Adult Salmon Distribution and Habitat Utilization Study

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Prepared for

Alaska Energy Authority

Prepared by

LGL Alaska Research Associates, Inc.

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Draft Report

Michael R. Link, Bryan Nass, Jason J. Smith, Dave Robichaud, Sean Burril, Karl English, Steve Crawford, Justin T. Priest, and Matthew J. Nemeth[1]

Prepared for:

Alaska Energy Authority
813 West Northern Lights Boulevard
Anchorage, Alaska 99503

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[1] LGL Alaska Research Associates, Inc., 2000 West International Airport Road, Anchorage, Alaska 99502

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
ARDGA	Aquatic Resources Data Gap Analysis
ATS	Applied Telemetry Systems
C	Celsius
cfs	Cubic feet per second
cm	Centimeter
CPUE	Catch per unit effort
DIDSON	Dual Frequency Identification Sonar
F	Fahrenheit
FERC	Federal Energy Regulatory Commission
FL	Nose to tail fork length
ft	Feet, foot
GIS	Geographic Information System
HSC	Habitat Suitability Criteria
ILP	Integrated Licensing Process
in	Inch
ISF	Instream Flow
km	Kilometer
kt	Knots
KS	Kolmogorov-Smirnov
m	Meter
MEF	Mid eye to tail fork length
mi	Mile
MHz	Megahertz
mm	Millimeter
NEPA	National Environmental Policy Act
NTU	Nephelometric Turbidity Unit
PAD	Pre-application Document
RM	River Mile
s	Second
TB	Terabyte
UCI	Upper Cook Inlet
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Five species of Pacific salmon (*Oncorhynchus* spp.) were radio-tagged and tracked in the mainstem Susitna River in 2012 as part of a multi-objective study to describe salmon migration behavior, identify salmon spawning locations, and evaluate techniques for future studies of salmon in turbid water. The study was conducted to support the licensing process for the proposed Susitna-Watana Hydroelectric Project (Project). The study design allowed for comparisons to salmon distribution and habitat use in the 1980s, when similar studies were conducted for the Alaska Power Authority Hydroelectric Project. The 2012 study focused on the mainstem Susitna River due to possible effects both above and below the Project dam site where the river was separated into Lower (river mile [RM] 0–98), Middle (RM 98–184), and Upper (upstream of RM 184) River segments.

Spawning Locations

Radio telemetry was used to assign final destinations (either the mainstem Susitna River, or tributaries) for 79–100 percent of salmon tagged by the Alaska Department of Fish and Game (ADF&G) in the Lower River (near RM 22 and 30), depending on species. For each species, most final destinations were in tributaries upstream from the portion of the tributaries potentially impacted by Project-induced changes to the Susitna River hydrology (81 percent of Chinook *O. tshawytscha*, 71 percent of chum *O. keta*, 82 percent of coho *O. kisutch*, 93 percent of pink *O. gorbuscha*, and 99 percent of sockeye salmon *O. nerka*). An additional two Chinook salmon (<1 percent of those tagged) had a final destination in a tributary upstream of the proposed Project dam site. Few salmon had final destinations in mainstem habitats that might be susceptible to flow effects resulting from future hydropower operations (2 percent of Chinook, 8 percent of chum, 6 percent of coho, 3 percent of pink, and 1 percent of sockeye salmon). Spawning could not be visually verified in mainstem river habitats in the Lower River due to high water turbidity. Final destinations could not be determined for the remaining proportions of each species tagged in the Lower River.

Radio telemetry was used to assign final destinations for 67–90 percent of salmon tagged in the Middle River at Curry (RM 120), depending on species. Below the Project dam site (RM 184), most final destinations of tagged fish were documented in tributaries (80 percent of Chinook, 63 percent of chum, 66 percent of coho, 67 percent of pink, and 14 percent of sockeye salmon). An additional four Chinook salmon (1.1 percent of those tagged) had a final destination in a tributary upstream of the proposed Project dam site. Relatively few final destinations for most salmon species were in mainstem river habitats (9 percent of Chinook, 20 percent of chum, 13 percent of coho, 4 percent of pink, and 53 percent of sockeye salmon). Some locations in the mainstem Susitna River had clear enough water to visually verify spawning and generally supported locations identified using radio telemetry. Final destinations could not be determined for the remaining proportions of each species tagged in the Middle River.

Salmon Migration Above Devils Canyon

Chinook salmon was the only species identified migrating upstream of any of the three high-velocity impediments in Devils Canyon (RM 150–161). One tagged sockeye salmon and one tagged chum salmon approached the farthest downstream impediment (Impediment 1) but did not migrate above it. Of the 313 viable Chinook salmon tagged in the Middle River, 23 (7 percent) migrated above Impediment 1, 20 (6 percent) above Impediment 2, and 10 (3 percent) above Impediment 3. Four (1 percent) of these Chinook salmon had final destinations upstream of the Project dam site. Of the 442 Chinook salmon tagged in the Lower River, three migrated above Impediment 1; of these, two migrated above Impediment 3.

Of all 26 tagged Chinook salmon (Lower and Middle River tagging-sites combined) that migrated upstream of Impediment 1, seven eventually migrated back downstream and were assigned to final destinations downstream of the lower end of Devils Canyon. Chinook salmon migrated through the Devils Canyon impediments between July 7–20. Average daily discharge of the Susitna River at Gold Creek (RM 136) ranged from 17,300–31,100 cubic feet per second (cfs) when Chinook salmon passed Impediment 1, 17,300–21,300 cfs when fish passed Impediment 2, and 17,300–19,000 cfs when fish passed Impediment 3.

Salmon Migration Behavior

Run timing at Curry peaked in early July for Chinook salmon, early August for chum and pink salmon, mid-July through mid-August for sockeye salmon, and mid-August for coho salmon. These results were similar to those obtained across five seasons in the early 1980s; however, the Chinook salmon run at Curry was late relative to three of the five years in the 1980s (1981, 1983, and 1984) and most similar to the 1982 run. Average daily discharge of the Susitna River at Gold Creek (RM 136) approached the 52-year high (1950–2011) in June 2012 and may have delayed the Chinook salmon run timing at Curry.

Approximately 10 percent of tagged salmon in the Middle River exhibited roaming behavior, ascending into the Middle River temporarily before moving downstream of Curry. This pattern of upstream migration followed by downstream movement to spawning destinations did not appear to be an immediate dropback effect from tagging because it was also exhibited by fish tagged many miles downstream in the Lower River. Of the salmon tagged at RM 22 or 30 in the Lower River, 69 (all species combined) ascended as high as Lane Creek (RM 114) in the Middle River, a distance of 83 to 91 river miles. Of these, 14 (20 percent) migrated back downstream and were ultimately assigned to areas in the Lower River (Chulitna River, Talkeetna River, and Montana Creek). Of the salmon tagged seven miles upstream of Lane Creek at Curry (RM 120), 902 were assigned final destinations (all species combined) and 93 (10 percent) of these showed that fish migrated back downstream and were ultimately assigned to areas downstream of Curry (e.g., Lane Creek, Chulitna River, Talkeetna River, Whiskers Creek, Montana Creek, and Deshka River). All species of salmon showed some level of roaming behavior in the Middle River (below Impediment 1) that did not appear associated with time or distance since tagging. Roaming behavior was also seen in Chinook salmon that migrated above Devils Canyon. For example, 4 of 12 (33 percent) Chinook salmon that passed Impediment 3 eventually entered a tributary downstream of Devils Canyon.

Current and Historical Distribution and Habitat Use

In 2012, sockeye salmon were observed spawning in five sloughs or side channels (Slough or Side Channel 21 and sloughs 19, 11, 9, 8A) and chum salmon were observed spawning in six sloughs or side channels (Slough or Side Channel 21 and sloughs 11, 9A, 9, 8A, and 4th of July) and two tributary deltas (Indian River and 4th of July Creek) in the mainstem of the Middle

River. Each of these species and locations was also documented in the 1980s. Several Middle River spawning locations documented in the 1980s were not verified in 2012, in part because of an absence of radio tagged fish or high water turbidity. No mainstem river spawning locations were identified for Chinook or coho salmon in the 1980s. In 2012, radio telemetry was used to identify potential mainstem spawning in the Lower and Middle River segments by Chinook, coho, and pink salmon, but this could not be visually verified due to high water turbidity. Mainstem spawning by sockeye and chum salmon was documented only in the Middle River in both the 1980s and in 2012. In both time periods, a substantial portion of spawning in sloughs (20–92 percent) occurred in the same three sloughs. Sonar was not effective for verifying spawning activity in turbid water in 2012.

Effectiveness of Methods Used in 2012 and Recommendations for 2013–2014

Fishwheels were used successfully for capturing salmon near Curry and describing species-specific run timing. Radio telemetry was suitable for tracking tagged salmon, assigning final destinations, identifying likely spawning locations, and guiding field crews to potential spawning locations in season. Radio telemetry was also effective for describing fish movement behavior, including passage through Devils Canyon and what appeared to be roaming by individual fish. Confirming spawning activity visually or with sonar was difficult due to high water turbidity and velocity. And lastly, too few tags were recovered from live and dead fish on the spawning grounds to thoroughly assess the representativeness of fishwheel catches.

The following aspects of the 2013–2014 study, as indicated in the Revised Study Plan (RSP), were based on the implementation of the 2012 study. The RSP includes the 2012 study objectives to improve data quality and quantity, and to increase capture variation across years, environmental conditions, and salmon run abundance. Tagging efforts will continue for all species in the Middle River, and for Chinook, coho, and pink salmon in the Lower River. The addition of a third tagging location just downstream of Devils Canyon will be assessed in 2013 to increase the sample size of tagged fish migrating into Devils Canyon and above the impediments. The number of Chinook and coho salmon migrating through the Lower River will be estimated using mark-recapture methods; this will require tagging salmon in the Lower River fishwheels, then recapturing salmon in various drainages upstream. Separately, the mark rate of salmon tagged at Curry will be reassessed to help estimate the actual number of salmon migrating past the site, and if sufficient data can be obtained, the number of fish above Devils Canyon. Visual verification of spawning will be continued during periods of low water volume or turbidity. Non-visual verification methods (e.g., sonar) will also be employed again in 2013.

1. INTRODUCTION

The Alaska Energy Authority (AEA) is preparing a License Application to submit to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project) using the Integrated Licensing Process (ILP). The Project is located on the Susitna River, an approximately 300-mile (mi) long river in the Southcentral Region of Alaska (Figure 1). The Project's dam site will be located at river mile (RM) 184 (see Table A-1 for a list of river mile designations). The results of this study will provide information that will serve as the basis for the Revised Study Plan (RSP) filed with FERC December 14, 2012, in preparing Exhibit E of the license application (18 CFR 4.41) and for use in FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-application Document (PAD; AEA 2011a) will modify the flow, thermal, and sediment regimes of the Susitna River, which may alter the composition and distribution of fish habitat. Several fisheries study plans were initiated during 2012 to describe fisheries resources in the Project area, prior to development of the RSP, including the Adult Salmon Distribution and Habitat Utilization Study. This study is the first of three years of study designed to help evaluate potential Project-related effects to fish habitat by characterizing adult salmon (*Oncorhynchus* spp.) habitat use in the Susitna River. The study plan outlining the proposed methods was published on the AEA web site (AEA 2012a; http://www.susitna-watanahydro.org). Proposed methods for the 2013 and 2014 study years were outlined in Section 9.7 (Salmon Escapement Study) of the RSP (AEA 2012c).

This report documents the final results from the first year of the study in 2012. Earlier, an interim report was submitted to license participants to provide an update on the progress of the 2012 study prior to its completion, identify any issues or obstacles that occurred, and allow for further refinement of the RSP (AEA 2012b). The final report provided here supersedes the interim report from September 2012.

This report describes the migration behavior and spawning habitat use of salmon in the Lower (RM 0–98), Middle (RM 98–184), and Upper (upstream of RM 184) River segments of the mainstem Susitna River (hereafter, Lower River, Middle River, and Upper River), while evaluating approaches such as sonar and radio telemetry for future use on the Project. The work in 2012 followed up on an extensive series of salmon distribution and spawning studies from the 1980s, thereby providing an assessment of similarities and differences between the 1980s and 2012. The Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011b) and PAD (AEA 2011a) summarized existing information and identified data gaps for adult salmon and resident and rearing fish. Adult salmon habitat utilization studies conducted by ADF&G during the 1980s were summarized by Woodward-Clyde Consultants and Entrix, Inc. (1985). In recent years, ADF&G conducted adult salmon (sockeye, chum, and coho) spawning distribution and abundance studies in the Susitna River (e.g., Merizon et al. 2010; Yanusz et al. 2011).

2. STUDY OBJECTIVES

The goals of Adult Salmon Distribution and Habitat Utilization Study in 2012 were to:

1. Characterize the distribution, migration behavior, and proportional abundance of adult anadromous salmon and determine their use of mainstem, side channel, and slough habitats in the Lower, Middle, and Upper River in 2012.
2. Determine whether historical study results and conclusions are consistent with the current distribution and relative abundance of spawning adult salmon in the mainstem Susitna River.
3. Provide spawning habitat data to support the selection of sites for the instream flow (ISF) study, develop site-specific habitat suitability criteria (HSC), and develop a habitat sampling protocol for 2013–2014.
4. Develop information to refine the scope, methods, and study sites for studying habitat use by adult salmon during the follow-on 2013–2014 studies.

To achieve these goals, we developed seven specific objectives for the 2012 study:

1. Capture, radio-tag, and track adults from five species of Pacific salmon in the Middle River in proportion to their abundance.
2. Determine the migration behavior and spawning locations of radio-tagged salmon in the Lower, Middle, and Upper River.
3. Assess the feasibility of using sonar to determine spawning locations in turbid water.
4. Characterize salmon migration behavior and timing above Devils Canyon.
5. Compare historical and current data on relative abundance and distribution of spawning and holding salmon across mainstem, side-channel, slough, and tributary delta habitat types.
6. Locate individual holding and spawning salmon in clear and turbid water and collect habitat data from holding and spawning salmon in the Lower and Middle River mainstem consistent with developing habitat suitability criteria for instream flow modeling.
7. Evaluate the effectiveness of methods used in 2012 to address study goals and objectives, and assess their suitability for future years' studies.

This study was coordinated with basin-wide radio telemetry studies conducted by the Alaska Department of Fish and Game (ADF&G). The goals of the ADF&G studies were to characterize the timing and distribution of the 2012 salmon escapement to the Susitna River among major and minor tributaries, and to estimate the system-wide escapement of chum *O. keta* and coho *O. kisutch* salmon above RM 22. In 2012, AEA supported an additional radio telemetry component by ADF&G to describe the distribution of adult Chinook *O. tshawytscha* and pink *O. gorbuscha* salmon in mainstem and tributary habitats. The 2012 AEA-supported ADF&G study also examined the feasibility of estimating the system-wide escapement of Chinook salmon to the Susitna River. In 2012, ADF&G anticipated radio-tagging 500 Chinook, 400 chum, 400 coho, 400 pink, and 100 sockeye salmon at capture sites at RM 22 and 30, combined. An array of fixed-station receivers located at mainstem sites and tributary mouths was combined with fixed-wing aerial surveys to apportion the radio-tagged fish to various water bodies. Radio-tagged fish were tracked to the nearest river mile and at intervals of approximately fourteen days.

This study differed from ADF&G's ongoing studies in that spatial data was collected from radio-tagged fish on finer spatial and temporal scale; the objective was to obtain locations of spawning and holding salmon at the macro- and microhabitat levels. This contrasted with the tributary apportionment and the nearest river mile spatial resolution of the ADF&G studies. This study expanded on the ADF&G effort by more frequent tracking of both AEA and ADF&G radio-tagged fish in the Lower, Middle, and Upper River. This study also used helicopter surveys to locate tagged fish, and then boat and foot surveys to determine more precise locations of those fish that were holding and/or spawning.

3. STUDY AREA

The Susitna River is one of the largest rivers in Alaska draining an area of 49,210 square kilometers (19,000 square miles). The river begins in the Alaska Range and Talkeetna Mountains and flows into Upper Cook Inlet (UCI) in Southcentral Alaska (Figure 1). The climate within the watershed varies from maritime, coastal conditions in the lower watershed to weather typical of interior Alaska in the upper watershed. Climate conditions at Talkeetna, Alaska (RM 97) have been recorded since 1918. From 1918 through 2007, mean monthly minimum and maximum air temperatures for the summer months (June–August) in Talkeetna ranged from 6.7°Celsius (C) to 20.3°C (44.1°Fahrenheit [F] to 68.5°F; ACRC 2012). Precipitation typically peaked in August at 12.27 centimeters (cm; 4.83 inches [in]) for the month. Mean monthly minimum and maximum air temperatures are coldest in January ranging from -17.3°C to -12.1°C (0.9°F to 10.2°F; ACRC 2012). The Susitna River freezes in October though pan ice is observed in late September. Though most of the river is frozen in winter, upwelling can cause some open sections of water. Break-up of the river typically occurs in late April to mid-May. Spring melting of snowfall (freshet) causes the river discharge to peak from mid-May to mid-June, dependent upon snow levels. Discharge data used to evaluate salmon migration at different water levels were obtained from the gaging stations at Gold Creek (RM 136), operated by the United States Geological Survey (USGS) via the National Water Information System web site (http://waterdata.usgs.gov/nwis). This station has a period of record from 1949 to 2012. Water temperatures were also collected by the fishwheel crew at Curry (RM 120) in 2012, using a handheld thermometer.

As indicated in the study plan for this study, the Susitna River was initially divided into three sections: the Upper River (above RM 150), the Middle River (RM 98–150), and the Lower River (RM 0–98). However, during subsequent agency consultation and RSP development, a standard Project-wide delineation of river segments was designated as follows:

- Upper River Segment – above the proposed dam site (RM 184).
- Middle River Segment – Three Rivers Confluence (RM 98) to the proposed dam site (RM 184).
- Lower River Segment – Cook Inlet (RM 0) to the Three Rivers Confluence (RM 98).

The analysis in this report follows the standard Project-wide Susitna River segment designations. The study area for this project encompasses the Susitna River mainstem from Cook Inlet (RM 0) to the Oshetna River (RM 234).

3.1. Upper Susitna River

The Upper River Segment is the stretch of river above the proposed dam site at RM 184 (Figure 2). The headwaters and tributaries are braided, fed by glaciers on the south slopes of the Alaska Range (Gatto et al. 1980). The Upper River is joined by the McLaren River (RM 260), the Tyone River draining Lake Louise and Susitna Lake (RM 247), and the Oshetna River (RM 233). After the Oshetna River, the river turns northwest and is mostly constrained for the remainder of the Upper River and passes through two major canyons with rapids: Vee Canyon and Watana Canyon. Elwood et al. (1984) report that the river gradient in the Upper River is 14 feet per mile (ft/mi; 4 meters per kilometer [m/km]).

3.2. Middle Susitna River

The Middle River Segment is defined as the Susitna River from the confluence of the Chulitna, Talkeetna, and Susitna rivers, referred to as the Three Rivers Confluence (RM 98), to the proposed dam site at RM 184 (Figure 2). The upper portion of this segment is mostly constrained and passes through a significant canyon with rapids: Devils Canyon. Several tributaries enter the Middle River Segment between the canyon and the dam site including: Tsusena (RM 181), Fog (RM 177), and Devil (RM 161) creeks. Within Devils Canyon the channel constricts forming three impediments that may block or impede fish passage (RM 150–161): Impediment 1 is the farthest downstream, Impediment 3 is the farthest upstream. Two tributaries enter the Middle River Segment in the canyon; Cheechako Creek enters between Impediment 1 and Impediment 2 at RM 152, the mouth of Chinook Creek is between Impediment 2 and Impediment 3 at RM 157. Sections of the river within the canyon can have a steep gradient, up to 31 ft/mi from Impediment 1 (RM 152) to Devil Creek (RM 161; Elwood et al. 1984). Sections of the river within the canyons can have a steep gradient, up to 31 feet per mile (ft/mi) (9.5 meters per kilometer [m/km]); Elwood et al. 1984). Below Devils Canyon, the river becomes less confined; in locations where the valley widens, silt and gravel depositions allow for the formation of sloughs and side channels (Elwood et al. 1984). The major tributaries in this section of river are non-glaciated streams entering from the north including Portage Creek, Indian River, and 4th of July Creek (Figure 2). There are no major lakes draining into the Middle River downstream of Fog Creek.

3.3. Lower Susitna River

The Lower River Segment is the stretch of river below the confluences of the Chulitna and Talkeetna rivers with the Susitna River (RM 98; Figure 1). The Chulitna River contributes a greater silt load to the Lower Susitna River because it is fed by many glaciers including those on Mt Denali, Mt Foraker, and Mt Hunter. Immediately downstream of the mouth of the Chulitna River, the Talkeetna River flows into the Susitna River from the west (RM 97). The Lower River floodplain is broad and braided with numerous side channels and gravel bars. Several tributaries enter the Lower River, including the Kashwitna River (RM 61), Willow Creek (RM 50), Deshka River (RM 41), and the Yentna River (RM 30) (which alone contributes about 40 percent of mean annual total discharge of the entire Susitna River drainage). The mouth of the Susitna River is approximately 38 km (24 mi) northwest of Anchorage, Alaska (Figure 1).

3.4. Fishes of the Susitna River

The Lower and Middle River below Devils Canyon provide habitat for Chinook, chum, coho, pink, and sockeye salmon; combined, these species are important for subsistence, commercial, and sport fisheries, either within the Susitna River drainage or downstream in Upper Cook Inlet (Ivey et al. 2009; Shields and Dupuis 2012). Preliminary studies in the 1980s documented relative abundance and habitat usage by species for salmon in the Lower and Middle River, finding no evidence that Chinook salmon spawn outside of the tributaries (Barrett et al. 1984, 1985; Thompson et al. 1986). Mainstem habitats (e.g., side channels and sloughs) provide important spawning habitats for other salmon species and rearing habitat for juveniles. After emergence, juvenile Chinook, coho, and some sockeye salmon rear in the Susitna River drainage and outmigrate as age 1+ or 2+ smolts. Chum, pink, and some sockeye salmon leave the Susitna River within several months after emergence (age 0+).

Chinook salmon are the only anadromous species documented in the tributaries within and above Devils Canyon. Aerial counts conducted 1982-1985 and 2012 found Chinook salmon adults each year in both Cheechako and Chinook creeks, which are below Impediment 3 in Devils Canyon. Above Impediment 3, Chinook salmon have been periodically documented in Devil, Fog and Tsusena creeks. Though studies in the 1980s did not find salmon in the Upper River Segment, recent surveys documented juvenile Chinook salmon rearing in Kosina Creek and the Oshetna River (Buckwalter 2011). Aerial salmon counts conducted in 2012 in the Upper River tributaries documented adult Chinook salmon spawning in Kosina Creek. No other anadromous salmon species has been found above Devils Canyon.

In addition to Pacific salmon, at least 13 anadromous and resident fishes are also present within the Susitna River drainage (Coutant and Van Winkle 1984). Resident fish species and juvenile anadromous fishes are found in higher densities in clear water because the high sediment load in the mainstem river impairs feeding (Schmidt et al. 1984). Northern pike (*Esox lucius*) are a non-indigenous species to the Susitna River and were likely introduced to the drainage in the 1950s (Rutz 1996). Northern pike are most often found in lakes and sloughs of the tributaries that drain into the Lower River.

4. METHODS

Many of the study objectives were interrelated and shared a common approach or method. Several objectives, for example, relied on data from fish originally captured and tagged in two areas of the drainage. Sonar was used to achieve some objectives, and to evaluate the effectiveness of the fish capture efforts elsewhere. Habitat was sampled as part of other, distinctly different, objectives. Table 1 presents an overview of the approaches and their various purposes; this overview is summarized below, with more detailed descriptions of the full methods used to achieve each objective following.

Salmon were captured and tagged in the Lower River, near the confluence with the Yentna River. These salmon were captured in fishwheels operated at RM 22 and RM 30 by ADF&G (ADF&G 2013). A subset of the salmon was tagged with radio tags; these salmon were then tracked by ADF&G to generate information for both this study and ongoing ADF&G research (ADF&G 2013). The fish tagged by ADF&G at these Lower River sites were also tracked as part of this study in the Lower, Middle, and Upper River segments. Tagged salmon were used to identify spawning locations in the mainstem river (Objective 2), to add to the sample size of fish potentially migrating above Devils Canyon (Objective 4), and to increase the sample sizes of spawning locations to classify and characterize (Objectives 5 and 6; Table 1). Geographic spawning locations identified using radio telemetry were termed destinations. Destinations were classified into one of three groups: tributary, mainstem, or other. Fish capture and tagging in the Lower River is described in Section 4.3.1 below, and in ADF&G (2013).

The second site used for salmon capture and tagging was in the Middle River, near the historic site of Curry. Here, salmon were captured in two fishwheels near RM 120. A subset of these salmon was tagged with radio tags and then tracked to generate information specifically for this study. The tags were used to track fish in the Middle River (Objective 1), to describe migration behavior and spawning locations in the mainstem river (Objective 2), to detect fish passage above Devils Canyon (Objective 4), and to help identify and characterize salmon spawning locations (Objectives 5 and 6; Table 1). Radio-tagged fish were tracked from aircraft, from boats, on foot from the stream bank, and from fixed-station receivers along the river; full details are described in Section 4.2, below.

An overall goal of the study in 2012 was to identify and characterize spawning habitat for each salmon species. This entailed classifying the type of habitat used, and collecting data needed to develop HSC and inform instream flow models being developed by AEA. Since the mainstem Susitna River is turbid, sonar was used to verify spawning activity and to help characterize spawning habitat that was not visible or was otherwise unable to be sampled. Sonar was also used to evaluate the behavior of fish swimming past the fishwheels in turbid water at Curry. The assessment of sonar as a study tool in future years is directly addressed as Objective 3 of this study (Table 1).

Data from other studies were also used to inform implementation of this study. ADF&G's capture and tagging in the Lower River (described in Section 4.3) was one such study. Others were average daily discharge of the Susitna River at Gold Creek (RM 136) from 1949 to 2012 (U.S. Geological Survey via the National Water Information System web site [http://waterdata.usgs.gov/nwis]); aerial surveys of untagged salmon conducted by ADF&G for fishery management (S. Ivey, ADF&G Fisheries Biologist, personal communication, July 25, 2012), and by AEA to document adult Chinook salmon above Devils Canyon.

4.1. Deviations from Study Plan

Study objectives and methods were described in detail in the 2012 Study Plan (AEA 2012a). Notable aspects of the 2012 field program that deviated from the study plan are listed below and further described in the following sections.

- Spaghetti tags were not placed in salmon radio-tagged at Curry (Section 4.2.2.1).
- Fish scales and DNA were not collected from salmon at Curry (Section 4.2.2.1).
- Dual Frequency Identification Sonar (DIDSON) was not mounted on the offshore corner of fishwheels at Curry and was only used at one of the two fishwheel sites (Section 4.2.3.1.1).
- Chinook, chum, and sockeye salmon were not sampled in clear-water side channels, sloughs, or tributaries to assess mark rates or size selectivity (Section 4.2.3.7.1).
- One DIDSON/side-scan survey, instead of three, was conducted from early August through September (Section 4.4.1).

4.2. Objective 1 – Capture, Tag and Track Fish in the Middle Susitna River

Fish were captured and tagged in the lower portion of the Middle River at Curry (RM 120) to provide the tagged salmon needed to address many study objectives. Salmon tagged at Curry were tracked to generate information such as migration behavior and spawning locations (Objective 2, described in Section 4.3) and passage through Devils Canyon (Objective 4, described in Section 4.5). Tagging at Curry mirrored similar efforts downstream in the Lower River (RM 22 and 30), thereby having a large sample of upstream-moving salmon tagged at the lower portion of each river segment. Data from the salmon tagged in the Lower and Middle River were combined to augment the individual data sets. The capture, tag, and tracking operation in the Middle River is described in the following sections. For the Lower River, the study operation is summarized in Section 4.3.1, below, and described in full detail by ADF&G (2013).

4.2.1. Fish Capture at Curry – Design and Operation

Fish were captured using three fishwheels (fishwheels 1, 2, and 3) operated at two different sites (sites 1 and 2) on the mainstem Susitna River near Curry, Alaska (Figure 2; Figure 3). Site 1 (RM 120) was located on the right bank of the Susitna River approximately 0.4 miles downstream from the mouth of Deadhorse Creek. Site 2 (RM 119) was located on the left bank of the Susitna River approximately 1 mile downstream of Site 1. Fishwheels 1 and 3 operated at Site 1 (one at a time), and Fishwheel 2 operated at Site 2.

All fishwheel components were delivered to Curry by train on June 4 and the fishwheels were assembled on site (Photo 1). Each fishwheel consisted of two aluminum pontoons (24 feet [ft] long by 30 in wide by 15 in deep), two partially submerged live tanks for holding fish in river water (7 ft long by 24 in wide by 46 in deep), and three baskets built from 1.5-in aluminum tubing and lined with 2.5-in knotless nylon mesh. A tower and winch assembly was used to adjust the height of the axles and ensure the baskets were fished within 1 ft of the river bottom. All fishwheel baskets were 8 ft wide, but their lengths varied: 88 in for Fishwheel 1, 76 in for Fishwheel 2, and 72 in for Fishwheel 3 (Figure 2; Figure 3). Typically, the axle was approximately 15 in above the water line, so maximum fishing depths were 79 in, 61 in, and 57 in, for fishwheels 1, 2, and 3, respectively. The bottom of each live tank had two panels of extruded aluminum mesh (21 in by 13 in each) to allow for ample water circulation. The fishwheels were secured along the riverbank using wire rope (5/16 in) and Polysteel rope (5/8 in) attached to large trees and steel anchor pins sunk into bedrock or rip-rap. Spar poles (2-in square

Telespar) were used to hold the fishwheels offshore in water deep enough to allow the baskets to rotate effectively. Lead nets were deployed at both sites between the fishwheels and adjacent riverbanks to direct fish away from shore and into the path of the baskets.

For safety reasons, all fish were sampled during daylight hours (encompassing the times 0604–0045 hours over the season) and a minimum of two people were present on each fishwheel. If the crews were not on the river, the fishwheel baskets were stopped. All fish were sampled and released immediately after being captured to minimize holding times in the live tanks. Fishing effort was calculated as the number of hours that a fishwheel operated on a given calendar day from midnight to midnight. Catch-per-unit-effort (fish/hour) was calculated by dividing the number of fish caught on a given day by the fishing effort. Fishwheel speed (RPM) was determined one or more times each day by measuring the time required for the fishwheel baskets to complete three revolutions.

4.2.2. Fish Tagging at Curry

Only healthy fish held in the live tanks for ≤30 minutes that met or exceeded a specific length threshold were radio-tagged. Length thresholds were ≥500 millimeters (mm; 19.7 in) mid eye to tail fork (MEF) for Chinook salmon; ≥400 mm (15.7 in) MEF for chum, coho, and sockeye salmon; and ≥330 mm (13.0 in) MEF for pink salmon. Fish measuring less than these threshold lengths were either jacks or considered too small to accommodate a radio tag. A dip net lined with knotless nylon mesh was used to transfer individual fish from the live tanks (or directly from the fishwheel slides) to a water-filled, foam-lined, V-shaped trough (Photo 2). Crews recorded the length of time that individual fish were held in a live tank (hold time), as well as the length of time it took to transfer a fish from a live tank to the sampling trough, apply a tag, collect biosamples, and release (process time). To minimize handling time 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 plastic tubing (3/8 in diameter by 8 in long). The whip antenna of the radio tag was left protruding from the mouth (Photo 3).

All tagged salmon were measured for length to the nearest 1 centimeter (cm; 0.39 in) and sexed using external morphological characteristics (coloration, body and fin shape, and jaw morphology). Both MEF and nose to tail fork (FL) lengths were recorded for each tagged fish until a reliable linear regression relationship was established. With the exception of pink salmon (which are all age 2 spawners), scales (age) were collected opportunistically from all tagged fish that remained relatively calm in the sampling trough. Scales were taken from the preferred location, posterior to the dorsal fin and above the lateral line.

All non-target fish species captured were counted and measured to the nearest 1 cm FL (0.39 in). At the request of ADF&G's Gene Conservation Lab, non-lethal tissue samples (axillary process or pelvic fin clip) for genetic analysis were to be collected from all non-target species. Dolly Varden *Salvelinus malma*, humpback whitefish *Coregonus pidschian*, least cisco *C. sardinella*, and Bering cisco *C. laurettae* measuring ≥250 mm FL (9.84 in) were to be sacrificed for their otoliths (up to a maximum of 12 individuals per species).

The initial goal of this study was to radio-tag 400 Chinook salmon and 200 each of chum, coho, pink, and sockeye salmon captured at the Curry fishwheels. Early season tagging rates of fish captured at the fishwheels was based on the average historical run timing at the Curry fishwheels (1981–1984 for Chinook; 1981–1985 for chum, coho, and sockeye; and 1982 and 1984 for pink salmon; Figure 4). Across the five years from 1981 to 1985, Chinook salmon were caught at Curry from as early as June 9 (range: June 9–20) to as late as August 20 (range: July 29 to August 20), with midpoints ranging from June 25 to July 9 (ADF&G 1981; Barrett et al. 1983, 1984, 1985; Thompson et al. 1986). During those studies, catches were 201–379 (mean: 301) sockeye salmon, 93–350 (mean: 215) coho salmon, 861–4,228 (mean: 2,131) chum salmon, and 17,394 for the 1984 even-year pink salmon run. Midpoints of the migrations at Curry ranged from about August 4–5 for sockeye, July 31 to August 7 for pink, August 3–15 for chum, and August 12–13 for coho salmon. The 2012 tag deployment schedule was adjusted in-season using run-timing information from the Lower River fishwheels and the ratio of daily catches at Curry to the expected catches based on historical data.

4.2.2.1. Deviations from the Study Plan (Section 4.1)

Every second radio-tagged fish was to receive a blue spaghetti tag sewn through the dorsal musculature. Fish with both radio and spaghetti tags would help to assess tag loss, the effects of spaghetti tagging on post-handling behavior and final spawning destination, and, in the case of Chinook and coho salmon, provide an external mark for anglers to recognize that a fish has a radio tag. In addition, it was anticipated that the fishwheels would capture more fish than the number of radio tags available for each species. Once the radio-tagging goals had been met for a given day, a systematic portion (i.e., one out of every n fish caught) of the Chinook, chum, and sockeye salmon were to receive a green spaghetti tag (up to an additional 400 Chinook, 700 chum, and 400 sockeye salmon). These additional tagged fish would help test assumptions about the representativeness of the fish captured to reflect the species-specific Middle River populations. However, through an emergency order (EO No. 2-KS-2-20-12) effective June 25, 2012, ADF&G closed the sport fishery targeting Chinook salmon in the Susitna River and all its tributaries in an effort to meet minimum spawning goals. It was therefore unlikely that any tagged Chinook salmon would be recovered. As a result, and in an effort to reduce the processing time for each fish, it was decided after the first four days of sampling that no additional spaghetti tags would be deployed for any species. Consequently, we lost one potential way to estimate mark rates (which was not needed for any primary objective).

Fish scales were only collected opportunistically from tagged fish that remained relatively calm in the sampling trough. Similar to spaghetti-tagging, the collection of scales ceased less than a week into sampling in order to minimize processing times on all species.

For similar reasons, tissue samples (DNA) were also not collected from radio-tagged fish at Curry. Consequently, this delays the eventual development of genetic baselines and parentage studies for salmon in the Middle and Upper River, which was also not a primary objective of this study.

4.2.3. Diagnostics to Assess Effectiveness and Representativeness of Catch and Tag Methods

4.2.3.1. Using DIDSON to Assess Fishwheel Effectiveness

A DIDSON sonar system was used to guide fishwheel placement, characterize changes in fish behavior around the fishwheels over time, and help detect substantial changes in fishwheel effectiveness over time. The following questions were addressed using DIDSON:

1. What proportion of the salmon that migrate nearshore and in the path of the fishwheel baskets are subsequently captured, and does this change over time and across different water conditions?
2. Do salmon migrate in higher velocity waters offshore of the fishwheel baskets, or are they strictly bank-oriented, and does this change over time and across different water conditions?
3. Is there a size difference between fish captured at the fishwheels and those that migrate nearshore and offshore?
4. What is the diel pattern of salmon migration past the fishwheels?

One standard DIDSON unit was deployed at Site 1 just off the shore downstream of the fishwheel and aimed nearly perpendicular to the flow. This configuration allowed the lateral distribution of Chinook salmon to be assessed as they approached the fishwheel at Site 1 (Figure 2; Figure 3). The sampling window length was approximately 10 m (33 ft), which included the offshore portion of the net weir and the width of the fishwheel capture area. The data collection system included the sonar head, DIDSON cable, topside control box, laptop computer, and external hard drive. The electronic components were housed in an environmental box on shore and powered by a portable generator. Data were collected in continuous (24 hours per day) successive 15-minute files, and each file name included the date, time, and deployment location. Data were ported directly to a 1 terabyte (TB) external drive and periodically backed up and archived to additional hard drives. Data were collected using the highest optimal frame rates. Data review involved replaying the files through the DIDSON software to observe detected salmon targets. For each target observed, the following were noted: deployment location, date, time, first and last range detected, direction of movement, and estimated body size. Avoidance of the fishwheel was assessed by comparing the estimated number of fish observed using DIDSON with the fishwheel catch.

4.2.3.1.1. Deviations from Study Plan (Section 4.1)

At Curry, the DIDSON was not mounted on the offshore corner of the fishwheels. Instead, the DIDSON was installed just off shore near the river bank to determine fish passage in proximity to the fishwheel and help with fishwheel placement, as described in Section 4.2.3.1. Also, the DIDSON was only operated at Site 1 in 2012. Further characterization of fish passage for effective fishwheel placement was deemed unnecessary following these initial DIDSON surveys. Catches at Site 2 were comparable to Site 1, and at an acceptable level.

4.2.3.2. Tests for Handling-Induced Changes in Behavior

One assumption of this study was that the capture and handling process did not affect the final spawning destination and/or migration behavior of a fish once it recovered from being tagged and resumed its upstream migration. This assumption could not be tested directly, but there were several indirect ways to assess its potential magnitude. First, comparing post-release survival and travel time (days) to first detection at upstream fixed-station receivers would indicate the level of handling-induced changes in behavior. Long delays to resume upstream migration and high mortality rates would be indicative of significant changes in behavior; little delay and low mortality rates would be indicative of little effect. Second, if sufficient contrast in handling times was available, it would allow comparison of survival and migration behavior (delays, migration rates) of radio-tagged fish subjected to different hold (in the live tanks) and process (sampling) times. Finally, comparing post-release survival and migration behavior of radio-tagged fish captured twice (i.e., recaptures) in the Curry fishwheels would help assess the potential for cumulative capture and handling effects.

4.2.3.3. Tests for Equal Capture Probabilities at Curry

Meeting several goals of this study required that the radio-tagged fish of each species were representative of the respective “populations” in the Middle River. Tagging particular stocks and/or sizes of fish at different rates than others would weaken inferences about habitat uses of the Middle River such as the relative distribution of spawning fish, migratory behavior, and any fish passage above Devils Canyon. Therefore, there was a need to examine whether all fish passing the tagging site were equally vulnerable to capture. If they were not, there are ways to stratify the data to mitigate or eliminate effects on results due to unequal capture probabilities. Equal probability of capture can be evaluated by time, area (stock), and size.

4.2.3.4. Capture Probabilities by Time

Our intent was to test whether all salmon (by species) had the same probability of being tagged, regardless of when they passed the tagging site, by comparing weekly (or some other temporal stratification) mark rates of fish sampled on the spawning grounds using contingency table analysis (Chi-square test). Significant test results would suggest fish were not sampled proportionally over time. However, insufficient spawning ground samples precluded these tests.

As described in Section 4.2.3.1, we also compared the relative effectiveness of the fishwheels, as determined from the ratio of fish caught by a fishwheel and the number of fish observed with DIDSON across different time periods and river discharge. DIDSON was also used to qualitatively assess fish approach behavior at the fishwheel relative to discharge and fish abundance.

To ensure complete coverage of the runs, sampling (marking) at the Curry fishwheels began prior to significant passage of fish and continued through the run until passage dropped to near zero.

4.2.3.5. Capture Probabilities by Area (Stock)

Our intent was to test whether all salmon (by species) had the same probability of being tagged, regardless of their spawning destination (stock), by comparing the mark rates of fish sampled in different spawning areas using contingency table analysis (Chi-square test). Significant test results would suggest fish were not sampled proportionally across stocks. This approach is better suited for fish that are readily accessible in clear-water tributaries and side channels, but not for fish in mainstem areas. Again, insufficient spawning ground samples precluded these tests.

It is possible that mainstem spawning populations could be more vulnerable to capture in the fishwheels due to higher residence time and milling around Curry. If this were to occur, the radio-tagging would overestimate the contribution of mainstem fish and habitat use by the Middle River population. To evaluate this potential source of bias, we compared the proportion of radio-tagged fish that was recaptured at the fishwheels across subsequent spawning locations (mainstem vs. tributary).

To assess whether fish from a particular spawning area were right or left bank-oriented with respect to capture at Curry, we used contingency table analyses to compare the proportion of fish migrating into specific areas with the collection bank at Curry.

4.2.3.6. Capture Probabilities by Fish Size

Fishwheels can be size-selective across a range of adult Pacific salmon body sizes (Meehan 1961; ADF&G 1983; Link and Nass 1999; Smith et al. 2005; Robichaud et al. 2010). The potential for size-related bias at the Curry fishwheels was tested using Kolmogorov-Smirnov (KS) two-sample tests. To determine whether fish size was independent of capture location, cumulative length-frequency distributions of fish caught at Site 1 were compared to those of fish caught at Site 2. Also, the cumulative length-frequency distributions of radio-tagged fish were compared to those of all fish captured at Curry to determine whether tagged fish were representative of all fish caught at the fishwheels. Size-related bias can usually be eliminated by size stratification of results (Link and Nass 1999; Smith et al. 2005).

4.2.3.7. Stream Counts and Carcass Surveys

Stream counts and carcass surveys were conducted for live and dead Chinook salmon in Indian River and Portage Creek to generate diagnostics useful for interpreting fishwheel catches and analyses. The three main objectives of the surveys were to:

1. Assess fishwheel catch rates based on the proportion of tagged to untagged fish (i.e., mark rate) observed on the spawning grounds.
2. Assess size selectivity at the fishwheels by comparing the size distributions of tagged and untagged fish.
3. Assess handling-related effects on survival by comparing the mortality rates of tagged and untagged fish.

Historical data suggest up to 90 percent of the spawning Chinook salmon population above the Three Rivers Confluence spawn in Portage Creek (70 percent) and Indian River (20 percent; Thompson et al. 1986). The proportion of tagged to untagged fish in these tributaries should therefore provide a reasonable estimate of the mark rate for the population of Chinook salmon in the Middle and Upper River.

For ground-based surveys, a two-person field crew was transported by helicopter to the top of a particular river section, typically near the upstream extent of where the bulk of the radio tags were detected on previous aerial-tracking surveys. As the crew walked downstream, they counted the number of live and dead Chinook salmon. The crew estimated their observer efficiency based on the environmental conditions (e.g., water level and turbidity) and proportion of habitat surveyed within each river section. For each carcass encountered, crews recorded a GPS location, measured the length (FL and MEF), inspected for tags, and collected tissue for DNA analysis. Crews also used mobile receivers and hand-held antennas to recover radio tags emitting inactive codes (and these were re-deployed in fish at the Curry fishwheels).

On the same day of each ground-based survey, an aerial-tracking survey was conducted to determine the number of active (live) radio tags present in the same river section.

Additionally, on July 24, ADF&G conducted its annual aerial-counting surveys for Chinook salmon in Indian River and Portage Creek. An aerial-tracking survey was conducted on the same day to determine the number of radio tags present in each river.

4.2.3.7.1. Deviations from Study Plan (Section 4.1)

Chinook, chum, and sockeye salmon were not sampled in clear-water side channels and sloughs because conditions during the target sampling periods precluded visual assessments in the mainstem river. Tributaries that were clear were surveyed for marked fish, as described in Section 5.1.3.6, but yielded only coarse information. Early in the season, water levels were near record highs and turbid, so very little clear-water habitat existed in the mainstem river. Thereafter, water levels dropped so fast and far that much side channel and slough habitat was inaccessible by boat. Given that only coarse information came from surveying tributaries, which were likely the source of greatest sample sizes, it is unlikely that side channels or sloughs would have added much mark-rate information.

4.2.4. Tracking of Salmon to Describe Distribution and Migration Behavior

4.2.4.1. Radio Transmitters

Applied Telemetry Systems (ATS; Isanti, MN) pulse-coded, extended-range radio tags were applied to a subset of salmon captured in the Middle River fishwheels. Twelve frequencies were allocated to the Middle River tag site (151.713–151.994 megahertz [MHz] range; Table B-1), and eighteen frequencies to ADF&G's Lower River tag site (151.033–151.633 MHz range). Model F1835B transmitters were purchased for pink salmon (0.6 oz, 12 in antenna, 96 day battery life), Model F1840B tags for sockeye, coho, and chum salmon (0.8 oz, 12 in antenna, 127 day battery life), and Model F1845B tags for Chinook salmon (0.9 oz, 16 in antenna, 162 day battery life). These transmitters are equipped with a sensor that changes the signal pattern to a "motionless" or an "inactive" mode once the tag becomes stationary for 24 consecutive hours. Tagged fish were presumed dead when inactive codes were received; effort was made to recover inactive tags and redeploy them on other fish captured at Curry. Each recovered tag was tested immediately prior to deployment to ensure it was functioning properly upon release.

4.2.4.2. Fixed-Station Receivers

Fixed-station receivers were operated at ten strategic locations in the Middle and Upper River, including: Lane Creek Station (RM 113), Gateway (RM 125, located near the Fifth of July Creek confluence), Slough 11 (RM 135), Indian River confluence (RM 139), Slough 21 (RM 141), Portage Creek confluence (RM 149), Cheechako Station (RM 152, located upstream of the Cheechako Creek confluence), Chinook Creek confluence (RM 157), Devil Station (RM 164, located upstream of the Devil Creek confluence), and Kosina Creek confluence (RM 207; Figure 2; Table B-2). These sites were chosen based on: 1) the need to provide basic geographic separation of the Middle River area (below Devils Canyon) to describe migration and spawning behaviors; 2) monitoring at the appropriate resolution to quantify passage through Devils Canyon; and 3) the need to focus mobile survey effort over an expansive area. In addition to these fixed-station receivers, ADF&G operated the following fixed-station receivers in the Lower River that scanned the frequencies of fish tagged at Curry: Sunshine, Talkeetna, and Chulitna stations (Figure 2). Fixed-station receiver data were used to track fish movements, calculate reach-specific travel speeds, and determine the timing of fish movements through migratory impediments.

In the Middle and Upper River, each fixed station included a waterproof housing unit, telemetry receiver, reference radio tag, 12-volt battery, 50-watt solar panel, and 4-element Yagi antennas (Photo 4). The reference (or beacon) tags were deployed to provide a continuous record of known signal detections. Many sites had additional antennas and a 4-way antenna switcher that allowed the telemetry receiver to scan each antenna individually. Some locations also included an additional receiver for scanning ADF&G radio frequencies. Some sites were enclosed within a bear fence.

During installation of fixed stations at Lane Creek, Gateway, Indian River, and Portage Creek, a reference radio tag was used to calibrate each receiver and verify that it would be capable of detecting tags passing along the opposite riverbank. The results from testing at these sites were used as a guide when installing the stations inaccessible by boat.

All Middle and Upper River fixed-station receivers used the same type of telemetry receiver (ATS model R4500). The receivers had user-programmable settings for scan time and store rate, room for four frequency tables, and the ability to store up to 100,000 blocks of data. In general, a receiver would scan all available antennas for three seconds. If no radio tag was detected, the receiver scanned the next frequency in the table. If a radio tag was detected, the receiver would scan each antenna individually for 12 seconds before moving to the next frequency in the table. Antennas were oriented to allow for determination of a fish's direction of migration, be it upstream, downstream, or in some cases into a tributary. Data were stored at different rates throughout the study area, depending on the number of tags located near a station, in order to best avoid the data loss that results from filling memory banks beyond their capacity.

From installation until early September, the Middle and Upper River fixed-station receivers were visited at least once per week. Data were downloaded from the R4500 receivers using a field laptop computer equipped with ATS's ATSWinRec_C (Version 1.0.14) software. Reference tag records were checked to ensure that all antennas were working properly. The most common problem encountered at stations involved animals chewing on the coaxial cable connecting the antennas to the receiver. Later in the season, as the days became shorter, the solar panels did not produce as much electricity, so that the 12-volt batteries needed replacement during the weekly visits. The date, time, battery voltage, file name, memory-bank status, and any changes made to the station were recorded onto a datasheet log stored at the station (a backup copy was also maintained in the laptop case).

During the period from July 1–10, receivers at the mouths of Indian River and Portage Creek stopped functioning after being over-taxed by the number of tags within their detection ranges. The manufacturer assessed this behavior to be a result of a software flaw, and provided replacement receivers while they repaired the original receivers. During this period data was not collected at these two fixed-station receivers (see Figure B-1 for details of receiver performance). The project objectives were still met because the receivers were visited more frequently than planned to download the data, and the problems were fixed relatively quickly. However, the system downtime may have affected estimates of travel times. To avoid bias, detection data from July 1–11 at the Indian River and Portage Creek stations were not used for travel time and travel speed analyses.

For all fixed-station receivers, detection efficiencies were estimated by dividing the total number of unique radio-tagged fish detected at the site by the total number of unique radio-tagged fish known to have passed. The number of fish detected at each site included only fish moving in the upstream direction (detection efficiencies would be artificially inflated if they included fish that were missed as they passed a receiver in the upstream direction, but which were subsequently detected as they dropped back past the receiver in a downstream direction). The total number known to have passed each receiver included all those radio-tagged fish detected at that site, or at any site located farther upstream. The detection efficiency of some receivers cannot be calculated as there are no upstream receivers to act as detection zones (e.g., Kosina Creek station). In this study, only tags deployed from the Curry fishwheels were included in detection efficiency calculations.

Receiver performance was also assessed as the percentage of deployment time during which the receiver was actively recording data. Activity and deployment were assessed on a per-hour basis, and then summed over days or weeks to calculate daily or weekly activity percentages. 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. Any detection (frequency-code) that did not correspond to a valid fish was considered as noise.

4.2.4.3. Mobile Tracking

Aerial-tracking surveys were conducted by helicopter (Robinson R44) to allow relatively accurate positioning of tagged fish (as compared to a fixed-wing aircraft), locate spawning areas, and identify salmon in clear water areas. A 4-element Yagi antenna was mounted to the cargo racks on each side of the helicopter (Photo 5). The antenna on the right side of the helicopter was oriented downward and was used to pinpoint the location of a tagged fish. The antenna on the left side of the helicopter was oriented forward and was used to scan in front of the helicopter for upcoming tags. Coaxial cable from the antennas was run into the body of the helicopter and connected to an antenna switcher that allowed the telemetry operator to scan for tags on one or both antennas. Coaxial cable from the antenna switcher was connected to a bank of two ATS R4520 and two R4500 receivers. Each receiver was equipped with a Garmin GPS antenna, so the receivers could record the coordinates of each tag detected. A Garmin GPS was also used to track the flight path on each survey.

Prior to the first survey of the season, the aerial setup was tested for accuracy in locating a tag's position. A radio tag was attached to a piece of rope with a buoy and placed in the river. The helicopter then flew multiple passes over the tag during which different combinations of flight path, antenna orientations, and receiver settings were used to determine the best technique for achieving high-power readings when near the tag. In general, the forward antenna could be used until the power reading reached approximately 95 (scale: 40–154), at which point it was best to switch to the downward oriented antenna to pinpoint the tag. As the season progressed and more tags were present in the river, often all river channels were flown and the downward-oriented antenna was used almost exclusively.

