U.S. Fish & Wildlife Service

Run Timing, Abundance, and Distribution of Adult Coho Salmon in the Kasilof River Watershed, Alaska, 2007-2009

Alaska Fisheries Data Series Number 2010-03

Kenai Fish and Wildlife Field Office
Soldotna, Alaska
March, 2010

The Alaska Region Fisheries Program of the U.S. Fish and Wildlife Service conducts fisheries monitoring and population assessment studies throughout many areas of Alaska. Dedicated professional staff located in Anchorage, Juneau, Fairbanks and Kenai Fish and Wildlife Offices and the Anchorage Conservation Genetics Laboratory serve as the core of the Program's fisheries management study efforts. Administrative and technical support is provided by staff in the Anchorage Regional Office. Our program works closely with the Alaska Department of Fish and Game and other partners to conserve and restore Alaska's fish populations and aquatic habitats. Additional information about the Fisheries Program and work conducted by our field offices can be obtained at:

http://alaska.fws.gov/fisheries/index.htm

The Alaska Region Fisheries Program reports its study findings through two regional publication series. The **Alaska Fisheries Data Series** was established to provide timely dissemination of data to local managers and for inclusion in agency databases. The **Alaska Fisheries Technical Reports** publishes scientific findings from single and multi-year studies that have undergone more extensive peer review and statistical testing. Additionally, some study results are published in a variety of professional fisheries journals.

Alaska Fisheries Data Series Number 2010-03, March 2010
U.S. Fish and Wildlife Service

Run Timing, Abundance, and Distribution of Adult Coho Salmon in the Kasilof River Watershed, Alaska, 2007 - 2009

Kenneth S. Gates[1], James K. Boersma[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 from 2007 through 2009 using fish weirs equipped with underwater video systems and radio telemetry. Combined total annual passage of coho salmon ranged from 623 to 1,556 at the Nikolai and Shantatalik creek weirs between 2007 and 2009. Peak weekly passage at each weir generally occurred during the second and third week of September. Distribution of coho salmon spawning above river kilometer 24 was determined by gastrically implanting a total of 349 radio transmitters into fish captured in the Kasilof River using drift gillnets during 2007 (*N*=109) and 2008 (*N*=240). Thirty-nine (2007) to sixty (2008) percent of the radio-tagged coho salmon selected spawning locations within the Kenai National Wildlife Refuge, upstream of the boundary at Silver Salmon Rapids (rkm 24). Of these fish, 51% spawned in the upper mainstem Kasilof River (2007 *N*=29 and 2008 *N*=94) and 26% (2007 *N*=14 and 2008 *N*=50) selected spawning locations in tributaries of Tustumena Lake. Tustumena Lake tributary streams included Shantatalik, Nikolai, Indian, Fox, West, Glacier and Clear creeks. Other radio-tagged coho salmon spawned outside the Kenai National Wildlife Refuge, in Crooked Creek, Coal Creek and the mainstem Kasilof River downstream of the refuge boundary. All remaining radio-tagged coho salmon did not spawn, and their fates 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 the primary target of 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 and 1997; Finn et al. 1997; Woody et al. 2000; Shields 2006). The Chinook salmon run to the Kasilof River consists of both early and late arriving spawners, and this species has been studied since the 1990’s. However, little research and monitoring effort has been directed toward understanding coho salmon within the watershed.

Coho salmon return to the Kasilof River as early as 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 equipped with underwater video between 2004 and 2007 (U.S. Fish and Wildlife Service and Alaska

Authors: [1]U.S. Fish and Wildlife Service, Kenai Fish and Wildlife Field Office, 43655 Kalifornsky Beach Road, Soldotna, Alaska 99669; or kenneth_gates@fws.gov, james_boersma@fws.gov, and douglas_palmer@fws.gov.
[2]U.S. Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, Alaska 99508; or jbromaghin@usgs.gov.

Department of Fish and Game, unpublished data). Estimates of annual escapement during this period ranged from 2,756 to 5,703 fish. Coho salmon began returning to Crooked Creek in early August, and returns generally peaked in early September. Most coho salmon 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; 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 three of these streams were less than 50 coho salmon, but Indian Creek had a peak count of 931 coho salmon on 9 November. Similar results were observed during ground and aerial surveys conducted for these same streams in 2006 by Palmer and Gates (2007). Coho salmon were observed in only three streams during 2006 surveys: Glacier, Indian, and Shantatalik creeks. Peak counts occurred between 17 and 30 October and ranged from 44 to 195 coho salmon. The greatest number was observed in Indian Creek. Coho salmon have also been documented as being present in Fox and Nikolai creeks (Johnson and Daigneault 2008), but were not observed in surveys conducted during either 1987 or 2006.

Coho salmon returning to the Kasilof River watershed are initially subject to harvests in terminal commercial and personal use gillnet fisheries. Coho salmon that have entered the watershed face additional harvests in personal use, Federal subsistence, and sport fisheries. The sport, personal use gillnet, and personal use dip-net fisheries have harvested an average of 3,670, 109, and 71 coho salmon, respectively, from 1999 to 2008 (Lafferty et. al 2007; Jennings et. al 2007, 2009a, and 2009b; Shields 2009; Jason Pawluk, Alaska Department of Fish and Game, personal communication). The harvest in the Kasilof River commercial terminal gillnet fishery has averaged 892 coho salmon from 2005 to 2008 (Shields 2006, 2007a, 2007b and 2009). Additional harvest of coho salmon can also occur in Federal subsistence fisheries, but no coho salmon harvest within the Kasilof River watershed have been reported since these fisheries began in 2007 (USFWS, unpublished data).

The Federal Subsistence Board determined that residents of Ninilchik qualified for customary and traditional use of salmon, trout, Dolly Varden *Salvelinus malma* and other char on Federal waters within the Kasilof River watershed in January 2006. 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. Recognizing the possibility for increased harvest of coho salmon by Federal subsistence fisheries, the Federal Subsistence Management Program recognized the need for more detailed information on the abundance and distribution of coho salmon within the Kasilof River watershed. We obtained funding through the Office of Subsistence Management's Fisheries Resource Monitoring Program to operate fish weirs equipped with underwater video systems and to use radio telemetry to estimate the abundance and run-timing of adult coho salmon in tributaries of Tustumena Lake and the mainstem Kasilof River upstream of the Kenai National Wildlife Refuge (Refuge) boundary at Silver Salmon Rapids.

Specific objectives of the project were to (1) determine the abundance and run-timing of adult coho salmon entering Nikolai and Shantatalik creeks from 2007 to 2009, (2) detect the ultimate spawning destination upstream of Silver Salmon Rapids (rkm 24) during 2007, via the presence of at least two tagged fish, of a population comprising 10% or more of all the coho salmon passing the capture site during each temporal stratum with probability 0.8, (3) identify the ultimate spawning destination upstream of Silver Salmon Rapids (rkm 24) during 2008, 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, (4) test the hypothesis that the distributions of spawners among temporal strata are equal (2007 and 2008), and (5) estimate the abundance and run timing of each identified spawning component upstream of Silver Salmon Rapids during 2008 using a maximum likelihood estimator. Information pertaining to objectives one to four is provided in this report; objective five results will be documented as a separate report that is currently under review. All information collected from this project will provide fisheries managers with a better understanding of spawning distribution, abundance, and run timing 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, including Chinook, coho, sockeye, and pink salmon, rainbow trout/steelhead *O. mykiss*, Dolly Varden, lake trout *S. namaycush*, and round whitefish *Prosopium cylindraceum* (Johnson and Daigneault 2008).

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 has 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).

Methods

Weir and Video Operations and Design

Weirs equipped with video systems were operated in Nikolai and Shantatalik creeks to estimate the abundance and run-timing of coho salmon (Figure 1). From 2007 through 2009 counting began at both weirs by the fourth week in August and was completed at Nikolai Creek by the end of October, and at Shantatalik Creek by mid November.

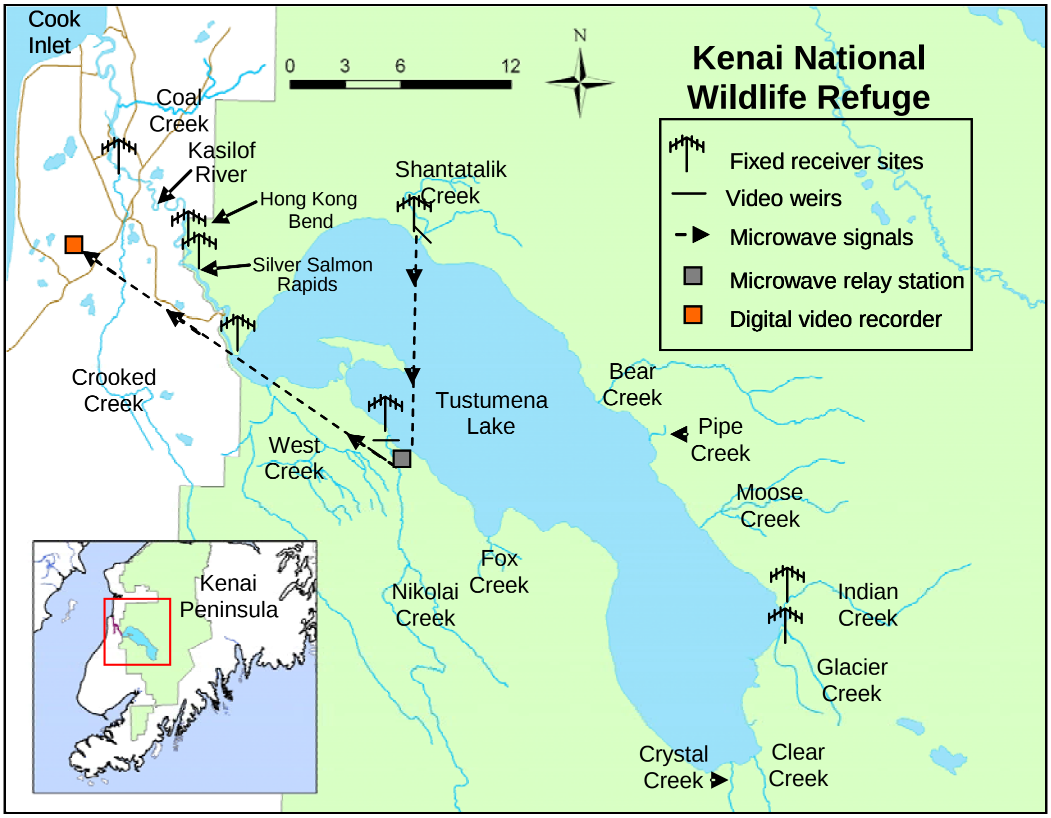

FIGURE 1.—Map of the Kasilof River watershed showing major water bodies, locations of the fixed telemetry receiver sites during 2007 and 2008, and associated equipment used for abundance and run timing estimates for Nikolai and Shantatalik creeks from 2007 through 2009. Kenai National Wildlife Refuge lands are shaded green.

