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Abundance, Run Timing, and Age, Sex, And Length of Adult Chinook Salmon in the Killey River and Quartz Creek, Kenai Peninsula, Alaska, 2014

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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 timely in-season management. The U.S. Fish and Wildlife Service and Alaska Department of Fish and Game are currently using weirs, radiotelemetry, and harvest information in a stock-specific abundance and run timing model to assess current in-river sonar escapement estimates. As part of this modeling effort, fish weirs equipped with underwater video systems were installed and operated in the Killey River and Quartz Creek between 16 May and 18 August 2014 to enumerate and characterize the demographics of adult Chinook Salmon. A total of 2,038 Chinook Salmon were observed passing the weirs, including 1,713 Killey River and 325 Quartz Creek fish. Peak weekly passage of Chinook Salmon in the Killey River occurred between 13 and 19 July and in Quartz Creek between 20 and 26 July. Females comprised 32 % of the Chinook Salmon escapement at Quartz Creek and 22 % 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 656 mm (SE = 7) and 833 mm (SE = 5), respectively. Ages of Killey River Chinook Salmon, determined from scale analysis, ranged between 3 and 6 years. Non-target fish species observed passing the weirs in 2014 included Sockeye Salmon *O. nerka*, Pink Salmon *O. gorbuscha,* Chum Salmon *O. keta*, Coho Salmon *O. kisutch*, 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 divided into two separate escapements based on run timing and are managed accordingly 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 the traditional split beam sonar to a newer Dual Frequency Identification Sonar (DIDSON™). This change 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 this need through the development of a cooperative study that identifies 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 the stock specific abundance estimates are outlined by Reimer (2014). Specific study objectives pertaining to the Killey River and Quartz Creek 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 15 June through 15 August 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 at river kilometer (rkm) 13. In-river run estimates ranged from 2,032 to 23,460 fish between 1986 and 2013 for the early run (McKinley and Fleischman 2013; Alaska Department of Fish and Game 2013a). 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 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 30 June during 2013 and 2014 because the in-river sport fishery was either restricted to catch and release (2013) or closed (2014) during the early run (Alaska Department of Fish and Game 2013b; Alaska Department of Fish and Game 2014a). However, some early-run Chinook Salmon were available to harvest during the late-run Chinook Salmon fishery from 1-12 July 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 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 2014 provide some insight regarding the migratory behavior and spawning distribution of early-run Kenai River Chinook Salmon. Results from 2014 are not available but in-season analysis indicates they are similar to prior years (Adam Reimer, 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 17 and 27 July 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 during 2012 and 2013 in the Killey River (Gates and Boersma 2013; Gates and Boersma 2014a) and the 12-22 July 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 29 June to 12 July between 2006 and 2014 (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b, 2011; Boersma and Gates 2012, 2013, 2014; Gates and Boersma 2014b). 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 1 and 28 July 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 have 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).

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 and Russian River) will be used in a stock-specific abundance and run timing (SSART) model developed by the Department. The model will produce an independent abundance estimate of Kenai River Chinook Salmon which will be used to investigate bias associated with the Department's abundance estimates developed using DIDSON™. This report does not address the Department's objectives or their SSART model.

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).