Before each flight, the aerial setup was tested to ensure that it was working properly. An extra radio tag was left in the vicinity of the landing area. After all the telemetry gear was attached to the helicopter and connected to the receiver bank inside the helicopter, each receiver was checked to ensure it was reading the tag correctly (antennas were tested individually and combined).

Aerial surveys were conducted in the mainstem Susitna River from RM 10 to approximately RM 223, about 16 river miles above the Kosina Creek confluence. Aerial surveys were flown upstream of the Kosina Creek confluence if the fixed-station receiver at Kosina Creek detected a radio-tagged fish passing (and it was not detected later in Kosina Creek or elsewhere). Additionally, approximately 20 tributaries in the Middle and Upper River, and two tributaries in the Lower River (the Chulitna and Talkeetna rivers) were covered during aerial surveys. Much of the river downstream of the confluence with the Chulitna River was highly braided and required multiple passes during each survey to ensure that all tagged fish were located as accurately as possible. Areas with large numbers of fish, such as creek mouths, were often flown over multiple times, or the helicopter hovered over the sites, to ensure that all tags were detected. Some areas of the Middle and Upper River were within buffer zones implemented to protect known raptor nesting areas. The buffer zone around these nests had a radius of 1,000 ft within which aerial surveys could not be conducted. In particular, Impediment 3 near Devil Creek and the mouth of Kosina Creek were surveyed from the fringes due to raptor buffer zones.

Focused aerial-tracking surveys were conducted from June 29 to November 12 (see Table B-3 for details of mobile survey effort). Tracking typically occurred weekly until late October, at which time surveys were done approximately every other week. Tracking effort was dependent on weather conditions, helicopter availability, whether fish had been documented passing fixed-station receivers, and whether fish were moving into areas where more frequent tracking information was sought. The Middle River was surveyed consistently; some areas were surveyed during certain parts of the year, and other areas were only surveyed as time allowed. The Middle River above Devils Canyon and the Upper River were surveyed heavily during the Chinook salmon run but never thereafter because no other fish were documented migrating through Devils Canyon (as indicated by fixed-station receivers downstream). No surveys were conducted below Montana Creek after September 27 and there was only one fixed-wing survey of tributaries in the Lower River in October. The mainstem below the confluence with the Deshka River (RM 41) was only surveyed a few times due to the effort involved to get there from upriver, and the few tags in that stretch of river.

Data were downloaded from the receivers and GPS unit after each flight, and the digital data were backed up at that time. Survey track information was recorded as a backup to the GPS track log, including the start/end time, river section, and GPS coordinates. For each tagged fish detected, the habitat type (mainstem, side channel, slough, and tributary delta) and relative water turbidity was recorded. A laptop computer with fish locations from the most recent surveys was used by the helicopter crew to help identify possible spawning locations in real time.

Using the guidance of fixed-station receiver and aerial survey data on the known positions of tagged fish, mobile tracking was also conducted opportunistically by boat to obtain high-resolution location information for any concentrations of tagged fish.

4.2.5. Telemetry Data Management

4.2.5.1. Fixed-Station Receiver Data

Files downloaded from fixed-station receivers were uploaded into custom processing software, *Telemetry Assessor*. *Telemetry Assessor* was used to run diagnostics before erasing the internal memory in the receiver, to ensure that all data were transferred, the file was readable, and the receiver and antennas were operating properly. The diagnostics included the number of detections per antenna per day, and the number of beacon-tag hits per antenna per day. Once diagnostics were checked, *Telemetry Assessor* was used to produce a processed download file containing the receiver number, and the date, time, antenna, frequency, code, and maximum signal strength for a set of tag (or beacon tag) detections. Next, the receivers' memory banks were erased, and the receiver was set to continue recording detection data. The processed download files were uploaded into custom database software, *Telemetry Manager*.

4.2.5.2. Mobile Data

During each mobile track, several receivers were run, each scanning a different table of frequencies. Data from all aerial receivers were downloaded and checked for completeness. Start and end times were checked to ensure that all data were present. GPS coordinates were checked to ensure that the receiver recorded locations for all detections. Missing coordinates were interpolated. All files from a given survey were loaded into *Telemetry Assessor*, which processed all the files together to generate a single file per survey containing the timestamp, coordinates and signal strength of the highest power detection for each tag (i.e., one record per tag), along with the number of detections per tag, and the proportion of detections that were in inactive mode. The processed mobile file was fed into geographic information system (GIS) software which assigned zone numbers to the detection coordinates, after which it was uploaded into *Telemetry Manager*.

4.2.5.3. Tag Returns

All tags were labeled with the principle investigator's address and phone number so that any fish recovered in in-river fisheries could be reported and/or returned. A form was kept at the principle investigator's Anchorage office to record all relevant recovery information, including: angler name, contact information, date reported, date fish caught, capture location, species, radio tag frequency/code, and spaghetti tag number. In general, recovery data were treated as mobile-tracking data for the purposes of data processing. Thus, the recoveries dataset was fed into GIS software which assigned zone numbers to the recovery coordinates, after which it was uploaded into *Telemetry Manager*. To avoid 'tracking' fish to an angler's residence, we removed all detections of a recovered fish that were recorded after the reported recovery date from the compressed *Telemetry Manager* operational database.

4.2.5.4. Data Processing

All files produced by *Telemetry Assessor* (fixed-station receiver and mobile-tracking files) and all tag-recovery files were processed and analyzed using *Telemetry Manager* which facilitates data organization, record validation, and analysis through the systematic application of user-defined criteria. Raw data were archived so that the temporal or spatial resolution, or noise filtering criteria could be changed by the user at any time without altering the raw data. An important aspect of radio-telemetry is the removal of false records in receiver files, for example, those that arise from electronic noise. In this study, the following criteria were set for records to be considered valid: 1) for fixed-station receiver data, there must have been at least five detections recorded per scan cycle (single records, or records separated by more than the scan cycle time minutes were rejected); 2) for mobile data, single detection were allowed; 3) all detections had to be recorded at zones that were geographically located between the locations of previous and subsequent valid detections; and 4) any detections requiring unrealistic travel times were removed. Once false records were removed, *Telemetry Manager* created a compressed database of sequential detections for each fish. Each record included the tag number, location (coordinates and zone number), the first and last time and date for sequential detections in that location, and the maximum power for all detections in that interval. For mobile data, the proportion of detections that were in inactive mode was also included. The compressed (i.e., “operational”) database was used to determine when each fish entered the study area, residence times at each fixed-station receiver or spawning area, rates of movement between detection sites, probable spawning locations and sites of last detection.

4.3. Objective 2 – Salmon Migration Behavior and Spawning Locations in the Lower, Middle, and Upper Susitna River

Salmon migration behavior and spawning locations were described by tracking the salmon tagged with radio transmitters in the Lower, Middle, and Upper River segments. Radio-tagged salmon were assigned to spawning locations at the end of the season based on mobile and fixed data collected throughout the season, which included combined results from AEA and ADF&G surveys.

Inseason, we also used the potential spawning locations identified from radio telemetry to guide field activities needed for other objectives, such as testing the ability of sonar to detect spawning fish (Section 4.4), and describing spawning habitat characteristics and collection of data needed to develop HSC models (Section 4.6). For this reason, we attempted to visually confirm spawning activity at sites identified using radio telemetry.

4.3.1. Middle and Lower River Tagging and Tracking

Most mobile surveys and many of the fixed stations collected telemetry data from fish tagged by both AEA and ADF&G. To provide comprehensive descriptions of behavior and spawning throughout the entire mainstem river, AEA and ADF&G crafted an agreement to share radio telemetry tracking data collected by each group. Middle River tagging and tracking was described in detail in Sections 4.2.2 and 4.2.4, above.

In the Lower River, salmon were captured and tagged by ADF&G as part of a separate, existing study to estimate abundance and spawning distribution in different parts of the Susitna River drainage (ADF&G 2013). The existing study was expanded to assist Project efforts to describe spawning and migration of all salmon species in the mainstem Susitna River. Salmon tagged by ADF&G were the only fish available for study in the Lower River, and augmented the number of salmon tagged at Curry for study in the Middle and Upper River.

Salmon in the Lower River were captured and tagged in six fishwheels in 2012. The lowest four fishwheels were grouped downstream of the confluence of the Susitna and Deshka rivers, near RM 22, and were used to catch and tag chum, coho, pink, and sockeye salmon. The upper two fishwheels were in a pair located above the confluence of the Susitna and Deshka rivers, at RM 30, and were used to capture Chinook salmon. Fishwheels were operated for various lengths of time during the 2012 field season, depending on the run timing of the target fish. Salmon were tagged with internal (esophageal) tags, following the schedule developed *a priori*. Tags were placed in 500 Chinook salmon, 400 each of chum, coho, and pink salmon, and 100 sockeye salmon. Full details of sampling and tagging protocols in the Lower River fishwheels are described in ADF&G (2013).

After tagging, fish were tracked with a combination of fixed-station receivers and mobile surveys. ADF&G installed four fixed-station receivers on the mainstem river. The lowest was Susitna Station (RM 26), which was upstream of the lowest group of four fishwheels and served as the gateway to the study for chum, coho, pink, and sockeye salmon (Figure 1). Next upstream, Deshka Station (RM 40) served as the gateway for Chinook salmon. Continuing upstream, Sunshine Station (RM 83) was the uppermost station on the Lower River, and Lane Creek Station (RM 113) was the lowermost station on the Middle River. Devil Station at RM 164 was the uppermost station able to monitor tags deployed with the tag frequencies used by ADF&G, and therefore the uppermost fixed station able to detect fish tagged in the Lower River.

The fraction of salmon tagged in the Lower River that did not migrate into tributaries (e.g., the Deshka, Yentna, Talkeetna, or Chulitna rivers, or other smaller tributaries) became part of the study of distribution and migration in the Middle and Upper River sections of the mainstem Susitna River. The size of this tag group was increased by tagging more salmon at Curry, in the lower part of the Middle River (RM 120). At Curry, another 400 Chinook, 200 chum, 200 coho, and 200 pink salmon were intended to be tagged and then tracked upstream in the Middle and Upper River; full description of the tagging at Curry is above, in Section 4.2.

4.3.2. Stock Classifications and Spawning Locations

Tracking histories (i.e., detection histories) of radio-tagged salmon were used to describe distribution, straying, run timing, travel timing, and travel speeds. The compressed operational database produced by *Telemetry Manager* was used to display tracking histories of individual fish, and was queried to quantify behavior.

4.3.2.1. Classification of Tributary Stocks and Mainstem Spawners

The detection history of each radio-tagged salmon was used to assign the salmon to one of three "destinations" (Tributary Destination, Mainstem Spawning, or Mainstem Other), based on temporal patterns in detection positions within the study area. Fish with detections that were restricted to the release area, fish that were never detected, fish whose tag was removed upon recapture, and those that moved only in a downstream direction were excluded to avoid potential handling-related biases. We used detection histories, instead of final tag locations, to assign a destination because salmon can drift downstream after spawning or death, obscuring the true destination and distribution of the salmon.

The Tributary Destination category consisted of all salmon that moved into a tributary, presumably for spawning, regardless of whether they subsequently returned to the mainstem river. The tributary into which the fish entered was recorded as its "stock." Any fish that entered one tributary, exited, and subsequently entered another tributary was given a stock assignment based on the latter tributary. The one exception, noted under Objective 4, was a Chinook salmon assigned to the Devil Creek Stock despite the fact that it later moved into Fog Creek (specifically, the fish spent more than a week in Devil Creek, then moved upstream into Fog Creek for likely less than two days before exiting and moving downriver). The study was not designed to identify exact spawning positions in the tributaries, so tributary spawning locations were not described.

All remaining fish were classified on a fish-by-fish basis into one of two remaining categories ("Mainstem Spawning" and "Other Mainstem"). Classifications were assigned to each individual fish after displaying its complete detection history on a base-map and examining each detection in succession. Before proceeding with classification, several detections were eliminated from consideration. First, movements were ignored after the tag entered mortality mode. Second, downstream movements following the most upstream location were typically ignored as the fish may have already been dead or moribund, unless the fish showed subsequent upstream movements. The remaining data were examined, looking for any geographically aggregated cluster of detections which might indicate that the fish should potentially be included in the Mainstem Spawning category. Clusters in which the last live detection was obviously before the published species-specific spawn-timing window were ignored. Each remaining cluster was scrutinized before placing it into one of two 'relative spawning probability' groups:

- Clusters were classified as "likely" spawning locations if the cluster consisted of several detections in relatively close proximity to one another. The number of detections was variable, but was greater than two; the distance between detections also varied, but was generally within a few hundred meters (<1,000 ft). In these cases, the fish was assigned to the Mainstem Spawning group.
- Clusters were classified as "possible" spawning locations if the cluster was made up of few detections, if the locations were more loosely aggregated, or if they were clustered in an area where fish may be holding (rather than spawning, e.g., tributary mouths). These fish were also assigned to the Mainstem Spawning group.
- When tags were physically recovered in a spawning area, the recovery location was listed as a "likely" mainstem spawning location, regardless of the nature of the detection cluster.

As described above, the Mainstem Spawning category included salmon whose tags were either physically recovered in a historic mainstem spawning areas (e.g., sloughs), or salmon whose movement behavior fit the above criteria considered to resemble spawning. Habitat used by fish in the Mainstem Spawning group was classified as Side Channel/Slough, Tributary Mouth, or Mainstem Proper, based on position of the potential spawning location.

All other remaining fish were assigned to the catch-all "Other Mainstem" classification. Most salmon in this group were only detected once, died well before the published species-specific spawn timing window, showed no clustered mainstem locations, or moved downstream after being tagged at Curry but then never subsequently moved into a tributary.

Determining the representative distribution of fish was only possible for salmon in the Mainstem Spawning group. Salmon in this group had a cluster of detections in the potential spawning area, and a single location was selected from within the cluster. To select the single point, we identified either the last live detection or a detection that appeared to represent the center of mass of the cluster.

4.3.3. Migration Behavior

4.3.3.1. Roaming Behavior in the Middle Susitna River

By assigning final destinations to all tagged fish, we were able to determine the proportion of fish that moved through different habitats and ultimately moved into certain areas for spawning. One category of interest was salmon that were detected in the Middle River, but that subsequently moved downstream to spawn. For this, we decided to use only those salmon with swimming behavior indicative of healthy fish not affected by the process of handling and tagging. We chose fish that were detected at Lane Creek Station (for fish tagged in the Lower River) or Gateway Station (for fish tagged in the Middle River), then moved downstream from that location before ascending into a tributary. Detection of fish at Lane or Gateway stations was taken as indication of the fish having recovered from tagging enough to migrate upstream; ascent into a final tributary was taken as an indication that fish dropping downstream were not injured or moribund. Note that none of these roaming fish were included in the Mainstem Spawning category.

4.3.3.2. Salmon Run Timing

The run timing of each salmon species in the Middle River was assessed using fishwheel catch data from Curry (RM 120). Run timing estimates assumed that 1) salmon were caught in a sequence that was representative of the timing of their arrival in the study area, and 2) species-specific catch rates did not vary over time. To create a run-timing curve, catch dates for all j fish of a given species were sorted sequentially, and then each was given an index number from 1 to j, starting at 1 for the earliest date, 2 for the next earliest date, etc., and ending at j for the latest date. Each index value was then multiplied by (j^{-1}) to calculate the cumulative proportion value, which for the species ranged from j^{-1} to 1.0. To show their similarity, species-specific run-timing curves from the Curry fishwheels were plotted together with the Lane Station passage dates for fish that were radio-tagged in the Lower River.

Tagged salmon that were assigned to a stock (Section 4.3.2.1) were grouped together to calculate stock-specific run-timing distributions. Stock-specific run-timing curves were produced in the same manner as the species-specific curves, except that only fish with radio tags were used (rather than the whole fishwheel catch—only tagged fish could be assigned to a stock). To create a stock-specific run-timing curve, the catch dates for all tagged fish of a given species that were assigned to a given stock were sorted sequentially. Only stocks represented by at least six tagged fish were plotted.

Run timing was also described for salmon passing each fixed station in the Middle and Upper River, using plots similar to those used for run timing at Curry. Cumulative passage timing curves were generated for each species' passage by Curry (release dates from fishwheels), Gateway (RM 125), Indian River (RM 139), and Portage Creek (RM 149). For Chinook salmon, we also generated cumulative passage curves for timing past Cheechako Station (RM 152), Chinook Creek (RM 157), Devil Station (RM 164), and the Kosina confluence (RM 207). For this analysis, passage times were interpolated from detections at neighboring sites (assuming a constant travel speed) whenever a fish passed a station without being detected. Median, minimum, and maximum passage dates were also tabulated for each receiver, by species (no interpolated data points were included). Passage by the Slough 11 and Slough 21 receivers were not plotted or tabulated due to the low numbers of fish detected in those locations.

Due to the malfunctioning of receivers at the Indian and Portage stations from July 1–10, accurate travel times could not be calculated from detections during this period. Detection data from July 1–11 at these two receivers were removed from analysis of run timing past these two stations. Station passage timing may have been affected by the interpolation of missing values if fish traveled at different speeds during the period of the malfunction relative to the remaining study period.

4.3.3.3. Travel Speeds

Travel speed for each individual radio-tagged fish was calculated based on the timing between detections at the various fixed-station receivers. Travel time between two receiver stations was calculated as the time between the first detection at the downstream receiver and that at the upstream receiver. Travel speeds were calculated by dividing the distance (in km) between receivers by the travel time. Travel speeds tended to be non-normal. For non-parametric comparisons, median travel speeds were compared among stocks, and among reaches using Kruskal-Wallis tests.

Due to the malfunctioning of the Indian and Portage receivers from July 1–10, travel speeds measured from detections made during this period could not be considered accurate. As such, detection data from July 1–11 at these two receivers were excluded from the travel speed analyses. If fish traveled at different speeds during the period of the malfunction relative to the remaining study period, then our travel speed estimates may be biased. Given the early date of the malfunction relative to species-specific run timing, this problem would conceivably only affect Chinook salmon data.

4.4. Objective 3 – Feasibility of using Sonar to Detect Spawning Locations in Turbid Water

Sonar has the potential to detect redds in turbid water and confirm spawning activity by directly observing fish behavior. Radio telemetry can be used to identify suspected spawning locations (based upon holding durations), but subsequent sampling with sonar may be needed to verify whether spawning actually occurred. To examine the feasibility of using sonar for this purpose, DIDSON and high-resolution, side-scan sonar were operated in suspected clear and turbid water spawning areas, and if possible, the results would be compared to visual surveys of spawning fish (in clear water) and counts of redds (in clear but previously turbid water). Two surveys were planned for the 2012 field season: the first survey was intended to coincide with Chinook salmon actively spawning, and the second survey was to occur later in the season when turbidity had decreased to maximize the chances of obtaining visual comparisons.

An EdgeTech 4125 600/1600 kHz side-scan sonar system was used which generates static images with a down-range resolution of 0.6 cm (0.2 in) and an across-range resolution at 10 m (33 ft) range of approximately 4–6 cm (1.6–2.4 in). The transducer “tow fish” was deployed with a chain and cable that were attached to a vertical pole mounted on the gunnel of the boat approximately 1.5 m (4.9 ft) aft of the bow. The length of the cable was adjusted so that the transducer was suspended at a depth of 20 cm (7.9 in) while the boat was moving. Side-scan sonar data were collected at boat speeds of 1–2 knots (kt) with a 25 m (82 ft) sampling range on each side (left and right) of the transducer. The minimum water depth required for the deployment of the transducer was approximately 0.5 m (1.6 ft).

Dynamic sonar data were collected with an unmodified DIDSON system deployed on a swivel pole mounted in the same position as the side-scan sonar. Data were collected with the boat stationary or at a slow drift (<1 kt; Photo 6). For stationary samples, the tilt angle was adjusted until optimal, and manually rotated to scan upstream and downstream. While searching for fish, data were collected in low-frequency mode (0.8 MHz) to a maximum range of 25 m (82 ft). For detailed observations of fish behavior, data were collected in high-frequency mode to a maximum range of 10–15 m (33–49 ft). Fish observed using DIDSON were categorized by size class. Although DIDSON data cannot be used to identify fish by species, size classes provide some ability to distinguish large adult salmon (e.g., Chinook salmon) from smaller resident fishes. All sonar data were correlated to positional data, acquired by a Trimble DSM 212 DGPS with a 10 Hz update rate and differential corrections received from the Alaska Coast Guard station in Kenai, Alaska.

4.4.1. Deviations from Study Plan (Section 4.1)

One DIDSON/side-scan survey was conducted from early August through September, instead of three, as proposed in the study plan. Following the first DIDSON/side-scan survey, described in Section 5.3, the ability of the sonar technologies to provide the level of detail needed to assess spawning activity at main channel locations was unclear. High water levels and poor access to suitable sample sites led to the cancellation of two scheduled trips. The first sampling trip was not overly successful, and the crew considered it unlikely that two more trips would have yielded substantially more spawning habitat validations.

4.5. Objective 4 – Characterize Salmon Migration Behavior and Timing Above Devils Canyon

Three potential impediments to fish passage were identified between Portage and Devil creeks at RM 152, RM 156, and RM 161 (

Figure 5). All fish radio-tagged at the Lower and Middle River fishwheels were included in the passage evaluation through Devils Canyon. Radio-tagged fish approaching or passing the farthest downstream of these, Impediment 1 (RM 152), were analyzed for species, length, sex, tag release date, and tag release location based on data recorded at the time of tagging. The dates of detection near or above each impediment, hold times, and a brief summary of the fish’s final destination were also summarized. River flows were compared to fish passage to assess movement at different levels of discharge.

Hold times were calculated as the time from the first to the last detection downstream of an impediment. When only a single detection was made downstream of an impediment, hold times were estimated from the timing of adjacent detections (i.e., the time below impediment must have been less than the time between two adjacent detections away from the impediments). As hold times tend to be non-normal, Kruskal-Wallis tests were used to compare median hold times between fish that passed and those that did not pass, with each impediment analyzed separately.

All flows used in this report were measured at Gold Creek (RM 136), where discharge is likely higher than at the Devils Canyon impediments due to water inputs in between. When assessing individual fish passage, this report uses average daily discharge at Gold Creek on dates each fish was first detected upstream of an impediment. Instantaneous discharges may vary across a calendar day. For fish that did not pass above an impediment, flows were determined on the date that a fish was first detected below the impediment. Because discharges were found to be highly skewed, Kruskal-Wallis tests were used to compare flows experienced by fish to those of fish that did not pass, with each impediment analyzed separately.

4.6. Objective 5 – Distribution Among Habitats: Current Versus Historic Use and Relative Abundance

From 1981 through 1985, ADF&G conducted radio telemetry, aerial, and ground surveys to locate mainstem spawning habitat for Chinook, chum, coho, pink, and sockeye salmon in the Lower and Middle River (Barrett et al. 1984, 1985; Thompson 1986). Mainstem spawning was separated into four mainstem habitat types: main channel, side channel, slough, and tributary delta. During peak spawning times, ADF&G field crews enumerated spawning salmon at various mainstem habitats on a weekly basis. These counts were used to produce estimates of percent distribution of a salmon species at a mainstem habitat location relative to the total number of that species enumerated at all similar mainstem habitat locations within the Middle River.

Methodology in 2012 was similar to that used in the 1980s studies (radio telemetry surveys in conjunction with aerial and ground visual surveys) to locate and confirm mainstem (main channel, side channel, slough, and tributary delta) spawning locations for Chinook, chum, coho, pink, and sockeye salmon. Spawning locations for each salmon species were compared to results from the 1980s spawning ground surveys (Barrett et al. 1984, 1985; Thompson et al. 1986). Because indices of relative abundance were not achieved in 2012, all inferences and comparisons to historic percent distribution data were based on 2012 field observations. These comparisons highlight specific spawning locations important (as indicated by past and present consistencies in usage) to mainstem spawning salmon species. Because no salmon species were found to spawn within the mainstem Lower River in the 1980s, all comparisons with the 2012 results were made for the Middle River.

4.7. Objective 6 – Locate Individual and Holding and Spawning Salmon, Collect Habitat Data in Lower and Middle River Consistent with HSC Data Collection

4.7.1. Spawning and Holding Fish Identified

From June 26 to October 29, 2012, we used concurrent radio telemetry studies, recent ADF&G radio telemetry studies, and 1980s data to locate salmon holding and spawning sites in mainstem habitats of the Lower and Middle River. These potential spawning sites were then assessed using visual aerial and ground surveys for confirmation of spawning activity. For more detail on this process see Sections 4.3.1 and 4.3.2.

4.7.2. Habitat Data Collection Consistent with Habitat Suitability Criteria

Potential spawning locations were surveyed by air or boat to verify the presence of spawning salmon (Section 4.7.1). Once identified, a subset of locations was chosen for spawning ground sampling, which was designed to acquire data needed for developing HSC to be used in the habitat models as part of the instream flow study.

Surveys to collect HSC data were conducted from August 11 to October 29 in the Middle River. The goal was to sample 10 to 20 redds for each salmon species for microhabitat data (water depth, water velocity, turbidity, substrate size and composition, surface water temperature, and presence/absence of upwelling). Potential spawning sites in turbid water areas were identified by radio telemetry. Some of these sites were also used to assess the feasibility of using sonar (combination of DIDSON and side-scan sonar) technologies to collect HSC data. Additional surveys were conducted by AEA in the Middle and Lower River as part of the instream flow study.

Some pre-selected sites, based on historic data, were also sampled in 2012. These sites included sloughs 21, 11, 9A, 9, and 8A, all of which provided spawning habitat for a large percentage of the chum, pink, and sockeye salmon that spawned within the mainstem Middle River from 1981 through 1985 (see Section 5.6). Additional sites were determined in-season from telemetry tracking and aerial visual surveys. Spawning sites located, but not sampled for microhabitat data in 2012, will be re-visited as part of the 2013–2014 study.

Habitat surveys were conducted by walking the habitat reach or sub-plot in an upstream direction and identifying the location of newly constructed redds. Only redds occupied by spawning salmon were sampled to ensure accurate species-specific HSC data collection. At each site, up to five redds were systematically sampled. A digital image, when practical, was taken of each sampled redd. Coordinates were recorded for the upper and lower extent of each spawning patch (grouping of redds) that was sampled. For each redd sampled, the following measurements of microhabitat and observations were made:

1. Redd dimensions, length and width, to nearest 1.0 cm (0.39 in), to allow computation of area;
2. Water depth to the nearest 1.0 cm (0.39 in) at the upstream end of each redd measured using a top setting wading rod;
3. Mean water column velocity at the upstream end of each redd to the nearest 0.01 meters per second (m/s; 0.033 ft/s) using a Swoffer Model 2100 flowmeter;
4. Turbidity to the nearest 1.0 Nephelometric Turbidity Unit (NTU) using a Hach Model 2100 Q turbidimeter;
5. Substrate size (dominant, sub-dominant, and percent dominant);
6. Surface water temperature to the nearest 0.2°C (0.36°F); and
7. Presence/absence of upwelling.

This field effort and data collection criteria were coordinated with the Instream Flow Program investigators to ensure quality and consistent data collection were achieved for developing HSC. As part of the integration of this study with the instream flow study, spawning locations and microhabitat data were provided to the instream flow study team for use in the development of their models. A compilation of site locations was also supplied to the aquatic habitat and geomorphic mapping team to ensure that necessary sections of river were digitized.

4.8. Objective 7 – Effectiveness of Methods used in 2012

While conducting the study, effort was spent to evaluate the effectiveness of the methods used in 2012 and to suggest changes or new approaches in 2013 and 2014. Our evaluation of methods consisted mainly of assessing the effectiveness of fishwheels to capture representative proportions of the salmon populations, and the usefulness of radio telemetry to describe salmon migration behavior and habitat use. Because this study was also interconnected with others conducted by different organizations, communication and information transfer were also evaluated to facilitate coordination in future years. Finally, results of salmon capture, distribution, and habitat use were incorporated into development of the RSP for 2013–2014 study years.

The use of sonar to sample fish and habitat in turbid water was an additional evaluation addressed specifically as Objective 3, and is described in Section 4.4.

4.8.1. Capture and Tagging of Fish at Curry

In addition to stream count and carcass survey data (Section 5.1.3.6), fish count data from ADF&G's inseason aerial surveys (Sam Ivey, Area Management Biologist, ADF&G, personal communication, July 25, 2012) were used to further refine the estimates of the proportion of Chinook salmon captured and tagged at the Middle River fishwheels.

4.8.2. Effectiveness of Radio Telemetry to Address Objectives

The effectiveness of radio telemetry for describing migration behavior, spawning locations, stock-specific run-timing, post-spawning mortality and passage through Devils Canyon was assessed using the extensive data collected from fixed-station receivers and mobile surveys. Estimates of migration speeds and post-release tracking success were compared with those from other radio telemetry studies conducted on Pacific salmon. The reliability of the telemetry equipment was assessed by calculating detection efficiencies for each fixed station and examining the sequential recorded for each radio tag to determine if the mortality sensors were functioning properly.

5. RESULTS

From June 10 to October 20, 2012, daily discharge of the Susitna River at Gold Creek (RM 136) averaged 23,073 cfs and ranged from a high of 73,584 cfs on September 22 to a low of 5,051 cfs on October 20 (Figure 6). From June 29 to August 30, water temperature of the Middle River near Curry (RM 120) ranged from a low of 9°C (48°F; July 9–10) to a high of 17°C (63°F; July 17–18).

5.1. Objective 1 – Fish Capture, Tagging, and Tracking in the Middle Susitna River

5.1.1. Fish Capture – Operation, Effort, and Catch

5.1.1.1. Fishwheel Operation in 2012

As stated in Section 4.2.1, three fishwheels were operated at two different sites near Curry in 2012 (Figure 3; Photo 7; Photo 8). Fishwheel 1 operated at Site 1 from June 17 to July 15, and then it was replaced at Site 1 by Fishwheel 3 from July 16 to September 1 (Photo 9). The riverbank at this site had a gradual slope, so the fishwheels were held 20–30 ft offshore using spar poles to keep them in water with sufficient depth and velocity to turn the baskets. As a result, a block net was required between the riverbank and fishwheel baskets to direct fish from the nearshore area into the fishwheel. Fishwheel 3 was built in mid-July with shallower baskets that were better suited for Site 1, particularly when river discharge decreased.

Fishwheel 2 operated at Site 2 from June 18 to August 22 (Photo 10). This site was heavily rip-rapped with large boulders to support the adjacent railroad. The fishwheel was located on the inside bank of a river bend, so it was somewhat protected from debris. As discharges decreased over the season, the fishwheel was moved upstream to keep it in fast-flowing water.

Due to highly variable water levels, frequent fishwheel adjustments (inshore/offshore), and rocky substrates, picket weirs could not be used at either site to direct fish away from shore and into the path of the fishwheel. No leads were used at either site prior to June 30. On June 30, leads were installed at both sites consisting of nylon net (2.5-in mesh) strung between the shore-side pontoon and riverbank. Rocks were tied along bottom of the nets to hold them in place. A review of DIDSON footage collected at Site 1 revealed that some fish were passing underneath the lead net. On July 16, a new lead net (3.5 in coated nylon mesh net, 2.5 lb/ft chain for a lead line) was installed at Site 1. Although the DIDSON had been removed from Site 1 by this time, the crew considered the new lead net impenetrable to upstream-migrating fish.

5.1.1.2. Effort

Two fishwheels operated at Site 1 for a total of 807 hours (FW1 = 373 hours; FW3 = 434 hours) between 11:45 A.M. on June 17 and 7:08 P.M. on September 1, which represented 44.1 percent of the available time they were in place (Figure 7; Table C-1). Daily fishing effort at Site 1 ranged from 0.0 to 17.7 hours, and fishwheel speed ranged from 1.7 to 4.7 RPM. Fishing effort was reduced to 4.2 hours on August 27, and 0.0 hours on August 28, due to a sudden rise in river discharge and the presence of large woody debris. Fishing ended for the season on September 1 at Site 1 when coho salmon catches dropped to zero.

Fishwheel 2 operated for a total of 646 hours at Site 2 between 10:00 A.M. on June 18 and 1:05 P.M. on August 22, which represented 41.3 percent of the available time it was in place. Daily fishing effort at Site 2 ranged from 0.0 to 16.8 hours, and fishwheel speed ranged from 2.1 to 4.5 RPM. Fishwheel 2 was not operated on July 15 as crew efforts were focused on building a third fishwheel. Fishing ended for the season on August 22 at Site 2 after five consecutive days of no coho salmon caught.

5.1.1.3. Catch

A total of 566 Chinook, 1,734 chum, 265 coho, 4,705 pink, and 100 sockeye, salmon were captured at the Curry fishwheels (including jacks and recaptures; Table 2; Table C-2 to Table C-6). Of the 566 Chinook salmon captured at the fishwheels from June 18 to August 9, 422 (74.6 percent) were adults and 144 (25.4 percent) were jacks (Table 2). The majority (59.9 percent) of Chinook salmon were captured at Site 1. Peak daily catches occurred on June 30 at Site 1 (26 fish) and July 2 at Site 2 (21 fish; Figure 8). Catch per unit effort (CPUE) peaked at 1.8 fish/hour at Site 1 (June 30) and 1.5 fish/hour at Site 2 (July 2; Figure 9; Table C-2). Chinook salmon (n = 492) averaged 71 cm FL (28.0 in) and ranged from 33 to 123 cm FL (13.0 to 48.4 in; Table 3).

Of the 100 sockeye salmon captured from July 2 to August 22, 92 (92 percent) were adults and eight (8 percent) were jacks (Table 2). The majority (63 percent) of sockeye salmon were captured at Site 2. Peak daily catches occurred on August 8 at Site 1 (3 fish) and August 6 at Site 2 (6 fish; Figure 8). Peak CPUE was 0.3 fish/hour at Site 1 (August 8) and 0.7 fish/hour at

Site 2 (August 6; Figure 9; Table C-3). Sockeye salmon (n = 91) averaged 54 cm FL (21.3 in) and ranged from 32 to 72 cm FL (12.6 to 28.3 in; Table 3).

From July 16 to August 31, 4,164 (89 percent) pink salmon were caught at Site 1 and 541 (11 percent) were caught at Site 2 (Table 2). Peak daily catches occurred on August 3 at Site 1 (451 fish) and August 2 at Site 2 (125 fish; Figure 8); while CPUE peaked at 49.5 (August 6) and 14.4 (August 2) fish/hour, respectively, at sites 1 and 2 (Figure 9; Table C-4). The average length of pink salmon (n = 588) was 49 cm FL (19.3 in) and ranged from 34 to 59 cm FL (13.4 to 23.2 in; Table 3).

Chum salmon were captured from July 10 to September 1 in comparable numbers at Site 1 (877 fish) and Site 2 (857 fish; Table 2). Peak daily catches occurred on August 2 at Site 1 (66 fish) and Site 2 (115 fish; Figure 8). Peak CPUE was on August 2 (7.5 fish/hour at Site 1, 13.2 fish/hour at Site 2; Figure 9; Table C-5). Chum salmon averaged 67 cm FL (26.4 in) and ranged from 52 to 77 cm FL (20.5 to 30.3 in; n = 867; Table 3).

From July 28 to August 31, 264 adult coho salmon and one jack were captured (229 at Site 1 and 35 at Site 2; Table 2). Daily catches peaked on August 11 at Site 1 (21 fish) and August 7 at Site 2 (7 fish; Figure 8). Peak daily CPUE was higher at Site 1 (2.3 fish/hour on August 11) than Site 2 (0.8 fish/hour on August 7; Figure 9; Table C-6). The average length of coho salmon was 55 cm FL (21.7 in) and ranged from 35 to 69 cm FL (13.8 to 27.2 in; n = 250; Table 3).

Site 1 was fished longer (807 hours) and captured more Chinook, chum, coho, and pink salmon than Site 2 (646 hours); but despite considerably less fishing effort, Site 2 captured more sockeye salmon than Site 1.

Six other fish species were captured and released, including 29 round whitefish, 23 rainbow trout, 22 longnose sucker, six humpback whitefish, one arctic grayling, and two Dolly Varden. Tissue samples and otoliths were collected from a portion of these fish (Table 4).

5.1.2. Fish Tagging

Radio tags were applied to 352 Chinook, 279 chum, 184 coho, 230 pink, and 70 sockeye salmon Figure 10; Table C-2 to Table C-6). Of the untagged, healthy adult salmon captured at the Curry fishwheels, radio tags were applied to 87.8 percent of Chinook, 16.1 percent of chum, 70.5 percent of coho, 4.9 percent of pink, and 77.8 percent of sockeye salmon. Figure 11 shows the cumulative proportion of daily catch, CPUE, and radio tags applied for each species. The daily number of radio tags applied peaked at 37 for Chinook, 30 for chum, 19 for coho, 24 for pink, and five for sockeye salmon.

Spaghetti tags were applied to every second Chinook salmon captured from June 19–22. Of the 352 radio-tagged Chinook salmon, 338 (96.0 percent) received a radio tag only and 14 (4.0 percent) received both a radio tag and spaghetti tag.

A number of tagged salmon were recaptured at the fishwheels, including 20 Chinook, seven chum, three coho, one pink, and two sockeye salmon (Table 5). Of these, four chum and one pink salmon were spaghetti-tagged by ADF&G at the Lower River fishwheels. Of the salmon both tagged and recaptured at Curry, 23 were recaptured at Site 1 and 10 at Site 2. The radio tags from two Chinook salmon recaptures were removed prior to release (one was tagged in the Lower River and one was tagged in the Middle River).

5.1.3. Diagnostics – Effectiveness of Catch, Representation of Run

5.1.3.1. Tests for Handling-Induced Changes in Behavior

For Chinook salmon radio-tagged at the Curry fishwheels, the elapsed time between tag and recapture events ranged from 3 minutes to 11 days (median = 6.9 hours, n = 13; Table 6). Nine out of thirteen Chinook salmon were recaptured the same day as they had been tagged (0–7 hour delay), two were recaptured the day after being tagged (15 and 23 hour delay), and two were recaptured several days later (6 and 11 day delay). Three Chinook salmon radio-tagged in the Lower River were recaptured at the Curry fishwheels 26 to 29 days (median = 26.7 days) after release in the Lower River. Two sockeye salmon radio-tagged at the Curry fishwheels were recaptured 2.6 hours and 20.7 days after being tagged; two chum salmon were captured 0.6 and 2.2 hours after being tagged; and three coho salmon were recaptured 1.6 hours, 1.9 hours, and 8 days after being tagged. No pink salmon tagged at Curry were recaptured.

Migration rates for Chinook salmon traveling between the Curry fishwheels and Gateway station were slower for radio-tagged fish that were captured twice at the fishwheels (mean = 9.1 km/day [5.7 mi/day], n = 8) than for fish that were captured only once (mean = 10.6 km/day [6.6 mi/day], n = 204) but the sample of eight fish was small and we made no attempt to correct for any confounding of time trends in discharge and any potential variation in fishwheel catch efficiencies, both of which could influence this metric.

Fourteen recaptured Chinook salmon (with known tag numbers) were released at the fishwheels with their radio tags intact. Of these, one (7.1 percent) was last detected at the release site while the remaining 13 (92.9 percent) were tracked into tributaries.

Ninety-seven percent of fish (all species) radio-tagged spent less than 10 minutes in the fishwheel live tanks prior to tagging and 84 percent spent less than five minutes. No radio-tagged fish (all species) were held in the live tanks for longer than 28 minutes. Due to a lack of contrast in holding times, we did not evaluate post-release survival and migration behavior as a function of holding time.

5.1.3.2. Test for Equal Capture Probabilities by Time

Temporally stratified mark-rate data were not obtained from spawning ground surveys due to a combination of limited access to clear-water spawning areas and too few carcasses available in accessible clear-water habitats (see Section 5.1.3.6). As a result we could not directly test for equal capture probabilities over time at the fishwheels. Section 5.1.3.5 describes the results of using DIDSON to evaluate fishwheel effectiveness.

Due to near-record high water levels at the start of the season, the fishwheel at Site 1 did not begin operating until June 17 (target start date was second week of June). Despite this delay, no fish were caught on the first day of operation and only one Chinook salmon was caught on June 18. This initial zero point suggests that it was unlikely that many Chinook salmon passed Curry prior to the onset of sampling. Historically, 0.0–3.5 percent (mean = 1.7 percent) of Chinook salmon catches at the Curry fishwheels occurred prior to June 17.

Fishing at Curry was stopped for the season on September 1. No coho salmon were captured that day, and only one coho salmon was captured on August 31. Historically, 0.0–13.7 percent (mean = 6.5 percent) of coho salmon catches at the Curry fishwheels occurred after September 1. It was possible that a small portion of late-run coho salmon passed Curry after the fishwheels were shut down and water levels subsided after September 1.

5.1.3.3. Tests for Equal Capture Probabilities by Area (Stock)

For the same reasons described in Section 5.1.3.2, geographically stratified mark-rate information was not collected in 2012 which precluded direct tests for equal capture probabilities by areas (stock).

Of the 21 radio-tagged salmon recaptured at the Curry fishwheels with known final destinations, two (9.5 percent) were classified as mainstem spawners (slough/side channel), whereas 19 fish (90.5 percent) were classified as tributary spawners. These results indicate mainstem spawning populations were not more vulnerable to capture than tributary spawners.

At Curry, there was some evidence of possible stock-specific bank orientation by coho salmon, but not by tributary stocks of Chinook, chum, or pink salmon. Sample sizes for sockeye salmon were too small to evaluate. A larger proportion of coho salmon tagged on the east bank at Curry (25 percent) returned to Portage Creek compared to those tagged on the west bank (9.6 percent; $\chi^2 = 5.3$, $P = 0.02$); one of the cells in the contingency table analysis, however, had an expected value less than five because of small sample sizes. Conversely, a larger proportion of coho salmon tagged on the west bank (41.0 percent) returned to Indian River compared to those tagged on the east bank (14.3 percent; $\chi^2 = 7.3$, $P = 0.01$). The proportion of Chinook salmon returning to Portage Creek did not differ for fish tagged on the east (48.1 percent) and west (42.6 percent) banks at Curry ($\chi^2 = 1.0$, $P = 0.32$). Similarly, the proportion of Chinook salmon returning to Indian River did not differ or fish tagged on the east (20.2 percent) and west (26.5 percent) banks ($\chi^2 = 1.8$, $P = 0.18$).

5.1.3.4. Tests for Equal Capture Probabilities by Fish Size

Size selectivity at the fishwheels could not be directly tested in 2012 because there were not enough independent, unbiased length samples available for comparison. As per Section 5.1.3.6, ground surveys conducted to collect length data observed that there were few carcasses available to measure. Only three adult Chinook salmon were measured for length on the spawning grounds (all from the Indian River). For all species, there were no significant differences detected between the cumulative length-frequency distributions of fish caught at sites 1 and 2 (Table 7; Figure 12; Figure 13). Similarly, the cumulative length-frequency distributions of fish caught at sites 1 and 2 (combined) were not significantly different than those for fish that were radio-tagged (Table 7; Figure 14; Figure 15). These results indicate that fish caught at sites 1 and 2, as well as those that were caught and tagged, had similar length distributions. However, we could not determine whether the length distributions of fish sampled at the fishwheels were necessarily representative of the population passing Curry.

5.1.3.5. Use of DIDSON to Assess Fishwheel Effectiveness

The DIDSON was operated consistently from June 15 to July 4 below the fishwheel at Site 1. Review of the DIDSON data was limited to periods of greatest interest (Table 8; Figure 16). Complete data reviews (i.e., all 24-hours) were performed for June 16–20 to aid in fishwheel placement and determine initial fishwheel effectiveness. Shorter blocks of data were reviewed from June 21–28 and July 4 to help answer questions about migration behavior and potential changes to fishwheel catch efficiency following a weir installation. Given the timing of its use, the DIDSON helped establish fishing sites and lead net configurations, but was not used late in the run once the fishwheels appeared effective at meeting the tagging goals and fishwheel CPUE appeared to be a good indication of run timing. The DIDSON data was useful to fully or partially address several questions related to fishwheel effectiveness. The DIDSON was not used to address the extended temporal aspects of the questions below (i.e., across the season).

5.1.3.5.1. Were fishwheels established in time to capture the leading and trailing ends of each species run?

DIDSON counts corrected for sampling effort (counts per hour) provided a good indication that the leading edge of the Chinook salmon run was captured (Figure 17; Figure 18). This conclusion was further reinforced by the CPUE of the fishwheel at Site 1 (Figure 10). Review of full 24-hour DIDSON files from June 15–16 provided counts of three and five Chinook salmon, respectively. The fishwheel CPUE generally conformed to the relative changes in Chinook salmon observed in the DIDSON data, although data was not analyzed through the peak of the Chinook salmon run.

The DIDSON was not operated after the fishwheels were removed on September 1 and therefore it was not used to characterize the end of the run at Curry. The DIDSON could not be used to address the end of species-specific runs that may have occurred at Curry prior to the fishwheels shutting down because distinguishing among the fish species migrating in August would have been impossible. Instead, fishwheel CPUE was used to assess the tail end of each run.

5.1.3.5.2. Can the DIDSON be used to assess fishwheel (and net lead) placement?

Shorter blocks of DIDSON data were reviewed from June 21–28 and on July 4 to help answer questions about migration behavior and potential changes to fishwheel effectiveness following a weir installation. These data provided crews in the field with excellent near video-quality imagery of the fish approaching the net lead and the fishwheel baskets. Fish were observed moving under the net prior to improvements to the anchoring system, and fish were seen moving through the area between the end of the lead and the fishwheel baskets.

5.1.3.5.3. Were fish migrating offshore of the fishwheel?

The majority of Chinook salmon reviewed on DIDSON data appeared to be bank oriented and were observed between 1 and 6 m (3 and 20 ft) from shore, with the majority of fish detected at 4 m (13 ft; Figure 18). Given that detectability of fish by the DIDSON generally decreases with range, Figure 16 should be interpreted with caution. However, in the area of what would be considered high detectability (out to at least 8 m or 26 ft), the fish peak at 4 m (13 ft) and begin to decline. Of possibly greater importance was that the fish size (as measured from the DIDSON imagery) did not show a pattern or significant difference across the lengths of Chinook salmon and the distance travelled from shore (Figure 19).

5.1.3.5.4. Was there a diel pattern of migration at the fishwheel sites?

Analysis of video files from June 21–28, during hours when the fishwheel was not operational, along with complete 24-hour video analysis from June 15–20, confirmed that the majority of Chinook salmon were migrating between 8:00 A.M. and 22:00 P.M. and that the majority of this migration occurred during hours of daily fishwheel operations (Figure 20). In fact, these data, combined with fishwheel CPUE, were used to optimize the periods of fishing for the fishwheels.

5.1.3.6. Stream Counts and Carcass Surveys

Ground-based stream counts and carcass surveys, aerial-tracking surveys, and aerial-counting surveys (ADF&G) were used to estimate the mark rate of Chinook salmon in Portage Creek and Indian River. River discharge and turbidity were low during all surveys making visibility very good or excellent for counting fish. These data were generally insufficient for rigorously testing assumptions about catch rates and representativeness of the tagged fish but are presented here for completeness and to inform planning efforts for 2013.

5.1.3.6.1. Ground and Aerial-Tracking Surveys

Visual ground surveys (stream walks) of Chinook salmon were conducted in sections of Portage Creek (July 30) and Indian River (July 31 and August 8; Table 9; Table 10). For all of the ground surveys, crews considered their observer efficiency to be roughly 80 percent. On July 30 in Portage Creek, surveyors on foot counted 146 live Chinook salmon, and estimated another 34 in part of a side channel blocked by a brown bear (*Ursus arctos*). Based on an observer efficiency of 80 percent, the 180 fish counted represented approximately 225 fish present in the survey area. A concurrent aerial-tracking survey documented 29 tags, and was assumed to have 100 percent detection efficiency in the study area. Based on these results, the mark rate of Chinook salmon in Portage Creek was 13 percent (29 tags / 216 fish total). To bound this estimate, an observer efficiency of 50 percent (unreasonably low) yields a mark rate of 11 percent (29 radio tags / 270 fish), and an observer efficiency of 100 percent (an unrealistically high number) yields a mark rate of 16 percent (29 radio tags / 180 fish).

On July 31, 82 live Chinook salmon were counted during a ground survey in Indian River (Table 9; Table 10), and 11 active tags were detected during the aerial-tracking survey. Again, assuming an observer efficiency of 80 percent during the ground surveys, the mark rate of Chinook salmon within the sampled reach of Indian River was 11 percent (11 tags / 98 fish total).

On August 8, 43 live Chinook salmon were counted during a ground survey in Indian River, and 17 active radio tags were detected during an aerial-tracking survey of the same area (Table 9; Table 10). However, because the ground-survey crew found three carcasses in the woods containing radio tags that were emitting an active signal, the estimated number of active tags was decreased to 14. Assuming 80 percent observer efficiency for ground surveys, the estimated mark-rate was 27 percent. We believe this estimate may be biased high because of uncertainty in the number of tags emitting an active signal that were unavailable to the ground-survey crew. Surveys that occur prior to significant numbers of dead fish appearing in the stream likely provide better but still potentially biased (high) mark-rate estimates.

One Chinook salmon carcass was found during the survey of Portage Creek on July 30 (Photo 11). This fish was a pre-spawn radio-tagged male that had been partially consumed by a bear (condition of carcass precluded measuring for length). No carcasses were found in Indian River.

On August 2, 5, and 8, efforts were made to recover inactive radio tags in Indian River. In total, 20 radio tags were recovered, of which the majority were assumed to be associated with bear predation (Table 11; Table D-1). Indicators of bear predation included fish remains in close proximity to a radio tag, a radio tag found in the woods, or a combination of both. It could not be determined if the actual cause of mortality was bear predation, natural, or human induced. Due to bears removing carcasses in Indian River (and likely Portage Creek), carcass recovery was not a suitable method of obtaining samples to evaluate fishwheel mark rates, size selectivity, or handling-related effects on mortality.

5.1.3.6.2. Aerial-Counting Survey (ADF&G)

On July 24, ADF&G aerial-counting surveys counted a total of 338 and 501 live Chinook salmon in Indian River and Portage Creek, respectively (Table 12; Sam Ivey, ADF&G, pers. comm., July 25, 2012). An aerial-tracking survey was conducted on the same day and 77 radio-tagged Chinook salmon were detected in Indian River (69 live, 8 dead) and 153 tags were detected in Portage Creek (139 live, 14 dead). Overall, 4.4 Chinook salmon were counted for every radio tag present in the Indian River and 3.5 fish were counted for every radio tag in Portage Creek (Table 12). Based on detections of live tags from Curry-tagged fish, and assuming 100 percent observer efficiency during the ADF&G aerial-counting surveys, the estimated mark rate of Curry-tagged fish was 23 percent (19 percent for Indian River and 26 percent for Portage Creek). The observer efficiency during the aerial-counting surveys was likely less than 100 percent. We conducted a sensitivity analysis to illustrate how the observer efficiency during the aerial-counting surveys would affect the estimated mark rate of Curry-tagged fish (Table 12). For example, if the observer efficiency during aerial-counting surveys was in the range of 50 percent, then the overall mark rate of Curry-tagged fish would be approximately 12 percent.

Note that 9.6 percent of the 230 radio tags detected in Portage Creek and Indian River on July 24 were transmitting inactive signals; however, no dead Chinook salmon were observed during the aerial-counting survey. These data should not be used to estimate the efficiency of the aerial observer to see carcasses because a portion of these fish may have been in the woods or otherwise outside of the surveyed area.

In summary, the 2012 spawner surveys resulted in crude mark-rate estimates of unknown precision and bias. These results will be used to improve the program in 2013.

5.1.4. Tracking of Tagged Salmon

5.1.4.1. Fixed-Station Receiver Detection Efficiency

Detection efficiencies and operational periods were summarized for each major fixed-station receiver site (Table 13; Table 14; Table 15). Since Slough 11 and Slough 21 were deliberately located away from the mainstem riverbank, it was not surprising that these stations did not detect every fish that passed. As noted in Section 4.2.4.2, the Indian River and Portage Creek stations had significant periods of receiver inactivity when many fish were potentially missed (July 1–10, and August 2–4 for both sites; August 10–14 again for Indian).