The Nikolai Creek weir has been used since 2005 to enumerate steelhead during spring season. This weir was approximately 200 m upstream from Tustumena Lake and 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 (east bank) and the rigid-picket panel (west bank) were installed between the bank and bulkhead of the resistance board weir to create a fish-tight weir. 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 constructed with three pieces of 6.4-cm aluminum angle bolted together forming an “A” frame; two additional 2.1-m pieces of aluminum angle with 28.6-mm holes drilled 3.2 cm apart were bolted to the front of the bulkhead and ‘A’ frame, creating a framework. The individual pickets were attached to the framework by sliding them through the aforementioned holes. Pickets were 1.8-m in length and made from 25-mm diameter schedule 40 aluminum pipe. The weir was unmanned, except when maintenance was required, and was outfitted with a video and microwave system to monitor upstream fish passage.

The weir located in Shantatalik Creek was a rigid picket weir installed 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 1.8-m in length and made from 25-mm diameter schedule 40 aluminum pipe. Pickets were spaced 3.2 cm apart and attached to the frame by individually sliding them through 28.6-mm holes drilled in two 6-m pieces of aluminum angle bolted to the front of the weir frame. 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 were described by Gates and Palmer (2006) and was similar to that used by Anderson et al. (2004) on Big Creek during 2003 (Appendix 1). One underwater video camera was located inside a sealed video box attached to a 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 enclosed in plywood to isolate it from exterior light. 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. The backdrop of the passage chute from which video images were captured could be adjusted laterally to reduce the number of fish passing through the chute at one time and push fish closer to the camera during turbid water conditions. The backdrop could be easily removed from the video chute when dirty and replaced with a new one.

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 (Appendix 1). 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 1). One DVR was used to record video images from both creeks. The relay station for Shantatalik Creek was co-located with the Nikolai Creek microwave equipment. Using microwave transmissions 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 12-V 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. Sex of each coho salmon was ascertained by observing external characteristics during video review. Coho salmon that could not be assigned a sex were marked as unknown and omitted from analyses.

Radio Telemetry

Radio telemetry was used during 2007 and 2008 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.

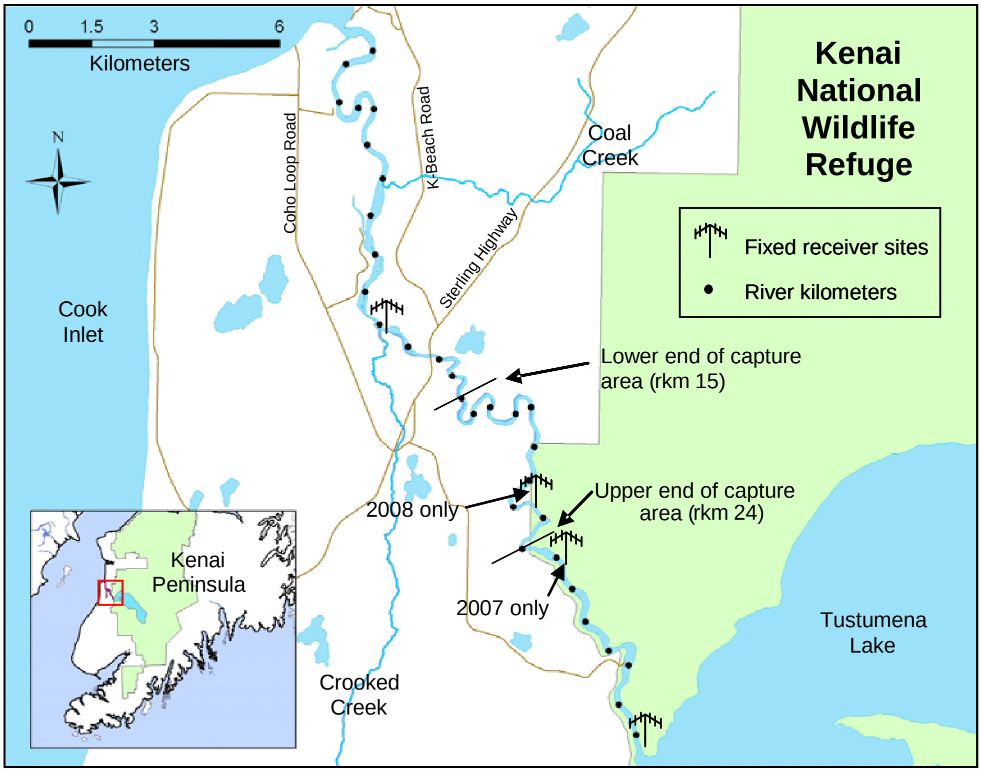

FIGURE 2.—Map of the Kasilof River illustrating the fixed receiver locations and fish capture area during 2007 and 2008.

Fish Capture.—Drift gillnets were actively fished from mid-August through mid-October during 2007 and 2008 between rkm 15 and 24 to capture coho salmon for radio tagging (Figure 2). 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). 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 coho salmon 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.

Radio Tagging.—Coho salmon were radio-tagged during 2007 and 2008 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 that 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 four (2007) to eight (2008) 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.

To develop an initial schedule for tag deployment, we assumed that nearly the entire migration of coho salmon past Silver Salmon Rapids (rkm 24) occurred during the second week in August through the third week in October. This assumption was based on the theory that the migration in the mainstem Kasilof River and related tributaries was similar to that observed at the Crooked Creek weir (U.S. Fish and Wildlife Service and Alaska Department of Fish and Game, unpublished data). Results of tagging during 2007 (Palmer et al. 2008) were then used to develop the tagging schedule for 2008. For both years, we assumed (1) capture and tagging did not change the ultimate spawning locations chosen by coho salmon, (2) coho salmon spawning at different locations had an equal probability of capture within each stratum, and (3) all tagged coho salmon behaved independently.

During 2007 radio transmitters were deployed over five time strata between 12 August and 20 October (Table 1). Stratum length was chosen to be inversely related to the expected abundance of coho salmon, with a 20-day stratum at the beginning and end of the season and three 10-day strata in between these. Radio transmitters were deployed over a short time period beginning at the first day within each stratum. We intended to satisfy the criteria of project Objective 2 using a multinomial probability model (Agresti 2002) of spawning distribution by allocating 30 radio transmitters to each of the five strata. However, 30 transmitters could not be used because of interference on one of the radio frequencies. Loss of these 30 transmitters resulted in a distribution of 24 transmitters per stratum.

TABLE 1.—Schedule for allocating radio transmitters in coho salmon during 2007.

Strata 1		Strata 2		Strata 3		Strata 4		Strata 5	
Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation	Tagging Dates	Tag Allocation
12-31 Aug	24	1-10 Sep	24	11-20 Sep	24	21-30 Sep	24	1-20 Oct	24

During 2008 radio transmitters were deployed over four 15-day strata between 17 August and 15 October 2008 (Table 2). Tags were deployed every other day in a systematic fashion to reduce the possibility of disproportionately representing a single group of coho salmon moving through the tagging area. Eight to nine radio transmitters were to be deployed during each tagging event, but if the daily allocation was not met, the remaining tags were deployed the following day. Sixty radio transmitters were allocated to each of the four strata to satisfy the criteria of Objective 3 using a multinomial probability model (Agresti 2002) of spawning distribution.

TABLE 2.—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.— During 2007 and 2008 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. The fixed receiver stations were located at Silver Salmon Rapids (2007), Hong Kong Bend (rkm 23, 2008), the mouths of Nikolai, Glacier, Indian, Shantatalik and Crooked creeks, and the outlet of Tustumena Lake (Figure 1 and 2). Fixed receiver stations were similar to those used on the Kenai River to monitor rainbow trout movements (Palmer 1998). Each station consisted of 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 tracking was also conducted both years. Boat surveys were 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 either a PA-18 or Cessna 185 fixed-wing aircraft. Aerial surveys were flown at an altitude of approximately 300-400 m 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-equipped weirs on Nikolai and Shantatalik creeks were entered into an Excel® spreadsheet to track the abundance and run-timing for each stream. 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 coho salmon was assigned one of seven possible fates based on information collected from mobile and fixed radio receivers (Table 3). To estimate spawning distribution from each stratum, only tagged coho salmon known to enter the study area, any water upstream of rkm 24, were included in analyses. Coho salmon assigned a fate of harvested or dead/regurgitated were censored from the sample, and those whose spawning location could not be determined with reasonable certainty were placed into an unknown category.

TABLE 3.—Possible fates of radio-tagged coho salmon in the Kasilof River watershed, 2007 and 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.

Spawning locations were defined based on tracking results. A tagged coho salmon 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 reached its spawning location. Potential spawning locations were considered to be the tributaries to Tustumena Lake and the Kasilof River mainstem between the lake and rkm 24.

The assumption that coho salmon destined for the various spawning locations had an equal probability of capture within each stratum was examined 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 carried out using the function "chisq.test" of R version 2.9.0 (RDCT 2009), with 100,000 replications to estimate test significance.

Maximum likelihood methods used to estimate the abundance and run timing of each identified spawning component upstream of Silver Salmon Rapids, based on the results of radio telemetry findings and information collected at each weir location, (Objective 5) will be reported in a separate publication (Bromaghin et al. In review).

Results

Weir and Video Operations

The weir and video systems at Nikolai and Shantatalik creeks were installed by the fourth week of August during all three years and operated through the fourth week in October (Nikolai Creek) and the second week of November (Shantatalik Creek) (Figure 3; Appendices 2 and 5). For each of the years, both weirs and video systems were installed before large numbers of coho salmon entered either stream. Each weir and video system functioned well except for a few interruptions. Flooding rendered the Nikolai Creek weir inoperable during early September 2007 and 2008. Vandalism to the Shantatalik Creek microwave relay resulted in video loss during September 2007. Incomplete counts were obtained for the Shantatalik Creek weir during the first week in October, 2009, due to a hole beneath the fish trap. 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 2007 and 2008. The low voltage in batteries was a direct result of decreased sunlight during the fall period (Appendices 2 and 3).

Escapement and Biological Information

Nikolai Creek.— The total number of coho salmon counted passing the video system at Nikolai Creek during 2007, 2008, and 2009 was 837, 721 and 522, respectively (Figures 3 and 4; Appendix 2). Peak weekly passage occurred on the third week of September during 2007 (N=292), and the second week of September during 2008 (N=367) and 2009 (N=373) (Figure 4). Median cumulative passage was reached and the highest daily count was obtained on the same day in each year: 19 September for 2007 (N=217), 9 September for 2008 (N=348) and 11 September for 2009 (N=332). The number of coho salmon counted after 30 September only represented 8% (N=60, 2008) to 15% (N=126, 2007) of the total escapement from 2007 through 2009.

