Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Salmon Escapement Study
Study Plan Section 9.7

Initial Study Report
Part A: Sections 1-6, 8-10

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
ARIS	Adaptive Resolution Imaging Sonar
ATS	Advanced Telemetry Systems, Inc.
cfs	cubic feet per second
CIRWG	Cook Inlet Region Working Group
cm	centimeter
CPUE	catch per unit effort
DIDSON	Dual Frequency Identification Sonar
FERC	Federal Energy Regulatory Commission
FL	fork length
ft	feet
ft/s	feet per second
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
LZ	landing zone
m	Meter
mi	mile
m/s	meters per second
METF	mid-eye to fork
MHW	mean high water
MHz	Megahertz
oz	ounce
PRM	Project River Mile
Project	Susitna-Watana Hydroelectric Project
RPM	revolutions per minute
RSP	Revised Study Plan

Abbreviation	Definition
RST	revised statute trail
SPD	study plan determination
USGS	United States Geological Survey
W	watt

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed its Revised Study Plan (RSP) with the Federal Energy Regulatory Commission (FERC or Commission) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241, which included 58 individual study plans (AEA 2012). Included within the RSP was the Salmon Escapement Study, Section 9.7. RSP Section 9.7 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).

On February 1, 2013, FERC staff issued its study determination (February 1 Study Plan Determination [SPD]) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. RSP Section 9.7 was one of the 13 approved with modifications. In its February 1 SPD, FERC recommended the following:

We recommend the study be modified to require AEA to extend the operation of its Curry Station fishwheels at RM 120 through the entire month of September.

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 into the project area.

On April 26, 2013, the Commission issued a determination requiring no additional changes to this study. AEA adopted the modifications outlined in FERC's February 1 SPD as part of the approved study plan.

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its 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)) This Initial Study Report on Salmon Escapement has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP and as modified by FERC's February 1 SPD (collectively referred to herein as the "Study Plan").

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 in the Middle and Upper Susitna River in proportion to their species-specific abundance. Capture and tag Chinook, coho, and pink *O. gorbuscha* 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 encompasses the Susitna River from Cook Inlet upstream to the Oshetna River, or as far upstream as Chinook salmon are detected (Figure 3-1), with an emphasis on wherever salmon spawn 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 are: 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 [2013] for more detail on the impediments).

4. METHODS

Descriptions of the study methods are organized below by objective. This is a multi-year study initiated in 2012. The methods below refer to research conducted in 2013 and planned for a next year of 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.

AEA implemented the methods with respect to Objective 1 as described in the Study Plan with the exception of variances explained below (Section 4.1.8). Tasks to address Objective 1 were listed in RSP Section 9.7.4.1.

4.1.1. Fish Capture

In the Lower River, two fishwheels and gillnets were used to capture adult salmon for tagging in 2013. The fishwheels were operated at locations that were fished in 2010–2012 (Figure 3-1). One fishwheel operated on the west bank of the Lower River at PRM 33.4 for 1,061 hours from June 3 to August 31, and the second fishwheel operated on the east bank at PRM 34.2 for 1,050 hours from June 3 to August 31 (Figure A-1). From June 3 to July 2, gillnets were fished in the vicinity of the fishwheels for a total of 39.6 hours (Figure A-2). The gillnets were 5.5 inch (in; stretch) or 7.5 in mesh, multi-strand web, 50–150 feet (ft) long, and 60 meshes deep. Seventeen percent of the effort was with 7.5-in mesh and 83 percent with 5.5-in mesh.

In addition, two fishwheels and gillnets were used on the lower Yentna River, and in the same locations as had been operated for three decades (Figures 3-1). One fishwheel operated on the south bank of the Yentna River (river mile 6) for 167 hours June 3–30, and the second fishwheel operated on the north bank of the Yentna River (RM 6) for 166 hours June 2–29 (Figure A-3). There was effort for both fishwheels every day in 2013, and both fishwheels achieved the targeted effort (12 hours/day) on nearly every day. From June 3 to 22, gillnets (5.5 and 7.5-in mesh) were fished in the vicinity of the fishwheels for a total of 74.1 hours (effort was split equally between mesh sizes; Figure A-4).

In the Middle River, three fishwheels and a beach seine were used to capture adult salmon for tagging in 2013. Two of the fishwheels were operated at the same two locations used in 1981–1985 and in 2012 (sites 1 and 2; Figures 3-1 and 4.1-1). From June 9 to September 17, one fishwheel operated for 1,167 hours (48.5 percent of the time it was in place) on the west bank of the Susitna River at Site 1 (PRM 124.1; Figure A-5). Excluding the days it did not operate, daily fishing effort at Site 1 averaged 13.6 hours (range: 5.1–24 hours). The targeted amount of daily fishing effort at Site 1 varied by period: 18 hours from June 9 to 27 and July 4 to 22; 24 hours from June 28 to July 3; 10–12 hours from July 23 to August 22; and 9 hours from August 23 to September 17. The Site 1 fishwheel did not operate during high water and heavy debris loads (August 22–23), or during low-water periods (July 18–22, August 9–11, August 18, and after September 17).

From June 13 to September 16, the second fishwheel operated for 1,150 hours (50.4 percent of the time it was in place) on the east bank of the river at Site 2 (PRM 123.0; Figure A-5). Daily fishing effort averaged 12.5 hours (range: 4.5–18.4 hours). Targeted daily fishing effort varied at Site 2: 18 hours from June 13 to 27 and July 4 to 16; 13–14 hours from June 28 to July 3; 12 hours from July 17 to August 21; and 9 hours from August 24 to September 16. The Site 2 fishwheel did not operate during high water and heavy debris loads (July 19, July 22, and August 22–23).

A third fishwheel was operated from July 17 to September 30 (550 hours of effort; 30.6 percent of the time it was in place) at a new site in 2013 (Site 3), which was located on the west bank of the Susitna River at PRM 126.0 (Figure A-5). Daily fishing effort averaged 10.2 hours (range: 2.2–12.5 hours). Targeted daily fishing effort varied at Site 3: 12 hours from July 18 to August 4 and August 8 to 20; 8 hours from August 5 to 7; and 9–10 hours from August 28 to September 30. The Site 3 fishwheel was not operational during high water (August 22–26, August 30–31, and September 2–16).

On September 25, two sets were made using a beach seine (80 ft long, 7 ft deep, 0.75-in mesh) at the mouth of Fourth of July Creek targeting adult coho salmon for radio-tagging.

The Middle River fishwheels consisted of 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 fishwheels and the adjacent riverbank to direct fish away from the bank and into the path of the fishwheel baskets. Fishwheels were operated 8–24 hours per day. A two-person crew staffed the fishwheels during operations; when the crew was absent from the fishwheel for more than one hour, the fishwheel baskets were raised from the water and stopped. Fishwheels operated in the Lower River were of similar construction, operated in a similar manner, and were staffed at all times during operation (Yanusz et al. 2011).

4.1.2. Radio-tagging

Pulse-coded, extended-range tags by Advanced Telemetry Systems, Inc., (ATS; www.atstrack.com) were applied to a subset of salmon captured in the Lower and Middle rivers. There were 100 unique codes on each available frequency. Model F1835B transmitters were used for pink salmon (16 grams [g; 0.6 ounces (oz)], 30 cm [11.8 in] antenna, 96-day battery life); Model F1840B tags for chum, coho, and sockeye salmon (22 g [0.8 oz], 30 cm [11.8 in] antenna, 127-day battery life); and Model F1845B tags for Chinook salmon (26 g [0.9 oz], 41 cm [16.1 in] antenna, 162-day battery life). 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 mid-eye to fork (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. Unless otherwise noted, all subsequent references to adult salmon sizes refer to METF lengths. All fish to be tagged were placed in a water-filled cooler. 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 only were tissue sampled (axillary process) for genetic baselines (see Section 4.7).

In the Middle River, only uninjured adult fish that met or exceeded a specific length threshold were radio-tagged, including: large Chinook measuring 50 cm (19.7 in) or greater in length; Chinook measuring 30–49 cm (11.8–19.3 in) in length (herein referred to as 'small'); and chum, coho, pink, and sockeye salmon measuring 40 cm (15.7 in) or greater in length. All fish to be tagged were placed in a water-filled, foam-lined, V-shaped trough. To minimize handling time (i.e., achieve less than 2 minutes per fish) and tagging-related effects on fish behavior, anesthetic was not used. Radio tags were inserted orally into the stomach of the fish 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 sexed based on external morphological characteristics (coloration, body and fin shape, jaw morphology). All radio-tagged Chinook salmon (small and large) captured at the Middle River fishwheels were marked with a blue spaghetti tag to assess tag loss, evaluate the effects of spaghetti-tagging on post-handling behavior and final spawning destination, and provide an external mark for anglers to recognize fish that had a radio tag. Half of the radio-tagged Chinook, coho, and sockeye salmon were sampled for scales (to age), and all radio-tagged salmon were tissue sampled (axillary process) for genetic baselines (see Section 4.7). To minimize any effects from fish holding, salmon were typically tagged immediately upon capture. All fish were released immediately after tagging. All fish captured were inspected for radio and spaghetti tags.

4.1.3. Spaghetti-tagging

In the Middle River, spaghetti-tagging was used to augment the ability to test assumptions about the representativeness of fish captured in the fishwheels. The fishwheels captured more fish of some species than were needed for radio-tagging alone, and additional marking of these fish provided more information to test assumptions about how representative the captured fish were of the population of fish passing fishwheel sites than the radio tags alone. A portion of these additional fish captured were spaghetti-tagged, and this portion varied among species according to availability of fish above radio-tagging goals and the opportunities available for examining fish subsequent to the tagging event.

Based on 2012 fishwheel catches at Curry, it was anticipated that a large number of chum salmon, a limited number of Chinook and sockeye salmon, and few to no coho salmon above those needed to meet daily radio-tagging goals would be available for spaghetti-tagging in 2013. It was also expected that an insufficient number of pink salmon could be spaghetti-tagged in order to develop defensible mark-rate estimates since it was an "off-peak" year. Unexpectedly, a large number of chum, coho, and pink salmon were available for spaghetti-tagging, so tags were implanted and fish were released.

4.1.4. Daily Tagging Goals

Recent (2012) and historical (1981–1985) fishwheel catches, effectiveness, and salmon run timing guided tag application rates over the season. For the Lower River, the study team met or came close to the majority of the species-specific, 2013 tagging goals. For Chinook salmon the goal was to radio-tag 300 fish per fishwheel; numbers tagged were 385 salmon from the west bank fishwheel, and 195 from the east bank fishwheel (Table A-1; Figure A-6). The goal for gillnetting was 100 Chinook salmon, and 118 salmon were actually radio-tagged. For coho salmon at the Lower River site, the goal was to radio-tag 300 fish per fishwheel; actually tagged numbers were 343 coho salmon from the west bank fishwheel, and 253 from the east bank fishwheel (Table A-1; Figure A-6). The difference was the result of re-apportioning radio tags inseason according to catches. The number of pink salmon tagged was similar to the tagging goal of 100 fish per fishwheel, with 99 radio-tagged from the west bank fishwheel, and 98 from the east bank fishwheel (Table A-1; Figure A-6).

The tagging goals for the Yentna River fishwheels were not met in 2013; however, the goal for tagging fish captured by gillnet was exceeded, so overall goal of tagging 700 Chinook salmon was almost met. The goal for radio-tagging Chinook salmon was 300 fish per fishwheel; instead, 145 fish were radio-tagged in the north bank fishwheel, and 278 in the east bank fishwheel (Table A-2; Figure A-7). The goal for gillnetting was 100 fish, while 267 fish were actually radio-tagged. Consistently low catches in both fishwheels, especially the north bank fishwheel, led to re-apportioning the radio tags in-season.

In the Middle River, the revised goal of this study was to radio-tag 560 large Chinook salmon (from an initial goal of 400) and, as outlined in the Study Plan, 200 each of chum, coho, pink, and sockeye salmon. As was done in 2012, the early season radio-tagging rates of fish captured in the fishwheels were developed prior to the season, and were based on average historical run timing and expected daily fishwheel catches at Curry. These initial radio-tagging rates were adjusted in-season using run-timing information from the fishwheels in the Lower River, and the ratio of current year's daily catch at Curry to the expected daily fishwheel catch based on historical data. All species-specific goals were met with the exception of sockeye salmon.

Final 2013 radio-tagging numbers in the Middle River were 603 Chinook (536 large, 67 small), 201 chum, 242 coho, 200 pink, and 139 sockeye salmon (Table A-3; Figure A-8).

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

4.1.5.1. Lower River and Yentna River

The primary goal of radio-tagging Chinook salmon in the Lower River and Yentna River was to estimate their system-wide abundance. This goal and tests of underlying assumptions are addressed under Objective 8 in Section 4.8.

4.1.5.2. Middle River

To test if Chinook, chum, pink, and sockeye salmon passing the fishwheels were equally vulnerable to being captured and radio-tagged, fish were examined in a tributary stream (i.e., Indian River) to develop two primary metrics: estimates of the proportion of fish tagged (mark rate), and the size distributions of tagged and untagged fish.

From June 26 to August 20, 2013, a picket weir was operated on the lower Indian River, approximately 1.6 river miles from the confluence with the Susitna River (Figure 3-1), 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 the majority of fish returning to the river would be available to count passing through the video chute.

The underwater video system at the weir was operated 24 hours a day, and collected 1,300 hours of video footage from June 26 to August 20 (Figure B-1). Two high-water events occurred during the operational period of the weir. During the first high-water event from July 19 (9:31 P.M.) to July 20 (3:26 P.M.), the video-recording equipment was temporarily removed from the chute for approximately 18 hours. The second high-water event occurred August 19–25; and on August 20 (12:00 P.M.) all video-recording equipment was permanently removed and weir operations ended for the season. Of the video imagery collected, 981 hours (75.5 percent) was reviewed in full (including all video obtained during the Chinook salmon run) and 319 hours (24.5 percent) was sub-sampled (15 minutes per hour; Figure B-1). Full review (24 hours/day) of video imagery for each hour was performed June 26 through August 1. From August 2 to 20, full review was performed from 0:00–1:00 A.M. and 8:00 P.M. to midnight, at a minimum, for each calendar day. For sub-sampled periods, species-specific counts were expanded (i.e., multiplied by four) to estimate the total count for each hour. For each salmon that passed through the chute, crews recorded the date/time, species, direction of travel (upstream, downstream), sex, fork length (FL; in cm), and whether a radio or spaghetti tag was observed. All fork lengths were converted to mid-eye to fork lengths using species-specific regression equations derived at Curry in 2012 (see Table 3 in AEA [2013]). The net upstream count of all salmon (by species) was estimated, and counts were made of all other fish species at the weir.

Net passage of fish at the weir, by species, was determined by subtracting the total number of downstream-moving fish (tagged and untagged) from the total number of upstream-moving fish. A positive number indicated a net upstream movement of fish and a negative number indicated a net downstream movement of fish. Accounting for the direction of fish movement reduced the potential for bias when individuals moved back and forth through the video chute, in some cases repeatedly; as all five salmon species (as well as other fish species) milled in the vicinity of the weir. Species-specific mark rates were estimated by dividing the net numbers of marked fish estimated to have passed the weir by the total number of fish counted through the chute on the video imagery. The numbers of passing chum, coho, and pink salmon that were spaghetti-tagged in the Middle River were estimated from fish inspected for tags on the video imagery. The numbers of passing fish that were radio-tagged in the Middle River were estimated from detections at a fixed-station receiver site located at the weir, and from aerial telemetry surveys. Radio-tagged chum, coho, pink, and sockeye salmon did not receive a spaghetti tag at the Middle River fishwheels, so video imagery was not a reliable method for identifying radio-tagged fish (radio-tag antennas were difficult to see protruding from the mouth).

Aerial spawner surveys were also used to count live and dead fish. Combined with fixed-station and aerial telemetry data, these provided a second set of counts of marked and unmarked fish in Indian River.

4.1.6. Examining Handling-Induced Changes in Behavior

An assumption of this study is that the behavior of radio-tagged fish was not materially affected by the capture and handling process. By materially affected, AEA means that the capture and tagging did not affect the final spawning destination of a fish and/or its migration behavior once it had recovered from the tagging event and resumed its migration. If (and when) sufficient genetic structure can be found among stocks of various species in the Susitna River, genetics could offer a reasonably good test of whether handling may have influenced the final destination of tagged fish. Until then, this assumption cannot be tested directly, but there are several indirect ways to assess the potential for handling effect.

As stated in RSP Section 9.7.4.1.6, potential handling affects were evaluated based on the survival and travel time of tagged fish, tag mark rates at spawning location, and the post-release migratory behavior of tagged fish recaptured in fishwheels.

Note that a potential handling effect will not pose an analysis issue if the effect is binomial in nature, i.e., simply a significant "on" or "off" with any individual fish. The study design allowed for some fish dropping back and not resuming their upstream migration, by removing these fish from the experiment and subsequent analyses. The potential handling effects would be of issue if the effects were more subtle and went undetected but materially affected fish behavior.

4.1.7. Assessing Any Stock- and Size-selective Capture

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. The assumption of equal probability of capture across fish from all spawning destinations was tested indirectly by examining several sources of information. If there were unequal probabilities of capture among spawning stocks, it would be caused by, and manifest itself, in multiple ways. These issues were addressed for fish tagged at the Lower and Middle River sites.

4.1.7.1. Lower River

The assumption that radio-tagged salmon represent the population of salmon passing the tagging site was evaluated for Chinook and coho salmon tagged at the Lower River site in the framework of the mark-recapture experimental design. Heterogeneity in probability of capture was investigated by fish size (length MEF), 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 Cleary et al. (2013). These tests have not yet been performed for Chinook salmon radio-tagged in the Yentna River because length and date of passage data from the Talachulitna River ARIS sonar site were not available in time to be included in this ISR.

The evaluations of the assumption of equal probability of capture and radio-tagging for all Chinook or coho salmon passing the lower mainstem tagging site are based on characteristics of all fish counted passing the Montana Creek and Deshka River weirs and of all marked fish "recaptured" at these weirs. Independent tests are performed for data from each weir site to evaluate equal probability of capture by size and temporally, while spatial tests require the data from both weirs.

4.1.7.1.1. Equal Probability of Capture by Size

Equal probability of capture by size was evaluated using the Kolmogorov-Smirnov (KS) two-sample test. This test determines if the distribution of lengths from all fish passing a weir site are similar to recaptured (radio-tagged) fish passing the weir site. Under the null hypothesis, the probability that a fish is radio-tagged is independent of the size of the fish, and the cumulative distribution function of the lengths of all fish passing a weir site are expected to be similar to the function of all recaptured fish passing that weir site. A significant test statistic from the KS test provides evidence for rejecting the null hypothesis in favor of the alternative that the probability that a fish was tagged was related to fish size.

4.1.7.1.2. Equal Probability of Capture Over Time

Equal probability of capture over time was evaluated using contingency table analysis with the $\chi 2$ test for independence. For a weir site, the observations of numbers of fish passing the weir by day and number of recaptures passing the weir by day are 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 contains the number of recaptured fish and the second contains the number of unmarked fish accounted for in the time period. Under the null hypothesis that the probability that a fish is radio-tagged is independent of when it passed the tagging site, it is expected that the marked-unmarked ratios of fish observed at each weir site are independent of time. This analysis determines if the ratio of marked-unmarked fish observed at each weir site is independent of time. A significant test statistic from the $\chi 2$ test provides evidence for rejecting the null hypothesis in favor of the alternative that the probability that a fish was tagged was related to when it passed the tagging site.

4.1.7.1.3. Spatial Variation in Probability of Capture

Spatial variation in probability of capture was also evaluated using contingency table analysis, using a 2x2 table containing the numbers of marked and unmarked fish observed at each of the 2 weir sites. This analysis determines if the marked-unmarked ratios of fish observed at each weir site are similar. If they are similar then the probability of tagging is independent of which tagging site (east or west bank (fishwheels) or midstream (gillnet sites) it passes. Under the null hypothesis that the probability that a fish is radio-tagged is independent of whether it passes the tagging site near the east or west banks (fishwheel sites) or nearer midstream (gillnet sites), it is expected that the marked-unmarked ratios of fish observed at each weir site are similar. A significant test statistic from the $\chi 2$ test provides evidence for rejecting the null hypothesis in favor of the alternative that the probability that a fish was tagged was related where or possibly when it passed the mainstem Susitna tagging site. Evaluation of a significant test statistic for this test requires consideration of both temporal and geographic variation in probability of capture, as a significant statistic could be a function of travel times from the tagging site to the weir site, as well as bank orientation of the salmon at the tagging site.

4.1.7.2. Middle River

4.1.7.2.1. Fishwheel effectiveness across time

The main assumption of this study component is 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, from a ratio of the number of fish caught to the number of fish observed. 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 7 to September 30, one ARIS unit operated 24 hours per day on the right bank of the Susitna River. The unit was located immediately downstream of the Site 1 fishwheel (Figure 4.1-1; Figure A-9). Daily review effort for Unit 1 varied over the season, and ranged from 24 hours per day (June 7–26), every second day (June 27 to July 12, and September 1–30), to no review effort (July 13 to August 29). A second ARIS unit was installed to sample fish migrating farther offshore. Unit 2 was operated from September 12 to 30, with 100 percent review effort (Figure A-9). The sonar sampling area was 0.67–10.7 meters (m; 2.2–35.1 ft) for Unit 1, and 9.2–24.9 m (30.2–81.7 ft) for Unit 2, which provided a 1.5 m (4.9 ft) overlap in coverage between the units.

The catch-per-unit-effort (CPUE; fish per fishwheel hour) for each fishwheel over time and across a range of discharges was also evaluated.

4.1.7.2.2. 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 to 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 to other tagged fish to determine whether fish that spawned in the mainstem were recaptured at a higher rate.

Size-related selectivity was tested using (KS) two-sample tests. For each species, comparisons included the cumulative length-frequency distributions of (1) radio-tagged and spaghetti-tagged fish and those fish randomly sampled at the Indian River weir; (2) radio-tagged and spaghetti-tagged fish and all other fish sampled for length at the Middle River fishwheels; and (3) radio-tagged and spaghetti-tagged fish captured in individual fishwheels.

4.1.8. Variances

4.1.8.1. Fish Capture

RSP Section 9.7.4.1 indicated that, if feasible, AEA would operate a fishwheel in Devils Canyon below the impediments from late June through late July in 2013 to supplement the Middle River fishing effort for Chinook salmon. The purpose of this recommendation was to explore whether it was possible to increase the sample size of radio-tagged Chinook salmon moving into and above Devils Canyon. However, land-access limitations precluded siting a fishwheel in Devils Canyon in 2013. Once it was determined that land access would not be available, AEA developed an alternative to increase the numbers of tagged fish in Devils Canyon, subject to the availability of additional tags from the tag vendor. Specifically, AEA increased the tag goal from 400 to 560 fish, and increased daily fishing effort at the fishwheels located near Curry (from a maximum of 12 hours/day to as high as 24 hours/day). This variance did not affect achieving study Objective 1.

RSP Section 9.7.4.1 indicated that two fishwheels would be used at Curry, in a similar fashion to what was done in 2012. AEA began the season with two fishwheels at the same sites as in 2012, and in July deployed a third fishwheel. This was needed due to changes in the river channel that occurred following the 2012 field season which made water velocities slower at the right bank fishwheel site (PRM 124); considerable effort was required to keep this fishwheel operating effectively, particularly during low water. A new third site was found (Site 3, right bank, PRM 126) that was more effective at lower discharges. Fishing began at Site 3 on July 17. This variance increased the likelihood of achieving Objective 1. AEA plans to operate a third fishwheel for the next year of study.

4.1.8.2. Radio-tagging

RSP Section 9.7.4.1.2 indicated that only large Chinook salmon would be radio-tagged in 2013. However, 536 large and 67 small Chinook salmon were radio-tagged. By late June, it became apparent that small Chinook salmon comprised a substantial portion of the total Chinook salmon catch in 2013, and the revised radio tag target for large Chinook salmon (560) might not be met. Given that small Chinook salmon behavior could help characterize spawning locations, it was deemed worthwhile to apply some tags to this segment of the population. Subsequently, all available large Chinook salmon were tagged while a sub-sample of small fish were tagged. All subsequent analyses stratified results by these two size groups, and therefore this did not bias results. This variance did not affect achieving study Objective 1. AEA plans to radio-tag small Chinook salmon again in the next year of study to ensure that all sizes are represented.

4.1.8.3. Assessing Any Stock- and Size-selective Capture

RSP Section 9.7.4.1.5 indicated that Chinook, sockeye, and chum salmon would be examined on selected spawning grounds to test whether fish were equally vulnerable to being captured and radio-tagged. However, results from spawning ground surveys in 2012 indicated that it was going to be difficult to achieve useful sample sizes from surveying spawning grounds on foot and from the water. Therefore, AEA determined that a floating picket weir and underwater video system on the lower Indian River would be a more effective means of examining a large number of fish in 2013. The same two metrics (i.e., mark rate and size distribution of tagged/untagged fish) were developed from fish counts at the weir that would have been developed from spawning ground surveys. In addition, the weir allowed development of these metrics for pink salmon. This variance increased the likelihood of AEA achieving study Objective 1. AEA plans to operate the Indian River weir again in the next year of study.

In RSP Section 9.7.4.1.6, AEA indicated that the upstream movements of tagged fish that were subjected to different holding densities and times in the fishwheels would be compared. However, crews continuously monitored the fishwheels while they were operated and tagged individual fish soon after they were captured. This resulted in brief holding times, generally less than 25 minutes, and consistently low densities of fish in holding tanks. Due to the similarity of holding conditions for all tagged fish, a comparison of post-release survival and migration behavior was determined to be unnecessary in 2013. This variance did not affect achieving study Objective 1. AEA plans to use the same approach for the next year of study.

RSP Section 9.7.4.1.7 indicated that the sex and age composition of radio-tagged fish would be used to assess fishwheel selectivity in 2013. Early on 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; therefore, these comparisons were not attempted. Results of scale analyses to determine fish ages were not available at the time this report was prepared. In light of the fact that size selectivity was tested in 2013, and that fish were randomly selected for tagging, this variance should not affect achieving study Objective 1. AEA plans to use the same approach for the next year of study.

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

AEA implemented the methods with respect to Objective 2 as described in the Study Plan with the exception of variances explained 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 (aerial, boat, and foot) 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 provided 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 deltas) and tributaries. In addition, observed spawning locations were characterized at a microhabitat level (e.g., depth, velocity, and substrate). 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 fates of individual tagged fish. Additional methods pertaining to the set-up and operation of fixed-station receiver sites were provided in RSP Section 9.7.4.2.1.

Figure 3-1 shows the locations of the fixed stations in the Lower, Middle, and Upper River. Twelve fixed-station receiver sites operated in the Lower River in 2013, and 11 fixed-station receiver sites were operated in the Middle and Upper rivers (Tables C-1 to C-3). Locations of the fixed stations in the Middle and Upper rivers are listed below. The fixed stations at Lane Creek and the Upper Indian River were operated with two receivers (Table C-1).

1. Whiskers Creek (PRM 105.1)
2. Lane Creek area (PRM 116.7)
3. Middle River Gateway (PRM 130.1)
4. Fourth of July Creek (PRM 134.3)
5. Indian River confluence (PRM 142.0)
6. Indian River Weir (RM 1.6 on the Indian River)
7. Powerline (PRM 145.7)
8. Devils Island (PRM 166.9)
9. Deadman Creek (PRM 191.2)
10. Kosina Creek confluence (PRM 209.2)
11. Oshetna River (PRM 235.1)

The Lower River fixed stations were chosen to represent significant tributaries that were known to contain Chinook salmon. The 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 through the Upper River to quantify passage through Devils Canyon. See Section 4.3 for additional details about the telemetric monitoring in Devils Canyon (Objective 3).

4.2.2. Aerial Telemetry Surveys

Aerial telemetry surveys of the mainstem Susitna were conducted from the mouth of the Yentna River (PRM 31.4) to PRM 307. Surveys were conducted by helicopter to allow relatively accurate positioning of tagged fish and to locate spawning areas, all with respect to mainstem habitat typing completed by Habitat Mapping, Study 9.9. The 2013 surveys began on June 22 and ended in late October (see Table C-4 for a summary of the surveys conducted). Survey timing was adjusted depending on the observed fishwheel catches in the Lower and Middle River. Surveys were scheduled to cover each section of the river (Lower, Middle, and Upper) each week. Once adult salmon were observed entering Devils Canyon, the Susitna River and its tributaries from Portage Creek to Devils Island were flown daily. Daily flights continued until upstream movement in Devils Canyon had stopped. During the peak chum and sockeye salmon migration and spawning periods in the Middle River, the stretch from the mouth of the Chulitna River to Devils Island was surveyed twice per week to monitor the movements of salmon into spawning locations.

Helicopter surveys were conducted at lower elevations 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. The spatial resolution of helicopter surveys was approximately 300 m (1,000 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. Geographic coordinates were recorded for each signal detected using an integrated communication link between the telemetry receiver and a global positioning system (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.

The mainstem aerial telemetry surveys covered over 200 river miles (Yentna River mouth to the Oshetna River and occasionally beyond), 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 laptop computer 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.

When aggregations of two or more tagged fish were found “stationary” (i.e., within 2 kilometers [km; 1.2 miles (mi)] on one or more surveys) or when visual observations of spawning fish were made from the helicopter-, ground-, or boat-based surveys, spawning locations were more intensely tracked to achieve relatively high-resolution geographic positions. This protocol was particularly important for ensuring coverage of any suspected Lower River habitats with the appropriate level of spatial resolution.

The habitat type (mainstem, side channel, or slough) and relative water turbidity was classified for each tag detected (time stamp, frequency, code, and power level). If other fish were seen in the area of the tag position, their relative abundance was noted to provide context for the tag observation.

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.

In 2013, fixed-wing surveys of tributary systems of the Susitna and Yenta rivers were conducted by ADF&G, from approximately PRM 23 to Devils Canyon and in the upper Chulitna River, at 7–10 day intervals from June 24 through September. These surveys provided fish locations to the nearest river mile and helped to characterize the fates of fish tagged in the Lower and Middle River. Although these 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. All tag frequencies for Chinook salmon released in the Lower and Middle River were scanned during surveys from June 24 to August 12. Tag frequencies for all coho salmon released were scanned during fixed-wing surveys on August 4 and later. Tag frequencies for chum, pink, and sockeye salmon released in the Middle River were not scanned during the fixed-wing surveys.

4.2.2.1. Lower River Surveys

Helicopter surveys of the Lower River covered mainstem areas from the mouth of the Yentna River (PRM 31.4) to the confluence of the Chulitna River (PRM 102.4). This reach was highly braided with side channels and sloughs, so complete coverage required considerable effort and in-flight route tracking.

4.2.2.2. Middle River Surveys

Helicopter surveys of the Middle River 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); this reach required approximately one day to complete. The river between Devils Island (PRM 166.9) and the proposed Watana Dam site was usually flown during surveys of the Upper River.

4.2.2.3. Upper River Surveys

Helicopter telemetry surveys of the Upper River generally were triggered by detection of fish moving above the Devil Creek fixed station. Upper River telemetry surveys covered the mainstem areas from the proposed Watana Dam site (PRM 187.1) to the Oshetna River (PRM 235.1). This reach included approximately 48 relatively confined river miles. This survey required approximately one survey day; less when done in conjunction with Middle River surveys (i.e., when less conveyance time was involved). Radio-tagged fish above Devils Canyon were located at a spatial resolution in habitat types similar to the Middle and Lower river surveys.

4.2.3. Boat and Ground Surveys

In support of Study 8.5 (RSP Section 8.5.4.5.1.1), telemetry surveys were also conducted by boat and on foot to obtain the most accurate and highest resolution positions of holding and spawning fish. Boat surveys were limited to the Susitna River mainstem. The resolution of these positions was within 5–10 m (16–32 ft) in turbid water and 2–3 m (6.5–10 ft) in clear water. A hand-held three-element Yagi antenna and judicious use of the signal gain control on the ATS receiver enabled radio-tagged fish to be located and GPS coordinates were recorded for each fish. These surveys were conducted opportunistically from July through September.

4.2.4. Variances

Five of the fixed stations listed in RSP Section 9.7.4.2.1 were not used in 2013. CIRWG land access limitations precluded siting three of these stations (Portage, Cheechako, Chinook creeks); and the remaining two stations (Slough 11 and Slough 21) were sited elsewhere in the Middle River, where a larger number of tags would be detected (relative to the 2012 study). New fixed stations in 2013 (i.e., sites not used in 2012) that were not listed in RSP Section 9.7.4.2.1 included Whiskers Creek (PRM 105.1), Fourth of July Creek (PRM 134.3), Indian River Weir (RM 1.6 on the Indian River), and Powerline (PRM 145.7) in the Middle River; and Deadman Creek (PRM 191.2) and Oshetna River (PRM 235.1) in the Upper River.

To address the lack of fixed stations at Portage, Cheechako, and Chinook creeks, AEA installed the Powerline station at PRM 145.7. This station was on the mainstem Susitna and provided monitoring to characterize the movement of fish into the area between Portage Creek and Devils Canyon. This provided an inventory of all tags in that area for aerial and boat-based surveys. The study team also flew aerial telemetry surveys daily, and at times twice daily, to monitor fish passage through Devils Canyon (Table C-4). In the end, these frequent aerial surveys provided more detailed information on geographic movements and holding periods below impediments than would have been provided by the previously proposed three fixed stations alone. Devils Canyon spans approximately 11 river miles (PRM 153.7–164.8). Fixed stations provide information only when the fish is near the station, whereas daily aerial telemetry surveys were able to locate tagged fish and characterize fine-scale movements within Devils Canyon and adjacent tributaries. The fixed station at Devil Island (PRM 166.9) was able to monitor for any tagged fish that may have moved above the third impediment; therefore, there was no gap in the study team's understanding of the daily positions of tagged fish while in Devils Canyon. As a result, these variances enhanced AEA's ability to achieve study Objective 2.

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

AEA implemented the methods with respect to Objective 3 as described in the Study Plan with the exception of variances explained 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 above and below (e.g., Powerline Station) Devils Canyon was used to determine the migration timing and behavior of radio-tagged salmon that passed into the Upper River (Figure 3-1). Fixed stations were deployed at locations where they had the highest probability of detecting radio-tagged salmon (within permitted areas). The fixed stations deployed at the confluences with Kosina Creek and Oshetna River provided additional information that was used to assess the detection efficiencies for all mainstem fixed stations downstream from these sites. The data from these fixed stations was also used to guide the aerial and ground-based survey efforts needed to identify spawning areas in the Upper River.

4.3.2. Aerial Telemetry Surveys

The mobile-telemetry survey data aided in confirming the presence of radio-tagged fish, and locating any tagged fish not detected at downstream fixed-station sites. These additional detections were combined with the aerial-survey data to estimate detection efficiencies for each fixed station. The timing and proportion of all tagged salmon that passed Devils Canyon was calculated and compared to the remaining tagged population, and their final spawning locations were identified.

4.3.3. Aerial Spawner Surveys

Aerial visual-observation surveys to determine the distribution and relative abundance of adult salmon were conducted in the Susitna River and its tributaries within and above Devils Canyon, upstream to and including the Oshetna River. A total of five aerial spawner survey events were conducted at approximate weekly intervals from July 19 through August 16, 2013 (Table 4.3-1). The survey extent covered major tributaries and clear water areas of the Susitna River from Cheechako Creek to the Oshetna River. A total of 19 streams were surveyed during each of the five events; 13 tributaries to the Susitna River and six secondary tributaries (Table 4.3-1). Additionally, two lake systems in the Tsisi Creek drainage were surveyed during August specifically to look for spawning sockeye salmon. All streams were surveyed from their confluence up to 3,000 feet in elevation, or to a predetermined barrier to anadromous fish passage, or to the stream's headwater origin, whichever came first (Figure 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, through comparison with concurrent weir counts.

4.3.4. Assess the Feasibility of Using Sonar to Enumerate Salmon and Resident Fish at the Proposed Dam Site

The FERC SPD 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. Prior to the 2013 field season, operation of a weir near the dam site was determined to be not feasible (see Appendix G for further details). However, AEA assessed the feasibility of placing a sonar counting station at or near the dam site. This effort involved sonar surveys at three potential sites between PRM 184 and PRM 188. The feasibility study is provided in Appendix G.

4.3.5. Variances

Lack of permission to access CIRWG land precluded siting fixed stations within Devils Canyon as described in RSP Section 9.7.4.3. To compensate for the absence of fixed stations within Devils Canyon and to ensure that the study objectives were achieved, helicopter surveys for tagged fish were flown through Devils Canyon daily starting in late June, and twice daily during the period of Chinook salmon passage (Table C-4). Daily surveys were attempted in and upstream of Devils Canyon and as long as there were fish above the first impediment. Section 4.2.4 provides additional information on the benefits of these additional aerial telemetry surveys. This variance did not affect achieving study Objective 3.

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

AEA implemented the methods with respect to Objective 4 as described in the Study Plan with the exception of variances explained below (Section 4.4.3). In 2013, ARIS was used to examine the feasibility of sampling turbid water to quantify spawning activity in mainstem habitats of the Susitna River.

From July 24 to 31, 2013, 15 potential Chinook salmon spawning sites were visited (Table 4.4-1) and eight were surveyed using ARIS. Salmon were observed at seven sites, however, spawning activity (nest-guarding behavior) by Chinook salmon was only observed at one site (Indian River Delta). At many sites, the presence of chum salmon made identification of Chinook salmon in the sonar image difficult. Several potential spawning sites could not be accessed via boat and other sites had physical characteristics not suitable for salmon spawning (e.g., high water velocity, thalwag of the river, or rapids).

On July 31 and August 12, two potential spawning sites for chum salmon were sampled using ARIS (Table 4.4-2). Chum salmon were observed at both sites, but spawning was only confirmed at one site. Confirmation of spawning, observed with ARIS, included nest-guarding behavior and visible redds.

Additional site-specific information was collected and subsequently relayed to the Fish and Aquatics Instream Flow Study (Study 8.5) team (Tables D-1 to D-6).

4.4.1. Sonar Equipment and Methods

The sonar system consisted of the ARIS unit, X2 rotator assembly, data transmission cable, laptop computer loaded with ARISScope data-acquisition software, and portable external hard drives. The system was powered with a 2,000 watt (W) Honda generator.

Data were acquired using an ARIS unit attached to a dual-axis rotator. The ARIS and rotator assembly were deployed from a winch-operated pole-mount secured to the gunwale of a jet boat. The rotator assembly allowed for panning and tilting of the ARIS; and depth was controlled by using the winch to raise and lower the assembly.

Potential spawning locations were identified from 2012 and 2013 detections of radio-tagged salmon. At each site, the ARIS was lowered from the side of the boat to approximately 10 cm (3.9 in) above the substrate along the edge of the river. The boat was slowly walked along the bank with the ARIS oriented approximately perpendicular to the riverbank. Survey lengths varied depending on river conditions and the presence of potential spawning habitat. 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; e.g., Gateway Slough).

Data were initially collected using 10–20 m (33–66 ft) sample windows. 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 ARIS depth and tilt angle was adjusted as necessary to maximize coverage of the substrate.

When fish were located and spawning behavior activities were suspected, the boat was stopped and 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.

4.4.2. Sonar Data Analysis and Reporting

Data were collected using a frame rate of eight frames per second in consecutive 10-minute files. Data were ported directly to external hard drives, and backed up and archived to additional hard drives after each survey. Locational data were collected during each survey using a hand-held GPS unit time-synchronized with the ARIS system to allow for geo-referencing locations of observed spawning activities.

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

- Presence or absence of redds. If redds were identified, the length and width of each redd was estimated using the software's sizing tool. The number of detected redds per square meter was estimated.
- Presence or absence of adult salmon. When adult salmon-sized fish were detected, total lengths of individual fish was estimated using the software's sizing tool. The number of adult salmon per cubic meter was estimated.
- 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.

4.4.3. Variances

RSP Section 9.7.4.4.2 indicated that side-scan sonar and Dual Frequency Identification Sonar (DIDSON) would be used for this component of the study; however, an ARIS sonar unit was used in 2013. Although 2012 side-scan images showed features of the river bathymetry and a variety of substrate types, no obvious salmon redds were observed and the utility of this method to identify features not observable with a DIDSON or ARIS sonar was minor at best. Thus, no side-scan sonar was deployed in 2013. ARIS is a second generation (after DIDSON) imaging sonar (www.soundmetrics.com) and the main improvement over DIDSON is its flexibility in setting the sampling window parameters. The size and start range of the sample window can also be customized to fit optimal sample volume configurations. This provided additional resolution and characterization of substrate features. ARIS provided all the capabilities of DIDSON and side-scan sonar for confirming salmon spawning in turbid water. Thus, the variance of using ARIS in 2013 instead of DIDSON and side-scan sonar did not affect achieving study objective 4. AEA plans to use ARIS again in the next year of study.

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. A comparison was made of this study's results from 2012 and 2013 to the historical results 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 to 1985) relevant to at least four fishwheel sites along the Susitna River. These abundance estimates were apportioned to mainstem, sloughs, and tributaries. One weakness of the 1980s studies was that they 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 and 2013, and by using radio telemetry and sonar technology not available in the 1980s. Both methods provide 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 are similar to earlier studies, the current study greatly increased the sample size and confidence in the conclusions from studies in both periods. Therefore, the explicit comparison and contrast of the distribution and habitat use of salmon in the Lower, Middle, and Upper river habitats of the Susitna River is valuable.

4.5.1. Variances

No variances from the methods described in the Study Plan occurred during the 2013 study season.

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

AEA implemented the methods with respect to Objective 6 as described in the Study Plan with the exception of variances explained below (Section 4.6.1). This objective was addressed by operating weirs on tributaries (see Objective 8) and conducting aerial spawner surveys in Indian River (see Objective 3) in 2013. 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 were used to estimate the abundance of salmon passing the tagging sites, and the abundance of Chinook salmon passing upstream of Devils Canyon.

Assumptions were made and tested regarding the representativeness of tagging and proportion of the run detected visually and by telemetry. All aerial spawner survey data was stratified as ‘above’ or ‘below’ the Indian River weir. A combination of aerial- and weir-based counts were used. Weirs were placed on the Indian River and in selected Lower River tributaries (see Objective 8). Aerial telemetry surveys by helicopter were conducted in July and August 2013 (Table C-4). Protocols developed based on 2012 experience, were implemented in 2013 to survey the Portage Creek and Indian River tributaries of the Middle River.

Aerial telemetry survey data were used to establish estimates of minimum and likely numbers of fish based on a range of observer efficiencies. The estimates were used to establish ranges of possible species-specific mark rates in 2013. Multiple aerial telemetry surveys were flown bracketing the peak timing of spawning. Survey aircraft were equipped with telemetry receivers and GPS to identify positions of radio-tagged fish, and visual observations were used to document the presence of Pacific salmon. The aerial spawner surveys did not provide a direct estimate of the total salmon abundance in tributaries. Instead, they provided a minimum count and then helped to establish minimum and likely tributary-specific mark rates, as was done for Portage Creek and Indian River tributaries in 2012.

4.6.1. Variances

Results from the 2012 escapement study indicated that it would be unlikely to obtain sufficient numbers of fish through spawning ground surveys to address both the original objectives of RSP Section 9.7.4.6 (mark rates), and the additional goal of estimating the numbers of fish above Devils Canyon that was established during the FERC Study Dispute process. Therefore, a decision was made to replace spawning ground surveys with operation of a weir and an underwater video system on the Indian River to enumerate tagged and untagged fish, and establish mark rates (see Section 5.6.2). This variance provided more rigorous data and did not affect achieving study objective 6.

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 objective 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 and from all untagged spawning fish that were sampled during spawning ground surveys. Sample collections were coordinated with the Genetic Baseline Study team (see ISR Study 9.14).

Similar to 2012, this study identified the locations of spawning fish and whenever feasible, collected tissue for use with genetics studies by AEA.

4.7.1. Variances

No variances from the methods described in the Study Plan occurred during the 2013 study season.

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

AEA implemented the methods with respect to Objective 8 as described in the Study Plan with the exception of variances explained 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. In the Susitna River, the capture event was provided by fishwheels operated throughout the seasonal salmon migration. Radio tags were applied to fish as close to proportional of the migrating salmon as possible. Later in the salmon migration, to establish the proportion of each species that had a tag (also known as the species-specific and stock-specific mark rate), recaptures were collected from tributary and mainstem weir and sonar sites. Using relatively simple algebra and making some testable assumptions, a species-specific estimate of total abundance passing the tagging site was estimated; more specifically, the abundance and in-river escapement at the fishwheels sites on the Susitna (Chinook and coho salmon) and the Yentna (Chinook salmon) rivers. Length, sex, and genetics 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 June 3 to August 31, 2013, 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 (river mile 6) from June 2 to 30 to capture fish for marking with radio tags (Table A-2; Figures A-3, A-4, and A-7). Lengths of tagged and untagged fish, and a tissue sample from tagged fish (for genetics sampling), were collected at each site.

Weirs or sonar on tributaries 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). Fish length was sampled at each site for testing assumptions of the mark-recapture experiment. At the sonar sites, 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). Fish length samples were attempted by seining or hook-and-line capture.

In the Susitna River drainage above the Yentna River confluence, a weir was operated on the Deshka River from June 9 to September 3, 2013, and on Montana Creek from June 17 to September 2, 2013. Sonar was operated on the Middle Fork Chulitna River from June 20 to August 5, 2013. In the Yentna River drainage, sonar was operated on the Talachulitna River from June 11 to July 31, 2013.

Finally, fish tagged in the Lower River that were collected at the Curry fishwheels were examined for mark rates. The size characteristics of the tagged and untagged fish at Curry were used along with weir-based information to estimate escapement and for testing assumptions of the mark-recapture experiment each year.

A two-event, capture-recapture experiment was also used to estimate the abundance of coho salmon in the Susitna River upstream of the confluence with the Yentna River. Only 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 31, 2013 (Table A-1; Figures A-1, A-2, and A-6). Coho salmon were counted and inspected for tags at the weirs on the Deshka River and Montana Creek, as described above. In addition, the Middle Fork Chulitna River was evaluated as a possible site using the 2012 coho salmon telemetry analyses; but, the relative size of the 2012 coho salmon return indicated too few tags were likely to be recovered to justify using the Middle Fork Chulitna River as a recapture site in 2013.

4.8.1. Variances

Montana Creek was selected as a weir site instead of Willow Creek in 2013. 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 did not affect achieving study Objective 8.

A weir was not operated on the Middle Fork Chulitna River in 2013. In June, 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. This variance may provide sufficient data to meet the abundance and distribution objectives for the Susitna River above the Yentna River, and may not affect achieving the Susitna abundance estimate component of study Objective 8.

No weir or sonar operations occurred at Lake Creek in 2013. In June, the stream discharge remained too high for weir installation and was hazardous for boat operation. Also, direct access to a site suitable for either a weir or sonar operation was not possible. This variance will affect achieving the Yentna component of study Objective 8 as an abundance estimate will not be determined.

A weir was not operated on the Talachulitna River in 2013. In June, the stream discharge was too high for weir installation; instead, a sonar unit was employed in order to obtain the counts necessary for the abundance experiment. Discharges remained too high to install the weir at a later date. No sampling at Lake Creek leaves only the Talachulitna River as a sampling site on the Yentna River. One site is not adequate for testing of the assumptions of the capture-recapture abundance experiment for Chinook salmon in the Yentna River. This variance will affect achieving the Yentna component of study Objective 8 as an abundance estimate will not be determined.

Although not part of the Study Plan, a picket weir was operated on the Indian River through its entire Chinook salmon run (Section 4.1.5.2) and size-specific mark rates pertaining to Lower River tagged fish were obtained. This variance will improve the likelihood of achieving the Middle River component of study Objective 8 (see Section 4.1.8.3 for details).

5. RESULTS

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr/9/9.7 and include the files ISR_9_7_ESCAPE_LGL 2013 Fishwheel Catch Tag Dataset QC3-sub20131216.xlsx, ISR_9_7_ESCAPE_LGL 2013 Curry Sonar ARIS Dataset QC3-sub20131218.xlsx, ISR_9_7_ESCAPE_LGL 2013 Indian River Weir Passage Dataset QC3-sub20131218.xlsx, and ISR_9_7_ESCAPE_SuWa LGL ESCAPE TelemMgr Export Flat Tables QC3 DR 20131213.

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.

Detailed summaries of fish capture and tagging are provided in Appendix A.

5.1.1. Fish Capture

5.1.1.1. Lower River

A total of 2,063 Chinook (1,232 large, 831 small), 3,512 chum, 3,277 coho, 33,995 pink, and 624 sockeye salmon were captured in the mainstem of the Lower River (Table A-5). The peak of Chinook salmon catch was on June 12 (204), whereas peak catches for pink and coho salmon were over a month later on July 20 (4,551) and August 3 (186), respectively. Catch-per-unit-effort for pink salmon peaked at 201 fish per hour (west bank), whereas CPUE for Chinook and coho salmon peaked at 10.6 (west bank) and 9.1 (west bank) fish per hour, respectively (Figure A-10). Chinook salmon catches were substantially higher in the west bank fishwheel during the peak of the run, coho salmon catches were consistently slightly higher in the west bank fishwheel, whereas pink salmon catches were relatively balanced along each bank.

5.1.1.2. Yentna River

Of the 2,295 adult Chinook salmon (1,201 large, 1,094 small) captured in the lower Yentna River, the majority (87 percent) were captured in fishwheels, and the remaining 13 percent in gillnets (

Table A-6). Daily catch peaked at 259 fish on June 17. The magnitude and timing of the peak CPUE for Chinook salmon was very similar for the north and south bank fishwheels (Figure A-11). Chinook salmon captured in the Lower River and Yentna River were similarly sized (Table A-7).

5.1.1.3. Middle River

In the Middle River, 616 large Chinook, 336 small Chinook, 3,417 chum, 1,734 coho, 15,695 pink, and 276 sockeye salmon were captured, including recaptures (Table A-8). The majority of Chinook and coho salmon were captured at Site 1, whereas the most sockeye salmon were captured at Site 2, and the most chum and pink salmon were captured at Site 3. Peak catches were earliest for Chinook salmon (July 1; 52 fish), followed by sockeye (August 1; 9 fish), chum and pink (August 3; 259 and 1,422 fish, respectively), and coho salmon (August 17; 139 fish). CPUE was highest for pink salmon (90.1 fish/hour; Site 3), followed by chum (11.3 fish/hour; Site 3), coho (9.7 fish/hour; Site 1), large Chinook (2.2 fish/hour; Site 1), and sockeye salmon (0.7 fish/hour; Site 3; Figure A-12). The mean length of large Chinook salmon captured in the Middle River (69.6 cm [27.4 in]; Table A-4) was greater than the mean length of large Chinook salmon captured in the Lower River and Yentna River (Table A-7). From largest to smallest, mean lengths for chum, coho, sockeye, and pink salmon captured in the Middle River were 59.0 cm, 51.1 cm, 44.8 cm, and 41.6 cm [23.2 in, 20.1 in, 17.6 in, and 16.4 in], respectively (Table A-4). Six other fish species were captured and released at the Middle River fishwheels, including 104 round whitefish *Prosopium cylindraceum*, 59 rainbow trout *O. mykiss*, 54 Arctic grayling *Thymallus arcticus*, 20 humpback whitefish *Coregonus pidschian*, 20 longnose sucker *Catostomus catostomus*, 14 Dolly Varden *Salvelinus malma*, and 2 burbot *Lota lota* (Table A-4).

5.1.2. Radio-tagging

5.1.2.1. Lower River

In the Lower River fishwheels, 580 large Chinook, 596 coho, and 197 pink salmon were radio-tagged (Table A-1; Figure A-6). These tagged fish represent 31 percent of the Chinook, 18 percent of the coho, and 0.6 percent of the pink salmon in the total fishwheel catch. Between the two fishwheels in the Lower River, 66 percent of the radio tags were deployed in the west bank fishwheel. In the Lower River gillnetting, 118 large Chinook were radio-tagged, which was 71 percent of the gillnet catch. Daily radio-tag deployment in the Lower River peaked at 128 for Chinook salmon on June 9, 36 for coho salmon on July 16, and 17 for pink salmon on July 24 and 25, 2013.

5.1.2.2. Yentna River

In the Yentna River fishwheels, 425 large Chinook salmon were radio-tagged (Table A-2; Figure A-7), which was 21 percent of the total fishwheel catch. In the gillnetting, 267 Chinook salmon were marked with radio tags, which was 86 percent of the gillnet catch. Between the two fishwheels in the Yentna River, 66 percent of the radio tags were deployed in the south bank fishwheel. Radio-tag deployment for Chinook salmon at the Yentna River peaked at 79 tags on June 14, 2013.

5.1.2.3. Middle River

In the Middle River, radio tags were applied to 536 large Chinook, 67 small Chinook, 201 chum, 242 coho, 200 pink, and 139 sockeye salmon (Table A-3; Figure A-8). Of the untagged, healthy adult salmon captured at the Middle River fishwheels, radio tags were applied to 89.9 percent of large Chinook, 20.2 percent of small Chinook, 6.0 percent of chum, 13.7 percent of coho, 1.3 percent of pink, and 80.3 percent of sockeye salmon. The daily number of radio tags applied peaked at 50 for large Chinook, 7 for small Chinook, 20 for chum, 26 for coho, 25 for pink, and 8 for sockeye salmon (Figure A-8). Radio tags were deployed in proportion to catch for Chinook and sockeye salmon in 2013 (Figure A-13). In contrast, relative to fishwheel catches in the 1980s, 2012, and 2013, the early components of the 2013 chum, coho, and pink salmon runs were likely over-tagged, and the later components of these runs were under-tagged.

5.1.3. Spaghetti-tagging

In the Middle River, spaghetti tags were applied as the primary mark to 1,959 chum, 962 coho, and 9,105 pink salmon (Table A-3; Figure A-14). The daily number of spaghetti tags deployed peaked at 139 for chum, 105 for coho, and 919 for pink salmon. Incidentally, seven Chinook (5 large, 2 small) and six sockeye salmon were also spaghetti-tagged.

A number of previously radio- and spaghetti-tagged salmon were recaptured at the Middle River fishwheels, including 20 large Chinook, 4 small Chinook, 82 chum, 37 coho, 460 pink, and 3 sockeye salmon. Of these, four Chinook and two coho salmon were radio-tagged fish released at the Lower River fishwheels.

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

5.1.4.1. Deshka River Weir

An estimated 18,003 Chinook salmon measuring 50 cm MEF or greater passed the Deshka River weir during June 9 to September 2, 2013, out of a total count of 18,531 Chinook salmon of all sizes. One hundred forty eight, or 0.82 percent, were radio-tagged fish (Table B-1) which were assumed to have spawned above the weir. The cumulative length-frequency distribution for Chinook salmon sampled at the Deshka River weir was significantly different than that for radio-tagged fish passing the weir ($D = 0.243$, $p < 0.001$), providing strong evidence of size biased sampling during the marking event. The cumulative length-frequency distribution for Chinook salmon sampled at the Deshka River weir was also significantly different than that for all radio-tagged fish above the tagging site ($D = 0.245$, $p < 0.001$) with the mean length of radio-tagged Chinook salmon (68.6cm) being smaller than that of Chinook salmon measuring 50 cm or greater that passed the Deshka River weir (73.4 cm; Table B-2).

A total of 22,141 coho salmon were counted during July 10 to September 3, 2013, all of which were estimated to be 40 cm MEF or greater. Sixty seven, or 0.30 percent, were radio-tagged fish (Table B-1) which passed the weir when counting was being conducted and later assumed to have spawned above the weir. The cumulative length-frequency distribution for coho salmon sampled at the Deshka River weir was significantly different than that for radio-tagged fish passing the weir ($D = 0.439$, $p < 0.001$), providing strong evidence of size biased sampling during the marking event. The cumulative length-frequency distribution for coho salmon sampled at the Deshka River weir was also significantly different than that for all radio-tagged fish above the tagging site ($D = 0.410$, $p < 0.001$) with the mean length of radio-tagged coho salmon (50.3 cm) smaller than coho salmon that passed the Deshka River weir (55.4 cm; Table B-2).

5.1.4.2. Montana Creek Weir

An estimated 1,949 Chinook salmon measuring 50 cm or greater passed the Montana Creek weir during July 8 to August 20 and August 26–27, 2013, out of a total count of 2,015 Chinook salmon of all sizes. Eleven, or 0.56 percent, were radio-tagged fish (Table B-3) which were assumed to have spawned above the weir. The cumulative length-frequency distribution for Chinook salmon sampled at the Montana Creek weir was not significantly different than that for radio-tagged fish passing the weir ($D = 0.233$, $p = 0.663$). 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 ($D = 0.136$, $p = 0.006$), with the mean length of radio-tagged Chinook salmon (68.6 cm) slightly larger than Chinook salmon measuring 50 cm or greater that passed the Deshka River weir (67.2 cm; Table B-2).

A total of 765 coho salmon were counted during July 31 to August 20 and August 26 to September 3, 2013, all of which were estimated to be 40 cm or greater. Seven, or 0.92 percent, were radio-tagged fish (Table B-3) which passed the weir when counting was being conducted and later assumed to have spawned above the weir. The cumulative length-frequency distribution for coho salmon sampled at the Montana Creek weir was significantly different than that for radio-tagged fish passing the weir ($D = 0.657$, $p = 0.005$), providing strong evidence of size biased sampling during the marking event. The cumulative length-frequency distribution for coho salmon sampled at the Montana Creek weir was also significantly different than that for all radio-tagged fish above the tagging site ($D = 0.263$, $p < 0.001$) with the mean length of radio-tagged coho salmon (50.3 cm) smaller than coho salmon that passed the Deshka River weir (53.2 cm; Table B-2).

5.1.4.3. Middle Fork Chulitna River Sonar

This data is currently under analysis.

5.1.4.4. Talachulitna River Sonar

This data is currently under analysis.

5.1.4.5. Indian River Weir

Net passage of Chinook salmon inspected for tags was 1,405 fish, including 1,137 large fish, 294 small fish, and minus 26 fish with an unknown length category (Table 5.1-2; Table B-4; Figure B-2). An additional net passage of 34 Chinook salmon were not inspected for tags, including 31 large fish and 3 fish with an unknown length category. Chinook salmon were counted at the weir from June 27 to August 19, and net passage peaked at 192 fish on July 10. Of the Chinook salmon inspected for tags, with a known length category, 72 (6.3 percent) were large fish and 13 (4.4 percent) were small fish with radio tags applied in the Middle River.

Net passage of chum salmon inspected for tags was 12,906 fish, including 12,847 fish measuring 40 cm (15.7 in) or greater in length, one fish measuring less than 40 cm (15.7 in) in length, and 58 fish with an unknown length category (Table B-4; Figure B-2). An additional net passage of 6 fish were not inspected for tags, including four fish measuring 40 cm (15.7 in) or greater in length and two fish with an unknown length category. Chum salmon were counted at the weir from June 27 to August 20, and net passage peaked at 884 fish on July 30. Of the 12,847 chum salmon measuring 40 cm (15.7 in) or greater in length that were inspected, 542 (4.2 percent) were tagged, which included 51 (0.4 percent) radio tags, and 491 (3.8 percent) spaghetti tags.

Net passage of coho salmon inspected for tags was 525 fish, including 514 fish measuring 40 cm (15.7 in) or greater in length, 12 fish measuring less than 40 cm (15.7 in) in length, and minus one fish with an unknown length category (Table B-4; Figure B-2). An additional net passage of 20 fish measuring 40 cm (15.7 in) or greater in length were not inspected for tags. Coho salmon were counted at the weir from July 20 to August 20, and net passage peaked at 300 fish on August 19. Of the 514 coho salmon measuring 40 cm (15.7 in) or greater in length that were inspected, 53 (10.3 percent) were tagged, which included 17 (3.3 percent) radio tags and 36 (7.0 percent) spaghetti tags.

Net passage of pink salmon inspected for tags was 37,181 fish (Table B-4; Figure B-2). An additional net passage of 66 fish were not fully inspected for tags. Pink salmon were counted at the weir from July 20 to August 20, and net passage peaked at 4,292 fish on August 10. Of the pink salmon inspected, 2,010 (5.4 percent) were tagged, including 35 (0.1 percent) radio tags and 1,975 (5.3 percent) spaghetti tags.

Net passage of sockeye salmon inspected for tags was 127 fish, including 120 fish measuring 40 cm (15.7 in) or greater in length, six fish measuring less than 40 cm (15.7 in) in length, and one fish with an unknown length category (Table B-4; Figure B-2). Sockeye salmon were counted at the weir from July 20 to August 18, and net passage peaked at 16 fish on August 17. Of the sockeye salmon measuring 40 cm (15.7 in) or greater in length that were inspected for tags, three (2.5 percent) were radio-tagged.

Other fish species counted at the weir included: rainbow trout (587 up, 274 down), Arctic grayling (93 up, 19 down), round whitefish (71 up, 24 down), humpback whitefish (22 up, 1 down), longnose sucker (8 up, 0 down), and Dolly Varden (12 up, 10 down; Figure B-3). A small number of juvenile salmon and sculpin species were also observed passing through the chute.

The mean length of tagged Chinook salmon (68.0 cm [26.7 in]) measured from video imagery at the Indian River weir was slightly smaller than the mean length of untagged fish (69.8 cm [27.5 in]; Table B-2). However, cumulative length-frequency distributions for marked, inspected, and recaptured Chinook salmon were statistically similar, which indicates no evidence of size-selective radio-tagging for large Chinook salmon at the Middle River fishwheels or at the weir (Figure A-15). These results suggest radio tags were randomly applied to fish in the Middle River regardless of size.

Cumulative length-frequency distributions for fish radio-tagged in the Middle River and those inspected at the weir were similar for small Chinook (D_{max} = 0.10, P = 0.69), coho (D_{max} = 0.11, *P* = 0.11), pink (D_{max} = 0.09, *P* = 0.14), and sockeye salmon (D_{max} = 0.17, *P* = 0.09; Figure A-15). In contrast, the cumulative length-frequency distributions of chum salmon radio-tagged in the Middle River and those inspected at the weir were significantly different (D_{max} = 0.13, *P* = 0.01); although the mean lengths of tagged (59.7 cm [23.5 in]) and inspected (60.4 cm [23.8 in]) fish differed only slightly. Nonetheless, for small Chinook, chum, coho, pink, and sockeye salmon, too few radio-tagged fish ($n \leq 4$) were recaptured at the weir to make additional comparisons and test for size selectivity.

There was evidence to suggest size-selective spaghetti-tagging occurred at the Middle River fishwheels for chum salmon, but not for pink salmon (Figure A-16). The mean length of chum salmon spaghetti-tagged at the Middle River fishwheels (59.0 cm [23.2 in]) was slightly smaller than the mean length of fish inspected at the weir (60.4 cm [23.8 in]). Spaghetti-tagged coho salmon released in the Middle River, and those fish inspected at the weir, had similar length distributions (D_{max} = 0.06, *P* = 0.66); however, too few spaghetti-tagged coho salmon (n = 14) were recaptured at the weir for further statistical comparisons.

5.1.5. Examining Handling-Induced Changes in Behavior

Of the 536 large Chinook salmon that were radio-tagged and released at the Middle River fishwheels, 14 (2.6 percent) were recaptured (i.e., captured twice) at one of the Middle River fishwheels. The elapsed time between tag and recapture events ranged from a few minutes to over eight days (median = 0.8 days). All recaptured fish were released and subsequently assigned spawning fates (i.e., classified into a specific tributary or mainstem spawning location). Four (6.0 percent) of the 67 radio-tagged small Chinook salmon were recaptured, of which three were assigned spawning fates (median time between capture events was 1.5 days). The elapsed time between capture events for chum (n = 3), pink (n = 10), and sockeye (n = 3) salmon was 0.3, 0.3, and 0.2 days, respectively; and all of these recaptures were assigned spawning fates. The relatively short time period between capture events and large proportion of recaptured fish that were assigned spawning fates suggests the additional handling time did not substantially influence behavior.

