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Abundance and Run Timing of Adult Chinook Salmon and Steelhead in the Funny River, Kenai Peninsula, Alaska, 2012

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James K. Boersma and Kenneth S. Gates

Abstract

A fish weir equipped with an underwater video system was installed and operated in the Funny River between 30 April and 6 August 2012 to collect abundance, run timing, and biological information on adult Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss* (anadromous rainbow trout). The total number of Chinook salmon and steelhead counted passing the weir was 879 and 54, respectively. Non-target species enumerated included 269 Dolly Varden *Salvelinus malma*, 20 rainbow trout, 13 pink salmon *O. gorbuscha*, 11 sockeye salmon *O. nerka*, 9 lamprey *Lampetra* spp., 8 round whitefish *Prosopium cylindraceum*, and 1 coho salmon *O. kisutch*. Peak weekly passage occurred between 17 and 23 June for Chinook salmon and 29 April and 5 May for steelhead. Age, sex, and length information was collected from 181 Chinook salmon and 17 steelhead. Sex of both species was also determined by examining recorded video images. Females comprised 32% of the Chinook salmon escapement and 59% of the steelhead escapement. The average length from mid eye to tail fork of Chinook salmon sampled was 587 mm for males and 784 mm for females. Ages of Chinook salmon determined from scale analysis ranged from 3 to 6 years. Lengths from mid eye to tail fork of steelhead averaged 534 mm for males and 598 mm for females.

Introduction

The Kenai River supports one of the largest recreational fisheries for Chinook salmon *Oncorhynchus tshawytscha* in Alaska (Nelson et al. 1999), with an annual in-river sport fishery effort in excess of 250,000 fishing hours (Eskelin 2010). Abundance indices indicate that the number of adult Chinook salmon returning to the Kenai River in 2012 was the lowest on record compelling unprecedented in-season management actions that restricted commercial, sport and personal use fisheries (Alaska Department of Fish and Game 2012a, 2012b, 2012c, 2012d). The recent declines in productivity and abundance have highlighted the need for continued intensive management and research programs focusing on Kenai River Chinook salmon stocks.

Several radiotelemetry studies and in-river abundance estimates have identified differential run times and spawning distributions for Chinook salmon returning to the Kenai River. Indices of run strength for Chinook salmon entry times into the Kenai River indicate a bimodal distribution with the early component of the run peaking between 8 and 20 June and a later component peaking between 17 and 25 July (Hammarstrom and Larson 1986; Conrad and Larson 1987; Conrad 1988; Carlon and Alexandersdottir 1989; Alexandersdottir and Marsh 1990; Miller et al. 2011). The majority of Chinook salmon returning to the Kenai River during May and June are referred to as “early-run” fish and spawn primarily in tributaries during late July and early August (Burger et al. 1983, 1985). Most early-run fish spawn in two Kenai River tributaries, the

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Killey and Funny rivers. Bendock and Alexandersdottir (1991, 1992) found that most radio-tagged early-run fish spawned in the Killey (42% to 64%) and Funny (20% to 21%) rivers while 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% spawned in the Killey River, 18% in the Funny River, 18% in the mainstem, and 5% in other Kenai River tributaries between 1980 and 1982. Chinook salmon entering during July and August are considered "late-run" fish and almost exclusively spawn during August in the mainstem Kenai River (Burger et al.1985; Bendock and Alexandersdottir 1991, 1992). The two distinct runs as evidenced by variable run timing and spawning distributions necessitates the need for independent management of each component. Recognizing this, the Alaska Board of Fisheries (BOF) adopted independent management plans for early-run fish entering the river during May and June, and late-run fish entering the river after 30 June (McBride et al. 1989).

Chinook salmon returning to the Funny River are considered part of the early run. Peak spawning times are thought to occur between 12 and 22 July (Burger et al. 1985). Many Chinook salmon destined for the Funny River and other tributaries have a tendency to mill for long periods prior to spawning events at or below their destination confluence (Burger et al.1983; Bendock and Alexandersdottir 1991, 1992; Adam Reimer, Alaska Department of Fish and Game, personal communication), and are thus susceptible to harvest throughout most of July (Bendock and Alexandersdottir 1991, 1992). Funny River spawners particularly exhibit this behavior along the south bank of the Kenai River between river kilometers (rkm) 45 and 48. In 1992, the BOF adopted a Chinook fishery closure at the mouth of the Funny River to prevent anglers from targeting Chinook salmon that are staging prior to entering this tributary and spawning. Additional protective measures were enacted in 1996 closing the confluence and the first half-mile of the Funny River to all fishing to prevent anglers from fishing for Chinook while ostensibly fishing for other species (Gamblin et al. 2004).

Most early-run Chinook salmon harvest occurs during May and June in the main-stem Kenai River sport fishery. Harvest also occurs, although not in great numbers, in three other fisheries: the Central Cook Inlet marine sport fishery, the Upper Cook Inlet Sub-district set gillnet commercial fishery, and an in-river educational fishery (McKinley and Fleischman 2010). Sport harvest of early-run Chinook salmon is monitored by the Alaska Department of Fish and Game (Department) through an in-river creel survey between the Warren Ames Bridge at rkm 8 and the Soldotna Bridge (rkm 32) and through the Statewide Harvest Survey between the Soldotna Bridge and Kenai Lake (rkm 132). From 1986 through 2011, annual sport harvest ranged from 899 to 15,209 fish and averaged 5,317 fish (Jennings et al. 2010a, 2010b, 2011a, 2011b; McKinley and Fleischman 2010). On average, about 72% of the sport harvest occurs below the Soldotna Bridge (Jennings et al. 2010a, 2010b, 2011a, 2011b; McKinley and Fleischman 2010). Much of the annual variation in harvest since 1986 is likely explained by fluctuations in run strength and changes in management strategy.

The number and composition of early-run Chinook salmon returning to the Kenai River has been estimated since 1986 using a combination of in-river netting and various sonar technologies. Since 2010 dual-frequency identification sonar (DIDSON™) has been used and early-run estimates from this sonar technology have ranged from 3,336 to 6,515 fish (Alaska Department of Fish and Game, unpublished data). The Department manages the early-run fishery to achieve a watershed-wide optimal escapement goal (OEG) of 5,300 to 9,000 Chinook salmon, as mandated by the Kenai River and Kasilof River Early-Run King Salmon Management Plan (*5 AAC 57.160*). The OEG is achieved primarily through restrictions and liberalizations in the recreational fishery because most early-run fish are harvested by sport anglers. Management actions are triggered when the lower OEG limits are not met or the upper limits are exceeded (McKinley and Fleischman 2010). Because information is limited about the run timing of specific tributary populations in the lower Kenai River, disproportionately harvesting early- or late-run fish could be detrimental to smaller populations of early-run Chinook salmon (McKinley et al. 2002).