Weekly sex composition estimates varied within and among years but usually favored males (Figure 5). The percentages of females in total annual coho salmon returns were estimated to be 50% in 2007, 48% in 2008, and 47% in 2009 (Figure 5).

Shantatalik Creek.— The total number of coho salmon counted passing the video system at Shantatalik Creek during 2007, 2008, and 2009 was 719, 594 and 101, respectively (Figures 3 and 6; Appendix 3). Peak weekly passage occurred on the third week of September during

2007 (N=295), the second week of September during 2008 (N=215), and first week of October in 2009 (N=66). Median cumulative passage was reached and the highest daily count was obtained on the same day for two years: 19 September for 2007 (N=190) and 9 October for 2009 (N=42) (Figure 6). For 2008, the highest daily count was obtained on 9 September (N=102) but median cumulative passage was not reached until 18 September. The number of coho salmon counted after 31 October only represented 0.2% (N=1, 2008) to 4% (N=29, 2007) of the total escapement from 2007 to 2009. The annual run to Shantatalik Creek was always less than that of the annual run to Nikolai Creek (Figure 3; Appendices 2 and 3). Annual runs to Nikolai Creek had from 14% (2008) to 81% (2009) more coho salmon than runs to Shantatalik Creek.

Similar to Nikolai Creek, weekly sex composition varied within and among years but usually favored males (Figure 7). However, the percentage of males in the run to Shantatalik Creek was generally greater than observed for Nikolai Creek (Figure 5). The percentages of females in total annual coho salmon returns were estimated to be 38% in 2007, 39% in 2008, and 42% in 2009 (Figure 7).

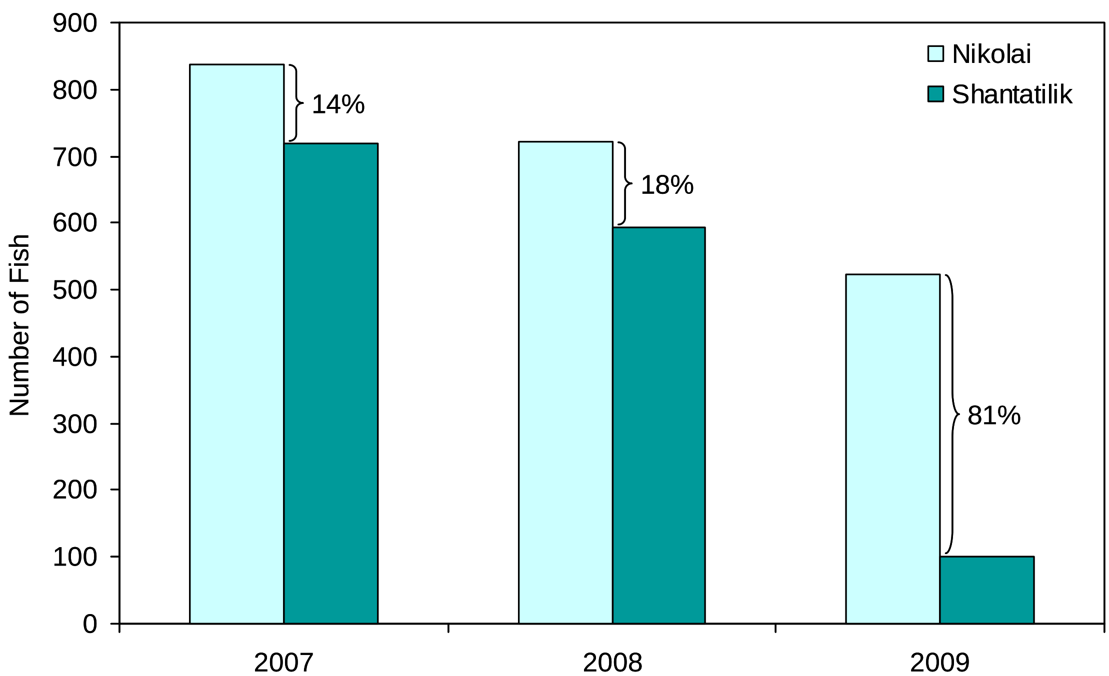

FIGURE 3. —Total escapement of coho salmon into Nikolai and Shantatalik creeks, Alaska, 2007-2009. Percent differences in coho salmon numbers between the two creeks are shown for each year.

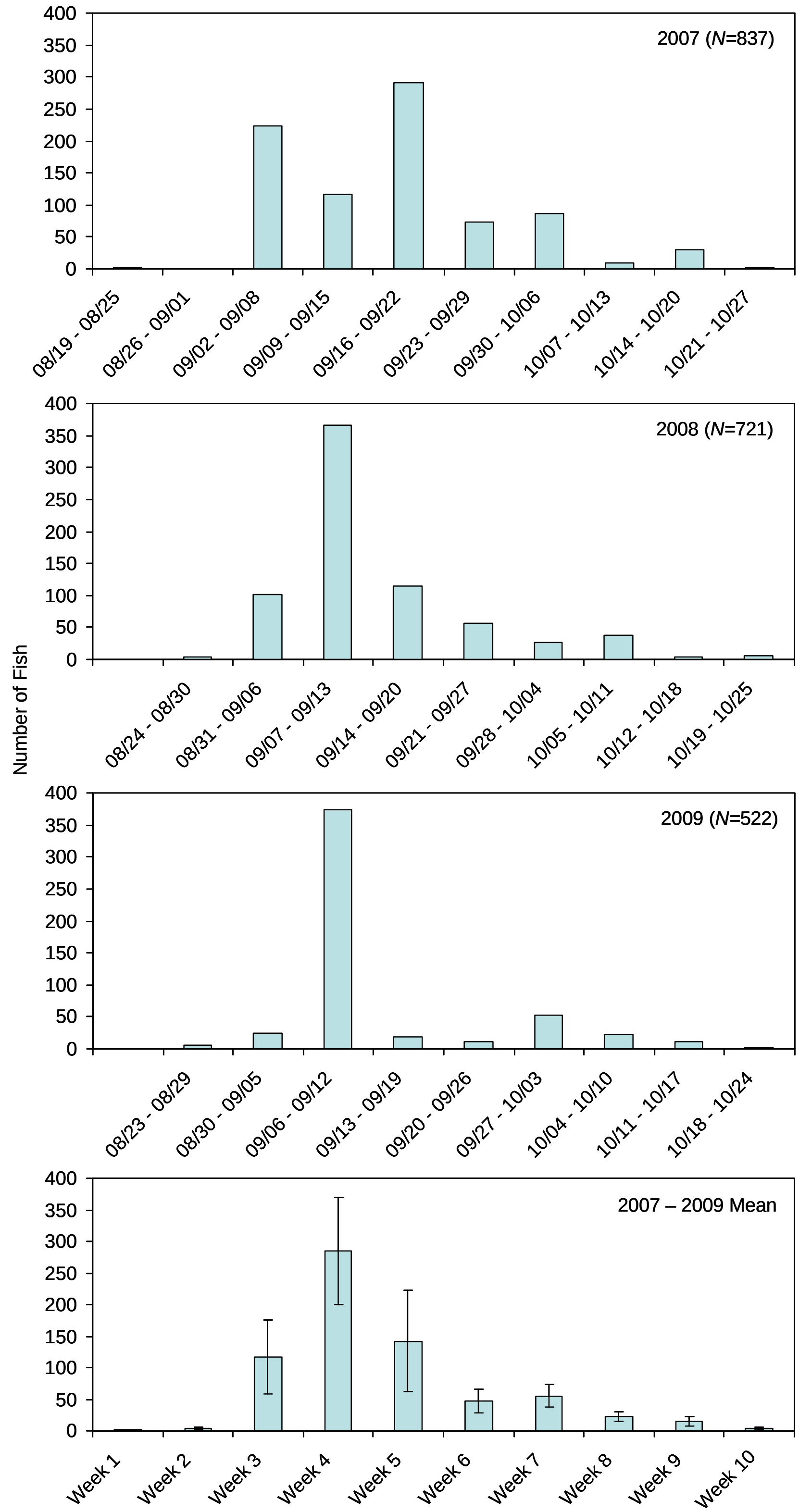

FIGURE 4. —Weekly coho salmon escapements for each year, and mean weekly escapements including standard errors, for all years, Nikolai Creek, Alaska, 2007-2009. The weir was operated from 4 August to 23 October in 2007, from 26 August to 23 October in 2008, and from 25 August to 20 October in 2009.

