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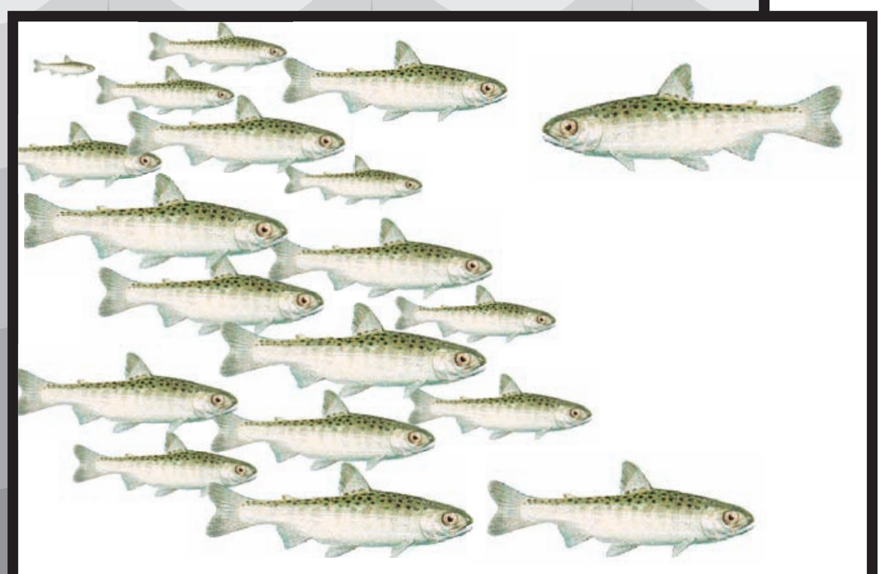
Evaluation of Downstream Migrant Salmon Production in 2003 from the Cedar River and Bear Creek



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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.

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EXECUTIVE SUMMARY

This report provides the results of monitoring five salmonid species as downstream migrants in 2003 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 2003, was expanded in 1999 with the addition of a second downstream migrant trap to estimate the production of juvenile chinook salmon. With this trap we also estimate the production of coho, steelhead and cutthroat smolts.

Assessment of sockeye fry production began in the Sammamish system in 1997. We placed the trap in the Sammamish River at Bothell where we also operated it during the 1998 season. In 1999, to assess chinook production as well as sockeye, we moved this monitoring program to Bear Creek. 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 1980's and early 1990's prompted the creation of a multi-agency 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 2003, the twelfth year of this project. As in previous years, the primary study goal was to estimate the season total migration of Cedar River wild and hatchery sockeye fry into Lake Washington. These estimates enable calculation of survival rates from egg deposition to lake entry, for hatchery fry from release to the trap, and for both production components from lake entry to subsequent life stages of smolts and adults.

Beginning in January and continuing through May, a floating inclined-plane screen 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, on 33 nights, dye-marked fry were released upstream of the trap. Due to the wide range of flows during releases, we were able to examine the effects of flow on capture rate. Linear regression analysis found that trap efficiency was significantly correlated to flow. We used this relationship to estimate daily trap efficiency.

Over the season, 16.0 million hatchery produced sockeye fry were released into the Cedar River from four locations. A quarter of these fry (4.4 million) was released below the fry trap at the Cedar River Trail Park. All hatchery fry were internally marked by slightly manipulating water temperatures in the hatchery. In order to avoid trapping large numbers of hatchery fry, we chose not to operate the trap during nights that fry were released at the Riviera site. Due to the high flows and the proximity of this release location to the trap, we assumed that all of the fry survived to the trap. Fry caught in the trap during the night of and the nights following Landsburg releases were randomly sampled for thermal marks to determine the proportion of hatchery fish present.

Over the 84 nights trapped, 1.9 million sockeye fry were captured. From this catch and the capture efficiency data, we estimated a total of 42.3 million wild and hatchery sockeye fry entered Lake

Washington in 2003. Based on otolith analysis and the hatchery release figures, we estimated that this total included 27.9 million wild fry and 14.4 million hatchery produced fry. Average survival to the trap of the 11.5 million hatchery fry released upstream of the trap was estimated at 86%. Fry released at the Landsburg Hatchery, located 21 miles upstream, survived at an average rate of 79%. Middle River releases, 13 miles upstream of the trap, averaged 80% survival. Fry released at the Riviera site, located one mile above the trap, survived at an average rate of 105%.

Migration timing for wild fry was nearly two weeks earlier than the average for the eleven broods measured thus far. February temperatures and flows explain most of the variation in median migration dates between years. Median migration date for hatchery fry was February 21, and that of wild fry was March 8.

Survival from egg deposition to lake entry of wild fry was estimated at 6.2%. This rate is the ratio of 27.9 million wild fry to an estimated deposition of 448 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, we expanded the existing sockeye fry monitoring program in 1999 to include an assessment of the natural chinook production in the Cedar River. The gear we operate each year starting in January to assess sockeye fry production also captures chinook fry. To capture the larger, later migrating chinook, which we classify as "smolts", we installed a screw trap at R.M. 1.1, and operated it until July.

Juvenile chinook production was estimated through applying capture rate estimates to 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 fry. 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 235,397 in 2003. Timing was bi-modal with fry emigrating in January through April 15 comprising over three-fourths (194,135) of the total migration. The smolt migration, April 16 through July, was estimated at 41,262. Egg-to-migrant survival was estimated at 18.6%. Over the season, age 0+ chinook increased in size from less than 40 mm in January to over 100 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 and cutthroat smolts at 74,507, 525 and 900, respectively.

Bear Creek

We installed the fry trap on Big Bear Creek 100 yards downstream of the Redmond Way Bridge and operated it from February 6 through April 8. On April 9, we replaced it with a screw trap that fished until the morning of July 8. Using the approach described for the Cedar River, we estimated downstream migrant production of sockeye fry, chinook, coho, steelhead, and cutthroat smolts.

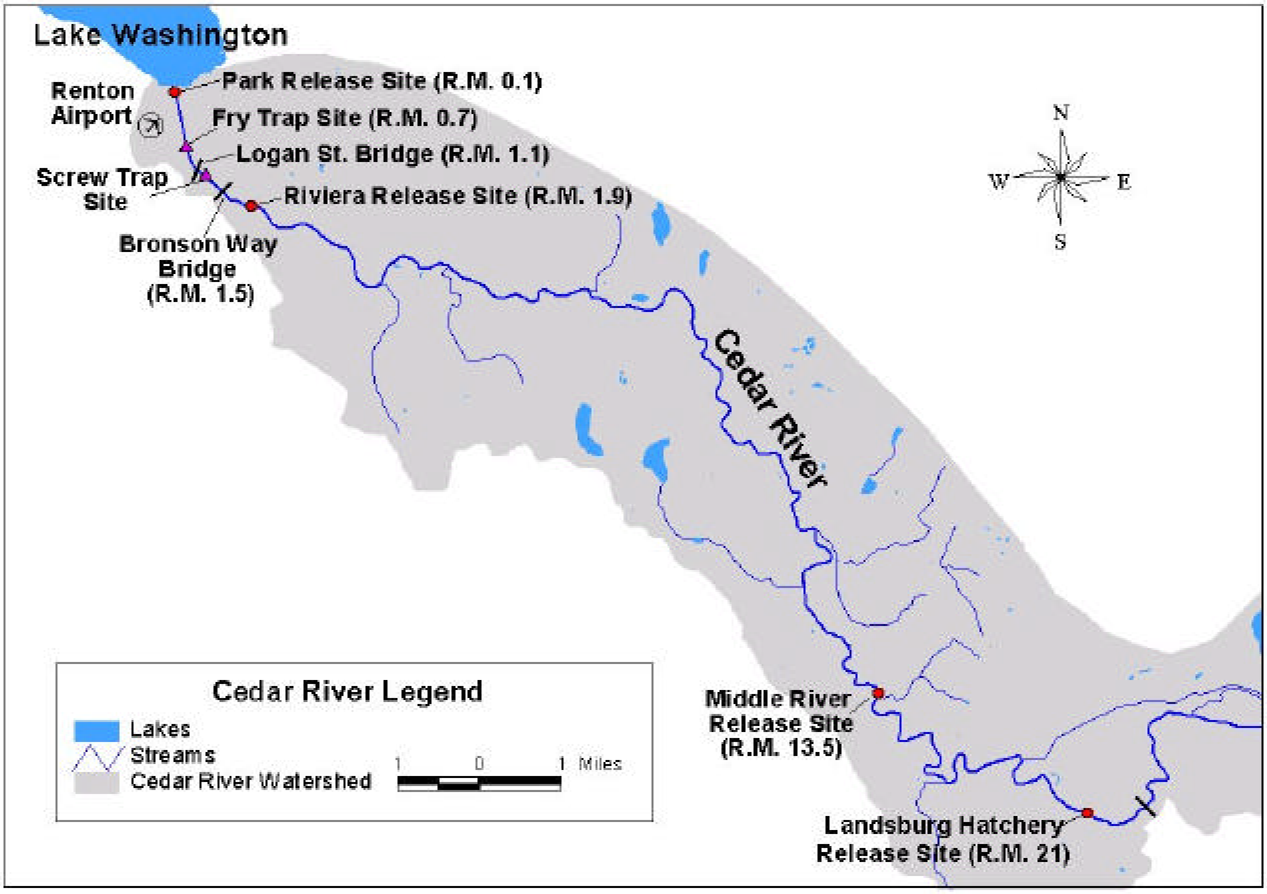

Figure 1. Site map of the lower Cedar River watershed depicting the fry and screw trap locations, hatchery sockeye release sites, and trap efficiency test release sites for the 2003 trapping season.

Throughout the fry trapping season, 40 efficiency tests were conducted using sockeye fry. Capture rates ranged from 6.8% to 31% and averaged 18.8%. Total sockeye production was estimated at 2.0 million fry. This estimate is the result of applying the average capture rate to the expanded catches and estimating migration before and after trap operation using linear extrapolation.

Migration of chinook during fry trap operation was estimated using the average efficiency measured with sockeye fry. During screw trap operation, 21 tests were conducted with chinook smolts, and capture rate averaged 49.1%. Total production of age 0+ chinook was estimated at 17,313 in 2003. Migration timing was bimodal, however most chinook migrated as smolts in May and June. Chinook fork lengths were less than 40 mm in February, and grew slightly larger than 90 mm by late June.

Coho production was estimated at 48,561 smolts and cutthroat production at 3,708 smolts. During the 2003 trapping season, no steelhead were caught in the Bear Creek screw trap.

INTRODUCTION

Adult sockeye salmon returns to the Lake Washington system have declined from peak runs in excess of 600,000 fish as recently as 1988, to under 100,000 fish in subsequent years. In 1991, a broad-based group was formed to address this decline. Resource managers developed a program to investigate the cause(s) of the sockeye decline through research and population monitoring in combination with an artificial production program. Information generated by these efforts 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 11.4%, 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, however, survival during the freshwater phase declined.

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 in defining possible causes for population declines. In 1992, we developed the trapping gear and methodology to estimate wild and hatchery sockeye fry production from the Cedar River and began monitoring. Monitoring sockeye fry production in the Sammamish Slough began in 1997 and since 1999 has continued in Bear Creek.

The Puget Sound Chinook ESU was listed under the Endangered Species Act as a threatened species in March 1999 by the National Marine Fisheries Service. 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 also includes passage through the lake, Ship Canal, Locks as well as 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. To estimate total production for the season we employed two different gear types. A small scoop trap was used in late winter/early spring to capture smaller newly emerged migrants (fry). Later in the season (beginning in April) a rotary screw trap was used to capture larger migrants (smolts) that reared upstream for several weeks following emergence and were able to avoid the scoop trap.

Cedar River

Since 1992, we have operated a downstream migrant scoop trap in the lower Cedar River to evaluate the production of wild and hatchery sockeye fry (Seiler *et al*. 2002). Production of sockeye fry at the Landsburg Hatchery on the Cedar River began with the 1991 brood. This brood, released in 1992, and all subsequent sockeye incubated at this hatchery, has been identified with thermally-induced otolith-marks (Volk *et al.* 1990). In 1995, we evaluated the effect of flow on survival using ten hatchery groups released 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, over the eleven broods measured that the 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 (Seiler *et al.* 2001). Therefore, over the range of spawning population levels we have thus far evaluated, the numbers of naturally produced sockeye fry entering Lake Washington are the product of the number of eggs deposited and the flow-affected survival rate.

In the summer of 1998, the lower Cedar River was dredged to reduce the flooding potential (USACOE 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 in 1999 and 2000. In addition, we expanded the trapping program 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 we operated a different gear type (a screw trap) in faster water. Concurrent operation of the fry and screw traps assessed the capture and size biases of each trap.

Bear Creek

In 1997 and 1998, we operated a downstream migrant trap 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 accomplished its goal of estimating 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, Bear Creek is the most heavily spawned tributary in the Sammamish watershed. Therefore, we elected to move the downstream migrant trapping operation in 1999 to the lower end of this stream where velocities were adequate. In addition to estimating chinook and sockeye production, operating the trap in high enough velocity to capture coho, steelhead and cutthroat smolts enabled estimating their production from Bear Creek as well.

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.** Estimating the combined survival through the lake, the Ballard Locks, and the marine environment via relating subsequent adult returns to a brood's juvenile production.
4. **Tag wild chinook.** As part of the multi agency study to assess survival of juvenile salmon through the lake system, wild chinook emigrating from the Cedar River and Bear Creek were injected with PIT tags.

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.
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 survival of hatchery fry by release group (Cedar River).** Correlating in-river survival of hatchery fry release groups with release location, timing, flow and total fry abundance will help explain the effects of habitat and environmental conditions on the in-river predation rates of hatchery and wild fry.
4. **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.
5. **Develop migration timing of wild and hatchery fry.** Comparison of the timing difference between wild and hatchery fry with subsequent survival to return rates will contribute to the adaptive management process guiding Cedar River sockeye production.

Coho, Steelhead, and Cutthroat

Quantifying the annual production of these smolt populations will measure the ecosystem health of the Cedar River and Bear Creek. Population levels and ratios between these species are indicative of habitat condition and performance of fisheries management.

METHODS

Trapping Gear and Operation

Cedar River

Fry (Scoop) 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 40x15 ft steel pontoon barge. 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.

The scoop trap operated through most nights from mid-January to May. Trapping began before dusk and continued past dawn. Trapping also occurred during a few daylight intervals. Captured fish were removed from the trap and counted each hour. Large sockeye fry catches were counted using an electronic counter. Calibration of this counter on March 3, 2003 determined that it counted 95.7% of the actual number of fish passing through it.

On nights that sockeye hatchery fish were released, a sample of the catch was collected for otolith analysis. To insure that the samples were not biased by differences in migration timing between wild and hatchery fry, we retained a constant proportion of each hour's catch over the entire night. Each morning, we gently stirred the retention tank to thoroughly mix the fry, and then we collected 155 fry that we placed in a labeled jar of alcohol.

Over the season, 15,977,000 hatchery-produced fry were released into the Cedar River (Table 1). Twenty-eight percent of this production (4,431,000) was released below the trap at the Cedar River Trail Park, 31% (4,905,000) was released directly from the hatchery at Landsburg, 21% (3,362,000) was transported downstream and released mid-river at R.M. 13.5, and 20% (3,279,000) was transported to the lower river and released at the Riviera Apartments site at R.M 1.9. Releases at Landsburg occurred on 11 nights, from January 30 to March 13. Mid-river releases occurred on eight nights between January 24 and April 3. Fry were released at the Riviera site on seven nights, between February 10 and March 11. Releases below the trap occurred on four nights, between February 12 and March 18. Sizes of groups released above the trap ranged from 40,000 to 721,000 fry. Hatchery fry were identified by twelve otolith codes: early, middle, and late from each of the four release sites.

Screw Trap

We used 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 the previous three seasons, we positioned this trap at RM 1.1, just upstream of the Logan Street Bridge near the right bank. This location is the lowest site with sufficient velocity. Screw trap operation began in mid-April and continued through mid-July. The catches were enumerated at dusk and in the early morning in order to discern diel movements. In May, we began to lift the trap during the daylight hours to avoid any potential hazard to recreational floaters using the river. By design, this trap allowed sockeye fry to escape from the live-box. 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 at four locations, Cedar River 2003.

Release Timing	Release Date	Riviera	Middle	Landsburg	Below Trap
Early	01/24		396,000		
	01/29		590,000		
	01/30			303,000	
	02/03			579,000	
	02/05			509,000	
	02/10	534,000			
	02/11	409,000			
	02/12				1,217,000
	02/13	527,000			
	02/18				1,178,000
Middle	02/19			506,000	
	02/20			630,000	
	02/21			540,000	
	02/24			274,000	
	02/25		525,000		
	02/26		577,000		
	02/27	430,000			
	03/03				871,000
	03/04	478,000			
Late	03/05			619,000	
	03/07		721,000		
	03/10	598,000			
	03/11	303,000		290,000	
	03/12			307,000	
	03/13			348,000	
	03/17		307,000		
	03/18				1,165,000
	03/21		206,000		
	04/03		40,000		
Total		3,279,000	3,362,000	4,905,000	4,431,000

Bear Creek

Fry Trap

We started the trapping season in Bear Creek with a low-angle inclined-plane screen trap (3 ft wide by 9 ft long). This gear was suspended from a 30x15 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 late January and ended mid-April. On nearly every date the trap was operated, we began trapping 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 mid-April we replaced the fry trap with a 5 ft diameter screw trap. Screw trap operation began in mid-April, and continued through mid-July. 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

We estimated the capture rate for sockeye fry in the Cedar River fry trap by releasing marked sockeye fry at the Logan Street Bridge (R.M. 1.1) over a number of nights throughout the season. On most such nights we released 3,000 sockeye fry. 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 usually equally distributed between left bank, mid-channel, and right bank release points from the bridge. When fewer fish were being released, the marked fry were released from the mid-channel point only or the left and right bank points. Pooled (left bank, mid-channel, and right bank) group recovery 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 and coho smolts. Groups of 30 or more smolts of each species were anesthetized in a solution of MS-222 and marked with variations of partial upper and lower caudal fin clips. Smolts were marked in the morning, and allowed to recover from the anesthetic during the day in flow through buckets suspended in calm river water. In the evening, the groups were released from the Bronson Way Bridge located one-half mile upstream. In the morning, the catch was examined for marks. Recapture rates were correlated with mean daily discharge to assess the effect of flow on capture rate.

Bear Creek

Fry Trap

In Bear Creek, we estimated the fry trap capture rate for sockeye by releasing groups of marked sockeye fry approximately 30 yards upstream of the trap on a number of nights over 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). 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 and coho smolts on a number of days over the season. Groups of smolts of each species were anesthetized in a solution of MS-222 and marked with partial caudal fin clips. The smolts were marked in the morning, and allowed to recover from the anesthetic during the day. In the evening, the groups were released from the Redmond Way Bridge or 30 yards upstream of the trap. Recapture rates were correlated with mean daily discharge to assess the effect of flow on capture rate.

Production Estimation

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 - $\hat{e}_i$.

Sockeye

Sockeye fry catch was estimated for nighttime periods when the 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);

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

where;

$$n = \textit{Number of sample nights used in the interpolation,}$$
$$\hat{C}_i = \textit{Nightly catch estimates used to estimate the un-fished interval, and}$$
$$\overline{C} = \textit{Interpolated nightly catch estimate.}$$

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;

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

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) was (were) estimated by;

Equation 3

$$\hat{C}_u = T_u \overline{R}$$

where;

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

The variance was estimated by;

Equation 4

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

where;

$$V(\overline{R}) = \textit{The variance of the mean catch rate from adjacent fished periods.}$$

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.

Once total nightly catch was estimated, wild and hatchery catch components were estimated. Otolith sampling was used to estimate hatchery catch during most nights. The proportion of sockeye hatchery fry by release group in the nightly catch $(\hat{p}_{hi})$ was estimated using the number of otolith-marks (m_{hi}) observed in the nightly sample (o_i) by;

$$\hat{p}_{hi} = \frac{m_{hi}}{o_i} \qquad \textbf{Equation 5}$$

and its variance by;

$$Var(\hat{p}_{hi}) = \frac{\hat{p}_{hi}(1-\hat{p}_{hi})}{o_i} \qquad \textbf{Equation 6}$$

The number of hatchery group h caught on night i was estimated by;

$$H_{hi} = \hat{C}_i \hat{p}_{hi} \qquad \textbf{Equation 7}$$

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

$$Var(H_{hi}) = Var(\hat{C}_i)\,\hat{p}_{hi}^{\,2} + \hat{C}_i^{\,2}\,Var(\hat{p}_{hi}) - Var(\hat{p}_{hi})Var(\hat{C}_i) \qquad \textbf{Equation 8}$$

The total number of hatchery fry caught on night i and the variance of the estimate were calculated by modifying Equations 7 and 8, respectively. The modifications involved substituting the proportion of hatchery fry from all groups in the nightly catch, $\hat{p}_i$, and the variance of this proportion, $Var(\hat{p}_i)$, for the proportion of hatchery fry from each release group, $\hat{p}_{hi}$, and its variance, $Var(\hat{p}_{hi})$, respectively.