In addition to an escapement goal range, the Department also manages salmon escapements "to maintain genetic and phenotypic characteristics of the stock by assuring appropriate geographic and temporal distribution of spawners as well as consideration of size range, sex ratio, and other population attributes" as stated by the State of Alaska Policy for the Management of Sustainable Salmon Fisheries *(5 AAC 39.222(c)(2)(d)).* In an effort to actively address this mandate, a slot limit protecting fish between 40 and 55 inches total length (TL; 1,016–1,397 mm), was adopted by the BOF in 2002 to reverse a declining proportion of ocean-age-5 Chinook salmon within the early run. This slot limit was revised in 2003 to protect fish between 44 and 55 inches TL (1,118–1,397 mm) and again in 2008 to protect fish between 46 and 55 inches TL (1,168–1,397 mm; McKinley and Fleischman 2010).

Stakeholders demand high levels of accuracy and repeated validation of ongoing Chinook salmon research programs and despite the current efforts several issues remain to be resolved. For instance, the degree of overlap in the run timing of tributary and main-stem spawning Chinook salmon is not known, nor is the abundance of tributary stocks which are a dominant component of the early run. This need for more detailed information prompted the development of the Funny River study in 2006. This study has been primarily focused on characterizing the demography of adult Chinook salmon returning to the Funny River. However, since the project's inception two secondary objectives have been developed: (1) assess the adult steelhead *O. mykiss* (anadromous rainbow trout) return to the Funny River, and (2) provide the Department with the necessary information to populate a stock specific abundance and run-timing (SSART) model.

Observations of steelhead in the Funny River were first made during 2006 and 2007 while enumerating Chinook salmon (Gates and Palmer 2007, 2008). Since then, the weir and video system have been installed early in the spring to enumerate the spawning migration, and escapements have ranged from 60 to 184 steelhead between 2008 and 2011 (Gates and Boersma 2009a; 2009b; 2011; Boersma and Gates 2012). Steelhead are also reportedly caught in other sport fisheries in the Kenai River but have never been officially documented. The life histories of steelhead returning to the Funny River are poorly understood although we believe they are similar to behaviors documented in other steelhead populations in Southcentral Alaska (Larson and Balland 1989; Begich 1997; Gates et al. 2010). Steelhead in the Kenai River watershed are likely fall-run fish, entering fresh water in the fall and overwintering before spawning in tributaries during May and June.

The SSART model will produce an independent abundance estimate for Kenai River Chinook salmon which will be used to investigate bias associated with the abundance estimates produced by the Department's newer DIDSON™. To accomplish this, the Department and the U.S. Fish and Wildlife Service (Service) have entered into a cooperative agreement that focuses on adult Chinook salmon. The information collected at the Funny River weir will be used in conjunction with abundance estimates produced from other tributaries using weirs throughout the Kenai River watershed.

Our study during 2012 used a resistance board weir and fish trap in conjunction with an underwater video system to: (1) enumerate adult Chinook salmon and steelhead entering the Funny River, (2) determine the run timing of Chinook salmon and steelhead entering the Funny River, (3) estimate the age, sex and length composition of the Chinook salmon escapement into the Funny River, (4) continue genetic tissue sampling of steelhead, and (5) provide the pertinent demographic data to inform the SSART model. Information pertaining to the run size, timing, age, sex and genetic composition of Chinook salmon and steelhead returning to the Funny River will provide managers valuable information to refine existing management strategies.

Study Area

The glacially turbid Kenai River originates in Cooper Landing at the outlet of Kenai Lake and flows 132 km before entering Cook Inlet (Figure 1). The watershed consists of mountains, glaciers, forests, and the Kenai Peninsula's second and third largest lakes, Skilak and Kenai lakes. The Funny River, one of several tributaries, enters the Kenai River at rkm 49 (60° 29.47'N and 150° 51.92'W; WGS84). The Funny River drains approximately 218 km^2 and most of the watershed lies within the Kenai National Wildlife Refuge. The river channel near the weir location has a moderate gradient, moderate to high sinuosity, and predominately coarse gravel substrate. Vegetation along the banks and throughout the floodplain consists primarily of willow *Salix* spp. and alders *Alnus sinuata* with some stands of spruce *Picea* spp. (Moser 1997). Water depth varies throughout the channel but is usually deepest near the outside bends and shallowest through the crossovers.

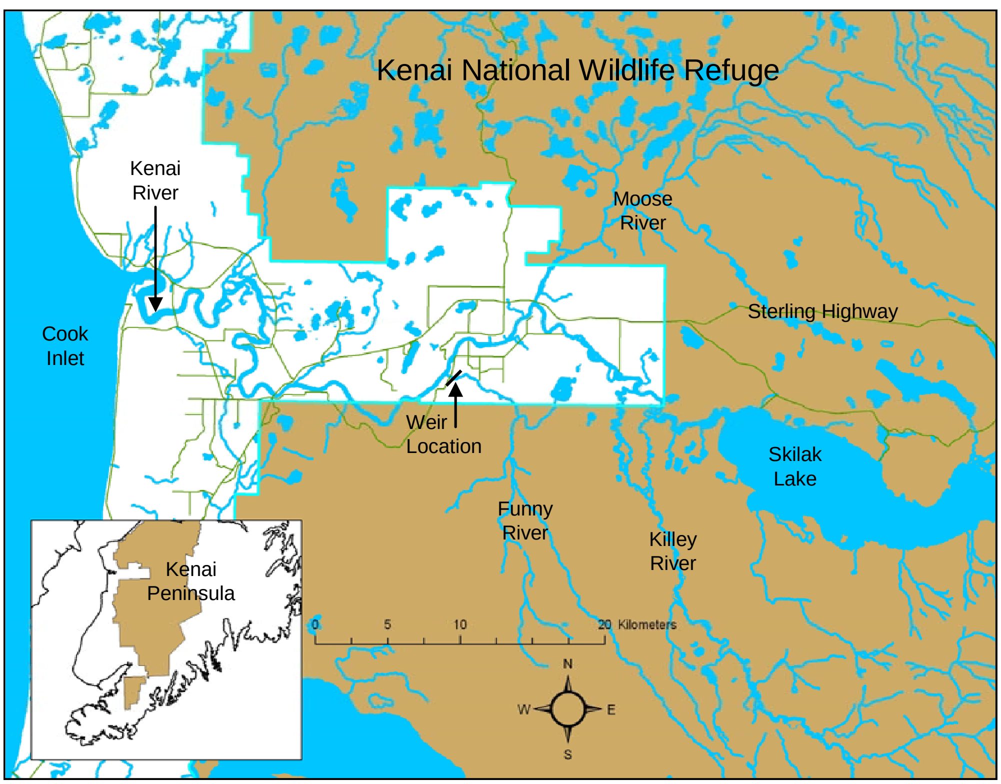

FIGURE 1. —Map of the Kenai River watershed below Skilak Lake showing the weir location on Funny River.

