U.S. Fish & Wildlife Service

Abundance and Run Timing of Adult Chinook Salmon and Steelhead in the Funny River, Kenai Peninsula, Alaska, 2010

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Kenneth S. Gates and James K. Boersma

Abstract

A fish weir equipped with an underwater video system was installed and operated between 29 April and 6 August in the Funny River during 2010 to collect abundance, run timing, and biological information on adult Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss*. The total number of Chinook salmon and steelhead counted past the weir was 1,187 and 60, respectively. Non-target species enumerated included 27 rainbow trout *O. mykiss*, 687 Dolly Varden *Salvelinus malma*, 9 round whitefish *Prosopium cylindraceum*, 1 lamprey *Lampetra* sp., 17 sockeye salmon *O. nerka*, 58 pink salmon *O. gorbuscha*, 1 chum salmon *O. keta*, and 3 coho salmon *O. kisutch*. Peak weekly passage of Chinook salmon and steelhead occurred between 20 and 26 June and 16 and 22 May, respectively. Age, sex, and length information was collected from 268 Chinook salmon and 27 steelhead. Sex of both species was also determined by examining recorded video images. Females comprised 31% of the Chinook salmon escapement and 77% of the steelhead escapement. The average mid-eye-fork length of sampled male and female Chinook salmon was 623 and 800 mm, respectively. Chinook salmon were aged using scale analysis and were comprised of 1.1, 1.2, 1.3, and 1.4 fish. Mid-eye-fork lengths of steelhead averaged 588 mm for males and 636 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). The popularity of this sport fishery requires intensive management and research programs focusing on Kenai River Chinook salmon stocks. The fishery is managed as two distinct runs; fish entering the river during May and June are managed as the early-run, whereas those entering the river after 30 June are managed as the late-run. In general, early-run fish spawn in the Kenai River tributaries and late-run fish spawn in the mainstem Kenai River. Early-run fish are harvested primarily by sport anglers in the Kenai River, whereas late-run fish are harvested by commercial, sport, and personal use fisheries. Chinook salmon returning to the Funny River are considered part of the early-run. The number of early-run Chinook salmon returning to the Kenai River has been estimated since 1987 using sonar located at river kilometer (rkm) 13. Sonar passage estimates for the early-run have ranged from 7,162 to 27,080 fish between 1986 and 2010 (McKinley and Fleischman 2010; Alaska Department of Fish and Game, unpublished data). These estimates provide the basis for estimating spawning escapement and implementing the Kenai River and Kasilof River Early-Run King Salmon Management Plan (5 AAC 57.160) that regulates harvest in the in-river sport fishery. Sport harvest of early-run Chinook salmon occurs below Skilak Lake during May and June. Harvest also occurs, although not in great numbers, in three other fisheries: the Central Cook Inlet marine sport fishery, the Upper Subdistrict set gillnet (Eastside set net)

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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 (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 2006 annual sport harvest has ranged from 899 to 15,209 fish and has averaged 5, 773 fish (McKinley and Fleischman 2010). On average, about 72% of the sport harvest occurs below 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.

Radio telemetry studies conducted during the early 1980's, 1990's and most recently in 2010 provide some insight regarding the migratory behavior and spawning distribution of early-run Kenai River Chinook salmon. Bendock and Alexandersdottir (1991, 1992) found that the majority of early-run fish spawned in larger tributaries such as the Killey (42 to 64%) and Funny (20 to 21%) rivers. The remainder of the radio-tagged fish spawned in smaller tributaries (6 to 10%) and the mainstem 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. Radio telemetry information collected during 2010 indicates similar results with the majority of the early run returning to the Killey River (58%), mainstem Kenai River (24%), and the Funny River (12%) (Adam Reimer, Alaska Department of Fish and Game, personal communication). Peak spawning times are thought to occur between 12 and 22 July in the Funny River, although estimates are subjective because of small sample sizes (Burger et al. 1985). Furthermore, many Chinook salmon destined for the Funny River and other tributaries have a tendency to mill for long periods prior to spawning events. 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) observed similar behavior and noted that early-run Chinook salmon mill for extended periods in the mainstem 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. Because early-run Chinook salmon have a tendency to mill in the mainstem Kenai River near spawning tributaries into late July and slowly exit areas open to sport fishing, some early-run fish are susceptible to harvest throughout most of July when the sport fishery is targeting late-run fish (Bendock and Alexandersdottir 1992).

Regulations pertaining to early-run Chinook salmon change frequently to address biological issues. For example, a slot limit protecting fish with a total length between 44 and 55 inches (1,117 and 1,397 mm), typically fish that spend four or five years in the ocean, was enacted in 2002 to address the biological concern of fewer large and older fish present in the in-river sport fishery. This slot limit was later changed to protect fish with a total length between 46 and 55 inches (1,168 and 1,397 mm) beginning in 2008. In January 2005, an optimum escapement goal (OEG) range of 5,300 to 9,000 fish was adopted by the Alaska Board of Fisheries, which replaced the previous biological escapement goal (BEG) of 7,200 to 14,400 early-run Chinook salmon. With the OEG, restrictions and liberalizations in the fishery would take place only when the lower limits are not met or the upper limits are exceeded (5 AAC 57.160). The effects of this change are unknown but most likely would create a more predictable sport fishery by reducing restrictions on the in-river sport fishery and allowing for an increase in harvest. For example, during the first year of management using an OEG, the in-river sport fishery was liberalized on 18 June 2005 allowing the use of bait from the mouth of the Kenai River upstream to 100 yards below the mouth of the Moose River (Alaska Department of Fish and Game 2005). Restricting or liberalizing the fishery early or late in the run could increase the possibility of disproportionately harvesting early-run Chinook salmon. Because information is limited about run timing of specific tributary populations, disproportionately harvesting early or late in the run could be detrimental to smaller populations of early-run Chinook salmon (McKinley et al. 2002).

Stakeholders demand high levels of accuracy and repeated validation of ongoing Chinook salmon research programs, and despite the current efforts, several issues remain unresolved. For instance, the degree of overlap in the run timing of tributary- and mainstem-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.

This study initially focused on early-run Chinook salmon and now includes the assessment of steelhead *O. mykiss* (anadromous rainbow trout). 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. Gates and Boersma (2009a, 2009b) observed 187 and 172 steelhead during 2008 and 2009, respectively. Steelhead are also incidentally 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 entering 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.

