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Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Salmon Escapement Study
Study Plan Section 9.7

Study Completion Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

LGL Alaska Research Associates, Inc. &
Alaska Department of Fish and Game, Division of Sport Fish

October 2015

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADCP	acoustic Doppler current profiler
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
ARIS	Adaptive Resolution Imaging Sonar
ATS	Advanced Telemetry Systems, Inc.
AUC	area under the curve
cfs	cubic feet per second
cm	Centimeter
CM	Complete Mixing (test)
CPUE	catch per unit effort
DIDSON	Dual Frequency Identification Sonar
ECDF	Empirical cumulative distribution function
EP	Equal Proportion (test)
FERC	Federal Energy Regulatory Commission
FOV	field-of-view
ft	Feet
ft/s	feet per second
g	Gram
GIS	geographic information system
GPS	global positioning system
HSC	Habitat Suitability Criteria
ILP	Integrated Licensing Process
in	Inch
ISR	Initial Study Report
km	Kilometer
KS	Kolmogorov-Smirnov
m	Meter
mi	Mile
m/s	meters per second
METF	mid-eye to fork
MHz	Megahertz
mm	Millimeter
NTU	nephelometric turbidity units

Abbreviation	Definition
oz	Ounce
PRM	Project River Mile
RM	river mile
RPM	revolutions per minute
RSP	Revised Study Plan
SMC	Sound Metrics Corporation
SPD	study plan determination
TL	total length
USGS	United States Geological Survey
W	Watt
V	Volt

1. INTRODUCTION

This Salmon Escapement Study, Section 9.7 of the Revised Study Plan (RSP) approved by the Federal Energy Regulatory Commission (FERC or Commission) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241, focuses on characterizing the current distribution, abundance, habitat use, and migratory behavior of all species of adult anadromous salmon (*Oncorhynchus* spp.) across mainstem river habitats and select tributaries above the Three Rivers Confluence (i.e., confluence of the Susitna, Chulitna, and Talkeetna rivers).

A summary of the development of this study, together with the Alaska Energy Authority's (AEA) implementation of it through the 2013 study season, appears in Part A, Section 1 of the Initial Study Report (ISR) filed with FERC in June 2014. As required under FERC's regulations for the Integrated Licensing Process (ILP), the ISR describes AEA's "overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)).

Since filing the ISR in June 2014, AEA has continued to implement the FERC-approved plan for the Salmon Escapement Study. For example:

- On September 30, 2014, AEA filed a Technical Memorandum with FERC to describe part of the methods, variances, and preliminary results of the 2014 Salmon Escapement Study (AEA 2014a). The methods and variances described therein were focused on activities conducted in the Middle and Upper rivers, and preliminary results were focused on Chinook Salmon (*O. tshawytscha*).
- On October 15, 2014, AEA held an ISR meeting for the Salmon Escapement Study.

In furtherance of the next round of ISR meetings and FERC's SPD expected in 2016, this report contains a comprehensive discussion of results of the Salmon Escapement Study from the beginning of AEA's study program in 2012, through the end of calendar year 2014. It describes the methods and results of the Salmon Escapement Study, and explains how all Study Objectives set forth in the Commission-approved Study Plan have been met. Accordingly, with this report, AEA has now completed all field work, data collection, data analysis, and reporting for this study.

2. STUDY OBJECTIVES

The study objectives were established in RSP Section 9.7.1.2, and include:

1) Capture, radio-tag, and track adults of five species of Pacific salmon (i.e., Chinook, Chum (*O. keta*), Coho (*O. kisutch*), Pink (*O. gorbuscha*), and Sockeye (*O. nerka*) salmon) in the Middle and Upper Susitna River in proportion to their species-specific abundance. Capture and tag Chinook, Coho, and Pink Salmon in the Lower Susitna River.

2) Characterize the migration behavior and spawning locations of radio-tagged salmon in the Lower, Middle, and Upper Susitna River.

3) Characterize adult salmon migration behavior and timing within and above Devils Canyon.

4) If shown to be an effective sampling method, and where feasible, use sonar to aid in documenting salmon spawning locations in turbid water in 2013 and 2014.

5) Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon.

6) Generate counts of adult Chinook Salmon spawning in the Susitna River and its tributaries to estimate the proportions of fish with tags for populations in the watershed.

7) Collect tissue samples to support the Fish Genetic Baseline Study (Study 9.14).

8) Estimate the system-wide Chinook Salmon escapement to the entire Susitna River, the Coho Salmon escapement to the Susitna River above the confluence with the Yentna River, and the distribution of Chinook, Coho, and Pink salmon among tributaries of the Susitna River (upstream of Yentna River confluence) in 2013 and 2014.

3. STUDY AREA

As established by RSP Section 9.7.3, the study area encompassed the Susitna River from Cook Inlet upstream to the Oshetna River, or as far upstream as Chinook Salmon were detected (Figure 3-1), with an emphasis on wherever salmon spawned in mainstem habitats of the Susitna River. The mainstem Susitna River was divided into three segments: the Lower River (Project River Mile [PRM] 33–102.4), Middle River (PRM 102.4–187.1), and Upper River (PRM 187.1–261.3). RSP Section 9.7.3 used Historical River Miles (RM) which were: Lower River (RM 30–98), Middle River (RM 98–184), and Upper River (RM 184–260). Devils Canyon extends from approximately PRM 153.4 to PRM 166.1 (RM 150 to 163, respectively). Within Devils Canyon, the channel constricts and increases in vertical gradient to form three potential fish passage impediments (referred to as Impediments 1, 2, and 3) that may block or delay fish passage (see Section 3.2 in AEA 2013a for more detail on the impediments).

4. METHODS

Descriptions of the study methods are organized below by objective. This was a multi-year study initiated in 2012 (AEA 2012, 2013a, 2014a,c). The description of the methods below is specific to the 2014 implementation of the study.

4.1. Objective 1: Capture, radio-tag, and track adults of five species of Pacific salmon in the Middle and Upper Susitna River in proportion to their abundance. Capture and tag Chinook, Coho, and Pink salmon in the Lower Susitna and Yentna rivers.

In 2014, the study team implemented the methods with respect to Objective 1 as described in the Study Plan, with the exception of modifications described in Section 7.1.2 of the ISR and variances explained below (Section 4.1.6). Tasks to address Objective 1 were listed in RSP Section 9.7.4.1.

4.1.1. Fish Capture

4.1.1.1. Lower River

In the Lower River, two fishwheels and gillnets were used to capture adult salmon for tagging in 2014. Capture sites were located approximately 1–2 river miles upstream of the Yentna River confluence. The fishwheels were operated from May 22 to August 26, at locations that were fished in 2010–2013 (Figure 3-1). One fishwheel operated on the west bank of the Lower River at PRM 33.4 for 1,153 hours, and the second fishwheel operated on the east bank at PRM 34.2 for 1,154 hours (Figure A-1). From May 22 to June 28, gillnets were fished in the vicinity of the fishwheels for a total of 79.2 hours (Figure A-2). The gillnet sampling was conducted to increase the probability of capture for larger Chinook Salmon, as it was expected that fishwheels would provide length-biased samples favoring smaller fish at this site (see ISR Part A Appendix I). The gillnets were 5.5 inch (in; stretch) or 7.5 in mesh, multi-strand web, 50–150 feet (ft) long, and 10–12 or 15–17 ft deep. Fifty-eight percent of the effort was with 7.5-in mesh and 42 percent with 5.5-in mesh.

4.1.1.2. Yentna River

In addition, two fishwheels and gillnets were used on the lower Yentna River (RM 6) to capture adult salmon for tagging in 2014. Capture sites were in the same locations as had been operated for three decades (Figure 3-1). One fishwheel operated on the south bank of the Yentna River (RM 6) for 539 hours from May 22 to June 25, and the second fishwheel operated on the north bank of the Yentna River (RM 6) for 529 hours from May 22 to June 25 (Figure A-3). There was effort for both fishwheels every day in 2014 until June 26, and both fishwheels achieved the targeted effort (16 hours/day) on most days. From May 22 to June 25, gillnets (5.5 and 7.5-in mesh) were fished in the vicinity of the fishwheels for a total of 281.8 hours (effort was split 53 and 47 percent between mesh sizes, respectively; Figure A-4).

The Study Plan provided that weirs would be used as a recapture method to support a two-event capture-recapture experiment to estimate abundance of Chinook Salmon in the Yentna River (RSP Section 9.7.4.8). In 2013, no suitable weir sites could be found. ISR Part C Section 7.1.2.6.1 indicated that the study team would modify the Study Plan and use fishwheels and gillnets for tag recapture in 2014. In 2014, a new site for two fishwheels and gillnetting was established on the Yentna River at RM 18 to recapture fish tagged at Yentna RM 6 (Figure 3-1). One fishwheel operated on the west bank of the Yentna River (RM 18.8) for 1,525 hours from May 24 to August 27, and the second fishwheel operated on the east bank of the Yentna River

(RM 18.6) for 1,536 hours from May 24 to August 27 (Figure A-3). There was effort for both fishwheels on 96 days in 2014 until August 27, and both fishwheels achieved the targeted effort (16 hours/day) on 94 days. From May 24 to June 30, gillnets (5.5 and 7.5-in mesh) were fished in the vicinity of the fishwheels for a total of 230.8 hours (effort was split 46 and 54 percent between mesh sizes, respectively; Figure A-4).

4.1.1.3. Middle River

In the Middle River, three fishwheels and gillnets were used to capture adult salmon for tagging in 2014. Two of the fishwheels were operated at the same two locations used in 1981–1985, 2012, and 2013 (sites 1 and 2), and a third fishwheel was operated at a site that was first used in 2013 (site 3; Figures 3-1 and 4.1-1). The addition of a third fishwheel represents a variance from the Study Plan (RSP Section 9.7.4.1.1): it was added to compensate for the lack of a Devils Canyon fishwheel (see ISR Section 7.1.2.1.2).

The Middle River fishwheels consisted of two aluminum pontoons, three baskets, and two partially submerged live tanks for holding fish in river water. A tower and winch assembly were used to adjust the height of the baskets and ensure that the baskets were fishing within 20 centimeters (cm; 7.9 in) of the river bottom. Net leads were installed between the fishwheels and adjacent riverbank to direct fish away from the bank and into the path of the fishwheel baskets. During daylight operations, crews were never away from the fishwheels for more than one hour. From late June to mid-July, the fishwheels were left unattended overnight (from ~11:30 P.M. until 9:00 A.M. the following morning).

From June 6 to September 7, the Site 1 fishwheel operated for 1,369 hours (61.3 percent of the time it was in place) on the west bank of the Susitna River (PRM 124.1; Figure A-5). Excluding the days it did not operate, daily fishing effort at Site 1 averaged 14.9 hours (range: 8.3–24 hours). The targeted amount of daily fishing effort at Site 1 varied by period: 13 hours from June 6–11, 15–17 hours from June 12–28, 24 hours from June 29 to July 18, 12 hours from July 19 to August 28, and 10 hours from August 29 to September 7. The Site 1 fishwheel did not operate during high water and heavy debris loads on June 26, June 27, and part of June 28.

From June 12 to September 7, the Site 2 fishwheel operated for 1,270 hours (60.6 percent of the time it was in place) on the east bank of the river (PRM 123.0; Figure A-5). Daily fishing effort averaged 14.8 hours (range: 8.8–24.0 hours). Targeted daily fishing effort varied at Site 2: 15–17 hours from June 12–29, 24 hours from June 30 to July 18, 12 hours from July 19 to August 28, and 10 hours from August 29 to September 7. The Site 2 fishwheel did not operate during high water and heavy debris loads on June 26, June 27, and part of June 28.

From June 9 to September 7, the Site 3 fishwheel operated for 1,302 hours (60.2 percent of the time it was in place) on the west bank of the Susitna River at PRM 126.0 (Figure A-5). Daily fishing effort averaged 14.8 hours (range: 4.8–24.0 hours). Targeted daily fishing effort varied at Site 3: 15–17 hours from June 9–29, 24 hours from June 30 to July 18, 12 hours from July 19 to August 29, and 10 hours from August 30 to September 7. The Site 3 fishwheel was not operational during high water from June 26–28.

In 2014, the study team introduced a variance to the Study Plan and used set gillnets to capture Coho Salmon in September. RSP Section 9.7.4.1.1 stated that only fishwheels would be used to capture adult salmon for tagging in the Middle River. The FERC SPD recommended that the Middle River fishwheel operation extend throughout the month of September; however, as described in ISR Part C Section 7.1.2.1.2, analysis of sonar data from 2013 showed that the Middle River fishwheels were not effective in September when river discharge and turbidity decreased substantially from summer conditions. ISR Part C Section 7.1.2.1.2 indicated that the study team would modify the Study Plan and use a beach seine as an alternative capture method in September 2014. However, beach seine sites with suitable water depth and velocity, and in areas where fish were migrating (and not holding), were limited in the vicinity of Curry in 2014. The study team instead used set gillnets, which can be an effective capture method when a river is low and clear.

In 2014, Middle River fishwheel operations ended on September 7, and every second day from September 10 to September 30 set gillnets were used to capture and tag adult Coho Salmon in the vicinity of Curry. Gillnets used in September were 18.3 m (60 ft) long and consisted of 7.6 cm (3.0 in) or 8.9 cm (3.5 in) multi-strand mesh. Fishing effort in September totaled 150.3 hours, and all sets were made between PRM 121.9 and PRM 126.0. On June 24, a set gillnet was used for 1.8 hours in the vicinity of Curry. This effort was simply exploratory in nature as crews investigated a few sites for the presence of Chinook Salmon. The gillnet used in June was 36.6 m (120 ft) long, 3.0 m (10 ft) deep, and had 8.9 cm (3.5 in) multi-strand mesh.

The RSP (Section 9.7.4.1.1) indicated that at least one fishwheel would be operated in Devils Canyon below the impediments. However, as described in ISR Section 7.1.2.1.2, it was not feasible.

4.1.2. Radio-tagging

Pulse-coded, extended-range tags by Advanced Telemetry Systems, Inc., (ATS; Isanti, MN, www.atstrack.com) were applied to a subset of salmon captured in the Lower River, Yentna River, and Middle River. There were 100 unique codes on each available frequency. Model F1835B transmitters (16 grams [g; 0.6 ounces (oz)], 30 cm [11.8 in] antenna, 96-day battery life) were used for small Chinook (mid-eye to fork [METF] length < 50 cm [19.7 in]) and Pink salmon; Model F1840B tags (22 g [0.8 oz], 30 cm [11.8 in] antenna, 127-day battery life) for Chum, Coho, and Sockeye salmon; and Model F1845B tags (26 g [0.9 oz], 41 cm [16.1 in] antenna, 162-day battery life) for large Chinook Salmon (METF ≥ 50 cm [19.7 in]). All transmitters were equipped with a mortality sensor that changed the signal pattern to an “inactive” mode for the remainder of the season once the tag became stationary for 24 hours. All of the radio tags were labeled with return contact information. Each tag was tested immediately prior to deployment to ensure it was functioning properly upon release.

In the Lower River, only uninjured Chinook Salmon with a METF length of 50 cm (19.7 in) or greater (herein referred to as ‘large’), and Coho and Pink salmon with METF length of 40 cm (15.7 in) or greater, were radio-tagged. In the Yentna River, only large Chinook Salmon were radio-tagged. In the Middle River, large Chinook Salmon; Chinook Salmon measuring 30–49 cm METF (11.8–19.3 in; herein referred to as ‘small’); and Chum, Coho, Pink, and Sockeye salmon measuring 40 cm METF (15.7 in) or greater in length, were radio-tagged. Unless otherwise noted, all subsequent references to adult salmon sizes refer to METF lengths. No anesthesia was used in order to minimize handling time and tagging effects. Radio tags were inserted through the fish's mouth into the stomach using a piece of PVC tubing ($^{1}/_{3}$-in diameter and 18 in long), with the tag antenna left to protrude from the mouth. All radio-tagged salmon were measured to determine METF length (to the nearest centimeter), and Chinook and Coho salmon were tissue sampled (axillary process) for genetic baselines (see Section 4.7).

Unlike 2013, no salmon captured in the Middle River were sampled for scales (to age) or tagged with an external mark (i.e., spaghetti tag) in 2014. Eliminating these steps reduced the amount of handling time and the potential for any effects of handling fish on their post-release behavior. As stated in ISR Part A Section 4.1.8.3 and ISR Part C Section 7.1.2.1.2, scales would not be collected in 2014 in light of the fact that size selectivity would be tested (as in 2013) and that fish were randomly selected for tagging. RSP Section 9.7.4.1.3 indicated that a portion of fish captured in the Middle River (in excess of those required for radio-tagging) would be spaghetti-tagged to augment the ability to test assumptions about the representativeness of fish captured in the fishwheels. However, once the Indian River weir was rendered inoperable in 2014 (see Section 5.1.2.4 below for more details), it was recognized that there would be limited opportunity to sample fish on the spawning grounds, so no spaghetti tags were applied at the Middle River fishwheels. The inoperability of the weir also impacted the ability to assess size selectivity. Due to this variance, the study team relied on various other means to provide insights into capture probabilities based on size at the Middle River tag site.

To minimize any effects of holding fish in live tanks, salmon captured during daylight hours were tagged upon capture. All fish were released immediately after tagging. All fish captured were inspected for tags.

4.1.3. Tagging Goals

Recent (2012 and 2013) and historical (1981–1985) fishwheel catches, effectiveness, and salmon run timing guided tag application rates over the season.

As stated in RSP Section 9.7.4.1, the goal for Chinook Salmon in the Lower River was to radio-tag 300 fish per fishwheel; numbers tagged were 259 salmon from the west bank fishwheel, and 271 from the east bank fishwheel (Table A-1; Figure A-6). The goal for gillnetting was 100 Chinook Salmon, and 129 salmon were actually radio-tagged. For Coho Salmon at the Lower River site, the goal was to radio-tag 300 fish per fishwheel; numbers tagged were 337 Coho Salmon from the west bank fishwheel, and 303 fish from the east bank fishwheel (Table A-1; Figure A-6). The difference between the goals and actual radio-tagging was the result of re-apportioning radio tags in season according to catches. The number of Pink Salmon tagged was similar to the tagging goal of 100 fish per fishwheel, with 106 radio-tagged from the west bank fishwheel, and 92 from the east bank fishwheel (Table A-1; Figure A-6).

The radio-tagging goals for the Yentna River (RM 6) fishwheels were 100 fish per fishwheel; numbers tagged were 95 salmon from the north bank fishwheel, and 95 from the south bank fishwheel (Table A-2; Figure A-7). The goal for gillnetting was 100 Chinook Salmon; and 106 salmon were radio-tagged. Occasionally low catches in both fishwheels led to re-apportioning the radio tags in-season.

As stated in ISR Section 7.1.2.1.2, the revised goal for the Middle River was to radio-tag 650 Chinook Salmon (550 large and 100 small fish; from an initial goal of 400 large fish as stated in RSP Section 9.7.4.1). As described in the Study Plan, 200 each of Chum, Coho, Pink, and Sockeye salmon were targeted for radio-tagging in 2014. All species-specific goals were met or exceeded with the exception of small Chinook Salmon. Final 2014 radio-tagging numbers in the Middle River were 622 Chinook (590 large, 32 small), 200 Chum, 230 Coho, 201 Pink, and 200 Sockeye salmon (Table A-3; Figure A-8).

4.1.4. Numbers and Size of Marked and Unmarked Fish at Selected Locations

Fish were randomly selected from the fishwheels for tagging. To assess whether these fish were representative of all fish in the river, several assumptions were tested for fish tagged at the Lower River, Yentna River, and Middle River sites, as described in RSP Sections 9.7.4.1.5, 9.7.4.1.7, and 9.7.4.6.

4.1.4.1. Lower River and Yentna River

The assumption that radio-tagged salmon were representative of the population of salmon passing the tagging sites was evaluated for Chinook (Lower River and Yentna River) and Coho salmon (Lower River) in the framework of the mark-recapture experimental design. Heterogeneity in probability of capture was investigated by fish size (METF length), and spatially and temporally using mark-recapture diagnostic tests described by Seber (1982). These diagnostic tests, along with model selection procedures based on test results to minimize bias in estimates of abundance and distribution of spawners, are described more explicitly in Seber (1982, p. 438–439) and Arnason et al. (1996).

The evaluations of the assumption of equal probability of capture and radio-tagging for all Chinook or Coho Salmon passing the Lower River tagging site were based on characteristics of all fish counted passing the Montana Creek and Deshka River weirs and of all marked fish "recaptured" at these weirs. Three independent tests were performed for data from each weir site to evaluate equal probability of capture by size and temporally, while spatial tests required the data from both weirs. Similar tests for Chinook Salmon, by size and temporally (but not spatially), were conducted using fish sampled at the tagging and recapture sites on the Yentna River. No size-selectivity tests were conducted for Pink Salmon radio-tagged in the Lower River.

4.1.4.1.1. Temporal Equal-Proportions Test: Consistency of Chapman Model

Contingency table analysis was used with the χ^2 test for independence to conduct the temporal Equal-Proportions test (see Appendix I for details). For a weir site, the observations of numbers of fish passing the weir by day and number of recaptures passing the weir by day were divided into 2 to 6 pairs of cells by time period with approximately uniform sample sizes in each pair of cells. For each pair of cells, one contained the number of recaptured fish and the second contained the number of unmarked fish accounted for in the time period. This analysis determined if the ratio of marked-unmarked fish observed at each weir site was independent of time of capture at the weir.

4.1.4.1.2. Spatial Equal Proportions Test: Consistency of Chapman Model

Contingency table analysis was used to conduct the spatial Equal-Proportions test (see Appendix I for details). A table (2 rows x 2 columns) containing the numbers of marked and unmarked fish observed at each of the two weir sites was used. This analysis determined if the marked-unmarked ratios were independent of weir site.

4.1.4.1.3. Equal Probability of Capture by Size

Equal probability of capture by size was evaluated using the Kolmogorov-Smirnov (KS) two-sample test (see Appendix I for details). For the Lower River, this test determined if the distribution of lengths from all fish passing a weir site were similar to recaptured (radio-tagged) fish passing the weir site. Under the null hypothesis, the probability that a fish was radio-tagged was independent of the size of the fish, and the cumulative distribution function of the lengths of all fish passing a weir site were expected to be similar to the function of all recaptured fish passing that weir site.

4.1.4.2. Middle River

RSP Section 9.7.4.1.5 stated that to test whether Chinook, Chum, and Sockeye salmon passing the Middle River fishwheels were equally vulnerable to being captured and radio-tagged, fish would be examined on selected spawning grounds to develop two primary metrics: estimates of the proportion of fish tagged (mark rate), and the size distributions of tagged and untagged fish. However, ground-based stream counts and carcass surveys conducted in the first study year (2012) did not produce adequate samples for generating these metrics (see Section 5.1.3.6 in AEA 2013a). As an alternative to stream counts and carcass surveys, the study team implemented a variance to the Study Plan in 2013 (ISR Section 4.1.8.3) and operated a picket weir on the lower Indian River approximately 1.6 river miles from the confluence with the Susitna River (Figure 3-1). The weir was designed to free-pass upstream- and downstream-moving adult fish past underwater video cameras. The weir was located far enough upstream to minimize the number of fish milling at the weir, yet far enough downstream to ensure that the majority of fish returning to the river would be available to count passing through the video chute.

Given the success of the Indian River weir in 2013, the study team proposed that the Study Plan be modified to include similar methodology (see ISR Part A Section 4.1.5.2) in 2014, as described in ISR Part C Section 7.1.2.1.2. Unfortunately, the Indian River weir was rendered inoperable during a flood on June 26, 2014, prior to the onset of the majority of the salmon runs. For Chinook Salmon, the study team considered various alternatives for estimating mark rates and decided the best available option was to increase the number of aerial spawner surveys and aerial telemetry surveys in the Indian River (as described further in Section 4.6.1). Apart from the weir, there were no viable options available for collecting sufficient spawning ground samples to estimate the mark rates of Chum and Sockeye salmon, or to directly test for size selectivity in Chinook, Chum, and Sockeye salmon (the RSP did not call for the same effort on Coho and Pink salmon). For this reason the study team determined that applying spaghetti tags to fish in excess of radio-tagging requirements was not necessary. The inability to spaghetti tag fish in excess of radio-tagging requirements, or to collect spawning ground samples to estimate mark rates and assess size selectivity, was a variance to the Study Plan implemented in 2014. Results from previous study years and the analyses described in the following sections were used to provide insight with respect to these data gaps and ensure that all project objectives were addressed.

As explained in ISR Section 4.1.8.3, external sexing of fish was not reliable at the Middle River fishwheels. Thus, fish sex was not recorded in 2014, a variance from the RSP (Section 9.7.4.1.7).

4.1.4.2.1. Fishwheel Effectiveness Across Time

The main assumption of this study component was that the radio tags were deployed at the fishwheels in proportion to abundance for each species. To help evaluate this assumption at the Middle River fishwheels, the relative effectiveness of one Middle River fishwheel (at Site 1) was determined using sonar, from a ratio of the number of fish caught at the fishwheel to the number of fish observed using sonar. Sonar was not used at fishwheel sites 2 and 3 because these locations had steep banks and high river velocities that were not suitable for a fixed-site sonar. At Site 1, fish were observed with an Adaptive Resolution Imaging Sonar (ARIS) system operated in close proximity to the fishwheel across multiple time periods and river discharges. ARIS was also used to qualitatively assess fish approach behavior at the fishwheel relative to discharge and fish abundance. From June 3–25 and August 29 to September 30, one ARIS unit operated 24 hours per day on the right bank of the Susitna River immediately downstream of the Site 1 fishwheel (Figure 4.1-1). Daily review effort varied over the season, and ranged from a third (20 minutes per hour) of the imagery collected each day being reviewed (e.g., June 18–25, September 1–30) to all of the imagery collected each day being reviewed (e.g., June 3–17). The sonar sampling area ranged from 0.7–13.6 m (2.3–44.6 ft) in June and 0.7–14.0 m (2.3–45.9 ft) in August and September.

The catch-per-unit-effort (CPUE; fish per fishwheel hour) for each fishwheel was compared over time and across a range of discharges to help evaluate the relative effectiveness of each fishwheel. For example, at Site 1, CPUE and ARIS data were used inseason to determine whether operational changes were required in order to increase fishwheel catch rates (e.g., high ARIS counts at a time of low CPUE suggested the fishwheel was not operating effectively and operational changes were required).

4.1.4.2.2. Differences Among Stocks

To assess whether fish from a particular spawning area were right or left bank-oriented with respect to the capture site, the proportion of fish migrating into specific areas was compared with the collection bank. One concern was that mainstem fish could be more vulnerable to the fishwheels because they linger or mill upstream and downstream of capture sites. Recaptures of radio-tagged fish at the tagging site fishwheels provided a good test of whether milling fish were exposed to greater capture rates. In addition to quantitative and qualitative assessment of subsequent behavior of these recaptured fish, the final destinations (mainstem/tributary) of recaptured fish were compared with other tagged fish to determine whether fish that spawned in the mainstem were recaptured at a higher rate.

4.1.4.2.3. Equal Probability of Capture by Size

Since no salmon were sampled for lengths on the spawning grounds above the Middle River tag site in 2014, size selectivity at the Middle River fishwheels could not be directly tested. Some comparisons were made using KS tests to provide insight into the potential for size-selective sampling. For each species, cumulative length-frequency distributions were compared for: 1) fish captured at each of the Middle River fishwheels; and 2) fish captured at the Middle River fishwheels and those that were radio-tagged. For the first set of comparisons, the null hypothesis was that fish of different length were captured with equal probability, regardless of capture location. A significant test result would indicate that the fishwheels did not capture fish of different length equally. For the second set of comparisons, the null hypothesis was that fish had an equal probability of being selected for tagging from those captured, regardless of length. A significant test result would indicate that fish of different length were not selected equally for tagging.

4.1.5. Examining Handling-Induced Changes in Behavior

As stated in RSP Section 9.7.4.1.6, an assumption of this study was that the behavior of radio-tagged fish was not affected by the capture and handling process or by the presence of a radio tag thereafter. The study design allowed for some fish dropping back and not resuming their upstream migration, and these radio-tagged fish were removed from the experiment and subsequent analyses. For the remaining fish, it was assumed that capture and tagging did not affect final spawning destinations or migration behaviors, once they had recovered from the tagging event and resumed migration. Four analyses were proposed in the RSP that would provide insight into the validity of that assumption. First, comparisons of travel times between recently-tagged and distantly-tagged fish could reveal handling effects if the recently-tagged fish moved more slowly through a common river reach. Second, performance comparisons could reveal handling effects if fish that were subjected to higher fishwheel holding densities (or longer holding times) performed worse than fish with lower-density (or shorter-duration) holding experiences. Third, examination of mark rates at spawning locations could provide an indication of possible handling-induced changes in behavior. Finally, comparisons of post-release migratory behavior between once-handled (fish that were never recaptured) and multiple-handled (fish that were recaptured in the fishwheels post-release) could provide data on the effects of the fish capture process, including any potential cumulative handling effects.

In 2014, handling-induced changes in behavior were evaluated using the first and fourth proposed methods. In 2014, holding times and densities were always low, thus it was not possible, nor necessary, to test whether longer times or higher densities impacted fish behavior or survival (i.e., it was not possible to perform the second proposed test). Also, since the Indian River weir was rendered inoperable in 2014, it was not feasible to make comparisons of mark rates, hence the third proposed test could not be performed. For Middle River fishwheels, potential handling effects were evaluated based on the post-release migratory behavior of recovered vs. recently-handled fish (first proposed test), and of once-handled vs. multiple-handled fish (fourth proposed test).

For the Yentna River mark-recapture experiment (Table B-5), the number of dart-tagged Chinook Salmon was deprecated based on an estimate of the proportion of radio-tagged fish not migrating upstream.

4.1.6. Variances

RSP Section 9.7.4.1.1 stated that fishwheels would be used to capture adult salmon for tagging in the Middle River. ISR Part C Section 7.1.2.1.2 indicated that the study team would modify the Study Plan to add beach seining as an alternative method for sampling in September. Instead, set gillnets were used to capture Coho Salmon in September 2014. As described in Section 4.1.1.3, beach seine sites with suitable water depth and velocity, and in areas where fish were migrating (and not holding), were limited in the vicinity of Curry in 2014. Gillnets proved to be an effective alternative capture method. Relative to using fishwheels, this variance increased the study team's ability to achieve Objective 1.

As an alternative to stream counts and carcass surveys to obtain mark rates and length samples, the study team implemented a variance to the Study Plan in 2013 (ISR Part A Section 4.1.8.3) and operated a picket weir on the lower Indian River approximately 1.6 river miles from the confluence with the Susitna River. This variance was carried over and conducted in 2014.

RSP Section 9.7.4.1.3 indicated that a portion of Chinook, Chum, and Sockeye salmon captured in the Middle River (in excess of those required for radio-tagging) would be spaghetti-tagged to augment the ability to test assumptions about the representativeness of fish captured in the fishwheels. As described in Section 4.1.4.2, once the Indian River weir was rendered inoperable in 2014, the study team recognized that there would be limited opportunity to sample fish on the spawning grounds, so no spaghetti tags were applied at the Middle River fishwheels. This was a variance to the Study Plan that reduced the likelihood of being able to test whether fish were equally vulnerable to being captured and tagged over time. In lieu of this variance, the study team used fixed-site sonar at Site 1, bank of capture comparisons, and various length-frequency comparisons to provide insights into capture probabilities at the Middle River tag site (as described in Section 4.1.4.2).

In addition to the variances described above, the study team also implemented several modifications to the Study Plan methods in 2014, as proposed in ISR Section 7.1.2. RSP Section 9.7.4.1 indicated that 700 Chinook Salmon would be radio-tagged in the Yentna River in 2014. As proposed in ISR Section 7.1.2.1.1, the study team modified the Study Plan such that all Chinook Salmon captured at the Yentna River tag site in 2014 were marked with uniquely numbered dart tags, of which up to 300 fish were also to receive radio tags. This modification to the tagging strategy in the Yentna River better supported the study team's objective (Objective 8) to estimate Chinook Salmon escapement to the entire Susitna River (see Section 4.8.1 for more detail).

RSP Section 9.7.4.1.1 indicated that at least one fishwheel would be operated in Devils Canyon below the impediments from late June through late July to explore whether the sample size of radio-tagged Chinook Salmon moving into and above the impediments could be increased. However, as described in ISR Section 7.1.2.1.2, it was not feasible to operate a fishwheel in Devils Canyon for a variety of reasons (e.g., uncertainty with respect to catch rates at an unproven site, logistical challenges, and cost). No fishwheels were operated in Devils Canyon in 2013 or 2014. The study team implemented two additional variances to the Study Plan in 2014 to compensate for the lack of a Devils Canyon fishwheel: three fishwheels were operated in the vicinity of Curry (RSP Section 9.7.4.1.1 indicated two fishwheels would be used), and the number of radio tags allocated to Chinook Salmon was increased to 650 (RSP Section 9.7.4.1 indicated that 400 radio tags would be used). These variances were first implemented in 2013 (ISR Section 4.1.8.1; the radio tag goal for Chinook Salmon in 2013 was increased from 400 to 560). All three of these variances were proposed modifications to the Study Plan described in ISR Part C Section 7.1.2.1.2 that increased AEA's ability to achieve Objective 1.

In 2014, the study team implemented a variance to the Study Plan to provide for a total of 650 Chinook Salmon to be radio-tagged in the Middle River in 2014, with a goal of tagging 550 large (METF ≥ 50 cm [19.7 in]) and up to 100 small (METF < 50 cm [19.7 in]) Chinook Salmon. RSP Section 9.7.4.1.2 stated that 400 large Chinook Salmon would be radio-tagged in the Middle River. In 2013, modifications to increase the tag goal (from 400 to 560 large Chinook Salmon) and radio tag small Chinook Salmon were both implemented as variances (ISR Sections 4.1.8.1 and 4.1.8.2). As indicated in RSP Section 4.1.8.2, small Chinook Salmon comprised a substantial portion of the catch in 2013, so it was deemed worthwhile to apply some tags to this segment of the population to help characterize spawning locations. The study team proposed this change as a modification to the Study Plan in ISR Part C Section 7.1.2.1.2. In both years, this variance increased AEA's ability to achieve Objectives 1, 2, and 3.

RSP Section 9.7.4.1.6 indicated that AEA would assess the effects of holding time and density on the behavior of tagged fish. Due to stipulations in the Fish Resource Permit, all fish were tagged soon after capture in 2014, thereby reducing holding times and densities to levels that made comparisons of post-release survival and migration behavior unnecessary. This variance was implemented in 2013 (ISR Section 4.1.8.3) and 2014 and it was proposed as a Study Plan modification in ISR Part C Section 7.1.2.1.2. This variance did not affect achieving study Objective 1.

RSP Section 9.7.4.1.7 indicated that contingency table analyses would be used to compare the sex and age composition of radio-tagged fish. However, as stated in ISR Section 4.1.8.3, early in the 2013 field season it became clear that correctly identifying fish sex based on external morphological characteristics would be difficult at the Middle River fishwheels. Fish sex was therefore not recorded in 2014. Scales were also not collected from salmon in 2014, in light of the fact that size selectivity would be tested, fish were randomly selected for tagging, and the study team minimized the amount of handling time for each fish. Contingency table analyses were not conducted in 2014, which was a Study Plan variance that was proposed as a modification in ISR Part C Section 7.1.2.1.2. The same variance was implemented in 2013 (ISR Section 4.1.8.3). Since size selectivity could not be directly tested in 2014 due to the Indian River weir being rendered inoperable, this variance decreased the ability to assess capture probabilities at the Middle River fishwheels (Objective 1). To meet this Objective without recapture data, the study team relied on length-frequency comparisons and results from previous study years to provide insights into capture probabilities based on size at the Middle River tag site.

4.2. Objective 2: Determine the migration behavior and spawning locations of radio-tagged fish in the Lower, Middle, and Upper Susitna River

In 2014, AEA implemented the methods with respect to Objective 2 as described in the Study Plan, with the exception of modifications described in Section 7.1.2 of the ISR and variances described below (Section 4.2.4). Tasks to address Objective 2 were listed in RSP Section 9.7.4.2.

Three groups of radio-tagged fish were tracked: 1) adult Chinook, Coho, Chum, Pink, and Sockeye salmon radio-tagged at the Middle River fishwheels (PRM 123–126); 2) Chinook, Coho, and Pink salmon radio-tagged in the Lower River (PRM 33–34); and 3) Chinook Salmon radio-tagged in the lower Yentna River (Figure 3-1). The three study components and data analyses were tightly coordinated. All mobile and fixed-station receiver data were analyzed together, and analysis products were characterized in a consistent manner.

The primary function of the telemetry component was to track these tagged fish spatially and temporally with a combination of fixed and mobile receivers. Time/date stamped, coded radio signals from tags implanted in fish were recorded by fixed-station or mobile positioning. All telemetry gear (tags and receivers) was manufactured by ATS.

The types of behavior characterized included the following:

- Arrival and departure timing at specific locations/positions
- Direction of travel
- Residence time at specific locations/positions
- Travel time between locations/positions
- Identification of migratory, holding, and spawning time and locations/positions
- Movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, and turbidity).

These data, in conjunction with habitat descriptions, allowed characterization of migratory behavior and final destinations for salmon in mainstem habitats (main channel, slough, side channel, and tributary mouths) and tributaries. Spawning or final locations of tagged fish were used to determine the number and proportion of the tagged fish of each species using mainstem habitats.

4.2.1. Fixed-station Monitoring

Stand-alone operating telemetry arrays were deployed at strategic locations in the Lower, Middle, and Upper River to provide migration checkpoints, develop spawning ground inventories, and monitor the destinations of individual tagged fish. In total, 20 fixed-station receiver sites were operated in 2014 (Figure 3-1; Table C-1). This was one more fixed-station monitoring site from what was proposed in the RSP Section 9.7.4.2.1 and three less sites than were implemented in 2013 (ISR Part A, Section 4.2.1). The receiver site proposed for the Indian River weir was not operated in 2014 since the weir was rendered inoperable by a flood.

Ten fixed-station receiver sites were operated in the Lower River in 2013 and 2014 and were largely chosen to represent significant tributaries that were known to contain Chinook Salmon. Eight sites were located in tributaries (Lower Yentna, Skwentna, Upper Yentna, Talkeetna, Chulitna, Deshka Weir, Montana Creek Weir, and Middle Fork Chulitna Weir) and two sites were located on the mainstem Susitna River (Deshka Mouth [PRM 40] and Sunshine [PRM 83]). All Lower River sites were equipped with two antennas to detect both upstream and downstream passage (Table C-1). In 2014, the first Lower River site began operating the week of May 19 and all sites were demobilized by the week of September 22 (Table C-2).

Middle and Upper River sites were chosen to both provide geographic separation of the Middle River area to describe migration and spawning behaviors, and monitor at the appropriate resolution to quantify passage through Devils Canyon and the Upper River. Five fixed-station receiver sites were operated in the Middle River within or below Devils Canyon, all of which were located on the mainstem Susitna River (Lane Creek area [PRM 116.7], Middle River Gateway [PRM 130.1], Indian River confluence [PRM 142.0], Cheechako Creek [PRM 157.3], and Chinook Creek [PRM 160.4]). One fixed-station receiver site was operated on the mainstem Susitna River in the Middle River above Devils Canyon (Devils Island [PRM 166.9]). All Middle River sites were equipped with at least two antennas to detect upstream and downstream passage (Table C-1). One antenna at the Indian River site was oriented directly up the tributary to detect fish moving into the lower Indian River. In 2014, the first Middle River site began operating the week of April 28 and all sites were demobilized by the week of October 27 (Table C-3).

Four fixed-station receiver sites were operated in the Upper River, all of which were located in the mainstem Susitna River (Watana Dam site [PRM 187], Watana Creek [PRM 197], Kosina Creek [PRM 209], and Oshetna River [PRM235]). Each of these sites was equipped with two antennas to detect upstream and downstream passage. The Watana Creek, Kosina Creek, and Oshetna River sites were also equipped with a third antenna to detect fish passage into the respective tributaries (Table C-1). The first Upper River site began operating the week of April 28 and all sites were demobilized by the week of October 13 (Table C-3). All receivers scanned Chinook Salmon tag frequencies to begin the season. Additional frequencies were scanned as other species were captured and tagged in the fishwheels.

Fixed-station receivers were manually downloaded at least once a week. All fixed stations were designed to cover the entire channel width of the respective tributary or mainstem Susitna River. The Lane Creek and Watana Dam sites were operated with two receivers (all other sites had just one receiver). Lane Creek operated with one receiver scanning the tag frequencies deployed in the Lower River and the other receiver scanning the tag frequencies deployed in the Middle River (Table C-1). The Watana Dam site fixed-station operated with one receiver scanning all salmon tag frequencies and a second receiver, operating as a backup, scanning all Chinook Salmon frequencies. Additional methods pertaining to the set-up and operation of fixed-station receiver sites were provided in RSP Section 9.7.4.2.1.

4.2.2. Aerial Telemetry Surveys

In 2014, aerial telemetry surveys were conducted in the Lower River by fixed-wing aircraft and helicopter, and in the Middle and Upper River by helicopter. Survey coverage included the mainstem Susitna River from the mouth (PRM 0) upstream to areas above the Clearwater Creek confluence (PRM 266.6) in the Upper River, as well as most major tributaries. Surveys targeting adult salmon began on June 11 and continued through October 30 (Table C-4). Surveys were scheduled to cover each section of the river (Lower, Middle, and Upper rivers) at least once every five days for helicopter surveys and every 14 days for fixed-wing surveys. Survey timing was adjusted depending on the observed fishwheel catches in the Lower and Middle rivers.

Helicopter surveys were conducted at lower elevations (100–200 m [328–656 ft]) and at slower speeds than possible with fixed-wing aircraft, and therefore allowed more time for signal acquisition, higher spatial resolution, and fish habitat observations. In general, the spatial resolution of helicopter surveys was approximately 300 m (984 ft). Higher precision was achievable in reaches where conditions were most favorable and observers could determine whether the fish was in off-channel or mainstem habitat. Fixed-wing aerial telemetry surveys provided fish locations to the nearest river mile and helped to characterize the destinations of radio-tagged fish. Although the fixed-wing surveys provided less precise spatial resolution of fish locations (and habitat use) than the helicopter surveys, they more effectively covered the large lineal distances of the Susitna River tributaries where higher spatial resolution was not required.

The mainstem aerial telemetry surveys covered over 265 river miles, and multiples of that total when side channels and braids of the Lower River were included. To allocate survey effort efficiently and to the highest priority needs, resolution was a function of fish behavior. The highest priority and highest resolution needs were for fish that appeared to be holding or spawning. For migrating fish, resolution to the nearest 500 m (1,640 ft) of river was generally sufficient. Frequent surveys enabled high-resolution and time-intensive tracking effort to identify the exact locations of spawning and holding fish. During salmon spawning periods, the crew used a GPS with a Geographic Information System (GIS) based map containing the locations of each fish during the previous survey. Locations where fish were repeatedly observed were further investigated to ensure an accurate position for the fish and look for visual evidence of spawning activity.

Geographic coordinates were recorded for each signal detected using an integrated communication link between the telemetry receiver and a GPS unit. The position of the fish was determined by the position of the aircraft at the time of the highest signal power. Range testing of the mobile aerial setup was conducted in the Middle River to confirm detection ranges for typical flying heights, and receiver gains, as well as to work with the helicopter pilot to refine the methods for achieving highest spatial resolution.

Tag identification and GPS coordinates were archived and systematically processed after each survey. A data-handling script was used to extract unique tag records with the highest power level from the receiver files generated during the survey. These records were imported into a custom database software application (Telemetry Manager) and incorporated into a GIS-based mapping database. Geographically and temporally stratified data for radio-tagged fish were provided to the habitat sampling team (Study 9.9) and Instream Flow Study (Study 8.5) to inform their field sampling efforts.

4.2.2.1. Lower River Surveys

Aerial telemetry surveys of the Lower River and tributaries covered areas from the mouth of the Susitna River to the confluence of the Chulitna River (PRM 102.4). From June 12 to October 30, 63 fixed-wing and helicopter surveys were conducted in the Lower River (Table C-4).

Fixed-wing telemetry surveys were conducted in the Lower River and tributaries from June 24 to September 23. Tag frequencies for Chinook Salmon (tags released in the Lower and Middle rivers) were scanned during Lower River fixed-wing surveys from June 24 to August 11, after which there was little value in collecting additional detections from the inactive tags. Tag frequencies for Coho Salmon were scanned through September 23 (except for August 8 and August 11 in the Yentna River when no tag frequencies for Middle River Coho Salmon were scanned). Tag frequencies for Chum, Pink, and Sockeye salmon released in the Middle River, as well as Pink Salmon released in the Lower River, were not scanned during fixed-wing surveys in the Lower River. These fish were tracked during helicopter surveys (Table C-4).

Helicopter telemetry surveys were conducted in the Lower River and tributaries from June 12 to October 30. The mainstem Susitna River was highly braided in this section with side channels and sloughs, so complete coverage with the helicopter required approximately one day of effort. Lower River tributaries were typically surveyed for approximately three miles. More extensive surveys were conducted in tributaries during the fall to locate pink salmon tags in tributaries. Tag frequencies for Chinook Salmon were scanned during Lower River helicopter surveys from June 12 to August 31. Tag frequencies were scanned through September 30 for Chum and Pink salmon, October 16 for Sockeye Salmon, and October 30 for Coho Salmon.

4.2.2.2. Middle River Surveys

Helicopter telemetry surveys of the Middle River and tributaries were conducted from June 11 to October 28 and covered mainstem areas from the confluence of the Chulitna River (PRM 102.4) through Devils Canyon to the proposed Watana Dam site (PRM 187.1). The reach from the Chulitna to Portage Creek required approximately one day to complete and was conducted on 63 days (Table C-4). The river between Devils Island (PRM 166.9) and the proposed Watana Dam site was usually flown on the same day as the surveys of the Upper River, but also on additional days to download fixed stations (a total of 49 days). Once adult salmon were observed entering Devils Canyon, the Susitna River and its tributaries from Portage Creek to Devils Island were surveyed every 1–2 days (June 28 to August 6) to ensure information on passage timing, hold duration, and potential spawning destinations. These frequent flights continued until upstream movement of fish in Devils Canyon had stopped. During the peak Chum and Sockeye salmon migration and spawning periods in the Middle River, the river section from the mouth of the Chulitna River to Devils Island was surveyed every third day (August 9 to October 28) to monitor the movements of salmon into spawning and holding locations. The interval between flights, shorter than the proposed 5-day interval (RSP Section 9.7.4.2.2), was proposed as a Study Plan modification that was detailed in ISR Part C Section 7.1.2.2 and implemented in 2014. For both Middle and Upper River helicopter surveys, tag frequencies were scanned through August 31 for Chinook Salmon, September 30 for Chum and Pink salmon, October 28 for Sockeye Salmon, and October 30 for Coho Salmon.

The increased frequency of aerial telemetry surveys conducted on the Middle River in 2014, from Whiskers to Portage creeks, provided multiple detections for most of the radio-tagged fish in this portion of the river. These detections before, during, and after the spawning period allowed for the identification of fish that were likely migrating and/or spawning in mainstem habitats. In 2014, there was a high degree of consistency between the potential spawning sites identified for radio-tagged Sockeye Salmon, and to a lesser degree Chum Salmon, and the visually confirmed redd sites for these species. This consistency provided further support as to the usefulness of using radio telemetry to detect spawning locations in mainstem habitats of the Susitna River.

4.2.2.3. Upper River Surveys

Helicopter telemetry surveys of the Upper River and tributaries were conducted from June 11 to October 14 and covered the mainstem areas from the proposed Watana Dam site (PRM 187.1) to upstream of the Clearwater Creek confluence (PRM 266.6). This reach included approximately 48 relatively confined river miles. This survey required approximately one day to complete and was conducted on 23 days (Table C-4). It took less time to complete this survey when done in conjunction with Middle River surveys because less conveyance time was required. Helicopter telemetry surveys of the Upper River generally were triggered by the detection of fish moving above the Devil Creek fixed station. When tags were detected above Devils Canyon, the aerial telemetry survey continued upstream and into the tributaries until all of the tag(s) that had passed were located. Surveys for Chinook Salmon were conducted until the end of August.

4.2.3. Telemetry Data Analysis

4.2.3.1. Data Filtering

As in 2012 and 2013, the following criteria were set for tag detection records to be considered valid in 2014:

1) for fixed-station receiver data, there must have been at least five detections recorded on directional antennas per minute (single records, or records separated by more than one minute were rejected; all detections on the pooled master antennas were ignored; the criterion at noisy receivers was 7 signals in one minute (slight noise) or 100 hits in 60 minutes (severe noise);

2) for mobile data, single detections were allowed but were closely scrutinized on a case-by-case basis; and

3) any detections requiring unrealistic travel times were removed.

Additional details regarding telemetry data processing were provided in Section 4.2.5.4 of the 2012 study report (AEA 2013a).

4.2.3.2. Classifying Spawning Destinations and Holding Locations

The detection history of each individual radio-tagged salmon was examined in order to classify the fish to one of two types of "spawning/holding destination" (Tributary vs. Mainstem Destination) based on temporal patterns in their detection positions. Spawning and holding locations for salmon are considered together from a biological and analytical perspective for the study. The study team used detection histories, instead of final tag locations, to assign a destination because salmon can drift downstream after spawning or death, obscuring the true destination and distribution of the fish. The algorithms that were used to define potential fish spawning behavior were developed based on assumptions about fish behavior and physiology. The specific steps used to classify each fish are described below.

Since these classifications were based on telemetry detections, they cannot be considered as 'confirmation of spawning', hence terms such as 'likely' and 'possible' were used in this report (see below). Confirmation of spawning/holding required further research, including the use of sonar for Chinook Salmon in turbid water (Objective 4), as well as aerial, boat-based, or visual surveys for all salmon species. As much as possible, the analyses described below were performed in season, and provided a list of potential locations for field crews to visit for confirmation of spawning activity.

Not all fish could be assigned to one of the two types of spawning/holding destination. For example, several fish were excluded from analyses because they exhibited unexpected behaviors that suggested potential handling-related effects. The detections of these fish indicated that: 1) the fish never left the release area, 2) the tag was never detected, or 3) the fish moved only in a downstream direction. Other tagged fish had tracking histories that suggested they never arrived at their spawning destination and thus, these fish were assigned to a classification called "Other Mainstem." The Other Mainstem category comprised all fish that were included in the analyses but which could not be assigned to one of the two destination categories.

Fish assigned to the Tributary Destination category included all salmon that moved into a tributary river or stream flowing into the Susitna River, presumably for spawning, regardless of whether they subsequently returned to the mainstem Susitna River. The tributary into which the fish entered was recorded as its spawning "stock." Any fish that entered one tributary, exited, and subsequently entered another tributary was given a stock assignment based on the tributary where more time was spent. Any fish that spent less than 6 days in a tributary was examined as described below, in order to assess it as a possible mainstem spawner. The study was not designed to identify exact spawning positions within the tributaries, so spawning locations in tributaries were not described.

After classifying the Tributary Destination fish, all remaining fish were classified on a fish-by-fish basis either into the Mainstem Destination or Other Mainstem category. Classifications were assigned after displaying a fish's complete detection history over ortho-rectified aerial imagery, and examining each detection in succession. Before proceeding with classification, several detections were eliminated from consideration. First, movements were ignored after the tag entered mortality mode (unless the movements indicated the tag's sensor malfunctioned). Second, downstream movements following the most upstream location were typically ignored as the fish may have already been dead or moribund, unless the fish showed subsequent upstream movements. Third, all fish that died within two weeks of tagging were classified immediately into the Other Mainstem category. The remaining data were examined, looking for any geographically aggregated cluster of detections which might indicate that the fish should potentially be included in the Mainstem Destination category. Clusters in which the last live detection was earlier than the published species-specific spawn-timing window (Schmidt and Bingham 1983, Barrett et al. 1985a,b, Jennings 1985, Thompson et al. 1986) were ignored as they were considered to be aberrant data points possibly resulting from bear-kills, angler-catches, handling related-mortalities, or other causes of mortality, and they were unlikely to have been at their spawning destination at the time of death (n = 32 combined for 2012, 2013, 2014). Each remaining cluster was scrutinized before placing it into one of two 'relative spawning probability' groups:

- Clusters were classified as "likely" spawning/holding locations based on the number of repeat detections and density of unique detections in the same area. A likely spawning cluster consisted of multiple unique detections in relatively close proximity to one another. The number of unique detections was variable, but could be as few as three if they were grouped tightly enough together; the distance between unique detections also varied, but was generally within a few hundred meters (< 1,000 ft). In these cases, the fish was assigned to the Mainstem Destination category.

- Clusters were classified as "possible" spawning/holding locations if the cluster was made up of fewer unique detections (sometimes only two); or, when more unique detections were present, but the locations were loosely aggregated. Also included in this group were clusters located in areas where fish may have been holding (rather than spawning, e.g., tributary mouths). These fish were also assigned to the Mainstem Destination category.

- When tags were physically recovered in a known mainstem spawning area (based on data for the 1980s studies), the recovery location was listed as a "likely" Mainstem Destination, regardless of the nature of the detection cluster.

Salmon in the Mainstem Destination category had a cluster of detections in the potential spawning/holding area, and a single representative location was selected from within the cluster. The single selected point was either the last live detection, the detection with the most powerful signal strength, or a detection that appeared to represent the center of mass of the cluster. For each fish, the position of its potential spawning/holding location was plotted on ortho-rectified aerial imagery in order to categorize the habitat as either Side Channel/Slough, Tributary Mouth, or Mainstem Proper, based on the position of the potential spawning location. All tag locations classified as spawning locations ("likely" and "possible") following radio-telemetry analysis were further investigated to confirm spawning and holding activity. This included the use of sonar for Chinook Salmon in turbid water, as well as aerial, boat-based, and visual surveys for all salmon species.

The timing of spawning events could not be confirmed using radio-telemetry. However, the tracking data were used to estimate approximate spawn-timing windows. For each fish assigned to Mainstem Destinations, their single representative location had an associated date. Taken together, the dates corresponding to all the representative locations had a distribution, whose 10^{th} and 90^{th} percentiles were used to describe mainstem spawn timing. For Tributary Destinations, the dates when fish were detected within the assigned spawning tributary were used to generate a spawn timing distribution. Detections in mortality mode were excluded, and so were fish that went to minor tributaries (i.e., those for which less than 10 percent of the fish in that river section had destinations). Tributary spawn timing was described in terms of the 10^{th} and 90^{th} percentiles of the dates in this distribution.

4.2.4. Variances

RSP Section 9.7.4.2.1 listed ten fixed-station receiver sites to be used in the Middle and Upper rivers. ISR Part C Section 7.1.2.2 described a Study Plan modification to include eleven fixed-station receiver sites in the Middle and Upper rivers in 2014, of which seven sites were listed in RSP Section 9.7.4.2.1 (Lane Creek, Gateway, Indian River confluence, Cheechako Creek, Chinook Creek, Devil Creek area, and Kosina Creek) and four sites were not (Indian River weir, Watana Dam sonar site, Watana Creek, and Oshetna River). However, only ten sites were used in 2014 (see Section 4.2.1). One of the eleven sites proposed for 2014 was planned for the Indian River weir in order to detect radio-tagged salmon passing the weir. Since the weir was rendered inoperable by a flood on June 26 prior to the start of the Chinook Salmon migration into the Indian River, this fixed-station receiver site was not operated in 2014. This variance did not affect AEA's ability to achieve Objective 3.

RSP Section 9.7.4.2.2 indicated that aerial telemetry surveys would be scheduled at five-day intervals with the intent to ensure a maximum of seven days between surveys with weather contingencies. In 2014, the study team implemented a variance to the Study Plan and increased the frequency of surveys in the Middle River to every 1-2 days between Portage Creek and Devils Island from June 28 to August 6, and every third day between the Chulitna River and Devils Island from August 9 to October 28 (as described in Section 4.2.2.2). This change was a proposed Study Plan modification described in ISR Part C Section 7.1.2.2. This variance improved the resolution of the geographic positions of tagged fish in the Middle River (below, within, and above Devils Canyon) and helped AEA achieve study Objectives 1, 2, and 3.

4.3. Objective 3: Characterize adult salmon migration behavior and timing within and above Devils Canyon

In 2014, AEA implemented the methods with respect to Objective 3 as described in the Study Plan, with the exception of modifications described in ISR Part C Section 7.1.2 and variances described below (Section 4.3.5). Tasks to address Objective 3 were listed in RSP Section 9.7.4.3.

4.3.1. Fixed-station Monitoring

A combination of aerial telemetry surveys and fixed stations below, within, and above Devils Canyon was used to determine the migration timing and behavior of radio-tagged salmon that passed into the Upper River (Figure 3-1). As described in Section 4.2.1, four fixed-station receiver sites were deployed in the Upper River (Watana Dam site, Watana Creek, Kosina Creek, and Oshetna River) at locations where they had the highest probability of detecting radio-tagged salmon. Fixed stations deployed at the confluences with Kosina Creek and the Oshetna River were used to guide aerial survey efforts needed to identify spawning areas in the Upper River.

4.3.2. Aerial Telemetry Surveys

Aerial telemetry surveys were conducted via helicopter within and above Devils Canyon from June 11 to October 28. These surveys provided location data for radio-tagged fish in areas that were not directly monitored by fixed-station receiver sites (i.e., in the mainstem between fixed-station receiver sites, and within tributaries). These detections assisted with the successful tracking of fish movements within and above Devils Canyon, providing day-to-day locations, passage timing, and hold durations. Surveys were typically flown until all radio-tagged fish known to have passed the Devil Creek fixed station had been detected. Additional details on the range of survey dates, survey frequency, and survey coverage were provided in Section 4.2.2, and details regarding the 2014 Study Plan variance to increase the frequency of aerial telemetry surveys were provided in Section 4.2.4. Aerial telemetry data were critical for the identification of potential spawning behavior and detecting potential spawning and holding locations. The goal of 300 m (984 ft) accuracy of geographic position when locating tagged fish, including spawning and holding fish (RSP Section 9.7.4.2.2), was achieved by the combined effect of airspeed, flight path, antenna direction, and receiver gain control. In addition, the aerial detections contributed to the estimation of detection efficiencies for each fixed station. The timing and proportion of all tagged salmon that passed Devils Canyon was calculated and compared with the remaining tagged population, and their final spawning locations were identified. The total number of radio-tagged fish that were detected at or above Gateway Station (PRM 130.1) was used to estimate the proportion of fish that migrated through the Middle River and above Devils Canyon.

4.3.3. Aerial Spawner Surveys

Aerial spawner surveys (by visual observation via low-flying helicopter) to determine the distribution and relative abundance of adult Chinook Salmon were conducted in Susitna River tributaries within and above Devils Canyon, upstream to and including the Oshetna River. These surveys helped to identify potential spawning locations for Chinook Salmon that may not be represented by the radio-tagged segment of the population. A total of seven aerial spawner survey events were conducted at approximate weekly intervals from July 14 through August 19, 2014 (Table 4.3-1). The survey extent covered the same major tributaries and clear-water areas of the Susitna River as during 2012 and 2013 (Table 4.3-1; Figure 4.3-1). From Cheechako Creek to the Oshetna River, a total of 18 streams were surveyed; 12 tributaries to the Susitna River and six secondary tributaries. All streams were surveyed from their confluence up to 3,000 ft in elevation, to a predetermined barrier to anadromous fish passage, or to the stream's headwater origin, whichever came first.

Additionally, two lakes in the Tsisi Creek drainage were surveyed in 2014 specifically to look for spawning Sockeye Salmon. Based on anecdotal information from a pilot that flies planes frequently in the Upper River, Alaska Department of Fish and Game (ADF&G) staff requested AEA extend the spawner surveys to include these locations and evaluate the claim that sockeye salmon may to be spawning in these lakes. Five surveys of the Tsisi lakes were conducted from late July to mid-August 2014 (Table 4.3-1).

Survey confidence was estimated independently for each stream during each survey event by ranking three variables that may have affected the observers' ability to see fish: 1) sun glare on the water; 2) clarity of the water (i.e., turbidity, not white water created by rapids); and 3) overhanging vegetation. Variables were ranked from zero to four, where four indicated optimal survey conditions and zero indicated poor survey conditions.

Quality-control measures included employing two observers on all surveys, with one observer remaining consistent throughout the study. Observers communicated fish sightings to each other and when necessary, the flight was slowed or halted until both observers had confirmed the number of fish present. The helicopter pilot was consistent for survey events two through five. Observer efficiency was evaluated with a one-time paired independent aerial spawner survey during the peak of Chinook Salmon spawning in Indian River.

4.3.4. Using Sonar to Enumerate Salmon at the Proposed Dam Site

As stated in Section 1 of the FERC SPD, it was recommended that AEA evaluate the feasibility of putting in a weir or operating a sonar counting station at or near the dam site in the next year of study to count fish migrating through Devils Canyon (FERC 2013a). Prior to the 2013 field season, operation of a weir near the dam site was determined to be not feasible due to the physical limitations of a weir withstanding the normal range of discharges for the mainstem Susitna River. In 2013, AEA assessed the feasibility of placing a sonar counting station at or near the dam site (see ISR Appendix G). Results from 2013 field activities showed that it was likely feasible to count salmon-sized fish and corroborate counts with radio-telemetry.

In 2014, AEA used sonar (ARIS) to count the number of salmon-sized fish passing the proposed Watana Dam site (PRM 187.1) from July 6 to August 22. Methods describing this study component were provided in the September 2014 *Implementation and Preliminary Results Technical Memorandum* (AEA 2014a) and Appendix G. The primary objectives for this study component were to estimate the number of net upstream-moving Chinook Salmon that passed through the sonar beams, and to describe temporal (daily and hourly) and spatial (range of passage) patterns of Chinook Salmon observations. AEA also implemented a variance to the Study Plan in 2014 and collected bathymetry and water-velocity profiles (acoustic Doppler current profiler, ADCP) at the monitoring sites to corroborate assumptions regarding the fish migration corridor at this site.

4.3.5. Variances

RSP Section 9.7.4.2.2 indicated that aerial telemetry surveys would be scheduled at five-day intervals. As proposed in ISR Section 7.1.2.2, AEA modified the Study Plan by increasing the frequency of aerial telemetry surveys from the mouth of the Chulitna River to Devils Island to three-day intervals in 2014. Increasing the frequency of aerial telemetry surveys was also implemented as a variance in 2013 (ISR Section 4.3.5). This modification enhanced AEA’s ability to characterize migration behavior and achieve study Objective 3.

To support further assessment of the fish migration corridor at the Watana Dam sonar site, AEA conducted seven ADCP transects in 2014. To supplement the velocity transects, bathymetric data were also collected. These two tasks were variances to the Study Plan that increased the likelihood of AEA achieving study Objective 3.

4.4. Objective 4: Use available technology to document salmon spawning locations in turbid water

In 2014, AEA implemented the methods with respect to Objective 4 as described in the Study Plan, with the exception of modifications described in Section 7 of the ISR and variances described below (Section 4.4.3).

In late July 2014, AEA used a Dual Frequency Identification Sonar (DIDSON) to characterize suspected Chinook Salmon spawning in turbid water of mainstem habitat of the Middle River. This was a variance to the Study Plan since RSP Section 9.7.4.4 indicated that sonar would be used to characterize any suspected salmon spawning in turbid water. As described in ISR Part A Section 6.5, sonar was not able to differentiate between Chum, Coho, Pink, and Sockeye salmon due to overlap in their run timing and body size. This variance was proposed as a Study Plan modification in ISR Part C Section 7.1.2.4. The use of a DIDSON in 2014 followed the RSP (Section 9.7.4.4), but varied from what was used in 2013 (ARIS; see ISR Part C Section 7.1.2.4), yet both tools have similar capabilities. Potential Chinook Salmon spawning locations were identified from historic spawning locations reported in the 1980s, and from 2012, 2013, and 2014 detections of radio-tagged fish. Sites with physical features indicative of Chinook Salmon spawning habitat were also sampled on an opportunistic basis. Potential spawning sites that could not be accessed by boat, or sites with physical characteristics not suitable for sonar sampling (e.g., low water or entrained air), were not sampled.

Additional site-specific information was collected and subsequently relayed to the Fish and Aquatics Instream Flow Study (Study 8.5) team.

4.4.1. Sonar Equipment and Methods

The sonar system consisted of a Sound Metrics Corporation (SMC) DIDSON, SMCX2 dual-axis rotator assembly, data transmission cable, top-side control box, laptop computer with DIDSON data acquisition software (version 5.26.06), and portable external hard drive. The system was deployed using a pole-mounted winch that was secured to the gunwale of a jet-drive boat. Once the sonar was lowered to an appropriate depth (which varied depending on site-specific conditions), the SMCX2 rotator was used to pan and tilt the sonar from the surface to search for fish activity. The system was powered by a battery bank consisting of four, 12-volt (V), deep-cycle batteries. The battery bank was recharged at the end of each day with a 2,000 watt (W) Honda EU2000i generator.

At each site, the boat was moored and the DIDSON was lowered to scan for suitable substrate and/or the presence of Chinook Salmon. If suitable substrate was observed, a scan was performed until fish were observed, or for a maximum of 15 minutes (if no fish were observed). Once fish were observed, recording of sonar imagery was initiated. If suitable substrate was not present or no fish were observed at the sample site, the DIDSON was retrieved and the system was relocated to another site. Only habitats with features known to support salmonid spawning (as defined by Groot and Margolis 1991; Quinn 2005) were surveyed. Sites were excluded if:

- The location was in the thalweg of the mainstem Susitna River, with no structure providing relief from the river flow.

- The location was an area of high velocity with no holding areas (i.e., greater than 1.5 meters per second [m/s; 4.9 feet per second (ft/s)]).
- The location consisted of shallow water with high velocity.
- The location was in the middle of a rapid or area with high velocity.
- The location had unsuitable substrate (i.e., mud, silt).
- Excessive amounts of entrained air occurred at the sample location.

Data were initially collected using 10–20 m (33–66 ft) sample windows. Typically the sonar unit was tilted down to allow the sample beams to spread along the substrate throughout as much of the sample range as possible. In reaches with a non-uniform slope or that had obstructions present, the DIDSON depth and tilt angle were adjusted as necessary to maximize coverage of the substrate.

When fish were located and spawning activity was suspected, up to 30 minutes of data were collected. Adjustments of the pan and tilt angles were made as required to maintain visual observation of individual fish. Due to the presence of Chum Salmon at some sites, the minimum total length (TL) for a target to be considered a Chinook Salmon was increased to 80 cm TL (31.4 in).

Data were collected using a frame rate of eight frames per second. Data were ported directly to external hard drives, and backed up and archived to additional hard drives after each survey. Locational data were collected using a hand-held GPS unit to allow for geo-referencing of sample locations.

4.4.2. Sonar Data Analysis and Reporting

Data processing involved playing back the streaming data files using DIDSON software. Files were reviewed to note the following for each survey:

- Presence or absence of Chinook Salmon. When adult salmon-sized fish were detected, total lengths of individual fish were estimated using the software's sizing tool.
- Presence or absence of spawning behavior activities. Behavior of individual fish was reviewed and observations of spawning activities (redd digging or covering, redd guarding, paired fish, aggressive territorial behaviors, egg laying, milt expulsion, quivering) were noted.
- Presence or absence of redds.

4.4.3. Variances

RSP Section 9.7.4.4 indicated that sonar would be used to characterize any suspected salmon spawning in turbid water of the mainstem habitats of the Susitna River (as indicated by radio-telemetry analysis). As discussed in Study 9.7 ISR Part A Section 6.5 for 2013, the use of sonar was limited particularly in shallow water, close to the shoreline, and at sites where multiple species of similar body lengths were present. It was confirmed that many of the shallow locations that were not accessible for sonar use were spawning sites for Chum and Sockeye salmon. Thus in 2014, the study team implemented a variance to the Study Plan and used sonar only to characterize suspected Chinook Salmon spawning. This variance was proposed as a Study Plan modification in ISR Part C Section 7.1.2.4. Although this variance limited the ability to document spawning locations in turbid water for Chum, Coho, Pink, and Sockeye salmon in 2014, the Objective was met by demonstrating that sonar is not an effective tool given the typical habitat conditions where these species spawn.

4.5. Objective 5: Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon

AEA implemented the methods with respect to Objective 5 as described in the Study Plan with no variances. Comparisons were made between this study's results (2012–2014) and historical results (1981–1985) that characterized the relative abundance; locations of spawning and holding salmon; and use of mainstem, side channel, slough, and tributary habitat types by adult salmon.

Research conducted in the early 1980s provided annual abundance estimates (1983–1985) relevant to at least four fishwheel sites along the Susitna River. These abundance estimates were apportioned to mainstem, sloughs, and tributaries. The 1980s studies relied heavily on visual observations of fish and abandoned late-season redds, and therefore, may have underestimated the use and relative importance of mainstem habitats, many of which occur in turbid water during a substantial portion of the spawning period. Another concern was that data collected approximately 30 years ago may not characterize the current habitat use by salmon in the mainstem Susitna River.

This study addressed both of these concerns by deploying a similarly scaled study of the spawning runs to the Susitna River in 2012, 2013, and 2014, and by using radio telemetry and sonar technology not available in the 1980s. Both methods provided a more rigorous characterization of the use of mainstem habitats than methods used in the 1980s. To the extent spawning distribution and habitat use in the current study were similar to earlier studies, the current study greatly increased the sample size and confidence in the conclusions from studies in both periods.

4.5.1. Variances

No variances from the methods described in the Study Plan occurred during the 2014 study season.

4.6. Objective 6: Generate counts of adult Chinook Salmon spawning in the Susitna River and its tributaries

The study team implemented the methods with respect to Objective 6 as described in the Study Plan, with the exception of modifications described in Section 7.1.2 of the ISR, and variances described below (Section 4.6.1). In 2014, this objective was addressed by attempting to operate a weir on the Indian River (see Section 4.1.4.2) and conducting aerial spawner surveys in the Indian River (see Section 4.3.3). The purpose of this work was to establish survey-area mark rates (proportion of fish tagged in different areas) that would support inferences about the representativeness of tagging across spawning stocks. In addition, mark rates from these areas could be used to estimate the abundance of salmon passing the tagging sites (the weir was rendered inoperable by a flood; the ensuing study variances are described in detail in Section 4.6.1). The aerial spawner surveys were not intended to provide a direct estimate of the total Chinook Salmon abundance. Instead, they provided a minimum count, and then helped to establish minimum and likely tributary-specific mark rates, as was done for Portage Creek (2012) and the Indian River (2012 and 2013) in previous years.

Concurrent aerial telemetry surveys were conducted in the Indian River in July and August 2014 to determine the number of live radio-tagged Chinook Salmon present. Protocols developed based on 2012 and 2013 experiences were implemented in 2014 to survey the Indian River. Multiple aerial telemetry surveys were flown bracketing the entire spawning period of Chinook Salmon. Survey aircraft were equipped with telemetry receivers and GPS to identify positions of radio-tagged fish.

4.6.1. Variances

RSP Section 9.7.4.6 indicated that Chinook Salmon would be examined on selected spawning grounds to test whether fish were equally vulnerable to being captured and radio-tagged. Results from the 2012 *Adult Salmon Distribution and Habitat Utilization Study* filed in February 2013 (AEA 2013a) indicated that it would be unlikely to obtain sufficient numbers of fish samples through spawning ground surveys to provide a robust mark rate, and in-turn, an estimate of the numbers of fish above Devils Canyon (as established during the FERC Study Dispute process). Therefore, prior to the 2013 field season, the study team decided to replace the spawning ground surveys with the operation of a weir and underwater video system, along with a fixed-station receiver site, on the Indian River to enumerate tagged and untagged fish, and establish mark rates. This change was implemented as a variance in 2013 (ISR Section 4.1.8.3) and 2014, and was a proposed modification to the Study Plan described in ISR Part C Section 7.1.2.1.2. The methods and approach of using weirs to obtain this information was consistent with RSP Sections 9.7.4.1.5 and 9.7.4.6. The same two metrics (i.e., mark rate and size distribution of tagged/untagged fish) would be developed from fish counts at the weir (and telemetry detections) that would have been developed from spawning ground surveys. However, as described in Sections 4.1.4.2 and 5.1.2.4, the Indian River weir was rendered inoperable by a flood on June 26, 2014, prior to the onset of the Chinook Salmon run.

In response, the study team considered alternative methods for estimating the mark rate of Chinook Salmon in the Indian River to ensure the study objective was met. One option considered was to install a sonar unit at or near the weir site to count passing fish. However, the advantages of being able to install a sonar unit soon after the weir was rendered inoperable were outweighed by the fact that multiple salmon species would be present in the river by mid-July, and thus Chinook Salmon could not be reliably counted (since sonar cannot distinguish between species). The study team considered conducting a gillnet operation below the Indian River weir site to capture and sample Chinook Salmon. Although physically handling fish is a reliable method of collecting mark-rate and length data, physical conditions in the lower river were not suitable for gillnetting, so it was unlikely crews could capture a sufficient number of fish. Also, there may be negative impacts on fish health due to the capture and handling process. The study team also considered stream walks to count Chinook Salmon, but their experiences in 2012 proved this method was unlikely to succeed.

The timing of the loss of the weir was shortly before the onset of the Chinook Salmon run into the Indian River. Thus, an immediate adjustment was required to ensure data were collected that would fulfill the objectives of estimating the escapement of Chinook Salmon returning to the Indian River and establishing a mark rate that could be used to make inferences about the relative abundance among recovery locations (e.g., above the proposed dam site). AEA decided that the best available option to fulfill the objectives was to increase the number of aerial spawner surveys and aerial telemetry surveys (every third day during the spawning period) in the Indian River. Instead of using the underwater video system at the weir, fish counts from aerial spawner surveys and area-under-the-curve (AUC) methods (Ames and Phinney 1977; English et al. 1992) were used to generate an escapement estimate for Chinook Salmon returning to the Indian River in 2014. The marked fraction of Chinook Salmon present in the Indian River, as well as estimates of residence time (i.e., the length of time Chinook Salmon were present in the river) that were required for the AUC approach were estimated from aerial detections of radio-tagged fish. Additional information related to AUC methods is provided in Appendix H. No fish length-frequency information was collected using these methods.

4.7. Objective 7: Collect tissue samples to support the Fish Genetics Study

AEA implemented the methods with respect to Objective 7 as described in the Study Plan with no variances. The task for this study component was to collect genetic samples from adult anadromous salmon in conjunction with addressing Objectives 1 and 2. Tissue samples were taken from all radio-tagged salmon. Sample collections were coordinated with the Genetic Baseline Study team (see ISR Study 9.14).

4.7.1. Variances

No variances from the methods described in the Study Plan occurred during the 2014 study season.

4.8. Objective 8: Estimate the system-wide Chinook Salmon escapement and the Coho Salmon escapement to the Susitna River above the Yentna River, and the distribution of those fish among tributaries of the Susitna River

In 2014, AEA implemented the methods with respect to Objective 8 as described in the Study Plan, with the exception of modifications described in Section 7.1.2 of the ISR, and variances described below (Section 4.8.1). A commonly applied two-event, capture-recapture experiment was used to estimate the annual abundance of Chinook Salmon in the entire Susitna River drainage, and the Coho Salmon abundance in the Susitna River above the Yentna River confluence. Due to the river channel configuration and availability of acceptable fishing sites, the abundance of Chinook Salmon for the entire Susitna River was designed to be the sum of two independent experiments: the abundance of Chinook Salmon in the Lower River (Susitna River above the Yentna confluence) plus the abundance of Chinook Salmon in the Yentna River. At the Lower River site, the capture event was provided by fishwheels and (and gillnets for Chinook Salmon only) operated throughout the seasonal salmon migration. Substantial effort was made to apply radio tags in proportion to abundance. Later in the salmon migration, recaptures were collected from tributary weir and sonar sites forming the second event of the experiment. In the Yentna River, the capture event was also provided by fishwheels (and gillnets for Chinook Salmon only) operated throughout the seasonal salmon migration, with effort expended to apply radio tags and also dart tags to fish in proportion to abundance. Radio tags were applied according to average run timing, and dart tags were applied to every healthy Chinook Salmon measuring 50 cm (19.7 in) METF or greater. The recaptures were collected from fishwheels (and gillnets for Chinook Salmon only) located 19.3 kilometers (km; 12 miles [mi]) farther upstream on the Yentna River. The abundance at the fishwheel sites on the Susitna (Chinook and Coho salmon) and Yentna (Chinook Salmon) rivers was estimated. Length and timing information from the tagged and untagged fish was used to assess the validity of most assumptions. Behavior of radio-tagged fish following tagging also provided information for evaluating two critical assumptions: knowing how many tagged fish have "entered" the experiment, and whether their behavior compromised the experiment.

Two fishwheels and drift gillnets were operated on the Lower River from May 22 to August 26, 2014, to capture fish for marking with radio tags (Table A-1; Figures A-1, A-2, and A-6). Two fishwheels and drift gillnets were operated on the Yentna River (RM 6) from May 22 to June 25 to capture fish for marking with radio tags and dart tags (Table A-2; Figures A-3, A-4, and A-7). Lengths of tagged and untagged fish, and a tissue sample from radio-tagged fish (for genetics sampling), were collected at each site. Dart tags (model FT-1-94 from Floy® Tag, Seattle, WA) were 15 cm (6 in) long, yellow, and uniquely numbered, with the unique number printed twice on each tag. Fish at Yentna RM 6 were tagged on the left side, immediately below the dorsal fin, with the barb on the tag inserted deep enough to lock into the dorsal pterygiophores. A hole-punch was used to make a hole in the adipose fin as a secondary mark to detect tag loss.

Weirs on tributaries of the Lower River were used to recapture tagged fish and estimate the proportion of each species' run that had a tag. At the weir recapture sites, Chinook Salmon were counted visually and tagged fish were detected by a fixed-station receiver adjacent to the weir (Table C-2). A weir was operated on the Deshka River from May 19 to September 2, 2014, (Table B-1) and on Montana Creek from June 4 to September 21, 2014 (Table B-2). The use of Montana Creek as a weir site represented a variance from the proposed Willow Creek site, as described in the ISR (Part A, Section 4.8.1). Fish length was sampled at each site for estimating the number of Chinook Salmon (METF $\geq$ 50 cm [19.7 in]) and testing assumptions of the mark-recapture experiment. Sonar was operated on the Middle Fork Chulitna River from June 20 to August 3, 2014 (the use of sonar rather than a weir represents a variance from the RSP, as described in the ISR, Part A, Section 4.8.1). At the sonar site, the total number of fish passing was counted by examining the recorded sonar files post-season, and tagged fish were detected by a fixed-station receiver adjacent to each sonar site (Table C-2).

In the Yentna River drainage, two fishwheels and gillnet operations were conducted at RM 18 to recapture tagged Chinook Salmon from May 24 to August 27, 2014 (Figure A-3). In 2013 and 2014, this represented a variance from the RSP (Section 9.7.4.8), as detailed in the ISR (Part A, Section 4.8.1). All Chinook Salmon were examined for a dart tag and an adipose fin punch. If a tag was found, the distal half of the tag, containing one of the unique tag numbers, was clipped off and retained as an absolute record of the tag found. Fish length was also sampled at this site for testing assumptions of the mark-recapture experiment.

A two-event, capture-recapture experiment was also used to estimate the abundance of Coho Salmon in the Lower River. Two fishwheels were used on the Lower River (PRM 33–34) to capture Coho Salmon for marking with radio tags, from July 6 to August 26, 2014 (Table A-1; Figures A-1, A-2, and A-6). Coho Salmon were counted, inspected for tags, and a sample measured for length at the weirs on the Deshka River and Montana Creek, as described above.

4.8.1. Variances

RSP Section 9.7.4.8 indicated that weirs would be operated on the Middle Fork Chulitna River and Willow Creek among other locations to inspect fish for estimating the proportion with tags. However, Montana Creek was selected as a weir site instead of Willow Creek in 2014. Montana Creek had a more uniform channel configuration and lower water velocity than Willow Creek. The two creeks were located near each other, had similar discharge and watershed characteristics, and had similar Chinook and Coho salmon run sizes. This variance also occurred in 2013 (ISR Part A Section 4.8.1) and did not affect AEA's ability to achieve study Objective 8.

A weir was not operated for Chinook Salmon on the Middle Fork Chulitna River in 2013 (see Study 9.7 ISR, Part A, Section 4.8.1) or 2014. In June of both years, the stream discharge was too high for weir installation; instead, the sonar unit designated for Lake Creek was reassigned to the Middle Fork Chulitna River in order to obtain the counts necessary for the abundance experiment. River discharges remained too high to install the weir at a later date. While a sonar was operated in 2014, post-season data analysis revealed that focus and aiming problems prevented obtaining reliable counts and length measurements. This variance did not prevent meeting the abundance and distribution objectives for the Lower River and the Susitna River abundance estimate component of study Objective 8 in either year but required additional assumptions for generating the Chinook Salmon escapement estimate. Without the Middle Fork Chulitna River, it was assumed that all Chinook Salmon stocks in the Susitna River were adequately represented by the Deshka River and Montana Creek stocks for the tag recapture sampling. Depending upon how similar the Middle Fork Chulitna River sampling results had been to the Deshka River and Montana Creek results, the accuracy and precision of the Lower River Chinook Salmon abundance estimate could be affected in either a positive or negative way.

RSP Section 9.7.4.8 indicated that weirs would be operated on the Talachulitna River and Lake Creek in the Yentna River drainage. No weir operations occurred at either location in 2014. Results from the 2013 (see ISR Section 4.8.1 for a description of the 2013 variance) and 2014 studies showed that stream discharges in both systems remained too high for weir installation. As proposed in ISR Section 7.1.2.6.1, AEA modified the Study Plan and used two fishwheels and gillnets in the Yentna River (RM 18) as recapture methods in 2014 instead of weirs. This modification helped AEA achieve study Objective 8 in 2014.

5. RESULTS

This section summarizes results from 2012 and 2013 and presents detailed results from the 2014 salmon escapement study. Detailed results from the 2012 and 2013 studies were summarized elsewhere (AEA 2013a, 2014a,c; Yanusz et al. 2013).

Data developed in support of this document are available for download at http://gis.suhydro.org/Post_ISR/09-Fish_and_Aquatics/9.7-Salmon_Escapement/ and include the files:

- 9_7_ESCAPE_20141219_QC3_LGL_CurrySonarData_2014.xlsx;
- 9_7_ESCAPE_20141219_QC3_LGL_FishwheelData_2014.xlsx;
- 9_7_ESCAPE_20141219_QC3_LGL_GillnetData_2014.xlsx;
- 9_7_ESCAPE_20141219_QC3_LGL_Susitna Salmon Flat Tables 2014.xlsx;
- 9_7_ESCAPE_20141219_QC3_LGL_TagRecoveryData_2014.xlsx;
- 9_7_ESCAPE_20141219_QC3_LGL_TelemMgr Salmon Database 2014.zip;
- 9_7_ESCAPE_20141219_QC3_LGL_WatanaSonarData_2014.xlsx;
- 9_7_ESCAPE_20150106_QC3_LGL_Turbid Water Sonar_2014.xlsx;
- SuWa LGL FAQ Escapement 201407 Indian River Weir Fish Passage Database QC3 KM 20140808.xlsx.

5.1. Objective 1: Capture, radio-tag, and track adults of five species of Pacific Salmon in the Middle and Upper Susitna River in proportion to their abundance. Capture and tag Chinook, Coho, and Pink salmon in the Lower Susitna and Yentna rivers.

A total of 9,286 adult salmon of five species were radio-tagged during this three-year study. Table 5.1-1 presents the number of tags implanted and tagged fish tracked for each species in each year of the study. While the tagged species were consistent each year in the Middle River, they varied each year in the Lower River (Table 5.1-1) in order to assist ADF&G with fulfilling statewide objectives regarding escapement to the Susitna River Basin.

The size of fish radio-tagged ranged from 28 cm (11.0 in) to 110 cm (43.3 in.) METF. Since fishwheels were the primary capture method and have the potential for biased catch based on size, several analyses for size-selective capture and tagging were conducted. When size-selective capture was detected adjustments were made as detailed below. During each study year, tracking began with the first tags implanted in the Lower River and continued through October or November. Detailed results related to fish capture, tagging, and tracking in 2014 are presented below and in Appendices A, B, and C.

5.1.1. Fish Capture and Fish Tagging

5.1.1.1. Lower River

In the Lower River, 2,048 Chinook Salmon (1,471 large, 577 small) were caught and 659 large Chinook Salmon were radio-tagged (Table A-1; Figure A-6, Figure A-9). The peak of Chinook Salmon catch in the fishwheels occurred on May 29 (111 fish) and CPUE for an individual fishwheel peaked at 5.6 Chinook Salmon per hour (west bank). Daily radio-tag deployment in the Lower River peaked at 39 Chinook Salmon on June 5. Seventy-seven percent (129) of large Chinook Salmon captured using gillnets in the Lower River were radio-tagged. Large Chinook Salmon captured in the Lower River averaged 67.6 cm [26.6 in] METF and small Chinook Salmon averaged 39.1 cm [15.4 in] METF (Table A-4).

A total of 1,513 Coho Salmon were captured in the Lower River in 2014, of which 640 were radio-tagged at the fishwheels. The peak catch occurred on August 3 (128 fish) and CPUE for an individual fishwheel peaked at 7.0 fish per hour (west bank). The daily number of radio tags deployed peaked on July 28 (71 tags).

Pink Salmon were the most abundant species captured in the Lower River (13,934 fish). Daily fishwheel catches peaked on July 20 (2,050 fish) and CPUE peaked at 130 fish per hour (west bank). A total of 198 Pink Salmon were radio-tagged, and the most tags deployed on a single day was 16 (July 24). Similar to Coho Salmon, Pink Salmon catches were consistently higher in the west bank fishwheel relative to the east bank fishwheel.

A total of 6,577 Chum and 853 Sockeye salmon were also captured in the Lower River in 2014.

5.1.1.2. Yentna River

Of the 3,025 Chinook Salmon (1,357 large, 1,668 small) captured at Yentna RM 6, the majority (87 percent) were captured in fishwheels and the remainder (13 percent) in gillnets (Table A-2). Daily catch peaked at 275 fish on June 4. The magnitude and timing of the peak CPUE for Chinook Salmon was very similar for the north and south bank fishwheels (Figure A-10). The average length of large Chinook Salmon captured at Yentna RM 6 (66.9 cm [26.3 in] was similar to that of fish captured in the Lower River, while small Chinook Salmon at Yentna RM 6 averaged 34.9 cm (13.7 in) METF, which was 4.3 cm (1.7 in) less than at the Lower River. A total of 190 large Chinook Salmon were radio-tagged at the Yentna RM 6 fishwheels (Table A-2; Figure A-7), which was 7.3 percent of the total fishwheel catch. In the gillnetting at Yentna RM 6, 106 large Chinook Salmon were radio-tagged, which was 27 percent of the gillnet catch. Radio-tag deployment for Chinook Salmon at Yentna RM 6 peaked at 24 tags on June 2.

Of the 2,305 adult Chinook Salmon (1,375 large, 930 small) captured at Yentna RM 18, the majority (95 percent) were captured in fishwheels, and the remaining 5 percent in gillnets (Table A-2). Daily catch peaked at 171 fish on June 5. The magnitude and timing of the peak CPUE for Chinook Salmon was very similar for the north and south bank fishwheels (Figure A-10). At Yentna RM 18, large and small Chinook Salmon averaged 66.8 cm (22.3 in) and 37.0 cm (14.6 in) METF, respectively (Table A-4).

5.1.1.3. Middle River

In the Middle River, 877 Chinook Salmon (672 large, 205 small) were captured in 2014 of which 876 were captured in fishwheels and one was captured in a gillnet (Table A-5,Table A-57). The daily catch of large Chinook Salmon peaked at 58 fish on July 1 (Figure A-11), and CPUE was highest for large Chinook on June 30 (1.6 fish/hour at Site 1; Figure A-12). The mean length of large Chinook Salmon captured in the Middle River (71.6 cm [28.2 in]; Table A-6) was greater than the mean length of large Chinook Salmon captured in the Lower River (67.6 cm [26.6 in]) or Yentna RM 6 (66.9 cm [26.3 in]) fishwheels (Table A-4). Radio tags were applied to 590 large and 32 small Chinook Salmon captured at the fishwheels (Table A-3; Figure A-8), which represented 88 and 16 percent of the fish captured, respectively. Daily tag deployment peaked at 51 for large Chinook Salmon and 3 for small Chinook Salmon.

In total, 1,552 Chum Salmon were captured in the Middle River of which 1,469 were captured in fishwheels and 83 in gillnets (Table A-5). Daily catch for Chum Salmon peaked at 89 fish on August 11 and CPUE peaked at 3.7 fish/hour on August 10 (Site 3; Figure A-12). Chum Salmon caught in the Middle River averaged 57.9 cm (22.8 in) METF (Table A-6). Radio tags were applied to 200 Chum Salmon at the fishwheels, or 14 percent of the fishwheel catch (Table A-3; Figure A-8). Daily tag deployment peaked at 12 for Chum Salmon.

A total of 377 Coho Salmon (375 large, 2 small) were captured in the Middle River of which 198 were caught in fishwheels and 42 in gillnets (Table A-5). Daily catch peaked on August 22 (30 fish) and CPUE peaked at 1.4 fish/hour at Site 3 on July 29 (Figure A-12). Coho Salmon captured in the Middle River averaged 54 cm (22.8 in; Table A-6). A total of 230 Coho Salmon (daily max = 13 tags) were radio-tagged in the Middle River in 2014 of which 212 were captured at fishwheels and 18 in set gillnets (Table A-3; Figure A-8).

In total, 7,473 Pink Salmon were caught in the Middle River fishwheels in 2014 (Table A-5). Peak daily catch was 979 fish (July 29) and peak daily CPUE was 52.0 fish/hour at Site 3 (July 29; Figure A-12). The mean length of Pink Salmon captured in the Middle River was 46 cm (18.1 in) METF (Table A-6). A total of 201 Pink Salmon were radio-tagged (2.7 percent of all fish caught), with a peak daily allocation of 15 tags (Table A-3; Figure A-8).

Two-hundred and thirty four Sockeye Salmon (223 large, 11 small) were caught in 2014, of which 223 were caught at fishwheels and 11 in gillnets (Table A-5). Peak catch occurred on July 28 (13 fish) and peak CPUE occurred on July 22 and August 7 at Site 2 (0.7 fish/hour; Figure A-12). The mean length of Sockeye Salmon was 49 cm (19.3 in) METF (Table A-6). Radio tags were applied to 200 Sockeye Salmon (95 percent of total catch), with a peak of 13 tags deployed on a given day (Table A-3; Figure A-8).

The largest proportion of Chum Salmon were captured at Site 1 (39.6 percent), whereas the largest proportion of Sockeye Salmon were captured at Site 2 (42.2 percent), and the largest proportion of Chinook (48.2 percent), Coho (59.1 percent), and Pink (58.7 percent) salmon were captured at Site 3. In general, radio tags were deployed in proportion to catch for Chinook and Sockeye salmon, but less so for Pink, Chum, and Coho salmon (Figure A-11).

Seven other fish species were captured and released at the Middle River fishwheels, including 68 Rainbow Trout *O. mykiss*, 67 Round Whitefish *Prosopium cylindraceum*, 17 Arctic Grayling *Thymallus arcticus*, 13 Humpback Whitefish *Coregonus pidschian*, 13 Longnose Sucker *Catostomus catostomus,* 8 Dolly Varden *Salvelinus malma*, and 2 Burbot *Lota lota* (Table A-6).

During Middle River gillnet operations, 1 small Chinook, 83 Chum, 42 Coho, and 11 Sockeye salmon (including one fish measuring less than 40 cm METF) were captured (Table A-5). Other species captured during gillnetting included Rainbow Trout, Round Whitefish, Arctic Grayling, Longnose Sucker, and Bering Cisco *Coregonus laurettae*.

5.1.1.4. Programmatic Summary

Catch rates in the Lower River, Yentna River, and Middle River were sufficient to achieve all of the requirements of study Objective 1, and met or exceeded the majority of species-specific tag goals in each of the three study years. There were only seven cases where less than 90 percent of the allocated radio tags were deployed. These cases included large Chinook Salmon in the Lower River in 2012 and 2013 (88 and 83 percent of tags were deployed, respectively), and in the Yentna River in 2013 (61 percent of tags were deployed). Catches of large Chinook Salmon at both of these locations were substantially greater than the tag goals, and not meeting the tag targets in these cases was an artifact of investigators attempting to deploy tags proportional to abundance over the entire run rather than due to low catch rates. The remaining three cases occurred in the Middle River and included large Chinook Salmon in 2012 (88 percent of tags deployed), small Chinook Salmon in 2014 (32 percent of tags deployed), and Sockeye Salmon in 2012 and 2013 (35 and 69 percent of tags deployed, respectively). In these cases, too few fish were captured to meet the tag goals.

Factors that influenced catches over the three-year study period included the timing of ice-out, periods of high river discharge, changes in flow patterns at the capture sites, the amount of fishing effort, and differences in relative fish abundance among years. In the Lower River, the timing of ice-out in 2012 was similar to past records, was approximately two weeks late in 2013, and in 2014 was several days earlier than in the past. As a result, the start dates of fishwheel operations in the Lower River varied: May 25 in 2012, June 3 in 2013, and May 22 in 2014. Nonetheless, the number of Chinook Salmon captured in the Lower River among years was similar and ranged from 1,916 (2012) to 2,063 (2013) fish. On the Yentna River, catches of Chinook Salmon increased from 2,295 fish in 2013 to 3,033 fish in 2014. In the Middle River, the same two fishwheel sites (sites 1 and 2) used during the 1980s studies were used successfully from 2012 to 2014. Due to changes in flow patterns observed in 2013 that made it difficult to operate the Site 1 fishwheel when river discharge decreased below 17,500 cfs at the Gold Creek gauge, a third fishwheel site (Site 3) was added to increase catch rates. The addition of a third fishwheel increased fishing effort in 2013 (starting July 17) and 2014 relative to 2012. A substantial portion of catches in 2014 was attributed to the Site 3 fishwheel (30 percent or greater capture of each salmon species). Despite increasing fishing effort in the Middle River, catch in 2014 was lower than in 2013 for all salmon species, but higher than in 2012 for all species except Chum Salmon. Apart from occasional temporary shut downs due to high river discharge, fishing effort across all locations was nearly continuous each season.

Fishwheel effectiveness was assessed using fixed-site sonar (DIDSON in 2012/2014, ARIS in 2013) at one of the Middle River fishwheels (Site 1) in each study year. Sonar data confirmed that the fishwheel sampling adequately covered the leading edge of the Chinook Salmon run in June and a representative portion of the run was captured in July. In September, the sonar data were useful for quantifying the relative abundance of passing fish (i.e., Chum, Coho, and Sockeye salmon), particularly when river discharge and turbidity decreased and the fishwheels could not be operated effectively at any of the sites. Under these river conditions, sonar counts were useful for informing Coho Salmon tag rates (e.g., for gillnetting in 2014).

Sonar was also used to assess the behavior of fish as they approached the Site 1 fishwheel. Sonar imagery collected at Site 1 showed that the vast majority of fish migrated upstream within 13 m (43 ft) of shore. As a result, lead nets were hung between the shore-side pontoons of the Middle River fishwheels and the adjacent riverbank to increase catch rates (particularly at Site 1 where the fishwheel was held up to 50 ft offshore with spar poles at times). Information on diel pattern obtained from the Site 1 sonar data were useful for informing the crew as to the best times to fish in order to achieve optimal catch rates.

Limitations of using sonar to evaluate fishwheel effectiveness were evident in July and August when large numbers of fish and multiple species were present. Under these conditions it took a substantial amount of effort to review the imagery, and apart from large Chinook Salmon, fish observed in the sonar imagery could not be identified by species. Fishwheel effectiveness was difficult to assess during this period, however, by this time protocols for operating the fishwheels under a range of river conditions had been established and there was not likely anything more that could be done to increase fishwheel effectiveness.

For all five species of salmon, 2014 catches at the Middle River fishwheels were lower than in 2013, despite a third fishwheel being operated for the entire 2014 season (Table A-8). Except for Chum Salmon, 2014 salmon catches were higher than in 2012. By excluding 2014 catch years at the Site 3 fishwheel and equalizing effort for comparison across years, a different pattern emerges. Fewer Chinook, Chum, Coho, and Pink salmon were captured in 2014 than in 2013 and 2012.

Reviewing total catch of Chinook Salmon in the Middle River fishwheels across years showed that 2013 was the highest (952 fish), followed by 2014 (877 fish) and 2012 (566 fish). High catches in 2013 were largely due to the abundance of small Chinook Salmon (336 fish or 55 percent of the catch). More large Chinook Salmon were captured in 2014 (672 fish) than in 2012 (422 fish) or 2013 (616 fish). The majority of Chinook Salmon were captured at the Site 1 fishwheel in 2012 (60 percent) and 2013 (82 percent), whereas only 41 percent of catch occurred at Site 1 in 2014. Operating a third fishwheel (at Site 3) throughout the entire run in 2014 increased overall catch (48 percent of Chinook Salmon were caught at Site 3). Over eight years of operation (1981–1985 and 2012–2014), catch of Chinook Salmon at the Middle River fishwheels was highest in 1984 (1,589 fish) and lowest in 1981 (284 fish; Table A-8; Figure A-13). Catches in 2012, 2013, and 2014, ranked 7th, 4th, and 5th highest among these years, respectively.

Chum Salmon catch at the Middle River fishwheels in 2014 (1,469 fish) was similar to 2012 (1,734 fish) but was 57 percent lower than in 2013 (3,417 fish; Table A-8; Figure A-14). The

2014 Chum Salmon catch was also similar to annual average catch from the 1980s (1,881 fish), but during that period annual catch varied more widely (range: 861–4,228 fish).

In 2014, Coho Salmon catch of 335 fish was greater than the average from the 1980s (average = 211 fish) and 2012 total catch (265 fish; Table A-8; Figure A-15); however, the 2014 catch was more than five times lower than 2013 (1,723 fish).

Compared with other even years, the 2014 catch of Pink Salmon (7,473 fish) was higher than in 1982 (7,302 fish) and 2012 (4,705 fish), but substantially lower than catch in 1984 (17,394 fish; Table A-8; Figure A-16).

From 2012 to 2014, annual catch of Sockeye Salmon at the Middle River fishwheels was among the lowest on record (Table A-8). In 2012, 2013, and 2014, a total of 100, 276, and 223 Sockeye Salmon, respectively, were captured at the Middle River fishwheels. In the 1980s, annual catches averaged 307 fish (range: 161–469 fish; Table A-8; Figure A-17).

5.1.2. Numbers and Size of Marked and Unmarked Fish Recovered at Selected Locations

5.1.2.1. Deshka River Weir

An estimated 13,908 Chinook Salmon measuring 50 cm (19.7 in) METF or greater passed the Deshka River weir during May 19 to September 2, 2014, out of a total count of 16,335 Chinook Salmon of all sizes (Table B-1). One hundred twenty-five, or 0.9 percent, were radio-tagged fish and were assumed to have spawned above the weir (Table B-1). The mean length of radio-tagged Chinook Salmon released in the Lower River (69.9 cm [27.5 in]) was larger than that of Chinook Salmon (METF ≥ 50 cm [19.7 in]) that passed the Deshka River weir (67.9 cm [26.7 in]; Table B-3).

A total of 11,578 Coho Salmon were counted at the Deshka Creek weir during July 4 to September 2, 2014, all of which were estimated to be 40 cm (15.7 in) METF or greater (Table B-1). Sixty-eight, or 0.59 percent, were radio-tagged fish and were assumed to have spawned above the weir. The mean length of radio-tagged Coho Salmon released in the Lower River (52.6 cm [20.7 in]) was smaller than that of Coho Salmon (METF ≥ 40 cm [15.7 in]) that passed the Deshka River weir (55.8 cm [22.0 in]; Table B-3).

5.1.2.2. Montana Creek Weir

An estimated 1,212 Chinook Salmon measuring 50 cm (19.7 in) or greater passed the Montana Creek weir during June 4 to September 21, 2014, out of a total count of 1,217 Chinook Salmon of all sizes (Table B-2). Fifteen, or 1.2 percent, were radio-tagged fish (Table B-2) and were assumed to have spawned above the weir. The mean length of radio-tagged Chinook Salmon released in the Lower River (69.9 cm [27.5 in]) was slightly larger than Chinook Salmon (METF ≥ 50 cm) that passed the Montana River weir (68.7 cm [27.0 in]; Table B-3).

A total of 934 Coho Salmon were counted at the Montana Creek weir during August 3 to September 21, 2014, all of which were estimated to be 40 cm (15.7 in) METF or greater (Table B-2). Four, or 0.43 percent, were radio-tagged fish and were assumed to have spawned above the weir (Table B-2). The mean length of radio-tagged Coho Salmon released in the Lower River (52.6 cm [20.7 in]) was smaller than that of Coho Salmon (METF ≥ 40 cm [15.7 in]) that passed the Montana Creek weir (56.6 cm [22.3 in]; Table B-3).

5.1.2.3. Middle Fork Chulitna River Sonar

An ARIS sonar was operated on the Middle Fork Chulitna River (Figure 3-1) from June 20 to August 3, 2014. Post-season analysis of echograms resulted in a total count of 772 Chinook Salmon measuring 50 cm (19.7 in) METF or greater. Forty-two Chinook Salmon, or 5.4 percent, were radio-tagged fish. Many of the sonar echograms were of poor quality, the total count seemed unusually low, and fish lengths estimated from the sonar appeared suspiciously large, and the data were not used further. It was determined post-season that improper focusing occurred during data collection.

5.1.2.4. Indian River Weir

The underwater video system at the Indian River weir was operated 24 hours a day, and collected 89 hours of video footage from 1:30 P.M. on June 22 to 6:29 A.M. on June 26, 2014 (Table B-4). Due to poor visibility, 5.2 hours of video imagery collected on June 26 was not reviewed. Persistent rain on June 25 and June 26 contributed to high-water conditions in the Susitna (Figures 5.1-1 and 5.1-2) and Indian rivers. At approximately 6:29 A.M. on June 26, due to high flows and debris loading, the anchoring system failed and the majority of the weir components were flushed approximately one mile down river. A portion of the weir components were retrieved from July 4–8, and the remainder were retrieved on August 15 when water levels were considerably lower. In total, three Rainbow Trout and two Round Whitefish were observed on the video footage, but no adult salmon (Table B-4).

5.1.2.5. Programmatic Summary

The combination of Deshka River and Montana Creek weirs provided a robust second-event sample for evaluating sources of potential bias (heterogeneity in probability) of capture for the mainstem Susitna River Chinook and Coho salmon mark-recapture experiments. When size-biased sampling was detected using these two sites for second event sampling, substantial numbers of all size classes of Chinook and Coho salmon in the mainstem Susitna River were detected at these sites, particularly at the Deshka weir site. As such, size-based capture heterogeneity in the first event was reliably detected and the appropriate size-stratification applied to minimize bias when estimating abundance and distribution.

In addition to evaluating size, the weir data allowed for an evaluation of the representation of tagging across each run. Radio-tagged Chinook and Coho salmon that were recaptured at Montana and Deshka weir proved to be tagged across the entire time-frame of the marking event, ensuring a non-zero probability of capture for fish tagged both early and late in the run of fish past the tagging site. As the numbers of fish that can be sampled at these two sites is "fixed" at the escapement for these two tributaries, the precision in estimates of spawning abundance and distribution can only be increased by increasing the number of radio-tags deployed during the marking event, or by identifying additional viable second event sampling sites.

Operating a floating picket weir and underwater video system in the lower Indian River did not provide reliable second-event sampling for the Middle River tag site. In 2013, the Indian River weir was successfully operated throughout the majority of the Chinook Salmon run; however, the video system was shut down temporarily from July 19–20, and then permanently on August 20, due to high-water events. In 2014, the weir was rendered inoperable due to a high-water event in late June, prior to the onset of the Chinook Salmon run. During each of these high-water events, discharge of the Susitna River at the Tsusena Creek gauge increased to over 20,000 cfs. At low to moderate Indian River discharges, the site was ideal for weir installation and day-to-day access and operation; however, discharge increased substantially during heavy rain and the effectiveness of the site for sampling was diminished. Other tributaries in the Middle River (e.g., Portage Creek) would likely respond to heavy rains in a similar manner as the Indian River. Based on these findings, tributary weirs in the Middle River are not an effective method for assessing the numbers and size of marked and unmarked fish.

5.1.3. Assessing Any Stock- and Size-selective Capture

5.1.3.1. Use of ARIS to Assess Middle River Fishwheel Effectiveness and Fish Approach Behavior

Catch-per-unit-effort at the Site 1 ARIS unit (located immediately downstream of the Site 1 fishwheel; see Figures 3-1 and 4.1-1), or the number of targets counted per hour of imagery reviewed, increased over time in June (Figure A-18, Figure A-19). The ARIS CPUE was zero during the first two days of operation (June 3–4) and only increased slightly from June 5 to June 12 (0.0–0.6 fish/hour). The ARIS CPUE showed a moderate increase from June 13 to June 17 (1.8–6.5 fish/hour), but increased substantially afterwards (10.9–37.0 fish/hour from June 18–25). In September, CPUE at the ARIS showed peaks on September 1 (37.9 fish/hour) and September 7 (39.0 fish/hour), but steadily declined from September 8 through September 28.

In June, trends in CPUE at the Site 1 fishwheel were similar to counts at the ARIS unit (Figure A-20). No adult salmon were captured at the Site 1 fishwheel from June 6 to June 12. The fishwheel CPUE was low from June 13 to June 16 (0.1–0.2 fish/hour), and peaked at 1.0 fish/hour on June 17. In September, CPUE at the Site 1 fishwheel decreased dramatically after August 30 (0.9 fish/hour), and remained low (or zero) through September 7 when the fishwheel was stopped for the season (Figure A-20). This trend contrasts with the ARIS CPUE which peaked in early September and remained relatively high through mid-September (Figure A-19). This decrease in CPUE at the Site 1 fishwheel (Figure A-20) appeared to be related to turbidity, which decreased steadily from 66 NTU on August 29 to 21 NTU on September 7 (Figure A-19).

