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Run Timing, Abundance, and Distribution of Adult Coho Salmon in the Kasilof River Watershed, Alaska, 2008

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Kenneth S. Gates[1], Douglas E. Palmer[1], and Jeffrey F. Bromaghin[2]

Abstract

Run timing, abundance, and distribution information was collected on coho salmon *Oncorhynchus kisutch* in the upper Kasilof River watershed during 2008 using fish weirs equipped with underwater video systems and radio telemetry. A combined total of 1,315 coho salmon was counted past the Nikolai (*N*=721) and Shantatalik (*N*=594) creek weirs between 27 August and 2 November. Peak weekly passage occurred between 7 and 13 September for both creeks. Radio-transmitters were implanted in 240 coho salmon captured in the Kasilof River between 18 August and 13 October. Seventy-two percent (*N*=144) of the radio-tagged coho salmon designated as spawners (*N*=200) selected locations in the study area upstream of the Kenai National Wildlife Refuge boundary at Silver Salmon Rapids (rkm 24). Of those fish, 94 spawned in the upper mainstem Kasilof River and 50 selected spawning locations in tributaries of Tustumena Lake. Tustumena Lake tributary streams included Shantatalik (*N*=6), Nikolai (*N*=4), Indian (*N*=20), Fox (*N*=1), West (*N*=9), Glacier (*N*=9) and Clear (*N*=1) creeks. Other radio-tagged fish spawned outside the study area in Crooked Creek (*N*=9), Coal Creek (*N*=1) and the mainstem Kasilof River downstream of the refuge boundary (*N*=46). All remaining radio-tagged fish (*N*=40) were determined to not have spawned and were classified as "Dead/Regurgitated", "Harvested", "Back Out", or "Unknown".

Introduction

The Kasilof River watershed provides spawning and rearing habitat for Chinook *Oncorhynchus tshawytscha*, coho *O. kisutch*, sockeye *O. nerka*, and pink salmon *O. gorbuscha* (Johnson and Daigneault 2008). Sockeye salmon are targeted primarily by commercial fisheries in Cook Inlet and have been the focus of numerous research, enhancement, and assessment projects within the Kasilof River watershed for nearly 30 years (Kyle 1992; Burger et al. 1995, 1997; Finn et al. 1997; Woody et al. 2000; Shields 2006). Conversely, little research and monitoring effort has been directed toward understanding coho salmon within the watershed.

Coho salmon return to the Kasilof River beginning in late July. Returns to Crooked Creek, a lower Kasilof River tributary, were monitored by the U.S. Fish and Wildlife Service (Service) and the Alaska Department of Fish and Game (Department) using a weir between 2004 and 2007. Estimates of annual escapement during this period ranged from 2,756 to 5,703 fish (U.S. Fish and Wildlife Service and Alaska Department of Fish and Game, unpublished data). Coho salmon begin returning to Crooked Creek in early August and the run peaks in early September. Most fish passed the weir by early October. Monitoring efforts prior to 2007 for coho salmon in the upper Kasilof River watershed were limited to ground and aerial survey counts in Tustumena Lake tributaries (Faurot and Jones1990;

Authors: [1]U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, 43655 Kalifornsky Beach Road, Soldotna, Alaska, 99669; [2]U.S. Geological Survey, Marine and Freshwater Ecology Branch, 4210 University Drive, Anchorage, Alaska, 99508.

Palmer and Gates 2007). Coho salmon were observed by Faurot and Jones (1990) in four of the eleven streams surveyed during 1987: Pipe, Indian, Glacier, and Seepage creeks. Index counts for all streams during 1987 were less than 50 fish, except for Indian Creek which had a peak count of 931 coho salmon on 9 November. Similar results were observed during ground and aerial surveys conducted for the same streams in 2006 by Palmer and Gates (2007). Coho salmon were found in only three streams during 2006: Glacier, Indian, and Shantatalik creeks. Peak counts during 2006 occurred between 17 and 30 October and ranged from 44 to 195 coho salmon. The greatest numbers were observed in Indian Creek. Coho salmon are also known to be present in Fox and Nikolai creeks (Johnson and Daigneault 2008), but were not observed in surveys conducted during 1987 or 2006. More recently in 2007, weirs equipped with underwater video systems and radio telemetry were used to further describe the run timing, abundance, and distribution of coho salmon in the upper Kasilof River watershed. Weirs were installed and operated in Nikolai and Shantatalik creeks to enumerate coho salmon between 4 August and 16 November (Palmer et al. 2008). A total of 1,556 coho salmon was counted past the Nikolai (N=837) and Shantatalik (N=719) creek weirs between 19 August and 15 November. Peak counts were observed between 16 and 22 September for both creeks. Results from radio-tagging identified four spawning locations in the upper Kasilof River watershed which included the mainstem Kasilof River, and Nikolai, Shantatalik, and Indian creeks.

Coho salmon returning to the Kasilof River watershed are harvested primarily in sport and personal use fisheries. Annual sport harvest in the Kasilof River has averaged 3,185 coho salmon between 1996 and 2003 (Howe et al. 2001a-d; Jennings et al. 2004, 2006a, 2006b; Walker et al. 2003). During the same period, estimated harvest of coho salmon in the personal use dip net fishery has averaged 625 fish annually (Reimer and Sigurdsson 2004). Harvest of coho salmon in federal subsistence fisheries has been minimal to date, but could increase in the near future. Ninilchik residents were granted a customary and traditional use designation for salmon, trout, Dolly Varden and other char on federal waters within the Kasilof River watershed by the Federal Subsistence Board in January 2006. In addition, new regulations implemented during 2007 and 2008 expanded the methods and means, seasons, and harvest limits for coho salmon and other fish species in the federal subsistence fisheries. These regulations include the use of a fish wheel to harvest salmon in the upper Kasilof River, but the organization approved to operate the fish wheel has not yet completed its construction.

The development of federal subsistence fisheries in the Kasilof River watershed has created a need for more detailed information on the abundance and distribution of coho salmon. To address this need, fish weirs equipped with underwater video systems and radio telemetry were used to estimate the abundance and run-timing of adult coho salmon in two tributaries of Tustumena Lake and to identify additional spawning areas upstream of the Kenai National Wildlife Refuge (Refuge) boundary at Silver Salmon Rapids. Project objectives during 2008 were to (1) determine the abundance and run-timing of adult coho salmon entering Nikolai and Shantatalik creeks, (2) identify the ultimate spawning destination upstream of Silver Salmon rapids (rkm 24), via the presence of at least one tagged fish, of a population comprising 5% or more of all the coho salmon passing the capture site during each temporal stratum with probability 0.95, (3) test the hypothesis that the distributions of spawners among temporal strata are equal, and (4) estimate the abundance of each identified spawning component upstream of Silver Salmon rapids using a maximum likelihood estimator. This report will document results for the first three objectives, while results for the fourth objective will be published in a separate report. Information collected from this project will provide fisheries managers with a better understanding of spawning distribution and abundance for coho salmon throughout the upper Kasilof River watershed.

Study Area

The Kasilof River drains a watershed of 2,150 km^2 of mountains, glaciers and forests, making it the second largest watershed on the Refuge. The Kasilof River is 31 km long and drains Tustumena Lake, the Kenai Peninsula's largest lake, which has a surface area of 29,450 hectares, a maximum depth of 287 m, and a mean depth of 124 m. All tributary streams in the watershed that drain refuge lands enter Tustumena Lake except Crooked Creek (Figure 1). Several species of fish use this watershed for spawning and rearing habitat (Johnson and Daigneault 2008), including Chinook, coho, sockeye, and pink salmon, rainbow/steelhead trout *O. mykiss*, Dolly Varden *Salvelinus malma*, lake trout *S. namaycush*, and round whitefish *Prosopium cylindraceum*.

Nikolai Creek enters the south shore of Tustumena Lake approximately 8 km SE of the lake outlet (60° 11.43'N and 151° 0.36'W; NAD83). Its watershed is approximately 95 km^2 and falls within the Refuge boundary and a designated wilderness area (Moser 1998). Nikolai Creek has a relatively steep gradient, low sinuosity, and predominately cobble substrate.

Shantatalik Creek is a tributary on the north shore of Tustumena Lake (60°17.54'N and 150°59.12'W; NAD83), approximately 12 km NE of the lake outlet (Figure 1). The creek is approximately 7 km long and can be described as having low gradient, moderate sinuosity, and a mixture of gravel and mud substrate. Shantatalik Creek provides spawning habitat for coho and sockeye salmon (Johnson and Daigneault 2008).

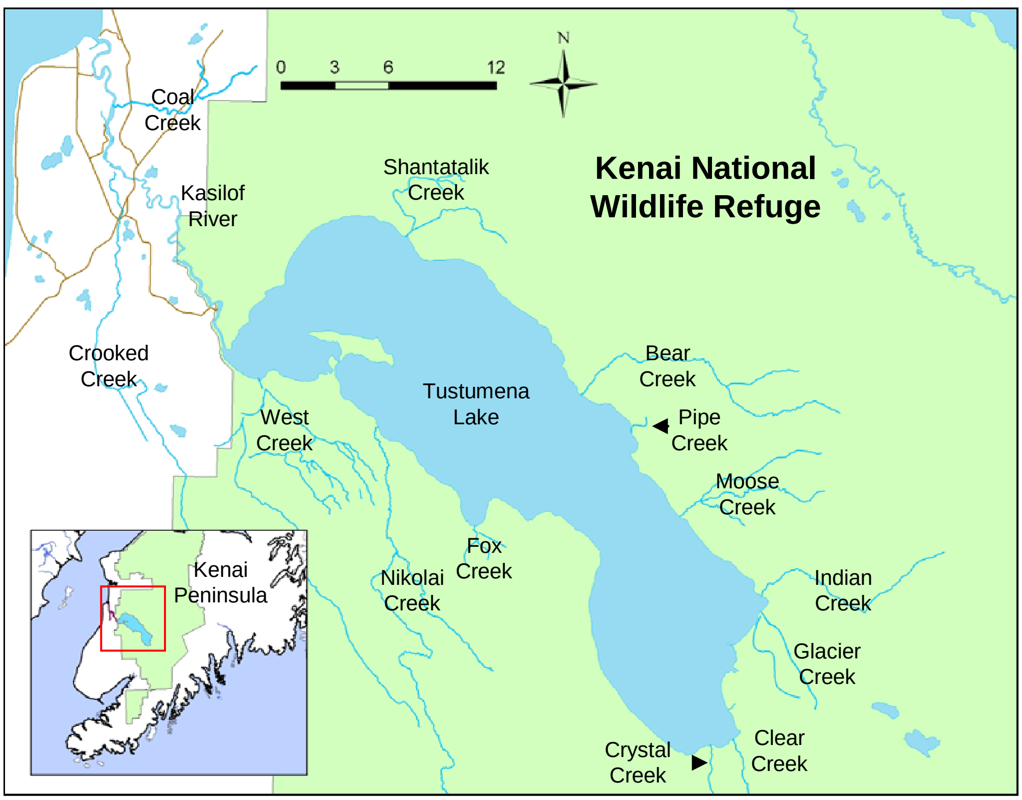

FIGURE 1.—Map of the Kasilof River watershed.

