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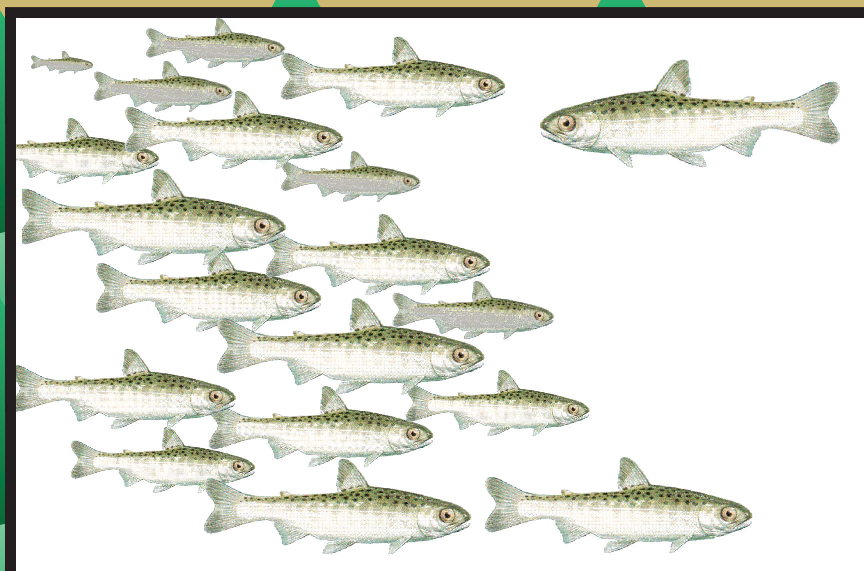
April 2015

Evaluation of Juvenile Salmon Production in 2014 from the Cedar River and Bear Creek



by Kelly Kiyohara

Washington Department of
FISH AND WILDLIFE
Fish Program
Fish Science Division

FPA 15-03

Evaluation of Juvenile Salmon Production in 2014 from the Cedar River and Bear Creek

Kelly Kiyohara

Wild Salmon Production Evaluation Unit
Science Division, Fish Program
Washington Department of Fish and Wildlife
Olympia, Washington 98501-1091

April 2015

Supported by
King County Department of Natural Resources and Parks
King County Flood Control District Cooperative Watershed Management grant
Seattle Public Utilities

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Introduction

This report describes the emigration of five salmonid species from two tributaries in the Lake Washington watershed: Cedar River and Bear Creek. Cedar River flows into the southern end of Lake Washington; Bear Creek flows into the Sammamish River, which flows into the north end of Lake Washington (Figure 1). In each watershed, the abundance of juvenile migrants is the measure of freshwater production upstream from the trapping location.

In 1992, the Washington Department of Fish and Wildlife (WDFW) initiated an evaluation of sockeye fry migrants in the Cedar River to investigate the causes of low adult sockeye returns. In 1999, the Cedar River juvenile monitoring study was expanded in scope in order to include juvenile migrant Chinook salmon. This new scope extended the trapping season to a six month period and, as a consequence, also allowed estimation of coho production, and assessment of steelhead and cutthroat trout movement.

In 1997, WDFW initiated an evaluation of sockeye fry migrants in the Sammamish watershed. In 1997 and 1998, a juvenile trap was operated in the Sammamish River during the downstream sockeye migration. In 1999, this monitoring study was moved to Bear Creek in order to simultaneously evaluate Chinook and sockeye production. Since 1999, the Bear Creek juvenile monitoring study has also provided estimates of coho production and described ancillary data on movement patterns of steelhead and cutthroat trout.

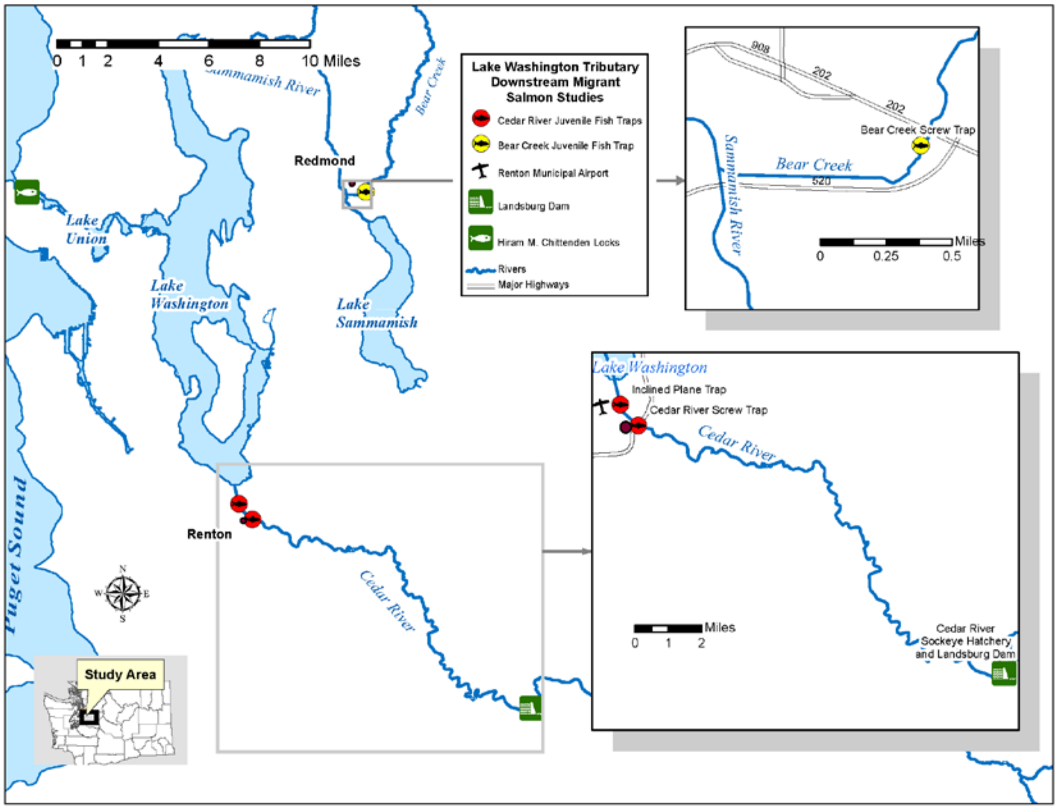

Figure 1. Map of Lake Washington trap sites used to monitor abundance of juvenile migrant salmonids in the Cedar River and Bear Creek, near Renton and Redmond, respectively.

The primary study goal of this program in 2014 was to estimate the number of juvenile sockeye fry, and natural-origin Chinook and coho migrating from the Cedar River and Bear Creek into Lake Washington. This estimate was used to calculate survival of the 2013 brood from egg deposition to lake/river entry and to describe the migration timing of each species. Cutthroat and steelhead movements were assessed through catch totals but no abundance estimates were made. Biological data representing each population is also summarized.

Methods

Fish Collection

Trapping Gear and Operation

Cedar River

Two traps were operated in the lower Cedar River during the late winter/spring out migration period. A small floating inclined-plane trap was operated late winter through spring to trap sockeye and Chinook fry. This trap was designed to minimize predation in the trap by reducing capture of yearling migrants. A floating rotary screw trap was operated early spring through summer to assess migration of larger subyearling Chinook as well as coho, steelhead/rainbow, and cutthroat smolts. This trap captured larger migrants that were potential predators of sockeye fry; therefore, the live box was designed to not retain sockeye fry. Together, these traps provided production estimates for each species while minimizing trap-related mortality.

The inclined-plane trap consists of one or two low-angle inclined-plane screen (scoop) traps (3-ft wide by 2-ft deep by 9-ft long) suspended from a 30x13 ft steel pontoon barge. Fish are separated from the water with a perforated aluminum plate (33 - 1/8 in. holes per in^2). The inclined-plane trap resembles larger traps used to capture juvenile salmonids in the Chehalis and Skagit rivers, described by Seiler et al. (1981) . Each scoop trap screens a cross-sectional area of 4 ft^2 when lowered to a depth of 16 inches. The screw trap consisted of a 5 ft diameter rotary screw trap supported by a 12-ft wide by 30-ft long steel pontoon barge (Seiler *et al.* 2003).

Over the 23 years that the Cedar River juvenile monitoring study has been conducted, trapping operations have been modified in response to changes in channel morphology and project objectives. In summer 1998, the lower Cedar River was dredged to reduce flooding potential (USACE 1997). Dredging lowered the streambed, created a wider and deeper channel, and reduced water velocity at the inclined-plane trap location to nearly zero. In response, the inclined-plane trap location was moved upstream in 1999 to river mile 0.8 in order to operate under suitable current velocities.

In 2014, the inclined-plane trap was anchored at RM 0.8, just downstream of the South Boeing Bridge (Figure 1). This trap was positioned off the east bank and repositioned within eight feet of the shoreline in response to changing flows. Two scoop traps were fished in parallel throughout the season except on 35 nights when only one trap was operated due to high flows, debris loads or large catches of either hatchery or naturally produced sockeye.

The inclined-plane trap began operating on the night of January 17 was operated 62 nights between January 17 and May 2. During each night of operation, trapping began before dusk and continued past dawn. Trapping was also conducted during 7 day-light periods between early February and the middle of April. Captured fish were removed from the trap, identified by species, and counted each hour. Fork lengths were randomly sampled on a weekly basis from all salmonid species, except for sockeye. There were twelve nights when trap operations were reduced to fishing a portion of each hour, rather than the whole night, due to high flows and debris.

The Cedar River Sockeye Hatchery released hatchery reared sockeye fry into the Cedar River above the trap on nineteen nights throughout the season; six releases at the lower site (R.M. 2.1), six releases occurred at the middle release location (R.M. 13.5) and six releases at upper location (R.M. 21.8). In addition there was a single night when fish were released from both the middle and upper release locations. The trap operated during one lower river release and all middle and upper river releases for a total of 14 releases.

In 2014, the screw trap was operated at R.M 1.6, just under the I-405 Bridge (Figure 1), on 91 nights between the evening of April 16 and July 16. There were periods when the trap did not fish due to high debris loads or day periods when trapping was intentionally halted due to public safety concerns or high flows and heavy debris. Catches were enumerated at dusk and in the early morning in order to discern diel movements. Fork length was measured from a weekly random sample of all Chinook, coho, steelhead/rainbow, and cutthroat smolts.

Bear Creek

A rotary screw trap was operated 100 yards downstream of the Redmond Way Bridge from January 28 to July 9, 2014. The screw trap is identical to that employed in the Cedar River and was positioned in the middle of the channel approximately 100 yards downstream of Redmond Way, below the railroad trestle (Figure 1). Catches were identified to species and enumerated at dusk and in the early morning. Fork lengths were randomly sampled on a weekly basis from all Chinook, coho, and cutthroat smolts.

PIT Tagging

During screw trap operation at both sites, a portion of natural-origin Chinook migrants were tagged with Passively Integrated Transponder (PIT) tags. Captured steelhead were tagged as well. Tagging occurred two to three times a week, depending on catches, between May 1 and July 9, 2014. Fish were often held from the previous day to be tagged to increase the total number of fish tagged per day. Fish were held in partially-perforated buckets suspended in the river off the stern of the trap or in the live box. Chinook longer than 65 mm that displayed good physical health were considered for tagging. Fork lengths were measured for all PIT tagged fish. Protocols for tagging follow those outlined for the Columbia River basin by the PIT Tag Steering Committee (2014).

In 2014, a portion of Issaquah Hatchery Chinook were also tagged and released on May 23, 2014. Survival and detection data are included and compared to that of Bear Creek and Cedar River.

At the Hiram Chittenden Locks facility demarcating the boundary between the Lake Washington watershed from the marine waters of Puget Sound, PIT tag antennas were positioned in the four smolt flumes and the adult fish ladder. Median migration date was the median date of all detected fish at all detection locations at the Hiram Chittenden Locks. Average travel times were calculated using tag date and subsequent detection date at the Hiram Chittenden Locks.

Trap Efficiencies

Cedar River

Inclined-Plane Trap

Trap efficiencies of the Cedar River inclined-plane trap were estimated from recaptures of marked natural-origin sockeye fry released above the trap. Fish captured in the early hours of the night were used for efficiency trials. All fry used for efficiency trials were marked in a solution of Bismarck brown dye (14 ppm for 1.5 hours). The health of marked fish was assessed prior to release. Deceased or compromised fish were not included in releases. Fish were transported in buckets with battery operated aerators if needed. At the release location, a swinging bucket on a rope distributed marked fry across the middle of the channel. Catches were examined for marked fish and recaptures were noted during each trap check. In 2014, Chinook catches were consistently large enough to form regular efficiency trials and were used to estimate Chinook abundance rather than sockeye fry as has been practice in previous trap seasons.

Screw Trap

Trap efficiencies of the Cedar River screw trap were determined for Chinook, coho, and cutthroat from recaptures of marked fish released above the trap. Trap efficiency trials were conducted for each species. Fish were anesthetized in a solution of MS-222 and marked with alternating upper and lower, vertical and horizontal partial-caudal fin clips. Marks were changed on weekly intervals or more frequently when there was a significant change in river discharge. Beginning May 4, Chinook parr larger than 65-mm FL were tagged with PIT tags while smaller Chinook continued to be fin clipped. Similar to fin marks, PIT tags enabled stratified releases and recaptures to be evaluated during data analysis. In addition, individual fish could be identified from the PIT tags, providing information on recapture timing for release groups.

Marked fish were allowed to recover from the anesthetic during the day in perforated buckets suspended in calm river water. In the evening, groups were released approximately 800-yards upstream of the trap (Riviera release location). Efficiency trial releases were conducted every night or every other night, with frequency driven by the availability of each species in the day’s catch. Catches were examined for marks or tags and recaptures were noted during each trap check.

