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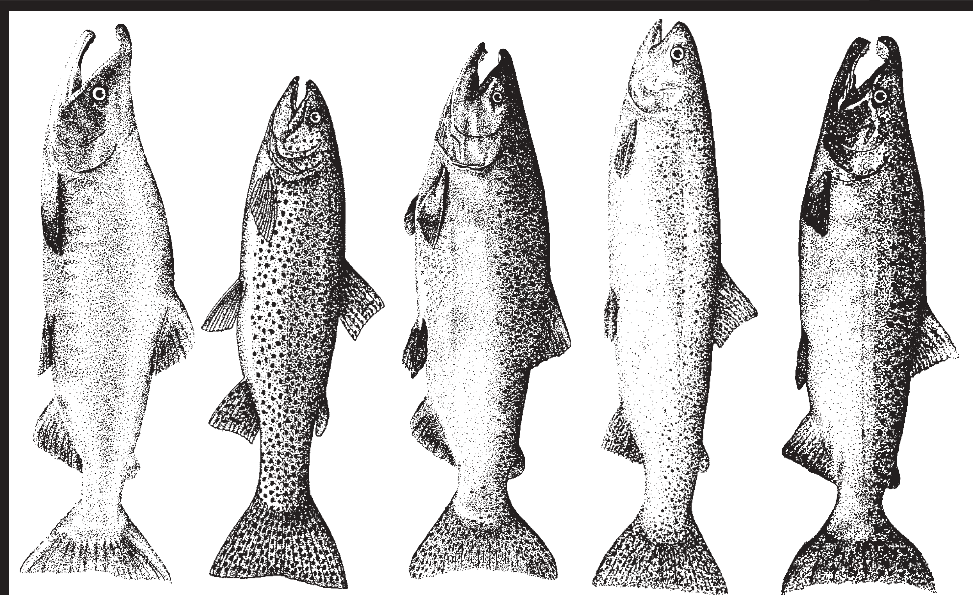
Evaluation of Downstream Migrant Salmon Production in 1999 and 2000 from three Lake Washington Tributaries:

Cedar River, Bear Creek, and Issaquah Creek



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

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Cedar River. The Boeing Company provided electrical power to the fry trap throughout both seasons. The City of Renton Parks Department provided access to the fry and screw traps and anchor cable connections on their property. The Renton Municipal Airport provided access and a measure of security to the lower river trap. The Seattle Public Utilities provided updates and coordination on changing stream flows. The United States Geological Survey provided continuous flow monitoring.

Bear Creek. Blockbuster Video graciously provided electricity throughout both seasons. Staff with the City of Redmond welcomed this project and our nightly presence. Regular visits from Redmond police officers which improved secuirty were particularly appreciated. King County provided flow monitoring data.

Issaquah Creek. The Issaquah Salmon Hatchery coordinated hatchery release information with the trap crew. USGS provide flow data.

The success of this project relied on the hard work of a number of dedicated permanent and temporary WDFW personnel. Escapement data was collected and estimates were developed by Region 4 biologist, Steve Foley, and staff. Scientific Technicians Paul Lorenz, Steve Wolthausen, Dan Estelle, Chuck Ridley, Jill Rossman, and Tim Eichler worked long hours usually at night operating the traps, marking, identifying and counting fish. Permanent biologists Mike Ackley and Pete Topping provided valuable experience and logistical support.

Table of Contents

Big Bear Creek

Issaquah Creek

List of Tables

List of Figures

Executive Summary

The Puget Sound Chinook Evolutionary Significant Unit (ESU) was listed under the Endangered Species Act as a threatened species in March 1999 by the National Marine Fisheries Service. The ESU includes 22 populations of chinook salmon, two of which are located in the Lake Washington basin (Ruckelshaus et al., in press). The North Lake Washington population includes tributaries to the Sammamish River, including Bear Creek and Issaquah Creek. In addition to wild chinook production, an artificial production program (Issaquah Hatchery) exists on Issaquah Creek, and releases approximately 2 million fingerling fall chinook each year. A second population of chinook salmon has been identified in the Cedar River, a tributary to the southern end of Lake Washington. Analysis of genetic data have shown that the Cedar River chinook population is genetically divergent from the North Lake Washington population, and that chinook salmon sampled from Bear Creek and Issaquah Creek are genetically similar (Marshall 2000).

Anticipating this listing, land, waters and fish managers in city, county, state, tribal, and federal government agencies began discussing and planning appropriate responses. In the Lake Washington watershed, it was evident that these 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 such 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 (survival during the freshwater stage) and migrant-to-returning adult (primarily survival during the marine stage). This provides a more direct accounting of the role of freshwater habitat in regulating population abundance, and an improved understanding of density independent and density dependent factors affecting the production of migrants (Seiler et al. 1981, Fuerstenberg and Luchetti 1998, Cramer et al. 1999).

In 1999, the Washington Department of Fish and Wildlife's Wild Salmon Production Evaluation Unit (WSPE) built upon an existing sockeye fry monitoring program in the Cedar River and Sammamish watershed to assess natural chinook production from the Cedar River and Bear Creek, a tributary of the Sammamish River. Since unmarked samples of juvenile or adult chinook taken in the Lake Washington system would also include naturally produced chinook from Issaquah Creek, we deemed it important to also assess natural juvenile chinook production from this stream. Therefore, we conducted a one-year assessment of natural chinook production from Issaquah Creek in 2000.

To accomplish these evaluations, floating downstream juvenile migrant fish traps were deployed to sample the juvenile salmonids migrating from each stream. Traps were operated from January or February to July on the Cedar River and Bear Creek in order to assess all or nearly all of the chinook migration period. The Issaquah Creek trap was operated from mid-March to July.

This report describes the results of our first and second-year investigations of wild chinook production in the Cedar River, Bear Creek, and Issaquah Creek watersheds within the Lake Washington Basin. It also describes the freshwater production of other anadromous salmonids in these systems, except sockeye fry production from the Cedar River during these two years (Seiler *et al.* 2001[a], Seiler *et al.* 2001[b]).

Cedar River

In each year since in 1992 we have operated an inclined-plane screen (scoop) trap at river mile (RM) 0.7 and 1.0, respectively. Trapping with this gear began each year in late January. In 1999, the scoop trap was used until May and until April in 2000. In March of 1999 and April of 2000, we installed a screw trap at RM 1.0 which was operated until trapping ceased in July. Each trap has advantages and disadvantages. The scoop trap was used early in the season since it was designed to sampled the small chinook and sockeye fry which migrate during that period. Predation of small fry in the trap live box is reduced with this trap since few larger predatory fish are captured using this trap design. The trap also incorporated a removable well that facilitated handling chinook and sockeye fry. The screw trap was used later in the spring because it better captures the larger salmonids that are migrating at that time.

Estimates of juvenile production were developed from trap catches by estimating the proportion of downstream migrants that were captured in the trap (capture rate or trap efficiency). These estimates were made by marking and releasing groups of captured age 0+ chinook, coho smolts, and sockeye fry above the trap. Trap efficiency was estimated by the recaptured proportion of the marked groups. Trap efficiency data was evaluated to determine if flow or other factors influenced trap efficiency.

Age 0+ chinook production from the Cedar River was estimated at 81,000 and 65,000 migrants in 1999 and 2000. The migration timing was bi-modal in both years with a substantial migration of newly emerged fry occurring from January to mid-April and a smaller migration of smolted chinook occurring from mid-April until July. The fry component was estimated at 67,000 in 1999 and 46,000 in 2000, whereas the smolt component ranged from 14,000 in 1999 to 19,000 in 2000. We believe the early "fry" component resulted from the downstream displacement of juveniles due to stream velocity and/or rearing density. Late winter flows in 2000 were lower than the 1999 levels which we believe resulted in the displacement of fewer fry downstream and provided more low velocity habitat for rearing to smolt size. Production of coho, steelhead, and anadromous cutthroat was also estimated in each year (see table below).

Juvenile downstream migrant production estimates for the Cedar River, 1999 and 2000.		
	Production Estimates	
Species	1999	2000
Chinook	81,000	65,000
Coho	39,000	32,000
Steelhead	6,700	2,900
Cutthroat	3,500	3,200

In 1999, chinook fry ranged in size from 35-mm to 54-mm during the fry migration period and from 37-mm to 131-mm during the smolt migration period. Similar size ranges were observed in 2000 except that chinook smolts as large as 153-mm were captured that year.

Bear Creek

A screw trap was operated at river mile one on Big Bear Creek between February 24 and July 13 in 1999 and from January 24 to July 13 in 2000. Using the approach described for the Cedar River, juvenile production was estimated for wild age 0+ chinook, coho, sockeye, steelhead, and cutthroat.

Natural production of age 0+ chinook was estimated at 15,000 in 1999 and 32,000 in 2000. Chinook migration timing was strongly bimodal in 2000, as was observed in the Cedar River, but was much less so in 1999. In 1999, most chinook migrated as smolts in May and June. Age 0+ chinook fork lengths were similar between years with newly emerged fry averaging between 35 and 40-mm and smolts averaging between 85 and 95-mm by mid-June.

Coho production was estimated at 63,000 in 1999 and 28,000 in 2000. In 1998, 166,000 coho fry were planted in Bear Creek. No releases occurred in 1999. Since these fish were not marked, we were unable to determine the extent, if any, that they may have contributed to the 1999 smolt production. Sockeye production was estimated at 1.5-million in 1999 and 190,000 in 2000. These differences are primarily related to parent-brood escapement levels. The cutthroat smolt migration past the Bear Creek trap was estimated at 3,400 in 1999 and 5,700 in 2000 during the period of trap operation. Steelhead production was fairly consistent between years with an estimated 1,800 smolts produced in 1999 and 2,000 smolts produced in 2000. Adipose marked smolts resulting from steelhead fry releases made up 77% and 82% of the 1999 and 2000 production, respectively.

In 2000, we assessed the stomach contents of cutthroat, steelhead, and coho smolts, and sculpins that were trapped. We found that a substantial number of sockeye fry and few chinook fry were consumed by these species. Sockeye fry were found in 61%, 24%, 42%, and 66% of the cutthroat, coho, steelhead, and sculpins sampled, respectively. When sockeye fry were found in a sample, the average number of sockeye consumed by cutthroat, coho, steelhead, and sculpins were 18, 4, 15, and 7, respectively. More sockeye fry were found to be consumed when fish were left in the trap live box for longer periods. This information was used to adjust the sockeye production estimate in 2000. Using this data, we estimated 3,546 sockeye fry and 92 chinook fry were consumed by cutthroat, steelhead, and coho captured in the Bear Creek screw trap.

Issaquah Creek

A screw trap was installed on March 14, 2000 at river mile two on Issaquah Creek and operated until July 3, 2000. The trap was operated continuously during this period except for periods when large numbers of hatchery fish from the Issaquah Hatchery (RM 3.1) were passing the trap. These periods necessitated suspending trap operation approximately 30% of the time during the March 14 to July 3 trapping interval. Naturally-produced chinook, coho, steelhead, and cutthroat production was estimated from this trapping effort.

Naturally-produced chinook production was estimated at 30,000 during the March 14 to July 3 period. A substantial number of newly emerged chinook fry were migrating when trap operation began and we were unable to estimate, with any certainty, how many of these migrated prior to trap installation. Chinook size at time was similar to that found in the Cedar River and Bear Creek.

During the period of trap operation, we estimated 19,000 naturally-produced coho smolts, 1,100 wild steelhead smolts, and 15,000 wild cutthroat smolts migrated past the screw trap. Based on coho and steelhead migration timing, these estimates represented virtually all of the production of these two species in the basin. By assuming the same timing for Issaquah Creek cutthroat as was found for Bear Creek cutthroat, the total production of Issaquah cutthroat is estimated at 18,000 smolts.

Comparisons Within and Between Streams

We believe the bimodal migration timing exhibited by age 0+ chinook migrants in these watersheds results from a combination of conditions. In the Cedar River, more smolts (19,000 compared to 14,000) and fewer fry (46,000 compared to 67,000) were produced in 2000 relative to 1999. Since the magnitude of late winter stream flows were much less in 2000 compared to 1999, we believe fewer newly emerged fry were washed downstream into the lake. Furthermore, the lower flows provided additional low velocity habitat for rearing to smolt size that year. In addition, fewer cutthroat were present in the river in 2000 which may have also helped to increase survival to smolt size. In Bear Creek, substantially more fry (14,000 compared to 2,000) and smolts (18,000 compared to 13,000) were produced in 2000 relative to 1999. In this case, we believe the higher escapement in 1999 (733 chinook compared to 401 in 1998) was able to more fully seed the habitat with the excess production migrating as fry in 2000. Chinook smolt production was similar between the three streams in 2000. The Cedar River, Bear Creek, and Issaquah Creek produced 18,800, 18,100, and 18,300 chinook smolts, respectively.

Chinook egg-to-migrant survival was estimated at 10.4% in 1999 and 8.0% in 2000 in the Cedar River, and 2.1% in 1999 to 2.4% in 2000 for Bear Creek. It is difficult to compare differences between the two streams since a larger proportion of Cedar River chinook leave the stream as fry. If only the ratio of smolts produced per eggs deposited is examined, smolt/egg productivity ranges from 1.8% in 1999 to 2.3% in 2000 for the Cedar River, 1.9% in 1999 and 1.4% in 2000 for Big Bear Creek, and 0.6% for Issaquah Creek. A strong density dependent effect is evident in these smolt/egg production rates since for each brood year, the highest rates were found where escapements were least and the lowest rates were found where escapements were highest.

Bear Creek sockeye egg-to-migrant survival was estimated at 11% for the 1998 brood and 7.4% for the 1999 brood. In comparing these survival rates with those from two years of trapping on the Sammamish River indicates that egg-to-migrant survival correlates well with the severity of peak flows during the egg incubation period. This relationship has also been observed for Cedar River sockeye (Seiler *et al.* 2001[b]).

Introduction

The Puget Sound Chinook Evolutionary Significant Unit (ESU) was listed under the Endangered Species Act as a threatened species in March 1999 by the National Marine Fisheries Service. The ESU includes 22 populations of chinook salmon, two of which are located in the Lake Washington basin (Ruckelshaus et al., in press). The North Lake Washington population includes tributaries to the Sammamish River, including Bear Creek and Issaquah Creek. In addition to wild chinook production, an artificial production program (Issaquah Hatchery) exists on Issaquah Creek, and releases approximately 2 million fingerling fall chinook each year. A second population of chinook salmon has been identified in the Cedar River, a tributary to the southern end of Lake Washington. Analysis of genetic data have shown that the Cedar River chinook population is genetically divergent from the North Lake Washington population, and that chinook salmon sampled from Bear Creek and Issaquah Creek are genetically similar (Marshall 2000).

Anticipating this listing, land, waters and fish managers in city, county, state, tribal, and federal government agencies began discussing and planning appropriate responses. In the Lake Washington watershed, it was evident that these 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 such 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 (survival during the freshwater stage) and migrant-to-returning adult (primarily survival during the marine stage). This provides a more direct accounting of the role of freshwater habitat in regulating population abundance, and an improved understanding of density independent and density dependent factors affecting the production of migrants (Seiler et al. 1981, Fuerstenberg and Luchetti 1998, Cramer et al. 1999).

In 1999, the Washington Department of Fish and Wildlife's Wild Salmon Production Evaluation Unit (WSPE) began to assess natural chinook production from the Cedar River and Bear Creek (Figure 1). Since samples of juvenile or adult chinook taken in the Lake Washington system could include a large number of unmarked naturally produced chinook from Issaquah Creek, we deemed it important to also assess chinook production from this stream. Therefore, a one-year assessment of natural chinook production from Issaquah Creek was completed in 2000.

The Issaquah Creek assessment was conducted only one year due to the difficulties associated with operating an efficient downstream migrant trap below a major hatchery. To avoid capturing hatchery produced fish, we were required to suspend trap operation following hatchery releases, sometimes for substantial periods of time.

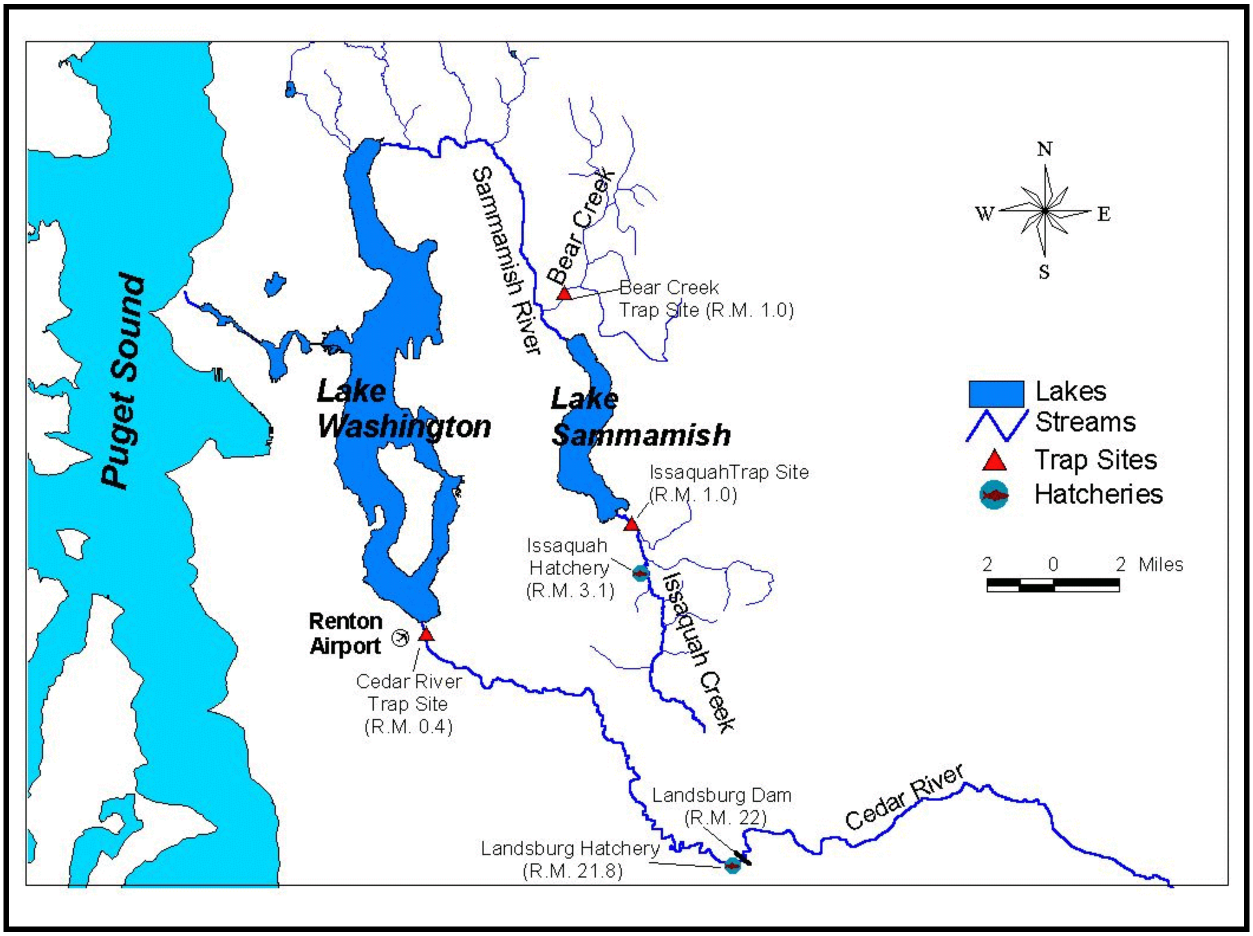


Figure 1. Location of the Cedar River, Bear Creek, and Issaquah Creek juvenile migrant fish traps in the Lake Washington Basin, 1999 - 2000.

Lake Washington chinook stocks inhabit low elevation, rain-fed systems and exhibit an ocean-type, rather than a stream type, life history (Healey 1991). Ocean-type chinook emigrate to saltwater within their first year of life. While assessing sockeye fry production, we found that the downstream movement of chinook fry began at least as early as January in the Cedar River. Chinook rear within the lake and the stream, although the proportions are currently unknown.

WSPE has been assessing sockeye fry production from the Cedar River since 1992 using one or two small inclined plane screen (scoop) traps (fry traps). The traps, employed to measure sockeye fry production, were too small and placed in a section of the stream with insufficient velocity to effectively capture chinook smolts. Despite these constraints, we began assessing the chinook migration from the Cedar River in 1998 by operating the fry trap until July 7, one month longer than in previous years. Over this season, we found that chinook smolts continued to increase in size, and although the emigration continued, it declined to a low level by early-July.

Juvenile chinook have been found rearing in Lake Washington as early as February (Kurt Fresh pers. comm.), and smolts are observed passing the Ballard Locks from mid-May through mid-September. In recent years, in the course of investigating downstream migrant fish passage at the Ballard Locks, biologists have observed and sampled numbers of juvenile chinook as late as August. Prior to the complete marking of all hatchery produced chinook in the basin, the origin of these fish were unknown. Beginning in 2000 all hatchery chinook were adipose marked. This has enabled the direct determination of the incidence of naturally produced chinook both as juveniles and returning adults.

This report describes the results of our first and second-year investigations of wild chinook production in the Cedar River, Bear Creek, and Issaquah Creek watersheds within the Lake Washington Basin. It also describes the freshwater production of other anadromous salmonids in these systems, except sockeye fry production from the Cedar River during these two years. 1999 and 2000 sockeye fry production from the Cedar River are described in separate reports (Seiler *et al.* 2001[a], Seiler *et al.* 2001[b]).

Cedar River

Introduction and Background

The downstream migrant evaluations conducted in the Cedar River, and Bear and Issaquah Creeks in 1999 and 2000 were the first in the Lake Washington Basin directed at estimating the production of wild juvenile chinook. Since 1992, we have operated a downstream migrant trap in the lower Cedar River to evaluate the production of wild and hatchery sockeye fry (Seiler and Kishimoto 1997, Seiler *et al.* 2001[a], Seiler *et al.* 2001[b]) (Figure 1). In 1999 and 2000, we operated this trap nightly, from late-January through May in 1999 and through late-April in 2000. Over these intervals, we determined its capture rate for sockeye fry with numerous releases of marked fry. Capture rate for a given species and size class of migrants, which is required to transform catch into an estimate of production, is affected by a number of variables (e.g., velocity, turbidity, depth, noise, flow, and channel morphology).

Sufficient velocity into a trap is required to reliably trap migrants. As swimming speed is a function of fish length, higher velocities are needed to trap larger migrants. Because sockeye fry, which average 28 to 30-mm, are easily trapped at moderate velocities (3-4 fps), beginning in 1992, we placed the fry trap in a location which had these velocities even at low flows. Chinook fry average nearly 40-mm in January, and continue to increase in size throughout the spring and summer. Applying the sockeye fry capture rates, which, in the past ranged as a function of discharge between 3% and 12% on a given night, to the larger chinook, produced estimates that may be biased, even early in the season when the size difference is minimized. This bias is likely to be at least partially off-set by typically higher stream discharge encountered in late-winter/early spring which produces higher velocities. Consequently, we believe that estimating chinook fry migration from catches in the fry (scoop) trap are least biased early in the season. As growth occurs in March, and as velocities decrease, these estimates likely become increasingly biased (low) as larger fish are able to avoid the trap.

The importance of velocity to unbiased capture is illustrated by the 1998 fry trap results. As a result of extensive sediment deposition in the lower Cedar River, by the 1998 season the streambed was substantially elevated compared to the previous six seasons. This increase in elevation relative to lake level created sufficient stream energy to cut a distinct channel which, at low discharge, confined flow. The resulting velocities were high enough in the trap even at minimum flows to capture large chinook smolts. This was also evident by the high numbers of coho smolts (which are larger than chinook smolts) that we captured relative to catches in all other years. In 1998, we caught 646 coho smolts, compared to an average catch for the previous seasons of just 92 coho smolts (WDFW unpublished data).

In Summer 1998, the lower Cedar River was dredged to reduce the flooding potential (USACOE 1997). Lowering the stream bed created a wider and deeper channel, which reduced the velocity to near zero where the fry trap was located (RM 0.25). Given this dramatic change in the channel, it was clear that capturing an unbiased sample of the chinook migrants over the entire flow range would require a different trap and location in 1999. To effectively capture larger chinook, in addition to the fry trap we elected to deploy and operate a different gear type (a screw trap) in faster water. Concurrent operation of the fry trap and screw trap in 1999 assessed the capture and size bias of the fry trap given the velocities in effect during the post-dredged condition in 1999. Determining the effectiveness of the fry trap also assessed the potential to estimate chinook migrants over the previous years from fry trap catch data.

In 2000, both the scoop trap and screw trap were used to capture chinook migrants. However, the traps were operated sequentially instead of concurrently. A single scoop trap operated from January through late-April and the screw trap operated from late-April through early July.

Goals and Objectives

This project was directed at assessing the production of juvenile chinook from the Cedar River. Achieving this goal, which includes estimating the numbers, sizes, and timing of chinook leaving the river over the entire migration period, provides the basis for meeting the following objectives:

1. **In-River survival of natural production**. Estimating the in-river (egg-to-migrant) survival for the 1988 and 1989 broods through relating migrant production to the estimated egg deposition in these years. Over time, significant variation in this rate among broods, as a function of spawner abundance and flows, will also be assessed.;

2. **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 the juvenile production; and

3. **Evaluation of gear bias.** Evaluating the potential for size selectivity in the fry trap and assessing the effects of this bias on estimating chinook production with the fry trap.

Objectives 1 and 3 are met in this report. Objective 2 is part of a larger, multi-agency study and will be addressed in another report. Additional objectives included estimating the production of and collecting biological information on coho, steelhead, and cutthroat trout migrating from the Cedar River. Sockeye fry production is documented in separate reports (Seiler *et al.* 2001[a], Seiler *et al.* 2001[b]).

Cedar River 1999

Trapping Gear and Operation

Fry (Scoop) Trap

Following lower river dredging in 1998, inadequate stream velocities for proper scoop trap function required moving the trap upstream of the position used in 1998, to just below the South Boeing Bridge. Trap operation began on January 23, and continued every other night through the end of that month. From February 1 through May 16, we fished the trap throughout each night, and then fished every other night between May 17 and May 25. At the South Boeing Bridge location, trap placement was adjusted to maximize our capture rates resulting in the use of three different trapping positions over the sockeye migration period. The trap was initially placed near the west bank of the channel (Position 1). On February 13, decreasing velocity and low capture rates prompted moving the trap to the east bank of the channel (Position 2). On February 17, the trap was again re-positioned approximately 10-ft toward the middle of the channel (Position 3), where it remained for the rest of the trapping season.

On most nights, we operated only one of the two scoop traps mounted on the fry trap barge to avoid catching too many sockeye fry. On ten nights, from February 1 through March 7, we operated both traps to evaluate relative capture rates between the two. We refer to the traps as Trap 2 and Trap 3 which denotes their position. Trap 2 is inboard of the port pontoon and Trap 3 is inboard of the starboard pontoon.

All species caught in the fry trap were identified and counted. Chinook fry were randomly sampled for size (fork length).

Screw Trap

In Fall 1998, we constructed two 30-ft steel barges to support the screw traps for the Cedar River and Bear Creek evaluations. Each barge was comprised of 3-ft wide steel air tank pontoons, front and rear steel decks, steel safety railings, and two front-mounted five-ton anchor winches spooled with ⅜-in. aircraft cable. To provide sufficient clearance under the anchor cables (which spanned the width of the river) for boaters and other river users to safely pass the trap, we fabricated a steel superstructure that suspended the anchor line blocks 5-ft above the deck level. The 5-ft diameter screw trap and live box assembly was suspended from two davits fitted with blocks and worm-drive winches. Because we did not want to retain sockeye fry in the Cedar River screw trap, we placed a panel of perforated plate with $^{3}/_{16}$-in. diameter holes on the floor and aft wall of the live box.

We selected a trapping location in the fastest water in the lower Cedar River, just upstream of the Logan Street Bridge (RM 1.0), near the right bank. At this point, the river has formed a constricted channel as it passes an old bridge abutment. We placed the trap in the river, positioning the screw trap entrance in the thalweg. To provide safe clearance for boaters under the anchor cables and the proper angles for stability and lateral positioning, we attached the starboard cable high in a tree on the left bank with a nylon strap. For the port (right-bank) cable attachment, we bolted a steel plate to the concrete abutment.

Screw trap operation began on the afternoon of March 18. For the first month, we ran the trap continuously, counting catches at dusk, and again early each morning. This schedule enabled separating the 24-hour catch into day and night components. Beginning in mid-April, we stopped daytime trapping on weekends. In mid-June we ceased daytime trapping almost entirely. These reductions minimized potential safety hazards that the trap presented to recreational river users (i.e., boaters, inner-tubers, etc.). As the weather warmed, and particularly when school let out for the summer, we observed an increase in recreational activity. With the exception of four nights, we operated the screw trap every night from March 18 through the morning of July 27.

All chinook, coho, steelhead, and cutthroat smolts were enumerated by species and randomly sampled for size (fork length).

Production Estimation

Fry Trap

Estimation of total chinook fry migration occurs in several steps. The data collected every night, i, consisted of:

- Count of total fry taken in the trap - C_i
- Flow - f_i

Nighttime data taken less frequently included:

- Proportion of marked fry released above the trap and subsequently retaken or trap efficiency - $\hat{e}_i$

Linear regression analysis was used to test the relationship between flow and trap efficiency. Where the relationship was significant, it provided an estimate of trap efficiency, $\hat{e}_i$, and its variance, at any flow, f_i;

$$\hat{e}_i = \alpha + \beta f_i \tag{1}$$

The variance of the predicted efficiency on any day *d* was estimated by;

$$V(\hat{e}_d|f_d) = MSE\left(1 + \frac{1}{n} + \frac{(f_d - \bar{f})^2}{(n-1)s_f^2}\right) \tag{2}$$

where,

MSE = *the mean square error for the regression*,
s_f^2 = *the sample variance of the observed flows*, *and*
$\bar{f}$ = *the mean of observed flows in* 1999.

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

$$\bar{e} = \frac{\sum_{i=1}^{n} \hat{e}_i}{n} \tag{3}$$

The variances of the individual trap efficiency estimates and the mean trap efficiency estimate were estimated by;

$$V(\hat{e}_i) = \frac{\hat{e}_i(1 - \hat{e}_i)}{(n-1)} \tag{4}$$

$$V(\bar{e}) = \frac{\sum (\hat{e}_i - \bar{e})^2}{n(n-1)} + \frac{\sum V(\hat{e}_i)}{n} \tag{5}$$

Where trap efficiency was predicted using the regression equation (Equation 1), the nightly total outmigration, $\hat{N}_i$, was estimated using the estimated trap efficiencies;

$$\hat{N}_i = \frac{C_i}{\hat{e}_i} \quad \textbf{(6)}$$

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

$$V(\hat{N}_i) = V(\hat{e}_i)\,\frac{C_i^{2}}{\hat{e}_i^{4}} \quad \textbf{(7)}$$

Where trap efficiency was estimated using mean trap efficiency, then ‘ is substituted for $\hat{e}$ in Equation 6 and *V(‘)* is substituted for $V(\hat{e})$ in Equation 7.

When both traps were running concurrently, nightly migration was estimated using Equation 6 except the sum of the catches from both traps was substituted for C_i and the sum of both trap efficiency estimates for the individual traps was substituted for $\hat{e}_i$ in the equation. The variance was calculated using the following:

$$V(N_i) = \sum_{i=1}^{2} V(e_i)\,\frac{\left(\sum_{i=1}^{2} C_i\right)^2}{\left(\sum_{i=1}^{2} e_i\right)^4} \quad \textbf{(8)}$$

To estimate migration during periods when we trapped every other night, straight-line interpolation was used. Where migration was interpolated for only a single night, the interpolated value was the mean of the preceding and following night’s estimates, therefore the variance for this estimate was;

$$V(\hat{N}_i) = \frac{\sum (\hat{N}_i - \bar{N})^2}{n(n-1)} + \frac{\sum V(\hat{N}_i)}{n} \quad \textbf{(9)}$$

Where more than one nightly migration estimate was interpolated, the variance for each interpolated migration estimate was found by interpolating between the coefficients of variation (CVs) for the two measured nightly wild migration estimates. These interpolated CVs were multiplied by their respective interpolated migration estimates and the product was squared to estimate the variance.

Daily (24-hour) migration, $\hat{N}_d$, was estimated by dividing the nightly migration estimate by the early-spring ratio of nightly to daily (24-hour) migration, $\hat{r}_d$, which was estimated by;

$$\hat{r}_d = \frac{T_f}{\overline{Q}_m T_u + T_f} \quad \textbf{(10)}$$

and an estimate of the variance developed using the delta method (Goodman 1960) by;

$$V(\hat{r}_d) = V(\overline{Q}_m) T_u^{\,2} \frac{T_f^{\,2}}{(\overline{Q}_m T_u + T_f)^4} \quad \textbf{(11)}$$

where,

T_f = *Time fished during night period f,*

T_u = *Time not fished during day period u, and*

$\overline{Q}_m$ = *Average 24 hour day / night catch rate ratio over month m.*

The variance of the daily (24 hour) migration was estimated using the delta method (Goodman 1960) by;

$$V(\hat{N}_d) = \hat{N}_d^{\,2}\left(\frac{V(\hat{N}_i)}{\hat{N}_i^{\,2}} + \frac{V(\hat{r}_d)}{\hat{r}_d^{\,2}}\right) \quad \textbf{(12)}$$

Straight-line extrapolation was used to estimate chinook migration prior to trap installation assuming a migration starting date of January 1. The extrapolation was based on the estimated mean migration for the first two days of trapping. The CV for the mean migration over the first two days was found using;

$$CV(\overline{N}) = \frac{\sqrt{\left(\frac{\sum_{d=1}^{n}(\hat{N}_d - \overline{N})^2}{n(n-1)} + \frac{\sum_{d=1}^{n} Var(\hat{N}_d)}{n}\right)}}{\overline{N}} \quad \textbf{(13)}$$

The variance for the estimated migration prior to trapping was estimated by;

$$V(\hat{N}_{before}) \quad (CV_{\bar{N}} \times \hat{N}_{before})^2 \qquad \textbf{(14)}$$

This variance estimate related only to the variability that might be expected if we were estimating migration from trapping data, if trapping were occurring. It did not reflect imprecision in selecting the migration starting date or the linear shape of the extrapolated data.

Screw Trap

Screw trap catch data was sorted into day and night strata. To interpolate catch for periods when the trap was not fishing, diel differences in migration rates were evaluated. Salmonids often migrate at different rates between day and night periods (Seiler *et al.* 1981), therefore, fished periods were stratified into daytime and nighttime periods. The stratification was simplified by performing the trap checks near day break and twilight periods. Catch rates were estimated by; Where:

$$\hat{R}_{fj} = \frac{C_{fj}}{T_{fj}} \qquad \textbf{(15)}$$

$\hat{R}_{fj}$ = *The catch rate during fishing period f in diel stratum j*,

C_{fj} = *Catch during fishing period f in diel stratum j, and*

T_{fj} = *The duration of fishing period f in diel stratum j.*

When part of a daytime or nighttime period was fished, catch for the remaining un-fished period was estimated by;

$$\hat{C}_{ij} = \hat{R}_{fj} \times T_{ij} \qquad \textbf{(16)}$$

Where:

$\hat{C}_{ij}$ = *The estimated catch during unfished period i in diel stratum j, and*

T_{ij} = *The duration of unfished period i in diel stratum j.*

Catch rates would be expected to vary within and between fished periods. Since we have no way of measuring the variance within a fished period, the variance in catch rates between fished periods was used to approximate the variance within a fished period. Therefore, the variance of the catch rate, $V(\hat{R}_{fj})$, was approximated by;

$$\hat{V}(\hat{R}_{fj}) \cong V(\overline{R}_{jk}) \tag{17}$$

Where:

$V(\overline{R}_{jk})$ = *The variance of the mean capture rate for fishing periods within diel stratum j in statistical week k.*

The variance for the estimated catch was found using;

$$\hat{V}(\hat{C}_{ij}) = V(\hat{R}_{fj}) \times T_{ij}^{\,2} \tag{18}$$

To facilitate the estimation of catch where entire daytime or nighttime periods were not fished, catch was interpolated using daytime or nighttime period catch rates from adjacent days, respectively. Where this information was not available for some daytime periods, weekly average daytime/nighttime catch rate ratios were calculated by,

$$\overline{Q}_k = \frac{\overline{R}_{fdk}}{\overline{R}_{fnk}} \tag{19}$$

Day catch rates were then estimated by;

$$\hat{R}_{idk} = \overline{R}_{f_1 f_2 n} \times \overline{Q}_k \tag{20}$$

Where:

$\overline{Q}_k$ = *The ratio of average day catch rates over average night catch rates during statistical week k,*

$\overline{R}_{f_1 f_2 n}$ = *The average catch rate during the preceeding and following fishing periods f_1 and f_2 for nighttime stratum n, and*

$\hat{R}_{idk}$ = *The estimated catch rate during unfished period i for daytime stratum d in statistical week k.*

The variance of the average day/night catch rate ratio was approximated using the variance of products with the delta method for independent variables (Goodman 1960);

$$\hat{V}(\overline{Q}_k) = (\overline{Q}_k)^2 \times \left(\frac{\hat{V}(\overline{R}_{dk})}{\overline{R}_{dk}^{\,2}} + \frac{\hat{V}(\overline{R}_{nk})}{\overline{R}_{nk}^{\,2}} \right) - \hat{V}(\overline{R}_{dk}) \frac{\hat{V}(\overline{R}_{nk})}{\overline{R}_{nk}^{\,4}} \qquad \textbf{(21)}$$

or where this equation resulted in very small or negative variances, the equation was reduced to;

$$\hat{V}(\overline{Q}_k) = (\overline{Q}_k)^2 \times \left(\frac{\hat{V}(\overline{R}_{dk})}{\overline{R}_{dk}^{\,2}} + \frac{\hat{V}(\overline{R}_{nk})}{\overline{R}_{nk}^{\,2}} \right) \qquad \textbf{(22)}$$

Similarly, the variance of the estimated day catch rate was estimated by;

$$\hat{V}(\hat{R}_{idk}) \cong \hat{V}(R_{fn})\overline{Q}_k^{\,2} + \hat{V}(\overline{Q}_k)R_{fn}^{\,2} + \hat{V}(R_{fn})\hat{V}(\overline{Q}_k) \qquad \textbf{(23)}$$

or if Equation 22 was used by;

$$\hat{V}(\hat{R}_{idk}) \cong \hat{V}(R_{fn})\overline{Q}_k^{\,2} + \hat{V}(\overline{Q}_k)R_{fn}^{\,2} \qquad \textbf{(24)}$$

With the estimated daytime catch rate, day catch was then estimated by,

$$\hat{C}_{idk} = \hat{R}_{idk} \times T_{idk} \qquad \textbf{(25)}$$

and the variance of the day catch by,

$$\hat{V}(\hat{C}_{idk}) = \hat{V}(\hat{R}_{idk}) \times T_{idk}^{2} \tag{26}$$

Capture rate was estimated with groups of fin-marked chinook and coho smolts released from the Bronson Way bridge (0.4-mile upstream). Because we conducted these calibration tests with wild fish caught in the trap, efficiency tests could not begin until catches increased. Each test group was identified with a partial fin-clip to the tip of a ventral or caudal fin. This entailed lightly anesthetizing the group in MS-222, squaring ⅛-in of the fin tip with a surgical scissors, and allowing for complete recovery before transporting and releasing from buckets.

As with the fry trap, the effect of flow on measured capture rates was assessed using linear regression analysis. Where this relationship was found not to be significant, the mean capture rate from efficiency tests was used to estimate migration for each species. Variances were calculated for the flow-based efficiency estimates, the individual efficiency tests, and the mean trap efficiency using Equations 2, 4, and 5, respectively. Equation 6 was used to estimate migration; except the daily (24-hour) catch, or its estimate, was used instead of the partial-day catch, C_i, in the equation. Equation 7 was similarly modified and used to estimate the variance of the migration estimate when actual catch data was used. Where catches were estimated, the variance was estimated using the delta method;

$$V(\hat{N}_d) = \hat{N}_d^{2}\left(\frac{V(\hat{e}_d)}{\hat{e}_d^{2}} + \frac{V(\hat{C}_d)}{\hat{C}_d^{2}}\right) - V(\hat{e}_d)\frac{V(\hat{C}_d)}{\hat{C}_d^{4}} \tag{27}$$

or where this equation resulted in a very small or negative variances, the equation was reduced to;

$$V(\hat{N}_d) = \hat{N}_d^{2}\left(\frac{V(\hat{e}_d)}{\hat{e}_d^{2}} + \frac{V(\hat{C}_d)}{\hat{C}_d^{2}}\right) \tag{28}$$

where:

$\hat{N}_d$ = *The estimated daily (24-hour) migration on day d,*

$\hat{e}_d$ = *The estimated trap efficiency on day d, and*

$\hat{C}_d$ = *The estimated catch on day d.*

1999 Results

Chinook - Fry Trap

Catch

On the first night of trap operation (January 23), we caught 16 chinook fry in the one inclined-plane trap that was fished. From that date through March, nightly catches in a single trap varied, from a low of one chinook fry to a high of 91 fry. While variation between nights was high, over the ten nights in which we fished both fry traps, catch ratios for chinook between the two traps were similar to those of sockeye (Table 1). Through March, we caught a total of 1,805 chinook fry, 95% of the season total catch. In April and May, catches declined to average only four and less than one per night, respectively (Appendix A). Over the season, 1,916 chinook fry were captured in the fry trap.

In addition to chinook fry, we also caught 756,897 sockeye fry, and 65 coho smolts over the season.

Size

From late-January through April, the mean fork length of chinook fry increased less than 2-mm, and averaged 40-mm (Table 2). Through mid-May, the lower end of the size range remained unchanged, around 40-mm or less (Figure 2). While the catch included individuals as large as 66-mm and mean fork length increased to 53-mm, catches were very low by mid-May. We attribute the decline in capture rates to increased size of chinook migrants and their swimming ability, and decreased water velocity as a result of reduced flow.

Trap Efficiency

From February 6 to May 11, we released 77,285 marked sockeye fry in 54 groups at Logan Street Bridge (RM 1). Of the three different trap positions used during the 1999 outmigration period, position 1 was fished from January 23 to February 13, position 2 was fished from February 13 to February 17, and position 3 was fished from February 17 through May 28, the last day of fry trap operation. Each move was initiated to optimize capture efficiency. The use of two traps in three different positions resulted in six possible strata for evaluating capture efficiency. Efficiency tests were made in four of the strata: Trap 2, positions 1, 2, and 3; and Trap 3, position 3 only (Table 3). Of the remaining strata, Trap 3 in positions 1 and 2, Trap 3 only operated a total of three nights. Trap 3 capture efficiencies on those nights were estimated by multiplying the Trap 2 capture efficiency by the ratio of the specific nightly Trap 3 to Trap 2 chinook 0+ catch.

Recapture rates from the 54 calibration tests ranged from 1.3% to 7.5% (Table 3). Linear

Table 1. Comparison of catches and catch ratios for sockeye and chinook fry in two inclined-plane traps, Cedar River fry trap 1999.

	Catch				Catch Ratio between Traps			
	Sockeye		Chinook		Sockeye		Chinook	
Date	Trap 2	Trap 3	Trap 2	Trap 3	Trap 2	Trap 3	Trap 2	Trap 3
Feb 1	120	222	11	16	35%	65%	41%	59%
Feb 11	9,479	12,797	3	3	43%	57%	50%	50%
Feb 13	1,726	1,630	36	37	51%	49%	49%	51%
Feb 17	19,571	16,620	39	44	54%	46%	47%	53%
Feb 19	2,699	3,702	77	91	42%	58%	46%	54%
Feb 20	1,740	2,357	13	17	42%	58%	43%	57%
Feb 21	3,363	4,603	14	35	42%	58%	29%	71%
Feb 23	3,247	3,925	21	27	45%	55%	44%	56%
Total	44,564	49,631	247	305				
Average					47%	53%	45%	55%

regression analysis was used to evaluate the relationship between capture efficiency and mean daily flow (as estimated from the USGS Renton Gage) while the traps were fishing in position 3. A weak ($r^2 = 0.27$), but significant relationship ($p<0.05$), was found for Trap 3 (Figure 3). A stronger ($r^2 = 0.73$) relationship was found for Trap 2 (Figure 4). However, this relationship was not significant at the 95% significance level as a result of low sample size. It was significant at a 93% significance level and we elected to use this regression equation because we believed it provided a more accurate estimate of capture efficiency than the sample mean.

Regression analysis was not performed on trap efficiency data collected while Trap 2 fished in positions 1 and 2 due to the low number of tests performed in these strata. Only two efficiency tests were performed while Trap 2 fished in position 1 and only a single test was conducted while Trap 2 fished in position 2. Therefore, the respective mean capture efficiencies were used to estimate migration within these strata.

On the nights that we ran calibration tests for position 3, the period in which the regression equations were used to predict trap efficiency, flows ranged between 563 and 1,190 cfs. Over the entire period that the traps fished in position 3, flows were outside this range four times, ranging from 543 to 1,610 cfs. Flow ranged from 543 to 2,060 cfs over the entire trapping period.

Trap efficiency for sockeye fry in 1999 averaged 4.5%, half of that (9.3%) measured in the 1998 season. Moreover, in 1998, flow explained most (67.5%) of the variation, over twice the rate measured in 1999 (Figure 3). We attribute these differences to the dredging project, conducted during summer 1998, which deepened and widened the channel, reducing velocities and capture rates.

Table 2. Mean chinook fork length, standard deviation, range, sample size, and catches in the fry and screw traps in 1999, and the 1998 fry trap, Cedar River at Renton.

STAT WEEK			1999 FRY TRAP						Signif	1999 SCREW TRAP						1998 FRY TRAP					
Begin	End	No.	Avg (mm)	s.d.	Range Min	Range Max	n	Catch	Diff[a] yes/no	Avg (mm)	s.d.	Range Min	Range Max	n	Catch	Avg (mm)	s.d.	Range Min	Range Max	n	Catch
01/23	01/24	4	*not sampled*					16								40.5	2.31	38	46	20	27
01/25	01/31	5	38.3	0.50	38	39	4	48								39.8	1.42	38	43	58	67
02/01	02/07	6	39.1	1.75	36	42	32	119								40.2	1.18	37	44	103	148
02/08	02/14	7	39.6	1.61	37	42	34	196								40.3	0.96	39	43	39	159
02/15	02/21	8	39.7	2.19	35	44	35	447								39.7	1.32	37	43	29	153
02/22	02/28	9	40.5	1.73	38	44	30	312								40.7	1.52	38	43	22	83
03/01	03/07	10	40.3	2.05	38	44	8	256								40.4	1.79	37	44	25	160
03/08	03/14	11	*not sampled*					179								40.9	2.68	37	51	54	250
03/15	03/21	12	40.1	1.42	37	43	33	100	no	40.3	3.10	37	59	76	210	40.8	3.59	37	54	45	306
03/22	03/28	13	40.0	2.50	36	50	97	97	no	40.6	3.17	36	61	167	241	51.7	11.20	38	74	41	102
03/29	04/04	14	40.3	2.41	37	51	52	57	no	41.2	4.42	37	67	139	157	53.2	10.16	38	69	33	79
04/05	04/11	15	40.1	2.70	36	50	23	24	no	43.0	7.06	36	72	101	123	57.3	10.92	40	78	41	67
04/12	04/18	16	40.0	3.15	37	54	29	36	yes	44.0	7.46	37	68	82	92	65.8	7.41	40	88	65	37
04/19	04/25	17	39.5	1.50	37	41	4	5	yes	57.6	10.22	40	74	27	30	70.7	6.72	40	81	34	54
04/26	05/02	18	42.0	7.15	38	62	9	9	yes	57.8	12.55	37	76	31	36	71.7	4.19	65	78	6	11
05/03	05/09	19	53.0	12.38	36	66	7	9	no	57.9	12.03	36	83	53	49	76.6	6.30	70	87	8	61
05/10	05/16	20	53.3	6.80	40	61	6	6	yes	68.5	11.75	35	98	146	126	81.3	9.19	71	128	39	137
05/17	05/23	21								67.7	11.67	38	96	154	237	85.7	4.66	77	97	59	115
05/24	05/30	22								76.5	7.85	52	95	165	318	81.6	8.75	60	103	60	117
05/31	06/06	23								79.4	9.03	39	106	159	635	88.1	9.64	71	140	64	77
06/07	06/13	24								81.3	7.75	66	93	12	215	*not sampled*					40
06/14	06/20	25								89.1	10.21	74	109	12	348	108.8	20.08	72	132	9	21
06/21	06/27	26								95.3	9.47	81	118	26	364	138.3	17.17	118	171	12	13
06/28	07/04	27								95.4	10.71	73	131	50	261	109.8	20.57	82	131	4	4
07/05	07/11	28								89.2	17.90	58	113	23	61						
07/12	07/18	29								103.7	8.38	60	119	118	125						
07/19	07/25	30								108.5	6.66	91	124	63	79						
07/26	07/27	31								106.6	9.24	95	119	7	8						
Totals							399	1,916						1,611	3,715					870	2,288

[a] Indicates whether the distributions of weekly fork length samples are significantly different ($p<0.05$) between the fry and screw traps using a Kolmogorov-Smirnov Two-Sample Test

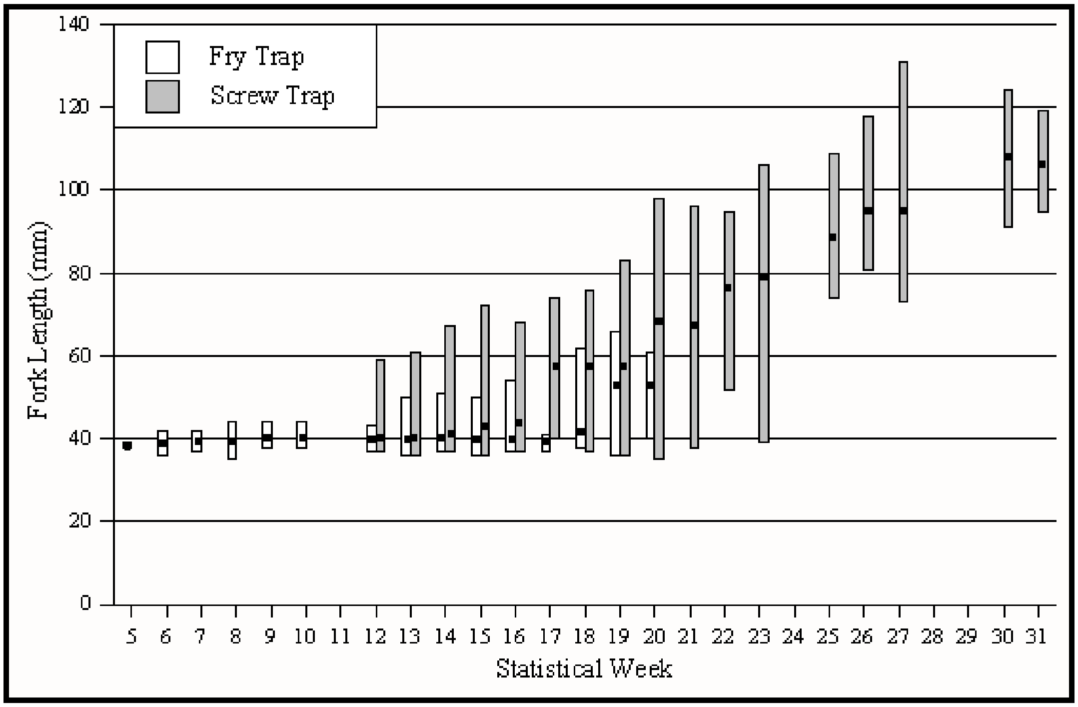


Figure 2. Average and range of fork lengths from age 0+ chinook sampled from the Cedar River, 1999

Table 3. Trap efficiency test results estimated with sockeye fry by trap number and position, Cedar River fry trap 1999.

	Trap Position, Trap Number			
	Pos. 1, Trap 2	Pos. 2, Trap 2	Pos. 3, Trap 2	Pos. 3, Trap 3
# of Tests	2	1	5	51
Average Trap Efficiency	2.26%	1.95%	4.77%	4.48%
Minimum Trap Efficiency	1.31%	1.95%	2.13%	1.80%
Maximum Trap Efficiency	3.20%	1.95%	7.52%	7.52%
Standard Deviation	0.95%	n/a	1.95%	1.19%
Significant Flow Regression ($p<0.05$)?	n/a	n/a	No	Yes
r^2			0.73	0.27

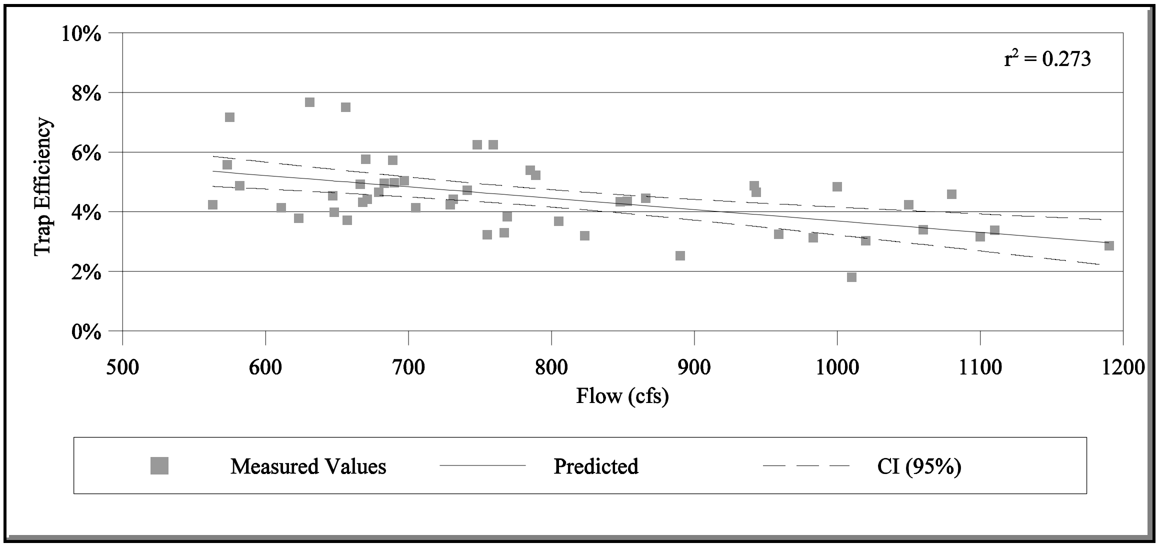


Figure 3. Regression analysis of the relationship between average daily stream flow and trap efficiency measured with sockeye fry for Trap 3, Position 3, in the Cedar River, 1999.

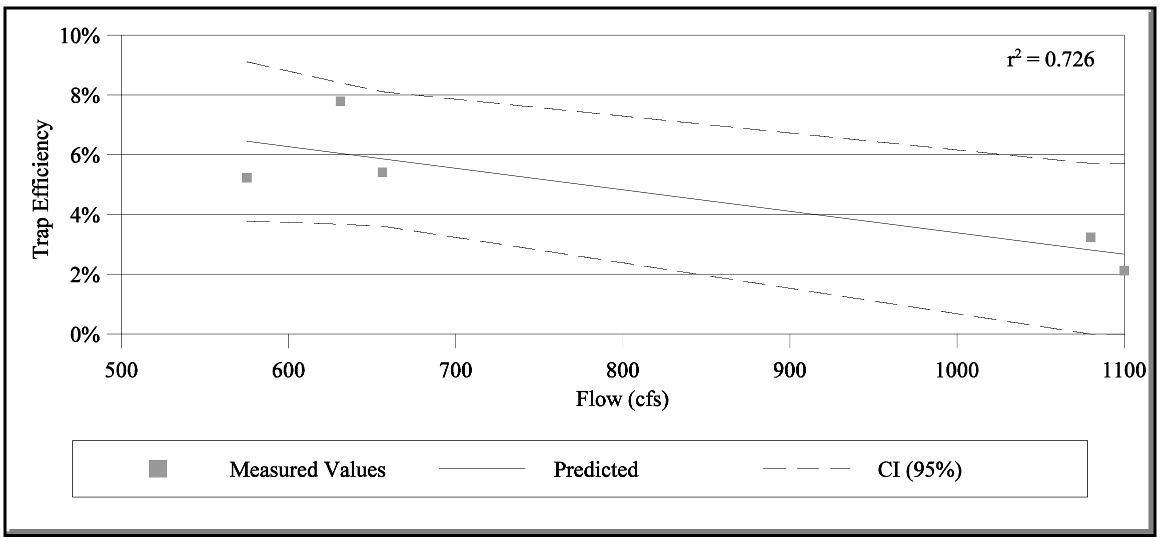


Figure 4. Regression analysis of the relationship between average daily stream flow and trap efficiency measured with sockeye fry for Trap 2, Position 3, in the Cedar River, 1999.