Otolith sampling was used to estimate the composition of sockeye hatchery fry in catches during the nights of releases and following the nights of Landsburg releases. Where otolith samples were not available, interpolation was used to estimate nightly wild catch based on the wild catch estimates from the preceding and following nights. The estimate of nightly wild fry catch was then subtracted from the estimated total nightly catch to estimate the nightly hatchery fry catch. Migrations from the two releases were estimated by using the average survival rate measured by otolith sampling for the corresponding release site. The variances of those nights were estimated by modifying Equation 1; replacing C_i with s_i, where s_i is survival of the hatchery group released during night i. Migrations of Riviera releases when we did not fish the trap were estimated by assuming 100% survival due to the proximity of the releases to the trap. No variances were calculated for those estimates.

When wild sockeye fry catch required interpolation for only a single night, straight-line interpolation was used, therefore the variance for the nightly wild fry catch estimate was found by using Equation 1, substituting $Var(W_i)$ for $Var(C_i)$. Hatchery catch was then estimated by subtracting the estimated nightly wild fry catch estimate from the total nightly catch. The variance for the hatchery catch estimate, $Var(\hat{H}_{hi})$, was found by summing the total nightly catch estimate and the wild catch estimate variances.

Where the nightly wild catch estimate was interpolated for two or more consecutive nights, the variance for each interpolated catch estimate was estimated by scaling the CV of the mean catch from adjacent nights by the interpolated catch estimates using Equation 2.

In order to estimate total sockeye migration, daytime catches were estimated. Daytime catch was estimated using the average day catch rate to night catch rate ratio ($\overline{Q}$) based on trap operations conducted in 2003. Daytime catch (C_d) was calculated by multiplying the nighttime catch estimate by the proportion (F_d) of the 24-hour catch caught during daylight. The proportion of the sockeye catch caught during daytime interval *d* was estimated by;

$$F_d = \frac{T_d}{\frac{1}{\overline{Q}}T_n + T_d} \qquad \textbf{Equation 9}$$

and its variance by;

$$Var(F_d) = \frac{V(\overline{Q})\,T_d^{\,2}\,T_n^{\,2}}{\overline{Q}^4\left(\frac{1}{\overline{Q}}T_n + T_d\right)^4} \qquad \textbf{Equation 10}$$

where,

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

Daytime catch was estimated by applying the estimated proportion caught during day to the nighttime catch. The variance for each daytime catch was estimated using the delta method (Goodman 1960);

$$Var(\hat{C}_d) = \hat{C}_i^{\,2}\,Var(F_d) + Var(\hat{C}_i)\,F_d^{\,2} - Var(\hat{C}_i)\,Var(F_d) \qquad \textbf{Equation 11}$$

To assess the relationship between trap efficiency and stream flow over the season we used linear regression analysis. Where the linear regression was used to predict daily efficiency, the variance of the daily migration estimates were calculated by;

$$Var\left(\frac{C_i}{\hat{e}_i}\right) = \frac{Var(C_i)}{\hat{e}_i^{\,2}} + \left(\frac{C_i}{\hat{e}_i^{\,2}}\right)^2 M\hat{S}E\left(1 + \frac{1}{n} + \frac{(flow_i - fl\overline{o}w)^2}{(n-1)s_f^{\,2}}\right) \qquad \textbf{Equation 12}$$

Due to the dependence of each estimated daily efficiency on the same linear regression equation, covariance between daily migration estimates were calculated by;

$$Cov\left(\frac{C_i}{\hat{e}_i},\frac{C_j}{\hat{e}_j}\right)=\frac{C_i}{\hat{e}_i^{\,2}}\frac{C_j}{\hat{e}_j^{\,2}}\left[Var(\hat{a})+flow_i flow_j Var(\hat{b})\right]$$ **Equation 13**

Where flow was not found to be a significant predictor of trap efficiency, the mean of all the season's trap efficiency tests was used;

$$\bar{e}=\frac{\sum_{i=1}^{n}\hat{e}_i}{n}$$ **Equation 14**

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

$$Var(\hat{e}_i)=\frac{\hat{e}_i(1-\hat{e}_i)}{n}$$ **Equation 15**

$$Var(\bar{e})=\frac{\sum(\hat{e}_i-\bar{e}_i)^2}{n(n-1)}$$ **Equation 16**

Daily sockeye fry migrations were estimated by;

$$\hat{N}=\frac{(\hat{C}_i+\hat{C}_d)}{\bar{e}}$$ **Equation 17**

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

$$Var(\hat{N})=\hat{N}^2\left(\frac{Var(\bar{e})}{\bar{e}^2}+\frac{\left(Var(\hat{C}_i)+Var(\hat{C}_d)\right)}{(\hat{C}_i+\hat{C}_d)^2}\right)$$ **Equation 18**

When multiple flow efficiency strata were used, the migration estimate and variance for the strata were estimated using Equations 17 and 18, substituting the total catch over the stratum for daily catches in both equations. Season total migration and variance were estimated by summing the migration and variance estimates for each flow strata. Where trap efficiency was calculated using a simple mean efficiency over the season, the total migration and its variance were calculated using Equations 17 and 18, substituting the season total catch for the daily catches in both equations.

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).

The severity of peak flow during sockeye egg incubation had been found to explain most of the inter-annual variation in egg-to-migrant survival between the previous 11 broods of Cedar River sockeye. A number of regression equations were used to evaluate this relationship once the 2002 brood natural fry production estimate was added to the dataset.

Chinook
Estimation of juvenile chinook migration followed similar procedures to that of the sockeye fry migration estimate described above. 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), therefore the variance for this estimate was calculated by;

$$Var(\hat{C}_i) = T_u^{\,2} \frac{\sum(\hat{R}_i - \overline{R}_i)^2}{n(n-1)} \qquad \textbf{Equation 19}$$

Wild chinook fry 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 based from trap operations conducted in 2003. The catch during daytime d was estimated by;

$$\hat{C}_d = \overline{Q}\,\overline{R}_i\,T_d \qquad \textbf{Equation 20}$$

and its variance was estimated by;

$$Var(\hat{C}_d) = T_d^{\,2}\left(Var(\overline{R}_i)\,\overline{Q}^2 + Var(\overline{Q})\,\overline{R}_i^{\,2}\right) \qquad \textbf{Equation 21}$$

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.*

Daily chinook fry migration was estimated by using Equation 17. The total season migration was estimated by summing the daily migration estimates. The chinook fry season migration variance was estimated using Equations 12 and 13 when trap efficiency was predicted using a linear regression.

In addition to estimating migration during the interval of trap operation, since initial catches indicated that the chinook migration was underway when trapping began, we approximated the migration occurring before fry trap operation began. Linear extrapolation was used to estimate migration from January 1 to January 20. The variance was calculated by interpolating between the coefficients of variation.

Screw Trap
For nighttime intervals not fished and during nights when heavy debris decreased the fishing ability of the trap we estimated catch for the hours missed by applying catch rates interpolated from the preceding and following nighttime intervals trapped. Variances for these estimates were calculated using Equation 19. Daytime intervals not fished were estimated with Equation 20, and its variance by Equation 21.

As with the fry trap, the effect of flow on measured capture rates was assessed using linear regression analysis. Where flow did not appear to explain variation in trap efficiency, the mean capture rate from all efficiency tests was used to estimate migration for each species. If a temporal trend was observed, efficiency strata were developed to best represent actual capture rates. Variances were calculated for the individual efficiency tests using Equation 15, and the mean trap efficiency using Equation 16. Equation 17 was used to estimate daily migration, and Equation 18 was used to estimate daily and total season variances of the migration estimates when using average efficiency.

Estimating the production of steelhead smolts and cutthroat trout involved approximating a season average capture rate since catches of these migrants were insufficient for directly assessing capture rate via mark and recapture. Instead, we used a reduced capture rate, estimated from previous studies, relative to that measured with coho smolts.

Bear Creek

Fry Trap

Estimation of total sockeye and chinook fry migrations followed the same steps as described for the Cedar River. Where flow significantly explained variation in trap efficiency, a linear regression was developed to predict daily efficiencies. Where flow appeared to marginally affect efficiency, flow strata were developed and the mean of the trap efficiency tests conducted within those flows were used to estimate migration. If flow did not appear to explain variation, the average trap efficiency was used (Equation 14) and its variance was calculated using Equation 16. Nightly migration was estimated using Equation 17, and the variance using Equation 18. Day catch during fry trap operation was minimal, and therefore not estimated. When trapping did not occur every night, interpolation was used to estimate the migration during un-fished nights and the nightly variance was calculated using Equation 1. The in-season production estimate was the sum of the nightly migration estimates, and the variance was estimated using Equation 18, substituting the total season catch for the nightly catch.

Screw Trap

Estimation of sockeye fry, chinook, coho, and cutthroat trout migrations occurred in several steps. The data collected every night consisted of the same as that collected at Cedar River. Trap efficiency was estimated using the same methods as the fry trap. Nightly migration was estimated using Equation 17, and the variance using Equation 18. The trap operated continuously; therefore, catch did not need to be estimated. The in-season production estimate was the sum of the nightly migration estimates. The variance of the total migration was estimated using Equation 18, substituting the total season catch for the nightly catch, when the season trap efficiency average was used to estimate migration.

CEDAR RIVER RESULTS

Sockeye

Trap Operation

Trap operation began on January 21, and continued every other night until February 2. The trap then fished every night until April 3 except on the Riviera release nights of February 10, February 13, February 27, March 4, and March 10. After April 3, trapping occurred on 22 nights until the last day of trapping on May 31. Five daytime trapping intervals were fished, occurring on a weekly or bi-weekly basis starting on February 7 and ending on March 20.

There were 22 nights when we did not fish continuously through the night due to heavy debris and high flows. During those nights, the hour trapping intervals were reduced to 5, 10, 15, 20 or 30 minutes.

Catch

During the first night of trapping (January 21), we caught 8,366 sockeye fry (Appendix A). Catches increased thereafter to peak at 109,807 wild and hatchery fry on February 21. On this night high water prevented continuous trapping. We estimated an additional 28,889 fry would have been caught had we fished continuously through the night. Catches decreased thereafter and on our last day of trapping, May 31, we caught 923 fry. Our combined nightly catches of wild and hatchery fry for the season totaled 1,897,583, and day catches totaled 2,310 fry. Twenty-two nights were expanded to represent entire nights fished, which added an additional 451,268 fry. Adding the catch estimates for the 47 nights not fished during the trapping season, the nightly catches would have totaled 3,198,245 wild and hatchery fry.

Trap Efficiency

Tests to determine the capture efficiency of the trap were conducted on 33 nights from January 23 to May 12. Recapture rates ranged from 4.9% to 12.1% and averaged 8.8% (Table 2). Linear regression was used to evaluate the relationship between capture efficiency and daily average flow, and a significant correlation was found ($r^2=0.47$, $p<0.001$) (Figure 2). We used this strong relationship to predict daily trap efficiency based on the daily average flow. Flows ranged from 402 to 1,570 cfs on the nights that efficiency tests were conducted and ranged from 332 to 1,880 cfs over the entire trapping period.

Table 2. Trap efficiency tests using sockeye fry released from the Logan Street Bridge, Cedar River scoop trap 2003.

Date	Flow (cfs)	Released	Recaps	Efficiency	Var(e)
01/23	619	2,140	226	10.6%	4.4E-05
02/06	1,140	2,297	154	6.7%	2.7E-05
02/08	801	1,492	120	8.0%	5.0E-05
02/12	491	3,104	232	7.5%	2.2E-05
02/14	471	4,620	463	10.0%	2.0E-05
02/17	404	3,024	297	9.8%	2.9E-05
02/19	386	3,019	366	12.1%	3.5E-05
02/23	774	3,021	349	11.6%	3.4E-05
02/25	918	3,126	343	11.0%	3.1E-05
02/26	933	2,079	222	10.7%	4.6E-05
02/28	862	3,017	281	9.3%	2.8E-05
03/01	728	3,027	359	11.9%	3.5E-05
03/02	591	2,509	269	10.7%	3.8E-05
03/05	548	3,124	327	10.5%	3.0E-05
03/17	1,419	3,120	226	7.2%	2.2E-05
03/18	1,440	3,017	279	9.2%	2.8E-05
03/21	1,250	2,546	177	7.0%	2.5E-05
03/23	1,270	3,133	211	6.7%	2.0E-05
03/24	1,130	3,019	273	9.0%	2.7E-05
03/29	1,590	1,587	100	6.3%	3.7E-05
03/30	1,570	1,185	58	4.9%	3.9E-05
03/31	1,670	2,371	165	7.0%	2.7E-05
04/05	1,620	2,493	146	5.9%	2.2E-05
04/07	1,540	2,750	153	5.6%	1.9E-05
04/11	1,090	2,568	258	10.0%	3.5E-05
04/13	1,190	2,134	162	7.6%	3.3E-05
04/15	1,030	1,959	181	9.2%	4.3E-05
04/17	1,050	2,666	213	8.0%	2.8E-05
04/19	883	2,113	216	10.2%	4.3E-05
04/21	746	3,096	286	9.2%	2.7E-05
04/26	638	2,502	217	8.7%	3.2E-05
04/29	455	2,303	207	9.0%	3.6E-05
05/12	401	1,412	116	8.2%	5.3E-05
Average				8.8%	
Variance				1.1E-05	
n				33	

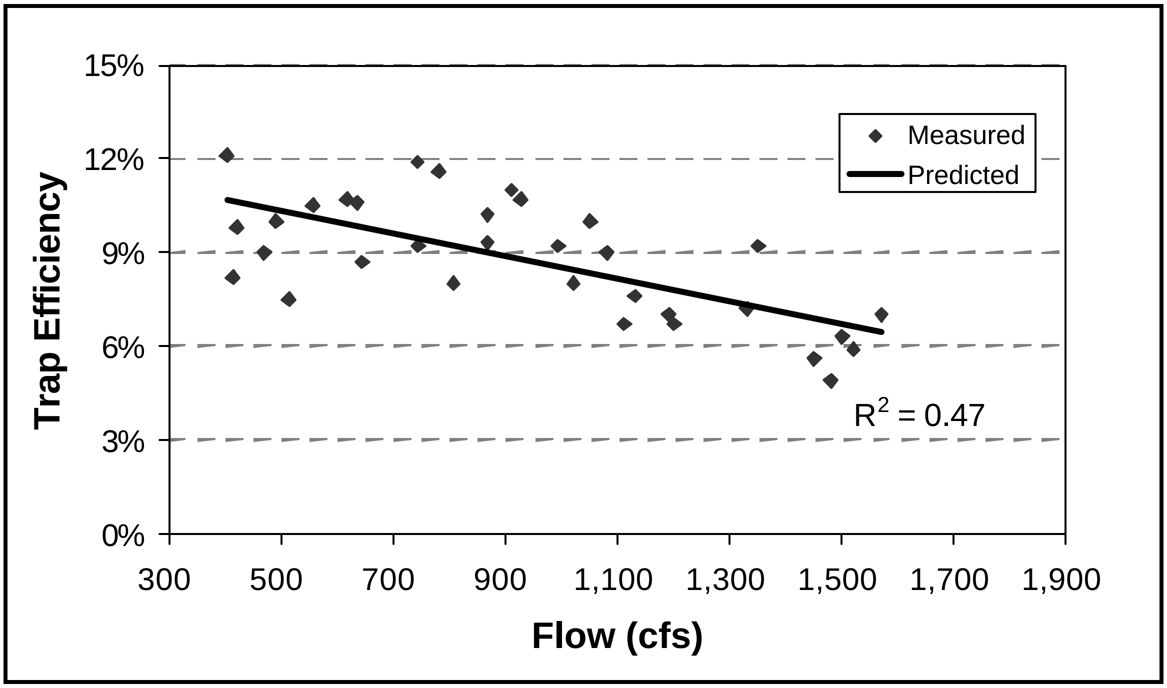

Figure 2. Linear relationship between trap efficiency tests using sockeye fry and daily average flow, Cedar River scoop trap, 2003.

Otolith Sampling

Otolith samples were collected on 21 nights that hatchery fry were present (Table 3). Sampling did not occur on nine hatchery release nights: Landsburg releases on January 30 and February 3, Mid-River releases on January 24 and March 17, and five Riviera releases on February 10, 13, 27, March 4 and 10. Over the 21 nights sampled, hatchery-produced fry comprised 40% of the 3,150 sockeye otoliths that were analyzed. The incidence of hatchery fry in samples collected during release nights ranged from 11.3% to 86.7% for Landsburg releases, 14.7% to 69.3% for Mid-River releases, and 23.3% to 82.7% for Riviera releases.

Otolith sampling on February 19 found two fry that were marked for release at the park below the trap. We surmise that these fish were mismarked or inadvertently released above the trap with another group.

Diel Migration

While the vast majority of sockeye fry migrate at night, daytime trapping indicated a small proportion of the migration occurred during the daylight. Over the five dates that we trapped during daylight intervals, the day to night catch rate ratios ranged from 0.34% to 3.88% (Table 4). Flows on these dates ranged from 629 to 1,220 cfs. The average D:N ratio (1.6%) was used to estimate daytime migrations for wild fry and hatchery fry for days following Mid-River and Landsburg hatchery releases. Hatchery day migrations following Riviera hatchery releases were not expanded due to their rapid movement downstream.

Table 3. Sockeye fry otolith sampling results, Cedar River 2003.

Sample Date	Number Marked	Percent Marked	Variance	Release Code	Release Location
01/29	104	69.3%	0.001417	E2	MID-RIVER
02/04	2	1.3%	0.000088	E1	LANDSBURG
02/05	130	86.7%	0.000770	E1	LANDSBURG
02/06	4	2.7%	0.000173	E1	LANDSBURG
02/11	124	82.7%	0.000955	E3	RIVIERA
02/19	1	0.7%	0.000044	E3	RIVIERA
	51	34.0%	0.001496	M1	LANDSBURG
	2	1.3%	0.000088	M8	PARK
02/20	68	45.3%	0.001652	M1	LANDSBURG
02/21	63	42.0%	0.001624	M1	LANDSBURG
02/22	3	2.0%	0.000131	M1	LANDSBURG
02/24	77	51.3%	0.001665	M1	LANDSBURG
02/25	2	1.3%	0.000088	M1	LANDSBURG
	102	68.0%	0.001451	M2	MID-RIVER
02/26	103	68.7%	0.001434	M2	MID-RIVER
03/05	42	28.0%	0.001344	L1	LANDSBURG
	3	2.0%	0.000131	M3	RIVIERA
03/06	40	26.7%	0.001304	L1	LANDSBURG
03/07	88	58.7%	0.001617	L2	MID-RIVER
03/11	6	4.0%	0.000256	L1	LANDSBURG
	35	23.3%	0.001193	L3	RIVIERA
03/12	17	11.3%	0.000670	L1	LANDSBURG
03/13	110	73.3%	0.001304	L1	LANDSBURG
03/14	1	0.7%	0.000044	L1	LANDSBURG
03/21	62	41.3%	0.001617	L2	MID-RIVER
04/03	22	14.7%	0.000834	L2	MID-RIVER

Table 4. Day:night catch rate ratios of sockeye fry estimated using the night before and the night after the daytime interval, Cedar River scoop trap, 2003.

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)
02/06	18:00	14.50	9,824	677.5	02/07	7:30	9.50	58	6.11	1.00%	944
02/07	17:00	14.50	7,859	542.0							
		29.00	17,683	609.8							
02/20	17:30	14.00	58,249	4,160.6	02/21	7:30	10.50	991	94.38	1.28%	569
02/21	18:00	8.75	109,807	12,549.4							
		22.75	168,056	7,387.1							
02/25	18:00	13.00	71,868	5,528.3	02/26	7:00	11.00	208	18.91	0.34%	927
02/26	18:00	13.00	73,704	5,669.5							
		26.00	145,572	5,598.9							
03/05	18:00	13.00	72,198	5,553.7	03/06	7:00	11.00	574	52.18	1.23%	629
03/06	18:00	13.00	37,892	2,914.8							
		26.00	110,090	4,234.2							
03/19	18:00	12.50	14,514	1,161.1	03/20	6:30	11.50	479	41.65	3.88%	1,220
03/20	18:00	13.00	12,861	989.3							
		25.50	27,375	1,073.5							
				Average						1.55%	
				Variance						3.7E-05	

Production Estimate

We estimated 42.3 million sockeye fry entered Lake Washington from the Cedar River in 2003 (Table 5, Figure 3, Appendix A). The total included 27.9 million wild fry and 14.4 million hatchery-produced fry. To estimate fry migration before and after trapping, we selected migration starting and ending dates of January 1 and July 1. Logarithmic extrapolation from January 1 to January 21 and linear extrapolation from May 29 to July 1 resulted in estimates of 402,000 and 172,000 wild fry, respectively. These components accounted for 2% of the total wild estimate.

