U.S. Fish & Wildlife Service

Abundance, Run Timing, and Age, Sex, And Length of Adult Chinook Salmon in the Killey River and Quartz Creek, Kenai Peninsula, Alaska, 2015

Alaska Fisheries Data Series Number 2016-2

Kenai Fish and Wildlife Conservation Office
Soldotna, Alaska
January 2016

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Kenneth S. Gates and James K. Boersma

Abstract

Chinook Salmon *Oncorhynchus tshawytscha* returning to the Kenai River support one of the largest sport fisheries in Alaska that requires accurate and precise abundance and demographic information to inform management decisions. To collect information, the U.S. Fish and Wildlife Service and U.S. Forest Service installed and operated fish weirs equipped with underwater video systems in the Killey River and Quartz Creek between May 30 and August 16, 2015, to enumerate and characterize the demographics of adult Chinook Salmon returning to these two river systems. A total of 3,104 Chinook Salmon were observed passing the weirs, including 2,656 Killey River and 448 Quartz Creek fish. Peak weekly passage of Chinook Salmon in the Killey River occurred between July 5 and 11 and in Quartz Creek between July 19 and 25. Females comprised 45% of the Chinook Salmon escapement at Quartz Creek and 28% at the Killey River. Age, sex, and length samples were only collected from Killey River Chinook Salmon. The average estimated mid eye to tail fork length of male and female Chinook Salmon was 632 mm (SE = 7) and 865 mm (SE = 4), respectively. Ages of Killey River Chinook Salmon, determined from scale analysis, ranged between 3 and 7 years. Non-target fish species observed passing the weirs in 2015 included Sockeye Salmon *O. nerka*, Pink Salmon *O. gorbuscha*, Rainbow Trout *O. mykiss*, Dolly Varden *Salvelinus malma*, Arctic Grayling *Thymallus arcticus*, and Round Whitefish *Prosopium cylindraceum*.

Introduction

Chinook Salmon *Oncorhynchus tshawytscha* returning to the Kenai River support popular sport fisheries that require in-season management. The Chinook Salmon fishery in the Kenai River is one of the largest in Alaska (Nelson et al. 1999) and often exceeds 250,000 fishing hours annually (Eskelin 2010). The return of Chinook Salmon is managed as two separate stocks based on historical run timing using the Kenai River and Kasilof River Early-Run King Salmon Conservation Management Plan (5 AAC 56.070) and the Kenai River Late-Run King Salmon Management Plan (5 AAC 21.359). To meet the escapement goals outlined in the management plans, the Alaska Department of Fish and Game (Department) implemented a sonar program in 1984 to estimate the run strength of Chinook Salmon returning to the Kenai River. Since the inception of this program, there have been several changes to improve the technology and methodology used to differentiate between Chinook Salmon and more numerous Sockeye Salmon *O. nerka*, which migrate concurrently

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during both the early and late runs. The most recent change is the transition from Dual Frequency Identification Sonar (DIDSON™) to a newer DIDSON technology called Adaptive Resolution Imaging Sonar (ARIS). DIDSON™ originally replaced traditional split beam sonar technology. In addition to changes in sonar technology, the location of the sonar program in the Kenai River was recently relocated to river kilometer (rkm) 22.5 from rkm 13.7. Some of these changes stimulated the need for an independent evaluation of the Department's sonar program and the need for more detailed information on specific spawning populations. The Department and the U.S. Fish and Wildlife Service (Service) addressed these needs through the development of a cooperative study from 2012 to 2014 that identified several objectives and associated tasks aimed at collecting new information pertaining to the abundance, run timing, and age, sex, and length (ASL) compositions of Chinook Salmon throughout the Kenai River watershed. Study objectives pertaining to stock-specific abundance estimates have been outlined by Reimer (2014). The cooperative study between the Department and the Service was concluded in 2014; however, the information collected at the Killey River and Quartz Creek weirs continues to be important for validating annual in-river assessment programs. Specific study objectives for 2015 were to:

1. Enumerate the daily escapement of adult Chinook Salmon passing video weirs located in the Killey River and Quartz Creek.
2. Estimate the age and sex composition of the Chinook Salmon escapement past the Killey River weir from June 15 through August 15 such that the estimates for each group were within 10 percentage points of the true value 95% of the time.
3. Estimate the mean length of Chinook Salmon in the Killey River by sex and age.

Chinook Salmon returning to the Killey River and Quartz Creek are part of the early-run Kenai River Chinook Salmon population. Early-run fish primarily spawn in Kenai River tributaries within the Kenai National Wildlife Refuge (Refuge), whereas late-run fish spawn in the main-stem Kenai River mixed among several different land ownerships. The number of early-run Chinook Salmon returning to the Kenai River has been estimated since 1986 using various sonar technologies primarily at rkm 13 and more recently at rkm 22.5. In-river run estimates ranged from 2,032 to 23,460 fish between 1986 and 2015 for the early run (McKinley and Fleischman 2013; Alaska Department of Fish and Game 2013a, 2015a). These estimates provide the basis for estimating spawning escapement and implementing the management plans that regulate harvest of the in-river sport fishery.

Harvest of early-run Chinook Salmon occurs primarily by sport anglers in the Kenai River downstream of Skilak Lake during May and June. However, harvest also occurs, though not in great numbers, in three other fisheries: the Central Cook Inlet marine sport fishery, the Upper Sub-district set gillnet commercial fishery, and an in-river educational fishery (McKinley and Fleischman 2013). Harvest of early-run Chinook Salmon can also occur in a rod-and-reel Federal subsistence fishery, but no participation or harvest of Chinook Salmon has been reported for this fishery (U.S. Fish and Wildlife Service, unpublished data). Sport harvest of early-run Chinook Salmon is monitored by the Department through an in-river creel survey between the Warren Ames Bridge (rkm 8) and the Soldotna Bridge (rkm 32) and through the Statewide Harvest Survey between the Soldotna Bridge and Skilak Lake (rkm 80). From 1986 through 2013, annual sport harvest of early-run fish ranged from 0 to 15,209 fish and averaged 4,739 fish (McKinley and Fleischman 2013; Alaska Department of Fish and Game 2013a). No harvest of fish occurred prior to June 30 between 2013 and 2015 because the in-river sport fishery was either restricted to catch and release (2013) or closed (2014 and 2015) during the early run (Alaska Department of Fish and Game 2013b, 2014, 2015b). However, some early-run Chinook

Salmon were available to harvest during the late-run Chinook Salmon fishery from July 1-12, 2013 (Reimer 2013). Actual numbers of early-run Chinook Salmon available to harvest during the late-run Chinook Salmon fishery are unknown, vary among years (Reimer 2013), and are largely dependent on areas open to fishing and harvest. Much of the annual variation in harvest of early-run fish since 1986 is likely explained by fluctuations in run strength, changes in management strategy, environmental conditions affecting fishing success, and in-season liberalization or restriction of the sport fishery.