Similar patterns observed in ARIS and fishwheel CPUE in June indicated that the ascending limb of the Chinook Salmon run was captured at the Middle River fishwheels. In contrast, the ARIS data suggested low fishwheel catches of Coho Salmon in the first week of September were not representative of abundance. From September 4–7 for example, CPUE at the ARIS ranged from 19.5–39.0 fish/hour with a net upstream count of 57–147 fish per day (during periods when the fishwheel was operational), yet no adult salmon were captured at the Site 1 fishwheel. Low Coho Salmon catches (Figure A-12) at the Site 1 fishwheel from late August through early September were likely due to low turbidity and not to low relative abundance. Anticipating this condition, the study team switched to gillnet operations to catch and tag Coho for this part of the run.

The proportion of targets observed on the Site 1 ARIS that were first detected within the capture range of the Site 1 fishwheel (~ 6 m [19.7 ft]) appeared to be influenced by river discharge. From June 3 to June 15, when fish measuring 50 cm TL (19.7 in) or greater passing Site 1 were likely Chinook Salmon, Susitna River discharges at the Gold Creek gauge were 19,800 cubic feet per second (cfs) or less and only 27 percent of targets were within 6 m (19.7 ft) of the transducer (Figure A-21). From June 16 to June 25, Susitna River discharges were 21,800 cfs or greater, and the proportion of fish passing within 6 m (19.7 ft) of the transducer increased to 47 percent. From August 29 to September 30, when most fish measuring 40 cm TL (15.7 in) or greater passing Site 1 were likely Coho Salmon, the vast majority (88 percent) of targets passed the Site 1 ARIS within 6 m of the transducer. These observations suggested that higher river discharge, likely through water velocity, can affect the cross-channel distribution of migrating Chinook Salmon such that they migrate closer to the bank. The effect was likely more pronounced on Coho Salmon due to their shorter body length.

During the periods of monitoring with ARIS at Site 1, migrations were lowest in the early part of the day. In June, 58 percent of upstream-moving fish measuring 50 cm TL (19.7 in) or greater (presumably Chinook Salmon) passed the Site 1 ARIS between noon and midnight (Figure A-22). Fish passage was lowest early in the morning (~1:00–5:00 A.M.). In September, fish passage (presumably mostly Chum and Coho salmon) was more evenly distributed throughout the day, with 58 percent of fish measuring 40 cm TL (15.7 in) or greater passing between 7:00 A.M. and 6:00 P.M. Fish passage in September was lowest early in the morning (~0:00–5:00 A.M.).

5.1.3.2. Bank Orientation & Capture Probability by Spawning Location (Middle River)

Results of contingency table tests comparing the bank of capture to the bank where fish were assigned a spawning destination did not indicate that radio-tagged large Chinook ($\chi^2 = 3.3$; $P = 0.07$), Pink ($\chi^2 = 0.1$; $P = 0.72$), or Sockeye ($\chi^2 = 2.7$; $P = 0.15$) salmon were bank-oriented when passing through the Middle River. Too few small Chinook and Chum salmon returned to left-bank spawning areas to reliably evaluate bank orientation with a contingency table. Specifically, 95 percent (n = 21) of Chum Salmon tagged on the left bank (when looking downstream), and 100 percent (n = 82) of Chum Salmon tagged on the right bank, were assigned to right-bank spawning areas. All small Chinook Salmon returned to spawning areas on the right bank regardless of whether they were captured on the left (n = 2) or right (n = 17) bank.

Mainstem spawning populations did not appear more vulnerable to recapture than those fish bound for tributaries ($\chi^2 = 0.1$; $P = 0.71$). Of the 34 radio-tagged salmon released and recaptured at the Middle River fishwheels that were subsequently assigned spawning destinations, 29 (85 percent) were assigned to tributaries and five (15 percent) were assigned to mainstem areas. Similar proportions were observed for radio-tagged fish released at the Middle River fishwheels that were never recaptured (87 percent to tributaries and 13 percent to mainstem areas).

5.1.3.3. Size-related Comparisons

The following subsections summarize the results of comparisons made between cumulative length-frequency distributions of fish captured and sampled in the Lower River, Yentna River, and Middle River. Two-sample KS tests were used to detect significant differences between the distributions. When interpreting the results of KS tests, it was important to consider both the sample sizes of each distribution and the P-value of the test. For example, in a case where the sample sizes for each distribution were very large and a significant test result was obtained, it was possible that the KS test was detecting small differences between the cumulative length-frequency distributions that had little potential to result in any bias. Despite a significant test result in such a case, there may be no biologically meaningful difference between the two cumulative length-frequency distributions.

5.1.3.3.1. Lower River

Cumulative length-frequency distributions for all Chinook Salmon captured at the Lower River tagging site showed significant differences between the size distributions of fish caught at the west bank fishwheel, the east bank fishwheel, and mid-river gillnetting sites. Chinook Salmon caught in mid-river gillnets were larger than fish caught in the west bank fishwheel ($D = 0.442$, $P < 0.001$) and the east bank fishwheel ($D = 0.387$, $P < 0.001$; Figure A-23; Table A-9). Chinook Salmon caught in the west bank fishwheel were smaller than those from the east bank fishwheel ($D = 0.111$, $P < 0.001$; Figure A-23; Table A-9). Average lengths (METF) of Chinook Salmon for each capture station were 75.3 cm (29.6 in) for mid-river gillnets, 57.7 cm (22.7 in) for the west bank fishwheel, and 59.5 cm (23.4 in) for the east bank fishwheel.

For Chinook Salmon measuring 50 cm (19.7 in) METF or greater, a significant difference was detected between the length distributions of fish captured at the Lower River tagging site and only those fish radio-tagged at that site ($D = 0.145$, $P < 0.001$; Figure A-24; Table A-9). This difference was due largely to the tagging strategy used at the site, which called for Chinook Salmon less than 58 cm (22.8 in) METF to be tagged at approximately one-third the rate of Chinook Salmon measuring 58 cm (22.8 in) METF or greater. This tagging strategy was intended to reduce the effects of size-selective capture by the fishwheels. No significant difference was detected between the length distributions of Chinook Salmon measuring 58 cm (22.8 in) METF or greater caught at the Lower River site and those tagged ($D = 0.03$, $P = 0.797$; Table A-9).

The cumulative length-frequency distributions for all Coho Salmon captured at the Lower River tagging site was significantly different between the west bank fishwheel and the east bank fishwheel ($D = 0.083$, $P = 0.011$; Table A-9). For Coho Salmon (METF $\geq$ 40 cm), the cumulative length-frequency distributions were not significantly different between the total catch and those tagged ($D = 0.023$, $P = 0.886$; Table A-9).

The cumulative length-frequency distributions for Pink Salmon tagged at the Lower River tagging site were not significantly different between the west bank fishwheel and the east bank fishwheel ($D = 0.145$, $P = 0.14$; Table A-9). For Pink Salmon, length data were collected only for fish that were radio-tagged so no further comparisons can be made (Figure A-24).

The cumulative length-frequency distribution for Chinook Salmon sampled at the Deshka River weir was not significantly different than that for all radio-tagged fish above the tagging site (D = 0.09, $P = 0.101$; Figure A-25).

The cumulative length-frequency distribution for Chinook Salmon sampled at the Montana Creek weir was significantly different than that for all radio-tagged fish above the tagging site (D = 0.13, $P = 0.006$; Figure A-25).

5.1.3.3.2. Yentna River

Cumulative length-frequency distributions for Chinook Salmon captured at the Yentna RM 6 tagging site showed significant differences between the size distributions of fish caught at the south bank fishwheel, the north bank fishwheel, and mid-river gillnetting sites. Chinook Salmon caught in mid-river gillnets were larger than fish caught in the south bank fishwheel (D = 0.519, $P < 0.001$) and the north bank fishwheel (D = 0.658, $P < 0.001$; Figure A-26; Table A-9). Chinook Salmon caught in the north bank fishwheel were smaller than those from the south bank fishwheel (D = 0.155, $P < 0.001$; Figure A-26; Table A-9). Average lengths (METF) of Chinook Salmon for each capture station were 72.0 cm (28.4 in) for mid-river gillnets, 48.9 cm (19.3 in) for the south bank fishwheel, and 43.2 cm (17.0 in) for the north bank fishwheel. For Chinook Salmon measuring 50 cm (19.7 in) METF or greater, no significant difference was detected between the length distributions of fish captured at the Yentna RM 6 tagging site and only those fish dart-tagged at that site (D = 0.005, $P = 1.00$; Figure A-27; Table A-9).

Cumulative length-frequency distributions for all Chinook Salmon captured at the Yentna RM 18 recapture site also showed significant differences between the size distributions of fish caught at the south bank fishwheel, the north bank fishwheel, and mid-river gillnetting sites. Chinook Salmon caught in mid-river gillnets were larger than fish caught in the south bank fishwheel (D = 0.528, $P < 0.001$) and the north bank fishwheel (D = 0.671, $P < 0.001$; Figure A-26; Table A-9). Chinook Salmon caught in the north bank fishwheel were smaller than those from the south bank fishwheel (D = 0.25, $P < 0.001$; Figure A-26; Table A-9). Average lengths (METF) of Chinook Salmon for each capture station were 77.9 cm (30.7 in) for mid-river gillnets, 59.3 cm (23.3 in) for the south bank fishwheel, and 50.7 cm (20.0 in) for the north bank fishwheel.

The cumulative length-frequency distribution for Chinook Salmon sampled at the Yentna RM 18 recapture site was not significantly different than that for all dart-tagged fish above the tagging site (D = 0.036, $P = 0.265$; Figure A-28).

5.1.3.3.3. Middle River

In the Middle River, the cumulative length-frequency distributions for Chum Salmon at site 2 was significantly different from that at site 1 (D = 0.14, $P = 0.01$) and site 3 (D = 0.15, $P < 0.01$). Also, Pink Salmon length distributions differed between sites 1 and 3 (D = 0.09, $P = 0.04$; Figure A-29; Table A-10). Sample sizes were large for these comparisons (n: 342–449) and tagging effort was distributed amongst the sites, so it was unlikely these differences introduced significant bias. Among sites, mean lengths were greatest at Site 2 for Chinook (66.4 cm; 26.2 in), Chum (58.6 cm; 23.1 in), Coho (55.6 cm; 21.9 in), and Sockeye (50.0 cm; 19.7 in) salmon; but greatest at Site 3 for Pink Salmon (46.0 cm; 18.1 in). Mean lengths were smallest at Site 1 for Chum (57.5 cm; 22.7 in), Coho (53.8 cm; 22.7 in), Pink (45.5 cm; 17.9 in), and Sockeye

(48.5 cm; 19.1 in) salmon; but smallest at Site 3 for Chinook Salmon (62.1 cm; 24.5 in). Small Chinook Salmon (METF < 50 cm [19.7 in]) comprised 23 percent of all Chinook Salmon caught in 2014 (versus 35 percent in 2013); and 5 percent of Sockeye Salmon caught in 2014 measured less than 40 cm (15.7 in) METF (versus 36 percent in 2013).

Cumulative length-frequency distributions for salmon captured at the Middle River fishwheels were significantly different than those of radio-tagged fish for small Chinook (D = 0.77, $P < 0.01$) and Pink Salmon (D = 0.15, $P < 0.01$), but not for large Chinook, Chum, Coho, or Sockeye salmon (Figure A-30; Table A-10). For small Chinook and Pink salmon, these results were consistent with tagging effort as it was not random across all sizes, but instead was limited to the larger-sized segment of these fish captured in the fishwheels.

5.1.3.3.4. Programmatic Summary

Achieving the goals of this study was dependent in part on tagging a representative group of fish from the entire population. However, fishwheels have been shown to be size and species selective for adult salmon. Meehan (1961) showed that fishwheels on the Taku River caught a larger proportion of smaller-sized Chinook Salmon compared with samples collected on the spawning grounds. Meehan (1961) also showed that Chinook and Coho salmon were least susceptible to recapture in a fishwheel, while Pink Salmon were most easily recaptured. In 1981 and 1982 on the Susitna River, ADF&G (1983a) compared observed and expected mark rates on the spawning grounds and found that fishwheels operated near Curry were species selective: Chinook and Chum salmon catches were biased low, and Pink Salmon catches were biased high. Meehan (1961) hypothesized that size selectivity was due to larger fish avoiding the fishwheel, or migrating in faster and deeper water away from shore, relative to smaller fish. A tendency for large salmon to swim upstream farther from the bank than smaller ones in locations where the river gradient is low and velocities offshore are modest also has been suggested by ADF&G (1983a) and Hughes (2004). In contrast, there is also evidence showing that fishwheels can catch a representative sample of salmon when deployed in areas where elevated water velocities force fish to migrate near shore (Link and Nass 1999).

KS tests indicated some size selectivity in capture (toward disproportionate capture of smaller-sized fish) in the Lower River fishwheels. Size-selective sampling was detected for Chinook Salmon radio-tagged at the Lower River site in 2013 and 2014, even where capture was achieved using a combination of fishwheels and drift gillnets. Chinook Salmon measuring less than 58 cm (22.8 in) METF were radio-tagged at approximately one-third the rate of larger fish based on an analysis of data from Chinook Salmon tagged in 2012 that passed the Deshka River weir site. These measures were not sufficient to eliminate sampling bias, but they likely reduced over-sampling of small fish. Size-selective sampling was also detected for Coho Salmon radio-tagged at the Lower River site in 2013 and 2014. And lastly, size selectivity was detected in the Yentna River in 2014 for Chinook Salmon. No length data were available for the second sample event in the Yentna drainage in 2013, so size selectivity could not be tested. Furthermore as described above, for cases where size selectivity was detected, size-stratification provided minimally biased estimates of abundance and distribution of spawning Chinook and Coho salmon.

In the Middle River, size selectivity could only be directly tested in one study year (2013) due to difficulties in collecting a sufficient number of length samples on the spawning grounds. As a result, ancillary length-frequency comparisons (i.e., between capture sites, and between fish captured and tagged), sonar data collected immediately below the Site 1 fishwheel, and expert opinion were used to provide some insights into the potential for size selectivity in the Middle River. In the first study year (2012), the study team conducted ground-based stream counts and carcass surveys in the Indian River and Portage Creek to sample fish for mark rates and lengths. Very few carcasses were found despite excellent survey conditions, which was likely due to carcasses being removed from the rivers by predators. In 2013, the study team installed a picket weir and underwater video system on the lower Indian River as a method of obtaining mark rates and length data on the spawning grounds. Comparisons of cumulative length-frequency distributions for large Chinook Salmon radio-tagged in the Middle River and those inspected and recaptured at the weir showed no evidence of size-selective sampling. Too few radio-tagged fish of the other salmon species were recaptured at the weir in 2013 to test for size selectivity. In 2014, the study team could not directly test for size-selective sampling because the Indian River weir was rendered inoperable prior to the onset of the Chinook Salmon run and thus no length samples were collected.

For small Chinook and Pink salmon, tagging efforts were not random at the Middle River fishwheels in 2013 and 2014 as only the larger-sized segment of the small fish captured were radio-tagged. This was due to the fact that the radio tags would simply not fit into the stomachs of smaller-sized fish. For Pink Salmon, the difference in mean length between captured and radio-tagged fish was less than 1.5 cm (0.6 in), and relatively few fish captured measured less than 40 cm (15.7 in) METF, so it was unlikely that selecting for slightly larger-sized fish to tag had a material effect on the study results. Small Chinook Salmon, however, comprised a substantial portion of the total number of Chinook Salmon captured at the Middle River fishwheels (23–35 percent in 2013 and 2014), yet only a fraction were radio-tagged (11 percent or less). In 2014, the smallest radio-tagged Chinook Salmon measured 36 cm (14.2 in) METF, yet 61 percent (121 of 198 fish) of small Chinook Salmon captured measured less than 36 cm (14.2 in) METF. No radio-tagged small Chinook Salmon passed above Devils Canyon in the three study years, so it was unlikely that any additional fish would have passed the impediments had additional small Chinook Salmon been radio-tagged.

Additional information suggested size-selectivity did not introduce significant bias to study results. Sonar data collected immediately downstream of the Site 1 fishwheel in the Middle River suggested that very few fish migrated upstream at distances greater than 13 m (42.7 ft) from the shore-based transducer, and that fish of all sizes seemed equally distributed at range from shore. Sonar was not used at sites 2 or 3, however, the higher water velocities at these sites suggested an even greater proportion of fish would be bank-oriented relative to Site 1. All size classes of salmon were captured at each fishwheel, indicating that fish of all lengths had a non-zero capture probability. And lastly, based on the experience of the study team, the Middle River fishwheel sites were characterized as generally high gradient with moderate-to-high offshore river velocities, which were similar features of fishwheel sites on other river systems where the least size selectivity was encountered (Link and Nass 1999; Smith et al. 2005).

5.1.4. Examining Handling-Induced Changes in Behavior

Fish that were obviously affected by handling (those that moved only in a downstream direction, and those that never moved) were not included in any of the behavioral analyses described in this report. Regardless, other fish may have also experienced handling-related changes in behavior. One way to quantify handling-induced effects was to compare the survival and behavior of fish that were handled twice (i.e., recaptured in fishwheels) to those of the general populations of tagged fish, specifically, comparing the proportions tracked to spawning destinations.

Of the 590 large Chinook Salmon that were radio-tagged and released at the Middle River fishwheels, 21 (3.6 percent) fish were recaptured at least once at the Middle River fishwheels, of which two fish were recaptured a second time. Most of the large Chinook Salmon recaptured for the first time were caught at the Site 3 fishwheel (14 fish), which was located the farthest upstream, while the remainder were caught at the Site 1 (6 fish) and Site 2 (1 fish) fishwheels. The elapsed time between tag and recapture events ranged from 14 minutes to 21 days (median = 4.1 days; n = 17). The fish recaptured 21 days after release was noted as a 'post-spawn' fish by the crew. Of the 21 fish recaptured at least once, the radio tag was coded for 17 fish. Of these 17 recaptured fish, 53 percent were subsequently assigned spawning destinations (i.e., classified into a specific tributary or mainstem spawning location); this percentage was low compared to the overall rate of 80 percent ($\chi^2 = 7.4$; $P < 0.01$). Neither of the two fish recaptured twice were assigned spawning destinations. The lower proportion of assigned destinations and relatively long times between capture events suggested that the behavior of large Chinook Salmon handled twice may have been negatively influenced by the recapture events, thus failing to dismiss the possible impacts of the original capture event

Three (9.4 percent) of the 32 radio-tagged small Chinook Salmon released at the Middle River fishwheels were recaptured (median time between capture events was 13.3 days; n = 3), all of which were assigned spawning destinations, suggesting that the additional handling did not substantially influence the behavior of these fish. The negligible impacts of second handling events suggest that the original handling of these fish was benign.

Ten Pink, 8 Chum, 5 Coho, and 4 Sockeye salmon released at the Middle River fishwheels were also recaptured. The radio tag was not coded upon recapture for one Chum and one Pink salmon. Of the recaptured fish with known tag codes, the elapsed time between capture events was longest for Sockeye (median = 1.4 days, n = 4), followed by Chum (median = 0.9 days, n = 7), Pink (median = 0.9 days, n = 9), and Coho (median = 0.8 days, n = 5) salmon. Seventy-one percent of recaptured Chum Salmon were assigned spawning destinations, which was similar to the overall rate of 80 percent ($\chi^2 = 0.3$; $P = 0.60$). All of the recaptured Pink, Sockeye, and Coho salmon were assigned spawning destinations. The relatively short time period between capture events and the large proportion of recaptured fish that were assigned spawning destinations suggests the additional handling did not substantially influence the behavior of Chum, Coho, Pink, or Sockeye salmon. Moreover, it was assumed that the short recapture period indicated the fish had sufficiently recovered from the first handling event, having rejoined the migration of untagged fish. The negligible impacts of second handling events suggest that the original handling of these species was benign.

Another way to quantify handling-induced effects was to examine swim speeds in a given river reach, comparing newly tagged fish to those that have had time to recover from handling. Few fixed-station receivers monitored both Lower and Middle River frequencies, hence the best test was to compare travel speeds of Lower-River-tagged fish from Sunshine to Lane to those of Middle-River-tagged fish from release (near Curry) to Gateway. If the newly tagged fish were experiencing handling-induced effects, their travel speeds should have been slower than those of nearby Lower-River-tagged fish. In all cases, the recently-handled Middle-River-tagged fish travelled faster than the unhandled (Lower-River-tagged) conspecifics (Figure 5.1-3), with effects being statistically significant for Coho Salmon (χ^2 = 9.7, P = 0.0018; Chinook Salmon: χ^2 = 0.8, P = 0.77; Pink Salmon: χ^2 = 3.5, P = 0.061).

As a comparison among tagging sites of the relative magnitude of potential handling-induced effects, the proportion of fish that either never left the release area or that moved only in a downstream direction was examined. For large Chinook Salmon, the proportion was 4 percent at the Lower River fishwheels, 10 percent at the Middle River fishwheels, and 19 percent in the Yentna River. For Coho Salmon, the proportion was 1 percent at the Lower River fishwheels, 11 percent at the Middle River fishwheels, and 12 percent in the Yentna River. For Pink Salmon, the proportion was 10 percent at the Lower River fishwheels, and 3 percent at the Middle River fishwheels.

5.2. Objective 2: Determine the migration behavior and spawning locations of radio-tagged fish in the Lower, Middle, and Upper Susitna River

Migration behavior and spawning locations were relatively consistent among years. Of the fish tagged in the Lower River that could be categorized to a destination, the majority (97–99 percent of the large Chinook Salmon, 90 percent of the Chum Salmon, 93–97 percent of the Coho Salmon, 84–99 percent of the Pink Salmon, and 100 percent of the Sockeye Salmon) had tributary destinations, rather than mainstem ones. The Talkeetna, Yentna, Deshka, and Chulitna rivers were the main tributary destinations. For the fish tagged in the Middle River a similar pattern was observed, showing predominant use of tributaries for all species (tributaries were used by 90–94 percent of the large Chinook Salmon, 83–93 percent of the small Chinook Salmon, 76–90 percent of the Chum Salmon, 84–94 percent of the Coho Salmon, and 91–94 percent of the Pink Salmon) except Sockeye Salmon. Sockeye Salmon tagged in the Middle River had the greatest tendency to have a mainstem destination (only 21–54 percent had tributary destinations), which was markedly different behavior from their Lower River conspecifics, and from all other salmon species. For fish tagged in the Middle River, Portage Creek and Indian River were the main tributary destinations for all species (AEA 2013a, 2014c). Detailed results related to the migration behavior and spawning locations of radio-tagged fish in 2014 are presented below and in Appendices D and E. Destinations and potential spawning sites for radio-tagged fish across years are shown in Figures D-1 to D-20.

5.2.1. Chinook Salmon

5.2.1.1. Fish tagged in Lower River

5.2.1.1.1. Tag Returns

Of the large Chinook Salmon radio tags deployed in the Lower River, 24 were recovered by anglers (23 tags) or project field staff (1 tag; Table E-1). Large Chinook Salmon tags were recovered in the Chulitna (1), Deshka (16), and Lower Susitna (1) rivers, as well as Clear (2), Deception (1), Lake (1), Peter's (1), and Sheep (1) creeks.

5.2.1.1.2. Stock Classifications and Spawning and Holding Locations

Of the 656 large Chinook Salmon tagged in the Lower River, 581 (89 percent) were classified by destination (Table 5.2-1). Of the remaining 75 tags, 44 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and 31 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (see "Other Classifications" in Table 5.2-1).

Of the 581 Chinook Salmon tracked to a destination, 7 (1 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1). There were six potential spawning and holding sites documented in the Lower River, including 3 within slough/side channel, 2 within main channel, and 1 within tributary mouth habitats. There were no potential spawning sites identified in the Middle River downstream or upstream of Devils Canyon, but there was one potential mainstem spawning site within Devils Canyon, located at the mouth of Cheechako Creek. Spawning was not confirmed at any of the potential spawning sites for Chinook Salmon. Lack of confirmation was largely due to high turbidity precluding visual observation.

Of the 581 Chinook Salmon tracked to a destination, 574 (99 percent) went to tributaries. Of these, 94.6 percent used Lower River tributaries, mainly the Yentna, Deshka, Talkeetna or Chulitna rivers (Figure 5.2-2). The remaining 5.4 percent had tributary destinations in the Middle River Segment below Devils Canyon, mainly in Indian River or Portage Creek. One fish had a tributary destination above Impediment 1, in Cheechako Creek.

5.2.1.1.3. Roaming Behavior in the Middle River

Of the large Chinook Salmon tagged in the Lower River that entered the Middle River, 13.9 percent of the fish with known-classification subsequently moved downstream into a tributary (Table 5.2-2). Roamers eventually went to either the Chulitna or Talkeetna rivers, or Montana Creek. Some roaming fish moved far up into the Middle River before dropping back to enter downstream tributaries (Table 5.2-3). For example, one Chinook Salmon tagged in Lower River moved upstream to the area below Impediment 1 before dropping back to enter the Chulitna River.

5.2.1.2. Fish Tagged in Yentna River

5.2.1.2.1. Tag Returns

Of the large Chinook Salmon radio tags deployed in the Yentna River, four were recovered by anglers (Table E-1). Large Chinook Salmon tags were recovered in the Yentna at the mouth of Lake Creek (2), or in Lake Creek itself (2).

5.2.1.2.2. Stock Classifications and Spawning Locations

Chinook Salmon radio-tagged in the Yentna River were expected to stay within this major tributary, and significant movement to other Susitna River tributaries was not expected (relative to Chinook Salmon tagged in the Lower River). As expected, 219 of the 295 Chinook Salmon released in the Yentna River (74 percent) were classified with a Yentna destination, and 8 (3 percent) were classified in other Lower Susitna River tributaries (Little Willow and Willow creeks, or Deshka or Chulitna rivers; Table 5.2-1). Of the remaining 68 tags, 64 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and four exhibited movements that prevented conclusive assignment to the mainstem or tributaries (see "Other Classifications" in Table 5.2-1).

5.2.1.2.3. Roaming Behavior in the Middle River

No fish tagged in the Yentna River migrated into the Middle River and subsequently moved downstream into a tributary.

5.2.1.3. Fish Tagged in Middle River

5.2.1.3.1. Tag Returns

Of the large Chinook Salmon radio tags deployed in the Middle River, thirteen were recovered by anglers (3 tags), project field staff (6 tags), or others (4 tags; Table E-2). Thirteen large Chinook Salmon tags were recovered in the Indian (5) and Middle Susitna (Indian River confluence; 1) rivers, at the mouth of Jack Long Creek (1), and at the Site 3 fishwheel (6).

5.2.1.3.2. Stock Classifications and Spawning Locations

Of the 590 large Chinook Salmon radio-tagged in the Middle River, 472 (80 percent) were classified by spawning destination (Table 5.2-1). Of the remaining 118 tags, 58 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and 60 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Of the 472 large Chinook Salmon tracked to a spawning and holding destination, 34 (7 percent) went to mainstem destinations, all in the Middle River downstream of Devils Canyon (Table 5.2-1; Figure 5.2-1; Table D-2), including 8 within slough/side channel, 4 within main channel, and 22 within tributary mouth habitats. The other 438 fish (93 percent) went to tributaries. Of these, 11 percent used Lower River tributaries (mainly Talkeetna or Chulitna rivers; Figure 5.2-3), 88.4 percent used tributaries in the Middle River below Devils Canyon (mainly Indian River or Portage Creek; Figure 5.2-3), 2 fish (0.5 percent) used a tributary within the canyon (Cheechako Creek), and 1 fish (0.2 percent) used an Upper River tributary (Kosina Creek).

In addition to the large Chinook Salmon described above, 32 small Chinook Salmon were radio-tagged and released in the Middle River. For these small Chinook Salmon, 24 (75 percent) were classified by destination (Table 5.2-1). Of the remaining 8 small Chinook Salmon tagged, 5 were ignored (never moved from release site, or moved only in the downstream direction) and 3 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (see "Other Classifications" in Table 5.2-1).

Of the 32 small Chinook Salmon tracked to a spawning destinations, 4 (17 percent) went to destinations in the mainstem Middle River downstream from Devils Canyon (Table 5.2-1; Table D-2; Figure 5.2-1): 3 were at the mouth of Indian River, and one was in a side channel habitat. The other 20 fish (83 percent) went to tributaries Of these, 1 fish (5 percent) used a Lower River tributary (Talkeetna River; Figure 5.2-3), and the remaining 19 fish (95 percent) used tributaries in the Middle River below Devils Canyon (mainly Indian River or Portage Creek; Figure 5.2-3).

Chinook Salmon (small and large) were tracked to 18 potential mainstem spawning and holding sites in the Middle River between PRM 111.0 and PRM 155.9 (Table D-2). There were five sites at which more than one radio-tagged Chinook Salmon was detected (#3, 10, 13, 15, 17). No potential mainstem spawning sites for Chinook Salmon were identified above PRM 160. To assess if there was spawning activity, all 18 sites were visually examined during aerial telemetry, boat, or foot surveys (Habitat Suitability Criteria [HSC]; Table D-1); and turbid water precluded visual confirmation of spawning activity at all sites. A DIDSON unit was used at six of the sites; however the remaining 12 sites were not surveyed using sonar due to lack of boat access or bathymetric features that were not conducive to sonar sampling. Holding behavior was observed at one main channel (#10) and three tributary mouth habitats (#5, 13, 17), but no fish were observed spawning at any of the 18 sites.

5.2.1.3.3. Roaming Behavior in the Middle River

Several fish tagged at the Curry fishwheels moved downstream into a Lower or Middle River tributary (Table 5.2-2). For large Chinook Salmon tagged at the Curry fishwheels, 472 had known classifications, of which 54 (11.4 percent) exhibited this roaming behavior. Most roamers eventually went to either the Chulitna or Talkeetna rivers. Some roaming fish moved far up into the Middle River before dropping back to enter downstream tributaries (Table 5.2-3). For example, two Chinook Salmon tagged in Middle River moved upstream to the area below Impediment 1 before dropping back to enter the Talkeetna River. For small Chinook Salmon tagged at the Curry fishwheels, 24 had known classifications of which 5 (20.8 percent) exhibited roaming behavior. The farthest upstream any of these fish reached was the Gateway site, and the farthest downstream tributary was Talkeetna River.

5.2.2. Chum Salmon

5.2.2.1. Fish Tagged in Middle River

5.2.2.1.1. Tag Returns

Of the Chum Salmon radio tags deployed in the Middle River, one was recovered by field crew at the mouth of 4th of July Creek (Table E-2).

5.2.2.1.2. Stock Classifications and Spawning Locations

Of the 200 Chum Salmon tagged in the Middle River, 159 (80 percent) were classified by destination (Table 5.2-1). Of the remaining 41 tags, 10 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and 31 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Of the 159 Chum Salmon tracked to a spawning destination, 18 (11 percent) went to destinations in the mainstem Middle River (Table 5.2-1; Table D-3; Figure 5.2-1), including 11 within slough/side channel, 2 within main channel, and 5 within tributary mouth habitats. The other 141 (89 percent) went to tributaries. Of these, 30.5 percent used Lower River tributaries (mainly

Talkeetna or Chulitna rivers; Figure 5.2-3), and 69.5 percent used tributaries in the Middle River below Devils Canyon (mainly Indian River or Portage Creek; Figure 5.2-3).

Chum Salmon were tracked to 14 potential mainstem spawning and holding sites in the Middle River between PRM 111.3 and PRM 155.9 (Table D-3). There were two sites at which more than one radio-tagged Chum Salmon was detected (#7, 9). No potential mainstem spawning sites for Chum Salmon were identified above PRM 152.3. To assess if there was spawning activity, all 14 sites were visually examined during aerial telemetry, boat, or foot surveys. Eleven sites were surveyed aerially (#1–6, 8, 10–14), and ten sites by boat/foot (#2, 5–13). No fish were observed at three of the sites (#3, 4, 7; Table D-3). Six sites were too turbid to see fish during aerial surveys (#1, 2, 6, 10, 11, 13) even though they were regularly monitored. Holding behavior was observed at two slough/side channel (#5, 9) and three tributary mouth habitats (#8, 12, 14), while fish were observed spawning at two of the 14 sites (#5, 12). Both confirmed spawning sites were also confirmed in 2012 and 2013.

5.2.2.1.3. Roaming Behavior in the Middle River

Several fish tagged at the Curry fishwheels moved downstream into a Lower or Middle River tributary (Table 5.2-2). Of the classified Chum Salmon tagged at the Curry fishwheels, 28 percent returned to a downstream tributary. Chum Salmon roamed as far as the mouth of Portage Creek before turning downstream. Most of the roamers eventually went to either the Chulitna or Talkeetna rivers, and three went as far as Montana Creek.

5.2.3. Coho Salmon

5.2.3.1. Fish Tagged in Lower River

5.2.3.1.1. Tag Returns

Of the Coho Salmon radio tags deployed in the Lower River, 36 were recovered by anglers (35 tags) or project field staff (1 tags; Table E-1). Coho Salmon tags were recovered in the Deshka (9), Kashwitna (2), Talachulitna (1), and Talkeetna (6) rivers; and Clear (4), Little Willow (1), Montana (2), Rabideaux (2), Sheep (1), Sunshine (2), Trapper (2), Troublesome (1), Whiskers (1), and Willow (2) creeks.

5.2.3.1.2. Stock Classifications and Spawning Locations

Of the 640 Coho Salmon tagged in the Lower River, 581 (91 percent) were classified by destination (Table 5.2-1). Of the remaining 59 tags, 10 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and 49 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (see “Other Classifications” in Table 5.2-1).

Of the 581 Coho Salmon tracked to a destination, 16 (3 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1). All sixteen potential spawning and holding sites were in the Lower River. These sites included 13 slough/side channel and 3 tributary mouth habitats. During the survey period, mainstem water clarity was ideal for visual confirmation of spawning activity; however, none of the potential spawning sites were confirmed for spawning.

Of the 581 Coho Salmon tracked to a destination, 565 (97 percent) went to tributaries. Of these, 94.2 percent used Lower River tributaries, mainly the Yentna, Deshka, Talkeetna, or Chulitna river (Figure 5.2-2). The remaining 5.8 percent had tributary destinations in Middle River downstream from Devils Canyon, mainly in Whiskers Creek or Indian River.

5.2.3.1.3. Roaming Behavior in the Middle River

Of the Coho Salmon tagged in the Lower River that entered the Middle River, 40 percent of the fish with known-classification subsequently moved downstream into a tributary (Table 5.2-2). Most roamers eventually went to Chase or Whiskers creeks, or Chulitna River. Roaming fish moved as far up into the Middle River as the mouth of Indian River before dropping back to enter downstream tributaries (Table 5.2-3).

5.2.3.2. Fish Tagged in Yentna River

5.2.3.2.1. Tag Returns

Of the Coho Salmon radio tags deployed in the Yentna River, two were recovered (Table E-1), both from Deshka River.

5.2.3.2.2. Stock Classifications and Spawning Locations

Coho Salmon radio-tagged in the Yentna River were expected to stay within this major tributary, and significant movement to other Susitna River tributaries was not expected (relative to Coho Salmon tagged in the Lower River). As expected, 43 of the 60 Coho Salmon released in the Yentna River (72 percent) were classified with a Yentna destination, and 5 (8 percent) were classified in other Lower Susitna River tributaries (Deshka or Chulitna rivers; Table 5.2-1). The remaining 12 tags were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction; see “Other Classifications” in Table 5.2-1).

5.2.3.2.3. Roaming Behavior in the Middle River

No fish tagged in the Yentna River migrated into the Middle River and subsequently moved downstream into a tributary.

5.2.3.3. Fish Tagged in Middle River

5.2.3.3.1. Tag Returns

Of the Coho Salmon radio tags deployed in the Middle River, two were recovered: one in the Talkeetna River and one in Portage Creek (Table E-2).

5.2.3.3.2. Stock Classifications and Spawning Locations

Of the 230 Coho Salmon tagged in the Middle River, 184 (80 percent) were classified by destination (Table 5.2-1). Of the remaining 46 tags, 26 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and 20 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Of the 184 Coho Salmon tracked to a spawning destination, 11 (6 percent) went to mainstem destinations: one in the Lower River (a side channel near the mouth of the Chulitna), and ten to the Middle river (Table 5.2-1; Table D-4; Figure 5.2-1), including 5 within slough/side channel, 2 within main channel, and 3 within tributary mouth habitats. The other 173 fish (94 percent) went to tributaries. Of these, 15 percent used Lower River tributaries (mainly Talkeetna River; Figure 5.2-3), and 85 percent used tributaries in the Middle River downstream from Devils Canyon (mainly Indian River or Portage Creek; Figure 5.2-3).

Coho Salmon were tracked to eight potential mainstem spawning and holding sites in the Middle River between PRM 111.3 and PRM 155.9 (Table D-4). There were two sites at which more than one radio-tagged Coho Salmon was detected (#3, 6). No potential mainstem spawning and holding sites for Coho Salmon were identified above PRM 152.3. To assess if there was spawning activity, seven sites were visually examined during aerial telemetry, boat, or foot surveys (HSC). Seven sites were surveyed aerially (#1–6, 8), and two sites by boat/foot (#2, 7). No fish were observed at five of the sites (#3-7; Table D-4). Two sites were too turbid to see fish during aerial surveys (#1, 2) even though they were regularly monitored. Holding behavior was observed at one tributary mouth habitat (#8), but no fish were observed spawning at any of the eight sites (despite ideal water clarity for visual inspection).

5.2.3.3.3. Roaming Behavior in the Middle River

Several fish tagged at the Curry fishwheels moved downstream into a Lower or Middle River tributary (Table 5.2-2). For Coho Salmon tagged at the Curry fishwheels, 29 percent of the classified fish exhibited this roaming behavior. Middle River Coho Salmon roamed as far as the mouth of Portage Creek before turning downstream, and one fish moved far enough downstream to enter Yenta River.

5.2.4. Pink Salmon

5.2.4.1. Fish Tagged in Lower River

5.2.4.1.1. Tag Returns

Of the Pink Salmon radio tags deployed in the Lower River, two were recovered (Table E-1): one from Willow Creek and one from Montana Creek.

5.2.4.1.2. Stock Classifications and Spawning Locations

Of the 199 Pink Salmon tagged in the Lower River, 156 (78 percent) were classified by destination (Table 5.2-1). Of the remaining 43 tags, 20 were ignored (never moved from release site) and 22 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (see “Other Classifications” in Table 5.2-1).

Of the 156 Pink Salmon tracked to a destination, only 1 fish (< 1 percent) was classified as having a destination in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1). It was a main channel site in the Lower River. Spawning was not confirmed at this location due to high turbidity precluding visual observation.

Of the 156 Pink Salmon tracked to a destination, 155 (~99 percent) went to tributaries. Of these, 97.4 percent used Lower River tributaries, mainly the Yenta, Deshka or Chulitna rivers, or Willow Creek (Figure 5.2-2). The remaining 2.6 percent (4 fish) had tributary destinations in Middle River below Devils Canyon, specifically, in 4th of July Creek or Indian River.

5.2.4.1.3. Roaming Behavior in the Middle River

Of the Pink Salmon tagged in the Lower River that entered the Middle River, 33 percent of the fish with known-classification subsequently moved downstream into a tributary, either to the Talkeetna or Chulitna rivers. These Pink Salmon roamed as far as the mouth of Portage Creek before turning downstream.

5.2.4.2. Fish Tagged in Middle River

5.2.4.2.1. Tag Returns

Of the Pink Salmon radio tags deployed in the Middle River, two were recovered: one in 4th of July Creek, and one at the Montana Creek weir (Table E-2).

5.2.4.2.2. Stock Classifications and Spawning Locations

Of the 201 Pink Salmon tagged in the Middle River, 176 (88 percent) were classified by destination (Table 5.2-1). Of the remaining 25 tags, 8 were ignored (zero or one detection, never moved from release site, or moved only in the downstream direction) and 17 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Of the 176 Pink Salmon tracked to a spawning destination, 12 (7 percent) went to destinations in the mainstem Middle River (Table 5.2-1; Table D-5; Figure 5.2-1), including 5 with slough/side channel, and 7 with tributary mouth habitats. The other 164 fish (93 percent) went to tributaries. Of these, 23.9 percent used Lower River tributaries (mainly Talkeetna or Chulitna rivers; Figure 5.2-3), and 67.1 percent used tributaries in the Middle River downstream from Devils Canyon (mainly 4th of July Creek or Indian River; Figure 5.2-3).

Pink Salmon were tracked to eight potential mainstem spawning and holding sites in the Middle River between PRM 111.3 and PRM 155.9 (Table D-5). There were three sites at which more than one radio-tagged Pink Salmon was detected (#1, 3, 7). No potential mainstem spawning and holding sites for Pink Salmon were identified above PRM 148. To assess if there was spawning activity, all eight sites were visually examined during aerial telemetry, boat, or foot surveys (HSC). Four sites were surveyed aerially (#1, 5, 6, 8), and four sites by boat/foot (#1, 5, 6, 8). No fish were observed at two of the sites (#2, 4). Three sites were too turbid to see fish during aerial surveys (#5, 6, 8) even though they were regularly monitored. Holding behavior was observed at two tributary mouth habitats (#3, 7), but no fish were observed spawning at any of the 8 sites (despite that water clarity was ideal for visual inspection). The two potential spawning sites that Pink Salmon were observed holding in 2014 had been spawning locations in at least one of the previous years (2012 and 2013).

5.2.4.2.3. Roaming Behavior in the Middle River

Several fish tagged at the Curry fishwheels moved downstream into a Lower or Middle River tributary (Table 5.2-2). For Pink Salmon tagged at the Middle River fishwheels, 39 percent of the classified fish exhibited this roaming behavior. Most of the roamers eventually went to either to Talkeetna River, Whiskers Creek or Chulitna River, although one fish moved far enough downstream to enter the Yenta River. Most Middle River Pink Salmon roamed as far upstream as the mouth of Indian River, others reached the mouth of Portage Creek, before turning downstream.

5.2.5. Sockeye Salmon

5.2.5.1. Fish Tagged in Middle River

5.2.5.1.1. Tag Returns

Of the Sockeye Salmon radio tags deployed in the Middle River, five were recovered (Table E-2) in the Middle Susitna River (PRM 141 and 145; 2); as well as in Chase (1), Disappointment (1), and Larson (1) creeks.

5.2.5.1.2. Stock Classifications and Spawning Locations

Of the 200 Sockeye Salmon tagged in the Middle River, 142 (71 percent) were classified by destination (Table 5.2-1). Of the remaining 58 tags, 9 were ignored (never moved from release site, or moved only in the downstream direction) and 49 exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Of the 142 Sockeye Salmon tracked to a spawning destination, 66 (46 percent) went to destinations in the mainstem Middle River (Table 5.2-1; Table D-6; Figure 5.2-1), all in slough/side channel habitats. The other 76 fish (54 percent) went to tributaries. Of these, 82.2 percent used Lower River tributaries (mainly Talkeetna or Chulitna rivers; Figure 5.2-3), and 11.8 percent used tributaries in the Middle River downstream from Devils Canyon (mainly Indian River or Portage Creek; Figure 5.2-3).

Sockeye Salmon were tracked to eight potential mainstem spawning and holding sites in the Middle River between PRM 111.3 and PRM 155.9 (Table D-6). At seven of the eight sites, more than one radio-tagged Sockeye Salmon was detected (#2–8). No potential mainstem spawning sites for Sockeye Salmon were identified above PRM 146. To assess if there was spawning activity, all eight sites were visually examined during aerial telemetry, boat, or foot surveys (HSC). Four sites were surveyed aerially (#1, 2, 6, 7) and seven sites by boat/foot (#2–8). No fish were observed at three of the sites (#1, 3, 4). Holding and spawning behavior was observed at five sites (#2, 5–8). All confirmed spawning sites were also confirmed in 2012 and 2013.

5.2.5.1.3. Roaming Behavior in the Middle River

Sockeye Salmon tagged at the Curry fishwheels were the most likely species to roam (Table 5.2-2): 49 percent of the classified Sockeye Salmon did so. These Sockeye Salmon moved far up into the Middle River before dropping back to enter downstream tributaries. For example, three Sockeye Salmon moved upstream to Impediment 1 (two above and one below) before dropping back. Middle River Sockeye Salmon moved downstream to a variety of Lower River locations. Most of the roamers eventually went to either the Chulitna or Talkeetna rivers, but one moved far enough downstream to enter the Deshka River.

5.3. Objective 3: Characterize adult salmon migration behavior and timing within and above Devils Canyon

5.3.1. Chinook Salmon

From 2012 to 2014, 17 large Chinook Salmon passed three impediments into the area above Devils Canyon (12 fish in 2012, 3 in 2013, and 2 in 2014; Table F-1). Of these, seven had final destinations that were above the proposed dam site, all in the Kosina Creek watershed (6 in 2012, 1 in 2014). A further three fish had destinations that were upstream of Devils Canyon but downstream of Watana (2 in Devil Creek and 1 in Tsusena Creek). Detailed results related to adult salmon migration behavior and timing within and above Devils Canyon in 2014 are presented below (see Tables 5.3-1 and 5.3-2) and in Appendices F and G.

Of the 590 radio-tagged large Chinook Salmon tagged and released at the Middle River fishwheels in 2014, 491 were detected at or above Gateway Station (PRM 130.1) after tagging (Table 5.3-1). Of these 491 fish, 11 (2.2 percent) were tracked above Impediment 1 (PRM 155.2), 8 (1.6 percent) above Impediment 2 (PRM 160.2), and 2 (0.4 percent) above Impediment 3 (PRM 164.8). Thirty-four of the 656 large Chinook Salmon radio-tagged and released at the Lower River fishwheels were detected above Gateway Station, of which two were tracked above Impediment 1; one of which subsequently passed Impediment 2 (Tables 5.3-1 and 5.3-2; Figure 5.3-1). In addition, 32 radio-tagged small Chinook Salmon were tagged and released at the Middle River fishwheels. Of these, 24 were detected above Gateway Station after tagging and none passed Impediment 1 (Table 5.3-2; Figure 5.3-2).

5.3.1.1. Size of Chinook Salmon Tracked In and Above Devils Canyon

In 2014, 38 radio-tagged Chinook Salmon passed and/or approached to within 1 km (0.6 mi) downstream of Impediment 1 (6 tagged in Lower River, 32 tagged in Middle River). The mean length of these fish (78.9 cm [31.1 in]) was significantly larger than that of radio-tagged fish which did not approach Impediment 1 (71.9 cm [28.3 in]; t_{522} = 3.10, P = 0.002). However, there was not a significant difference in length between fish that passed Impediment 1 (77.3 cm [30.4 in]) versus those that approached to within 1 km (0.6 mi) downstream of the Impediment (79.7 cm [31.4 in]); Table 5.3-1; t_{36} = 0.53, P = 0.60). The mean length of fish that approached, but did not pass Impediment 3 (79.0 cm [31.1 in], n = 4) was similar to that of fish that passed Impediment 3 (n = 2; Table 5.3-1). These observations suggest that length may have been a factor in approaching to within 1 km (0.6 mi) downstream of Impediment 1 for Chinook Salmon, but was not a factor in successful passing of the impediments (although sample sizes for statistical assessment of Impediment 3 passage were small).

5.3.1.2. Behavior of Chinook Salmon At Devils Canyon

Fish showed noticeable milling or holding behavior below Impediment 1 and Impediment 3. Fish that moved past Impediment 1 held below it for an average of 3.9 days; similar in duration to individuals that did not pass (average 4.5 days; Table D-7). Four fish that passed Impediment 1 did not attempt to pass Impediment 2; rather they moved into Cheechako Creek, backed downstream to Portage Creek, or dropped downstream and died. All of the fish that approached Impediment 2 passed it quickly (≤ 1 day; Table D-7). Three fish that passed Impediment 2 did not attempt to pass Impediment 3; rather, they explored the area around Chinook Creek, and eventually dropped back downstream. When considering patterns for the six fish that approached Impediment 3, the hold times were shorter and approach dates were later for the fish that passed as compared with those that did not pass. The two fish that passed Impediment 3 held below it for an average of 6.8 days, whereas those that did not pass, held for an average of 11.3 days before moving downstream (Figure 5.3-3). The two fish that passed approached on or after July 30, where approach dates of the non-passing fish ranged from July 2 to 28.

The destination for the 13 Chinook Salmon tracked above Impediment 1 are provided in Table 5.3-3. Three of four Chinook Salmon that did not pass Impediment 2 could be conclusively assigned to a spawning destination, with one (33 percent) of those being downstream of Impediment 1. Three of seven Chinook Salmon that did not pass Impediment 3 could be conclusively assigned to a spawning destination, and all 3 (100 percent) had a destination downstream of Impediment 2. Overall, seven of the 13 Chinook Salmon that passed at least one of the three impediments could be conclusively assigned to a spawning destination; and 4 of 7 destinations (57 percent) were downstream of the last impediment passed – two of these went to Portage Creek, one to Cheechako Creek, and one to the mainstem near the mouth of Cheechako Creek.

5.3.1.3. Passage Timing and Flows

In 2014, the first Chinook Salmon to successfully pass Impediment 1 passed on June 30 when flow at the Tsusena Creek gauge was 19,400 cfs (26,000 cfs at the Gold Creek gauge; Figure 5.3-1). Other fish passed Impediment 1 on July 1 and July 6, during flows of 23,200 cfs or greater at the Tsusena Creek gauge (27,900 cfs or greater at the Gold Creek gauge). No other fish passed Impediment 1 until the period from July 18 to August 1, when Tsusena Creek gauge flows ranged between 15,500 and 23,400 cfs (18,800–27,100 cfs at the Gold Creek gauge). There was a period from July 7 to July 17 during which no fish passed, and flows ranged from 19,900 to 35,300 cfs at the Tsusena Creek gauge (24,200–36,500 at the Gold Creek gauge; Table 5.3-1; Figure 5.3-1). Both Chinook Salmon that later passed Impediment 3, had passed Impediment 1 on the same day (July 20; Table D-7). Discharge when the two fish passed Impediment 3 ranged from 15,900 cfs (July 30) to 16,400 cfs (August 4) at the Tsusena Creek gauge (19,200–19,400 cfs at the Gold Creek gauge).

5.3.1.4. Behavior Upstream of Devils Canyon

Two Chinook Salmon passed Impediment 3, each showing markedly different behaviors (Figures F-1 and F-2). One Chinook Salmon just barely passed Impediment 3, subsequently returned downstream of it, and eventually died in the mainstem downstream of Devils Canyon (Figure F-1). The other Chinook Salmon travelled directly into Kosina Creek, spent 6 days therein, then took 5 days to swim to and return from Oshetna River (40 km [25 mi] each way), before returning to Kosina Creek (Figure F-2). This latter fish stayed in Kosina Creek for another 6 days, and then drifted out, settling just downstream of the mouth of Fog Creek.

5.3.1.5. Programmatic Summary

There was not strong or consistent evidence to suggest that body length influenced passage success through Devils Canyon. In 2012, Chinook Salmon that passed Impediments 1 and 3 were larger on average than those than dropped back, but the differences were not statistically significant (AEA 2013a). In 2013 and 2014, Chinook Salmon that passed the impediments were slightly smaller on average than those that dropped back, and again the differences were not statistically significant (AEA 2014c). In 2014, the Chinook Salmon that approached Devils Canyon were significantly larger on average than the fish that never came within 1 km of Impediment 1, but in 2012 and 2013 the same pattern was not observed. For large Chinook Salmon tagged at the Middle River fishwheels in 2012 and 2014, the mean length of fish that passed Impediment 3 was longer than that of the rest of the population (samples sizes were too small for rigorous statistical analysis), yet the pattern was opposite in 2013 (unpublished data). Overall, Chinook Salmon that ascended the impediments were at least 61 cm METF, but Sockeye Salmon that passed Impediment 1 ranged from 45–49 cm METF. Given the inconsistent results, it remains uncertain whether length is an important factor in successful passage above the impediments.

In 2012, there were results to suggest that river flow rates influenced passage success through Devils Canyon (AEA 2013a). In 2013, results similarly suggested that Impediment 3 passage occurred only when Susitna River flows were lower than 19,000 cfs near Tsusena Creek (20,000 cfs at the Gold Creek gauge). In 2014, fish passage at Impediment 3 occurred only during periods in which flow at the Tsusena Creek gauge dropped below 16,500 cfs (19,500 cfs at the Gold Creek gauge). In all years, results were limited in sample size, and were not part of a formal control-treatment experiment. Therefore, the degree to which lower flows played a primary causal role in the passage of Chinook Salmon is not quantifiable. Of particular concern is the potential confounding effects of “time of year.” Since, in all years, fish moved above the final impediment during lower-flow periods that occurred at around the same timeframe (July 17–20 in 2012; July 13–30 in 2013; July 30 to August 4 in 2014), it is not possible to separate out the relative importance of flows versus time of year.

Adult salmon migration behavior and timing within and above Devils Canyon has several consistent characteristics. As we currently understand it, only large Chinook Salmon (METF $\geq$ 50 cm [19.7 in]) regularly move upstream of Devils Canyon. Individuals that move upstream of the canyon are not significantly different in size than other large Chinook Salmon. Passage generally occurs in mid or late July. Passage events have not been observed during the highest flow conditions (Table 5.3-1, Figure 5.3-1), yet specific flows that may trigger canyon-passage behaviors were not evident from the data, other than that many occurred near the 10% exceedance level.

The main spawning destination in the Upper River is Kosina Creek, where peak counts have ranged from 26 July to 5 August (Table 5.3-4; Figure 5.3-4; i.e., more than 2 weeks after the radio-tagged fish were observed passing Impediment 3). Middle River spawning destinations that are upstream of Devils Canyon and downstream of the dam site include Tsusena, Fog and Devil creeks, where peak counts have ranged from 21 July (in Fog Creek in 1984) to 15 August (in Fog Creek in 2013; Table 5.3-5; i.e., 2-4 weeks after radio-tagged fish were observed passing Impediment 3). Within the canyon, Chinook Salmon spawn in Cheechako and Chinook creeks, where peaks counts have generally been in late July or early August, although the peak count in 1985 was quite late (23 August in Chinook Creek; Table 5.3-5). Small Chinook (METF < 50 cm [19.7 in]) and Sockeye salmon have successfully passed Impediment 1, but have always returned downstream shortly thereafter without passing Impediment 2.

5.3.1.6. Aerial Spawner Surveys

Chinook Salmon was the only salmon species observed during aerial spawner surveys that were flown from Cheechako Creek upstream to the Oshetna River in 2014. Adult Chinook Salmon were observed in Middle River tributaries between Impediments 1 and 2 (Cheechako Creek), between Impediments 2 and 3 (Chinook Creek), and above Impediment 3 (Devil and Fog creeks). No adult salmon were observed in the mainstem Susitna River or in any Upper River tributaries in 2014 (Table D-8).

In streams where they were observed, adult Chinook Salmon were not consistently seen over the course of the season. They were documented in one stream during Survey 1, two streams during Surveys 2 and 3, four streams during Surveys 4 and 5, one stream during Survey 6, and two streams during Survey 7 (Table D-8). Peak observations occurred on July 19 in Cheechako and Chinook creeks, July 31 in Fog Creek, and August 6 in Devil Creek.

In Cheechako Creek, the number of Chinook Salmon observed increased from 11 fish on July 14 to 16 fish on July 19. A steady decline in fish numbers was observed following July 31, and by the final survey on August 18, zero fish were seen. Chinook Creek followed a similar trend with five fish observed during the July 19 and July 25 surveys, two fish on the July 31 and August 6 surveys, and zero fish observed on the last two surveys.

Cheechako Creek is located between Impediment 1 and Impediment 2. It has high-gradient, step-pools within steep-walled canyons. Chinook Salmon habitat terminates within three miles of the Susitna River confluence at large waterfalls. The turbulent water and confined canyon walls presented challenges to salmon observation. Nevertheless, salmon were observed throughout this lower 3-mile reach of this creek, and groups of fish were seen holding in pools. In Cheechako Creek, a no-fly zone around a raptor nest within the canyon prevented aerial observation of approximately 0.5 miles of stream during the first two surveys.

Chinook Creek is located between Impediment 2 and Impediment 3. Chinook Creek has long stretches of high-gradient cascades, but it does not have a barrier to Chinook Salmon migration below 3,000 ft in elevation where the surveys terminated (at approximately tributary river mile 9). Regardless, fish were not seen beyond 0.5 miles upstream of the Chinook Creek confluence with the Susitna River.

Devil Creek is located just upstream of Devils Canyon. Devil Creek has similar geomorphology to Cheechako Creek, featuring high-gradient, step-pools within steep-walled canyons. Chinook Salmon habitat terminates within three miles of the Susitna River confluence at large impassable waterfalls. The turbulent water and confined canyon walls presented challenges to salmon observation. Nevertheless, fish were observed throughout the anadromous reach of this creek, and groups of fish were seen holding in pools.

Low numbers of adult Chinook Salmon were observed in Fog Creek. The lower reach of Fog Creek, where all the Chinook Salmon were observed, is dominated by high-gradient riffle confined within a steep-walled canyon. The upper reach is much lower gradient and has long stretches of gravel and cobble substrate that appeared suitable for Chinook Salmon spawning. An additional five miles of a tributary to Fog Creek was also surveyed. Three adult Chinook Salmon were observed in Fog Creek during Survey 4 on July 31; two fish were seen on Survey 5; zero on survey 6; and then one fish was observed during the final survey on August 18. The farthest upstream observation was approximately three miles from the Fog Creek confluence with the Susitna River.

Overall, weather conditions were favorable for observation throughout the study duration. While weather was variable, it was not a limiting factor in observing fish and did not delay survey completion (Table D-9). Low clouds and rain were the most influential weather factors; low light conditions occasionally reduced visibility into the deeper water and rain on the aircraft windows sometimes created difficult viewing conditions. Sun glare on the water was not a major factor in limiting fish observations; polarized glasses, helicopter orientation, and survey direction (some streams were surveyed from upstream to downstream) worked to improve visibility when glare was present. Tall trees and overhanging vegetation partially obscured some areas of most streams (Table D-10).

Overall, most streams had very clear water. The Black and Oshetna rivers were the only streams of glacial origin within the study area and turbidity severely limited visibility in the Black River and the Oshetna River downstream of the Black River confluence during all surveys. Visibility in Watana and Jay creeks was typically poor in the lower few miles due to erosion produced from landslides; whereas upstream of the landslides the water was clear. Kosina Creek experienced several minor erosion events upstream of the study area which reduced visibility slightly. The most prevalent impairment to seeing fish was white-water turbulence, which was significant within all streams surveyed; white water was noted as limiting the observer's ability to find fish during all surveys (Table D-10).

5.3.1.7. Using Sonar to Enumerate Salmon at the Proposed Dam Site

Detailed results pertaining to 2014 field activities are provided in Appendix G, and a brief summary is provided here.

During sonar operations from July 6 to August 22 at the proposed dam site, a total net-upstream count of 24 Chinook Salmon was estimated based on the number of fish measuring 50 cm (19.7 in) TL or greater. Passage of these fish at Watana was observed from July 10 through August 22, and compared well with the passage of radio-tags at Impediment 3 on July 20. Aerial spawner surveys were conducted between July 14 and August 19, so multiple forms of monitoring were occurring in the region over the same time period. The sonar array covered approximately 58 percent of the channel width where the substrate was in the field of view and water velocities outside the sonar range were too high (greater than 1.8 m/s [6 ft/s]) to be a primary migration corridor. All observations of fish were within 4 m (13.1 ft) of the transducers with most occurring at 3 m (9.8 ft). No apparent diel passage patterns were observed. Size estimates for upstream migrants ranged from 50 to 110 cm (19.7–43.3 in) TL, with an average of 78 cm (30.7 in) TL. In addition, 213 fish measuring 40–49 cm (15.7-19.3 in) TL, and 1,044 fish measuring less than 40 cm (15.7 in) TL, were counted at the sonar stations. Assuming the length distribution of Chinook Salmon at Watana was the same as that at the Middle River fishwheels, then an estimated 24.1 percent of Chinook Salmon at Watana were less than 50 cm (19.7 in). This percentage would be a conservative estimate based on the length analysis presented in Section 5.3.1.1 that demonstrated bigger fish were the ones approaching the impediments in Devils Canyon. Even so, applying this conservative estimate to the sonar data, 24 Chinook Salmon at Watana (targets ≥ 50 cm [19.7 in]) then represent 75.9 percent of the Chinook Salmon that passed, and 8 additional Chinook Salmon measuring less than 50 cm (19.7 in) could have passed (= 24 * 24.1 / 75.9). Note however, based on radio telemetry, no tagged Chinook Salmon measuring less than 50 cm (19.7 in) METF have passed Impediment 3 in three seasons of study. Considering all available information, it was estimated that greater than 90 percent of Chinook Salmon migrating past Watana were observed by the sonar, or that about an additional 3 passage events could have occurred.

5.3.2. Sockeye Salmon

Of the 200 radio-tagged Sockeye Salmon released at the Middle River fishwheels, 146 were detected at or above Gateway Station (PRM 130.1; Table 5.3-1). Of these 146 fish, 3 (2.1 percent) were tracked above Impediment 1 (Tables 5.3-1 and 5.3-2; Figure 5.3-2). From 2012 – 2014, a total of 409 Sockeye Salmon were radio-tagged in the Middle River, and of these, 3 were tracked above Impediment 1 (i.e., no Sockeye Salmon passed Impediment 1 in 2012 or 2013).

5.3.2.1. Size of Sockeye Salmon Tracked At Devils Canyon

Sixteen radio-tagged Sockeye Salmon passed and/or approached to within 1 km (0.6 mi) downstream of Impediment 1. The mean length of these fish (48.5 cm [19.1 in]) was not significantly different from that of fish that did not approach Impediment 1 (50.8 cm [20.0 in]; $t_{144} = 1.7$, $P = 0.09$). The mean body length of fish that approached, but did not pass Impediment 1 (48.8 cm [19.2 in]) was not significantly different from that of fish that passed Impediment 1 (47.3 cm [18.6 in]; Table 5.3-1; $t_{14} = 0.44$, $P = 0.66$). These observations indicate length was not a factor in determining approach or successful passage of Impediment 1 for Sockeye Salmon (although sample sizes for statistical assessment of impediment passage were small).

5.3.2.2. Behavior of Sockeye Salmon At Devils Canyon

The first Sockeye Salmon to successfully pass Impediment 1 passed on July 27 (Table D-7) when flow at the Tsusena Creek gauge was 18,900 cfs (Figure 5.3-2; 23,900 cfs at the Gold Creek gauge). No other Sockeye Salmon passed Impediment 1 until September 8, when two fish were detected just above Impediment 1, but which returned downstream by the next day. From July 27 to September 10, flows were relatively stable, averaging 15,600 cfs and ranging from

12,900 to 18,900 cfs at the Tsusena Creek gauge (Figure 5.3-2; at Gold Creek gauge, flows averaged 18,972, and ranged from 16,200 to 23,900 cfs). Sockeye Salmon that moved past Impediment 1 held downstream for an average of 1.5 days before passing upstream; this is a shorter holding time than for individuals that did not pass (average 4.7 days; Table D-7). None of the three Sockeye Salmon that passed Impediment 1 approached Impediment 2.

All three of the Sockeye that passed Impediment 1 were later tracked to spawning destinations that were downstream of the impediment: two went to the Chulitna River, and one to Jack Long Creek.

5.3.2.3. Aerial Spawner Surveys

No adult Sockeye Salmon, nor Chinook Salmon, were observed during 2014 aerial surveys of the two lakes in the Tsisi Creek drainage. Surveys were conducted approximately two weeks after the timing of documented salmon passage above the Devils Canyon impediments and thus were consistent with the timing of salmon presence in the Upper River. In addition, opportunistic fish sampling was conducted in one of these lakes in late August and September and demonstrated the presence of Lake Trout in the size range of 372-456 mm fork length (R2 Resource Consultants 2015).

5.3.3. Other Species

No salmon species other than Chinook and Sockeye salmon were detected within Devils Canyon in any of the three recent years of telemetry study and only Chinook Salmon were documented above Impediment 3 of the canyon (AEA 2013a, 2014c).

5.4. Objective 4: Use available technology to document salmon spawning locations in turbid water

Radio telemetry surveys were used to locate potential spawning locations for Chinook Salmon in turbid water habitats of the Middle River from 2012–2014. In total, radio telemetry identified 98 radio-tagged Chinook Salmon suspected of spawning within turbid mainstem habitats of the Middle River. The locations of these Chinook Salmon led ground crews to sample 44 potential spawning areas, of which 18 were sampled using sonar technologies (side-scan, DIDSON, and ARIS). Seven of the 44 potential spawning locations were repeat locations in at least two of the three sampling years (2012-2014). Of the 18 locations sampled with sonar over the three study years (sampling dates ranged from July 19 to July 31), Chinook Salmon spawning activity (i.e., nest-guarding behavior) was observed at one location in the mainstem Susitna River: near the mouth of the Indian River (Table 5.4-1). At four turbid water locations (4^{th} of July Creek Mouth, Portage Creek Mouth, and two main channel habitats), Chinook Salmon were present or holding, but exhibited no behavior indicative of spawning. The remaining 26 locations were either not accessible by boat, were not suitable as spawning habitat, or did not contain Chinook Salmon when viewed with sonar. Additionally, Chinook Salmon spawning behavior was confirmed using sonar at the mouth of Jack Long Creek (2014); however, this location was not identified by radio telemetry analysis. During the latter part of the Chinook Salmon migration in early August, the presence of Chum Salmon at some locations made confirmation of Chinook Salmon difficult.

Spawning activity was not confirmed for any other salmon species using sonar technology. The utility of using sonar to document spawning in turbid water was limited for several reasons. First, Chum, Coho, Pink, and Sockeye salmon have a complete overlap in body size and run timing making confirmation of species in turbid water using sonar impossible. Finally, due to bathymetry and substrate size at many locations sonar imagery was not effective for detecting features indicative of redds. Similarly, due to the slope of the river bed, redd digging behavior could not be captured despite collecting several hours of imagery containing Chinook Salmon and other salmon species in areas considered suitable for spawning. Worthy of mention, sonar was able to confirm spawning behavior for a species of salmon at 4th of July Side Channel; however, species ID was not able to be confirmed until water clarity increased later in the season allowing visual confirmation of species.

5.4.1. Programmatic Summary

Over the three-year period, several limitations of the sonar method were identified. Redd depressions were often difficult to observe in sonar imagery because of the slope of the river bed or size of the substrate relative to the orientation of the redd depression. Tiffan et al. (2004) found that DIDSON was more effective when Chinook Salmon redds exhibited sufficient morphology (i.e., well-developed tailspills) and where the topography of the river bed was somewhat smooth so that redds would not be confused with other bottom features. When a fish swam into a redd depression (e.g., to dig), it could not be detected by the sonar. Given proper orientation, fish could be observed on the sonar holding, swimming in and out of areas considered to be redds, and displaying nest-guarding behavior. However, when a fish was not oriented perpendicular to the sonar beam its acoustic signal became weak which made identifying behavioral observations difficult. At times when multiple fish species with a large degree of overlap in body length could be present (e.g., Chinook/Chum or Chum/Coho/Pink/Sockeye), sonar was not able to positively identify species. This was less of an issue for Chinook Salmon which spawned in part during a period when few other species were present, and because they are typically much larger than most other salmon species. And lastly, the equipment needed to operate a sonar was heavy and required a boat with a suitable gunnel-mount. Many of the potential spawning locations were in side channels or sloughs that were too shallow for the boat, so this limited the number of sites that could be sampled using the equipment. Still, the study team successfully met this objective by demonstrating that sonar technologies could be used to document spawning behaviors, but that the utility was limited, given the current state of the technology, by bed topography and shallow depths at which salmon spawn.

5.5. Objective 6: Generate counts of adult Chinook Salmon spawning in the Susitna River and its tributaries

In July 2012, stream walks (visual counts) and aerial-tracking surveys proved to be ineffective for generating counts and establishing mark rates in sections of the Indian River and Portage Creek due to bear predation on Chinook Salmon. Thus, no escapement estimates for Chinook Salmon above Devils Canyon were made in 2012. In 2013, a weir and underwater video system were used to estimate an escapement of 1,137 large Chinook Salmon (mark rate of 6.3 percent) to the Indian River. These data were used to estimate escapements of 6,952 large Chinook Salmon above Gateway, and 48 large Chinook Salmon migrated above Devils Canyon in 2013.

In 2014, the Indian River weir was rendered inoperable due to a flood so the study team used the AUC method to estimate an escapement of 1,297 large Chinook Salmon in the Indian River (mark rate of 13.2 percent). Detailed results related to counts of adult Chinook Salmon spawning in the Susitna River and its tributaries in 2014 are presented below and in Appendix H.

5.5.1. Indian River Escapement Estimate

Chinook Salmon abundance in the Indian River was estimated using the AUC method (Appendix H). From July 7 to August 19, 16 aerial spawner surveys were conducted in the Indian River (Table 4.3-1). In all three river sections combined, 127 Chinook Salmon were counted on the first survey (July 7) and three fish were counted on the last survey (August 19; Table H-1). Observed counts peaked at 798 Chinook Salmon on July 22. Estimated observer efficiencies ranged from 40 to 80 percent (Table H-1). The lowest observer efficiencies occurred on July 19 due to poor weather conditions. For most surveys, conditions ranged from good to excellent.

Chinook Salmon counts in the Indian River were very similar during concurrent surveys conducted by the study team and ADF&G. ADF&G counted 558 Chinook Salmon on July 31 (S. Ivey, ADF&G, Sport Fish Division, personal communication) and the study team observers counted 544 Chinook Salmon on August 1.

For the purpose of analysis, it was assumed that no Chinook Salmon were present in the Indian River prior to June 26 or after August 19 (Figure H-1). No Chinook Salmon were observed at the Indian River weir through June 25, and survey crews indicated that the three remaining live Chinook Salmon observed on August 19 were moribund. Residence times above Bridge 1 for radio-tagged large Chinook Salmon averaged 15.0 days and ranged from 0.1 to 60.6 days (median = 15.6 days, n = 184; Figure H-2). Based on the observed aerial survey counts, estimated observer efficiencies, and median residence time of radio-tagged fish, the estimated escapement of large Chinook Salmon above Bridge 1 in 2014 was 1,297 fish (Table H-2).

Over the study period, 184 radio-tagged large Chinook Salmon were detected above Bridge 1, of which 171 were tagged in the Middle River and 13 were tagged in the Lower River. Thus, the mark rate of large Chinook Salmon at the Middle River fishwheels was estimated to be 13.2 percent (171 tags/1,297 fish; Table H-2).

In 2013, estimated observer efficiencies for Chinook Salmon in the Indian River during the study team and ADF&G aerial spawner surveys ranged from 35.8 to 46.3 percent (Table H-1 in AEA 2014c). Based on the 2013 results, it is possible the 2014 estimates of observer efficiency were biased high. For this reason the study team conducted a sensitivity analysis of the 2014 escapement estimate and mark rate to determine how sensitive calculations were to a small decrease in observer efficiency. All else remaining constant, decreasing observer efficiencies by 15 percent for each survey and river reach led to a 29 percent increase in the escapement estimate (from 1,297 to 1,674 fish) and a 23 percent decrease in the mark rate (from 13.2 to 10.2 percent).

5.5.1.1. Programmatic Summary

In the Middle River, efforts to count Chinook Salmon in tributaries from 2012 to 2014 were focused on Indian River (with some minor effort in Portage Creek in 2012) for the purposes of estimating survey-area mark rates (to test the representativeness of tagging efforts), estimating abundance above the tagging site, and making inferences about the relative abundance among recovery locations. Visual counts (stream walks) in the Indian River and Portage Creek in 2012 proved difficult due to the removal of Chinook Salmon by bears. In 2013, 1,137 large Chinook Salmon were inspected for tags at the Indian River weir, of which 72 (6.3 percent) were radio-tagged. Based on the number of fish entering the study area, mark-recapture methods were used to estimate that 6,952 (SE = 682) large Chinook Salmon passed the Gateway Station in the Middle River from June 18 to July 28 in 2013. In 2014, since the Indian River weir was rendered inoperable, AUC methods were used to generate an escapement estimate of 1,297 large Chinook Salmon, of which 13.2 percent were tagged.

5.5.2. Estimated Abundance of Chinook Salmon Upstream of Devils Canyon

Abundance of Chinook Salmon upstream of Devils Canyon was estimated using two methods. The first method expanded the counts of radio-tagged fish by the 'mark rate' (i.e., the proportion of fish that were marked). In 2014, the mark rate was 13.2 percent: approximately one in every 7.6 large Chinook Salmon at the Middle River fishwheels was tagged (Table H-2). For this method, it is important to understand that the positions of the fixed-station receivers and the extensive mobile survey effort made it unlikely that any radio-tagged fish passed upstream of Devils Canyon undetected. Since, in 2014, two radio-tagged large Chinook Salmon passed Impediment 3, and one tagged fish passed the Watana Dam site (Tables 5.3-1 and 5.3-2), the study team would expect that 15.2 large Chinook Salmon (2 divided by 13.2 percent) passed Impediment 3, and 7.6 fish (1 divided by 13.2 percent) passed Watana Dam site.

In 2014, a second independent method was available to estimate the number of salmon that passed the dam site. Specifically, a sonar was deployed at the Watana site, and a total of 24 salmon-sized targets passed during the study period. Given the species composition of the radio-tagged fish that passed Impediment 3, coupled with that from spawner surveys, it is probable that all of these targets were Chinook Salmon. Together, these two methods suggest that the abundance of Chinook Salmon upstream of the dam site likely ranged from 7.6 to 24 fish.

5.5.2.1. Programmatic Summary

The abundance of Chinook Salmon passing Devils Canyon was not directly estimated in 2013 or 2014 (e.g., using mark-recapture methods). However, mark rates established for large Chinook Salmon in the Indian River, combined with the number of radio-tagged fish present above Devils Canyon, were used to make inferences about the relative abundance of large Chinook Salmon above Devils Canyon. In 2013, an estimated 48 large Chinook Salmon migrated above Devils Canyon (3 radio tags present above Devils Canyon expanded by 6.3 percent mark rate). Although too few radio-tagged fish migrated above Devils Canyon to develop a statistically precise estimate, an estimate of similar magnitude was produced when the peak aerial spawner count was expanded by the estimated observer efficiency (29 fish counted expanded by 46.3 percent observer efficiency = 63 fish total).

In 2014, results from three independent study components indicated that the abundance of large Chinook Salmon above Devils Canyon was likely on the order of magnitude of 50 fish or less, with a portion of that number passing above the potential dam site. First, aerial spawner surveys of clear-water tributaries above Devils Canyon had a peak count of 12 Chinook Salmon (10 in Devil Creek, 2 in Fog Creek). If the observer efficiencies on these surveys were as low as 40–50 percent, the peak count would expand to only 24–30 fish. Second, a net-upstream count of 24 salmon-sized fish was obtained at the Watana Canyon sonar site in 2014. Although this count was considered a minimum estimate, there was no evidence to suggest that fish passage at the site was significantly greater than that observed. And third, based on a 13.2 percent mark rate for large Chinook Salmon at the Middle River tag site, the two radio-tagged fish that migrated above Devils Canyon represented approximately 15 fish in total.

5.6. Objective 7: Collect tissue samples to support the Fish Genetics Study

Genetic samples were collected from 4,016 Chinook, 395 Chum, 2,074 Coho, 798 Pink, and 336 Sockeye salmon across the three study years and sample locations. In 2012, 443 Chinook Salmon were sampled. In 2013, genetic samples were collected from 1,999 Chinook, 201 Chum, 1,016 Coho, 399 Pink, and 138 Sockeye salmon. In 2014, genetic samples were collected from 659 Chinook, 640 Coho, and 198 Pink salmon in the Lower River. Genetic samples were also collected from 296 Chinook Salmon in the Yentna River and 204 Coho Salmon in Montana Creek. In the Middle River, genetic samples were collected from 619 Chinook (small and large fish combined), 194 Chum, 214 Coho (199 at fishwheels, 15 in gillnets), 201 Pink, and 198 Sockeye salmon in 2014 (Table A-6). All genetic tissue samples were delivered to ADF&G's Gene Conservation Lab for analysis. Results were reported by the Genetic Baseline Study for Selected Fish Species (Study 9.14).

The study team completed all tasks required to fulfill the requirements of study Objective 7. Genetic samples were collected from adult anadromous salmon in conjunction with addressing study objectives 1 and 2. All samples were delivered to ADF&G's Gene Conservation Lab for analysis, and results were reported by the Genetic Baseline Study for Selected Fish Species (Study 9.14).

5.7. Objective 8: Estimate the system-wide Chinook Salmon escapement and the Coho Salmon escapement to the Susitna River above the Yentna River, and the distribution of those fish among tributaries of the Susitna River

In 2013, the abundance of Chinook Salmon measuring 50 cm (19.7 in) METF or greater spawning in the Susitna River above the Lower River mainstem tagging site was 89,463 (SE = 9,523). Based on radio-telemetry tracking results (see Table 5.2-1 in the ISR), it is estimated that Deshka, Talkeetna and Chulitna Rivers were the main destinations (Figure 5.7-1). As discussed in Study 9.7 ISR Appendix I, no estimate was produced for the Yentna River in 2013.

In 2014, the system-wide escapement estimate for Chinook Salmon was 68,225 [SE = 10,615] upstream of the confluence of the Yentna River and 22,267 [SE = 2,871] in the Yentna River). Based on radio-telemetry tracking results (Table 5.2-1), it is estimated that Deshka, Talkeetna and Chulitna Rivers were the main destinations (Figure 5.7-2) upstream of Yentna River.

The 2014 escapement estimate (84,879; SE = 9,550) for Coho Salmon measuring 40 cm (15.7 in) METF or greater above the Lower River tagging site was 35 percent lower than the 2013 estimate (130,026; SE = 24,342). Based on radio-telemetry tracking results (Table 5.2-1), it is estimated that Deshka, Talkeetna and Chulitna Rivers were the main destinations in both years (Figures 5.7-3 and 5.7-4).

Detailed results related to the 2014 escapement and distribution estimates as part of Objective 8 are provided in Appendix I.

6. DISCUSSION

This Discussion section focuses on Objective 5 of the RSP: "Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon." Recent and historic data pertinent to these aspects of salmon ecology are reviewed by species for the Lower and Middle Susitna River.

Fish abundance as calculated by mark-recapture experiments (i.e., escapement estimates) were determined in the early 1980's (1981-1984), and recently as part of the Susitna-Watana project. Marking target species was accomplished with visual tags or radio-tags via capture by fishwheels. A portion of the tags were then recovered at weirs or by telemetry monitoring at strategic locations in the basin. Historically, escapement estimates were derived for the Lower Susitna (Sunshine Station), the Middle Susitna (Talkeetna Station), and select tributaries. More recent (2000's) Lower River estimates are available for salmon species except Pink Salmon, and recent Middle River estimates are available for Chinook and Coho salmon. All studies partition out abundance of the Yentna River so that general comparisons can be made between the historical and recent estimates upstream of its confluence. Estimating Chinook and Coho salmon abundance in 2013 and 2014 accomplishes Objective 8 of the Study Plan.

Habitat classifications described during studies conducted in the 1980's (Barrett et al. 1985a,b; Thompson et al. 1986) were not defined exactly as in the 2012-2014 studies, and should be taken into consideration when making comparisons. Specifically, spawning habitat studies conducted from 1981 to 1983 classified a "tributary mouth" as including the lower 1/3 mile of the tributary, and survey sections did not sample the zone of confluence with tributary and the Susitna River. However, in 1984, the methodological approach was modified, and spawning behavior at the confluence of the tributary was documented for several streams in the Middle River (Barrett et al. 1985a,b). For the purpose of analysis, only historic spawning locations that specifically mentioned the confluence with the Susitna River were used for comparison with recent spawning locations.

6.1. Chinook

6.1.1. Timing of Migration

- Lower River

Fishwheel catches were compared among years to assess variability in the timing of migration through the Lower River; however, it should be noted that some conditions varied across years (e.g., number of fishwheels operated, location of fishwheels, operational period, daily fishing effort, river discharge, relative fish abundance). From 2012 to 2014, fishwheels were operated in the Lower River (PRM 33–34) and Chinook Salmon were captured as early as May 22 and as late as August 19. Peak catches occurred in early to mid-June in 2012, 2013, and 2014. This run timing from recent studies is considerably earlier that than reported from studies in the 1980s. In 1982 and 1983, Chinook Salmon were captured from June 28 to September 2 at the Lower River fishwheels (ADF&G 1983b, 1984). At the Flathorn fishwheels (PRM 26–28), Chinook Salmon were caught between June 30 and August 27 in 1984 and 1985 (Barrett et al. 1985a,b; Thompson et al. 1986). And in 1983, Chinook Salmon were captured at the Sunshine fishwheels (~PRM 84) from June 5 to August 18 (ADF&G 1984).

- Middle River (downstream of Devils Canyon)

Fishwheels were operated in the Middle River near Curry from 1981 to 1985 and 2012 to 2014. Again, it should be noted that many factors related to fishwheel sampling were not constant across years. From 2012 to 2014, Chinook Salmon (all sizes combined) were captured at the Middle River fishwheels as early as June 11 and as late as August 28 (Table A-8, Figure A-13). This run timing was similar to historic records from the 1980s, when the earliest that a Chinook Salmon was captured at the Middle River fishwheels was June 9 (1984) and the latest was August 20 (1981; Table A-8, Figure A-13). The midpoint of Chinook Salmon catches ranged from June 30 to July 3 for the years 2012 to 2014, and from June 24 to July 9 for the years 1981 to 1985. The dates of peak catch were similar over the recent 3-year period (July 2 in 2012 and 2013, and July 1 in 2014).

- Middle River (upstream of Devils Canyon), Watana Dam, Upper River

Migration timing for radio-tagged Chinook Salmon passing Impediment 3 in the Middle River was fairly consistent in recent study years and ranged from July 17–20 in 2012 (n = 12), July 13–30 in 2013 (n = 3), and July 30 to August 4 in 2014 (n = 2). This timing was similar to that of Chinook Salmon observed upstream of Impediment 3 during two years of aerial spawner surveys (2012 and 2013). Furthermore, at the proposed Watana Dam site, shore-based sonar units detected fish determined as Chinook Salmon, from July 10 to August 22 in 2014 (Appendix G) and on July 20, 2013. There was no run timing data upstream of Devils Canyon from the 1980s studies to compare to recent studies.

6.1.2. Timing of Spawning

- Lower River and Tributaries

The migration timing of Chinook Salmon in the Lower River was slightly earlier and more protracted for recent studies as compared to timing data from the 1980s. For Chinook Salmon classified to the Yentna, Deshka, Chulitna or Talkeetna rivers, the 10th and 90th percentile dates when fish were spawning ranged from June 24 to August 10. Each potential mainstem spawner had a single location position that was selected as representative of its ‘cluster’ (see Section 4.2.3.2), and each of those representative locations had an associated date. The 10th and 90th percentile dates for Chinook Salmon Lower River mainstem destinations ranged from June 22 to September 2. In comparison, from 1981 through 1984, the spawning period for Chinook Salmon in the Lower River ranged from mid-July through mid-August, with peak spawning occurring during the last week of July (summarized in Barrett et al. 1985a,b).

- Middle River (within and downstream of Devils Canyon) and Tributaries

For Chinook Salmon classified to Indian River or Portage Creek, the 10th and 90th percentile dates during which fish were in the tributary to which they were classified spanned from July 8 to August 6. The 10th and 90th percentile ‘representative’ dates for Chinook Salmon Middle River mainstem destinations downstream of Devils Canyon ranged from July 12 to August 3. In comparison, from 1981 through 1984, the spawning period for Chinook Salmon in the Middle River was very similar ranging from mid-July through mid-August, with peak spawning occurring during the last week of July (summarized in Barrett et al. 1985a,b). For Chinook Salmon classified to Devils Canyon tributaries (Cheechako or Chinook creeks), the 10th and 90th percentile dates during which fish were in the tributary to which they were classified spanned from July 17 to August 7. From 2012-2014, two Chinook Salmon were classified as having mainstem destinations within Devils Canyon. The ‘representative’ dates for the two fish were July 21 and September 2.

- Middle River (upstream of Devils Canyon), Watana Dam, Upper River and Tributaries.

For Middle River tributaries upstream of Devils Canyon (Devils or Tsusena creeks), the 10th and 90th percentile dates ranged from July 22 to August 9. In the Upper River (i.e., in Kosina Creek and its tributaries), date ranges were July 23 to August 11.

Aerials surveys conducted in the 1980s documented few spawners in the areas upstream of Devils Canyon. In 1983, the single aerial survey over Devil Creek (August 1) documented the presence of one fish. In 1984, four flights over Fog Creek found a peak count of two fish on July 21. Other than these few data points, the historical timing of spawning for Chinook Salmon upstream of Devils Canyon was not previously documented.

6.1.3. Distribution to Mainstem and Tributaries

6.1.3.1. Radio-tags applied in Lower River

- Lower River and Tributaries

During 2012-2014, Chinook Salmon tagged in the Lower River moved mostly into Lower River tributaries. The main Lower River tributary destinations were the Yentna (13.2 percent), Deshka (24.5 percent), Talkeetna (16.2 percent) and Chulitna (16.6 percent) rivers (Figure D-1). In addition, 0.6 to 2.4 percent of the tagged Chinook Salmon in the Lower River were classified as having mainstem destinations in the Lower River. Note that the percentages presented here were not weighted according to size-specific tag rates, and are not directly comparable to the weighted percentages. Similarly, from 1976-1984, most Chinook Salmon caught in the Lower River moved into tributaries of the Lower River (summarized in Jennings 1985). In addition, estimated percent distributions of Chinook Salmon were higher, historically, to the Yentna (20.0 percent) and Deshka (35.0 percent) rivers and lower to the Chulitna River (5.0 percent); however, the contribution of Chinook Salmon to the Talkeetna River was similar (Jennings 1985). Chinook Salmon had no Lower River mainstem destinations during historic surveys.

- Middle River (within and downstream of Devils Canyon) and Tributaries

Each year during AEA's studies, Chinook Salmon tagged in the Lower River moved into Middle River tributaries. Fish used Indian River, and Whiskers, 4th of July and Portage creeks, together accounting for 5.2 percent of the overall destinations of the Lower-River-tagged Chinook Salmon (Figure D-1). In addition, between 0 and 0.5 percent were classified as having mainstem destinations in the Middle River downstream of the canyon.

In 2013, two fish (0.3 percent) moved into a tributary destination that was in Devils Canyon (Cheechako Creek). In 2014, one fish went to Cheechako Creek, and one fish had a mainstem destination at the mouth of Cheechako Creek (combined, 0.3 percent of the overall destinations of the 2013 Lower-River-tagged Chinook Salmon, or 0.2 percent as an average of the annual usage over three years; Figure D-1).

Similar to 2012-2014, 5.0 percent of the Chinook Salmon caught in the Lower River, from 1976-1984, had destinations within the Middle River (downstream from Devils Canyon) and tributaries of the Middle River (Jennings 1985).

- Middle River (upstream of Devils Canyon), Watana Dam, Upper River and Tributaries.

In 2012, two Lower-River-tagged Chinook Salmon passed Devils Canyon and moved into Kosina Creek, an Upper River tributary. These fish represent 0.5 percent of the overall destinations of the 2012 Lower-River-tagged Chinook Salmon, or 0.2 percent as an average of the annual usage over three years (Figure D-1). In 2012-2014, no Lower-River-tagged Chinook Salmon had mainstem destinations upstream of Devils Canyon. In comparison, from 1976-1984, < 0.5 percent of Chinook Salmon had destinations upstream of Devils Canyon (Jennings 1985).

6.1.3.2. Radio-tags applied in Middle River

- Lower River and Tributaries

Annually, there were Middle-River-tagged Chinook Salmon that moved to tributaries in the Lower River. The main Lower River tributary destinations were the Talkeetna and Chulitna rivers. From 2012-2014, these two tributaries represented an average of 11.3 percent of the overall destinations of the Middle-River-tagged Chinook Salmon (Figure D-2). In 2013, two fish (0.4 percent) were classified to mainstem destinations in the Lower River, but there were none so classified in 2012 or 2014.

- Middle River (within and downstream of Devils Canyon) and Tributaries

The majority of the Middle-River-tagged Chinook Salmon moved into tributaries in the Middle River downstream of Devils Canyon. Indian River and Portage Creek were the main destinations. From 2012-2014, Indian River and Portage Creek accounted for an average of 26.0 percent and 41.9 percent of the overall destinations of the Middle-River-tagged Chinook Salmon, respectively (Figure D-2). Each year, a few Middle-River-tagged Chinook Salmon travelled to destinations within Devils Canyon, including Cheechako (average 1.0 percent annually) and Chinook (average 0.4 percent annually) creeks.

Each year, a portion of the Middle-River-tagged Chinook Salmon were classified as having a mainstem destination, and most of these were located in the Middle River downstream of Devils Canyon. From 2012-2014, Middle-River mainstem destinations ranged from 5.3 to 9.8 percent of the overall destinations of the Middle-River-tagged Chinook Salmon. In 2013, a single fish (0.2 percent) had a mainstem destination within Devils Canyon (in the mainstem proper near the mouth of Chinook Creek), whereas no Middle River-tagged Chinook Salmon had mainstem locations within Devils Canyon in 2012 or 2014.

- Middle River (upstream of Devils Canyon), Watana Dam, Upper River and Tributaries.

In 2014, two radio-tagged Chinook Salmon passed Devils Canyon, which was down from three in 2013, and 12 in 2012, despite the fact that more large Chinook Salmon were tagged in the Middle River during each successive year (590 in 2014, 536 in 2013, 352 in 2012). From 2012-2014, tributary use upstream of Devils Canyon averaged 0.2 percent in Devil Creek, 0.1 percent in Tsusena Creek, and 0.5 percent in Kosina Creek (Figure D-2). Wandering behavior was evident in all three years of tagging although the degree that individual fish wandered varied considerably. In 2012-2014, no Middle-River-tagged Chinook Salmon had mainstem destinations upstream of Devils Canyon.

6.1.4. Mainstem Habitat and Tributary Use

- Lower River and Tributaries

Telemetry results indicated that the majority of Chinook Salmon tagged in the Lower River likely spawned in tributaries. Proportions of tributary spawners were relatively consistent among years for Chinook Salmon (97–99 percent). Chinook Salmon used the Yentna, Deshka, Talkeetna, and Chulitna rivers in all years.

From 2012 through 2014, 23 radio-tagged Chinook Salmon were identified with potential spawning sites within mainstem macro habitats of the Lower River (Figure D-11). These radio-tagged fish represented 14 distinct spawning locations (a cluster of points or an isolated point represented one spawning location) of which three were associated with tributary mouths/confluences. None of these potential spawning locations were visually confirmed. Historic surveys only indicated spawning within tributaries and there was no indication of spawning behavior observed at the confluence of tributaries in the Lower River (Barrett et al.1985a,b, Thompson et al.1986).

- Middle River (downstream of Devils Canyon) and Tributaries

Telemetry results indicated that most of the Chinook Salmon tagged in the Middle River were most likely to have spawned in tributaries. Proportions in 2014 (93 percent) were similar to those estimated in 2012 (90 percent; AEA 2013a) and 2013 (94 percent; AEA 2014c), as was the main suite of Middle River tributary destinations (Indian River, Portage Creek), although relative use of these tributaries varied among years. Analysis of salmon detection histories identified several potential mainstem spawning locations in the Middle River which included the mouths of tributaries, side channels, and main channel habitats.

From 2012 to 2014, 100 radio-tagged Chinook Salmon were identified with potential spawning sites within mainstem macrohabitats of the Middle River (Figure D-12; see section 5.4 for a summary of results). Although numerous radio- tagged Chinook Salmon were tracked to mainstem habitats, spawning activity was only confirmed at the confluence of tributary mouths. These results are consistent with studies conducted in the 1980's where Chinook Salmon were only documented spawning within mainstem habitats at the confluence of five tributary mouths (Chinook, Cheechako, Portage, and 4th of July creeks, and Indian River; Figure D-12; Barrett et al. 1985a,b).

Results from three years of tagging, including the number of fish tagged and tracked via fixed stations and mobile surveys, and the number of detections across river segments and habitats, characterize the distribution of salmon throughout the Middle and Lower River. Specifically, the data collected demonstrates that the licensing participant concern (study dispute issue) as to whether radio-telemetry efforts as designed in the Study Plan were sufficient to determine Chinook Salmon spawning sites in the Middle River between PRM102 (confluence of Middle River with Lower River) and PRM124 (Curry) was not realized.

During the period 2012 through 2014, 1,681 and 1,478 Chinook Salmon were radio-tagged in the Lower and Middle river, respectively. This resulted in the detection of 88 Lower River origin and 500 Middle River origin Chinook Salmon tags at the Lane Creek telemetry fixed station located at PRM 116.8. Also over these years and over the salmon migration season, a total of 80 complete aerial telemetry surveys were conducted over the river from PRM102 to PRM124. Mobile telemetry surveys resulted in identifying a total of five potential spawning-holding locations for Chinook Salmon in mainstem habitats (tributary confluence), and 10 tags having their destination in tributaries (Lane, Whiskers, and Chase creeks) for that section of river. This compares to a total of 95 potential spawning-holding locations identified for Chinook Salmon in mainstem habitats, and 1,092 in tributaries upstream of PRM124.

Radio-tagged Chinook Salmon of Lower River origin had the same opportunity to choose destinations in either section of the river. Further, documented roaming behavior supports that Chinook Salmon of Middle River origin also have substantial opportunity to choose destinations downstream of PRM124. These results indicate that the Middle River upstream of PRM124 includes a substantially higher proportion of spawning (95.0% of mainstem locations, 99.1% of tributaries) than that downstream of PRM124 (5.0% of mainstem locations, 0.9% of tributaries), and is consistent with historical studies (Barrett et al 1985). Therefore, the methodological approach outlined in the Study Plan and respective variances provided sufficient sample size and telemetry detections to evaluate spawning locations for adult Chinook Salmon in the Middle River downstream and upstream of PRM124 and meet the objective of the study.

- Middle River (within and upstream of Devils Canyon), Watana Dam, Upper River and Tributaries.

No radio-tagged Chinook Salmon were tracked to potential mainstem, slough, or side-channel locations in the Middle River upstream of Devils Canyon. The preponderance of evidence to date suggests that the relatively low numbers (e.g., 50 – 100) of Chinook Salmon in the Upper River are using tributaries for spawning. Tributaries and tributary mouths upstream of Devils

Canyon with documented Chinook Salmon spawning included Cheechako, Fog, Devil, Tsusena, and Kosina Creeks and the Oshetna River.

The first evidence of spawning within or upstream of Devils Canyon came in 1982 when ADF&G found adult Chinook Salmon in Cheechako (n = 16) and Chinook (n = 5) creeks, along with redds containing live eggs (ADF&G 1983b). The first scientific observations of Chinook Salmon upstream of Devils Canyon came in 1983, when ADF&G found one adult fish in Devil Creek (ADF&G 1984). In 1984, Chinook Salmon spawning was observed in Chinook (n = 15) and Fog (n = 2) creeks. In 2003, presence of juvenile Chinook Salmon in Fog Creek, Kosina Creek, and the Oshetna River, also implied past spawning activity (Buckwalter 2011). In 2012, 2013 and 2014, radio-tagged Chinook Salmon were detected and appeared to spawn in Kosina, Tsusena or Devil creeks (AEA 2013a, 2014c). In total, AEA tracked 17 Chinook Salmon which migrated above Impediment 3 (Figure F-1 through Figure F-17).

6.1.5. Abundance Estimates

- Lower River (RM30)

Historically, Chinook Salmon average escapement was 88,000 (range 53,000 to 122,000) in the Lower River at Sunshine Station (i.e., upstream of the Yentna River). This compares closely to an average of 79,000 (approximate range 68,000 to 89,000) for 2013 and 2014 for the Susitna River (upstream of the confluence of the Yentna River, Appendix I).

- Middle River (RM120 / Curry)

Historically, Chinook Salmon average escapement was 13,000 (range 9,700 to 18,000) for the Middle River at Talkeetna Station. This is 1.8 times higher than an average of 7,100 (range 6,600 to 7,700) for 2013 and 2014 (Appendix I).

- Middle River (upstream of Devils Canyon), Watana Dam, and Upper River

Recent studies conducted by AEA from 2012 to 2014 provide the only available information on the abundance of Chinook Salmon upstream of Devils Canyon. Radio-telemetry documented Chinook Salmon passage through the canyon and into tributaries, and ARIS sonar made counting of Chinook Salmon passing the Watana Dam site possible. Counts of 12, 3 and 2 radio-tags passed Impediment 3 in 2012, 2013, and 2014 respectively. These counts were used to generate escapement estimates for 2013 and 2014 of 23 and 24 salmon respectively. These three independent metrics indicate that the population of Chinook Salmon upstream of Devils Canyon appears to be on an order of magnitude of <100 adults, with a portion of that upstream of Watana Dam.

6.2. Chum

6.2.1. Timing of Migration

- Lower River

Chum Salmon migrate through the Lower River from early June through at least early September. In 2013 and 2014, Chum Salmon were captured at the Lower River fishwheels (PRM 33-34) from June 11 to August 26, and fish were still being captured on the last day of fishwheel operation in each year so it was likely the run continued beyond these dates. Chum Salmon daily catches peaked on July 20 in 2013 and August 7 in 2014. This migration timing is similar to historic reports with an earlier onset of the run in recent studies. Chum Salmon were captured in the Lower River from June 30 to September 4 during fishwheel operations in 1981 and 1982 (ADF&G 1981, 1983b).

- Middle River (downstream of Devils Canyon)

Chum Salmon begin their migration through the Middle River about a month later than in the Lower River, early July, and continue through late September. From 2012 to 2014, Chum Salmon were caught at the Middle River as early as July 5 and as late as September 28. This migration timing was similar to the 1980s, when Chum Salmon were caught in fishwheels between as early as July 10 (1983) and as late as September 15 (1981) (Table A-8, Figure A-14). The midpoint of runs as indicated by catch was August 5–12 in 2012 to 2014, and from August 3–17 in the 1980s.

6.2.2. Timing of Spawning

- Lower River and Tributaries

For Chum Salmon classified to the Yentna, Chulitna or Talkeetna rivers, the 10th and 90th percentile dates when fish were in spawning tributaries spanned from August 7 to September 13. This estimate of spawning timing is shorter by a couple of weeks in comparison with historic data. From 1981 through 1984, the spawning period for Chum Salmon in the Lower River ranged from mid-August through the first week of October, with peak spawning occurring during the last week of August through the first week of September (summarized in Barrett et al. 1985a,b).

- Middle River (downstream of Devils Canyon) and Tributaries

For spawning Chum Salmon classified to Indian River or Portage Creek, the 10th and 90th percentile dates spanned from August 5 to 30. The 10th and 90th percentile dates for Chum Salmon Middle River mainstem destinations downstream of Devils Canyon ranged from August 8 to September 9 indicating a slightly longer spawning window. However, both of these recent estimates of spawn timing are shorter in comparison with historic estimates. From 1981 through 1984, the spawning period for Chum Salmon in the Middle River ranged from late July through the first week of October, (summarized in Barrett et al. 1985a,b).

6.2.3. Distribution to Mainstem and Tributaries

6.2.3.1. Radio-tags applied in Lower River

- Lower River and Tributaries

In 2012, 400 Chum Salmon tagged in the Lower River moved mostly into Lower River tributaries. The primary Lower River tributary destinations were the Yentna (33.6 percent), Talkeetna (2.1 percent) and Chulitna (9.1 percent) rivers (Figure D-3). In addition, 9.2 percent of the Lower-River-tagged Chum Salmon were classified as having mainstem destinations in the Lower River. No Chum Salmon were tagged in the Lower River in 2013 or 2014.

In comparison, historical Chum Salmon tagging results (Merizon et al. 2010) showed that 96 percent had destinations within the Lower River and tributaries of the Lower River. The historical contributions of Chum Salmon to the Yentna (41.0 percent) and Chulitna (4.0 percent) rivers were similar to recent results. Historical Chum Salmon contributions to the Lower River mainstem (26.0 percent) and Talkeetna River (11.0 percent) were higher, as compared to the 2012 tracking results.

- Middle River and Tributaries

In 2012, a few of the Chum Salmon tagged in the Lower River moved into Middle River tributaries. Fish used Indian River, 4th of July and Portage creeks, together accounting for 4.2 percent of the overall destinations of the Lower-River-tagged Chum Salmon (Figure D-3). In addition, three fish (1.0 percent) were classified as having mainstem destinations in the Middle River. Similarly in 2009, 4.0 percent of the Lower River caught Chum Salmon had a destination in the Middle River and tributaries (downstream of Devils Canyon; Merizon et al. 2010). Tributary use also was similar in a 1984 study, with use of the Indian River, Portage Creek, and 4^{th} of July Creek. However, the proportion of mainstem use was higher historically with more than half of the Chum Salmon having spawning destinations in mainstem habitats of the Middle River (Barrett et al. 1985a,b). No Lower River Chum Salmon had destinations within or upstream of Devils Canyon during recent or historic studies.

6.2.3.2. Radio-tags applied in Middle River

- Lower River and Tributaries

There were Middle-River-tagged Chum Salmon that moved to tributaries in the Lower River each year from 2012 to 2014. The main Lower River tributary destinations were the Talkeetna and Chulitna rivers. These two tributaries represented an average of 12.7 and 2.6 percent of the overall destinations of the Middle-River-tagged Chum Salmon, respectively (Figure D-4). In three years of tracking, no Middle-River-tagged Chum Salmon were classified to mainstem destinations in the Lower River.

- Middle River and Tributaries

The majority of the Middle-River-tagged Chum Salmon moved into tributaries in the Middle River downstream of Devils Canyon. Indian River and Portage Creek were the main destinations. From 2012-2014, Indian River and Portage Creek accounted for an average of 27.5

percent and 23.6 percent of the overall destinations of the Middle-River-tagged Chum Salmon, respectively (Figure D-4). Each year, a portion (ranging from 10.4 to 23.9 percent) of the Middle-River-tagged Chum Salmon were classified as having a mainstem destination, all of which were located in the Middle River downstream of Devils Canyon. In three years of tracking, no Middle-River-tagged Chum Salmon had destinations within or upstream of Devils Canyon.

6.2.4. Mainstem Habitat and Tributary Use

- Lower River

From 2012 to 2014, 31 radio-tagged Chum Salmon were identified with potential spawning sites within mainstem habitat of the Lower River as based on 400 tags applied in the Lower River in 2012, and 4680 tags applied in the Middle River from 2012 – 2014 (Figure D-13). None of the potential spawning locations were visually confirmed. During historic surveys mainstem spawning activity was documented at 33 locations (Barrett et al. 1985a,b). Six of these historic locations were closely associated with a potential spawning location indicated by recent studies (Figure D-13).

- Middle River and Tributaries

Recent telemetry results indicated that most of the Chum Salmon tagged in the Middle River likely spawned in tributaries. Proportions varied among years: 76 percent in 2012 (AEA 2013a), 90 percent in 2013 (AEA 2014c), and 89 percent in 2014. Although the main suite of Middle-River tributaries was relatively stable (Indian River, Portage Creek), the proportional use of each tributary varied among years. Analysis of salmon detection histories identified several potential mainstem spawning locations in the Middle River. As for the types of mainstem spawning habitats used, Chum Salmon appeared to prefer the mouths of tributaries or side channels. No radio-tagged Chum Salmon were tracked to potential mainstem, slough, or side-channel locations in the Middle River upstream of Devils Canyon or in the Upper River.

From 2012 to 2014, 75 radio-tagged Chum Salmon were identified with potential spawning sites in mainstem habitat of the Middle River (Figures D-14 and D-15). Through ground surveys, aerial surveys, and opportunistic visual surveys, spawning was visually confirmed at seven locations indicated by radio telemetry and 16 locations visited opportunistically. Of the visually confirmed spawning locations, 12 were sloughs, six were side channels, and five were tributary mouths/confluences. No Chum Salmon were confirmed spawning in main channel habitats.

Chum Salmon were observed present or holding at five potential spawning locations, but spawning behavior was not exhibited. In comparison, historic surveys visually confirmed spawning at 73 locations within mainstem habitats (main channel, side channel, slough, and tributary mouth confluence) of the Middle River. Of all the slough habitats that were visually confirmed as spawning locations during this study, all were also visually confirmed during 1980's studies (Table 6.2-1). Similarly, all but 13 mainstem spawning locations documented during the 1980's surveys were closely associated with a potential spawning location indicated by recent radio telemetry analysis (Figures D-14 and D-15).

Results from three years of tagging, including the number of fish tagged and tracked via fixed stations and mobile surveys, and the number of detections across river segments and habitats, characterize the distribution of salmon throughout the Middle and Lower River. Specifically, the data collected demonstrates that the license participant concern (study dispute issue) as to whether radio-telemetry efforts as designed in the Study Plan were sufficient to determine Chum Salmon spawning sites in the Middle River between PRM102 (confluence of Middle River with Lower River) and PRM124 (Curry) was not realized.

During the period 2012 through 2014, 400 and 680 Chum Salmon were radio-tagged in the Lower and Middle river, respectively. This resulted in the detection of 24 Lower River origin and 215 Middle River origin Chum Salmon tags at the Lane Creek telemetry fixed station located at PRM 116.8. Also, over these years and over the salmon migration season, a total of 80 complete aerial telemetry surveys were conducted over the river from PRM102 to PRM124. Mobile telemetry surveys resulted in identifying a total of three potential spawning-holding locations for Chum Salmon in mainstem habitats (tributary confluence), and 11 tags having their destination in tributaries (Lane Creek, Whiskers Creek) for that section of river. This compares to a total of 72 potential spawning-holding locations identified for Chum Salmon in mainstem habitats, and 378 in tributaries upstream of PRM124.

Radio-tagged Chum Salmon of Lower River origin had the same opportunity to choose destinations in either section of the river. Further, documented roaming behavior supports that Chum Salmon of Middle River origin also have substantial opportunity to choose destinations downstream of PRM124. These results indicate that the Middle River upstream of PRM124 includes a substantially higher proportion of spawning (96.0% of mainstem locations, 97.2% of tributaries) than that downstream of PRM124 (4.0% of mainstem locations, 2.8% of tributaries), and is consistent with historical studies (Barrett et al 1985). Therefore, implementation of the Study Plan for radio telemetry including all variances provided sufficient sample size and telemetry detections to evaluate spawning locations for adult Chum Salmon in the Middle River downstream upstream of PRM124 and meet the objective of the study.