Table 5. Estimated 2003 Cedar River wild and hatchery sockeye fry migrations entering Lake Washington with 95% confidence intervals.

Component	Period	Dates	Estimated Migration	95% CI Low	95% CI High	Percent Standard Error	Prop. of Total
Wild	Before Trapping	January 1 - 21	402,353	171,519	633,187	29.3%	1.0%
	During Trapping	January 21 - May 29	27,287,185	20,374,951	34,199,419	12.9%	64.5%
	After Trapping	May 29 - July 1	171,585	59,892	283,278	33.2%	0.4%
		Wild Subtotal	27,861,123	20,944,134	34,778,112	12.7%	65.9%
Landsburg	During Trapping	January 30 - March 13	3,854,139	2,529,014	5,179,264	17.5%	9.1%
Middle	During Trapping	January 24 - April 7	2,683,719	2,017,155	3,350,283	12.7%	6.3%
Riviera	During Trapping	February 10 - March 11	3,445,914			n/a	8.2%
Below Trap	During Trapping	February 12 - March 18	4,431,000	4,431,000	4,431,000	0.0%	10.5%
		Hatchery Subtotal	14,414,772			n/a	34.1%
		Season Total	42,275,895			n/a	100.0%

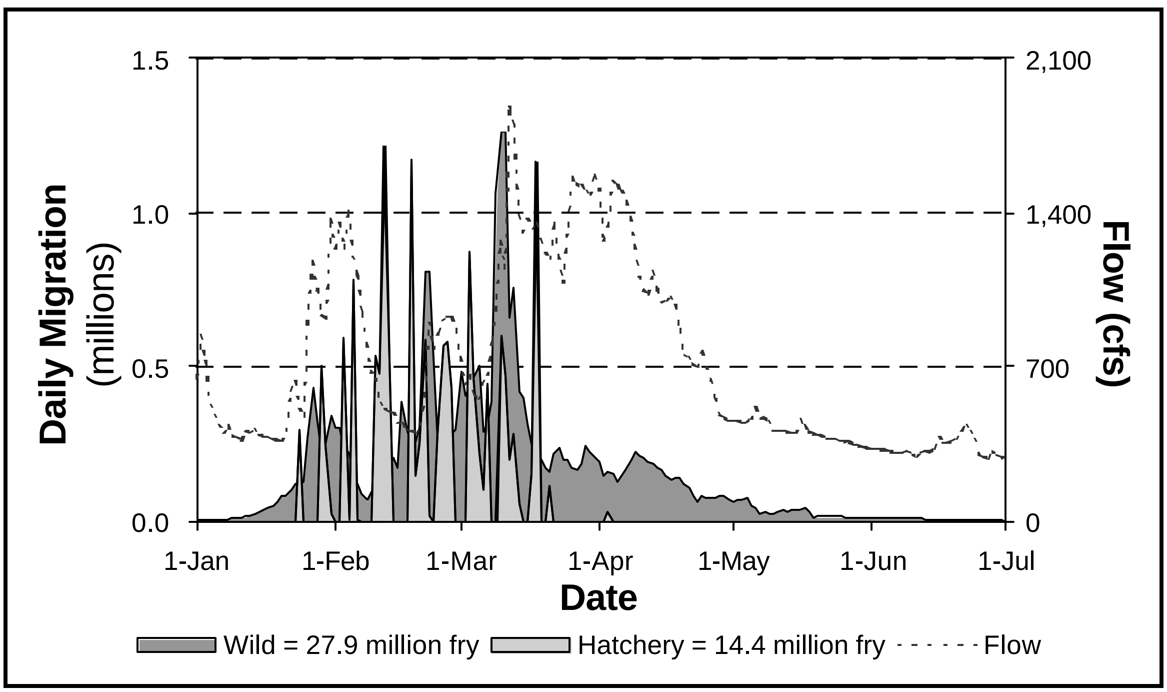

Figure 3. Estimated daily migration of wild and hatchery Cedar River sockeye fry into Lake Washington and flow, 2003.

Wild and Hatchery Timing

Releases of hatchery-produced fry began on January 24 and continued through April 3 (Table 1, Figure 4). The wild fry migration was under way when we began trapping on January 21, peaked during mid March, and declined through late March to low levels by late May when we stopped trapping. Median migration dates for hatchery and wild fry occurred on February 21 and March 8, respectively (Table 6).

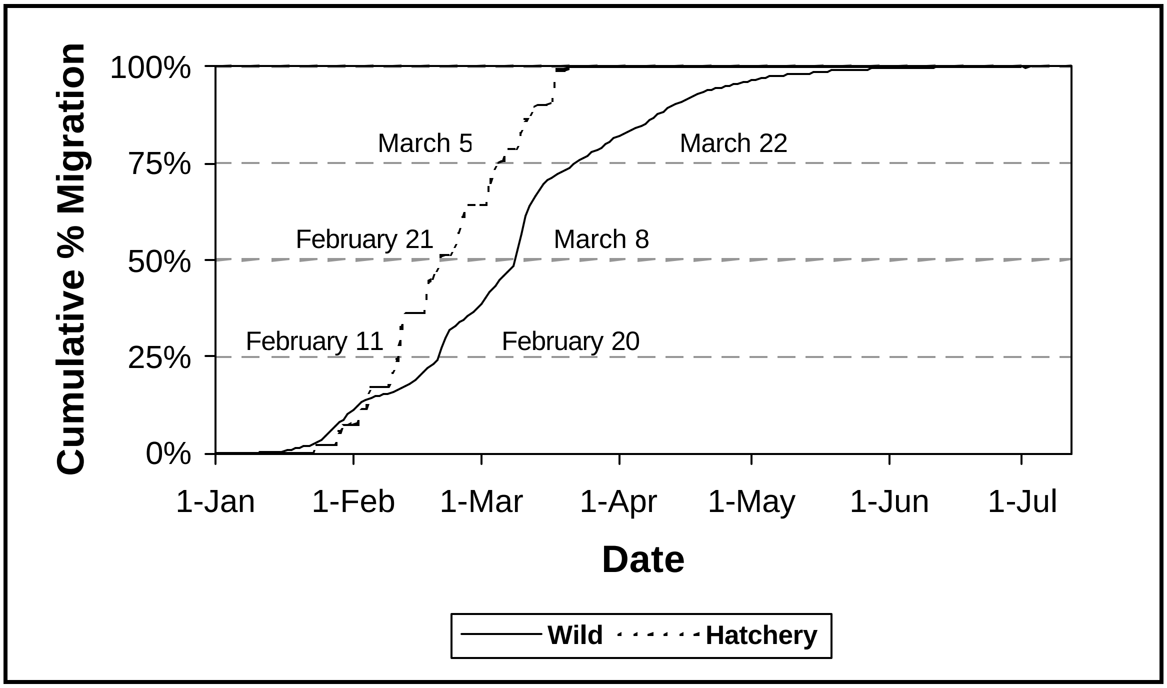

Figure 4. Cumulative wild and hatchery sockeye fry migration timing, Cedar River 2003.

Table 6. Median migration dates of wild, hatchery, and the 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	02/21	03/03	15
	Average	03/24	03/01	03/14	23

Wild timing in 2003 was earlier than the previous 11 broods evaluated (Table 6). The wild median migration date was two weeks earlier than the average and two days earlier than any measured in previous years. Over all 12 broods measured, median migration dates for wild fry have ranged from March 8 to April 7. Timing of hatchery fry in 2003 was slightly earlier than the average for the 12 broods evaluated thus far. As in previous years, it appears that timing of the 2003 wild fry migration was related to stream temperature. Warmer temperatures result in earlier migration timing (Seiler *et al*. 2001). After evaluating temperature data from throughout the period of fry incubation and migration, February stream temperatures best predicted migration timing ($r^2 = 0.58$) (Figure 5). February stream temperatures averaged 6.6C in 2003, compared to 6.1C in 2002 and 5.6C in 2001. Migration year 2001 was treated as an outlier due to extreme low flows and an earthquake, which triggered a landslide upstream that temporarily blocked flow.

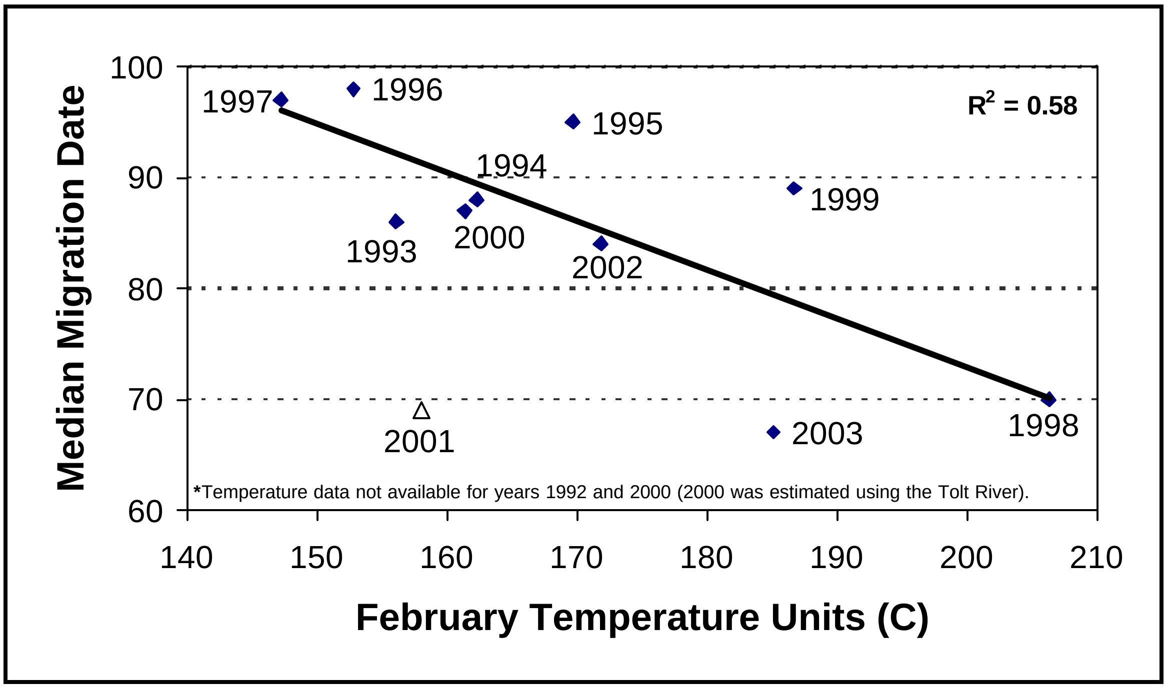

Figure 5. Linear regression of median migration Julian Calendar date for wild Cedar River sockeye fry as a function of the sum of February 1-28 daily average temperature as measured at the USGS Renton Gaging Station #12119000 for migration years 1993-2003, with 2001 as an outlier.

Survival of Hatchery Release Groups

To avoid extremely high volumes of fry, we did not operate the trap on five of the seven nights that fry were released at Riviera. Instead we assumed that fry released from this site, just one mile upstream, survived at 100%. On the two nights that Riviera releases occurred that we operated the trap and sampled otoliths, February 11 and March 11, survival was estimated at 117% and 132% (Table 7). While the vast majority of fry released at Riviera migrate past the trap within the release night, otolith samples on two non-release nights contained Riviera fry. The sample taken on February 19 indicated that approximately 2,600 Riviera marked fry passed the trap. These fry either migrated six days after being released, were mismarked, or were inadvertently released with Landsburg fry on that night. The otolith sample taken on March 5 contained three Riviera fry, which estimated 14,300 fry migrated past the trap the day after the March 4 release.

Survival estimates of Middle-River release groups ranged from 50.8% to 107% (Table 7). The release on January 24 was estimated by applying the average survival of the seven groups estimated by otolith sampling and interpolation. Survival estimates may be slightly low if migration past the trap was not completed during the night of release. We have no data to assess migration duration for the Middle-River releases in 2003. Otolith sampling occurred during one night following a release (February 26), however, the otolith codes could not be differentiated between the two nights.

Survival estimates of individual Landsburg release groups ranged from 49.4% to 154% (Table 7). Over all 11 release groups, survival averaged 78.6%. When releases occurred on subsequent nights, they were grouped due to Landsburg fry taking more than one night to migrate past the trap and the otolith marks between groups could not be differentiated. Survival was estimated using otolith samples, except for two releases: on January 30 when we did not trap, and February 3 when an otolith sample was not taken. Hatchery migration during the night of January 30 was estimated by the average survival of the six groups estimated from otoliths. The hatchery migration during the night of February 3 was estimated by interpolation.

Survival estimates in excess of 100% are, of course, impossible and therefore indicate that either we overestimated the sockeye fry migration, and/or hatchery release groups contained more fry than estimated. If the former explanation is correct, we believe that overestimation could only occur through underestimating capture rate. Another possibility would be that some hatchery release groups take longer to migrate past the trap, and because some release groups share the same otolith code, some groups could be overestimated while underestimating other groups. We have more confidence in the overall release group average survival rates than that of individual groups.

In addition to capturing fry from the three release sites, an otolith sample taken on February 19 contained two fry marked for release from the Cedar River Trail Park below the trap. This resulted in an estimated migration of 5,273 fry from this release past the trap. Given their small size, we doubt that they swam upstream from the park to above the trap (approximately one-half mile). Therefore, we believe it more likely that these fish were mismarked, misidentified, or mistakenly released above the trap with another group.

Confidence intervals and percent standard errors only account for the precision of trap-based estimates. The error associated with hatchery derived release size estimates is not included.

Table 7. In-river survival estimates of hatchery sockeye fry estimated using otolith samples (unless otherwise noted), Cedar River 2003.

Release Site	Release Date	Sockeye Released	Recovery Date(s)	Estimated Migration	Estimated Survival	95% CI +/-	Percent Standard Error
Landsburg	01/30	303,000	01/30-02/01	[a]271,824	89.7%	66.2%	37.7%
	02/03	579,000	02/03-02/04	[b]597,347	103.2%	50.3%	25.0%
	02/05	509,000	02/05-02/06	783,384	153.9%	69.5%	23.0%
	02/19	506,000	02/19	136,027			
	02/20	630,000	02/20	252,720			
	02/21	540,000	02/21	585,277			
			02/22	16,453			
	Sum	1,676,000		990,477	59.1%	17.8%	15.4%
	02/24	274,000	02/24-02/25	296,666	108.3%	37.3%	17.6%
	03/05	619,000	03/05-03/06	306,001	49.4%	17.3%	17.9%
	03/11	290,000	03/11	69,424			
	03/12	307,000	03/12	200,227			
	03/13	348,000	03/13	285,108			
			03/14	53,681			
	Sum	945,000		608,440	64.4%	69.7%	55.2%
	Total	4,905,000		3,854,139	78.6%	27.0%	17.5%
Middle	01/24	396,000	01/24	[a]298,354	75.3%	39.5%	26.8%
	01/29	590,000	01/29	503,914	85.4%	28.9%	17.3%
	02/25	525,000	02/25	559,488	106.6%	35.9%	17.2%
	02/26	577,000	02/26	583,442	101.1%	34.2%	17.2%
	03/07	721,000	03/07	442,802	61.4%	23.6%	19.6%
	03/17	307,000	03/17	[b]155,804	50.8%	45.4%	45.6%
	03/21	206,000	03/21	113,004	54.9%	26.3%	24.5%
	04/07	40,000	04/07	26,911	67.3%	48.8%	37.0%
	Total	3,362,000		2,683,719	79.8%	19.8%	12.7%
Riviera	02/10	534,000	02/10	[c]534,000			
	02/11	409,000	02/11	479,053	117.1%	12.2%	5.3%
	02/13	527,000	02/13	[c]524,359			
			02/19	2,641			
	02/27	430,000	02/27	[c]430,000			
	03/04	478,000	03/04	[c]463,741			
			03/05	14,259			
	03/10	598,000	03/10	[c]598,000			
	03/11	303,000	03/11	399,861	132.0%	53.7%	20.8%
	Total	3,279,000		3,445,914	105.1%		

[a] Sample average survival rate of the release location was used to estimate migration.
[b] Interpolation was used to estimate migration.
[c] Migration estimated based on an assumed survival of 100%.

Egg-to-Migrant Survival of Naturally-Produced Fry

Overall survival of the 2002 brood sockeye fry to lake entry was estimated at 6.2%. This rate is the ratio of 27.9 million wild fry to an estimate of 448 million eggs potentially deposited. This PED is based on a spawning escapement estimate of 264,046, an assumed even sex ratio and an average fecundity of 3,395 (Table 8). Of these three values, the estimate of fecundity may be the most accurate since it is the average number of eggs per female estimated in brood stock collected at RM 6.5 over most of the spawning season (Antipa pers. comm.).

For the purpose of this analysis, we computed Cedar River spawners for the 1991 through 2002 broods by subtracting from the estimated sockeye run passing the Ballard Locks the following estimates:

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

We have used this methodology for several years, however, the data in this report are somewhat changed from that in previous reports. These differences originate with the estimation of sockeye passing the Ballard Locks (data provided by Mike Mahovlich, Muckleshoot Tribe). Some of these differences in brood year estimates involve differences in intervals counted. While counting always began on June 12, prior to 1995 counting stopped before October 2. In addition, using data from subsequent years to project the uncounted portion of the run resulted in slightly different estimates.

Regressing the survival estimates on peak brood year incubation flow resulted in a correlation coefficient of 78% (Figure 6). The best fit for this data series was derived from fitting the data to the first 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 8. Estimated egg-to-migrant survival of naturally-produced sockeye fry in the Cedar River relative to peak mean daily flows during the incubation period as measured at the USGS Renton gage, brood years 1991-2002.

Brood Year	Spawners	Females (@50%)	Fecundity	PED	Fry Production	Survival Rate	Peak Incubation Flow (cfs)	Date
1991	74,600	37,300	3,282	122,418,600	9,800,000	8.0%	2,060	01/28/1992
1992	183,190	91,595	3,470	317,834,650	27,100,000	8.5%	1,570	01/26/1993
1993	99,197	49,599	3,094	153,457,759	18,100,000	11.8%	927	01/14/1994
1994	124,000	62,000	3,176	196,912,000	8,700,000	4.4%	2,730	12/27/1994
1995	26,665	13,333	3,466	46,210,445	730,000	1.6%	7,310	11/30/1995
1996	332,182	166,091	3,298	547,768,118	24,390,000	4.5%	2,830	01/02/1997
1997	119,933	59,967	3,292	197,409,718	25,350,000	12.8%	1,790	01/23/1998
1998	80,799	40,400	3,176	128,308,812	9,500,000	7.4%	2,720	01/01/1999
1999	47,488	23,744	3,591	85,264,704	8,058,909	9.5%	2,680	12/18/1999
2000	215,364	107,682	3,451	371,610,582	38,447,878	10.3%	627	01/06/2001
2001	233,569	116,785	3,568	416,687,096	31,673,029	7.6%	1,930	11/23/2001
2002	264,046	132,023	3,395	448,218,085	27,861,123	6.2%	1,410	02/04/2003

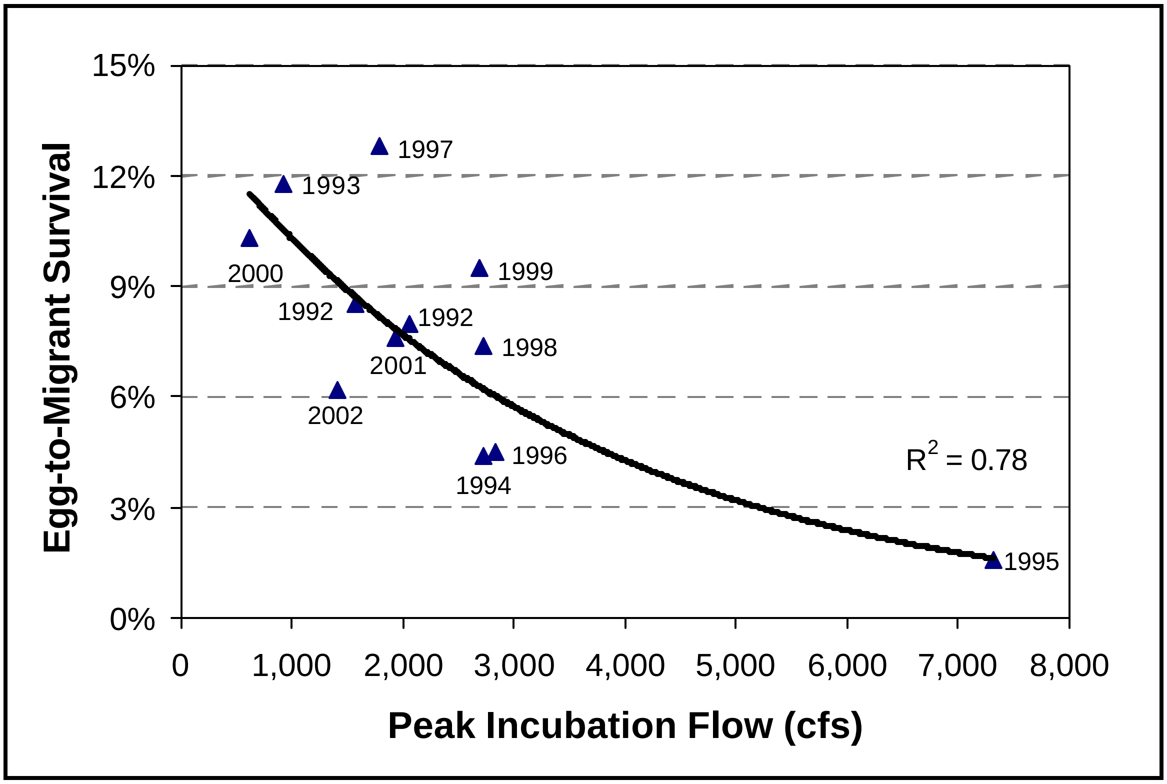

Figure 6. Exponential regression of wild sockeye egg-to-migrant survival from brood years 1991 to 2002 as a function of peak flow during the winter egg incubation period, Cedar River.