Radio-telemetry studies conducted during the early 1980s, 1990s, and most recently from 2010 to 2015 provide some insight regarding the migratory behavior and spawning distribution of early-run Kenai River Chinook Salmon. Results from 2014 and 2015 are not available but in-season analysis indicate similarities with prior years (Anthony Eskelin, Alaska Department of Fish and Game, personal communication). Bendock and Alexandersdottir (1991, 1992) found that most radio-tagged early-run fish spawned in larger tributaries such as the Killey (42% to 64%) and Funny (20% to 21%) rivers, whereas the remainder spawned in smaller tributaries (6% to 10%) and the main-stem Kenai River (9% to 28%). Similarly, Burger et al. (1985) found that 56% of early-run fish spawned in the Killey River, 18% in the Funny River, 18% in the main stem, and 5% in other Kenai River tributaries between 1980 and 1982. The most recent published information collected between 2010 and 2013 indicates similar results with the majority of the early run returning to the Killey River (54% to 66%), main-stem Kenai River (17% to 28%), and the Funny River (10% to 19%) (Reimer 2013).

Run timing and spawn periods can vary between tributaries depending on their locations within the Kenai River watershed. Documented peak spawning times occur between July 17 and 27 in the Killey River, based on a small sample size (n = 36) of radio-tagged Chinook Salmon between 1980 and 1982 (Burger et al. 1985). This timing is similar to the peak weekly passage of Chinook Salmon observed between 2012 and 2014 in the Killey River (Gates and Boersma 2013, 2014a, 2014b) and the July 12-22 peak spawning period identified by Burger et al. (1985) in the Funny River. Median passage dates through a video weir located in the Funny River ranged from June 29 to July 12 between 2006 and 2014 (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b, 2011; Boersma and Gates 2012, 2013, 2014; Gates and Boersma 2014c). Differential run timing makes some early-run Chinook Salmon susceptible to harvest throughout most of July when the in-river sport fishery is targeting late-run Chinook Salmon (Bendock and Alexandersdottir 1992; Reimer 2013).

Harvest of tributary spawners in the main-stem Kenai River during July can be partially attributed to extended milling behavior. Burger et al. (1983) identified radio-tagged Chinook Salmon that milled near the mouth of the Funny River between July 1 and 28 before entering to spawn. Bendock and Alexandersdottir (1992) also observed similar behavior and noted that early-run Chinook Salmon mill for extended periods in the main-stem Kenai River at or downstream of tributary confluences. Funny River spawners particularly exhibited this behavior along the south bank of the Kenai River between rkm 45 and 48 (Bendock and Alexandersdottir 1992). Similar milling behaviors have been observed by Liscom et al. (1978) for Columbia River Chinook Salmon tributary spawners, which can spend 6 to 38 days near a confluence before entering to spawn. The Department and Alaska Board of Fish recognized this, and sanctuary areas in the main-stem Kenai River have been established near the mouths of some tributary streams (Killey River, Funny River, and Slikok Creek) to protect fish that are milling prior to entering tributary streams. Disproportionately harvesting fish early or late in the run

could be detrimental to smaller populations of early-run Chinook Salmon (McKinley et al. 2002).

Prior to 2015, the abundance information collected from the Killey River and Quartz Creek in conjunction with abundance estimates produced from other tributaries with weirs throughout the Kenai River watershed (i.e., Funny River, Slikok Creek, Russian River) were used in a stock-specific abundance and run timing (SSART) model developed by the Department. The model produced an independent abundance estimate of Kenai River Chinook Salmon which was used to investigate bias associated with the Department's abundance estimates developed using DIDSON™.

Study Area

The Killey River is a tributary to the Kenai River. The glacially turbid Kenai River originates in Cooper Landing at the outlet of Kenai Lake and terminates at Cook Inlet 132 rkm down river (Figure 1). The Killey River drains approximately 596 km^2 and flows almost entirely within the Refuge except the lower 1-2 rkms that transect through a combination of state and private lands. The Killey River is glacially fed most of the year. Water clarity diminishes beginning in late May and early June and remains turbid through late fall. Most of the upper watershed is vegetated with stands of large cottonwood (*Populus trichocarpa*) and spruce (*Picea* spp.) with patches of alder (*Alnus sinuata*) along the stream banks (Moser 1998). The lower watershed flows through an unconfined alluvial plain and is vegetated with grass, willow *Salix* spp., spruce and cottonwood. Within the upper watershed, the substrate is primarily gravel and cobble mixed with boulders. Most of the river channel is steep in gradient with variable sinuosity. The Killey River supports greater than half of the early-run Chinook Salmon returning to the Kenai River based on past and present radio-telemetry studies (Burger et al. 1985; Bendock and Alexandersdottir 1991 and 1992; Reimer 2013). The video weir was located in the Killey River approximately 45 rkm upstream of its confluence with the Kenai River (60.280795°N and -150.440011°W; WGS 84).

The Quartz Creek watershed is 102 km^2 and drains into Kenai Lake in the upper Kenai River watershed. The clear-water creek and several of its tributaries support important spawning and rearing habitat for several species of Pacific salmon, including Chinook Salmon (Johnson and Blanche 2011). Quartz Creek watershed is comprised of fewer early-run Chinook Salmon compared to other Kenai River tributaries (e.g., Killey and Funny rivers) and main-stem Kenai River spawning aggregates. The video weir was located approximately 0.4 km upstream from its confluence with Kenai Lake (60.477819°N and -149.722980°W; WGS 84).