Methods

Weir and Video Operations and Design

Weirs equipped with video systems were operated in Nikolai and Shantatalik creeks to determine the abundance and run-timing of coho salmon (Figure 2). Both weirs were installed by 28 August. The weir in Nikolai Creek was operated through 23 October, and the weir in Shantatalik Creek was operated through 4 November.

The Nikolai Creek weir has been used since 2005 to enumerate steelhead trout during the spring season. This weir is approximately 200 m upstream from Tustumena Lake and is constructed using a combination of floating resistance board panels (Tobin 1994) and flexible-picket panels (Gates and Palmer 2004). The floating resistance board panels are constructed using specifications outlined by Tobin (1994), with minor changes to some materials, panel width, and resistance boards. The panels are attached to a steel rail anchored to the river bottom and are configured to pass fish near the deepest part of the channel through a fish passage panel. The flexible-picket panels are installed between the banks and bulkheads of the resistance board weir to create a fish-tight weir. The flexible-picket panels are constructed from 2.5-cm inside diameter polyvinyl chloride (PVC) electrical conduit. Panel dimensions are 3-m long by 1.5-m high with 1.9-cm spacing between pickets. Panels are held together by 3-mm stainless wire rope. The weir was unmanned, except when maintenance was required, and outfitted with a video and microwave system.

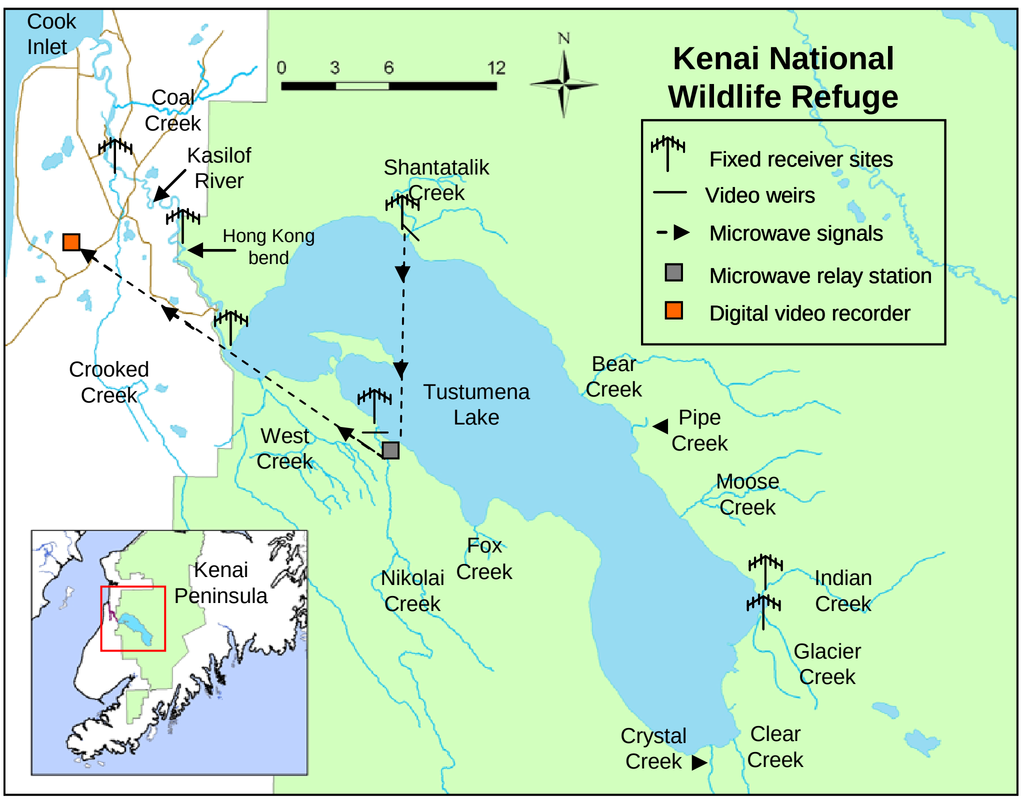

FIGURE 2.—Map of the Kasilof River watershed illustrating the locations of the fixed receivers, microwave relay station and transmission routes, video weirs, and the location of the digital video recorder during 2008.

A rigid picket weir was installed on Shantatalik Creek approximately 100 m upstream from Tustumena Lake. The creek is approximately 4-m wide at the weir site. The weir framework consisted of several pieces of 6.4-cm aluminum angle bolted together forming a self-standing frame. The weir pickets were made from 25-mm schedule 40 aluminum pipe. Each picket measured 1.8-m in length and attached to the frame by individually sliding through 28.6-mm holes drilled in two 6-m pieces of aluminum angle bolted to the front of the weir frame. Weir pickets were spaced 3.2 cm apart. Like Nikolai Creek, the weir was unmanned and outfitted with a video and microwave system.

Setup and design of the video systems used to monitor fish passage is described by Gates and Palmer (2006) and was similar to that used by Anderson et al. (2004) on Big Creek during 2003. 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 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 video 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 limit the number of fish passing through the chute at one time. The backdrop could be easily removed from the video chute when dirty and replaced with a new one. The video box and fish passage chute were artificially lit using a pair of 12-V underwater pond lights equipped with 10-W bulbs. This system provided a consistent light source during day and night hours and allowed recording of good quality images.

Video images from the Nikolai Creek weir site were transmitted via a 2.4 GHz microwave frequency signal to a digital video recorder (DVR) located at a private residence near the Sterling Highway. A combination of 1.8 and 2.4 GHz microwave transmitters were used at Shantatalik Creek because a relay station was necessary to transmit the video images from the creek to the DVR (Figure 2). The relay station was co-located with the Nikolai Creek microwave equipment. Microwave transmission of video signals reduced the power requirements at each remote site and allowed the field crew to remotely monitor fish passage. A pair of 80-W solar panels wired in parallel and one 54-W thermoelectric generator (TEG) provided power to four 400 Ah 6-volt batteries wired in series and parallel at each weir site. The batteries supplied 12-VDC power to the underwater camera, microwave transmitter, and underwater pond lights at Shantatalik Creek and only to the underwater pond lights at Nikolai Creek. One additional 80-W solar panel and two 100 Ah 12-V batteries powered the underwater camera and microwave equipment located on a hill near Nikolai Creek. All video images were recorded on a removable 500 gigabyte hard drive at 20 frames-per-second using a computer-based DVR. Fish passage was recorded 24 hours per day seven days each week. Stored video files were generally reviewed every two or three days. The DVR was equipped with motion detection to reduce the amount of blank video footage and review time. Appendix 1 provides a list of video and microwave equipment model numbers and manufacturers used with the project.

Radio Telemetry

Radio telemetry was used to uniquely identify and track individual coho salmon. Movements of radio-tagged coho salmon were documented using a combination of fixed data-logging receiver stations located throughout the Kasilof River watershed and mobile tracking using boats and fixed-wing aircraft.

Fish Capture.—Drift gillnets were actively fished between rkm 15 and 24 to capture coho salmon for radio tagging (Figure 3). Methods for deploying gillnets were similar to those used to capture coho salmon for radio telemetry studies in the Holitna, Kenai, and Kasilof rivers (Chythlook and Evenson 2003; Carlon and Evans 2007; Palmer et al. 2008). A three person crew would deploy a single gillnet using a 5.5-m boat. One crew member piloted the boat while two crewmembers positioned on the bow of the boat tended the net. Gillnets had 11.4-cm stretched mesh constructed from Miracle® (MS-30) brand twisted nylon webbing. Each gillnet fished was 12.2-m long and 29 meshes deep. Drift gillnets were fished until either the end of the fishing area was reached or a fish became entangled in the net. Once a fish became entangled in the net, the net was immediately pulled from the water. The portion of net containing the fish was placed in a large tote filled with river water, and the fish was disentangled or cut from the net. Once freed from the net, the condition of each coho salmon was examined and, based on physical appearance; it was either released or fitted with a radio-tag. Each tagged fish was immediately placed in a submerged fish cradle to measure its mid-eye to fork length. These methods were used to reduce stress associated with capture and handling.

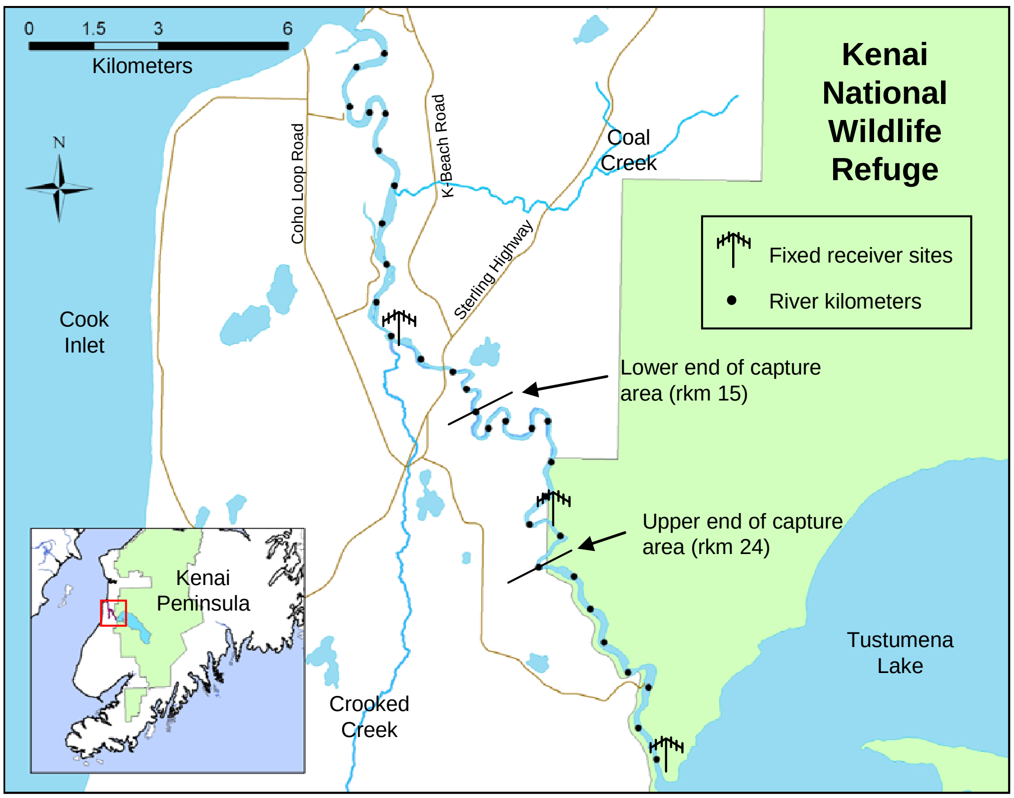

FIGURE 3.—Map of the Kasilof River illustrating the fixed receiver locations and fish capture area during 2008.