5.1.4.2. Tag Returns

Eight salmon tagged in the Middle River were recovered by anglers (Table D-1). Two Chinook salmon tags were found in the Indian River on August 18. One chum salmon was recovered on August 8 in the Byers Creek drainage (Chulitna River). It migrated 22 miles downstream after release at Site 1 on July 22, and then 27 miles up the Chulitna River prior to recovery. Three coho salmon were caught by anglers: two at the mouth of Byer's Creek (August 15 and September 13) and one at the mouth of Portage Creek (August 26). Two pink salmon were recovered in Clear Creek (August 16 and October 3). These fish migrated 22 miles downstream after release at Site 2 on August 10, then approximately 6 miles up the Talkeetna River prior to capture.

Forty-four of the radio tags deployed in the Lower River were recovered (presumably by anglers; Table D-2). This included 15 Chinook salmon recovered in the Deshka (8), Talkeetna (2), and Chulitna (1) rivers, as well as Willow (1), Sheep (1), Montana (1), and Sunshine (1) creeks. Five chum salmon were recovered from the Yentna River (1) and Willow (2) and Montana (2) creeks. Twenty coho salmon were recovered from a variety of tributaries, including the Deshka (6), Yentna (5), Talkeetna (3) and Kashwitna (1) rivers, and one from each of Alexander, Willow, Goose, Sunshine, and Rabideaux creeks. Three pink salmon were recovered: one in Indian River, one in Willow Creek, and one in Montana Creek. And lastly, one sockeye salmon was recovered in the Yentna River.

5.1.4.3. Radio Tag Performance

No problems were detected with the performance of the radio tags in "active" mode. Of the 1,115 salmon released with radio tags at Curry, only one was not detected after release. Radio tags were readily detected at distances up to 2 km (1.2 mi) during aerial surveys and up to 500 m (0.3 mi) during on-water surveys. All recovered radio tags were transmitting when recovered.

The mortality sensors malfunctioned in some tags. As described in Section 4.2.4.1, each radio tag was equipped with a mortality sensor that changed the signal pattern to an "inactive" mode once the tag became stationary for 24 hours (i.e., the fish is presumed dead). Of the radio tags deployed in the Middle River and detected during AEA mobile surveys, 87 percent entered mortality mode. Of these, 10.2, 7.5, and 6.7 percent of small, midsized and large model tags 'resurrected' (i.e., changed from their mortality signal mode, in which they were supposed to be locked, to the live signal mode (Table 16). The majority of resurrection events occurred during periods of increasing river discharge, presumably the result of carcasses washing downstream (Figure 21). Additionally, a small fraction (0.0 to 1.7 percent) of radio tags had faulty sensors, as they remained in live mode when they were likely in fish that had been dead for longer than 24 hours. The proportion of malfunctioning tags (resurrections and sensor failures combined) was largest for small model tags (10.1 percent), followed by large (6.4 percent) and midsized (6.3 percent) model tags. Although tag malfunctions can make it more difficult to determine the behavior and subsequent fate of a radio-tagged fish, this was not a significant issue in 2012 due to the frequency of mobile surveys.

5.2. Objective 2 – Migration Behavior and Spawning Locations in the Lower, Middle, and Upper Susitna River

Radio-tagged salmon were assigned to spawning locations based on mobile and fixed-station receiver data collected from May 9 through October 16 in the Lower River, June 17 through November 12 in the Middle River, and June 29 through September 4 in the Upper River. In the Lower River, mobile surveys were flown 11 times below the Deshka River confluence and 18–21 times between the Deshka and Talkeetna rivers (Table B-3). In the Middle River, aerial and ground reconnaissance surveys were conducted 23 times from Talkeetna to Lane, and from 34 to

37 times along the mainstem between Lane and Impediment 1 (depending on the area), 31 times in the reach from Impediment 1 to Cheechako Creek, 22 to 24 times between Cheechako Creek and Devil Station, and 16 times from Devil Station to Watana Creek (Table B-3). In the Upper River, there were 14 aerial surveys in the reach from Watana Creek to Kosina Creek. The reach above Kosina Creek was surveyed once (Table B-3).

Potential spawning locations in the Middle and Upper River were visually validated inseason when water conditions were suitable to guide additional sonar and physical habitat data collections (see Sections 5.3 and 5.6). Water turbidity in the main channel of the Lower River was always too high to visually confirm any potential spawning salmon.

Each of the 1,742 radio-tagged fish released in the Lower River and 1,115 radio-tagged fish released in the Middle River was assigned a final destination using all available fixed station and mobile tracking data (Table 17). The portion of each species tracked to tributaries, the various mainstem habitat types, and other locations is presented in Figure 22 for each release site. Tracking results by species are described in the following sections.

5.2.1. Stock Classifications and Spawning Locations – Lower River

5.2.1.1. Chinook Salmon

Of the 442 Chinook salmon tagged in the Lower River, 371 (84 percent) were classified by destination. Of these, 360 (97 percent) went to tributaries (mainly the Deshka, Chulitna, Talkeetna, and Yentna rivers), and 11 (3 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 23). The remaining salmon, not able to be classified by a specific destination (see "other classifications" in Table 17) exhibited movements that prevented conclusive assignment to the mainstem or tributaries.

Telemetry crews tracked 10 radio-tagged Chinook salmon to nine mainstem spawning locations classified as "possible" within the Lower River (Figure 24). Six of the nine locations were between the Yentna and Deshka junction, and three of the ten fish were at the mouth of the Deshka River. Initially, one Chinook salmon was classified as "likely" at a spawning location due to the close proximity of the sequential detections, but the first detection of that tag in mortality mode was June 29 and thus well before the spawning period.

5.2.1.2. Chum Salmon

Of the 400 chum salmon tagged in the Lower River, 315 (79 percent) were classified by destination. Of these, 283 (90 percent) went to tributaries (mainly the Yentna, Talkeetna and Chulitna rivers; Table 17; Figure 22; Figure 23) and 32 (10 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Telemetry crews tracked four radio-tagged chum salmon to mainstem spawning locations classified as "likely" and 26 to locations classified as "possible" within the Lower River (Figure 25). The greatest concentration of detections was from immediately downstream of the Deshka River confluence, upstream to the Kashwitna River confluence. Of the four chum salmon classified as "likely" mainstem spawners, one appeared to be within main channel habitats and three were likely associated with side channel/slough habitat types.

5.2.1.3. Coho Salmon

Of the 399 coho salmon tagged in the Lower River, 349 (85 percent) were classified by destination. Of these, 326 (93 percent) went to tributaries (mainly the Yentna, Chulitna, Talkeetna, and Deshka rivers) and 23 (7 percent) and went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 23). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Telemetry crews tracked three coho salmon to mainstem spawning locations classified as "likely" and 20 to locations classified as "possible" within the Lower River (Figure 26). Of the three coho salmon classified as "likely" spawners, one was associated with main channel habitat, one with side channel/slough habitat, and one with tributary mouth habitat. Aggregations of possible spawners were distributed throughout the Lower River from just above the fishwheel tagging sites to sites near the confluence with Whiskers Creek above the Chulitna River junction.

5.2.1.4. Pink Salmon

Of the 401 pink salmon tagged in the Lower River, 383 (96 percent) were classified by destination. Of these, 372 (97 percent) went to tributaries (mainly the Yentna, Chulitna, Deshka and Talkeetna rivers) and 11 (3 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 23). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Telemetry crews tracked two pink salmon to mainstem spawning locations classified as "likely" and nine to locations classified as "possible" within the Lower River (Figure 27). Of the two pink salmon classified as "likely" spawners, one was associated with a side channel/slough habitat in close proximity to the confluence of Willow Creek, and the other was in a main channel habitat just downstream of the confluence with the Kashwitna River. All aggregations of pink salmon detections were in close proximity to tributary confluences.

5.2.1.5. Sockeye Salmon

All of the 100 sockeye salmon tagged in the Lower River were classified by destination. Of these, 99 (99 percent) were tracked to tributaries (96 in Yentna, 2 in Chulitna, and 1 in Deshka) and 1 (1 percent) was tracked to a mainstem location in the Middle River upstream of Lane Creek (Table 17; Figure 22; Figure 23). Telemetry crews did not track sockeye salmon to any potential mainstem spawning locations in the Lower River. This may have been partially due to the location of the Lower River tagging site, which was located just downstream of the Yentna River, a major sockeye salmon spawning river.

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

In the Middle Susitna, we did not distinguish between "possible" and "likely" spawning locations because it was more important to display the consistency between the September and Final tracking results for each species (Figures 28–32) and the data available for the Middle River was much more extensive than that for the Lower River. Consequently, we have classified all the mainstem spawning locations on the Middle River derived from radio telemetry data as "potential" spawning locations. Later sections of the report present the locations of confirmed spawning sites and compare these with the "potential" spawning locations.

5.2.2.1. Chinook Salmon

Of the 352 Chinook salmon tagged in the Middle River, 317 (90 percent) were able to be classified by destination. Of these, 286 (90 percent) went to tributaries (mainly Portage Creek or Indian River; Figure 33) and 31 (10 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

The telemetry crews tracked radio-tagged Chinook salmon to 13 potential mainstem spawning locations in between Curry and Portage Creek, prior to the end of August. Each of these locations was visually examined during mobile surveys (helicopter or boat; Table 18; Figure 28). Our final analysis of the radio-telemetry data revealed one additional fish tracked to a "potential" mainstem spawning location just upstream of Cheechako Creek above Impediment 1 (Figure 28). No evidence of spawning was detected at any of the 13 locations surveyed. Holding behavior was documented at three tributary delta locations (4^{th} of July Creek, Indian River, and Portage Creek) and two mainstem locations (between Gateway and Slough 11, and between Indian River and Slough 21; Table 18). All mainstem locations were too turbid to assess using visual survey techniques during the peak spawning period for Chinook salmon (July 25–August 15).

Chinook salmon was the only salmon species detected spawning upstream of Portage Creek. The telemetry crew tracked radio-tagged Chinook salmon upstream of Portage Creek to one potential mainstem spawning location and four potential spawning tributaries (one of which was in the Upper River). High water turbidity prevented visual confirmation of spawning in the mainstem location, which was near the Cheechako Creek station. Of the four possible spawning tributaries, Cheechako, Chinook, and Devil creeks were too turbulent to verify spawning activity from the air, and steep terrain precluded landing the helicopter for ground surveys. The potential spawning area in both Cheechako and Chinook creeks was the lower 0.5 mile of each stream. The Devil Creek potential spawning area was the lower 1.5 miles (below a barrier waterfall). In the upper River, Kosina Creek was the only potential spawning area located. The Kosina Creek location was 6.5 miles upstream from the Susitna River; most of the tagged Chinook salmon were located in a low gradient reach. A ground level survey on July 27 confirmed the presence of Chinook salmon upstream from where Tsisi Creek enters Kosina Creek, but spawning activity was not observed.

5.2.2.2. Chum Salmon

Of the 279 chum salmon tagged in the Middle River, 230 (82 percent) were able to be classified by destination. Of these, 175 (76 percent) went to tributaries (mainly Portage Creek and Indian and Talkeetna rivers) and 55 (24 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 33). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Radio telemetry crews tracked tagged chum salmon to 19 potential mainstem spawning or holding sites in the Middle River; these sites were then visually surveyed using aerial or boat-based observations (Table 19; Figure 29). Spawning was visually confirmed at six sloughs and two tributary delta locations. Chum salmon were initially observed spawning on August 15 in 4th of July Slough and Slough 21, and were the first salmon species observed spawning in mainstem Susitna River habitats. Holding was visually confirmed at six sloughs and four tributary delta locations (Table 19). No evidence of holding or spawning was detected at the six potential mainstem locations, where water was too turbid to see chum salmon in late August during the presumed peak of spawning.

5.2.2.3. Coho Salmon

Of the 184 coho salmon tagged in the Middle River, 145 (79 percent) were able to be classified by destination. Of these, 122 (84 percent) went to tributaries (primarily the Indian River and Portage and Jack Long creeks) and 23 (16 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 33). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Radio telemetry crews tracked tagged coho salmon to 10 potential mainstem spawning or holding sites in the Middle River; these sites were then visually surveyed using aerial or boat-based observations (Table 20; Figure 30). Crews did not visually confirm spawning at any sites, and confirmed holding at one site in the tributary delta. Radio telemetry and aerial visual surveys for coho salmon continued until November 12. Visual observations of mainstem spawning activity during the peak of the coho salmon run were complicated by higher than normal river discharge, heavy flooding, and associated high turbidity levels. No evidence of mainstem spawning by coho salmon was seen in five aerial surveys conducted after water levels subsided in early October.

5.2.2.4. Pink Salmon

Of the 230 pink salmon tagged in the Middle River, 163 (71 percent) were able to be classified by destination. Of these, 154 (94 percent) went to tributaries (primarily Indian River, Portage Creek, 4th of July Creek, and Talkeetna River) and 9 (6 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 33). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Radio telemetry crews tracked tagged pink salmon to six potential mainstem spawning or holding sites in the Middle River; these sites were then visually surveyed using aerial or boat-based observations (Table 21; Figure 31). Crews did not visually confirm spawning at any sites, and confirmed holding behavior at three tributary deltas (the mouths of 4th of July Creek, Indian River, and Portage Creek; Table 21). Surveys included multiple visits to Sloughs 11 and 21, which contained a substantial proportion of pink salmon spawning in mainstem habitats from 1981 through 1985 (see Section 5.5.1.4).

5.2.2.5. Sockeye Salmon

Of the 70 sockeye salmon tagged in the Middle River, 47 (67 percent) were able to be classified by destination. Of these, 10 (21 percent) went to tributaries (three to Portage Creek, three to Chulitna River, two to 4th of July Creek, and one each to Indian and Talkeetna rivers) and 37 (79 percent) went to destinations in the mainstem Susitna River (Table 17; Figure 22; Figure 33). The remaining salmon, not able to be classified by a specific destination, exhibited movements that prevented conclusive assignment to the mainstem or tributaries (Table 17).

Radio telemetry crews tracked tagged sockeye salmon to 13 potential mainstem spawning or holding sites in the Middle River; these sites were then visually surveyed using aerial or boat-based observations (Table 22; Figure 32). Sockeye salmon were first observed spawning on August 22, and spawning was visually verified in a total of five Susitna River mainstem habitats (four sloughs and a side channel). No evidence of holding or spawning sockeye was detected at the other eight locations with tagged sockeye, where water turbidity was high (Table 22).

5.2.3. Migration Behavior

5.2.3.1. Roaming Behavior in the Middle Susitna River

Several fish tagged at the Curry fishwheels moved upstream after release (i.e., were detected at least as far as Gateway), then moved downstream below Curry before again swimming upstream into a Lower or Middle River tributary (Table 23). Based on what appeared to be directed movements by unimpaired fish, 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 is not clear, and was classified as roaming behavior. The proportions of salmon tagged at Curry that exhibited this roaming behavior were 7 percent of Chinook salmon, 13 percent of chum salmon, 12 percent of coho salmon, 12 percent of pink salmon, and 9 percent of sockeye salmon. Similarly, there were several salmon tagged in the Lower River that showed this same behavior: these fish migrated as far upstream as Lane Station (in the Middle River), then moved downstream into the Lower River before swimming upstream 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 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 13 percent of Chinook salmon, 15 percent of chum salmon, 17 percent of coho salmon, 46 percent of pink salmon, and 67 percent of sockeye salmon.

Some roaming fish in the Middle River later moved as far up as the Portage Creek mouth (fish tagged at Curry) or the mouth of Indian River (Chinook and pink salmon tagged in the Lower River; Table 24), before dropping back to enter downstream tributaries (e.g., the Chulitna River, Talkeetna River, and Lane Creek; Table 23). One Chinook salmon (Fish 505) tagged at Curry on July 13 moved upstream to Portage Creek on July 17 and then dropped back to enter the Deshka River on July 31. This tributary migration was late with respect to run timing on the Deshka River.

5.2.3.2. Run Timing

Chinook salmon moved past the Curry fishwheel sites from late June to early August with the midpoint of catches occurring on July 2 (Figure 34; Table C-2). Among major stock groupings (as defined in Section 4.3.2.1), only five days (range: June 29–July 3) separated the 50th percentiles of passage at Curry (and this was likely within the range of expected measurement error). Those Chinook salmon that migrated upstream of Devils Canyon had passed Curry the earliest, and those that had mainstem destinations below the canyon started running the latest (Figure 35).

Chum salmon moved past the Curry fishwheel sites from mid-July to early September with the midpoint occurring on August 7 (Figure 34; Table C-5). Only six days separated the 50^{th} percentiles of passage among four stock groupings at Curry (August 2–7), with the Indian River stock passing the earliest and the Talkeetna River stock the latest (Figure 35).

Coho salmon moved past the Curry fishwheel sites from late July to the end of August with the midpoint occurring on August 15 (Figure 34; Table C-6). There was little differentiation in the 50^{th} percentiles of passage among five stock groupings (range: August 11–14), except that the Indian River stock ran latest (Figure 32).

The pink salmon run was relatively short compared to the run timing of other salmon species. Pink salmon passed Curry from mid-July to the end of August with a midpoint of catches occurring on August 6 (Figure 34; Table C-4). Again, there was little distinction in run timing among five stock groupings (50^{th} percentiles ranged from August 3–7), although fish that headed downstream to the Talkeetna River passed Curry on relatively late dates (Figure 35).

Sockeye salmon moved past the Curry fishwheel sites from early July to late August (Figure 34; Table C-3). Too few sockeye salmon were assigned to tributaries to identify run timing by tributary stock. Fish classified as mainstem spawners arrived at Curry consistently but in low numbers from mid-July to mid-August, with no obvious peak (50 percent had passed by August 3; Figure 35).

5.2.3.3. Travel Timing

Median Chinook salmon travel times were 0.9 days from release at the Curry fishwheels to Gateway, 2.0 days from Gateway to Indian River, 1.1 days from Indian River to Portage Creek, 7.7 days from Portage Creek to Cheechako Station, 0.3 days from Cheechako Station to Chinook Creek, 3.8 days from Chinook Creek to Devil Station, and 2.2 days from Devil Station to Kosina Creek (Table 25). Minimum, median, and maximum arrival dates are also shown in Table 25.

All other fish species migrated from Curry to Portage relatively quickly, with little differentiation in arrival dates among fixed-station receivers (Figure 36). Median travel times from Curry to Portage were 3.3 days for chum salmon, 3.5 days for coho salmon, 2.3 days for pink salmon, and 3.1 days for sockeye salmon.

5.2.3.4. Travel Speeds

Travel speeds are shown by species and river-reach in Figure 37. Chinook salmon travel speeds from Deshka to Sunshine were significantly slower (median 8.9 km/d [5.1 mi/d]) than those in either the Sunshine to Lane reach (16.9 km/d [10.5 mi/d]), or the Indian to Portage reach (14.6 km/d [9.1 mi/d]; $\chi^2 = 15.3$, $P = 0.0016$). Although the fastest median travel speeds were observed for fish released in the Lower River (between Sunshine and Lane), the slowest median speeds were also observed there (between Deshka and Sunshine; Figure 37).

For Chinook salmon released at Curry, travel speeds varied significantly among reaches ($\chi^2 = 67.6$, $P < 0.0001$; Figure 38). Chinook salmon travel speeds between Cheechako Station and Chinook Creek (median 24.7 km/d [15.3 mi/d]), and those upstream of Devil Station (31.0 km/d [19.3 mi/d]) were significantly faster than those in other reaches. Moreover, travel speeds between Portage Creek and Cheechako Station (0.8 km/d [0.5 mi/d]), and those between Chinook Creek and Devil Station (3.0 km/d [1.9 mi/d]) were significantly slower than those in all other reaches. This result suggests that Impediment 1 and Impediment 3 posed greater delays to Chinook salmon travel than Impediment 2 (between Cheechako Station and Chinook Creek).

For Chinook salmon that passed all impediments and were later detected at Devil Station, there was no trend for travel times to have been affected by arrival date or release location (Figure 39).

Chum salmon travel speeds from Indian to Portage were significantly faster (median 22.1 km/d [13.7 mi/d]) than those in any other reach (medians 12.5–16.7 km/d [7.8–10.4 mi/d]; $\chi^2 = 22.3$, $P < 0.0001$; Figure 37).

Among-reach differences in travel speed were not statistically significant for coho, pink and sockeye salmon (χ^2 = 3.9, 4.2, and 0.7, respectively; *P* = 0.27, 0.24, and 0.87, respectively; Figure 37).

Stock-specific travel speeds were compared (Portage vs. Indian stocks) for each species (Figure 40). For chum and pink salmon, fish that entered Portage Creek traveled faster between Gateway and Indian than did fish that entered Indian River (chum salmon: $\chi^2 = 4.2$, $P = 0.04$; pink salmon: $\chi^2 = 5.4$, $P = 0.02$). No other stock differences in travel speed were statistically significant (Chinook, coho and sockeye salmon: χ^2 = 0.7, 0.7, and 1.0, respectively; *P* = 0.41, 0.39, and 0.32, respectively).

5.3. Objective 3 – Feasibility of Sonar to Identify Spawning Locations in Turbid Water

In late July, six potential sonar sampling sites were identified in the Middle River using in-season radio telemetry data and aerial observations (Table 26; Figure 28). From July 28–29, DIDSON and side-scan sonar were used to sample four of the sites (sites 2, 4, 5, and 6) located in the mainstem Susitna River. The two remaining sites (sites 1 and 3) were in side channels too shallow to access by boat and thus were not sampled.

Four transects were made at Site 2 (mouth of 4th of July Creek) using the side-scan sonar, covering a length of river approximately 170 m (558 ft) long in an upstream-downstream direction and approximately 100 m (328 ft) from the river bank. None of the side-scan images showed obvious signs of salmon redds (no redds were seen during visual observations of the clear-water areas downstream from the mouth of the creek either). A gravel bar and different substrate types could be identified from the side-scan images. Gravel (<8 cm [3.1 in]) was seen on the bar, while cobble and rock were seen along the shore and offshore of the gravel bar. A DIDSON operated at this site collected approximately 90 minutes of data: images were collected while pulling the boat along shore and while stationary (manually panning the transducer). The maximum range sampled alternated between 10 and 20 m (33 and 66 ft). We used the longer range window to find fish and the shorter range window to watch the behavior of the fish. The maximum number of fish visible on a single frame was 15 fish. These fish were milling and appeared to stay mostly within a restricted band that roughly coincided with the clear-turbid water interface. We did not observe any redd digging activity, nor did we see any redd-shaped depressions in the river bottom. Visual observations conducted from the boat identified Chinook, chum, and one sockeye salmon in the clear-water area.

At Site 4, the side-scan survey covered an area of approximately 280 m (919 ft) in length from upstream to downstream, and with a width of 50 m (164 ft) extending from shore. Farther offshore the current was too fast to keep the boat stable enough to provide useful images. Photo

12 shows an example image taken at high frequency (1600 kHz). Though the image includes some artifacts introduced by the boat rolling in the current, it does provide a good picture of the substrate at this site (primarily gravel with a band of sand). The sonar did not record any obvious signs of redds, and the water was too turbid for any visual observations. We also recorded approximately 30 minutes of DIDSON data. Over this time, a solitary fish moved through the field of view on two occasions, but no obvious signs of redds were observed.

Side-scan data collection was hindered at Site 5 by high water velocities which made it difficult to maneuver the boat. Image quality was less than optimal because of the pitch and roll of the boat. We collected approximately 80 minutes of DIDSON data at Site 5, less than 100 m (328 ft) upstream of the mouth of Gold Creek. Most DIDSON data were collected with the boat tied to shore, with the transducer aimed at different pan angles. No fish were observed at Gold Creek even though radio-tagged fish were detected nearby. An attempt to sample with the DIDSON while the boat was moving was aborted because the strong current put too much pressure on the transducer and side mount.

Approximately 45 minutes of DIDSON data were collected at Site 6 while the boat was tied to shore and the transducer was panned in search of fish. On several occasions we observed a solitary large fish (>75 cm [29.5 in]); and on one occasion a second fish was observed following the first one. No obvious spawning or holding behavior or signs of obvious redds. Side-scan sonar data was not collected at Site 6 because of high water velocities (similar to Site 5).

5.4. Objective 4 – Characterize Salmon Migration Behavior and Timing Above Devils Canyon

5.4.1. Survey Effort

Aerial surveys above Devils Canyon were guided by data on tagged fish passing from the fixed-station receivers in the canyon. Surveys were not conducted in the Upper River until radio-tagged Chinook salmon had passed Devil Station. Surveys were not conducted upstream of Kosina Creek until a radio-tagged salmon had moved up the Susitna River beyond that location. From July into November, a total of 31 aerial tracking surveys included reaches above Impediment 1; 14 of these surveys extended upstream to Kosina Creek. The majority of these surveys were conducted during July and August (Table B-3). The surveys in the Upper River primarily focused on eight tributaries upstream of Portage Creek, with tagged Chinook salmon detected in six of those tributaries (Cheechako, Chinook, Devil, Fog, Watana, and Kosina creeks).

At least one fixed-station was monitoring for radio-tagged salmon in Devils Canyon from June 21 to November 12 (Table 14). All fixed stations in Devils Canyon were operational over 95 percent of the time they were deployed until the week of August 27, when a reduction of solar energy partially interrupted coverage at some stations. Coverage among all stations remained sufficient to operate effectively, despite this interruption. The Kosina Creek fixed station was 100 percent operational during the time it was deployed.

5.4.2. Species, Number, and Destination

Chinook salmon were the only species tracked above Impediment 1. Of the 313 radio-tagged Chinook salmon released at the Curry fishwheels that entered the study area (i.e., were detected above Gateway Station after tagging), 23 (7.3 percent) were tracked above Impediment 1, 20 (6.4 percent) above Impediment 2, and 10 (3.2 percent) above Impediment 3. Three of the Chinook salmon radio-tagged and released at the RM32 fishwheels in the Lower River were tracked above Impediment 1; two of these were then tracked above Impediment 3 (Table 27).

Based on final tag assignments, the likely spawning areas for each of the 26 Chinook salmon that passed Impediment 1 are provided in Table 28. Of the 12 Chinook salmon that passed Impediment 3, five (42 percent) dropped back and likely spawned in tributaries downstream of Impediment 3. Of the 10 Chinook salmon that passed Impediment 2 but not Impediment 3, seven (70 percent) dropped back and likely spawned in tributaries downstream of Impediment 2. Of the four Chinook salmon that passed Impediment 1 but not Impediment 2, one dropped back and likely spawned in a tributary downstream of Impediment 1. Overall, 50 percent of the Chinook salmon that passed at least one of the three impediments likely spawned downstream of the last impediment they passed and 54 percent (7 of 13) of these drop-back fish likely spawned in Portage Creek.

The 12 Chinook salmon that passed Impediment 3 (2 tagged in Lower River, 10 tagged in Middle River) showed a wide range of movement distance and times. Of these Chinook salmon, seven were tracked to locations 24–93 km (15–58 mi) upstream of their eventual spawning location. These relatively extensive upstream explorations ranged from 1–26 days (Table 29). The peak spawning interval for these 12 fish was July 25 to August 5 (11 days) and fish were detected alive in their spawning streams for 3–20 days. The shortest live period was for two fish that entered Kosina Creek on July 23, were tracked alive on July 26, and then detected with mortality signals on the next Kosina Creek survey on July 31. After spawning, three fish (Tag numbers 27, 94, and 5005) appeared to remain alive for 8–16 days and move downstream considerable distances (19–103 km [12–65 mi]) before their tags started transmitting a mortality signal. Using the last live detection for each of these 12 fish, we estimated their life span after passing Impediment 3 to range from 6–31 days (calculated from values in Table 27 and Table 29).

5.4.3. Migration Timing for Fish Passing Above Devils Canyon

The 10 Curry-tagged Chinook salmon that passed Impediment 3 had passed Impediment 1 from two to seven days earlier than those that only passed Impediment 1 or Impediment 2 (Table 27). Run timing at Curry was similar for tagged Chinook salmon that were subsequently detected at or above Devils Canyon vs. Chinook salmon that were not (Table 27).

The first successful fish passage past Impediment 1 occurred on July 7 when flows dropped to 21,000 cfs from previous sustained levels in excess of 30,000 cfs (Figure 41, Table 29. Summary of migration and spawning behavior for 12 radio-tagged Chinook salmon after they passed Impediment 3. **Distances are in kilometers.**

					Spawning Period			Explorations before Spawning			Downstrea	
Tag Number	Capture Date	Length (TL cm)	Sex	Spawning Area	First Live	Last Live	Days	Max Upstream Location	Max Upstream Distance	Days	Max Downstream Location	De
27	22-Jun	78	Undetermined	Chinook	28-Jul	05-Aug	8	Kosina	80	11	Curry	
52	25-Jun	89	Undetermined	Kosina	20-Jul	09-Aug	20					
94	29-Jun	81	Undetermined	Devil	23-Jul	05-Aug	13	Fog	30	4	Cheechako	
104	29-Jun	66	Undetermined	Portage	24-Jul	30-Jul	6	Above Devil	30	10		
113	30-Jun	84	Undetermined	Kosina	26-Jul	07-Aug	12					
219	2-Jul	73	Male	Kosina	23-Jul	26-Jul	3	Above Kosina	30	1		
246	3-Jul	85	Female	Kosina	23-Jul	26-Jul	3					
257	3-Jul	89	Female	Portage	30-Jul	17-Aug	18	Devil	24	13		
266	4-Jul	101	Male	Portage	24-Jul	06-Aug	13	Near Fog	44	15		
359	6-Jul	93	Male	Portage	06-Aug	11-Aug	5	Kosina	93	26		
5005	26-May	-	Undetermined	Kosina	23-Jul	31-Jul	8				Portage	
5019	28-May	87 MEF	Undetermined	Kosina	23-Jul	11-Aug	19					
Average					25-Jul	05-Aug	11		47	11		

Notes:

[1] Total days the fish was alive after passing Impediment 3.

Table 30). Two Chinook salmon passed impediments 1 and 2 on July 7 before flows increased to above 30,000 cfs on July 9. One Chinook salmon was detected passing Impediment 1 on July 8 and another on July 9. All of the remaining successful passage events for each impediment (48/51 or 94 percent) occurred between July 12–20 when flows were at or below 21,000 cfs (Figure 41).

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 3.3 days. Fish moved quicker past Impediment 2, with only two of the 22 radio-tagged salmon holding below it for more than one day (Table 29. Summary of migration and spawning behavior for 12 radio-tagged Chinook salmon after they passed Impediment 3. **Distances are in kilometers.**

					Spawning Period			Explorations before Spawning			Downstream
Tag Number	Capture Date	Length (TL cm)	Sex	Spawning Area	First Live	Last Live	Days	Max Upstream Location	Max Upstream Distance	Days	Max Downstream Location
27	22-Jun	78	Undetermined	Chinook	28-Jul	05-Aug	8	Kosina	80	11	Curry
52	25-Jun	89	Undetermined	Kosina	20-Jul	09-Aug	20				
94	29-Jun	81	Undetermined	Devil	23-Jul	05-Aug	13	Fog	30	4	Cheechako
104	29-Jun	66	Undetermined	Portage	24-Jul	30-Jul	6	Above Devil	30	10	
113	30-Jun	84	Undetermined	Kosina	26-Jul	07-Aug	12				
219	2-Jul	73	Male	Kosina	23-Jul	26-Jul	3	Above Kosina	30	1	
246	3-Jul	85	Female	Kosina	23-Jul	26-Jul	3				
257	3-Jul	89	Female	Portage	30-Jul	17-Aug	18	Devil	24	13	
266	4-Jul	101	Male	Portage	24-Jul	06-Aug	13	Near Fog	44	15	
359	6-Jul	93	Male	Portage	06-Aug	11-Aug	5	Kosina	93	26	
5005	26-May	-	Undetermined	Kosina	23-Jul	31-Jul	8				Portage
5019	28-May	87 MEF	Undetermined	Kosina	23-Jul	11-Aug	19				
Average					25-Jul	05-Aug	11		47	11	

Notes:

[1] Total days the fish was alive after passing Impediment 3.

Table 30). Four fish that passed Impediment 1 did not attempt to pass Impediment 2 and moved directly to their final destinations. Of the 22 fish that passed Impediment 2, the 12 that also passed Impediment 3 held below the upper Impediment for just under 2 days on average. Nine of the remaining fish above Impediment 2 held below Impediment 3 for an average of 9.8 days before moving to downstream habitats. A single fish that passed Impediment 2 did not attempt to pass Impediment 3. All of the fish that did not pass Impediment 3 were present above Impediment 2 from July 17–20, when all passage events past Impediment 3 occurred (Figure 42). One Chinook salmon (Tag number 5005) passed all three Impediments on July 17 on its way to Kosina Creek.

5.4.4. 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 313 Chinook salmon tagged at Curry and detected moving above Gateway Station, 10 (3.2 percent) successfully migrated through all three impediments located in Devils Canyon (Table 27). Given the extensive mobile survey effort and the high detection efficiency for the Cheechako, Chinook, Devil and Kosina creek stations, it is unlikely that any radio-tagged fish passed upstream of Devils Canyon undetected.

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

Of the 36 radio-tagged Chinook salmon that entered Devils Canyon, the mean body length of fish that approached but did not pass Impediment 1 (74.2 cm [29.2 in]) was less than that of fish that passed Impediment 1 (79.3 cm [31.2 in]; Table 27; $t_{33} = 0.93$, $P = 0.36$). No fish approached Impediment 2 without passing it. The mean fork length of fish that approached but did not pass Impediment 3 (75.0 [29.5 in]) was smaller than that of fish that passed Impediment 3 (84.9 cm [33.4 in]; $t_{18} = 1.71$, $P = 0.11$). These observations are suggestive that fish size may have been a factor in successful passage for Impediments 1 and 3. These results should be interpreted cautiously as group sample sizes were small, and neither comparison was statistically significant.

Converted to snout-fork length (FL mm = -9.508535 + 1.0999002*MEF mm), the two Lower River Chinook that migrated upstream of Impediment 1 were 94.7 cm and 63.9 cm (37.3 and 25.2 in; Table 27).

5.5. Objective 5 – Distribution Among Habitats: Current Versus Historic Use and Relative Abundance

In 2012, potential spawning locations of Chinook, chum, coho, pink, and sockeye salmon in the mainstem river were identified using radio telemetry (Section 5.2). Some spawning locations were able to be visually confirmed for sockeye and chum salmon in the Middle River. Mainstem spawning for both sockeye and chum salmon occurred in slough and, to a lesser extent, side channel habitats. In addition, a few chum salmon were confirmed spawning in tributary delta habitats. Of the confirmed spawning habitats located during the 2012 surveys, many were the same as those used for spawning by sockeye and chum salmon from 1981–1985 (Thompson et al. 1986; Table 31). In addition, the absence of mainstem spawning by Chinook and coho salmon was also similar to results from the 1980s. The only appreciable difference in results from 2012 and the 1980s surveys was the absence of confirmed mainstem spawning by pink salmon.

5.5.1.1. Chinook Salmon

In 2012, Chinook salmon were tracked to nine possible mainstem spawning locations in the Lower River and 13 locations in the Middle River (Table 18; Figure 24; Figure 28). Despite multiple visual surveys and DIDSON and side-scan sonar surveys (see Section 5.3), spawning could not be confirmed at any of these locations. Similarly, spawning ground surveys from 1981–1985 could not confirm any mainstem spawning locations for Chinook salmon (Barrett et al. 1985; Thompson et al. 1986). The only confirmed locations, from the 2012 and 1980s surveys, of spawning habitat for Chinook salmon in the Lower and Middle River were tributaries.

5.5.1.2. Sockeye Salmon

In 2012, sockeye salmon were only tracked to mainstem spawning locations within the Middle River (Figure 32). Confirmed spawning locations were confined to five sloughs and one side channel (Table 22). Based on visual observations of sockeye salmon densities, the sloughs with the highest use for sockeye salmon spawning were Sloughs 11, 8A, and 21 (Photo 13). Of the radiotagged sockeye salmon using sloughs, 47 percent had these destinations (Table 17). A few sockeye salmon were also confirmed spawning in sloughs 9 and 19 and side channel 21. Similarly, from 1981–1985, of all the sockeye salmon enumerated spawning in sloughs, an average of 92.5 percent were in sloughs 11, 8A, and 21 (Table 31). Historically, sloughs 9 and 19 only provided spawning habitat for a combined average of 1.4 percent of all the enumerated sockeye salmon that spawned within the mainstem habitats of the Middle River. All other locations where sockeye salmon were observed spawning in the 1980s, with the exception of Moose Slough (1.6 percent) and Slough 9B (1.9 percent) contained an average of <1.0 percent of the total sockeye salmon enumerated (Table 31). Sockeye salmon were not confirmed spawning in Slough 9B during the 2012 surveys. A low number of sockeye salmon (<10) were present spawning in Side Channel 21 in 2012, and there were no reports of sockeye salmon at this location in the 1980s. It is important to note that it is often difficult to determine both the boundary that separates a slough and a side channel and the distinction between a slough and a side channel at various river discharges, therefore, the sockeye salmon observed in Side Channel 21 may have actually been within Slough 21.

5.5.1.3. Chum Salmon

In 2012, chum salmon were radio-tracked to several potential mainstem spawning locations within the Lower and Middle River (Figure 25; Figure 29). Of the sites identified via radio telemetry, only sites in the Middle River were visually confirmed. Spawning was confirmed for chum salmon at 6 sloughs, 1 side channel, and 2 tributary deltas (Table 19). Based on visual observations of chum salmon densities, the sloughs with the highest use by chum salmon for spawning were sloughs 21, 8A, 11, and 4th of July Slough (historically referred to as 4th of July side channel), respectively. Of the radiotagged chum salmon using sloughs, 21 percent had these destination (Table 17). Other sloughs confirmed for spawning, but to a lesser extent were sloughs 9, 9A, and 19. In comparison, from 1981–1985, of all the chum salmon enumerated spawning within the mainstem Middle River, an average of 56.7 percent were in sloughs 21, 11, and 8A (Table 31); percent distribution data was not available for 4th of July slough/side channel, but spawning was confirmed at this location (Barrett et al. 1984). Sloughs 9 and 9A provided spawning habitat for an additional 14.9 percent of the enumerated mainstem spawning chum salmon in the 1980s. The remaining 28.4 percent of chum salmon were distributed across 27 other sloughs, of which 24 sloughs each accounted for less than 3.0 percent of the total average distribution (Table 31).

Side Channel 21 was the only side channel habitat confirmed as a spawning location for chum salmon during the 2012 surveys. Based on visual observations, densities of chum salmon at Side Channel 21 were comparable to densities of chum salmon within Slough 21. During the 1980s surveys, chum salmon were reported as spawning in Side Channel 21 in addition to a few other side channels, but the overall contribution of chum salmon at these locations to that of slough habitat was considered minor (Barrett et al. 1984, 1985; Thompson et al. 1986). It is important to note that it is often difficult to determine the boundary that separates a slough and a side channel and the distinction between a slough and a side channel at various river discharges; therefore, the chum salmon observed in Side Channel 21 may have actually been within Slough 21.

As in the 1980s, chum salmon in 2012 were confirmed spawning at the tributary deltas for 4th of July Creek and Indian River (Barrett et al. 1984). Repeated visits to these locations in 2012 confirmed one chum salmon redd in the tributary delta of 4th of July Creek and four chum salmon redds in the tributary delta of Indian River. As an overall comparison, tributary deltas provided spawning habitat for chum salmon in 2012 and in the 1980s, but the contribution of chum salmon use relative to slough habitats was minor in both time periods.

5.5.1.4. Pink Salmon

In 2012, pink salmon were tracked to several mainstem spawning locations within the Lower and Middle River (Figure 27; Figure 31). Despite several aerial and ground surveys, spawning by pink salmon was not confirmed at any locations (Table 21). From 1981–1985, Sloughs 8A, 9, 11, and 21 provided spawning habitat for an average of 32.1 percent of all the pink salmon enumerated spawning within mainstem Middle River habitats (Table 31); all of these sloughs were visited during 2012 during times when pink salmon should have been spawning, but no pink salmon spawning was observed.

5.5.1.5. Coho Salmon

In 2012, coho salmon were tracked to several potential mainstem spawning locations in the Lower and Middle River (Figure 26; Figure 30). Despite multiple aerial and ground surveys, spawning could not be confirmed at any of these locations (Table 20). Similarly, spawning ground surveys from 1981–1985 could not confirm any mainstem spawning locations for coho salmon (Barrett et al. 1985; Thompson et al. 1986). The only confirmed locations from the 2012 and 1980s surveys of spawning habitat for coho salmon were tributaries.

5.6. Objective 6 – Locate Individual and Holding and Spawning Salmon, Collect Habitat Data in Middle and Lower River Consistent with HSC Data Collection

From June 26 through November 12, crews tracked Chinook, chum, coho, pink, and sockeye salmon to potential spawning locations within the Lower and Middle River. Following designation as a potential spawning site, each site was classified to the mainstem habitat level as a main channel, side channel, slough, or tributary delta. Then, aerial and ground reconnaissance surveys were made to confirm each site for spawning prior to the collection of HSC data. For more detail on spawning site location and classification, see Section 5.2.

HSC surveys were conducted from August 11 to October 29. Turbidity in the main channel of the Susitna River, from June through mid-October was too high to visually confirm any potential spawning salmon or locate redds. In addition, elevated water levels in the Susitna River from mid-August through October prevented crews from revisiting previously sampled spawning locations, or visiting newly confirmed locations.

5.6.1. Habitat Data Collection

Of the potential spawning sites detected for all species of salmon by telemetry in the Lower and Middle River (see Section 5.2), only the Middle River contained sites in off-channel habitats where spawning was visually verified and were then sampled for HSC data. Of the potential Middle River spawning sites detected, only five sockeye and eight chum salmon sites were confirmed (Figure 29; Figure 32). Of these, three sockeye and seven chum salmon sites were sampled for HSC data (Figure 43; Figure 44). Of the three sockeye salmon spawning sites sampled for HSC, all were slough habitats. Of the seven chum salmon spawning sites sampled, five were slough and two were tributary delta habitats. In total, 11 and 28 redds were sampled from slough habitats for sockeye and chum salmon, respectively, and an additional four chum salmon redds were sampled in tributary delta habitats (Table 32). Additional sites (Slough 19 and Side Channel 21) that were confirmed as spawning locations, but were not sampled due to environmental conditions, will be targeted in 2013 for collection of HSC data.

In the Lower River, despite multiple aerial surveys, field crews did not visually verify any mainstem spawning habitats for sampling of HSC data. All potential spawning locations suggested by radio telemetry were provided to the ISF field crews for focused HSC data efforts that are reported elsewhere.

In the Middle River, many slough habitats used for spawning by sockeye and chum salmon were side channels until flows at their mainstem head were cut-off. As an example, Sloughs 8A and 9A, and 4th of July Slough remained side channels until mainstem flows were just under approximately 17,000 cfs; only at flows below this threshold did the water in these habitats become clear enough to sample for HSC data. Other slough habitats (e.g., Slough 9) experienced similar main channel re-connectivity, but had a greater tolerance in flow levels (>24,000 cfs) before the upstream head of the slough was breached. Large fluctuations in precipitation during early and late fall 2012 caused repeated main channel re-connectivity, increased water velocities, and increased turbidity at many of these side channel/slough locations and prevented either the confirmation of spawning by salmon or HSC sampling visits during much of the peak spawning periods. As another example, following the first HSC survey on August 11, flows prevented HSC sampling at Sloughs 8A and 9, and 4th of July Slough during these date ranges: August 11–15, August 21–22, August 27–29, September 3–6, and September 18–29.

5.7. Objective 7 – Effectiveness of 2012 Methods

5.7.1. Capture and Tagging of Fish at Curry

The goal of capturing and tagging relatively large numbers of all species of salmon and tracking them in mainstem and tributary habitats was met in 2012. Relatively high catches were achieved at Curry in 2012, considering the fishwheels operated at sites 1 and 2, respectively, for only 41 and 44 percent of the time they were in place. Relative to the 1980–1985 studies, where fishwheels were generally operated 24 hours per day and salmon were generally more abundant than in 2012 we captured 41 percent fewer Chinook, 8 percent fewer chum, 62 percent fewer pink (even years only), and 67 percent fewer sockeye salmon, on average, were caught at the Curry fishwheels in 2012. On average, 25 percent more coho salmon were captured in 2012 than in the 1980s studies, despite concerns about generally low coho salmon returns to the Susitna River in 2012.

The preseason tag targets were exceeded for chum (140 percent) and pink (115 percent of target) salmon, but not met for Chinook (88 percent of target), coho (92 percent), and sockeye (35 percent) salmon. When it became apparent that the initial tagging goals for Chinook and sockeye salmon would not be met, an amendment to the Fish Resource Permit (SF2012-128) was obtained to allow for additional chum and pink salmon to be radio-tagged using the available inventory of tags. In 2013, we recommend similar flexibility be maintained in the Fish Resource Permit to maximize the benefits across species from the considerable telemetry survey effort.

5.7.2. Effectiveness of Radio Telemetry to Address Questions

The radio telemetry techniques used in the 2012 study were successful in providing the data needed to address the related study objectives. Of the 1,115 radio-tagged salmon released at Curry, only one was not detected after release. Data was efficiently processed during the field season so field crews could use the information from fixed-station receivers to direct mobile survey effort, and tracking results from mobile surveys were used to direct ground surveys to determine spawning locations. There were a few initial problems with receiver software that were quickly sorted out and resolved without any major impact on study results. Receiver sensitivity and tag signal power were sufficient to ensure that most of the tagged fish passing a fixed-station receiver were detected (Table 13). All of the radio telemetry data from AEA and ADF&G fixed stations and mobile surveys were efficiently analyzed using *Telemetry Manager* software.

There was no evidence of negative effects on tagged fish from the capture, handling or tagging process. Tagged fish moved consistently and without delay in reaching fixed stations up to Portage Creek (Figure 36). In some instances fish returned downstream, but these migrated to other spawning destinations, suggesting unimpaired swimming behavior. The only deficiency with the radio tags was associated with mortality sensors. This was not a major problem because of the frequent mobile surveys and the observation that most of the tags were detected in mortality mode after the peak spawning period and only a few of these were resurrected to their live signal mode. This malfunction was communicated to the tag supplier and we are optimistic that they will find a solution to this problem.

The configuration and operation of the fixed-station receivers could be improved in future years. Additional fixed-station receivers or greater separation between the antennas at tributary junctions would provide greater certainty on whether a fish had entered a tributary or was continuing up the mainstem. The detection efficiencies should be improved in 2013 with the elimination of software problems and our greater familiarity with the ATS equipment.

5.7.3. How Our Studies of Distribution and Categorization (e.g., Habitat Used) Affect 2013/2014

Results from 2012 were used throughout the preparation of the 2013/2014 Revised Study Plan (RSP) in the fall of 2012. Noteworthy was the expansion of the Genetics Study Plan to address the genetics of Chinook salmon above Devils Canyon, and the recommendation in the 2013/2014 Salmon Escapement Study that tagging effort be augmented in the vicinity of Devils Canyon to better characterize behavior in and above the canyon. Data on fish spawning locations in the Middle River are also being considered for site selection of Focus Areas and fish sampling.

6. DISCUSSION

6.1. Fish Capture at Curry for Purpose of Marking Fish to Determine Distribution of the Middle and Upper River Population(s)

6.1.1. Fishwheel Effectiveness

High catch rates at the Curry fishwheels 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 the only locations within several miles of Curry with suitable water depths and velocities to allow the fishwheel baskets to rotate effectively from mid-June through early September in 2012. The sites were protected from floating debris at low to moderate river discharges, yet had sufficiently high water velocities offshore to force fish against the bank and into the path of the fishwheels (2–3 m/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.

The Curry fishwheels were custom-built in 2012 and modeled after fishwheels used successfully in the lower Susitna (Yanusz et al. 2011), Copper (Smith et al. 2005), and Nass (Link and English 1996) rivers. A key feature of the Curry fishwheels was the ability to vary the fishing depths (by raising or lowering the baskets) as water levels changed. Minor adjustments each day kept the baskets fishing near the river bottom and reduced the amount of down time required had the fishwheels needed to be moved to a new location every time water levels changed. Three sets of variable-depth baskets (72, 76, and 88 in) were built that provided investigators with some flexibility when deciding which fishwheels to place at each site. And lastly, due to the solid three-basket design, there were no extended periods of down time due to damage (e.g., from floating debris).

Lead nets hung between the shore-side pontoon and adjacent riverbank also contributed to higher catch rates in 2012, particularly at Site 1 where the fishwheels were held up to 25 ft offshore with spar poles. DIDSON footage showed that the majority of fish migrated upstream within 13 ft of shore, so without the lead net these fish would not have been directed offshore and into the path of the fishwheel. Every three or four days, crews spent approximately 20 minutes cleaning organic debris from the lead net at Site 1.

Experience from 2012 will help improve and refine fishwheel effectiveness in future years. The development, installation, and evaluation with DIDSON sonar was informative, and the 2013/14 program will benefit significantly from this experience. In addition, we encountered wide fluctuations in river discharge and this will help with preparations for 2013. Maintaining high fishwheel effectiveness was most difficult during periods of low flows; we expect the greatest challenge to capturing sufficient numbers of fish in 2013 will be from sustained very low flows at critical periods (e.g., August).

6.1.2. Size Selectivity

Achieving the goals of this study was dependent on the size composition of tagged fish being representative of their respective spawning populations. Tagging particular stocks and/or sizes of fish at different rates than others might weaken inferences about habitat uses of the Middle and Upper River 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 our experience, we characterize the Curry sites as generally high gradient, and similar to locations where we have encountered the least size selectivity in fishwheels.

In 2012, early season DIDSON data suggested that there was not a strong offshore component to the Chinook salmon run at Site 1 (Figure 18) and fish of all sizes seemed equally distributed at range from shore (Figure 19). Also, length frequencies of the Chinook salmon catch (Figure 12) suggests that fish across all sizes appeared at least somewhat vulnerable to capture and tagging, something that would not be possible if there was significant size selectivity like is sometimes seen with fishwheel projects on low gradient rivers. However, a lack of spawning ground samples for length of marked and not marked fish for all species (there were very few carcasses ever found) precluded direct testing for size selectivity. Ancillary comparisons (e.g., Site 1 vs. Site 2, length of fish captured vs. tagged) provided no evidence to suggest the Curry fishwheels were size selective. More focused efforts to obtain length measurements will be needed in 2013 than was achieved in 2012.

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

6.2.1. Lower River

The tracking results for salmon tagged in the lower Susitna indicated that 71–99 percent of these fish, depending on the species, likely spawned in tributaries (Figure 22). Despite the high proportion of tagged fish returning to tributaries, the remaining number of tagged Chinook, chum, coho, and pink salmon allowed major spawning locations in the mainstem river to be identified (Figures 24–27). In contrast, so great a proportion of the radio-tagged sockeye salmon migrated into tributaries (96 of 100 tagged fish) that the few sockeye salmon remaining in the mainstem river were not sufficient to identify most mainstem spawning locations.

High and turbid river flows throughout the salmon spawning period prevented our field crews from being able to visually verify potential spawning locations identified by radio telemetry in the Lower River. It is possible that some late-run salmon (e.g., coho salmon) last tracked to mainstem locations could have entered tributaries after the last surveys, which would have resulted in overestimating the number of mainstem spawning fish.

6.2.2. Middle and Upper River

The tracking results for Chinook, chum, coho, and pink salmon tagged at Curry indicated that 63–81 percent of these fish likely spawned in tributaries (Figure 22). The number of radio tags applied to Chinook, chum, pink and coho (184–352 per species) identified major spawning locations for these species (Figures 28–31). The relatively small sockeye return to the Middle River in 2012 resulted in only 70 radio tags applied to sockeye. Mainstem habitats contributed to over 50 percent of sockeye spawning destinations (Figure 22) and were concentrated in five primary areas between 5th of July Creek and Portage Creek (Figure 32).