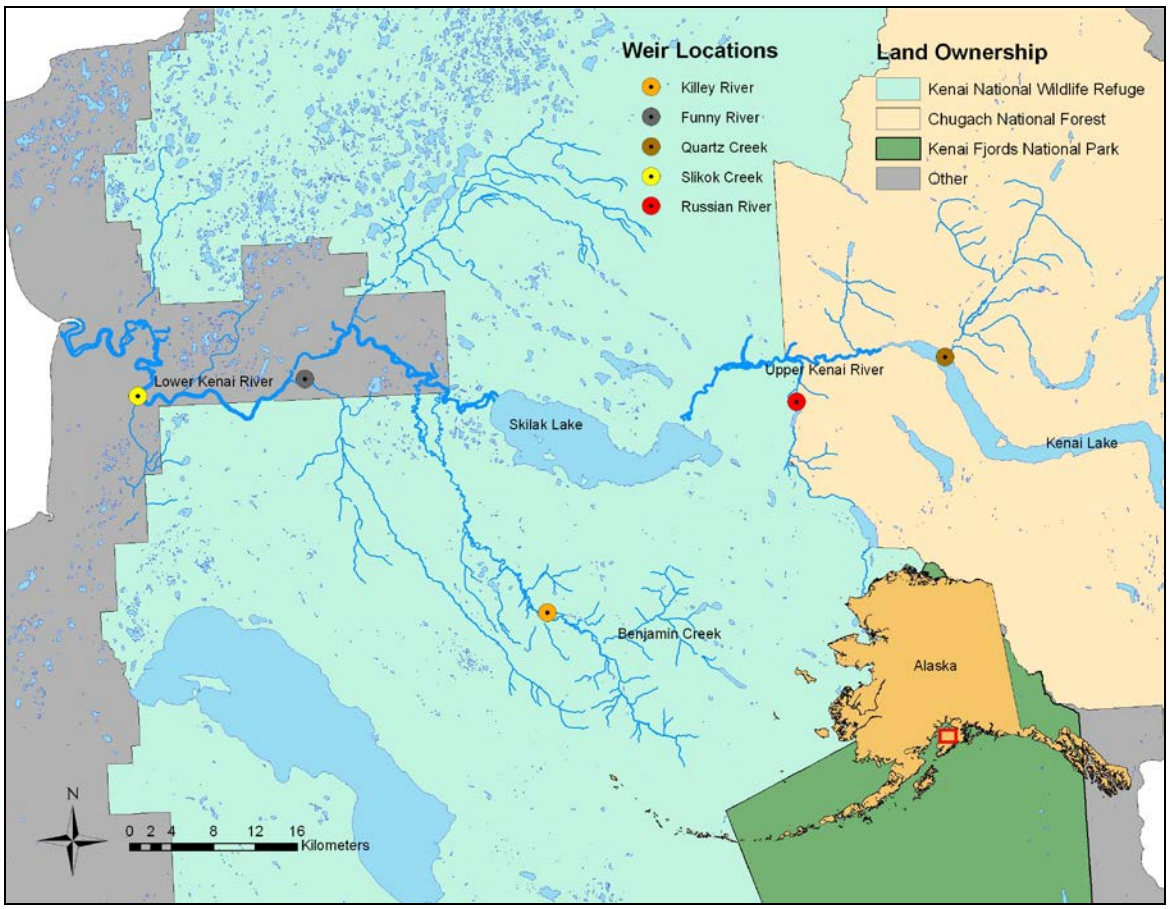

FIGURE 1. —Map of the Kenai River illustrating present and past fish weir locations contributing Chinook Salmon escapement data. The Slikok Creek weir has not been operated since 2012.

Methods

Weir and Video Operations and Design

A resistance board weir and underwater video system was operated in the Killey River from May 30 to August 4 and in Quartz Creek from June 16 to August 16, 2015. The weirs were constructed using a combination of floating resistance board panels and rigid-picket panels. The floating resistance board panels were constructed using specifications outlined by Tobin (1994), with minor changes to some materials, panel width, and resistance boards. The panels were attached to a steel rail anchored to the river bottom and were configured to allow fish to pass through a modified panel. The rigid-picket panels were installed between the bank and bulkhead of the resistance board weir to create a fish-tight weir. The rigid-picket panel framework was comprised of an "A" frame constructed from three pieces of 6.4-cm aluminum angle and two additional 2.1-m pieces of aluminum angle, drilled with 28.6-mm holes every 3.2 cm, spanning between the bulkhead and the "A" frame. Individual pickets were inserted into the framework by sliding them through the drilled holes. Pickets were schedule 40 aluminum pipe measuring 25-mm in diameter by 1.8-m in length. Upstream fish passage was monitored using a live trap (Killey River) and underwater video monitoring system (Killey River and Quartz Creek). The live trap in the Killey River facilitated biological sampling and was attached upstream of the fish passage panel. The video system, consisting of a sealed camera box and fish passage chute, was attached upstream of the live trap.

Setup and design of the video systems were similar to that used by Boersma and Gates (2012) in the Funny River. One underwater video camera was located inside a sealed video box attached to the fish passage chute. Each video box was constructed of 3.2-mm aluminum sheeting and was filled with filtered water. Safety glass was installed on the front of the video boxes for a scratch-free, clear surface through which images were captured. The passage chutes were constructed from aluminum angle and were enclosed in plywood isolating them from exterior light. The backdrops of the passage chutes could be adjusted laterally to reduce the number of fish passing through each chute at one time and to guide fish closer to the camera during turbid water conditions. The backdrops could also be easily removed from the video chute for cleaning and replacement as needed. The video boxes and fish passage chutes were artificially lit using a pair of 12-V DC underwater pond lights. Pond lights were equipped with 20-W bulbs which produced a quality image and provided a consistent source of lighting during day and night. All video images were recorded on one-terabyte external hard drives at a minimum of 22 frames-per-second using computer-based digital video recorders (DVR). Fish passage was recorded 24 hours per day 7 days each week at both weir locations. Stored video files were reviewed daily at the Killey River and approximately every other day at Quartz Creek. The DVRs were operated with motion detection to minimize the amount of blank video footage and review time. The underwater cameras, lights, DVRs and monitors were powered by 110-V AC inverted from 12-V DC. Power was supplied using five 120-W solar panels wired in parallel and one 240-W propane thermoelectric generator at the Killey River. Two 120-W propane thermoelectric generators were used to power the Quartz Creek video system. Power storage consisted of four 400-Ampere-hour (Ah) 6-V DC batteries wired in a series–parallel circuit to produce 12-V DC at the Killey River. Two 400-Ah 6-V DC batteries wired in series were used to store power at Quartz Creek. A list of essential video equipment used during this project can be found in Appendix 1.

Biological Sampling

Age, sex, and length (ASL) samples were collected from Chinook Salmon in the Killey River using a temporally stratified sample design (Cochran 1977) because abundance, age, size, and sex are thought to vary throughout the migration. Sampling effort was scaled in real time to consistently sample 10 to 20 percent of the run. Samples were collected between approximately 1500 and 1800 hours nearly every day.

The ASL sampling in the Killey River consisted of sex determinations, length measurements, and scale collections. Sex was determined by observing external morphologic characteristics during video review and stratified ASL sampling, providing a complete census of gender. Females were identified as having blunt-shaped heads, presence of an ovipositor (ASL sampling only), and a round-shaped belly, whereas males generally exhibit a prolonged head accompanied with a kype, a gradual dorsal hump, and a stream-lined belly. Length measurements for Chinook Salmon were taken to the nearest 5 mm from the mid eye to tail fork (MEF) and from the tip of the nose to tail fork. Scales were removed from the preferred area using methods described by Mosher (1968) and Koo (1962). The preferred area is located on the left side of the fish, two scale rows above the lateral line and on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin. Four scales were taken from each Chinook Salmon, mounted on gummed cards, and pressed on acetate to make an impression. Chinook Salmon scales were aged by the Service.

Data Analysis

Age, sex, and length —Age and sex composition for the total escapement of Chinook Salmon were estimated directly from the age and sex composition in the weekly weir sample using a stratified sampling design (Cochran 1977), with the escapement in each stratum as a weight. Age (*i*) and sex (*j*) specific escapements in a stratum (*h*), A_{hij}, and their variances, $V[A_{hij}]$ were estimated as:

$$\hat{A}_{hij} = N_h \hat{P}_{hij} \tag{1}$$

and

$$\hat{V}\left[\hat{A}_{hij}\right] = \hat{N}_h^2 \left(1 - \frac{n_h}{N_h}\right)\left(\frac{\hat{P}_{hij}\left(1-\hat{P}_{hij}\right)}{n_h - 1}\right) \tag{2}$$

where

N_h = total escapement during stratum *h*;
$\hat{p}_{hij}$ = estimated proportion of age *i* and sex *j* fish in stratum *h*; and
n_h = total number of fish in the sample for stratum *h*.