Methods

Weir and Video Operations and Design

A resistance board weir and underwater video system was operated in the Funny River approximately 1.1 km above the bridge crossing the Funny River Road from 30 April through 6 August 2012. The weir was 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 near the deepest part of the channel through a fish 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. The weir was unmanned, except when maintenance was required, and was outfitted with an underwater video monitoring system to monitor upstream fish passage. A live trap 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 system was similar to that used by Gates et al. (2010) in Crooked and Nikolai creeks, and Anderson et al. (2004) in Big Creek. One underwater video camera was located inside a sealed video box attached to the fish passage chute. The 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 box to allow for a scratch-free, clear surface through which images were captured. The passage chute was constructed from aluminum angle and was enclosed in plywood isolating it from exterior light. The backdrop of the passage chute could be adjusted laterally to minimize the number of fish passing through the chute at one time and to push fish closer to the camera during turbid water conditions. The backdrop could also be easily removed from the video chute when dirty and cleaned or replaced with a new one. The video box and fish passage chute 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 an external 500 gigabyte hard drive at 22 frames-per-second using a computer-based digital video recorder (DVR). The DVR was equipped with motion detection to minimize the amount of blank video footage and review time. Fish passage was recorded 24 hours per day 7 days each week. Stored video files were generally reviewed daily. All video equipment was supplied with 110-V AC power and converted to 12-V DC for the underwater camera and lights. A 1,000-W charger/inverter was used inline with two 6-V batteries rated at 400 Ah creating a large battery backup in the event of a power outage. Appendix 1 contains a complete list of all equipment used.

Steelhead were differentiated from resident rainbow trout during video review and biological sampling using visual external characteristics similar to those used by Fleming (1999) in upper Copper River drainages. Resident rainbow trout typically have a dense spotting pattern covering the entire body of the fish whereas steelhead have fewer spots that do not extend to the ventral side of the fish. In addition, sampled steelhead will be distinguished from rainbow trout through extensive saltwater growth as indicated on their scales.

Biological Sampling

Data on fish age, sex, and length (ASL) were collected from Chinook salmon using a temporally stratified sample design (Cochran 1977). Sampling effort was divided into strata and was scaled in real time to consistently sample at least twenty percent of the run from one stratum to the next. Each stratum was a calendar week consisting of 7 days, in which sampling took place in a 2-4 day time period. Samples were collected as quickly as possible within each stratum to minimize fish handling and sampling effort. Sampling efforts for steelhead occurred daily from 7 May to 25 May 2012, with the exception of 12, 18, 19, 22, and 23 May. The sample included ASL and genetic tissue from 17 captured fish.

The ASL sampling consisted of sex determination, length measurements, and scale collections. Sex was determined by observing external characteristics during video review and stratified ASL sampling. 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 and steelhead were taken to the nearest 5 mm from mid eye to tail fork 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 and steelhead, mounted on gummed cards, and pressed on acetate to make an impression. Chinook salmon scales were aged by the Service whereas steelhead scales were archived and will be forwarded to the Department's Trout Research Program in Juneau for age determinations once an adequate sample size is achieved. Scale analysis and reporting utilize methods described by Mosher (1969). Age determinations for Chinook salmon include the number of years spent in fresh water as a juvenile and the number of years spent in salt water as an adult. Steelhead age determinations denote the number of years spent in fresh water as a juvenile followed by the number of years spent in salt water as an adult prior to each spawning event. Spawning events for steelhead are denoted using the letter "S" (e.g., 3.2S1; Mosher 1969).

Data Analysis

Age and sex composition for the total escapement of Chinook salmon were estimated directly from the age and sex composition in the weekly 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, of a given species, in the stratum *h*; and
n_h = total number of fish, of a given species, 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

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

Results

Weir and Video Operations

The weir and video system was installed on 30 April and operated through 6 August. The video system and weir ran smoothly during the entire operational period, with the exception of a partial submergence of the weir due to high water, resulting in no or incomplete counts from 13 to 16 June. No attempt was made to estimate passage for these dates.

Biological Data

Steelhead. —A total of 54 steelhead were counted through the Funny River weir between 30 April and 31 May (Figure 2; Appendix 2). Peak weekly passage (*N*=15) took place between 29 April and 5 May (Figure 2). Both the highest daily count (*N*=8) and median cumulative passage occurred on 15 May. The number of steelhead counted after 25 May only represented 9% (*N*=5) of the total escapement (Figure 2; Appendix 2).

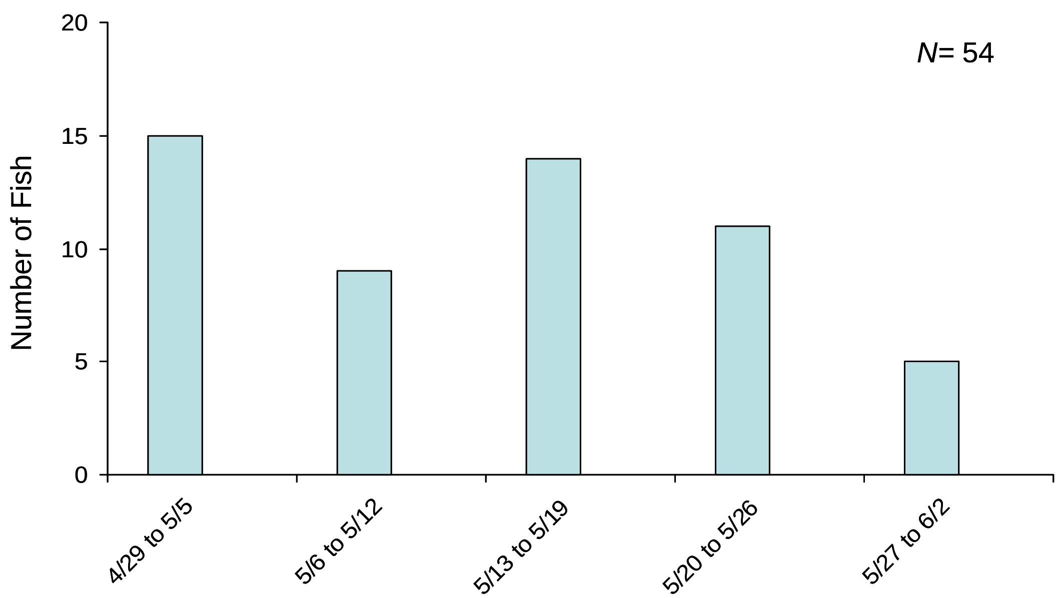

FIGURE 2. —Weekly escapement of adult steelhead passed through the Funny River weir during 2012. Counts began mid-day on 30 April and ended mid-day on 6 August.

Sex composition of steelhead was determined from a combination of ASL samples and review of video records. Females comprised 59% of the run and were dominant after the second week of the run (Figure 3; Appendix 2).