Production Estimate

In order to estimate the nightly chinook migration during the period of fry trap operation, sockeye fry trap efficiency estimates were applied to the chinook fry catches using Equation 6. Daytime migration was estimated by using the monthly average of the ratio of day/night catch rates ($\overline{Q}_m$ in Equation 10) measured during operation of the screw trap. Day/night catch rate ratios declined over the period of screw trap operation, averaging 0.445 in March, 0.384 in April, 0.177 in May, and 0.053 in June (too little catch occurred in July to estimate the ratio). Since the screw trap did not begin operation until March, daytime catch rate estimates were unavailable for earlier periods. Therefore, we assumed the relationship between daytime/nighttime migration rates that occurred earlier in the year was equal to the catch rate ratio observed in March. Based on these data and assumptions, we estimated that the nighttime catch during fry trap operation ranged from 58% to 85% of the total daily (24 hour) catch ($\hat{r}_d$ in Equation 10) depending on the time of year and the length of the nightly trapping period. Summing these results and interpolating migration for the four nights in January that we did not fish, resulted in an estimate of 68,297 chinook fry passing the fry trap from January 23 through May 28 (Appendix A).

Within the period of fry trap operation, chinook fry were most abundant during February, with an estimated average daily migration past the trap of 1,211 fry. This rate compares with 707 fry/day in January, and 729 fry/day in March. Over the first half of March, chinook fry were nearly as abundant as in February, with an average migration of 1,104 fry/day. During the last half of March, estimated migration declined to an average rate of 378 fry/day. Fry trap-based migration estimates were further reduced in April and May.

Mortality

Over the season, two chinook fry mortalities occurred in the fry trap. As a proportion of the total catch, this loss amounted to a mortality rate of 0.1%.

Chinook - Screw Trap

Catch

Over the 132-day interval that we operated the screw trap (March 18 through July 27), we captured 3,715 chinook, as well as coho, steelhead, and cutthroat smolts (Appendix B). We also captured numbers of chum, coho, and sockeye fry. These were not counted prior to June, however, as the trap was designed to pass small fry through escape panels. By June, these fish had grown to a large enough size to be retained in the trap, enabling accurate counts.

Chinook fry catches declined from levels as high as 80 fry/night in March, to less than ten fry/night in late-April. Catches increased in mid-May, peaked in early-June at 150 on June 6, then generally declined thereafter.

During the 62 days that we operated the trap 24-hours, all species were captured at night at much higher rates than during daylight. Over the first six weeks trapped, weekly d:n ratios for chinook varied from 17% to 59%. As the season progressed, weekly d:n ratios declined (Figure 5). Chinook had the highest d:n ratios, followed by coho, cutthroat, then steelhead (Table 4.).

Size

Chinook increased in size from a weekly average fork length of 40-mm in mid-March to 109-mm in late-July (Table 2, Figure 2).

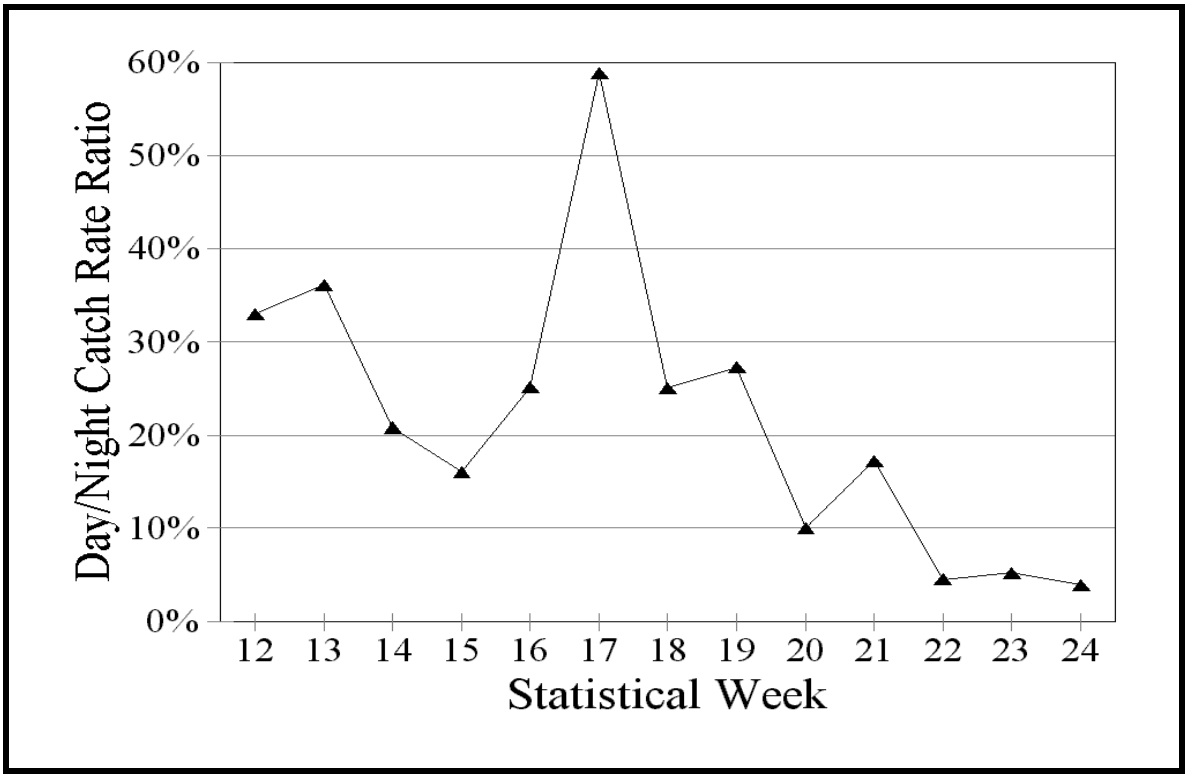


Figure 5. Ratio of day to night chinook catch rates by statistical week, Cedar River screw trap 1999.

Catch Expansion

Catch data was expanded to estimate the numbers of chinook smolts we would have caught had we fished the trap continuously from March 18 through the morning of July 27. Expansion resulted in the addition of 433 chinook to the catch (Appendix B). This increase represented 10% of the combined total catch estimate. The catch expansion included estimates for six of the ten intervals when we found the screw stopped by debris. Based on catch comparisons with the previous and following dates, we judged that the screw was stopped for an insignificant time during the other four intervals.

Table 4. Comparison of salmonid catch rates during day and night hours, Cedar River screw trap 1999.

Trap Interval Stat Week			DAY HOURS	Catch Rate (fish/hour)				NIGHT HOURS	Catch Rate (fish/hour)				DAY:NIGHT CATCH RATIO Species			
No	Start	End	Hours Fished	Chin 0+	Coho 1+	Sthd	Cutt	Hours Fished	Chin 0+	Coho 1+	Sthd	Cutt 0+	Chin 0+	Coho 1+	Sthd	Cutt
12	03/18	03/21	31.75	1.23	0.00	0.00	0.00	47.25	4.28	0.57	0.08	0.25	28.74%	0.00%	0.00%	0.00%
13	03/22	03/28	54.92	0.75	0.02	0.00	0.00	71.25	1.60	0.44	0.04	0.41	46.88%	4.55%	0.00%	0.00%
14	03/29	04/04	78.17	0.32	0.03	0.00	0.00	87.17	1.56	0.71	0.02	0.29	20.51%	4.23%	0.00%	0.00%
15	04/05	04/11	81.42	0.21	0.01	0.00	0.00	82.25	1.24	0.91	0.05	0.19	16.94%	1.10%	0.00%	0.00%
16	04/12	04/18	35.75	0.28	0.11	0.00	0.00	68.33	1.19	1.68	0.01	0.23	23.53%	6.55%	0.00%	0.00%
17	04/19	04/25	52.25	0.19	0.56	0.06	0.10	65.25	0.32	2.15	0.12	0.32	59.38%	26.05%	50.00%	31.25%
18	04/26	05/02	39.50	0.13	0.08	0.00	0.00	63.58	0.50	5.58	0.47	0.38	26.00%	1.43%	0.00%	0.00%
19	05/03	05/09	60.83	0.20	0.10	0.00	0.00	49.50	0.79	13.49	1.66	0.51	25.32%	0.74%	0.00%	0.00%
20	05/10	05/16	58.25	0.21	0.10	0.02	0.05	58.92	2.22	15.24	1.63	0.07	9.46%	0.66%	1.23%	71.43%
21	05/17	05/23	70.50	0.50	0.10	0.01	0.00	59.50	3.04	20.82	2.24	0.12	16.45%	0.48%	0.45%	0.00%
22	05/24	05/30	50.08	0.26	0.08	0.00	0.00	59.92	5.01	10.48	1.29	0.07	5.19%	0.76%	0.00%	0.00%
23	05/31	06/06	53.92	0.43	0.00	0.00	0.00	63.83	9.18	3.56	1.16	0.22	4.68%	0.00%	0.00%	0.00%
24	06/07	06/13	81.83	0.11	0.02	0.00	0.00	62.83	3.15	1.03	0.19	0.27	3.49%	1.94%	0.00%	0.00%
25	06/14	06/20	13.00	0.08	0.15	0.00	0.00	80.00	4.74	0.33	0.01	0.10	1.69%	45.45%	0.00%	0.00%
29	07/12	07/18	4.00	0.00	0.00	0.00	0.00	75.75	1.65	0.09	0.03	0.11	0.00%	0.00%	0.00%	0.00%
Total			766.17	0.33	0.09	0.01	0.01	995.33	2.58	3.58	0.42	0.23	0.13	0.03	0.02	0.04

Trap Efficiency

Twelve mark-recapture trap efficiency tests were conducted between April 29 and June 14. Out of the twelve groups, trap efficiencies ranged from 0 to 66%; however, the estimates at the ends of the range were from small groups (Table 5). Because confidence in the results of tests using small numbers of marked fish was low, we combined groups from adjacent tests to develop test groups of at least 40 marked migrants. The combining of tests with small numbers of fish resulted in better weighting between test groups.

Table 5. Estimated chinook smolt recapture rate from screw trap efficiency tests, Cedar River 1999.

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Actual Test Groups				
04/29	3	2	66.67%	0.111111
05/26	30	7	14.00%	0.004152
05/28	28	5	17.86%	0.005433
06/01	71	11	15.49%	0.001870
06/02	96	18	18.75%	0.001604
06/03	50	21	42.00%	0.004971
06/04	50	11	22.00%	0.003502
06/09	69	17	24.64%	0.002731
06/10	19	12	63.16%	0.012927
06/11	24	6	25.00%	0.008152
06/12	21	0	0.00%	0
06/14	20	2	10.00%	0.004737
	481	112		
	All Release Groups	Average	26.63%	
		Var(ʻ)	0.0169	
Combined Test Groups				
04/29 - 05/28 Combined	61	14	22.95%	0.002947
06/01	71	11	15.49%	0.001870
06/02	96	18	18.75%	0.001604
06/03	50	21	42.00%	0.004971
06/04	50	11	22.00%	0.003502
06/09	69	17	24.64%	0.002731
06/10 - 06/11 Combined	43	18	41.86%	0.005795
06/12 - 06/14 Combined	41	2	4.88%	0.001160
	481	112		
Combined (40 or larger) Release Groups		**Average**	**24.07%**	
		Var(ʻ)	**0.00506**	

Linear regression analysis using all release groups did not yield a significant relationship between daily mean flow and trap efficiency ($p>0.05$). The results may have been affected by the small size of some of the release groups. More consistent results would be expected from larger groups. However, regression analysis performed on the five release groups of 50 or more fish per group was also not significant. Mean daily stream flow during these five tests ranged from 488 to 562-cfs, which was not enough variation to adequately assess the flow relationship. Because these analyses failed to develop a significant relationship with flow, mean trap efficiency from the eight combined tests was used to estimate the capture rate in the screw trap over the entire period of operation.

Production Estimate

During the period of screw trap operation (March 18 through July 27), we estimated that 17,230 age 0+ chinook passed the trap (Figure 6). This estimate is based on our expanded catch estimate of 4,148 migrants (Appendix B), and the estimated average trap efficiency of 24.07% (Table 5).

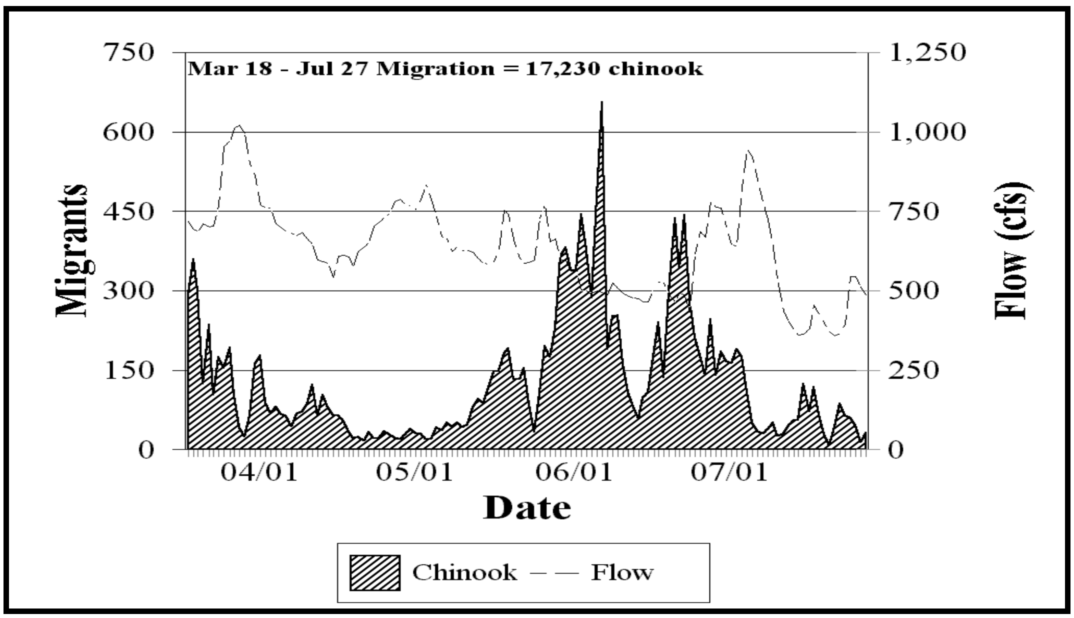


Figure 6. Daily estimated age 0+ chinook migration and flow (USGS Renton Gage) between March 18 and July 27, 1999, Cedar River screw trap.

Mortality

Over the season, one cutthroat, two steelhead, 25 chinook, and 35 coho smolts were found dead in the trap. Mortality rates were related to fish size. Coho and chinook mortality rates were 0.69% and 0.66%, about twice that of steelhead (0.33%) and cutthroat (0.31%). Most of the mortalities occurred when large woody debris jammed the screw trap. Although most of the observed chinook mortalities occurred after late-May (by which time mean size exceeded 75 mm), 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 may be somewhat higher than the 25 that were counted.

Total Juvenile Chinook Production

The fry trap and screw trap ran concurrently between March 18 and May 28 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 five of the 11 weeks tested ($p<0.05$)(Table 6, Figure 7). These results led us to question whether chinook production was best estimated using the fry trap or screw trap data during the period in which both traps operated. We elected to use the screw trap estimate since, as chinook fry grew in the spring, it became obvious that the larger chinook were able to avoid the fry trap. The significant differences found in the size distributions of chinook caught in the two traps over the period of concurrence supported this observation (Table 2, Figure 2).

Table 6. Independent weekly estimates of chinook migration, N_w, from the fry trap and screw trap with results from Z-test comparison of the weekly estimates (α=0.05), Cedar River 1999.

Statistical Week			Fry Trap		Screw Trap		Significant Difference?
Begin	**End**	**No.**	**Est. Migration (N_w)**	**+/-$CI_{95\%}$**	**Est. Migration (N_w)**	**+/-$CI_{95\%}$**	**(Yes/No)**
03/18	03/21	12	1,371	534	1,079	354	No
03/22	03/28	13	3,394	1,206	1,006	239	Yes
03/29	04/04	14	1,941	846	667	166	Yes
04/05	04/11	15	731	518	524	120	No
04/12	04/18	16	1,121	892	468	119	No
04/19	04/25	17	360	252	175	16	No
04/26	05/02	18	405	323	204	49	No
05/03	05/09	19	254	11	267	68	No
05/10	05/16	20	156	59	617	157	Yes
05/17	05/23	21	0	0	1,029	236	Yes
05/24	05/28	22	0	0	740	212	Yes

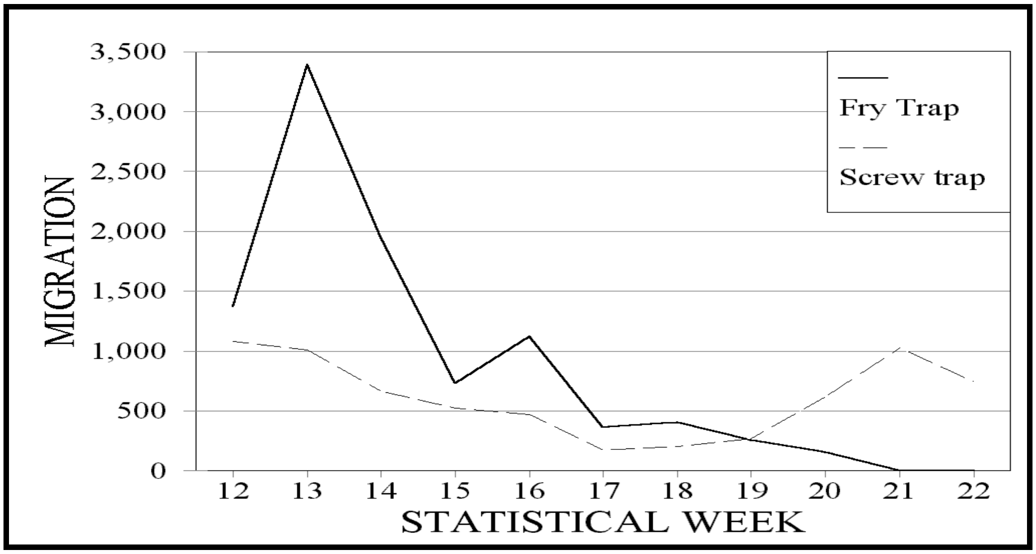


Figure 7. Independent weekly age 0+ chinook migration estimates from the Cedar River fry and screw traps, 1999.

Combining the chinook production estimated from the fry trap for January 23 through March 17, with the estimate from the screw trap for March 18 through July 27, yielded a total migration over this interval of 75,787 fry (Table 7).

To estimate the number of chinook migrating before trapping began, we used straight line extrapolation to estimate migration from January 1 - 22. We based the extrapolation on a migration rate of 468 chinook fry/day at the start of trapping (the average rate estimated from the first two dates trapped). This estimates 5,145 chinook passed the fry trap before January 23 (Table 7). Therefore, we estimate a total of 80,932 chinook migrated from the Cedar River in 1999 (Figure 8).

Table 7. 1999 Cedar River juvenile chinook production estimate and confidence intervals.

Gear	Period	Estimated Migration	Coefficient of Variation	95% CI Low	95% CI High
Before Trapping	January 1 - January 22	5,145	23.47%	2,778	7,511
Fry Trap	January 23 - March 17	58,557	6.32%	51,303	65,811
Screw Trap	March 18 - July 27	17,230	3.69%	15,984	18,477
Total	January 1 - July 27	80,932	4.87%	73,200	88,663

The majority of juvenile chinook emigrated by mid-March (Figure 8). We estimate that the migration was 25%, 50%, and 75% complete by February 3, February 24, and March 3, respectively (Figure 9).

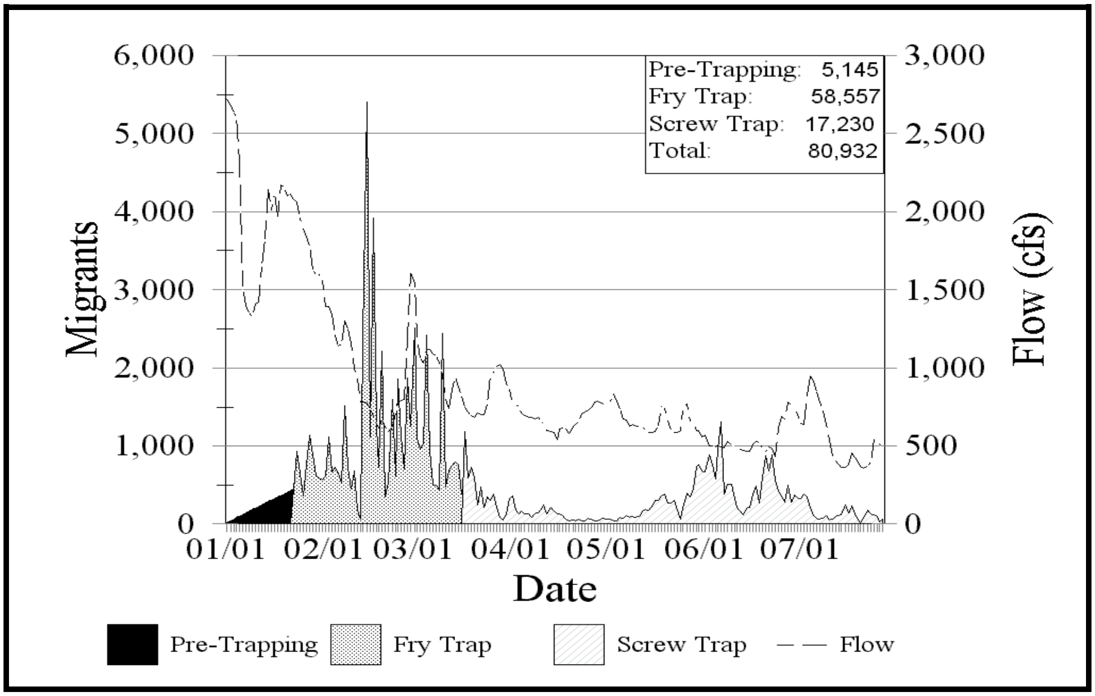


Figure 8. Estimated daily Cedar River 0+ chinook migration from fry and screw trap estimates and flow (USGS Renton Gage), 1999.

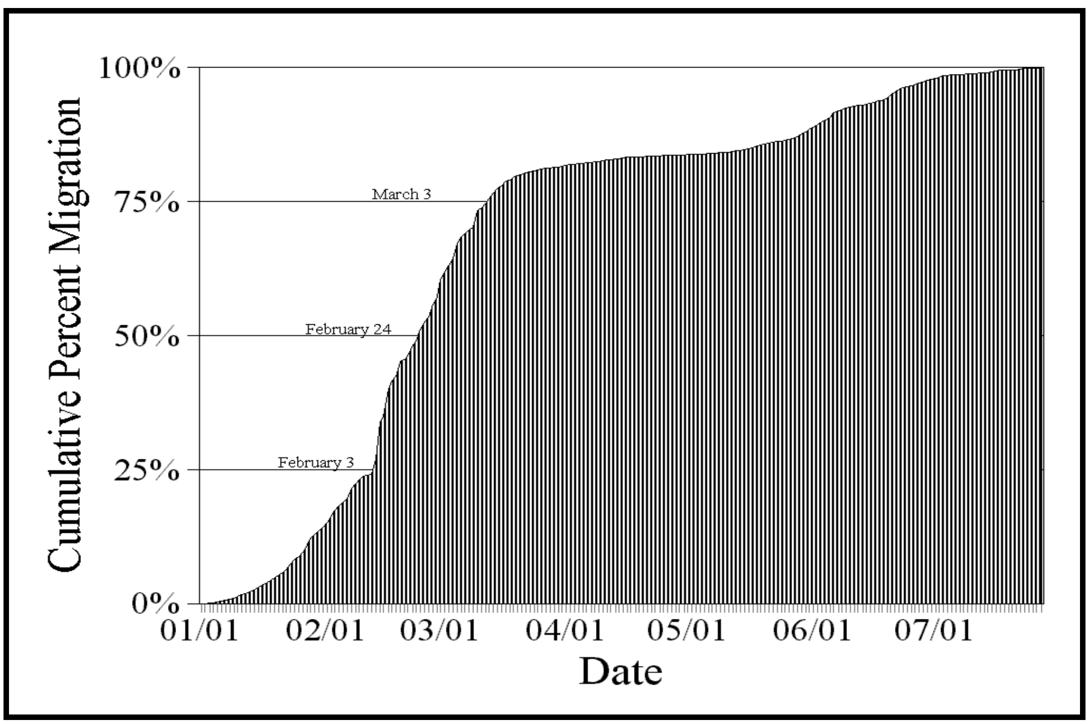


Figure 9. Cumulative percent migration of age 0+ chinook, Cedar River 1999.

Coho

Catch

We captured a total of 5,018 coho smolts between March 18 and July 27 (Appendix B). Over 90% of the catch occurred between April 16 and June 4. Catch distribution was unimodal with the peak daily catch of 303 smolts occurring on May 18.

Over the period of both daytime and nighttime screw trap operation, weekly day/night catch rate ratios for coho smolts averaged 5%. Day/night catch rate ratios were somewhat higher earlier in the trapping season when stream flows were higher and few fish were migrating (Figure 10). Catch was highest during weeks 18 (beginning April 26) through 23 (through June 6). During this period, day/night catch rate ratios decreased to average less than 3%.

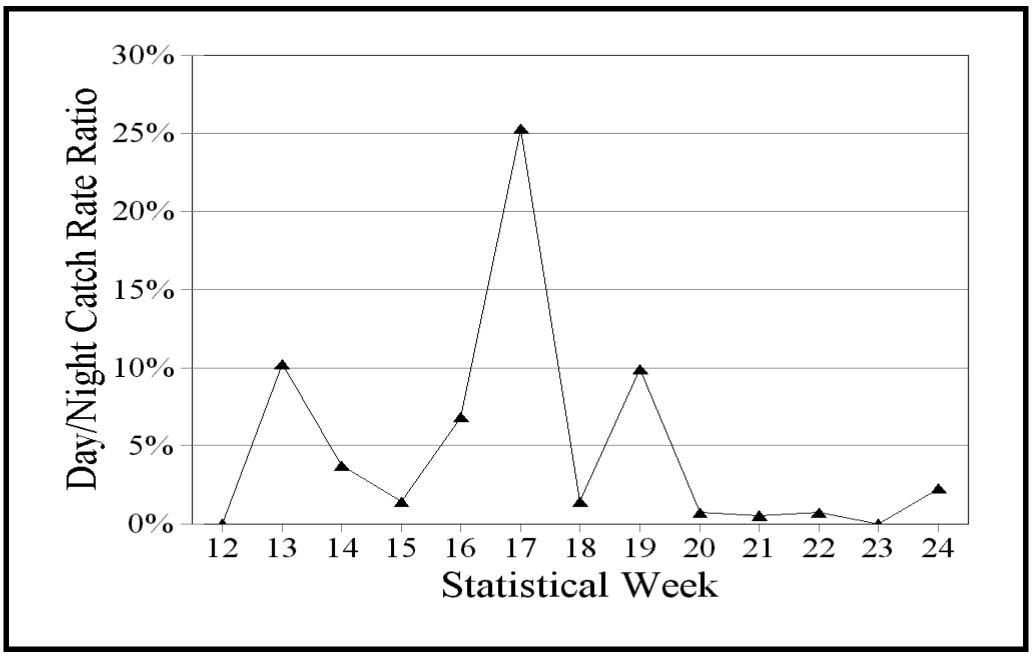


Figure 10. Ratio of daytime to nighttime coho catch rates by statistical week, Cedar River screw trap 1999.

Size

Over the season, coho smolt fork length averaged 106-mm (Table 8, Figure 11). There was very little variation in mean fork lengths between weeks.

Table 8. Weekly mean fork length, standard deviation, range, sample size and catches by species, excluding chinook, from the Cedar River screw trap, 1999.

STAT WEEK			COHO SMOLTS						STEELHEAD						CUTTHROAT					
Begin	End	No.	Avg (mm)	s.d.	**Range** Min	Max	n	Catch	Avg (mm)	s.d.	Range Min	Max	n	Catch	Avg (mm)	s.d.	Range Min	Max	n	Catch
03/18	03/21	12	106.8	17.45	86	154	25	27	179.0	25.00	154	204	2	4	161.1	14.97	125	183	12	13
03/22	03/28	13	104.4	7.98	92	120	28	35	197.0	30.41	155	226	3	3	159.1	25.34	121	222	32	36
03/29	04/04	14	107.3	18.79	84	242	78	66	254.0	6.00	248	260	2	2	155.0	26.14	95	210	29	27
04/05	04/11	15	106.0	10.83	85	133	48	70	200.7	6.55	193	209	3	4	172.6	26.36	130	218	10	15
04/12	04/18	16	106.5	7.84	86	125	76	125	210.0		210	210	1	1	171.6	31.83	100	220	14	17
04/19	04/25	17	108.0	5.42	96	113	7	169	198.0	16.23	165	215	6	11	182.1	38.89	128	255	14	26
04/26	05/02	18	108.1	10.97	87	150	73	358	183.4	17.78	156	220	19	30	179.5	2.50	177	182	2	24
05/03	05/09	19	104.6	9.88	85	145	102	829	180.6	21.29	122	226	101	101	171.2	27.12	110	212	10	31
05/10	05/16	20	105.8	9.91	89	166	208	971	176.2	17.72	142	272	107	109	135.5	24.50	111	160	2	8
05/17	05/23	21	106.4	11.68	88	165	55	1,398	171.7	17.45	94	213	97	159	158.0	9.00	149	167	2	8
05/24	05/30	22	102.9	7.54	82	121	69	652	170.1	14.15	141	220	77	78	151.0		151	151	1	4
05/31	06/06	23	104.6	6.76	87	118	33	263	168.9	13.63	145	223	80	81	164.0	19.77	120	199	13	16
06/07	06/13	24	103.7	7.66	91	120	17	66	171.7	14.99	144	194	12	12	161.2	16.23	136	194	17	17
06/14	06/20	25	105.3	7.40	94	114	4	28	174.0		174	174	1	1	147.0	18.00	129	165	2	8
06/21	06/27	26	110.0	23.34	87	142	3	11	169.0		169	169	1	3	167.4	10.85	153	184	8	30
06/28	07/04	27	114.3	8.73	102	121	3	6	233.5	26.50	207	260	2	5	173.9	33.13	114	255	14	18
07/05	07/11	28	118.5	28.50	90	147	2	20						1	214.0		214	214	1	5
07/12	07/18	29	130.3	14.13	112	145	4	7	255.0	52.00	203	307	2	2	167.0	12.75	143	184	8	8
07/19	07/25	30	100.5	11.50	88	116	4	4						0	172.2	11.12	155	190	10	10
07/26	07/28	31						0						0						0
Group Statistics			105.9	11.46	82	242	839	5,105	175.8	20.09	94	307	556	607	165.3	26.43	95	255	201	321

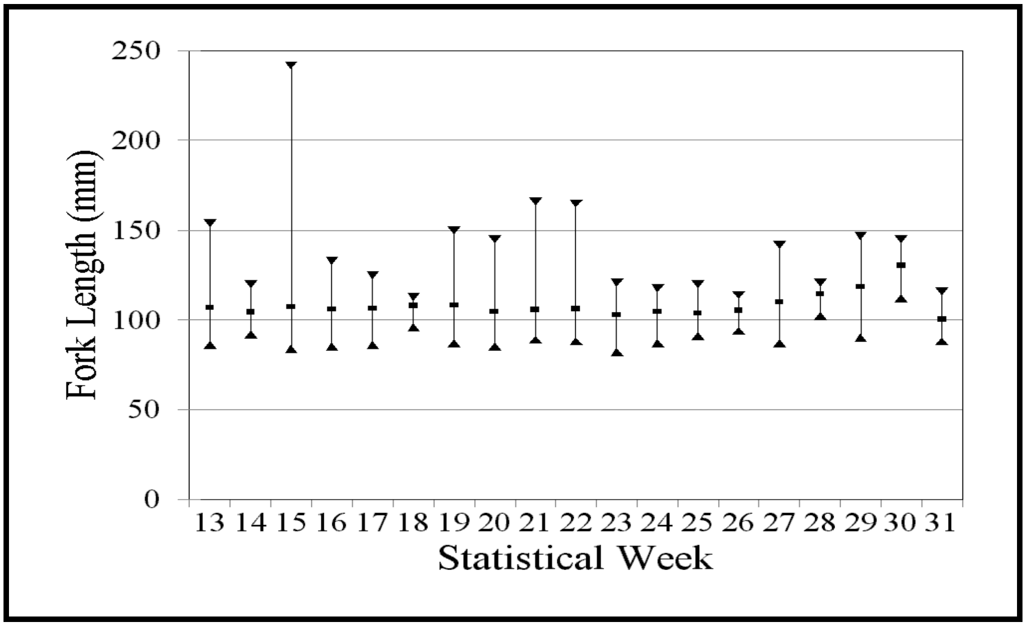


Figure 11. Weekly ranges and mean fork lengths for coho smolts captured in the Cedar River screw trap, 1999.

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 625 coho. This addition represented 11% of the expanded catch (Appendix B).

Trap Efficiency

Twenty five mark-recapture tests were conducted to measure trap efficiency for coho. Recapture rates for individual groups ranged from 2% to 31% and averaged 14.7% (Table 9). As was done with the chinook tests, we combined small release groups (<40 marked coho released) with adjacent groups to form groups of at least 40 individuals. This adjustment reduced the number of mark-recapture tests from 25 to 22, but increased our confidence in the results from individual tests. Grouping also resulted in better weighting among tests. Trap efficiency in the resulting 22 tests ranged from 3% to 30% and averaged 14.4%. As with chinook, regression analysis failed to find a significant flow effect on trap efficiency ($p>0.05$).

Table 9. Estimated coho smolt recapture rates from screw trap efficiency tests, Cedar River 1999.

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)	Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Actual Test Groups					***Combined Test Groups***				
04/29	62	6	9.68%	0.001433	04/29	62	6	9.68%	0.001433
05/03	50	12	24.00%	0.003722	05/03	50	12	24.00%	0.003722
05/04	100	19	19.00%	0.001555	05/04	100	19	19.00%	0.001555
05/05	100	15	15.00%	0.001288	05/05	100	15	15.00%	0.001288
05/06	50	15	30.00%	0.004286	05/06	50	15	30.00%	0.004286
05/10	50	3	6.00%	0.001151	05/10	50	3	6.00%	0.001151
05/11	43	6	13.95%	0.002859	05/11	43	6	13.95%	0.002859
05/13	50	8	16.00%	0.002743	05/13	50	8	16.00%	0.002743
05/14	53	9	16.98%	0.002711	05/14	53	9	16.98%	0.002711
05/17	50	4	8.00%	0.001502	05/17	50	4	8.00%	0.001502
05/19	47	8	17.02%	0.003070	05/19	47	8	17.02%	0.003070
05/20	50	4	8.00%	0.001502	05/20	50	4	8.00%	0.001502
05/21	50	4	8.00%	0.001502	05/21	50	4	8.00%	0.001502
05/23	50	3	6.00%	0.001151	05/23	50	3	6.00%	0.001151
05/25	50	14	28.00%	0.004114	05/25	50	14	28.00%	0.004114
05/26	50	7	14.00%	0.002457	05/26	50	7	14.00%	0.002457
05/27	50	2	4.00%	0.0007844	05/27	50	2	4.00%	0.0007844
05/28	50	8	16.00%	0.002743	05/28	50	8	16.00%	0.002743
06/01	61	10	16.39%	0.002284	06/01	61	10	16.39%	0.002284
06/02	36	6	16.67%	0.003968	06/02-03	86	15	17.44%	0.000905
06/03	50	9	18.00%	0.003012	06/04-09	63	13	20.63%	0.003845
06/04	37	5	13.51%	0.003246	06/10-14	58	2	3.45%	0.012069
06/09	26	8	30.77%	0.008521					
06/10	49	1	2.04%	0.0004165					
06/14	9	1	11.11%	0.012346					
	1273	187				1273	187		
	All Release Groups		Average	14.73%	**Combined (40 or larger) Release Groups**			**Average**	**14.43%**
			V(‘)	0.003209				**V(‘)**	**0.002051**

Coho Production

Application of the average coho smolt trap efficiency to the expanded catch of 5,643 smolts estimates a total coho production of 39,088 smolts with a coefficient of variation of 5.0% and a 95% confidence interval of 35,241 to 42,935 smolts (Figure 12).

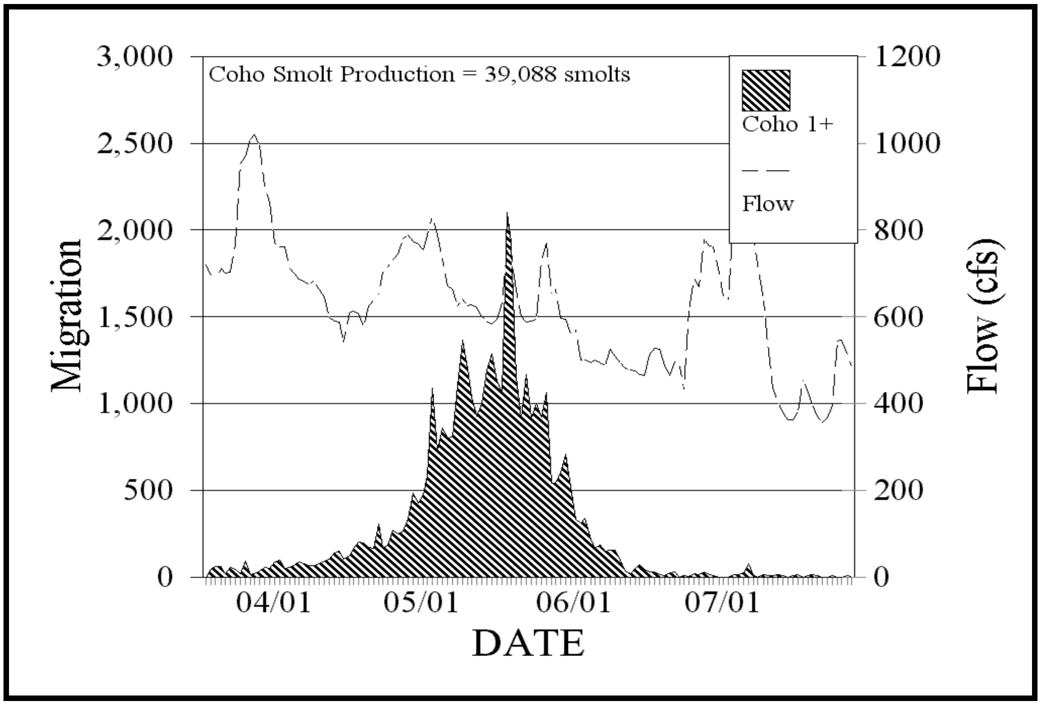


Figure 12. Estimate of daily coho smolt migration and flow (USGS Renton Gage), Cedar River screw trap 1999.

Steelhead and Cutthroat

Catch

A total of 594 steelhead smolts were captured between March 18 and July 27 (Appendix B). Steelhead migration was unimodal. Migration timing was narrower for steelhead than for other species with over 90% of the catch occurring between April 27 and June 6. Daily catch peaked on May 18 with the capture of 29 smolts.

The weekly day/night catch rate ratios for steelhead smolts averaged 5%; however, the ratio was much less for most weeks. Of the 14 weeks in which the screw trap operated in both daytime and nighttime periods, daytime catch of steelhead only occurred on a total of four days. On two of those days, the day catch rate exceeded the night rate, which skewed the average. The median daytime/nighttime ratio was 0% for steelhead smolts.

A total of 320 cutthroat trout were captured in the screw trap between March 18 and July 27 (Appendix B). Unlike chinook, coho, and steelhead, cutthroat did not exhibit a definable timing pattern during the period of trap operation. Cutthroat migration appeared strongest between mid-March and mid-May; however, relatively large daily catches occurred throughout the trapping period. Daily expanded catches varied between zero and ten over the trapping period.

As with steelhead, daytime migration of cutthroat trout was rare. Daytime catches only occurred on four days over the 14 weeks that both daytime and nighttime trapping occurred. Yet, the day/night catch rate ratios during those four days was high enough that the weekly day/night catch rate ratios for cutthroat trout averaged 7%. The weekly ratios were not normally distributed, therefore, the median ratio (0%) provided a better indicator of the central tendency than the average.

Size

Over the season, steelhead smolt fork length averaged 176-mm (Table 8, Figure 13). Outside of a couple of weeks with low sample size, average steelhead fork length varied little from week to week; especially during the peak of the migration between statistical weeks 18 and 24 (April 26 to June 13).

Cutthroat trout fork length averaged 165-mm (Table 8, Figure 14). Average weekly fork length varied little throughout the trapping period (coefficient of variation = 9.7%) except for a couple of weeks in which sample size was low.

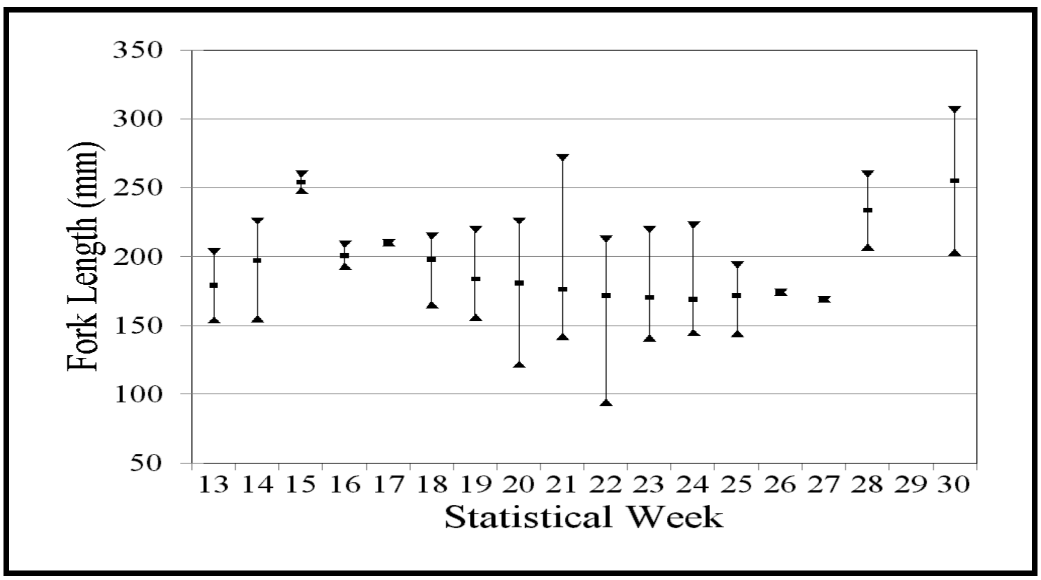


Figure 13. Weekly ranges and mean fork lengths for steelhead smolts trapped in the Cedar River screw trap, 1999.

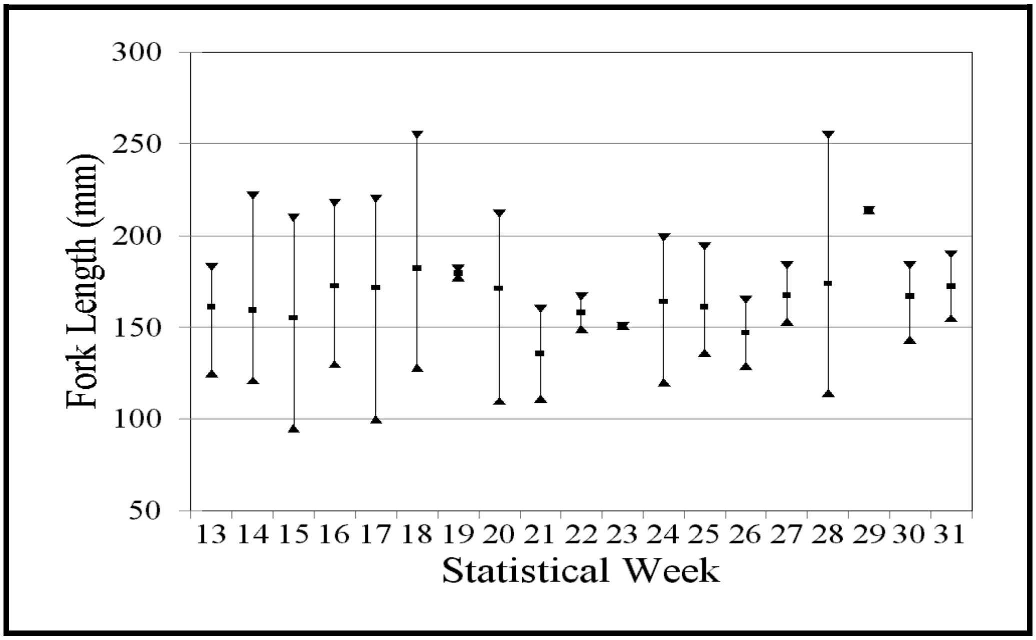


Figure 14. Weekly ranges and mean fork lengths for cutthroat trout trapped in the Cedar River screw trap, 1999.

Catch Expansion

Expansion of the actual catch to represent the number of steelhead and cutthroat that would have been caught if the screw trap had fished continuously resulted in the addition of 69 steelhead smolts and 34 cutthroat. These additions increased the actual catches of steelhead and cutthroat by 10% (Appendix B).

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 (14.4%) estimates a steelhead capture rate in the Cedar River screw trap of 8.6%. This rate may underestimate the steelhead catch rate in the screw trap because the trapping operations on the Toutle, Green, and White Salmon employed scoop traps from which steelhead can more easily escape. Therefore, we selected a trap efficiency value of 10% for estimating steelhead and cutthroat migration in the Cedar River in 1999.

Steelhead and Cutthroat Production

Application of a catch rate of 10% to the expanded catch of 663 steelhead estimates a total migration of 6,692 smolts (Figure 15). Applying this rate to the expanded catch of 354 cutthroat estimates the total cutthroat migration during the trapping period at 3,522 (Figure 16). No confidence intervals were developed for these estimates which apply only to the period of screw trap operation (March 18 - July 27). While cutthroat migration very likely occurred before and after this interval, no migration timing trends, other than a slightly decreasing catch rate after mid-May, 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. This estimate of cutthroat migration during the trapping season represents an unknown portion of the total production of downstream migrant cutthroat from the Cedar River.

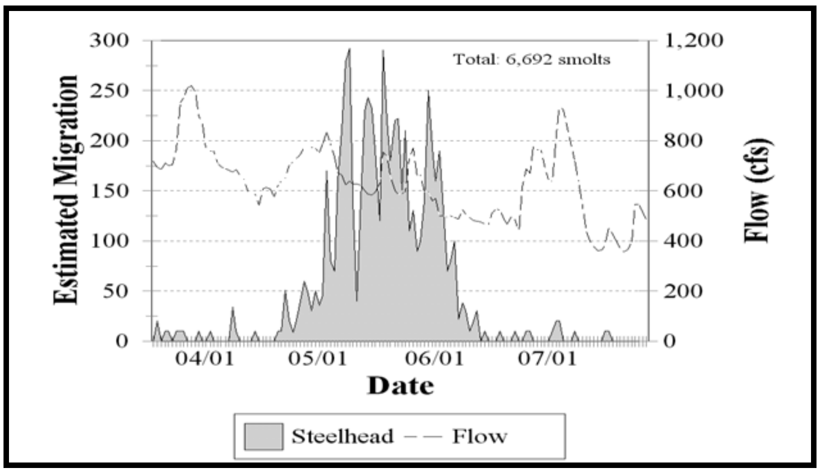


Figure 15. Estimated daily steelhead migration and flow (USGS Renton Gage), Cedar River screw trap 1999.

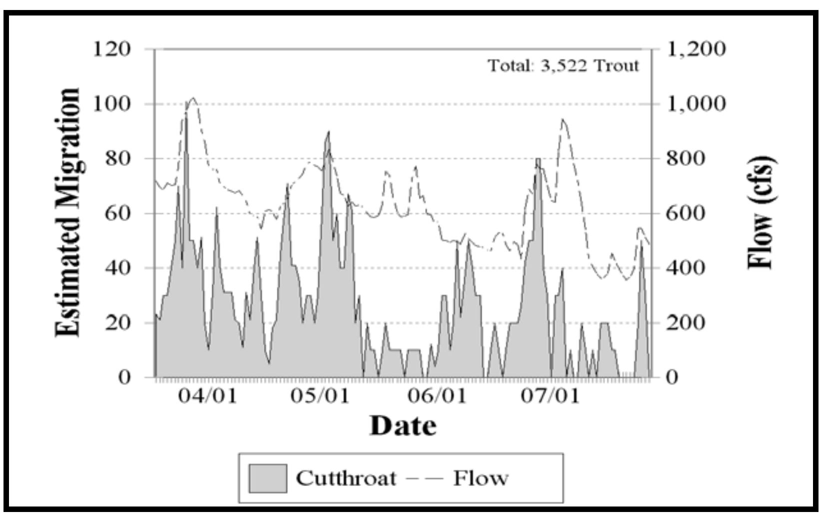


Figure 16. Estimated daily cutthroat trout migration and flow (USGS Renton Gage), Cedar River screw trap 1999.

Cedar River 2000

Trapping Gear and Operation

Fry Trap

The trap was placed approximately 200-yards downstream of the Logan Street Bridge in the thalweg of the channel near the left bank. Trap operation began on January 20, and continued through April 26. Initially, we operated the trap every other night through February 5. From February 6 through April 26, we operated the trap throughout each night. Unlike previous years, only a single inclined-plane screen (scoop) trap was used in 2000. The scoop trap was mounted in lieu of the screw trap on the screw trap pontoon barge to preclude capturing too many sockeye fry and, thereby, maintain our ability to operate during peak migration periods. An additional advantage of this small scoop trap was that it captured few larger migrants such as coho and cutthroat, which readily consume fry in the live box. This trap was outfitted with a removable sump bucket which enabled safe and easy removal of all fry.

All species caught in the fry trap were identified and counted. Chinook fry were randomly sampled for size (fork length).

Screw Trap

Screw trap operation began on April 27 when the scoop trap was replaced with the screw trap. Initially, the screw trap was placed in the same location as the fry trap since velocities appeared adequate for capturing chinook migrants and the larger coho and steelhead smolts. However, after a week's trapping resulted in fewer-than-expected catch of chinook and coho migrants, on May 3 we moved the trap upstream to the Logan Street Bridge location used in 1999.

The trap was operated nearly continuously through July 13. Catches were counted at dusk and early each morning. This schedule enabled separating the 24-hour catch into day and night components.

All chinook, coho, steelhead, and cutthroat smolts were enumerated by species and randomly sampled for size (fork length).

Production Estimation

Fry Trap

Techniques used to estimate production in 2000 were similar to those used in 1999. As in 1999, trap efficiency was measured using sockeye fry; however, the new trap position just below Logan Street required that we release the marked fry at the Bronson Way Bridge (0.5-miles upstream). The resulting capture rates were correlated with stream flow to determine if there was a flow effect.

Screw Trap

As in 1999, wild chinook captured in the screw trap were used for trap efficiency testing. The only difference in how these tests were conducted had to do with how the fish were marked. In 1999, a combination of caudal and ventral clips were used whereas in 2000, only upper or lower caudal clips were used.

Procedures used to estimate chinook migration past the screw trap were similar to those used in 1999. As with the fry trap data, flow was used to estimate trap efficiency where a significant flow relationship ($\alpha=0.05$) was found. Where the flow relationship was not found to be significant, trap efficiency data from the screw trap were stratified into two groups based on the time of day that marked fish were released. Tests occurring in the morning were compared with those occurring in the evening to evaluate differences in capture rates between day and night fishing periods. The mean trap efficiency estimates from the two strata were tested for differences at a 95% significance level. Where a flow-derived relationship was not used to predict trap efficiency, efficiency was estimated by using the mean trap efficiency from the total data set or from the final strata, depending on the outcome of the strata analysis. Where this occurred, as in 1999, mark-recapture tests conducted using fewer than 40 marked fish were combined with adjacent tests to create mark groups of at least 40 fish. This procedure was used since we were not very confident in the results of individual tests made with small release groups. In addition, grouping the efficiency tests this way resulted in better weighting between mark-recapture tests.

2000 Results

Chinook - Fry Trap

Catch

On the first night of fry trap operation (January 20), we caught one chinook fry. Through the end of January, chinook catches averaged 16 migrants per night. Over the period of fry trap operation, January 20 through April 26, nightly catches varied, from a low of one chinook 0+ migrant to a high of 195 migrants on February 29 (Appendix C). This was over twice as high as the peak single trap nightly catch that occurred in 1999 (Appendix A). Nearly twice as many fry were captured in February (1,617) as were captured in March (818), the month with the second highest catch. Over the season, a total of 2,713 chinook migrants were captured in the fry trap.

In addition to chinook, over the season we caught 754,580 sockeye fry, 80 yearling coho, 122 coho fry, 12 chum, and 27 cutthroat trout.

Size

The size at time of chinook migrants captured in the fry trap was similar to those captured in 1999. Chinook averaged less than 45-mm through the first week of April (Figure 18). During the remainder of April, average migrant chinook size increased, averaging 61-mm during the final week of fry trap operation (April 18 to April 24).

Trap Efficiency

Marked sockeye fry were released on 43 nights between February 8 and April 26 to measure the capture efficiency of the fry trap. Capture rates ranged from 3.88% to 10.74% (Seiler *et al. In Prep*). On the nights that efficiency tests were conducted, the daily average flows ranged from 514 to 1,170 cfs. In 2000, unlike previous years, flow did not explain a significant portion of the variation in capture rates. We attribute this, at least partially to the channel configuration and resultant flow vectors at the location trapped in 2000.

Independent of flow, capture rates generally declined over the season. We attributed this outcome to increasing predation rates in the half-mile reach above the trap (Seiler *et al. In Prep*). Predation on marked sockeye fry was also indicated by the difference in capture rates between tests conducted on nights with and without hatchery releases of sockeye. To minimize the bias resulting from predation and thereby represent the average actual capture rate of the fry trap, we used the rate of 8.2% estimated from the 13 groups from the first half of the trapping season which occurred on hatchery sockeye release nights.

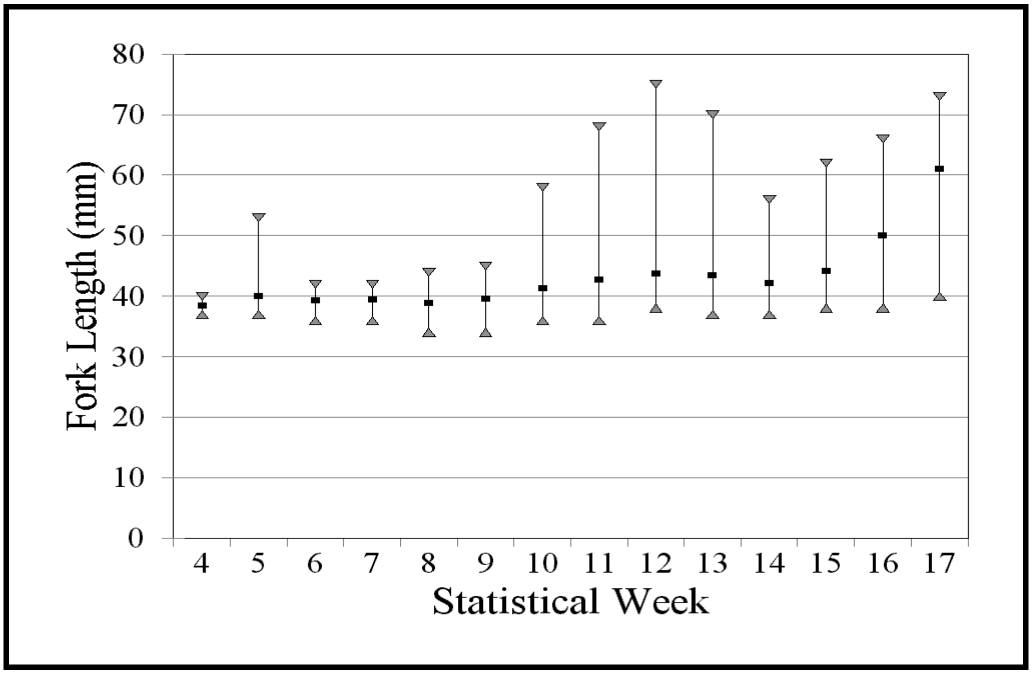


Figure 18. Weekly ranges and mean fork lengths for chinook migrants captured in the Cedar River fry trap, 2000.

Production Estimate

Applying the average sockeye fry trap efficiency estimate of 8.2% to the chinook fry catches, resulted in an estimate of 44,252 chinook 0+ migrants passing the fry trap from January 20 through April 26 (Appendix C). This estimate includes the interpolated migration estimates for nine nights when the trap was not fished and also factors in the proportion of the total migration that occurred during the nightly trapping period ($\hat{r}_d$ in Equation 10), as ascertained by comparing daytime catch rates from four daytime periods with the preceding and following nighttime catch rates. Nightly migration estimates ranged from 68.5% to 81.0% of the total daily chinook 0+ migration estimates in 2000.

Mortality

Zero chinook mortalities were observed over the trapping season.