Bear Creek

Similarly to the Cedar River inclined-plane trap, sockeye efficiencies for the Bear Creek screw trap were estimated from recaptures of marked sockeye fry released above the trap, approximately 100 yards upstream of the trap at the Redmond Way Bridge. Fry releases occurred when adequate numbers of fish were available. Fry captured the previous night were marked in a solution of Bismarck brown dye (14 ppm for 1.5 hours). The health of marked fish was assessed prior to release. All deceased or compromised fish were not included in releases. Catches were examined for marks and recaptures were noted during each trap check. When Chinook fry were not abundant enough to form efficiency trial groups, sockeye fry were assumed adequate surrogates for estimating trap efficiencies.

Trap efficiencies of Chinook parr, coho, and cutthroat in Bear Creek screw trap were estimated using the same approach described for similar species at the Cedar River screw trap. Efficiency trial releases were conducted every night or every other night, with frequency driven by the availability of each species in the day's catch.

Analysis

The abundance of juvenile migrant salmonids was estimated using a mark-recapture approach and a single trap design (Volkhardt et al. 2007). The analysis was stratified by time in order to account for heterogeneity in capture rates throughout the season. The general approach was to estimate (1) missed catch, (2) efficiency strata, (3) abundance for each strata, (4) extrapolated migration prior to and post trapping, and (5) total production.

Missed Catch

Total catch ($\hat{u}_i$) during period *i* was the actual catch (*n*) summed with estimated missed catch ($\hat{n}$) during trap outages. Missed catch was estimated using three different approaches depending on what type of trap outage occurred: 1) entire night periods when trap operations were suspended, 2) partial day or night periods when trap operations were suspended, and 3) entire day periods when trap operations were suspended. Three approaches were used because salmonid catch rates differ between the day and night time hours.

Missed Catch for Entire Night Periods

When the trap operations were suspended for entire night periods, missed catch was estimated using a straight-line interpolation between catches on adjacent nights. This approach assumes that the fishing period during the adjacent nights was the same as the outage period. When the outage occurred on a single night, variance of the estimated catch was the variances of the mean catch on adjacent nights (Equation 1). When the outage occurred on multiple consecutive nights, then one or both adjacent night catches were estimates and Equation 2 was used.

Equation 1

$$Var(\bar{n}_i) = \frac{\sum (n_i - \bar{n}_i)^2}{k(k-1)}$$

Equation 2

$$Var(\bar{n}_i) = \frac{\sum (\hat{n}_i - \bar{n}_i)^2}{k(k-1)} + \frac{\sum Var(\hat{n}_i)}{k}$$

where:

k = number of sample nights used in the interpolation,

n_i = actual night catch of unmarked fish used to estimate the un-fished interval,

$\bar{n}_i$ = interpolated night catch estimate (mean of adjacent night catches), and

$\hat{n}_i$ = missed night catch (estimated) of unmarked fish used to estimate the un-fished interval

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

Equation 3

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

Missed Catch for Partial Day and Night Periods

When the inclined-plane trap was operated intermittently through the night or the screw trap operated intermittently, missed catch during the un-fished interval ($\hat{n}_i$) was estimated by:

$$\hat{n}_i = T_i * \overline{R} \qquad \text{Equation 4}$$

where:

T_i = Hours during non-fishing period *i*

$\overline{R}$ = Mean catch rate (fish/hour) from adjacent fished periods

Variance associated with $\hat{u}_i$ was estimated by:

$$Var(\hat{n}_i) = T_i^{\,2} * Var(\overline{R}) \qquad \text{Equation 5}$$

Variance of the mean catch rate ($\overline{R}$) for *k* adjacent fishing periods was:

$$Var\left(\overline{R}\right) = \frac{\sum_{i=1}^{i=k} (R_i - \overline{R}\ )^2}{k\left(k-1\right)} \qquad \text{Equation 6}$$

Missed Catch for Entire Day Periods

Missed day-time catches in the inclined-plane trap were estimated by multiplying the previous night catch by the proportion of the 24-hour catch caught during the day. This proportion (F_d) was estimated as:

$$\hat{F}_d = \frac{T_d}{\overline{Q}^{-1} T_n + T_d} \qquad \text{Equation 7}$$

Variance in the day-to-night catch ratio was:

$$Var(\hat{F}_d) = \frac{Var(\overline{Q})T_n^{\;2}T_d^{\;2}}{\overline{Q}^4\left(\frac{1}{\overline{Q}}T_n + T_d\right)^4} \qquad \text{Equation 8}$$

where:

T_n = hours of night during 24 hour period,

T_d = hours of day during 24 hour period, and

$\overline{Q}_d$ = bi-weekly day-to-night catch ratio.

Efficiency Strata

Stratification of the capture and recapture data was necessary to accommodate for changes in trap efficiency over the season. These changes result from a number of factors including river flows, turbidity, and fish sizes. However, when using a mark-recapture approach to estimate abundance, precision of the estimate increases with the number of recaptures. A manufactured drawback of stratification can be a large variance associated with the estimate. Therefore, a *G*-test was used to determine whether to pool or hold separate adjacent efficiency trials (Sokal and Rohlf 1981).

Of the marked fish (*M*) released in each efficiency trial, a portion are recaptured (*m*) and a portion are not seen (*M*-*m*). If the seen:unseen [*m*:(*M*-*m*)] ratio differs between trials, the trial periods were considered as separate strata. However, if the ratio did not differ between trials, the two trials were pooled into a single stratum. A *G*-test determined whether adjacent efficiency trials were statistically different ($\alpha = 0.05$). Trials that did not differ were pooled and the pooled group compared to the next adjacent efficiency trial. Trials that did differ were held separately. Pooling of time-adjacent efficiency trials continued iteratively until the seen:unseen ratio differed between time-adjacent trials. Once a significant difference was identified, the pooled trials were assigned to one strata and the significantly different trial indicated the beginning of the next strata.

Abundance for Each Strata

The abundance of juvenile migrants for a given strata *h* was calculated from maiden catch (actual and missed, $\hat{u}_h$), marked fish released in that strata (M_h), and marked fish recaptured in that strata (m_h). Abundance was estimated using a Bailey estimator appropriate for single trap designs (Carlson et al. 1998, Volkhardt et al 2007):

Equation 9

$$\hat{U}_h = \frac{\hat{u}_h (M_h + 1)}{m_h + 1}$$

Variance associated with the Bailey estimator was modified to account for variance of the estimated catch during trap outages (derivation in Appendix A):

Equation 10

$$V(\hat{U}_h) = V(\hat{u}_h)\left(\frac{(M_h + 1)(M_h m_h + 3M_h + 2)}{(m_h + 1)^2 (m_i + 2)}\right) + \left(\frac{(M_h + 1)(M_h - m_h)\hat{u}_h(\hat{u}_h + m_h + 1)}{(m_h + 1)^2 (m_h + 2)}\right)$$

Maiden catch ($\hat{u}_h$) was the sum of all actual and estimated catch during strata *h*. Variance of the catch [$V(\hat{u}_h)$] was the sum of all estimated catch variances during strata *h*.

Extrapolate Migration Prior to and Post Trapping

Modality of the trap catches suggested that migration outside the period of trap operation was minimal. Pre- and post-trapping migrations were estimated using linear extrapolation.

Equation 11

$$\hat{N}_e = \frac{\sum_{d=1}^{d=k} \hat{N}_d}{k} * \frac{t}{2}$$

Variance of the extrapolation was estimated as:

Equation 12

$$V(\hat{N}_e) = \frac{\sum_{d=1}^{d=k} (\hat{N}_d - \overline{N})^2}{k(k-1)} * \left(\frac{t}{2}\right)^2$$

where:

$\hat{N}_d$ = Daily migration estimates,

k = Number of daily migration estimates used in calculation, and

t = Number of days between assumed start/end of migration and the first/last day of trapping.

Pre- and post-season migration was based on the first and last five days of measured migration. The assumed migration for sockeye was January 1 to June 30 on the Cedar River and January 1 to April 30 on Bear Creek. The assumed migration for Chinook in both watersheds was January 1 to July 13. Pre- and post-season migration was not estimated for coho or cutthroat.

Total Production

Total production was the sum of the stratified abundance estimates for all *k* strata and the extrapolated migration estimates:

Equation 13

$$\hat{N} = \hat{N}_{before} + \sum_{h=1}^{h=k} \hat{U}_h + \hat{N}_{after}$$

Total variance was the sum of stratified abundance variances and extrapolated migration variances. Confidence intervals and coefficient of variation associated with abundances were calculated from the variance.

Hatchery Catch and Survival

Hatchery catch and survival was estimated for eight nights when releases occurred upstream from the trap. Although the trap attempted to fish for the duration of the evening on all fifteen upper and middle river releases, high flows and heavy debris were persistent throughout the season resulting in partially fished nights and a high amount of uncertainty in applying any method to estimate hatchery abundance and survival.

Survival of hatchery fry was estimated for releases that occurred on eight nights that the trap was able to operate continuously using both indirect and direct measurements of hatchery fish in trap catches. On the nights of February 12, 21 and 27, and April 4, the nightly timing method was the preferred indirect method of measuring of hatchery fish abundance. Due to the inability to visually distinguish hatchery and natural-origin sockeye, the portion of each in the catch is unknown on hatchery release nights. Therefore, we assumed that natural-origin nightly migration timing (i.e. hourly catch proportion) on hatchery release nights was similar to surrounding nights. On hatchery release nights, the arrival of the pulse of hatchery fish was clearly indicated by a dramatic increase in catch rate. For each hour after the arrival of the hatchery fish pulse, we estimated the catch of natural-origin sockeye by applying the hourly proportion observed on adjacent nights to the number of natural-origin sockeye salmon counted in the period prior to the arrival of the hatchery fish pulse. Estimated hatchery catch was the total catch minus the expected hourly natural-origin catch.

On some hatchery release nights, calcein and otolith sampling were used to directly estimate the abundance of hatchery sockeye based on the presence of marked fish in trap catches. All sockeye salmon released from the Cedar River Sockeye Hatchery were otolith marked. On March 6 a portion of the hatchery release was dyed with calcein and marks were recovered at the trap. On March 25, April 4 and April 29, entire trap catches were kept for otolith analysis.

Total hatchery abundance was estimated by expanding estimated hatchery catch by the measured nighttime efficiency. If an efficiency trial was not conducted on a hatchery release night, then the appropriate strata efficiency was applied. Survival of releases above the trap was calculated by dividing estimated hatchery abundance at the trap by total number of sockeye released above the trap.

Egg-to-Migrant Survival and Productivity

Egg-to-migrant survival estimates for sockeye was the measured survival between egg deposition and migration of juveniles into Lake Washington. Survival was estimated by dividing the 2014 abundance of natural-origin juvenile migrants by the 2013 potential egg deposition (PED) for each species and watershed. PED was the product of the number of female spawners and their fecundity. Sockeye spawner abundances in the Cedar River and Bear Creek were Area-Under-the-Curve estimates that were calculated and agreed upon in a multi-agency effort. This estimate assumed an even sex ratio for sockeye. Cedar River sockeye fecundity was estimated by the average number of eggs per female during 2013 sockeye brood stock collection for the Cedar River Sockeye Hatchery (Shoblom 2014). Fecundity of Bear Creek sockeye was assumed to be the same as the fecundity of Cedar River sockeye.

Productivity for Chinook in both Cedar River and Bear Creek was measured by the number of migrants produced per female spawner that contributed to the outmigrating brood year. We acknowledge that there are two life-history forms of sub yearling Chinook salmon observed in Puget Sound: small fry migrating immediately after emergence and larger parr that spend some time rearing in freshwater. The small fry are defined as fish emigrating between January and early May and larger parr are defined as fish emigrating between early May and July. Since there is an unknown in-river mortality rate from fry to parr migration, we have chosen to measure Chinook freshwater success based on the number of migrants per female rather than any measure of survival. We believe that the measure of parr survival as previously calculated underestimates the actual survival of those migrants that choose to leave as parr. Productivity is further divided into the number of fry and parr per female. The number of female Chinook was based on annual redd counts conducted by state and local agencies and assumed to represent one female per redd (Burton et al. 2014). Fecundity for Cedar River and Bear Creek (4,500 eggs per female) is assumed to be similar to the fecundity of Soos Creek Hatchery Chinook on the Green River.

Cedar River

Sockeye

Production Estimate

Total catch (actual and estimated missed) in the inclined-plane trap was 296,094 sockeye fry. A total of 95,474 natural-origin sockeye fry were caught in the inclined-plane trap during trap operations. We estimated a missed catch of an additional 200,620 sockeye fry for all night trap outages between January 17 and May 2, 2014. Seven day intervals were trapped to evaluate day-time migration: February 3, 10, 24, and March 3, 23, 31, and April 7. Flows on these days ranged from 703 cfs to 1,819 cfs at the Cedar River USGS gage (#12119000). Day-to-night catch ratios ranged from 1.44% to 71.83%. We estimated a missed catch of 78,780 fry for all day-time trap outages. Missed day-time catch represented 27% of the season's total catch. Flows were extremely high for the duration of the outmigration period and are expected to be the main contributor of such a large estimated daytime migration in 2014.

Table 1. Abundance of natural-origin sockeye fry entering Lake Washington from the Cedar River in 2014. Table includes abundance of fry migrants, 95% confidence intervals (C.I.), and coefficients of variation (*CV*).

Component	Period	Dates	Fry Abundance	95% C.I.		*CV*
				Low	High	
Natural Origin	Pre Trapping	January 1 - 16	289,741	248,581	330,901	7.25%
	During Trapping	January 17-May 2	37,441,954	31,278,457	43,605,451	8.40%
	Post Trapping	May 3- June 30	244,074	189,735	298,413	11.36%
		Total	**37,975,769**	**31,811,895**	**44,139,643**	**0.20%**

A total of 40 efficiency trials were conducted in 2014. Efficiency data were aggregated into ten strata. Capture rates for these strata ranged from 0.32% to 1.96% (Appendix B). Trap efficiencies were extremely low in 2014 compared to previous years. This is a reflection of the higher than normal flows during the outmigration period.