Chinook

Catch

Fry Trap

On the first night of fry trap operation (January 21), we caught 24 chinook fry. Through March, nightly catches varied from a low of four to a high of 1,021 fry. The highest catches occurred on nights with high flows and heavy debris. Through March, we caught a total of 7,028 chinook fry, 98% of the season total. Catches totaled only 158 fry from April to May 31 during the 25 nights we fished. We fished during five daytime intervals in order to estimate migration during daylight hours not fished, and day to night catch rate ratios ranged from 1% to 31% (Table 9). Over the season, a total of 7,235 chinook were captured in the fry trap.

Screw Trap

Over the 94-day interval that we operated the screw trap (April 10 through July 12), we captured 3,675 wild and 54 adipose-clipped hatchery chinook. From the first night of trapping through April, nightly catches varied slightly and ranged from two to 38 age 0+ chinook. During May and June, we caught a total of 3,335 wild chinook smolts, 91% of the season total. The highest nightly catch, 212 chinook smolts, occurred on June 10.

Table 9. Day/night catch ratios estimated at the Cedar River fry trap, 2003.

		Nighttime					Daytime			D:N	Flow
Date	Time	Hours	Catch	Catch/Hr	Date	Time	Hours	Catch	Catch/Hr	Ratio	(cfs)
02/06	18:00	14.50	195	13.4	02/07	7:30	9.50	31	3.26	31.23%	944
02/07	17:00	14.50	108	7.4							
		29.00	303	10.4							
02/20	17:30	14.00	35	2.5	02/21	7:30	10.50	5	0.48	1.03%	569
02/21	18:00	8.75	1,021	116.7							
		22.75	1,056	46.4							
02/25	18:00	13.00	200	15.4	02/26	7:00	11.00	6	0.55	3.84%	927
02/26	18:00	13.00	169	13.0							
		26.00	369	14.2							
03/05	18:00	13.00	98	7.5	03/06	7:00	11.00	6	0.55	12.33%	629
03/06	18:00	13.00	17	1.3							
		26.00	115	4.4							
03/19	18:00	12.50	28	2.2	03/20	6:30	11.50	1	0.09	3.76%	1,220
03/20	18:00	13.00	31	2.4							
		25.50	59	2.3							
Average										10.44%	
Variance										3.1E-03	

Catch Expansion

Fry Trap

For the day and night periods not fished we estimated the numbers of chinook we would have caught. Nighttime intervals not fished were estimated using interpolation of catches from the previous and following nights fished. Daytime migration was estimated by using the average (10.4%) ratio of day/night catch rates measured during operation of the fry trap. Due to high flows and large amounts of debris, on 22 nights we expanded partial catches by hourly interpolation when whole hours were not fished. We estimated an additional 7,569 chinook would have been caught at night and 1,100 fry would have been caught during the daytime had we fished the fry trap continuously from January 21 to May 31 (Appendix B).

Screw Trap

Catch data was expanded to estimate the numbers of chinook we would have caught in the screw trap had we fished the trap continuously from the evening of April 10 through the morning of July 13 (Appendix B). Expansion resulted in the addition of only 100 chinook to the wild catch. This increase represented 3% of the combined total catch estimate. The catch expansion included daytime migration estimates through May when we did not fish, and four trapping intervals when we found the screw stopped by debris. Eight other trapping intervals were slowed or stopped by debris but were not expanded due to an estimated catch of zero or the actual catch was higher than the intervals before and after the outage. Daytime migration estimates after June 1 were not estimated due to lack of daytime catch data, and catch rates were near zero during the last two weeks of May.

Size

From January through March, the mean fork length of chinook fry caught in the fry trap increased 3-mm, and averaged 40-mm (Table 10). Through early-May, the lower end of the size range increased to 60-mm and the average rose to approximately 70-mm during this period. While the catch included individuals as large as 90-mm and mean fork length increased to 85-mm, catches were very low by mid-April (Figure 7). We attribute the decline in capture rates to the increased swimming ability of the larger chinook and decreased water velocity as a result of lower flows in May.

Chinook caught in the screw trap increased in size from a weekly average fork length of 58 mm in mid-April to 111 mm in mid-July (Table 10, Figure 7).

Table 10. Mean chinook fork length, standard deviation, range, sample size, and catches in the Cedar River fry and screw traps, 2003.

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
01/20	01/26	4	39.1	0.93	37	41	24	121						
01/27	02/02	5	39.4	1.41	36	42	40	628						
02/03	02/09	6	40.1	2.00	35	44	78	1,065						
02/10	02/16	7	39.4	2.12	34	43	27	213						
02/17	02/23	8	36.7	1.15	36	38	3	2,287						
02/24	03/02	9	39.9	1.86	36	47	87	1,216						
03/03	03/09	10	40.2	3.32	36	59	53	497						
03/10	03/16	11					0	331						
03/17	03/23	12	41.2	3.69	36	57	74	328						
03/24	03/30	13	40.9	4.54	37	63	58	324						
03/31	04/06	14	42.5	3.78	39	51	15	55						
04/07	04/13	15	48.8	10.19	37	73	29	44	58.4	6.33	47	71	31	31
04/14	04/20	16	56.0	8.00	41	74	20	21	61.2	9.55	42	82	49	57
04/21	04/27	17	64.3	9.64	41	77	16	16	65.5	9.45	48	84	81	109
04/28	05/04	18	73.0	7.59	59	85	14	14	72.0	7.28	54	87	79	154
05/05	05/11	19	71.5	10.66	59	85	4	4	78.1	7.80	63	92	51	344
05/12	05/18	20	75.3	9.21	60	90	19	20	83.2	7.31	64	100	117	383
05/19	05/25	21	84.5	3.54	82	87	2	2	85.4	6.39	72	104	144	270
05/26	06/01	22						0	93.2	6.00	74	110	235	356
06/02	06/08	23							97.4	6.07	77	115	417	716
06/09	06/15	24							98.9	6.74	62	118	343	677
06/16	06/22	25							100.1	8.01	71	115	139	416
06/23	06/29	26							102.4	8.21	82	128	67	90
06/30	07/06	27							107.7	8.78	92	123	20	56
07/07	07/13	28							111.2	8.32	100	121	9	16
		Totals	44.3	10.79	34	90	563	7,186	91.0	13.69	42	128	1,782	3,675

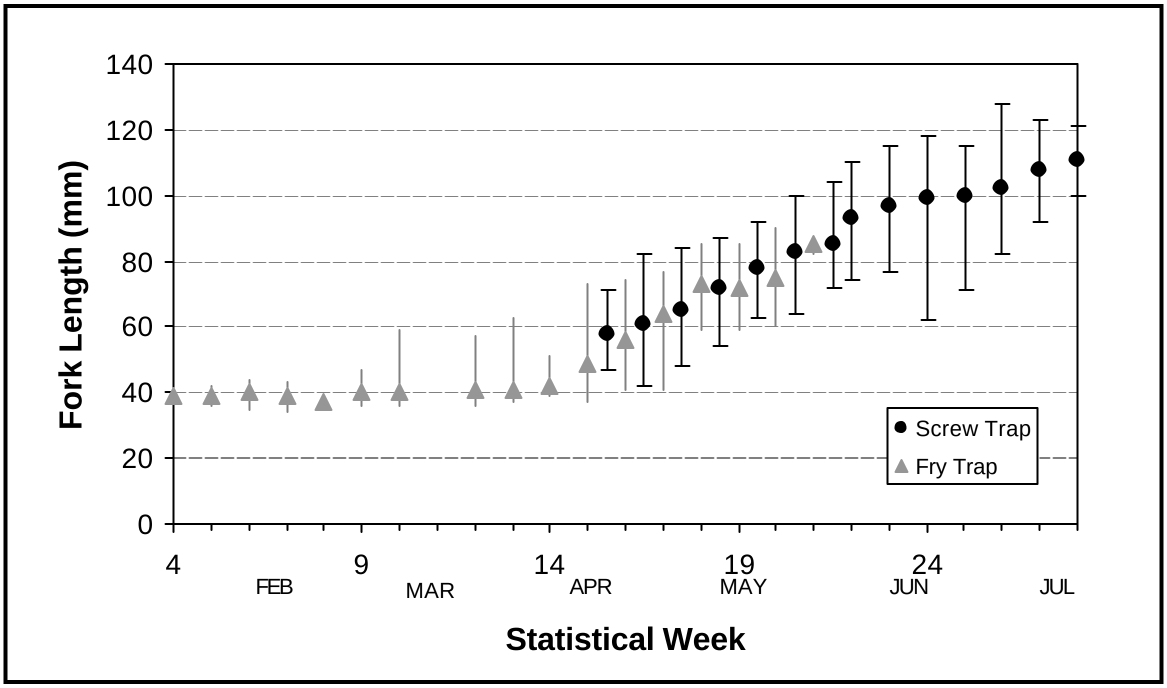

Figure 7. Average and range of fork lengths from age 0+ chinook sampled from the Cedar River, 2003.

Trap Efficiency

Fry Trap

Capture efficiency for chinook caught in the fry trap was estimated by releasing marked sockeye fry upstream of the trap and subsequently recapturing them (p. 17). A linear regression was used to evaluate the relationship between capture efficiency and flow, and a significant correlation was found (r^2=0.47, p<0.001) (Figure 2). Due to this strong relationship, the linear regression was used to predict daily trap efficiency using the daily average flow.

Screw Trap

Capture rate of chinook in the screw trap was estimated by releasing fifteen mark-recapture groups between May 8 and June 22 (Table 11). Trap efficiencies ranged from 4% to 31.6%. Flows during releases ranged from 288 to 457 cfs, and did not significantly explain the variation among trap efficiency tests. Although flow failed to explain the variation among test groups, a negative temporal trend was observed (Figure 8). As chinook grow larger, they have a greater ability to avoid the trap, thus decreasing trap efficiency. Due to this trend, we averaged the efficiency test results into early, middle, and late season intervals: April 10 to May 25, May 26 to June 10, and June 11 to July 12 (Table 11).

Table 11. Estimated chinook smolt recapture rates from screw trap efficiency tests, Cedar River 2003.

Temporal Interval	Date	Flow (cfs)	NUMBER Released	NUMBER Recaptured	Recapture Rate	Variance
EARLY (April 10 - May 25)	05/08/03	457	43	4	9.3%	0.00196
	05/11/03	396	50	15	30.0%	0.00420
	05/12/03	401	50	14	28.0%	0.00403
	05/15/03	391	50	11	22.0%	0.00343
	05/18/03	395	58	13	22.4%	0.00300
	05/24/03	364	38	12	31.6%	0.00569
	Average				23.9%	
	Variance				0.0066	
	n				6	
MIDDLE (May 26 - June 10)	05/26/03	355	85	9	10.6%	0.00111
	06/01/03	326	90	6	6.7%	0.00069
	06/03/03	320	60	8	13.3%	0.00193
	06/04/03	319	80	5	6.3%	0.00073
	06/06/03	309	46	3	6.5%	0.00133
	Average				8.7%	
	Variance				0.0010	
	n				5	
LATE (June 11 - July 12)	06/11/03	288	109	5	4.6%	0.00040
	06/16/03	382	50	2	4.0%	0.00077
	06/19/03	364	30	2	6.7%	0.00207
	06/22/03	437	99	5	5.1%	0.00048
	Average				5.1%	
	Variance				0.0001	
	n				4	

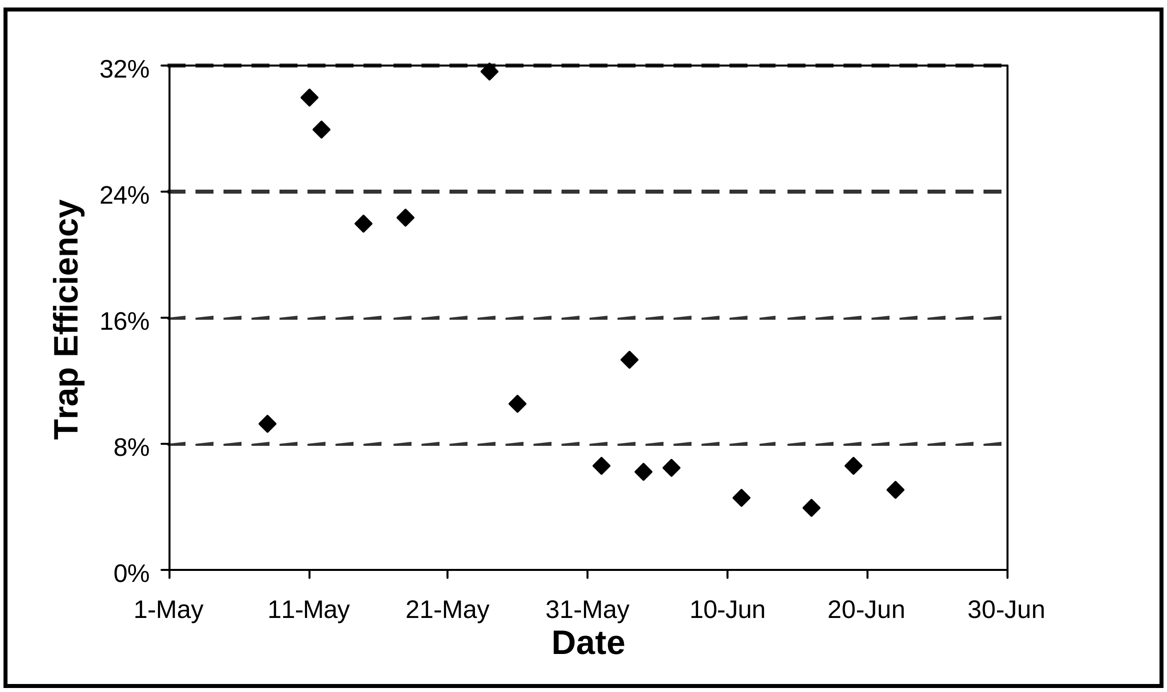

Figure 8. Chinook trap efficiency tests plotted by date, Cedar River screw trap 2003.

Production Estimate

During the period of fry trap operation (January 21 through May 31), we estimate that 192,402 chinook passed the trap. This estimate is based on our expanded catch of 15,855 chinook and the daily estimated trap efficiency predicted by flow. During the period of screw trap operation (April 10 through July 12), we estimate that 41,106 chinook passed the trap. This estimate is based on our expanded catch of 3,775 migrants, and the estimated average trap efficiency for each of the three temporal strata.

The fry trap and screw trap ran concurrently between April 10 and May 31 providing independent daily estimates of chinook migration from each trap. Daily estimates from each trap were summed for each gear type by week and tested for equality using a Z-test. Differences were significant in seven of the eight weeks tested ($p<0.05$) (Table 12). Weekly population estimates based on fry trapping declined each week with the exception of just one week (statistical week 20). Over the same period weekly migrations estimated with the screw trap increased with the exception of just two weeks. During the first three weeks of April, when the smallest chinook were still less than 40 mm, these fish could escape through the 3/16-inch holes in the screw trap floor. By May, as chinook grew, all chinook entering the screw trap were retained and larger chinook were able to avoid the fry trap (Table 10, Figure 7). We elected to use the screw trap estimate after statistical week 16.

Combining the chinook production estimated from the fry trap for January 21 through April 20, with the estimate from the screw trap for April 21 through July 12, yielded a total migration over this interval of 231,527 age 0+ chinook. To estimate the number of chinook migrating before trapping began, we used straight-line extrapolation to estimate migration from January 1 to 20. We based the extrapolation on a migration rate of 387 chinook fry/day (the average rate estimated from the first two days trapped). This estimates 3,870 chinook passed the fry trap before January 21. Therefore, we estimate a total of 235,397 chinook migrated from the Cedar River in 2003 (Table 13, Figure 9, Appendix B).

Table 12. Independent weekly estimates of chinook migration, N_w, from the fry and screw traps with results from Z-test comparison of the weekly estimates, Cedar River 2003.

Statistical Week			Fry Trap		Screw Trap		Significant
Begin	End	Number	Estimated Migration (N_w)	$V(N_w)$	Estimated Migration (N_w)	$V(N_w)$	Difference? (Yes/No)
04/07	04/13	15	968	8,485	129	109	Yes
04/14	04/20	16	653	840	237	232	Yes
04/21	04/27	17	423	740	457	1,048	No
04/28	05/04	18	383	81	645	1,496	Yes
05/05	05/11	19	212	603	1,791	18,706	Yes
05/12	05/18	20	491	3,379	1,616	29,514	Yes
05/19	05/25	21	63	0	1,130	9,785	Yes
05/26	06/01	22	45	14	4,104	66,345	Yes

Table 13. 2003 Cedar River juvenile chinook production estimate and confidence intervals.

Gear	Period	Estimated Catch	Estimated Migration	95% CI Low	95% CI High	CV
Before Trapping	January 1 - January 20		3,870	891	6,849	39.3%
Fry Trap	January 21 - April 20	15,855	190,787	141,494	240,080	13.2%
Screw Trap	April 21 - July 12	3,775	40,740	26,179	55,301	18.2%
	Season Total	19,630	235,397	183,912	286,882	11.2%

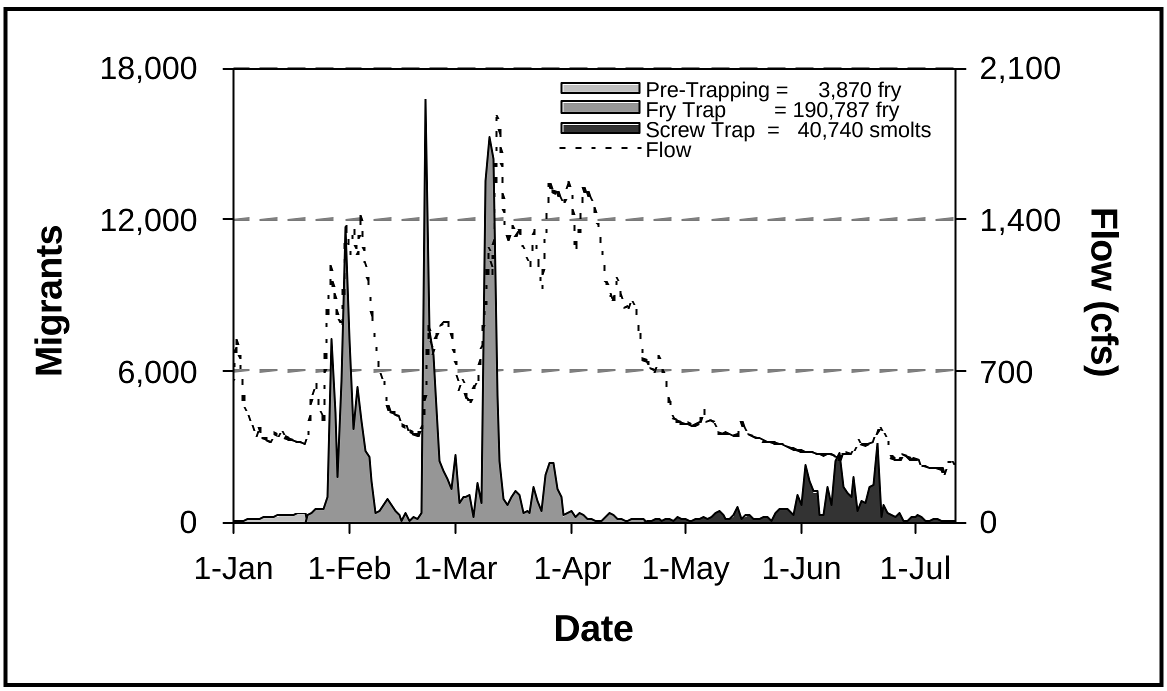

Figure 9. Estimated daily Cedar River 0+ chinook migration from fry and screw trap estimates and flow (USGS Renton Gage), 2003.

The majority of juvenile chinook emigrated as fry between February and March. We estimate that the migration was 25%, 50%, and 75% complete by February 5, March 4, and March 17, respectively (Figure 10).