Radio Tagging.—Coho salmon were radio-tagged using radio transmitters developed by Lotek Wireless Incorporated®. Each radio transmitter (Model SR-M 16-25) measured 16 x 51 mm, was digitally encoded, equipped with a motion sensor, and outfitted with a 1,100-d battery which was programmed to shut off after 200 days. These radio transmitters were similar to those used by Ramstad and Woody (2003) when they examined transmitter retention and tag-related mortality in adult sockeye salmon. Each transmitter weighed 17 g in air and did not exceed 2% of the fish's body weight (Winter 1983). Radio transmitters were dispersed over eight radio frequencies between 162 and 166 MHz. Radio transmitters were gastrically implanted through the esophagus using methods similar to Burger et al. (1985). Radio-tagged fish were immediately released into the river after the tagging process.

Radio transmitters were scheduled to be deployed every other day over four 15-d strata between 17 August and 15 October (Table 1). Eight to nine radio transmitters were to be deployed during each tagging event and if the daily allocation was not met, the remaining tags were deployed the following day. Deploying radio transmitters every other day in a systematic fashion reduced the possibility of disproportionately representing a single group of fish moving through the tagging area. We assumed that 17 August to 15 October would encompass nearly the entire migration past Silver Salmon Rapids (rkm 24) based on previous radio-tagging by Palmer et al. (2008) during 2007. We also assumed that (1) capture and tagging of coho salmon did not cause them to change their ultimate spawning locations, (2) fish destined for the various spawning locations had an equal probability of capture within each stratum, and (3) tagged fish behaved independently. Sixty radio transmitters were allocated to each of the four strata to satisfy the criteria of Objective 2 using a multinomial probability model (Agresti 2002) of spawning distribution.

TABLE 1.—Schedule for deploying radio transmitters in coho salmon during 2008.

Strata 1		Strata 2		Strata 3		Strata 4	
Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation
18-Aug	9	2-Sep	9	16-Sep	9	1-Oct	9
20-Aug	9	4-Sep	9	18-Sep	9	3-Oct	9
22-Aug	9	6-Sep	9	20-Sep	9	5-Oct	9
24-Aug	9	8-Sep	9	22-Sep	9	7-Oct	9
26-Aug	8	10-Sep	8	24-Sep	8	9-Oct	8
28-Aug	8	12-Sep	8	26-Sep	8	11-Oct	8
30-Aug	8	14-Sep	8	28-Sep	8	13-Oct	8
Total	60		60		60		60

Radio Tracking.—Radio telemetry receivers manufactured by Lotek Wireless Incorporated® were used for all mobile and fixed station tracking. Fixed receiver stations were used to automatically identify and record fish movements at the mouths of Nikolai, Glacier, Indian, Shantatalik and Crooked creeks, the lake outlet, and Hong Kong bend (rkm 22.5) (Figure 2). Fixed receiver stations were similar to those used on the Kenai River to monitor rainbow trout movements (Palmer 1998). Each station was a strongbox and antenna mast comprised of a single data-logging receiver, two Yagi antennas, antenna switch box, three 12-V deep cycle batteries, solar panel, and voltage regulator. Mobile boat tracking was conducted each week from early September through mid November on the Kasilof River between the lake outlet and tidewater. Aerial surveys were conducted once during September, October, and December and twice during November using a PA-18 and Cessna 185 fixed-wing aircraft. Aerial surveys were conducted at approximately 300-400 m above ground for each tributary stream and the perimeter of Tustumena Lake. A portable global positioning system (GPS) was used during all mobile tracking surveys to accurately identify the latitude and longitude of each located fish.

Data Analysis

Daily counts of coho salmon passing the video weirs on Nikolai and Shantatalik creeks were entered into an Excel® spreadsheet to track the abundance and run-timing in each stream. Sex composition was estimated from external characteristics during the review of video records. Radio telemetry information collected with the various tracking methods was integrated into one Excel® database to archive the location and date for each encounter, as well as the fate of each radio-tagged coho salmon. Locations were recorded as latitude and longitude coordinates (WGS84) and displayed on a geographic coverage of the Kasilof River watershed using ArcMap® software.

Each radio-tagged fish was assigned one of seven possible fates based on information collected from mobile and fixed radio receivers (Table 2). The collection of tagged fish known to enter the study area, any water upstream of rkm 24, constituted the sample for purposes of estimating spawning distribution from each stratum. Fish assigned a fate of harvested or dead/regurgitated were censored from the sample. Fish whose spawning location could not be determined with reasonable certainty were placed into an unknown category.

Spawning locations were defined based on the tracking results. A tagged fish that migrated to a particular location and remained in the area for an extended period of time without activating the mortality sensor was considered to have identified a potential spawning location. Potential spawning locations are considered to be the tributaries to Tustumena Lake and the Kasilof River mainstem between the lake and rkm 24.

TABLE 2.—Possible fates of radio-tagged coho salmon in the Kasilof River watershed during 2008.

Fate	Description
Tributary Spawner	A fish that spawns in a tributary to Tustumena Lake.
Mainstem Spawner	A fish that spawns in the Kasilof River upstream of rkm 24.
Other Spawner	A fish that spawns in waters below rkm 24.
Dead/Regurgitated	A fish that did not complete its spawning migration because it has either died or regurgitated its radio transmitter.
Harvested	A fish that is harvested in either subsistence or sport fisheries.
Back Out	A fish that has dropped out of the Kasilof River watershed.
Unknown	A fish that has a loss of contact with mobile or fixed radio receivers or cannot be assigned another fate with reasonable certainty.

The assumption that coho salmon destined for the various spawning locations had an equal probability of capture within each stratum was tested using chi-square tests of homogeneity (Greenwood and Nikulin 1996). Given the relatively small stratum sample size and the potential existence of small spawning aggregations, the stratum-by-location contingency table was expected to be sparse and the distribution of the Pearson test statistic for a test of homogeneity may not be well approximated by a chi-square distribution. For that reason, an exact chi-square test (Agresti 2002) was conducted using the function "chisq.test" of R version 2.9.0 (RDCT 2009), with 100,000 replications to estimate test significance.

Methods used to determine the abundance of each spawning component, based on the results of radio telemetry findings and information collected at each weir location using a maximum likelihood estimator, will be reported in a separate publication.

Results

Weir and Video Operations

The weir and video systems at Nikolai and Shantatalik creeks were installed on 26 and 28 August and operated through 23 October and 4 November, respectively. Both weirs and video systems were installed before large numbers of coho salmon entered either stream. Each video system functioned well except for periodic interruptions caused by flooding events and power failures. High water periodically rendered the Nikolai Creek weir inoperable on 11, 14, and 15 September. Low voltage in batteries supplying power to parts of the video system at Nikolai Creek and the microwave relay station resulted in a loss of video from both sites sporadically during September and October. The low voltage in batteries was a direct result of decreased sunlight during the fall period.

Biological Data

A total of 721 coho salmon was counted passing the video system at Nikolai Creek between 27 August and 22 October (Figure 2; Appendix 2). The total escapement estimate did not include 41 coho salmon that passed downstream through the video system. Peak weekly passage (*N*=367) occurred between 7 and 13 September, and the median cumulative passage date was 9 September. The highest daily count (*N*=348) also occurred on 9 September. The number of coho salmon counted after 30 September only represented 8% (*N*=60) of the total escapement.

Sex was visually estimated for all but two of the coho salmon counted on Nikoli Creek video recordings. Overall about 48% of the total coho salmon return was estimated to be females, although weekly estimates ranged from about 30% to 57% (Figure 3).

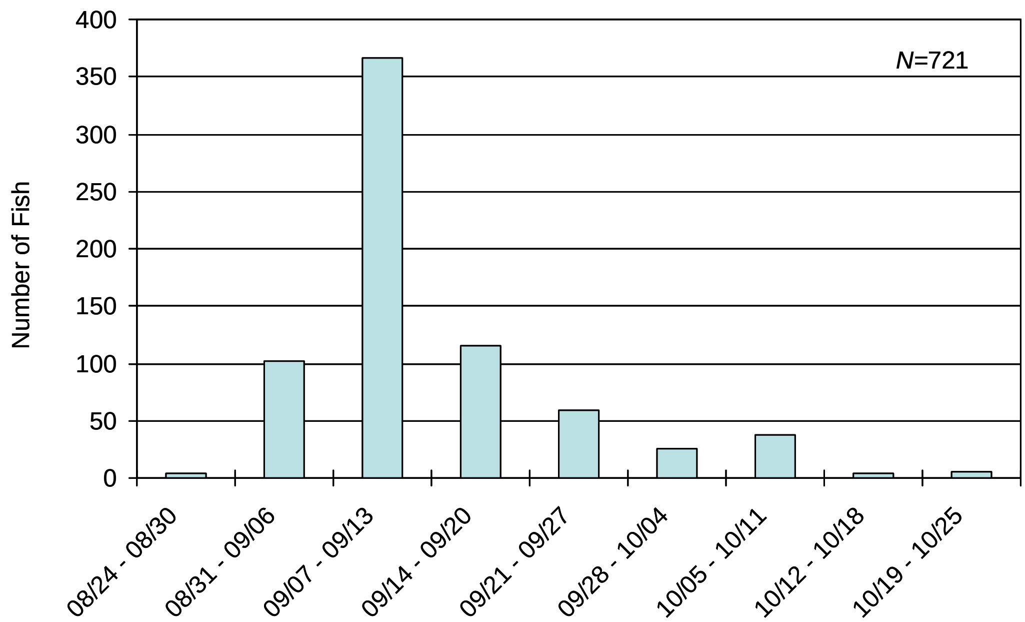

FIGURE 2. —Weekly escapement of coho salmon in Nikolai Creek, Alaska during 2008. Counts were made between 26 August and 23 October.