6.2.5. Abundance Estimates

- Lower River (RM30)

Historically, Chum Salmon average escapement was 431,000 (range 263,000 to 765,000) in the Lower River at Sunshine Station (i.e., upstream of the Yentna River). This is lower but modestly similar to an average of 616,000 (range 151,000 to 1,500,000) for 2010 - 2012 for the Susitna River (upstream of the confluence of the Yentna River; Cleary et al. 2013, Cleary et al. in prep A, Cleary et al. in prep B).

- Middle River (RM120 / Curry) and Tributaries

Historically, Chum Salmon average escapement was 28,000 (range 13,000 to 49,000) for the Middle River at Talkeetna Station. This is very similar to an average of 26,000 for 2012 - 2014 using the proportion of radio-tags with a destination in the Middle River (4.2 percent of the Lower River escapement).

License participants raised the concern as to whether use of existing and recent escapement information (2010 - 2012) in combination with new distribution data in the Middle River (2012 – 2014) as designed in the Study Plan were sufficient to evaluate Chum Salmon distribution and abundance. AEA completed three years of radio-tagging on Chum Salmon in the Middle River, and one year in the Lower River. In combination, these data produce the recent average abundance estimate presented above and meet the objective of the study.

6.3. Coho

6.3.1. Timing of Migration

- Lower River

Based on fishwheel catches, the migration timing of Coho Salmon through the Lower River ranged from the end of June to early September. In 2013 and 2014 Coho Salmon were captured from June 28 to August 31. In comparison, Coho Salmon collections were later in 1981 and 1982, ranging July 4 to September 4 (ADF&G 1981, 1983b).

- Middle River (downstream of Devils Canyon)

The timing of migration for Coho Salmon through the Middle River extends from late July to at least the end of September. In 2014, the first Coho Salmon was captured at the Middle River fishwheels on July 22, which was similar to 2013 (July 23) but 6 days earlier than in 2012 (July 28; Table A-8, Figure A-15). In the 1980s, the beginning of Coho Salmon collections was between July 18 (1984) and August 4 (1981). The midpoint of catches in 2014 (August 20) occurred 5 days later than in 2012 and 2013 (August 15). In the 1980s, the midpoint of catches ranged from August 12–23. The last Coho Salmon was captured on September 30 in 2014. Also, sonar data collected at Curry indicated that salmon-sized fish (presumably Chum and Coho Salmon) continued to migrate past Curry through the end of September in 2014 (Figures A-19 and A-20). Prior to 2014, the latest that a Coho Salmon had been captured at the Middle River fishwheels was September 21 (2013), although the fishwheels were shut down for the season between September 12 and September 21 in the 1980s.

6.3.2. Timing of Spawning

- Lower River and Tributaries

For Coho Salmon classified to the Yentna, Deshka, Chulitna or Talkeetna rivers, the 10th and 90th percentile dates when fish were in assigned spawning tributaries spanned from August 7 to September 23. Spawn timing in the mainstem appeared similar with the 10th and 90th percentile dates for Coho Salmon Lower River mainstem destinations ranging from August 9 to September 30. This spawning timing appears to be protracted and shifted earlier in comparison with historic data. From 1981-1984, the spawning period for Coho Salmon in the Lower River ranged from late September through mid-October, with peak spawning occurring during the last week of September (summarized in Barrett et al. 1985a,b).

- Middle River (downstream of Devils Canyon) and Tributaries

For Coho Salmon classified to Indian River or Portage Creek, the 10th and 90th percentile dates when fish were in assigned spawning tributaries spanned from August 20 to October 9. The 10th and 90th percentile dates for Coho Salmon Middle River mainstem destinations downstream of Devils Canyon ranged from August 20 to September 26. This spawn timing appears to be shifted earlier than historically. During the 1980s, the spawning period for Coho Salmon in the Susitna River ranged from late September through mid-October, with peak spawning occurring during the last week of September (summarized in Barrett et al. 1985a,b).

6.3.3. Distribution to Mainstem and Tributaries

6.3.3.1. Radio-tags applied in Lower River

- Lower River and Tributaries

During 2012-2014, Coho Salmon tagged in the Lower River moved mostly into Lower River tributaries. The primary Lower River tributary destinations were the Yentna (22.8 percent), Deshka (12.1 percent), Talkeetna (11.6 percent) and Chulitna (24.8 percent) rivers (Figure D-5). In addition, 2.8 to 6 percent of the Lower-River-tagged Coho Salmon were classified as having mainstem destinations in the Lower River. Similarly, Merizon et al. (2010) estimated that most (98 percent) Coho Salmon caught in the Lower River had destination in the Lower River and tributaries. Using data collected in the 1980's and 2009, the distribution of Coho Salmon to the Yentna River ranged from 23.0 percent (1980's) to 47.0 percent (2009). The Talkeetna and Chulitna rivers had a combined contribution of 29.0 (1980's) to 34.0 (2009) percent. The remaining Lower River, including the Deshka River had contributions of 27.0 (2009) to 46.0 percent (1980's; Barrett et al. 1985a, b; Merizon et al. 2010).

- Middle River and Tributaries

Each year during recent studies, Coho Salmon tagged in the Lower River moved into Middle River tributaries. Fish used Indian River, and Whiskers, Chase, Lane and Portage creeks, together accounting for 2.6 percent of the overall destinations of the Lower-River-tagged Coho Salmon (Figure D-5). In addition, between 0 and 0.6 percent were classified as having mainstem destinations in the Middle River. In comparison, of the estimated Coho Salmon that entered the Middle River from 1981-1984, most had destinations in Gash, Whiskers, and Chase creeks and Indian River (Barrett et al. 1985a, b). No Coho Salmon from recent or historic studies had destination upstream of Devils Canyon.

6.3.3.2. Radio-tags applied in Middle River

- Lower River and Tributaries

There were Middle-River-tagged Coho Salmon that moved to tributaries in the Lower River during each year of recent telemetry studies. The main Lower River tributary destinations were the Talkeetna and Chulitna rivers. From 2012-2014, these two tributaries represented an average of 5.6 and 13.4 percent of the overall destinations of the Middle-River-tagged Coho Salmon, respectively (Figure D-6). In three years of tracking, there were four Middle-River-tagged Coho

Salmon (annual percentages ranged from 0 to 1.7 percent) that were classified to mainstem destinations in the Lower River.

- Middle River and Tributaries

The majority of the Middle-River-tagged Coho Salmon moved into tributaries in the Middle River downstream of Devils Canyon. Indian River and Portage Creek were the main destinations. From 2012-2014, Indian River and Portage Creek accounted for an average of 37.6 percent and 9.0 percent of the overall destinations of the Middle-River-tagged Coho Salmon, respectively (Figure D-6). Each year, a portion (ranging from 5.4 to 15.9 percent) of the Middle-River-tagged Coho Salmon were classified as having a mainstem destination in the Middle River downstream of Devils Canyon. In three years of tracking, no Middle-River-tagged Coho Salmon had destinations within or upstream of Devils Canyon.

6.3.4. Mainstem Habitat and Tributary Use

- Lower River and Tributaries

Telemetry results indicated that the majority of Coho Salmon tagged in the Lower River likely spawned in tributaries. Proportions of tributary spawners were relatively consistent among years for Coho Salmon (93–96 percent). Coho Salmon used the Yentna, Deshka, Talkeetna, and Chulitna rivers in all years.

From 2012 to 2014, 40 radio-tagged Coho Salmon were identified with potential spawning sites in mainstem habitats of the Lower River (Figure D-16). Seven suspected spawning locations were at tributary mouths/confluences and the remaining were either main channel, side channel, or slough locations. None of these potential spawning locations were visually confirmed for spawning. During surveys conducted in the 1980's, six mainstem spawning locations were visually confirmed for Coho Salmon. Five of these historic spawning locations were closely associated with locations indicated from 2012- 2014 analyses.

- Middle River and Tributaries

Telemetry results indicated that most of the Coho Salmon tagged in the Middle River likely spawned in tributaries. Proportions in 2014 (94 percent) were similar to those estimated in 2012 (84 percent; AEA 2013a) and 2013 (89 percent; AEA 2014c). The specific tributary destinations were also similar, although relative use of these tributaries varied among years. Analysis of salmon detection histories identified several potential mainstem spawning locations in the Middle River. As for the types of mainstem spawning habitats used, Coho Salmon appeared to prefer the mouths of tributaries or side channels. No radio-tagged Coho Salmon were tracked to potential mainstem, slough, or side-channel locations in the Middle River upstream from Devils Canyon or in the Upper River.

From 2012 to 2014, 35 radio-tagged Coho Salmon were identified with potential spawning sites in mainstem habitat of the Middle River (Figure D-17). Through ground surveys, aerial surveys, and opportunistic visual surveys, spawning was confirmed at three locations visited opportunistically. Of the visually-confirmed spawning locations one was a slough, and two were at tributary mouths/confluences (Skull and Whiskers creeks). Coho Salmon were present or holding at two locations (Indian River and Portage Creek) indicated by radio telemetry analysis. During spawning surveys conducted in the 1980's, 12 mainstem spawning locations were visually confirmed for Coho Salmon and seven were closely associated with a location indicated by radio telemetry analyses.

Results from three years of tagging, including the number of fish tagged and tracked via fixed stations and mobile surveys, and the number of detections across river segments and habitats, characterize the distribution of salmon throughout the Middle and Lower River. Specifically, the data collected demonstrates that the licensing participant concern (study dispute issue) as to whether radio-telemetry efforts as designed in the Study Plan were sufficient to determine Coho Salmon spawning sites in the Middle River between PRM102 (confluence of Middle River with Lower River) and PRM124 (Curry) was not realized.

During the period 2012 through 2014, 1,653 and 638 Coho Salmon were radio-tagged in the Lower and Middle river, respectively. This resulted in the detection of 58 Lower River origin and 315 Middle River origin Coho Salmon tags at the Lane Creek telemetry fixed station located at PRM 116.8. Also over these years and over the salmon migration season, a total of 80 complete aerial telemetry surveys were conducted over the river from PRM102 to PRM124. Mobile telemetry surveys resulted in identifying a total of four potential spawning-holding locations for Coho Salmon in mainstem habitats (tributary confluence), and 61 tags having their destination in tributaries (Lane, Whiskers, Chase, Stash, and Gash creeks) for that section of river. This compares to a total of 31 potential spawning-holding locations identified for Coho Salmon in mainstem habitats, and 320 in tributaries upstream of PRM124.

Radio-tagged Coho Salmon of Lower River origin had the same opportunity to choose destinations in either section of the river. Further, documented roaming behavior supports that Coho Salmon of Middle River origin also have substantial opportunity to choose destinations downstream of PRM124. These results indicate that the Middle River upstream of PRM124 includes a substantially higher proportion of spawning (88.6% of mainstem locations, 84.0 % of tributaries) than that downstream of PRM124 (11.4% of mainstem locations, 16.0% of tributaries), and is consistent with historical studies (Barrett et al 1985). Therefore, implementation of the Study Plan for radio telemetry including all variances provided sufficient sample size and telemetry detections to evaluate spawning locations for adult Coho Salmon in the Middle River downstream and upstream of PRM124 and meet the objective of the study.

6.3.5. Abundance Estimates

- Lower River (RM30)

Historically, Coho Salmon average escapement was 44,000 (range 15,000 to 95,000) in the Lower River at Sunshine Station (i.e., upstream of the Yentna River). This is almost half of an average of 102,000 (range 73,000 to 132,000) for the period 2010 - 2014 for the Susitna River (upstream of the confluence of the Yentna River; Cleary et al. 2013, Cleary et al. in prep A, Cleary et al. in prep B, Appendix I).

- Middle River (RM120 / Curry) and Tributaries

Historically, Coho Salmon average escapement was 1,600 (range 800 to 2,400) for the Middle River at Talkeetna Station. This is approximately on quarter of recent estimate of 7,200 (range 6,200 to 8,300) based on 2013 and 2014 data (Cleary et al. 2013, Cleary et al. in prep A, Cleary et al. in prep B, Appendix I).

6.4. Pink

6.4.1. Timing of Migration

- Lower River

Pink Salmon migrate through the Lower River from late June to the end of August. In 2013 and 2014, Pink Salmon were captured at the Lower River fishwheels from June 23 to August 25. This was very similar to historic timing from the early 1980s. In 1981 and 1982, Pink Salmon catches occurred from June 28 to August 30 (ADF&G 1981, 1983b) and in 1985Pink Salmon were caught at the Flathorn fishwheels from June 22 to September 1 (Thompson et al. 1986).

- Middle River (downstream of Devils Canyon)

From 2012 to 2014, Pink Salmon were captured at the Middle River fishwheels as early as July 8 and as late as September 4 (Table A-8, Figure A-16). In the 1980s, Pink Salmon were caught with a similar migration timing, as early as July 7 in 1984 to as late as August 29 in 1981 and 1984. The midpoint of catches from 2012 to 2014 ranged from July 31 to August 8, which was similar to those observed in the 1980s (August 1–8).

6.4.2. Timing of Spawning

- Lower River and Tributaries

For Pink Salmon classified to the Yentna, Deshka, Chulitna or Talkeetna rivers, the 10th and 90th percentile dates when fish were in spawning tributaries spanned from August 6 to 29. The 10th and 90th percentile dates for Pink Salmon Lower River mainstem destinations ranged from July 31 to August 30. In comparison, from 1981 through1984, the spawning period for Pink Salmon in the Lower River was similar. Historic Pink Salmon spawning ranged from late July through early September, with peak spawning occurring during the first two weeks of August (summarized in Barrett et al. 1985a, b).

- Middle River (downstream of Devils Canyon) and Tributaries

For Pink Salmon classified to Indian River or to 4^{th} of July or Portage creeks for spawning, the 10th and 90th percentile dates when fish were in the spawning tributaries spanned from July 31 to August 20. The 10th and 90th percentile dates for Pink Salmon Middle River mainstem destinations downstream of Devils Canyon ranged from August 5 to 27. In comparison the historic spawn timing was similar from 1981 through 1984, the spawning period for Pink Salmon in the Middle River ranged from late July through early September, with peak spawning occurring during the second and third week of August (summarized in Barrett et al. 1985a,b).

6.4.3. Distribution to Mainstem and Tributaries

6.4.3.1. Radio-tags applied in Lower River

- Lower River and Tributaries

During 2012-2014, Pink Salmon tagged in the Lower River moved mostly into Lower River tributaries. The main Lower River tributary destinations were the Yentna (21.6 percent), Deshka (12 percent), Talkeetna (5 percent) and Chulitna (21.3 percent) rivers, and Willow (7 percent) and Montana (5.5 percent) creeks (Figure D-7). In addition, 0.6 to 14.7 percent of the Lower-River-tagged Pink Salmon were classified as having a mainstem destination in the Lower River. Similarly, Barrett et al. (1985a, b) indicated that, historically, most of the Pink Salmon caught in the Lower River also had destinations in the Lower River and Tributaries. In 1984, this included about 10.0 percent to the Yentna, 60.0 percent to tributaries between the Yentna and Sunshine Station, and the remaining 30.0 percent had destination upstream of Sunshine Station.

- Middle River and Tributaries

Each year, Pink Salmon tagged in the Lower River moved into Middle River tributaries. Fish used Indian River, and Lane, 4th of July, Gold and Portage creeks, together accounting for 3 percent of the overall destinations of the Lower-River-tagged Pink Salmon (Figure D-7). In 2013, one fish (0.9 percent) was classified as having mainstem destinations in the Middle River (at the mouth of 4th of July Creek). Similarly, from 1981-1984, most Pink Salmon with destinations in the Middle River ended up in tributaries. The three most important tributary destinations were tributaries used in recent years, Indian River, 4th of July Creek and Lane Creek (Barrett et al. 1985a,b). No Lower-River-tagged Pink Salmon had destinations within or upstream of Devils Canyon either historically or in recent studies.

6.4.3.2. Radio-tags applied in Middle River

- Lower River and Tributaries

Annually, there were Middle-River-tagged Pink Salmon that moved to tributaries in the Lower River during each year of recent studies. The main Lower River tributary destinations were the Talkeetna and Chulitna rivers. From 2012-2014, these two tributaries represented an average of 11.7 and 2.2 percent of the overall destinations of the Middle-River-tagged Pink Salmon, respectively (Figure D-8). In three years of tracking, no Middle-River-tagged Pink Salmon were classified to mainstem destinations in the Lower River.

- Middle River and Tributaries

The majority of the Middle-River-tagged Pink Salmon moved into tributaries in the Middle River downstream of Devils Canyon. Indian River and 4th of July and Portage creeks were the main destinations, accounted for an average of 34.7, 9.6 and 10.7 percent of the overall destinations of the Middle-River-tagged Pink Salmon, respectively (Figure D-8). Each year, a portion (ranging from 5.5 to 9.0 percent) of the Middle-River-tagged Pink Salmon were classified as having a mainstem destination, all of which were located in the Middle River downstream of Devils Canyon. In three years of tracking, no Middle-River-tagged Pink Salmon had destinations within or upstream of Devils Canyon.

6.4.4. Mainstem Habitat and Tributary Use

- Lower River and Tributaries

Telemetry results indicated that the majority of Pink Salmon tagged in the Lower River likely spawned in tributaries. Proportions of tributary spawners were more variable for Pink Salmon (84–97 percent) compared to Chinook or Coho salmon. Pink Salmon used the Yentna and Deshka rivers in all three years, and used Willow and Montana creeks and Talkeetna and Chulitna rivers to extents that varied among years (AEA 2013a, 2014c).

In contrast to 2013, when 16 percent of the Lower River Pink Salmon were classified to mainstem destinations (AEA 2014c), 1–3 percent were so classified in 2012 and 2014 (AEA 2013a). The difference can most likely be explained by lower tracking effort in tributaries in 2013, thus biasing Pink Salmon classifications away from tributary designations, and creating the appearance of a higher proportion of mainstem spawning. With higher effort of tributary tracking in 2012 and 2014, the mainstem spawning results were likely more realistic than in 2013.

From 2012 through 2014, 12 radio-tagged Pink Salmon were identified with potential spawning sites within mainstem habitats of the Lower River (Figure D-18). Of these, eight were associated with tributary mouths/confluences. Spawning was not visually confirmed for any Lower River potential spawning locations for Pink Salmon. Similarly, during spawning surveys conducted in the 1980's, Pink Salmon spawning was not observed within mainstem habitats of the Lower River.

- Middle River and Tributaries

Telemetry results indicated that most of the Pink Salmon tagged in the Middle River likely spawned in tributaries. Proportions in 2014 (93 percent) were similar to those estimated in 2012 (94 percent; AEA 2013a) and 2013 (91 percent; AEA 2014c), as were the primary Middle River tributary destinations (4^{th} of July Creek, Indian River, Portage Creek), although the relative use of these tributaries varied among years. Analysis of salmon detection histories identified several potential mainstem spawning locations in the Middle River. As for the types of mainstem spawning habitats used, Pink Salmon appeared to prefer the mouths of tributaries or side channels. No radio-tagged Pink Salmon were tracked to potential mainstem, slough, or side-channel locations in the Middle River upstream of Devils Canyon nor in the Upper River.

From 2012 through 2014, 21 radio-tagged Pink Salmon were identified with potential spawning sites within mainstem habitats of the Middle River (Figure D-19). Spawning was visually confirmed at three locations (Indian River Mouth, 4^{th} of July Creek Mouth, and Lane Creek Mouth) as indicated by radio telemetry and at three additional locations (Portage, Gold, and 5^{th} of July creek mouths) visually confirmed during opportunistic surveys. Spawning surveys conducted in the 1980's visually confirmed spawning by Pink Salmon at twenty locations; four were tributary mouth confluences (Fourth of July, Skull, and Portage creeks and Indian River) and 16 were slough habitats (Table 6.2-1). Nine of the historic spawning locations were closely associated with potential spawning locations indicated by recent studies.

Results from three years of tagging, including the number of fish tagged and tracked via fixed stations and mobile surveys, and the number of detections across river segments and habitats, characterize the distribution of salmon throughout the Middle and Lower River. Specifically, the data collected demonstrates that the licensing participant concern (study dispute issue) as to whether radio-telemetry efforts as designed in the Study Plan were sufficient to determine Pink Salmon spawning sites in the Middle River between PRM102 (confluence of Middle River with Lower River) and PRM124 (Curry) was not realized.

During the period 2012 through 2014, 796 and 631 Pink Salmon were radio-tagged in the Lower and Middle river, respectively. This resulted in the detection of 28 Lower River origin and 328 Middle River origin Pink Salmon tags at the Lane Creek telemetry fixed station located at PRM 116.8. Also over these years and over the salmon migration season, a total of 80 complete aerial telemetry surveys were conducted over the river from PRM102 to PRM124. Mobile telemetry surveys resulted in identifying a total of three potential spawning-holding locations for Pink Salmon in mainstem habitats (tributary confluence), and 39 tags having their destination in tributaries (Lane and Whiskers creeks) for that section of river. This compares to a total of 18 potential spawning-holding locations identified for Pink Salmon in mainstem habitats, and 373 in tributaries upstream of PRM124.

Radio-tagged Pink Salmon of Lower River origin had the same opportunity to choose destinations in either section of the river. Further, documented roaming behavior supports that Pink Salmon of Middle River origin also have substantial opportunity to choose destinations downstream of PRM124. These results indicate that the Middle River upstream of PRM124 includes a substantially higher proportion of spawning (85.7% of mainstem locations, 90.5% of tributaries) than that downstream of PRM124 (14.3% of mainstem locations, 9.5% of tributaries), and is consistent with historical studies (Barrett et al 1985). Therefore, implementation of the Study Plan for radio telemetry including all variances provided sufficient sample size and telemetry detections to evaluate spawning locations for adult Pink Salmon in the Middle River downstream and upstream of PRM124 and meet the objective of the study.

6.4.5. Abundance Estimates

- Lower River (RM30) and Middle River (RM120 / Curry)

Historically, Pink Salmon average escapement was 388,000 (range 40,000 to 1,017,000) in the Lower River at Sunshine Station (i.e., upstream of the Yentna River), and average escapement was 46,000 (range 1,000 to 117,000) for the Middle River at Talkeetna Station. No escapement estimates were made for recent studies.

Licensing participants posited that an escapement estimate was needed for Pink Salmon (FERC 2013b). In the 1980's Pink Salmon abundance estimates varied 120- to 50-fold from year to year and seven-fold between even year returns (ADF&G 1983b, 1985a,b). Recent data from ADF&G's Deshka River weir showed that even year returns varied 40-fold from 2004-2012 (AEA 2013b). Due to this wide inter-annual variation documented for Pink Salmon abundance, two years of abundance estimates would provide little, or no, additional value for determining impacts of project developments.

6.5. Sockeye

6.5.1. Timing of Migration

- Lower River

Sockeye Salmon migrate through the Lower River from approximately late May to the start of September. In recent years (2013 and 2014), Sockeye Salmon were captured at the Lower River fishwheels from June 4 to August 26. This migration timing is similar to historic records. Based on Lower River fishwheel catches from 1982 to 1984, the migration timing for the first run of Sockeye Salmon ranged from May 26 - June 28 with peak migration occurring during mid-June (Barrett et al. 1985a,b; Thompson et al. 1986). Similarly, fishwheel catches from 1981-1984 describe the migration timing for the second run of Sockeye Salmon as occurring from June 27 (1982) to September 12 (1982) with peak migrations occurring from mid-to late July (Barrett et al. 1985,a,b; Thompson et al. 1986)

- Middle River (downstream of Devils Canyon)

Migration timing for Sockeye Salmon in the Middle River has been relatively consistent across the years. From 2012 to 2014, Sockeye Salmon were captured between June 15 and September 10 (Table A-8, Figure A-17). This run timing and duration was similar to the 1980s, when the earliest that a Sockeye Salmon was captured was June 26 (1984) and the latest was September 18 (1982). Consistent with 2012 and 2013, catches of Sockeye Salmon in 2014 were relatively low and sporadic through July and August. The midpoint of catch in 2014 (August 1) was consistent with previous records, although earlier than 1981 to 1983, 1985, and 2013 (range: August 5–7), and similar to 1984 and 2012 (range: July 30 to August 1).

6.5.2. Timing of Spawning

- Lower River and Tributaries

For Sockeye Salmon classified as spawning in the Yentna, Chulitna or Talkeetna rivers, the 10th and 90th percentile dates when fish were spawning spanned from August 7 to September 13. From 2012-2014, three Sockeye Salmon were classified as having mainstem destinations in the Lower River. The spawn timing for the three fish was earlier than that estimated for tributary spawning (July 17 and 25) but was similar to historic timing. In 1981 through 1984, the spawning period for Sockeye Salmon in the Lower River ranged from mid-to late July for the first run and from late August through early October for the second run. Peak spawning for the second run occurred during the last week of August through mid-September (summarized in Barrett et al. 1985a, b).

- Middle River (downstream of Devils Canyon) and Tributaries

For Sockeye Salmon classified as spawning in Indian River or Portage Creek, the 10th and 90th percentile dates when fish were in the spanned from July 26 to September 7. The 10th and 90th percentile dates for Sockeye Salmon Middle River mainstem destinations downstream of Devils Canyon were later than in tributaries and occurred over a shorter duration. Mainstem dates ranged from August 16 to September 20 during recent studies. Historic data indicates that Middle River Sockeye Salmon spawning was more similar to timing of recent mainstem spawners and was protracted as spawning continued into October. From 1981 through 1984, the spawning period for Sockeye Salmon in the Susitna River ranged from late August through early October, with the peak spawning occurring during the last week of August through mid-September (summarized in Barrett et al. 1985a, b).

6.5.3. Distribution to Mainstem and Tributaries

6.5.3.1. Radio-tags applied in Lower River

- Lower River and Tributaries.

In 2012, 100 Sockeye Salmon tagged in the Lower River moved mostly into Lower River tributaries. The overwhelming majority moved into the Yenta River (96 percent), however fish also used Deshka (1 percent) and Chulitna (2 percent) rivers (Figure D-9). None of the Lower-River-tagged Sockeye Salmon were classified as having mainstem destinations in the Lower River. Similarly, most Sockeye Salmon destinations from historic surveys in the Lower River were within tributaries (Fair 2009; Yanusz et al. 2011a, b). The Yentna River received up to 80.0 percent of the Sockeye Salmon distribution while the Talkeetna and Chulitna river basins followed in importance with 14.5 and 5.0 percent distribution, respectively. In the 1980s, however, the Yentna River was estimated as having 48.0 percent of the Sockeye Salmon distribution while the Talkeetna and Chulitna Rivers made up the 46.0 percent (ADFG 1981, 1982; Barrett et al. 1985a, b; Thompson et al. 1986).

- Middle River and Tributaries

Sockeye Salmon tagged in the Lower River in 2012 did not use any Middle River tributaries. However, a single fish (1 percent) was classified as having a mainstem destination in the Middle River. Historically, about 1.0 (1980's) to 2.0 (2007-2008) percent of Sockeye Salmon had destinations within the Middle River and tributaries (ADFG 1981, 1982; Barrett et al. 1985a,b; Thompson et al. 1986; Fair 2009; Yanusz et al. 2011a,b). Of the Sockeye Salmon that had destinations in the Middle River, 98.0 percent had mainstem destinations (sloughs) while < 1.0 percent had a destination in Indian River. No Sockeye Salmon, from either the recent or historic data set, had destinations within or upstream of Devils Canyon.

6.5.3.2. Radio-tags applied in Middle River

- Lower River and Tributaries

There were Middle-River-tagged Sockeye Salmon that moved to tributaries in the Lower River during each year of recent studies. The main Lower River tributary destinations were the Talkeetna and Chulitna rivers. From 2012-2014, these two tributaries represented an average of 10.2 and 9.2 percent of the overall destinations of the Middle-River-tagged Sockeye Salmon, respectively (Figure D-10). In 2013 three fish (3.3 percent) were classified to mainstem destinations in the Lower River, but there were none so classified in 2012 or 2014.

- Middle River and Tributaries

Middle-River-tagged Sockeye Salmon were the most likely group to be classified with a mainstem destination in the Middle River, with annual proportions ranging from 46.5 to 78.7 percent in 2012-2014. Many of the remaining fish moved into tributaries in the Middle River downstream from Devils Canyon. Indian River, and 4th of July and Portage creeks were the main destinations, accounting for an average of 3.9, 1.3 and 4.9 percent of the overall destinations of the Middle-River-tagged Sockeye Salmon, respectively (Figure D-10). In three years of tracking, no Middle-River-tagged Sockeye Salmon had destinations within or upstream of Devils Canyon.

6.5.4. Mainstem Habitat and Tributary Use

- Lower River and Tributaries

From 2012 through 2014, no radio-tagged Sockeye Salmon were identified with potential spawning sites in mainstem habitats of the Lower River (based on 100 tags applied in the Lower River in 2012, and 409 tags applied in the Middle River from 2012 – 2014). Similarly, spawning surveys conducted during the 1980's found no evidence of Sockeye Salmon spawning in Lower River mainstem habitats.

- Middle River and Tributaries

For Sockeye Salmon, the percent tracked into tributaries varied among years (21–54 percent), but never approached the levels seen for other salmon species in the Middle River, or for Sockeye Salmon in the Lower River. Primary Middle River tributaries used included Indian River and Portage Creek. Analysis of salmon detection histories identified several potential mainstem spawning locations in the Middle River. As for the types of mainstem spawning habitats used, Sockeye Salmon showed a stronger preference for sloughs. Of particular interest to Sockeye Salmon in all three years were Slough 8A, Slough 9, and Slough 11 (e.g., in 2014, 46 spawning Sockeye Salmon were classified to these three sloughs, i.e., 32 percent of the number classified to a destination, and 70 percent of the total number that were classified to a mainstem destination). No radio-tagged Sockeye Salmon were tracked to potential mainstem, slough, or side-channel locations in the Middle River upstream of Devils Canyon or in the Upper River.

From 2012 through 2014, 104 radio-tagged Sockeye Salmon were identified with potential spawning sites within mainstem habitats of the Middle River. Ten locations indicated by radio telemetry were visually confirmed for spawning by Sockeye Salmon (Figure D-20). This included nine sloughs (Table 6.2-1) and one side channel (Side Channel 21). Sockeye Salmon were present or holding at two locations (Portage Creek Mouth and 4th of July Side Channel), but spawning behavior was not observed. Additionally, opportunistic surveys visually confirmed spawning at two locations. Spawning surveys conducted in the 1980's visually confirmed 27 mainstem spawning locations for Sockeye Salmon (Figure D-20; Table 6.2-1). Of these, 23 were within slough habitats, three were within main channel or side channel habitats, and one was at the confluence of a tributary mouth (Portage Creek). Thirteen of the 27 historic spawning locations for Sockeye Salmon were closely associated with a potential spawning location indicated by radio telemetry.

Results from three years of tagging, including the number of fish tagged and tracked via fixed stations and mobile surveys, and the number of detections across river segments and habitats, characterize the distribution of salmon throughout the Middle and Lower River. Specifically, the data collected demonstrates that the licensing participant concern (study dispute issue) as to whether radio-telemetry efforts as designed in the Study Plan were sufficient to determine Sockeye Salmon spawning sites in the Middle River between PRM102 (confluence of Middle River with Lower River) and PRM124 (Curry) was not realized.

During the period 2012 through 2014, 100 and 409 Sockeye Salmon were radio-tagged in the Lower and Middle river, respectively. This resulted in the detection of three Lower River origin and 237 Middle River origin Sockeye Salmon tags at the Lane Creek telemetry fixed station located at PRM 116.8. Also over these years and over the salmon migration season, a total of 80 complete aerial telemetry surveys were conducted over the river from PRM102 to PRM124. Mobile telemetry surveys resulted in identifying one potential spawning/holding location for Sockeye Salmon and zero tags having their destination in tributaries for that section of river. This compares to a total of 104 potential spawning-holding locations identified for Sockeye Salmon in mainstem habitats, and 41 in tributaries upstream of PRM124.

Radio-tagged Sockeye Salmon of Lower River origin had the same opportunity to choose destinations in either section of the river. Further, documented roaming behavior supports that Sockeye Salmon of Middle River origin also have substantial opportunity to choose destinations downstream of PRM124. These results indicate that the Middle River upstream of PRM124 includes a substantially higher proportion of spawning (100% of mainstem locations, 97.6% of tributaries) than that downstream of PRM124 (0% of mainstem locations, 2.4% of tributaries), and is consistent with historical studies (Barrett et al 1985). Earlier Sockeye Salmon studies, applying ~550 radio-tags to Sockeye Salmon in the Lower River (Yanusz et al. 2011a,b), did not track any of those fish to destinations in the Middle River downstream of PRM124. Therefore, implementation of the Study Plan for radio telemetry including all variances and other recent studies provided sufficient sample size and telemetry detections to evaluate spawning locations for adult Sockeye Salmon in the Middle River downstream and upstream of PRM124 and meet the objective of the study.

6.5.5. Abundance Estimates

- Lower River (RM30)

Historically, Sockeye Salmon average escapement was 122,000 (range 71,000 to 152,000) in the Lower River at Sunshine Station (i.e., upstream of the Yentna River). This is higher than but modestly comparable to an average of 88,000 (range 70,000 to 107,000) for 2006 - 2008 for the Susitna River (upstream of the confluence of the Yentna River; Yanusz et al. 2007, 2011a, b).

- Middle River (RM120 / Curry) and Tributaries

Historically, Sockeye Salmon average escapement was 2,400 (range 1,300 to 3,600) for the Middle River at Talkeetna Station. This is very similar to an average of 2,000 for 2007 - 2008 using the proportion of radio-tags with a destination in the Middle River (2.4 percent of the Lower River escapement). None of the radio-tags applied in the Lower River in 2012 had a destination in the Middle River.

License participants raised the concern as to whether using existing and recent escapement information (2006 - 2008) in combination with new distribution data in the Middle River (2012 – 2014) as designed in the Study Plan were sufficient to evaluate Sockeye Salmon distribution and abundance. AEA completed three years of radio-tagging on Sockeye Salmon in the Middle River, and one year in the Lower River. In combination, these data produced confirming information of the distribution of sockeye salmon and the recent average abundance estimate presented above and met the objective of the study.

License participants raised the concern as to whether a contemporary escapement estimate was not needed for Sockeye Salmon (FERC 2013b). ADFG released a total of 1,524 radio tags in Sockeye Salmon from 2006-2008 which provided Susitna River basin wide distribution and abundances (327,732 – 418,197) for each year (Yanusz et al. 2007, 2011a,b). Furthermore, recent research were consistent with historical data from the 1980's, as well as AEA studies which demonstrated the low proportional contribution of Sockeye Salmon to the Middle River relative to the Susitna River basin.

7. CONCLUSIONS

From 2012 to 2014, the study team completed three consecutive years of adult salmon escapement studies on the Susitna River. The 2012 Adult Salmon Distribution and Habitat Utilization Study (AEA 2012) was an AEA-sponsored initiative that successfully met all seven study objectives and helped to refine the scope and methods of the 2013–2014 studies. The 2013 Salmon Escapement Study (Study 9.7; AEA 2014c) met seven of the eight study objectives outlined in RSP Section 9.7.1.2 and adopted both of the modifications outlined in FERC's February 1 SPD as part of the approved Study Plan. The 2014 Salmon Escapement Study (Study 9.7), as reported herein and earlier by AEA (2014a), successfully met all eight study objectives as outlined in the Study Plan. The study team has completed all field work, data analysis, and reporting related to the Salmon Escapement Study (Study 9.7).

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9. TABLES

Table 4.3-1. Aerial spawner surveys conducted in the Middle and Upper River by location and date, 2014.

River Section	Waterbody	Confluence Project River Mile	Miles Surveyed	Survey Dates						
Middle River - Below Impediment 3	Cheechako Creek	Susitna 155.9	2.4	14-Jul	19-Jul	26-Jul	31-Jul	6-Aug	12-Aug	18-Aug
	Chinook Creek	Susitna 160.4	8.7	14-Jul	19-Jul	26-Jul	31-Jul	6-Aug	12-Aug	18-Aug
Middle River - Above Impediment 3	Devil Creek	Susitna 164.8	2.5	14-Jul	19-Jul	26-Jul	31-Jul	6-Aug	12-Aug	18-Aug
	Fog Creek	Susitna 179.3	19.3	14-Jul	19-Jul	25-Jul	31-Jul	6-Aug	12-Aug	18-Aug
	Fog Creek Tributary L1	Fog 5.1	7.6	14-Jul	19-Jul	25-Jul	31-Jul	6-Aug	12-Aug	18-Aug
	Bear Creek	Susitna 184.0	5.7	14-Jul	19-Jul	25-Jul	31-Jul	6-Aug	12-Aug	18-Aug
	Bear Creek Tributary R1	Bear 0.8	8.2	14-Jul	19-Jul	25-Jul	31-Jul	6-Aug	12-Aug	18-Aug
	Tsusena Creek	Susitna 184.4	3.6	15-Jul	19-Jul	25-Jul	31-Jul	6-Aug	12-Aug	18-Aug
Upper River - Within Reservoir	Deadman Creek	Susitna 188.4	0.3	15-Jul	19-Jul	25-Jul	31-Jul	7-Aug	13-Aug	19-Aug
	Watana Creek	Susitna 196.9	21.3	15-Jul	20-Jul	25-Jul	1-Aug	7-Aug	13-Aug	19-Aug
	Watana Creek Tributary R5	Watana 8.6	8.6	15-Jul	20-Jul	25-Jul	1-Aug	7-Aug	13-Aug	19-Aug
	Kosina Creek	Susitna 209.2	18.8	15-Jul	20-Jul	25-Jul	1-Aug	7-Aug	12-Aug	18-Aug
	Gilbert Creek	Kosina 6.2	6	15-Jul	NS[2]	NS[2]	1-Aug	7-Aug	13-Aug	19-Aug
	Tsisi Creek	Kosina 7.3	6.4	15-Jul	NS[2]	26-Jul	1-Aug	7-Aug	12-Aug	18-Aug
	Tsisi Lake 1	Tsisi 7.2	2.8	NS[1]	NS[1]	26-Jul	1-Aug	7-Aug	12-Aug	NS[1]
	Tsisi Lake 2	Tsisi 10.6	5.2	NS[1]	NS[1]	26-Jul	1-Aug	7-Aug	12-Aug	18-Aug
	Jay Creek	Susitna 211.0	13.3	15-Jul	20-Jul	26-Jul	1-Aug	7-Aug	13-Aug	19-Aug
Upper River - Above Reservoir	Goose Creek	Susitna 232.9	11.2	15-Jul	20-Jul	26-Jul	1-Aug	7-Aug	13-Aug	19-Aug
	Oshetna River	Susitna 235.1	26.3	15-Jul	20-Jul	26-Jul	1-Aug	NS[2]	13-Aug	19-Aug
	Black River	Oshetna	6.2	15-Jul	20-Jul	26-Jul	1-Aug	NS[2]	13-Aug	19-Aug

[1] No survey - surveys targeting Sockeye Salmon began July 25-26.

[2] No survey - high and/or turbid water prevented survey.

Table 5.1-1. Number of adult salmon radio-tagged in the Susitna River Basin from 2012 to 2014, by species, fish size, and tagging location.

Species (and Fish Size)	Tagging Location	2012	2013	2014	Total (All Years)
Chinook Salmon (Large[a])	Lower River	442	580	659	1,681
	Yentna River	0	425	296	721
	Middle River	352	536	590	1,478
	Total (All Locations)	794	1,541	1,545	3,880
Chinook Salmon (Small[a])	Middle River	0	67	32	99
Chum Salmon	Lower River	400	0	0	400
	Middle River	279	201	200	680
	Total (All Locations)	679	268	232	1,179
Coho Salmon	Lower River	399	596	658	1,653
	Middle River	184	242	212	638
	Total (All Locations)	583	838	870	2,291
Pink Salmon	Lower River	401	197	198	796
	Middle River	230	200	201	631
	Total (All Locations)	631	397	399	1,427
Sockeye Salmon	Lower River	100	0	0	100
	Middle River	70	139	200	409
	Total (All Locations)	170	139	200	509
Total (All Species)	Lower River	1,742	1,373	1,515	4,630
	Yentna River	0	425	296	721
	Middle River	1,115	1,385	1,435	3,935
	Total (All Locations)	2,857	3,183	3,246	9,286

[a] MEF $\geq$ 50 cm for large Chinook Salmon; MEF < 50 cm for small Chinook Salmon.

Table 5.2-1. Classifications for radio-tagged salmon in 2014, by species and release location.

	Chinook Salmon (≥ 50 cm)			Chinook (< 50 cm)	Pink Salmon		Coho Salmon			Sockeye Salmon	Chum Salmon
Classification (PRM)	Lower River	Middle River	Yentna River	Middle River	Lower River	Middle River	Lower River	Middle River	Yentna River	Middle River	Middle River
Tributary Destinations (total)	**574**	**438**	**227**	**20**	**155**	**164**	**565**	**173**	**48**	**76**	**141**
Yentna River (32.4)	113	0	219	0	20	1	46	1	43	0	0
Deshka River (44.9)	136	0	4	0	24	0	89	0	3	1	0
Willow Creek (52.2)	30	0	2	0	13	1	15	0	0	0	0
Little Willow Creek (55.6)	22	0	1	0	5	0	15	0	0	0	0
Kashwitna River (64.7)	16	1	0	0	5	1	9	1	0	0	0
Caswell Creek (67.4)	0	0	0	0	1	0	15	0	0	0	0
Sheep Creek (70.1)	6	0	0	0	1	0	4	1	0	0	0
Goose Creek (76.9)	3	1	0	0	0	1	10	0	0	0	0
Montana Creek (80.9)	16	5	0	0	7	5	11	2	0	0	3
Rabideux Creek (87.4)	0	0	0	0	0	0	10	1	0	0	0
Sunshine Creek (88.1)	1	0	0	0	0	0	26	4	0	0	0
Birch Creek (93.5)	2	1	0	0	1	0	10	3	0	0	0
Trapper Creek (95.0)	0	0	0	0	0	1	12	1	0	0	0
Talkeetna River (101.1)	89	25	0	1	5	33	88	8	0	41	30
Chulitna River (102.4)	109	15	1	0	69	11	172	4	2	25	10
Whiskers Creek (104.8)	1	1	0	1	0	11	11	9	0	1	0
Chase Creek (110.5)	0	1	0	0	0	0	6	6	0	0	0
Trib 113.7 (113.7)	0	0	0	0	0	0	0	1	0	0	0
Slash Creek (114.8)	0	0	0	0	0	0	0	2	0	0	0
Gash Creek (115.1)	0	0	0	0	0	1	0	4	0	0	0
Lane Creek (117.1)	0	3	0	2	0	0	1	4	0	0	0
5th of July Creek (127.3)	0	0	0	0	0	1	0	0	0	0	0
4th of July Creek (134.3)	0	8	0	0	2	26	0	4	0	0	3
Gold Creek (140.1)	0	6	0	0	0	0	0	0	0	0	0
Indian River (141.8)	17	182	0	8	2	61	14	98	0	2	49
Jack Long Creek (148.2)	0	3	0	0	0	0	0	2	0	1	0
Portage Creek (152.3)	12	183	0	8	0	10	1	17	0	5	46
Cheechako Creek (155.9)	1	2	0	0	0	0	0	0	0	0	0
Kosina Creek (209.1)	0	1	0	0	0	0	0	0	0	0	0

Table 5.2-1. Continued.

Classification (PRM)	Chinook Salmon (≥ 50 cm)			Chinook (< 50 cm)	Pink Salmon		Coho Salmon			Sockeye Salmon	Chum Salmon
	Lower River	Middle River	Yentna River	Middle River	Lower River	Middle River	Lower River	Middle River	Yentna River	Middle River	Middle River
Mainstem Destinations (total)	**7**	**34**	**0**	**4**	**1**	**12**	**16**	**11**	**0**	**66**	**18**
Mainstem Proper	2	4	0	0	1	0	0	2	0	0	2
Downstream of Lane (117.1)	*2*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*
no prior spawn location	*2*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*
Upstream of Lane (117.1)	*0*	*4*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*1*
no prior spawn location	*0*	*3*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*1*
was in Portage Creek	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Tributary Mouths	2	22	0	3	0	7	3	3	0	0	5
Trapper Mouth (44.9)	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Montana Mouth (80.9)	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Rabideux Mouth (87.4)	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Talkeetna Mouth (101.0)	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Lane Mouth (117.1)	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
no prior spawn location	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
was up Talkeetna River	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
5th of July Mouth (127.3)	*0*	*3*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*
4th of July Mouth (134.3)	*0*	*3*	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*0*	*1*
no prior spawn location	*0*	*1*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*1*
was up 4th of July Creek	*0*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*
was up Indian River	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Gold Mouth (140.1)	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
Indian Mouth (141.8)	*0*	*10*	*0*	*3*	*0*	*3*	*0*	*2*	*0*	*0*	*1*
no prior spawn location	*0*	*8*	*0*	*1*	*0*	*3*	*0*	*2*	*0*	*0*	*1*
was up Indian River	*0*	*2*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Portage Mouth (152.3)	*0*	*4*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*1*
no prior spawn location	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
was up Portage Creek	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*
Cheechako Mouth (155.9)	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Table 5.2-1. Continued.

Classification (PRM)	Chinook Salmon (≥ 50 cm) Lower River	Chinook Salmon (≥ 50 cm) Middle River	Chinook Salmon (≥ 50 cm) Yentna River	Chinook (< 50 cm) Middle River	Pink Salmon Lower River	Pink Salmon Middle River	Coho Salmon Lower River	Coho Salmon Middle River	Coho Salmon Yentna River	Sockeye Salmon Middle River	Chum Salmon Middle River
Side Channels & Sloughs	3	8	0	1	0	5	13	6	0	66	11
Slough 8A (129.2)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*23*	*0*
Slough 9 (131.4)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*10*	*1*
Slough 11 (138.6)	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*13*	*0*
no prior spawn location	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*12*	*0*
was up Portage Creek	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*
Slough 21 (145.1)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other areas	*3*	*7*	*0*	*1*	*0*	*5*	*13*	*6*	*0*	*20*	*10*
no prior spawn location	*3*	*6*	*0*	*1*	*0*	*5*	*11*	*5*	*0*	*20*	*9*
was up Deshka River	*0*	*0*	*0*	*0*	*0*	*0*	*2*	*0*	*0*	*0*	*0*
was up Chulitna River	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
was up Indian River	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
was up Portage Creek	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*
Other Classifications (total)	**75**	**118**	**68**	**8**	**43**	**25**	**59**	**46**	**12**	**58**	**41**
Other Mainstem	31	60	4	3	22	17	49	20	0	49	31
Max Zone downstream of Lane	*30*	*0*	*4*	*0*	*22*	*0*	*48*	*0*	*0*	*0*	*0*
Max Zone upstream of Lane	*1*	*60*	*0*	*3*	*0*	*17*	*1*	*20*	*0*	*49*	*31*
Downstream Only	16	40	46	4	0	4	4	17	6	8	1
Near Release Site	13	17	10	1	20	3	2	8	1	1	7
No or Single Detections	15	1	8	0	1	1	4	1	5	0	2
Total Tags Released	656	590	295	32	199	201	640	230	60	200	200

Notes:

Fish that were detected on several occasions within a limited area were classified with a 'Mainstem Destination' (either in side-channel/slough locations, in a tributary mouth, or in the mainstem proper). Some of the fish that showed the 'Mainstem Destination' detection pattern did so after entering a spawning tributary (those that had at least one live detection in the mainstem location and that spent less than 6 days in the tributary location are noted in the table – otherwise the mainstem detection was ignored and the fish was assigned to the tributary location). Tags that were recovered or returned were included in this table either under the 'Other Mainstem' classification (if the recovery date was outside of the range of probable spawning dates) or within the row that was associated with the recovery location (if recoveries were from within a tributary, or were in a possible mainstem spawning location).

Table 5.2-2. The proportions of radio-tagged salmon of known destination that were detected in the Middle and Upper rivers, and that subsequently returned downstream to enter a Lower River tributary, or that appeared to have a mainstem destination in the Lower River, 2014.

Tagged in Lower River

Classification	Chinook Salmon	Pink Salmon	Coho Salmon
Reached Lane Station	37	6	26
Unknown Destination	1	0	1
Known Classification (a)[1]	36	6	25
Mid/Upper-Susitna Tributary	30	4	15
Mid/Upper-Susitna Mainstem	1	0	0
Returned Downstream (b)[1]	5	2	10
Lane Creek	*0*	*0*	*1*
Chase Creek	*0*	*0*	*2*
Whiskers Creek	*0*	*0*	*3*
Chulitna River	*3*	*1*	*3*
Talkeetna River	*1*	*1*	*0*
Sunshine Creek	*0*	*0*	*1*
Montana Creek	*1*	*0*	*0*
Proportion Roaming (c)[1]	13.9%	33.3%	40.0%

Tagged in Middle River

Classification / Fate	Chinook Salmon (≥ 50 cm)	Chinook Salmon (< 50 cm)	Pink Salmon	Coho Salmon	Sockeye Salmon	Chum Salmon
Tagged at Curry	590	32	201	230	200	200
Other Classification (from Table Table 5.2-1)	118	8	25	46	58	41
Other Mainstem	60	3	17	20	49	31
Downstream Only	40	4	4	17	8	1
Near Release Site	17	1	3	8	1	7
No / Single Detections	1	0	1	1	0	2
Known Classification (a)[1]	472	24	176	184	142	159
Tributary above Curry	385	16	98	121	8	98
Susitna Mainstem above Curry	33	3	10	9	65	17
Returned Downstream (b)[1]	54	5	68	54	69	44
Mainstem Destination	*1*	*1*	*2*	*2*	*1*	*1*
Lane Creek	*3*	*2*	*0*	*4*	*0*	*0*
Gash Creek	*0*	*0*	*1*	*4*	*0*	*0*
Slash Creek	*0*	*0*	*0*	*2*	*0*	*0*
Trib 113.7	*0*	*0*	*0*	*1*	*0*	*0*
Chase Creek	*1*	*0*	*0*	*6*	*0*	*0*
Whiskers Creek	*1*	*1*	*11*	*9*	*1*	*0*
Chulitna River	*15*	*0*	*11*	*4*	*25*	*10*
Talkeetna River	*25*	*1*	*33*	*8*	*41*	*30*
Trapper Creek	*0*	*0*	*1*	*1*	*0*	*0*

Table 5.2-2. Continued.

Tagged in Middle River

Classification / Fate	**Chinook Salmon (≥ 50 cm)**	**Chinook Salmon (< 50 cm)**	**Pink Salmon**	**Coho Salmon**	**Sockeye Salmon**	**Chum Salmon**
Birch Creek	*1*	*0*	*0*	*3*	*0*	*0*
Rabideux Creek	*0*	*0*	*0*	*1*	*0*	*0*
Sunshine Creek	*0*	*0*	*0*	*4*	*0*	*0*
Montana Creek	*5*	*0*	*5*	*2*	*0*	*3*
Sheep Creek	*0*	*0*	*0*	*1*	*0*	*0*
Goose Creek	*1*	*0*	*1*	*0*	*0*	*0*
Kashwitna River	*1*	*0*	*1*	*1*	*0*	*0*
Willow Creek	*0*	*0*	*1*	*0*	*0*	*0*
Deshka River	*0*	*0*	*0*	*0*	*1*	*0*
Yentna River	*0*	*0*	*1*	*1*	*0*	*0*
Proportion Roaming (c)[1]	11.4%	20.8%	38.6%	29.3%	48.6%	27.7%

Notes:

[1] c = b / a

Table 5.2-3. Farthest upstream detection locations for radio-tagged fish that were eventually assigned to mainstem or tributary spawning locations downstream of Lane Station (top panel: fish released in the Lower River; bottom panel: fish released in the Middle River), 2014. Project river miles are shown in parentheses.

Tagged in Lower River

Farthest Upstream Location	Chinook Salmon	Pink Salmon	Coho Salmon
Lane Station (116.7)	2	1	8
Near Curry (124.2)	1	0	0
4th of July Ck. Mouth (134.3)	0	0	1
Indian R. mouth (141.8)	0	0	1
Powerline (145.7)	1	0	0
Portage Ck. Mouth (152.3)	0	1	0
Below Impediment 1 (155.2)	1	0	0
Total number that reached Lane Station, then were assigned a downriver destination	5	2	10

Tagged in Middle River

Farthest Upstream Location	Chinook Salmon (≥ 50 cm)	Chinook Salmon (< 50 cm)	Pink Salmon	Coho Salmon	Sockeye Salmon	Chum Salmon
Near Curry (124.2)	32	3	27	30	41	35
Gateway (130.1)	6	2	9	6	5	2
4th of July mouth (134.3)	1	0	0	1	0	0
Slough 11 mouth (138.7)	0	0	0	1	0	0
Gold Creek mouth (140.1)	0	0	0	0	1	0
Indian R. mouth (141.8)	8	0	29	10	7	2
Powerline (145.7)	1	0	0	1	3	1
Jack Long Ck. Mouth (148.2)	0	0	0	0	3	1
Portage Ck. Mouth (152.3)	4	0	3	5	6	3
Below Impediment 1 (155.2)	2	0	0	0	1	0
Above Impediment 1 (155.2)	0	0	0	0	2	0
Total number released in the Middle River, then were assigned a downriver destination	54	5	68	54	69	44

Table 5.3-1. Number of salmon radio-tagged in the Lower and Middle rivers, and the number of radio-tagged salmon that were detected at or above the Gateway Station, above each impediment, and above the proposed dam site, 2014.

Species Tag Site	Radio Tags Applied	At or Above Gateway (PRM 130.1)	Above Impediment 1 (PRM 155.2)	Above Impediment 2 (PRM 160.2)	Above Impediment 3 (PRM 164.8)	Above Dam Site (PRM 187.1)
Chinook Salmon (Large)						
Tagged in Lower River	659	34	2	1	0	0
Tagged in Middle River	590	491	11	8	2	1
Total Tagged	1,249	525	13	9	2	1
Chinook Salmon (Small)						
Tagged in Middle River	32	24	0	0	0	0
Chum Salmon						
Tagged in Middle River	200	154	0	0	0	0
Coho Salmon						
Tagged in Lower River	640	17	0	0	0	0
Tagged in Middle River	230	170	0	0	0	0
Total Tagged	870	187	0	0	0	0
Pink Salmon						
Tagged in Lower River	198	5	0	0	0	0
Tagged in Middle River	201	164	0	0	0	0
Total Tagged	399	169	0	0	0	0
Sockeye Salmon						
Tagged in Middle River	200	146	3	0	0	0

Table 5.3-2. Details of the radio-tagged salmon that approached or passed the Middle River impediments, 2014.

Chinook Salmon (≥ 50 cm) that Passed Impediment 3 (PRM 164.4)

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
537	Curry, Site Three	4 Jul	80	Male	20 Jul	20 Jul	4 Aug	Just above I3, then mort DS
787	Curry, Site Two	11 Jul	78	Undetermined	20 Jul	20 Jul	30 Jul	Kosina (8/2-8/7), Oshetna (8/9), then Kosina (8/12-18), drfited to below Fog Ck.

Chinook Salmon (≥ 50 cm) that Passed Impediment 2 (PRM 160.2) but not Impediment 3 (PRM 164.4)

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
17	Curry, Site One	14 Jun	70	Undetermined	30 Jun	30 Jun	-	Below I3, then Cheechako (7/10) then Portage (7/14-8/6) then mort DS
139	Curry, Site One	21 Jun	61	Undetermined	24 Jul	28 Jul	-	Cheechako (7/25-26) then mort near Chinook Creek
222	Curry, Site Two	24 Jun	75	Undetermined	6 Jul	18 Jul	-	Below I3, then mort DS
516	Curry, Site One	4 Jul	87	Undetermined	1 Aug	1 Aug	-	Cheechako to Chinook mouths, then Cheechako (8/9) then out, mort at mouth
882	Curry, Site Three	16 Jul	51	Undetermined	25 Jul	1 Aug	-	Chinook mouth then Cheechako (8/3-9) then mort DS
903	Curry, Site Three	17 Jul	78	Undetermined	23 Jul	24 Jul	-	Below I3, mort between Chinook and I3
5531	Lower River, gill net	12 Jun	93	n/a	18 Jul	18 Jul	-	Below I3, then in Cheechako (8/12) and at mouth (8/15-9/2)

Chinook Salmon (≥ 50 cm) that Passed Impediment 1 (PRM 155.2) but not Impediment 2 (PRM 160.2)

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
221	Curry, Site One	24 Jun	92	Undetermined	20 Jul	-	-	Portage (7/10), just Above I1, then Below I1, drifted as mort DS
828	Curry, Site Three	13 Jul	55	Undetermined	18 Jul	-	-	Cheechako Stn, then Portage
868	Curry, Site Three	15 Jul	94	Male	23 Jul	-	-	Cheechako (7/31-8/1 and 8/6-8/12), mouth (to 8/18) then drifted DS to below Portage
5702	Lower River, gill net	23 May	91	n/a	1 Jul	-	-	0.75 mi above Cheechako Stn, then in Cheechako

Table 5.3-2. Continued.

Chinook Salmon (≥ 50 cm) that Approached Impediment 1 (PRM 155.2) but did not Pass

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
23	Curry, Site Two	14 Jun	63	Undetermined	-	-	-	Below I1, Portage (7/25-8/4), then mort DS
33	Curry, Site Two	15 Jun	63	Undetermined	-	-	-	Below I1, then Talkeetna
40	Curry, Site Two	16 Jun	68	Undetermined	-	-	-	Below I1, then Portage
91	Curry, Site Three	19 Jun	92	Undetermined	-	-	-	Below I1, then Portage
103	Curry, Site One	20 Jun	81	Undetermined	-	-	-	mort Below I1
108	Curry, Site Two	20 Jun	99	Undetermined	-	-	-	Below I1, Portage (7/22-23) then DS
111	Curry, Site Three	20 Jun	97	Undetermined	-	-	-	Portage (7/4-7/5), Below I1, Portage (7/19-onwards)
166	Curry, Site One	22 Jun	63	Undetermined	-	-	-	Below I1, Portage (7/14), Portage mouth (7/22-8/4), mort DS
198	Curry, Site One	23 Jun	78	Undetermined	-	-	-	Below I1, then Talkeetna
237	Curry, Site One	25 Jun	93	Male	-	-	-	Below I1, Indian (7/22-8/6) then DS
239	Curry, Site One	25 Jun	87	Female	-	-	-	Below I1, then Portage
244	Curry, Site Two	25 Jun	84	Undetermined	-	-	-	Below I1, then Portage (mid-Aug onward, incl mort 8/20)
264	Curry, Site One	28 Jun	78	Undetermined	-	-	-	Below I1, then Gold Creek
300	Curry, Site One	29 Jun	66	Undetermined	-	-	-	Portage mouth , Below I1, then up Portage
359	Curry, Site Three	30 Jun	59	Undetermined	-	-	-	Below I1, then mort DS
562	Curry, Site One	5 Jul	79	Undetermined	-	-	-	Below I1, then Portage
611	Curry, Site Three	5 Jul	91	Undetermined	-	-	-	Below I1, then Portage
621	Curry, Site One	6 Jul	87	Undetermined	-	-	-	Below I1, then Portage
668	Curry, Site Three	6 Jul	80	Undetermined	-	-	-	Below I1, then Portage
716	Curry, Site One	8 Jul	95	Undetermined	-	-	-	Below I1, then mort DS
818	Curry, Site Two	13 Jul	64	Undetermined	-	-	-	Below I1, then Indian (7/26-8/5) then mort DS of mouth
5242	Lower River, East Bank	4 Jun	75.5	n/a	-	-	-	Chulitna, Below I1, then Chulitna
5255	Lower River, East Bank	7 Jun	83	n/a	-	-	-	Deshka, Below I1, then Portage
5384	Lower River, West Bank	17 Jun	73.5	n/a	-	-	-	Below I1, then mort DS
5408	Lower River, gill net	31 May	93	n/a	-	-	-	Below I1, then Portage

Table 5.3-2. Continued.

Chinook Salmon (< 50 cm) that Approached Impediment 1 (PRM 155.2) but did not Pass

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
574	Curry, Site One	5 Jul	41	Undetermined	-	-	-	Below I1, Portage (7/25-8/4), then Indian (8/9), then back to Portage (8/15-onwards)

Sockeye Salmon That Passed Impediment 1 (PRM 155.2) but not Impediment 2 (PRM 160.2)

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
785	Curry, Site Two	11 Jul	48	Undetermined	27 Jul	-	-	Cheechako Stn, dropback, held below I1, moved into Jack Long (9/5), then mort DS
955	Curry, Site Three	19 Jul	49	Undetermined	8 Sep	-	-	Detected above I1 for a single survey (9/8), then moved into Chulitna
2214	Curry, Site Three	8 Aug	45	Undetermined	8 Sep	-	-	Chulitna (8/13-19), moved above I1 for a single survey (9/8), then wandered

Sockeye Salmon That Approached Impediment 1 (PRM 155.2) but did not Pass

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
647	Curry, Site Two	6 Jul	60	Undetermined	-	-	-	Below I1, then mort DS
837	Curry, Site Two	14 Jul	47	Undetermined	-	-	-	Below I1, then mort DS
1053	Curry, Site One	23 Jul	46	Undetermined	-	-	-	Portage (1 survey), Below I1, then Side-channel outside Slough 21
1260	Curry, Site Three	26 Jul	48	Undetermined	-	-	-	Below I1 four times interspersed by wandering, then mort DS
1293	Curry, Site Two	27 Jul	55	Undetermined	-	-	-	Below I1, then Talkeetna
1346	Curry, Site Two	28 Jul	45	Undetermined	-	-	-	Below I1 , then mort DS
1404	Curry, Site Two	29 Jul	43	Undetermined	-	-	-	Below I1 , then mort DS
1851	Curry, Site Two	4 Aug	54	Female	-	-	-	Below I1 , then mort DS
2076	Curry, Site Two	7 Aug	45	Undetermined	-	-	-	Below I1, then into 4th of July Slough
2156	Curry, Site One	8 Aug	42	Undetermined	-	-	-	Below I1 , then mort DS

Table 5.3-2. Continued.

Sockeye Salmon That Approached Impediment 1 (PRM 155.2) but did not Pass

Tag Number	Capture/ Release Site	Capture Date	METF Length (cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
2157	Curry, Site One	8 Aug	45	Undetermined	-	-	-	Below I1, Portage, Below I1, Side Channel 21
2606	Curry, Site One	13 Aug	51	Undetermined	-	-	-	Below I1 three times interspersed by wandering, then mort DS
2770	Curry, Site One	15 Aug	53	Male	-	-	-	Below I1 twice interspersed by wandering, the Side Channel 21

Notes:

Fish characteristics include 'tag numbers' (unique numbers assigned to each individual radio-tagged fish), capture and release site, capture date, METF (mid-eye to fork length, in cm) and sex. Tracking details include the date of first detections above each impediment, and a comment about the general movments of the fish. Top panel: Chinook salmon (≥ 50 cm) that passed Impediment 3. Second panel: Chinook salmon (≥ 50 cm) that passed Impediment 2, but not Impediment 3. Third panel: Chinook salmon (≥ 50 cm) that passed Impediment 1, but not Impediment 2. Fouth panel: Chinook salmon (≥ 50 cm) that approached within 1 km of Impediment 1, but did not pass. Fifth panel: Chinook salmon (< 50 cm) that approached within 1 km of Impediment 1, but did not pass. Fifth panel: Chinook salmon (< 50 cm) that approached within 1 km of Impediment 1, but did not pass. Sixth panel: Sockeye salmon that passed Impediment 1, but not Impediment 2. Seventh panel: Sockeye salmon that approached within 1 km of Impediment 1, but did not pass.

Table 5.3-3. Destinations of radio-tagged salmon that passed each Middle River impediment, 2014.

	Chinook Salmon (≥ 50 cm)				Sockeye Salmon	
	Passed I1 but not I2	Passed I2 but not I3	Passed I3	Total	Passed I1 but not I2	Grand Total
Classification						
Tributary Destinations						
Chulitna River					2	2
Jack Long Creek					1	1
Portage Creek	1	1		2		2
Cheechako Creek	2	1		3		3
Kosina Creek			1	1		1
Mainstem Destinations						
Mouth of Cheechako		1		1		1
Unknown Destination	1	4	1	6		6
Total	**4**	**7**	**2**	**13**	**3**	**16**
Downstream from Impediment						
Number	1	3	0	4	3	7
Percent	33%	100%	0%	57%	100%	70%

Notes:

An "I" refers to "impediment." Shaded cells refer to areas that are located downstream of the impediment in question.

Table 5.3-4. Dates on which radio-tagged fish were first detected upstream of Impediment 3 (2012-2014), with corresponding flows as measured at Tsusena and Gold creeks.

	First	First	First	Tsusena Creek			Gold Creek		
Tag Number	Detection Above I-1	Detection Above I-2	Detection Above I-3	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
Chinook Salmon (≥ 50 cm) that Passed Impediment 3 in 2012									
27	15 Jul 2012	16 Jul 2012	18 Jul 2012	15,800	16,500	15,200	18,608	19,252	17,774
52	7 Jul 2012	7 Jul 2012	17 Jul 2012	17,800	17,800	15,800	21,302	21,302	19,042
94	8 Jul 2012	12 Jul 2012	17 Jul 2012	20,800	16,400	15,800	26,550	20,060	19,042
104	18 Jul 2012	18 Jul 2012	20 Jul 2012	15,200	15,200	15,000	17,774	17,774	17,320
113	15 Jul 2012	15 Jul 2012	19 Jul 2012	15,800	15,800	14,900	18,608	18,608	17,407
219	15 Jul 2012	16 Jul 2012	19 Jul 2012	15,800	16,500	14,900	18,608	19,252	17,407
246	13 Jul 2012	14 Jul 2012	20 Jul 2012	15,600	15,500	15,000	18,755	18,275	17,320
257	15 Jul 2012	16 Jul 2012	20 Jul 2012	15,800	16,500	15,000	18,608	19,252	17,320
266	15 Jul 2012	16 Jul 2012	19 Jul 2012	15,800	16,500	14,900	18,608	19,252	17,407
359	12 Jul 2012	12 Jul 2012	17 Jul 2012	16,400	16,400	15,800	20,060	20,060	19,042
5005	17 Jul 2012	17 Jul 2012	17 Jul 2012	15,800	15,800	15,800	19,042	19,042	19,042
5019	9 Jul 2012	17 Jul 2012	18 Jul 2012	24,600	15,800	15,200	31,067	19,042	17,774
Chinook Salmon (≥ 50 cm) that Passed Impediment 3 in 2013									
241	13 Jul 2013	14 Jul 2013	16 Jul 2013	14,383	15,410	16,672	16,178	18,233	18,632
272	13 Jul 2013	14 Jul 2013	30 Jul 2013	14,383	15,410	18,848	16,178	18,233	19,657
395	11 Jul 2013	12 Jul 2013	13 Jul 2013	16,876	15,058	14,383	20,272	17,985	16,178
Chinook Salmon (≥ 50 cm) that Passed Impediment 3 in 2014									
537	20 Jul 2014	20 Jul 2014	4 Aug 2014	21,400	21,400	16,400	25,900	25,900	19,200
787	20 Jul 2014	20 Jul 2014	30 Jul 2014	21,400	21,400	15,900	25,900	25,900	19,400

Table 5.3-5. Aerial Chinook Salmon spawning escapement surveys. Number of flights, and date and magnitude of peak counts per stream and survey year. The number of radio-tagged Chinook Salmon that were classified to each stream (see Table 5.2-1) is included for 2012-2014.

	1982			1983			1984			1985		
Stream	# Flights	Date of Peak Count	Peak Count	# Flights	Date of Peak Count	Peak Count	# Flights	Date of Peak Count	Peak Count	# Flights	Date of Peak Count	Peak Count
Cheechako Cr	9	6 Aug	16	2	1 Aug	25	7	1 Aug	29	11	24 Jul	18
Chinook Cr	5	6 Aug	5	2	1 Aug	8	7	1 Aug	15	11	23 Aug	1
Devil Cr	5	na	0	1	1 Aug	1	6	na	0	11	na	0
Fog Cr	0			0			4	21 Jul	2	3	na	0
Bear Cr	0			0			4	na	0	3	na	0
Tsusena Cr	0			0			4	na	0	3	na	0
Deadman Cr	0			0			3	na	0	0		
Watana Cr	0			0			2	na	0	0		
Kosina Cr	0			0			0			0		
Jay Cr	0			0			0			0		
Goose Cr	0			0			0			0		
Oshetna Cr	0			0			0			0		

Table 5.3-5. Continued.

	2012				2013				2014			
Stream	# Flights	Date of Peak Count	Peak Count	Classified Radio-tagged Fish	# Flights	Date of Peak Count	Peak Count	Classified Radio-tagged Fish	# Flights	Date of Peak Count	Peak Count	Classified Radio-tagged Fish
Cheechako Cr	4	30 Jul	5	6	5	26 Jul	40	6	6	19 Jul	16	3
Chinook Cr	4	5 Aug	5	3	5	26 Jul	2	1	6	19/25 Jul	5	0
Devil Cr	4	5 Aug	7	1	5	26 Jul	25	1	6	6 Aug	10	0
Fog Cr	4	30 Jul	1	0	5	9/15 Aug	2	0	6	31 Jul	3	0
Bear Cr	4	na	0	0	5	na	0	0	6	na	0	0
Tsusena Cr	4	na	0	0	5	9 Aug	4	1	6	na	0	0
Deadman Cr	4	na	0	0	5	na	0	0	6	na	0	0
Watana Cr	4	na	0	0	5	na	0	0	6	na	0	0
Kosina Cr	4	5 Aug	16	6	5	26 Jul	3	0	6	na	0	1
Jay Cr	4	na	0	0	5	na	0	0	6	na	0	0
Goose Cr	4	na	0	0	5	na	0	0	6	na	0	0
Oshetna Cr	4	na	0	0	5	na	0	0	5	na	0	0

Table 5.4-1. Survey effort and observations using DIDSON to identify Chinook Salmon spawning behavior in turbid water, 2014.

Date	Sample Location	Latitiude	Longitude	DIDSON Used	Chinook Observed	Spawning Observed	Redds Observed	Comments
19-Jul	Gateway Slough	62.67643	-149.89302	Yes	No	-	-	
19-Jul	Mainstem gravel bar, d/s PRM 133	62.70674	-149.84082	No	No	-	-	
19-Jul	4th of July Slough (60 m u/s of outlet)	62.71587	-149.80301	Yes	No	-	-	
19-Jul	Mainstem side channel, PRM 135.5	62.72485	-149.75978	No	No	-	-	Inaccessible by boat
19-Jul	Slough 10	62.73838	-149.74134	No	No	-	-	No potential sampling sites
19-Jul	Slough 11	62.74281	-149.72163	No	No	-	-	Inaccessible by boat
20-Jul	Slough ?1 "Hidden Slough"	62.58162	-150.04994	Yes	No	-	-	
20-Jul	Side channel, near PRM 117	62.53213	-150.10708	Yes	No	-	-	Entrained air and river velocity precluded usable sonar imagery
20-Jul	Mainstem d/s 4th of July Creek mouth	62.71481	-149.80823	Yes	Yes	No	No	Individuals observed milling/holding
20-Jul	4th of July Slough (30 m u/s of outlet)	62.71558	-149.80345	No	No	-	-	
20-Jul	4th of July Slough (100 m u/s outlet)	62.71701	-149.80208	No	No	-	-	Large cobble substrate
21-Jul	Portage Creek mouth, river right	62.83034	-149.38153	No	No	-	-	
21-Jul	Mainstem d/s Portage Cr. mouth, river right	62.83035	-149.38403	Yes	Yes	No	No	Individuals observed milling/holding
21-Jul	Mainstem d/s Portage Cr. mouth, river right	62.83116	-149.38715	No	No	-	-	
21-Jul	Mainstem u/s Jack Long Cr. mouth, river left	62.82270	-149.49220	No	No	-	-	Sand substrate
21-Jul	Mainstem u/s Jack Long Cr. mouth, river left	62.82264	-149.49434	No	No	-	-	Large cobble substrate
21-Jul	Mainstem d/s Jack Long Cr. mouth, river left	62.82243	-149.49821	Yes	Yes	Yes	Yes	Individual observed guarding and holding
21-Jul	Mainstem d/s Jack Long Cr. mouth, river left	62.82150	-149.50507	Yes	No	-	-	
21-Jul	Mainstem d/s Gold Cr. mouth, river left	62.76779	-149.69141	No	No	-	-	
21-Jul	Mainstem d/s Sherman Cr. mouth, river left	62.7131	-149.81103	No	No	-	-	
21-Jul	Mainstem d/s Skull Cr. mouth, river left	62.67699	-149.86920	No	No	-	-	
22-Jul	Side channel entrance u/s Indian R., river right	62.79191	-149.62464	No	No	-	-	Areas of upwelling
22-Jul	Side channel exit u/s Indian R., river right	62.78956	-149.63977	No	No	-	-	
22-Jul	Mainstem below side channel, river right	62.78861	-149.64438	No	No	-	-	Sand substrate
22-Jul	Mainstem at Beaver impoundment exit, river right	62.78752	-149.65044	No	No	-	-	

Table 5.4-1. Continued.

Date	Sample Location	Latitiude	Longitude	DIDSON Used	Chinook Observed	Spawning Observed	Redds Observed	Comments
22-Jul	Mainstem d/s Indian R. delta (10 m), river right	62.78514	-149.65891	Yes	Yes	No	No	Individuals observed milling/holding
22-Jul	Mainstem d/s Indian R. delta, over flow channel, river right	62.78413	-149.66248	No	No	-	-	
22-Jul	Mainstem d/s Indian R. slough entrance	62.78296	-149.66805	Yes	Yes	No	No	Individuals observed milling/holding
22-Jul	Mainstem d/s Indian R., river right	62.78145	-149.67789	No	No	-	-	
22-Jul	Mainstem d/s Indian R. slough exit	62.77943	-149.68706	Yes	No	-	-	
23-Jul	Slough u/s Gold Cr., river left	62.77146	-149.68672	No	No	-	-	Sand and large cobble substrate
23-Jul	Mainstem d/s Gold Cr., river right	62.76829	-149.69449	No	No	-	-	
23-Jul	Mainstem d/s Gold Cr., river right	62.76650	-149.71121	Yes	Yes	No	No	Traveling u/s observed
23-Jul	Mainstem channel d/s Curry unnamed tributary delta, river right	62.59989	-150.03344	No	No	-	-	
25-Jul	Confirmation: d/s Portage Cr Mouth	62.83044	-149.38871	Yes	Yes	No	No	Individuals observed milling/holding
25-Jul	Confirmation: d/s Jack Long Cr Mouth	62.82243	-149.49821	Yes	Yes	No	No	Individual observed milling/holding
25-Jul	Confirmation: d/s 4th of July Cr Mouth	62.71475	-149.80908	Yes	Yes	No	Yes	Individual observed milling/holding

Table 6.2-1. Confirmed spawning salmon in slough habitats of the Middle River from 1981 to 1985, and confirmed spawning locations in 2012, 2013, and 2014.

	Project	Confirmed Spawning (1981-1985)				Confirmed Spawning											
	River	Chum	Coho	Pink	Sockeye	Chum Salmon			Coho Salmon			Pink Salmon			Sockeye Salmon		
Slough	Mile	Salmon	Salmon	Salmon	Salmon	2012	2013	2014	2012	2013	2014	2012	2013	2014	2012	2013	2014
1	103.2	X			X												
2	104.3	X		X	X												
3B	105.5	X		X	X			X									X
3A	105.7	X		X	X												
4	108.9																
5	111.3	X		X	X												
6	111.9																
6A	115.9	X		X	X												
7	116.6																
8	117.2	X		X	X												
Bushrod	117.8	X		X													
8D	125.2	X					X										
8C	125.2	X		X	X												
8B	125.7	X		X	X												
Moose	126.7	X		X	X												
A'	128.0	X		X													
A	128.3	X		X			X										
8A	129.5	X	X	X	X	X	X	X		X					X	X	X
B	130.0	X		X	X												
9	131.7	X		X	X	X	X						X		X	X	
9B	132.5	X			X												
9A	136.3	X			X	X	X	X								X	
10	137.1	X			X		X									X	X
11	138.7	X		X	X	X	X	X							X	X	X
12	138.2																
13	138.9	X						X									X
14	139.4	X															
15	140.6	X		X	X												
16	141.1	X		X													

Table 6.2-1. Continued.

Slough	Project River Mile	Confirmed Spawning (1981-1985) Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon	Confirmed Spawning Chum Salmon 2012	Chum Salmon 2013	Chum Salmon 2014	Coho Salmon 2012	Coho Salmon 2013	Coho Salmon 2014	Pink Salmon 2012	Pink Salmon 2013	Pink Salmon 2014	Sockeye Salmon 2012	Sockeye Salmon 2013	Sockeye Salmon 2014
17	142.3	X		X	X												
18	142.5	X		-													
19	143.2	X		X	X			X							X		X
20	143.6	X		X	X												
21	145.2	X		X	X	X	X	X							X	X	X
22	147.6	X			X		X	X									X
21A	148.6	X					X										

Note:

Historic data (1981 - 1985) was synthesized from Barrett et al. (1985) and Thompson et al. (1986)

Results from 2012 - 2014 also include some confirmed spawning locations provided by R2USA

10. FIGURES

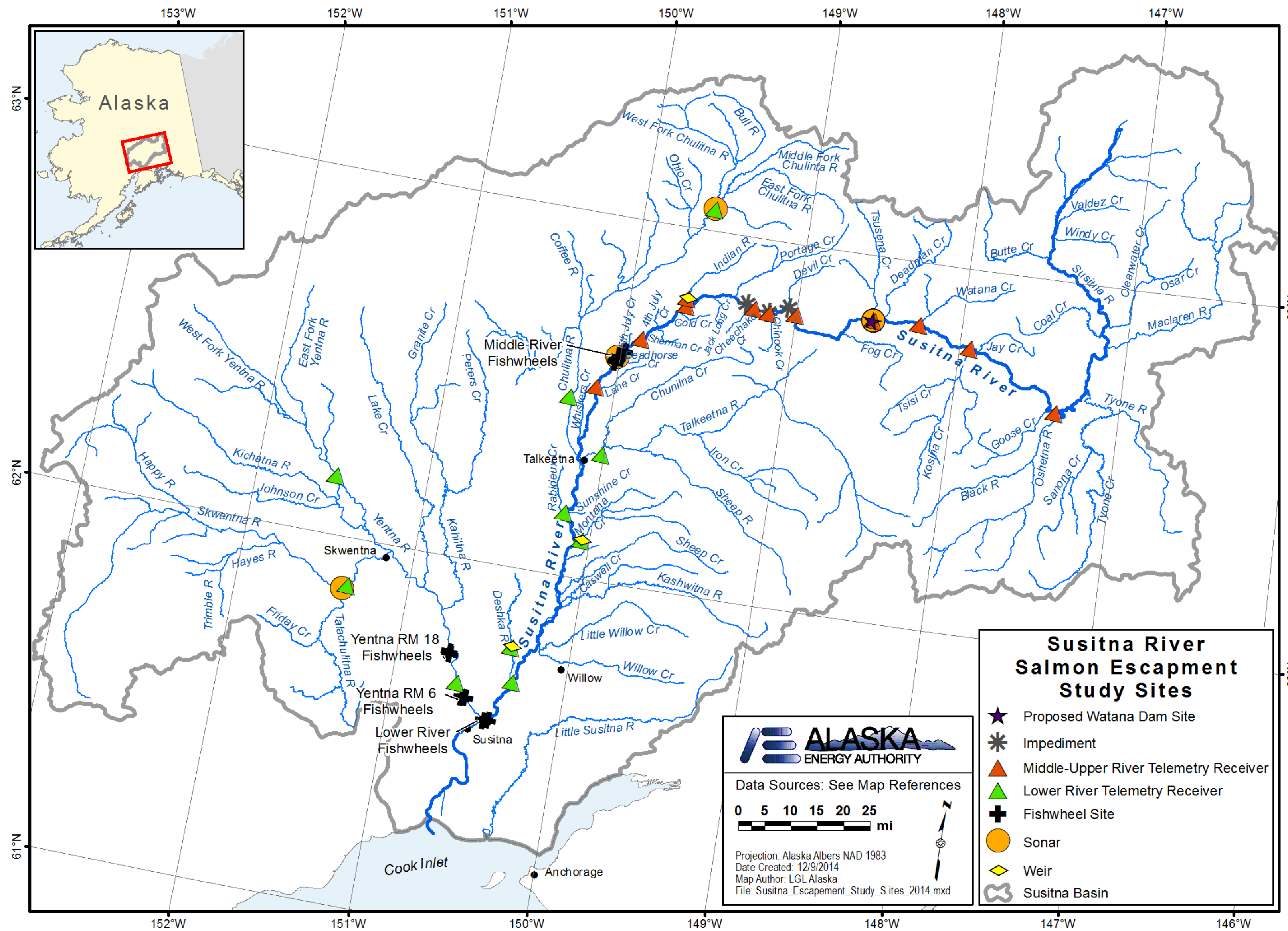

Figure 3-1. Susitna River watershed showing fish capture sites (fishwheels) and the locations of fixed-station telemetry receiver sites, 2014.

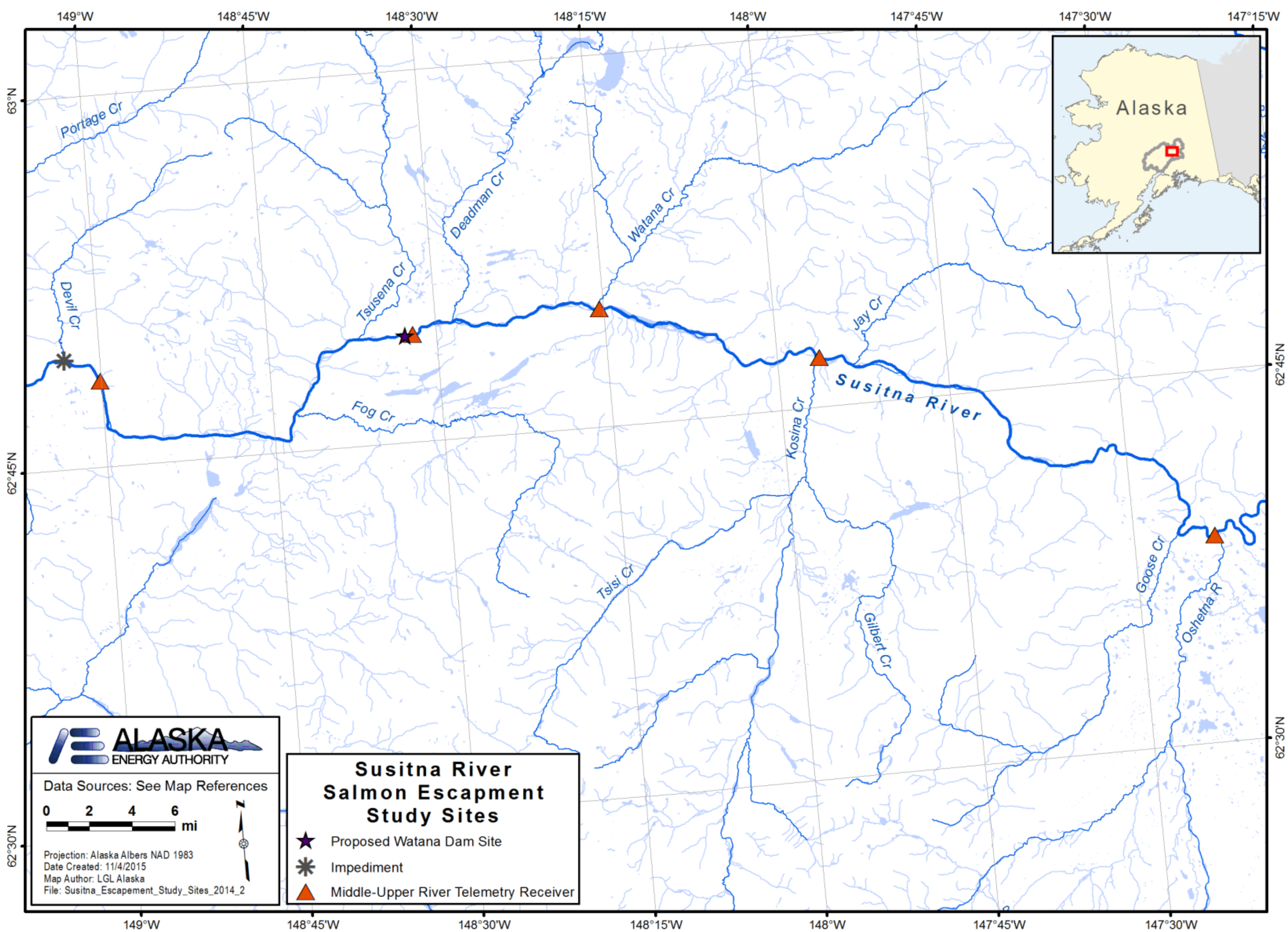

Figure 3-1 (cont). Susitna River watershed showing fish capture sites (fishwheels) and the locations of fixed-station telemetry receiver sites, 2014.

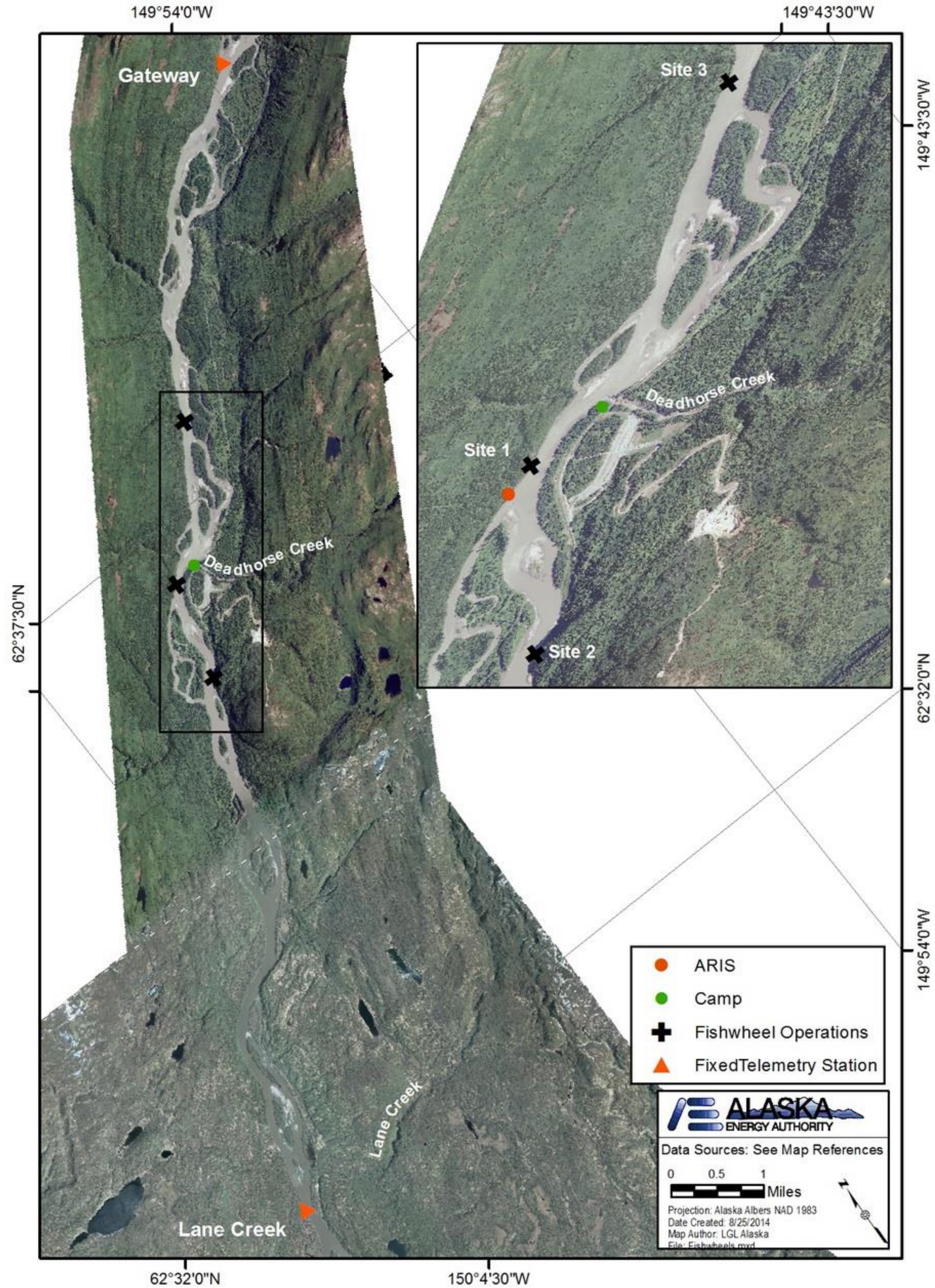

Figure 4.1-1. Middle River Segment showing sites for fish capture (Site 1, PRM 124.1; Site 2, PRM 123.0; and Site 3, PRM 126.0), sonar (ARIS; PRM 124.0), Curry camp (PRM 124.2), and the Lane Creek (PRM 116.7) and 'Gateway' (PRM 130.1) fixed-station receiver sites, 2014.

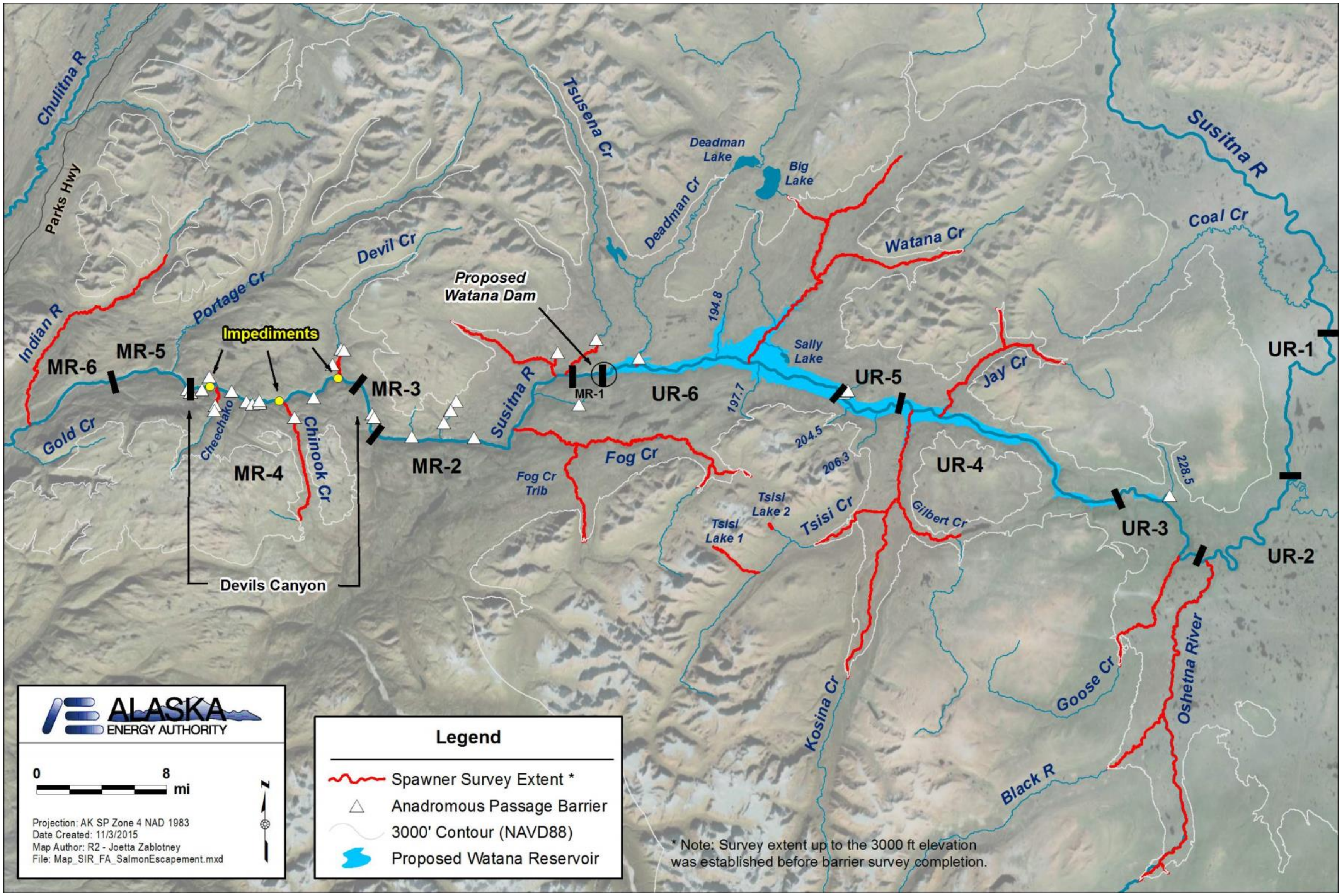

Figure 4.3-1. Extent of aerial spawner surveys in the Indian River and tributaries in and above Devils Canyon, 2014.

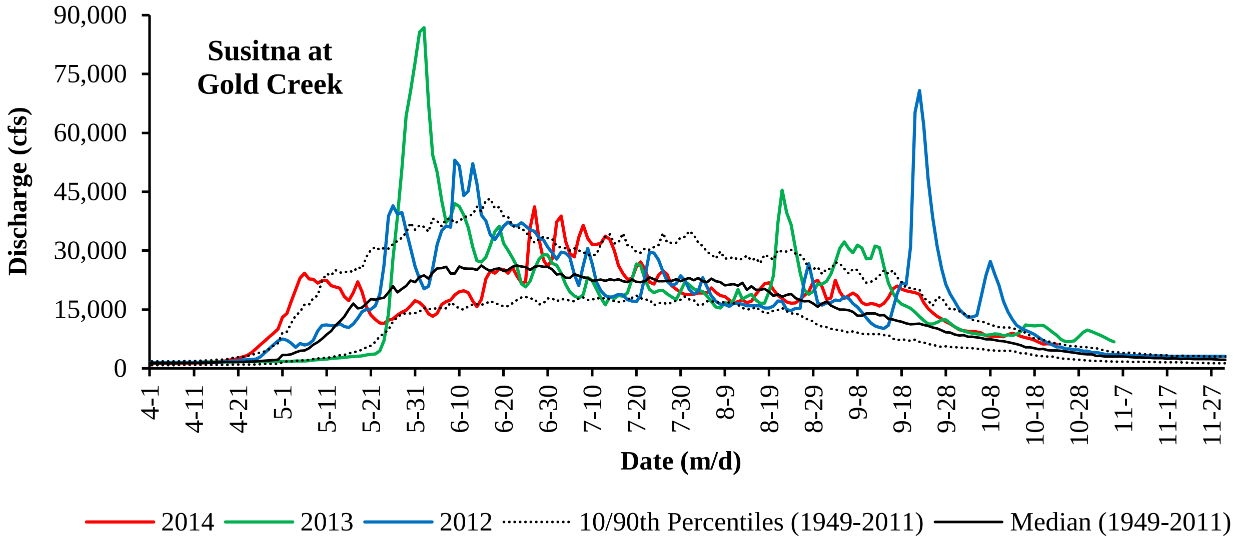

Figure 5.1-1. Daily discharge of the Susitna River at the Gold Creek gauge from April to November in 2012, 2013, and 2014. Historical (1949-2011) median, and 10th and 90th percentile discharges are shown for reference. Source: USGS National Water Information System (http://waterdata.usgs.gov/nwis).

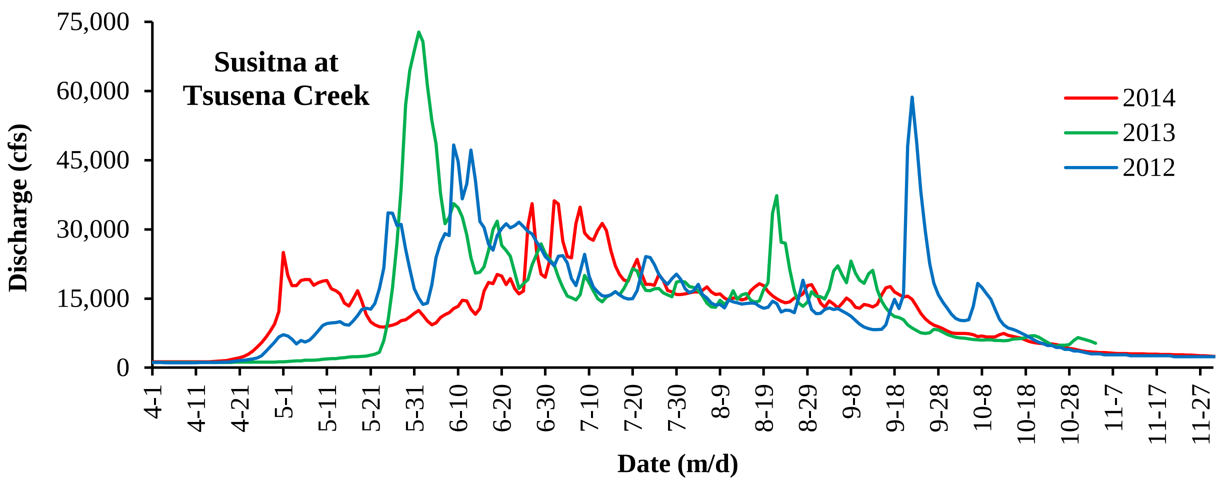

Figure 5.1-2. Daily discharge of the Susitna River at the Tsusena Creek gauge from April to November in 2012, 2013, and 2014. Source: USGS National Water Information System (http://waterdata.usgs.gov/nwis).

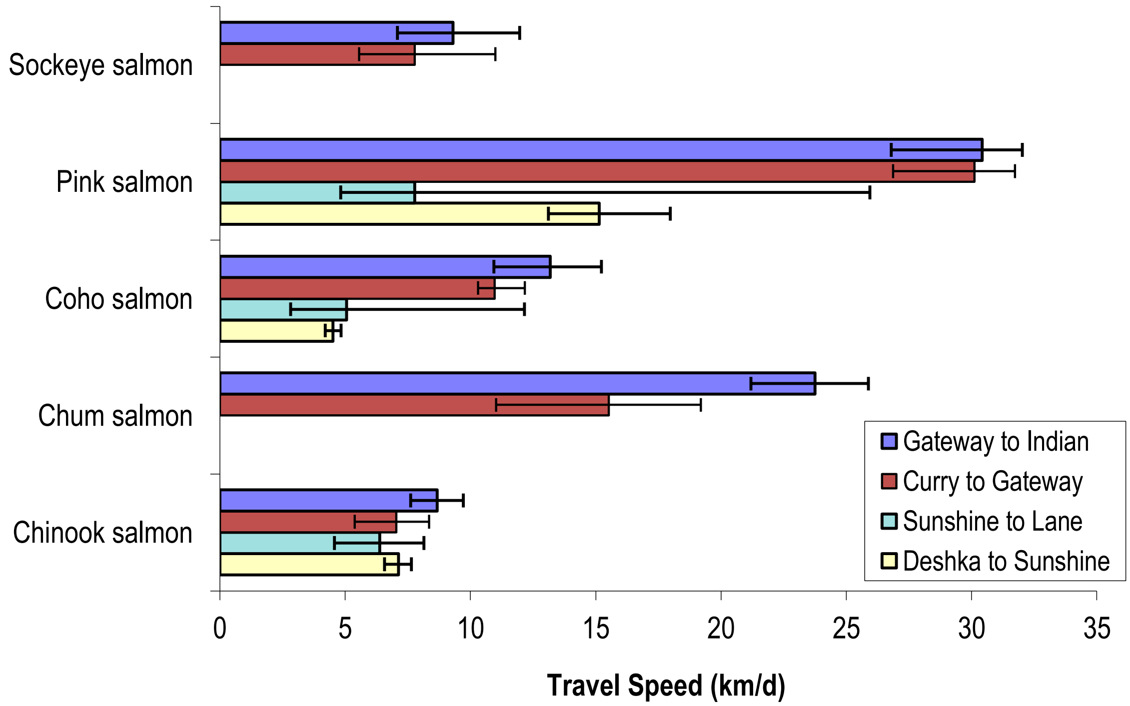

Figure 5.1-3. Median travel speeds of radio-tagged fish in four major river reaches, by species. Error bars represent 95% confidence in the median value (generated using the method recommended in Zar 1984). Statistical comparisons (see text) were done using Kruskal-Wallis tests; overlapping error bars do not preclude statistical significance.

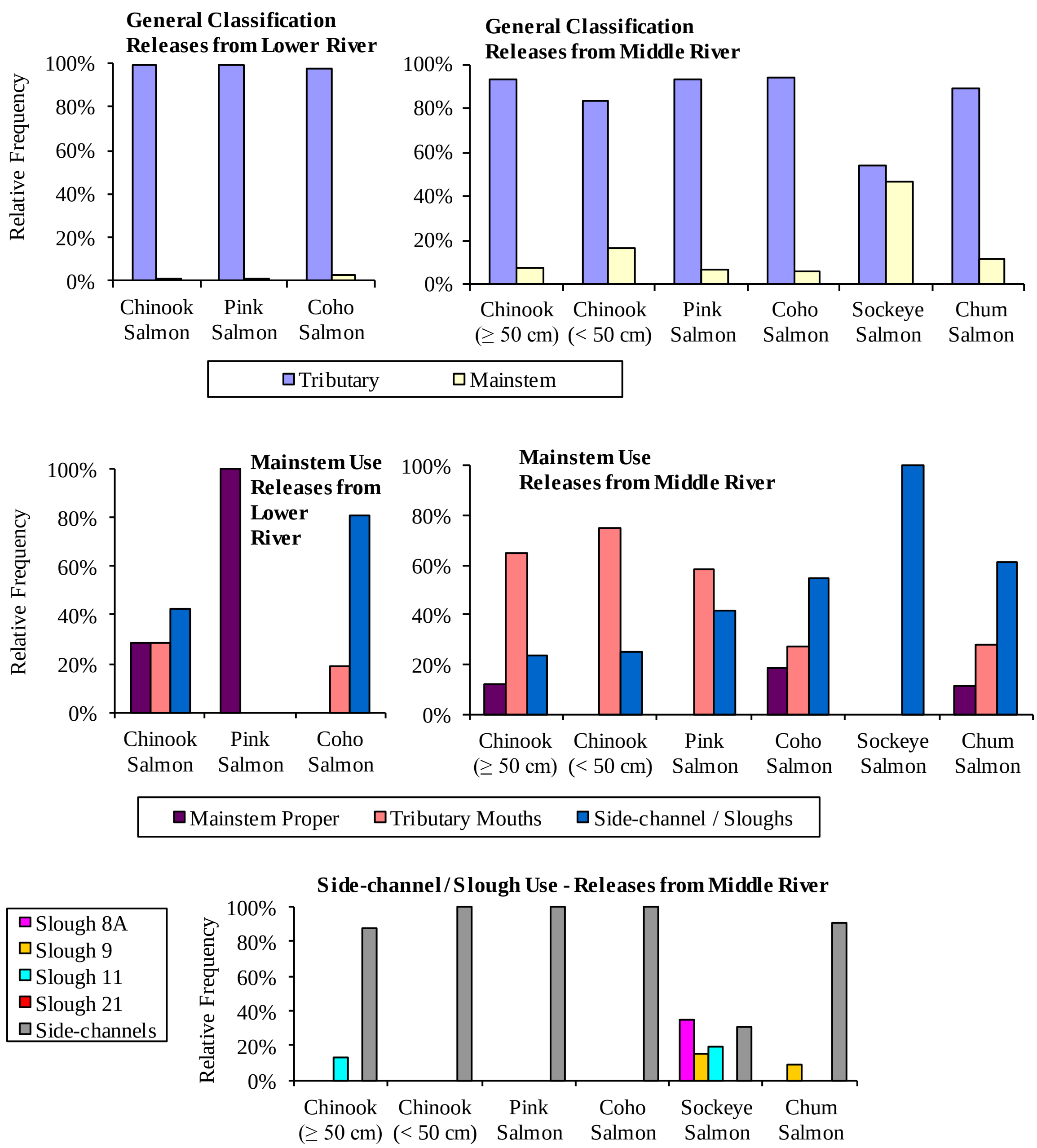

Figure 5.2-1. Classifications for radio-tagged salmon released in the Lower River (left panels) or Middle River (right panels), by species/life history stage, 2014. Top panels: Relative use of tributary and mainstem destinations, shown as a percentage of the total number of fish that were classified to a destination. Middle Panels: Relative use of mainstem habitats (side-channel/slough locations, tributary mouths, and the mainstem proper), shown as a percentage of the total number of fish that were classified with a 'Mainstem Destination'. Bottom Panel: Relative use of various sloughs and side-channel locations, shown as a percentage of the total number of fish that were classified with a 'Side-channel/Slough Mainstem Destination'. See text and Table 5.2-1 for more detailed classifications.