The frequent aerial surveys conducted on the Middle River from Whiskers to Portage creeks provide 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 early September 2012 and the confirmed redd sites for these species (Figure 43; Figure 44). This consistency provides further support for using radio-telemetry to direct HSC survey crews. Additional HSC survey efforts should be conducted in 2013 to reconfirm these results for chum and sockeye salmon and assess potential mainstem spawning locations for the other salmon species.

6.3. Current Versus Historical Spawning Locations, Use of Habitat Types

Overall, spawning locations documented in 2012 were consistent with results from the 1981–1985 surveys. In both the 2012 and historic surveys, potential spawning locations identified by radio telemetry were not visually confirmed in the mainstem Lower River. In 2012, however, we did identify potential spawning sites using radio telemetry, and were able to confirm some of these sites when water cleared in the Middle and Upper River. In 2012, radio telemetry analysis suggested behavior indicative of spawning at multiple locations within main channel areas of the Lower and Middle River by all species of salmon (sections 4.3 and 5.2). In 2012 and historically, only mainstem habitats in the Middle River were confirmed as spawning habitats, and only for sockeye (1981–1985 and 2012), chum (1981–1985 and 2012), and pink salmon (1981–1985). In both surveys, the most extensive spawning in mainstem habitats was by chum and sockeye salmon. Of those sockeye and chum salmon that were confirmed spawning, sloughs were the primary habitat occupied. Of the 32 sloughs identified within the Middle River from 1981–1985 (Table 27), five sloughs (21, 11, 9A, 9, and 8A) provided spawning habitat for the bulk of spawning salmon in both 2012 and 1981–1985. Historical and recent consistencies among the usage of these five sloughs by sockeye and chum salmon highlight their importance as habitat within the mainstem Susitna River.

Similar to the 1981–1985 surveys, surveys conducted in 2012 did not confirm any spawning activity in mainstem habitat by Chinook and coho salmon. All confirmed spawning by these species was within tributaries.

The absence of pink salmon spawning in slough habitats in 2012 was the only major difference in the comparison of both surveys. In 2012, despite multiple surveys to slough habitats historically important to pink salmon spawning (sloughs 21, 11, 9A, 9, and 8A), pink salmon spawning was not confirmed within mainstem habitats. The reason for the lack of observations of pink salmon spawning in 2012 is unknown and difficult to assess given one year of data.

In summary, due to the intensity of spawning activity at a small number of sloughs along the Middle River, and the consistency of these results with historic studies, a better understanding is warranted on how mainstem flows affect the physical properties at each of these habitats and how changes to these physical properties might affect the behavior of sockeye, chum, and pink salmon. In addition, further efforts are needed to develop methodologies capable of confirming spawning activity in turbid water.

6.4. Salmon Migration Above Devils Canyon

The extensive mobile tracking effort in 2012 detected a substantial number of pre-spawning and post-spawning movements of Chinook salmon that passed Devils Canyon. These data revealed that seven of the 12 Chinook salmon that passed Impediment 3 migrated 24–93 km (15–58 mi) upstream from their eventual spawning location, and four of these fish moved back downstream of Devils Canyon and likely spawned in Portage Creek. One male Chinook salmon (Fish 359) was detected in two tributaries (Devil Creek and Portage Creek) during potential spawning intervals after being detected at the mouth of Kosina Creek. Although these behaviors suggest exploratory movements, more fish and more study years are needed to know how well the movements represent the entire population, and how much the behavior varies among years and different environmental conditions.

The telemetry gear worked well for detecting fish moving into and above Devils Canyon. All salmon detected at Devil Station, at the lower end of Devils Canyon, were subsequently detected during aerial surveys. Any fish that went undetected past Devil Station would have also had to have moved back down undetected in order to have gone undocumented. Given the reliability of these stations and the close agreement between fixed station and aerial survey detections, undetected migration through Devils Canyon was unlikely.

The observation of Chinook spawning in streams above Devils Canyon is consistent with the results from surveys conducted in previous years. As summarized in AEA (2011b), few Chinook salmon (20–45 fish) were observed in tributaries above Devils Canyon in 1982–83. 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). No other salmon species have been reported spawning above Devils Canyon (AEA 2011b).

The information collected on fish size, passage timing, and flow data for the successful fish passages events suggests that a broad size range of Chinook salmon passed through Devils Canyon when flows were at or below 21,000 cfs, but not above 30,000 cfs. The coincident timing of fish passage above Devils Canyon at times of low flows in 2012 leads to questions of whether flow affected passage. However suggestive, the 2012 results are limited in sample size, confounded with time and discharge, and were not part of a formal control-treatment experiment, and therefore are insufficient to infer whether low flow played a causal role in the passage of Chinook salmon in late July. The results from 2012 will help, however, with planning for 2013 (maximizing sample sizes and spatial coverage of fixed-station receivers and mobile telemetry) and with providing a more detailed look at the flows during various successful and unsuccessful passage periods.

6.5. Ability to Detect Salmon in Clear and Turbid Water, and to Collect Spawning Habitat Data in Turbid, Mainstem Water

6.5.1. Sonar to Identify Spawning Locations in Turbid Water

Using sonar to identify spawning locations in turbid water proved difficult in 2012. Side-scan images showed features of the river bathymetry (e.g., gravel bars) and a variety of substrate types (e.g., sand, gravel, cobble, and rocks); however, no obvious salmon redds were observed with side-scan or DIDSON sonar. No sonar sampling occurred during low, clear-water conditions, so crews could not ‘ground-truth’ the turbid-water sample sites using visual observations. Shallow water also limited boat access to some sites, including at least two (side channels 1 and 3) where radio-tagged fish had been reported over a prolonged period of time. Thus, though sonar did not detect the presence of redds, it remains unknown whether this was attributable to the absence of redds, or because redds were not recognizable on the images; furthermore, some sites were inaccessible due to shallow water.

For the identification of Chinook salmon redds, Tiffan (2004) found that DIDSON was more effective when redds exhibited sufficient morphology (i.e., well-developed tailspills) and where the topography of the riverbed was somewhat smooth so that redds would not be confused with other bottom features. In 2012, the DIDSON footage provided a rough estimate (order of magnitude) of the number of fish present, and indicated that observed fish were milling rather than engaged in spawning activity. In the absence of unidirectional movement, and given the relatively small area sampled, it was difficult to provide more precise estimates of fish abundance.

6.6. Operational Lessons about the Effectiveness of Our Approaches in 2012, with Implications for 2013

The following is a summary of operational lessons that augment or emphasize lessons from 2012 raised elsewhere in the report. The focus is on those that will influence the 2013 Salmon Escapement Study, and are in addition to those lessons that directly influenced the genetics and other study plans submitted to FERC in December as part of the RSP.

1. To better characterize Chinook salmon migration behavior and timing in and above Devils Canyon, it would be beneficial to increase the numbers of radio-tagged fish in Devils Canyon in 2013 and 2014 over that achieved in 2012. To achieve this goal without jeopardizing the other study component (characterize mainstem habitat use in the Middle River), we propose to augment and split the Chinook salmon tagging effort at Curry with two additional fishwheels located in lower Devils Canyon. Although we are not certain of the feasibility of operating fishwheels in the area, the additional fishing effort in Devils Canyon has a disproportionate impact on increasing the numbers of radio-tagged Chinook salmon in Devils Canyon.
2. Establish tagging goal ranges for each species that are contingent upon estimated fishwheel catches and the number of radio tags available. When applying for the initial Fish Resource Permit from ADF&G, request permission to tag up to the upper boundary of the tag goal ranges. This will provide greater flexibility in-season to adjust tag goals, maximize the use of considerable survey effort, ensure all radio tags available can be deployed in a given year, and eliminate the paperwork associated with amending the permit midseason.
3. Explore alternative methods for sampling (e.g., mark rates, lengths) fish on the spawning grounds so that investigators can test whether tagged fish were representative of their respective runs. In 2012, bear predation on Chinook salmon precluded effective spawning ground sampling in the Indian River and Portage Creek. In future studies, consider a strategically located adult salmon weir and/or video system with partial weir in either of these systems to provide the necessary samples.
4. Fixed-station receivers located at tributaries (e.g., Indian River, Portage Creek) should be added farther upstream from their confluence with the Susitna River. This will improve our ability to differentiate between mainstem and tributary spawners and reduce the amount of aerial-tracking effort required in the tributaries.

5. Continue a high level of aerial-tracking coverage and expand collaboration and integration with the Lower River investigators (i.e., ADF&G). Surveys were conducted weekly in 2012 and provided extremely high-resolution information on fish movements throughout the drainage. Data processing time was not significantly increased with regular surveys, and the benefits were substantial when detecting and tracking fish above Devils Canyon. With an expanded Lower River program in 2013, the need for coordination and integration of efforts among investigators will grow.
6. Install intergravel temperature probes in close proximity to redds in the fall and remove them the following spring. These probes will provide data on hyphoreic flows through spawning gravels at mainstem locations over the winter incubation months. These data may help to characterize the influence of mainstem flows (over the winter months) on hyphoreic stability on a site-by-site basis, and indicate why only a few of these sites (e.g., sloughs 21, 11, 8A) comprised the majority of mainstem spawning in 2012 and the 1980s.
7. Conduct more frequent spawner and HSC surveys in mainstem habitats of the Middle River to more accurately define spawning activity and timing in relation to discharge. Observations in 2012 and the 1980s indicated that relatively specific conditions appear to trigger spawning activity on a site-by-site basis. The additional information gained from more frequent surveys will provide more specific criteria for ISF analyses.
8. When using boat-based sonar to survey redds, a side mount that isolates the transducer from the rolling motion of the boat is required. In deeper water, a side-scan transducer is usually towed on a long tether to separate it from the heave, pitch, and roll of the survey vessel. This was not an option at the 2012 sample sites due to shallow water. However, since roll appeared to have the biggest effect on image quality, it is possible that improvements can be made by mounting the transducer at the bow of the boat (a new bow mount has been designed for future studies).

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TABLES

Table 1. Use of various methods to accomplish each of seven major objectives in 2012.

Objective	Middle River Fishwheel Operation	Lower River Fishwheel Operation[1]	Middle River Radio-tagging	Lower River Radio-tagging[1]	Sonar	Mobile and Fixed Tracking Surveys	Physical Habitat Sampling
1. Fish capture, tagging, and tracking in Middle River	X		X		X	X	
2. Migration behavior, spawning locations of salmon in up/middle/lower Susitna River	X	X	X	X	X	X	
3. Feasibility of sonar to determine spawning locs in turbid water					X		
4. Characterize salmon migration behavior, timing above Devils Canyon	X	X	X	X		X	
5. Habitat use historic and current	X	X	X	X		X	
6. Locate individual holding and spawning salmon (clear, turbid) & collect habitat data in middle and lower river, consistent with developing HSC.	X	X	X	X	X	X	X
7. Evaluate effectiveness of 2012 methods.	X		X		X	X	

Notes:

[1] Operated by ADF&G and reported in Yanusz et al. (2013).

Table 2. Total catch of salmon at two fishwheel sites near Curry on the Susitna River, 2012.

	Site 1			Site 2			Total		
Species [1]	Adult	Jack	Total	Adult	Jack	Total	Adult	Jack	Total
Chinook Salmon	256	83	339	166	61	227	422	144	566
Sockeye Salmon	35	2	37	57	6	63	92	8	100
Pink Salmon	4,164		4,164	541		541	4,705		4,705
Chum Salmon	877		877	857		857	1,734		1,734
Coho Salmon	229	1	230	35	0	35	264	1	265
Total	5,561	86	5,647	1,656	67	1,723	7,217	153	7,370

Notes:

[1] Adult salmon catches include recaptures: 20 Chinook, 2 sockeye, 1 pink, 7 chum, 3 coho.

Table 3. Fork lengths and linear regression equations for fish sampled at the Curry fishwheels, 2012.

	Fork Length (cm)				Linear Regression: MEF-FL (cm)		
Species	Min	Max	Mean	*n*	Equation	*n*	R^2
Chinook Salmon	33	123	71	492	MEF = 0.9001 * FL + 1.4705	207	0.99
Sockeye Salmon	32	72	54	91	MEF = 0.8494 * FL + 3.4589	71	0.97
Pink Salmon	34	59	49	588	MEF = 0.8383 * FL + 3.8108	307	0.94
Chum Salmon	52	77	67	867	MEF = 0.7675 * FL + 9.3872	843	0.94
Coho Salmon	35	69	55	250	MEF = 0.8498 * FL + 3.7535	247	0.93

Table 4. Number of fish, by species and location, sampled for DNA and otoliths.

	Number	Fork Length (cm)				Number of Samples	
Species	Caught	Min	Max	Mean	*n*	DNA	Otolith
Arctic Grayling	1	31	31	31.0	1		
Dolly Varden	2	25	33	29.0	2	1	1
Longnose Sucker	22	22	36	30.1	15	9	
Rainbow Trout	23	17	50	30.2	21	10	
Round Whitefish	29	15	38	30.1	19	15	
Humpback Whitefish	6	17	34	27.0	5	4	2

Table 5. Number of adult salmon tagged and recaptured at two fishwheel sites near Curry on the Susitna River, 2012.

	Preseason	Site 1		Site 2		Total	
Species	Tag Goal	Tagged	Recaps	Tagged	Recaps	Tagged	Recaps
Chinook salmon	400	214	15	138	5	352	20
Sockeye Salmon	200	27	0	43	2	70	2
Pink Salmon	200	122	1	108	0	230	1
Chum Salmon	200	140	4	139	3	279	7
Coho Salmon	200	156	3	28	0	184	3
Total	1,200	659	23	456	10	1,115	33

Table 6. Number of recaptured radio-tagged fish, by location of tagging, and the elapsed time between tag and recapture events.

Location		Number of	Time Between Capture Events (Hours)			
of Tagging	Species	Recaptures	Min	Max	Median	*n*
Middle River	Chinook Salmon	17	0.0	263.1	6.9	13
(Curry)	Sockeye Salmon	2	2.6	495.8	249.2	2
	Chum Salmon	2	0.6	2.2	1.4	2
	Coho Salmon	3	1.6	193.3	2.0	3
Lower River	Chinook Salmon	3	630.8	693.7	640.5	3
	Pink Salmon	3				
	Chum Salmon	1				

Table 7. Statistical results of Kolmogorov-Smirnov tests comparing cumulative length-frequency distributions of fish measured at the Curry fishwheels, 2012.

Location / Species	n_1	n_2	D_{max}	P-value
Site 1 vs. Site 2				
Chinook Salmon	314	178	0.05	1.00
Sockeye Salmon	34	57	0.16	0.71
Pink Salmon	388	200	0.12	0.06
Chum Salmon	460	407	0.05	0.70
Coho Salmon	216	34	0.16	0.39
Captured vs. Tagged				
Chinook Salmon	404	350	0.03	1.00
Sockeye Salmon	79	70	0.04	1.00
Pink Salmon	584	230	0.03	1.00
Chum Salmon	867	279	0.06	0.45
Coho Salmon	248	184	0.05	1.00

Table 8. Chinook salmon capture efficiency by the Site 1 fishwheel, 2012.

	DIDSON Count			Percent Caught	
Date	24-h Period	When FW1 Operating	FW1 Count	24-h Period	When FW1 Operating
19-Jun	29	20	2	6.9	10.0
20-Jun	54	48	3	5.6	6.3
04-Jul		69	13	0.0	18.8
Total	83	137	18	21.7	13.1

Table 9. Tag rate estimate adjustments based on theoretical observation efficiency during stream counts of Chinook salmon in Portage Creek and Indian River, 2012.

Date	Location	Actual Count	Observer Efficiency (%)	Fish Missed	Adjusted Count	Adjusted Tag Rate (%)
30-Jul	Portage Creek	146+34[1]	100.0	0.0	180.0	16.1
			90.0	18.0	198.0	14.6
			85.0	27.0	207.0	14.0
			80.0	36.0	216.0	13.4
			75.0	45.0	225.0	12.9
			70.0	54.0	234.0	12.4
31-Jul	Indian River	82	100.0	0.0	82.0	13.4
			90.0	8.2	90.2	12.2
			85.0	12.3	94.3	11.7
			80.0	16.4	98.4	11.2
			75.0	20.5	102.5	10.7
			70.0	24.6	106.6	10.3
08-Aug	Indian River	43	100.0	0.0	43.0	32.6
			90.0	4.3	47.3	29.6
			85.0	6.5	49.5	28.3
			80.0	8.6	51.6	27.1
			75.0	10.8	53.8	26.0
			70.0	12.9	55.9	25.0

Note:

[1] the 34 additional counts represent an estimated number of Chinook salmon present in a section of stream blocked by bear activity.

Table 10. Summary of visual ground surveys for live Chinook salmon in Portage Creek and Indian River, 2012. Coordinates are in decimal degrees.

		Start Location		Stop Location		
Date	**Location**	**Lat**	**Long**	**Lat**	**Long**	**Live Count**
30-Jul	Portage Creek	62.90057	-149.24913	62.87752	-149.32030	146+34[1]
31-Jul	Upper Indian	62.87892	-149.58368	62.86988	-149.59747	82
08-Aug	Lower Indian	62.82844	-149.64476	62.78484	-149.66217	43

Note:

[1] the 34 additional counts represent an estimated number of Chinook salmon present in a section of stream blocked by bear activity.

Table 11. Summary of the Chinook salmon mortality tag recovery efforts in Indian River, 2012. Coordinates are in decimal degrees.

		Start Location		Stop Location		Tags	Bear-Related
Date	**Location**	**Lat**	**long**	**Lat**	**Long**	**Recovered**	**Recoveries**
02-Aug	Lower Indian	62.78484	-149.66217	62.78955	-149.66135	1	1
05-Aug	Upper Indian	62.88493	-149.56596	62.85728	-149.61330	8	4
08-Aug	Lower Indian	62.82844	-149.64476	62.78484	-149.66217	11	8

Table 12. Comparison of the number of radio-tagged Chinook salmon detected during an aerial-tracking survey on July 24, and the number of Chinook salmon visually counted on an aerial survey conducted the same day. A sensitivity analysis of the estimated proportion of fish marked in the Middle River as a function of observer efficiency on the aerial surveys is also shown.

Survey Method	Tag Site and Status	Indian River	Portage Creek	Total
Aerial-Tracking	Middle River - Live	65	131	196
Survey (LGL)	Middle River - Dead	8	12	20
	Lower River - Live	4	8	12
	Lower River - Dead	0	2	2
	Total	77	153	230
Aerial-Counting	No. of Chinook Observed	338	501	839
Survey (ADF&G)	Count:Radio Ratio	4.4	3.3	3.6
	Count:Radio Ratio (Middle River)	4.6	3.5	3.9

Sensitivity of Estimated Mark Rate in Middle River to Observer Efficiency on Aerial-Counting Survey

Observer Efficiency	Mark Rate (Middle River Live Tags / Visual Count)		
20%	3.8%	5.2%	4.7%
40%	7.7%	10.5%	9.3%
60%	11.5%	15.7%	14.0%
80%	15.4%	20.9%	18.7%
100%	19.2%	26.1%	23.4%

Table 13. Detection efficiencies of fixed-station receivers in the Middle River, by species. Also shown: numbers of radio-tagged fish that were detected at each fixed-station receiver, and numbers known to have passed (i.e., detected at or upstream of the receiver). No terminal zones are included because detection efficiencies for these sites cannot be computed (there are no upstream detection zones). Only tags deployed from the Curry fishwheels are included. To be included in the 'detected' column, a fish had to be detected during its upstream movements (i.e., detections of fish moving downstream are not included).

	Chinook Salmon			Chum Salmon			Coho Salmon			Pink Salmon			Sockeye Salmon		
Receiver	Detect	Pass	DE (%)	Detect	Pass	DE (%)	Detect	Pass	DE (%)	Detect	Pass	DE (%)	Detect	Pass	DE (%)
Gateway	212	313	67.7	233	238	97.9	149	153	97.4	192	194	99.0	62	63	98.4
Slough 11	30	305	9.8	1	199	0.5	0	136	0.0	0	147	0.0	1	53	1.9
Indian River	226	303	74.6	179	198	90.4	124	136	91.2	134	147	91.2	45	53	84.9
Slough 21	26	230	11.3	0	121	0.0	0	70	0.0	0	71	0.0	1	47	2.1
Portage Creek	205	225	91.1	113	117	96.6	63	65	96.9	67	70	95.7	45	46	97.8
Cheechako Station	23	23	100.0	0	0	.	0	0	.	0	0	.	0	0	.
Chinook Creek	20	20	100.0	0	0	.	0	0	.	0	0	.	0	0	.
Devil Station	9	9	100.0	0	0	.	0	0	.	0	0	.	0	0	.

Table 14. Monitoring efficiency (percent operational) of fixed-station receivers in the Middle and Upper River in 2012, by week. 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; "-" = '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.

	Fixed-station Receiver											
Week	Lane Station ADFG	Lane Station LGL	Gateway	Slough 11	Indian River	Slough 21	Portage Creek	Cheechako Station	Chinook Creek	Devil Station ADFG	Devil Station LGL	Kosina Creek
6/11 - 6/17	-	44	92	100	-	-	-	-	-	-	-	-
6/18 - 6/24	70	100	95	100	88	-	25	100	100	100	-	-
6/25 - 7/1	100	100	100	100	91	100	98	100	100	100	-	100
7/2 - 7/8	99	100	100	100	20	100	24	100	100	99	-	100
7/9 - 7/15	100	100	100	100	79	100	80	100	100	98	-	100
7/16 - 7/22	100	100	100	100	100	86	100	100	100	100	100	100
7/23 - 7/29	100	60	100	100	100	100	100	100	100	100	100	100
7/30 - 8/5	95	64	100	99	87	100	67	100	100	100	100	100
8/6 - 8/12	100	100	95	100	67	100	88	100	100	100	100	100
8/13 - 8/19	100	100	100	100	81	100	100	100	100	100	100	100
8/20 - 8/26	100	100	100	100	100	100	100	100	100	100	100	100
8/27 - 9/2	100	93	73	100	100	100	100	100	100	81	68	100
9/3 - 9/9	100	100	100	-	100	-	100	100	63	100	100	100
9/10 - 9/16	100	60	22	-	100	-	100	100	-	-	-	-
9/17 - 9/23	100	100	88	-	79	-	54	100	-	-	-	-
9/24 - 9/30	100	100	100	-	93	-	50	100	-	-	-	-
10/1 - 10/7	100	100	100	-	100	-	100	100	-	-	-	-
10/8 - 10/14	100	100	100	-	100	-	100	100	-	-	-	-
10/15 - 10/21	100	100	100	-	100	-	100	64	-	-	-	-
10/22 - 10/28	-	-	-	-	-	-	-	100	-	-	-	-
10/29 - 11/4	-	-	-	-	-	-	-	100	-	-	-	-
11/5 - 11/11	-	-	-	-	-	-	-	100	-	-	-	-
11/12 - 11/18	-	-	-	-	-	-	-	100	-	-	-	-

Table 15. Monitoring efficiency (percent operational) of Lower River fixed-station receivers in 2012, by week. 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; "-" = '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.

	Fixed-station Receiver								
Week	Susitna Station	Lower Yentna	Upper Yentna	Skwentna River	Deshka Mouth	Deshka Weir	Sunshine Mouth	Talkeetna Station	Chulitna Station
4/30 - 5/6	-	-	-	-	-	-	-	-	-
5/7 - 5/13	100	100	-	-	-	-	-	-	-
5/14 - 5/20	100	100	-	-	100	100	100	-	-
5/21 - 5/27	100	100	-	-	100	100	100	100	100
5/28 - 6/3	100	100	-	-	100	100	100	100	100
6/4 - 6/10	100	100	100	100	100	100	100	100	100
6/11 - 6/17	100	100	100	100	100	100	100	100	100
6/18 - 6/24	100	100	100	100	100	100	100	100	100
6/25 - 7/1	100	100	100	100	100	100	100	100	100
7/2 - 7/8	100	100	100	100	100	100	100	100	100
7/9 - 7/15	100	100	100	100	100	100	100	100	100
7/16 - 7/22	100	100	100	100	100	100	100	100	100
7/23 - 7/29	100	100	100	100	100	100	100	100	100
7/30 - 8/5	100	100	100	100	100	100	100	100	100
8/6 - 8/12	100	100	100	100	100	100	100	100	100
8/13 - 8/19	100	100	100	38	100	100	100	100	100
8/20 - 8/26	100	100	100	0	100	100	100	100	100
8/27 - 9/2	100	100	100	0	100	100	100	100	100
9/3 - 9/9	100	100	100	0	100	100	100	80	100
9/10 - 9/16	100	100	100	0	100	100	100	26	100
9/17 - 9/23	-	-	100	0	-	-	100	55	100
9/24 - 9/30	-	-	100	0	-	-	100	-	100
10/1 - 10/7	-	-	100	0	-	-	-	-	100
10/8 - 10/14	-	-	-	-	-	-	-	-	-

Table 16. The numbers and proportions of tags that had malfunctioning mortality functions. Resurrections: some tags that changed from their mortality signal mode, in which they were supposed to be locked, to the live signal mode. Sensor failures: some tags failed to go into mortality when after being inactive for long periods of time. Results are shown separately for each model type.

	Tag Model		
	Small	Mid-sized	Large
Detected During LGL Mobile-tracks	179	505	375
Entered Mortality Mode	147	429	345
'Resurrection' Events	15	32	23
% Resurrections	10.2%	7.5%	6.7%
Remained in Live Mode	32	76	30
Likely dead fish with 'live' tags	3	0	1
% Sensor Failure	1.7%	0.0%	0.3%
Total Malfunctions	18	32	24
% Malfunctions	10.1%	6.3%	6.4%

Table 17. Destinations of radio-tagged fish by species and release location. Fish that did not enter tributaries and 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). 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).

	Chinook Salmon		Chum Salmon		Coho Salmon		Pink Salmon		Sockeye Salmon	
Classification	Lower River	Middle River	Lower River	Middle River	Lower River	Middle River	Lower River	Middle River	Lower River	Middle River
Tributary Destinations (total)	**360**	**286**	**283**	**175**	**326**	**122**	**372**	**154**	**99**	**10**
Alexander Creek	2	0	1	0	0	0	0	0	0	0
Yentna River	40	0	122	0	133	0	168	0	96	0
Deshka River	109	1	3	0	28	0	42	0	1	0
Willow Creek	19	0	14	0	3	0	13	0	0	0
Little Willow Creek	23	0	4	0	7	0	5	0	0	0
Kashwitna Creek	12	0	3	0	3	0	3	0	0	0
Goose Creek	2	0	1	0	6	0	0	0	0	0
Sheep Creek	10	0	3	0	2	0	0	0	0	0
Montana Creek	10	3	11	0	5	0	6	0	0	0
Rabideaux Creek	0	0	0	0	1	0	0	0	0	0
Talkeetna River	53	6	73	23	41	4	30	14	0	1
Chulitna River	60	13	33	4	91	7	99	2	2	3
Whiskers Creek	0	0	0	0	0	0	0	2	0	0
Unnamed trib (Zone 97)	0	0	0	0	1	1	0	0	0	0
Lane Creek	0	0	0	2	0	5	1	2	0	0
5th of July Creek	0	0	0	0	0	0	0	2	0	0
Sherman Creek	0	0	0	0	0	1	0	0	0	0
4th of July Creek	0	5	1	5	0	1	0	18	0	2
Gold Creek	0	1	0	0	0	0	0	0	0	0
Indian River	7	85	5	68	5	68	5	80	0	1
Jack Long Creek	0	1	0	0	0	13	0	0	0	0
Portage Creek	11	157	9	73	0	22	0	34	0	3
Cheechako Creek	0	6	0	0	0	0	0	0	0	0
Chinook Creek	0	3	0	0	0	0	0	0	0	0
Devil Creek	0	1	0	0	0	0	0	0	0	0
Kosina Creek	2	4	0	0	0	0	0	0	0	0

Table 17. Continued.

Classification	Chinook Salmon Lower River	Chinook Salmon Middle River	Chum Salmon Lower River	Chum Salmon Middle River	Coho Salmon Lower River	Coho Salmon Middle River	Pink Salmon Lower River	Pink Salmon Middle River	Sockeye Salmon Lower River	Sockeye Salmon Middle River
Mainstem Destinations (total)	**11**	**31**	**32**	**55**	**23**	**23**	**11**	**9**	**1**	**37**
Mainstem Proper	4	11	10	13	7	5	2	3	1	3
Downstream of Lane	*3*	*0*	*10*	*0*	*7*	*0*	*2*	*0*	*0*	*0*
Upstream of Lane	*1*	*11*	*0*	*13*	*0*	*5*	*0*	*3*	*1*	*3*
Tributary Mouths	2	18	3	8	3	10	6	3	0	4
Deshka River	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Willow Creek	*0*	*0*	*0*	*0*	*1*	*0*	*4*	*0*	*0*	*0*
Montana Creek	*0*	*0*	*1*	*0*	*1*	*0*	*2*	*0*	*0*	*0*
Talkeetna River	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*
Chulitna River	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
4th of July Creek	*0*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*
Indian River	*0*	*10*	*0*	*3*	*0*	*5*	*0*	*2*	*0*	*0*
Jack Long Creek	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Portage Creek	*0*	*7*	*0*	*4*	*0*	*4*	*0*	*1*	*0*	*4*
Side Channels & Sloughs	5	2	19	34	13	8	3	3	0	30
Slough 8A	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*5*
Slough 9	*0*	*0*	*0*	*3*	*0*	*0*	*0*	*1*	*0*	*3*
Slough 11	*0*	*0*	*0*	*5*	*0*	*1*	*0*	*0*	*0*	*9*
Slough 21	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*
Other areas	*5*	*2*	*19*	*24*	*13*	*7*	*3*	*2*	*0*	*13*
Other Classifications (total)	**71**	**35**	**85**	**49**	**50**	**39**	**18**	**67**	**0**	**23**
Other Mainstem	29	11	48	34	42	14	12	40	0	17
Max Zone downstream of Lane	*29*	*0*	*43*	*0*	*42*	*0*	*12*	*0*	*0*	*0*
Max Zone upstream of Lane	*0*	*11*	*5*	*34*	*0*	*14*	*0*	*40*	*0*	*17*
Downstream Only	32	6	6	7	0	13	0	22	0	5
Near Release Site	6	17	21	7	3	12	3	5	0	1
Not Detected	3	0	10	1	5	0	3	0	0	0
Tag Removed	1	1	0	0	0	0	0	0	0	0
Total Tags Released	442	352	400	279	399	184	401	230	100	70

Table 18. Summary of monitoring effort at potential spawning sites for Chinook salmon in the Middle River, 2012. River flows are in cubic feet per second.

Site #	Location	Habitat Type	Survey Date [1]	Survey Type	Fish Observed: None	Fish Observed: Holding	Fish Observed: Spawning	River Flow
1	5th of July Creek	Tributary Delta		Aerial/Boat Recon		Too Turbid To Assess		
2	Lane Creek - Gateway	Mainstem	06-Aug	Aerial/Boat Recon		Too Turbid To Assess		19,578
				Aerial	X			
3	4th of July Creek	Tributary Delta	20-Jul	Aerial		Too Turbid To Assess		17,320
			25-Jul	Boat Recon		Too Turbid To Assess		28,891
			28-Jul	Aquacoustics		X		22,132
4	Gateway - Slough 11	Mainstem		Aerial/Boat Recon		Too Turbid To Assess		
5	Gateway - Slough 11	Mainstem		Aerial/Boat Recon		Too Turbid To Assess		
			28-Jul	Aquacoustics		X		22,132
6	Gold Creek	Tributary Delta		Aerial/Boat Recon		Too Turbid To Assess		
			28-Jul	Aquacoustics	X			22,132
7	Slough 11 - Indian River	Mainstem		Aerial		Too Turbid To Assess		
8	Indian River	Tributary Delta		Aerial/Boat Recon		X		
9	Indian River - Slough 21	Mainstem		Aerial/Boat Recon		Too Turbid To Assess		
10	Indian River - Slough 21	Mainstem		Aerial/Boat Recon		Too Turbid To Assess		
			29-Jul	Aquacoustics		X		22,621
11	Slough 21 - Portage Creek	Mainstem		Aerial/Boat Recon		Too Turbid To Assess		
12	Slough 21 - Portage Creek	Mainstem		Aerial/Boat Recon		Too Turbid To Assess		
13	Portage Creek	Tributary Delta		Aerial/Boat Recon		X		

Notes:

[1] Blank cells indicate locations that were monitored on a regular basis, but fish were not observed or confirmed and specific dates of monitoring were not recorded. Most are turbid water locations.

Table 19. Summary of monitoring effort at potential spawning sites for chum salmon in the Middle River, 2012. River flows are in cubic feet per second.

Site #	Location	Habitat Type	Survey Date [1]	Survey Type	Fish Observed			River Flow
					None	Holding	Spawning	
1	Lane Creek - Gateway	Tributary Delta	01-Sep	Boat Recon		X		16,592
2	Slough 8C & 8D	Slough	06-Aug	Boat Recon	X			19,578
			07-Aug	Boat Recon	X			18,043
				Aerial	X			
3	Moose Slough	Slough		Aerial	X			
4	Lane Creek - Gateway	Mainstem		Aerial		Too Turbid To Assess		
5	Lane Creek - Gateway	Mainstem		Aerial		Too Turbid To Assess		
6	Slough 8A	Slough	13-Aug	Aerial	X			17,366
			16-Aug	Aerial	X			16,972
			22-Aug	Aerial		X	X	17,728
			26-Aug	HSC		X	X	15,408
			27-Aug	Aerial		Too Turbid To Assess		22,851
			03-Sep	Aerial		Too Turbid To Assess		17,173
7	Mainstem	Mainstem		Aerial		Too Turbid To Assess		
8	Slough 9	Slough	13-Aug	Aerial	X			17,366
			16-Aug	Aerial	X			16,972
			22-Aug	Aerial		X	X	17,728
			27-Aug	HSC		X	X	22,851
9	4th of July Creek	Tributary Delta	11-Aug	Boat Recon		X		17,397
			15-Aug	HSC		X	X	16,992
10	4th of July Slough	Slough	11-Aug	Boat Recon		X		17,397
			13-Aug	Aerial		X	X	17,366
			15-Aug	HSC		X	X	16,992
			27-Aug	Aerial		Too Turbid To Assess		22,851
11	Slough 9A	Slough	22-Aug	Aerial		X	X	17,728
			26-Aug	HSC		X	X	15,408
			27-Aug	Aerial	X			22,851
				Aerial	X			
12	Side Channel 11	Side Channel		Aerial		Too Turbid To Assess		
13	Slough 11	Slough	15-Aug	Boat Recon		X		16,992
			29-Aug	HSC		X	X	22,271

Table 19. Continued.

Site #	Location	Habitat Type	Survey Date [1]	Survey Type	Fish Observed None	Fish Observed Holding	Fish Observed Spawning	River Flow
14	Mainstem	Mainstem		Aerial		Too Turbid To Assess		
15	Indian River	Tributary Delta	11-Aug	Boat Recon		X		17,397
			26-Aug	HSC		X	X	15,408
			29-Aug	HSC		X	X	22,271
16	Slough 21	Slough	05-Aug	Aerial	X			21,966
			06-Aug	Aerial	X			19,578
			11-Aug	Boat Recon/HSC		X	X	17,397
17	Mainstem	Mainstem		Aerial		Too Turbid To Assess		
18	Mainstem	Mainstem		Aerial		Too Turbid To Assess		
19	Portage Creek	Tributary Delta		Aerial/Boat Recon		X		

Notes:

[1] Blank cells indicate locations that were monitored on a regular basis, but fish were not observed or confirmed and specific dates of monitoring were not recorded. Most are turbid water locations.

Table 20. Summary of monitoring effort at potential spawning sites for coho salmon in the Middle River, 2012. River flows are in cubic feet per second.

Site #	Location	Habitat Type	Survey Date [1]	Survey Type	Fish Observed: None	Fish Observed: Holding	Fish Observed: Spawning	River Flow
1	Lane Creek	Tributary Delta		Aerial/Boat Recon	X			
2	Moose Slough	Slough		Aerial	X			
3	Slough 8A	Slough	22-Aug	Aerial	X			17,728
			26-Aug	Boat Recon	X			15,408
			27-Aug	Aerial		Too Turbid To Assess		22,851
				Aerial	X			
4	Gateway - Slough 11	Mainstem		Aerial		Too Turbid To Assess		
5	4th of July Slough	Slough	27-Aug	Aerial		Too Turbid To Assess		22,851
				Aerial		Too Turbid To Assess		
6	Gateway - Slough 11	Mainstem		Aerial		Too Turbid To Assess		
7	Indian River	Tributary Delta	26-Aug	Boat Recon	X			15,408
			29-Aug	Boat Recon	X			22,271
				Aerial		X		
8	Slough 21 - Portage Creek	Mainstem		Aerial		Too Turbid To Assess		
9	Slough 21 - Portage Creek	Mainstem		Aerial		Too Turbid To Assess		
10	Portage Creek	Tributary Delta		Aerial/Boat Recon	X			

Notes:

[1] Blank cells indicate locations that were monitored on a regular basis, but fish were not observed or confirmed and specific dates of monitoring were not recorded. Most are turbid water locations.

Table 21. Summary of monitoring effort at potential spawning sites for pink salmon in the Middle River, 2012. River flows are in cubic feet per second.

		Habitat	Survey	Survey	Fish Observed			River
Site #	Location	Type	Date [1]	Type	None	Holding	Spawning	Flow
1	5th of July Creek	Trubtary Delta		Aerial	X			
2	Slough 9	Slough	13-Aug	Aerial	X			17,366
			16-Aug	Aerial	X			16,972
			22-Aug	Aerial	X			17,728
			27-Aug	Boat Recon	X			22,851
			29-Aug	Boat Recon	X			22,271
3	4th of July Creek	Trubtary Delta	11-Aug	Boat Recon		X		17,397
			15-Aug	Boat Recon		X		16,992
				Aerial		X		
4	Slough 11	Slough	15-Aug	Boat Recon	X			16,992
			29-Aug	Boat Recon	X			22,271
5	Indian River	Trubtary Delta	11-Aug	Boat Recon		X		17,397
			26-Aug	Boat Recon		X		15,408
			29-Aug	Boat Recon	X			22,271
6	Portage Creek	Trubtary Delta		Aerial/Boat Recon		X		

Notes:

[1] Blank cells indicate locations that were monitored on a regular basis, but fish were not observed or confirmed and specific dates of monitoring were not recorded. Most are turbid water locations.

Table 22. Summary of monitoring effort at potential spawning sites for sockeye salmon in the Middle River, 2012. River flows are in cubic feet per second.

Site #	Location	Habitat Type	Survey Date [1]	Survey Type	Fish Observed: None	Fish Observed: Holding	Fish Observed: Spawning	River Flow
1	Moose Slough	Slough		Aerial	X			
2	Slough 8A	Slough	13-Aug	Aerial		Too Turbid to Assess		17,366
			16-Aug	Aerial		Too Turbid to Assess		16,972
			22-Aug	Aerial		X	X	17,728
			26-Aug	HSC		X	X	15,408
			27-Aug	Aerial		Too Turbid to Assess		22,851
			03-Sep	Aerial		Too Turbid to Assess		17,173
3	Lane Creek - Gateway	Mainstem		Aerial		Too Turbid to Assess		
4	Slough 9	Slough	13-Aug	Aerial	X			17,366
			16-Aug	Aerial	X			16,972
			22-Aug	Aerial		X	X	17,728
			27-Aug	HSC		X	X	22,851
5	Slough 10	Slough	11-Aug	Recon	X			17,397
			22-Aug	Aerial		X		17,728
			27-Aug	Recon	X			22,851
6	Side Channel 11	Side Channel		Aerial		Too Turbid to Assess		
7	Slough 11	Slough	15-Aug	Recon		X		16,992
			29-Aug	HSC		X	X	22,271
8	Slough 19	Slough		Aerial	X			
			09-Sep	Aerial		X	X	13,283
			18-Sep	Aerial		Too Turbid to Assess		20,719
9	Slough 20	Slough		Aerial	X			
10	Side Channel 21	Side Channel		Aerial		Too Turbid to Assess		
			09-Sep	Aerial		X	X	13,283
			18-Sep	Aerial		Too Turbid to Assess		20,719
11	Slough 21 - Portage	Mainstem		Aerial		Too Turbid to Assess		
12	Portage Creek	Tributary Delta		Aerial/Recon	X			
13	Portage - Impediment 1	Mainstem		Aerial	X			

Notes:

[1] Blank cells indicate locations that were monitored on a regular basis, but fish were not observed or confirmed and specific dates of monitoring were not recorded. Most are turbid water locations.

Table 23. Salmon displaying roaming behavior in the Middle River. These were radio-tagged fish of known destination that passed Lane Creek (for released in the Lower River, top panel) or Gateway (for fish released at Curry, bottom panel), then subsequently returned downstream to enter a tributary. See Table 17 for further details about classifications of fish destinations.

Tagged in Lower River

Classification / Destination	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon
Reached Lane Station	24	25	6	11	3
Unknown Classification	0	5	0	0	0
Tag removed	1	0	0	0	0
Known Destination (a)[1]	23	20	6	11	3
Mid/Upper-Susitna Tributary	19	15	5	6	0
Mid/Upper-Susitna Mainstem	1	2	0	0	1
Returned Downstream (b)[1]	3	3	1	5	2
Chulitna River	*2*	*0*	*1*	*4*	*2*
Talkeetna River	*0*	*3*	*0*	*1*	*0*
Montana Creek	*1*	*0*	*0*	*0*	*0*
Proportion Roaming (c)1	13.0%	15.0%	16.7%	45.5%	66.7%

Tagged at Curry

Classification / Destination	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon
Tagged at Curry	352	279	184	230	70
Other Classifications (from Table 17)	35	49	39	67	23
Other Mainstem	11	34	14	40	17
Downstream Only	6	7	13	22	5
Near Release Site	17	7	12	5	1
Not Detected	0	1	0	0	0
Tag removed	1	0	0	0	0
Known Destination (a)[1]	317	230	145	163	47
Susitna Trib. above Gateway	263	146	105	134	6
Susitna Mainstem above Gateway	31	55	23	9	37
Returned Downstream (b)[1]	23	29	17	20	4
Lane Creek	*0*	*2*	*5*	*2*	*0*
Chulitna River	*13*	*4*	*7*	*2*	*3*
Talkeetna River	*6*	*23*	*4*	*14*	*1*
Whiskers Creek	*0*	*0*	*0*	*2*	*0*
Trib, Zone 97	*0*	*0*	*1*	*0*	*0*
Montana Creek	*3*	*0*	*0*	*0*	*0*
Deshka River	*1*	*0*	*0*	*0*	*0*
Proportion Roaming (c)1	7.3%	12.6%	11.7%	12.3%	8.5%

Notes:

[1] c = b / a

Table 24. Farthest upstream detection locations for radio-tagged fish that eventually entered a tributary downstream of Lane (for fish released in the Lower River, top panel) or Gateway (for fish released at Curry, bottom panel).

Tagged in Lower River

Farthest Upstream Location	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon
Near Indian River	1	0	0	1	0
Slough 11	0	0	0	0	1
4th of July	0	0	0	0	1
Curry	1	0	0	0	0
Lane Station	1	3	1	4	0
Total number that reached Lane Station, then entered downriver tributary	3	3	1	5	2

Tagged at Curry

Farthest Upstream Location	Chinook Salmon	Chum Salmon	Coho Salmon	Pink Salmon	Sockeye Salmon
Portage Creek mouth	4	2	2	3	3
Indian River mouth	2	1	3	0	0
4th of July	1	0	0	0	0
Gateway	2	5	7	9	0
Total number that reached Gateway, then entered downriver tributary	9	8	12	12	3

Table 25. Minimum, median and maximum dates of fishwheel and fixed-station receiver passage, by species. Only fish radio-tagged at the Curry fishwheels are included. Receivers at Slough 11 and Slough 21 detected few fish and are not included.

	Middle River Fishwheels	Gateway	Indian River	Portage Creek	Cheechako Station	Chinook Creek	Devil Station	Kosina Creek
Chinook Salmon								
Minimum	18-Jun	19-Jun	20-Jun	23-Jun	7-Jul	7-Jul	17-Jul	19-Jul
Median	2-Jul	4-Jul	7-Jul	8-Jul	15-Jul	16-Jul	19-Jul	21-Jul
Maximum	2-Aug	27-Aug	17-Oct	3-Oct	20-Jul	20-Jul	6-Aug	23-Jul
Chum Salmon								
Minimum	10-Jul	13-Jul	14-Jul	17-Jul				
Median	4-Aug	6-Aug	7-Aug	8-Aug				
Maximum	26-Aug	20-Sep	13-Sep	3-Oct				
Coho Salmon								
Minimum	31-Jul	2-Aug	4-Aug	7-Aug				
Median	13-Aug	14-Aug	16-Aug	16-Aug				
Maximum	31-Aug	7-Sep	13-Sep	17-Sep				
Pink Salmon								
Minimum	16-Jul	26-Jul	27-Jul	30-Jul				
Median	5-Aug	5-Aug	6-Aug	8-Aug				
Maximum	22-Aug	25-Aug	17-Sep	16-Aug				
Sockeye Salmon								
Minimum	2-Jul	6-Jul	7-Jul	5-Jul				
Median	1-Aug	4-Aug	4-Aug	5-Aug				
Maximum	20-Aug	22-Aug	26-Aug	28-Aug				

Table 26. Sites visited during assessment of sonar to identify Chinook salmon spawning locations in turbid water.

Location	River Mile	Sonar Type	Turbidity	Fish Observed?	Notes
Site 1	123.8	n/a	n/a	n/a	Could not access
Site 2 - Fourth of July	131.1	DIDSON/Side-scan	Some clear water	Yes	
Site 3	132.5	n/a	n/a	n/a	Could not access
Site 4	134.0	DIDSON/Side-scan	Very turbid	Yes	
Site 5 - Gold Creek	137.0	DIDSON	Very turbid	No	
Site 6	142.0	DIDSON	Very turbid	Yes	

Table 27. Details of the fish that approached or passed the Middle River impediments. Fish characteristics include 'tag numbers' (unique numbers assigned to each individual radio-tagged fish), species (CN = Chinook salmon, CM = Chum salmon, SO = Sockeye salmon), capture and release site ('Left' and 'Right Bank' fishwheels were near Curry), capture date, fork length (except for fish tagged in the Lower River, which had mid eye to fork (MEF) measurements) and sex. Tracking details include the date of first detections above each impediment, and a comment about the general conclusion of the fish. Top panel: fish that passed Impediment 3. Second panel: fish that passed Impediment 2, but not Impediment 3. Third panel: fish that passed Impediment 1, but not Impediment 2. Bottom panel: fish that approached within 1 km of Impediment 1, but did not pass.

Fish that Passed I3

Tag Number	Species	Capture/ Release Fishwheel	Capture Date	Length (FL cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
27	CN	Left Bank	22-Jun	78	Undetermined	15-Jul	16-Jul	18-Jul	In Chinook Creek late Jul - early Aug
52	CN	Right Bank	25-Jun	89	Undetermined	7-Jul	7-Jul	17-Jul	Died in Kosina Creek
94	CN	Right Bank	29-Jun	81	Undetermined	8-Jul	12-Jul	17-Jul	In Devils Creek 19 Jul - 8 Aug
104	CN	Left Bank	29-Jun	66	Undetermined	18-Jul	18-Jul	20-Jul	Died in Portage Creek
113	CN	Left Bank	30-Jun	84	Undetermined	15-Jul	15-Jul	19-Jul	Died in Tsisi Creek
219	CN	Right Bank	2-Jul	73	Male	15-Jul	16-Jul	19-Jul	Died in Kosina Creek
246	CN	Left Bank	3-Jul	85	Female	13-Jul	14-Jul	20-Jul	Died in Kosina Creek
257	CN	Left Bank	3-Jul	89	Female	15-Jul	16-Jul	20-Jul	In Portage since 30 Jul
266	CN	Right Bank	4-Jul	101	Male	15-Jul	16-Jul	19-Jul	Died in Portage Creek
359	CN	Right Bank	6-Jul	93	Male	12-Jul	12-Jul	17-Jul	In Devils Creek 23-31 Jul, Died in Portage Creek
5005	CN	Lower River	26-May	-	Undetermined	17-Jul	17-Jul	17-Jul	In Kosina Creek 23 Jul - 7 Aug
5019	CN	Lower River	28-May	94.7	Undetermined	9-Jul	17-Jul	18-Jul	Died in Kosina Creek

Table 27. Continued.

Tag Number	Species	Capture/ Release Fishwheel	Capture Date	Length (FL cm)	Sex	First Detection Above I-1	First Detection Above I-2	First Detection Above I-3	Comments
Fish That Passed I2 but not I3									
16	CN	Right Bank	21-Jun	69	Male	17-Jul	18-Jul	-	Died in Cheechako Creek
48	CN	Left Bank	24-Jun	87	Undetermined	7-Jul	7-Jul	-	Died at mouth of Cheechako
71	CN	Right Bank	27-Jun	55	Undetermined	15-Jul	15-Jul	-	In Chinook Creek 5-11 Aug
159	CN	Right Bank	1-Jul	57	Undetermined	18-Jul	19-Jul	-	In Chinook Cr. (23-28 Jul) then died in Cheechako
264	CN	Left Bank	3-Jul	94	Female	13-Jul	14-Jul	-	Died at mouth of Cheechako
313	CN	Right Bank	5-Jul	90	Female	18-Jul	18-Jul	-	Died in Cheechako Creek
397	CN	Right Bank	7-Jul	92	Female	18-Jul	18-Jul	-	Died in Chinook Creek
416	CN	Left Bank	7-Jul	68	Undetermined	20-Jul	20-Jul	-	In Chinook Cr. (31 Jul-7 Aug) then died in Portage Cr
459	CN	Left Bank	10-Jul	63	Undetermined	19-Jul	19-Jul	-	In Cheechako Cr. (31 Jul) then in Portage Cr.
494	CN	Left Bank	12-Jul	86	Undetermined	17-Jul	17-Jul	-	Died in Susitna upstream of Cheechako mouth
Fish That Passed I1 but not I2									
119	CN	Left Bank	30-Jun	99	Male	17-Jul	-	-	Died in Cheechako Creek
152	CN	Right Bank	1-Jul	67	Undetermined	15-Jul	-	-	Died in Portage Creek
161	CN	Right Bank	1-Jul	58	Undetermined	20-Jul	-	-	Died in Cheechako Creek
5041	CN	Lower River	30-May	63.9	Undetermined	17-Jul	-	-	Held downstream of Cheech. Stn from 17 Jul-9 Aug
Fish That Approached I1 but didn't pass									
2	CN	Right Bank	19-Jun	61	Female	-	-	-	Died in Portage Creek
91	CN	Left Bank	28-Jun	59	Undetermined	-	-	-	Died in Portage Creek
297	CN	Right Bank	5-Jul	63	Undetermined	-	-	-	Entered Indian River
302	CN	Right Bank	5-Jul	93	Male	-	-	-	Died in Portage Creek
475	CN	Right Bank	11-Jul	68	Male	-	-	-	Approached mouth of Indian, died in Portage Creek
486	CN	Right Bank	12-Jul	95	Undetermined	-	-	-	Died in Portage Creek
504	CN	Right Bank	13-Jul	91	Undetermined	-	-	-	Died in Portage Creek
508	CN	Left Bank	13-Jul	64	Undetermined	-	-	-	Died in Indian River
509	CN	Left Bank	13-Jul	91	Female	-	-	-	Died in Portage Creek
624	CM	Left Bank	26-Jul	67	Male	-	-	-	Entered Portage Creek, left
742	SO	Left Bank	29-Jul	62	Female	-	-	-	Held between I1 and Portage. Potential MS Spawner
5014	CN	Lower River	28-May	57.3	Undetermined	-	-	-	Died in Portage Creek

Table 28. Destinations of radio-tagged Chinook salmon that passed each impediment. An "I" refers to "impediment".

