**Regional Information Report No. 2A13-06**

# Migratory Timing and Distribution of Kenai River Chinook Salmon, 2010–2013, a Report to the Alaska Board of Fisheries 2014

**by**

**Adam M. Reimer**

**December 2013**

**Alaska Department of Fish and Game** **Divisions of Sport and Commercial Fisheries**

## Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat or long |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | $e$ |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular ) | ° |
| degrees of freedom | df |
| expected value | $E$ |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $\log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

*REGIONAL INFORMATION REPORT 2A13-06*

# MIGRATORY TIMING AND DISTRIBUTION OF KENAI RIVER CHINOOK SALMON, 2010–2013, A REPORT TO THE ALASKA BOARD OF FISHERIES 2014

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The Regional Information Report Series was established in 1987 and was redefined in 2007 to meet the Division of Commercial Fisheries regional need for publishing and archiving information such as area management plans, budgetary information, staff comments and opinions to Alaska Board of Fisheries proposals, interim or preliminary data and grant agency reports, special meeting or minor workshop results and other regional information not generally reported elsewhere. Reports in this series may contain raw data and preliminary results. Reports in this series receive varying degrees of regional, biometric and editorial review; information in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author or the Division of Commercial Fisheries if in doubt of the level of review or preliminary nature of the data reported. Regional Information Reports are available through the Alaska State Library and on the Internet at: http://www.adfg.alaska.gov/sf/publications/

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# ABSTRACT

The migratory timing and distribution of Kenai River Chinook salmon was examined using radio telemetry for early-run and late-run Chinook salmon during the 2010–2013 seasons. Spawning destinations were assigned for 86 fish in 2010, 134 fish in 2011, 197 fish in 2012, and 123 fish in 2013. In all years, the most abundant components of the early run were the Chinook salmon spawning in the Killey River drainage, followed by the Chinook salmon spawning in the mainstem of the Kenai River. With the exception of 1 fish, all Chinook salmon radiotagged during the late run spawned in the mainstem of the Kenai River.

Radiotagged Chinook salmon were present in closed to Chinook salmon fishing areas near the confluences of the Funny and Killey Rivers in the latter half of July in most years studied. Radiotagged Chinook salmon that spawned within the Funny River were present in the closed to fishing area near the confluence of the Funny and Kenai Rivers through 31 July in 2010, 20 July in 2011, 8 July in 2012, and 22 July in 2013. Radiotagged Chinook salmon that spawned within the Killey River were present in the closed to fishing area near the confluence of the Killey and Kenai Rivers through August 8 in 2010, 28 July in 2011, 25 July in 2012, and 12 July in 2013.

Over 50% of the radiotagged early-run Chinook salmon were in waters with existing closures or restrictions by 1 July in every year studied. On 1 July, 20% (SE 5%), 28% (SE 5%), 11% (SE 5%), and 13% (SE 6%) of radiotagged early-run Chinook salmon were downstream of Slikok Creek in the years 2010–2013, respectively. Upstream of Slikok Creek, 20% (SE 5%), 17% (SE 4%), 20% (SE 6%) and 19% (SE 7%) of radiotagged early-run Chinook salmon were in waters open to sport fishing on 1 July 2010–2013, respectively.

Over 75% of the radiotagged early-run Chinook salmon were in waters with existing closures or restrictions by 16 July in every year studied. On 16 July, 8% (SE 4%), 13% (SE 4%), 2% (SE 2%), and 0% of radiotagged, early-run Chinook salmon were downstream of Slikok Creek in 2010–2013, respectively. Upstream of Slikok Creek, 8% (SE 4%), 10% (SE 3%), 15% (SE 6%) and 19% (SE 7%) of radiotagged early-run Chinook salmon were in waters open to sport fishing on 16 July in 2010–2013, respectively.

Key words: Kenai River, Chinook salmon, *Oncorhynchus tshawytscha*, radiotelemetry, stock composition, spawning distribution, run timing.

# INTRODUCTION

The Kenai River watershed encompasses approximately 2,200 square miles of the Kenai Peninsula including diverse landscapes such as glaciers, large lakes, high mountains, and vast lowlands. The Kenai River mainstem is approximately 82 miles long including a 15-mile stretch through Skilak Lake (Figure 1). Tidal influence extends upstream to river mile (RM) 12.

Populations of Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), pink salmon (*O. gorbuscha*), Dolly Varden (*Salvelinus malma*), and rainbow trout (*O. mykiss*) live in the Kenai River. Kenai River Chinook salmon are particularly prized due to their large size (Roni and Quinn 1995) and support popular and valuable recreational fisheries (Perschbacher 2012). Regulations are complex and highly refined, as appropriate for such a heavily utilized fishery. A major source of management uncertainty involves implementing stock-specific fishing regulations during mixed stock sport fisheries.

For management purposes, Kenai River Chinook salmon are separated temporally into 2 runs: early-run fish are those that enter the river prior to 1 July and late-run fish are those that enter the river on or after 1 July. Accurate enumeration of run size has proven difficult because of uncertainty surrounding the inriver run estimate; however, it is known that the total annual run of early-run Chinook salmon (range: 5,605 [CV 0.09] to 23,800 [CV 0.12]) is considerably smaller than the total annual run of late-run Chinook salmon (range: 28,550 [CV 0.09] to 99,690 [CV 0.10]) (Fleischman and McKinley 2013; McKinley and Fleischman 2013).

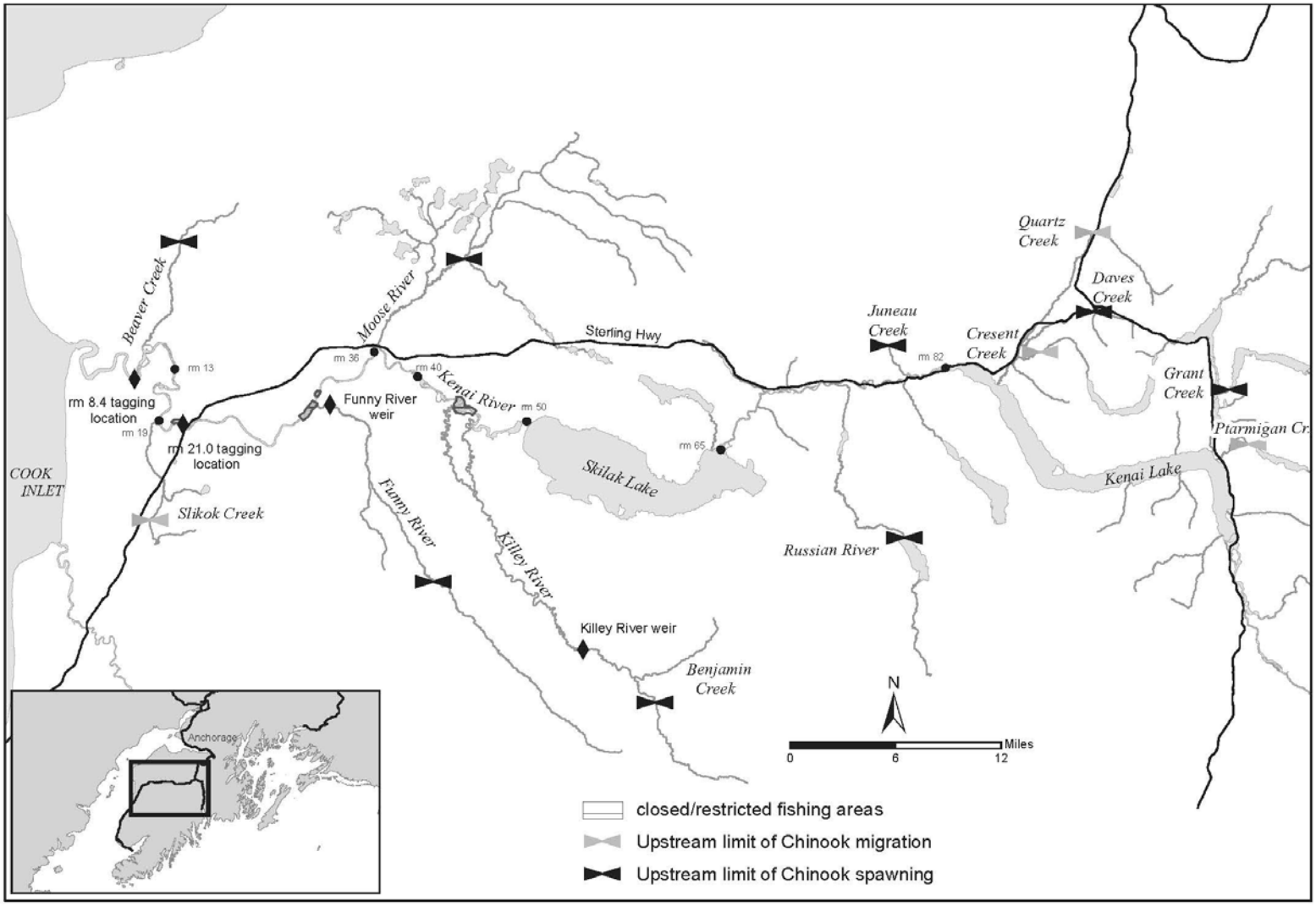


Figure 1.–The Kenai River drainage.

*Note:* The area closed to Chinook salmon fishing near the confluence of Slikok Creek and the Kenai River, and the boat-restricted fishing areas near the Soldotna Bridge and near the confluence of the Moose and Kenai Rivers are obscured due to their small size relative to the scale of the map. The area closed to Chinook salmon fishing in the mainstem Kenai River upstream of Skilak Lake and in the tributaries to the Kenai River are not identified here to reduce clutter.

Early-run Chinook salmon spawn in tributaries of the Kenai River and in the Kenai River mainstem (Table 1). Tributaries of the Kenai River that support populations of Chinook salmon include Slikok Creek, Funny River, Killey River, Russian River, Juneau Creek, Quartz Creek, Ptarmigan Creek, and Grant Creek (Figure 1[1]; Bendock and Alexandersdottir 1992; Burger et al. 1983; Johnson and Daigneault 2013). Benjamin Creek, a tributary of the Killey River, and Crescent and Daves creeks, tributaries of Quartz Creek, also contain Chinook salmon. The Killey River drainage supports the largest population of tributary spawning Chinook salmon (Table 1), followed by Funny River. Other drainages support modest spawning populations.

Table 1.–Historic spawning distribution of early-run Kenai River Chinook salmon by date of tagging, 1980, 1981, and 1990–1991.

| | Early run | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 19 May–30 Jun 1980[a] | | 13 May–30 Jun 1981[a] | | 16 May–30 Jun 1990[b] | | 16 May–30 Jun 1991[b] | |
| Location | N | % | N | % | N | % | N | % |
| Tributary | | | | | | | | |
| Slikok C. | | | 1 | 5% | 1 | 1% | 2 | 3% |
| Funny R. | 3 | 14% | 3 | 16% | 19 | 20% | 16 | 21% |
| Killey R. | 18 | 86% | 12 | 63% | 39 | 41% | 28 | 36% |
| Benjamin C. | | | | | 4 | 4% | 21 | 27% |
| Russian R. | | | | | | | | |
| Juneau C. | | | 1 | 5% | 1 | 1% | 1 | 1% |
| Quartz C. | | | 1 | 5% | 1 | 1% | 2 | 3% |
| Crescent C. | | | | | | | | |
| Daves C. | | | | | | | | |
| Grant C. | | | | | 1 | 1% | | |
| Tributary sum | 21 | 100% | 18 | 95% | 66 | 70% | 70 | 91% |
| Mainstem | | | | | | | | |
| Kenai R. RM 10–21 | | | 1 | 5% | 8 | 9% | 1 | 1% |
| Kenai R. RM 21–40 | | | | | 10 | 11% | 5 | 6% |
| Kenai R. RM 40–50 | | | | | 3 | 3% | 1 | 1% |
| Skilak Lake | | | | | 2 | 2% | | |
| Kenai R. RM 65–82 | | | | | 5 | 5% | | 0% |
| Mainstem sum | 0 | 0% | 1 | 5% | 28 | 30% | 7 | 9% |

[a] Gillnet captured fish (Burger et al. 1983).

[b] Sport captured fish (Bendock and Alexandersdottir 1992).

[1] Chinook salmon have also been documented in Beaver Creek and Moose River. In both cases, a few Chinook salmon were observed during 1 year of a 2-year project, and no fish were observed in the other year. These observations likely represent stray Chinook salmon rather than spawning populations (Booth and Otis 1996; Elliott and Finn 1984).

Mainstem spawning Chinook salmon contribute to both the early and late runs but at different levels (Table 1 and Table 2). During the early run, the mainstem Kenai River provided a spawning destination for a small percentage of the radiotagged Chinook salmon in 1980, 1981 and 1991 and for a larger percentage in 1990. Conversely, most late-run Chinook salmon spawn in the mainstem of the Kenai River (Table 2).

The entire Kenai River mainstem upstream of the intertidal area is suitable spawning habitat for Chinook salmon (Burger et al. 1983; Johnson and Daigneault 2013). Mainstem Kenai River spawning distribution has been quantified by dividing the river into 4 sections (Figure 1): RM 10–21 (downstream of the Sterling Highway Bridge in Soldotna), RM 21–40 (Soldotna Bridge to Naptown Rapids), RM 40–50 (Naptown Rapids to Skilak Lake) and RM 65–82 (Skilak Lake to Kenai Lake). Chinook salmon spawned in all sections; however, the furthest downstream section was the most heavily used in 4 of 6 late runs (Table 2). Fishery regulations are more conservative during the early run than during the late run. For example, bait is not allowed prior to 1 July in the Kenai River and Chinook salmon between 46 and 55 inches total length cannot be retained prior to 1 July downstream of the Soldotna Bridge. The length restriction "follows the fish," meaning it remains in effect through 14 July upstream of the Soldotna Bridge. In addition, spawning tributaries are closed to Chinook salmon fishing as well as areas of the mainstem Kenai River around the confluences of Slikok Creek, Funny River, and Killey River (Figure 1). Sport fishing for Chinook salmon also closed upstream of Skilak Lake. Finally, 3 areas are closed to fishing from a boat. The largest area is located immediately downstream of the Soldotna Bridge, with additional areas near Morgan's Hole (just upstream of the Funny River) and near the confluence of the Moose River (Figure 1). Harvest is not totally eliminated in the boat-restricted fishing areas; for example, a successful shore fishery occurs in the boat closure area downstream of the Soldotna Bridge.

Sport fishing regulations are less conservative after 1 July, bait is allowed and length restrictions are lifted in July. Closed and restricted fishing areas in the mainstem Kenai River remain in effect during July.

The existing early- and late-run regulations previously described can be superseded by inseason emergency orders during times of low abundance. Emergency orders were issued frequently during the study period in response to low Chinook salmon runs[2]. Often, emergency orders are used to extend conservative regulations in upstream areas. During the study period, the downstream edge of the Slikok Creek closed area (RM 18.5) was used as the boundary between downstream and upstream areas when emergency orders were issued.

## REPORT OBJECTIVES

Past telemetry data for Kenai River Chinook salmon has been heavily relied upon to identify conservation measures for early-run Chinook salmon. These data are over 20 years old. This report reexamines many of the conclusions drawn from past Kenai River Chinook salmon telemetry data with a new and greatly expanded dataset.

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[2] Throughout this report we describe the location of radiotagged Chinook salmon relative to the existing regulations prior to any inseason emergency orders. For example, we may use the description "open waters upstream of Slikok Creek" to mean areas that would have been open to sport fishing in the absence of an inseason emergency order, when, the waters upstream of Slikok Creek were actually closed during the time period being discussed because an emergency order was in effect. The reader should note that we are not attempting to accurately describe the regulations in place during the time period being discussed.

Table 2.–Historic spawning distribution of late-run Kenai River Chinook salmon by date of tagging, 1979, 1980, 1981, 1984, and 1989–1990.

| | Late Run | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25 Jun–31 Jul 1979[a] | | 16 Jul–31 Jul 1980[a] | | 1 Jul–25 Aug 1981[a] | | 25 Jun–12 Aug 1984[b] | | 1–31 Jul 1989[c] | | 1–31 Jul 1990[c] | |
| Location | N | % | N | % | N | % | N | % | N | % | N | % |
| Tributary | | | | | | | | | | | | |
| Slikok C. | | | | | | | | | | | 1 | 1% |
| Funny R. | | | | | | | 1 | 2% | | | | |
| Killey R. | | | | | | | | | | | | |
| Benjamin C. | | | | | | | | | | | 1 | 1% |
| Russian R. | | | | | | | | | | | 1 | 1% |
| Juneau C. | | | | | | | | | | | 1 | 1% |
| Quartz C. | | | | | | | | | | | | |
| Crescent C. | | | | | | | | | | | | |
| Daves C. | | | | | | | | | | | | |
| Grant C. | | | | | | | | | | | | |
| Tributary sum | | | | | | | 1 | 2% | | | 3 | 4% |
| Mainstem | | | | | | | | | | | | |
| Kenai R. RM 10–21 | 12 | 46% | 9 | 60% | 11 | 42% | 14 | 29% | 11 | 28% | 33 | 46% |
| Kenai R. RM 21–40 | 1 | 4% | 2 | 13% | 6 | 23% | 12 | 25% | 15 | 38% | 22 | 31% |
| Kenai R. RM 40–50 | 13 | 50% | 2 | 13% | 5 | 19% | 8 | 17% | 6 | 15% | 9 | 13% |
| Skilak Lake | | | | | | | | | 1 | 3% | | |
| Kenai R. RM 65–82 | 0 | 0% | 2 | 13% | 4 | 15% | 13 | 27% | 6 | 15% | 4 | 6% |
| Mainstem sum | 26 | 100% | 15 | 100% | 26 | 100% | 47 | 98% | 39 | 100% | 68 | 96% |

[a] Gillnet captured fish (Burger et al. 1983).

[b] Gillnet and sport caught fish (Hammarstrom et al. 1985).

[c] Sport captured fish (Bendock and Alexandersdottir 1992).

Herein we describe the location of radiotagged Chinook salmon relative to both the existing regulations and inseason emergency orders. Locations are presented relative to the existing regulations by separating fish that were detected within closed and restricted fishing areas from those that were within waters open to sport fishing for Chinook salmon. Locations are presented relative to the inseason emergency orders by considering fish detected above and below Slikok Creek separately. Specific reporting objectives are as follows.

- Report the spawning distribution for Chinook salmon tagged during the early and late runs from 2010–2013.
- Report the date when all radiotagged Chinook salmon that spawned in the Funny River had entered the Funny River during each year studied, 2010–2013.
- Report the date when all radiotagged Chinook salmon that spawned in the Killey River had entered the Killey River during each year studied, 2010–2013.
- Report the percentage of Chinook salmon radiotagged prior to July 1 that were in waters open to sport fishing upstream of Slikok Creek on July 1 during each year studied,
  2010–2013.
- Report the percentage of Chinook salmon radiotagged prior to July 1 that were in waters open to sport fishing upstream of Slikok Creek on July 16 during each year studied, 2010–2013.

# METHODS

## STUDY DESIGN

The radio tags deployed for this project were part of a larger study designed to estimate the abundance of Kenai River Chinook salmon using the *Stock Specific Abundance and Run Timing* (SSART) model. SSART model estimates are reported elsewhere (Fleischman and McKinley 2013; McKinley and Fleischman 2013). The spawning destination of radiotagged Chinook salmon was utilized by the SSART model to improve the precision of stock composition estimates derived from allele frequency data.

### Netting and Tagging Procedure

Esophageal implant radio transmitters (Advanced Telemetry Systems[3], model F1845B, 14-17 frequencies per year [151.130-151.635 MHz], up to 25 tags per frequency) were deployed during all years. The bottle-shaped radio tags were 19 mm in diameter, 56 mm long, weighed 24 g, and were equipped with a 12-inch antenna. Warranty battery life for these transmitters was 162 days. While fish as small as 1.2 kg (2.64 lbs) could be tagged without exceeding 2% of fish weight (Winter 1983), project biologists determined Chinook salmon smaller than 550 mm mid eye to tail fork (METF) suffered increased rates of mortality in 2010[4]. From 2011 to 2013, Chinook salmon less than 550 mm METF were released without tagging. Fish with profusely bleeding gills or observed to be lethargic were also released without tagging to minimize potential differences in survival and behavior between tagged and untagged populations.

[3] Product names used in this publication are included for completeness but do not constitute product endorsement.

[4] The percentage of Chinook salmon that failed to migrate upstream was higher amongst fish less than 550 mm METF (59%) than it was for fish greater than 549 METF (23%).

Gillnets of 2 mesh sizes (5.0 and 7.5 inches) were fished with equal frequency to capture Chinook salmon. The nets were constructed of a multi-fiber mesh in colors that closely matched Kenai River water. Specifications are shown below:

1) 5.0 inch (stretched mesh) multi-fiber, 80 meshes deep, 10 fathoms long, Shade 1 (clear-steel blue), MS73 (14 strand) twine
2) 7.5 inch (stretched mesh) multi-fiber, 55 meshes deep, 10 fathoms long, Shade 1, MS93 (18 strand) twine

Captured Chinook salmon were untangled from nets and restrained by placing a cotton "tail tie" around the caudal peduncle. Tail ties were attached to the boat gunwale using bungee cord. This combination allowed the fish to recuperate prior to sampling and protected the fish from injury if it swam vigorously away from the boat. Tethered Chinook salmon were transferred to a padded aluminum cradle (Larson 1995) for sampling and tagging. The sampling cradle was positioned such that the fish's gills remained partially submerged while being handled.

All radiotagged Chinook salmon were given a fin "hole-punch" to prevent resampling, and sampled for age, sex, and length (ASL) information. Data were recorded electronically using data entry software on a Juniper Systems Inc. Allegro CE field computer.

Transmitters were inserted with an applicator made from 2 concentric plastic tubes. The transmitter fit snugly within the outer tube. Transmitters were inserted by gently pressing the tag against the esophageal sphincter until the sphincter relaxed, allowing the tag to pass into the stomach. The transmitter was dislodged from the applicator using the inner tube as a plunger. Glycerin was used as a lubricant during some tag applications. Every tag application was followed by a visual inspection of the esophageal sphincter. Successful applications were confirmed when the transmitter body was completely obscured by the esophageal sphincter and the antenna was directed forward out of the mouth. Unsuccessful applications were removed and repeated.

During the years 2010–2011, transmitters were inserted without a supplementary aid to retention. In the years 2012–13, 2 methods were used to minimize regurgitation of implanted radio tags. One method used a one-eighth inch wide rubber band to encircle the tag, with 3–4 wraps on the thickest diameter portion adjacent the bottleneck taper. The alternative method involved manipulating plastic "hootchie skirts" (Silver Horde 4 three-eighth inch plastic cuttlefish), which are recreational fishing lures designed to mimic small squid. The "head" of each skirt was removed by cutting the skirt crosswise with scissors 1¼ inches from the tip. The resulting tube was rolled over itself until the "tentacles" formed 8–12 mm circumference loops before returning inside the "body." The result was slid over a lubricated radio transmitter such that the loops pointed toward the antenna and were located adjacent to the bottleneck taper. Finally, the "tentacle" tips were trimmed flush with the "body."

### *2010–2013: River Mile 8.5 Inriver Gillnetting, Midriver*

The majority of the radio tags were deployed from RM 8.5 in association with an inriver gillnetting project conducted annually (Perschbacher 2012) by the Alaska Department of Fish and Game (ADF&G). In the text and tables herein, this tagging vehicle is referred to as "RM 8.5, midriver."

The project was operational from 16 May through 10 August. In 2010 and 2011, every Chinook salmon of the appropriate size and vitality that was captured from 16 May through 5 July was

radiotagged. In 2012, every healthy Chinook salmon greater than or equal to 550 mm METF that was captured from 16 May through 5 July and approximately every third healthy Chinook salmon greater than or equal to 550 mm METF that was captured from 6 July to 17 August was radiotagged. In 2013, every healthy Chinook salmon greater than or equal to 550 mm METF that was captured from 16 May through 15 July and approximately every third healthy Chinook salmon greater than or equal to 550 mm METF that was captured from 16 July to 17 August was radiotagged.

Netting began 5 hours before low tide and ended 1 hour after low tide. The study area was approximately one-half km (0.3 mi) in length, located just downstream of the RM 8.5 Chinook salmon sonar site. Drifts were located near the river's thalweg, and were intended to capture fish that would pass through the insonified area of the river channel. Crews drifted the net downriver roughly perpendicular to the bank, and within the cross-sectional area that was insonified by the sonar. Drifts were terminated as follows: 1) when the net became snagged on the bottom, 2) when the net drifted outside of the insonified zone, 3) when the end of the study area was reached or, 4) when at least 5 fish were thought to be captured in the net.

During the 2010 season, a second crew deployed radio tags near RM 8.5 from 5 to 15 June. Because the primary objective of the second crew was to deploy radio tags, standardization with respect to the sonar's insonifed zone was relaxed. In the text and tables herein, this tagging operation is referred to as "RM 8.5, tagging."

### *2013: River Mile 8.5 Inriver Gillnetting, Nearshore*

In 2013, ADF&G deployed a second crew, tasked with fishing between the insonified area and the shoreline. Recent analysis suggests that approximately 35% of Kenai River Chinook salmon pass the RM 8.5 Chinook salmon sonar site outside of the insonified zone, primarily between each transducer and the shoreline (McKinley and Fleischman 2013). These fish are not subject to capture by the midriver netting crew, which strives to keep the drifting nets positioned in water that passes through the insonified zone. In the text and tables herein this tagging vehicle is referred to as "RM 8.5, nearshore."

RM 8.5, nearshore gillnetting was conducted 2 days each week, 2 hours before to 4 hours after high tide. The study area was approximately one-half km (0.3 mi) in length, located just downstream of the RM 8.5 Chinook salmon sonar site, but between the sonar transducers and each bank. Every healthy Chinook salmon greater than or equal to 550 mm METF that was captured was radiotagged.

### *2011–2013: River Mile 21 Inriver Gillnetting*

Radio tags were also deployed on fish captured between RM 20.1 and RM 21.1 in 2011, 2012, and 2013 in an attempt to increase the proportion of radiotagged fish that successfully migrated to spawning destinations. Improvements in the survival rate of tagged fish were expected at the RM 21 tagging location because tagged fish were expected to be better acclimated to fresh water and because the majority of the sport fishery occurs downstream of this location. The RM 21 tagging location was most appropriate for tributary spawning Chinook salmon because the majority of spawning tributaries are upstream of RM 21, and substantial mainstem spawning is known to occur downstream of RM 21.

River mile 21 gillnetting was conducted 1 day each week for 3–6 hours. From 2 June to 13 July 2011 and from 7 June to 4 July 2012, a fixed number of radio tags were deployed each day.

From 30 May to 27 June 2013, crews fished for 6 hours per day and tagged all Chinook salmon greater than or equal to 550 mm METF that were captured. Fishing effort was distributed throughout the sampling area to the extent practical although fast current and abundant rocks constrained the fishable waters.