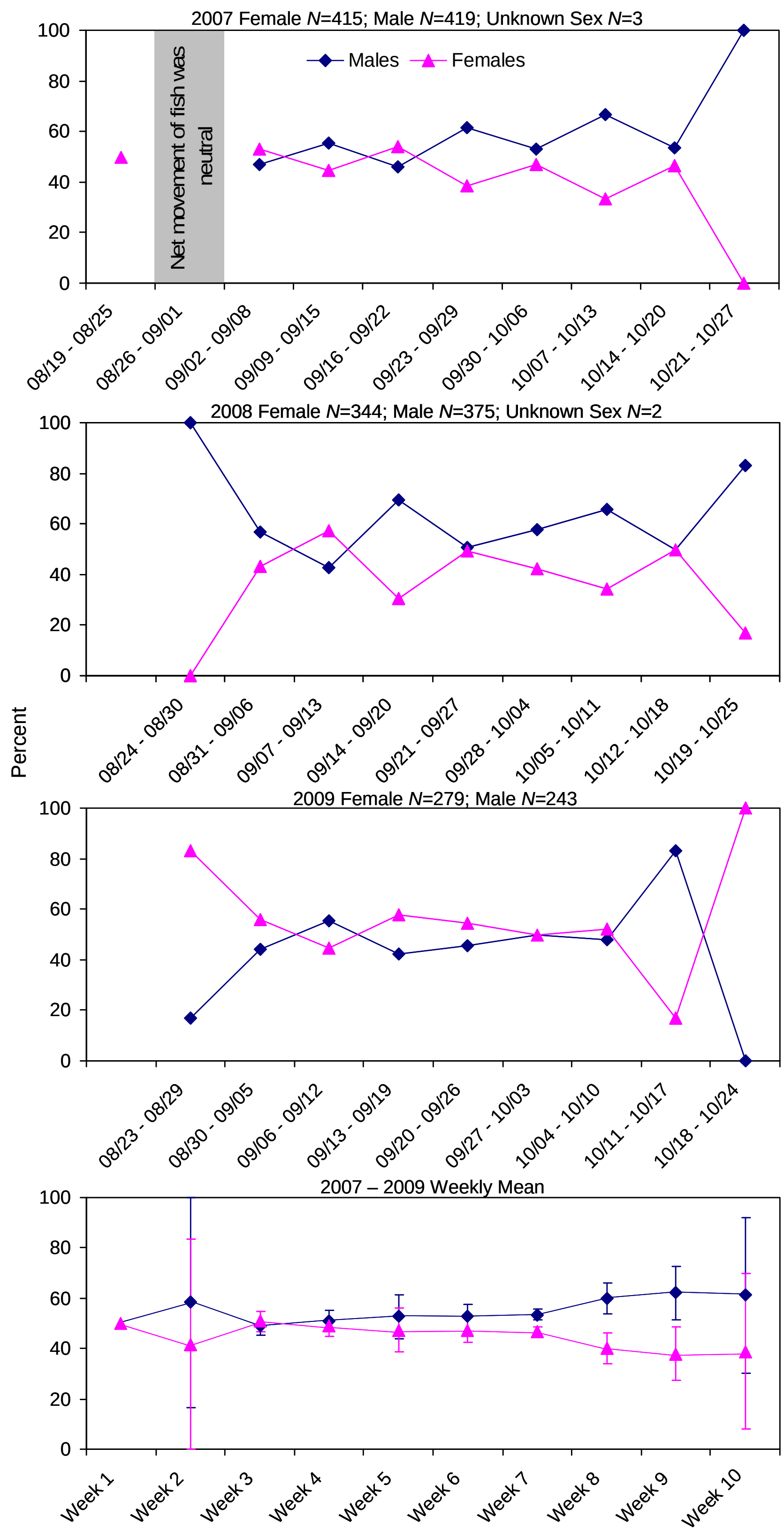

FIGURE 5. —Weekly coho salmon sex composition for each year, and mean weekly sex composition, including standard errors, for all years, Nikolai Creek, Alaska, 2007-2009. Sampling occurred at a weir that was operated from 4 August to 23 October in 2007, 26 August to 23 October in 2008, and 25 August to 20 October in 2009.

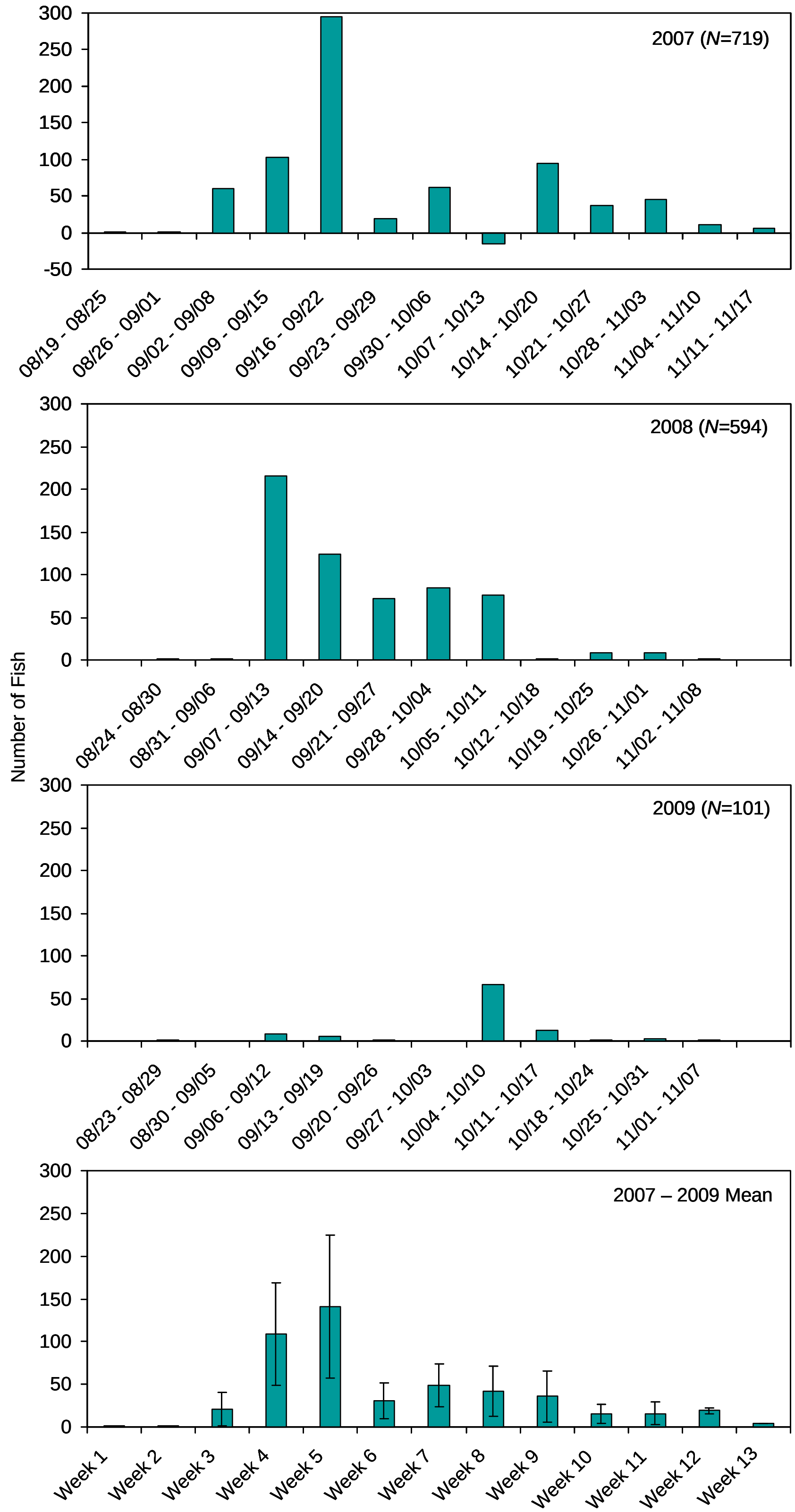

FIGURE 6. —Weekly coho salmon escapements for each year, and mean weekly escapement including standard errors for all years, Shantatalik Creek, Alaska, 2007-2009. The weir was operated from 14 August to 16 November in 2007, from 28 August to 4 November in 2008, and from 25 August to 3 November in 2009. For 2007, the first ten days of weir operation, 14-23 August, was omitted from the figure since no coho migrated past the weir site.

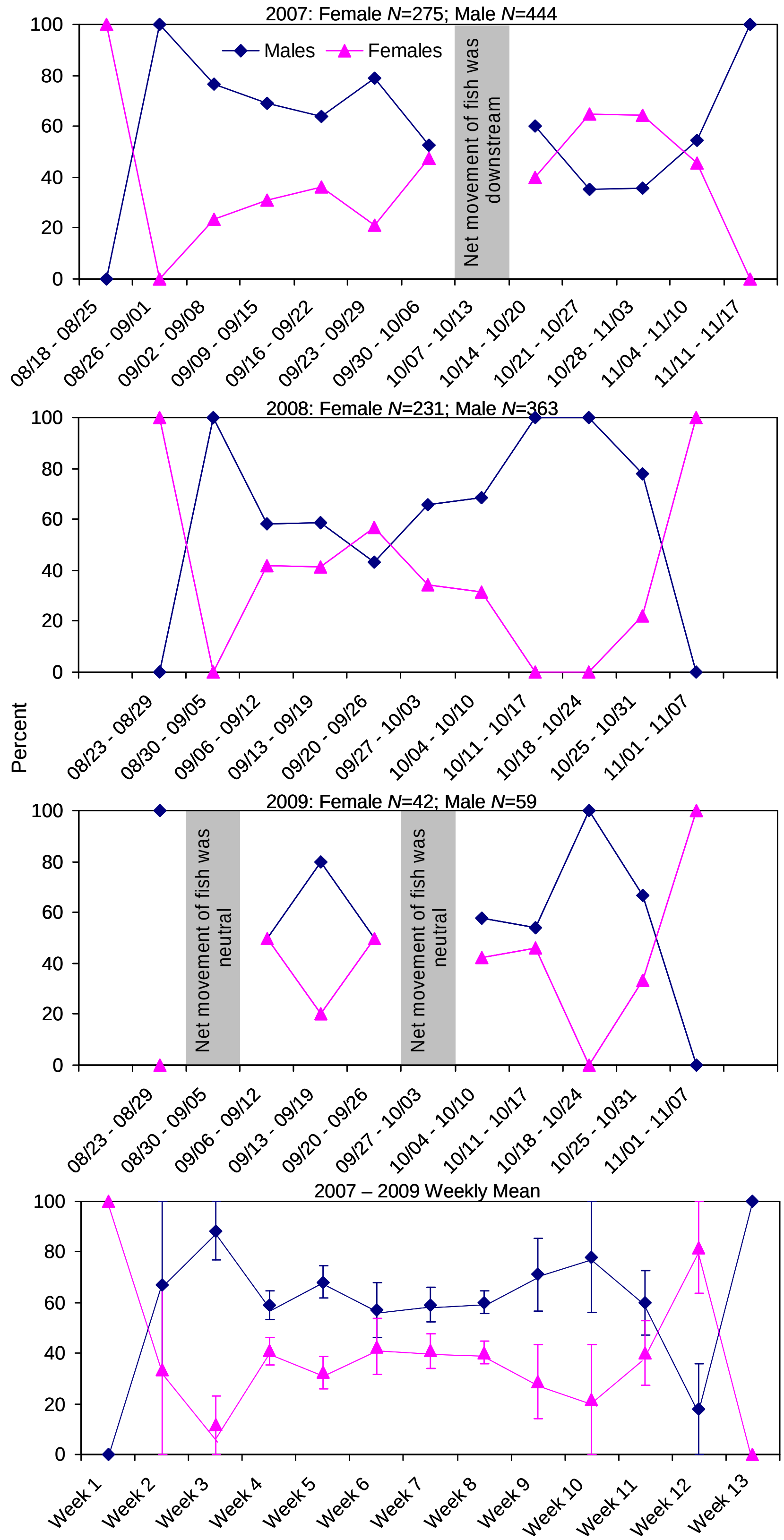

FIGURE 7. —Weekly coho salmon sex composition for each year, and mean weekly sex composition including standard errors for all years, Shantatalik Creek, Alaska, 2007-2009. Sampling occurred at a weir operated from 14 August to 16 November in 2007, 28 August to 4 November in 2008, and 25 August to 3 November in 2009.