	Passed I1 but not I2	Passed I2 but not I3	Passed I3	Total
Classification				
Tributary Destinations				
Portage Creek	1	2	4	7
Cheechako Creek	2	5		7
Chinook Creek		2	1	3
Devil Creek			1	1
Kosina Creek			6	6
Mainstem Destinations				
Near Cheechako	1	1		2
Total	4	10	12	26
Downstream from Impediment				
Number	1	7	5	13
Percent	25%	70%	42%	50%

Table 29. Summary of migration and spawning behavior for 12 radio-tagged Chinook salmon after they passed Impediment 3. Distances are in kilometers.

					Spawning Period			Explorations before Spawning			Downstream After Spawning		
Tag Number	Capture Date	Length (TL cm)	Sex	Spawning Area	First Live	Last Live	Days	Max Upstream Location	Max Upstream Distance	Days	Max Downstream Location	Max Downstream Distance	Days
27	22-Jun	78	Undetermined	Chinook	28-Jul	05-Aug	8	Kosina	80	11	Curry	60	8
52	25-Jun	89	Undetermined	Kosina	20-Jul	09-Aug	20						
94	29-Jun	81	Undetermined	Devil	23-Jul	05-Aug	13	Fog	30	4	Cheechako	19	12
104	29-Jun	66	Undetermined	Portage	24-Jul	30-Jul	6	Above Devil	30	10			
113	30-Jun	84	Undetermined	Kosina	26-Jul	07-Aug	12						
219	2-Jul	73	Male	Kosina	23-Jul	26-Jul	3	Above Kosina	30	1			
246	3-Jul	85	Female	Kosina	23-Jul	26-Jul	3						
257	3-Jul	89	Female	Portage	30-Jul	17-Aug	18	Devil	24	13			
266	4-Jul	101	Male	Portage	24-Jul	06-Aug	13	Near Fog	44	15			
359	6-Jul	93	Male	Portage	06-Aug	11-Aug	5	Kosina	93	26			
5005	26-May	-	Undetermined	Kosina	23-Jul	31-Jul	8				Portage	103	16
5019	28-May	87 MEF	Undetermined	Kosina	23-Jul	11-Aug	19						
Average					25-Jul	05-Aug	11		47	11		61	12

Notes:

[1] Total days the fish was alive after passing Impediment 3.

Table 30. Details of impediment-passage events. Details include the date of first detections above each impediment, the duration of holding time below each impediment, and the flow (measured at Gold Creek) at the time of the first detection upstream of the impediment. When single detections were made downstream of an impediment, hold times were estimated from the timing of adjacent detections (i.e., time below impediment must have been less than the time between two adjacent detections away from the impediments). "d.n.a" = Did not approach next upstream impediment. Top panel: fish that passed Impediment 3. Second panel: fish that passed Impediment 2, but not Impediment 3. Third panel: fish that passed Impediment 1, but not Impediment 2. Bottom panel: fish that approached within 1 km of Impediment 1, but did not pass. See Table 17 for details of each fish and its destination.

Fish that Passed I3

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)
27	15-Jul	16-Jul	18-Jul	2.2	0.3	1.4	18,608	19,252	17,774
52	7-Jul	7-Jul	17-Jul	2.0	0.2	9.6	21,302	21,302	19,042
94	8-Jul	12-Jul	17-Jul	2.5	3.4	0.1	26,550	20,060	19,042
104	18-Jul	18-Jul	20-Jul	1.3	0.2	1.1	17,774	17,774	17,320
113	15-Jul	15-Jul	19-Jul	6.8	0.2	1.9	18,608	18,608	17,407
219	15-Jul	16-Jul	19-Jul	2.4	0.3	0.5	18,608	19,252	17,407
246	13-Jul	14-Jul	20-Jul	7.9	0.6	1.1	18,755	18,275	17,320
257	15-Jul	16-Jul	20-Jul	4.3	0.3	1.1	18,608	19,252	17,320
266	15-Jul	16-Jul	19-Jul	5.3	0.8	0.5	18,608	19,252	17,407
359	12-Jul	12-Jul	17-Jul	3.1	0.3	4.5	20,060	20,060	19,042
5005	17-Jul	17-Jul	17-Jul	11.7	0.0	0.1	19,042	19,042	19,042
5019	9-Jul	17-Jul	18-Jul	3.8	7.9	1.3	31,067	19,042	17,774
Average	13 Jul	14 Jul	18 Jul	4.4	1.2	1.9	20,633	19,264	17,991

Table 30. Continued.

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)
Fish That Passed I2 but not I3									
16	17-Jul	18-Jul	-	0.0	0.3	5.9	19,042	17,774	-
48	7-Jul	7-Jul	-	1.3	0.3	22.1	21,302	21,302	-
71	15-Jul	15-Jul	-	5.6	0.3	14.1	18,608	18,608	-
159	18-Jul	19-Jul	-	1.4	0.3	< 1.4	17,774	17,407	-
264	13-Jul	14-Jul	-	4.4	0.4	14.1	18,755	18,275	-
313	18-Jul	18-Jul	-	0.7	0.4	7.1	17,774	17,774	-
397	18-Jul	18-Jul	-	0.7	0.3	4.1	17,774	17,774	-
416	20-Jul	20-Jul	-	1.1	0.2	5.0	17,320	17,320	-
459	19-Jul	19-Jul	-	0.8	0.3	5.9	17,407	17,407	-
494	17-Jul	17-Jul	-	2.7	0.0	d.n.a.	19,042	19,042	-
Average	16 Jul	16 Jul		1.9	0.3	9.8	18,480	18,268	
Fish That Passed I1 but not I2									
119	17-Jul	-	-	6.4	d.n.a.	-	19,042	-	-
152	15-Jul	-	-	2.0	d.n.a.	-	18,608	-	-
161	20-Jul	-	-	0.6	d.n.a.	-	17,320	-	-
5041	17-Jul	-	-	4.0	d.n.a.	-	19,042	-	-
Average	17 Jul			3.2			18,503		

Table 31. Average percent distribution of spawning salmon in slough habitats of the Middle River from 1981–1985, and confirmation of spawning in 2012. An "X" indicates a confirmed spawning location.

	River	1981-1985 Percent Distribution[1]			2012 Confirmed Spawning		
Slough	Mile	Sockeye	Chum	Pink	Sockeye	Chum	Pink
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	
B	126.3	0.8	2.3	2.1			
9	128.3	0.6	8.9	1.9	X	X	
9B	129.2	1.9	1.2	-			
9A	133.8	0.1	6.0	-		X	
10	133.8	0.1	0.2	-			
11	135.3	65.6	20.9	17.6	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			
21	141.1	13.2	22.1	4.5	X	X	
22	144.5	0.1	3.7	-			
21A	145.3	-	0.1	-			
Total Fish Count (1981-85)		4,252	15,827	1,639			

Notes:

[1] 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)

Table 32. Sites sampled for habitat suitability criteria data in the Middle River, 2012. Values indicate the number or redds sampled at each location.

	Salmon Species				
Mainstem Habitat Type	**Chinook**	**Sockeye**	**Pink**	**Chum**	**Coho**
Slough					
Slough 21	0	* [1]	0	7	0
Slough 20	0	0	0	0	0
Slough 19	0	* [1]	0	0	0
Slough 11	0	4	0	4	0
4th of July Slough	0	0	0	10	0
Slough 9A	0	0	0	5	0
Slough 9	0	3	0	1	0
Slough 8A	0	4	0	1	0
Slough 10	0	0	0	0	0
Total	0	11	0	28	0
Tributary Delta					
Indian River	0	0	0	3	0
4th of July Creek	0	0	0	1	0
Total	0	0	0	4	0
Side Channel					
Side Channel 21	0	0	0	* [1]	0
Main Channel	0	0	0	0	0
Grand Total	0	11	0	32	0

Notes:

[1] asterisks indicate a location visually confirmed as a spawning habitat, but not sampled for HSC.

FIGURES

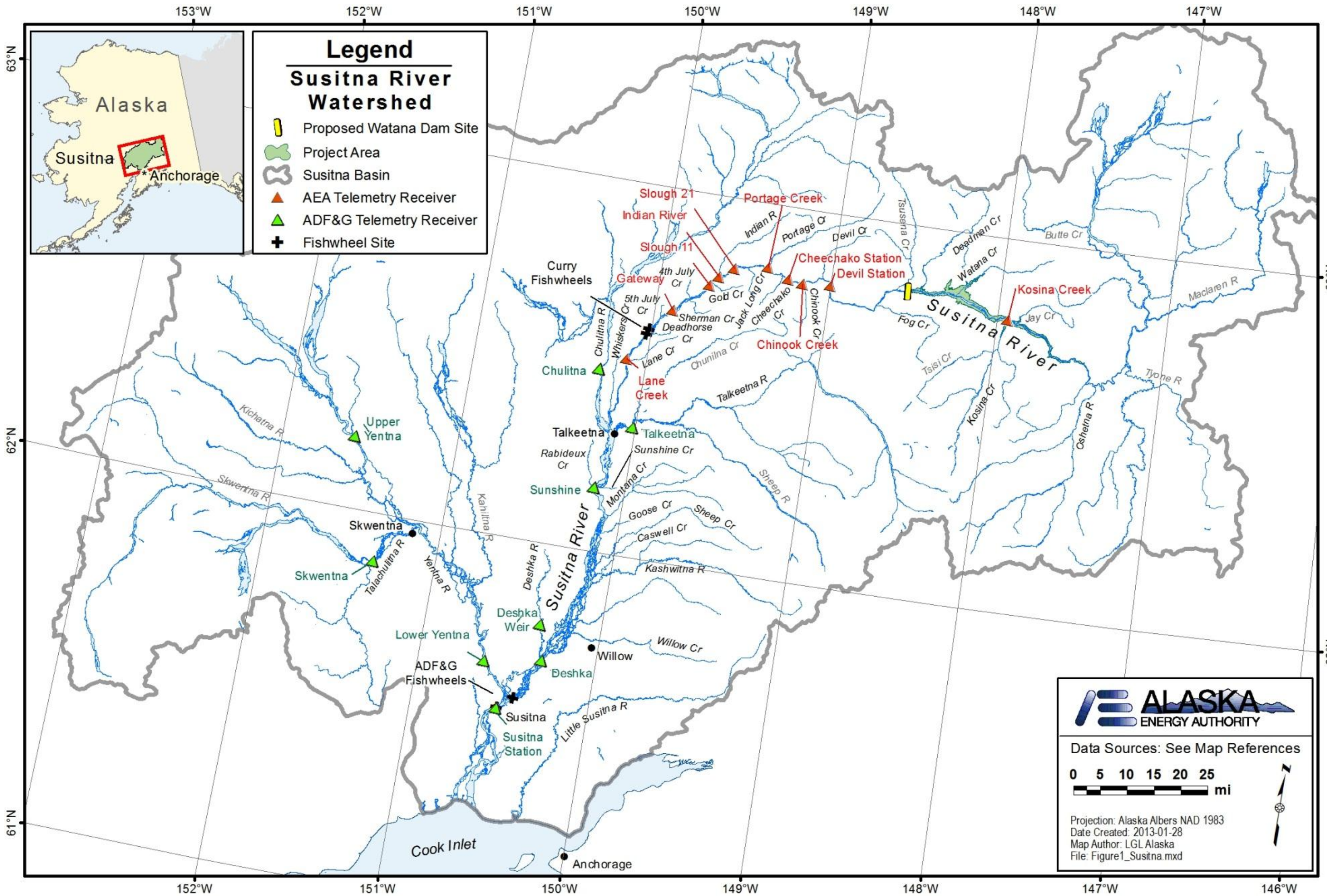


Figure 1. Susitna River watershed showing fish capture sites (ADF&G and Curry fishwheels), fixed-station receivers, and the proposed reservoir area for the Susitna-Watana Hydroelectric Project.

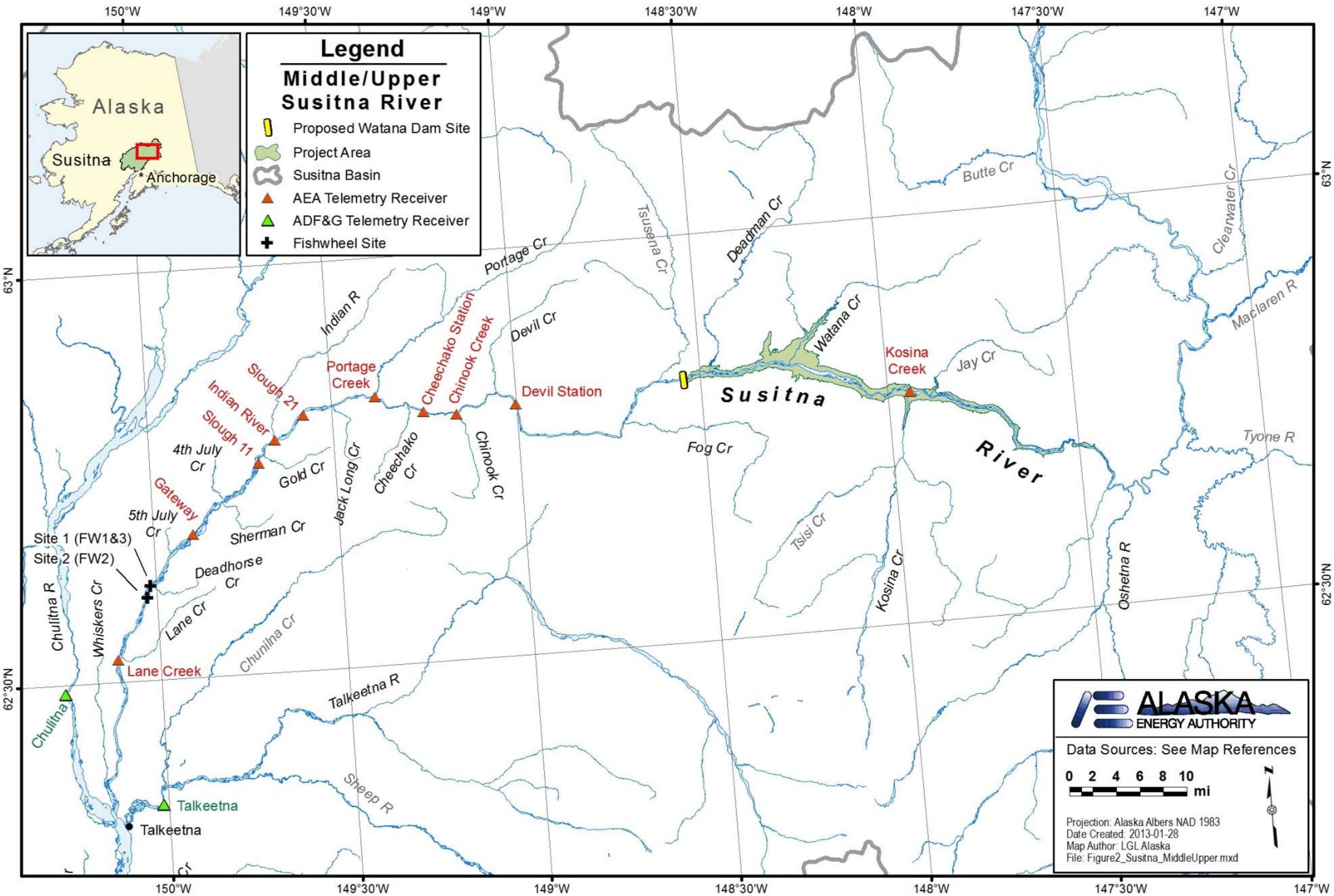


Figure 2. Middle and Upper River segments showing fish capture sites (sites 1 and 2), fixed-station receivers, and the proposed reservoir area for the Susitna-Watana Hydroelectric Project. Fishwheels 1 and 3, as well as a shore-based DIDSON unit, were operated at Site 1; Fishwheel 2 was operated at Site 2.

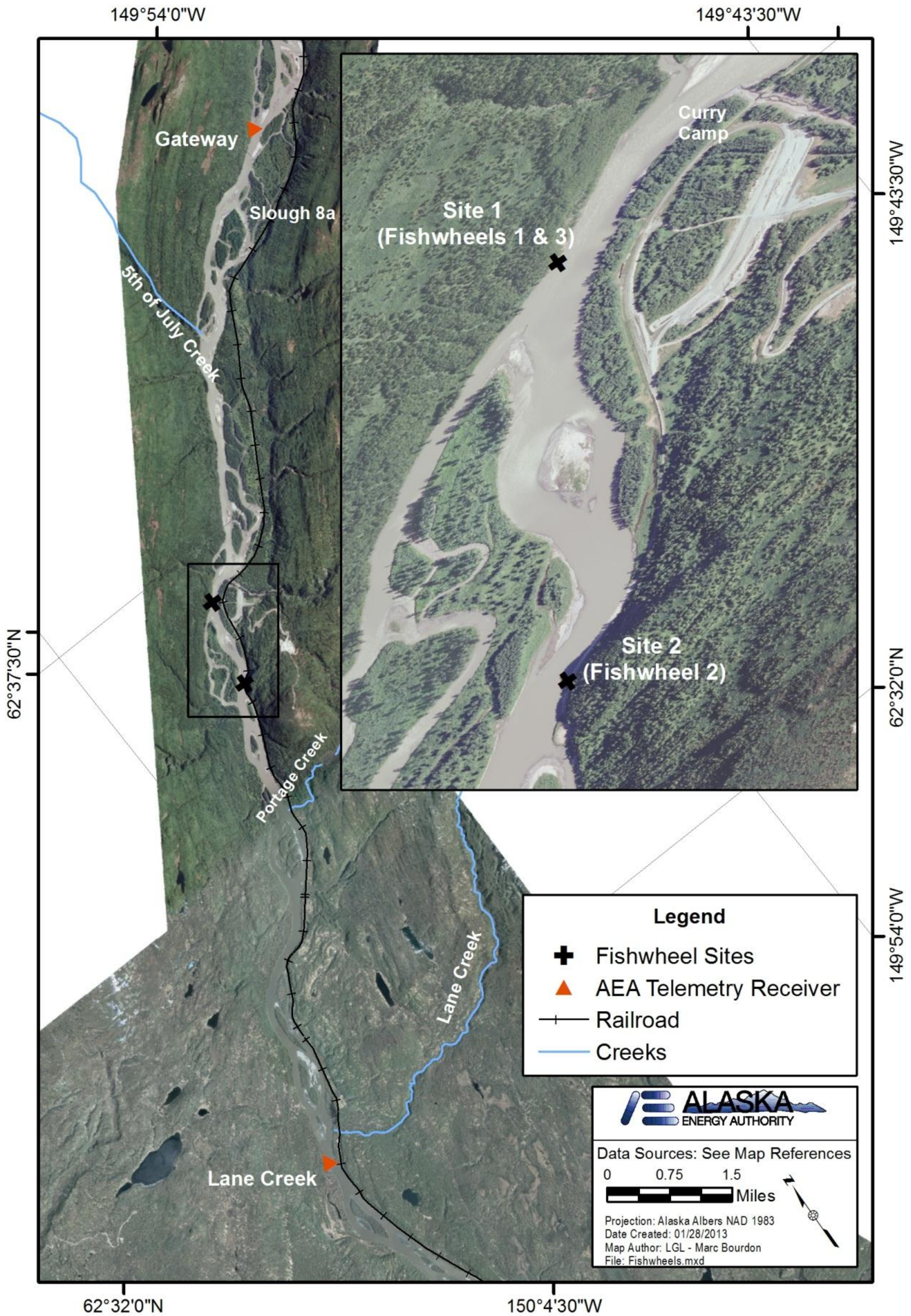


Figure 3. Middle River Segment showing fish capture sites (sites 1 and 2), the Lane Creek and Gateway fixed-station receivers, and the camp site in Curry. Fishwheels 1 and 3, as well as a shore-based DIDSON unit, were operated at Site 1; Fishwheel 2 was operated at Site 2.

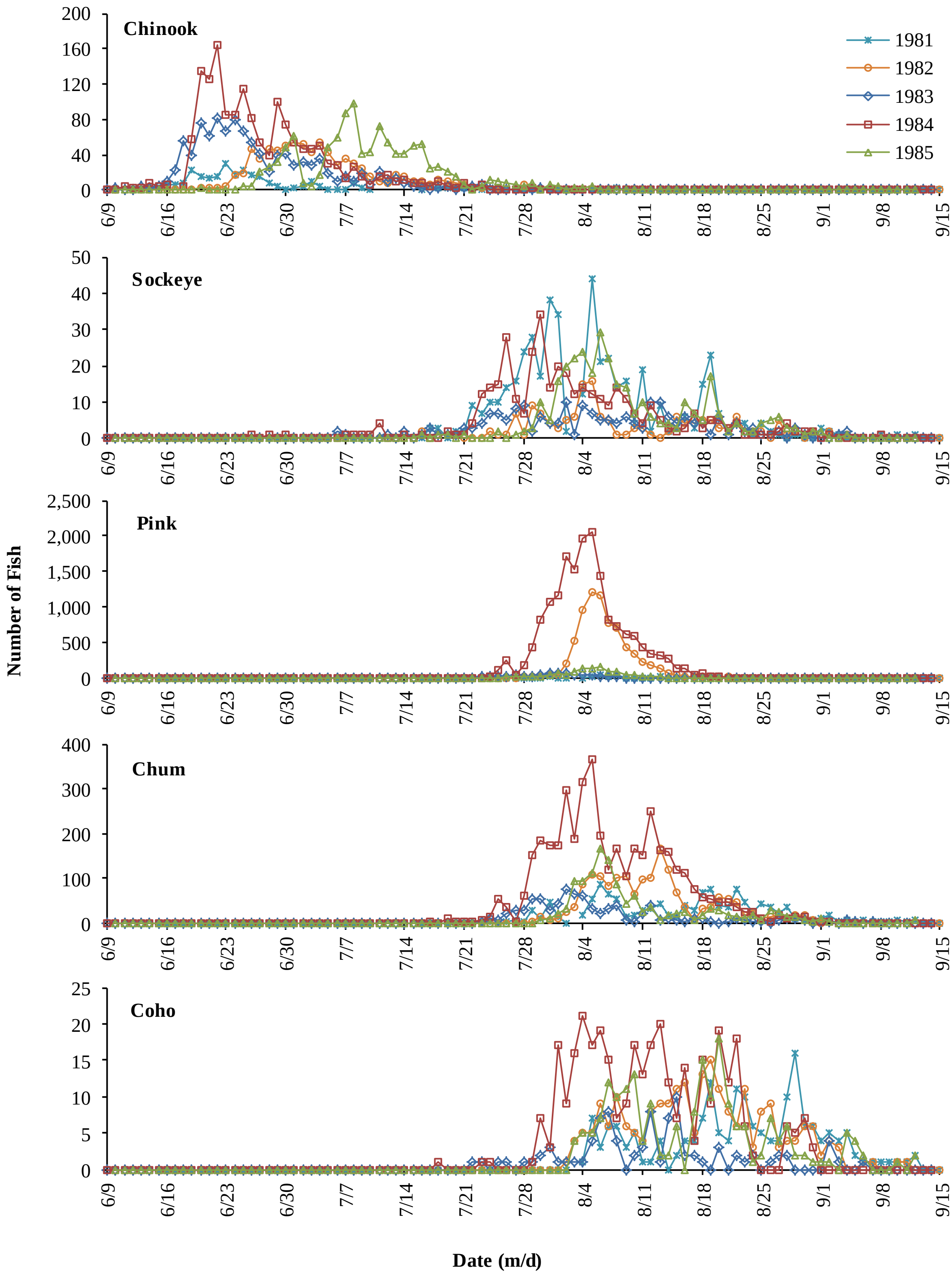


Figure 4. Daily catch by species at the Curry fishwheels (east and west bank combined), 1981–1985.

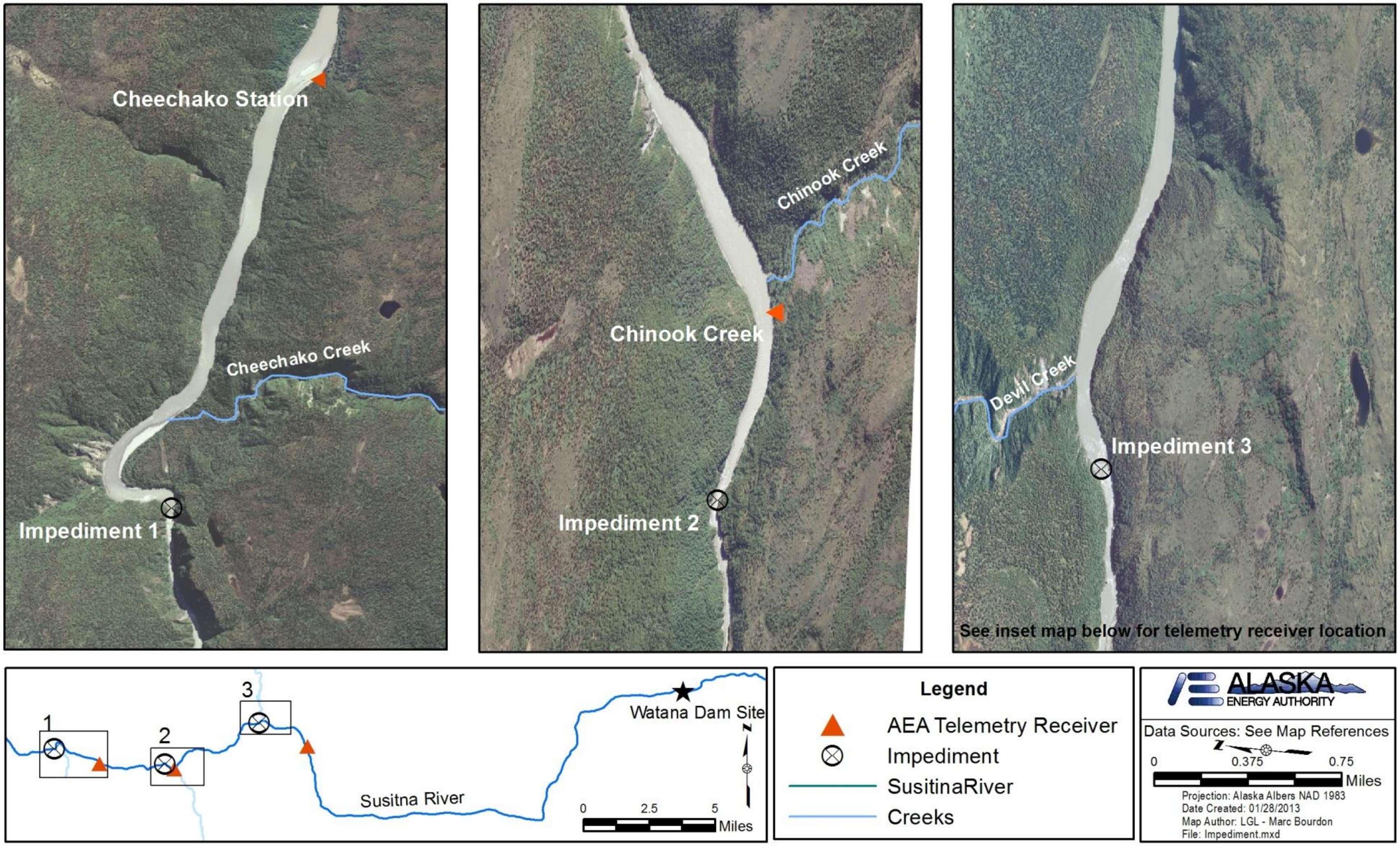


Figure 5. Three potential impediments (impediments 1, 2, and 3) to fish passage on the Susitna River located between Portage and Devil creeks at the top end of the Middle River Segment.

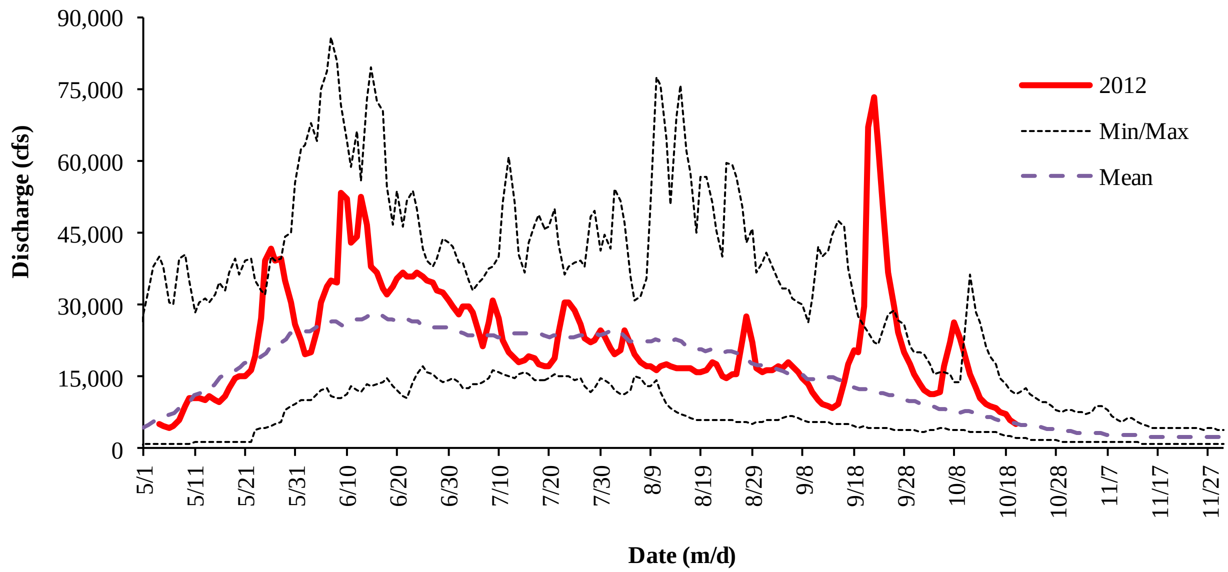


Figure 6. Average daily discharge of the Susitna River at Gold Creek (RM 136), May 1 to November 30, 2012. Historical (1949–2011) minimum, maximum, and mean data are also shown.

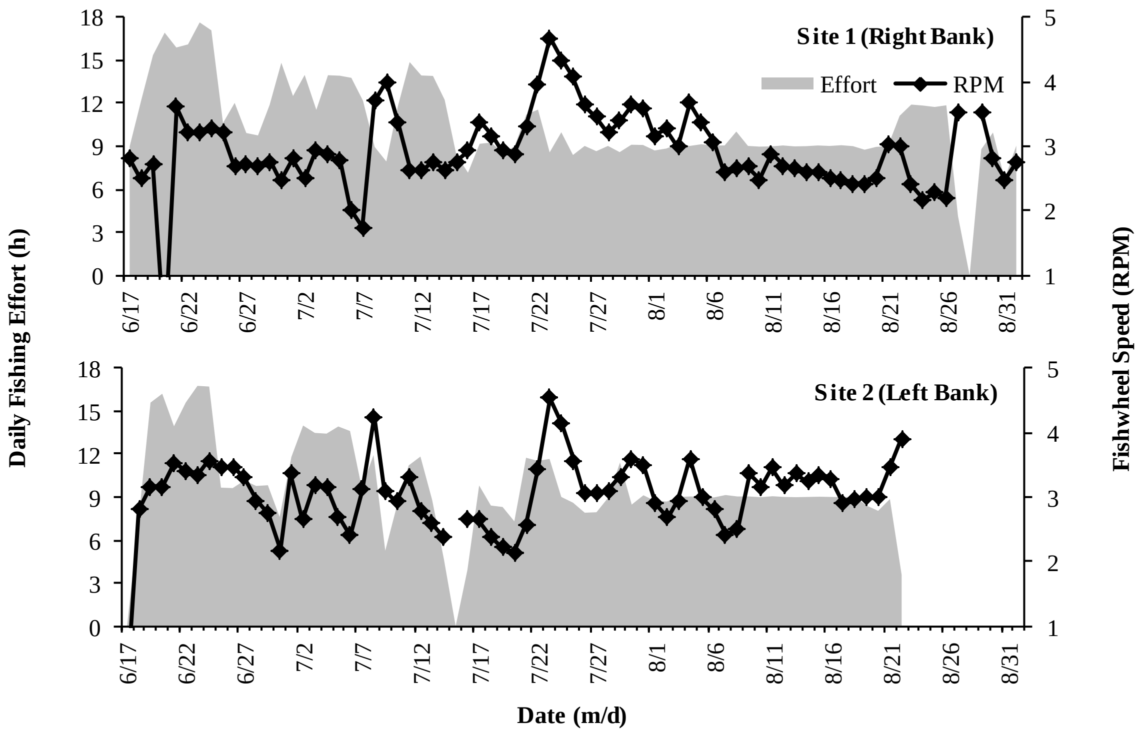


Figure 7. Daily fishing effort (hours) and fishwheel speed (RPM) for the fishwheels operated near Curry on the Susitna River, 2012.

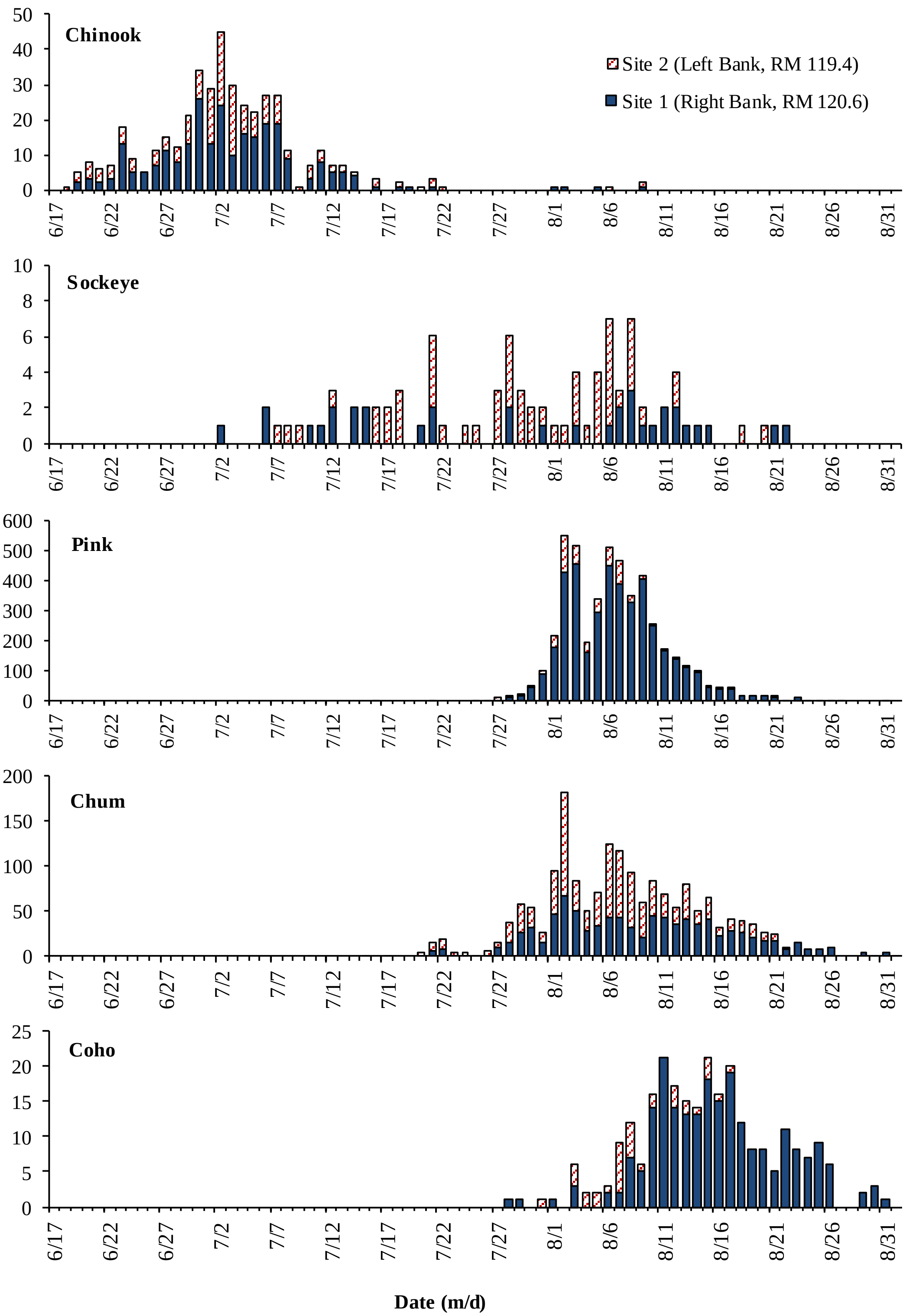


Figure 8. Daily catch of adult salmon at the fishwheels operated near Curry on the Susitna River, 2012. Recaptures were included in these data; however, jacks were excluded. Y-axis is numbers of fish.

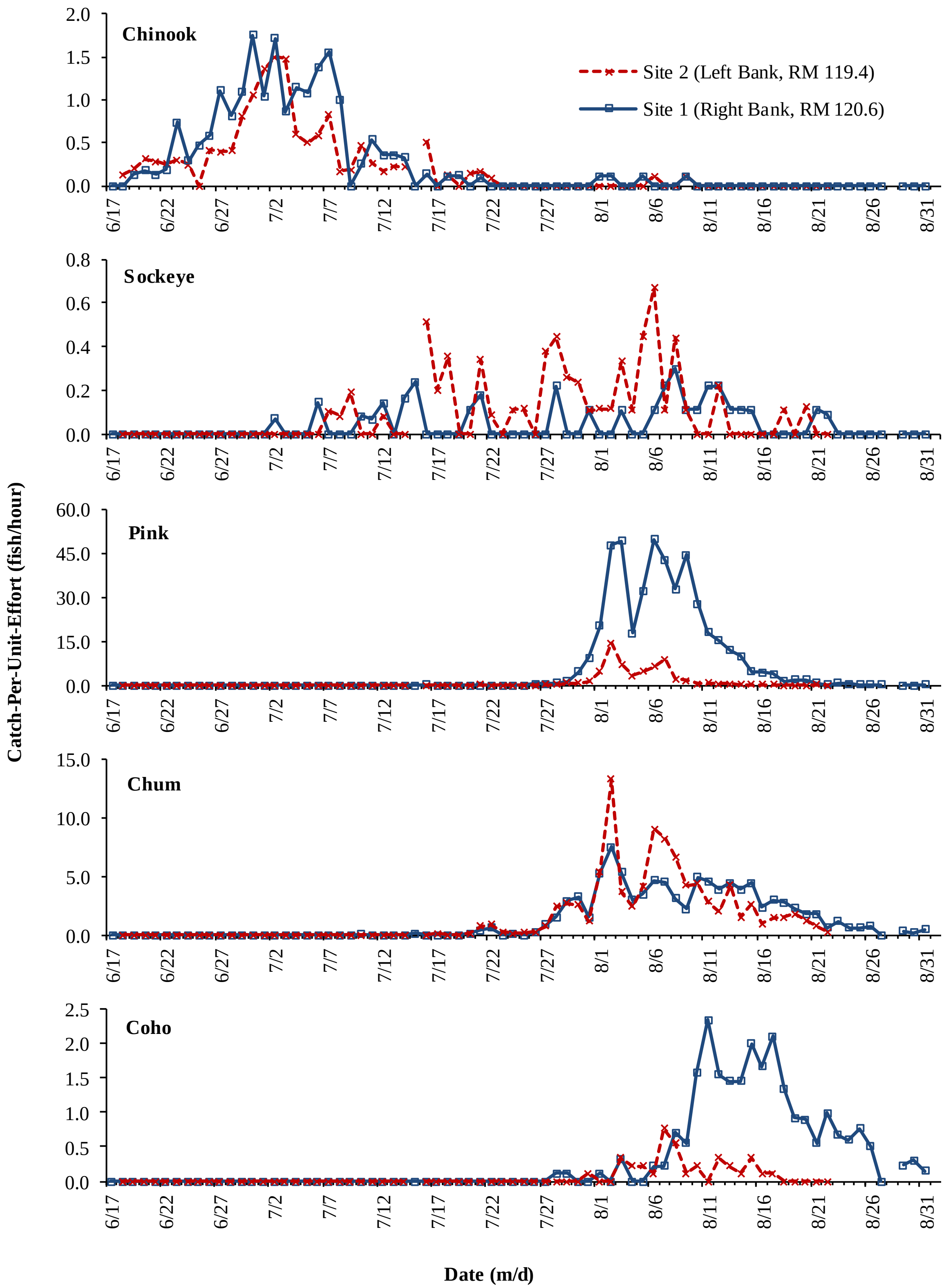


Figure 9. Daily catch-per-unit-effort of adult salmon at the fishwheels operated near Curry on the Susitna River, 2012. Recaptures were included in these data; however, jacks were excluded.

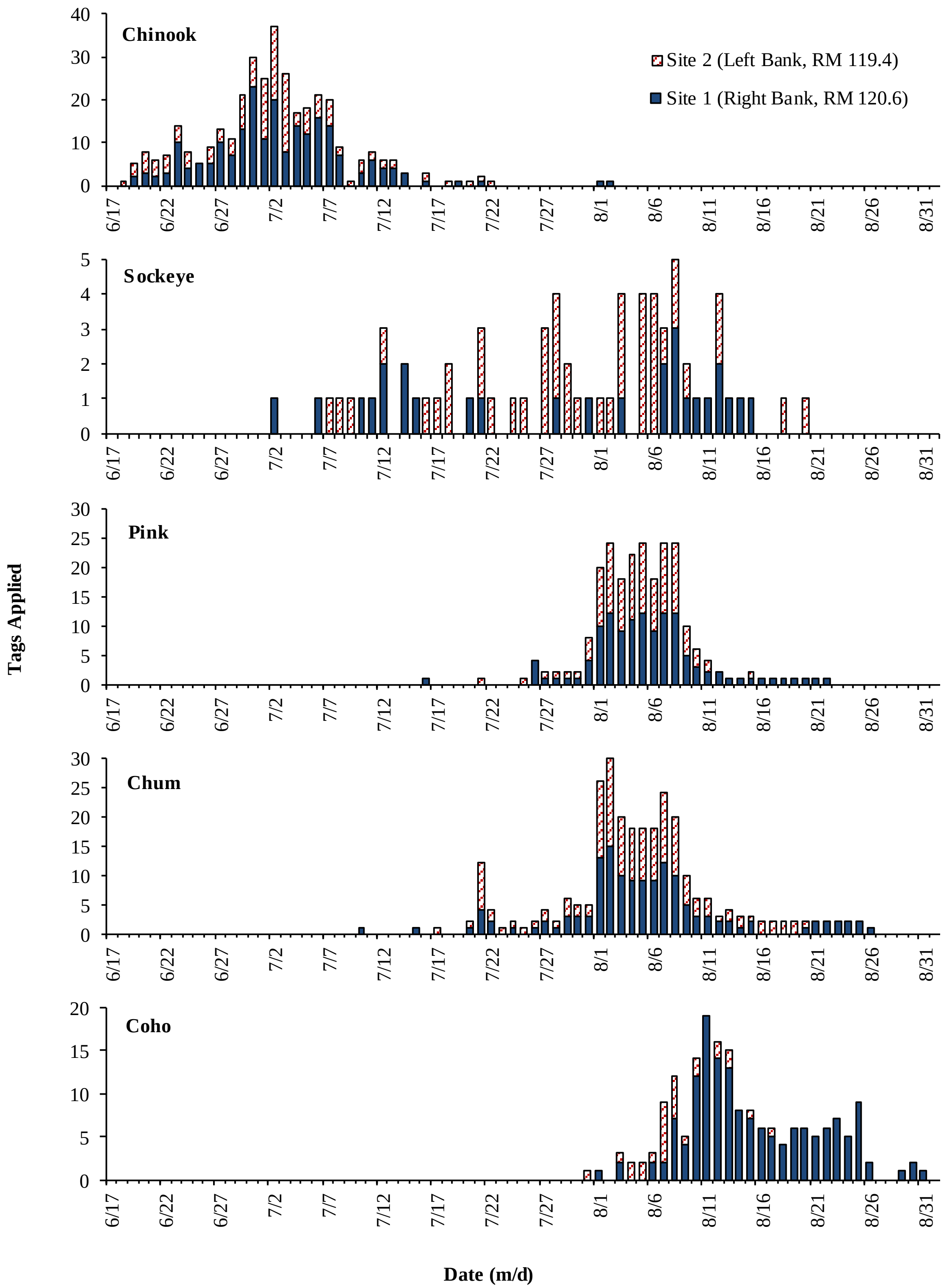


Figure 10. Daily number of tags applied to adult salmon at the fishwheels operated near Curry on the Susitna River, 2012.

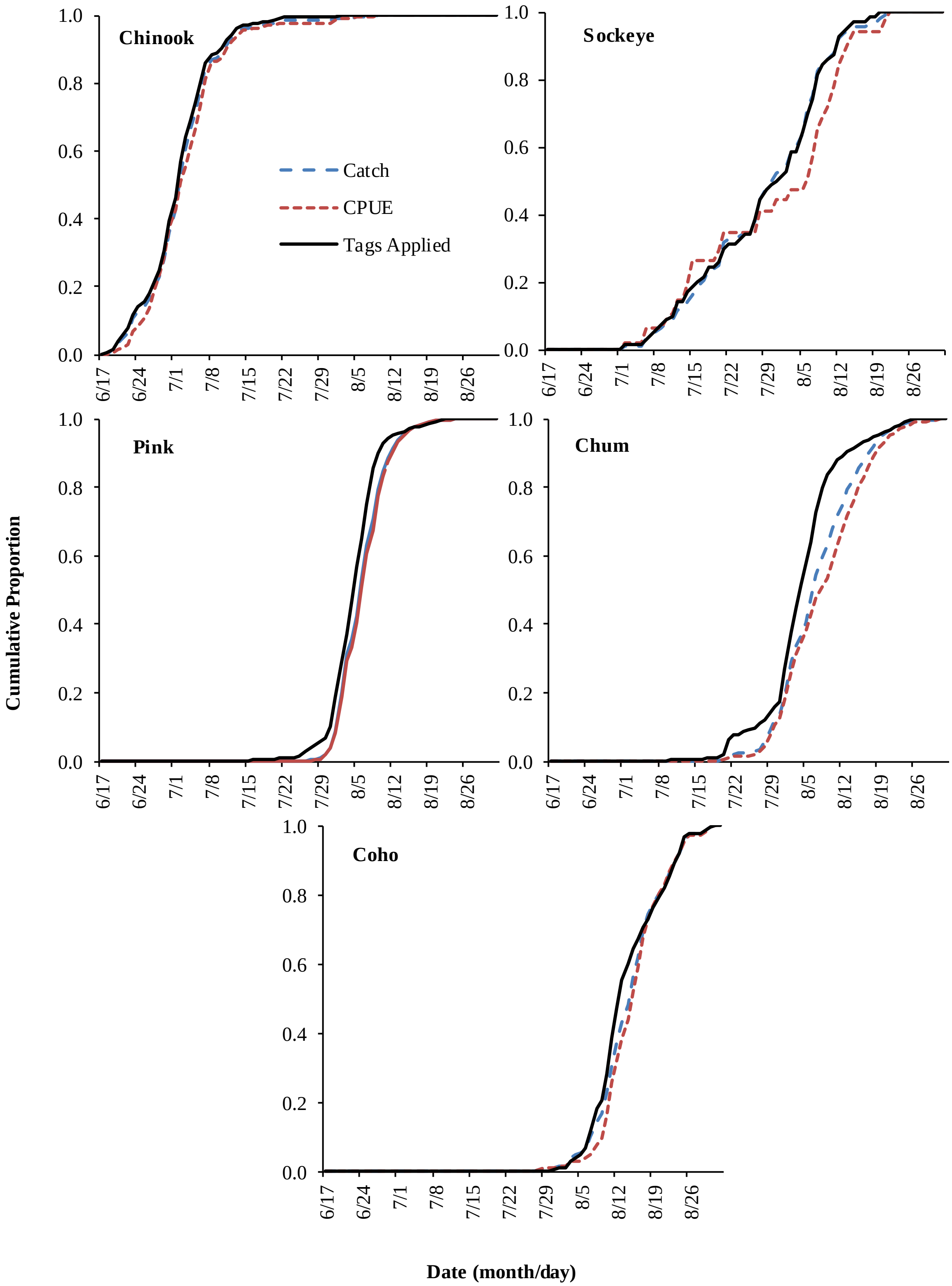


Figure 11. Cumulative proportion of daily catch, catch-per-unit-effort (CPUE), and tags applied to adult salmon at the fishwheels operated near Curry on the Susitna River, 2012.

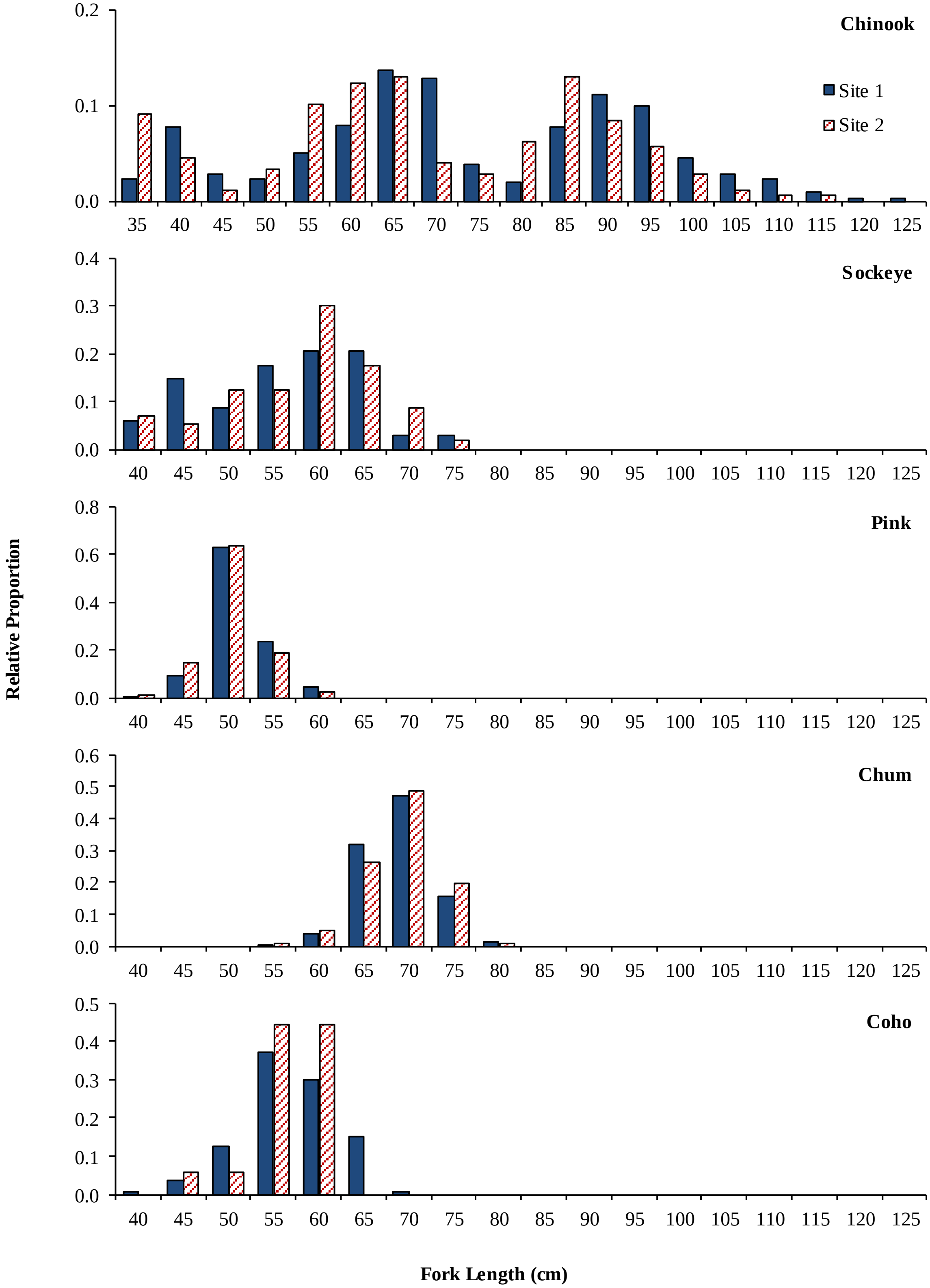


Figure 12. Relative length-frequency distributions of fish caught at sites 1 and 2 near Curry on the Susitna River, 2012.