5.1.6. Assessing Any Stock- and Size-selective Capture

5.1.6.1. Use of ARIS to Assess Fishwheel Effectiveness and Fish Approach Behavior

Catch-per-unit-effort data at the ARIS (Unit 1), or the number of targets counted per hour of imagery reviewed, showed several pulses of fish passing Site 1 in the Middle River (Figure A-17). These included: two small pulses on June 10–11 (peak = 1.7 fish/hour) and June 16–17 (peak = 3.0 fish/hour), a moderate but steady pulse from late June to early July (peak = 6.0 fish/hour), a large pulse from August 30 to September 3 (peak = 17.0 fish/hour), and a small but steady pulse for the remainder of September. The number of adult salmon captured at the Site 1 fishwheel was compared to concurrent net upstream counts of fish on the ARIS (Unit 1; Figure A-18). The two pulses of fish observed in June on Unit 1 corresponded to peak catches of Arctic grayling, rainbow trout, and round whitefish at the Site 1 fishwheel. Although these pulses of smaller-sized fish measured 50 cm (19.7 in) or greater on the ARIS imagery, the vast majority of these species measured less than 50 cm (19.7 in) when sampled at the fishwheel (and thus are not reflected in the fishwheel catch data in Figure A-18). These results suggest that the length measurements collected from ARIS imagery in the first half of June may be biased high.

The ARIS data provided a good indication that the leading edge of the Chinook salmon run was captured at the Middle River fishwheels. As counts at Unit 1 increased from late June through early July, there was a concurrent pulse in Chinook salmon catches at the Site 1 fishwheel (peak of 51 Chinook salmon on July 1). From August 30 to September 3, fishwheel catches at Site 1 were comprised largely of coho salmon.

The ARIS data suggests that the trailing end of the coho salmon run was not well-represented by fishwheel catches. Despite the small but steady stream of fish observed using ARIS after September 4, which presumably was comprised largely of coho salmon, only five adult salmon (three coho, one chum, and one sockeye salmon) were captured at the Site 1 fishwheel from September 4 to 17. The decrease in turbidity in the first half of September (Figure A-17) likely contributed to the apparent low fishwheel catches, as fish would be able to see the fishwheel baskets and avoid being captured.

From June 16 to July 12, when most fish measuring 50 cm (19.7 in) or greater passing Site 1 were Chinook salmon, the just over half (58.4 percent) of the targets at Unit 1 were within 6 m (19.7 ft) of the transducer (Figure A-19). From September 1–30, when most fish measuring 40 cm (15.7 in) or greater passing Site 1 were likely coho salmon, a larger proportion (69.4 percent) of targets at Unit 1 were within 6 m (19.7 ft) of the transducer. Counts at that range for Unit 2 in September indicated that relatively few fish migrated greater than 13 m (42.7 ft) from the transducer.

Counts of upstream-moving targets on days when the full 24 hours of imagery were reviewed showed that the majority of fish (presumably Chinook salmon) passed between midnight and 11:00 A.M. from June 16 to July 12 (Figure A-20). In contrast, from September 1 to 30, fish passage (presumably mostly coho salmon) was highest from 8:00 A.M. to 8:00 P.M.

5.1.6.2. 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 fate showed no evidence to suggest that radio-tagged large Chinook, chum, or pink salmon were bank-oriented when passing through the Middle River. However, due to small sample sizes, at least one cell in each of the species-specific tests had an expected value of less than five. In contrast, sockeye salmon appeared bank-oriented in the Middle River (χ^2 = 13.9, df = 1, $P < 0.001$). Eighty percent (16 of 20) of sockeye salmon radio-tagged on the left bank (when looking downstream) were assigned to left-bank spawning areas, and 76 percent (19 of 25) of fish tagged on the right bank returned to right-bank spawning areas. All small Chinook salmon returned to right-bank spawning areas, regardless of whether they were captured on the left (n = 8) or right (n = 23) bank.

Mainstem spawning populations did not appear more vulnerable to recapture than those fish bound for tributaries. Of the 31 radio-tagged salmon released and recaptured at the Middle River fishwheels that were subsequently assigned spawning fates, 27 (87 percent) were assigned to tributaries and only four (13 percent) were assigned to mainstem areas. Similar proportions were observed for radio-tagged fish that were never recaptured (88 percent to tributaries and 12 percent to mainstem areas).

5.1.6.3. Size-related Comparisons

5.1.6.3.1. 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 ($D = 0.308$, $p < 0.001$) and the east bank fishwheel ($D = 0.615$, $p < 0.001$). Chinook salmon caught in the west bank fishwheel were larger than those from the east bank fishwheel ($D = 0.311$, $p < 0.001$). Average lengths (MEF) of Chinook salmon for each capture station was 67.8 cm for mid-river gillnets, 57.4 cm for the west bank fishwheel, and 46.4 cm for the east bank fishwheel. Coho salmon caught in the west bank fishwheel were significantly larger than those caught in the east bank fishwheel ($D = 0.073$, $p = 0.001$). Average lengths were 50.0 cm for west bank fish and 49.2 cm for east bank fish. There was no difference detected between lengths of pink salmon caught at the two fishwheels ($D = 0.070$, $p = 0.968$), with average lengths of 43.0 cm for west bank fish and 42.8 cm for east bank fish (Figure A-21).

For Chinook salmon measuring 50 cm 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 ($D = 0.153$, $p < 0.001$). This difference is due largely to the tagging strategy used at the site, which called for Chinook salmon less than 58 cm to be tagged at approximated 1/3 the rate of larger fish. No significant difference was detected between the length distributions of Chinook salmon measuring 58 cm or greater caught at the Lower River site and those tagged ($D = 0.058$, $p = 0.231$). For coho salmon measuring 40 cm or greater, no 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 ($D = 0.038$, $p = 0.481$). For pink salmon, length data were collected only for fish that were radio-tagged (Figure A-22).

For Chinook salmon measuring 50 cm or greater, a significant difference was detected between length distributions of radio-tagged fish that spawned above the Lower River tagging site and fish recaptured at the Montana Creek and Deshka River weirs ($D = 0.272$, $p < 0.001$). There was a significant difference detected between the length distribution of Chinook salmon measuring 50 cm or greater passing the Deshka River weir and recaptured radio-tagged fish that spawned above the weir ($D = 0.243$, $p < 0.001$). No significant difference was detected at the Montana Creek weir between the length distributions of Chinook salmon measuring 50 cm or greater spawning above the weir and recaptures at the weir ($D = 0.233$, $p = 0.663$). For coho salmon measuring 40 cm or greater, no significant difference was detected between length distributions of radio-tagged fish that spawned above the lower river tagging site and fish recaptured at the Montana Creek and Deshka River weirs ($D = 0.079$, $p = 0.754$). There was a significant difference detected between the length distribution of coho salmon measuring 40 cm or greater passing the Deshka River weir and recaptured radio-tagged fish that spawned above the weir ($D = 0.439$, $p < 0.001$). Similarly, a significant difference was detected at the Montana Creek weir between the length distributions of coho salmon measuring 40 cm or greater spawning above the weir and recaptures at the weir ($D = 0.657$, $p = 0.005$; Figure A-23).

5.1.6.3.2. Yentna River

Comparisons of cumulative length-frequency distributions for all Chinook salmon captured at the Yentna River tagging site showed significant differences between the size distributions of fish caught at the north bank fishwheel, the south bank fishwheel, and mid-river gillnetting sites. Chinook salmon caught in mid-river gillnets were larger than fish caught in the north bank fishwheel ($D = 0.736$, $p < 0.001$) and the south bank fishwheel ($D = 0.579$, $p < 0.001$). Chinook salmon caught in the south bank fishwheel were larger than those from the north bank fishwheel ($D = 0.233$, $p < 0.001$). Average lengths (MEF) of Chinook salmon for each capture station was 75.9 cm for mid-river gillnets, 50.3 cm for the south bank fishwheel, and 43.0 cm for the east bank fishwheel (Figure A-24).

For Chinook salmon measuring 50 cm or greater, a significant difference was detected between the length distributions of fish captured at the Yentna River tagging site and only those fish radio-tagged at that site ($D = 0.174$, $p < 0.001$). This difference is due largely to the tagging strategy used at the site, which called for Chinook salmon measuring less than 58 cm to be tagged at approximated 1/3 the rate of larger fish. No significant difference was detected between the length distributions of Chinook salmon measuring 58 cm or greater caught at the Yentna River site and those tagged ($D = 0.022$, $p = 0.995$; Figure A-25).

5.1.6.3.3. Middle River

Comparisons of cumulative length-frequency distributions for fish captured at the Middle River fishwheels showed significant differences for Chinook salmon captured at sites 1 and 2; chum salmon captured at sites 1 and 2, and sites 2 and 3; coho salmon captured at sites 1 and 2, and sites 1 and 3; and sockeye salmon captured at sites 1 and 2, and sites 1 and 3 (Figure A-26). Pink salmon were the only species with similar length-frequency distributions across all three sites. The mean lengths of fish captured at Site 1 were greater than those captured at Site 2 for Chinook (58.4 vs. 54.6 cm [23.0 vs. 21.5 in]), chum (59.1 vs. 58.4 cm [23.2 vs. 23.0 in]), coho (51.9 vs. 50.0 cm [23.3 vs. 19.7 in]). The mean length of chum salmon captured at Site 3 (59.2 cm [23.3 in]) was greater than at Site 2 (58.4 cm [23.0 in]). Results associated with Site 3 are limited to species other than Chinook salmon and are confounded with time. Fishing at Site 3 was limited to the latter part of the run (i.e., July 17 and later), and sample sizes were too small to compare period-specific data.

It is worth noting that a larger proportion of Chinook, coho, and sockeye salmon captured in 2013 were comprised of smaller-sized fish (commonly referred to as jacks) compared to 2012. In 2013, 35 percent (336 of 952) of Chinook salmon measured less than 50 cm (19.7 in) in length (versus 25 percent in 2012), and 36 percent (100 of 276) of sockeye salmon measured less than 40 cm (15.7 in) in length (versus 8 percent in 2012). When it became apparent in late June that there were a large number of small Chinook salmon being captured and the tagging goal for large Chinook (and sockeye) salmon would not likely be met, the decision was made to allocate some radio tags ($n = 67$) to small Chinook salmon.

Significant differences in the length distributions of radio-tagged and captured fish were found for small Chinook, chum, and pink salmon, but not for large Chinook, coho, or sockeye salmon (Figure A-27). In the three cases where significant differences were found, the mean lengths for radio-tagged fish were greater than mean lengths for those captured (38.1 vs. 36.3 cm [15.0 vs. 14.3 in] for small Chinook; 59.7 vs. 59.0 cm [23.5 vs. 23.2 in] for chum; and 42.9 vs. 41.6 cm [16.9 vs. 16.4 in] for pink salmon). For chum, coho, and pink salmon, the cumulative length-frequency distributions of spaghetti-tagged fish were similar to all other fish captured (Figure A-27). For small Chinook salmon, results were consistent with tagging effort as it was not random across all sizes, but instead was limited to the larger segment of the small fish captured in the fishwheels.

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

5.2.1. Tag Returns

Forty-six of the radio tags deployed in the Lower River and Yentna River were recovered by project field staff (Table E-1). This included 25 large Chinook salmon, recovered in the Deshka (5), Indian (3), and Talachulitna (1) rivers, as well as Johnson (1), Lake (6), Moose (1), Peter's (3), Prairie (1), Willow (3), and 8 Mile (1) creeks. Twenty-one coho salmon tagged in the Lower River were recovered from a variety of locations, including the Deshka (2), Lower Susitna (2), Talachulitna (2), and Yentna (3) rivers; and Caswell (3), Chase (1), Clear (3), Johnson (1), Lake (1), Peter's (1), Sheep (1), and Sunshine (1) creeks.

Additionally, 54 of the radio tags initially deployed in the Middle Susitna River were recovered by anglers (8) and project field staff (46; Table E-2). Twenty-four large Chinook salmon were recovered from the Chulitna (1), Indian (17), and Middle Susitna (1) rivers, as well as Portage (2) and Troublesome (1) creeks. Recovery location information was not provided for two of the Chinook salmon tags recovered from this size cohort. Six small Chinook salmon were recovered from the Indian (4) and Middle Susitna (1) rivers, as well as one from Spink Creek, a tributary of the Chulitna River. Eleven pink salmon were recovered from the Indian (4) and Middle Susitna (6) rivers, along with one from Fifth of July Creek. One sockeye salmon was recovered from Slough 8A of the Middle River. Seven chum salmon were recovered from the Indian (4) and Middle Susitna (1) rivers, as well as Clear (1) and Montana (1) creeks. Lastly, five coho salmon were recovered from Indian River (1), as well as Clear (1), Lake (1), Sunshine (1), and Whiskers (1) creeks.

5.2.2. Stock Classifications and Spawning Locations – Lower River

5.2.2.1. Chinook Salmon

Of the 689 Chinook salmon tagged in the Lower River, 621 (90 percent) were classified by destination. Of these, 617 (99 percent) went to tributaries (mainly the Deshka, Talkeetna, Chulitna, or Yentna rivers), and 4 (1 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figure D-1 and D-2). The remaining 68 Chinook salmon, not able to be classified by a specific destination (see "Other Fates" classification in Table 5.2-1), exhibited movements that prevented conclusive assignment to the mainstem or tributaries.

5.2.2.2. Coho Salmon

Of the 596 coho salmon tagged in the Lower River, 500 (84 percent) were classified by destination. Of these, 478 (96 percent) went to tributaries (mainly the Yentna, Deshka, Talkeetna, or Chulitna rivers), and 22 (4 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figures D-1, D-3, and D-4). The remaining 96 coho salmon, not able to be classified by a specific destination (see "Other Fates" classification in Table 5.2-1), exhibited movements that prevented conclusive assignment to the mainstem or tributaries.

Coho salmon were tracked to twelve potential spawning sites within mainstem habitats of the Lower River (Figure D-3). Sites included six main channel, five slough/side channels, and one tributary delta. During the survey period, mainstem water clarity was ideal for visual confirmation of spawning activity; however, none of the twelve potential spawning sites were confirmed for spawning.

5.2.2.3. Pink Salmon

Of the 200 pink salmon tagged in the Lower River, 116 (58 percent) were classified by destination. Of these, 98 (84 percent) went to tributaries (mainly the Deshka or Yentna rivers, or Montana or Willow creeks) and 18 (16 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figures D-1, D-5, and D-6). The remaining salmon (42 percent) were not classified to a specific destination due to insufficient telemetry data for the specific timing and distribution of pink salmon in the Lower River. This issue will be resolved in year 2 studies by enhancing fixed-station and/or mobile-survey coverage for pink salmon in the Lower River (Table 5.2-1).

5.2.3. Stock Classifications and Spawning Locations – Yentna River

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). Of the 692 Chinook salmon released in the Yentna River, 596 (86 percent) were classified with a Yentna destination, and 6 (1 percent) were classified in other Susitna River tributaries (Talkeetna River, Montana Creek, and Chulitna River; Table 5.2-1). The remaining 90 salmon were not able to be classified by a specific destination.

5.2.4. Stock Classifications and Spawning Locations – Middle and Upper River

5.2.4.1. Chinook Salmon

Of the 536 large Chinook salmon radio-tagged in the Middle River, 449 (84 percent) were classified by spawning destination (Table 5.2-1). Of these, 422 (94 percent) went to tributaries (mainly Portage Creek or Indian River; Figure D-7) and 27 (6 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figures D-2 and D-8). Destinations of the remaining 87 large Chinook salmon could not be classified, due to movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

In addition to the large Chinook described above, 67 small Chinook salmon were radio-tagged and released in the Middle River. In all, 45 (67 percent) were classified by destination (Table 5.2-1). Of these, 42 (93 percent) went to tributaries (mainly Indian River or Portage Creek; Figure D-7) and 3 (7 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1). Destinations of the remaining 22 small Chinook salmon could not be classified (Table 5.2-1).

Chinook salmon were tracked to 13 potential mainstem spawning sites in the Middle River between Lane and Chinook creeks (Table D-2; Figure D-8). To confirm spawning activity, each of these sites was visually examined during mobile surveys (e.g., by helicopter or boat, or on foot during HSC surveys). An ARIS unit was used at sites where water conditions were too turbid for visual examination. The only potential evidence of spawning was observed with ARIS at Site 9 (Indian River Delta; Table D-1), where a holding Chinook salmon exhibited behavior indicative of nest guarding; redds or redd digging behavior could not be confirmed. Six turbid water sites (five mainstem and one side channel) were not surveyed due to inaccessibility by the boat for ARIS sampling, and one mainstem site was not surveyed because the physical characteristics (e.g., water velocity and turbulence) of the river were considered unsuitable for spawning. One site (Site 13) was above Devils Canyon Impediment 1 and inaccessible by boat, and the river was too turbid for visual confirmation of spawning activity during aerial surveys. Holding behavior was observed, but only at tributary delta habitats. Groups of radio-tagged Chinook salmon (i.e., more than one) were detected at four sites (Indian River Delta, Portage Creek, Side Channel 21, and Site 11), but only the Indian River Delta was confirmed as a spawning site. The only repeat confirmed spawning sites in 2012 and 2013 were at tributary deltas.

5.2.4.2. Chum Salmon

Of the 201 chum salmon tagged in the Middle River, 164 (82 percent) were classified by destination (Table 5.2-1). Of these, 147 (90 percent) went to tributaries (mainly Portage Creek, or Indian or Talkeetna rivers; Figure D-7) and 17 (10 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figures D-9 and D-10). The remaining 37 chum salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Chum salmon were tracked to nine potential mainstem spawning locations in the Middle River (Table D-3; Figure D-10). Each site was examined during mobile surveys (e.g., helicopter, boat, or HSC). An ARIS was used at sites where water conditions were too turbid for visual confirmation. Spawning by chum salmon was visually confirmed at five sites (four sloughs and one side channel). Two mainstem sites were not surveyed as the physical characteristics (e.g., water velocity and turbulence) of the river were considered unsuitable as spawning habitat, and one side channel site was not surveyed due to access difficulty with the boat for ARIS sampling. The only site where fish were observed holding, but spawning could not be confirmed, was at the delta of Jack Long Creek. Two sites (sloughs 8A and 9) had more than one tagged chum salmon detected. All 2013 confirmed spawning sites were also surveyed and confirmed in 2012.

5.2.4.3. Coho Salmon

Of the 242 coho salmon tagged in the Middle River, 173 (71 percent) were classified by destination (Table 5.2-1). Of these, 154 (89 percent) went to tributaries (mainly Talkeetna, Chulitna, or Indian rivers) and 19 (11 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figures D-3 and D-4). The remaining 69 coho salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Coho salmon were tracked to 17 potential spawning sites within mainstem habitats of the Middle River (Figure D-4). Sites included seven main channel, seven side channel/sough, and three tributary deltas. During the survey period, mainstem water clarity was ideal for visual confirmation of spawning activity; however, none of the 17 potential spawning sites were confirmed for spawning.

5.2.4.4. Pink Salmon

Of the 200 pink salmon tagged in the Middle River, 166 (83 percent) were classified by destination (Table 5.2-1). Of these, 151 (91 percent) went to tributaries (primarily Indian or Talkeetna rivers, and Portage, Fourth of July or Lane creeks; Figure D-7) and 15 (9 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figures D-5 and D-6). The remaining 34 pink salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Pink salmon were tracked to nine potential spawning sites in the Middle River (Table D-4; Figure D-6). Each site was examined during mobile surveys (e.g., helicopter, boat, or HSC). Sites where water conditions were too turbid for visual confirmation, an ARIS was used. Spawning by pink salmon was confirmed at two sites, both were tributary delta habitats. Holding behavior was observed at all sites, with the exception of Site 2. Fish observed in the sonar imagery could not be identified to species, at potential spawning sites, but only holding or migrating behavior were observed. Three sites had more than one tagged pink salmon detected, but only one site (Site 8) had spawning confirmed. All spawning sites confirmed in 2013 were also surveyed and spawning was confirmed in 2012.

5.2.4.5. Sockeye Salmon

Of the 137 sockeye salmon tagged in the Middle River, 92 (67 percent) were classified by destination (Table 5.2-1). Of these, 44 (48 percent) went to tributaries (mainly Chulitna, Talkeetna or Indian rivers, or Portage Creek; Figure D-7) and 48 (52 percent) went to destinations in the mainstem Susitna River (Table 5.2-1; Figure 5.2-1; Figures D-11 and D-12). The remaining 45 sockeye salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 5.2-1).

Sockeye salmon were tracked to 13 potential spawning sites in the Middle River (Table D-5; Figure D-12). Each site was examined during mobile surveys (e.g., helicopter, boat, or HSC). ARIS was used at sites where water conditions were too turbid for visual confirmation. Seven of the potential spawning sites had more than one tagged sockeye salmon detected, and three of the sites (Slough 8A, Slough 10, and Slough 11) included at least five fish. Spawning by sockeye salmon was confirmed at six sites (four sloughs, one side channel, and one tributary delta). Holding behavior was observed at all surveyed sites, except Site 1. Four sites with confirmed spawning in 2013 (sloughs 8A, 9A and 11, and side channel 21) were also surveyed and spawning was confirmed in 2012.

5.2.5. 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). These salmon appeared to have temporarily entered the Middle River in the course of migrating to final spawning destinations elsewhere. The purpose of this behavior was not clear, and was classified as roaming behavior. The proportions of salmon tagged at Curry that exhibited this roaming behavior were 25 percent of large Chinook, 24 percent of small Chinook, 61 percent of coho, 27 percent of chum, 29 percent of pink, and 29 percent of sockeye salmon. Similarly, salmon tagged in the Lower River also showed this same behavior: these fish migrated as far upstream as Lane Station (in the Middle River), then moved downstream into a Lower River tributary. These were also roaming fish in the Middle River, but were evaluated separately from fish tagged at Curry to discern any differences in roaming behavior between fish tagged in the Lower River versus those tagged at Curry. The proportion of fish tagged in the Lower River that exhibited this roaming behavior was 29 percent of Chinook salmon, 75 percent of coho, and 10 percent of pink salmon. The proportion of radio-tagged fish exhibiting this behavior in 2013 was greater than that observed in 2012, and this difference between years may be due to proportionately larger returns to the Chulitna and Talkeetna rivers in 2013.

Some roaming fish moved far up into the Middle River before dropping back to enter downstream tributaries (Table 5.2-3). One Chinook salmon (Fish 280) tagged at Curry on June 23 moved upstream to below Impediment 3 on July 13, and then dropped back to enter the Talkeetna River on August 7.

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

5.3.1. Species, Number, and Destination

Chinook salmon was the only species tracked above Impediment 1 (Table 5.3-1). Of the 445 radio-tagged large Chinook salmon released at the Curry fishwheels that were detected above Gateway Station after tagging, 17 (3.8 percent) were tracked above Impediment 1, 13 (2.9 percent) above Impediment 2, and 3 (0.7 percent) above Impediment 3. Three of the Chinook salmon radio-tagged and released in the Lower River mainstem were tracked above Impediment 2, neither of which passed Impediment 3 (Table 5.3-1). One small Chinook salmon passed Impediment 1 (2.2 percent of the 45 small Chinook salmon that passed Gateway into the study area).

The likely spawning areas for each of the 21 Chinook salmon that passed Impediment 1 are provided in Table 5.3-2. Of the 3 Chinook salmon that passed Impediment 3, 1 (33 percent) dropped back and likely spawned in a tributary downstream of Impediment 3 (Figures F-1 to F-3). Of the 13 Chinook salmon that passed Impediment 2 but not Impediment 3, 9 (69 percent) dropped back and likely spawned in tributaries downstream of Impediment 2. Of the five Chinook salmon that passed Impediment 1 but not Impediment 2, four (80 percent) dropped back and likely spawned in a tributary downstream of Impediment 1. Overall, 67 percent of the Chinook salmon that passed at least one of the three impediments likely spawned downstream of the last impediment they passed – 36 percent (5 of 14) of these drop-back fish likely spawned in Chinook Creek, and 29 percent (4 of 14) in Portage Creek.

The three Chinook salmon that passed Impediment 3 showed a wide range of movement-distances and times (Figures F-1 to F-3). One Chinook salmon lived for 46 days after passing Impediment 3. It travelled upstream in the mainstem Susitna River to PRM 309 before dropping back below the impediments. The fish then spent three days in Portage Creek, followed by movement farther downstream in the mainstem, downstream of Sunshine Creek (PRM 96; Table 5.3-1; Table F-1). The other two fish lived for less than 20 days after passing Impediment 3 (Table F-1): one headed straight for Devil Creek, and died in 14 days; and the other fish was detected once near Deadman Creek, about 6.5 km (4.0 mi) beyond its eventual destination in Tsusena Creek, then it held for six days below the confluence of Tsusena Creek, before entering Tsusena Creek where it died after 11 days (Table F-1).

5.3.2. Migration Timing for Fish Passing Above Devils Canyon

The first successful fish passage past Impediment 1 occurred on June 30 when flows at the Gold Creek and Tsusena Creek gages were 28,871 and 25,352 cubic feet per second (cfs), respectively (Figure 5.3-1). No other fish passed until the period from July 11–17, when Tsusena Creek gage flows declined to between 14,383 and 16,876 cfs. There was a period with no fish passage from July 18 to 22 (in which flows exceeded 17,000 cfs at the Tsusena Creek gage), and then the final passage event occurred on July 24 with Tsusena Creek flows at 16,884 cfs (Figure 5.3-1; Table D-6).

The three Chinook salmon that passed Impediment 3 had passed Impediment 1 at the same approximate period (July 11–13) as those that only passed Impediment 1 or Impediment 2 (Table D-6).

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 3.8 days (Table D-6). Fish moved more quickly past Impediment 2, with only one of the 16 radio-tagged Chinook salmon holding below it for more than one day (Table D-6). Two fish that passed Impediment 1 did not attempt to pass Impediment 2, rather they moved into and out of Cheechako Creek, and eventually moved to their final destinations near Portage Creek. The three fish that passed Impediment 3 held below it for an average of 6.5 days, whereas those that did not pass, held for an average of 8.3 days before moving downstream. All of the fish that did not pass Impediment 3 were present above Impediment 2 from July 12 to 29, when all Impediment 3 passage events occurred (Figure 5.3-2).

5.3.3. Relative Abundance of Salmon Passing Above Devils Canyon

Chinook salmon was the only species with radio-tagged fish detected upstream of Devils Canyon. Of the 445 Chinook salmon tagged at Curry and detected moving above Gateway

Station, three (0.7 percent) successfully migrated through all three impediments located in Devils Canyon (Table 5.3-1). Given the extensive mobile survey effort, it is unlikely that any radio-tagged fish passed upstream of Devils Canyon undetected.

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

Of the 70 radio-tagged Chinook salmon that entered Devils Canyon, the mean body length of fish that approached but did not pass Impediment 1 (70.1 cm [27.6 in]) was not significantly different from that of fish that passed Impediment 1 (69.7 cm [27.4 in]; Table 5.3-1; $t_{68} = 0.66$, $P = 0.51$). Similarly, the mean length of fish that approached, but did not pass, Impediment 2 (78 cm [30.7 in], n = 2) was not significantly different from that of fish that passed Impediment 2 (65.8 cm [25.9 in]; Table 5.3-1; $t_{16} = 1.54$, $P = 0.14$). The mean length of fish that approached, but did not pass Impediment 3 (66.1 cm [26.0 in]) was not significantly different from that of fish that passed Impediment 3 (64.3 cm [25.3 in]; n = 3; Table 5.3-1; $t_{14} = 0.25$, $P = 0.81$). These observations are suggestive that length was not a factor in successful passage through Devils Canyon for Chinook salmon.

5.3.5. Aerial Spawner Surveys

Chinook salmon were the only salmon species observed from Cheechako Creek upstream to the Oshetna River. No adult salmon were observed in the mainstem Susitna River. 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, Fog, and Tsusena creeks), and in one Upper River tributary (Kosina Creek; Figure D-13).

In streams were they had been determined to be present, adult Chinook salmon were not consistently observed. They were documented in three streams during Survey 1, five during Survey 2, three during Survey 3, four during Survey 4, and three during Survey 5 (Table D-7). Cheechako Creek had the most Chinook salmon overall and was the only stream where Chinook salmon were observed during all five surveys. Devil Creek had the second-highest number of adult Chinook salmon, with significant numbers of fish present during the first four surveys. In all other streams where adult Chinook salmon were observed, they were present in low numbers. Peak observations for four of the streams occurred during the period of July 25–27, and during the period of August 8–9 for two of the streams.

In Cheechako Creek, the number of Chinook salmon observed increased from five fish on July 21 to 40 fish on July 25. A steady decline in fish numbers was observed following the July 25 peak count, and by the final survey on August 15 only 1 fish was seen. Devil Creek followed a similar trend with seven fish present during the first survey, peak count occurring on July 25, and zero fish observed on the final survey. Cheechako and Devil creeks have similar geomorphology consisting of high-gradient, step pools within steep-walled canyons. Chinook salmon habitat in both streams terminates within three miles of the Susitna River confluence at large waterfalls. The turbulent water and confined canyon walls presented challenges to salmon observation in both streams. However, fish were observed throughout the anadromous reach of each stream and groups of five to seven fish were seen holding in pools. Note that 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 peak survey.

Chinook Creek, located between Cheechako and Devil creeks, had a much lower relative abundance of Chinook salmon, with a peak observation of just two fish on July 25. Fish were only observed during two of the five surveys. 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). However, fish were not seen beyond 0.25 miles upstream of the Chinook Creek confluence with the Susitna River.

Low numbers of adult Chinook salmon were observed in Fog Creek. The lower reach of Fog Creek is dominated by high-gradient riffle confined within a steep-walled canyon with no barrier to Chinook salmon migration below 3,000 ft in elevation where the surveys terminated (at approximately tributary river mile 20). 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 up to 3,000 ft in elevation. One adult Chinook salmon was observed in Fog Creek during Survey 2 on July 25; no fish were found on Survey 3; two fish were seen on Survey 4; and then a pair of fish was observed during the final survey on August 15. The farthest upstream observation was approximately three miles from the Fog Creek confluence with the Susitna River.

In Tsusena Creek, the next major tributary upriver from Fog Creek and the most upstream tributary within the Middle River, a peak count of four Chinook salmon was obtained on August 8. No fish were seen in Tsusena Creek prior to August 8, and then a pair of fish was observed on August 15. The fish were distributed throughout the anadromous reach, which terminates at a large waterfall at approximately tributary river mile 4.

Kosina Creek was the only tributary within the Upper River where adult Chinook salmon were observed. Kosina Creek was the second largest tributary surveyed, and the lower reach was dominated by moderate gradient, boulder riffle within multiple channels, and the upper reach contained extensive shallow braided island complexes. During Survey 1 on July 21, one fish was seen at approximately tributary river mile 1.5, and another fish was found near tributary river mile 9. During Survey 2 on July 27, three fish were sighted near tributary river miles 11, 15, and 16. Although conditions were favorable for aerial observation, no fish were seen on subsequent surveys.

Overall, weather conditions were favorable 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-8). Wind was the most influential weather factor, occasionally limiting the ability to position the aircraft optimally above the stream, especially within canyons. 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. Water clarity, however, was a major factor in the observation of fish, with turbidity from both glacial and erosion sources impairing surveys in four streams. Overhanging vegetation, where present, completely obscured areas of stream (Table D-9).

Overall, most streams had very clear water. The Black and Oshetna rivers were the only streams of glacial origin within the study area and were the most turbid. 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 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 erosion events upstream of the study area which reduced visibility. The most prevalent impairment to visibility 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.

5.3.6. Assess the Feasibility of Using Sonar to Enumerate Salmon and Resident Fish at the Proposed Dam Site

Results pertaining to the 2013 feasibility study are provided in Appendix G. The general conclusion of that study was that sonar could be used to enumerate fish in the area, but more work would be needed to determine the accuracy of such counts.

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

From July 24–31, 2013, 15 different sites were visited to assess Chinook salmon spawning activity (Table 4.4-1), of which eight were surveyed using ARIS. Fish were observed at seven sites, however, spawning activity (i.e., nest-guarding behavior) by Chinook salmon was only observed at one site (Indian River Delta). At many sites it was difficult to distinguish Chinook from chum salmon in the sonar images due to their overlap in length range. Several potential spawning sites could not be accessed with a boat, while others were not suitable salmon spawning habitat due to high water velocity, inappropriate substrate, or being located in the thalwag of the river.

On July 31 and August 12, two potential spawning sites for chum salmon were sampled using ARIS (Table 4.4-2). Chum salmon were observed at both sites, but spawning was only confirmed at one of the sites. Confirmation of spawning with ARIS included nest-guarding behavior and visible redds.

Seven HSC surveys were conducted from August 13 to September 2 (Table D-1). Locations surveyed included historic spawning sites (see Section 5.5), potential spawning sites as indicated from radio-telemetry analysis (see Section 5.2.3), and other sites that appeared suitable as spawning habitat. Fifty-eight redds were sampled in slough and side-channel habitats, including 34 for chum, 6 for pink, and 18 for sockeye salmon. All data are reported by the Fish and Aquatics Instream Flow Study (ISR Study 8.5).

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

5.5.1. Run Timing

In 2013, Chinook salmon were captured at the Middle River fishwheels from June 16 to August 10. The midpoint of catches occurred on June 29, which was earlier than in 1982, 1985, and

2012 (range: July 2–9), but later than the midpoints in 1981, 1983, and 1984 (range: June 24–25). Peak catches in 2012 and 2013 occurred at the start of July (Figure A-13).

For chum salmon, the midpoint of catches at Curry in 2013 (August 5) was similar to those observed from 1983 to 1985, and in 2012 (range: August 3–7), but earlier than those in 1981 and 1982 (range: August 12–17). Catches in 2012 and 2013 both peaked in early August (Figure A-13).

The first coho salmon captured at the Middle River fishwheels in 2013 (July 23) occurred five days earlier than in 2012 (July 28), but the midpoint of catches in both years occurred on August 15. In comparison, the midpoint of catches ranged from August 12–23 in the 1980s. The last fish was captured on September 21, 2013; however, ARIS sonar data collected at Curry indicated that coho salmon continued to migrate past Curry after September 21 (Figures A-17 and A-18).

Pink salmon moved past Curry from July 8 to September 4, 2013, with the midpoint of catches occurring on August 3. The midpoint of catches in 2013 was later than in 1983 (August 1), but earlier than in previous odd-numbered years (August 8 in 1981; August 5 in 1985).

The first sockeye salmon was caught at Curry on June 15, 2013, which was considerably earlier than in years past (range: June 26–July 17), and the last fish was caught on September 10. Catches in 2013 were relatively low and sporadic through July and August with no obvious peak. The midpoint of catches in 2013 occurred on August 3, which was four days later than in 2012 (July 30), but in between the midpoints observed during the 1980s (range: August 1–7).

5.5.2. Relative Abundance

For all five species of salmon, catches of larger-sized fish at the Middle River fishwheels were higher in 2013 than in 2012 (by 1.5–6.5 times). Changes in catch rates between these years were largest for coho (1,711 in 2013; 264 in 2012) and pink (15,695 in 2013; 4,705 in 2012) salmon, and smallest for Chinook salmon (616 in 2013; 422 in 2012). Approximately twice as many chum (3,417 in 2013; 1,734 in 2012) and sockeye (176 in 2013; 92 in 2012) salmon were captured in 2013 compared to 2012.

Catches of large Chinook and sockeye salmon in 2013 were 36 percent and 43 percent lower than the average catches observed at the Curry fishwheels from 1981 to 1985, respectively. In contrast, catches of chum, coho, and pink salmon in 2013 were roughly 2–8 times higher than the average catches observed for these species in the 1980s. Interestingly, the number of pink salmon captured in 2013 was substantially greater than catches observed during odd-numbered years in the 1980s (range: 234–1,172), and similar to the highest catches observed in even-numbered years (17,394 in 1984).

5.5.3. Spawning and Holding Salmon Locations

Potential spawning sites of Chinook, chum, coho, pink, and sockeye salmon in the mainstem river were identified using radio telemetry (Sections 5.2.2 to 5.2.4) and HSC ground surveys. Spawning sites were confirmed visually or with ARIS (sonar) for Chinook, chum, pink, and sockeye salmon in the Middle River. Mainstem spawning occurred for chum, pink, and sockeye salmon primarily in slough habitats, and to a lesser extent in tributary deltas and side channels.

Most confirmed spawning sites in 2013 were also confirmed in 2012, and from 1981–1985 (Thompson et al. 1986; Table 5.5-1).

In 2013, radio-tagged Chinook salmon were tracked to eight potential spawning sites in the Lower River (Figure D-2), and 13 sites in the Middle River (Figure D-8; see Sections 5.2.2 and 5.2.4). The only confirmed spawning site for Chinook salmon was Indian River delta (Middle River). Similarly, tributary deltas were the only mainstem habitats confirmed for Chinook salmon spawning during the 1980s surveys (Barrett et al. 1985; Thompson et al. 1986).

Chum salmon were tracked to no potential mainstem spawning sites in the Lower River (Figure D-9) and nine sites in the Middle River in 2013 (Figure D-10; see Section 5.2.4). All confirmed spawning sites in 2013 were previously confirmed sites from the 1980s or 2012 (Table 5.5-1; Barrett et al. 1985; Thompson et al. 1986), with the exception of one unknown slough (coordinates: N 62.58199, W 150.04903).

Coho salmon were tracked to 12 potential spawning sites in the Lower River (Figure D-3), and 17 sites in the Middle River (Figure D-4). Water clarity between October and ice-up was suitable for visual confirmation of coho salmon spawning activity in mainstem habitats by aerial telemetry crews; however, spawning was not confirmed at any of the potential spawning locations indicated by radio-telemetry analysis.

In 2013, tagged pink salmon were tracked to twelve potential spawning sites in the Lower River (Figure D-5), and nine sites in the Middle River (Figure D-6; see Sections 5.2.2 and 5.2.4). All confirmed spawning sites in 2013 were previously confirmed as spawning sites during the 1980s or in 2012 (Table 5.5-1; Barrett et al. 1985; Thompson et al. 1986).

Sockeye salmon were tracked to three potential spawning sites in the Lower River (Figure D-11), and 13 sites in the Middle River (Figure D-12; see Section 5.2.4). All confirmed sloughs, side channel 21, and Skull Creek were previously confirmed as spawning sites during the 1980s or in 2012 (Table 5.5-1; Barrett et al. 1985; Thompson et al. 1986).

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

5.6.1. Observer Efficiency During Aerial Spawner Surveys

On July 25, 363 live Chinook salmon were counted above the Indian River weir during an aerial spawner survey conducted by AEA (2-person crew; Tables 4.3-1, D-8, and H-1; Figure D-13). During a concurrent survey conducted by ADF&G (1-person crew), 281 live Chinook salmon were counted above the weir (Table H-1; Sam Ivey, ADF&G, Sport Fish Division, personal communication). The net passage of Chinook salmon above the weir on July 25 was 1,094 fish (all sizes combined; Tables B-4 and H-1; Figure B-2). The same day, 71.7 percent (43 of 60) of all radio-tagged Chinook salmon last detected upstream of the weir were emitting a 'live' signal. Based on this proportion, an estimated 784 (71.7 percent of 1,094) live Chinook salmon were located above the weir at the time of the aerial spawner surveys. Therefore, assuming only live fish were available to count during aerial spawner surveys, the estimated observer efficiency during the AEA survey was 46.3 percent, which was considerably higher than during the ADF&G survey (35.8 percent; Table H-1).

5.6.2. Chinook Salmon Mark Rates: Indian River vs. Portage Creek

On July 25, 868 live Chinook salmon were counted during an aerial spawner survey of Portage Creek conducted by ADF&G (S. Ivey, personal communication). If it is assumed that the observer efficiency on the Portage Creek survey was the same as that on ADF&G's Indian River survey (35.8 percent; Table H-1), then the adjusted number of live Chinook salmon in Portage Creek on July 25 was 2,425. The same day, 174 (84.5 percent) of the radio-tagged Chinook salmon released at the Middle River fishwheels were last detected alive in Portage Creek. Therefore, the estimated mark rate for live fish in Portage Creek was 7.2 percent (174 of 2,425), which was statistically similar to the overall mark rate in Indian River (6.3 percent; $\chi 2 = 0.9$, df = 1, $P = 0.36$). These results support the hypothesis that Chinook salmon had an equal probability of being tagged at the Middle River fishwheels, regardless of their spawning location.

5.6.3. Estimated Abundance Above Curry (Chinook, Chum, and Pink Salmon)

Two-sample mark-recapture methods were used to estimate the inriver abundance of large Chinook, pink, and chum salmon above the Middle River Gateway fixed station (PRM 130.1) in 2013.

5.6.3.1. Chinook Salmon

A total of 536 large Chinook salmon were radio-tagged at the Middle River fishwheels, of which 445 (83.0 percent) entered the study area (i.e., were detected at or above the Middle River Gateway fixed station; Tables H-2 and H-3). At the Indian River weir, 1,137 large Chinook salmon were inspected for tags from June 26 to August 20, of which 72 (6.3 percent) were radio-tagged (Table H-2). The first two tagged large Chinook salmon passed the weir on June 28 (released on June 18 and 19 at Curry), and the last radio-tagged fish passed the weir on August 5 (released July 16 at Curry). Mark rates at the weir varied significantly across statistical weeks ($\chi^2 = 12.1$, df = 5, $P = 0.03$); however, weekly recapture rates were similar ($\chi^2 = 6.3$, df = 4, $P = 0.18$). These results indicated that no stratification by time was required to estimate abundance. Using a modified Petersen estimator, an estimated 6,952 large Chinook salmon (SE = 782; 95% confidence interval [CI] = 5,536–8,724) passed the Middle River Gateway fixed station from June 18 to July 28 (Table H-3).

5.6.3.2. Chum Salmon

Of the 201 chum salmon radio-tagged at the Middle River fishwheels, 149 (74.1 percent) entered the study area (Tables H-3 and H-4). Weekly proportions (range: 0.4–1.0) of radio-tagged chum salmon that entered the study area were used to estimate the number of spaghetti-tagged fish that entered the study area (1,365, or 69.6 percent of the 1,962 spaghetti tags applied; Table I-3). Since spaghetti-tagged chum (and pink) salmon were not uniquely identifiable at the Indian River weir, only radio-tagged fish could be used to evaluate whether mark and recapture rates varied over time. Similar to Chinook salmon, mark rates for radio-tagged chum salmon varied across statistical weeks ($\chi^2 = 11.6$, df = 3, $P = 0.01$), and weekly recapture rates were similar ($\chi^2 = 7.4$, df = 3, $P = 0.06$; Table H-4). By pooling all tagged fish, an estimated 36,010 chum salmon (SE = 1,511; 95% CI = 33,108–39,166) passed the Middle River Gateway fixed station from July 13 to August 24 (Table H-3).

5.6.3.3. Pink Salmon

In total, 151 (75.5 percent) of the pink salmon radio-tagged at the Middle River fishwheels entered the study area (Tables H-3 and H-5). Of the 9,108 spaghetti-tagged pink salmon released at the Middle River fishwheels, 6,736 were estimated to have entered the study area (Table H-3). Similar to Chinook and chum salmon, mark rates for radio-tagged pink salmon varied by statistical week (χ^2 = 9.9, df = 3, P = 0.02), and weekly recapture rates were similar (χ^2 = 3.6, df = 3, P = 0.30; Table H-5). Using both radio- and spaghetti-tagged fish in the marked sample, an estimated 127,353 pink salmon (SE = 2,761; 95% CI = 121,909–133,041) passed the Middle River Gateway fixed station from July 8 to August 16 (Table H-3).

5.6.4. Estimated Abundance Above Devils Canyon (Chinook Salmon)

Too few tagged and untagged Chinook salmon were observed above Devils Canyon to develop statistically precise estimates. Two different approaches were used to estimate the abundance of Chinook salmon above Devils Canyon (i.e., above Impediment 3). The first approach involved expanding the peak aerial count by the estimated observer efficiency during the spawner surveys. In 2013, the peak count of live Chinook salmon (all sizes combined) above Devils Canyon was 29 fish (25 in Devil Creek, 1 in Fog Creek, and 3 in Kosina Creek), which was obtained during the aerial spawner survey conducted from July 25–27 (Table D-7). If this number (29) is expanded based on an observer efficiency of 46.3 percent, which was obtained during the AEA aerial spawner survey in Indian River (Table H-1), then 63 live Chinook salmon were estimated to have been above Devils Canyon at the time of the survey. This would be considered a minimum number as the visibility of Chinook salmon during aerial surveys is better in Indian River than some of the tributaries above Devils Canyon.

The second approach involved expanding the number of radio-tagged Chinook salmon detected above Devils Canyon by the marked fraction of Chinook salmon in the Middle River. Of the 445 radio-tagged large Chinook salmon that entered the study area in 2013, three (0.7 percent) were detected above Devils Canyon (Table 5.2-1). If AEA expands these three radio-tagged fish by the estimated marked fraction of large Chinook salmon (6.3 percent, or each tagged fish represented at total of approximately 15.9 fish), then it can be inferred that 48 large Chinook salmon migrated above Devils Canyon in 2013. As a sensitivity analysis of an extreme but unlikely event, if four or five radio-tagged large Chinook salmon had actually migrated above Impediment 3 in 2013, then the expanded counts would have been 63 or 79 fish, respectively.

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

Genetic samples were collected from 609 Chinook (small and large fish combined), 201 chum, 220 coho, 199 pink, and 138 sockeye salmon captured at the Middle River fishwheels (Table A-4). Genetic samples were also collected from Arctic grayling (40), burbot (1), Dolly Varden (11), longnose sucker (5), rainbow trout (33), round whitefish (56), and humpback whitefish (10; Table A-4). In the Lower River, genetic samples were collected from 699 Chinook, 596 coho, and 200 pink salmon. Genetic samples were also collected from 691 Chinook salmon in the Yentna River and 200 coho salmon in Montana Creek.

All genetic tissue samples were delivered to Alaska Department of Fish and Game's (ADF&G's) Gene Conservation Lab for analysis. Results are reported in the ISR for the Genetic Baseline Study for Selected Fish Species (ISR Study 9.14).

5.8. Objective 8: Estimate the system-wide Chinook and coho salmon escapement to the Susitna River above Yentna River and the distribution of those fish among tributaries of the Susitna River

Results pertaining to Objective 8 are provided in Appendix I. This portion of Study 9.7 was carried out by ADF&G.

6. DISCUSSION

6.1. Fish Capture and Tagging

6.1.1. Catch Rates

Ice-out in the Susitna River in 2013 was among the latest ever, approximately two weeks later than normal. In the Lower River, fish capture started on May 25 in 2012, but not until June 4 in 2013. By June 4 in 2012, 469 Chinook salmon had been captured. The total catch of 2,063 Chinook salmon in 2013 was very similar to the total catch of 1,916 fish in 2012 in the Lower River.

This was the first year of sampling Chinook salmon on the Yentna River at tributary river mile 6. While the 2,295 Chinook salmon captured in all gear types combined exceeded the radio-tagging goal of 700 fish, the north bank fishwheel had chronically low catches. To achieve the radio-tagging goal, tags scheduled for the north bank fishwheel were instead deployed on gillnet-caught fish.

In the Middle River, catches of all five species of salmon were higher in 2013 than they were in 2012 (1.7, 2.0, 2.1, 3.3, and 6.5 times higher, respectively, for Chinook, chum, sockeye, pink, and coho salmon). Even when catches at the Site 3 fishwheel (added in 2013) were excluded, catch rates in 2013 were still higher than those in 2012, with the exception of pink salmon. Similar to 2012, high catches at the Middle River fishwheels in 2013 were due largely to the physical characteristics of the sites, design and operation of the fishwheels, and use of leads. Sites 1 and 2 were protected from floating debris at low to moderate river discharges, yet for most of the season these sites had sufficiently high water velocities offshore to force fish against the bank and into the path of the fishwheels (2–3 m/s [6.6–9.8 ft/s] offshore of the outer fishwheel pontoon). These were undoubtedly the same characteristics that made these sites attractive to ADF&G biologists during the 1980s studies. However in 2013, river velocities and depths for a given discharge at sites 1 and 2 had changed significantly since the 2012 season, due to an apparent shift in channel morphology. These changes made it difficult to operate the Site 1 fishwheel when river discharge decreased below around 17,500 cfs. As a result, the new site (Site 3) was located upstream of Curry, where a third fishwheel could be operated effectively at lower discharges. Although Site 3 was more exposed to floating debris, it proved very effective at capturing fish across a range of late-summer discharges.

Again, similar to 2012, lead nets hung between the shore-side pontoons of the Middle River fishwheels and the adjacent riverbank also contributed to higher catch rates in 2013, particularly at Site 1 where the fishwheel was held up to 50 ft offshore with spar poles. ARIS imagery from Site 1 showed that the vast majority of fish migrated upstream within 13 m (43 ft) of shore, so without the lead net these fish would not have been directed offshore and into the path of the fishwheel.

In the Middle River, radio-tagging goals were easily met for chum, coho, and pink salmon, but were not met for Chinook (96 percent of target) or sockeye (70 percent of target) salmon. Due to the unexpectedly high catches of chum, coho, and pink salmon, a disproportionately large number of radio tags were deployed on the early components of these runs relative to the later components.

6.1.2. Use of ARIS to Assess Fishwheel Effectiveness and Fish Approach Behavior

The use of ARIS at Site 1 in the Middle River, to assess fishwheel effectiveness and fish approach behavior, was most valuable in June and September. In June, ARIS data confirmed that the leading edge of the Chinook salmon run was being covered by fishwheel effort. The ARIS data also assisted with placement of the lead net at the Site 1 fishwheel. In September, the ARIS data was useful for quantifying the relative abundance of passing coho salmon, particularly when water levels and turbidity decreased and the fishwheel could not be operated effectively or at all at Site 1. Under these river conditions, ARIS counts in September could be useful for informing coho salmon tag rates for an alternative capture method at Curry (e.g., beach seine). Information on diel pattern obtained from ARIS data was useful for informing the crew as to the best times to operate the fishwheels in order to achieve optimal catch rates.

ARIS data at Site 1 was less useful in July and August when a large number of fish, as well as multiple species of salmon, began migrating through the Middle River. When large numbers of fish were passing, it took a substantial amount of effort to review the ARIS imagery, and the data was only marginally useful to guide fishwheel and tagging operations. Outside of large Chinook salmon, fish observed in the ARIS imagery could not be identified by species.

6.1.3. Size Selectivity

Achieving the goals of this study was dependent on tagging a representative group of fish from the entire population. The size composition of tagged fish compared to the entire population was examined in this regard. Tagging particular stocks and/or sizes of fish at different rates than others might weaken inferences about habitat uses of the Lower, Middle, and Upper rivers, such as the relative distribution of spawning fish, migratory behavior, and any fish passage above Devils Canyon. 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 to 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 (1983) 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. Species selectivity may also be a function of fish size, as there is 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 (ADF&G 1983; 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). Based on the experience of the study team, the Curry sites were characterized as generally high gradient, and similar to locations where the least size selectivity in fishwheels was encountered.

Radio-tagging of Chinook and coho salmon at the Lower River site and Chinook salmon in the Yentna River was conducted within the framework of a mark-recapture experiment. This approach provided for the use of robust diagnostic tools to evaluate assumptions of equal probability of capture (Seber 1982) during both radio-tagging and second event sampling at weir sites. When heterogeneity in probability of capture is detected, the results of diagnostics tests provide specific for selecting the proper models to minimize or eliminate biases due to unequal probability of capture when estimating abundance. These same tools are used to minimize or eliminate bias in estimates of numbers of spawners in different tributaries when heterogeneity in probability of capture is detected during marking.

Size selective sampling was detected for Chinook salmon radio-tagged at the Lower River site when tagging was conducted using a combination of fishwheels and drift gillnets for sampling. The gillnet sampling was conducted to increase the probability of capture for larger Chinook salmon, as it was expected that fishwheels would provide biased samples favoring smaller fish at that site. Additionally, Chinook salmon <58cm were radio-tagged at approximately 1/3 the rate of larger fish based on the analysis of data from Chinook salmon tagged in 2012 that passed the Deshka River weir site. These measures were not sufficient to eliminate heterogeneity in probability of capture by size for the combined sample of radio-tagged fish. However, analysis of data from these radio-tagged fish in the framework of a mark-recapture experiment provided minimally biased estimates in the distribution of spawning Chinook salmon among tributaries of the Susitna River above the Lower River site.

Size selective sampling was detected for coho salmon radio-tagged at the Lower River site where tagging was conducted using 2 fishwheels situated on opposing banks of the river. While the fishwheels were effective in capturing all sizes of coho salmon present, diagnostic test results indicated the fishwheels were biased in favor of smaller coho salmon. Similar to the Chinook salmon experiment, analysis of data from these radio-tagged fish in the framework of a mark-recapture experiment provided minimally biased estimates in the distribution of spawning coho salmon among tributaries of the Susitna River above the Lower River site.

In 2013, radio-tagged small Chinook, chum, and pink salmon tended to be slightly larger than those fish captured at all Middle River fishwheel sites. For smaller-sized Chinook and pink salmon in particular, this was likely due to the fact that the radio tags would simply not fit into their stomachs. This was reflected in the fact that spaghetti-tagged chum, coho, and pink salmon, for which the tag is just as easily inserted in small and large fish, were similar in length to those fish captured. To avoid this potential source of bias, some more appropriately sized radio tags should be purchased to accommodate the full range of fish lengths likely to be encountered for each species.

No evidence of size selectivity at the Middle River fishwheels was detected for radio-tagged large Chinook salmon or spaghetti-tagged pink salmon when samples collected at the Indian River weir were used for comparison. There was evidence to suggest some size-selective spaghetti-tagging occurred for chum salmon; however, due to large sample sizes it was possible that the KS tests were detecting small differences between length-frequency distributions which have little potential to result in bias (e.g., during escapement estimation).

6.2. Use of Tributary Weirs (and Sonar) to Assess Numbers and Size of Marked and Unmarked Fish

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 salmon mark-recapture experiment. While size biased sampling was detected when using only these two sites for second event sampling, substantial numbers of all size classes of Chinook salmon in the mainstem Susitna River are detected at these sites. As such, capture heterogeneity can be detected and the appropriate remedial measure applied to minimize bias when estimating abundance and distribution of spawning Chinook salmon. Radio-tagged Chinook salmon that were recaptured at these sites were tagged across the entire time-frame of the marking event, ensuring a non-zero probability of capture for Chinook salmon tagged both early and late in the run of Chinook salmon passed 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.

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 coho salmon mark-recapture experiment. No size biased sampling was detected when using only these two sites for second event sampling, indicating that the size distribution of coho salmon spawning above these to weir sites is similar to, at least in combination, to the size distribution of all coho salmon spawning above the Lower River tagging site. Radio-tagged coho salmon that were recaptured at these sites were tagged across the entire time-frame of the marking event, ensuring a non-zero probability of capture for coho salmon tagged both early and late in the run of Chinook salmon passed 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.

6.2.1. Indian River Weir

Mark rates for fish inspected at the Indian River weir that were tagged in the Middle River were highest for large Chinook salmon (6.3 percent), followed by small Chinook (4.4 percent), coho (3.3 percent), sockeye (2.5 percent), chum (0.4 percent), and pink (0.1 percent) salmon. Mark rates for Chinook, chum, and pink salmon were considered reliable for accuracy and precision with respect to estimating abundance. A few minor issues had the potential to introduce uncertainty into these mark-rate estimates (e.g., detection efficiency at the fixed-station receiver at the weir was less than 100 percent); however, given the short amount of time when video imagery was not being collected in 2013, and the fact that aerial telemetry surveys were conducted regularly, these issues had an inconsequential effect on the mark-rate estimates for any species.

The results of size-selectivity tests using fish sampled at the Indian River weir should be viewed with caution, as some uncertainty exists. Length measurements collected from video imagery at the Indian River weir were less precise than those collected from fish that were physically handled, for a variety of reasons. Also, since fork lengths were collected at the weir, they had to be converted to mid-eye to fork lengths in order to make them comparable to the length measurements collected at the Middle River fishwheels. Regression equations, established during the 2012 study, were used to do this. The degree of bias introduced by this methodology was not quantified, but it was likely inconsequential to the results. Also, our overall conclusions about the degree or presence of size selectivity are relatively robust to imprecision.

6.3. Migration Behavior and Spawning Locations of Salmon in the Lower, Middle, and Upper Susitna River

6.3.1. Lower River

The tracking results for salmon tagged in the Lower River indicated that at least 49 percent of the pink salmon and 90 percent of the Chinook salmon likely spawned in tributaries (Figure 5.2-1). Due to the high proportion of Chinook salmon that returned to tributaries, only four potential mainstem spawning locations were identified in the Lower River, all near the Deshka River and Willow Creek mouths (Figure D-2). Two additional possible mainstem sites were identified based on the behaviors of Chinook salmon tagged in the Middle River (Figure D-2). In contrast, many potential mainstem spawning sites were identified for pink salmon, located throughout the Lower River from the confluence of the Yentna River up to the Caswell Creek area, and between Sunshine and Whiskers creeks (Figure D-5). However, it should be noted that these results were likely biased towards an over-abundance of potential mainstem spawning sites. The bias exists because insufficient effort was made to track pink salmon during aerial telemetry surveys of the tributaries in the Lower River. Due to inadequate tributary coverage for this species, pink salmon classifications were biased away from tributary designations, thus creating the appearance of a higher proportion of mainstem spawning. This bias must be kept in mind when drawing conclusions about pink salmon spawning in the Lower River mainstem.

6.3.2. Middle and Upper River

The tracking results for Chinook (small and large fish combined), chum, and pink salmon radio-tagged in the Middle River indicated that 73–77 percent of these fish likely spawned in tributaries (Figure 5.2-1). Nevertheless, the number of radio tags applied to these fish (200–603 per species) was adequate to identify several potential mainstem spawning locations in the Middle River (9–13 locations, depending on the species). For sockeye salmon, 13 potential spawning locations were located in the Middle River; sockeye salmon did not show the same preference for tributary spawning as was observed for the other salmon species (Figure 5.2-1). Of particular interest was Slough 8A, near which 15 spawning sockeye salmon were classified (Figure D-12), including 13 fish in the slough itself (Table 5.2-1). This number represents 11 percent of the total number of sockeye salmon tagged, 16 percent of the number that were successfully classified, and 31 percent of the total number that were classified with mainstem destinations. No radio-tagged fish were tracked to potential mainstem, slough, or side-channel locations in the Upper River.

The frequent aerial telemetry surveys conducted on the Middle River, 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 us to identify those fish that were likely holding and/or spawning in mainstem habitats. There was a high degree of consistency between the potential spawning sites identified for radio-tagged chum and sockeye salmon in 2013, 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.

6.4. Salmon Migration Behavior and Timing Within and Above Devils Canyon

In 2013, only three radio-tagged fish (all Chinook salmon) passed Devils Canyon, which was down from the 12 tagged fish in 2012, even though more fish were tagged in 2013 than in 2012 (536 large Chinook salmon radio-tagged in 2013 versus 352 in 2012). Two of the three Chinook salmon in 2013 (Fish 272 and 395) headed almost directly to the their destination tributary (Fish 395 made a 6.5 km [4 mi] overshoot for approximately 1 day). In contrast, the third Chinook salmon in 2013 (Fish 241) showed considerable pre-spawning movements. This third fish moved more than 200 km (124 mi) beyond Devils Canyon to an area near the Susitna headwaters (PRM 309), before moving back downstream and spending three days in Portage Creek among other spawning fish. None of the 12 tagged fish above Devils Canyon in 2012 exhibited this degree of pre-spawn wandering (AEA 2013). This behavior suggests some interesting exploratory behavior, but with a sample of three tagged fish, it is difficult to characterize the relative significance of this wandering behavior to all fish above Devils Canyon.

In 2013, there was evidence suggestive of Chinook salmon spawning upstream of Devils Canyon. This was consistent with the results from surveys conducted in previous years. For example, a few Chinook salmon (20–45 fish) were observed in tributaries above Devils Canyon in 1982–1983 (AEA 2011). In 1984, Chinook salmon spawning was observed in Chinook (n = 15) and Fog (n = 2) creeks. In 2003, juvenile Chinook salmon were sampled in Fog Creek, Kosina Creek, and as far upstream as the mouth of the Oshetna River; adult Chinook salmon were also documented in the Upper River (Buckwalter 2011). In 2012, radio-tagged Chinook salmon were detected and appeared to spawn in Kosina and Devil creeks (AEA 2013). Thus, the 2013 results add to the body of knowledge about the distribution and abundance of salmon spawning above Devils Canyon (see AEA 2011).

In 2012, there were results to suggest that fish length and river flow rates influenced passage success through Devils Canyon (AEA 2013). In 2013, there was no effect of fish length on passage success, but results similarly suggest that passage was minimal when Susitna River flows were greater than 17,000 cfs (as measured near Tsusena Creek). Similar to 2012, our results were fairly 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 difficult to quantify. Of particular concern is the potential confounding effects of "time of year." Since, in both years, fish moved above the final impediment during lower-flow periods that occurred at around the same timeframe (July 17–20 in 2012 and July 13–30 in 2013), it is difficult to quantify the relative importance of flows versus time of year. In both years, there were Chinook salmon that approached Impediment 3 during periods of higher flows, in the latter half of July, and did not pass Impediment 3. In 2012, flows increased substantially after July 20 and remained above the 19,000 cfs level at Gold Creek through August 7 (AEA 2013). This flow at Gold Creek was roughly equivalent to 15,800 cfs at Tsusena Creek in 2012. In 2013, flows measured at Tsusena Creek increased after the second fish passed Impediment 3 on July 16 and remained above 16,500 cfs until late July. While four Chinook salmon that approached Impediment 3 after July 16 in 2013, only one of these fish passed Impediment 3. This was the only fish that held below Impediment 3 until July 28–29, when flows dropped below 16,500 cfs (Figure 5.3-1). This last Chinook salmon that passed Impediment 3 was detected upstream of Impediment 3 on July 30, and likely passed Impediment 3 at flows below 16,000 cfs on July 29, prior to the increase in flow to over 18,500 cfs on July 30. The rapid changes in flow over a 24-hour period observed in late July in 2012 and 2013 emphasize the benefits of having fixed-station receivers near each impediment to determine the precise timing of fish passage and assess the relationship between passage and flow levels.

6.5. Use of ARIS to Document Spawning Locations in Turbid Water

ARIS was used successfully to confirm spawning behavior was confirmed for two species (Chinook and chum salmon) at two separate locations (Indian River, and Fourth of July side channel).; however, the limitations of ARIS should be considered before further surveys are conducted in the next year of study. These limitations were identified at a site where spawning by chum salmon was confirmed visually during times of decreased turbidity. Of particular concern is the use of ARIS to characterize spawning activity in shallow water and close to the shoreline.

The equipment required to operate the ARIS is heavy and required a boat with a suitable gunnel-mount. To obtain the needed resolution and stability, the boat and sonar had to be positioned next to the shoreline; however, most spawning activity, with the exception of Chinook salmon, occurred in close proximity to the shoreline (10–15 ft). Chinook salmon (e.g., those confirmed spawning at Indian River delta) typically spawned farther offshore compared to observations for other salmon species. Shoreline-spawning made data collection with ARIS difficult, because the noise associated with the activity and the close proximity of the boat often spooked the target fish. Up to 20 minutes was required for the target fish to return to the original locations and continue pre-disturbance activities. In some cases, the target fish did not return until after the boat was moved.

Another issue with the ARIS was related to detecting redds' construction. In many instances, due to the slope of the substrate and the orientation of redd depressions, redds could not be visualized in the sonar images. However, fish could be seen on the sonar holding and displaying nest-guarding behavior. Redd digging was not captured on the sonar despite several hours of footage covering fish that could be visually observed constructing redds. When fish swam into a redd depression (e.g., to dig), they could not be detected by the sonar. In addition, when a fish was not perpendicular to the sonar beam, its signal became weak and made behavioral observations of fish traveling toward or away from the sonar difficult.

Many of the potential spawning locations indicated by radio telemetry could not be accessed safely by boat, and thus could not be sampled with ARIS. As indicated above, the weight of the ARIS equipment precluded a smaller, more mobile platform. However, sites that were inaccessible by boat were also typically too shallow to sample with ARIS.

It is worth noting that many locations considered inaccessible by boat were later confirmed as spawning sites for chum and sockeye salmon during aerial and HSC surveys (Study 8.5). Most turbid water sites identified as potential spawning locations for chum and sockeye salmon using telemetry were in areas that were eventually isolated from the turbid mainstem water and became clear; or the turbid water became clear due to decreased glacial input later in the season. As such, sonar confirmation of potential spawning by chum and sockeye salmon should be a lower priority than Chinook salmon, because Chinook salmon have a spawning window entirely within a period when the Middle River discharge and turbidity are generally high.

At sites where multiple fish species with a large degree of overlap in body length could be present, ARIS was not able to positively identify species. This issue was most obvious during the spawning period for chum, pink, sockeye, and coho salmon, and was further complicated due to the relatively high abundance of chum and pink salmon in 2013. This is much less of an issue with Chinook salmon, which spawn, in part, during a period when few other species are present, and they are typically much larger than most other salmon species.