In 2003, we estimate that 82.5% of the chinook migration occurred as fry before April 16 (Table 14). The smolt portion of the migration between April 16 and July 13 represented 17.5% of the chinook migration. These proportions are comparable to previous years showing that more fry migrate than smolts in response to higher spring flows when chinook are smaller. These findings are in contrast to those of the 2001 trapping season, when more smolts than fry migrated. Flows were low throughout that winter and early spring, which allowed fry to stay in the river system and grow for a longer period of time.

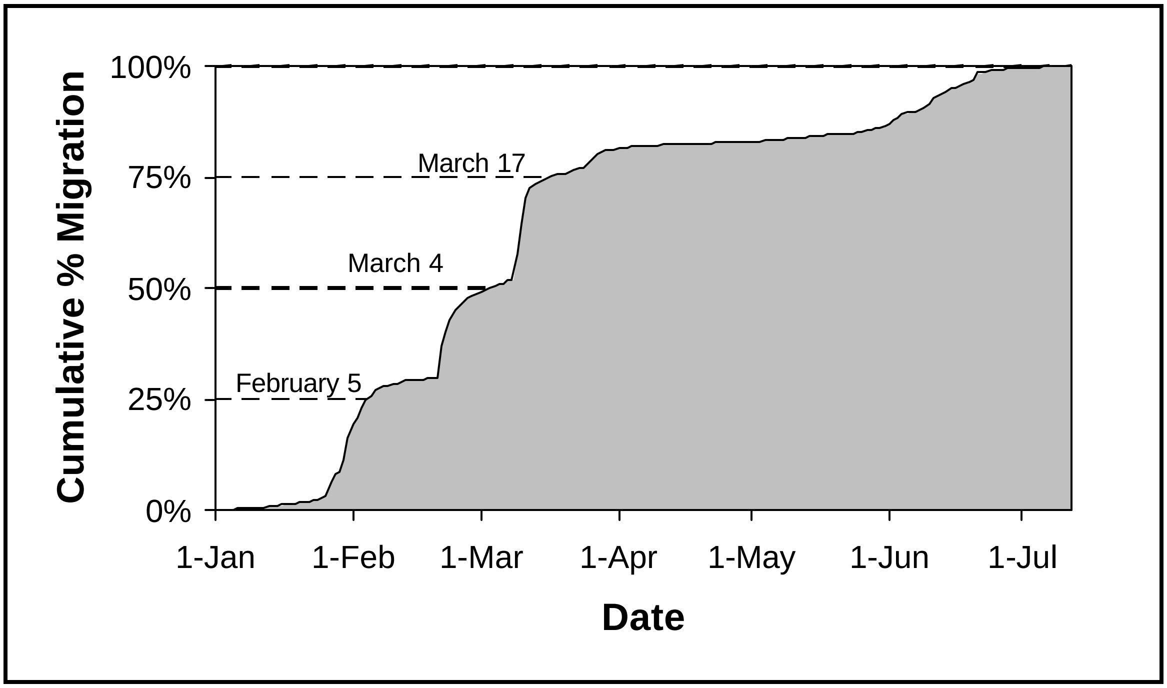

Figure 10. Cumulative percent migration of age 0+ chinook, Cedar River 2003.

Table 14. Comparison of fry and smolt components between years for wild chinook production standardized by assuming a January 1 to July 13 migration period, Cedar River broods 1998 to 2002.

Brood Year	Migration Fry Jan 1-Apr 15	Migration Smolt Apr 16-Jul 13	Migration Total Jan 1-Jul 13	% Migration Fry Jan 1-Apr 15	% Migration Smolt Apr 16-Jul 13
1998	67,293	12,811	80,104	84.0%	16.0%
1999	45,906	18,817	64,723	70.9%	29.1%
2000	10,994	21,157	32,151	34.2%	65.8%
2001	79,813	39,326	119,139	67.0%	33.0%
2002	194,135	41,262	235,397	82.5%	17.5%

Egg-to-Migrant Survival

Relating our overall estimates of juvenile chinook emigrating from the Cedar River to estimates of annual egg deposition yields an estimate of egg-to-migrant survival. For the 2002 brood, we estimated a wild chinook egg-to-migrant survival of 18.6% based on an escapement of 281 females and a fecundity of 4,500 eggs per female (Table 15).

Table 15. Wild age 0+ chinook egg-to-migrant survival estimates for brood years 1998-2002, 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%

Coho

Catch

We captured a total of 3,763 wild coho smolts in the screw trap between April 10 and July 12. Over 80% of the catch occurred between April 24 and June 1. Catch distribution was uni-modal with the peak catch of 300 smolts on May 6. In addition to trapping every night, we also operated the trap during 52 daytime intervals. Only 32 smolts were caught on 13 of those days. Only one smolt was caught during the daytime in the last two weeks of May.

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 201 coho. This addition represented 5.1% of the expanded catch. These expansions account for additions made for two screw stoppers that occurred during the season. Although ten other screw stoppers occurred, catch was not expanded on those dates due to high actual catches and daytime catches of zero for previous and following days. Due to the low daytime catch, during June and July we did not expand missed daytime intervals.

Size

Over the season, coho smolt fork lengths averaged 112 mm (Table 16, Figure 11). There was very little variation in mean size over the season.

Trap Efficiency

Twenty-six mark-recapture tests were conducted to measure trap efficiency for coho. Recapture rates ranged from 1% to 17% and averaged 5.5% (Table 17). As with chinook, regression analysis failed to find a significant flow effect on trap efficiency ($p>0.05$), and the average was used to estimate daily migration.

Table 16. Weekly mean fork length, standard deviation, range, sample size and catches for coho from the Cedar River screw trap, 2003.

Statistical Week			Avg.	s.d.	Range		n	Catch
Begin	End	No.			Min	Max		
04/07	04/13	15	108.9	9.75	88	136	38	98
04/14	04/20	16	110.5	13.85	77	154	71	243
04/21	04/27	17	110.0	12.38	72	141	70	307
04/28	05/04	18	112.8	10.70	85	147	362	468
05/05	05/11	19	112.2	10.79	87	158	415	1,058
05/12	05/18	20	110.0	9.82	88	147	290	628
05/19	05/25	21	113.5	10.54	91	136	30	374
05/26	06/01	22	113.7	8.98	97	141	77	292
06/02	06/08	23	111.3	8.74	95	127	38	187
06/09	06/15	24	109.3	8.66	95	117	8	61
06/16	06/22	25					0	24
06/23	06/29	26	112.0	25.46	94	130	2	13
06/30	07/06	27	127.7	41.59	97	175	3	8
07/07	07/13	28	97.0	22.63	81	113	2	2
Season Total			111.6	10.94	62	175	1,406	3,763

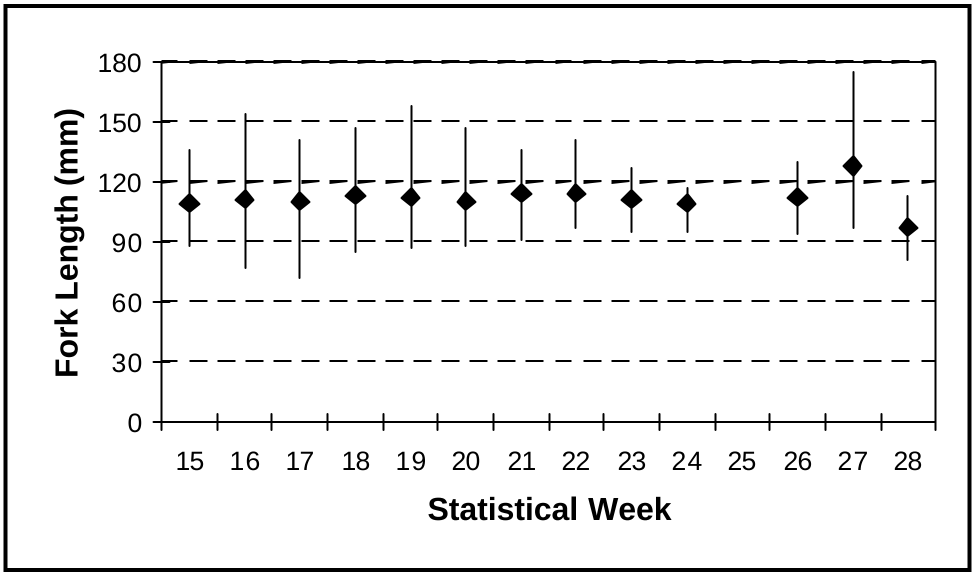

Figure 11. Weekly ranges and mean fork lengths for coho smolts captured in the Cedar River screw trap, 2003.

Table 17. Estimated coho smolt recapture rates from screw trap efficiency tests, Cedar River 2003.

Date	Flow (cfs)	NUMBER Released	Recaptured	Recapture Rate	Variance
04/12/03	1,070	29	1	3.45%	0.001189
04/13/03	1,190	22	1	4.55%	0.002066
04/14/03	1,090	27	2	7.41%	0.002638
04/18/03	1,010	44	1	2.27%	0.000517
04/19/03	883	57	3	5.26%	0.000890
04/20/03	757	51	2	3.92%	0.000754
04/21/03	746	28	2	7.14%	0.002457
04/23/03	698	29	2	6.90%	0.002293
04/25/03	705	96	6	6.25%	0.000617
04/26/03	638	53	3	5.66%	0.001027
04/28/03	467	68	4	5.88%	0.000826
05/03/03	435	56	3	5.36%	0.000922
05/07/03	453	100	4	4.00%	0.000388
05/08/03	457	50	2	4.00%	0.000784
05/11/03	396	49	3	6.12%	0.001197
05/12/03	401	50	3	6.00%	0.001151
05/15/03	391	86	15	17.44%	0.001694
05/16/03	445	41	3	7.32%	0.001695
05/18/03	395	82	2	2.44%	0.000294
05/19/03	387	85	5	5.88%	0.000659
05/20/03	383	52	2	3.85%	0.000725
05/24/03	364	46	2	4.35%	0.000924
05/26/03	355	100	1	1.00%	0.000100
05/28/03	342	57	5	8.77%	0.001429
06/01/03	326	37	1	2.70%	0.000730
06/04/03	319	47	2	4.26%	0.000886
Total		1,442	80		
Average				5.5%	
Variance				0.000036	
n				26	

Production Estimate

Application of the average coho smolt trap efficiency to the expanded catch of 3,964 smolts estimates a production of 72,491 smolts during the trapping season. Using linear extrapolation, we estimated that an additional 2,016 smolts would have been caught had we begun trapping on April 1. The total estimated coho production is 74,507 smolts with a coefficient of variation of 10.7% and a 95% confidence interval of 58,947 to 90,067 smolts (Figure 12, Appendix B).

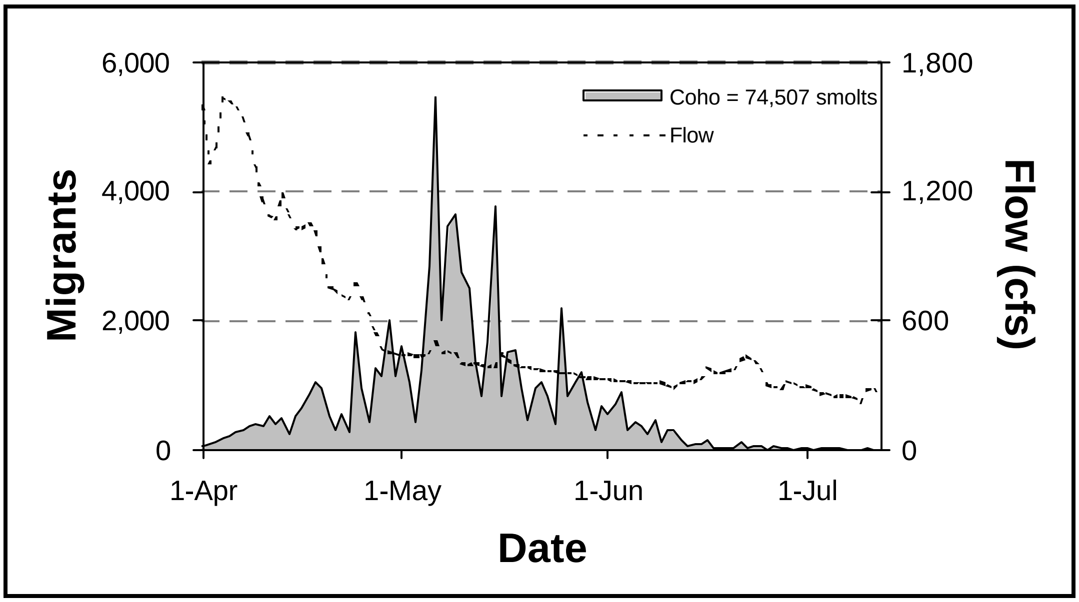

Figure 12. Estimate of daily coho smolt migration and flow, Cedar River screw trap, 2003.

Steelhead and Cutthroat

Catch

A total of 21 steelhead smolts were captured between April 19 and July 10. Due to the low catches, there was no definable timing pattern during the period of trap operation. Steelhead were not observed in any of the daytime catches.

A total of 35 cutthroat trout were captured in the screw trap between April 10 and July 5. Due to the low catches, there was no definable timing pattern during the period of trap operation. Cutthroat were also not observed in any of the daytime catches. During the night of April 16, we estimate that one cutthroat would have migrated had the screw not been stopped by debris.

Size

Over the season, steelhead smolt fork length averaged 184 mm and ranged from 155 to 229 mm over the season (Table 18). Cutthroat trout fork length averaged 169 mm, and varied from 121 to 255 mm throughout the trapping season (Table 18).

Table 18. Weekly mean steelhead and cutthroat fork length, standard deviation, range, sample size and catches, Cedar River screw trap 2003.

Statistical Week			STEELHEAD						CUTTHROAT					
Begin	End	No.	Avg.	s.d.	Range Min	Range Max	n	Catch	Avg.	s.d.	Range Min	Range Max	n	Catch
04/07	04/13	15						0	178.4	47.0	134	255	5	5
04/14	04/20	16	198.0				1	1	183.0	25.5	165	201	2	2
04/21	04/27	17	176.3	33.5	155	215	3	3	162.6	24.3	132	195	5	5
04/28	05/04	18						0	153.2	21.9	123	178	6	6
05/05	05/11	19						0					0	3
05/12	05/18	20	180.3	17.6	166	200	3	3	163.3	47.7	121	215	3	3
05/19	05/25	21	183.5	3.5	181	186	2	2	193.0				1	1
05/26	06/01	22	165.0				1	1	173.0				1	1
06/02	06/08	23	181.4	16.0	161	210	7	7	187.3	31.6	163	223	3	4
06/09	06/15	24	185.0	4.2	182	188	2	2					0	1
06/16	06/22	25						0	168.0				1	2
06/23	06/29	26						0						0
06/30	07/06	27						0	160.5	16.3	149	172	2	2
07/07	07/13	28	229.0				1	2						0
Season Totals			183.5	19.6	155	229	20	21	168.9	30.2	121	255	29	35

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 ratio. Applying this ratio to our average coho smolt catch rate (5.5%) estimates a steelhead capture rate in the Cedar River screw trap of 3.3%. This rate may underestimate the steelhead catch rate in the screw trap because the trapping operations on the Toutle, Green, and White Salmon Rivers employed scoop traps, from which steelhead can more easily escape. Therefore, we selected a trap efficiency value of 4% for estimating steelhead and cutthroat migration in the Cedar River in 2003.

Production Estimate

Application of a catch rate of 4% to the catch of 21 steelhead estimates a total migration of 525 smolts (Figure 13). Applying this rate to the expanded catch of 36 cutthroat estimates the total cutthroat migration during the trapping period at 900 smolts (Figure 14, Appendix B). No confidence intervals were developed for these estimates, which apply only to the period of screw trap operation (April 10 through July 12). While cutthroat migration very 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, we did not attempt to expand our 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.

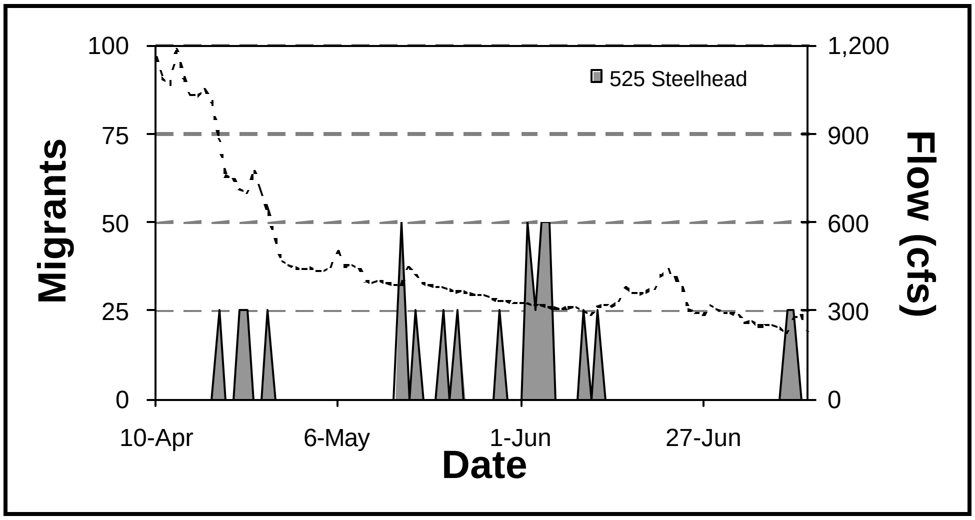

Figure 13. Estimated daily steelhead migration and flow, Cedar River screw trap 2003.

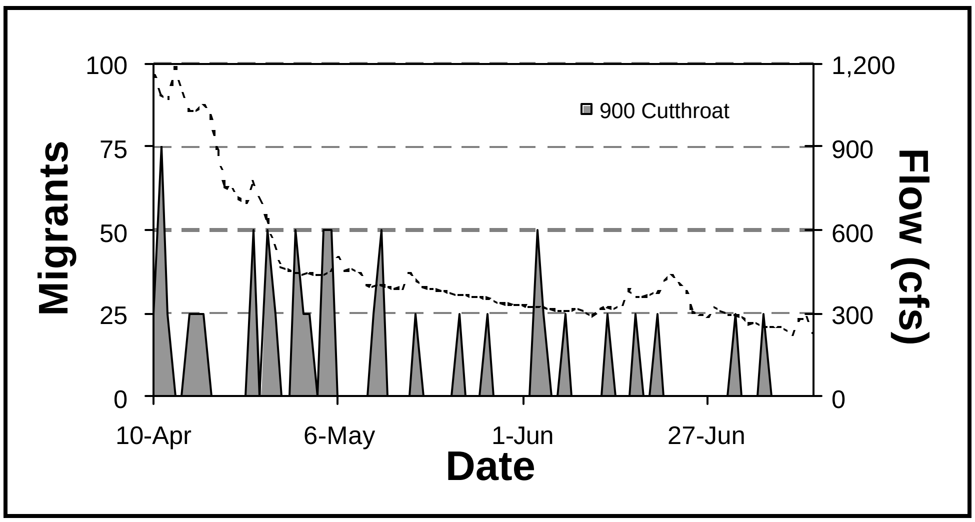

Figure 14. Estimated daily cutthroat migration and flow, Cedar River screw trap 2003.

PIT Tagging

PIT tagging began on April 29 and continued through July 2. A total of 1,726 wild chinook, six hatchery chinook, 1,027 coho, one sockeye smolt, and five steelhead smolts were tagged throughout the season (Table 19). An additional 165 wild chinook were tagged and released at Gene Coulon Memorial Beach Park on May 8. Those chinook were beach seined by USFWS at the park, which is located east of the Cedar River mouth on Lake Washington.

Genetic Sampling

Steelhead and cutthroat trout genetic samples were collected throughout the season by preserving partial fin clips in vials filled with ethanol. Over the season, a total of three cutthroat and 17 steelhead samples were collected (Table 20). In addition, samples were also taken from one trout fry and one rainbow adult.

Table 19. Summary of PIT tagged fish from the Cedar River screw trap, 2003.

Statistical Week			Cedar River Screw Trap				
#	Start	End	Wild Chin	Hat. Chin	Coho	Sockeye	Steelhead
18	04/28	05/04	35	0	298	0	0
19	05/05	05/11	104	0	450	0	0
20	05/12	05/18	165	0	279	1	2
21	05/19	05/25	191	0	0	0	0
22	05/26	06/01	160	0	0	0	0
23	06/02	06/08	355	6	0	0	2
24	06/09	06/15	400	0	0	0	1
25	06/16	06/22	218	0	0	0	0
26	06/23	06/29	73	0	0	0	0
27	06/30	07/06	25	0	0	0	0
		Total	1,726	6	1,027	1	5

Table 20. Genetic samples collected from the Cedar River screw trap, 2003.