Abundance estimates and their variances for each stratum were summed to estimate age and sex-specific escapements for the season as follows:

$$\hat{A}_{ij} = \sum_h \hat{A}_{hij} \tag{3}$$

and

$$\hat{V}\left[\hat{A}_{ij}\right] = \sum_h \hat{V}\left[\hat{A}_{hij}\right]. \tag{4}$$

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Basic data summaries, scatter plots, bar graphs, and statistical analyses (i.e., means, standard errors, and ranges) were used to describe the length distribution of Chinook Salmon sampled at the Killey River weir.

Results

Weir and Video Operations

The Killey River and Quartz Creek weirs were installed between April 16 and 20 and May11 and 13, respectively. Each weir was installed prior to spring run-off and high water and were left unattended until project start dates. Debris and fish passage were unobstructed during this time period. Video systems and associated power components were installed just prior to each weir becoming fully operational on May 30 (Killey River) and June 16 (Quartz Creek). High water submerged portions of the Killey River weir during early June and again during early July. Fish passage was monitored with the underwater video system without interruption during these periods. Few to no fish were observed passing through the weir during June, whereas passage during the July high water event was modest. Passage of fish over the top of the weir was possible during these high water events but was not estimated.

Biological Data

Killey River —A total of 2,656 Chinook Salmon were observed passing through the video system and live trap at the Killey River weir between June 10 and August 4 (Figure 2; Appendices 2 and 4). Peak weekly passage (n = 819) occurred between July 5 and 11; passage was also high between July 12 and 18 (n=811). The highest daily count (n = 258) and median cumulative passage occurred on July 11 and 12, respectively (Appendix 2).

Age, sex, and length samples were collected from 863 Chinook Salmon between June 13 and August 4. Ten percent (n=85) of the sampled fish were excluded from the ASL analysis because of inconclusive age determinations. Of the aged scales, female Chinook Salmon were comprised of two age groups, ages 1.3 (59%) and 1.4 (41%). Male Chinook Salmon were comprised of five age groups, ages 1.1 (8%), 1.2 (63%), 1.3 (21%), 1.4 (8%), and 1.5 (0.002%; Tables 1 and 2). Age-1.2 males comprised 46% of the total run (Table 2). Females comprised 29% of the ASL sample and 27% of the sexed video images. Overall, females comprised 28% of the run (Video and ASL combined) and averaged 865 mm MEF (Tables 1 and 2). Male MEF lengths averaged 632 mm. Combined male and female MEF lengths averaged 699 mm and ranged from 290 mm to 1,080 mm (Table 1; Figure 3). Male Chinook Salmon outnumbered females throughout most of the run (Figure 4).

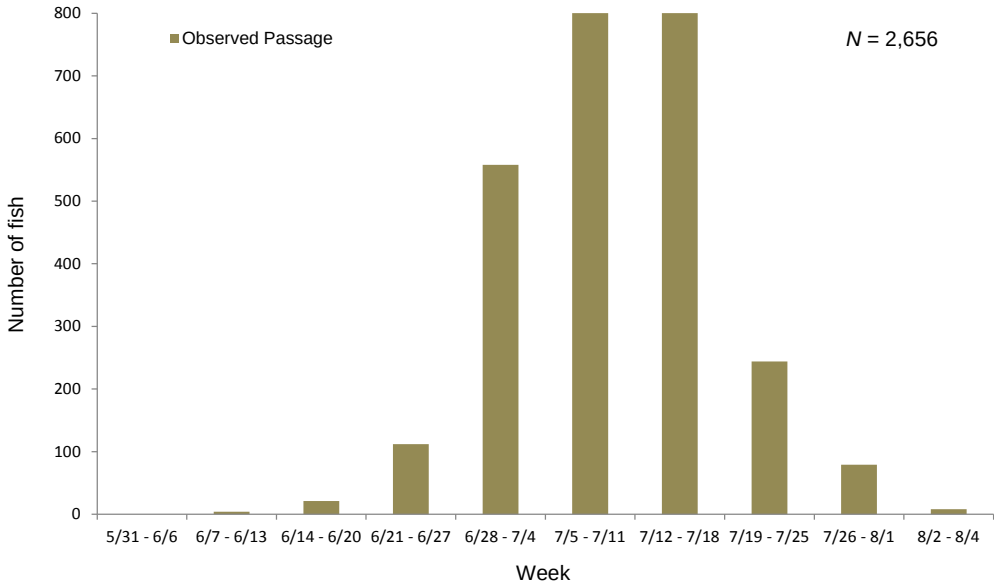

FIGURE 2. —Observed weekly escapement of adult Chinook Salmon passing through the Killey River weir during 2015. Counts began mid-day on May 30 and ended mid-day on August 4.

TABLE 1. —Length-at-age for adult Chinook Salmon sampled at the Killey River weir during 2015.

			Mid Eye to Tail Fork Length		
Sex	Age	*n* [a]	Mean	Range	Standard Error
Female	1.3	132	837	715 - 1,010	4.1
	1.4	92	905	805 - 1,050	5.5
Female Total		224	865	715 - 1,050	3.9
Male	1.1	46	363	290 - 580	13.0
	1.2	349	579	375 - 835	5.4
	1.3	114	792	520 - 1,035	6.3
	1.4	44	956	785 - 1,080	20.9
	1.5	1	1,010	–	–
Male Total		554	632	290 - 1,080	6.9
Cumulative Total		778	699	290 - 1,080	6.3

[a] Fish with inconclusive age determinations were omitted from this table (*n*=85)

TABLE 2. —Age and sex composition estimates for Chinook Salmon returning to the Killey River during 2015.

		Brood Year and Age Group					
		2012	2011	2010	2009	2008	
		1.1	1.2	1.3	1.4	1.5	Total
Sample period: June 13 to August 4							
Female:	Number in sample:			132	92		224
	Percent age group			58.9	41.1		100
	Estimated escapement:			433	302		735 [b]
	Standard error:			20.2	20.2		
	Percent of escapement:			16.3	11.4		28
Male:	Number in sample:	46	349	114	44	1	554
	Percent age group:	8.3	63.0	20.6	7.9	0.002	100
	Estimated escapement:	159	1,210	395	153	4	1,920 [b]
	Standard error:	18.9	39.8	37.2	30.4	2.9	
	Percent of escapement:	6.0	45.6	14.9	5.7	0.1	72
Total:	Number in Sample:	46	349	246	136	1	778
	Estimated Escapement:	159	1210	828	454 [b]	4	2,655 [a]
	Percent of escapement:	6.0	45.6	31.2	17.1	0.1	100

[a] Chinook Salmon with unkown sex were omitted from the analysis (*n*=1).
[b] Rounding error may affect totals