6.6. Estimated Abundance of Chinook Salmon Above Devils Canyon

Given the large number of Chinook salmon that the mark rate was based on, the approach of estimating abundance by expanding the number of radio tags detected above Devils Canyon was a more robust approach than expanding the peak count from aerial spawner surveys. In any event, the two independent estimates were remarkably similar, and regardless of the approach used, it could be concluded that roughly 50–65 Chinook salmon migrated above Devils Canyon in 2013. No fewer than 29 fish migrated above Devils Canyon (i.e., the minimum aerial count). To conclude that 100 fish moved above Devil Canyon in 2013 would require that the mark rate on fish above Devils Canyon was half (i.e., 1 in 33 fish) that observed in 1,137 fish examined at the Indian River weir (1 in 16) – although a possibility, this was statistically unlikely.

6.7. Study Interdependencies

Four Project studies provided predecessor information useful to the Salmon Escapement Study. The Upper River Fish Distribution and Abundance Study (ISR Study 9.5), and Middle and Lower River Fish Distribution and Abundance Study (ISR Study 9.6) provided salmon distribution and abundance information from aerial telemetry surveys that was useful for determining spawning locations (Objective 1) and estimating Chinook salmon escapement and relative distribution among tributaries (Objective 8). The Characterization and Mapping of Aquatic Habitats Study (ISR Study 9.9) provided habitat characterization information useful for describing spawning locations visited as part of turbid water and visual confirmation of spawning surveys (Objective 2). The Fish Genetic Baseline Study (ISR Study 9.14) provided information on Chinook salmon spawning locations (Objective 1) from sample collections conducted in 2012. The Salmon Escapement Study, along with the Upper River Fish Distribution Study (ISR Study 9.5), and Middle and Lower River Fish Distribution Study (ISR Study 9.6), provided genetic tissue samples for the Genetic Baseline Study (ISR Study 9.14).

The Salmon Escapement Study also interrelates with other Project studies and provided useful output information in 2013. Weekly updates were provided via email to the various study leads that contained inseason information on the Salmon Escapement Study (e.g., Curry fishwheel catches, Indian River weir counts, and distribution of radio-tagged fish). These data provided guidance to potential spawning locations where the Genetics Baseline Study (ISR Study 9.14) might collect samples and the Instream Flow Study (Study 8.5) might collect Habitat Suitability Criteria data for redds. The Salmon Escapement Study provided extensive opportunity to collect fixed and mobile telemetry data for resident fish radio-tagged as part of the Upper River Fish Distribution and Abundance Study (ISR Study 9.5), and Middle and Lower River Fish Distribution and Abundance Study (ISR Study 9.6), and also provided catch from the fishwheels for tagging. Characterizations of migration behavior and spawning locations (Objective 2), and fish movement in and upstream of Devils Canyon (Objective 3) were provided to the Fish Passage Feasibility Study (ISR Study 9.11) and were used to inform target species, timing and location of potential passage alternatives.

7. COMPLETING THE STUDY

[Section 7 appears in the Part C section of this ISR.]

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9. TABLES

Table 4.3-1. Aerial spawner surveys conducted in the Middle and Upper River by location and date, 2013.

River Section	Waterbody	Confluence Project River Mile	Miles Surveyed	Survey Dates				
Middle River -	Indian River	Susitna 142.1	14.8	21-Jul	25-Jul	01-Aug	08-Aug	15-Aug
Below Impediment 3	Cheechako Creek	Susitna 155.9	2.4	21-Jul	25-Jul	01-Aug	08-Aug	15-Aug
	Chinook Creek	Susitna 160.4	8.7	19-Jul	25-Jul	01-Aug	08-Aug	15-Aug
Middle River -	Devil Creek	Susitna 164.8	2.5	19-Jul	25-Jul	01-Aug	08-Aug	15-Aug
Above Impediment 3	Fog Creek	Susitna 179.3	19.3	19-Jul	25-Jul	01-Aug	08-Aug	15-Aug
	Fog Creek Tributary L1	Fog Mile 5.1	7.6	20-Jul	26-Jul	01-Aug	08-Aug	15-Aug
	Unnamed PRM 184.0	Susitna 184.0	5.7	20-Jul	27-Jul	01-Aug	08-Aug	15-Aug
	Unnamed PRM 184.0 Tributary R1	Unnamed 0.8	8.2	20-Jul	27-Jul	01-Aug	08-Aug	15-Aug
	Tsusena Creek	Susitna 184.4	3.6	20-Jul	25-Jul	01-Aug	08-Aug	15-Aug
Upper River -	Deadman Creek	Susitna 188.4	0.3	20-Jul	27-Jul	01-Aug	09-Aug	15-Aug
Within Reservoir	Watana Creek	Susitna 196.9	21.3	20-Jul	27-Jul	02-Aug	09-Aug	15-Aug
	Watana Creek Tributary R5	Watana 8.6	8.6	20-Jul	27-Jul	02-Aug	09-Aug	No Survey
	Kosina Creek	Susitna 209.2	18.8	20-Jul	26-Jul	02-Aug	09-Aug	16-Aug
	Gilbert Creek	Kosina 6.2	6	20-Jul	27-Jul	02-Aug	09-Aug	No Survey
	Tsisi Creek	Kosina 7.3	6.4	20-Jul	27-Jul	02-Aug	09-Aug	16-Aug
	Tsisi Lake 1	Tsisi 7.2	2.8	No Survey	No Survey	No Survey	09-Aug	16-Aug
	Tsisi Lake 2	Tsisi 10.6	5.2	No Survey	No Survey	No Survey	09-Aug	16-Aug
	Jay Creek	Susitna 211.0	13.3	21-Jul	27-Jul	02-Aug	09-Aug	16-Aug
Upper River -	Goose Creek	Susitna 232.9	11.2	21-Jul	26-Jul	02-Aug	09-Aug	16-Aug
Above Reservoir	Oshetna River	Susitna 235.1	26.3	21-Jul	26-Jul	02-Aug	09-Aug	16-Aug
	Black River	Oshetna	6.2	21-Jul	26-Jul	02-Aug	09-Aug	16-Aug

Table 4.4-1. Survey effort and observations using ARIS to identify Chinook salmon spawning behavior in turbid water, 2013.

Site	Date	Sample Location	Latitude	Longitude	ARIS Used	Fish Observed	Spawning Observed	Redds Observed	Comments
1	24-Jul	4th of July Creek	62.71482	-149.80826	Yes	Yes	No	No	Most fish (90% pinks and some chum) were just arriving and appeared to be entering creek.
2	24-Jul	4th of July Slough	62.71574	-149.80327	Yes	Yes	No	No	Fish appeared to be holding and waiting
3	25-Jul	Indian River Delta			Yes	Yes	Yes	No	Multiple salmon observed, including Chinook salmon that were holding in one location for > 1 hr. Likely one Chinook observed had already spawned as its behavior was indicative of redd guarding; several fish chased away during data collection.
4	26-Jul	ID'ed by RT'ed CN (724-11)	62.65749	-149.95197	Yes	No	No	No	Tag in small rapid running along edge of rock face - not a spawning location.
5	26-Jul	ID'ed by RT'ed CN (724-0); near Gateway	62.67645	-149.89300	No	No	No	-	No potential areas for spawning or set-up of Sonar
6	26-Jul	ID'ed by RT'ed CN (876-38); 1/4 mile d/s Indian on river right	62.78304	-149.66826	Yes	Yes	No	No	Single large fish observed on sonar; not holding and constantly moving
7	26-Jul	ID'ed by RT'ed Chinook (876-22), below Sherman Creek			No	No	No	-	Mortality signal upon arrival
8	27-Jul	ID'ed by RT'ed Chinook (685-91)			No	No	No	-	Mortality signal upon arrival
9	27-Jul	4th of July Creek mouth; just u/s	62.81764	-149.80300	No	-	-	-	Tag not located
10	31-Jul	Portage Creek mouth (200-yd stretch d/s); sites 12 & 13 in 2012	62.83092	-149.38589	Yes	Yes	No	No	Lots of fish holding/milling, none could be IDed as Chinook due to abundance of chum
11	31-Jul	Site 11 in 2012 (d/s Portage)			No	-	-	-	Water too swift, did not sample
12	31-Jul	Site 10 in 2012 (u/s Indian a ways)			No	-	-	-	Water too swift, did not sample
13	31-Jul	Sites 7-9 in 2012 (u/s to d/s Indian)	62.78601	-149.65587	Yes	Yes	No	No	Fish were migrating, holding, and milling
14	31-Jul	Gold Creek area	62.76869	-149.68796	Yes	Yes	No	No	Couple of fish observed passing by
15	31-Jul	4th of July Creek			Yes	Yes	No	No	> 1 hr imagery at the Creek/Slough; lots of PK trying to get up Creek
16	31-Jul	Gateway			No	No	No	-	No sites suitable for sampling

Table 4.4-2. Survey effort and observations using ARIS to identify chum salmon spawning behavior in turbid water, 2013.

Site	Date	Sample Location	Latitude	Longitude	ARIS Used	Fish Observed	Spawning Observed	Redds Observed	Comments
1	31-Jul	4th of July Creek			Yes	Yes	Yes	No	> 1 hr imagery collected at the Creek/Slough; lots of PK trying to get up the creek
2	31-Jul	4th of July Slough			Yes	Yes	No	No	Lots of chum in the slough; no spawning, just milling/holding
3	12-Aug	4th of July Slough			Yes	Yes	Yes	Yes	Nest guarding behavior and redds visible, but no nest building behavior

Table 5.1-2. Number of tagged and untagged adult salmon counted at the Deshka River, Montana Creek, and Indian River weirs in 2013, by species and size category.

	Deshka River Weir			Montana Creek Weir			Indian River Weir [3]		
Species[1]	Tagged	Not Tagged [2]	Total	Tagged	Not Tagged [2]	Total	Tagged	Not Tagged	Total
Chinook Salmon									
METF < 50 cm	0	528	528	0	66	66	13	281	294
METF ≥ 50 cm	148	17,855	18,003	11	1,938	1,949	72	1,065	1,137
Total	148	18,383	18,531	11	2,004	2,015	85	1,346	1,431
Chum Salmon									
METF < 40 cm							0	1	1
METF ≥ 40 cm							542	12,305	12,847
Total							542	12,306	12,848
Coho Salmon									
METF < 40 cm	0	0	0	0	0	0	0	12	12
METF ≥ 40 cm	67	22,074	22,141	7	758	765	53	461	514
Total	67	22,074	22,141	7	758	765	53	473	526
Pink Salmon									
All lengths							2,010	35,171	37,181
Sockeye Salmon									
METF < 40 cm							0	6	6
METF ≥ 40 cm							3	117	120
Total							3	123	126

[1] Appendix B contains more detailed daily summaries of weir counts for each site.

[2] Numbers of fish 'not tagged' were estimated.

[3] These data are net upstream counts (or net passage). Subsampled data were expanded accordingly. Only fish released at the Middle River fishwheels were included in the 'Tagged' field, and only fish of known size category, and fish that were inspected for tags were included.

Table 5.2-1. Fate classifications for radio-tagged fish in 2013, by species and release location.

	Chinook Salmon (≥ 50 cm)			Chinook (< 50 cm)	Coho Salmon		Chum Salmon	Pink Salmon		Sockeye Salmon
Classification	Lower River	Middle River	Yentna	Middle River	Lower River	Middle River	Middle River	Lower River	Middle River	Middle River
Tributary Destinations (total)	**617**	**422**	**602**	**42**	**478**	**154**	**147**	**98**	**151**	**44**
Alexander Creek	2	0		0	0	0	0	0	0	0
Yentna River	72	0	596	0	153	1	0	17	0	0
Deshka River	155	0		0	85	1	0	18	0	1
Willow Creek	37	0		0	6	0	0	16	0	1
Little Willow Creek	22	0		0	5	0	0	2	0	0
Kashwitna Creek	21	0		0	11	0	0	7	0	0
Goose Creek	1	0		0	2	0	0	1	1	0
Sheep Creek	11	1		0	6	0	0	5	0	0
Montana Creek	12	4	1	0	10	1	5	17	4	0
Rabideux Creek	0	0	0	0	2	0	0	0	0	0
Talkeetna River	134	30	4	4	59	20	26	7	21	9
Chulitna River	110	71	1	7	134	65	2	0	0	12
Whiskers Creek	0	0		0	0	10	1	0	0	0
Lane Creek	0	2		0	0	1	8	3	19	0
5th of July Creek	0	0		0	0	0	0	0	5	0
Sherman Creek	0	0		0	0	0	0	0	1	0
4th of July Creek	1	4		0	0	3	1	0	12	1
Gold Creek	0	2		0	0	0	9	1	6	0
Indian River	11	88		18	4	42	59	3	62	11
Jack Long Creek	0	0		0	0	1	0	0	1	0
Portage Creek	26	213		13	1	9	36	1	19	9
Devil Creek	0	1		0	0	0	0	0	0	0
Chinook Creek	0	1		0	0	0	0	0	0	0
Cheechako Creek	2	4		0	0	0	0	0	0	0
Tsusena Creek	0	1		0	0	0	0	0	0	0

Table 5.2-1. Continued.

Classification	Chinook Salmon (≥ 50 cm)			Chinook (< 50 cm)	Coho Salmon		Chum Salmon	Pink Salmon		Sockeye Salmon
	Lower River	Middle River	Yentna	Middle River	Lower River	Middle River	Middle River	Lower River	Middle River	Middle River
Mainstem Destinations (total)	**4**	**27**	**0**	**3**	**22**	**19**	**17**	**18**	**15**	**48**
Mainstem Proper	0	7		2	5	7	3	4	2	4
Downstream of Lane	*0*	*2*		*0*	*5*	*3*	*1*	*4*	*0*	*1*
no prior spawn location	*0*	*1*		*0*	*5*	*3*	*1*	*2*	*0*	*0*
was in Kashwitna	*0*	*0*		*0*	*0*	*0*	*0*	*1*	*0*	*0*
was in Talkeetna	*0*	*1*		*0*	*0*	*0*	*0*	*1*	*0*	*0*
was in Portage	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*1*
Upstream of Lane	*0*	*5*		*2*	*0*	*4*	*2*	*0*	*2*	*3*
no prior spawn location	*0*	*5*		*2*	*0*	*3*	*2*	*0*	*1*	*2*
was in 4th of July	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*1*	*0*
was at Portage Mouth	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*1*
was in Portage Creek	*0*	*0*		*0*	*0*	*1*	*0*	*0*	*0*	*0*
Tributary Mouths	4	15		0	1	3	1	6	12	2
Yentna Mouth	*0*	*0*		*0*	*0*	*0*	*0*	*2*	*0*	*0*
Deshka Mouth	*3*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Willow Mouth	*1*	*0*		*0*	*0*	*0*	*0*	*3*	*0*	*0*
Montana Mouth	*0*	*0*		*0*	*1*	*0*	*0*	*0*	*0*	*0*
Talkeetna Mouth	*0*	*1*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Lane Mouth	*0*	*1*		*0*	*0*	*1*	*0*	*0*	*2*	*0*
5th of July Mouth	*0*	*0*		*0*	*0*	*1*	*0*	*0*	*1*	*0*
4th of July Mouth	*0*	*1*		*0*	*0*	*0*	*0*	*1*	*3*	*0*
no prior spawn location	*0*	*1*		*0*	*0*	*0*	*0*	*1*	*2*	*0*
was up 4th of July Creek	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*1*	*0*
Indian Mouth	*0*	*6*		*0*	*0*	*0*	*0*	*0*	*4*	*0*
no prior spawn location	*0*	*6*		*0*	*0*	*0*	*0*	*0*	*2*	*0*
was up Indian River	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*2*	*0*
Jack Long Mouth	*0*	*0*		*0*	*0*	*1*	*0*	*0*	*0*	*0*
Portage Mouth	*0*	*6*		*0*	*0*	*0*	*0*	*0*	*2*	*2*
no prior spawn location	*0*	*5*		*0*	*0*	*0*	*0*	*0*	*1*	*2*
was up Portage Creek	*0*	*1*		*0*	*0*	*0*	*0*	*0*	*1*	*0*
Unnamed Creek Mouth	*0*	*0*		*0*	*0*	*0*	*1*	*0*	*0*	*0*

Table 5.2-1. Continued.

Classification	Chinook Salmon (≥ 50 cm) Lower River	Chinook Salmon (≥ 50 cm) Middle River	Chinook Salmon (≥ 50 cm) Yentna	Chinook (< 50 cm) Middle River	Coho Salmon Lower River	Coho Salmon Middle River	Chum Salmon Middle River	Pink Salmon Lower River	Pink Salmon Middle River	Sockeye Salmon Middle River
Side Channels & Sloughs	0	5		1	16	9	13	8	1	42
Slough 8A	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*13*
Slough 9	*0*	*0*		*0*	*0*	*0*	*5*	*0*	*0*	*4*
no prior spawn location	*0*	*0*		*0*	*0*	*0*	*4*	*0*	*0*	*4*
was up 4th of July Creek	*0*	*0*		*0*	*0*	*0*	*1*	*0*	*0*	*0*
Slough 11	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*6*
Slough 21	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
Other areas	*0*	*5*		*1*	*16*	*9*	*8*	*8*	*1*	*19*
no prior spawn location	*0*	*3*		*1*	*16*	*9*	*8*	*8*	*1*	*18*
was up Portage Creek	*0*	*2*		*0*	*0*	*0*	*0*	*0*	*0*	*0*
was up Talkeetna River	*0*	*0*		*0*	*0*	*0*	*0*	*0*	*0*	*1*
Other Fates (total)	**68**	**87**	**90**	**22**	**96**	**69**	**37**	**84**	**34**	**45**
Other Mainstem	22	43	12	9	63	19	26	37	22	29
Max Zone downstream of Lane	*20*	*0*	*12*	*0*	*61*	*0*	*0*	*35*	*0*	*0*
Max Zone upstream of Lane	*2*	*43*	*0*	*9*	*2*	*19*	*26*	*2*	*22*	*29*
Downstream Only	10	30	29	8	12	32	7	0	11	16
Near Release Site	22	14	23	5	11	18	4	10	1	0
No or Single Detections	14	0	26	0	10	0	0	37	0	0
Total Tags Released	689	536	692	67	596	242	201	200	200	137

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 fish of known fate 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, 2013.

Tagged in Lower River

Classification / Fate	**Chinook Salmon (≥ 50 cm)**	**Coho Salmon**	**Pink Salmon**
Reached Lane Station	58	26	12
Unknown Fate	2	2	2
Known Fate (a)[1]	56	24	10
Mid/Upper-Susitna Tributary	40	5	8
Mid/Upper-Susitna Mainstem	0	1	1
Returned Downstream (b)[1]	16	18	1
Mainstem Destination	*0*	*1*	*0*
Chulitna River	*14*	*11*	*0*
Talkeetna River	*1*	*5*	*1*
Sheep Creek	*0*	*1*	*0*
Montana Creek	*1*	*0*	*0*
Proportion Wandering (c)[1]	28.6%	75.0%	10.0%

Tagged in Middle River

Classification / Fate	**Chinook Salmon (≥ 50 cm)**	**Chinook Salmon (< 50 cm)**	**Chum Salmon**	**Coho Salmon**	**Pink Salmon**	**Sockeye Salmon**
Tagged at Curry	536	67	201	242	200	137
Other Fates (from Table Table 5.2-1)	87	22	37	69	34	45
Other Mainstem	43	9	26	19	22	29
Downstream Only	30	8	7	32	11	16
Near Release Site	14	5	4	18	1	0
No / Single Detections	0	0	0	0	0	0
Known Fate (a)[1]	449	45	164	173	166	92
Mid/Upper-Susitna Tributary	314	31	105	55	106	21
Mid/Upper-Susitna Mainstem	23	3	15	12	12	44
Returned Downstream (b)[1]	112	11	44	106	48	27
Mainstem Destination	*4*	*0*	*2*	*7*	*3*	*4*
Lane Creek	*2*	*0*	*8*	*1*	*19*	*0*
Whiskers Creek	*0*	*0*	*1*	*10*	*0*	*0*
Chulitna River	*71*	*7*	*2*	*65*	*0*	*12*
Talkeetna River	*30*	*4*	*26*	*20*	*21*	*9*
Montana Creek	*4*	*0*	*5*	*1*	*4*	*0*
Goose Creek	*0*	*0*	*0*	*0*	*1*	*0*
Sheep Creek	*1*	*0*	*0*	*0*	*0*	*0*
Willow Creek	*0*	*0*	*0*	*0*	*0*	*1*
Deshka River	*0*	*0*	*0*	*1*	*0*	*1*
Yentna River	*0*	*0*	*0*	*1*	*0*	*0*
Proportion Wandering (c)[1]	24.9%	24.4%	26.8%	61.3%	28.9%	29.3%

Notes:

Fish released in the lower river (top panel) were included only if they were detected at or upstream of Lane Station. Fish tagged at Curry (bottom panel) include all fish released at Curry. See Table 5.2-1 for further details about classifications of fish 'fates.'

[1] c = a / b

Table 5.2-3. Farthest upstream detection locations for radio-tagged fish that eventually entered a Lower River tributary, 2013.

Tagged in Lower River

Farthest Upstream Location	Chinook Salmon (≥ 50 cm)	Coho Salmon	Pink Salmon
Lane Station	3	6	0
Near Curry	2	1	1
Gateway	0	2	0
4th of July Ck. mouth	2	2	0
Slough 11	1	0	0
Gold Creek	0	1	0
Slough 21	1	0	0
Powerline	0	1	0
Jack Long Ck. mouth	1	0	0
Portage Ck. mouth	2	4	0
Above Portage Ck.	2	1	0
Below Impediment One	2	0	0
Total number that reached Lane Station, then entered Lower River tributary	16	18	1

Tagged at Curry

Farthest Upstream Location	Chinook Salmon (≥ 50 cm)	Chinook Salmon (< 50 cm)	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon
Gateway	8	2	5	5	4	2
4th of July mouth	12	1	5	8	12	2
Indian R. mouth	12	1	0	7	0	1
Gold Creek	0	0	0	1	0	0
Above Indian R.	2	0	0	0	0	0
Powerline	8	1	1	24	1	5
Above Powerline	1	0	0	0	0	1
Jack Long Ck. mouth	3	0	0	1	0	0
Portage Ck. mouth	7	0	0	23	0	2
Above Portage Ck.	7	1	0	10	0	5
Below Impediment One	7	0	0	3	0	1
Below Impediment Three	1	0	0	0	0	0
Total number that reached Gateway, then went to a Lower River spawn location	68	6	11	17	82	19

Notes:

Fish released in the lower river (top panel) were included only if they were detected at or upstream of Lane Station. Fish released at Curry (bottom panel) were included only if they were detected at or upstream of Gateway.

Table 5.3-1. Details of the radio-tagged fish that approached or passed the Middle River impediments, 2013.

Chinook Salmon (≥ 50 cm) that Passed Impediment 3

Tag Number	Species	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
241	CN	Curry, Site Two	21-Jun	64	Undetermined	13 Jul	14 Jul	16 Jul	Approached headwaters, then moved down in Tsusena Creek (1 day), in Portage Creek (3 days), then down to below Sunshine
272	CN	Curry, Site One	23-Jun	64	Undetermined	13 Jul	14 Jul	30 Jul	Died in Devils Creek
395	CN	Curry, Site One	26-Jun	65	Undetermined	11 Jul	12 Jul	13 Jul	Died in Tsesena Creek

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

Tag Number	Species	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
254	CN	Curry, Site One	22-Jun	89	Undetermined	12 Jul	13 Jul	-	Died at mouth of Chinook Creek
280	CN	Curry, Site Two	23-Jun	64	Undetermined	13 Jul	13 Jul	-	Last seen in Talkeetna River
309	CN	Curry, Site One	24-Jun	58	Undetermined	12 Jul	13 Jul	-	Died Below I3
355	CN	Curry, Site Two	25-Jun	55	Undetermined	14 Jul	16 Jul	-	Died in Cheechako Creek
418	CN	Curry, Site One	27-Jun	74	Undetermined	13 Jul	13 Jul	-	In Chinook Creek (7/18-8/7), then quickly dropped to Chulitna mouth
528	CN	Curry, Site One	28-Jun	52	Undetermined	16 Jul	19 Jul	-	Died in Cheechako Creek
555	CN	Curry, Site One	29-Jun	80	Undetermined	24 Jul	24 Jul	-	Drifted downstream after 7/29, died downstream
658	CN	Curry, Site One	30-Jun	67	Undetermined	12 Jul	12 Jul	-	Drifted downstream after 7/29, was near Slough 21 (8/3-8/2: was inaccessible at the time) then downstream
715	CN	Curry, Site One	1-Jul	60	Undetermined	13 Jul	14 Jul	-	Died in Cheechako Creek
798	CN	Curry, Site One	2-Jul	81	Undetermined	14 Jul	14 Jul	-	Died in maintem upstream of Chinook Creek
6535	CN	Lower Susitna, Site Two	12-Jun	64	Undetermined	12 Jul	13 Jul	-	In Cheechako Creek (7/16 - 7/31), then downstream
6604	CN	Lower Susitna, Site Two	8-Jun	60	Undetermined	17 Jul	18 Jul	-	In Cheechako Creek (7/23-7/31, as late an 8/4), then downstream
7082	CN	Lower Susitna, Site Two	15-Jun	55	Undetermined	13 Jul	14 Jul	-	In Portage Creek (7/27-8/7) then various downstream locations

Table 5.3-1. Continued.

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

Tag Number	Species	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
219	CN	Curry, Site One	21-Jun	93	Undetermined	30 Jun	-	-	In Portage Creek (7/7-8/8) then Jack Long Creek (8/10), then various mainstem locations
278	CN	Curry, Site One	23-Jun	63.5	Undetermined	13 Jul	-	-	Died at Portage Mouth
353	CN	Curry, Site Two	25-Jun	68	Undetermined	14 Jul	-	-	Died in Portage Creek
593	CN	Curry, Site One	29-Jun	88	Male	16 Jul	-	-	Died in Cheechako Creek

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

Tag Number	Species	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
176	CN	Curry, Site Two	17-Jun	60	Undetermined	-	-	-	Last in Talkeetna River
178	CN	Curry, Site Two	17-Jun	62	Undetermined	-	-	-	Died in Portage Creek
210	CN	Curry, Site One	20-Jun	82	Undetermined	-	-	-	Died in Portage Creek
224	CN	Curry, Site One	21-Jun	58	Undetermined	-	-	-	Last in Chulitna River
299	CN	Curry, Site One	24-Jun	52	Undetermined	-	-	-	In Portage Creek 7/20 - 8/10
328	CN	Curry, Site One	25-Jun	81	Female	-	-	-	In Portage Creek 7/10 - 7/13, then in a side-Channel near Slough 21
332	CN	Curry, Site One	25-Jun	82	Undetermined	-	-	-	Died in Portage Creek
338	CN	Curry, Site One	25-Jun	78	Male	-	-	-	In Portage Creek 7/20 - 7/30
347	CN	Curry, Site One	25-Jun	81	Female	-	-	-	Died in Portage Creek
404	CN	Curry, Site One	26-Jun	55	Undetermined	-	-	-	Died in Portage Creek
447	CN	Curry, Site One	27-Jun	53	Undetermined	-	-	-	Died in Portage Creek
479	CN	Curry, Site Two	27-Jun	80	Undetermined	-	-	-	Died in Portage Creek
501	CN	Curry, Site One	28-Jun	84	Undetermined	-	-	-	Died in Below I1
517	CN	Curry, Site One	28-Jun	85	Undetermined	-	-	-	Died in Gold Creek
524	CN	Curry, Site One	28-Jun	66	Undetermined	-	-	-	Died in Portage Creek

Table 5.3-1. Continued.

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

Tag Number	Species	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
532	CN	Curry, Site One	28-Jun	80	Undetermined	-	-	-	In Portage Creek 7/17 - 7/24
541	CN	Curry, Site One	29-Jun	64	Undetermined	-	-	-	Died in Portage Creek
543	CN	Curry, Site One	29-Jun	54	Undetermined	-	-	-	Died in Portage Creek
550	CN	Curry, Site One	29-Jun	61	Undetermined	-	-	-	Last in Chulitna River
564	CN	Curry, Site One	29-Jun	86	Male	-	-	-	In Portage Creek (7/15-7/27), then various downstream locations
615	CN	Curry, Site One	30-Jun	61	Undetermined	-	-	-	In Portage Creek 7/7 - 8/11
632	CN	Curry, Site One	30-Jun	71	Male	-	-	-	Died in Portage Creek
671	CN	Curry, Site One	30-Jun	80	Female	-	-	-	Last in Chulitna River
700	CN	Curry, Site One	1-Jul	56	Undetermined	-	-	-	Died in Portage Creek
714	CN	Curry, Site One	1-Jul	56	Undetermined	-	-	-	Last in Chulitna River
746	CN	Curry, Site One	1-Jul	63	Undetermined	-	-	-	In Portage Creek (7/15-7/19) then died at Portage mouth
760	CN	Curry, Site Two	1-Jul	62	Undetermined	-	-	-	In Portage Creek (7/18) then downstream
762	CN	Curry, Site One	2-Jul	75	Undetermined	-	-	-	Died near Portage Mouth
764	CN	Curry, Site One	2-Jul	72	Undetermined	-	-	-	Last in Chulitna River
781	CN	Curry, Site One	2-Jul	63	Undetermined	-	-	-	In Portage Creek (7/22 - 7/31, maybe as long as 8/6), then downstream
815	CN	Curry, Site One	2-Jul	86	Undetermined	-	-	-	Died in Portage Creek
880	CN	Curry, Site One	3-Jul	59	Undetermined	-	-	-	mouth
920	CN	Curry, Site One	4-Jul	67	Undetermined	-	-	-	Died in Indian River
925	CN	Curry, Site Two	4-Jul	83	Male	-	-	-	Died downstream of I1
927	CN	Curry, Site Two	4-Jul	82	Undetermined	-	-	-	Died in Portage Creek
951	CN	Curry, Site One	5-Jul	78	Female	-	-	-	Died in Portage Creek
962	CN	Curry, Site Two	5-Jul	67	Undetermined	-	-	-	Died in Portage Creek
1004	CN	Curry, Site One	8-Jul	91	Undetermined	-	-	-	Died Below I1

Table 5.3-1. Continued.

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

Tag Number	Species	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
1039	CN	Curry, Site Two	9-Jul	63	Undetermined	-	-	-	Died in Portage Creek
1056	CN	Curry, Site One	10-Jul	54	Undetermined	-	-	-	Died in Portage Creek
1061	CN	Curry, Site One	10-Jul	84	Male	-	-	-	In Portage Creek 7/15, then in Talkeetna River
1081	CN	Curry, Site One	11-Jul	58	Undetermined	-	-	-	Died in Portage Creek
1149	CN	Curry, Site One	16-Jul	81	Female	-	-	-	Died in Portage Creek
6811	CN	Lower Susitna, Site Two	9-Jun	59	Undetermined	-	-	-	In Chulitna River
6866	CN	Lower Susitna, Site One	10-Jun	85	Undetermined	-	-	-	Died in Portage Creek
6885	CN	Lower Susitna Gillnets	15-Jun	72	Undetermined	-	-	-	In Portage Creek (7/7-7/9, 7/13-7/27), then downstream
7063	CN	Lower Susitna, Site One	10-Jun	84	Undetermined	-	-	-	Died in Portage Creek
7203	CN	Lower Susitna Gillnets	7-Jun	54	Undetermined	-	-	-	In Chulitna River
7255	CN	Lower Susitna, Site One	10-Jun	77	Undetermined	-	-	-	Died in Portage Creek
7281	CN	Lower Susitna, Site One	14-Jun	67.5	Undetermined	-	-	-	In 4th of July Creek

Chinook Salmon(< 50 cm) that Passed Impediment 1 but not Impediment 2

Tag Number	Species	Capture/ Release Site	Capture Date	Length (MEF cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
1024	CNj	Curry, Site Two	8-Jul	42	Male	26 Jul	-	-	In lower Portage Creek, then died in Indian River

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

Tag Number	Species	Capture/ Release Site	Capture Date	Length (MEF cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
713	CNj	Curry, Site One	1-Jul	40	Undetermined	-	-	-	Died in Portage Creek
717	CNj	Curry, Site One	1-Jul	35	Undetermined	-	-	-	Drifted Downstream

Table 5.3-1. Continued.

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

Tag Number	Species	Capture/ Release Site	Capture Date	Length (MEF cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
959	CNj	Curry, Site Two	5-Jul	35	Undetermined	-	-	-	Died in Portage Creek
1117	CNj	Curry, Site Two	13-Jul	39	Male	-	-	-	In lower Portage Creek, then died in Indian

Sockeye Salmon that Approached Impediment 1 but did not Pass

Tag Number	Species	Capture/ Release Site	Capture Date	Length (MEF cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
898	SO	Curry, Site One	4-Jul	51	Undetermined	-	-	-	Below I1, then mortality signals detected at the mouth of Portage Creek
1074	SO	Curry, Site One	11-Jul	58	Female	-	-	-	Portage mouth (7/15-7/28) then downstream, and up again to a Slough below Gold Creek (7/31-8/12)
1093	SO	Curry, Site One	12-Jul	57	Undetermined	-	-	-	In Portage Creek (7/18-7/20) then in a mainstem area near Birch Creek (7/25 then mort)
2011	SO	Curry, Site Two	26-Jul	46	Undetermined	-	-	-	Drifted Downstream
2216	SO	Curry, Site Three	28-Jul	50	Undetermined	-	-	-	Died in Indian River
2414	SO	Curry, Site One	31-Jul	59	Undetermined	-	-	-	Drifted Downstream
2724	SO	Curry, Site Three	2-Aug	50	Male	-	-	-	Died in Slough 11
2900	SO	Curry, Site One	4-Aug	56	Male	-	-	-	At mouth of Portage
3831	SO	Curry, Site Two	10-Aug	56	Male	-	-	-	Died in Indian River

Coho Salmon that Approached Impediment 1 but did not Pass

Tag Number	Species	Capture/ Release Site	Capture Date	Length (MEF cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
2522	CO	Curry, Site One	1-Aug	54	Undetermined	-	-	-	Below I1 (8/10) then Chulitna
2705	CO	Curry, Site Three	2-Aug	45	Undetermined	-	-	-	Above Portage, Portage mouth, Below I1 (~8/22-26) then Chulitna

Table 5.3-1. Continued.

Coho Salmon that Approached Impediment 1 but did not Pass

Tag Number	Species	Capture/ Release Site	Capture Date	Length (MEF cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
2805	CO	Curry, Site Two	3-Aug	53	Undetermined	-	-	-	Portage area, Below I1 (8/27 - ~29) then Whiskers Creek
3304	CO	Curry, Site Three	6-Aug	55	Female	-	-	-	Below I1 (8/11) then Chulitna
3511	CO	Curry, Site Three	7-Aug	43	Male	-	-	-	Below I1 (8/27 - ~29) then Chulitna
3626	CO	Curry, Site Two	8-Aug	51	Male	-	-	-	Portage mouth, then Below I1 (~8/29 8/30, ~9/1 - 9/2) then Mainstem in Zone 125 (2 live hits then mort)

Notes:

Fish characteristics include 'tag numbers' (unique numbers assigned to each individual radio-tagged fish), species (CN = Chinook salmon ≥ 50 cm; CNj = Chinook salmon < 50 cm; and SO = sockeye salmon), 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 passed Impediment 1 but not Impediment 2. Sixth panel: Chinook salmon (< 50 cm) that approached within 1 km of Impediment 1, but did not pass. Seventh panel: sockeye salmon that approached within 1 km of Impediment 1, but did not pass.

Table 5.3-2. Destinations of radio-tagged Chinook salmon that passed each Middle River impediment, 2013.

	Chinook Salmon (≥ 50 cm)				Chinook (< 50 cm)
	Passed I1 but not I2	Passed I2 but not I3	Passed I3	Total	Passed I1 but not I2
Classification					
Tributary Destinations					
Talkeetna River		1		1	
Indian River					1
Portage Creek	2	1	1	4	
Cheechako Creek	1	5		6	
Chinook Creek		1		1	
Devils Creek			1	1	
Tsesena Creek			1	1	
Mainstem Destinations					
Near Slough 11		1			
Near Slough 21		1			
Near Portage	1			1	
Near Chinook		1		1	
Mort		2		2	
Total	**4**	**13**	**3**	**20**	**1**
Downstream from Impediment					
Number	3	9	1	13	1
Percent	75%	69%	33%	65%	100%

Notes:
An “I” refers to “impediment.”

Table 5.5-1. Average percent distribution of spawning salmon in slough habitats of the Middle River from 1981 to 1985, and confirmed spawning locations in 2012 and 2013.

		Percent Distribution (1981-1985 average)			Confirmed Spawning					
					Sockeye		Chum		Pink	
Slough	River Mile	Sockeye	Chum	Pink	2012	2013	2012	2013	2012	2013
1	99.6	0.3	0.1	-						
2	100.2	0.2	1.5	0.1						
3B	101.4	0.8	0.2	0.7						
3A	101.9	0.4	0.1	2.2						
4	105.2	-	-	-						
5	107.6	0.0	0.0	0.1						
6	108.2	-	-	-						
6A	112.3	0.0	0.2	2.8						
7	113.2	-	-	-						
8	113.7	0.1	3.3	20.7						
Bushrod	117.8	0.1	1.2	4.0						
8D	121.8	-	0.5	-						
8C	121.9	0.1	1.5	0.0						
8B	122.2	0.2	6.3	4.1						
Moose	123.5	1.6	2.9	1.0						
A'	124.6	-	2.5	0.6						
A	124.7	-	0.5	3.0						
8A	125.4	13.8	13.7	8.1	X	X	X	X		
B	126.3	0.8	2.3	2.1						
9	128.3	0.6	8.9	1.9	X	X	X	X		X
9B	129.2	1.9	1.2	-						
9A	133.8	0.1	6.0	-		X	X	X		
10	133.8	0.1	0.2	-		X		X		
11	135.3	65.6	20.9	17.6	X	X	X	X		
12	135.4	-	-	-						
13	135.9	-	0.2	-						
14	135.9	-	0.0	-						
15	137.2	0.0	0.7	19.4						
16	137.3	-	0.2	35.7						
17	138.9	0.8	2.4	0.0						
18	139.1	-	0.1	-						
19	139.7	0.8	0.2	1.3	X					
20	140.0	0.0	2.5	13.6						

Table 5.5-1. Continued.

		Percent Distribution (1981-1985 average)			Confirmed Spawning					
					Sockeye		Chum		Pink	
Slough	River Mile	Sockeye	Chum	Pink	2012	2013	2012	2013	2012	2013
21	141.1	13.2	22.1	4.5	X	X	X	X		
22	144.5	0.1	3.7	-				X		
21A	145.3	-	0.1	-				X		
Total Fish Count (1981-85)		4,252	15,827	1,639						

Notes:

Average percent distribution data were synthesized from Barrett et al. (1985) and Thompson et al. (1986).

Annual total counts for each species:

1981: sockeye (1,241), chum (2,596), and pink salmon (28)

1982: sockeye (607), chum (2,244), and pink salmon (507)

1983: sockeye (555), chum (1,467), and pink salmon (21)

1984: sockeye (926), chum (7,556), and pink salmon (1,069)

1985: sockeye (923), chum (1,964), and pink salmon (14)

10. FIGURES

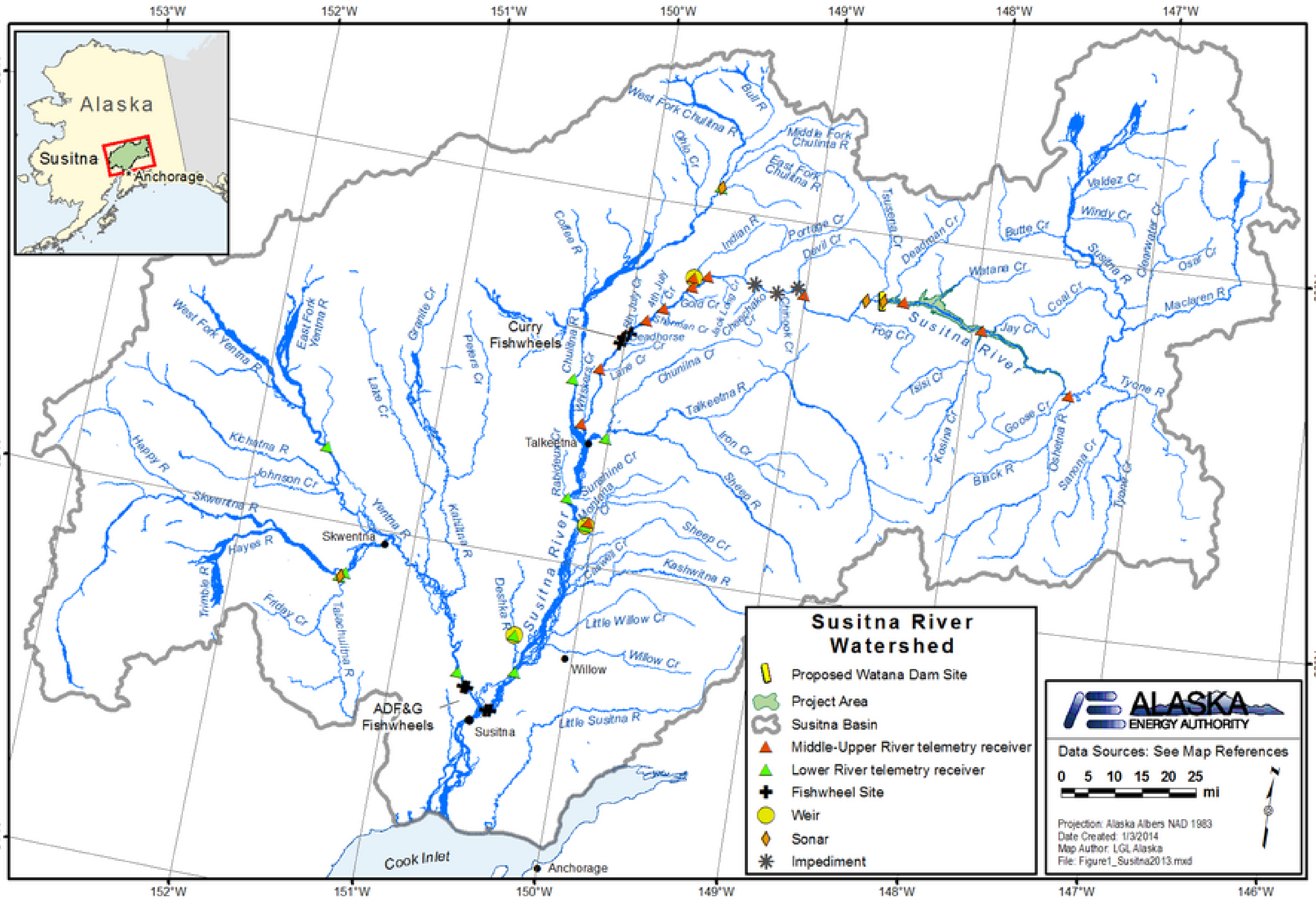


Figure 3-1. Susitna River watershed showing fish capture sites (fishwheels) and the locations of fixed-station telemetry receiver sites, 2013.

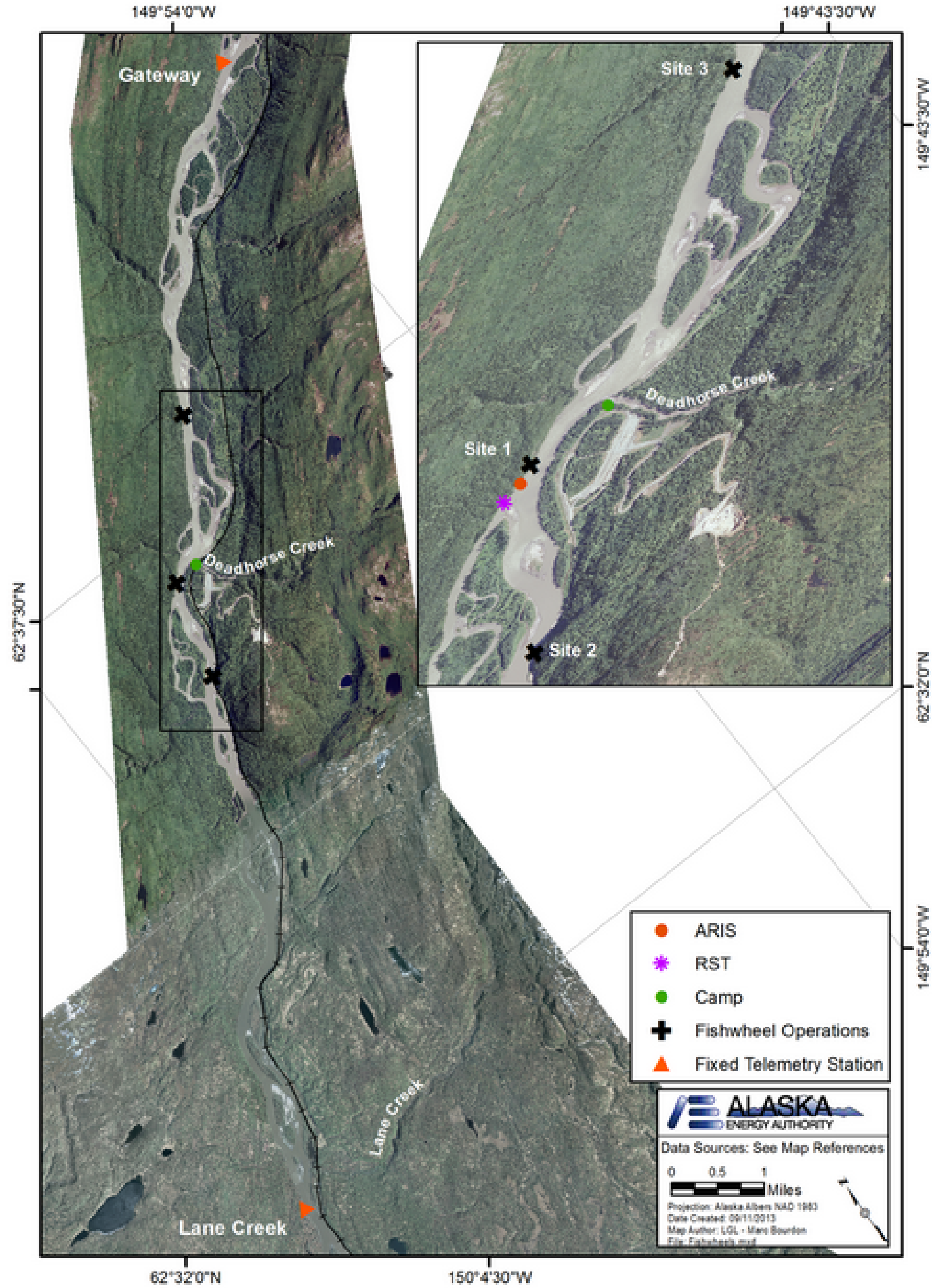


Figure 4.1-1. Middle River Segment showing sites for fish capture (sites 1, 2, and 3), ARIS, rotary screw trap (RST), Curry camp, and the Lane Creek and Gateway fixed-station receivers, 2013.

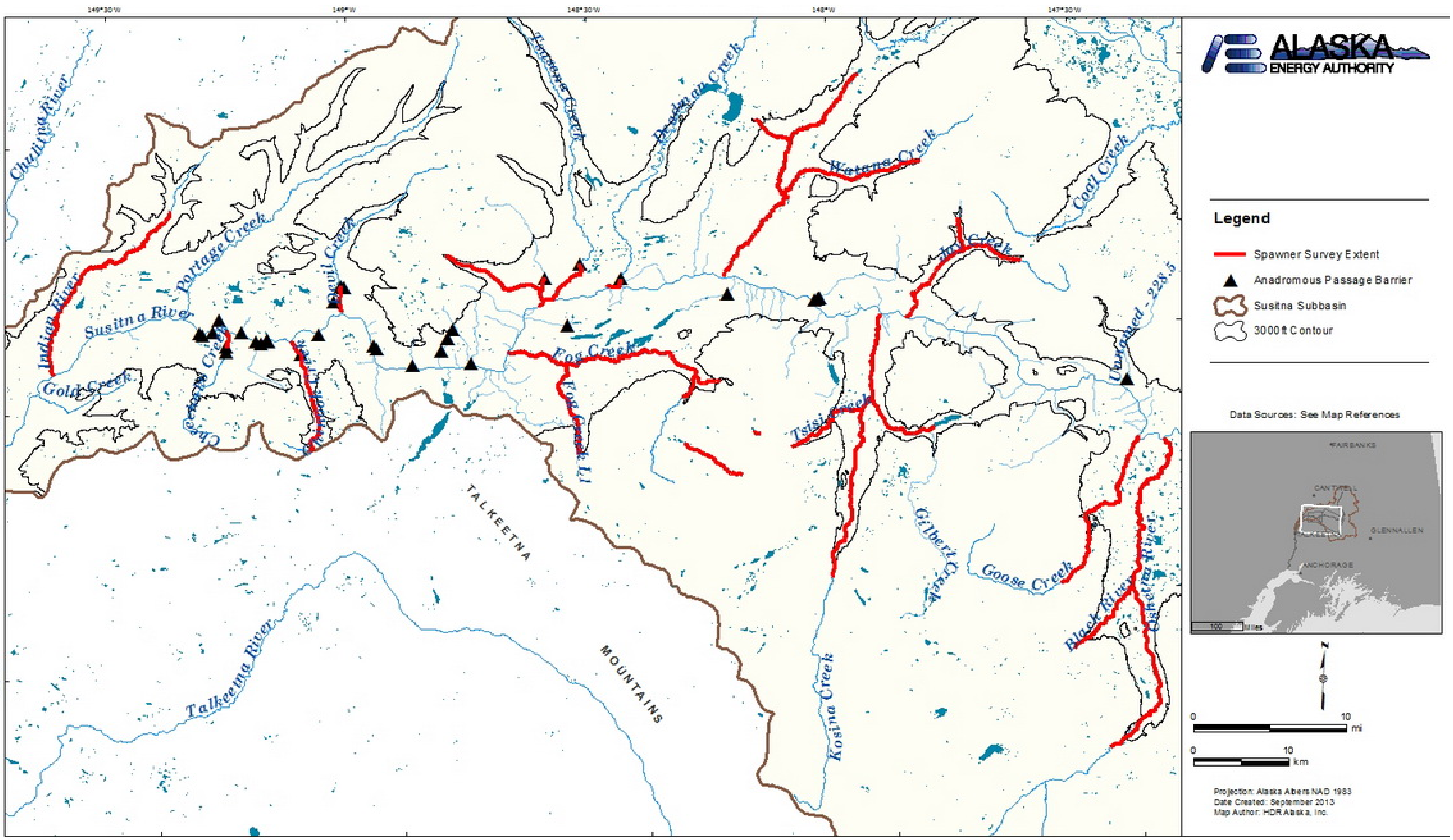


Figure 4.3-1. Aerial spawner survey extent for Indian River and tributaries in and above Devils Canyon, 2013.

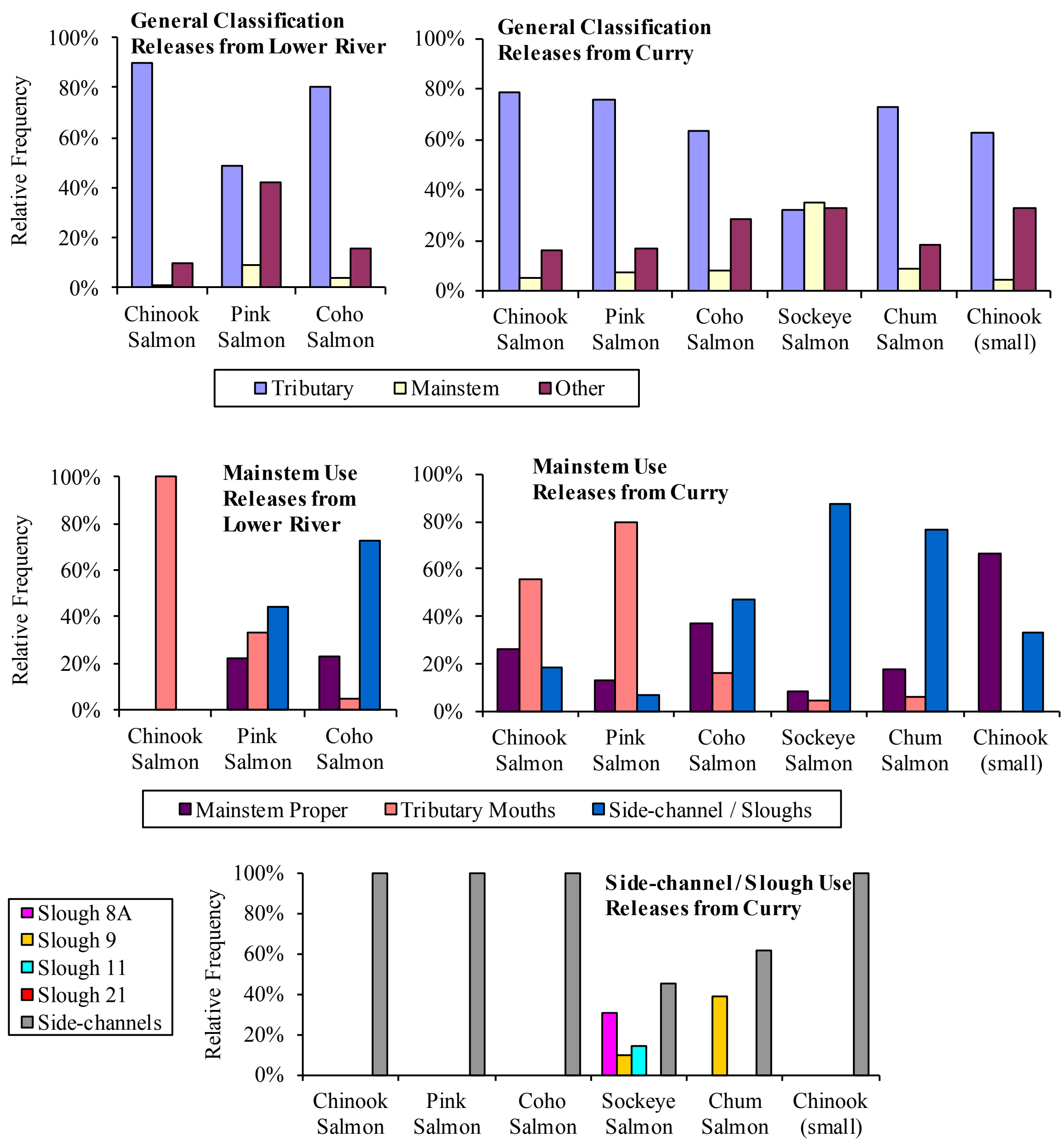


Figure 5.2-1. Fate classifications for radio-tagged fish released in the lower river (left panels) or at Curry (right panels), by species/life history stage, 2013. Top panels: Fish that were detected on several occasions within a limited area were classified with a 'Mainstem Destination' (either in side-channel/slough 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, and those that had at least one live detection in the mainstem location. See text and Table 5.2-1 for more detailed classifications. Middle Panels: Relative use of side-channel/slough locations, tributary mouths, and the mainstem proper, by fish that were classified with a 'Mainstem Destination.' Bottom Panel: Relative use of sloughs vs. side-channel habitats by fish classified with a 'Mainstem Destination.' 'tbd' = to be determined.

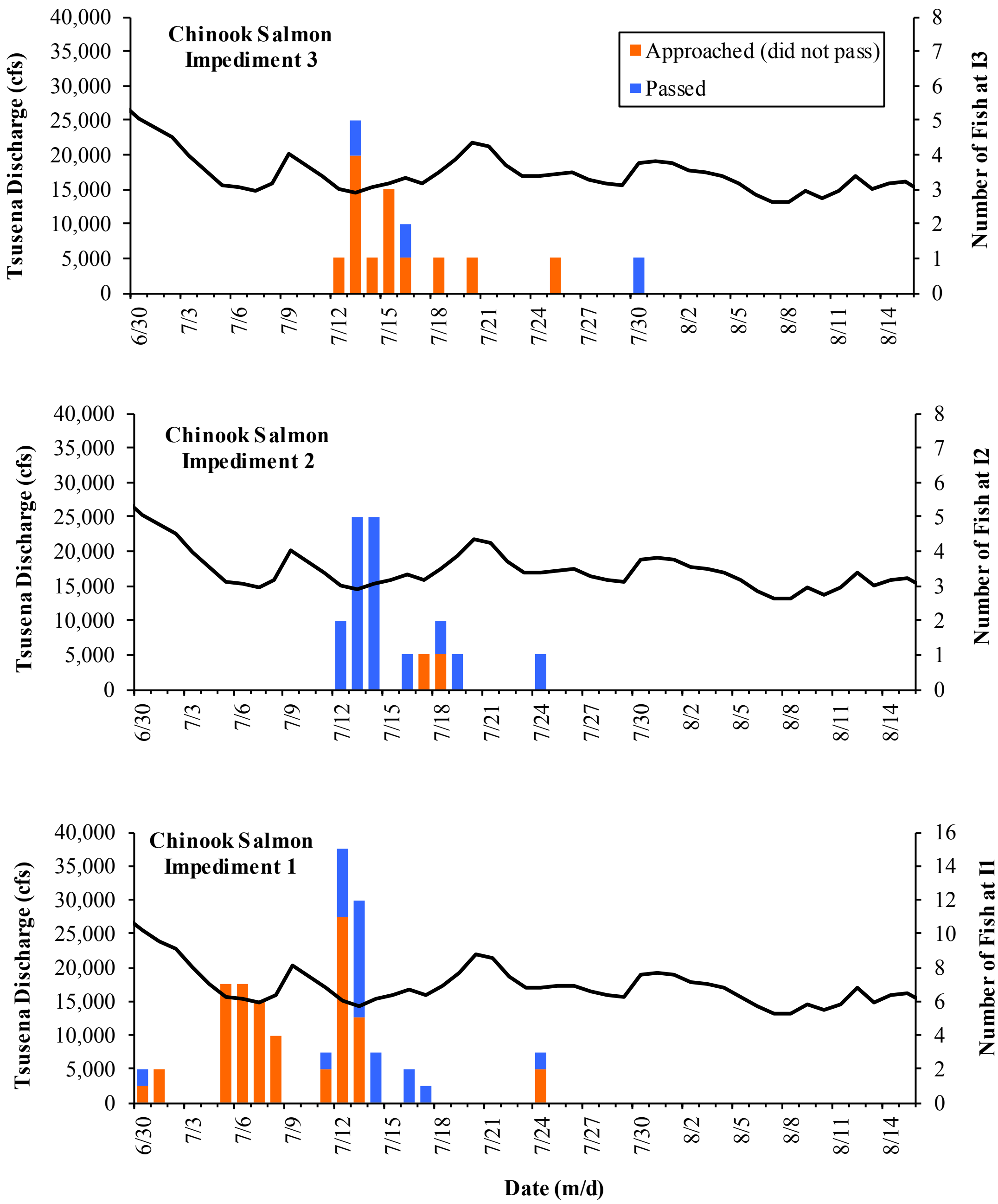
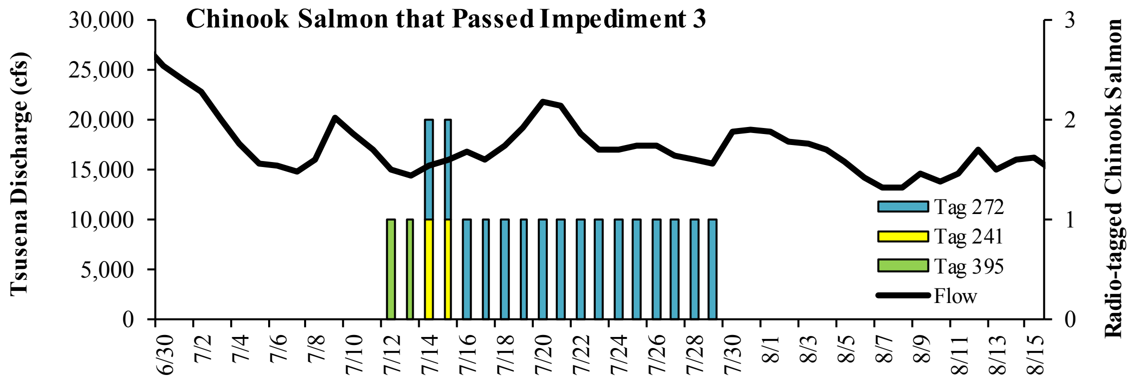


Figure 5.3-1. Daily numbers of Chinook salmon that approached and passed each of the three Middle River impediments in 2013. Orange bars: fish that approached but did not pass. Blue bars: fish that approached and successfully passed. Figures show the date of first detection above the impediment (blue) or the date of first detection below the impediment (orange). Also shown is the average daily flow as measured at Tsusena Creek.



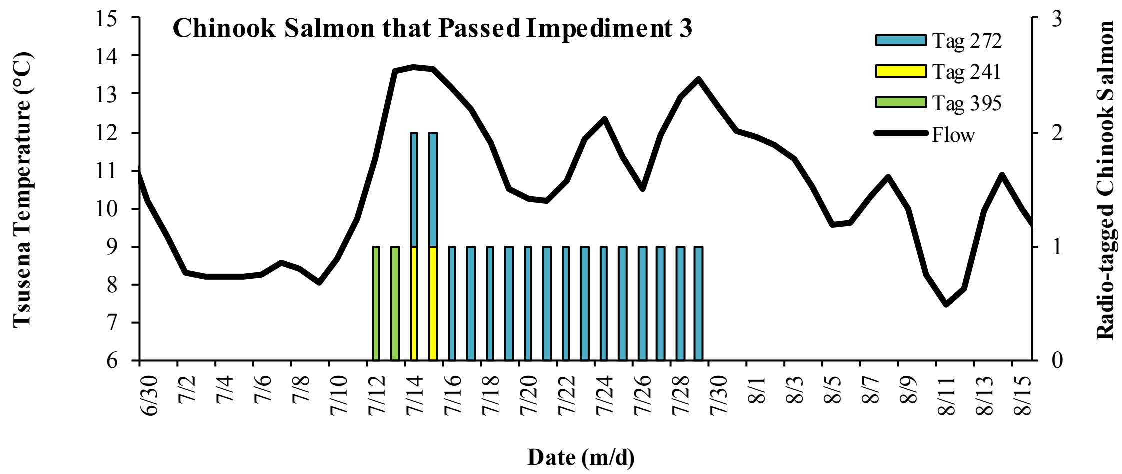


Figure 5.3-2. Daily number of radio-tagged Chinook salmon that held below Impediment 3 in 2013. Each of the three fish is shown using a unique color. Passage dates can be read by noting the date after which each of the tags disappears from the chart. The top panel includes the average daily flow of the Susitna River as measured at Tsusena Creek, and the bottom panel includes the average daily water temperature of the Susitna River as measured at Tsusena Creek.

PART A - APPENDIX A: FISH CAPTURE AND TAGGING

Table A-1. Number of salmon radio-tagged at two fishwheel sites and from gillnets in the Lower River, 2013.

Species	Radio Tag Target	Fishwheel West Bank	Fishwheel East Bank	Gillnet	Total
Chinook salmon[1]	700	385	195	118	698
Coho Salmon	600	343	253		596
Pink Salmon	200	99	98		197
Total	1,500	827	546	118	1,491

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

Table A-2. Number of Chinook salmon radio-tagged at two fishwheel sites and in gillnets in the Yentna River, 2013.

Radio Tag Target	Fishwheel South Bank	Fishwheel North Bank	Gillnet	Total
700	282	143	267	692

Notes:

All tagged Chinook salmon measured 50 cm METF or greater.

Table A-3. Number of salmon radio- and spaghetti-tagged at three fishwheel sites and in a beach seine in the Middle River, 2013.

Species	Radio Tag Target	Fishwheels Site 1 Radio	Fishwheels Site 1 Spaghetti	Fishwheels Site 2 Radio	Fishwheels Site 2 Spaghetti	Fishwheels Site 3 Radio	Fishwheels Site 3 Spaghetti	Beach Seine Radio	Total Radio	Total Spaghetti	Total Total
Chinook salmon (≥ 50 cm)	560	449		81		6			536		536
Chinook salmon (< 50 cm)	0	55		12					67		67
Chum Salmon	200	16	252	78	344	107	1,363		201	1,959	2,160
Coho Salmon	200	75	484	54	98	102	380	11	242	962	1,204
Pink Salmon	200	32	346	81	1,239	87	7,520		200	9,105	9,305
Sockeye Salmon	200	58		51		30			139		139
Total	1,360	685	1,082	357	1,681	332	9,263	11	1,385	12,026	13,411

Table A-4. Number of fish sampled at the Middle River fishwheels (length, fin clip, and scales) and transferred to the FDA Study to be surgically radio-tagged, 2013.

