U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Chinook Salmon in the Killey River and Quartz Creek, Kenai Peninsula, Alaska, 2013

Alaska Fisheries Data Series Number 2014-4

Kenai Fish and Wildlife Field Office
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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. To assess current sonar escapement estimates, the Alaska Department of Fish and Game and U.S. Fish and Wildlife Service have initiated a joint project using an independent model to estimate stock-specific abundance and run timing of Chinook salmon using a combination of weirs, radiotelemetry, and harvest information. As part of this joint project, fish weirs equipped with underwater video systems were installed and operated in the Killey River and Quartz Creek between 7 June and 12 August 2013 to estimate abundance and characterize the demographics of adult Chinook salmon. A total of 2,161 Chinook salmon was composed of 1,881 Killey River and 280 Quartz Creek fish. Peak weekly passage of Chinook salmon occurred between 7 and 13 July for both runs. Females comprised 30% of the Chinook salmon escapement at Quartz Creek (video only) and 15% at the Killey River (video and age, sex, and length (ASL) samples). The ASL samples were only collected from Killey River Chinook salmon. The average estimated mid-eye to fork length of male and female Chinook salmon from the Killey River was 607 mm (SE = 64) and 911 mm (SE = 30), respectively. Ages of Killey River Chinook salmon determined from scale analysis ranged between 3 and 7 years. Non-target fish species 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 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™).

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Early-run fish primarily spawn in Kenai River tributaries within the Kenai National Wildlife Refuge (Refuge), whereas late-run fish spawn in the mainstem Kenai River mixed among several different land ownerships. Chinook salmon returning to the Killey River and Quartz Creek are part of the early run. 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 2013). 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 below Skilak Lake during May and June. 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). 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 2012, annual sport harvest of early-run fish ranged from 316 to 15,209 fish and averaged 4,914 fish (Jennings et al. 2010a, 2010b, 2011a, 2011b; McKinley and Fleischman 2010, 2013). No harvest occurred during 2013 because the in-river sport fishery was closed beginning 16 May through 30 June (Alaska Department of Fish and Game 2013). On average, about 72% of the early-run sport harvest occurs downstream of the Soldotna Bridge. Much of the annual variation in harvest since 1986 can be explained by fluctuations in run strength and in-season liberalization or restriction of the sport fishery.

Radiotelemetry studies conducted during the early 1980s, 1990s, and most recently from 2010 to 2013 provide some insight regarding the migratory behavior and spawning distribution of early-run Kenai River Chinook salmon. 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 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. Peak spawning times are thought to 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 in the Killey River (Gates and Boersma 2013) and the 12 to 22 July period that Burger et al. (1985) identified as peak spawning times 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 2011 (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b, 2011; Boersma and Gates 2012).

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 has been documented in the main-stem Kenai River when entry into tributaries is delayed due to extended milling behavior. Burger et al. (1983) identified one 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 below their destination confluence. 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 issue, 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. Because information is limited about run timing of specific tributary populations, 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 need for an independent evaluation of the Department's sonar program and the need for more detailed information on specific spawning populations prompted the development of a cooperative study between the Department and the U.S. Fish and Wildlife Service (Service). The cooperative project 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 populations throughout the Kenai River watershed.

Specific Service objectives of this study 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 are within 10 percentage points of the true values 95% of the time;
3. Estimate the mean length of Chinook salmon in the Killey River by sex and age.

The abundance information collected from the Killey River and Quartz Creek will be used in conjunction with abundance estimates produced from other tributaries with weirs throughout the Kenai River watershed (i.e., Funny River, Slikok Creek, and Russian River) to populate a stock-specific abundance and run timing (SSART) model developed by the Department. The SSART model will produce an independent abundance estimate of Kenai River Chinook salmon, which will be used to investigate bias associated with abundance estimates produced by the Department's DIDSON™. This report pertains to the Service's objectives of the cooperative study, operating video weirs in the main-stem Killey River and Quartz Creek, and does not address methods associated with the Department's objectives or 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 (60.47943°N and 150.61700°W; WGS84) 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 radiotelemetry studies (Burger et al. 1985; Bendock and Alexandersdottir 1991 and 1992; Adam Reimer, Alaska Department of Fish and Game, personal communication). 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 (60.47566°N and 149.72464°W; WGS84) watershed is 102 km^2 and drains into Kenai Lake in the upper Kenai River watershed. The creek is comprised of clear-water and several tributaries that 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).