Chinook - Screw Trap

Catch

Over the 78-day interval that we operated the screw trap (April 27 through July 13), we captured 1,682 unmarked chinook and 149 marked chinook migrants (Appendix D). The marked chinook were probably Issaquah Hatchery or University of Washington fish that entered the Cedar River. In addition to chinook, coho and steelhead smolts, cutthroat trout, and chum, coho, and sockeye fry were also captured. We also captured 15 yearling sockeye that either entered the Cedar River from Lake Washington or reared in the Cedar River.

Chinook fry were captured in low numbers following installation of the screw trap on April 27. Lower than expected catches of coho and steelhead smolts suggested that the trap was operating at a low capture rate and, therefore, was moved upstream on May 3 to a site with higher water velocity. Chinook catches increased following this move and peaked on May 31 at 100 per day, then generally declined thereafter (Appendix D).

The screw trap ran continuously from April 27 until June 11 except during ten events. Six events occurred during the day and included:

- A 5-hour stoppage on May 3 when the trap was being moved to the upstream position,
- A 7-hour event on May 19 and another 3-hour event on May 22 when the trap was being repaired, and
- Screw stoppages due to debris on May 24, May 26, and June 4.

Daytime catch rates were extremely low during these periods and no adjustments were made to catches to account for the un-fished periods. Four other events occurred at night and included:

- One event on May 19 resulted from the mechanical failure of the trap, and
- Screw stoppages due to debris on the night of May 15, May 20, and May 23.

None of the screw stoppages were detected until morning. The amount of down time resulting from each stoppage was unknown and no adjustments were made to the catches.

Between June 11 and July 13, the trap primarily operated at night. During this period, daytime trapping was only conducted on two occasions. The trap was fished during the day on June 19 to evaluate daytime migration, and no chinook were caught. The trap was also fished through a 25-hour period on June 21-22 and a total of 26 wild chinook migrants were caught, but the daytime component of the catch was unknown. In addition to the daytime periods when the trap was not fished, debris stopped the screw three times. These stoppages occurred on June 12, June 15, and June 27. Although the unfished daytime periods and screw stoppages resulted in a substantial amount of lost fishing time, no adjustments were made to the daily catches between June 11 and July 13 to account for these periods. This decision was made because daytime catch rates during this period were very low and the amount of down-time resulting from each stoppage was unknown.

All species were captured at night at higher rates than during daylight. Over the period of screw trap operation, weekly day:night catch rate ratios for chinook averaged 6% and varied from 0% to 18%. As the season progressed, weekly day:night catch rate ratios declined (Figure 19).

Size

Chinook fork lengths increased steadily from a weekly average fork length of 70-mm in late

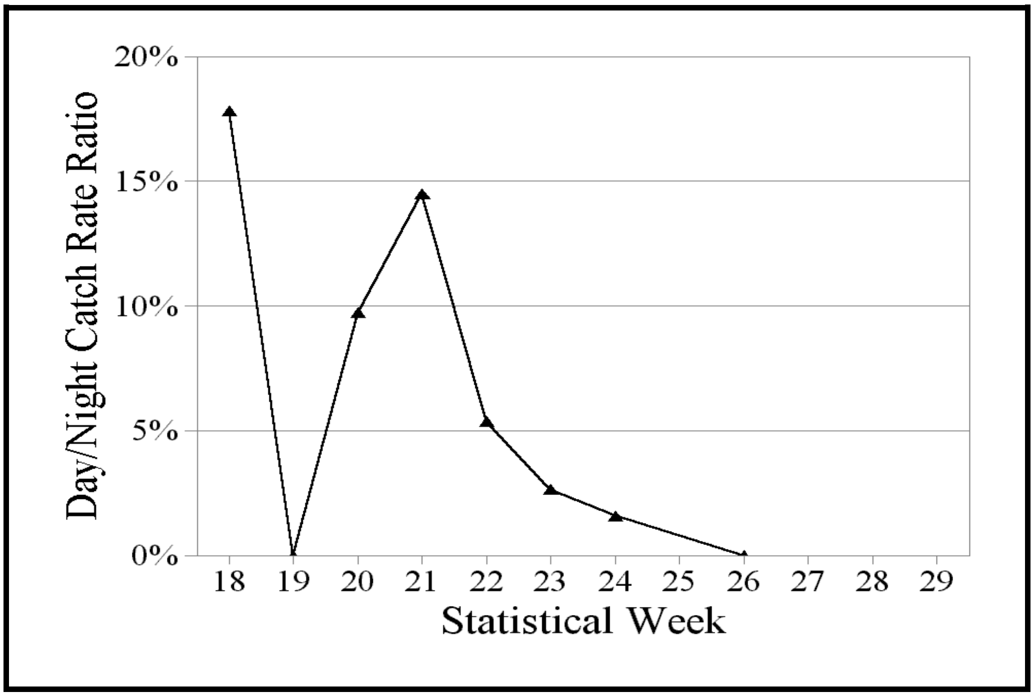


Figure 19. Ratios of day to night chinook catch rates by statistical week, Cedar River screw trap 2000.

April to 117-mm when trapping ended in July (Table 10, Figure 20).

Table 10. Weekly mean fork length, standard deviation, range, sample size and catches by species from the Cedar River screw trap, 2000.

Stat Week			Chinook Smolts						Coho Smolts						Steelhead Smolts					
			Avg		Range				Avg		Range				Avg		Range			
Begin	End	No.	(mm)	s.d.	Min	Max	n	Catch	(mm)	s.d.	Min	Max	n	Catch	(mm)	s.d.	Min	Max	n	Catch
04/24	04/30	18	70	8.0829	52	83	13	20	145	n/a	145	145	1	63	186	n/a	186	186	1	1
05/01	05/07	19	76	8.8646	52	91	37	74	109	17.3085	76	175	47	655		Not Sampled				21
05/08	05/14	20	76	9.3814	51	112	40	183	107	11.9793	91	151	42	987	191	23.3387	160	225	9	34
05/15	05/21	21	79	10.2259	57	99	38	118	106	8.3401	92	123	25	237	166	11.9108	154	185	6	8
05/22	05/28	22	84	9.1625	49	106	68	188	106	11.3159	90	154	40	262	167	11.7556	147	185	9	9
05/29	06/04	23	89	9.2874	55	122	196	313	100	6.4862	86	109	14	147	187	16.3920	156	210	8	11
06/05	06/11	24	98	13.6655	76	128	111	342	108	12.4119	93	155	32	65	173	n/a	173	173	1	1
06/12	06/18	25	99	20.1622	72	142	51	162	105	17.1114	89	126	5	16						
06/19	06/25	26	106	24.1706	51	146	67	239		Not Sampled				6						
06/26	07/02	27	103	18.5502	52	153	46	131	95	8.0829	88	104	3	4						
07/03	07/09	28	104	16.4862	87	141	16	41	90	5.6569	86	94	2	2						
07/10	07/16	29	117	14.1050	103	143	14	20	100	n/a	100	100	1	2						
Group Statistics					49	153	697	1,831	107	13.1475	76	175	212	2,446	178	19.2922	147	225	34	87

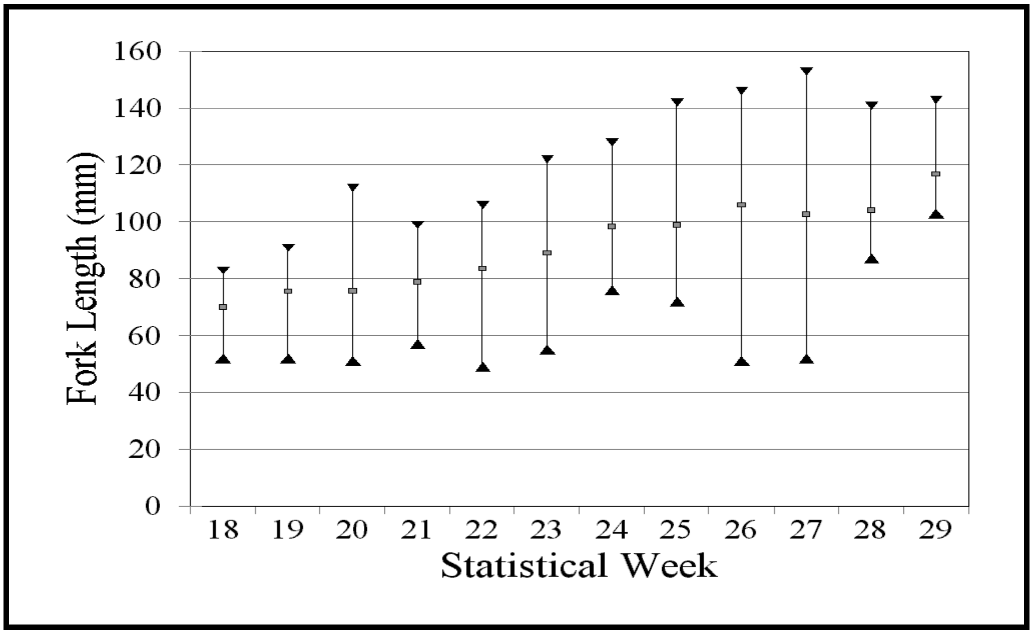


Figure 20. Weekly ranges and mean fork lengths for chinook migrants captured in the Cedar River screw trap, 2000.

Trap Efficiency

Five-hundred thirty two marked chinook were released in 21 trap efficiency tests between May 10 and July 10. All of the releases occurred after the trap had been moved upstream on May 4, where it was operated until trapping ceased on July 13. Recapture rates on marked fish ranged from 0% to 27% with average daily flows that ranged from 268-cfs to 657-cfs (Table 11). Linear regression analysis did not yield a significant relationship between trap efficiency and daily mean flow ($p>0.05$).

Trap efficiency tests were made during both morning (4 tests) and evening (17 tests) time periods. As a result of differences in catch rates between day and night trapping periods, we hypothesized that trap efficiency may differ between morning and evening tests. To test for differences between periods, data within each strata were tested for normality using a Kosmogorov-Smirnov test for goodness of fit. Since the data assumed a significant departure from a normal distribution ($p>0.05$), we tested the trap efficiency data to determine if the distributions between strata were significantly different using the non-parametric Wilcoxin 2-sample test for homogeneity of samples. The results of the trap efficiency tests were not found to be significantly different between strata ($p>0.05$). Therefore, as with the 1999 screw trap data, we combined tests using release groups of less than 40 marked chinook with adjacent tests to develop test groups of at least 40 marked chinook. The average capture rate from the ten resulting test groups was used to estimate daily chinook migration in Equation 6 (Table 11).

The estimated average trap efficiency, 9.66%, was used to estimate migration past the trap during the May 3 to July 13 period that the trap fished in the upstream position (Appendix C). To estimate trap efficiency during the period between April 27 and May 3 when the screw trap fished in the same position as the fry trap, we multiplied this trap efficiency value by the ratio of average daily catch prior to and after the move. This adjustment resulted in a capture efficiency of 2.72% for the April 27 to May 3 time period.

Table 11. Chinook smolt recapture rates from screw trap efficiency tests, Cedar River 2000.

Date	Flow (cfs)	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Stratum 1. AM Tests					
05/20	561	14	1	7.14%	0.005102
05/21	540	39	5	12.82%	0.002941
06/03	483	42	0	0.00%	0
06/05	494	12	0	0.00%	0
Sample Average				4.99%	
Sample Variance				0.000964	
n				4	
Stratum 2. PM Tests					
05/10	647	60	14	23.33%	0.003032
05/12	600	45	6	13.33%	0.002626
05/17	547	12	2	16.67%	0.012626
05/22	551	13	2	16.38%	0.010848
05/26	577	34	4	11.76%	0.003146
05/27	507	22	0	0.00%	0
05/28	525	24	5	20.83%	0.007171
05/29	535	16	1	6.25%	0.003906
05/30	523	27	2	7.41%	0.002638
06/07	508	23	0	0.00%	0
06/22	657	33	2	6.06%	0.001779
06/23	595	29	0	0.00	0
06/25	454	33	1	3.03	0.000918
06/29	360	10	1	10.00	0.010000
07/01	375	18	0	0.00	0
07/05	352	11	3	27.27	0.019835
07/10	268	15	1	6.67%	0.004444
Sample Average				9.88%	
Sample Variance				0.000433	
n				17	
Combined Strata					
Sums		532	50		
Sample Average				8.95%	
Sample Variance				0.004358	
n				17	

Table 11. Chinook smolt recapture rates from screw trap efficiency tests, Cedar River, 2000 (continued).

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Combined groups of at least 40				
05/10	60	14	23.33%	0.003032
05/12	45	6	13.33%	0.002626
05/17 - 05/21 Combined	65	8	12.31%	0.001686
05/22 - 05/26 Combined	47	6	12.77%	0.002421
05/27 - 05/28 Combined	46	5	10.87%	0.002153
05/29 - 05/30 Combined	43	3	6.98%	0.001545
06/03 - 05/07 Combined	77	0	0.00%	0
06/22 - 06/23 Combined	62	2	3.23%	0.000512
06/25 - 06/29 Combined	43	2	4.65%	0.001056
07/01 - 07/10 Combined	44	4	9.09%	0.001922
Average			**9.66%**	
Variance			**0.002124**	
n			**10**	

Production Estimate

By applying our trap efficiency estimates to the catch data, we estimate 18,223 wild chinook migrants passed the trap during the April 27 to July 13 screw trapping period (Appendix C).

Mortality

Over the season, four chinook migrants were found dead in the trap, resulting in a chinook mortality rate of 0.24%. Half of the chinook mortalities occurred when large woody debris jammed the screw trap or other damage to the trap occurred which affected its operation. Although most of the observed chinook mortalities occurred after mid-May (by which time mean size exceeded 75-mm), 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 may be somewhat higher than were counted.

Total Juvenile Chinook Production

Combining the chinook production estimated from the fry trap for January 20 through April 26 with that estimated from the screw trap for April 27 through July 13, yields a total migration over this interval of 62,475 chinook migrants (Table 12).

To estimate the number of chinook migrating before trapping began, we used straight line extrapolation to estimate migration from January 1 - 19. We based the extrapolation on a migration rate of 237 chinook fry per day at the start of trapping (the average rate estimated from the six days trapped in January). This estimated 2,248 chinook passed the fry trap before January 20 (Table 12). Therefore, we estimate a total of 64,723 naturally produced chinook migrated from the Cedar River in 2000 (Figure 21).

The majority of juvenile chinook emigrated by mid-March. We estimate that the migration was 25%, 50%, and 75% complete by February 18, March 2, and May 9, respectively (Figure 22).

Table 12. 2000 Cedar River juvenile chinook production estimate and confidence intervals.

Gear	Period	Estimated Migration	Coefficient of Variation	95% CI	
				Low	High
Before Trapping	January 1 - January 19	2,248	20.68%	1,337	3,160
Fry Trap	January 20 - April 26	44,252	4.72%	40,155	48,349
Screw Trap	April 27- July 13	18,223	10.42%	14,502	21,944
Total	January 1 - July 13	64,723	4.42%	59,114	70,332

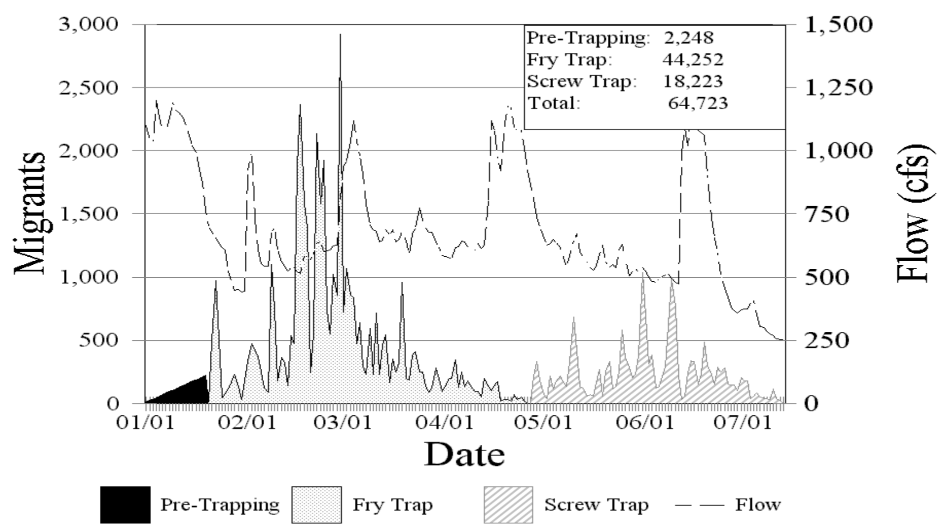


Figure 21. Estimated daily 0+ chinook migration and flow (USGS Renton Gage), Cedar River 2000.

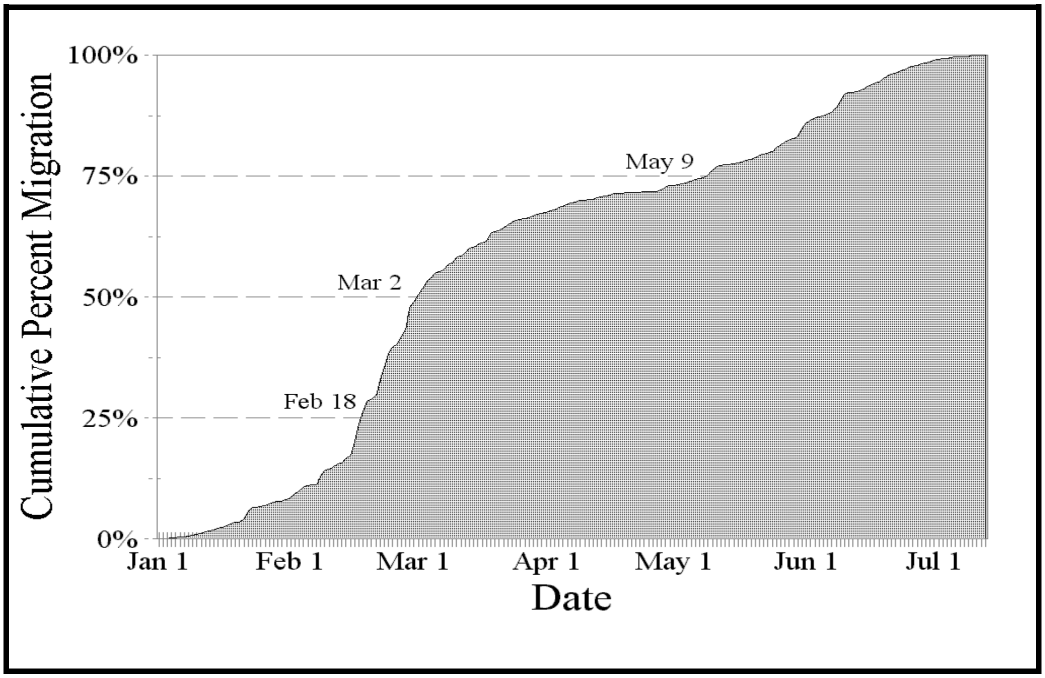


Figure 22. Cumulative percent migration of age 0+ chinook by day from the Cedar River, 2000.

Coho

Catch

A total of 2,446 coho smolts were captured between April 27 and July 13 (Appendix D). Over the first three days of screw trap operation, coho catches averaged 16 smolts per day, indicating that the migration was underway when screw trap operation began. Catches peaked on May 10 (304 smolts) before declining to very low levels by mid-June.

Very few coho were caught during daytime trap operation. Over the period of both daytime and nighttime screw trap operation, the day/night catch rate ratio of coho smolts averaged 1.6%. The weekly rates were highly variable, ranging from 0% to 6.5%. However, between May 1 and May 21 (statistical weeks 19 to 21), when the highest daily migration rates occurred, weekly day/night catch rate ratios ranged from 0 to 1.4% (Figure 23).

A few age 1+ coho were caught during fry trap operation; however, catch rates were low. The fry trap was designed to catch a relatively small percentage of the large number of age 0+ migrants leaving the Cedar River, but not yearling or larger migrants. Therefore, these data were not used in estimating wild coho smolt migration.

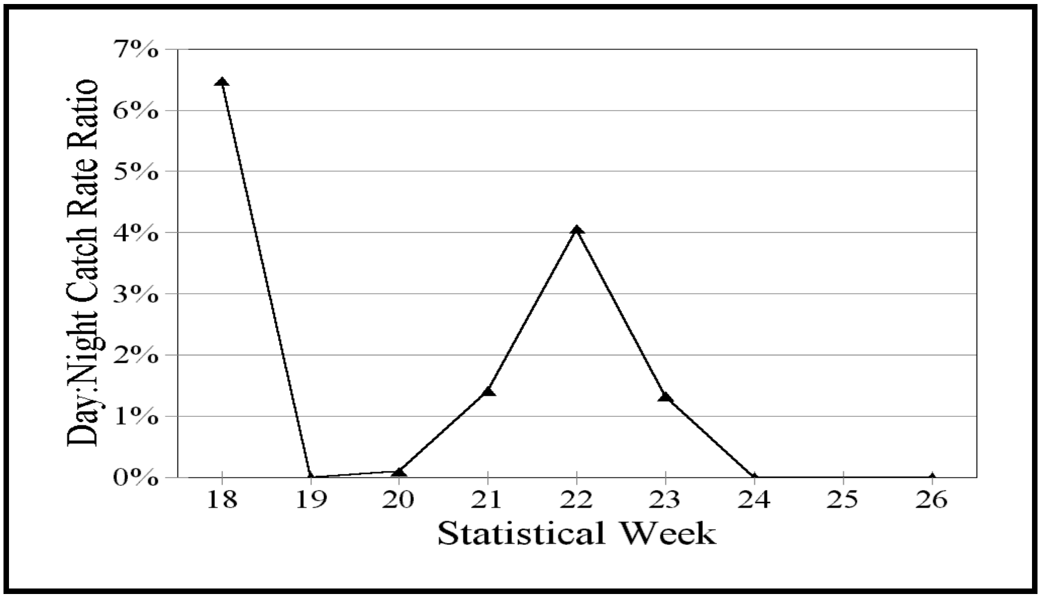


Figure 23. Ratios of day to night coho catch rates by statistical week, Cedar River screw trap 2000.

Size

Over the season, coho smolt fork lengths ranged in size from 76-mm to 175-mm and averaged 107-mm (Table 10, Figure 24).

Trap Efficiency

A total of 18 mark-recapture tests were conducted to measure trap efficiency for coho. Five tests were conducted during the day and 13 were conducted in the evening. One of the evening tests was thrown out because debris stopped the screw trap during the test. Of the remaining 17 tests, recapture rates ranged from 0% to 30%, and averaged 9.8% (Table 13).

Linear regression analysis was used to identify and test the relationship between trap efficiency and stream flow. Trap efficiency was found to not vary significantly with flow ($p>0.05$). Therefore, daily migration was estimated using mean trap efficiency values. However, stratification was first attempted to explore diel differences in trap efficiency. We stratified the tests by the diel period (morning vs. evening) and tested for differences between the sample means from each stratum. Since the distribution of trap efficiency values generally followed a normal distribution and the variances between strata were homoscedastic (i.e., the data was similarly distributed), we were able to use the more powerful analysis of variance (ANOVA) procedure to test for differences between sample means from each stratum in lieu of the non-parametric tests used with the chinook data. The ANOVA found no significant difference between the means ($p>0.05$), suggesting that stratification was un-necessary. Therefore, tests conducted using fewer than 40 marked smolts were combined with adjacent tests to develop 11 test groups of at least 40 fish. Trap efficiency was estimated by the mean capture rate, 8.49%, from these 11 groups (Table 13).

Coho Production

Application of the mean coho smolt trap efficiency to the catch of 2,446 smolts estimates a migration of 28,806 coho smolts during the trapping period. In 1999, the screw trap was deployed on March 18 and coho salmon were steadily captured beginning on the second night of trapping (Figure 12). Since screw trapping didn't begin in 2000 until April 27, we estimated migration from March 18 to April 26 by the proportion of the total 1999 wild coho production that migrated during this period (10.5%). This approach estimated 3,363 wild coho smolts migrated between March 18 and April 26. The log-function appeared to best fit the shape of the migration curve observed in 1999 and was used to distribute these fish to the 2000 migration (Figure 25). The total coho production from the basin, therefore, was estimated at 32,169 smolts with a 95% confidence interval of 30,506 to 33,833 smolts.

Mortality

Over the trapping period, seven coho smolt mortalities were found, which represent a 0.29% mortality rate. As was observed with chinook, most of the coho mortalities (86%) occurred when woody debris jammed the screw or other damage to the trap affected its operation.

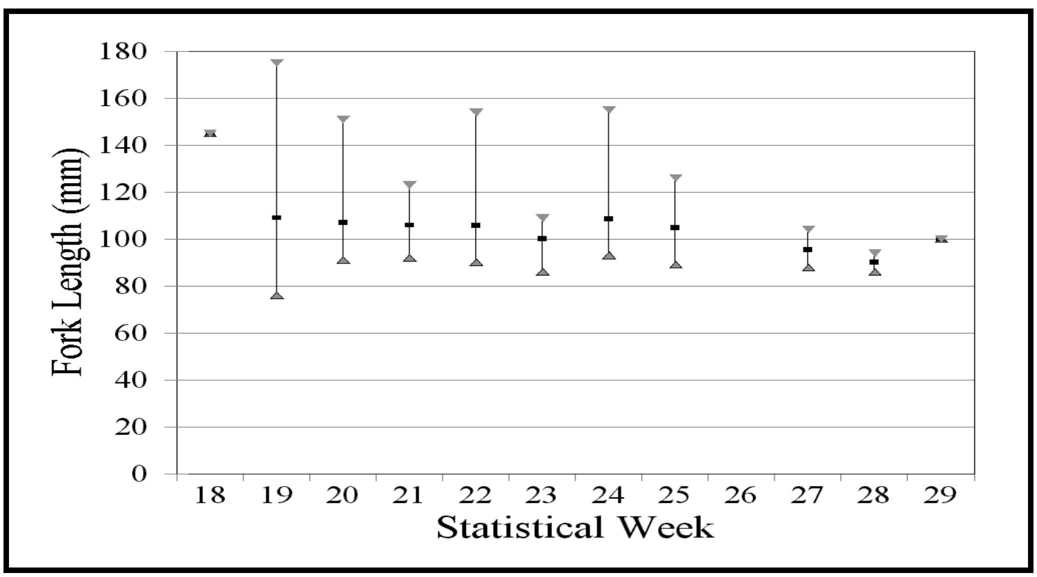


Figure 24. Weekly ranges and mean fork lengths for coho smolts captured in the Cedar River screw trap, 2000.

Table 13. Coho smolt recapture rates from screw trap efficiency tests, Cedar River 2000.

Date	Number Released	Number Recaptured	Recovery Rate ($\hat{e}$)	V ($\hat{e}$)
Stratum 1. AM Tests				
05/04	100	5	5.00%	0.000480
05/09	82	9	10.98%	0.001206
05/20	46	7	15.22%	0.002867
06/03	25	1	4.00%	0.001600
06/05	8	0	0.00%	0
Average			7.04%	
Variance			0.001957	
n			5	
Stratum 2. PM Tests				
05/05	85	10	11.76%	0.001236
05/07	50	4	8.00%	0.001502
05/11	87	5	5.75%	0.000630
05/13	82	2	2.44%	0.000294
05/17	45	4	8.89%	0.001841
05/22	32	0	0.00%	0
05/26	40	5	12.50%	0.002804
05/27	39	3	7.69%	0.001869
05/28	17	3	17.65%	0.009083
05/29	10	3	30.00%	0.023333
05/30	15	2	13.33%	0.008254
06/07	8	0	0.00%	0
Average			9.83%	
Variance			0.004816	
n			12	
Combined Strata				
Sums	771	63		
Average			9.01%	
Variance			0.003697	
n			17	

Table 13. Coho smolt recapture rates from screw trap efficiency tests, Cedar River 2000 (continued).

Date	Number Released	Number Recaptured	Recovery Rate ($\hat{e}$)	V ($\hat{e}$)
Combined Groups of at Least 40				
05/04	100	5	5.00%	0.000480
05/05	85	10	11.76%	0.001236
05/07	50	4	8.00%	0.001502
05/09	82	9	10.98%	0.001206
05/11	87	5	5.75%	0.000630
05/13	82	2	2.44%	0.000294
05/17	45	4	8.89%	0.001841
05/20 - 05/22 Combined	78	7	8.97%	0.001061
05/26 - 05/27 Combined	79	8	10.13%	0.001167
05/28 - 05/30 Combined	42	8	19.05%	0.003761
06/03 - 06/07 Combined	41	1	2.44%	0.000595
Average			**8.49%**	
Variance			**0.001456**	
n			**11**	

Note: As a result of a screw stoppage during the test, the release on May 15, 2000 is not included in this table.

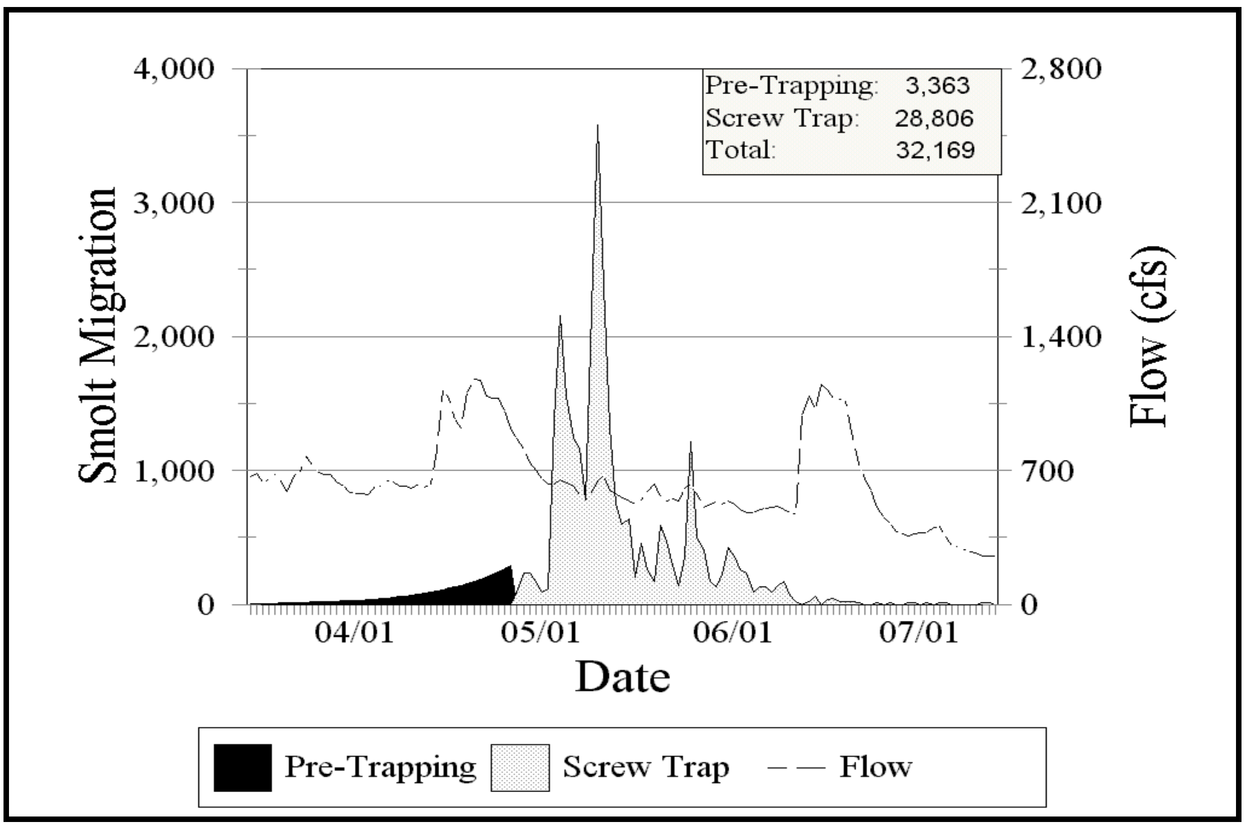


Figure 25. Estimated daily coho smolt migration and flow (USGS Renton Gage), Cedar River screw trap 2000.

Steelhead and Cutthroat

Catch

A total of 87 steelhead smolts were captured between April 27 and July 13 (Appendix D). This was well below the 564 steelhead smolts captured during the same period in 1999. Daily catch was quite low and peaked on May 11 with the capture of nine smolts.

No steelhead were caught during the daytime in 2000.

A total of 90 cutthroat trout were captured in the screw trap between April 27 and July 13 (Appendix D). Zero to two cutthroat per day were captured over most of the trapping period except for the first week of May and the third week in June when greater numbers were caught. The highest catches occurred on May 4 and May 10, when eight cutthroat were caught.

Daytime cutthroat trout migration was rare, as indicated by catch. Only two cutthroat were captured during daytime trap operation.

Size

Of the 34 steelhead smolt fork lengths measured over the season, the average length was 178-mm (Table 10). Weekly mean fork length varied from 166-mm to 191-mm between May 8 and June 4, when most captures occurred (Figure 26). The variation in mean size was likely the result of small samples sizes.

Only one cutthroat fork length was measured in 2000, a 190-mm fish.

Trap Efficiency

Catches of steelhead and cutthroat migrants were, again, too low to calibrate the trap. Therefore, as in 1999, we estimated steelhead and cutthroat trap efficiency at 60% of the coho rate. This adjustment was based on the ratio of steelhead/coho capture rates measured on the Toutle, Green, and White Salmon Rivers. This resulted in a capture rate of 5.1%. This rate may underestimate the steelhead catch rate in the screw trap because the trapping operations on the Toutle, Green, and White Salmon employed scoop traps from which steelhead can escape. Therefore, we selected a trap efficiency value of 6% for estimating steelhead and cutthroat migration.

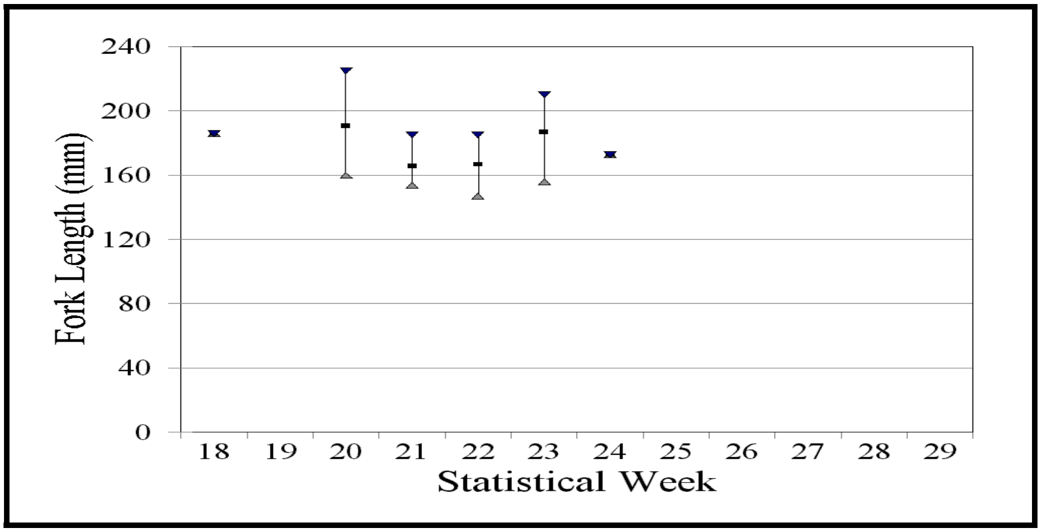


Figure 26. Weekly ranges and mean fork lengths for steelhead smolts trapped in the Cedar River screw trap, 2000.

Steelhead and Cutthroat Production

Application of a catch rate of 6% to the catch of 87 steelhead estimates the steelhead migration during the trapping period at 1,450 smolts (Figure 27). Since steelhead trapping did not effectively begin until the trap was moved on May 3 (1 steelhead smolt was captured prior to this date), this estimate was biased low. In 1999, the steelhead smolt catch prior to May 3 represented 8.8% of the steelhead catch over the entire season. However, this proportion was considered small and represented a very late migration timing for steelhead when compared to other streams. The steelhead migration in Big Beef Creek, for example, is typically well over 50% complete by the end of April (WDFW unpublished data). Therefore, we were uncomfortable applying the same migration timing observed in 1999 to the 2000 data to estimate the total wild steelhead production. In two subsequent years (2001 and 2002), the proportion of Cedar River steelhead caught prior to May 3 averaged slightly over 50%. To estimate the steelhead production in 2000, we assumed that 50% of the migrants had passed the trap prior to May 3. This assumption resulted in a total wild steelhead smolt production estimate of 2,867 smolts. Given the assumptions of trap efficiency and migration timing, no confidence intervals were developed for the steelhead migration estimate.

No cutthroat were captured prior to moving the trap on May 3. Using the same trap efficiency assumed for steelhead, the catch of 90 cutthroat captured between May 3 and July 11 estimated a cutthroat migration of 1,500 (Figure 28). Since we had no indication that the migration timing in 1999 was abnormal, we expanded the cutthroat estimate of 1,500 smolts based on migration timing observed in 1999 when the trap operated for a longer period. In this year, cutthroat migration during the May 3 to July 13 period represented 47% of the cutthroat migration estimated over the March 18 to July 27 period trapped that year. Assuming the same migration timing occurred in 2000, cutthroat migration past the trap for the March 18 to July 27 period was estimated at 3,191 trout. Given the assumptions of trap efficiency and migration timing, no confidence intervals were developed for the cutthroat migration estimate. As in 1999, we had no indication of the start or end of this migration. Therefore, we did not attempt to expand our estimate beyond the March 18 to July 27 period.

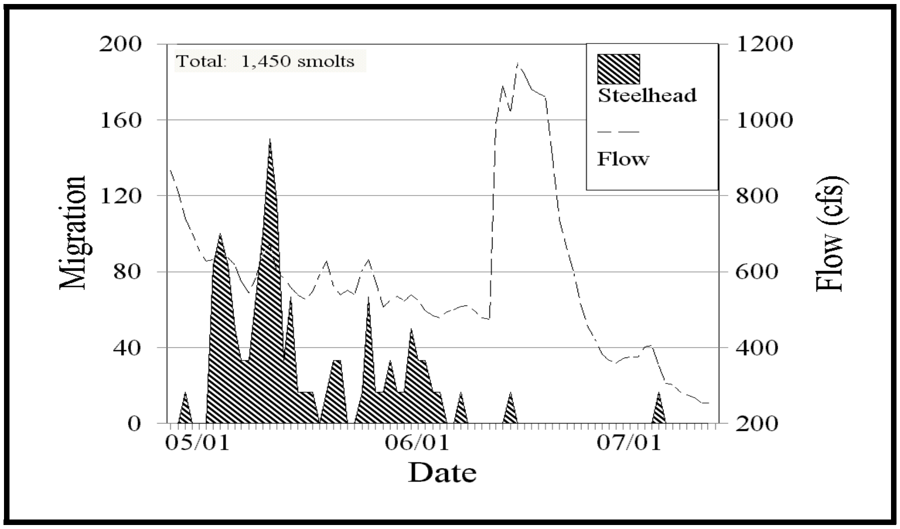


Figure 27. Estimated daily steelhead smolt migration and flow (USGS Renton Gage), Cedar River screw trap 2000.

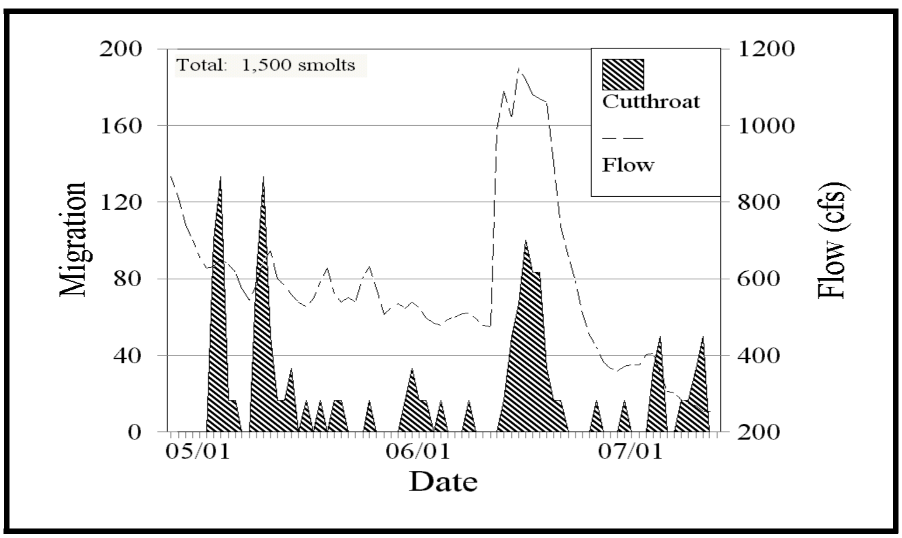


Figure 28. Estimated daily cutthroat smolt migration and flow (USGS Renton Gage), Cedar River screw trap 2000.

Big Bear Creek

Introduction and Background

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 (Seiler and Kishimoto 1997[b], Seiler et al. 2001[c]). 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. Unbiased capture of larger migrants such as chinook, coho, steelhead and cutthroat smolts requires higher velocities than those needed for sockeye fry. Therefore, assessing the freshwater production of chinook and these other migrants required selecting a trapping location with sufficient velocity.

With estimated sockeye escapements of over 50,000 in some years, Bear Creek is the most heavily spawned tributary in the Sammamish watershed. Approximately 90% of the Sammamish Basin sockeye spawners utilizing tributaries below Lake Sammamish are thought to spawn in Bear Creek (Foley pers. comm.). It also has the flow characteristics to enable trapping larger migrants. Therefore, we elected to move the downstream migrant trapping operation to the lower end of this stream where velocities were adequate. Trapping in the Sammamish Slough had demonstrated that sockeye fry produced from its tributaries migrate downstream to Lake Washington. Prior to conducting this work, it had been theorized that sockeye fry emigrating from Bear Creek may migrate up the Slough to rear in Lake Sammamish. With this question answered, estimating the numbers of sockeye fry emigrating from Bear Creek would account for the majority of sockeye fry produced in the Sammamish Basin that recruit to Lake Washington. The numbers of fry entering Lake Sammamish from tributaries to that lake, primarily Issaquah Creek, presumably rear to smolts in Lake Sammamish.

To estimate production from the entire Sammamish system below the lake, the numbers of sockeye fry and age 0+ chinook emigrating from Bear Creek can be expanded on the basis of the proportion of system spawners using Bear Creek. 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.

Bear Creek, along with most other tributaries in the Sammamish and Lake Washington basins, has been annually planted with hatchery produced coho fry for many years. In May of 1998, 166,000 coho fry (436 fry/lb) from Issaquah Hatchery were stocked throughout the Bear Creek system. Coho fry were not stocked in 1999. However, in addition to fry planted in 1998, a remote-site incubation project on a tributary to Evans Creek incubated 20,000 coho eggs in both 1998 and 1999. Steelhead parr from two broods were also stocked into Bear Creek. These fish were the offspring of a small number of wild steelhead captured at the Ballard Locks during the spring of 1997 and 1998 and incubated and reared at Issaquah Hatchery. On October 15, 1997 a total of 13,464 steelhead fry at an average size of 198 fry per pound were scatter planted throughout the Bear Creek system. A similar number (13,000 at 208 fry/lb) of steelhead fry were stocked into Bear Creek on September 24, 1998. In September 1999, only 6,650 steelhead fry were released. All of these release groups were identified with the removal of the adipose fin.

Goals and Objectives

Our primary goals were to quantify the production of chinook and sockeye fry from Bear Creek in 1999 and 2000, and to begin characterizing the freshwater life history of juvenile chinook in this system. Ancillary objectives included estimating the production, size and timing of coho, steelhead and cutthroat smolts and evaluating the steelhead supplementation experiment.

Accomplishing these goals will allow us to estimate the egg to migrant survival rates of chinook and sockeye spawning in Bear Creek and thereby assess the productivity of this system for these species given the environmental conditions and species interactions affecting these broods. Future objectives not covered in this report include relating the number of adult chinook that return to Bear Creek from the 1998 and 1999 broods to the estimated juvenile production in order to estimate the survival of this stock through the Lake Washington system and the marine environment.

Bear Creek 1999

Trapping Gear and Operation

We constructed a screw trap identical to the one used in the Cedar River (see Cedar River 1999 - Trapping Gear and Operation). After surveying the lower reaches of Bear Creek, we selected a trapping location immediately downstream of the railroad trestle below Redmond Way (RM 1.0) (Figure 1). At this point, flow is constricted by the support pilings and bulkheads under the trestle providing relatively high velocity and noise. This constriction has directed stream energy to create a large pool which provided enough depth and width to float the 30-ft long by 12-ft wide trap even at the lowest flows. This location was also attractive because we felt that the noise generated by the stream passing under the bridge would help to mask the noise of the trap and increase trap efficiency.

Trap operation began on the afternoon of February 23 at 4:45 pm and continued through the morning of July 13 at 9 am. Over this 141 day period, we operated the trap continuously except for three daytime intervals on April 14 and 15 and June 3. Early in the season when the sockeye fry catches were high, catches were enumerated throughout each night. On almost every date, catches were counted near dusk and again at dawn to separate twenty-four hour catches into day and night intervals.

All salmonids were identified to species and counted. Random samples of chinook, coho, steelhead and cutthroat were measured (fork length) each week. All steelhead were examined for the adipose fin mark and scale samples along with fork lengths were collected for age and size determination.

Production Estimation

Estimating downstream migrant production involved two steps; interpolating catch data to estimate the numbers of migrants we would have caught during the intervals that the trap did not fish and estimating the capture rate for each species. Because we operated the trap nearly continuously, very little catch expansion was required.

To determine capture rate, groups of Bear Creek sockeye fry marked with bismark brown dye were released upstream of the trap. Groups of chinook and coho caught in the Bear Creek trap were also marked and released upstream of the trap to estimate capture rates for these species. Chinook and coho were marked with partial ventral and caudal fin marks. Marked fish were transported in small groups (< 50) in five-gallon buckets approximately 200-yds upstream of the trap and released. The resulting capture rates were analyzed to determine if there was a relationship between trap efficiency and stream flow. Where a significant relationship was found, trap efficiency was estimated using Equation 1. Where a less than significant relationship with flow existed, mean trap efficiency was estimated using Equation 3. As with the Cedar River, trap efficiency tests employing fewer than 40 marked migrants were combined with adjacent tests to form test groups of at least 40 individuals. This was done to provide better weighting between marked release groups and because we had lower confidence in the results of trap efficiency tests employing small numbers of marked fish.

Catch estimation during periods when the trap was not operated was accomplished in a manner similar to that described for the Cedar River screw trap. When only part of a day or night period was fished, the catch for the remaining unfished period was estimated using Equation 16 and the variances using Equations 17 and 18. When the trap was not fished for an entire day or night period, catch rates were interpolated using catch rates from adjacent days. Finally, when the trap was not fished for an entire day, catch was estimated by the average catch from adjacent days when the trap operated for a full 24 hours. In addition to estimating catch when the trap was not operated, sockeye catch was also estimated when catches were large. During these periods, technicians counted the sockeye fry found in one or more dip net loads and estimated the sockeye catch by multiplying the average rate by the number of dip net loads removed from the trap. Since the number of fry counted from individual dip net loads was not recorded, we were not able to estimate the variance of these catch estimates. We, therefore, treated the sockeye catch estimates as actual catch.

Daily migration and the variance of the daily migration were estimated using Equations 6 and 7, respectively. In each case, the equations were modified by substituting the expanded daily (24-hour) catch for the nightly catch to estimate total daily migration instead of nightly migration. Daily estimates of migration and their variances were summed across the season to estimate total migration and variance.

1999 Results

The trap was operated nearly continuously throughout the 141 day trapping season. Woody debris stopped the screw on ten occasions during this period. Actual catches were expanded to include the estimated catch that would have occurred during six of the screw stoppage events using catch rates from adjacent time periods. No adjustments were made to account for missed catch during the other four events since catch rates were similar to catch rates from adjacent days, suggesting the screw stoppages occurred near the end of the fishing interval. Trapping was suspended during daylight hours on two days (April 16-17). Catches on these days were expanded using the day catch rates from adjacent periods.

Chinook

Catch

On the first night of trapping, February 23, we caught 12 age 0+ chinook. Over the entire 141 day season, we caught 5,964 of these migrants (Appendix E). In addition to the age 0+ migrants, one chinook was caught in early March that we classified as a yearling based on its large size.

Through April, age 0+ chinook catches remained low, varying from zero to ten per day. Chinook catches began increasing in early May and peaked at 533 on May 25 then declined through June to very low levels by early July.

Size

Age 0+ chinook averaged slightly over 40-mm at the beginning of the trapping season, but grew rapidly and doubled their length within ten weeks (Table 14, Figure 29). Fork length averaged about 90-mm over the final six weeks of the trapping season with individuals measuring as high as 114-mm.

Catch Expansion

Expanding catch data on the eight dates when the trap did not fish continuously (six screw stoppers and two un-fished day periods) estimated an additional 109 age 0+ chinook (Appendix E). These estimates amounted to 1.8% of the season total expanded catch of chinook.

Trap Efficiency

Capture rate with a given trap size and design for any species and size of fish varies as a function of a number of factors all of which are affected by discharge. Changes in velocity upstream of

Table 14. Weekly descriptive statistics relating to fork length of chinook and coho captured in the Bear Creek screw trap, 1999.

STAT WEEK			Chinook						Coho					
			Avg	s.d.	Range		n	Catch	Avg	s.d	Range		n	Catch
Begin	End	No.	(mm)		Min	Max			(mm)		Min	Max		
02/23	02/28	9						67						0
03/01	03/07	10						70	97.0	15.92	75	125	6	6
03/08	03/14	11	41.4	1.50	40	44	5	68	112.0	12.88	102	136	5	5
03/15	03/21	12	41.9	1.76	39	46	16	23	122.5	4.87	111	131	11	11
03/22	03/28	13	50.1	6.72	38	63	22	30	122.8	9.92	93	133	13	21
03/29	04/04	14	49.4	5.14	37	61	29	36	128.7	10.68	107	174	37	103
04/05	04/11	15	54.5	6.92	43	65	6	6	123.0	9.30	100	141	63	63
04/12	04/18	16	52.4	6.06	42	62	15	18	127.3	11.78	99	171	88	97
04/19	04/25	17	55.5	7.10	40	65	13	12	126.5	10.43	98	173	155	406
04/26	05/02	18	67.9	7.80	44	82	36	42	120.6	9.90	95	186	681	2,096
05/03	05/09	19	72.2	9.44	40	90	208	210	116.4	9.41	95	147	253	4,039
05/10	05/16	20	77.0	8.33	38	92	147	358	113.3	9.09	95	136	212	2,060
05/17	05/23	21	80.5	6.63	50	96	187	865	112.4	9.92	85	140	176	3,178
05/24	05/30	22	84.5	6.11	69	100	138	2,117	109.4	9.08	90	140	144	2,238
05/31	06/06	23	85.5	7.41	71	104	85	686	110.1	8.91	91	129	73	442
06/07	06/13	24	92.4	8.03	75	114	70	764	113.5	9.87	98	141	55	128
06/14	06/20	25	94.6	6.94	81	111	26	419	107.3	6.34	101	116	3	31
06/21	06/27	26	97.3	3.30	93	101	3	133						20
06/28	07/04	27	89.3	4.92	81	95	10	39	122.7	17.99	96	151	9	19
07/05	07/11	28	93.4	8.76	78	105	9	14	108.7	19.11	91	152	7	13
07/12	07/13	29	88.0	0.00	88	88	1	1						0
		Totals					1,026	5,978					1,991	14,976

and into the trap, channel width and depth, flow vectors, noise, turbidity and temperature are all a function of or influenced to some degree by flow. Therefore, as with the Cedar River traps, our experimental design in Bear Creek involved calibrating the trap over the range of flows in effect and relating capture rates to discharge. We intended to maintain the original trap position throughout the season (position 1); however as stream flows declined, we had to adjust the trap location to gain the requisite depth of just over 2.5-ft and center it in the flow. Therefore, on May 14, we moved the trap 2.5-ft toward the right bank and downstream several feet into the pool (position 2). In addition, we installed sideboards upstream of the trap to direct flow into it.

Trap efficiency tests for sockeye were used to estimate chinook trap efficiency while the trap fished in position 1. From February 28 through April 11 we released a total of 12,010 dye-marked sockeye fry in 31 groups (Table 15). Recapture rates averaged 24.7% and varied just over twofold, from a low of 16.3% to a high of 38%. Over the interval that we conducted these trap efficiency tests, flows declined from 263-cfs to 72-cfs. Flow explained little of the variation in recapture rates (9.1%) and was found not to be significant ($p>0.05$).

Trap efficiency tests were made using juvenile chinook while the trap fished in position 2. From May 17 through June 15, we released 990 marked chinook in 17 groups at flows that ranged from 29-cfs to 48-cfs. Capture rates ranged from 25% to 80% and averaged 46.9%, and were found not to be significantly correlated with flow (Table 16). Trap efficiencies measured at each extreme of the range were produced from release groups of less than 40. We combined these two tests with adjacently timed tests to form 15 tests of at least 40 marked chinook each. Trap efficiency from these 15 groups averaged 45.6%.

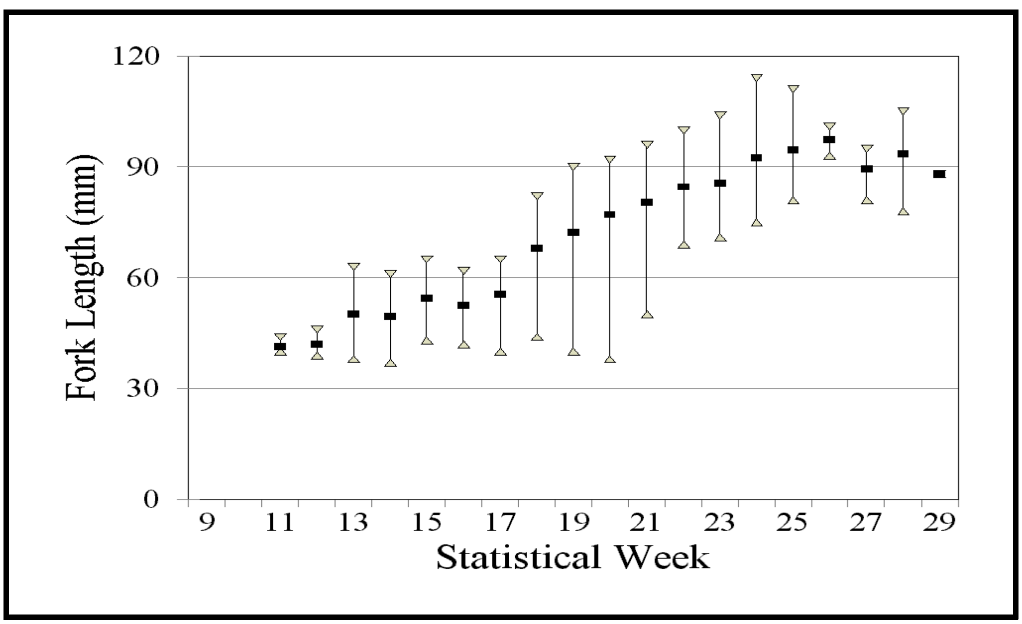


Figure 29. Weekly ranges and mean fork lengths for age 0+ chinook captured in the Bear Creek screw trap, 1999.

Table 15. Sockeye fry recapture rates from trap efficiency tests in Bear Creek trap position 1, 1999.

Date	Number Released	Recaptured Number	Recaptured Rate	Var($\hat{e}$)
02/28	300	66	22.00%	0.0005739
03/02	400	65	16.25%	0.0003411
03/03	427	84	19.67%	0.0003709
03/04	400	103	25.75%	0.0004792
03/05	400	98	24.50%	0.0004636
03/05	400	133	33.25%	0.0005563
03/06	400	76	19.00%	0.0003857
03/08	400	101	25.25%	0.0004730
03/10	396	104	26.26%	0.0004903
03/11	400	74	18.50%	0.0003779
03/11	400	93	23.25%	0.0004472
03/12	400	109	27.25%	0.0004969
03/16	445	95	21.35%	0.0003782
03/17	395	99	25.06%	0.0004767
03/18	395	110	27.85%	0.0005100
03/19	399	102	25.56%	0.0004781
03/19	396	124	31.31%	0.0005445
03/20	398	106	26.63%	0.0004922
03/22	397	151	38.04%	0.0005952
03/24	400	102	25.50%	0.0004761
03/25	398	95	23.87%	0.0004577
03/25	400	94	23.50%	0.0004506
03/26	387	81	20.93%	0.0004287
03/28	483	81	16.77%	0.0002896
03/30	401	118	29.43%	0.0005192
03/31	400	94	23.50%	0.0004506
04/01	395	98	24.81%	0.0004735
04/02	396	95	23.99%	0.0004616
04/03	297	63	21.21%	0.0005646
04/10	265	77	29.06%	0.0007808
04/11	240	64	26.67%	0.0008182
Total	12,010	2,955		
		Average	**24.71%**	
		Var(ʻ)	**0.0005567**	

Note: Sockeye fry were marked with bismark brown dye.