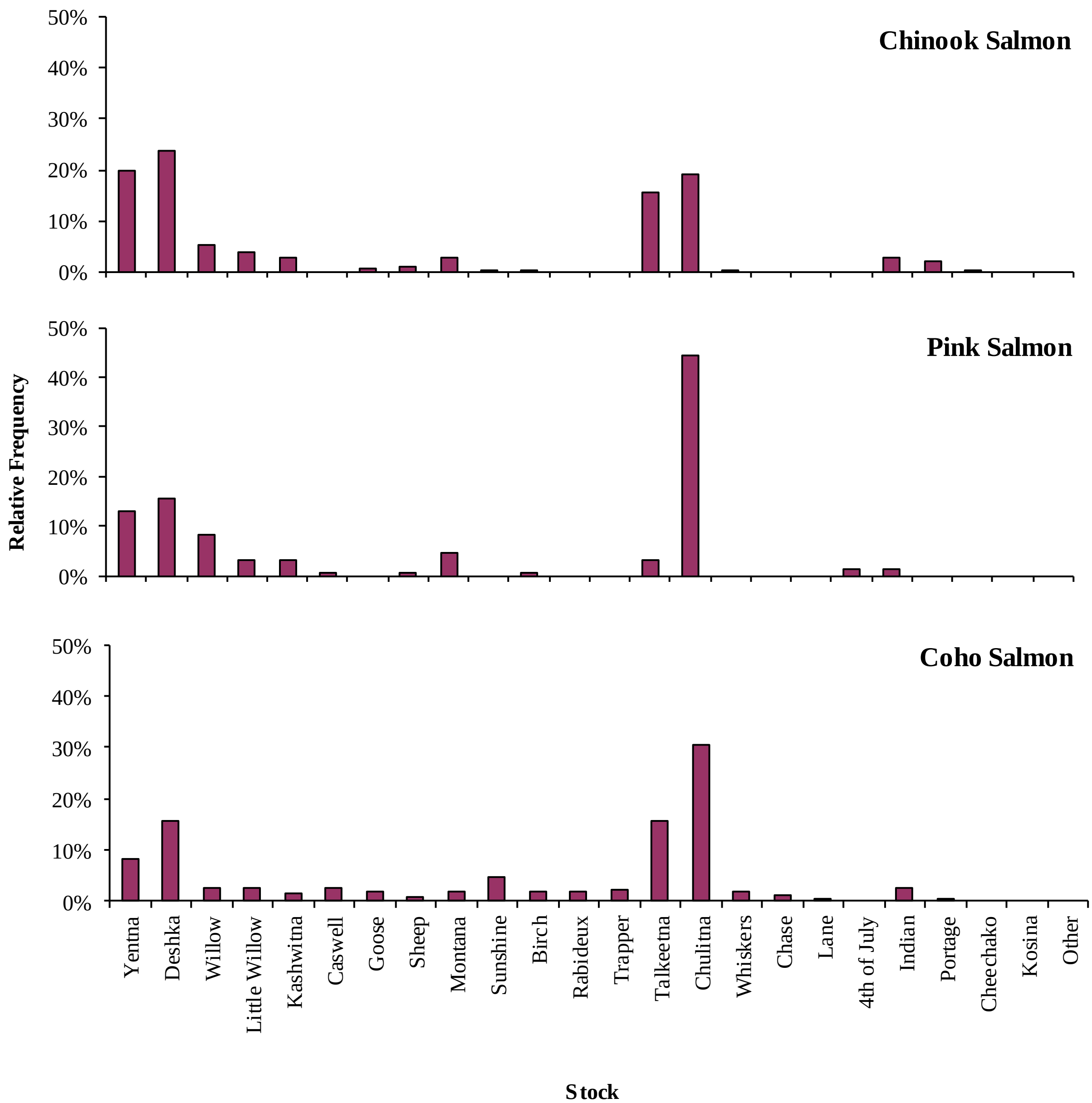

Figure 5.2-2. Relative frequencies of tributary use by radio-tagged salmon released in the Lower River, by species, 2014. Shown as a percentage of all fish classified to a tributary destination. Shown as a percentage of all fish classified to a tributary destination.

Figure 5.2-3. Relative frequencies of tributary use by radio-tagged salmon released in the Middle River, by species, 2014.hown as a percentage of all fish classified to a tributary destination.

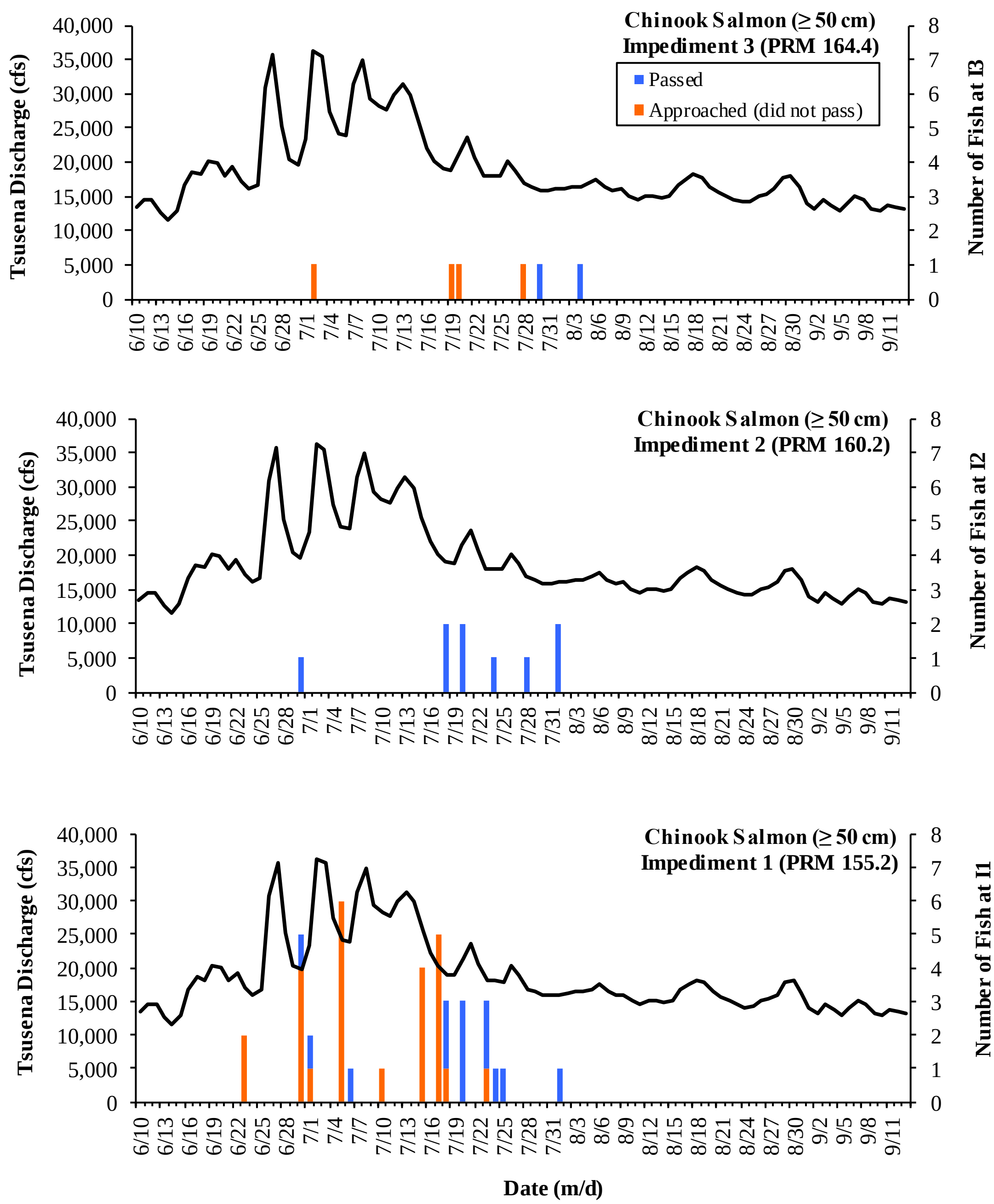

Figure 5.3-1. Daily numbers of radio-tagged large Chinook Salmon that approached and passed each of the three Middle River impediments in 2014. Orange bars: fish that approached but did not pass. Blue bars: fish that approached and successfully passed. Figures show the date of first detection above the impediment (blue) or the date of first detection below the impediment (orange). Also shown is the average daily flow of the Susitna River as measured at the Tsusena Creek gauge. An "I" refers to "Impediment."

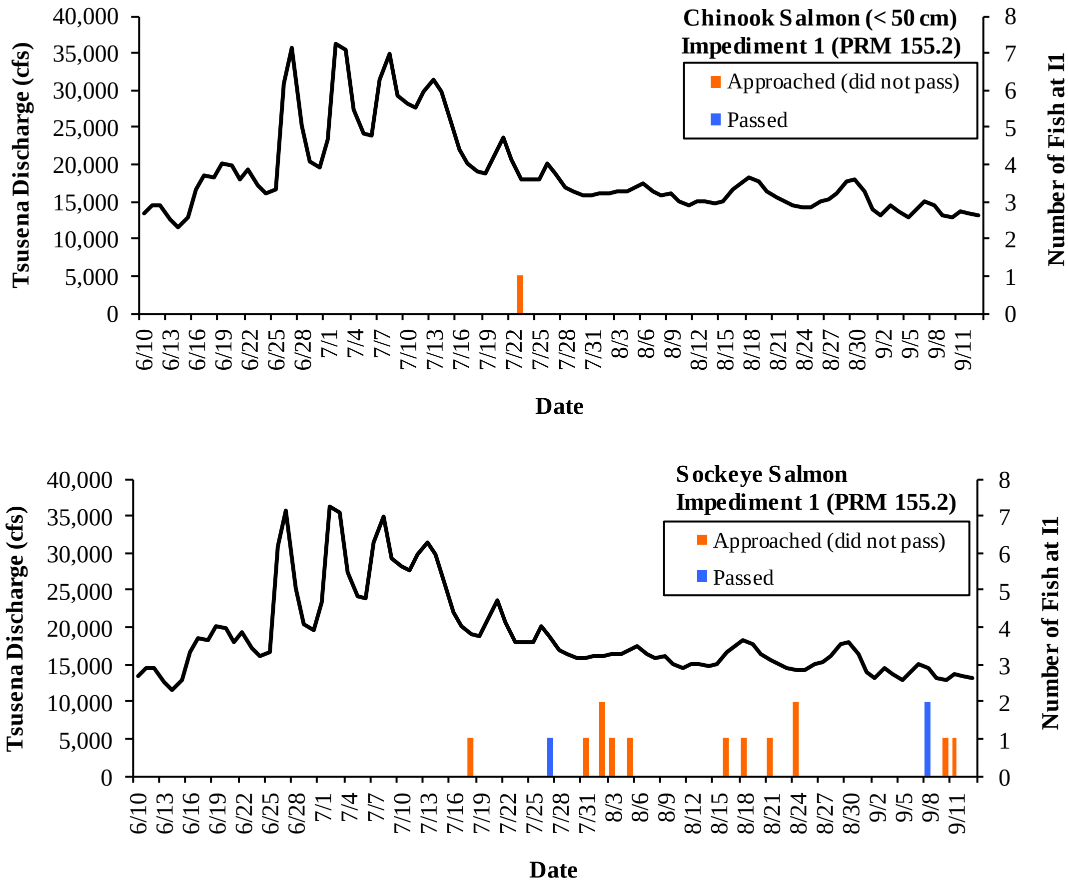

Figure 5.3-2. Daily numbers of radio-tagged small Chinook (top panel) and Sockeye (bottom panel) salmon that approached and passed Middle River Impediment 1 in 2014. Orange bars: fish that approached but did not pass. Blue bars: fish that approached and successfully passed. Figures show the date of first detection above the impediment (blue) or the date of first detection below the impediment (orange). Also shown is the average daily flow of the Susitna River as measured at the Tsusena Creek gauge. An "I" refers to "Impediment." No Chinook Salmon measuring less than 50 cm (19.7 in) METF or Sockeye Salmon approached or passed Impediment 2 or Impediment 3.

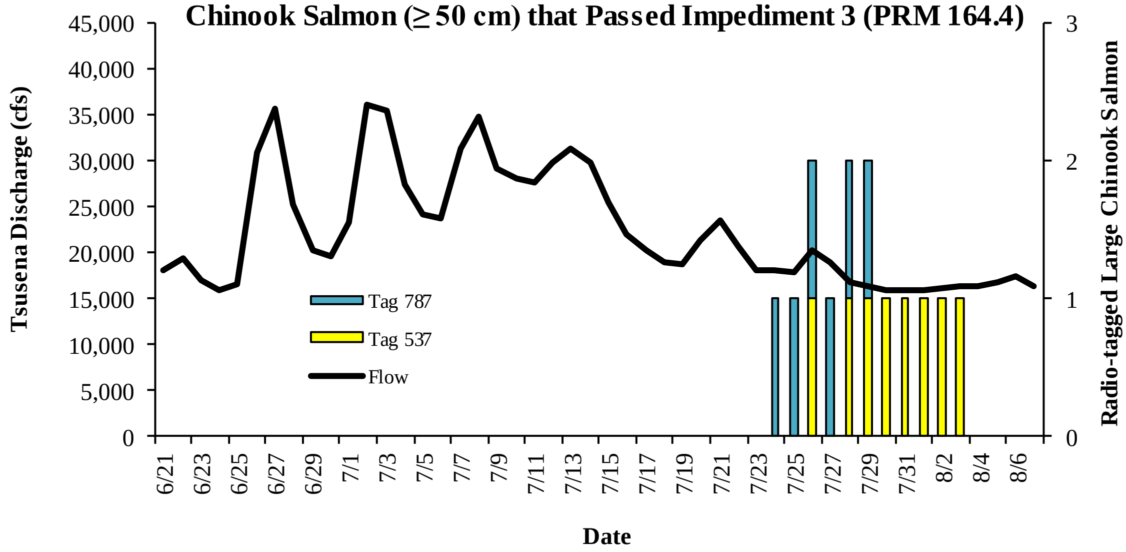

Figure 5.3-3. Daily number of radio-tagged Chinook Salmon that held below Impediment 3 in 2014. Each of the two fish is shown using a unique color. Passage dates can be read by noting the date after which each of the tags disappears from the chart. Also shown is the average daily flow of the Susitna River as measured at the Tsusena Creek gauge.

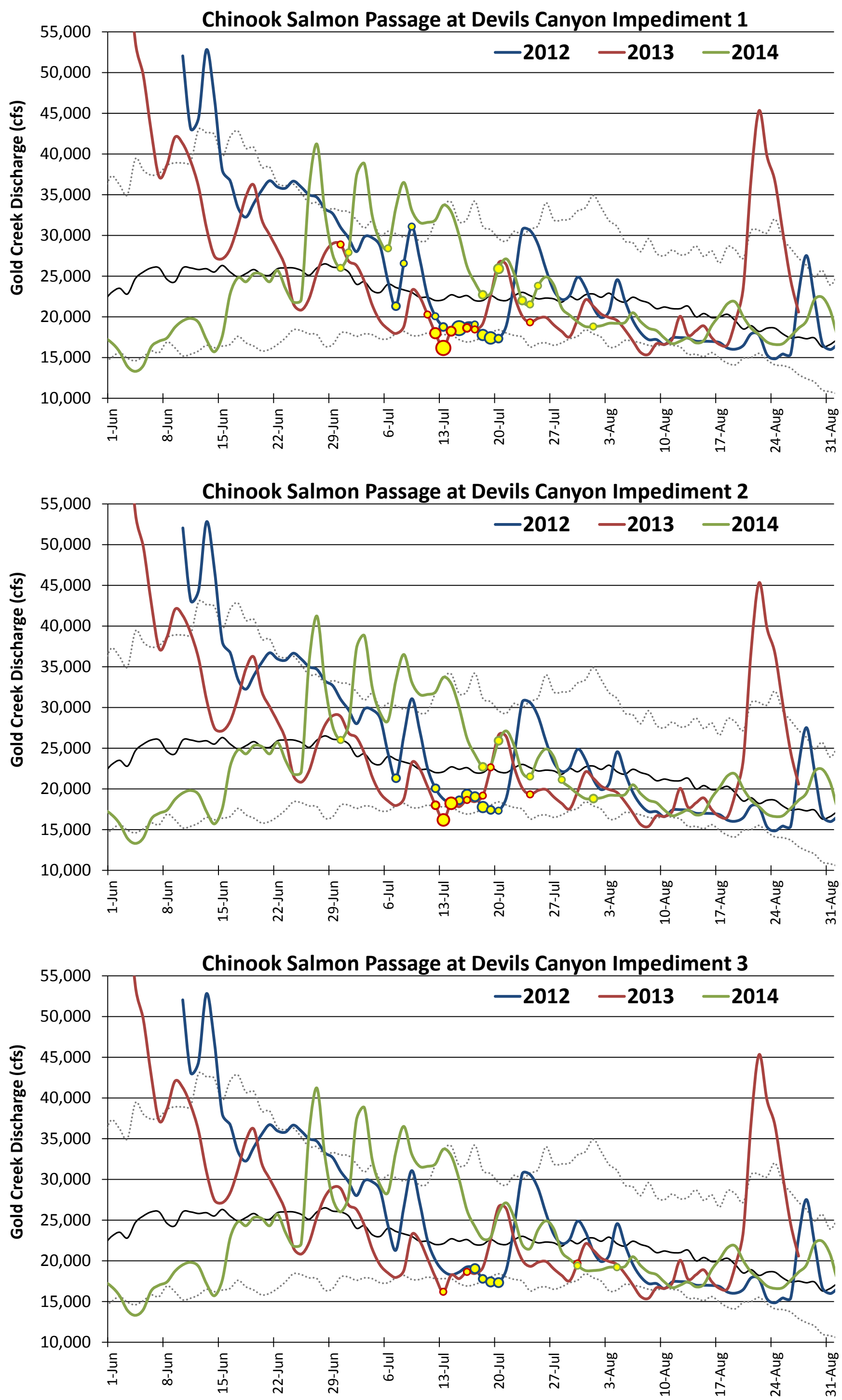

Figure 5.3-4. Flows (measured at Gold Creek) in 2012, 2013 and 2014, along with median (solid black line), and the 10th and 90th percentile (dotted lines) historical flows. Plotted along the flow curves are passage events (yellow dots), where the dot size is scaled to indicate the number of fish that passed. Passage events and corresponding discharge are presented in Table 5.3-4.

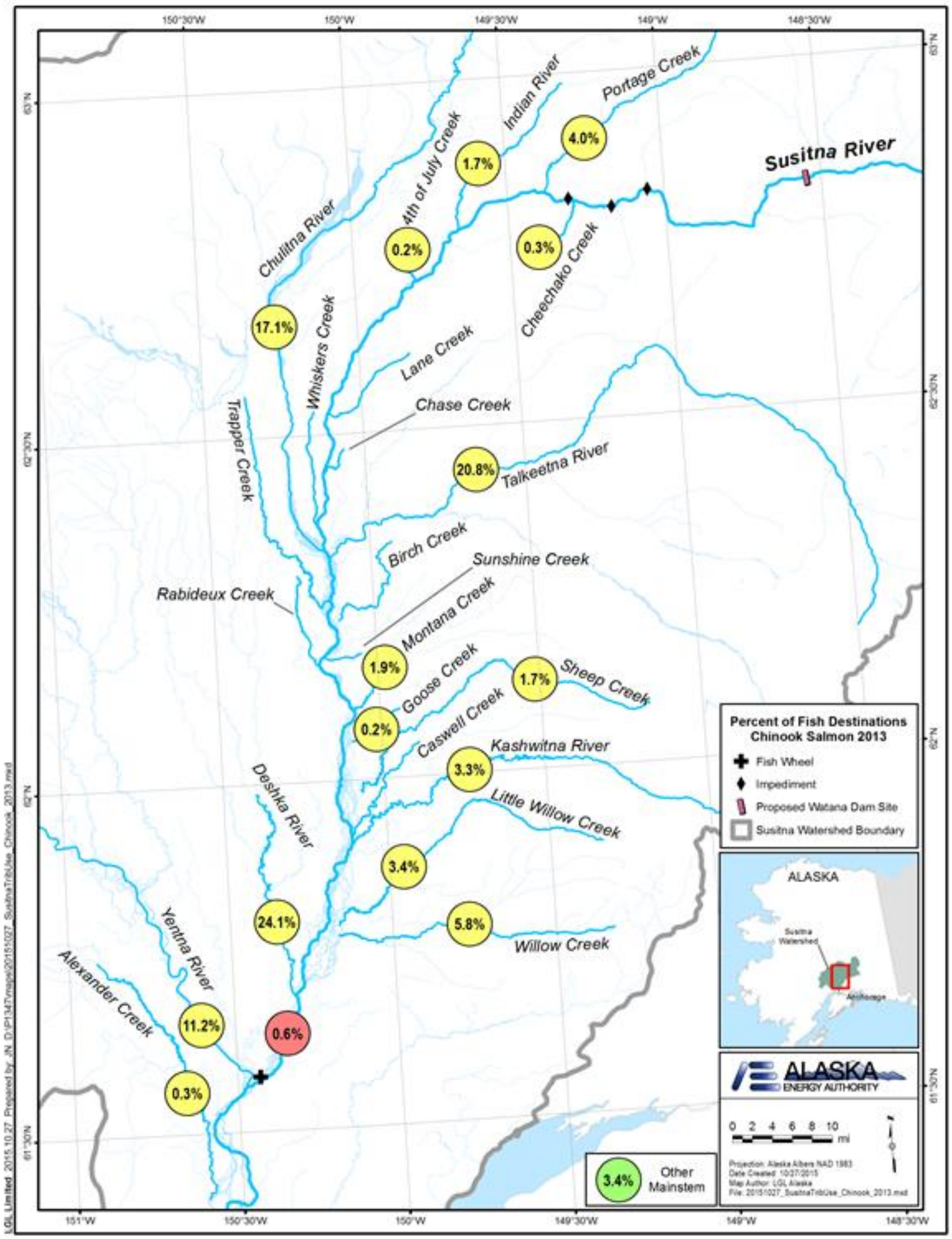

Figure 5.7-1. Destinations for radio-tagged Chinook Salmon released in the Lower River in 2013. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination. Data from Table 5.2-1 in the ISR. Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

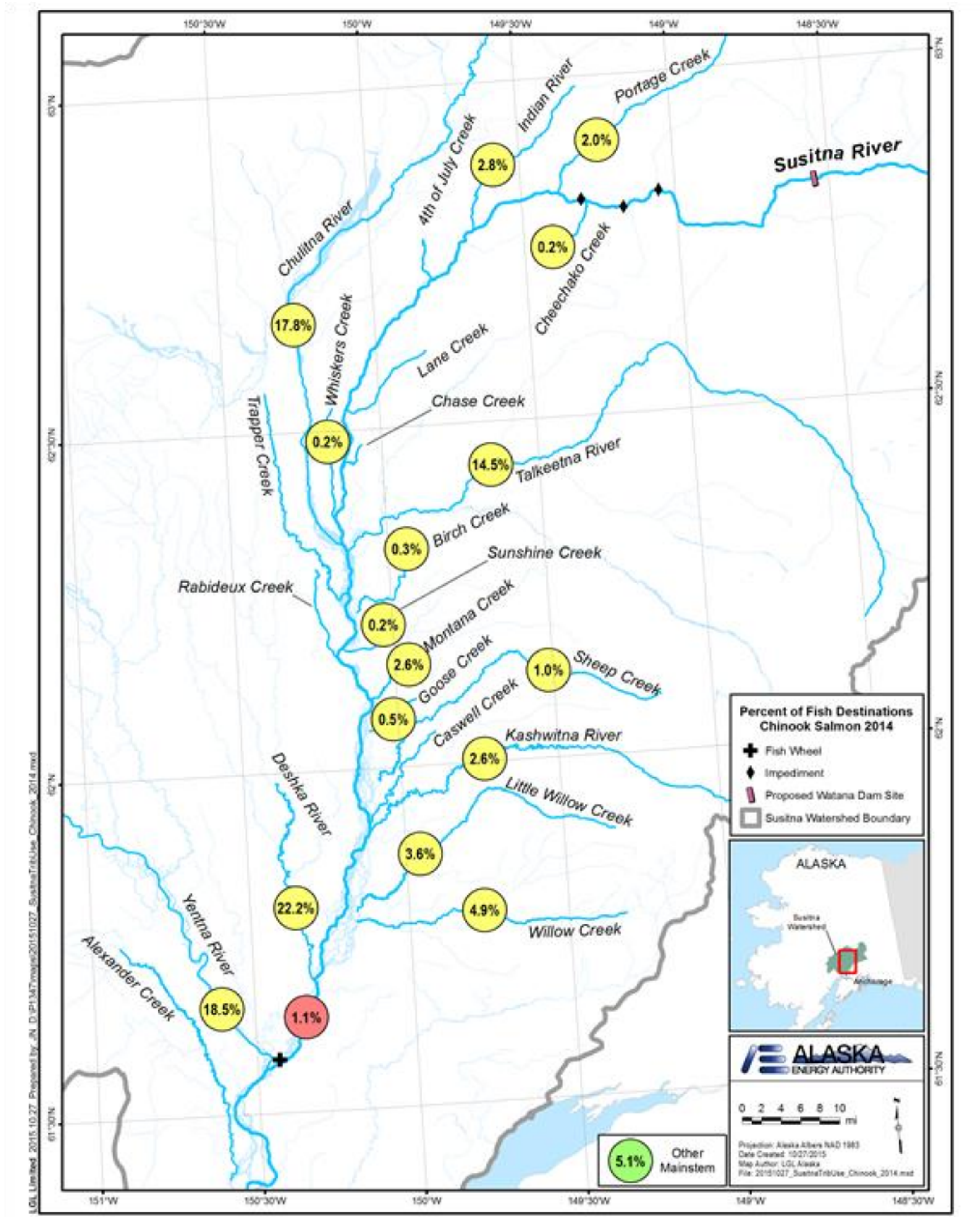

Figure 5.7-2. Destinations for radio-tagged Chinook Salmon released in the Lower River in 2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination. Data from Table 5.2-1. Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

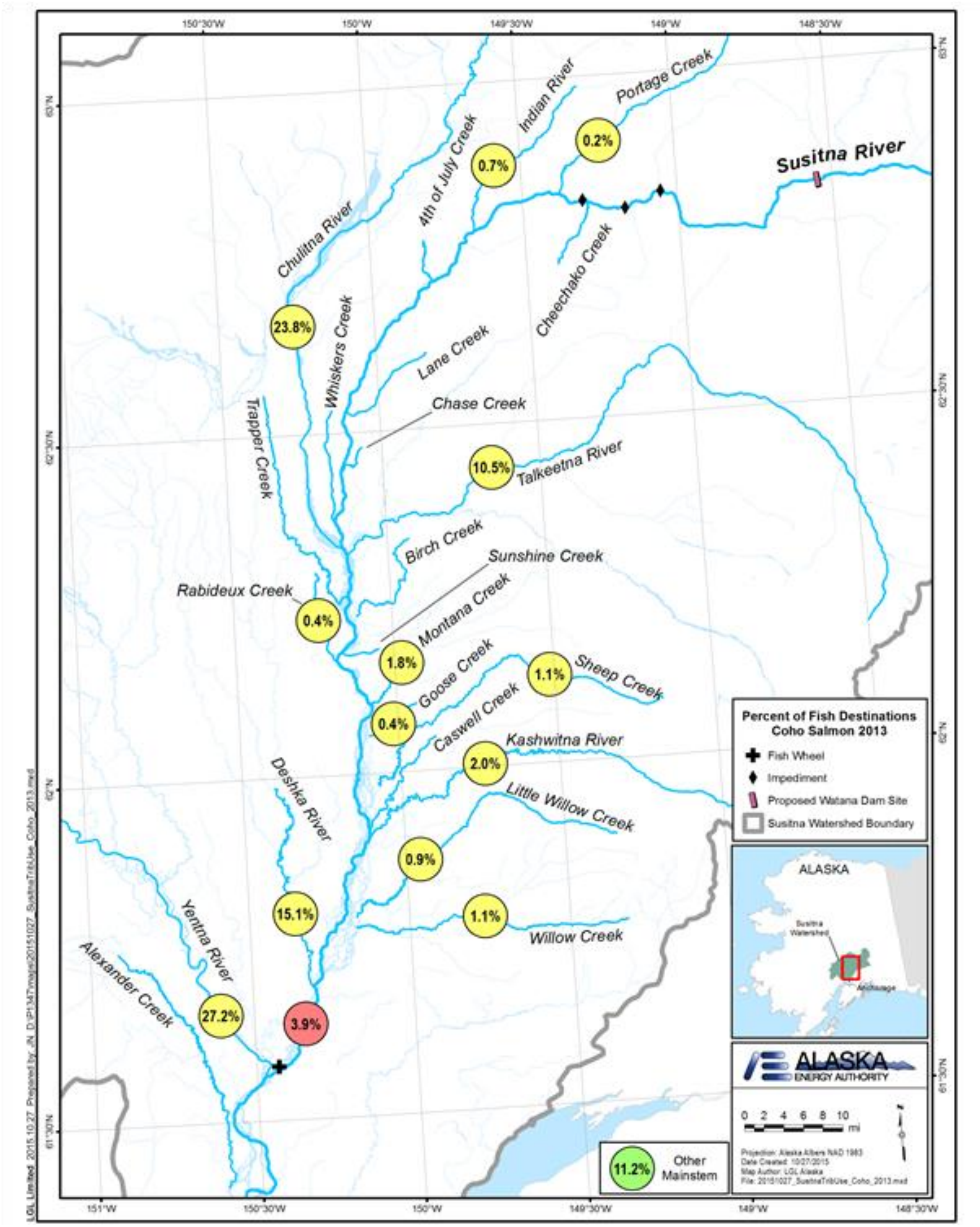

Figure 5.7-3. Destinations for radio-tagged Coho Salmon released in the Lower River in 2013 (yellow circles). Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination. Data from Table 5.2-1 in the ISR. Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

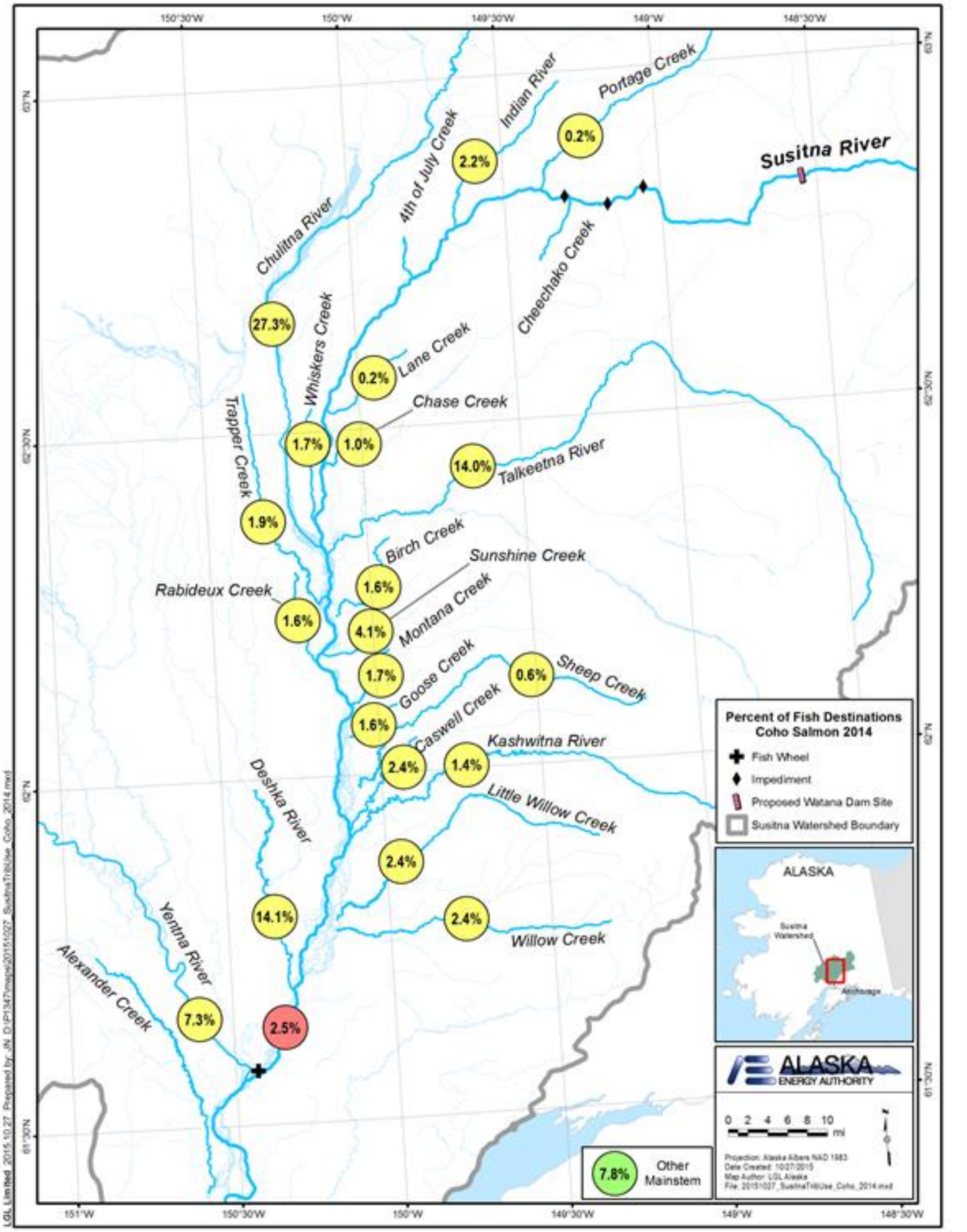

Figure 5.7-4. Destinations for radio-tagged Coho Salmon released in the Lower River in 2014 (yellow circles). Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination. Data from Table 5.2-1. Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

Appendix A: Fish Capture and Tagging

Table A-1. Number of salmon caught and radio-tagged at two fishwheel sites and from gillnets in the Lower River, PRM 33.4–34.2, 2014.

Species	Caught[1]/ Tagged	Radio Tag Target	Fishwheel West Bank	Fishwheel East Bank	Gillnet	Total
Chinook Salmon	Caught		921	959	168	2,048
	Tagged[2]	700	259	271	129	659
Chum Salmon	Caught		2,295	4,282	0	6,577
Coho Salmon	Caught		910	603	0	1,513
	Tagged	600	337	303		640
Pink Salmon	Caught		10,063	3,871	0	13,934
	Tagged	200	106	92		198
Sockeye Salmon	Caught		396	453	4	853
Total	Caught		14,585	10,168	172	24,925
(all species)	Tagged	1,500	702	666	129	1,497

[1] Total caught includes all adult salmon regardless of size, as well as all recaptured fish.

[2] Adult fish measuring 50 cm METF or greater.

Table A-2. Number of Chinook Salmon caught and radio-tagged at fishwheel sites and in gillnets in the Yentna River (RM 6 and RM 18), 2014.

Location	Caught[1]/ Tagged	Radio Tag Target	Fishwheel South	Fishwheel North	Gillnet	Total
Yentna River (RM 6)	Caught		1,213	1,413	399	3,025
	Tagged[2]	300	95	95	106	296
			East	**West**		
Yentna River (RM 18)	Caught		1,440	743	122	2,305

[1] Total caught includes all adult salmon regardless of size, as well as all recaptured fish.

[2] All tagged Chinook Salmon measured 50 cm METF or greater.

Table A-3. Number of salmon radio-tagged at three fishwheel sites and in gillnets in the Middle River, by size category, 2014.

	Fishwheels														
	Site 1 (PRM 124.1)			Site 2 (PRM 123.0)			Site 3 (PRM 126.0)			Gill Net			All Gear Combined		
Species	Large	Small	Total	Large	Small	Total	Large	Small	Total	Large	Small	Total	Large	Small	Total
Chinook Salmon	247	17	264	75	2	77	268	13	281	0	0	0	590	32	622
Chum Salmon	60	0	60	53	0	53	87	0	87	0	0	0	200	0	200
Coho Salmon	73	0	73	14	0	14	125	0	125	18	0	18	230	0	230
Pink Salmon	73	0	73	27	0	27	101	0	101	0	0	0	201	0	201
Sockeye Salmon	54	0	54	89	0	89	57	0	57	0	0	0	200	0	200
Total	507	17	524	258	2	260	638	13	651	18	0	18	1,421	32	1,453

Notes:

Large Chinook Salmon measured 50 cm METF or greater; and large Chum, Coho, Pink, and Sockeye salmon measured 40 cm METF or greater.

Table A-4. Number of salmon caught in the Lower River and Yentna River and their length statistics, 2014.

Location Species Name	Total Catch	Length (cm METF) Min	 Max	 Mean	 n
Lower River					
Chinook Salmon (≥ 50 cm)[a]	1,471	50.0	105.0	67.6	1,431
Chinook Salmon (< 50 cm)[a]	577	27.0	49.5	39.1	561
Total Chinook Salmon	2,048				
Chum Salmon	6,577	-	-	-	-
Coho Salmon	1,513	28.0	68.0	52.5	1,361
Pink Salmon	13,934	40.0	56.5	44.8	198
Sockeye Salmon	849	32.4	69.0	49.3	592
Yentna River (RM 6)					
Chinook Salmon (≥ 50 cm)[a]	1,357	50.0	109.0	66.9	1,355
Chinook Salmon (< 50 cm)[a]	1,668	21.5	49.5	34.9	1,666
Total Chinook Salmon	3,025				
Yentna River (RM 18)					
Chinook Salmon (≥ 50 cm)[a]	1,375	50.0	110.0	66.8	1,367
Chinook Salmon (< 50 cm)[a]	930	24.0	49.5	37.0	924
Total Chinook Salmon	2,305				

[a] Total catch by size category estimated from length samples.

Table A-5. Number of salmon captured at three fishwheel sites and in gillnets in the Middle River, by size category, 2014.

	Fishwheels														
	Site 1			Site 2			Site 3			Gill Net			All Gear Combined		
Species	Large	Small	Total	Large	Small	Total	Large	Small	Total	Large	Small	Total	Large	Small	Total
Chinook Salmon	273	84	357	79	18	97	320	102	422	0	1	1	672	205	877
Chum Salmon	581	0	581	417	0	417	471	0	471	83	0	83	1,552	0	1,552
Coho Salmon	111	1	112	25	0	25	197	1	198	42	0	42	375	2	377
Pink Salmon	3,011	0	3,011	73	0	73	4,389	0	4,389	0	0	0	7,473	0	7,473
Sockeye Salmon	59	4	63	92	2	94	62	4	66	10	1	11	223	11	234
Total	4,035	89	4,124	686	20	706	5,439	107	5,546	135	2	137	10,295	218	10,513

Notes:

Totals include all tagged fish recaptured at the fishwheels (30 large Chinook, 2 small Chinook, 8 Chum, 5 Coho, 10 Pink, and 3 Sockeye salmon). Large Chinook Salmon measured 50 cm METF or greater; and large Chum, Coho, Pink, and Sockeye salmon measured 40 cm METF or greater.

Table A-6. Number of fish caught, tagged, and biosampled at the Middle River fishwheels, 2014.

Species Name	Total Catch[a]	Radio-tagged	MEF / Fork Length (cm) [b]				Tissue Samples[c]
			Min	Max	Mean	n	
Chinook Salmon (≥ 50 cm)	672	590	50	108	71.6	624	589
Chinook Salmon (< 50 cm)	204	32	27	49	35.9	198	30
Chum Salmon	1,469	200	45	69	57.9	1,102	194
Coho Salmon	333	212	33	65	54.0	324	199
Pink Salmon	7,473	201	32	67	45.7	955	201
Sockeye Salmon	213	200	33	61	49.3	217	198
Arctic Grayling	17	-	13	36	20.9	16	-
Burbot	2	-	15	15	15.0	2	-
Dolly Varden	8	-	20	43	32.4	5	6
Longnose Sucker	13	-	14	38	29.8	13	-
Rainbow Trout	68	-	16	53	27.3	63	-
Round Whitefish	67	-	13	37	26.2	65	-
Humpback Whitefish	13	-	18	41	31.0	11	9

[b] Total catch includes recaptures for all salmon, and small (MEF < 40 cm) Coho and Sockeye salmon.

[a] Salmon are measured from mid-eye to fork of tail (MEF); other species are fork lengths (FL).

[c] No tissue samples were collected from Arctic Grayling, Burbot, Longnose Sucker, Rainbow Trout, or Round Whitefish because the required sample sizes had been met prior to the 2014 field season.

[d] An additonal 18 Coho Salmon were captured using gillnets and radio-tagged; of which 15 were tissue-sampled.

Table A-7. Daily fishing effort and the number of salmon caught and radio-tagged during gillnet operations in the vicinity of Curry, 2014.

			Adult Salmon Catch				
Date	Number of Crews	Total Effort (net hours)	Chinook Salmon (Small)	Sockeye Salmon	Chum Salmon	Coho Salmon	Coho Salmon Tagged
24-Jun	1	1.8	1	0	0	0	0
10-Sep	2	16.4	0	2	16	14	3
12-Sep	2	16.0	0	1	5	5	3
14-Sep	1	8.0	0	0	7	7	3
16-Sep	1	8.0	0	3	1	2	1
18-Sep	2	16.0	0	2	17	9	5
20-Sep	2	16.0	0	2	19	4	2
22-Sep	2	16.0	0	0	9	0	0
24-Sep	2	16.0	0	1	3	0	0
26-Sep	2	16.0	0	0	3	0	0
28-Sep	2	16.0	0	0	3	0	0
30-Sep	1	6.0	0	0	0	1	1
Total		152.1	1	11	83	42	18

Notes:

Two of the coho salmon captured on September 20 were recaptures. One of the 11 sockeye salmon caught was a jack (MEF < 40 cm). Fishing sites were located between PRM 121.9 and 126.0.

Table A-8. Summary of run-timing and catch information for salmon captured in fishwheels located in the Middle River near Curry, by year and species.

	Year							
Species	**1981**	**1982**	**1983**	**1984**	**1985**	**2012**	**2013**	**2014**
				Chinook Salmon				
Date First Fish Caught	6-15	6-15	6-10	6-9	6-20	6-18	6-16	6-11
Date Last Fish Caught	8-20	8-6	7-31	7-29	8-16	8-9	8-28	8-24
Midpoint of Catch Date (50%)	6-24	7-3	6-25	6-25	7-9	7-3	6-30	7-2
Peak Daily Catch (Date)	6-23	7-4	6-22	6-22	7-8	7-2	7-2	7-1
Peak Daily Catch (Fish)	31	55	82	165	98	62	78	70
Total Catch (Fish)	284	791	1,064	1,589	1,098	566	952	876
				Chum Salmon				
Date First Fish Caught	7-20	7-25	7-10	7-15	7-17	7-10	7-13	7-5
Date Last Fish Caught	9-15	9-14	9-9	9-7	9-12	9-1	9-9	9-5
Midpoint of Catch Date (50%)	8-17	8-12	8-3	8-6	8-7	8-7	8-5	8-12
Peak Daily Catch (Date)	8-6	8-13	8-2	8-5	8-6	8-2	8-3	8-11
Peak Daily Catch (Fish)	87	168	78	366	166	181	259	89
Total Catch (Fish)	1,276	1,736	861	4,228	1,305	1,734	3,417	1,469
				Coho Salmon				
Date First Fish Caught	8-4	8-2	7-22	7-18	8-3	7-28	7-23	7-22
Date Last Fish Caught	9-19	9-11	9-6	8-31	9-12	8-31	9-21	9-3
Midpoint of Catch Date (50%)	8-23	8-18	8-12	8-12	8-18	8-15	8-15	8-20
Peak Daily Catch (Date)	8-29	8-19	8-15	8-4	8-20	8/11,8/15	8-17	8-22
Peak Daily Catch (Fish)	16	15	10	21	18	21	139	30
Total Catch (Fish)	182	229	93	350	203	265	1,723	335
				Pink Salmon				
Date First Fish Caught	7-18	7-22	7-20	7-7	7-15	7-16	7-8	7-16
Date Last Fish Caught	8-29	8-26	8-23	8-29	8-28	8-31	9-4	8-30
Midpoint of Catch Date (50%)	8-8	8-6	8-1	8-4	8-5	8-6	8-3	7-31
Peak Daily Catch (Date)	8-6	8-5	8-1	8-5	8-6	8-2	8-3	7-29
Peak Daily Catch (Fish)	39	1,199	67	2,052	147	548	1,422	979
Total Catch (Fish)	234	7,302	589	17,394	1,172	4,705	15,695	7,473
				Sockeye Salmon				
Date First Fish Caught	7-17	7-16	7-6	6-26	7-16	7-2	6-15	6-29
Date Last Fish Caught	9-12	9-18	9-4	9-8	9-4	8-22	9-10	9-3
Midpoint of Catch Date (50%)	8-5	8-5	8-5	8-1	8-7	7-30	8-5	8-1
Peak Daily Catch (Date)	8-5	8-5	8/2,8/12,8/13	7-30	8-6	7-21	8-15	7-28
Peak Daily Catch (Fish)	44	16	10	34	29	8	16	13
Total Catch (Fish)	469	161	201	379	324	100	276	223

Table A-9. Comparisons between the cumulative length-frequency distributions of fish sampled in the Lower River and Yentna River using the Kolmogorov-Smirnov (KS) two-sample test, 2014.

Length-Frequency Distributions		Sample Size			
Sample 1	**Sample 2**	**n_1**	**n_2**	**D_{max}**	**P-value**
Lower River					
Chinook Salmon					
East bank fishwheel	West bank fishwheel	937	937	0.111	< 0.001
East bank fishwheel	Gillnet	937	164	0.387	< 0.001
West bank fishwheel	Gillnet	937	164	0.442	< 0.001
Total catch (METF ≥ 50 cm)	Tagged (METF ≥ 50 cm)	1,503	656	0.145	< 0.001
Total catch (METF ≥ 58 cm)	Tagged (METF ≥ 58 cm)	1,086	569	0.030	0.797
Coho Salmon					
East bank fishwheel	West bank fishwheel	551	810	0.083	0.011
Total catch (METF ≥ 40 cm)	Tagged (METF ≥ 40 cm)	1,349	640	0.023	0.886
Pink Salmon (METF ≥ 40 cm)					
East bank fishwheel	West bank fishwheel	90	107	0.145	0.140
Yentna River					
Chinook Salmon @ RM6					
South bank fishwheel	North bank fishwheel	1,213	1,410	0.155	< 0.001
South bank fishwheel	Gillnet	1,213	398	0.519	< 0.001
North bank fishwheel	Gillnet	1,410	398	0.658	< 0.001
Total catch (METF ≥ 50 cm)	Tagged (METF ≥ 50 cm)	1,355	1,277	0.005	1.000
Chinook Salmon @ RM18					
South bank fishwheel	North bank fishwheel	739	1,435	0.250	< 0.001
South bank fishwheel	Gillnet	739	118	0.528	< 0.001
North bank fishwheel	Gillnet	1,435	118	0.671	< 0.001

Table A-10. Comparisons between the cumulative length-frequency distributions of fish sampled in the Middle River using the Kolmogorov-Smirnov (KS) two-sample test, 2014.

Length-Frequency Distributions		Sample Size			
Sample 1	Sample 2	n_1	n_2	D_{max}	P-value
Chinook Salmon (Large)					
Site 1 fishwheel catch	Site 2 fishwheel catch	339	95	0.12	0.22
Site 1 fishwheel catch	Site 3 fishwheel catch	339	388	0.04	1.00
Site 2 fishwheel catch	Site 3 fishwheel catch	95	388	0.12	0.19
Total catch (METF ≥ 50 cm)	Tagged (METF ≥ 50 cm)	624	589	0.01	1.00
Chinook Salmon (Small)					
Total catch (METF < 50 cm)	Tagged (METF < 50 cm)	198	32	0.77	< 0.01
Chum Salmon					
Site 1 fishwheel catch	Site 2 fishwheel catch	399	342	0.14	0.00
Site 1 fishwheel catch	Site 3 fishwheel catch	399	361	0.04	0.93
Site 2 fishwheel catch	Site 3 fishwheel catch	342	361	0.15	< 0.01
Total catch (METF ≥ 40 cm)	Tagged (METF ≥ 40 cm)	1,102	200	0.08	0.25
Coho Salmon					
Site 1 fishwheel catch	Site 2 fishwheel catch	108	25	0.24	0.20
Site 1 fishwheel catch	Site 3 fishwheel catch	108	191	0.05	1.00
Site 2 fishwheel catch	Site 3 fishwheel catch	25	191	0.24	0.15
Total catch (METF ≥ 40 cm)	Tagged (METF ≥ 40 cm)	324	212	0.04	1.00
Pink Salmon					
Site 1 fishwheel catch	Site 2 fishwheel catch	440	66	0.06	1.00
Site 1 fishwheel catch	Site 3 fishwheel catch	440	449	0.09	0.04
Site 2 fishwheel catch	Site 3 fishwheel catch	66	449	0.1	0.66
Total catch	Tagged	955	201	0.15	< 0.01
Sockeye Salmon					
Site 1 fishwheel catch	Site 2 fishwheel catch	60	93	0.1	0.93
Site 1 fishwheel catch	Site 3 fishwheel catch	60	64	0.08	1.00
Site 2 fishwheel catch	Site 3 fishwheel catch	93	64	0.09	1.00
Total catch (METF ≥ 40 cm)	Tagged (METF ≥ 40 cm)	217	200	0.04	1.00

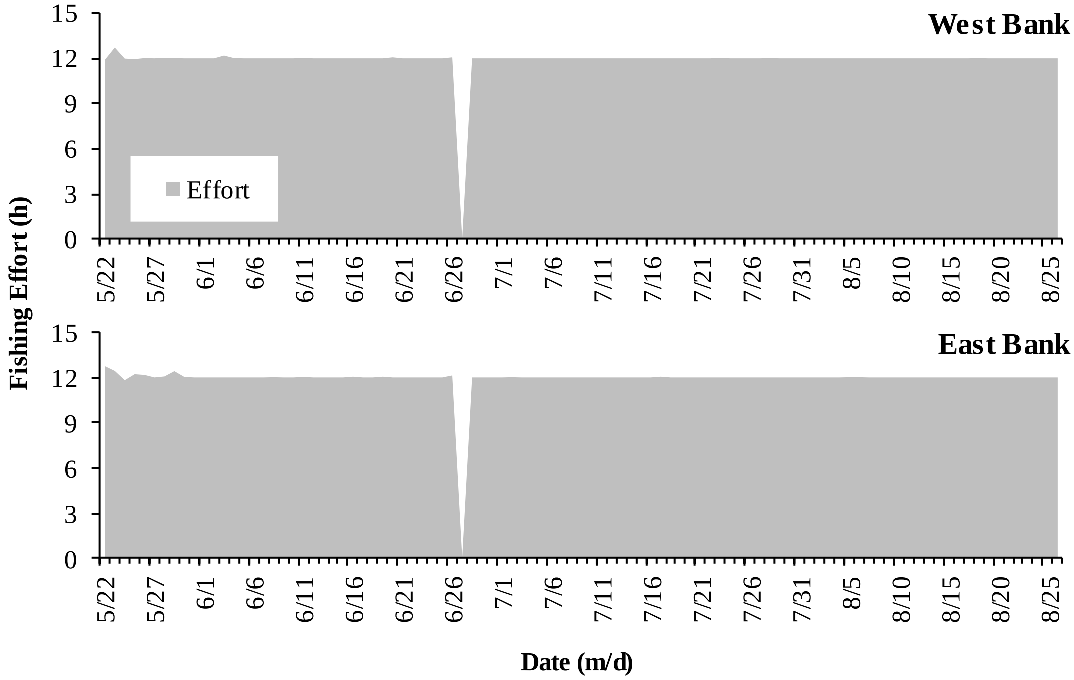

Figure A-1. Daily fishing effort (hours) at two fishwheel sites in the Lower River, 2014.

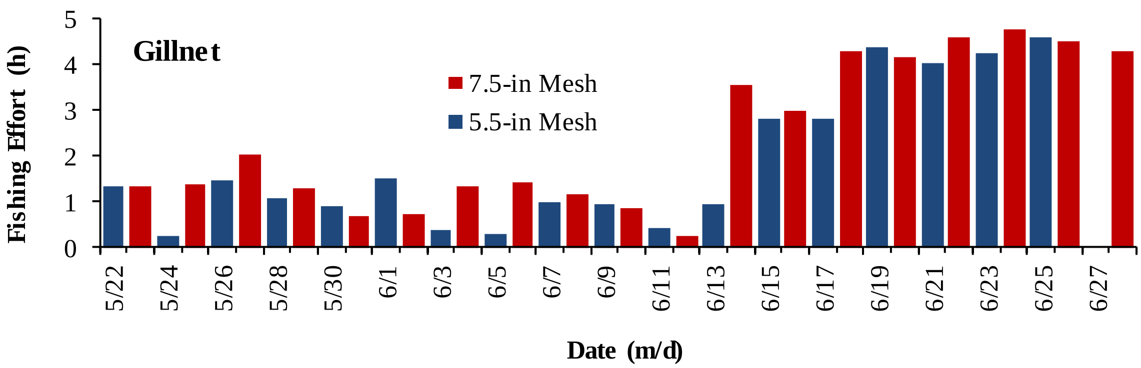

Figure A-2. Daily gillnet effort (hours) in the Lower River, by mesh size, 2014.

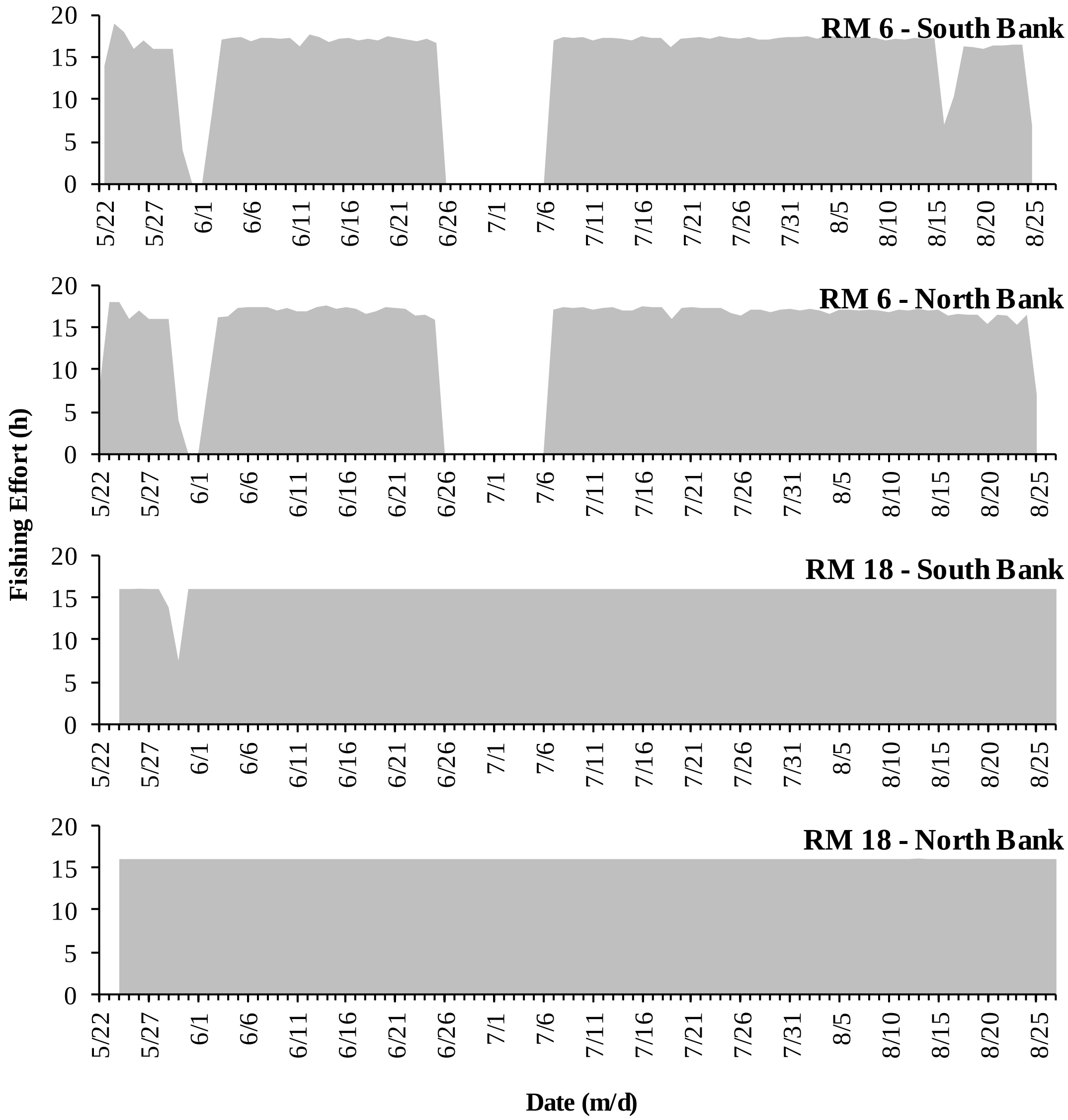

Figure A-3. Daily fishing effort (hours) at four fishwheel sites in the Yentna River, 2014.

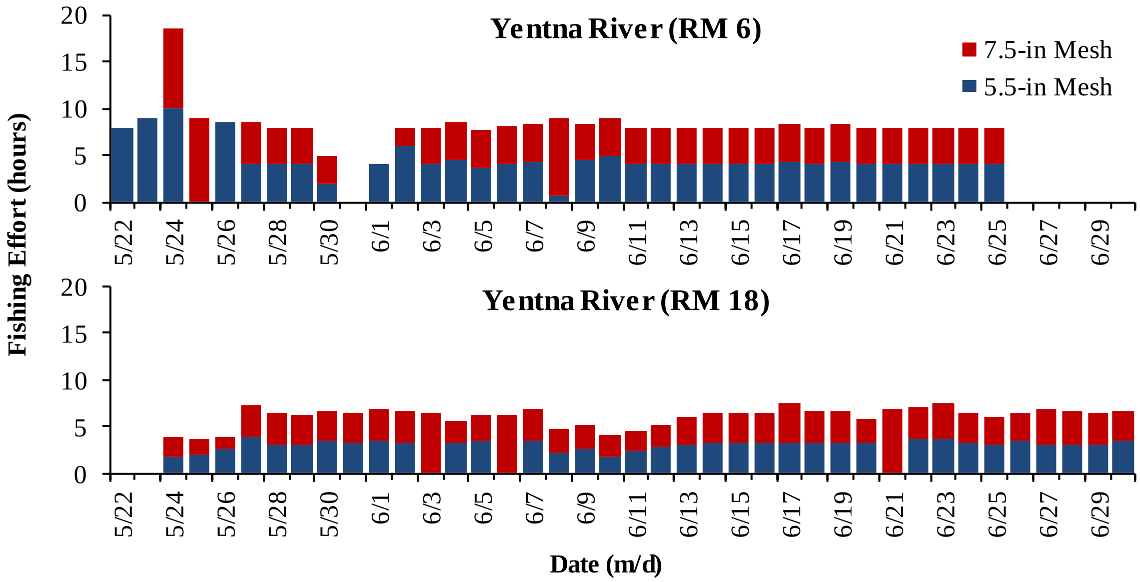

Figure A-4. Daily gillnet effort (hours) during tagging (top panel) and recovery (bottom panel) operations in the Yentna River, by mesh size, 2014.

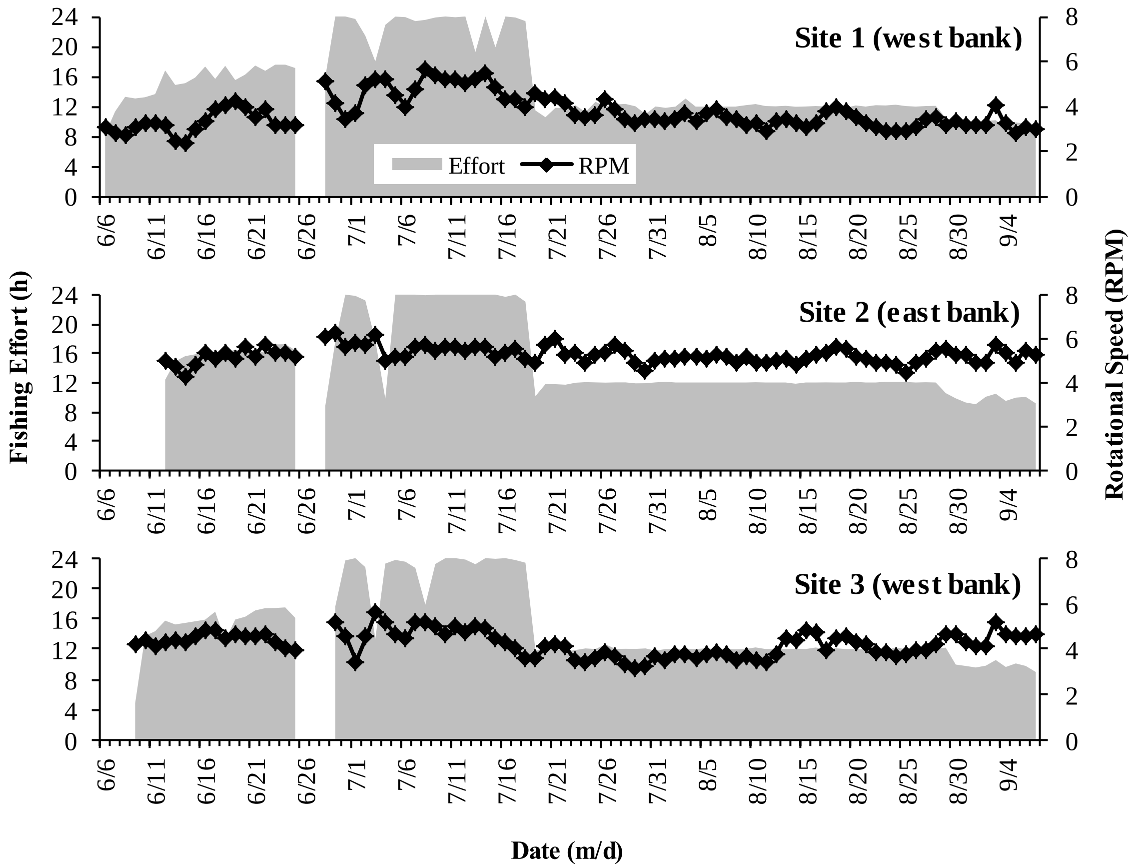

Figure A-5. Daily fishing effort (hours) and rotational speed (RPM) at three fishwheel sites in the Middle River, 2014.

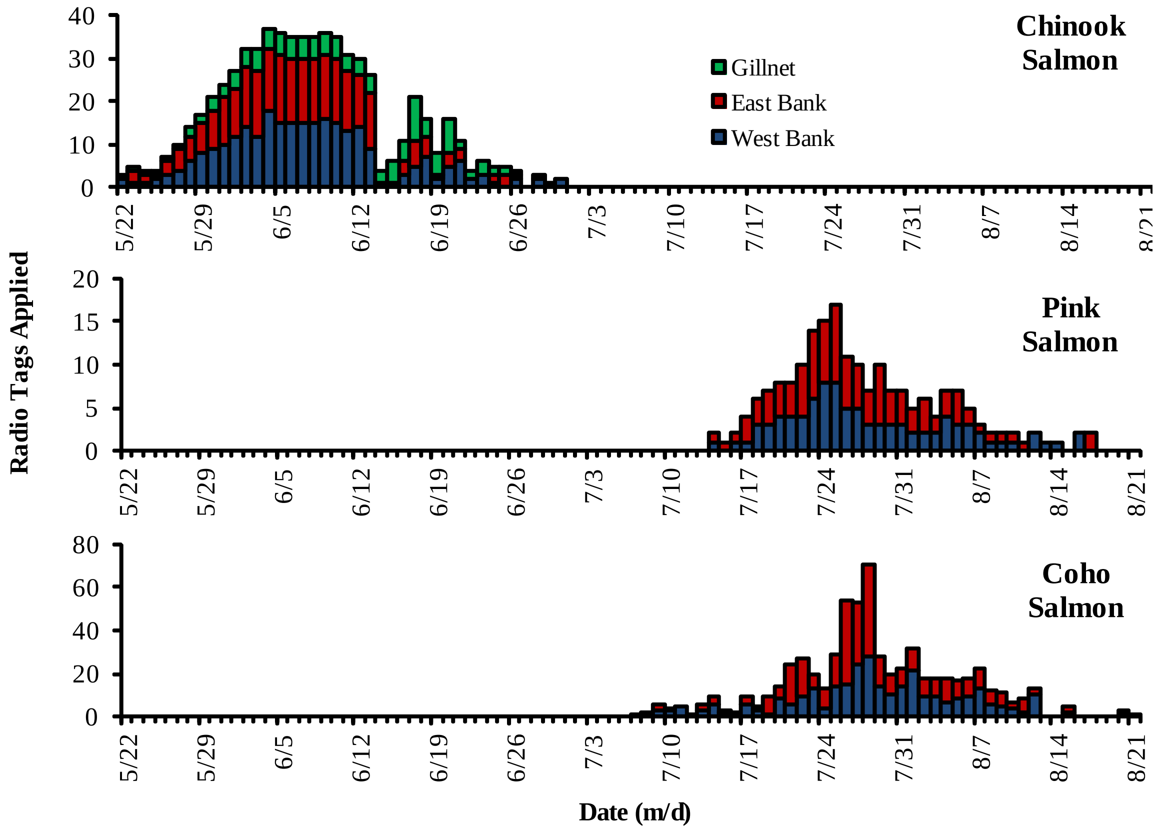

Figure A-6. Daily number of radio tags applied to adult salmon species captured at two fishwheel sites and in gillnets in the Lower River, 2014.

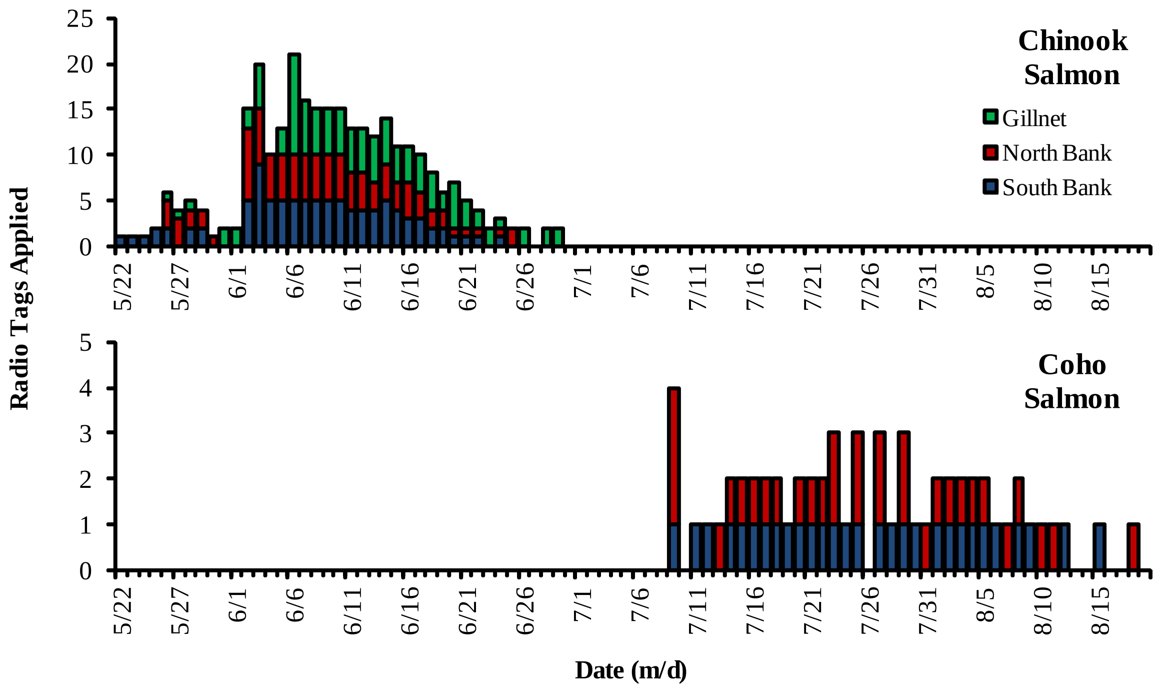

Figure A-7. Daily number of radio tags applied to adult salmon species captured at two fishwheel sites and in gillnets in the Yentna River (RM 6), 2014.

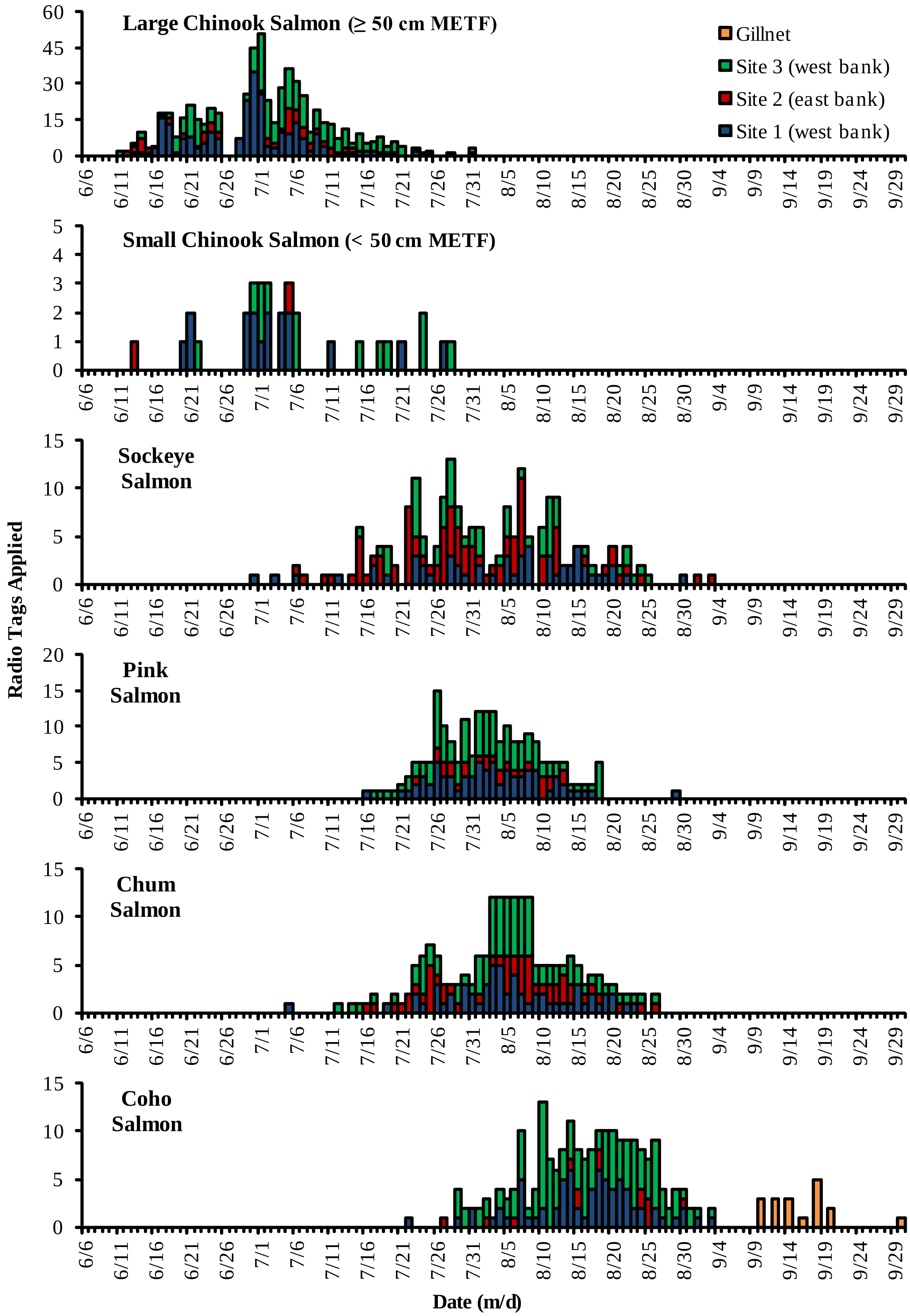

Figure A-8. Daily number of radio tags applied to adult salmon species captured at three fishwheel sites and in gillnets in the Middle River, 2014.

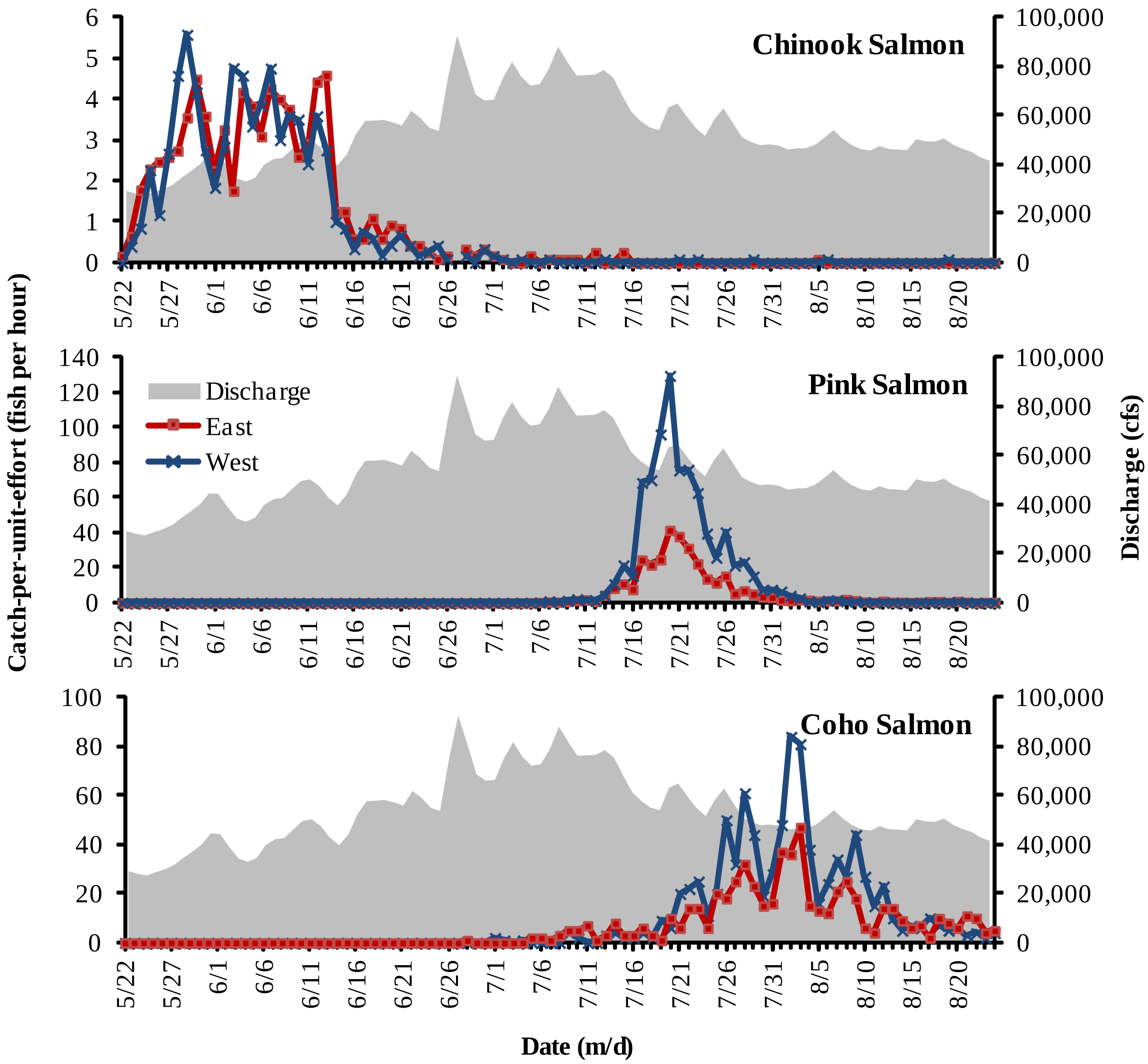

Figure A-9. Daily catch-per-unit-effort of adult salmon species at the Lower River fishwheels, and the Susitna River discharge at Sunshine, 2014.

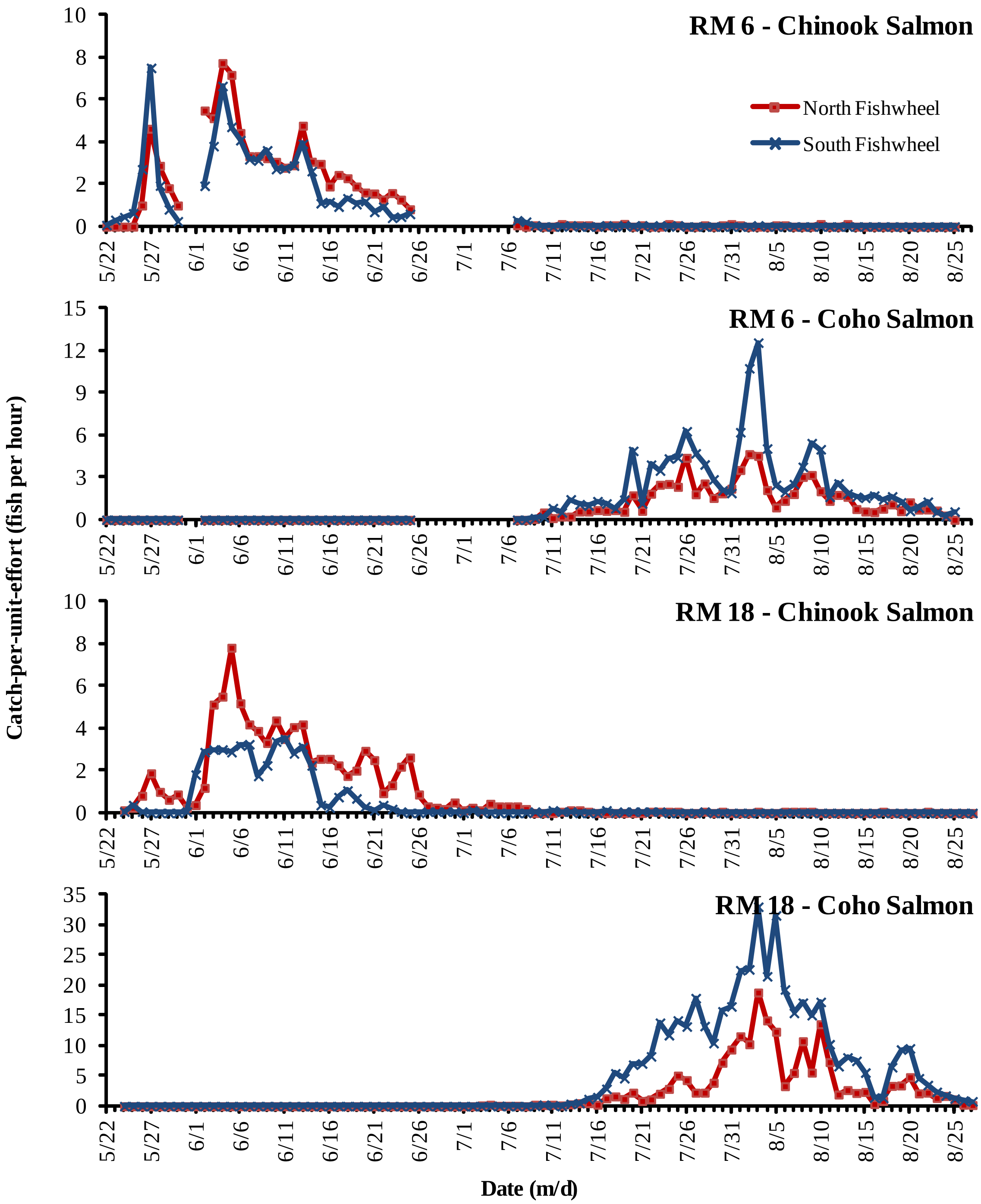

Figure A-10. Daily catch-per-unit-effort for Chinook and Coho salmon at the Yentna River fishwheels, by site, 2014.

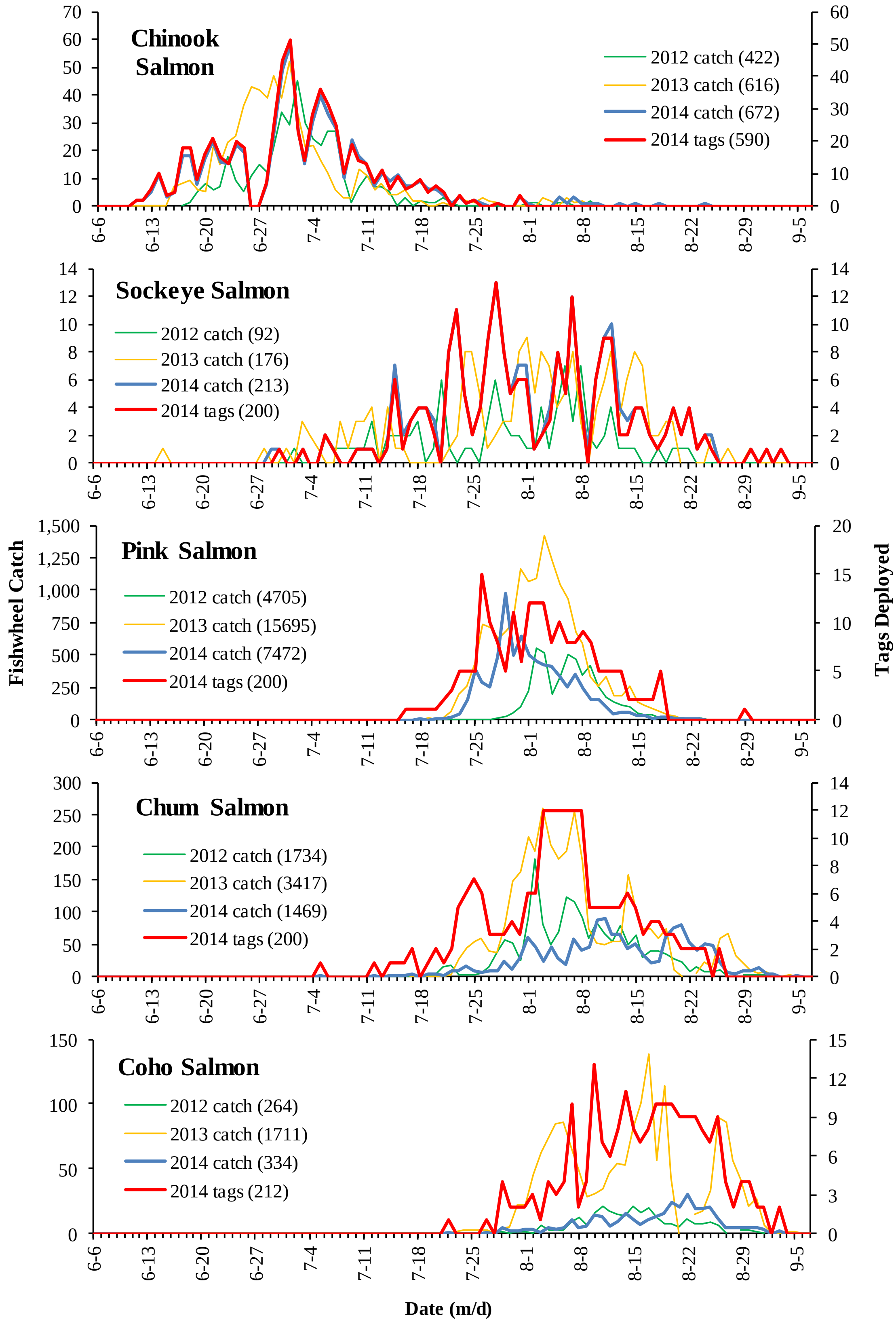

Figure A-11. Number of radio tags deployed in species of salmon at the Middle River fishwheels in 2014 relative to fishwheel catches in 2012, 2013, and 2014.

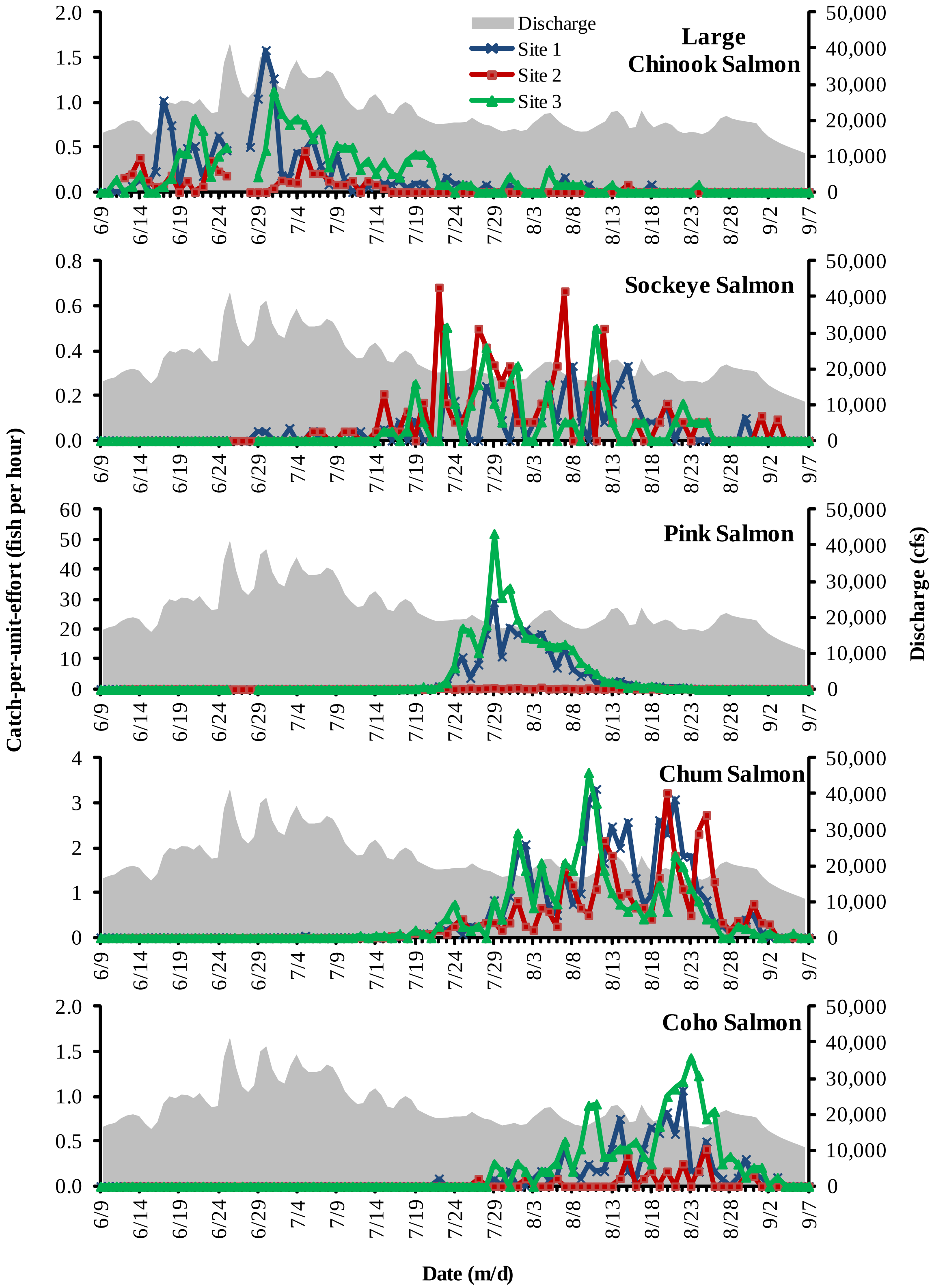

Figure A-12. Daily catch-per-unit-effort at the Middle River fishwheels, by species, and the Susitna River discharge at Gold Creek, 2014.

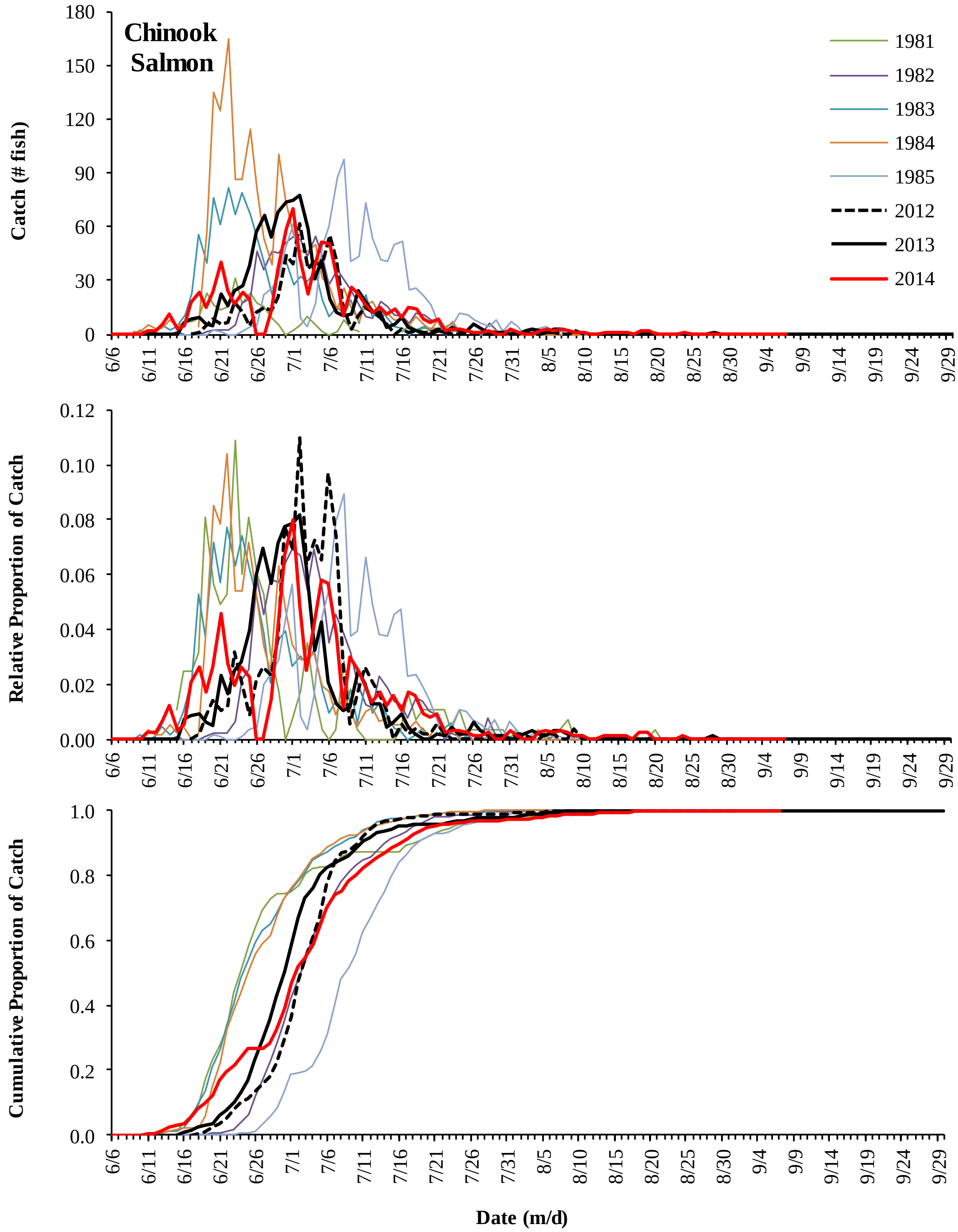

Figure A-13. Comparison of Chinook Salmon catches (top panel), relative proportion of catches (middle panel), and cumulative proportion of catches (bottom panel), at the Middle River fishwheels near Curry, by year. These data include Chinook Salmon of all size categories and catches at two (1981-2012) or three (2013 and 2014) fishwheels.

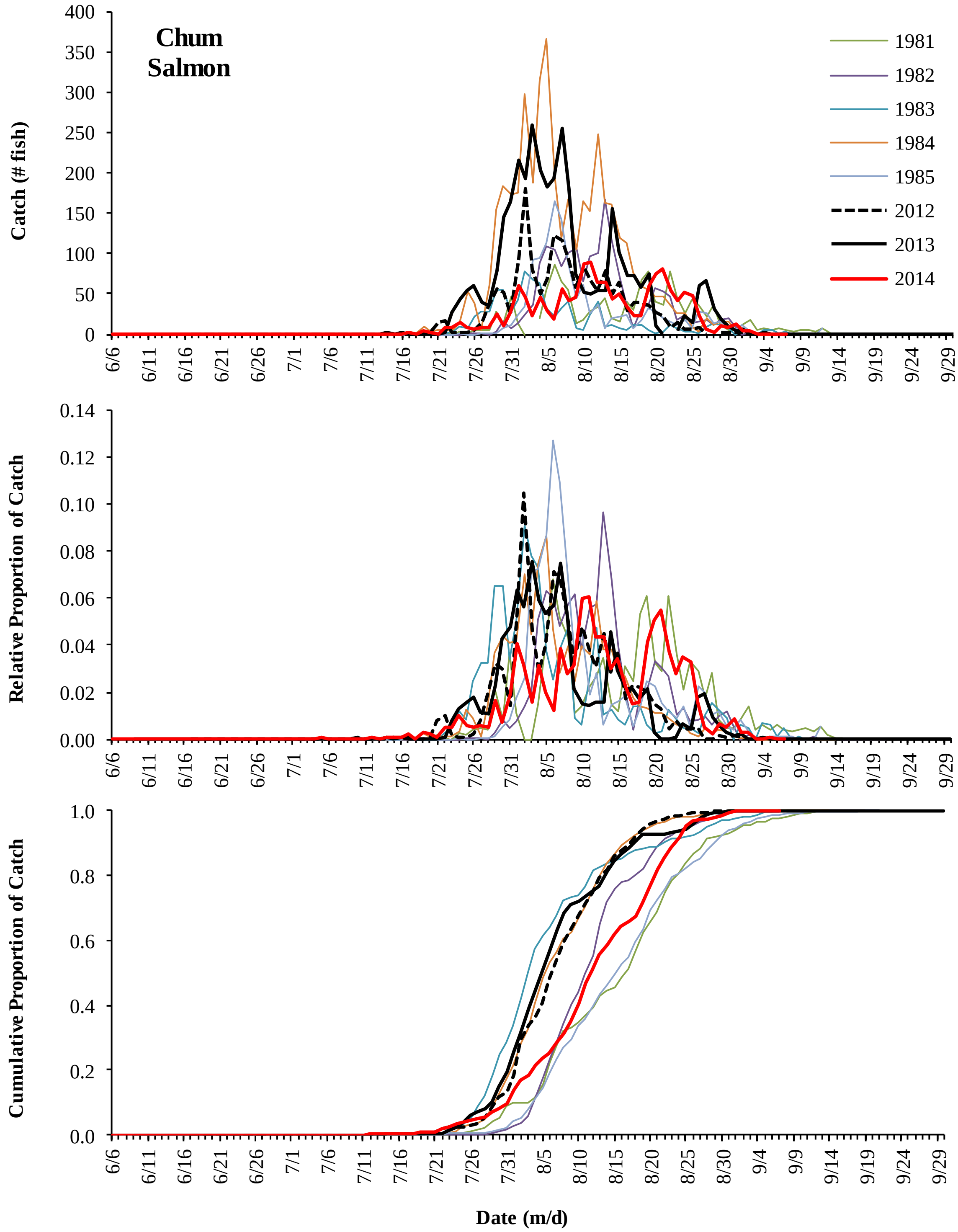

Figure A-14. Comparison of Chum Salmon catches (top panel), relative proportion of catches (middle panel), and cumulative proportion of catches (bottom panel), at the Middle River fishwheels near Curry, by year. These data include adult Chum Salmon of all size categories and catches at two (1981-2012) or three (2013 and 2014) fishwheels.

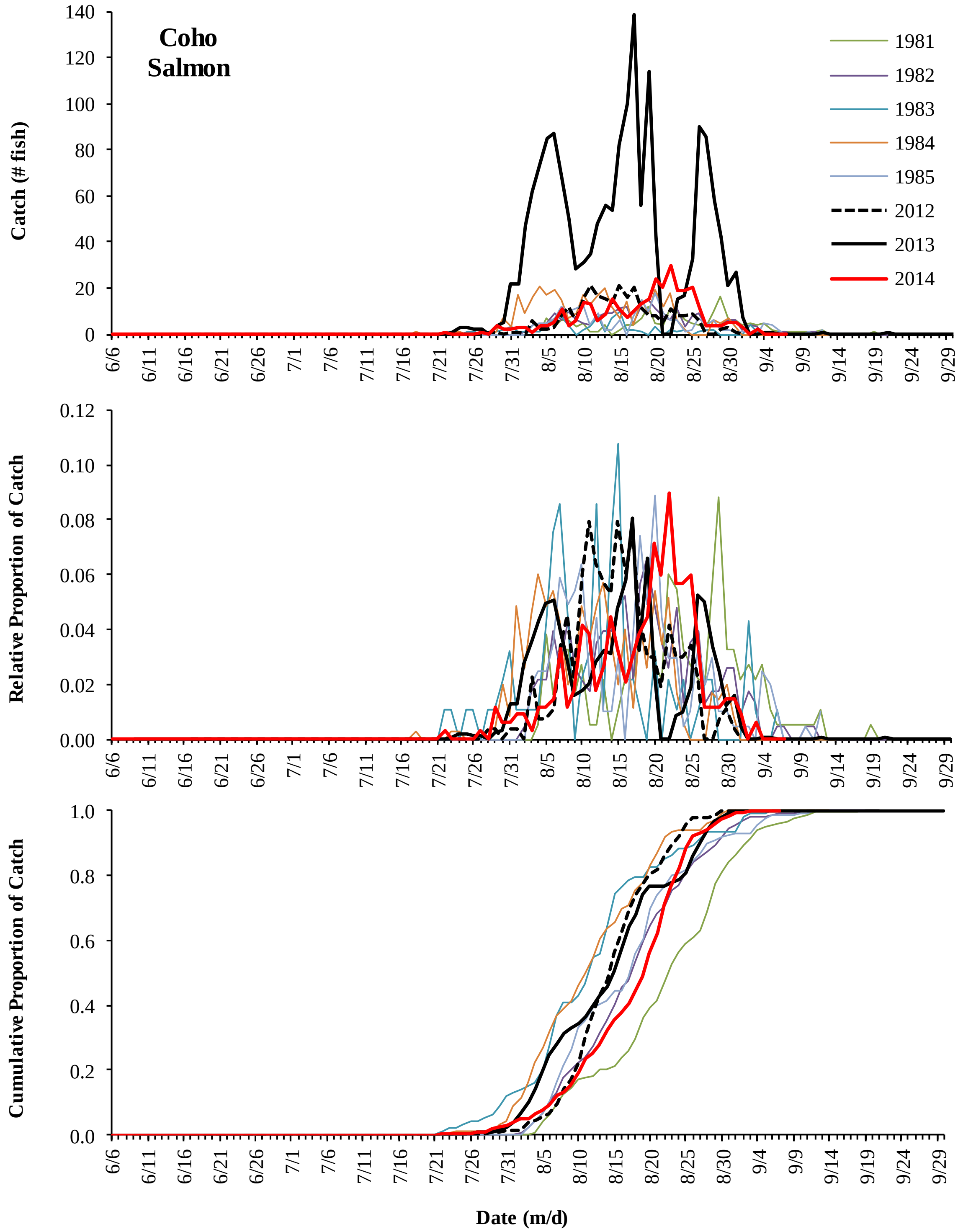

Figure A-15. Comparison of Coho Salmon catches (top panel), relative proportion of catches (middle panel), and cumulative proportion of catches (bottom panel), at the Middle River fishwheels near Curry, by year. These data include adult Coho Salmon of all size categories and catches at two (1981-2012) or three (2013 and 2014) fishwheels.

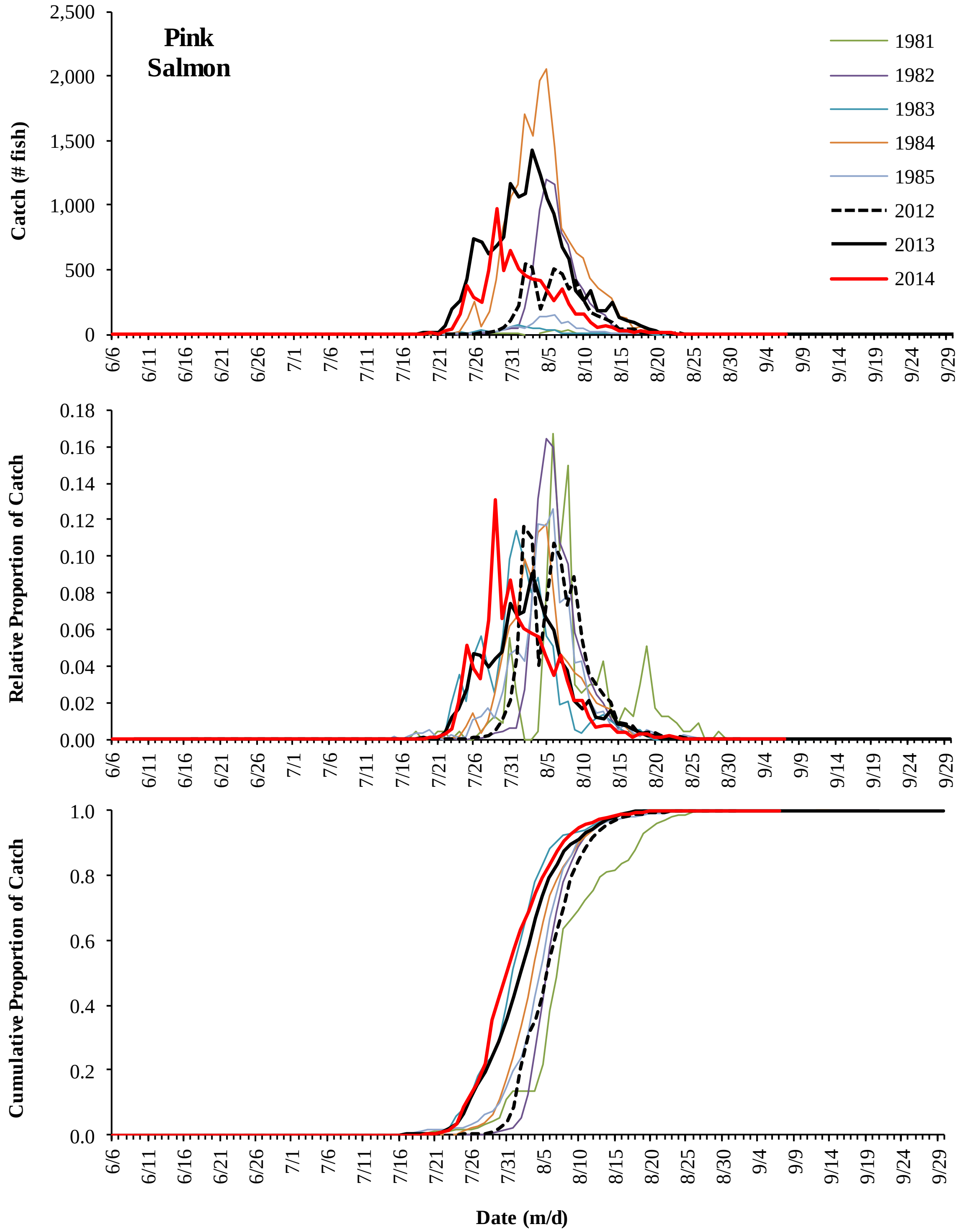

Figure A-16. Comparison of Pink Salmon catches (top panel), relative proportion of catches (middle panel), and cumulative proportion of catches (bottom panel), at the Middle River fishwheels near Curry, by year. These data include adult Pink Salmon of all size categories and catches at two (1981-2012) or three (2013 and 2014) fishwheels.

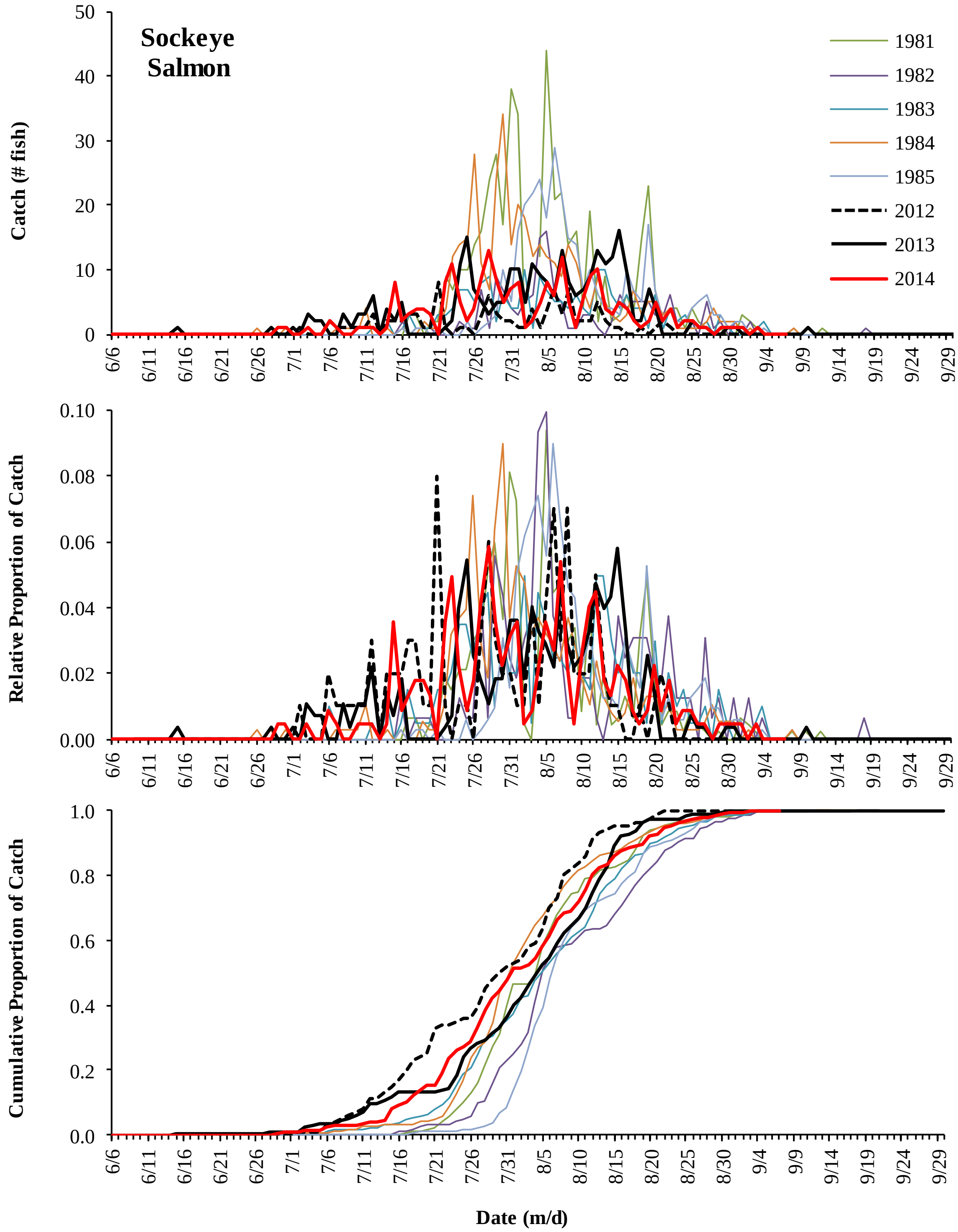

Figure A-17. Comparison of Sockeye Salmon catches (top panel), relative proportion of catches (middle panel), and cumulative proportion of catches (bottom panel), at the Middle River fishwheels near Curry, by year. These data include adult Sockeye Salmon of all size categories and catches at two (1981-2012) or three (2013 and 2014) fishwheels.