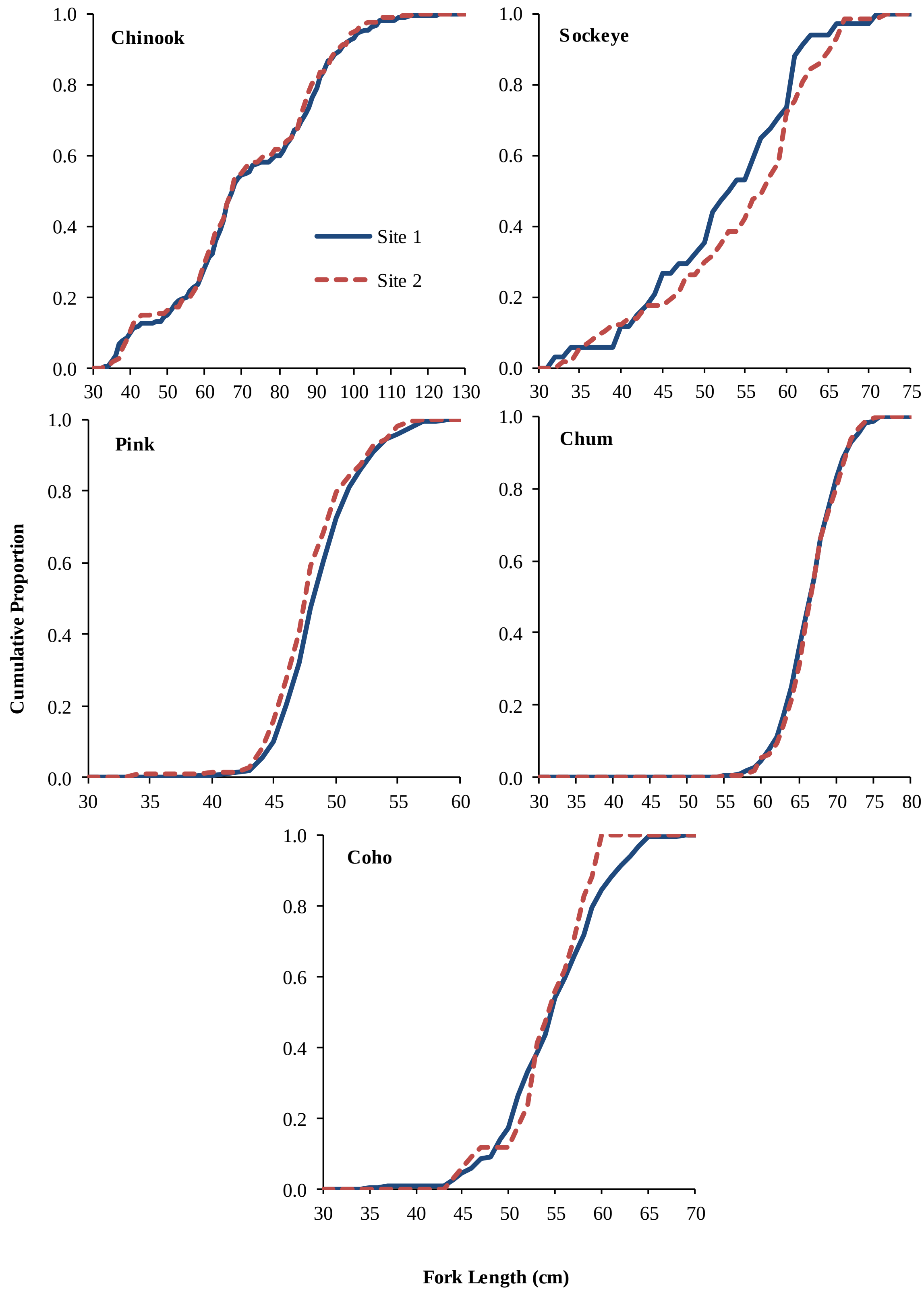


Figure 13. Cumulative length-frequency distributions of fish caught at sites 1 and 2 near Curry on the Susitna River, 2012.

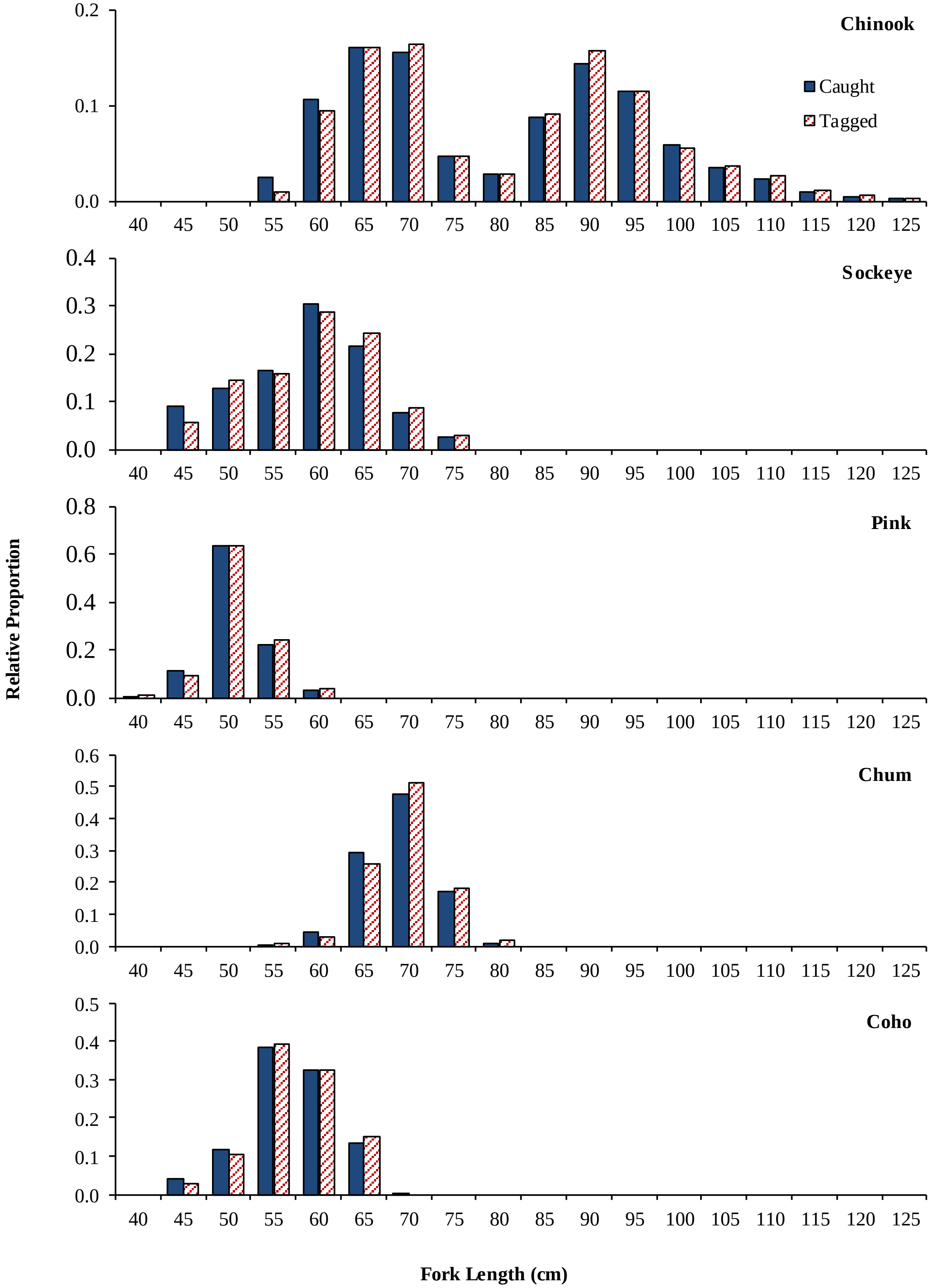


Figure 14. Relative length-frequency distributions of fish caught and radio-tagged at sites 1 and 2 near Curry on the Susitna River, 2012.

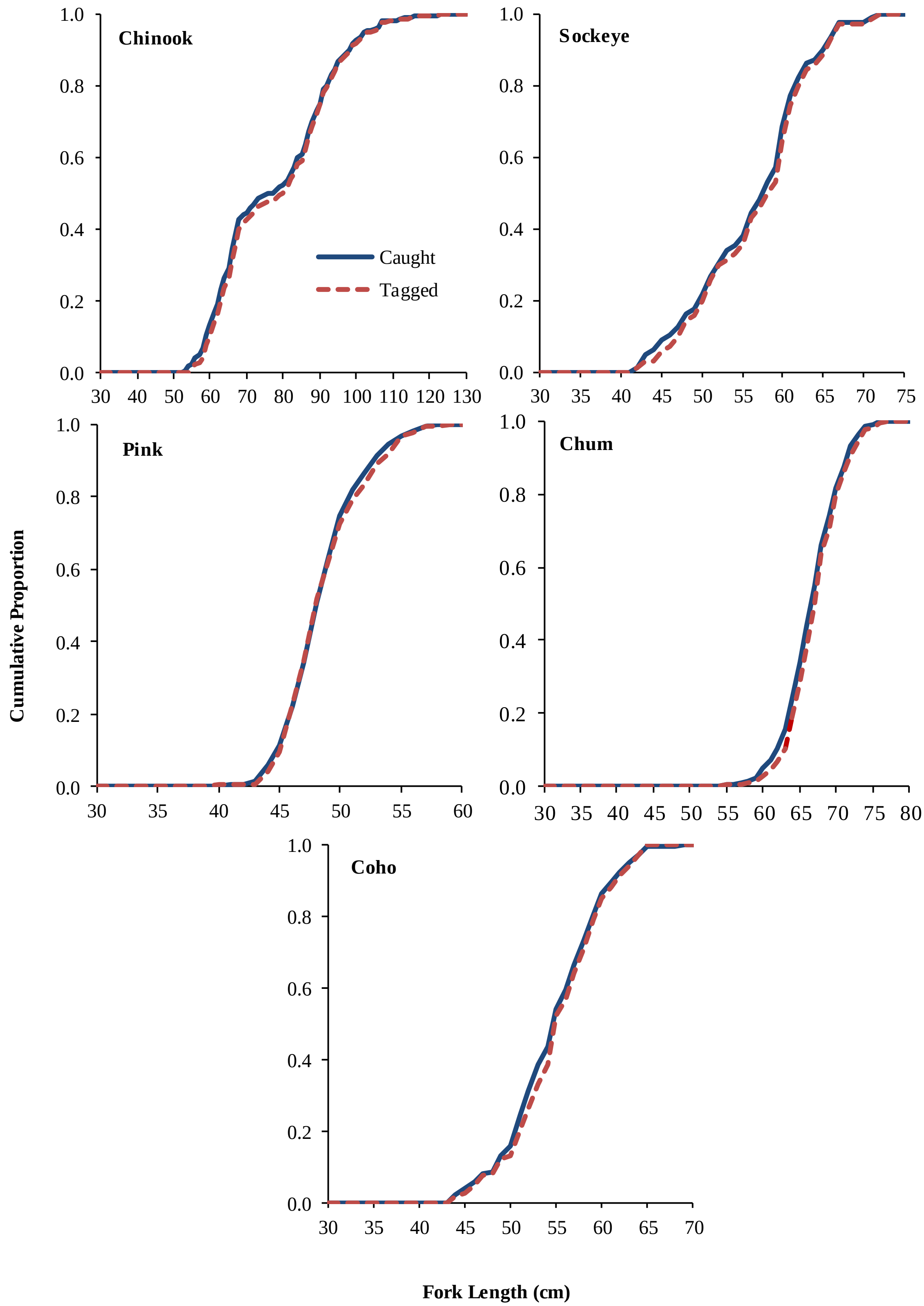


Figure 15. Cumulative length-frequency distributions of fish caught and radio-tagged at sites 1 and 2 near Curry on the Susitna River, 2012.

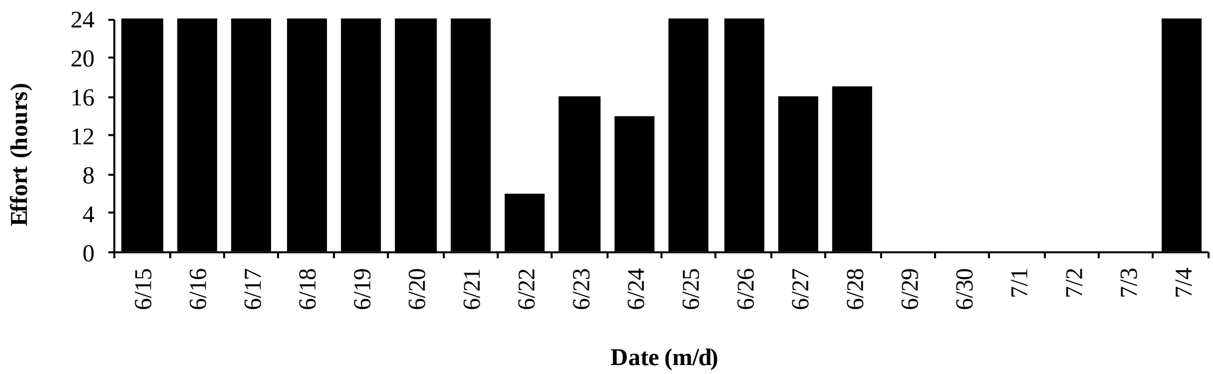


Figure 16. DIDSON data review effort of Chinook salmon passage below the fishwheel at Site 1 on the Middle River, June 15 to July 4, 2012.

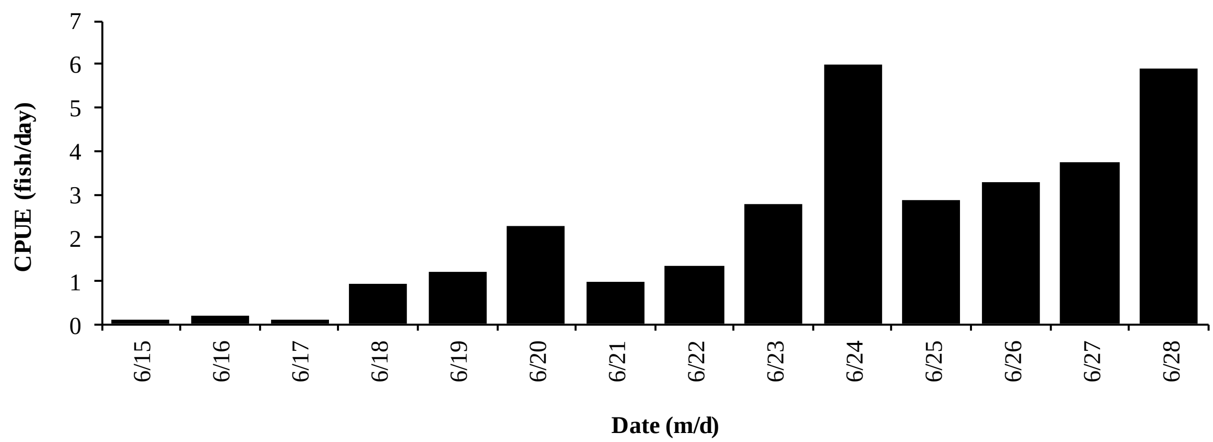


Figure 17. Catch per unit effort (CPUE), or the number of Chinook salmon counted using the DIDSON per hour, below the fishwheel at Site 1 in the Middle River, June 15–28, 2012.

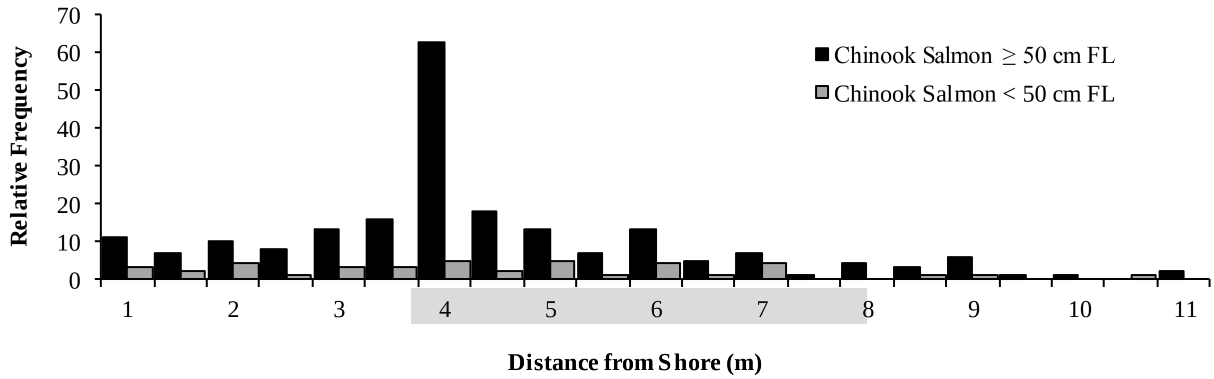


Figure 18. Number of Chinook salmon, by size category, counted using DIDSON at Site 1 as a function of the distance from shore where they were first detected in the field of view, June 19–20, 2012. The shaded area on the x-axis represents the confirmed capture range of Chinook salmon by the fishwheel at Site 1.

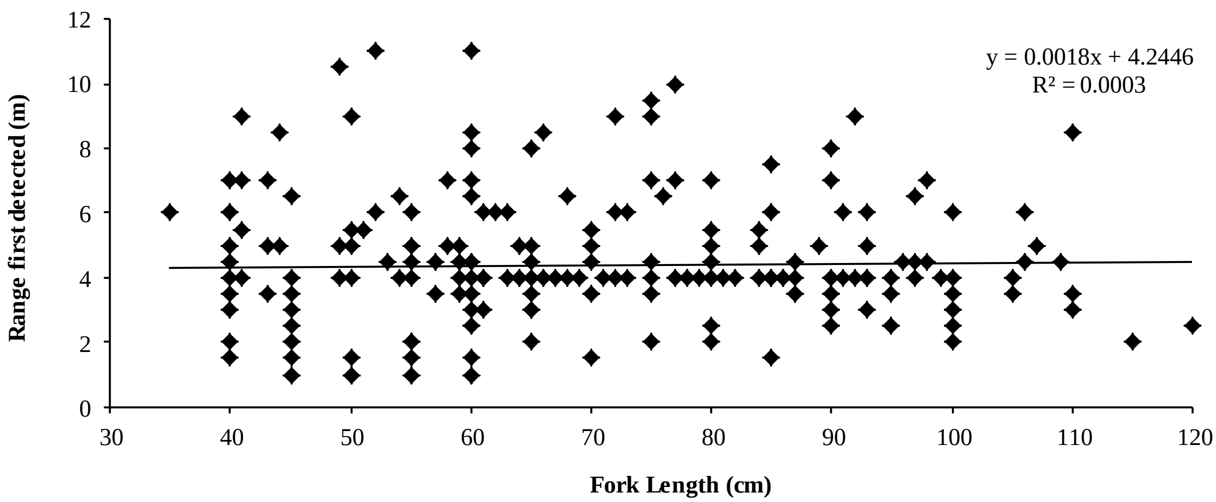


Figure 19. Linear regression of the detection range where Chinook salmon were first observed by DIDSON and fish length as estimated from DIDSON images, June 15 to July 4, 2012.

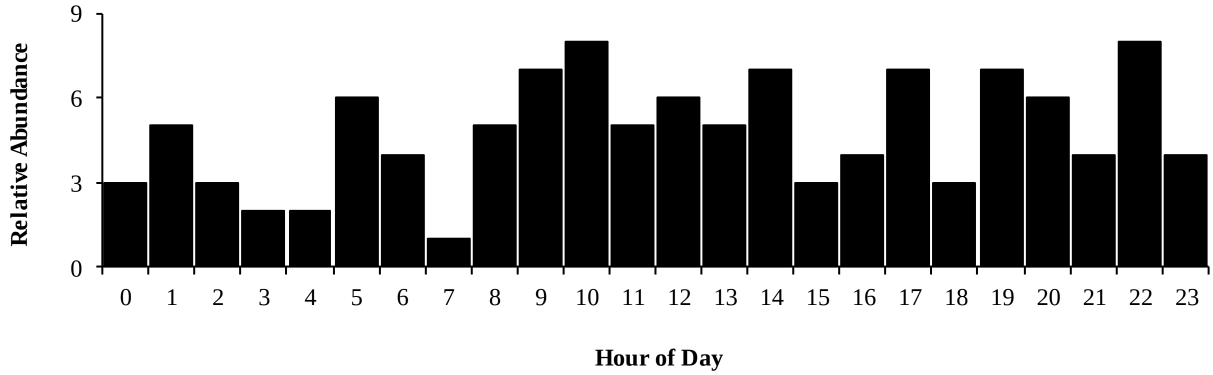


Figure 20. Diel migration of Chinook salmon observed at fishwheel Site 1using DIDSON technology, June 15–20, 2012.

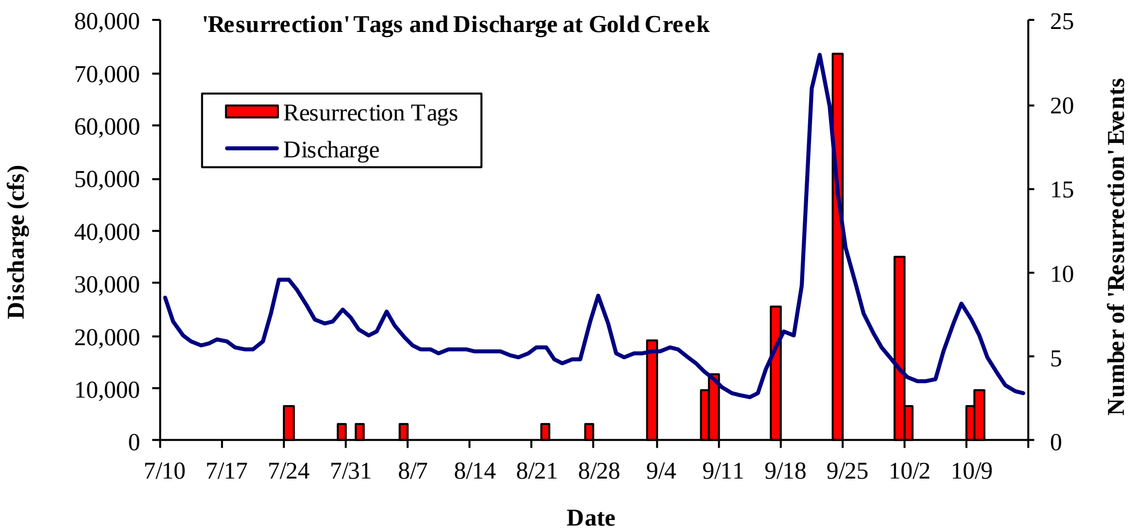


Figure 21. Average daily discharge of the Susitna River at Gold Creek (RM 136), and the daily number of radio tags that 'resurrected' (i.e., changed from their mortality signal mode, in which they were supposed to be locked, to the live signal mode).

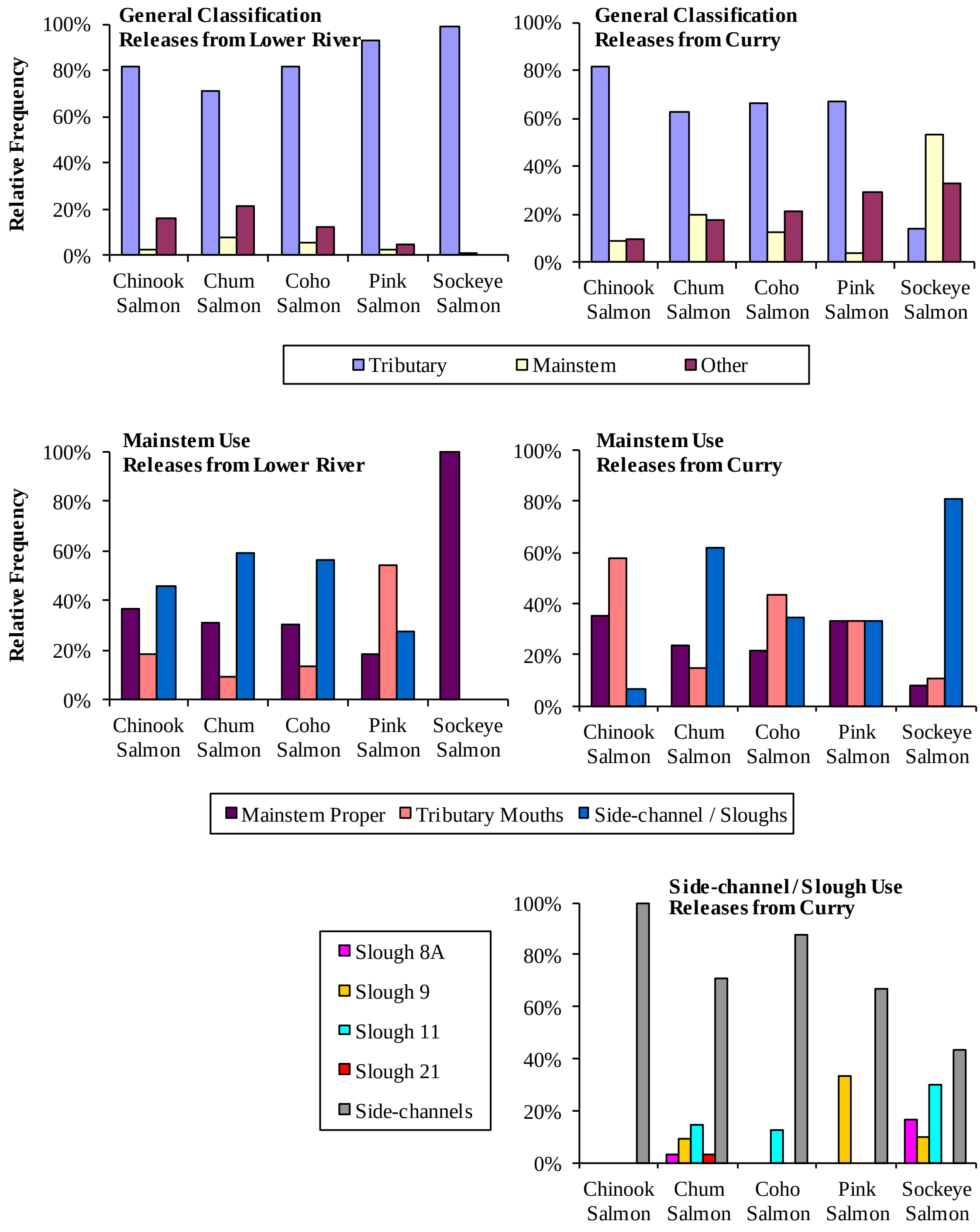


Figure 22. Destinations of radio-tagged fish released in the Lower River (left panels) or at Curry (right panels), by species. Top panels: Fish that entered a tributary were given a 'Tributary Destination' classification; those that did not enter any tributaries and that were detected on several occasions within a limited area were classified with a 'Mainstem Destination'. See text and Table 17 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'.

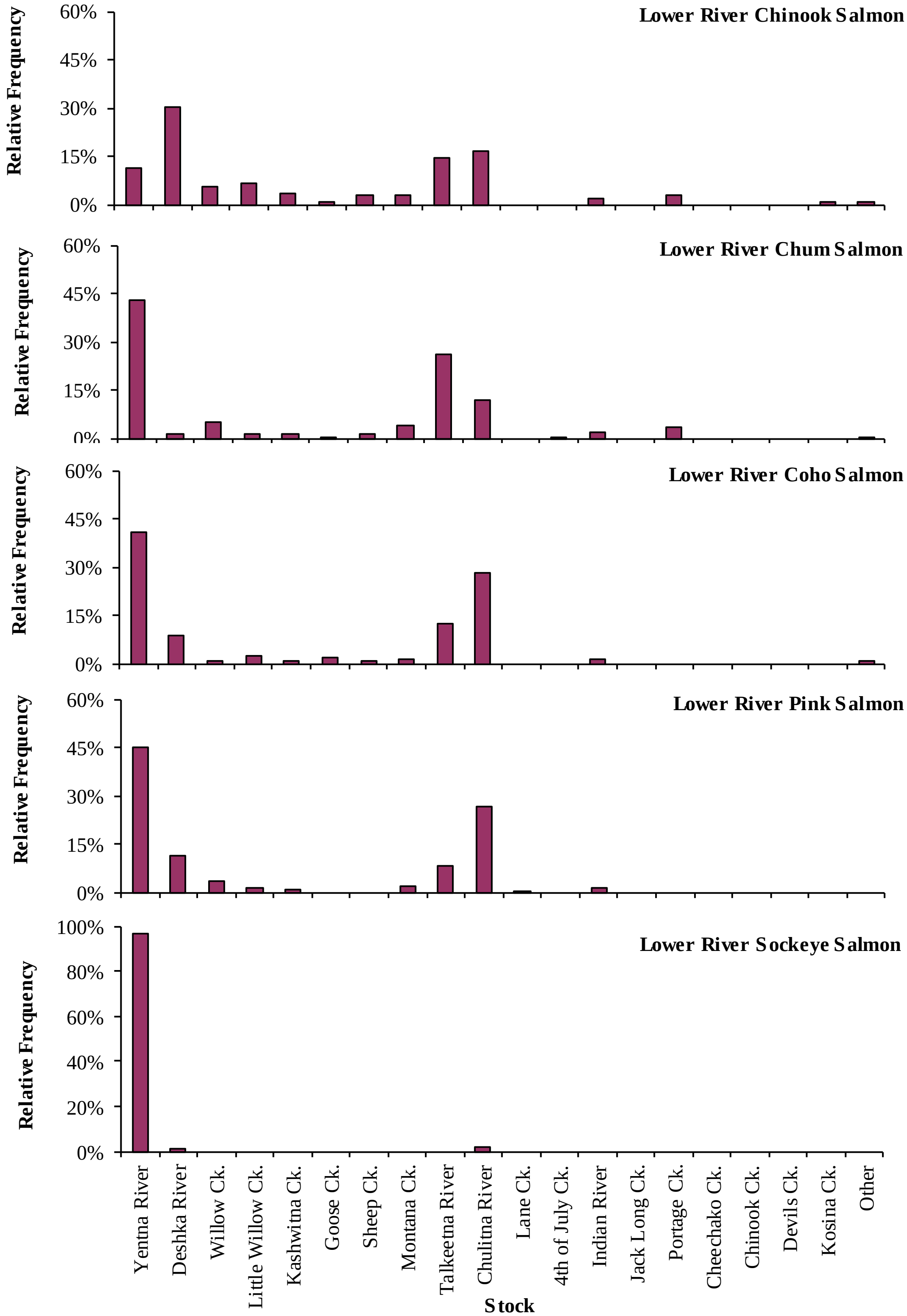


Figure 23. Relative frequencies of tributary use by radio-tagged fish released in the Lower River.

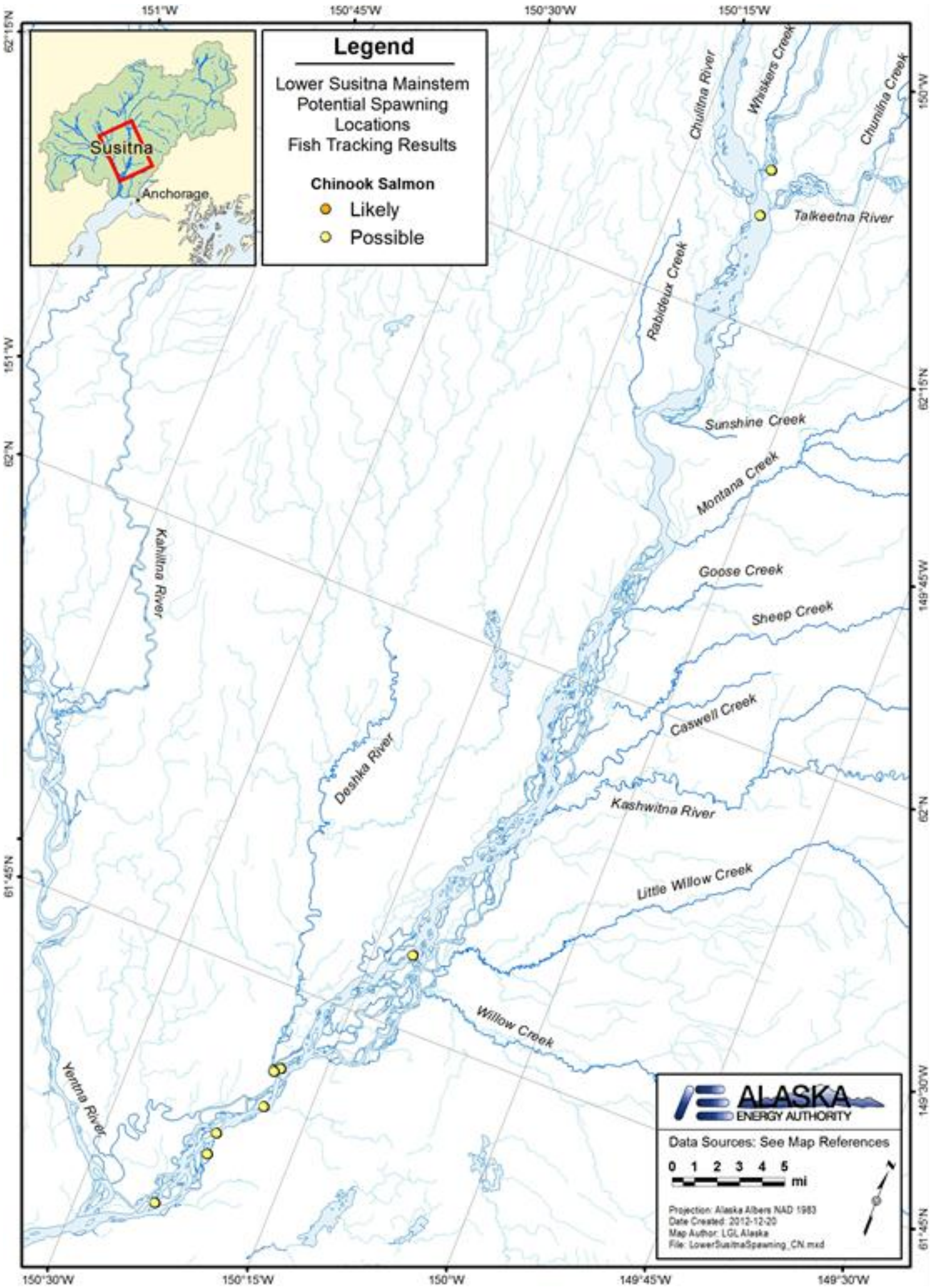


Figure 24. Potential mainstem spawning locations in the Lower River for all radio-tagged Chinook salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

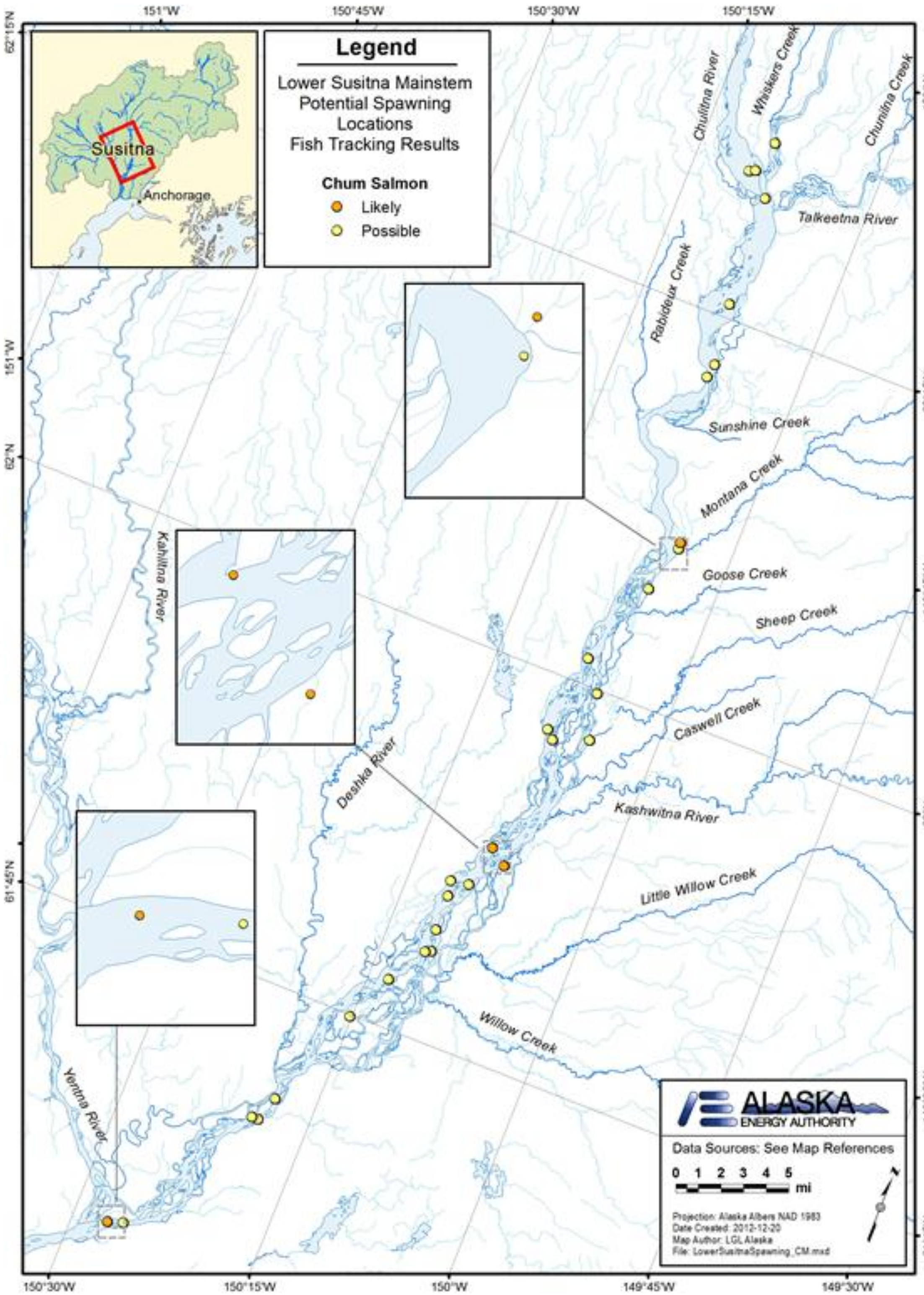


Figure 25. Potential mainstem spawning locations in the Lower River for all radio-tagged chum salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

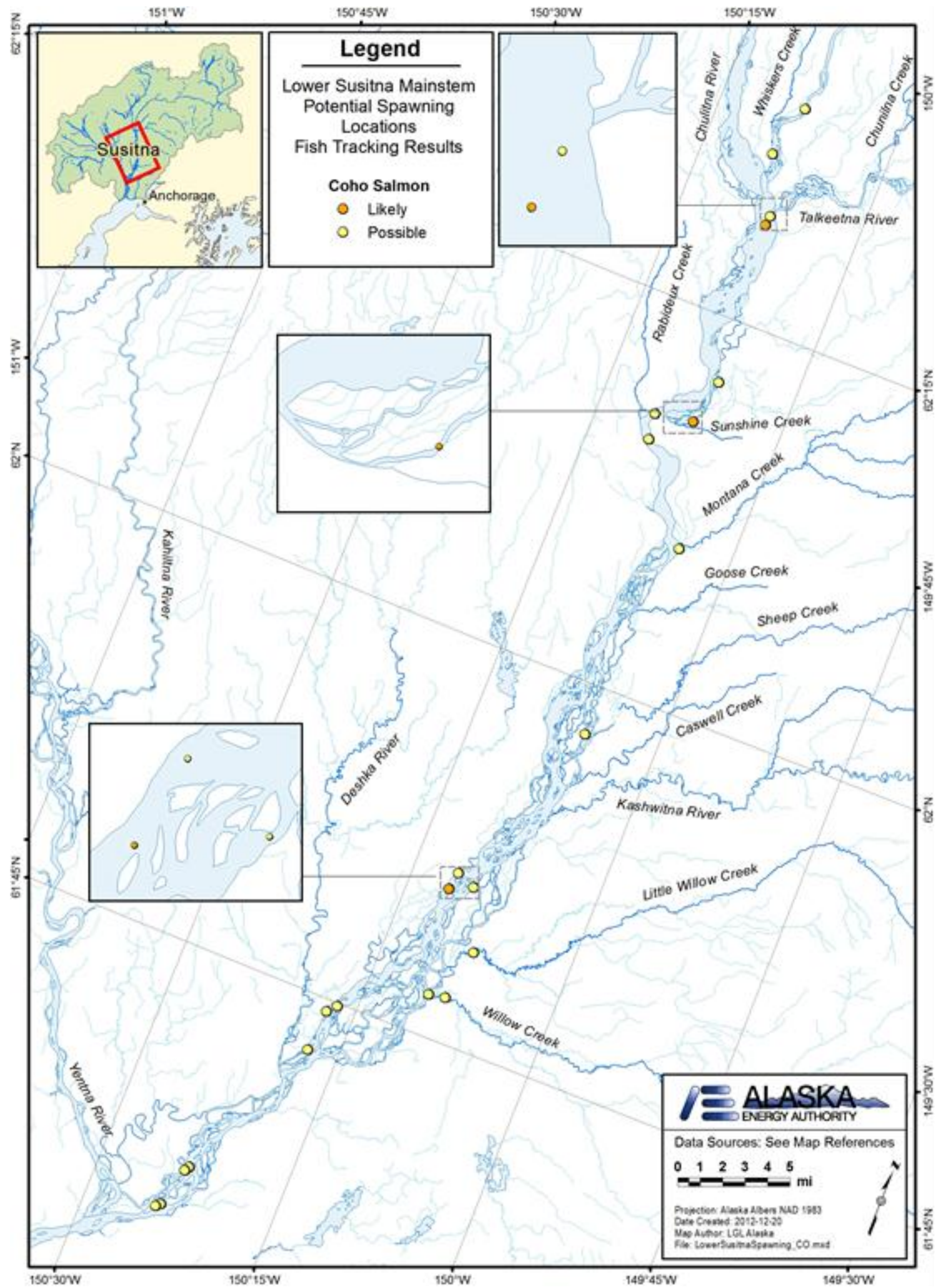


Figure 26. Potential mainstem spawning locations in the Lower River for all radio-tagged coho salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

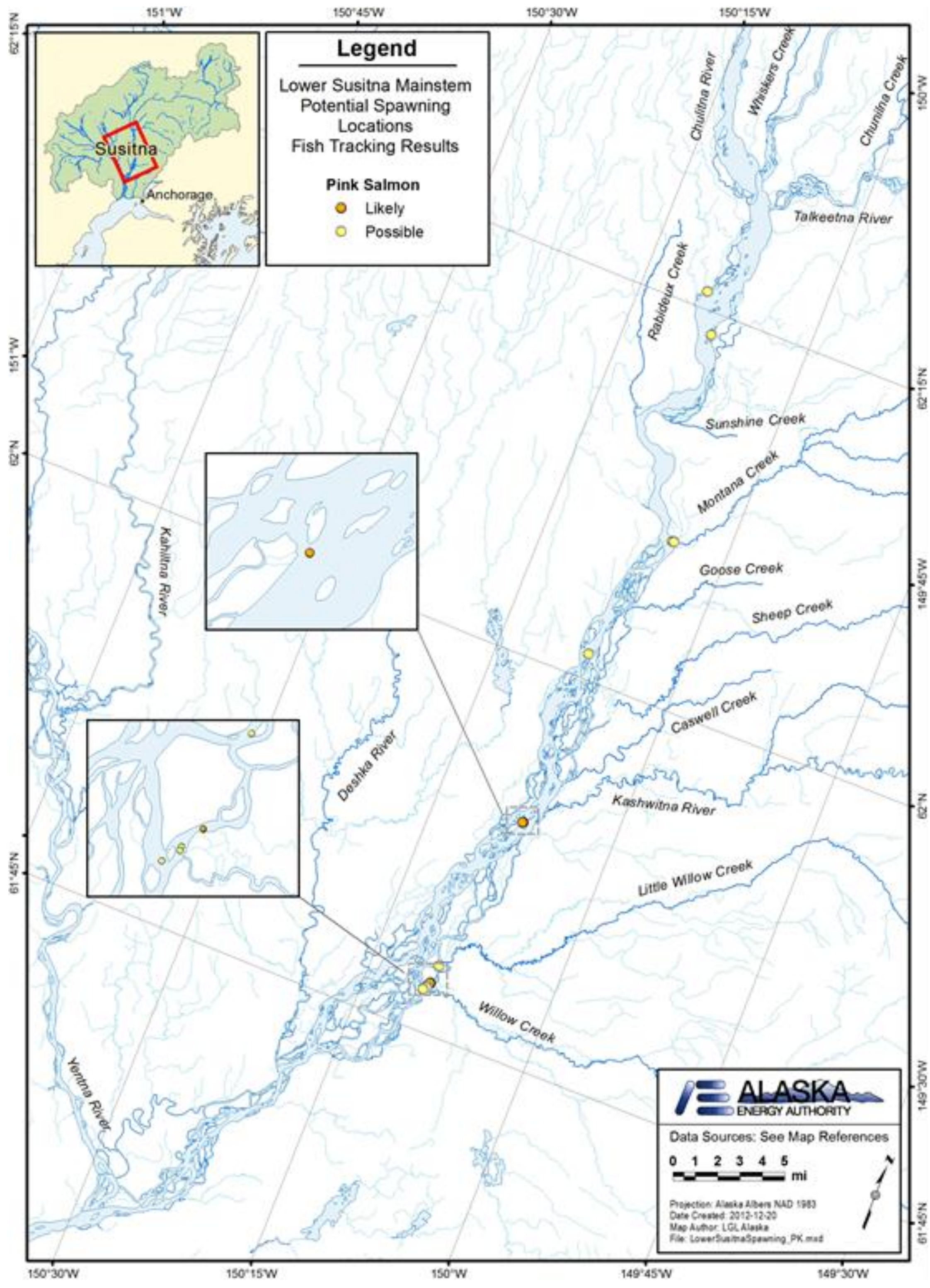


Figure 27. Potential mainstem spawning locations in the Lower River for all radio-tagged pink salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

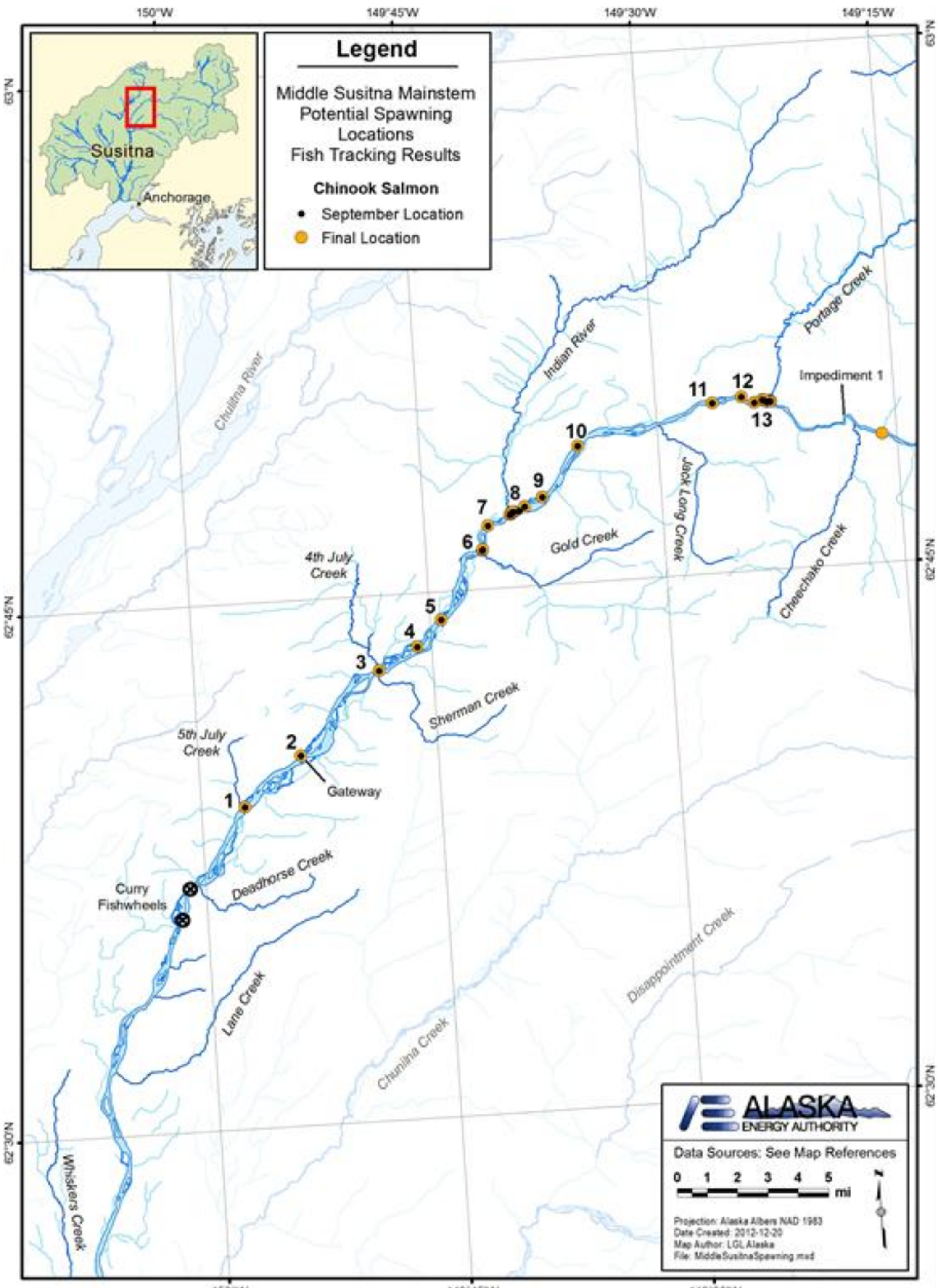


Figure 28. Potential mainstem spawning locations in the Middle River for all radio-tagged Chinook salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