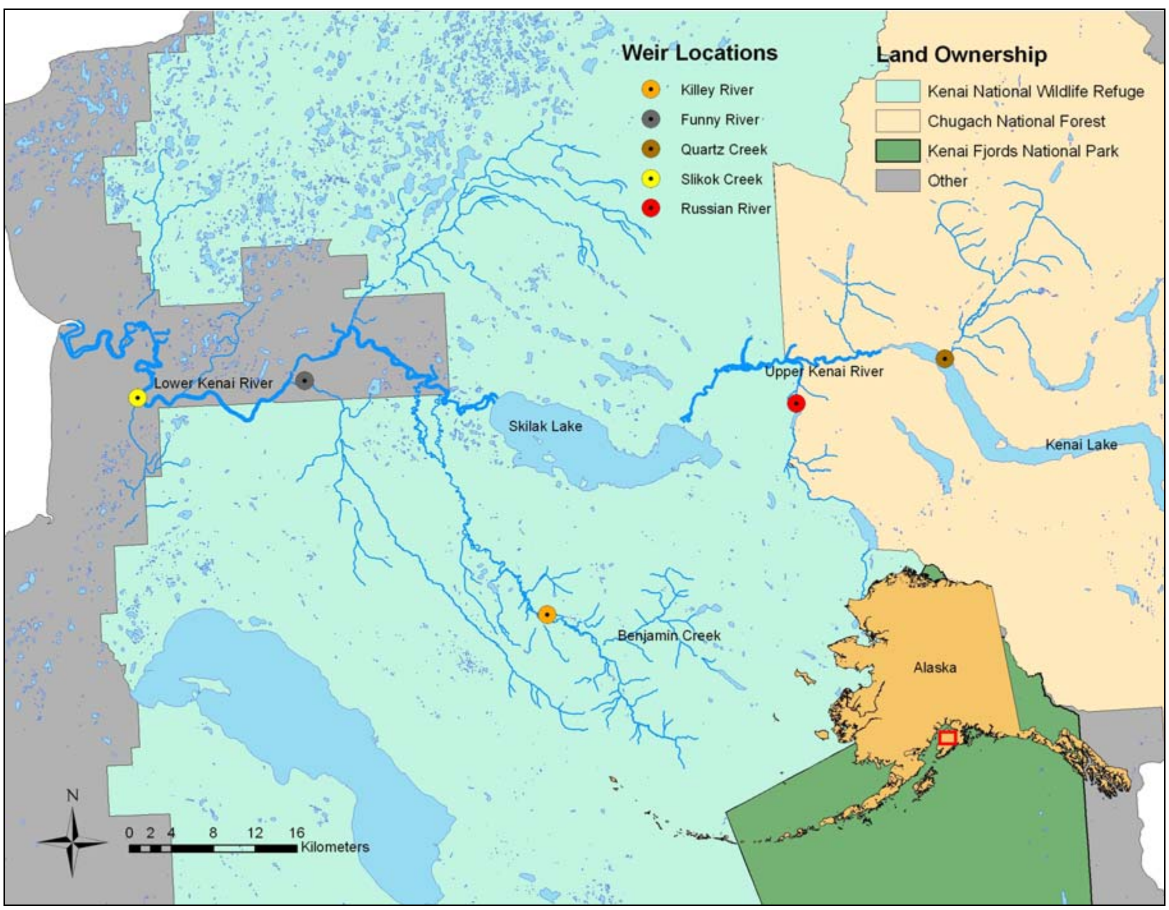

FIGURE 1. —Map of the Kenai River illustrating weir locations.

Methods

Weir and Video Operations and Design

A resistance board weir and underwater video system was operated in the Killey River from 7 June to 6 August and in Quartz Creek from 21 June to 12 August 2013. 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 external 500 gigabyte 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-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.

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. Strata were divided by the date in which each quartile of the fish run passed the weir, 7 June to 8 July, 9 to 11 July, 12 to 14 July, and 15 July to 6 August. 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 fork (MEF) in the tail and from the tip of the nose to the fork in the tail. 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. —Statistics describing the ASL composition for the total escapement of Chinook salmon were estimated directly from the ASL composition in the stratified samples, with the escapement in each stratum as a weight (Cochran 1977). Within a given stratum *m*, the proportion of species *i* passing the weir that are of sex *j* and age *k* (p_{ijkm}) was estimated as

$$\hat{p}_{ijkm} = \frac{n_{ijkm}}{n_{i++m}}, \tag{1}$$

where n_{ijkm} denotes the number of fish of species *i*, sex *j*, and age *k* sampled in stratum *m* and a subscript of "+" represents summation over all possible values of the corresponding variable, e.g., n_{i++m} denotes the total number of fish of species *i* sampled in stratum *m*. The variance was estimated as

$$\hat{v}\left(\hat{p}_{ijkm}\right) = \left(1 - \frac{n_{i++m}}{N_{i++m}}\right) \frac{\hat{p}_{ijkm}\left(1 - \hat{p}_{ijkm}\right)}{n_{i++m} - 1}, \tag{2}$$

where N_{i++m} denotes the total number of species *i* fish passing the weir in stratum *m*. The estimated number of fish of species *i*, sex *j*, age *k* passing the weir in stratum *m* (N_{ijkm}) is

$$\hat{N}_{ijkm} = N_{i++m}\,\hat{p}_{ijkm}, \tag{3}$$

with estimated variance:

$$\hat{v}\left(\hat{N}_{ijkm}\right) = N_{i++m}^{2}\,\hat{v}\left(\hat{p}_{ijkm}\right). \tag{4}$$

Estimates of proportions for the entire period of weir operation were computed as weighted sums of the stratum estimates, i.e.,

$$\hat{p}_{ijk} \quad = \quad \sum_m \left(\frac{N_{i++m}}{N_{i+++}} \right) \hat{p}_{ijkm} \, , \tag{5}$$

with estimated variance:

$$\hat{v}\left(\hat{p}_{ijk}\right) \quad = \quad \sum_m \left(\frac{N_{i++m}}{N_{i+++}} \right)^2 \hat{v}\left(\hat{p}_{ijkm}\right). \tag{6}$$