Our study during 2010 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, and (4) determine if the steelhead spawning group in the Funny river is genetically distinct from other populations on the Kenai Peninsula and, if so, estimate the level of genetic differentiation. 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 flood plain consists primarily of willow and alders with some stands of spruce (Moser 1997). Water depth varies throughout the channel but is usually deepest near the outside bends and shallowest through the crossovers.

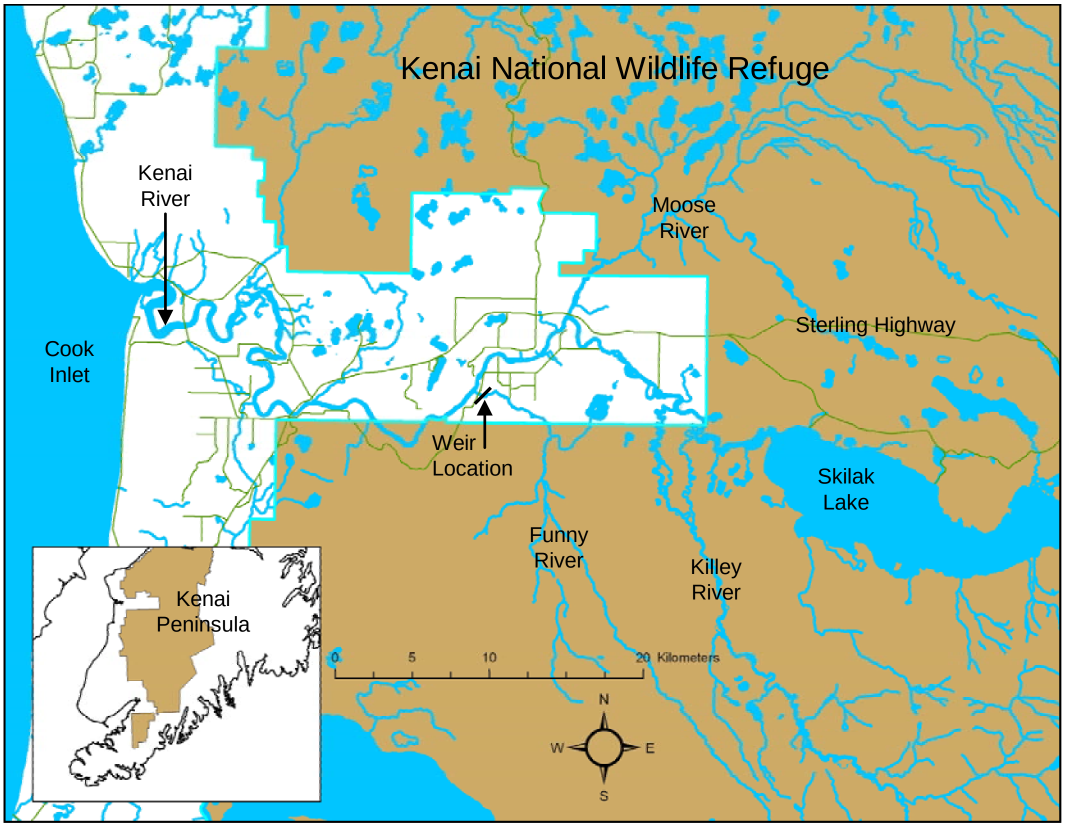

FIGURE 1. —Map of the Kenai River watershed below Skilak Lake showing the weir location on Funny River. The Kenai National Wildlife Refuge is shaded in brown.

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 29 April through 6 August 2010. The weir was constructed using a combination of floating resistance board panels (Tobin 1994), a rigid-picket panel, and flexible-picket panels (Gates and Palmer 2004). 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 flexible-picket panels (west bank) and the rigid-picket panel (east bank) were installed between the bank and bulkhead of the resistance board weir to create a fish-tight structure. The flexible-picket panels were constructed from 2.5-cm inside diameter polyvinyl chloride electrical conduit. Panel dimensions were 3-m long by 1.5-m high with 1.9-cm spacing between pickets. Panels were held together by 3-mm stainless steel wire rope. The rigid-picket panel was framework 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 aforementioned 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 system to monitor upstream fish passage. A live trap facilitated biological sampling and was attached to the front of the fish passage panel. The video system, consisting of a sealed camera box and fish passage chute, was attached to the front 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. 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 from which video images were captured 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 replaced with a new one. 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). Fish passage was recorded 24 hours per day seven days each week. Stored video files were generally reviewed daily. 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 hours. The DVR was equipped with motion detection to minimize the amount of blank video footage and review time. All video equipment was supplied with 110-V AC power available at the site and converted to 12-V DC for the underwater camera and lights. A 1000-W charger/inverter was used inline with two 6-V DC batteries rated at 400 ampere-hours creating a large battery backup in the event of a power outage. Appendix 1 contains a complete list of all equipment used.

Steelhead trout will be 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 trout have fewer spots that do not extend to the ventral side of the fish. For sampled fish, steelhead trout will be distinguished from rainbow trout through extensive saltwater growth as indicated on their scales.

Biological Sampling

Data concerning 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 based upon the 2009 in-season run size and timing. Each stratum was a calendar week consisting of seven days, in which sampling took place in a 2-3 day time period. Samples were taken in as minimal amount of time as possible and are considered a “snap shot” sample (Geiger et al. 1990). Sampling efforts for steelhead were continuous from 29 April to 16 May 2010, the live fish trap was set and checked twice daily (~10:00 P.M. and ~8:30 A.M). The sample included ASL and genetic tissue from the axillary process of 27 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. Length measurements for Chinook salmon and steelhead were taken to the nearest 5 mm from the mid-eye to fork 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 and steelhead, mounted on gummed cards, and pressed on acetate to make an impression. Chinook salmon scales were aged by the U.S. Fish and Wildlife Service (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 is achieved. Scale analysis and reporting utilize methods described by Mosher (1969). Age determinations for Chinook salmon include the number of years spent in freshwater as a juvenile and the number of years spent in saltwater as an adult. Steelhead age determinations will denote the number of years spent in freshwater as a juvenile followed by the number of years spent in salt water as an adult prior to each spawning event. Spawning events are incorporated into the reporting methods described by Mosher (1969) and are denoted using the letter "S" (e.g. 3.2S1).