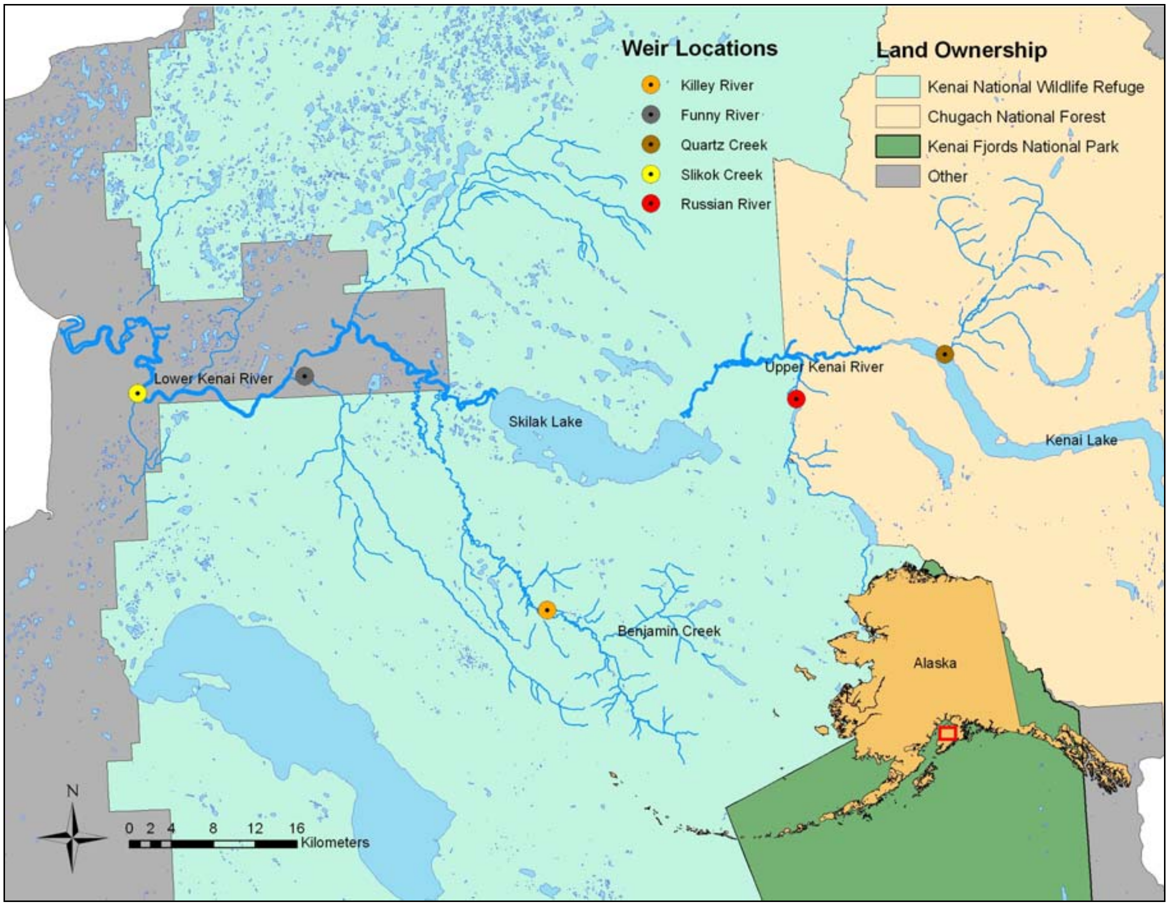

FIGURE 1. —Map of the Kenai River illustrating present and past fish weir locations contributing Chinook Salmon escapement data to a stock-specific abundance and run timing model.

Methods

Weir and Video Operations and Design

A resistance board weir and underwater video system was operated in the Killey River from 24 May to 4 August and in Quartz Creek from 16 May to 18 August 2014. 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 pass fish through a passage 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 divided into four temporal strata and was scaled in real time to consistently sample 10 to 20 percent of the run from one stratum to the next. Samples were collected between 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:

$$\hat{A}_{hij} = N_h \hat{P}_{hij} \quad (1)$$

and

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

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:

$$\hat{A}_{ij} = \sum_h \hat{A}_{hij} \quad (3)$$

and

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

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 10 and 15 May and 23 and 29 April, 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 24 May (Killey River) and 16 May (Quartz Creek). Although high water submerged portions of the Killey River weir from 11 to 12 July, fish passage was monitored with the underwater video system without interruption. Passage of fish overtop of the weir was possible during this time, but was not estimated.

Biological Data

Killey River —A total of 1,713 Chinook Salmon were observed passing through the video system and live trap at the Killey River weir between 18 June and 4 August (Figure 2;

Appendices 2 and 4). Peak weekly passage (*n* = 629) occurred between 13 and 19 July. The highest daily count (*n* = 117) and median cumulative passage occurred on 13 July (Appendix 2).

Age, sex, and length samples were collected from 556 Chinook Salmon between 18 June and 1 August. Ten percent (*n*=53) 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 (80%) and 1.4 (20%). Male Chinook Salmon were comprised of four age groups, ages 1.1 (5%), 1.2 (54%), 1.3 (38%), and 1.4 (3%; Tables 1 and 2). Age-1.2 males comprised 42% of the total run (Table 2). Overall, the ASL sample was comprised of 22% (*n*=112) females averaging 833 mm in length (MEF; Tables 1 and 2). Male MEF lengths averaged 656 mm. Combined male and female MEF lengths averaged 696 mm and ranged from 260 mm to 1,035 mm (Table 1; Figure 3). Male Chinook Salmon outnumbered females throughout most of the run (Figure 4).