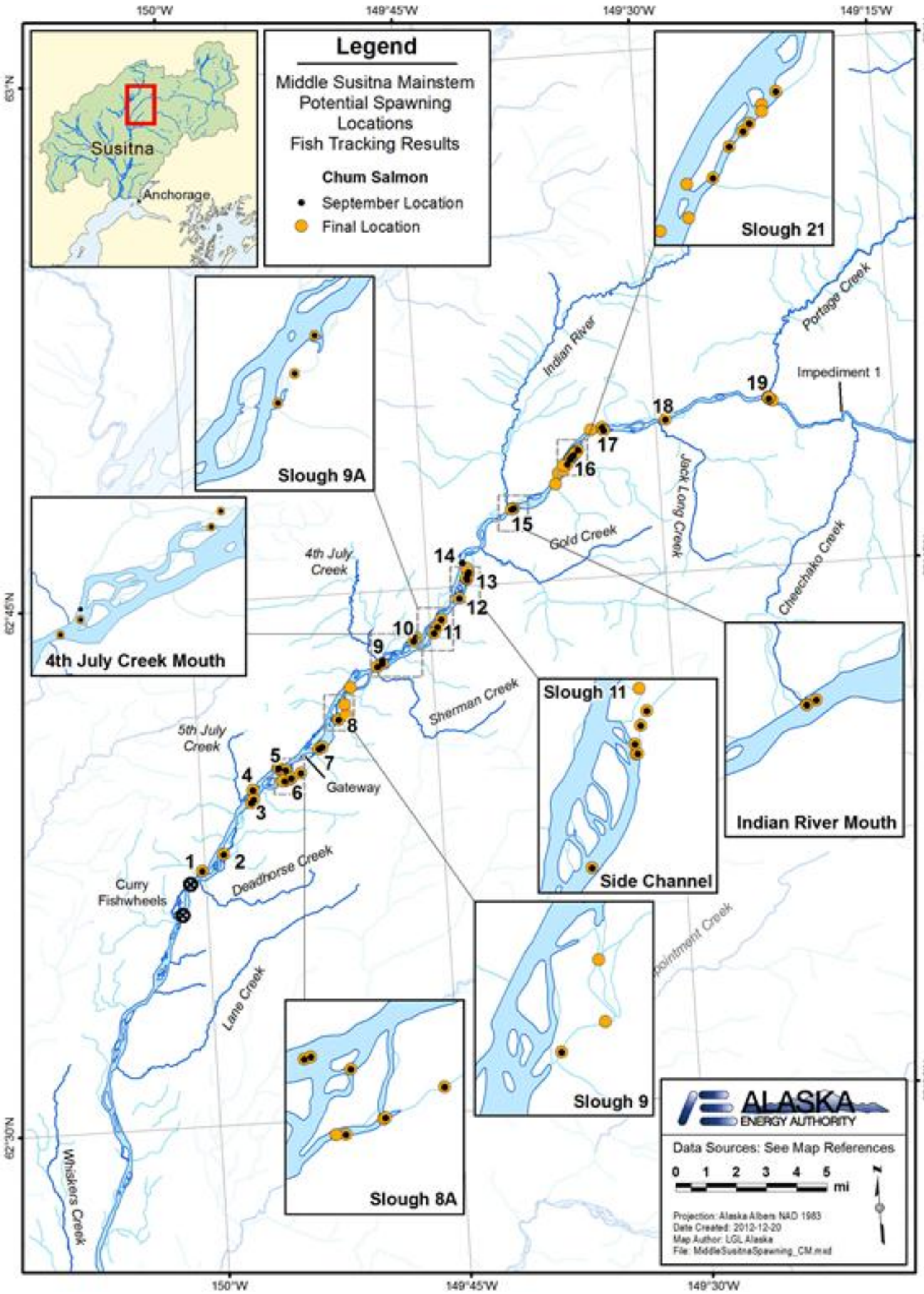


Figure 29. Potential mainstem spawning locations in the Middle River for all radio-tagged chum salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

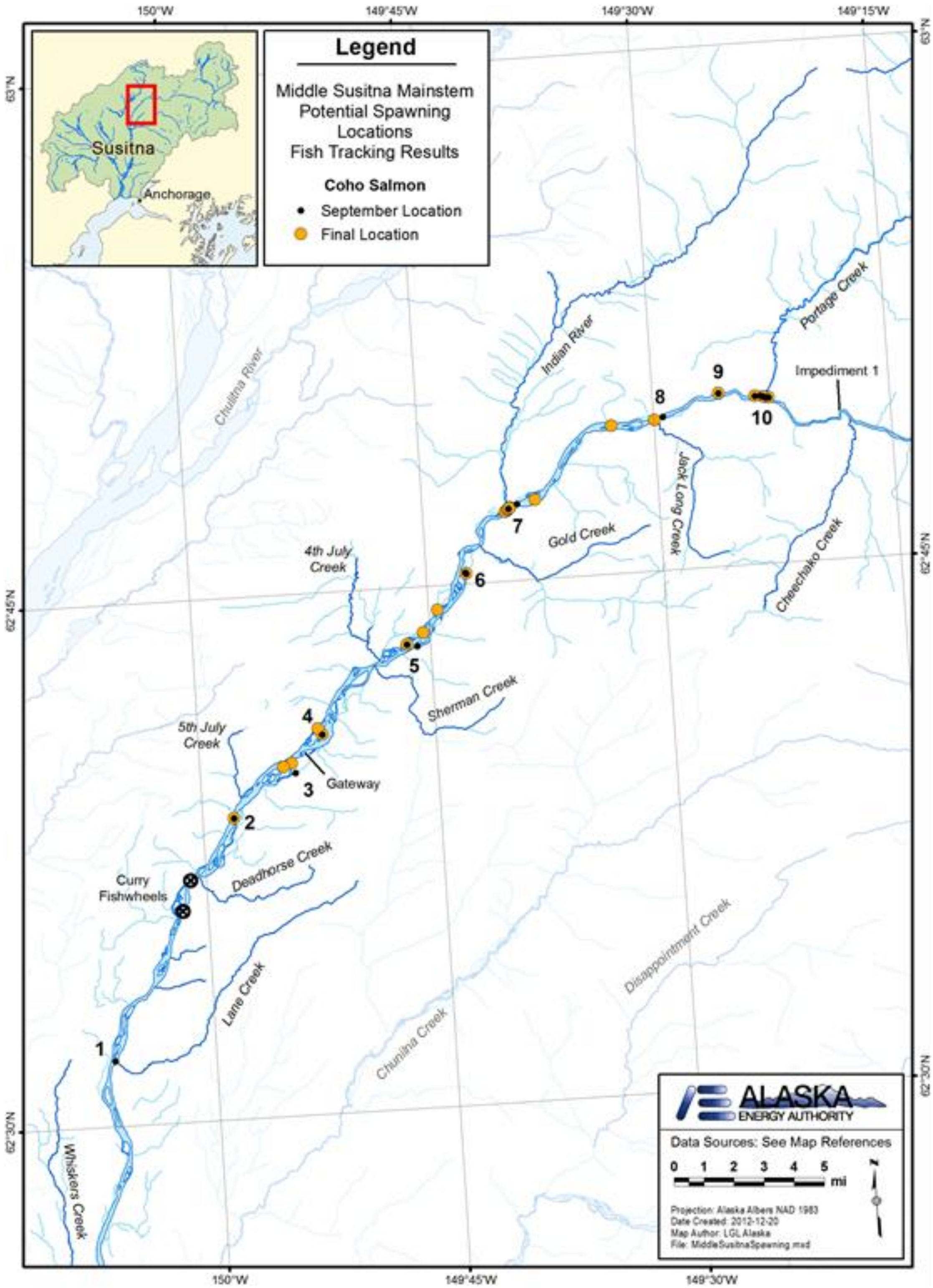


Figure 30. Potential mainstem spawning locations in the Middle River for all radio-tagged coho salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

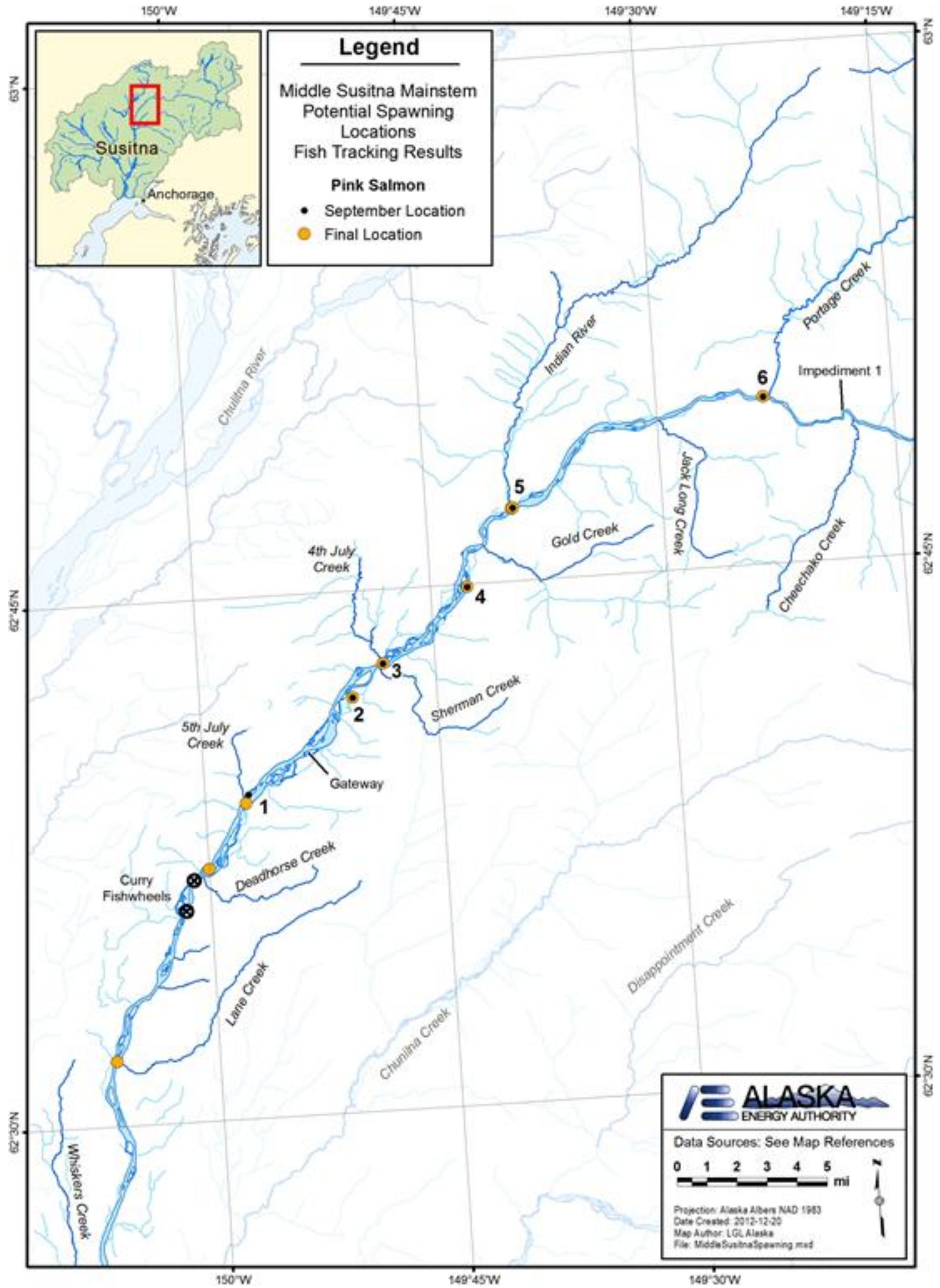


Figure 31. Potential mainstem spawning locations in the Middle River for all radio-tagged pink salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

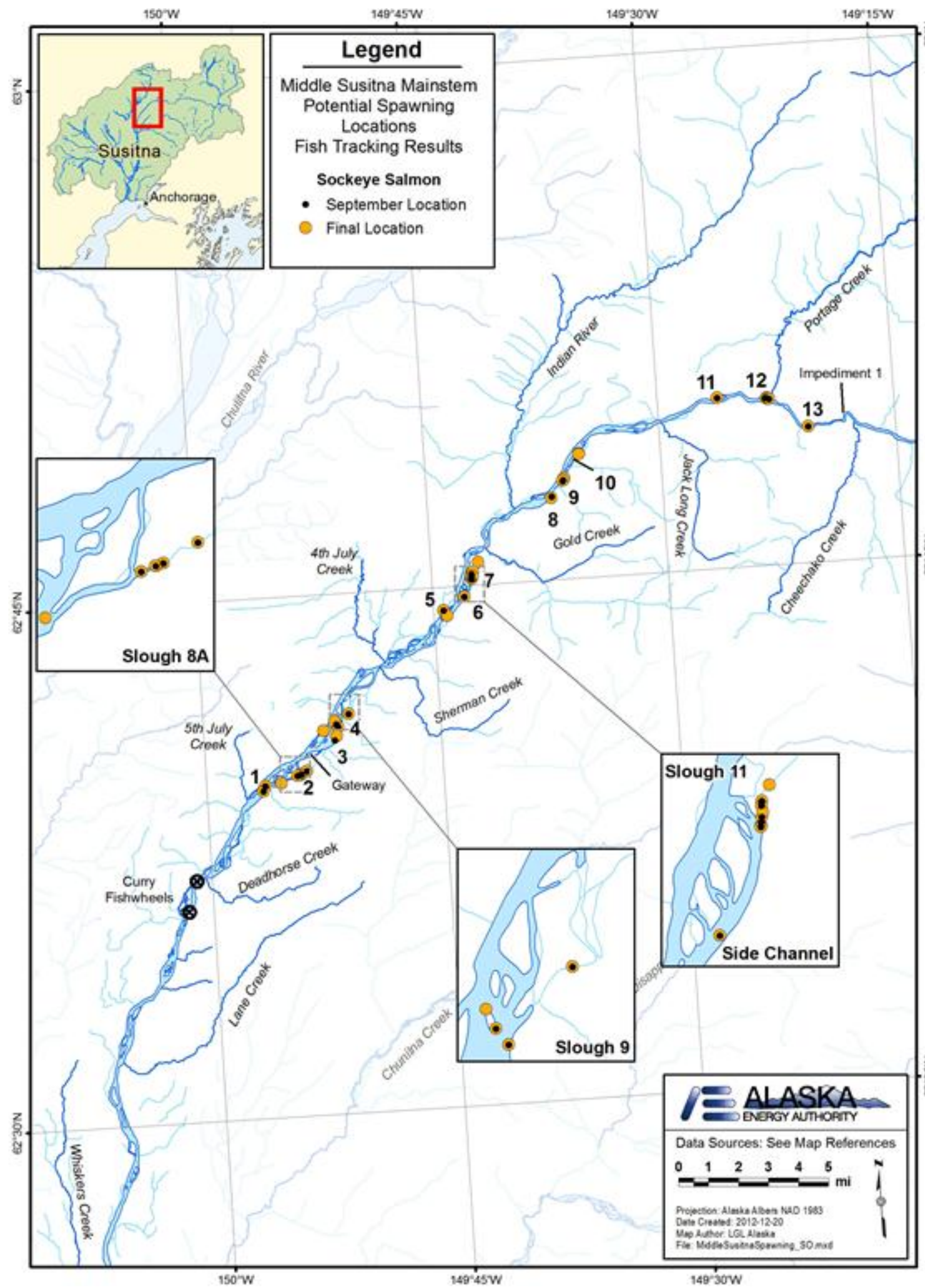


Figure 32. Potential mainstem spawning locations in the Middle River for all radio-tagged sockeye salmon that did not enter a tributary and were detected at least twice near the same mainstem location during the spawning period in 2012.

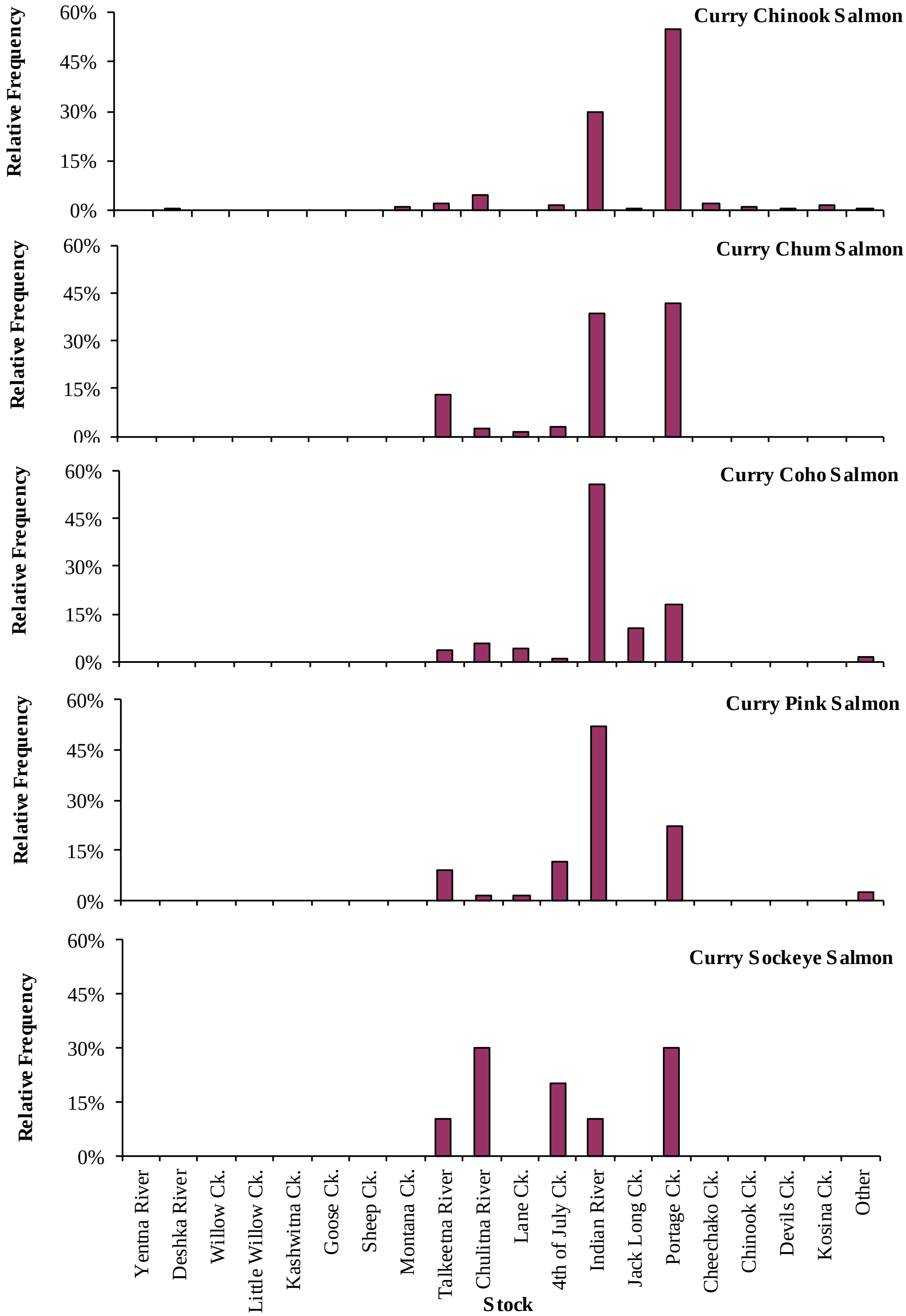


Figure 33. Relative frequencies of tributary use by radio-tagged fish released at Curry.

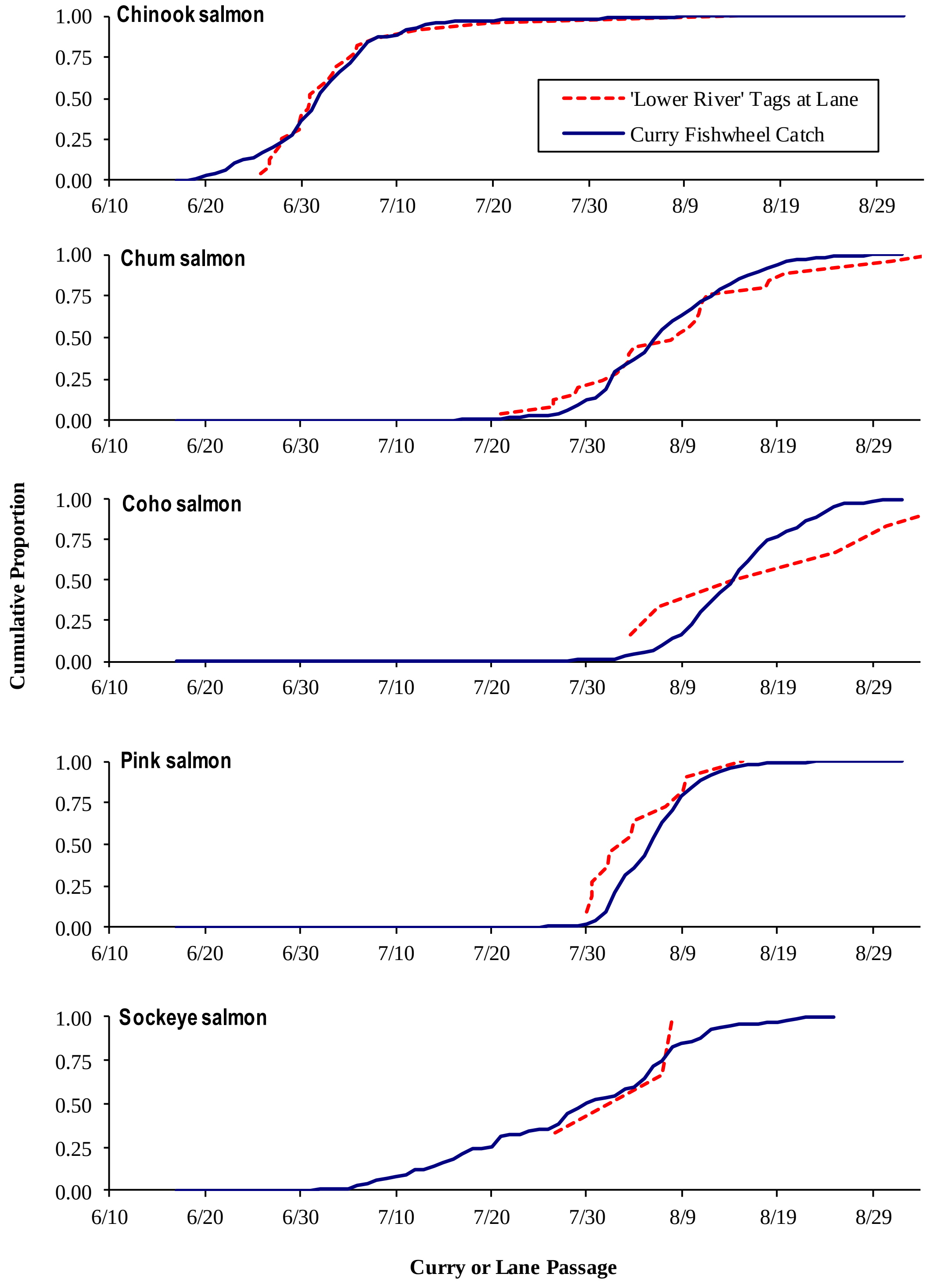


Figure 34. Run timing in the Middle River, by species. Lines show cumulative proportions of fish either passing Lane Station (red lines: cumulative timing of fish that were radio-tagged in the Lower River and passed Lane Station) or being caught in the Curry fishwheels (blue lines), by date.

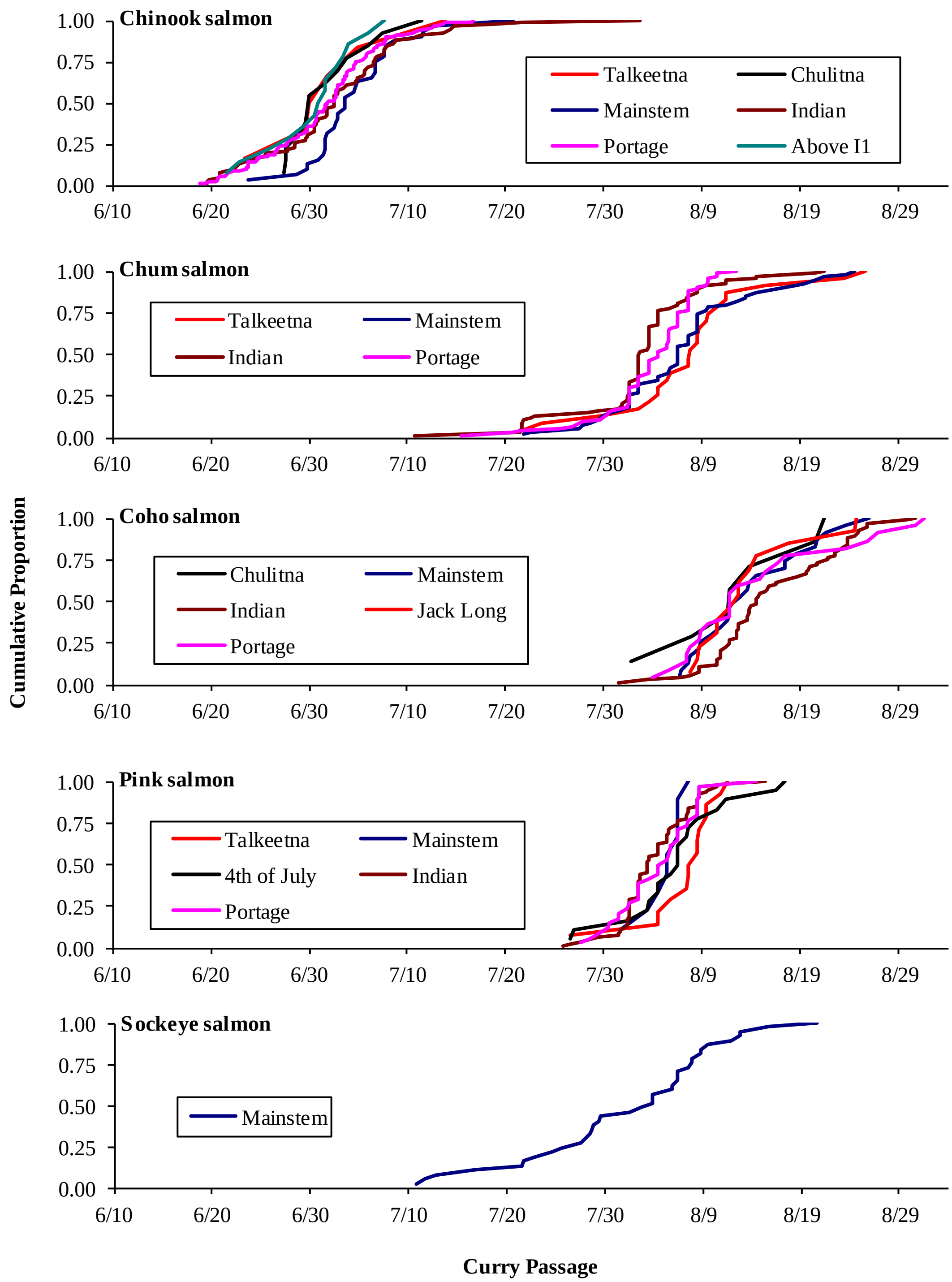


Figure 35. Stock-specific run timing in the Middle River, by species. Only fish tagged at Curry fishwheels, and, within a species only stocks with > 6 radio-tagged fish were included. Lines show cumulative timing of fish released at Curry. 'Mainstem' stock includes fish in tributary mouths, sloughs/side-channels, and in the mainstem proper. 'Above Impediment 1' stock includes fish in Cheechako (6), Chinook (3), Devil (1), and Kosina (4).

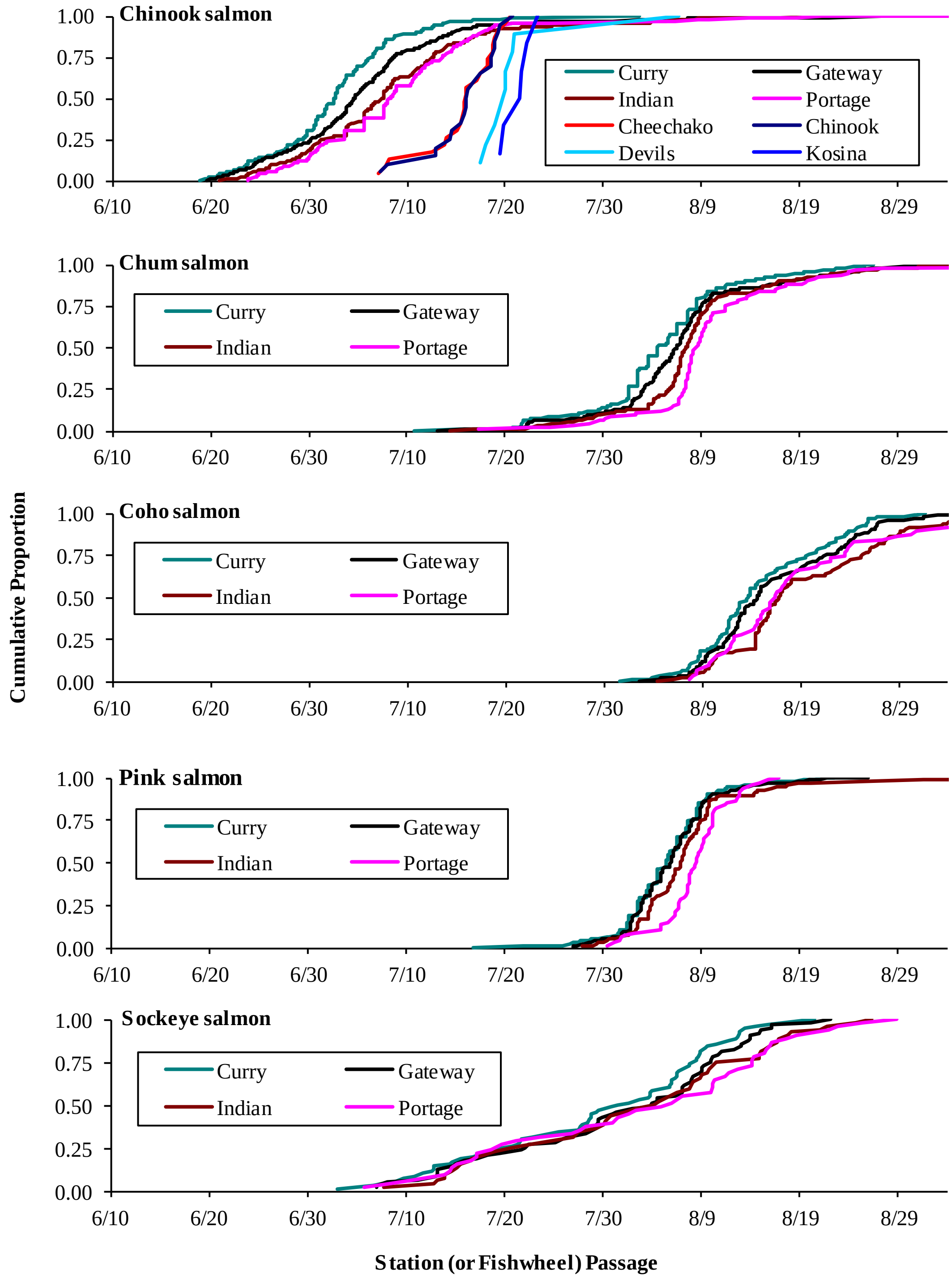


Figure 36. Timing of fishwheel and fixed-station receiver passage in the Middle River, by species. Lines show cumulative proportions of passage dates at the Curry fishwheels, and at upstream fixed-station receivers. Only fish radio-tagged at the Curry fishwheels are included.

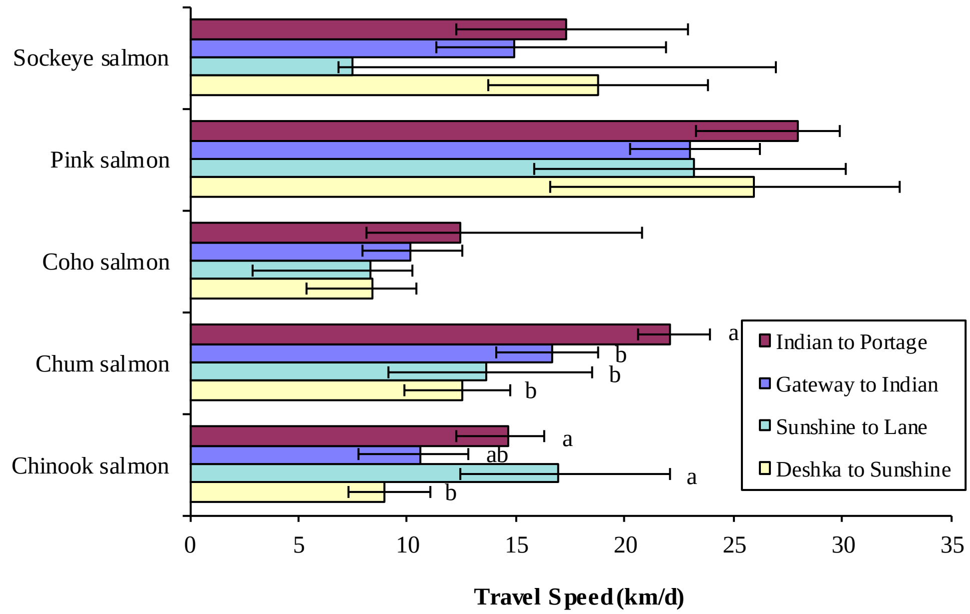


Figure 37. Median travel speeds of radio-tagged fish in four major river reaches, by species. Error bars represent 95 percent confidence in the median value (generated using the method recommended in Zar 1984). Statistical comparisons (see text) were done using non-parametric Kruskal-Wallis tests; overlapping error bars do not preclude statistical significance. For species with significant differences among reaches, letters indicate the results of post-hoc comparisons (i.e., reaches that do not share a letter were statistically different from each other).

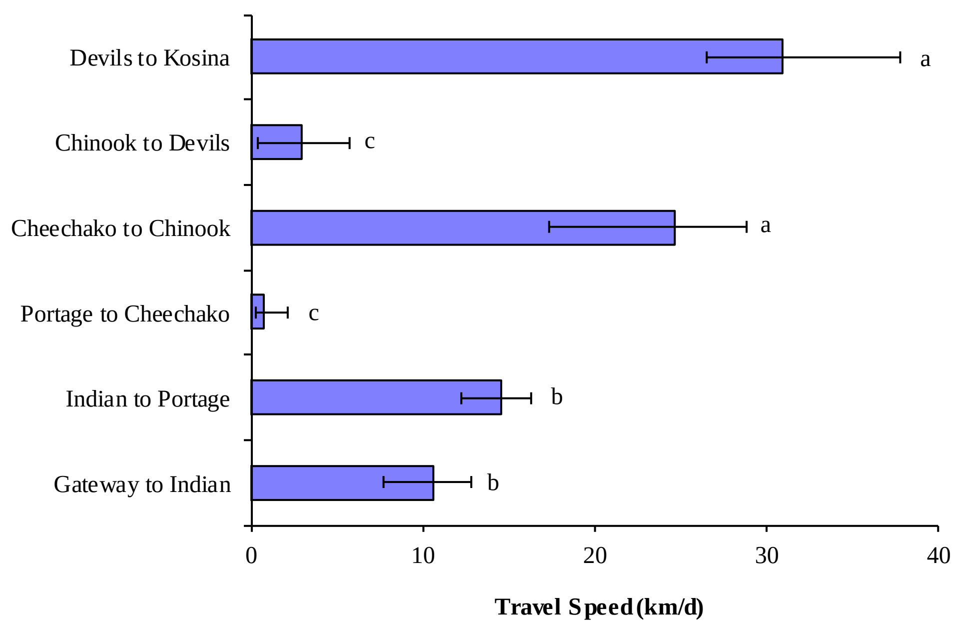


Figure 38. Median travel speeds of radio-tagged for Chinook salmon, by river reach. Error bars represent 95 percent confidence in the median value (generated using the method recommended in Zar, 1984). Statistical comparisons (see text) were done using non-parametric Kruskal-Wallis tests; overlapping error bars do not preclude statistical significance. Letters indicate the results of post-hoc comparisons (i.e., reaches that do not share a letter were statistically different from each other).

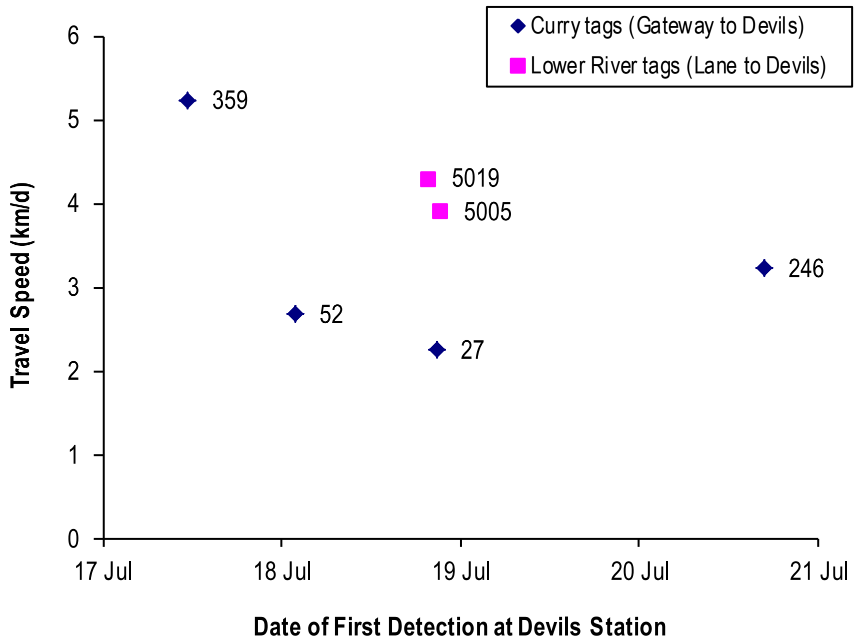


Figure 39. Middle River (downstream of Devils Canyon) travel speeds for Chinook salmon that were detected at Devil Station, by first-detection date. Data labels are 'tag numbers' (unique numbers assigned to each individual radio-tagged fish), which were greater than 5,000 for Chinook released in the Lower River.

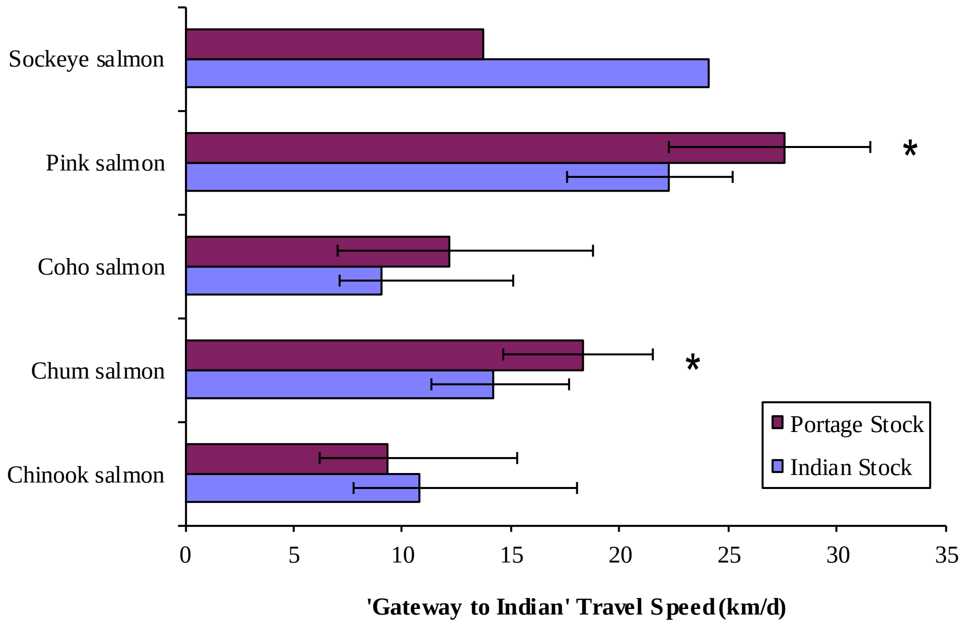


Figure 40. Median travel speeds of radio-tagged fish in the 'Gateway to Indian' river reach, for Portage Creek and Indian River stocks, by species. Error bars represent 95 percent confidence in the median value (generated using the method recommended in Zar 1984). Statistical comparisons (see text) were done using non-parametric Kruskal-Wallis tests; overlapping error bars do not preclude statistical significance. Asterisks mark species for which travel speeds varied significantly between stocks.

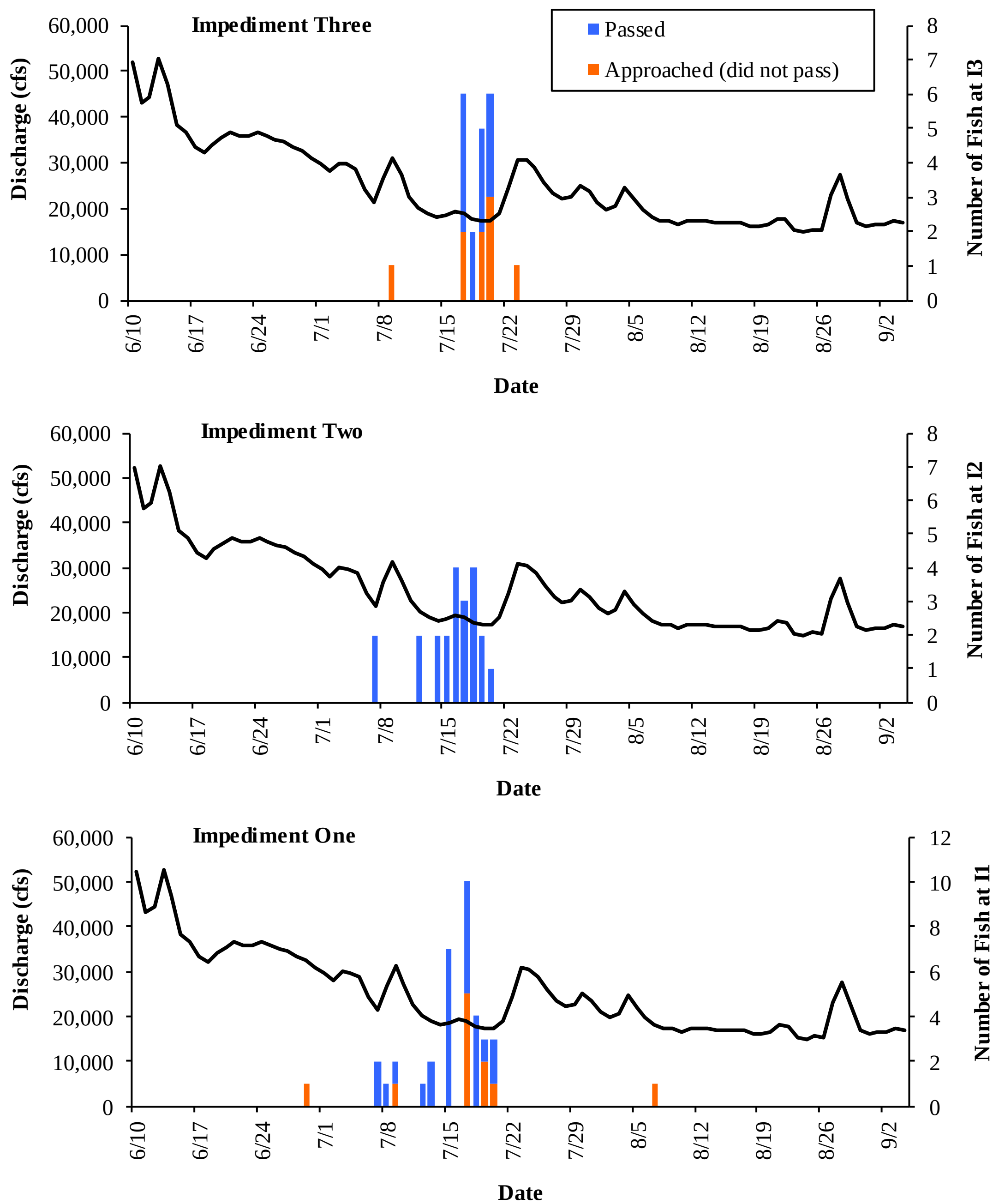


Figure 41. Daily numbers of fish that approached and passed each of the three Middle River impediments. Orange bars: fish that approached but did not pass. Blue bars: fish that approached and successfully passed. No fish approached Impediment 2 without passing. Figures show the date of first detection above the impediment (blue) or the date of first detection below the impediment (orange). Also shown is the average daily discharge of the Susitna River at Gold Creek (RM 136).

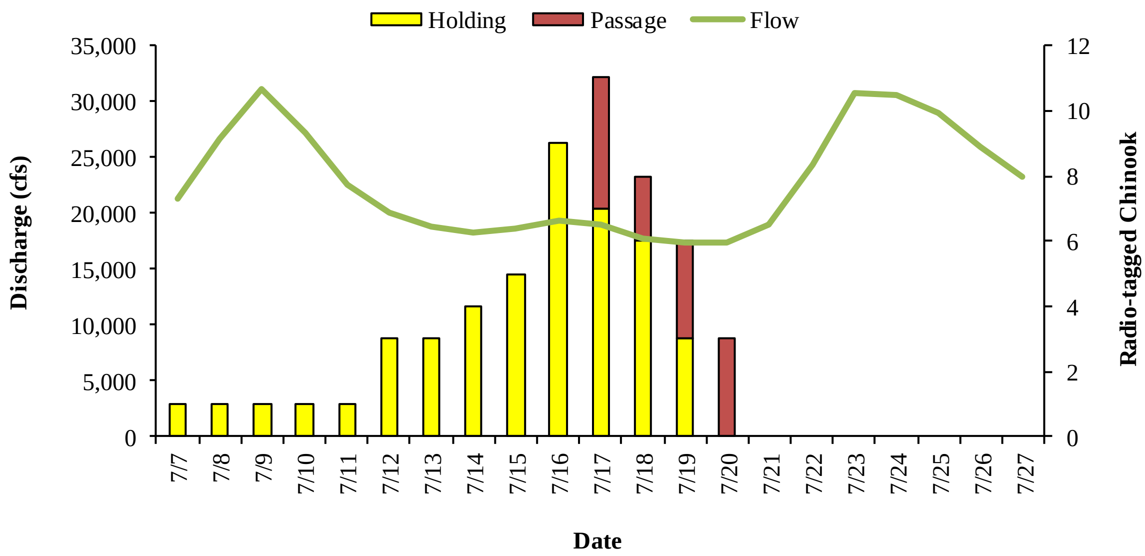


Figure 42. Daily number of radio-tagged Chinook salmon that held or passed Impediment 3. Also shown is the average daily discharge of the Susitna River at Gold Creek (RM 136).

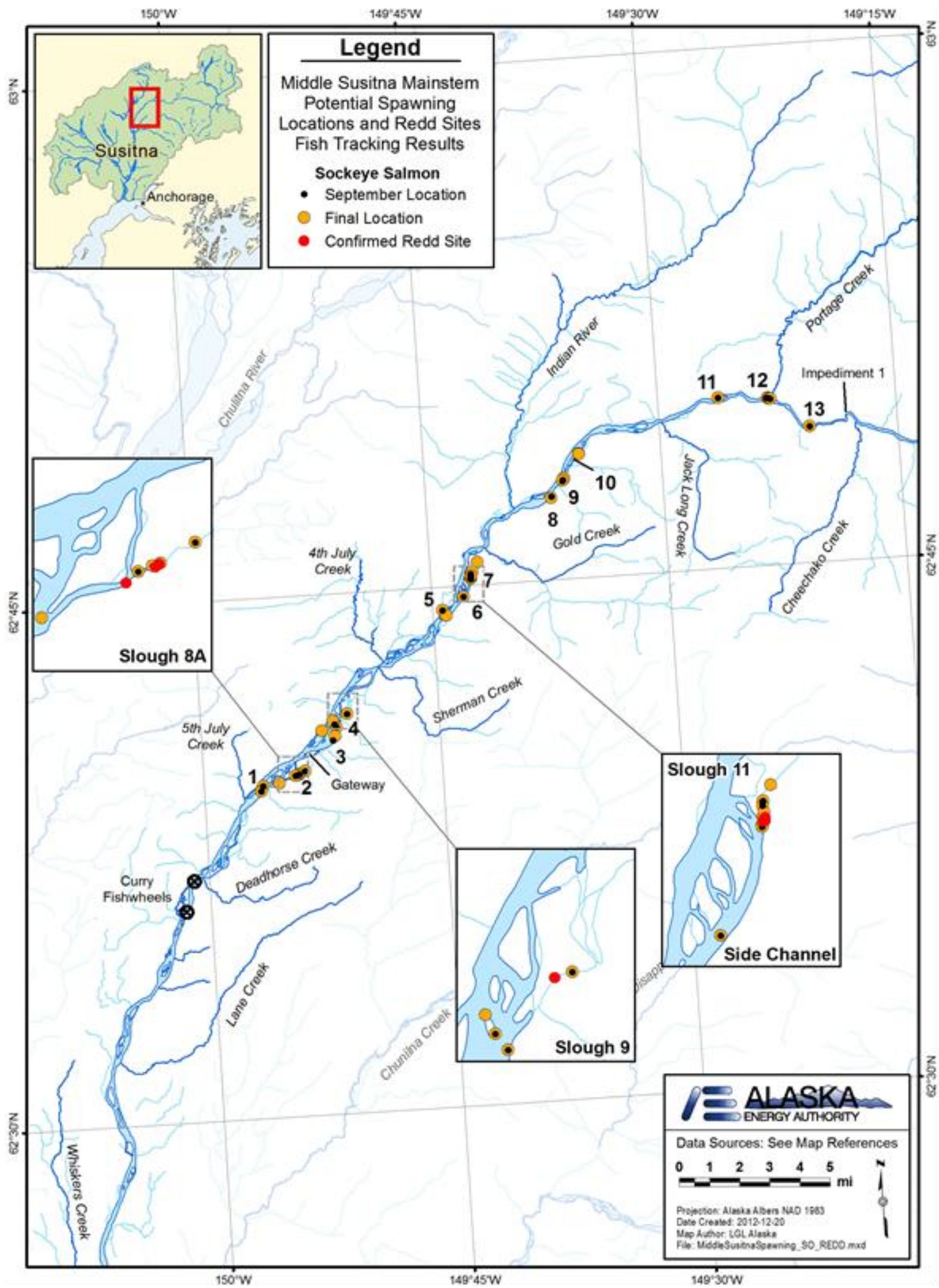


Figure 43. Potential mainstem spawning locations and redd sites for sockeye salmon in the Middle River.

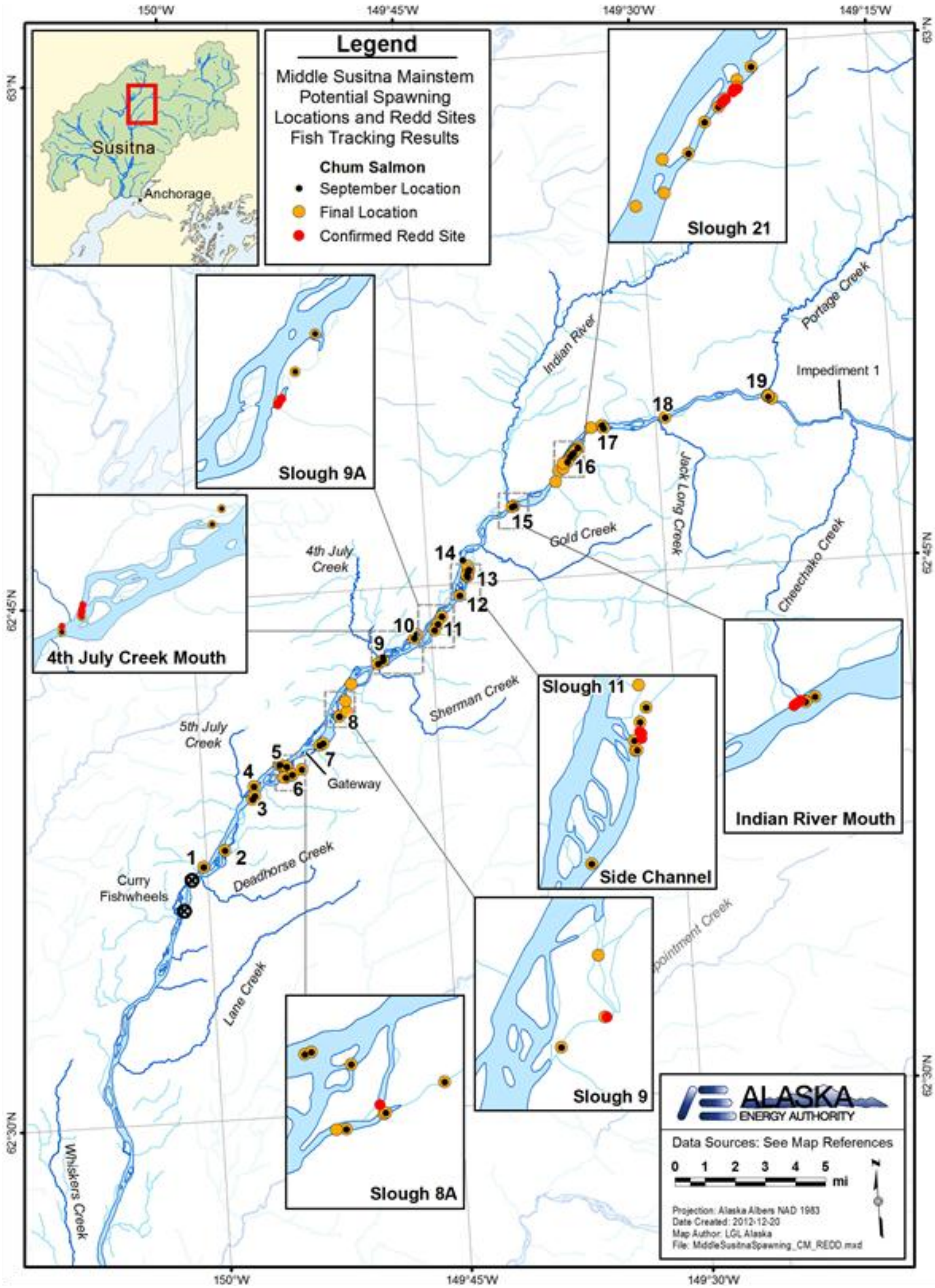


Figure 44. Potential mainstem spawning locations and redd sites for chum salmon in the Middle River.