### *2012: Saltwater Trolling*

During 2012, the Division of Commercial Fisheries conducted a pilot study deploying radio transmitters on Chinook salmon captured in Cook Inlet. Two vessels trolled sport fishing gear and applied radio tags to Chinook salmon caught within 1 mile of the beach between Deep Creek and Anchor Point from 7 July to 31 July. Radio transmitters were the same make and model described above, broadcasting on frequencies 151.134 MHz and 151.143 MHz. Sport caught Chinook salmon were transferred by landing net to 20–30 mg/L eugenol (AQUI-S 20E) anesthetic for sampling and tagging. Radio transmitters were applied as described above without a retention aid. Total sampling time, and exposure to the anesthetic, averaged 2.5 minutes. Tagged fish were transferred back to the ocean in a U-shaped net trough and revived prior to release.

## Radio Telemetry

Radio transmitters for this project were pulse-coded, with up to 25 individually identifiable signals broadcasting on each frequency. Due to manufacturing irregularities, radio tags were tracked on frequencies up to 2 kHz from their printed frequency. Warranty battery life was 162 days, which is 2–3 times the estimated stream life for Kenai River Chinook salmon (Bendock and Alexandersdottir 1992).

Radiotagged Chinook salmon were monitored passively, using a network of stationary radio receiving stations; and actively, by foot, boat, or plane surveys. Stationary receiving stations allowed 24-hour monitoring of radiotagged Chinook salmon at key points along their migration routes while active tracking was used to determine specific locations. This system provided multiple, redundant locations for each animal with resolution sufficient to detect noteworthy behavior patterns.

### *Stationary Telemetry Sites*

Most telemetry data were collected at automated, stationary, data-recording stations (fixed stations). Pulse-coded transmitters allow the use of fewer frequencies, and thus reduced total scan time. During stationary radio tracking, the scan time for each frequency was 7 s with a 2 s timeout. Thus, each frequency was monitored for 2 s; if a transmission was noted then the frequency was monitored for an additional 7 s on each antenna while the equipment determined and electronically recorded the pulse code and the signal strength. Given an average pulse rate of 45.8 pulses per minute, a 2 s timeout provides sufficient time for each tag to send 2 transmissions. Total scan time for all frequencies ranged from approximately 30 s, when no signals were detected, up to 7 min when several signals were detected. For sites where multiple, collocated, radiotagged fish were expected, 15 second scan times were used to ensure all of the radio tags present were decoded.

Each site consisted of a 3–4.5 m (10–15 ft) pole supporting a solar panel and 2 or 3 Yagi directional antennas (Cuschcraft Inc. model P154-4) connected via coaxial and communication cable to a 3 dB attenuator (Mini-Circuits, model CAT-3), antenna switch (ATS, model 200 or 300), radio receiver (ATS, model 4100, 4500 or 4520), and data collection computer (ATS, model 5041). The receiver and computer were stored in a weather-resistant box with a 12-volt

marine battery. The system continuously scanned the transmitter frequencies and electronically recorded the frequency, pulse code, mortality code, date, time, antenna, and a measure of signal strength whenever a decodable transmission was detected. Sites were visited weekly to download stored data and check the system configuration.

Fixed stations were placed at key sites along Kenai River Chinook salmon migration routes (Table 3). Sites were chosen to maximize antenna height above the river surface using adjacent cut banks or bluffs whenever possible. The fixed stations located near RM 8.5 and RM 12.0 had poor reception and the data collected at these stations were not used in any analysis. The remaining sites had complete signal detection; the only instances of fish migrating past a site without detection were the result of operator error due to incorrectly configured equipment. This happened twice in 2013; in both cases 2 fish passed 1 site without detection.

Table 3.–Location of fixed telemetry stations on the Kenai River drainage, 2010–2013.

| Location | Kenai River RM | Years | Purpose |
|---|---|---|---|
| RM 8.5 sonar site | 8.5 | 2010–11 | Upstream migration |
| Eagle Rock | 12.0 | 2012 | DCF request |
| RM 13.5 sonar site | 13.5 | 2013 | Mainstem migration |
| Slikok Creek confluence | 18.9 | 2010–13 | Tributary use, mainstem migration |
| Soldotna Bridge | 20.9 | 2010–13 | Mainstem migration |
| Funny River confluence | 30.3 | 2010–13 | Tributary use, mainstem migration |
| Moose River confluence | 36.3 | 2010–13 | Mainstem migration |
| Killey River confluence | 44.3 | 2010–13 | Tributary use, mainstem migration |
| Killey River weir | – | 2012 | % of Killey migrants above weir |
| Skilak Lake outlet | 49.3 | 2010–13 | Mainstem migration |
| Skilak Lake inlet | 66.2 | 2010–13 | Mainstem migration |
| Kenai Lake outlet | 81.3 | 2010–13 | Tributary use |

By orienting each site's antennas parallel to the river channel (and tributary when applicable), direction of travel could be discerned by comparing each antenna's signal strength within the chronological data. Individual fish were assigned date, time, and direction of passage for each migration past each fixed station. Passage dates and times were used to assign each fish to river sections. The river sections of interest herein were as follows:

1) Downstream of Slikok Creek: A large sport fishery occurs in this section. Slikok Creek approximates the boundary used by fishery managers to enact additional inseason protection for early-run Chinook salmon, with the waters downstream of Slikok Creek typically unaffected by inseason action. There are no closed or restricted fishing areas in this section.

2) Upstream of Slikok Creek to Skilak Lake: A smaller sport fishery occurs in this area. Slikok Creek approximates the boundary used by fishery managers to enact additional inseason protection for early-run Chinook salmon, with the waters upstream of Slikok Creek typically restricted by inseason action. There are several closed or restricted fishing areas in this section.

3) Closed or restricted fishing areas: Areas closed to Chinook salmon fishing exist around the confluence of Slikok Creek (400 yards in length), Funny River (1.1 miles in length), Killey River (1.75 miles in length), upstream of Skilak Lake, and in all tributaries to the Kenai River (Figure 1). In addition, there are sizable areas closed to boat fishing downstream of the Soldotna Bridge and upstream of Funny River (Morgan's Landing) (Figure 1). The presence or absence of individual fish in each of these areas was assessed using fixed station data. The number of radiotagged Chinook salmon in the Slikok Creek closed area and the boat-restricted area near the Soldotna Bridge was approximated by the number of fish between RM 18.9 and 20.9 because the fixed station data alone could not locate individual fish within these areas, and this approximation introduced negligible error to the results presented herein. Radiotagged fish in these areas are reported as a group.

### *Active tracking*

To complement fixed-station data, radio tags were located by boat using an ATS 4520 receiver and single Yagi-style antenna (Cuschcraft Inc. model P154-4). The area between Cook Inlet and Skilak Lake was searched 2 times per week while the area between Skilak and Kenai lakes was searched once per week. The boat was driven at a moderate speed while scanning active frequencies for 2 seconds each. If a signal was heard, the scan was paused until the tag location could be inferred from the recorded signal strength and the antenna's direction during detection. For each radiotagged fish that was located, the date, time, frequency, pulse code, mortality code, RM, and coordinates (determined by a global positioning system [GPS]) were recorded using an Allegro CX field computer.

Radio tags were also located by airplane using an ATS 4520 receiver and 2 H-style antennas (Telonics Inc. model RA-2AK) attached to the strut for each wing. When the plane flew level to the ground, the antennas were pointed approximately 45 degrees to the ground surface. Signals could be monitored from each individual antenna or both antennas together using an ATS Inc. manual antenna switch box. Both antennas were monitored while flying except when attempting to discern direction. The plane typically flew 700–1000 ft above the ground surface at approximately 65 mph. The Funny and Killey rivers plus the tributaries upstream of Skilak Lake were searched approximately every 10 days between late June and early August. Each frequency was scanned for 2 seconds. If a signal was heard, the scan was paused briefly while the receiver decoded the tag and recorded the date, time, frequency, pulse code, mortality code, and GPS coordinates. This process was repeated each time a transmission was heard. The record with the largest signal strength best described the tag position. A secondary paper matrix was used to back up the electronic record and verify adequate detection.

Radio tags were also located by foot using an ATS 4520 receiver and a handheld H-style antenna (Telonics Inc. model RA-23K). Each frequency was scanned for 2 seconds. If a signal was heard, the scan was paused until the tag location could be inferred from the recorded signal strength and the antenna's direction during detection. For each radiotagged fish that was located, the date, time, frequency and pulse code, mortality code, and GPS coordinates were recorded electronically by the receiver.

## Determination of Fate

Radiotagged fish were assigned 1 of 4 fates based on their behavior post tagging: drop-out, regurgitation, censor, or migrant. All of the telemetry data was consolidated into one graphic per

fish before deciding on a fate. Drop-outs, regurgitations, and censors are similar in their failure to provide useful spawning destination or migratory timing information.

1) Drop-outs: Fish categorized as drop-outs entered salt water immediately after tagging. Because radio tags cannot transmit a signal through salt water, drop-outs were rarely located after being deployed. Some of these fish were direct handling mortalities, although commercial harvest of tagged fish and tagged fish reentering the Kenai River after a post-tagging absence indicate some estuarine and salt water milling occurred after tagging, without handling induced mortality.

2) Regurgitation: Tags that were permanently stationary immediately after deployment, proximate to or downstream of the tagging site, were categorized as regurgitations. Regurgitated tags were presumed ejected from the esophagus and are distinguishable from mortalities because dead, radiotagged fish are often characterized by rapid downstream movement. Because radio tags were deployed in the tidally influenced zone, some fish classified as regurgitations could have been drop-outs that were not flushed out to salt water due to a lack of current. This error would have little influence on our primary results because neither fate was used in the spawning destination analysis or migratory timing analysis. Permanently stationary tags upstream of the tagging site were very rare, indicating regurgitation upstream of the tagging site is very rare, especially because some instances of permanently stationary tags upstream of the tagging site clearly resulted from harvest.

3) Censor: Fish that displayed post-tagging upstream migration that was insufficient in length, or duration, or both could not be placed in a spawning area during a spawning period for a period of time sufficient for spawning. Criteria for classifying censored fish are explained in detail below.

4) Migrant: Fish that migrated upstream of the tagging site and entered known spawning areas during known spawning periods for a period of time sufficient for spawning were considered migrants. Chinook salmon that entered a Kenai River tributary were considered migrants to that tributary. Tributary use was verified by both station and air tracking data in most cases. A handful of instances occurred where tributary use was definitively indicated by station data but not verified by air tracking data. Mainstem Kenai River spawning Chinook salmon were assigned an approximate spawning RM based on demonstrated site fidelity. In most cases, a specific RM was clearly indicated while in others, fidelity was displayed to an area spanning up to a few RMs. In the latter case, an approximate median was reported.

### *Censoring Criteria for Fish in the Mainstem Kenai River*

The most difficult process in determining the fate of radiotagged fish was discriminating between fish that failed to spawn and should be censored from further analysis from fish that should be considered migrants that spawned in the mainstem of the Kenai River. Migrating Chinook salmon often hold in the mainstem of the Kenai River for days or weeks prior to resuming upstream migration. However, most of the Kenai River provides suitable spawning substrate, and spawning and migrating fish are indistinguishable while collocated. Often holding behavior is revealed by subsequent upstream migration. When holding behavior is followed by mortality, we censored fish that failed to meet the following minimum spawning requirements.

These criteria were applied sequentially, although many fish would have been censored by several criteria:

1) Fish that were harvested could not have spawned.
2) Fish that failed to display site fidelity upstream of RM 13 (Honeymoon Cove) could not have spawned.
3) Fish deemed mortalities prior to 1 July could not have spawned.
4) Fish that failed to display 6 days of site fidelity prior to mortality could not have spawned.
5) Fish deemed mortalities within 18 days of release could not have spawned.

Previous authors (Bendock and Alexandersdottir 1990; Bendock and Alexandersdottir 1991; Bendock and Alexandersdottir 1992) have used RM 12 as the downstream limit to Chinook salmon spawning. In 2009, ADF&G staff used drift gillnets to capture mainstem spawning Chinook salmon in the lower Kenai River for genetic baseline sampling, but were unable to locate spawning Chinook salmon downstream of RM 13.0 (Honeymoon Cove). While we used RM 13 herein as the downstream limit of Chinook salmon spawning, the difference is negligible because the few fish that may have migrated upstream of RM 12 but failed to migrate upstream of RM 13 would have been censored by other criteria.

The earliest returning Kenai River Chinook salmon enter freshwater in May, migrate 44 miles upstream, and congregate at the confluence with the Killey River prior to migrating up the Killey River a maximum of 33 additional miles. Spawning site selection, gamete deposition, and redd defense follow migration. These fish congregate near the Killey River confluence from early June to late July. Because the earliest arriving Kenai River Chinook salmon are still migrating in late June, 1 July is considered a conservative estimate of the earliest spawning date for Kenai River Chinook salmon.

ADF&G staff used drift gillnets to capture mainstem spawning Chinook salmon in various river sections during August and September of 2003, 2006, 2009, and 2011. For all years and sampling events, the majority of the Chinook salmon captured in the middle of August were firm[5], but the majority of the Chinook salmon captured by the end of August were ripe[6]. Based on these observations, we used the minimum values for site fidelity and stream life displayed by fish spawning in September to approximate the minimum values of fish that spawned earlier in the season. This method should be conservative because stream life is known to be decreased for the latest arriving salmon (Quinn 2005).

### *Mortality Criteria*

Most of the censoring criteria require assigning a mortality date to radiotagged Chinook salmon. Two complementary sources of information were used to determine mortality: 1) rapid, permanent, downstream movement and 2) the radio tag's mortality signal. Downstream movement was detected by boat and airplane tracking and by sequential records on downstream fixed stations. The radio tag mortality signal was activated after 18 hours without detectable movement. Permanent downstream movement was a definitive indicator of mortality, in that it

[5] Chinook salmon failed to express gametes in response to light abdominal pressure.
[6] Chinook salmon expressed gametes in response to light abdominal pressure.

either resulted in the radio tag being flushed into Cook Inlet or was followed by mortality signals if the radio tag remained in fresh water afterward. Mortality signals alone were less definitive because radio tags in obviously live fish can emit a mortality signal and conversely radio tags in obviously dead fish can fail to emit a mortality signal. Therefore, mortality signals were considered in aggregate, and fish were deemed mortalities only after consistent mortality signals were detected for the remaining tracking events. When inconsistent mortality signals were detected, a mortality date was not assigned.

In some situations, tagged Chinook salmon were proximate to a fixed station prior to mortality and the mortality date could be determined in daily resolution. When a mortality occurred out of range of a fixed station, the midpoint between the last live track and the first indication of mortality was used as the mortality date. This system worked particularly well in the mainstem Kenai River because voluminous manual and stationary tracking data were available. The rare occasions when mortalities could not be assigned to radiotagged fish within the mainstem Kenai River were usually associated with late arriving fish that were still alive during the last tracking event of the season.

Tributary spawning Chinook salmon were assigned mortality dates less often, and less precisely, due to the lack of fixed stations within tributaries and the resulting paucity of telemetry data available while the fish was in the tributary.

## Radio Tag Weights

### *Spawning Destinations of Fish Tagged at River Mile 8.5*

In 2010, a second crew deployed radio tags near RM 8.5 from 5 to 15 June alongside the midriver crew that was deploying tags from 16 May through 5 July. Sampling by the midriver crew was designed to provide a constant daily effort throughout the season, while sampling by the second crew was design to maximize the number of radio tags deployed during the 11-day period. Both crews tagged every healthy Chinook salmon caught during those time periods. To reduce bias in spawning distribution estimates due to uneven tagging efforts by the two crews, we split the early run into 3 time strata: 1) 16 May– 4 June, 2) 5–15 June, and 3) 16–30 June. We then assigned weights ($w_i$) to each stratum proportional to the number of fish caught by the midriver crew:

$$w_i = \frac{c_i}{\sum_{i=1}^{T} c_i} \tag{1}$$

where $c_i$ is the number of Chinook salmon caught by the midriver crew during time stratum *i*, and $T = 3$ is the number of time strata.

Then $p_s$, the contribution of stock *s*, can be estimated as a weighted proportion:

$$\hat{p}_s = \sum_{i=1}^{T} w_i \hat{p}_{s,i} \tag{2}$$

where $\hat{p}_{s,i}$ is the estimated contribution of fish from stock *s* that were tagged during time stratum *i*. The variance of $\hat{p}_s$ is estimated using standard technique for estimating variance of a weighted proportion (Cochran 1977).

### *Spawning Destinations of Fish Tagged at River Mile 21*

In the years 2011–2013, additional tagging was done at the RM 21 sampling site. During 2011 and 2012, a fixed number of radio tags were deployed each day, whereas in 2013 crews fished with constant effort and radiotagged all healthy Chinook salmon that were greater than or equal to 550 mm METF. To reduce bias in spawning distribution estimates due to uneven daily fishing effort for the years 2011–2012, we used a stratified estimator, with each tagging day as its own stratum. We assigned weights ($w_i$) to each day proportional to the CPUE for that day:

$$w_i = \frac{CPUE_i}{\sum_{i=1}^{D} CPUE_i} \tag{3}$$

where $CPUE_i$ is the catch per unit effort during tagging day *i;* and *D* is the number of days that sampling occurred at the RM 21 site. Then $p_s$, the contribution of stock *s,* can be estimated as a weighted proportion:

$$\hat{p}_s = \sum_{i=1}^{D} w_i \hat{p}_{s,i} \tag{4}$$

where $\hat{p}_{s,i}$ is the estimated contribution of fish from stock *s* that were tagged during day *i*.

The variance of $\hat{p}_s$ is estimated using standard technique for estimating variance of a weighted proportion (Cochran 1977). For 2013, no weighting was necessary because constant fishing effort was realized for each day.

### *Temporal Weighting for Chinook Salmon Released from River Mile 8.5*

The spawning destinations assigned to Chinook salmon radiotagged during 2010–2013 were used to estimate composition (early-run mainstem spawners, late-run mainstem spawners, or tributary spawners) of Chinook salmon subject to the Kenai River sport fishery upstream and downstream of Slikok Creek as well as to determine the locations of various stocks or run timing groups relative to regulatory boundaries throughout their instream migration. To reduce bias in these estimates, we used only fish tagged by the midriver tagging crew at RM 8.5 and then used post stratification to account for different tagging rates during the sampling season. The majority of the radio tags were deployed from the midriver crew at RM 8.5 and the sampling design provided constant fishing effort each day. However, tagging rates varied with the fraction of Chinook salmon sampled by the midriver tagging crew at RM 8.5 and by the fraction of sampled fish that were radiotagged. The midriver crew sampled every fish captured from 16 May to 30 June and every other fish captured per drift from 1 July to the end of the season in all 4 years. Thus, the sub-sampling rate varied depending on the number of fish captured per drift. Radio tags were deployed on every sampled Chinook salmon of the appropriate size from 16 May to 5 July in the years 2010–2012 and from 16 May to 15 July in 2013. After 5 July (2010–2012), or 15 July (2013), every other Chinook salmon that was sampled was radiotagged. To account for the different tagging rates within each year, we split each tagging season into 3 time strata: 1) 16 May to 30 June, 2) 1 July to 5 July (15 July in 2013), and 3) 6 July (16 July in 2013) to the end of the season. We then assigned weights ($w_i$) to each time stratum inversely proportional to the tagging rate for that stratum:

$$w_i = \frac{c_i}{t_i} \tag{5}$$

where $c_i$ is the number of Chinook salmon caught by the midriver crew during time stratum *i*, and $t_i$ is the number of fish tagged by the midriver crew during stratum *i*.

Then $p_s$, the contribution of stock *s* can be estimated as follows:

$$\hat{p}_s = \frac{\sum_{i=1}^{T} w_i n_i}{\sum_{i=1}^{T} w_i m_i} \tag{6}$$

where $n_i$ is the number of fish from stock *s* tagged during time stratum *i* that was found in a specific section of the river, $m_i$ is the number of fish tagged during time stratum *i* that was found in a specific section of the river, and *T* is the number of time strata.

Assuming independence of the tagging events in different time strata and treating $m_i$ as a constant, the variance of $\hat{p}_s$ can be estimated as follows:

$$\mathrm{var}(\hat{p}_s) = \frac{\sum_{i=1}^{T} w_i^{\,2}\, \mathrm{var}(n_i)}{(\sum_{i=1}^{T} w_i m_i)^2} \tag{7}$$

where $\mathrm{var}(n_i) = m_i \hat{p}_i (1 - \hat{p}_i)$ and $\hat{p}_i = \frac{n_i}{m_i}$.

# RESULTS

## TAG DEPLOYMENTS AND FATES

### 2010

A total of 249 radio tags, 215 in the early run and 34 in the late run, were deployed near RM 8.5 between 16 May and 5 July 2010 (Table 4). The majority of those tags were deployed by the midriver netting crew, although 69 tags were deployed by a second crew during an 11-day period from 5 to 15 June 2010. Only 86 (35%) of the radio tags deployed were assigned a spawning destination. The remaining tags were split between 23 drop-outs (9%), 42 regurgitations (17%), and 98 censors (39%). The 2010 season was the only year when Chinook salmon less than 550mm MEFT were radio tagged.

Table 4.–Fate of radiotagged Kenai River Chinook salmon by tagging event, 2010.

| | | 2010 | | | | | |
|---|---|---|---|---|---|---|---|
| | | RM 8.5, midriver | | RM 8.5, tagging | | Total | |
| Run | Fate | N | % | N | % | N | % |
| Early run | | | | | | | |
| | Drop-out | 15 | 10% | 2 | 3% | 17 | 8% |
| | Regurgitate | 23 | 16% | 6 | 9% | 29 | 13% |
| | Censor | 51 | 35% | 38 | 55% | 89 | 41% |
| | Migrant | 57 | 39% | 23 | 33% | 80 | 37% |
| | Total | 146 | | 69 | | 215 | |
| Late run | | | | | | | |
| | Drop-out | 6 | 18% | | | 6 | 18% |
| | Regurgitate | 13 | 38% | | | 13 | 38% |
| | Censor | 9 | 26% | | | 9 | 26% |
| | Migrant | 6 | 18% | | | 6 | 18% |
| | Total | 34 | | | | 34 | |
| Totals | | | | | | | |
| | Drop-out | 21 | 12% | 2 | 3% | 23 | 9% |
| | Regurgitate | 36 | 20% | 6 | 9% | 42 | 17% |
| | Censor | 60 | 33% | 38 | 55% | 98 | 39% |
| | Migrant | 63 | 35% | 23 | 33% | 86 | 35% |
| | Grand total | 180 | | 69 | | 249 | |

## 2011

A total of 228 radio tags, 183 in the early run and 45 in the late run, were deployed near RM 8.5 between 16 May and 5 July 2011 (Table 5). Only 91 (40%) of these radio tags were assigned a spawning destination. The remaining tags were split between 15 drop-outs (7%), 62 regurgitations (27%), and 60 censors (26%). An additional 49 radio tags were deployed near RM 21 between 2 June and 13 July: 35 in the early run and 14 in the late run (Table 5). Forty-three (88%) of these tags were assigned a spawning destination. The remaining tags were split between 3 regurgitations (6%) and 3 censors (6%).

## 2012

A total of 225 radio tags, 84 in the early run and 141 in the late run, were deployed near RM 8.5 between 16 May and 15 August 2012 (Table 6). Only 123 (55%) of these radio tags were assigned a spawning destination. The remaining tags were split between 12 drop-outs (5%), 18 regurgitations (8%), and 72 censors (32%). An additional 38 radio tags were deployed near RM 21 between 7 June and 4 July: 30 in the early run and 8 in the late run (Table 6). Thirty five (92%) of these tags were assigned a spawning destination. The remaining tags were split between 2 regurgitations (5%) and 1 censor (3%).

The Division of Commercial Fisheries deployed an additional 50 radio tags in Cook Inlet during July 2012. Forty of those tags entered the Kenai River and 39 of those were assigned a spawning destination. Seven tags were never located after release and 3 entered the Kasilof River.

Table 5.–Fate of radiotagged Kenai River Chinook salmon by tagging event, 2011.

| | | 2011 | | | | | |
|---|---|---|---|---|---|---|---|
| | | RM 8.5, midriver | | RM 21, tagging | | Total | |
| Run | Fate | N | % | N | % | N | % |
| Early run | | | | | | | |
| | Drop-out | 10 | 5% | 0 | 0% | 10 | 5% |
| | Regurgitate | 51 | 28% | 2 | 6% | 53 | 24% |
| | Censor | 44 | 24% | 3 | 9% | 47 | 22% |
| | Migrant | 78 | 43% | 30 | 86% | 108 | 50% |
| | Total | 183 | | 35 | | 218 | |
| Late run | | | | | | | |
| | Drop-out | 5 | 11% | 0 | 0% | 5 | 8% |
| | Regurgitate | 11 | 24% | 1 | 7% | 12 | 20% |
| | Censor | 16 | 36% | 0 | 0% | 16 | 27% |
| | Migrant | 13 | 29% | 13 | 93% | 26 | 44% |
| | Total | 45 | | 14 | | 59 | |
| Totals | | | | | | | |
| | Drop-out | 15 | 7% | 0 | 0% | 15 | 5% |
| | Regurgitate | 62 | 27% | 3 | 6% | 65 | 23% |
| | Censor | 60 | 26% | 3 | 6% | 63 | 23% |
| | Migrant | 91 | 40% | 43 | 88% | 134 | 48% |
| | Grand total | 228 | | 49 | | 277 | |

Table 6.–Fate of radiotagged Kenai River Chinook salmon by tagging event, 2012.

| | | 2012 | | | | | |
|---|---|---|---|---|---|---|---|
| | | RM 8.5, midriver | | RM 21, tagging | | Total | |
| Run | Fate | N | % | N | % | N | % |
| Early run | | | | | | | |
| | Drop-out | 8 | 10% | 0 | 0% | 8 | 7% |
| | Regurgitate | 10 | 12% | 0 | 0% | 10 | 9% |
| | Censor | 20 | 24% | 1 | 3% | 21 | 18% |
| | Migrant | 46 | 55% | 29 | 97% | 75 | 66% |
| | Total | 84 | | 30 | | 114 | |
| Late run | | | | | | | |
| | Drop-out | 4 | 3% | 0 | 0% | 4 | 3% |
| | Regurgitate | 8 | 6% | 2 | 25% | 10 | 7% |
| | Censor | 52 | 37% | 0 | 0% | 52 | 35% |
| | Migrant | 77 | 55% | 6 | 75% | 83 | 56% |
| | Total | 141 | | 8 | | 149 | |
| Totals | | | | | | | |
| | Drop-out | 12 | 5% | 0 | 0% | 12 | 5% |
| | Regurgitate | 18 | 8% | 2 | 5% | 20 | 8% |
| | Censor | 72 | 32% | 1 | 3% | 73 | 28% |
| | Migrant | 123 | 55% | 35 | 92% | 158 | 60% |
| | Grand total | 225 | | 38 | | 263 | |

## 2013

A total of 157 radio tags, 45 in the early run and 112 in the late run, were deployed near RM 8.5 by the midriver tagging crew between 16 May and 15 August 2013 (Table 7). Only 89 (57%) of these radio tags were assigned a spawning destination. The remaining tags were split between 10 drop-outs (6%), 11 regurgitations (7%), and 47 censors (30%). An additional 29 radio tags, 15 in the early run and 14 in the late run, were deployed near RM 8.5 by the nearshore tagging crew between 16 May and 15 August (Table 7). A smaller percentage of early-run fish tagged by the nearshore crew yielded a spawning destination when compared to fish captured by the midriver crew, although fish tagged by both crews displayed similar fates during the late run. Chinook salmon captured by the nearshore crew were smaller then fish captured by the offshore crew during both runs, although the difference was larger for early run fish. In the early run, the mean length of tagged Chinook salmon was 700 mm (SE 36 mm) for the nearshore netting crew versus 870 mm (SE 28 mm) for the midriver netting crew ($t$ = -3.89, df = 57, $P < 0.01$). In the late run, the difference was smaller; the mean length of tagged Chinook salmon was 854 mm (SE 56 mm) for the nearshore netting crew versus 898 mm (SE 16 mm) for the midriver netting crew ($t$ = -0.89, df = 124, $P = 0.38$).