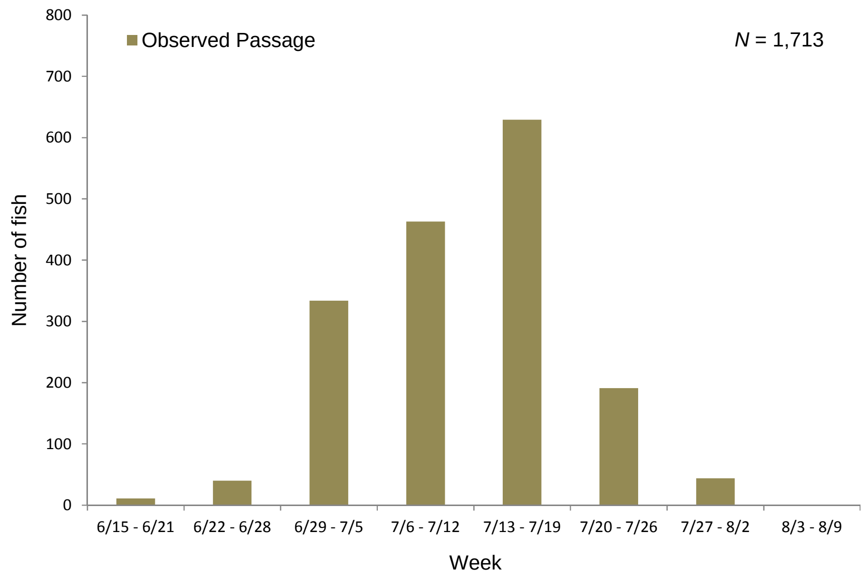

FIGURE 2. —Observed weekly escapement of adult Chinook Salmon passing through the Killey River weir during 2014. Counts began mid-day on 24 May and ended mid-day on 4 August.

TABLE 1. — Length-at-age for adult Chinook Salmon sampled at the Killey River weir during 2014.

				Mid Eye to Tail Fork Length		
	Sex	Age	*n* [a]	Mean	Range	Standard Error
	Female	1.3	90	815	740 - 950	4.0
		1.4	22	904	805 - 990	11.6
Female Total			112	833	740 - 990	5.2
	Male	1.1	21	381	260 - 490	13.0
		1.2	210	579	370 - 785	5.4
		1.3	150	783	580 - 980	6.3
		1.4	10	956	835 - 1,035	20.9
Male Total			391	656	260 - 1,035	7.4
Cumulative Total			503	696	260 - 1,035	6.7

[a] Fish with inconclusive age determinations were omitted from this table (*n*=53)

TABLE 2. —Age and sex composition estimates for Chinook Salmon returning to the Killey River during 2014.

		Brood Year and Age Group				
		2011	2010	2009	2008	
		1.1	1.2	1.3	1.4	Total
Sample period: 18 June to 1 August						
Female:	Number in sample:			90	22	112
	Percent age group			80.4	19.6	100
	Estimated escapement:			306	75	381
	Percent of escapement:			17.9	4.4	22
	Standard error:			12.1	12.1	
Male:	Number in sample:	21	210	150	10	391
	Percent age group:	5.4	53.7	38.4	2.6	100
	Estimated escapement:	72	715	511	34	1,332
	Percent of escapement:	4.2	41.7	29.8	2.0	78
	Standard error:	11.0	22.7	19.8	7.1	
Total:	Number in Sample:	21	210	240	32	503
	Estimated Escapement:	72	715	817	109	1,713
	Percent of escapement:	4.2	41.7	47.7	6.4	100

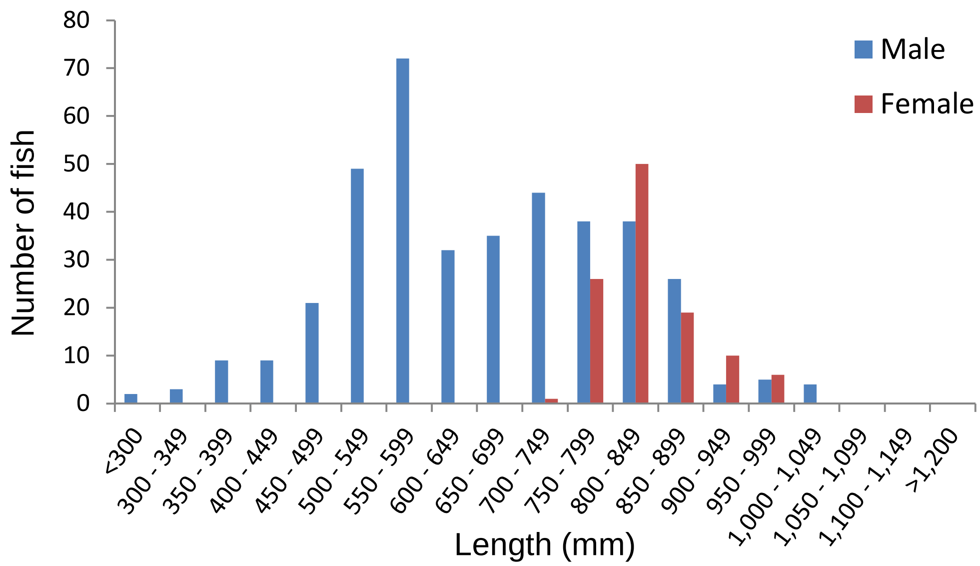

FIGURE 3. —Mid eye to tail fork length frequency distribution of male and female Chinook Salmon sampled at the Killey River during 2014.