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:

$$\hat{A}_{hij} = N_h \hat{p}_{hij} \qquad (1)$$

and

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

where

N_h = total escapement during stratum h;
$\hat{p}_{hij}$ = estimated proportion of age i and sex j fish in the 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:

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

and

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

Basic data summaries, scatter plots, and statistical analyses including simple linear regression were used to explore differences in Chinook salmon age composition estimates among the Kenai River sonar, sport harvest, and Funny River escapement.

Results

Weir and Video Operations

The weir and video system was installed on 29 April and operated through 6 August. Video counts began at 2000 hours on 16 May and ceased at 0900 on 6 August. The video system and weir ran smoothly during the entire operational period, with the exception of random interference of the video signal between 18 and 23 May. During this period, the video signal was scrambled between one and ten hours each day. Fish could be identified during all of the interruptions with the exception of sixteen total hours on 21 May (8 hours) and 23 May (8 hours) when the video signal was lost completely. The resulting interference during this period was due to excessive wear on the video cable which was repaired on 24 and 25 May. Fish were passed manually through the weir while the video cable was repaired and no attempt was made to estimate passage for the interrupted time intervals.

Biological Data

Steelhead. **—**A total of 60 steelhead was counted through either the video system or live fish trap in the Funny River between 29 April and 6 June (Figure 2; Appendix 2). Peak weekly passage (*N*=28) took place between 16 and 22 May (Figure 2). The highest daily count occurred on 12 May (*N*=9), whereas the median cumulative passage occurred on 17 May. The number of steelhead counted after 22 May only represented 12% (*N*=7) of the total escapement (Figure 2; Appendix 2).

Sex composition of steelhead was determined from ASL samples and review of video records. Females comprised 77% of the run and were dominant throughout the entire return (Figure 3, Appendix 2).

Chinook salmon. **—**A total of 1,187 Chinook salmon was counted through the video system and live trap at the Funny River weir between 31 May and 4 August (Figure 4; Appendix 3). Peak weekly passage (*N*=489) occurred between 20 June and 26 June. The highest daily count (*N*=265) and median cumulative passage occurred on 23 June and 5 July, respectively.

ASL samples were collected from 268 Chinook salmon between 22 June and 27 July. Two percent (*N*=6) of the sample could not be aged because of regeneration or the inability to determine freshwater or saltwater age. Female Chinook salmon age composition was composed of three age groups, ages 1.2, 1.3, and 1.4 and male age composition was composed of four age groups, ages 1.1, 1.2, 1.3, and 1.4 (Table 1). Overall, females averaged 800 mm in length and accounted for 29% (*N*=78) of the sample while males averaged 623 mm in length. Sex composition for the entire return of Chinook salmon including both ASL and video records was 31% female. Sex ratios favored males throughout most of the run (Figure 5).

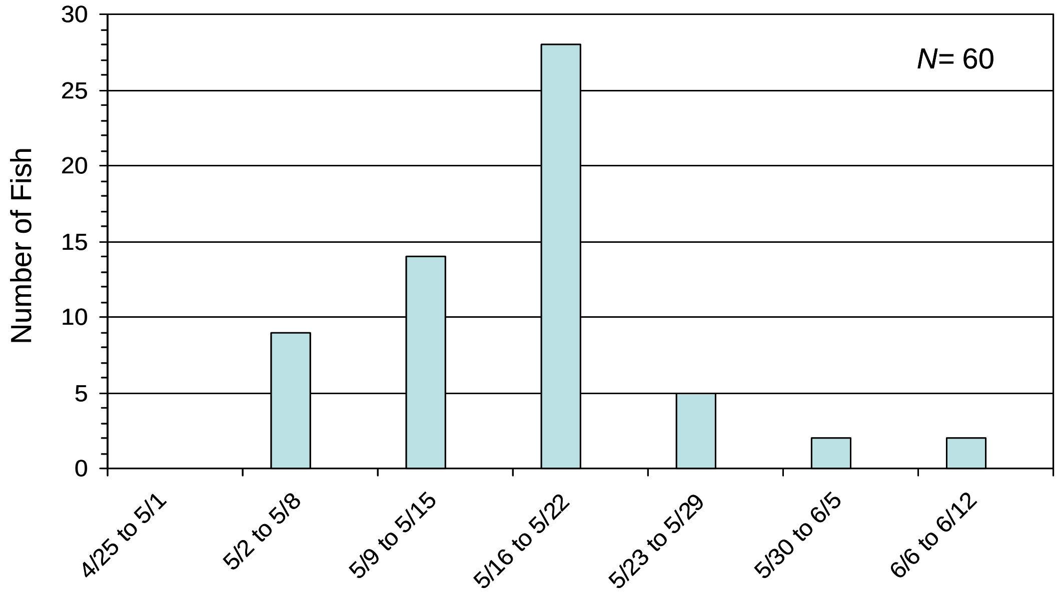

FIGURE 2. —Weekly escapement of adult steelhead passed through the Funny River weir during 2010. Counts began mid-day on 29 April and ended mid-day on 6 August.