An additional 28 radio tags were deployed near RM 21 between 6 and 27 June (Table 7). Twenty-two (79%) of these tags were assigned a spawning destination. The remaining 6 tags were censored (21%).

## Yearly Variation in Assigned Fates

In general, the proportion of radio tags deployed at RM 8.5 that yielded a spawning destination increased as the study progressed. Some of the improvement resulted from sampling decisions. For example, the percentage of fish classified as drop-outs decreased after the minimum tagging size (550 mm METF) was instituted after 2010. Also, the percentage of radio tags classified as regurgitations decreased after we began using supplementary aids to retention in 2012 and 2013. Two types of retention aids were used in 2012 and 2013, deployed alternately as fish were released. In both years, the percent of radio tags that yielded a spawning destination was higher for the "hootchie" retention aid than for the "band" retention aid, although the difference was only significant in 2012 (2012: $\chi^2 = 7.73$, df = 1, $P = 0.01$; 2013: $\chi^2 = 0.9$, df = 1, $P = 0.34$). Most of the difference was from a smaller percentage of fish classified as censored (Table 8). We are uncertain what mechanism could be driving this difference because regurgitation after upstream migration appears to be rare.

The dominant criteria for censoring a Chinook salmon differed according to particular situations present within each year (Table 9). In 2010 and 2011, when radio tags were only deployed through 5 July and the inriver fisheries were subject to fewer inseason restrictions, at least 64% of censored radio tags in each tagging event were censored because they were harvested or deemed mortalities prior to 1 July. In 2012 and 2013, fewer Chinook salmon were tagged and harvested in the early run, Chinook salmon tagging continued through mid-August, and inseason fishery restrictions were common. During 2012 and 2013, at least 50% of censored radio tags in each tagging event were censored because they did not display fidelity to a potential spawning area for at least 6 days. Many fish that failed to meet the site fidelity criterion would have failed to satisfy the stream life criterion had they not been applied sequentially. For example, of the 35 Chinook salmon censored via the site fidelity criterion in 2013, 22 also failed to meet the stream life criterion.

Table 7.–Fate of radiotagged Kenai River Chinook salmon by tagging event, 2013.

| | | 2013 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | RM 8.5, midriver | | RM 8.5, nearshore | | RM 21, tagging | | Total | |
| Run | Fate | N | % | N | % | N | % | N | % |
| Early run | | | | | | | | | |
| | Drop-out | 0 | 0% | 2 | 13% | 0 | 0% | 2 | 2% |
| | Regurgitate | 3 | 7% | 2 | 13% | 0 | 0% | 5 | 6% |
| | Censor | 10 | 22% | 6 | 40% | 6 | 21% | 22 | 25% |
| | Migrant | 32 | 71% | 5 | 33% | 22 | 79% | 59 | 67% |
| | Total | 45 | | 15 | | 28 | | 88 | |
| Late run | | | | | | | | | |
| | Drop-out | 10 | 9% | 1 | 7% | | | 11 | 9% |
| | Regurgitate | 8 | 7% | 2 | 14% | | | 10 | 8% |
| | Censor | 37 | 33% | 4 | 29% | | | 41 | 33% |
| | Migrant | 57 | 51% | 7 | 50% | | | 64 | 51% |
| | Total | 112 | | 14 | | | | 126 | |
| Totals | | | | | | | | | |
| | Drop-out | 10 | 6% | 3 | 10% | 0 | 0% | 13 | 6% |
| | Regurgitate | 11 | 7% | 4 | 14% | 0 | 0% | 15 | 7% |
| | Censor | 47 | 30% | 10 | 34% | 6 | 21% | 63 | 29% |
| | Migrant | 89 | 57% | 12 | 41% | 22 | 79% | 123 | 57% |
| | Grand total | 157 | | 29 | | 28 | | 214 | |

Table 8.–Fate of radiotagged Kenai River Chinook salmon released from RM 8.5 by retention aid, 2012–2013.

| | 2012 | | | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|
| | Band | | Hootchie | | Band | | Hootchie | |
| Fate | N | % | N | % | N | % | N | % |
| Drop-out | 5 | 5% | 5 | 5% | 5 | 6% | 8 | 8% |
| Regurgitate | 11 | 10% | 6 | 6% | 8 | 9% | 7 | 7% |
| Censor | 40 | 38% | 30 | 28% | 31 | 35% | 26 | 27% |
| Migrant | 49 | 47% | 67 | 62% | 45 | 51% | 55 | 57% |
| Total | 105 | | 108 | | 89 | | 96 | |

Table 9.–Censoring criteria by tagging event for radiotagged Kenai River Chinook salmon released from RM 8.5, 2010–2013.

| | 2010 | | | | 2011 | | 2012 | | 2013 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RM 8.5, midriver | | RM 8.5, tagging | | RM 8.5, midriver | | RM 8.5, midriver | | RM 8.5, midriver | | RM 8.5, nearshore | |
| Censor criteria | N | % | N | % | N | % | N | % | N | % | N | % |
| Harvest | 14 | 23% | 3 | 8% | 22 | 37% | 3 | 4% | 4 | 9% | 0 | 0% |
| Date | 30 | 50% | 29 | 76% | 16 | 27% | 10 | 14% | 1 | 2% | 2 | 20% |
| Rivermile | 6 | 10% | 5 | 13% | 8 | 13% | 18 | 25% | 8 | 17% | 3 | 30% |
| Site fidelity | 7 | 12% | 0 | 0% | 13 | 22% | 38 | 53% | 30 | 64% | 5 | 50% |
| Stream life | 3 | 5% | 1 | 3% | 1 | 2% | 3 | 4% | 4 | 9% | 0 | 0% |
| Total | 60 | | 38 | | 60 | | 72 | | 47 | | 10 | |

## SPAWNING DESTINATIONS

### Bias in Spawning Destination Estimates

Spawning destination estimates from radiotagged Chinook salmon are almost certainly biased. Bias is minimized when a representative sample of migrating Chinook salmon is tagged and when mortality between tagging and migration are similar for each stock. Bias associated with tagging an unrepresentative sample of Chinook salmon can be shown by comparing length data for fish migrating past weirs on the Funny and Killey rivers to similar data for radiotagged Chinook salmon that migrated past the weirs. The cumulative length distributions of radiotagged Chinook salmon that migrated through the weirs on the Funny and Killey rivers were different (skewed towards large fish) than the cumulative length distributions of untagged fish (Figure 2). The mean length of radiotagged Chinook salmon migrating through the Funny River weir was similar to the mean length of untagged fish in 2010 ($t$ = 1.01, df = 276, $P$ = 0.31), but was larger in 2011 ($t$ = 4.01, df = 214, $P$ < 0.01), 2012 ($t$ = 4.47, df = 187, $P$ < 0.01), and 2013 ($t$ = 1.75, df = 1.75, $P$ = 0.08). Also, the mean length of radiotagged Chinook salmon migrating through the Killey River weir was larger than the mean length of untagged fish in 2012 ($t$ = 6.44, df = 26.5, $P$ < 0.01) and 2013 ($t$ = 4.17, df = 678, $P$ < 0.01). Therefore, spawning destination proportions from radiotagged fish should underestimate stock proportions for tributaries with abundant small Chinook salmon. Most of the difference in length distributions was from the smallest Chinook salmon (<550 mm METF), which were not tagged after the 2010 season due to post-tagging survival issues[7]. Additionally, length distribution can vary substantially between stocks (Figure 2). In 2012, fish sampled at the Funny River weir were smaller than fish sampled at the Killey River weir ($t$ = −12.92, df = 440, $P$ < 0.01), while in 2013, fish sampled at the Killey River weir were smaller than fish sampled at the Funny River weir ($t$ = 2.55, df = 535, $P$ = 0.01).

We can directly assess the bias of our spawning destination estimates by comparing the ratio of Funny River to Killey River weir counts for all Chinook salmon to the ratio of Funny River to Killey River weir counts of radiotagged Chinook salmon (Table 10). In 2012, Funny River fish were underrepresented in the sample of radiotagged Chinook salmon. In 2013, the ratios comparing the Funny and Killey rivers (weir counts and radiotagged fish from the RM 8.5 tagging site) were similar. The ratio of Funny River to Killey River weir counts of all Chinook salmon was more similar to the ratio of the weir counts for radio tags deployed at RM 8.5 than for those deployed at RM 21.0 in both years.

Table 10.–Ratio of Funny River to Killey River weir passage, 2012–2013.

| | Telemetry | | |
|---|---|---|---|
| Year | RM 8.5[a] | RM 21[b] | Weirs[c] |
| 2012 | 0.42 | 0.33 | 0.54 |
| 2013 | 0.58 | 0.00 | 0.55 |

[a] Ratio of Kenai River Chinook salmon radiotagged near RM 8.5.

[b] Ratio of Kenai River Chinook salmon radiotagged near RM 21.

[c] Ratio of all Chinook salmon (with and without radio tags).

[7] Theproblem actually persists in some later years because the smallest size classes are also underrepresented in the catch of our sampling programs.

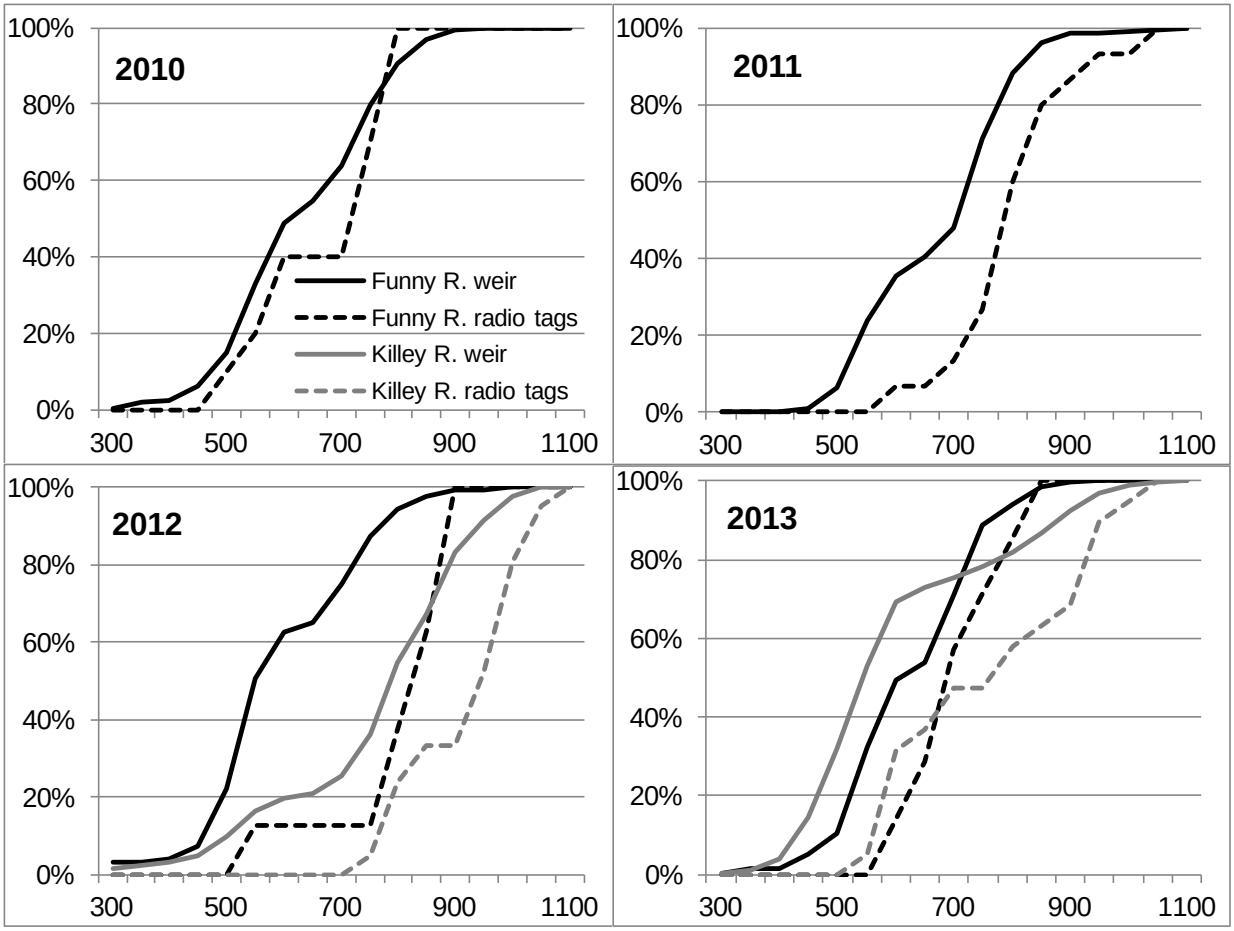


Figure 2.–Cumulative length distribution for Chinook salmon migration past the Funny River and Killey River weirs, 2010–2013.

## Fish Radiotagged Near River Mile 8.5

### *Early Run*

During 2010, radio tags were deployed by 2 crews near RM 8.5. Because one of the crews was absent for a portion of the run, spawning distribution estimates were weighted by time strata using the catch of the midriver netting crew (Table 11). Early-run Chinook salmon tagged during 2010 were assigned spawning destinations primarily in the Killey River (38%, SE 5%), followed by Benjamin Creek (25%, SE 5%), mainstem Kenai River (19%, SE 5%), and Funny River (12%, SE 4%). One radiotagged fish was assigned a spawning destination in each of the following drainages, respectively: Russian River, Juneau Creek, Crescent Creek, Daves Creek, and Grant Creek.

Early-run Chinook salmon tagged during 2011 were assigned spawning destinations primarily in the Killey River (29%, SE 5%), followed by Benjamin Creek (28%, SE 5%), mainstem Kenai River (28%, SE 5%), and Funny River (10%, SE 3%). One radiotagged fish was assigned to a spawning destination in Slikok, Juneau, and Grant creeks, respectively.

Early-run Chinook salmon tagged during 2012 were assigned spawning destinations primarily in the Killey River (46%, SE 7%), followed by Benjamin Creek (22%, SE 6%), mainstem Kenai River (15%, SE 5%), and Funny River (11%, SE 5%). One and 2 radiotagged fish were assigned spawning destinations in Juneau Creek and Grant Creek, respectively.

During 2013, radio tags were deployed by 2 crews operating near RM 8.5. The number of "migrants" resulting from either of the tagging crews efforts was low, but sampling effort was distributed equally through time by both crews, so fates for fish released by both crews were combined and are reported as such hereafter. During 2013, early-run Chinook salmon were assigned spawning destinations primarily in Killey River (27%, SE 7%), followed by Benjamin Creek (27%, SE 7%), mainstem Kenai River (22%, SE 7%), and Funny River (19%, SE 6%). One radiotagged fish was assigned a spawning destination in Quartz Creek and Crescent Creek, respectively.

Mainstem spawning Chinook salmon that returned during the early run were distributed throughout all sections of the Kenai River in all years (2010–2013; Table 11). Two fish located in Skilak Lake during 2010 were classified as spawners despite the lack of significant, identified spawning habitat in the lake. However, these fish satisfied all of the censoring criteria, and are not without precedent (Bendock and Alexandersdottir 1992).

Table 11.–Spawning distributions determined for early-run Kenai River Chinook salmon tagged near RM 8.5, 2010–2013.

| | 2010 | | 2011 | | 2012 | | 2013 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Midriver | | Nearshore | | Combined | |
| Location | N | % (SE)[a] | N | % (SE) | N | % (SE) | N | % (SE) | N | % (SE) | N | % (SE) |
| Tributary | | | | | | | | | | | | |
| Slikok C. | | | 1 | 1% (1%) | | | | | | | | |
| Funny R. | 10 | 12% (4%) | 8 | 10% (3%) | 5 | 11% (5%) | 7 | 22% (7%) | | | 7 | 19% (6%) |
| Killey R. | 31 | 38% (5%) | 23 | 29% (5%) | 21 | 46% (7%) | 6 | 19% (7%) | 4 | 80% (18%) | 10 | 27% (7%) |
| Benjamin C. | 19 | 25% (5%) | 22 | 28% (5%) | 10 | 22% (6%) | 9 | 28% (8%) | 1 | 20% (18%) | 10 | 27% (7%) |
| Russian R. | 1 | 1% (1%) | | | | | | | | | | |
| Juneau C. | 1 | 1% (1%) | 1 | 1% (1%) | 1 | 2% (2%) | | | | | | |
| Quartz C. | | | | | | | 1 | 3% (3%) | | | 1 | 3% (3%) |
| Crescent C. | 1 | 1% (1%) | | | | | 1 | 3% (3%) | | | 1 | 3% (3%) |
| Daves C. | 1 | 1% (1%) | | | | | | | | | | |
| Grant C. | 1 | 1% (1%) | 1 | 1% (1%) | 2 | 4% (3%) | | | | | | |
| Tributary sum | 65 | 81% (9%) | 56 | 72% (5%) | 39 | 85% (5%) | 24 | 75% (8%) | 5 | 100% (0%) | 29 | 78% (7%) |
| Mainstem | | | | | | | | | | | | |
| Kenai R. RM 0–21 | 4 | 5% (2%) | 7 | 9% (3%) | 1 | 2% (2%) | 2 | 6% (4%) | | | 2 | 5% (4%) |
| Kenai R. RM 22–39 | 4 | 5% (2%) | 5 | 6% (3%) | 3 | 7% (4%) | 3 | 9% (5%) | | | 3 | 8% (4%) |
| Kenai R. RM 40–50 | 5 | 6% (3%) | 2 | 3% (2%) | 2 | 4% (3%) | 1 | 3% (3%) | | | 1 | 3% (3%) |
| Skilak Lake | 2 | 3% (2%) | | | | | | | | | | |
| Kenai R. RM 65–82 | | | 8 | 10% (3%) | 1 | 2% (2%) | 2 | 6% (4%) | | | 2 | 5% (4%) |
| Mainstem sum | 15 | 19% (5%) | 22 | 28% (5%) | 7 | 15% (5%) | 8 | 25% (8%) | 0 | 0% (0%) | 8 | 22% (7%) |

[a] The number of tags was weighted to account for varied levels of tagging effort.

### *Late Run*

During both 2010 and 2011, Chinook salmon were only radiotagged during the first 5 days of the late run (1–5 July). Fish tagged during this time period were assigned spawning destinations throughout all sections of the Kenai River (Table 12).

During 2012 and 2013, Chinook salmon were radiotagged from 1 July through mid-August. During both seasons, the largest percentages were assigned spawning destinations downstream of the Soldotna Bridge (RM 0–21): 43% (SE 6%) in 2012 and 37% (SE 6%) in 2013. The Kenai River between Skilak Lake and Kenai Lake (RM 65–82) was the spawning destination for the smallest percentage of radiotagged Chinook salmon in both years: 12% (SE 4%) in 2012 and 13% (SE 4%) in 2013. Intermediate numbers of radiotagged Chinook salmon were assigned spawning destinations in the areas between the Soldotna Bridge and Naptown Rapids (RM 22–39): 26% (SE 5%) in 2012 and 22% (SE 5%) in 2013, and between Naptown Rapids and Skilak Lake (RM 40–50): 19% (SE 5%) in 2012 and 29% (SE=6%) in 2013. Between 2010 and 2013, only 1 tributary spawning Chinook salmon (in Juneau Creek, captured on 9 July 2013) was radiotagged during the late run.

## Fish Radiotagged Near River Mile 21.0

### *Early Run*

During 2011 and 2012, a fixed number of radio tags were deployed per sampling day at the RM 21 tagging site; resulting spawning distribution estimates were therefore weighted by daily CPUE (Table 13).

Chinook salmon tagged during 2011 were assigned spawning destinations primarily in the Killey River (32%, SE 8%), followed by Benjamin Creek (24%, SE 9%), Funny River (21%, SE 7%), and mainstem Kenai River (20%, SE 8%). A single radiotagged fish was assigned as spawning destination in Quartz Creek.

Chinook salmon tagged during 2012 were assigned spawning destinations primarily in the Killey River (51%, SE 9%), followed by Benjamin Creek (23%, SE 8%), mainstem Kenai River (9%, SE 6%), and Funny River (7%, SE 5%). One radiotagged fish also spawned in Juneau Creek and Quartz Creek, respectively.

Chinook salmon tagged during 2013 spawned primarily in the Killey River (55%, SE 11%), followed by Benjamin Creek (27%, SE 9%), and the mainstem Kenai River (18%, SE 8%).

### *Late Run*

In 2011, a fixed number of radio tags were deployed during only 2 days in early July; the resulting spawning distribution estimates were weighted by daily CPUE. In 2012, Chinook salmon were radiotagged during only 1 day in early July. Spawning destinations were assigned to radiotagged fish throughout all sections of the Kenai River in both years (Table 14). No Chinook salmon radiotagged during July in either year spawned outside of the mainstem Kenai River.

Table 12.–Spawning distributions determined for late-run Kenai River Chinook salmon tagged near RM 8.5, 2010–2013.

| | 1–5 Jul 2010 | | 1–5 Jul 2011 | | 1 Jul–15 Aug 2012 | | Midriver 1 Jul–17 Aug 2013 | | Nearshore 1 Jul–16 Aug 2013 | | Combined 1 Jul–16 Aug 2013 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Location | N | % (SE) | N | % (SE) | N | % (SE) | N | % (SE) | N | % (SE) | N | % (SE) |
| Tributary | | | | | | | | | | | | |
| Juneau C. | | | | | | | 1 | 100% (0%) | | | 1 | 100% (0%) |
| Tributary sum | | | | | | | 1 | 2% (2%) | | | 1 | 2% (2%) |
| Mainstem | | | | | | | | | | | | |
| Kenai R. RM 0–21 | 2 | 33% (19%) | 4 | 31% (13%) | 33 | 43% (6%) | 23 | 41% (7%) | | | 23 | 37% (6%) |
| Kenai R. RM 22–39 | 2 | 33% (19%) | 3 | 23% (12%) | 20 | 26% (5%) | 14 | 25% (6%) | | | 14 | 22% (5%) |
| Kenai R. RM 40–50 | 1 | 17% (15%) | 5 | 38% (13%) | 15 | 19% (5%) | 12 | 21% (5%) | 6 | 86% (13%) | 18 | 29% (6%) |
| Skilak Lake | | | | | | | | | | | | |
| Kenai R. RM 65–82 | 1 | 17% (15%) | 1 | 8% (7%) | 9 | 12% (4%) | 7 | 13% (4%) | 1 | 14% (13%) | 8 | 13% (4%) |
| Mainstem sum | 6 | 100% (0%) | 13 | 100% (0%) | 77 | 100% (0%) | 56 | 98% (2%) | 7 | 100% (0%) | 63 | 98% (2%) |

Table 13.–Spawning distributions determined for early-run Kenai River Chinook salmon tagged near RM 21.0, 2011–2013.

| | 2–29 Jun 2011 | | 7–28 Jun 2012 | | 30 May–27 Jun 2013 | |
|---|---|---|---|---|---|---|
| Location | N | % (SE)[a] | N | % (SE)[a] | N | % (SE) |
| Tributary | | | | | | |
| Slikok C. | | | | | | |
| Funny R. | 7 | 21% (7%) | 3 | 7% (5%) | | |
| Killey R. | 11 | 32% (8%) | 15 | 51% (9%) | 12 | 55% (11%) |
| Benjamin C. | 6 | 24% (9%) | 7 | 23% (8%) | 6 | 27% (9%) |
| Russian R. | | | | | | |
| Juneau C. | | | 1 | 6% (5%) | | |
| Quartz C. | 1 | 3% (3%) | 1 | 4% (4%) | | |
| Crescent C. | | | | | | |
| Daves C. | | | | | | |
| Grant C. | | | | | | |
| Tributary sum | 25 | 80% (14%) | 27 | 91% (6%) | 18 | 82% (8%) |
| Mainstem | | | | | | |
| Kenai R. RM 0–21 | 2 | 7% (4%) | | | | |
| Kenai R. RM 22–39 | 1 | 3% (3%) | 1 | 4% (4%) | 2 | 9% (6%) |
| Kenai R. RM 40–50 | 2 | 10% (6%) | 1 | 6% (5%) | 2 | 9% (6%) |
| Skilak Lake | | | | | | |
| Kenai R. RM 65–82 | | | | | | |
| Mainstem sum | 5 | 20% (8%) | 2 | 9% (6%) | 4 | 18% (8%) |

[a] The number of tags was weighted to account for varied levels of tagging effort.

Table 14.–Spawning distributions determined for late run Kenai River Chinook salmon tagged near RM 21.0 and in Cook Inlet, 2011–2013.

| | Kenai RM 21 | | | | Saltwater | |
|---|---|---|---|---|---|---|
| | 8 & 13 Jul 2011 | | 4 Jul 2012 | | 14 Jul–17 Aug 2012[b] | |
| Location | N | % (SE)[a] | N | % (SE) | N | % (SE) |
| No Tributary Spawners | | | | | | |
| Mainstem | | | | | | |
| Kenai R. RM 0–21 | 2 | 22% (13%) | 1 | 17% (15%) | 14 | 36% (8%) |
| Kenai R. RM 22–39 | 3 | 27% (14%) | 3 | 50% (20%) | 7 | 18% (6%) |
| Kenai R. RM 40–50 | 4 | 25% (12%) | 1 | 17% (15%) | 14 | 36% (8%) |
| Skilak Lake | | | | | | |
| Kenai R. RM 65–82 | 4 | 25% (12%) | 1 | 17% (15%) | 4 | 10% (5%) |
| Mainstem sum | 13 | 100% (0%) | 6 | 100% (0%) | 39 | 100% (0%) |

[a] The number of tags was weighted to account for varied levels of tagging effort.