Species Name	Total Catch[1]	Length (cm) Min	Max	Mean	n	Transferred to FDA[2] Tagged	n	Biosamples DNA	Scales
		Mid-eye-to-fork Length							
Chinook Salmon (≥ 50 cm)	616	50	110	69.6	576			542	283
Chinook Salmon (< 50 cm)	336	23	49	36.3	320			67	33
Chum Salmon	3,417	27	70	59.0	1,358			201	
Coho Salmon	1,734	31	67	51.1	1,030			220	120
Pink Salmon	15,695	31	61	41.6	1,696			199	
Sockeye Salmon	276	24	64	44.8	261			138	86
		Nose-fork Length							
Arctic Grayling	54	20	40	33.8	51	10	11	40	
Burbot	2	41	45	42.8	2	1	2	1	
Dolly Varden	14	19	43	28.6	14	2	3	11	
Longnose Sucker	20	20	39	29.4	20	5	8	5	
Rainbow Trout	59	15	46	32.1	52	8	11	33	
Round Whitefish	104	14	42	27.2	102	12	18	56	
Humpback Whitefish	20	24	38	28.7	17	2	6	10	

[1] Total catch for chum, coho, pink, and sockeye salmon includes all adult fish, regardless of length.

[2] Some fish captured at the Middle River fishwheels were transferred to Fish Distribution & Abundance (FDA) crews to be surgically radio-tagged at Curry; and a portion of these fish were released untagged.

Table A-5. Number of salmon captured at two fishwheel sites and in gillnets in the Lower River, 2013.

Species	Fishwheels West Bank	East Bank	Gillnet	All Gear Combined
Chinook Salmon	1,120	789	154	2,063
Chum Salmon	1,337	2,175		3,512
Coho Salmon	2,164	1,113		3,277
Pink Salmon	16,177	17,818		33,995
Sockeye Salmon	364	260		624
Total	21,162	22,155	154	43,471

Notes:

Totals include all adult salmon regardless of size, as well as all recaptured fish.

Table A-6. Number of Chinook salmon captured at two fishwheel sites and in gillnets in the Yentna River, 2013.

Fishwheels			All Gear
South	North	Gillnet	Combined
1,050	951	295	2,296

Notes:

Totals include all adult salmon regardless of size, as well as all recaptured fish.

Table A-7. Number of salmon caught in the Lower River and Yentna River and their length statistics, 2013.

Location	Total	Length (cm METF)			
Species Name	Catch	Min	Max	Mean	n
Lower River					
Chinook Salmon (≥ 50 cm)	1,232	50.0	106.0	65.7	1,232
Chinook Salmon (< 50 cm)	831	24.5	49.5	36.6	831
Chum Salmon	3,512	-	-	-	-
Coho Salmon	3,277	24.5	62.0	49.7	3,290
Pink Salmon	33,995	40.0	50.5	42.8	200
Sockeye Salmon	624	-	-	-	-
Yentna River					
Chinook Salmon (≥ 50 cm)	1,201	50.0	107.0	65.8	1,094
Chinook Salmon (< 50 cm)	1,094	20.5	49.5	35.2	1,200

Table A-8. Number of salmon captured at three fishwheel sites and in a beach seine in the Middle River, by size category, 2013.

	Fishwheels									Beach Seine	All Gear Combined		
	Site 1			Site 2			Site 3						
Species	Large	Small	Total	Large	Small	Total	Large	Small	Total	Large	Large	Small	Total
Chinook Salmon	514	262	776	89	64	153	13	10	23		616	336	952
Chum Salmon	1,263		1,263	510		510	1,644		1,644		3,417		3,417
Coho Salmon	949	1	950	186	5	191	576	6	582	11	1,722	12	1,734
Pink Salmon	2,385		2,385	2,125		2,125	11,185		11,185		15,695		15,695
Sockeye Salmon	73	18	91	64	50	114	39	32	71		176	100	276
Total	5,184	281	5,465	2,974	119	3,093	13,457	48	13,505	11	21,626	448	22,074

Notes:

Totals include all tagged fish recaptured at the fishwheels. Large Chinook salmon measured 50 cm METF or greater; and large chum, coho, pink, and sockeye salmon measured 40 cm METF or greater.

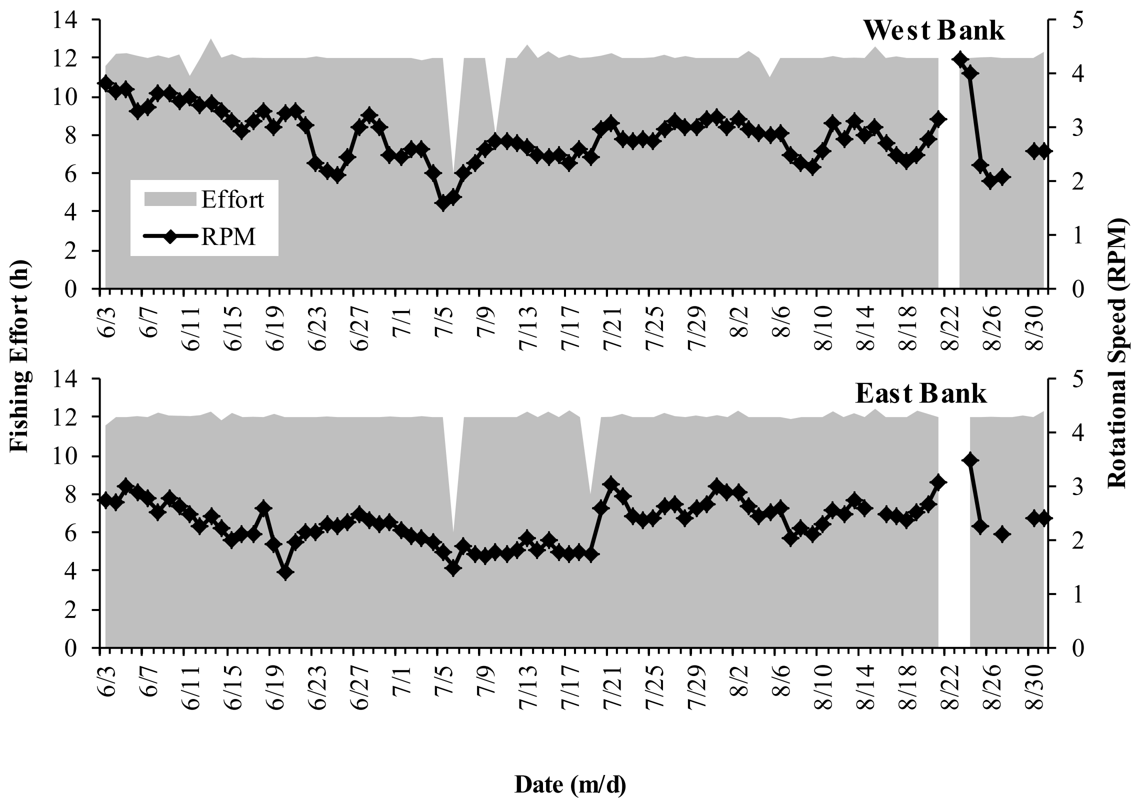


Figure A-1. Daily fishing effort (hours) and rotational speed (RPM) at two fishwheel sites in the Lower River, 2013.

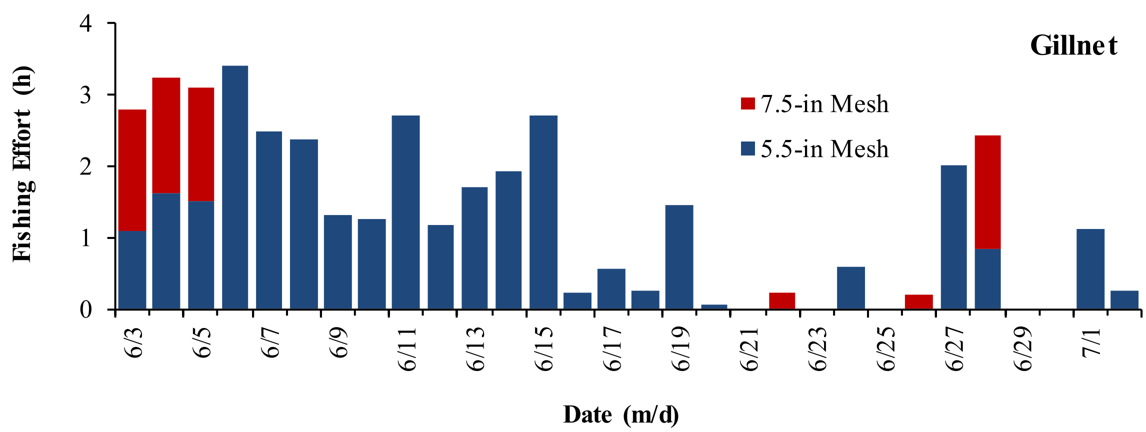


Figure A-2. Daily gillnet effort (hours) in the Lower River, by mesh size, 2013.

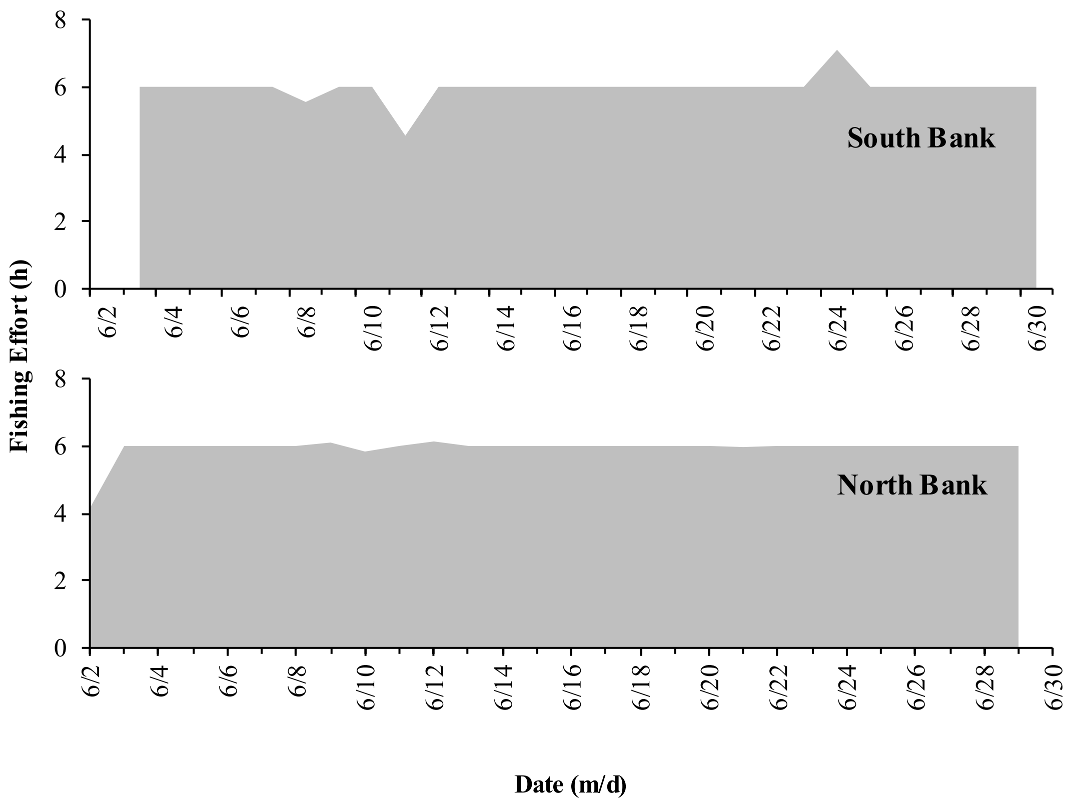


Figure A-3. Daily fishing effort (hours) at two fishwheel sites in the Yentna River, 2013.

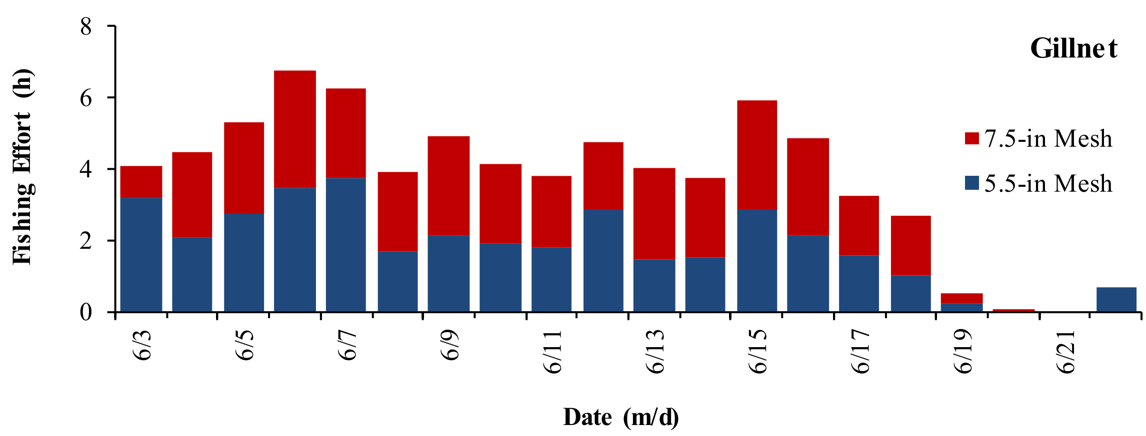


Figure A-4. Daily gillnet effort (hours) in the Yentna River, by mesh size, 2013.

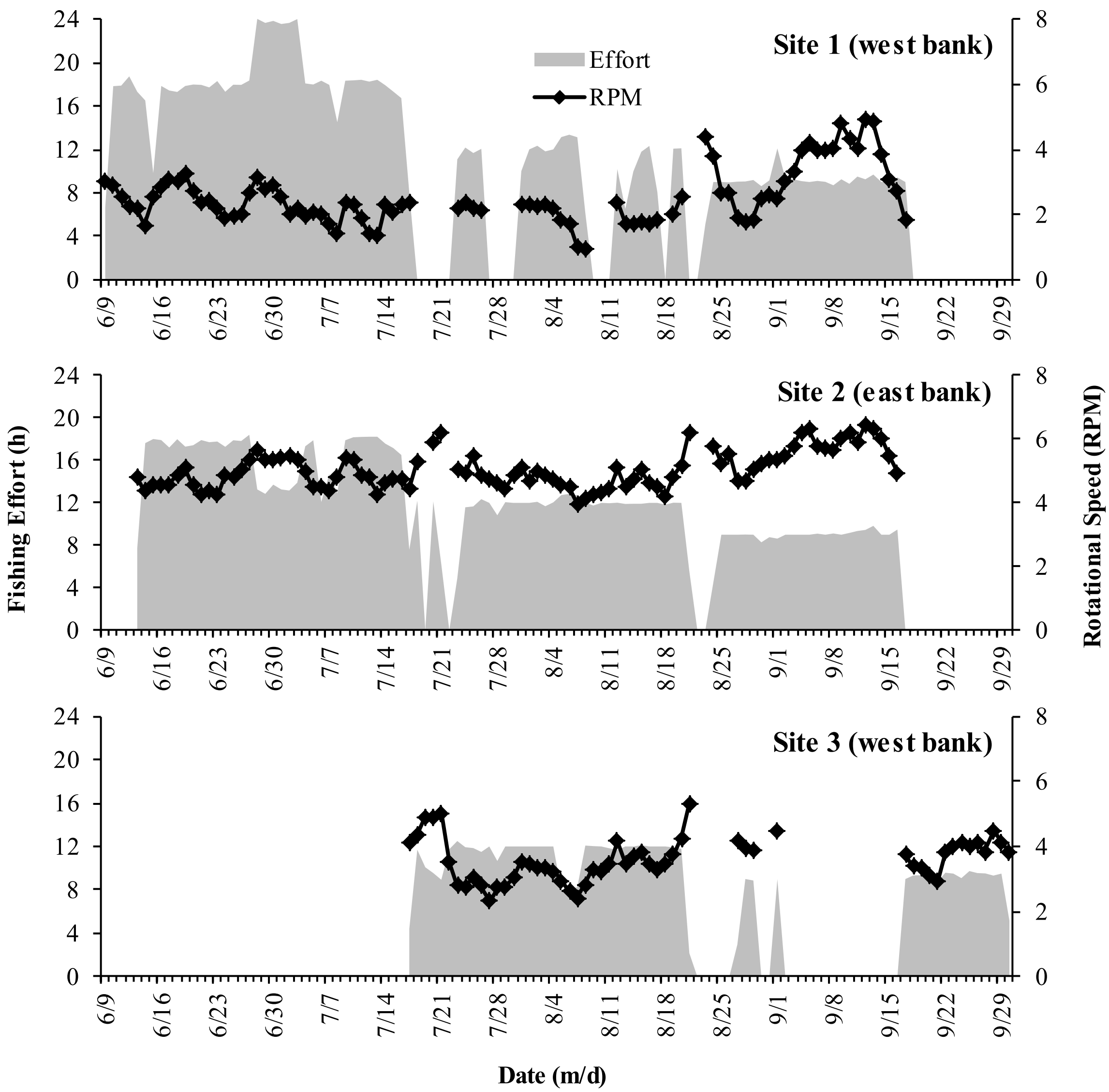


Figure A-5. Daily fishing effort (hours) and rotational speed (RPM) at three fishwheel sites in the Middle River, 2013.

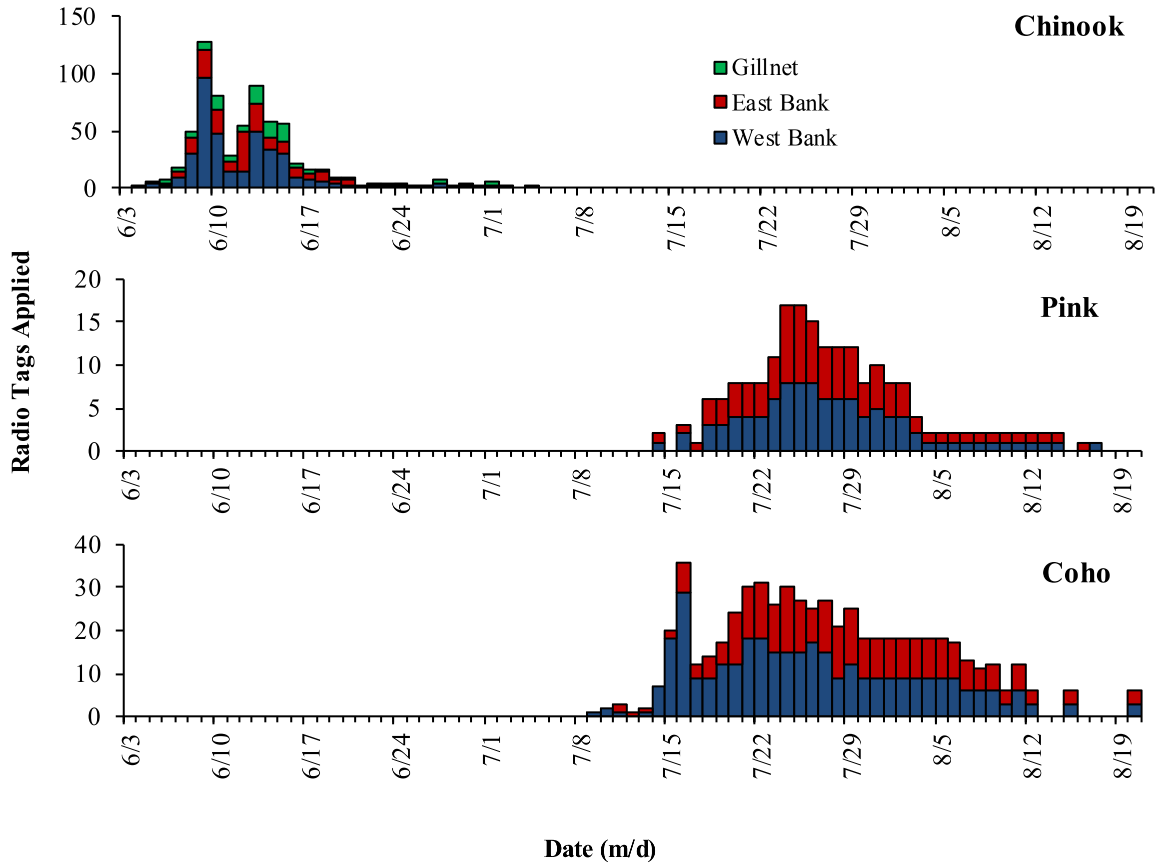


Figure A-6. Daily number of radio tags applied to adult Chinook, pink, and coho salmon captured at two fishwheel sites and in gillnets in the Lower River, 2013.

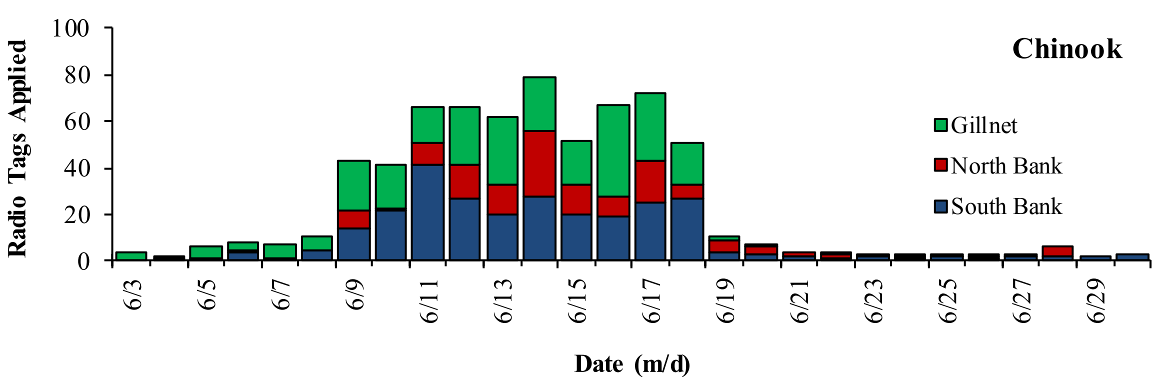


Figure A-7. Daily number of radio tags applied to adult Chinook salmon captured at two fishwheel sites and in gillnets in the Yentna River, 2013.

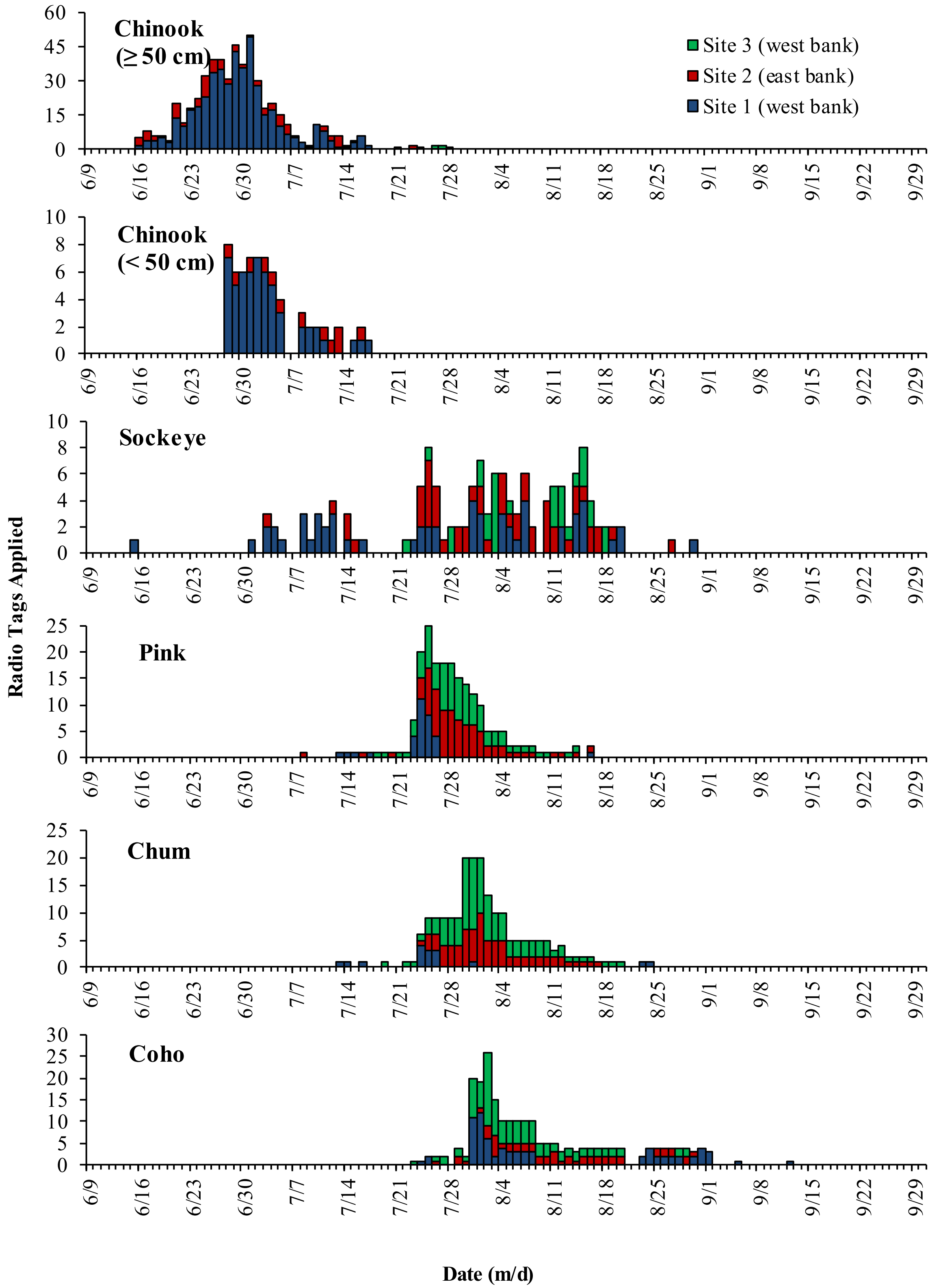


Figure A-8. Daily number of radio tags applied to adult Chinook, sockeye, pink, chum, and coho salmon captured at three fishwheel sites in the Middle River, 2013.

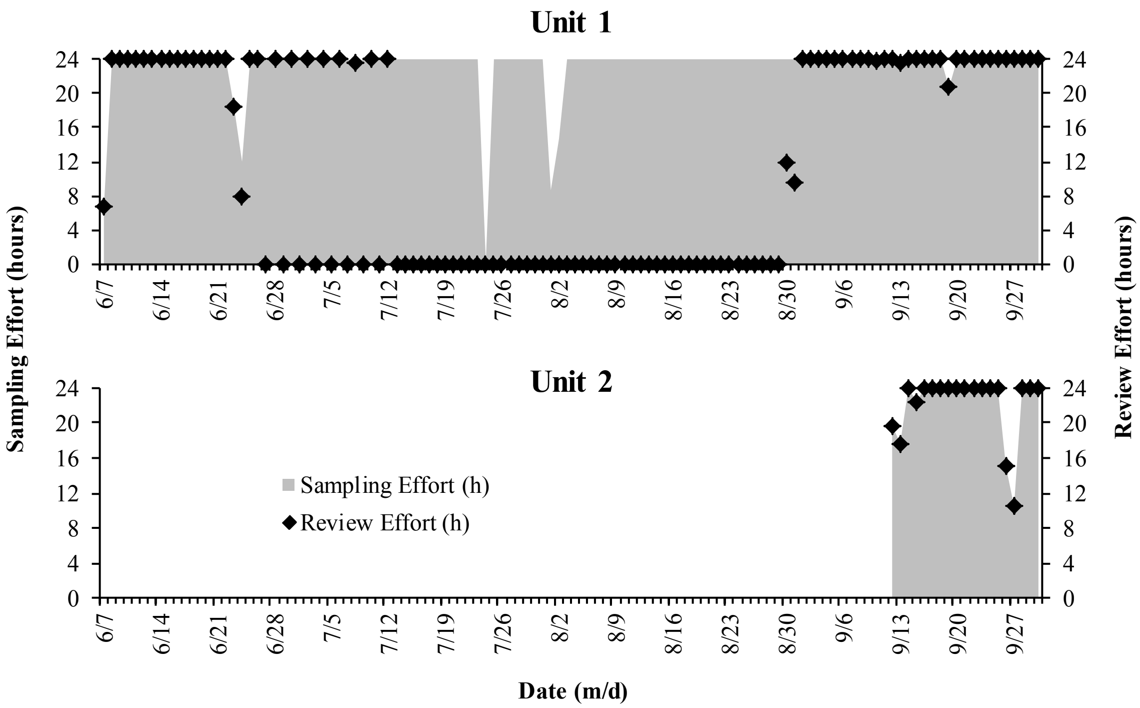


Figure A-9. Daily sampling effort, and the amount of imagery reviewed (review effort), for two ARIS units operated immediately downstream of the fishwheel at Site 1 in the Middle River, 2013.

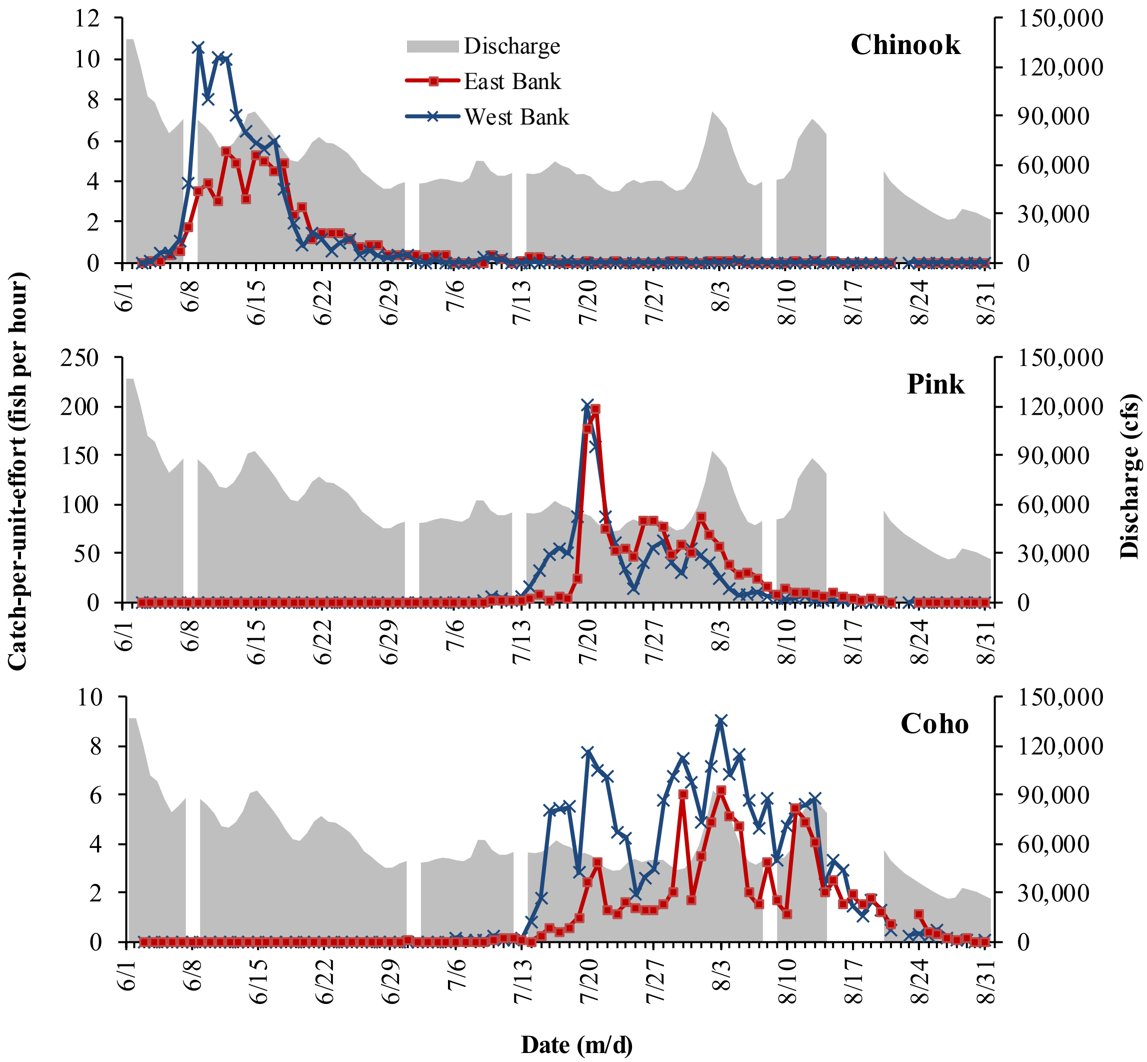


Figure A-10. Daily catch-per-unit-effort at the Lower River fishwheels, by species, and the Susitna River discharge at Sunshine, 2013.

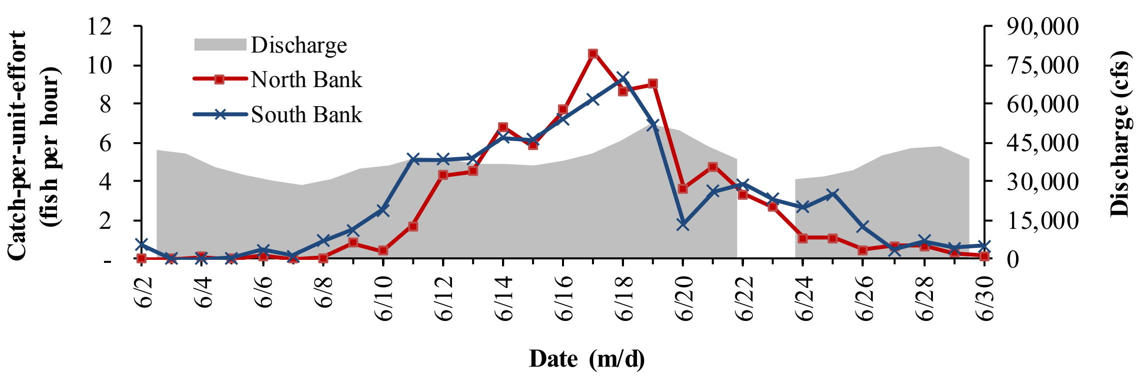


Figure A-11. Daily catch-per-unit-effort for Chinook salmon at the Yentna River fishwheels, and the Yentna River discharge at Lake Creek, 2013.

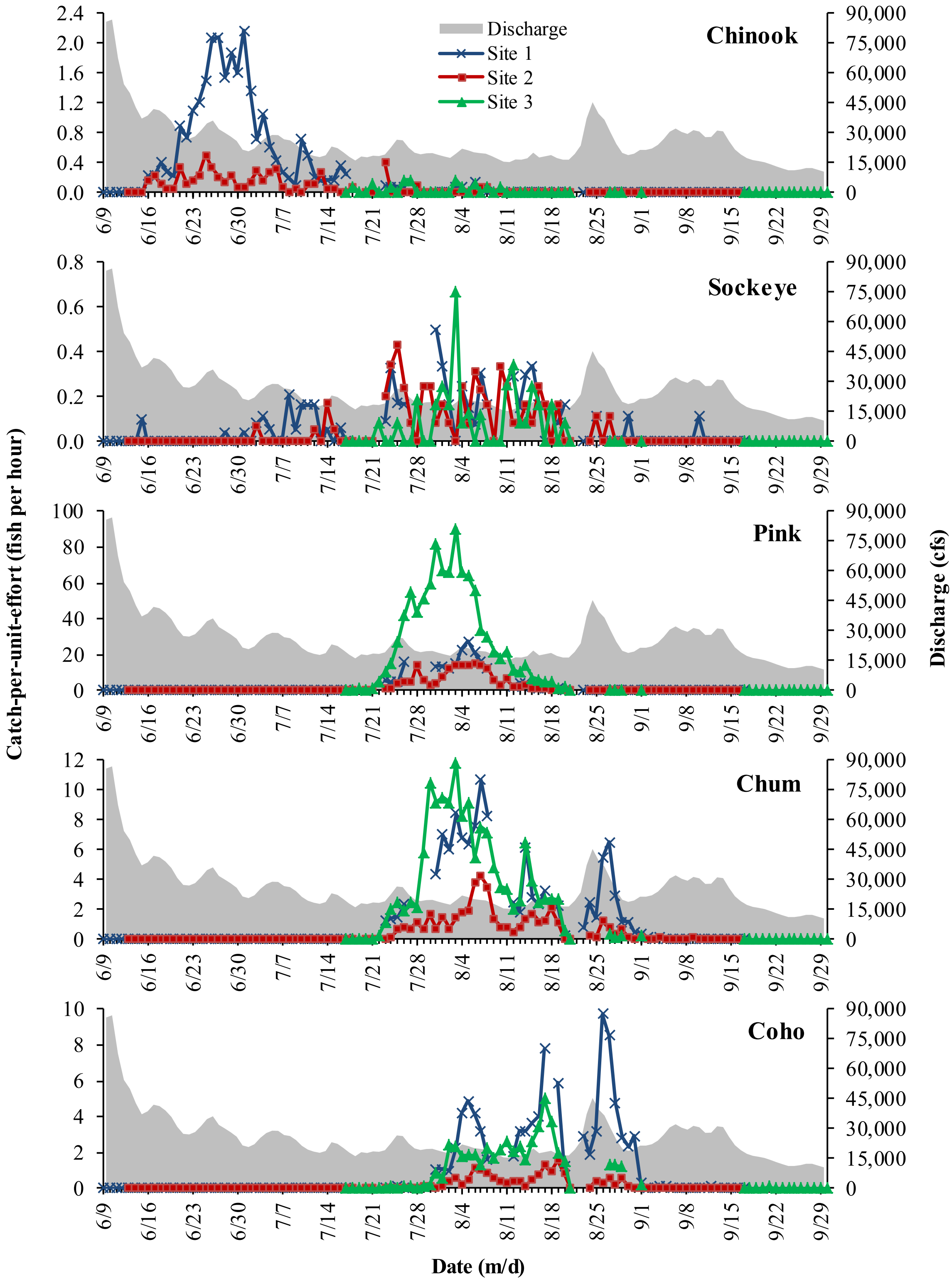


Figure A-12. Daily catch-per-unit-effort at the Middle River fishwheels, by species, and the Susitna River discharge at Gold Creek, 2013.

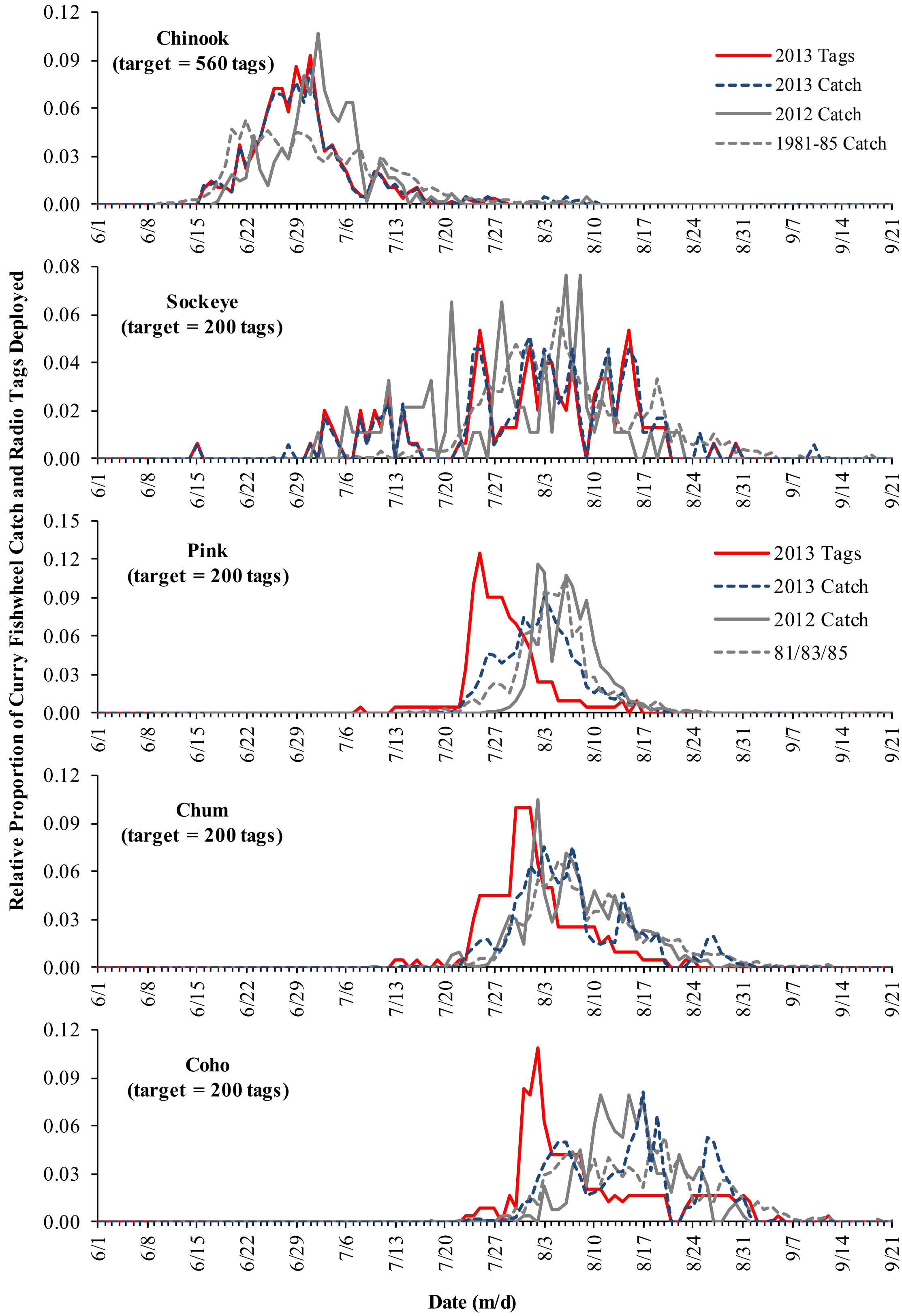


Figure A-13. Daily number of radio tags deployed at the Middle River fishwheels relative to fishwheel catches in the 1980s, 2012, and 2013.

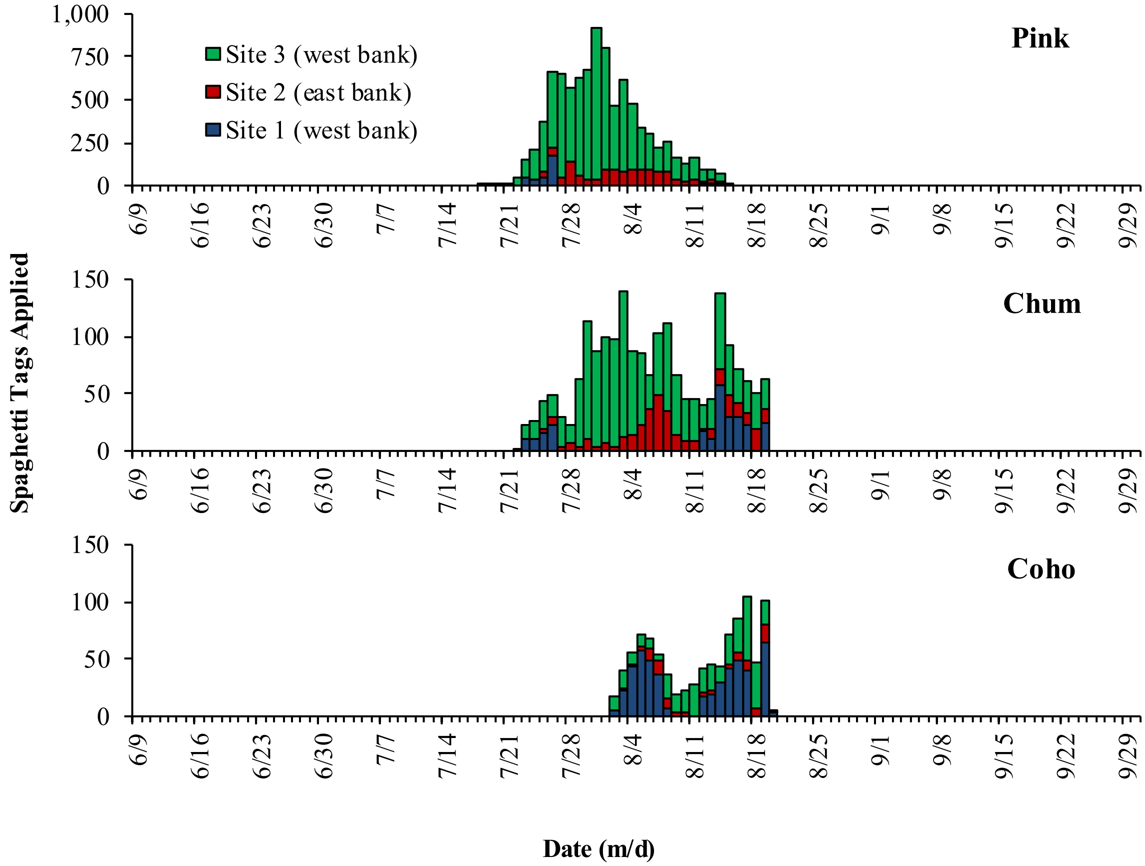


Figure A-14. Daily number of spaghetti tags applied to adult pink, chum, and coho salmon captured at three fishwheel sites in the Middle River, 2013.

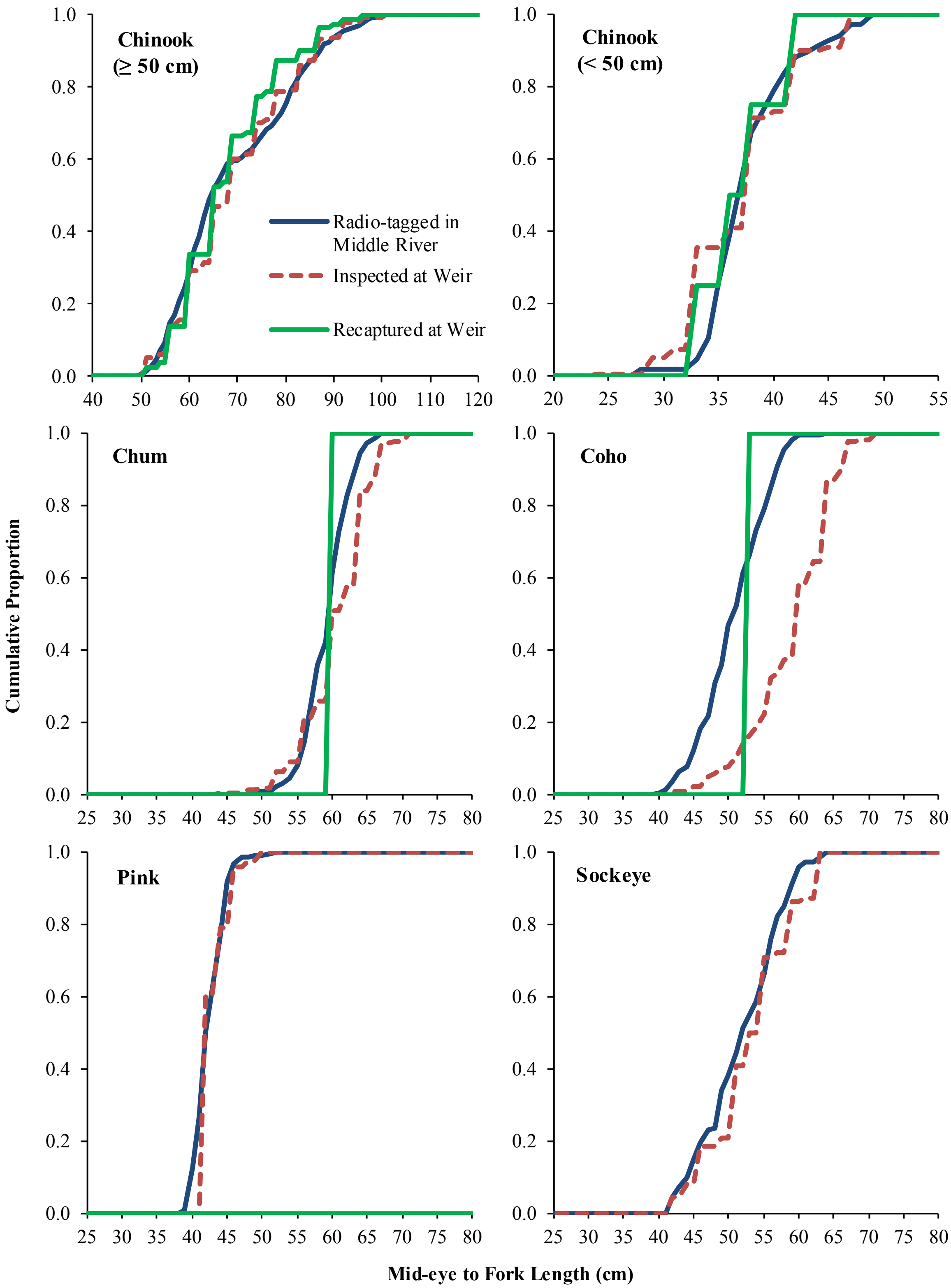


Figure A-15. Cumulative length-frequency distributions for salmon radio-tagged in the Middle River and inspected and recaptured at the Indian River weir site, by species, 2013.

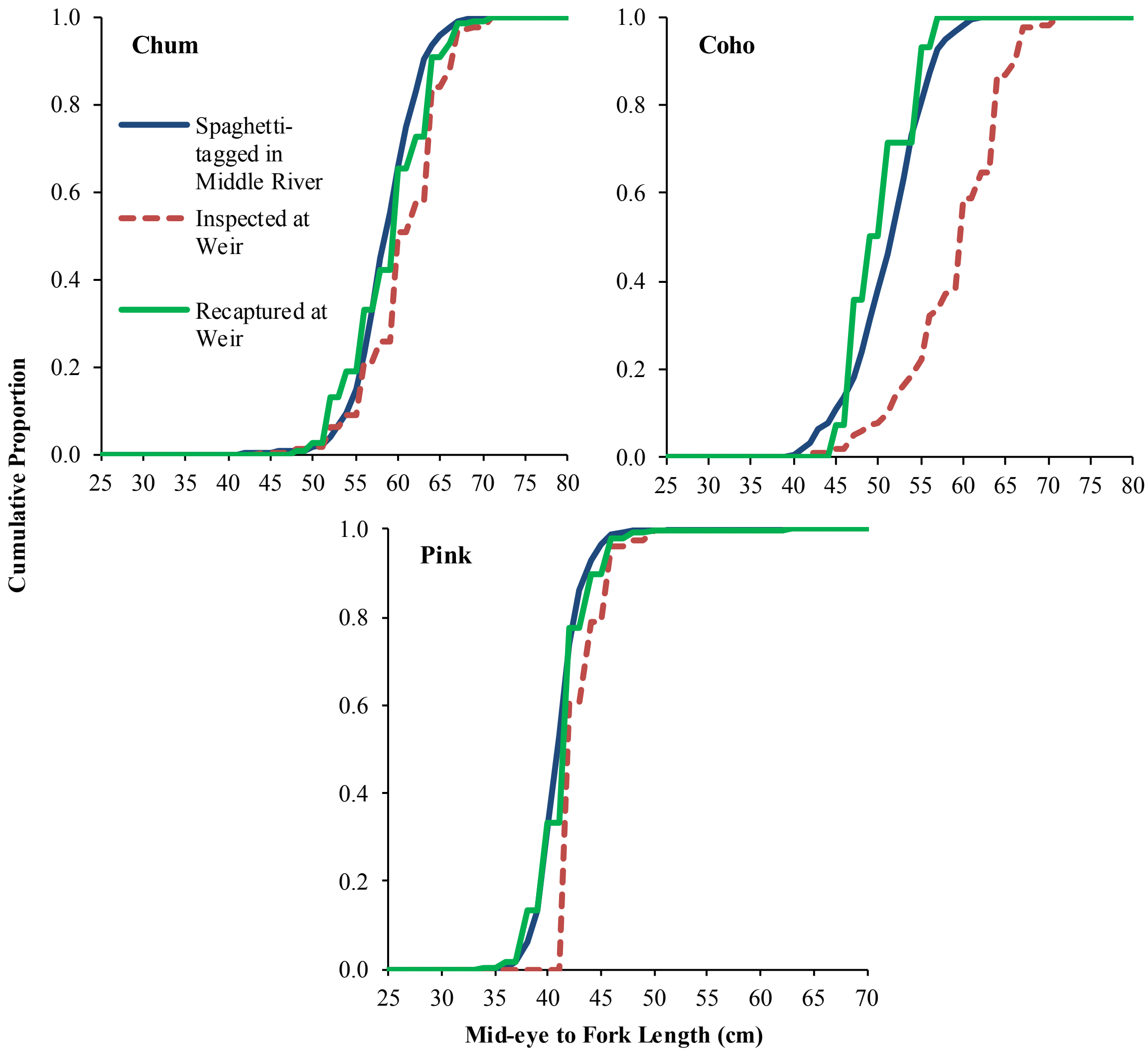


Figure A-16. Cumulative length-frequency distributions for salmon spaghetti-tagged in the Middle River and inspected and recaptured at the Indian River weir site, by species, 2013.

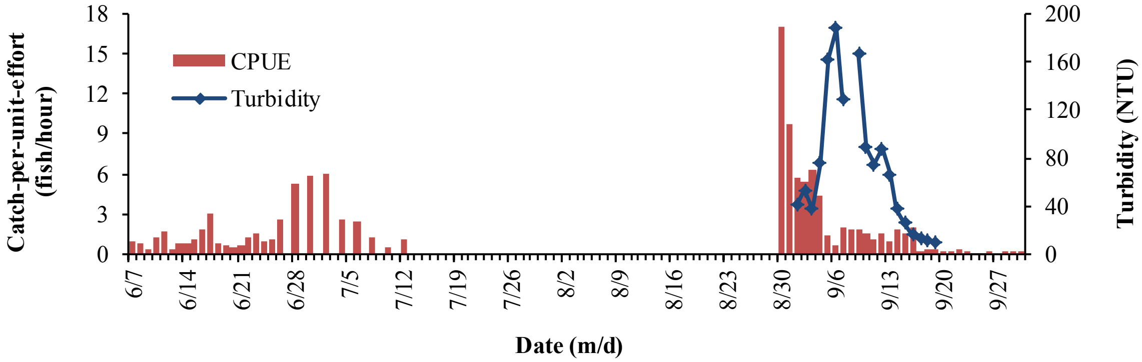


Figure A-17. Catch-per-unit-effort, or the number of targets counted per hour of imagery reviewed, on the ARIS (Unit 1) located immediately downstream of the Site 1 fishwheel, 2013. All ARIS data were included, regardless of whether the Site 1 fishwheel was operational. From June 7 to July 12, only targets measuring 50 cm or greater were recorded from ARIS imagery, whereas from August 30 to September 17, targets measuring 40 cm or greater were recorded. Turbidity measurements at Site 1 are also shown.

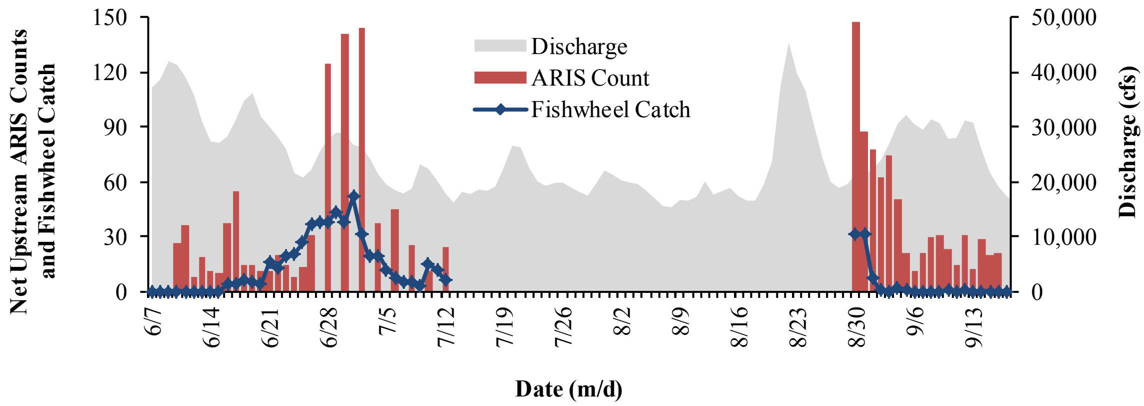


Figure A-18. Comparison of the number of adult salmon (≥ 50 cm METF) captured at the Site 1 fishwheel and concurrent net upstream counts of fish on the ARIS unit (Unit 1) located immediately downstream of the fishwheel, 2013. From June 7 to July 12, only targets measuring 50 cm or greater were recorded from ARIS imagery, whereas from August 30 to September 17, targets measuring 40 cm or greater were recorded. Discharge of the Susitna River at Gold Creek is also shown.

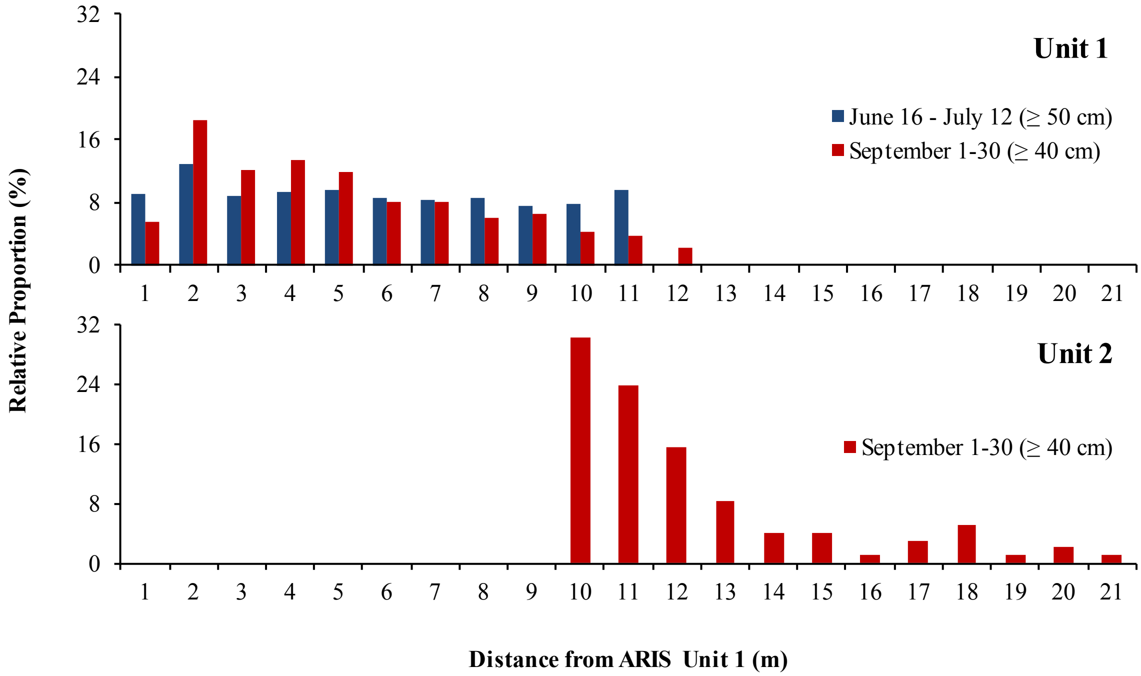


Figure A-19. Number of fish counted using ARIS at Site 1 as a function of the distance from each unit where they were first detected in the field of view, by time period and size category, 2013.

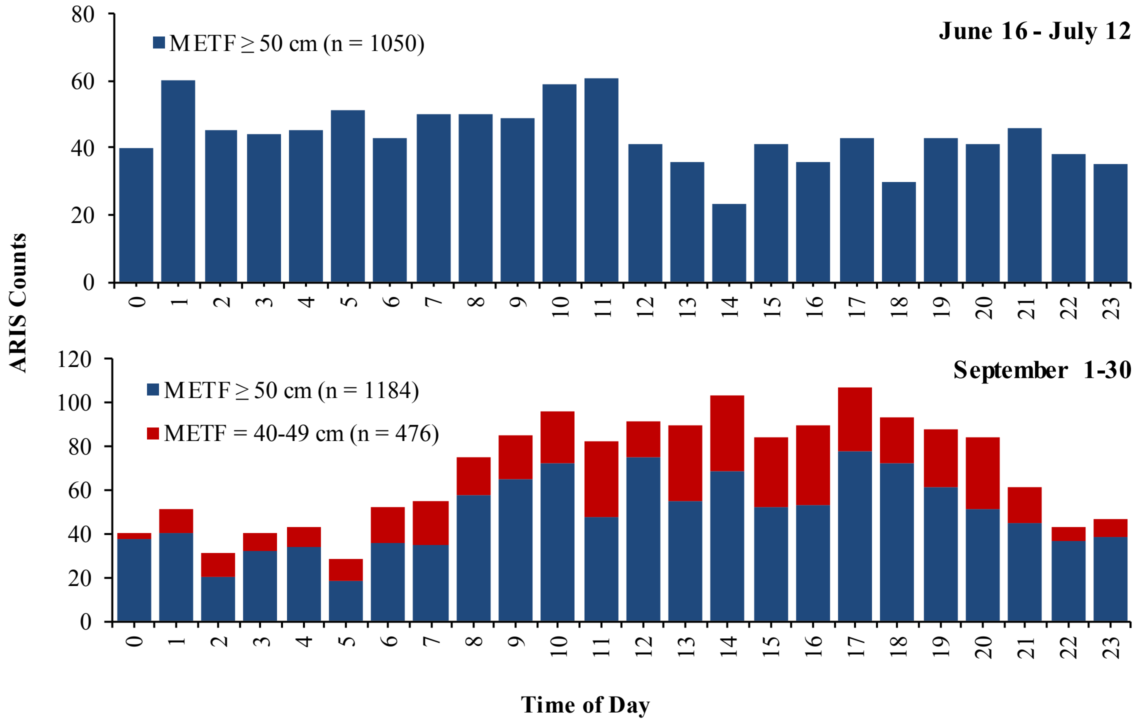


Figure A-20. Diel migration of fish counted using ARIS (Unit 1) at Site 1, by size category, 2013. Only upstream-moving fish counted during periods when 24-hours of imagery was reviewed were included. The top panel shows counts from June 16 to July 12 when mainly Chinook salmon were being captured at the Site 1 fishwheel. The bottom panel shows counts from September 1–30 when chum and coho salmon were presumably the predominant species migrating through the Middle River.

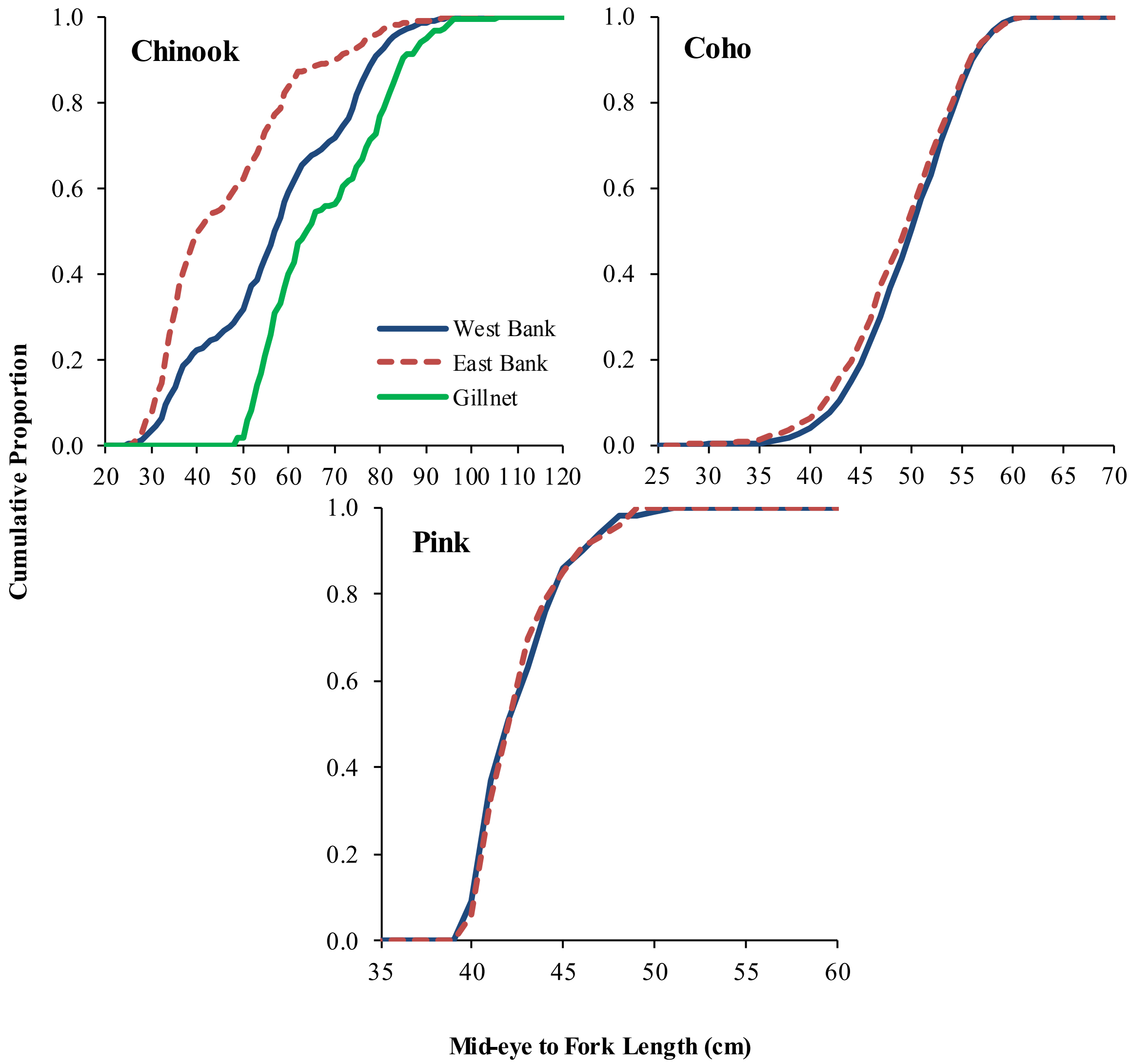


Figure A-21. Cumulative length-frequency distributions for salmon captured in the Lower River, by species and capture site, 2013.