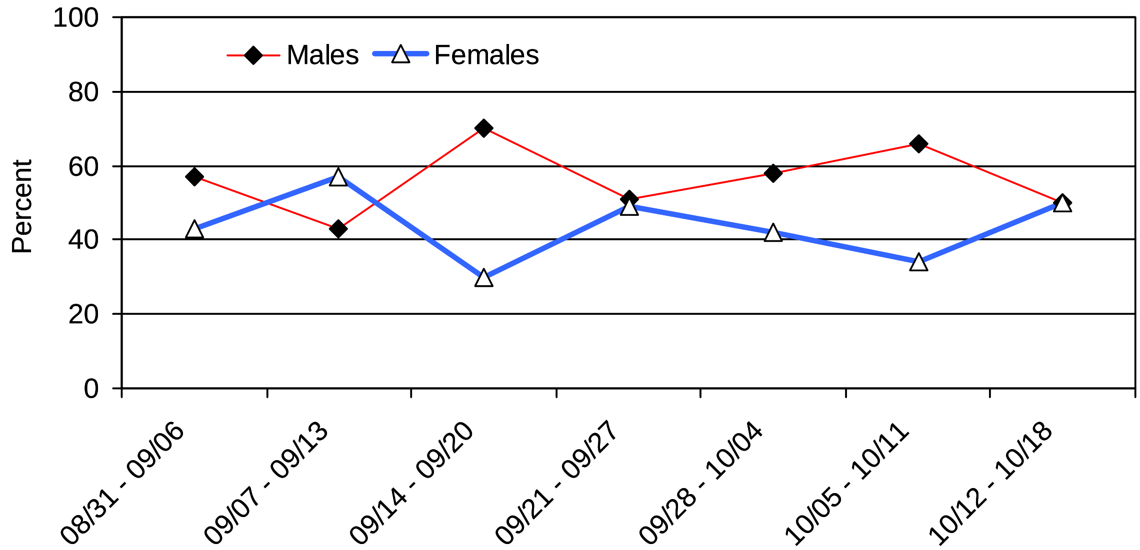

FIGURE 3. —Weekly percent of male and female coho salmon observed at Nikolai Creek weir during 2008. The first (*N*=4 males) and last (*N*=5 males and *N*=1 female) weeks of operation were omitted from this figure.

A total of 594 coho salmon was counted passing Shantatalik Creek weir between 29 August and 3 November 2008 (Figure 4; Appendix 3). The total escapement estimate did not include 173 coho salmon that passed downstream through the video system. Peak weekly passage (*N*=215) occurred between 7 and 13 September, and the median cumulative passage date was 18 September.

Sex was visually estimated for all of the coho salmon counted on Shantatalik Creek video recordings. Overall, about 39% of the total coho salmon return was estimated to be females, although weekly percentages ranged from about 22% to 57% (Figure 5). Sex composition was skewed towards males for most of the run (Figure 5).

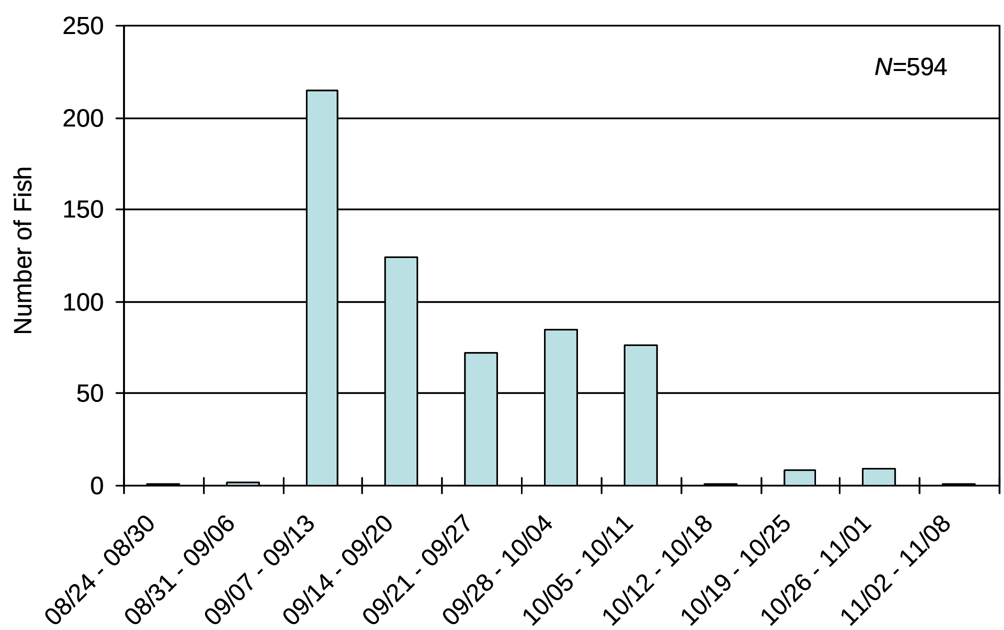

FIGURE 4. —Weekly escapement of coho salmon in Shantatalik Creek, Alaska during 2008. Counts were made between 28 August and 4 November.

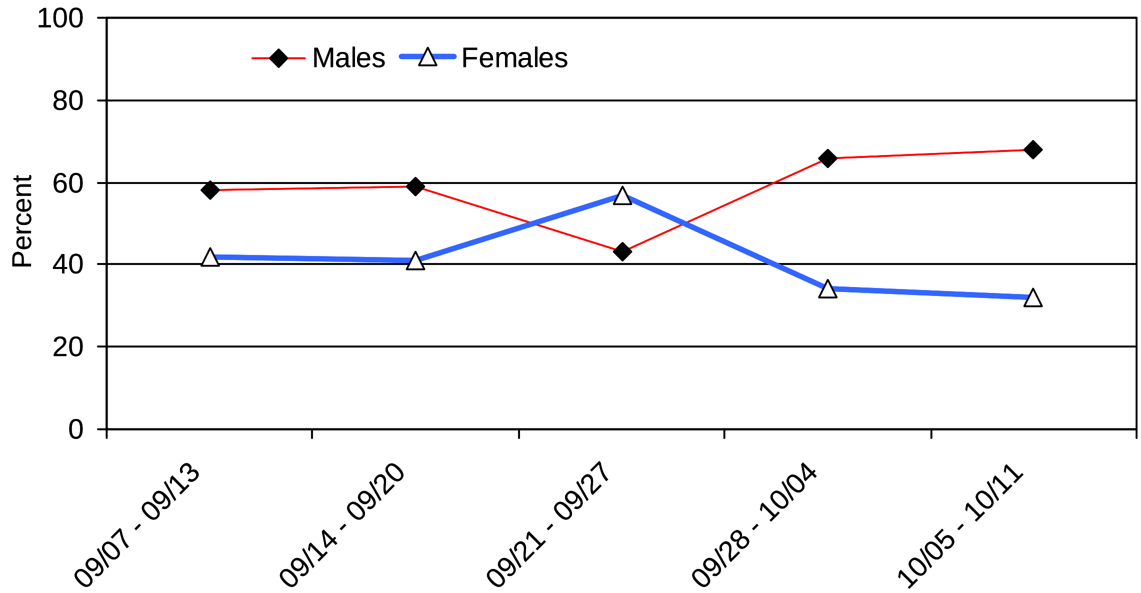

FIGURE 5. —Weekly percent of male and female coho salmon observed at Shantatalik Creek during 2008. Six weeks of operations were omitted from this figure because passage (*N*=22) was less than 10 fish during each week.

Radio Telemetry

A total of 240 coho salmon (97 females and 143 males) was radio-tagged in the Kasilof River between 18 August and 13 October 2008 (Appendix 4). Radio transmitters were deployed over four temporal strata, containing equal numbers of radio-tagged coho salmon. All radio-tagged fish were captured in an approximate 8-km section of river immediately downstream from the refuge boundary at Silver Salmon Rapids. Coho salmon receiving a transmitter ranged in length from 465 to 770 mm.

Eighty-three percent (*N*=200) of all radio-tagged coho salmon were assigned to a spawning location based on information collected from mobile and fixed radio receivers (Table 3). Sixty percent (*N*=144) of the radio-tagged fish selected spawning locations upstream of the refuge boundary at Silver Salmon Rapids. Of those fish, 94 spawned in the upper mainstem Kasilof River between rkm 24 and the Tustumena Lake boat ramp (Figure 6). Fifty radio-tagged coho salmon spawned in tributaries of Tustumena Lake including Shantatalik (*N*=6), Nikolai (*N*=4), Indian (*N*=20), Fox (*N*=1), West (*N*=9), Glacier (*N*=9) and Clear (*N*=1) creeks. Other radio-tagged fish spawned outside the study area in Crooked Creek (*N*=9), Coal Creek (*N*=1) and the mainstem Kasilof River downstream of the refuge boundary (*N*=46). No spawning destination could be determined for 17% of the radio-tagged fish (*N*=40). These fish were assigned fates of "Dead/Regurgitated" (*N*=24), "Back Out" (*N*=8), "Unknown" (*N*=5), and "Harvested (*N*=3). Radio-tagged fish that were classified as "Unknown" were last detected either below the study area (*N*=3) or in Tustumena Lake (*N*=2).

Spawners were classified into three categories for the exact chi-square procedure used to test the hypothesis that the distributions of spawners were equal among all temporal strata: tributary spawners (*N*=50), mainstem refuge spawners (*N*=94), and other spawners (*N*=56). The test was significant ($\chi^2 = 79.79$, p-value < 0.0001), indicating that the distributions of spawners were not equal among all strata. The significance of the test was primarily driven by changes in the relative abundance of tributary and mainstem spawners early and late in the run (Table 3).

TABLE 3. —Fates assigned to coho salmon radio-tagged in the Kasilof River between 18 August and 13 October, 2008.