Radio Telemetry

A total of 349 coho salmon (153 females and 196 males) were fitted with radio tags during 2007 (*N*=109) and 2008 (*N*=240). Radio tagging occurred between the second week of August and the second week of October during both years (Appendices 4 and 5). Radio transmitters were deployed over five temporal strata in 2007 and four temporal strata in 2008. During 2007, as a result of catch rates and tag redeployment, strata one through five contained 23, 25, 24, 8, and 29 radio transmitters, respectively. During 2008, 60 coho salmon were fitted with radio tags in each of the four temporal strata. All radio-tagged coho salmon were captured in an 8-km section of river immediately downstream from the refuge boundary at Silver Salmon Rapids. Radio-tagged coho salmon ranged in length from 465 to 770 mm.

Thirty-nine to sixty percent (2007 *N*=43 and 2008 *N*=144) of radio-tagged coho salmon were assigned to a spawning location within the study area upstream of rkm 24 based on information collected from mobile and fixed radio receivers (Tables 4 and 5). Most of those 187 coho salmon (29 in 2007 and 94 in 2008) spawned in the upper mainstem Kasilof River between rkm 24 and the Tustumena Lake boat ramp (Figures 8 and 9). The remainder (*N*=64) spawned in tributaries of Tustumena Lake including Shantatalik, Nikolai, Indian, Fox, West, Glacier and Clear creeks. Sixty-six radio-tagged coho salmon spawned outside the study area in Crooked Creek, Coal Creek and the mainstem Kasilof River downstream of the refuge boundary. No spawning location could be determined for 51% of the radio-tagged coho salmon during 2007 (*N*=56) and 17% during 2008 (*N*=40). These were assigned fates of “Dead/Regurgitated”, “Back Out”, “Unknown”, and “Harvested (Tables 4 and 5). All radio-tagged coho salmon classified as “Unknown” were last detected either below the study area or in Tustumena Lake.

To test the hypothesis that the distributions of spawners were equal among all temporal strata, spawners were classified into three categories for the exact chi-square procedure used: tributary spawners (2007: *N*=14 and 2008: *N*=50), mainstem refuge spawners (2007: *N*=29 and 2008: *N*=94), and other spawners (2007: *N*=10 and 2008: *N*=56). The test was significant for both 2007 ($\chi2 = 29.2745$, df = 8, $P = 0.0003$) and 2008 ($\chi^2 = 79.79$, df = 6, $P < 0.0001$), indicating that the distributions of spawners were not equal among all strata. The significance of the test was primarily driven by changes in relative abundance of tributary and mainstem spawners early and late in the run (Tables 4 and 5).

TABLE 4. —Fates assigned to coho salmon fitted with radio tags, Kasilof River, Alaska, 17 August-15 October, 2007.

	Strata						
Fate	1	2	3	4	5	Total	%
Tributary Spawners							
Shantatalik Creek	5		1			6	5.5
Nikoilai Creek	3	1				4	3.7
Indian Creek	2		2			4	3.7
Mainstem Spawners above rkm 24 (Refuge)	2	6	5	2	14	29	26.6
Other Spawners							
Maintstem below rkm 24		1		1	2	4	3.7
Crooked Creek		2	1	1	1	6	5.5
Dead/Regurgitated	1	1	4	2	9	17	15.6
Back Out	2	10	9	2	1	24	22.0
Unknown	7	4	2		2	15	13.8

TABLE 5. —Fates assigned to coho salmon fitted with radio tags, Kasilof River, Alaska, 18 August-13 October, 2008.

	Strata					
Fate	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

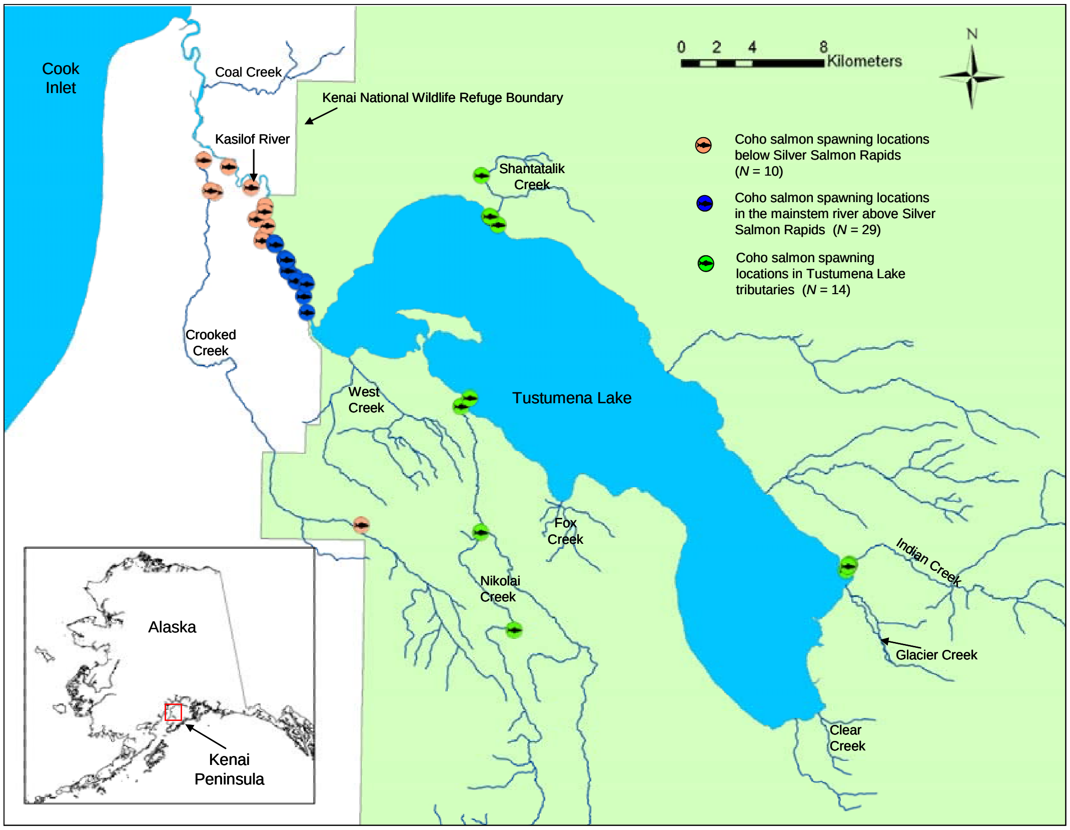

FIGURE 8. —Spawning locations selected by radio-tagged coho salmon in the Kasilof River watershed during 2007.

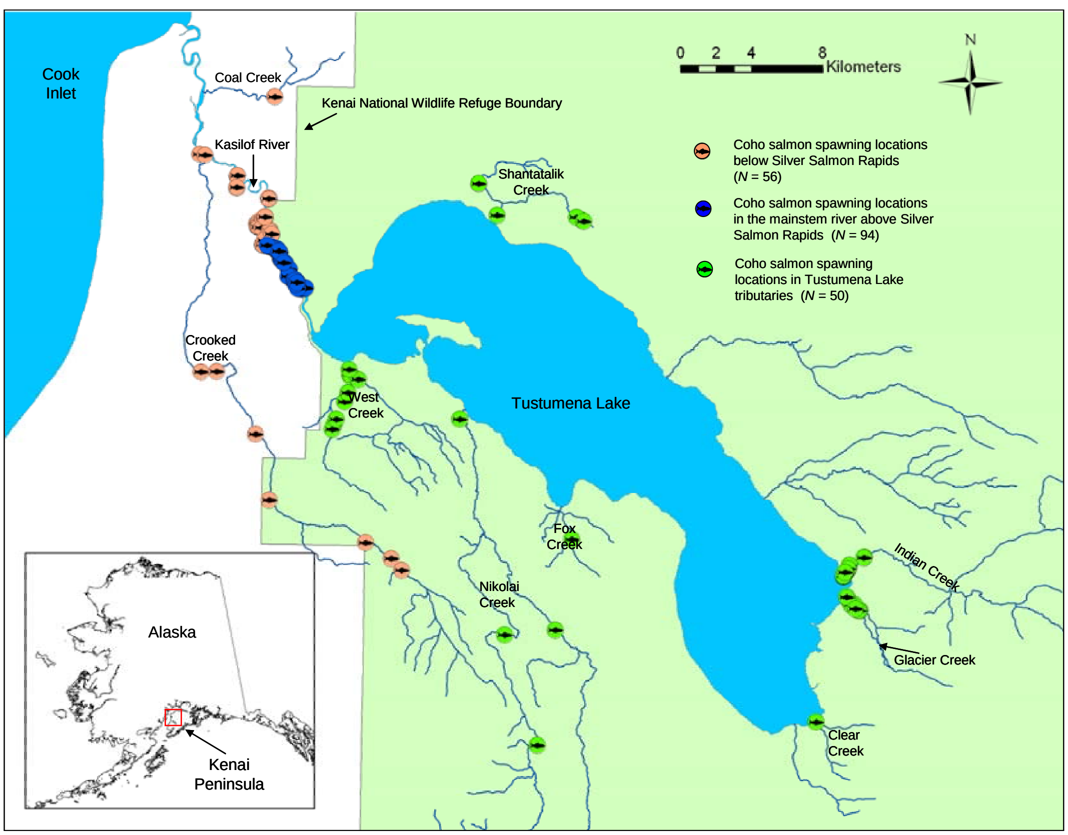

FIGURE 9. —Spawning locations selected by radio-tagged coho salmon in the Kasilof River watershed during 2008.

Discussion

Although not all coho salmon passing the Nikolai and Shantatalik creek weir sites were counted each year, primarily because of periodic interruptions in counts caused by vandalism, flooding events, changes in stream morphology, and power failures, we feel that our estimates probably account for most coho salmon returning to these streams (Figure 3; Appendices 2 and 3). The interruptions resulted in missed counts for a total of 14 days at Nikolai Creek and missed or incomplete counts for a total of 20 days at Shantatalik Creek for all three years (Appendices 2 and 3). We did not try to estimate the numbers of coho salmon that could have been passed the sites without being counted during these days since passage rates varied greatly from day to day throughout the season. However, most of the days with missing counts were either prior to or after days when most coho salmon passage was recorded. Therefore, we think the annual differences in run abundance we documented among and between the two creeks represented actual differences with one possible exception: the large difference between 2009 annual counts for the two weirs. In 2009, a breach in the Shantatalik Creek weir, coupled with dramatic changes in stream morphology near the mouth of this creek, may have allowed a relatively large number of coho salmon to pass this weir site without being counted. This may be why there was an 81% difference in counts between the weirs in 2009 and only 14% and 18% differences during 2007 and 2008, respectively. The changes in stream morphology near the mouth of Shantatalik Creek in 2009 were substantial, and caused by flooding during the spring. The mouth of the creek was shifted approximately 200 m east along the lake shore, and water depth near the mouth was reduced to less than 7.5 cm. The creek mouth gradually changed its location throughout the entire summer and fall until it reached its original location by November. The hole beneath the weir and fish trap developed between visits to the site during early October, and was probably present less than five days before we eliminated it. We do not feel that large numbers of coho salmon passed the weir undetected during this period because some coho salmon are typically observed passing through the video chute even when a breach occurs, especially if large numbers of coho salmon are passing the weir site. Aside from effects of changes in stream morphology and the weir breach, the total coho salmon return to the Kasilof River watershed was probably relatively low during 2009, since counts at both weirs were less than counts obtained during 2007 and 2008.