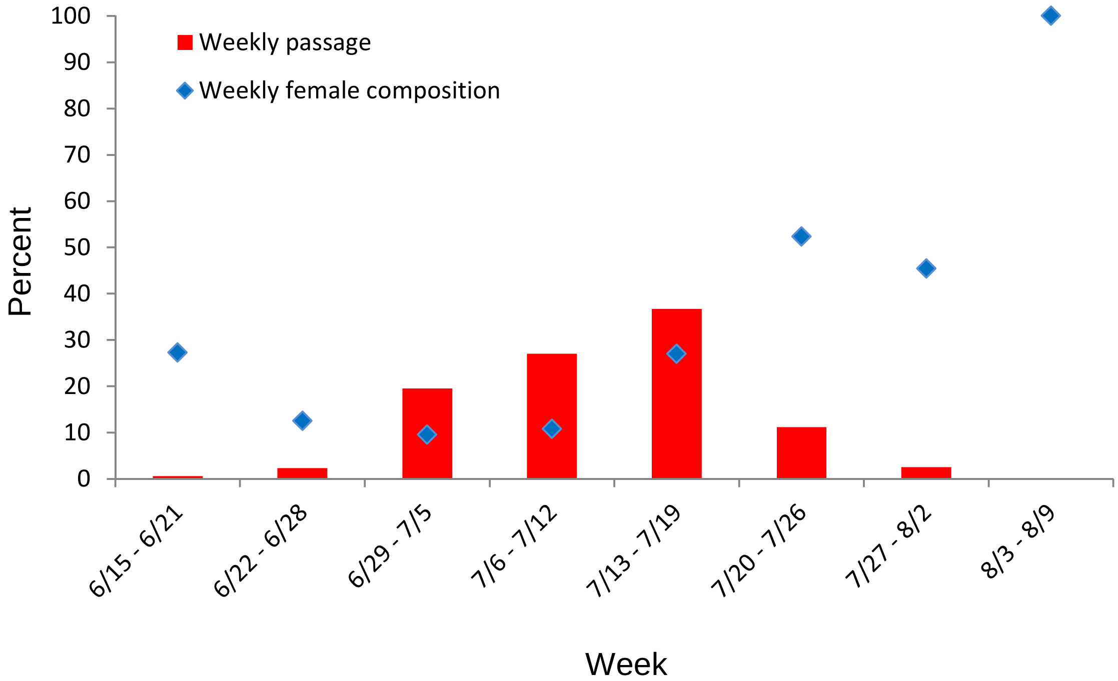

FIGURE 4. —Weekly passage (%) of Chinook Salmon including adult female Chinook Salmon composition (%) observed at the Killey River video weir from 18 June to 1 August, 2014. Passage includes video review and ASL sampling.

Quartz Creek. — A total of 325 Chinook Salmon were observed passing through the video system at the Quartz Creek weir between 19 June and 16 August (Figure 5; Appendices 3 and 5). Peak weekly passage (n = 140) occurred between 20 and 26 July. The highest daily count (n = 77) and median cumulative passage occurred on 21 July (Appendix 3). Females comprised 32% of the Chinook Salmon run, determined exclusively during video review. Male Chinook Salmon outnumbered females throughout the entire run (Figure 6). Other than determining the sex of fish during video review, no attempt was made to collect ASL samples.

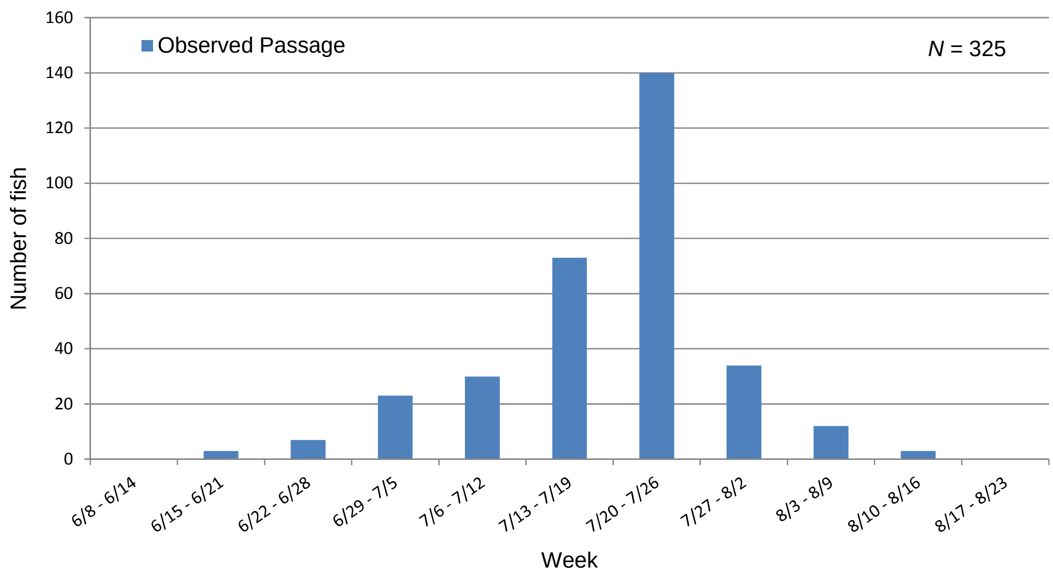

FIGURE 5. —Observed weekly escapement of adult Chinook Salmon passing through the Quartz Creek video weir during 2014. Counts began mid-day on 16 May and ended mid-day on 18 August.