Fate	Strata 1	2	3	4	Total	%
Tributary Spawners						
Shantatalik Creek	5	1			6	2.5
Nikoilai Creek	3	1			4	1.7
Indian Creek	13	7			20	8.3
Fox Creek	1				1	0.4
West Creek	8			1	9	3.8
Glacier Creek	2	3	2	2	9	3.8
Clear Creek		1			1	0.4
Mainstem Spawners above rkm 24 (Refuge)	5	31	30	28	94	39.2
Other Spawners						
Maintstem below rkm 24		7	17	22	46	19
Crooked Creek	8		1		9	3.8
Coal Creek	1				1	0.4
Dead/Regurgitated	6	6	7	5	24	10.0
Harvested	2		1		3	1.3
Back Out	3	2	2	1	8	3.3
Unknown	3	1	0	1	5	2.1

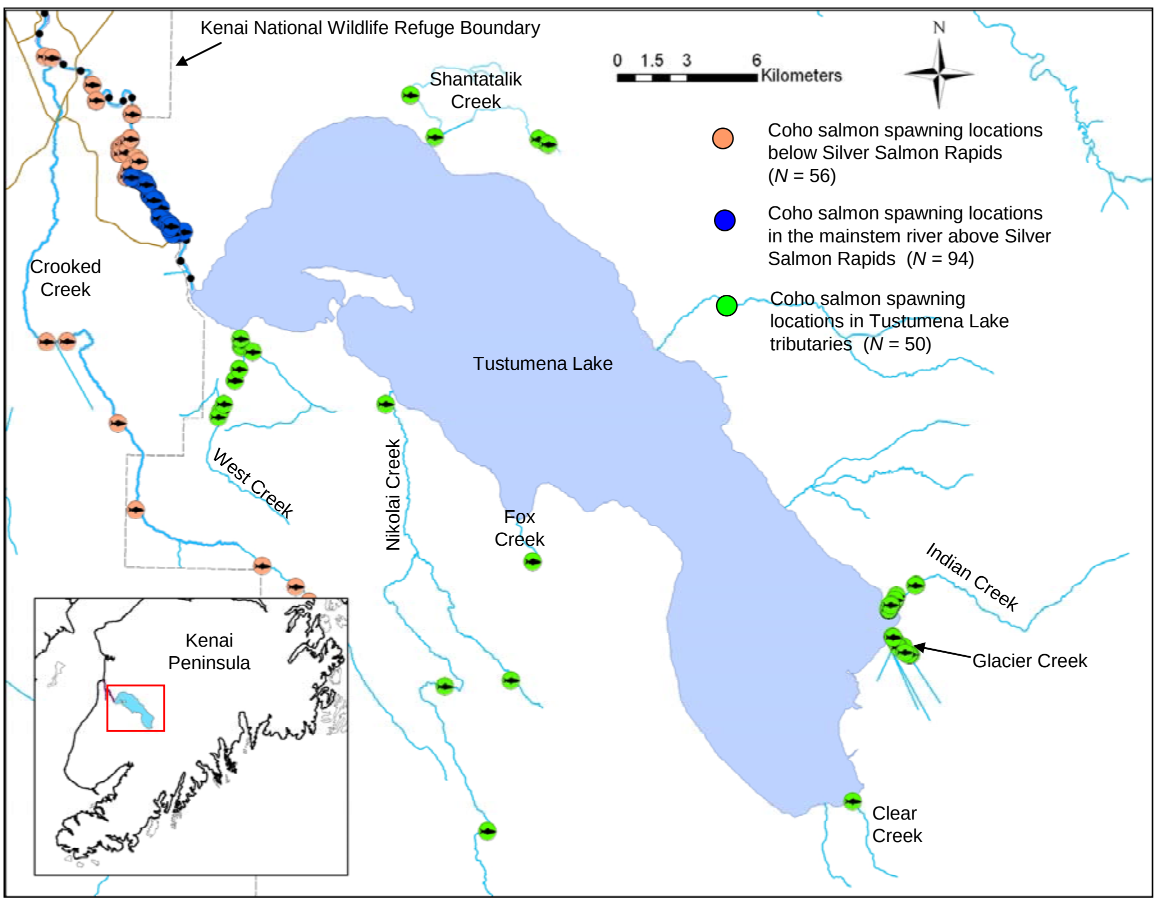

FIGURE 6. —Spawning locations selected by radio-tagged coho salmon in the Kasilof River watershed during 2008

Discussion

A combined total of 1,315 coho salmon was counted past the Nikolai (*N*=721) and Shantatalik (*N*=594) creek weirs between 27 August and 2 November. These estimates of abundance represent the relative strength of the coho salmon return to each of these streams; however, estimates from each creek may be conservative because of periodic interruptions of video images. Interruptions in video signals were caused by a flooding event and power failures resulting in 8 days of lost video at Nikolai Creek and 6 days of lost video at Shantatalik Creek (Appendices 2 and 3).

Our findings show that the upper mainstem Kasilof River is an important spawning area for coho salmon and are generally consistent with the Department's Anadromous Water's Catalog (Johnson and Daigneault 2008) and previous studies conducted by the Service on Tustumena Lake in 1987 (Faurot and Jones 1990), 2006 (Palmer and Gates 2007), and 2007 (Palmer et al. 2008). The primary difference between observations made in 2008 and previous studies was that radio-tagged coho salmon were found in two additional streams, West and Clear creeks. This makes a total of seven Tustumena Lake tributary streams that have been identified as coho salmon spawning habitat: Shantatalik, Nikolai, Indian, Fox, West, Glacier, and Clear creeks.

We also observed differences in run-timing between mainstem and tributary spawners similar to that reported during 2007 (Palmer et al. 2008). Differences in run timing between tributary and mainstem spawners are common in *Onchorhychus* spp., especially in streams, where timing of upstream migration extends over a period of several weeks (Groot and Margolis 1991). Although mainstem spawners were represented in all four of our tagging strata during 2008, most mainstem spawners (69%) were tagged in strata 3 and 4. Conversely, almost all tributary spawners (90%) were tagged in strata 1 and 2. However, there was one exception to this pattern. Radio-tagged coho salmon returning to Glacier Creek to spawn were represented in all four strata, which suggest this population could have a later run-timing than other tributary spawning populations. This could be a result of temperature conditions in Glacier creek since it is spring fed.

Our efforts during 2008 provided the most inclusive and representative spawning and distribution information available for coho salmon in the upper Kasilof River watershed. We were able to assign spawning destinations to a greater percentage of tagged fish in 2008 than Palmer et al. (2008) were able to do in 2007. In 2008, only 17% of radio-tagged coho salmon could not be assigned a spawning destination, which was a 34% reduction from what Palmer et al. (2008) observed in 2007. This was due to a much lower percentage of tagged coho salmon that backed out of the system in 2008 (3%) than in 2007 (22%) as well as much smaller percentage of tagged coho salmon that either died or regurgitated their transmitters in 2008 (10%) than in 2007 (16%). The remainder of the radio-tagged coho salmon were assigned a fate of "Unknown" (*N*=5) for which no spawning destination could be determined. Two of these fish entered Tustumena Lake but did not select a spawning tributary. While the ultimate fates of these fish are unclear, it is possible that handling stress may have altered their behavior eventually leading to delayed mortality or these fish could have selected a spawning location within the lake.

Much of our success in 2008 is a result of being able to reduce handling effects on radio-tagged fish through use of the different tagging strategy. During 2007, radio transmitters were deployed in as short a time period as possible to help ensure that all allocated tags were deployed in each stratum (Palmer et al. 2008). In contrast, we radio-tagged coho salmon every other day during 2008 in an attempt to get a more representative sample of the fish available within each strata. This also allowed tagging crews to capture greater numbers of fish and, therefore, to be more selective in choosing fish to tag. High rates of handling-induced mortality have been observed by other researchers that have captured and handled adult coho salmon during their transition from marine to freshwater habitats. For example, Carlon and Evans (2007) observed "failure" rates as high as 40% for coho salmon radio-tagged in the Kenai River.

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APPENDIX 1. —List of video and microwave equipment used to monitor coho salmon abundance at Nikolai and Shantatalik creeks, Alaska during 2008.

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
2.4 GHz Microwave Transmitter	BE-530T	Premier Wireless, Inc	http://www.premierwirelessinc.com
1.8 GHz Microwave Transmitter	BE-700T	Premier Wireless, Inc	http://www.premierwirelessinc.com
2.4 GHz Microwave Receiver	BE-322R	Premier Wireless, Inc	http://www.premierwirelessinc.com
1.8 GHz Microwave Receiver	BE-700R	Premier Wireless, Inc	http://www.premierwirelessinc.com
2.4 GHz Parabolic Antennas	130135	California Amplifier	http://www.calamp.com
1.8 GHz Parabolic Antennas	AB10227	California Amplifier	http://www.calamp.com
80 W Solar Module	NE-80EJEA	Sharp	http://solar.sharpusa.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/
Charge Controller	ASC8-12	Specialty Concepts, Inc.	http://www.specialtyconcepts.com/
Charge Controller	ASC16-12	Specialty Concepts, Inc.	http://www.specialtyconcepts.com/
Thermoelectric Generator	5060L-12-SI-RS	Global Thermoelectric	http://www.globalte.com/

APPENDIX 2. —Daily counts and cumulative proportion of coho salmon passing through Nikolai Creek weir during 2008. Boxed areas represent the second and third quartile and median passage dates. Shaded areas represent complete days with no video because of high water and power outages.

Date	Upstream Male	Upstream Female	Downstream Male	Downstream Female	Unknown Sex	Total	Daily Cumulative	Cumulative Proportion
8/26	0	0	0	0	0	0	0	0.0000
8/27	3	0	0	0	0	3	3	0.0042
8/28	0	0	0	0	0	0	3	0.0042
8/29	1	0	0	0	0	1	4	0.0055
8/30	0	0	0	0	0	0	4	0.0055
8/31	37	27	0	0	0	64	68	0.0943
9/1	19	16	-1	0	0	34	102	0.1415
9/2	0	1	0	0	0	1	103	0.1429
9/3	3	1	-1	-1	0	2	105	0.1456
9/4	0	0	0	0	0	0	105	0.1456
9/5	0	0	0	0	0	0	105	0.1456
9/6	1	0	0	0	0	1	106	0.1470
9/7	2	1	-2	0	0	1	107	0.1484
9/8	10	7	0	0	0	17	124	0.1720
9/9	155	206	-8	-5	0	348	472	0.6546
9/10	1	0	-3	-5	0	-7	465	0.6449
9/11	0	0	0	0	0	0	465	0.6449
9/12	3	5	-1	0	0	7	472	0.6546
9/13	0	2	0	-1	0	1	473	0.6560
9/14	0	0	0	0	0	0	473	0.6560
9/15	0	0	0	0	0	0	473	0.6560
9/16	60	24	0	-1	0	83	556	0.7712
9/17	5	3	0	-1	0	7	563	0.7809
9/18	7	1	-2	0	0	6	569	0.7892
9/19	7	5	0	0	0	12	581	0.8058
9/20	3	4	0	0	0	7	588	0.8155
9/21	7	3	-1	0	1	10	598	0.8294
9/22	4	1	0	0	0	5	603	0.8363
9/23	0	3	0	0	0	3	606	0.8405
9/24	4	1	0	0	1	6	612	0.8488
9/25	10	18	0	0	0	28	640	0.8877
9/26	3	0	0	0	0	3	643	0.8918
9/27	2	2	0	0	0	4	647	0.8974
9/28	4	2	-1	0	0	5	652	0.9043
9/29	5	2	-2	0	0	5	657	0.9112
9/30	2	2	0	0	0	4	661	0.9168
10/1	0	1	0	0	0	1	662	0.9182
10/2	1	0	-2	0	0	-1	661	0.9168
10/3	5	1	0	0	0	6	667	0.9251
10/4	3	3	0	0	0	6	673	0.9334
10/5	5	3	0	0	0	8	681	0.9445
10/6	6	2	-2	0	0	6	687	0.9528
10/7	3	0	0	0	0	3	690	0.9570
10/8	6	4	-1	0	0	9	699	0.9695
10/9	5	1	0	0	0	6	705	0.9778
10/10	0	2	0	0	0	2	707	0.9806
10/11	3	1	0	0	0	4	711	0.9861
10/12	0	0	0	0	0	0	711	0.9861
10/13	0	0	0	0	0	0	711	0.9861
10/14	0	0	0	0	0	0	711	0.9861
10/15	1	0	0	0	0	1	712	0.9875
10/16	0	1	0	0	0	1	713	0.9889
10/17	0	1	0	0	0	1	714	0.9903
10/18	1	0	0	0	0	1	715	0.9917
10/19	0	0	0	0	0	0	715	0.9917
10/20	2	1	0	0	0	3	718	0.9958
10/21	0	0	0	0	0	0	718	0.9958
10/22	3	0	0	0	0	3	721	1.0000
10/23	0	0	0	0	0	0	721	1.0000
Total	402	358	-27	-14	2	721		