[b] Tags deployed in salt water, between 38 and 57 miles from the Kenai River. Date range reflects the first day each tag was found in the Kenai River and approximates the dates of deployment shown for the inriver tagging events.

## Fish Radiotagged in Cook Inlet

During 2012, 39 Chinook salmon were radiotagged in Cook Inlet from 7 to 31 July and arrived in the Kenai River between 14 July and 17 August (Table 14). Based on tagging conducted inriver prior to 7 July, radio tags deployed in Cook Inlet did not include the earliest arriving mainstem spawning Kenai River Chinook salmon. Spawning destinations for most of the Chinook salmon radiotagged in Cook Inlet were downstream of the Soldotna Bridge (RM 0–21; 36%, SE 8%) or between Naptown Rapids and Skilak Lake (RM 40–50; 36%, SE 8%). The areas between Soldotna Bridge and Naptown Rapids (RM 22–39; 18%, SE 6%) and between Skilak Lake and Kenai Lake (RM 65–82; 10%, SE 5%) were spawning destinations for smaller percentages of radiotagged Chinook salmon.

Three of the 42 Chinook salmon radiotagged in Cook Inlet and later located at a spawning destination were located in the Kasilof River (7% [SE 4%] of the Chinook salmon that were assigned spawning destinations). The percentage of Kasilof River spawners was determined by a single aerial track conducted by staff from the Division of Commercial Fisheries on 18 September 2012. The tags were located near RMs 7, 12.6, and 15.5, and only the tags located near RMs 7 and 15.5 were transmitting in mortality mode. All 3 radio tags were located in areas where Chinook salmon have been confirmed to spawn (Reimer and Fleischman 2012: Figure 2).

## Within Tributary Spawning Distribution

Spawning distributions within the Funny and Killey rivers drainages were approximated as the most upstream location recorded via airplane tracking flights (Figure 3). Because airplane tracking flights were infrequent (every 10–20 days), it's likely that some fish traveled further upstream than recorded. Additional error is due to the fact that recorded coordinates show the location of the plane where the strongest signal was received, not the location of the signal. On some occasions, particularly near Benjamin Creek, the recorded coordinates are far from the anadromous stream. These instances reflect signals received while the plane was circling over a small area where fish were densely concentrated.

### *Funny River*

Radiotagged Chinook salmon were distributed throughout the lower two-thirds of the Funny River drainage during the spawning period (Figure 3). The downstream reaches of the Funny River are road accessible and have been visually confirmed as spawning areas. The United States Fish and Wildlife Service (USFWS) operated a weir annually on the Funny River during the years 2010–2013. The weir was located low in the drainage (Figure 3), although some Chinook salmon may spawn downstream of the weir location. For example, spawning activity was visually confirmed downstream of the weir in 2013, including the most downstream radiotagged Chinook salmon location in Figure 3. Spawning activity near the weir was greater in 2013 than noted in previous years but still did not constitute a large portion of the total run. A second radiotagged Chinook salmon may have spawned downstream of the Funny River weir in 2010, although the exact location of this fish with respect to the weir was not visually confirmed, and aerial locations are not accurate enough to be conclusive.

### *Killey River*

Chinook salmon were distributed throughout most reaches of the Killey River during the spawning period (Figure 3). The Killey River is murky during the summer glacial melt and spawning activity has not been confirmed in the lower sections of the Killey River proper. However the Killey River has abundant beds of suitably-sized gravel throughout its length that could provide spawning habitat for Chinook salmon. Dense concentrations of Chinook salmon are present in Benjamin Creek and in the Killey River near the confluence with Benjamin Creek. Benjamin Creek is a well-known spawning area where spawning has been visually confirmed and spawning fish have been sampled on multiple occasions.

The USFWS operated a weir on the Killey River during 2012 and 2013. The weir was located such that all Benjamin Creek bound Chinook salmon migrate through the weir, but only a portion of the Killey River bound Chinook salmon do (Figure 3). In 2012, 53 radiotagged Chinook salmon migrated into the Killey River drainage; 17 of those fish migrated into Benjamin Creek, 4 remained in the Killey River but migrated upstream of the weir, and 32 remained in the Killey River downstream of the weir. In 2013, 38 radiotagged Chinook salmon migrated into the Killey River drainage; 16 of those fish migrated into Benjamin Creek, 3 remained in the Killey River but migrated upstream of the weir, and 19 remained in the Killey River downstream of the weir.

Based on ADF&G staff observations since 2005, the amount of available spawning habitat within Benjamin Creek is highly variable among years. Presently, Benjamin Creek forks into 2 disparate channels before entering the Killey River. However, when ADF&G staff visited the area during the 2005 and 2006 spawning events, Benjamin Creek entered the Killey River via one channel and spawning activity was densely concentrated in the northern channel and the waters upstream of the fork (Figure 4). The area was not revisited until 2011 when conversely, there was minimal flowing water in the northern channel, with most of the water entering the Killey River via the shorter southern channel. During 2011, the low flow rates and water level in the longer northern channel precluded most spawning in that channel. The change is substantial because the southern channel is significantly shorter (Figure 4) and contains poor spawning substrate. Streamflow changes occurred again in 2013 when flowing water appeared to be evenly split between the two channels. Variability in the quantity and quality of available spawning substrate within the Benjamin Creek drainage is expected to affect productivity.

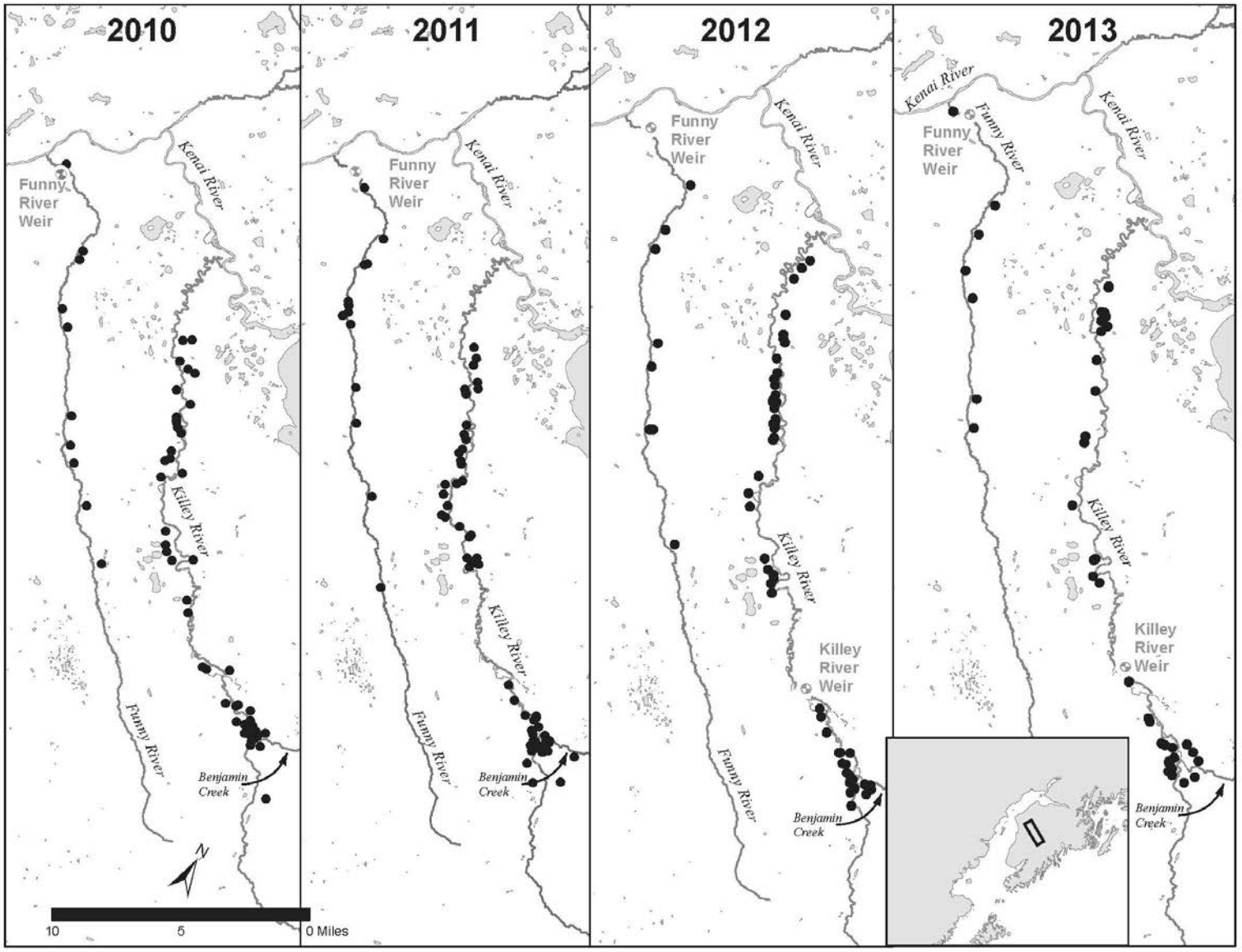


Figure 3.–Farthest upstream location for radiotagged Chinook salmon within the Funny River and Killey River drainages, 2010–2013.

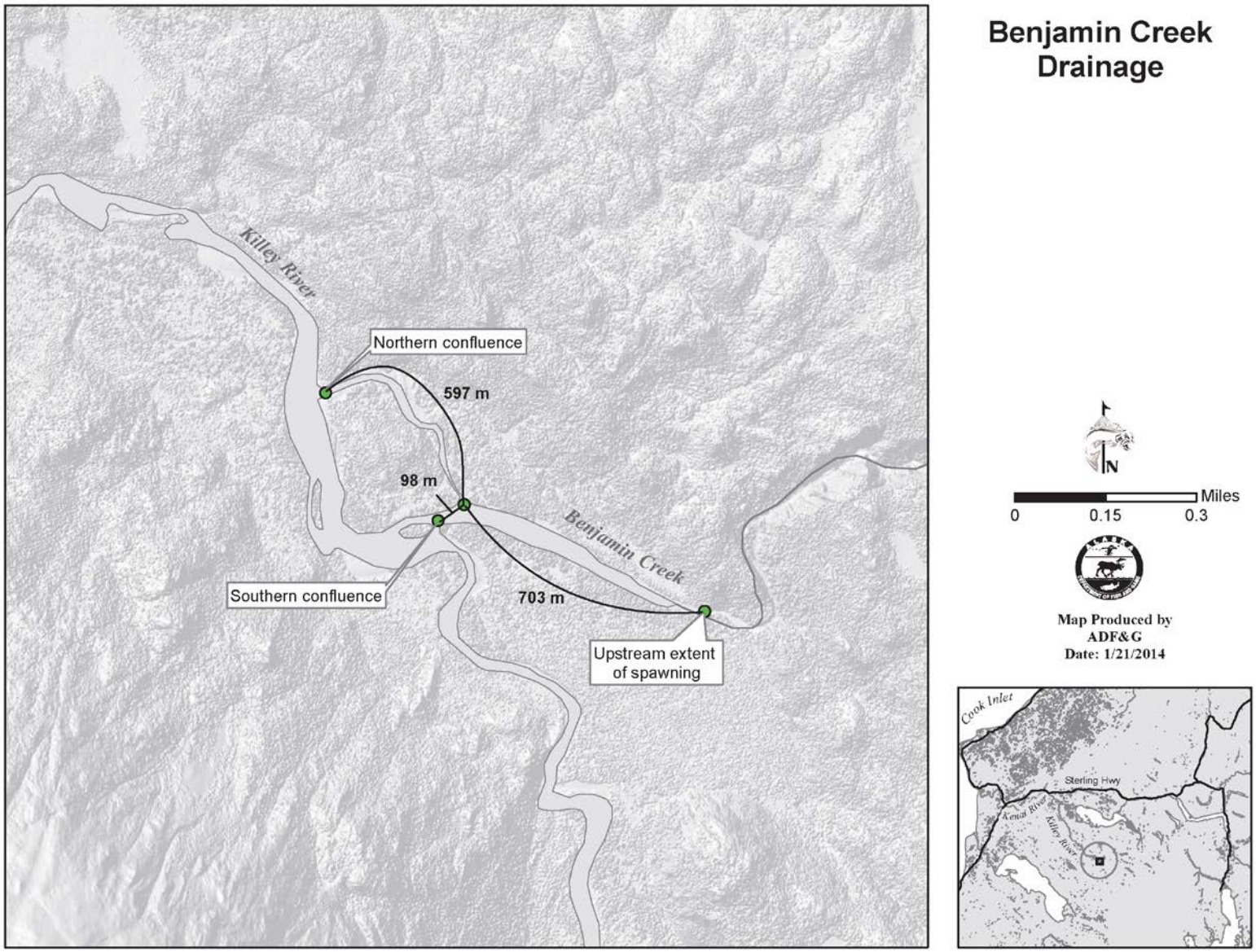


Figure 4.–Length of Benjamin Creek available for spawning in the northern and southern channels.

The Killey River drainage has also recently changed near it's confluence with the Kenai River. The Killey River enters the Kenai River through what are termed the Lower, Middle, and Upper forks. The Upper Fork enters at RM 45.9 and currently has a marginal connection to the Kenai River. We have not documented use of the Upper Fork by adult Chinook salmon. The Middle and Lower forks enter the Kenai River at RM 44.3 and 44.0, respectively. Both have had notable streamflow and migratory use in recent years; however, the relative magnitudes have changed since 2005. During 2005 and 2006, the main water discharge occurred through the Lower Fork, and ADF&G staff captured significant numbers of adult Chinook salmon in the Lower Fork using fish wheels. By 2010, a majority of the water discharge occurred through the Middle Fork, and fixed stations were located at both confluences to detect use patterns between the two forks. No radiotagged Chinook salmon were detected in the Lower Killey River in 2010. A fixed station was not installed at the Lower Fork during 2011–2013; however, significant use of the Lower Fork would have been apparent with manual radio tracking. During 2011–2012, no use of the lower Killey River was noted, although some Killey River bound Chinook salmon may have used the Lower Fork to migrate upstream in 2013.

### Mainstem Spawning Distribution

Spawning destinations for Chinook salmon radiotagged during 2010–2013 were assigned throughout the Kenai River mainstem upstream of tidal influence (Figure 5). The most heavily utilized sections, in terms of radiotag detections, were RMs 14–15, 17–21, and 46–47 (Figure 6). Large areas where no radio tags were detected correspond to areas with rapids (Naptown rapids, RM 39; Skilak Canyon, RM 67–69; and Schooner Bend, RM 76–77) or the slow, deep water associated with lake outlets (Skilak Lake outlet, RM 49–50; and Kenai Lake outlet, 81–82).

## MIGRATORY TIMING

### Bias in Migratory Timing Estimates

Migratory timing estimates derived from radiotagged Chinook salmon are likely biased as a result of migratory delays that occur due to handling. The severity of this bias can be assessed by comparing the timing of radiotagged Chinook salmon to all Chinook salmon migrating past the weirs on the Funny River (Figure 7) and the Killey River (Figure 8). Radiotagged Chinook salmon migrating past both weirs do not show a systematic bias across years towards later migration. Delayed migration after tagging seems unrelated to other measures of handling success, because fish tagged near RM 21 (where migration success is high) migrated past the weir concurrently or after fish tagged at RM 8.5.

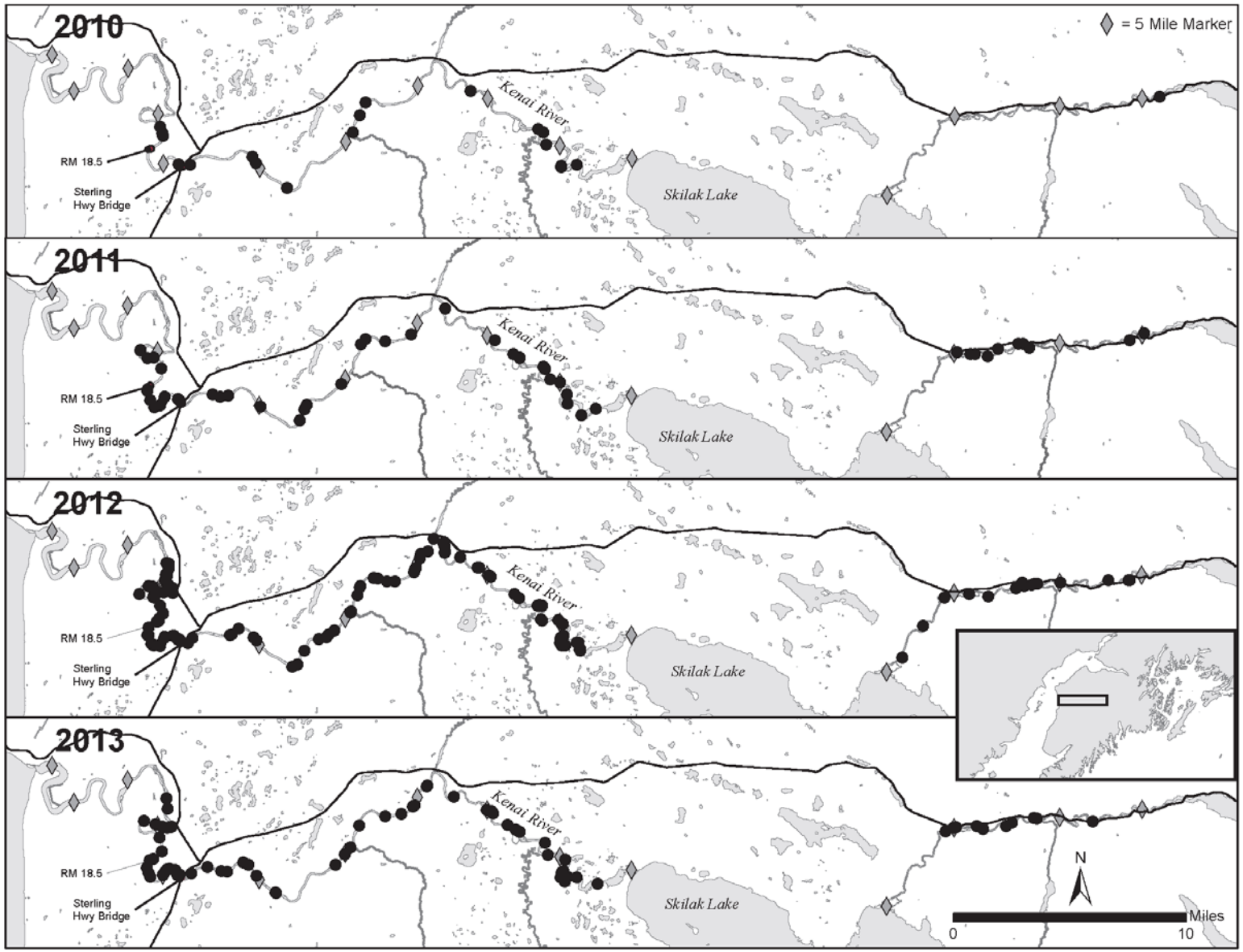


Figure 5.–Spawning destinations determined for radiotagged Chinook salmon within mainstem Kenai River, 2010–2013.

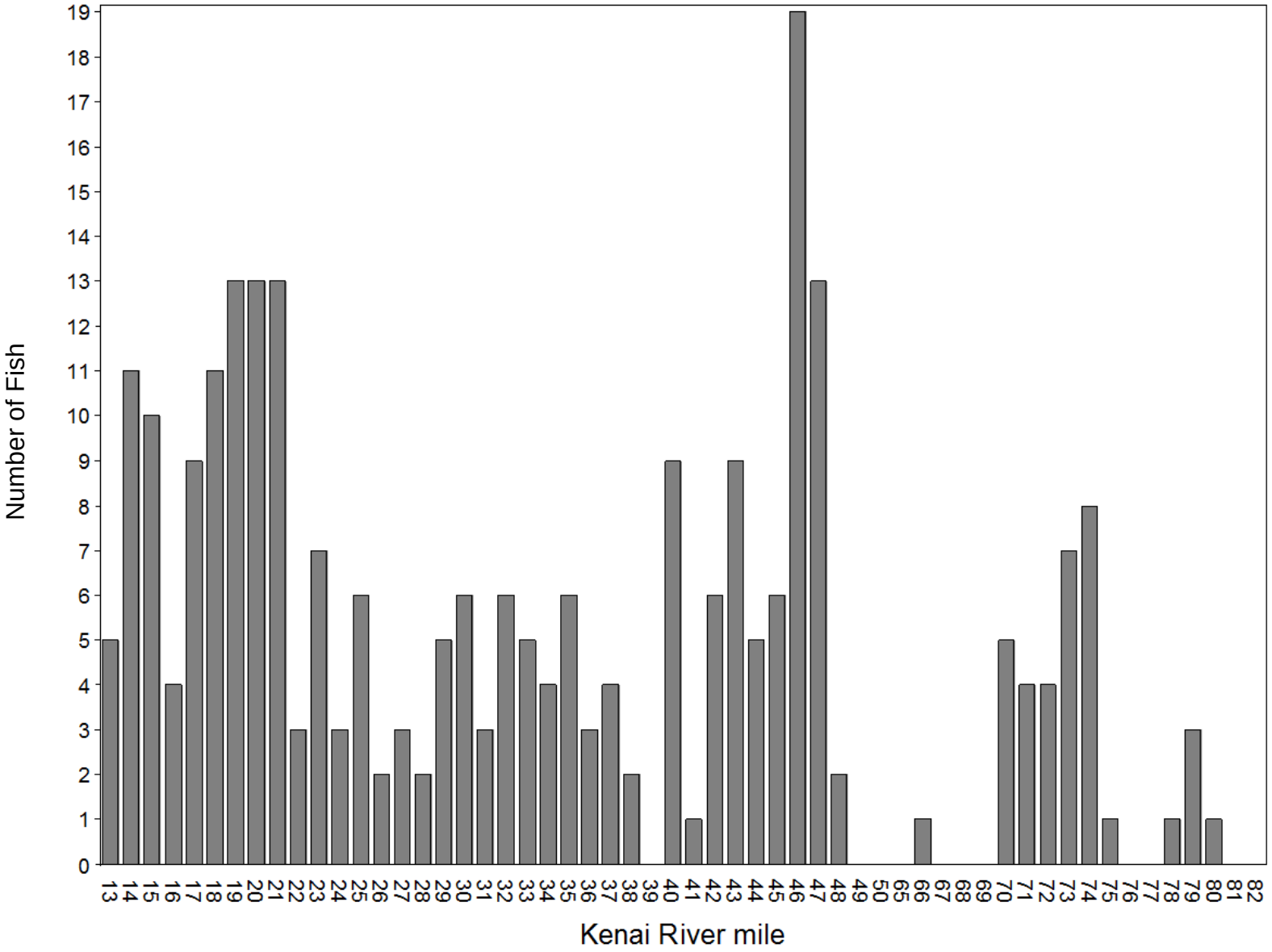


Figure 6.–Spawning destinations determined for Chinook salmon within the mainstem Kenai River by river mile, 2010–2013.

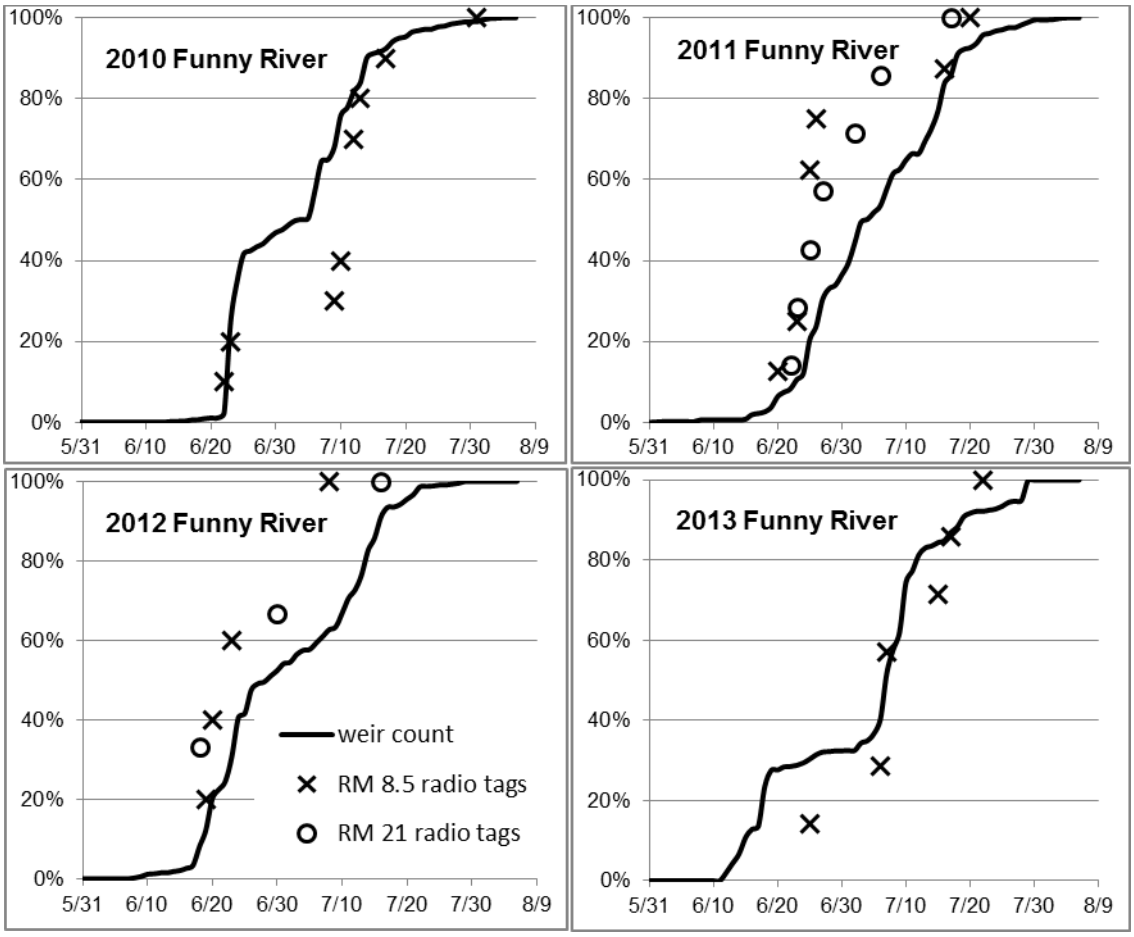


Figure 7.–Date of migration past the Funny River weir for radiotagged Chinook salmon and all Chinook salmon, 2010–2013.

