 | 0 | 0 |
| 07/03 | 34 | | 5 | 0 | 0 |
| 07/04 | 34 | | 6 | 0 | 0 |
| 07/05 | 33 | | 6 | 0 | 0 |
| 07/06 | 37 | | 5 | 0 | 0 |
| 07/07 | 31 | | 2 | 0 | 0 |
| 07/08 | 31 | | 3 | 0 | 0 |
| 07/09 | 32 | | 5 | 0 | 0 |
| 07/10 | 39 | | 2 | 0 | 0 |
| 07/11 | 36 | | 3 | 0 | 0 |
| 07/12 | 32 | | 2 | 0 | 0 |
| 07/13 | 28 | | 0 | 0 | 0 |
| 07/14 | 26 | | 0 | 0 | 0 |
| Seasonal Total | | 202,815 | 9,317 | 43,725 | 4,441 |

Note: Shade values represent migration estimated through extrapolation that would have occurred if fry trap operation continued.