The total number of fish in a species, sex, and age category passing the weir in the entire period of operation was estimated as

$$\hat{N}_{ijk} \quad = \quad \sum_m \hat{N}_{ijkm} \, , \tag{7}$$

with estimated variance:

$$\hat{v}\left(\hat{N}_{ijk}\right) \quad = \quad \sum_m \hat{v}\left(\hat{N}_{ijkm}\right). \tag{8}$$

If the length of the r^th^ fish of species *i*, sex *j*, and age *k* sampled in stratum *m* is denoted x_{ijkmr}, the mean length of all such fish (μ_{ijkm}) was estimated as

$$\hat{\mu}_{ijkm} \quad = \quad \left(\frac{1}{n_{ijkm}} \right) \sum_r x_{ijkmr} \, , \tag{9}$$

with corresponding variance estimator:

$$\hat{v}\left(\hat{\mu}_{ijkm}\right) \quad = \quad \left(1 - \frac{n_{ijkm}}{\hat{N}_{ijkm}} \right) \frac{\sum_r \left(x_{ijkmr} - \hat{\mu}_{ijkm} \right)^2}{n_{ijkm}\left(n_{ijkm} - 1\right)} \, . \tag{10}$$

The mean length of all fish by species *i*, sex *j*, and age *k* (μ_{ijk}) was estimated as a weighted sum of the stratum means, i.e.,

$$\hat{\mu}_{ijk} \quad = \quad \sum_m \left(\frac{\hat{N}_{ijkm}}{\hat{N}_{ijk}} \right) \hat{\mu}_{ijkm} \, . \tag{11}$$

An approximate estimator of the variance of $\hat{\mu}_{ijk}$ was obtained using the delta method (Seber 1982):

$$\hat{v}\left(\hat{\mu}_{ijk}\right) = \sum_{m}\left\{\hat{v}\left(\hat{N}_{ijkm}\right)\left[\frac{\hat{\mu}_{ijkm}}{\sum_{x}\hat{N}_{ijkx}} - \sum_{y}\frac{\hat{N}_{ijky}\,\hat{\mu}_{ijky}}{\left(\sum_{x}\hat{N}_{ijkx}\right)^{2}}\right]^{2} + \left(\frac{\hat{N}_{ijkm}}{\sum_{x}\hat{N}_{ijkx}}\right)^{2}\hat{v}\left(\hat{\mu}_{ijkm}\right)\right\}. \quad (12)$$

To characterize the relative length frequency of the population, length-at-age distributions were sampled repeatedly in proportion to their estimated weights using the “rnorm” function of R version 2.15.1 (RDCT 2013). To do this we assumed that fish of a given sex and age were described by a normal distribution based on the mean length and SD estimated by the stratified samples.

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 at later dates just prior to each weir becoming fully operational on 7 June (Killey River) and 21 June (Quartz Creek). High water submerged portions of the Killey River weir from approximately 10 - 27 June. Passage was not estimated for this time period because few fish likely passed the weir uncensored based on prior year estimates and movement information determined from radio tagged Chinook salmon.

Biological Data

Killey River —A total of 1,881 Chinook salmon were observed passing through the video system and live trap at the Killey River weir between 16 June and 6 August (Figure 2; Appendix 2). Peak weekly passage (n = 955) occurred between 7 and 13 July. The highest daily count (n = 197) occurred on 10 July and the median cumulative passage occurred on 11 July.

We collected ASL samples from 661 Chinook salmon between 5 and 30 July. Forty-five samples (7%) were excluded from the analysis because of incomplete ASL data from regenerated scale samples (n = 39) or the inability to determine freshwater age (n = 6). Of the aged scales, female Chinook salmon were comprised of two age groups, ages 1.3 (48%) and 1.4 (52%) (Table 1; Figure 3). Males were comprised of five age groups, ages 1.1 (4%), 1.2 (81%), 1.3 (11%), 1.4 (4%), and 1.5 (0.1%) (Table 1; Figure 3). Relative frequencies of MEF length appear to be normally distributed for the estimated Chinook salmon passage at the weir. Overall, females averaged 911 mm MEF length and accounted for 14% (n = 88) of the sample (Table 1). Males averaged 607 mm MEF length. Analysis of age and length samples by stratum using 95% confidence intervals (CI) indicated that larger male Chinook salmon passed the weir during stratum one, whereas size and age of females did not differ among strata (Figure 4; Appendix 2). Male Chinook salmon were observed in greater numbers than females throughout the entire return (Figure 5).