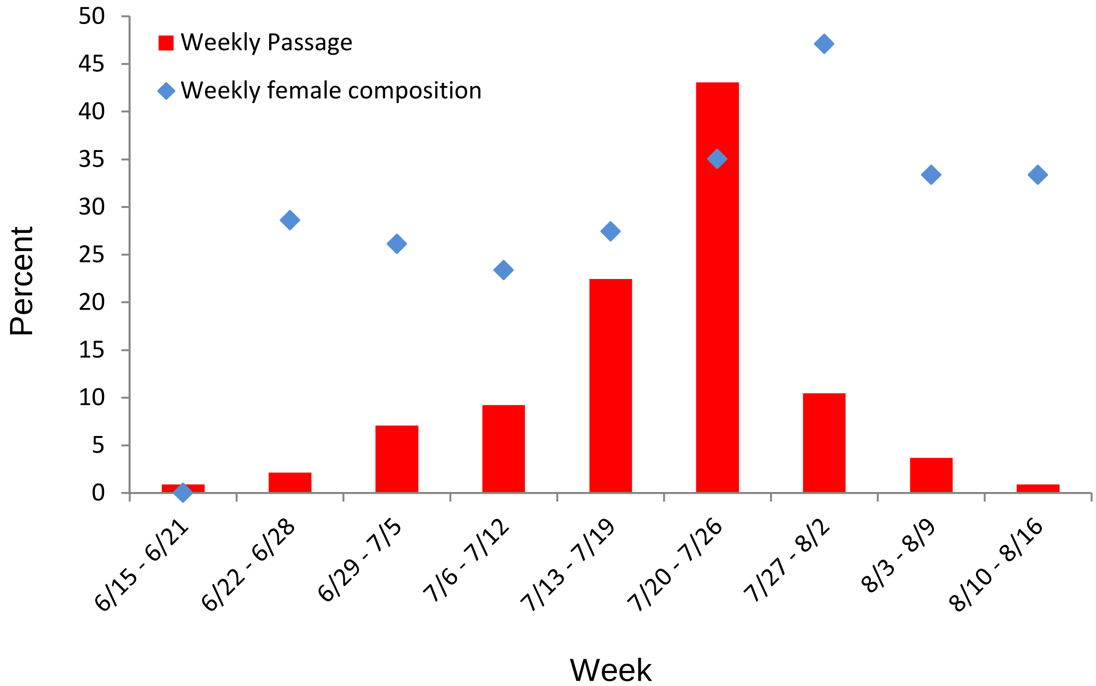

FIGURE 6. —Weekly passage (%) of Chinook Salmon including adult female Chinook Salmon composition (%) observed at the Quartz Creek video weir from 19 June to 16 August, 2014. Passage and sex composition was determined from video records.

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*, Coho Salmon *O. kisutch*, , Chum Salmon *O. keta*, Dolly Varden *Salvelinus malma*, Rainbow Trout *O. mykiss*, Arctic Grayling *Thymallus arcticus*, and Round Whitefish *Prosopium cylindraceum* (Tables 3 and 4).

TABLE 3. —Weekly passage of non-target species passing through the Killey River weir during 2014. Counts were conducted between 24 May and 4 August.

Week	Sockeye Salmon	Pink Salmon	Chum Salmon	Dolly Varden	Rainbow Trout	Arctic Grayling	Round Whitefish
24-May	0	0	0	0	0	1	0
25 - 31 May	2	0	0	13	0	2	0
1 - 7 Jun	3	0	0	40	0	1	4
8 - 14 Jun	5	0	0	34	0	1	0
15 - 21 Jun	64	0	0	48	0	0	0
22 - 28 Jun	41	1	0	53	0	0	2
29 Jun - 5 Jul	120	0	0	92	0	0	0
6 - 12 Jul	74	0	0	58	0	0	0
13 - 19 Jul	176	0	0	250	0	0	0
20 - 26 Jul	22	3	1	218	1	0	1
27 Jul - 2 Aug	2	0	0	68	0	0	3
3 - 4 Aug	0	0	0	11	0	0	0
	509	4	1	885	1	5	10

TABLE 4. —Weekly passage of non-target species passing through the Quartz Creek video weir during 2014. Counts were conducted between 16 May and 18 August.