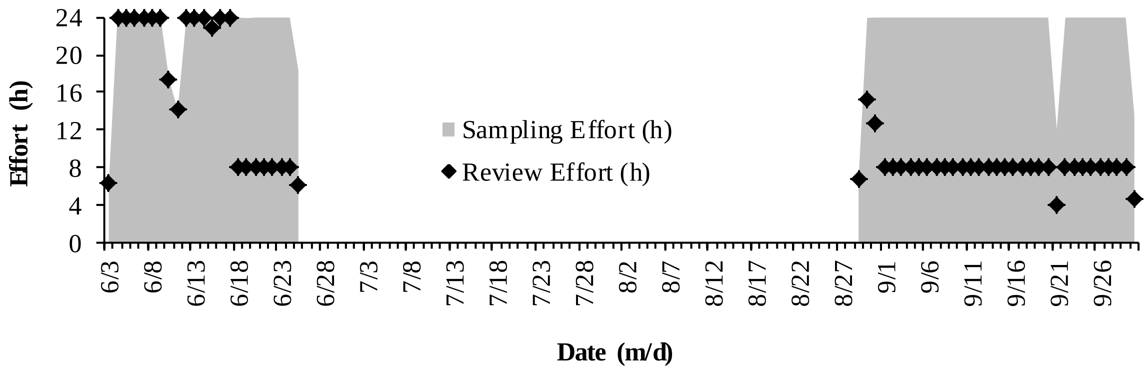

Figure A-18. Daily sampling effort, and the amount of imagery reviewed (review effort), for an ARIS sonar unit operated immediately downstream of the fishwheel at Site 1 in the Middle River, 2014.

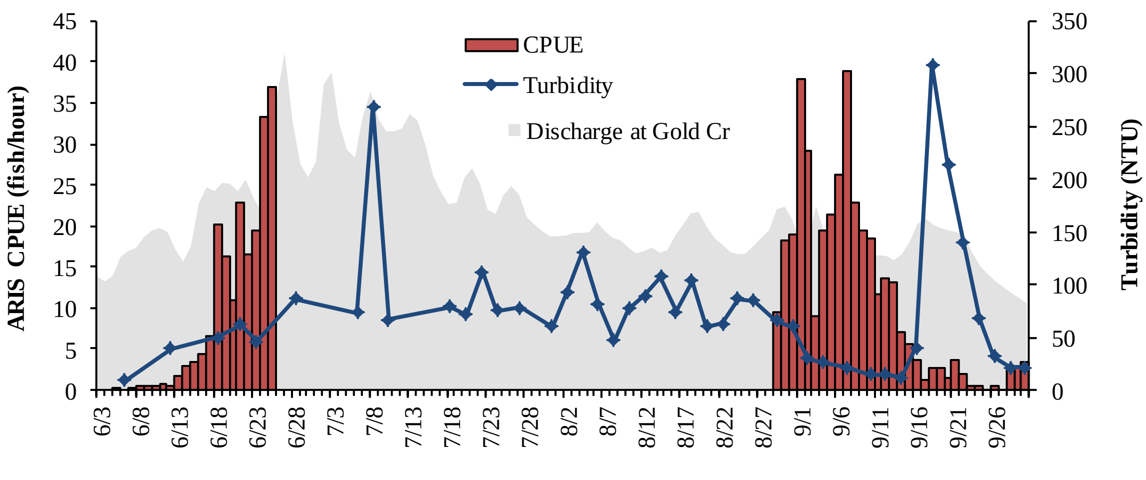

Figure A-19. Catch-per-unit-effort, or the number of targets counted per hour of imagery reviewed, on the ARIS unit located immediately downstream of the Site 1 fishwheel, 2014. ARIS data were included, regardless of whether the Site 1 fishwheel was operational. Imagery collected after June 17 was subsampled and the counts were expanded to full hourly counts. From June 3 to June 25, targets measuring 50 cm or greater were included; whereas from August 29 to September 30, targets measuring 40 cm or greater were included. Data on two days when CPUE was less than zero were excluded (-0.8 fish/hour on September 25 and -1.1 fish/hour on September 27). Turbidity measurements recorded at Site 1 and an overlay of Susitna River discharge at the Gold Creek gauge are also shown.

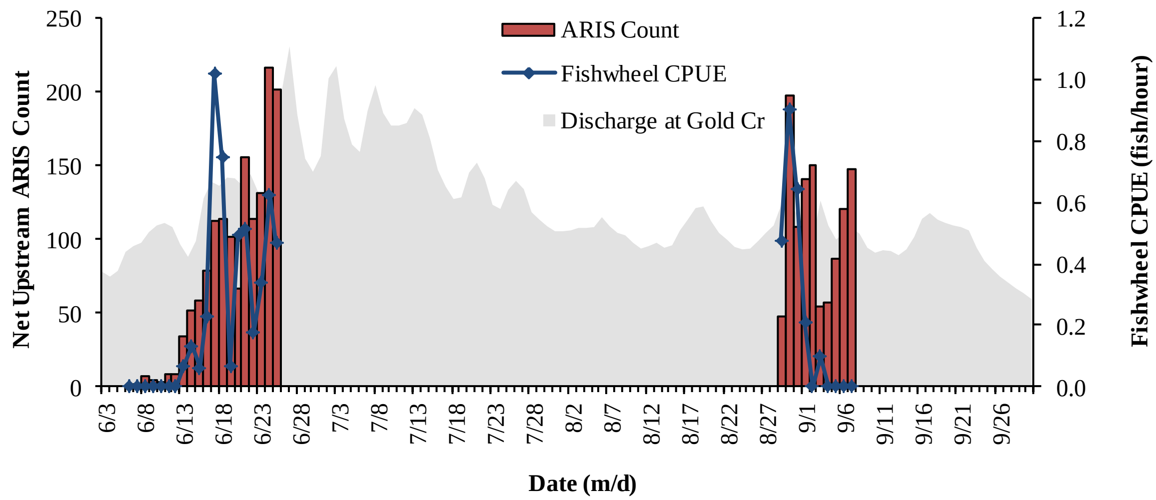

Figure A-20. Comparison of the catch-per-unit-effort of adult salmon at the Site 1 fishwheel and concurrent net upstream counts of fish on the ARIS unit located immediately downstream of the fishwheel, 2014. Imagery collected after June 17 was subsampled and the counts were expanded to full hourly counts. From June 3 to June 25, targets measuring 50 cm or greater were included; whereas from August 29 to September 30, targets measuring 40 cm or greater were included. An overlay of Susitna River discharge at the Gold Creek gauge is also shown.

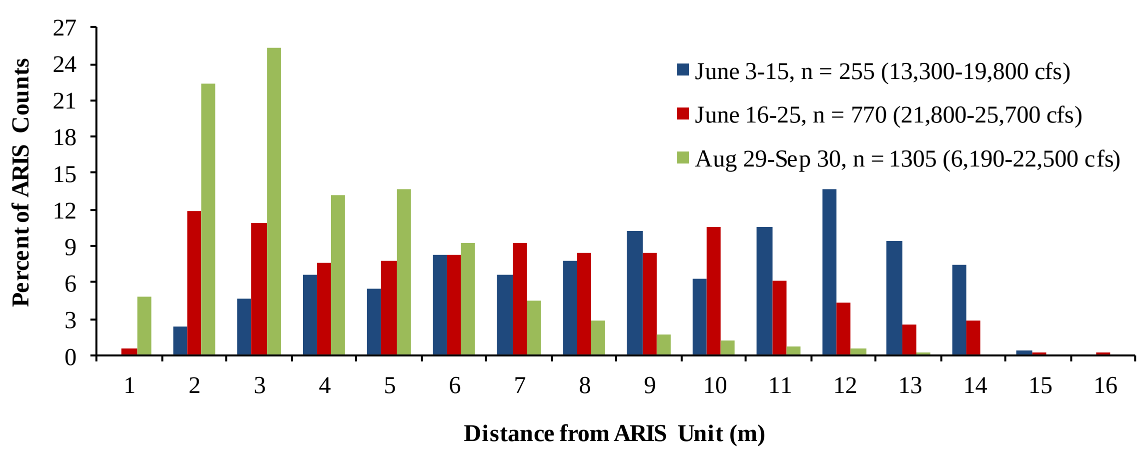

Figure A-21. Relative percentage of fish counted using ARIS at Site 1 as a function of the distance where they were first detected in the field of view, by time period, 2014. From June 3 to June 25, targets measuring 50 cm or greater were included; whereas from August 29 to September 30, targets measuring 40 cm or greater were included. Discharges (cfs) refer to the Susitna River at the Gold Creek gauge.

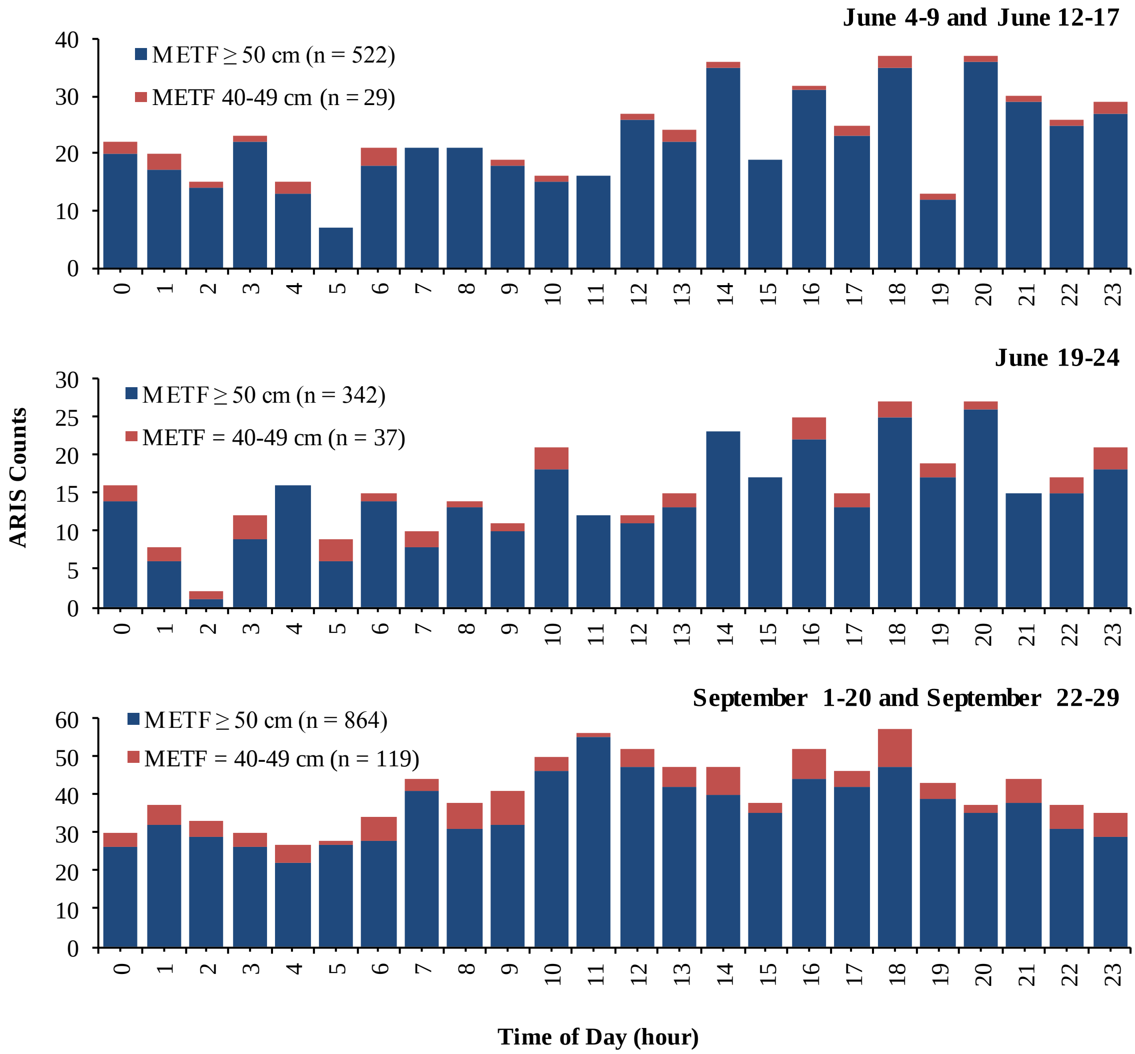

Figure A-22. Diel migration of upstream-moving fish counted using ARIS at Site 1, by size category and time period, 2014. Top panel: 24 hours of imagery collected, all imagery reviewed. Middle panel: 24 hours of imagery collected, 8 hours of imagery reviewed each day. Chinook Salmon were the main species being captured at the Site 1 fishwheel through late June. Bottom panel: 24 hours of imagery collected, 8 hours of imagery reviewed each day. Chum and Coho salmon were presumably the predominant species migrating through the Middle River in September.

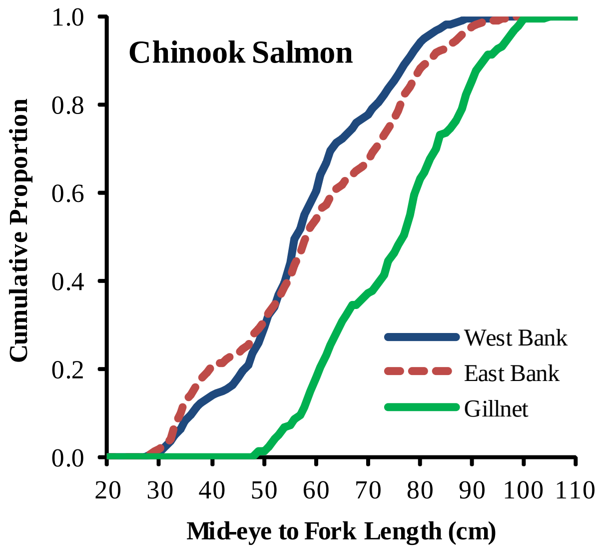

Figure A-23. Cumulative length-frequency distributions for Chinook Salmon captured in the Lower River, by capture site, 2014.

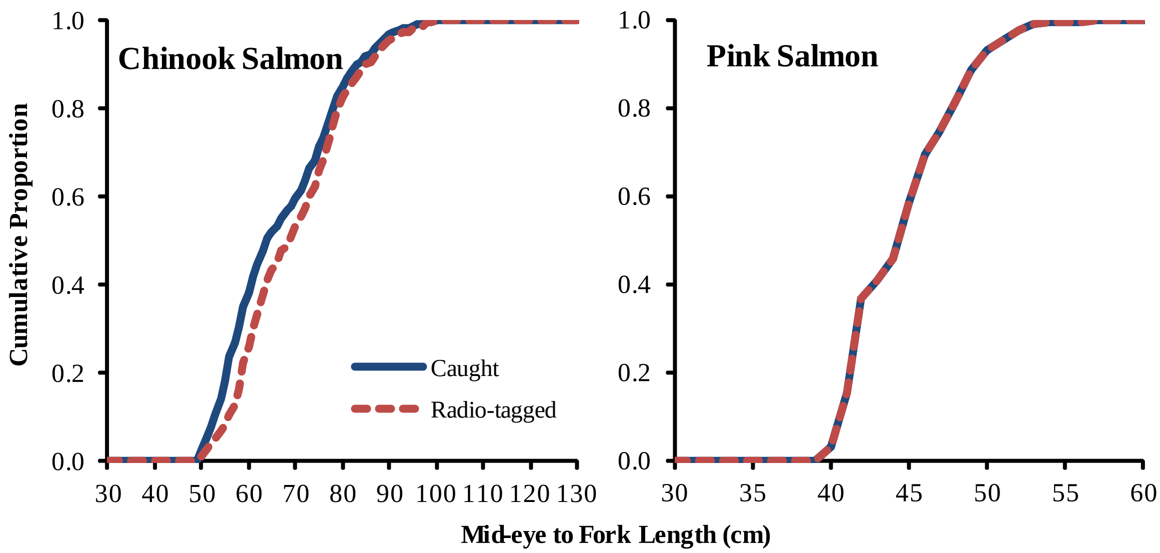

Figure A-24. Cumulative length-frequency distributions for Chinook and Pink salmon caught and radio-tagged in the Lower River, by species, 2014.

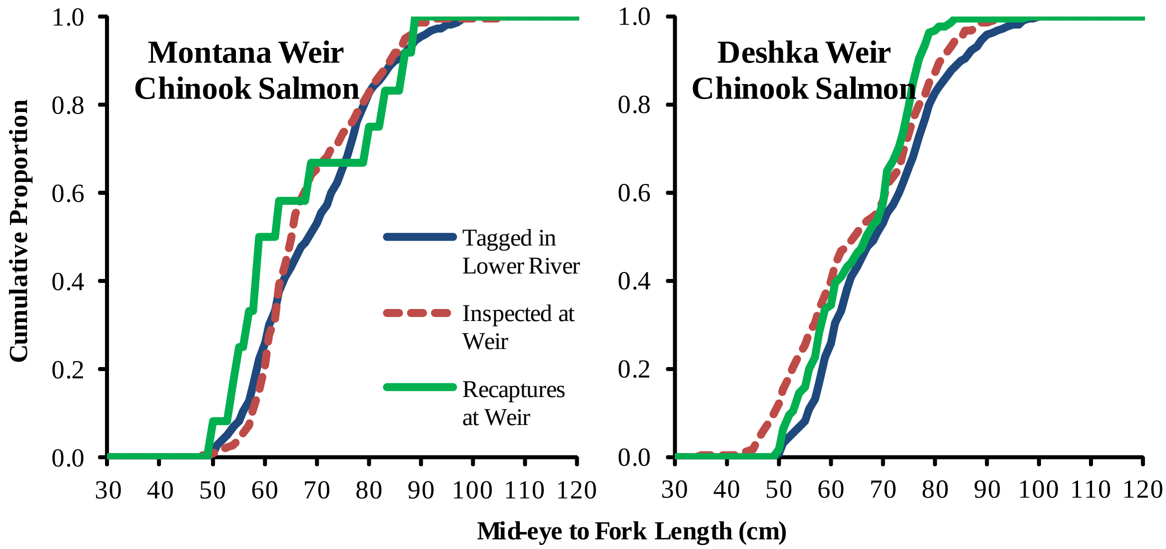

Figure A-25. Cumulative length-frequency distributions for Chinook Salmon radio-tagged in the Lower River and inspected and recaptured at the Deshka River and Montana Creek weir sites, 2014.

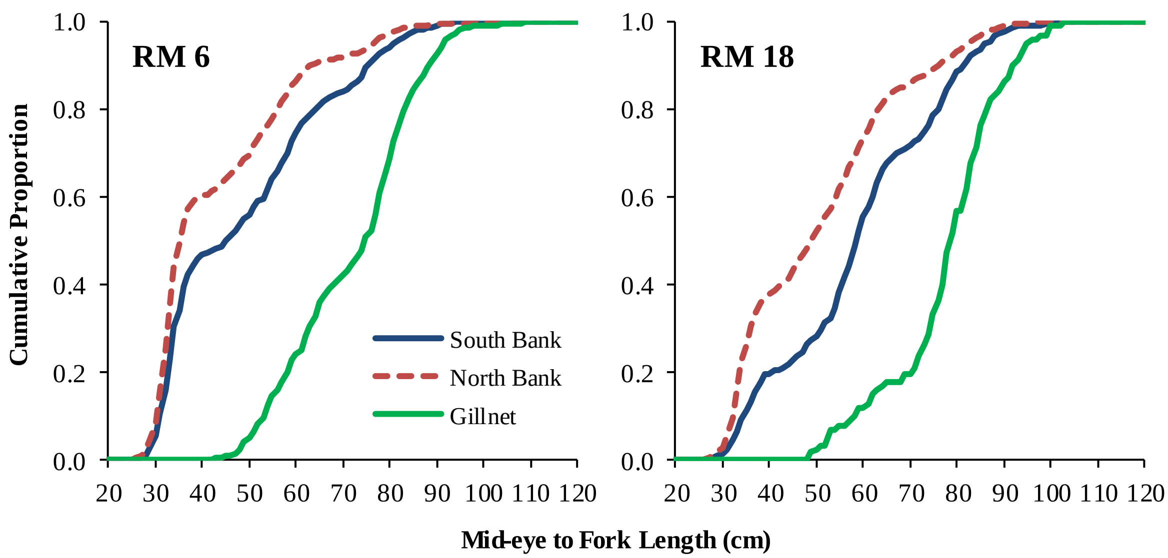

Figure A-26. Cumulative length-frequency distributions for Chinook Salmon captured at RM 6 (left panel) and RM 18 (right panel) in the Yentna River, 2014.

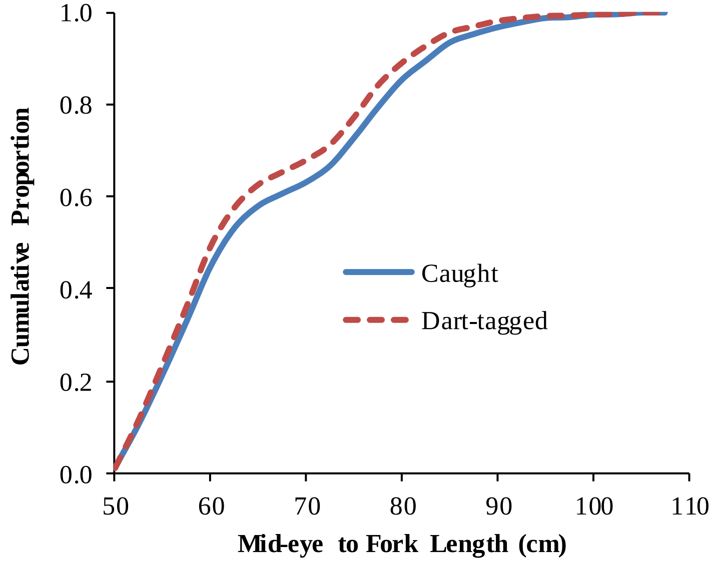

Figure A-27. Cumulative length-frequency distributions for Chinook Salmon measuring 50 cm METF or greater that were caught and dart-tagged in the Yentna River (RM 6), 2014.

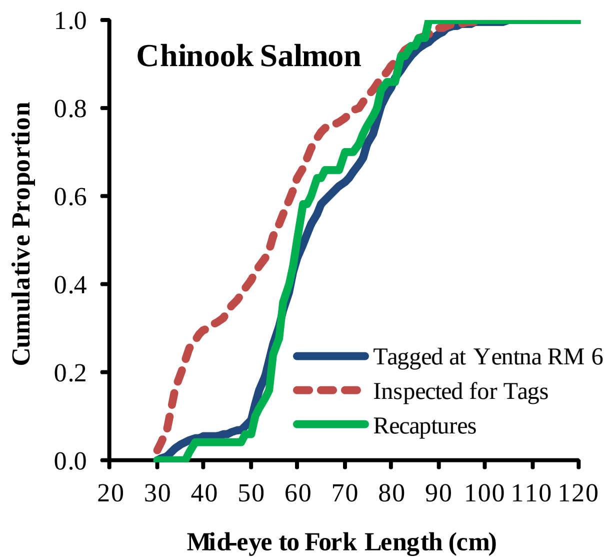

Figure A-28. Cumulative length-frequency distributions for Chinook Salmon dart-tagged at Yentna RM 6 and inspected and recaptured at Yentna RM 18 (fishwheels and gillnets combined), 2014.

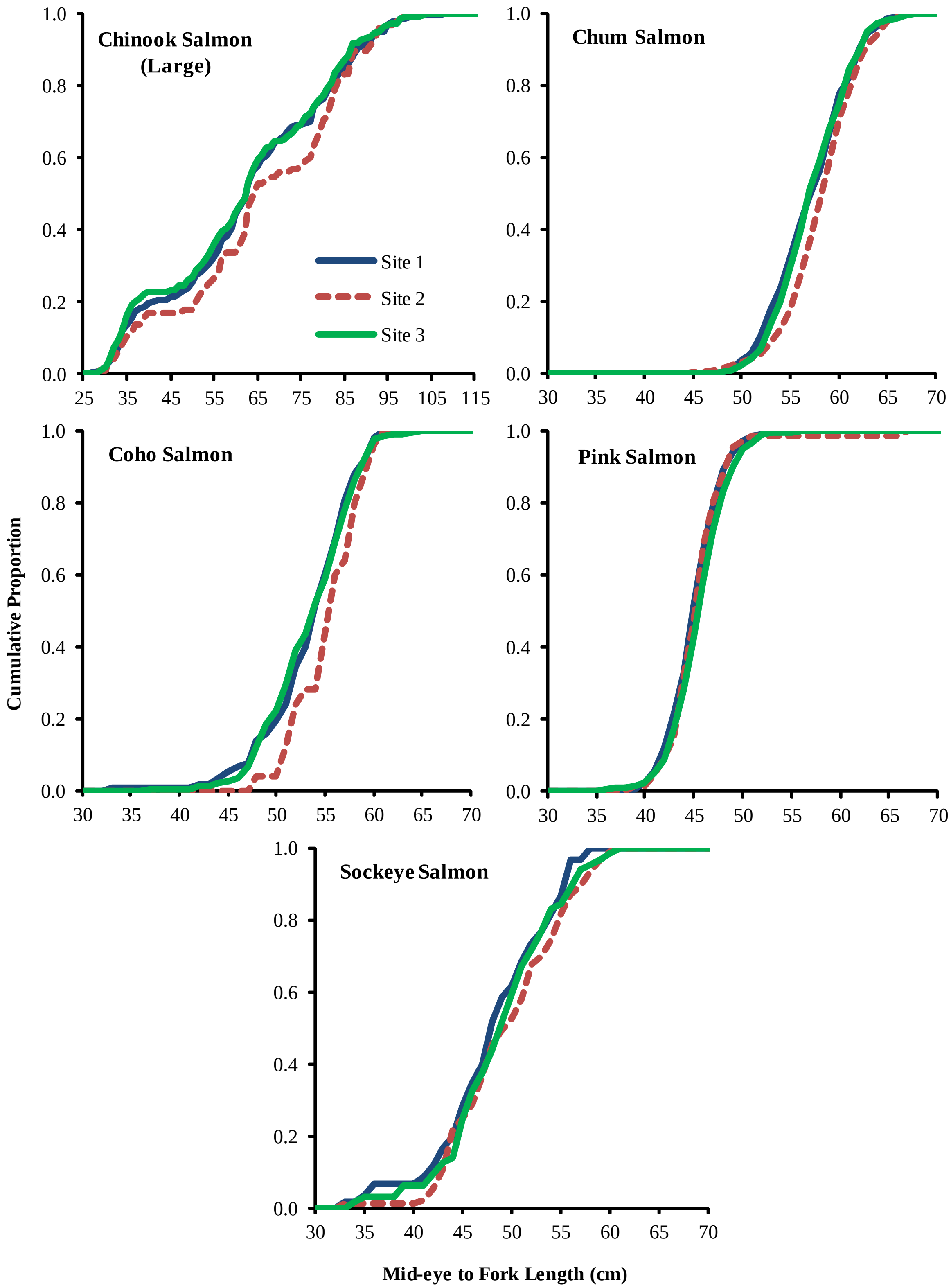

Figure A-29. Cumulative length-frequency distributions for salmon captured in the Middle River fishwheels, by species and capture site, 2014.

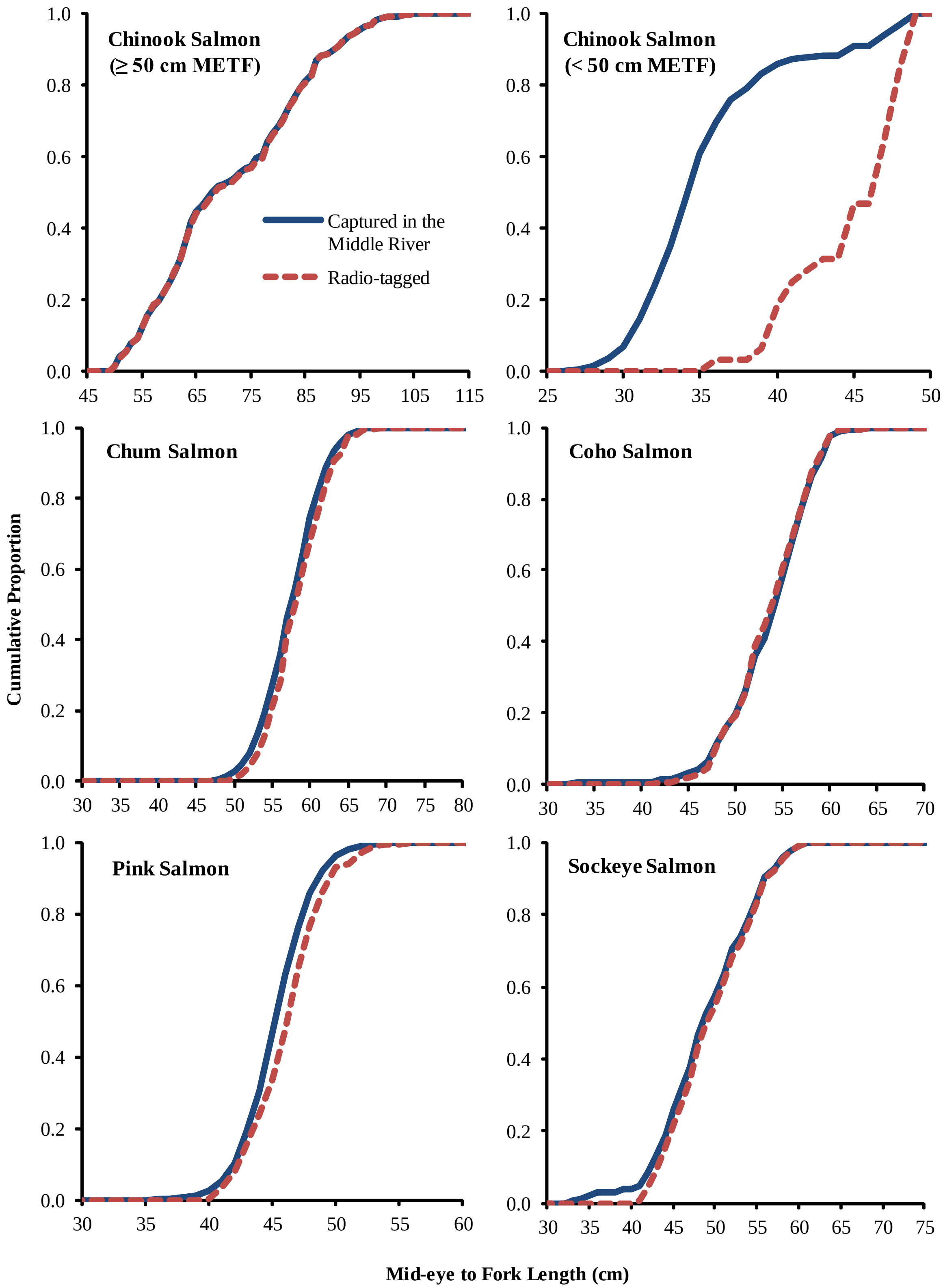

Figure A-30. Cumulative length-frequency distributions for salmon caught and radio-tagged in the Middle River, by species, 2014.

Appendix B: Daily fish passage at weir and sonar sites in the Lower and Middle rivers

Table B-1. Deshka River weir daily passage rates and tag recaptures, by species, 2014.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
19-May	2	2	0	0		0	0	0	0	0	
20-May	3	5	0	0		0	0	0	0	0	0
21-May	4	9	0	0		0	0	0	0	0	0
22-May	10	19	0	0		0	0	0	0	0	0
23-May	8	27	1	0		0	0	0	0	0	0
24-May	9	36	1	0		0	0	0	0	0	0
25-May	15	51	0	0		0	0	0	0	0	0
26-May	25	76	0	0		0	0	0	0	0	0
27-May	6	82	2	0		0	0	0	0	0	0
28-May	7	89	0	0		0	0	0	0	0	0
29-May	93	182	1	0	0	0	0	0	0	0	0
30-May	14	196	4	0	0	0	0	0	0	0	0
31-May	39	235	3	0	0	0	0	0	0	0	0
01-Jun	13	248	4	0	0	0	0	0	0	0	0
02-Jun	166	414	6	0	0	0	0	0	0	0	0
03-Jun	214	628	9	0	0	0	0	0	0	0	0
04-Jun	86	714	8	0	0	0	0	0	0	0	0
05-Jun	454	1,168	8	0	0	0	0	0	0	0	0
06-Jun	735	1,903	10	0	0	0	0	0	0	0	0
07-Jun	715	2,618	5	0	0	0	0	0	0	0	0
08-Jun	608	3,226	6	0	0	0	0	0	0	0	0
09-Jun	1,065	4,291	5	0	0	0	0	0	0	0	0
10-Jun	2,279	6,570	8	0	0	0	0	0	0	0	0
11-Jun	1,463	8,033	7	0	0	0	0	0	0	0	0
12-Jun	1,033	9,066	5	0	0	0	0	0	0	0	0
13-Jun	994	10,060	8	0	0	0	0	0	0	0	0
14-Jun	666	10,726	1	0	0	0	0	0	0	0	0
15-Jun	758	11,484	0	0	0	0	0	0	0	0	0
16-Jun	955	12,439	4	0	0	0	0	0	0	0	0
17-Jun	712	13,151	3	0	0	0	0	0	0	0	0
18-Jun	455	13,606	5	0	0	0	0	0	0	0	0

Table B-1. Continued.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
19-Jun	320	13,926	1	0	0	0	0	0	0	0	0
20-Jun	432	14,358	1	0	0	0	0	0	0	0	0
21-Jun	278	14,636	5	0	0	0	0	0	0	0	0
22-Jun	206	14,842	1	0	0	0	0	0	0	0	0
23-Jun	556	15,398	0	0	0	0	0	0	0	0	0
24-Jun	92	15,490	2	0	0	0	0	0	0	0	0
25-Jun	163	15,653	0	0	0	0	0	0	0	0	0
26-Jun	94	15,747	0	0	0	0	0	0	0	0	0
27-Jun	14	15,761	0	0	0	0	0	0	0	0	0
28-Jun	0	15,761	0	0	0	0	0	0	0	0	0
29-Jun	0	15,761	1	0	0	0	0	0	0	0	0
30-Jun	10	15,771	0	0	0	0	0	0	0	0	0
01-Jul	36	15,807	0	0	0	0	0	0	0	0	0
02-Jul	37	15,844	0	0	0	0	0	0	0	0	0
03-Jul	101	15,945	0	0	0	0	0	0	0	0	0
04-Jul	11	15,956	0	5	5	1	1	0	0	0	0
05-Jul	43	15,999	0	2	7	0	1	0	0	0	0
06-Jul	18	16,017	0	0	7	9	10	0	0	0	0
07-Jul	15	16,032	0	2	9	21	31	0	0	0	0
08-Jul	11	16,043	0	4	13	12	43	0	0	0	0
09-Jul	10	16,053	0	0	13	6	49	0	0	0	0
10-Jul	33	16,086	0	3	16	26	75	2	2	0	0
11-Jul	28	16,114	0	11	27	68	143	0	2	0	0
12-Jul	19	16,133	0	16	43	207	350	1	3	1	1
13-Jul	29	16,162	0	18	61	156	506	0	3	0	1
14-Jul	4	16,166	0	9	70	172	678	1	4	0	1
15-Jul	11	16,177	0	23	93	564	1,242	2	6	0	1
16-Jul	11	16,188	0	36	129	3,012	4,254	7	13	6	7
17-Jul	13	16,201	0	11	140	3,100	7,354	13	26	0	7
18-Jul	10	16,211	0	34	174	6,466	13,820	5	31	0	7
19-Jul	4	16,215	0	85	259	10,630	24,450	4	35	0	7

Table B-1. Continued.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
20-Jul	2	16,217	0	88	347	4,350	28,800	1	36	0	7
21-Jul	12	16,229	0	132	479	11,144	39,944	5	41	4	11
22-Jul	3	16,232	0	82	561	3,351	43,295	2	43	0	11
23-Jul	7	16,239	0	155	716	10,275	53,570	2	45	0	11
24-Jul	0	16,239	0	139	855	7,837	61,407	4	49	2	13
25-Jul	2	16,241	0	136	991	3,686	65,093	2	51	3	16
26-Jul	3	16,244	0	487	1,478	3,367	68,460	3	54	1	17
27-Jul	3	16,247	0	296	1,774	2,976	71,436	2	56	1	18
28-Jul	1	16,248	0	79	1,853	1,610	73,046	1	57	0	18
29-Jul	0	16,248	0	58	1,911	731	73,777	1	58	1	19
30-Jul	2	16,250	0	412	2,323	1,650	75,427	3	61	0	19
31-Jul	2	16,252	0	123	2,446	642	76,069	4	65	0	19
01-Aug	0	16,252	0	19	2,465	107	76,176	1	66	0	19
02-Aug	0	16,252	0	80	2,545	482	76,658	1	67	0	19
03-Aug	2	16,254	0	65	2,610	240	76,898	0	67	0	19
04-Aug	5	16,259	0	12	2,622	144	77,042	9	76	0	19
05-Aug	2	16,261	0	152	2,774	194	77,236	5	81	2	21
06-Aug	1	16,262	0	308	3,082	192	77,428	0	81	0	21
07-Aug	2	16,264	0	262	3,344	152	77,580	1	82	1	22
08-Aug	1	16,265	0	364	3,708	134	77,714	3	85	0	22
09-Aug	3	16,268	0	385	4,093	79	77,793	1	86	0	22
10-Aug	0	16,268	0	376	4,469	73	77,866	0	86	0	22
11-Aug	2	16,270	0	418	4,887	31	77,897	2	88	2	24
12-Aug	3	16,273	0	177	5,064	15	77,912	0	88	1	25
13-Aug	3	16,276	0	210	5,274	14	77,926	0	88	0	25
14-Aug	6	16,282	0	179	5,453	41	77,967	2	90	0	25
15-Aug	5	16,287	0	265	5,718	19	77,986	3	93	0	25
16-Aug	5	16,292	0	380	6,098	17	78,003	2	95	0	25
17-Aug	7	16,299	0	2,810	8,908	34	78,037	5	100	0	25
18-Aug	7	16,306	0	153	9,061	11	78,048	4	104	0	25
19-Aug	8	16,314	0	184	9,245	19	78,067	2	106	0	25

Table B-1. Continued.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
20-Aug	1	16,315	0	128	9,373	12	78,079	0	106	0	25
21-Aug	5	16,320	0	103	9,476	3	78,082	1	107	0	25
22-Aug	1	16,321	0	130	9,606	2	78,084	0	107	0	25
23-Aug	0	16,321	0	137	9,743	3	78,087	0	107	0	25
24-Aug	0	16,321	0	102	9,845	1	78,088	1	108	0	25
25-Aug	2	16,323	0	142	9,987	2	78,090	1	109	1	26
26-Aug	0	16,323	0	159	10,146	1	78,091	0	109	0	26
27-Aug	2	16,325	0	284	10,430	3	78,094	1	110	0	26
28-Aug	5	16,330	0	418	10,848	8	78,102	0	110	0	26
29-Aug	0	16,330	0	649	11,497	9	78,111	0	110	0	26
30-Aug	0	16,330	0	0	11,497	0	78,111	0	110	0	26
31-Aug	2	16,332	0	28	11,525	0	78,111	0	110	0	26
01-Sep	3	16,335	0	31	11,556	0	78,111	0	110	0	26
02-Sep	0	16,335	0	22	11,578	0	78,111	0	110	0	26
Total	16,335		125	11,578		78,111		110		26	

Table B-2. Montana Creek weir daily passage rates and tag recaptures, by species, 2014.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Comment
29-May			1							
30-May			0							
31-May			0							
01-Jun			1							
02-Jun			0							
03-Jun			0							
04-Jun	0	0	0	0	0	0	0	0	0	Weir installed 6/4
05-Jun	0	0	1	0	0	0	0	0	0	
06-Jun	0	0	0	0	0	0	0	0	0	
07-Jun	0	0	1	0	0	0	0	0	0	
08-Jun	0	0	1	0	0	0	0	0	0	
09-Jun	0	0	2	0	0	0	0	0	0	
10-Jun	0	0	2	0	0	0	0	0	0	
11-Jun	0	0	0	0	0	0	0	0	0	
12-Jun	0	0	1	0	0	0	0	0	0	
13-Jun	0	0	0	0	0	0	0	0	0	
14-Jun	0	0	0	0	0	0	0	0	0	
15-Jun	0	0	2	0	0	0	0	0	0	
16-Jun	0	0	0	0	0	0	0	0	0	
17-Jun	0	0	2	0	0	0	0	0	0	
18-Jun	0	0	0	0	0	0	0	0	0	
19-Jun	0	0	0	0	0	0	0	0	0	
20-Jun	0	0	0	0	0	0	0	0	0	
21-Jun	0	0	0	0	0	0	0	0	0	
22-Jun	0	1	0	0	0	0	0	0	0	
23-Jun	1	1	0	0	0	0	0	0	0	
24-Jun	0	4	0	0	0	0	0	0	0	
25-Jun	3	4	0	0	0	0	0	0	0	
26-Jun	0	4	1	0	0	0	0	0	0	Weir topped
27-Jun	0	4	0	0	0	0	0	0	0	Weir topped
28-Jun	0	4	0	0	0	0	0	0	0	Weir topped

Table B-2. Continued.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Comment
29-Jun	0	4	0	0	0	0	0	0	0	Weir topped
30-Jun	0	4	0	0	0	0	0	0	0	Weir topped
01-Jul	0	11	0	0	0	0	0	0	0	
02-Jul	7	25	0	0	0	0	0	0	0	
03-Jul	14	57	0	0	0	0	0	0	0	
04-Jul	32	85	0	0	0	0	0	0	0	
05-Jul	28	119	0	0	0	0	0	0	0	
06-Jul	34	253	0	0	0	0	0	0	0	
07-Jul	134	320	0	0	0	0	0	1	1	
08-Jul	67	324	0	0	0	0	0	0	1	
09-Jul	4	403	0	0	0	0	0	0	1	
10-Jul	79	455	0	0	0	0	0	2	3	
11-Jul	52	477	0	0	0	0	0	10	13	
12-Jul	22	493	0	0	0	0	0	1	14	
13-Jul	16	545	0	0	0	0	0	2	16	
14-Jul	52	594	0	0	0	0	0	9	25	
15-Jul	49	2	0	0	0	0	0	3	28	
16-Jul	12	615	0	0	0	0	0	4	32	
17-Jul	9	645	0	0	0	0	0	12	44	
18-Jul	30	647	0	0	0	0	0	9	53	
19-Jul	2	768	0	0	0	0	0	8	61	
20-Jul	121	797	0	0	0	0	0	28	89	
21-Jul	29	823	0	0	0	1	1	6	95	
22-Jul	26	900	0	0	0	0	1	16	111	
23-Jul	77	905	0	0	0	2	3	45	156	
24-Jul	5	997	0	0	0	8	11	43	199	
25-Jul	92	1,031	0	0	0	118	129	161	360	
26-Jul	34	1,033	0	0	0	34	163	74	434	
27-Jul	2	1,040	0	0	0	17	180	15	449	
28-Jul	7	1,071	0	0	0	23	203	59	508	
29-Jul	31	1,120	0	0	0	36	239	121	629	

Table B-2. Continued.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Comment
30-Jul	49	1,129	0	0	0	28	267	71	700	
31-Jul	9	1,134	0	0	0	34	301	89	789	
01-Aug	5	1,139	0	0	0	64	365	159	948	
02-Aug	5	1,146	0	0	0	69	434	189	1,137	
03-Aug	7	1,159	0	2	2	46	480	202	1,339	
04-Aug	13	1,172	0	0	2	68	548	372	1,711	
05-Aug	13	1,177	0	0	2	91	639	357	2,068	
06-Aug	5	1,188	0	1	3	70	709	152	2,220	
07-Aug	11	1,192	0	3	6	59	768	239	2,459	
08-Aug	4	1,193	0	0	6	49	817	97	2,556	
09-Aug	1	1,193	0	1	7	67	884	171	2,727	
10-Aug	0	1,196	0	2	9	37	921	127	2,854	
11-Aug	3	1,199	0	3	12	42	963	179	3,033	
12-Aug	3	1,200	0	7	19	49	1,012	140	3,173	
13-Aug	1	1,201	0	3	22	35	1,047	227	3,400	
14-Aug	1	1,203	0	7	29	29	1,076	196	3,596	
15-Aug	2	1,204	0	21	50	57	1,133	524	4,120	
16-Aug	1	1,205	0	5	55	12	1,145	90	4,210	
17-Aug	1	1,207	0	6	61	17	1,162	60	4,270	
18-Aug	2	1,208	0	2	63	21	1,183	66	4,336	
19-Aug	1	1,208	0	6	69	12	1,195	114	4,450	
20-Aug	0	1,208	0	3	72	8	1,203	90	4,540	
21-Aug	0	1,208	0	6	78	4	1,207	111	4,651	
22-Aug	0	1,208	0	4	82	10	1,217	134	4,785	
23-Aug	0	1,208	0	1	83	3	1,220	149	4,934	
24-Aug	0	1,211	0	3	86	3	1,223	135	5,069	
25-Aug	3	1,213	0	32	118	9	1,232	249	5,318	
26-Aug	2	1,215	0	5	123	4	1,236	92	5,410	
27-Aug	2	1,215	0	52	175	6	1,242	134	5,544	Weir partially topped
28-Aug	0	1,215	0	87	262	2	1,244	112	5,656	Weir topped
29-Aug	0	1,215	0	1	263	0	1,244	3	5,659	Weir partially topped

Table B-2. Continued.

	Chinook Salmon			Coho Salmon		Pink Salmon		Chum Salmon		
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count	Comment
30-Aug	0	1,215	0	3	266	1	1,245	11	5,670	Weir topped
31-Aug	0	1,215	0	4	270	0	1,245	40	5,710	Weir topped until 15:30
01-Sep	0	1,215	0	2	272	8	1,253	50	5,760	
02-Sep	0	1,215	0	26	298	3	1,256	97	5,857	
03-Sep	0	1,215	0	62	360	6	1,262	71	5,928	
04-Sep	0	1,215	0	9	369	0	1,262	38	5,966	
05-Sep	0	1,215	0	46	415	3	1,265	69	6,035	
06-Sep	0	1,215	0	59	474	1	1,266	110	6,145	
07-Sep	0	1,215	0	12	486	0	1,266	46	6,191	
08-Sep	0	1,215	0	8	494	2	1,268	45	6,236	
09-Sep	0	1,215	0	16	510	0	1,268	60	6,296	
10-Sep	0	1,217	0	113	623	1	1,269	40	6,336	
11-Sep	2	1,217	0	82	705	1	1,270	48	6,384	
12-Sep	0	1,217	0	12	717	0	1,270	18	6,402	
13-Sep	0	1,217	0	41	758	0	1,270	17	6,419	
14-Sep	0	1,217	0	45	803	0	1,270	25	6,444	
15-Sep	0	1,217	0	31	834	0	1,270	17	6,461	
16-Sep	0	1,217	0	23	857	0	1,270	15	6,476	
17-Sep	0	1,217	0	16	873	0	1,270	15	6,491	
18-Sep	0	1,217	0	32	905	0	1,270	12	6,503	
19-Sep	0	1,217	0	25	930	0	1,270	5	6,508	Weir partially topped
20-Sep	0	1,217	0	0	930	0	1,270	0	6,508	
21-Sep	0	1,217	0	4	934	0	1,270	3	6,511	
Total	1,217		15	934		1,270		6,511		

Table B-3. Length statistics for tagged and untagged adult salmon sampled at the Deshka River and Montana Creek weirs, by species, 2014.

	Deshka River Weir			Montana Creek Weir		
Species	Tagged	Not Tagged	Total	Tagged	Not Tagged	Total
Chinook Salmon (≥ 50 cm METF)						
Min	50.0	50.0	50.0	50.0	51.0	50.0
Max	98.0	94.5	98.0	88.5	107.0	107.0
Mean	66.1	68.8	67.9	66.4	69.1	68.7
n	125	251	376	15	226	241
Chinook Salmon (< 50 cm METF)						
Min	-	34.5	34.5	-	48.0	48.0
Max	-	49.5	49.5	-	48.0	48.0
Mean	-	46.8	46.8	-	-	-
n	-	45	45	-	1	1
Coho Salmon (≥ 40 cm METF)						
Min	40.0	44.0	40.0	52.0	40.0	40.0
Max	61.0	64.5	64.5	58.5	64.0	64.0
Mean	54.4	56.2	55.8	55.1	56.6	56.6
n	68	304	372	4	213	217

Table B-4. Daily amount of video imagery collected and reviewed at the Indian River weir, and the net upstream count of fish, by species, 2014.

			Net Upstream Count	
Date	Sample Effort (h)	Review Effort (h)	Rainbow Trout	Round Whitefish
22-Jun	10.5	10.5	0	0
23-Jun	24.0	24.0	0	1
24-Jun	24.0	24.0	1	0
25-Jun	24.0	24.0	2	1
26-Jun	6.5	1.3	0	0
Total	89.0	83.8	3	2

Table B-5. Daily number of Chinook Salmon inspected for tags, and the number of dart-tag recaptures, at RM 18 sites on the Yentna River, 2014.

Date	Daily Count	Cum. Count	Dart Tags	Cum. Tags
24-May	3	3	0	0
25-May	9	12	0	0
26-May	16	28	0	0
27-May	38	66	3	3
28-May	17	83	1	4
29-May	10	93	0	4
30-May	16	109	0	4
31-May	4	113	1	5
01-Jun	6	119	0	5
02-Jun	19	138	1	6
03-Jun	118	256	3	9
04-Jun	149	405	1	10
05-Jun	171	576	3	13
06-Jun	135	711	5	18
07-Jun	114	825	0	18
08-Jun	113	938	5	23
09-Jun	112	1,050	4	27
10-Jun	104	1,154	3	30
11-Jun	94	1,248	2	32
12-Jun	127	1,375	3	35
13-Jun	131	1,506	2	37
14-Jun	99	1,605	5	42
15-Jun	110	1,715	5	47
16-Jun	91	1,806	2	49
17-Jun	48	1,854	2	51
18-Jun	40	1,894	3	54
19-Jun	44	1,938	1	55
20-Jun	66	2,004	1	56
21-Jun	53	2,057	1	57
22-Jun	20	2,077	0	57
23-Jun	23	2,100	0	57
24-Jun	43	2,143	1	58
25-Jun	45	2,188	2	60
26-Jun	16	2,204	0	60
27-Jun	5	2,209	0	60
28-Jun	5	2,214	0	60
29-Jun	4	2,218	0	60
30-Jun	10	2,228	1	61
01-Jul	3	2,231	0	61
02-Jul	5	2,236	0	61
03-Jul	2	2,238	0	61
04-Jul	9	2,247	0	61
05-Jul	6	2,253	0	61
06-Jul	5	2,258	0	61
07-Jul	5	2,263	0	61

Table B-5. Continued.

Date	Daily Count	Cum. Count	Dart Tags	Cum. Tags
09-Jul	0	2,266	0	61
10-Jul	0	2,266	0	61
11-Jul	1	2,267	0	61
12-Jul	1	2,268	0	61
13-Jul	4	2,272	0	61
14-Jul	3	2,275	0	61
15-Jul	2	2,277	0	61
16-Jul	0	2,277	0	61
17-Jul	3	2,280	0	61
18-Jul	0	2,280	0	61
19-Jul	2	2,282	0	61
20-Jul	0	2,282	0	61
21-Jul	1	2,283	0	61
22-Jul	2	2,285	0	61
23-Jul	2	2,287	0	61
24-Jul	2	2,289	0	61
25-Jul	2	2,291	0	61
26-Jul	0	2,291	0	61
27-Jul	1	2,292	0	61
28-Jul	1	2,293	0	61
29-Jul	2	2,295	0	61
30-Jul	3	2,298	0	61
31-Jul	0	2,298	0	61
01-Aug	0	2,298	0	61
02-Aug	0	2,298	0	61
03-Aug	1	2,299	0	61
04-Aug	0	2,299	0	61
05-Aug	0	2,299	0	61
06-Aug	1	2,300	0	61
07-Aug	1	2,301	0	61
08-Aug	1	2,302	0	61
09-Aug	1	2,303	0	61
10-Aug	0	2,303	0	61
11-Aug	0	2,303	0	61
12-Aug	0	2,303	0	61
13-Aug	0	2,303	0	61
14-Aug	0	2,303	0	61
15-Aug	0	2,303	0	61
16-Aug	0	2,303	0	61
17-Aug	1	2,304	0	61
18-Aug	0	2,304	0	61
19-Aug	0	2,304	0	61
20-Aug	0	2,304	0	61
21-Aug	0	2,304	0	61
22-Aug	1	2,305	0	61
Total	2,305		61	

Appendix C: Fixed-station receiver sites (setup and performance) and mobile-tracking survey effort

Table C-1. Location and antenna orientation of fixed-station receivers in the Susitna River drainage, 2014.

Site Location	Receiver No.	Project River Mile	Latitude	Longitude	River Bank	Antenna	Antenna Orientation
Lower Yentna	12		61.66359	-150.62567	Right	1	Downstream Yentna River
						2	Upstream Yentna River
Skwentna	14		61.87268	-151.35259	Right	1	Downstream Skwentna River
						2	Upstream Skwentna River
Upper Yentna	17		62.16243	-151.53392	Left	1	Downstream Yentna River
						2	Upstream Yentna River
Deshka Mouth	8	40	61.69127	-150.30632	Right	1	Downstream Sustina River
						2	Upstream Susitna River
Sunshine	18	83	62.17300	-150.17428	Left	1	Downstream Sustina River
						2	Upstream Susitna River
Talkeetna	9		62.34754	-150.01463	Left	1	Downstream Talkeetna River
						2	Upstream Talkeetna River
Chulitna	29		62.55397	-150.23167	Left	1	Downstream Chulitna River
						2	Upstream Chulitna River
Deshka Weir	20		61.78585	-150.34572	Right	1	Downstream Deshka River
						2	Upstream Deshka River
Montana Creek Weir	27		62.10556	-150.04861	Right	1	Downstream Montana Creek
						2	Upstream Montana Creek
Middle Fork Chulitna Weir	28		63.05900	-149.58222	Left	1	Downstream Middle Fork Chulitna River
						2	Upstream Middle Fork Chulitna River
Lane Creek	5,10	117	62.52792	-150.11407	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Across Susitna River
Gateway	15	130	62.67645	-149.89303	Right	1	Downstream Susitna River
						2	Upstream Susitna River
Indian River	25	142	62.78530	-149.65793	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Up Indian River
Cheechako	40	157	62.80794	-149.25392	Left	1	Downstream Susitna River
						2	Upstream Susitna River
Chinook Creek	45	160	62.80176	-149.16079	Left	1	Downstream Susitna River
						2	Upstream Susitna River

Table C-1. Continued.

Site Location	Receiver No.	Project River Mile	Latitude	Longitude	River Bank	Antenna	Antenna Orientation
Devils Island	50	167	62.80926	-149.00268	Mainstem island	1	Downstream Susitna River
						2	Upstream Susitna River
Watana Dam site	56, 57	187	62.82342	-148.53477	Right	1	Downstream Susitna River
						2	Upstream Susitna River
Watana Creek	59	197	62.82987	-148.25578	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Up Watana Creek
Kosina Creek	60	209	62.78389	-147.93802	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Up Kosina Creek
Oshetna River	65	235	62.63997	-147.38348	Left	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Up Oshetna River

[1] These stations were located primarily on tributaries; river bank orientations are with respect to the tributary not the Susitna River.

Table C-2. Monitoring efficiency (percent operational) of fixed-station receivers in the Lower River Basin in 2014, by week.

Week	Lower Yentna	Upper Yentna	Skwentna River	Deshka Mouth	Deshka Weir	Montana Weir	Sunshine Mouth	Talkeetna Station	Chulitna Station	Middle Chulitna
4/28 - 5/4	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5/5 - 5/11	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5/12 - 5/18	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
5/19 - 5/25	100	nd	nd	100	100	nd	100	nd	nd	nd
5/26 - 6/1	100	100	100	100	100	nd	100	100	nd	nd
6/2 - 6/8	100	100	100	100	100	100	100	100	100	nd
6/9 - 6/15	100	100	100	100	100	100	100	100	100	nd
6/16 - 6/22	100	100	100	100	100	100	100	100	100	100
6/23 - 6/29	100	100	100	100	100	100	100	100	100	100
6/30 - 7/6	100	50	100	100	100	100	100	100	100	100
7/7 - 7/13	100	0	100	100	54	100	100	100	100	100
7/14 - 7/20	100	0	100	100	25	100	100	100	100	100
7/21 - 7/27	100	0	100	100	91	100	100	100	100	100
7/28 - 8/3	100	44	100	100	100	100	100	100	100	100
8/4 - 8/10	100	43	100	100	100	100	100	100	100	100
8/11 - 8/17	100	64	100	100	100	100	100	100	100	nd
8/18 - 8/24	100	13	100	100	100	100	100	100	100	nd
8/25 - 8/31	100	12	nd	100	100	100	100	100	100	nd
9/1 - 9/7	100	7	nd	100	100	100	100	100	100	nd
9/8 - 9/14	100	100	nd	100	nd	100	100	100	100	nd
9/15 - 9/21	100	nd	nd	100	nd	100	100	100	100	nd
9/22 - 9/28	100	nd	nd	100	nd	100	100	100	100	nd
9/29 - 10/5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
10/6 - 10/12	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
10/13 - 10/19	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
10/20 - 10/26	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
10/27 - 11/2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Notes:

Percentages were calculated as the number of hours of recorded receiver activity divided by the number of hours for which it was deployed, summed by week; "nd" = 'not deployed'. Receivers were considered active in a given hour if at least one fish detection, beacon-tag hit, or noise event was recorded during the hour.

Grey: Receiver not scanning; Red: Unknown malfunction.

Table C-3. Monitoring efficiency (percent operational) of fixed-station receivers in the Middle and Upper River basins in 2014, by week.

Week	Lane Station (LR Tags)	Lane Station (MR Tags)	Gateway	Indian River	Cheechako	Chinook	Devils Station	Watana Dam Site	Watana Creek	Kosina Creek	Oshetna Creek
4/28 - 5/4	nd	nd	nd	100	nd	nd	nd	nd	nd	100	nd
5/5 - 5/11	nd	nd	nd	100	nd	nd	nd	nd	nd	100	nd
5/12 - 5/18	nd	nd	nd	100	nd	nd	nd	nd	nd	94	nd
5/19 - 5/25	100	100	nd	100	nd	nd	nd	nd	nd	78	100
5/26 - 6/1	100	100	nd	100	nd	nd	nd	nd	nd	100	100
6/2 - 6/8	99	100	nd	100	nd	nd	nd	nd	nd	100	100
6/9 - 6/15	100	100	100	100	100	100	34	nd	62	100	100
6/16 - 6/22	100	100	100	100	100	100	93	nd	91	100	100
6/23 - 6/29	100	9	100	100	100	100	99	nd	24	100	100
6/30 - 7/6	100	94	58	100	100	100	88	nd	79	100	100
7/7 - 7/13	100	100	100	100	100	100	100	100	100	100	100
7/14 - 7/20	100	100	100	100	100	100	100	100	100	100	100
7/21 - 7/27	100	100	100	100	100	100	100	100	100	100	100
7/28 - 8/3	100	100	100	100	100	100	74	100	100	100	100
8/4 - 8/10	100	100	100	100	100	100	100	100	100	100	100
8/11 - 8/17	100	100	100	100	100	100	100	100	100	100	100
8/18 - 8/24	100	100	100	100	100	100	100	100	100	100	100
8/25 - 8/31	100	100	100	100	100	100	100	100	100	100	100
9/1 - 9/7	100	100	100	100	100	100	100	30	100	100	100
9/8 - 9/14	100	100	100	100	100	100	100	94	100	100	100
9/15 - 9/21	100	100	100	100	100	100	100	100	100	100	100
9/22 - 9/28	100	100	100	100	100	100	100	100	100	100	100
9/29 - 10/5	100	100	nd	100	100	100	100	100	100	100	100
10/6 - 10/12	nd	nd	nd	100	100	nd	100	100	100	100	100
10/13 - 10/19	nd	nd	nd	100	nd	nd	100	100	nd	100	nd
10/20 - 10/26	nd	nd	nd	100	nd	nd	100	nd	nd	nd	nd
10/27 - 11/2	nd	nd	nd	100	nd	nd	100	nd	nd	nd	nd

Notes:

Percentages were calculated as the number of hours of recorded receiver activity divided by the number of hours for which it was deployed, summed by week; "nd" = 'not deployed'.

Receivers were considered active in a given hour if at least one fish detection, beacon-tag hit, or noise event was recorded during the hour.

Two receivers were deployed at Lane Station, one to monitor tags released in the lower river ('LR tags') and one for tags released in the middle river ('MR Tags').

Yellow: Low power/dead battery; Grey: Receiver not scanning; Orange: station damaged by wildlife.

Table C-4. List of the aerial telemetry surveys conducted in 2014, by location, date, and vehicle type (helicopter, fixed-wing).

	PRM		Survey Date (m-d)																						
Zone	From:	To:	6-11	6-12	6-16	6-17	6-18	6-21	6-22	6-24	6-25	6-26	6-28	6-29	7-1	7-2	7-4	7-5	7-7	7-8	7-9	7-10	7-11	7-12	7-13
MOB - Little Susitna River	-	-																							
MOB - Beyond Confluence	-	-																							H
MOB - Confluence - Yentna	3.5	32.4		H		H				F		H		H			H			F					H
MOB - Yentna River	32.4	-		H		H			H	F	F	H		H			H				F				H
MOB - Yentna - Deshka	32.4	45.0		H		H			H	F		H		H			H			F					H
MOB - Deshka River	44.9	-		H		H			H	F		H		H			H				F				H
MOB - Willow and Little Willow cr	52.2	55.6		H		H			H	F		H		H			H			F					H
MOB - Kashwitna River	64.7	-		H		H			H			H		H			H			F					H
MOB - Deshka - Kashwitna	45.0	64.7		H		H			H	F		H		H			H			F					H
MOB - Caswell Creek	67.4	-																							
MOB - Sheep Creek	70.1	-				H			H			H					H			F					H
MOB - Goose Creek	76.9	-																		F					H
MOB - Kashwitna - Montana	64.7	80.7		H		H			H	F		H		H			H			F					H
MOB - Montana Creek	80.9	-		H		H			H			H		H			H			F					H
MOB - Montana - Sunshine	80.7	88.5		H		H			H	F		H		H			H			F					H
MOB - Sunshine Creek	88.1	-		H		H						H													H
MOB - Rabideux Creek	87.4	-		H		H			H			H		H			H								H
MOB - Birch Creek	93.5	-																							
MOB - Talkeetna River	101.0	-		H		H			H	F	H			H				H	H	F					H
MOB - Chulitna River	101.7	-		H					H	F	H			H				H	H	F					H
MOB - Sunshine - Talkeetna	88.5	102.3		H		H			H	F	H			H		H		H	H	F					H
MOB - Talkeetna - Lane	102.3	116.7		H		H		H			H		H			H		H	H				H		H
MOB - Whiskers Creek	104.8	-		H				H			H		H			H		H	H				H		H
MOB - Trib off zone 95	110.5	-																							
MOB - Lane - Gateway	116.7	130.1		H		H		H			H		H			H		H	H			H	H		H
MOB - Lane Creek	117.1	-				H		H					H					H	H				H		
MOB - 5th of July Creek	127.3	-																				H			
MOB - Slough 8A	129.2	129.8			H			H			H		H					H	H			H			
MOB - Gateway - 4th of July	130.1	134.3			H			H			H		H			H		H	H			H			
MOB - Slough 9	131.4	133.5			H			H			H							H	H			H			
MOB - Sherman Creek	134.1	-																							

Table C-4. Continued.

Zone	PRM From:	PRM To:	6-11	6-12	6-16	6-17	6-18	6-21	6-22	6-24	6-25	6-26	6-28	6-29	7-1	7-2	7-4	7-5	7-7	7-8	7-9	7-10	7-11	7-12	7-13
MOB - 4th of July Creek	134.3	-			H			H			H		H			H		H	H			H			
MOB - 4th of July - Slough 11	134.3	140.2			H			H			H		H			H		H	H			H			
MOB - Slough 11	138.6	-			H			H			H		H					H	H			H			
MOB - Gold Creek	140.1	-			H			H			H		H			H		H	H			H			
MOB - Slough 11 - Indian	140.1	142.0			H			H			H		H			H		H	H			H			
MOB - Indian trib	141.8	-			H			H			H		H			H		H	H			H			
MOB - Indian - Slough 21	142.0	145.7			H			H			H		H			H		H	H			H			
MOB - Slough 21	145.1	145.6			H			H			H		H			H		H	H			H			
MOB - above Powerline	145.7	146.0			H			H			H		H			H		H	H			H			
MOB - abv Powerline - Portage	146.0	152.3			H			H			H		H			H		H	H			H		H	
MOB - Jack Long Creek	148.2	-									H		H			H			H			H			
MOB - Portage trib	152.3	-			H			H			H		H		H	H	H	H	H			H		H	
MOB - Portage - Impediment1	152.3	155.2			H			H			H		H		H	H	H	H	H			H		H	
MOB - Impediment1 - Cheechako	155.2	157.3			H			H		H	H		H		H	H	H	H	H			H		H	
MOB - Cheechako Creek	155.9	-			H					H			H		H	H	H	H	H			H		H	
MOB - Cheechako - Impediment2	157.3	160.2	H		H			H					H		H	H	H	H	H			H		H	
MOB - Impediment2 - Chinook	160.2	160.4	H		H			H					H		H	H	H	H	H			H		H	
MOB - Chinook Creek	160.4	-													H	H	H	H	H			H		H	
MOB - Chinook - Impediment3	160.4	164.8	H		H			H					H		H	H	H	H	H			H		H	
MOB - Devils Creek	164.8	-									H		H		H	H	H	H	H			H		H	
MOB - Impediment3 - Devil Stn	164.8	166.9	H		H			H			H		H		H	H	H	H	H			H		H	
MOB - Devil Stn - Fog	166.9	179.4	H				H	H			H		H									H			
MOB - Fog Creek	179.3	-	H		H			H			H		H									H			
MOB - Fog - Dam Site	179.4	187.2	H		H			H			H		H									H			
MOB - Tsusena Creek	184.5	-	H		H			H			H		H									H			
MOB - Dam Site - Deadman	187.2	189.4	H		H			H			H		H									H			
MOB - Deadman Creek	189.4	-	H		H			H			H											H			
MOB - Deadman - Watana	189.4	196.9	H		H			H			H		H									H			
MOB - 'Creek 192'	194.8	-																				H			
MOB - Watana Creek	196.9	-	H		H			H		H	H		H									H			
MOB - Wantana - Kosina	196.9	209.2	H		H			H		H			H									H			

Table C-4. Continued.

	PRM		Survey Date (m-d)																						
Zone	From:	To:	6-11	6-12	6-16	6-17	6-18	6-21	6-22	6-24	6-25	6-26	6-28	6-29	7-1	7-2	7-4	7-5	7-7	7-8	7-9	7-10	7-11	7-12	7-13
MOB - Kosina Creek	209.2	-	H		H			H		H			H									H			
MOB - Kosina - Jay Creek	209.2	211.0	H		H			H		H												H			
MOB - Jay Creek	211.0	-	H		H			H		H												H			
MOB - Jay - Goose	211.0	232.9	H		H			H		H												H			
MOB - Goose Creek (Upper River)	232.9	-	H		H			H		H												H			
MOB - Goose - Oshetna	232.9	235.1	H		H			H		H												H			
MOB - Oshetna River	235.1	-	H		H			H		H												H			
MOB - Oshetna - Tyone	235.1	247.3	H																						
MOB - Tyone River	247.3	-	H																						
MOB - Tyone - Clearwater Cr	247.3	266.6																							
MOB - Clearwater Creek	266.6	-																							
MOB - above Clearwater Cr	266.6	-																							

Table C-4. Continued.

	PRM		Survey Date (m-d)																						
Zone	From:	To:	7-14	7-16	7-17	7-19	7-20	7-21	7-22	7-23	7-25	7-26	7-28	7-29	7-31	8-1	8-3	8-4	8-5	8-6	8-7	8-8	8-9	8-10	8-11
MOB - Little Susitna River	-	-																							
MOB - Beyond Confluence	-	-																			H			H	
MOB - Confluence - Yentna	3.5	32.4		H			H	F		H			H		H				F		H			H	
MOB - Yentna River	32.4	-		H			H		F	H			H		H						H	F		H	F
MOB - Yentna - Deshka	32.4	45.0		H			H	F		H			H		H				F		H			H	
MOB - Deshka River	44.9	-		H			H			F/H			H		H				F		F/H			H	
MOB - Willow and Little Willow cr	52.2	55.6		H			H			F/H			H		H				F		F/H			H	
MOB - Kashwitna River	64.7	-		H			H	F		F/H			H		H						F/H			H	
MOB - Deshka - Kashwitna	45.0	64.7		H			H	F		H			H		H				F		H			H	
MOB - Caswell Creek	67.4	-					H			H			H		H						H			H	
MOB - Sheep Creek	70.1	-		H			H	F		H		H	H		H						F/H			H	
MOB - Goose Creek	76.9	-		H			H	F				H	H		H						F/H			H	
MOB - Kashwitna - Montana	64.7	80.7		H			H	F		H		H	H		H				F		H			H	
MOB - Montana Creek	80.9	-		H		H		F		H		H	H		H						F/H			H	
MOB - Montana - Sunshine	80.7	88.5		H		H		F		H		H	H		H			H	F		H			H	
MOB - Sunshine Creek	88.1	-		H		H				H		H		H		H		H			H			H	
MOB - Rabideux Creek	87.4	-		H		H				H		H	H		H	H		H			H			H	
MOB - Birch Creek	93.5	-								H		H		H		H		H						H	
MOB - Talkeetna River	101.0	-		H		H		F	H	H		H		H		H		H	F		H			H	
MOB - Chulitna River	101.7	-		H		H		F	H			H		H		H		H	F		F/H			H	
MOB - Sunshine - Talkeetna	88.5	102.3		H		H		F	H	H		H		H		H		H	F		H			H	
MOB - Talkeetna - Lane	102.3	116.7		H		H			H			H		H		H		H			H		H	H	
MOB - Whiskers Creek	104.8	-		H		H			H			H		H		H		H			H			H	
MOB - Trib off zone 95	110.5	-																						H	
MOB - Lane - Gateway	116.7	130.1	H	H	H	H			H			H		H		H		H			H		H		
MOB - Lane Creek	117.1	-		H	H	H			H			H		H		H		H			H		H		
MOB - 5th of July Creek	127.3	-			H							H											H		
MOB - Slough 8A	129.2	129.8	H		H	H			H			H		H		H	H			H			H		
MOB - Gateway - 4th of July	130.1	134.3	H		H	H			H			H		H		H	H			H			H		
MOB - Slough 9	131.4	133.5	H		H	H			H			H		H		H	H			H			H		
MOB - Sherman Creek	134.1	-																							

Table C-4. Continued.

	PRM		Survey Date (m-d)																						
Zone	**From:**	**To:**	**7-14**	**7-16**	**7-17**	**7-19**	**7-20**	**7-21**	**7-22**	**7-23**	**7-25**	**7-26**	**7-28**	**7-29**	**7-31**	**8-1**	**8-3**	**8-4**	**8-5**	**8-6**	**8-7**	**8-8**	**8-9**	**8-10**	**8-11**
MOB - 4th of July Creek	134.3	-	H		H	H			H			H		H		H	H			H			H		
MOB - 4th of July - Slough 11	134.3	140.2	H		H	H			H			H		H		H	H			H			H		
MOB - Slough 11	138.6	-												H		H	H			H			H		
MOB - Gold Creek	140.1	-	H		H	H			H			H		H		H	H			H			H		
MOB - Slough 11 - Indian	140.1	142.0	H		H	H			H			H		H		H	H			H			H		
MOB - Indian trib	141.8	-	H		H	H			H			H		H	H	H	H			H			H		
MOB - Indian - Slough 21	142.0	145.7	H		H	H			H			H		H		H	H			H			H		
MOB - Slough 21	145.1	145.6	H		H	H			H		H			H		H	H			H			H		
MOB - above Powerline	145.7	146.0	H		H	H			H		H			H		H	H			H			H		
MOB - abv Powerline - Portage	146.0	152.3	H		H	H			H	H	H			H		H	H			H			H		
MOB - Jack Long Creek	148.2	-	H		H	H			H		H			H		H	H			H			H		
MOB - Portage trib	152.3	-	H		H	H			H	H	H			H		H	H	H		H			H		
MOB - Portage - Impediment1	152.3	155.2	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Impediment1 - Cheechako	155.2	157.3	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Cheechako Creek	155.9	-	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Cheechako - Impediment2	157.3	160.2	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Impediment2 - Chinook	160.2	160.4	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Chinook Creek	160.4	-	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Chinook - Impediment3	160.4	164.8	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Devils Creek	164.8	-	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Impediment3 - Devil Stn	164.8	166.9	H	H	H	H			H	H	H	H	H	H	H	H	H	H		H			H		
MOB - Devil Stn - Fog	166.9	179.4			H				H		H				H	H	H			H					
MOB - Fog Creek	179.3	-			H						H					H	H			H					
MOB - Fog - Dam Site	179.4	187.2			H				H		H					H	H			H					
MOB - Tsusena Creek	184.5	-			H						H					H	H			H					
MOB - Dam Site - Deadman	187.2	189.4			H						H					H	H			H					
MOB - Deadman Creek	189.4	-			H						H					H	H			H					
MOB - Deadman - Watana	189.4	196.9			H						H					H	H			H					
MOB - 'Creek 192'	194.8	-			H																				
MOB - Watana Creek	196.9	-			H						H					H	H			H					
MOB - Wantana - Kosina	196.9	209.2			H						H					H	H			H					

Table C-4. Continued.

	PRM		Survey Date (m-d)																						
Zone	From:	To:	7-14	7-16	7-17	7-19	7-20	7-21	7-22	7-23	7-25	7-26	7-28	7-29	7-31	8-1	8-3	8-4	8-5	8-6	8-7	8-8	8-9	8-10	8-11
MOB - Kosina Creek	209.2	-			H						H						H			H					
MOB - Kosina - Jay Creek	209.2	211.0			H						H						H								
MOB - Jay Creek	211.0	-			H						H						H								
MOB - Jay - Goose	211.0	232.9									H						H								
MOB - Goose Creek (Upper River)	232.9	-									H						H						H		
MOB - Goose - Oshetna	232.9	235.1									H						H						H		
MOB - Oshetna River	235.1	-									H						H								
MOB - Oshetna - Tyone	235.1	247.3	H																						
MOB - Tyone River	247.3	-	H																						
MOB - Tyone - Clearwater Cr	247.3	266.6	H																						
MOB - Clearwater Creek	266.6	-	H																						
MOB - above Clearwater Cr	266.6	-	H																						

Table C-4. Continued.

	PRM		Survey Date (m-d)																						
Zone	From:	To:	8-12	8-13	8-15	8-16	8-17	8-18	8-19	8-21	8-22	8-24	8-25	8-27	8-28	8-29	8-30	8-31	9-2	9-3	9-4	9-5	9-6	9-8	9-9
MOB - Little Susitna River	-	-																							
MOB - Beyond Confluence	-	-					H		H														H		
MOB - Confluence - Yentna	3.5	32.4					H	F	H		H		H			H				F/H			H		H
MOB - Yentna River	32.4	-					H	F	H		H		H			H		H		F/H			H		H
MOB - Yentna - Deshka	32.4	45.0		H			H	F	H		H		H			H		H		F/H			H		H
MOB - Deshka River	44.9	-		H			H	F	H		H		H			H		H		F/H			H		H
MOB - Willow and Little Willow cr	52.2	55.6		H			H	F	H		H		H			H		H		H	F		H		H
MOB - Kashwitna River	64.7	-		H		H		F	H		H		H			H		H		H	F		H		H
MOB - Deshka - Kashwitna	45.0	64.7		H		H		F	H		H		H			H		H		F/H			H		H
MOB - Caswell Creek	67.4	-		H		H					H		H			H		H		H			H		H
MOB - Sheep Creek	70.1	-		H		H		F	H		H		H			H		H			F		H		H
MOB - Goose Creek	76.9	-		H		H		F	H		H		H		H			H		H	F		H		H
MOB - Kashwitna - Montana	64.7	80.7		H		H		F	H		H		H		H			H		F/H			H		H
MOB - Montana Creek	80.9	-		H		H		F	H		H		H		H			H		H	F		H		H
MOB - Montana - Sunshine	80.7	88.5		H		H		F	H		H		H		H			H		F/H			H		H
MOB - Sunshine Creek	88.1	-		H		H			H		H		H		H			H		H			H		H
MOB - Rabideux Creek	87.4	-		H		H			H		H		H		H			H		H			H		H
MOB - Birch Creek	93.5	-		H		H			H		H		H		H			H		H			H		H
MOB - Talkeetna River	101.0	-		H		H		F	F/H		H		H		H			H		F/H			H	H	
MOB - Chulitna River	101.7	-		H		H		F	F/H		H		H		H			H		F			H		H
MOB - Sunshine - Talkeetna	88.5	102.3		H		H		F	H		H		H		H			H		F/H			H	H	H
MOB - Talkeetna - Lane	102.3	116.7		H		H			H		H		H	H				H	H				H	H	
MOB - Whiskers Creek	104.8	-		H		H			H		H		H	H				H	H				H	H	
MOB - Trib off zone 95	110.5	-				H																			
MOB - Lane - Gateway	116.7	130.1	H			H			H		H	H	H	H			H	H	H				H	H	
MOB - Lane Creek	117.1	-	H			H			H		H		H	H				H	H				H	H	
MOB - 5th of July Creek	127.3	-						H			H			H			H						H	H	
MOB - Slough 8A	129.2	129.8	H			H		H			H	H		H			H		H				H	H	
MOB - Gateway - 4th of July	130.1	134.3	H			H		H			H	H		H			H		H				H	H	
MOB - Slough 9	131.4	133.5	H			H		H			H	H		H			H		H				H	H	
MOB - Sherman Creek	134.1	-																							

Table C-4. Continued.

	PRM		Survey Date (m-d)																						
Zone	From:	To:	8-12	8-13	8-15	8-16	8-17	8-18	8-19	8-21	8-22	8-24	8-25	8-27	8-28	8-29	8-30	8-31	9-2	9-3	9-4	9-5	9-6	9-8	9-9
MOB - 4th of July Creek	134.3	-	H			H		H		H		H		H			H		H				H	H	
MOB - 4th of July - Slough 11	134.3	140.2	H			H		H		H		H		H			H		H				H	H	
MOB - Slough 11	138.6	-	H			H		H		H		H		H			H		H				H	H	
MOB - Gold Creek	140.1	-	H		H			H		H		H		H			H		H				H	H	
MOB - Slough 11 - Indian	140.1	142.0	H		H			H		H		H		H			H		H				H	H	
MOB - Indian trib	141.8	-	H		H			H		H		H		H			H		H			H		H	
MOB - Indian - Slough 21	142.0	145.7	H		H			H		H		H		H			H		H			H		H	
MOB - Slough 21	145.1	145.6	H		H			H		H		H		H			H		H			H		H	
MOB - above Powerline	145.7	146.0	H		H			H		H		H		H			H		H			H		H	
MOB - abv Powerline - Portage	146.0	152.3	H		H			H		H		H		H			H		H			H		H	
MOB - Jack Long Creek	148.2	-	H		H			H		H		H		H			H		H			H		H	
MOB - Portage trib	152.3	-	H		H			H		H		H		H			H		H			H		H	
MOB - Portage - Impediment1	152.3	155.2	H		H			H		H		H		H			H		H			H		H	
MOB - Impediment1 - Cheechako	155.2	157.3	H		H			H		H		H		H			H		H			H		H	
MOB - Cheechako Creek	155.9	-	H		H			H		H		H		H			H		H			H		H	
MOB - Cheechako - Impediment2	157.3	160.2	H		H			H		H		H		H			H		H			H		H	
MOB - Impediment2 - Chinook	160.2	160.4	H		H			H		H		H		H			H		H			H		H	
MOB - Chinook Creek	160.4	-	H		H			H		H		H		H			H		H			H		H	
MOB - Chinook - Impediment3	160.4	164.8	H		H			H		H		H		H			H		H			H		H	
MOB - Devils Creek	164.8	-	H		H			H		H		H		H			H		H			H		H	
MOB - Impediment3 - Devil Stn	164.8	166.9	H		H			H		H		H		H			H		H			H		H	
MOB - Devil Stn - Fog	166.9	179.4			H			H		H		H		H			H					H			
MOB - Fog Creek	179.3	-			H			H		H		H		H			H					H			
MOB - Fog - Dam Site	179.4	187.2			H			H		H		H					H					H			
MOB - Tsusena Creek	184.5	-			H			H		H							H								
MOB - Dam Site - Deadman	187.2	189.4			H			H		H							H					H			
MOB - Deadman Creek	189.4	-			H			H		H							H					H			
MOB - Deadman - Watana	189.4	196.9			H			H		H							H					H			
MOB - 'Creek 192'	194.8	-			H					H															
MOB - Watana Creek	196.9	-			H			H		H							H					H			
MOB - Wantana - Kosina	196.9	209.2	H		H			H		H							H					H			

Table C-4. Continued.

Zone	PRM From:	PRM To:	8-12	8-13	8-15	8-16	8-17	8-18	8-19	8-21	8-22	8-24	8-25	8-27	8-28	8-29	8-30	8-31	9-2	9-3	9-4	9-5	9-6	9-8	9-9
MOB - Kosina Creek	209.2	-	H		H			H		H							H					H			
MOB - Kosina - Jay Creek	209.2	211.0	H							H							H					H			
MOB - Jay Creek	211.0	-								H							H					H			
MOB - Jay - Goose	211.0	232.9	H							H							H					H			
MOB - Goose Creek (Upper River)	232.9	-	H							H							H					H			
MOB - Goose - Oshetna	232.9	235.1	H							H							H					H			
MOB - Oshetna River	235.1	-	H							H							H					H			
MOB - Oshetna - Tyone	235.1	247.3	H																						
MOB - Tyone River	247.3	-																							
MOB - Tyone - Clearwater Cr	247.3	266.6	H																						
MOB - Clearwater Creek	266.6	-																							
MOB - above Clearwater Cr	266.6	-																							

Table C-4. Continued.

	PRM		Survey Date (m-d)																							
Zone	From:	To:	9-11	9-14	9-15	9-16	9-17	9-18	9-20	9-21	9-23	9-24	9-25	9-30	10-1	10-2	10-7	10-8	10-9	10-14	10-15	10-16	10-17	10-28	10-29	10-30
MOB - Little Susitna River	-	-																								
MOB - Beyond Confluence	-	-																H				H			H	
MOB - Confluence - Yentna	3.5	32.4			H				H				H		H			H				H			H	
MOB - Yentna River	32.4	-			H				H				H		H			H				H			H	
MOB - Yentna - Deshka	32.4	45.0			H				H				H		H			H				H			H	
MOB - Deshka River	44.9	-			H				H		F		H		H			H				H			H	
MOB - Willow and Little Willow cr	52.2	55.6			H	F			H				H		H			H			H				H	
MOB - Kashwitna River	64.7	-			H	F		H	H				H		H			H			H				H	
MOB - Deshka - Kashwitna	45.0	64.7			H	F			H				H		H			H			H	H			H	
MOB - Caswell Creek	67.4	-			H					H			H		H			H			H				H	
MOB - Sheep Creek	70.1	-			H	F		H		H			H		H			H			H				H	
MOB - Goose Creek	76.9	-			H	F		H		H			H		H						H				H	
MOB - Kashwitna - Montana	64.7	80.7			H	F		H		H			H		H			H			H					H
MOB - Montana Creek	80.9	-			H	F		H		H			H		H			H			H					H
MOB - Montana - Sunshine	80.7	88.5			H			H		H	F		H		H			H			H					H
MOB - Sunshine Creek	88.1	-			H			H		H			H		H			H			H					H
MOB - Rabideux Creek	87.4	-			H			H		H			H		H			H			H					H
MOB - Birch Creek	93.5	-			H			H		H			H		H						H					H
MOB - Talkeetna River	101.0	-		H				H	H		F	H		H			H				H					H
MOB - Chulitna River	101.7	-			H			H		H	F	H		H	H		H				H					H
MOB - Sunshine - Talkeetna	88.5	102.3			H			H		H	F	H		H	H		H	H			H					H
MOB - Talkeetna - Lane	102.3	116.7		H				H		H		H		H			H				H		H			
MOB - Whiskers Creek	104.8	-		H				H		H		H		H			H				H		H	H		
MOB - Trib off zone 95	110.5	-																								
MOB - Lane - Gateway	116.7	130.1	H	H				H		H		H		H			H		H		H		H	H		
MOB - Lane Creek	117.1	-	H	H				H		H		H		H			H				H		H	H		
MOB - 5th of July Creek	127.3	-	H	H																						
MOB - Slough 8A	129.2	129.8	H	H				H		H		H		H			H		H		H		H	H		
MOB - Gateway - 4th of July	130.1	134.3	H	H				H		H		H		H			H		H		H		H	H		
MOB - Slough 9	131.4	133.5	H	H				H		H		H		H			H		H		H		H	H		
MOB - Sherman Creek	134.1	-																								

Table C-4. Continued.

	PRM		Survey Date (m-d)																							
Zone	From:	To:	9-11	9-14	9-15	9-16	9-17	9-18	9-20	9-21	9-23	9-24	9-25	9-30	10-1	10-2	10-7	10-8	10-9	10-14	10-15	10-16	10-17	10-28	10-29	10-30
MOB - 4th of July Creek	134.3	-	H	H				H		H		H		H			H		H		H			H		
MOB - 4th of July - Slough 11	134.3	140.2	H	H				H		H		H		H			H		H		H		H	H		
MOB - Slough 11	138.6	-	H	H				H		H		H		H			H		H		H		H	H		
MOB - Gold Creek	140.1	-	H	H			H		H			H		H			H		H	H						
MOB - Slough 11 - Indian	140.1	142.0	H	H			H		H			H		H			H		H	H			H	H		
MOB - Indian trib	141.8	-	H	H			H		H			H		H			H		H	H			H	H		
MOB - Indian - Slough 21	142.0	145.7	H	H			H		H			H		H			H		H	H			H	H		
MOB - Slough 21	145.1	145.6	H	H			H		H			H		H			H		H	H			H	H		
MOB - above Powerline	145.7	146.0	H	H			H		H			H		H			H		H	H			H	H		
MOB - abv Powerline - Portage	146.0	152.3	H	H			H		H			H		H			H		H	H			H	H		
MOB - Jack Long Creek	148.2	-	H	H			H		H			H		H			H		H	H						
MOB - Portage trib	152.3	-	H	H			H		H			H		H			H		H	H			H	H		
MOB - Portage - Impediment1	152.3	155.2	H	H			H		H			H		H		H	H		H	H			H	H		
MOB - Impediment1 - Cheechako	155.2	157.3	H	H			H		H			H		H		H	H		H	H				H		
MOB - Cheechako Creek	155.9	-	H	H			H		H			H		H			H			H				H		
MOB - Cheechako - Impediment2	157.3	160.2	H	H			H		H			H		H			H			H				H		
MOB - Impediment2 - Chinook	160.2	160.4	H	H			H		H			H		H			H			H				H		
MOB - Chinook Creek	160.4	-	H	H			H		H			H		H						H				H		
MOB - Chinook - Impediment3	160.4	164.8	H	H			H		H			H		H			H			H				H		
MOB - Devils Creek	164.8	-	H	H			H		H			H		H						H				H		
MOB - Impediment3 - Devil Stn	164.8	166.9	H	H			H		H			H		H			H			H				H		
MOB - Devil Stn - Fog	166.9	179.4					H									H				H						
MOB - Fog Creek	179.3	-					H									H				H						
MOB - Fog - Dam Site	179.4	187.2					H									H				H						
MOB - Tsusena Creek	184.5	-					H									H				H						
MOB - Dam Site - Deadman	187.2	189.4					H									H				H						
MOB - Deadman Creek	189.4	-					H									H				H						
MOB - Deadman - Watana	189.4	196.9					H									H				H						
MOB - 'Creek 192'	194.8	-					H																			
MOB - Watana Creek	196.9	-					H									H				H						
MOB - Wantana - Kosina	196.9	209.2					H									H				H						

Table C-4. Continued.

	PRM		Survey Date (m-d)																							
Zone	From:	To:	9-11	9-14	9-15	9-16	9-17	9-18	9-20	9-21	9-23	9-24	9-25	9-30	10-1	10-2	10-7	10-8	10-9	10-14	10-15	10-16	10-17	10-28	10-29	10-30
MOB - Kosina Creek	209.2	-					H									H				H						
MOB - Kosina - Jay Creek	209.2	211.0					H									H				H						
MOB - Jay Creek	211.0	-					H									H				H						
MOB - Jay - Goose	211.0	232.9					H									H				H						
MOB - Goose Creek (Upper River)	232.9	-					H									H				H						
MOB - Goose - Oshetna	232.9	235.1					H									H				H						
MOB - Oshetna River	235.1	-					H									H				H						
MOB - Oshetna - Tyone	235.1	247.3					H									H				H						
MOB - Tyone River	247.3	-					H									H				H						
MOB - Tyone - Clearwater Cr	247.3	266.6																								
MOB - Clearwater Creek	266.6	-																								
MOB - above Clearwater Cr	266.6	-																								

Appendix D: Spawning destinations

Table D-1. Summary of monitoring effort at potential spawning sites, by species, as part of the Habitat Suitability Criteria (HSC) component of the Fish and Aquatics Instream Flow Study (RSP Section 8.5), 2014.

	Sockeye		Pink		Chum	
Survey Date	**Presence**	**Spawning**	**Presence**	**Spawning**	**Presence**	**Spawning**
11-Aug						
Slough 10 North Fork						
Slough 10 East Fork						
Slough 9A						
4th of July Side Channel					X	
12-Aug						
Oxbow 1						
Unnamed Slough RR (PRM 121.3)						
Slough 9						
5th of July Slough						
13-Aug						
4th of July Side Channel					X	
4th of July Creek Mouth			X		X	
Sherman Creek Mouth						
Skull Creek Mouth						
Deadhorse Creek Mouth						
Oxbow 2						
14-Aug						
Jack Long Creek Mouth						
Indian River Mouth			X		X	
Slough 22					X	X
30-Aug						
Unnammed Slough RL (near PRM 119)						
Mainstem RL [a] (near PRM 114)						
Oxbow 1						
Slough 22	X	X			X	X
31-Aug						
Slough 21						
Slough 19	X	X			X	X
Slough 16						
Slough 15						
Slough 10 North Fork					X	
Slough 10 East Fork	X	X				
Slough 9A					X	X
Side Channel (PRM 131.5)					X	X
Side Channel(PRM 137)					X	X

Notes:

RL indicates a sampling site located on river left; RR indicates a site on river right.

[a] Sample site located bewteen Gash Creek and Oxbow 1.

Table D-2. Summary of monitoring effort at potential spawning sites for Chinook Salmon in the Middle River, 2014.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed: None	Fish Observed: Presence	Fish Observed: Holding	Fish Observed: Spawning
1	681	Lane Creek	Tributary Mouth	20-Jul	DIDSON	X			
2[a]	515	Lane Creek - Gateway	Side Channel	20-Jul	Boat		Site not surveyed		
				*	Aerial		Too turbid to assess		
3	373, 749, 677	5th of July Creek	Tributary Mouth	*	Aerial		Too turbid to assess		
4	663	Lane Creek - Gateway	Main Channel	NA	Boat		Site not visited		
5	319	4th of July Creek	Tributary Mouth	20-Jul	DIDSON			X	
				25-Jul	DIDSON			X	
6	809	4th of July Side Channel	Side Channel	19-Jul	DIDSON	X			
				20-Jul	Boat/Visual	X			
7[a]	233	Gateway - Slough 11	Main Channel	19-Jul	Boat		Site not surveyed		
8[a]	673	Slough/Side Channel 10	Side Channel	19-Jul	Boat		Site not surveyed		
9[a]	768	Slough/Side Channel 11	Side Channel	19-Jul	Boat/Visual		Site not surveyed		
10	291, 634, 708	Gateway - Slough 11	Main Channel	23-Jul	DIDSON			X	
11	695	Gold Creek	Tributary Mouth	21-Jul	Boat	X			
12[a]	335	Slough 11 - Slough 21	Side Channel	23-Jul	Boat		Site not surveyed		
13	cluster	Indian River	Tributary Mouth	22-Jul	DIDSON			X	
14[a]	714	Slough 11 - Slough 21	Main Channel	NA	NA		Site not visited		
15[a]	390, 540	Side Channel 21	Side Channel	*	Boat/Aerial		Too turbid to assess		
16	444	Slough 21 - Portage Creek	Main Channel	NA	NA		Site not visited		
17	cluster	Portage Creek	Tributary Mouth	21-Jul	DIDSON			X	
				25-Jul	DIDSON			X	
18[a]	5531	Chinook Creek	Tributary Mouth	*	Aerial		Too turbid to assess		

[a] Indicates a site that was visually assessed and considered too difficult to access with boat-mounted DIDSON.

* Indicates a site that was monitored on a regular basis, but spawning was not observed or confirmed. Most are turbid water locations.

Table D-3. Summary of monitoring effort at potential spawning sites for Chum Salmon in the Middle River, 2014.

			Habitat	Survey	Survey	Fish Observed			
Site #	Fish #	Location	Type	Date	Type	None	Presence	Holding	Spawning
1	2024	Talkeetna - Lane Creek	Main Channel	*	Aerial	Too turbid to assess			
2	2628	Lane Creek - Gateway	Side Channel	*	Aerial	Too turbid to assess			
3	2201	5th of July Creek	Tributary Mouth	12-Aug	HSC	X			
				*	Aerial	X			
4	3331	Slough 8D	Slough	*	Aerial	X			
5	3082	Slough 8A	Slough	10-Sep	Aerial			X	X
				24-Sep	HSC			X	X
6	1923	Gateway - Slough 11	Side Channel	*	Aerial/Boat	Too turbid to assess			
7	1998, 2120, 2169	Slough 9	Slough	12-Aug	HSC	X			
8	2981	4th of July Creek	Tributary Mouth	13-Aug	HSC			X	
				*	Aerial			X	
9	2078, 3238, 3426	4th of July Side Channel	Side Channel	11-Aug	HSC			X	
				13-Aug	HSC			X	
10	2929	Slough 11 - Indian River	Main Channel	*	Aerial/Boat	Too turbid to assess			
11	2177	Slough 11 - Indian River	Main Channel	*	Aerial/Boat	Too turbid to assess			
12	2746	Indian River	Tributary Mouth	14-Aug	HSC			X	
				10-Sep	Aerial			X	X
13	3094	Indian River - Slough 21	Main Channel	*	Aerial/Boat	Too turbid to assess			
14	2329	Portage Creek	Tributary Mouth	*	Aerial			X	

* Indicates a site that was monitored on a regular basis, but spawning was not observed or confirmed. Most are turbid water locations.

Table D-4. Summary of monitoring effort at potential spawning sites for Coho Salmon in the Middle River, 2014.

			Habitat	Survey	Survey	Fish Observed			
Site #	Fish #	Location	Type	Date	Type	None	Presence	Holding	Spawning
1[a]	3639	Lane Creek - Gateway	Main Channel	*	Aerial	Too turbid to assess			
2	2901	Oxbow 2	Side Channel	*	Aerial/Boat	Too turbid to assess			
3	2932, 3371	Gateway - Slough 11	Side Channel	*	Aerial	X			
4	1830	Slough 13	Slough	*	Aerial	X			
5	1881	Slough 11 - Indian River	Main Channel	*	Aerial	X			
6	3370, 3398	Indian River	Tributary Mouth	*	Aerial	X			
7	3396	Slough 22	Slough	30-Aug	HSC	X			
8	1960	Portage Creek	Tributary Mouth	10-Sep	Aerial			X	

[a] Indicates a site that was visually assessed and not considered suitable for spawning based on physical characteristics

* Indicates a site that was monitored on a regular basis, but spawning was not observed or confirmed. Most are turbid water locations.

Table D-5. Summary of monitoring effort at potential spawning sites for Pink Salmon in the Middle River, 2014.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed: None	Presence	Holding	Spawning
1	1709, 1856	Side Channel 6A	Side Channel	*	Boat/Aerial	Too turbid to assess			
2	2019	5th of July Creek	Tributary Mouth	12-Aug	HSC	X			
3	1663, 1664, 2926	4th of July Creek	Tributary Mouth	11-Aug	HSC		X	X	
				13-Aug	HSC		X	X	
4	2432	4th of July Side Channel	Side Channel	11-Aug	HSC	X			
				13-Aug	HSC	X			
5	2423	Gateway - Slough 11	Main Channel	*	Boat/Aerial	Too turbid to assess			
6	1537	Slough 11 - Slough 21	Side Channel	*	Boat/Aerial	Too turbid to assess			
7	1300, 2033	Indian River	Tributary Mouth	14-Aug	HSC		X	X	
8	2198	Side Channel 21	Side Channel	*	Boat/Aerial	Too turbid to assess			

* Indicates a site that was monitored on a regular basis, but spawning was not observed or confirmed. Most are turbid water locations.

Table D-6. Summary of monitoring effort at potential spawning sites for Sockeye Salmon in the Middle River, 2014.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed			
						None	Presence	Holding	Spawning
1	2056	Slough 8D	Slough	*	Aerial	X			
2	cluster	Slough 8A	Slough	10-Sep	Aerial			X	X
				24-Sep	HSC			X	X
3	cluster	Slough 9	Slough	12-Aug	HSC	X			
4	1392, 1914, 2076	4th of July Side Channel	Side Channel	11-Aug	HSC	X			
				13-Aug	HSC	X			
5	cluster	Slough 10	Slough	11-Aug	HSC	X			
				31-Aug	HSC			X	X
				23-Sep	HSC			X	X
6	cluster	Slough 11	Slough	10-Sep	Aerial			X	X
				21-Sep	HSC			X	X
7	cluster	Slough/Side Channel 21	Slough/SideChannel	30-Aug	Aerial			X	X
				31-Aug	HSC	X			
				10-Sep	Aerial			X	X
				22-Sep	HSC			X	X
8	cluster	Slough 22	Slough	14-Aug	HSC	X			
				30-Aug	HSC			X	X

[b] Indicates a site that was visually assessed and not considered suitable for spawning based on physical characteristics

* Indicates a site that was monitored on a regular basis, but spawning was not observed or confirmed. Most are turbid water locations.

Table D-7. Details of impediment-passage events for radio-tagged fish, 2014.

Chinook Salmon (≥ 50 cm) that Passed Impediment 3

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
537	20 Jul	20 Jul	4 Aug	4.5	0.5	8.0	21,400	21,400	16,400
787	20 Jul	20 Jul	30 Jul	2.5	0.5	5.5	21,400	21,400	15,900
Average	20 Jul	20 Jul	2 Aug	3.5	0.5	6.8	21,400	21,400	16,150

Chinook Salmon (≥ 50 cm) That Passed Impediment 2 but not Impediment 3

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
17	30 Jun	30 Jun	-	1.0	0.5	4.5	19,600	19,600	-
139	24 Jul	28 Jul	-	7.0	1.0	d.n.a.	18,100	16,800	-
222	6 Jul	18 Jul	-	1.0	0.5	17.0	23,800	19,000	-
516	1 Aug	1 Aug	-	10.5	0.5	d.n.a.	16,000	16,000	-
882	25 Jul	1 Aug	-	4.5	0.5	d.n.a.	17,900	16,000	-
903	23 Jul	24 Jul	-	0.5	0.5	10.5	18,100	18,100	-
5531	18 Jul	18 Jul	-	2.5	0.5	13.0	19,000	19,000	-
Average	18 Jul	22 Jul		3.9	0.6	11.3	18,929	17,786	

Chinook Salmon (≥ 50 cm) That Passed Impediment 1 but not Impediment 2

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
221	20 Jul	-	-	4.5	d.n.a.	-	21,400	-	-
828	18 Jul	-	-	2.5	d.n.a.	-	19,000	-	-
868	23 Jul	-	-	5.5	d.n.a.	-	18,100	-	-
5702	1 Jul	-	-	3.0	d.n.a.	-	23,300	-	-
Average	16 Jul			3.9	-		20,450		

Table D-7. Continued.

Chinook Salmon (≥ 50 cm) That Approached Impediment 1 but did not Pass

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
23	-	-	-	3.0	-	-	-	-	-
33	-	-	-	4.5	-	-	-	-	-
40	-	-	-	1.5	-	-	-	-	-
91	-	-	-	4.5	-	-	-	-	-
103	-	-	-	25.5	-	-	-	-	-
108	-	-	-	5.0	-	-	-	-	-
111	-	-	-	4.5	-	-	-	-	-
166	-	-	-	1.5	-	-	-	-	-
198	-	-	-	1.5	-	-	-	-	-
237	-	-	-	4.0	-	-	-	-	-
239	-	-	-	1.5	-	-	-	-	-
244	-	-	-	13.5	-	-	-	-	-
264	-	-	-	7.5	-	-	-	-	-
300	-	-	-	2.5	-	-	-	-	-
359	-	-	-	1.5	-	-	-	-	-
562	-	-	-	1.5	-	-	-	-	-
611	-	-	-	2.5	-	-	-	-	-
621	-	-	-	12.0	-	-	-	-	-
668	-	-	-	0.5	-	-	-	-	-
716	-	-	-	0.5	-	-	-	-	-
818	-	-	-	1.0	-	-	-	-	-
5242	-	-	-	2.0	-	-	-	-	-
5255	-	-	-	3.0	-	-	-	-	-
5384	-	-	-	5.5	-	-	-	-	-
5408	-	-	-	1.5	-	-	-	-	-
Average				4.5					

Table D-7. Continued.

Chinook Salmon (< 50 cm) That Approached Impediment 1 but did not Pass

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
574	-	-	-	1.5	-	-	-	-	-
Average	-			1.5			-		

Sockeye Salmon That Passed Impediment 1 but not Impediment 2

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
785	27 Jul	-	-	0.5	d.n.a.	-	18,900	-	-
955	8 Sep	-	-	1.0	d.n.a.	-	14,400	-	-
2214	8 Sep	-	-	3.0	d.n.a.	-	14,400	-	-
Average	25 Aug			1.5	-		15,900		

Sockeye Salmon That Approached Impediment 1 but did not Pass

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
647	-	-	-	1.5	-	-	-	-	-
837	-	-	-	1.5	-	-	-	-	-
1053	-	-	-	1.5	-	-	-	-	-
1260	-	-	-	20.5	-	-	-	-	-
1293	-	-	-	2.5	-	-	-	-	-
1346	-	-	-	1.5	-	-	-	-	-
1404	-	-	-	1.5	-	-	-	-	-
1851	-	-	-	3.0	-	-	-	-	-
2076	-	-	-	3.5	-	-	-	-	-
2156	-	-	-	1.0	-	-	-	-	-
2157	-	-	-	10.5	-	-	-	-	-
2606	-	-	-	5.5	-	-	-	-	-

Table D-7. Continued.

Sockeye Salmon That Approached Impediment 1 but did not Pass

Tag Number	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Hold Time Below I1 (d)	Hold Time Below I2 (d)	Hold Time Below I3 (d)	Flow at I-1 Passage (cfs)	Flow at I-2 Passage (cfs)	Flow at I-3 Passage (cfs)
2770	-	-	-	7.0	-	-	-	-	-
Average				4.7					

Notes:

Details include the date of first detections above each impediment, the duration of holding time below each impediment, and the flow (measured at Tsusena Creek) at the time of the first detection upstream of the impediment. "d.n.a" = Did Not Approach next upstream impediment. Top panel: Chinook salmon (≥ 50 cm) that passed Impediment 3. Second panel: Chinook salmon (≥ 50 cm) that passed Impediment 2, but not Impediment 3. Third panel: Chinook salmon (≥ 50 cm) that passed Impediment 1, but not Impediment 2. Fouth panel: Chinook salmon (≥ 50 cm) that approached within 1 km of Impediment 1, but did not pass. Fifth panel: Chinook salmon (< 50 cm) that approached within 1 km of Impediment 1, but did not pass. Sixth panel: Sockeye salmon that passed Impediment One, but not Impediment Two. Seventh panel: Sockeye salmon that approached within 1 km of Impediment 1, but did not pass.

Table D-8. Number of Chinook Salmon counted during aerial spawner surveys, by location and survey period, 2014.

River Section	Waterbody	Confluence Project River Mile	Miles Surveyed	Survey Dates: Jul 14 - Jul 15	Jul 19 - Jul 20	Jul 25 - Jul 26	Jul 31 - Aug 1	Aug 6 - Aug 7	Aug 12 - Aug 13	Aug 18- Aug 19
Between Impediment 1 & 2	Cheechako Creek	Susitna 155.9	2.4	11	16	8	13	7	0	0
Between Impediment 2 & 3	Chinook Creek	Susitna 160.4	8.7	0	5	5	2	2	0	0
Middle River -	Devil Creek	Susitna 164.8	2.5	0	0	0	2	10	5	2
Above Impediment 3	Fog Creek	Susitna 179.3	19.3	0	0	0	3	2	0	1
	Fog Creek Tributary L1	Fog 5.1	7.6	0	0	0	0	0	0	0
	Bear Creek	Susitna 184.0	5.7	0	0	0	0	0	0	0
	Bear Creek Tributary R1	Bear 0.8	8.2	0	0	0	0	0	0	0
	Tsusena Creek	Susitna 184.4	3.6	0	0	0	0	0	0	0
Upper River -	Deadman Creek	Susitna 188.4	0.3	0	0	0	0	0	0	0
Within Reservoir	Watana Creek	Susitna 196.9	21.3	0	0	0	0	0	0	0
	Watana Creek Tributary R5	Watana 8.6	8.6	0	0	0	0	0	0	0
	Kosina Creek	Susitna 209.2	18.8	0	0	0	0	0	0	0
	Gilbert Creek	Kosina 6.2	6	0	NS[2]	NS[2]	0	0	0	0
	Tsisi Creek	Kosina 7.3	6.4	0	NS[2]	0	0	0	0	NS[1]
	Tsisi Lake 1	Tsisi 7.2	2.8	NS[1]	NS[1]	0	0	0	0	0
	Tsisi Lake 2	Tsisi 10.6	5.2	NS[1]	NS[1]	0	0	0	0	0
	Jay Creek	Susitna 211.0	13.3	0	0	0	0	0	0	0
Upper River -	Goose Creek	Susitna 232.9	11.2	0	0	0	0	0	0	0
Above Reservoir	Oshetna River	Susitna 235.1	26.3	0	0	0	0	NS[2]	0	0
	Black River	Oshetna	6.2	0	0	0	0	NS[2]	0	

[1] No survey - surveys targeting Sockeye Salmon began July 25-26.