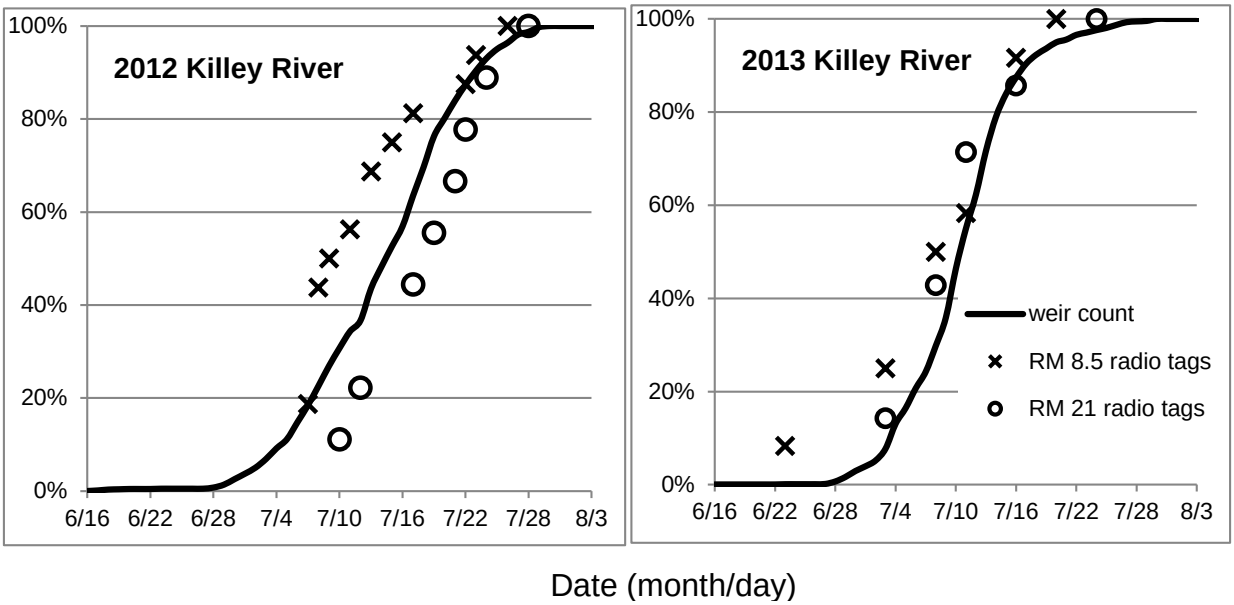


Figure 8.–Date of migration past the Killey River weir for radiotagged Chinook salmon and all Chinook salmon, 2012–2013.

## Entry Timing

Tributary bound Chinook salmon were captured at RM 8.5 starting in May in all years (Table 15). Killey River and Benjamin Creek spawners spanned the entire early run. Funny River spawners were not captured until late May. Migrants to other tributaries have primarily been captured in June. Only one tributary bound Chinook salmon (bound for Juneau Creek), captured on 9 July 2013, was captured in July during any season (2010–2013).

Chinook salmon that were assigned spawning destinations within the Kenai River mainstem were first captured at RM 8.5 beginning in the first or second week in June (Table 16). The median dates of capture for mainstem spawning Chinook salmon were later in 2012 than in 2013 for fish that spawned in all river sections downstream of Skilak Lake.

## Site Fidelity and Mortality Dates

Mortalities were detected for radiotagged Chinook salmon with tributary spawning destinations beginning in early July and continuing through mid-August (Table 13). The median mortality date for tributary bound Chinook salmon was 30 July for all years.

While we cannot detect the start of the spawning event for each radiotagged Chinook salmon we can identify an earlier date; when radiotagged Chinook salmon showed fidelity to their eventual spawning area (Table 14). The date when a radiotagged Chinook salmon showed fidelity to their eventual spawning area is not intended to approximate active spawning, but rather to provide a early bound on the date when spawning could have begun. Chinook salmon with spawning destinations within the Kenai River mainstem began displaying site fidelity to their eventual spawning area as early as late June although in most years and river sections, no site fidelity was displayed until July. The median date for radiotagged Chinook salmon to begin displaying site fidelity to their eventual spawning area varied between 12 and 21 August for all years and river sections. All radiotagged Chinook salmon with a mainstem spawning destination displayed site fidelity to their eventual spawning area by early September. Site fidelity lasted for 6–63 days (median 14 days)[8]. Spawning is assumed to have occurred toward the end of each fish's site fidelity period, followed by mortality. Mortalities for mainstem spawning Chinook salmon were recorded as early as 7 July and as late as 18 September. The median date of mortality varied between 29 August and 2 September for all years and river sections. These mortality dates are in agreement with staff observations from inriver gillnetting of Chinook salmon during spawning periods in the Kenai River mainstem. When Chinook salmon with spawning destinations within the Kenai River mainstem are separated by return timing, there is considerable overlap between the median mortality dates for each group (Figure 9). Chinook salmon that returned during the early run had a median mortality date of 21 August whereas Chinook salmon that returned during the late run had a median mortality date of 30 August.

[8] Our censoring criteria required minimum site fidelity of 6 days for mainstem spawning Chinook salmon.

Table 15.–Date of capture and mortality for tributary spawning Kenai River Chinook salmon, 2010–2013.

| Spawning destination | Year | N | Capture | | | Mortality | | |
|---|---|---|---|---|---|---|---|---|
| | | | First | Median[a] | Last | First | Median | Last |
| Funny River | 2010 | 6 | 29 May | 12 Jun | 28 Jun | 26 Jul | 10 Aug | 13 Aug |
| | 2011 | 8 | 26 May | 3 Jun | 30 Jun | 5 Jul | 26 Jul | 4 Aug |
| | 2012 | 5 | 26 May | 7 Jun | 22 Jun | 8 Jul | 27 Jul | 4 Aug |
| | 2013 | 7 | 8 Jun | 18 Jun | 23 Jun | 26 Jul | 3 Aug | 13 Aug |
| | All | 26 | 26 May | 9 Jun | 30 Jun | 5 Jul | 3 Aug | 13 Aug |
| Killey River | 2010 | 21 | 19 May | 9 Jun | 19 Jun | 2 Jul | 29 Jul | 17 Aug |
| | 2011 | 23 | 17 May | 8 Jun | 28 Jun | 5 Jul | 30 Jul | 12 Aug |
| | 2012 | 21 | 19 May | 3 Jun | 27 Jun | 5 Jul | 25 Jul | 16 Aug |
| | 2013 | 6 | 7 Jun | 8 Jun | 14 Jun | 15 Jul | 22 Jul | 3 Aug |
| | All | 71 | 17 May | 8 Jun | 28 Jun | 2 Jul | 26 Jul | 17 Aug |
| Benjamin Creek | 2010 | 15 | 20 May | 11 Jun | 27 Jun | 26 Jul | 13 Aug | 13 Aug |
| | 2011 | 22 | 3 Jun | 9 Jun | 21 Jun | 16 Jul | 4 Aug | 12 Aug |
| | 2012 | 10 | 16 May | 2 Jun | 20 Jun | 16 Jul | 27 Jul | 4 Aug |
| | 2013 | 9 | 22 May | 8 Jun | 26 Jun | 22 Jul | 26 Jul | 3 Aug |
| | All | 56 | 16 May | 8 Jun | 27 Jun | 16 Jul | 4 Aug | 13 Aug |
| All tributaries | 2010[a] | 47 | 19 May | 11 Jun | 28 Jun | 2 Jul | 10 Aug | 17 Aug |
| | 2011[b] | 56 | 17 May | 8 Jun | 30 Jun | 5 Jul | 4 Aug | 17 Aug |
| | 2012[c] | 39 | 16 May | 4 Jun | 27 Jun | 5 Jul | 26 Jul | 16 Aug |
| | 2013[d] | 25 | 20 May | 11 Jun | 9 Jul | 15 Jul | 27 Jul | 13 Aug |
| | All | 167 | 16 May | 8 Jun | 9 Jul | 2 Jul | 30 Jul | 17 Aug |

[a] Capture dates include fish from Skilak Lake (28 May and 14 June), Russian River (22 June), Juneau Creek (26 June) and Grant Creek (27 June). Mortality dates include fish from Skilak Lake (22 July) and Russian River (13 Aug).

[b] Capture dates include fish from Slikok Creek (31 May), Juneau Creek (29 June) and Grant Creek (30 June). Mortality dates include fish from Slikok Creek (11 August) and Juneau Creek (17 August).

[c] Capture dates include fish from Juneau Creek (11 June) and Grant Creek (22 and 24 June). Mortality dates include fish from Juneau Creek (1 August).

[d] Capture dates include fish from Juneau Creek (9 July), Quartz Creek (20 May), and Crescent Creek (11 June). Mortaility dates include fish from Quartz Creek (15 July) and Crescent Creek (3 August).

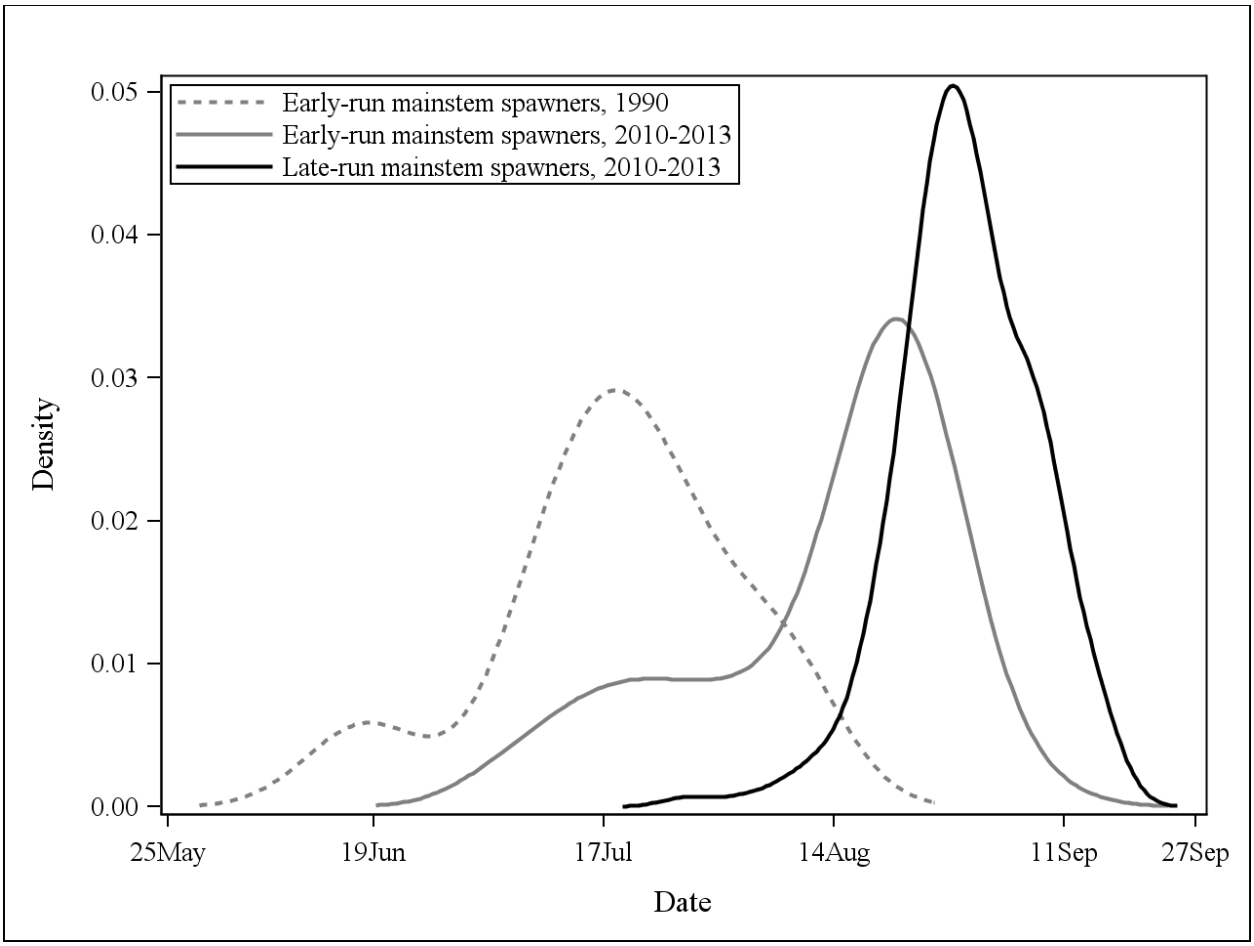


Figure 9.–Kernal density of post spawning mortality date for Chinook salmon with Kenai River mainstem spawning destinations; 1990, 2010–2013.

Table 16.–Date of capture, beginning of spawning site fidelity, and mortality for mainstem spawning Kenai River Chinook salmon, 2010–2013.

| | | | Capture | | | Site fidelity | | | Mortality | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Spawning destination | Year | N | First | Median | Last | First | Median | Last | First | Median | Last |
| Honeymoon Cove to Soldotna Bridge | | | | | | | | | | | |
| | 2010[a] | 6 | 17 Jun | | | 23 Jun | | | 24 Jul | | |
| | 2011[a] | 11 | 16 Jun | | | 1 Jul | | | 7 Jul | | |
| | 2012 | 34 | 27 Jun | 30 Jul | 14 Aug | 20 Jul | 19 Aug | 1 Sep | 1 Aug | 30 Aug | 13 Sep |
| | 2013 | 25 | 9 Jun | 17 Jul | 15 Aug | 26 Jul | 16 Aug | 9 Sep | 13 Aug | 29 Aug | 17 Sep |
| | 2012–2013 | 59 | 9 Jun | 27 Jul | 15 Aug | 20 Jul | 18 Aug | 9 Sep | 1 Aug | 30 Aug | 17 Sep |
| Soldotna Bridge to Moose River | | | | | | | | | | | |
| | 2010[a] | 4 | 14 Jun | | | 21 Jun | | | 11 Jul | | |
| | 2011[a] | 8 | 9 Jun | | | 14 Jul | | | 1 Aug | | |
| | 2012 | 21 | 13 Jun | 1 Aug | 10 Aug | 31 Jul | 20 Aug | 7 Sep | 15 Aug | 31 Aug | 18 Sep |
| | 2013 | 16 | 11 Jun | 10 Jul | 14 Aug | 28 Jun | 16 Aug | 1 Sep | 17 Jul | 28 Aug | 16 Sep |
| | 2012–2013 | 37 | 11 Jun | 29 Jul | 14 Aug | 28 Jun | 18 Aug | 7 Sep | 17 Jul | 30 Aug | 18 Sep |
| Moose River to Skilak Lake | | | | | | | | | | | |
| | 2010[a] | 5 | 25 Jun | | | 13 Jul | | | 22 Aug | | |
| | 2011[a] | 7 | 18 Jun | | | 1 Aug | | | 24 Aug | | |
| | 2012 | 19 | 14 Jun | 25 Jul | 7 Aug | 7 Jul | 21 Aug | 5 Sep | 17 Jul | 1 Sep | 15 Sep |
| | 2013 | 14 | 17 Jun | 12 Jul | 14 Aug | 9 Jul | 16 Aug | 6 Sep | 28 Jul | 29 Aug | 16 Sep |
| | 2012–2013 | 33 | 14 Jun | 18 Jul | 14 Aug | 7 Jul | 18 Aug | 6 Sep | 17 Jul | 1 Sep | 16 Sep |
| Skilak Lake to Kenai Lake | | | | | | | | | | | |
| | 2010[a] | 1 | 1 Jul | | | 11 Aug | | | | | |
| | 2011[a] | 9 | 13 Jun | | | 20 Jul | | | 6 Aug | | |
| | 2012 | 10 | 27 Jun | 17 Jul | 3 Aug | 1 Aug | 12 Aug | 2 Sep | 19 Aug | | |
| | 2013 | 9 | 21 Jun | 18 Jul | 14 Aug | 24 Jul | 18 Aug | 4 Sep | 25 Aug | 2 Sep | 10 Sep |
| | 2012–2013 | 19 | 21 Jun | 17 Jul | 14 Aug | 24 Jul | 16 Aug | 4 Sep | 19 Aug | 2 Sep | 10 Sep |
| Entire Kenai River | | | | | | | | | | | |
| | 2010[a] | 16 | 14 Jun | | | 21 Jun | | | 11 Jul | | |
| | 2011[a] | 35 | 9 Jun | | | 1 Jul | | | 7 Jul | | |
| | 2012 | 84 | 13 Jun | 27 Jul | 14 Aug | 7 Jul | 20 Aug | 7 Sep | 17 Jul | 31 Aug | 18 Sep |
| | 2013 | 64 | 9 Jun | 14 Jul | 15 Aug | 28 Jun | 16 Aug | 9 Sep | 17 Jul | 29 Aug | 17 Sep |
| | 2012–2013 | 148 | 9 Jun | 24 Jul | 15 Aug | 28 Jun | 18 Aug | 9 Sep | 17 Jul | 30 Aug | 18 Sep |

[a] In 2010 and 2011, radio tags were only deployed through 5 July, and failed to span the entry timing of mainstem spawning Chinook salmon.

## Use of the Funny River and Killey River Closed Areas by Radiotagged Fish

Areas closed to Chinook salmon fishing exist around the confluence areas of the Funny and Kenai rivers and the Killey and Kenai rivers to protect tributary spawning Chinook salmon that stage in these areas prior to migrating up the tributary. Under the 2010–2013 existing regulations, these areas were closed to Chinook salmon fishing through 31 July. The number of radiotagged Chinook salmon present in the Funny and Killey rivers closed areas in 2010–2013 was determined for fish captured near RM 8.5 of the Kenai River. Fish captured near RM 21 and by the second tagging crew in 2010 were omitted because of bias in those tagging events; date of capture and date of entry into the spawning tributary were correlated and these tagging events did not deploy tags throughout the entire run. When considered separately, fish from these tagging events used the Funny and Killey rivers closed areas during the same time periods but within a narrower date range.

Funny River bound radiotagged Chinook salmon milled within the Funny River closed area prior to entering the Funny River (2010–2013; Figure 10). Funny River bound radiotagged fish were not present in the closed area until the middle of June in any year (Figure 11). All radiotagged Funny River bound Chinook salmon had exited the closed area by 8 July in 2012, but had lingered until 20 July in 2011, 22 July in 2013, and as late as 31 July in 2010. Radiotagged Chinook salmon with a Funny River spawning destination staged within the Funny River closed area for longer periods in 2010 and 2013 than in 2011 and 2012 (Figure 10). The largest numbers of Funny River bound Chinook salmon were located in the Funny River closed area on 8–12 July in 2010, 22–24 June in 2011, 20 June and 8 July in 2012, and 4–6 July in 2013 (Figure 11).

Chinook salmon destined for other spawning areas were also present in the Funny River closed area (Figure 11). The first radiotagged fish present in the Funny River closed area each year were bound for tributaries upstream of the Funny River (primarily Killey River and Benjamin Creek). Kenai River mainstem spawning Chinook salmon were present as early as mid-June and utilized the area through the month of July.

Killey River bound radiotagged Chinook salmon entered the Killey River closed area prior to entering the Killey River in each year (2010–2013; Figure 12). Radiotagged Killey River bound fish were present in the area by the end of May in 2011, and soon after in 2012 and 2013 (Figure 13). Killey River bound fish were not present in the closed area until 14 June in 2010. All radiotagged Killey River bound Chinook salmon had exited the closed area by 12 July in 2013, but lingered until 25 July in 2012, 28 July in 2011, and into August in 2010. Killey River spawners staged within the Killey River closed area for less time in 2013 as compared to the other years (Figure 12). The largest numbers of Killey River bound Chinook salmon were located in the Killey River closed area on 2 July in 2010, 4 July in 2011, 30 June in 2012, and 6 July in 2013 (Figure 13).

Radiotagged Chinook salmon bound for other spawning areas were also present in the Killey River closed area. Radiotagged fish bound for tributaries upstream of Skilak Lake were present in June and July (Figure 13). Fish bound for tributaries upstream of Skilak Lake were the first radiotagged fish located in the Killey River closed area in 2010 and 2013 and the last tributary bound radiotagged fish located in the closed area in 2011 and 2013. Radiotagged Kenai River mainstem spawning Chinook salmon were first present in the closed area on 29 June in 2011, but did not appear until 7 July in 2012, 11 July in 2010, and 17 July in 2013. Kenai River mainstem spawning Chinook salmon utilized the Killey River closed area through the month of July.

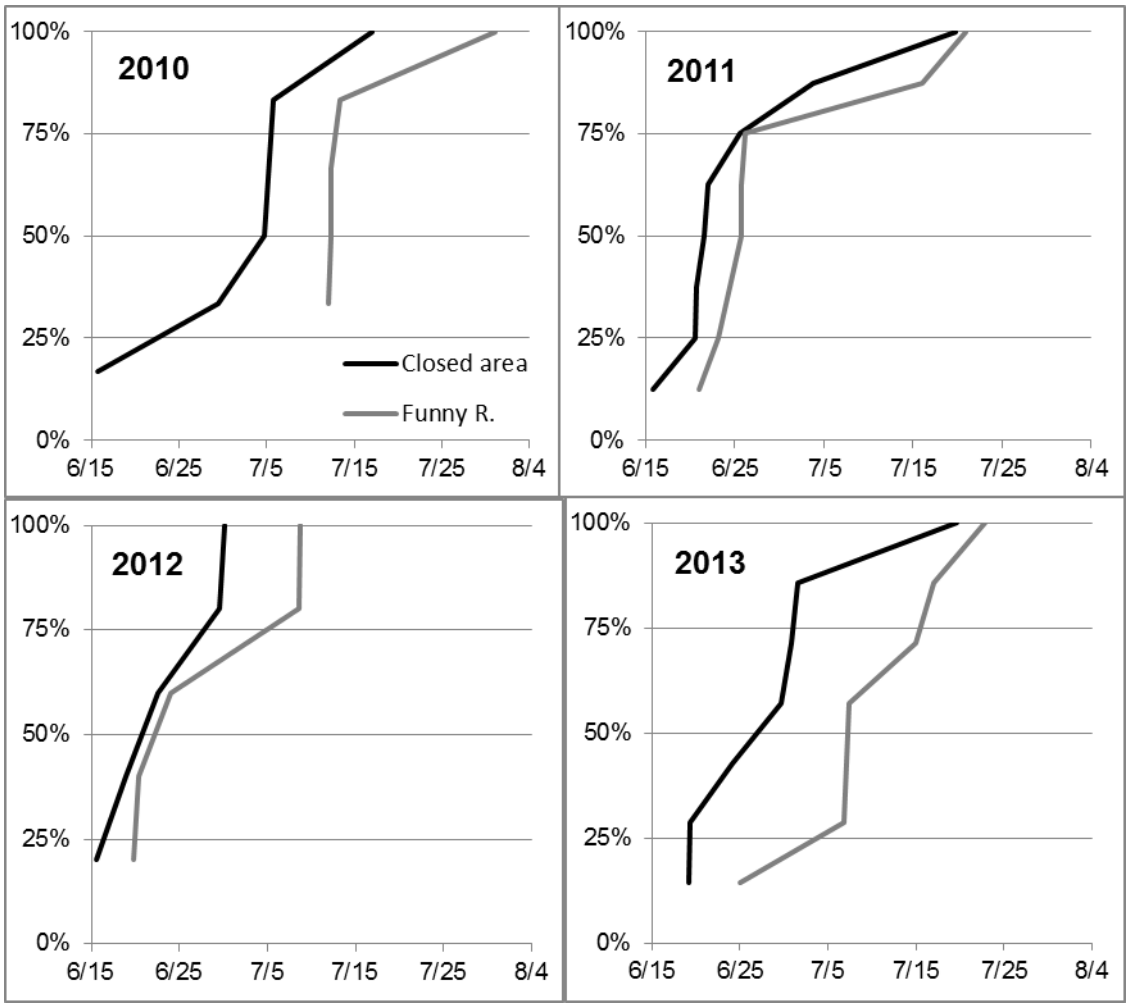


Figure 10.–Cumulative entry timing of Funny River bound Chinook salmon (radiotagged at RM 8.5) into the Funny River closed area and into the Funny River drainage, 2010–2013.

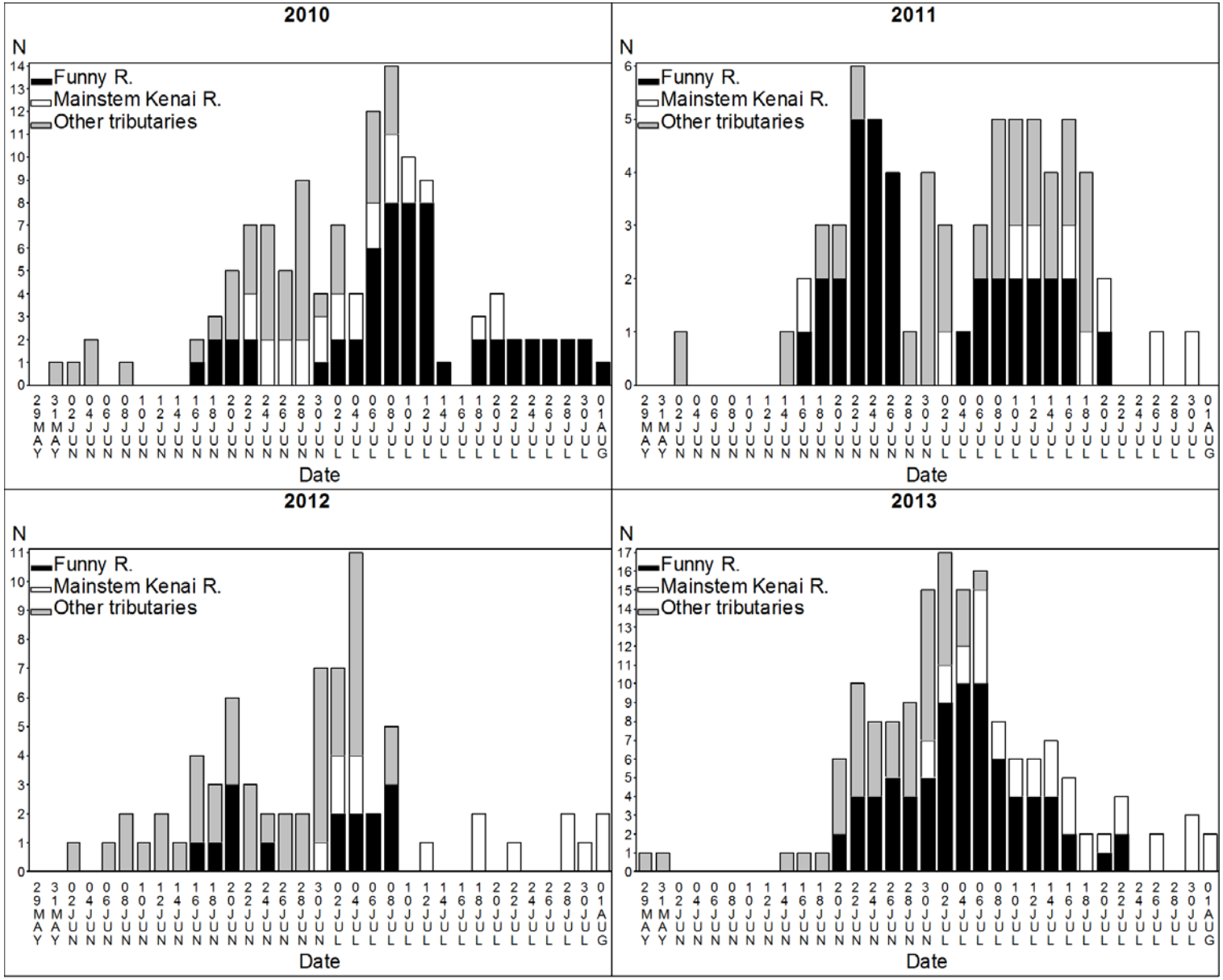


Figure 11.–Number of Chinook salmon (radiotagged at RM 8.5) in the Funny River closed area by spawning destination and date, 2010–2013.