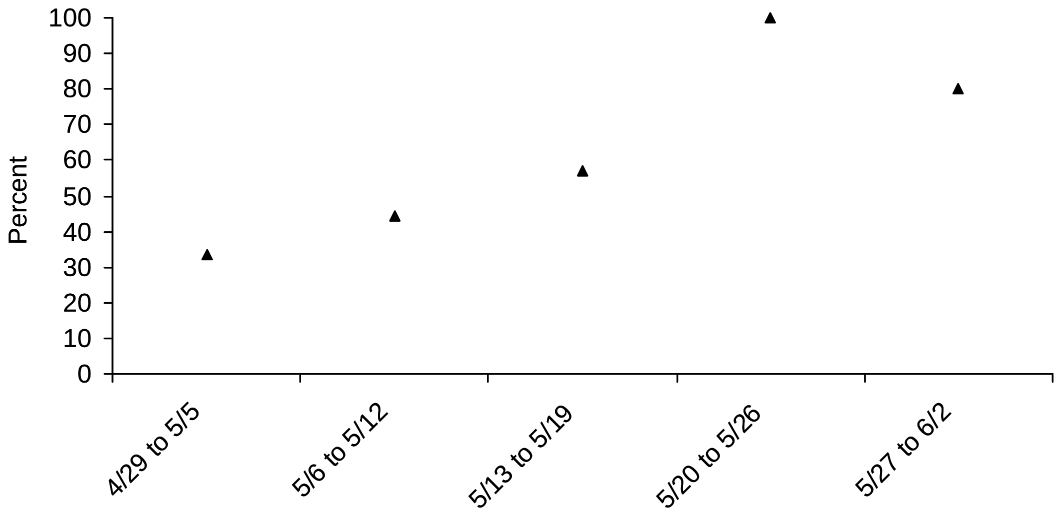

FIGURE 3. — Weekly percent of adult female steelhead observed during video review and ASL sampling at the Funny River weir from 30 April to 2 June, 2012.

Chinook salmon. **—**A total of 879 Chinook salmon were counted through the Funny River weir between 31 May and 5 August (Figure 4; Appendix 3). Peak weekly passage (*N*=245) occurred between 17 and 23 June. The highest daily count (*N*=84) occurred on 24 June and the median cumulative passage occurred 29 June.

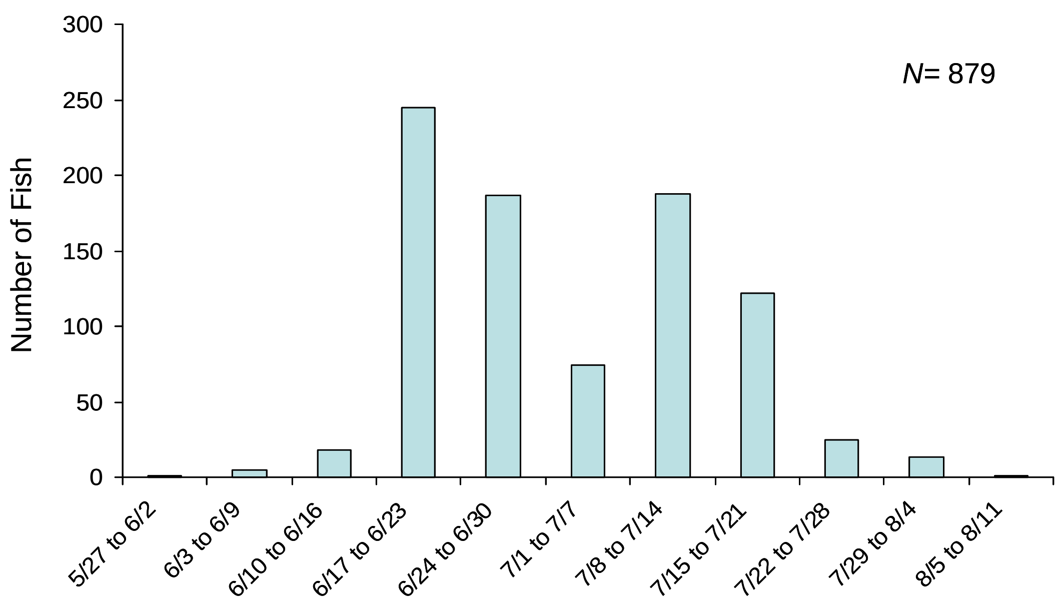

FIGURE 4. —Weekly escapement of adult Chinook salmon passed through the Funny River weir during 2012. Counts began mid-day on 30 April and ended mid-day on 6 August.

Age, sex, and length samples were collected from 181 Chinook salmon between 20 June and 16 July. Four percent (*N*=7) of the sampled fish were excluded from the ASL collection because age could not be determined due to regeneration of the scale or the inability to determine freshwater age. Of the aged scales, female Chinook salmon were comprised of two age groups, ages 1.3 (84%), and 1.4 (16%) and males were comprised of five age groups, ages 1.1 (8%), 1.2 (72%), 2.2 (1%), 1.3 (18%), and 1.4 (2%) (Tables 1 and 2). Age-1.2 males comprised greater than 50% of the total return (Table 2; Figure 5). Overall, the average length of females from mid eye to tail fork was 784 mm and accounted for 24% (*N*=43) of the sample (Tables 1 and 2) whereas average length of males was 587 mm. Sex composition for the entire return of Chinook salmon including both ASL and video records was 32% female (Appendix 3). Sex ratios favored males throughout most of the run (Figure 6).

TABLE 1. —Length-at-age for adult Chinook salmon sampled at the Funny River weir during 2012.

			Mid Eye to Fork Length		
Sex	Age	*N* [a]	Mean	Range	Standard Error
Female	1.3	36	766	605 - 880	8.5
	1.4	7	875	835 - 900	8.7
Female Total		43	784	605 - 900	9.5
Male	1.1	11	388	300 - 500	24.7
	1.2	94	563	470 - 650	3.7
	1.3	23	751	635 - 870	11.2
	1.4	2	965	930 - 1000	35.0
	2.2	1	580	N/A	N/A
Male Total		131	587	300 - 1000	9.8
Cumulative Total		174	636	300 - 1000	10.1

[a] Fish with inconclusive ages were omitted from this table (*N* =7)

TABLE 2. —Age and sex composition for the entire Funny River Chinook salmon return estimated from the age and sex data collected during 2012.