[2] No survey - high and/or turbid water prevented survey.

Table D-9. Summary of weather variability during the adult salmon aerial spawner surveys in the Middle and Upper rivers, 2014.

	Weather Condition					
Date	Sunny	Partly Cloudy	Overcast	Showers	Rain	Wind
July 14-15		X	X	X		X
July 19-20			X	X	X	
July 25-26	X	X	X	X		X
July 31-Aug 1	X	X	X			X
Aug 6-7		X	X	X		
Aug 12-13		X	X			
Aug 18-19	X	X	X	X		

Table D-10. Summary of survey condition rankings during the adult salmon aerial spawner surveys in the Middle and Upper rivers, 2014.

Variable	Average Rank	Observed Range	Standard Deviation
Sun Glare	4	3 to 4	0.5
Water clarity	3	0 to 4	0.8
Vegetation Cover	3	1 to 4	0.8

Notes:

Variables were ranked from 0 to 4, with 4 being optimal and 0 being poor.

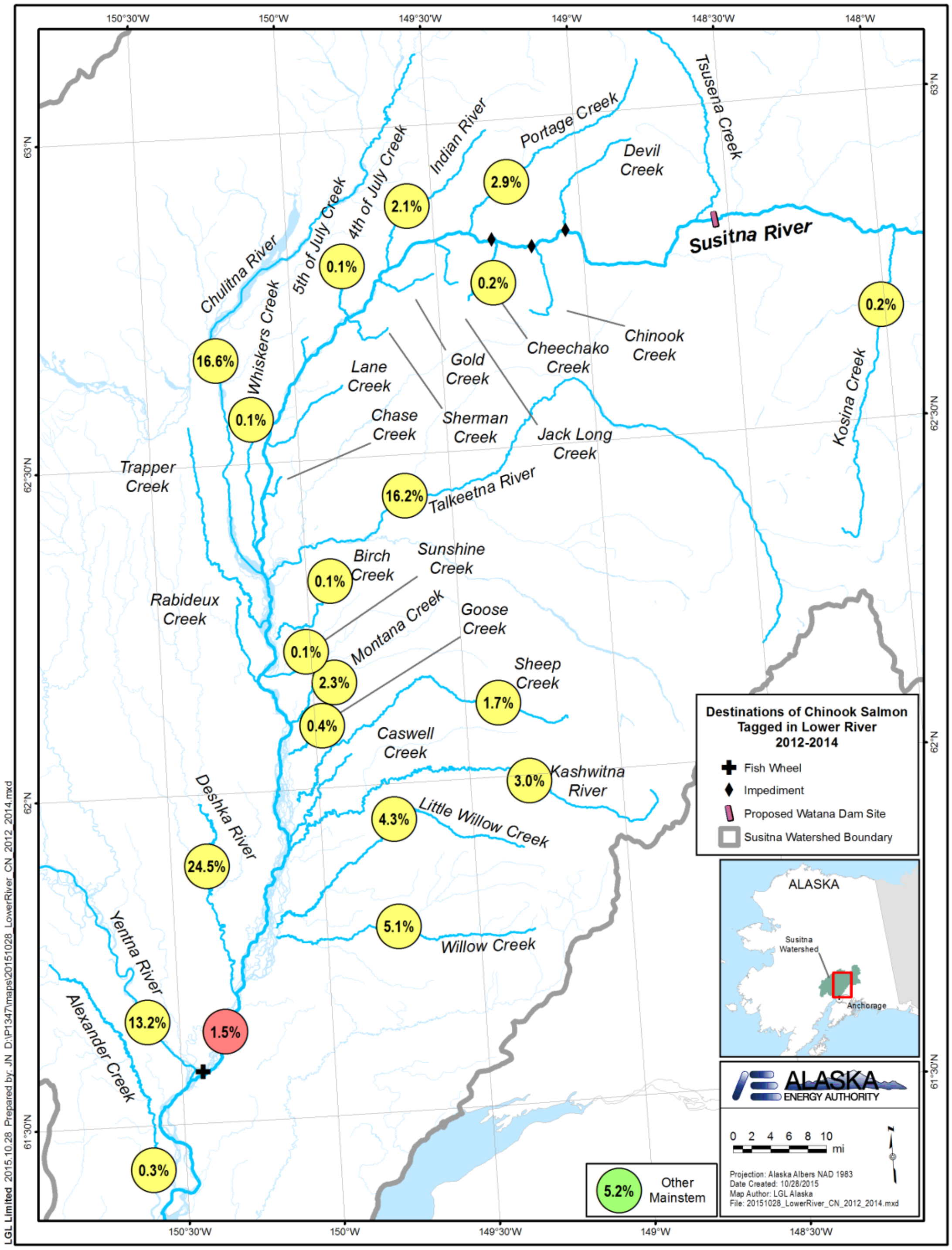

Figure D-1. Destinations for radio-tagged Chinook Salmon released in the Lower River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination. Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

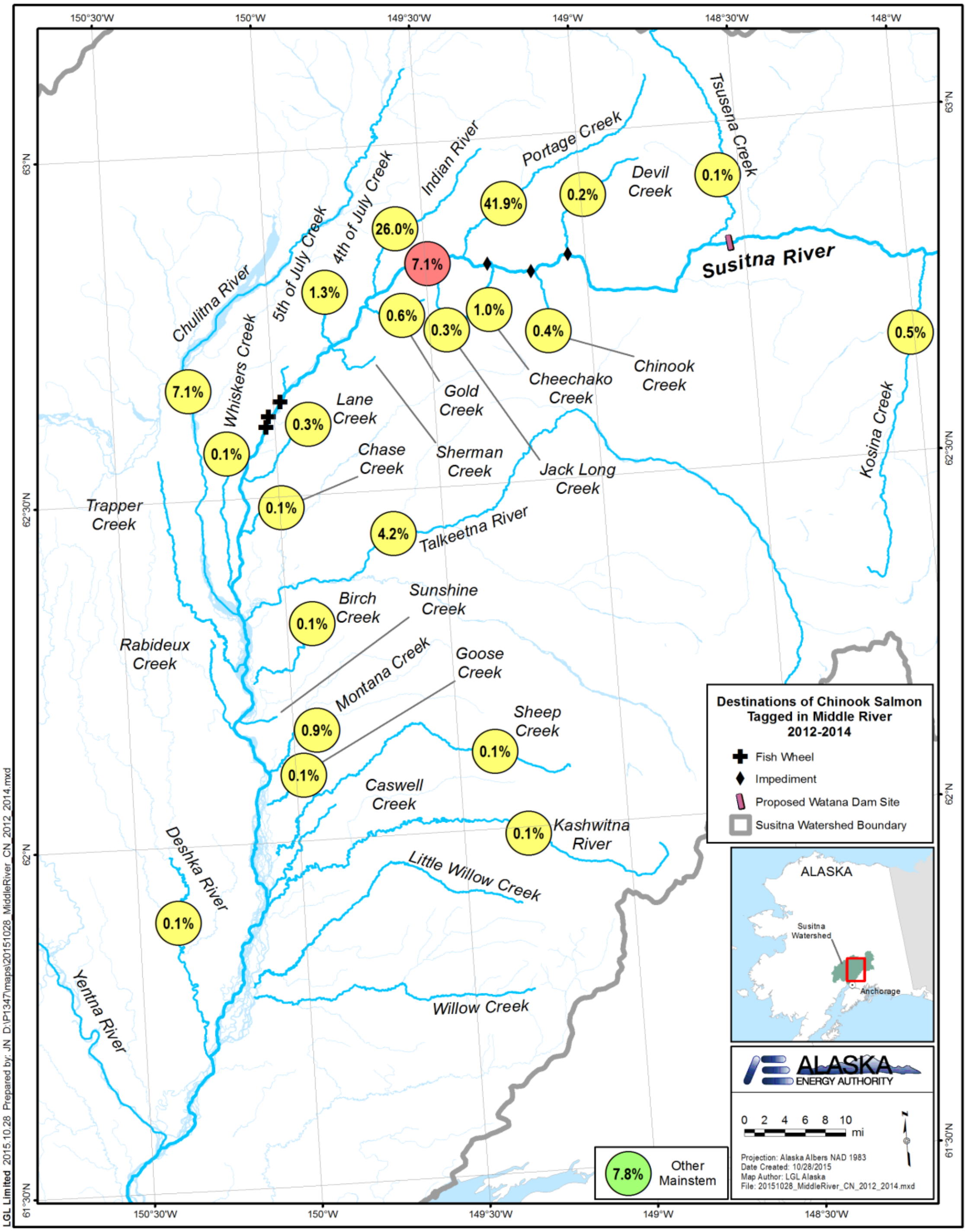

Figure D-2. Destinations for radio-tagged Chinook Salmon released in the Middle River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

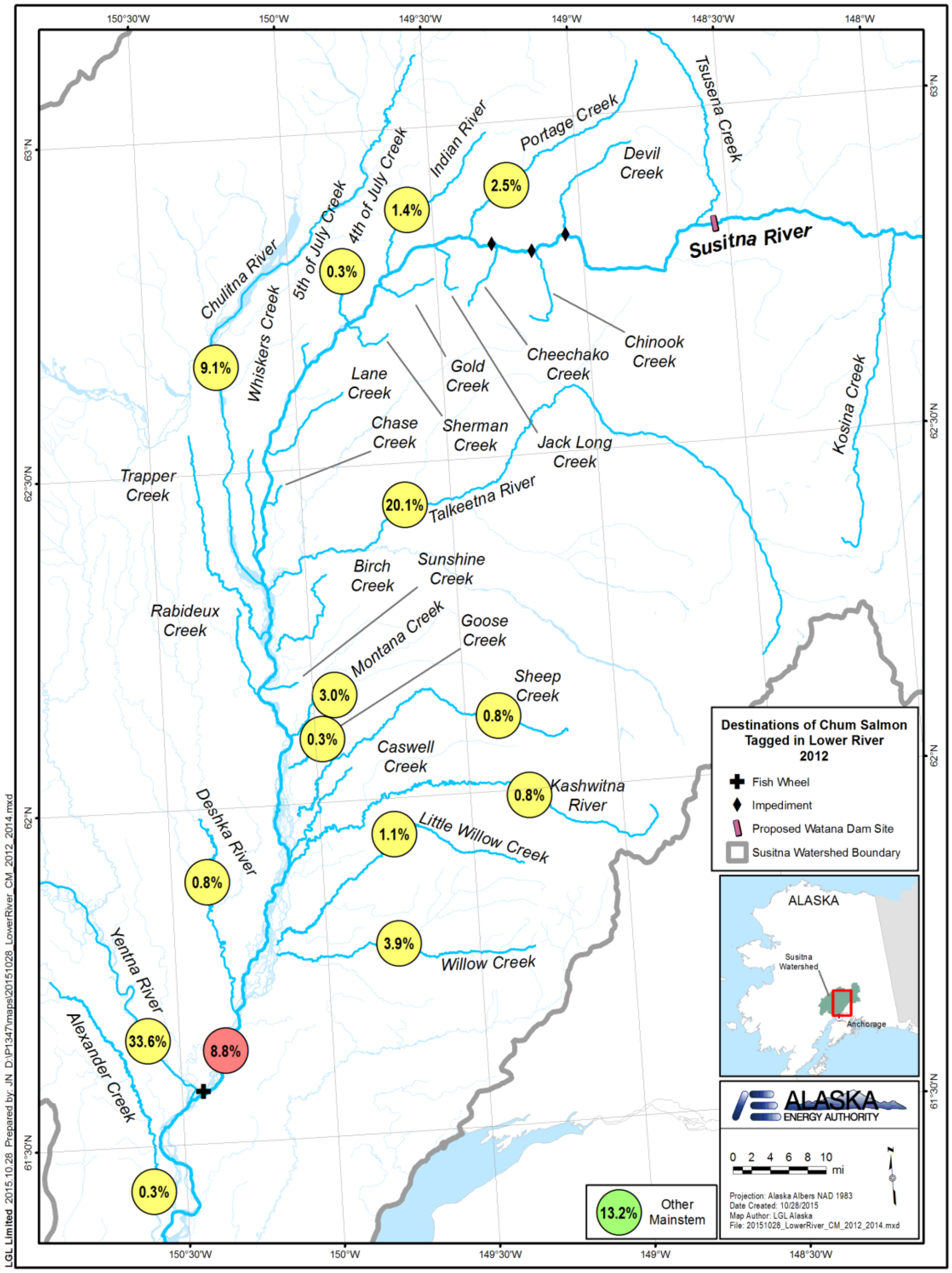

Figure D-3. Destinations for radio-tagged Chum Salmon released in the Lower River in 2012. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

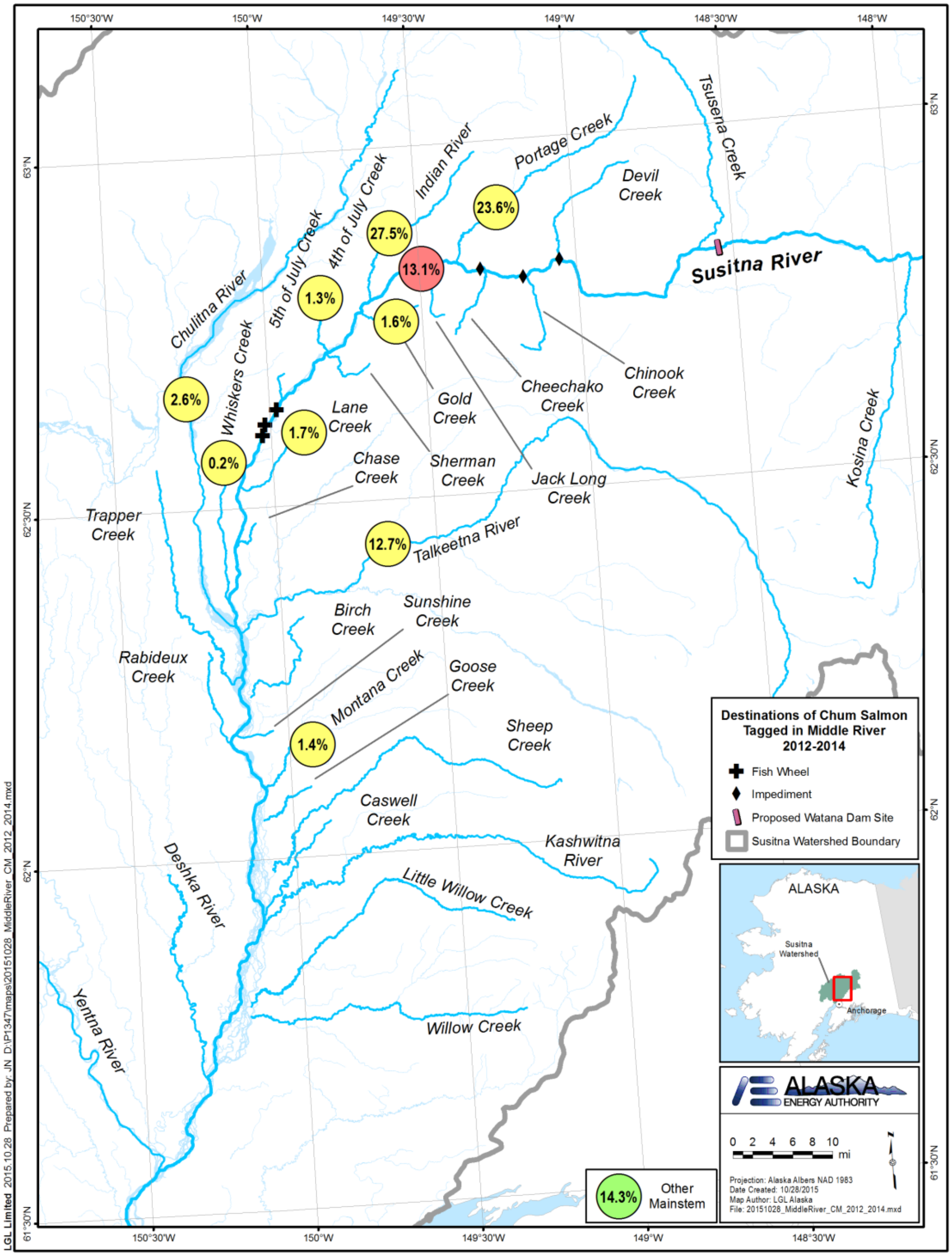

Figure D-4. Destinations for radio-tagged Chum Salmon released in the Middle River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

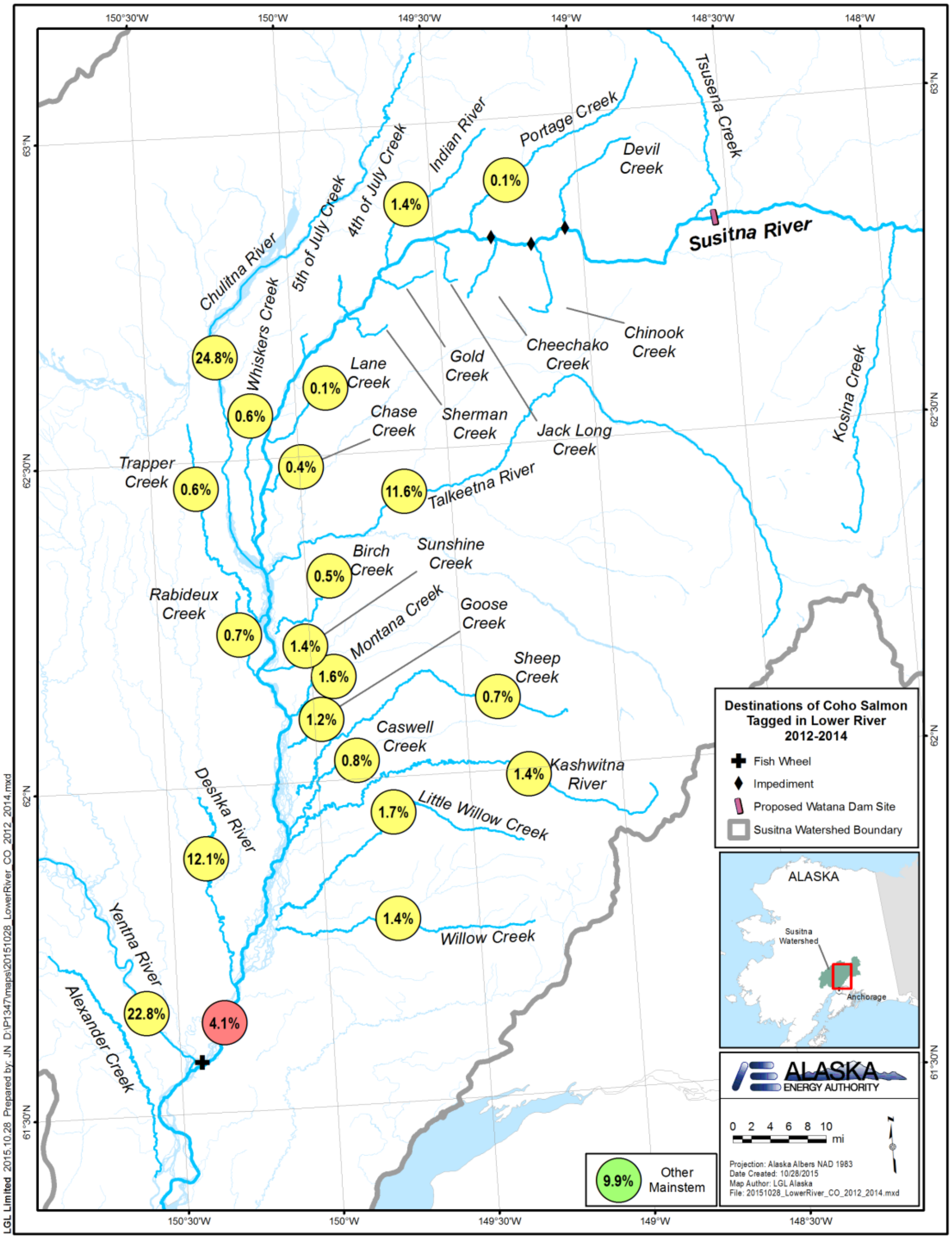

Figure D-5. Destinations for radio-tagged Coho Salmon released in the Lower River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

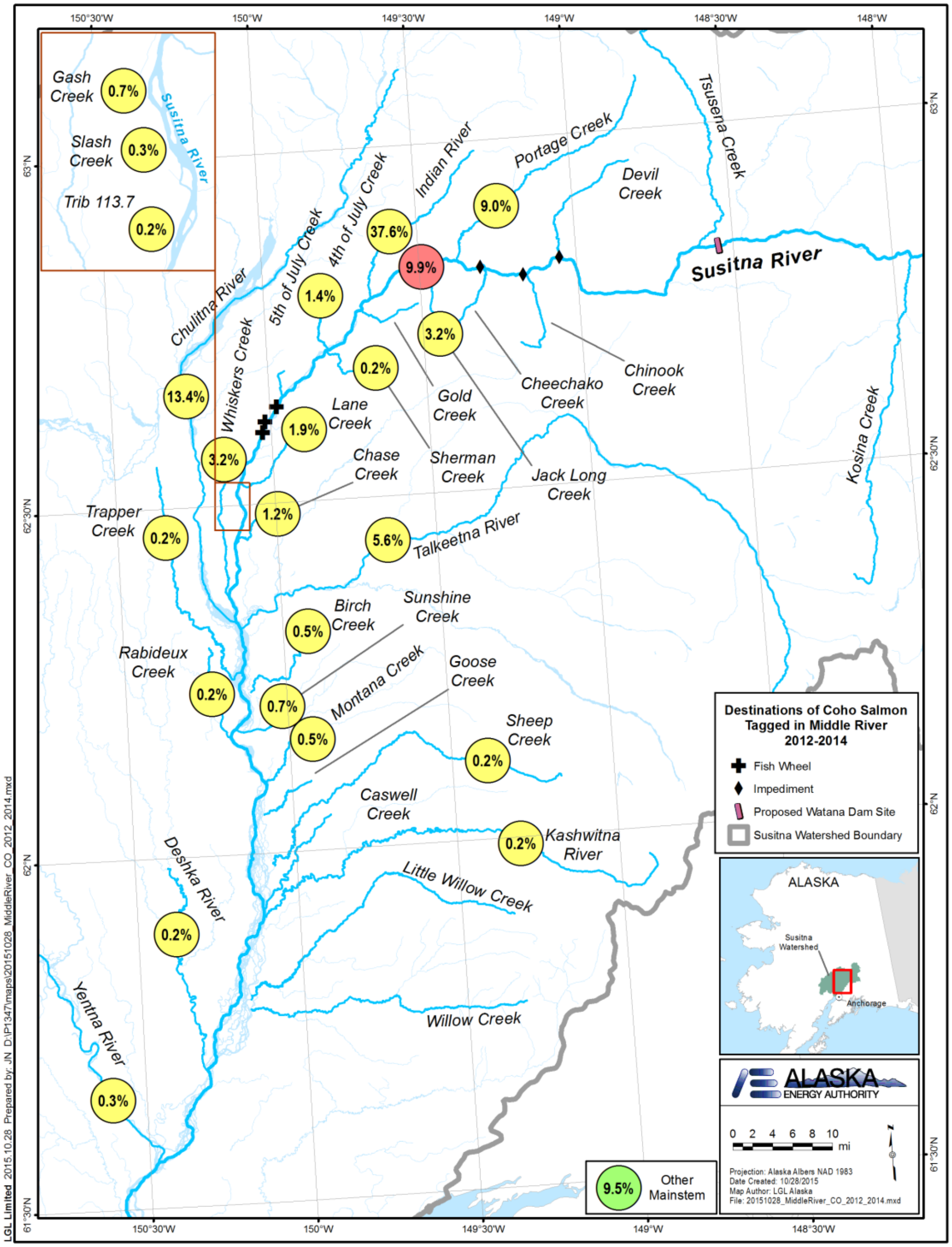

Figure D-6. Destinations for radio-tagged Coho Salmon released in the Middle River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections that never moved, or moved only downstream.

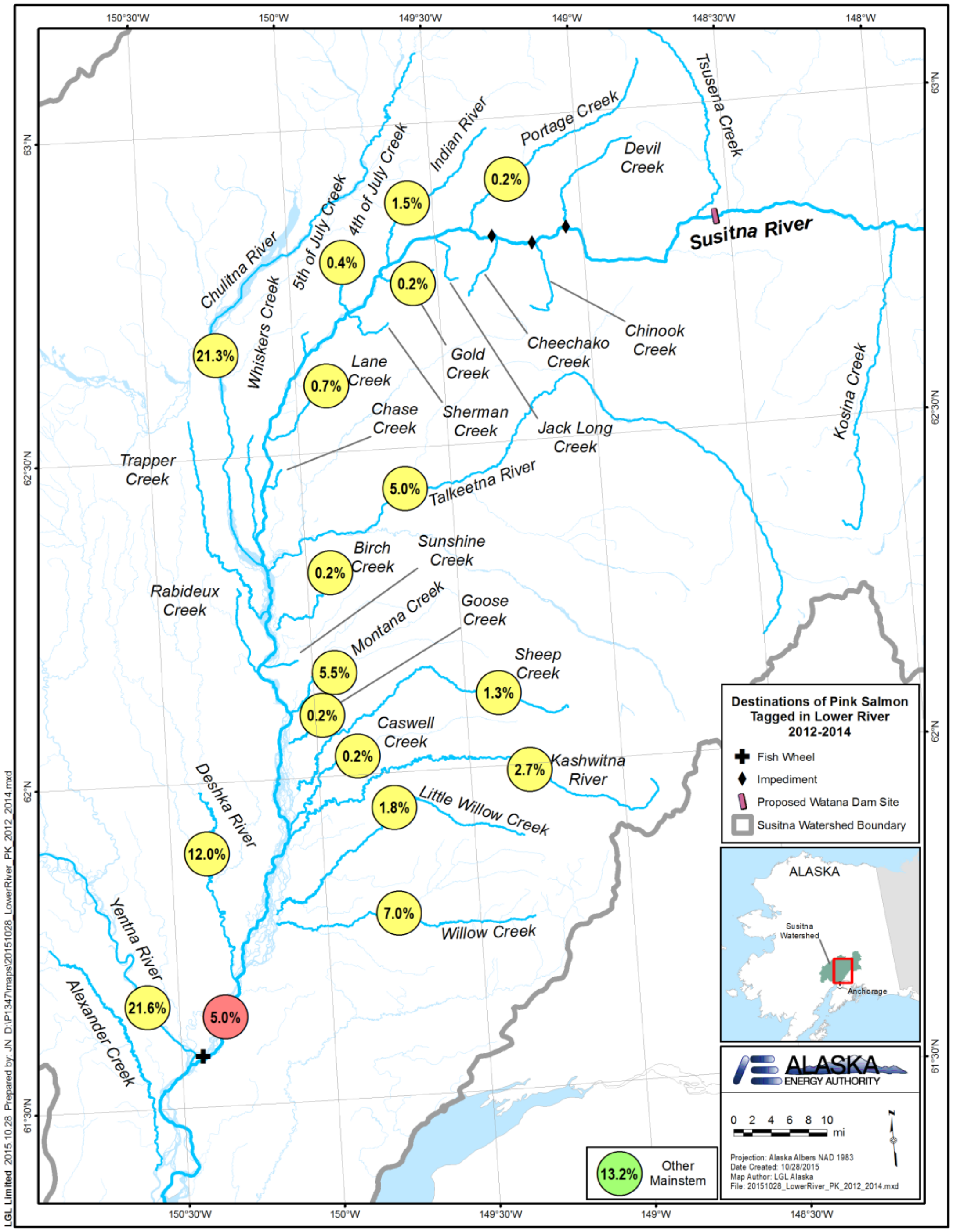

Figure D-7. Destinations for radio-tagged Pink Salmon released in the Lower River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

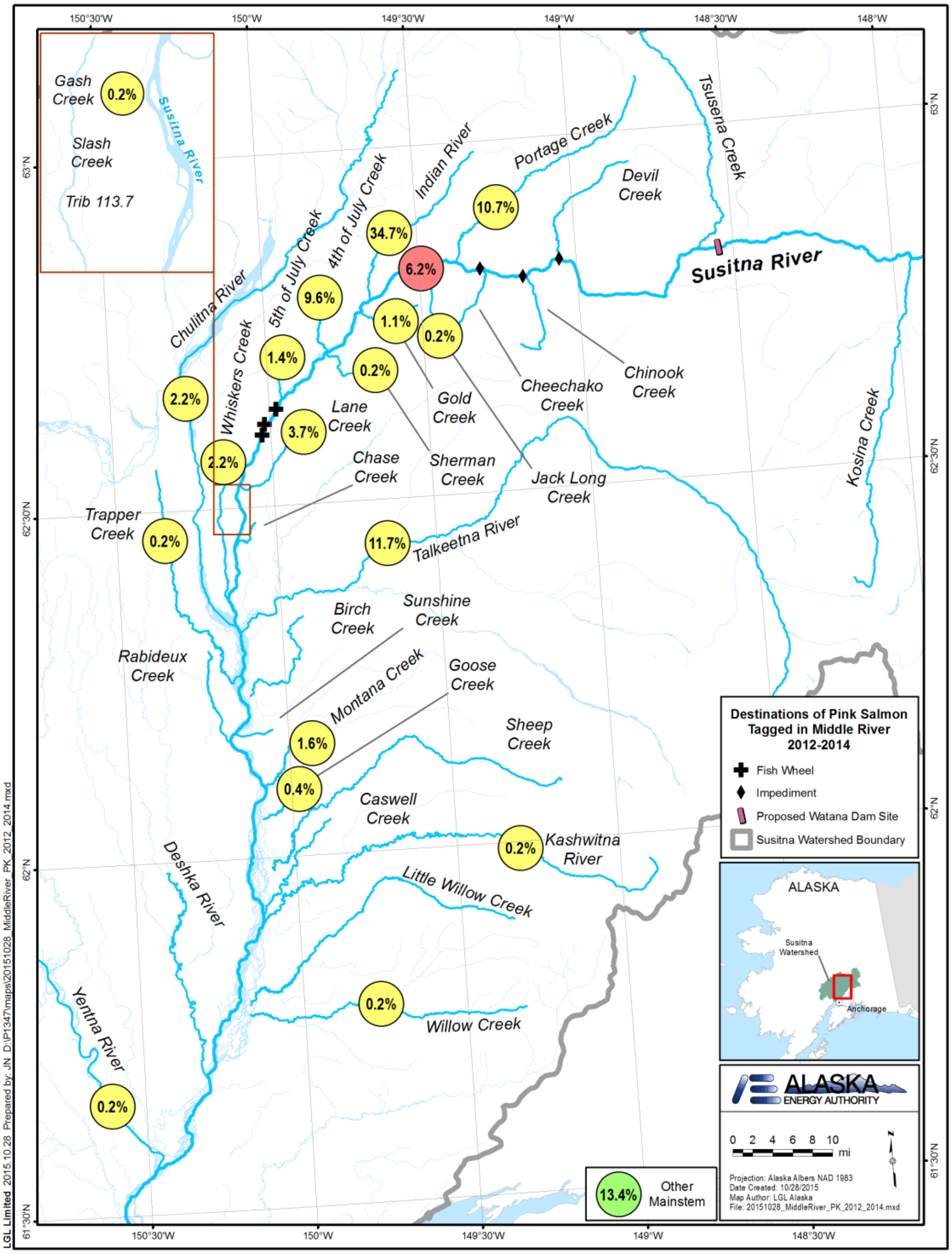

Figure D-8. Destinations for radio-tagged Pink Salmon released in the Middle River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

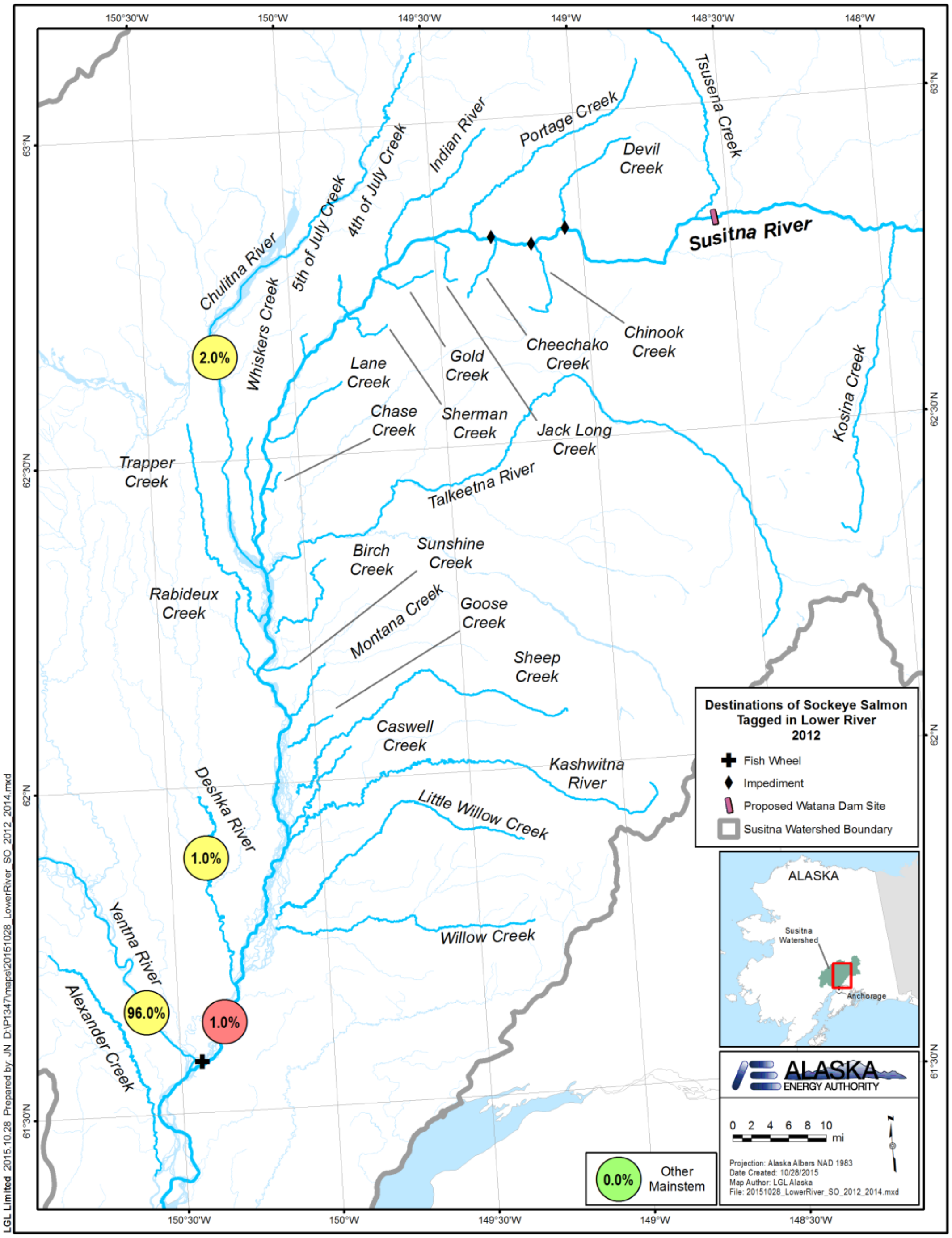

Figure D-9. Destinations for radio-tagged Sockeye Salmon released in the Lower River in 2012. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

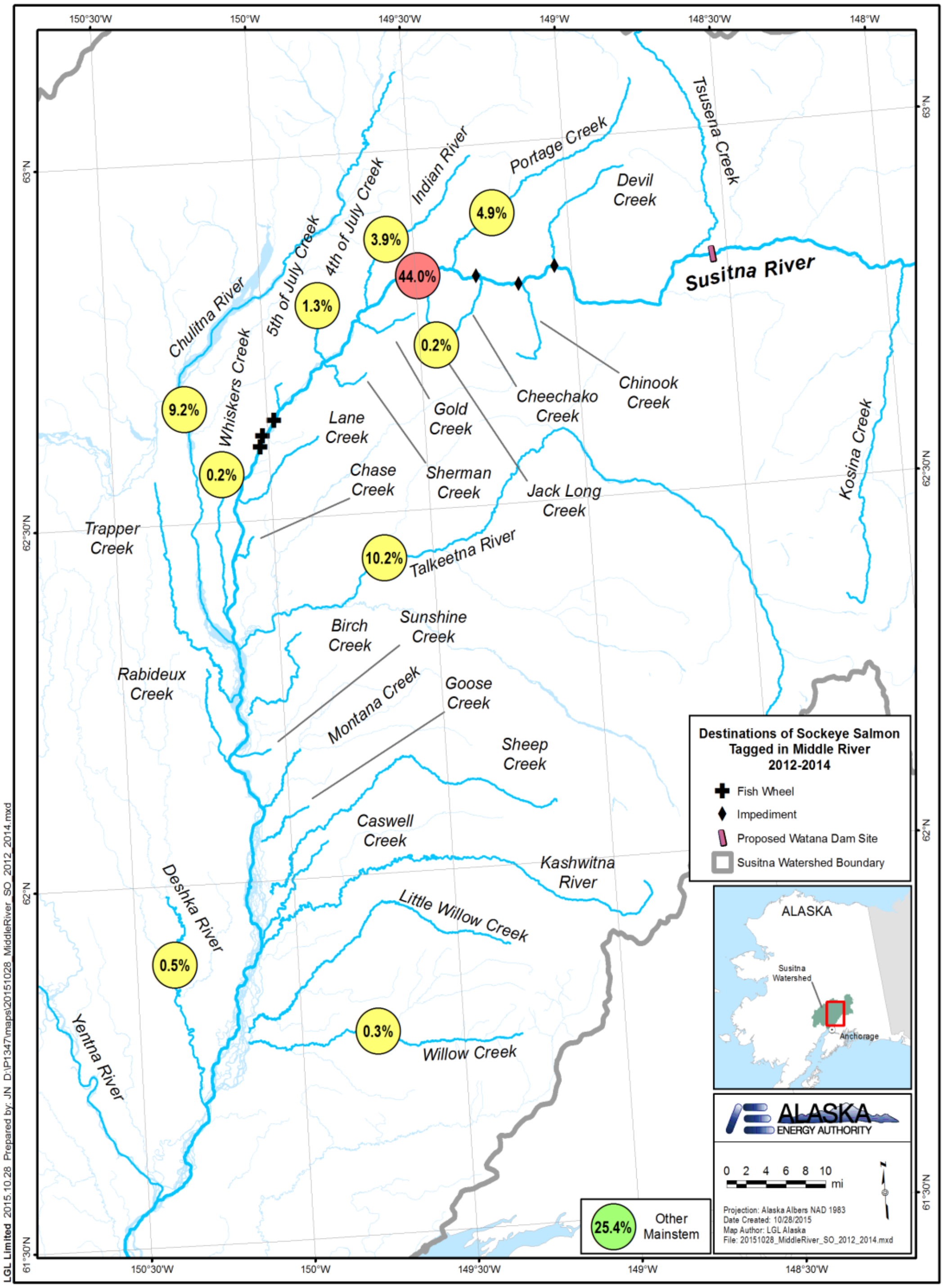

Figure D-10. Destinations for radio-tagged Sockeye Salmon released in the Middle River in 2012-2014. Proportions classified to tributary destinations are shown in yellow circles. The proportion classified to any mainstem destination is shown in an arbitrarily-placed pink circle. In the green circle shows the proportion of fish that were tracked but that could not be conclusively assigned to a destination Proportions are calculated from the total numbers of tags released, after excluding fish with one or fewer detections, that never moved, or moved only downstream.

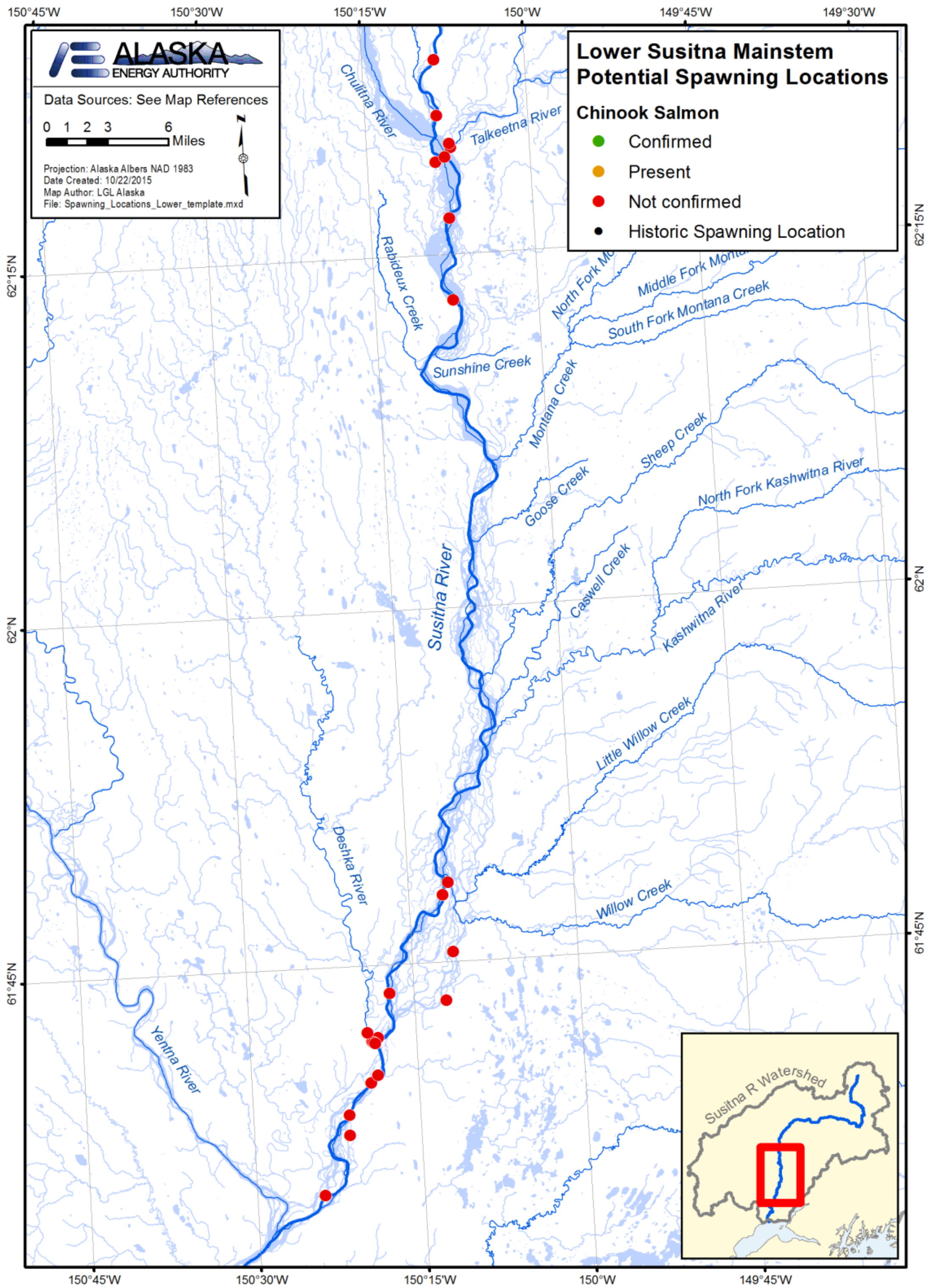

Figure D-11. Potential mainstem spawning sites for radio-tagged Chinook Salmon in the Lower River, PRM 40–104, 2012-2014. Red dots indicate locations of individual radio-tagged fish.

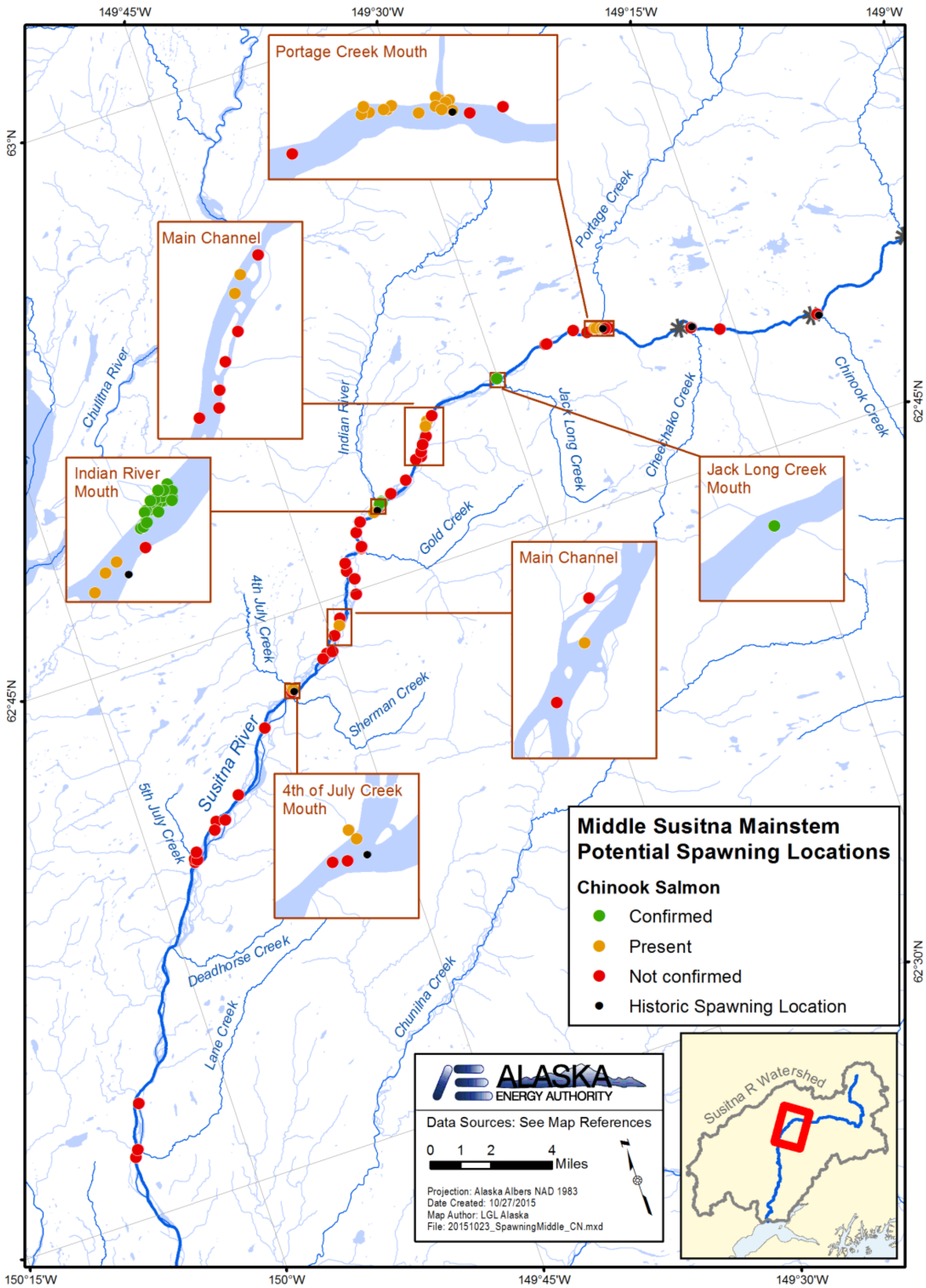

Figure D-12. Potential mainstem spawning sites for radio-tagged Chinook Salmon in the Middle River (red and yellow dots), PRM 103–157, 2012 - 2014. Colored dots (red, yellow, or green) indicate individual radio-tagged fish. Green dots also include locations that did not have a radio-tagged fish, but spawning was confirmed during opportunistic surveys. Black dots indicate spawning locations by project river mile confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986). Multiple green dots within an inset indicate a location that was confirmed for spawning and not each individual fish.

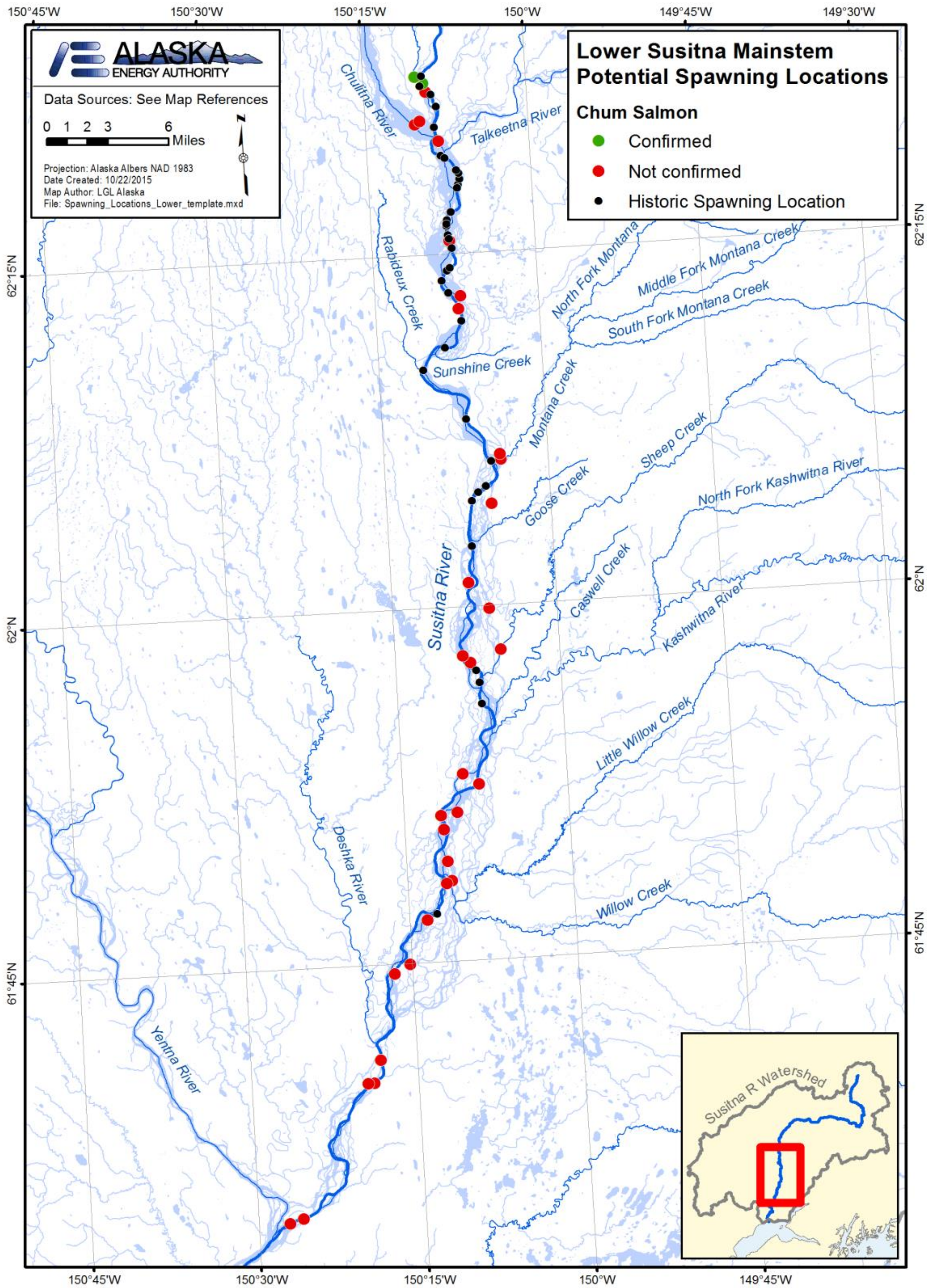

Figure D-13. Potential mainstem spawning sites for radio-tagged Chum Salmon in the Lower River, PRM 103–157, 2012 - 2014. Colored dots (red, yellow, or green) individual radio-tagged fish. Black dots indicate spawning locations confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986).

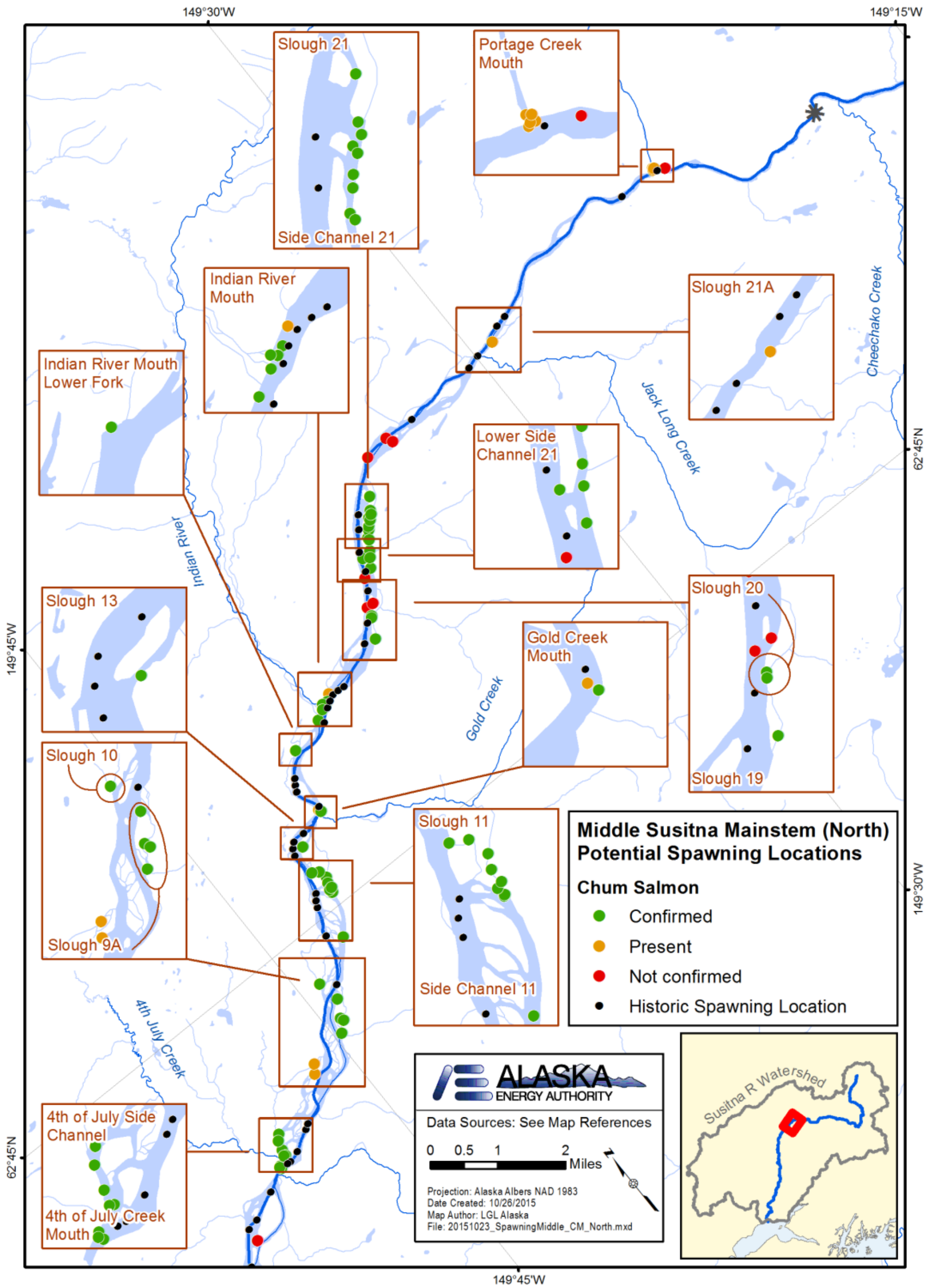

Figure D-14. Potential mainstem spawning sites for radio-tagged Chum Salmon in the northern half of the Middle River, PRM 40–104, 2012 - 2014. Colored dots (red, yellow, or green) indicate individual radio-tagged fish. Green dots also include locations that did not have a radio-tagged fish, but spawning was confirmed during opportunistic surveys. Black dots indicate spawning locations by project river mile confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986). Multiple green dots within an inset indicate a location that was confirmed for spawning and not each individual fish.

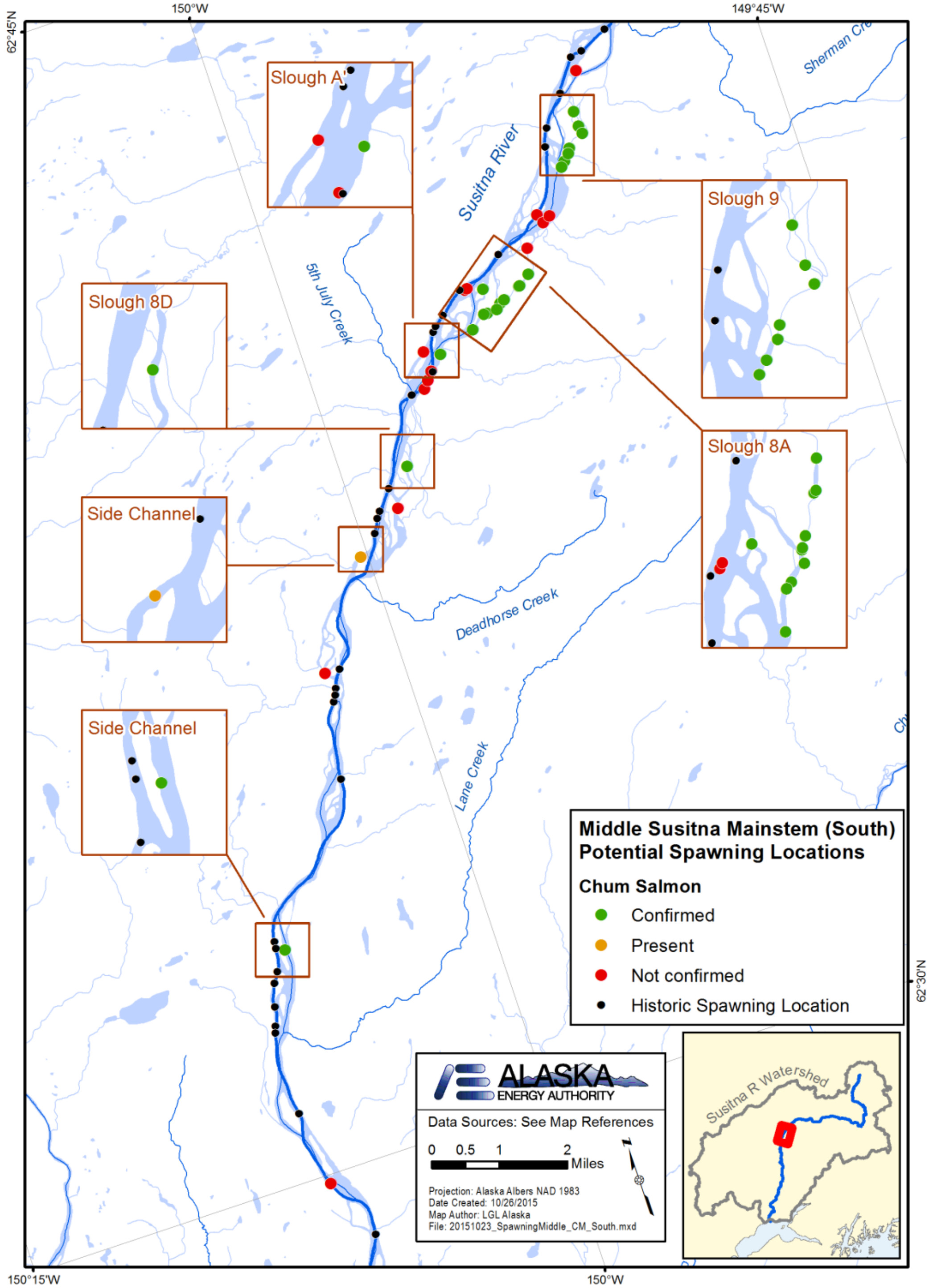

Figure D-15. Potential mainstem spawning sites for radio-tagged Chum Salmon in the southern half of the Middle River, PRM 103–157, 2012 -2014. Colored dots (red, yellow, or green) indicate individual radio-tagged fish. Green dots also include locations that did not have a radio-tagged fish, but spawning was confirmed during opportunistic surveys. Black dots indicate spawning locations by project river mile confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986). Multiple green dots within an inset indicate a location that was confirmed for spawning and not each individual fish.

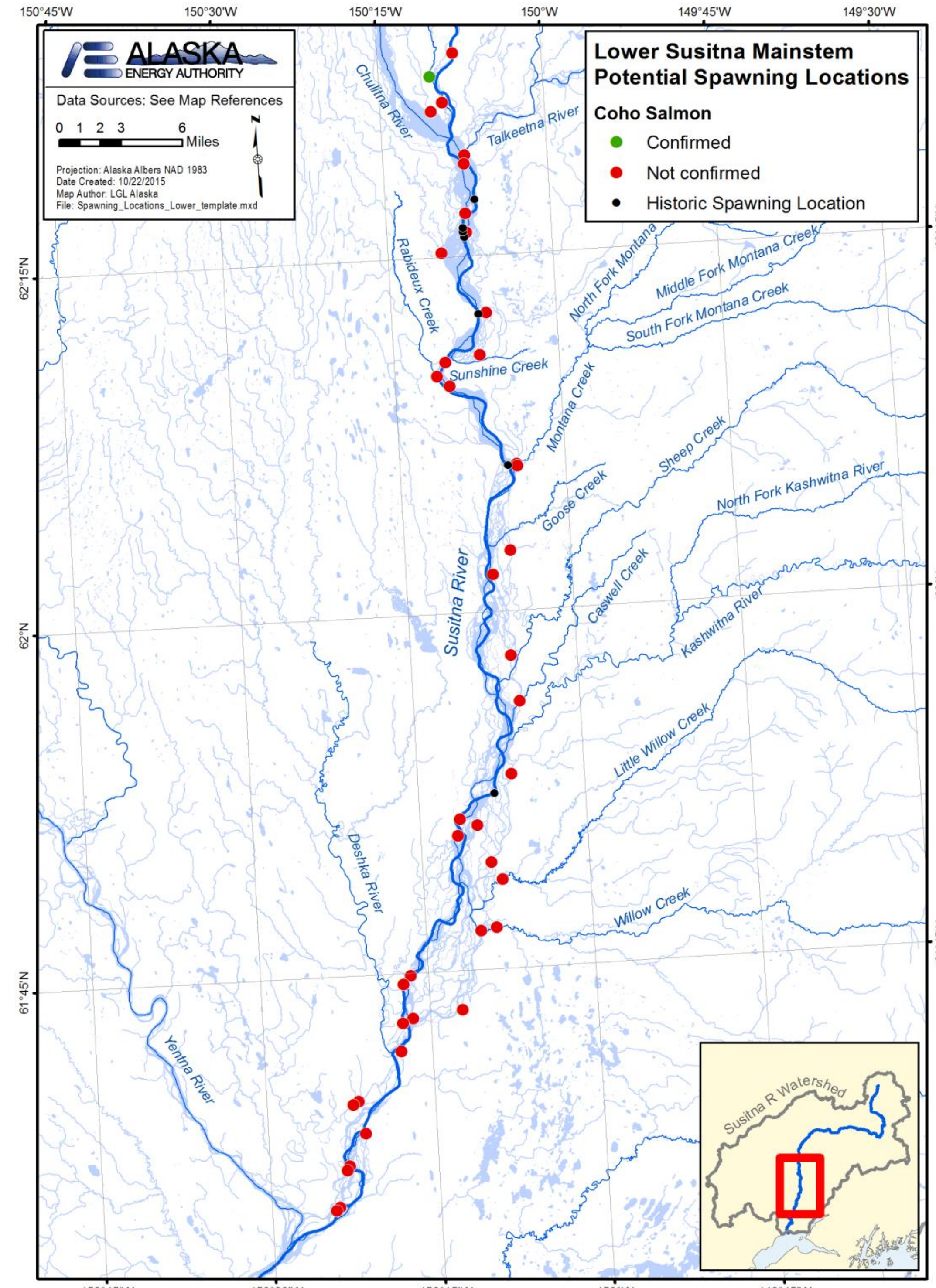

Figure D-16. Potential mainstem spawning sites for radio-tagged Coho Salmon in the Lower River, PRM 40–104, 2012 - 2014. Red dots represent individual radio-tagged fish. Black dots indicate spawning locations confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986).

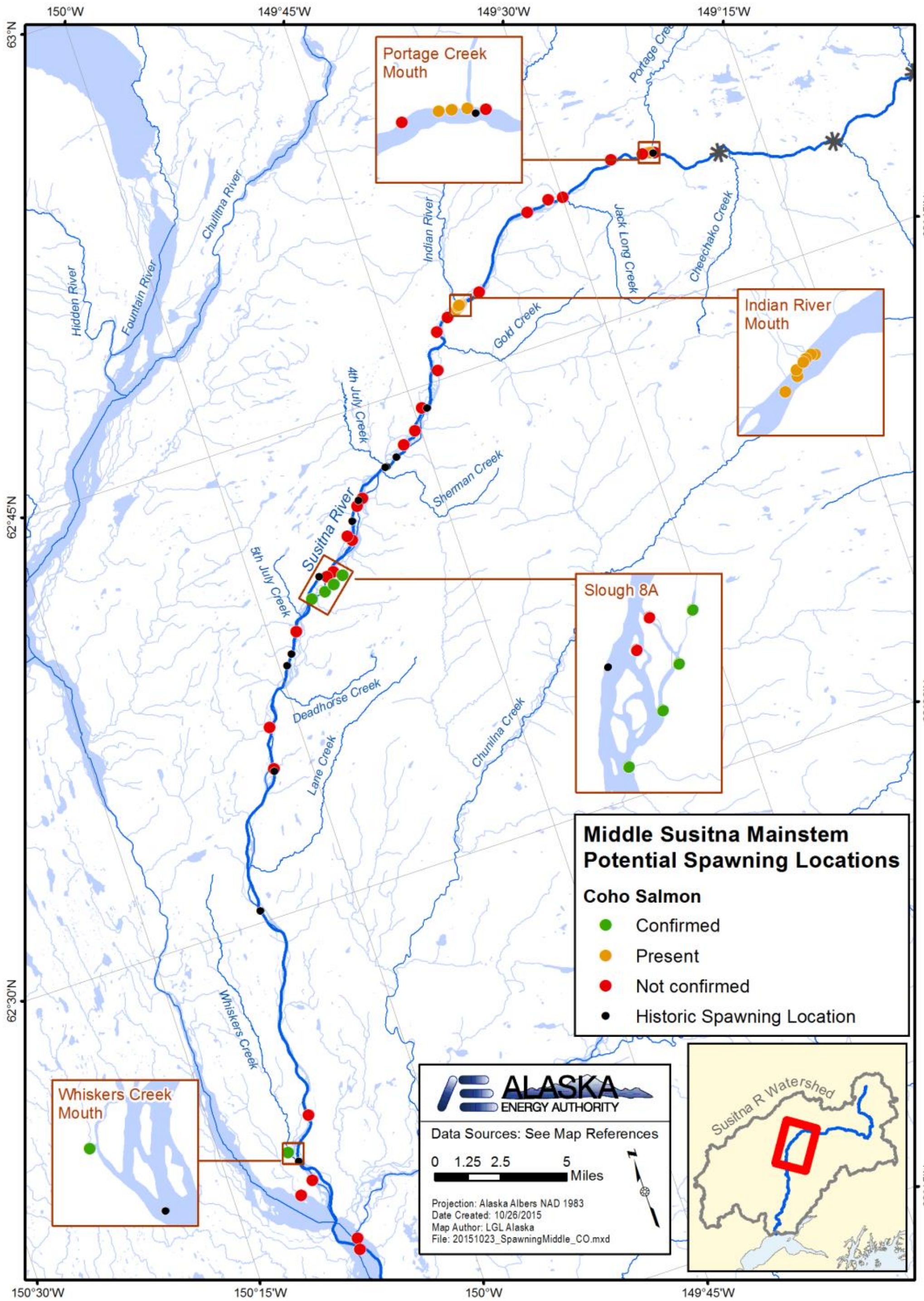

Figure D-17. Potential mainstem spawning sites for radio-tagged Coho Salmon in the Middle River, PRM 103–157, 2012 - 2014. Colored dots (red, yellow, or green) indicate individual radio-tagged fish. Green dots also include locations that did not have a radio-tagged fish, but spawning was confirmed during opportunistic surveys. Black dots indicate spawning locations by project river mile confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986). Multiple green dots within an inset indicate a location that was confirmed for spawning and not each individual fish.

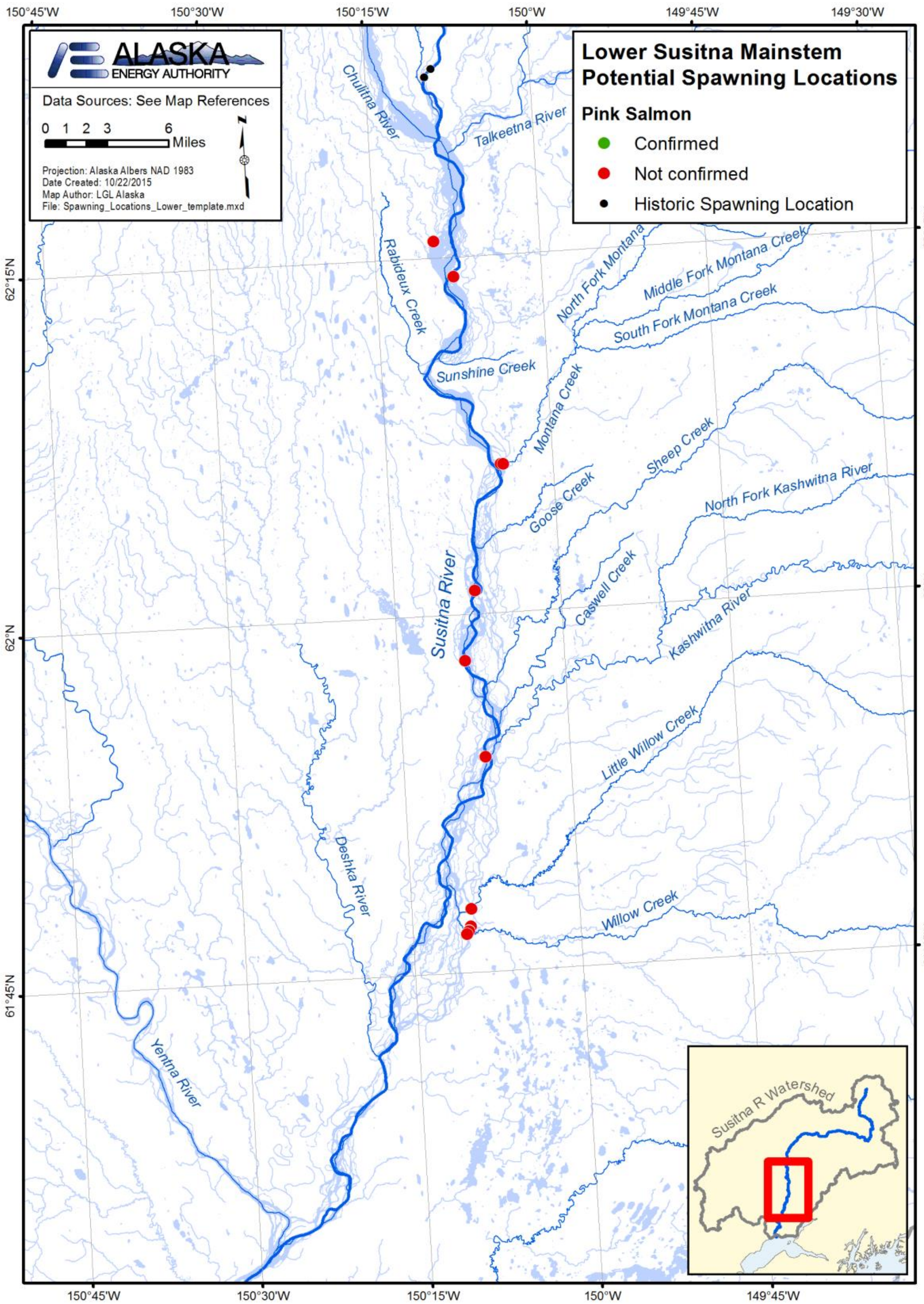

Figure D-18. Potential mainstem spawning sites for radio-tagged Pink Salmon in the Lower River, PRM103–157, 2012 -2014. Red dots represent individual radio-tagged fish.

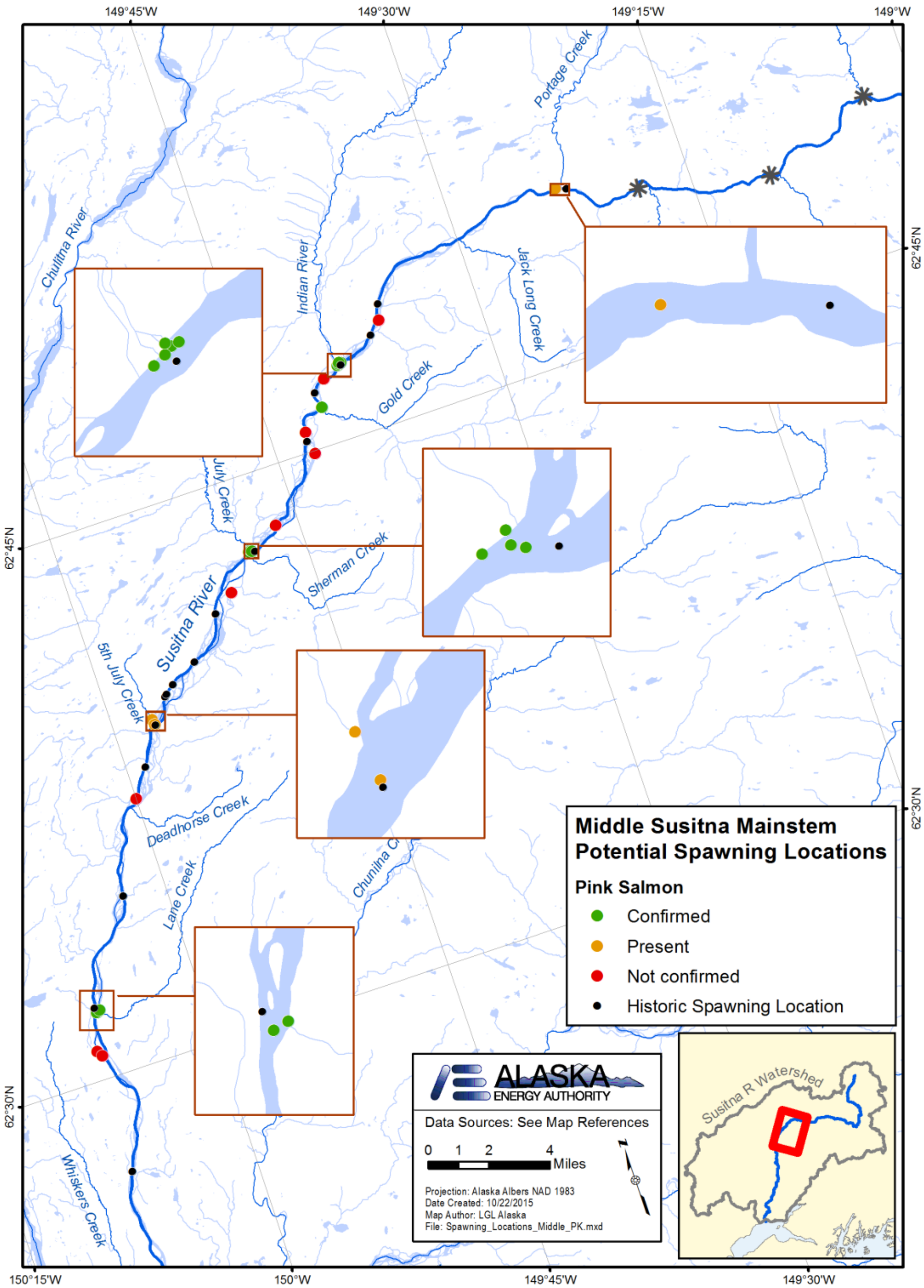

Figure D-19. Potential mainstem spawning sites for radio-tagged Pink Salmon in the Middle River, PRM 103–157, 2012 - 2014. Colored dots (red, yellow, or green) indicate individual radio-tagged fish. Green dots also include locations that did not have a radio-tagged fish, but spawning was confirmed during opportunistic surveys. Black dots indicate spawning locations by project river mile confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986). Multiple green dots within an inset indicate a location that was confirmed for spawning and not each individual fish.

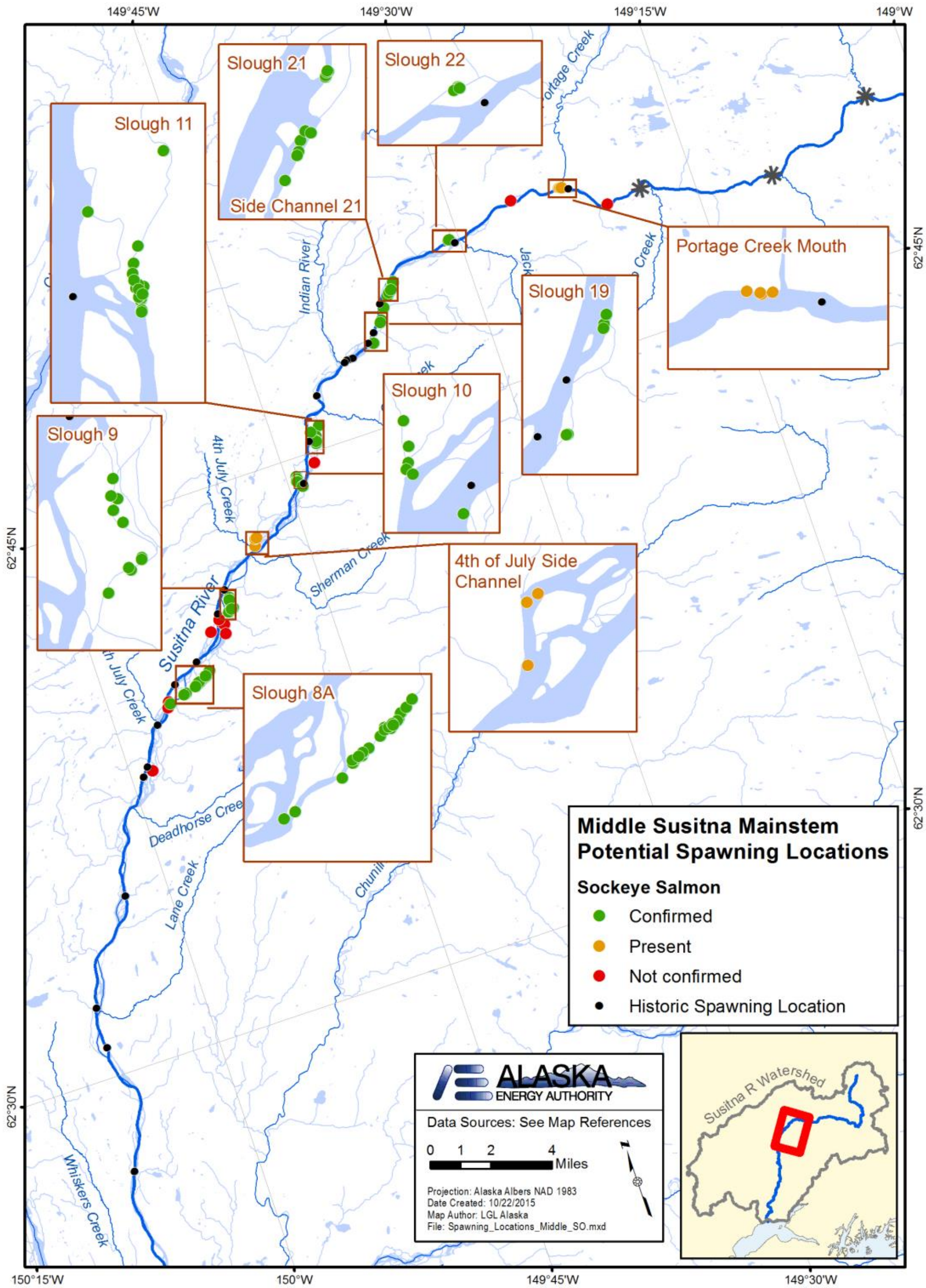

Figure D-20. Potential mainstem spawning sites for radio-tagged Sockeye Salmon in the Middle River, PRM 103–157, 2012 - 2014. Colored dots (red, yellow, or green) indicate individual radio-tagged fish. Green dots also include locations that did not have a radio-tagged fish, but spawning was confirmed during opportunistic surveys. Black dots indicate spawning locations by project river mile confirmed during historic surveys (summarized in Barrett et al. 1985a,b and Thompson et al. 1986). Multiple green dots within an inset indicate a location that was confirmed for spawning and not each individual fish.

Appendix E: Radio Tag Recoveries

Table E-1. Radio tag recovery information for fish released in the Lower River and Yentna River, 2014.

Species (Release Location)	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Chinook Salmon,	5245	23 Jun	Clear Cr., Talkeetna trib.	62.3799	-150.0162	angler
METF ≥ 50 cm	5285	22 Jun	Deshka River mouth	61.6976	-150.3173	angler
(Lower River)	5337	30 Jun	Clear Creek (Chunilna), river mile 1.75	62.3799	-150.0162	angler
	5340	14 Jun	Deshka River	61.7294	-150.3192	angler
	5374	18 Jun	Deshka River mouth	61.6976	-150.3173	angler
	5378	18 Jun	Deshka River	61.7294	-150.3192	angler
	5402	31 May	Deshka River mouth	61.6976	-150.3173	angler
	5416	4 Jun	Deshka River mouth	61.6976	-150.3173	angler
	5476	16 Jun	Deshka River mouth	61.6976	-150.3173	angler
	5492	1 Jul	Deshka River, river mile 17	61.7886	-150.3398	angler
	5494	30 Jun	Lake Creek mouth	61.9092	-150.9096	angler
	5552	15 Jun	Susitna R., 3/4 mi. below Montana Cr.	62.0720	-150.1022	angler
	5563	11 Aug	Peters Creek, 8mi. upstream from Petersville bridge	62.4611	-150.7463	angler
	5566	5 Aug	Middle Fork Chulitna River, by Parks Highway crossing	63.2553	-149.2454	angler
	5686	14 Jul	Sheep Creek mouth	61.9712	-150.0875	angler
	5693	1 Jul	Deshka River, 3 miles up	61.7418	-150.3119	angler
	5755	14 Jun	Deshka River above river mile 7	61.7886	-150.3398	angler
	5757	13 Jun	Deshka River mouth	61.6976	-150.3173	angler
	5774	14 Jun	Deshka River mouth	61.6976	-150.3173	angler
	5871	14 Jun	Deshka River mouth	61.6976	-150.3173	angler
	5876	14 Jun	Deshka River	61.7294	-150.3192	angler
	5881	22 Jun	Deshka River, 3/4mi. below Laub's homestead	61.7475	-150.3215	angler
	5889	1 Aug	Deception Creek, at Four Mile Road	61.7479	-149.9343	field crew
	5893	25 Jun	Deshka River, 2 mi. upstream	61.7294	-150.3192	angler
Chinook Salmon,	6513	28 Jul	Lake Creek	61.9307	-150.9127	angler
METF ≥ 50 cm	6696	11 Jul	Lake Cr. about 1 mi. upstream from Yentna	61.9307	-150.9127	angler
(Yentna River)	6724	20 Jun	Yentna River, mouth of Lake Cr.	61.9092	-150.9096	angler
	6753	16 Jun	Yentna River, mouth of Lake Creek, McDougal Slough	61.9092	-150.9096	angler

Table E-1. Continued.

Species	Tag	Date	Recovery Location[1]			Recovery
(Release Location)	Number	Recovered	Description	Latitude	Longitude	Method
Coho Salmon	5298	30 Jul	Little Willow Creek	61.8101	-150.1020	angler
(Lower River)	5300	1 Aug	Deshka River mouth	61.6976	-150.3173	angler
	5398	21 Aug	Talkeetna River	62.3393	-150.1042	angler
	5946	11 Aug	Sunshine Creek	62.1782	-150.1032	angler
	5983	24 Aug	Trapper Creek [assume at the mouth]	62.2551	-150.1723	angler
	5985	8 Aug	Deshka mouth	61.6976	-150.3173	angler
	6031	22 Aug	Talkeetna River, foot of Mainstem	62.3287	-150.1136	angler
	6055	9 Aug	Talkeetna River, 2.5 miles upstream	62.3484	-150.0578	angler
	6105	9 Aug	Talkeenta River	62.3393	-150.1042	angler
	6108	18 Jul	Deshka River mouth	61.6976	-150.3173	angler
	6127	1 Aug	Deshka River	61.7294	-150.3192	angler
	6137	4 Aug	Willow Creek mouth	61.7833	-150.1671	angler
	6140	6 Aug	Kashwitna River, 0.25 up from mouth	61.9146	-150.0964	angler
	6156	24 Aug	Trapper Creek [assume at the mouth]	62.2531	-150.1680	angler
	6157	16 Aug	Rabideux Creek mouth	62.1750	-150.1933	angler
	6182	16 Aug	Clear Creek	62.3799	-150.0162	angler
	6202	4 Aug	Whiskers Creek	62.3770	-150.1720	angler
	6210	15 Aug	Deshka River (Moose Creek at Oilwell Rd.)	61.7538	-150.3265	angler
	6213	15 Aug	Clear Creek	62.3799	-150.0162	angler
	6244	6 Aug	Deshka mouth	61.6976	-150.3173	angler
	6253	21 Aug	Talkeetna River, ~2 miles up	62.3463	-150.0754	angler
	6260	10 Aug	Clear Creek mouth (Chunilna)	62.3799	-150.0162	angler
	6260	31 Aug	Clear Creek (Talkeenta River)	62.3799	-150.0162	angler
	6264	1 Aug	Deshka River mouth	61.6976	-150.3173	angler
	6285	27 Aug	Kashwitna River, 0.5 mile up from RR Bridge	61.9383	-150.0455	angler
	6296	15 Aug	Willow Creek mouth	61.7833	-150.1671	angler
	6341	11 Aug	Montana Creek mouth	62.1045	-150.0757	angler
	6393	23 Aug	Talachulitna, Mouth	61.8658	-151.4143	angler
	6413	20 Aug	Troublesome Creek, Mouth	62.6546	-150.2399	angler
	6420	15 Aug	Deshka River, about 1 mile upstream	61.7294	-150.3192	angler

Table E-1. Continued.

Species (Release Location)	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Coho Salmon	6429	16 Aug	Sunshine Creek, 100 yards above Susitna confluence	62.1782	-150.1032	angler
(Lower River)	6459	31 Jul	Deshka River	61.7294	-150.3192	field crew
	6488	17 Aug	Little Willow mouth	61.7986	-150.1519	angler
	6489	17 Aug	Montana Creek mouth	62.1045	-150.0757	angler
	6495	19 Aug	Sheep Creek	61.9915	-150.0725	angler
	6498	29 Aug	Talkeetna River	62.3393	-150.1042	angler
Coho Salmon	6806	24 Aug	Deshka River, ~4 miles up	61.7538	-150.3265	other
(Yentna River)	6851	6 Aug	Deshka weir	61.7856	-150.3450	field crew
Pink Salmon	5058	6 Aug	Willow Creek, downstream of Deception Creek mouth	61.7788	-150.1259	angler
(Lower River)	5174	30 Jul	Montana Creek	62.1056	-150.0486	angler

[1] Recovery coordinates were estimated based on the site description; radio tag recoveries only.

Table E-2. Radio tag recovery information for fish released in the Middle River, 2014.

Species	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Chinook Salmon	48	16 Jul	Indian River	62.8263	-149.6484	other
(METF ≥ 50 cm)	48	16 Jul	Indian River	62.8263	-149.6484	other
	160	19 Aug	Indian River (mile 266.7 on RR)	62.8394	-149.6435	other
	245	3 Jul	Susitna River at Indian	62.7845	-149.6596	angler
	297	7 Aug	Twin Bridges South of Curry	62.8394	-149.6435	angler
	333	1 Jul	LGL Fishwheel 3	62.6374	-149.9775	field crew
	388	2 Jul	LGL Fishwheel 3	62.6374	-149.9775	field crew
	459	25 Aug	LGL Fishwheel 3	62.6374	-149.9775	field crew
	564	29 Jul	LGL Fishwheel 3	62.6374	-149.9775	field crew
	590	29 Jul	LGL Fishwheel 3	62.6374	-149.9775	field crew
	739	22 Jul	LGL Fishwheel 3	62.6374	-149.9775	field crew
	806	3 Oct	Mouth of Jack Long	62.8227	-149.4976	other
	812	10 Aug	Indian River mouth	62.7845	-149.6596	angler
Chum Salmon	1680	4 Sep	4th of July Mouth	62.7156	-149.8053	field crew
Coho Salmon	2130	22 Aug	Portage Creek	62.8384	-149.3741	angler
	2810	27 Aug	Talkeetna River, just below Clear Creek	62.3799	-150.0162	angler
Pink Salmon	1664	4 Sep	4th of July Mouth	62.7156	-149.8053	field crew
	2073	20 Aug	Montana Creek Weir	62.1056	-150.0486	field crew
Sockeye Salmon	1346	26 Sep	in a slough at PRM141	62.7832	-149.6696	other
	1927	12 Oct	RM 145, ouside Slough 21	62.8137	-149.5802	other
	1950	7 Aug	Larson Creek	62.3708	-149.8563	angler
	2330	10 Oct	Chase Creek	62.4447	-150.1321	other
	2609	11 Sep	Disappointment Creek (trib to Talkeetna R)	62.4556	-149.6672	other

[1] Recovery coordinates were estimated based on the site description

Appendix F: Tracking histories of chinook salmon above Impediment 3

Table F-1. Summary of migration and spawning behavior for radio-tagged Chinook Salmon after they passed Impediment 3, 2012–2014.

					Spawning Period			Explorations Before Spawning			Downstream After Spawning			
Tag Number	Capture Date	Length (cm)	Sex	Spawning Area	First Live	Last Live	Days	Max Upstream Location	Max Upstream Distance	Days	Max Downstream Location	Max Downstream Distance	Days	Total Live Days[1]
2012														
27	22 Jun	78 TL	Undetermined	Chinook	28 Jul	5 Aug	8	Kosina Mouth	80	11	Curry	60	8	26
52	25 Jun	89 TL	Undetermined	Kosina	20 Jul	9 Aug	20	-	-	-	-	-	-	28
94	29 Jun	81 TL	Undetermined	Devil	23 Jul	5 Aug	13	Fog	30	4	Cheechako	19	12	31
104	29 Jun	66 TL	Undetermined	Portage	24 Jul	30 Jul	6	Above Devil Creek	30	10	-	-	-	10
113	30 Jun	84 TL	Undetermined	Kosina	26 Jul	7 Aug	12	-	-	-	-	-	-	19
219	2 Jul	73 TL	Male	Kosina	23 Jul	26 Jul	3	Above Kosina	30	1	-	-	-	7
246	3 Jul	85 TL	Female	Kosina	23 Jul	26 Jul	3	-	-	-	-	-	-	6
257	3 Jul	89 TL	Female	Portage	30 Jul	17 Aug	18	Devil Creek	24	13	-	-	-	28
266	4 Jul	101 TL	Male	Portage	24 Jul	6 Aug	13	Near Fog	44	15	-	-	-	19
359	6 Jul	93 TL	Male	Portage	6 Aug	11 Aug	5	Kosina	93	26	-	-	-	25
5005	26 May	-	Undetermined	Kosina	23 Jul	31 Jul	8	-	-	-	Portage	103	16	30
5019	28 May	87 MEF	Undetermined	Kosina	23 Jul	11 Aug	19	-	-	-	-	-	-	24
2013														
241	21 Jun	64 MEF	Undetermined	Unknown	-	30 Aug	-	Near headwater	-	-	Below Talkeetna	-	-	45
272	23 Jun	64 MEF	Undetermined	Devils	30 Jul	12 Aug	14	Devils Creek	0	0	Devils Creek	0	0	13
395	26 Jun	65 MEF	Undetermined	Tsesena	22 Jul	1 Aug	11	near Deadman Creek	6.5	1	Tsusena Creek	0	0	19
2014														
537	4 Jul	80 MEF	Male	Unknown	-	9 Aug	-	Just Above I-3	-	-	-	-	-	36
787	11 Jul	78 MEF	Undetermined	Kosina	2 Aug	18 Aug *	17 *	Oshetna	40	5	-	-	-	20 *

* Motion sensor malfunctioned. Mortality date is approximate.

[1] Total days the fish was alive after passing Impediment 3 (accounts for the 1 day that tags must be motionless before going into mortality mode).

Notes:

Distances are in kilometers (1 km = 0.62 mi)

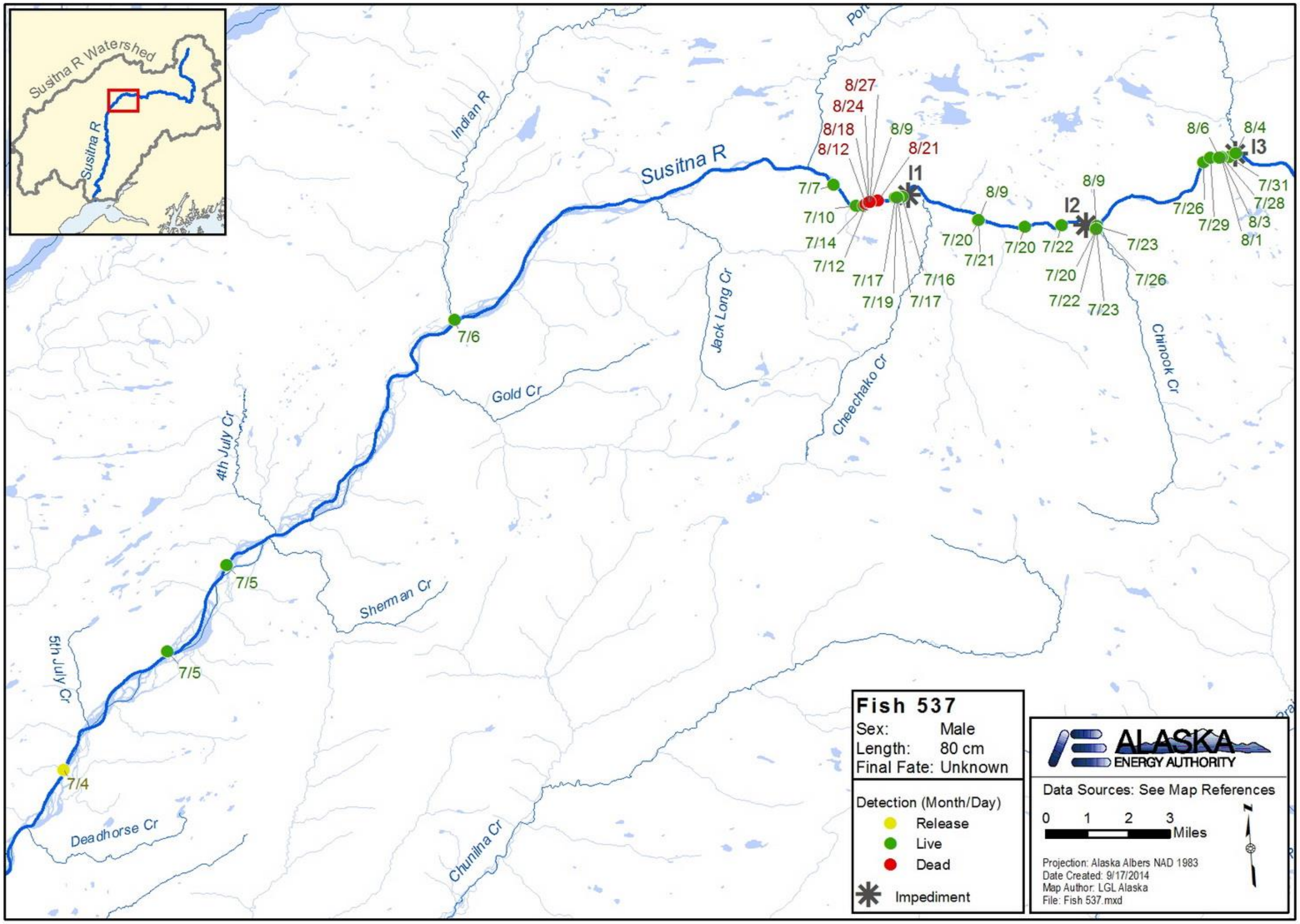

Figure F-1. Tracking history of a radio-tagged Chinook Salmon (tag #537) that was detected above Impediment 3, PRM 123–167, 2014.

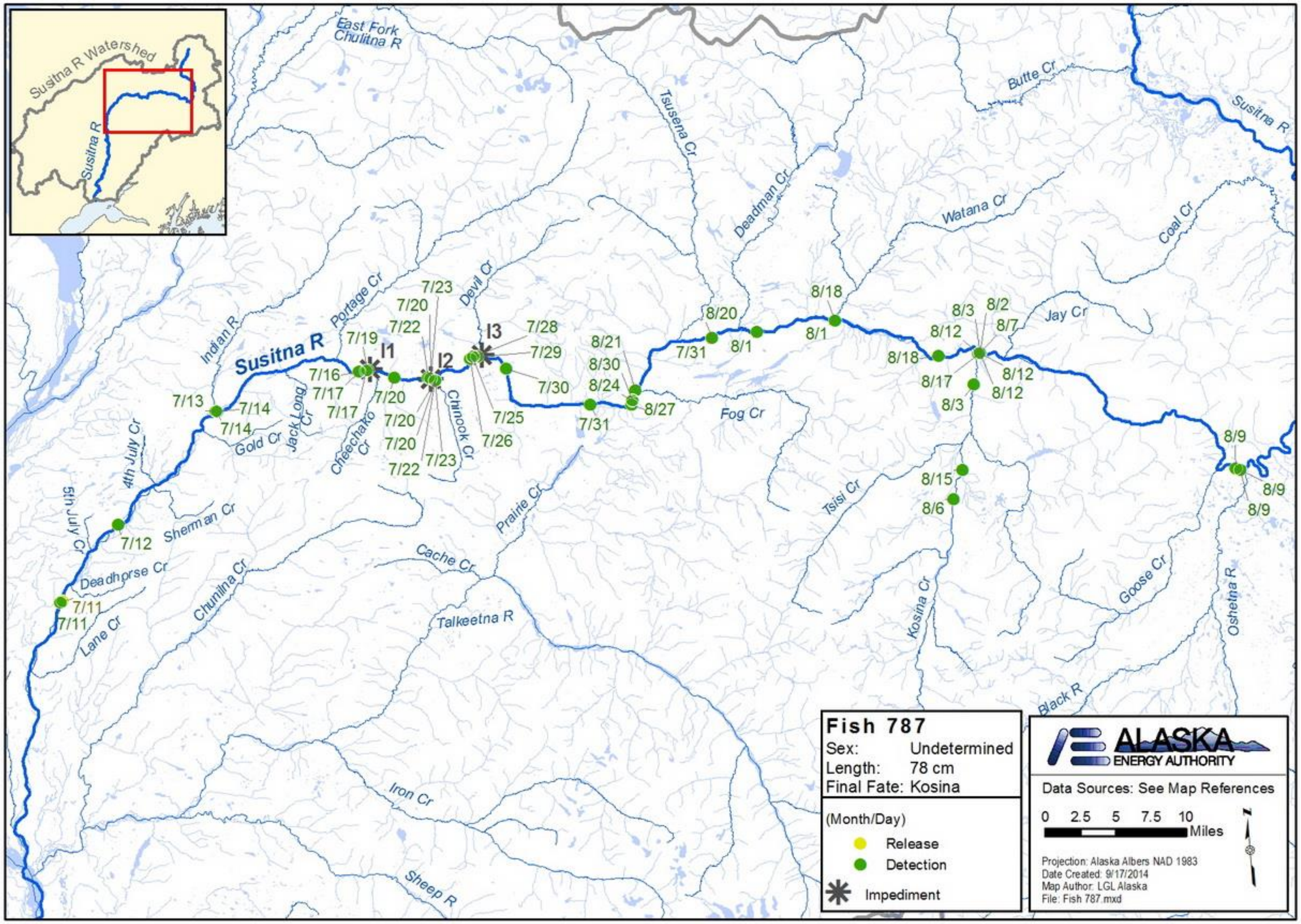

Figure F-2. Tracking history of a radio-tagged Chinook Salmon (tag #787) that was detected above Impediment 3, PRM 97–245, 2014.

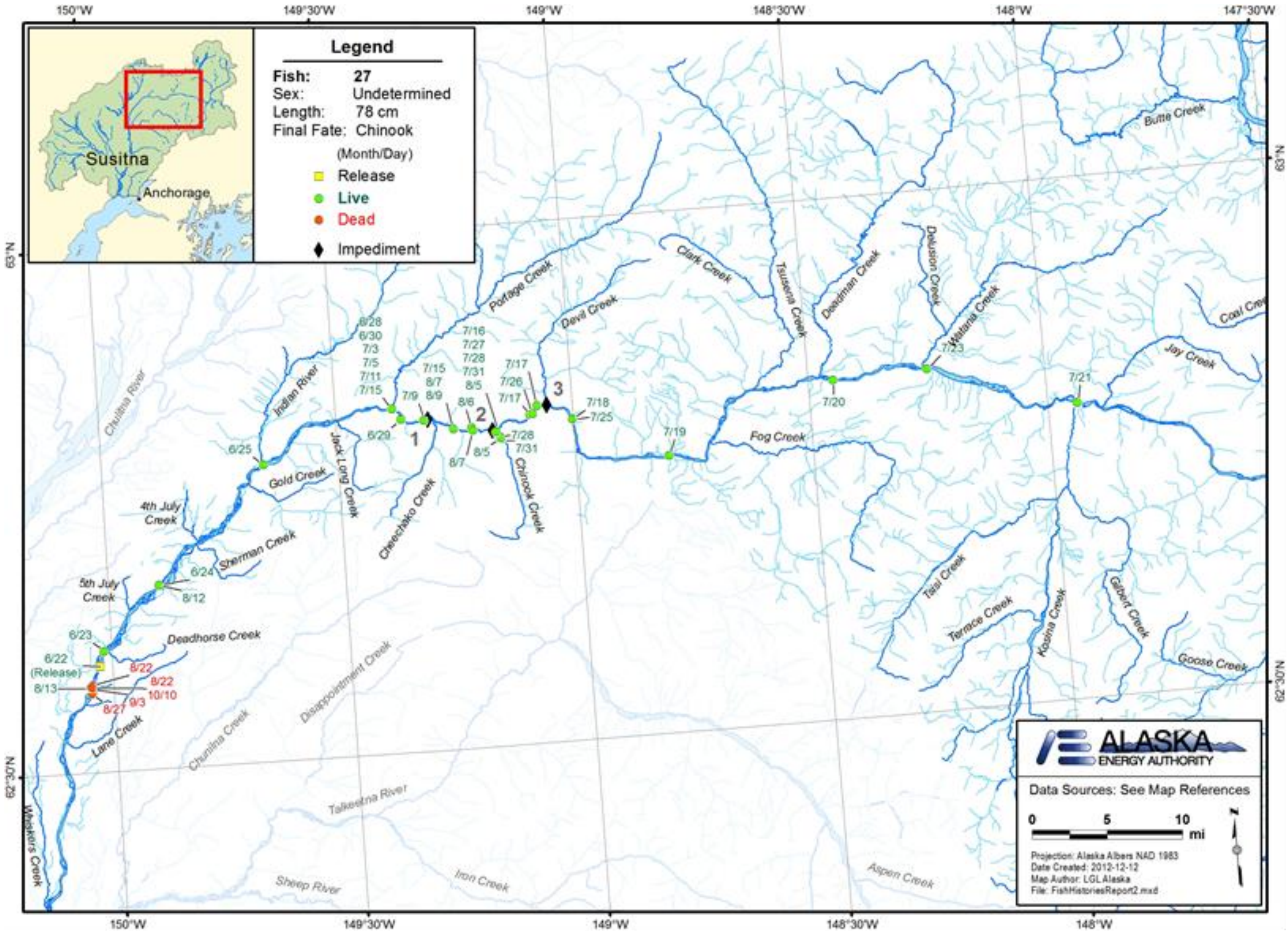

Figure F-3. Tracking history of a radio-tagged Chinook Salmon (tag #27) that was detected above Impediment 3, 2012.

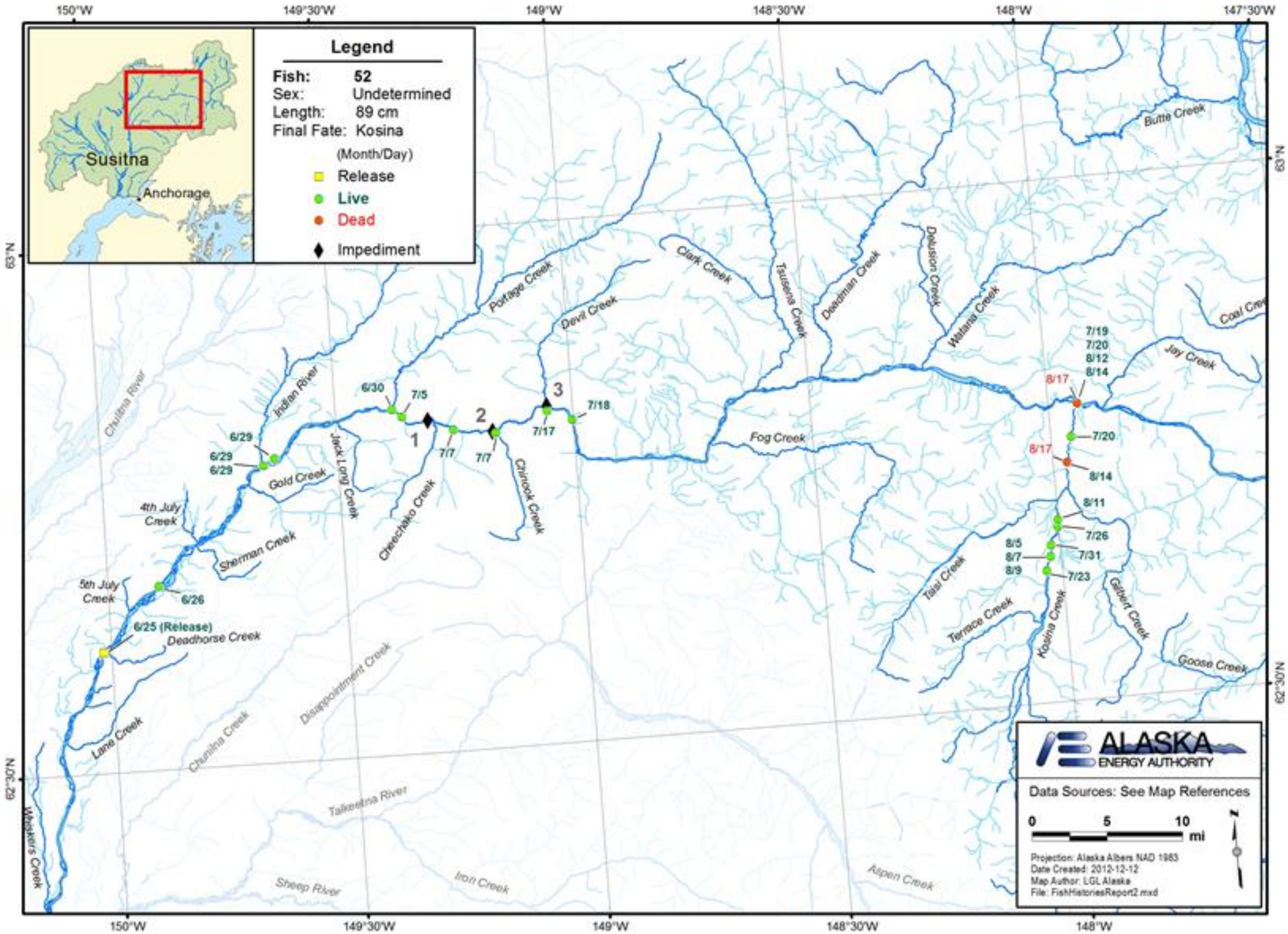

Figure F-4. Tracking history of a radio-tagged Chinook Salmon (tag #52) that was detected above Impediment 3, 2012.