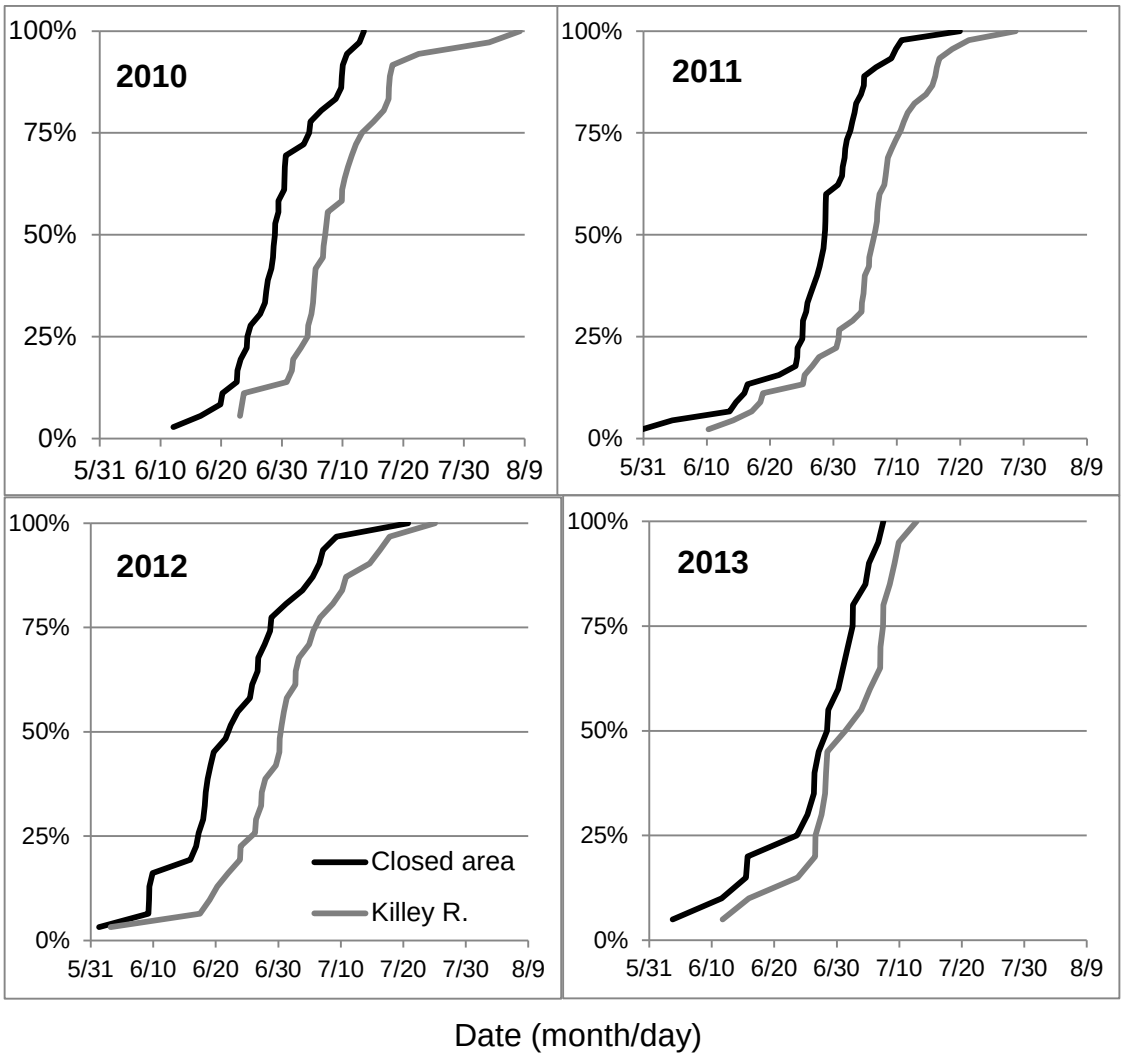


Figure 12.–Cumulative entry timing of Killey River and Benjamin Creek bound Chinook salmon (radiotagged at RM 8.5) into the Killey River closed area and into the Killey River drainage, 2010–2013.

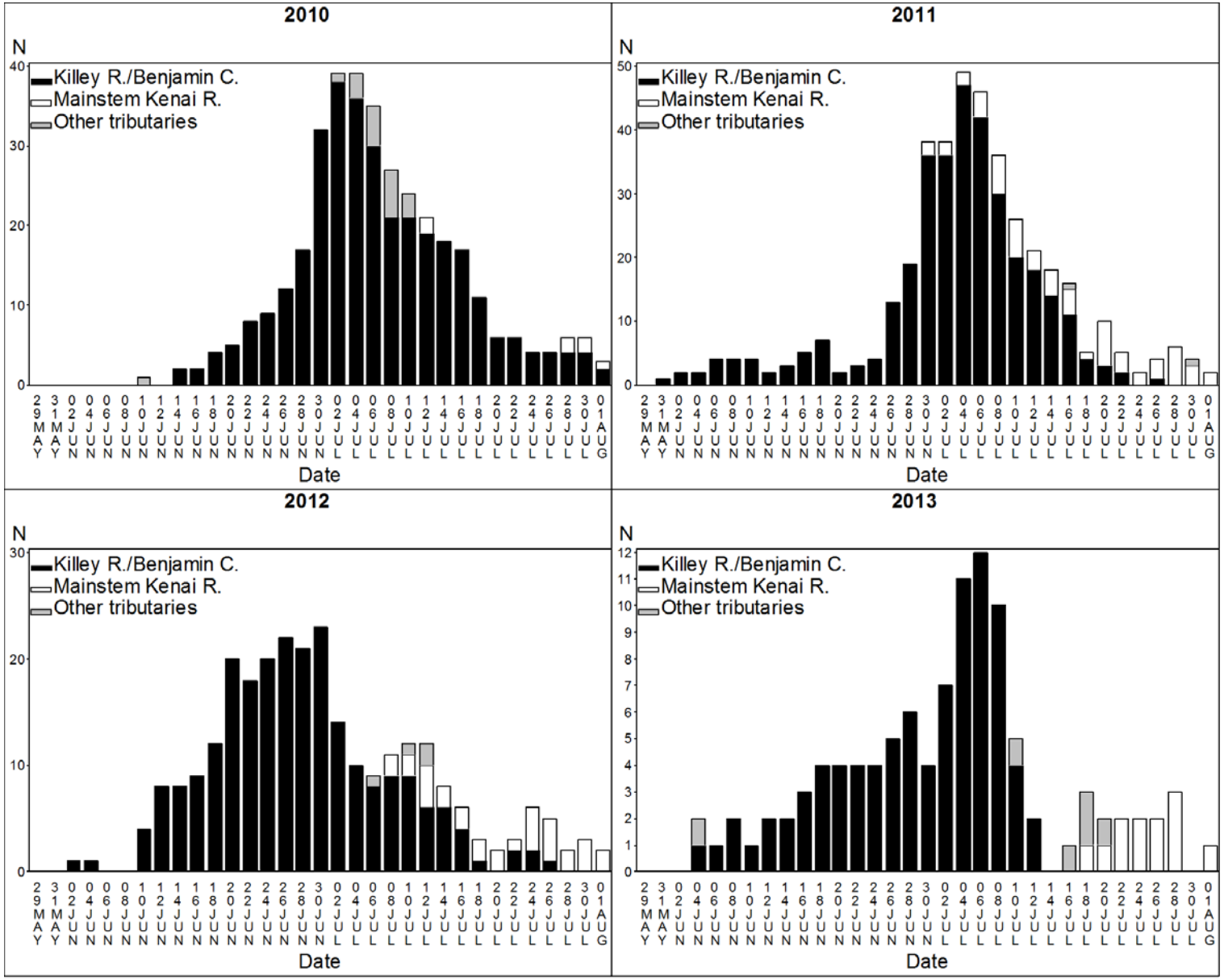


Figure 13.–Number of Chinook salmon (radiotagged at RM 8.5) in the Killey River closed area by spawning destination and date, 2010–2013.

## COMPOSITION BY MANAGEMENT AREA

The proportional composition of Chinook salmon exposed to sport fisheries within the Kenai River is presented herein to approximate the fish available for harvest relative to entry timing and spawning destination. Because sport caught Chinook salmon may be released based on size, sex, coloration or maturity, regulations, or other factors the composition of fish available for harvest demonstrated herein will differ from the composition of the actual harvest based on harvest decisions made by individual anglers.

Kenai River Chinook salmon fishery management differs by year, by time of year, and by river section. Herein we use RM 18.5 (Slikok Creek) to separate the Kenai River sport fishery into 2 areas. For the Kenai River upstream of Slikok Creek, fixed telemetry stations were used to exclude fish located within the areas closed to fishing around the confluences of Slikok Creek, Funny River, and Killey River and upstream of Skilak Lake; and the areas restricted to shore fishing near Centennial Park and upstream of Funny River (Morgan's Landing). Radiotagged Kenai River Chinook salmon located within these areas were divided into 3 groups (early-run mainstem [ERM], late-run mainstem, and tributary) based on arrival time to the Kenai River (determined by the date of capture and tagging before or after 1 July), and assigned spawning destination (mainstem or tributary).

### Composition in Open Waters Downstream of Slikok Creek

In 2012, the majority of radiotagged Chinook salmon that were detected within the waters open to sport fishing downstream of Slikok Creek during May and most of June were assigned tributary spawning destinations (Figure 14; Appendix A1). On 1 July, 40% (SE 22%) of the radiotagged Chinook salmon that were detected downstream of Slikok Creek were assigned a tributary spawning destination and 60% (SE 22%) were assigned a mainstem spawning destination. After 5 July, over 50% of the radiotagged Chinook salmon that were detected downstream of Slikok Creek were late-run mainstem spawning Chinook salmon. ERM spawning Chinook salmon were present downstream of Slikok Creek throughout July in 2012.

In 2013, the majority of radiotagged Chinook salmon that were detected within the waters open to sport fishing downstream of Slikok Creek during all of May and most of June were tributary spawners (Figure 14; Appendix A1). On 1 July, 100% of the radiotagged Chinook salmon detected downstream of Slikok Creek were ERM spawning Chinook salmon. After 3 July, over 50% of the radiotagged Chinook salmon detected downstream of Slikok Creek were late-run mainstem spawning Chinook salmon. ERM spawning Chinook salmon were not detected downstream of Slikok Creek after 13 July 2013.

### Composition in Open Waters Upstream of Slikok Creek

In 2012, the majority of radiotagged Chinook salmon that were detected within the waters open to sport fishing upstream of Slikok Creek during May and most of June were tributary spawners (Figure 14; Appendix A1). On 1 July, 78% (SE 14%) of the radiotagged Chinook salmon detected upstream of Slikok Creek were tributary spawners and 22% (SE 14%) were ERM spawning Chinook salmon. On 16 July, 9% (SE 8%) of the radiotagged Chinook salmon detected upstream of Slikok Creek were tributary spawners, 45% (SE 8%) were ERM spawners, and 45% (SE 0%) were late-run mainstem spawners. After 16 July, over 50% of the radiotagged Chinook salmon upstream of Slikok Creek were late-run mainstem spawning Chinook salmon.

In 2013, the majority of radiotagged Chinook salmon detected within the waters open to sport fishing upstream of Slikok Creek during May and most of June were tributary spawners (Figure 14; Appendix A1). On 1 July, 67% (SE 19%) of the radiotagged Chinook salmon detected upstream of Slikok Creek were tributary spawners, and 33% (SE 19%) were ERM spawners. On 16 July, 8% (SE 7%) of the radiotagged Chinook salmon detected upstream of Slikok Creek were tributary spawners, 40% (SE 7%) were ERM spawners and 52% (SE 0%) were late-run mainstem spawners. After 16 July, over 50% of the radiotagged Chinook salmon detected upstream of Slikok Creek were late-run mainstem spawning Chinook salmon.

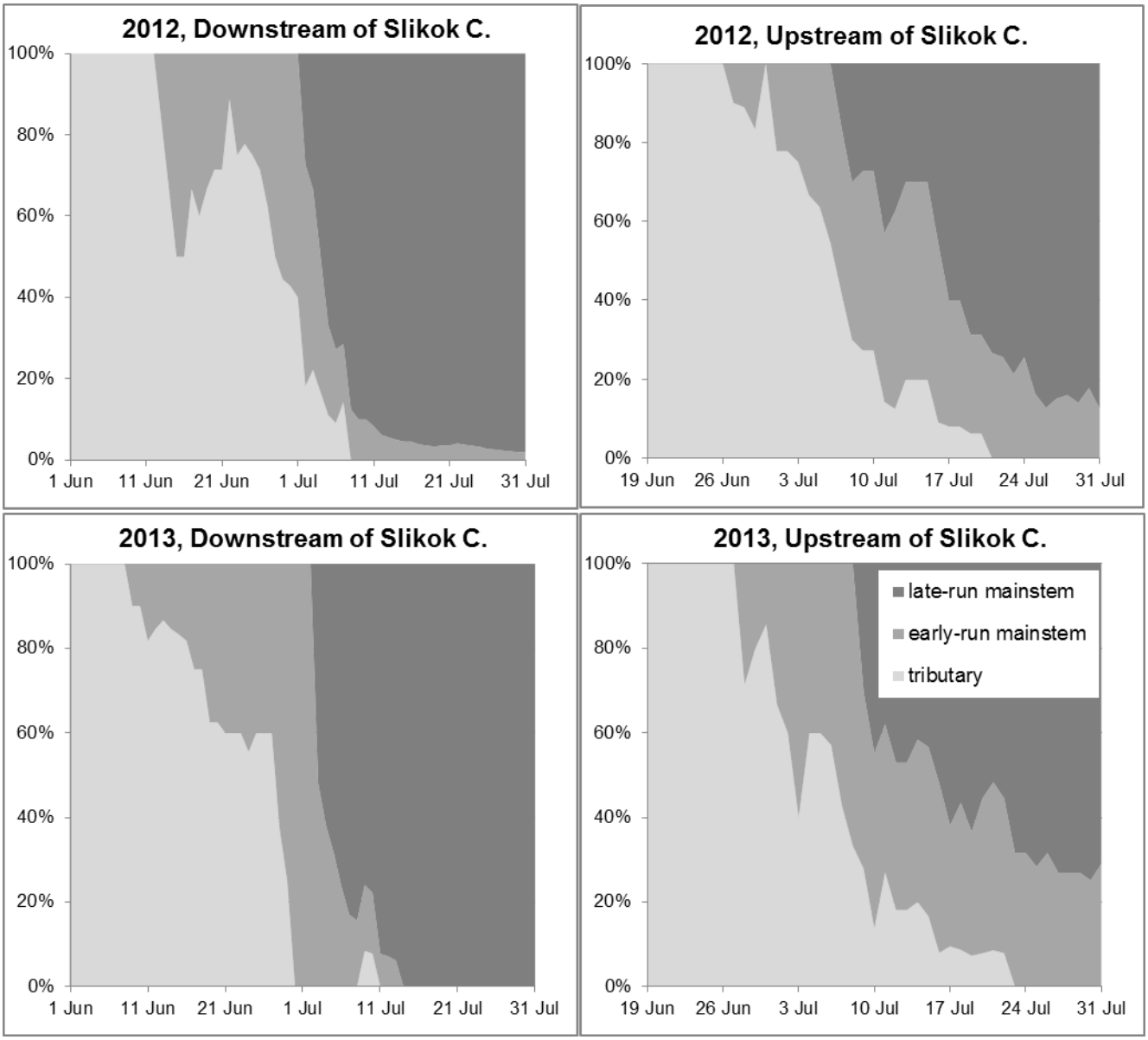


Figure 14.–Proportion of radiotagged Chinook salmon detected in the Kenai River Chinook salmon sport fishery upstream and downstream of Slikok Creek by assigned spawning destination and entry timing, 2012 and 2013.

*Note:* "Upstream of Slikok Creek" excludes the closed and restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River plus the Kenai River upstream of and including Skilak Lake.

## DISTRIBUTION BETWEEN MANAGEMENT AREAS

Kenai River Chinook salmon fishery management differs by year, time of year, and river section. Herein we use RM 18.5 (Slikok Creek) to separate the Kenai River sport fishery into 3 areas: RM 0–18.5, unrestricted waters upstream of RM 18.5, and closed or restricted waters upstream of RM 18.5. Closed or restricted waters include areas around the confluences of Slikok Creek, Funny River, and Killey River and the boat-restricted fishing areas near Centennial Park and upstream of Funny River (Morgan's Landing). Only Chinook salmon released near RM 8.5 of the Kenai River[9] are included in Figures 15–19. The proportional distribution of Chinook salmon relative to these 3 areas is presented relative to date of capture (early run or late run), assigned spawning destination (mainstem or tributary) and a combination (ERM).

### Distribution by Date of Capture

Early-run, radiotagged Chinook salmon began migrating upstream of Slikok Creek in the second half of May and began entering closed or restricted fishing areas immediately (Figure 15; Appendix B1). Most early-run tagged fish were downstream of Slikok Creek through early June in 2012 and through late June in 2010, 2011, and 2013. Early-run tagged fish upstream of Slikok Creek were generally evenly distributed between unrestricted and closed or restricted waters through mid to late June, after which time the majority were in closed or restricted waters. In July, early-run tagged fish continued to migrate into closed or restricted waters while exiting both fisheries. Approximately 10–20% of early-run Chinook salmon remained in waters open to sport fishing through July each year.

On 1 July, 20% (SE 5%), 28% (SE 5%), 11% (SE 5%), and 13% (SE 6%) of radiotagged early-run Chinook salmon were downstream of Slikok Creek in the years 2010–2013, respectively (Appendix B1). Upstream of Slikok Creek, 20% (SE 5%), 17% (SE 4%), 20% (SE 6%) and 19% (SE 7%) of radiotagged early-run Chinook salmon were in waters open to sport fishing on 1 July 2010–2013, respectively. Thus, over 50% of the radiotagged early-run Chinook salmon were in waters with existing closures or restrictions by 1 July in every year studied.

On 16 July, 8% (SE 4%), 13% (SE 4%), 2% (SE 2%), and 0% of radiotagged, early-run Chinook salmon were downstream of Slikok Creek in 2010–2013, respectively. Upstream of Slikok Creek, 8% (SE 4%), 10% (SE 3%), 15% (SE 6%) and 19% (SE 7%) of radiotagged early-run Chinook salmon were in waters open to sport fishing on 16 July in 2010–2013, respectively. Thus, over 75% of the radiotagged early-run Chinook salmon were in waters with existing closures or restrictions by 16 July in every year studied.

Kenai River Chinook salmon were radiotagged throughout the entire late run in 2012 and 2013 only. Late-run radiotagged Chinook salmon began migrating upstream of Slikok Creek in the first week of July and began entering waters with existing closures or restrictions immediately (Figure 16; Appendix B2). The majority of these fish were downstream of Slikok Creek throughout July. In both seasons, approximately 10% of late-run Chinook salmon were in waters with existing closures or restrictions for most of July.

[9] Fish captured by the tagging boat that operated at RM 8.4 from 5 to 15 June 2010 are omitted to avoid bias associated with uneven tagging rates.

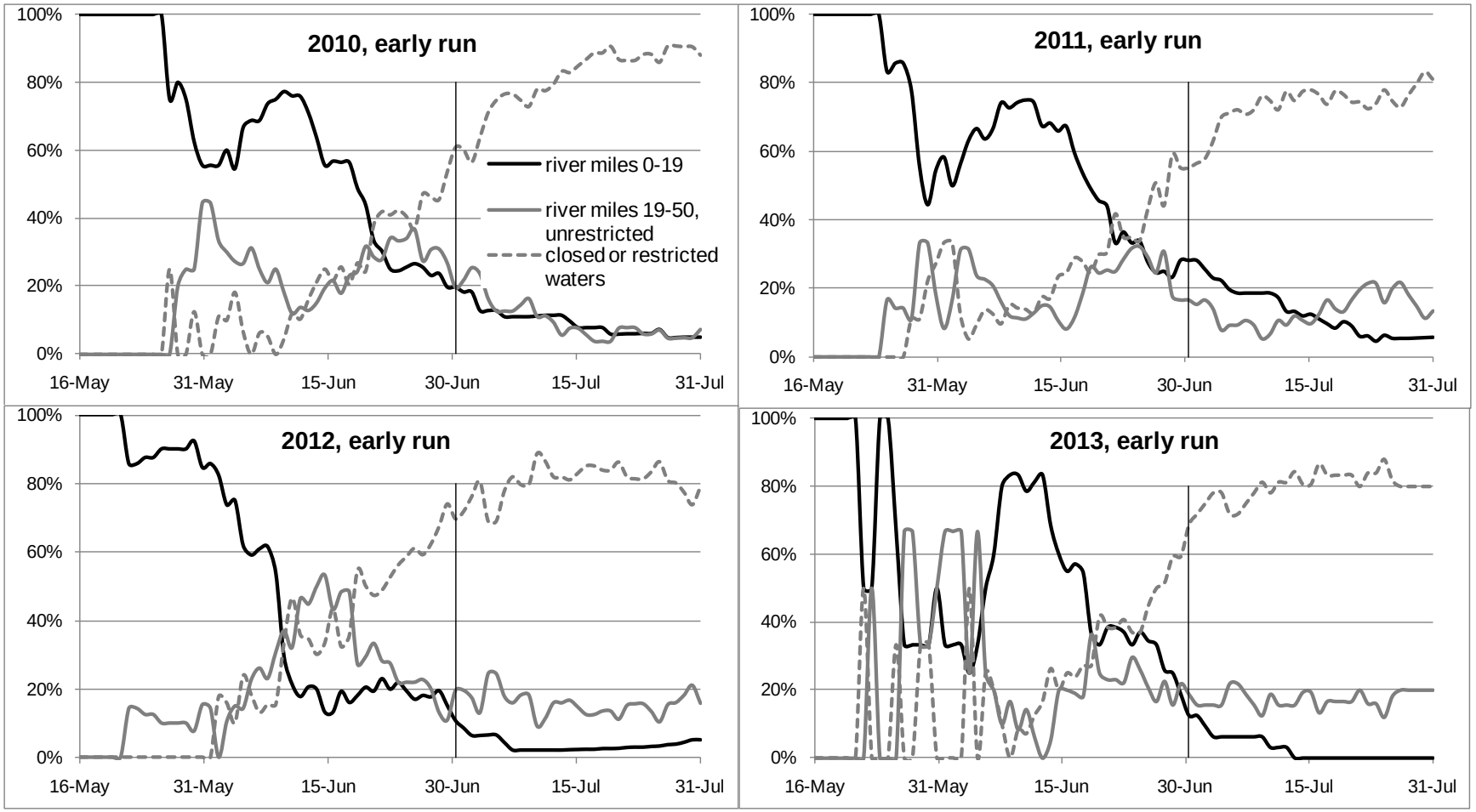


Figure 15.–Proportional distribution of early-run radiotagged Chinook salmon by date and area, Kenai River, 2010–2013.

*Note:* River miles 0–19 describe Cook Inlet to Slikok Creek. River miles 19–50 describe Slikok Creek to Skilak Lake excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage. The vertical line in each panel represents July 1.

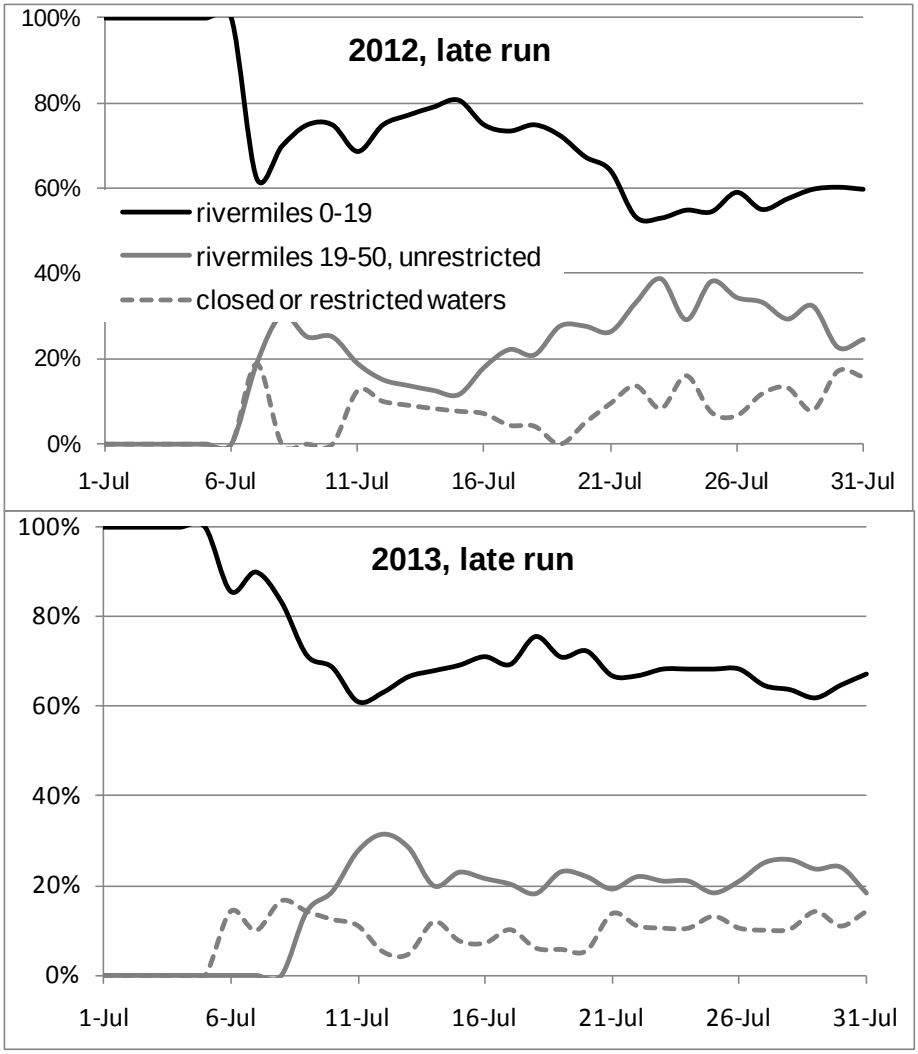


Figure 16.–Proportional distribution of late-run radiotagged Chinook salmon by date and area, Kenai River, 2012–2013.