While our samples showed a wide range of variability across years for weekly estimates of sex ratios in both Nikolai and Shantatalik creeks, most weekly samples had more males than females. Sex ratios that were skewed towards males were also documented for coho salmon sampled for genetic tissue during 2009 at both Shantatalik (1.2:1) and Nikolai creeks (1.2:1) (U.S. Fish and Wildlife Service, unpublished data).

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

Differences in run timing between mainstem and tributary spawners were similar among years during our project. Although mainstem spawners were represented in all five of our tagging strata during 2007 and all four of our tagging strata during 2008, most mainstem spawners (69% in 2007 and 72% in 2008) were tagged after mid-September, while almost all tributary spawners (79% in 2007 and 90% in 2008) were tagged by the second week in September. The one exception to this pattern was documented for Glacier Creek. Radio-tagged coho salmon returning to this creek were represented evenly in all four tagging strata during 2008, which suggest this population could have a later run-component. This could be due to temperature conditions in Glacier Creek since it is spring fed. Differences in run timing between tributary and mainstem spawners are common in *Oncorhynchus* spp., especially in streams where timing of upstream migration extends over a period of several weeks (Groot and Margolis 1991).

Estimates of the abundance and run timing for each identified spawning component upstream of Silver Salmon Rapids (rkm 24) during 2008 will be published in a separate report by Bromaghin et al. (In review). This report will outline the statistical methods used to estimate the population specific abundance and run timing of coho salmon spawning upstream of rkm 24 using partial abundance information in conjunction with radio telemetry.

Our project represents the most inclusive spawning and distribution information available for coho salmon in the upper Kasilof River watershed, and results will be of use in managing the various fisheries that harvest this species. For example, knowledge of differential run timing of mainstem and lake tributary spawners will be important in managing any future Federal subsistence harvest of coho salmon using a fish wheel on the mainstem Kasilof River. Federal subsistence regulations currently do not distinguish between these two spawning groups, but it may be necessary to separately manage harvests of these two groups to ensure that the smaller tributary populations are not adversely impacted. Coho salmon passing a mainstem fish wheel prior to mid-September would likely to represent primarily lake tributary spawners (Tables 4 and 5). Most of these tributaries support spawning populations of less than 1,000 coho salmon, and these relatively small populations are more vulnerable to overharvest than larger mainstem Kasilof River spawning populations (Bromaghin et al. In Review).

Recommendations

Our recommendation for future work on coho salmon within the Kasilof River drainage would be to first document the genetic structure of known spawning groups and then determine whether differences can be detected in mixed-stock samples with a reliable level of accuracy. If accurate stock composition estimates can be made, then a mixed-stock analysis of coho salmon captured in the mainstem Kasilof River should be conducted to identify the stocks that would likely be impacted the most. Finally, a repeat of the population estimate conducted during 2008 (Bromaghin et al. In review) may be needed, if there is substantial harvest of coho salmon by the fish wheel fishery.

Acknowledgements

Special appreciation is extended to those who participated in project setup, data collection, and video review including Waylon Marler, Chad Whaley, Todd Anderson, Adam Reimer, Haley Ohms, and Bill Carter. We also thank Michael and Linda Sipes for providing us access to their property to operate the microwave equipment and DVR for Nikolai and Shantatalik creeks weir projects.

The U.S. Fish and Wildlife Service, Office of Subsistence Management provided funds for this project through the Fisheries Resource Monitoring Program, Project FIS 07-507 and FIS 08-502.

References

Agresti, A. 2002. Categorical data analysis, 2nd edition. John Wiley & Sons, Hoboken, New Jersey.

Anderson, J. L., K. S. Whitton, K. K. Cornum, and T. D. Auth. 2004. Abundance and run timing of adult Pacific salmon in Big Creek, Becharof National Wildlife Refuge, 2003. U. S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2004-7, King Salmon, Alaska.

Bromaghin, J.F., K.S. Gates, and D.E. Palmer. In review. Estimation of adult salmon abundance and migratory timing using telemetric mark-recapture.

Burger, C. V., R. L. Wilmot, and D. B. Wangaard. 1985. Comparison of spawning areas and times for two runs of Chinook salmon *Oncorhynchus tshawytscha* in the Kenai River, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 42: 693-700.

Burger, C. V., J. E. Finn, and L. Holland-Bartels. 1995. Pattern of shoreline spawning by sockeye salmon in a glacially turbid lake: Evidence for subpopulation differentiation. Transactions of the American Fisheries Society 124:1–15.

Burger, C. V., W. J. Spearman, and M. A. Cronin. 1997. Genetic differentiation of sockeye salmon subpopulations from a geologically young Alaskan lake system. Transactions of the American Fisheries Society 126:926–938.

Carlon, J. A., and D. Evans. 2007. Abundance of adult coho salmon in the Kenai River, Alaska, 1999-2003. Alaska Department of Fish and Game, Fishery Data Series Number 07-81, Anchorage, Alaska.

Chythlook, J. S., and M. J. Evenson. 2003. Assessment of Chinook, chum, and coho salmon escapements in the Holitna River drainage using radio telemetry, 2002. Alaska Department of Fish and Game, Fishery Data Series Number 03-23, Anchorage, Alaska.

Faurot, D., and R. N. Jones. 1990. Run timing and spawning distribution of coho and late run Chinook salmon in the Kasilof River watershed, Alaska, 1987. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 9, Kenai, Alaska.

Finn, J. E., C. V. Burger, and L. Holland-Bartels. 1997. Discrimination among populations of sockeye salmon fry with fourier analysis of otolith banding patterns formed during incubation. Transactions of the American Fisheries Society 126:559–578.

Gates, K. S., and D. E. Palmer. 2004. Estimation of the sockeye salmon escapement into McLees Lake, Unalaska Island, Alaska, 2003. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2004-1, Kenai, Alaska.

Gates, K. S., and D. E. Palmer. 2006. Abundance and run timing of adult steelhead trout in Crooked and Nikolai Creeks, Kenai Peninsula, Alaska, 2006. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2006-13, Kenai, Alaska.

Greenwood, P. E., and M. S. Nikulin. 1996. A guide to chi-square testing. John Wiley & Sons, New York, New York.

Groot, C., and L. Margolis. 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver, British Columbia.

Jennings, G. B., K. Sundet, and A. E. Bingham. 2007. Participation, catch, and harvest in Alaska sport fisheries during 2004. Alaska Department of Fish and Game, Fishery Data Series Number 07-40, Anchorage, Alaska.

Jennings, G. B., K. Sundet, and A. E. Bingham. 2009a. Participation, catch, and harvest in Alaska sport fisheries during 2006. Alaska Department of Fish and Game, Fishery Data Series Number 09-47, Anchorage, Alaska.

Jennings, G. B., K. Sundet, and A. E. Bingham. 2009b. Participation, catch, and harvest in Alaska sport fisheries during 2005. Alaska Department of Fish and Game, Fishery Data Series Number 09-54, Anchorage, Alaska.

Johnson, J., and M. Daigneault. 2008. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southcentral Region, Effective June 2, 2008. Alaska Department of Fish and Game, Special Publication Number 08-05, Anchorage, Alaska.

Kyle, G. B. 1992. Summary of sockeye salmon (*Oncorhynchus nerka*) investigations in Tustumena Lake, 1981-1991. Alaska Department of Fish and Game, Fisheries Rehabilitation and Enhancement Division, Report 122, Juneau, Alaska.

Lafferty, R., R. Massengill, D. Bosch, and J. J. Hasbrouck. 2007. Stock status of Coho Salmon in Upper Cook Inlet: Report to the Alaska Board of Fisheries, January 2005. Alaska Department of Fish and Game, Fishery Manuscript No. 07-01, Anchorage, Alaska.

Moser, E. 1998. Water resource inventory and assessment, Kenai National Wildlife Refuge, 1997 stream discharge gauging data. U.S. Fish and Wildlife Service, Water Resource Branch, WRB 98-01, Anchorage, Alaska.

Palmer, D. E. 1998. Migratory behavior and seasonal distribution of radio-tagged rainbow trout in the Kenai River, Alaska. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 46, Kenai, Alaska.

Palmer, D. E., and K. S. Gates. 2007. Coho salmon spawning assessment in Tustumena Lake tributaries, 2006. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2007-10, Kenai, Alaska.

Palmer, D. E., K. S. Gates, and J. F. Bromaghin. 2008. Run timing, abundance, and distribution of adult coho salmon in the Kasilof River watershed, Alaska, 2007. U.S. Fish and Wildlife Service, Alaska Fisheries Data Series Report Number 2008-19, Soldotna, Alaska.

Ramstad, K. M., and C. A. Woody. 2003. Radio tag retention and tag-related mortality among adult sockeye salmon. North American Journal of Fisheries Management 23:978-982.

RDCT (R Development Core Team). 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Shields, P. 2006. Upper Cook Inlet commercial fisheries annual management report, 2005. Alaska Department of Fish and Game, Fishery Management Report Number 06-42, Anchorage, Alaska.

Shields, P. 2007a. Upper Cook Inlet commercial fisheries annual management report, 2006. Alaska Department of Fish and Game, Fishery Management Report Number 07-36, Anchorage, Alaska.

Shields, P. 2007b. Upper Cook Inlet commercial fisheries annual management report, 2007. Alaska Department of Fish and Game, Fishery Management Report Number 07-64, Anchorage, Alaska.

Shields, P. 2009. Upper Cook Inlet commercial fisheries annual management report, 2008. Alaska Department of Fish and Game, Fishery Management Report Number 09-32, Anchorage, Alaska.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

Winter, J. D. 1983. Underwater biotelemetry. Pages 371 – 395 *in* L.A. Nielsen and D.L. Johnson, editors. Fisheries techniques. American Fisheries Society, Bethesda, Maryland.

Woody, C. A., J. Olsen, J. Reynolds, and P. Bentzen. 2000. Temporal variation in phenotypic and genotypic traits in two sockeye salmon populations, Tustumena Lake, Alaska. Transactions of the American Fisheries Society 129:1031-1043.