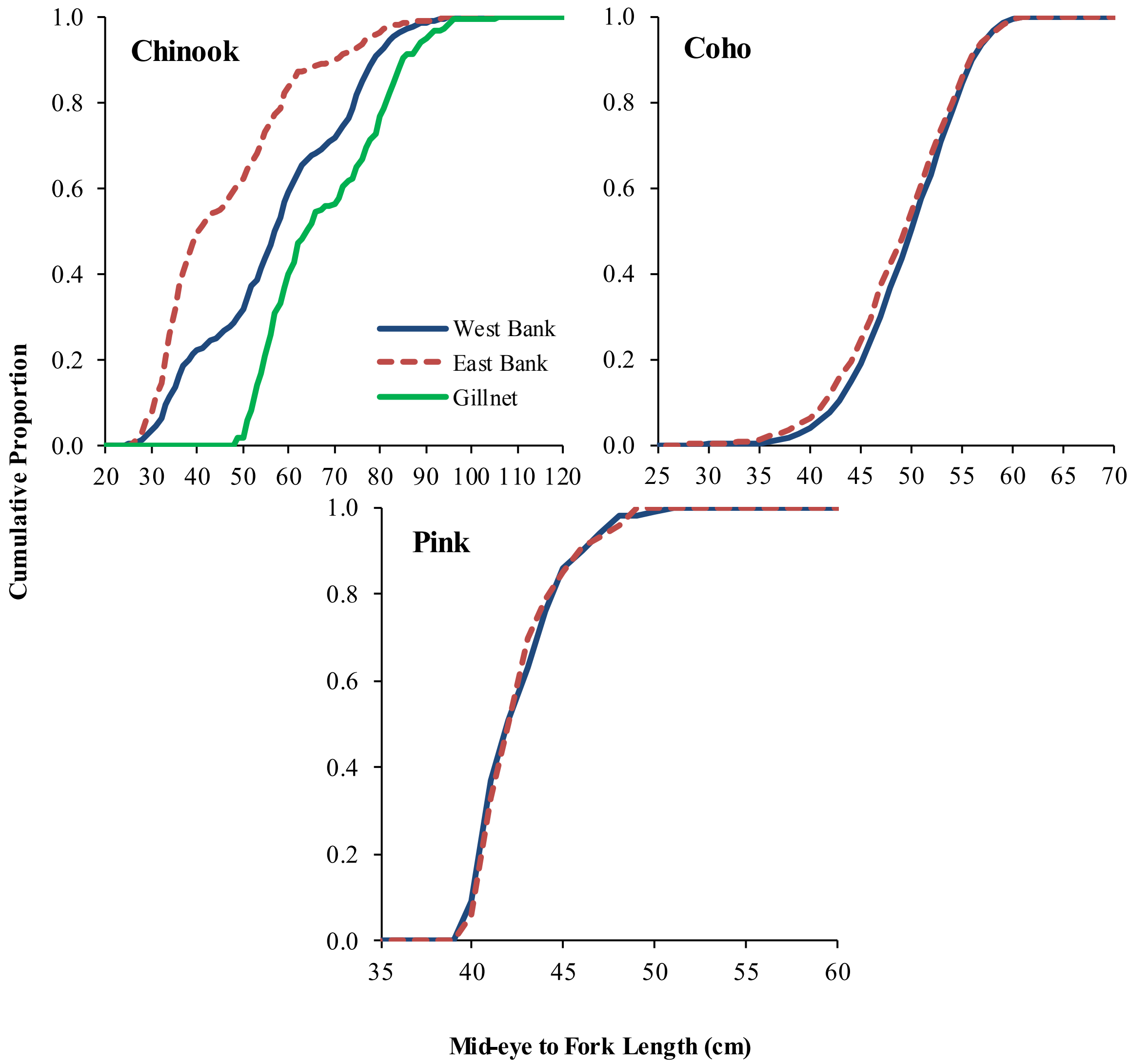


Figure A-22. Cumulative length-frequency distributions for salmon caught and radio-tagged in the Lower River, by species, 2013.

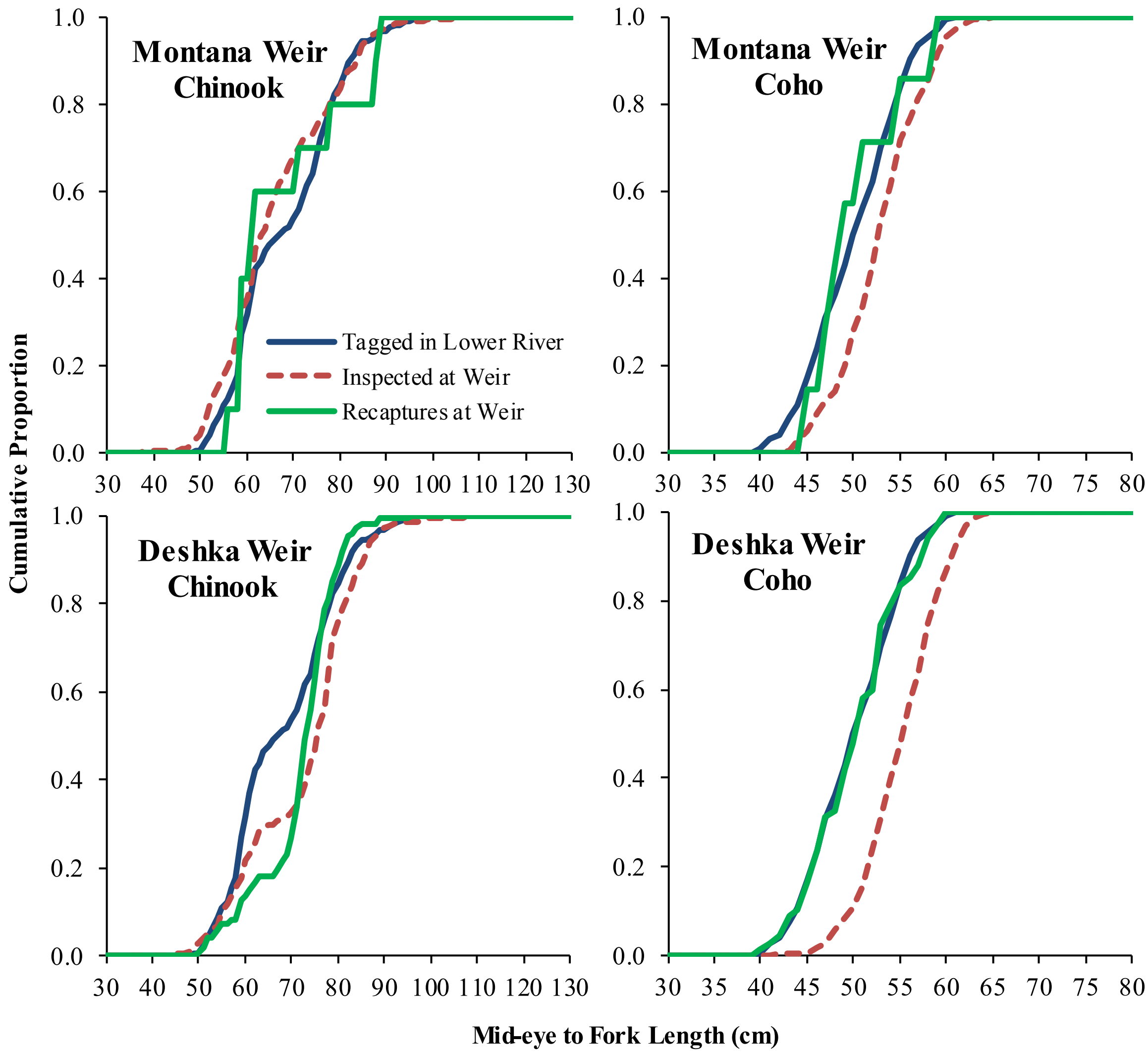


Figure A-23. Cumulative length-frequency distributions for salmon radio-tagged in the Lower River and inspected and recaptured at the Deshka River and Montana Creek weir sites, by species, 2013.

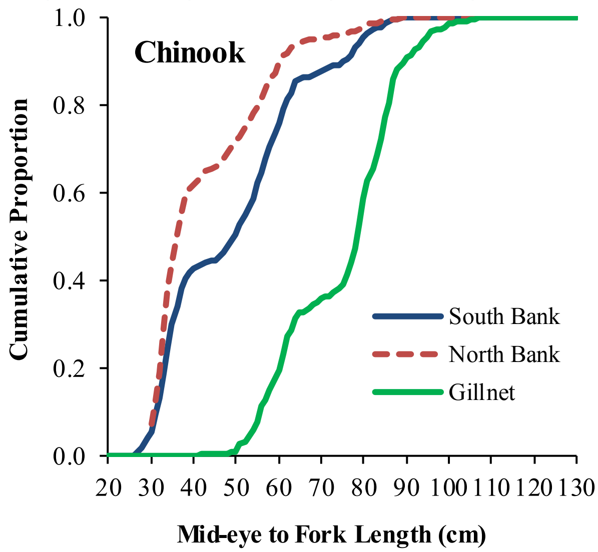


Figure A-24. Cumulative length-frequency distribution for Chinook salmon captured in the Yentna River, by capture site, 2013.

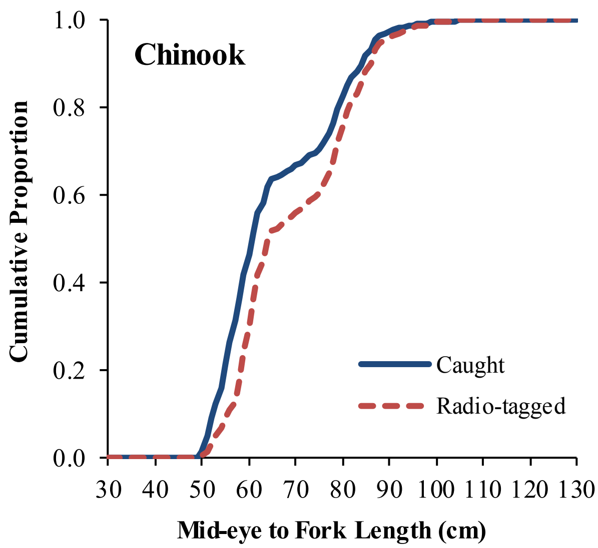


Figure A-25. Cumulative length-frequency distribution for Chinook salmon caught and radio-tagged in the Yentna River, 2013.

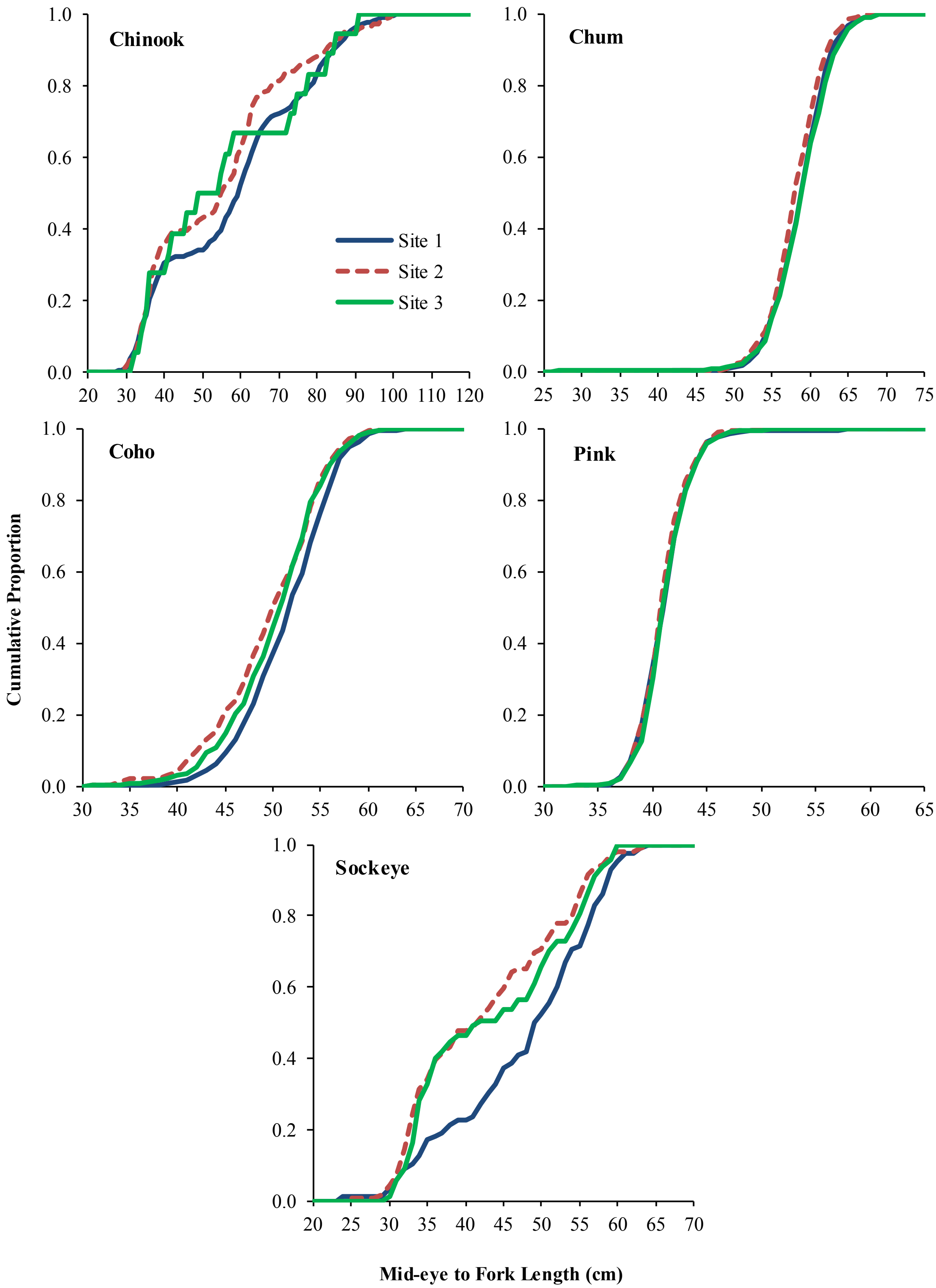


Figure A-26. Cumulative length-frequency distributions for salmon captured in the Middle River, by species and capture site, 2013.

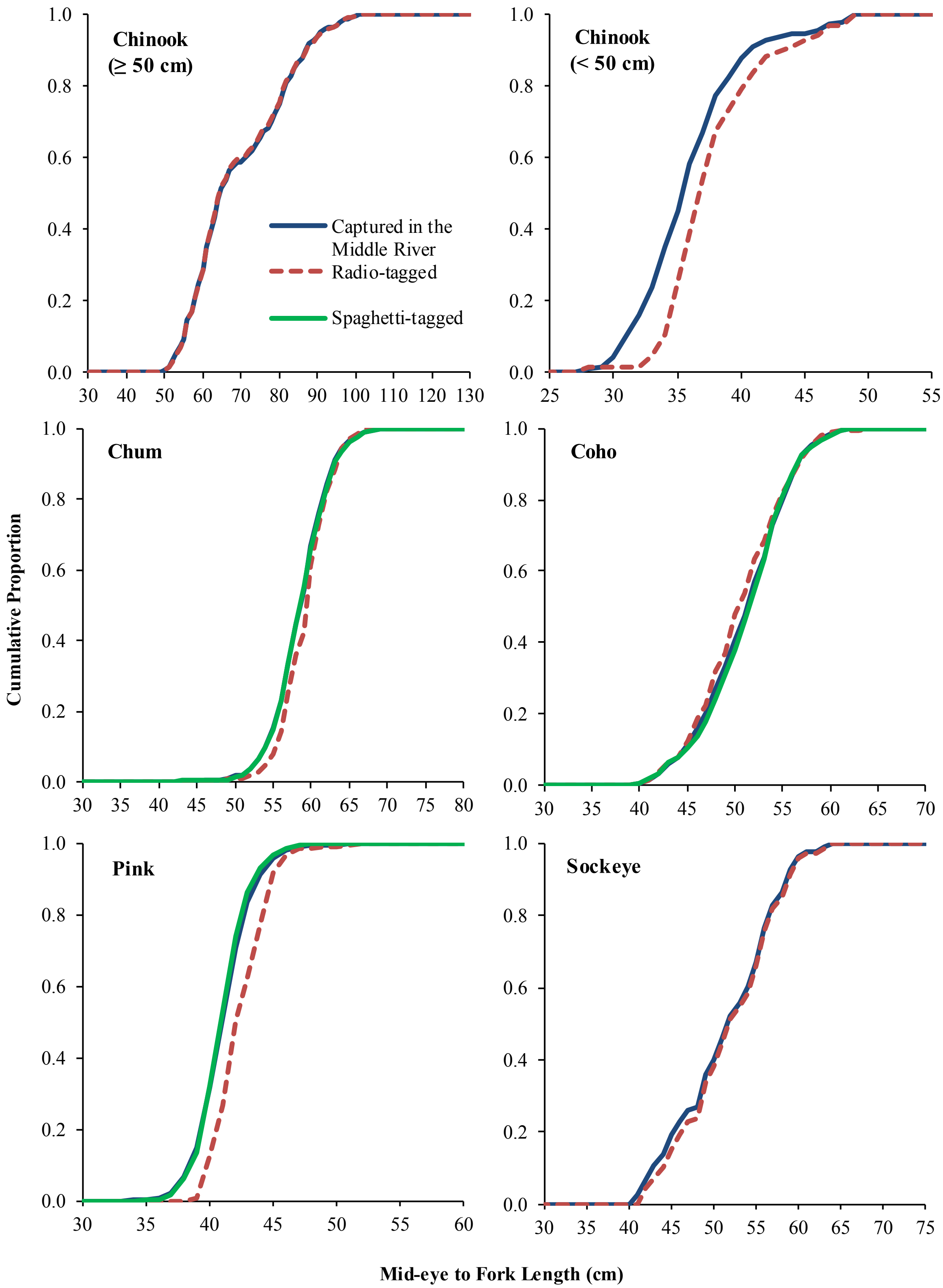


Figure A-27. Cumulative length-frequency distributions for salmon caught, radio-tagged, and spaghetti-tagged in the Middle River, by species, 2013.

PART A - 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, 2013.

	Chinook Salmon			Coho Salmon			Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
09-Jun	43	43	0	0	0	0	0	0	0	0	0	0
10-Jun	382	425	1	0	0	0	0	0	0	0	0	0
11-Jun	141	566	1	0	0	0	0	0	0	0	0	0
12-Jun	89	655	0	0	0	0	0	0	0	0	0	0
13-Jun	206	861	2	0	0	0	0	0	0	0	0	0
14-Jun	98	959	2	0	0	0	0	0	0	0	0	0
15-Jun	89	1,048	1	0	0	0	0	0	0	0	0	0
16-Jun	155	1,203	0	0	0	0	0	0	0	0	0	0
17-Jun	262	1,465	1	0	0	0	0	0	0	0	0	0
18-Jun	174	1,639	2	0	0	0	0	0	0	0	0	0
19-Jun	44	1,683	0	0	0	0	0	0	0	0	0	0
20-Jun	110	1,793	3	0	0	0	0	0	0	0	0	0
21-Jun	752	2,545	4	0	0	0	0	0	0	0	0	0
22-Jun	1,810	4,355	14	0	0	0	0	0	0	0	0	0
23-Jun	2,583	6,938	16	0	0	0	0	0	0	0	0	0
24-Jun	481	7,419	1	0	0	0	0	0	0	0	0	0
25-Jun	3,055	10,474	23	0	0	0	0	0	0	0	0	0
26-Jun	1,313	11,787	2	0	0	0	0	0	0	0	0	0
27-Jun	1,072	12,859	10	0	0	0	0	0	0	0	0	0
28-Jun	310	13,169	4	0	0	0	0	0	0	0	0	0
29-Jun	295	13,464	1	0	0	0	0	0	0	0	0	0
30-Jun	563	14,027	6	0	0	0	0	0	0	0	0	0
01-Jul	1,158	15,185	19	0	0	0	0	0	0	0	0	0
02-Jul	215	15,400	1	0	0	0	0	0	0	0	0	0
03-Jul	474	15,874	2	0	0	0	0	0	0	0	0	0
04-Jul	842	16,716	10	0	0	0	0	0	0	0	0	0
05-Jul	557	17,273	12	0	0	0	0	0	0	0	2	2
06-Jul	529	17,802	9	0	0	0	0	0	0	0	0	2
07-Jul	37	17,839	1	0	0	0	12	12	0	0	0	2
08-Jul	8	17,847	0	0	0	0	16	28	0	0	0	2
09-Jul	63	17,910	0	0	0	0	10	38	0	0	0	2

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	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
10-Jul	17	17,927	0	2	2	0	3	41	0	0	0	2
11-Jul	81	18,008	0	14	16	0	0	41	0	0	0	2
12-Jul	46	18,054	0	3	19	0	4	45	0	0	0	2
13-Jul	24	18,078	0	7	26	0	8	53	0	0	0	2
14-Jul	5	18,083	0	1	27	0	7	60	0	0	0	2
15-Jul	45	18,128	0	1	28	0	10	70	0	0	0	2
16-Jul	16	18,144	0	0	28	0	3	73	0	0	0	2
17-Jul	11	18,155	0	0	28	0	9	82	0	0	0	2
18-Jul	43	18,198	0	8	36	0	5	87	0	0	0	2
19-Jul	28	18,226	0	14	50	1	13	100	6	6	3	5
20-Jul	9	18,235	0	10	60	1	45	145	0	6	0	5
21-Jul	6	18,241	0	9	69	0	553	698	2	8	1	6
22-Jul	8	18,249	0	26	95	1	584	1,282	1	9	2	8
23-Jul	16	18,265	0	12	107	0	266	1,548	0	9	0	8
24-Jul	9	18,274	0	6	113	0	353	1,901	1	10	0	8
25-Jul	2	18,276	0	2	115	0	1,842	3,743	0	10	0	8
26-Jul	5	18,281	0	10	125	0	1,407	5,150	0	10	0	8
27-Jul	5	18,286	0	11	136	0	964	6,114	0	10	0	8
28-Jul	4	18,290	0	1	137	0	281	6,395	0	10	0	8
29-Jul	4	18,294	0	3	140	0	1,537	7,932	0	10	0	8
30-Jul	2	18,296	0	0	140	0	1,439	9,371	0	10	0	8
31-Jul	2	18,298	0	0	140	0	593	9,964	0	10	0	8
01-Aug	4	18,302	0	2	142	0	260	10,224	0	10	0	8
02-Aug	12	18,314	0	11	153	0	167	10,391	1	11	0	8
03-Aug	8	18,322	0	10	163	0	211	10,602	0	11	2	10
04-Aug	6	18,328	0	58	221	0	676	11,278	0	11	1	11
05-Aug	7	18,335	0	167	388	0	2,017	13,295	0	11	4	15
06-Aug	3	18,338	0	131	519	0	4,676	17,971	0	11	4	19
07-Aug	5	18,343	0	296	815	0	2,792	20,763	1	12	2	21
08-Aug	0	18,343	0	269	1,084	0	1,603	22,366	0	12	0	21
09-Aug	1	18,344	0	616	1,700	2	749	23,115	2	14	0	21

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	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
10-Aug	0	18,344	0	178	1,878	0	1,384	24,499	0	14	1	22
11-Aug	0	18,344	0	539	2,417	0	320	24,819	3	17	1	23
12-Aug	49	18,393	0	8,119	10,536	21	446	25,265	5	22	3	26
13-Aug	14	18,407	0	1,519	12,055	6	155	25,420	0	22	0	26
14-Aug	8	18,415	0	1,132	13,187	3	393	25,813	0	22	0	26
15-Aug	10	18,425	0	664	13,851	2	1,173	26,986	0	22	0	26
16-Aug	4	18,429	0	484	14,335	0	198	27,184	0	22	2	28
17-Aug	6	18,435	0	1,052	15,387	3	154	27,338	1	23	0	28
18-Aug	16	18,451	0	843	16,230	2	109	27,447	3	26	2	30
19-Aug	7	18,458	0	243	16,473	1	89	27,536	1	27	0	30
20-Aug	3	18,461	0	490	16,963	3	111	27,647	0	27	0	30
21-Aug	4	18,465	0	747	17,710	3	79	27,726	3	30	1	31
22-Aug	8	18,473	0	3,745	21,455	15	31	27,757	9	39	5	36
23-Aug	11	18,484	0	430	21,885	3	21	27,778	0	39	0	36
24-Aug	9	18,493	0	31	21,916	0	23	27,801	0	39	0	36
25-Aug	10	18,503	0	25	21,941	0	83	27,884	0	39	1	37
26-Aug	9	18,512	0	48	21,989	0	11	27,895	4	43	0	37
27-Aug	5	18,517	0	19	22,008	0	3	27,898	0	43	0	37
28-Aug	5	18,522	0	30	22,038	0	4	27,902	5	48	0	37
29-Aug	1	18,523	0	25	22,063	0	10	27,912	3	51	0	37
30-Aug	3	18,526	0	16	22,079	0	5	27,917	0	51	0	37
31-Aug	3	18,529	0	10	22,089	0	7	27,924	1	52	0	37
01-Sep	0	18,529	0	9	22,098	0	4	27,928	0	52	0	37
02-Sep	2	18,531	0	42	22,140	0	1	27,929	2	54	0	37
03-Sep	0	18,531	0	1	22,141	0	0	27,929	0	54	0	37
Total	18,531		148	22,141		67	27,929		54		37	

Table B-2. Length statistics for tagged and untagged adult salmon sampled at the Deshka River, Montana Creek, and Indian River weirs in 2013, by species.

	Deshka River Weir			Montana Creek Weir			Indian River Weir		
Species	**Tagged**	**Not Tagged**	**Total**	**Tagged**	**Not Tagged**	**Total**	**Tagged**	**Not Tagged**	**Total**
Chinook Salmon (≥ 50 cm)									
Min	50	51	50	56	50	50	51	51	51
Max	96	108	108	89	105	105	96	114	114
Mean	72.0	73.4	72.9	68.1	67.2	67.3	68.0	69.8	69.7
n	148	273	421	11	207	218	80	1,131	1,211
Chinook Salmon (< 50 cm)									
Min		45	45		38	38	33	24	24
Max		50	50		49	49	42	46	46
Mean		47.7	47.7		46.7	46.7	36.9	37.2	37.2
n		8	8		7	7	4	369	373
Chum Salmon (≥ 40 cm)									
Min							48	44	44
Max							71	75	75
Mean							58.7	61.0	60.4
n							299	988	1,287
Coho Salmon (≥ 40 cm)									
Min	40	42	40	45	43	43	44	42	42
Max	60	65	65	52	65	65	57	63	63
Mean	50.4	55.4	54.4	47.9	53.2	53.1	50.1	51.2	51.1
n	67	267	334	7	200	207	15	249	264
Pink Salmon									
Min							33	29	29
Max							62	58	62
Mean							41.3	41.7	41.4
n							930	623	1,553
Sockeye Salmon (≥ 40 cm)									
Min								42	42
Max								63	63
Mean								53.2	53.2
n								86	86

Notes:

Lengths are mid-eye to fork (METF).

Table B-3. Montana Creek weir daily passage rates and tag recaptures, by species, 2013.

	Chinook Salmon			Coho Salmon			Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
17-Jun	0	0	0	0	0	0	0	0	0	0	0	0
18-Jun	0	0	0	0	0	0	0	0	0	0	0	0
19-Jun	0	0	0	0	0	0	0	0	0	0	0	0
20-Jun	0	0	0	0	0	0	0	0	0	0	0	0
21-Jun	0	0	0	0	0	0	0	0	0	0	0	0
22-Jun	0	0	0	0	0	0	0	0	0	0	0	0
23-Jun	0	0	0	0	0	0	0	0	0	0	0	0
24-Jun	0	0	0	0	0	0	0	0	0	0	0	0
25-Jun	0	0	0	0	0	0	0	0	0	0	0	0
26-Jun	0	0	0	0	0	0	0	0	0	0	0	0
27-Jun	0	0	0	0	0	0	0	0	0	0	0	0
28-Jun	0	0	0	0	0	0	0	0	0	0	0	0
29-Jun	0	0	0	0	0	0	0	0	0	0	0	0
30-Jun	0	0	0	0	0	0	0	0	0	0	0	0
01-Jul	0	0	0	0	0	0	0	0	0	0	0	0
02-Jul	0	0	0	0	0	0	0	0	0	0	0	0
03-Jul	0	0	0	0	0	0	0	0	0	0	0	0
04-Jul	0	0	0	0	0	0	0	0	0	0	0	0
05-Jul	0	0	0	0	0	0	0	0	0	0	0	0
06-Jul	0	0	0	0	0	0	0	0	0	0	0	0
07-Jul	0	0	0	0	0	0	0	0	0	0	0	0
08-Jul	2	2	0	0	0	0	0	0	0	0	0	0
09-Jul	7	9	0	0	0	0	0	0	0	0	0	0
10-Jul	201	210	3	0	0	0	0	0	0	0	0	0
11-Jul	336	546	1	0	0	0	0	0	0	0	0	0
12-Jul	4	550	0	0	0	0	0	0	0	0	0	0
13-Jul	323	873	1	0	0	0	0	0	0	0	0	0
14-Jul	54	927	1	0	0	0	0	0	0	0	0	0
15-Jul	161	1,088	0	0	0	0	0	0	0	0	0	0
16-Jul	69	1,157	1	0	0	0	0	0	0	0	0	0
17-Jul	160	1,317	0	0	0	0	0	0	0	0	0	0

Table B-3. Continued.

	Chinook Salmon			Coho Salmon			Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
18-Jul	96	1,413	0	0	0	0	0	0	0	0	0	0
19-Jul	8	1,421	0	0	0	0	0	0	0	0	0	0
20-Jul	20	1,441	0	0	0	0	26	26	4	4	0	0
21-Jul	70	1,511	0	0	0	0	26	52	17	21	0	0
22-Jul	73	1,584	0	0	0	0	61	113	39	60	0	0
23-Jul	13	1,597	0	0	0	0	9	122	6	66	0	0
24-Jul	21	1,618	1	0	0	0	25	147	13	79	0	0
25-Jul	103	1,721	0	0	0	0	1,420	1,567	118	197	0	0
26-Jul	181	1,902	0	0	0	0	2,380	3,947	348	545	0	0
27-Jul	12	1,914	0	0	0	0	575	4,522	86	631	0	0
28-Jul	3	1,917	1	0	0	0	77	4,599	29	660	0	0
29-Jul	4	1,921	1	0	0	0	144	4,743	23	683	0	0
30-Jul	4	1,925	0	0	0	0	38	4,781	7	690	0	0
31-Jul	3	1,928	0	0	0	0	87	4,868	185	875	0	0
01-Aug	2	1,930	0	1	1	0	217	5,085	255	1,130	0	0
02-Aug	5	1,935	0	0	1	0	115	5,200	190	1,320	0	0
03-Aug	0	1,935	0	4	5	0	312	5,512	295	1,615	0	0
04-Aug	4	1,939	0	7	12	0	266	5,778	499	2,114	0	0
05-Aug	14	1,953	0	17	29	0	498	6,276	948	3,062	0	0
06-Aug	9	1,962	0	10	39	0	307	6,583	409	3,471	0	0
07-Aug	2	1,964	0	8	47	0	136	6,719	161	3,632	0	0
08-Aug	6	1,970	0	8	55	0	122	6,841	111	3,743	0	0
09-Aug	4	1,974	0	11	66	0	387	7,228	204	3,947	0	0
10-Aug	8	1,982	0	28	94	0	499	7,727	580	4,527	0	0
11-Aug	6	1,988	0	17	111	1	126	7,853	201	4,728	0	0
12-Aug	12	2,000	0	30	141	1	169	8,022	218	4,946	0	0
13-Aug	4	2,004	0	13	154	0	192	8,214	130	5,076	0	0
14-Aug	1	2,005	0	12	166	0	227	8,441	93	5,169	0	0
15-Aug	1	2,006	1	11	177	1	401	8,842	131	5,300	0	0
16-Aug	3	2,009	0	7	184	1	101	8,943	308	5,608	0	0
17-Aug	1	2,010	0	14	198	0	149	9,092	370	5,978	0	0

Table B-3. Continued.

	Chinook Salmon			Coho Salmon			Pink Salmon		Chum Salmon		Sockeye Salmon	
Date	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Radio Tags	Daily Count	Cum. Count	Daily Count	Cum. Count	Daily Count	Cum. Count
18-Aug	2	2,012	0	7	205	0	109	9,201	337	6,315	0	0
19-Aug	1	2,013	0	10	215	0	243	9,444	137	6,452	0	0
20-Aug	1	2,014	0	454	669	2	281	9,725	288	6,740	0	0
21-Aug	0	2,014	0	0	669	0	0	9,725	0	6,740	0	0
22-Aug	0	2,014	0	0	669	0	0	9,725	0	6,740	0	0
23-Aug	0	2,014	0	0	669	0	0	9,725	0	6,740	0	0
24-Aug	0	2,014	0	0	669	0	0	9,725	0	6,740	0	0
25-Aug	0	2,014	0	0	669	0	0	9,725	0	6,740	0	0
26-Aug	0	2,014	0	4	673	0	10	9,735	21	6,761	0	0
27-Aug	1	2,015	0	8	681	0	16	9,751	40	6,801	0	0
28-Aug	0	2,015	0	16	697	0	9	9,760	67	6,868	0	0
29-Aug	0	2,015	0	17	714	0	7	9,767	37	6,905	0	0
30-Aug	0	2,015	0	15	729	0	5	9,772	31	6,936	0	0
31-Aug	0	2,015	0	10	739	0	2	9,774	26	6,962	0	0
01-Sep	0	2,015	0	26	765	0	0	9,774	31	6,993	0	0
02-Sep	0	2,015	0	0	765	0	0	9,774	0	6,993	0	0
03-Sep	0	2,015	0	0	765	0	0	9,774	0	6,993	0	0
04-Sep	0	2,015	0	0	765	0	0	9,774	0	6,993	0	0
05-Sep	0	2,015	0	0	765	0	0	9,774	0	6,993	0	0
Total	2,015		11	765		6	9,774		6,993		0	

Table B-4. Indian River weir daily passage rates and tag recaptures, by species, 2013.

	Chinook Salmon				Chum Salmon			Coho Salmon			Pink Salmon			Sockeye Salmon	
	METF ≥ 50 cm		METF < 50 cm												
Date	Daily Count	Radio Tags	Daily Count	Radio Tags	Daily Count	Radio Tags	Spag. Tags	Daily Count	Radio Tags	Spag. Tags	Daily Count	Radio Tags	Spag. Tags	Daily Count	Radio Tags
26-Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Jun	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jun	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Jun	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
30-Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Jul	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
02-Jul	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-Jul	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Jul	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Jul	64	2	4	0	0	0	0	0	0	0	0	0	0	0	0
06-Jul	37	4	10	0	0	0	0	0	0	0	0	0	0	0	0
07-Jul	36	2	2	0	0	0	0	0	0	0	0	0	0	0	0
08-Jul	21	4	2	0	0	0	0	0	0	0	0	0	0	0	0
09-Jul	16	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Jul	170	16	19	0	0	0	0	0	0	0	0	0	0	0	0
11-Jul	51	2	13	0	0	0	0	0	0	0	0	0	0	0	0
12-Jul	35	3	7	1	0	0	0	0	0	0	0	0	0	0	0
13-Jul	89	4	12	1	0	0	0	0	0	0	0	0	0	0	0
14-Jul	76	9	15	0	1	0	0	0	0	0	0	0	0	0	0
15-Jul	22	0	9	1	0	0	0	0	0	0	0	0	0	0	0
16-Jul	11	3	2	0	0	0	0	0	0	0	0	0	0	0	0
17-Jul	26	1	4	0	0	0	0	0	0	0	0	0	0	0	0
18-Jul	25	2	1	0	0	0	0	0	0	0	0	0	0	0	0
19-Jul	48	5	12	0	0	0	0	0	0	0	0	0	0	0	0
20-Jul	27	1	14	0	9	0	0	6	0	0	1	0	0	9	0
21-Jul	42	2	3	0	6	0	0	3	0	0	6	0	0	11	0
22-Jul	34	0	-2	0	1	0	0	1	0	0	2	0	0	4	0
23-Jul	26	1	5	2	5	0	0	0	0	0	4	0	1	0	0
24-Jul	29	0	0	0	6	0	0	0	0	0	6	0	0	1	0
25-Jul	24	1	7	0	23	0	0	-1	0	0	5	0	0	0	0

Table B-4. Continued.

Date	Chinook Salmon METF ≥ 50 cm Daily Count	Chinook Salmon METF ≥ 50 cm Radio Tags	Chinook Salmon METF < 50 cm Daily Count	Chinook Salmon METF < 50 cm Radio Tags	Chum Salmon Daily Count	Chum Salmon Radio Tags	Chum Salmon Spag. Tags	Coho Salmon Daily Count	Coho Salmon Radio Tags	Coho Salmon Spag. Tags	Pink Salmon Daily Count	Pink Salmon Radio Tags	Pink Salmon Spag. Tags	Sockeye Salmon Daily Count	Sockeye Salmon Radio Tags
26-Jul	14	0	6	1	74	0	1	3	0	0	17	0	1	1	0
27-Jul	17	0	18	3	128	1	10	0	0	0	27	0	1	1	0
28-Jul	12	0	23	0	314	2	12	0	0	0	74	0	0	4	0
29-Jul	13	1	10	0	609	1	21	4	0	0	172	0	5	2	0
30-Jul	22	2	14	0	884	2	13	1	0	0	408	0	14	3	0
31-Jul	8	0	16	0	637	1	20	2	0	0	421	0	17	1	0
01-Aug	3	1	5	0	637	1	20	2	0	0	707	0	44	2	0
02-Aug	15	1	7	0	705	1	28	0	0	0	1,514	0	85	4	0
03-Aug	1	0	18	2	772	0	42	2	0	0	1,828	0	115	2	0
04-Aug	-4	0	8	0	660	0	26	2	0	0	2,015	0	116	0	0
05-Aug	9	1	4	0	760	17	31	11	0	0	2,619	13	144	1	0
06-Aug	14	0	5	0	730	0	35	3	1	0	2,923	0	104	13	0
07-Aug	0	0	11	2	794	0	27	17	0	0	3,288	0	213	12	0
08-Aug	17	0	8	0	604	0	4	5	0	0	3,422	1	191	4	0
09-Aug	5	0	2	0	589	0	39	16	0	0	3,128	1	190	-1	0
10-Aug	9	0	0	0	694	13	26	13	2	1	4,292	5	241	10	0
11-Aug	5	0	0	0	440	0	15	17	1	4	1,156	0	53	2	0
12-Aug	0	0	0	0	567	5	31	20	1	0	2,234	9	135	5	0
13-Aug	4	0	0	0	389	0	15	21	0	2	1,633	0	62	5	0
14-Aug	4	0	0	0	404	0	11	20	1	0	1,218	1	70	4	0
15-Aug	0	0	0	0	336	0	11	5	0	1	787	0	41	4	1
16-Aug	0	0	0	0	173	0	0	19	1	0	523	0	17	0	0
17-Aug	0	0	0	0	198	4	9	19	2	0	853	4	38	16	2
18-Aug	0	0	0	0	215	1	19	7	1	0	525	1	36	0	0
19-Aug	2	0	0	0	463	0	25	292	4	28	1,369	0	41	0	0
20-Aug	0	0	0	0	20	2	0	4	3	0	4	0	0	0	0
Total	1,137	72	294	13	12,847	51	491	514	17	36	37,181	35	1,975	120	3

Notes:

These data are net upstream counts (or net passage). Subsampled data were expanded accordingly. Only fish released at the Middle River fishwheels were included in the tag totals. Only fish of known size category, and fish that were inspected for tags were included.

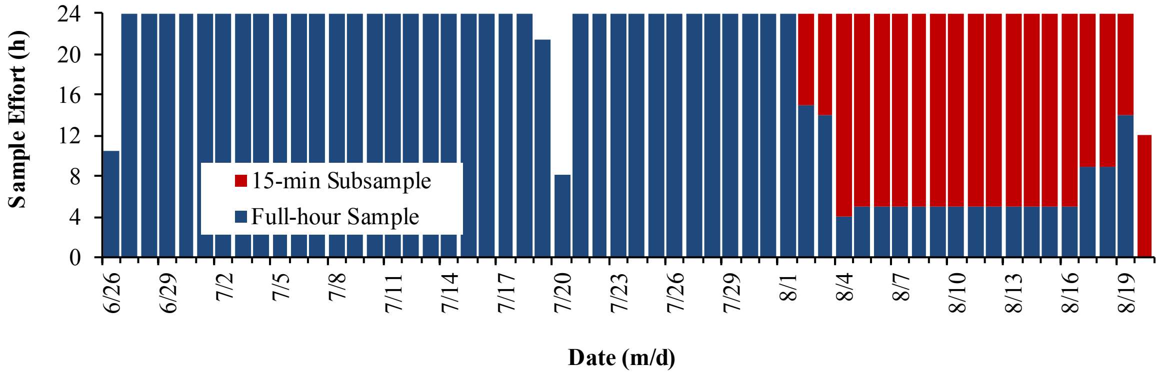


Figure B-1. Daily amount of video imagery collected at the Indian River weir and the type of sampling method used to review the imagery (15-min sub-sample, full-hour sample), June 26 to August 20, 2013.

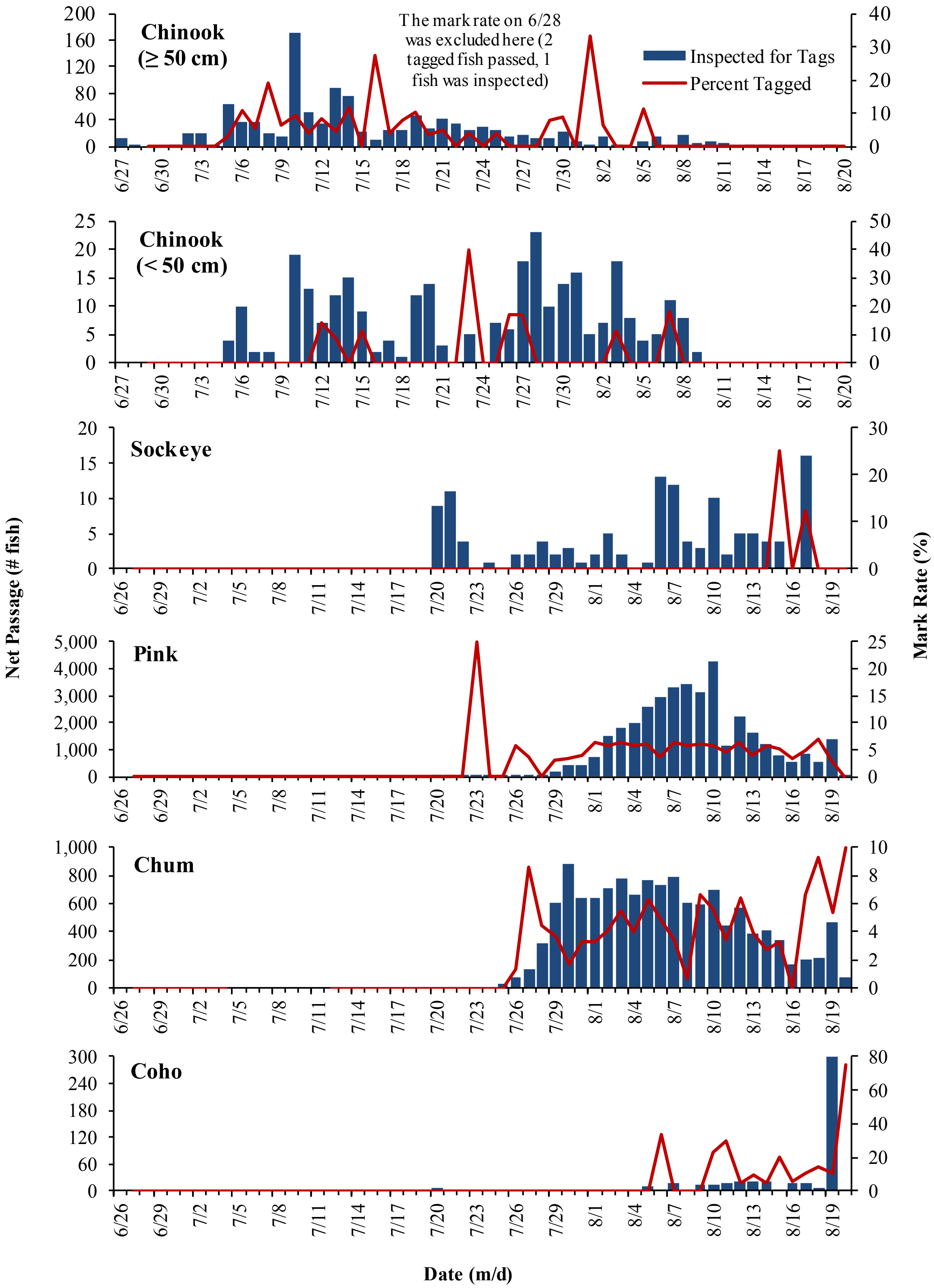


Figure B-2. Net passage of adult salmon that were inspected for tags, and the percent that were tagged (mark rate), at the Indian River weir from June 26 to August 20, 2013.

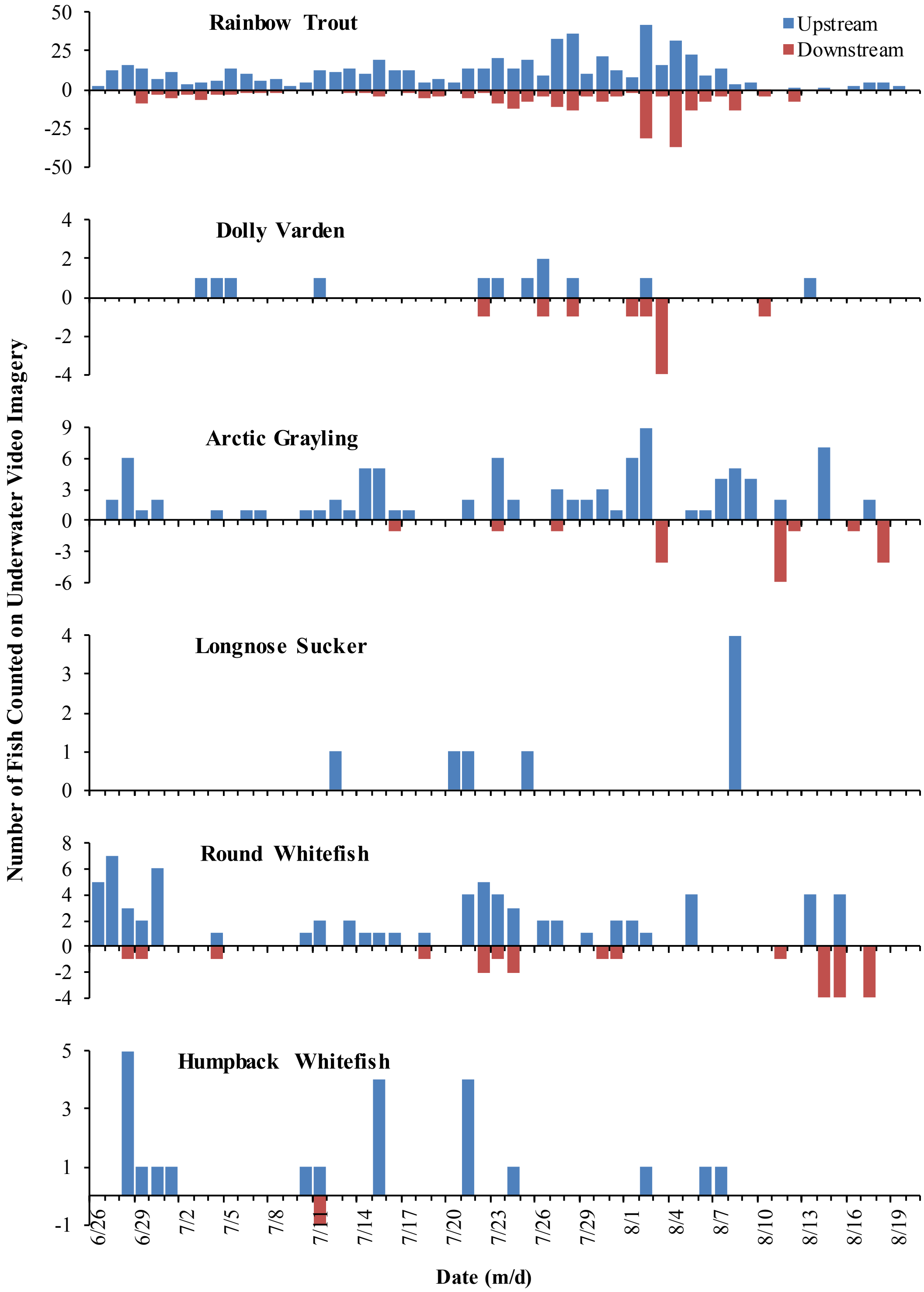


Figure B-3. Number of rainbow trout, Dolly Varden, Arctic grayling, longnose sucker, round whitefish, and humpback whitefish counted on video imagery collected at the Indian River weir, by direction of movement, 2013.

PART A - 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, 2013.

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	19		62.19382	-151.58783	Left	1	Downstream Yentna River
						2	Upstream Yentna River
Talachulitna Weir	15		61.86028	-151.43159	Right	1	Downstream Talachulitna River
						2	Upstream Talachulitna 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	46		62.55397	-150.23167	Left	1	Downstream Chulitna River
						2	Upstream Chulitna River
Deshka Weir	24		61.78585	-150.34572	Right	1	Downstream Deshka River
						2	Upstream Deshka River
Montana Creek Weir	45		62.10556	-150.04861	Right	1	Downstream Montana Creek
						2	Upstream Montana Creek
Middle Fork Chulitna Weir	44		63.05900	-149.58222	Left	1	Downstream Middle Fork Chulitna River
						2	Upstream Middle Fork Chulitna River
Montana Creek	1		62.11816	-150.03607	Left[1]	1	Downstream Montana Creek
						2	Upstream Montana Creek
Whiskers Creek	2	105	62.37468	-150.16802	Left[1]	1	Downstream Whiskers Slough
						2	Upstream Susitna River
						3	Upstream Whiskers Slough
Lane Creek	5,10	117	62.52792	-150.11407	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Across Susitna River

Table C-1. Continued.

Site Location	Receiver No.	Project River Mile	Latitude	Longitude	River Bank	Antenna	Antenna Orientation
Gateway	15	130	62.67645	-149.89303	Right	1	Downstream Susitna River
						2	Upstream Susitna River
4th of July Creek	17	134	62.71538	-149.80478	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Up 4th of July Creek
Indian River	25	142	62.78530	-149.65793	Right	1	Downstream Susitna River
						2	Upstream Susitna River
						3	Up Indian River
Upper Indian River	26,27		62.80930	-149.66245	Left[1]	1	Across Indian River
						2	At weir
Powerline	31	146	62.81904	-149.57602	Right	1	Downstream Susitna River
						2	Upstream Susitna River
Devils Island	50	167	62.80926	-149.00268		1	Downstream Susitna River
						2	Upstream Susitna River
Deadman	58	191	62.82991	-148.41756	Right	1	Downstream Susitna River
						2	Upstream Susitna River
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 2013, by week.

	Fixed-station Receiver											
Week	Lower Yentna	Upper Yentna	Skwentna River	Talachulitna River	Deshka Mouth	Deshka Weir	Montana Weir	Montana Creek	Sunshine Mouth	Talkeetna Station	Chulitna Station	Middle Chulitna
5/20 - 5/26	nd	nd	nd	nd	nd	nd	nd	nd	100	nd	nd	nd
5/27 - 6/2	100	nd	nd	nd	100	100	nd	nd	100	nd	nd	nd
6/3 - 6/9	100	100	100	nd	100	100	nd	100	100	nd	nd	nd
6/10 - 6/16	74	100	100	100	100	100	100	100	100	100	nd	nd
6/17 - 6/23	100	100	100	100	100	100	100	100	100	100	nd	100
6/24 - 6/30	100	100	100	100	100	100	100	100	100	100	nd	100
7/1 - 7/7	100	100	100	100	100	100	100	100	100	100	100	100
7/8 - 7/14	100	100	100	100	100	100	100	100	100	100	100	100
7/15 - 7/21	100	100	100	100	100	100	100	100	100	100	100	100
7/22 - 7/28	100	100	100	100	100	100	100	100	100	100	100	100
7/29 - 8/4	100	100	100	100	100	100	100	100	100	100	100	100
8/5 - 8/11	100	100	100	100	100	100	100	100	100	100	100	nd
8/12 - 8/18	100	100	100	100	100	100	100	100	100	100	100	nd
8/19 - 8/25	100	100	100	100	100	100	100	100	100	100	100	nd
8/26 - 9/1	100	100	100	100	100	100	100	100	91	100	100	nd
9/2 - 9/8	100	nd	nd	nd	100	100	100	100	10	100	100	nd
9/9 - 9/15	100	nd	nd	nd	100	100	nd	100	64	nd	100	nd
9/16 - 9/22	100	nd	nd	nd	100	100	nd	100	100	nd	100	nd
9/23 - 9/29	100	nd	nd	nd	100	nd	nd	100	100	nd	100	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.

Red = full memory caused loss of data; Yellow = low power/dead battery.

Table C-3. Monitoring efficiency (percent operational) of fixed-station receivers in the Middle and Upper River basins in 2013, by week.

	Fixed-station Receiver											
Week	Whiskers Creek	Lane Station (LR Tags)	Lane Station (MR Tags)	Gateway	4th of July Creek	Indian River	Indian Weir (salmon)	Powerline	Devils Station (salmon)	Deadman	Kosina Creek	Oshetna Creek
5/27 - 6/2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
6/3 - 6/9	100	100	100	100	100	100	nd	nd	nd	nd	nd	nd
6/10 - 6/16	100	100	100	100	100	100	nd	100	nd	nd	nd	nd
6/17 - 6/23	100	100	100	100	100	100	nd	100	nd	nd	nd	nd
6/24 - 6/30	100	100	100	100	39	100	100	38	100	nd	100	4
7/1 - 7/7	100	100	100	100	91	100	100	92	100	100	100	0
7/8 - 7/14	100	100	100	100	100	100	100	68	100	100	100	34
7/15 - 7/21	100	100	100	100	100	100	100	35	100	100	100	100
7/22 - 7/28	100	100	100	100	100	100	100	79	100	100	100	100
7/29 - 8/4	100	100	100	100	100	100	100	100	100	100	37	100
8/5 - 8/11	100	100	100	100	100	95	100	100	100	100	0	100
8/12 - 8/18	100	100	100	100	100	43	100	100	100	100	17	100
8/19 - 8/25	100	100	100	100	100	100	100	100	100	100	92	100
8/26 - 9/1	100	100	100	100	100	100	100	100	100	100	100	100
9/2 - 9/8	100	100	100	100	100	100	nd	36	100	100	100	100
9/9 - 9/15	100	100	100	100	100	100	nd	64	100	100	100	100
9/16 - 9/22	100	100	100	100	100	100	nd	100	80	nd	100	100
9/23 - 9/29	100	100	100	nd	nd	100	nd	nd	93	nd	100	100

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. For hours in which no beacon tags, radio tags, or noise events were recorded, crew notes were consulted to determine the cause of the data gap. In some instances, the receiver was determined to be fully active despite a lack of detection data (i.e., beacon tags were malfunctioning, or poorly placed).

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').

Gray = receiver not scanning; Red = full memory caused loss of data; Yellow = low power/dead battery.

Table C-4. List of the aerial telemetry surveys conducted through September 21, 2013, by location, date, and vehicle type (helicopter, fixed-wing).

	PRM			Survey Date (m-d)																						
Zone Name	From	To	Zone #	6-22	6-23	6-24	6-25	6-26	6-28	6-29	6-30	7-1	7-2	7-3	7-4	7-5	7-6	7-7	7-8	7-9	7-10	7-11	7-12	7-13	7-14	7-15
MOB - Little Susitna River	-	-	3																							
MOB - Beyond Confluence	-	-	4			F														F						
MOB - Confluence - Yentna	3.5	32.4	5			F														F	H					
MOB - Yentna River	32.4	-	22		H	F			H						H						F					
MOB - Yentna - Deshka	32.4	45.0	35		H	F			H						H						F					
MOB - Deshka River	44.9	-	42		H	F			H						H							F				
MOB - Willow and Little Willow	52.2	55.6	53		H		F		H						H						F/H					
MOB - Kashwitna River	64.7	-	54		H		F		H					H							F					
MOB - Deshka - Kashwitna	45.0	64.7	55		H		F		H					H	H					F						
MOB - Caswell area tribs	65.8	76.3	63				F							H							F/H					
MOB - Kashwitna - Montana	64.7	80.7	65		H		F		H					H						F	H					
MOB - Montana Creek	80.9	-	71		H		F		H											F	H					
MOB - Montana - Sunshine	80.7	88.5	75		H		F		H					H						F	H					
MOB - Sunshine Creek	88.1	-	76				F																			
MOB - Rabideux Creek	87.4	-	77		H		F							H												
MOB - Talkeetna River	101.0	-	81		H		F		H					H						F						
MOB - Chulitna River	101.7	-	83		H		F													F						H
MOB - Sunshine - Talkeetna	88.5	102.3	85		H		F		H					H						F	H					
MOB - Talkeetna - Lane	102.3	116.8	95	H					H					H						H	H					H
MOB - Whiskers Creek	104.8	-	97																							H
MOB - Trib off zone 95	110.5	-	98																							
MOB - Lane - Gateway	116.8	130.1	105	H			H	H	H	H		H	H	H		H		H		H					H	H
MOB - Lane Creek	117.1	-	106																							H
MOB - 5th of July Creek	127.3	-	108																							
MOB - Slough 8A	129.2	129.8	109																							
MOB - Gateway - 4th of July	130.1	134.3	111	H			H	H	H	H		H	H	H		H		H		H					H	
MOB - Slough 9	131.4	133.5	112																							
MOB - Sherman Creek	134.1	-	114																							
MOB - 4th of July Creek	134.3	-	116	H			H		H					H											H	
MOB - 4th of July - Slough 11	134.3	140.2	117	H			H	H	H	H		H	H	H		H		H		H					H	
MOB - Slough 11	138.6	-	118											H												

Table C-4. Continued.

Zone Name	PRM From	PRM To	Zone #	7-16	7-17	7-18	7-19	7-20	7-21	7-22	7-23	7-24	7-25	7-26	7-27	7-28	7-29	7-30	7-31	8-1	8-2	8-3	8-4	8-5	8-6	8-7
MOB - Little Susitna River	-	-	3																							
MOB - Beyond Confluence	-	-	4							F														F		
MOB - Confluence - Yentna	3.5	32.4	5							F														F		
MOB - Yentna River	32.4	-	22		H						F		H								H					
MOB - Yentna - Deshka	32.4	45.0	35		H					F			H								H			F		
MOB - Deshka River	44.9	-	42		H							F	H								H			F		
MOB - Willow and Little Willow	52.2	55.6	53		H							F	H							H				F		
MOB - Kashwitna River	64.7	-	54								F									H				F		
MOB - Deshka - Kashwitna	45.0	64.7	55		H					F			H							H				F		
MOB - Caswell area tribs	65.8	76.3	63									F	H							H						
MOB - Kashwitna - Montana	64.7	80.7	65		H					F			H							H				F		
MOB - Montana Creek	80.9	-	71		H							F	H							H						
MOB - Montana - Sunshine	80.7	88.5	75		H					F			H							H				F		
MOB - Sunshine Creek	88.1	-	76																							
MOB - Rabideux Creek	87.4	-	77																	H						
MOB - Talkeetna River	101.0	-	81		H					F		H									H					F
MOB - Chulitna River	101.7	-	83							F		H								H						F
MOB - Sunshine - Talkeetna	88.5	102.3	85		H					F			H							H				F		
MOB - Talkeetna - Lane	102.3	116.8	95									H						H		H				H		
MOB - Whiskers Creek	104.8	-	97																	H				H		
MOB - Trib off zone 95	110.5	-	98																							
MOB - Lane - Gateway	116.8	130.1	105									H						H	H					H		
MOB - Lane Creek	117.1	-	106									H						H	H					H		
MOB - 5th of July Creek	127.3	-	108																							
MOB - Slough 8A	129.2	129.8	109									H						H						H		
MOB - Gateway - 4th of July	130.1	134.3	111									H						H	H					H		
MOB - Slough 9	131.4	133.5	112									H						H						H		
MOB - Sherman Creek	134.1	-	114									H							H							
MOB - 4th of July Creek	134.3	-	116									H						H	H					H		
MOB - 4th of July - Slough 11	134.3	140.2	117									H						H	H					H		
MOB - Slough 11	138.6	-	118															H						H		

Table C-4. Continued.

	PRM		Zone	Survey Date (m-d)																						
Zone Name	From	To	#	8-8	8-9	8-10	8-11	8-12	8-13	8-16	8-17	8-19	8-20	8-23	8-24	8-25	8-26	8-27	8-30	8-31	9-2	9-3	9-4	9-5	9-20	9-21
MOB - Little Susitna River	-	-	3																							
MOB - Beyond Confluence	-	-	4												F								F			F
MOB - Confluence - Yentna	3.5	32.4	5												F								F			F
MOB - Yentna River	32.4	-	22	F				F		H				H					H				F			F
MOB - Yentna - Deshka	32.4	45.0	35		H					H				H	F				H				F		F	
MOB - Deshka River	44.9	-	42		H					H				H	F				H				F			F
MOB - Willow and Little Willow	52.2	55.6	53		H					H				H	F				H				F		F	
MOB - Kashwitna River	64.7	-	54		H					H				H	F				H				F		F	
MOB - Deshka - Kashwitna	45.0	64.7	55		H					H				H	F				H				F		F	
MOB - Caswell area tribs	65.8	76.3	63	F	H					H					F								F		F	
MOB - Kashwitna - Montana	64.7	80.7	65		H					H				H	F				H				F		F	
MOB - Montana Creek	80.9	-	71	F	H					H				H	F				H					F	F	
MOB - Montana - Sunshine	80.7	88.5	75		H					H				H	F				H					F	F	
MOB - Sunshine Creek	88.1	-	76		H					H				H					H							
MOB - Rabideux Creek	87.4	-	77							H				H					H							
MOB - Talkeetna River	101.0	-	81		H					H				H	F				H					F	F	
MOB - Chulitna River	101.7	-	83		H					H				H	F				H					F	F	
MOB - Sunshine - Talkeetna	88.5	102.3	85		H					H				H	F	H			H					F	F	
MOB - Talkeetna - Lane	102.3	116.8	95		H	H				H						H				H		H				
MOB - Whiskers Creek	104.8	-	97		H	H		H			H		H			H		H		H		H				
MOB - Trib off zone 95	110.5	-	98					H			H		H			H		H		H		H				
MOB - Lane - Gateway	116.8	130.1	105			H		H			H		H			H		H		H		H				
MOB - Lane Creek	117.1	-	106			H		H			H		H			H		H		H		H				
MOB - 5th of July Creek	127.3	-	108					H			H		H			H				H						
MOB - Slough 8A	129.2	129.8	109			H		H			H		H			H		H		H		H				
MOB - Gateway - 4th of July	130.1	134.3	111			H		H			H		H			H		H		H		H				
MOB - Slough 9	131.4	133.5	112			H		H			H		H			H		H		H		H				
MOB - Sherman Creek	134.1	-	114					H								H						H				
MOB - 4th of July Creek	134.3	-	116			H		H			H		H			H		H		H		H				
MOB - 4th of July - Slough 11	134.3	140.2	117			H		H			H		H			H		H		H		H				
MOB - Slough 11	138.6	-	118			H		H			H		H			H		H		H		H				

Table C-4. Continued.