*Note:* River miles 0–19 describe Cook Inlet to Slikok Creek. River miles 19–50 describe Slikok Creek to Skilak Lake excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage.

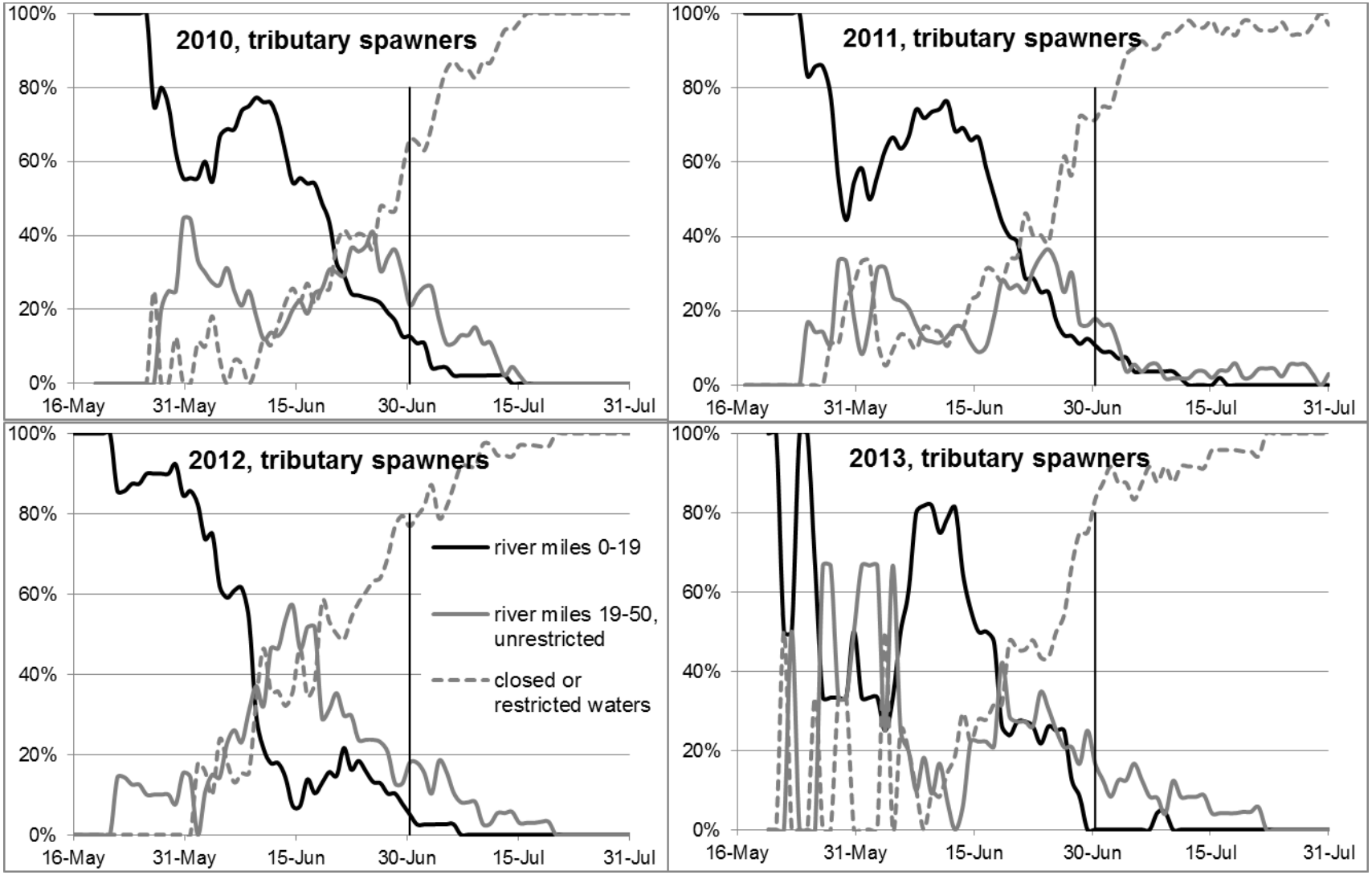


Figure 17.–Proportional distribution of tributary spawning radiotagged Chinook salmon by date and area, Kenai River, 2010–2013.

*Note:* River miles 0–19 describe Cook Inlet to Slikok Creek. River miles 19–50 describe Slikok Creek to Skilak Lake excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage. The vertical line in each panel represents July 1.

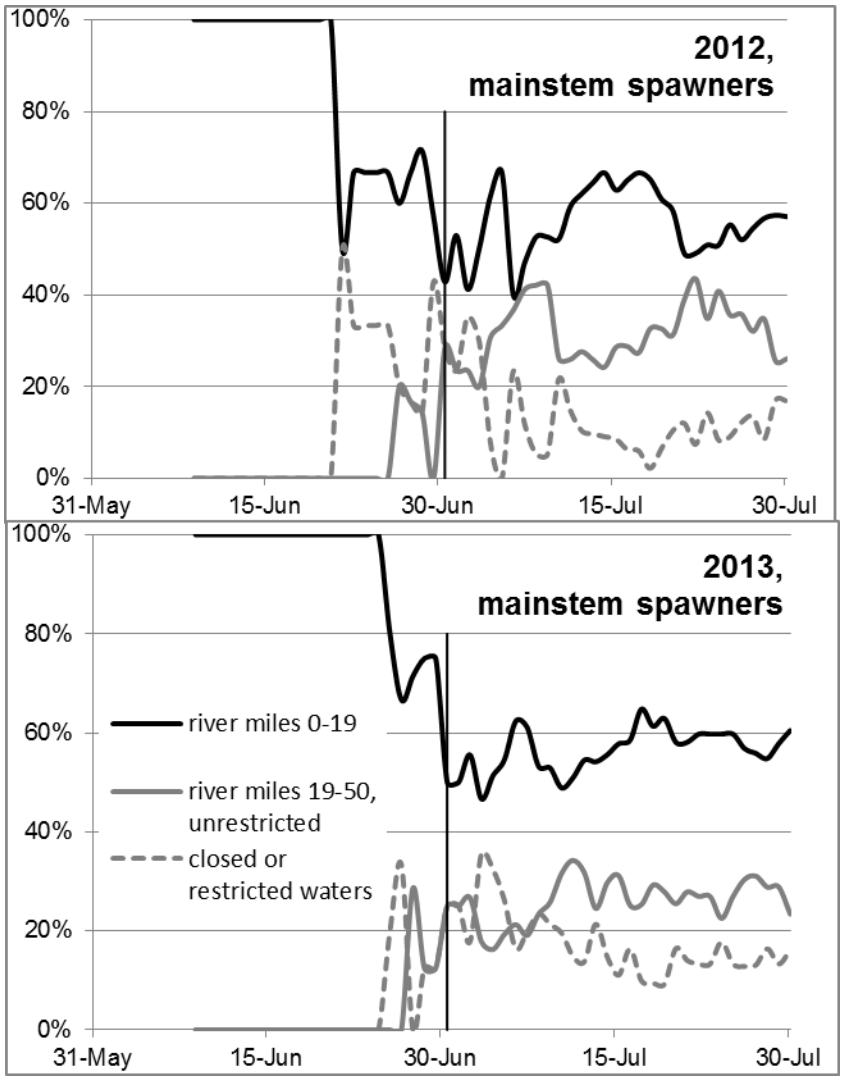


Figure 18.–Proportional distribution of mainstem spawning radiotagged Chinook salmon by date and area, Kenai River, 2012–2013.

*Note:* River miles 0–19 describe Cook Inlet to Slikok Creek. River miles 19–50 describe Slikok Creek to Skilak Lake excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage. The vertical line in each panel represents July 1.

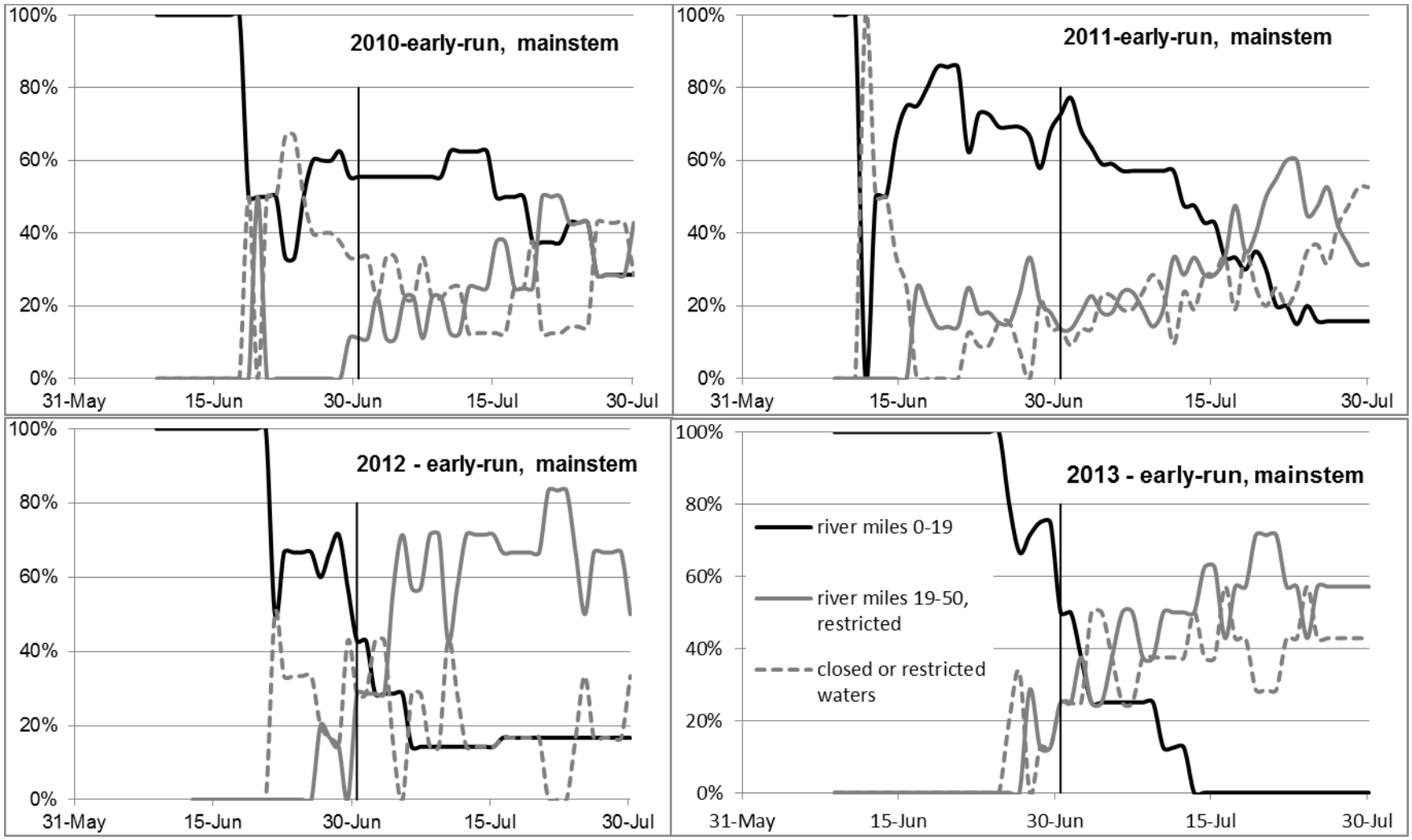


Figure 19.–Proportional distribution of early-run mainstem spawning radiotagged Chinook salmon by date and area, Kenai River 2010–2013.

*Note:* River miles 0–19 describe Cook Inlet to Slikok Creek. River miles 19–50 describe Slikok Creek to Skilak Lake excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage. The vertical line in each panel represents July 1.

## Distribution of Tributary Spawning Fish

Radiotagged Chinook salmon with a tributary spawning destination began migrating upstream of Slikok Creek in the second half of May and began entering waters with existing closures or restrictions immediately (Figure 17; Appendix B3). Most tributary spawning fish were downstream of Slikok Creek through early June in 2012 and through late June in the years 2010–2011 and 2013. Tributary spawning Chinook salmon upstream of Slikok Creek were mixed between waters with and without existing closures or restrictions through mid to late June, after which time the majority were in waters with existing closures or restrictions. In July, tagged fish with tributary spawning destinations continued to migrate into waters with existing closures or restrictions. All tributary spawning radiotagged Chinook salmon were in waters with existing closures or restrictions by 17 July in 2010, 21 July in 2012, and by 23 July in 2013. In 2011, one tributary spawning radiotagged Chinook salmon, bound for Grant Creek, was present in sport fisheries through 31 July.

On 1 July, 13% (SE 5%), 11% (SE 4%), 5% (SE 4%), and 0% of radiotagged tributary spawning Chinook salmon were downstream of Slikok Creek in the years 2010–2013, respectively (Appendix B3). Upstream of Slikok Creek, 21% (SE 6%), 18% (SE 5%), 18% (SE 6%), and 17% (SE 8%) of radiotagged tributary spawning Chinook salmon were in waters without existing closures or restrictions on 1 July in the years 2010–2013, respectively. Thus, at least 66% of the radiotagged tributary spawning Chinook salmon were in waters with existing closures or restrictions by 1 July in every year studied.

On 16 July, 0% of radiotagged tributary spawning Chinook salmon were downstream of Slikok Creek in the years 2010–2013, respectively (Appendix B3). Upstream of Slikok Creek, 2% (SE 2%), 2% (SE 2%), 3% (SE 3%), and 4% (SE 4%) of radiotagged tributary spawning Chinook salmon were in waters without existing closures or restrictions on 16 July in the years 2010–2013, respectively. Thus, at least 96% of the radiotagged tributary spawning Chinook salmon were in waters with existing closures or restrictions by 16 July in every year studied.

## Distribution of Mainstem Spawning Fish

Radiotagged Chinook salmon with mainstem spawning destinations began migrating upstream of Slikok Creek in late June and began entering waters with existing closures or restrictions immediately (Figure 18; Appendix B4). Approximately 50% of mainstem spawning radiotagged Chinook salmon were downstream of Slikok Creek throughout July. In both years, approximately 10–20% of mainstem spawning radiotagged Chinook salmon were in waters with existing closures or restrictions for most of July.

The migratory timing of ERM spawning Chinook salmon differed each year. In 2010, a majority of the radiotagged ERM spawning Chinook salmon were downstream of Slikok Creek until mid-July; afterwards, there were approximately equal numbers of radiotagged Chinook salmon in all 3 river sections (downstream of Slikok Creek, unrestricted areas upstream of Slikok Creek, and restricted or closed areas upstream of Slikok Creek) (Figure 19; Appendix B5). In 2011, approximately 70% of ERM spawning fish were downstream of Slikok Creek in June and early July. By the end of July less than 20% remained downstream of Slikok Creek while the remaining fish were upstream of Slikok Creek in areas with and without existing closures or restrictions. In 2012, approximately 70% of ERM spawning fish were downstream of Slikok Creek in June. By early July, about 70% were in waters without existing restrictions upstream of Slikok Creek while the remaining fish were split evenly between the waters downstream of

Slikok Creek and waters with existing closures or restrictions. In 2013, ERM spawning radiotagged fish migrated through the lower Kenai River fishery quickly. By mid-July all of the radiotagged Chinook salmon were evenly distributed between waters with existing closures or restrictions and waters without existing restrictions upstream of Slikok Creek.

# DISCUSSION

## COMPARISON TO HISTORIC DATA

Spawning distributions estimated between 2010 and 2013 are subject to similar biases as historic estimates, but are based on larger sample sizes of radiotagged fish, more frequent radio tracking, and improved radio tag technology. (Tables 1–2 vs. Tables 11–14). While Chinook salmon with a spawning destination in the Killey River drainage were the largest component of the early run in both datasets, the relative contribution of Chinook salmon with a mainstem spawning destination was larger in the 2010–2013 data. In the historic data, Funny River spawners were the second largest contributor to early-run Chinook salmon abundance in 3 of 4 years while Kenai River spawners were the second largest contributor in the other year. In the 2010–2013 data, Kenai River spawners were the second largest contributor to early-run abundance in all years.

While radiotagged Chinook salmon with a mainstem spawning destination were a large component of the last 4 early runs (Table 11), the timing of their post-spawning mortality differed from previous studies. During 1990, the median date for the completion of spawning activity was 19 July for mainstem spawning Chinook salmon that returned during the early run and 15 August for mainstem spawning Chinook salmon that returned during the late run (Bendock and Alexandersdottir 1992; Burger et al. 1983; Johnson and Daigneault 2013). In our study, the median date for the completion of spawning activity was 21 August for mainstem spawning Chinook salmon that returned during the early run and 30 August for mainstem spawning Chinook salmon that returned during the late run. In 2010–2013, some mainstem spawning Chinook salmon did spawn in July, but in low numbers compared to those that spawned in August (Figure 9). Apparently, the spawning events for mainstem spawning Chinook salmon from the early and the late runs were temporally distinct in 1990 (nearly one month apart), but formed an overlapping continuum in 2010–2013.

The difference in median spawning dates for ERM Chinook salmon may be a result of the methods used by each study, and we note that neither study was designed to determine post spawning mortality directly. If our censoring criteria were relaxed, more fish would be assigned spawning destinations within the mainstem of the Kenai River and the post-spawning mortality date of the mainstem spawning Chinook salmon that returned during the early run would be earlier. However, the relative contribution of mainstem spawning Chinook salmon to the early run would also increase, from values that were already above the historic average. We also note that our censoring criteria were based on minimum requirements for successful spawning and were likely conservative in the sense that some migrating fish may have been classified as spawners erroneously. Finally, we note that the 1990 study used a radio tag associated with greater latent tagging effect than those used in the 2010–2013 study (Reimer and Fleischman 2012) and holding and spawning behavior are difficult to distinguish when fish are subject to large tagging effects.

## STOCK SPECIFIC MANAGEMENT

ADF&G has responded to inseason conservation concerns for early-run Chinook salmon in recent years by issuing an emergency order to close areas upstream of Slikok Creek to Chinook salmon harvest. This practice appears to be effective because most Chinook salmon radiotagged in the early run were located upstream of Slikok Creek by the end of June in all years (Figure 15). However, because many of early-run fish were in waters with existing closures or restrictions by 1 July, the additional protection afforded by the emergency order is modest. Of the fish that remained in waters without existing closures or restrictions, approximately equal numbers were located above and below Slikok Creek in 2010 and 2011, while greater numbers were located upstream of Slikok Creek in 2012 and 2013.

The areas closed to fishing around the mouths of Slikok Creek and the Funny and Killey rivers effectively safeguard Chinook salmon from harvest prior to entering the spawning tributary, in both time and area. The highest densities of radiotagged fish noted in each year occurred in the Killey River closed area during late June to early July, when the area was closed. The Killey River closed area is also appropriately sized in that high densities of radiotagged fish were noted throughout its area in all years. Likewise, only 1 radiotagged fish spawned in Slikok Creek during this study, and this fish was located within 1 mile of the Slikok Creek confluence on 10 occasions prior to entering Slikok Creek in August. Eight of the 10 locations were within the Slikok Creek closed area, despite its small size. On the two occasions when this fish was outside of the Slikok Creek closed area, it was located less than 600 feet upstream of the upstream boundary. The Funny River closed area was equally effective as a conservation measure with respect to the holding patterns of radiotagged Chinook salmon bound for the Funny River.

Management proposals intending to conserve mainstem spawning Chinook salmon cannot be evaluated in terms of their spawning distribution relative to potential conservation zones because the majority of mainstem spawning Chinook salmon do not show fidelity to their eventual spawning area until well after the Chinook salmon fishery closes on 31 July (Table 16). Spawning distribution can be used to identify spawning aggregates that will not be protected, because few radiotagged Chinook salmon migrate farther upstream than their eventual spawning destination. Thus, upstream closures akin to those traditionally used for early-run Chinook salmon conservation will be ineffective for Chinook salmon that spawn downstream of the boundary. Recently, the boundary for upstream Chinook salmon conservation has been located just below Slikok Creek (RM 18.5). Because the Kenai River downstream of the Soldotna Bridge (RM 21) is the most heavily utilized mainstem spawning area in both historic and recent data (Table 2 and Tables 11–12), closures upstream of Slikok Creek have little conservation value for the largest spawning aggregate, and will fail to conserve mainstem spawning Chinook salmon in proportion to abundance. This situation is illustrated for 2012 and 2013 in Figure 20. During both seasons, conservation measures enacted downstream of Slikok Creek would more effectively conserve mainstem spawning Chinook salmon that spawn in all sections of the Kenai River drainage. Conservation measures enacted downstream of Slikok Creek are also applicable to more Chinook salmon because most use of the area upstream of Slikok Creek by fish we monitored did not occur until after the fishery closed (July 31) in both years (Figure 20).

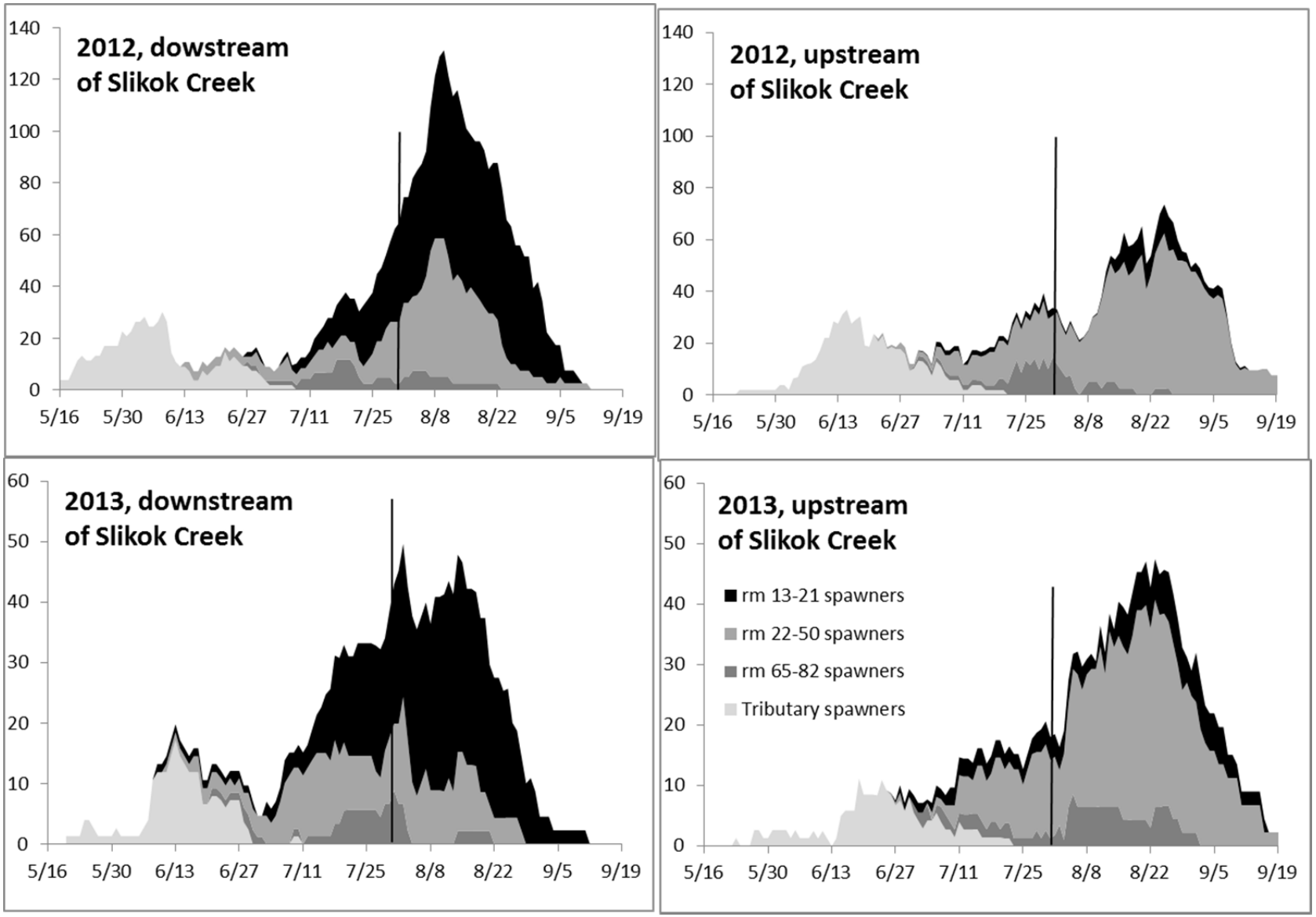


Figure 20.–Temporally-weighted, radiotagged Chinook salmon abundance by spawning destination, Kenai River section, and date, 2012–2013.
*Note:* The vertical line in each panel represents July 31.

## RECOMMENDATIONS FOR FUTURE RESEARCH

The percentage of radio tags yielding a spawning destination was substantially higher for fish released from RM 21 compared to RM 8.5 in all years (2011–2013). Because capture and sampling procedures were similar between the two sites, the improvement at the upper site is likely due to a longer freshwater hardening period prior to capture and a reduced likelihood for sport catch or harvest after tagging. Freshwater hardening has been demonstrated for Kenai River coho salmon, a higher percentage of which resumed upstream migration when captured and radiotagged 9 miles further upstream (Carlon and Evans 2007). Because a high percentage of Chinook salmon radiotagged in Cook Inlet in 2012 yielded a spawning destination, with completely different handling techniques, estuarine waters appear to be the worst possible location for the capture and radiotagging of Chinook salmon. Unfortunately neither alternative tagging site is a realistic solution for studying migrating Kenai River Chinook salmon. River mile 21 is the only feasible site for deploying radio tags for tributary spawning Chinook salmon because significant mainstem spawning occurs downstream of the tagging site. With regard to a Cook Inlet tagging location, there are 3 major drawbacks. First, the catch per unit effort would be too low to allow for significant sample sizes. Second, the 2012 season was notable for the extensive fishery restrictions that occurred on both sport and commercial fisheries. Typical fisheries would have harvested a substantial percentage of the radio tags released prior to yielding a spawning destination. Finally, not all fish tagged in Cook Inlet would be destined for the Kenai River.

Similar studies on Kenai River Chinook salmon would be improved by reducing the disparity in the length distribution of tagged and untagged Chinook salmon (Figure 2). Chinook salmon captured by our tagging crews would better represent the untagged population if a larger percentage of the available tags were deployed by a tagging crew sampling nearshore at RM 8.5. Also, Chinook salmon below 550 mm METF should be tagged. The survival concerns associated with tagging Chinook salmon less than 550 mm METF could be addressed by utilizing smaller radio tags.