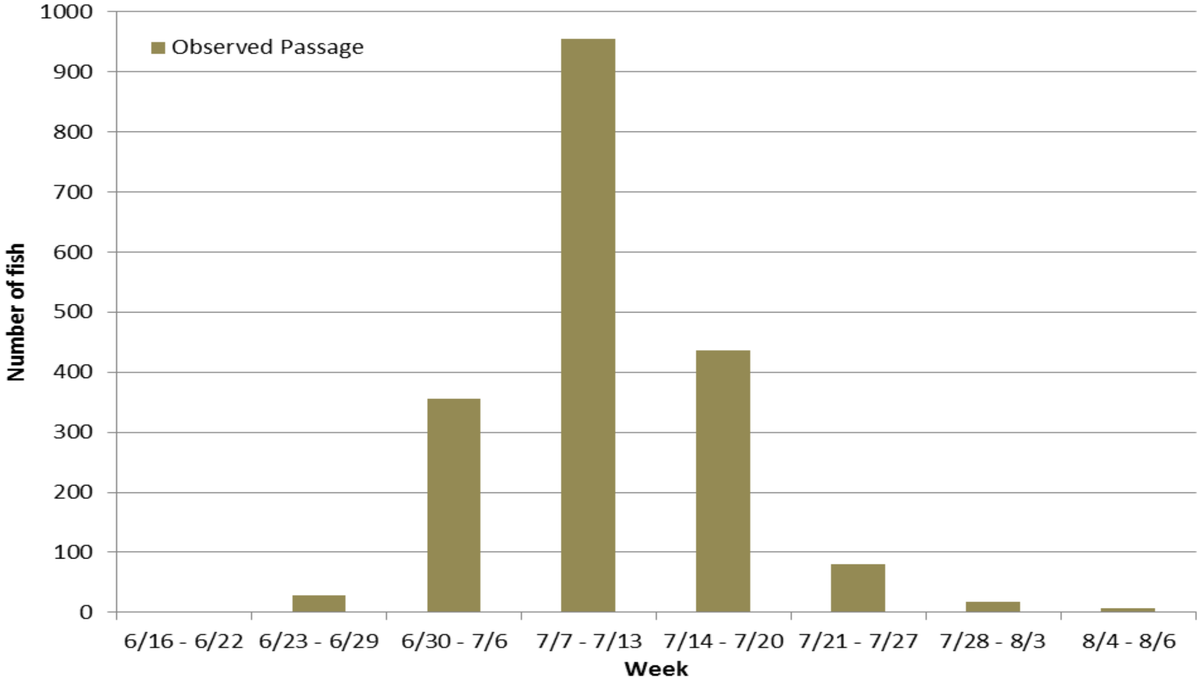

FIGURE 2. —Observed weekly escapement of adult Chinook salmon passing through the Killey River weir during 2013. Counts began mid-day on 7 June and ended mid-day on 6 August.

TABLE 1. —Estimated length-at-age and escapement of adult Chinook salmon sampled at the Killey River weir during 2013.

	Sex	Age	Sample size (*n*)[a]	Estimated Escapement[b] *N*	Estimated Escapement[b] SE	Mid-Eye to Fork Length (mm) $\hat{\mu}$	Mid-Eye to Fork Length (mm) SE	Mid-Eye to Fork Length (mm) Range
	Female	1.3	42	127	16	878	28	770 - 1,000
		1.4	46	142	16	942	23	815 - 1,025
Female Total			88	269	22	911	30	770 - 1,025
	Male	1.1	21	66	11	407	25	275 - 500
		1.2	426	1,299	29	571	25	430 - 730
		1.3	60	184	18	792	36	640 - 985
		1.4	20	59	11	1,010	29	875 - 1,110
		1.5	1	3	3	1,050	N/A	N/A
Male Total			528	1,612	22	607	64	275 - 1,110
Cumulative Total			616	1,881		650	82	275 - 1,110

[a] Fish with incomplete age, sex, and length data were omitted from this analysis (*n*=45).