Zone Name	PRM From	PRM To	Zone #	9-23	9-24	9-27	9-30	10-1	10-2	10-7	10-9	10-21	10-22	10-23	10-24
MOB - Little Susitna River	-	-	3												
MOB - Beyond Confluence	-	-	4												
MOB - Confluence - Yentna	3.5	32.4	5												H
MOB - Yentna River	32.4	-	22			H			H						H
MOB - Yentna - Deshka	32.4	45.0	35			H			H						H
MOB - Deshka River	44.9	-	42			H			H						H
MOB - Willow and Little Willow	52.2	55.6	53			H			H						H
MOB - Kashwitna River	64.7	-	54						H						H
MOB - Deshka - Kashwitna	45.0	64.7	55			H			H						H
MOB - Caswell area tribs	65.8	76.3	63												H
MOB - Kashwitna - Montana	64.7	80.7	65			H			H						H
MOB - Montana Creek	80.9	-	71			H			H		H				H
MOB - Montana - Sunshine	80.7	88.5	75			H			H		H				H
MOB - Sunshine Creek	88.1	-	76												H
MOB - Rabideux Creek	87.4	-	77			H			H		H				H
MOB - Talkeetna River	101.0	-	81			H			H		H				H
MOB - Chulitna River	101.7	-	83			H			H		H			H	
MOB - Sunshine - Talkeetna	88.5	102.3	85			H			H		H			H	
MOB - Talkeetna - Lane	102.3	116.8	95		H	H		H	H		H			H	
MOB - Whiskers Creek	104.8	-	97		H			H			H			H	
MOB - Trib off zone 95	110.5	-	98											H	
MOB - Lane - Gateway	116.8	130.1	105		H			H			H		H		
MOB - Lane Creek	117.1	-	106		H			H			H		H		
MOB - 5th of July Creek	127.3	-	108												
MOB - Slough 8A	129.2	129.8	109		H			H			H		H		
MOB - Gateway - 4th of July	130.1	134.3	111		H			H			H		H		
MOB - Slough 9	131.4	133.5	112					H			H		H		
MOB - Sherman Creek	134.1	-	114												
MOB - 4th of July Creek	134.3	-	116		H			H			H		H		
MOB - 4th of July - Slough 11	134.3	140.2	117		H			H			H		H		
MOB - Slough 11	138.6	-	118		H			H			H		H		

Table C-4. Continued.

	PRM		Zone	Survey Date (m-d)																						
Zone Name	From	To	#	6-22	6-23	6-24	6-25	6-26	6-28	6-29	6-30	7-1	7-2	7-3	7-4	7-5	7-6	7-7	7-8	7-9	7-10	7-11	7-12	7-13	7-14	7-15
MOB - Gold Creek	140.1	-	119																							
MOB - Slough11 - Indian	140.1	142.1	125	H			H	H	H	H		H	H	H		H		H	H	H				H	H	
MOB - Indian trib	141.8	-	132	H			H	H	H	H		H		H					H	H				H	H	
MOB - Indian - Slough 21	142.1	145.7	135	H			H	H	H			H	H			H		H	H	H				H	H	
MOB - Slough 21	145.1	145.6	136																							
MOB - above Powerline	145.7	146.0	138	H			H	H	H			H	H			H		H	H					H	H	
MOB - abv Powerline - Portage	146.0	152.3	145	H			H	H	H	H		H	H		H	H	H	H	H		H	H	H	H	H	
MOB - Jack Long Creek	148.2	-	146				H						H					H						H	H	
MOB - Portage trib	152.3	-	152	H			H	H		H		H	H		H			H	H	H	H	H	H	H	H	H
MOB - Portage - Impediment1	152.3	155.2	153	H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Impediment1 - Cheechako	155.2	157.4	157	H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Cheechako Creek	155.9	-	158				H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Cheechako - Impediment2	157.4	160.2	163	H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Impediment2 - Chinook	160.2	160.5	167	H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Chinook Creek	160.4	-	168				H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Chinook - Impediment3	160.5	164.8	173	H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Devils Creek	164.8	-	176				H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Impediment3 - Devil Stn	164.8	166.9	177	H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Devil Stn - Fog	166.9	179.4	185										H				H	H					H		H	H
MOB - Fog Creek	179.3	-	192																						H	
MOB - Fog - Dam Site	179.4	186.8	195										H				H						H		H	H
MOB - Tsusena Creek	184.5	-	197																						H	
MOB - Dam Site - Deadman	186.8	189.4	201										H				H	H					H			H
MOB - Deadman Creek	189.3	-	203																							
MOB - Deadman - Watana	189.4	196.9	205										H				H	H					H			
MOB - 'Creek 192'	194.8	-	207																							
MOB - Watana Creek	196.8	-	212																							
MOB - Wantana - Kosina	196.9	209.3	215																				H			
MOB - Kosina Creek	209.1	-	222														H									
MOB - Kosina - Oshetna	209.3	235.2	225														H						H			
MOB - Oshetna River	235.1	-	232																							
MOB - above Oshetna	235.2	321.1	235																							

Table C-4. Continued.

	PRM		Zone	Survey Date (m-d)																						
Zone Name	From	To	#	7-16	7-17	7-18	7-19	7-20	7-21	7-22	7-23	7-24	7-25	7-26	7-27	7-28	7-29	7-30	7-31	8-1	8-2	8-3	8-4	8-5	8-6	8-7
MOB - Gold Creek	140.1	-	119					H											H					H		
MOB - Slough11 - Indian	140.1	142.1	125					H				H						H	H					H		
MOB - Indian trib	141.8	-	132					H				H			H				H					H		
MOB - Indian - Slough 21	142.1	145.7	135					H				H			H			H	H					H		
MOB - Slough 21	145.1	145.6	136					H				H			H			H						H		
MOB - above Powerline	145.7	146.0	138					H				H			H			H	H					H		
MOB - abv Powerline - Portage	146.0	152.3	145					H				H			H			H	H					H		
MOB - Jack Long Creek	148.2	-	146					H											H					H		
MOB - Portage trib	152.3	-	152	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Portage - Impediment1	152.3	155.2	153	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Impediment1 - Cheechako	155.2	157.4	157	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Cheechako Creek	155.9	-	158	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Cheechako - Impediment2	157.4	160.2	163	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Impediment2 - Chinook	160.2	160.5	167	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Chinook Creek	160.4	-	168	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Chinook - Impediment3	160.5	164.8	173	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Devils Creek	164.8	-	176	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Impediment3 - Devil Stn	164.8	166.9	177	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
MOB - Devil Stn - Fog	166.9	179.4	185	H	H	H	H	H	H	H	H	H		H	H	H		H	H	H	H	H			H	
MOB - Fog Creek	179.3	-	192						H					H											H	
MOB - Fog - Dam Site	179.4	186.8	195	H	H	H	H	H	H	H	H	H		H	H			H	H	H	H				H	
MOB - Tsusena Creek	184.5	-	197			H	H					H	H	H	H	H	H	H	H	H	H				H	
MOB - Dam Site - Deadman	186.8	189.4	201			H	H	H	H	H				H	H	H			H	H					H	
MOB - Deadman Creek	189.3	-	203																	H					H	
MOB - Deadman - Watana	189.4	196.9	205			H	H	H						H					H	H					H	
MOB - 'Creek 192'	194.8	-	207																							
MOB - Watana Creek	196.8	-	212																	H					H	
MOB - Wantana - Kosina	196.9	209.3	215			H	H	H						H					H	H					H	
MOB - Kosina Creek	209.1	-	222																H						H	
MOB - Kosina - Oshetna	209.3	235.2	225				H	H											H						H	
MOB - Oshetna River	235.1	-	232					H											H						H	
MOB - above Oshetna	235.2	321.1	235					H	H	H	H	H	H	H	H	H	H	H	H						H	

Table C-4. Continued.

	PRM			Survey Date (m-d)																						
Zone Name	From	To	Zone #	8-8	8-9	8-10	8-11	8-12	8-13	8-16	8-17	8-19	8-20	8-23	8-24	8-25	8-26	8-27	8-30	8-31	9-2	9-3	9-4	9-5	9-20	9-21
MOB - Gold Creek	140.1	-	119			H		H			H		H			H		H		H		H				
MOB - Slough11 - Indian	140.1	142.1	125			H		H			H		H		H	H		H		H		H				
MOB - Indian trib	141.8	-	132			H		H			H		H		H	H		H		H		H				
MOB - Indian - Slough 21	142.1	145.7	135			H		H			H		H		H			H		H		H				
MOB - Slough 21	145.1	145.6	136			H		H			H		H		H			H		H		H				
MOB - above Powerline	145.7	146.0	138			H		H			H		H		H			H		H		H				
MOB - abv Powerline - Portage	146.0	152.3	145			H		H			H		H		H			H		H		H				
MOB - Jack Long Creek	148.2	-	146			H		H			H		H		H			H		H		H				
MOB - Portage trib	152.3	-	152		H	H	H	H	H		H	H	H		H		H	H	H	H	H	H				
MOB - Portage - Impediment1	152.3	155.2	153		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H	H				
MOB - Impediment1 - Cheechako	155.2	157.4	157		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H	H				
MOB - Cheechako Creek	155.9	-	158		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H					
MOB - Cheechako - Impediment2	157.4	160.2	163		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H	H				
MOB - Impediment2 - Chinook	160.2	160.5	167		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H	H				
MOB - Chinook Creek	160.4	-	168		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H					
MOB - Chinook - Impediment3	160.5	164.8	173		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H	H				
MOB - Devils Creek	164.8	-	176		H	H	H	H	H	H	H	H	H		H		H	H	H	H	H					
MOB - Impediment3 - Devil Stn	164.8	166.9	177		H	H		H	H	H	H	H	H		H		H	H	H	H	H	H				
MOB - Devil Stn - Fog	166.9	179.4	185						H			H					H				H					
MOB - Fog Creek	179.3	-	192						H			H					H				H					
MOB - Fog - Dam Site	179.4	186.8	195						H			H					H				H					
MOB - Tsusena Creek	184.5	-	197						H			H					H				H					
MOB - Dam Site - Deadman	186.8	189.4	201						H			H					H				H					
MOB - Deadman Creek	189.3	-	203						H			H					H				H					
MOB - Deadman - Watana	189.4	196.9	205						H			H					H				H					
MOB - 'Creek 192'	194.8	-	207						H			H					H									
MOB - Watana Creek	196.8	-	212						H			H					H				H					
MOB - Wantana - Kosina	196.9	209.3	215						H			H					H				H					
MOB - Kosina Creek	209.1	-	222						H			H					H				H					
MOB - Kosina - Oshetna	209.3	235.2	225						H			H					H				H					
MOB - Oshetna River	235.1	-	232						H			H					H				H					
MOB - above Oshetna	235.2	321.1	235																							

Table C-4. Continued.

	PRM														
Zone Name	From	To	Zone #	9-23	9-24	9-27	9-30	10-1	10-2	10-7	10-9	10-21	10-22	10-23	10-24
MOB - Gold Creek	140.1	-	119		H			H			H		H		
MOB - Slough11 - Indian	140.1	142.1	125		H			H			H		H		
MOB - Indian trib	141.8	-	132		H			H					H		
MOB - Indian - Slough 21	142.1	145.7	135		H			H			H		H		
MOB - Slough 21	145.1	145.6	136		H			H			H		H		
MOB - above Powerline	145.7	146.0	138		H			H			H		H		
MOB - abv Powerline - Portage	146.0	152.3	145		H			H			H		H		
MOB - Jack Long Creek	148.2	-	146		H			H			H				
MOB - Portage trib	152.3	-	152	H	H		H	H		H	H		H		
MOB - Portage - Impediment1	152.3	155.2	153	H	H		H	H		H	H	H			
MOB - Impediment1 - Cheechako	155.2	157.4	157	H	H		H	H		H	H	H			
MOB - Cheechako Creek	155.9	-	158	H	H		H	H		H	H	H			
MOB - Cheechako - Impediment2	157.4	160.2	163	H	H		H	H		H	H	H			
MOB - Impediment2 - Chinook	160.2	160.5	167	H	H		H	H		H	H	H			
MOB - Chinook Creek	160.4	-	168	H	H		H	H		H	H	H			
MOB - Chinook - Impediment3	160.5	164.8	173	H	H		H	H			H	H			
MOB - Devils Creek	164.8	-	176	H	H		H	H			H	H			
MOB - Impediment3 - Devil Stn	164.8	166.9	177	H	H		H	H				H			
MOB - Devil Stn - Fog	166.9	179.4	185	H			H			H		H			
MOB - Fog Creek	179.3	-	192	H			H			H		H			
MOB - Fog - Dam Site	179.4	186.8	195	H			H			H		H			
MOB - Tsusena Creek	184.5	-	197	H			H			H		H			
MOB - Dam Site - Deadman	186.8	189.4	201	H			H			H		H			
MOB - Deadman Creek	189.3	-	203	H						H		H			
MOB - Deadman - Watana	189.4	196.9	205	H			H			H			H		
MOB - 'Creek 192'	194.8	-	207												
MOB - Watana Creek	196.8	-	212	H			H			H			H		
MOB - Wantana - Kosina	196.9	209.3	215	H			H			H			H		
MOB - Kosina Creek	209.1	-	222	H			H			H		H			
MOB - Kosina - Oshetna	209.3	235.2	225	H			H			H		H			
MOB - Oshetna River	235.1	-	232	H			H			H		H			
MOB - above Oshetna	235.2	321.1	235												

PART A - 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), 2013.

	Sockeye		Pink		Chum	
Survey Date	Presence	Spawning	Presence	Spawning	Presence	Spawning
13-Aug						
Indian River Delta			X		X	X
4th of July Slough/Side Channel					X	
14-Aug						
Slough 10					X	X
Slough 8A	X	X	X		X	X
15-Aug						
4th of July Slough/Side Channel			X		X	X
16-Aug						
Slough 1						
Slough 2						
Slough 4						
Slough 5						
Slough 6A						
Oxbow 1						
Slough ?1			X		X	X
18-Aug						
Slough 21						
Side Channel 21					X	X
Slough 20						
Slough 17						
Slough 14						
Slough 11	X		X			
Slough 9A	X				X	
Slough 9	X		X	X	X	X
01-Sep						
Slough 21A	X	X	X		X	X
slough 21					X	X
slough 22	X	X	X		X	X
Slough 19	X					
Slough 11	X	X			X	X
Slough 10	X	X	X		X	X
02-Sep						
Slough 9A	X	X			X	X
5th of July Slough					X	X
Slough ?1					X	X

Table D-2. Summary of monitoring effort at potential spawning sites for Chinook salmon in the Middle River, 2013.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed: None	Migrating	Holding	Spawning
1	295	Lane Creek	Tributary Delta	NA	NA		Site not visited		
2[a,b]	696	Lane Creek - Gateway	Mainstem	24-Jul	Boat		Site not surveyed		
3[b]	783	Lane Creek - Gateway	Mainstem	24-Jul	ARIS	X			
4[b]	516	Lane Creek - Gateway	Mainstem	24-Jul	Boat		Site not surveyed		
5[a]	739	Gateway - Slough 11	Mainstem	26-Jul	Boat		Site not surveyed		
6	731	4th of July Creek	Tributary Delta	24-Jul	ARIS			X	
				27-Jul	Boat			X	
				31-Jul	ARIS	X			
7[a]	548	Gateway - Slough 11	Mainstem	27-Jul	Boat		Site not surveyed		
8[a]	474	Gateway - Slough 11	Mainstem	27-Jul	Boat		Site not surveyed		
9	Cluster	Indian River	Tributary Delta	25-Jul	ARIS		X	X	X
				31-Jul	ARIS		X	X	
10[a]	723, 734	Side Channel 21	Side Channel	*	Aerial		Too turbid to assess		
11[a]	346, 328	Slough 21 - Portage Creek	Mainstem	31-Jul	Boat		Site not surveyed		
12[c]	Cluster	Portage Creek	Tributary Delta	31-Jul	ARIS/Visual		X	X	
13	254	Chinook Creek	Tributary Delta	*	Aerial		Too turbid to assess		

[a] Indicates a site that was visually assessed and considered too difficult to sample with ARIS.

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

[c] Indicates a site where sonar detected fish, but species could not be determined.

* 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, 2013.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed: None	Migrating	Holding	Spawning
1	2908, 3808, 5247	Slough 8A	Side Slough	14-Aug	HSC			X	X
				16-Sep	HSC				X
				29-Sep	HSC				X
2	Cluster	Slough 9	Side Slough	18-Aug	HSC			X	X
				17-Sep	HSC				X
3[b]	2079	Gateway - Slough 11	Mainstem	*	Aerial/Boat	Site not surveyed			
4[b]	2291	Gateway - Slough 11	Mainstem	*	Aerial/Boat	Site not surveyed			
5	3502	Gateway - Slough 11	Side Slough	07-Sep	Aerial			X	X
6	3631	Slough 9A	Side Slough	18-Aug	HSC			X	
				02-Sep	HSC			X	X
				29-Sep	HSC				X
7[a]	2578	Indian River - Slough 21	Side Channel	*	Aerial	Site not surveyed			
8	3596	Side Channel 21	Side Channel	18-Aug	HSC			X	X
				01-Sep	HSC			X	X
				15-Sep	HSC				X
				28-Sep	HSC				X
9	4483	Jack Long Creek	Tributary Delta	01-Sep	HSC			X	
				*	Aerial			X	

[a] Indicates a site that was visually assesed and considered too difficult to sample with ARIS

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

[c] Indicates a site where sonar detected fish, but species could not be determined

* 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 pink salmon in the Middle River, 2013.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed: None	Migrating	Holding	Spawning
1	2972	Lane Creek	Tributary Delta	13-Aug	HSC			X	X
2[b]	3876	Lane Creek - Gateway	Mainstem	*	Boat/Aerial	Site not Surveyed			
3	2255	5th of July Creek	Tributary Delta	02-Sep	HSC			X	
4[b]	2059	Gateway - Slough 11	Mainstem	*	Boat/Aerial	Site not Surveyed			
5[c]	1498, 2106, 2302	4th of July Creek	Tributary Delta	31-Jul	ARIS		X	X	
				12-Aug	ARIS		X	X	
6[c]	8188	4th of July Side Channel	Side Channel	31-Jul	ARIS		X	X	
				13-Aug	ARIS		X	X	
7[b,c]	1571	Gateway - Slough 11	Mainstem	31-Jul	ARIS		X		
				*	Aerial				
8	Cluster	Indian River	Tributary Delta	12-Aug	HSC		X	X	X
				13-Aug	HSC		X	X	X
9[c]	2306, 2349	Portage Creek	Tributary Delta	31-Jul	ARIS		X	X	
				31-Jul	Visual		X	X	

[a] Indicates a site that was visually assesed and considered too difficult to sample with ARIS

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

[c] Indicates a site where sonar detected fish, but species could not be determined

* 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 sockeye salmon in the Middle River, 2013.

Site #	Fish #	Location	Habitat Type	Survey Date	Survey Type	Fish Observed: None	Migrating	Holding	Spawning
1	2568	Slough 8B	Side Slough	*	Aerial	X			
2	4533	Skull Creek	Tributrary Delta	07-Sep	Aerial			X	X
				14-Sep	HSC			X	X
				30-Sep	HSC			X	X
3[b]	4060	Lane Creek - Gateway	Mainstem	*	Boat	Site not surveyed			
4	Cluster	Slough 8A	Side Slough	14-Aug	HSC			X	X
				29-Sep	HSC			X	X
5[a,b]	3390	Gateway - Slough 11	Side Channel	*	Boat/Aerial	Site not surveyed			
6	Cluster	Slough 9	Side Slough	18-Aug	HSC			X	
				17-Sep	HSC	X			
7[c]	4553, 4347	4th of July Side Channel	Side Channel	31-Jul	ARIS		X	X	
				13-Aug	ARIS		X	X	
				17-Sep	HSC	X			
8[b]	2516	Gateway - Slough 11	Mainstem	*	Boat/Aerial	Site not surveyed			
9	4034	Slough 9A	Side Slough	18-Aug	HSC			X	
				02-Sep	HSC			X	X
10	Cluster	Slough 10	Upland Slough	14-Aug	HSC	X			
				01-Sep	HSC			X	X
11	Cluster	Slough 11	Upland Slough	18-Aug	HSC			X	
				01-Sep	HSC			X	X
12	1982, 2896	Slough/Side Channel 21	Side Channel	18-Aug	HSC	X			
				01-Sep	HSC	X			
				15-Sep	HSC			X	X
				28-Sep	HSC			X	X
13[c]	1041, 2900	Portage Creek	Tributary Delta	31-Jul	ARIS		X	X	

[a] Indicates a site that was visually assesed and considered too difficult to sample with ARIS

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

[c] Indicates a site where sonar detected fish, but species could not be determined

* 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. Details of impediment-passage events for radio-tagged fish, 2013.

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)
241		13 Jul	14 Jul	16 Jul	1.0	0.5	2.0	14,383	15,410	16,672
272		13 Jul	14 Jul	30 Jul	8.5	0.5	16.0	14,383	15,410	18,848
395		11 Jul	12 Jul	13 Jul	3.0	1.0	1.5	16,876	15,058	14,383
Average		12 Jul	13 Jul	19 Jul	4.2	0.7	6.5	15,214	15,293	16,634
Chinook Salmon (≥ 50 cm) that Passed Impediment 2 but not Impediment 3										
254		12 Jul	13 Jul	-	6.0	0.5	1.5	15,058	14,383	-
280		13 Jul	13 Jul	-	1.0	0.5	4.5	14,383	14,383	-
309		12 Jul	13 Jul	-	6.0	0.5	1.5 Mort*	15,058	14,383	-
355		14 Jul	16 Jul	-	6.0	1.0	13.0	15,410	16,672	-
418		13 Jul	13 Jul	-	4.0	0.0	4.0	14,383	14,383	-
528		16 Jul	19 Jul	-	2.5	3.5	9.5	16,672	19,202	-
555		24 Jul	24 Jul	-	1.5	0.5	4.8	16,884	16,884	-
658		12 Jul	12 Jul	-	3.0	0.5	17.0	15,058	15,058	-
715		13 Jul	14 Jul	-	5.0	0.5	16.5	14,383	15,410	-
798		14 Jul	14 Jul	-	2.0	0.5	14.5	15,410	15,410	-
6535		12 Jul	13 Jul	-	2.5	0.5	0.5	15,058	14,383	-
6604		17 Jul	18 Jul	-	2.0	0.5	4.5	15,872	17,353	-
7082		13 Jul	14 Jul	-	1.5	0.5	9.0	14,383	15,410	-
Average		14 Jul	15 Jul		3.3	0.7	8.3	15,232	15,640	
Chinook Salmon (≥ 50 cm) that Passed Impediment 1 but not Impediment 2										
219	†	30 Jun	-	-	4.0	d.n.a.	-	25,352	-	-
278		13 Jul	-	-	4.0	d.n.a.	-	14,383	-	-
353		14 Jul	-	-	2.5	1.0	-	15,410	-	-
593		16 Jul	-	-	7.0	1.5	-	16,672	-	-
Average		12 Jul			4.4	1.3		17,954		

Table D-6. Continued.

Chinook Salmon (≥ 50 cm) that Approached Impediment 1 but didn't 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)
176	†	-	-	-	2.5	-	-	-	-	-
178		-	-	-	4.0	-	-	-	-	-
210		-	-	-	2.0	-	-	-	-	-
224	†	-	-	-	4.0	-	-	-	-	-
299		-	-	-	11.5	-	-	-	-	-
328		-	-	-	6.0	-	-	-	-	-
332		-	-	-	3.0	-	-	-	-	-
338		-	-	-	2.0	-	-	-	-	-
347		-	-	-	6.0	-	-	-	-	-
404		-	-	-	1.0	-	-	-	-	-
447		-	-	-	2.0	-	-	-	-	-
479		-	-	-	3.5	-	-	-	-	-
501		-	-	-	5.5	-	-	-	-	-
517		-	-	-	3.0	-	-	-	-	-
524		-	-	-	2.0	-	-	-	-	-
532		-	-	-	5.0	-	-	-	-	-
541		-	-	-	6.0	-	-	-	-	-
543		-	-	-	1.0	-	-	-	-	-
550		-	-	-	2.5	-	-	-	-	-
564		-	-	-	1.0	-	-	-	-	-
615		-	-	-	1.0	-	-	-	-	-
632		-	-	-	2.0	-	-	-	-	-
671		-	-	-	2.0	-	-	-	-	-
700		-	-	-	4.0	-	-	-	-	-
714		-	-	-	1.0	-	-	-	-	-
746		-	-	-	1.5	-	-	-	-	-
760		-	-	-	3.0	-	-	-	-	-
762		-	-	-	0.5	-	-	-	-	-
764		-	-	-	1.0	-	-	-	-	-
781		-	-	-	7.0	-	-	-	-	-

Table D-6. Continued.

Chinook Salmon (≥ 50 cm) that Approached Impediment 1 but didn't 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)
815	-	-	-	1.0	-	-	-	-	-
880	-	-	-	4.0	-	-	-	-	-
920	-	-	-	3.5	-	-	-	-	-
925	-	-	-	2.0	-	-	-	-	-
927	-	-	-	10.5	-	-	-	-	-
951	-	-	-	2.0	-	-	-	-	-
962	-	-	-	0.5	-	-	-	-	-
1004	-	-	-	4.5 Mort*	-	-	-	-	-
1039	-	-	-	1.0	-	-	-	-	-
1056	-	-	-	3.5	-	-	-	-	-
1061	-	-	-	1.5	-	-	-	-	-
1081	-	-	-	3.5	-	-	-	-	-
1149	-	-	-	2.0	-	-	-	-	-
6811 †	-	-	-	1.5	-	-	-	-	-
6866	-	-	-	7.0	-	-	-	-	-
6885	-	-	-	1.0	-	-	-	-	-
7063	-	-	-	7.0	-	-	-	-	-
7203	-	-	-	1.0	-	-	-	-	-
7255	-	-	-	4.5	-	-	-	-	-
7281	-	-	-	1.0	-	-	-	-	-
Average				3.2					

Table D-6. Continued.

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)
1024		26 Jul	-	-	6.0	d.n.a.	-	17,386	-	-
Average		26 Jul			6.0			17,386		

Chinook Salmon (< 50 cm) that Approached Impediment 1 but didn't 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)
635		-	-	-	2.5	-	-	-	-	-
638		-	-	-	0.5	-	-	-	-	-
713		-	-	-	0.5	-	-	-	-	-
717		-	-	-	2.0	-	-	-	-	-
959		-	-	-	0.5	-	-	-	-	-
1117		-	-	-	1.5	-	-	-	-	-
Average					1.3					

Sockeye Salmon that Approached Impediment 1 but didn't 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)
898		-	-	-	5.5	-	-	-	-	-
1074		-	-	-	0.5	-	-	-	-	-
1093		-	-	-	0.5	-	-	-	-	-
2011	†	-	-	-	9.0	-	-	-	-	-
2216		-	-	-	0.5	-	-	-	-	-
2414	†	-	-	-	8.0	-	-	-	-	-
2724	†	-	-	-	3.5	-	-	-	-	-
2900	†	-	-	-	2.0	-	-	-	-	-
3831		-	-	-	0.5	-	-	-	-	-
Average					3.3					

Table D-6. Continued.

Coho Salmon that Approached Impediment 1 but didn't 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)
2522		-	-	-	1.0	-	-	-	-	-
2705	†	-	-	-	4.5	-	-	-	-	-
2805	†	-	-	-	2.0	-	-	-	-	-
3304		-	-	-	1.0	-	-	-	-	-
3511	†	-	-	-	2.0	-	-	-	-	-
3626	†	-	-	-	3.5	-	-	-	-	-
Average					2.3					

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. Fish that died while holding below an impediment were not included in calculations of average hold time. Hold times for fish noted with a dagger (†) were interpolated since surveys were not conducted every day during the period when the fish was present. 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 passed Impediment 1 but not Impediment 2. Sixth panel: Chinook salmon (< 50 cm) that approached within 1 km of Impediment 1, but did not pass. Seventh panel: sockeye salmon that approached within 1 km of Impediment 1, but did not pass. Eighth panel: coho salmon that approached within 1 km of Impediment 1, but did not pass.

Table D-7. Number of Chinook salmon counted during aerial spawner surveys, by location and survey period, 2013.

Stream	Survey 1 (July 19-21)	Survey 2 (July 25-27)	Survey 3[1] (Aug 1-3)	Survey 4[2] (Aug 8-10)	Survey 5[3] (Aug 14-16)
Cheechako	5	40	24	16	1
Chinook	0	2	1	0	0
Devil	7	25	15	12	0
Fog	0	1	0	2	2
Fog L1	0	0	0	0	0
PRM 184.0	0	0	0	0	0
PRM 184.0 R1	0	0	0	0	0
Tsusena	0	0	0	4	2
Deadman	0	0	0	0	0
Watana	0	0	0	0	0
Watana R5	0	0	0	0	0
Kosina	2	3	0	0	0
Gilbert	0	0	0	0	0
Tsisi	0	0	0	0	0
Tsisi Lakes	0	0	0	0	0
Jay	0	0	0	0	0
Goose	0	0	0	0	0
Oshetna	0	0	0	0	0
Black	0	0	0	0	0
Susitna	0	0	0	0	0
Indian River - above weir	336	363	192	69	1
Indian River - below weir	90	90	14	2	0

Notes:

[1] An estimated 2,600 other salmon (1,650 below weir): 85 percent pink, 10 percent chum, 5 percent sockeye salmon.

[2] An estimated 4,475 pink (2,355 below weir), 1,310 chum (20 below weir), and 35 sockeye (19 below weir) salmon.

[3] An estimated 1,355 pink (1,030 below weir), 80 chum (0 below weir), and 3 sockeye (0 below weir) salmon.

Table D-8. Summary of weather variability during the adult salmon aerial spawner surveys in the Middle and Upper rivers, 2013.

	Weather Condition					
Date	Sunny	Partly Cloudy	Overcast	Light Rain	Rain	Wind
July 19–21		x	x	x		x
July 25–27	x	x	x	x		
August 1–2	x	x				x
August 8–9		x	x	x		x
August 15–16	x	x	x			

Table D-9. Summary of survey condition rankings during the adult salmon aerial spawner surveys in the Middle and Upper rivers, 2013.

Variable	Average Rank	Reported Range	Standard Deviation
Sun Glare	2.8	1 to 4	0.55
Water clarity	2.8	0 to 4	1.32
Vegetation Cover	2.5	0 to 4	0.94

Notes:

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

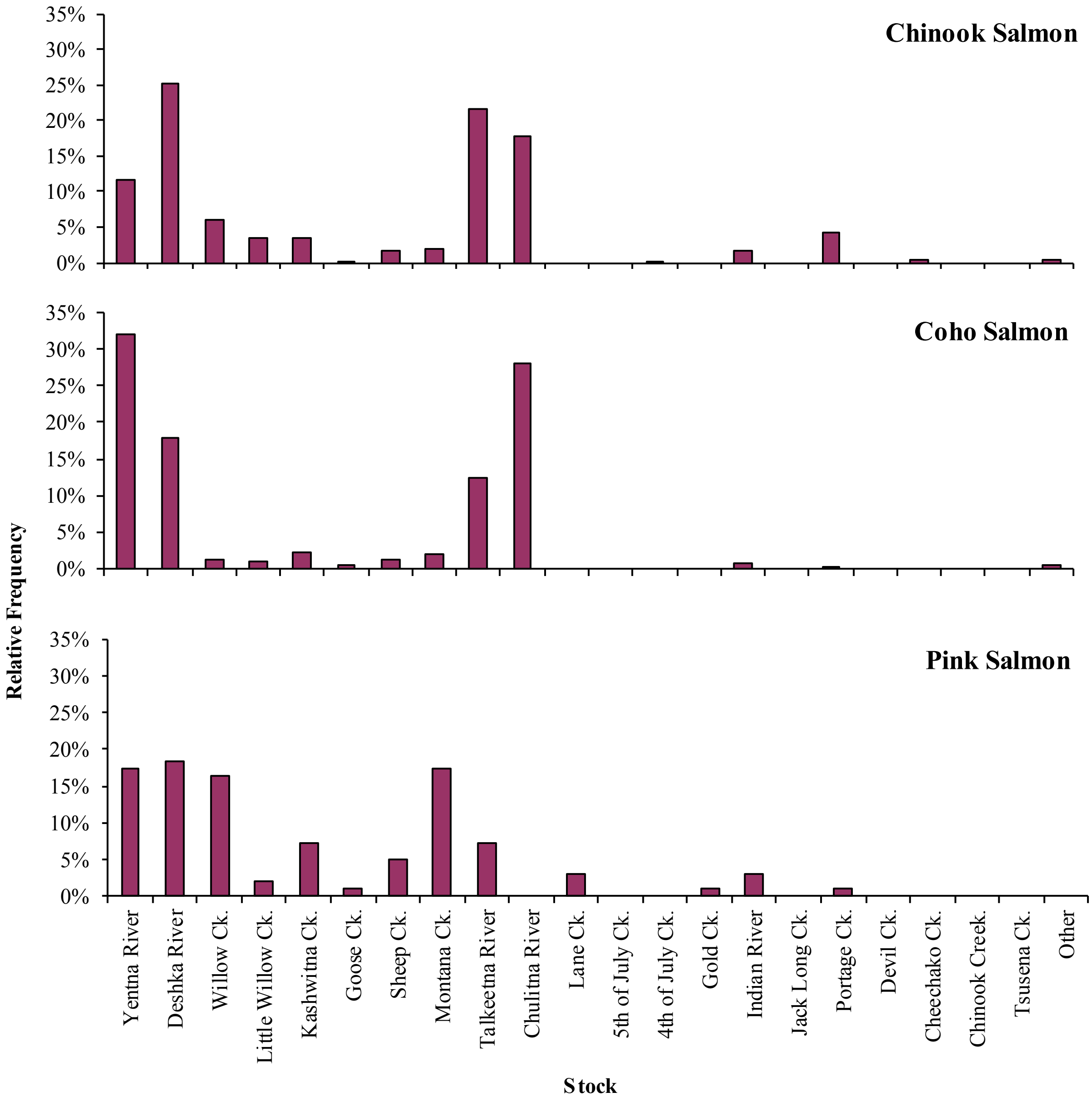


Figure D-1. Relative frequencies of tributary use by radio-tagged salmon released in the Lower River, by species, 2013.

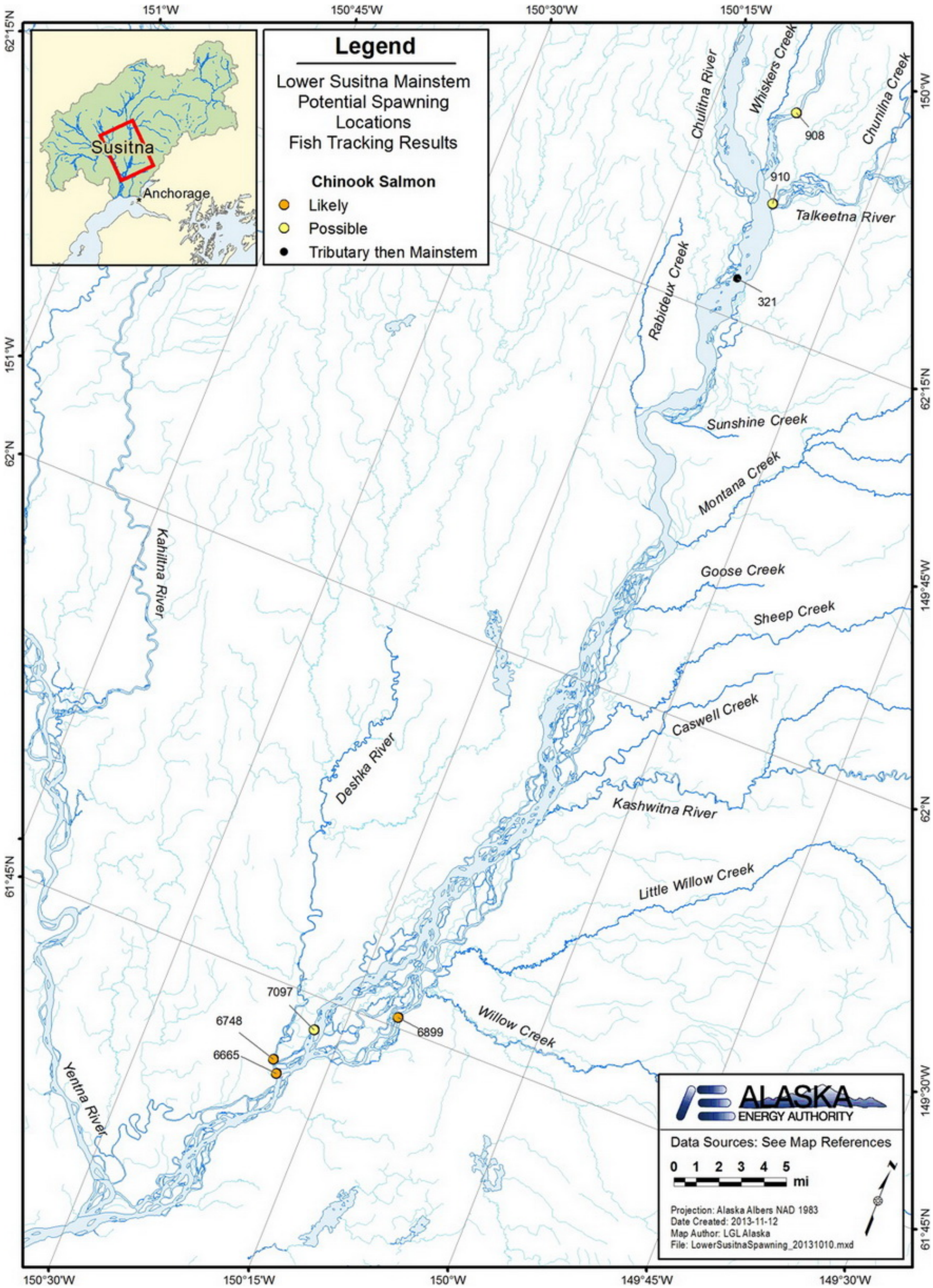


Figure D-2. Potential mainstem spawning sites for radio-tagged Chinook salmon in the Lower River, 2013.

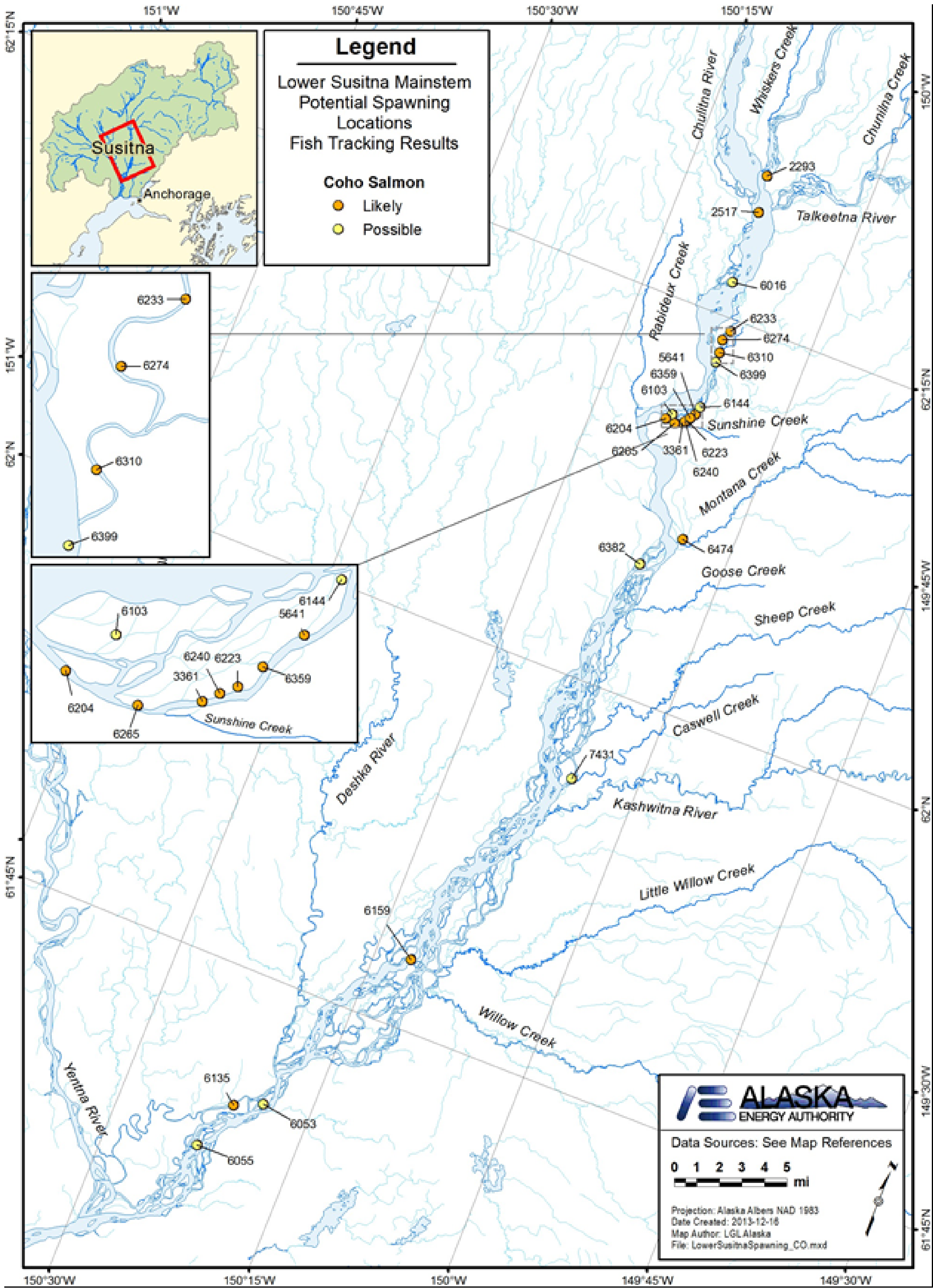


Figure D-3. Potential mainstem spawning sites for radio-tagged coho salmon in the Lower River, 2013.

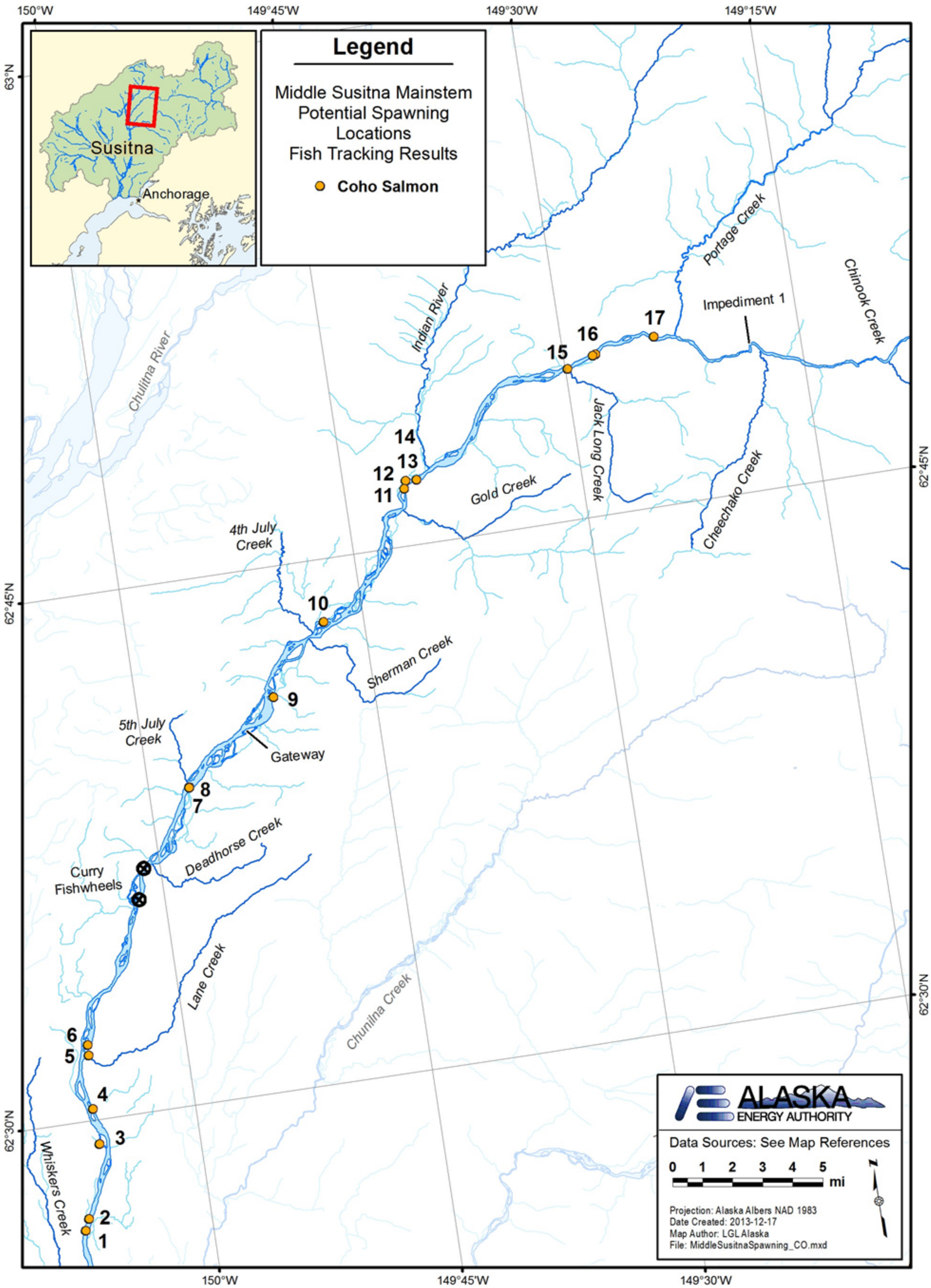


Figure D-4. Potential mainstem spawning sites for radio-tagged coho salmon in the Middle River, 2013.

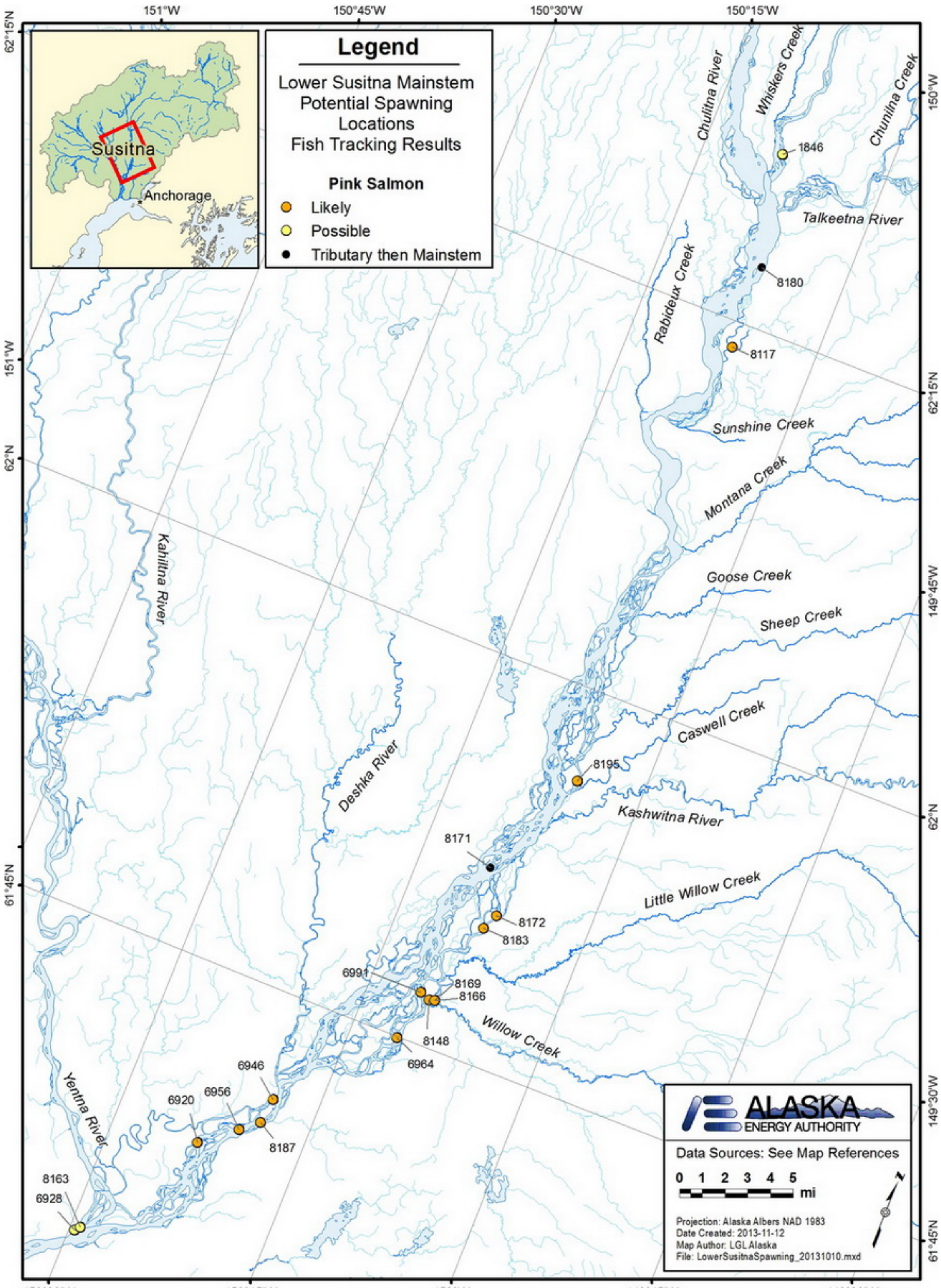


Figure D-5. Potential mainstem spawning sites for radio-tagged pink salmon in the Lower River, 2013.

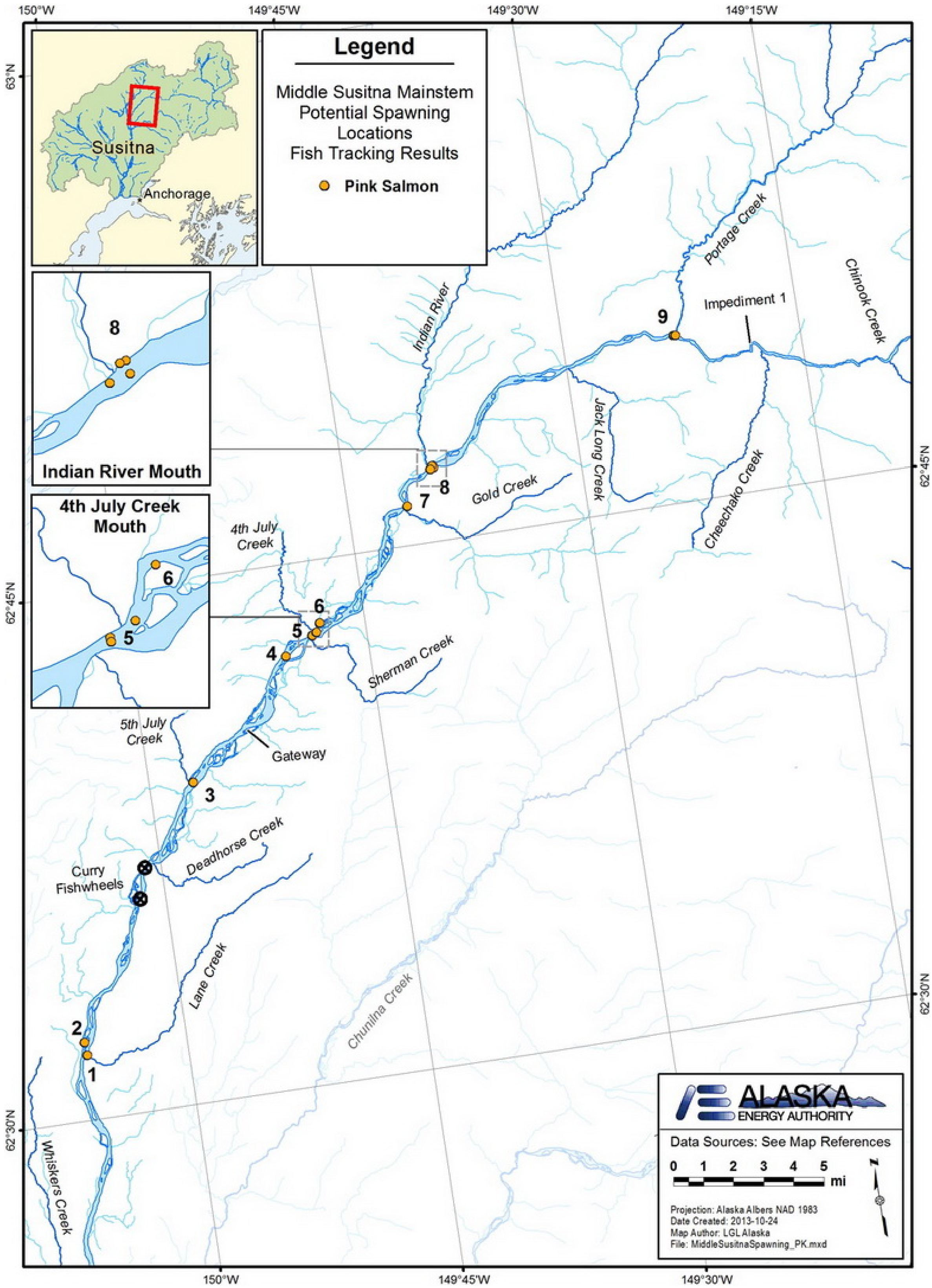


Figure D-6. Potential mainstem spawning sites for radio-tagged pink salmon in the Middle River, 2013.

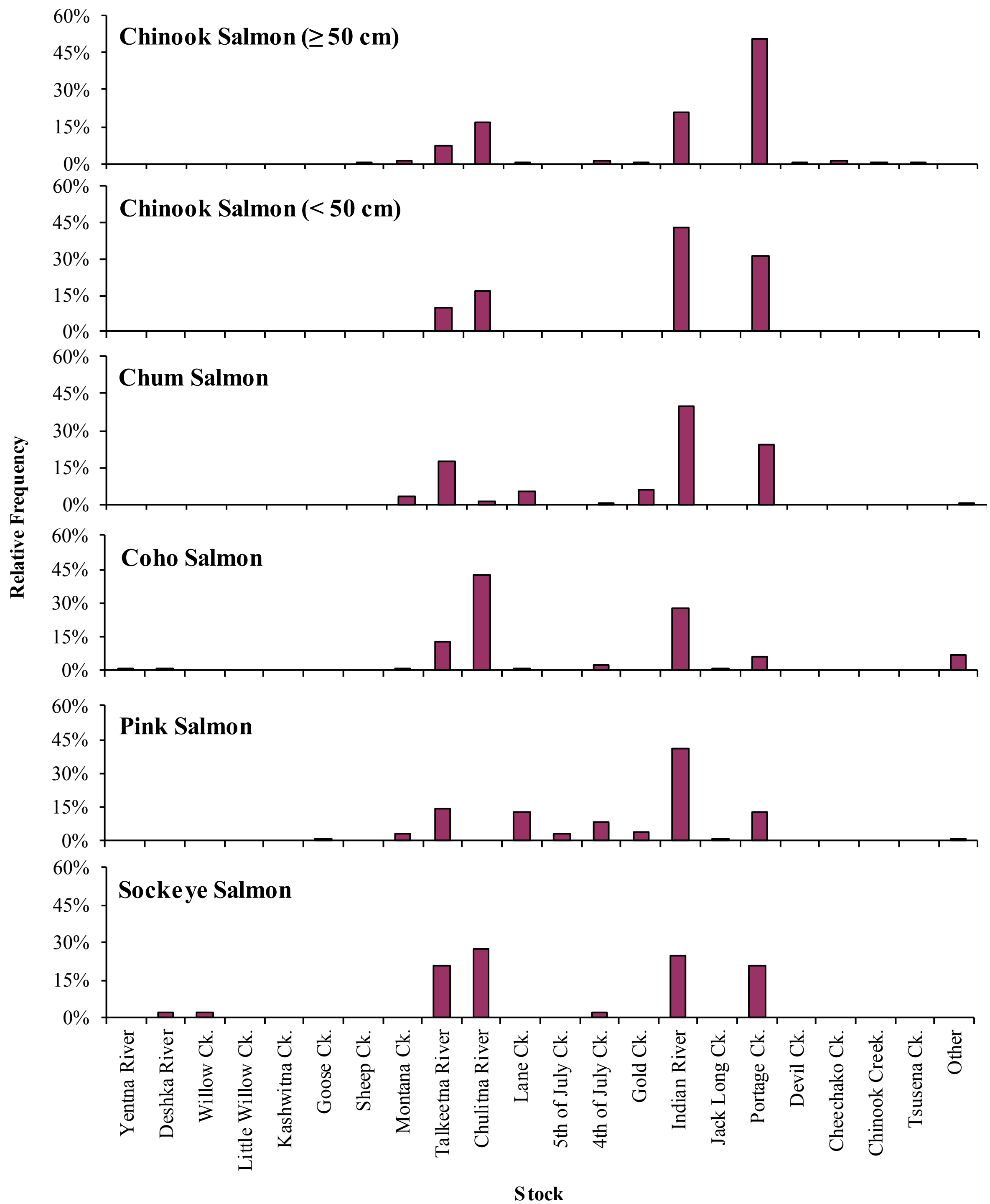


Figure D-7. Relative frequencies of tributary use by radio-tagged salmon released in the Middle River, by species, 2013.

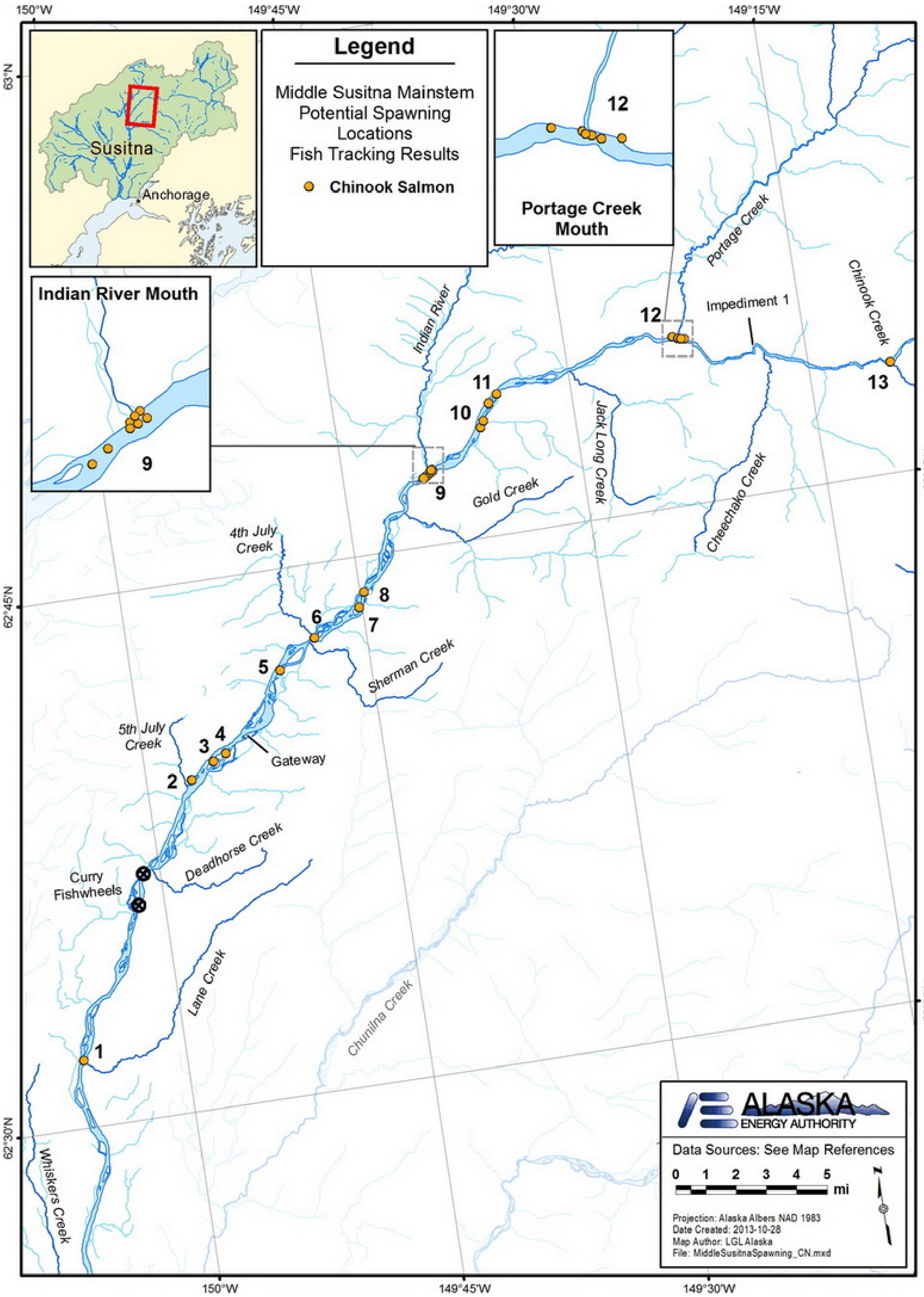


Figure D-8. Potential mainstem spawning sites for radio-tagged Chinook salmon in the Middle River, 2013.

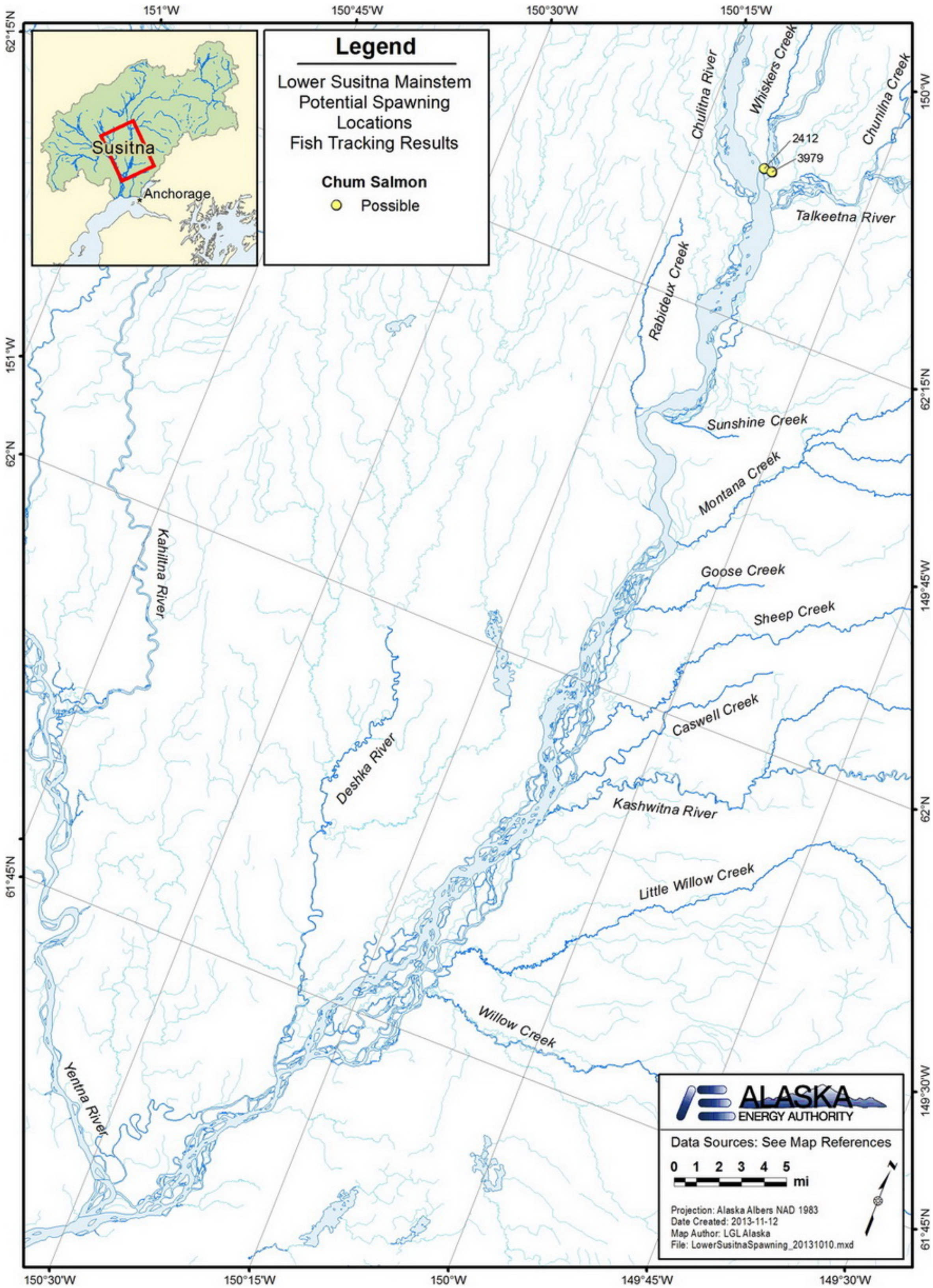


Figure D-9. Potential mainstem spawning sites for radio-tagged chum salmon in the Lower River, 2013.