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# APPENDIX A: PROPORTION OF RADIOTAGGED CHINOOK SALMON DETECTED IN THE SPORT FISHERY UPSTREAM AND DOWNSTREAM OF SLIKOK CREEK BY ASSIGNED SPAWNING DESTINATION AND ENTRY TIMING, 2012 AND 2013

Appendix A1.–Proportion of radiotagged Chinook salmon detected in the sport fishery upstream and downstream of Slikok Creek by assigned spawning destination and entry timing, 2012 and 2013.

| | Spawning destination downstream of Slikok Creek | | | Spawning destination upstream of Slikok Creek[a] | | |
|---|---|---|---|---|---|---|
| | Tributary | Mainstem | | Tributary | Mainstem | |
| | | Early run[b] | Late run[c] | | Early run[b] | Late run[c] |
| Date | Prop. (SE) | Prop. (SE) | Prop. (SE) | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2012 | | | | | | |
| 1 Jun | 1.0 (0.0) | . (.) | . (.) | 1.0 (0.0) | . (.) | . (.) |
| 6 Jun | 1.0 (0.0) | . (.) | . (.) | 1.0 (0.0) | . (.) | . (.) |
| 11 Jun | 1.0 (0.0) | . (.) | . (.) | 1.0 (0.0) | . (.) | . (.) |
| 16 Jun | 0.5 (0.25) | 0.5 (0.25) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 21 Jun | 0.71 (0.17) | 0.29 (0.17) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 26 Jun | 0.71 (0.17) | 0.29 (0.17) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 1 Jul | 0.4 (0.22) | 0.6 (0.22) | . (.) | 0.78 (0.14) | 0.22 (0.14) | . (.) |
| 6 Jul | 0.09 (0.07) | 0.18 (0.07) | 0.73 (0.0) | 0.55 (0.15) | 0.45 (0.15) | 0.0 (0.0) |
| 11 Jul | 0.0 (0.0) | 0.08 (0.0) | 0.92 (0.0) | 0.14 (0.12) | 0.43 (0.12) | 0.43 (0.0) |
| 16 Jul | 0.0 (0.0) | 0.05 (0.0) | 0.95 (0.0) | 0.09 (0.08) | 0.45 (0.08) | 0.45 (0.0) |
| 21 Jul | 0.0 (0.0) | 0.04 (0.0) | 0.96 (0.0) | 0.0 (0.0) | 0.27 (0.0) | 0.73 (0.0) |
| 26 Jul | 0.0 (0.0) | 0.03 (0.0) | 0.97 (0.0) | 0.0 (0.0) | 0.13 (0.0) | 0.87 (0.0) |
| 31 Jul | 0.0 (0.0) | 0.02 (0.0) | 0.98 (0.0) | 0.0 (0.0) | 0.12 (0.0) | 0.88 (0.0) |
| 2013 | | | | | | |
| 1 Jun | 1.0 (0.0) | . (.) | . (.) | 1.0 (0.0) | . (.) | . (.) |
| 6 Jun | 1.0 (0.0) | . (.) | . (.) | 1.0 (0.0) | . (.) | . (.) |
| 11 Jun | 0.82 (0.12) | 0.18 (0.12) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 16 Jun | 0.82 (0.12) | 0.18 (0.12) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 21 Jun | 0.6 (0.15) | 0.4 (0.15) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 26 Jun | 0.6 (0.15) | 0.4 (0.15) | . (.) | 1.0 (0.0) | 0.0 (0.0) | . (.) |
| 1 Jul | 0.0 (0.0) | 1.0 (0.0) | . (.) | 0.67 (0.19) | 0.33 (0.19) | . (.) |
| 6 Jul | 0.0 (0.0) | 0.27 (0.0) | 0.73 (0.0) | 0.57 (0.19) | 0.43 (0.19) | 0.0 (0.0) |
| 11 Jul | 0.0 (0.0) | 0.08 (0.0) | 0.92 (0.0) | 0.27 (0.13) | 0.35 (0.1) | 0.38 (0.08) |
| 16 Jul | 0.0 (0.0) | 0.0 (.) | 1.0 (0.0) | 0.08 (0.07) | 0.4 (0.07) | 0.52 (0.0) |
| 21 Jul | 0.0 (0.0) | 0.0 (.) | 1.0 (0.0) | 0.09 (0.08) | 0.4 (0.0) | 0.52 (0.08) |
| 26 Jul | 0.0 (0.0) | 0.0 (.) | 1.0 (0.0) | 0.0 (0.0) | 0.32 (0.0) | 0.68 (0.0) |
| 31 Jul | 0.0 (0.0) | 0.0 (.) | 1.0 (0.0) | 0.0 (0.0) | 0.27 (0.0) | 0.73 (0.0) |

*Note:* zero standard errors occur when unweighted proportions in all 3 time strata equal either 0 or 1 and thus their corresponding binomial variances, used in calculation of total variance (Eq. 7), equals 0. However, the overall proportion calculated using the stratified estimator (Eq. 6) can be non-zero because it represents the weighted proportion. Two factors contribute to this situation: 1) small sample sizes and 2) correlation of tagging time strata with stock composition during tagging.

[a] "Upstream of Slikok Creek" excludes the closed and restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River plus the Kenai River upstream of and including Skilak Lake.

[b] Fish captured and radiotagged during the early run.

[c] Fish captured and radiotagged during the late run.

# APPENDIX B: PROPORTIONAL DISTRIBUTION OF RADIOTAGGED CHINOOK SALMON BY DATE AND AREA, KENAI RIVER, 2010–2013

Appendix B1.–Proportional distribution of early-run radiotagged Chinook salmon by date and area, Kenai River, 2010–2013.

| | | | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | Downstream of Slikok Creek | Unrestricted | Closed or restricted |
| Year | Date | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2010 | | | | |
| | 17 May | 1.0 (0.0) | . (.) | . (.) |
| | 22 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 27 May | 0.75 (0.22) | 0.0 (0.0) | 0.25 (0.22) |
| | 1 Jun | 0.56 (0.17) | 0.44 (0.17) | 0.0 (0.0) |
| | 6 Jun | 0.69 (0.12) | 0.31 (0.12) | 0.0 (0.0) |
| | 11 Jun | 0.76 (0.09) | 0.12 (0.06) | 0.12 (0.06) |
| | 16 Jun | 0.57 (0.08) | 0.22 (0.07) | 0.22 (0.07) |
| | 21 Jun | 0.33 (0.07) | 0.29 (0.07) | 0.38 (0.07) |
| | 26 Jun | 0.27 (0.06) | 0.37 (0.07) | 0.37 (0.07) |
| | 1 Jul | 0.2 (0.05) | 0.2 (0.05) | 0.61 (0.07) |
| | 6 Jul | 0.13 (0.04) | 0.13 (0.04) | 0.75 (0.06) |
| | 11 Jul | 0.11 (0.04) | 0.11 (0.04) | 0.78 (0.06) |
| | 16 Jul | 0.08 (0.04) | 0.08 (0.04) | 0.85 (0.05) |
| | 21 Jul | 0.06 (0.03) | 0.08 (0.04) | 0.87 (0.05) |
| | 26 Jul | 0.07 (0.04) | 0.07 (0.04) | 0.86 (0.05) |
| | 31 Jul | 0.05 (0.03) | 0.07 (0.04) | 0.88 (0.05) |
| 2011 | | | | |
| | 17 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 22 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 27 May | 0.86 (0.13) | 0.14 (0.13) | 0.0 (0.0) |
| | 1 Jun | 0.58 (0.14) | 0.08 (0.08) | 0.33 (0.14) |
| | 6 Jun | 0.64 (0.1) | 0.23 (0.09) | 0.14 (0.07) |
| | 11 Jun | 0.75 (0.07) | 0.11 (0.05) | 0.14 (0.06) |
| | 16 Jun | 0.67 (0.07) | 0.08 (0.04) | 0.24 (0.06) |
| | 21 Jun | 0.44 (0.06) | 0.25 (0.06) | 0.31 (0.06) |
| | 26 Jun | 0.28 (0.06) | 0.29 (0.06) | 0.43 (0.06) |
| | 1 Jul | 0.28 (0.05) | 0.17 (0.04) | 0.55 (0.06) |
| | 6 Jul | 0.2 (0.05) | 0.09 (0.03) | 0.71 (0.05) |
| | 11 Jul | 0.19 (0.04) | 0.07 (0.03) | 0.75 (0.05) |
| | 16 Jul | 0.13 (0.04) | 0.1 (0.03) | 0.78 (0.05) |
| | 21 Jul | 0.09 (0.04) | 0.17 (0.05) | 0.74 (0.05) |
| | 26 Jul | 0.05 (0.03) | 0.2 (0.05) | 0.75 (0.06) |
| | 31 Jul | 0.06 (0.03) | 0.13 (0.05) | 0.81 (0.05) |

-continued-

| | | | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | Downstream of Slikok Creek | Unrestricted | Closed or restricted |
| Year | Date | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2012 | | | | |
| | 17 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 22 May | 0.86 (0.13) | 0.14 (0.13) | 0.0 (0.0) |
| | 27 May | 0.9 (0.09) | 0.1 (0.09) | 0.0 (0.0) |
| | 1 Jun | 0.86 (0.09) | 0.14 (0.09) | 0.0 (0.0) |
| | 6 Jun | 0.59 (0.1) | 0.23 (0.09) | 0.18 (0.08) |
| | 11 Jun | 0.21 (0.08) | 0.32 (0.09) | 0.46 (0.09) |
| | 16 Jun | 0.13 (0.06) | 0.43 (0.09) | 0.43 (0.09) |
| | 21 Jun | 0.19 (0.07) | 0.33 (0.08) | 0.47 (0.08) |
| | 26 Jun | 0.17 (0.06) | 0.22 (0.06) | 0.61 (0.08) |
| | 1 Jul | 0.11 (0.05) | 0.2 (0.06) | 0.7 (0.07) |
| | 6 Jul | 0.07 (0.04) | 0.24 (0.06) | 0.69 (0.07) |
| | 11 Jul | 0.02 (0.02) | 0.09 (0.04) | 0.89 (0.05) |
| | 16 Jul | 0.02 (0.02) | 0.15 (0.06) | 0.83 (0.06) |
| | 21 Jul | 0.03 (0.03) | 0.11 (0.05) | 0.86 (0.06) |
| | 26 Jul | 0.03 (0.03) | 0.1 (0.06) | 0.86 (0.06) |
| | 31 Jul | 0.05 (0.05) | 0.16 (0.08) | 0.79 (0.09) |
| 2013 | | | | |
| | 17 May | 1.0 (0.0) | . (.) | . (.) |
| | 22 May | 0.5 (0.35) | 0.0 (0.0) | 0.5 (0.35) |
| | 27 May | 0.33 (0.27) | 0.67 (0.27) | 0.0 (0.0) |
| | 1 Jun | 0.33 (0.27) | 0.67 (0.27) | 0.0 (0.0) |
| | 6 Jun | 0.5 (0.25) | 0.25 (0.22) | 0.25 (0.22) |
| | 11 Jun | 0.79 (0.11) | 0.14 (0.09) | 0.07 (0.07) |
| | 16 Jun | 0.55 (0.11) | 0.2 (0.09) | 0.25 (0.1) |
| | 21 Jun | 0.38 (0.1) | 0.23 (0.08) | 0.38 (0.1) |
| | 26 Jun | 0.34 (0.09) | 0.21 (0.08) | 0.45 (0.09) |
| | 1 Jul | 0.13 (0.06) | 0.19 (0.07) | 0.69 (0.08) |
| | 6 Jul | 0.06 (0.04) | 0.22 (0.07) | 0.72 (0.08) |
| | 11 Jul | 0.03 (0.03) | 0.19 (0.07) | 0.78 (0.07) |
| | 16 Jul | 0.0 (0.0) | 0.19 (0.07) | 0.81 (0.07) |
| | 21 Jul | 0.0 (0.0) | 0.17 (0.07) | 0.83 (0.07) |
| | 26 Jul | 0.0 (0.0) | 0.18 (0.08) | 0.82 (0.08) |
| | 31 Jul | 0.0 (0.0) | 0.2 (0.09) | 0.8 (0.09) |

*Note:* "Downstream of Slikok Creek" includes Cook Inlet to Slikok Creek (RM 0–19). The unrestricted portion of "Upstream of Slikok Creek" includes Slikok Creek to Skilak Lake (RM 19–50) excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage.

Appendix B2.–Proportional distribution of late-run radiotagged Chinook salmon by date and area, Kenai River, 2012–2013.

| | | | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | Downstream of Slikok Creek | Unrestricted | Closed or restricted |
| Year | Date | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2012 | | | | |
| | 1 Jul | 1.0 (0.0) | . (.) | . (.) |
| | 6 Jul | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 11 Jul | 0.69 (0.15) | 0.19 (0.09) | 0.12 (0.11) |
| | 16 Jul | 0.75 (0.11) | 0.18 (0.09) | 0.07 (0.07) |
| | 21 Jul | 0.64 (0.1) | 0.26 (0.09) | 0.1 (0.06) |
| | 26 Jul | 0.59 (0.09) | 0.34 (0.08) | 0.07 (0.05) |
| | 31 Jul | 0.6 (0.07) | 0.24 (0.06) | 0.16 (0.05) |
| 2013 | | | | |
| | 1 Jul | 1.0 (0.0) | 0.0 (.) | . (.) |
| | 6 Jul | 0.86 (0.13) | 0.0 (0.0) | 0.14 (0.13) |
| | 11 Jul | 0.61 (0.11) | 0.0 (0.11) | 0.11 (0.07) |
| | 16 Jul | 0.71 (0.08) | 0.0 (0.08) | 0.07 (0.05) |
| | 21 Jul | 0.67 (0.07) | 0.0 (0.06) | 0.14 (0.06) |
| | 26 Jul | 0.68 (0.07) | 0.0 (0.06) | 0.11 (0.05) |
| | 31 Jul | 0.67 (0.05) | 0.0 (0.05) | 0.14 (0.05) |

*Note:* "Downstream of Slikok Creek" includes Cook Inlet to Slikok Creek (RM 0–19). The unrestricted portion of "Upstream of Slikok Creek" includes Slikok Creek to Skilak Lake (RM 19–50) excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage.

Appendix B3.–Proportional distribution of tributary spawning radiotagged Chinook salmon by date and area, Kenai River, 2012–2013.

| | | | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | Downstream of Slikok Creek | Unrestricted | Closed or restricted |
| Year | Date | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2010 | | | | |
| | 17 May | . (.) | . (.) | . (.) |
| | 22 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 27 May | 0.75 (0.22) | 0.0 (0.0) | 0.25 (0.22) |
| | 1 Jun | 0.56 (0.17) | 0.44 (0.17) | 0.0 (0.0) |
| | 6 Jun | 0.69 (0.12) | 0.31 (0.12) | 0.0 (0.0) |
| | 11 Jun | 0.76 (0.09) | 0.12 (0.06) | 0.12 (0.06) |
| | 16 Jun | 0.56 (0.08) | 0.22 (0.07) | 0.22 (0.07) |
| | 21 Jun | 0.33 (0.07) | 0.3 (0.07) | 0.38 (0.08) |
| | 26 Jun | 0.23 (0.06) | 0.41 (0.07) | 0.36 (0.07) |
| | 1 Jul | 0.13 (0.05) | 0.21 (0.06) | 0.66 (0.07) |
| | 6 Jul | 0.04 (0.03) | 0.11 (0.05) | 0.85 (0.05) |
| | 11 Jul | 0.02 (0.02) | 0.11 (0.05) | 0.87 (0.05) |
| | 16 Jul | 0.0 (0.0) | 0.02 (0.02) | 0.98 (0.02) |
| | 21 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| | 26 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| | 31 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| 2011 | | | | |
| | 17 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 22 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 27 May | 0.86 (0.13) | 0.14 (0.13) | 0.0 (0.0) |
| | 1 Jun | 0.58 (0.14) | 0.08 (0.08) | 0.33 (0.14) |
| | 6 Jun | 0.64 (0.1) | 0.23 (0.09) | 0.14 (0.07) |
| | 11 Jun | 0.74 (0.07) | 0.11 (0.05) | 0.14 (0.06) |
| | 16 Jun | 0.67 (0.07) | 0.09 (0.04) | 0.24 (0.06) |
| | 21 Jun | 0.38 (0.07) | 0.27 (0.06) | 0.35 (0.07) |
| | 26 Jun | 0.17 (0.05) | 0.33 (0.07) | 0.5 (0.07) |
| | 1 Jul | 0.11 (0.04) | 0.18 (0.05) | 0.71 (0.06) |
| | 6 Jul | 0.04 (0.03) | 0.06 (0.03) | 0.91 (0.04) |
| | 11 Jul | 0.04 (0.03) | 0.02 (0.02) | 0.94 (0.03) |
| | 16 Jul | 0.0 (0.0) | 0.02 (0.02) | 0.98 (0.02) |
| | 21 Jul | 0.0 (0.0) | 0.02 (0.02) | 0.98 (0.02) |
| | 26 Jul | 0.0 (0.0) | 0.06 (0.04) | 0.94 (0.04) |
| | 31 Jul | 0.0 (0.0) | 0.03 (0.03) | 0.97 (0.03) |

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Appendix B3.–Page 2 of 2.

| Year | Date | Downstream of Slikok Creek | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | | Unrestricted | Closed or restricted |
| | | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2012 | | | | |
| | 17 May | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 22 May | 0.86 (0.13) | 0.14 (0.13) | 0.0 (0.0) |
| | 27 May | 0.9 (0.09) | 0.1 (0.09) | 0.0 (0.0) |
| | 1 Jun | 0.86 (0.09) | 0.14 (0.09) | 0.0 (0.0) |
| | 6 Jun | 0.59 (0.1) | 0.23 (0.09) | 0.18 (0.08) |
| | 11 Jun | 0.21 (0.08) | 0.32 (0.09) | 0.46 (0.09) |
| | 16 Jun | 0.07 (0.05) | 0.46 (0.09) | 0.46 (0.09) |
| | 21 Jun | 0.15 (0.06) | 0.35 (0.08) | 0.5 (0.09) |
| | 26 Jun | 0.13 (0.05) | 0.24 (0.07) | 0.63 (0.08) |
| | 1 Jul | 0.05 (0.04) | 0.18 (0.06) | 0.77 (0.07) |
| | 6 Jul | 0.03 (0.03) | 0.16 (0.06) | 0.82 (0.06) |
| | 11 Jul | 0.0 (0.0) | 0.03 (0.03) | 0.97 (0.03) |
| | 16 Jul | 0.0 (0.0) | 0.03 (0.03) | 0.97 (0.03) |
| | 21 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| | 26 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| | 31 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| 2013 | | | | |
| | 17 May | . (.) | . (.) | . (.) |
| | 22 May | 0.5 (0.35) | 0.0 (0.0) | 0.5 (0.35) |
| | 27 May | 0.33 (0.27) | 0.67 (0.27) | 0.0 (0.0) |
| | 1 Jun | 0.33 (0.27) | 0.67 (0.27) | 0.0 (0.0) |
| | 6 Jun | 0.5 (0.25) | 0.25 (0.22) | 0.25 (0.22) |
| | 11 Jun | 0.75 (0.13) | 0.17 (0.11) | 0.08 (0.08) |
| | 16 Jun | 0.5 (0.12) | 0.22 (0.1) | 0.28 (0.11) |
| | 21 Jun | 0.27 (0.09) | 0.27 (0.09) | 0.45 (0.11) |
| | 26 Jun | 0.25 (0.09) | 0.25 (0.09) | 0.5 (0.1) |
| | 1 Jul | 0.0 (0.0) | 0.17 (0.08) | 0.83 (0.08) |
| | 6 Jul | 0.0 (0.0) | 0.17 (0.08) | 0.83 (0.08) |
| | 11 Jul | 0.0 (0.0) | 0.12 (0.05) | 0.88 (0.05) |
| | 16 Jul | 0.0 (0.0) | 0.04 (0.04) | 0.96 (0.04) |
| | 21 Jul | 0.0 (0.0) | 0.04 (0.0) | 0.96 (0.0) |
| | 26 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |
| | 31 Jul | 0.0 (0.0) | 0.0 (0.0) | 1.0 (0.0) |

*Note:* "Downstream of Slikok Creek" includes Cook Inlet to Slikok Creek (RM 0–19). The unrestricted portion of "Upstream of Slikok Creek" includes Slikok Creek to Skilak Lake (RM 19–50) excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage.

Appendix B4.–Proportional distribution of mainstem spawning radiotagged Chinook salmon by date and area, Kenai River, 2012–2013.

| | | | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | Downstream of Slikok Creek | Unrestricted | Closed or restricted |
| Year | Date | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2012 | | | | |
| | 16 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 21 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 26 Jun | 0.67 (0.27) | 0.0 (0.0) | 0.33 (0.27) |
| | 1 Jul | 0.43 (0.19) | 0.29 (0.17) | 0.29 (0.17) |
| | 6 Jul | 0.67 (0.08) | 0.33 (0.08) | 0.0 (0.0) |
| | 11 Jul | 0.52 (0.11) | 0.26 (0.09) | 0.22 (0.1) |
| | 16 Jul | 0.63 (0.09) | 0.29 (0.08) | 0.09 (0.06) |
| | 21 Jul | 0.58 (0.09) | 0.31 (0.08) | 0.1 (0.06) |
| | 26 Jul | 0.55 (0.08) | 0.36 (0.08) | 0.09 (0.04) |
| | 31 Jul | 0.57 (0.07) | 0.26 (0.06) | 0.17 (0.05) |
| 2013 | | | | |
| | 16 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 21 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 26 Jun | 0.8 (0.18) | 0.0 (0.0) | 0.2 (0.18) |
| | 1 Jul | 0.5 (0.18) | 0.25 (0.15) | 0.25 (0.15) |
| | 6 Jul | 0.55 (0.1) | 0.19 (0.09) | 0.26 (0.11) |
| | 11 Jul | 0.49 (0.09) | 0.32 (0.09) | 0.2 (0.08) |
| | 16 Jul | 0.58 (0.07) | 0.31 (0.07) | 0.11 (0.05) |
| | 21 Jul | 0.58 (0.06) | 0.25 (0.06) | 0.16 (0.05) |
| | 26 Jul | 0.6 (0.06) | 0.27 (0.06) | 0.13 (0.05) |
| | 31 Jul | 0.6 (0.04) | 0.23 (0.05) | 0.16 (0.04) |

*Note:* "Downstream of Slikok Creek" includes Cook Inlet to Slikok Creek (RM 0–19). The unrestricted portion of "Upstream of Slikok Creek" includes Slikok Creek to Skilak Lake (RM 19–50) excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage.

Appendix B5.–Proportional distribution of early-run, mainstem spawning radiotagged Chinook salmon by date and area, Kenai River, 2010–2013.

| | | | Upstream of Slikok Creek | |
|---|---|---|---|---|
| | | Downstream of Slikok Creek | Unrestricted | Closed or restricted |
| Year | Date | Prop. (SE) | Prop. (SE) | Prop. (SE) |
| 2010 | | | | |
| | 16 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 21 Jun | 0.5 (0.35) | 0.0 (0.0) | 0.5 (0.35) |
| | 26 Jun | 0.6 (0.22) | 0.0 (0.0) | 0.4 (0.22) |
| | 1 Jul | 0.56 (0.17) | 0.11 (0.1) | 0.33 (0.16) |
| | 6 Jul | 0.56 (0.17) | 0.22 (0.14) | 0.22 (0.14) |
| | 11 Jul | 0.63 (0.17) | 0.13 (0.12) | 0.25 (0.15) |
| | 16 Jul | 0.5 (0.18) | 0.38 (0.17) | 0.13 (0.12) |
| | 21 Jul | 0.38 (0.17) | 0.5 (0.18) | 0.13 (0.12) |
| | 26 Jul | 0.43 (0.19) | 0.43 (0.19) | 0.14 (0.13) |
| | 31 Jul | 0.29 (0.17) | 0.43 (0.19) | 0.29 (0.17) |
| 2011 | | | | |
| | 16 Jun | 0.75 (0.22) | 0.0 (0.0) | 0.25 (0.22) |
| | 21 Jun | 0.86 (0.13) | 0.14 (0.13) | 0.0 (0.0) |
| | 26 Jun | 0.69 (0.13) | 0.15 (0.1) | 0.15 (0.1) |
| | 1 Jul | 0.73 (0.09) | 0.14 (0.07) | 0.14 (0.07) |
| | 6 Jul | 0.59 (0.1) | 0.18 (0.08) | 0.23 (0.09) |
| | 11 Jul | 0.57 (0.11) | 0.19 (0.09) | 0.24 (0.09) |
| | 16 Jul | 0.43 (0.11) | 0.29 (0.1) | 0.29 (0.1) |
| | 21 Jul | 0.3 (0.1) | 0.5 (0.11) | 0.2 (0.09) |
| | 26 Jul | 0.16 (0.08) | 0.47 (0.11) | 0.37 (0.11) |
| | 31 Jul | 0.16 (0.08) | 0.32 (0.11) | 0.53 (0.11) |
| 2012 | | | | |
| | 16 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 21 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 26 Jun | 0.67 (0.27) | 0.0 (0.0) | 0.33 (0.27) |
| | 1 Jul | 0.43 (0.19) | 0.29 (0.17) | 0.29 (0.17) |
| | 6 Jul | 0.29 (0.17) | 0.71 (0.17) | 0.0 (0.0) |
| | 11 Jul | 0.14 (0.13) | 0.43 (0.19) | 0.43 (0.19) |
| | 16 Jul | 0.14 (0.13) | 0.71 (0.17) | 0.14 (0.13) |
| | 21 Jul | 0.17 (0.15) | 0.67 (0.19) | 0.17 (0.15) |
| | 26 Jul | 0.17 (0.15) | 0.5 (0.2) | 0.33 (0.19) |
| | 31 Jul | 0.17 (0.15) | 0.5 (0.2) | 0.33 (0.19) |
| 2013 | | | | |
| | 16 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 21 Jun | 1.0 (0.0) | 0.0 (0.0) | 0.0 (0.0) |
| | 26 Jun | 0.8 (0.18) | 0.0 (0.0) | 0.2 (0.18) |
| | 1 Jul | 0.5 (0.18) | 0.25 (0.15) | 0.25 (0.15) |
| | 6 Jul | 0.25 (0.15) | 0.38 (0.17) | 0.38 (0.17) |
| | 11 Jul | 0.13 (0.12) | 0.5 (0.18) | 0.38 (0.17) |
| | 16 Jul | 0.0 (0.0) | 0.63 (0.17) | 0.38 (0.17) |
| | 21 Jul | 0.0 (0.0) | 0.71 (0.17) | 0.29 (0.17) |
| | 26 Jul | 0.0 (0.0) | 0.57 (0.19) | 0.43 (0.19) |
| | 31 Jul | 0.0 (0.0) | 0.57 (0.19) | 0.43 (0.19) |

*Note:* "Downstream of Slikok Creek" includes Cook Inlet to Slikok Creek (RM 0–19). The unrestricted portion of "Upstream of Slikok Creek" includes Slikok Creek to Skilak Lake (RM 19–50) excluding closed or restricted fishing areas around Slikok Creek, Centennial Park, Funny River, Morgan's Landing, and Killey River. Closed or restricted waters describe the exclusions noted above plus the Kenai River upstream of and including Skilak Lake and all tributaries to the Kenai River drainage.