Table 16. Chinook smolt recapture rate from trap efficiency tests in Bear Creek trap position 2, 1999.

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Actual Test Groups				
05/17	102	42	41.18%	0.002398
05/21	32	8	25.00%	0.006048
05/25	50	17	34.00%	0.004580
05/26	50	18	36.00%	0.004702
05/27	50	16	32.00%	0.004441
05/28	75	40	53.33%	0.003363
05/30	63	22	34.92%	0.003666
05/31	57	36	63.16%	0.004155
06/01	81	46	56.79%	0.003067
06/03	60	27	45.00%	0.004195
06/06	60	32	53.33%	0.004218
06/08	52	19	36.54%	0.004547
06/09	51	18	35.29%	0.004567
06/10	64	30	46.88%	0.003953
06/11	63	48	76.19%	0.002926
06/12	30	24	80.00%	0.005517
06/15	50	21	42.00%	0.004971
	990	464		
	All Release Groups	Average	46.57%	
		V(ʻ)	0.005603	
Combined Test Groups				
05/17	102	42	41.18%	0.002398
05/21 - 05/25 Combined	82	25	30.49%	0.002616
05/26	50	18	36.00%	0.004702
05/27	50	16	32.00%	0.004441
05/28	75	40	53.33%	0.003363
05/30	63	22	34.92%	0.003666
05/31	57	36	63.16%	0.004155
06/01	81	46	56.79%	0.003067
06/03	60	27	45.00%	0.004195
06/06	60	32	53.33%	0.004218
06/08	52	19	36.54%	0.004547
06/09	51	18	35.29%	0.004567
06/10	64	30	46.88%	0.003953
06/11 - 06/12 Combined	93	72	77.42%	0.001900
06/15	50	21	42.00%	0.004971
	990	464		
Combined (40 or larger) Release Groups		**Average**	**45.62%**	
		V(ʻ)	**0.004931**	

Chinook Production

From February 23 through July 13 we estimate 14,600 age 0+ chinook passed the screw trap (Appendix E). The 95% confidence interval about this estimate ranged from 13,862 to 15,338 chinook (Table 17).

Linear extrapolation was used to estimate the number of age 0+ chinook migrants that emigrated from Big Bear Creek prior to trap installation. We chose a migration starting date of February 1 for this analysis. Daily migration was extrapolated to the mean daily migration estimate derived from the first two days of trapping (37 chinook). This procedure resulted in the estimated migration of an additional 402 age 0+ chinook between February 1 and February 22, increasing the total basin production estimate to 15,002 age 0+ chinook migrants with a confidence interval of 14,262 to 15,741 (Table 17, Figure 30).

Table 17. Estimated age 0+ chinook migration from Big Bear Creek, 1999.

Gear	Period	Estimated Migration	CV	95% CI	
				Low	High
Before Trapping	February 1 - February 22	402	4.84%	363	440
Trap Position 1	February 23 - May 13	2,816	2.18%	2,696	2,936
Trap Position 2	May 14 - July 13	11,784	3.15%	11,056	12,512
Trapping Total	February 23 - July 13	14,600	2.58%	13,862	15,338
Total	February 1 - July 13	15,002	2.51%	14,262	15,741

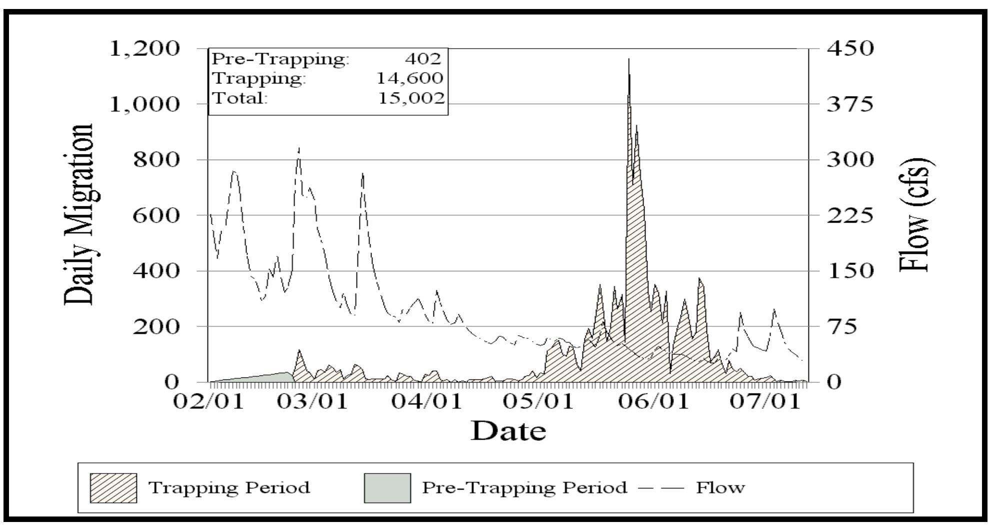


Figure 30. Estimated daily age 0+ chinook migration and flow (King County Union Hill Gage), Bear Creek 1999.

Coho

Catch

Yearling coho salmon began to appear in the catch on March 3. Over the entire 140 day season, we caught 14,896 coho smolts (Appendix E). Coho catches were generally less than 20 per day until mid April, when catches increased. The run peaked in early May and again in late May, reaching 839 on May 5 and 968 on May 25, before declining to low levels in June.

Size

Over the trapping season, weekly average fork lengths ranged from 97 to129-mm (Table 14, Figure 31). Size of individual smolts ranged from 75-mm to 186-mm over the trapping season.

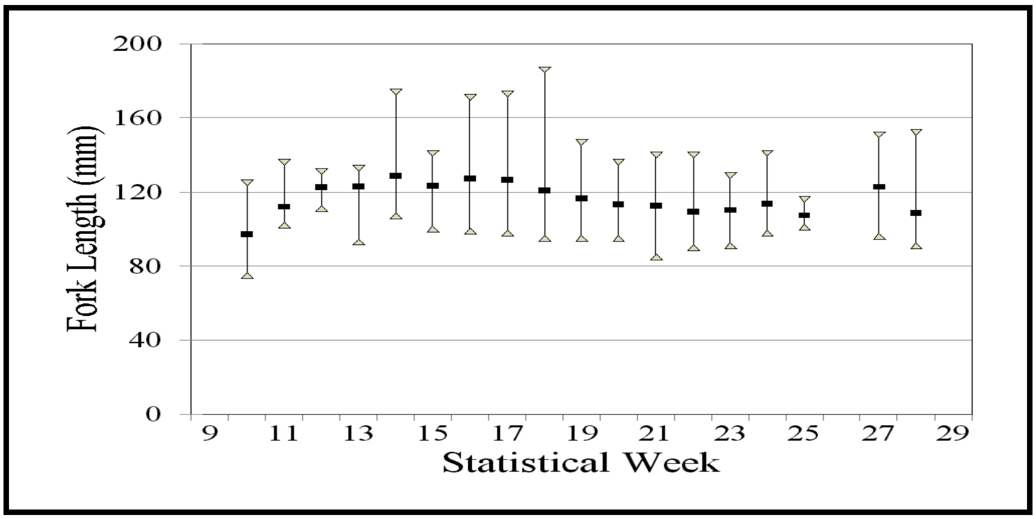


Figure 31. Weekly ranges and mean fork lengths for coho smolts trapped in the Bear Creek screw trap, 1999.

Catch Expansion

Expanding catch data on the seven days when the trap did not fish continuously estimated an additional 38 coho smolts (Appendix E). These estimates amounted to 0.25% of the season total expanded catch.

Trap Efficiency

Twelve groups of marked coho were released upstream of the trap while it was fishing in position 1. Efficiency ranged from 4% to 40% with flow explaining a significant amount of the variability in the recapture rates when all release groups were used in the analysis (Figure 32). Therefore, a regression-derived flow relationship was used to estimate efficiency while the trap fished in this position.

Eight groups were released while the trap fished in position 2 (Table 18). Recapture rates from these groups ranged from 20% to 58%. Flow failed to explain a significant portion of the variation; therefore, the mean recapture rate (32.6%) was used when the trap fished in this position. Small release groups were combined with adjacent groups to form seven groups of at least 40 marked smolts in each test. Mean trap efficiency from these combined groups (34.2%) was used to estimate coho production.

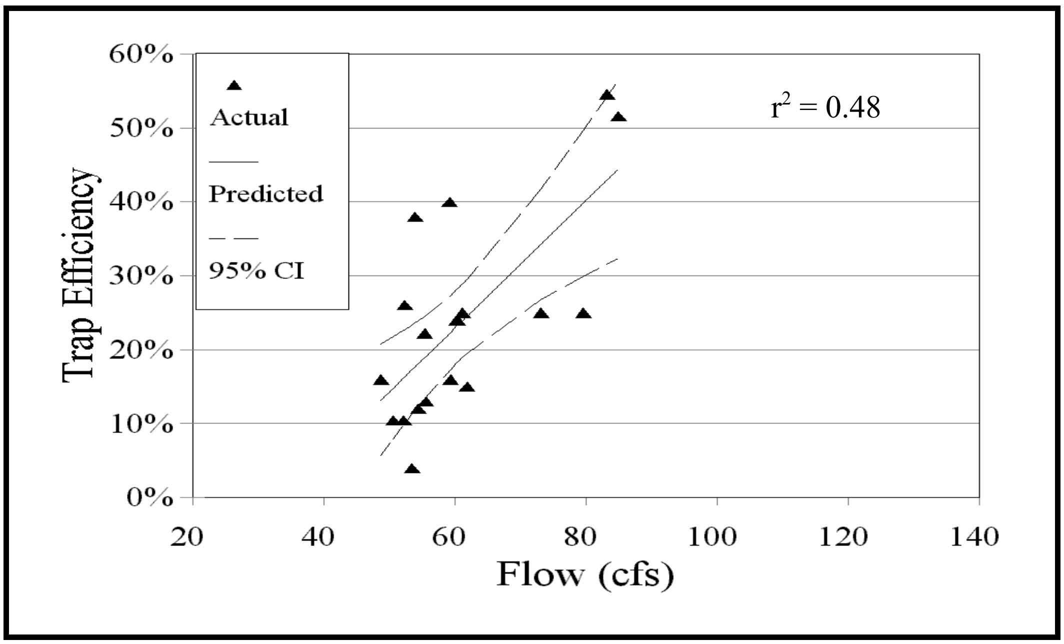


Figure 32. Scatter plot of relationship between coho trap efficiency (screw trap position 1) and mean daily stream flow (King County Union Hill Gage), Bear Creek 1999.

Coho Production

From February 23 through July 13 we estimate 62,970 coho smolts passed the screw trap (Figure 33, Appendix E). The coefficient of variation for this estimate was 10.0% and it had a confidence interval of 50,645 to 75,295 coho. The entire coho migration was sampled during the trapping period, so adjustments were not made to reflect migration during pre- or post-trapping periods.

Table 18. Coho smolt recapture rates from trap efficiency tests in Bear Creek trap positions 1 and 2, 1999.

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)	Flow (cfs)
Position 1					
04/01	31	16	51.61%	0.008325	85
04/06	11	6	54.55%	0.024793	83
04/08	8	2	25.00%	0.026786	80
04/11	4	1	25.00%	0.062500	73
04/14	8	2	25.00%	0.026786	61
04/16	9	2	22.22%	0.021605	55
04/18	19	2	10.53%	0.005232	52
04/20	20	3	15.00%	0.006711	62
04/22	23	3	13.04%	0.005156	56
04/23	23	6	26.09%	0.008764	52
04/26	25	6	24.00%	0.007600	61
04/28	50	8	16.00%	0.002743	59
04/29	50	6	12.00%	0.002155	54
05/02	38	4	10.53%	0.002545	51
05/03	50	12	24.00%	0.003722	60
05/06	50	20	40.00%	0.004898	59
05/08	50	19	38.00%	0.004808	54
05/10	50	8	16.00%	0.002743	49
05/13	50	2	4.00%	0.000784	53
	569	128			
	Regression Statistics:	α	0.008599		
		&	-0.28708		
		r^2	0.4783		
		F	15.6		
Position 2					
Actual Test Groups					
05/14	50	10	20.00%	0.003265	48
05/19	50	16	32.00%	0.004441	64
05/24	50	12	24.00%	0.003722	49
05/26	50	21	42.00%	0.004971	49
05/28	50	18	36.00%	0.004702	41
06/01	40	23	57.50%	0.006266	31
06/04	44	13	29.55%	0.004841	48
06/15	10	2	20.00%	0.017778	27
	344	115			
	All Release Groups	**Average**	32.63%		
		Var(ʻ)	0.002002		

Table 18. Coho smolt recapture rates from trap efficiency tests in Bear Creek trap positions 1 and 2, 1999 (cont'd).

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Position 2				
Combined Test Groups				
05/14	50	10	20.00	0.003265
05/19	50	16	32.00	0.004441
05/24	50	12	24.00	0.003722
05/26	50	21	42.00	0.004971
05/28	50	18	36.00	0.004702
06/01	40	23	57.50	0.006266
06/04 - 06/15 Combined	54	15	27.78	0.003785
	344	115		
Combined (40 or larger) Release Groups		**Average**	34.18	
		V($\hat{e}$)	0.003905	

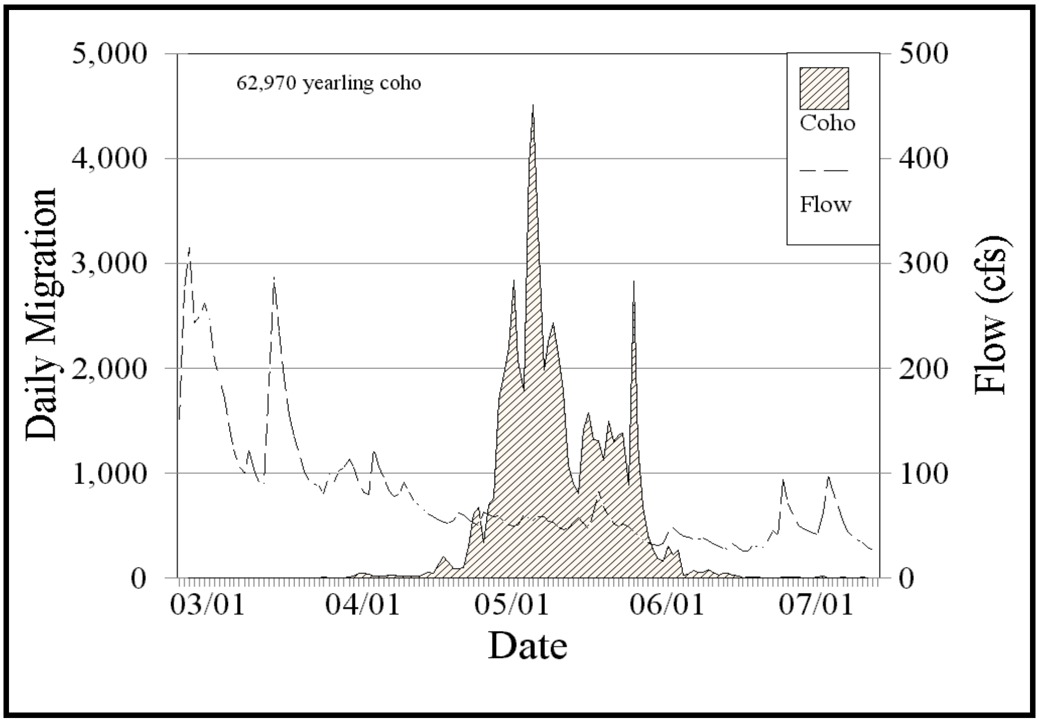


Figure 33. Estimated daily coho smolt migration and flow (King County Union Hill Gage), Bear Creek 1999.

Sockeye

Catch

On the first night of trapping, February 23, we caught 8,400 sockeye fry. Over the entire 140 day season, we caught 327,694 sockeye fry (Appendix E). Nightly sockeye catches increased to a high of nearly 16,000 on March 16 before declining in late March and April.

Catch Expansion

Catch expansion resulted in the addition of 10,722 sockeye fry, an increase of 3.3% over the actual catch (Appendix E).

Trap Efficiency

Over the season, trap efficiency estimates for sockeye averaged 24.7% (Table 15). These estimates are described in the chinook results section of this report since they were also used to estimate chinook capture rates while the trap fished in position 1.

Sockeye Fry Production

Over the trapping interval we estimate 1,369,611 sockeye fry passed the trap (Table 19, Figure 34). The CV and confidence interval (95%) for this estimate was 1.89% and 1,318,763 to 1,420,459 sockeye, respectively. The sockeye fry migration was well underway when we began trapping on February 23. Data from trapping in previous years suggested a migration starting date of January 15 to be appropriate for Bear Creek sockeye. Using the mean migration estimate from the first two days of trapping, an exponential curve was used to estimate the number of sockeye migrating prior to trap installation. Comparison with migration timing from the Sammamish River in 1998 suggested exponential, rather than linear, extrapolation would better approximate the shape of the run-timing curve (Figure 35). This procedure resulted in the estimated migration of an additional 156,597 sockeye fry, expanding the total Bear Creek migration estimate to 1,526,208.

Table 19. Estimated sockeye fry migration from Big Bear Creek, 1999.					
Gear	**Period**	**Estimated Migration**	**CV**	**95% CI**	
				Low	**High**
Before Trapping	January 15 - February 22	156,597	8.73%	129,817	183,377
Trapping Period	February 23 - July 13	1,369,611	1.89%	1,318,763	1,420,459
Position 1	February 23 - May 13	1,369,319	1.89%	1,318,471	1,420,167
Position 2	May 14 - July 13	292	4.53%	266	318
Total	January 15 - July 13	1,526,208	1.92%	1,468,739	1,583,677

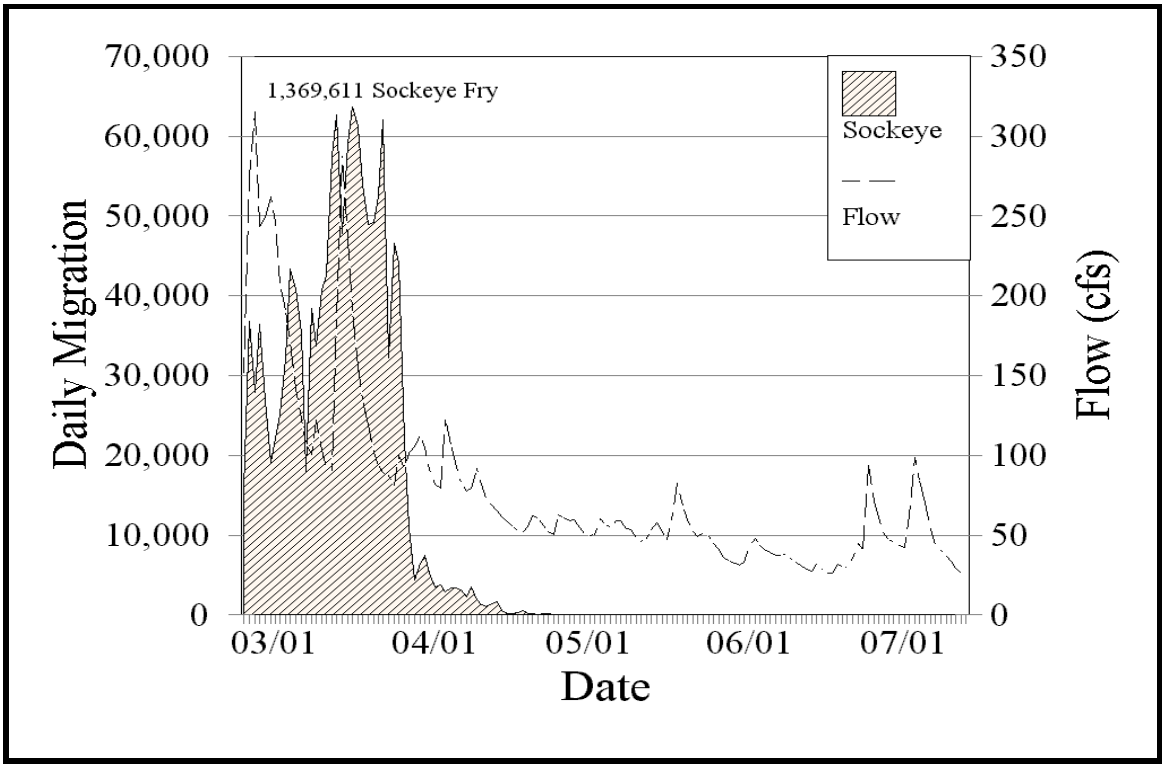


Figure 34. Estimated daily sockeye fry migration and flow (King County Union Hill Gage) between February 23 and July 13, 1999, Bear Creek screw trap.

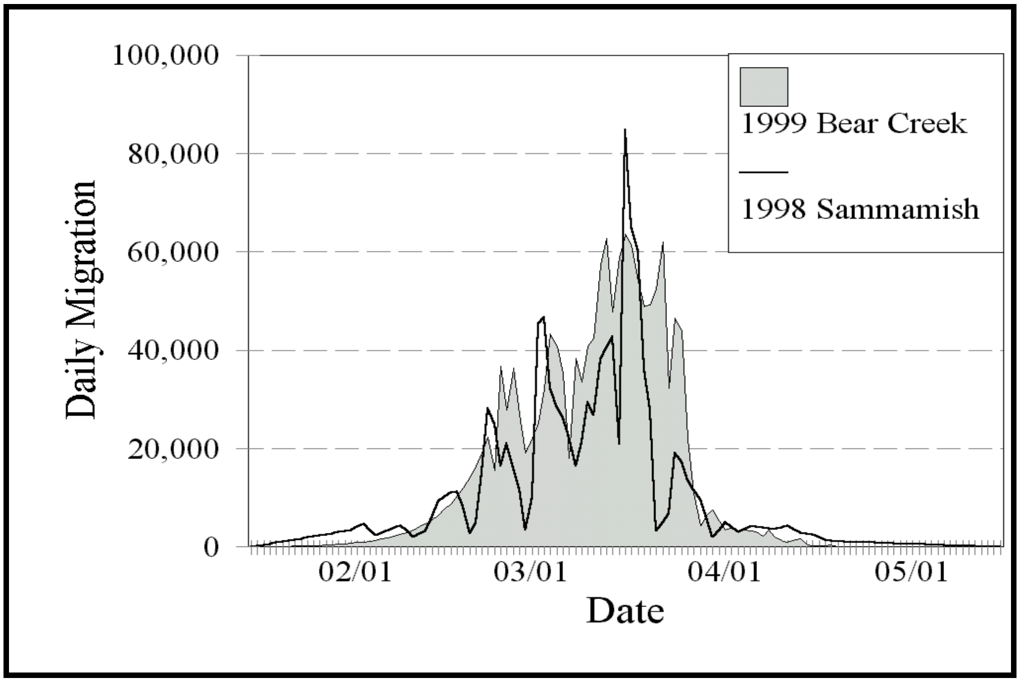


Figure 35. Migration timing comparison between 1999 Bear Creek sockeye and 1998 Sammamish River sockeye migrations.

Steelhead and Cutthroat

Catch

Over the trapping season, we caught 289 steelhead smolts and 545 juvenile cutthroat (Appendix F). Of the 289 steelhead smolts captured, 225 were marked representing 78% of the catch. Virtually all steelhead smolts were caught from early April through mid-June.

Juvenile cutthroat were captured throughout the trapping period while most of the adult cutthroat were caught in March. Capture rates for steelhead and cutthroat were low, therefore catch expansions were not made for those periods when the trap was not fishing.

Size

Monthly average steelhead fork length declined over the trapping period from a high of 218-mm in March to 153-mm in June (Figure 36). Monthly average fork length for cutthroat did not exhibit a definitive trend (Figure 37). Fork length ranged widely for both species over the trapping season. Steelhead fork length ranged from 105-mm to 280-mm. Cutthroat ranged from 66-mm to 310-mm.

Trap Efficiency

As in the Cedar River, daily catches of steelhead and cutthroat were too low to be used in mark-recapture trap efficiency experiments. Applying the 60% average steelhead to coho capture rate, derived from the Toutle, Green, and White Salmon Rivers as described in the Cedar River results section of this report (pg. 40), to the average coho trap efficiency in Bear Creek of 23.8% for position 1 and 32.6% for position 2 yielded estimated trap efficiencies for steelhead of 14.3% and 19.6%, respectively. Rounding, adjusting for the use of a screw trap instead of the inclined-plane screen traps used in the Toutle, Green, and White Salmon Rivers, and for the general lack of precision of this estimator resulted in our selecting trap efficiency rates of 15% for position 1 and 20% for position 2 for estimating both steelhead and cutthroat migration.

Steelhead and Cutthroat Production

Application of these trap efficiency rates to steelhead catches estimates total basin production of 1,772 steelhead smolts (Figure 38) (Appendix F). The marked component of the steelhead production is estimated at 1,365 steelhead or 77% of the total. Migration of cutthroat during trapping operations is estimated at 3,413 cutthroat (Figure 39). No attempt was made to estimate cutthroat migration outside the period trapped.

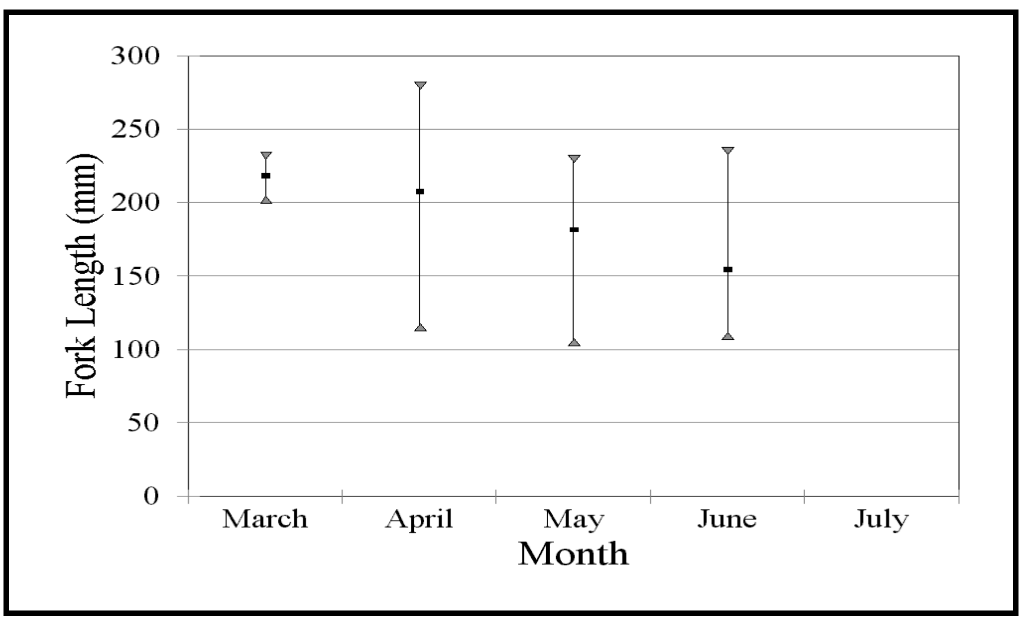


Figure 36. Monthly ranges and mean fork lengths for steelhead smolts trapped in the Bear Creek screw trap, 1999.

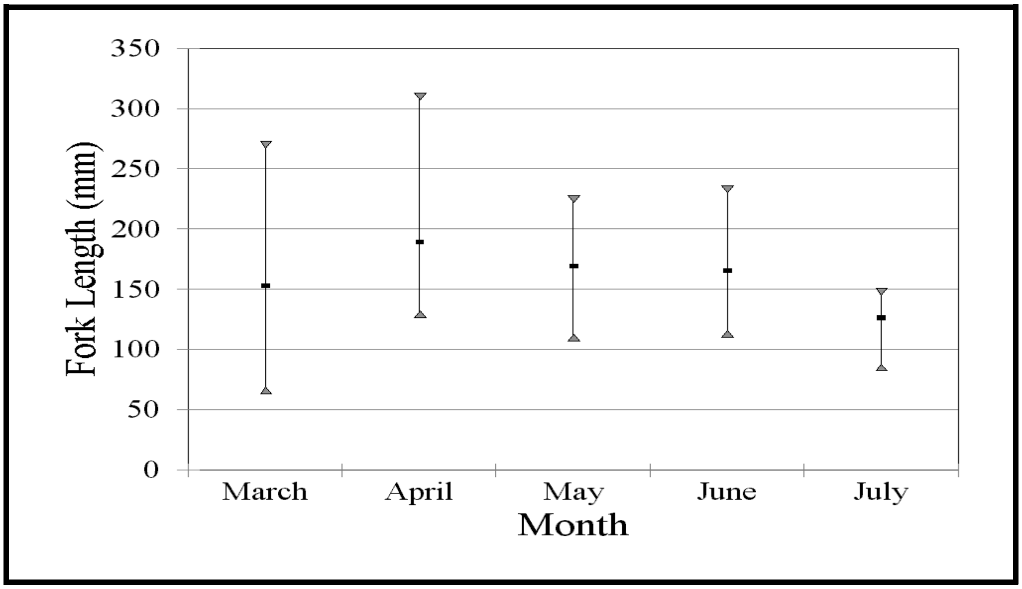


Figure 37. Monthly ranges and mean fork lengths for cutthroat trapped in the Bear Creek screw trap, 1999.

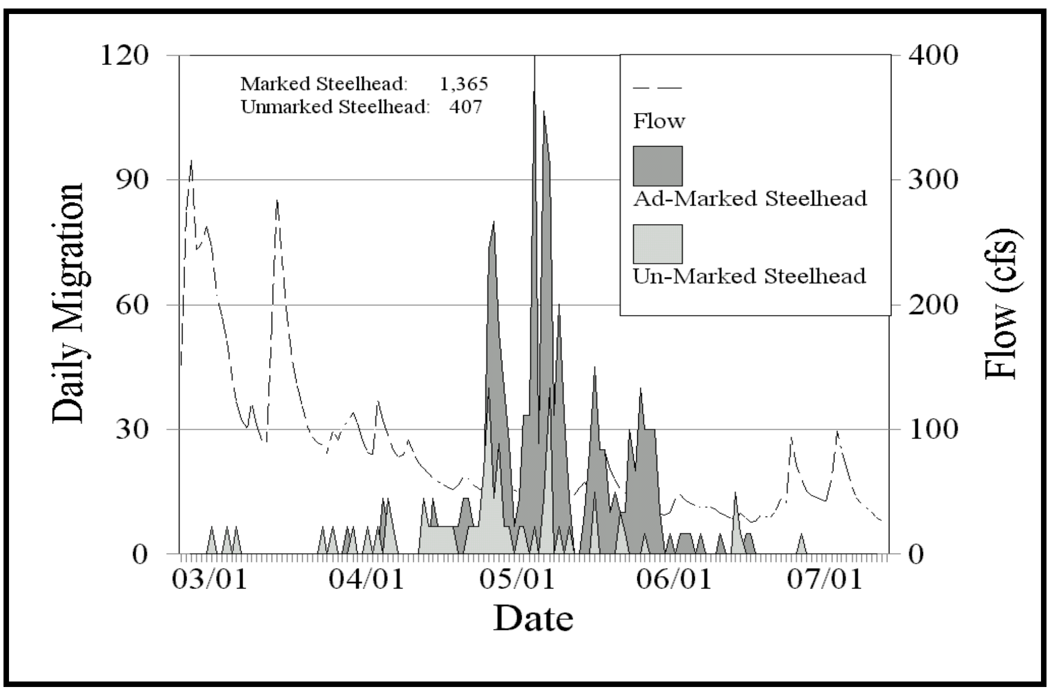


Figure 38. Estimated daily migrations of marked and unmarked steelhead smolts and flow (King County Union Hill Gage), Bear Creek 1999.

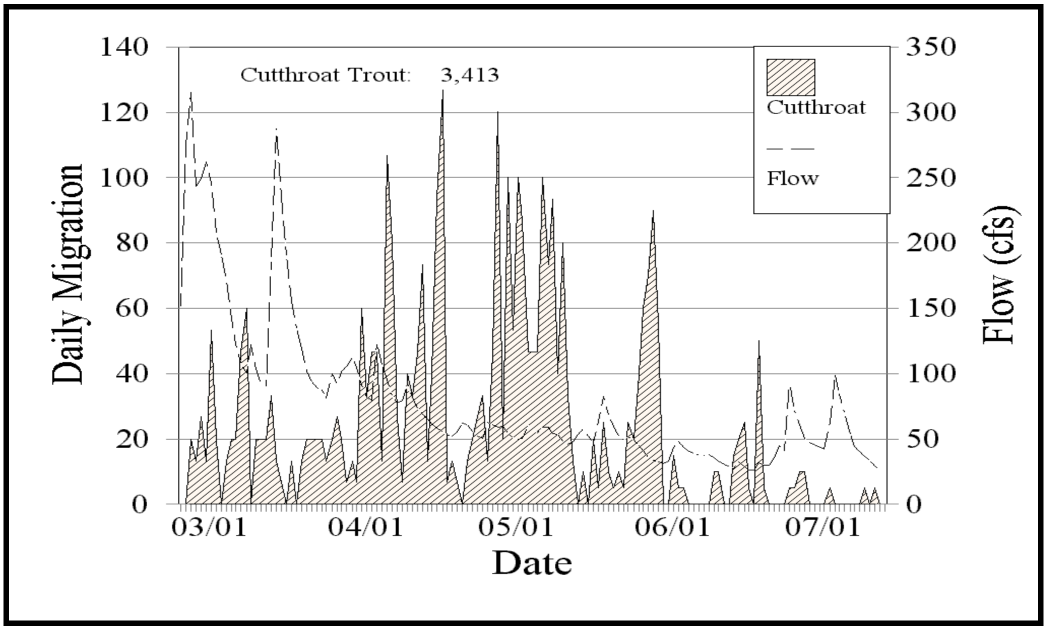


Figure 39. Estimated daily migration of cutthroat trout and flow (King County Union Hill Gage), Bear Creek 1999.

Bear Creek 2000

Trapping Gear and Operation

In 2000, the screw trap was installed on January 24 and operated continuously until July 13. On most days, the trap was checked once in the morning and once in the evening. During periods when sockeye catch rates were high, hourly trap checks were performed (evening and early morning hours). Towards the end of the trapping period, in July, trap checks were sometimes made only once per day or even once every other day since catches were very small and the amount of debris entering the trap was low.

The same data collected in 1999 was also collected in 2000. In addition, stomach content analysis was done on a subsample of the cutthroat and sculpin captured to evaluate the level of predation on salmonid migrants. A syringe filled with water was used to lavage the stomach contents from sampled fish. Coarse analysis of stomach contents was done on site. Afterwards, the material was discarded. Material collected in each sample was categorized as either fish or invertebrate matter. An attempt was made to identify and count fish present in each sample collected.

Production Estimation

As with the Cedar River, methods used to estimate trap efficiency in 2000 were slightly different from those used in 1999. In both years, linear regression analysis was used to test the effect of mean daily flow on capture rate. Where the slope of the regression equation was found to be significantly different from zero (" = 0.05), mean daily flow was used to estimate daily trap efficiency using Equation 1.

The difference between years was related to how the trap efficiency estimates were derived in cases where there was not a significant relationship between trap efficiency and streamflow. Where this occurred in 1999, trap efficiency was averaged across the calibration tests made for the trap position using Equation 3 and $\overline{e}_i$ was substituted for $\hat{e}_i$ in Equation 6 to estimate total daily (24-hour) migration instead of nightly migration. Variances were estimated for regression-based and mean efficiency values using Equations 2 and 5, respectively.

In 2000, we wanted to evaluate whether trap efficiency differed between day and night trapping periods. Therefore, efficiency tests were stratified by release period (morning or evening). Because sockeye production was relatively low in 2000, we also wanted to evaluate whether the length of time that recaptured marked sockeye fry were held in the live well biased our trap efficiency results (presumably due to predation). In this case, efficiency tests were stratified based on the amount of time between the release of marked sockeye fry and their subsequent removal from the trap live well. In both cases, the mean efficiencies for the strata were tested for differences. Test results were evaluated using a 95% significance level. The results of the analysis were used to produce the final strata used for the chinook production estimates. The mean trap efficiencies from the final strata were used to estimate migration. As was done at the Cedar River and Bear Creek in 1999, individual trap efficiency tests employing less than 40 marked chinook were combined with adjacent test groups to form efficiency test groups of at least 40 marked migrants.

For both years, daily estimates of migration and their variances were summed across the season to estimate total migration and variance.

Chinook

Catch

When trapping began on January 24, chinook were migrating at very low levels. We caught only two age 0+ chinook the first night and one on the second. Over the entire 172 day season, we caught 10,833 age 0+ chinook (Appendix G). Of these, 38 were adipose-marked, presumably from the Issaquah Hatchery, that had entered into Big Bear Creek. The total catch of wild chinook was 10,795 migrants.

Chinook catches remained low through April, except for three spikes which occurred in early, mid, and late March (Appendix G). The spikes in catches corresponded with the occurrence of freshets. During these periods, catch rates increased from less than 70/day to between 100 and 327/day. After a lull in April, daily chinook catches again increased in early May and peaked at 469 on May 12. Catches remained relatively high through May, then declined through June to very low levels by early July.

The trap operated continuously through the trapping period except for three screw stoppage events that occurred during the night or early morning hours of February 23-24, the early morning hours of April 1, and during the night or early morning hours of June 11-12. In each case, rotation of the screw was stopped by large woody debris that had entered the trap. By examining the catch data from adjacent days, we judged that the magnitude of catch during the impacted trapping periods were not substantially reduced. Therefore, no adjustments were made to the catch data.

Size

Chinook 0+ averaged 41-mm or less through mid-March, but grew rapidly afterwards (Table 20, Figure 40). By late-May, chinook averaged around 80-mm or longer. Over the trapping period, fork lengths ranged from 31-mm to 106-mm.

Table 20. Weekly descriptive statistics relating to fork length of chinook and coho captured in the Bear Creek screw trap, 2000.

STAT WEEK			Chinook					Coho				
			Avg		Range			Avg		Range		
Begin	End	No.	(mm)	s.d.	Min	Max	n	(mm)	s.d.	Min	Max	n
01/24	01/30	5	36.8	1.21	35	40	30	97.0	N/A	97	97	1
01/31	02/06	6	39.3	1.42	37	42	10	105.0	N/A	105	105	1
02/07	02/13	7										
02/14	02/20	8						114.7	11.93	105	128	3
02/21	02/27	9	39.6	2.98	31	45	14					
02/28	03/05	10	40.2	1.57	36	44	51					
03/06	03/12	11	40.3	1.96	37	44	55					
03/13	03/19	12	40.7	3.39	34	48	42	106.0	14.14	96	116	2
03/20	03/26	13	45.9	9.67	38	68	22					
03/27	04/02	14	45.8	7.70	37	70	36	128.6	27.08	106	186	8
04/03	04/09	15	46.1	6.35	38	61	85	114.8	11.91	90	136	18
04/10	04/16	16	52.1	6.69	38	67	49	121.2	19.48	80	190	47
04/17	04/23	17	58.1	5.26	45	73	53	119.6	13.96	91	162	111
04/24	04/30	18	61.8	5.97	49	75	56	110.1	14.08	88	146	62
05/01	05/07	19	68.8	6.66	49	79	57	112.0	12.48	92	141	73
05/08	05/14	20	40.9	9.07	44	88	109	107.4	11.73	81	144	93
05/15	05/21	21	76.9	6.68	58	90	95	109.6	16.43	91	141	89
05/22	05/28	22	81.8	7.86	62	106	124	112.1	13.46	89	129	19
05/29	06/04	23	80.9	8.49	60	106	90	110.8	13.29	94	129	6
06/05	06/11	24	81.7	7.76	68	96	23					
06/12	06/18	25	78.6	5.51	69	87	17					
06/19	06/25	26	88.8	6.22	76	104	33					
06/26	07/02	27	84.9	6.19	74	96	11					
07/03	07/09	28	84.5	4.95	81	88	2					
07/10	07/13	29	89.9	5.47	81	96	10					
		Totals					1,074					533

Trap Efficiency

As previously discussed, trap efficiency is a function of fish size, and a number of variables related to or influenced by flow, such as swimming ability, stream velocity, and the cross sectional area of the trap relative to that of the channel. Since trap efficiency testing using chinook did not begin until early May, we used sockeye trap efficiency data to estimate chinook trap efficiency during the earlier part of the trapping period, between January 24 and April 16. The efficiency tests made with chinook later in the spring were not representative of conditions in January to mid-April. The chinook used for the efficiency tests were much larger than those trapped early in the season and stream flows measured during chinook efficiency testing

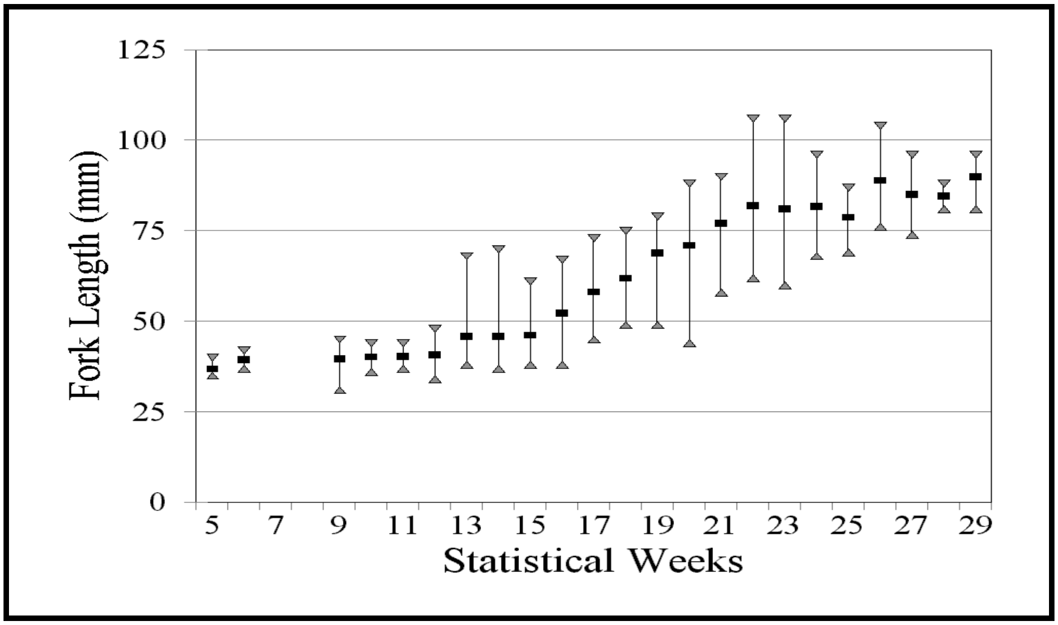


Figure 40. Weekly ranges and mean fork lengths of age 0+ chinook trapped in the Bear Creek screw trap, 2000.

averaged about half of those measured prior to April 16. We believe the sockeye trap efficiency tests provide the best data available to develop chinook trap efficiency estimates during the early part of the chinook migration since the fry sizes were similar between the two species.

Sockeye trap efficiency tests were conducted between February 21 through April 4. From these tests, a total of 6,700 marked sockeye fry were released in 20 groups. Results from two of the tests were not used. Debris jammed and stopped the screw trap during one test on February 23. The capture rate from this test was much lower than the average, probably a result of the screw stoppage event. We also elected not to use the results of a test conducted on March 12. No re-captures were reported from a release of 280 fry. We believe the crew neglected to look for marked sockeye during the next trap check, 14-hours later. Recapture rates for the remaining 18 tests using a total of 6,178 marked sockeye fry averaged 14% and ranged from a low of 6.4% to a high of 22.4% (Table 21). Over the interval that we conducted these trap efficiency tests, flows declined from 221 cfs to 82 cfs. Flow explained little of the variation in recapture rates (18%) and were found not to be significant ($p>0.05$).

The 14% mean trap efficiency for sockeye fry measured in 2000 was substantially below the 25% trap efficiency measured in 1999. Trap efficiencies for coho and chinook smolts in 2000 were only slightly lower than those measured in 1999 for coho salmon and for chinook smolts (tests conducted between April 17 and July 13). Pooling the results from all tests resulted in average coho efficiencies of 27% in 1999 compared to 25% in 2000 and chinook efficiencies of 48% in 1999 compared to 40% in 2000. Since the trap was placed in a section of river with a relatively stable, confined, channel morphology, we believe the difference in sockeye trap efficiencies between the two years was predominately due to increased predation. Following the release of marked sockeye fry during trap efficiency tests, the interval until the first trap check averaged 6.67 hours in 2000, compared to only 3.75 hours in 1999. Stomach content analysis done on sculpin, cutthroat, coho and steelhead showed that substantial predation on sockeye fry was occurring. Most of this predation may have occurred within the trap live box, and that would at least partially account for the reduction in capture efficiency. Instream predation may also be higher in 2000 due to increased numbers of predators. We caught nearly twice as many cutthroat in 2000 (1,022) compared to 1999 (543). Peak flows during the November through February periods were substantially lower over the winter of 1999 - 2000 relative to the winter of 1998 - 1999 which may have resulted in increased survival and higher densities of cutthroat and sculpin (Figure 41). We could not verify a change in the population of the later, however, since sculpin abundance cannot be estimated using screw trap catch data.

To test for predation within the trap box, sockeye trap efficiency rates were stratified based on the length of time between the marked fish release and the first post-release trap check (Table 21). The data stratified nicely into two groups of nine data points each, with Stratum 1 residing in the trap box for 10.75 to 13.5 hours and Stratum 2 residing in the trap box for 2.5 hours or less. Stratum 1 trap efficiency averaged 11.7%, whereas Stratum 2 averaged 16.4%. An ANOVA was performed and showed the two means to be significantly different ($p<0.05$). This strongly suggested that predation on marked sockeye fry was occurring in the trap.

The 16.4% trap efficiency rate observed for Stratum 2 tests was still below the 25% average observed for 1999 tests. The difference may be the result of increased in-stream predation (between release point and trap) on marked sockeye fry that occurred in 2000. In addition, as a function of the much lower sockeye abundance (catches in 2000 were just 7% of those in 1999), predation in the stream and live box combined resulted in substantially higher predation rates on both captured unmarked and recaptured marked sockeye fry than were observed in 1999.

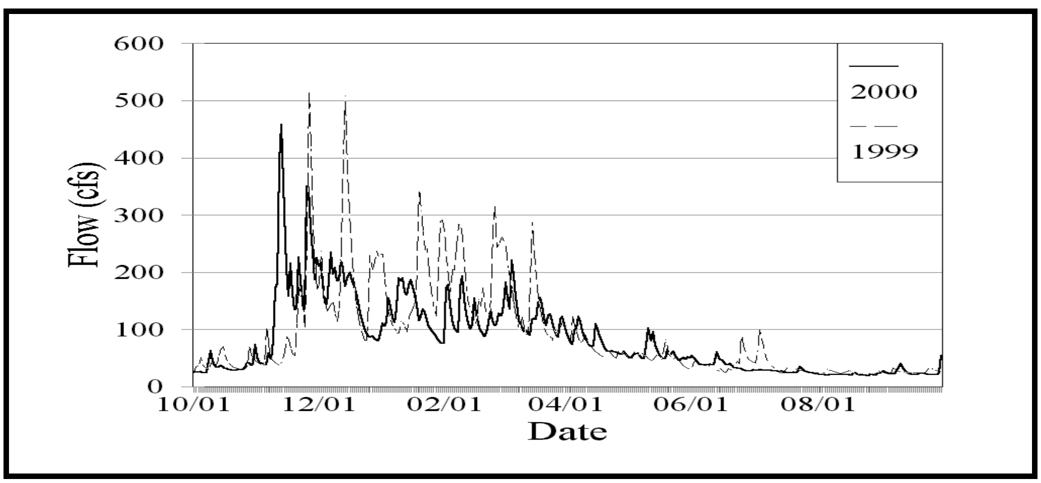


Figure 41. Comparison of average daily stream flow in Big Bear Creek between water year 1999 and 2000 (King County Union Hill Gage).

Table 21. Sockeye fry recapture rates from trap efficiency tests in Bear Creek, 2000.

Date	Trap Check Interval	Flow (cfs)	Number Released	RECAPTURED Number	Rate	Var($\hat{e}$)
Stratum 1. Long Interval						
02/21	13.50	95	112	18	16.07%	0.001215
02/25	13.25	106	218	14	6.42%	0.000277
02/26	13.25	109	89	12	13.48%	0.001326
02/29	13.50	143	437	34	7.78%	0.000165
03/02	11.25	155	400	36	9.00%	0.000205
03/04	10.75	221	400	47	11.75%	0.000260
03/05	11.25	194	400	32	8.00%	0.000184
03/07	13.00	132	400	63	15.75%	0.000333
03/15	13.50	120	400	68	17.00%	0.000354
			2,856	324		
	Average (‘)				11.70%	
	V(‘)				0.000662	
	n				9	
Stratum 2. Short Interval						
03/03	2.50	135	400	40	10.00%	0.000226
03/09	1.00	105	400	77	19.25%	0.000390
03/14	0.25	118	400	65	16.25%	0.000341
03/17	1.00	145	400	60	15.00%	0.000320
03/19	0.25	143	245	41	16.73%	0.000571
03/20	0.75	121	400	68	17.00%	0.000354
03/24	1.00	114	398	89	22.36%	0.000437
04/01	0.50	82	279	37	13.26%	0.000414
04/04	1.00	99	400	71	17.75%	0.000366
			3,322	548		
	Average (‘)				16.40%	
	V(‘)				0.000517	
	n				9	
Combined Strata						
	Sum		6,178	872		
	Average (‘)	130			14.05%	
	V(‘)				0.000537	
	n				18	

In order to apply the sockeye capture efficiency data to estimate efficiency for chinook, we needed to ascertain whether predation rates on chinook were similar to those encountered by sockeye. Using catch in the trap as an indicator of species abundance, we found through stomach
content analysis done on cutthroat and sculpin that the number of sockeye found in the stomach of predators represent nearly 16% of the number found live in the trap compared to less than 1% for chinook. These results indicate that the predation rate on chinook is substantially lower than that of sockeye, which led us to believe that the measured sockeye trap efficiencies are also lower than those for chinook. Therefore, we opted to use the same efficiency value, 25%, measured using sockeye in 1999. We applied this rate to chinook catches from January 24 to April 16.

For the period between April 17 and July 13, trap efficiency was estimated using the results from tests made with chinook migrants captured in the trap. During these tests, a total of 1,654 chinook were released in 29 tests conducted between May 5 and June 29. During the tests, flow ranged from 27 cfs to 96 cfs. Capture rates ranged from 10.5% to 71.8% and averaged 39.6% (Table 22). The measured efficiency values changed somewhat with flow, so based on the shape of the data points we developed linear, power, and quadratic regression equations. The highest r^2 (0.33) was achieved by the quadratic equation, yet neither it nor any of the other relationships were found to be significant ($p>0.05$) and, therefore, were not considered useful for predictive purposes.

Tests were stratified by morning and evening test periods to test for diel differences in capture rates (Table 22). We tested the variances between the two strata and found that they were heteroscedastic which prevented using ANOVA to test for differences between means. We, therefore, used an approximate *t-test* to test the equality of means where variances are assumed to be unequal (Sokal and Rohlf 1981). The test found no significant differences between the means ($p>0.05$), suggesting that stratification between AM and PM test periods was not warranted. Therefore, after first combining small test groups to achieve a minimum of 40 marked releases per group, we estimated trap efficiency as the average of all of the combined test groups, 40.14%.

Chinook Production

From January 24 through July 13 we estimate 32,220 wild age 0+ chinook passed the screw trap (Table 23, Figure 42). We also estimate 94 ad-marked hatchery chinook that had entered Bear Creek passed the gear. Because migration estimates were low at the beginning and ending of the trapping period, there was no need to estimate migration prior to or following trapping.

Table 22. Chinook migrant recapture rates from trap efficiency tests in Bear Creek, 2000.

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
AM Tests				
05/05	46	24	52.17%	0.005545
05/08	50	18	36.00%	0.004702
05/14	39	28	71.79%	0.005329
05/19	61	21	34.43%	0.003762
05/20	50	21	42.00%	0.004971
05/26	67	30	44.78%	0.003747
05/27	53	27	50.94%	0.004806
06/14	22	8	36.36%	0.011019
06/18	25	3	12.00%	0.004400
06/19	14	6	42.86%	0.018838
06/21	19	2	10.53%	0.005232
06/29	53	15	28.30%	0.003902
	499	203		
	AM Tests	Average	38.51%	
		V(‘)	0.002377	
		n	12	
PM Tests				
05/12	100	41	41.00%	0.002443
05/15	75	37	49.33%	0.003378
05/17	70	29	41.43%	0.003517
05/19	60	21	35.00%	0.003856
05/21	65	19	29.23%	0.003232
05/22	75	38	50.67%	0.003378
05/24	101	40	39.60%	0.002392
05/26	50	24	48.00%	0.005094
05/28	61	24	39.34%	0.003977
05/30	51	24	47.06%	0.004983
05/31	100	41	41.00%	0.002443
06/02	100	42	42.00%	0.002461
06/05	79	24	30.38%	0.002712
06/09	50	22	44.00%	0.005029
06/10	80	35	43.75%	0.003115
06/15	16	6	37.50%	0.015625
06/25	22	6	27.27%	0.009445
	1155	473		
	PM Tests	Average	40.39%	
		V(‘)	0.000277	
		n	17	

Table 22. Chinook migrant recapture rate from trap efficiency tests in Bear Creek, 2000 (cont'd).

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Combined (40 or larger) Release Groups				
05/05	46	24	52.17%	0.005545
05/08	50	18	36.00%	0.004702
05/12	100	41	41.00%	0.002443
05/14 - 05/15 Combined	114	65	57.02%	0.028494
05/17	70	29	41.43%	0.003517
05/19	61	21	34.43%	0.003762
05/19	60	21	35.00%	0.003856
05/20	50	21	42.00%	0.004971
05/21	65	19	29.23%	0.003232
05/22	75	38	50.67%	0.003378
05/24	101	40	39.60%	0.002392
05/26	67	30	44.78%	0.003747
05/26	50	24	48.00%	0.005094
05/27	53	27	50.94%	0.004806
05/28	61	24	39.34%	0.003977
05/30	51	24	47.06%	0.004983
05/31	100	41	41.00%	0.002443
06/02	100	42	42.00%	0.002461
06/05	79	24	30.38%	0.002712
06/09	50	22	44.00%	0.005029
06/10 - 06/14 Combined	102	43	42.16%	0.000408
06/15 - 06/19 Combined	55	15	27.27%	0.016550
06/21 - 06/25 Combined	41	8	19.51%	0.003926
06/29	53	15	28.30%	0.003902
	1,654	676		
	Combined (40 or larger) Release Groups	**Average**	**40.14%**	
		V(ʹ)	**0.004047**	
		n	**24**	

Table 23. Estimated migration of wild and hatchery age 0+ chinook, Bear Creek 2000.

Species	Period	Estimated Migration	CV	95% CI	
				Low	High
Wild Chinook	January 24 - July 13	32,220	1.71%	31,143	33,297
Ad-Marked Chinook	January 24 - July 13	94	12.18%	72	116

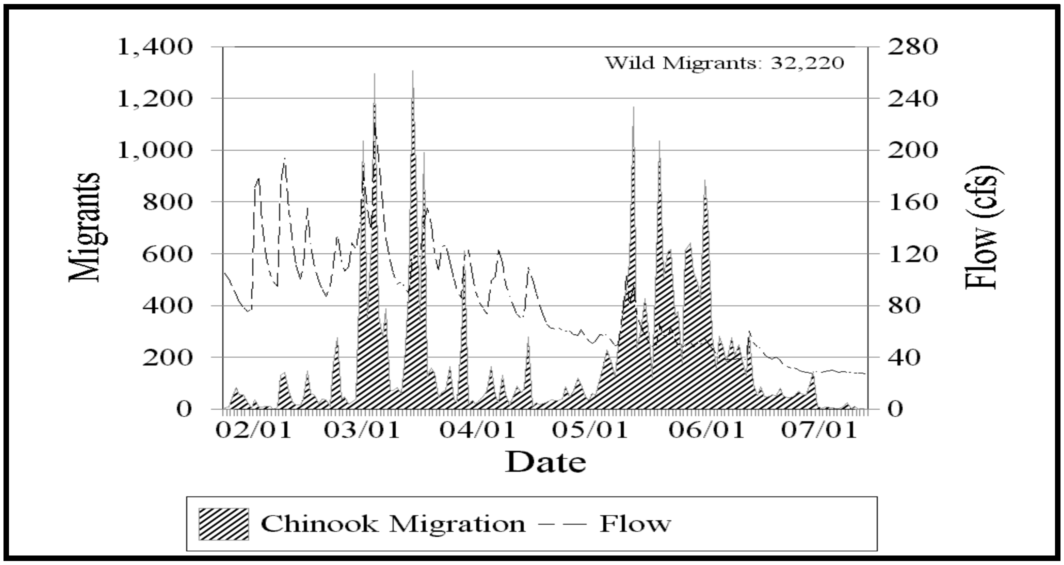


Figure 42. Estimated daily wild age 0+ chinook migration and flow (King County Union Hill Gage), Bear Creek 2000.