APPENDIX 3. —Daily counts and cumulative proportion of coho salmon passing through Shantatalik Creek weir during 2008. Boxed areas represent the second and third quartile and median passage dates. Shaded areas represent complete days with no video because of power outages.

Date	Upstream Male	Upstream Female	Downstream Male	Downstream Female	Unknown Sex	Total	Daily Cumulative	Cumulative Proportion
8/28	0	0	0	0	0	0	0	0.0000
8/29	0	1	0	0	0	1	1	0.0017
8/30	0	0	0	0	0	0	1	0.0017
8/31	0	0	0	0	0	0	1	0.0017
9/1	0	0	0	0	0	0	1	0.0017
9/2	0	0	0	0	0	0	1	0.0017
9/3	1	0	0	0	0	1	2	0.0034
9/4	0	0	0	0	0	0	2	0.0034
9/5	2	0	-1	0	0	1	3	0.0051
9/6	0	1	0	-1	0	0	3	0.0051
9/7	1	0	0	0	0	1	4	0.0067
9/8	9	1	0	0	0	10	14	0.0236
9/9	67	57	-3	-1	0	120	134	0.2256
9/10	14	6	-1	-2	0	17	151	0.2542
9/11	1	1	0	-1	0	1	152	0.2559
9/12	26	20	0	0	0	46	198	0.3333
9/13	12	9	-1	0	0	20	218	0.3670
9/14	4	6	-1	-1	0	8	226	0.3805
9/15	1	1	0	0	0	2	228	0.3838
9/16	0	0	0	0	0	0	228	0.3838
9/17	24	12	-12	-2	0	22	250	0.4209
9/18	67	28	-20	-4	0	71	321	0.5404
9/19	17	4	-12	-1	0	8	329	0.5539
9/20	12	12	-7	-4	0	13	342	0.5758
9/21	3	6	0	-4	0	5	347	0.5842
9/22	2	3	-1	0	0	4	351	0.5909
9/23	1	1	0	0	0	2	353	0.5943
9/24	6	10	0	-1	0	15	368	0.6195
9/25	11	10	0	0	0	21	389	0.6549
9/26	7	13	0	-1	0	19	408	0.6869
9/27	3	6	-1	-2	0	6	414	0.6970
9/28	6	8	-5	-1	0	8	422	0.7104
9/29	1	4	-1	-1	0	3	425	0.7155
9/30	0	1	-2	-1	0	-2	423	0.7121
10/1	2	0	-1	0	0	1	424	0.7138
10/2	3	2	0	0	0	5	429	0.7222
10/3	43	16	-3	0	0	56	485	0.8165
10/4	13	3	0	-2	0	14	499	0.8401
10/5	4	1	-4	0	0	1	500	0.8418
10/6	4	3	-5	-4	0	-2	498	0.8384
10/7	3	2	-1	-2	0	2	500	0.8418
10/8	0	2	-2	-3	0	-3	497	0.8367
10/9	7	7	-1	0	0	13	510	0.8586
10/10	44	17	-1	-4	0	56	566	0.9529
10/11	6	5	-2	0	0	9	575	0.9680
10/12	4	1	0	-2	0	3	578	0.9731
10/13	1	0	-1	0	0	0	578	0.9731
10/14	0	0	0	-2	0	-2	576	0.9697
10/15	4	0	-1	-2	0	1	577	0.9714
10/16	1	0	-1	-3	0	-3	574	0.9663
10/17	3	0	-1	-1	0	1	575	0.9680
10/18	1	2	-1	-1	0	1	576	0.9697
10/19	4	0	0	-2	0	2	578	0.9731
10/20	0	2	-2	0	0	0	578	0.9731
10/21	0	0	-1	-2	0	-3	575	0.9680

-continued-

APPENDIX 3. —(Page 2 of 2)

Date	Upstream Male	Upstream Female	Downstream Male	Downstream Female	Unknown Sex	Total	Daily Cumulative	Cumulative Proportion
10/22	8	0	-9	0	0	-1	574	0.9663
10/23	2	0	-1	0	0	1	575	0.9680
10/24	5	2	-1	0	0	6	581	0.9781
10/25	4	0	-1	0	0	3	584	0.9832
10/26	3	0	-2	0	0	1	585	0.9848
10/27	2	2	0	0	0	4	589	0.9916
10/28	3	0	0	0	0	3	592	0.9966
10/29	2	0	-1	0	0	1	593	0.9983
10/30	1	0	-2	0	0	-1	592	0.9966
10/31	2	0	-1	0	0	1	593	0.9983
11/1	0	0	0	0	0	0	593	0.9983
11/2	0	1	0	0	0	1	594	1.0000
11/3	1	0	-1	0	0	0	594	1.0000
11/4	0	0	0	0	0	0	594	1.0000
Total	478	289	-115	-58	0	594		

APPENDIX 4. —Tagging and fate summaries for coho salmon radio-tagged in the Kasilof River during 2008.

Transmitter number	Stratum	Mid-eye to fork length (mm)	Sex	Tagging date	Tagging Location (WGS84) Latitude	Longitude	Final fate
13	1	530	F	18-Aug	60.30884	-151.23684	Tributary Spawner (Indian Cr.)
233	1	595	M	18-Aug	60.30884	-151.23684	Tributary Spawner (Fox Cr.)
363	1	620	M	18-Aug	60.30821	-151.23765	Other Spawner (Crooked Cr.)
43	1	660	F	18-Aug	60.30910	-151.23657	Back Out
533	1	585	F	18-Aug	60.30872	-151.23712	Tributary Spawner (Shantatalik Cr.)
663	1	680	F	18-Aug	60.30793	-151.23845	Tributary Spawner (Indian Cr.)
73	1	635	M	18-Aug	60.30772	-151.23799	Tributary Spawner (Indian Cr.)
833	1	490	F	18-Aug	60.30747	-151.23860	Dead/Regurgitated
14	1	640	F	18-Aug	60.30872	-151.23642	Tributary Spawner (Nikolai Cr.)
234	1	600	F	20-Aug	60.30934	-151.23538	Tributary Spawner (West Cr.)
364	1	650	M	20-Aug	60.30928	-151.23625	Tributary Spawner (Indian Cr.)
44	1	545	M	20-Aug	60.30825	-151.23751	Unknown
534	1	610	F	20-Aug	60.30860	-151.23759	Tributary Spawner (Indian Cr.)
664	1	635	F	20-Aug	60.30934	-151.23576	Dead/Regurgitated
74	1	650	M	20-Aug	60.30649	-151.24022	Tributary Spawner (Nikolai Cr.)
834	1	605	M	20-Aug	60.30371	-151.22948	Tributary Spawner (West Cr.)
15	1	590	F	20-Aug	60.30851	-151.23755	Tributary Spawner (Shantatalik Cr.)
235	1	590	M	20-Aug	60.30894	-151.23607	Tributary Spawner (Indian Cr.)
365	1	640	F	22-Aug	60.28676	-151.21406	Dead/Regurgitated
45	1	575	F	22-Aug	60.28880	-151.22023	Other Spawner (Crooked Cr.)
535	1	685	M	22-Aug	60.30871	-151.23636	Sport Harvest
665	1	465	M	22-Aug	60.30896	-151.23558	Tributary Spawner (Glacier Cr.)
75	1	475	F	22-Aug	60.30834	-151.23709	Unknown
835	1	725	M	22-Aug	60.30765	-151.23808	Mainstem Spawners above rkm 24
16	1	695	M	22-Aug	60.31606	-151.23187	Tributary Spawner (Indian Cr.)
236	1	580	M	22-Aug	60.30713	-151.23281	Other Spawner (Crooked Cr.)
366	1	680	M	22-Aug	60.30852	-151.23685	Tributary Spawner (Nikolai Cr.)
46	1	610	M	24-Aug	60.30749	-151.24026	Tributary Spawner (Indian Cr.)
536	1	615	F	24-Aug	60.30782	-151.23783	Mainstem Spawners above rkm 24
666	1	630	F	24-Aug	60.30899	-151.23577	Mainstem Spawners above rkm 24
76	1	620	M	24-Aug	60.30854	-151.23657	Tributary Spawner (Shantatalik Cr.)
836	1	585	M	24-Aug	60.30791	-151.23804	Tributary Spawner (Indian Cr.)
17	1	600	M	24-Aug	60.30727	-151.23924	Tributary Spawner (West Cr.)
237	1	620	F	24-Aug	60.30552	-151.24017	Sport Harvest
367	1	625	F	24-Aug	60.30675	-151.24166	Mainstem Spawners above rkm 24
47	1	635	M	24-Aug	60.30633	-151.24210	Tributary Spawner (West Cr.)
537	1	660	F	26-Aug	60.30858	-151.23326	Tributary Spawner (Indian Cr.)
667	1	585	M	26-Aug	60.30805	-151.23880	Tributary Spawner (Shantatalik Cr.)
77	1	670	M	26-Aug	60.30790	-151.23901	Tributary Spawner (Glacier Cr.)
837	1	650	M	26-Aug	60.30755	-151.23968	Back Out
18	1	685	M	26-Aug	60.30752	-151.23979	Tributary Spawner (West Cr.)
238	1	665	F	26-Aug	60.30098	-151.21331	Tributary Spawner (West Cr.)
368	1	595	M	26-Aug	60.30098	-151.21331	Tributary Spawner (West Cr.)
48	1	510	F	26-Aug	60.30382	-151.22542	Other Spawner (Crooked Cr.)
538	1	555	F	28-Aug	60.28103	-151.21299	Back Out
668	1	540	F	28-Aug	60.28103	-151.21299	Other Spawner (Crooked Cr.)
78	1	650	M	28-Aug	60.30632	-151.24210	Dead/Regurgitated
838	1	575	M	28-Aug	60.30509	-151.24195	Tributary Spawner (Indian Cr.)
19	1	653	M	28-Aug	60.30410	-151.24184	Mainstem Spawners above rkm 24
239	1	660	M	28-Aug	60.30513	-151.24156	Other Spawner (Crooked Cr.)
369	1	650	F	28-Aug	60.30891	-151.23614	Other Spawner (Crooked Cr.)
49	1	505	F	28-Aug	60.31706	-151.25904	Other Spawner (Crooked Cr.)
539	1	625	M	30-Aug	60.31706	-151.25904	Unknown
669	1	580	F	30-Aug	60.30675	-151.24177	Tributary Spawner (Shantatalik Cr.)
79	1	595	F	30-Aug	60.30893	-151.23604	Tributary Spawner (West Cr.)
839	1	620	F	30-Aug	60.30899	-151.23565	Tributary Spawner (Indian Cr.)
110	1	655	M	30-Aug	60.30913	-151.23475	Other Spawner (Coal Cr.)
240	1	530	M	30-Aug	60.30883	-151.23623	Tributary Spawner (Indian Cr.)
370	1	590	M	30-Aug	60.28577	-151.21445	Dead/Regurgitated
410	1	595	M	30-Aug	60.30698	-151.23996	Dead/Regurgitated