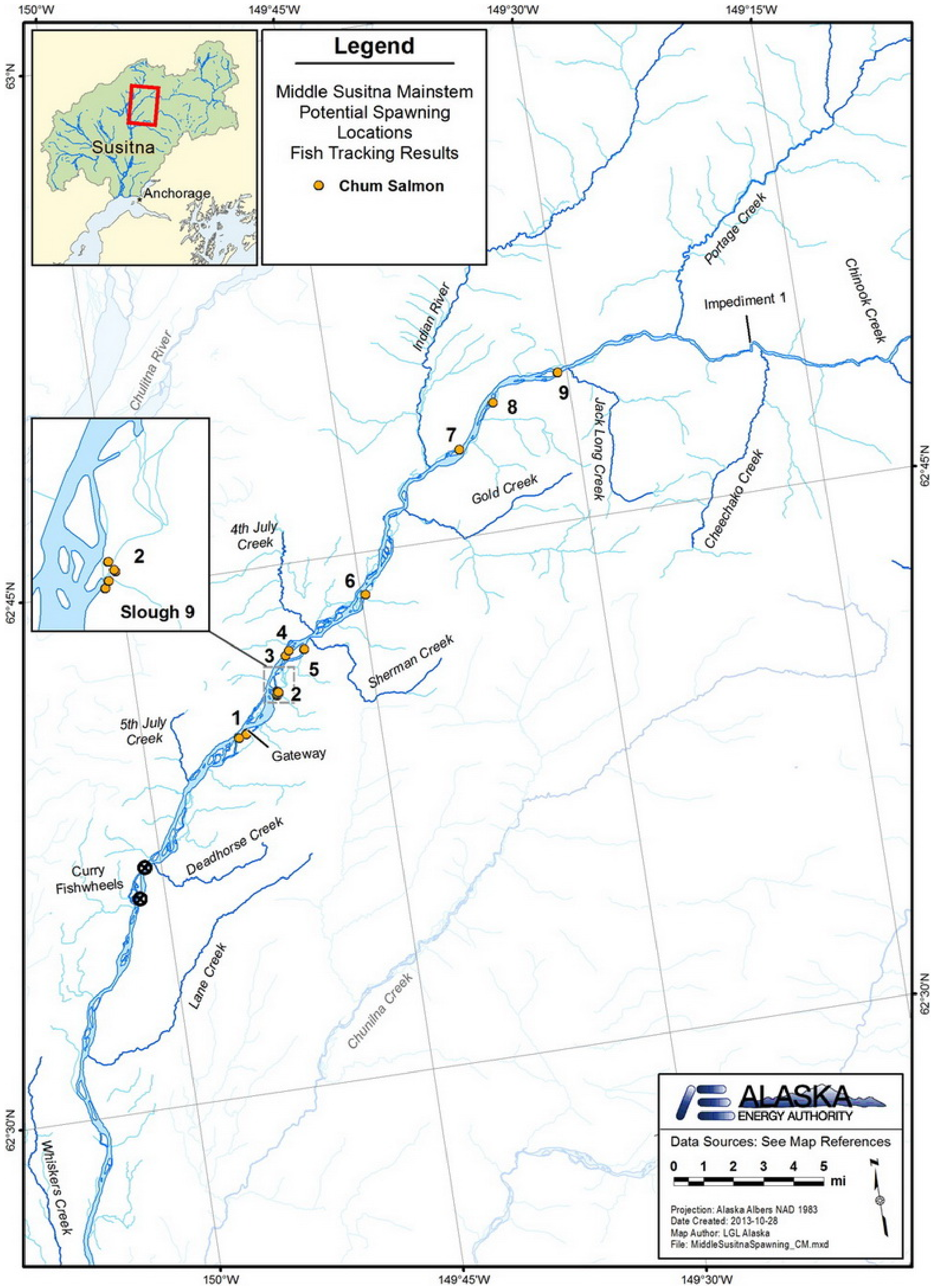


Figure D-10. Potential mainstem spawning sites for radio-tagged chum salmon in the Middle River, 2013.

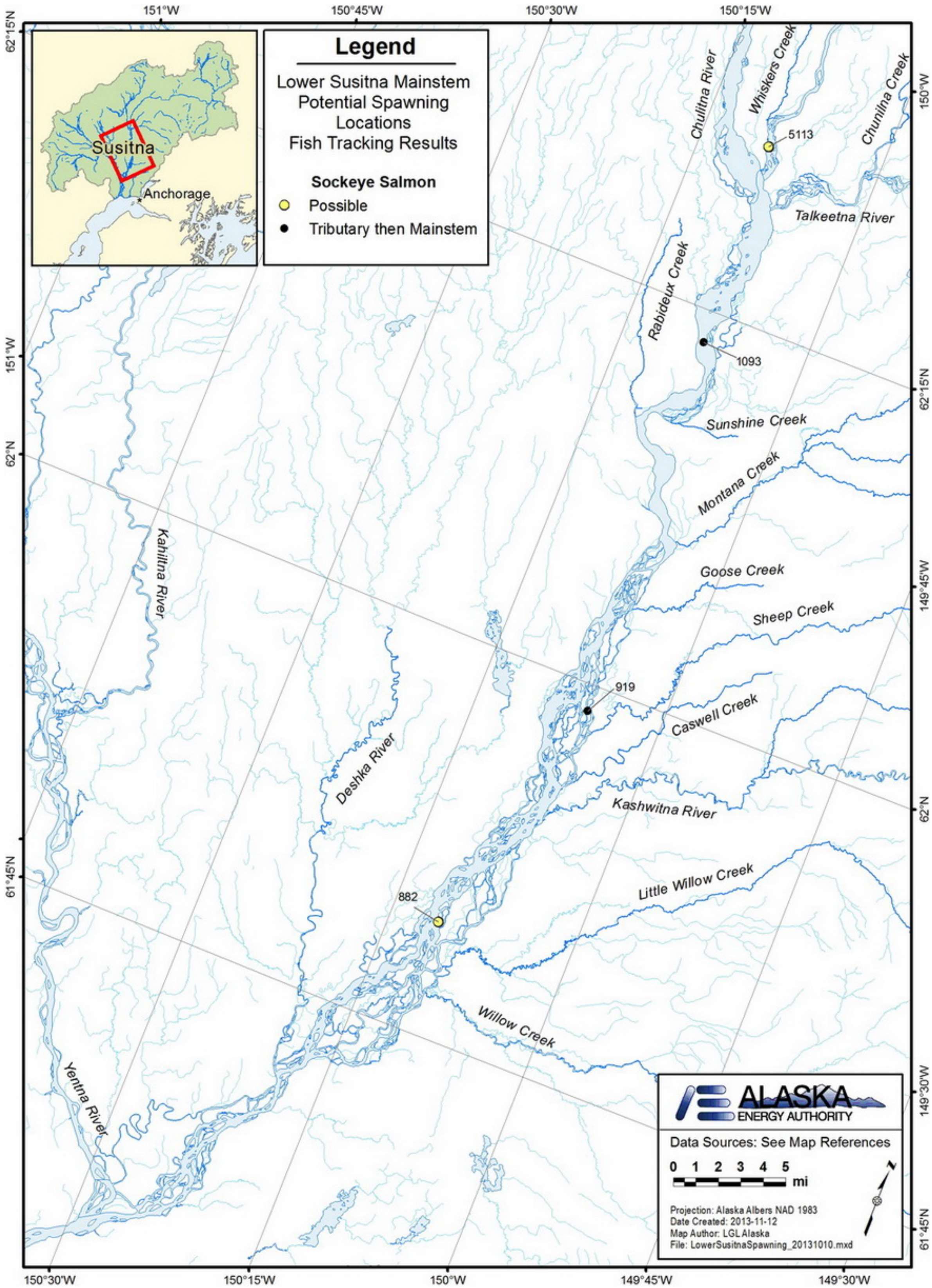


Figure D-11. Potential mainstem spawning sites for radio-tagged sockeye salmon in the Lower River, 2013.

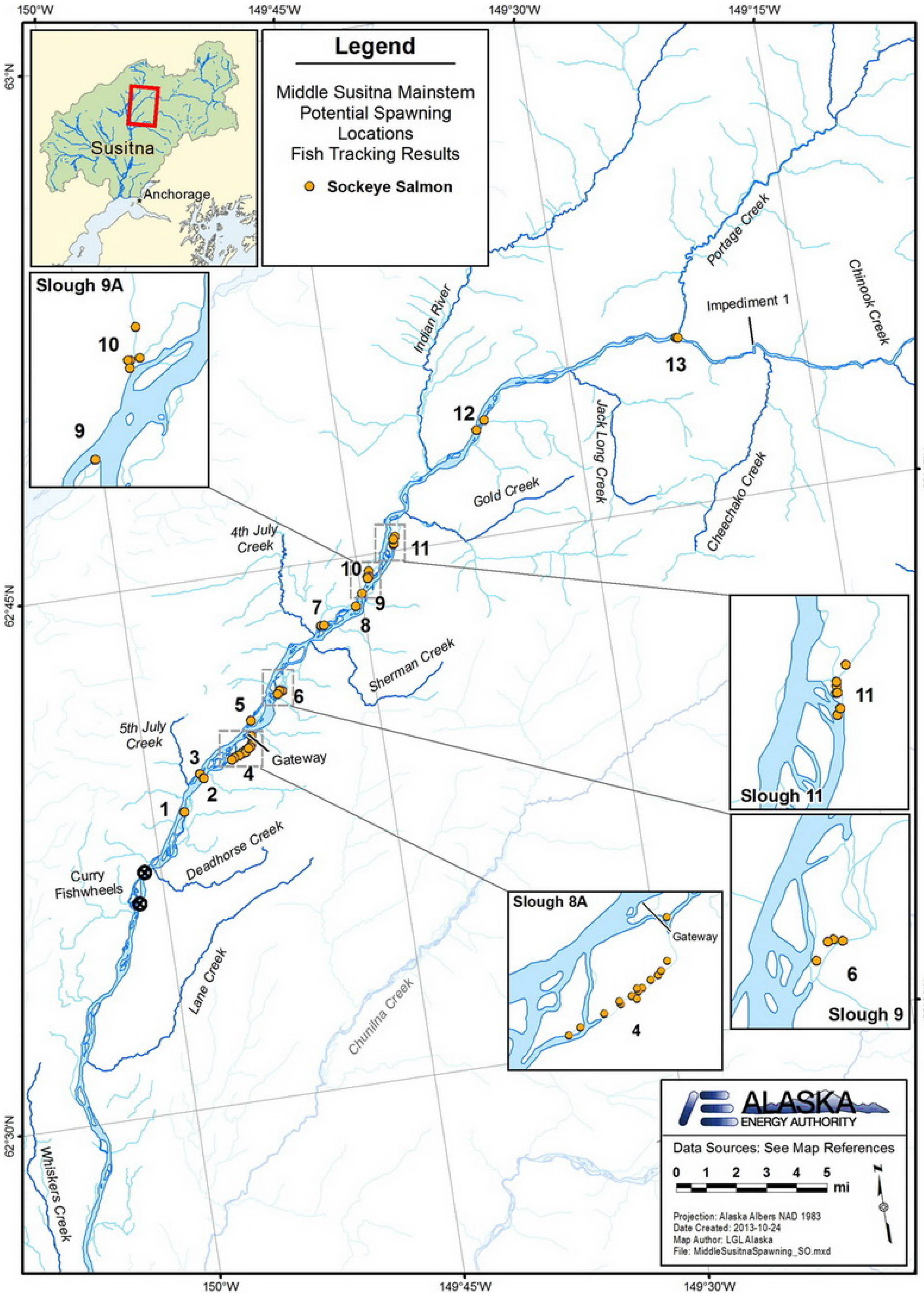


Figure D-12. Potential mainstem spawning sites for radio-tagged sockeye salmon in the Middle River, 2013.

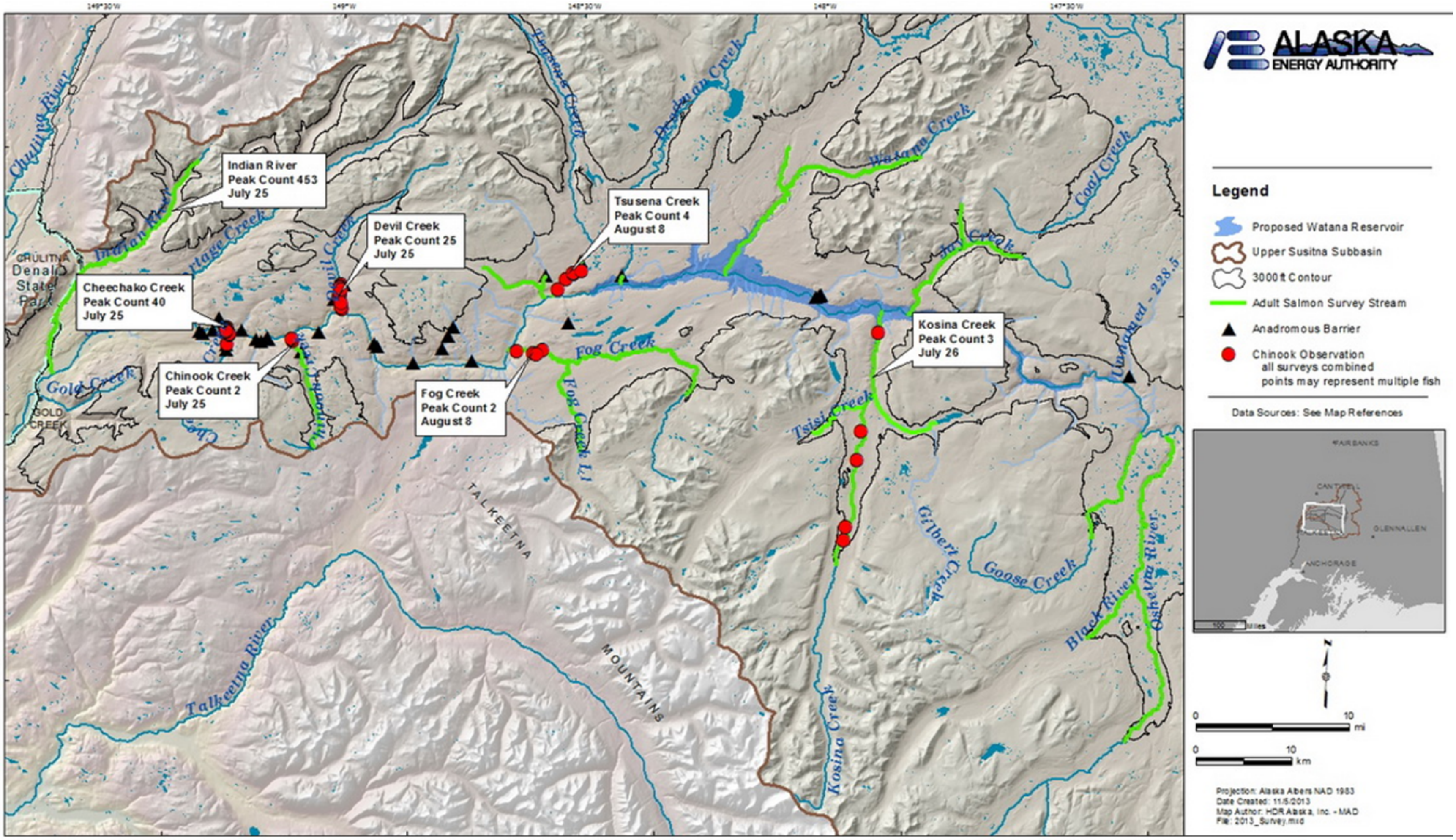


Figure D-13. Summary of Chinook salmon observations during aerial spawner surveys in the Middle and Upper rivers, 2013. All survey observations were combined; and observation points may represent multiple fish.

PART A - APPENDIX E: RADIO TAG RECOVERIES

Table E-1. Tag recovery information for fish released in the Lower River and Yentna River, 2013.

Species	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Chinook Salmon	6547	7 Aug	Willow Creek 100 yd upstream of railroad bridge	61.7658	-150.0417	Field Crews
(METF ≥ 50 cm)	6561	12 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	6570	11 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	6628	22 Jun	Deshka river mile 6	61.7735	-150.3419	Field Crews
	6649	6 Aug	Prairie Cr.	62.6167	-149.0554	Field Crews
	6687	24 Jun	Willow mouth	61.7785	-150.1662	Field Crews
	6734	24 Jun	Willow mouth	61.7785	-150.1662	Field Crews
	6882	30 Jun	Deshka River mile 2	61.7294	-150.3192	Field Crews
	7105	1 Jul	Deshka River mile 2	61.7294	-150.3192	Field Crews
	7124	8 Jul	Deshka R., above weir (RM7)	61.7886	-150.3398	Field Crews
	7126	5 Jul	mouth of Peters Cr.	62.1765	-150.8787	Field Crews
	7131	7 Jul	mouth of Clear Cr.	62.3799	-150.0162	Field Crews
	7227	13 Jul	Peters Cr., 5 mi. downstream of Forks Roadhouse	62.3053	-150.7257	Field Crews
	7258	22 Jun	Deshka ~1 mi. upstream	61.7121	-150.3238	Field Crews
	7263	25 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	7397	26 Jun	Lake Cr. near mouth	61.9092	-150.9096	Field Crews
	7588	1 Jul	Talachulitna river mile 1	61.8564	-151.3886	Field Crews
	7637	1 Jul	Johnson Creek (Yentna tributary)	62.0655	-151.6068	Field Crews
	7744	7 Jul	Moose Cr. (Yentna trib.)	61.7971	-150.6966	Field Crews
	7803	21 Jun	8 Mile Cr. on Skwentna R.	61.9548	-151.1964	Field Crews
	7825	5 Jul	Lake Creek near Yenlo Creek	62.0627	-150.9906	Field Crews
	7881	3 Sep	Lake Creek, ~6 miles downstream from Chelatna Lake	62.3664	-151.2955	Field Crews
	7959	26 Jun	Lake Cr. near mouth	61.9092	-150.9096	Field Crews
	8005	22 Jun	Lake Cr. river mile 1.5	61.9307	-150.9127	Field Crews
	8017	5 Jul	Lake Creek near Yenlo Creek	62.0627	-150.9906	Field Crews

Table E-1. Continued.

Species	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Coho salmon	6006	19 Aug	Peters Creek	62.3053	-150.7257	Field Crews
	6012	13 Sep	Chase Cr, middle Susitna ~2 mi. downstream of Lane Cr.	62.4956	-150.0951	Field Crews
	6038	4 Aug	Sustina River at Susitna Landing (Kashwitna confluence)	61.9110	-150.1033	Field Crews
	6106	10 Aug	Caswell Creek mouth	61.9392	-150.0839	Field Crews
	6131	21 Aug	Susitna River, mouth of Trapper Creek	62.2578	-150.1685	Field Crews
	6133	15 Aug	Clear Creek (Talkeetna River)	62.3799	-150.0162	Field Crews
	6151	18 Aug	Malone Slough (Yentna R. near Johnson C. confluence)	62.0841	-151.4969	Field Crews
	6200	7 Aug	Talachulitna river at Friday Creek	61.7108	-151.4597	Field Crews
	6212	20 Aug	Johnson Creek (Yentna tributary)	62.0655	-151.6068	Field Crews
	6238	14 Aug	Sheep Creek mouth	61.9712	-150.0875	Field Crews
	6241	1 Aug	mouth of Caswell Cr.	61.9392	-150.0839	Field Crews
	6256	20 Aug	Yentna River	61.7971	-150.6966	Field Crews
	6309	3 Aug	Deshka mouth	61.6976	-150.3173	Field Crews
	6349	3 Aug	Yentna River, 20-mile Slough	61.8265	-150.7918	Field Crews
	6410	10 Aug	Caswell Creek mouth	61.9392	-150.0839	Field Crews
	6460	22 Aug	Clear Creek (Talkeetna River)	62.3799	-150.0162	Field Crews
	6490	13 Aug	Deshka River, ~RM 4	61.7475	-150.3215	Field Crews
	6491	17 Aug	Lake Creek mouth	61.9092	-150.9096	Field Crews
	7422	17 Aug	Clear Creek (Talkeetna River)	62.3799	-150.0162	Field Crews
	7433	6 Aug	Sunshine Creek (Susitna trib.)	62.1782	-150.1032	Field Crews
	7496	19 Aug	Talachulitna River	61.8564	-151.3886	Field Crews

[1] Recovery coordinates are estimates, based on the site description.

Table E-2. Tag recovery information for fish released in the Middle River, 2013.

Species	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Chinook Salmon	178	31 Jul	Portage Creek	62.8367	-149.3729	Field Crews
(METF ≥ 50 cm)	214	14 Jul	no info	-	-	Field Crews
	298	1 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	305	17 Jul	Above Indian Weir	62.8112	-149.6592	Field Crews
	348	16 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	387	24 Aug	no info	-	-	Field Crews
	440	5 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	479	30 Jul	Portage Mouth	62.8290	-149.3800	Field Crews
	569	12 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	578	24 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	718	3 Aug	Troublesome Creek	62.6687	-150.2250	Angler
	727	5 Jul	Fishwheel Site 1 Curry	62.6165	-150.0161	Field Crews
	744	16 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	777	22 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	789	24 Jul	Above Indian Weir	62.8112	-149.6592	Field Crews
	805	18 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	812	2 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	841	22 Jul	Chulitna River	62.4910	-150.2480	Field Crews
	897	11 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	955	20 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	993	22 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	1003	3 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1062	5 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1123	29 Jul	Indian Weir	62.8124	-149.6624	Field Crews

Table E-2. Continued.

Species	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Chinook salmon	491	21 Jul	Spink Creek (Chulitna)	62.7280	-150.2410	Angler
(METF < 50 cm)	1024	11 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1067	14 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1117	3 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1138	30 Jul	Indian Weir	62.8124	-149.6624	Field Crews
	1157	7 Sep	West bank of Susitna	62.3238	-150.1381	Angler
Pink salmon	1503	14 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1504	14 Aug	1/2 mile up Indian River	62.7918	-149.6615	Field Crews
	1986	23 Aug	Fishwheel Site 3 Curry	62.6374	-149.9775	Field Crews
	2094	7 Aug	RM 138 - sandbar	62.7840	-149.6630	Angler
	2106	2 Aug	Slough 8A	62.6641	-149.9053	Field Crews
	2157	17 Aug	RM 148	62.8280	-149.4530	Field Crews
	2321	18 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	2586	11 Aug	Slough 8A	62.6709	-149.9000	Field Crews
	2595	8 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	2770	no info	Fishwheel Site 3 Curry	62.6374	-149.9775	Field Crews
	3490	28 Aug	5th of July	62.6536	-149.9578	Field Crews
Sockeye salmon	3863	no info	Slough 8A	62.6666	-149.8932	Field Crews
Chum salmon	1855	10 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	1980	13 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	2116	2 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	2196	10 Aug	Indian Weir	62.8124	-149.6624	Field Crews
	2502	12 Aug	Fishwheel Site 3 Curry	62.6374	-149.9775	Field Crews
	3877	13 Aug	Clear Creek	62.4950	-149.8770	Angler
	4106	17 Aug	Montana Creek weir	62.1056	-150.0486	Field Crews

Table E-2. Continued.

Species	Tag Number	Date Recovered	Recovery Location[1] Description	Latitude	Longitude	Recovery Method
Coho salmon	2739	17 Aug	Mouth of Indian	62.7853	-149.6582	Field Crews
	4917	28 Aug	Whiskers Creek	62.3747	-150.1690	Field Crews
	2721	8 Aug	Sunshine	62.1850	-150.1410	Angler
	2732	15 Aug	Lake Creek (Yentna)	61.9440	-150.9130	Angler
	2711	20 Aug	Clear Creek	62.4950	-149.8770	Angler

[1] Recovery coordinates are estimates, based on the site description.

PART A - APPENDIX F: TRACKING HISTORIES OF CHINOOK SALMON ABOVE IMPEDIMENT 3

Table F-1. Summary of migration and spawning behavior for three radio-tagged Chinook salmon after they passed Impediment 3, 2013.

					Spawning Period			Explorations Before Spawning			Downstream After Spawning			
Tag Number	Capture Date	METF (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]
241	21-Jun	64	Undetermined	Unknown	-	30-Aug	-	Near headwater	-	-	Below Talkeetna	-	-	45
272	23-Jun	64	Undetermined	Devils	30-Jul	12-Aug	14	Devils Creek	0	0	Devils Creek	0	0	13
395	26-Jun	65	Undetermined	Tsesena	22-Jul	01-Aug	11	near Deadman Creek	6.5	1	Tsusena Creek	0	0	19
Average					26-Jul	14-Aug	12.5		3.25	0.5		0	0	25.7

[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)

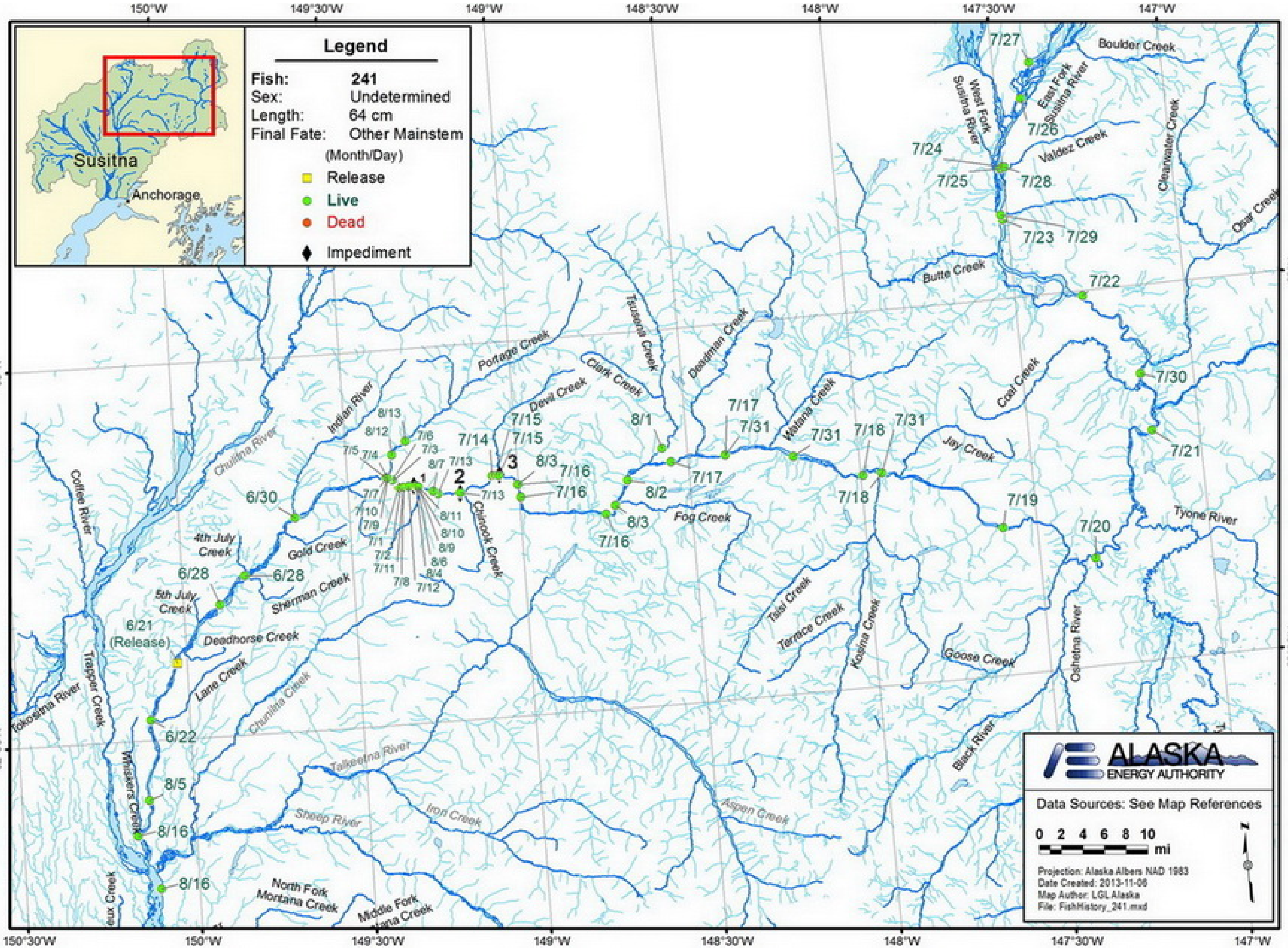


Figure F-1. Tracking history of a radio-tagged Chinook salmon (tag #241) that was detected above Impediment 3, 2013.

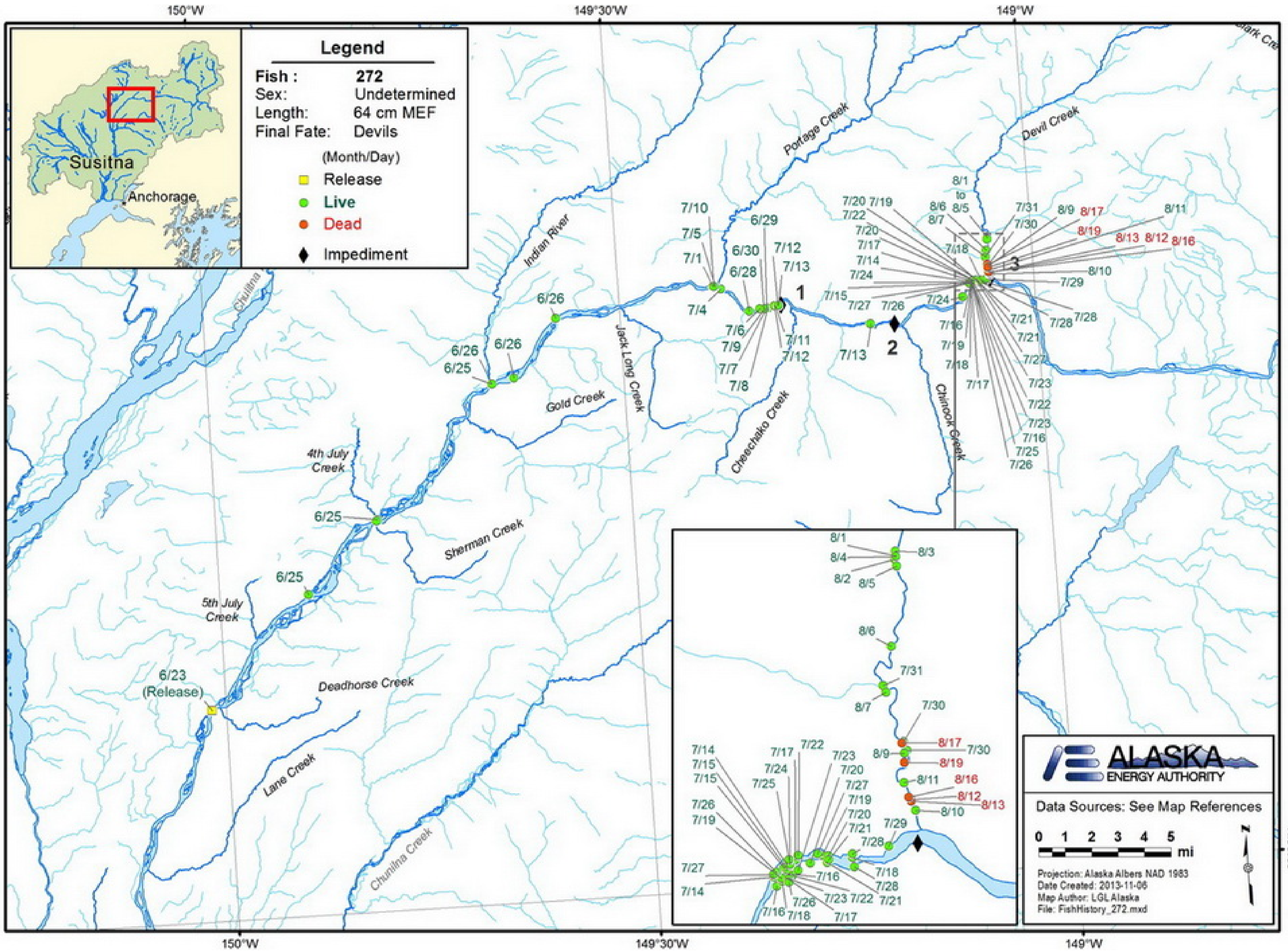


Figure F-2. Tracking history of a radio-tagged Chinook salmon (tag #272) that was detected above Impediment 3, 2013.

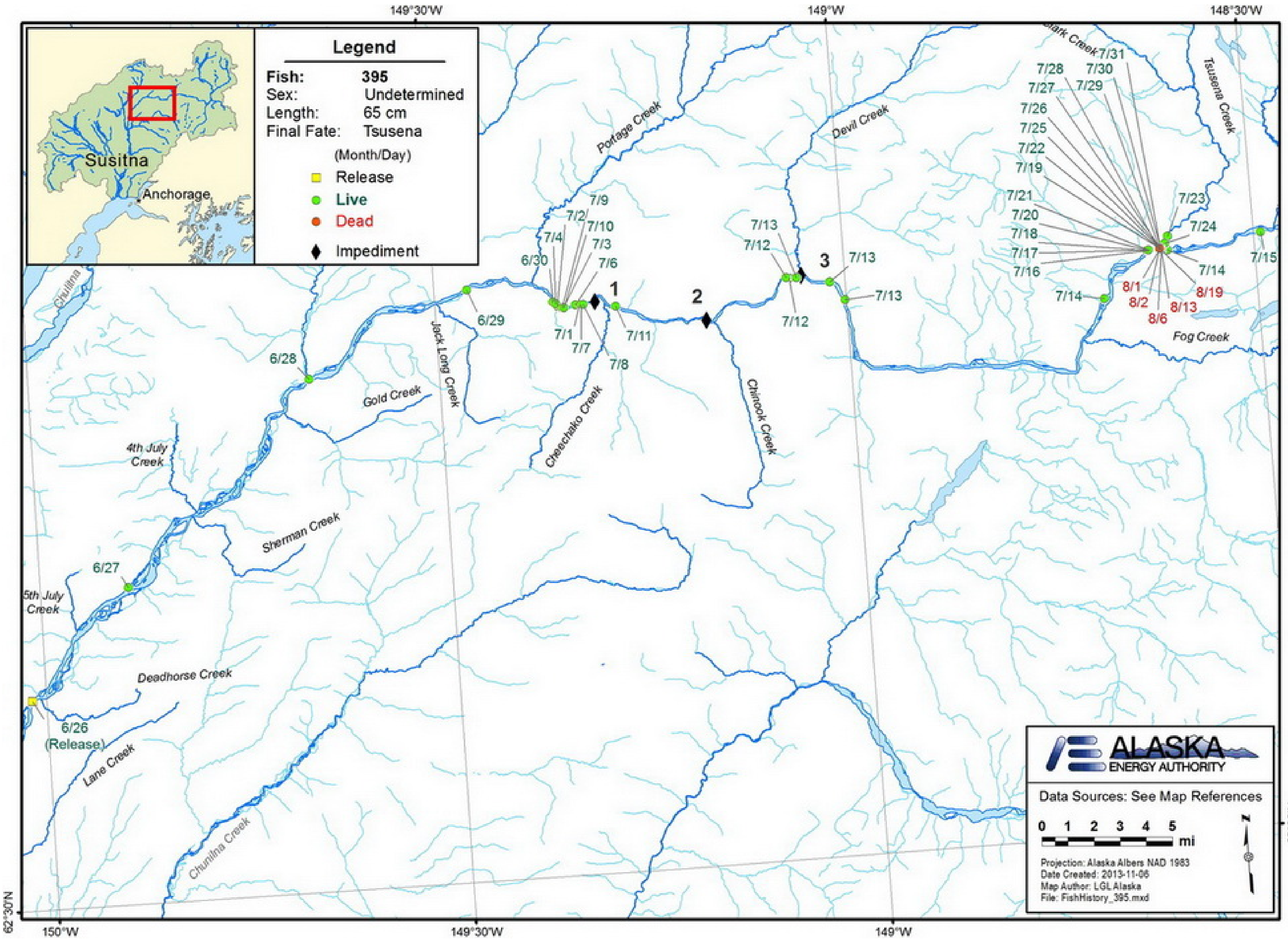


Figure F-3. Tracking history of a radio-tagged Chinook salmon (tag #395) that was detected above Impediment 3, 2013.

PART A - APPENDIX G: FEASIBILITY STUDY ASSESSING FISH COUNTS WITH SONAR IN WATANA CANYON, 2013

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 not well understood. 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 2013, 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 into the project area."*

Assessing the potential to accurately count fish requires a number of different considerations, including physical site characteristics, the ability to effectively operate gear, and whether the counts are indices, estimates, or a complete census. The life history and behavior of each fish species can further affect these considerations – resident fish, for example, can migrate both upstream and downstream, and thus may require a different study design than salmon migrating only upstream.

AEA followed up on FERC's recommendation by evaluating the feasibility of using sonar to detect and count fish in the Watana Canyon area in July of 2013. AEA chose multi-beam imaging sonar because it provided the highest likelihood of being able to observe fish behavior and movement, and, to a lesser extent identify species or species groups. As stated in Section 4.3.4, a weir was deemed physically impossible due to the high volume and variability of water flow (summer flows in Watana Canyon range from about 15,000 to over 40,000 cfs), depth, and complex bathymetry.

This report describes the site feasibility study in July of 2013, evaluates the ability to count fish given site conditions and other considerations, and describes the plans for 2014.

1.1. Study Objectives

The specific objectives for this feasibility study were:

1. Identify suitable deployment sites and verify that multi-beam imaging sonar can detect fish in Watana Canyon near the Watana Dam site.

2. Combine field results with study design considerations to evaluate the potential for using sonar to accurately count fish species migrating upstream through Devils Canyon and into the Watana Canyon area.

3. Describe logistical considerations and equipment necessary to establish a monitoring station, if sonar counts of fish were determined to be feasible.

2. STUDY AREA

The study area was in the Watana Canyon reach of the Susitna River near the proposed Watana Dam site, between PRM 184 and PRM 187 (Figure G-1). Lack of CIRWG land access limited study sites to places where a helicopter could land below mean high water (MHW). Additional criteria for site selection included the presence of a level area above MHW that could be used to operate electronic equipment if the site were chosen for future use, laminar water flow, a river bottom with a consistent, gradual slope, and a width narrow enough to be completely ensonified by sonar directed from shore. These latter features are usually found in straight, moderately constrained stretches of river with a gravel bottom and no bedrock outcrops.

3. METHODS

The Watana Canyon reach was surveyed by helicopter on July 19, 2013 to locate potential sites for installing an Adaptive Resolution Imaging Sonar (ARIS) system to monitor fish. Three sites were chosen, each of which was evaluated for one day from July 20–23 (Figure G-1). All fieldwork, including helicopter landings, was done below the MHW of the Susitna River. Each site was then assessed for overall suitability for future sonar studies.

Sonar imaging was conducted using an ARIS 1200 (www.soundmetrics.com) mounted to an aluminum H-mount frame (Photo G-1). The ARIS 1200 can be operated with two different frequencies (1.2 and 0.7 megahertz [MHz]) and has a sample volume defined with a 29 degree (horizontal) by 14 degree (vertical) field of view. Maximum range for viewing fish measuring 26 in or greater in length is about 200 ft. The ARIS system consisted of a sonar head, 50 ft data transmission cable, topside switch box, Ethernet cable, Toughbook laptop computer, and portable external hard drives. The system was powered by a gasoline-powered Honda 2000 generator. Data were collected using ARIScope software in consecutive 10-minute files, and the system was typically configured to use an imaging frame rate of between four and seven frames per second. Both operational frequencies (0.7 and 1.2 MHz) were used at each site. All data were ported directly to the external hard drives, and backed up and archived to additional hard drives.

Data were processed using ARISFish software (www.soundmetrics.com) to assess fish presence. Processed data were reviewed in echogram mode, which allowed entire 10-minute data files to be viewed on the computer screen with time on the X-axis and sonar range on the Y-axis. Fish present in the data were shown as echo traces. When traces were observed, the data segment containing the trace was played back in streaming data mode, which allowed direction of travel and fish length to be characterized.

4. RESULTS

4.1. Site Characteristics

The ARIS was tested on one day at each of three sites in the Watana Canyon Area, for three to five hours at each site (Table G-1; Figure G-1). The three sites were selected based on access permission and the basic shoreline criteria described above. Additional potential study sites likely existed, but were not accessible because they would have required a helicopter landing above MHW. River discharge during the July 19–23 study period decreased from 21,840 to 16,953 cfs over the four-day study period, based on data from the Tsusena Creek gauge (Figure G-2; data obtained from http://waterdata.usgs.gov/usa/nwis/uv?15291700).

All sites had a helicopter landing zone (LZ) below MHW, and suitable areas above MHW for a battery bank and electronics. Site locations, physical characteristics, and basic testing details are provided in Figure G-1 and Table G-1. The ARIS was deployable and operable at each site. The ARIS detected multiple species of fish at Site 1, demonstrating that Objective 1 (detection of fish in the Watana Canyon area using sonar) is technically feasible. Each site, however, presented its own set of challenges that must be addressed before Objective 2 (accurately counting fish) can be met. These challenges differ for the type of counts and the species of interest.

Site 1 was near PRM 184, approximately 3 miles downstream from the proposed Watana Dam site (Photo G-2). A dry gravel beach extended 65 ft from MHW on the river right bank (looking downstream) to the water's edge (Photo G-3). The ARIS was operated at the wetted edge of this beach on July 20 from 10:15 to 14:15, for a total of four hours. The ARIS was able to ensonify most of the water column (proportion of the water column ensonified is unknown since water depth during the time of the survey was also unknown) out to halfway across the river (98 of 196 ft). Substrate could be seen in the field of view out to 98 ft in range. The inability to see substrate beyond this indicated a change in bed slope. Along river left, velocities were high and a large boulder caused rapids. It is conceivable that the swift water could deflect upstream-moving fish to the calmer water on river right, where they would be ensonified; if so, all fish moving upstream at this site could be counted. The low frequency setting provided better resolution (more clear imagery of the substrate and water column) than did the high-resolution setting. This was likely the result of greater amounts of noise generated with the high frequency setting associated with the turbid water conditions. The low frequency setting afforded a greater signal to noise ratio than did the high frequency setting.

Site 2 was just upstream of the Watana Dam site near PRM 187 (Figure G-1; Photo G-4). The river had an approximately 262 ft wetted channel at this site (Photo G-4). The ARIS was placed on the river right bank and operated on July 21 from 10:15 to 14:20, for a total of 4.08 hours. The ARIS was able to sample out to 20 m (65 ft) before the channel slope increased, based on how far substrate could be seen in the field of view (Photo G-5). As with Site 1, the low frequency setting provided better resolution than did the high frequency setting. Approximately 60 m (192 ft) of the river cross section was outside of field of view, based on substrate in the sample volume. Although the field of view was not as long as at Site 1, it may be possible to operate a second ARIS from the opposite bank at Site 2. This second ARIS would need to have a field of view of approximately 200 ft to ensonify all potential fish; this distance is within the specifications of the ARIS, but would require a favorable river bed topography (flat to gradually sloping).

Site 3 was located at PRM 187.8 (Figure G-1; Photo G-6). The wetted channel was approximately 134 ft wide (Photo G-6). The ARIS was operated from the river left bank on July 22 from 11:03 to 14:10, for a total of 3.12 hours. The ARIS was able to see the river bottom for only 4 m (13 ft) before the channel slope increased. As at Site 2, ensonification of the river channel would require a second ARIS unit operated from river left, with a gradual enough bed slope to allow a field of view of approximately 120 ft.

4.2. Detection of Fish with Sonar

Fish were detected at Site 1, where the imagery showed promise for counting fish if suitable locations or designs can be identified. At Site 1, three distinct large fish greater than 80 cm (31 in) in estimated total length passed between 12 m (39 ft) and 16 m (52 ft) from shore all moving upstream (e.g., Figure G-3). Based on their body length it is likely these fish were Chinook salmon *Oncorhynchus tshawytscha*. Other fish (typically five to eight individuals) from 20 cm (7 in) to 40 cm (15 in) in total length were observed milling within the sonar sample volume for the entire data collection period. Most of the milling fish were between 3 m (9 ft) and 12 m (39 ft) from shore. Thirty fish were caught by angling in the vicinity of this site in an attempt to identify the ensonified fish; all thirty were Arctic grayling *Thymallus arcticus*. No fish were observed in the sonar beyond a sonar range of 16 m (52 ft).

4.3. Accurate Counts of Fish

The entire river channel could not be ensonified at any of the three sites using a single ARIS unit. Other forms of sonar (such as non-imaging) would also be limited by the bed slope bathymetry at these sites. The three main options for using sonar to attain fish counts appear to be (1) finding another site where the river bed slopes more gradually than at the sites tested in 2013, (2) to use multiple ARISs in combination at one site (with overlapping fields of view), or (3) to use ARIS in combination with another method such as mark recapture. Adult Chinook salmon can probably be distinguished from other species due to their longer body length; all other fishes would need to be actively sampled to identify to species. If complete counts of fishes are not required, indices could be developed for some or all fish. The development of indices would be most consistent at Site 1 due to the high water velocities offshore and the likelihood that fish would be more bank-oriented, and thus more likely to be ensonified.

5. DISCUSSION

5.1. Site Feasibility

The three sites tested in this study were the most promising of those where access was permitted. It is likely that there are other equally good or superior sites that would be feasible if access above the MHW in the Watana Canyon reach was permitted by landowners. The ARIS 1200 has a maximum range of about 200 ft for detection of fish less than 26 inches in length, but in a riverine application such as the Susitna River in Watana Canyon, the bottom profile may limit this range. None of the three sites tested had suitable underwater bed slopes for verifying distances beyond 98 ft (substrate was clearly seen up to this point). Substrate visibility is a critical feature of sonar monitoring sites to ensure that low-lying channels or troughs are not present in the substrate where fish might move undetected by the sonar.

Based on the testing in 2013, the inability to ensonify the entire river width in the Watana Canyon area can be broken down into the following short list of potential solutions:

1. Find an alternate site with a bed slope and streamside features suitable for using a single ARIS to ensonify the entire river. This seems unlikely, given the river's width.

2. Find a site in which two ARIS units operated from opposite banks can have overlapping fields of view. This seems more likely to be feasible.

3. Demonstrate at Site 1 (or elsewhere) that the rapid on river left pushes upstream-migrating fish to river right, into the beam of an ARIS operated from that shore. This has potential and may be supported by published studies from elsewhere and by on-site water velocity measurements, but could remain vulnerable to changes in water levels during low-flow periods.

In addition to being able to ensonify the desired river width, a suitable site will also have to be accessible by air (i.e., a viable LZ), and have an area above MHW able to house the equipment (two areas if using the ARIS on opposite banks).

5.2. Fish Image Detection

Within the field of view, the ARIS was able to effectively detect fish (Site 1). The ARIS was able to document fish movement direction, another essential component. Importantly, some targets were distinctly larger than others, indicating that adult Chinook salmon greater than 20 in METF length can be differentiated by their larger body size from resident fish species. This differentiation relies on the assumption that Chinook salmon are the only salmon species present above Devils Canyon. All historic fish data as well as fish sampling and radio telemetry studies conducted by AEA in 2012 and 2013 indicate that this assumption is accurate. The ARIS will not be able to differentiate among most other fish species. ARIS may be able to identify the group of species with anguilliform (sinuous) swimming motions, such as burbot *Lota lota* and Arctic lamprey *Lethenteron camtschaticum* and Pacific lamprey *Lampetra tridentate.* While burbot are known to be present in the Upper River, lamprey species have not been documented above Devils Canyon. The common approach in mixed species environments is to use direct capture methods to apportion species, and apply this apportionment to sonar counts to yield an estimate of the total number of each fish species present (e.g., Westerman and Willette 2013). To summarize, it is likely that the ARIS alone can provide counts of Chinook salmon larger than 20 inches; for most other fish, ARIS images will need to be paired with direct capture sampling to determine species composition. Finally, future sonar work will also need to assess the detectability of fish at range to properly calibrate counts. The detectability of fish will likely decline with distance from the sonar; there are ways to quantify this phenomenon, usually involving multiple sonar units at different ranges from shore.

Direct capture sampling to estimate the species composition of fish besides Chinook salmon is a common need in sonar studies; potential direct capture sampling methods to use in Watana Canyon include beach seining and drift or set gillnet sampling. Sampling could be used periodically (e.g., daily or weekly) throughout the sonar operation period. Once apportioned to species, sonar counts of anadromous fish could be developed for corresponding time periods.

5.3. Using Sonar to Accurately Count Fish

It is possible the ARIS can be used to generate counts of adult salmon in Watana Canyon, but it is unlikely to be feasible for resident fish for several reasons. First, there would be no effective way to count resident fish holding below or above the sonar site. Second, a resident fish would only be counted if it migrated past the sonar, and the migration times of various species of resident fish are temporally separated such that operation of the sonar would be required year-round. Freeze-up in the fall would limit the operational period of the sonar. Neither of these limitations applies to adult salmon because they all originate from downstream, and because the possible migration upstream would be during the open water period.

Accurate (i.e., unbiased) counts of fish would require either a complete census or some means of estimation. A complete census would require ensonifying the entire river width, as described in Section 5.1. The two best options for counting Chinook salmon in Watana Canyon are to find a place where ARIS can cover the entire river channel, or to demonstrate that swift-moving water such as the rapids at Site 1 push upstream-moving fish into a part of the channel that can be entirely ensonified. This latter approach would require testing of the assumption that the rapids pose a velocity barrier under all relevant flow conditions.

An estimate would require subsampling part of the river, but must be paired with other information to know how the number of fish in the sub-sample (e.g., the ensonified area) represents the entire fish population. Two common approaches to estimation are to expand the sub-sample counts by a quantity thought to represent the unsampled area, and to use any of several forms of mark-recapture methods. Both approaches have been used extensively to count fish in riverine applications similar to Watana Canyon. Both hold promise, but are sufficiently complicated that a full discussion is beyond the scope of this report. In each case, the species apportionment sampling discussed in Section 5.2 would still be needed (except for large Chinook salmon).

The mark-recapture approach for estimating total fish abundance is possible because salmon are already being marked downstream with radio tags as part of the Escapement Study (Study 9.7). At Watana Canyon, a combination of telemetry receivers, the ARIS, and both marked and unmarked salmon would be used to assess sonar efficiency and ultimately expand sonar counts to estimate total abundance. This is most feasible with relatively low numbers of salmon passing the site each hour. Further simplifying this approach, it is likely that only Chinook salmon migrate through Watana Canyon en route to spawning destinations. Juvenile and adult Chinook salmon are the only salmon species confirmed to be in the Upper River by historic studies, ADF&G studies and AEA's extensive radio tagging and fish sampling studies conducted in 2012 and 2013. If other salmon species migrate through Watana Canyon, then alternate sampling methods would be needed to apportion fish counts to species.

One alternative to both complete counts and estimates of salmon abundance is to provide an index over time and a minimum estimate of salmon abundance; this would be more feasible, and may be sufficient to meet the intent of the FERC recommendation.

5.4. Using Fish Counts at Watana Canyon to Estimate Fish Migrating Through Devils Canyon

Part of FERC's recommendation was that AEA evaluate the ability to use the Watana Canyon site(s) to count fish able to migrate up through Devils Canyon. Taken literally, this would require counting fish, by species, migrating through Devils Canyon and then reaching Watana Canyon. This would also require adjusting for additions and subtractions (e.g., due to spawning and/or movement between tributaries and the mainstem river), and would be beyond the scope of a weir or sonar site at Watana Canyon alone. For resident fish, a sonar monitoring station located in Watana Canyon can only be used to assess numbers of resident fish that use the reach; it would not be able to assess whether these fish originated from above or below Devils Canyon.

5.5. Logistical Needs for Future Work

The 2013 sonar site selections and assessments were limited to locations with a gravel bar to accommodate a helicopter landing and sonar operation below MHW during a 4-day period. Other sites likely exist within the area of interest, but further assessment requires permission for access above MHW

A two-person crew would be needed to set up, operate and maintain the monitoring station(s). Daily site visits by helicopter (approximately 15 minutes each way) would be required to maintain the sonar system(s), switch out and backup external hard drives and conduct direct capture sampling.

Each ARIS system (sonar head, data transmission cable, sonar switch box, laptop computer, and multiple portable external hard drives), fabricated aluminum mount, also requires twelve 6-volt AGM sealed batteries, a 2,000-Watt gas generator and a 15-gallon fuel containment unit housed above the MHW mark. A sheltered platform is needed to house the electronic equipment. A small boat with an outboard motor would be necessary to tend and maintain the systems at both sites and conduct the direct capture sampling.

6. CONCLUSIONS AND RECOMMENDATIONS

The ARIS technology could be used to count fish in Watana Canyon, but providing an accurate count for Chinook salmon is more feasible and likely to be more effective than providing counts for other species. Providing an accurate count will require more assessment to find a site where the entire river channel slopes gradually enough to be ensonified; alternatively, an area where high water velocity pushes fish to a part of the river that can be ensonified would work as well. If other salmon species are present in Watana Canyon, active sampling methods would be needed to apportion fish counts to species. Although commonly done in other riverine sonar applications for salmon, this species apportionment would require a substantial amount of additional effort. In conclusion, sonar counts of fish in Watana Canyon are much more feasible for Chinook salmon than for other anadromous or resident fish species.

During the next study year, implementation in late June or early July may enable a sonar unit to count Chinook salmon in mid-to late July and early August, when the Chinook salmon run presumably passes through Watana Canyon. The plan for project implementation in June of the next study year is as follows:

1. Determine whether the scope of fish counts can be limited to index and minimum counts, and whether the target species can be limited to Chinook salmon. Such limitations would then affect feasibility plans and sonar sampling design.

2. Clarify whether the location in Watana Canyon matters – e.g., upstream or downstream of the proposed dam site and major tributaries such as Tsusena Creek.

3. Obtain land access to more sites.

4. Perform aerial reconnaissance of the study area in early June, when water levels are low and provide the best view of channel configuration. From these, determine whether to attempt ensonification of the entire channel or a portion.

5. Measure water velocity at key site/sites in July to bolster any assumptions about fish use of offshore areas beyond any potential reach of the sonar.

6. Mobilize a crew and gear near the site, using daily site visits through the migration period.

Table G-1. Characteristics of three sites surveyed with ARIS in July, 2013.

Site	Date	Lat	Long	River Discharge (cfs)	Wetted Channel Width (ft)	Maximum Field of View (ft)	Hours of Video Collected	Fish Detected
1	20-Jul	62.81917	-148.64011	21,837	196	98	4.00	yes
2	21-Jul	62.82312	-148.53665	21,312	257	65	4.08	no
3	22-Jul	62.82582	-148.52315	18,634	134	13	3.12	no

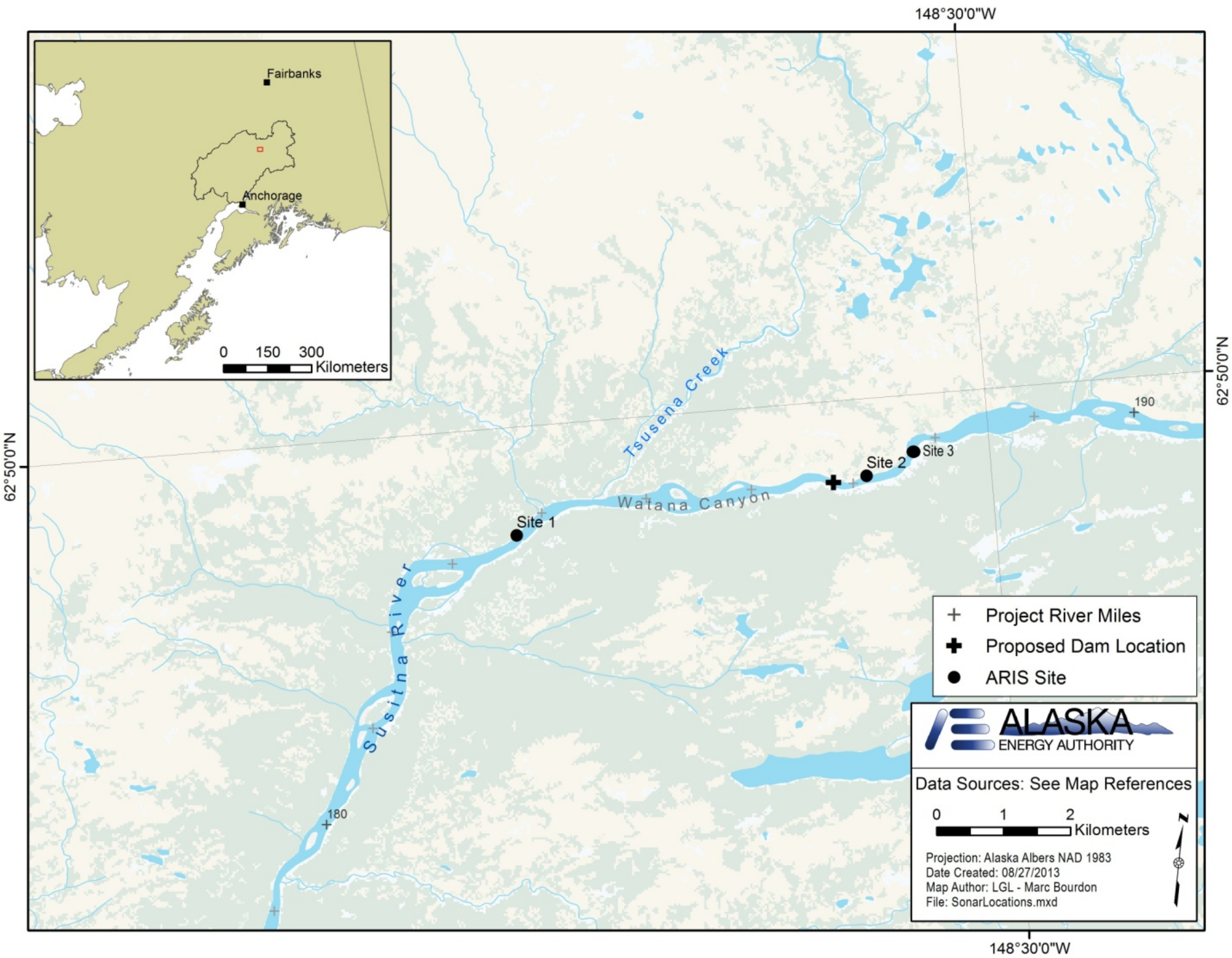


Figure G-1. Location of study sites in the Watana Canyon reach of the Susitna River for evaluating feasibility of sonar for counting fish, July, 2013. Site 1 is located near PRM 184 and the dam site is located near PRM 187.1. Flow is from right to left.

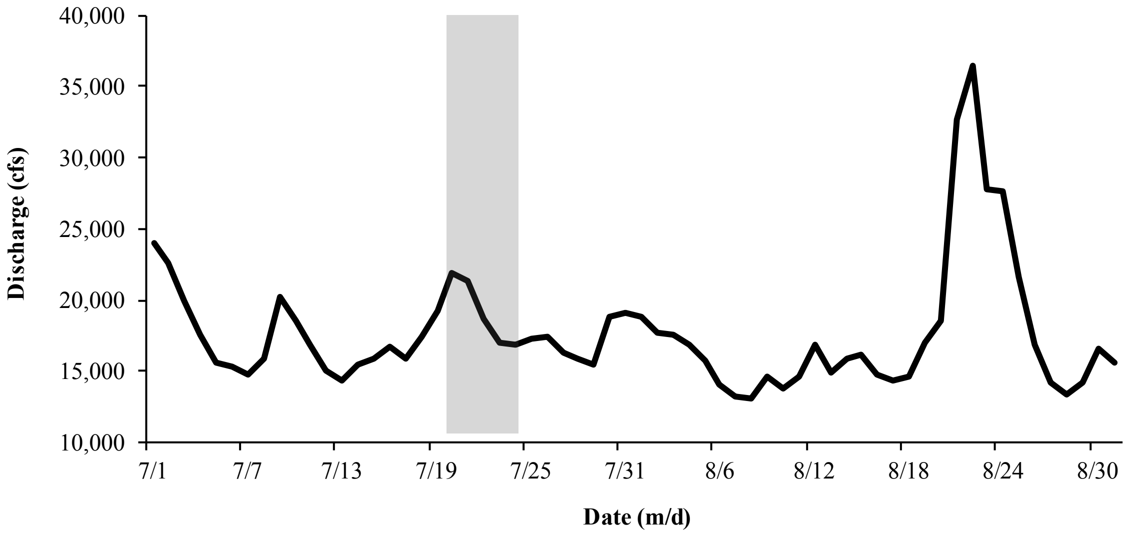


Figure G-2. Susitna River discharge at the US Geological Survey (USGS) gauge at Tsusena Creek for the period July 1 through August 31, 2013. The dates when the sonar feasibility study was conducted are shown with the gray column.

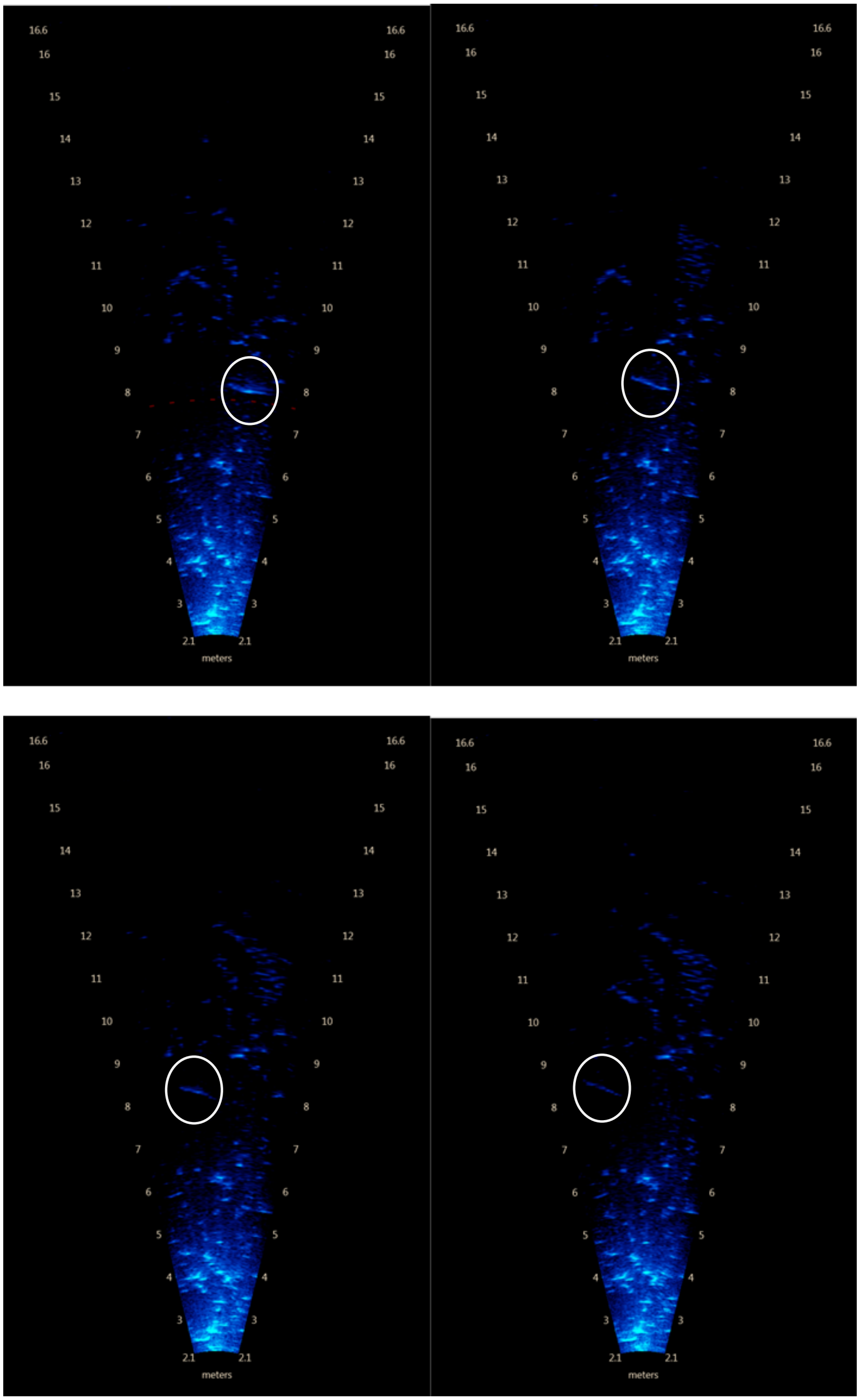


Figure G-3. Series of still images (top left to right then bottom left to right) that show an adult Chinook salmon (inside the white circles) migrating through the ARIS sonar sample volume in Watana Canyon at Site 1 on July 20, 2013. Flow is from left to right. The fish is estimated to be 95 cm (37 in) TL. The white objects in the foreground are cobble on the river substrate. Note range bands are shown in 1-m (3.3 ft) increments.