Coho

Catch

The first yearling coho was caught on January 27, but catches were at trace levels with only 23 caught prior to March 31. From this date on, yearling coho were caught every day through June 6. Over the entire 172 day trapping season, we caught 7,737 unmarked wild coho smolts and seven adipose marked coho, presumably Issaquah Hatchery smolts (Appendix G). Coho catches were generally less than 20 per day until mid April, when catches increased. The migration peaked on May 1, with a catch of 482 smolts, before declining to low levels in June.

As discussed in the chinook section, three screw stoppage events occurred during the trapping period (February 23-24, April 1, and June 11-12). All of the stoppages occurred outside the period of peak migration, between April 15 and May 31; therefore, no adjustments were made to the catch.

Size

Over the trapping season, weekly average fork lengths ranged from 106-mm to 129-mm for weeks when at least two coho smolt fork lengths were taken (Table 20, Figure 43). Size of individual smolts ranged from 80-mm to 190-mm over the trapping season.

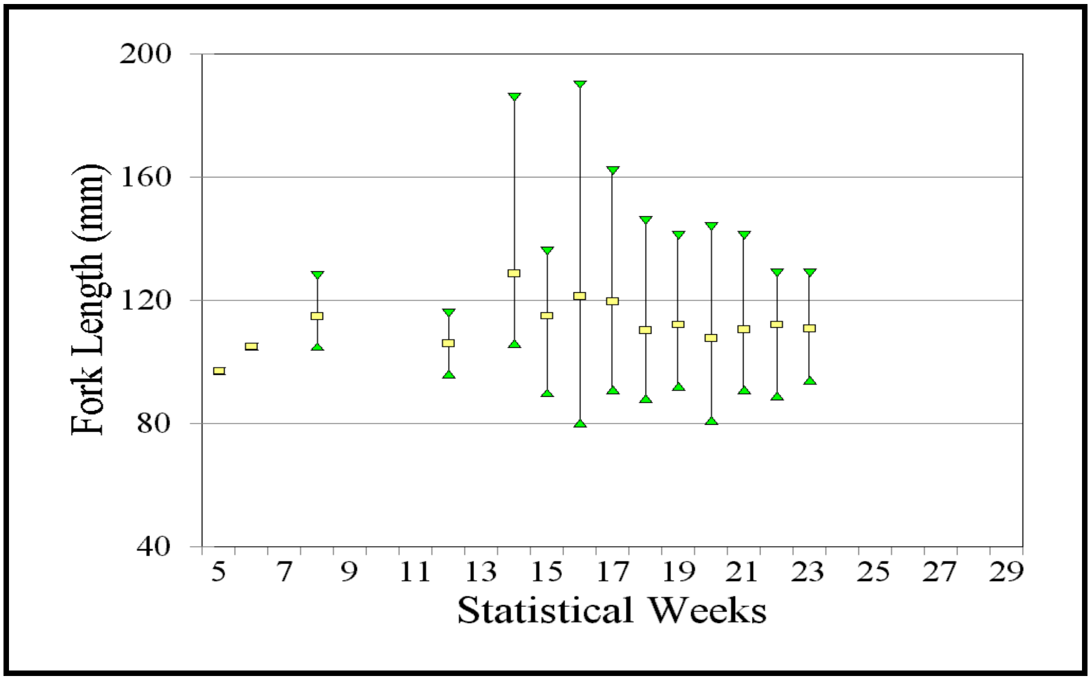


Figure 43. Weekly ranges and mean fork lengths of wild coho smolts trapped in the Bear Creek screw trap, 2000.

Trap Efficiency

A total of 1,719 marked coho were released in 24 groups upstream of the trap between March 31 and May 22. Combinations of upper and lower lobe caudal clips and right ventral clips were used. Recaptures were recorded for 22 of the release groups. Recaptures from two release groups were not recorded, therefore, these two tests were not used to estimate trap efficiency. Efficiency ranged from 8% to 46% for the 21 release groups, not counting a 0% recovery for the first release group that contained only two coho (Table 24). Linear regression analysis failed to produce a significant flow relationship and a plot of the data did not suggest additional regression models or treatments that would improve the fit.

The trap efficiency tests were stratified by the diel period in which they occurred, during AM and PM hours (Table 24). ANOVA was used to test for differences between the mean trap efficiency values. Since the means were not found to be significantly different ($p<0.05$), we combined small tests into release groups of at least 40 marked coho and estimated trap efficiency using the mean, 27.50%.

Coho Production

From January 24 through July 13 we estimate 28,170 coho smolts passed the screw trap (Appendix G). Of these, we estimate 28,142 were wild (Figure 44) and 28 were ad-marked hatchery smolts that entered lower Bear Creek. The coefficient of variation for the wild coho estimate was 3.64% and the migration estimate had a confidence interval of 26,133 to 30,151 coho. The entire coho migration was sampled during the trapping period so no adjustments were made to reflect migration during pre- or post-trapping periods.

Table 24. Coho smolt recapture rates from trap efficiency tests in Bear Creek, 2000.

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
AM Tests				
04/17	26	11	42.31%	0.009763
04/18	38	3	7.89%	0.001965
04/23	69	14	20.29%	0.002378
04/24	100	10	10.00%	0.000909
04/25	80	19	23.75%	0.002292
05/02	74	18	24.32%	0.002522
05/03	60	17	28.33%	0.003442
05/06	100	42	42.00%	0.002461
05/07	100	31	31.00%	0.002161
05/13	75	15	20.00%	0.002162
	722	180		
	AM Tests	Average	24.99%	
		V(‘)	0.004342	
		n	10	
PM Tests				
04/16	18	5	27.78%	0.011801
04/22	84	32	38.10%	0.002841
04/28	100	15	15.00%	0.001288
04/30	100	39	39.00%	0.002403
05/09	100	25	25.00%	0.001894
05/11	100	27	27.00%	0.001991
05/14	94	29	30.85%	0.002294
05/17	81	19	23.46%	0.002244
05/18	57	17	29.82%	0.003737
05/19	56	26	46.43%	0.004522
05/22	40	10	25.00%	0.048080
	830	244		
	PM Tests	Average	29.77%	
		V(‘)	0.004301	
		n	11	

Table 24. Coho smolt recapture rates from trap efficiency tests in Bear Creek, 2000 (cont'd).

Date	Number Released	Number Recaptured	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Combined (40 or larger) Release Groups				
04/16 - 04/18 Combined	82	19	23.17%	0.002198
04/22	84	32	38.10%	0.002841
04/23	69	14	20.29%	0.002378
04/24	100	10	10.00%	0.000909
04/25	80	19	23.75%	0.002292
04/28	100	15	15.00%	0.001288
04/30	100	39	39.00%	0.002403
05/02	74	18	24.32%	0.002522
05/03	60	17	28.33%	0.003442
05/06	100	42	42.00%	0.002461
05/07	100	31	31.00%	0.002161
05/09	100	25	25.00%	0.001894
05/11	100	27	27.00%	0.001991
05/13	75	15	20.00%	0.002162
05/14	94	29	30.85%	0.002294
05/17	81	19	23.46%	0.002244
05/18	57	17	29.82%	0.003737
05/19	56	26	46.43%	0.004522
05/22	40	10	25.00%	0.048080
	1,552	424		
Combined (40 or larger) Release Groups		**Average**	**27.50%**	
		V(‛)	**0.002989**	
		n	**19**	

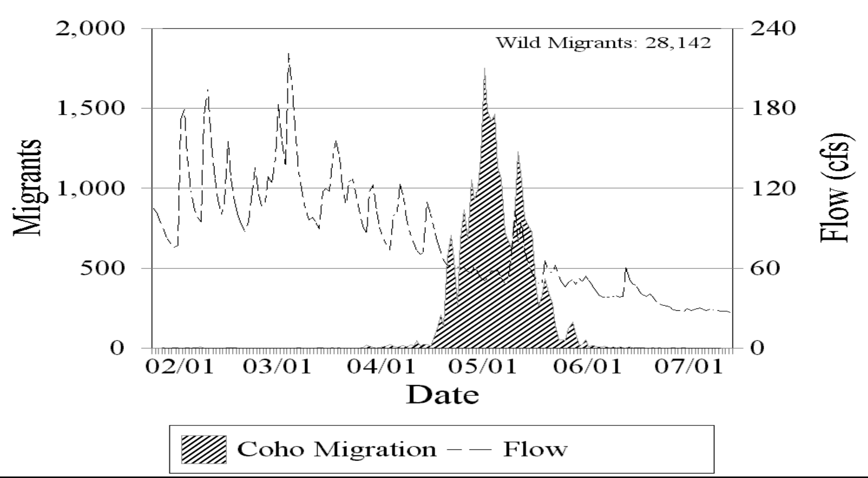


Figure 44. Estimated daily wild coho smolt migration and flow (King County Union Hill Gage), Bear Creek 2000.

Sockeye

Catch

On the first night of trapping, January 24 - 25, we caught 15 sockeye fry. Over the entire 172 day season, catches totaled 23,564 sockeye fry (Appendix G). From the last week in February through the first week in April, nightly sockeye catches generally exceeded 100 sockeye fry with several intermediate peaks within this period. Peak daily catch (nearly all were caught at night) occurred on March 24 with the capture of 1,585 sockeye fry. Daily catch declined to near zero by mid-April.

The three screw stoppage events that occurred during the trapping season did not appear to substantially affect the resulting catches of sockeye fry. Therefore, no adjustments were made to the catch to account for the decreased trapping time.

Trap Efficiency

Sockeye trap efficiency tests were conducted between February 21 through April 4 (Table 21). As previously discussed, we believe predation in the trap live box biased the results of some of the trap efficiency tests (see 2000 Bear Creek Chinook Trap Efficiency). By stratifying the trap efficiency tests based on the amount of time between the release of marked fish and their subsequent removal from the trap, we found a significant difference ($p<0.05$) between tests where marked fry were removed within 2.5 hours of release and those that were removed after 10.75 hours or more from release. We attribute this difference in mean trap efficiency to within-trap predation on sockeye fry.

Under the assumption that unmarked fry were subjected to similar levels of predation in the trap as were marked fry, we applied the resulting two mean efficiency estimates to derive a migration estimate based on the amount of time that the trap fished between trap checks. Four hours was chosen as the threshold period between trap checks that resulted in a change in efficiency. For example, when a trap check was performed after 4 or more hours of trapping time, the catch was divided by the Stratum 1 mean trap efficiency of 11.7% to estimate migration; whereas, when the trap fished for less than 4-hours, we assumed a lower level of predation occurred and the catch was divided by the Stratum 2 efficiency of 16.4%. This method differed from those previously discussed in that migration was estimated for individual fished periods rather than for days.

Sockeye Fry Production

Over the trapping interval we estimate 189,571 sockeye fry passed the trap (Figure 45, Appendix G). The CV and confidence interval for this estimate was 3.31% and 177,258 to 201,883 sockeye, respectively. Although the sockeye fry migration was underway when trapping began on January 24, daily migration was occurring at low levels (less than 150 fry/day). We elected not to extrapolate migration for the period prior to trapping because estimating migration for that short period of time would have had little effect on the overall estimate.

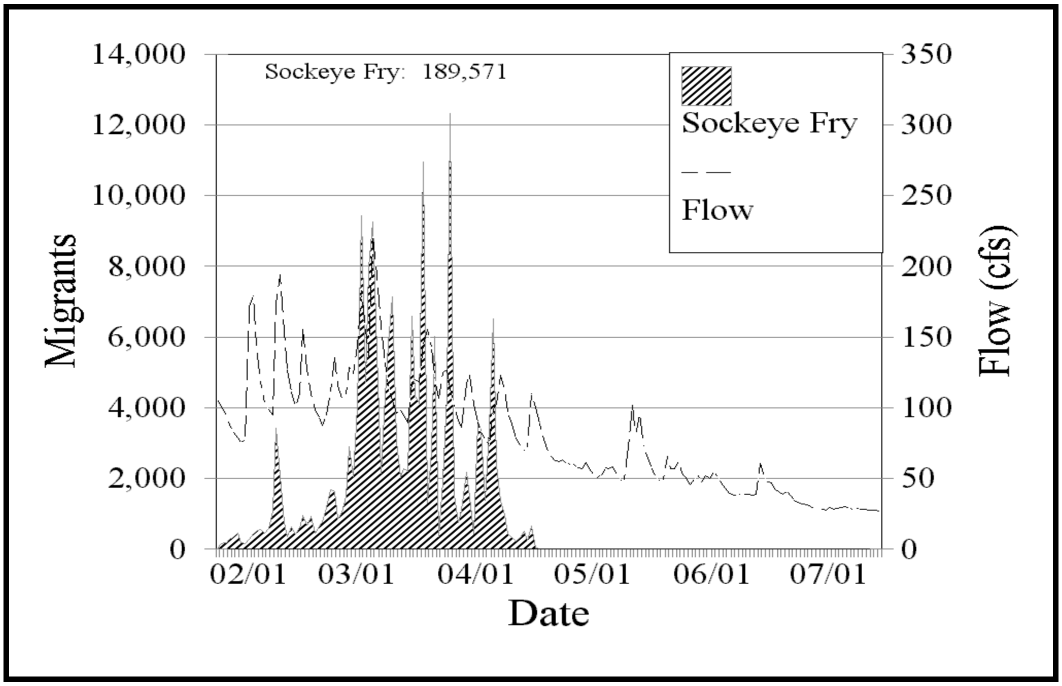


Figure 45. Estimated daily sockeye fry migration and flow (King County Union Hill Gage), Bear Creek 2000.

Steelhead and Cutthroat

Catch

Over the trapping season, we caught 353 steelhead smolts (Appendix H). Of these, 288 were marked representing 82% of the catch. Nearly all steelhead smolts were caught from early April through the third week in May (Figure 46).

A total of 1,023 age 1+ or older juvenile cutthroat were captured throughout the trapping period (Appendix H). The cutthroat migration was underway when trapping began. Generally, one to ten fish per day were caught through the third week in March (Figure 47). Daily catches climbed after this period and peaked at 24 on April 2, and again at 47 on May 1, before declining in June. Only three cutthroat were captured in the final month of trapping (June 14 - July 13).

Adult cutthroat were captured sporadically between January 24 and May 27. A total of 19 adults were captured during the trapping period. As with the other species, catch expansions were not made for the three screw stoppage events.

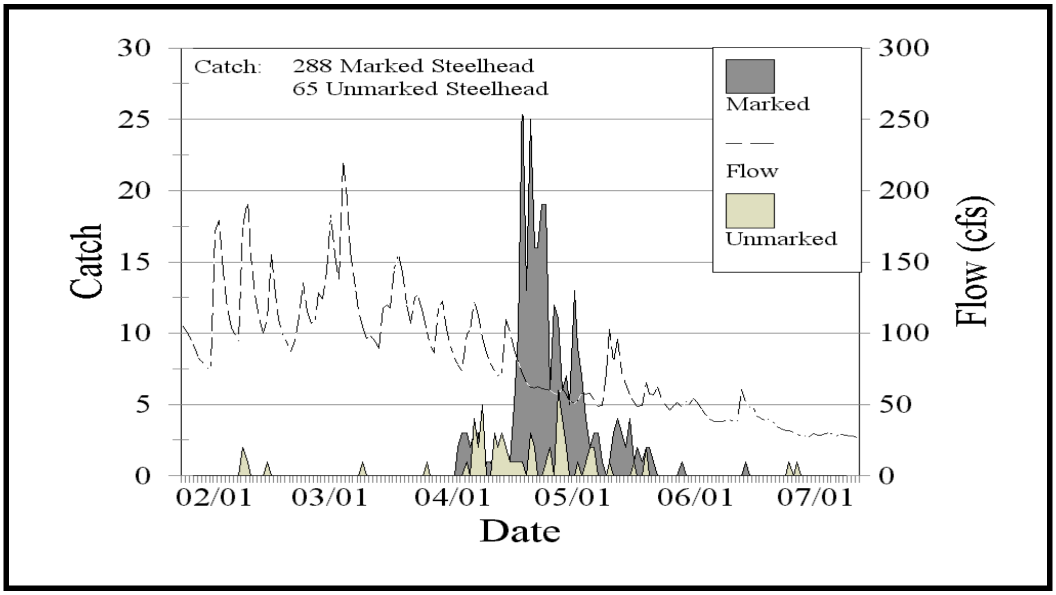


Figure 46. Daily catches of marked and unmarked steelhead smolts and flow (King County Union Hill Gage), Bear Creek 2000.

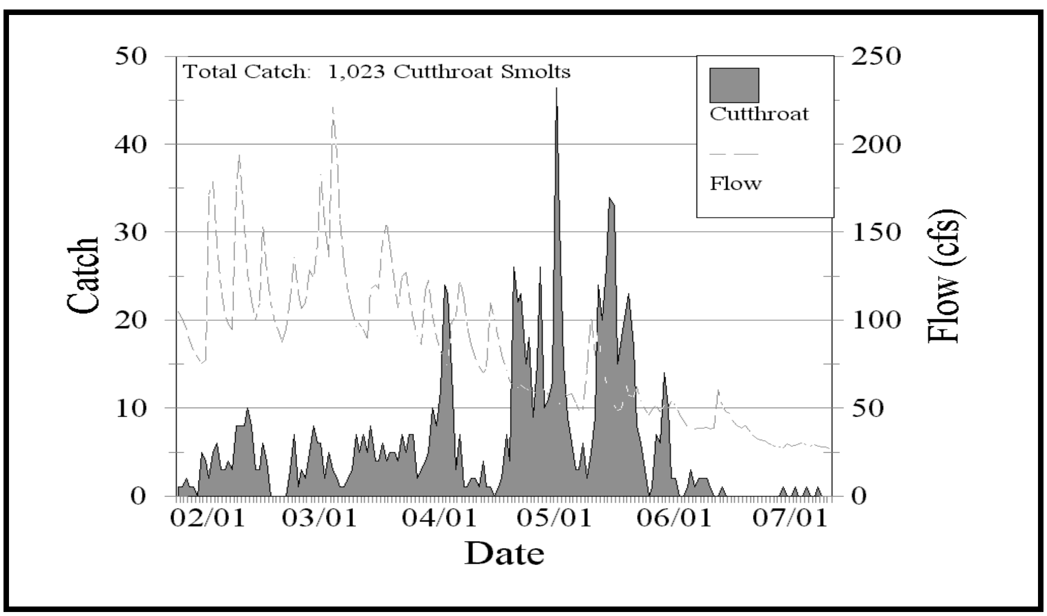


Figure 47. Daily cutthroat catch and flow (King County Union Hill Gage), Bear Creek 2000.

Size

Steelhead smolts averaged 188-mm fork length and showed no distinct trends over the trapping period (Figure 48). Sampling was low except for Statistical Weeks 15 - 17 (April 3 - 23). Over the trapping period, fork lengths from sampled steelhead ranged from 120-mm to 288-mm.

Cutthroat smolts averaged 157-mm fork length over the trapping season (Figure 49). Weekly mean fork length declined to the lowest level measured (130-mm) during the second week, and then slowly followed an increasing trend through the third week in April. By this week, average fork lengths were again over 165-mm. No cutthroat fork lengths were taken after April 19.

Trap Efficiency

As in the Cedar River, daily catches of steelhead and cutthroat were too low to enable their use in mark-recapture trap efficiency experiments. Applying the 60% average steelhead to coho capture rate, derived from the Toutle, Green, and White Salmon Rivers as described in the Cedar River results section of this report (pg 40), to the average coho trap efficiency in Bear Creek of 27.5% yielded an estimated steelhead and cutthroat trap efficiency of 16.5%. After adjusting for the use of a screw trap instead of the inclined-plane screen traps used in the Toutle, Green, and White Salmon Rivers, and rounding to consider the general lack of precision of this estimator, we selected a rate of 18%.

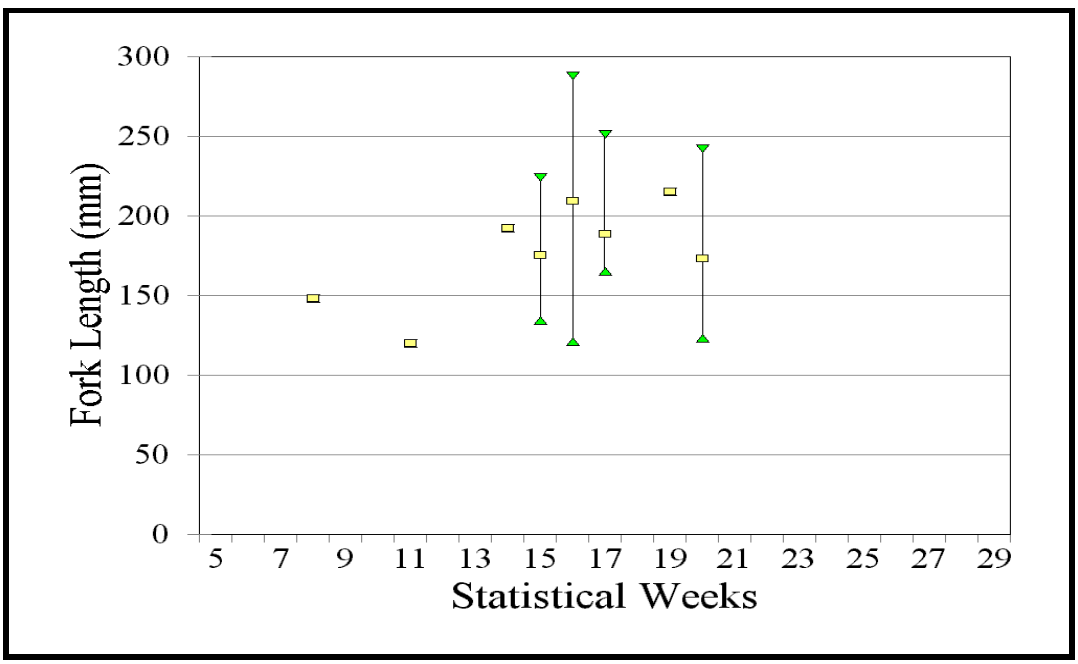


Figure 48. Weekly ranges and mean fork lengths of steelhead smolts captured in the Bear Creek screw trap, 2000.

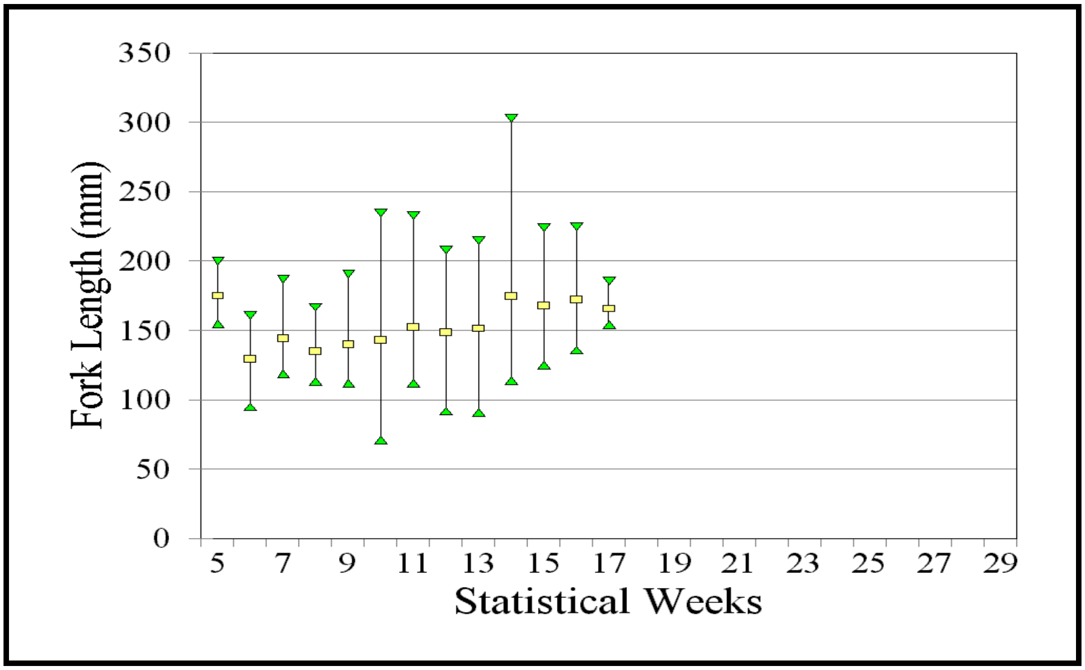


Figure 49. Weekly ranges and mean fork lengths of cutthroat smolts captured in the Bear Creek screw trap, 2000.

Steelhead and Cutthroat Production

Application of the 18% trap efficiency rate to the season total steelhead catch estimates the total basin production at 1,961 steelhead smolts (Appendix H). The marked component of the steelhead production is estimated at 1,600 steelhead or 82% of the total. Total migration of cutthroat during trapping operations is estimated at 5,683 cutthroat. Cutthroat were actively migrating when trapping began, but we have no timing information with which to expand this estimate. Therefore, our estimate of cutthroat production applies only to the trapping interval and is an underestimate of the total downstream migrant population.

Stomach Content Analysis

Stomach contents were examined from 275 cutthroat, 117 sculpin, 21 coho smolts, and 20 steelhead smolts between February 9 and May 25, 2000 (Table 25). During this period, sockeye fry were the dominant prey item for all species. However, not all fish sampled were found to have recently eaten. Stomachs were empty for 71% of coho sampled and 55% of steelhead sampled. The highest predation rates on sockeye were exhibited by sculpin and cutthroat. Sockeye fry were found in 66% of the sculpin stomachs sampled and 61% of the cutthroat stomachs sampled. The incidence of sockeye fry in steelhead and coho stomachs was less, 40% and 24%, respectively. However, when sockeye were eaten, they tended to be preyed upon in large numbers by steelhead as well as cutthroat. Cutthroat and steelhead averaged 18 and 20 sockeye fry per sample when sockeye fry were found in the sample compared to 7 and 4 sockeye fry found in sculpin and coho, respectively.

Chinook fry were preyed upon to a much lessor extent by all species. Sixteen percent of cutthroat and 13% of sculpin contained juvenile chinook (Table 25). The incidence of chinook in coho and steelhead stomachs was 5% for each. When chinook were present in the stomach sample, the number of chinook per sample averaged from one to two for all species.

Table 25. Stomach content analysis from samples taken from fish caught in the Bear Creek screw trap, 2000.

		Number of Samples with Prey Items Present					
Predator	***Number Sampled***	***Empty***	***Sockeye***	***Chinook***	***Coho***	***Unidentified***	***Invertebrates***
Cutthroat	275	63	169	45	0	1	51
Coho	21	15	5	1	0	0	0
Steelhead	20	11	8	1	0	0	0
Sculpin	117	13	77	15	3	0	9
		Number of Prey Items Found in Samples					
Predator	***Number Sampled***		***Sockeye***	***Chinook***	***Coho***	***Unidentified***	***Invertebrates***
Cutthroat	275		3,081	64	0	5	Not Counted
Coho	21		18	1	0	0	Not Counted
Steelhead	20		158	2	0	0	Not Counted
Sculpin	117		534	27	4	0	Not Counted
		Percentage of Samples with the Prey Item					
Predator	***Number Sampled***	***Empty***	***Sockeye***	***Chinook***	***Coho***	***Unidentified***	***Invertebrates***
Cutthroat	275	22.91%	61.45%	16.36%	0.00%	0.36%	18.55%
Coho	21	71.43%	23.81%	4.76%	0.00%	0.00%	0.00%
Steelhead	20	55.00%	40.00%	5.00%	0.00%	0.00%	0.00%
Sculpin	117	11.11%	65.81%	12.82%	2.56%	0.00%	7.69%
		Avg # Prey/Sample when Present					
Predator	***Number Sampled***		***Sockeye***	***Chinook***	***Coho***		
Cutthroat	275		18.2	1.4	0.0		
Coho	21		3.6	1.0	0.0		
Steelhead	20		19.8	2.0	0.0		
Sculpin	117		6.9	1.8	1.3		

Weekly average consumption rates were calculated to estimate the number of sockeye and chinook fry consumed by cutthroat, steelhead, and coho that were captured in the trap between January 24 and April 15, the period of sockeye and chinook fry migrations. Stomach contents were not sampled consistently throughout this period, therefore consumption rates were estimated using the ratio of prey abundance in unsampled weeks to abundance in sampled weeks to scale the measured consumption rates. For example, cutthroat were not sampled for stomach content analysis prior to week 7 (February 7 to 13), therefore, weekly sockeye consumption rates prior to this week were estimated by multiplying the Week 7 consumption rate by the ratios of the previous weeks sockeye catches to the Week 7 sockeye catch. This approach was similarly applied to estimate the chinook consumption rates prior to Week 7. Using this approach, we estimate a total of 3,519 sockeye and 92 chinook fry were consumed by captured cutthroat, steelhead, and coho (Table 26). We did not estimate consumption by sculpins as part of this analysis since we were not able to address sculpins size-related predation (no sculpin length data was taken). We were concerned that an analysis performed without incorporating sculpin size could exert substantial bias to the resulting consumption estimates. The estimated consumption of sockeye and chinook fry represents 14.9% and 0.8%, respectively, of the total catch of these species over the season. The proportion of this predation that occurred within the trap live well is uncertain, but likely represents a substantial proportion of the estimated predation.

Table 26. Estimated sockeye and chinook fry consumed by cutthroat, steelhead, and coho smolts in the Bear Creek screw trap between January 24 and April 15, 2000.

Week	Predators Sampled	Sockeye Consumed in Sample	Chinook Consumed in Sample	Sockeye Consumption Rate (Sock/Predator)	Chinook [1]Consumption Rate (Chin/Predator)	Predators Caught	Estimated Sockeye Consumed	Estimated Chinook Consumed
Cutthroat Predation								
5				0.21	0.09	11	2.30	1.02
6				0.36	0.03	27	9.74	0.73
7	15	16	2	1.07	0.13	48	51.20	6.40
8	10	25	5	2.50	0.50	13	32.50	6.50
9	10	26	5	2.60	0.50	21	54.60	10.50
10	27	377	21	13.96	0.78	32	446.81	24.89
11	28	441	6	15.75	0.21	26	409.50	5.57
12	38	474	15	12.47	0.39	36	449.05	14.21
13	17	241	2	14.18	0.12	37	524.53	4.35
14	85	1,137	5	13.38	0.06	66	882.85	3.88
15	34	132	3	3.88	0.09	51	198.00	4.50
16	7	12	0	1.71	0.00	10	17.14	0.00
						Total	3,078	83

Table 26. Estimated sockeye and chinook fry consumed by cutthroat, steelhead, and coho smolts in the Bear Creek screw trap between January 24 and April 15, 2000 (Cont'd).								
Week	**Predators Sampled**	**Sockeye Consumed in Sample**	**Chinook Consumed in Sample**	**Sockeye Consumption Rate (Sock/Predator)**	**Chinook [1]Consumption Rate (Chin/Predator)**	**Predators Caught**	**Estimated Sockeye Consumed**	**Estimated Chinook Consumed**
Steelhead Predation								
5				0.31	0.37	0	0	0
6				0.54	0.11	0	0	0
7				1.59	0.54	3	4.76	1.62
8				0.91	0.53	1	0.91	0.53
9				1.94	0.79	0	0	0
10				8.05	5.69	0	0	0
11				4.96	1.51	1	4.96	1.51
12				5.97	5.72	0	0	0
13				5.19	0.74	1	5.19	0.74
14				2.90	1.37	2	5.80	2.73
15	11	40	0	3.64	0	27	98	0
16	3	37	0	12.33	0	21	259	0
						Total	379	7
Coho Predation								
5				0.29	0.03	2	0.57	0.06
6				0.49	0.01	4	1.98	0.04
7				1.46	0.05	2	2.92	0.09
8				0.84	0.05	3	2.52	0.14
9				1.79	0.07	0	0	0
10				7.42	0.50	0	0	0
11				4.57	0.13	1	4.57	0.13
12	2	11	1	5.50	0.50	4	22.00	2.00
13				3.22	0.05	1	3.22	0.05
14	2	0	0	0	0	15	0	0
15	8	6	0	0.75	0	24	18.00	0
16	9	1	0	0.11	0	58	6.44	0
						Total	62	2
						Grand Total	3,519	92

Note: Consumption rates in weeks not sampled were estimated by scaling consumption rates in sampled weeks by the ratio of prey captured in the unsampled weeks over prey captured in the sampled weeks.

[1] Chinook consumption rates by steelhead in weeks where no sampling occurred were developed by scaling the week 19 measured consumption rate of 2 chinook/steelhead by the ratio of chinook catch in the unsampled weeks to the chinook catch in week 19.

Issaquah Creek

Introduction and Background

Issaquah Creek is the largest tributary to Lake Sammamish. It originates on Tiger Mountain and drains an approximately 53-square mile area. Contrary to the chinook production from the Cedar River and Bear Creek, nearly all of the naturally-produced chinook originating from Issaquah Creek are thought to be from progeny of hatchery adults. Issaquah Hatchery has been releasing chinook salmon since 1937 (Mike Griffin pers. comm.) and currently releases nearly two million age 0+ chinook each year. Consequently, this stream usually receives more chinook spawners than either the Cedar River or Bear Creek. Depending on return rates, anywhere between a few hundred and several thousand chinook may spawn in Issaquah Creek. Chinook are released above the hatchery rack (RM 4.0), but also spawn in East Fork Issaquah Creek and downstream of the hatchery, particularly when flows are low. In total, chinook may utilize up to 15 stream miles for spawning in Issaquah Creek.

In addition to chinook, coho salmon and steelhead smolts are released from the Issaquah Hatchery. As with Bear Creek, 1998 brood hatchery-produced steelhead fry were released into Issaquah Creek and its tributaries. These fry, produced from wild steelhead broodstock collected at the Ballard Locks in 1998, were ad-marked before stocking into upper Issaquah Creek and its tributaries in November of 1998.

We installed and operated a screw trap on the lower mainstem Issaquah Creek during the spring, 2000 to measure the production of naturally produced chinook originating in the system (Figure 1). The Issaquah Creek assessment was only conducted one year due to the difficulties associated with operating an efficient downstream migrant trap below a major hatchery. Precluding the capture of too many fish during hatchery release periods required close coordination with the hatchery personnel. The trap was raised during those intervals to avoid capturing the hatchery production. Evaluating production from Issaquah Creek enabled a nearly complete assessment of the level of juvenile chinook production occurring in the Lake Washington basin in 2000.

Goals and Objectives

Our primary goal in trapping downstream migrating juvenile salmonids in Issaquah Creek was to assess the level of production and biological attributes of naturally-produced chinook originating from primarily hatchery-origin parents. Accomplishing this goal would estimate the relative contribution of juvenile chinook from Issaquah Creek relative to total chinook production in the Lake Washington basin. Ancillary objectives included assessing the natural production of coho salmon, steelhead, and cutthroat trout.

Issaquah Creek 2000

Trapping Gear and Operation

As in the Cedar River and Bear Creek, a screw trap was used to capture downstream migrant salmonids in Issaquah Creek. However, whereas 30-ft steel pontoon barges were used to support the screw traps in Cedar River and Bear Creek, the barge used to support the Issaquah trap was smaller. Overall, this trap measured just 16-ft long and nine feet wide, but supported the same five foot diameter by 12-ft long screw trap/live box assembly as in the other two streams. As a result, floatation and deck space were minimal but sufficient given the magnitude of flows in Issaquah Creek.

Placing the trap downstream of the hatchery was required by the distribution of spawners which includes the lower reaches of Issaquah Creek. We found the lowest site with adequate velocities about 200-ft downstream of the SE 56Th St bridge (RM 1.0). Velocities at the mouth of the trap were sufficient to produce rotational trap speeds in the range of 4-7 rpms which we consider sufficient velocity for this trap.

On March 14, 2000, we installed the trap and commenced operation. We operated this trap continuously except for intervals when hatchery fish were migrating in large numbers. Operating a trap that captures 10-20% of all migrants during a large release of hatchery fish presents an untenable problem. Several days following releases we resumed trapping for limited time intervals to insure that most hatchery fish were past before resuming continuous operation. As with the other traps we enumerated catches near dusk and dawn on most days to assess diel timing.

Production Estimation

Three steps were used to estimate migration from Issaquah Creek. The first step involved estimating the number of unmarked hatchery fish that were present in the catch. The second step involved interpolating catch for periods when the trap did not fish, and the third step involved estimating the capture rate for each species.

To estimate the capture rate, small groups of age 0+ chinook, age 1+ coho, and age 1+ cutthroat migrants were released upstream of the trap. As at the other traps, we marked fish caught the previous night with partial fin-marks. Upper and lower caudal clips and left and right ventral clips were used to mark the fish. These fish were transported in 5-gallon buckets and released approximately 200-feet upstream of the trap in the middle of the stream. Tests were conducted during morning and evening periods to ascertain whether trap efficiency responded differently between day and nighttime fished periods.

Estimating the number of unmarked hatchery fish in the catch was performed using the proportion on unmarked hatchery fish reported by the Issaquah Hatchery in their releases. For chinook, the proportion of unmarked fish represented 5% of the total release. For coho smolts, unmarked fish represented 2.47% of the release. When marked hatchery fish were found in the catch, the total catch of hatchery fish was estimated by dividing the marked component by the proportion of marked fish in the release. The wild catch was found by the difference between the total catch and the estimated catch of hatchery fish. Where the estimated number of hatchery fish caught exceeded the total catch, it was assumed that the entire catch was hatchery fish. Since the precision of the proportions of unmarked hatchery fish in the releases were not known, we could not estimate variances for the estimates of hatchery and wild catch. These estimates were treated as the actual catches of hatchery and wild fish.

Catch estimation was required during two types of non-fished events. As previously discussed, non-fished periods of several days occurred when hatchery fish were present in the stream. During these non-fished events, catch for each 24-hour day not fished, $\hat{C}_{dm}$, was estimated by the mean daily (24-hour) catch for complete days fished during the calendar month in which the non-fished event occurred, or by the mean of an equal number of complete days fished before and after the non-fished event. The variance, $V(\overline{C}_{dm})$, was estimated by the variance of the mean. Catch was estimated for partial days not fished at the beginning and end of this period by;

$$\hat{C}_{id} = \frac{\overline{C}_{dm} \times T_{id}}{24} \qquad \textbf{(29)}$$

and the variance by;

$$V(\hat{C}_{id}) = V(\overline{C}_{dm}) \times \left(\frac{T_{id}}{24}\right)^2 \qquad \textbf{(30)}$$

where:

$\hat{C}_{id}$ = *Estimated catch during unfished period i in day d, and*

T_{id} = *The duration of unfished period i in day d.*

Non-fished events also occurred when debris or substrate stopped the trap screw or when vandalism resulted in suspect catch numbers. During these periods, catch for day or night periods was estimated by;

$$\hat{C}_{ij} = \overline{R}_{fj} \times T_{ij} \tag{31}$$

and the variance by;

$$V(\hat{C}_{ij}) = V(\overline{R}_{fj}) \times T_{ij}^{\ 2} \tag{32}$$

where:

$\hat{C}_{ij}$ = *Estimated catch during unfished period i in diel stratum j,*

$\overline{R}_{fj}$ = *The mean catch rate over specified fished periods f in diel stratum j,*

T_{ij} = *The duration of unfished period i in diel stratum j, and*

$V(\overline{R}_{fj})$ = *The variance of the mean capture rate over specified fished periods f in diel stratum j.*

Migration was estimated using Equation 6, except $\hat{C}_{ij}$ or $\hat{C}_{id}$ was inserted in the place of C_i during periods when catch was estimated and the entire daily (24-hour) catch was inserted in place of C_i when the trap was fished for the entire day. Variances for partial-day migration was estimated using Equation 7 where actual catch data was available. Equation 7 was also used to estimate the variance for entire-day migration estimates where actual catch data existed, except that total daily (24-hour) catch was substituted for the nighttime catch, C_i, in the equation. Where catch was estimated, the variance of the migration estimate was found using Equation 27 or 28.

Methods used to analyze the trap efficiency data were similar to those used for the Cedar River and Bear Creek data sets. Linear regression analysis was used to test the effect of mean daily flow on capture rate. Where the regression was found to be significant ("=0.05), mean daily flow was used to estimate daily trap efficiency using Equation 1. Where regression derived relationships were not found to be significant, trap efficiency tests were stratified by release period (morning versus evening) to determine if capture rate differences existed using a 95% significance level. Where significant differences existed, the mean rate from morning tests was used to estimate migration during daytime trapping periods and the mean rate from evening tests was used to estimate migration during nighttime trapping periods. Where trapping periods spanned both day and night intervals, the mean trap efficiency from all trap efficiency tests was used. Where the comparison between morning and evening trap efficiency tests failed to show a significant difference, migration was estimated using the mean trap efficiency from all tests. In all cases, small test groups from final strata were combined with adjacent tests to ensure all release groups contained at least 40 marked migrants. This treatment provided better weighting among the individual efficiency tests and increased our confidence in using the results of small tests.

Mean trap efficiencies for morning, evening, or all tests were calculated using Equation 3. The variance of the mean trap efficiency was calculated using Equation 5.

Daily or fished period-based estimates of migration and their variances were summed across the season to estimate total migration. No estimates were made of the migration that may have occurred before or after the period of trap operation.

2000 Results

Trapping on Issaquah Creek began March 14 and continued until July 3. Due to the trap's close proximity to the Issaquah Hatchery, continuous operation of the trap through this period would have resulted in the capture of large numbers of hatchery salmonids. To avoid this, trapping operation was suspended during periods when large numbers of hatchery migrants were passing the gear. Continuous non-fished periods lasted as long as 14 days (Appendix I) and likely resulted in a failure to sample substantial portions of the wild salmonid migration. Nevertheless, results include estimates of migration throughout the trapping period using assumptions about the temporal distribution of migrants during periods that were not sampled.

Chinook

Catch

On the first night of trapping, March 14, we caught 17 juvenile chinook. Over the entire 112 day season, we captured 3,702 unmarked age 0+ chinook migrants (Appendix I). On most nights, the trap was checked and fish were counted in the evening and again in the morning. As with data from the Cedar River and Bear Creek, catches over this time interval were apportioned to before and after midnight by assuming a constant catch rate to enable estimation of daily catch and migration.

Over the season, we estimate 286 unmarked hatchery chinook migrants were captured. Subtracting this number from the total unmarked catch of 3,702 results in an estimated naturally-produced chinook catch of 3,416 (Appendix I).

Marked chinook migrants began to be caught on April 18, three weeks prior to the first chinook release on May 10 (Appendix I). We captured a total of 5,357 marked chinook prior to the May 10 release suggesting a large number of hatchery chinook escaped prior to the intended first release date.

Catches averaged over 60 wild chinook per day for the first week trapped, then declined to less than 11 chinook per day from the last week in March through early April (Appendix I). Catches slowly increased beginning in mid-April to its seasonal high on June 10 when an estimated 329 wild chinook were captured. By late June, chinook catches had declined to less than ten per day.

A total of 6,001 marked chinook hatchery migrants were captured over the season (Appendix I). This catch was expanded by 286 estimated unmarked hatchery fish to a total estimated hatchery chinook catch of 6,287. Although trap outages were timed to avoid capture of excessive numbers of hatchery salmonids, catches of as many as 603 marked, or 635 total, hatchery chinook occurred in a single day.

Size

Wild age 0+ chinook averaged 50-mm during the last week in March and the first week in April. They grew rapidly afterwards, averaging greater than 80-mm by mid-June (Table 27, Figure 50). Migrants measuring 41-mm or smaller were found through the third week in April, after which, the minimum size increased steadily to over 70-mm at the end of the trapping period.

Table 27. Weekly fork length statistics for unmarked age 0+ chinook migrants captured in the Issaquah Creek screw trap, 2000.

		Number	Fork Length (mm)					
Stat Week	Dates	Sampled	Average	Std Dev	Max	Min	Catch	% Sampled
12	3/13 - 3/19						398	0.00%
13	3/20 - 3/26	1	40.0		40	40	364	0.27%
14	3/27 - 4/2	43	51.4	10.8525	71	38	67	64.18%
15	4/3 - 4/9	3	50.0	2.6458	53	48	2	[a]150.00%
16	4/10 - 4/16						1	0.00%
17	4/17 - 4/23	54	60.3	9.5811	80	41	228	23.68%
18	4/24 - 4/30	20	51.9	3.6978	58	46	265	7.55%
19	5/1 - 5/7	33	61.1	7.5885	85	48	404	8.17%
20	5/8 - 5/14	11	64.5	8.3829	84	54	144	7.64%
21	5/15 - 5/21						0	
22	5/22 - 5/28	55	75.8	8.0854	95	63	161	34.16%
23	5/29 - 6/4	49	75.4	6.9612	99	56	445	11.01%
24	6/5 - 6/11	58	78.3	4.8595	88	67	800	7.25%
25	6/12 - 6/18	10	84.4	4.5753	91	77	187	5.35%
26	6/19 - 6/25	27	83.0	4.6284	92	75	207	13.04%
27	6/26 - 7/2	7	80.0	6.9041	91	71	27	25.93%
	Totals	371					3,700	10.03%

[a] This rate resulted from the apportionment of nightly catch to before and after midnight periods whereas the number sampled for length was not apportioned.

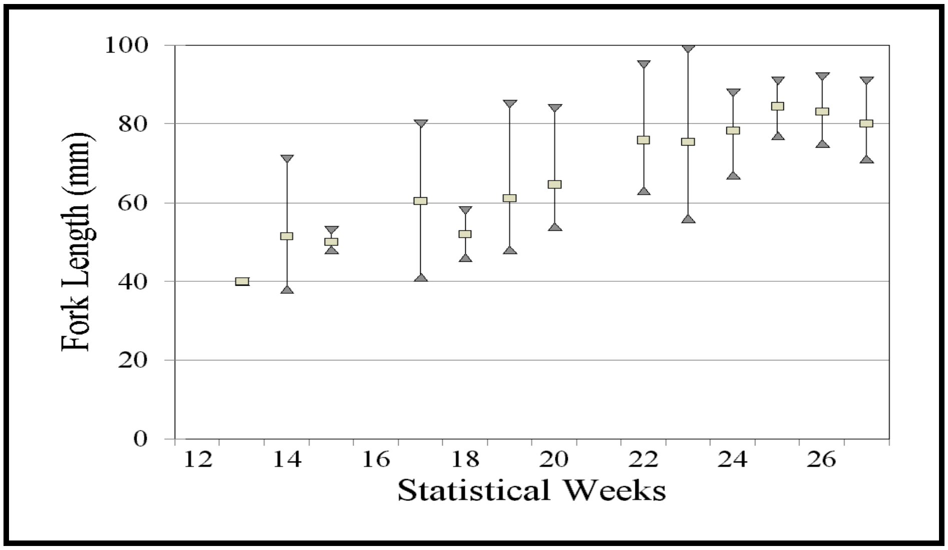


Figure 50. Weekly ranges and mean fork lengths of unmarked age 0+ chinook captured in the Issaquah Creek screw trap, 2000.

Catch Expansion

Trapping was suspended during four time intervals over the trapping season (Appendix I). During these periods, expected daily wild chinook catch was estimated by the average daily wild chinook catch over the month when the outage occurred. In addition to these four periods, catch was also expanded on the first day of trapping, March 14, to estimate the catch of wild chinook migrants that would have occurred if the trap had fished the entire day.

In addition to periods when the trap was intentionally not operated, unintentional trap failure and vandalism also occurred on several occasions. Over the season, six events occurred when the trap screw was jammed with woody debris that prevented its operation. During two fished periods, evidence of tampering was noted. Finally, during lower flow conditions on June 9, the screw was found to be intermittently spinning as a result of grounding on the stream bed.

During each of these periods, catches for the affected period were compared to those from adjacent periods. Catches were substantially different only during two of the screw stoppage events when woody debris jammed the screw. These occurred during the nights of April 18 and April 24. Catch was estimated for these periods using average hourly nighttime catch rates for statistical weeks 17 and 18, respectively.

Using these techniques, we estimate an additional 1,541 naturally-produced age 0+ chinook would have been captured if continuous trapping had occurred between March 14 and July 3. Adding these to our estimated actual catch of 3,416 naturally-produced age 0+ chinook results in an estimated catch of 4,957 naturally-produced age 0+ chinook migrants (Appendix I). This expansion represents 31% of the total estimated catch.

Trap Efficiency

A total of 660 unmarked age 0+ chinook migrants were marked and released upstream of the trap in 11 groups (Table 28). Numbers of fish released in each group ranged from 13 to 118 chinook. Recapture rates averaged 16% and ranged from 4% to 49%. However, values at the low end of the range were from small (<40) release groups.

Over the interval that we conducted these trap efficiency tests, flows declined from 128-cfs to 70-cfs. The small range of flows experienced during these tests explained very little of the variation between tests and was not significant ($p>0.05$).

The tests were stratified by morning and evening test periods to determine if differences in capture rates existed between these two time periods (Table 28). Since the data from the two strata were not normally distributed, the non-parametric Wilcoxon two-sample test for homogeneity was used to determine if the distribution of test results were different between the two time periods. Test results determined that the trap efficiency during the evening periods was significantly higher than those found for day periods ($p<0.05$). Therefore, mean trap efficiency was calculated for each strata and used to estimate migration. As with the Cedar River and Bear Creek efficiency data, efficiency tests employing small numbers of released fish were combined with adjacent tests to create groups of at least 40 marked fish. Some trapping periods included both day and night fishing (i.e., day trapping that extended to after dusk and night trapping that extended to after dawn). When this occurred, the capture rate was estimated by the mean of both the day and night trap efficiency tests combined (all tests).

Chinook Production

From March 14 through July 3 we estimate 30,025 age 0+ naturally-produced chinook migrants passed the screw trap (Table 29, Figure 51). The 95% confidence interval about this estimate ranged from 26,371 to 33,678 chinook. The variance of the estimate of the unmarked component of the hatchery chinook migrants released (5.0%) is not known and therefore, not reflected in this confidence interval nor the variances of the migration estimates. In addition, no attempts were made to estimate either hatchery chinook migration past the trap or wild chinook migration prior to or after the period of trap operation.

Table 28. Trap efficiency test and stratification results for age 0+ chinook migrants, Issaquah Creek screw trap 2000.

Date	Number Released	Number Recovered	Recapture Rate (ʻ)	V(ʻ)
Actual Morning Tests				
06/17	16	2	12.50%	0.007292
06/19	25	1	4.00%	0.001600
06/20	118	9	7.63%	0.000602
06/22	23	1	4.35%	0.001890
06/23	13	1	7.69%	0.005917
Actual Evening Tests				
05/06	100	21	21.00%	0.001676
05/07	100	11	11.00%	0.000989
05/09	100	14	14.00%	0.001216
06/09	50	16	32.00%	0.004441
06/10	100	49	49.00%	0.002524
06/25	15	2	13.33%	0.008254
Combined (40 or more) Morning Tests				
06/17 - 06/19 Combined	41	3	7.32%	0.001695
06/20 - 06/23 Combined	154	11	7.14%	0.000434
Combined (40 or more) Evening Tests				
05/06	100	21	21.00%	0.001676
05/07	100	11	11.00%	0.000989
05/09	100	14	14.00%	0.001216
06/09	50	16	32.00%	0.004441
06/10 - 06/25 Combined	115	51	44.35%	0.002165
Combined (40 or more) All Tests				
05/06	100	21	21.00%	0.001676
05/07	100	11	11.00%	0.000989
05/09	100	14	14.00%	0.001216
06/09	50	16	32.00%	0.004441
06/10	100	49	49.00%	0.002524
06/17 - 06/19 Combined	41	3	7.32%	0.001695
06/20	118	9	7.63%	0.000602
06/22 - 06/25 Combined	51	4	7.84%	0.001446

Table 28. Trap efficiency test and stratification results for age 0+ chinook migrants, Issaquah Creek screw trap 2000 (cont'd).			
Stratum/Statistic	**Number Released**	**Number Recovered**	**Value**
Combined AM Tests	195	14	
Average			**7.23%**
V(')			**0.001065**
n			**2**
Combined PM Tests	465	113	
Average			**24.47%**
V(')			**0.005872**
n			**5**
Combined All Tests	660	127	
Average			**18.72%**
V(')			**0.004595**
n			**8**

Table 29. Estimated migration of naturally-produced age 0+ chinook from March 14 to July 3, 2000 from Issaquah Creek.

Period	**Expanded Catch**	**Estimated Migration**	**CV**	**95% CI**	
				Low	**High**
Trapped Period	3,416	22,114	6.64%	19,235	24,993
Un-Trapped Period	1,541	7,911	14.51%	5,661	10,160
Total	4,957	30,025	6.21%	26,371	33,678

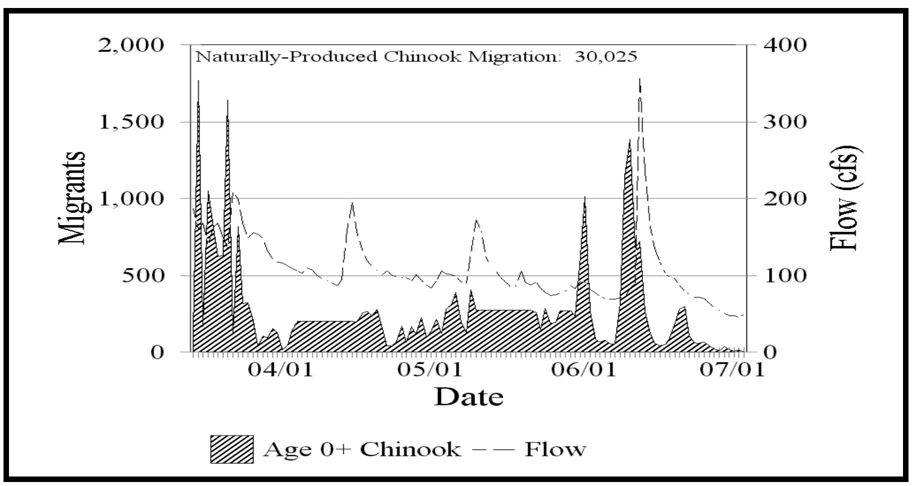


Figure 51. Estimated daily naturally-produced age 0+ chinook migration and flow (USGS Issaquah Creek Gage #12121600), Issaquah Creek 2000.

Coho

Catch

Coho catches contained both ad-marked and unmarked components. Hatchery age 1+ coho salmon were marked with an adipose fin clip; however, the actual mark rate estimated by the hatchery was 97.53%. Therefore, when catches included ad-marked coho, we adjusted catches of unmarked coho migrants to reflect the presence of unmarked hatchery coho using the same methods employed for the wild chinook migrant estimates.

Prior to April 24, we estimated that wild yearling coho catches averaged less than two per day (Appendix I). Thereafter, daily catches quickly rose to a season high of 244 wild smolts on May 4. Catches of wild coho declined to average less than 10 per day by May 24, and less than two per day by June 13. Our total catch of unmarked coho over the entire season was 2,301 smolts. However, after subtracting an estimated 100 unmarked hatchery coho from this total, the estimated catch of wild coho smolts was 2,201.

Marked yearling coho salmon were captured throughout the trapping period from the first night through the last. The first hatchery coho release occurred on April 3. Prior to this date we captured 4,885 marked yearling coho salmon, therefore, as with chinook, a substantial number of coho salmon escaped prior to the intended release date.

Size

Over the trapping season, weekly average fork length ranged from 85-mm to 117-mm (Table 30, Figure 52). Size of individual smolts sampled ranged from 72-mm to 144-mm and averaged 106-mm over the trapping season.

Catch Expansion

Out of the four periods when trapping was suspended, wild coho catches were estimated for three of those periods using the average daily (24-hour) catches for periods adjacent to the outages. During the first outage from April 3 through April 16, catch was estimated using the daily average catch from all days that the trap fished prior to April 24. Wild smolt catches averaged two smolts per day during this period (Appendix I). Similarly, the catches for the third outage, May 26 to May 30, and for the fourth outage, June 12 to June 14, were estimated using the average daily wild coho catch for the three days prior to and following each period. A different method was used to estimate wild coho catches during the second outage, May 11 to May 22. Daily catches of wild coho were decreasing from the peak daily catch which occurred on May 4. To capture this rate of decline, we interpolated the daily wild coho catch using a negative exponential curve.

Wild coho catches were also estimated for the two screw stoppage events that also affected the capture of chinook migrants (Appendix I). The same method used to estimate the chinook catch was also used to estimate coho catch during these events.

We estimate 2,935 wild coho would have been captured if the screw trap had been operated continuously over the entire trapping period,(Appendix I). The catch expansions added 734 wild coho to the estimated actual catch of 2,201, representing 25% of the total projected catch.