[b] Rounding error may affect totals

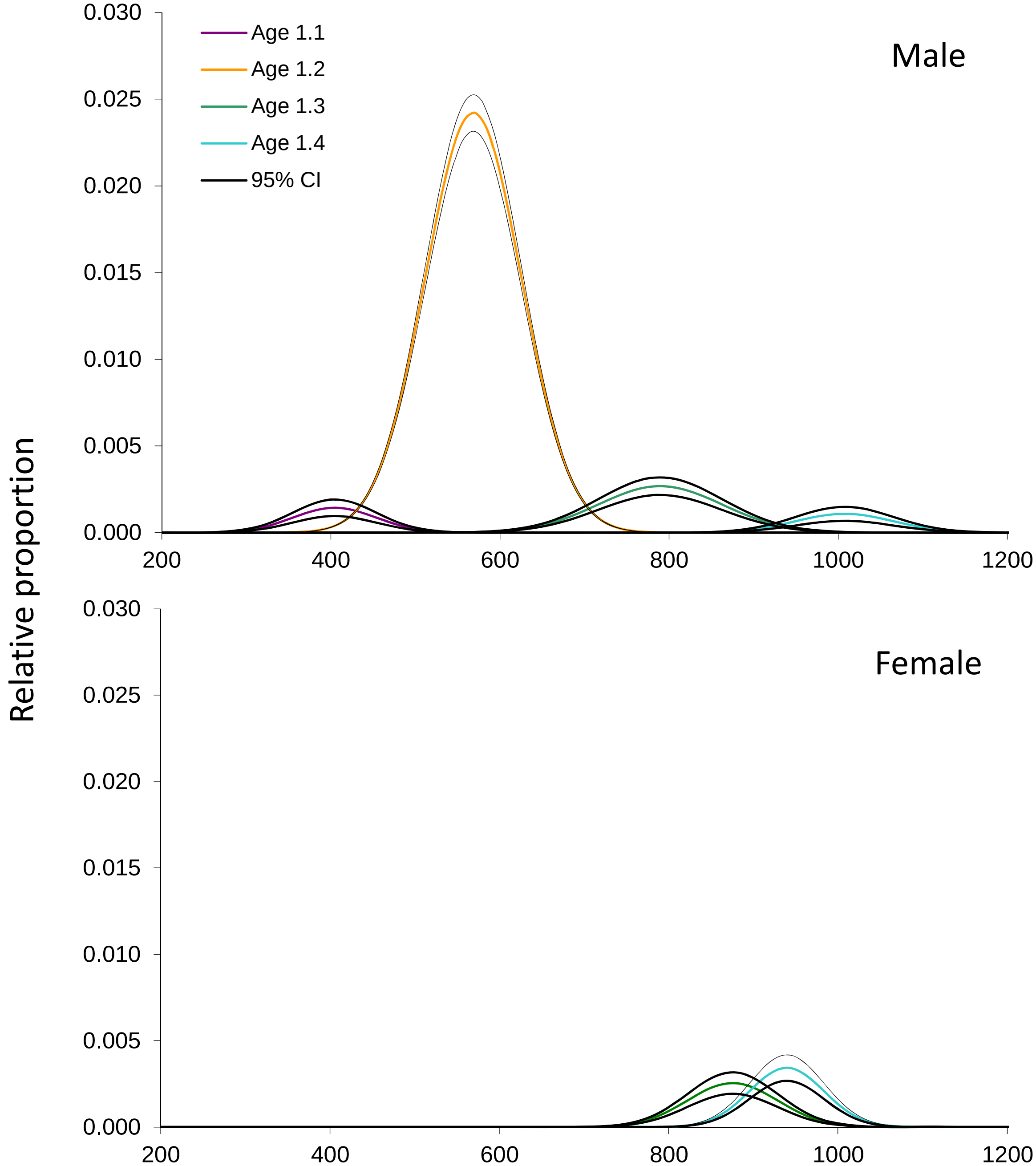

FIGURE 3. —Estimated relative proportion of mid-eye to fork length at age of adult male and female Chinook salmon passing through the Killey River weir during 2013. The area under the curve represents the cumulative proportion for each individual age group. The estimated escapement of age 1.5 Chinook salmon was three fish and therefore was excluded from this analysis.