Week	Sockeye Salmon	Pink Salmon	Coho Salmon	Chum Salmon	Dolly Varden	Rainbow Trout	Arctic Grayling	Round Whitefish
16 -17 May	0	0	0	0	55	19	3	16
18 - 24 May	0	0	0	0	238	36	5	52
25 - 31 May	0	0	0	0	302	55	1	34
1 - 7 Jun	1	0	0	0	282	62	2	49
8 - 14 Jun	1	0	0	0	148	35	3	41
15 - 21 Jun	4	0	0	0	183	73	1	69
22 - 28 Jun	11	0	0	0	144	36	1	13
29 Jun - 5 Jul	32	0	0	0	108	9	0	4
6 - 12 Jul	39	0	0	0	199	12	0	5
13 - 19 Jul	3,946	14	0	1	565	26	0	3
20 - 26 Jul	11,421	42	0	0	977	36	0	6
27 Jul - 2 Aug	14,149	38	1	2	1,673	19	0	5
3 - 9 Aug	13,513	33	14	2	2,724	63	0	0
10 - 16 Aug	6,621	21	65	0	1,852	61	1	0
17 - 18 Aug	443	3	32	0	318	10	0	1
	50,181	151	112	5	9,768	552	17	298

Discussion

The observed passage of Chinook Salmon during 2014 through the Killey River and Quartz Creek video weirs was similar to 2012 and 2013 returns (Gates and Boersma 2013 and 2014a) and represents the run strength and timing of Chinook Salmon returning to the Upper Killey River watershed and the Quartz Creek drainage. High water, caused by a several day rain event, partially submerged the Killey River weir for approximately 41 hours beginning early morning on 11 July and ending midafternoon on 12 July. The river stage height, measured twice daily from a stream gauge located approximately 100 yards upstream of the weir, peaked during the morning of 11 July before quickly dropping over the following two days. A small lag in run timing during this period was observed in the cumulative run distribution (Appendices 2 and 4) indicating that the high water event allowed fish to pass over the weir uncensored or fish migration was interrupted. Radio-telemetry information collected from a fixed receiver station located adjacent to the weir supports the notion that the fish migration was interrupted to some degree. Three radio-tagged Chinook Salmon were identified by the fixed receiver station immediately downstream of the weir when it was submerged (U.S. Fish and Wildlife Service and Alaska Department of Fish and Game, unpublished data). Of these three radio-tagged Chinook Salmon, only one passed the weir during peak flows during the morning of 11 July whereas the other two fish did not migrate past the weir until the afternoon of 12 July once the river level began to rapidly drop. It is widely known that weirs can delay fish migration during normal operations. However, the effects of a floating weir on fish migration is thought to be less during periods when the weir is submerged and fish can pass freely over top of the weir. Because of the uncertainty of fish behavior and our ability to count some 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 ran smoothly throughout the operating season. 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. Daily passage 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 we did not collect ASL samples from Chinook Salmon returning to Quartz Creek, we recommend that this run be sampled 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. The higher ratio of females to males in this population compared to other Kenai River populations supports the visual observations of larger fish.

We feel that the 556 ASL samples of Chinook Salmon at the Killey River weir accurately describe the Chinook Salmon run returning to the Upper Killey River watershed. The sample was 32% of the observed escapement and was collected almost daily throughout the entire Chinook Salmon run. The sample taken during 2014 identified few (6%) age-1.4 Chinook Salmon in the spawning population. Observations of age-1.4 Chinook Salmon at the Killey River weir were similar to what Gates and Boersma (2014b) identified returning to the Funny River during 2014 (i.e., 5.6% age-1.4). The near absence of large and old Chinook Salmon returning to the Kenai River watershed during May and June is a management concern and may warrant additional conservation measures to protect age-1.4 Chinook Salmon returning to the Kenai River during the early 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 in the in-river test net fishery near rkm 13 in the lower Kenai River. We recommend that the Killey River weir operations be extended into 2015 if funding is available because of the recent low abundance and asymmetric length and age distributions of Chinook Salmon returning to the Kenai River. 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 and potential changes to the test netting program). 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 and Andrew Waldo were responsible for the day to day maintenance and project operations including ASL collections at the Killey River weir. Taylor Gregory was responsible for the day to day operations and maintenance of the Quartz Creek weir. Maritime Helicopters and Alaska West Air 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 2014.

Item	Model #	Manufacturer	Contact
Digital Video Recorder	DVSM 4-120	Veltek International, Inc.	http://www.veltekcctv.com/
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 2014. Boxed areas represent the second and third quartile and median passage dates.