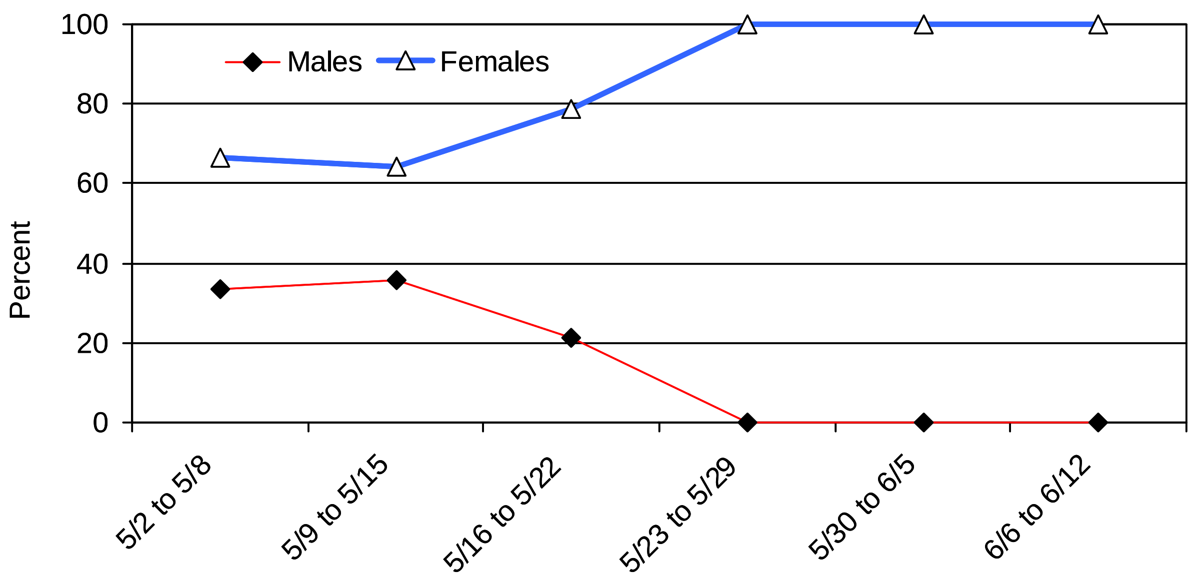

FIGURE 3. —Weekly percent of adult male and female steelhead observed during video review and ASL sampling at the Funny River weir from 29 April to 6 June 2010.

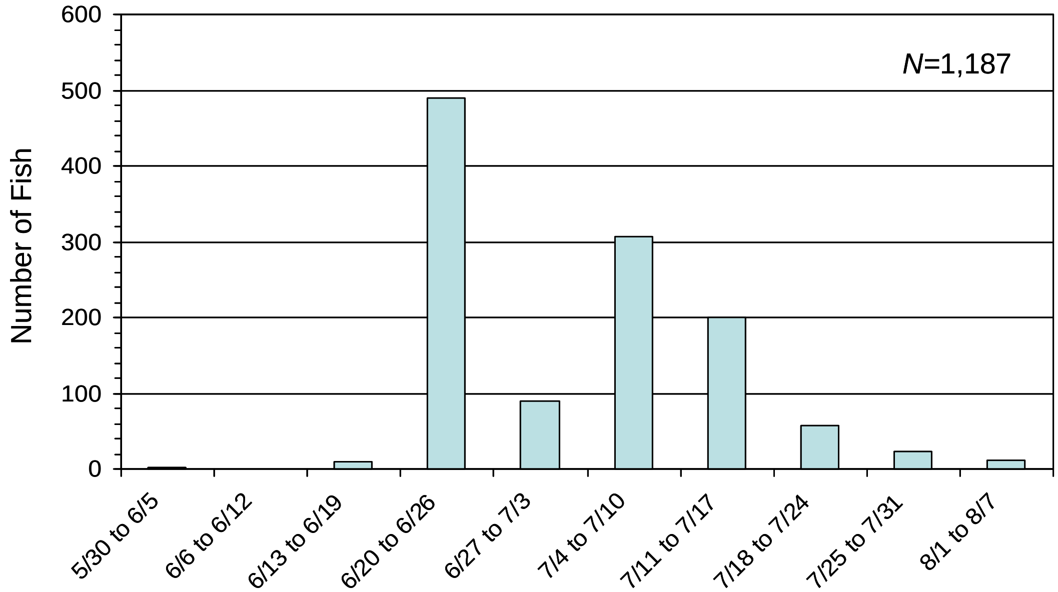

FIGURE 4. —Weekly escapement of adult Chinook salmon passed through the Funny River weir during 2010. Counts began mid-day on 29 April and ended mid-day on 6 August.

TABLE 1. —Length-at-age for adult Chinook salmon sampled at the Funny River weir during 2010.

				Mid-Eye to Fork Length		
	Sex	Age	*N* [a]	Mean	Range	Standard Error
	Female	1.2	2	590	580 - 600	10.0
		1.3	52	790	615 - 915	7.7
		1.4	24	843	755 - 920	9.6
Total			78			
	Male	1.1	16	434	340 - 515	13.5
		1.2	116	594	485 - 780	5.3
		1.3	44	720	555 - 890	11.9
		1.4	8	831	725 - 1020	35.4
Total			184			

[a] Fish with incomplete age data were omitted from this table (*N* =6)

The age and sex composition was estimated for the entire return of Funny River Chinook salmon through further data analysis and was based on the ASL sample. Most females were age 1.3 (75%) whereas most males were age 1.2 (61%; Table 2). Sex composition of the 2010 return including ASL samples and video records was estimated to be 31% female (*N*=364; Appendix 3).

The relationships were significant between the estimated age-specific sport harvest of Chinook salmon in the Kenai River and the differences in age composition between the Kenai River sonar and Funny River weir for age 1.3 (r^2 = 0.82; P = 0.02) and 1.4 (r^2 = 0.94; P = 0.004) fish, but not for age 1.2 fish (P = 0.929; Figure 6).

Other species. **—**Eight additional species of fish were observed passing the Funny River weir including 27 rainbow trout, 687 Dolly Varden *Salvelinus malma*, nine round whitefish *Prosopium cylindraceum*, one lamprey *Lampetra* sp., 17 sockeye salmon *O. nerka*, 58 pink salmon *O. gorbuscha*, one chum salmon *O. keta*, and three coho salmon *O. kisutch* (Appendix 4). Weekly passage of all non-target species is summarized in Table 3.

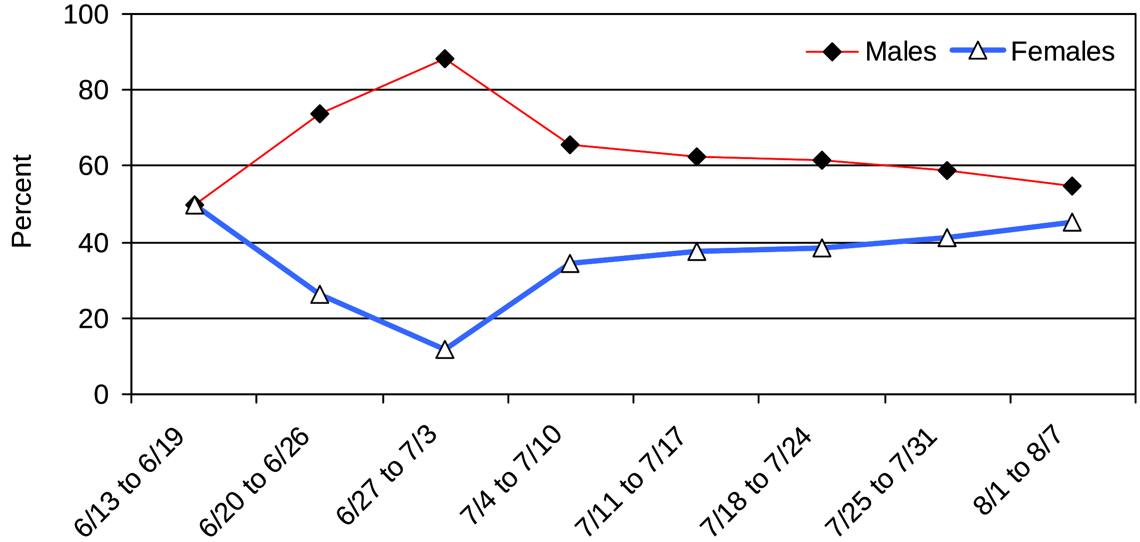

FIGURE 5. —Weekly percent of adult male and female Chinook salmon observed during video review and ASL sampling at the Funny River weir from 14 June to 6 August 2010. Escapement prior to 14 June (*N*=1) was omitted from this figure.