Photo G-1. Aluminum H-mount frame used to deploy the ARIS 1200 sonar at Site 1 during the Watana Canyon sonar feasibility study, July, 2013.

Photo G-2. Aerial view of Site 1 from the sonar feasibility study, July 22, 2013. Direction of river flow is from bottom to top of the photo. A conceptual depiction of ARIS sonar sampling area is shown with black triangle; actual sample volume is an expanding trapezoid with the longest axis in the upstream-downstream direction. River discharge at the time the photograph was taken was 18,634 cfs at the Tsusena Creek gage.

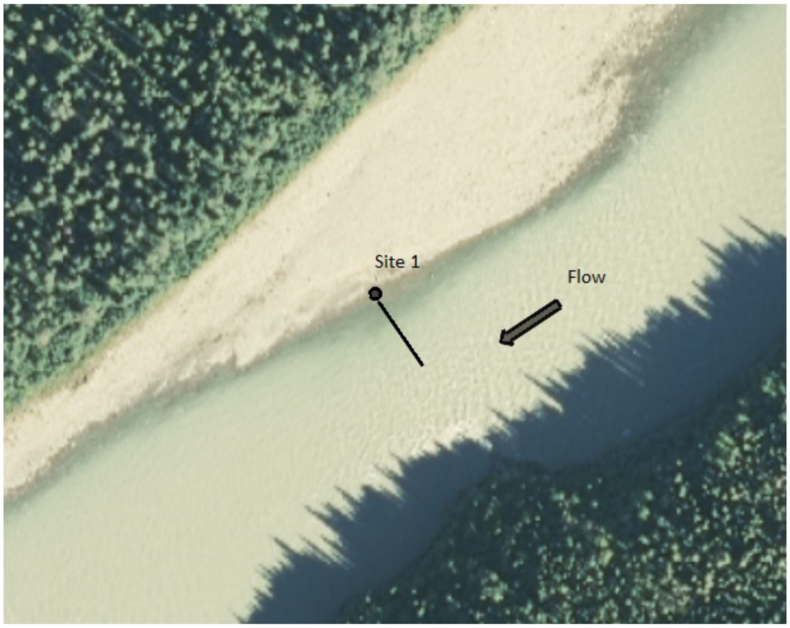


Photo G-3. Ortho-rectified aerial photograph of Site 1 assessed for sonar monitoring suitability in the Watana Canyon reach of the Susitna River, July, 2013. The line projecting from shore depicts the effective range (30 m [98 ft]) of the sonar tested during the feasibility study.

Photo G-4. Aerial view of Site 2 of the sonar feasibility study, July, 2013. Direction of river flow is from bottom to top of the photo. A conceptual depiction of ARIS sonar sampling area is shown with black triangle; actual sample volume is an expanding trapezoid with the longest axis in the upstream-downstream direction. River discharge at the time the photograph was taken was 21,313 cfs at the Tsusena Creek gage.

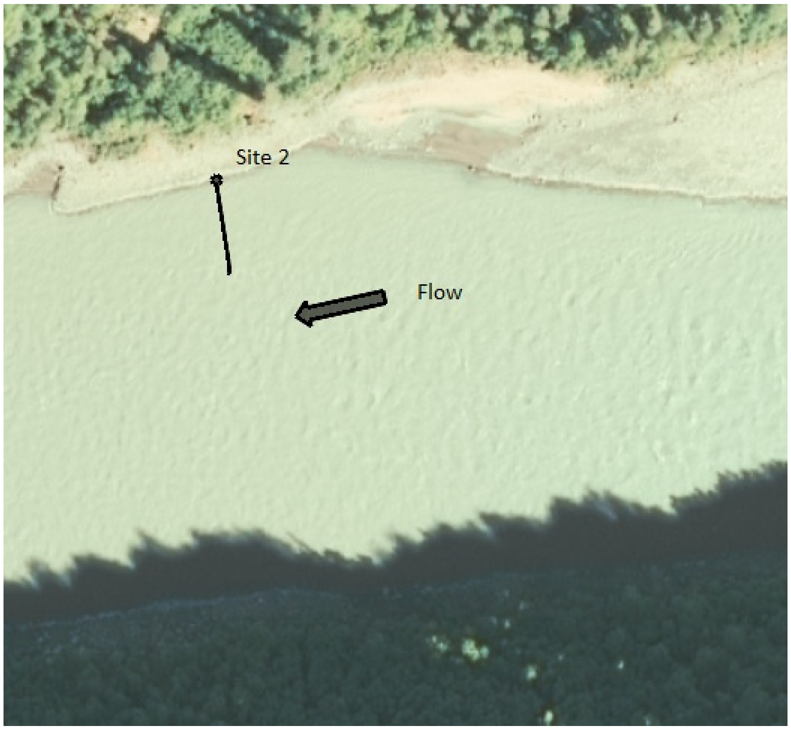


Photo G-5. Ortho-rectified aerial photographs of Site 2 assessed for sonar monitoring suitability in the Watana Canyon reach of the Susitna River, 2013. The line projecting from the sample site location depicts the effective range (20 m [65 ft]) of the sonar tested during the feasibility study.

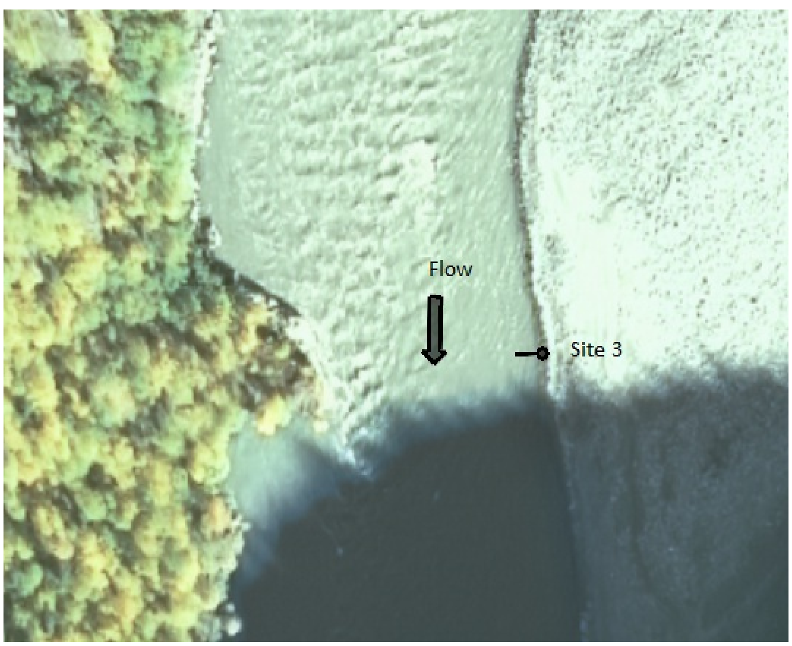


Photo G-6. Ortho-rectified aerial photographs of Site 3 assessed for sonar monitoring suitability in the Watana Canyon reach of the Susitna River, 2013. The line projecting from the sample site location depicts the effective range (4 m [13 ft]) of the sonar tested during the feasibility study.

PART A - APPENDIX H: ABUNDANCE ESTIMATES FOR CHINOOK, PINK, AND CHUM SALMON ABOVE CURRY AND CHINOOK SALMON ABOVE DEVILS CANYON

Table H-1. Estimated observer efficiencies during aerial spawner surveys for Chinook salmon conducted by AEA and ADF&G upstream of the Indian River weir on July 25, 2013.

Net Passage at the Weir (July 25)	Estimated Number of Live Fish Above Weir [a]	Number of Fish Counted Above the Weir During Aerial Spawner Survey		Estimated Observer Efficiency (%)	
		AEA	ADF&G	AEA	ADF&G
1,094	784	363	281	46.3	35.8

Notes:

[a] On July 25, 71.7 percent (43 of 60) of all radio-tagged Chinook salmon last detected upstream of the weir were emitting a 'live' signal.

Table H-2. Recapture matrix for large Chinook salmon radio-tagged at the Middle River fishwheels, and inspected for tags at the Indian River weir, 2013.

Period of Marking	Period of Recapture (Statistical Week)										Not		Recapture
(Statistical Week)	26	27	28	29	30	31	32	33	34	Recaptured	Recaptured	Marked [a]	Rate
25	2	2	1	1						**6**	**49**	55	0.109
26	1	2	20	4		1				**28**	**169**	197	0.142
27		2	11	12	1	2				**28**	**115**	143	0.196
28				3	2					**5**	**30**	35	0.143
29				1	1	1	1			**4**	**5**	9	0.444
30										**0**	**5**	5	0.000
31						1				**1**	**0**	1	1.000
32										0	0	0	
33										0	0	0	
34										0	0	0	
Marked	**3**	**6**	**32**	**21**	**4**	**5**	**1**	**0**	**0**	72	373	445	0.162
Unmarked	**11**	**139**	**386**	**214**	**182**	**69**	**49**	**13**	**2**	1,065			
Inspected	14	145	418	235	186	74	50	13	2	1,137			
Mark rate	0.214	0.041	0.077	0.089	0.022	0.068	0.020	0.000	0.000	0.063			

Notes:

[a] 91 of the 536 large Chinook salmon released at the Middle River fishwheels were never detected at or above the Middle River Gateway fixed station; and these fish were censored from the marked sample.

Bold numbers were used in contingency table tests (Chi-square) to evaluate whether mark and recapture rates varied by week. Adjacent shaded cells were pooled.

Table H-3. Estimated abundance of large Chinook, chum, and pink salmon above the Middle River Gateway fixed station (PRM 130.1), 2013.

	Large Chinook Salmon	Chum Salmon			Pink Salmon		
Parameters/Statistics	Radio Tags	Radio Tags	Spaghetti Tags	All Tags	Radio Tags	Spaghetti Tags	All Tags
Tags Released at Curry	536	201	1,962	2,163	200	9,108	9,308
Tags that Entered the Study Area (M) [a]	445	149	1,365	1,514	151	6,736	6,887
Inspected at the Indian River Weir (C)	1,137	12,906	12,906	12,906			37,181
Tagged Fish Recaptured at the Weir (R)	72	51	491	542	35	1,975	2,010
Abundance Estimate (N) [b]	6,952	37,231	35,834	36,010	156,990	126,768	127,353
Standard Error (SE)	782	5,104	1,583	1,511	25,797	2,774	2,761
Lower 95% Confidence Limit	5,536	28,448	32,807	33,108	113,760	121,301	121,909
Upper 95% Confidence Limit	8,724	48,660	39,140	39,166	216,041	132,480	133,041

Notes:

[a] Radio-tagged fish not detected at or above the Middle River Gateway fixed station were censored from the marked sample (M). The weekly proportions of radio-tagged chum and pink salmon censored from the marked sample were used to estimate the number of spaghetti-tagged fish that entered the study area.

[b] For chum and pink salmon, abundance estimates were generated using radio- and spaghetti-tagged fish separately, as well as by pooling both tag types.

Table H-4. Recapture matrix for chum salmon radio-tagged at the Middle River fishwheels and inspected for tags at the Indian River weir, 2013.

Period of Marking	Period of Recapture (Statistical Week)										Not		Recapture
(Statistical Week)	26	27	28	29	30	31	32	33	34	Recaptured	Recaptured	Marked [a]	Rate
25										0	0	0	
26										0	0	0	
27										0	0	0	
28										**0**	**1**	1	0.000
29										**0**	**2**	2	0.000
30					1	6	7	1		**15**	**12**	27	0.556
31						2	21	3	1	**27**	**50**	77	0.351
32							2	5	1	**8**	**23**	31	0.258
33									1	**1**	**8**	9	0.111
34										**0**	**2**	2	0.000
Marked	0	0	0	**0**	**1**	**8**	**30**	**9**	**3**	51	98	149	0.342
Unmarked	0	0	0	**11**	**244**	**4550**	**4801**	**2498**	**751**	12,855			
Inspected	0	0	0	11	245	4558	4831	2507	754	12,906			
Mark rate				0.000	0.004	0.002	0.006	0.004	0.004	0.004			

Notes:

[a] 51 of the 201 radio-tagged chum salmon released at the Middle River fishwheels were never detected at or above the Middle River Gateway fixed station; and these fish were censored from the marked sample.

Bold numbers were used in contingency table tests (Chi-square) to evaluate whether mark and recapture rates varied by week. Adjacent shaded cells were pooled.

Table H-5. Recapture matrix for pink salmon radio-tagged at the Middle River fishwheels and inspected for tags at the Indian River weir, 2013.

Period of Marking	Period of Recapture (Statistical Week)										Not		Recapture
(Statistical Week)	26	27	28	29	30	31	32	33	34	Recaptured	Recaptured	Marked [a]	Rate
25										0	0	0	
26										0	0	0	
27										0	0	0	
28										**0**	**2**	2	0.000
29							1			**1**	**2**	3	0.333
30							13	9		**22**	**52**	74	0.297
31							6	3	1	**10**	**47**	57	0.175
32								2		**2**	**9**	11	0.182
33										**0**	**4**	4	0.000
34										0	0	0	
Marked	0	0	0	**0**	**0**	**0**	**20**	**14**	**1**	35	116	151	0.232
Unmarked	0	0	0	**1**	**67**	**5124**	**21667**	**8390**	**1897**	37,146			
Inspected	0	0	0	1	67	5124	21687	8404	1898	37,181			
Mark rate				0.000	0.000	0.000	0.001	0.002	0.001	0.001			

Notes:

[a] 49 of the 200 radio-tagged pink salmon released at the Middle River fishwheels were never detected at or above the Middle River Gateway fixed station; and these fish were censored from the marked sample.

Bold numbers were used in contingency table tests (Chi-square) to evaluate whether mark and recapture rates varied by week. Adjacent shaded cells were pooled.

PART A - APPENDIX I: ABUNDANCE ESTIMATES FOR CHINOOK SALMON IN THE SUSITNA RIVER DRAINAGE AND COHO SALMON ABOVE THE YENTNA RIVER

1. INTRODUCTION

Additional data analyses were required to estimate the Chinook salmon escapement to the entire Susitna River and the coho salmon escapement in the Susitna River above the Yentna River confluence, leading to the Results and Discussion for these objectives being presented separately in this appendix.

1.1. Study Objective

From ISR 9.7, 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

See ISR 9.7, Section 3.

3. METHODS

See ISR 9.7, Section 4.8.

4. RESULTS

4.1. Estimated Abundance

4.1.1. Chinook Salmon

A total of 2,049 Chinook salmon were captured in drift gillnets and two fishwheels at the lower mainstem Susitna River tagging site (PRM 34) from June 4 to August 15, 2013. Radio tags were deployed on 699 Chinook salmon measuring 50 cm METF or greater. Based on observations made at fixed tracking stations and using aerial radio-telemetry, 568 of these radio-tagged fish moved upstream and remained upstream of the tagging site, comprising the first event in the mark-recapture experiment. The remaining 131 radio-tagged Chinook salmon were not used in the experiment, as they migrated to the Yentna River drainage or the Susitna River below PRM 34, were taken by anglers prior to spawning, possibly regurgitated the radio tag, possibly failed to migrate due to handling stress, or while unlikely, were above the tagging site and not detected.

Second event sampling was conducted at weirs on Deshka River and Montana Creek. A total of 18,531 Chinook salmon were counted through the Deshka River weir from June 9 to September 2, 2013, with 18,003 of these fish estimated to be 50 cm METF or greater. At the Montana Creek weir, 2,015 Chinook salmon were counted from July 8 to August 27, of which 1,949 were estimated to be 50 cm METF or greater. Second event sampling was also conducted at a site on the Chulitna River using ARIS sonar. However, estimates of Chinook salmon passage and length composition from the sonar data were not available as of this ISR, so these data were not used to compute the estimates. The estimated numbers of Chinook salmon measuring 50 cm METF or greater that passed the Deshka River and Montana Creek weirs comprise the second event of the mark-recapture experiment.

Based on observations made at fixed tracking stations and using aerial radio-telemetry, 148 radio-tagged Chinook salmon passed the Deshka River weir and were assumed to have spawned above the weir. Similarly, 11 radio-tagged Chinook salmon passed the Montana Creek weir and were assumed to have spawned above the weir. These 159 fish comprise the recaptured fish for the mark-recapture experiment.

Tests for size biased sampling were conducted using the KS two-sample test (Cleary et al. 2013; Appendix A). The test for the second sampling event provided significant evidence of size biased sampling ($p < 0.001$; Figure I-1). The test for 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 first event using data from fish passing the Montana Creek weir provided no evidence of size biased sampling ($p = 0.663$; Figure I-3). Based on these test results, the data were stratified into three size strata: 50.0–65.9 cm METF, 66.0–77.4 cm METF, and 77.5 cm METF or greater. Length data were not available for eight radio-tagged fish caught with gillnet gear in the first event sample, one each of which was recaptured at the Montana Creek and Deshka River weir sites. These fish were allocated among the three size strata based on the size distribution of the 84 known length fish captured in gillnets in the first event sample.

Tests for temporal and/or spatial variation in probability of capture were conducted within each of the three size strata (Cleary et al. 2013). Tests for variation in probability of capture during the first event 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.

For the 50.0–65.9 cm METF stratum, significant variation in probability of capture was detected for the second sampling event on a spatial scale ($p = 0.003$; Table I-1a) but not on a temporal scale ($p = 0.548$; Table I-1b). No significant variation in probability of capture was detected for the first sampling event on either a spatial scale ($p = 0.887$; Table I-1c) or a temporal scale ($p = 0.907$, $p = 0.347$; Tables I-1e,f, respectively). These results indicate that the Chapman (1951) model is appropriate for estimating abundance for the 50.0–65.9 cm METF stratum.

For the 66.0–77.4 cm METF stratum, significant variation in probability of capture was detected for the second sampling event on a spatial scale ($p = 0.023$; Table I-2a) but not on a temporal scale ($p = 0.786$; Table I-2b). Significant variation in probability of capture was detected for the first sampling event on a spatial scale ($p = 0.011$; Table I-2c) but not on a temporal scale ($p = 0.127$; Table I-2d). However, given the differences in run timing of fish past the Deshka River vs Montana Creek weirs, significant results from the test reported in Table I-2c (and Tables I-1c and I-3c) may well indicate temporal variation instead of or in addition to spatial variation in probability of capture during the marking event. These results indicate that the partially stratified model described by Darroch (1961) is necessary for estimating abundance for the 660–774 mm METF stratum. Attempts to fit a Darroch-type model that reflected the variation in probability of capture detected during both sampling events were unsuccessful. As a result, an estimate of abundance based on the Chapman (1951) model is reported and these results are assumed to be biased to an unknown degree.

For the 77.5 cm METF or greater stratum, no significant variation in probability of capture was detected for the second sampling event on a spatial scale ($p = 0.068$; Table I-3a) or on a temporal scale ($p = 0.596$; Table I-3b). No significant variation in probability of capture was detected for the first sampling event on either a spatial scale ($p = 0.347$; Table I-3c) or a temporal scale ($p = 0.202$, $p = 0.947$; Tables I-3d, e). These results indicate that the Chapman (1951) model is appropriate for estimating abundance for the 77.5 cm METF or greater stratum.

Abundance for each stratum was estimated using the Chapman (1951) model with variances estimated using a bootstrapping approach (Efron and Tibshirani 1993), adapting the methods described by Buckland and Garthwaite (1991) to this experimental design. Within each size stratum, the probability that a marked fish was recaptured was modeled as a binomial process with observed numbers of fish marked and recaptured as model parameters. For each of the two weir sites, the numbers of fish per strata 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. The allocation of the eight fish of unknown length among size strata was modeled as a multinomial process with total number of known length fish caught with gillnet and the size distribution of these fish used to define model parameters. One million bootstrap samples were generated. Confidence intervals reported are percentiles of the bootstrap distributions of estimated parameters (Table I-4).

The abundance of Chinook salmon measuring 50 cm METF or greater spawning in the Susitna River above the Lower River mainstem tagging site in 2013 is estimated to be 89,463 (SE = 9,523).

4.1.2. Coho Salmon

A total of 3,278 coho salmon were captured in two fishwheels at the lower mainstem Susitna River tagging site from June 4 to August 15, 2013. Radio tags were deployed on 596 coho salmon measuring 40 cm METF or greater. Based on observations made at fixed tracking stations and using aerial radio-telemetry, 411 of these radio-tagged fish moved upstream and remained upstream of the tagging site, comprising the first event in the mark-recapture experiment. The remaining 185 radio-tagged coho salmon were not used in the experiment, as they migrated to the Yentna River drainage or the Susitna River below PRM 34, were taken by anglers prior to spawning, possibly regurgitated the radio tag, possibly failed to migrate due to handling stress, or while unlikely, were above the tagging site and not detected.

Second event sampling was conducted at weirs on Deshka River and Montana Creek. A total of 22,141 coho salmon were passed through the Deshka River weir from July 10 to September 3, 2013, with all of these fish estimated to be 40 cm METF or greater. At the Montana Creek weir, 765 coho salmon were counted from July 31 to August 20 and August 26 to September 3, all of which were estimated to be 40 cm METF or greater. The Montana Creek weir was under water and no counting was conducted from August 21 to late on August 26. The estimated numbers of coho salmon 40 cm METF or greater passing the Deshka River and Montana Creek weirs comprise the second event of this mark-recapture experiment.

Based on observations made at fixed tracking stations and using aerial radio-telemetry, 67 radio-tagged coho salmon passed the Deshka River weir when the weir was operational and were assumed to have spawned above that site. Similarly seven radio-tagged coho salmon passed the Montana Creek weir when the weir was operational and spawned above that site. These 74 fish comprise the recaptured fish for the mark-recapture experiment.

Tests for size biased sampling were conducted using the Kolmogorov-Smirnov (KS) two-sample test (Cleary et al. 2013). The test for the second sampling event provided no evidence of size biased sampling ($p = 0.754$; Figure I-4). The test for the first event using data from fish passing the Deshka River weir provided significant evidence of size biased sampling ($p < 0.001$; Figure I-5). A similar test for first event using data from fish passing the Montana Creek weir also provided significant evidence of size biased sampling ($p = 0.005$; Figure I-6). These test results indicate that no stratification by size is necessary to provide an overall estimate of abundance. However, due to the size biased sampling detected during the marking event it was necessary to stratify these data in order to provide the necessary weights for radio-tagged fish to provide unbiased estimates of spawning distribution. Therefore, the data were stratified into three size strata: 40.0–47.9 cm METF, 48.0–53.4 cm METF, and 53.5 cm METF or greater.

Tests for temporal and/or spatial variation in probability of capture were conducted within each of the three size strata (Cleary et al. 2013). Tests for variation in probability of capture during the first event 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.

For the 40.0–47.9 cm METF stratum, no significant variation in probability of capture was detected for the second sampling event on a spatial scale ($p = 0.607$; Table I-6a) or on a temporal scale ($p = 0.757$; Table I-6b). Significant variation in probability of capture was detected for the first sampling event on a spatial scale ($p = 0.002$; Table I-6c) but not on a temporal scale ($p = 0.151$, $p = 0.273$; Table I-6e, f, respectively). However, given the differences in run timing of fish past the Deshka River vs Montana Creek weirs, significant results from the test reported in Table I-6c (and Tables I-7c and I-8c) may well indicate temporal variation instead of or in addition spatial variation in probability of capture during the marking event. These results indicate that the Chapman (1951) model is appropriate for estimating abundance for the 40.0–47.9 cm METF stratum.

For the 48.0–53.4 cm METF stratum, significant variation in probability of capture was detected for the second sampling event on a spatial scale ($p = 0.005$; Table I-7a) but not on a temporal scale ($p = 0.215$; Table I-7b). No significant variation in probability of capture was detected for the first sampling event on a spatial scale ($p = 0.167$; Table I-7c) or on a temporal scale ($p = 0.785$; Table I-7d). These results indicate that the Chapman (1951) model is appropriate for estimating abundance for the 48.0–53.4 cm METF stratum.

For the 53.5 cm METF or greater stratum, no significant variation in probability of capture was detected for the second sampling event on either a spatial scale ($p = 0.341$; Table I-8a) or on a temporal scale ($p = 0.296$; Table I-8b). No significant variation in probability of capture was detected for the first sampling event on a spatial scale ($p = 0.476$; Table I-8c) or on a temporal scale (p = 0.081; Table I-8e). These results indicate that the Chapman (1951) model is appropriate for estimating abundance for the 53.5 cm METF or greater stratum.

Abundance for each stratum was estimated using the Chapman (1951) model with variances estimated using a bootstrapping approach (Efron and Tibshirani 1993), adapting the methods described by Buckland and Garthwaite (1991) to this experimental design. Within each size stratum, the probability that a marked fish was recaptured was modeled as a binomial process with observed numbers of fish marked and recaptured as model parameters. For each of the two weir sites, the numbers of fish per strata 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. One million bootstrap samples were generated. Confidence intervals reported are percentiles of the bootstrap distributions of estimated parameters (Table I-9).

The abundance of coho salmon measuring 40 cm METF or greater spawning in the Susitna River above the mainstem tagging site in 2013 is estimated to be 130,026 (SE = 24,342).

4.2. Estimated Distribution of Spawning Salmon

4.2.1. Chinook Salmon

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-4). Numbers of fish were then summed over size strata for each tributary (Table I-5).

4.2.2. 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).

4.2.3. Pink Salmon

See ISR 9.7, Section 5.2.2.3.

5. DISCUSSION

The objective to estimate the system-wide Chinook salmon escapement was not fully met, as no estimate could be produced for the Yentna River, due to the lack of any sampling at Lake Creek and sonar operated at only one site, the Talachulitna River, as described in ISR 9.7, Section 4.8.1. An estimate for the Susitna River above the Yentna River was generated, although with some unknown bias. However, the bias is restricted to one size class, 66.0–77.4 cm METF, which is likely only about 11 percent of the escapement (9,482/89,463). The objective to estimate the coho salmon escapement for the Susitna River above the Yentna River was successful, as variations in probability of capture could be compensated for. The objective to estimate the distribution of the Chinook and coho escapements among the tributaries of the Susitna River above the Yentna River was successful, as knowledge of the marked fraction for each size stratum allowed adjusting for unequal marked rates to reduce bias.

6. CONCLUSIONS AND RECOMMENDATIONS

To meet the objective to estimate the system-wide Chinook salmon escapement, sampling methods other than weir or sonar on Yentna River tributaries should be attempted, such as an additional fishwheel and gillnet site on the mainstem Yentna River. Tagging different size strata of Chinook salmon at different rates should be investigated as a way to reduce size bias.

Table I-1. Tests for temporal and spatial variation in probability of capture for mainstem Susitna River Chinook salmon 50.0–65.9 cm METF, 2013.

Event Tested	Parameter				
a) Second event[a]					
	Gear	Gillnet	Fishwheel 1 west	Fishwheel 2 east	
	Marks	35	127	102	
	Recaptured	1	25	7	
	Not recaptured	34	102	95	
b) Second event[b]					
	Julian day	155-160	161-164	165-180	
	Marks	77	98	88	
	Recaptured	7	14	12	
	Not recaptured	70	84	76	
c) First event[c]					
	Weir site	Deshka R	Montana Cr		
	Inspected[d]	5,012	1,045		
	Marked	27	6		
	Unmarked	4,985	1,039		
d) First event[e]					
Deshka weir	Julian day	160-174	175-177	178-182	183-247
	Inspected[d]	1,876	1,311	919	905
	Marked	8	8	5	5
	Unmarked	1,868	1,303	914	900
e) First event[f]					
Montana weir	Julian day	169-193	194-197	198-258	
	Inspected[d]	360	397	563	
	Marked	3	2	1	
	Unmarked	357	395	562	

[a] Test of equal probability of capture during second event sampling: $\chi^2 = 11.933$, $P = 0.003$.
[b] Test of equal probability of capture during second event sampling: $\chi^2 = 1.203$, $P = 0.548$.
[c] Test of equal probability of capture during second event sampling: $\chi^2 = 0.020$, $P = 0.887$.
[d] Number of fish inspected for marks is estimated.
[e] Test of equal probability of capture during second event sampling: $\chi^2 = 0.554$, $P = 0.907$.
[f] Test of equal probability of capture during second event sampling: $\chi^2 = 2.117$, $P = 0.347$.

Table I-2. Tests for temporal and spatial variation in probability of capture for mainstem Susitna River Chinook salmon 66.0–77.4 cm METF, 2013.

Event Tested	Parameter				
a) Second event[a]					
	Gear	Gillnet	Fishwheel 1 west	Fishwheel 2 east	
	Marks	16	105	41	
	Recaptured	5	66	19	
	Not recaptured	11	39	22	
b) Second event[b]					
	Julian day	155-160	161-164	165-180	
	Marks	51	63	74	
	Recaptured	30	34	39	
	Not recaptured	21	29	35	
c) First event[c]					
	Weir site	Deshka R	Montana Cr		
	Inspected[d]	4,814	451		
	Marked	89	1		
	Unmarked	4,725	451		
d) First event[e]					
Deshka weir	Julian day	160-173	174-176	177-182	183-247
	Inspected[d]	1,131	1,590	1.224	869
	Marked	24	19	26	20
	Unmarked	1,107	1,571	1.198	849

[a] Test of equal probability of capture during second event sampling: $\chi^2 = 7.505$, $P = 0.023$.
[b] Test of equal probability of capture during second event sampling: $\chi^2 = 0.482$, $P = 0.786$.
[c] Test of equal probability of capture during second event sampling: $\chi^2 = 6.516$, $P = 0.011$.
[d] Number of fish inspected for marks is estimated.
[e] Test of equal probability of capture during second event sampling: $\chi^2 = 5.704$, $P = 0.127$.

Table I-3. Tests for temporal and spatial variation in probability of capture for mainstem Susitna River Chinook salmon measuring 77.5 cm METF or greater, 2013.

Event Tested	Parameter				
a) Second event[a]					
	Gear	Gillnet	Fishwheel 1 west	Fishwheel 2 east	
	Marks	33	72	29	
	Recaptured	6	24	4	
	Not recaptured	27	48	25	
b) Second event[b]					
	Julian day	155-160	161-164	165-180	
	Marks	53	49	32	
	Recaptured	14	14	6	
	Not recaptured	39	35	26	
c) First event[c]					
	Weir site	Deshka R	Montana Cr		
	Inspected[d]	8,177	452		
	Marked	31	3		
	Unmarked	8,146	459		
d) First event[e]					
Deshka weir	Julian day	160-173	174-176	177-182	183-247
	Inspected[d]	1,922	2,700	2,079	1,477
	Marked	4	8	10	9
	Unmarked	1,918	2,692	2,069	1,468
e) First event[f]					
Montana weir	Julian day	169-193	194-197	198-258	
	Inspected[d]	64	70	99	
	Marked	1	1	1	
	Unmarked	63	69	98	

[a] Test of equal probability of capture during second event sampling: $\chi^2 = 5.364$, $P = 0.068$.
[b] Test of equal probability of capture during second event sampling: $\chi^2 = 1.036$, $P = 0.596$.
[c] Test of equal probability of capture during second event sampling: $\chi^2 = 0.884$, $P = 0.347$.
[d] Number of fish inspected for marks is estimated.
[e] Test of equal probability of capture during second event sampling: $\chi^2 = 4.623$, $P = 0.202$.
[f] Test of equal probability of capture during second event sampling: $\chi^2 = 0.109$, $P = 0.947$.

Table I-4. 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, 2013.

Size Strata	Estimated Abundance	Estimated SE	Radio Tags Deployed[a]	Relative Weight spawners/tag
50.0-65.9 cm METF	46,667	7,981	263	175.2
66.0-77.4 cm METF	9,482	711	161	58.3
≥77.5 cm METF	33,315	5,239	134	242.9

[a] Does not include two radio-tagged fish for which final spawning locations were not determined.

Table I-5. Chinook salmon spawning distributions, based on weighted abundance (Table I-4), in the mainstem Susitna River above the lower river tagging site, 2013.

	Estimated		Intervals	
Location	Abundance	SE	95% lower	95% upper
Susitna River above the mainstem tagging site	89,463	9.523	77,720	114,954
PRM 34–102.4 mainstem Susitna River [a]	2,432	259	2,112	3,124
Deshka River	18,469	1,573	16,643	22,801
Eastside Susitna River	16,867	1,873	14,541	21,860
Talkeetna River	24,408	3,008	20,619	32,362
PRM 102.4–153.4 mainstem Susitna River [b]	7,680	898	6,560	10,066
Chulitna River	19,607	2,161	16,907	25,352

[a] PRM 34 upstream to the Chulitna River Confluence
[b] Chulitna River Confluence to Devils Canyon

Table I-6. Tests for temporal and spatial variation in probability of capture for mainstem Susitna River coho salmon 40.0–47.9 cm METF, 2013.

Event Tested	Parameter				
a) Second event[a]					
	Gear	Fishwheel 1 west	Fishwheel 2 east		
	Marks	79	75		
	Recaptured	14	11		
	Not recaptured	65	64		
b) Second event[b]					
	Julian day	190-203	204-207	208-232	
	Marks	62	40	52	
	Recaptured	11	5	9	
	Not recaptured	51	35	43	
c) First event[c]					
	Weir site	Deshka R	Montana Cr		
	Inspected[d]	912	37		
	Marked	21	4		
	Unmarked	891	33		
d) First event[e]					
Deshka weir	Julian day	190-223	224	225-228	229-246
	Inspected[d]	100	334	157	322
	Marked	3	4	7	7
	Unmarked	97	330	150	315
e) First event[f]					
Montana weir	Julian day	190-231	232-246		
	Inspected[d]	10	27		
	Marked	2	2		
	Unmarked	8	25		

[a] Test of equal probability of capture during second event sampling: $\chi^2 = 0.264$, $P = 0.607$.
[b] Test of equal probability of capture during second event sampling: $\chi^2 = 0.558$, $P = 0.757$.
[c] Test of equal probability of capture during second event sampling: $\chi^2 = 10.035$, $P = 0002$.
[d] Number of fish inspected for marks is estimated.
[e] Test of equal probability of capture during second event sampling: $\chi^2 = 5.302$, $P = 0.151$.
[f] Test of equal probability of capture during second event sampling: $\chi^2 = 1.200$, $P = 0.273$.

Table I-7. Tests for temporal and spatial variation in probability of capture for mainstem Susitna River coho salmon 48.0–53.4 cm METF, 2013.

Event Tested	Parameter				
a) Second event[a]					
	Gear	Fishwheel 1 west	Fishwheel 2 east		
	Marks	74	74		
	Recaptured	23	9		
	Not recaptured	51	65		
b) Second event[b]					
	Julian day	190-207	208-211	212-232	
	Marks	80	24	44	
	Recaptured	20	2	10	
	Not recaptured	60	22	34	
c) First event[c]					
	Weir site	Deshka R	Montana Cr		
	Inspected[d]	5,888	270		
	Marked	29	3		
	Unmarked	5,859	267		
d) First event[e]					
Deshka weir	Julian day	190-223	224	225-233	234-246
	Inspected[d]	643	2,159	1.908	1,178
	Marked	2	12	8	7
	Unmarked	641	2,147	1.900	1.171

[a] Test of equal probability of capture during second event sampling: $\chi^2 = 7.815$, $P = 0.005$.
[b] Test of equal probability of capture during second event sampling: $\chi^2 = 3.071$, $P = 0.215$.
[c] Test of equal probability of capture during second event sampling: $\chi^2 = 1.911$, $P = 0.167$.
[d] Number of fish inspected for marks is estimated.
[e] Test of equal probability of capture during second event sampling: $\chi^2 = 1.066$, $P = 0.785$.

Table I-8. Tests for temporal and spatial variation in probability of capture for mainstem Susitna River coho salmon measuring 53.5 cm METF or greater, 2013.

Event Tested	Parameter			
a) Second event[a]				
	Gear	Fishwheel 1 west	Fishwheel 2 east	
	Marks	59	50	
	Recaptured	11	6	
	Not recaptured	48	44	
b) Second event[b]				
	Julian day	190-208	209-212	213-232
	Marks	54	18	37
	Recaptured	11	1	5
	Not recaptured	43	17	32
c) First event[c]				
	Weir site	Deshka R	Montana Cr	
	Inspected[d]	15,341	458	
	Marked	17	0	
	Unmarked	15,324	458	
d) First event[e]				
Deshka weir	Julian day	190-224	225-233	234-246
	Inspected[d]	7,300	4,971	3,070
	Marked	5	5	7
	Unmarked	7,295	4,966	3,063

[a] Test of equal probability of capture during second event sampling: $\chi^2 = 0.908$, $P = 0.341$.
[b] Test of equal probability of capture during second event sampling: $\chi^2 = 2.435$, $P = 0.296$.
[c] Test of equal probability of capture during second event sampling: $\chi^2 = 0.508$, $P = 0.476$.
[d] Number of fish inspected for marks is estimated.
[e] Test of equal probability of capture during second event sampling: $\chi^2 = 5.038$, $P = 0.081$.

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, 2013.

Size Strata	Estimated Abundance	Estimated SE	Radio Tags Deployed[a]	Relative Weight spawners/tag
40.0-47.9 cm METF	5,666	1,129	154	36.8
48.0-53.4 cm METF	27,805	4,585	147	189.1
≥53.5 cm METF	96,556	23.880	109	885.8

[a] Does not include 1 radio-tagged fish for which final spawning location was not determined.

Table I-10. Coho salmon spawning distributions, based on weighted abundance (Table I-9), in the mainstem Susitna River above the lower river tagging site, 2013.

			Intervals	
Location	**Estimated Abundance**	**SE**	**95% lower**	**95% upper**
Susitna River above the mainstem tagging site	130,026	24,342	100,411	193,403
PRM 34–102.4 mainstem Susitna River[a]	31,204	6,604	23,224	48,365
Deshka River	29,215	5,386	22,629	43,231
Eastside Susitna River	11,038	1,837	8,764	15,839
Talkeetna River	13,372	2,277	10,568	19,324
PRM 102.4–153.4 mainstem Susitna River[b]	8,313	1,566	6,402	12,383
Chulitna River	36,844	6,726	28,684	54,413

[a] PRM 34 upstream to the Chulitna River Confluence
[b] Chulitna River Confluence to Devils Canyon

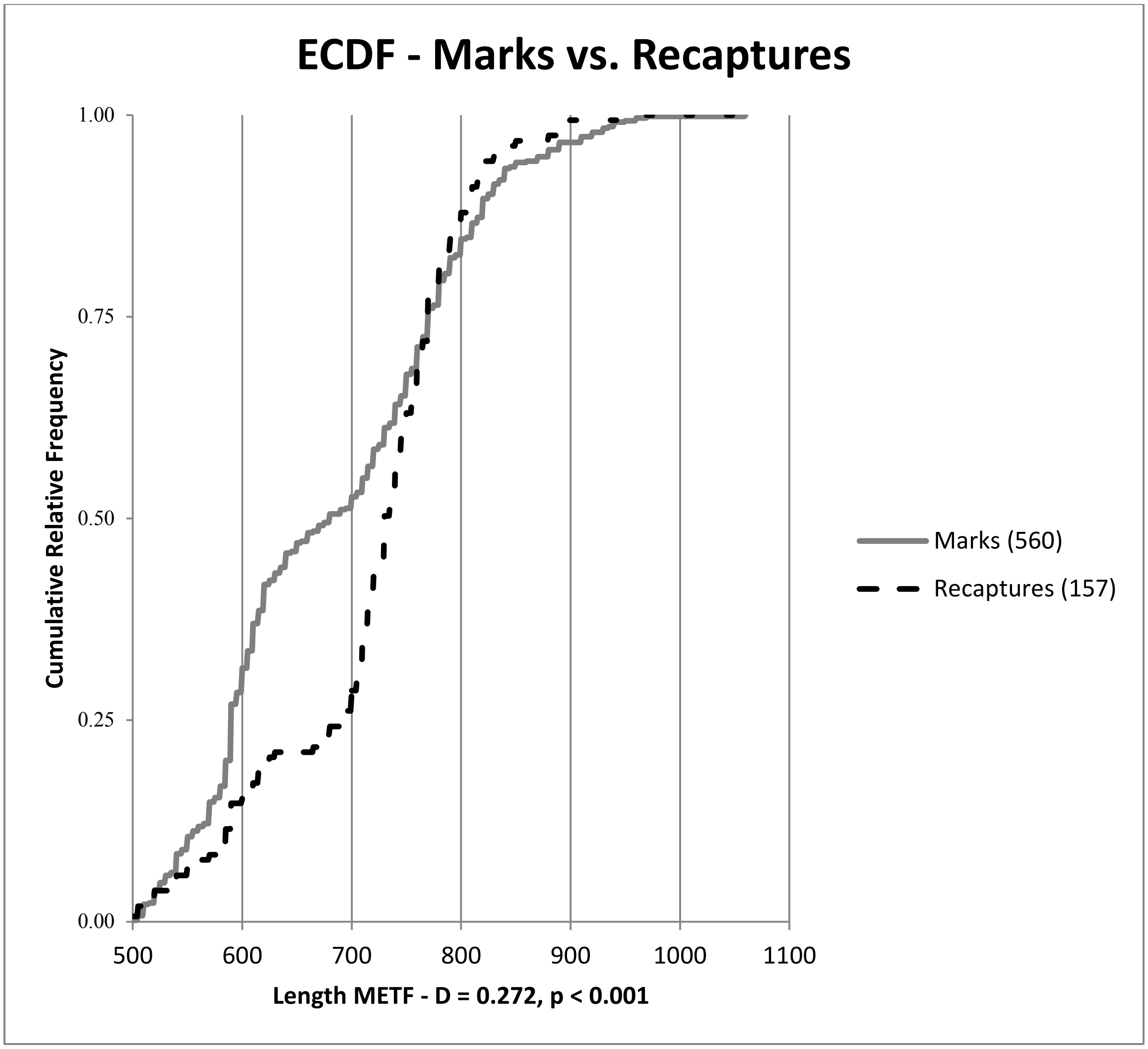


Figure I-1. Empirical cumulative distribution functions (ECDF) of length (in mm) of all Chinook salmon marked during first event sampling at the lower mainstem Susitna River tagging site and all recaptures during second event sampling, 2013.

Note: The Kolmogorov-Smirnov test results for equal probability of capture based on METF length during second event sampling were D = 0.272, $P < 0.001$.

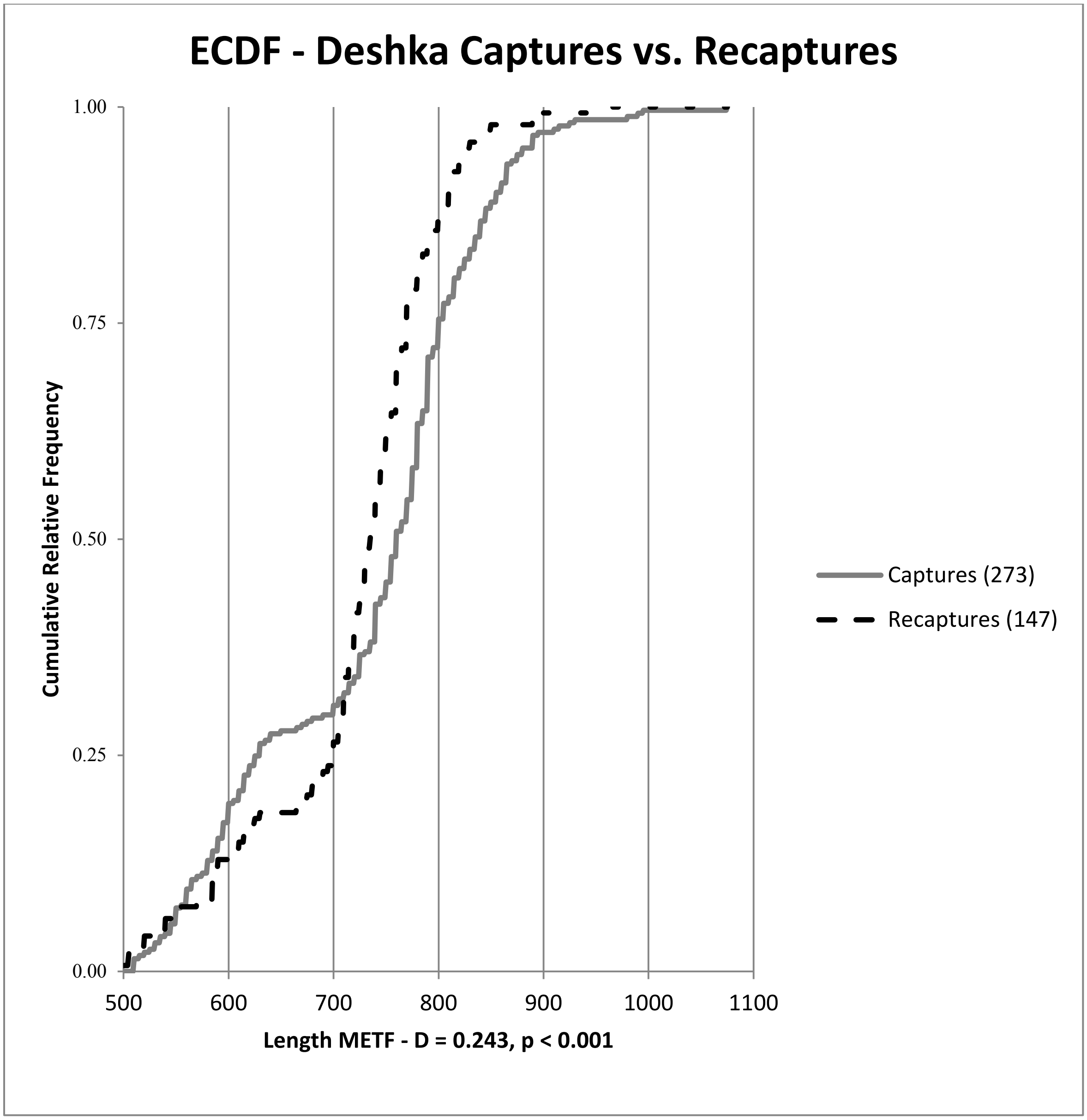


Figure I-2. Empirical cumulative distribution functions (ECDF) of length (in mm) of Chinook salmon inspected for marks and all recaptured salmon during second event sampling at the Deshka River weir, 2013.

Note: The Kolmogorov-Smirnov test results for equal probability of capture based on METF length during first event sampling were D = 0.243, $P < 0.001$.

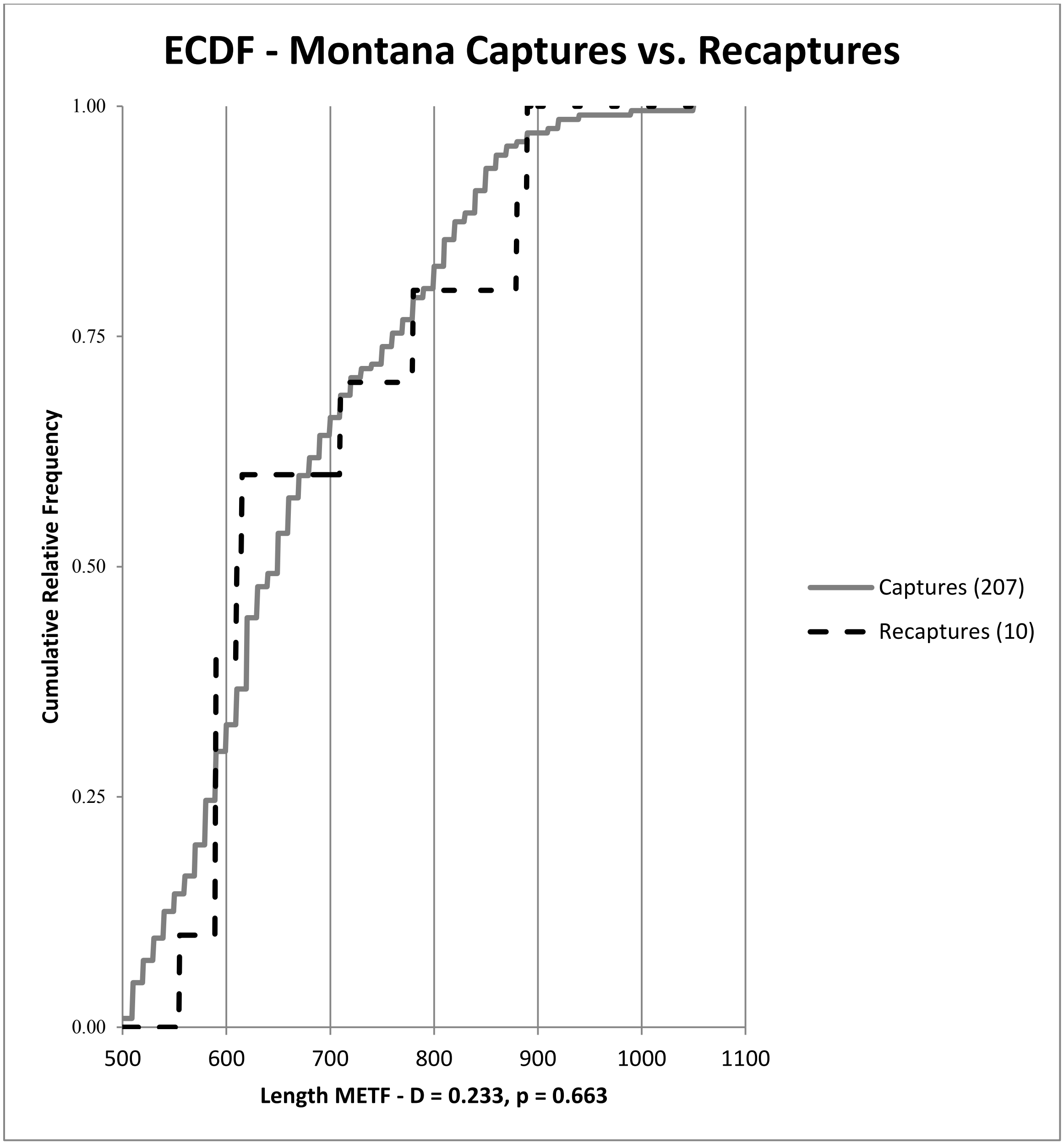


Figure I-3. Empirical cumulative distribution functions (ECDF) of length (in mm) of Chinook salmon inspected for marks and all recaptured salmon during second event sampling at the Montana Creek weir, 2013.

Note: The Kolmogorov-Smirnov test results for equal probability of capture based on METF length during first event sampling were D = 0.233, $P = 0.663$.

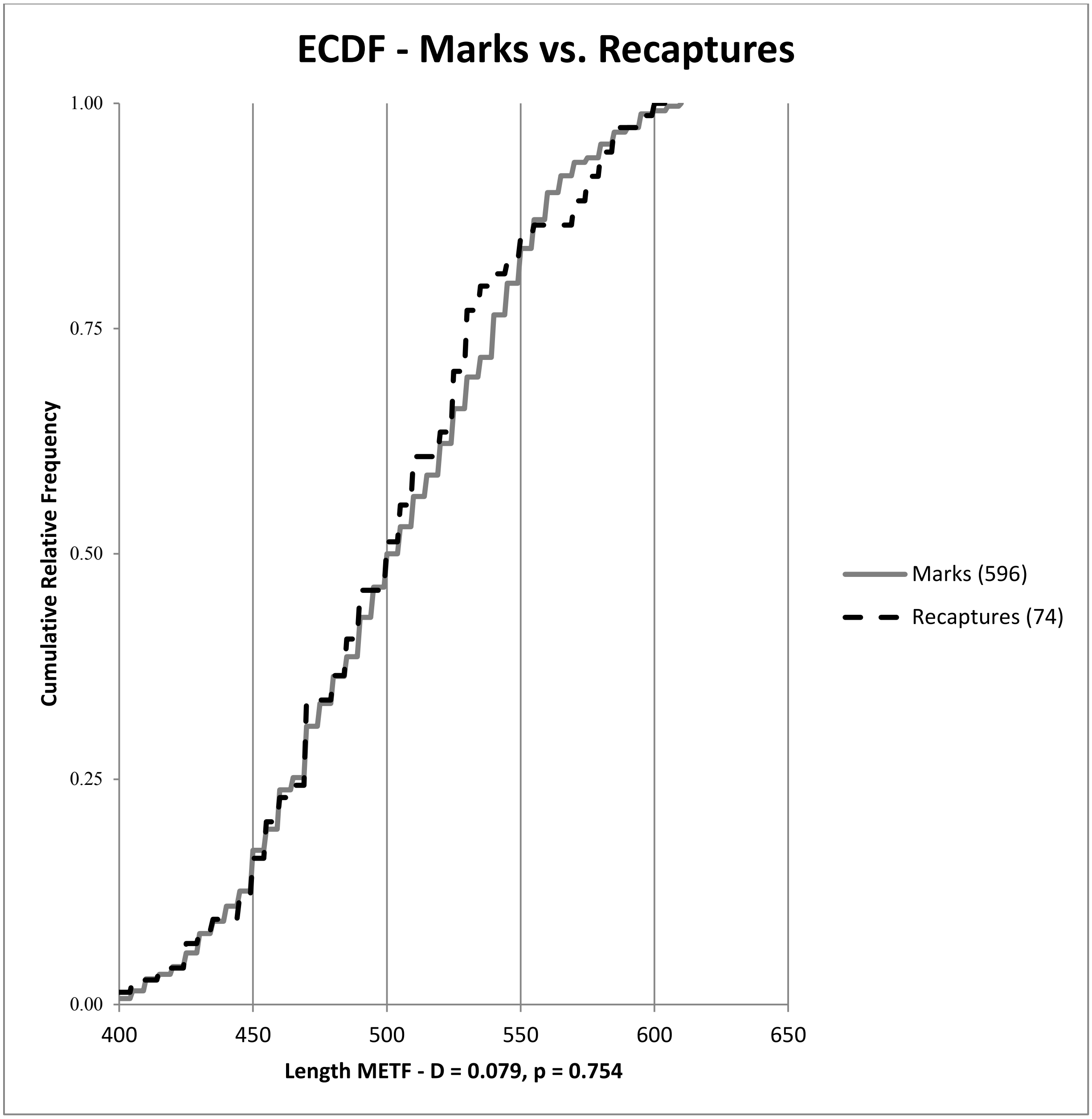


Figure I-4. Empirical cumulative distribution functions (ECDF) of length (in mm) of all coho salmon marked during first event sampling at the lower mainstem Susitna River tagging site and all recaptures during second event sampling, 2013.

Note: The Kolmogorov-Smirnov test results for equal probability of capture based on METF length during second event sampling were D = 0079, *P* = 0.754.

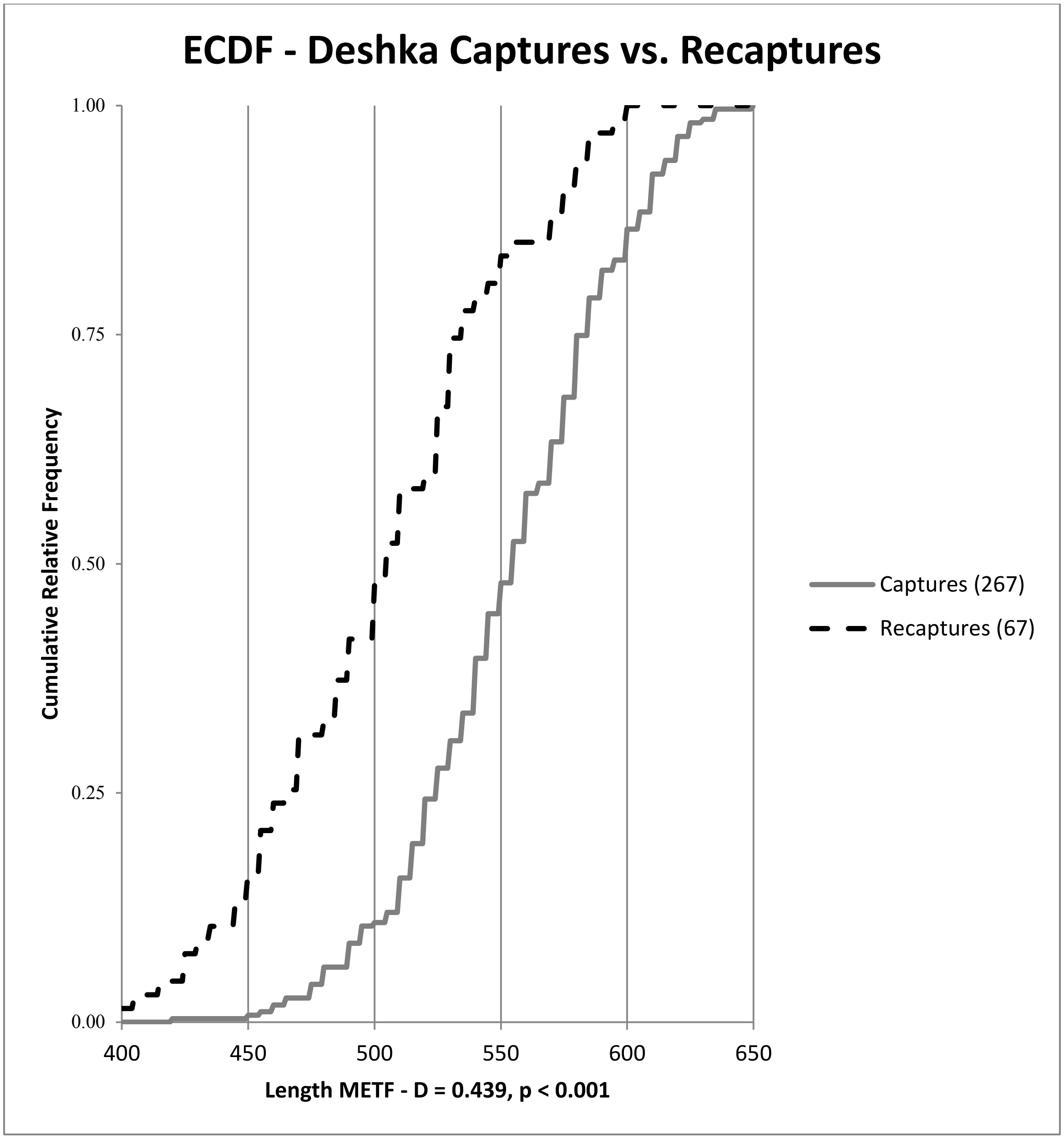


Figure I-5. Empirical cumulative distribution functions (ECDF) of length (in mm) of coho salmon inspected for marks and all recaptured salmon during second event sampling at the Deshka River weir, 2013.

Note: The Kolmogorov-Smirnov test results for equal probability of capture based on METF length during first event sampling were D = 0.439, $P < 0.001$.

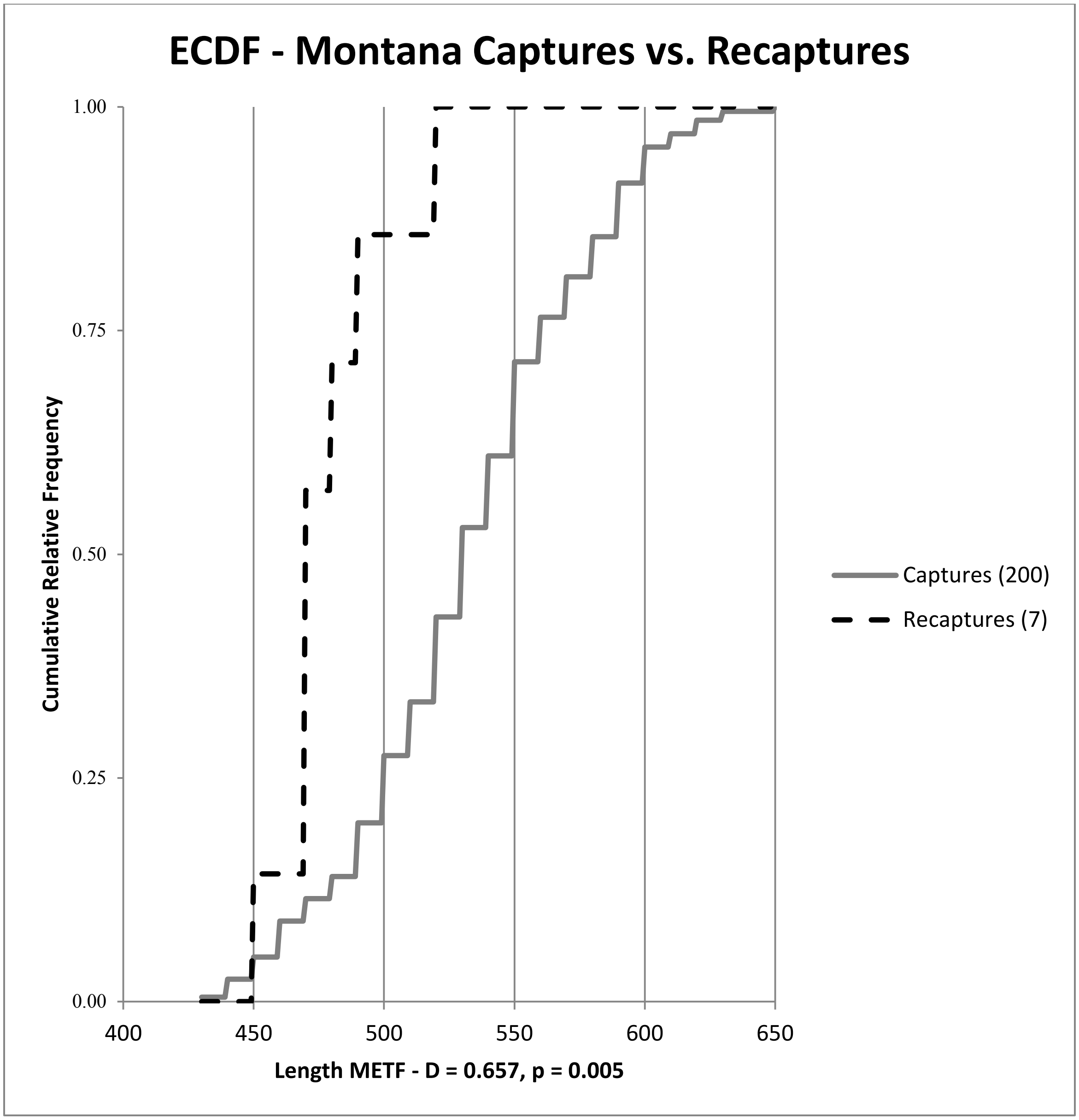


Figure I-6. Empirical cumulative distribution functions (ECDF) of length (in mm) of coho salmon inspected for marks and all recaptured salmon during second event sampling at the Montana Creek weir, 2013.

Note: The Kolmogorov-Smirnov test results for equal probability of capture based on METF length during first event sampling were D = 0.657, $P = 0.005$.