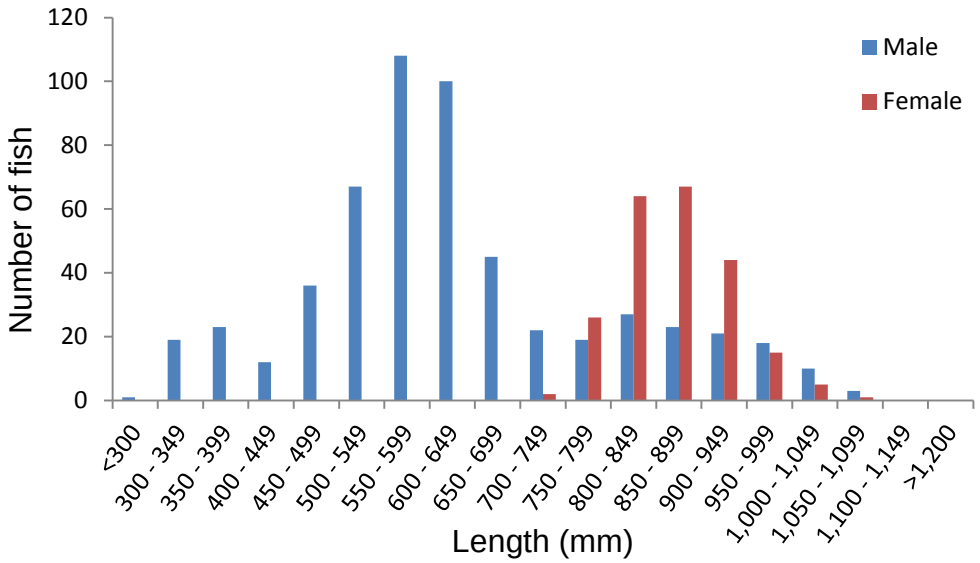

FIGURE 3. —Mid eye to tail fork length frequency distribution of male and female Chinook Salmon sampled at the Killey River during 2015.

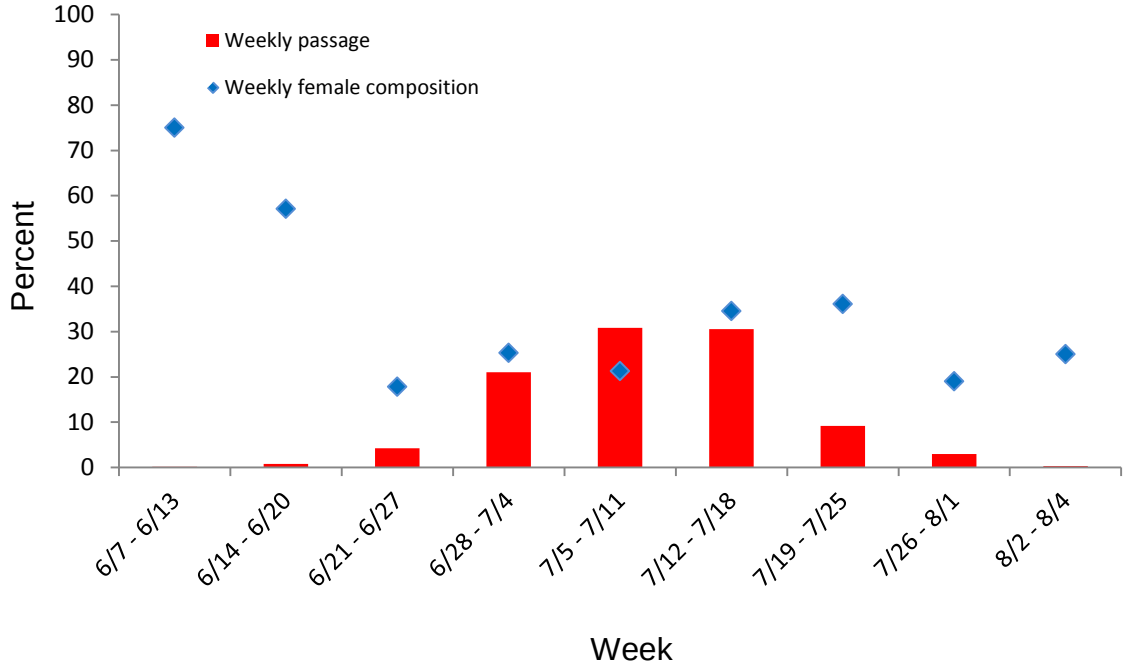

FIGURE 4. —Weekly passage (%) of Chinook Salmon including adult female Chinook Salmon composition (%) observed at the Killey River video weir from June 10 to August 4, 2015. Passage and female composition includes video review and ASL sampling.

Quartz Creek. — A total of 448 Chinook Salmon were observed passing through the weir using the video system at the Quartz Creek weir between June 19 and August 15 (Figure 5; Appendices 3 and 5). Peak weekly passage (n = 138) occurred between July 19 and 25. The median cumulative passage and highest daily count (n = 61) occurred on July 21 and 23, respectively

(Appendix 3). Females comprised 45% of the Chinook Salmon run, determined exclusively during video review. Male Chinook Salmon outnumbered females throughout the majority of the run (Figure 6). Other than determining the sex of fish during video review, no attempt was made to collect ASL samples.

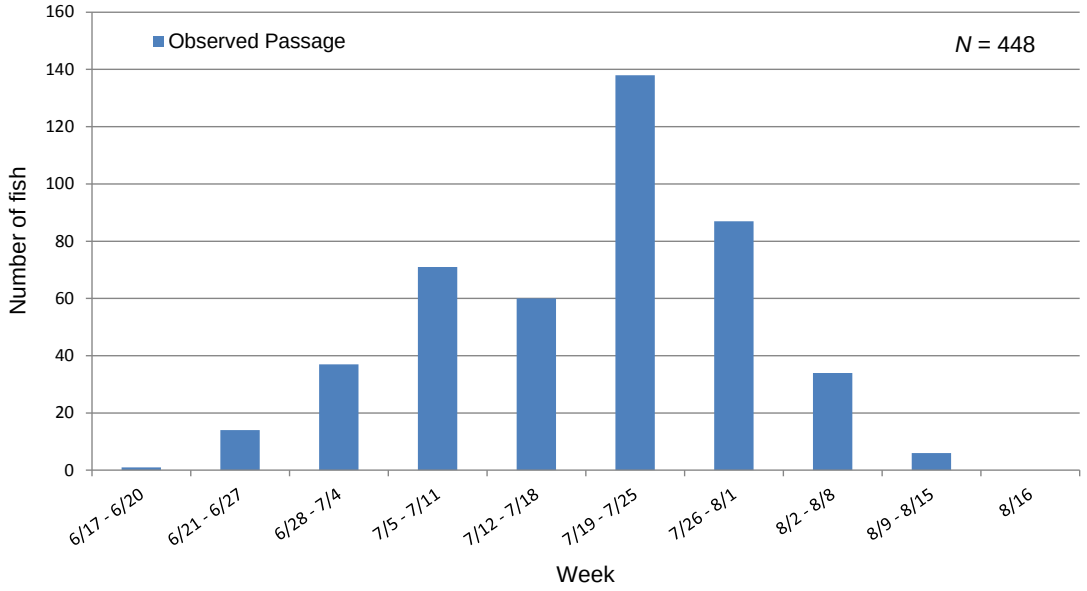

FIGURE 5. —Observed weekly escapement of adult Chinook Salmon passing through the Quartz Creek video weir during 2015. Counts began mid-day on June 17 and ended on August 16.