TABLE 2. —Age and sex composition estimated from age, sex, and length samples of Chinook salmon returning to the Funny River weir during 2010.

		Brood Year and Age Group				
		2007	2006	2005	2004	
		1.1	1.2	1.3	1.4	Total
Sample Period: 22 June to 27 July						
Female:	Number in Sample:		2	52	24	78
	% Females in Age Group:		2.6	66.7	30.8	100.0
	Estimated % of Escapement:		0.8	19.8	9.2	29.8
	Estimated Escapement:		9	236	109	353
	Standard Error:		5.6	25.9	18.7	
Male:	Number in Sample:	16	116	44	8	184
	% Males in Age Group:	8.7	63.0	23.9	4.3	100.0
	Estimated % of Escapement:	6.1	44.3	16.8	3.1	70.2
	Estimated Escapement:	72	526	199	36	834
	Standard Error:	15.5	32.2	24.2	11.2	
Total:	Number in Sample:	16	118	96	32	262
	Estimated % of Escapement:	6.1	45.0	36.6	12.2	100.0
	Estimated Escapement:	72	535	435	145	1,187
	Standard Error:	15.5	32.3	31.3	21.2	

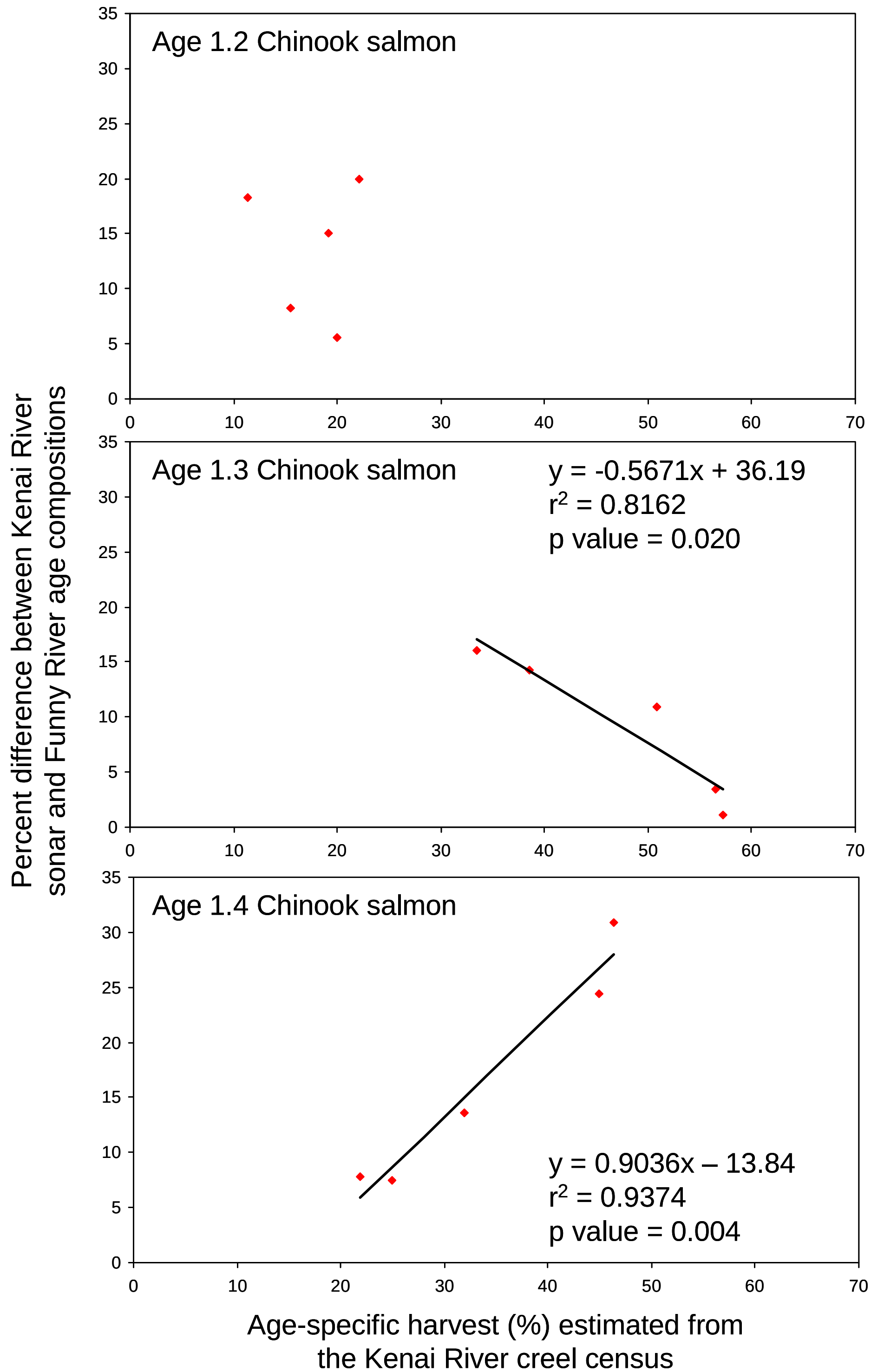

FIGURE 6. —Percent difference in age compositions between the Kenai River sonar and Funny River weir as a function of estimated age-specific sport harvest of Chinook salmon between 2006 and 2010. Percent difference values are reported as an absolute value.

TABLE 3. —Weekly passage of non-target fish species observed at the Funny River weir during 2010. Video counts began mid-day on 29 April and ended mid-day on 6 August.