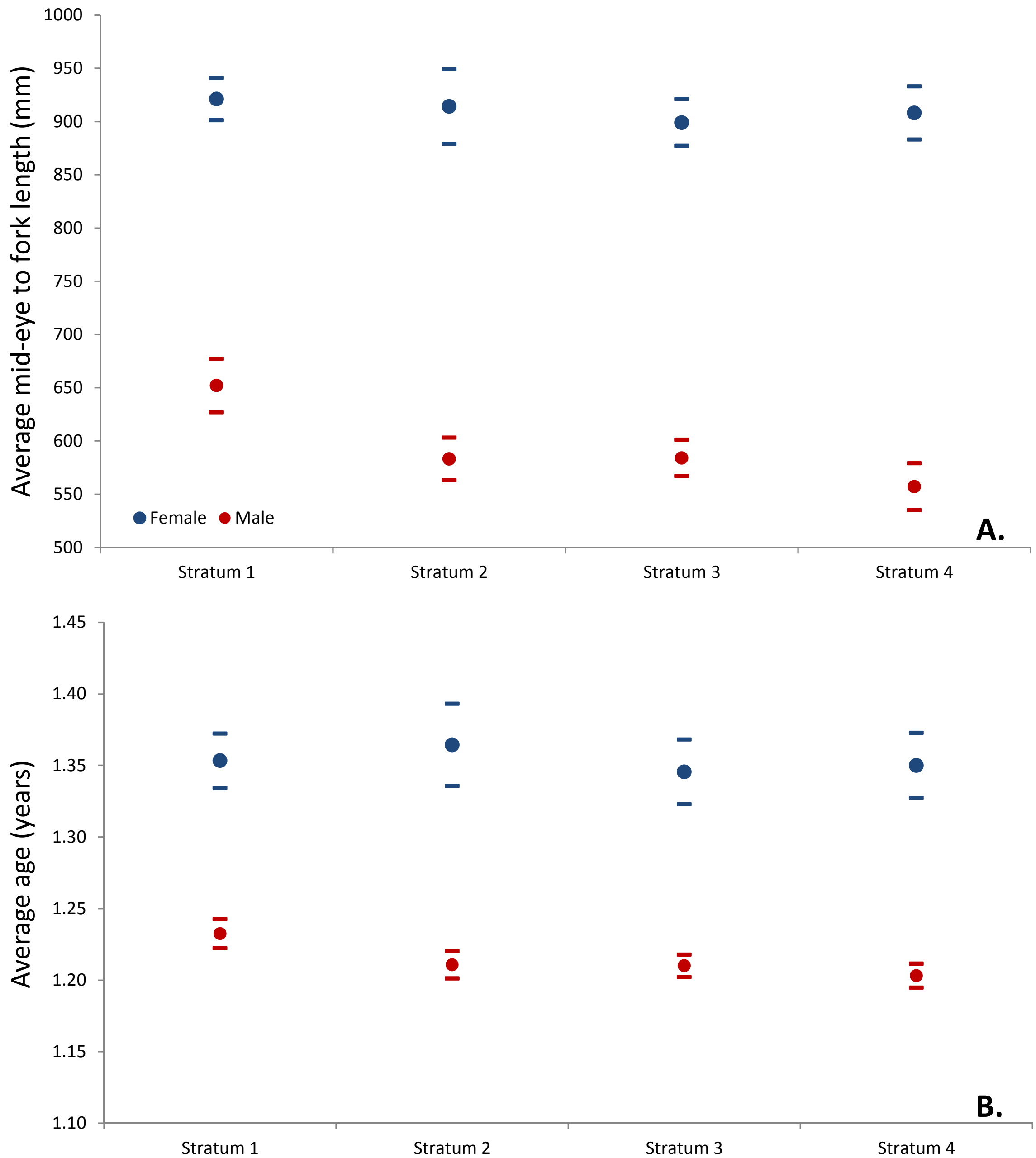

FIGURE 4. —Average mid-eye to fork length represented in (A) and average age represented in (B) including 95% confidence intervals by stratum for female and male adult Chinook salmon passing through the Killey River weir during 2013.

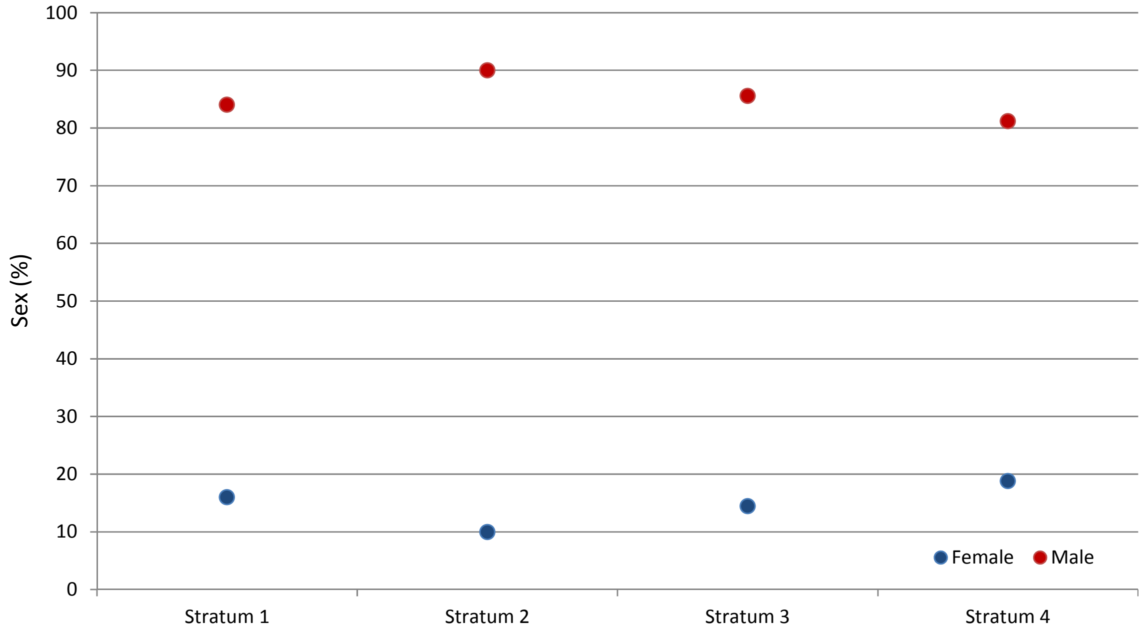

FIGURE 5. — Combined sex composition (%) by stratum estimated from age, sex, and length samples and from recorded video footage for Chinook salmon observed at the Killey River weir from 7 June to 6 August 2013.

Quartz Creek —A total of 280 Chinook salmon were observed passing through the video system at the Quartz Creek weir between 21 June and 12 August (Figure 6). Peak weekly passage (n = 75) occurred between 7 and 13 July. The highest daily count (n = 28) and median cumulative passage occurred on 18 July. Seventy-four Chinook salmon were observed during this week (14-20 July). Females comprised 30% of the Chinook salmon return, determined exclusively during video review. Other than sex determined during video review, no attempt was made to sample fish for ASL.