Species	Date	Fork Length (mm)	DNA Vial #
Cutthroat	04/25/03	195	03BH-5
	05/18/03	121	03BH-10
	05/24/03	193	03BH-13
Steelhead	04/20/03	198	03BH-1
	04/23/03	155	03BH-3
	04/24/03	159	03BH-4
	04/27/03	215	03BH-6
	05/16/03	175	03BH-7
	05/16/03	166	03BH-8
	05/18/03	200	03BH-9
	05/22/03	186	03BH-11
	05/24/03	181	03BH-12
	05/30/03	165	03BH-14
	06/03/03	174	03BH-15
	06/03/03	174	03BH-16
	06/06/03	210	03BH-17
	06/06/03	181	03BH-18
	06/13/03	188	03BH-19
	07/10/03	229	03BH-20
	07/11/03	224	03BH-21
Trout Fry	04/21/03	52	03BH-2
Rainbow Adult	07/12/03	~430	03BH-22

Mortality

Over the season, 11 chinook fry mortalities occurred in the fry trap.

Over the season, two steelhead, five coho, two sockeye smolts, and 16 chinook smolts were found dead in the screw trap. Coho and chinook mortality rates were 0.1% and 0.4%, while steelhead was 9.5%. The two steelhead mortalities were found late in the season (July 10 and 11), and not associated with heavy debris or high flows. These mortalities most likely occurred prior to entering the trap. Chinook mortality earlier in the season, when chinook were smaller, may be underestimated for two reasons. First, larger migrants, particularly cutthroat, often eat fry in the collection box.

Second, dead fry could be removed from the trap by the debris drum, which cycles detritus from the trap. Therefore, chinook fry mortalities in the screw trap may be somewhat higher than counted.

Incidental Species

In addition to the species and age classes listed above, we also caught 167 age 1+ coho, 19 coho fry, 68 chum fry, three trout parr, one steelhead smolt, six cutthroat smolts, and one cutthroat adult in the fry trap. We also caught nine coho fry, 54 hatchery chinook smolts, three chinook yearlings, 44 sockeye smolts, two trout parr, and one cutthroat adult in the screw trap. Other species caught included long-fin smelt, three-spine sticklebacks, sculpin, large-scale suckers, pea-mouth, and lampreys.

BEAR CREEK RESULTS

Sockeye

Catch

On the first night of fry trapping, February 6, we caught 843 sockeye fry. We fished 45 nights from February 6 through April 8. Catch peaked the night of March 15 when 30,482 fry were caught during increasing flows. We caught a total of 263,208 sockeye fry in the fry trap by the time trapping ended on the morning of April 9 (Appendix C). We fished during one daytime interval for five hours on February 6 and caught no sockeye fry. As a result, migration during daylight hours was considered minimal and therefore not estimated.

Catch expansion for the 17 nights not fished resulted in an estimated catch of 86,446 sockeye fry. The night of March 13 was not fished continuously due to high flows, but we estimated an additional 11,462 fry would have been caught had we fished throughout the night.

Trap Efficiency

Over the season, 40 groups of marked sockeye fry were released upstream of the fry trap to assess trap efficiency. Capture rates ranged from 6.8% to 31% (Table 21). Efficiency tests were evaluated for a relationship with flow and there was a slight negative trend, however, it was not significant (r^2=0.13) (Figure 15). Trap efficiency throughout the trapping season was estimated by using the average of the capture rate tests, 18.8%.

Production Estimate

During the period of fry trap operation (February 6 through April 8), we estimate that 1,920,928 sockeye fry passed the trap. This estimate is based on our expanded catch and the estimated trap efficiency. Migration had already begun when we started trapping, and we estimated that an additional 8,575 fry would have been caught had we started trapping on February 1. Although fry migration was still is progress when we replaced the fry trap with the screw trap on April 9, trap efficiency tests using sockeye fry were not conducted during screw trap operation. Due to the differences in capture rates and predation by larger migrants in the screw trap, migration after April 8 was estimated using logarithmic extrapolation through the estimated end migration date of May 1. Migration occurring after April 8 was estimated to be 65,791 fry. We estimate a total of 1,995,294 sockeye fry migrated from Bear Creek in 2003 (Table 22, Figure 16, Appendix C).

Overall survival of the 2002 brood sockeye fry was estimated at 3.6%. This rate is the ratio of 1,995,294 fry to an estimate of 55.5 million eggs potentially deposited. Egg deposition is based on 34,700 spawning adults in Bear Creek, an even sex ratio, and an estimated fecundity of 3,200 eggs per female (Foley pers. comm.).

Table 21. Sockeye fry trap efficiency tests, Bear Creek 2003.

Date	Flow (cfs)	Released	Recaptured	Trap Efficiency	Variance
02/09	72	210	49	23.3%	0.00085
02/10	67	249	28	11.2%	0.00040
02/11	63	200	20	10.0%	0.00045
02/13	56	200	62	31.0%	0.00107
02/16	62	400	113	28.3%	0.00051
02/17	76	200	43	21.5%	0.00084
02/18	72	249	46	18.5%	0.00060
02/20	65	299	70	23.4%	0.00060
02/22	105	400	86	21.5%	0.00042
02/23	97	300	44	14.7%	0.00042
02/24	83	400	116	29.0%	0.00051
02/25	72	399	94	23.6%	0.00045
02/27	57	300	60	20.0%	0.00053
03/01	52	250	36	14.4%	0.00049
03/02	51	199	49	24.6%	0.00093
03/03	58	400	59	14.8%	0.00031
03/04	53	75	9	12.0%	0.00141
03/06	46	400	122	30.5%	0.00053
03/08	109	399	117	29.3%	0.00052
03/09	126	400	110	27.5%	0.00050
03/10	118	397	87	21.9%	0.00043
03/11	109	400	76	19.0%	0.00038
03/15	227	400	29	7.3%	0.00017
03/16	176	394	53	13.5%	0.00030
03/17	149	398	77	19.3%	0.00039
03/18	135	400	98	24.5%	0.00046
03/20	123	400	27	6.8%	0.00016
03/22	188	399	28	7.0%	0.00016
03/23	168	400	61	15.3%	0.00032
03/24	151	400	89	22.3%	0.00043
03/25	137	350	80	22.9%	0.00050
03/27	122	400	57	14.3%	0.00031
03/29	99	400	65	16.3%	0.00034
03/30	89	399	58	14.5%	0.00031
03/31	118	400	83	20.8%	0.00041
04/01	118	400	67	16.8%	0.00035
04/03	122	398	41	10.3%	0.00023
04/06	116	400	84	21.0%	0.00041
04/07	112	400	77	19.3%	0.00039
04/08	111	400	41	10.3%	0.00023
Total		13,864	2,611		
Average				18.8%	
Variance				1.1E-04	
n				40	

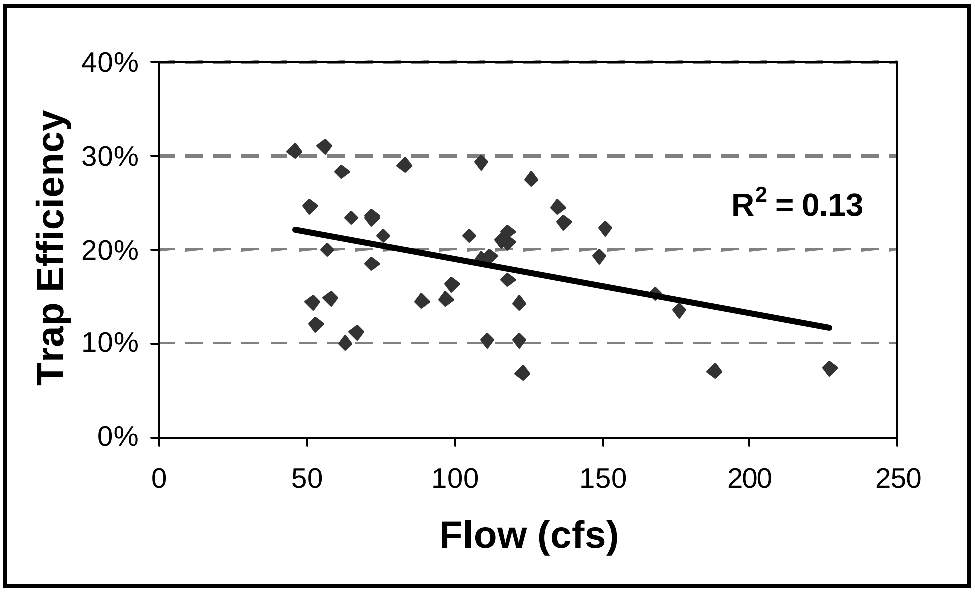

Figure 15. Regression analysis of the relationship between average daily stream flow and trap efficiency measured with sockeye fry, Bear Creek fry trap 2003.

Table 22. Estimated 2003 Bear Creek sockeye fry migration entering Lake Washington with 95% confidence intervals.

Period	Dates	Est. Migration	CV	95% CI Low	95% CI High
Pre-Trapping	February 1 - 5	8,575	31.3%	3,321	13,829
Fry Trap	February 6 - April 8	1,920,928	6.9%	1,659,279	2,182,577
Post-Trapping	April 9 - May 1	65,791	37.9%	16,970	114,612
	Totals	1,995,294	6.8%	1,729,077	2,261,511

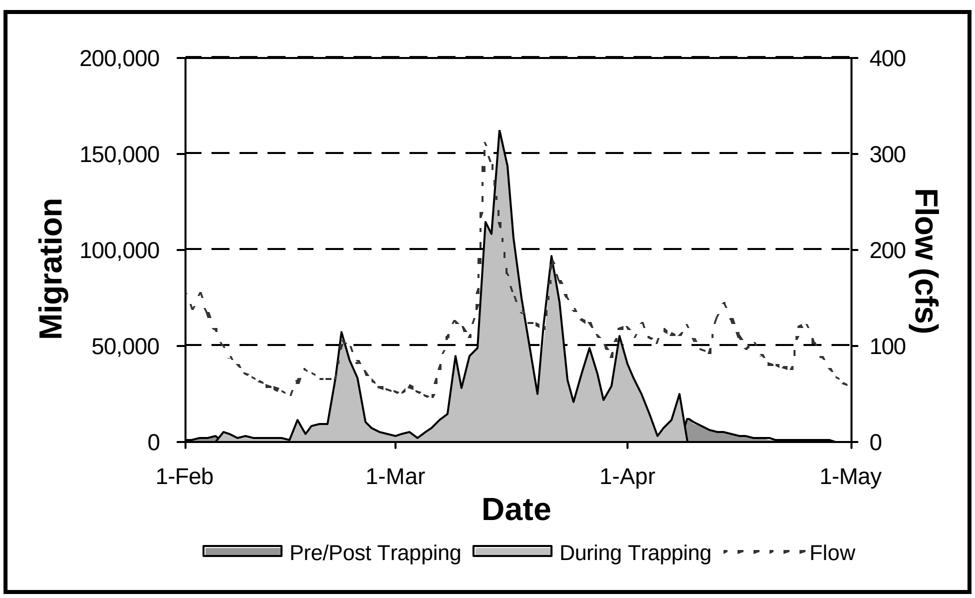

Figure 16. Estimated daily migration of sockeye fry from Bear Creek and flow, 2003.

Chinook

Catch

Fry Trap

On the first night of fry trapping, February 6, we caught four chinook fry. During the 45 nights that the fry trap fished, we caught only 86 chinook fry. Catches remained low until late February, and the peak occurred during the night of March 27 when 11 chinook fry were caught. Catches declined through the remaining trapping season until the trap was removed on April 9.

Catch expansion for the 17 nights not fished resulted in an estimated catch of 35 chinook fry. On March 13 we did not fish continuously through the night due to high flows; however, no additional catch was estimated in response to low actual catches.

Screw Trap

We replaced the fry trap with the screw trap on April 9, and fished it continuously through July 8. On the first night of trapping, we caught zero chinook. Catches began to increase by late April, and peaked on May 28 when 646 chinook were caught. Catches then declined to less than ten per day by June 30. A total of 8,182 chinook were caught throughout the trapping period.

Size

From early February through March, the weekly mean fork length of chinook fry increased by less than five millimeters, to an average of 40 mm (Table 23). By early April weekly mean size averaged around 45 mm with a few individuals over 50 mm (Figure 17).

Weekly average fork lengths during screw trap operation increased throughout the season. Chinook averaged 47 mm in early April, and grew to average 69 mm by early May (Table 23). Fork lengths over the season ranged from less than 40 mm to more than 100 mm (Figure 17).

Trap Efficiency

Sockeye fry were used to estimate fry trap efficiency because inadequate numbers of chinook fry were available to complete reliable efficiency tests. Capture efficiency was estimated at 18.8%, the average of all individual tests (Table 21, Figure 15).

Tests to estimate the capture rate of the screw trap were conducted with chinook on 21 days from May 5 to June 6. Efficiency rates ranged from 31% to 72% and averaged 49% (Table 24). Daily average flows ranged from 23 to 111 cfs during the tests, while flows throughout the trapping season ranged from 19 to 143 cfs. Flow did not explain any of the variation in capture rates; therefore, we used the average (49%) to estimate production.

Table 23. Chinook 0+ and coho smolt mean fork lengths, standard deviations, ranges, sample sizes, and catches in the Bear Creek fry and screw traps, 2003.

GEAR	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	02/03	02/09	6	35.5	1.9	34	38	4	8						
	02/10	02/16	7	38.0		38	38	1	1						
	02/17	02/23	8	40.0	1.4	38	41	7	7						
	02/24	03/02	9	39.6	1.5	38	41	7	7						
	03/03	03/09	10	41.3	0.6	41	42	3	3						
	03/10	03/16	11	40.4	1.4	38	42	7	9						
	03/17	03/23	12	41.3	2.5	38	47	24	26						
	03/24	03/30	13	41.2	1.2	40	44	13	13						
	03/31	04/06	14	43.1	6.0	38	54	8	8						
	04/07	04/08	15	44.8	4.5	41	51	4	4						
SCREW TRAP	04/08	04/13	15	46.8	9.3	35	56	4	4	126.7	11.2	107	146	15	18
	04/14	04/20	16	57.4	7.6	43	73	13	13	131.3	13.8	101	191	74	129
	04/21	04/27	17	61.5	7.9	45	82	82	129	124.2	12.3	99	159	107	930
	04/28	05/04	18	68.7	6.2	56	85	95	452	118.3	11.2	90	165	1,249	3,531
	05/05	05/11	19	72.2	7.7	43	88	92	980	110.8	10.2	88	145	412	4,599
	05/12	05/18	20	77.1	5.5	58	88	58	1,681	113.6	11.4	89	155	411	2,963
	05/19	05/25	21	65.7	16.2	47	75	3	1,029	107.4	10.1	87	134	86	1,800
	05/26	06/01	22	80.6	6.8	66	95	60	2,293	112.2	12.3	95	133	10	820
	06/02	06/08	23	80.4	8.0	57	97	98	1,109	100.9	10.1	88	112	27	159
	06/09	06/15	24	81.9	7.4	65	98	79	250	116.2	15.9	90	153	13	44
	06/16	06/22	25	85.7	7.1	69	106	101	149	124.5	26.6	100	160	4	23
	06/23	06/29	26	91.2	6.4	74	102	24	71	117.0	23.4	86	154	16	26
	06/30	07/06	27					0	21	147.0				1	6
	07/07	07/13	28					0	1						0
Season Totals				72.5	15.0	34	106	787	8,268	116.3	12.4	86	191	2,425	15,048

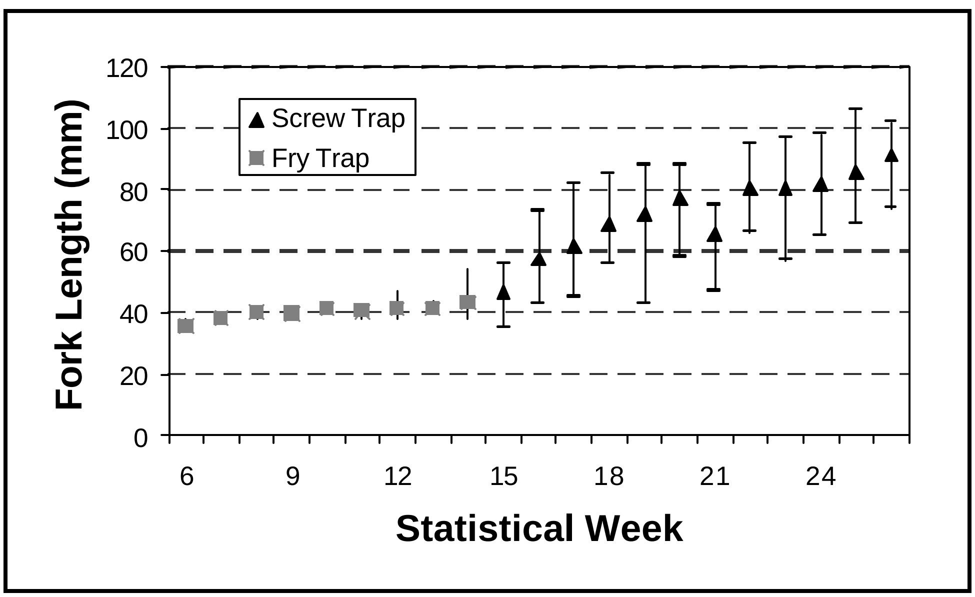

Figure 17. Average and range of chinook 0+ fork lengths sampled from Bear Creek, 2003.

Table 24. Chinook 0+ trap efficiency test results by date, Bear Creek 2003.

Date	NUMBER Released	NUMBER Recap	Efficiency Rate	Variance	Flow (cfs)
05/05	100	31	31.0%	0.0021	111
05/10	100	36	36.0%	0.0023	57
05/11	50	21	42.0%	0.0049	54
05/12	50	22	44.0%	0.0049	47
05/15	59	41	69.5%	0.0036	44
05/16	50	36	72.0%	0.0040	42
05/17	50	26	52.0%	0.0050	57
05/18	50	22	44.0%	0.0049	49
05/19	50	26	52.0%	0.0050	43
05/21	100	53	53.0%	0.0025	40
05/24	33	16	48.5%	0.0076	36
05/26	50	24	48.0%	0.0050	38
05/28	100	59	59.0%	0.0024	31
05/29	50	18	36.0%	0.0046	29
05/30	100	49	49.0%	0.0025	29
05/31	50	24	48.0%	0.0050	30
06/01	50	28	56.0%	0.0049	28
06/03	50	19	38.0%	0.0047	26
06/04	50	27	54.0%	0.0050	25
06/05	50	26	52.0%	0.0050	24
06/06	49	23	46.9%	0.0051	23
Totals	1,291	627			
Average			49.1%		
Variance			4.9E-04		
n			21		

Production Estimate

From February 6 to April 8 we estimated a total of 645 chinook fry passed the fry trap. The screw trap fished continuously throughout the season with no screw stoppages. Applying the average efficiency to daily catches, we estimated that 16,668 chinook passed the trap from April 9 to July 8. Daily migrations in April averaged less than 20 chinook. Migration increased in May and averaged 541 chinook per day for the second half of May. Migration declined thereafter to average 209 chinook per day during the first half of June. By July the migration was virtually over, averaging only four chinook per day.

Combining the chinook production estimates from the fry and screw traps estimates total juvenile production at 17,313 chinook. The coefficient of variation for this estimate was 4.5% and the 95% confidence interval was 15,784 to 18,842 smolts (Figure 18, Appendix C).

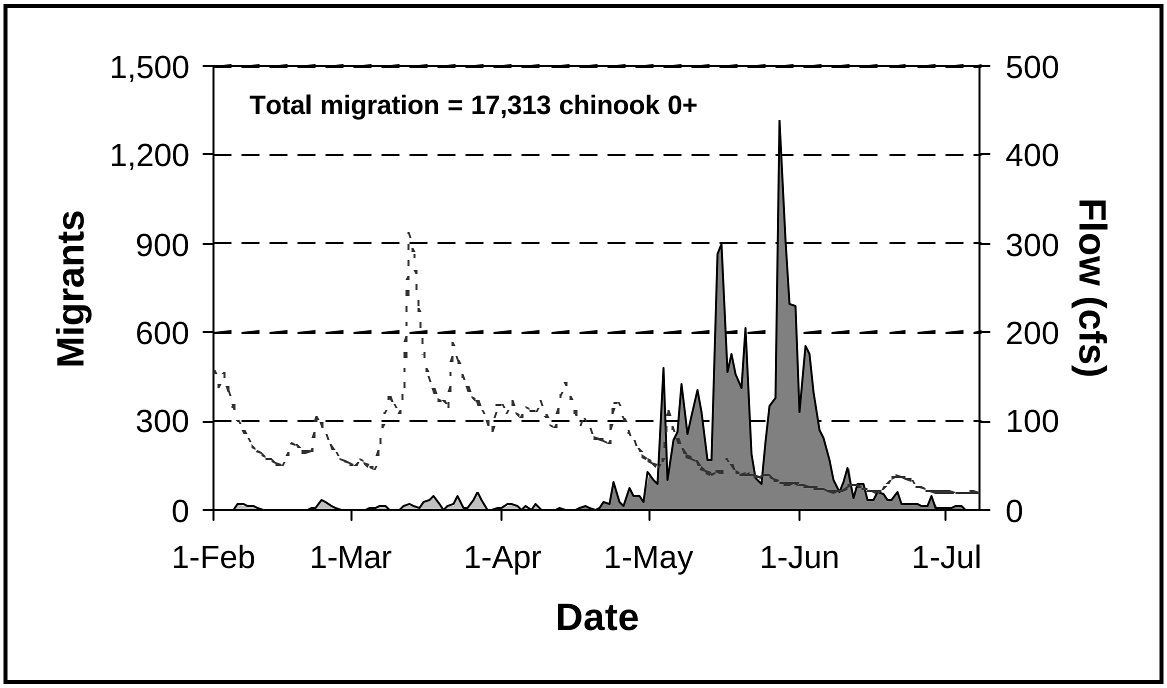

Figure 18. Estimated daily chinook 0+ migration from Bear Creek, 2003.