Week	Rainbow Trout	Dolly Varden	Round Whitefish	Lamprey sp.	Sockeye Salmon	Pink Salmon	Chum Salmon	Coho Salmon
4/25 to 5/1	0	0	0	0	0	0	0	0
5/2 to 5/8	2	0	1	0	0	0	0	0
5/9 to 5/15	0	0	0	0	0	0	0	0
5/16 to 5/22	2	0	1	0	0	0	0	0
5/23 to 5/29	1	0	1	0	0	0	0	0
5/30 to 6/5	0	1	0	0	0	0	0	0
6/6 to 6/12	3	5	1	1	0	0	0	0
6/13 to 6/19	3	9	1	0	0	0	0	0
6/20 to 6/26	4	12	0	0	0	0	0	0
6/27 to 7/3	1	15	0	0	3	1	0	0
7/4 to 7/10	3	13	0	0	2	0	0	0
7/11 to 7/17	4	39	2	0	3	2	0	0
7/18 to 7/24	1	64	1	0	1	1	0	0
7/25 to 7/31	2	159	1	0	3	14	1	0
8/1 to 8/7	1	370	0	0	5	40	0	3
Total	27	687	9	1	17	58	1	3

Discussion

Since 2006, the return of Chinook salmon has averaged 1,680 fish and has ranged from 1,114 (2009) to 2,779 (2006) fish (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b). The escapement estimate for Chinook salmon during 2010 (N=1,187) marks the third consecutive year of below average escapements. The steelhead escapement (N=60) was approximately one-third of the returns observed during 2008 (N=184) and 2009 (N=171). Similarly, lower than expected returns were observed for other steelhead populations throughout the Kenai Peninsula during 2010, including Soldotna Creek and the Anchor River (USFWS, unpublished data). Estimates of steelhead abundance also declined during 2009 in the Kasilof River watershed (Gates et al. 2010). In addition to the lower than expected run strength, the run timing of steelhead was delayed by a minimum of one week compared to median passage dates from 2008 and 2009 (Figure 7). We suspect some of this delay could have been a result of trap operations during the ASL and genetic tissue sampling. The live trap was operated continuously between 29 April and 16 May and checked twice daily, but steelhead may have escaped the trap and returned to hold below the weir between our sampling periods. Starting on 16 May fish were allowed to pass unobstructed through the video system and the patterns of passage beyond this date were similar to previous years. We do not believe that the interruptions in the video signal between 18 and 23 May had much of an effect on the overall steelhead count because fish passage was typically low during this period in 2008 and 2009 and we were able to count fish throughout most interruptions.

The installation of the weir on 29 April was the earliest date the weir could be installed during 2010 due to ice conditions within the Funny River. Our trapping results do not indicate that the steelhead migration had begun prior to this date. However, we are skeptical and believe that we did miss some fish as indicated by the skewed female to male sex ratios (3.3:1). Observations of other steelhead populations on the Kenai Peninsula show that early stages of steelhead spawning migrations are generally comprised of males (Gates et al. 2010). However, more female steelhead than males have been observed at the Funny River weir during 2008 (69% female; Gates and Boersma 2009a) and 2009 (70% female; Gates and Boersma 2009b). Installing the weir and video system earlier would identify any early migrants and possibly a sex ratio less skewed towards females. Analysis of scale patterns to determine age compositions and spawning histories may also provide additional information pertaining to sex ratios because of differential survival rates and spawning histories for male and female steelhead. We are planning to enumerate and collect ASL and genetic tissue from steelhead returning to the Funny River during 2011. Our sample goals will be at least 50 fish throughout the entire run. We plan to modify the live trap (i.e. addition of cod fingers to prevent fish from escaping the trap) and focus our sampling effort to periods of known fish passage (i.e., between 10:00 P.M. and 2:00 A.M.) to minimize any trapping effects on run timing. The scale and genetic tissue samples will be processed by the Department and the Service's Conservation Genetics Laboratory, respectively.

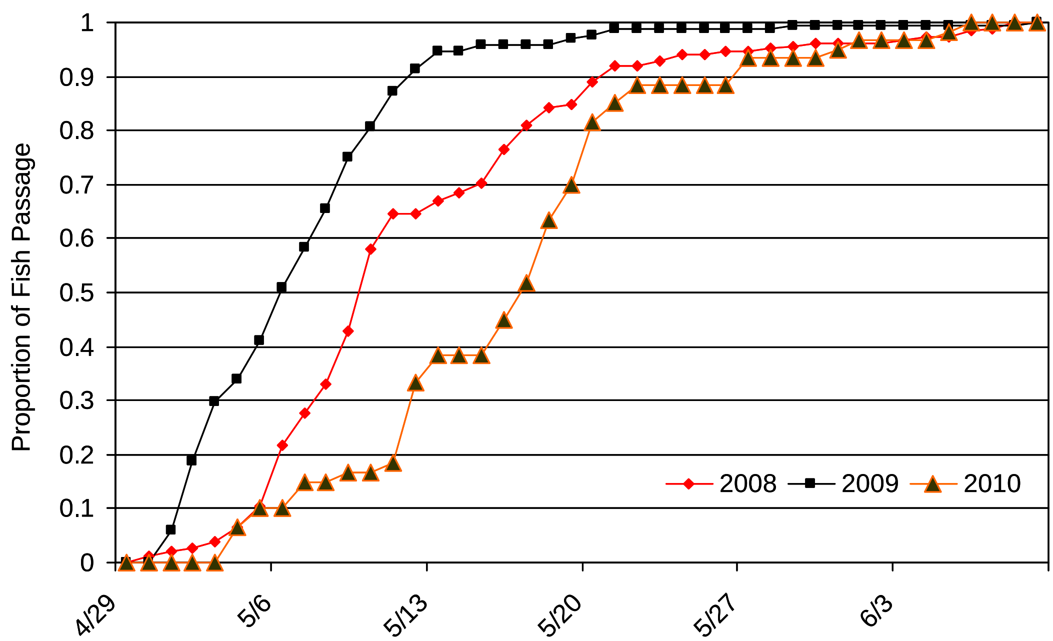

FIGURE 7 —Proportion of steelhead passage by date through the Funny River weir between 2008 and 2010.