An estimated 37.9 million natural-origin sockeye fry entered Lake Washington from the Cedar River in 2014 (Table 1, Appendix A 1). This estimate includes pre-season and post-season estimates of roughly 0.53 million fry total, as well as the estimated abundance of fry during the trapping period of 37.4 million fry. Both pre- and post-season tails each represent less than 2% of the total natural production. Coefficient of variation (*CV*) associated with the natural-origin migration was 0.20%.

Migration began moderately and quickly climbed by the end of February through the middle of March with a small pulse of sockeye in early April before slowing for the remainder of the season (Figure 2). Median migration date for natural-origin sockeye was March 2 (Table 2). Hatchery fish migrated later (nine days) than naturally produced fish in 2014 (Table 2). The median migration date for hatchery sockeye does not include releases when the trap was not fished or when the trap did not obtain reliable catch data. These excluded releases totaled 4.57 million fry; their absence likely biases the estimate of hatchery migration timing towards an earlier date (see Hatchery Abundance and Survival section, Table 3) because most of these releases were later in the season.

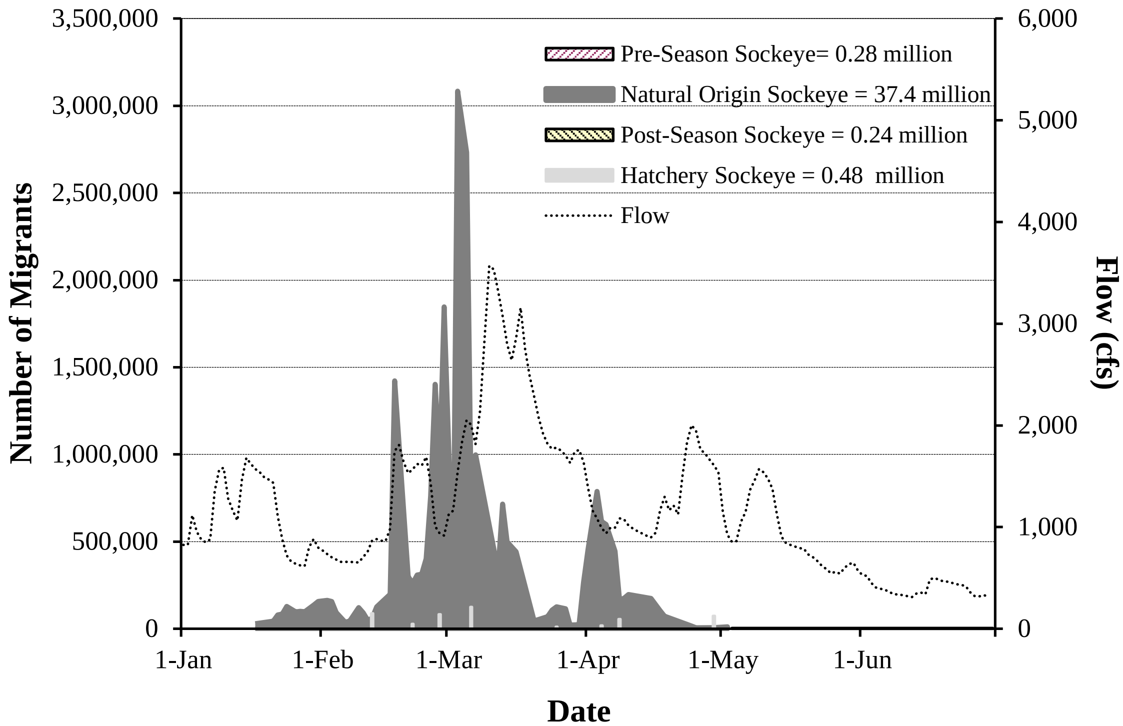

Figure 2. Estimated daily migration of natural-origin and hatchery sockeye fry migrating from the Cedar River into Lake Washington between January 17 and May 2, 2014. Pre- and post-trapping migration estimates are included. Graph includes daily average flows during this period (USGS Renton gage Station #12119000).

Table 2. Median migration dates of natural-origin, hatchery, and total (combined) sockeye fry from the Cedar River for brood years 1991 to 2013. Total thermal units for February were measured in degrees Celsius at the USGS Renton gage, Station #12119000. Temperature was not available for the 1991 brood year.

Brood Year i	Trap Year i+1	February Thermal Units	Median Migration Date Wild	Hatchery	Combined	Difference (days) W-H
1991	1992		03/18	02/28	03/12	19
1992	1993	156	03/27	03/07	03/25	20
1993	1994	162	03/29	03/21	03/26	8
1994	1995	170	04/05	03/17	03/29	19
1995	1996	153	04/07	02/26	02/28	41
1996	1997	147	04/07	02/20	03/16	46
1997	1998	206	03/11	02/23	03/06	16
1998	1999	187	03/30	03/03	03/15	27
1999	2000	161	03/27	02/23	03/20	32
2000	2001	158	03/10	02/23	03/08	15
2001	2002	186	03/25	03/04	03/19	21
2002	2003	185	03/08	02/24	03/03	12
2003	2004	186	03/21	02/23	03/15	26
2004	2005	193	03/02	02/23	03/01	7
2005	2006	184	03/20	03/06	03/16	14
2006	2007	193	03/23	02/20	02/26	31
2007	2008	170	03/16	03/06	03/15	10
2008	2009	187	03/19	03/06	03/13	13
2009	2010	219	03/07	03/08	03/07	-1
2010	2011	163	03/25	02/18	03/01	35
2011	2012	170	03/22	03/08	03/18	14
2012	2013	184	03/07	03/06	03/07	1
2013	2014	160	03/02	03/11	03/04	-9
	Average		03/20	03/02	03/11	18

Hatchery Abundance and Survival

Over the season a total of 7.43 million hatchery-produced sockeye were released into the Cedar River (Table 3). On six separate nights, a total of 2.96 million sockeye were released at R.M. 2.1. This is a new release location for the lower river which is located above the trap site. The previous release site was located at R.M. 0.1, below the trap site. Due to trap staffing constraints and our historical inability to assess the lower river releases due to trap location, efforts were focused on continued monitoring of the upper and middle river releases. However, the trap operated on the night of February 12 lower river release to assess the feasibility of operating with such a large number of fish released directly above the trap and to assess the veracity of the assumption that fish released so close to the mouth survived at 100% to lake entry. The assumption of 100% fry survival for the lower river release location was previously held but never tested for the 0.1 R.M. release location.

Of the 286,003 hatchery sockeye released on February 12 release, using the nightly timing approach, we estimated that 88,995 sockeye survived to the trap, for a survival of 31.1%. It is possible that the stress of handling and trucking the sockeye had a detrimental effect on their ability to navigate their new environment following release. This stress incurred would be similar to that experienced by those released at the middle river location and may account for some of the loss documented from those releases. It is also possible that a portion of the sockeye migrated on the following day or evening but went undocumented since it is difficult to visually differentiate between hatchery and naturally produced sockeye. Loss at the 0.1 R.M. release location has not been previously documented making it difficult to compare the two lower river release locations. We also acknowledge that there is some error around our trap efficiency estimate and nightly timing method used to estimate hatchery abundance. However, we do not believe that there is enough error incurred to account for the loss of nearly 70% of sockeye released at the new lower river release location.

An additional 2.65 million hatchery fry were released at R.M. 13.5 on six separate nights and a total of 1.01 million fry were released at the Cedar River Sockeye Hatchery (R.M. 21.8) on six different nights (Table 3). On one night 828,624 sockeye were released at both locations. The inclined-plane trap operated on 12 of these 13 releases. However, we were only able to make hatchery abundance and survival estimates for seven of the 13 upper or middle releases. Rather than fishing the trap continuously, the trap was reduced to fishing only a portion of each hour on the remaining nights due to high flows and heavy debris during the majority of the season. Unfortunately this change in operation prevented us from developing reliable estimates of hatchery fish abundance. Hatchery sockeye abundance and survival were not estimated for the following nights: February 18, March 11, 18, 21, April 22, and May 1. These releases are not included in any season totals as an unknown portion of the release survived to lake entry.

Hatchery abundance and survival was estimated for seven releases that occurred at either the middle or upper release location. The March 6 release was partially marked with calcein and provided direct counts of hatchery sockeye in trap catches. Estimates of hatchery sockeye for releases occurring on March 25, April 8, and 29 were formed by submitting the entire nights catch for otolith analysis, which also provided direct counts of hatchery sockeye to determine abundance and survival.

The nightly timing approach was used to estimate abundance and survival for three releases that occurred from the upper or middle release location (February 21, 27 and April 4). This approach was chosen because it was the only indirect approach that provided consistent reasonable estimates (0% < survival < 100%). Summed across all seven nights that hatchery releases from the middle and upper sites were monitored, a total of 2.54 million hatchery sockeye fry were released. Of those seven releases, total abundance surviving to the trap was estimated at 394,787 fry, for an overall in-river survival of 18.6%. From these releases, in-river survival of hatchery sockeye ranged from 5.3% to 81.9% for individual releases (Table 3).

Overall, of the 19 releases of hatchery sockeye that occurred in 2014, we were able to make abundance estimates for eight releases (one lower river release and seven upper or middle river releases). Of those eight releases, and a total of 2.83 million sockeye released, we estimate a total of 483,782 hatchery sockeye entered Lake Washington with an overall survival of 17.1%. The actual number of hatchery sockeye entering Lake Washington in 2014 is greater. These estimates do not include survival of releases that were not fished or that we were unable to attain reliable catch data to form confident estimates for.

We recognize that direct measurement of hatchery catch on hatchery release nights is vital to providing accurate hatchery and natural origin abundance estimates. On seven different hatchery release nights since 2012 we directly measured hatchery fish in trap catches, using calcein and otolith sampling methods. The hatchery abundance estimates formed using these direct methods were compared to estimates formed using indirect methods (nightly timing, specifically), and do not consistently fall within the 95% confidence intervals of the direct estimates and fail to provide consistent reliable estimates. This concern further confirms the need to develop additional methods to directly measure hatchery fish in trap catches. Two new methods involving calcein and otolith sampling will be tested in 2015 and further refined following in-season results.

Table 3. Estimated hatchery sockeye abundance, variance, survival, and method used for estimation for 8 of 19 releases conducted above the Cedar River inclined-plane trap, 2014. Releases where no estimate is provided are nights the trap was either not operated or unable to operate fully to provide reliable data for forming hatchery estimates. Flow data was measured at the USGS Renton gage, Station #12119000.

Date Released	Daily Average Flow (cfs)	Sockeye Released	Release Location	Estimated Hatchery Sockeye			Estimate Method
				Abundance	Variance	Survival	
02/12/2014	870	286,034	Lower	88,955	7.11×10^8	31.10%	Nightly Timing
02/18/2014	1,808	828,624	Upper/Middle				
02/21/2014	1,569	523,564	Middle	27,719	1.48×10^8	5.29%	Nightly Timing
02/26/2014	1,008	493,249	Lower				Not Fished
02/27/2014	937	525,933	Upper	82,072	1.57×10^8	15.61%	Nightly Timing
03/06/2014	2,008	1,045,519	Middle	124,450	3.74×10^8	11.90%	Calcein
03/11/2014	3,535	53,280	Upper				
03/12/2014	3,318	1,064,469	Lower				Not Fished
03/18/2014	2,750	276,476	Upper				
03/21/2014	2,079	555,672	Middle				
03/25/2014	1,783	92,542	Upper	12,049	7.33×10^6	13.02%	Otolith Sample
03/26/2014	1,752	508,734	Lower				Not Fished
04/02/2014	1,161	95,332	Lower				Not Fished
04/04/2014	991	23,558	Upper	19,299	2.23×10^7	81.92%	Nightly Timing
04/08/2014	1,086	129,054	Middle	55,780	1.00×10^8	43.22%	Otolith Sample
04/16/2014	944	514,718	Lower				Not Fished
04/22/2014	1,508	168,626	Middle				
04/29/2014	1,610	202,848	Middle	73,418	6.12×10^7	36.19%	Otolith Sample
05/01/2014	1,150	38,696	Upper				
	Season Total	**7,426,928**		**483,742**	**1.58×10^9**	**17.1%**	

Egg-to-Migrant Survival of Natural-Origin Fry

Egg-to-migrant survival of the 2013 brood Cedar River sockeye was estimated to be 16.0%

Table 4). Survival was based on 37.3 million natural-origin fry surviving from a potential 236 million eggs deposited by 70,341 females (B. Craig, Washington Department of Fish and Wildlife, personal communication). Average fecundity for the 2013 brood was 3,362 eggs per female sockeye (Shoblom 2014). Survival of the 2013 brood is near the long-term average over 23 years of monitoring.

Table 4. Egg-to-migrant survival of natural-origin sockeye fry in the Cedar River and peak mean daily flows during egg incubation period for brood years 1991 - 2013. Incubation period is defined from November to February. Flow was measured at the USGS Renton gage, Station #12119000.