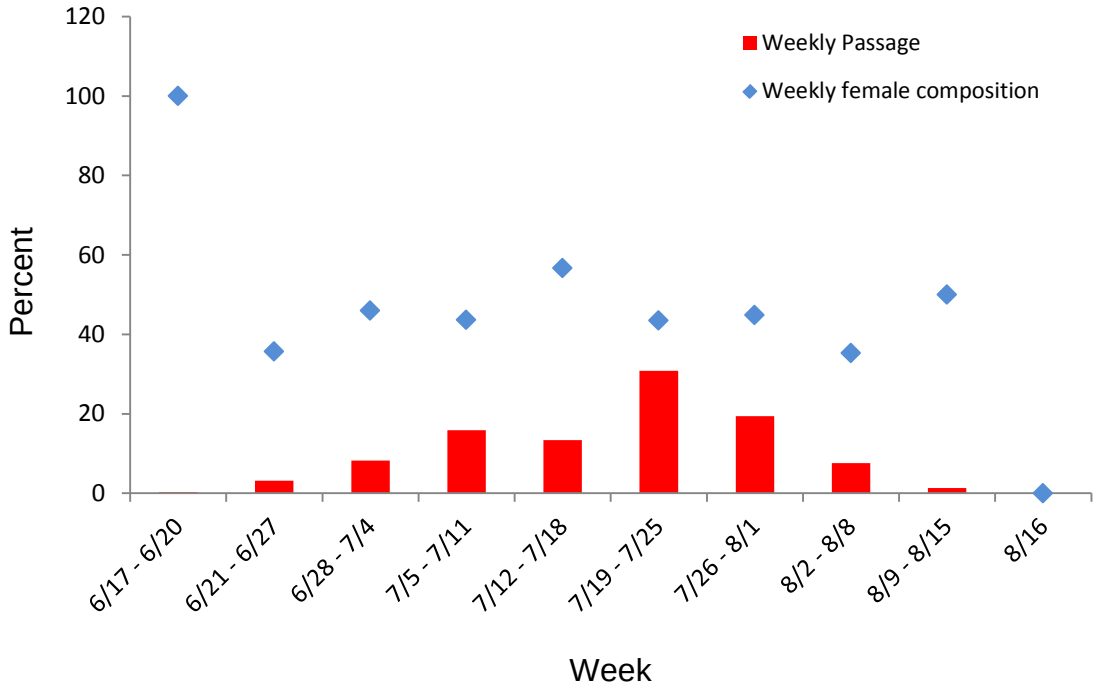

FIGURE 6. —Weekly passage (%) of Chinook Salmon including adult female Chinook Salmon composition (%) observed at the Quartz Creek video weir from June 19 to August 15, 2015. Passage and sex composition were determined from video records.

Other species. —Species other than Chinook Salmon passing through the Killey River and Quartz Creek video weirs included Sockeye Salmon *O. nerka*, Pink Salmon *O. gorbuscha*, Dolly Varden *Salvelinus malma*, Rainbow Trout *O. mykiss*, Arctic Grayling *Thymallus arcticus*, and Round Whitefish *Prosopium cylindraceum* (Tables 3 and 4).

TABLE 3. —Weekly counts of non-target species passing through the Killey River weir during 2015. Counts were conducted between May 30 and August 4.

Week	Sockeye Salmon	Pink Salmon	Dolly Varden	Rainbow Trout	Arctic Grayling	Round Whitefish
5/30	2	0	2	0	0	0
5/31 - 6/6	11	0	6	1	0	1
6/7 - 6/13	36	0	37	0	0	1
6/14 - 6/20	55	0	37	0	0	0
6/21 - 6/27	74	0	45	0	2	0
6/28 - 7/4	268	0	117	0	0	0
7/5 - 7/11	586	2	253	0	0	0
7/12 - 7/18	399	3	314	0	0	0
7/19 - 7/25	34	9	303	0	0	0
7/26 - 8/1	2	9	100	0	0	0
8/2 - 8/4	1	0	11	0	0	0
	1,468	23	1,225	1	2	2

TABLE 4. —Weekly counts of non-target species passing through the Quartz Creek video weir during 2015. Counts were conducted between June 17 and August 16.

Week	Sockeye Salmon	Pink Salmon	Dolly Varden	Rainbow Trout	Round Whitefish
6/17 - 6/20	2	0	138	10	0
6/21 - 6/27	15	0	235	27	5
6/28 - 7/4	9	0	218	24	17
7/5 - 7/11	305	0	337	17	15
7/12 - 7/18	1069	38	388	19	1
7/19 - 7/25	4942	35	681	50	7
7/26 - 8/1	11,950	111	1,903	134	15
8/2 - 8/8	10,134	42	2,341	135	0
8/9 - 8/15	3,086	16	1,528	55	0
8/16	184	0	88	6	0
	31,696	242	7,857	477	60

Discussion

The observed passage of Chinook Salmon during 2015 through the Killey River and Quartz Creek video weirs was greater than those observed from 2012 to 2014 (Gates and Boersma 2013, 2014a, 2014b). However, the run timing of Chinook Salmon past the weirs remained similar to all other years. Flooding from snow melt and spring rain occurred at the Killey River weir site during June similar to other years which resulted in the weir being submerged at times. High water during this period has minimal effects on fish passage as the Chinook Salmon run typically does not begin until late June. Moderately high water also occurred for a short period between July 6 and 8 resulting in the weir being partially submerged. The highest flows were observed

on July 7. A short lag in run timing during this period was observed in the cumulative run distribution (Appendices 2 and 4) indicating a disruption in fish counts, fish migration, or both. Chinook Salmon were continuously counted during this period using video indicating some passage occurred despite higher water flows. Radio-telemetry information collected from a fixed receiver station located adjacent to the weir supports the notion that some fish continued to pass the weir as well as possible disruption in migration. Six radio-tagged Chinook Salmon were identified by the fixed receiver station between July 6 and 8 (U.S. Fish and Wildlife Service and Alaska Department of Fish and Game, unpublished data). Of these six radio-tagged Chinook Salmon, four arrived at the weir between July 6 and 8 and passed on July 7 and 8. One of the six radio-tagged Chinook Salmon passed the weir site prior to the high water event and was detected for a second time upstream of the weir but was moving downriver towards the weir during peak flows. Although this fish never passed downriver of the weir it exhibited downstream movement during the high water event. The sixth radio-tagged fish was located downriver of the weir on July 7 and did not pass until July 10 after moving downriver out of detection range for 2 days. Because of the uncertainty of fish behavior and our ability to count Chinook Salmon during this high water event, no attempt was made to estimate fish passage during this period.