Coho

Catch

Five coho smolts were caught on the first night of screw trapping, April 9. From this date on, catches steadily increased to peak on May 4 with a catch of 946 smolts. Catches declined thereafter, and by mid-June daily catches averaged less than six smolts per day. Over the entire 91 day trapping season, we caught 15,048 coho smolts.

Size

Over the trapping period, fork lengths ranged from 86 mm to 191 mm and averaged 116 mm (Table 23). Size varied little over the season (Figure 19).

Trap Efficiency

A total of 2,084 marked coho were released in 29 groups upstream of the trap between April 20 and May 30. Trap efficiencies ranged from 14% to 60% and averaged 31% (Table 25). Capture rates were not significantly correlated with flow due to the small range of flows that occurred during the season. We used the average (31%) of the efficiency tests to estimate daily migration.

Production Estimate

Coho production is estimated at 48,561 smolts with a coefficient of variation of 6.6% and a 95% confidence interval of 42,304 to 54,818 smolts (Figure 20, Appendix C).

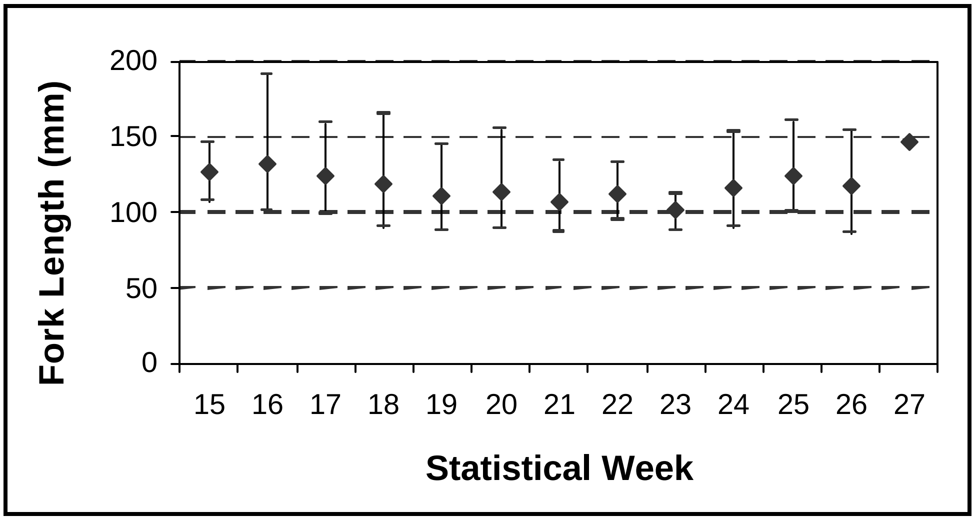

Figure 19. Average and range of fork lengths from coho smolts sampled from Bear Creek, 2003.

Table 25. Estimated coho smolt recapture rates from screw trap efficiency tests, Bear Creek 2003.

Date	Flow (cfs)	Grouped Efficiency Tests			Variance
		Released	Recaptured	Rate	
04/20	81	40	7	17.5%	0.00361
04/21	80	37	6	16.2%	0.00367
04/22	78	42	13	31.0%	0.00509
04/23	75	71	19	26.8%	0.00276
04/24	120	50	13	26.0%	0.00385
04/25	121	100	18	18.0%	0.00148
04/26	103	50	9	18.0%	0.00295
04/27	88	50	11	22.0%	0.00343
04/28	76	100	26	26.0%	0.00192
04/30	61	100	44	44.0%	0.00246
05/02	53	100	28	28.0%	0.00202
05/03	48	100	27	27.0%	0.00197
05/04	55	100	18	18.0%	0.00148
05/05	111	100	26	26.0%	0.00192
05/06	92	94	35	37.2%	0.00249
05/07	79	100	29	29.0%	0.00206
05/08	67	100	41	41.0%	0.00242
05/09	61	100	36	36.0%	0.00230
05/11	54	50	16	32.0%	0.00435
05/12	47	50	17	34.0%	0.00449
05/13	43	50	15	30.0%	0.00420
05/14	39	100	44	44.0%	0.00246
05/15	44	50	30	60.0%	0.00480
05/16	44	100	41	41.0%	0.00242
05/17	57	50	24	48.0%	0.00499
05/19	43	50	21	42.0%	0.00487
05/20	40	50	20	40.0%	0.00480
05/29	29	50	7	14.0%	0.00241
05/30	29	50	13	26.0%	0.00385
Totals		2,084	654		
Average				31.0%	
Variance				4.1E-04	
n				29	

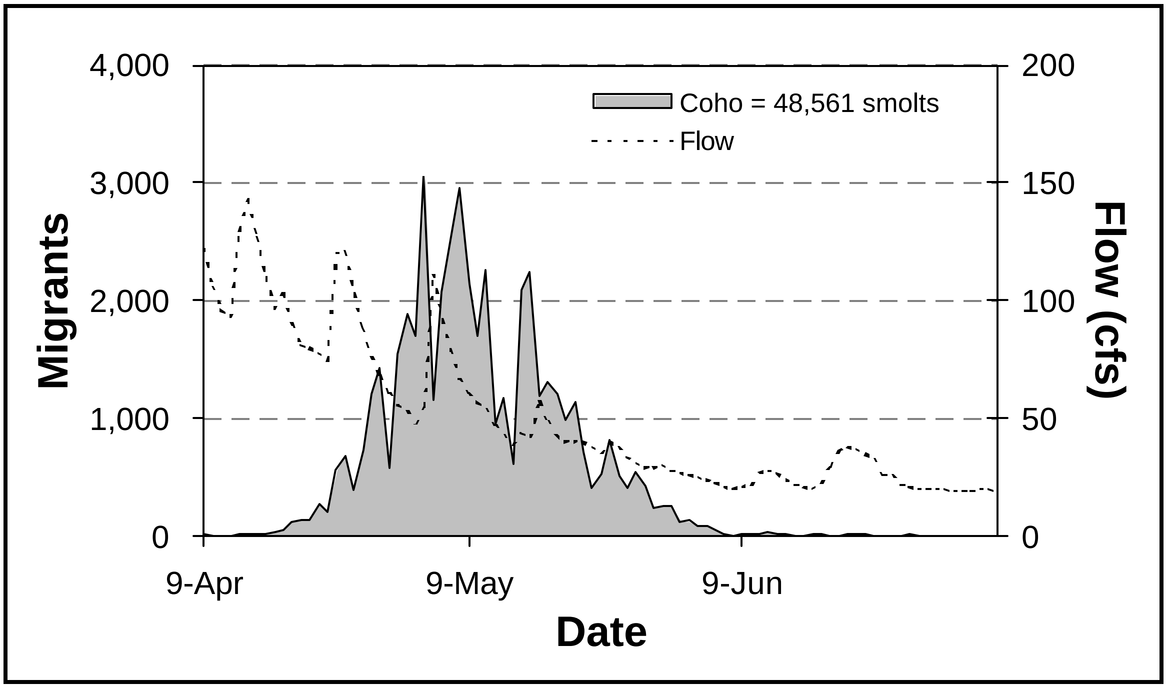

Figure 20. Estimated daily coho smolt migration, Bear Creek screw trap 2003.

Steelhead and Cutthroat

No steelhead were captured during the 2003 trapping season in Bear Creek.

A total of 927 cutthroat trout were captured in the screw trap between April 12 and July 3. Daily catch peaked on April 21 when 61 cutthroat were caught.

Cutthroat trout fork lengths averaged 178 mm, and ranged from 106 to 281 mm throughout the trapping season (Table 26).

As in the Cedar River, most daily catches of cutthroat were too low to enable their use in mark-recapture trap efficiency experiments. Two efficiency tests were conducted on April 17 and May 3, when catches were high enough to mark 12 and 21 cutthroat, respectively. Both tests resulted in zero marked recaptures. The test release site on April 17 was 30 yards upstream of the trap, and on May 3 cutthroat were released from the railroad trestle, just 20 feet upstream of the trap. In light of not recapturing any of the marked cutthroat, capture rate was estimated as in previous years by applying the 60% average steelhead to coho capture rate, derived from the Toutle, Green, and White Salmon Rivers to the estimated average coho smolt catch rate of 31%. The resulting capture rate was estimated at 19%. This rate may underestimate the actual catch rates in the screw trap because the trapping operations on the Toutle, Green, and White Salmon Rivers employed scoop traps; from which steelhead can more easily escape. Therefore, we elected to round the trap efficiency to 20% for estimating cutthroat migration from Bear Creek in 2003.

Table 26. Mean cutthroat fork length, standard deviation, range, sample size, and catch by statistical week, Bear Creek screw trap 2003.

Statistical Week			CUTTHROAT					
					Range			
Begin	End	No.	Avg.	s.d.	Min	Max	n	Catch
04/08	04/13	15	201.4	33.3	161	279	16	16
04/14	04/20	16	189.0	20.7	147	258	72	98
04/21	04/27	17	183.5	25.2	145	281	76	234
04/28	05/04	18	174.6	22.8	129	235	74	142
05/05	05/11	19	175.9	21.9	106	228	33	136
05/12	05/18	20	169.6	18.2	138	217	33	123
05/19	05/25	21	164.2	24.8	114	280	52	94
05/26	06/01	22					0	36
06/02	06/08	23	159.8	8.0	148	166	4	26
06/09	06/15	24	143.6	14.5	122	160	5	12
06/16	06/22	25	166.0		166	166	1	6
06/23	06/29	26					0	2
06/30	07/06	27	170.0		170	170	1	2
07/07	07/13	28						0
Season Totals			178.0	25.1	106	281	367	927

Application of this catch rate to the actual catch estimates a total migration of 4,635 cutthroat smolts (Figure 21, Appendix C). No confidence intervals were developed for this estimate, which applies only to the period of screw trap operation (April 9 through July 8). While we expect that some cutthroat migrated before and after this interval, the catch data indicate that the majority of the migration occurred during the trapping season. Therefore, we did not attempt to expand our 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 Bear Creek.

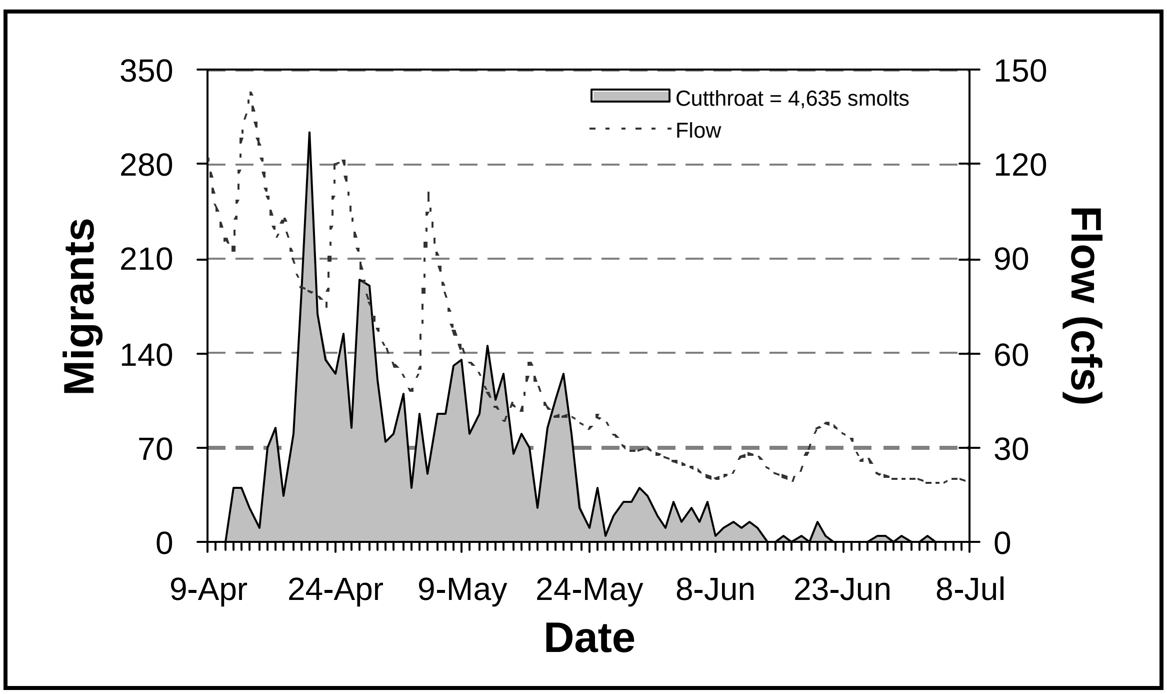

Figure 21. Daily estimated migration of cutthroat trout and flow, Bear Creek screw trap 2003.

PIT Tagging

PIT tagging began on April 29 and continued through July 2. A total of 2,305 chinook and 2,040 coho smolts were tagged throughout the season (Table 27).

Table 27. Chinook and coho smolts PIT tagged at Bear Creek screw trap, 2003.

Statistical Week			Chinook	Coho
#	Start	End		
18	04/28	05/04	25	990
19	05/05	05/11	362	605
20	05/12	05/18	472	395
21	05/19	05/25	555	50
22	05/26	06/01	289	0
23	06/02	06/08	242	0
24	06/09	06/15	154	0
25	06/16	06/22	122	0
26	06/23	06/29	54	0
27	06/30	07/06	30	0
		Total	2,305	2,040

Mortality

Throughout the fry trapping season, there were four chinook 0+ mortalities. Those mortalities most likely occurred before they entered the trap due to predator and parasite marks and scoliosis. The screw trap had 24 chinook, 12 coho (of which, seven entered the trap dead), and three cutthroat mortalities throughout the trapping season.

Incidental Species

In addition to sockeye and chinook fry caught in the fry trap, we also caught four coho fry, two coho smolts, three cutthroat smolts, and nine cutthroat adults. In addition to the species estimated for the screw trap, we also caught three hatchery coho smolts, seven coho fry, four sockeye smolts, and two adult cutthroat. Non-salmonids caught included lamprey, large-scale suckers, three-spine stickleback, sculpin, pumpkinseed, bluegill, peamouth, dace, whitefish, crayfish, and one large-mouth bass.

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Foley, Steve. Fish and Wildlife Biologist. Washington Department of Fish and Wildlife, Mill Creek. Electronic mail on September 21, 2004.

Appendix A: Daily Estimated Cedar River Wild and Hatchery Sockeye Fry Migration into Lake Washington, 2003.

Appendix A. Daily estimated Cedar River wild and hatchery sockeye fry migration into Lake Washington, 2003.

Date	Flow	Nightly Catch		Estimated Daily Catch		Trap	Daily Migration	
	(cfs)	Actual	Estimate	Wild	Hatchery	Efficiency	Wild	Hatchery
01/01	648						1,261	
01/02	840						1,569	
01/03	723						1,952	
01/04	529						2,428	
01/05	485						3,021	
01/06	438						3,758	
01/07	406						4,676	
01/08	432						5,817	
01/09	387						7,236	
01/10	382						9,003	
01/11	369						11,200	
01/12	413						13,933	
01/13	400						17,334	
01/14	417						21,565	
01/15	393						26,828	
01/16	383						33,376	
01/17	379						41,523	
01/18	372						51,657	
01/19	368						64,265	
01/20	363						79,951	
01/21	407	8,366		8,436	0	10.7%	79,137	0
01/22	597		10,020	10,020	0	10.0%	100,447	0
01/23	634	11,673		11,790	0	9.8%	119,792	0
01/24	509		43,063	12,485	30,708	10.3%	121,303	298,354
01/25	478	13,036		13,178	0	10.4%	126,661	0
01/26	965		23,260	23,509	0	8.6%	271,800	0
01/27	1,180	5,808	27,675	33,838	0	7.9%	429,706	0
01/28	1,050		26,401	26,676	0	8.3%	319,737	0
01/29	936	62,992		19,512	44,112	8.8%	222,896	503,914
01/30	918		43,526	22,114	21,663	8.8%	250,762	245,648
01/31	1,370	4,579	21,711	24,715	1,882	7.2%	343,738	26,176
02/01	1,240		23,044	23,320	0	7.7%	304,499	0
02/02	1,350	21,680		21,924	0	7.3%	301,895	0
02/03	1,240	58,438	4,925	18,501	45,526	7.7%	241,575	594,452
02/04	1,410	15,140		15,108	204	7.0%	214,421	2,895
02/05	1,200	69,475		9,364	60,870	7.8%	120,011	780,123
02/06	1,110	9,824		9,658	265	8.1%	118,840	3,261
02/07	944	7,859		7,917	0	8.7%	90,739	0
02/08	806	6,019		6,079	0	9.2%	65,916	0
02/09	678	9,061		9,152	0	9.7%	94,511	0
02/10	648		61,943	9,758	52,287	9.8%	99,657	534,000
02/11	533	59,143		10,363	48,892	10.2%	101,539	479,053
02/12	512	14,528		14,716	0	10.3%	143,129	1,217,000
02/13	503		71,798	17,923	54,083	10.3%	173,772	524,359
02/14	490	20,902		21,130	0	10.4%	203,940	0

Appendix A. Daily estimated Cedar River wild and hatchery sockeye fry migration into Lake Washington, 2003 (cont'd.).

Date	Flow (cfs)	Nightly Catch Actual	Nightly Catch Estimate	Estimated Daily Catch Wild	Estimated Daily Catch Hatchery	Trap Efficiency	Daily Migration Wild	Daily Migration Hatchery
02/15	449	17,945		18,125	0	10.5%	172,477	0
02/16	440	40,614		41,058	0	10.5%	389,505	0
02/17	420	30,265		30,596	0	10.6%	288,284	0
02/18	408	27,374		27,673	0	10.7%	259,685	1,172,727
02/19	402	42,259		27,341	15,370	10.7%	256,050	143,941
02/20	434	58,249		32,191	26,694	10.6%	304,761	252,720
02/21	569	109,807	28,889	81,435	58,974	10.1%	808,187	585,277
02/22	901	72,199		71,596	1,461	8.9%	806,263	16,453
02/23	780	48,439		49,064	0	9.3%	526,665	0
02/24	858	49,644		24,472	25,813	9.0%	270,860	285,703
02/25	910	71,868		22,325	50,471	8.8%	252,330	570,451
02/26	927	73,704		23,302	51,263	8.8%	265,208	583,442
02/27	923		87,299	24,822	62,749	8.8%	282,045	430,000
02/28	867	26,006		26,342	0	9.0%	292,608	0
03/01	743	44,828		45,407	0	9.4%	480,533	0
03/02	616	39,642		40,154	0	9.9%	405,313	0
03/03	659	41,326		41,860	0	9.8%	429,247	871,000
03/04	572		94,046	46,527	48,113	10.1%	462,245	463,741
03/05	555	72,198		51,192	21,920	10.1%	505,515	216,457
03/06	629	37,892		28,361	10,235	9.9%	287,635	103,803
03/07	662	72,586		30,389	43,134	9.7%	311,965	442,802
03/08	820	35,271		35,726	0	9.2%	389,518	0
03/09	1,010	7,504	81,002	89,835	0	8.5%	1,058,472	0
03/10	1,270		145,450	95,254	51,494	7.6%	1,261,577	598,000
03/11	1,150	35,734	101,064	100,672	37,462	8.0%	1,261,115	469,285
03/12	1,880	9,209	36,059	35,212	10,717	5.4%	657,871	200,227
03/13	1,800	15,177	42,772	42,756	16,082	5.6%	757,994	285,108
03/14	1,390	11,242	22,000	29,900	3,821	7.1%	420,062	53,681
03/15	1,310	20,708	8,246	29,360	0	7.4%	396,421	0
03/16	1,370	11,647	10,491	22,448	0	7.2%	312,208	0
03/17	1,330	29,431		18,417	11,427	7.3%	251,111	155,804
03/18	1,350	14,185		14,384	0	7.3%	198,069	1,165,000
03/19	1,280	14,514		14,718	0	7.5%	195,865	0
03/20	1,220	12,861		13,340	0	7.7%	172,562	0
03/21	1,190	21,110		12,574	8,858	7.8%	160,410	113,004
03/22	1,350	5,458	10,175	15,878	0	7.3%	218,641	0
03/23	1,200	18,264		18,520	0	7.8%	237,356	0
03/24	1,080	15,961		16,185	0	8.2%	196,539	0
03/25	1,340	7,960	6,329	14,495	0	7.3%	198,612	0
03/26	1,560	5,591	5,499	11,246	0	6.5%	172,870	0
03/27	1,530	5,652	5,306	11,155	0	6.6%	168,669	0
03/28	1,520	6,356	5,940	12,517	0	6.6%	188,237	0
03/29	1,500	9,558	6,693	16,568	0	6.7%	246,487	0
03/30	1,480	9,160	5,802	15,242	0	6.8%	224,355	0
03/31	1,570	9,259	3,657	13,113	0	6.5%	202,692	0
04/01	1,510	3,273	9,290	12,818	0	6.7%	191,725	0

Appendix A. Daily estimated Cedar River wild and hatchery sockeye fry migration into Lake Washington, 2003 (cont'd.).