Brood Year	**Spawners**	**Females** (@50%)	**Fecundity**	**Potential Egg Deposition**	**Fry Production**	**Survival Rate**	**Peak Incubation Flow** (cfs)	Date
1991	76,592	38,296	3,282	125,687,226	9,800,000	7.80%	2,060	1/28/1992
1992	99,849	49,924	3,470	173,237,755	27,100,000	15.64%	1,570	1/26/1993
1993	74,677	37,338	3,094	115,524,700	18,100,000	15.67%	927	1/14/1994
1994	107,767	53,883	3,176	171,133,837	8,700,000	5.08%	2,730	12/27/1994
1995	21,443	10,721	3,466	37,160,483	730,000	1.96%	7,310	11/30/1995
1996	228,391	114,196	3,298	376,616,759	24,390,000	6.48%	2,830	1/2/1997
1997	102,581	51,291	3,292	168,848,655	25,350,000	15.01%	1,790	1/23/1998
1998	48,385	24,193	3,176	76,835,676	9,500,000	12.36%	2,720	1/1/1999
1999	21,755	10,877	3,591	39,060,930	8,058,909	20.63%	2,680	12/18/1999
2000	146,060	73,030	3,451	252,025,754	38,447,878	15.26%	627	1/5/2001
2001	117,225	58,613	3,568	209,129,787	31,673,029	15.15%	1,930	11/23/2001
2002	192,395	96,197	3,395	326,590,484	27,859,466	8.53%	1,410	2/4/2003
2003	109,164	54,582	3,412	186,233,926	38,686,899	20.77%	2,039	1/30/2004
2004	114,839	57,419	3,276	188,106,200	37,027,961	19.68%	1,900	1/18/2005
2005	49,846	24,923	3,065	76,388,804	10,861,369	14.22%	3,860	1/11/2006
2006	105,055	52,527	2,910	152,854,370	9,246,243	6.05%	5,411	11/9/2006
2007	45,066	22,533	3,450	77,738,114	25,072,141	32.25%	1,820	12/3/2007
2008	17,300	8,650	3,135	27,118,177	1,630,081	6.01%	9,390	1/8/2009
2009	12,501	6,250	3,540	22,125,910	12,519,260	56.58%	2,000	11/19/2009
2010	59,795	29,898	3,075	91,935,489	4,517,705	4.91%	5,960	1/18/2011
2011	23,655	11,827	3,318	39,243,121	14,763,509	37.62%	2,780	1/30/2012
2012	88,974	44,487	3,515	156,371,805	55,793,120	35.68%	1,513	12/7/2012
2013	140,682	70,341	3,362	236,486,442	37,975,769	16.06%	1,762	11/20/2013

Chinook

Production Estimate

Production of natural-origin Chinook was estimated to be 1,458,761 ± 390,182 (±95% C.I.) sub-yearlings, based on operation of both the inclined-plane and screw traps. Between January 1 and May 2, 2014 1,426,631 ± 390,140 (±95% C.I.) natural-origin Chinook were estimated to have passed the inclined-plane trap (Table 6, Appendix A 2). This includes an estimate for a pre-trapping period from January 1 to 16 of 17,045 fry and an estimate of 1,409,586 Chinook during the time the inclined-plane trap was operating from January 17 to May 2. This estimate was based on a total catch of 21,428 and Chinook trap efficiency strata ranging from 0.12% to 2.53%. This is the first year the trap has captured sufficient Chinook to conduct large trap efficiency trials consistently throughout the season. Chinook trap efficiencies were approximately double those measured for sockeye. Trap efficiency estimates for the two species were statistically significantly different from the each other for the early part of the season (Table 5). We chose to apply Chinook trap efficiencies to estimate Chinook fry abundance in 2014. Application of sockeye trap efficiencies would estimate 2.8 million Chinook fry. The fry migration is denoted by one prominent peak in mid-February when we estimated nearly 300,000 Chinook moved past the trap (Figure 3). This large movement was driven a substantial change in flows overnight that reduced our trap efficiency but increased Chinook catches. The parr portion of the migration was moderate with one prominent peak in mid-June estimating over 1,600 parr migrating.

Table 5. Sockeye and Chinook inclined-plane trap efficiencies during 2014.

Date	Flow (cfs)	Trap Efficiencies	
		Sockeye	Chinook
1/23/2014	881	1.33%	1.00%
1/27/2014	624	0.91%	3.64%
1/28/2014	618	1.25%	2.22%
1/31/2014	798	1.09%	2.21%
2/3/2014	703	1.16%	4.89%
2/4/2014	681	0.83%	2.85%
2/7/2014	659	1.52%	1.19%
2/10/2014	705	1.06%	2.78%
2/11/2014	758	0.84%	2.01%
2/12/2014	870	1.60%	1.11%
2/13/2014	880	1.96%	2.30%
2/17/2014	1,748	0.39%	1.20%
2/18/2014	1,808	0.53%	2.30%
2/20/2014	1,530	0.12%	1.10%
2/21/2014	1,569	0.72%	2.42%
2/24/2014	1,692	0.37%	0.63%
2/25/2014	1,427	0.93%	1.92%
2/28/2014	916	1.22%	1.36%
3/3/2014	1,535	0.44%	0.79%
3/7/2014	1,816	1.14%	1.18%
3/28/2014	1,629	1.73%	1.89%
4/8/2014	1,086	1.21%	2.38%

Between May 3 and July 16, 2014, 31,988 ± 5,751 (±95% C.I.) natural-origin Chinook were estimated to have passed the screw trap (Table 6, Figure 4, Appendix A 3). This estimate is based on a total catch of 3,149 natural-origin juvenile Chinook in the screw trap and trap efficiency ranging from 6.3% to 44.4%. Post-trapping Chinook migration was estimated at 142 Chinook.

We estimated the abundance of two life-history forms of subyearling Chinook salmon observed in Puget Sound: small fry migrating immediately after emergence and larger parr that spend some time rearing and growing in freshwater. The small fry are defined as fish emigrating between January and early May and comprised 98% of all sub-yearlings. The larger parr are defined as fish emigrating between early May and July and comprised 2% of the total migration (Table 8).

Table 6. Abundance of natural-origin juvenile migrant Chinook in the Cedar River in 2014. Data are total catch, abundance, 95% confidence intervals (C.I), and coefficient of variation (*CV*).

Capture Method	Period	Total Catch	Abundance	95% C.I. Low	95% C.I. High	CV
Pre-trapping	January 1 - 16		17,045	11,697	22,394	16.01%
Fry Trap	Janunary 17 - May 2	21,428	1,409,586	1,019,483	1,799,689	14.12%
Fry Trap subtotal		21,428	1,426,631	1,036,492	1,816,771	13.95%
Screw Trap	May 3 - July 16	3,149	31,988	11,166	27,272	9.17%
Post Trapping	July 17 - July 31		142	69	215	26.15%
Screw Trap subtotal		3,149	32,130	26,379	37,882	9.13%
TOTAL		**24,577**	**1,458,761**	**1,068,580**	**1,848,944**	**13.65%**

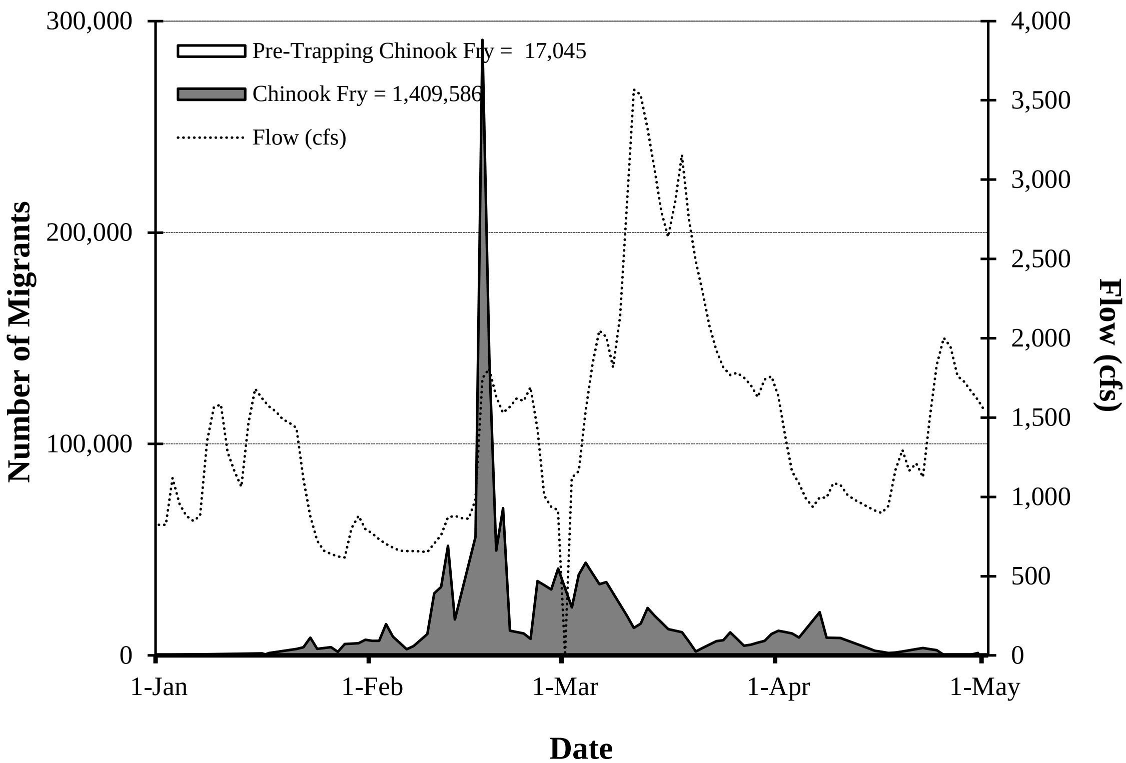

Figure 3**.** Estimated daily migration of Chinook fry from the Cedar River in 2014 based on inclined-plane trap estimates from January 1 to May 2. Pre-trapping migration estimate included. Graph includes mean daily flows during this time period (USGS Renton gage, Station #12119000) in 2014.

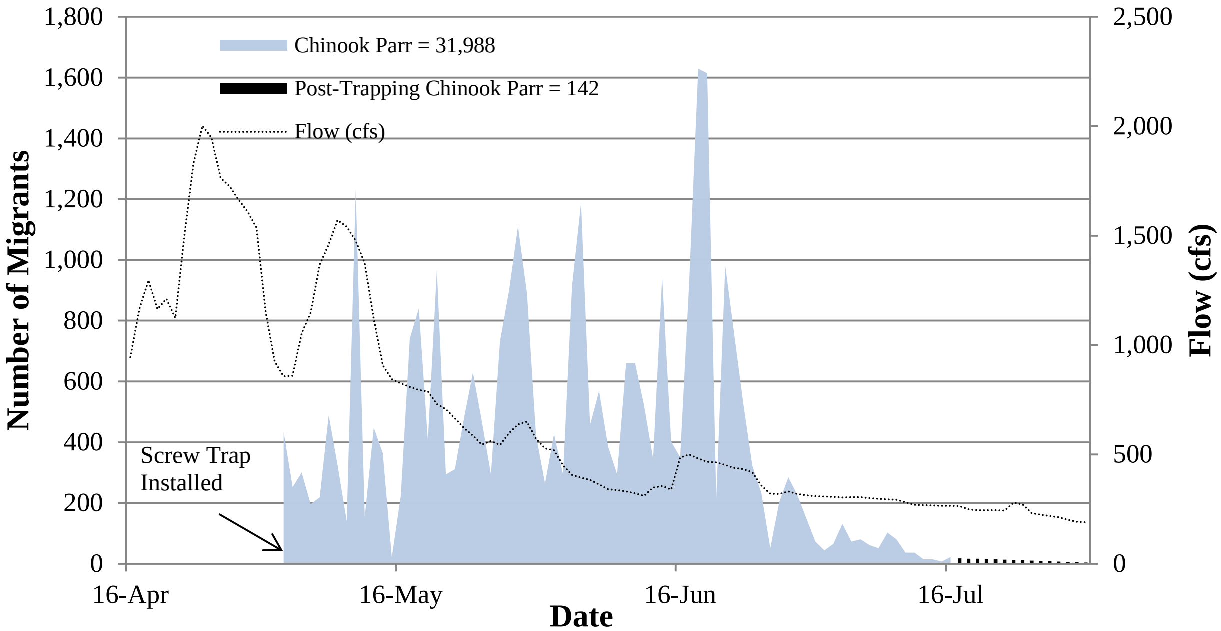

Figure 4. Estimated daily migration of Chinook parr from the Cedar River in 2014 based on screw trap estimates from May 3 to July 31. Graph includes mean daily flows during this time period (USGS Renton gage, Station #12119000) in 2014.

Productivity

The number of juvenile migrants produced per female spawner was the third highest observed from the Cedar River at 1,971 migrants per female (Table 6). The number of fry per female is also the third highest (1,928) however the number of parr per female is the fourth lowest since monitoring began. Incubation flows were moderate with one flow event peaking at 1,762 cfs in Renton in late November. Aside from that particular event, flows averaged 766 cfs in Renton from October through the end of December. These moderate flows may have contributed to the higher than average number of migrants per female. Flows during outmigration were abnormally higher and may have been a driving force of the high fry component and overall larger number of migrants for the 2013 brood. Productivity was based on 740 female spawners (Burton et al. 2014).

Table 7. Abundance of Chinook fry and parr and productivity (juveniles per female) among brood years. Fry migration estimates were made using inclined-plane trap data. Chinook parr estimates were formed using screw trap data for the remainder of the season. Transition date represents the date which the change from inclined-plane to screw trap data was used to form Chinook estimates. Data are Cedar River broods 1998 to 2013.