The Quartz Creek weir and video system was operated by the U.S Forest Service during 2015. The weir and video system ran smoothly throughout most of the operating season with the exception of two time periods. The DVR stopped recording for most of July 16 for unknown reasons and power was interrupted for 22 hours spanning July 19 and 20 due to a lack of fuel. Because daily Chinook Salmon passage in Quartz Creek is sporadic; often times experiencing days of low to near zero passage between two single days of high passage, estimates of escapement for the lost video were not generated. Daily passage in Quartz Creek is likely triggered by multiple factors such as the environment (e.g., flow), physiological condition (e.g., ripeness), and sheer numbers of fish in the lower creek and Kenai Lake. The underwater video system has allowed us to accurately count and identify Chinook Salmon mixed with hundreds and sometimes thousands of Sockeye Salmon. Although ASL samples were not collected from Chinook Salmon returning to Quartz Creek, we continue to recommend that this run be sampled for ASL in the future. Fish observed during video review suggests that this run may be comprised of greater numbers of larger and older Chinook Salmon when compared to other spawning populations of Chinook Salmon monitored in the Kenai River watershed. This is evidenced by the higher ratio of females to males compared to other Kenai River populations.

We believe the 778 ASL samples taken from Chinook Salmon at the Killey River weir accurately describes the Chinook Salmon run returning to the Upper Killey River watershed. The samples were 29% of the observed escapement and were collected almost daily throughout the entire Chinook Salmon run. The samples taken during 2015 had a greater proportion (17%) of age-1.4 Chinook Salmon compared to 2014 (6%). However, small male Chinook Salmon continue to dominate, comprising 46% of the run.

The information collected from this study is important to the successful management of early-run Chinook Salmon returning to the Kenai River. Most notably, the information collected on age, sex, and length compositions from the Killey River is instrumental in validating the ASL samples collected by the Department's in-river test net fishery near rkm 13 in the lower Kenai River. We recommend that the Killey River weir operations be extended into 2016 if funding is available because of the persistent low abundance and asymmetric length and age distributions of Chinook Salmon returning to the Kenai River and its tributaries. This project, combined with the Funny River Chinook Salmon assessment project, provides the most accurate post-season assessment of abundance and ASL compositions within the Kenai River watershed. This is

especially important during changes to in-season management programs (i.e., new sonar location, potential changes to the test netting program and escapement goals). The Killey River samples will also be used as a benchmark to monitor future trends in abundance and ASL data for Chinook Salmon returning to the Kenai and Killey rivers. Further investigation into the composition of Quartz Creek Chinook Salmon may be warranted due to its small run size, larger female to male sex ratio, and observations during video review of larger and older fish than what is currently observed at other locations within the Kenai River watershed.

Acknowledgements

Special appreciation is extended to all those who participated in project setup and support, data collection, and video review. Austin Huff, Mike Canino, Andrew Waldo, and Chanice Davies were responsible for the day to day maintenance and project operations including ASL collections at the Killey River weir. Staff from the U.S. Forest Service including Adam Bahr, Cole Sellers, Mike Yaros, Dave Pearson, Neal Schoenfelder, John Lang were responsible for the day to day operation and maintenance of the Quartz Creek weir and video system. Maritime Helicopters provided air support for the project which included reconnaissance, resupply, and equipment and personnel transport. A special thanks is also extended to Kenai National Wildlife Refuge wildlife biologist/pilot, Nathan Olson, for providing air support throughout the project.

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APPENDIX 1. —List of video equipment used to monitor adult Chinook Salmon on Killey River and Quartz Creek during 2015.

Item	Model #	Manufacturer	Contact
Digital Video Recorder	DVSM 4-120	Veltek International, Inc.	No longer Available
Underwater Camera	Model AM060	Applied Micro Video	http://www.appliedmicrovideo.com/
Underwater Camera	Model AM070	Applied Micro Video	http://www.appliedmicrovideo.com/
Underwater Lights	Lunaqua 2 12-v	OASE	http://www.pondusa.com
External Harddrive	Seagate 1TB	Seagate Technologies, LLC	http://www.seagate.com
Thermoelectric Generator (propane)	5220L-SI-RS	Global Thermoelectric Corp.	http://www.globalte.com/
Thermoelectric Generator (propane)	5120L-SI-RS	Global Thermoelectric Corp.	http://www.globalte.com/
Thermoelectric Generator (propane)	5120L-SI-RS	Global Thermoelectric Corp.	http://www.globalte.com/
110 W Solar Module	SW-S110P	Sunwize	http://www.sunwize.com
400 Ah 6 Volt Battery	S-530	Rolls	http://www.rollsbattery.com/
100 Ah 12 Volt Battery	ES27	Exide Technologies	http://www.exide.com/
40A Charge Controller	C40	Xantrex	http://www.Xantrex.com/
12 Volt Inverter	GP-SW600	Go Power	http://gpelectric.com/
Charge Controller	ASC16-12	Specialty Concepts, Inc.	http://www.specialtyconcepts.com/

APPENDIX 2. —Daily passage totals including cumulative and proportional passage of adult Chinook Salmon observed at the Killey River weir during 2015. Boxed areas represent the second and third quartile and median passage dates.

Date	Male	Female	Unknown Sex	Daily Total	Daily Cumulative	Cumulative Proportion
5/30	0	0	0	0	0	0.0000
5/31	0	0	0	0	0	0.0000
6/1	0	0	0	0	0	0.0000
6/2	0	0	0	0	0	0.0000
6/3	0	0	0	0	0	0.0000
6/4	0	0	0	0	0	0.0000
6/5	0	0	0	0	0	0.0000
6/6	0	0	0	0	0	0.0000
6/7	0	0	0	0	0	0.0000
6/8	0	0	0	0	0	0.0000
6/9	0	0	0	0	0	0.0000
6/10	0	1	0	1	1	0.0004
6/11	0	1	0	1	2	0.0008
6/12	0	0	0	0	2	0.0008
6/13	1	1	0	2	4	0.0015
6/14	1	3	0	4	8	0.0030
6/15	3	4	0	7	15	0.0056
6/16	1	1	0	2	17	0.0064
6/17	0	1	0	1	18	0.0068
6/18	2	2	0	4	22	0.0083
6/19	0	0	0	0	22	0.0083
6/20	2	1	0	3	25	0.0094
6/21	7	3	0	10	35	0.0132
6/22	12	0	0	12	47	0.0177
6/23	5	6	0	11	58	0.0218
6/24	14	2	0	16	74	0.0279
6/25	22	5	0	27	101	0.0380
6/26	11	1	0	12	113	0.0425
6/27	21	3	0	24	137	0.0516
6/28	14	5	0	19	156	0.0587
6/29	28	14	0	42	198	0.0745
6/30	48	13	0	61	259	0.0975
7/1	73	16	0	89	348	0.1310
7/2	34	12	0	46	394	0.1483
7/3	101	37	0	138	532	0.2003
7/4	119	44	0	163	695	0.2617
7/5	94	38	0	132	827	0.3114