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
5/24	0	0	0	0	0.0000
5/25	0	0	0	0	0.0000
5/26	0	0	0	0	0.0000
5/27	0	0	0	0	0.0000
5/28	0	0	0	0	0.0000
5/29	0	0	0	0	0.0000
5/30	0	0	0	0	0.0000
5/31	0	0	0	0	0.0000
6/1	0	0	0	0	0.0000
6/2	0	0	0	0	0.0000
6/3	0	0	0	0	0.0000
6/4	0	0	0	0	0.0000
6/5	0	0	0	0	0.0000
6/6	0	0	0	0	0.0000
6/7	0	0	0	0	0.0000
6/8	0	0	0	0	0.0000
6/9	0	0	0	0	0.0000
6/10	0	0	0	0	0.0000
6/11	0	0	0	0	0.0000
6/12	0	0	0	0	0.0000
6/13	0	0	0	0	0.0000
6/14	0	0	0	0	0.0000
6/15	0	0	0	0	0.0000
6/16	0	0	0	0	0.0000
6/17	0	0	0	0	0.0000
6/18	1	1	2	2	0.0012
6/19	0	0	0	2	0.0012
6/20	4	1	5	7	0.0041
6/21	3	1	4	11	0.0064
6/22	3	0	3	14	0.0082
6/23	6	0	6	20	0.0117
6/24	2	0	2	22	0.0128
6/25	2	0	2	24	0.0140
6/26	5	0	5	29	0.0169
6/27	2	2	4	33	0.0193
6/28	15	3	18	51	0.0298
6/29	18	2	20	71	0.0414
6/30	22	2	24	95	0.0555
7/1	29	1	30	125	0.0730
7/2	44	3	47	172	0.1004
7/3	59	6	65	237	0.1384
7/4	50	9	59	296	0.1728
7/5	80	9	89	385	0.2248

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APPENDIX 2. —(Page 2 of 2)

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
7/6	87	6	93	478	0.2790
7/7	66	15	81	559	0.3263
7/8	84	14	98	657	0.3835
7/9	85	6	91	748	0.4367
7/10	56	6	62	810	0.4729
7/11	17	0	17	827	0.4828
7/12	18	3	21	848	0.4950
7/13	90	27	117	965	0.5633
7/14	85	24	109	1,074	0.6270
7/15	94	24	118	1,192	0.6959
7/16	39	15	54	1,246	0.7274
7/17	44	25	69	1,315	0.7677
7/18	63	36	99	1,414	0.8255
7/19	44	19	63	1,477	0.8622
7/20	22	28	50	1,527	0.8914
7/21	24	22	46	1,573	0.9183
7/22	17	25	42	1,615	0.9428
7/23	3	7	10	1,625	0.9486
7/24	13	7	20	1,645	0.9603
7/25	3	5	8	1,653	0.9650
7/26	9	6	15	1,668	0.9737
7/27	10	12	22	1,690	0.9866
7/28	4	1	5	1,695	0.9895
7/29	2	3	5	1,700	0.9924
7/30	2	2	4	1,704	0.9947
7/31	2	0	2	1,706	0.9959
8/1	4	1	5	1,711	0.9988
8/2	0	1	1	1,712	0.9994
8/3	0	0	0	1,712	0.9994
8/4	0	1	1	1,713	1.0000
Total	1,332	381	1,713		

APPENDIX 3. —Daily passage totals including cumulative and proportional passage of adult Chinook Salmon observed at the Quartz Creek weir during 2014. Boxed areas represent the second and third quartile and median passage dates.