Brood	Trapping Dates			Juvenile Abundance			95%	Percent Abundance		Est.	Juveniles/Female		
Year	Start	Transition	End	Fry	Parr	Total	CI (±)	Fry	Parr	Fem.	Fry	Parr	Total
1998	23-Jan	18-Mar	27-Jul	63,702	17,230	80,932	7,732	79%	21%	173	368	100	468
1999	20-Jan	27-Apr	13-Jul	46,500	18,223	64,723	5,609	72%	28%	182	255	100	356
2000	18-Jan	9-Apr	22-Jul	10,833	21,416	32,249	5,220	34%	66%	53	204	404	608
2001	25-Jan	15-Apr	22-Jul	79,799	39,875	119,674	41,349	67%	33%	398	201	100	301
2002	21-Jan	21-Apr	12-Jul	194,657	40,740	235,397	51,485	83%	17%	281	693	145	838
2003	18-Jan	14-Apr	20-Jul	65,752	55,124	120,876	2,518	54%	46%	337	195	164	359
2004	21-Jan	11-Apr	29-Jul	74,292	60,006	134,298	42,912	55%	45%	511	145	117	263
2005	20-Jan	1-May	16-Jul	98,967	18,592	117,559	16,233	84%	16%	339	292	55	347
2006	18-Jan	18-Apr	20-Jul	110,961	14,225	125,186	16,912	89%	11%	587	189	24	213
2007	13-Jan	18-May	19-Jul	705,583	61,379 - 67,037	766,962 - 772,620	76,106	89.5-90.1%	9.9-10.5%	899	785	68-75	853-859
2008	1-Feb	22-Apr	18-Jul	127,064	12,388	139,452	38,399	91%	9%	599	212	21	233
2009	17-Jan	16-Apr	4-Jul	115,474	36,916	152,390	13,058	76%	24%	285	405	130	535
2010	30-Jan	10-May	16-Jul	177,803	10,003	187,806	63,560	95%	5%	266	668	38	706
2011	22-Jan	11-May	14-Jul	863,595	38,919	902,514	165,973	96%	4%	324	2,665	120	2,786
2012	24-Jan	30-Apr	17-Jul	874,658	19,219	893,877	77,993	98%	2%	433	2,020	44	2,064
2013	17-Jan	3-May	16-Jul	1,426,631	32,130	1,458,761	390,039	98%	2%	740	1,928	43	1,971

Size

Weekly average lengths of sub yearling Chinook increased from 39.8 mm fork length (FL) in January to 102.9 mm FL by July (Figure 5). Chinook caught in the inclined-plane trap ranged from 34 mm FL to 129 mm FL and averaged 49.0 mm FL. Chinook caught in the screw trap increased in size from 39.0 mm FL to 122 mm FL and averaged 80.9 mm FL.

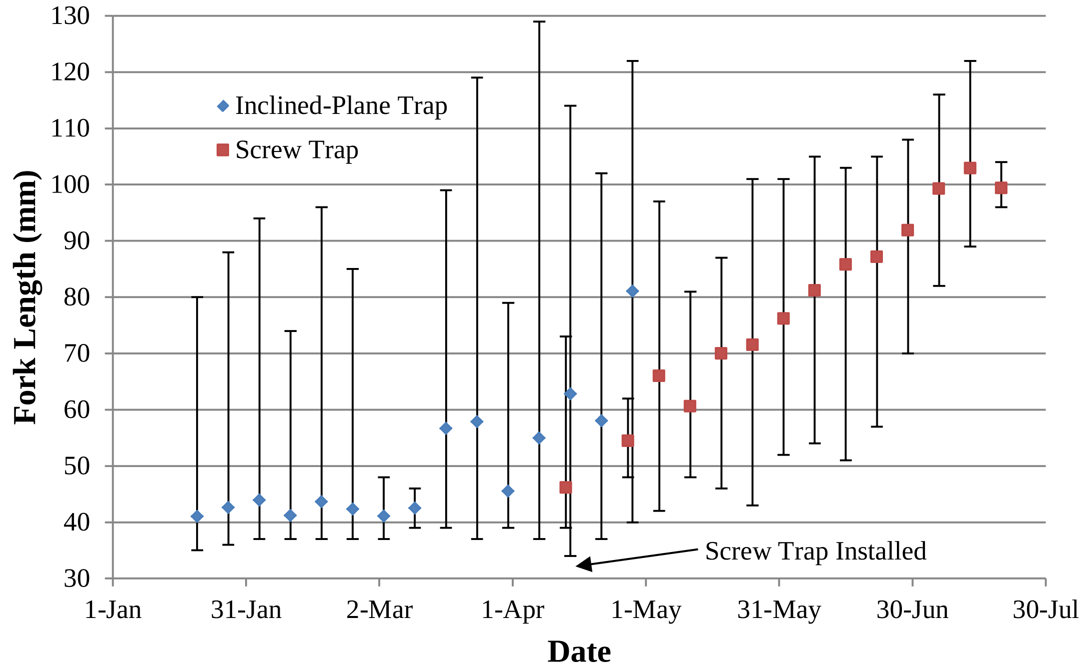

Figure 5. Fork lengths of natural-origin juvenile Chinook sampled from the Cedar River, 2014. Graph shows average, minimum, and maximum lengths by statistical week.

Coho

Production Estimate

Total catch (actual and missed) of all coho migrants captured in the screw trap was 8,019 coho smolts. This included 5,768 natural-origin coho caught in the screw trap between April 17 and July 16 and an estimated missed catch of 2,251 coho due to trap outages.

A total of 29 efficiency trials were conducted. Efficiency trials were aggregated into three strata. Capture rates for the season ranged from 2.3% to 7.0% (Appendix A 4). Total coho production was estimated to be 128,951 ± 25,212 (±95% C.I.) migrants for the period the trap was operating with a coefficient of variation of 9.98% (Table 8, Appendix A 4). This estimate includes both yearling and sub yearlings that moved past the trap during screw trap operations (Figure 6). We acknowledge that there are two life history forms observed in the Cedar River: typical 1+ yearling coho but also a component that is visually noted as sub yearling coho, further confirmed by scale analysis. We are unable to determine if these subyearling coho exit to marine waters the same year they migrate out of the Cedar River. This abundance estimate represents total abundance of coho exiting the Cedar River into Lake Washington.

Table 8. Abundance of coho migrants from Cedar River in 2014. Table includes abundance of sub-yearling and yearling migrants, 95% confidence intervals (C.I.), and coefficient of variation (*CV*).

Capture Method	**Dates**	**Total Catch**	**Abundance**	***CV***	**95% C.I.**	
					Low	**High**
Screw Trap	April 17 - July 16	8,019	128,951	9.98%	103,740	154,163

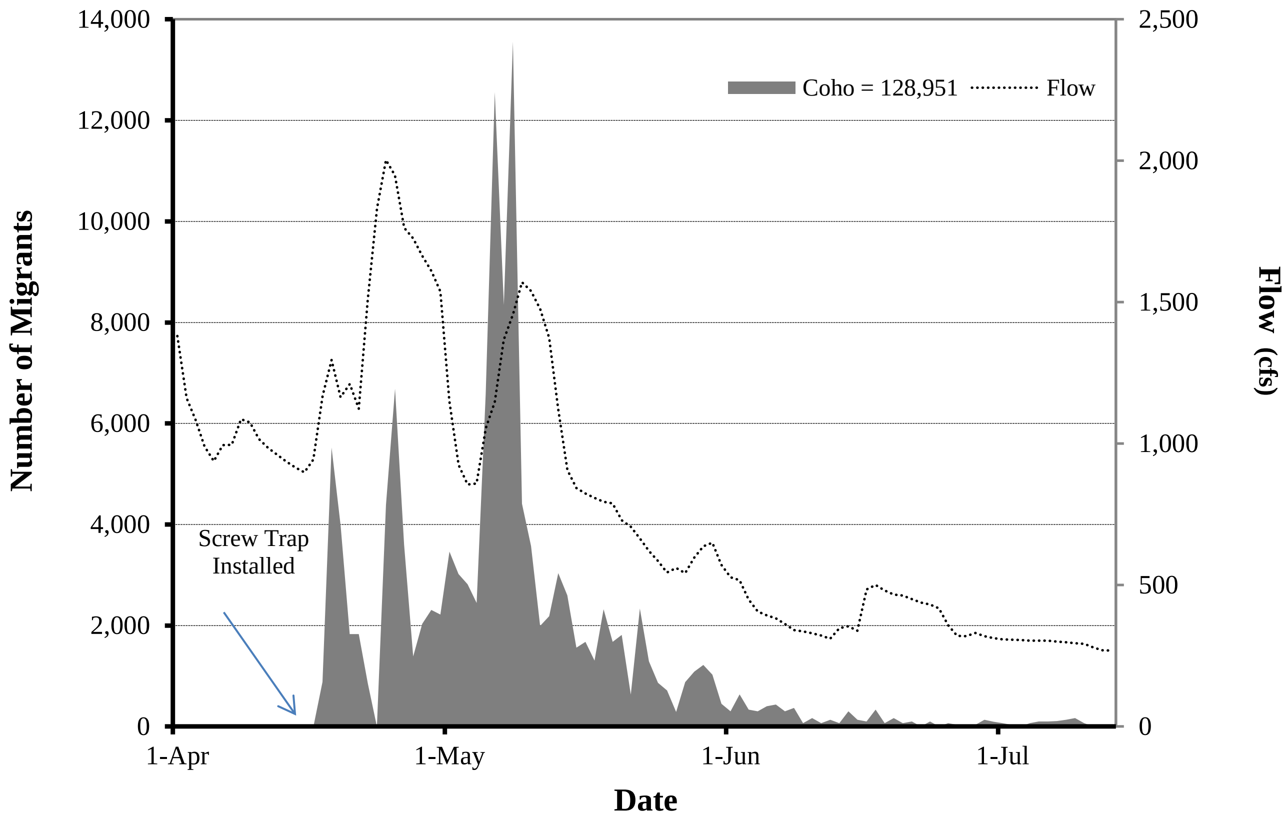

Figure 6. Daily coho migration and daily average flow (USGS Renton gage Station #12119000) at the Cedar River screw trap, 2014. Coho abundance includes both sub-yearling and yearling coho caught in the Cedar River screw trap.

Size

Average fork length of all measured coho migrants, both yearlings and sub-yearlings, was 102.2 mm FL; weekly averages ranged from 92.9 mm to 105.2 mm FL. Individual migrants ranged from 35 mm to 189 mm FL (Figure 7).

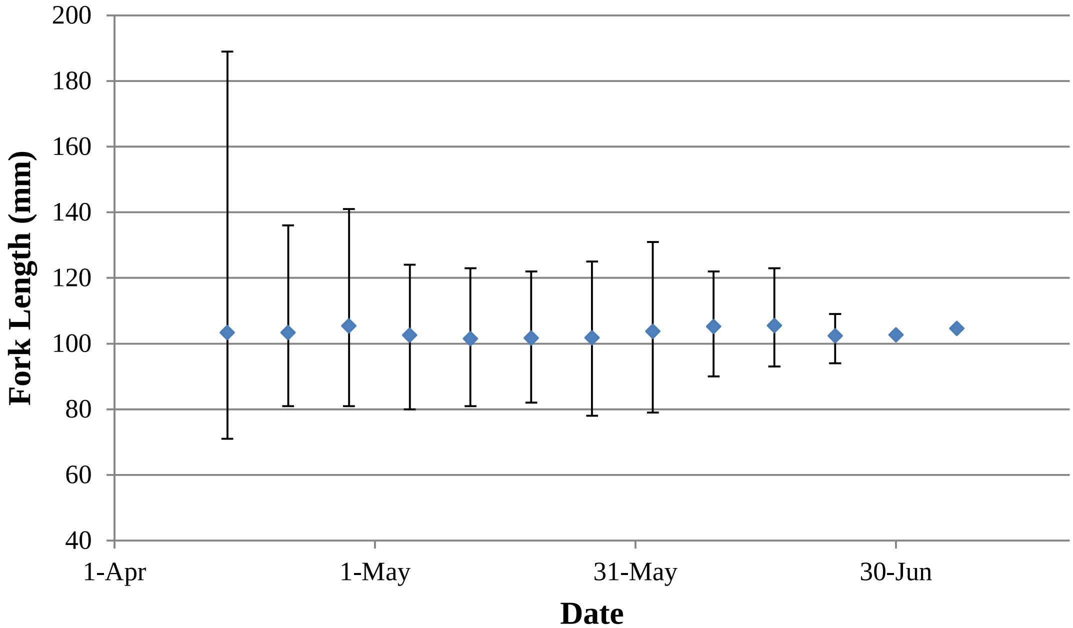

Figure 7. Fork lengths for coho migrants captured in the Cedar River screw trap in 2014. Data are mean, minimum, and maximum lengths.

Trout

Life history strategies used by trout in the Cedar River include anadromous, adfluvial, fluvial, and resident forms. For simplicity, catches and estimates reported herein are for trout that were visually identified as either *Oncorhynchus clarki* (cutthroat trout) or *Oncorhynchus mykiss* (steelhead/rainbow trout). Cutthroat-rainbow hybrids are included and indistinguishable in these totals. The juvenile anadromous life history strategy, or "smolt," was assigned to *O. mykiss* that had a silver coloration upon capture. Those that did not display smolt-like characteristics were assigned as rainbow trout.

A total of 12 steelhead migrants and 125 cutthroat trout were captured in the screw trap. No rainbow trout were caught. Catches were too few to estimate migrant abundance. *O. mykiss* fork lengths ranged from 148 mm to 222 mm FL and averaged 181.0 mm FL. Cutthroat fork lengths ranged from 105 mm to 245 mm FL, and averaged 157.6 mm FL.

Incidental Catch

Incidental catches in the inclined-plane trap included 126 coho fry, 161 coho smolts, 1 pink fry, 3 chum fry, 1 rainbow trout and 4 cutthroat trout. Other species caught included three-spine stickleback (*Gasterosteus aculeatus*), unspecified sculpin species (*Cottus* spp.), lamprey (*Lampetra* spp.), speckled dace (*Rhinichthys osculus)*, and large-scale sucker (*Catostomus macrocheilus*).