		Brood Year and Age Group					
		2009	2008	2007		2006	
		1.1	1.2	2.2	1.3	1.4	Total
Sample Period: 20 June to 16 July							
Female:	Number in Sample:				36	7	43
	% Females in Age Group:				83.7	16.3	100
	Estimated % of Escapement:				20.7	4.0	24.7
	Estimated Escapement:				182	35	217
	Standard Error:				24.2	11.8	
Male:	Number in Sample:	11	94	1	23	2	131
	% Males in Age Group:	8.4	71.8	0.8	17.6	1.5	100
	Estimated % of Escapement:	6.3	54.0	0.6	13.2	1.1	75.3
	Estimated Escapement:	56	475	5	116	10	662
	Standard Error:	14.6	29.8	4.5	20.3	6.4	
Total:	Number in Sample:	11	94	1	59	9	174
	Estimated % of Escapement:	6.3	54.0	0.6	33.9	5.2	100
	Estimated Escapement:	56	475	5	298	45	879
	Standard Error:	14.6	29.8	4.5	28.3	13.3	

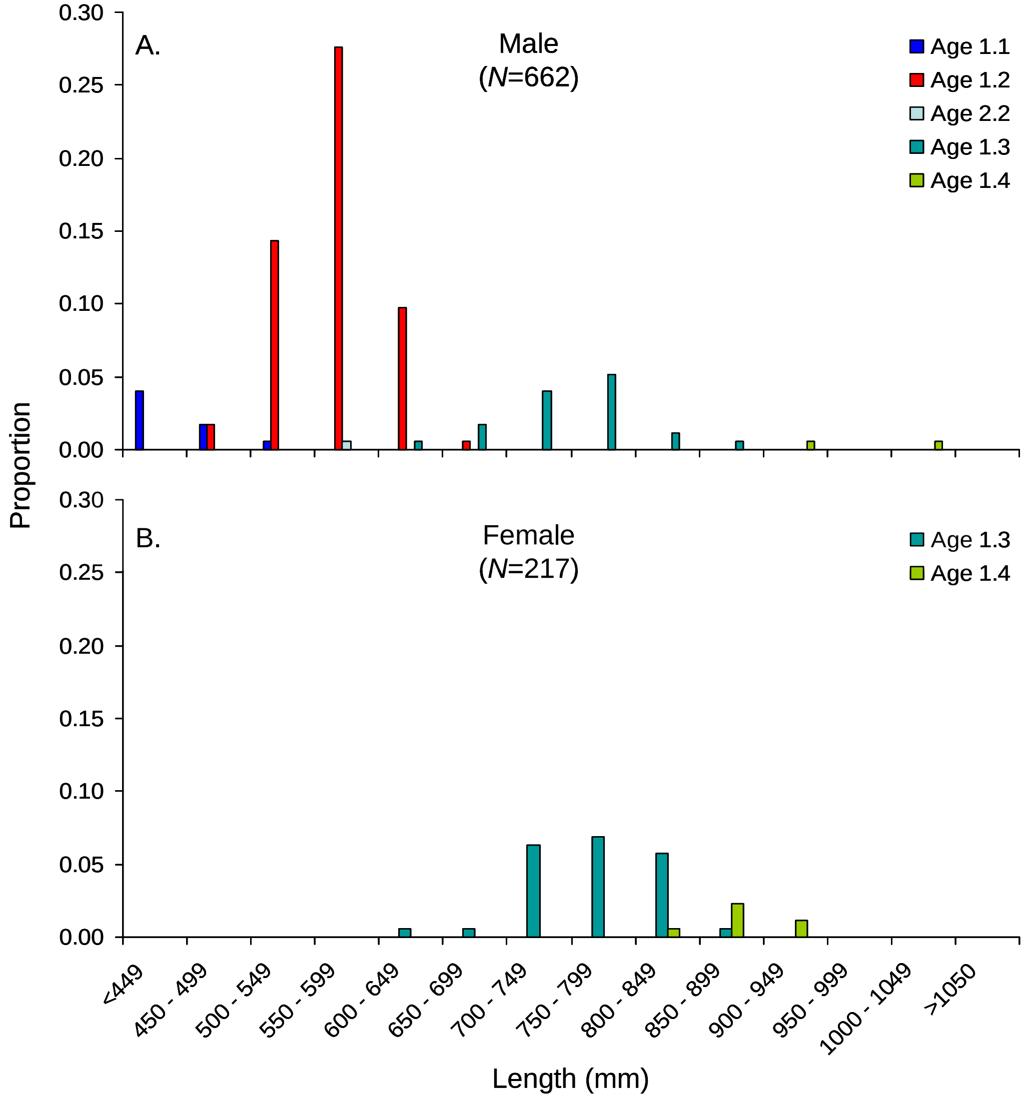

FIGURE 5. —Proportion of adult (A) male and (B) female Chinook salmon estimated to pass the Funny River weir during 2012 delineated by age and length.

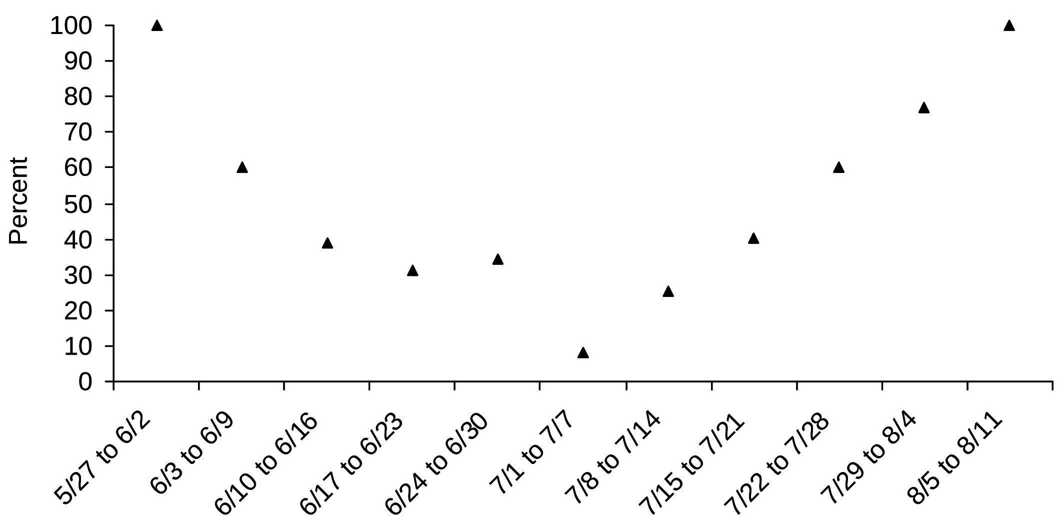

FIGURE 6. —Weekly percent of adult female Chinook salmon observed during video review and ASL sampling at the Funny River weir from 31 May to 6 August, 2012.

Other species. **—**Seven additional species of fish were observed passing the Funny River weir including 269 Dolly Varden *Salvelinus malma*, 20 rainbow trout, 13 pink salmon *O. gorbuscha*, 11 sockeye salmon *O. nerka*, 9 lamprey *Lampetra* spp., 8 round whitefish *Prosopium cylindraceum*, and 1 coho salmon *O. kisutch* (Appendix 4). Weekly passage of all non-target species is summarized in Table 3.

TABLE 3. —Weekly passage of non-target fish species passed through Funny River weir during 2012. Video counts began mid-day on 30 April and ended mid-day on 6 August.