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Transmitter number	Stratum	Mid-eye to fork length (mm)	Sex	Tagging date	Tagging Location (WGS84) Latitude	Longitude	Final fate
540	2	630	M	2-Sep	60.30804	-151.23882	Tributary Spawner (Indian Cr.)
670	2	560	M	2-Sep	60.30755	-151.23928	Mainstem Spawners above rkm 24
710	2	595	M	2-Sep	60.30756	-151.23961	Tributary Spawner (Glacier Cr.)
840	2	580	M	2-Sep	60.30756	-151.23961	Tributary Spawner (Indian Cr.)
111	2	600	F	2-Sep	60.28028	-151.21351	Mainstem Spawners above rkm 24
241	2	595	M	2-Sep	60.28535	-151.21981	Mainstem Spawners above rkm 24
371	2	640	F	2-Sep	60.30767	-151.23940	Mainstem Spawners above rkm 24
411	2	545	F	2-Sep	60.30842	-151.23697	Other Spawner (Maintstem Below rkm 24)
541	2	585	M	2-Sep	60.30779	-151.23918	Tributary Spawner (Nikolai Cr.)
412	2	635	M	4-Sep	60.30621	-151.24210	Mainstem Spawners above rkm 24
542	2	560	M	4-Sep	60.30770	-151.23951	Tributary Spawner (Indian Cr.)
671	2	700	M	4-Sep	60.30761	-151.23962	Mainstem Spawners above rkm 24
711	2	615	F	4-Sep	60.30728	-151.24010	Tributary Spawner (Indian Cr.)
841	2		F	4-Sep	60.30723	-151.24040	Mainstem Spawners above rkm 24
112	2	665	F	4-Sep	60.30368	-151.22896	Mainstem Spawners above rkm 24
242	2	540	M	4-Sep	60.28111	-151.21258	Tributary Spawner (Indian Cr.)
372	2	560	F	4-Sep	60.30817	-151.23721	Other Spawner (Maintstem Below rkm 24)
672	2	610	M	4-Sep	60.30817	-151.23721	Dead/Regurgitated
712	2	615	F	6-Sep	60.30658	-151.24002	Mainstem Spawners above rkm 24
842	2	590	F	6-Sep	60.30543	-151.24202	Mainstem Spawners above rkm 24
113	2	685	M	6-Sep	60.30766	-151.23956	Mainstem Spawners above rkm 24
243	2	630	F	6-Sep	60.30738	-151.24015	Dead/Regurgitated
373	2	660	M	6-Sep	60.30714	-151.24087	Tributary Spawner (Shantatalik Cr.)
413	2	565	M	6-Sep	60.28137	-151.21239	Tributary Spawner (Glacier Cr.)
543	2	600	F	6-Sep	60.28517	-151.22007	Dead/Regurgitated
673	2	700	M	6-Sep	60.28990	-151.21730	Tributary Spawner (Indian Cr.)
713	2	615	F	6-Sep	60.30748	-151.23988	Tributary Spawner (Glacier Cr.)
843	2	660	M	8-Sep	60.30703	-151.24106	Unknown
114	2	575	F	8-Sep	60.28583	-151.21393	Dead/Regurgitated
244	2	710	M	8-Sep	60.30366	-151.22727	Mainstem Spawners above rkm 24
374	2	680	M	9-Sep	60.30602	-151.24256	Mainstem Spawners above rkm 24
414	2	535	M	9-Sep	60.30701	-151.24141	Mainstem Spawners above rkm 24
544	2	630	M	9-Sep	60.30453	-151.24710	Mainstem Spawners above rkm 24
674	2	620	F	9-Sep	60.30363	-151.22961	Back Out
714	2	730	M	9-Sep	60.28652	-151.21738	Mainstem Spawners above rkm 24
844	2	630	M	9-Sep			Other Spawner (Maintstem Below rkm 24)
115	2	675	F	10-Sep	60.28552	-151.22057	Mainstem Spawners above rkm 24
245	2	720	M	10-Sep	60.28552	-151.22057	Back Out
375	2	640	F	10-Sep	60.28548	-151.22018	Mainstem Spawners above rkm 24
415	2	730	M	10-Sep	60.28550	-151.22190	Dead/Regurgitated
545	2	670	M	10-Sep	60.28514	-151.22034	Dead/Regurgitated
675	2	615	F	10-Sep	60.30101	-151.21298	Mainstem Spawners above rkm 24
715	2	675	F	10-Sep	60.30101	-151.21298	Mainstem Spawners above rkm 24
845	2	580	M	10-Sep	60.30911	-151.22000	Mainstem Spawners above rkm 24
116	2	720	M	12-Sep	60.28661	-151.21568	Other Spawner (Maintstem Below rkm 24)
246	2	720	M	12-Sep	60.28613	-151.21870	Other Spawner (Maintstem Below rkm 24)
376	2	655	F	12-Sep	60.28659	-151.21634	Mainstem Spawners above rkm 24
416	2	690	F	12-Sep	60.28632	-151.21439	Mainstem Spawners above rkm 24
546	2	550	F	12-Sep	60.28527	-151.21348	Mainstem Spawners above rkm 24
676	2	650	M	12-Sep	60.28601	-151.21384	Mainstem Spawners above rkm 24
716	2	630	M	12-Sep	60.28601	-151.21384	Mainstem Spawners above rkm 24
846	2	660	F	12-Sep	60.28632	-151.21468	Other Spawner (Maintstem Below rkm 24)
117	2	645	M	14-Sep	60.28655	-151.21664	Mainstem Spawners above rkm 24
247	2	560	M	14-Sep	60.28655	-151.21664	Mainstem Spawners above rkm 24
377	2	675	M	14-Sep	60.28599	-151.21421	Mainstem Spawners above rkm 24
417	2	660	M	14-Sep	60.28648	-151.21538	Tributary Spawner (Clear Cr.)
547	2	655	M	14-Sep	60.28613	-151.21443	Tributary Spawner (Indian Cr.)
677	2	510	M	14-Sep	60.28580	-151.21385	Mainstem Spawners above rkm 24
717	2	655	M	14-Sep	60.28634	-151.21468	Mainstem Spawners above rkm 24
847	2	585	M	14-Sep	60.28210	-151.20970	Other Spawner (Maintstem Below rkm 24)