Other salmonids caught in the screw trap include 42 ad-marked hatchery Chinook parr, 3 chum fry, 5 sockeye smolt, 5,466 sockeye fry, and 17 trout fry. Other species caught included three-spine stickleback, unspecified sculpin species, large-scale suckers, peamouth (*Mylocheilus caurinus*), longnose dace (*Rhinichthys cataractae)*, pumpkinseed (*Lepomis gibbosus*), brown bullhead catfish (*Ameriurus nebulosus,* bluegill (*Lepomis macrochirus*), lamprey (*Lampetra* spp.) and yellow perch (*Perca flavenscens*).

Bear Creek

Sockeye

Production Estimate

Total catch (actual and estimated missed) in the Bear Creek screw trap was 27,252 sockeye fry during the trapping period from January 28 to July 9. This included an actual catch of 18,388 sockeye fry and an estimated missed catch of 8,864 sockeye fry. Trap outages included 23 full days and 10 additional night periods in which severe ice buildup, heavy debris, or other issues prevented trapping.

Fourteen efficiency trials using sockeye fry were conducted during the season and aggregated into four final strata, with capture rates ranging from 2.4% to 13.3% (Appendix B1). Catches were initially low and the first efficiency group was not released until March 8. Efficiency releases continued nearly twice or more weekly until April 10 when catches declined near the end of migration.

We estimated a total abundance of 438,534 ± 67,785 (±95% C.I.) sockeye fry emigrating from Bear Creek in 2014 (Table 9, Figure 8). Due to low catch at the beginning of the season, there was no pre-trapping catch estimated.

Table 9. Abundance of sockeye fry migrants from Bear Creek in 2014. Table includes abundance of fry migrants, 95% confidence intervals (C.I.), and coefficient of variation (*CV*).

Capture Method	Dates	Total Catch	Fry Abundance	*CV*	95% C.I.	
					Low	High
Screw Trap	Jan 28-July 9	27,252	438,534	7.9%	370,748	506,319

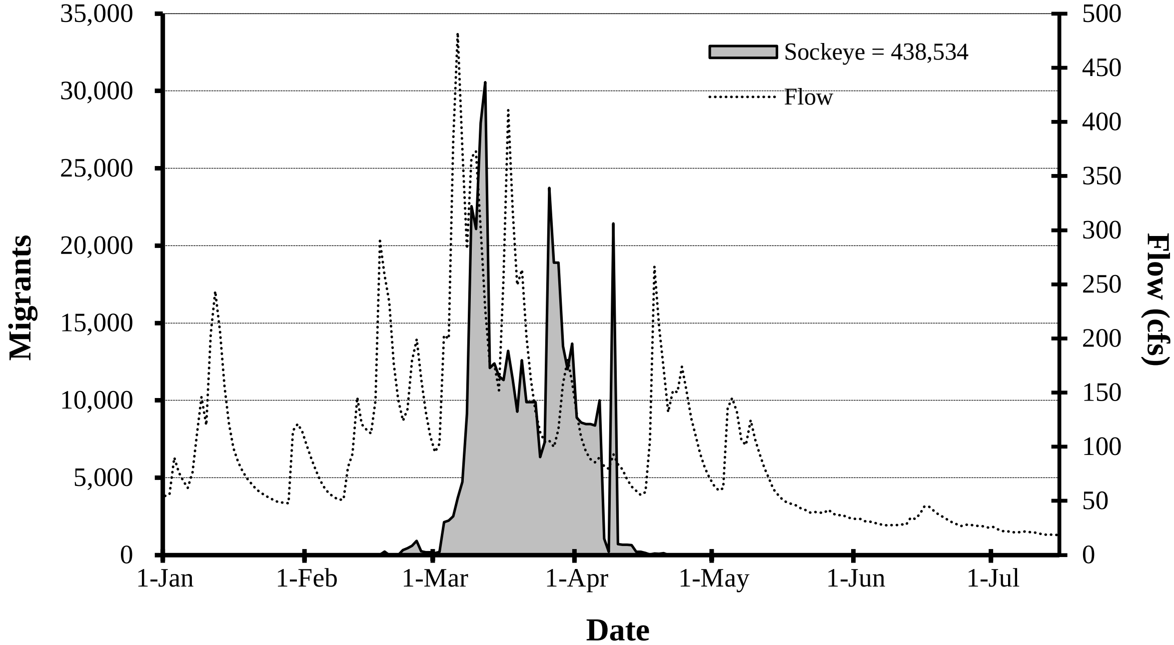

Figure 8. Estimated daily migration of sockeye fry from Bear Creek and daily average flow measured by the King County gage 02a at Union Hill Road in 2014 (http://green.kingcounty.gov/wlr/waterres/hydrology).

Egg-to-Migrant Survival

Egg-to-migrant survival of the 2013 brood of Bear Creek sockeye was estimated to be 13.0% (Table 10). Survival was based on 438,534 fry migrants and a PED of 3,365,362 eggs. PED was estimated based on 1,001 females in 2013 (B. Craig, Washington Department of Fish and Wildlife, personal communication) and an average fecundity of 3,362 eggs per female based on the data from the Cedar River Sockeye Hatchery from brood year 2013 (Shoblom 2014).

Table 10. Egg-to-migrant survival of Bear Creek sockeye by brood year. Potential egg deposition (PED) was based on fecundity of sockeye brood stock in the Cedar River.

Brood Year	Spawners	Females (@ 50%)	Fecundity	PED	Fry Abundance	Survival Rate	Peak Incubation Flow (cfs)	Peak Incubation Flow Date
1998	8,340	4,170	3,176	13,243,920	1,526,208	11.5%	515	11/26/1998
1999	1,629	815	3,591	2,924,870	189,571	6.5%	458	11/13/1999
2000	43,298	21,649	3,451	74,710,699	2,235,514	3.0%	188	11/27/2000
2001	8,378	4,189	3,568	14,946,352	2,659,782	17.8%	626	11/23/2001
2002	34,700	17,350	3,395	58,903,250	1,995,294	3.4%	222	1/23/2003
2003	1,765	883	3,412	3,011,090	177,801	5.9%	660	1/30/2004
2004	1,449	725	3,276	2,373,462	202,815	8.5%	495	12/12/2004
2005	3,261	1,631	3,065	4,999,015	548,604	11.0%	636	1/31/2005
2006	21,172	10,586	2,910	30,805,260	5,983,651	19.4%	581	12/15/2006
2007	1,080	540	3,450	1,863,000	251,285	13.5%	1,055	12/4/2007
2008	577	289	3,135	904,448	327,225	36.2%	546	1/8/2009
2009	1,568	784	3,540	2,775,360	129,903	4.7%	309	11/27/2009
2010	12,527	6,264	3,075	19,260,263	8,160,976	42.4%	888	12/13/2010
2011	911	455	3,318	1,509,690	266,899	17.7%	348	11/23/2011
2012	4,219	2,110	3,515	7,414,893	1,553,602	21.0%	467	1/10/2013
2013	2,003	1,001	3,362	3,365,362	438,534	13.0%	244	1/12/2014

Chinook

Total catch (actual and estimated missed) in the Bear Creek screw trap was 5,891 Chinook during the trapping period of January 28 to July 9. This included actual catch of 5,196 Chinook and an estimated missed catch of 695 Chinook during 23 full days and 10 night periods when the trap was not fished.

Production Estimate

For the period between January 28 and March 31, sockeye trap efficiencies were used to estimate Chinook fry abundance because Chinook catches were insufficient for efficiency trials (Figure 9). From April 1 forward, a total of 39 efficiency trials were conducted with Chinook sub-yearlings. Trials were aggregated into 12 strata; capture rates of these strata ranged between 1.7% and 66.7%. Chinook migration during screw trap operation was estimated to be 62,775 ± 26,304 (±95% C.I.) (Table 11, Appendix B2).

Table 11. Abundance of natural-origin juvenile Chinook emigrating from Bear Creek in 2014. Table includes abundance of juvenile migrants, 95% confidence intervals (C.I.), and coefficient of variation (*CV*).

Capture Method	Period	Total Catch	Abundance	95% C.I. Low	95% C.I. High	*CV*
Screw Trap	January 28 - July 19	5,891	62,775	36,471	89,079	21.40%

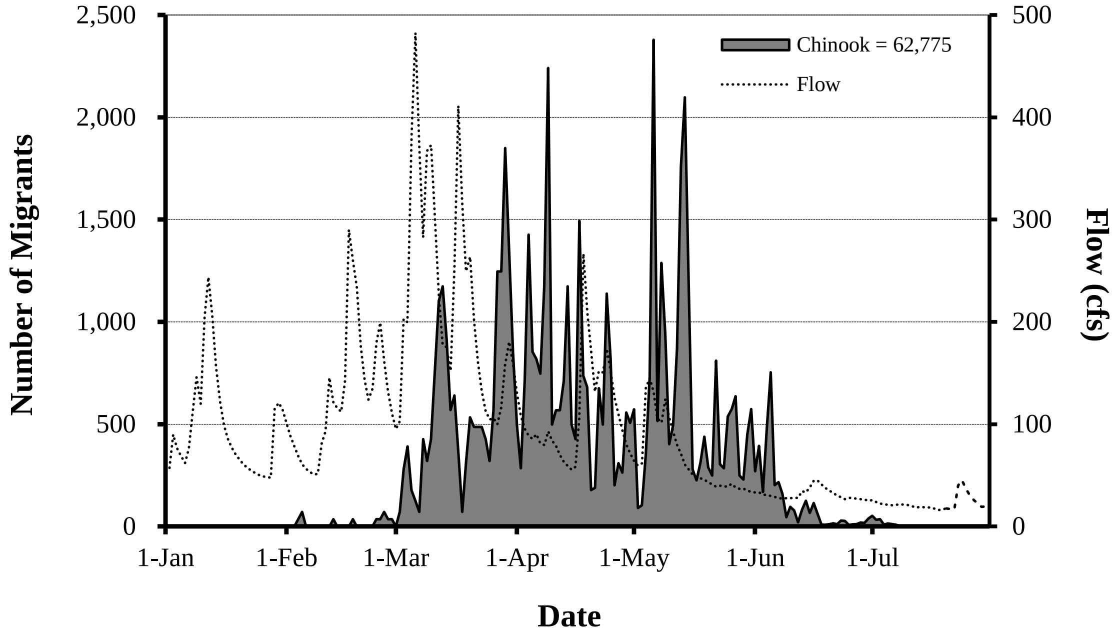

Figure 9. Daily migration of sub yearling Chinook and daily average flow from Bear Creek, 2014. Daily mean flows were measured at King County gage 02a at Union Hill Road in 2014 (http://green.kingcounty.gov/wlr/waterres/hydrology).

We estimated the abundance of two life-history forms of subyearling Chinook salmon observed in Puget Sound: small fry migrating immediately after emergence and larger parr that spend some time rearing and growing in freshwater. Small fry migrants, defined by their emigration between February and April, comprised 38.7% of the total migration (Table 12). Large parr migrants, defined by emigration between May and July, represented 61.3% of total production in Bear Creek during 2014.

Productivity

The 2013 brood of Bear Creek Chinook produced over two times the most migrants per female observed since monitoring began. Both the fry and parr components individually were also the highest number produced per female. Productivity was based on 48 female spawners which is tied as the lowest number of female spawners since monitoring began (B. Craig, Washington Department of Fish and Wildlife, personal communication).

Table 12. Abundance and productivity (juveniles per female) of natural-origin Chinook in Bear Creek. Fry are assumed to have migrated between February 1 and April 8. Parr are assumed to have migrated between April 9 and June 30. Data are 2000 to 2013 brood years.

Brood	Juvenile Abundance			% Abundance		Est.	Juveniles/Female		
Year	Fry	Parr	Total	Fry	Parr	Females	Fry	Parr	Total
2000	419	10,087	10,506	4.0%	96.0%	133	3	76	79
2001	5,427	15,891	21,318	25.5%	74.5%	138	39	115	154
2002	645	16,636	17,281	3.7%	96.3%	127	5	131	136
2003	2,089	21,558	23,647	8.8%	91.2%	147	14	147	161
2004	1,178	8,092	9,270	12.7%	87.3%	121	10	67	77
2005	5,764	16,598	22,362	25.8%	74.2%	122	47	136	183
2006	3,452	13,077	16,529	20.9%	79.1%	131	26	100	126
2007	1,163	11,543	12,706	9.2%	90.8%	89	4	143	147
2008	14,243	50,959	65,202	21.8%	78.2%	132	108	386	494
2009	1,530	7,655	9,185	16.7%	83.3%	48	32	159	191
2010	901	16,862	17,763	5.1%	94.9%	60	15	281	296
2011	4,000	18,197	22,197	18.0%	82.0%	55	73	331	404
2012	24,776	19,823	44,599	55.6%	44.4%	147	169	135	303
2013	24,266	38,509	62,775	38.7%	61.3%	48	506	802	1,308

Size

The minimum weekly average lengths of sub yearling Chinook migrants was less than 40.0 mm FL until mid-March and increased to average 60 mm FL by late April. In early May Chinook ranged in size from 46 mm to 103 mm FL. By the end of June Chinook averaged 88.5 mm FL with all Chinook larger than 75 mm FL (Figure 10).