Week	Dolly Varden	Rainbow Trout	Pink Salmon	Sockeye Salmon	Lamprey spp.	Round Whitefish	Coho Salmon
4/29 to 5/5	1	2	0	0	1	1	0
5/6 to 5/12	0	0	0	0	0	0	0
5/13 to 5/19	1	1	0	0	1	1	0
5/20 to 5/26	2	1	0	0	2	1	0
5/27 to 6/2	1	3	0	0	0	0	0
6/3 to 6/9	0	0	0	0	1	0	0
6/10 to 6/16	0	0	0	0	3	0	0
6/17 to 6/23	2	1	0	1	0	1	0
6/24 to 6/30	8	3	0	0	1	1	0
7/1 to 7/7	11	2	0	0	0	0	0
7/8 to 7/14	8	1	1	1	0	0	0
7/15 to 7/21	25	3	1	3	0	0	0
7/22 to 7/28	45	2	4	2	0	3	0
7/29 to 8/4	142	1	5	3	0	0	1
8/5 to 8/11	23	0	2	1	0	0	0
Total	269	20	13	11	9	8	1

Discussion

The estimate of 879 Chinook salmon was probably conservative due to the intermittent and partial submergence of the weir from 13 to 16 June. The steelhead escapement (*N*=54) was also most likely conservative because steelhead were immediately observed passing the weir and video system after installation indicating that the steelhead migration had begun. However, these periods of no or incomplete counts are thought to minimally affect the estimates of both Chinook salmon and steelhead because they are limited to periods when historically few fish are observed passing the weir (Gates and Boersma 2009a, 2009b, 2011; Boersma and Gates 2012).

Chinook salmon and steelhead escapements have declined in recent years in the Funny River and were the lowest on record during 2012 (Gates and Boersma 2009a, 2009b, 2011; Boersma and Gates 2012). Similar depressed returns of Chinook salmon and steelhead have been observed for other populations throughout Southcentral Alaska during the last few years (Anderson and Stillwater Sciences 2011; Alaska Department of Fish and Game 2012e; U.S. Fish and Wildlife Service, unpublished data).

The observed female to male sex ratios during the course of the steelhead spawning migration were similar to other Kenai Peninsula populations, with a majority of males migrating early in the run and a preponderance of females throughout the remainder of the run (Figure 3; Gates et al. 2010). Overall, the female to male sex ratio (1.5:1) was similar to observations in 2011 (1.7:1) and other steelhead populations on the Kenai Peninsula (Gates et al. 2010). The scale and genetic tissue samples collected during 2008 through 2012 will be processed by the Department’s Trout Research Program and the Service’s Conservation Genetics Laboratory, respectively. Analysis of scale patterns to determine age compositions and spawning histories will further inform the mechanisms driving these sex ratios.

Age, sex and length information was collected from Funny River Chinook salmon between 20 June and 16 July. Our sample strategy coincided with the observed Chinook salmon run and exceeded twenty percent of escapement. We feel that the identified age groups accurately represent the ages of Chinook salmon present in the Funny River during 2012. After combining the ASL samples and video records, we feel that the sex composition of 32% females is accurate and is similar to sex compositions observed between 2006 and 2011 (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b, 2011; Boersma and Gates 2012).

The sport harvest of early-run Chinook salmon in the lower Kenai River has exceeded exploitation rates of 70% (McKinley and Fleischman 2010) and likely influences the demographic composition of Chinook salmon returning to the Funny River. Fish populations that experience increases in mortality and decreases in population densities can exhibit a reduction in average ages and lengths (Ricker 1981). Altering the structure of a fish population toward smaller younger fish can lead to decreased fecundity (Walsh et al. 2006), lowered reproductive rates (Venturelli et al. 2009), loss of yield (Conover and Munch 2002), increased variability in abundance (Hsieh et al. 2006), and ultimately fishery collapse (Olsen et al. 2004). The consideration of the effects of a fishery on adult Chinook salmon can be complicated by a complex population structure (Ricker 1980), environmental variability affecting fish growth and survival (Kendall and Quinn 2011), or a naturally skewed life-history population structure. Nonetheless, adult Chinook salmon returning to the Funny River display a dissimilar population structure from other Southcentral Alaska Chinook salmon populations, and appear to be heavily skewed towards smaller younger fish (Table 1; Figure 5; Roni and Quinn 1995), a classic sign of over exploitation (Ricker 1981).

The contribution of the Funny River to the total Kenai River early-run Chinook salmon escapement appears to be decreasing over time. An ad-hoc estimate of the total proportional contribution of early-run Chinook salmon destined for the Funny River can be projected for every year since 2006 by dividing the passage estimates at the Funny River weir (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b, 2011) by the remainder of the passage estimates obtained with sonar in the lower Kenai River (Miller et al. 2011; Jeff Perschbacher, Alaska Department of Fish and Game, personal communication; Appendix 5) and the harvest estimates for early-run Chinook salmon (Jennings et al. 2010a, 2010b; McKinley and Fleischman 2010; Jennings et al. 2011a, 2011b; Jeff Perschbacher, Alaska Department of Fish and Game, personal communication; Appendix 5). These estimates indicate a downward trend in the contribution of Chinook salmon from the Funny River to the overall Kenai River early-run escapement (0.20 of overall run in 2006, 0.25 in 2007, 0.16 in 2008, 0.14 in 2009, 0.10 in 2010, and 0.12 in 2011). However, the scale of the contribution and the slope of change could be markedly different than estimates using this method. Potential sources of bias could include imprecise estimation of the Kenai River early-run Chinook salmon escapement and imprecise estimation of the Kenai River early-run Chinook salmon harvest.

In conclusion, installing the Funny River weir during late April and successfully operating it through 6 August resulted in an accurate estimate of escapement for Chinook salmon and adult steelhead. The use of underwater video continues to be an inexpensive and reliable method to estimate the abundance and run timing of Chinook salmon and steelhead in the Funny River. We plan to continue operating the video weir during 2013 and will use the run timing observed between 2006 and 2012 to determine our ASL sampling strategy during 2013. Information collected from the Funny River will be useful in formulating future management strategies for early run Chinook salmon and steelhead in the Kenai River watershed.

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APPENDIX 1. —List of video equipment used to monitor adult Chinook salmon and steelhead abundance and run timing in the Funny River during 2012.

Item	Model #	Manufacturer	Contact
Digital Video Recorder	DVSM 4-120	Veltek International, Inc.	http://www.veltekcctv.com/
Underwater Camera	Model 10	Applied Micro Video	http://www.appliedmicrovideo.com/
Underwater Lights	Lunaqua 2 12-v	OASE	http://www.pondusa.com
External Harddrive	One Touch 500 GB	Maxtor.com	http://www.maxstore.com
400 Ah 6 Volt Battery	S-530	Rolls	http://www.rollsbattery.com/
Inverter/Charger	Prosine 2.0	Xantrex	http://www.xantrex.com

APPENDIX 2.—Daily counts of adult steelhead observed at the Funny River weir during 2012. Boxed areas represent the second and third quartile and median passage dates. Lightly shaded areas represent periods when the fish trap was operated for age, sex, and length sampling of steelhead.