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APPENDIX 2. —(Page 2 of 2)

Date	Male	Female	Unknown Sex	Daily Total	Daily Cumulative	Cumulative Proportion
7/6	60	23	0	83	910	0.3426
7/7	31	12	0	43	953	0.3588
7/8	54	15	0	69	1,022	0.3848
7/9	106	21	0	127	1,149	0.4326
7/10	127	24	0	151	1,300	0.4895
7/11	173	41	0	214	1,514	0.5700
7/12	183	74	1	258	1,772	0.6672
7/13	100	56	0	156	1,928	0.7259
7/14	68	28	0	96	2,024	0.7620
7/15	72	28	0	100	2,124	0.7997
7/16	31	29	0	60	2,184	0.8223
7/17	37	40	0	77	2,261	0.8513
7/18	39	25	0	64	2,325	0.8754
7/19	36	17	0	53	2,378	0.8953
7/20	22	9	0	31	2,409	0.9070
7/21	24	7	0	31	2,440	0.9187
7/22	24	15	0	39	2,479	0.9334
7/23	15	11	0	26	2,505	0.9431
7/24	19	12	0	31	2,536	0.9548
7/25	16	17	0	33	2,569	0.9672
7/26	13	3	0	16	2,585	0.9733
7/27	10	7	0	17	2,602	0.9797
7/28	2	0	0	2	2,604	0.9804
7/29	13	0	0	13	2,617	0.9853
7/30	9	2	0	11	2,628	0.9895
7/31	10	2	0	12	2,640	0.9940
8/1	7	1	0	8	2,648	0.9970
8/2	4	1	0	5	2,653	0.9989
8/3	1	1	0	2	2,655	0.9996
8/4	1	0	0	1	2,656	1.0000
Total	1,920	735	1	2,656		

APPENDIX 3. —Daily passage totals including cumulative and proportional passage of adult Chinook Salmon observed at the Quartz Creek weir during 2015. Boxed areas represent the second and third quartile and median passage dates.

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
6/17	0	0	0	0	0.0000
6/18	0	0	0	0	0.0000
6/19	0	1	1	1	0.0022
6/20	0	0	0	1	0.0022
6/21	2	3	5	6	0.0134
6/22	2	0	2	8	0.0179
6/23	1	0	1	9	0.0201
6/24	2	1	3	12	0.0268
6/25	2	0	2	14	0.0313
6/26	0	0	0	14	0.0313
6/27	0	1	1	15	0.0335
6/28	0	0	0	15	0.0335
6/29	1	2	3	18	0.0402
6/30	1	2	3	21	0.0469
7/1	2	1	3	24	0.0536
7/2	1	7	8	32	0.0714
7/3	2	1	3	35	0.0781
7/4	13	4	17	52	0.1161
7/5	8	4	12	64	0.1429
7/6	13	9	22	86	0.1920
7/7	12	9	21	107	0.2388
7/8	4	1	5	112	0.2500
7/9	2	8	10	122	0.2723
7/10	0	0	0	122	0.2723
7/11	1	0	1	123	0.2746
7/12	4	0	4	127	0.2835
7/13	2	2	4	131	0.2924
7/14	7	1	8	139	0.3103
7/15	2	8	10	149	0.3326
7/16	0	0	0	149	0.3326
7/17	3	6	9	158	0.3527
7/18	8	17	25	183	0.4085
7/19	1	4	5	188	0.4196
7/20	16	11	27	215	0.4799
7/21	6	7	13	228	0.5089
7/22	4	5	9	237	0.5290
7/23	32	29	61	298	0.6652
7/24	7	4	11	309	0.6897
7/25	12	0	12	321	0.7165
7/26	20	8	28	349	0.7790
7/27	6	15	21	370	0.8259
7/28	5	2	7	377	0.8415
7/29	1	5	6	383	0.8549
7/30	3	1	4	387	0.8638
7/31	5	6	11	398	0.8884
8/1	8	2	10	408	0.9107
8/2	10	3	13	421	0.9397
8/3	2	3	5	426	0.9509

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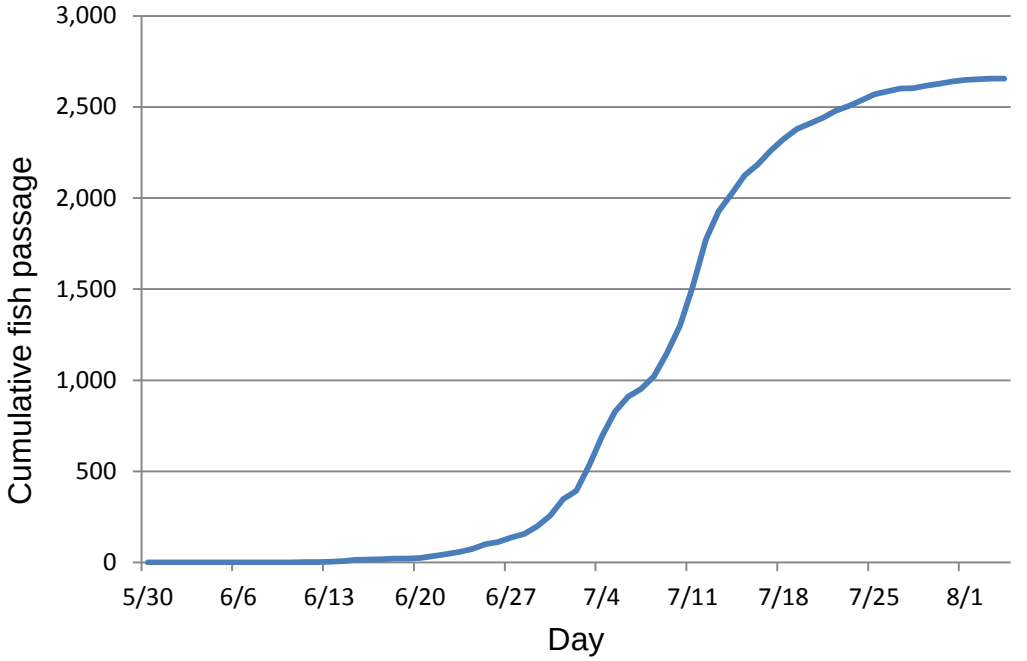
APPENDIX 3. —(Page 2 of 2)

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
8/4	2	0	2	428	0.9554
8/5	5	1	6	434	0.9688
8/6	3	2	5	439	0.9799
8/7	0	1	1	440	0.9821
8/8	0	2	2	442	0.9866
8/9	0	0	0	442	0.9866
8/10	2	2	4	446	0.9955
8/11	0	0	0	446	0.9955
8/12	0	0	0	446	0.9955
8/13	0	0	0	446	0.9955
8/14	1	0	1	447	0.9978
8/15	0	1	1	448	1.0000
8/16	0	0	0	448	1.0000
Total	246	202	448		

APPENDIX 4. —Cumulative Chinook Salmon passage at the Killey River weir during 2015.



APPENDIX 5. —Cumulative Chinook Salmon passage at the Quartz Creek weir during 2015.