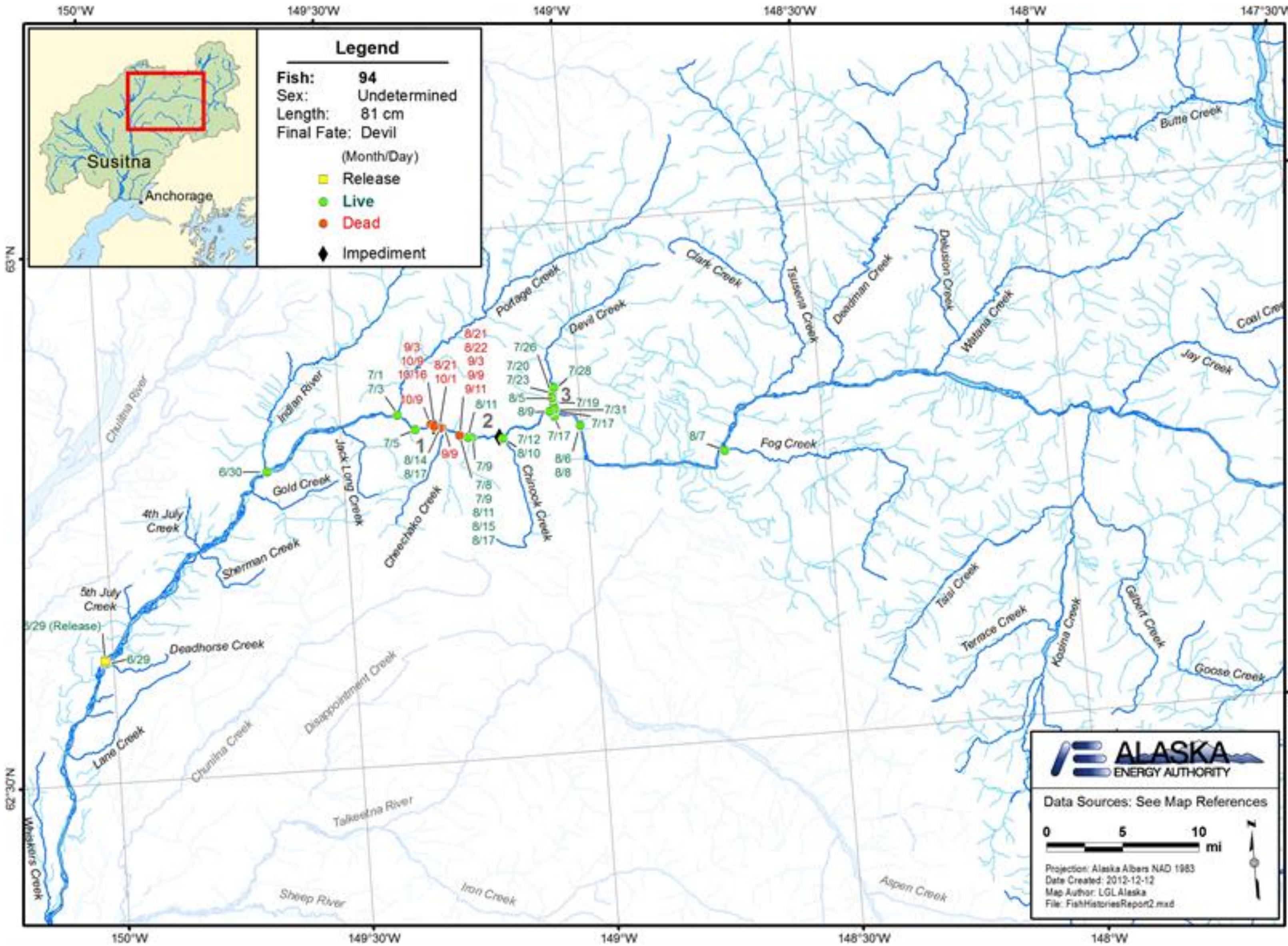

Figure F-5. Tracking history of a radio-tagged Chinook Salmon (tag #94) that was detected above Impediment 3, 2012.

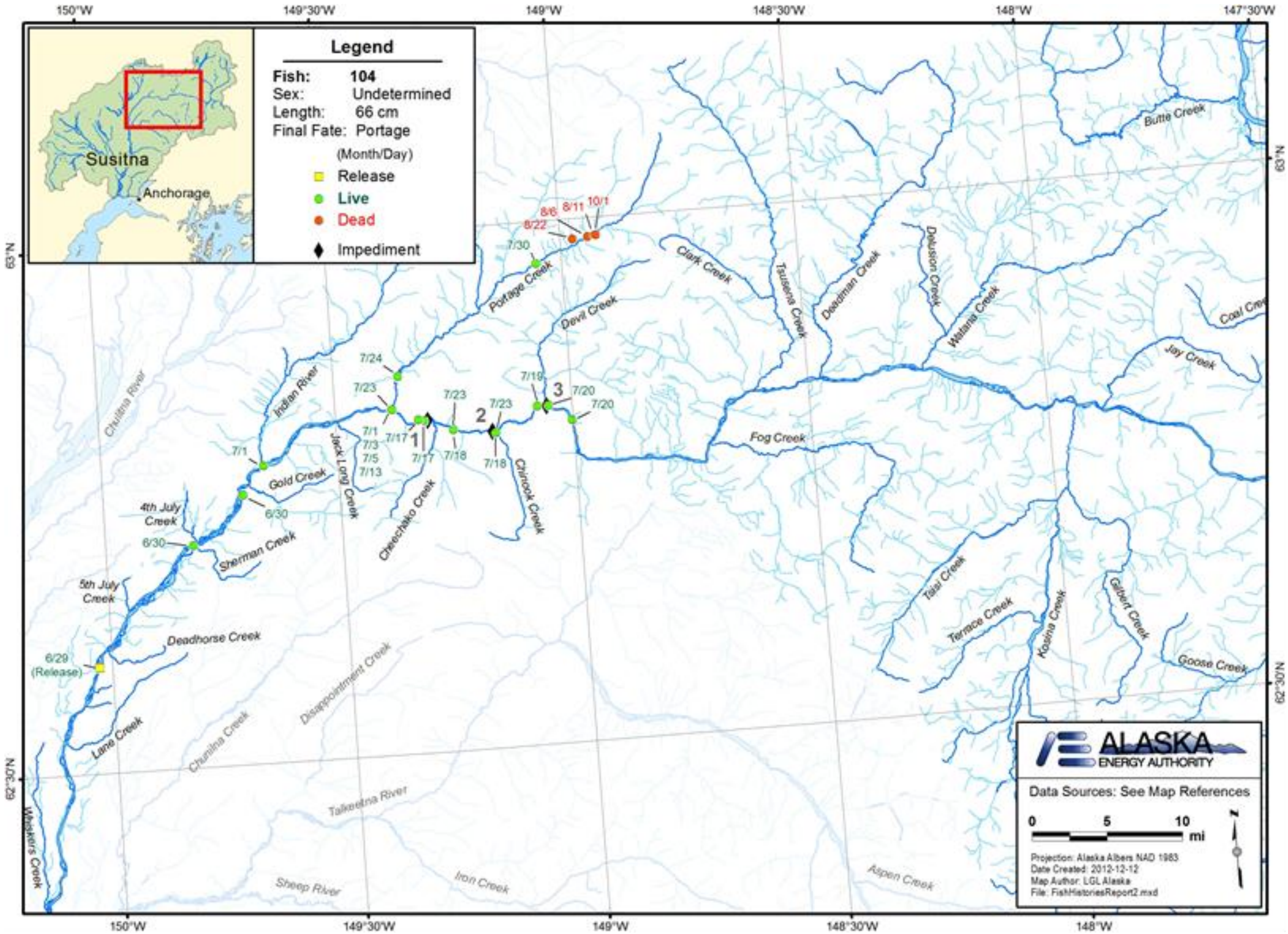

Figure F-6. Tracking history of a radio-tagged Chinook Salmon (tag #104) that was detected above Impediment 3, 2012.

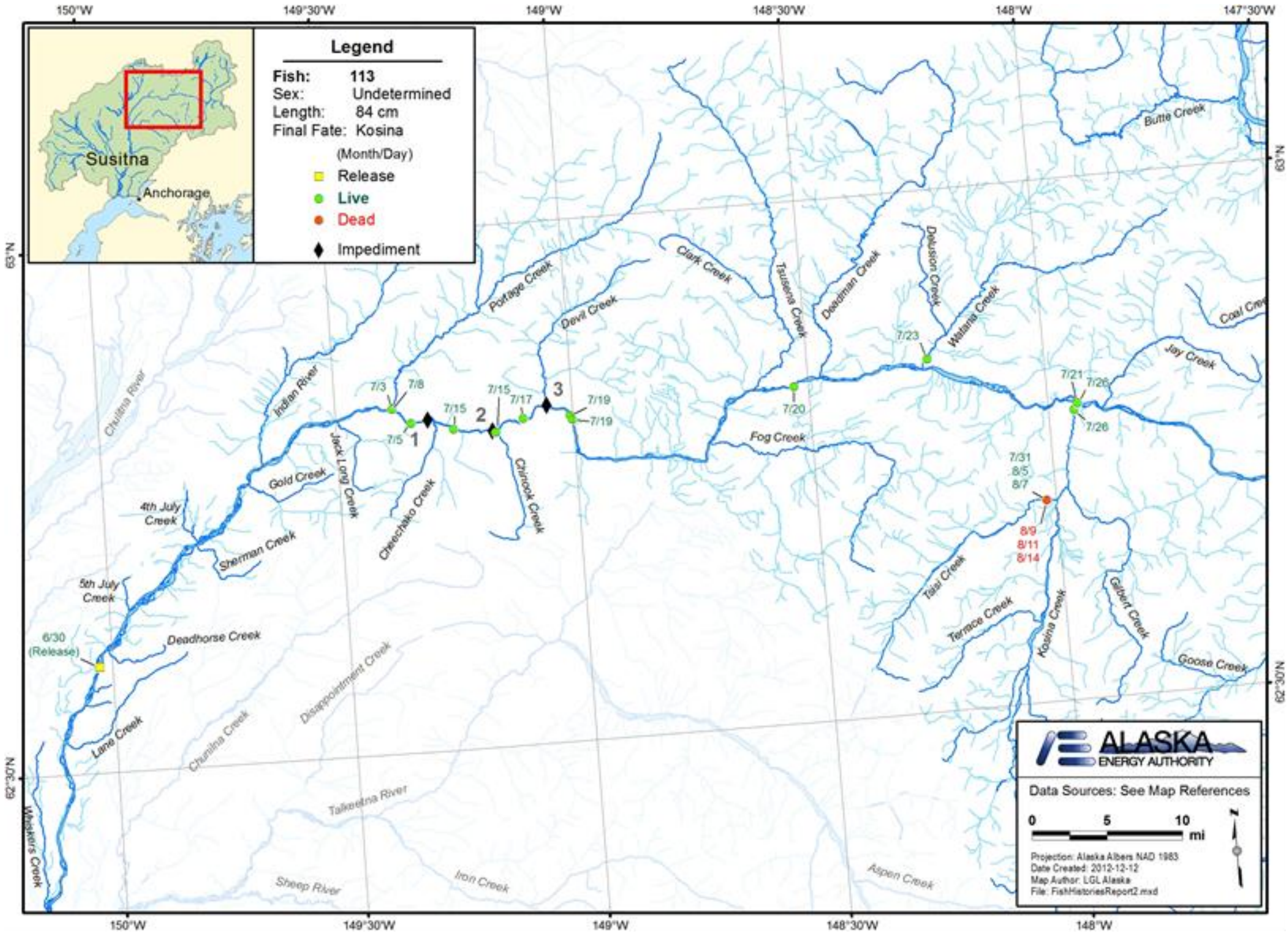

Figure F-7. Tracking history of a radio-tagged Chinook Salmon (tag #113) that was detected above Impediment 3, 2012.

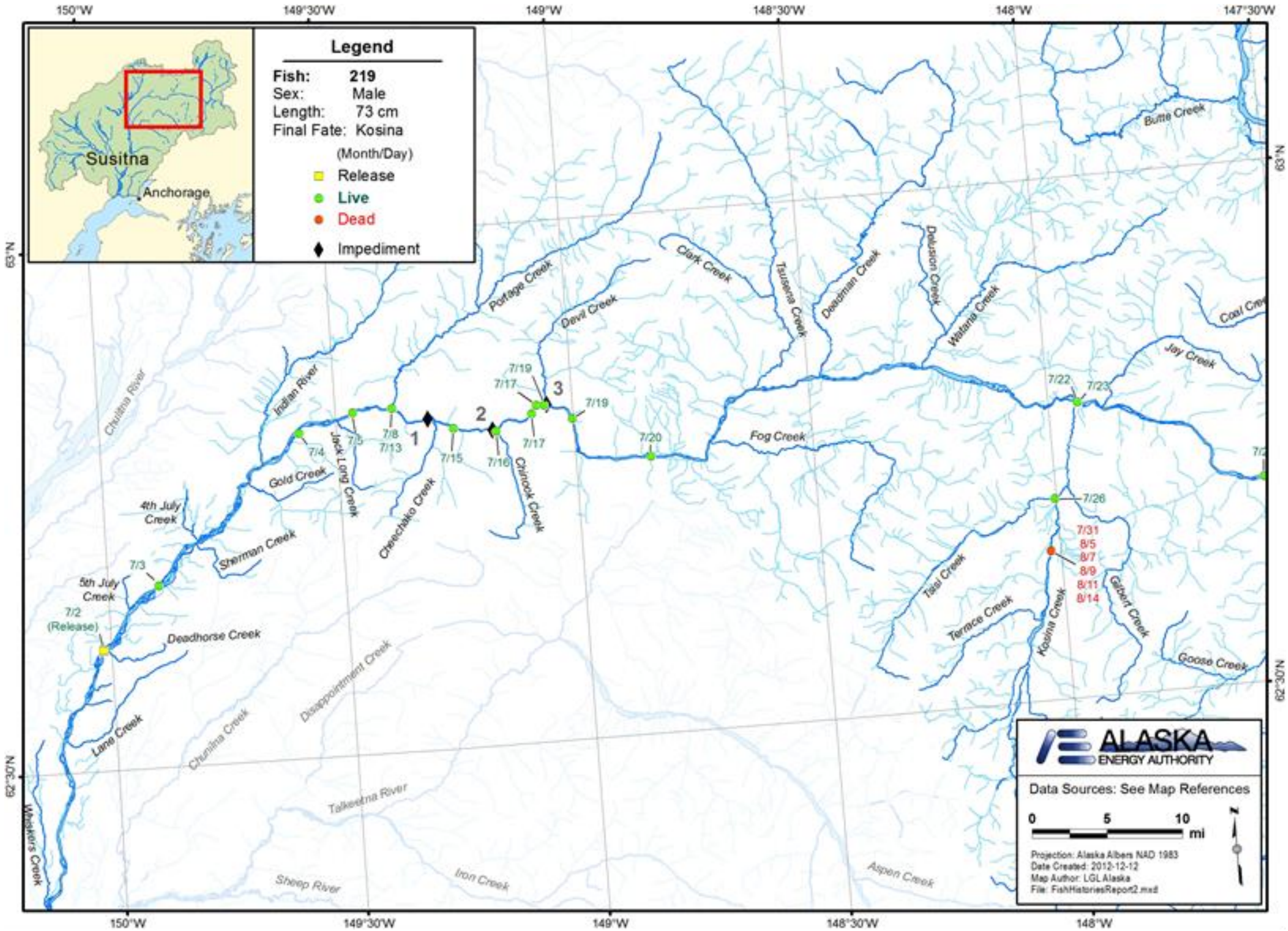

Figure F-8. Tracking history of a radio-tagged Chinook Salmon (tag #219) that was detected above Impediment 3, 2012.

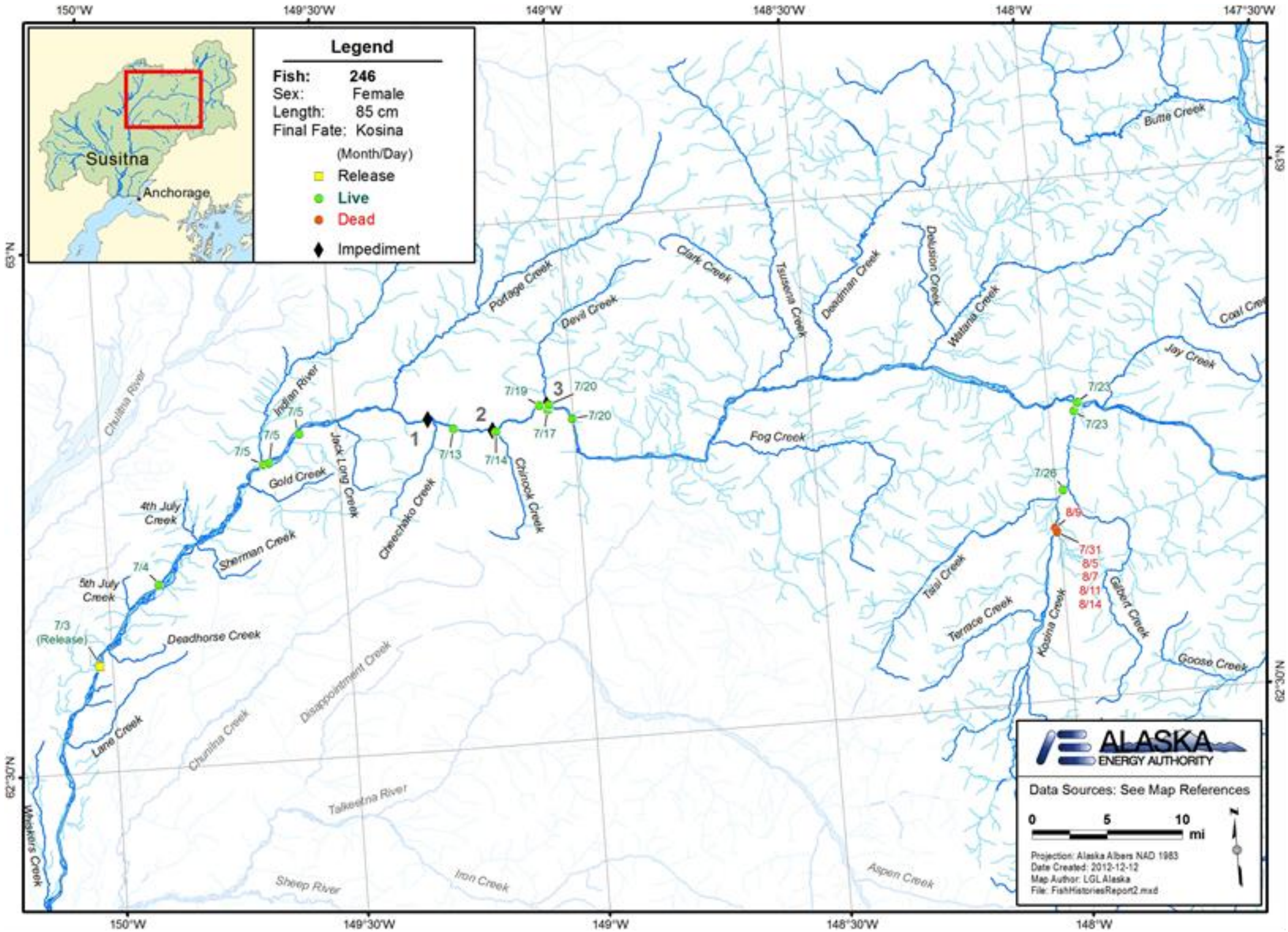

Figure F-9. Tracking history of a radio-tagged Chinook Salmon (tag #246) that was detected above Impediment 3, 2012.

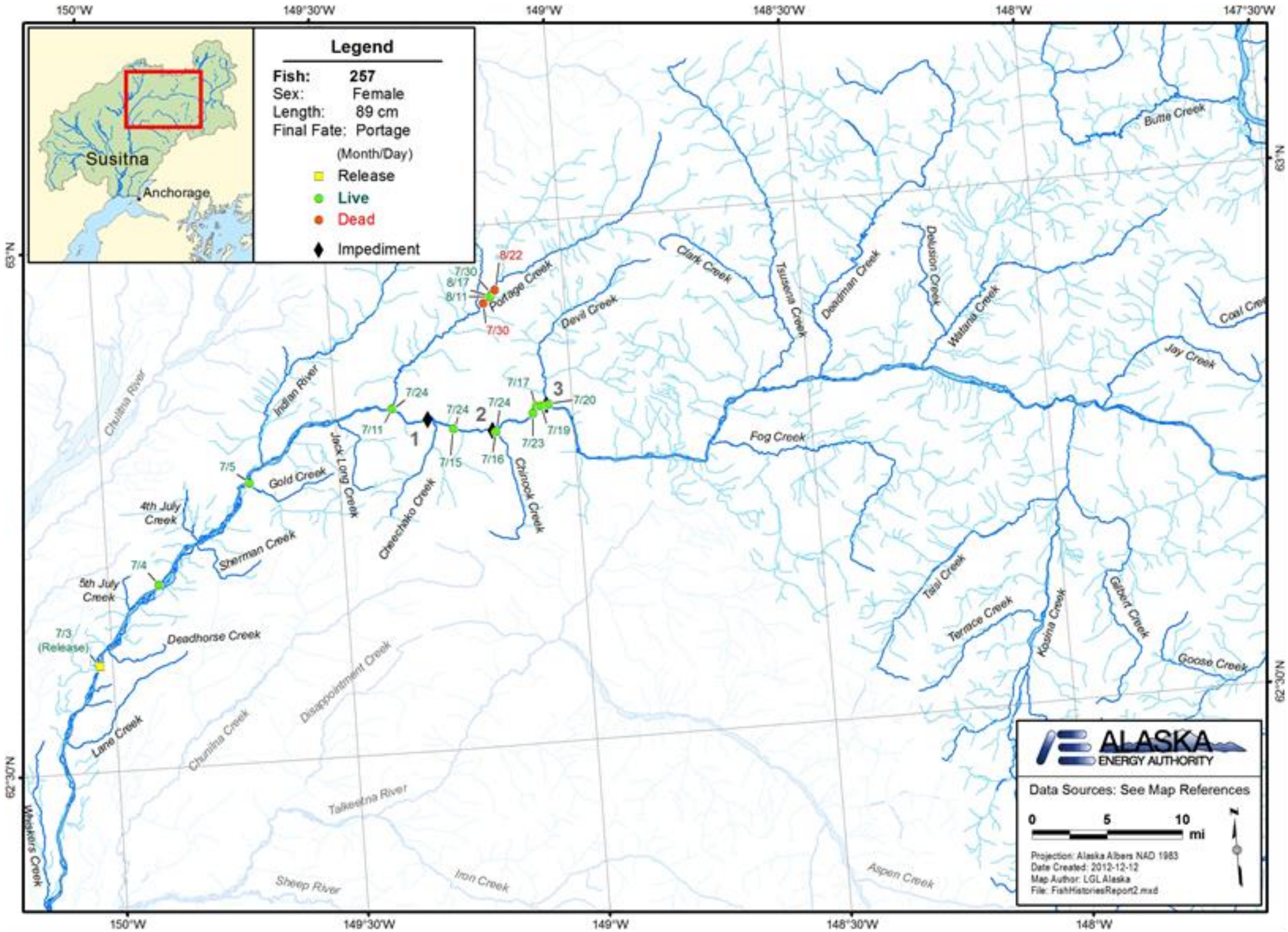

Figure F-10. Tracking history of a radio-tagged Chinook Salmon (tag #257) that was detected above Impediment 3, 2012.

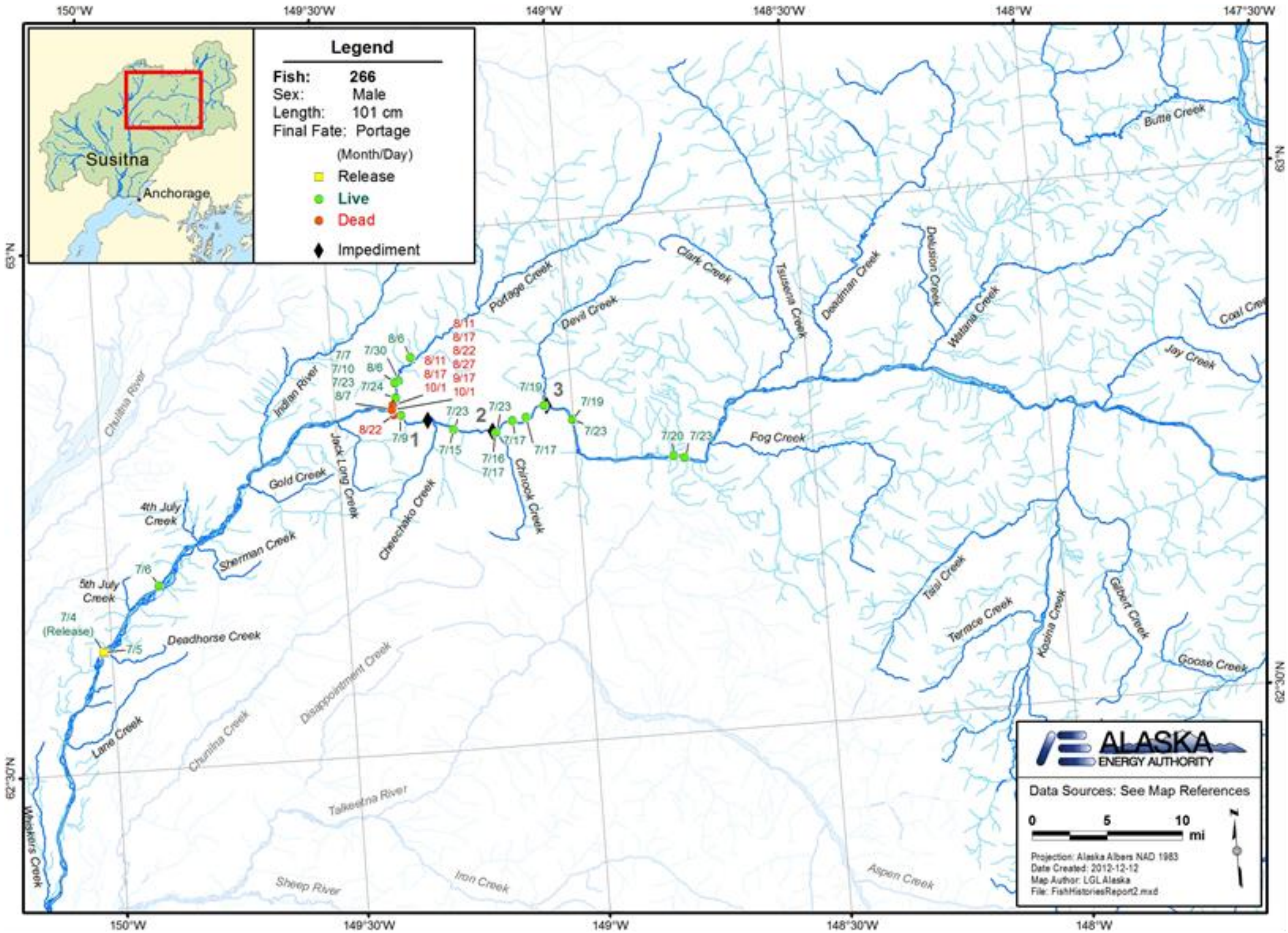

Figure F-11. Tracking history of a radio-tagged Chinook Salmon (tag #266) that was detected above Impediment 3, 2012.

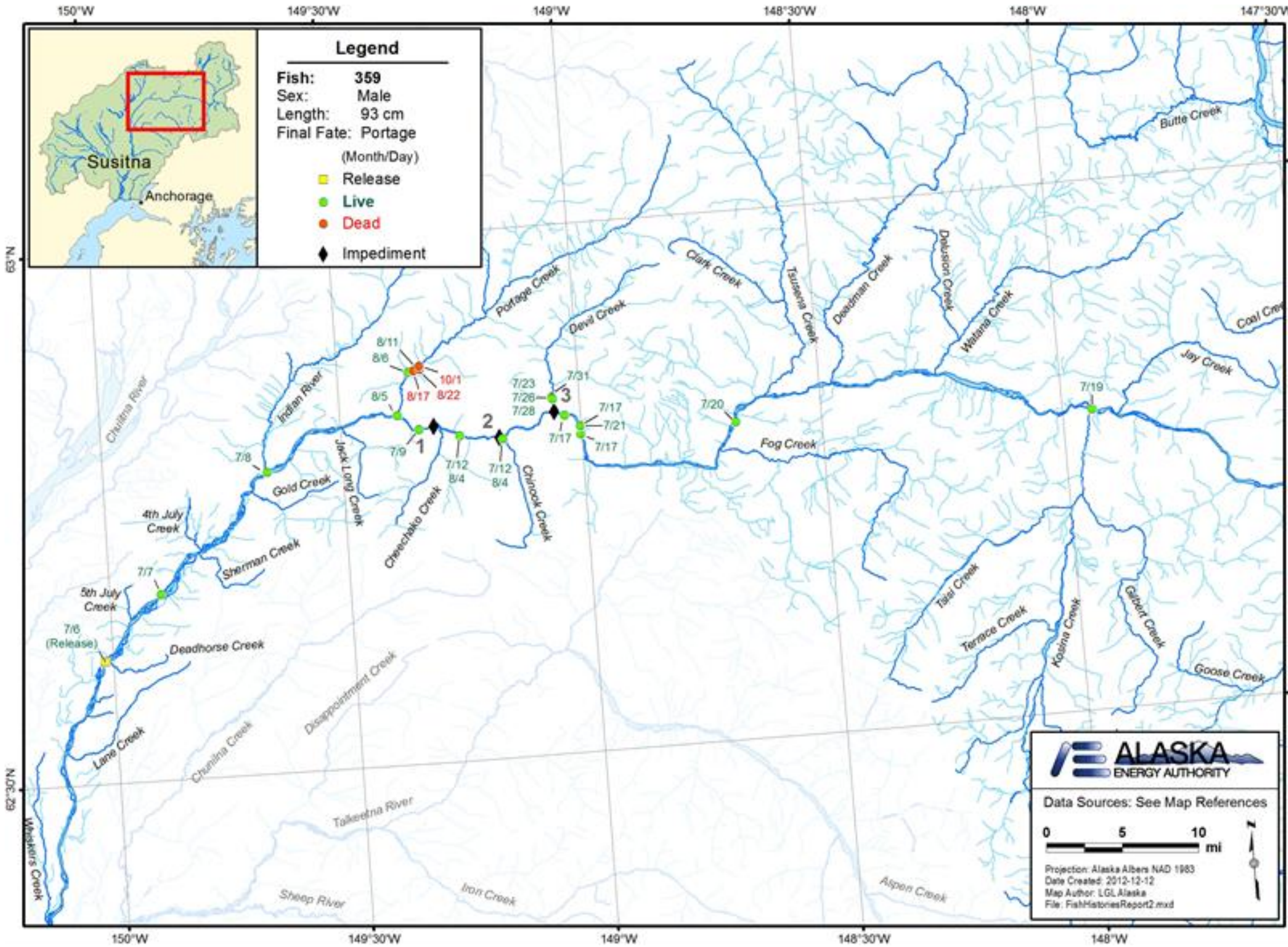

Figure F-12. Tracking history of a radio-tagged Chinook Salmon (tag #359) that was detected above Impediment 3, 2012.

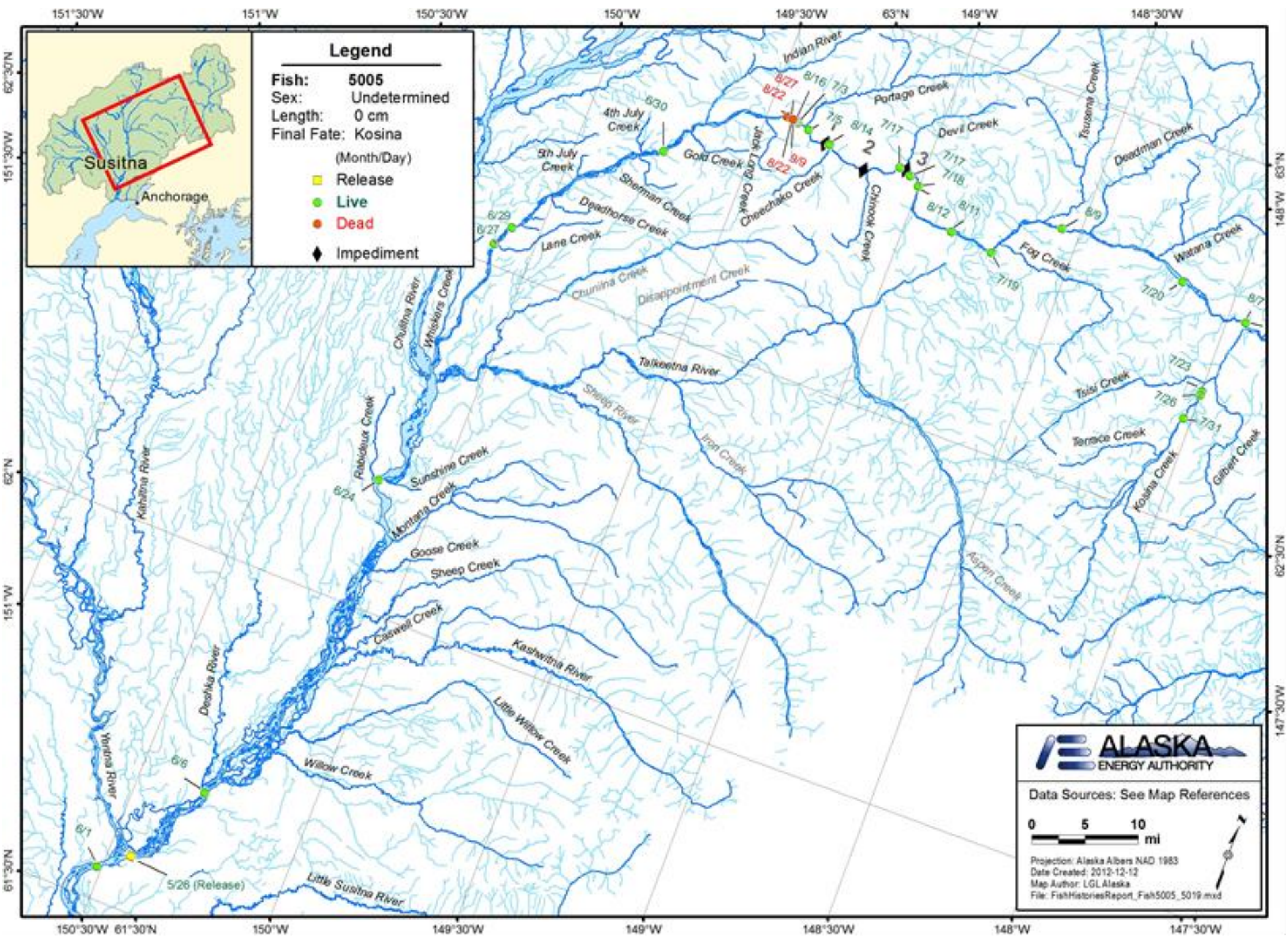

Figure F-13. Tracking history of a radio-tagged Chinook Salmon (tag #5005) that was detected above Impediment 3, 2012.

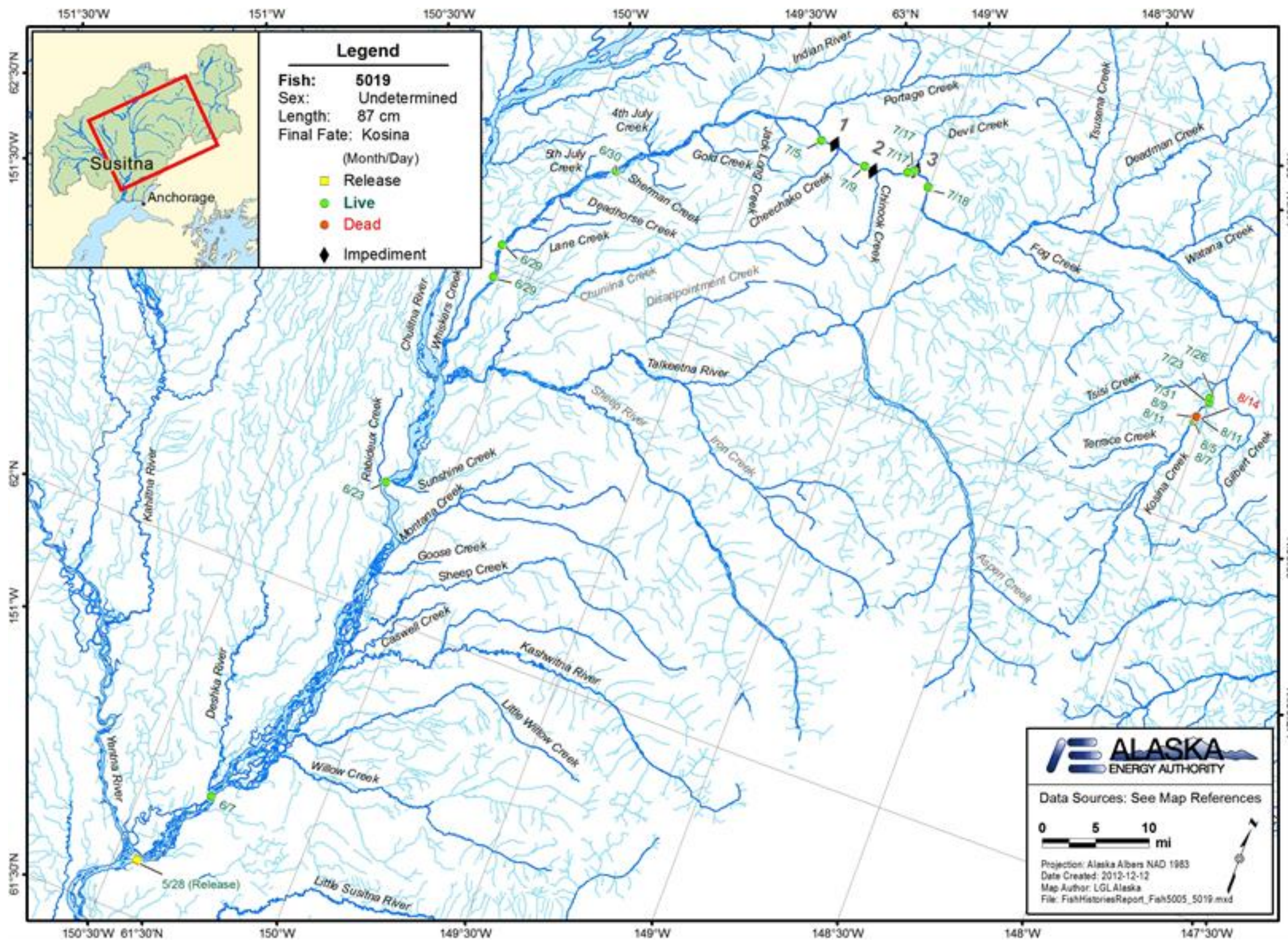

Figure F-14. Tracking history of a radio-tagged Chinook Salmon (tag #5019) that was detected above Impediment 3, 2012.

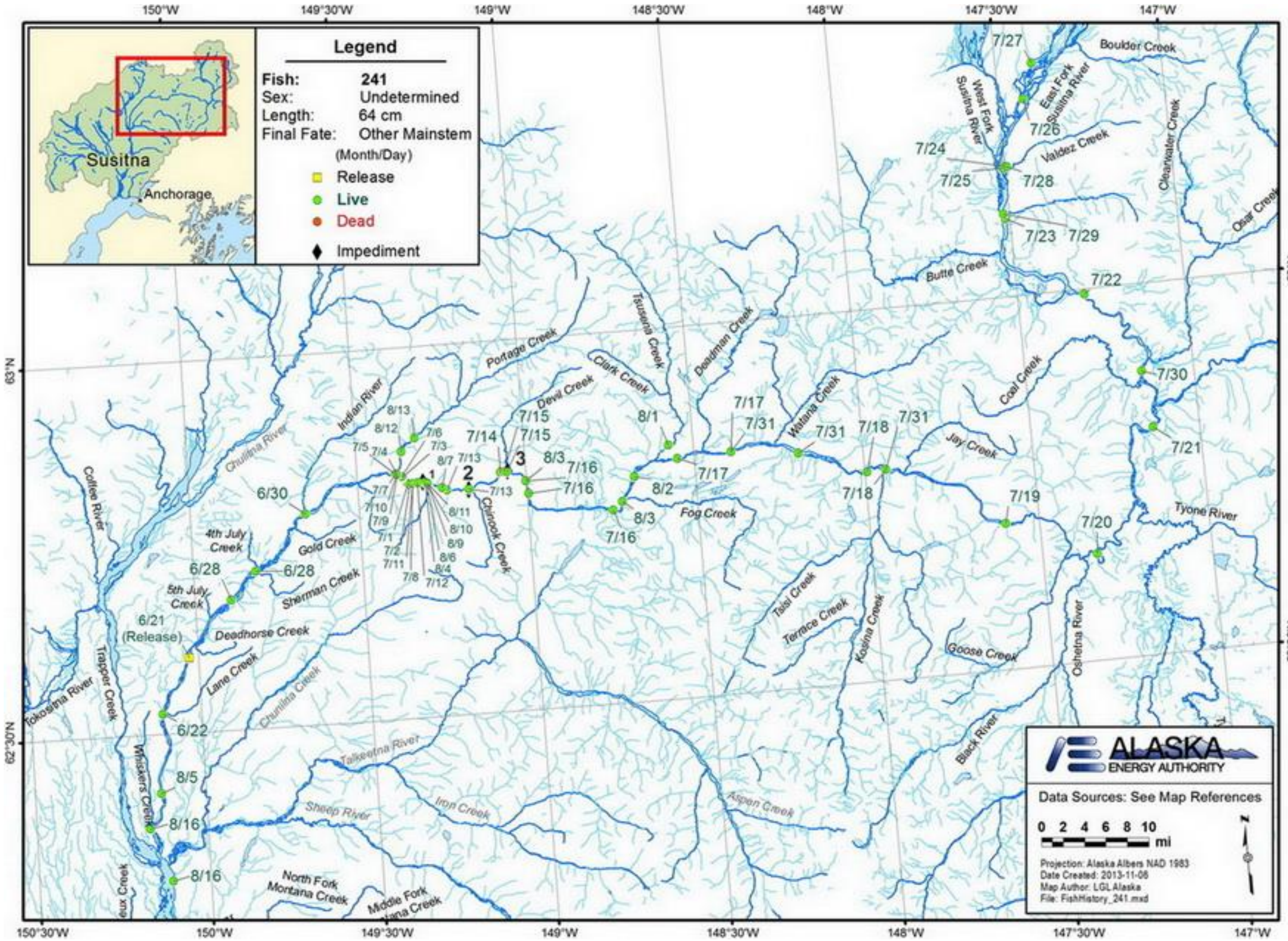

Figure F-15. Tracking history of a radio-tagged Chinook Salmon (tag #241) that was detected above Impediment 3, 2013.

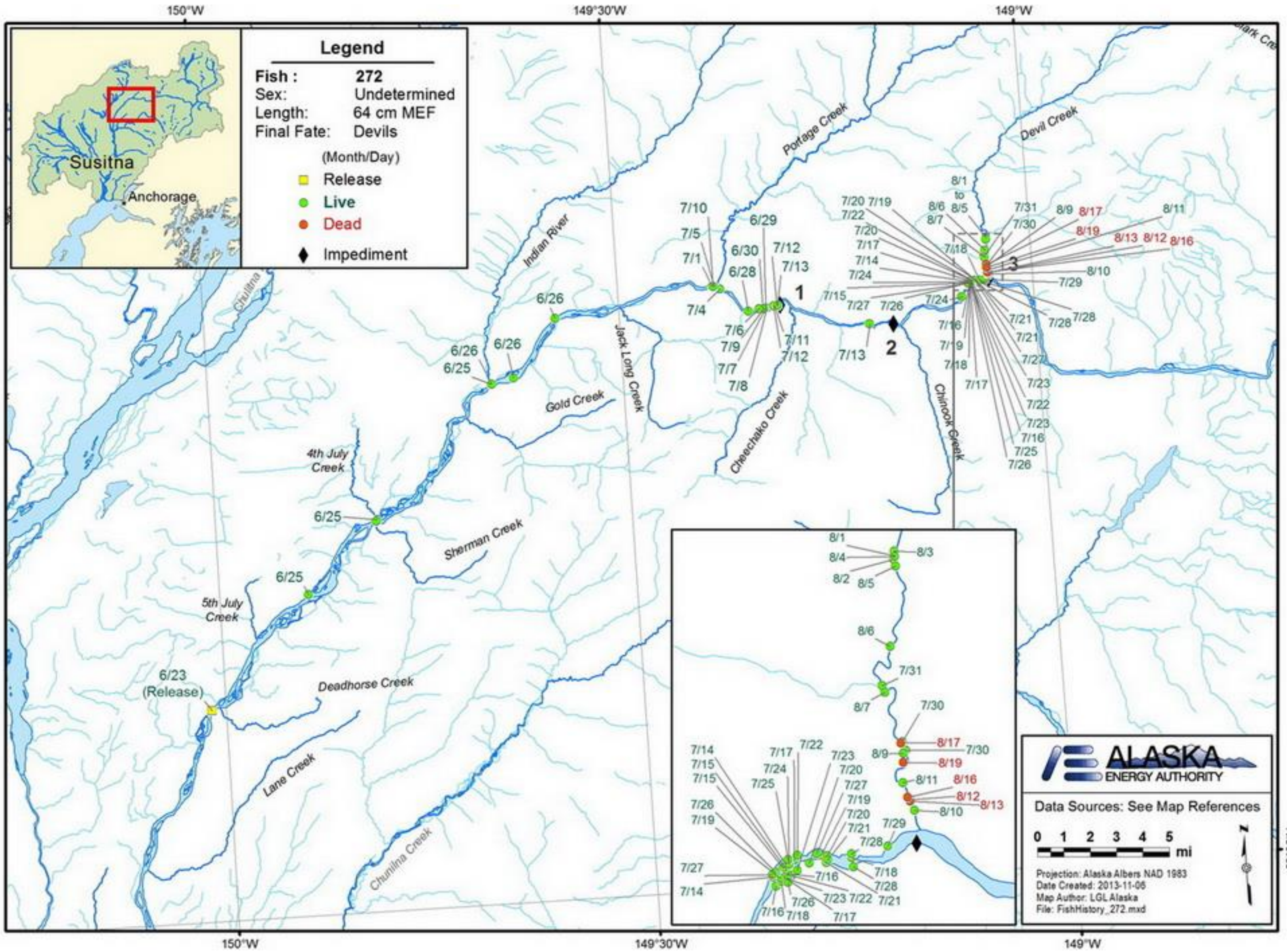

Figure F-16. Tracking history of a radio-tagged Chinook Salmon (tag #272) that was detected above Impediment 3, 2013.

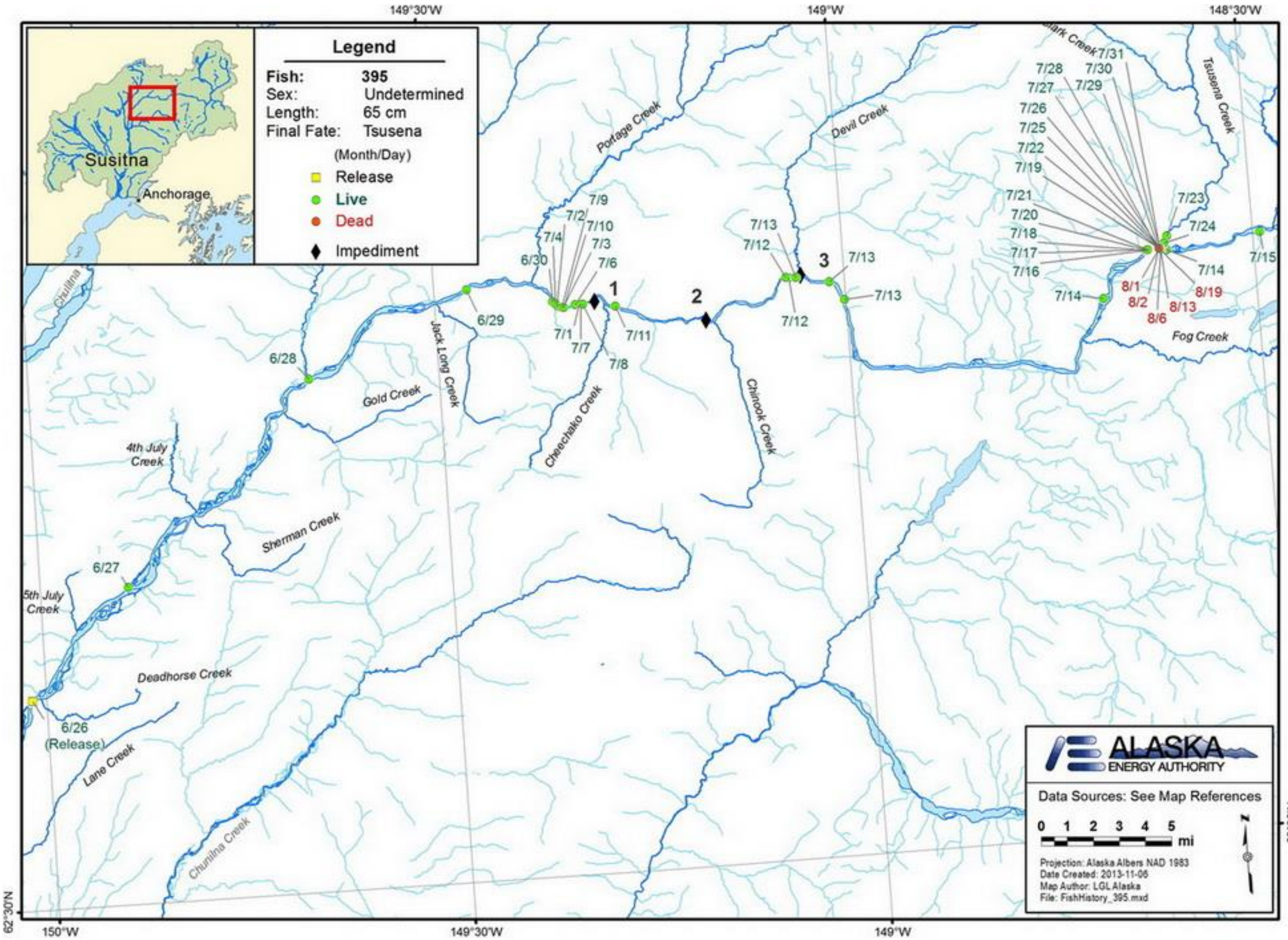

Figure F-17. Tracking history of a radio-tagged Chinook Salmon (tag #395) that was detected above Impediment 3, 2013.

Appendix G: Counts of chinook salmon at Watana Canyon using sonar

1. INTRODUCTION

The Alaska Energy Authority (AEA) has selected a site for the proposed development of a hydroelectric dam within Watana Canyon on the Upper Susitna River. The degree to which fish, in particular adult salmon, use this area as a migration corridor is currently uncertain. Reliable estimates of the number of fish that migrate through Watana Canyon will help describe the potential impacts on fishery resources of constructing and operating a hydropower project. Additionally, information regarding fish use of Watana Canyon as a migration corridor will inform discussions concerning fish passage facilities at the hydropower project.

In its study plan determination (SPD), the FERC (Federal Energy Regulatory Commission) requested that AEA modify Study 9.7 to include an evaluation of the future feasibility of counting fish at or near the Watana Dam Site as follows (FERC 2013a, page B-20):

> *"We recommend the study be modified to require AEA to include in the initial study report an evaluation, based on site-specific data obtained during the 2013 study season, of the feasibility of putting in a weir or sonar counting station at or near the dam site during the 2014 study season to provide an accurate count of any resident or anadromous fish that are successfully able to migrate upstream through Devils Canyon in the project area."*

AEA followed up on FERC's recommendation and determined that operation of a weir near the dam site was not feasible due to the physical impossibility of any structure handling the normal levels and range of discharge for the mainstem Susitna River. Further, it did not appear feasible to provide an accurate count of resident fish, or to know if a fish has migrated upstream through Devils Canyon (except for anadromous adult salmon).

In 2013, the study team assessed the feasibility of placing a sonar counting station at or near the dam site (see Appendix G in AEA 2014c). Given several assumptions, it was likely feasible to count salmon-sized fish (50 cm [19.7 in] TL or greater) in Watana Canyon, in particular Chinook Salmon, and to quantify the accuracy of those counts using corroboration with the passage of radio-tagged Chinook Salmon (Appendix G in AEA 2014c).

In 2014, the study team implemented the methods for achieving the objectives of sonar monitoring near the proposed Watana Dam site as described in the ISR. This appendix report describes the use of multi-beam imaging sonar for estimating the number of Chinook Salmon (fish 50 cm [19.7 in] TL or greater), as well as those measuring less than 50 cm (19.7 in) TL, that passed the proposed Watana Dam Site from July 6 to August 22, 2014. In addition, the study team collected bathymetry and water velocity profiles at the monitoring sites.

2. Study Goal and Objectives

Following FERC's recommendations, the primary goal of the study as modified by the feasibility assessment was to provide an accurate count of anadromous fish (specifically Chinook Salmon) near the proposed dam site (i.e., Watana Canyon). The specific objectives for this study were to:

1. Estimate the number of net upstream-moving Chinook Salmon that passed through the sonar beams; and

2. Describe temporal (daily and hourly) and spatial (range of passage) patterns of Chinook Salmon observations.

3. STUDY AREA

The study area was located in the Upper Susitna River near the location of the proposed Watana Dam Site. The section of river is characterized by a single channel with steep canyon walls, undisturbed forested areas, and gravel bars with occasional sand bars.

4. METHODS

4.1. Site Selection

A reconnaissance flight was conducted on July 5, 2014, to assess the suitability of various locations for setting up sonar count stations. A location immediately downstream of the proposed Watana Dam Site at PRM 187.2 was determined to be the most suitable within the areas that were accessible. To find the optimal location for sonar sampling along the selected reach, an ARIS 1200 unit was used on July 6, 2014 to map the bathymetry along multiple transects from the right and left banks. Bottom-profiling allows for determination of optimal sonar alignment and aiming angles, and determination of the presence of depressions or troughs in the field-of-view (FOV) that would allow for fish to move past the sonar undetected (Maxwell and Smith 2007; Faulkner and Maxwell 2009). A single sonar location was established on each side of the river just below the proposed Watana Dam Site (Figure G-1).

4.2. Data Collection

ARIS systems were used to monitor for Chinook Salmon escapement from each side of the river. Two different models of ARIS units were used: the ARIS 1200, which has operating frequencies of 0.7 and 1.2 megahertz (MHz), was installed on the left bank. The ARIS 1800, which has operating frequencies of 1.1 and 1.8 MHz, was installed on the right bank. Each ARIS system consisted of the sonar head, data transmission cable, switch box, Ethernet cable, laptop computer and an external hard drive.

The sonar heads were deployed using aluminum H-mounts equipped with boat-trailer jacks that allowed for adjustment of sonar tilt angles. The mounts were typically positioned 5 to 10 ft from the edge of the wetted width (Figure G-2). The sonar heads were typically positioned between 0.2 and 1.5 ft off the bottom, aimed towards the opposite bank and tilted down to allow the sampling beams to spread across the substrate throughout the majority of the sampling windows. Sand bags filled with cobble and gravel were placed on the feet of the mounts to keep them secured to the substrate. The mounts, depth of sonar heads and tilt angles were adjusted periodically as river levels fluctuated throughout the study. Rock wall barriers were constructed to prevent fish from passing behind the mounts. Electronic components were housed in aluminum environmental boxes fastened to trees above mean high water level (Figure G-3). The systems were powered using banks of six, 6-V batteries that were recharged each day with Honda 2000 gasoline-powered generators.

Data were acquired using ARISScope software (version 1.0 for the 1800 unit and version 2.0 for the 1200 unit, SoundMetrics Corp., Bellevue, WA). Data collection started at the left bank station at 4:51 P.M. on July 6 and at 12:12 P.M. on July 7 at the right bank station (see Table G-1 for sample site details). Data were collected continuously in consecutive 10-minute files until the study period ended on August 22 (with the exception of the period 10:40 A.M. on July 30 through 1:45 P.M. on August 7 when the left bank station was shut down). Data were ported directly to 1-terabyte external hard drives. Hard drives were changed daily and the data were backed up and archived to additional hard drives each day.

The maximum sample ranges used were based on the extent to which substrate was visible in the FOVs. The gradually sloping bottom along the left bank allowed for substrate to be evident out to 37 m (121.4 ft) in range, whereas the bottom dropped off at 16 m (52.4 ft) in range along the right bank (Figure G-4). Seeing substrate throughout the FOV ensures that no depressions or troughs exist that would allow for fish to move past the ensonified area undetected. An aerial photograph of the sampling locations with depictions of the ensonified areas in plan-view is shown in Figure G-5. Operating frequencies and typical data collection parameters used for the two sonar stations are shown in Table G-2. There were sometimes slight adjustments to data collection parameters when mounts where repositioned to accommodate variable river levels (see Table G-6 for daily data collection parameters).

4.3. Data Processing

Processing of ARIS data involved reviewing the data files using ARISFish software (version 1.0, SoundMetrics Corp.). Technicians in the field reviewed files by displaying the data in echogram form, which is a visual representation of the entire image file with time plotted along the horizontal axis and range plotted along the vertical axis. Fish targets that move across the FOV are shown as tracks. Reviewers scrolled through the echograms to locate tracks, and when tracks were observed the tracks were framed with the cursor to prompt the sonar imagery of the track to display (see Figure G-6 for example of this process). Sonar images of fish were enlarged and fish lengths were estimated using the software's sizing tool.

Fish targets were classified as resident fish or Chinook Salmon based on their estimated size. Chinook Salmon were defined as any fish targets that were 50 cm (19.7 in) or greater in estimated total length. For each Chinook Salmon detected, the following parameters were recorded: estimated total length, range at first and last detection, and direction of travel. Lengths of some fish could not be estimated when they passed immediately in front of the sonar units. If greater than or equal to 50 cm TL (19.7 in) of length could be measured for targets larger than the width of the FOV, then these fish were classified as Chinook with an unknown estimated length. Any fish targets measuring less than 50 cm (19.7 in) TL were not classified by species, and only their estimated total length was recorded. The accuracy of length measurements from the sonar data is approximately ± 10 percent based on known targets.

Level-three quality control on the data review process was conducted in three steps by a senior scientist with sonar expertise:

1. All Chinook Salmon targets identified by field technicians were reviewed to ensure that each observation was accurate with respect to estimated size, first and last detected range, and direction of travel;

2. All resident fish targets identified by field technicians and classified as being 40 to 49 cm (15.7–19.3 in) in estimated length were reviewed to ensure that none of these targets exceeded 49 cm (19.3 in) and thus should be classified as Chinook Salmon; and
3. Ten percent of the sonar data files from each day and from both monitoring stations were randomly selected and processed (as described above) to assess whether any Chinook Salmon observations were missed during the in-field review.

4.4. River Discharge

Discharge data for the Upper Susitna River reported here were obtained from United States Geological Survey (USGS) gauge at Tsusena Creek.

4.5. Current Velocity and Bathymetry Profiles

To support further assessment of the fish migration corridor at the sample reach, seven ADCP transects were measured at approximately 80-ft intervals along the reach (Figure G-5). The ADCP surveys were conducted on August 15, 2014. To supplement the velocity transects, bathymetric data were collected on August 16, 2014 using an Odom CV-100 echosounder and a TopCon GPS receiver along transects associated with sonar data collection (Transects 3 and 6). AEA (2014b) provides detailed methods associated with ADCP and bathymetry data collection.

5. RESULTS

5.1. River Discharge

During sonar operations from July 6 to August 22, Susitna River flows at the Tsusena Creek gauge ranged from 14,200 to 35,300 cfs (Figure 4.1-3; 16,700–36,500 cfs at the Gold Creek gauge). Discharge in the Upper Susitna River generally decreased during the sonar sampling period after a peak of 35,300 cfs at the Tsusena Creek gauge on July 8 (36,500 cfs at the Gold Creek gauge). Periodic increases in discharge occurred in mid to late July. Throughout August, discharge remained below 19,000 cfs at the Tsusena Creek gauge (below 22,000 cfs at the Gold Creek gauge).

5.2. Sampling Effort

With the exception of the period from July 30 through August 7 when the left bank station was demobilized, both stations operated continuously throughout the sample period (Figure G-7).

5.3. Sonar Coverage

After initial setup of the sonar systems, the left bank station ensonified an estimated 41.5 percent of the wetted channel width and the right bank station ensonified an estimated 16.1 percent of the wetted channel width (Table G-3). With respect to overall scope, the systems covered 57.6 percent of the wetted channel widths, leaving 42.4 percent of the thalweg section of the river uncovered with sonar. Proportional coverage increased slightly as the mounts were periodically moved further out as water surface elevation decreased through the sampling period.

Cross-sectional coverage of the water column throughout the sampling ranges of the left and right bank sonar systems is shown in Figure G-8. The bottom profiles along the main axes of the sampling areas shown in Figure G-8 are based on geo-referenced data collected during the bathymetry surveys. The cross-sectional sonar coverage shown in Figure G-8 is conceptual given that the sonar heads were re-positioned and re-aimed throughout the study to accommodate changing river levels. The sonar systems sampled along the substrate throughout the entire range for the right bank sonar and 97 percent for the left bank sonar (see Figure G-4). Portions of the water column near the water surface at both locations were not sampled (top 2 ft) given the shape of the channel relative to the height of the sample volume.

5.4. Chinook Salmon Counts

A total of 24 net upstream-migrating (26 upstream, 2 downstream) Chinook Salmon were counted at the sonar stations in 2014 (Table G-4). The first fish was observed on July 10 and last fish was observed on August 22. On a daily basis, Chinook counts ranged from 0 to 3, and counts greater than 0 generally coincided with decreasing or stabilized river discharge (Figure G-9). Twenty-two of the 24 fish (92 percent) were observed with the right bank sonar station.

On an hourly basis, the distribution of fish counts indicated no apparent diel passage patterns (Figure G-10). All fish detections were within 4 m (13.1 ft) from the sonar units with most occurring at 3 m (9.8 ft) in range (Figure G-11). Size estimates for upstream migrants ranged from 50 to 110 cm (19.7–43.3 in), with an average of 78 cm (30.7 in).

In addition, 213 fish measuring 40–49 cm (15.7–19.3 in) TL, and 1,044 fish measuring less than 40 cm TL (15.7 in), were counted at the sonar stations (direction of movement for these fish was not recorded). These fish could not be identified to species using sonar. For fish which were less than 50 cm (19.7 in) TL, a percentage of these fish could potentially be small Chinook Salmon (as based on measurements at the Middle River fishwheels (minimum 27 cm [10.6 in] METF; see Figure A-29). However, the potential species as based on sampling from Study 9.5, and in order of likelihood in the observed size range, are Arctic grayling, burbot, round whitefish, and longnose sucker.

5.5. Water Velocity and Bathymetry Profiles

A plot of serial water velocity profiles below the Watana dam site and along the reach of river where sonar sampling was conducted shows a general trend of lower velocities near the shorelines and higher velocities in the main channel (Figures G-12 to G-14). Comparing near-shore velocities between the left and right bank indicates that, with the exception of Transect 2, the River Right shorelines had lower velocities across a broader area than did the River Left shorelines. Transect 2 was unique among all transects in that the River Right edge terminated at a steep canyon wall that extended out onto a point (see Figure G-5). Velocities along River Right were typically less than 5 ft/s (1.5 m/s), whereas velocities along River Left were often greater than 5 ft/s. Velocities within the main channel often exceeded 10 ft/s (3 m/s) with transects 6 and 7 exhibiting the highest velocities. The river channel is characterized as having relatively steep banks that slope off to the maximum depth within 50 ft of ordinary high water level and a relatively flat in between (Figure G-15).

The velocity data were spatially integrated and represented as transect-specific discharge estimates (Table G-5). The discharge estimates provide measures of precision and accuracy on the velocity data.

6. DISCUSSION

One hundred percent sonar coverage of the river width at PRM 182.1 was not possible in 2014 given the technical limitations of the sonar equipment and the physical bathymetry of the river. The maximum range at which 50 cm (19.7 in) TL targets can be detected with the ARIS 1200 unit is about 40 m (131 ft) and with the ARIS 1800 about 35 m (115 ft). Even with the most suitable bottom topography that would allow coverage along the substrate to the maximum ranges, coverage would still not achieve 100 percent. With the two ARIS units used in 2014, an estimated 58 percent of the river width was sampled. The sonar coverage was scaled to the extent of visible substrate. The un-sampled 42 percent consisted of primarily the middle of the river channel. The lack of complete sonar coverage creates uncertainty around the fish counts and raises two important questions – 1) Is there a more suitable location in the canyon that would provide higher proportional sonar coverage of the river width and thus less uncertainty around estimates of abundance?, and 2) How likely is it that some fish passed undetected in 2014 through the Watana Canyon in the main river channel beyond the maximum ranges sampled?

Given the gradient and morphological features controlling the rivers width and depth in much of the Upper River, finding a location with a gradual and uniform substrate slope from river right to left that has a wetted width within the range needed for 100 percent sonar coverage is very unlikely. An aerial reconnaissance survey in 2014 did not identify any new potential sonar sites. All potential locations with a wetted width closer to the range needed for 100 percent sonar coverage had unsuitable bottom profiles and depths for the multi-beam sonar technology to provide effective coverage. Many locations are inaccessible by helicopter, and others provide no option for a site installation, even by boat, due to the steep rock walls present along many sections of the river. There may be suitable locations below Tsusena Creek, but establishing count stations below a major tributary creates uncertainty regarding whether the fish detected at the site will spawn above the Watana Dam site or up in the tributary. Presently, the count stations established in 2014 are the most suitable locations for monitoring fish passage above the dam site with sonar.

To address the question of whether fish may have passed the count stations undetected beyond the sampling ranges used in 2014, it is informative to examine water velocity and bathymetry profile across the width of the river to understand the physical environment and potential fish migration corridors. Bathymetry and velocity surveys were conducted at seven transects in the river reach in which sonar data were collected during the 2014 sample period. Profile data from these surveys provide important information collected concurrently with the sonar data to help determine potential migration corridors and aid in assessing effectiveness of the sonar sampling near the dam site.

The 2014 water velocity profiles (Figures G-12 to G-14) indicate higher water velocities with increasing distance from shore, and generally, a greater extent of lower water velocities along the right bank as compared with the left bank. Given the availability of low water velocity areas along the banks (especially along the right bank) as compared with the high velocities observed throughout the main channel, it is likely the primary migration corridors in this section of river are along the banks. The velocity is too high for a majority of the channel to be conducive to fish passage. Further, there does not appear to be any unique bathymetry which would provide a corridor for passage except for relatively close to the banks (Figure G-15). It is important to point out that the velocity data were collected when discharge of the river was 14,900 cfs. This level of discharge reflects river conditions throughout much of the latter half of the study, but does not reflect conditions earlier in the study period when discharge was considerably higher. Nonetheless, it likely that the general pattern of high velocities in the main channel and lower velocities along the banks would persist at higher flow levels.

Overall, the precision of the velocity data was estimated to be within 1–2 percent, but the accuracy of the data showed a slight negative bias relative to USGS gauge data (D. Brailey, Brailey Hydrologic Consultants, pers. comm). Data are being evaluated across the past three years relative to USGS data to quantify accuracy of the velocity data; the current estimate is about a 1 to 2 percent negative bias.

With respect to the likelihood of fish passing through the canyon in the high-velocity areas beyond the reach of the sonar count stations, it is instructive to review what is known about swimming speeds and capabilities of migrant adult salmon. Previous research on Chinook Salmon swimming capabilities (Watts 1974; Bell 1986) suggest a sustained swimming speed (normal function for long periods of time without fatigue) of 0.0–3.4 ft/s (0.0 to 1.0 m/s), and a prolonged swimming speed (sustainable for 15 s to 200 s) of 3.1–10.8 ft/s (1.0 to 3.3 m/s). A swimming speed of greater than 10.8 ft/s (3.3 m/s) is considered sustainable for 15 s or less. At river discharges of 27,600 cfs and greater, based on the presumed swimming capabilities of Chinook Salmon and the measured water velocities shown in Figures G-13 and G-14, fish passage along the river right and river left banks would not be expected outside of 65 ft (20 m) and 33 ft (10 m) from shore, respectively. The ADF&G does not have any data that suggest Chinook Salmon negotiate flows greater than 9.8 ft/s (3 m/s) at any of their sonar sampling locations throughout the state, but they do not rule out the possibility (Debby Burwen and Bruce McIntosh, ADF&G, pers. comm., July 7, 2014).

The fish count data collected in 2014 support the general notion that migrating salmon use low velocity areas as migration corridors when available. The highly skewed distribution of counts towards the right bank as compared with the left bank follows the 2014 velocity profile patterns that show greater proportions of low velocity areas along the right bank as compared with the left bank. Additionally, the distribution of counts as a function of distance from the sonar units indicates that fish passage through the canyon was shore-oriented with all detections occurring within 4 m (13.1 ft) of the units. If some fish did migrate up through the main channel undetected, it is reasonable to assume that the distribution of counts would have included detections further out in range from the sonar units. The sonar data, together with velocity profile data and known swimming capabilities of salmon, suggest there is a low probability that some fish passed through the canyon undetected due to incomplete sonar coverage.

To aid in assessing efficiency of the sonar systems, two telemetry receiver stations were deployed about 300 feet upstream from the sonar units on the right bank. One tagged Chinook Salmon was detected by the receivers at 11:19 P.M. on July 31. Unfortunately the timing of this detection coincided with the period in which the left bank count station had been demobilized.

There were no sonar detections of fish measuring 50 cm (19.7 in) TL or greater from the right bank station around the time of the detected tagged fish. Presumably that fish passed along the left bank, or less likely up the main channel. Due to the limited number of tagged fish that migrated up as far as Watana Canyon (just that one fish) telemetry data could not be used to assess efficiency of the sonar systems.

An important issue that contributed uncertainty regarding whether some targets were of sufficient size to classify them as Chinook Salmon involved fish that passed extremely close to the sonar units. Some fish either moved through the blanking range (within 0.7 m [2.3 ft] of the units), or through the most narrow part of the sample volume in the near-field. It was not possible to measure these fish. Of 1,366 total observations, 100 (7.3 percent) could not be measured for length. As a result, it is technically possible that some Chinook Salmon may have passed by undetected. Given that 2.5 percent of the observations where a length was determined were classified as Chinook Salmon, it is reasonable to estimate that 3 of 100 observations without a length were Chinook Salmon.

7. CONCLUSIONS

The results of the sonar sampling in 2014 led to the following conclusions:

- A net total of 24 upstream-migrant Chinook Salmon were counted, and this should be considered a minimum estimate of Chinook Salmon abundance in the Watana Canyon;
- Daily passage through the canyon was low, ranging from 0 to 3 fish per day;
- There were no apparent diel passage patterns;
- The distribution of passage was highly skewed towards the right bank; and
- Distributions of fish detections as a function of distance from the sonar units indicate that passage was shore-oriented.

Table G-1. Location details for Watana Canyon sonar sites near PRM 187.1 in 2014.

Install Date	ARIS Unit	Sonar Location	Latitude	Longitude	Wetted Channel Width (m)	Wetted Edge to Sonar (m)
06-Jul	1200	River Left	62.82214	-148.5381	96 (315 ft)	1.5 (4.9 ft)
07-Jul	1800	River Right	62.82307	-148.5370	106.1 (348 ft)	3 (9.8 ft)
		Combined				

Table G-2. Operating frequencies and data collection parameters used for the ARIS monitoring stations at Watana Canyon in 2014.

	Left Bank	Right Bank
Operating Frequency (MHz)	0.7	1.1
Sample Window Start (m)	0.7 (2.3 ft)	0.7 (2.3 ft)
Sample Window End (m)	39.2 (128.6 ft)	16.6 (54.5 ft)
Sample Rate (frames per second)	5.4	6.8
Sonar Heading (degrees)	329	140
Sonar Tilt Angle (degrees)	-9.6	-15.1
Sonar Roll Angle (degrees)	1.7	0.5

Table G-3. Percent coverage for each sonar station and combined based on wetted channel width, wetted edge to sonar, and ensonified range at sample sites near PRM 187.1 in Watana Canyon.

Sonar Location	Wetted Channel Width (m)	Wetted Edge to Sonar (m)	Ensonified Range (m)	Coverage %
River Left	96 (315 ft)	1.5 (4.9 ft)	39.2 (128.6 ft)	41.5
River Right	106.1 (348 ft)	3 (9.8 ft)	16.6 (54.5 ft)	16.1
Combined				57.6

Table G-4. Sample effort, CPUE, and net upstream count of fish measuring 50 cm or greater at two ARIS units located at PRM 187.1 in the Upper River, 2014. Mean daily discharge of the Susitna River at Tsusena Creek is also shown.

	River Left					River Right					
	Fish Count					Fish Count					Mean
Date	Upstream	Down-stream	Net Upstream	Sample Effort (h)	CPUE (fish/h)	Upstream	Down-stream	Net Upstream	Sample Effort (h)	CPUE (fish/h)	Discharge (cfs)
06-Jul	0	0	0	7.1	0.00						23,648
07-Jul	0	0	0	24.0	0.00	0	0	0	11.8	0.00	31,521
08-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	35,331
09-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	29,431
10-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	28,232
11-Jul	0	0	0	24.0	0.00	0	0	0	23.7	0.00	27,668
12-Jul	0	0	0	24.0	0.00	0	1	-1	24.0	-0.04	30,000
13-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	31,527
14-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	31,069
15-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	25,300
16-Jul	0	0	0	24.0	0.00	2	0	2	24.0	0.08	21,900
17-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	19,900
18-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	18,700
19-Jul	0	0	0	24.0	0.00	1	1	0	24.0	0.00	18,500
20-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	21,100
21-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	23,400
22-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	20,400
23-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	17,800
24-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	17,800
25-Jul	1	0	1	24.0	0.04	1	0	1	24.0	0.04	17,600
26-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	20,000
27-Jul	0	0	0	24.0	0.00	1	0	1	24.0	0.04	18,600
28-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	16,500
29-Jul	0	0	0	24.0	0.00	0	0	0	24.0	0.00	16,100
30-Jul	0	0	0	10.7	0.00	0	0	0	24.0	0.00	15,500

Table G-4. Continued.

	River Left					River Right					
	Fish Count					Fish Count					
Date	Upstream	Down-stream	Net Upstream	Sample Effort (h)	CPUE (fish/h)	Upstream	Down-stream	Net Upstream	Sample Effort (h)	CPUE (fish/h)	Mean Discharge (cfs)
31-Jul	River left sonar not operational					2	0	2	24.0	0.08	15,600
01-Aug						3	0	3	24.0	0.13	15,700
02-Aug						2	0	2	24.0	0.08	15,900
03-Aug						1	0	1	24.0	0.04	16,200
04-Aug						0	0	0	24.0	0.00	16,200
05-Aug						1	0	1	24.0	0.04	16,600
06-Aug						1	0	1	24.0	0.04	17,300
07-Aug	0	0	0	10.3	0.00	0	0	0	23.9	0.00	16,200
08-Aug	0	0	0	24.0	0.00	1	0	1	24.0	0.04	15,600
09-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	15,700
10-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	14,800
11-Aug	0	0	0	23.7	0.00	0	0	0	24.0	0.00	14,200
12-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	14,700
13-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	14,800
14-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	14,500
15-Aug	0	0	0	24.0	0.00	1	0	1	24.0	0.04	14,700
16-Aug	1	0	1	24.0	0.04	0	0	0	24.0	0.00	16,400
17-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	17,300
18-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	18,000
19-Aug	0	0	0	23.8	0.00	0	0	0	24.0	0.00	17,700
20-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	16,200
21-Aug	0	0	0	24.0	0.00	0	0	0	24.0	0.00	15,400
22-Aug	0	0	0	10.1	0.00	1	0	1	12.0	0.08	14,700
Total	**2**	**0**	**2**	891.5		**24**	**2**	**22**	1067.2		

Table G-5. Discharge estimates based on spatial integration of velocity data for ADCP surveys conducted in the Watana Canyon in August, 2014.

Transect	Start Edge	Start Time	Duration	Width (ft)	Area (ft2)	Mean Speed (ft/s)	Left Q (cfs)	Right Q (cfs)	Total Q (cfs)	Percent Measured
T7	Right Bank	14:08	0:02:25	344.1	2176	6.9	-0.8	-1.7	14,993	74.7
T7	Left Bank	14:19	0:04:06	329.5	2069	7.2	-4.7	2.6	14,980	74.9
T6	Right Bank	14:39	0:03:09	324.7	2265	6.6	8.7	0.8	15,058	73.6
T6	Left Bank	14:59	0:04:07	320.2	2200	6.8	8.3	0.6	14,988	73.9
T5	Right Bank	15:19	0:03:27	299.9	2132	6.7	3.8	0.9	14,601	74.3
T5	Left Bank	15:23	0:03:18	306.0	2179	6.7	5.4	0.9	14,913	74.5
T4	Right Bank	16:16	0:03:27	327.8	2347	6.3	0.4	1.0	15,267	74.8
T4	Left Bank	16:31	0:03:06	327.4	2338	6.4	2.4	-3.1	15,125	75.3
T3	Left Bank	16:42	0:02:39	305.4	2418	6.0	5.8	-2.9	14,698	75.8
T3	Right Bank	16:46	0:03:12	309.2	2465	6.0	3.2	24.3	15,102	75.7
T2	Right Bank	17:00	0:02:40	273.4	2401	6.1	3.9	23.5	15,030	76.4
T2	Left Bank	17:03	0:02:43	265.8	2496	5.9	3.1	25.9	14,895	76.2
T1	Left Bank	17:11	0:02:36	282.7	2414	6.2	6.2	1.2	14,890	76.3
T1	Right Bank	17:20	0:02:30	276.7	2359	6.1	4.7	1.5	14,346	74.5
		Mean	0:03:06	306.6	2304	6.4	3.6	5.4	14,920	75.1
		Std Dev	0:00:32	23.3	129	0.4	3.4	10.2	227	0.9
		COV		0.076	0.056	0.063	0.95	1.9	0.015	0.011

Table G-6. Daily data collection parameters at the Watana Canyon sonar sites, 2014.

Date	Time (hh:mm)	Sample Location	Range Start (m)	Range End (m)	Sonar Heading (deg.)	Sonar Tilt Angle (deg.)	Crew
6 Jul	16:51	River Left	2.9	39.2	329	-9.6	PJohnson, KShippen, SBurril
7 Jul	12:11	River Right	0.7	16.6	50	-17.0	KShippen, PJohnson
	14:52	River Left	0.7	39.1	330	-9.5	
8 Jul	11:53	River Right	0.7	16.5	50	-17.0	KShippen, PJohnson
	11:38	River Left	0.7	39.1	327	-10.0	
9 Jul	08:40	River Right	0.7	16.5	49	-17.1	KShippen, SBurril
	08:12	River Left	0.7	39.1	327	-9.7	
10 Jul	08:53	River Right	0.7	16.5	50	-17.1	KShippen, SBurril
	08:36	River Left	0.7	39.1	327	-9.9	
11 Jul	09:34	River Right	0.7	16.5	47	-15.5	KShippen, SBurril
	08:59	River Left	0.7	38.9	327	-9.8	
12 Jul	08:22	River Right	0.7	16.5	47	-15.4	KShippen, JBures
	08:42	River Left	0.7	38.9	326	-9.8	
13 Jul	11:45	River Right	0.7	16.5	47	-16.5	KShippen, JBures
	11:26	River Left	0.7	38.9	327	-9.8	
14 Jul	08:28	River Right	0.7	16.5	48	-15.3	KShippen, JBures
	09:09	River Left	0.7	38.9	324	-13.2	
15 Jul	12:32	River Right	0.7	16.5	48	-15.4	KShippen, JBures
	08:35	River Left	0.7	38.9	325	-13.2	
16 Jul	09:23	River Right	0.7	16.5	50	-16.3	KShippen, JBures
	08:44	River Left	0.7	38.9	324	-13.2	
17 Jul	09:41	River Right	0.7	16.5	48	-15.2	KShippen, JBures
	10:23	River Left	0.7	38.9	322	-12.6	
18 Jul	11:55	River Right	0.7	16.5	47	-15.1	JBures, LGasek
	12:26	River Left	0.7	39.1	318	-11.6	
19 Jul	8:48	River Right	0.7	16.5	47	-15.2	JBures, LGasek
	09:02	River Left	0.7	39.1	318	-11.6	
20 Jul	8:48	River Right	0.7	16.5	47	-15.1	JBures, LGasek
	09:10	River Left	0.7	39.0	318	-11.6	
21 Jul	09:00	River Right	0.7	16.5	47	-15.6	JBures, LGasek
	08:39	River Left	0.7	38.9	317	-11.5	
22 Jul	12:03	River Right	0.7	16.5	56	-15.7	JBures, LGasek
	12:22	River Left	0.7	39.0	318	-11.4	
23 Jul	08:46	River Right	0.7	16.6	55	-14.9	JBures, LGasek
	09:05	River Left	0.7	39.1	317	-11.5	
24 Jul	09:53	River Right	0.7	16.5	54	-14.2	JBures, LGasek
	09:38	River Left	0.7	39.0	317	-11.5	
25 Jul	08:50	River Right	0.7	16.5	53	-14.2	JBures, LGasek
	09:00	River Left	0.7	39.0	317	-11.5	
26 Jul	08:51	River Right	0.7	16.5	53	-14.2	JBures, LGasek
	09:07	River Left	0.7	38.8	317	-11.5	
27 Jul	08:40	River Right	0.7	16.5	53	-14.2	JBures, LGasek
	08:51	River Left	0.7	38.9	317	-11.5	
28 Jul	10:15	River Right	0.7	16.5	53	-13.9	JBures, LGasek
	10:55	River Left	0.7	39.0	334	-9.1	
29 Jul	11:00	River Right	0.7	16.5	53	-14.1	JBures, LGasek
	11:21	River Left	0.7	39.0	336	-9.2	

Table G-6. Continued.

Date	Time (hh:mm)	Sample Location	Range Start (m)	Range End (m)	Sonar Heading (deg.)	Sonar Tilt Angle (deg.)	Crew
30 Jul	13:20	River Right	0.7	16.5	54	-14.0	JBures, LGasek
	10:43	River Left	0.7	39.0	336	-9.1	
31 Jul	09:28	River Right	0.7	16.6	54	-14.3	JBures, LGasek
1 Aug	09:24	River Right	0.7	16.6	54	-14.2	JBures, LGasek
2 Aug	08:46	River Right	0.7	16.5	54	-14.2	JBerry, LFerreira
3 Aug	09:36	River Right	0.7	16.5	54	-14.1	JBerry, LFerreira
4 Aug	09:56	River Right	0.7	16.5	54	-14.2	JBerry, LFerreira
5 Aug	09:37	River Right	0.7	16.5	54	-14.2	JBerry, LFerreira
6 Aug	11:33	River Right	0.7	16.5	53	-14.1	JBerry, LFerreira
7 Aug	09:56	River Right	0.7	16.5	54	-14.2	JBerry, LFerreira
	13:47	River Left	0.7	39.5	327	-8.4	
8 Aug	08:23	River Right	0.7	16.5	54	-14.2	JBerry, LFerreira
	08:53	River Left	0.7	39.5	329	-8.3	
9 Aug	08:40	River Right	0.7	16.5	54	-14.1	JBerry, LFerreira
	08:29	River Left	0.7	39.5	329	-8.4	
10 Aug	08:27	River Right	0.7	16.5	54	-14.2	JBerry, LFerreira
	08:16	River Left	0.7	39.5	330	-8.3	
11 Aug	08:13	River Right	0.7	16.6	54	-14.1	JBerry, LFerreira
	08:30	River Left	0.7	39.5	330	-10.0	
12 Aug	08:31	River Right	0.7	16.6	52	-13.0	JBerry, LFerreira
	08:12	River Left	0.7	39.5	330	-10.0	
13 Aug	08:26	River Right	0.7	16.6	52	-13.0	JBerry, LFerreira
	08:14	River Left	0.7	39.5	329	-10.0	
14 Aug	08:26	River Right	0.7	16.5	52	-13.0	JBerry, LFerreira
	08:15	River Left	0.7	39.5	330	-10.0	
15 Aug	08:19	River Right	0.7	16.5	52	-13.0	JBerry, NCollin
	08:37	River Left	0.7	39.6	330	-10.0	
16 Aug	11:07	River Right	0.7	16.5	52	-13.0	JBerry, NCollin
	10:55	River Left	0.7	39.5	330	-10.2	
17 Aug	08:21	River Right	0.7	16.4	51	-13.1	JBerry, NCollin
	08:39	River Left	0.7	39.6	330	-10.1	
18 Aug	08:30	River Right	0.7	16.4	51	-13.1	JBerry, NCollin
	09:12	River Left	0.7	39.5	330	-10.1	
19 Aug	08:10	River Right	0.7	16.5	46	-10.2	JBerry, NCollin
	08:35	River Left	0.7	38.8	331	-8.4	
20 Aug	09:04	River Right	0.7	16.5	50	-11.8	JBerry, NCollin
	08:46	River Left	0.7	39.0	332	-8.4	
21 Aug	08:03	River Right	0.7	16.5	56	-14.1	JBerry, NCollin
	08:20	River Left	0.7	39.0	332	-8.4	
22 Aug	08:39	River Right	0.7	16.5	55	-14.0	JBerry, NCollin
	09:00	River Left	0.7	39.0	332	-8.4	

Figure G-1. Photograph of the Susitna River immediately downstream of the proposed Watana Dam Site (PRM 187.1) showing the location of the river left and river right sonar sites and the wetted channel width.

Figure G-2. Photographs showing the ARIS mounts deployed at the left bank (left) and right bank (right) monitoring stations.

Figure G-3. Photographs showing the environmental boxes used to house the ARIS systems electronic components, and power sources (battery banks are inside action packers) for the left bank (left) and right bank (right) monitoring stations.

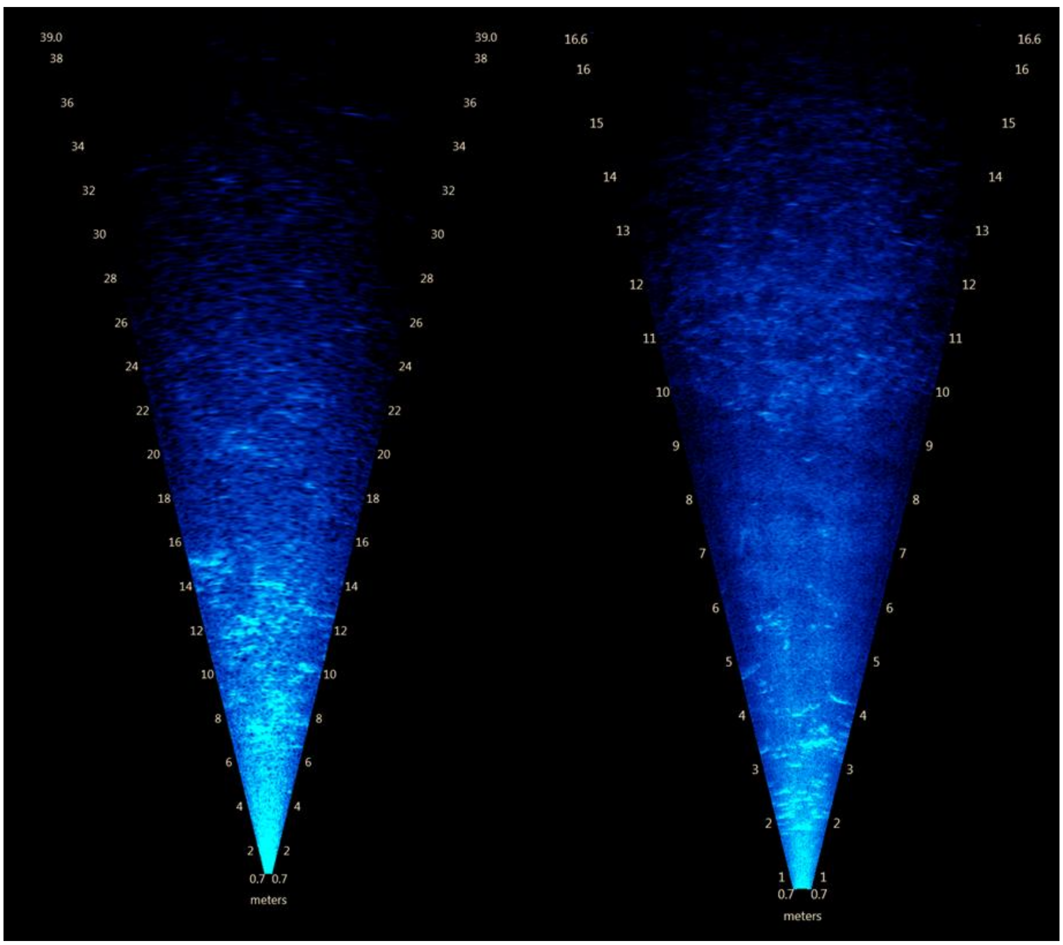

Figure G-4. Still images from ARIS data showing the cobble substrate (light-colored structure) along the left bank (left) and right bank (right) fields-of-view. Substrate is visible to 38 and 16 m in range from the left and right bank FOVs, respectively. Note range markers are shown in 2-m increments on left and 1-m increments on right.

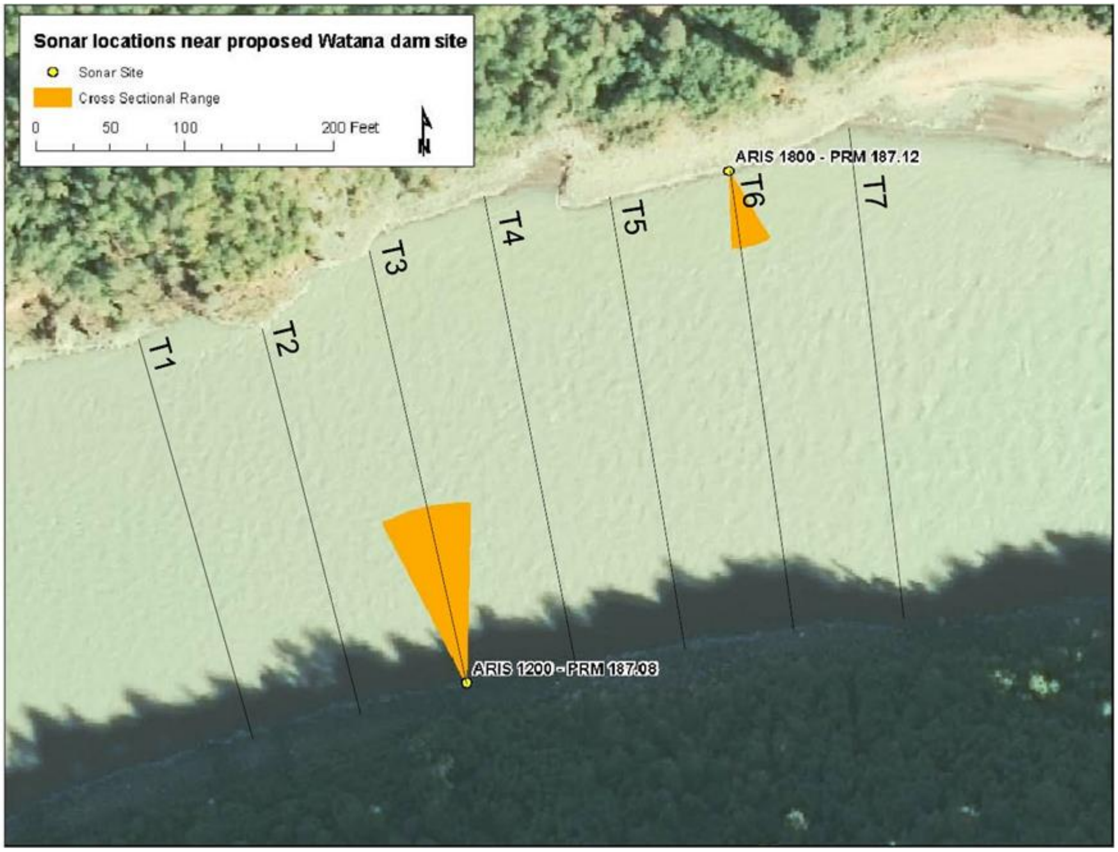

Figure G-5. Ortho image showing the ensonified wetted width coverage of each ARIS unit near the Watana Dam Site, 2014. Ensonified coverage is scaled to match the width of the river. River flow is from right to left.

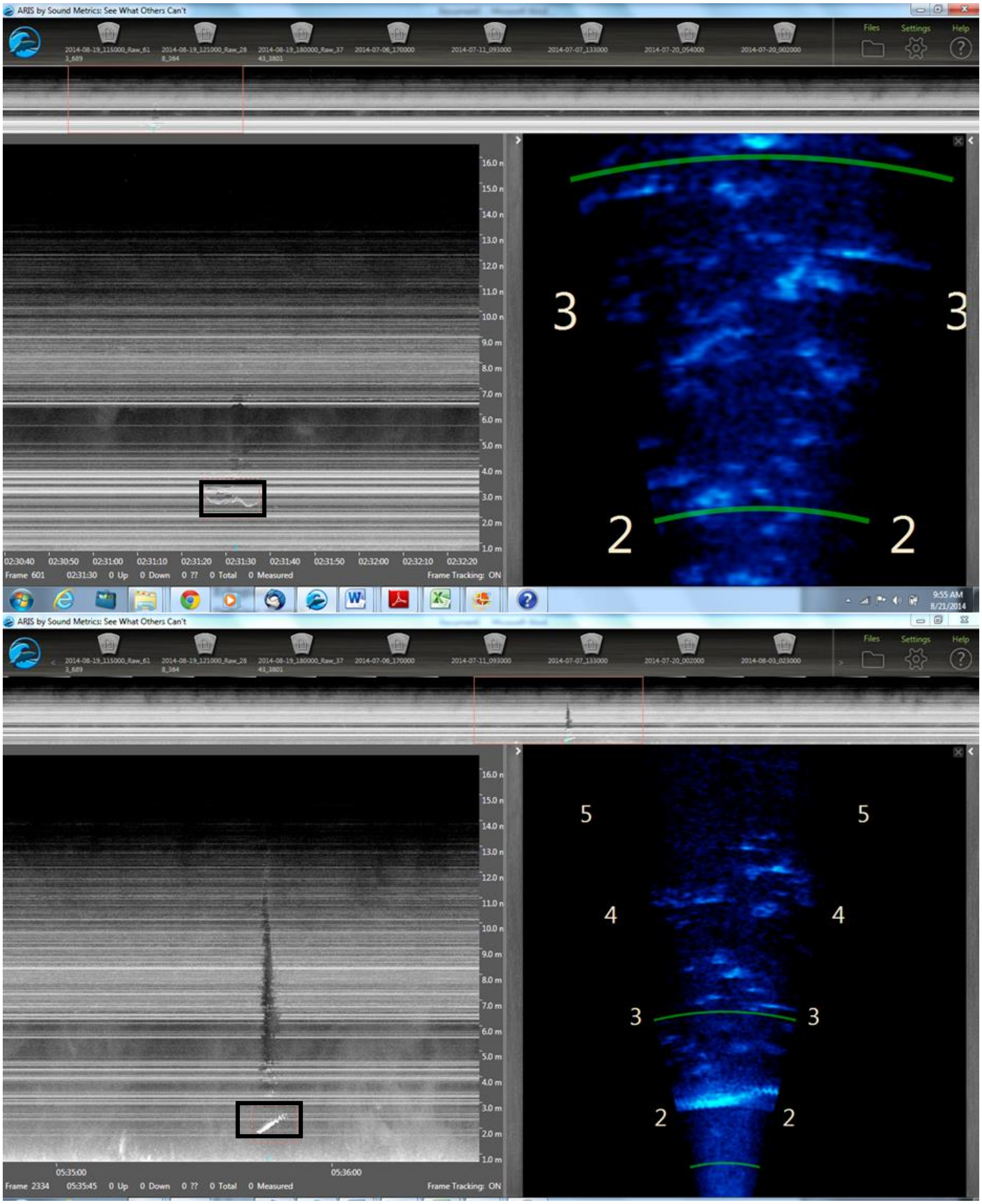

Figure G-6. Screen shots of Right Bank ARIS data showing echograms (left) and still sonar imagery (right) for a resident fish (top) and Chinook Salmon (bottom). Echogram tracks are shown inside the black rectangles and the fish targets in the imagery data are shown inside the white circles.

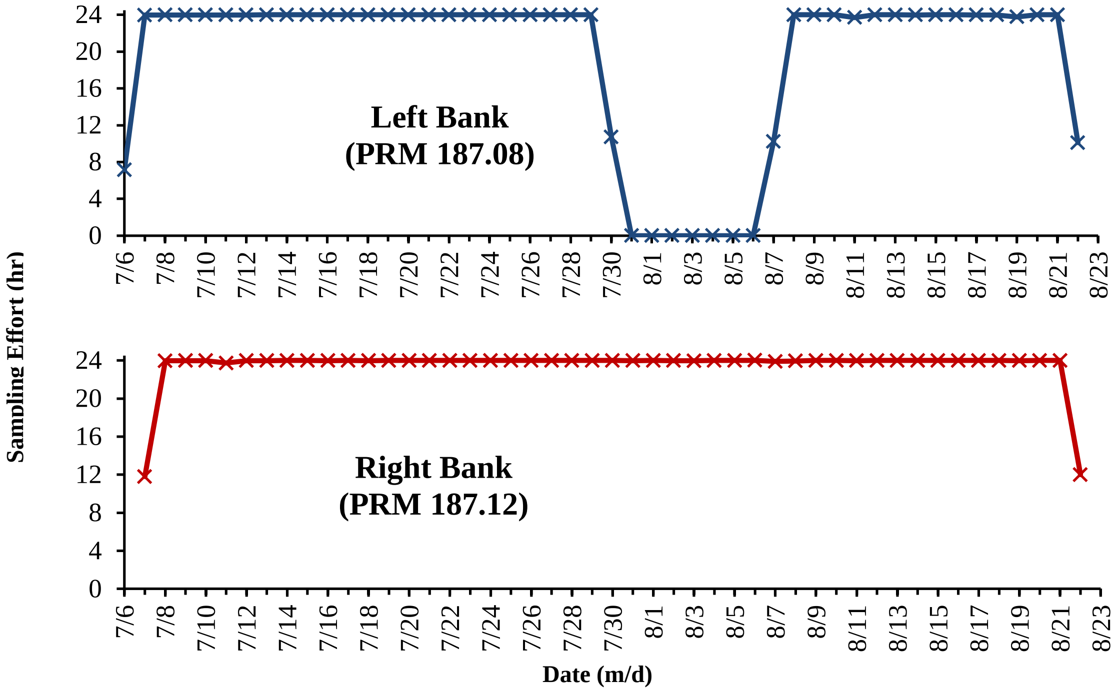

Figure G-7. Daily sampling effort at two ARIS sonar units located at PRM 187.1 in the Upper River, 2014.

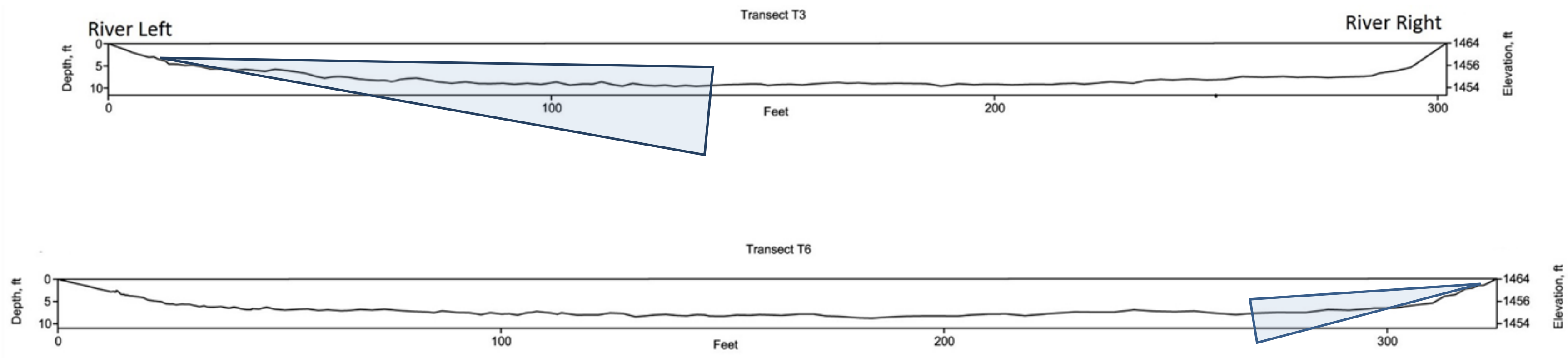

Figure G-8. Bathymetry profiles derived from ADCP data for transects aligned with ARIS sampling locations (PRM 187.1). Typical cross-sectional coverage of ARIS sample areas are depicted with the overlaid triangles.

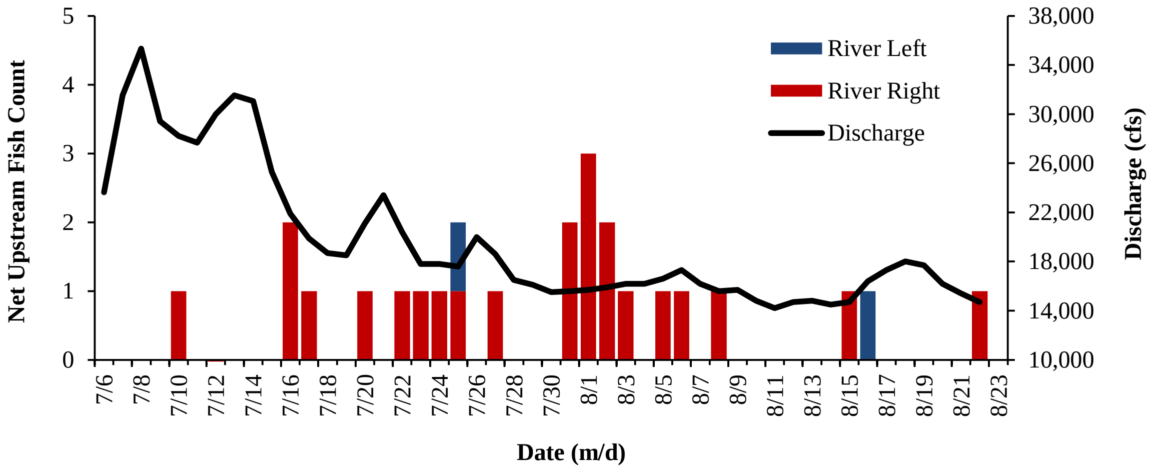

Figure G-9. Net upstream count of fish measuring 50 cm or greater at two ARIS sonar units located at PRM 187.1 in the Upper River, 2014. Discharge of the Susitna River at Tsusena Creek is also shown.

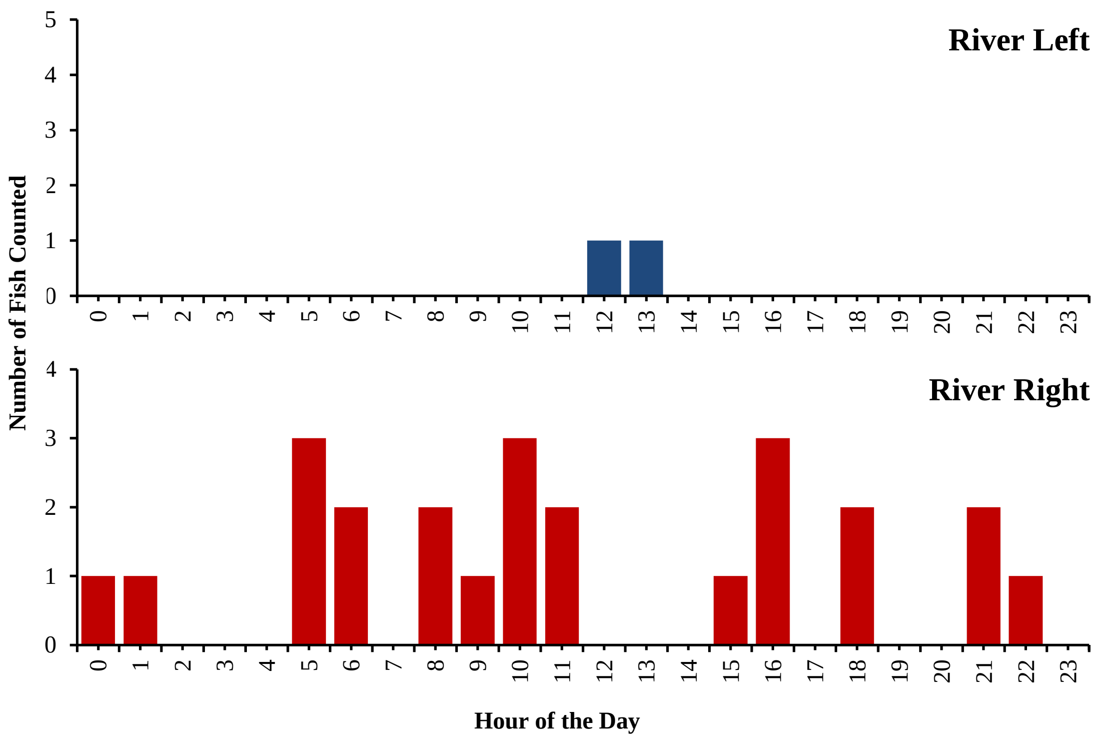

Figure G-10. Diel migration of fish measuring 50 cm or greater counted at two ARIS sonar units located at PRM 187.1 in the Upper River. Only upstream-moving fish are shown.