Date	Flow	Nightly Catch		Estimated Daily Catch		Trap	Daily Migration	
	(cfs)	Actual	Estimate	Wild	Hatchery	Efficiency	Wild	Hatchery
04/02	1,270	10,557	495	11,250	0	7.6%	148,999	0
04/03	1,340	5,895	7,248	11,425	1,964	7.3%	156,546	26,911
04/04	1,540		9,782	9,962	0	6.6%	151,455	0
04/05	1,520	8,349		8,499	0	6.6%	127,813	0
04/06	1,500		9,835	10,021	0	6.7%	149,085	0
04/07	1,450	11,320		11,541	0	6.9%	167,217	0
04/08	1,380		14,058	14,332	0	7.2%	200,335	0
04/09	1,250	16,796		17,123	0	7.6%	224,639	0
04/10	1,110		16,726	17,052	0	8.1%	209,822	0
04/11	1,050	16,656		16,981	0	8.3%	203,533	0
04/12	1,030		15,699	15,994	0	8.4%	190,062	0
04/13	1,130	14,742		15,006	0	8.1%	186,298	0
04/14	1,050		14,196	14,461	0	8.3%	173,329	0
04/15	993	13,650		13,916	0	8.5%	162,789	0
04/16	998		12,390	12,632	0	8.5%	148,081	0
04/17	1,020	11,129		11,346	0	8.5%	134,253	0
04/18	977		11,805	12,046	0	8.6%	139,970	0
04/19	867	12,480		12,744	0	9.0%	141,561	0
04/20	753		11,096	11,331	0	9.4%	120,373	0
04/21	742	9,712		9,918	0	9.5%	104,920	0
04/22	714		7,846	8,013	0	9.6%	83,872	0
04/23	698	5,979		6,106	0	9.6%	63,528	0
04/24	769		7,217	7,377	0	9.4%	78,851	0
04/25	704		6,902	7,058	0	9.6%	73,599	0
04/26	643	7,363		7,533	0	9.8%	76,792	0
04/27	555		7,641	7,816	0	10.1%	77,182	0
04/28	480		8,010	8,195	0	10.4%	78,821	0
04/29	468	8,333		8,525	0	10.4%	81,656	0
04/30	458		7,428	7,428	0	10.5%	70,903	0
05/01	452	6,523		6,673	0	10.5%	63,565	0
05/02	457		7,231	7,348	0	10.5%	70,116	0
05/03	447		7,133	7,308	0	10.5%	69,495	0
05/04	449	7,438		7,625	0	10.5%	72,559	0
05/05	464		5,144	5,274	0	10.5%	50,447	0
05/06	516		4,150	4,258	0	10.3%	41,472	0
05/07	466	2,506		2,575	0	10.4%	24,647	0
05/08	470		3,152	3,237	0	10.4%	31,027	0
05/09	456		2,653	2,726	0	10.5%	26,003	0
05/10	412	2,727		2,802	0	10.6%	26,330	0
05/11	407		3,080	3,165	0	10.7%	29,690	0
05/12	412	3,432		3,526	0	10.6%	33,133	0
05/13	405		3,385	3,482	0	10.7%	32,642	0
05/14	399		3,538	3,641	0	10.7%	34,064	0
05/15	402	3,591		3,699	0	10.7%	34,641	0
05/16	458		3,935	4,053	0	10.5%	38,688	0
05/17	432	4,278		4,406	0	10.6%	41,684	0

Appendix A. Daily estimated Cedar River wild and hatchery sockeye fry migration into Lake Washington, 2003 (cont'd.).

Date	Flow (cfs)	Nightly Catch Actual	Nightly Catch Estimate	Estimated Daily Catch Wild	Estimated Daily Catch Hatchery	Trap Efficiency	Daily Migration Wild	Daily Migration Hatchery
05/18	406		2,812	2,896	0	10.7%	27,158	0
05/19	395	1,346		1,386	0	10.7%	12,949	0
05/20	390		1,355	1,396	0	10.7%	13,021	0
05/21	386		1,365	1,407	0	10.7%	13,106	0
05/22	376		1,375	1,418	0	10.8%	13,164	0
05/23	372		1,385	1,429	0	10.8%	13,249	0
05/24	370		1,395	1,440	0	10.8%	13,342	0
05/25	365	1,405		1,451	0	10.8%	13,421	0
05/26	361		1,325	1,368	0	10.8%	12,637	0
05/27	360		1,245	1,285	0	10.8%	11,866	0
05/28	349		1,165	1,202	0	10.9%	11,059	0
05/29	341		1,085	1,119	0	10.9%	10,268	0
05/30	338		1,005	1,036	0	10.9%	9,497	0
05/31	332	923		953	0	10.9%	8,719	0
06/01	329						10,724	
06/02	327						10,378	
06/03	324						10,032	
06/04	323						9,686	
06/05	316						9,340	
06/06	312						8,994	
06/07	311						8,648	
06/08	313						8,303	
06/09	318						7,957	
06/10	304						7,611	
06/11	291						7,265	
06/12	312						6,919	
06/13	320						6,573	
06/14	314						6,227	
06/15	331						5,881	
06/16	380						5,535	
06/17	358						5,189	
06/18	356						4,843	
06/19	362						4,497	
06/20	374						4,151	
06/21	415						3,805	
06/22	436						3,459	
06/23	408						3,113	
06/24	373						2,768	
06/25	300						2,422	
06/26	290						2,076	
06/27	287						1,730	
06/28	316						1,384	
06/29	304						1,038	
06/30	288						692	
07/01	292						346	
Season Total		1,897,583	1,300,662	2,318,966	918,514		27,861,123	14,414,772

Appendix B: Estimated Chinook, Coho, Steelhead and Cutthroat Daily Migrations, Cedar River 2003.

Appendix B. Estimated chinook, coho, steelhead and cutthroat daily migrations, Cedar River 2003.

Date	Flow (cfs)	Est. Chinook Catch		Daily Migration			
		Scoop	Screw	Chinook	Coho	Steelhead	Cutthroat
01/01	648			18			
01/02	840			37			
01/03	723			55			
01/04	529			74			
01/05	485			92			
01/06	438			111			
01/07	406			129			
01/08	432			147			
01/09	387			166			
01/10	382			184			
01/11	369			203			
01/12	413			221			
01/13	400			240			
01/14	417			258			
01/15	393			276			
01/16	383			295			
01/17	379			313			
01/18	372			332			
01/19	368			350			
01/20	363			369			
01/21	407	25		235			
01/22	597	39		391			
01/23	634	53		539			
01/24	509	52		505			
01/25	478	50		481			
01/26	965	89		1,029			
01/27	1,180	568		7,213			
01/28	1,050	363		4,351			
01/29	936	157		1,793			
01/30	918	492		5,579			
01/31	1,370	838		11,655			
02/01	1,240	555		7,247			
02/02	1,350	270		3,718			
02/03	1,240	411		5,367			
02/04	1,410	280		3,974			
02/05	1,200	218		2,794			
02/06	1,110	207		2,547			
02/07	944	139		1,593			
02/08	806	36		390			
02/09	678	43		444			
02/10	648	68		694			
02/11	533	91		892			
02/12	512	72		700			
02/13	503	49		475			
02/14	490	25		241			
02/15	449	4		38			
02/16	440	36		342			
02/17	420	7		66			
02/18	408	18		169			
02/19	402	16		150			
02/20	434	37		350			

Appendix B. Estimated chinook, coho, steelhead and cutthroat daily migrations, Cedar River 2003 (cont'd.).

Date	Flow (cfs)	Est. Chinook Catch Scoop	Est. Chinook Catch Screw	Daily Migration Chinook	Daily Migration Coho	Daily Migration Steelhead	Daily Migration Cutthroat
02/21	569	1,692		16,792			
02/22	901	670		7,545			
02/23	780	615		6,602			
02/24	858	470		5,202			
02/25	910	216		2,441			
02/26	927	175		1,992			
02/27	923	149		1,693			
02/28	867	121		1,344			
03/01	743	248		2,625			
03/02	616	77		777			
03/03	659	94		964			
03/04	572	101		1,003			
03/05	555	106		1,047			
03/06	629	23		233			
03/07	662	152		1,560			
03/08	820	70		763			
03/09	1,010	1,148		13,526			
03/10	1,270	1,150		15,231			
03/11	1,150	1,150		14,406			
03/12	1,880	271		5,063			
03/13	1,800	138		2,447			
03/14	1,390	65		913			
03/15	1,310	48		648			
03/16	1,370	72		1,001			
03/17	1,330	90		1,227			
03/18	1,350	77		1,060			
03/19	1,280	30		399			
03/20	1,220	32		414			
03/21	1,190	26		332			
03/22	1,350	102		1,405			
03/23	1,200	65		833			
03/24	1,080	38		461			
03/25	1,340	133		1,822			
03/26	1,560	153		2,352			
03/27	1,530	155		2,344			
03/28	1,520	89		1,338			
03/29	1,500	68		1,012			
03/30	1,480	16		236			
03/31	1,570	24		371			
04/01	1,510	30		449	45		
04/02	1,270	17		225	90		
04/03	1,340	29		397	134		
04/04	1,540	20		304	179		
04/05	1,520	10		150	224		
04/06	1,500	7		104	269		
04/07	1,450	3		43	314		
04/08	1,380	4		56	358		
04/09	1,250	4		52	403		
04/10	1,110	18	5	221	366	0	25
04/11	1,050	30	8	360	530	0	75
04/12	1,030	21	11	250	402	0	25

Appendix B. Estimated chinook, coho, steelhead and cutthroat daily migrations, Cedar River, 2003 (cont'd.).

Date	Flow (cfs)	Est. Chinook Catch		Daily Migration			
		Scoop	Screw	Chinook	Coho	Steelhead	Cutthroat
04/13	1,130	11	7	137	494	0	0
04/14	1,050	8	2	96	238	0	0
04/15	993	3	11	35	512	0	25
04/16	998	7	13	82	658	0	25
04/17	1,020	9	7	106	860	0	25
04/18	977	10	8	116	1,042	0	0
04/19	867	11	10	122	951	25	0
04/20	753	9	6	96	512	0	0
04/21	742	7	6	25	293	0	0
04/22	714	5	14	59	549	25	0
04/23	698	2	20	84	274	25	0
04/24	769	3	21	88	1,810	0	50
04/25	704	6	4	17	969	0	0
04/26	643	9	22	92	439	25	50
04/27	555	9	22	92	1,280	0	25
04/28	480	7	16	67	1,134	0	0
04/29	468	5	39	163	1,993	0	0
04/30	458	5	25	105	1,134	0	50
05/01	452	5	22	92	1,609	0	25
05/02	457	5	12	50	1,042	0	25
05/03	447	6	14	59	421	0	0
05/04	449	7	26	109	1,225	0	50
05/05	464	8	24	100	2,835	0	50
05/06	516	5	45	188	5,486	0	0
05/07	466	1	30	126	2,012	0	0
05/08	470	1	50	209	3,475	0	0
05/09	456	2	92	385	3,639	0	0
05/10	412	3	111	465	2,743	0	0
05/11	407	2	76	318	2,505	0	25
05/12	412	1	23	96	1,353	0	50
05/13	405	2	20	84	823	0	0
05/14	399	10	57	239	1,664	0	0
05/15	402	18	136	569	3,767	50	0
05/16	458	12	22	92	823	0	0
05/17	432	5	59	247	1,500	25	25
05/18	406	4	69	289	1,554	0	0
05/19	395	1	37	155	951	0	0
05/20	390	1	23	96	457	0	0
05/21	386	1	27	113	951	25	0
05/22	376	1	44	184	1,061	0	0
05/23	372	1	38	159	841	25	25
05/24	370	1	14	59	384	0	0
05/25	365	1	87	364	2,194	0	0
05/26	361	1	46	530	823	0	0
05/27	360	1	47	542	1,042	0	25
05/28	349	1	44	507	1,207	0	0
05/29	341	1	36	415	731	25	0
05/30	338	1	26	300	293	0	0
05/31	332	0	95	1,095	677	0	0
06/01	329		62	715	567	0	0
06/02	327		199	2,295	695	50	0

Appendix B. Estimated chinook, coho, steelhead and cutthroat daily migrations, Cedar River, 2003 (cont'd.).

Date	Flow (cfs)	Est. Chinook Catch		Daily Migration			
		Scoop	Screw	Chinook	Coho	Steelhead	Cutthroat
06/03	324		143	1,649	896	25	50
06/04	323		103	1,188	311	50	25
06/05	316		103	1,188	439	50	0
06/06	312		27	311	366	0	0
06/07	311		22	254	256	0	25
06/08	313		119	1,372	457	0	0
06/09	318		62	715	110	0	0
06/10	304		212	2,445	311	25	0
06/11	291		139	2,738	293	0	0
06/12	312		69	1,359	146	25	0
06/13	320		57	1,123	73	0	25
06/14	314		49	965	91	0	0
06/15	331		89	1,753	91	0	0
06/16	380		24	473	146	0	0
06/17	358		43	847	37	0	25
06/18	356		38	749	37	0	0
06/19	362		69	1,359	37	0	0
06/20	374		73	1,438	37	0	25
06/21	415		160	3,152	128	0	0
06/22	436		9	177	18	0	0
06/23	408		35	690	73	0	0
06/24	373		17	335	55	0	0
06/25	300		16	315	0	0	0
06/26	290		9	177	55	0	0
06/27	287		20	394	18	0	0
06/28	316		4	79	37	0	0
06/29	304		2	39	0	0	0
06/30	288		9	177	18	0	0
07/01	292		10	197	37	0	25
07/02	283		15	296	0	0	0
07/03	259		10	197	37	0	0
07/04	262		2	39	18	0	0
07/05	247		3	59	18	0	25
07/06	249		7	138	18	0	0
07/07	250		5	99	0	0	0
07/08	244		2	39	0	0	0
07/09	225		1	20	0	25	0
07/10	275		4	79	37	25	0
07/11	280		2	39	0	0	0
07/12	233		2	39	0	0	0
Season Totals		15,855	3,775	235,397	74,507	525	900

Appendix C: Estimated Sockeye, Chinook, Coho, and Cutthroat Daily Migrations, Bear Creek 2003.

Appendix C. Estimated sockeye, chinook, coho, and cutthroat daily migrations, Bear Creek 2003.

Date	Flow (cfs)	Sockeye	Chinook	Coho	Cutthroat
Pre-Trapping					
02/01	157	571			
02/02	138	1,143			
02/03	154	1,715			
02/04	133	2,287			
02/05	117	2,859			
Fry Trap					
02/06	100	4,484	21		
02/07	88	3,431	16		
02/08	80	2,378	11		
02/09	72	2,724	11		
02/10	67	2,383	5		
02/11	63	1,974	0		
02/12	58	2,048	0		
02/13	56	2,117	0		
02/14	52	1,463	0		
02/15	50	809	0		
02/16	62	11,447	0		
02/17	76	3,718	0		
02/18	72	8,298	0		
02/19	65	8,942	0		
02/20	65	9,580	0		
02/21	66	33,199	5		
02/22	105	56,817	5		
02/23	97	42,002	32		
02/24	83	33,305	27		
02/25	72	10,229	11		
02/26	64	7,367	5		
02/27	57	4,506	0		
02/28	55	3,771	0		
03/01	52	3,032	0		
03/02	51	3,431	0		
03/03	58	4,835	0		
03/04	53	1,782	0		
03/05	48	4,537	5		
03/06	46	7,293	5		
03/07	76	10,788	11		
03/08	109	14,277	11		
03/09	126	44,625	0		
03/10	118	27,448	0		
03/11	109	44,880	0		
03/12	139	49,173	11		
03/13	311	114,431	16		
03/14	287	107,803	11		
03/15	227	162,147	5		
03/16	176	143,013	27		
03/17	149	106,053	32		
03/18	135	74,557	43		

Appendix C. Estimated sockeye, chinook, coho, and cutthroat daily migrations, Bear Creek 2003 (cont'd.).

Date	Flow (cfs)	Sockeye	Chinook	Coho	Cutthroat
Fry Trap					
03/19	124	49,769	21		
03/20	123	24,975	0		
03/21	117	60,657	11		
03/22	188	96,335	16		
03/23	168	73,084	48		
03/24	151	31,667	5		
03/25	137	20,746	5		
03/26	127	34,826	32		
03/27	122	48,901	59		
03/28	111	35,172	32		
03/29	99	21,443	0		
03/30	89	28,448	0		
03/31	118	55,338	5		
04/01	118	40,507	5		
04/02	109	32,831	16		
04/03	122	25,150	21		
04/04	109	14,065	11		
04/05	104	2,979	0		
04/06	116	6,708	11		
04/07	112	11,410	0		
04/08	111	24,820	21		
Screw Trap					
04/09	122		0	16	0
04/10	106		2	0	0
04/11	96		0	10	0
04/12	93		0	6	40
04/13	130		6	26	40
04/14	143		0	23	25
04/15	127		2	23	10
04/16	110		0	19	70
04/17	97		6	35	85
04/18	103		12	55	35
04/19	90		4	119	80
04/20	81		2	142	185
04/21	80		8	145	305
04/22	78		29	271	170
04/23	75		20	207	135
04/24	120		96	571	125
04/25	121		26	678	155
04/26	103		10	397	85
04/27	88		73	733	195
04/28	76		49	1,210	190
04/29	68		49	1,426	120
04/30	61		29	587	75
05/01	56		130	1,539	80
05/02	53		104	1,888	110
05/03	48		84	1,691	40

Appendix C. Estimated sockeye, chinook, coho, and cutthroat daily migrations, Bear Creek 2003 (cont'd.).

Date	Flow	Sockeye	Chinook	Coho	Cutthroat
Screw Trap					
05/04	55		477	3,053	95
05/05	111		104	1,149	50
05/06	92		234	2,069	95
05/07	79		263	2,572	95
05/08	67		422	2,953	130
05/09	61		253	2,146	135
05/10	57		318	1,691	80
05/11	54		403	2,262	95
05/12	47		328	946	145
05/13	43		171	1,171	105
05/14	39		171	610	125
05/15	44		868	2,088	65
05/16	42		896	2,249	80
05/17	57		466	1,184	70
05/18	49		524	1,313	25
05/19	43		462	1,213	85
05/20	40		411	984	105
05/21	40		611	1,133	125
05/22	40		189	713	80
05/23	38		106	413	25
05/24	36		90	526	10
05/25	40		226	826	40
05/26	38		352	520	5
05/27	34		379	407	20
05/28	31		1,316	555	30
05/29	29		909	420	30
05/30	29		695	239	40
05/31	30		691	252	35
06/01	28		330	255	20
06/02	27		552	126	10
06/03	26		524	129	30
06/04	25		399	84	15
06/05	24		269	84	25
06/06	23		244	58	15
06/07	21		169	23	30
06/08	20		102	10	5
06/09	21		59	23	10
06/10	22		92	23	15
06/11	27		139	19	10
06/12	28		41	39	15
06/13	27		90	13	10
06/14	24		90	26	0
06/15	22		35	8	0
06/16	21		35	8	5

Appendix C. Estimated sockeye, chinook, coho, and cutthroat daily migrations, Bear Creek 2003 (cont'd).

Date	Flow (cfs)	Sockeye	Chinook	Coho	Cutthroat
Screw Trap					
06/17	20		59	19	0
06/18	23		53	13	5
06/19	30		32	6	0
06/20	36		32	6	15
06/21	38		59	13	5
06/22	37		17	15	0
06/23	35		17	15	0
06/24	33		18	11	0
06/25	26		18	11	0
06/26	26		13	6	0
06/27	22		13	6	5
06/28	21		47	19	5
06/29	20		6	3	0
06/30	20		6	3	5
07/01	20		3	5	0
07/02	20		3	5	0
07/03	19		12	3	5
07/04	19		10	0	0
07/05	19		0	0	0
07/06	20		2	0	0
07/07	20		0	0	0
07/08	19		2	0	0
Season Totals		1,995,294	17,313	48,561	4,635