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Transmitter number	Stratum	Mid-eye to fork length (mm)	Sex	Tagging date	Tagging Location (WGS84) Latitude	Longitude	Final fate
118	3	740	M	16-Sep	60.28585	-151.21389	Mainstem Spawners above rkm 24
248	3	650	F	16-Sep	60.28608	-151.21420	Mainstem Spawners above rkm 24
378	3	720	M	16-Sep	60.28586	-151.21383	Mainstem Spawners above rkm 24
418	3	655	M	16-Sep	60.28146	-151.21217	Sport Harvest
548	3	730	M	16-Sep	60.28160	-151.21193	Tributary Spawner (Glacier Cr.)
678	3	670	F	16-Sep	60.28170	-151.21173	Mainstem Spawners above rkm 24
718	3	655	M	16-Sep	60.28324	-151.20949	Mainstem Spawners above rkm 24
848	3	630	F	16-Sep	60.30662	-151.24165	Other Spawner (Maintstem Below rkm 24)
119	3	673	M	16-Sep	60.28239	-151.20886	Mainstem Spawners above rkm 24
249	3	615	F	18-Sep	60.28610	-151.21409	Mainstem Spawners above rkm 24
379	3	615	F	18-Sep	60.28602	-151.21424	Dead/Regurgitated
419	3	690	F	18-Sep	60.28626	-151.21438	Mainstem Spawners above rkm 24
549	3	685	M	18-Sep	60.28606	-151.21443	Mainstem Spawners above rkm 24
679	3	615	M	18-Sep	60.28650	-151.21596	Mainstem Spawners above rkm 24
719	3	640	M	18-Sep	60.28482	-151.21293	Other Spawner (Maintstem Below rkm 24)
849	3	655	F	18-Sep	60.30363	-151.22809	Back Out
120	3	605	F	18-Sep	60.30375	-151.22941	Other Spawner (Maintstem Below rkm 24)
250	3	530	M	18-Sep	60.30716	-151.24079	Mainstem Spawners above rkm 24
380	3	640	F	20-Sep	60.30709	-151.24086	Other Spawner (Maintstem Below rkm 24)
420	3	610	M	20-Sep	60.30671	-151.24144	Mainstem Spawners above rkm 24
550	3	615	F	20-Sep	60.28924	-151.21928	Mainstem Spawners above rkm 24
680	3	540	F	20-Sep	60.30744	-151.22259	Mainstem Spawners above rkm 24
720	3	665	M	20-Sep	60.30420	-151.24666	Mainstem Spawners above rkm 24
850	3	645	M	20-Sep	60.30674	-151.24489	Dead/Regurgitated
121	3	500	F	20-Sep	60.30537	-151.24643	Tributary Spawner (Glacier Cr.)
251	3	620	F	22-Sep	60.28627	-151.21424	Other Spawner (Maintstem Below rkm 24)
381	3	645	M	22-Sep	60.28666	-151.21621	Other Spawner (Maintstem Below rkm 24)
421	3	595	M	22-Sep	60.30582	-151.22239	Other Spawner (Maintstem Below rkm 24)
551	3	655	M	22-Sep	60.30386	-151.23207	Back Out
681	3	610	F	22-Sep	60.30378	-151.23142	Mainstem Spawners above rkm 24
721	3	630	F	22-Sep	60.30602	-151.24208	Mainstem Spawners above rkm 24
851	3	590	F	22-Sep	60.30601	-151.24216	Other Spawner (Crooked Cr.)
122	3	640	M	22-Sep	60.30682	-151.24452	Other Spawner (Maintstem Below rkm 24)
252	3	615	F	22-Sep	60.30427	-151.24163	Dead/Regurgitated
382	3	525	F	22-Sep	60.30396	-151.22488	Mainstem Spawners above rkm 24
422	3	630	M	22-Sep	60.30456	-151.24685	Other Spawner (Maintstem Below rkm 24)
552	3	680	M	24-Sep	60.30365	-151.22830	Mainstem Spawners above rkm 24
682	3	670	M	24-Sep	60.30365	-151.22919	Other Spawner (Maintstem Below rkm 24)
722	3	675	M	24-Sep	60.29194	-151.21391	Dead/Regurgitated
852	3	665	F	24-Sep	60.29129	-151.21424	Mainstem Spawners above rkm 24
123	3	675	M	25-Sep	60.28619	-151.21434	Other Spawner (Maintstem Below rkm 24)
253	3	690	M	25-Sep	60.28533	-151.21972	Other Spawner (Maintstem Below rkm 24)
383	3	595	F	25-Sep	60.28205	-151.21045	Mainstem Spawners above rkm 24
423	3	640	F	25-Sep	60.29104	-151.21426	Mainstem Spawners above rkm 24
553	3	535	M	25-Sep	60.27893	-151.21520	Mainstem Spawners above rkm 24
723	3	680	F	25-Sep	60.28648	-151.22315	Other Spawner (Maintstem Below rkm 24)
683	3	560	M	25-Sep	60.28645	-151.22391	Other Spawner (Maintstem Below rkm 24)
853	3	675	M	25-Sep	60.28749	-151.22398	Mainstem Spawners above rkm 24
124	3	680	M	26-Sep	60.30599	-151.23409	Mainstem Spawners above rkm 24
254	3	680	M	26-Sep	60.30729	-151.24028	Mainstem Spawners above rkm 24
384	3	655	M	26-Sep	60.28615	-151.21417	Other Spawner (Maintstem Below rkm 24)
424	3	645	M	26-Sep	60.28538	-151.22156	Dead/Regurgitated
554	3	640	M	26-Sep	60.28623	-151.21423	Mainstem Spawners above rkm 24
684	3	645	F	26-Sep	60.28590	-151.21392	Dead/Regurgitated
724	3	635	M	26-Sep	60.28555	-151.21970	Other Spawner (Maintstem Below rkm 24)
854	3	630	M	26-Sep	60.28633	-151.21467	Other Spawner (Maintstem Below rkm 24)
125	3	600	M	28-Sep	60.28610	-151.21452	Mainstem Spawners above rkm 24
255	3	665	M	28-Sep	60.28688	-151.22408	Mainstem Spawners above rkm 24
385	3	630	M	28-Sep	60.28795	-151.22266	Dead/Regurgitated
425	3	655	M	28-Sep	60.28668	-151.22416	Mainstem Spawners above rkm 24

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Transmitter number	Stratum	Mid-eye to fork length (mm)	Sex	Tagging date	Tagging Location (WGS84) Latitude	Longitude	Final fate
555	4	640	F	1-Oct	60.28247	-151.20870	Other Spawner (Maintstem Below rkm 24)
685	4	645	M	1-Oct	60.28265	-151.20847	Mainstem Spawners above rkm 24
725	4	680	F	1-Oct	60.28256	-151.20868	Tributary Spawner (Glacier Cr.)
855	4	660	M	1-Oct	60.28186	-151.21126	Mainstem Spawners above rkm 24
126	4	620	F	1-Oct	60.27671	-151.21864	Other Spawner (Maintstem Below rkm 24)
256	4	620	F	1-Oct	60.27691	-151.21807	Other Spawner (Maintstem Below rkm 24)
386	4	535	M	1-Oct	60.30369	-151.22944	Tributary Spawner (West Cr.)
426	4	635	F	2-Oct	60.28716	-151.22431	Other Spawner (Maintstem Below rkm 24)
556	4	590	M	2-Oct	60.28935	-151.21892	Tributary Spawner (Glacier Cr.)
686	4	550	M	2-Oct	60.28959	-151.21841	Other Spawner (Maintstem Below rkm 24)
726	4	635	M	2-Oct	60.28640	-151.21684	Other Spawner (Maintstem Below rkm 24)
856	4	610	M	2-Oct	60.28569	-151.21561	Other Spawner (Maintstem Below rkm 24)
127	4	710	M	2-Oct	60.28145	-151.21218	Mainstem Spawners above rkm 24
257	4	490	F	2-Oct	60.28212	-151.21008	Mainstem Spawners above rkm 24
387	4	675	M	3-Oct	60.30361	-151.23237	Mainstem Spawners above rkm 24
427	4	660	M	3-Oct	60.27829	-151.21622	Other Spawner (Maintstem Below rkm 24)
557	4	585	F	3-Oct	60.27880	-151.21760	Other Spawner (Maintstem Below rkm 24)
687	4	610	M	3-Oct	60.27850	-151.21582	Mainstem Spawners above rkm 24
727	4	610	F	5-Oct	60.28655	-151.21665	Mainstem Spawners above rkm 24
857	4	630	F	5-Oct	60.28045	-151.21321	Unknown
128	4	615	F	5-Oct	60.28162	-151.21180	Mainstem Spawners above rkm 24
258	4	580	F	5-Oct	60.28122	-151.21257	Mainstem Spawners above rkm 24
388	4	555	F	5-Oct	60.28058	-151.21360	Back Out
428	4	665	M	5-Oct	60.28189	-151.21095	Dead/Regurgitated
558	4	585	F	5-Oct	60.28621	-151.21423	Mainstem Spawners above rkm 24
688	4	665	M	5-Oct	60.30362	-151.23238	Mainstem Spawners above rkm 24
728	4	660	F	5-Oct	60.30366	-151.23251	Mainstem Spawners above rkm 24
858	4	630	M	7-Oct	60.28036	-151.21311	Mainstem Spawners above rkm 24
129	4	620	M	7-Oct	60.28183	-151.21094	Mainstem Spawners above rkm 24
259	4	635	M	7-Oct	60.28044	-151.21344	Other Spawner (Maintstem Below rkm 24)
389	4	660	F	7-Oct	60.28176	-151.21117	Other Spawner (Maintstem Below rkm 24)
429	4	645	M	7-Oct	60.27950	-151.21415	Other Spawner (Maintstem Below rkm 24)
559	4	670	F	7-Oct	60.27637	-151.21801	Mainstem Spawners above rkm 24
689	4	655	F	7-Oct	60.28598	-151.21431	Mainstem Spawners above rkm 24
729	4	680	M	7-Oct	60.28106	-151.21257	Mainstem Spawners above rkm 24
859	4	645	M	7-Oct	60.28104	-151.21303	Other Spawner (Maintstem Below rkm 24)
130	4	770	M	7-Oct	60.28358	-151.20595	Mainstem Spawners above rkm 24
260	4	645	M	7-Oct	60.28358	-151.20595	Other Spawner (Maintstem Below rkm 24)
390	4	525	M	7-Oct	60.28512	-151.22076	Mainstem Spawners above rkm 24
430	4	580	M	7-Oct	60.28564	-151.21377	Other Spawner (Maintstem Below rkm 24)
560	4	680	F	9-Oct	60.28134	-151.21238	Dead/Regurgitated
690	4	600	M	9-Oct	60.28117	-151.21245	Mainstem Spawners above rkm 24
730	4	660	M	9-Oct	60.28139	-151.21237	Other Spawner (Maintstem Below rkm 24)
860	4	610	F	9-Oct	60.28119	-151.21233	Mainstem Spawners above rkm 24
131	4	615	F	9-Oct	60.28099	-151.21283	Other Spawner (Maintstem Below rkm 24)
261	4	635	F	9-Oct	60.28233	-151.20820	Dead/Regurgitated
391	4	720	M	9-Oct	60.28240	-151.20789	Mainstem Spawners above rkm 24
431	4	670	M	9-Oct	60.28124	-151.21257	Dead/Regurgitated
561	4	645	M	9-Oct	60.28619	-151.22568	Mainstem Spawners above rkm 24
691	4	675	F	9-Oct	60.28748	-151.22413	Mainstem Spawners above rkm 24
731	4	590	M	11-Oct	60.28104	-151.21268	Other Spawner (Maintstem Below rkm 24)
861	4	490	M	11-Oct	60.28122	-151.21248	Other Spawner (Maintstem Below rkm 24)
132	4	635	M	11-Oct	60.28182	-151.21106	Other Spawner (Maintstem Below rkm 24)
262	4	545	M	11-Oct	60.28541	-151.21957	Other Spawner (Maintstem Below rkm 24)
392	4	640	F	11-Oct	60.28658	-151.22435	Mainstem Spawners above rkm 24
432	4	705	M	13-Oct	60.28227	-151.20926	Other Spawner (Maintstem Below rkm 24)
562	4	655	F	13-Oct	60.28155	-151.21159	Dead/Regurgitated
692	4	690	M	13-Oct	60.28093	-151.21274	Mainstem Spawners above rkm 24
732	4	665	F	13-Oct	60.28148	-151.21209	Mainstem Spawners above rkm 24
862	4	535	M	13-Oct	60.27717	-151.21962	Mainstem Spawners above rkm 24