Preliminary sonar passage and in-river harvest estimates for early-run Chinook salmon during 2010 from Warren Ames Bridge to Soldotna Bridge were 13,248 and 837, respectively (Jeff Perschbacher, Alaska Department of Fish and Game, personal communication). Based on these estimates, approximately 12,411 early-run Chinook salmon escaped the fishery below the Soldotna Bridge, but it is not yet known how many were harvested in the sport fishery above the Soldotna Bridge. Sport harvest of early-run Chinook salmon above the Soldotna Bridge is estimated using the Statewide Harvest Survey. Although this information is not yet available, the estimated annual harvest in this reach over a 21-year period (1986 to 2006) has averaged 1,618 fish. Using the current year passage estimate obtained with the sonar in the lower Kenai River and harvest estimates for early-run Chinook salmon, we estimate that approximately 11% of the early-run fish entered the Funny River to spawn. This estimate is slightly lower than the 14% average observed from 2006 to 2009 but coincides with preliminary distribution results (12%) from a radio telemetry study conducted by the Department during 2010 (Adam Reimer, Alaska Department of Fish and Game, personal communication). These estimates of contribution calculated from the Funny River weir are considered crude because the harvest above the Soldotna Bridge is currently unknown for 2010 and may differ substantially from the

21 year average based on the preliminary low in-river harvest estimate below the Soldotna Bridge during 2010. Regardless, this level of escapement into the Funny River is markedly lower than the 19% average observed from earlier radio telemetry studies conducted by the Service and Department in the early 1980's and 1990's (Burger et al. 1985; Bendock and Alexandersdottir 1991, 1992).

The reduced contribution of Chinook salmon from the Funny River to the overall Kenai River early-run escapement during 2010 could be a result of several factors including natural variations in run strength, selective harvest in the in-river sport fishery, or an overestimation of the Kenai River early-run Chinook salmon run size using sonar near rkm 13. A mixed-stock genetic analysis of harvest could describe any selective harvest that might be occurring spatially and temporally in the in-river sport fishery. The Department is currently developing a genetic baseline for Chinook salmon in the Kenai River watershed to address this and other management concerns. To date, nine spawning populations of Chinook salmon within the Kenai River drainage have been sampled for genetic tissue of which four main groups of fish can be identified based on geography, behavior, and genetics – 1) lower Kenai River tributaries (Funny River and Slikok Creek), 2) Kenai River mainstem, 3) Killey River and Benjamin Creek, and 4) Quartz Creek (Begich et al. 2010). Based on these reporting groups, simulations of mixed-stock analysis were run with a 94% success rate. Success rates for assigning samples back to individual spawning groups was much lower and varied among populations. Chinook salmon sampled from Funny River had the second highest correct mean allocation rate of 90.7% (Begich et al. 2010).

Several issues pertaining to the split-beam sonar estimates remain unresolved; most important is the inability to distinguish sockeye salmon from Chinook salmon, especially during times of high sockeye salmon passage (Miller et al. 2010). To address this concern, the Department plans to continue the use and testing of two Dual-Frequency Identification Sonar (DIDSON™) units in 2011, one on each bank at their existing sonar site at rkm 13 (Robert Begich, Alaska Department of Fish and Game, personal communication). The DIDSON™ technology is expected to aid in the identification of multiple species because it operates at two different frequencies and produces high-definition images that may allow discrimination of larger Chinook salmon from smaller salmon species (Burwen et al. 2007).

Age, sex, and length information was collected from Funny River Chinook salmon between 22 June and 27 July. Our sample strategy coincided with the observed Chinook salmon run. We feel that the identified age groups accurately represent the ages of Chinook salmon present in the Funny River during 2010. Similar percentages of females were observed through video review and with the ASL samples, 31% and 30%, respectively. Overall, after combining the ASL sample and video records, we feel that the estimated sex composition of 31% females is accurate and is similar to sex compositions observed at the Funny River weir between 2006 and 2009 (Gates and Palmer 2007, 2008; Gates and Boersma 2009a, 2009b).

Chinook salmon of like ages were identified in both the Kenai River sonar and Funny River ASL samples during 2010; however, dissimilar age proportions were observed (Table 4). The most prominent differences occur between the estimated proportion of age 1.2 and 1.4 fish. Similar consistent results were also observed from 2006 to 2009 (Appendix 5) and could be partially explained by selective harvest in the in-river sport fishery. As sport harvest increases for age 1.4 Chinook salmon, the difference in age compositions for age 1.4 fish increases between the Kenai River sonar and Funny River (Figure 6; Table 4; Appendix 5). This has resulted in a 17%

reduction on average of age 1.4 Chinook salmon in the Funny River between 2006 and 2010 when compared to the age composition estimated at the Kenai River sonar. This is a strong indication that the current sport harvest of Chinook salmon in the lower Kenai River is affecting the age and sex composition of spawning fish returning to the Funny River (Table 4; Appendix 5). However, stock-specific age compositions need to be determined for Chinook salmon at the Kenai River sonar site (pre-harvest) and in the sport harvest in order to verify any differences between unique spawning stocks. Lacking this information, we assume age compositions of all spawning stocks are equal and sport harvest should be comprised of fewer age 1.4 Chinook salmon and greater numbers of age 1.2 and 1.3 fish in order to maintain age compositions observed at the Kenai River sonar in the Funny River and other locations (Figure 7).

TABLE 4. —Estimated age composition of adult early-run Chinook salmon from the Funny River weir, Kenai River sonar and Kenai River creel survey during 2010.

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

[a] Jeff Perschbacher, Alaska Department of Fish and Game, personal communication.

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 early-run Chinook salmon and a conservative estimate for 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 are planning to continue operating the video weir during 2011 and will use the run timing observed between 2006 and 2010 to determine our ASL sampling strategy for Chinook salmon during 2011. We intend to collect genetic tissue and ASL samples from at least 50 adult steelhead returning to the Funny River weir in 2011. 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. Currently, Funny River Chinook salmon escapement data are being used by the Department to improve accuracy and precision of Kenai River early-run Chinook salmon abundance estimates.

Acknowledgements

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APPENDIX 1. —List of video equipment used to monitor Chinook salmon and steelhead abundance and run timing in the Funny River during 2010.