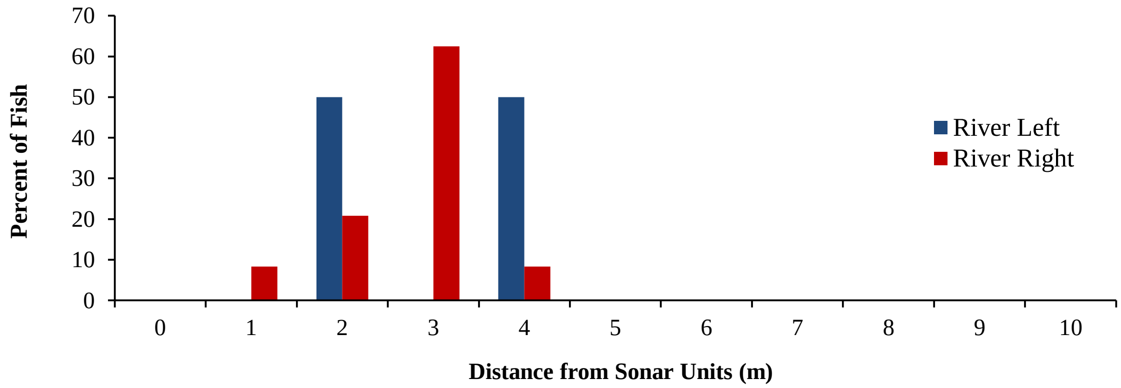

Figure G-11. Percent of fish measuring 50 cm or greater counted at two ARIS sonar units located at PRM 187.1 in the Upper River as a function of distance from the sonar units, 2014. The mid-range distance was calculated as the average of where a fish was first and last detected in the FOV. Only upstream-moving fish are shown.

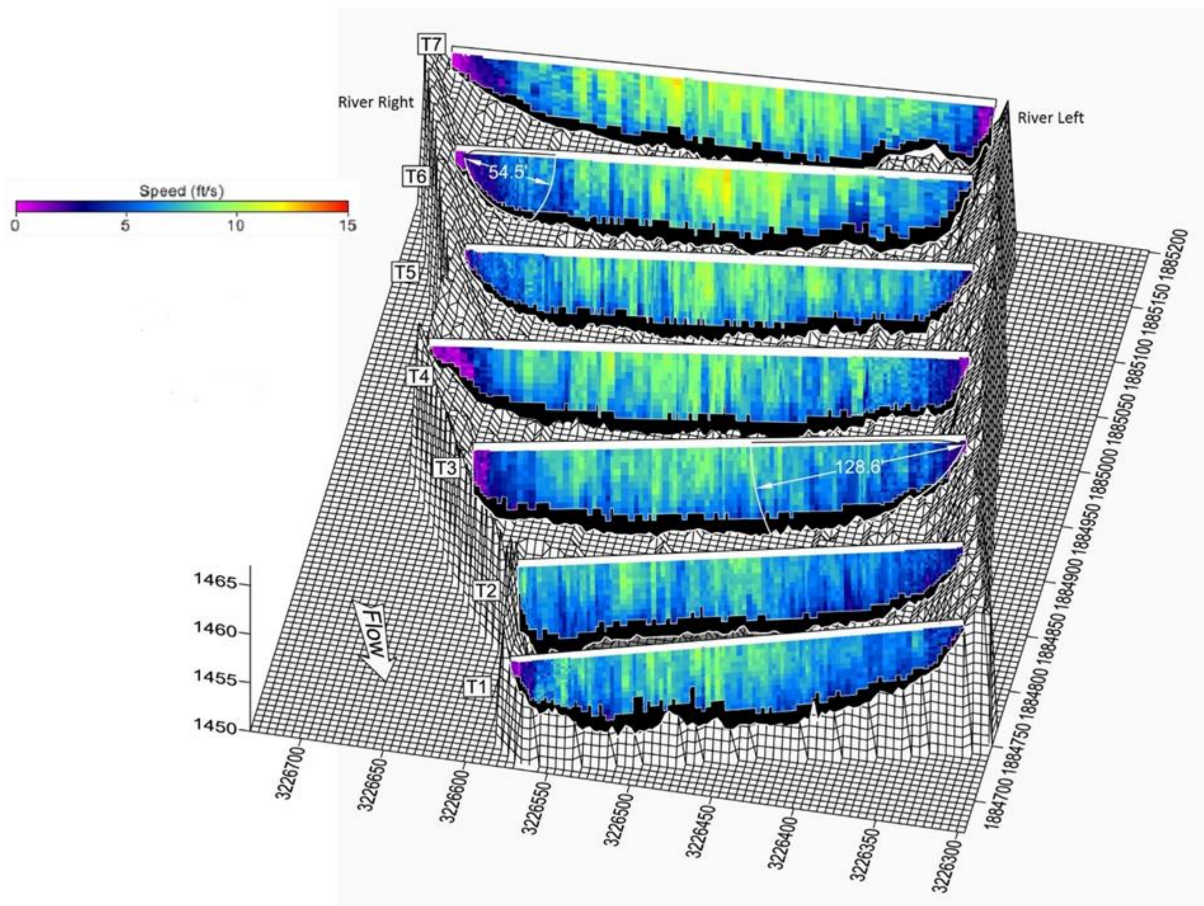

Figure G-12. Series of velocity profiles collected along transects using an ADCP at Watana Canyon (PRM 187.1) in 2014. Transects are arranged from upstream (top) to downstream (bottom) to allow for best presentation of the transect-to-transect channel morphology. Range of sonar stations is shown for the River Left site at Transect 3 and River Right site at Transect 6.

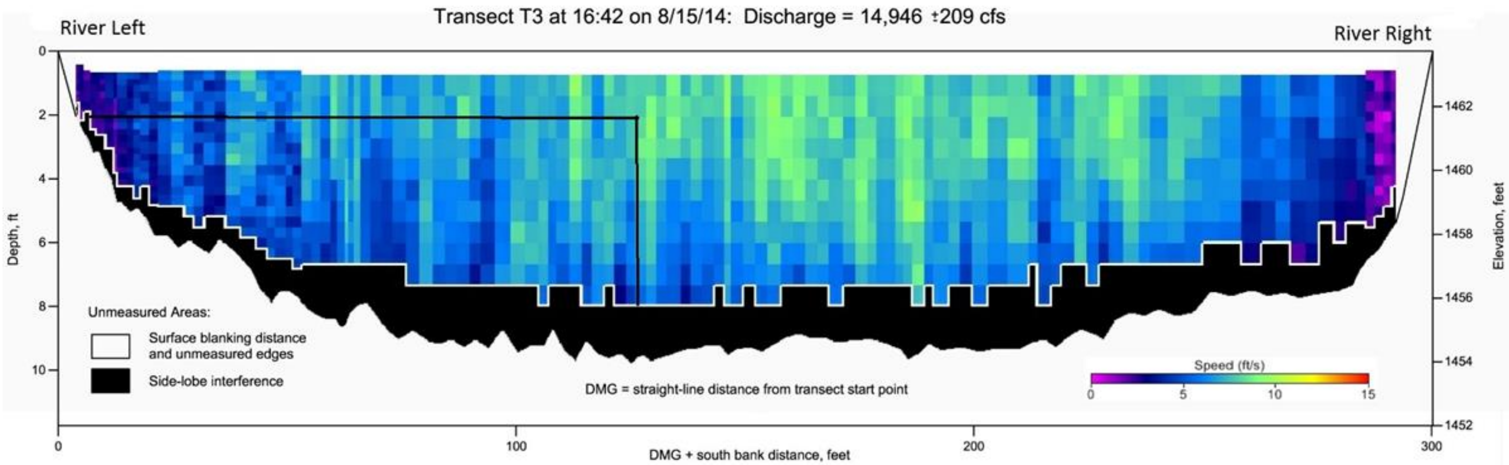

Figure G-13. Individual velocity profile for Transect 3 in Watana Canyon (PRM 187.1) collected with an ADCP in 2014. This profile corresponds to the location of the sonar station on River Left (ensonified zone illustrated).

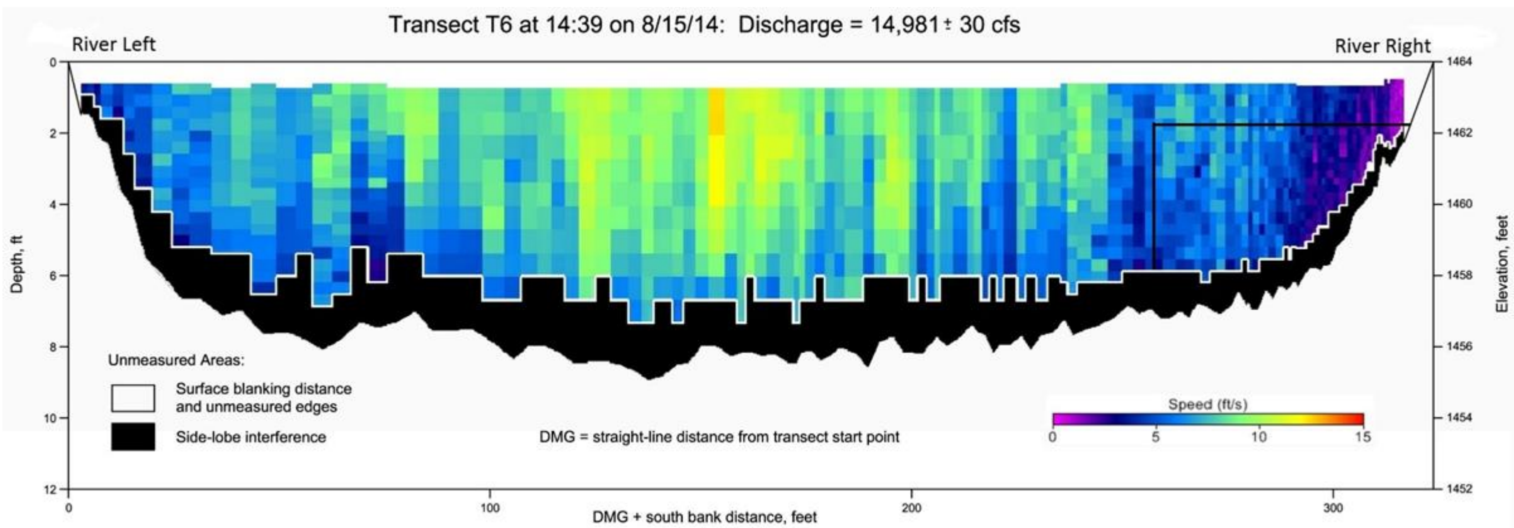

Figure G-14. Individual velocity profile for Transect 6 in Watana Canyon (PRM 187.1) collected with an ADCP in 2014. This profile corresponds to the location of the sonar station on River Right (ensonified zone illustrated).

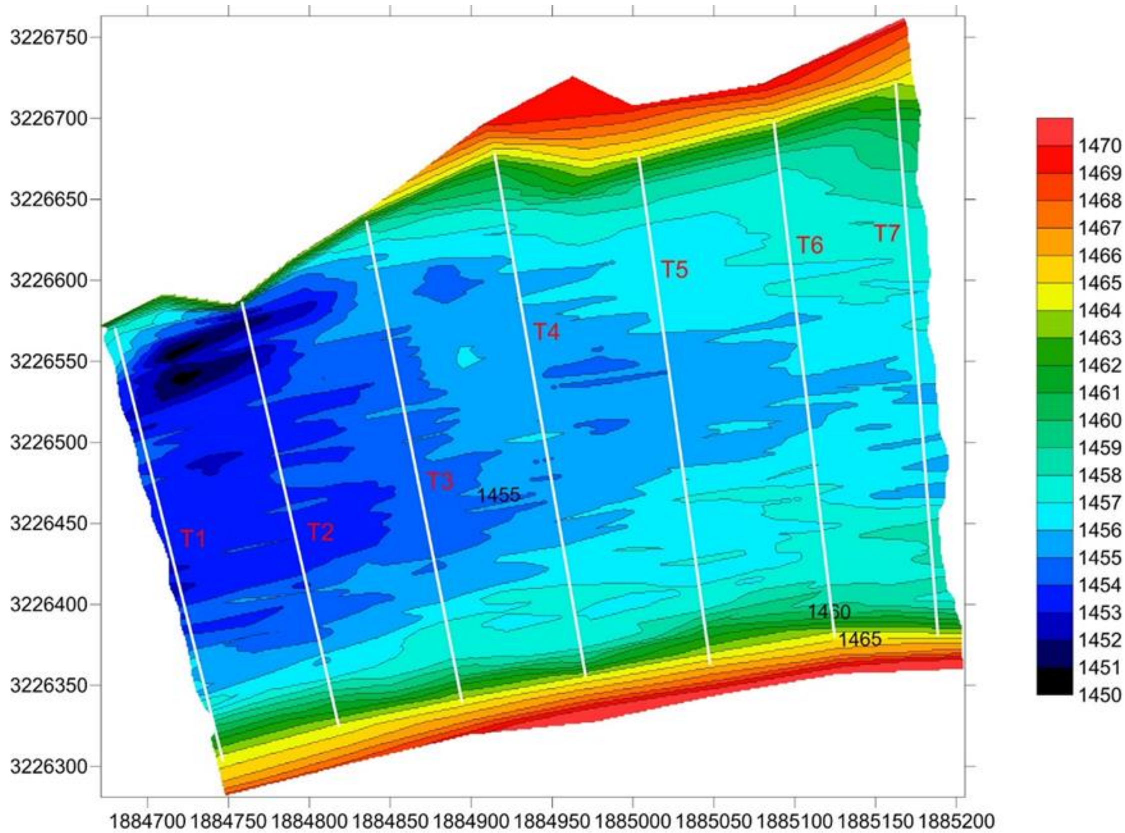

Figure G-15. Bathymetry in Watana Canyon (PRM 187.1) based on seven serial ADCP transects, 2014.

Appendix H: Indian River Escapement Estimate for chinook salmon

1. INDIAN RIVER ESCAPEMENT ESTIMATE

Two components are required to estimate abundance using AUC methods: 1) an estimate of the number of fish-days derived from an area under the escapement curve; and 2) an estimate of the residence time, or the length of time that fish are alive in the survey area. For this study, the escapement curve was derived from Chinook Salmon counts made during aerial spawner surveys, and residence time was estimated from detections of radio-tagged Chinook Salmon made during aerial telemetry surveys in the Indian River.

Aerial spawner surveys were conducted in the Indian River every third day from early July to late August to count the number of live Chinook Salmon present in the river. Aerial spawner counts were stratified into three river sections. Section 1 extended from the clear-water plume at the confluence with the Susitna River up to Bridge 1 in the lower Indian River; Section 2 ranged from Bridge 1 to the power-line crossing; and Section 3 ranged from the power-line crossing to the Forks. Due to the resolution available from radio telemetry, the study team could not definitively assign radio-tagged Chinook Salmon detected in proximity to the confluence (below Bridge 1) to either Section 1 or the turbid waters of the mainstem Susitna River. To estimate residence time (and mark rates), it was important that the aerial spawner counts and radio-tag detections correspond to the same survey areas, thus all subsequent AUC calculations were germane to the area upstream of Bridge 1 (i.e., only data from river sections 2 and 3 were used).

For each river section, crews recorded their observed counts and an estimate of observer efficiency. As part of the AUC calculations described below, the estimates of observer efficiency were used to ‘adjust’ the observed counts. Observer efficiency was estimated for each river section because there were differences in the physical characteristics of each (e.g., gradient, substrate, flow dynamics, vegetation cover); and these differences can influence an observer’s ability to count fish. Environmental conditions used to estimate observer efficiency included water clarity, sun glare, and vegetation cover, all of which were ranked on a scale of 0 to 4 (0 is poor, 4 is optimal). Survey crews also took weather conditions and professional judgment into account when estimating observer efficiency for each river section.

Aerial telemetry surveys were also conducted in the Indian River every third day from early July to late August, on the same days as the aerial spawner surveys. Aerial telemetry surveys were used to count the number of radio-tagged Chinook Salmon in each of the river sections, and to record whether the radio-tagged fish were alive or dead.

As described by English et al. (1992), the number of live fish present in the study area on the i^{th} day (p_i) was estimated by:

$$p_i = \sum_{h=1}^{L} f_o \cdot N_h \cdot ns_{ih}^{-1} \cdot oe_{ih}^{-1} \quad (1)$$

where: L is the number of spatial strata (h) within each stream; fo_{ih} is the fish observed during surveys in stratum h on the i^{th} sampling day; n_h is the number of sampling units in stratum h; ns_{ih} is the number of units surveyed in stratum h on the i^{th} sampling day; and oe_{ih} is the observer efficiency.

The area under the escapement curve (auc) was estimated by:

$$auc = 0.5 \cdot \sum_{i=2}^{n} (t_i - t_i) \cdot (p_i + p_{i-1}) \quad (2)$$

where: t_i is the number of days measured from the first day fish enter the survey area to the i^{th} sampling day; and n-2 is the number of surveys when fish were seen.

An escapement estimate (N) was then calculated as:

$$N = auc/rt \quad (3)$$

Residence time (rt) of Chinook Salmon in the Indian River was estimated using radio-tagged fish that were released in the Lower and Middle rivers. All radio tags were equipped with a mortality sensor that changed the signal pattern to an "inactive" mode for the remainder of the season once the tag became stationary for 24 hours. Residence times for individual fish were calculated as the cumulative length of time spent alive in the study area. Aerial telemetry surveys were not flown daily, so the dates that some fish died were approximated. Median residence times were used in AUC calculations.

Escapement estimates derived using AUC methods are dependent on the input values for observer efficiency and residence time. Despite using consistent aerial surveying methods with an experienced crew, and having access to telemetry data from dozens of radio-tagged fish in the Indian River, the estimates of these parameters were potentially biased to some degree in 2014. Validation was compromised by the Indian River weir being rendered inoperable prior to the onset of the Chinook Salmon run, so there were no weir counts available to 'ground-truth' the aerial spawner surveys. As such, the study team conducted a sensitivity analysis to determine the potential impact of reducing estimates of observer efficiency on the escapement estimate.

2. MARK RATE

The mark rate, or the proportion of the Chinook Salmon run that was tagged, was estimated for the Middle River fishwheels by dividing the total number of large, radio-tagged Chinook Salmon released in the Middle River that were detected above Bridge 1 by the estimated escapement of fish above Bridge 1.

Table H-1. Number of Chinook Salmon counted during aerial spawner surveys in the Indian River, and the number of radio-tagged large Chinook Salmon detected, by tag site, 2014. These data are preliminary, and additional aerial spawner surveys are planned for August (these data will be added to the table later).

			Aerial Count		Live Tags Detected[c] (by Tag Site)		Mark Rate[c] (by Tag Site)		
Survey Date	River Section[a]	Observer Efficiency	Observed	Adjusted	Middle River	Lower River	Middle River	Lower River	Comment
07-Jul	1	60%	36	60	x	x			Good conditions
	2	70%	91	130	17	2			Most fish holding in pools
	3	80%	0	0	1	0			pool count estimated
	Total		**127**	**190**			13.8%	1.5%	
10-Jul	1	50%	82	164	x	x			Fair conditions
	2	60%	184	307	20	2			dark, light rain
	3	70%	29	41	3	1			Most fish holding in pools
	Total		**295**	**512**			6.6%	0.9%	pool count estimated
14-Jul	1	60%	123	205	x	x			Good conditions
	2	70%	233	333	48	3			Some fish holding in pools
	3	80%	72	90	10	2			pool count estimated
	Total		**428**	**628**			13.7%	1.2%	
17-Jul	1	60%	110	183	x	x			Good conditions
	2	70%	389	556	67	5			Less fish in pools
	3	80%	101	126	15	4			Spawning activity
	Total		**600**	**865**			12.0%	1.3%	
19-Jul	1	40%	61	153	x	x			Poor conditions
	2	50%	330	660	68	3			Bad weather
	3	60%	56	93	20	5			dark and rainy
	Total		**447**	**906**			11.7%	1.1%	
22-Jul	1	60%	160	267	x	x			Excellent conditions
	2	70%	490	700	77	5			Fish evenly distributed
	3	80%	148	185	28	3			on spawning grounds
	Total		**798**	**1,152**			11.9%	0.9%	
26-Jul	1	50%	70	140	x	x			Fair conditions
	2	60%	327	545	85	6			Turbidity in lower reaches
	3	80%	108	135	30	5			following high water event
	Total		**505**	**820**			16.9%	1.6%	
29-Jul	1	60%	67	112	x	x			Excellent conditions
	2	70%	379	541	83	4			Fish redistributed
	3	80%	160	200	26	5			following high water event
	Total		**606**	**853**			14.7%	1.2%	
01 Aug [b]	1	60%	47	78	x	x			Good conditions
	2	70%	351	501	82	6			Corresponding aerial
	3	80%	146	183	22	3			telemetry survey was
	Total		**544**	**762**			15.2%	1.3%	conducted on July 31

Table H-1. Continued.

			Aerial Count		Live Tags Detected[c] (by Tag Site)		Mark Rate[c] (by Tag Site)		
Survey Date	River Section[a]	Observer Efficiency	Observed	Adjusted	Middle River	Lower River	Middle River	Lower River	Comment
03-Aug	1	60%	59	98	x	x			Good conditions
	2	70%	323	461	47	4			
	3	80%	96	120	16	5			
	Total		**478**	**680**			10.8%	1.5%	
06-Aug	1	60%	34	57	x	x			Good conditions
	2	70%	214	306	38	4			
	3	80%	58	73	11	4			
	Total		**306**	**435**			13.0%	2.1%	
09-Aug	1	60%	18	30	x	x			Good conditions
	2	70%	127	181	32	3			
	3	80%	24	30	7	3			
	Total		**169**	**241**			18.4%	2.8%	
12-Aug	1	60%	6	10	x	x			Good conditions
	2	70%	55	79	22	2			
	3	80%	14	18	3	2			
	Total		**75**	**106**			26.0%	4.2%	
15-Aug	1	60%	5	8	x	x			Good conditions
	2	70%	16	23	13	2			
	3	80%	4	5	3	2			
	Total		**25**	**36**			57.4%	14.4%	
18-Aug	1	60%	0	0	x	x			Good conditions
	2	70%	2	3	4	3			
	3	80%	1	1	3	3			
	Total		**3**	**4**			170.4%	146.1%	
19-Aug	1	60%	0	0	No aerial telemetry survey was flown on 8/19				Good conditions
	2	70%	2	3					
	3	80%	1	1					
	Total		**3**	**4**					

[a] Section 1 = clearwater plume to Bridge 1; Section 2 = Bridge 1 to Powerline; Section 3 = Powerline to Forks.

[b] The aerial telemetry survey corresponding to the August 1 aerial spawner survey was conducted on July 31.

[c] Counts of live tags (and mark rate calculations) were based on data collected in sections 2 and 3 and excluded section 1.

Table H-2. Summary of AUC abundance estimate, mark rate at the Middle River tag site, and the expected number of fish passed the Watana Dam sonar site, 2014.

Area under the escapement curve (fish days)	**20,280**
Median residence time (days)	**15.6**
Estimated abundance of large Chinook salmon above Bridge 1	**1,297**
Number of Middle River tags above Bridge 1	**171**
Mark rate at Middle River fishwheels (%)	**13.2**
One of every 'X' fish was tagged in Middle River, where 'X' =	**7.6**
Expected number of fish passed Watana given that one tag passed =	**7.6**
Expected number tags passed Watana given sonar count of 24 fish =	**3.2**

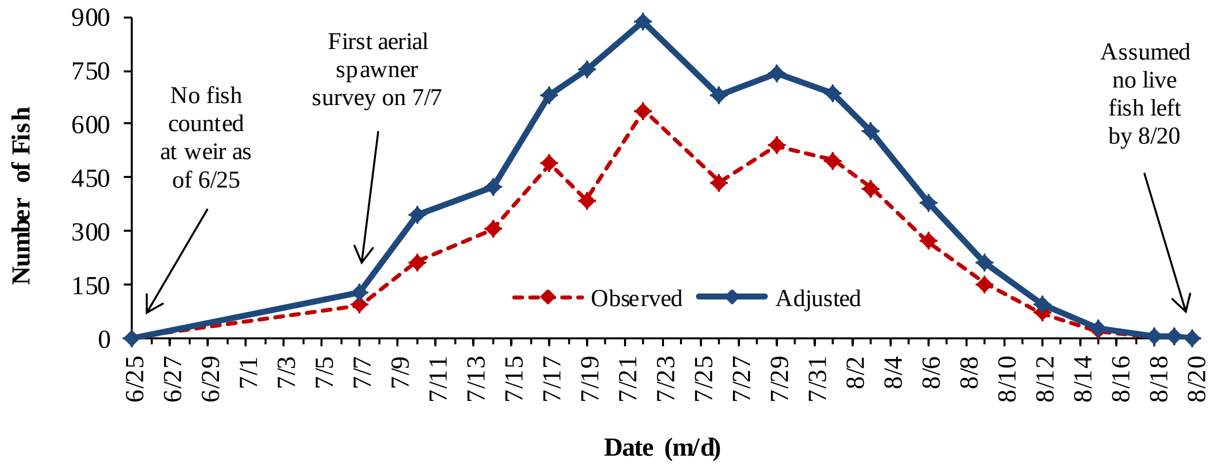

Figure H-1. Number of Chinook Salmon counted during aerial spawner surveys above Bridge 1 in the Indian River, 2014. Observed counts (dashed red line) for each survey were expanded by reach-specific estimates of observer efficiency to derive 'adjusted' counts (solid blue line). The zero count on June 25 was estimated; no Chinook Salmon were observed passing the Indian River weir through June 25 (prior to it being washed out by a high-water event). The zero count on August 20 was estimated (surveyors indicated that the three remaining live Chinook Salmon observed on August 19 were moribund).

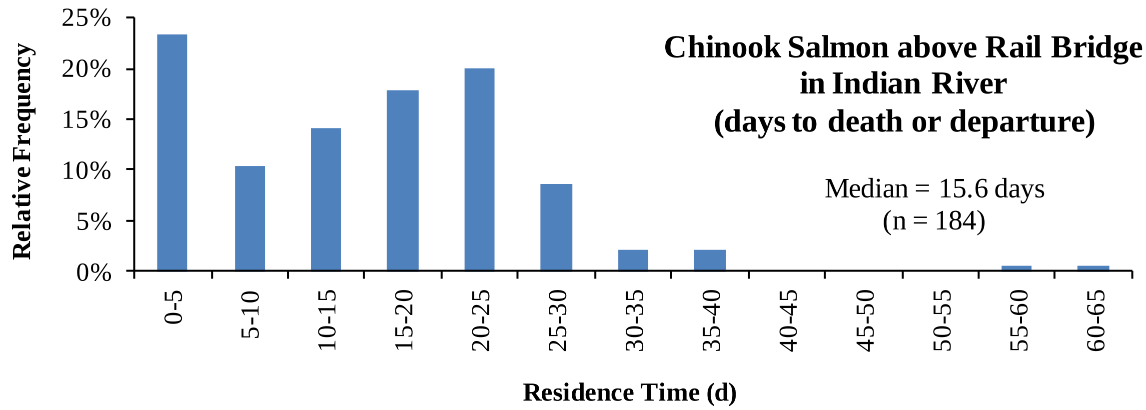

Figure H-2. Relative frequency of residence times (days) for radio-tagged Chinook Salmon above Bridge 1 in the Indian River, 2014.

Appendix I: Estimate the system-wide Chinook Salmon escapement, Coho Slamon escapement above the Yentna River, and the distribution of those fish among tributaries of the susitna river

1. INTRODUCTION

This appendix presents the data analyses pertinent to the estimation of Chinook and Coho salmon abundance in the Susitna River upstream of the confluence with the Yentna River, and Chinook Salmon abundance in the Yentna River drainage.

1.1. Study Objective

The Chinook and Coho salmon abundance and distribution estimates reported herein are a component of the following study objective.

From Section 2, Objective 8:

8) Estimate the system-wide Chinook Salmon escapement to the entire Susitna River, the Coho Salmon escapement to the Susitna River above the confluence with the Yentna River, and the distribution of Chinook, Coho, and Pink salmon among tributaries of the Susitna River (upstream of Yentna River confluence) in 2013 and 2014.

2. STUDY AREA

The section of the Susitna River upstream of the confluence with the Yentna River is hereafter referred to as the "mainstem Susitna River" and encompasses the "Lower," "Middle," and "Upper" sections of the Susitna River as defined in Section 3. For Yentna River Chinook Salmon, the abundance and spawning distribution estimates are germane to the Chinook Salmon population passing the marking sites on the lower Yentna River at river mile 6.

3. METHODS

See Section 4.8.

4. RESULTS

4.1. Estimated Abundance of Chinook Salmon

4.1.1. Mainstem Susitna River Above the Yentna River Confluence

A total of 2,048 Chinook Salmon of all sizes were captured in drift gillnets and two fishwheels at the lower mainstem Susitna River tagging site (PRM 34) from May 22 to August 19, 2014. Radio tags were deployed on 659 Chinook Salmon measuring 50 cm (19.7 in) METF or greater. Based on observations made at fixed-station receiver sites and using aerial radio-telemetry, 494 of these radio-tagged fish moved upstream and remained one mile upstream of the east bank fishwheel and therefore met criteria to be in the mark-recapture experiment. The remaining 165 (659–494) radio-tagged Chinook Salmon either migrated to the Yentna River drainage or the Susitna River below PRM 34, failed to migrate due to handling stress, or were above the tagging site and not detected (unlikely). It was also possible that some tags were regurgitated below the point at which the tagged fish were categorized as being part of the mark-recapture experiment (one mile upstream of the east bank fishwheel). Second event sampling was conducted at weirs on the Deshka River and at Montana Creek. A total of 16,335 Chinook Salmon were counted through the Deshka River weir from May 19 to September 2, 2014, with 13,908 of these fish estimated to be 50 cm (19.7 in) METF or greater. At the Montana Creek weir, 1,217 Chinook Salmon were counted from June 23 to September 11, of which 1,212 fish were estimated to be 50 cm (19.7 in) METF or greater. Second event sampling was also conducted at a site on the Chulitna River using telemetry and an ARIS sonar system. However, the sonar echogram quality, counts, and length determinations suggest the data to be unreliable and they were not used. The estimated numbers of Chinook Salmon measuring 50 cm (19.7 in) METF or greater that passed the Deshka River and Montana Creek weirs comprised the second event of the mark-recapture experiment.

Based on observations made at fixed-station receivers and using aerial radio-telemetry, 125 radio-tagged Chinook Salmon passed the Deshka River weir and were assumed to have spawned above the weir. Similarly, 15 radio-tagged Chinook Salmon passed the Montana Creek weir and were assumed to have spawned above the weir. Flood events at the Deshka weir on June 28–29 and at the Montana Creek weir on June 26–30 prevented accurate counting. Recaptures associated with these periods were removed from the data (one tag was removed for each of the Deshka River and Montana Creek datasets). The remaining 138 recaptures (125+15-2) were used in the mark-recapture experiment.

Tests for size-biased sampling in the marking and recapture events were conducted using the KS two-sample test (Cleary et al. 2013). The tests for the second sampling event, which compared the length distributions of marked and recaptured fish, provided significant evidence of size biased sampling (P = 0.016; Figure I-1).

The test for size-biased sampling during the first event using data from fish passing the Deshka River weir provided significant evidence of size biased sampling (P < 0.001; Figure I-2). A similar test for size-biased sampling during the first event using data from fish passing the Montana Creek weir also provided evidence of size biased sampling (P = 0.026, Figure I-3), although the length of the maximum D-value, and hence the suggested stratification point, was considerably smaller. Given that the sample sizes at the Montana weir were substantially lower than those at the Deshka River weir results of the first-event KS test using data from the Deshka River weir were preferred. Montana Creek weir counts (of fish measuring 50 cm [19.7 in] or greater) and recaptures were approximately 9 percent and 11 percent of those at the Deshka River weir.

Based on these test results, the data were stratified into two size strata: 50.0–78.5 cm (19.7–30.9 in) METF, and 78.5 cm (30.9 in) METF or greater. Re-running the KS tests for size selectivity within each size category failed to detect any selectivity at $\alpha = 0.05$. Moreover, for each of the size categories, one of the two KS tests described above was not significant at $\alpha = 0.2$.

Tests for consistency of the Chapman (1951) model for estimation of abundance with respect to temporal and/or spatial variation in probability of capture were conducted within the each of the 2 size strata. These tests were first described by Seber (1982; p. 438–439) and subsequently described as the ‘Equal Proportions Test” (EP) and the “Complete Mixing Test” (CM) by Arnason et al. (1996). A passing EP or CM test means the Chapman model is valid. The EP tests examine the consistency of marked fractions in the second event sample over spatial and temporal strata. The EP tests were only approximate, because the number of fish inspected for marks during second event sampling within each stratum was not known, but was estimated using size composition data collected at each weir.

Before the EP tests were conducted an adjustment to the timing of the recaptures at the weirs was made; this adjustment affected the EP tests on temporal strata. Analysis of the timing of weir counts and recaptures at the Deshka weir strongly suggested a tag-induced lag for the recaptured fish. The median run timing of the untagged fish was significantly earlier than that of the recaptured fish (Mann-Whitney test; W = 764, 482; P < 0.001); the median difference was estimated at 4 days (Figure I-4). Tag-induced delay in migration has been previously observed in Chinook Salmon (Bendock and Alexandersdottir 1993; Bernard et al. 1999). The latter authors found a lag of approximately 4–5 days before radio-tagged Chinook Salmon in the Kenai River, Alaska, resumed upstream migration. Recoveries at the Montana Creek weir were too sparse to show an effect. The run timing of the recaptures was adjusted at the Deshka and Montana weirs by moving them 4 days earlier (note that the flood adjustment described earlier was performed on the lag-adjusted data).

For the 50.0–78.5 cm (19.7–30.9 in) METF stratum, the EP test passed on the spatial (Test 3 in Table I-1; P = 0.921) and temporal scales (Tests 4 and 5 in Table I-1; P = 0.09 and 0.189 for Deshka and Montana, respectively). The CM test passed on a temporal scale (Test 2 in Table I-1; P = 0.311), but not on a spatial scale (Test 1 in Table I-1; P < 0.001). These results indicate that the Chapman model is appropriate for estimating abundance for the 50.0–78.5 cm (19.7–30.9 in) METF stratum.

For the 78.5 cm (30.9 in) METF or greater stratum, the EP test passed on the temporal scale (Tests 4 and 5 in Table I-2; P = 0.70 and 1 for Deshka and Montana, respectively); the EP test did not pass on the spatial scale (Test 3 in Table I-2; P = 0.001). The CM test passed on the spatial and temporal scale (Tests 1 and 2 in Table I-2; P = 0.187 and P = 0.148, respectively). It is noted that the contingency tables used in Table I-2 are sparse, and the sample sizes border the conditions at which the chi-square tests are not strictly valid. As given, however, these results indicate that the Chapman model is appropriate for estimating abundance for the 50.0–78.5 cm (19.7–30.9 in) METF stratum; moreover, no stratified design would be possible with the sparse sample sizes in this category.

Abundance for each stratum was estimated using the Chapman (1951) model. The distribution of mark-recapture estimates is recognized to be frequently asymmetric (e.g., Zwane and van der Heijden 2003), thus the utility of analytically-estimated standard errors in calculating confidence intervals is limited. Also, the analytical formula of variance of the Chapman estimate of abundance assumes the number of fish examined in the second event for tags is a constant. In this experiment length samples were used to estimate the number of fish measuring 50 cm (19.7 in) METF or greater inspected at the weirs for tags. Finally, estimating the number of fish examined in each stratum creates dependency among the stratum-specific abundance estimates because higher estimates of small fish necessarily means smaller estimates of larger fish and vice versa. For these reasons, variances and confidence intervals were estimated using a parametric bootstrap (e.g., Buckland and Garthwaite 1991).

Within each size stratum, the probability that a marked fish was recaptured was modeled as a hypergeometric process with observed numbers of fish marked, estimated number inspected in the second event and estimated abundance as model parameters. For each of the two weir sites, the numbers of fish inspected for marks was modeled as a multinomial process with total observed passage at the weir and the empirical size distribution data collected at each weir used to define model parameters. A 100,000 parametric bootstrap samples were generated. Variance of the abundance estimate of fish of each size class was calculated as the sample variance of the 100,000 bootstrap estimates of each estimate. Variance of the abundance estimate of all fish measuring 50 cm (19.7 in) METF or greater was calculated as the sample variance of the 100,000 bootstrap estimates of the sum of the abundance of the two size classes (Table I-3). Confidence intervals reported in Table I-4 are percentiles of the parametric bootstrap distributions of estimated parameters.

The abundance of Chinook Salmon measuring 50 cm (19.7 in) METF or greater spawning in the Susitna River above the mainstem tagging site in 2014 is estimated to be 68,225 (SE = 10,615).

4.1.2. Yentna River

A total of 3,071 Chinook Salmon were captured in drift gillnets and two fishwheels at the Yentna River tagging site (RM 6) from May 22 to August 25, 2014. Dart tags were deployed on 1,281 Chinook Salmon measuring 50 cm (19.7 in) METF or greater. Radio tags were also deployed on 296 of the dart-tagged fish. These radio-tagged fish were used to a) estimate the drop-out rate of the dart-tagged fish due to handling mortality and migration to the mainstem Susitna drainage, and b) estimate spawning distribution in the Yentna drainage. Based on observations made at fixed tracking stations and using aerial radio telemetry, 219 of the radio-tagged fish moved upstream and remained at least one mile upstream of the east bank fishwheel for at least 48 hours and therefore met criteria to be used in the mark recapture study. The remaining 77 (296-219) radio-tagged Chinook Salmon either migrated to the Susitna River drainage or the Susitna River below the Yentna-mainstem Susitna confluence, failed to migrate due to handling stress, or migrated above the tagging site and not detected (unlikely). The number of deployed dart tags was deprecated based on the proportion of radio tags failing to enter the mark-recapture experiment. Of the 1,281 dart tags deployed, it is estimated that 963 tags entered the mark-recapture experiment. With respect to the spawning distribution study, 5 radio-tagged fish were harvested and 7 made it to the recapture wheels but then died, leaving only 207 (219-12) radio-tagged fish for inclusion in the distribution study.

Second event sampling was conducted using two fishwheels and a mid-river gillnet at RM 18. A total of 2,308 Chinook Salmon were caught in the second event sampling from May 24 to August 22, 2014, with 1,371 of these fish measuring 50 cm (19.7 in) METF or greater. Second event sampling recovered 59 dart tags, 25 on the west fishwheel, 31 on the east fishwheel, and 3 in the gillnet. Ten of the 59 recovered dart tagged fish were also radio tagged.

Tests for size-biased sampling in the marking and recapture events were conducted using the KS two-sample test (Appendix A1 in Cleary et al. 2013). The test for the second sampling event, which compared the length distributions of marked and recaptured fish, provided no evidence of size biased sampling (P = 0.65, D = 0.088; Figure I-5).

The tests for size-biased sampling during the first event using data from fish passing the fishwheels and gillnet at RM 6 provided no significant evidence of size biased sampling

(P = 0.12, D = 0.196 for the east fishwheel, P = 0.67, D = 0.131 for the west fishwheel and P = 0.97, D = 0.053 for pooled fishwheel and gillnet data; Figures I-6, I-7, and I-8). No test was performed for the second event gillnet-only data as there were too few recaptures (3). Based on these test results, the data were pooled into one size class (all fish ≥ 50 cm [19.7 in] METF).

Tests for consistency of the Chapman (1951) model for estimation of abundance with respect to temporal and/or spatial variation in probability of capture were conducted. These tests were first described by Seber (1982, p. 438–439) and subsequently described as the 'Equal Proportions Test" (EP) and the "Complete Mixing Test" (CM) by Arnason et al. (1996). A passing EP or CM test means the Chapman model is valid. The EP tests examine the consistency of marked fractions in the second event sample over spatial and temporal strata. Before the EP tests were conducted an adjustment to the timing of the recaptures at the second event capture site was made; this adjustment affected the EP tests on temporal strata. Analysis of the timing of fishwheel catches (≥ 50 cm [19.7 in] METF) and recaptures at the recapture wheels strongly suggested a tag-induced lag for the recaptured fish. The median run timing of the untagged fish was significantly earlier than that of the recaptured fish (Mann-Whitney test, W = 46,870, P = 0.019); the median difference was estimated at 3 days (Figure I-9). Tag-induced delay in migration has been previously observed in Chinook Salmon (Bendock and Alexandersdottir 1993; Bernard et al. 1999). The latter authors found a lag of approximately 4–5 days before radio-tagged Chinook Salmon in the Kenai River, Alaska, resumed upstream migration. Moreover, a tag-induced lag of 4 days was also detected for radio-tagged fish in the mainstem Susitna mark recapture component of this study in 2014. The run timing of the recaptures in the current study was adjusted at the second event fishwheels by moving the recapture date 3 days earlier.

The EP test passed on the spatial (Test 3 in Table I-5; P = 0.58) and temporal scales (Tests 4-6 in Table I-5; P = 0.83, P = 0.55 and P = 0.44 for the east fishwheel, west fishwheel and pooled gear, respectively). The CM test passed on the spatial scale (Test 1 in Table I-5; P = 0.68) and on the temporal scale (Test 2 in Table I-5; P = 0.35). These results indicate that the Chapman model is appropriate for estimating abundance for the Chinook Salmon measuring 50 cm (19.7 in) METF or greater on the Yentna River.

The distribution of mark recapture estimates is recognized to be frequently asymmetric (e.g. Zwane and van der Heijden 2003), thus the utility of analytically-estimated standard errors in calculating confidence intervals is limited. Also, the analytical formula of variance of the Chapman estimate of abundance assumes the number of fish marked in the first event is a constant. In this experiment, we used radio tag migration data to estimate the proportion of marked fish that migrated into the mark-recapture experiment. For these reasons, variances and confidence intervals were estimated using a parametric bootstrap (e.g., Buckland and Garthwaite 1991).

We note that we found variation in the downstream migration pattern of radio-tagged Chinook Salmon among (two) different crews. Pooled over gear types, fish radio-tagged by one crew (A) experienced a drop-out rate of about 33 percent, while the rate for the other crew was (B) was about 12 percent. Consistently, the recapture rate of dart-tagged fish for crew A was about 2.8 percent, while for crew B it was 6.2 percent. The influence on tagged fish by crew B was not therefore limited to the act of radio-tagging, and appears related to general handling of fish. It is also noted that timing of radio-tagging or type of gear appears not to explain the differences in drop-out rate between crews. To accommodate these differences in the abundance analysis, we applied crew-specific drop-out rates to marked fish.

For the simulation, the probability that a marked fish was recaptured was modeled as a hypergeometric process with estimated number of fish marked, number inspected in the second event, and estimated abundance as model parameters. For each of the two crews, the numbers of fish exhibiting downstream migration was modeled as a binomial process with number of radio tags deployed and the estimated drop-out rate used to define model parameters. A sample of 50,000 parametric bootstrap realizations was generated. Variance of the abundance estimate was calculated as the sample variance of the 50,000 bootstrap estimates of each estimate. The 95 percent confidence interval for the abundance estimate was calculated as the 2.5 and 97.5 percentiles of the parametric bootstrap distributions of the estimated abundance.

The abundance of Chinook Salmon measuring 50 cm (19.7 in) METF or greater spawning in the Yentna River above the lower tagging site in 2014 is estimated to be 22,267 (SE = 2,871; CV = 13 percent; Table I-6). The 95 percent parametric bootstrap confidence interval is 17,466 to 28,701.

4.2. Estimated Abundance of Coho Salmon

A total of 1,513 Coho Salmon were captured in two fishwheels at the lower mainstem Susitna River tagging site (PRM 34) from June 28 to August 26, 2014. Radio tags were deployed on 640 Coho Salmon measuring 40 cm (15.7 in) METF or greater. Based on observations made at fixed tracking stations and using aerial radio-telemetry, 582 of these radio-tagged fish moved upstream and remained one mile upstream of the east bank fishwheel and therefore met criteria to be included in the mark- recapture experiment. The remaining 58 (640-582) radio-tagged Coho Salmon either migrated to the Yentna River drainage or the Susitna River below PRM 34, failed to migrate due to handling stress, or were above the tagging site and not detected (unlikely). It is also possible that some tags were regurgitated below the point at which the tagged fish were categorized as being part of the mark-recapture experiment (one mile upstream of the east bank fishwheel). Second event sampling was conducted at weirs on the Deshka River and at Montana Creek. A total of 11,578 Coho Salmon were counted through the Deshka River weir from July 4 to September 2, 2014, with all of them estimated to be 40 cm (15.7 in) METF or greater. At the Montana Creek weir 934 Coho Salmon were counted from August 3 to September 21; all were estimated to be 40 cm (15.7 in) METF or greater. The estimated number of Coho Salmon measuring 40 cm (15.7 in) METF or greater that passed the Deshka River and Montana Creek weirs comprised the second event of the mark-recapture experiment.

Based on observations made at fixed tracking stations and using aerial radio-telemetry, 68 radio-tagged Coho Salmon passed the Deshka River weir and were assumed to have spawned above the weir. Similarly, 4 radio-tagged Coho Salmon passed the Montana Creek weir and were assumed to have spawned above the weir. A total of 72 recaptures (68 + 4) were used in the mark-recapture experiment.

Tests for size-biased sampling in the marking and recapture events were conducted using the KS two-sample test (Appendix A1 in Cleary et al. 2013). The tests for the second sampling event, which compared the length distributions of marked and recaptured fish, provided significant evidence of size biased sampling ($P < 0.001$; Figure I-10).

The test for size-biased sampling during the first event using data from fish passing the Deshka River weir provided significant evidence of size biased sampling ($P \leq 0.001$, Figure I-11). No test for size-biased sampling during the first event was conducted using data from the Montana Creek weir because only four fish were recaptured at that site.

Based on the test results of the above KS tests, the data were stratified into two size strata: 40–55 cm (15.7–21.7 in) METF, and 55 cm (21.7 in) METF or greater. Rerunning the KS tests for size selectivity within each size category indicated that no further size stratification was needed.

Tests for consistency of the Chapman (1951) model for estimation of abundance with respect to temporal and/or spatial variation in probability of capture were conducted within the each of the 2 size strata. These tests were first described by Seber (1982; hypotheses H2 and H4 on p. 438–439) and were subsequently described as the "Complete Mixing Test" (CM; H2) and the 'Equal Proportions Test" (EP; H4) by Arnason et al. (1996). A passing EP or CM test indicates the Chapman model is valid. The EP tests examine the consistency of marked fractions in the second event sample over spatial and temporal strata. The EP tests were only approximate, because the number of fish inspected for marks during second event sampling within each stratum was not known, but was estimated using size composition data collected at each weir.

No adjustment to the timing of the recaptures at the weirs was made; we found no evidence of a difference in the timing at the Deshka weir of tagged and untagged fish.

For the 40–55 cm (15.7–21.7 in) METF stratum, the EP test passed on the spatial (Test 3 in Table I-7; $P = 0.382$) and temporal scales (Test 4 in Table I-7; $P = 0.217$ for the Deshka recovery site). There were too few recoveries at Montana to conduct the test for this site. The CM test passed on a temporal scale (Test 2 in Table I-7; $P = 0.225$), but not on a spatial scale (Test 1 in Table I-7; $P \leq 0.001$). These results indicate that the Chapman model is appropriate for estimating abundance for the 40–55 cm (15.7–21.7 in) METF stratum.

For the 55 cm (21.7 in) METF or greater stratum, the EP test passed on the spatial scale (Test 3 in Table I-8; $P \sim 1.0$) and temporal scales (Test 4 in Table I-8; $P = 0.13$ for the Deshka recovery site). There were too few recoveries at Montana to conduct the test for this site. The CM test passed on the temporal scale (Test 2 in Table I-8; $P = 0.113$), but not the spatial scale (Test 1 in Table I-8; $P = 0.006$). These results indicate that the Chapman model is appropriate for estimating abundance for the 55 cm (21.7 in) METF or greater stratum.

Abundance for each stratum was estimated using the Chapman (1951) model. The distribution of mark recapture estimates is recognized to be frequently asymmetric (e.g., Zwane and van der Heijden 2003), thus the utility of analytically-estimated standard errors in calculating confidence intervals is limited. Also, the analytical formula of variance of the Chapman estimate of abundance assumes the number of fish examined in the second event for tags is a constant. In this experiment length samples were used to estimate the number of fish within each size stratum that were inspected at the weirs for tags. Finally, estimating the number of fish examined in each stratum creates dependency among the stratum-specific abundance estimates because higher estimates of small fish necessarily means smaller estimates of larger fish and vice versa. For these reasons, variances and confidence intervals were estimated using a parametric bootstrap (e.g., Buckland and Garthwaite 1991).

Within each size stratum, the probability that a marked fish was recaptured was modeled as a hypergeometric process with observed numbers of fish marked, estimated number inspected in the second event and estimated abundance as model parameters. For each of the two weir sites, the numbers of fish inspected for marks was modeled as a multinomial process with total observed passage at the weir and the empirical size distribution data collected at each weir used to define model parameters. A sample of 100,000 parametric bootstrap realizations was generated. Variance of the abundance estimate of fish of each size class was calculated as the sample variance of the 100,000 bootstrap estimates of each estimate. Variance of the abundance estimate of all fish measuring 40 cm (15.7 in) METF or greater was calculated as the sample variance of the 100,000 bootstrap estimates of the sum of the abundance of the two size classes (Table I-9). Confidence intervals reported in Table I-4 are percentiles of the parametric bootstrap distributions of estimated parameters.

The abundance of Coho Salmon measuring 40 cm (15.7 in) METF or greater spawning in the Susitna River above the mainstem tagging site in 2014 is estimated to be 84,879 (SE = 9,550; Table I-10).

4.3. Estimated Distribution of Spawning Salmon

4.3.1. Chinook Salmon

4.3.1.1. Mainstem Susitna River Above the Yentna River Confluence

Results from the mark–recapture experiment indicate that radio tags were not deployed in Chinook Salmon proportional to the size distribution of fish in the population. To estimate abundance of spawning salmon in different tributaries within the mainstem Susitna River drainage, the number of spawners among tributaries was first estimated within each size stratum. Numbers of fish by tributary within a size stratum was then calculated as the product of the proportion by tributary within size stratum and estimated abundance for that size stratum (Table I-3). Numbers of fish were then summed over size strata for each tributary.

4.3.1.2. Yentna River

No size selectivity was found for the marked fish in the mark-recapture analysis described above. We also found no significant difference between the size distributions of the radio-tagged fish and the marked fish used in the mark-recapture analysis (D = 0.084, $P = 0.1$); we assume therefore there to be no size selectivity among the radio-tagged fish. Recoveries of radio tags in the second sampling event were too sparse to conduct the CM tests for radio tags. It is noted, however, that no significant CM tests were found in the mark-recapture analysis involving (primarily) darts tags, and given that radio tags were applied systematically to all Chinook Salmon measuring 50 cm (19.7 in) METF or greater, we assume that a representative sample of fish measuring 50 cm (19.7 in) METF or greater were radio-tagged in the first sampling event.

To estimate abundance of spawning salmon in different tributaries within the Yentna River drainage, the proportion of spawners among tributaries was first estimated. Number of fish by tributary was then calculated as the product of the proportion by tributary and estimated abundance (Table I-6).

4.3.2. Coho Salmon

Results from the mark–recapture experiment indicate that radio tags were not deployed in Coho Salmon proportional to the size distribution of fish in the population. To estimate abundance of spawning salmon in different tributaries within the mainstem Susitna River drainage, the number of spawners among tributaries was first estimated within each size stratum. Numbers of fish by tributary within a size stratum was then calculated as the product of the proportion by tributary within size stratum and estimated abundance for that size stratum (Table I-9). Numbers of fish were then summed over size strata for each tributary (Table I-10).

5. DISCUSSION

An estimate of Chinook Salmon abundance for the Susitna River upstream of the Yentna River confluence was generated after size-stratification. It is unfortunate that the diagnostic KS tests suggested a stratification point at the higher end of the length scale (78.5 cm METF [30.9 in]), because it meant the estimate of abundance for fish of the large size category was based on relatively few recaptures (12 fish). It is noted that the pooled estimate of all Chinook Salmon measuring 50 cm (19.7 in) METF or greater is 53,246 (22 percent smaller), demonstrating the influence of size-stratification. The objective to estimate the distribution of the Chinook Salmon escapements among the tributaries of the Susitna River above the Yentna River was successful.

With the estimate of the Yentna River Chinook Salmon abundance for 2014 complete, the objective to estimate the system-wide Chinook Salmon escapement in 2014 has now been met. The marking and capture techniques and choice of locations provided sufficient sample sizes to achieve a reasonably precise abundance estimate, with a coefficient of variation of 13 percent. The marking and capture techniques and locations also provided conditions that allowed for consistent spatial and temporal marking of fish, without being size selective (except for one instance in the RM 18 east fishwheel). Not having to stratify the data helped to minimize the variance of the abundance estimate.

Defining fish that entered the experiment was occasionally difficult as there was no stationary telemetry site at the RM 18 recapture site. It had to be assumed that all fish passing the lower Yentna stationary telemetry site (approximately RM 9) and staying upstream of that site for at least 48 hours, continued upstream to the recapture site at RM 18. This is an important assumption, as it affects the dropout rate, which affects the number of tags out, and thus the entire abundance estimate. While most radio-tagged fish passing the lower Yentna stationary telemetry site continued upstream to later be detected in aerial telemetry surveys and confirmed as in the experiment, some did not.

An estimate of 84,879 Coho Salmon migrating into the Susitna River upstream of the Yentna River confluence was generated after size-stratification. Without stratification a biased estimate of approximately 100,000 Coho Salmon is calculated (17 percent larger). It is apparent that smaller fish are marked at a higher rate than larger fish at the lower Susitna River fishwheels.

The objective to estimate the distribution of the Coho Salmon escapements among the tributaries of the Susitna River above the Yentna River was successful. A weakness in the overall design of the 2014 project is that we only had two recapture sites, one of which (Montana) was associated with relatively few fish, and therefore recaptures (4). The small number of recaptures at Montana compromises the EP spatial test, leaving us to largely assume the fish passing the Deshka river weir were tagged at the same rate as the other stocks in the drainage.

6. CONCLUSIONS AND RECOMMENDATIONS

The 2014 mark-recapture experiment for Chinook Salmon in the mainstem Susitna River appears to have been successful. It is recommended, however that the differential tagging rates of fish 50–58 cm (19.7–22.8 in) METF be maintained in future experiments of this kind, but additionally, that more effort also be directed into tagging larger fish. It is noted that a sizeable portion of the estimated abundance of Chinook Salmon was based on a relatively small portion of the recaptured fish. Larger fish are typically tagged via gillnets and concern over the mortality rate of this method of sampling has hindered tagging larger fish. Adjustments to gillnet sampling may be required such that more large fish (METF $\geq$ 58 cm [22.8 in]) can be tagged without undue mortality. An additional recapture event is recommended on Clear Creek, replacing the failed attempts on the Chulitna River. Clear Creek is shallower and more accessible than the Chulitna River site, allowing more attention to the sonar operation, and has a larger Chinook Salmon escapement, which should result in more recaptured fish. Tethered fish experiments, crucial to calibration of sonar-derived length data, should also be easier at this site.

The 2014 mark-recapture experiment for Chinook Salmon in the Yentna River appears to have been successful with the current design. It is recommended, however, that the reasons for the substantially differential drop-out rates among crews be investigated before further similar work is done, and efforts taken to standardize the sampling protocol between crews and minimize handling time. Adding a stationary telemetry site at the RM 18 recapture site would clearly identify when tagged fish become available for recapture and increase the accuracy of the dropout rate estimate.

The 2014 mark-recapture experiment for Coho Salmon in the mainstem Susitna River appears to have been successful. It is, however, recommended that additional recapture sites be considered in the future that allow assessment of the tagging rates of other stocks. These sites could be additional weirs or upriver fishwheels.

Table I-1. Diagnostic tests for mark-recapture data for mainstem Susitna River Chinook Salmon measuring 50.0–78.5 cm METF, 2014.

Test[a]	Parameter				
1) CM-Spatial[b]					
	Gear	Gillnet	Fishwheel 1 west	Fishwheel 2 east	
	Marks	42	148	191	
	Recaptured	6	66	55	
	Not recaptured	36	82	137	
2) CM-Temporal[c]					
	Julian day	142-156	157-162	163-181	
	Marks	164	120	97	
	Recaptured	48	42	37	
	Not recaptured	116	79	60	
3) EP-Spatial[d]					
	Weir site	Deshka R	Montana Cr		
	Inspected[e]	10,138	952		
	Marked	116	10		
	Unmarked	10,022	942		
4) EP-Temporal[f]					
Deshka weir	Julian day	138-159	160-162	163-167	168-246
	Inspected[e]	1941	2974	2852	2371
	Marked	30	25	29	32
	Unmarked	1911	2949	2823	2339
5) EP-Temporal[g]					
Montana weir	Julian day	174-191	192-203	204-254	
	Inspected[e]	339	328	285	
	Marked	3	6	1	
	Unmarked	336	322	284	

[a] CM = “Complete Mixing Test” and EP = “Equal Proportions Test” (see text; Arnason et al. 1996).
[b] $\chi^2 = 17.22$, $P < 0.001$.
[c] $\chi^2 = 2.332$, $P = 0.311$.
[d] $\chi^2 = 0.01$, $P = 0.921$.
[e] Number of fish inspected for marks is estimated.
[f] $\chi^2 = 6.48$, $P = 0.09$.
[g] $\chi^2 = 3.33$, $P = 0.189$.

Table I-2. Diagnostic tests for mark-recapture data for mainstem Susitna River Chinook Salmon measuring 78.5 cm METF or greater, 2014.

Test[a]	*Parameter*			
1) CM-Spatial[b]				
	Gear	Gillnet	Fishwheel 1 west	Fishwheel 2 east
	Marks	45	24	43
	Recaptured	4	5	3
	Not recaptured	41	19	40
2) CM-Temporal[c]				
	Julian day	142-156	157-162	
	Marks	45	67	
	Recaptured	2	10	
	Not recaptured	43	57	
3) EP-Spatial[d]				
	Weir site	Deshka R	Montana Cr	
	Inspected[e]	3770	260	
	Marked	8	4	
	Unmarked	3762	256	
4) EP-Temporal[f]				
Deshka weir	Julian day	138-162	162-246	
	Inspected[e]	1906	1864	
	Marked	3	5	
	Unmarked	1903	1859	
5) EP-Temporal[g]				
Montana weir	Julian day	174-198	199-254	
	Inspected[e]	93	167	
	Marked	1	3	
	Unmarked	92	164	

[a] CM = “Complete Mixing Test” and EP = “Equal Proportions Test” (see text; Arnason et al. 1996).

[b] $\chi^2 = 3.35$, $P = 0.187$

[c] $\chi^2 = 2.09$, $P = 0.148$

[d] $\chi^2 = 10.28$, $P = 0.001$

[e] Number of fish inspected for marks is estimated.

[f] $\chi^2 = 0.148$, $P = 0.70$

[g] $\chi^2 = 0$, $P = 1$

Table I-3. Estimated abundance, number of radio tags deployed, and relative weights (number of spawners per tag) used to estimate abundance within size stratum for Chinook Salmon spawning upstream from the lower mainstem tagging site in the Susitna River, 2014.

Size Strata	Estimated Abundance	Estimated SE	Radio Tags Deployed	Relative Weight spawners/tag
50.0 - 78.5 cm METF	33,184	2,783	381	86.6
≥ 78.5 cm METF	35,041	10,645	112	312.9
≥ 50 cm METF	68,225	10,615		

Table I-4. Chinook Salmon measuring 50 cm METF or greater spawning distributions, based on weighted abundance (Table I-3), in the mainstem Susitna River above the Lower River tagging site, 2014.

Location	Estimated Abundance	SE	Intervals 95% lower	Intervals 95% upper
Susitna River above the mainstem tagging site	68,225	10,615	53,473	94,240
PRM 34–102.4 mainstem Susitna River [a]	2,098	682	1,064	3,717
Deshka River	14,024	816	12,451	15,667
Eastside Susitna River	15,073	3,398	10873	23,939
Talkeetna River	14,024	3,713	9,622	23,657
PRM 102.4–153.4 mainstem Susitna River [b]	6,609	2,365	3,781	12,700
Chulitna River	16,397	3,961	11,653	26,708

[a] PRM 34 upstream to the Chulitna River Confluence.
[b] Chulitna River Confluence to Devils Canyon.

Table I-5. Diagnostic tests for mark-recapture data for Yentna River Chinook Salmon ≥50 cm METF, 2014[a].

Test	Parameter			
1) CM-Spatial[b]				
	Gear	North Fishwheel	South Fishwheel	Gillnet
	Marked	311	396	256
	Recaptured	16	26	17
	Not recaptured	295	370	239
2) CM-Temporal[c]				
	Julian day	146-154	155-159	160-176
	Marked	335	298	330
	Recaptured	25	14	20
	Not recaptured	310	284	310
3) EP-Spatial[d]				
	Gear	East Fishwheel	West Fishwheel	Gillnet
	Inspected	725	540	120
	Marked	31	25	3
	Unmarked	694	515	117
4) EP-Temporal[e]				
East 2nd event fishwheel	Julian day	144-157	158-163	164-234
	Inspected	322	181	222
	Marked[h]	15	8	8
	Unmarked	307	173	214
5) EP-Temporal[f]				
West 2nd event fishwheel	Julian day	144-157	158-163	164-234
	Inspected	172	213	155
	Marked[h]	8	12	5
	Unmarked	164	201	150
6) EP-Temporal[g]				
Both 2nd event fishwheels	Julian day	144-157	158-163	164-234
plus gillnet	Inspected	513	419	453
	Marked[h]	23	21	15
	Unmarked	490	398	438

[a] CM="Complete Mixing Test" and EP="Equal Proportions Test" (see text; Arnason et al. 1996)

[b] $\chi^2 = 0.77$, $P = 0.68$; Marks are estimated.

[c] $\chi^2 = 2.1$, $P = 0.35$; Marks are estimated.

[d] $\chi^2 = 1.1$, $P = 0.58$

[e] $\chi^2 = 0.37$, $P = 0.83$

[f] $\chi^2 = 1.18$, $P = 0.55$

[g] $\chi^2 = 1.64$, $P = 0.44$

[h] Julian days for marked fish adjusted for estimated 3 day lag; see text for details.

Table I-6. Chinook Salmon spawning distributions in the Yentna River above the RM 6 tagging site, 2014.

Location	Estimated Abundance	SE	Intervals 95% lower	95% upper
Yentna River above tagging site	22,267	2,871	17,466	28,701
Lake Creek drainage	5,163	986	3,496	7,334
Kahiltna River drainage	4,195	855	2,746	6,082
Talachulitna River drainage	1,721	482	892	2,783
Skwentna River drainage, other than the Talachulinta River drainage	4,303	868	2,824	6,213
Remaining Yentna River drainage, other than the areas above	6,885	1,214	4,805	9,557

Table I-7. Diagnostic tests for mark-recapture data for mainstem Susitna River Coho Salmon 40-55 cm METF, 2014[a].

Test				
1) CM-Spatial[b]				
	Gear		Fishwheel 1 west	Fishwheel 2 east
	Marks		191	203
	Recaptured		34	4
	Not recaptured		157	199
2) CM-Temporal[c]				
	Julian day	188-207	208-212	213-232
	Marks	155	128	111
	Recaptured	13	17	8
	Not recaptured	142	111	103
3) EP-Spatial[d]				
	Weir site	Deshka R	Montana Cr	
	Inspected[e]	3,257	402	
	Marked	36	2	
	Unmarked	3,221	400	
4) EP-Temporal[f]				
Deshka weir	Julian day	185-216	217-228	229-245
	Inspected[e]	804	970	1,482
	Marked	10	6	20
	Unmarked	747	1,012	1,462
5) EP-Temporal[g]				
Montana weir				

a CM="Complete Mixing Test" and EP="Equal Proportions Test" (see text; Arnason et al. 1996)

b $\chi^2 = 26.51$, P =<0.001.

c $\chi^2 = 2.98$, P =0.225.

d χ^2 =0.763, P = 0.382.

e Number of fish inspected for marks is estimated.

f $\chi^2 = 3.05$,P=0.217

g Insufficient recaptures to conduct test (2 recaptures at Montana weir in size class 40-55 cm).

Table I-8. Diagnostic tests for mark-recapture data for mainstem Susitna River Coho Salmon >55 cm METF, 2014[a].

Test				
1) CM-Spatial[b]				
	Gear	Fishwheel 1 west	Fishwheel 2 east	
	Marks	95	93	
	Recaptured	25	9	
	Not recaptured	70	84	
2) CM-Temporal[c]				
	Julian day	188-207	208-212	213-232
	Marks	70	52	66
	Recaptured	17	10	7
	Not recaptured	53	42	59
3) EP-Spatial[d]				
	Weir site	Deshka R	Montana Cr	
	Inspected[e]	8,288	529	
	Marked	32	2	
	Unmarked	8,256	527	
4) EP-Temporal[f]				
Deshka weir	Julian day	185-216	217-228	229-245
	Inspected[e]	1,817	2,505	3,998
	Marked	5	6	21
	Unmarked	1,812	2,499	3,976
5) EP-Temporal[g]				
Montana weir				

a CM="Complete Mixing Test" and EP="Equal Proportions Test" (see text; Arnason et al. 1996)

b $\chi^2 = 7.69$, $P = 0.006$

c $\chi^2 = 4.35$, $P = 0.113$

d $\chi^2 \sim 0$, $P \sim 1$

e Number of fish inspected for marks is estimated.

f $\chi^2 = 4.01$, $P = 0.13$

g Insufficient recaptures to conduct test (2 recaptures at Montana weir in size class >55cm).

Table I-9. Estimated abundance, number of radio tags deployed, and relative weights (number of spawners per tag) used to estimate abundance within size stratum for Coho Salmon spawning upstream from the lower mainstem tagging site in the Susitna River, 2014.

Size Strata	Estimated Abundance	Estimated SE	Radio Tags Deployed[a]	Relative Weight spawners/tag
40-55 cm METF	37,069	6,495	394	94
≥55 cm METF	47,810	7,667	188	254
≥ 40 cm METF	84,879	9,550		

[a] Available to estimate spawning distribution

Table I-10. Coho Salmon spawning distributions, based on weighted abundance (Table I-3), in the mainstem Susitna River above the lower river tagging site, 2014.

	Estimated		Intervals	
Location	Abundance	SE	95% lower	95% upper
Susitna River above the mainstem tagging site	84,879	9,550	68,799	106,083
PRM 34–102.4 mainstem Susitna River [a]	10,889	2,096	7,792	15,979
Deshka River	15,377	1,138	13,737	18,215
Eastside Susitna River	16,515	2,790	12,446	23,312
Talkeetna River	12,130	2,244	8,797	17,598
PRM 102.4–153.4 mainstem Susitna River [b]	6,184	1,414	4,030	9,559
Chulitna River	23,783	3,788	18,307	33,099

[a] PRM 34 upstream to the Chulitna River Confluence

[b] Chulitna River Confluence to Devils Canyon

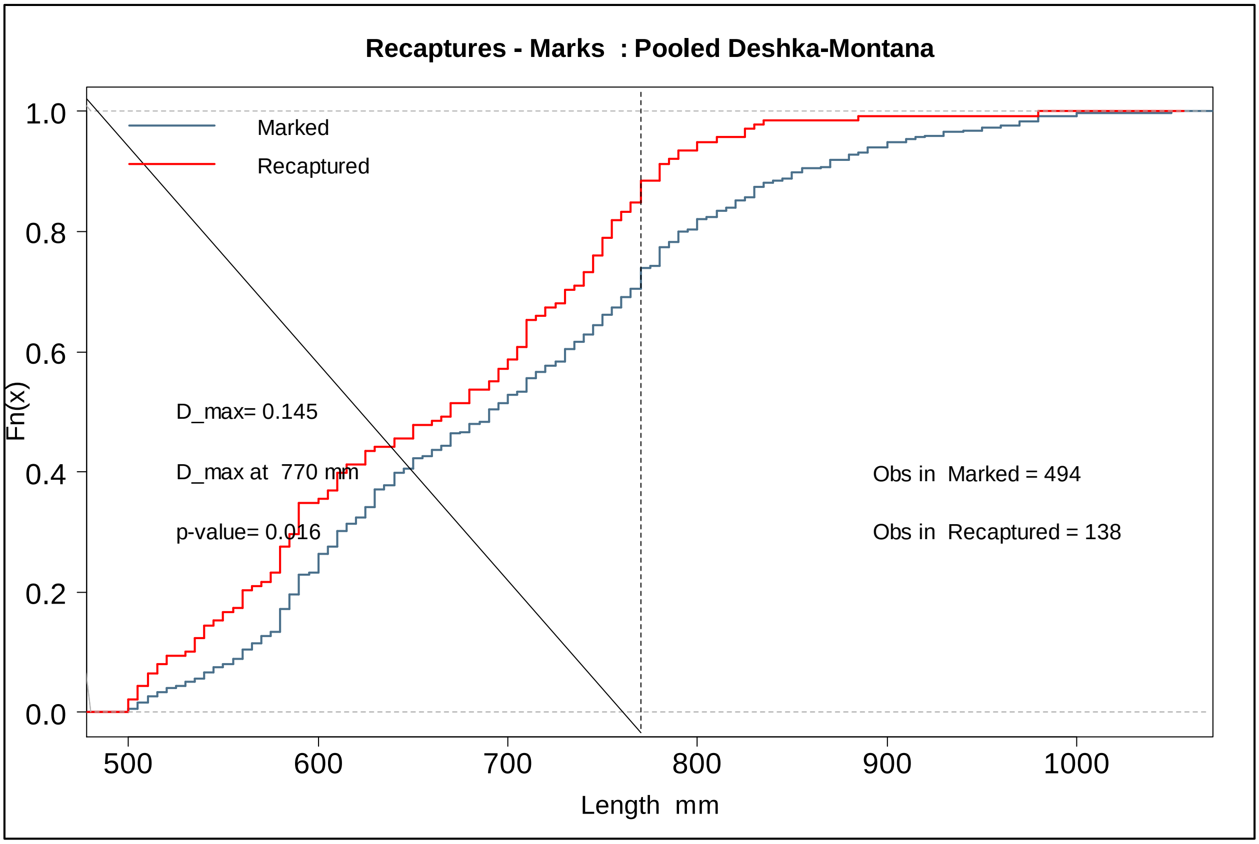

Figure I-1. Empirical cumulative distribution functions (ECDF) of length (in mm) of Chinook Salmon (METF ≥ 50 cm) marked during first event sampling at the lower mainstem Susitna River tagging site and all recaptures during second event sampling at the Deshka River and Montana Creek weirs, 2014.

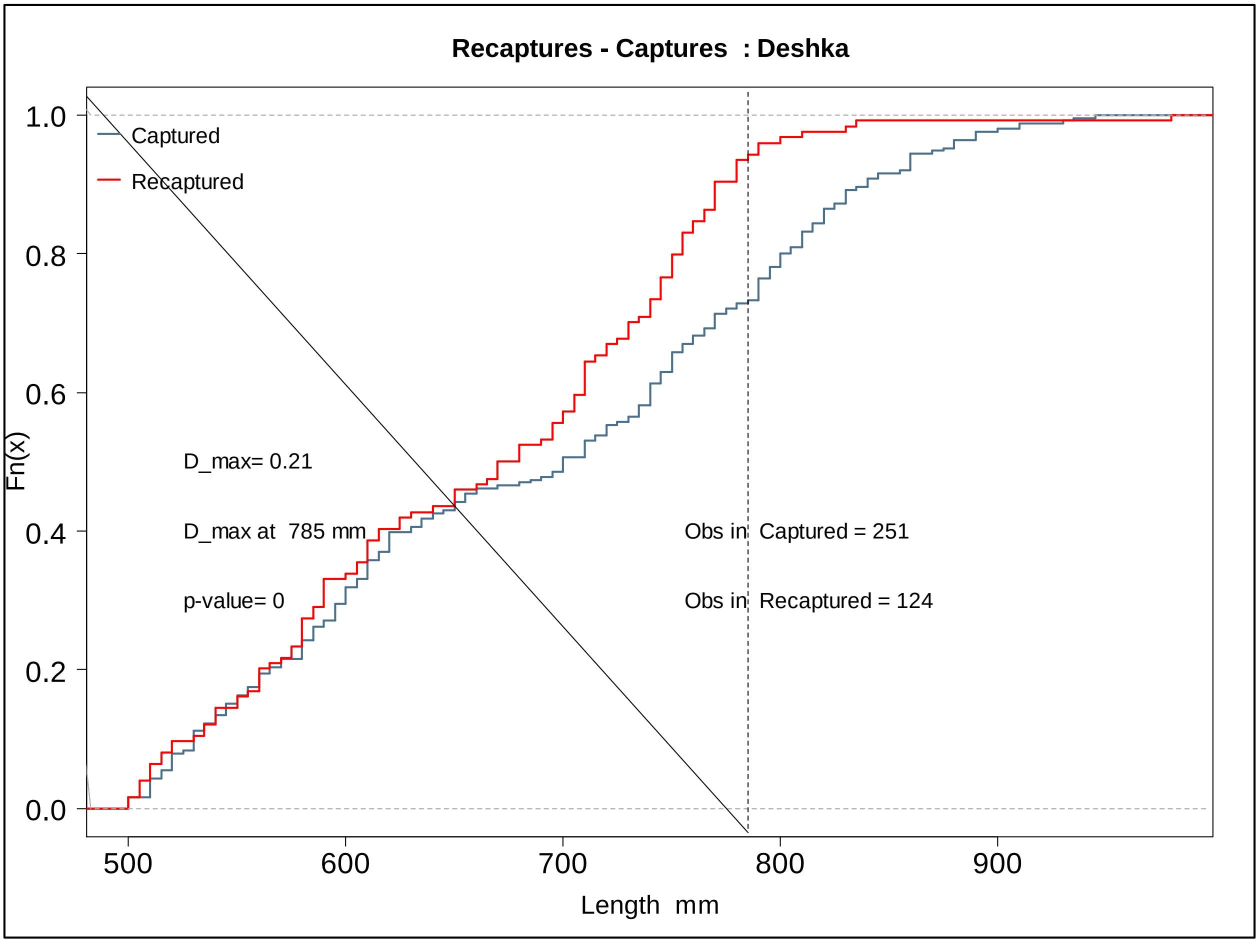

Figure I-2. Empirical cumulative distribution functions (ECDF) of length (in millimeters, mm) of Chinook (METF ≥ 500 mm) inspected for marks and all recaptured salmon during second event sampling at the Deshka River weir, 2014.

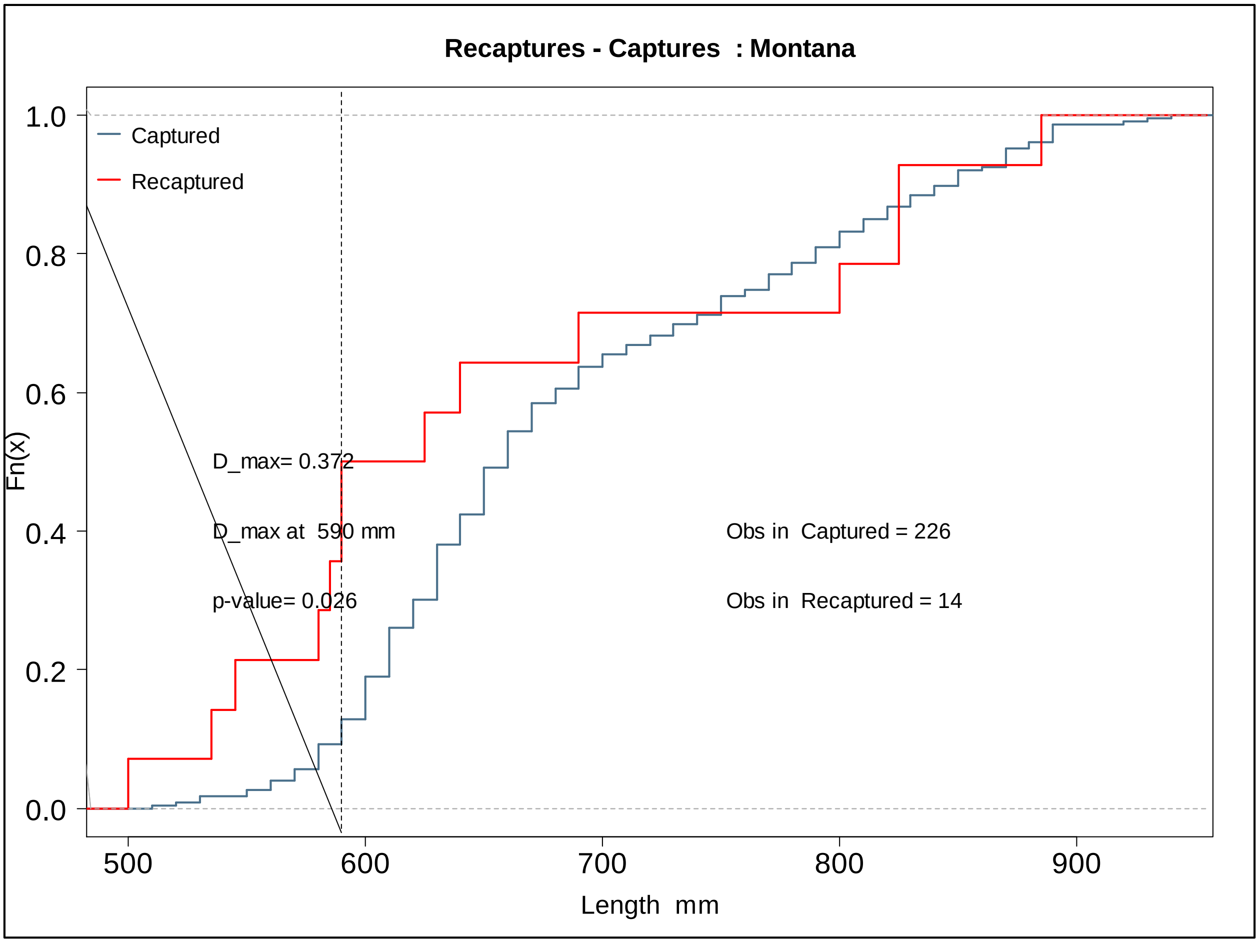

Figure I-3. Empirical cumulative distribution functions (ECDF) of length (in mm) of Chinook Salmon (METF ≥ 500 mm) inspected for marks and all recaptured salmon during second event sampling at the Montana Creek weir, 2014.

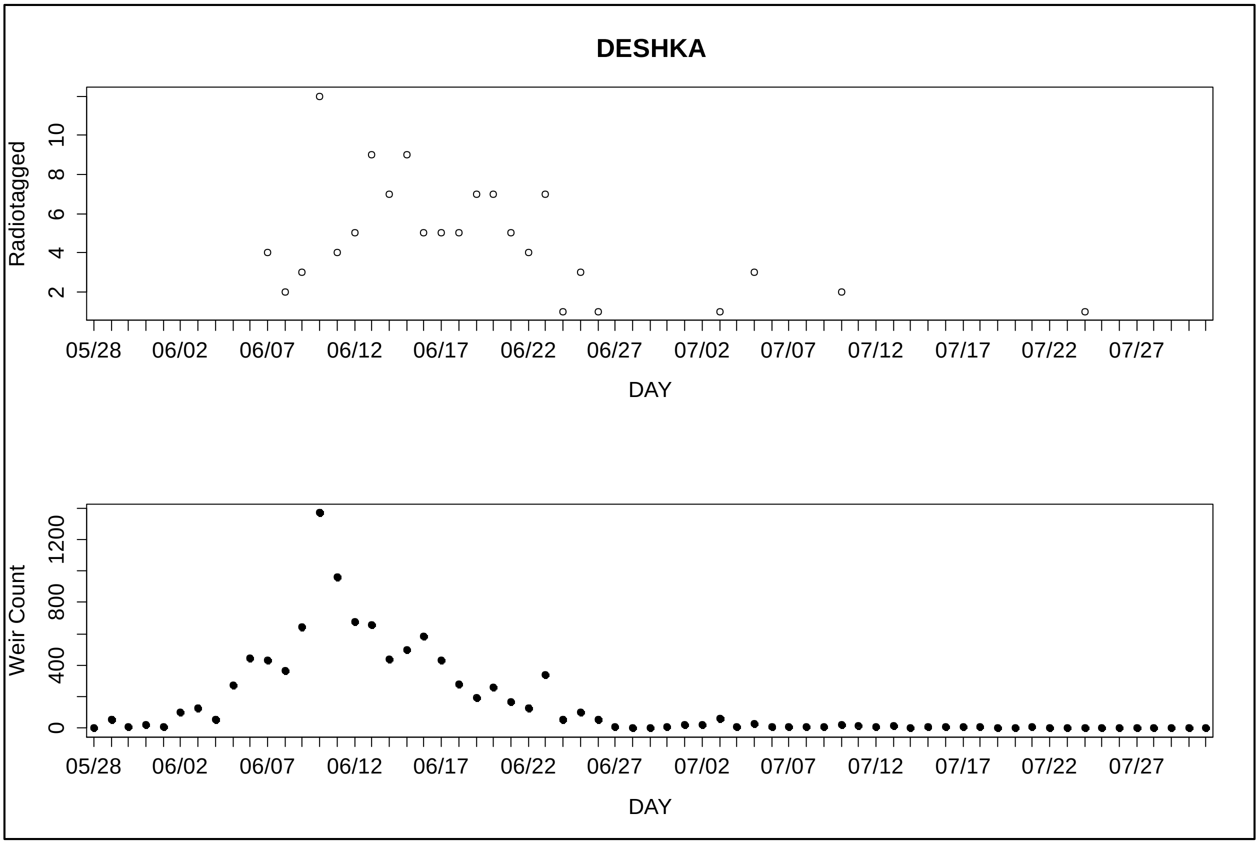

Figure I-4. The 4-day lag between total weir count and radio-tagged Chinook Salmon at the Deshka River weir, 2014.

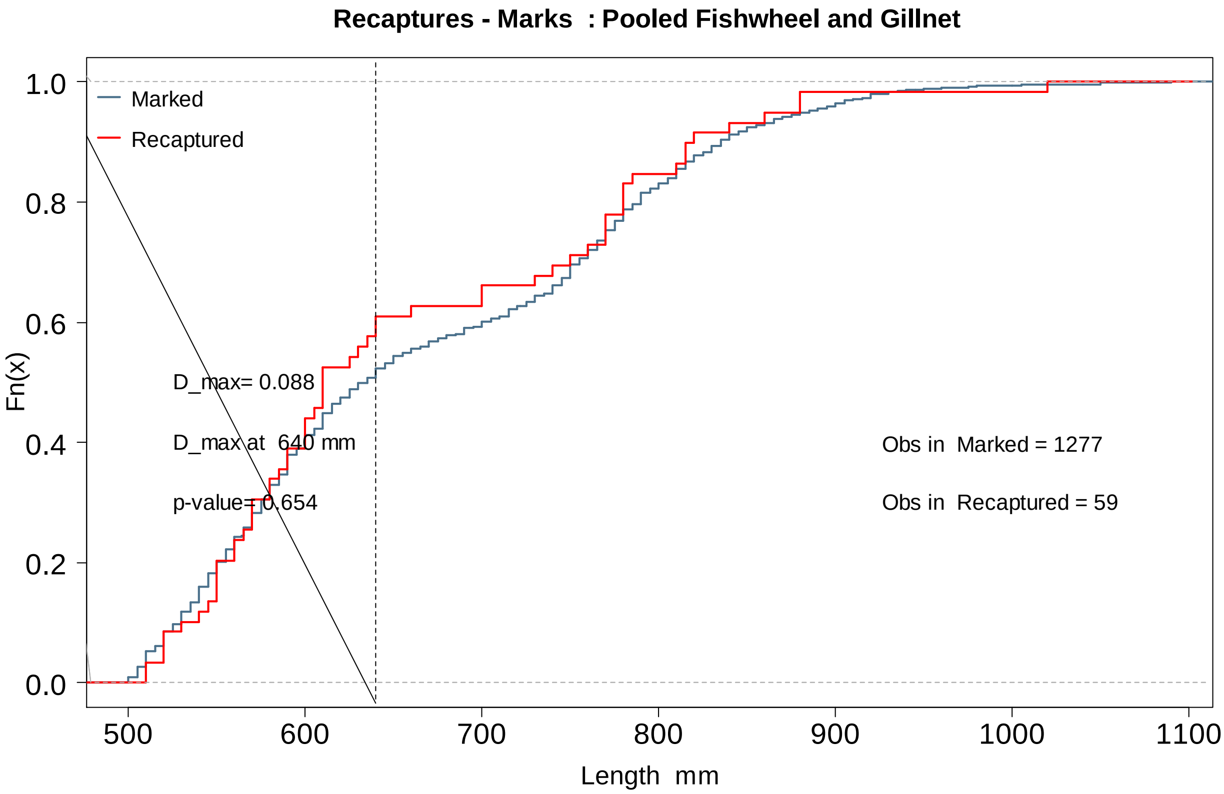

Figure I-5. Empirical cumulative distribution functions of METF length (mm) of all Chinook Salmon (≥ 500 mm) marked during first event at the lower Yentna River tagging site at RM 6 and of all salmon recaptured during second event sampling at RM 18 of the lower Yentna River, 2014.

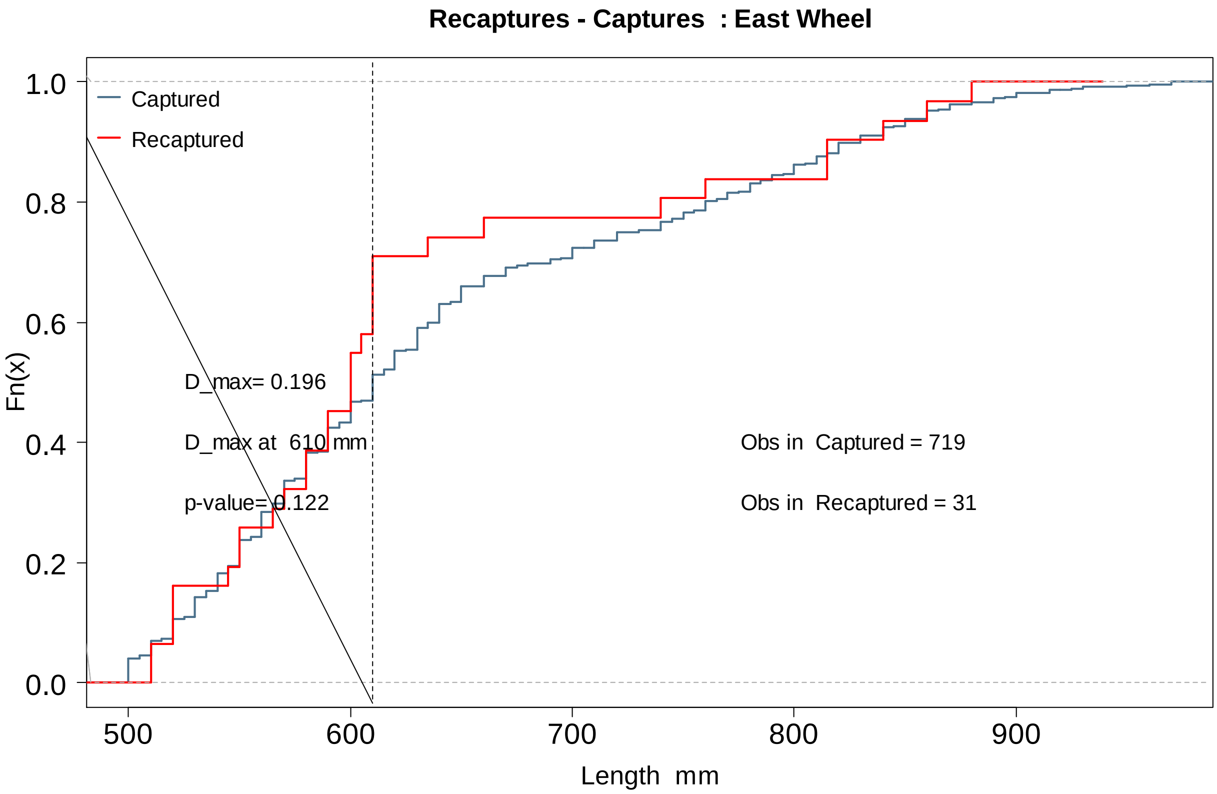

Figure I-6. Empirical cumulative distribution functions of METF length (mm) of Chinook Salmon (≥ 500 mm) inspected for marks during second event sampling at the Yentna RM 18 east fishwheel, and all salmon recaptured during inspection in 2014.

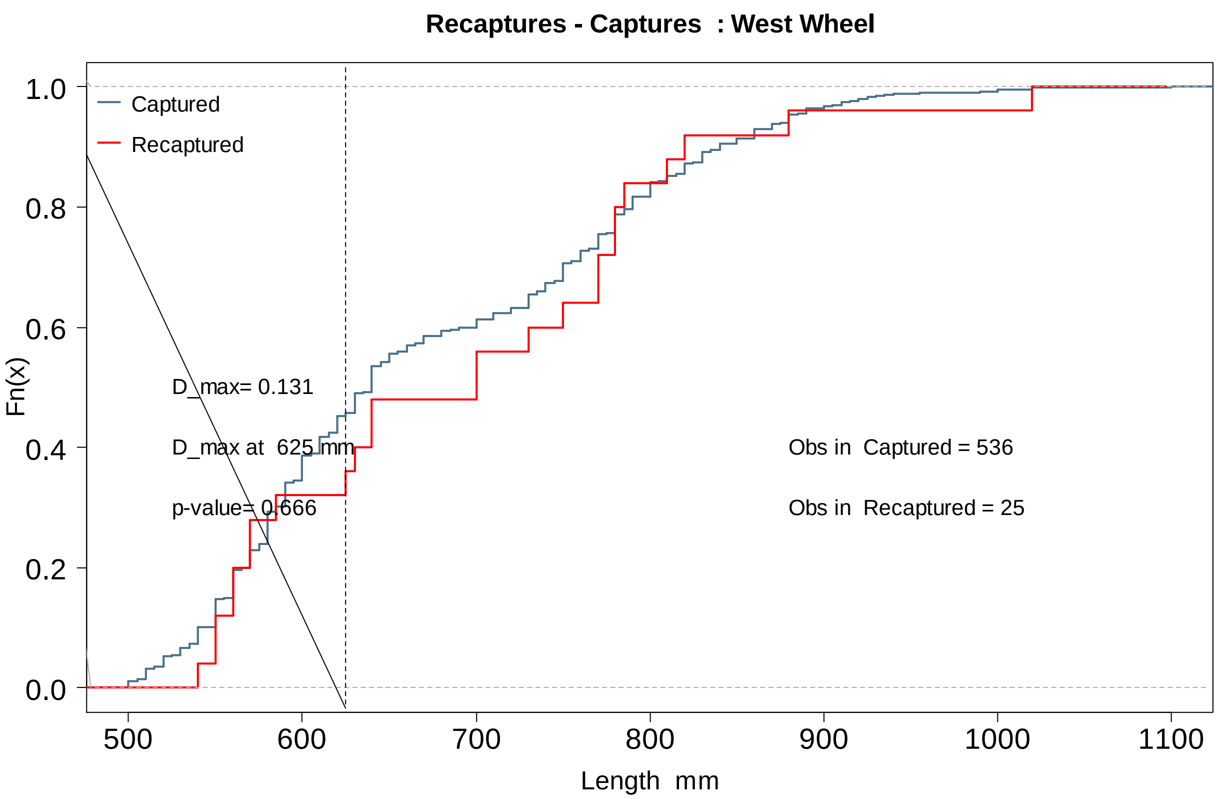

Figure I-7. Empirical cumulative distribution functions of METF length (mm) of Chinook Salmon (≥500 mm) inspected for marks during second event sampling at the Yentna RM 18 west fishwheel, and all salmon recaptured during inspection in 2014.

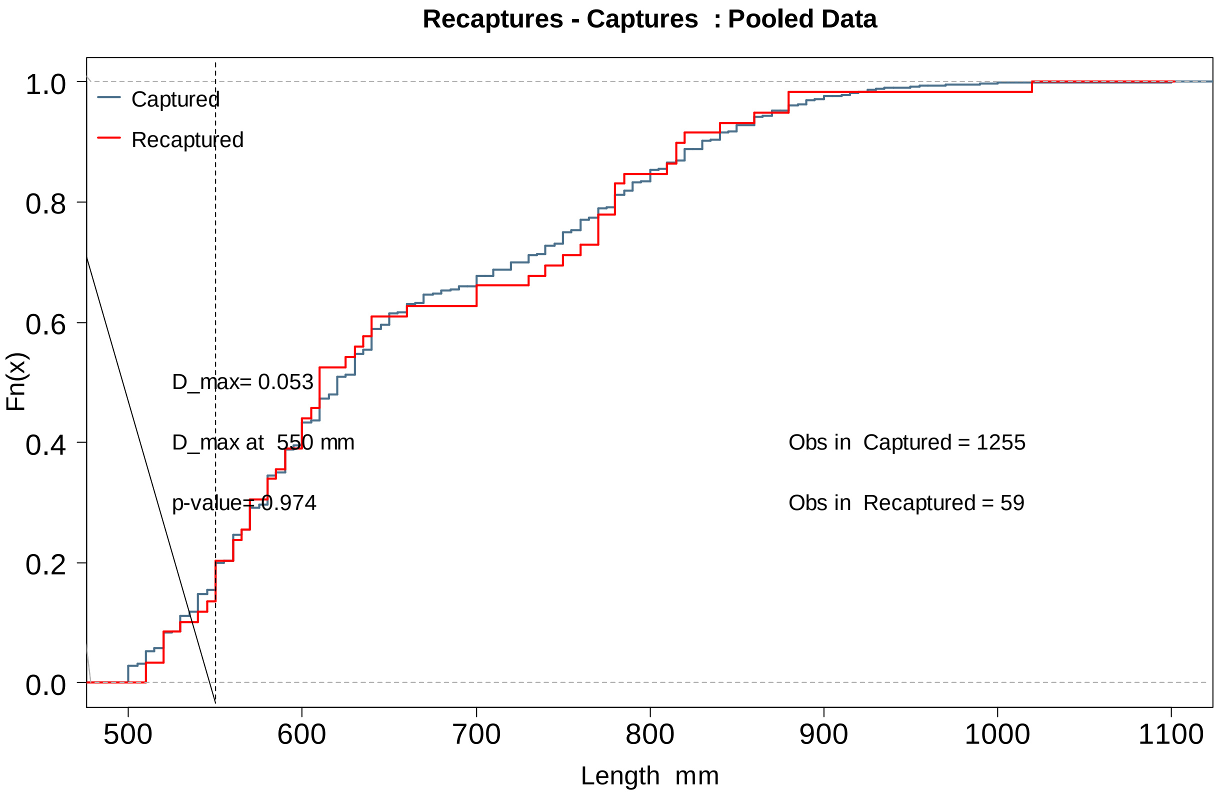

Figure I-8. Empirical cumulative distribution functions of METF length (mm) of Chinook Salmon (≥500 mm) inspected for marks during second event sampling (pooled data) and all salmon recaptured during inspection at Yentna RM 18 in 2014.

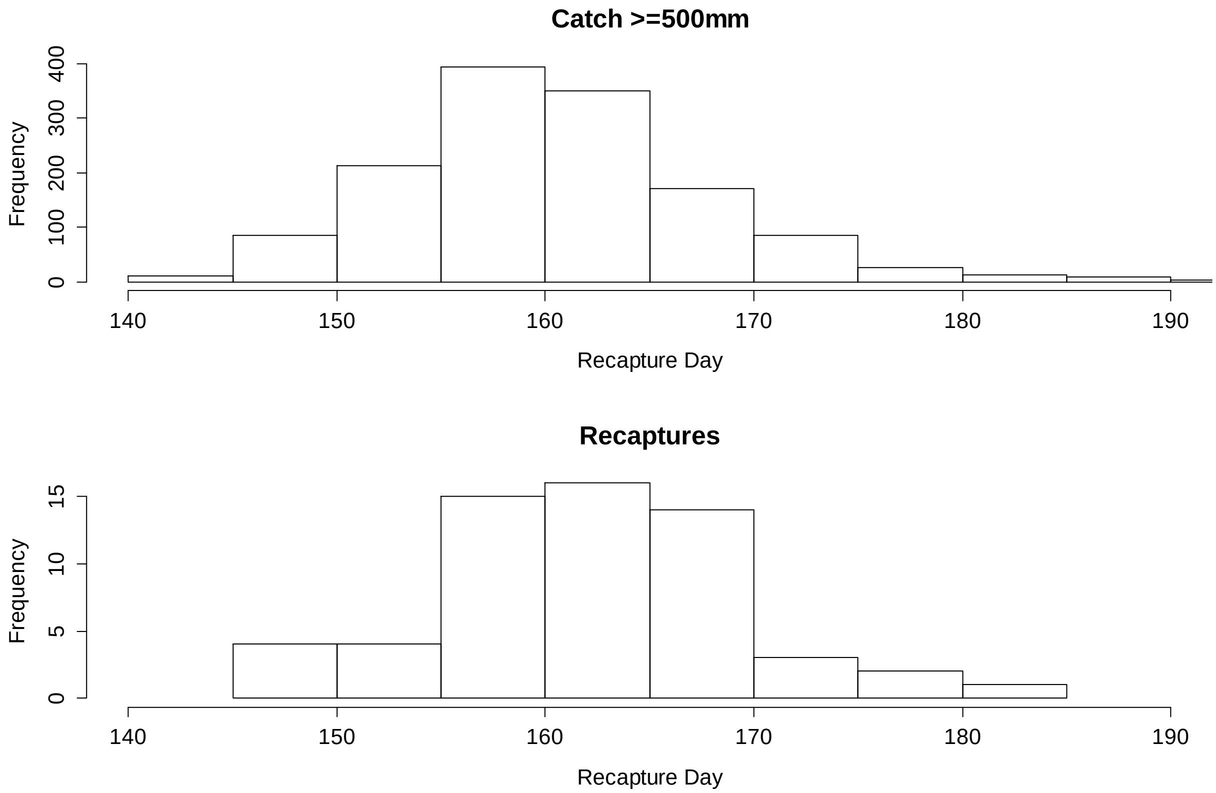

Figure I-9. Timing at Yentna River second event fishwheels (RM 18) of all fish caught >500 mm METF and of recaptures.

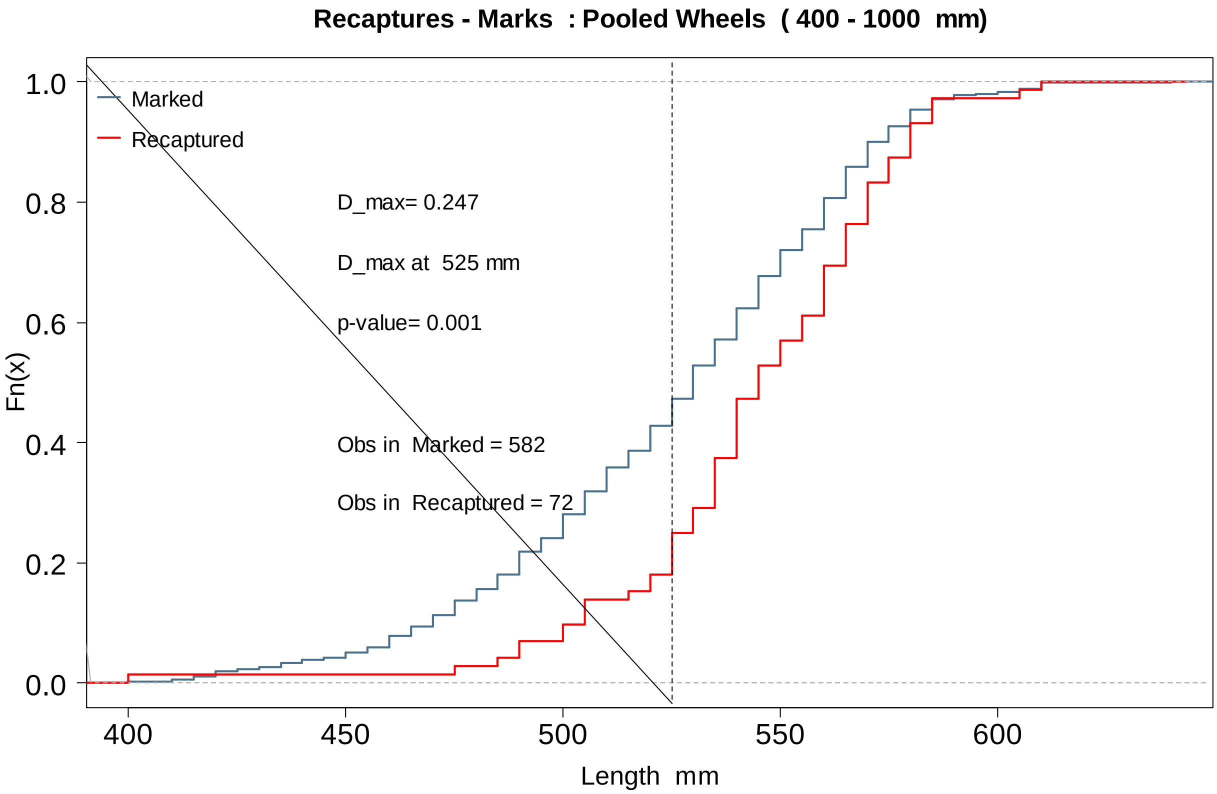

Figure I-10. Empirical cumulative distribution functions of METF length (mm) of all Coho Salmon ($\geq$ 400 mm) marked during first event at the lower mainstem Susitna River tagging site and of all salmon recaptured during second event sampling at the Deshka River and Montana Creek weirs during second event, 2014.

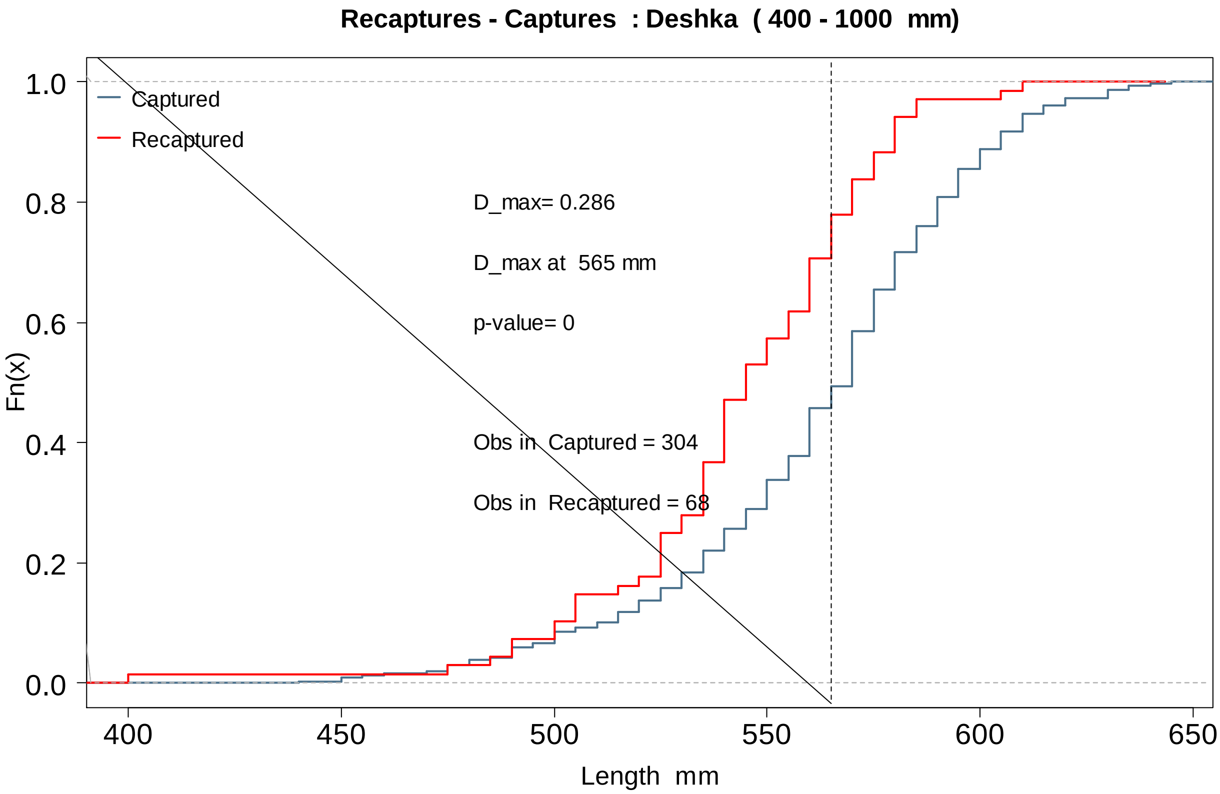

Figure I-11. Empirical cumulative distribution functions of METF length (mm) of Coho Salmon (≥ 400 mm) inspected for marks during second event sampling at the Deshka River weir, 2014 and of all salmon recaptured during inspection.