APPENDIX 1. —List of video and microwave equipment used to monitor coho salmon abundance at Nikolai and Shantatalik creeks, Alaska during 2007 and 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 2007 through 2009. Boxed areas represent the second and third quartiles and median passage dates. Shaded areas represent complete days with no video because of high water and power outages.

	2007		2008		2009	
Date	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion
8/4	0	0.0000				
8/5	0	0.0000				
8/6	0	0.0000				
8/7	0	0.0000				
8/8	0	0.0000				
8/9	0	0.0000				
8/10	0	0.0000				
8/11	0	0.0000				
8/12	0	0.0000				
8/13	0	0.0000				
8/14	0	0.0000				
8/15	0	0.0000				
8/16	0	0.0000				
8/17	0	0.0000				
8/18	0	0.0000				
8/19	0	0.0000				
8/20	2	0.0024				
8/21	0	0.0024				
8/22	0	0.0024				
8/23	0	0.0024				
8/24	0	0.0024				
8/25	0	0.0024			0	0.0000
8/26	0	0.0024	0	0.0000	0	0.0000
8/27	0	0.0024	3	0.0042	2	0.0038
8/28	0	0.0024	0	0.0042	2	0.0077
8/29	0	0.0024	1	0.0055	2	0.0115
8/30	0	0.0024	0	0.0055	1	0.0134
8/31	0	0.0024	64	0.0943	8	0.0287
9/1	0	0.0024	34	0.1415	1	0.0307
9/2	0	0.0024	1	0.1429	7	0.0441
9/3	0	0.0024	2	0.1456	6	0.0556
9/4	0	0.0024	0	0.1456	1	0.0575
9/5	0	0.0024	0	0.1456	1	0.0594
9/6	67	0.0824	1	0.1470	1	0.0613
9/7	40	0.1302	1	0.1484	3	0.0670
9/8	118	0.2712	17	0.1720	5	0.0766
9/9	47	0.3274	348	0.6546	15	0.1054
9/10	0	0.3274	-7	0.6449	36	0.1743
9/11	1	0.3286	0	0.6449	332	0.8103
9/12	1	0.3297	7	0.6546	-19	0.7739
9/13	58	0.3990	1	0.6560	16	0.8046
9/14	10	0.4110	0	0.6560	3	0.8103
9/15	0	0.4110	0	0.6560	0	0.8103
9/16	-1	0.4098	83	0.7712	0	0.8103
9/17	-1	0.4086	7	0.7809	0	0.8103
9/18	3	0.4122	6	0.7892	0	0.8103

-Continued-

APPENDIX 2. —(Page 2 of 2)

	2007		2008		2009	
Date	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion
9/19	217	0.6714	12	0.8058	0	0.8103
9/20	75	0.7611	7	0.8155	0	0.8103
9/21	-1	0.7599	10	0.8294	0	0.8103
9/22	0	0.7599	5	0.8363	0	0.8103
9/23	0	0.7599	3	0.8405	0	0.8103
9/24	8	0.7694	6	0.8488	8	0.8257
9/25	7	0.7778	28	0.8877	3	0.8314
9/26	9	0.7885	3	0.8918	0	0.8314
9/27	0	0.7885	4	0.8974	0	0.8314
9/28	29	0.8232	5	0.9043	0	0.8314
9/29	21	0.8483	5	0.9112	0	0.8314
9/30	1	0.8495	4	0.9168	14	0.8582
10/1	2	0.8519	1	0.9182	38	0.9310
10/2	0	0.8519	-1	0.9168	0	0.9310
10/3	2	0.8542	6	0.9251	0	0.9310
10/4	29	0.8889	6	0.9334	0	0.9310
10/5	22	0.9152	8	0.9445	0	0.9310
10/6	31	0.9522	6	0.9528	2	0.9349
10/7	1	0.9534	3	0.9570	3	0.9406
10/8	0	0.9534	9	0.9695	18	0.9751
10/9	0	0.9534	6	0.9778	0	0.9751
10/10	0	0.9534	2	0.9806	0	0.9751
10/11	0	0.9534	4	0.9861	0	0.9751
10/12	-1	0.9522	0	0.9861	0	0.9751
10/13	9	0.9630	0	0.9861	2	0.9789
10/14	5	0.9689	0	0.9861	2	0.9828
10/15	2	0.9713	1	0.9875	3	0.9885
10/16	4	0.9761	1	0.9889	4	0.9962
10/17	15	0.9940	1	0.9903	1	0.9981
10/18	4	0.9988	1	0.9917	0	0.9981
10/19	0	0.9988	0	0.9917	1	1.0000
10/20	0	0.9988	3	0.9958	0	1.0000
10/21	1	1.0000	0	0.9958		
10/22	0	1.0000	3	1.0000		
10/23	0	1.0000	0	1.0000		
10/24	0	1.0000				
Total	837		721		522	

APPENDIX 3. —Daily counts and cumulative proportion of coho salmon passing through Shantatalik Creek weir during 2007 through 2009. Boxed areas represent the second and third quartiles and median passage dates. Shaded areas represent incomplete counts due to a breach in the weir and days with no video because of power outages and vandalism.

	2007		2008		2009	
Date	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion
8/14	0	0.0000				
8/15	0	0.0000				
8/16	0	0.0000				
8/17	0	0.0000				
8/18	0	0.0000				
8/19	1	0.0014				
8/20	0	0.0014				
8/21	0	0.0014				
8/22	0	0.0014				
8/23	0	0.0014				
8/24	0	0.0014				
8/25	0	0.0014			0	0.0000
8/26	0	0.0014			0	0.0000
8/27	1	0.0028			0	0.0000
8/28	0	0.0028	0	0.0000	0	0.0000
8/29	0	0.0028	1	0.0017	1	0.0099
8/30	0	0.0028	0	0.0017	0	0.0099
8/31	0	0.0028	0	0.0017	0	0.0099
9/1	0	0.0028	0	0.0017	0	0.0099
9/2	0	0.0028	0	0.0017	0	0.0099
9/3	0	0.0028	1	0.0034	0	0.0099
9/4	0	0.0028	0	0.0034	0	0.0099
9/5	0	0.0028	1	0.0051	0	0.0099
9/6	0	0.0028	0	0.0051	0	0.0099
9/7	3	0.0070	1	0.0067	0	0.0099
9/8	57	0.0862	10	0.0236	0	0.0099
9/9	10	0.1001	120	0.2256	5	0.0594
9/10	-2	0.0974	17	0.2542	2	0.0792
9/11	6	0.1057	1	0.2559	-1	0.0693
9/12	62	0.1919	46	0.3333	2	0.0891
9/13	35	0.2406	20	0.3670	0	0.0891
9/14	2	0.2434	8	0.3805	2	0.1089
9/15	-10	0.2295	2	0.3838	0	0.1089
9/16	-2	0.2267	0	0.3838	0	0.1089
9/17	-1	0.2253	22	0.4209	3	0.1386
9/18	11	0.2406	71	0.5404	0	0.1386
9/19	190	0.5049	8	0.5539	0	0.1386
9/20	93	0.6342	13	0.5758	0	0.1386
9/21	4	0.6398	5	0.5842	0	0.1386
9/22	0	0.6398	4	0.5909	0	0.1386
9/23	-9	0.6273	2	0.5943	0	0.1386
9/24	-1	0.6259	15	0.6195	0	0.1386
9/25	32	0.6704	21	0.6549	2	0.1584
9/26	-1	0.6690	19	0.6869	0	0.1584
9/27	-1	0.6676	6	0.6970	0	0.1584
9/28	2	0.6704	8	0.7104	0	0.1584

-Continued-

APPENDIX 3. —(Page 2 of 2)

	2007		2008		2009	
Date	Daily	Cumulative Proportion	Daily	Cumulative Proportion	Daily	Cumulative Proportion
9/29	-3	0.6662	3	0.7155	0	0.1584
9/30	1	0.6676	-2	0.7121	0	0.1584
10/1	7	0.6773	1	0.7138	0	0.1584
10/2	10	0.6912	5	0.7222	0	0.1584
10/3	2	0.6940	56	0.8165	0	0.1584
10/4	-2	0.6912	14	0.8401	0	0.1584
10/5	8	0.7024	1	0.8418	0	0.1584
10/6	35	0.7510	-2	0.8384	3	0.1881
10/7	7	0.7608	2	0.8418	2	0.2079
10/8	-5	0.7538	-3	0.8367	12	0.3267
10/9	-7	0.7441	13	0.8586	42	0.7426
10/10	-2	0.7413	56	0.9529	7	0.8119
10/11	-4	0.7357	9	0.9680	0	0.8119
10/12	-5	0.7288	3	0.9731	0	0.8119
10/13	1	0.7302	0	0.9731	4	0.8515
10/14	38	0.7830	-2	0.9697	2	0.8713
10/15	9	0.7955	1	0.9714	6	0.9307
10/16	4	0.8011	-3	0.9663	1	0.9406
10/17	2	0.8039	1	0.9680	0	0.9406
10/18	-20	0.7761	1	0.9697	1	0.9505
10/19	58	0.8567	2	0.9731	0	0.9505
10/20	4	0.8623	0	0.9731	0	0.9505
10/21	-10	0.8484	-3	0.9680	0	0.9505
10/22	-3	0.8442	-1	0.9663	0	0.9505
10/23	0	0.8442	1	0.9680	1	0.9604
10/24	5	0.8512	6	0.9781	0	0.9604
10/25	20	0.8790	3	0.9832	0	0.9604
10/26	24	0.9124	1	0.9848	0	0.9604
10/27	1	0.9138	4	0.9916	0	0.9604
10/28	0	0.9138	3	0.9966	1	0.9703
10/29	0	0.9138	1	0.9983	0	0.9703
10/30	11	0.9291	-1	0.9966	1	0.9802
10/31	22	0.9597	1	0.9983	1	0.9901
11/1	14	0.9791	0	0.9983	1	1.0000
11/2	0	0.9791	1	1.0000	0	1.0000
11/3	-2	0.9764	0	1.0000	0	1.0000
11/4	-1	0.9750	0	1.0000		
11/5	0	0.9750				
11/6	0	0.9750				
11/7	0	0.9750				
11/8	6	0.9833				
11/9	5	0.9903				
11/10	1	0.9917				
11/11	1	0.9930				
11/12	3	0.9972				
11/13	1	0.9986				
11/14	0	0.9986				
11/15	1	1.0000				
11/16	0	1.0000				
Total	719		594		101	

APPENDIX 4. —Tagging and fate summaries for coho salmon radio-tagged in the Kasilof River during 2007.