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
4/30	4	3	7	7	0.1296
5/1	1	2	3	10	0.1852
5/2	1	0	1	11	0.2037
5/3	1	0	1	12	0.2222
5/4	2	0	2	14	0.2593
5/5	1	0	1	15	0.2778
5/6	0	0	0	15	0.2778
5/7	0	1	1	16	0.2963
5/8	0	0	0	16	0.2963
5/9	3	0	3	19	0.3519
5/10	0	1	1	20	0.3704
5/11	1	2	3	23	0.4259
5/12	1	0	1	24	0.4444
5/13	0	0	0	24	0.4444
5/14	0	0	0	24	0.4444
5/15	3	5	8	32	0.5926
5/16	1	0	1	33	0.6111
5/17	0	1	1	34	0.6296
5/18	2	1	3	37	0.6852
5/19	0	1	1	38	0.7037
5/20	0	0	0	38	0.7037
5/21	0	3	3	41	0.7593
5/22	0	0	0	41	0.7593
5/23	0	6	6	47	0.8704
5/24	0	1	1	48	0.8889
5/25	0	1	1	49	0.9074
5/26	0	0	0	49	0.9074
5/27	0	1	1	50	0.9259
5/28	0	1	1	51	0.9444
5/29	0	0	0	51	0.9444
5/30	0	1	1	52	0.9630
5/31	1	1	2	54	1.0000
Total	22	32	54		

APPENDIX 3. —Daily counts of adult Chinook salmon observed at the Funny River weir during 2012. Boxed areas represent the second and third quartile and median passage dates. Darkly shaded areas represent periods when the weir was partially inoperable resulting in no or incomplete counts. Lighter shaded areas represent periods when the fish trap was operated for age, sex, and length sampling of Chinook salmon.

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
5/31	0	1	1	1	0.0011
6/1	0	0	0	1	0.0011
6/2	0	0	0	1	0.0011
6/3	0	0	0	1	0.0011
6/4	0	0	0	1	0.0011
6/5	0	0	0	1	0.0011
6/6	0	0	0	1	0.0011
6/7	0	0	0	1	0.0011
6/8	1	1	2	3	0.0034
6/9	1	2	3	6	0.0068
6/10	3	2	5	11	0.0125
6/11	0	1	1	12	0.0137
6/12	2	0	2	14	0.0159
6/13	0	0	0	14	0.0159
6/14	2	1	3	17	0.0193
6/15	0	2	2	19	0.0216
6/16	4	1	5	24	0.0273
6/17	6	0	6	30	0.0341
6/18	30	11	41	71	0.0808
6/19	23	14	37	108	0.1229
6/20	48	21	69	177	0.2014
6/21	10	9	19	196	0.2230
6/22	14	4	18	214	0.2435
6/23	38	17	55	269	0.3060
6/24	45	39	84	353	0.4016
6/25	5	4	9	362	0.4118
6/26	36	16	52	414	0.4710
6/27	10	3	13	427	0.4858
6/28	3	1	4	431	0.4903
6/29	12	1	13	444	0.5051
6/30	12	0	12	456	0.5188
7/1	13	2	15	471	0.5358
7/2	3	0	3	474	0.5392
7/3	16	1	17	491	0.5586
7/4	8	1	9	500	0.5688
7/5	2	0	2	502	0.5711
7/6	13	1	14	516	0.5870
7/7	13	1	14	530	0.6030
7/8	13	2	15	545	0.6200
7/9	5	1	6	551	0.6268
7/10	23	7	30	581	0.6610
7/11	28	5	33	614	0.6985
7/12	14	4	18	632	0.7190
7/13	24	9	33	665	0.7565

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APPENDIX 3. —(Page 2 of 2)

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
7/14	33	20	53	718	0.8168
7/15	19	8	27	745	0.8476
7/16	22	24	46	791	0.8999
7/17	16	5	21	812	0.9238
7/18	0	1	1	813	0.9249
7/19	4	2	6	819	0.9317
7/20	6	5	11	830	0.9443
7/21	6	4	10	840	0.9556
7/22	8	9	17	857	0.9750
7/23	0	1	1	858	0.9761
7/24	1	0	1	859	0.9772
7/25	1	1	2	861	0.9795
7/26	0	0	0	861	0.9795
7/27	0	2	2	863	0.9818
7/28	0	2	2	865	0.9841
7/29	1	3	4	869	0.9886
7/30	0	0	0	869	0.9886
7/31	0	1	1	870	0.9898
8/1	1	2	3	873	0.9932
8/2	0	2	2	875	0.9954
8/3	1	0	1	876	0.9966
8/4	0	2	2	878	0.9989
8/5	0	1	1	879	1.0000
8/6	0	0	0	879	1.0000
Total	599	280	879		

APPENDIX 4. —Daily counts of non-target fish species passing through the Funny River weir during 2012. Darkly shaded areas represent periods when the weir was partially inoperable resulting in no or incomplete counts. Lighter shaded areas represent periods when the fish trap was operated for age, sex, and length sampling for Chinook salmon and steelhead.

Date	Dolly Varden	Rainbow Trout	Pink Salmon	Sockeye Salmon	Lamprey spp.	Round Whitefish	Coho Salmon
4/30	0	0	0	0	0	0	0
5/1	0	1	0	0	1	1	0
5/2	0	0	0	0	0	0	0
5/3	1	0	0	0	0	0	0
5/4	0	1	0	0	0	0	0
5/5	0	0	0	0	0	0	0
5/6	0	0	0	0	0	0	0
5/7	0	0	0	0	0	0	0
5/8	0	0	0	0	0	0	0
5/9	0	0	0	0	0	0	0
5/10	0	0	0	0	0	0	0
5/11	0	0	0	0	0	0	0
5/12	0	0	0	0	0	0	0
5/13	0	0	0	0	0	0	0
5/14	0	0	0	0	0	0	0
5/15	0	0	0	0	0	0	0
5/16	0	0	0	0	0	0	0
5/17	0	0	0	0	0	1	0
5/18	0	1	0	0	0	0	0
5/19	1	0	0	0	1	0	0
5/20	0	0	0	0	0	0	0
5/21	0	0	0	0	0	0	0
5/22	0	0	0	0	0	0	0
5/23	1	0	0	0	1	1	0
5/24	0	1	0	0	0	0	0
5/25	1	0	0	0	1	0	0
5/26	0	0	0	0	0	0	0
5/27	0	0	0	0	0	0	0
5/28	0	0	0	0	0	0	0
5/29	0	0	0	0	0	0	0
5/30	1	2	0	0	0	0	0
5/31	0	1	0	0	0	0	0
6/1	0	0	0	0	0	0	0
6/2	0	0	0	0	0	0	0
6/3	0	0	0	0	0	0	0
6/4	0	0	0	0	0	0	0
6/5	0	0	0	0	0	0	0
6/6	0	0	0	0	0	0	0
6/7	0	0	0	0	0	0	0
6/8	0	0	0	0	0	0	0
6/9	0	0	0	0	1	0	0
6/10	0	0	0	0	2	0	0

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APPENDIX 4. —(Page 2 of 3)