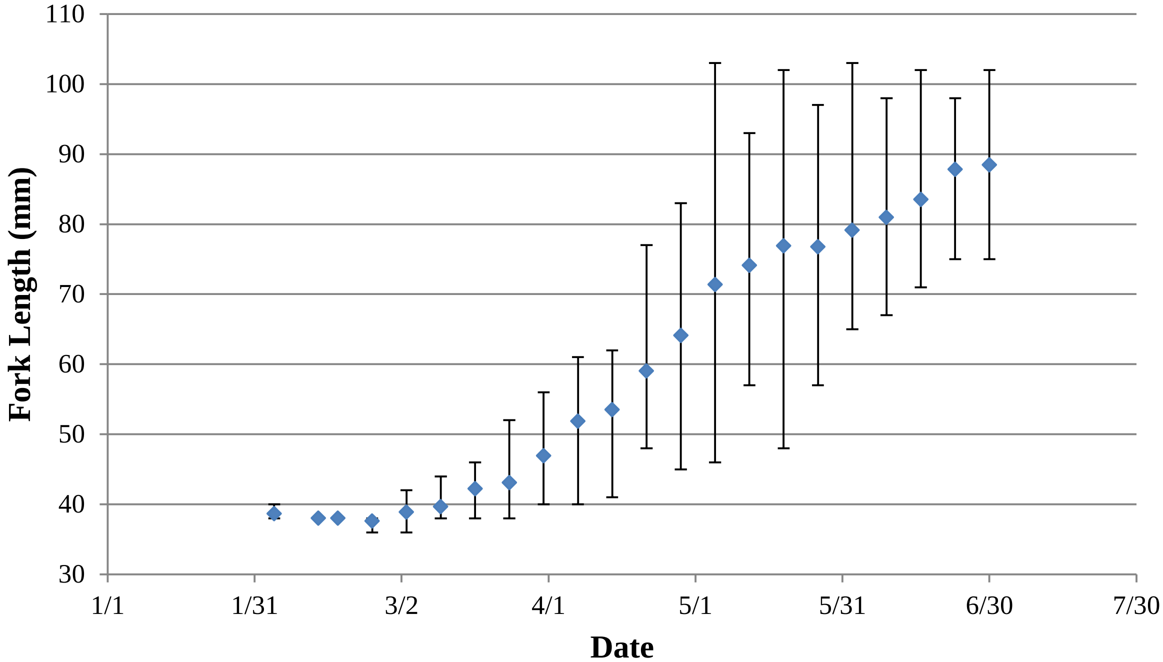

Figure 10. Fork lengths of sub yearling Chinook sampled from Bear Creek in 2014. Data are mean, minimum, and maximum lengths for each statistical week.

Coho

Total catch (actual and estimated missed) in the Bear Creek screw trap was 4,682 sub-yearling and yearling coho. This included an actual catch of 4,269 coho migrants and an estimated missed catch of 413 coho due to trap outages.

Production Estimate

Abundance of coho was based on total catch and 27 efficiency trials, which were aggregated into 8 strata. Capture rates of efficiency strata ranged from 1.2% to 44.0%. Coho production was estimated to be 36,119 ± 7,253 (±95% C.I.) smolts (Table 13, Figure 11, Appendix B 3). Similar to the Cedar River, coho fry and subyearlings may exit Bear Creek and rear downstream for an unknown period of time before migrating. Coho abundance is a measurement of total coho exiting Bear Creek in any given year.

Table 13. Abundance of natural-origin juvenile coho emigrating from Bear Creek in 2014. Table includes abundance of juvenile migrants, 95% confidence intervals (C.I.), and coefficient of variation (*CV*).

Capture Method	Period	Total Catch	Abundance	95% C.I.		*CV*
				Low	High	
Screw Trap	January 28 - July 9	4,682	36,119	28,866	43,371	10.20%

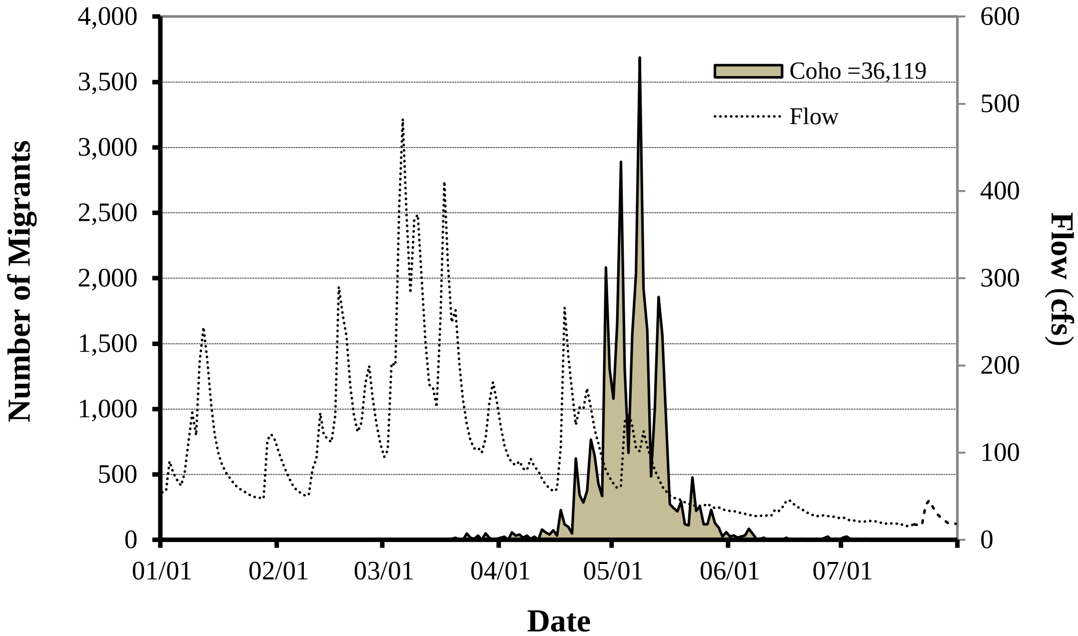

Figure 11. Daily migration of coho smolts in Bear Creek from January 28 to July 9, 2014. Graph also shows mean daily flows during this period. Flow data were measured at King County gage 02a at Union Hill Road in 2014 (http://green.kingcounty.gov/wlr/waterres/hydrology).

Size

Over the trapping period, fork lengths of sub yearling and yearling coho ranged from 33 mm to 153 mm FL and averaged 111.3 mm FL (Figure 12). Weekly mean lengths ranged from 102.7 mm to 124.9 mm FL during trap operation.

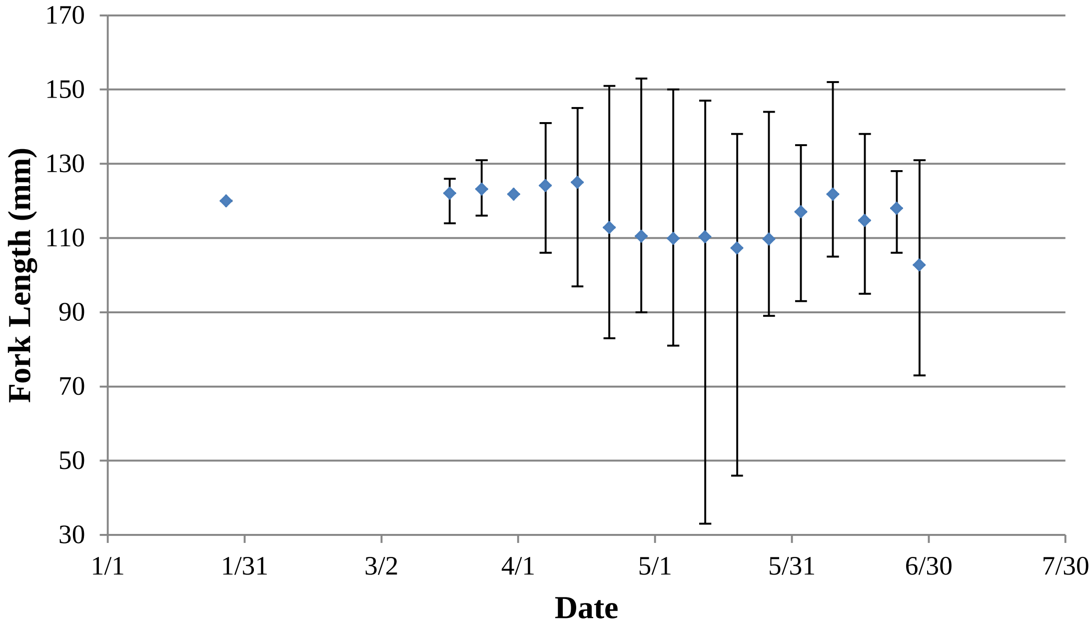

Figure 12. Fork lengths of migrating coho smolts caught at the Bear Creek screw trap in 2014. Data are statistical week mean, minimum, and maximum lengths.

Trout

The identification of trout in Bear Creek poses the same difficulties discussed earlier in the Cedar River section. Trout were identified to species when possible based on visual identification. The cutthroat estimate does not differentiate migration for different life history strategies and is a measure of the number of cutthroat moving past the trap, not necessarily the number of cutthroat migrating downstream towards Lake Washington and the marine waters of Puget Sound.

Production Estimate

No steelhead were captured during the entire 2014 trapping season in Bear Creek.

Total catch of cutthroat trout was 712. Catch was sporadic, making it difficult to conduct trap efficiency trials. A total of 6 trials, which released 101 cutthroat total, only recapture five fish (5.0%) over the entire season. Due to low recapture rates, we did not estimate the number of trout moving past the trap in 2014.

Size

Cutthroat trout fork lengths averaged 157.6 mm FL and ranged between 64 mm to 245 mm FL throughout the trapping season (Table 14). Average fork lengths showed no consistent trend across weeks.

Table 14. Cutthroat fork length (mm), standard deviation (SD), range, sample size (n), and catch by statistical week in the Bear Creek screw trap, 2014.

Statistical Week			Fork Length (mm)					
			Avg.	SD	Range		n	Catch
Begin	End	No.			Min	Max		
01/27	02/02	5	245.0	n/a	245	245	1	24
02/03	02/09	6	126.0	n/a	126	126	1	3
02/10	02/16	7	117.7	13.8	89	134	10	14
02/17	02/23	8	144.6	20.4	112	186	37	37
02/24	03/02	9	148.9	20.9	106	188	15	14
03/03	03/09	10	151.6	18.9	104	181	15	16
03/10	03/16	11	147.2	17.0	134	170	6	6
03/17	03/23	12	178.0	n/a	178	178	1	1
03/24	03/30	13	152.1	25.9	93	216	50	61
03/31	04/06	14	158.0	20.1	129	189	8	9
04/07	04/13	15	132.5	9.7	118	138	4	4
04/14	04/20	16	174.7	36.1	109	232	15	69
04/21	04/27	17	159.4	23.7	105	223	52	64
04/28	05/04	18	160.0	21.7	118	212	39	53
05/05	05/11	19	162.2	23.6	104	216	41	112
05/12	05/18	20	167.9	20.9	138	225	30	149
05/19	05/25	21	146.0	19.2	115	210	31	31
05/26	06/01	22	137.2	14.8	116	169	13	18
06/02	06/08	23	149.7	10.2	138	157	3	5
06/09	06/15	24	137.1	15.7	110	158	9	10
06/16	06/22	25	178.5	65.8	132	225	2	4
06/23	06/29	26	215.0	n/a	215	215	1	3
06/30	07/06	27	101.5	49.1	64	170	4	4
07/07	07/14	28						1
		Season Totals	**157.6**	**42.0**	**64**	**245**	**388**	**712**

Incidental Species

In addition to target species, the screw trap captured 2 hatchery coho smolts, 15 trout fry, 30 hatchery trout plants from Cottage Lake and 11 cutthroat adults. Other species caught included lamprey (*Lampetra* spp.), green sunfish (*Lepomis cyanellus*), three-spine stickleback (*Gasterosterus aculeatus*), sculpin (*Cottus* spp.), whitefish (*Prosopium* spp.), peamouth (*Mylocheilus caurinus*), dace (*Rhinichthys* spp), bluegill (*Lepomis macrochirus*), large-scale suckers (*Catostomus macrocheilus*), small mouth bass (*Micropterus dolomieu*), pumpkinseed (*Lepomis gibbosus*),and brown bullhead catfish (*Ameriurus nebulosus*).

PIT Tagging

To support the ongoing, multi-agency evaluation of salmonid survival within the Lake Washington watershed, natural-origin Chinook were tagged with passive integrated transponder (PIT) tags. Tagging occurred two to three times a week. Due to low catches of Chinook parr, fish were held from the previous day in order to increase the number of tags released per day. Only the Chinook parr migrants were represented in the tag groups.

Tagging occurred in the Cedar River from May 6 through July 10, 2014. Over the season, a total of 1,944 natural-origin Chinook parr were PIT tagged at the Cedar River screw trap (Table 15). This tag group comprised 5.8% of the estimated Chinook parr production from the Cedar River in 2014. A total of 172 Chinook PIT tags (8.8%) were detected as they moved through the smolt flumes at the Chittenden Locks while exiting Lake Washington. The first Chinook was detected on May 24, 2014 and the last on July 29, 2014 (Table 16). Median migration date of Chinook detected at the Locks was June 13, 2014. Individual travel times averaged 24.4 days (SD = 7.5). Average fork length of Chinook PIT tagged was 83.3 mm and ranged from 65 mm to 122 mm during the season. Average fork length of Chinook detected at the Chittenden Locks was 81.9 mm, ranging from 65 mm to 112 mm throughout the season.

In Bear Creek tagging occurred from May 1 through July 6, 2014. A total of 1,968 Chinook were tagged throughout the season and represented 4.8% of estimated Chinook parr production. A total of 324 Chinook PIT tags (16.5%) were detected as they moved through the smolt flumes at the Chittenden Locks (Table 15). The first Chinook was detected at the Locks was May 20, 2014 and the last was detected July 14, 2014 (Table 17). Individual travel times averaged 24.0 days (SD = 7.4). Average fork length of Chinook PIT tagged at Bear Creek was 77.6 mm and ranged from 62 mm to 103 mm. Average fork length of Chinook detected at the Chittenden Locks was 77.4 mm and ranged from 65 mm to 102 mm during the season.

The portion of PIT tagged Chinook detected at the Locks from the Cedar River in 2014 appears to be the lowest since 2010. However detection rates at the Locks for Bear Creek Chinook appear to be similarly to previous years (Table 16, Table 17).