Trap Efficiency

Nineteen groups of marked coho were released upstream of the trap between March 17 and June 17 (Table 31). Efficiency ranged from 7% to 33%. However, the 33% efficiency was observed from a very small release group (three marked fish). When comparing results from the other eighteen groups, that ranged in size from 38 to 140 marked smolts, efficiencies ranged from 7% to 24%. Linear regression analysis resulted in flow explaining only 11% of this variation, which was not significant ($p>0.05$). A scatter plot of the data failed to suggest any treatments or alternative regression curves that would improve this result.

Table 30. Weekly fork length statistics for unmarked coho smolts captured in the Issaquah Creek screw trap, 2000.

Stat Week	Dates	Number Sampled	Fork Length (mm) Average	Std Dev	Max	Min	Catch	% Sampled
12	3/13 - 3/19	0					27	0.00%
13	3/20 - 3/26	0					18	0.00%
14	3/27 - 4/2	13	100.9	8.1799	121	88	18	72.22%
15	4/3 - 4/9	3	96.7	2.3094	98	94	2	[a]150.00%
16	4/10 - 4/16	0					3	0.00%
17	4/17 - 4/23	33	106.5	11.7024	134	91	49	67.35%
18	4/24 - 4/30	23	104.1	10.0964	126	89	725	3.17%
19	5/1 - 5/7	39	116.6	13.5542	144	91	1,069	3.65%
20	5/8 - 5/14	8	108.6	10.3225	123	96	235	3.40%
21	5/15 - 5/21							
22	5/22 - 5/28	0					137	0.00%
23	5/29 - 6/4	0					28	0.00%
24	6/5 - 6/11	15	84.5	8.7983	107	72	62	24.19%
25	6/12 - 6/18	3	102.3	26.7270	133	84	19	15.79%
26	6/19 - 6/25	0					6	0.00%
27	6/26 - 7/02	0					2	0.00%
28	7/03 - 7/09	0					1	0.00%
	Totals	137	105.8				2,301	5.96%

[a] This rate resulted from the apportionment of nightly catch to before and after midnight periods whereas the number sampled for length was not apportioned.

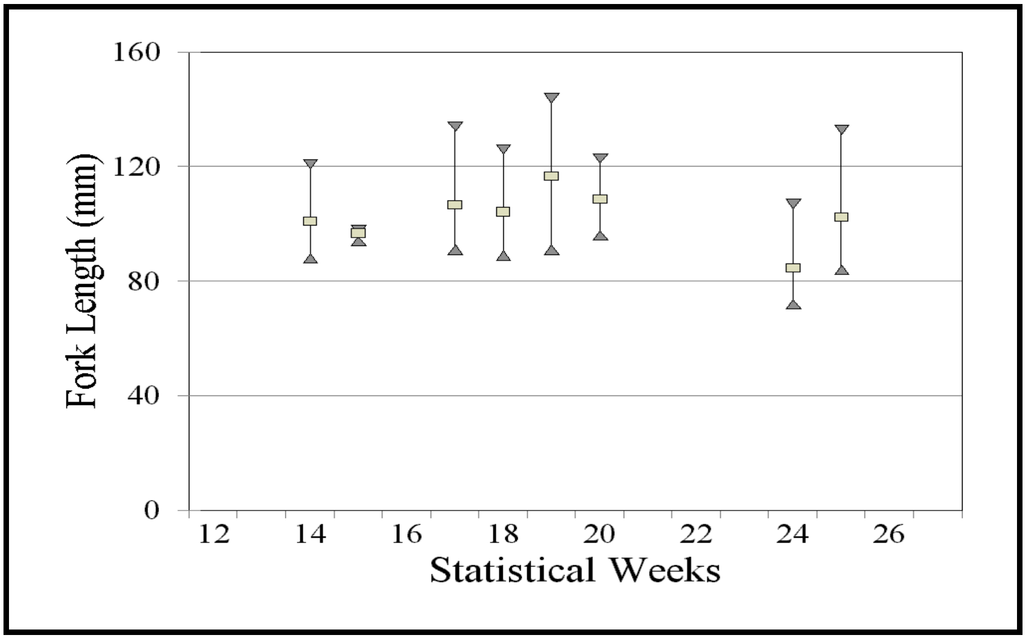


Figure 52. Weekly ranges and mean fork lengths of unmarked coho smolts captured in the Issaquah Creek screw trap, 2000.

During these tests, three of the groups were released during morning hours and 16 groups were released during evening hours. Since so few groups were released in the morning, we decided not to stratify based on this treatment. Therefore, as with the other sites/years/species, small groups were combined with adjacent groups to develop tests where at least 40 marked migrants were released. This reduced the number of mark groups to 17 and produced an average trap efficiency of 15.30% (Table 31).

Coho Production

From March 14 through July 3, we estimated that 19,182 wild coho smolts passed the screw trap (Table 32, Figure 53). The coefficient of variation for this estimate was 6.52% and it had a confidence interval of 16,731 to 21,633 wild coho. We estimated that of this total, 14,387 naturally-produced coho smolts passed the screw trap while it was operating and 4,795 naturally-produced smolts passed while trapping was suspended due to hatchery releases or screw stoppers. The entire coho migration was sampled during the trapping period so this estimate represents the entire production of naturally-produced coho from Issaquah Creek in 2000.

Table 31. Trap efficiency test results for coho smolts, Issaquah Creek screw trap 2000.

Date	Number Released	Number Recovered	Recapture Rate ($\hat{e}$)	V($\hat{e}$)
Actual Morning Tests				
03/17	71	7	9.86%	0.001270
03/18	92	13	14.13%	0.001333
06/17	3	1	33.33%	0.111111
Actual Evening Tests				
03/22	140	10	7.14%	0.000477
03/25	100	14	14.00%	0.001216
03/27	100	22	22.00%	0.001733
03/28	93	17	18.28%	0.001624
03/29	100	10	10.00%	0.000909
03/31	100	17	17.00%	0.001425
04/01	100	12	12.00%	0.001067
04/02	100	16	16.00%	0.001358
04/17	100	19	19.00%	0.001555
04/22	50	9	18.00%	0.003012
04/23	100	17	17.00%	0.001425
04/26	50	12	24.00%	0.003722
04/28	50	6	12.00%	0.002155
05/01	50	7	14.00%	0.002457
05/05	38	3	7.89%	0.001965
05/08	42	9	21.43%	0.004107
Combined Tests				
03/17	71	7	9.86%	0.001270
03/18	92	13	14.13%	0.001333
03/22	140	10	7.14%	0.000477
03/25	100	14	14.00%	0.001216
03/27	100	22	22.00%	0.001733
03/28	93	17	18.28%	0.001624
03/29	100	10	10.00%	0.000909
03/31	100	17	17.00%	0.001425
04/01	100	12	12.00%	0.001067
04/02	100	16	16.00%	0.001358
04/17	100	19	19.00%	0.001555
04/22	50	9	18.00%	0.003012
04/23	100	17	17.00%	0.001425
04/26	50	12	24.00%	0.003722
04/28	50	6	12.00%	0.002155
05/01	50	7	14.00%	0.002457
05/05 - 06/17 Combined	83	13	15.66%	0.001611
	1,479	221		
	Combined (40 or larger) Release Groups	**Average**	**15.30%**	
		V(̂)	**0.001781**	
		n	**17**	

Table 32. Estimated migration of naturally-produced coho smolts from March 14 to July 3, 2000 from Issaquah Creek.					
Period	**Expanded Catch**	**Estimated Migration**	**CV**	**95% CI Low**	**95% CI High**
Trapped Period	2,201	14,387	5.55%	12,822	15,953
Un-Trapped Period	734	4,795	20.07%	2,909	6,681
Total	2,935	19,182	6.52%	16,731	21,633

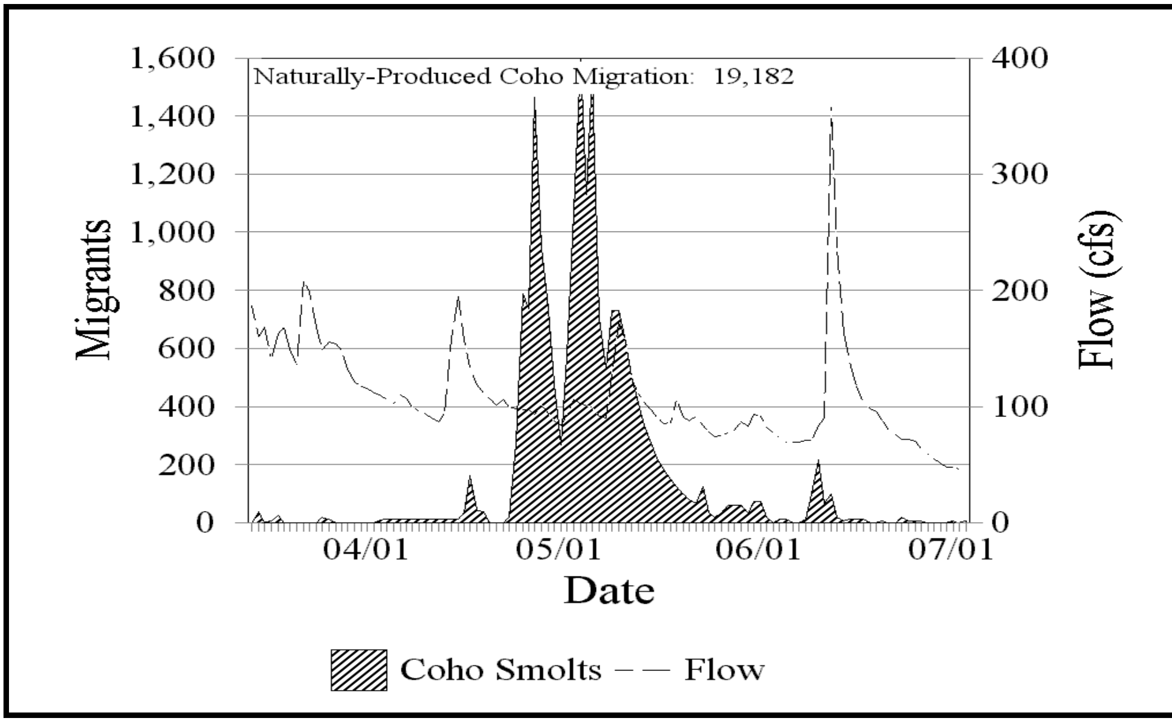


Figure 53. Estimated daily naturally-produced coho smolt migration and flow (USGS Issaquah Creek Gage #12121600), Issaquah Creek 2000.

Steelhead and Cutthroat

Catch

Over the trapping season, we caught 52 unmarked steelhead smolts (Appendix I). We also captured 189 marked steelhead that had been released from the Issaquah Hatchery or resulted from the 1998 fry plants in the upper river, resulting in a total steelhead catch of 241. Wild steelhead catches were sporadic, occurring throughout the trapping period, and didn't follow a discernable trend.

Of the 189 marked steelhead captured, 142 were caught prior to the May 10 release date. Unlike the early captures of marked chinook and coho, the marked steelhead were not thought to be escaped from the hatchery, but instead were thought to be the smolts surviving from the 1998 fry plants (Steve Foley pers. comm.). Hatchery personnel estimated all steelhead released from the facility were marked, therefore, we assumed all unmarked steelhead caught were of natural origin.

A total of 695 cutthroat smolts were captured during trapping (Appendix I). Cutthroat were captured as soon as trapping began and throughout the trapping period. Catches were slightly higher in April and early May than at other times. The peak daily catches occurred on April 20 and May 2 with 21 cutthroat caught each day.

Size

Steelhead fork lengths were not measured due to the low numbers of wild smolts caught. Cutthroat fork lengths were taken in only four weeks over the trapping period. Fork lengths of individual cutthroat ranged from 92-mm to 188-mm. Length-frequency analysis shows that cutthroat fork lengths were slightly skewed right with the majority of smolts ranging from 108-mm to 139-mm in length (Figure 54).

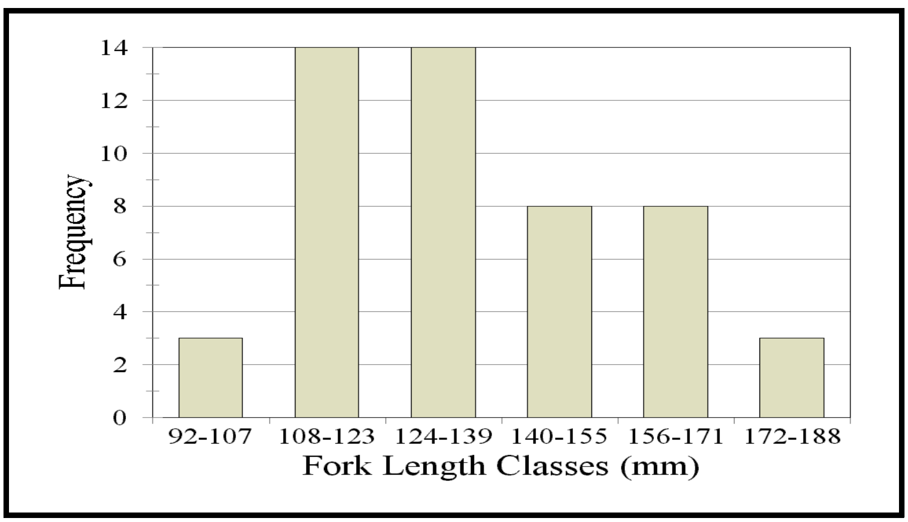


Figure 54. Length frequency of cutthroat smolts captured in the Issaquah Creek screw trap, 2000.

Catch Expansion

During the four periods when trapping was suspended, wild steelhead and cutthroat catches were estimated using catch data from adjacent days. Over the first two periods when few steelhead were captured (April 3 to April 16 and May 11 to May 22), wild steelhead and cutthroat catches were estimated using the average daily catches from the preceding and following seven day trapped periods. Over the third and fourth suspended trapping periods (May 26 to May 30, and June 12 to June 14), catches were estimated using the average daily catches from the preceding and following three day trapping periods.

Wild steelhead catch was also estimated for the screw stoppage event on April 19. Cutthroat catch was estimated for this event, as well as the screw stoppage events on March 23 and April 25. Catch was estimated using the same methods used to estimate chinook catch during these events.

Assuming the trap was operated over the entire trapping period, we estimate 79 wild steelhead and 1,047 cutthroat would have been captured in the screw trap (Appendix I). The catch expansions added an additional 27 wild steelhead and 352 cutthroat to the actual catches of 52 wild steelhead and 695 cutthroat. These expansions result in a 52% and 51% increase in the actual catches of wild steelhead and cutthroat smolts, respectively.

Trap Efficiency

Two trap efficiency tests were conducted using juvenile cutthroat. The tests were conducted during the morning of June 16 and the evening of June 17 using 17 and 26 marked cutthroat, respectively. We recaptured one cutthroat in the first test and two in the second test. Because tests were conducted so closely together with few fish, we decided to pool the results, which resulted in a capture efficiency of 6.98% with a variance of 0.001545. Since steelhead and cutthroat trout smolts are similar in size, we used this capture efficiency value for both species.

We had concerns about the accuracy of this rate since it was based on a small sample size and on tests conducted over a very limited portion of cutthroat and steelhead migration timing. However, we opted to use this value because it was the best data available and was within the range of expected efficiencies for these species based on our observations while trapping other streams.

Steelhead and Cutthroat Production

Application of the cutthroat trap efficiency estimate to the expanded wild steelhead catch resulted in the estimated migration of 1,128 wild steelhead smolts during the period of trap operation (Figure 55). Using the same trap efficiency estimate, cutthroat migration past the trap was estimated at 15,005 cutthroat (Figure 56). The cutthroat migration was well underway when trapping began, therefore this is a very conservative estimate of cutthroat production from Issaquah Creek. This level of production indicates a very large cutthroat population exists in the stream.

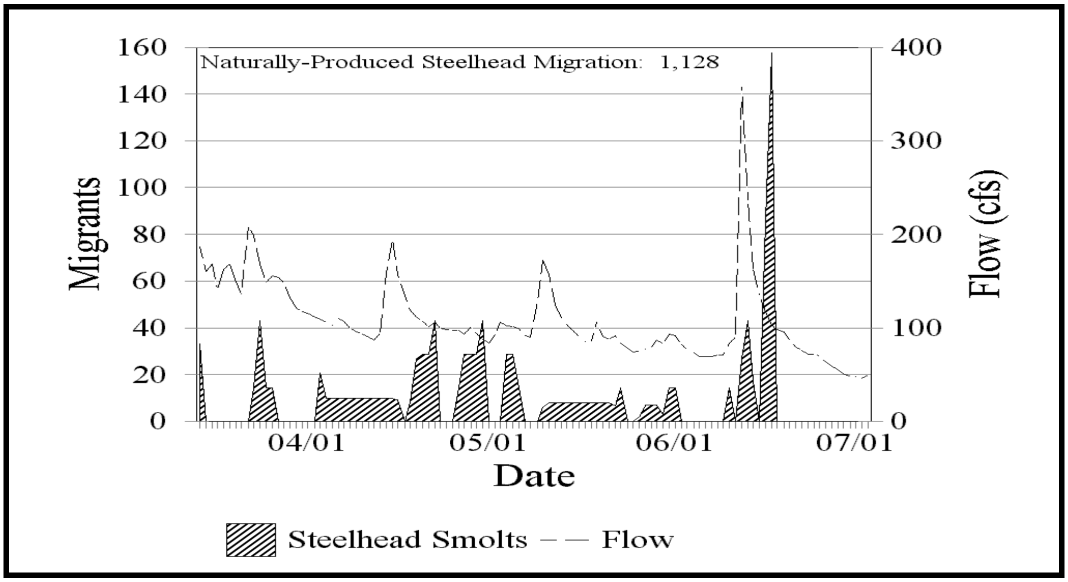


Figure 55. Estimated daily naturally-produced steelhead smolt migration during the trapping period and flow (Issaquah Creek Gage #1212600), Issaquah Creek 2000.

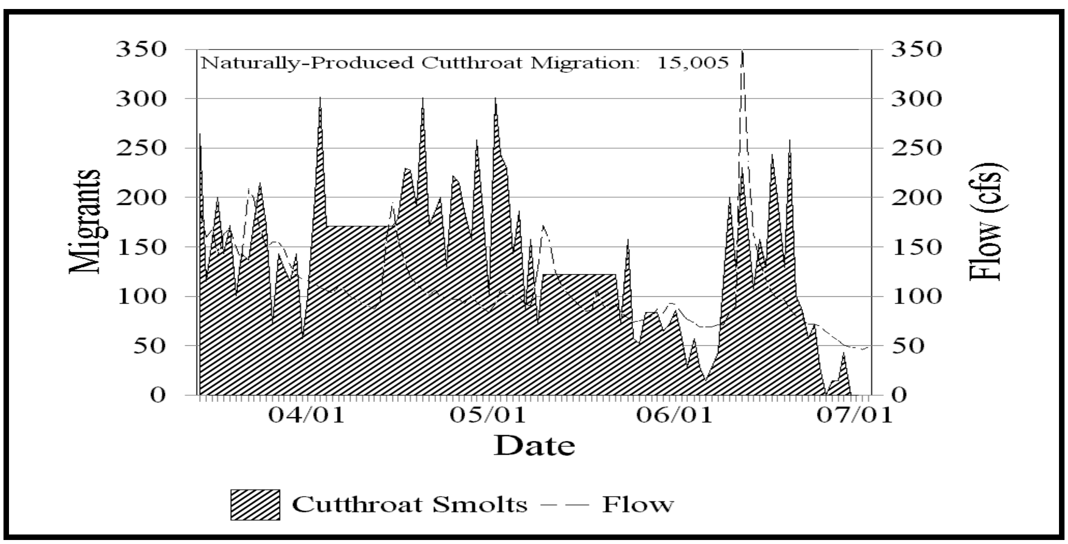


Figure 56. Estimated daily wild cutthroat smolt migration during the trapping period and flow (Issaquah Creek Gage #1212600), Issaquah Creek 2000.

DISCUSSION

Chinook

Production Estimates

Cedar River

From 1992 to 1998, the WSPE has focused its Cedar River work on assessing sockeye fry production through downstream-migrant trapping. Incidental to this work, we measured a substantial early emigration (January 15 to April 15) of chinook fry from the Cedar River (Figure 57). Beginning in 1999, the scope of work was expanded to include the assessment of wild chinook smolt production, as well as for coho salmon, steelhead and cutthroat trout.

Trapping throughout the entire migration in 1999 and 2000 assessed the timing and the proportion of the migration comprised by this early portion. In 1999, we estimate that 84% of the chinook migration occurred before April 16, whereas in 2000,71% migrated prior to this date

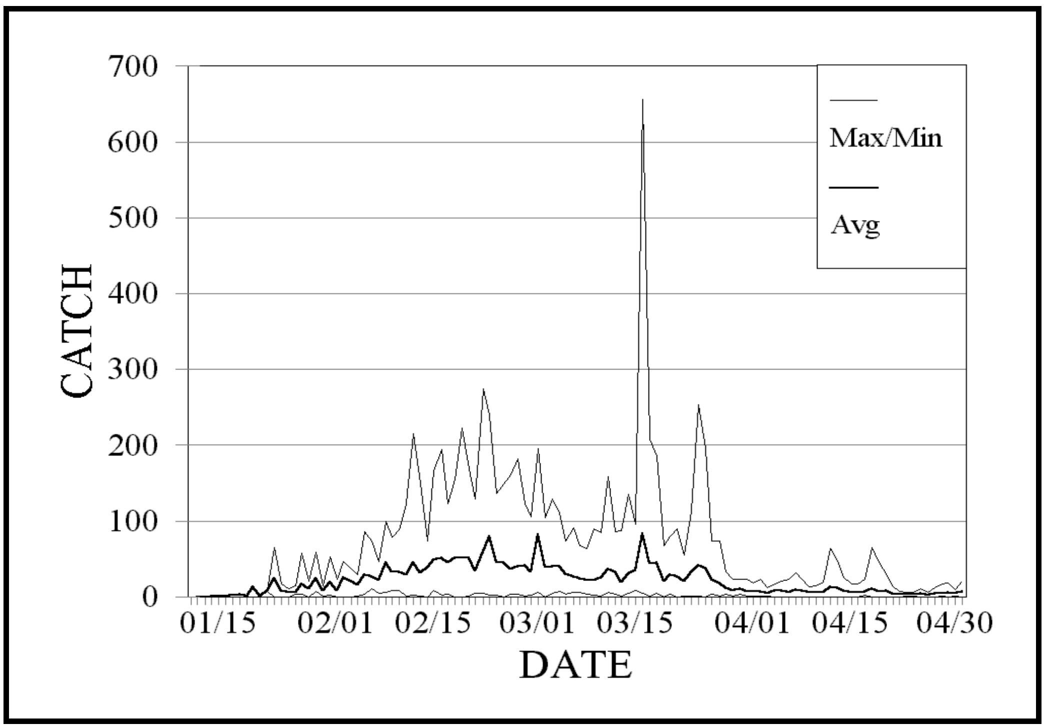


Figure 57. Range of nightly chinook fry catches in the Cedar River sockeye fry trap, 1992-2000.

(Table 33). After adjusting for differences in the period trapped, chinook production was slightly higher in 1999 (80,000) compared to 2000 (65,000). The difference in production relates to the higher proportion that rears to smolt size in 2000 and the additional in-river mortality they experience relative to the earlier migrating fry. In other words, this difference reflects the "cost", in-terms of increased mortality, for rearing a higher proportion of the production to smolt size. Therefore, if the two broods produced the same proportion of smolts, we believe their total production levels would be similar. This similarity in total production is not too surprising since peak stream flow over both years were also similar (Figure 58). Peak stream flow during the incubation period has been shown to be a principal determinant of egg to migrant survival for sockeye in the Cedar River (Seiler *et al.* 2001[b]) and for chinook in other rivers (Seiler *et al.* 2001[d]).

Chinook smolt production in 2000 was nearly 50% higher than the production observed in 1999. We believe this increase may result from a reduction in the magnitude of late winter flows in 2000 which allowed newly emerged fry to rear in the additional low velocity habitat in the Cedar River rather than being washed downstream (Figure 58).

Table 33. 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 1999 and 2000.

Smolt Year (i)	Estimated Migration			Percent Migration	
	Fry Period through Apr 15	Smolt Period Apr 16-Jul 13	Total	through Apr 15	Apr 16-Jul 13
1999	67,293	12,811	80,104	84%	16%
2000	45,906	18,817	64,723	71%	27%

In both 1999 and 2000 we estimated daily chinook migration during the period of fry trap operation based on nightly catches alone. In 1999, we estimated what the daytime catch would have been using the average monthly day/night catch rate ratios from the screw trap adjusted for the number of hours per day that are fished to estimate daytime catch. Since the screw trap did not begin operation until March, we assumed the average March day/night ratios reflected the proportion of fry migrating during the day in January and February. A similar approach was used in 2000, except that since the screw trap did not begin operation until after the fry migration was completed (April 15), we based the day/night catch rate ratios on the limited amount of daytime fishing that occurred using the fry trap. Because data was limited, we used the average day/night catch rate ratio for the entire fry migration period instead of the monthly ratios used in 1999.

Both of these approaches are problematic. Although the screw trap provided a substantial amount of daytime trapping data in 1999, operation did not begin until March. Daytime catch estimates for January and February may be biased since flows and turbidity in March are generally less than those observed in January and February. The average catch rate ratio used in

2000 was based on only three daytime fished periods. These also occurred only in March and early April; therefore, this ratio resulted in the same bias as the 1999 approach when applied to January and February night catches. To avoid having to make this assumption in the future, trapping in 2001 will include additional daytime fry trap sampling to measure the daytime chinook migration rate.

The chinook production estimates developed in this report are a function of the capture efficiency of the gear. The sockeye fry-based trapping efficiencies used to estimate chinook fry migration in 1999 averaged 4.5%, half of that (9.3%) measured in the 1998 season. Moreover, in 1998, flow explained most (67.5%) of the variation in trap efficiency, over twice the rate measured in 1999 (Figure 3). Sockeye efficiencies in 2000 were intermediate to the 1998 and 1999 values. We believe these differences resulted from two factors. First, the dredging project conducted during summer 1998 deepened and widened the lower Cedar River channel, reduced velocities at the trap site, which caused a reduction in capture rates in 1999. The improving capture rate measured in 2000 suggests that channel morphology is continuing to change in response to the dredging and the resulting sediment re-distribution that followed. Secondly, sockeye abundance was estimated at 33 million in 1998 (Seiler et al 2001[a]), compared to 18.5 million in 1999 (Seiler et al. 2001[b]) and 10.5 million in 2000 (Seiler et al. *in prep*). Marked sockeye made up a smaller proportion of the migration in 1998 compared to 1999 and 2000, reducing the likelihood of their being preyed upon.

Trap efficiency estimates derived from tests using chinook differed between the fry and screw traps during concurrent operation in 1999. Over the 11 weeks that both traps operated, chinook migration estimates were significantly different in five weeks (Table 6, Figure 7). Size selectivity in the fry trap clearly resulted in underestimating chinook migration during the last

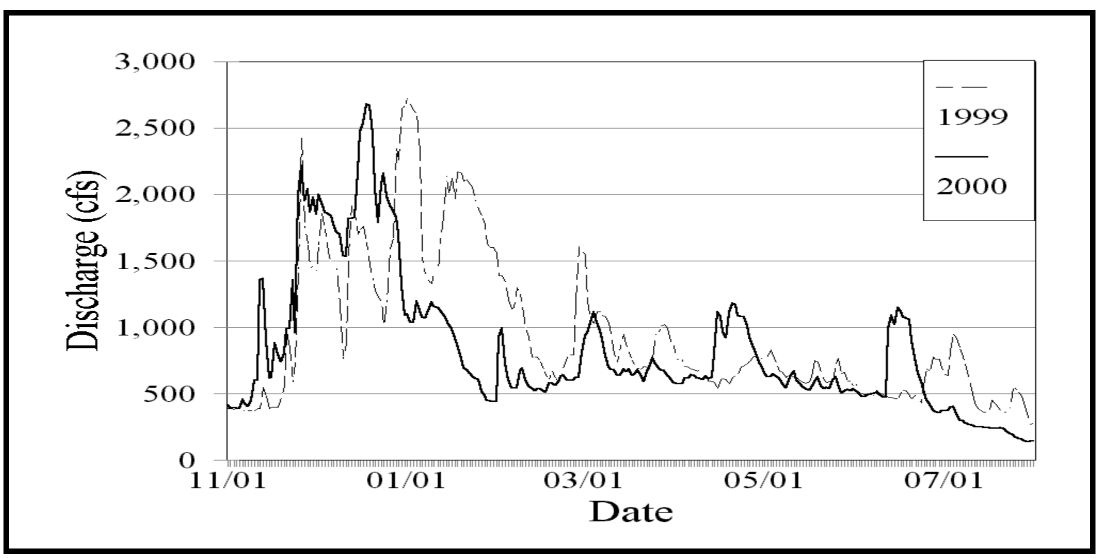


Figure 58. Comparison of the Cedar River hydrographs for water years 1999 and 2000 (USGS Renton Gage #12119000).

three weeks that it operated (weeks 20, 21 and 22). Over the other eight weeks, the screw trap estimates were lower than those from the fry trap in seven weeks, and significantly lower ($p<0.05$) in two weeks, 13 and 14. Correlation of the differences in estimates between the two traps with flow found that differences were positively correlated with flow. During weeks 13 and 14, daily mean flows included values around 1,000 cfs, nearly double the 552 cfs mean flow over the period we calibrated the trap for chinook. Because chinook fry are larger in size and are better able to avoid the fry trap than sockeye fry, higher flows may have actually increased efficiency in the fry trap for chinook (through increasing velocity), rather than decreasing it as our sockeye-based efficiency:flow model predicts. If this is the case, then we overestimated migration with the fry trap at higher flows. Conversely, because capture rate in the screw trap is likely a negative function of flow, at least at the higher levels, by using the average trap efficiency derived at lower flows, we probably overestimated capture rate at high flows which underestimated migration.

Both estimates may be biased in different directions, but we believe it is likely that the screw trap estimates during the two weeks of higher water, weeks 13 and 14, are biased low. Screw trap catches in each of these weeks totaled less than a third of that of the fry trap. In addition to decreased screw trap efficiency at higher flows, small migrants can exit the screw trap via the slowly rotating debris drum, particularly when organic debris loads are heavy such as in high and rising flows. We call this “riding the wheel,” and it results in underestimating the catch of small migrants. Chinook averaged near 40-mm through week 14, and the size distribution through week 22 included fish this small (Table 2, Figure 2). Fish of this size are susceptible to escape over the debris drum. Another source of bias for the screw trap early in the season was the panel that we placed in the trap to allow sockeye fry to escape. The $^{3}/_{16}$ in. holes probably also allowed some smaller chinook fry to escape. In contrast, small chinook could not escape from the fry trap because it was designed to capture and retain sockeye fry which average less than 30-mm. While we believe the screw trap may exert a capture bias relative to size, it could not be detected in the data. Weekly minimum fork lengths from chinook captured in the scoop and screw traps were nearly identical over the first 8 weeks of concurrent operation (Table 2). The same was not seen with respect to the maximum sized chinook captured each week. The screw trap always captured larger migrants compared to the fry trap indicating the fry trap was selective for smaller migrants.

Despite concluding that weekly migration estimates were significantly different in two of eight weeks (excluding the last three weeks), we elected to make no adjustment to the estimates because it is not clear which is more accurate. While the screw trap estimate is probably biased low in weeks 13 and 14, it is likely that over the season, regardless of trap, the estimates are biased slightly high. Any failure of marked fish to reach the traps and be identified underestimates capture rate. While we believe survival to the trap and recognition of marks was very high, any violation of these assumptions results in overestimating migration. An advantage with using the screw trap-based estimate is that since the trap generally operates 24-hours per day, the migration is continuously sampled. Since the fry trap was only fished at night, we are forced to make assumptions about daytime migration rates. These assumptions will only be validated with additional daytime fry trap operation.

Screw trap efficiency in 2000 was substantially reduced from levels measured in 1999. Changing channel morphology was likely a significant contributor to this reduction. Trap efficiency in 2000 may also have been reduced by filamentous algae that was present in the water column and clogged the trap screens and live well. The algae was particularly hard to remove and, during periods of substantial buildup, may have resulted in the loss of trap efficiency. Reducing the porosity of the screens slows the rotation of the screw causing a bulge of slower water to form in front of the trap that the fish more easily pass around. Algae levels were extremely heavy in 2000 and nonexistent in 1999.

Bear Creek

In 1999, the chinook 0+ trapping efficiency of the Bear Creek trap was estimated from mark and recapture experiments using sockeye fry while it fished in position 1. Captured chinook were used to estimate trap efficiency while the trap fished in position 2. The trap fished in position 1 between February 23 and May 13. Although chinook size was increasing during the later part of this period, we do not believe it substantially effected chinook trap efficiency at this site. Stream velocity and the constriction of the creek at the trapping site likely had a greater effect on efficiency than fish size for migrants between 40 to 140-mm, fork length. While the trap fished in position 1, sockeye trap efficiency averaged 24.7% and coho trap efficiency averaged 23.8%. These estimates were not significantly different ($p>0.05$). Chinook migrants, which are intermediate in size between sockeye fry and coho smolts, would be expected to be captured at the same rate as these two species.

In 2000, sockeye fry-based efficiency estimates were considered for estimating chinook capture efficiency during the early portion of the trapping season. These estimates were found to be problematic in 2000 due to predation on marked fry which biased our mark-recapture experiments. Predation was much lower in 1999 due to fewer predators and more prey which resulted in our removing fry from the live box more frequently.

Given this bias, we elected to use the same trap efficiency for the early part of the chinook migration as was used in 1999. We believe this to be appropriate since the 2000 coho efficiency and chinook efficiency (from the latter part of the trapping season) were similar to 1999 results. This suggested that changing conditions between 1999 and 2000 affected only sockeye capture efficiency.

Like the Cedar River, Bear Creek chinook also exhibited an early and late migration timing. But in contrast to the Cedar River, the majority of the production emigrated after mid-April (Figures 30 and 42). Between the two years there was also a notable difference. Eighty nine percent of the production in 1999 occurred after mid-April, while in 2000, 56% of the migration occurred after mid-April (Table 34).

While chinook production in the Cedar River was only slightly higher in 1999 compared to 2000, Bear Creek production in 2000 was estimated to have more than doubled the 1999 production level (Table 34). This increase may at least partially be explained by differences in escapement of the parent broods. An escapement of 733 adult chinook was estimated in 1999, whereas only 401 adult chinook were estimated to have escaped in 1998. Most of the additional production measured in 2000 migrated as fry (prior to April 16) (Figure 59). While the smolt component was approximately 4,800 smolts higher in 2000 compared to 1999, the fry component increased by nearly 12,400. The higher spawning levels observed in 1999 may have increased density-dependent effects which forced a higher proportion of the production downstream as fry.

Table 34. Comparison of fry and smolt components between years for wild chinook production standardized by assuming a January 24 to July 13 migration period, Bear Creek 1999 and 2000.

Smolt Year (i)	Estimated Migration			Percent Migration	
	Fry Period thru Apr 15	Smolt Period Apr 16-Jul 13	Total	thru Apr 15	Apr 16-Jul 13
1999	1,720	13,282	15,002	11%	89%
2000	14,116	18,104	32,220	44%	56%

Issaquah Creek

Trapping occurred on Issaquah Creek from March 14 until July 3, 2000. Over this 106 day period, trapping was completely suspended on 25 days to avoid large numbers of hatchery fish being released from the Issaquah hatchery. Trapping was suspended for some or most of an additional 14 days due to the presence of hatchery fish or as a result of screw stoppers (e.g., woody debris that jammed the screw). In all, the trap was operated 1,774.91 hours out of a possible 2,544 hours, or 69.77% of the time. Because hatchery fish were generally released during periods when migration rates for naturally-reared chinook were moderate or higher, we estimated that the catch of naturally-reared age 0+ chinook would have increased 45% over the actual catch if we had continued to operate the trap during suspended periods. While we believe that our naturally-produced age 0+ chinook migration estimate is reasonably accurate over the period of trap operation, the interpolation of missed catch represents a potential source of error.

To validate the Issaquah Creek smolt production estimate, we compared the ratios of peak daily smolt migration to total smolt migration between streams. Using the assumption that the magnitude of the highest daily migration observed should vary with the magnitude of the total migration, our expectation was that this ratio for Issaquah Creek would be within the range

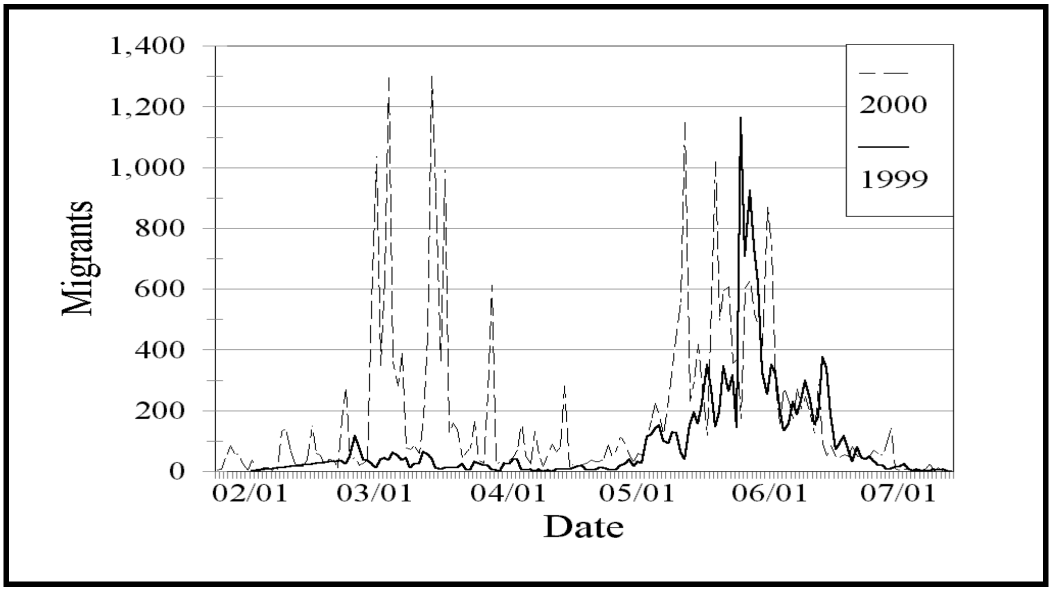


Figure 59. Comparison of 1999 and 2000 daily wild chinook migration estimates for Big Bear Creek.

observed for other chinook streams monitored in 2000. Results showed that the daily peak smolt migration-to-total smolt migration ratio ranged from 4.9% to 14.9% for the chinook streams monitored in 2000 (Figure 60). This range suggests the indicator is not very robust, yet if the Green River ratio were removed, the range reduces to 4.9% to 6.8%. The Issaquah Creek estimate forms the higher end of this range, 6.8%, and is similar to values estimated for Cedar River, Bear Creek, and Skagit River. These results provide an indication that the estimated wild age 0+ migration estimate for Issaquah Creek is within, or at least very close to, the values measured in other streams.

The early January through March migration of chinook fry was not measured in Issaquah Creek in 2000. This component of the total production appears to vary widely between streams and years based on the results of our trapping operations in the Cedar River and Bear Creek. Notwithstanding the production of these newly emerged fry, the 2000 production estimates of the larger chinook smolts, as defined by migrants passing the traps after April 15, is nearly identical between these three systems (Figure 61).

Egg-to-Migrant Survival

Cedar River

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 1998 brood, we

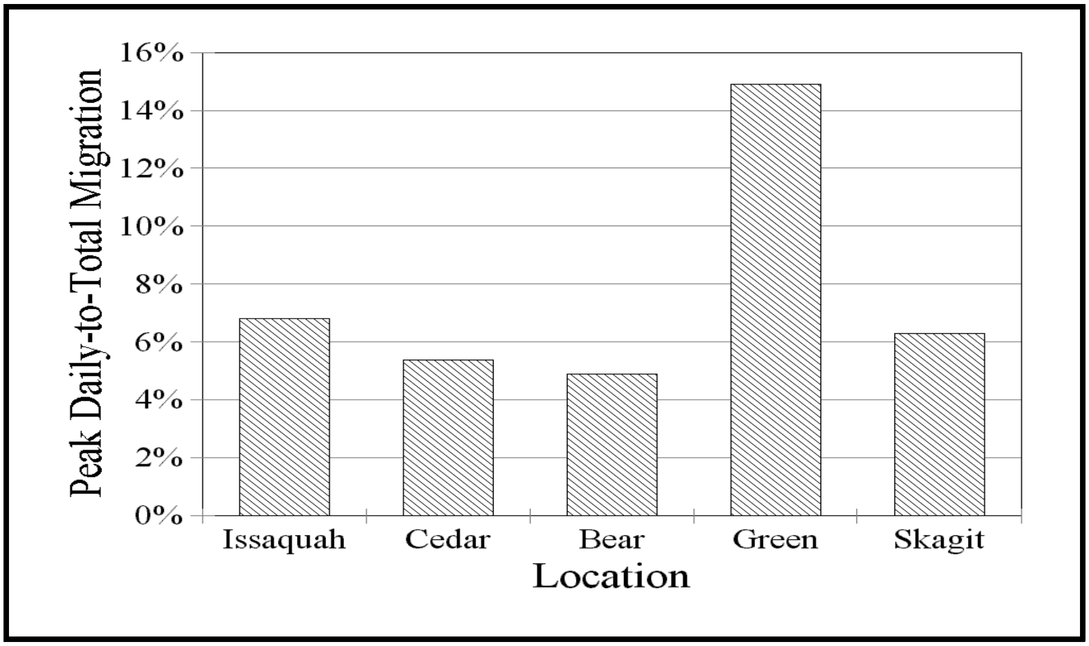
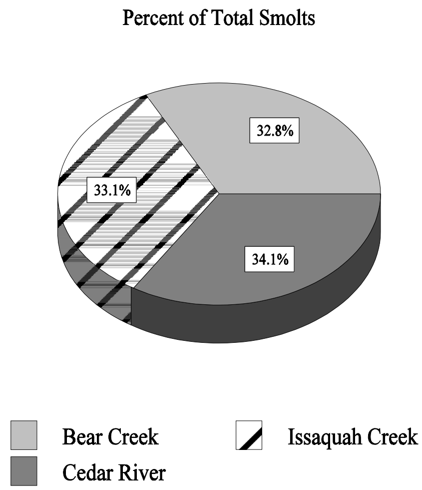


Figure 60. Ratio of peak daily naturally-produced age 0+ chinook smolt migration to total smolt migration for watersheds trapped in 2000.

estimated a wild chinook egg-to-migrant survival of 10.4% based on a potential deposition of 778,500 eggs (Table 35). Egg deposition for this brood was based on an area-under-the-curve (AUC) spawning escapement of 432 adult chinook (unpublished WDFW data), with an assumed component of 173 females (40%) and an average chinook fecundity of 4,500 eggs (based on Issaquah Hatchery chinook)(Antipa pers. comm.). A redd count method was used to estimate chinook escapement for the 1999 brood (Burton 2000). A total of 180 redds with female chinook were counted in 1999 which, assuming an average fecundity of 4,500 eggs, yielded an estimated egg deposition of 810,000. This egg deposition coupled with the migration estimate for 2000 yields an estimated egg-to-migrant survival of 8.0%. The 95% confidence intervals of the production estimates yield survival rates of 9.4% to 11.4% and 7.2% to 8.8% for the 1998 and 1999 brood year chinook, respectively. Since we do not know the variance associated with the escapement and average fecundity estimates, the confidence intervals only reflect error associated with the estimates of chinook migrants. If more or less eggs were deposited, then these survival estimates are biased high or low, respectively.

Bear Creek

We estimated wild age 0+ chinook production at 15,002 migrants for the 1998 brood (1999 trapping). Using the same approach and assumptions that were used for the Cedar River, we estimated 1998 brood egg-to-migrant survival at 2.1%, assuming an egg deposition of 715,500



Stream	Smolt Production	Basin Area (sq. mi.)
Bear Creek	18,104	48
Issaquah Creek	18,270	57
Cedar River	18,817	188

Smolt production is described by migration occurring after April 15, 2000.

Figure 61. Proportion of the estimated 2000 wild chinook smolt production originating in each stream in the Lake Washington Basin.

Table 35. Wild age 0+ chinook egg-to-migrant survival estimates for smolt years 1999 and 2000, Cedar River.

Smolt Year (i)	Estimated Female Escapement (i-1)	Potential Egg Deposition	Chinook Migrants	Egg-to-Migrant Survival
1999	173	778,500	80,932	10.4%
2000	180	810,000	64,723	8.0%

Note: The 1999 estimate uses 40% of an AUC-derived 1998 brood escapement estimate of 432 chinook. The 2000 estimate uses a redd count of 180 redds to estimate 180 females.

based on a total escapement of 398 adult chinook (WDFW unpublished data). Assuming the deposition estimate is correct, the 95% confidence intervals of the production estimate yield survival rates of 2.0% to 2.2%. If more or fewer eggs were deposited, then this survival estimate is biased high or low, respectively.

Using the same method to calculate egg-to-migrant survival for the 1999 brood, a production of 32,220 chinook migrants produced from an escapement of 732 chinook adults (WDFW unpublished data) results in a survival of 2.4%, with a 95% confidence interval of 2.3% to 2.5%. Again, these confidence intervals assume egg deposition is known.

Comparison of Chinook Production and Productivity Between Streams

Total age 0+ chinook production from the Cedar River was over twice that measured from Bear Creek over the two years studied (Table 36). Comparisons of total production cannot be made for Issaquah Creek chinook since we were not able to estimate migration prior to installation of the screw trap on March 14, 2000. However, describing and comparing total riverine production and egg-to-migrant survival may have little utility given the protracted migration of age 0+ chinook from the Lake Washington tributaries and the growth which occurs over the seven-month interval that these fish emigrate from the river. In both years, we estimated that a substantial portion of the total Cedar River chinook migration entered the lake by mid-March (Figures 8 and 21). A similar occurrence was observed with the 2000 migration from Bear Creek (Figure 42). However, given their small size and timing, we expect considerable mortality to occur on these early migrants after their entry into the lake. Conversely, the later-migrating portion of the populations, having survived rearing in the river to substantially larger sizes, should experience relatively high subsequent survival.

Table 36. Naturally-produced age 0+ chinook total production and smolt production for Lake Washington tributaries trapped in 1999 and 2000.

Stream	Smolt Year	Est. Female Escapement	Total Migration	Smolt Migration	Egg-to-Migrant Survival	Smolt/Egg Productivity
Cedar River	1999	173	80,932	13,638	10.4%	1.75%
	2000	180	64,723	18,817	8.0%	2.32%
Bear Creek	1999	159	15,002	13,282	2.1%	1.86%
	2000	293	32,220	18,104	2.4%	1.37%
Issaquah Creek	2000	**633	*30,025	18,270	– n/a --	0.64%

* The estimate for Issaquah Creek only reflects that part of the total migration that occurred on or after March 14, 2000.
** Confidence in the Issaquah Creek escapement estimate is low (Steve Foley pers. comm.).

Some patterns are beginning to emerge that may enable future modeling of chinook migration timing. We observed higher proportions of the chinook production emigrate as fry when late-winter flows were elevated as was observed in the Cedar River in 1999, or when juvenile densities were high as was the result of the high escapements observed in Bear Creek in 1999. These observations indicate that with adequate escapement, smolt production reflects the amount of stream rearing habitat that is available. It is interesting that smolt production from Issaquah and Bear Creeks are similar in magnitude to that of the Cedar River, which is a much larger stream. However, production from the Cedar River is limited by Landsburg Dam which confines fish use to the lower 22 miles of the river. Like the Cedar River, Issaquah Creek flows within a confined, moderate gradient channel. Yet we believe this smaller stream may better mitigate high flows by providing more velocity refugia due to increased habitat complexity and channel roughness. Smaller, lower gradient, unconfined streams like Bear Creek may do the same as a result of the reduced stream energy that develops from this channel-form.

As with total production, it is difficult to compare chinook egg-to-migrant survival between Bear Creek and the Cedar River. Uncertainty exists relative to the accuracy and precision of escapement estimates. It is likely that the level of accuracy and precision in escapement estimates is different between them. Also, since a larger proportion of the Cedar River age 0+ chinook leave the system prior to smolting. A higher proportion of the Bear Creek migrants rear for a longer period of time before migrating past the trap, therefore a lower egg-to-migrant survival rate is expected. Notwithstanding these distinctions, differences in egg-to-migrant survival are considerable.

Bear Creek drains the gently rolling terrain north of Lake Sammamish whereas the Cedar River flows out of the Cascade foothills. Stream gradient in Bear Creek is lower than in the Cedar River or Issaquah Creek and its channel is less confined over most of its length. While these attributes result in more low velocity habitat that chinook use for rearing, we believe they also contribute to deleterious impacts on the early life stages of chinook which affects egg-to-migrant survival. For example, due to the reduced stream gradient and wider channel configuration, stream velocity is reduced during the winter incubation and early spring rearing periods. These conditions limit the ability of the stream to transport fine sediments from the spawning gravel; thereby reducing the hatching rate of deposited eggs. They also provide excellent rearing conditions for larger piscivores such as cutthroat, coho, and sculpin. The low velocity conditions make juvenile chinook more susceptible to predation by these as well as avian predators.

Since we did not estimate the total production of age 0+ chinook from Issaquah Creek, we were unable to compare egg-to-migrant survival rates from this stream with those from the Cedar River and Bear Creek. Instead, the ratios of smolts produced per eggs deposited by spawners returning in 1999 were compared between the three streams. Potential egg deposition for Issaquah Creek was estimated using the same approach described for the Cedar River except that a different method was used to estimate escapement. The escapement estimate for Issaquah Creek was based on carcass counts below the hatchery weir and on the East Fork, and on a count of live adults passed above the weir. This procedure assumes that carcasses from the live adults passed upstream of the weir do not wash downstream of the weir and get counted again. It further assumes that all spawners passing the weir were counted. Since violations of both assumptions may have occurred, our confidence in this escapement estimate is low. We are also uncertain of the direction of any bias.

Estimates of smolt/egg productivity rates suggest a strong density dependent effect. The highest rate estimated for the 1999 brood was for the Cedar River; which also had the lowest escapement (Table 36). The lowest rate was estimated for Issaquah Creek, which had the highest escapement. The same trend was observed for the 1998 brood for the Cedar River and Bear Creek.

Cedar River Gear-Specific Size Selection and Inter-annual Variation in Size at Time

One of the objectives of the Cedar River studies was to evaluate the size selectivity of the different trapping gear at different times in the migration period. This information would be used to develop estimates of chinook production between 1992 and 1998, when only the fry trap was operated over shorter trapping periods (Seiler and Kishimoto 1997[a], 1997[c]).

Concurrent operation of both traps over an 11 week period in 1999 enabled assessing the size selectivity of the fry trap. It also provided an opportunity to evaluate migration estimates independently generated from each trap. Beginning in mid-April of that year, chinook captured in the fry trap were smaller and had a significantly different distribution than those caught in the screw trap (Kolmogorov-Smirnov Two Sample Test, $p<0.05$, Table 2). As chinook continued to grow, fry trap efficiency declined to zero. Size selectivity of this trap in 1999 resulted from insufficient velocity. The dredging project conducted during the summer of 1998 deepened and widened the channel, substantially reducing velocities downstream of Boeing's south bridge.

In 1998, before the dredging project, velocities into the fry trap were high enough to preclude size-biased chinook capture. Chinook caught in the fry trap in 1998 were even larger than those caught in the screw trap in 1999 (Table 2). The difference in size between the two years probably resulted from the generally warmer temperatures in 1998 than in 1999.

The fry and screw traps operated sequentially in 2000, therefore, comparisons in the size distribution of captured chinook migrants between these two gear types were not made. Chinook captured in the screw trap, beginning in late April, were similar in size to those captured in the fry trap in 1998 and larger than those captured in 1999 (Tables 2 and 10).

Differences in chinook size and the capture efficiency of the gear makes estimation of chinook production in previous years a difficult endeavor. If the timing distributions of the chinook migration were consistent between years, the production from the earlier years could be estimated by measuring the proportion that migrated prior to Statistical Week 12, when fish are of a consistent, small size. Work done in 1999 and 2000 suggests, however, that the outmigration timing distribution is not consistent between years. The proportion of the total production migrating prior the onset of fry growth is not consistent. Whereas 80% of the migration had occurred by the end of week 12 in 1999, only 55% had occurred by this date in 2000 (Figures 9 and 22). We concluded that while the sockeye fry trap estimates chinook fry production, it does not effectively capture the larger chinook smolts.

Size Comparison Between Streams

Growth patterns were similar between all three streams in 2000. Fork lengths averaged about 40-mm in the middle of March. Afterwards, Issaquah Creek chinook grew steadily and averaged just over 80-mm by mid-June. Bear Creek chinook grew a bit faster, reaching a greater than 80-mm average by late-May. Cedar River chinook reached a greater than 80-mm average at about the same time as Bear Creek chinook, but continued to grow to 100-mm or greater by mid-June. Differences in growth rates and size among the three streams is likely a function of water temperature, stream energy, and food availability.

While average fork lengths increased after the middle of March on all streams, we continued to catch migrants of less than 40-mm through the third week in May and the first week in June, 1999, in Bear Creek (Figure 29) and the Cedar River (Figure 2), respectively. In 2000, less than 40-mm chinook were captured through the third week in April in Bear Creek (Figure 40) and Issaquah Creek (Figure 50), and the end of April in Cedar River (Figure 20). These small chinook appeared to be newly emerged fry that immediately migrated downstream into the traps. We believe that an increase in the size of these smallest migrants signaled the end of the chinook incubation period.

Coho

As with chinook, migration estimates for Cedar River coho smolts were also fairly consistent between years. Work in other systems have suggested that annual coho production in steeper gradient stream systems such as the Cedar River may be most influenced by the severity of peak winter stream flows whereas other, lower gradient systems, are affected by different factors. As previously discussed, peak winter storms were fairly similar between years (Figure 58).

While Cedar River coho production declined only slightly between 1999 and 2000, Bear Creek coho production in 2000 was less than half of that estimated in 1999. Smolt production evaluations done on other Puget Sound lowland streams have suggested that differences in production between years is often positively correlated with summer low stream flow levels, assuming the system is adequately escaped. Summer low flows between the two years were similar, therefore, the lower production-level in 2000 is possibly the result of low escapement in 1998 or a different environmental impact. Factors that influence Bear Creek coho production may be revealed with additional years of study.

Whereas the Cedar River and Bear Creek produced similar numbers of wild coho smolts in 2000, 32,000 and 28,000, respectively; Issaquah Creek only produced about 60% of that level. Issaquah Creek would not be expected to produce the numbers of coho that Bear Creek and the Cedar River produce. Although the stream is about the same size as Bear Creek, overall it has a higher stream gradient that is less favorable to coho. While the Cedar River also has a higher stream gradient, its larger size provides more habitat than the other streams. Another indicator that suggests the reduced suitability of Issaquah Creek habitat for coho production is the low coho-to-cutthroat production ratio. Low coho-to-cutthroat ratios have been identified as an indication of degraded habitat condition (Horner *et al.* 1996). The coho-to-cutthroat ratio measured for Issaquah Creek in 2000 was 1.25. This is one of the lowest ratios that we have found in over 22 years of monitoring downstream migrants from numerous streams in western Washington.

Coho Supplementation

Approximately 166,000 coho fry were stocked into the Bear Creek watershed in May 1998. No coho supplementation was performed in 1999. Since the fry released in 1998 were not marked, the extent that they contributed to the 63,000 coho smolts produced in this basin in 1999 is unknown. However, it could explain some or all of the difference in smolt production between the two years. Continued monitoring of Bear Creek production will help to determine the role that supplementation plays in enhancing Bear Creek coho production.

Issaquah Hatchery Escapees

It became apparent over the course of our trapping season that some Issaquah Hatchery salmonids escaped prior to release. Using our average daily trap efficiency estimates, a total of 28,000 chinook and 32,000 coho are estimated to have escaped prior to their respective hatchery release dates. These estimates represent approximately 2% and 6% of the reported chinook and coho releases, respectively.

Bear Creek Sockeye Production and Egg-to-Migrant Survival

While catches of sockeye fry in 1999 and 2000 were higher than for any other species, sockeye production during this period declined dramatically (190,000 in 2000 versus 1.53-million in 1999). Sockeye runs in Washington are typically characterized by stronger and weaker broods that continue over time. Data from 1999 and 2000 represent the third and fourth years that we have estimated fry production for Sammamish sockeye. As we continue monitoring this system, comparisons of production within and between broods will enable development of a better understanding of the factors which influence sockeye productivity.

Egg-to-migrant survival for 1998 brood sockeye from Bear Creek is estimated at 10%. This estimate was produced using the following steps and assumptions:

- The 1998 Bear Creek sockeye escapement was estimated at approximately 9,000 fish based on WDFW estimation methods (Steve Foley pers. comm.),
- The male:female ratio was assumed to be 50:50,
- Fecundity of female spawners was assumed to average 3,282 eggs (eight year mean fecundity from the Cedar River),
- This escapement coupled with these assumptions yields an estimated egg deposition of 13.5-million eggs, and by
- Dividing our estimated fry migration of 1.53-million by this deposition results in an egg to migrant survival of 10.4%.