Date	Dolly Varden	Rainbow Trout	Pink Salmon	Sockeye Salmon	Lamprey spp.	Round Whitefish	Coho Salmon
6/11	0	0	0	0	0	0	0
6/12	0	0	0	0	0	0	0
6/13	0	0	0	0	0	0	0
6/14	0	0	0	0	1	0	0
6/15	0	0	0	0	0	0	0
6/16	0	0	0	0	0	0	0
6/17	0	0	0	1	0	0	0
6/18	0	0	0	0	0	0	0
6/19	0	0	0	0	0	0	0
6/20	0	1	0	0	0	0	0
6/21	0	0	0	0	0	0	0
6/22	0	0	0	0	0	0	0
6/23	2	0	0	0	0	1	0
6/24	0	0	0	0	0	0	0
6/25	0	0	0	0	0	0	0
6/26	2	0	0	0	0	0	0
6/27	2	0	0	0	0	0	0
6/28	1	0	0	0	0	0	0
6/29	1	1	0	0	1	0	0
6/30	2	2	0	0	0	1	0
7/1	1	0	0	0	0	0	0
7/2	2	0	0	0	0	0	0
7/3	3	1	0	0	0	0	0
7/4	1	0	0	0	0	0	0
7/5	0	0	0	0	0	0	0
7/6	4	1	0	0	0	0	0
7/7	0	0	0	0	0	0	0
7/8	0	0	0	0	0	0	0
7/9	2	0	0	0	0	0	0
7/10	1	1	1	0	0	0	0
7/11	2	0	0	0	0	0	0
7/12	0	0	0	0	0	0	0
7/13	0	0	0	0	0	0	0
7/14	3	0	0	1	0	0	0
7/15	0	0	0	0	0	0	0
7/16	0	2	0	2	0	0	0
7/17	11	0	0	0	0	0	0
7/18	1	0	0	0	0	0	0
7/19	1	0	0	0	0	0	0
7/20	5	0	0	0	0	0	0
7/21	7	1	1	1	0	0	0
7/22	8	0	3	1	0	0	0
7/23	3	0	0	1	0	1	0
7/24	2	0	0	0	0	0	0

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APPENDIX 4. —(Page 3 of 3)

Date	Dolly Varden	Rainbow Trout	Pink Salmon	Sockeye Salmon	Lamprey spp.	Round Whitefish	Coho Salmon
7/25	8	1	0	0	0	0	0
7/26	7	0	0	0	0	1	0
7/27	11	0	1	0	0	0	0
7/28	6	1	0	0	0	1	0
7/29	13	0	0	0	0	0	0
7/30	9	0	0	1	0	0	0
7/31	19	0	1	0	0	0	0
8/1	39	0	1	2	0	0	0
8/2	17	1	0	0	0	0	1
8/3	20	0	3	0	0	0	0
8/4	25	0	0	0	0	0	0
8/5	9	0	0	1	0	0	0
8/6	14	0	2	0	0	0	0
Total	269	20	13	11	9	8	1

APPENDIX 5. —Age compositions of early-run Chinook salmon estimated for the Kenai and Funny river escapements and Kenai River harvest between Warren Ames and Soldotna bridges from 2006 to 2012.

	Age Groups						
2006	1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement[a]							
Female			9.1%	10.7%			
Male	6.6%	39.7%	26.4%	7.4%			
Estimated Kenai River sonar passage[b]							
Female		8.6%	8.6%	24.5%	1.5%		
Male	1.2%	22.9%	12.6%	18.0%	2.0%		
Estimated Kenai River early-run harvest[b]							
Female		1.7%	17.2%	35.1%			
Male	1.1%	13.8%	21.3%	9.8%			

	Age Groups						
2007	1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement[c]							
Female			16.4%	22.0%			
Male	0.5%	36.4%	17.8%	7.0%			
Estimated Kenai River sonar passage[d]							
Female		7.7%	18.6%	19.9%	0.9%		
Male		23.1%	16.7%	12.7%		0.5%	
Estimated Kenai River early-run harvest[d]							
Female		2.7%	23.6%	15.5%	0.9%		
Male		17.3%	33.6%	6.4%			

	Age Groups						
2008	1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement[e]							
Female			23.8%	25.4%			
Male	0.8%	32.0%	14.8%	3.3%			
Estimated Kenai River sonar passage[f]							
Female		2.4%	20.7%	28.9%	0.6%		
Male		11.3%	21.4%	13.4%	0.6%		0.7%
Estimated Kenai River early-run harvest[f]							
Female			26.0%	22.3%	0.3%		
Male		11.4%	30.5%	9.6%			

	Age Groups						
2009	1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement[g]							
Female			19.6%	20.6%	0.9%		
Male	2.8%	29.9%	20.6%	4.7%	0.9%		
Estimated Kenai River sonar passage[f]							
Female		0.8%	12.5%	32.8%			
Male	3.1%	14.1%	11.7%	23.4%	1.6%		
Estimated Kenai River early-run harvest[f]							
Female			14.2%	30.1%			
Male	1.0%	19.2%	19.3%	16.2%			

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APPENDIX 5. —(Page 2 of 2)

2010	Age Groups 1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement[h]							
Female		0.8%	19.8%	9.2%			
Male	6.1%	44.3%	16.8%	3.1%			
Estimated Kenai River sonar passage[f]							
Female		2.2%	27.2%	10.3%	0.5%		
Male	7.0%	22.9%	20.3%	9.7%			
Estimated Kenai River early-run harvest[f]							
Female			30.9%	10.7%			
Male	2.2%	22.1%	19.9%	14.2%			

2011	Age Groups 1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement							
Female			27.1%	11.1%			
Male	3.5%	30.7%	24.6%	3.0%			
Estimated Kenai River sonar passage[f]							
Female			16.5%	24.2%			
Male	1.6%	25.8%	14.3%	16.5%	1.1%		
Estimated Kenai River early-run harvest[f]							
Female			17.9%	30.4%			
Male		19.6%	17.9%	14.3%			

2012	Age Groups 1.1	1.2	1.3	1.4	1.5	2.2	2.4
Estimated Funny River weir escapement							
Female			20.7%	4.0%			
Male	6.3%	54.0%	13.2%	1.1%		0.6%	
Estimated Kenai River sonar passage[f]							
Female		1.3%	20.8%	23.5%			
Male	5.4%	8.1%	15.1%	24.3%	1.3%		
Estimated Kenai River early-run harvest[f,i]							
Female			5.3%	57.9%			
Male		2.6%	18.4%	15.8%			

[a] U.S. Fish and Wildlife Service, unpublished data.
[b] Eskelin 2009.
[c] Gates and Palmer 2008.
[d] Eskelin 2010.
[e] Gates and Boersma 2009a.
[f] Jeff Perschbacher, Alaska Department of Fish and Game, personal communication.
[g] Gates and Boersma 2009b.
[h] Gates and Boersma 2011.
[i] Sport fishery closed by emergency order on 22 June 2012