In 2014, 5,000 hatchery Chinook were PIT tagged at Issaquah Hatchery between May 5 and May 8. Fork lengths of Chinook at tagging ranged from 62 mm to 96 mm and averaged 71.2 mm. The tagging occurred roughly 2 weeks prior to release, so the length of fish at release is unknown but assumed to accurately represent the hatchery population. According to hatchery records, the average length of Chinook at release was 81.6 mm. Healthy Chinook were placed back into the general hatchery population for release which occurred on May 23, 2014. Issaquah Hatchery Chinook were first detected at the Chittenden Locks on June 8 and continued through July 27, 2014. Average travel time was 34 days. Detection rate was 2.74%, considerably lower compared to both Cedar River and Bear Creek Chinook. It is unclear where along the migration route the loss of hatchery Chinook was highest. Installation of PIT tag antenna along the migration corridor may help identify mortality hotspots. Alternatively, it is possible that hatchery Chinook simply chose an alternate route through the Chittenden Locks at a higher rate than the natural-origin Chinook from Cedar River and Bear Creek.

Table 15. Natural-origin Chinook parr PIT tagged from the Cedar River and Bear Creek screw traps in 2014.

Statistical Week			Cedar River Screw Trap							Bear Creek Screw Trap						
			# Tagged	Length (mm)			Portion of Parr Migration	# Detected @ Locks	% of Tags Detected	# Tagged	Length (mm)			Portion of Parr Migration	# Detected @ Locks	% of Tags Detected
Begin	End	No.		Avg	Min	Max					Avg	Min	Max			
28-Apr	4-May	18	15	75.9	65	112	1.3%	5	33.3%	87	70.5	62	83	3.6%	26	29.9%
5-May	11-May	19	14	69.9	65	81	0.5%	3	21.4%	246	73.5	65	103	3.6%	74	30.1%
12-May	18-May	20	68	72.7	65	87	2.4%	14	20.6%	231	74.3	65	93	3.4%	59	25.5%
19-May	25-May	21	300	75.3	65	101	8.4%	65	21.7%	600	77.3	64	102	20.6%	132	22.0%
26-May	1-Jun	22	142	77.5	66	101	3.1%	22	15.5%	206	77.0	65	97	6.9%	23	11.2%
2-Jun	8-Jun	23	344	82.1	66	105	8.1%	35	10.2%	208	79.1	65	103	8.8%	7	3.4%
9-Jun	15-Jun	24	399	86.2	67	103	10.4%	12	3.0%	155	81.0	67	98	30.2%	1	0.6%
16-Jun	22-Jun	25	430	87.5	67	105	6.6%	15	3.5%	116	83.4	71	102	50.1%	1	0.9%
23-Jun	29-Jun	26	142	91.9	70	108	7.7%	1	0.7%	46	87.8	75	98	37.5%	1	2.2%
30-Jun	6-Jul	27	59	99.3	82	116	9.6%			73	88.5	75	102	37.5%		
7-Jul	13-Jul	28	31	103.4	89	122	8.1%							0.0%		
Season Total			1,944	83.8	65	122	5.9%	172	8.8%	1,968	77.6	62	103	4.8%	324	16.5%

Table 16. Biological and migration timing data of PIT tagged natural-origin Chinook released from the Cedar River screw trap, tag years 2010 to 2014. Detection data is from the Hiram Chittenden Locks.

Tag Year	# Tagged	Length (mm)			Portion of Parr Migration	# Detected @ Locks	% of Tags Detected	Avg Travel Time (days)	First Detection	Last Detection	Median Date
		Avg	Min	Max							
2010	2,232	84.2	65	127	6.10%	482	21.59%	29.9	05/24	08/25	06/24
2011	594	87.3	65	118	5.80%	116	19.53%	19.3	05/26	08/27	06/07
2012	1,671	84.0	64	123	4.29%	212	12.69%	30.0	05/29	09/14	07/08
2013	711	81.3	58	108	3.70%	209	29.40%	17.3	05/26	07/17	06/19
2014	1,944	83.8	65	122	5.89%	172	8.8%	24.8	05/24	07/29	06/13

Table 17. Biological and migration timing data of PIT tagged natural-origin Chinook released from the Bear Creek screw trap, tag years 2010 to 2014. Detection data is from the Hiram Chittenden Locks.

Tag Year	# Tagged	Length (mm)			Portion of Parr Migration	# Detected @ Locks	% of Tags Detected	Avg Travel Time (days)	First Detection	Last Detection	Median Date
		Avg	Min	Max							
2010	589	77.9	65	99	7.80%	103	17.49%	26.1	06/06	07/07	06/23
2011	2,316	79.9	65	102	26.30%	337	14.55%	15.1	05/23	07/29	06/05
2012	2,721	75.2	62	97	12.2%	316	11.61%	31.3	05/22	08/13	06/21
2013	1,858	79.3	58	102	9.75%	518	27.88%	12.3	05/16	07/20	06/12
2014	1,968	77.6	62	103	4.83%	324	16.46%	23.9	05/20	07/14	06/12

Appendix A

Catch and Migration Estimates by Strata for Cedar River Sockeye, Chinook, and Coho Salmon, 2014.

Appendix A 1. Catch and migration by strata for Cedar River natural-origin sockeye fry, 2014.

Strata	Date Begin	Date End	Total Catch	Recapture Rate	Estimated Migration	Variance
Pre-Trap	1/1/2014	1/16/2014			289,741	$4.4x10^{8}$
1	1/17/2014	2/12/2014	27,043	1.12%	2,413,930	$2.6x10^{10}$
2	2/13/2014	2/16/2014	13,173	1.96%	647,065	$1.6x10^{10}$
3	2/17/2014	2/26/2014	43,465	0.61%	6,888,693	$1.5x10^{12}$
4	2/27/2014	3/2/2014	51,220	1.25%	4,052,530	$4.0x10^{11}$
5	3/3/2014	3/5/2014	42,911	0.44%	8,723,764	$6.9x10^{12}$
6	3/6/2014	3/12/2014	55,429	1.16%	4,722,541	$3.1x10^{11}$
7	3/13/2014	3/27/2014	11,502	0.32%	3,553,382	$3.2x10^{11}$
8	3/28/2014	3/30/2014	1,387	1.73%	67,052	$6.3x10^{8}$
9	3/31/2014	4/7/2014	19,174	0.44%	4,310,366	$4.1x10^{11}$
10	4/8/2014	5/2/2014	30,964	1.49%	2,062,631	$4.6x10^{10}$
Post Trap	5/3/2014	6/30/2014			244,074	$7.7x10^{8}$
		Total	**296,268**		**37,975,769**	$\mathbf{9.9x10^{12}}$

Appendix A 2. Catch and migration by strata for Cedar River natural-origin Chinook fry, 2014.

Strata	Date Begin	Date End	Total Catch	Recapture Rate	Estimated Migration	Variance
Pre Trap	1/1/2014	1/16/2014			17,045	$7.6x10^{6}$
1	1/17/2014	2/11/2014	4,899	2.53%	189,817	$6.7x10^{8}$
2	2/12/2014	2/19/2014	3,977	1.32%	281,064	$4.9x10^{9}$
3	2/20/2014	2/20/2014	169	0.12%	69,662	$1.6x10^{10}$
4	2/21/2014	5/2/2014	12,383	1.36%	869,043	$3.2x10^{10}$
		Total	**21,428**		**1,426,631**	$\mathbf{4.0x10^{10}}$

Appendix A 3. Catch and migration by strata for Cedar River natural-origin Chinook parr, 2014.

Strata	Date Begin	Date End	Total Catch	Recapture Rate	Estimated Migration	Variance
1	5/3/2014	5/21/2014	607	6.70%	8,493	$4.3x10^{6}$
2	5/22/2014	5/22/2014	142	44.44%	311	$2.7x10^{3}$
3	5/23/2014	6/12/2014	1199	9.69%	12,181	$2.4x10^{6}$
4	6/13/2014	6/17/2014	525	17.32%	2,971	$1.9x10^{5}$
5	6/18/2014	6/24/2014	397	6.36%	5,997	$1.5x10^{6}$
6	6/25/2014	7/17/2014	279	13.10%	2,036	$1.9x10^{5}$
Post Trap	7/18/2014	7/31/2014			142	$1.4x10^{3}$
		Total	**3,149**		**32,130**	$\mathbf{8.6x10^{6}}$

Appendix A 4. Catch and migration by strata for Cedar River natural-origin coho migrants, 2014.

Strata	Date		Total Catch	Recapture Rate	Estimated Migration	Variance
	Begin	End				
1	4/17/2014	4/26/2014	849	3.0%	26,787	3.7×10^7
2	4/27/2014	5/31/2014	6,986	7.2%	95,997	1.2×10^8
3	6/1/2014	7/16/2014	184	2.3%	6,167	7.5×10^6
Total			**8,019**		**128,951**	1.7×10^8

Appendix B

Catch and Migration Estimates by Strata for Bear Creek
Sockeye, Chinook, Coho Salmon, and Cutthroat Trout, 2014.

Appendix B 1 Catch and migration by strata for Bear Creek sockeye, 2014.

Strata	Date Begin	Date End	Total Catch	Recapture Rate	Estimated Migration	Variance
1	1/28/2014	3/12/2014	3,136	2.4%	124,472	$6.6x10^8$
2	3/13/2014	3/25/2014	7,551	5.6%	134,299	$3.6x10^8$
3	3/26/2014	4/9/2014	16,074	9.1%	176,123	$2.2x10^8$
4	4/10/2014	7/9/2014	491	13.3%	3,640	$2.1x10^5$
		Total	**27,252**		**438,534**	**$1.2x10^9$**

Appendix B 2. Catch and migration by strata for Bear Creek natural-origin Chinook, 2014.

Strata	Date Begin	Date End	Total Catch	Recapture Rate	Estimated Migration	Variance
1	1/28/2014	4/25/2014	1,043	2.4%	37,111	$1.7x10^8$
2	4/26/2014	5/1/2014	301	12.4%	2,333	$2.1x10^5$
3	5/2/2014	5/4/2014	247	44.7%	545	$4.7x10^3$
4	5/5/2014	5/6/2014	102	1.7%	3,111	$3.2x10^6$
5	5/7/2014	5/16/2014	1,905	18.8%	9,818	$3.5x10^6$
6	5/17/2014	5/29/2014	1,300	25.1%	5,139	$2.4x10^5$
7	5/30/2014	6/5/2014	273	7.9%	3,069	$1.2x10^6$
8	6/6/2014	6/12/2014	323	38.9%	816	$1.3x10^4$
9	6/13/2014	6/13/2013	55	66.7%	81	$1.3x10^2$
10	6/14/2013	6/22/2014	192	44.8%	423	$2.7x10^3$
11	6/23/2014	7/1/2014	110	50.9%	214	$9.1x10^2$
12	7/2/2014	7/9/2014	39	32.9%	115	$5.6x10^2$
		Total	**5,891**		**62,775**	**$1.8x10^8$**

Appendix B 3. Catch and migration by strata for Bear Creek natural-origin coho smolts, 2014.

Strata	Date Begin	Date End	Total Catch	Recapture Rate	Estimated Migration	Variance
1	1/28/2014	4/26/2014	526	11.9%	4,289	$5.2x10^5$
2	4/27/2014	4/28/2014	292	37.9%	764	$6.7x10^3$
3	4/29/2014	5/1/2014	592	12.7%	4,465	$9.4x10^5$
4	5/2/2014	5/3/2014	107	1.2%	4,548	$6.9x10^6$
5	5/4/2014	5/10/2014	1,404	10.7%	12,784	$3.8x10^6$
6	5/11/2014	5/11/2014	219	44.0%	486	$6.0x10^3$
7	5/12/2014	5/19/2014	1,259	19.3%	6,370	$1.3x10^6$
8	5/20/2014	7/9/2014	283	11.3%	2,414	$2.2x10^5$
		Total	**4,682**		**36,119**	**1.4x107**

Acknowledgements

Evaluation of 2014 juvenile salmon production in the Cedar River and Bear Creek was made possible by multiple agencies. The City of Seattle Public Utilities (SPU) funded operations of the inclined-plane trap in the Cedar River. King County Department of Natural Resources and Parks (DNRP) provided funding through the King County Flood Control District Cooperative Watershed Management grant for the Bear Creek and the Cedar River screw traps, and PIT tagging in both systems.

Success of these projects relied on the hard work of a number of dedicated Washington Department of Fish and Wildlife (WDFW) personnel. Escapement data were collected and estimates developed by individuals from several agencies: Aaron Bosworth, Bethany Craig, and Casey Green from WDFW; Brian Footen, Jesse Nitz, Ernie Reynolds, and Dwayne Ross Jr. from the Muckleshoot Tribe; Karl Burton and Dwayne Paige SPU; and Dan Lantz from King County DNRP. WDFW scientific technicians Paul Lorenz, Dan Estell, and Ben Nelson worked long hours in order to operate juvenile traps, and identify, count, and mark juvenile salmon. WDFW biologist Pete Topping provided valuable experience and logistical support for the juvenile trapping operation. The WDFW Hatcheries Program successfully collected adult sockeye brood stock and incubated eggs, releasing over 7.4 million sockeye fry into the Cedar River. Project management was provided by Paul Faulds and Michele Koehler from SPU and Hans Berge from DNRP.

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

Cedar River

The Boeing Company provided electrical power and a level of security for our inclined-plane trap.

The Renton Municipal Airport provided security for the inclined-plane trap and other equipment housed at the airport.

The City of Renton Parks Department and the Washington State Department of Transportation provided access and allowed us to attach anchor cables to their property.

The United States Geological Survey provided continuous flow monitoring.

Seattle Public Utilities communicated changes in flow due to dam operation.

Bear Creek

The City of Redmond Police Department and Redmond Town Center Security staff provided a measure of security for the crew and trap.

King County DNRP provided continuous flow monitoring.

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