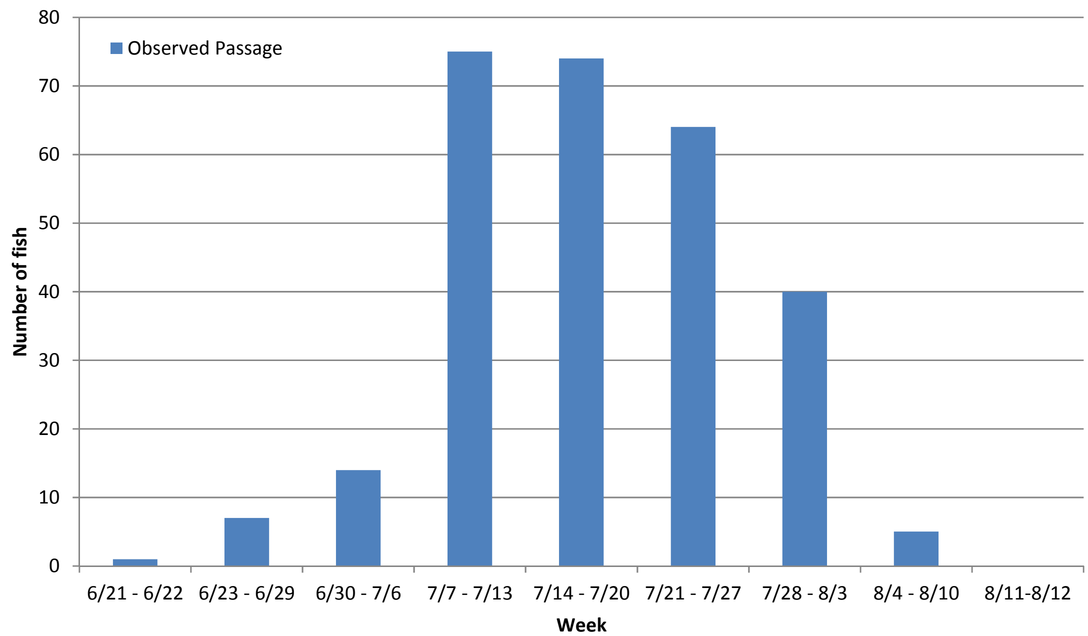

FIGURE 6. —Observed weekly escapement of adult Chinook salmon passing through the Quartz Creek video weir during 2013. Counts began mid-day on 21 June and ended mid-day on 12 August.

Other species. **—**Species other than Chinook salmon passing through the Killey River and Quartz Creek video weirs included sockeye salmon *O. nerka*, coho salmon *O. kisutch*, pink salmon *O. gorbuscha*, chum salmon *O. keta*, Dolly Varden *Salvelinus malma*, Arctic grayling *Thymallus arcticus*, round whitefish *Prosopium cylindraceum*, and rainbow trout *O. mykiss*, (Table 2).

TABLE 2. —Weekly passage of non-target species passing through the Killey River and Quartz Creek video weirs during 2013. Counts were conducted between 7 June and 6 August for the Killey River and from 21 June to 12 August in Quartz Creek.

	Killey River							
Week	Sockeye salmon	Pink salmon	Coho salmon	Chum salmon	Dolly Varden	Rainbow trout	Arctic grayling	Round whitefish
7 - 8 Jun	0	0	–	–	1	0	1	0
9 - 15 Jun	3	0	–	–	9	1	3	1
16 - 22 Jun	2	0	–	–	7	0	0	0
23 - 29 Jun	12	0	–	–	32	0	1	0
30 Jun - 6 Jul	129	0	–	–	111	0	0	2
7 - 13 Jul	132	1	–	–	92	0	0	0
14 - 20 Jul	86	9	–	–	82	0	0	1
21 - 27 Jul	0	3	–	–	51	0	0	0
28 Jul - 3 Aug	1	0	–	–	31	0	0	1
4 - 6 Aug	0	0	–	–	11	0	0	0
	365	13	0	0	427	1	5	5

	Quartz Creek							
Week	Sockeye salmon	Pink salmon	Coho salmon	Chum salmon	Dolly Varden	Rainbow trout	Arctic grayling	Round whitefish
21 - 22 Jun	0	0	0	0	10	2	1	0
23 - 29 Jun	2	0	0	0	33	11	1	0
30 Jun - 6 Jul	0	0	0	0	28	1	0	0
7 - 13 Jul	90	2	0	0	258	6	0	2
14 - 20 Jul	2,347	14	0	1	262	1	0	0
21 - 27 Jul	4,152	12	2	0	221	0	0	0
28 Jul - 3 Aug	11,064	62	11	0	539	11	1	1
4 - 10 Aug	11,015	20	66	0	305	13	2	1
11 - 12 Aug	911	3	26	0	46	0	0	0
	29,581	113	105	1	1,702	45	5	4

Discussion

The observed passage of Chinook salmon during 2013 through the Killey River and Quartz Creek video weirs accurately represents the run strength and timing of Chinook salmon returning to the Upper Killey River watershed above 60.280795°N and -150.440011°W (WGS 84) and the Quartz Creek drainage. High water, caused by above average air temperatures and sudden snow melt early in the season, submerged the Killey River weir during two weeks in June. This potentially affected the fish counts early in the season. However, examination of the run timing distribution data (e.g., historical and current weir and radio telemetry data) indicated that any estimates of passage would likely be exceedingly small. The Quartz Creek weir experienced similar high water and as a result we did not initiate counts until 21 June, after the water began to subside. We suspect few, if any, Chinook salmon passed uncensored even though the weekly observed passage appears truncated early in the season. We attribute the truncation to the small overall return in which a modest daily passage can affect the distribution. Daily Chinook salmon passage in Quartz Creek was sporadic and often times experienced several 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 accumulation of fish numbers in the lower creek and Kenai Lake.

Our ASL sample of 661 Chinook salmon from the Upper Killey River is the largest individual sample taken to date from a single spawning population of Chinook salmon in the Kenai River watershed. The sample was 35% of the observed escapement and was collected almost daily throughout the entire salmon run. When analyzing the estimated MEF length information, we assumed that Chinook salmon of a given sex and age were normally distributed within the population (Table 1; Figure 3). The modeled length distribution reported as relative proportion of MEF length (Figure 3) supported the assumption of normality and also the assumption that the collected sample was representative of predicted lengths. The quality of the ASL sample collected during 2013 and ability to identify the sex of all Chinook salmon using video has allowed us to accurately describe the spawning population of Chinook salmon in the Upper Killey River watershed.