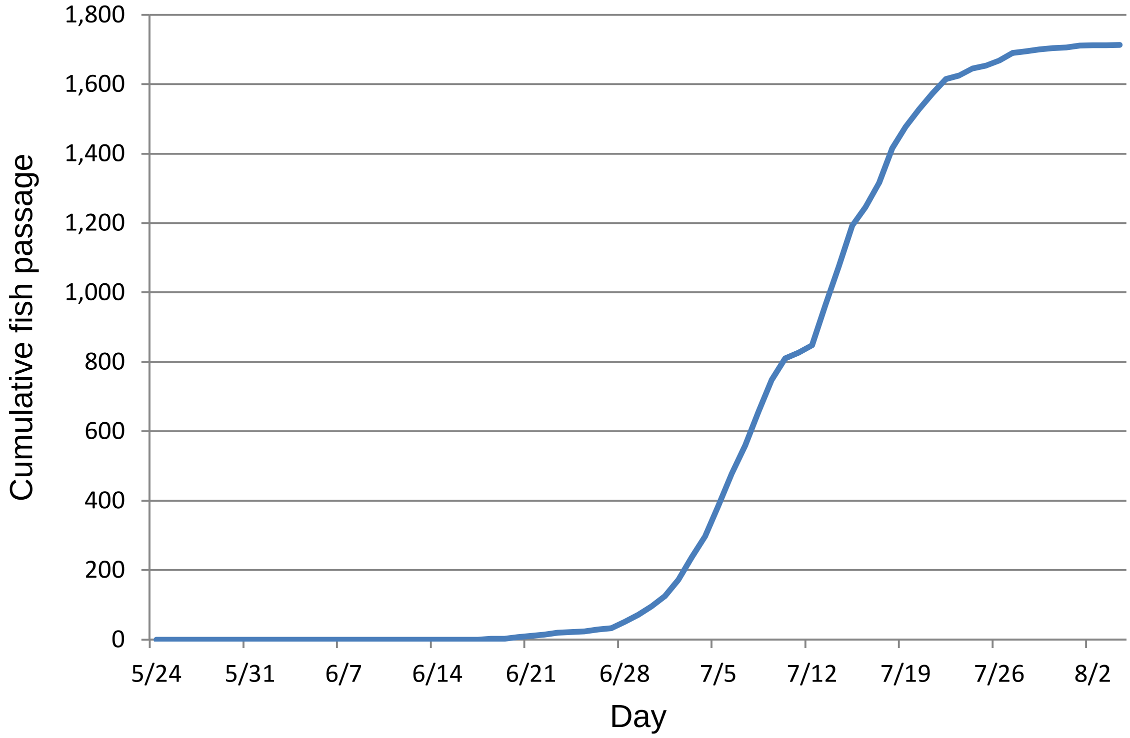
Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
5/16	0	0	0	0	0.0000
5/17	0	0	0	0	0.0000
5/18	0	0	0	0	0.0000
5/19	0	0	0	0	0.0000
5/20	0	0	0	0	0.0000
5/21	0	0	0	0	0.0000
5/22	0	0	0	0	0.0000
5/23	0	0	0	0	0.0000
5/24	0	0	0	0	0.0000
5/25	0	0	0	0	0.0000
5/26	0	0	0	0	0.0000
5/27	0	0	0	0	0.0000
5/28	0	0	0	0	0.0000
5/29	0	0	0	0	0.0000
5/30	0	0	0	0	0.0000
5/31	0	0	0	0	0.0000
6/1	0	0	0	0	0.0000
6/2	0	0	0	0	0.0000
6/3	0	0	0	0	0.0000
6/4	0	0	0	0	0.0000
6/5	0	0	0	0	0.0000
6/6	0	0	0	0	0.0000
6/7	0	0	0	0	0.0000
6/8	0	0	0	0	0.0000
6/9	0	0	0	0	0.0000
6/10	0	0	0	0	0.0000
6/11	0	0	0	0	0.0000
6/12	0	0	0	0	0.0000
6/13	0	0	0	0	0.0000
6/14	0	0	0	0	0.0000
6/15	0	0	0	0	0.0000
6/16	0	0	0	0	0.0000
6/17	0	0	0	0	0.0000
6/18	0	0	0	0	0.0000
6/19	1	0	1	1	0.0031
6/20	0	0	0	1	0.0031
6/21	2	0	2	3	0.0092
6/22	0	1	1	4	0.0123
6/23	0	0	0	4	0.0123
6/24	0	0	0	4	0.0123
6/25	0	0	0	4	0.0123
6/26	2	0	2	6	0.0185
6/27	3	1	4	10	0.0308
6/28	0	0	0	10	0.0308
6/29	0	0	0	10	0.0308
6/30	6	0	6	16	0.0492
7/1	1	0	1	17	0.0523
7/2	6	2	8	25	0.0769

–continued–

APPENDIX 3. —(Page 2 of 2)

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
7/3	0	0	0	25	0.0769
7/4	2	1	3	28	0.0862
7/5	2	3	5	33	0.1015
7/6	1	2	3	36	0.1108
7/7	14	3	17	53	0.1631
7/8	0	0	0	53	0.1631
7/9	1	0	1	54	0.1662
7/10	1	0	1	55	0.1692
7/11	4	1	5	60	0.1846
7/12	2	1	3	63	0.1938
7/13	0	0	0	63	0.1938
7/14	0	0	0	63	0.1938
7/15	4	1	5	68	0.2092
7/16	15	6	21	89	0.2738
7/17	7	3	10	99	0.3046
7/18	12	8	20	119	0.3662
7/19	15	2	17	136	0.4185
7/20	7	0	7	143	0.4400
7/21	46	31	77	220	0.6769
7/22	11	4	15	235	0.7231
7/23	8	6	14	249	0.7662
7/24	7	0	7	256	0.7877
7/25	5	2	7	263	0.8092
7/26	7	6	13	276	0.8492
7/27	2	1	3	279	0.8585
7/28	0	0	0	279	0.8585
7/29	3	5	8	287	0.8831
7/30	6	4	10	297	0.9138
7/31	4	2	6	303	0.9323
8/1	2	3	5	308	0.9477
8/2	1	1	2	310	0.9538
8/3	3	2	5	315	0.9692
8/4	0	1	1	316	0.9723
8/5	2	1	3	319	0.9815
8/6	0	0	0	319	0.9815
8/7	2	0	2	321	0.9877
8/8	0	0	0	321	0.9877
8/9	1	0	1	322	0.9908
8/10	0	0	0	322	0.9908
8/11	0	0	0	322	0.9908
8/12	0	0	0	322	0.9908
8/13	0	1	1	323	0.9938
8/14	0	0	0	323	0.9938
8/15	1	0	1	324	0.9969
8/16	1	0	1	325	1.0000
8/17	0	0	0	325	1.0000
8/18	0	0	0	325	1.0000
Total	220	105	325		

APPENDIX 4. —Cumulative Chinook Salmon passage at the Killey River weir during 2014.



APPENDIX 5. —Cumulative Chinook Salmon passage at the Quartz Creek weir during 2014.