Using the same methods, our production estimate for the 1999 brood of 190,000 fry coupled with a 1999 escapement estimate of 1,705 adult sockeye resulted in an egg-to-migrant survival of 6.8%.

Assuming that 90% of the Sammamish Basin sockeye escapement that spawns downstream of Lake Sammamish is destined for Bear Creek, the total 1999 and 2000 migrations of Sammamish sockeye fry into Lake Washington are estimated at 1.70-million fry and 211,000 fry, respectively.

Egg-to-migrant survival for the 1997 to 1999 broods are estimated to have been much higher than the the 1% survival rate found for the 1996 brood (Figure 62). Peak winter flows appear to explain a substantial portion of this difference ($r^2 = 0.85$, $p<0.08$). The 1996 brood experienced flows from a 1996 late December-early January ice storm which generated the highest stream flows measured in over 30-years in the Sammamish River. Peak flows affecting the 1997 through 1999 broods were much lower.

Residual variation in egg-to-migrant survival not explained by the flow relationship may be related to predation. The 1999 brood survival rate was lower than the 1997 and 1998 brood survival rates even though peak flows were similar. Fry production from the low number of parent spawners in 1999 was also much lower than for the two previous broods. In this year, we measured a substantial increase in the production of downstream migrant cutthroat Increased predation on sockeye fry by cutthroat would account for the lower than expected egg-to-migrant survival.

Steelhead and Cutthroat

Migration estimates for Cedar River steelhead were much lower in 2000 compared to 1999 levels. Most steelhead smolts leave the river as 2-year olds. Yet escapements that contributed to

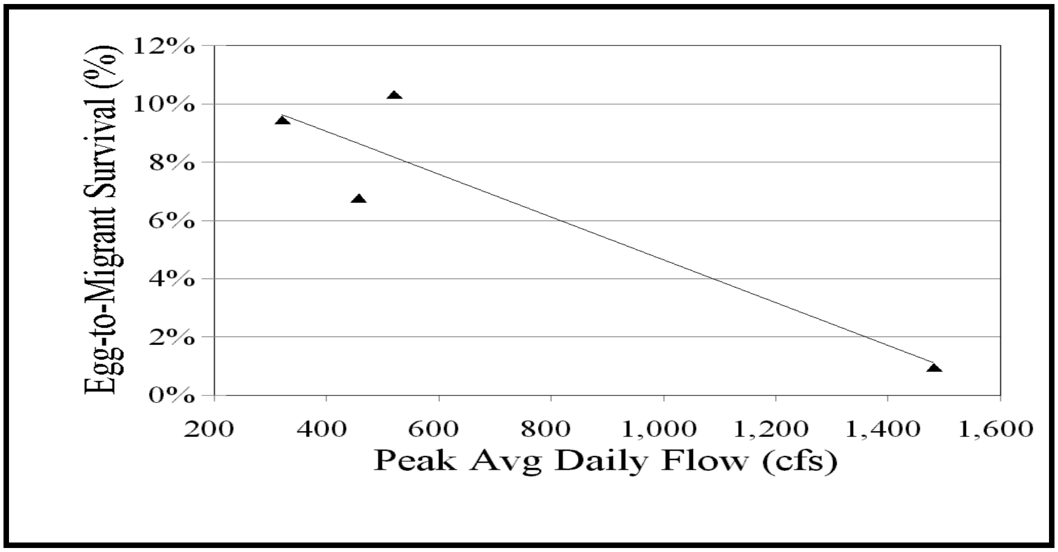


Figure 62. Sammamish River/Bear Creek sockeye egg-to-migrant survival as a function of peak average daily stream flow (King County Union Hill Gage), brood years 1996 to 1999.

these production levels were very similar between years (620 adult steelhead in 1997, 580 in 1998). Our confidence in the accuracy of both steelhead and cutthroat estimates is lower than for chinook and coho for which trap efficiency is directly measured. Trap efficiency for steelhead and cutthroat are based on the estimates developed for coho smolts, which are smaller in size relative to steelhead and cutthroat smolts.

Trap efficiency is inversely related to fish size as demonstrated by differences in trap efficiency for chinook and coho smolts (Figure 63). Steelhead and cutthroat smolts are similarly sized and substantially larger than coho smolts; therefore we expect trap efficiency for these species to be similar to each other and lower than that for coho smolts. We estimated steelhead and cutthroat trap efficiency in the Cedar River by multiplying the coho catch rate by the ratios between steelhead and coho capture rates from other trap sites.

In the Cedar River, trap efficiency for coho measured 14.4% in 1999 and 8.5% in 2000. We estimated steelhead and cutthroat efficiency as 60% of the value measured for coho. This assumes a linear relationship between trap efficiency for these species, however, if the relationship has another shape or the linear function changes at a threshold coho efficiency (i.e., velocity) level, then the accuracy of the estimates and the precision between estimates are suspect. Velocity at the trap in 2000 may have been reduced when compared to 1999 due to changing channel morphology and/or the buildup of algae on the screw. Velocities may have been reduced to the point where steelhead and cutthroat could more easily escape the trap in 2000 than was predicted by the coho-steelhead/cutthroat trap efficiency relationship.

In 2000, a screw trap was operated in Bear Creek from January 24 until July 13. This was the earliest occurrence of trapping capable of capturing cutthroat smolts out of the five stream-year trapping combinations described in this report. While the proportion of the Bear Creek cutthroat migration occurring before trap installation in 2000 is unknown, this data defines cutthroat downstream migration timing during the trapping interval. If we assume the same migration timing occurred in the other streams-years, production estimates from the trapping periods could be expanded to represent total migration for this same interval. During the period in which a screw trap was operated in the Cedar River in 1999 and 2000, 80% and 34% of the total cutthroat were estimated to have migrated past the Bear Creek trap in 2000, respectively. Assuming the same migration timing, the 1999 Cedar River estimate of 3,522 cutthroat expands to a total migration estimate of 4,406. The 2000 Cedar River estimate of 1,400 expands to 4,080.

In Bear Creek, steelhead production increased 11% in 2000 over the 1999 level. Similar numbers of steelhead fry were released in 1997 and 1998 which contributed to these production levels. The number of cutthroat estimated to have migrated past the trap during the trapping period in 1999 was 60% of the level estimated in 2000, however, the trapping period in 2000 was also longer. If we assume the timing distribution observed in 2000 also occurred in 1999, then the 1999 cutthroat estimate of 3,413 expands to a total production estimate of 3,791, still only 67% of the level measured in 2000.

Wild steelhead production in Issaquah Creek was about half of that produced in the Cedar River when examined over comparable trapping periods. Conversely, cutthroat production was much higher. If we assume cutthroat timing distribution for Issaquah Creek was the same as observed in Bear Creek in 2000, the estimated production during trapping of 15,005 expands to a total production estimate of 18,322. The cutthroat total production estimated from Issaquah Creek in

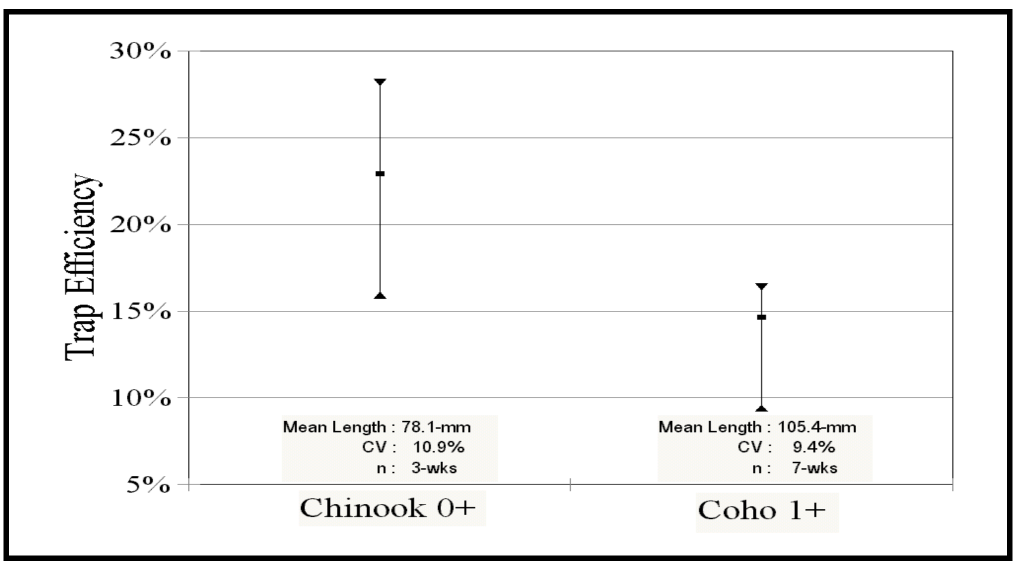


Figure 63. Range and mean of weekly chinook and coho trap efficiency estimates, Cedar River screw trap 1999.

2000 was six times the total production measured in the Cedar River and over three times the Bear Creek production measured in that year. Steelhead and cutthroat migration estimates for Issaquah Creek are based on the trap efficiency estimate derived from only two efficiency tests using cutthroat where a total of only 43 fish were released. Nevertheless, the estimate of steelhead/cutthroat trap efficiency divided by the coho trap efficiency yields 0.46, which is only slightly lower than the range of 0.5 to 0.6 cutthroat and steelhead to coho trap efficiency observed elsewhere. If we instead develop a steelhead and cutthroat trap efficiency for Issaquah Creek by using 60% of the coho efficiency rate as was done for Cedar River and Bear Creek, total cutthroat production would still be estimated at 13,926 smolts, which is nearly 2-1/2 times the Bear Creek production and over 4-1/2 times the total Cedar River production. Either approach still results in a very large total production estimate of cutthroat from Issaquah Creek. We believe, therefore, that the estimates for Issaquah Creek, Bear Creek, and the Cedar River reasonably depict the relative production of steelhead and cutthroat smolts from these systems.

We believe the high cutthroat production levels measured in Issaquah Creek relative to Bear Creek and Cedar River are primarily the result of habitat condition. As spring spawners, steelhead and cutthroat tend to experience better production in higher gradient streams such as Issaquah Creek since they avoid the severe bed scour during incubation that these streams experience during peak winter flows. Development in the Issaquah Creek basin over the last ten years has probably exacerbated these flow related impacts. The high level of cutthroat production occurring in Issaquah Creek may provide a competitive advantage that is currently limiting the production of naturally-reared steelhead.

Steelhead Supplementation

Of the estimated 1,772 steelhead smolts produced in the Bear Creek watershed in 1999, approximately 77% or 1,365 smolts were marked. Scale analysis was performed on a sample of the captured marked smolts and all were two-year-old fish indicating they came from the October 1997 release. Assuming all smolts were from that release, then the estimated fry to smolt survival was 10%.

In 1998, 13,000 ad-marked steelhead fry were released into Bear Creek. Fry to smolt survival was 12% for this release based on the 1,600 marked smolts we estimated to have migrated past the trap in 2000.

Steelhead were also released into Issaquah Creek. Marked fry were released into the upper river November 4, 1998. These releases included an estimated 4,221 fry into Issaquah Creek, 1,742 fry into Holder Creek, and 2,680 fry into Carey Creek, for a total release of 8,642 fry. A total of 142 marked steelhead were captured prior to the May 10 release of hatchery steelhead smolts and we interpolated another 29 marked smolts would have been caught between April 3 and April 16 for a total expanded catch of 171 marked smolts. Using the cutthroat trap efficiency of 6.98%, this estimates a migration of 2,450 marked steelhead prior to release of the hatchery steelhead. Assuming all of these smolts were from these fry plants, the result is a fry-to-smolt survival of 28%, over twice the survival rate of Bear Creek plants. This survival estimate is conservative since it is based solely on those smolts that passed the trap prior to May 10. Undoubtedly additional smolts resulting from the fry plant would have left after May 10. By comparison, we estimated the fry to smolt survival of Bear Creek fry plants at 10% for the 1997 release and 12% for the 1998 release. The Issaquah Creek survival rate for the 1998 brood releases, while plausible, seems a little high and may indicate that we underestimated the cutthroat and steelhead capture rate in Issaquah Creek.

If we instead assume steelhead trap efficiency is 60% of the coho efficiency rate as was used for the Cedar River and Bear Creek traps, the survival rate is reduced to 21.6%, still a very high survival rate for these releases. Although it is possible that steelhead fry survived twice as well in Issaquah Creek as they did in Bear Creek, there could be other valid explanations. For instance, we assume that all of the marked fish caught prior to May 10 were from the fry plants; however if some were hatchery escapees (as we believe occurred with age 0+ chinook and coho smolts), counting them with the fry plant smolts would inflate the marked catch and result in a higher fry-to-smolt survival. While Issaquah Creek undoubtedly contains better habitat than Bear Creek for steelhead rearing, we believe this alone would not account for the high survival rates measured. The inclusion of escaped marked hatchery steelhead in the count of what we assumed were marked steelhead from the supplemental releases is the most plausible explanation for what we believe are excessively high estimated survival rates.

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Appendix A

Estimated Chinook 0+ Migration, Cedar River Fry Trap 1999

Appendix A. Estimated chinook 0+ migration, Cedar River fry trap 1999.

Date	Catch Trap 2	Catch Trap 3	Flow (cfs)	Estimated Trap Efficiency Trap 2	Estimated Trap Efficiency Trap 3	Estimated Migration Night	Estimated Migration Prop. Night	Estimated Migration Total
01/23	16		2,060	2.3%		710	76%	935
01/24			1,960	2.3%		488	75%	650
01/25	6		1,890	2.3%		266	74%	358
01/26			1,840	2.3%		599	78%	767
01/27	21		1,780	2.3%		932	82%	1,139
01/28			1,630	2.3%		710	80%	883
01/29	11		1,600	2.3%		488	79%	618
01/30			1,600	2.3%		466	79%	590
01/31	10		1,560	2.3%		444	79%	562
Total	64					5,102		6,504

Date	Catch Trap 2	Catch Trap 3	Flow (cfs)	Estimated Trap Efficiency Trap 2	Estimated Trap Efficiency Trap 3	Estimated Migration Night	Estimated Migration Prop. Night	Estimated Migration Total
02/01	11	16	1,390	2.3%	3.3%	488	80%	610
02/02	20		1,390	2.3%		887	79%	1,109
02/03	12		1,340	2.3%		532	76%	662
02/04	13		1,210	2.3%		577	76%	731
02/05	11		1,140	2.3%		488	79%	643
02/06	9		1,150	2.3%		399	79%	526
02/07	27		1,300	2.3%		1,198	79%	1,518
02/08	13		1,250	2.3%		577	79%	731
02/09	8		1,160	2.3%		355	76%	450
02/10	12		996	2.3%		532	76%	674
02/11	3	3	929	2.3%	2.3%	133	78%	175
02/12	1		780	2.3%		44	79%	58
02/13	36	37	780	2.0%	2.0%	1,850	73%	2,370
02/14	83		775	2.0%		4,265	77%	5,404
02/15	16	8	740	2.0%		822	61%	1,119
02/16	59		690	2.0%		3,032	76%	3,915
02/17	39	44	646	6.0%	5.0%	759	71%	1,253
02/18	34		612	6.2%		549	77%	723
02/19	77	91	671	5.8%	4.9%	1,573	80%	2,217
02/20	13	17	619	6.2%	5.1%	268	74%	346
02/21	14	35	590	6.4%	5.2%	426	76%	530
02/22	72		627	6.1%		1,182	74%	1,592
02/23	21	27	713	5.5%	4.8%	468	74%	617
02/24		63	778		4.6%	1,378	79%	1,855
02/25		38	792		4.5%	839	76%	1,129
02/26		28	796		4.5%	553	74%	701
02/27		47	1,190		3.3%	1,417	73%	1,867
02/28		19	1,610		2.0%	933	73%	1,256
Total	604	470				26,525		34,782
Cum.	668	470				31,627		41,285

Appendix A. Estimated chinook 0+ migration, Cedar River fry trap 1999 (continued).

	Catch		Flow	Estimated Trap Efficiency		Estimated Migration				Catch		Flow	Estimated Trap Efficiency		Estimated Migration		
Date	Trap 2	Trap 3	(cfs)	Trap 2	Trap 3	Night	Prop. Night	Total	Date	Trap 2	Trap 3	(cfs)	Trap 2	Trap 3	Night	Prop. Night	Total
03/01		42	1,540		2.3%	1,867	74%	2,512	04/01		4	770		4.6%	87	69%	127
03/02		28	1,200		3.3%	852	77%	1,100	04/02		3	760		4.6%	65	71%	92
03/03		26	1,060		3.7%	700	73%	964	04/03		10	760		4.6%	216	69%	314
03/04		30	1,030		3.8%	789	77%	1,018	04/04		5	710		4.8%	105	69%	152
03/05		62	1,120		3.5%	1,756	73%	2,418	04/05		5	697		4.8%	104	69%	151
03/06	19	25	1,120	2.6%	3.5%	714	76%	941	04/06		2	686		4.9%	41	69%	60
03/07	14	10	1,090	2.8%	3.6%	371	73%	511	04/07		3	681		4.9%	62	72%	86
03/08		13	1,080		3.7%	356	73%	490	04/08		4	674		4.9%	82	67%	122
03/09		12	1,030		3.8%	315	73%	434	04/09		2	683		4.9%	41	65%	63
03/10		70	954		4.0%	1,734	71%	2,444	04/10		7	663		4.9%	142	65%	219
03/11		15	800		4.5%	333	71%	469	04/11		1	646		5.0%	20	67%	30
03/12		23	742		4.7%	491	71%	692	04/12		7	597		5.1%	137	65%	210
03/13		23	858		4.3%	531	71%	749	04/13		12	591		5.1%	233	65%	359
03/14		23	947		4.1%	567	71%	799	04/14		2	587		5.2%	39	65%	60
03/15		23	876		4.3%	538	71%	758	04/15		10	543		5.3%	189	65%	291
03/16		12	814		4.5%	269	71%	379	04/16		3	609		5.1%	59	65%	91
03/17		19	753		4.7%	409	69%	591	04/17		2	613		5.1%	39	65%	61
03/18		9	718		4.8%	189	77%	244	04/18		0	607		5.1%	33	65%	51
03/19		15	694		4.8%	311	69%	449	04/19		0	577		5.2%	26	65%	41
03/20		4	685		4.9%	82	69%	119	04/20		1	625		5.0%	20	65%	31
03/21		18	711		4.8%	377	67%	559	04/21		1	638		5.0%	20	65%	31
03/22		7	701		4.8%	146	66%	222	04/22		1	652		5.0%	20	65%	31
03/23		5	703		4.8%	104	67%	155	04/23		2	704		4.8%	42	65%	64
03/24		33	767		4.6%	716	67%	1,063	04/24		0	716		4.8%	49	65%	76
03/25		24	954		4.0%	595	67%	882	04/25		0	731		4.7%	57	65%	87
03/26		18	971		4.0%	452	66%	689	04/26		3	744		4.7%	64	65%	99
03/27		3	1,010		3.9%	78	69%	112	04/27		1	779		4.6%	65	65%	100
03/28		7	1,020		3.8%	183	67%	271	04/28		3	788		4.5%	66	63%	105
03/29		6	995		3.9%	153	67%	228	04/29		1	773		4.6%	22	60%	36
03/30		11	900		4.2%	262	66%	400	04/30		0	768		4.6%	22	59%	37
03/31		18	863		4.3%	417	66%	637									
Total	33	634				16,658		23,301	Total		95				2,166		3,274
Cum.	701	1,104				48,285		64,586	Cum.	701	1,199				50,451		67,86

Appendix A. Estimated chinook 0+ migration, Cedar River fry trap 1999 (continued).

Date	Catch Trp 2	Catch Trp 3	Flow (cfs)	Estimated Trap Efficiency Trap 2	Estimated Trap Efficiency Trap 3	Estimated Migration Night	Estimated Migration Prop. Night	Estimated Migration Total	Date	Catch Trap 2	Catch Trap 3	Flow (cfs)	Estimated Trap Efficiency Trap 2	Estimated Trap Efficiency Trap 3	Estimated Migration Night	Estimated Migration Prop. Night	Estimated Migration Total
05/01		1	755		4.6%	22	77%	28									
05/02		0	788		4.5%	0	76%	0									
05/03		1	832		4.4%	23	75%	30									
05/04		4	787		4.6%	88	76%	116									
05/05		0	734		4.7%	0	74%	0									
05/06		0	672		4.9%	0	76%	0									
05/07		2	663		4.9%	41	76%	54									
05/08		2	625		5.0%	40	75%	53									
05/09		0	639		5.0%	0	75%	0									
05/10		1	626		5.0%	20	76%	26									
05/11		2	627		5.0%	40	76%	53									
05/12		0	622		5.1%	0	76%	0									
05/13		0	601		5.1%	0	76%	0									
05/14		2	587		5.2%	39	76%	51									
05/15		1	584		5.2%	19	75%	26									
05/16		0	593		5.1%	0	75%	0									
05/17			631		5.0%												
05/18		0	754		4.7%	0	74%	0									
05/19			740		4.7%												
05/20		0	661		4.9%	0	75%	0									
05/21			601		5.1%												
05/22		0	587		5.2%	0	76%	0									
05/23			589		5.2%												
05/24			595		5.1%												
05/25		0	729		4.7%	0	75%	0									
05/26			770		4.6%												
05/27			655		5.0%												
05/28		0	664		4.9%	0	70%	0									
Total		16				330		437									
Cum.	701	1,21				50,782		68,297									

Appendix B

Actual Daily Smolt Catches and Estimated Potential Catches Assuming a 24-Hour Trapping Day, Cedar River Screw Trap 1999

Appendix B. Actual daily smolt catches and estimated potential catches assuming a 24-hour trapping day, Cedar River screw trap 1999.

	Hours		Actual Daily Catch				Expanded Daytime Catch				Expanded Nighttime Catch				Estimated 24-Hour Catch			
Date	Fished	Out	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
03/18	9.00	15.00	24	0	0	1	34	0	0	2	37	0	0	0	71	0	0	2
03/19	23.17	0.83	84	6	2	2	16	0	0	0	71	6	2	2	87	6	2	2
03/20	23.75	0.25	72	9	0	3	14	0	0	0	58	9	0	3	72	9	0	3
03/21	24.00	0.00	30	9	1	3	10	0	0	0	20	9	1	3	30	9	1	3
03/22	24.00	0.00	57	3	1	4	11	0	0	0	46	3	1	4	57	3	1	4
03/23	24.00	0.00	25	8	0	5	5	0	0	0	20	8	0	5	25	8	0	5
03/24	24.00	0.00	42	6	1	7	9	0	0	0	33	6	1	7	42	6	1	7
03/25	23.75	0.25	37	3	1	4	13	0	0	0	24	3	1	4	37	3	1	4
03/26	23.75	0.25	46	13	1	10	21	4	0	6	25	9	1	4	46	13	1	10
03/27	23.50	0.50	24	2	0	5	13	1	0	0	12	1	0	5	25	2	0	5
03/28	24.00	0.00	10	3	0	5	4	0	0	0	6	3	0	5	10	3	0	5
03/29	24.00	0.00	6	5	0	4	2	1	0	0	4	4	0	4	6	5	0	4
03/30	23.67	0.33	15	8	1	5	3	1	0	0	13	7	1	5	16	8	1	5
03/31	23.50	0.50	38	7	0	2	5	0	0	0	34	7	0	2	39	7	0	2
04/01	23.50	0.50	42	12	0	1	3	0	0	0	40	12	0	1	43	12	0	1
04/02	23.33	0.67	21	14	1	3	0	0	0	0	21	14	1	3	21	14	1	3
04/03	23.42	0.58	16	7	0	6	6	0	0	0	10	7	0	6	16	7	0	6
04/04	23.42	0.58	19	8	0	4	6	0	0	0	13	8	0	4	19	8	0	4
04/05	23.50	0.50	16	10	0	3	3	0	0	0	13	10	0	3	16	10	0	3
04/06	23.42	0.58	15	12	0	3	2	0	0	0	13	12	0	3	15	12	0	3
04/07	23.42	0.58	10	11	0	3	0	1	0	0	11	10	0	3	11	11	0	3
04/08	23.17	0.83	16	9	3	2	1	0	0	0	15	10	3	2	16	10	3	2
04/09	23.42	0.58	17	9	1	2	4	0	0	0	13	9	1	2	17	9	1	2
04/10	23.50	0.50	20	11	0	1	2	0	0	0	19	11	0	1	21	11	0	1
04/11	23.42	0.58	29	13	0	3	5	0	0	0	24	13	0	3	30	13	0	3
04/12	23.33	0.67	15	14	0	2	2	0	0	0	14	15	0	2	16	15	0	2
04/13	11.25	12.75	22	19	0	4	3	1	0	0	22	19	0	4	25	20	0	4
04/14	23.42	0.58	19	21	1	5	4	2	0	0	15	20	1	5	19	22	1	5
04/15	11.50	12.50	12	13	0	3	4	2	0	0	12	13	0	3	16	15	0	3

Appendix B. Actual smolt catches and estimated potential catches assuming a 24-hour trapping day, Cedar River screw trap 1999 (continued).

	Hours		Actual Daily Catch				Expanded Daytime Catch				Expanded Nighttime Catch				Estimated 24-Hour Catch			
Date	Fished	Out	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
04/16	23.42	0.58	15	17	0	1	4	2	0	0	11	16	0	1	15	18	0	1
04/17	7.00	17.00	8	12	0	0	2	2	0	0	11	22	0	1	13	24	0	1
04/18	4.50	19.50	1	12	0	1	2	2	0	0	6	27	0	2	8	29	0	2
04/19	23.50	0.50	5	28	0	2	1	1	0	0	4	28	0	2	5	29	0	2
04/20	10.75	13.25	4	23	1	4	2	2	0	1	4	23	1	4	6	25	1	5
04/21	24.00	0.00	4	24	1	6	3	3	0	1	1	21	1	5	4	24	1	6
04/22	23.50	0.50	8	43	5	7	5	24	3	4	3	20	2	3	8	44	5	7
04/23	23.75	0.25	5	23	2	4	1	2	0	0	4	21	2	4	5	23	2	4
04/24	7.00	17.00	1	9	0	2	3	7	1	1	3	20	1	3	5	27	1	4
04/25	5.00	19.00	3	16	1	1	3	7	1	1	6	32	2	3	8	39	2	4
04/26	24.00	0.00	7	36	4	2	2	2	0	0	5	34	4	2	7	36	4	2
04/27	11.50	12.50	4	37	6	3	2	1	0	0	4	37	6	3	6	38	6	3
04/28	24.00	0.00	5	49	5	3	1	0	0	0	4	49	5	3	5	49	5	3
04/29	24.00	0.00	7	70	3	2	1	1	0	0	6	69	3	2	7	70	3	2
04/30	9.33	14.67	7	60	5	3	3	1	0	0	7	60	5	3	10	61	5	3
05/01	7.00	17.00	4	38	2	3	2	1	0	0	6	67	4	6	8	68	4	6
05/02	4.00	20.00	2	36	2	4	2	1	0	0	5	83	5	9	7	84	5	9
05/03	24.00	0.00	5	157	17	9	2	105	13	4	3	52	4	5	5	157	17	9
05/04	24.00	0.00	5	105	8	5	1	1	0	0	4	104	8	5	5	105	8	5
05/05	24.00	0.00	10	124	7	6	3	1	0	0	7	123	7	6	10	124	7	6
05/06	24.00	0.00	9	116	16	4	3	1	0	0	6	115	16	4	9	116	16	4
05/07	22.17	1.83	12	116	21	4	5	2	0	0	8	114	21	4	13	116	21	4
05/08	6.17	17.83	4	76	13	4	3	21	3	1	7	138	22	6	10	159	25	7
05/09	4.00	20.00	4	75	9	2	3	21	3	1	9	176	23	6	12	197	26	6
05/10	9.50	14.50	9	171	14	2	1	2	0	1	9	171	14	2	10	173	14	3
05/11	20.08	3.92	6	93	0	3	3	0	0	3	9	150	4	0	12	150	4	3
05/12	18.00	6.00	11	47	8	0	2	0	0	0	18	134	14	0	20	134	14	0
05/13	24.00	0.00	23	144	23	2	1	5	0	0	22	139	23	2	23	144	23	2
05/14	16.08	0.17	21	169	24	1	1	1	1	0	20	171	23	1	21	172	24	1
05/15	10.75	13.25	24	184	23	1	3	2	0	0	24	184	23	1	27	186	23	1
05/16	11.00	13.00	32	162	19	0	4	1	0	0	32	162	19	0	36	163	19	0
05/17	24.00	0.00	36	153	12	1	8	1	0	0	28	152	12	1	36	153	12	1

Appendix B. Actual smolt catches and estimated potential catches assuming a 24-hour trapping day, Cedar River screw trap 1999 (continued).

	Hours		Actual Daily Catch				Expanded Daytime Catch				Expanded Nighttime Catch				Estimated 24-Hour Catch			
Date	Fished	Out	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
05/18	24.00	0.00	44	303	29	2	12	3	0	0	32	300	29	2	44	303	29	2
05/19	24.00	0.00	46	279	22	1	7	1	0	0	39	278	22	1	46	279	22	1
05/20	24.00	0.00	32	166	18	1	5	2	0	0	27	164	18	1	32	166	18	1
05/21	24.00	0.00	32	132	22	1	3	0	1	0	29	132	21	1	32	132	22	1
05/22	10.00	14.00	30	167	22	1	7	1	0	0	30	167	22	1	37	168	22	1
05/23	10.00	14.00	17	131	15	0	4	1	0	0	17	131	15	0	21	132	15	0
05/24	24.00	0.00	8	144	21	1	1	0	0	0	7	144	21	1	8	144	21	1
05/25	24.00	0.00	26	133	11	1	4	1	0	0	22	132	11	1	26	133	11	1
05/26	9.75	14.25	44	152	13	1	3	2	0	0	44	152	13	1	47	154	13	1
05/27	23.25	0.75	42	78	9	1	2	2	0	0	40	76	9	1	42	78	9	1
05/28	24.00	0.00	55	78	10	0	6	1	0	0	49	77	10	0	55	78	10	0
05/29	8.50	15.50	82	86	14	0	6	1	0	0	82	86	14	0	88	87	14	0
05/30	11.50	12.50	61	74	18	1	4	1	0	0	87	102	25	1	92	102	25	1
05/31	10.17	13.83	30	26	7	0	5	0	0	0	77	75	19	0	82	75	19	0
06/01	23.75	0.25	81	48	16	1	2	0	0	0	79	48	16	1	81	48	16	1
06/02	24.00	0.00	107	45	19	3	3	0	0	0	104	45	19	3	107	45	19	3
06/03	24.00	0.00	91	49	13	3	6	0	0	0	85	49	13	3	91	49	13	3
06/04	24.00	0.00	69	31	7	1	12	0	0	0	57	31	7	1	69	31	7	1
06/05	11.50	12.50	107	24	8	2	8	0	0	0	107	24	8	2	115	24	8	2
06/06	10.50	13.50	150	27	10	5	8	0	0	0	150	27	10	5	158	27	10	5
06/07	24.00	0.00	26	13	1	1	2	0	0	0	44	21	2	2	46	21	2	2
06/08	23.67	0.33	31	10	2	2	2	0	0	0	59	22	4	4	61	22	4	4
06/09	24.00	0.00	61	22	3	5	2	0	0	0	59	22	3	5	61	22	3	5
06/10	24.00	0.00	39	14	1	4	0	0	0	0	39	14	1	4	39	14	1	4
06/11	24.00	0.00	26	5	2	3	2	0	0	0	24	5	2	3	26	5	2	3
06/12	11.00	13.00	18	2	3	3	2	1	0	0	18	2	3	3	20	3	3	3
06/13	24.00	0.00	14	7	0	0	1	2	0	0	13	5	0	0	14	7	0	0
06/14	24.00	0.00	24	10	1	0	1	2	0	0	23	8	1	0	24	10	1	0
06/15	11.75	12.25	25	6	0	1	1	0	0	0	25	6	0	1	26	6	0	1
06/16	11.25	12.75	43	4	0	2	2	0	0	0	43	4	0	2	45	4	0	2
06/17	11.50	12.50	56	4	0	1	2	0	0	0	56	4	0	1	58	4	0	1
06/18	11.75	12.25	31	2	1	0	2	0	0	0	31	2	1	0	33	2	1	0

Appendix B. Actual smolt catches and estimated potential catches assuming a 24-hour trapping day, Cedar River screw trap 1999 (continued).

	Hours		Actual Daily Catch				Expanded Daytime Catch				Expanded Nighttime Catch				Estimated 24-Hour Catch			
Date	Fished	Out	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
06/19	10.75	13.25	68	1	0	1	4	0	0	0	68	1	0	1	72	1	0	1
06/20	11.00	13.00	101	3	0	2	4	0	0	0	101	3	0	2	105	3	0	2
06/21	11.00	13.00	78	4	0	2	4	0	0	0	78	4	0	2	82	4	0	2
06/22	12.00	12.00	103	0	1	2	4	0	0	0	103	0	1	2	107	0	1	2
06/23	12.58	11.42	46	1	0	1	2	0	0	0	66	1	0	3	68	1	0	3
06/24	9.75	14.25	7	0	0	1	3	0	0	0	48	0	0	4	51	0	0	4
06/25	10.50	13.50	41	3	1	5	2	0	0	0	41	3	1	5	43	3	1	5
06/26	11.00	13.00	32	2	1	5	2	0	0	0	32	2	1	5	34	2	1	5
06/27	11.00	13.00	57	4	0	8	2	0	0	0	57	4	0	8	59	4	0	8
06/28	10.00	14.00	32	2	0	8	2	0	0	0	32	2	0	8	34	2	0	8
06/29	12.50	11.50	43	1	0	4	1	0	0	0	43	1	0	4	44	1	0	4
06/30	13.00	11.00	39	0	0	3	1	0	0	0	39	0	0	3	40	0	0	3
07/01	12.75	11.25	38	0	0	0	1	0	0	0	38	0	0	0	39	0	0	0
07/02	14.00	10.00	44	0	1	3	1	0	0	0	44	0	1	3	45	0	1	3
07/03	8.75	15.25	40	2	2	3	2	0	0	0	40	2	2	3	42	2	2	3
07/04	10.50	13.50	25	2	2	4	1	0	0	0	25	2	2	4	26	2	2	4
07/05	10.75	13.25	12	3	0	0	0	0	0	0	12	3	0	0	12	3	0	0
07/06	12.00	12.00	8	11	0	1	0	0	0	0	8	11	0	1	8	11	0	1
07/07	11.00	13.00	7	1	0	0	0	0	0	0	7	1	0	0	7	1	0	0
07/08	10.50	13.50	9	0	1	0	1	0	0	0	9	0	1	0	10	0	1	0
07/09	10.50	13.50	12	2	0	2	0	0	0	0	12	2	0	2	12	2	0	2
07/10	10.50	13.50	6	1	0	1	0	0	0	0	6	1	0	1	6	1	0	1
07/11	10.00	14.00	7	1	0	0	0	0	0	0	7	1	0	0	7	1	0	0
07/12	12.50	11.50	11	2	0	1	0	0	0	0	11	2	0	1	11	2	0	1
07/13	12.25	11.75	13	1	0	0	0	0	0	0	13	1	0	0	13	1	0	0
07/14	11.00	13.00	13	0	0	2	1	0	0	0	13	0	0	2	14	0	0	2
07/15	11.00	13.00	29	1	0	2	1	0	0	0	29	1	0	2	30	1	0	2
07/16	9.50	14.50	16	2	1	2	1	0	0	0	16	2	1	2	17	2	1	2
07/17	9.50	14.50	27	0	1	1	1	0	0	0	27	0	1	1	28	0	1	1
07/18	14.50	9.50	16	1	0	1	0	0	0	0	16	1	0	1	16	1	0	1
07/19	11.50	12.50	7	2	0	0	0	0	0	0	7	2	0	0	7	2	0	0
07/20	11.00	13.00	2	1	0	0	0	0	0	0	2	1	0	0	2	1	0	0

Appendix B. Actual smolt catches and estimated potential catches assuming a 24-hour trapping day, Cedar River screw trap 1999 (continued).

	Hours		Actual Daily Catch				Expanded Daytime Catch				Expanded Nighttime Catch				Estimated 24-Hour Catch			
Date	Fished	Out	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
07/21	11.00	13.00	10	0	0	0	1	0	0	0	10	0	0	0	11	0	0	0
07/22	11.00	13.00	20	0	0	0	1	0	0	0	20	0	0	0	21	0	0	0
07/23	11.00	13.00	15	1	0	0	1	0	0	0	15	1	0	0	16	1	0	0
07/24	12.00	12.00	14	0	0	2	1	0	0	0	14	0	0	2	15	0	0	2
07/25	12.00	12.00	11	0	0	5	0	0	0	0	11	0	0	5	11	0	0	5
07/26	10.75	13.50	3	1	0	3	0	0	0	0	3	1	0	3	3	1	0	3
07/27	7.00	17.00	5	0	0	0	0	0	0	0	7	0	0	0	8	0	0	0
Actual	2,190.75	969.75	3,715	5,018	594	320	296	175	18	19	3,419	4,843	576	301	3,715	5,018	594	320
Est.							168	84	8	6	264	541	61	28	433	625	69	34
Total							464	259	26	25	3,683	5,384	637	329	4,148	5,643	663	354
% Est.							36%	32%	30%	25%	7%	10%	10%	8%	10%	11%	10%	10%
% of Total							11%	5%	4%	7%	89%	95%	96%	93%				

Note: Shaded catch estimates indicate intervals when the trap was not fishing.
"Daytime" catch on May 3 includes night fishing (no trap check before midnight).
Assumes that the catch rates on March 18 and July 26 apply to the full 24-hour period (midnight to midnight).

Appendix C

Estimated Wild Chinook 0+ Migration, Cedar River 2000

Appendix C. Estimated wild chinook 0+ migration, Cedar River 2000.

Date	Catch Fry Trap	Catch Screw Trap	Estimated Trap Efficiency Fry Trap	Estimated Trap Efficiency Screw Trap	Estimated Migration Night	Estimated Migration Night/Total Ratio	Estimated Migration Total
01/01							12
01/02							24
01/03							36
01/04							47
01/05							59
01/06							71
01/07							83
01/08							95
01/09							106
01/10							118
01/11							130
01/12							142
01/13							154
01/14							166
01/15							178
01/16							189
01/17							201
01/18							213
01/19							225
01/20	1		8.23%		12	81.0%	15
01/21					401		495
01/22	65		8.23%		790	81.0%	975
01/23					413		514
01/24	3		8.23%		36	79.7%	46
01/25					67		83
01/26	8		8.23%		97	79.7%	122
01/27					104		175
01/28	15		8.23%		182	79.7%	229
01/29					103		135
01/30	2		8.23%		24	73.7%	33
01/31					142		185
Total	94				2,371		5,256

Date	Catch Fry Trap	Catch Screw Trap	Estimated Trap Efficiency Fry Trap	Estimated Trap Efficiency Screw Trap	Estimated Migration Night	Estimated Migration Night/Total Ratio	Estimated Migration Total
02/01					259		338
02/02	31		8.23%		377	79.7%	473
02/03					334		423
02/04	24		8.23%		292	78.3%	373
02/05					195		249
02/06	8		8.23%		97	78.3%	124
02/07	6		8.23%		73	79.7%	92
02/08	72		8.23%		875	79.7%	1,099
02/09	49		8.23%		596	79.7%	748
02/10	12		8.23%		146	81.0%	180
02/11	24		8.23%		292	79.7%	366
02/12	21		8.23%		255	79.7%	320
02/13	9		8.23%		109	77.5%	141
02/14	35		8.23%		426	79.7%	534
02/15	31		8.23%		377	79.7%	473
02/16	123		8.23%		1,495	79.7%	1,877
02/17	155		8.23%		1,884	79.7%	2,365
02/18	104		8.23%		1,264	79.7%	1,587
02/19	91		8.23%		1,106	79.7%	1,388
02/20	16		8.23%		195	79.7%	244
02/21	37		8.23%		450	79.7%	565
02/22	140		8.23%		1,702	79.7%	2,136
02/23	102		8.23%		1,240	78.5%	1,580
02/24	126		8.23%		1,532	79.4%	1,928
02/25	48		8.23%		584	79.2%	737
02/26	36		8.23%		438	79.4%	551
02/27	67		8.23%		815	79.7%	1,022
02/28	55		8.23%		669	78.3%	854
02/29	195		8.23%		2,371	81.0%	2,925
Total	1,617				20,448		25,692
Season	1,711				22,819		30,948

Appendix C. Estimated wild chinook 0+ migration, Cedar River 2000 (continued).

Date	Catch		Estimated Trap Efficiency		Estimated Migration			Date	Catch		Estimated Trap Efficiency		Estimated Migration		
	Fry Trap	Screw Trap	Fry Trap	Screw Trap	Night	Night/Total Ratio	Total		Fry Trap	Screw Trap	Fry Trap	Screw Trap	Night	Night/Total Ratio	Total
03/01	47		8.23%		571	79.0%	723	04/01	9		8.23%		109	77.5%	141
03/02	70		8.23%		851	79.7%	1,068	04/02	12		8.23%		146	76.0%	192
03/03	56		8.23%		681	79.7%	854	04/03	16		8.23%		195		198
03/04	55		8.23%		669	79.7%	839	04/04	21		8.23%		255	73.7%	346
03/05	26		8.23%		316		477	04/05	8		8.23%		97	76.8%	127
03/06	42		8.23%		511	79.4%	643	04/06	15		8.23%		182	73.7%	247
03/07	19		8.23%		231	79.0%	292	04/07	8		8.23%		97	73.7%	132
03/08	15		8.23%		182	79.7%	229	04/08	11		8.23%		134	73.7%	181
03/09	39		8.23%		474	79.7%	595	04/09	8		8.23%		97	73.7%	132
03/10	15		8.23%		182	79.0%	231	04/10	6		8.23%		73	73.7%	99
03/11	46		8.23%		559	78.3%	715	04/11	6		8.23%		73	73.7%	99
03/12	15		8.23%		182	79.0%	231	04/12	3		8.23%		36	73.7%	49
03/13	30		8.23%		365	78.3%	466	04/13	12		8.23%		146	73.7%	198
03/14	35		8.23%		426	78.3%	544	04/14	8		8.23%		97	72.9%	133
03/15	11		8.23%		134	80.1%	167	04/15	6		8.23%		73	72.0%	101
03/16	23		8.23%		280	79.7%	351	04/16	9		8.23%		109		148
03/17	16		8.23%		195	78.3%	249	04/17	10		8.23%		122	71.2%	171
03/18	21		8.23%		255	78.5%	325	04/18	1		8.23%		12	71.2%	17
03/19	62		8.23%		754	78.3%	963	04/19	2		8.23%		24	72.0%	34
03/20	13		8.23%		158	79.7%	198	04/20	2		8.23%		24	72.0%	34
03/21	12		8.23%		146	79.7%	183	04/21	1		8.23%		12	72.0%	17
03/22	25		8.23%		304	79.4%	383	04/22	4		8.23%		49	72.0%	68
03/23	34		8.23%		413		413	04/23	2		8.23%		24	68.5%	35
03/24	16		8.23%		195	76.8%	253	04/24	3		8.23%		36	68.5%	53
03/25	16		8.23%		195	76.8%	253	04/25	1		8.23%		12	72.0%	17
03/26	9		8.23%		109	77.8%	141	04/26	0		8.23%		0	67.4%	0
03/27	6		8.23%		73	77.8%	94	04/27		0		2.72%			0
03/28	8		8.23%		97	77.5%	125	04/28		6		2.72%			221
03/29	18		8.23%		219	76.8%	285	04/29		9		2.72%			331
03/30	12		8.23%		146	75.3%	194	04/30		5		2.72%			184
03/31	6		8.23%		73	73.7%	99								
Total	818				9,946		12,583	Total	184	20			2,234		3,705
Season	2,529				32,765		43,531	Season	2,713	20			34,999		47,236

Appendix C. Estimated wild chinook 0+ migration, Cedar River 2000 (continued).

Date	Catch		Estimated Trap Efficiency		Estimated Migration			Date	Catch		Estimated Trap Efficiency		Estimated Migration		
	Fry Trap	Screw Trap	Fry Trap	Screw Trap	Night	Night/Total Ratio	Total		Fry Trap	Screw Trap	Fry Trap	Screw Trap	Night	Night/Total Ratio	Total
05/01		2		2.72%			74	06/01		67		9.66%			694
05/02		1		2.72%			37	06/02		30		9.66%			311
05/03		6		2.72%			221	06/03		37		9.66%			383
05/04		11		9.66%			114	06/04		12		9.66%			124
05/05		17		9.66%			176	06/05		13		9.66%			135
05/06		21		9.66%			217	06/06		21		9.66%			217
05/07		16		9.66%			166	06/07		28		9.66%			290
05/08		13		9.66%			135	06/08		60		9.66%			621
05/09		32		9.66%			331	06/09		95		9.66%			984
05/10		66		9.66%			684	06/10		74		9.66%			766
05/11		41		9.66%			425	06/11		21		9.66%			217
05/12		13		9.66%			135	06/12		3		9.66%			31
05/13		12		9.66%			124	06/13		6		9.66%			62
05/14		6		9.66%			62	06/14		24		9.66%			249
05/15		7		9.66%			72	06/15		33		9.66%			342
05/16		6		9.66%			62	06/16		32		9.66%			331
05/17		16		9.66%			166	06/17		15		9.66%			155
05/18		26		9.66%			269	06/18		23		9.66%			238
05/19		6		9.66%			62	06/19		47		9.66%			487
05/20		25		9.66%			259	06/20		29		9.66%			300
05/21		32		9.66%			331	06/21		22		9.66%			228
05/22		11		9.66%			114	06/22		15		9.66%			155
05/23		13		9.66%			135	06/23		28		9.66%			290
05/24		25		9.66%			259	06/24		24		9.66%			249
05/25		56		9.66%			580	06/25		27		9.66%			280
05/26		35		9.66%			362	06/26		15		9.66%			155
05/27		28		9.66%			290	06/27		14		9.66%			145
05/28		20		9.66%			207	06/28		14		9.66%			145
05/29		22		9.66%			228	06/29		10		9.66%			104
05/30		37		9.66%			383	06/30		20		9.66%			207
05/31		100		9.66%			1,036								176
Total		722					7,715	Total		859					8,897
Season		3,455			34,999		54,951	Season		4,4314			34,999		63,848

Appendix C. Estimated wild chinook 0+ migration, Cedar River 2000 (continued).

Date	Catch		Estimated Trap Efficiency		Estimated Migration		
	Fry Trap	Screw Trap	Fry Trap	Screw Trap	Night	Night/Tot Ratio	Total
07/01		17		9.66%			176
07/02		17		9.66%			176
07/03		4		9.66%			41
07/04		6		9.66%			62
07/05		8		9.66%			83
07/06		5		9.66%			52
07/07		4		9.66%			41
07/08				9.66%			36
07/09		3		9.66%			31
07/10		11		9.66%			114
07/11		4		9.66%			41
07/12		2		9.66%			21
07/13		0		9.66%			0
Total		81					875
Season		4,395			34,999		64,723

Note: Shaded sections represent periods when the trap either did not fish or fished only a partial night.

Night/total ratios vary based on the length of the nighttime fished period and the relative proportion of day/night catch rates. Where night/total ratios are not found for fry trap estimates between February 6 and April 26, some daytime fishing occurred which provided daytime catch rates from which estimates were made.

Wild Chinook Production Estimate			
	Migration Dates		
Estimate Source	Start	Finish	Total Migration
Prior to Trapping	Jan 1	Jan 19	2,248
Fry Trap	Jan 20	Apr 26	44,252
Screw Trap	Apr 27	Jul 13	18,223
Total	Jan 1	Jul 13	64,723

Appendix D

Daily Downstream Migrant Catches, Cedar River Screw Trap 2000

Appendix D. Daily downstream migrant catches, Cedar River screw trap 2000.

	Chinook		Chinook 0+		Chum	Coho		Sockeye		Trout	Steelhead	Cutthroat
Date	0+	1+	Unmarked	Marked	Fry	0+	1+	Fry	1+	Parr	Smolts	Smolts
04/27	0	0	0	0	0	3	8	754	0	0	0	0
04/28	6	0	6	0	0	1	20	1,516	0	0	0	0
04/29	9	0	9	0	0	3	20	1,057	0	0	1	0
04/30	5	0	5	0	0	0	15	722	0	0	0	0
05/01	2	0	2	0	0	1	8	1,138	0	0	0	0
05/02	1	0	1	0	0	0	10	1,127	0	0	0	0
05/03	6	0	6	0	0	0	117	1,083	0	0	5	6
05/04	11	0	11	0	1	0	183	1,468	0	0	6	8
05/05	17	0	17	0	0	0	132	1,561	0	0	5	1
05/06	21	0	21	0	0	0	106	1,021	0	0	3	1
05/07	16	0	16	0	0	0	99	1,657	0	0	2	0
05/08	13	0	13	0	0	0	66	667	0	0	2	0
05/09	32	0	32	0	0	0	187	712	0	0	4	5
05/10	66	0	66	0	0	2	304	707	0	0	6	8
05/11	41	0	41	0	0	1	202	334	0	0	9	3
05/12	13	0	13	0	0	0	113	225	0	0	7	1
05/13	12	0	12	0	0	0	64	216	0	1	2	1
05/14	6	0	6	0	0	0	51	124	0	0	4	2
05/15	7	0	7	0	0	0	54	142	0	0	1	0
05/16	6	0	6	0	0	0	17	155	0	0	1	1
05/17	16	0	16	0	0	0	39	234	0	0	1	0
05/18	26	0	26	0	0	0	22	93	0	0	0	1
05/19	6	0	6	0	0	0	15	46	0	0	1	0
05/20	25	0	25	0	0	0	50	73	0	0	2	1
05/21	32	0	32	0	0	0	40	49	0	0	2	1
05/22	11	0	11	0	0	0	25	84	0	0	0	0
05/23	13	0	13	0	0	0	12	56	0	0	0	0
05/24	25	0	25	0	0	0	30	42	0	0	1	0

Appendix D. Daily downstream migrant catches, Cedar River screw trap 2000 (continued).

	Chinook		Chinook 0+		Chum	Coho		Sockeye		Trout	Steelhead	Cutthroat
Date	0+	1+	Unmarked	Marked	Fry	0+	1+	Fry	1+	Parr	Smolts	Smolts
05/25	56	0	56	0	0	0	103	50	0	0	4	1
05/26	35	0	35	0	0	0	42	71	0	0	1	0
05/27	28	0	28	0	0	2	35	112	1	0	1	0
05/28	20	0	20	0	0	1	15	144	1	0	2	0
05/29	22	0	22	0	0	1	11	195	1	0	1	0
05/30	37	0	37	0	0	0	19	163	1	0	1	1
05/31	100	0	100	0	0	0	36	164	0	1	3	2
06/01	67	0	67	0	0	0	31	222	0	0	2	1
06/02	31	0	30	1	0	0	22	204	1	0	2	1
06/03	39	0	37	2	0	0	20	221	2	0	1	0
06/04	17	1	12	5	0	0	8	129	3	0	1	1
06/05	24	0	13	11	0	0	11	94	5	0	0	0
06/06	27	0	21	6	0	0	11	35	0	0	0	0
06/07	31	0	28	3	0	0	8	61	0	0	1	0
06/08	62	0	60	2	0	0	12	98	0	0	0	1
06/09	102	0	95	7	0	0	15	76	0	0	0	0
06/10	75	0	74	1	0	0	6	82	0	1	0	0
06/11	21	0	21	0	0	0	2	99	0	0	0	0
06/12	3	0	3	0	0	0	0	0	0	0	0	0
06/13	6	0	6	0	0	0	2	9	0	0	0	1
06/14	25	0	24	1	0	1	5	30	0	0	1	3
06/15	35	0	33	2	0	1	0	27	0	0	0	4
06/16	39	0	32	7	0	0	3	68	0	0	0	6
06/17	23	0	15	8	0	0	4	76	0	0	0	5
06/18	31	0	23	8	0	0	2	49	0	0	0	5
06/19	49	0	47	2	0	0	2	37	0	0	0	2
06/20	32	0	29	3	0	0	2	25	0	0	0	1
06/21	32	0	22	10	0	0	1	65	0	0	0	1

Appendix D. Daily downstream migrant catches, Cedar River screw trap 2000 (continued).

	Chinook		Chinook 0+		Chum	Coho		Sockeye		Trout	Steelhead	Cutthroat
Date	0+	1+	Unmarked	Marked	Fry	0+	1+	0+	1+	Parr	Smolts	Smolts
06/22	21	0	15	6	0	0	0	16	0	0	0	0
06/23	39	0	28	11	0	0	0	7	0	0	0	0
06/24	34	0	24	10	0	0	1	6	0	0	0	0
06/25	32	0	27	5	0	0	0	37	0	0	0	0
06/26	20	0	15	5	0	0	1	78	0	0	0	1
06/27	20	0	14	6	0	0	0	51	0	0	0	0
06/28	18	0	14	4	0	0	0	30	0	0	0	0
06/29	13	0	10	3	0	0	1	37	0	0	0	0
06/30	22	0	20	2	0	1	1	12	0	0	0	1
07/01	19	0	17	2	0	1	0	18	0	0	0	0
07/02	19	0	17	2	0	0	1	31	0	0	0	0
07/03	6	0	4	2	0	0	0	21	0	2	0	0
07/04	8	0	6	2	0	0	1	23	0	0	0	2
07/05	9	0	8	1	0	0	1	38	0	0	1	3
07/06	8	0	5	3	0	1	0	30	0	0	0	0
07/07	6	0	4	2	0	0	0	13	0	0	0	0
07/09	4	0	3	1	0	0	0	3	0	0	0	1
07/10	12	0	11	1	0	1	0	7	0	0	0	1
07/11	5	0	4	1	0	3	1	2	0	0	0	2
07/12	3	0	2	1	0	2	1	8	0	0	0	3
07/13	0	0	0	0	0	0	0	0	0	0	0	0
	1,831	1	1,682	149	1	26	2,446	20,137	15	5	87	90

Appendix E

Daily Migrant Chinook 0+, Coho Smolt, and Sockeye Fry Catches and Migration Estimates, Bear Creek 1999

Appendix E. Daily migrant age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek 1999.

	Flow	HOURS		ACTUAL CATCH			EXPANDED CATCH			ESTIMATED MIGRATION		
Date	(cfs)	Fished	Out	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye
02/23	152	9.50	0.00	6	0	3,868	6	0	3,868	24	0	15,654
02/24	275	17.00	7.00	9	0	4,973	12	0	9,077	49	0	36,736
02/25	315	16.00	8.00	29	0	3,068	29	0	6,877	117	0	27,832
02/26	244	16.50	7.50	20	0	6,376	20	0	8,990	81	0	36,384
02/27	249	24.00	0.00	10	0	6,663	10	0	6,663	40	0	26,966
02/28	**262**	**24.00**	**0.00**	**9**	**0**	**4,724**	**9**	**0**	**4,724**	**36**	**0**	**19,119**
03/01	246	24.00	0.00	3	0	5,468	3	0	5,468	12	0	22,130
03/02	208	24.00	0.00	10	0	6,226	10	0	6,226	40	0	25,198
03/03	191	24.00	0.00	11	1	7,933	11	1	7,933	45	1	32,106
03/04	171	24.00	0.00	9	1	10,724	9	1	10,724	36	1	43,402
03/05	142	24.00	0.00	15	1	10,103	15	1	10,103	61	1	40,888
03/06	123	24.00	0.00	13	1	8,737	13	1	8,737	53	1	35,360
03/07	108	24.00	0.00	9	2	4,449	9	2	4,449	36	3	18,006
03/08	101	24.00	0.00	11	0	9,490	11	0	9,490	45	0	38,407
03/09	122	24.00	0.00	3	5	8,314	3	5	8,314	12	7	33,648
03/10	103	24.00	0.00	6	0	10,076	6	0	10,076	24	0	40,779
03/11	92	24.00	0.00	7	0	10,501	7	0	10,501	28	0	42,499
03/12	90	24.00	0.00	16	0	14,186	16	0	14,186	65	0	57,413
03/13	185	18.75	5.25	14	0	15,314	14	0	15,481	57	0	62,654
03/14	287	23.00	1.00	11	0	11,800	11	0	11,800	45	0	47,756
03/15	236	24.00	0.00	3	0	14,592	3	0	14,592	12	0	59,056
03/16	190	24.00	0.00	2	1	15,747	2	1	15,747	8	1	63,730
03/17	156	24.00	0.00	3	1	15,127	3	1	15,127	12	1	61,221
03/18	135	24.00	0.00	3	2	13,355	3	2	13,355	12	2	54,050
03/19	119	24.00	0.00	3	1	12,098	3	1	12,098	12	1	48,962
03/20	102	24.00	0.00	3	4	12,153	3	4	12,153	12	7	49,185
03/21	93	24.00	0.00	6	2	12,964	6	2	12,964	24	4	52,467
03/22	89	24.00	0.00	2	2	15,328	2	2	15,328	8	4	62,035

Appendix E. Daily migrant age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek 1999 (continued).