This study will be used in conjunction with abundance estimates obtained from other weir projects throughout the Kenai River watershed to populate the Department’s SSART model. To facilitate the success of the SSART model, the Service plans to operate the Killey River and Quartz Creek weirs during 2014 to complete its obligation identified in the cooperative agreement.

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 will be instrumental in validating the ASL samples collected by the Department for the in-river test net fishery near rkm 13 in the lower Kenai River. Using the two DIDSON™ based estimates of 2,037 (rkm 13) and 2,366 (rkm 21) (Alaska Department of Fish and Game 2013), over 80% to 92% of the estimated early-run escapement migrated past the Killey River weir during 2013. We recognize that a contribution of 80% and 92% is likely inaccurate because the combined Chinook salmon count from just two of several spawning groups, the Killey River and Quartz Creek, exceeded or nearly exceeded the DIDSON™ estimates during 2013. It is recommended that the Killey River weir be extended beyond 2014 if funding is available. This would provide a more accurate assessment of abundance and ASL compositions because of the recent low abundance and asymmetric length and age distributions of Chinook salmon returning to the Kenai River watershed and 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 for future studies to monitor trends in abundance and ASL data for Chinook salmon returning to the Kenai and Killey rivers. For now, we do not recommend monitoring at the Quartz Creek weir beyond 2014.

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APPENDIX 1. —List of video equipment used to monitor adult Chinook salmon on Killey River and Quartz Creek during 2013.

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. —Age compositions and estimated escapement of Chinook salmon in the Killey River during 2013.

Stratum One (6/16 - 7/8)			Estimated Escapment[e]		Mid-Eye to Fork Length (mm)		
Sex	Age	Sample size (n)[a]	N	SE	$\hat{\mu}$	SE	Range
Female	1.3	14	42	9	888	16	795 - 1000
	1.4	16	48	9	949	9	880 - 1010
Female Total		30	89	12	921	10	795 - 1010
Male	1.1	1	3	2	500		500 - 500
	1.2	117	348	16	573	5	440 - 730
	1.3	27	80	12	828	13	735 - 985
	1.4	11	33	8	1039	13	970 - 1,110
	1.5	1	3	2	1050	N/A	1050 - 1,050
Male Total		157	467	12	652	13	440 - 1,110
Cumulative Total		187	556	N/A	695	13	500 - 1,110

Stratum Two (7/9 - 7/11)			Estimated Escapment[e]		Mid-Eye to Fork Length (mm)		
Sex	Age	Sample size (n)[b]	N	SE	$\hat{\mu}$	SE	Range
Female	1.3	5	17	6	856	15	810 - 900
	1.4	9	31	8	947	19	830 - 1,025
Female Total		14	48	10	914	18	810 - 1,025
Male	1.1	8	28	8	419	9	385 - 460
	1.2	96	332	16	558	6	440 - 660
	1.3	15	52	11	747	17	640 - 875
	1.4	3	10	5	982	26	935 - 1,025
Male Total		122	423	10	583	10	385 - 1,025
Cumulative Total		136	471	N/A	617	13	385 - 1,025

Stratum Three (7/12 - 7/14)			Estimated Escapment[e]		Mid-Eye to Fork Length (mm)		
Sex	Age	Sample size (n)[c]	N	SE	$\hat{\mu}$	SE	Range
Female	1.3	12	31	7	876	16	800 - 960
	1.4	10	26	6	927	11	885 - 1,005
Female Total		22	57	9	899	11	800 - 1,005
Male	1.1	6	16	5	405	13	375 - 450
	1.2	129	336	12	605	485	525 - 600
	1.3	11	29	7	752	20	665 - 870
	1.4	5	13	5	961	31	875 - 1,060
Male Total		151	393	9	584	9	375 - 1,060
Cumulative Total		173	450	N/A	624	11	375 - 1,060

Stratum Four (7/15 - 8/06)			Estimated Escapment[e]		Mid-Eye to Fork Length (mm)		
Sex	Age	Sample size (n)[d]	N	SE	$\hat{\mu}$	SE	Range
Female	1.3	11	37	9	877	15	770 - 925
	1.4	11	37	9	938	15	815 - 1000
Female Total		22	74	12	908	12	770 - 1000
Male	1.1	6	20	7	377	28	275 - 455
	1.2	84	283	14	544	6	430 - 675
	1.3	7	24	7	813	12	770 - 870
	1.4	1	3	3	995		995 - 995
Male Total		98	330	12	557	11	275 - 995
Cumulative Total		120	404	N/A	621	16	275 - 995

[a] Fish with incomplete age, sex, and length data were omitted from this analysis (n=12)
[b] Fish with incomplete age, sex, and length data were omitted from this analysis (n=10)
[c] Fish with incomplete age, sex, and length data were omitted from this analysis (n=13)
[d] Fish with incomplete age, sex, and length data were omitted from this analysis (n=10)
[e] Rounding errors may affect totals