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 2010. Boxed areas represent the second and third quartile and median passage dates. 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
4/29	0	0	0	0	0.0000
4/30	0	0	0	0	0.0000
5/1	0	0	0	0	0.0000
5/2	0	0	0	0	0.0000
5/3	0	0	0	0	0.0000
5/4	2	2	4	4	0.0667
5/5	0	2	2	6	0.1000
5/6	0	0	0	6	0.1000
5/7	1	2	3	9	0.1500
5/8	0	0	0	9	0.1500
5/9	0	1	1	10	0.1667
5/10	0	0	0	10	0.1667
5/11	1	0	1	11	0.1833
5/12	2	7	9	20	0.3333
5/13	2	1	3	23	0.3833
5/14	0	0	0	23	0.3833
5/15	0	0	0	23	0.3833
5/16	1	3	4	27	0.4500
5/17	1	3	4	31	0.5167
5/18	1	6	7	38	0.6333
5/19	1	3	4	42	0.7000
5/20	2	5	7	49	0.8167
5/21	0	2	2	51	0.8500
5/22	0	2	2	53	0.8833
5/23	0	0	0	53	0.8833
5/24	0	0	0	53	0.8833
5/25	0	0	0	53	0.8833
5/26	0	0	0	53	0.8833
5/27	0	3	3	56	0.9333
5/28	0	0	0	56	0.9333
5/29	0	0	0	56	0.9333
5/30	0	0	0	56	0.9333
5/31	0	1	1	57	0.9500
6/1	0	1	1	58	0.9667
6/2	0	0	0	58	0.9667
6/3	0	0	0	58	0.9667
6/4	0	0	0	58	0.9667
6/5	0	1	1	59	0.9833
6/6	0	1	1	60	1.0000
Total	14	46	60		

APPENDIX 3. —Daily counts of adult Chinook salmon observed at the Funny River weir during 2010. Boxed areas represent the second and third quartile and median passage dates. Shaded areas represent periods when fish trap was operated for age, sex, and length sampling.

Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
5/31	0	1	1	1	0.0008
6/1	0	0	0	1	0.0008
6/2	0	0	0	1	0.0008
6/3	0	0	0	1	0.0008
6/4	0	0	0	1	0.0008
6/5	0	0	0	1	0.0008
6/6	0	0	0	1	0.0008
6/7	0	0	0	1	0.0008
6/8	0	0	0	1	0.0008
6/9	0	0	0	1	0.0008
6/10	0	0	0	1	0.0008
6/11	0	0	0	1	0.0008
6/12	0	0	0	1	0.0008
6/13	0	0	0	1	0.0008
6/14	1	1	2	3	0.0025
6/15	0	0	0	3	0.0025
6/16	0	1	1	4	0.0034
6/17	2	1	3	7	0.0059
6/18	0	1	1	8	0.0068
6/19	2	1	3	11	0.0093
6/20	2	0	2	13	0.0110
6/21	0	0	0	13	0.0110
6/22	8	6	14	27	0.0229
6/23	196	69	265	292	0.2475
6/24	88	31	119	411	0.3483
6/25	63	17	80	491	0.4161
6/26	6	3	9	500	0.4237
6/27	9	3	12	512	0.4339
6/28	6	3	9	521	0.4415
6/29	16	2	18	539	0.4568
6/30	14	1	15	554	0.4695
7/1	8	0	8	562	0.4763
7/2	11	5	16	578	0.4890
7/3	11	1	12	590	0.4992
7/4	3	0	3	593	0.5017
7/5	3	0	3	596	0.5051
7/6	58	21	79	675	0.5720
7/7	50	36	86	761	0.6449
7/8	5	0	5	766	0.6492
7/9	28	10	38	804	0.6805
7/10	59	34	93	897	0.7593
7/11	16	6	22	919	0.7780
7/12	27	20	47	966	0.8178
7/13	18	7	25	991	0.8390

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Date	Male	Female	Daily Total	Daily Cumulative	Cumulative Proportion
7/14	41	37	78	1069	0.9006
7/15	9	4	13	1082	0.9115
7/16	2	3	5	1087	0.9158
7/17	6	4	10	1097	0.9242
7/18	14	6	20	1117	0.9410
7/19	5	5	10	1127	0.9495
7/20	4	0	4	1131	0.9528
7/21	9	6	15	1146	0.9655
7/22	1	3	4	1150	0.9688
7/23	3	1	4	1154	0.9722
7/24	0	0	0	1154	0.9722
7/25	4	3	7	1161	0.9781
7/26	2	0	2	1163	0.9798
7/27	3	3	6	1169	0.9848
7/28	2	1	3	1172	0.9874
7/29	1	2	3	1175	0.9899
7/30	1	0	1	1176	0.9907
7/31	0	0	0	1176	0.9907
8/1	3	3	6	1182	0.9958
8/2	3	0	3	1185	0.9983
8/3	0	1	1	1186	0.9992
8/4	0	1	1	1187	1.0000
Total	823	364	1187		

APPENDIX 4. —Daily counts of non-target fish species passing through the Funny River weir during 2010. Shaded areas represent periods when the fish trap was operated for age, sex, and length sampling of Chinook salmon and steelhead.

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

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APPENDIX 4. —(Page 2 of 3)

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

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APPENDIX 4. —(Page 3 of 3)

Date	Rainbow Trout	Dolly Varden	Round Whitefish	Lamprey sp.	Sockeye Salmon	Pink Salmon	Chum Salmon	Coho Salmon
7/26	0	16	0	0	0	0	0	0
7/27	1	9	0	0	1	2	0	0
7/28	0	40	0	0	1	3	0	0
7/29	0	41	0	0	0	4	0	0
7/30	0	39	1	0	0	3	1	0
7/31	0	38	0	0	0	10	0	0
8/1	0	26	0	0	1	4	0	0
8/2	1	49	0	0	0	13	0	0
8/3	0	47	0	0	0	6	0	1
8/4	0	61	0	0	0	5	0	2
8/5	0	83	0	0	4	2	0	0
8/6	0	66	0	0	0	0	0	0
Total	27	687	9	1	17	58	1	3

APPENDIX 5. —Age compositions of early-run Chinook salmon estimated for the Kenai River sonar passage estimate, Funny River escapement, and Kenai River harvest between Warren Ames and Soldotna bridges from 2006 to 2009.

	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%			

[a] U.S. Fish and Wildlife Service, unpublished data.
[b] Eskelin 2009.
[c] Gates and Palmer 2008a.
[d] Eskelin 2010.
[e] Gates and Boersma 2009a.
[f] Jeff Perschbacher, Alaska Department of Fish and Game, personal communication.
[g] Gates and Boersma 2009b.