Transmitter number	Stratum	Mid-eye to fork length (mm)	Sex	Tagging date	Tagging Location (WGS84) Latitude	Longitude	Final fate
0342	1	645	F	17-Aug	60.2826	-151.2075	Tributary Spawner (Indian Cr.)
3344	1	640	M	17-Aug	60.2887	-151.2200	Unknown
6345	1	560	M	17-Aug	60.2861	-151.2244	Other Spawner (Crooked Cr.)
3352	1	640	F	17-Aug	60.2944	-151.2155	Unknown
0442	1	510	F	20-Aug	60.2837	-151.2120	Unknown
0542	1	540	F	20-Aug	60.3038	-151.2262	Tributary Spawner (Shantatalik Cr.)
3444	1	535	F	20-Aug	60.2816	-151.2117	Unknown
3544	1	640	M	20-Aug	60.3075	-151.2386	Tributary Spawner (Nikolai Cr.)
6445	1	610	F	20-Aug	60.2858	-151.2139	Unknown
3452	1	640	F	20-Aug	60.3037	-151.2265	Unknown
3552	1	570	M	20-Aug	60.2855	-151.2135	Tributary Spawner (Shantatalik Cr.)
0642	1	540	F	22-Aug	60.2852	-151.2133	Dead/Regurgitated
0742	1	560	F	22-Aug	60.3086	-151.2216	Tributary Spawner (Indian Cr.)
0842	1	575	M	22-Aug	60.3038	-151.2250	Tributary Spawner (Shantatalik Cr.)
3644	1	590	F	22-Aug	60.2855	-151.2134	Mainstem Spawners above rkm 24
3744	1	565	F	22-Aug	60.3065	-151.2334	Back Out
3844	1	520	F	22-Aug	60.3078	-151.2389	Tributary Spawner (Shantatalik Cr.)
6645	1	580	F	22-Aug	60.2891	-151.2193	Back Out
6745	1	580	M	22-Aug	60.3038	-151.2250	Tributary Spawner (Nikolai Cr.)
6845	1	625	M	22-Aug	60.3078	-151.2389	Unknown
3652	1	530	F	22-Aug	60.2932	-151.2144	Tributary Spawner (Nikolai Cr.)
3752	1	575	M	22-Aug	60.3038	-151.2250	Mainstem Spawners above rkm 24
3852	1	595	M	22-Aug	60.3048	-151.2416	Tributary Spawner (Shantatalik Cr.)
0942	2	650	M	4-Sep	60.3040	-151.2266	Dead/Regurgitated
1042	2	620	F	4-Sep	60.2852	-151.2196	Mainstem Spawners above rkm 24
1242	2	530	F	4-Sep	60.3049	-151.2478	Back Out
3944	2	520	M	4-Sep	60.3040	-151.2266	Back Out
4044	2	630	F	4-Sep	60.2851	-151.2202	Mainstem Spawners above rkm 24
4144	2	575	F	4-Sep	60.3074	-151.2400	Back Out
4244	2	590	F	4-Sep	60.3049	-151.2478	Other Spawner (Crooked Cr.)
6945	2	530	M	4-Sep	60.3040	-151.2266	Other Spawner (Crooked Cr.)
7045	2	620	F	4-Sep	60.3070	-151.2224	Mainstem Spawners above rkm 24
7145	2	495	M	4-Sep	60.3074	-151.2400	Back Out
7245	2	550	F	4-Sep	60.3079	-151.2463	Back Out
3952	2	520	M	4-Sep	60.2857	-151.2137	Unknown
4052	2	595	F	4-Sep	60.3037	-151.2266	Unknown
4152	2	580	F	4-Sep	60.3042	-151.2409	Mainstem Spawners above rkm 24
1142	2	495	M	6-Sep	60.3040	-151.2251	Back Out
1342	2	615	M	6-Sep	60.3039	-151.2250	Tributary Spawner (Nikolai Cr.)
1442	2	535	M	6-Sep	60.3040	-151.2251	Mainstem Spawners above rkm 24
4344	2	565	F	6-Sep	60.3039	-151.2250	Back Out
4444	2	615	F	6-Sep	60.3082	-151.2387	Unknown
6545	2	630	F	6-Sep	60.2853	-151.2195	Mainstem Spawners above rkm 24
7345	2	600	F	6-Sep	60.2937	-151.2157	Back Out
7445	2	545	F	6-Sep	60.3082	-151.2387	Back Out
4252	2	490	M	6-Sep	60.3039	-151.2250	Back Out
4352	2	600	F	6-Sep	60.2885	-151.2206	Other Spawner (Maintstem Below rkm 24)
4452	2	565	M	6-Sep	60.3082	-151.2387	Unknown
1542	3	675	M	11-Sep	60.3042	-151.2251	Tributary Spawner (Shantatalik Cr.)
1642	3	635	M	11-Sep	60.3042	-151.2251	Dead/Regurgitated
1742	3	615	M	11-Sep	60.3090	-151.2206	Back Out
1842	3	640	F	11-Sep	60.2857	-151.2137	Unknown
1942	3	640	M	11-Sep	60.2857	-151.2187	Tributary Spawner (Indian Cr.)
2042	3	520	F	11-Sep	60.3074	-151.2401	Other Spawner (Crooked Cr.)
4544	3	610	F	11-Sep	60.3042	-151.2251	Back Out
4644	3	575	F	11-Sep	60.3042	-151.2251	Back Out
4744	3	495	F	11-Sep	60.3090	-151.2206	Dead/Regurgitated
4844	3	620	M	11-Sep	60.2857	-151.2137	Mainstem Spawners above rkm 24
4944	3	660	F	11-Sep	60.3077	-151.2321	Back Out
5044	3	580	M	11-Sep	60.3076	-151.2381	Mainstem Spawners above rkm 24

-continued-

APPENDIX 4. —(Page 2 of 2)

Transmitter number	Stratum	Mid-eye to fork length (mm)	Sex	Tagging date	Tagging Location (WGS84) Latitude	Longitude	Final fate
7545	3	615	F	11-Sep	60.3042	-151.2251	Back Out
7645	3	520	M	11-Sep	60.3042	-151.2251	Mainstem Spawners above rkm 24
7745	3	615	M	11-Sep	60.2940	-151.2149	Back Out
7845	3	640	F	11-Sep	60.2857	-151.2189	Unknown
7945	3	600	F	11-Sep	60.3090	-151.2337	Back Out
8045	3	610	M	11-Sep	60.3093	-151.2361	Mainstem Spawners above rkm 24
4552	3	640	F	11-Sep	60.3042	-151.2251	Dead/Regurgitated
4652	3	590	M	11-Sep	60.3042	-151.2251	Mainstem Spawners above rkm 24
4752	3	610	M	11-Sep	60.2857	-151.2137	Tributary Spawner (Indian Cr.)
4852	3	550	F	11-Sep	60.2838	-151.2118	Dead/Regurgitated
4952	3	590	M	11-Sep	60.3074	-151.2401	Back Out
5052	3	575	F	11-Sep	60.3093	-151.2361	Back Out
2142	4	635	M	21-Sep	60.3037	-151.2263	Back Out
2242	4	595	F	21-Sep	60.2825	-151.2077	Dead/Regurgitated
5144	4	610	F	21-Sep	60.3037	-151.2263	Mainstem Spawners above rkm 24
8145	4	565	F	21-Sep	60.3060	-151.2220	Other Spawner (Crooked Cr.)
5152	4	560	M	21-Sep	60.2855	-151.2190	Dead/Regurgitated
5244	4	605	F	25-Sep	60.2851	-151.2209	Mainstem Spawners above rkm 24
8245	4	555	F	25-Sep	60.3036	-151.2281	Other Spawner (Maintstem Below rkm 24)
5252	4	585	F	28-Sep	60.2864	-151.2163	Back Out
2342	5	585	F	4-Oct	60.2810	-151.2132	Dead/Regurgitated
5344	5	660	M	4-Oct	60.2810	-151.2132	Other Spawner (Crooked Cr.)
8345	5	575	M	5-Oct	60.2808	-151.2130	Mainstem Spawners above rkm 24
5352	5	510	M	5-Oct	60.2808	-151.2130	Mainstem Spawners above rkm 24
2442	5	620	M	5-Oct	60.2808	-151.2130	Dead/Regurgitated
5444	5	610	M	5-Oct	60.2808	-151.2130	Mainstem Spawners above rkm 24
8445	5	645	F	5-Oct	60.2808	-151.2130	Mainstem Spawners above rkm 24
5452	5	660	M	9-Oct	60.2805	-151.2133	Dead/Regurgitated
2542	5	545	M	9-Oct	60.2805	-151.2133	Dead/Regurgitated
5544	5	650	M	9-Oct	60.2805	-151.2133	Back Out
8545	5	615	M	9-Oct	60.2805	-151.2133	Unknown
5552	5	580	M	9-Oct	60.2805	-151.2133	Mainstem Spawners above rkm 24
2642	5	660	M	9-Oct	60.2805	-151.2133	Mainstem Spawners above rkm 24
5644	5	620	F	9-Oct	60.2805	-151.2133	Mainstem Spawners above rkm 24
8645	5	635	F	10-Oct	60.2842	-151.2125	Mainstem Spawners above rkm 24
5652	5	640	F	10-Oct	60.2842	-151.2125	Mainstem Spawners above rkm 24
2742	5	685	M	10-Oct	60.2842	-151.2125	Other Spawner (Maintstem Below rkm 24)
5744	5	570	M	10-Oct	60.2842	-151.2125	Dead/Regurgitated
8745	5	510	M	10-Oct	60.2842	-151.2125	Mainstem Spawners above rkm 24
3042	5	630	M	12-Oct	60.2800	-151.2138	Dead/Regurgitated
5944	5	660	F	12-Oct	60.2937	-151.2150	Unknown
2842	5	645	M	15-Oct	60.2892	-151.2197	Mainstem Spawners above rkm 24
2942	5	575	M	15-Oct	60.2863	-151.2150	Dead/Regurgitated
5844	5	620	F	15-Oct	60.2928	-151.2144	Mainstem Spawners above rkm 24
8845	5	595	M	15-Oct	60.2851	-151.2218	Other Spawner (Maintstem Below rkm 24)
8945	5	650	M	15-Oct	60.2879	-151.2221	Dead/Regurgitated
5752	5	640	F	15-Oct	60.2800	-151.2138	Mainstem Spawners above rkm 24
5852	5	575	M	15-Oct	60.2851	-151.2218	Mainstem Spawners above rkm 24
5952	5	550	F	15-Oct	60.2905	-151.2169	Dead/Regurgitated

APPENDIX 5. —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

-continued-

APPENDIX 5. —(Page 2 of 4)

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)

-continued-

APPENDIX 5. —(Page 3 of 4)

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

-continued-

APPENDIX 5. —(Page 4 of 4)

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