	Flow	HOURS		ACTUAL CATCH			EXPANDED CATCH			ESTIMATED MIGRATION		
Date	(cfs)	Fished	Out	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye
03/23	88	24.00	0.00	1	3	7,972	1	3	7,972	4	6	32,264
03/24	81	24.00	0.00	8	4	11,512	8	4	11,512	32	10	46,591
03/25	99	24.00	0.00	7	1	10,885	7	1	10,885	28	2	44,053
03/26	92	24.00	0.00	5	4	5,441	5	4	5,441	20	8	22,021
03/27	102	24.00	0.00	5	4	2,704	5	4	2,704	20	7	10,943
03/28	105	24.00	0.00	2	3	1,090	2	3	1,090	8	5	4,411
03/29	113	23.00	1.00	1	6	1,611	1	6	1,611	4	9	6,520
03/30	105	24.00	0.00	0	12	1,852	0	12	1,852	0	19	7,495
03/31	91	24.00	0.00	7	22	1,293	7	22	1,293	28	44	5,233
04/01	82	24.00	0.00	6	19	875	6	19	875	24	46	3,541
04/02	79	24.00	0.00	10	15	943	10	15	943	40	38	3,816
04/03	124	24.00	0.00	10	16	710	10	16	710	40	21	2,873
04/04	107	24.00	0.00	2	13	848	2	13	848	8	21	3,432
04/05	95	24.00	0.00	1	9	831	1	9	831	4	17	3,363
04/06	83	24.00	0.00	2	12	768	2	12	768	8	28	3,108
04/07	78	24.00	0.00	0	10	548	0	10	548	0	26	2,218
04/08	80	24.00	0.00	2	8	882	2	8	882	8	20	3,570
04/09	91	24.00	0.00	0	10	483	0	10	483	0	20	1,955
04/10	82	24.00	0.00	1	7	332	1	7	332	4	17	1,344
04/11	73	24.00	0.00	0	7	259	0	7	259	0	20	1,048
04/12	69	24.00	0.00	2	5	336	2	5	336	8	16	1,360
04/13	65	24.00	0.00	2	9	400	2	9	400	8	33	1,619
04/14	61	24.00	0.00	2	14	133	2	14	133	8	59	538
04/15	58	24.00	0.00	2	10	50	2	10	50	8	46	202
04/16	55	11.00	13.00	2	14	37	3	27	51	12	142	206
04/17	53	11.00	13.00	3	21	72	4	34	86	16	202	348
04/18	52	23.50	0.50	5	24	115	5	24	115	20	148	465
04/19	55	23.50	0.50	1	18	37	1	18	37	4	96	150
04/20	62	23.50	0.50	1	23	36	1	23	36	4	94	146
04/21	61	23.50	0.50	1	24	29	1	24	29	4	102	117

Appendix E. Daily migrant age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek 1999 (continued).

	Flow	HOURS		ACTUAL CATCH			EXPANDED CATCH			ESTIMATED MIGRATION		
Date	(cfs)	Fished	Out	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye
04/22	56	24.00	0.00	3	58	34	3	58	34	12	303	138
04/23	52	24.00	0.00	3	100	34	3	100	34	12	613	138
04/24	50	24.00	0.00	2	97	22	2	97	22	8	672	89
04/25	63	24.00	0.00	1	86	16	1	86	16	4	341	65
04/26	61	24.00	0.00	2	163	6	2	163	6	8	698	24
04/27	59	24.00	0.00	5	167	2	5	167	2	20	760	8
04/28	59	24.00	0.00	6	379	10	6	379	10	24	1,697	40
04/29	54	24.00	0.00	10	350	7	10	350	7	40	1,934	28
04/30	51	24.00	0.00	4	334	2	4	334	2	16	2,205	8
05/01	50	24.00	0.00	8	396	3	8	396	3	32	2,840	12
05/02	51	24.00	0.00	7	307	6	7	307	6	28	2,075	24
05/03	60	24.00	0.00	28	415	9	28	415	9	113	1,792	36
05/04	57	24.00	0.00	30	802	10	30	802	10	121	3,941	40
05/05	55	24.00	0.00	35	839	4	35	839	4	142	4,513	16
05/06	59	24.00	0.00	37	737	1	37	737	1	150	3,318	4
05/07	59	24.00	0.00	25	432	0	25	432	0	101	1,982	0
05/08	54	24.00	0.00	23	397	0	23	397	0	93	2,247	0
05/09	53	24.00	0.00	32	417	3	32	417	3	130	2,430	12
05/10	49	24.00	0.00	31	282	6	31	282	6	125	2,134	24
05/11	46	23.67	0.33	16	190	1	16	190	1	65	1,788	4
05/12	48	24.00	0.00	10	133	0	10	133	0	40	1,070	0
05/13	53	24.00	0.00	38	156	4	38	156	4	154	902	16
05/14	57	24.00	0.00	89	277	7	89	277	7	194	810	28
05/15	52	24.00	0.00	72	484	1	72	484	1	158	1,416	4
05/16	48	24.00	0.00	102	538	3	102	538	3	224	1,574	12
05/17	64	24.00	0.00	160	452	2	160	452	2	351	1,322	8
05/18	82	24.00	0.00	125	448	0	125	448	0	274	1,311	0
05/19	68	24.00	0.00	67	384	0	67	384	0	147	1,123	0
05/20	60	24.00	0.00	90	511	1	90	511	1	197	1,495	4
05/21	52	24.00	0.00	158	444	0	158	444	0	346	1,299	0

Appendix E. Daily migrant age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek 1999 (continued).

	Flow	HOURS		ACTUAL CATCH			EXPANDED CATCH			ESTIMATED MIGRATION		
Date	(cfs)	Fished	Out	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye
05/22	49	24.00	0.00	121	468	2	121	468	2	265	1,369	8
05/23	52	24.00	0.00	144	471	8	144	471	8	316	1,378	32
05/24	49	24.00	0.00	66	302	2	66	302	2	145	883	8
05/25	45	24.00	0.00	533	968	0	533	968	0	1,168	2,832	0
05/26	42	24.00	0.00	324	435	1	324	435	1	710	1,273	4
05/27	36	24.00	0.00	423	233	3	423	233	3	927	682	12
05/28	34	24.00	0.00	339	141	4	339	141	4	743	412	16
05/29	32	24.00	0.00	283	95	1	283	95	1	620	278	4
05/30	31	24.00	0.00	149	64	0	149	64	0	327	187	0
05/31	33	24.00	0.00	116	54	2	116	54	2	254	158	8
06/01	44	24.00	0.00	160	103	7	160	103	7	351	301	28
06/02	48	24.00	0.00	147	76	8	147	76	8	322	222	32
06/03	43	24.00	0.00	97	93	2	97	93	2	213	272	8
06/04	41	24.00	0.00	62	10	2	62	10	2	136	29	8
06/05	39	24.00	0.00	14	6	0	73	13	0	160	38	0
06/06	37	24.00	0.00	60	20	1	105	25	1	230	73	4
06/07	38	24.00	0.00	86	19	1	86	19	1	189	56	4
06/08	38	24.00	0.00	107	20	0	107	20	0	235	59	0
06/09	35	24.00	0.00	137	28	2	137	28	2	300	82	8
06/10	33	24.00	0.00	108	20	0	108	20	0	237	59	0
06/11	31	24.00	0.00	71	10	0	71	10	0	156	29	0
06/12	28	24.00	0.00	83	15	0	83	15	0	182	44	0
06/13	27	24.00	0.00	172	16	1	172	16	1	377	47	4
06/14	32	24.00	0.00	156	11	1	156	11	1	342	32	4
06/15	29	24.00	0.00	86	8	0	86	8	0	189	23	0
06/16	26	24.00	0.00	33	1	0	33	1	0	72	3	0
06/17	26	24.00	0.00	43	3	1	43	3	1	94	9	4
06/18	32	24.00	0.00	53	3	2	53	3	2	116	9	8
06/19	30	24.00	0.00	34	3	0	34	3	0	75	9	0
06/20	30	24.00	0.00	14	2	0	14	2	0	31	6	0

Appendix E. Daily migrant age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek 1999 (continued).

	Flow	HOURS		ACTUAL CATCH			EXPANDED CATCH			ESTIMATED MIGRATION		
Date	(cfs)	Fished	Out	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye	Chinook	Coho	Sockeye
06/21	36	24.00	0.00	36	2	2	36	2	2	79	6	8
06/22	**45**	**24.00**	**0.00**	**22**	**2**	**5**	**22**	**2**	**5**	**48**	**6**	**20**
06/23	41	24.00	0.00	18	2	0	18	2	0	39	6	0
06/24	94	24.00	0.00	23	3	0	23	3	0	50	9	0
06/25	71	24.00	0.00	16	3	0	16	3	0	35	9	0
06/26	61	24.00	0.00	9	5	0	9	5	0	20	15	0
06/27	51	24.00	0.00	9	3	0	9	3	0	20	9	0
06/28	47	24.00	0.00	3	2	0	3	2	0	7	6	0
06/29	45	24.00	0.00	5	0	0	5	0	0	11	0	0
06/30	43	24.00	0.00	6	2	0	6	2	0	13	6	0
07/01	42	24.00	0.00	8	4	0	8	4	0	18	12	0
07/02	62	24.00	0.00	11	8	1	11	8	1	24	23	4
07/03	**99**	**24.00**	**0.00**	**5**	**2**	**0**	**5**	**2**	**0**	**11**	**6**	**0**
07/04	84	24.00	0.00	1	1	0	1	1	0	2	3	0
07/05	**70**	**24.00**	**0.00**	**3**	**2**	**0**	**3**	**2**	**0**	**7**	**6**	**0**
07/06	**53**	24.00	0.00	1	3	0	1	3	0	2	9	0
07/07	44	24.00	0.00	1	1	0	1	1	0	2	3	0
07/08	40	24.00	0.00	1	0	0	1	0	0	2	0	0
07/09	37	24.00	0.00	3	2	0	3	2	0	7	6	0
07/10	34	24.00	0.00	2	4	0	2	4	0	4	12	0
07/11	29	24.00	0.00	3	1	0	3	1	0	7	3	0
07/12	26	24.00	0.00	1	0	0	1	0	0	2	0	0
07/13	25	9.00	0.00	0	0	0	0	0	0	0	0	0
Total		3,278.25	76.25	5,964	14,896	327,694	6,073	14,934	338,416	14,600	62,970	1,369,611

Note: Shaded entries indicate screw stoppages which appeared to significantly reduce catch. On these dates, catches were estimated via catch/hour rates, from appropriate strata.
Bold entries indicate that the screw stoppage appeared to occur just before the trap check .
On April 15-16, we installed the Haskell Slough trap, and did not check Bear Creek more than once in a 24-hour period.
Chinook estimate used average sockeye trap efficiency while fishing in position 1(from Feb 23 to May 13) and average chinook trap efficiency while fishing in position 2 (From May 14 to July 13).

Appendix F

Daily Steelhead and Cutthroat Smolt Catches and Migration Estimates, Bear Creek 1999

Appendix F. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek 1999.

	Flow	Hours		ACTUAL CATCH			ESTIMATED MIGRATION		
				Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Fished	Out	Ad-Marked	Unmarked		Ad-Marked	Unmarked	
02/23	152	9.50	0.00	0	0	0	0	0	0
02/24	275	17.00	7.00	0	0	0	0	0	0
02/25	315	16.00	8.00	0	0	3	0	0	20
02/26	244	16.50	7.50	0	0	2	0	0	13
02/27	249	24.00	0.00	0	0	4	0	0	27
02/28	262	24.00	0.00	0	0	2	0	0	13
03/01	246	24.00	0.00	1	0	8	7	0	53
03/02	208	24.00	0.00	0	0	3	0	0	20
03/03	191	24.00	0.00	0	0	0	0	0	0
03/04	171	24.00	0.00	1	0	2	7	0	13
03/05	142	24.00	0.00	0	0	3	0	0	20
03/06	123	24.00	0.00	1	0	3	7	0	20
03/07	108	24.00	0.00	0	0	7	0	0	47
03/08	101	24.00	0.00	0	0	9	0	0	60
03/09	122	24.00	0.00	0	0	0	0	0	0
03/10	103	24.00	0.00	0	0	3	0	0	20
03/11	92	24.00	0.00	0	0	3	0	0	20
03/12	90	24.00	0.00	0	0	3	0	0	20
03/13	185	18.75	5.25	0	0	5	0	0	33
03/14	287	23.00	1.00	0	0	2	0	0	13
03/15	236	24.00	0.00	0	0	1	0	0	7
03/16	190	24.00	0.00	0	0	0	0	0	0
03/17	156	24.00	0.00	0	0	2	0	0	13
03/18	135	24.00	0.00	0	0	0	0	0	0
03/19	119	24.00	0.00	0	0	2	0	0	13
03/20	102	24.00	0.00	0	0	3	0	0	20
03/21	93	24.00	0.00	0	0	3	0	0	20
03/22	89	24.00	0.00	0	0	3	0	0	20

Appendix F. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek 1999 (continued).

	Flow	Hours		ACTUAL CATCH			ESTIMATED MIGRATION		
				Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Fished	Out	Ad-Marked	Unmarked		Ad-Marked	Unmarked	
03/23	88	24.00	0.00	1	0	3	7	0	20
03/24	81	24.00	0.00	0	0	2	0	0	13
03/25	99	24.00	0.00	1	0	3	7	0	20
03/26	92	24.00	0.00	0	0	4	0	0	27
03/27	102	24.00	0.00	0	0	3	0	0	20
03/28	105	24.00	0.00	0	1	1	0	7	7
03/29	113	23.00	1.00	1	0	2	7	0	13
03/30	105	24.00	0.00	0	0	1	0	0	7
03/31	91	24.00	0.00	0	0	9	0	0	60
04/01	82	24.00	0.00	1	0	5	7	0	33
04/02	79	24.00	0.00	0	0	7	0	0	47
04/03	124	24.00	0.00	1	0	7	7	0	47
04/04	107	24.00	0.00	0	2	2	0	13	13
04/05	95	24.00	0.00	2	1	16	13	7	107
04/06	83	24.00	0.00	1	0	12	7	0	80
04/07	78	24.00	0.00	0	0	4	0	0	27
04/08	80	24.00	0.00	0	0	1	0	0	7
04/09	91	24.00	0.00	0	0	6	0	0	40
04/10	82	24.00	0.00	0	0	5	0	0	33
04/11	73	24.00	0.00	0	0	7	0	0	47
04/12	69	24.00	0.00	2	0	11	13	0	73
04/13	65	24.00	0.00	1	0	2	7	0	13
04/14	61	24.00	0.00	1	2	6	7	13	40
04/15	58	24.00	0.00	1	1	14	7	7	93
04/16	55	11.00	13.00	1	0	19	7	0	127
04/17	53	11.00	13.00	1	0	1	7	0	7
04/18	52	23.50	0.50	1	1	2	7	7	13
04/19	55	23.50	0.50	0	1	1	0	7	7
04/20	62	23.50	0.50	0	2	0	0	13	0
04/21	61	23.50	0.50	1	2	2	7	13	13

Appendix F. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek 1999 (continued).

	Flow	Hours		ACTUAL CATCH			ESTIMATED MIGRATION		
				Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Fished	Out	Ad-Marked	Unmarked		Ad-Marked	Unmarked	
04/22	56	24.00	0.00	1	1	3	7	7	20
04/23	52	24.00	0.00	1	1	4	7	7	27
04/24	50	24.00	0.00	3	2	5	20	13	33
04/25	63	24.00	0.00	6	11	2	40	73	13
04/26	61	24.00	0.00	2	12	7	13	80	47
04/27	59	24.00	0.00	4	8	18	27	53	120
04/28	59	24.00	0.00	1	6	3	7	40	20
04/29	54	24.00	0.00	1	4	15	7	27	100
04/30	51	24.00	0.00	0	1	8	0	7	53
05/01	50	24.00	0.00	1	2	15	7	13	100
05/02	51	24.00	0.00	1	5	13	7	33	87
05/03	60	24.00	0.00	0	5	7	0	33	47
05/04	57	24.00	0.00	1	18	7	7	120	47
05/05	55	24.00	0.00	0	4	7	0	27	47
05/06	59	24.00	0.00	2	16	15	13	107	100
05/07	59	24.00	0.00	6	14	11	40	93	73
05/08	54	24.00	0.00	0	5	14	0	33	93
05/09	53	24.00	0.00	1	9	6	7	60	40
05/10	49	24.00	0.00	0	5	12	0	33	80
05/11	46	23.67	0.33	1	2	5	7	13	33
05/12	48	24.00	0.00	0	0	2	0	0	13
05/13	53	24.00	0.00	0	0	0	0	0	0
05/14	57	24.00	0.00	0	2	2	0	10	10
05/15	52	24.00	0.00	0	5	0	0	25	0
05/16	48	24.00	0.00	3	9	4	15	45	20
05/17	64	24.00	0.00	0	5	1	0	25	5
05/18	82	24.00	0.00	0	5	5	0	25	25
05/19	68	24.00	0.00	0	2	2	0	10	10
05/20	60	24.00	0.00	0	3	1	0	15	5
05/21	52	24.00	0.00	2	2	2	10	10	10

Appendix F. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek 1999 (continued).

	Flow	Hours		ACTUAL CATCH			ESTIMATED MIGRATION		
				Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Fished	Out	Ad-Marked	Unmarked		Ad-Marked	Unmarked	
05/22	49	24.00	0.00	1	2	1	5	10	5
05/23	52	24.00	0.00	0	6	5	0	30	25
05/24	49	24.00	0.00	0	4	4	0	20	20
05/25	45	24.00	0.00	0	8	8	0	40	40
05/26	42	24.00	0.00	1	6	12	5	30	60
05/27	36	24.00	0.00	0	6	14	0	30	70
05/28	34	24.00	0.00	0	6	18	0	30	90
05/29	32	24.00	0.00	0	2	11	0	10	55
05/30	31	24.00	0.00	0	0	0	0	0	0
05/31	33	24.00	0.00	0	1	0	0	5	0
06/01	44	24.00	0.00	0	0	3	0	0	15
06/02	48	24.00	0.00	0	1	1	0	5	5
06/03	43	24.00	0.00	0	1	1	0	5	5
06/04	41	24.00	0.00	0	1	0	0	5	0
06/05	39	24.00	0.00	0	0	0	0	0	0
06/06	37	24.00	0.00	0	1	0	0	5	0
06/07	38	24.00	0.00	0	0	0	0	0	0
06/08	38	24.00	0.00	0	0	0	0	0	0
06/09	35	24.00	0.00	0	0	2	0	0	10
06/10	33	24.00	0.00	0	1	2	0	5	10
06/11	31	24.00	0.00	0	0	0	0	0	0
06/12	28	24.00	0.00	0	0	0	0	0	0
06/13	27	24.00	0.00	3	0	3	15	0	15
06/14	32	24.00	0.00	1	0	4	5	0	20
06/15	29	24.00	0.00	0	1	5	0	5	25
06/16	26	24.00	0.00	0	1	1	0	5	5
06/17	26	24.00	0.00	0	0	0	0	0	0
06/18	32	24.00	0.00	0	0	10	0	0	50
06/19	30	24.00	0.00	0	0	1	0	0	5
06/20	30	24.00	0.00	0	0	0	0	0	0

Appendix F. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek 1999 (continued).

	Flow	Hours		ACTUAL CATCH			ESTIMATED MIGRATION		
				Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Fished	Out	Ad-Marked	Unmarked		Ad-Marked	Unmarked	
06/21	36	24.00	0.00	0	0	0	0	0	0
06/22	45	24.00	0.00	0	0	0	0	0	0
06/23	41	24.00	0.00	0	0	0	0	0	0
06/24	94	24.00	0.00	0	0	1	0	0	5
06/25	71	24.00	0.00	0	0	1	0	0	5
06/26	61	24.00	0.00	1	0	2	5	0	10
06/27	51	24.00	0.00	0	0	2	0	0	10
06/28	47	24.00	0.00	0	0	0	0	0	0
06/29	45	24.00	0.00	0	0	0	0	0	0
06/30	43	24.00	0.00	0	0	0	0	0	0
07/01	42	24.00	0.00	0	0	0	0	0	0
07/02	62	24.00	0.00	0	0	1	0	0	5
07/03	99	24.00	0.00	0	0	0	0	0	0
07/04	84	24.00	0.00	0	0	0	0	0	0
07/05	70	24.00	0.00	0	0	0	0	0	0
07/06	53	24.00	0.00	0	0	0	0	0	0
07/07	44	24.00	0.00	0	0	0	0	0	0
07/08	40	24.00	0.00	0	0	0	0	0	0
07/09	37	24.00	0.00	0	0	1	0	0	5
07/10	34	24.00	0.00	0	0	0	0	0	0
07/11	29	24.00	0.00	0	0	1	0	0	5
07/12	26	24.00	0.00	0	0	0	0	0	0
07/13	25	9.00	0.00	0	0	0	0	0	0
Total		3,278.25	76.25	64	225	545	407	1,365	3,413

Note: On April 15-16, we installed the Haskell Slough trap, and did not check Bear Creek more than once in a 24-hour period.
Steelhead and cutthroat migration estimates were based on a trap efficiency of 15% while fishing in position 1(from Feb 23 to May 13) and of 20% while fishing in position 2 (From May 14 to July 13).

Appendix G

Daily Age 0+ Chinook, Coho Smolt, and Sockeye Fry Catches and Migration Estimates, Bear Creek Screw Trap 2000

Appendix G. Daily age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek screw trap 2000.

		Actual Catch					Estimated Migration				
	Flow	Chinook		Coho			Chinook		Coho		
Date	(cfs)	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye
01/24	105	1	0	0	0	8	4	0	0	0	69
01/25	101	2	0	0	0	19	8	0	0	0	163
01/26	95	11	0	0	0	22	44	0	0	0	190
01/27	88	21	0	1	0	32	84	0	4	0	273
01/28	83	14	0	0	0	43	56	0	0	0	367
01/29	78	14	0	0	0	55	56	0	0	0	470
01/30	76	6	0	1	0	22	24	0	4	0	185
01/31	77	1	0	1	0	19	4	0	4	0	167
02/01	172	9	0	0	0	33	36	0	0	0	279
02/02	179	2	0	0	0	51	8	0	0	0	432
02/03	144	2	0	1	0	58	8	0	4	0	502
02/04	118	3	0	0	0	65	12	0	0	0	553
02/05	104	3	0	1	0	54	12	0	4	0	460
02/06	98	0	0	1	0	67	0	0	4	0	572
02/07	95	2	0	2	0	126	8	0	7	0	1,080
02/08	174	33	0	0	0	400	132	0	0	0	3,418
02/09	194	35	0	0	0	244	140	0	0	0	2,089
02/10	154	17	0	0	0	88	68	0	0	0	755
02/11	127	6	0	0	0	43	24	0	0	0	361
02/12	111	4	0	0	0	74	16	0	0	0	640
02/13	100	4	0	0	0	51	16	0	0	0	433
02/14	110	10	0	0	0	72	40	0	0	0	616
02/15	155	37	0	1	0	113	148	0	4	0	965
02/16	127	15	0	1	0	79	60	0	4	0	676
02/17	109	13	0	1	0	109	52	0	4	0	928
02/18	99	5	0	0	0	53	20	0	0	0	457
20/19	93	10	0	0	0	77	40	0	0	0	659
02/20	87	9	0	0	0	88	36	0	0	0	751
02/21	95	3	0	0	0	136	12	0	0	0	1,164
02/22	112	43	0	0	0	195	172	0	0	0	1,671
02/23	**135**	**69**	**0**	**0**	**0**	**192**	**276**	**0**	**0**	**0**	**1,636**

Appendix G. Daily age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch					Estimated Migration				
	Flow	Chinook		Coho			Chinook		Coho		
Date	(cfs)	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye
02/24	**115**	**9**	**0**	**0**	**0**	**99**	**36**	**0**	**0**	**0**	**847**
02/25	107	12	0	0	0	120	48	0	0	0	1,031
02/26	110	5	0	0	0	175	20	0	0	0	1,498
02/27	129	7	0	0	0	339	28	0	0	0	2,893
02/28	124	10	0	0	0	240	40	0	0	0	2,056
02/29	143	138	0	0	0	488	552	0	0	0	4,054
03/01	183	259	0	0	0	1,104	1,036	0	0	0	9,432
03/02	155	87	0	0	0	550	348	0	0	0	4,705
03/03	136	159	0	0	0	1,096	636	0	0	0	7,954
03/04	221	324	0	0	0	1,083	1,296	0	0	0	9,256
03/05	194	90	0	0	0	651	360	0	0	0	5,564
03/06	157	70	0	0	0	250	280	0	0	0	2,144
03/07	132	97	0	1	0	506	388	0	4	0	4,327
03/08	115	19	0	0	0	679	76	0	0	0	5,804
03/09	105	18	0	0	0	914	72	0	0	0	7,130
03/10	96	21	0	0	0	357	84	0	0	0	3,048
03/11	98	15	0	0	0	236	60	0	0	0	2,020
03/12	95	44	0	0	0	267	176	0	0	0	2,283
03/13	89	112	0	1	0	257	448	0	4	0	2,197
03/14	118	327	0	1	0	817	1,308	0	4	0	6,594
03/15	120	229	0	0	0	507	916	0	0	0	4,340
03/16	118	86	0	0	0	481	344	0	0	0	4,111
03/17	145	248	0	1	0	1,311	992	0	4	0	10,937
03/18	155	31	0	0	0	151	124	0	0	0	1,293
03/19	143	40	0	1	0	341	160	0	4	0	2,777
03/20	121	35	0	0	0	720	140	0	0	0	6,012
03/21	107	11	0	0	0	40	44	0	0	0	343
03/22	125	16	0	0	0	229	64	0	0	0	1,957
03/23	127	19	0	0	0	513	76	0	0	0	4,383
03/24	114	41	0	0	0	1,585	164	0	0	0	12,315
03/25	101	9	0	0	0	182	36	0	0	0	1,562

Appendix G. Daily age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch					Estimated Migration				
	Flow	Chinook		Coho			Chinook		Coho		
Date	(cfs)	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye
03/26	91	7	0	1	0	88	28	0	4	0	751
03/27	86	64	0	5	0	128	256	0	18	0	1,096
03/28	117	153	0	3	0	255	612	0	11	0	2,123
03/29	123	5	0	1	0	173	20	0	4	0	1,479
03/30	103	8	0	0	0	49	32	0	0	0	420
03/31	90	5	0	1	0	561	20	0	4	0	3,606
04/01	**82**	**9**	**0**	**2**	**0**	**551**	**36**	**0**	**7**	**0**	**3,368**
04/02	78	12	0	3	0	160	48	0	11	0	1,365
04/03	74	18	0	6	0	520	72	0	22	0	3,426
04/04	99	41	0	3	0	1,006	164	0	11	0	6,510
04/05	102	13	0	1	0	349	52	0	4	0	2,388
04/06	123	6	0	3	0	209	24	0	11	0	1,356
04/07	113	33	0	4	0	160	132	0	15	0	977
04/08	97	14	0	2	0	63	56	0	7	0	429
04/09	86	4	0	5	0	46	16	0	18	0	296
04/10	79	14	0	4	0	30	56	0	15	0	233
04/11	73	22	0	13	0	45	88	0	47	0	339
04/12	70	16	0	3	0	76	64	0	11	0	494
04/13	72	20	0	7	0	31	80	0	25	0	263
04/14	110	70	0	7	0	77	280	0	25	0	658
04/15	100	3	0	3	0	4	12	0	11	0	35
04/16	89	6	0	21	0	0	24	0	76	0	4
04/17	80	7	0	33	0	2	17	0	120	0	13
04/18	72	9	0	57	0	0	22	0	207	0	0
04/19	65	11	0	37	0	0	27	0	135	0	0
04/20	62	15	0	156	1	0	37	0	567	4	0
04/21	62	13	0	194	0	0	32	0	705	0	0
04/22	63	13	0	154	0	0	32	0	560	0	0
04/23	61	16	0	74	0	0	40	0	269	0	0
04/24	60	35	0	188	0	0	87	0	684	0	0
04/25	60	19	0	238	0	0	47	0	865	0	0
04/26	58	30	0	186	0	0	75	0	676	0	0

Appendix G. Daily age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch					Estimated Migration				
	Flow	Chinook		Coho			Chinook		Coho		
Date	(cfs)	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye
04/27	57	48	0	289	0	0	120	0	1,051	0	0
04/28	62	38	0	255	0	0	95	0	927	0	0
04/29	57	21	0	275	0	1	52	0	1,000	0	9
04/30	53	13	0	329	0	0	32	0	1,196	0	0
05/01	51	24	0	482	0	0	60	0	1,753	0	0
05/02	52	21	0	408	1	0	52	0	1,484	4	0
05/03	58	45	0	391	0	0	112	0	1,422	0	0
05/04	57	69	0	402	1	0	172	0	1,462	4	0
05/05	58	91	0	312	0	0	227	0	1,134	0	0
05/06	53	75	0	291	0	0	187	0	1,058	0	0
05/07	49	50	0	198	0	0	125	0	720	0	0
05/08	49	97	0	186	0	0	242	0	676	0	0
05/09	72	142	0	171	1	0	354	0	622	4	2
05/10	103	188	0	246	0	1	468	0	895	0	6
05/11	80	228	0	338	0	0	568	0	1,229	0	0
05/12	96	469	0	288	0	0	1,168	0	1,047	0	0
05/13	73	95	0	224	1	0	237	0	815	4	0
05/14	64	121	0	211	1	0	301	0	767	4	0
05/15	57	171	0	200	0	0	426	0	727	0	0
05/16	52	112	0	113	0	0	279	0	411	0	0
05/17	49	49	0	72	0	0	122	0	262	0	0
05/18	49	227	0	92	0	0	566	0	335	0	0
05/19	65	416	0	120	0	0	1,036	0	436	0	0
05/20	57	204	0	95	0	0	508	0	345	0	0
05/21	57	243	0	78	0	0	605	0	284	0	0
05/22	62	248	11	41	0	0	618	27	149	0	0
05/23	54	145	27	14	0	1	361	67	51	0	9
05/24	49	151	0	14	1	0	376	0	51	4	0
05/25	46	71	0	13	0	0	177	0	47	0	0
05/26	49	246	0	34	0	0	613	0	124	0	0
05/27	52	258	0	45	0	0	643	0	164	0	0
05/28	48	212	0	25	0	0	528	0	91	0	0

Appendix G. Daily age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch					Estimated Migration				
	Flow	Chinook		Coho			Chinook		Coho		
Date	(cfs)	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye
05/29	52	196	0	4	0	0	488	0	15	0	0
05/30	50	169	0	6	0	0	421	0	22	0	1
05/31	54	355	0	14	0	1	884	0	51	0	7
06/01	51	300	0	2	0	0	747	0	7	0	0
06/02	47	114	0	4	0	1	284	0	15	0	9
06/03	43	64	0	3	0	0	159	0	11	0	0
06/04	40	113	0	2	0	0	282	0	7	0	0
06/05	38	94	0	2	0	0	234	0	7	0	0
06/06	38	71	0	3	0	0	177	0	11	0	0
06/07	38	111	0	0	0	0	277	0	0	0	0
06/08	39	84	0	2	0	0	209	0	7	0	0
06/09	39	100	0	0	0	0	249	0	0	0	0
06/10	38	76	0	2	0	0	189	0	7	0	0
06/11	**39**	**52**	**0**	**1**	**0**	**0**	**130**	**0**	**4**	**0**	**0**
06/12	**60**	**117**	**0**	**0**	**0**	**0**	**291**	**0**	**0**	**0**	**0**
06/13	51	38	0	2	0	0	95	0	7	0	0
06/14	48	21	0	0	0	0	52	0	0	0	0
06/15	47	34	0	1	0	0	85	0	4	0	0
06/16	42	19	0	1	0	0	47	0	4	0	0
06/17	40	19	0	1	0	0	47	0	4	0	0
06/18	39	22	0	0	0	0	55	0	0	0	0
06/19	40	20	0	0	0	0	50	0	0	0	0
06/20	38	33	0	1	0	0	82	0	4	0	0
06/21	34	20	0	0	0	0	50	0	0	0	0
06/22	33	18	0	1	0	0	45	0	4	0	0
06/23	32	18	0	0	0	0	45	0	0	0	0
06/24	32	21	0	0	0	0	52	0	0	0	0
06/25	30	28	0	0	0	0	70	0	0	0	0
06/26	29	23	0	1	0	0	57	0	4	0	0
06/27	28	21	0	0	0	0	52	0	0	0	0
06/28	28	40	0	0	0	0	100	0	0	0	0
06/29	27	58	0	1	0	0	145	0	4	0	0

Appendix G. Daily age 0+ chinook, coho smolt, and sockeye fry catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch					Estimated Migration				
	Flow	Chinook		Coho			Chinook		Coho		
Date	(cfs)	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye	Unmarked	Ad-Marked	Unmarked	Ad-Marked	Sockeye
06/30	29	4	0	0	0	0	10	0	0	0	0
07/01	28	1	0	0	0	0	2	0	0	0	0
07/02	29	3	0	0	0	0	7	0	0	0	0
07/03	30	3	0	0	0	0	7	0	0	0	0
07/04	30	2	0	0	0	0	5	0	0	0	0
07/05	29	1	0	0	0	0	2	0	0	0	0
07/06	28	1	0	0	0	0	2	0	0	0	0
07/07	29	4	0	0	0	0	10	0	0	0	0
07/08	28	10	0	0	0	0	25	0	0	0	0
07/09	28										
07/10	28	5	0	0	0	0	12	0	0	0	0
07/11	28										
07/12	28	1	0	0	0	0	2	0	0	0	0
07/13	27	0	0		0	0	0	0	0	0	0
Total		10,795	38	7,737	7	23,564	32,220	94	28,142	28	189,571

Note: Bold entries indicate a screw stoppage occurred which did not appear to substantially effect catch.
Trap efficiency estimates used to estimate migration: Chinook - 25% prior to and including April 16, 40.14% after April 16, Coho - 27.50%, and Sockeye (adjusted for predation) - 16.4% where trap checks were less than 4-hours apart, and 11.7% where trap checks were 4-hours or more apart.

Appendix H

Daily Steelhead and Cutthroat Smolt Catches and Migration Estimates, Bear Creek 2000

Appendix H. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek screw trap 2000.

		Actual Catch			Estimated Migration		
	Flow	Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Unmarked	Ad-Marked		Unmarked	Ad-Marked	
01/24	105	0	0	1	0	0	6
01/25	101	0	0	1	0	0	6
01/26	95	0	0	2	0	0	11
01/27	88	0	0	1	0	0	6
01/28	83	0	0	1	0	0	6
01/29	78	0	0	0	0	0	0
01/30	76	0	0	5	0	0	28
01/31	77	0	0	4	0	0	22
02/01	172	0	0	2	0	0	11
02/02	179	0	0	5	0	0	28
02/03	144	0	0	6	0	0	33
02/04	118	0	0	3	0	0	17
02/05	104	0	0	3	0	0	17
02/06	98	0	0	4	0	0	22
02/07	95	0	0	3	0	0	17
02/08	174	2	0	8	11	0	44
02/09	194	1	0	8	6	0	44
02/10	154	0	0	8	0	0	44
02/11	127	0	0	10	0	0	56
02/12	111	0	0	8	0	0	44
02/13	100	0	0	3	0	0	17
02/14	110	1	0	3	6	0	17
02/15	155	0	0	6	0	0	33
02/16	127	0	0	4	0	0	22
02/17	109	0	0	0	0	0	0
02/18	99	0	0	0	0	0	0
20/19	93	0	0	0	0	0	0
02/20	87	0	0	0	0	0	0
02/21	95	0	0	0	0	0	0
02/22	112	0	0	3	0	0	17
02/23	**135**	**0**	**0**	**7**	**0**	**0**	**39**

Appendix H. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch			Estimated Migration		
	Flow	Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Unmarked	Ad-Marked		Unmarked	Ad-Marked	
02/24	**115**	**0**	**0**	**1**	**0**	**0**	**6**
02/25	107	0	0	3	0	0	17
02/26	110	0	0	2	0	0	11
02/27	129	0	0	5	0	0	28
02/28	124	0	0	8	0	0	44
02/29	143	0	0	6	0	0	33
03/01	183	0	0	6	0	0	33
03/02	155	0	0	2	0	0	11
03/03	136	0	0	5	0	0	28
03/04	221	0	0	3	0	0	17
03/05	194	0	0	2	0	0	11
03/06	157	0	0	1	0	0	6
03/07	132	0	0	1	0	0	6
03/08	115	0	0	2	0	0	11
03/09	105	1	0	3	6	0	17
03/10	96	0	0	7	0	0	39
03/11	98	0	0	5	0	0	28
03/12	95	0	0	7	0	0	39
03/13	89	0	0	5	0	0	28
03/14	118	0	0	8	0	0	44
03/15	120	0	0	4	0	0	22
03/16	118	0	0	4	0	0	22
03/17	145	0	0	6	0	0	33
03/18	155	0	0	4	0	0	22
03/19	143	0	0	5	0	0	28
03/20	121	0	0	5	0	0	28
03/21	107	0	0	4	0	0	22
03/22	125	0	0	7	0	0	39
03/23	127	0	0	5	0	0	28
03/24	114	0	0	7	0	0	39
03/25	101	1	0	7	6	0	39

Appendix H. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek screw trap 2000 (continued).

Date	Flow (cfs)	Actual Catch: Steelhead Unmarked	Actual Catch: Steelhead Ad-Marked	Actual Catch: Cutthroat	Estimated Migration: Steelhead Unmarked	Estimated Migration: Steelhead Ad-Marked	Estimated Migration: Cutthroat
03/26	91	0	0	2	0	0	11
03/27	86	0	0	3	0	0	17
03/28	117	0	0	4	0	0	22
03/29	123	0	0	5	0	0	28
03/30	103	0	0	10	0	0	56
03/31	90	0	0	8	0	0	44
04/01	**82**	**0**	**0**	**12**	**0**	**0**	**67**
04/02	78	0	2	24	0	11	133
04/03	74	0	3	23	0	17	128
04/04	99	1	3	14	6	17	78
04/05	102	0	2	3	0	11	17
04/06	123	4	3	7	22	17	39
04/07	113	2	3	1	11	17	6
04/08	97	5	0	1	28	0	6
04/09	86	0	1	2	0	6	11
04/10	79	0	1	2	0	6	11
04/11	73	3	0	1	17	0	6
04/12	70	2	1	4	11	6	22
04/13	72	3	1	1	17	6	6
04/14	110	2	0	1	11	0	6
04/15	100	1	1	0	6	6	0
04/16	89	1	5	1	6	28	6
04/17	80	1	10	2	6	56	11
04/18	72	1	27	7	6	150	39
04/19	65	0	13	4	0	72	22
04/20	62	3	25	26	17	139	144
04/21	62	2	16	22	11	89	122
04/22	63	0	16	23	0	89	128
04/23	61	0	19	15	0	106	83
04/24	60	1	19	18	6	106	100
04/25	60	2	6	9	11	33	50
04/26	58	0	12	15	0	67	83

Appendix H. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek screw trap 2000 (continued).

Date	Flow (cfs)	Actual Catch: Unmarked Steelhead	Actual Catch: Ad-Marked Steelhead	Actual Catch: Cutthroat	Estimated Migration: Unmarked Steelhead	Estimated Migration: Ad-Marked Steelhead	Estimated Migration: Cutthroat
04/27	57	6	11	26	33	61	144
04/28	62	4	6	10	22	33	56
04/29	57	2	7	11	11	39	61
04/30	53	0	5	13	0	28	72
05/01	51	0	13	47	0	72	261
05/02	52	1	9	31	6	50	172
05/03	58	0	7	15	0	39	92
05/04	57	1	4	9	6	22	50
05/05	58	2	2	6	11	11	33
05/06	53	2	3	3	11	17	17
05/07	49	0	3	3	0	17	17
05/08	49	0	1	6	0	6	33
05/09	72	0	0	2	0	0	11
05/10	103	1	1	5	6	6	28
05/11	80	0	3	9	0	17	50
05/12	96	0	4	24	0	22	133
05/13	73	0	3	20	0	17	111
05/14	64	0	2	26	0	11	144
05/15	57	0	4	34	0	22	189
05/16	52	1	1	33	6	6	183
05/17	49	0	2	15	0	11	83
05/18	49	0	1	18	0	6	100
05/19	65	2	2	21	11	11	117
05/20	57	0	2	23	0	11	128
05/21	57	0	1	17	0	6	94
05/22	62	0	0	8	0	0	44
05/23	54	0	0	6	0	0	33
05/24	49	0	0	3	0	0	17
05/25	46	0	0	0	0	0	0
05/26	49	0	0	1	0	0	6
05/27	52	0	0	7	0	0	39
05/28	48	0	1	6	0	6	33

Appendix H. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch			Estimated Migration		
	Flow	Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Unmarked	Ad-Marked		Unmarked	Ad-Marked	
05/29	52	0	0	14	0	0	78
05/30	50	0	0	10	0	0	56
05/31	54	0	0	2	0	0	11
06/01	51	0	0	2	0	0	11
06/02	47	0	0	0	0	0	0
06/03	43	0	0	0	0	0	0
06/04	40	0	0	1	0	0	6
06/05	38	0	0	3	0	0	17
06/06	38	0	0	1	0	0	6
06/07	38	0	0	2	0	0	11
06/08	39	0	0	2	0	0	11
06/09	39	0	0	2	0	0	11
06/10	38	0	0	1	0	0	6
06/11	**39**	**0**	**0**	**0**	**0**	**0**	**0**
06/12	**60**	**0**	**0**	**0**	**0**	**0**	**0**
06/13	51	0	1	1	0	6	6
06/14	48	0	0	0	0	0	0
06/15	47	0	0	0	0	0	0
06/16	42	0	0	0	0	0	0
06/17	40	0	0	0	0	0	0
06/18	39	0	0	0	0	0	0
06/19	40	0	0	0	0	0	0
06/20	38	0	0	0	0	0	0
06/21	34	0	0	0	0	0	0
06/22	33	0	0	0	0	0	**0**
06/23	32	0	0	0	0	0	**0**
06/24	32	1	0	0	6	0	0
06/25	30	0	0	0	0	0	0
06/26	29	1	0	0	6	0	0
06/27	28	0	0	0	0	0	0
06/28	28	0	0	0	0	0	0
06/29	27	0	0	1	0	0	6

Appendix H. Daily steelhead and cutthroat smolt catches and migration estimates, Bear Creek screw trap 2000 (continued).

		Actual Catch			Estimated Migration		
	Flow	Steelhead		Cutthroat	Steelhead		Cutthroat
Date	(cfs)	Unmarked	Ad-Marked		Unmarked	Ad-Marked	
06/30	29	0	0	0	0	0	0
07/01	28	0	0	0	0	0	0
07/02	29	0	0	1	0	0	6
07/03	30	0	0	0	0	0	**0**
07/04	30	0	0	0	0	0	0
07/05	29	0	0	1	0	0	6
07/06	28	0	0	0	0	0	0
07/07	29	0	0	0	0	0	0
07/08	28	0	0	1	0	0	6
07/09	28						
07/10	28	0	0	0	0	0	0
07/11	28						
07/12	28	1	0	1	6	0	6
07/13	27	0	0	0	0	0	0
Total		65	288	1,023	361	1,600	5,683

Note: Bold entries indicate a screw stoppage occurred which did not appear to substantially effect catch.
A trap efficiency estimate of 18% were used to estimate steelhead and cutthroat migration.

Appendix I

Daily Catch and Migration Estimates Assuming 24-Hour per Day Trap Operation, Issaquah Creek Screw Trap 2000

Appendix I. Daily catch and migration estimates assuming 24-hour per day trap operation, Issaquah Creek screw trap 2000.

	Hours		Actual Daily Catch									Expanded Wild Catch				Estimated Wild Migration			
			Chinook			Coho			Steelhead		Cutts								
Date	Fished	Out	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
03/14	10.42	13.58	0	10	10	232	5	0	0	1	8	23	0	2	18	120	0	33	264
03/15	24.00	0.00	0	140	140	237	11	6	0	0	8	140	6	0	8	1,770	39	0	115
03/16	24.00	0.00	0	29	29	125	3	0	0	0	11	29	0	0	11	167	0	0	158
03/17	24.00	0.00	0	93	93	94	2	1	0	0	14	93	1	0	14	1,050	7	0	201
03/18	24.00	0.00	0	67	67	110	4	4	0	0	10	67	4	0	10	809	26	0	143
03/19	24.00	0.00	0	59	59	267	2	0	0	0	12	59	0	0	12	621	0	0	172
03/20	24.00	0.00	0	56	56	348	1	0	0	0	7	56	0	0	7	628	0	0	100
03/21	24.00	0.00	0	120	120	193	2	0	0	0	10	120	0	0	10	1,642	0	0	143
03/22	24.00	0.00	0	27	27	208	0	0	0	0	6	27	0	0	10	118	0	0	137
03/23	24.00	0.00	0	87	87	229	1	0	0	1	6	87	0	0	12	817	0	14	174
03/24	24.00	0.00	0	26	26	466	2	0	0	3	15	26	0	1	15	316	0	43	215
03/25	24.00	0.00	0	29	29	355	8	3	1	1	12	29	3	3	12	323	20	14	172
03/26	24.00	0.00	0	19	19	142	4	2	0	1	5	19	2	1	5	204	13	14	72
03/27	24.00	0.00	0	5	5	154	3	0	0	0	10	5	0	1	10	40	0	0	143
03/28	04.00	0.00	0	12	12	239	2	0	0	0	9	12	0	0	9	108	0	0	129
03/29	24.00	0.00	0	13	13	444	2	0	1	0	8	13	0	0	8	92	0	0	115
03/30	24.00	0.00	0	18	18	184	0	0	0	0	10	18	0	0	10	152	0	0	143
03/31	24.00	0.00	0	13	13	223	2	0	0	0	4	13	0	0	4	131	0	0	57
04/01	24.00	0.00	0	2	2	282	5	0	0	0	7	2	0	0	7	18	0	0	100
04/02	24.00	0.00	0	4	4	353	4	0	0	0	14	4	0	0	14	46	0	0	201
04/03	7.75	16.25	0	2	2	281	2	0	0	1	13	28	1	1	21	147	9	21	302
04/04	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/05	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/06	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/07	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/08	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/09	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/10	0.25	23.75	0	0	0	93	0	0	0	0	0	38	2	1	12	203	13	10	171
04/11	3.08	20.92	0	2	2	412	0	0	0	0	6	38	2	1	12	203	13	10	171
04/12	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/13	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171

Appendix I. Daily catch and migration estimates assuming 24-hour per day trap operation, Issaquah Creek screw trap 2000 (Continued).

	Hours		Actual Daily Catch									Expanded Wild Catch				Estimated Wild Migration			
			Chinook			Coho			Steelhead		Cutts								
Date	Fished	Out	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
04/14	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/15	0.00	24.00	0	0	0	0	0	0	0	0	0	38	2	1	12	203	13	10	171
04/16	1.00	23.00	0	1	1	14	3	3	0	0	1	37	5	1	12	196	33	9	178
04/17	24.00	0.00	0	43	43	263	32	25	4	0	16	43	25	0	16	254	163	0	229
04/18	24.00	0.00	5	49	49	333	11	3	5	0	11	65	7	1	16	266	46	8	227
04/19	24.00	0.00	5	27	27	60	0	0	0	1	6	51	6	2	13	238	39	27	191
04/20	24.00	0.00	14	64	63	206	0	0	8	2	21	63	0	2	21	280	0	29	301
04/21	24.00	0.00	88	22	18	78	0	0	4	2	12	18	0	2	12	154	0	29	172
04/22	24.00	0.00	235	12	3	82	0	0	2	3	13	3	0	3	13	41	0	43	186
04/23	24.00	0.00	359	11	3	112	6	3	6	0	14	3	3	0	14	41	20	0	201
04/24	24.00	0.00	291	7	0	79	7	5	7	0	5	13	42	0	9	71	274	0	130
04/25	24.00	0.00	269	16	2	36	36	35	4	0	6	30	121	0	15	170	788	0	222
04/26	24.00	0.00	602	35	11	89	115	113	10	1	15	11	113	1	15	64	739	14	215
04/27	24.00	0.00	603	70	38	173	228	224	9	2	13	38	224	2	13	165	1,464	29	186
04/28	24.00	0.00	439	50	27	117	148	145	4	2	11	27	145	2	11	118	948	29	158
04/29	24.00	0.00	264	64	50	96	116	113	5	2	18	50	113	2	18	224	739	29	258
04/30	24.00	0.00	84	23	18	72	75	73	5	3	13	18	73	3	13	96	477	43	186
05/01	24.00	0.00	34	19	17	28	42	41	5	0	7	17	41	0	7	133	268	0	100
05/02	24.00	0.00	98	46	40	31	88	88	14	0	21	40	88	0	21	214	575	0	301
05/03	24.00	0.00	221	39	27	127	167	164	8	0	17	27	164	0	17	123	1,072	0	244
05/04	24.00	0.00	413	83	61	137	248	244	12	2	16	61	244	2	16	281	1,595	29	229
05/05	24.00	0.00	205	69	58	61	175	173	4	2	10	58	173	2	10	310	1,131	29	143
05/06	24.00	0.00	435	96	73	80	240	238	6	1	13	73	238	1	13	390	1,556	14	186
05/07	24.00	0.00	274	52	37	58	109	108	5	0	6	37	108	0	6	198	706	0	86
05/08	24.00	0.00	98	29	24	41	82	81	6	0	11	24	81	0	11	128	529	0	158
05/09	24.00	0.00	321	95	78	61	113	112	7	0	5	78	112	0	5	405	732	0	72
05/10	5.50	18.50	71	20	16	23	40	39	2	0	5	55	112	0	9	274	731	0	122
05/11	0.00	24.00	0	0	0	0	0	0	0	0	0	51	95	1	9	272	621	8	122
05/12	0.00	24.00	0	0	0	0	0	0	0	0	0	51	77	1	9	272	503	8	122
05/13	0.00	24.00	0	0	0	0	0	0	0	0	0	51	63	1	9	272	412	8	122
05/14	0.00	24.00	0	0	0	0	0	0	0	0	0	51	51	1	9	272	333	8	122

Appendix I. Daily catch and migration estimates assuming 24-hour per day trap operation, Issaquah Creek screw trap 2000 (Continued).

	Hours		Actual Daily Catch: Chinook			Coho			Steelhead		Cutts	Expanded Wild Catch				Estimated Wild Migration			
Date	Fished	Out	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
05/15	0.00	24.00	0	0	0	0	0	0	0	0	0	51	42	1	9	272	275	8	122
05/16	0.00	24.00	0	0	0	0	0	0	0	0	0	51	34	1	9	272	222	8	122
05/17	0.00	24.00	0	0	0	0	0	0	0	0	0	51	28	1	9	272	183	8	122
05/18	0.00	24.00	0	0	0	0	0	0	0	0	0	51	23	1	9	272	150	8	122
05/19	0.00	24.00	0	0	0	0	0	0	0	0	0	51	19	1	9	272	124	8	122
05/20	0.00	24.00	0	0	0	0	0	0	0	0	0	51	15	1	9	272	98	8	122
05/21	0.00	24.00	0	0	0	0	0	0	0	0	0	51	12	1	9	272	78	8	122
05/22	4.00	20.00	12	8	7	0	8	8	4	0	1	50	10	0	9	258	65	7	122
05/23	24.00	0.00	42	32	31	2	19	19	11	1	5	31	19	1	5	146	124	14	72
05/24	24.00	0.00	40	62	60	3	5	5	6	0	11	60	5	0	11	284	33	0	158
05/25	24.00	0.00	32	35	33	1	3	3	1	0	4	33	3	0	4	185	20	0	57
05/26	17.25	6.75	49	24	22	4	2	2	1	0	2	36	5	0	4	192	33	2	52
05/27	0.00	24.00	0	0	0	0	0	0	0	0	0	51	9	1	6	271	59	7	84
05/28	0.00	24.00	0	0	0	0	0	0	0	0	0	51	9	1	6	271	59	7	84
05/29	0.00	24.00	0	0	0	0	0	0	0	0	0	51	9	1	6	271	59	7	84
05/30	13.58	10.42	22	21	20	1	1	1	0	0	2	42	5	0	5	233	33	3	65
05/31	24.00	0.00	35	122	120	1	11	11	1	1	5	120	11	1	5	628	72	14	72
06/01	24.00	0.00	64	215	212	3	11	11	2	1	6	212	11	1	6	1,013	72	14	86
06/02	24.00	0.00	26	49	48	2	3	3	0	0	4	48	3	0	4	264	20	0	57
06/03	24.00	0.00	18	22	21	1	0	0	1	0	2	21	0	0	2	86	0	0	29
06/04	24.00	0.00	2	16	16	0	2	2	3	0	4	16	2	0	4	65	13	0	57
06/05	24.00	0.00	3	18	18	1	2	2	6	0	2	18	2	0	2	77	13	0	29
06/06	24.00	0.00	2	10	10	1	0	0	2	0	1	10	0	0	1	53	0	0	14
06/07	24.00	0.00	1	10	10	0	0	0	1	0	2	10	0	0	2	53	0	0	29
06/08	24.00	0.00	19	61	60	0	2	2	0	0	3	60	2	0	3	320	13	0	43
06/09	24.00	0.00	55	210	207	1	15	15	0	0	8	207	15	0	8	1,141	98	0	115
06/10	24.00	0.00	73	333	329	2	33	33	0	1	14	329	33	1	14	1,384	216	14	201
06/11	24.00	0.00	14	158	157	0	10	10	1	0	9	157	10	0	9	681	65	0	129
06/12	9.00	15.00	11	137	136	0	13	13	0	0	9	167	15	2	16	721	98	27	231
06/13	0.00	24.00	0	0	0	0	0	0	0	0	0	50	3	3	11	267	20	43	162
06/14	14.50	9.50	0	3	3	0	0	0	0	0	3	23	1	1	7	123	7	17	107

Appendix I. Daily catch and migration estimates assuming 24-hour per day trap operation, Issaquah Creek screw trap 2000 (Continued).

	Hours		Actual Daily Catch: Chinook			Coho			Steelhead		Cutts	Expanded Wild Catch				Estimated Wild Migration			
Date	Fished	Out	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd Wild	Ad Clip	Unmkd	Unmkd	Chin	Coho	Sthd	Cutt	Chin	Coho	Sthd	Cutt
06/15	24.00	0.00	0	9	9	0	2	2	0	0	11	9	2	0	11	57	13	0	158
06/16	24.00	0.00	2	9	9	0	2	2	0	6	9	9	2	6	9	42	13	86	129
06/17	24.00	0.00	3	11	11	0	2	2	0	11	17	11	2	11	17	50	13	158	244
06/18	24.00	0.00	1	18	18	0	0	0	0	0	14	18	0	0	14	96	0	0	201
06/19	24.00	0.00	12	42	41	0	0	0	0	0	9	41	0	0	9	190	0	0	129
06/20	24.00	0.00	24	65	64	0	1	1	1	0	18	64	1	0	18	281	7	0	258
06/21	24.00	0.00	1	35	35	0	0	0	0	0	7	35	0	0	7	299	0	0	100
06/22	24.00	0.00	1	21	21	0	0	0	0	0	6	21	0	0	6	105	0	0	86
06/23	24.00	0.00	0	15	15	0	3	3	1	0	4	15	3	0	4	61	20	0	57
06/24	24.00	0.00	1	14	14	0	1	1	0	0	5	14	1	0	5	57	7	0	72
06/25	24.00	0.00	2	15	15	0	1	1	0	0	2	15	1	0	2	66	7	0	29
06/26	24.00	0.00	1	8	8	0	1	1	0	0	0	8	1	0	0	43	7	0	0
06/27	24.00	0.00	0	4	4	0	0	0	0	0	1	4	0	0	1	21	0	0	14
06/28	24.00	0.00	0	2	2	0	0	0	1	0	1	2	0	0	1	11	0	0	14
06/29	24.00	0.00	0	7	7	0	0	0	1	0	3	7	0	0	3	37	0	0	43
06/30	24.00	0.00	1	2	2	0	0	0	1	0	0	2	0	0	0	19	0	0	0
07/01	24.00	0.00	2	1	1	0	1	1	0	0	0	1	1	0	0	4	7	0	0
07/02	24.00	0.00	1	3	3	0	0	0	0	0	0	3	0	0	0	12	0	0	0
07/03	12.00	0.00	1	0	0	0	1	1	0	0	0	0	1	0	0	0	7	0	0
Totals			6,001	3,702	3,416	8,151	2,301	2,201	189	52	695	4,957	2,935	79	1,047	30,025	19,182	1,128	15,005

Note: Dates where trapping was suspended due to the presence of large numbers of hatchery fish are lightly shaded. Dates where catches were affected by screw stoppers are darkly shaded.