PHOTOS

Photo 1. Fishwheel components being taken off a rail car at Curry, June 4, 2012.

Photo 2. Chinook salmon being measured for length while held in a water-filled trough at Site 1, 2012.

Photo 3. A radio-tagged adult Chinook salmon just prior to release from a fishwheel at Site 1, July 16, 2012. Note the whip antenna of the radio tag protruding from the mouth.

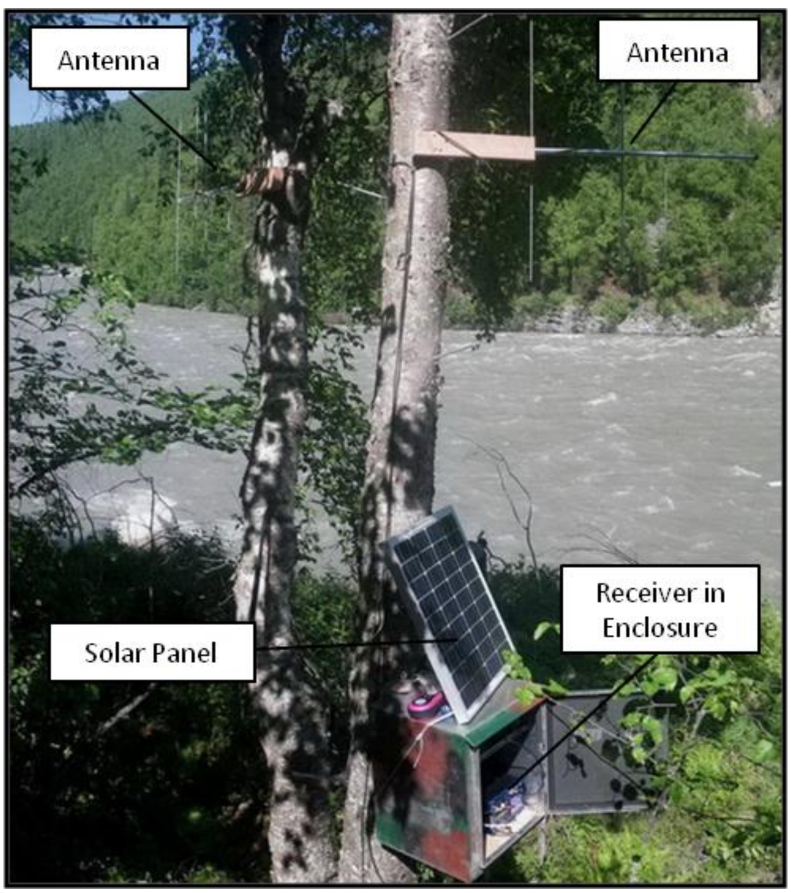


Photo 4. Fixed-station receiver site near Chinook Creek on the Susitna River, July 19, 2012.

Photo 5. Helicopter (R44) setup for aerial-tracking surveys conducted on the Susitna River in 2012.

Photo 6. Setup for boat surveys using sonar to assess spawning activity in turbid water, July 28, 2012.

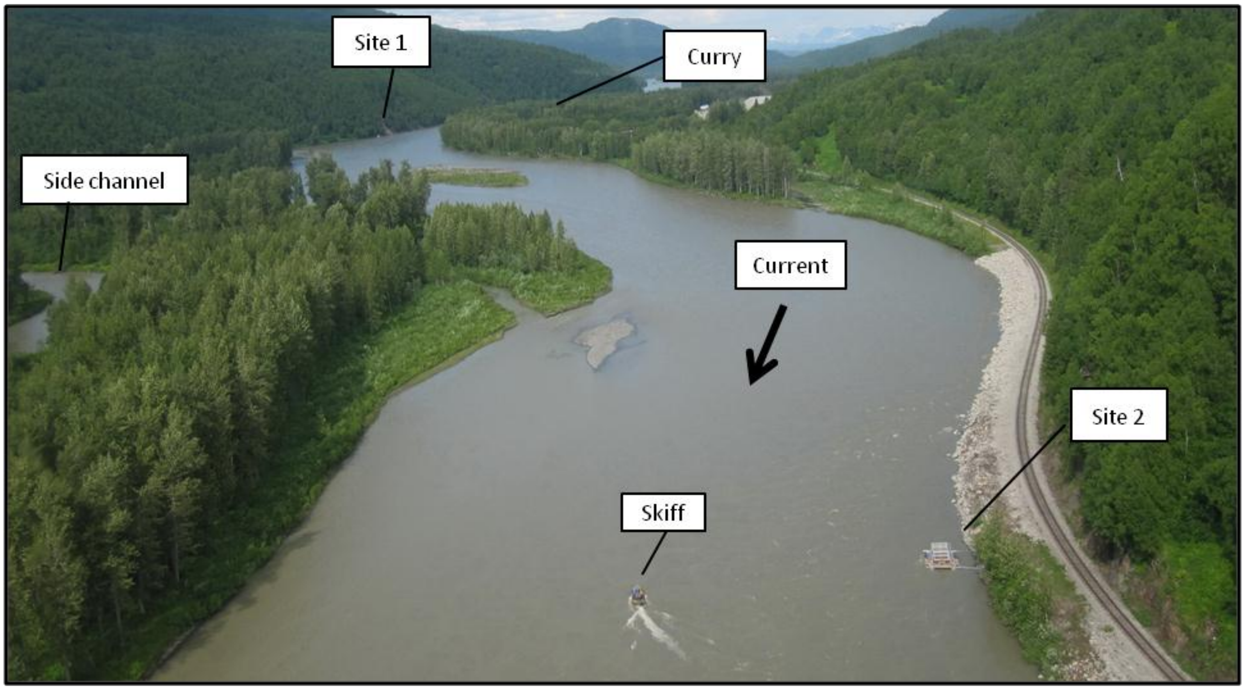


Photo 7. Aerial photograph (downstream view) of the Susitna River at Curry showing the location of two fishwheel sites (RM 119.4 and 120.6) used in 2012 (photo taken: June 19, 2012).

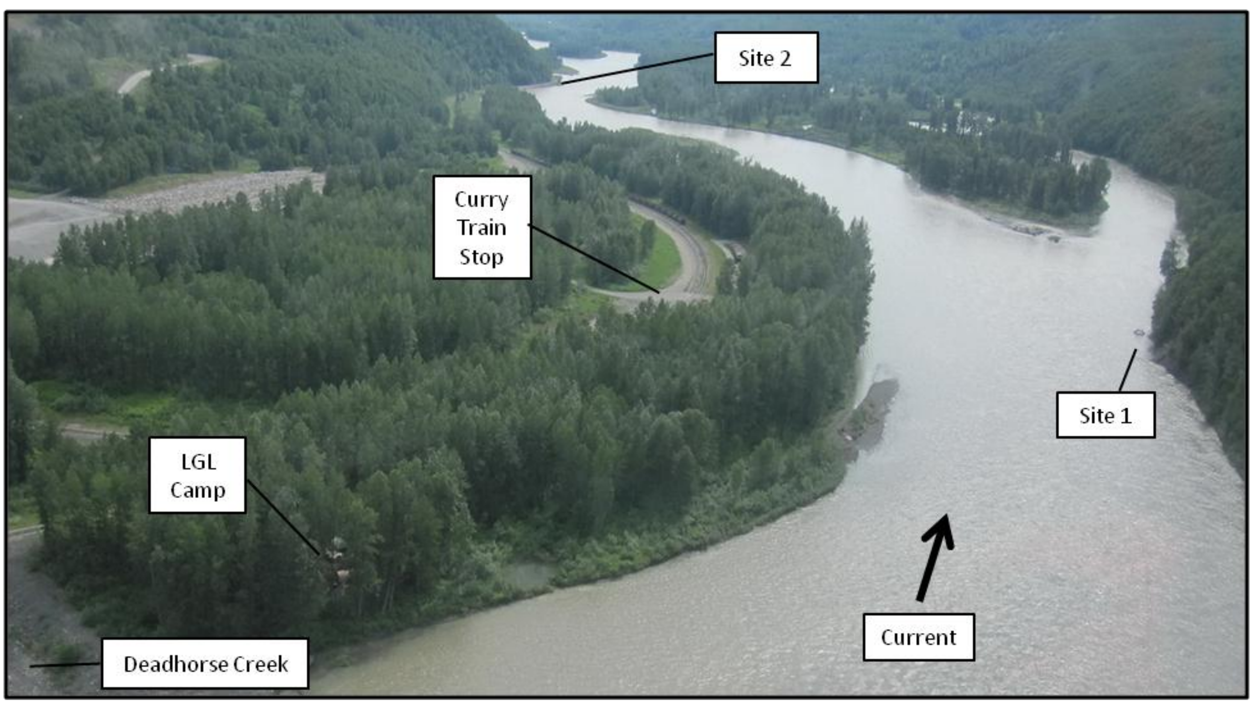


Photo 8. Aerial photograph (upstream view) of the Susitna River near Curry showing the location of two fishwheel sites (RM 119.4 and 120.6) used in 2012 (photo taken: June 19, 2012).

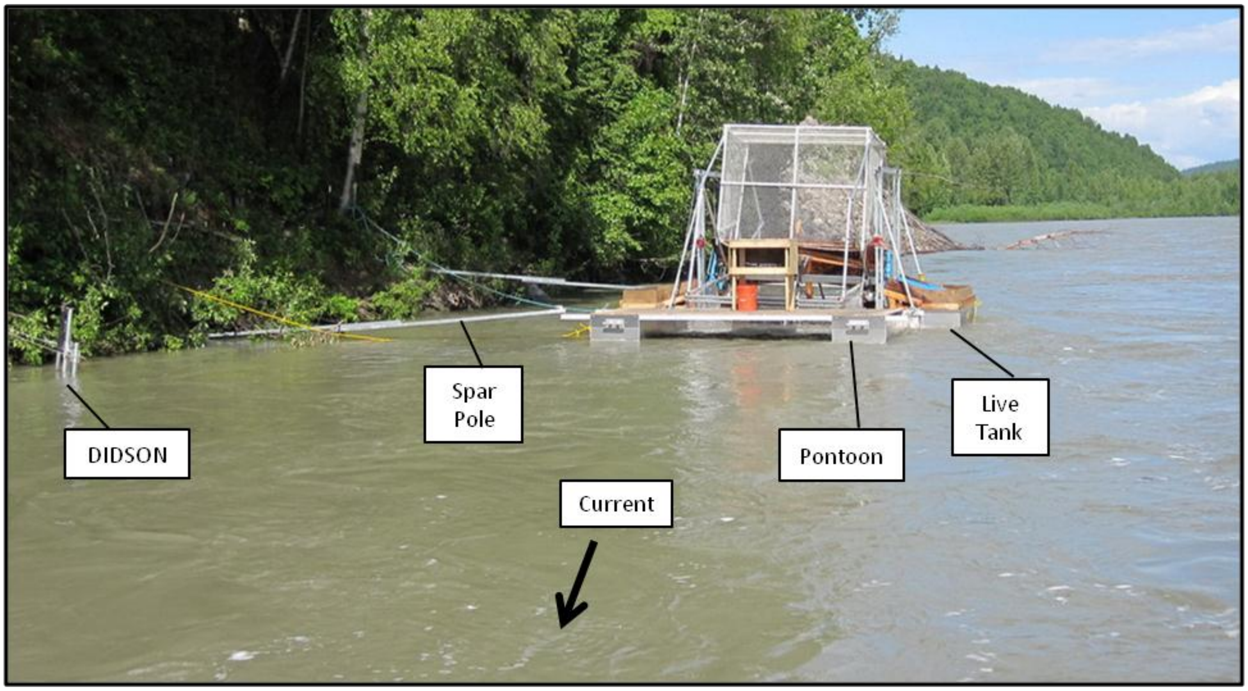


Photo 9. Fishwheel 1 operating at Site 1 (RM 120.6) on the right bank of the Susitna River, June 19, 2012.

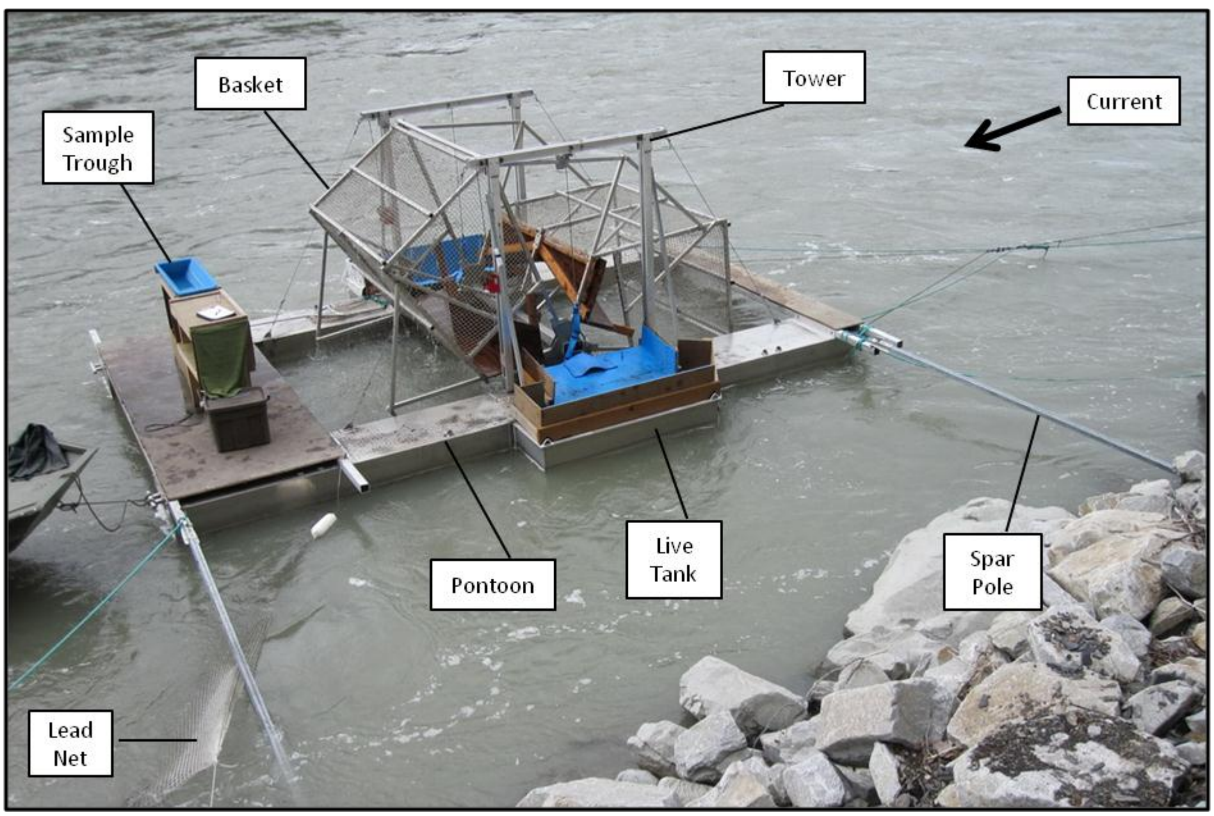


Photo 10. Fishwheel 2 operating at Site 2 (RM 119.4) on the left bank of the Susitna River, July 11, 2012.

Photo 11. Chinook salmon carcass found along the bank of Portage Creek, July 30, 2012. Note the blue spaghetti tag sewn into the dorsal musculature and the radio tag still present in the stomach contents that had been removed by a bear.

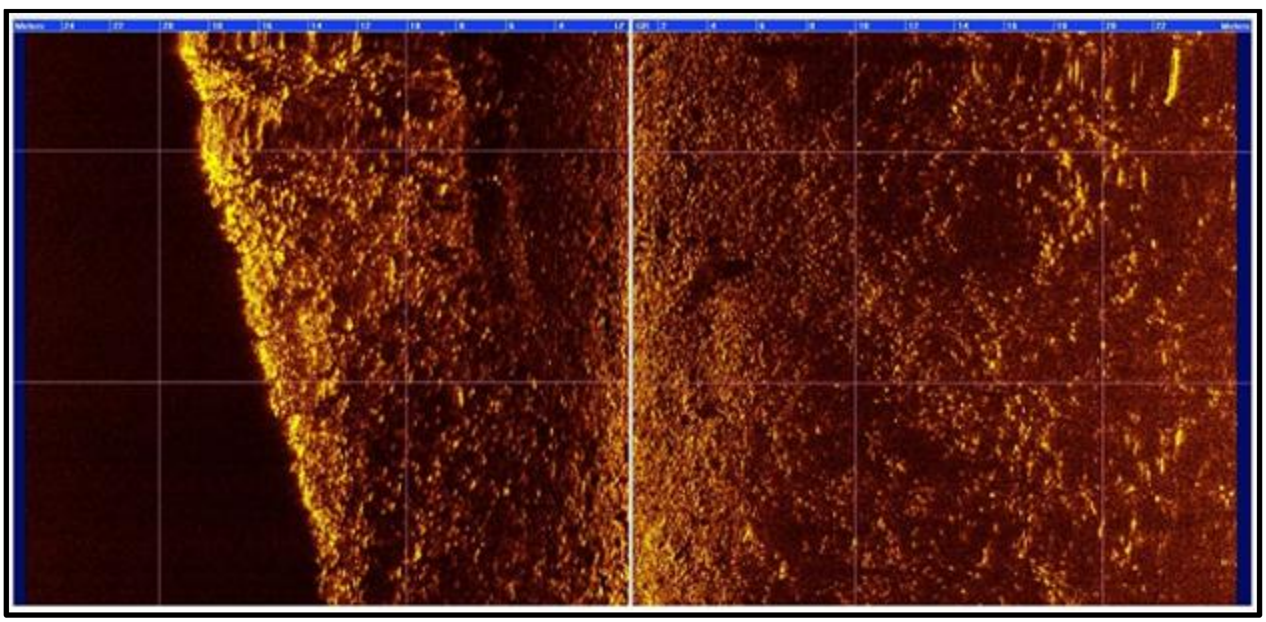


Photo 12. Image produced from the side-scan sonar (600 kHz) taken while pointed upstream at the mouth of 4th of July Creek. The photograph is a composite of simultaneous data received on the port (left half of the image) and starboard side (right half of the image) of the towed transducer. Left to right the image covers a total of 50 m (164 ft). On the left side the image shows the shoreline is visible between 15 and 20 m (49 and 66 ft) from the center. The image shows basic bathymetry: areas with a shallower slope reflect less sound and therefore appear darker, while steeper slopes appear brighter. Larger substrate can be seen closer to shore.

Photo 13. Pre-spawn sockeye salmon holding in Slough 8A, August 26, 2012.

APPENDICES

APPENDIX A. RIVER MILE DESIGNATIONS

Table A-1. Index of location names and historical river mile designations.

Sorted By River Mile		Sorted By Location Name	
Location Name	**River Mile**	**Location Name**	**River Mile**
Alexander Creek	10.1	Alexander Creek	10.1
Flathorn Station	18.2	Anderson Creek	23.8
Anderson Creek	23.8	Answer Creek	84.0
Susitna Station	25.5	Birch Creek	88.4
Kroto Slough Mouth	30.1	Birch Creek Slough	88.4
Yentna River	30.1	Byers Creek (Chulitna R)	98.6
Mainstem Susitna Slough	31.0	Cache Creek	96.0
Mid Kroto Slough	36.3	Cache Creek Slough	95.5
Deshka River	40.6	Caswell Creek	63.0
Delta Islands	44.0	Chase Creek	106.4
Little Willow Creek	50.5	Cheechako Creek	152.4
Rustic Wilderness	58.1	Chinook Creek	157.0
Kashwitna River	61.0	Chulitna River	98.6
Caswell Creek	63.0	Curry Station	120.0
Slough West Bank	65.6	Dead Horse Creek	120.9
Sheep Creek Slough	66.1	Deadman Creek	186.7
Goose Creek	72.0	Delta Islands	44.0
Montana Creek	77.0	Deshka River	40.6
Sunshine Station	80.0	Devil Creek	161.0
Rabideaux Creek Slough	83.1	Devils Canyon Back Eddy	150.0
Parks Highway Bridge	83.9	Fat Canoe Island	147.0
Answer Creek	84.0	Fifth of July Creek	123.7
Question Creek	84.1	Fish Creek (Talkeetna R)	97.2
Sunshine Creek	85.7	Flathorn Station	18.2
Birch Creek Slough	88.4	Fog Creek	176.7
Birch Creek	88.4	Fourth of July Creek	131.1
Cache Creek Slough	95.5	Gash Creek	111.6
Cache Creek	96.0	Gold Creek	136.7
Fish Creek (Talkeetna R)	97.2	Gold Creek Bridge	136.7
Talkeetna River	97.2	Goose Creek	72.0
Byers Creek (Chulitna R)	98.6	Goose Creek	231.3
Troublesome Creek (Chulitna R)	98.6	Indian River	138.6
Swan Lake (Chulitna R)	98.6	Jack Long Creek	144.5
Chulitna River	98.6	Jay Creek	208.5
Slough 1	99.6	Kashwitna River	61.0
Slough 2	100.2	Kosina Creek	206.8
Whiskers Creek Slough	101.2	Kroto Slough Mouth	30.1
Whiskers Creek	101.4	Lane Creek	113.6
Slough 3B	101.4	Little Portage Creek	117.7
Slough 3A	101.9	Little Willow Creek	50.5
Talkeetna Station	103.0	Lower McKenzie Creek	116.2
Slough 4	105.2	Mainstem Susitna Slough	31.0
Chase Creek	106.4	Mid Kroto Slough	36.3
Slough 5	107.6	Montana Creek	77.0
Slough 6	108.2	Moose Slough	123.5
Oxbow I	110.2	Oshetna River	233.4

Sorted By River Mile		Sorted By Location Name	
Location Name	River Mile	Location Name	River Mile
Slash Creek	111.5	Oxbow I	110.2
Gash Creek	111.6	Parks Highway Bridge	83.9
Slough 6A	112.3	Portage Creek	148.9
Slough 7	113.2	Question Creek	84.1
Lane Creek	113.6	Rabideaux Creek Slough	83.1
Slough 8	113.7	Rustic Wilderness	58.1
Lower McKenzie Creek	116.2	Sheep Creek Slough	66.1
Upper McKenzie Creek	116.7	Sherman Creek	130.8
Little Portage Creek	117.7	Side Channel 10A	132.1
Curry Station	120.0	Skull Creek	124.7
Dead Horse Creek	120.9	Slash Creek	111.5
Susitna Side Channel	121.6	Slough 1	99.6
Slough 8D	121.8	Slough 10	133.8
Slough 8C	121.9	Slough 10	133.8
Slough 8B	122.2	Slough 10 Side Channel	133.7
Moose Slough	123.5	Slough 11	135.3
Fifth of July Creek	123.7	Slough 12	135.4
Slough A prime	124.6	Slough 13	135.9
Slough A	124.7	Slough 14	135.9
Skull Creek	124.7	Slough 15	137.2
Slough 8A	125.1	Slough 16B	137.3
Slough B	126.3	Slough 17	138.9
Slough 9	128.3	Slough 18	139.1
Slough 9B	129.2	Slough 19	139.7
Sherman Creek	130.8	Slough 2	100.2
Fourth of July Creek	131.1	Slough 20	140.0
Side Channel 10A	132.1	Slough 21	141.1
Slough 10 Side Channel	133.7	Slough 21 Side Channel	140.5
Slough 10	133.8	Slough 21A	144.3
Slough 9A	133.8	Slough 22	144.3
Slough 10	133.8	Slough 3A	101.9
Slough 11	135.3	Slough 3B	101.4
Slough 12	135.4	Slough 4	105.2
Slough 13	135.9	Slough 5	107.6
Slough 14	135.9	Slough 6	108.2
Gold Creek	136.7	Slough 6A	112.3
Gold Creek Bridge	136.7	Slough 7	113.2
Slough 15	137.2	Slough 8	113.7
Slough 16B	137.3	Slough 8A	125.1
Indian River	138.6	Slough 8B	122.2
Slough 17	138.9	Slough 8C	121.9
Slough 18	139.1	Slough 8D	121.8
Slough 19	139.7	Slough 9	128.3
Slough 20	140.0	Slough 9A	133.8
Slough 21 Side Channel	140.5	Slough 9B	129.2
Slough 21	141.1	Slough A	124.7
Slough 21A	144.3	Slough A prime	124.6
Slough 22	144.3	Slough B	126.3

Sorted By River Mile		Sorted By Location Name	
Location Name	**River Mile**	**Location Name**	**River Mile**
Jack Long Creek	144.5	Slough West Bank	65.6
Fat Canoe Island	147.0	Sunshine Creek	85.7
Portage Creek	148.9	Sunshine Station	80.0
Devils Canyon Back Eddy	150.0	Susitna Side Channel	121.6
Cheechako Creek	152.4	Susitna Station	25.5
Chinook Creek	157.0	Swan Lake (Chulitna R)	98.6
Devil Creek	161.0	Talkeetna River	97.2
Fog Creek	176.7	Talkeetna Station	103.0
Tsusena Creek	181.3	Troublesome Creek (Chulitna R)	98.6
Watana Dam Site	184.0	Tsusena Creek	181.3
Deadman Creek	186.7	Upper McKenzie Creek	116.7
Watana Creek	194.1	Watana Creek	194.1
Kosina Creek	206.8	Watana Dam Site	184.0
Jay Creek	208.5	Whiskers Creek	101.4
Goose Creek	231.3	Whiskers Creek Slough	101.2
Oshetna River	233.4	Yentna River	30.1

APPENDIX B: FIXED-STATION RECEIVER SITES (SETUP AND PERFORMANCE) AND MOBILE-TRACKING SURVEY EFFORT

Table B-1. Number of radio tags deployed at the Curry fishwheels on specific radio frequencies.

Frequency (MHz)	Chinook	Sockeye	Pink	Chum	Coho
151.713	85			5	
151.763	89			11	
151.783	92			6	
151.914	86			14	
151.924		12	5	36	33
151.934		14	3	39	24
151.943		7	6	43	34
151.954		10	3	46	29
151.963		14	6	38	33
151.974		13	6	41	31
151.983			101		
151.994			100		
Total	352	70	230	279	184

Notes:
151.000 MHz was used for reference tags

Table B-2. Location and antenna orientation of fixed-station receivers in the Middle and Upper Susitna River, 2012.

Site Location	Receiver No.	RM	Latitude	Longitude	River Bank	Antenna	Antenna Orientation
Lane Creek	1,2	113	62.52792	-150.11407	Right	1	Downstream
						2	Upstream
						3	Across the river
Gateway	3	126	62.67645	-149.89303	Right	1	Downstream
						2	Upstream
Slough 11	4	136	62.75823	-149.70432	Left	1	Across the slough
Indian River	5	139	62.7853	-149.65793	Right	1	Downstream
						2	Upstream
						3	Up tributary
Slough 21	6	142	62.81361	-149.57637	Left	1	Across the slough
Portage Creek	7	149	62.83009	-149.38151	Right	1	Downstream
						2	Upstream
						3	Up tributary
Cheechako Creek	8	154	62.80732	-149.2526	Left	1	Downstream
						2	Upstream
Chinook Creek	9	157	62.80153	-149.16333	Left	1	Downstream
						2	Upstream
Devil Creek	10, 11	164	62.80846	-149.00186		1	River Left Channel
						2	River Right Channel
						3	Upstream
Kosina Creek	12	207	62.78389	-147.93802	Right	1	Downstream
						2	Upstream
						3	Up tributary

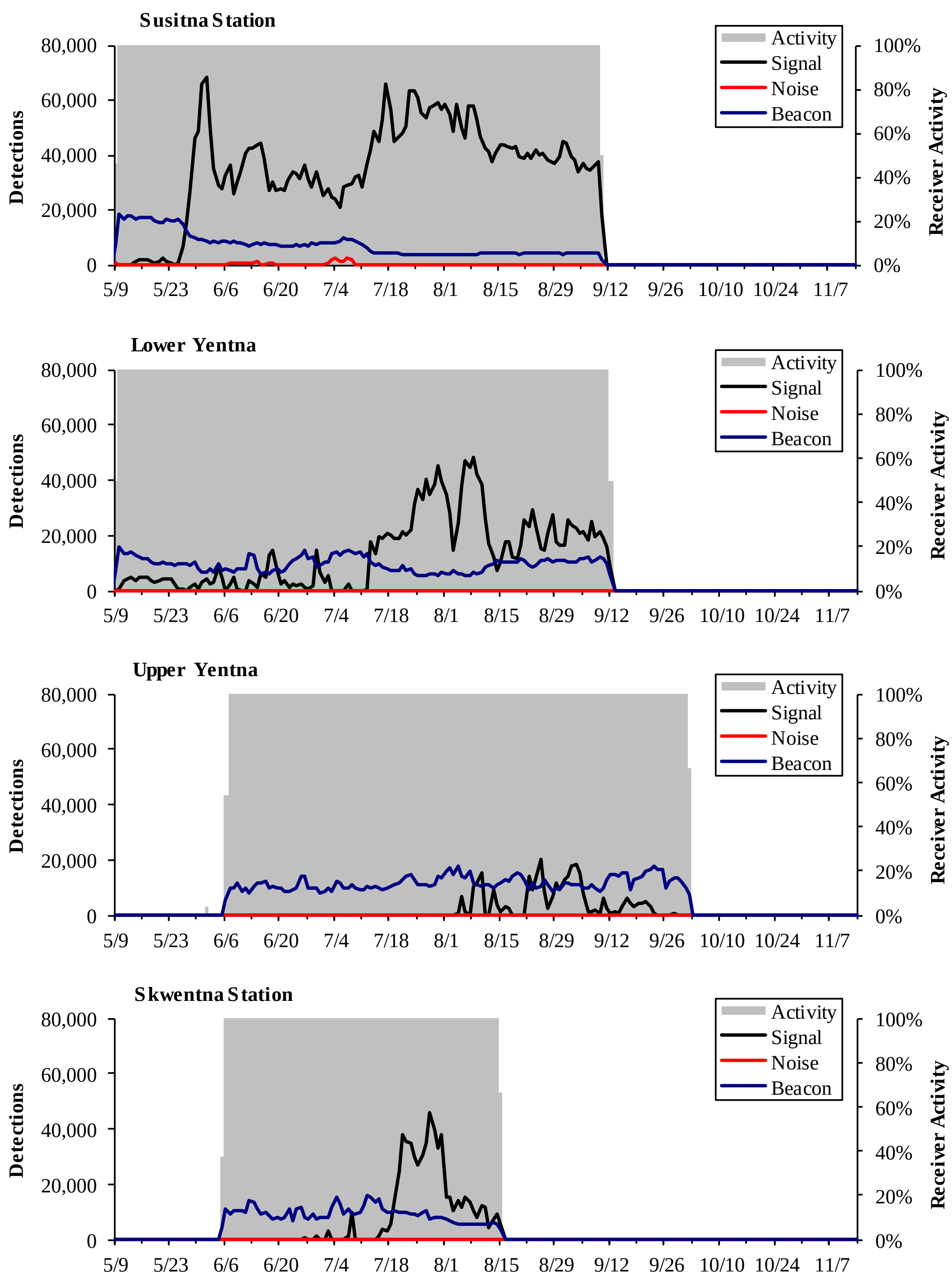


Figure B-1. Detection activity at fixed-station receivers, including numbers of fish detections (black line), beacon-tag hits (blue line) and noise events (red line), by day. Also shown, receiver activity patterns (grey shading, right axis). Any detection (frequency-code) that did not correspond to a valid fish was considered as noise. Note: Y-axis scale varies among panels.

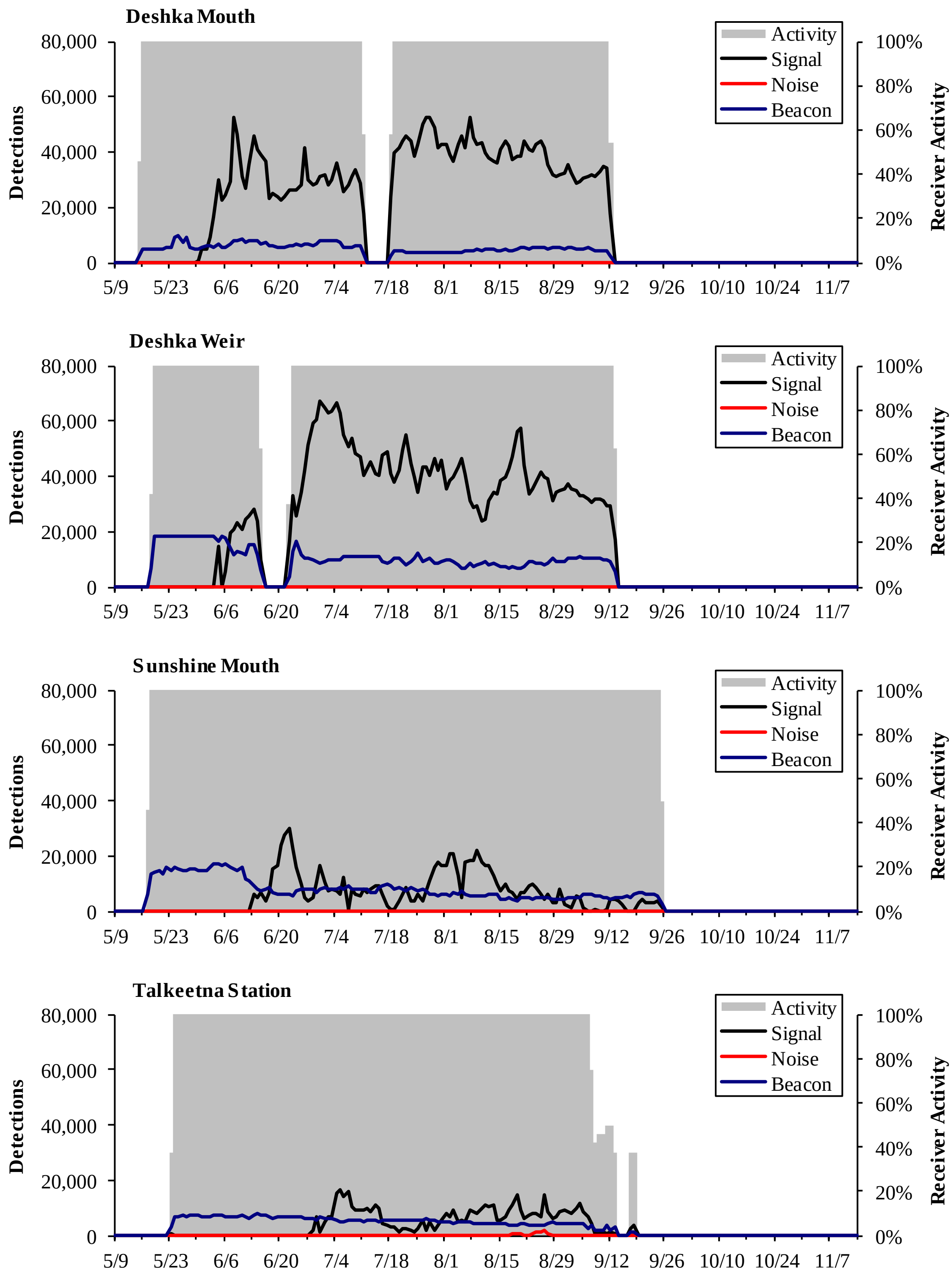


Figure B-1. Continued.

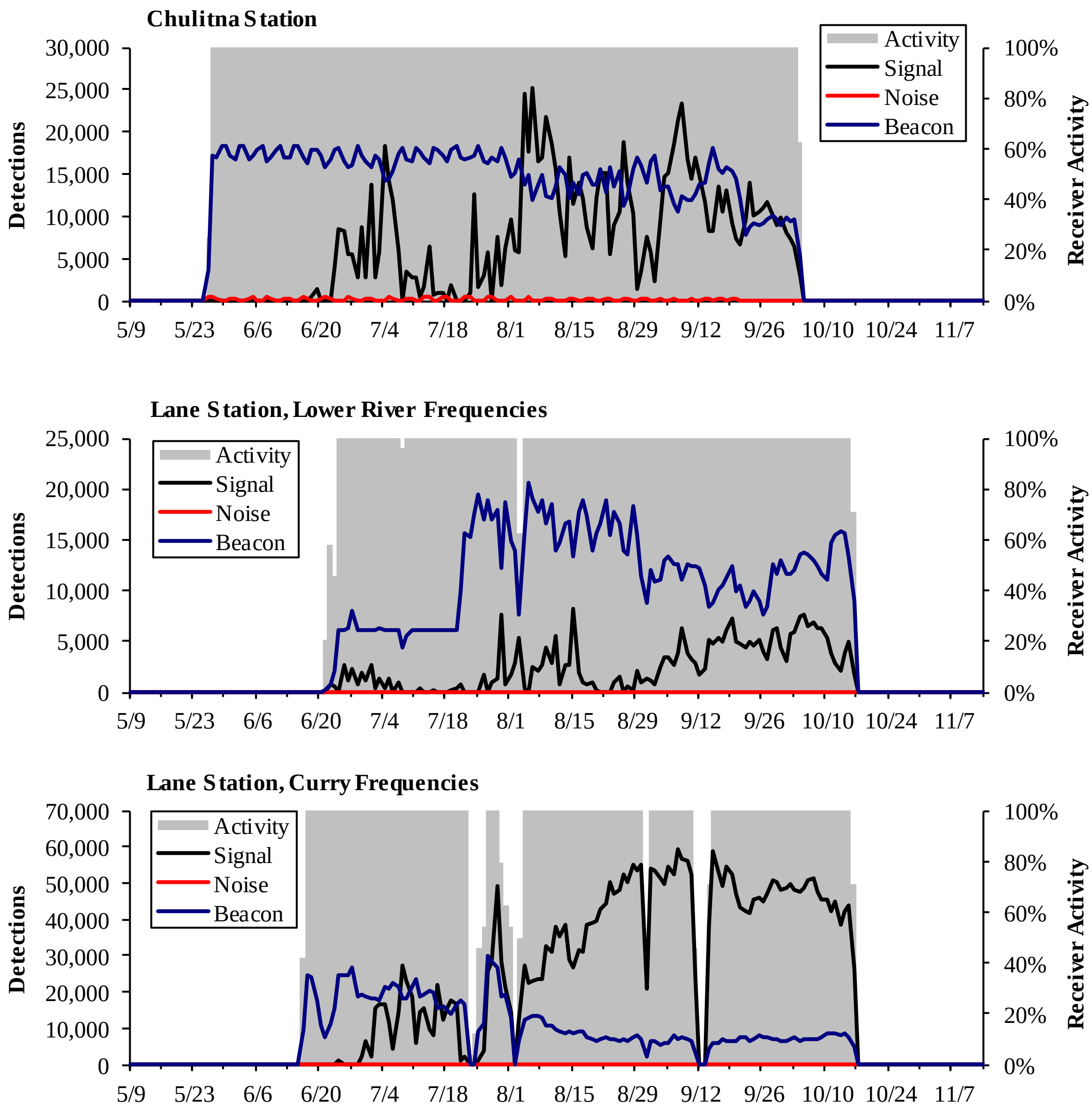


Figure B-1. Continued.

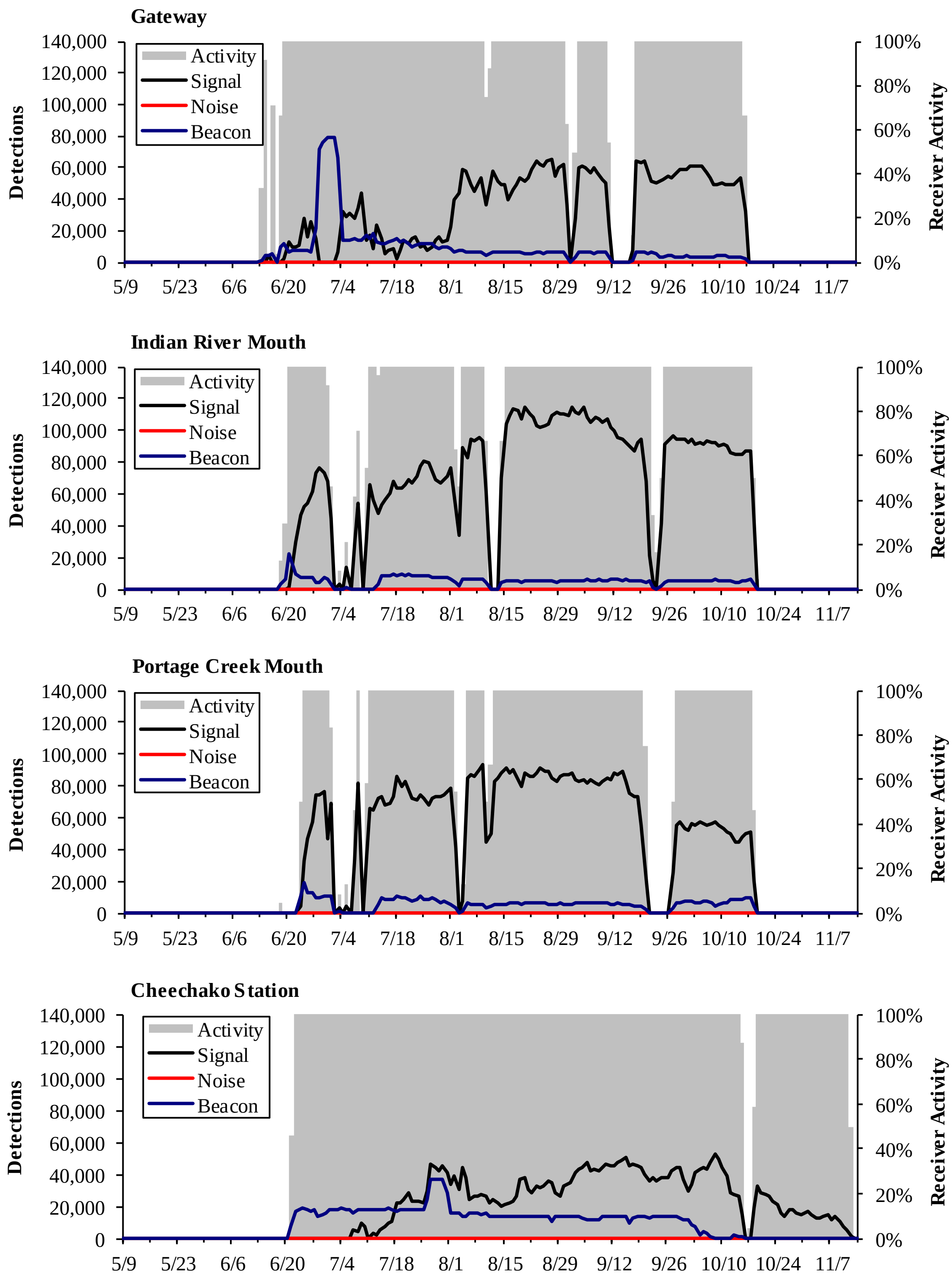


Figure B-1. Continued.

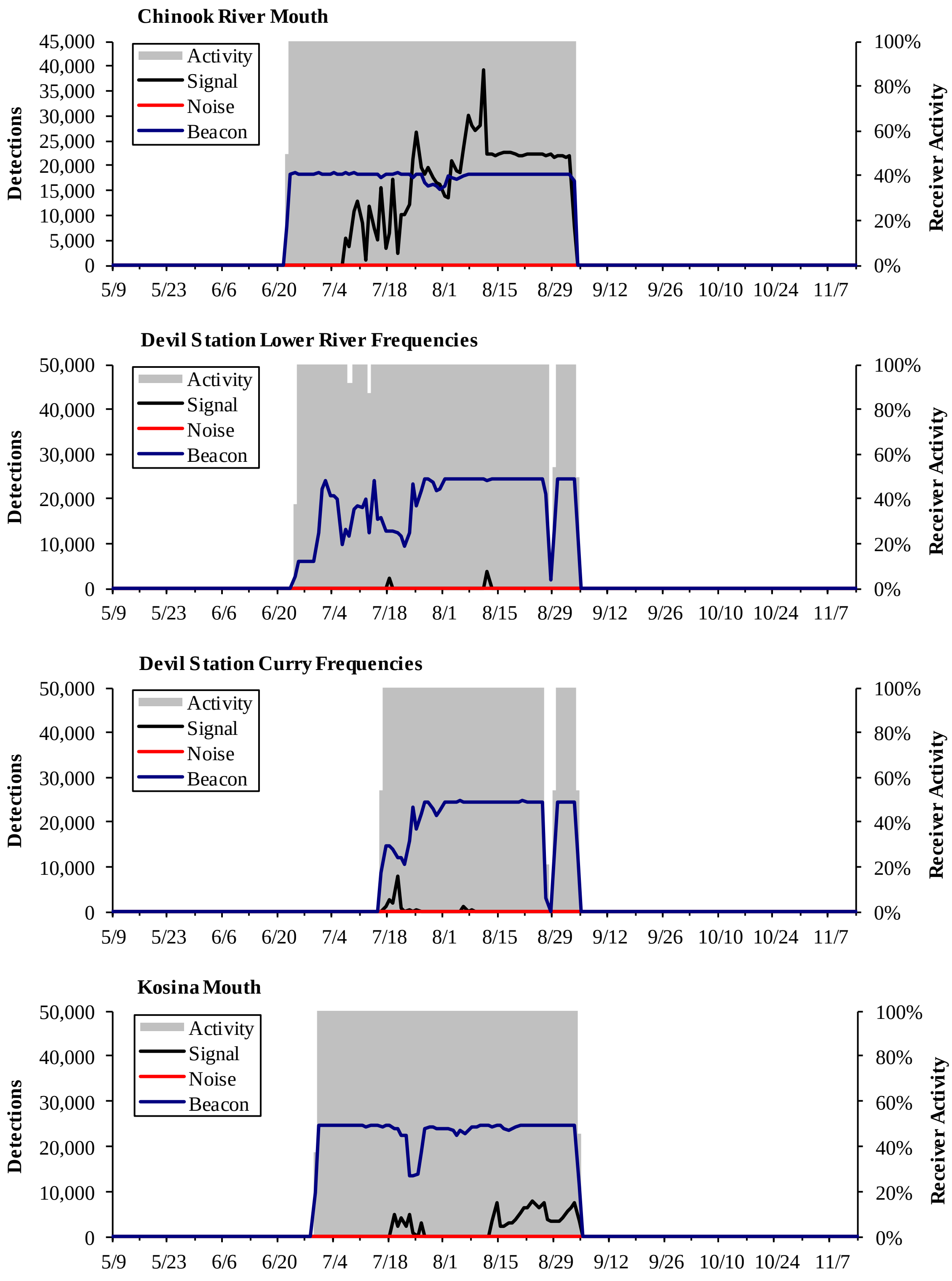


Figure B-1. Continued.

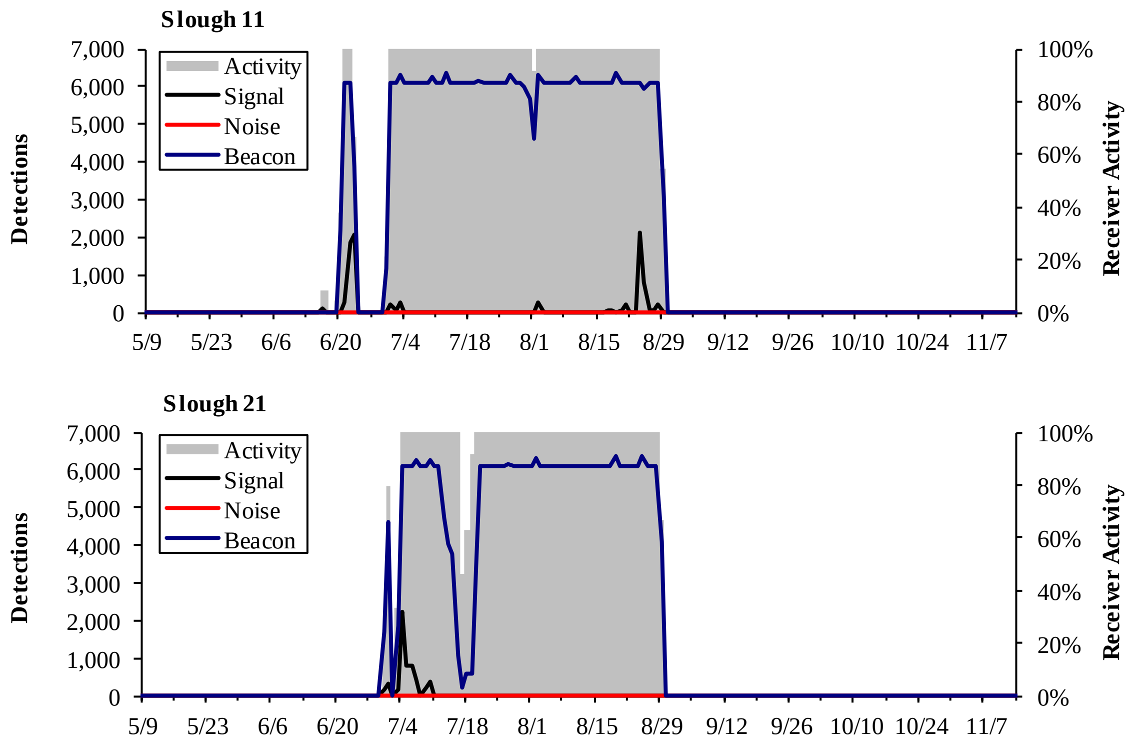


Figure B-1. Continued.

Table B-3. List of the mobile-tracking surveys conducted in 2012, by location, date and vehicle type.

	Survey Date																				
Susitna Mainstem	**6/29**	**6/30**	**7/3**	**7/5**	**7/8**	**7/9**	**7/10**	**7/13**	**7/16**	**7/17**	**7/18**	**7/19**	**7/20**	**7/23**	**7/24**	**7/25**	**7/26**	**7/28**	**7/30**	**7/31**	**8/1**
Outside Susitna											F										
Confluence - Yentna	F						F				F					H					
Yentna - Deshka	F						F				F					H					
Deshka - Kashwitna	F						F			F	HF					H					H
Kashwitna - Montana	F									F	HF					H					H
Montana - Sunshine	F									F	HF					H					H
Sunshine - Talkeetna	F									HF	H					H			H		
Talkeetna - Lane	F									H					H				H		
Lane - Gateway	F	B	B	B	B	H		B	H	HF		H	H	H	H			H	H	H	
Gateway - Slough11	F	B	B	B		H		B	H	HF		H	H	H	H			H	H	H	
Slough11 - Indian	F	B	B	B		H		B	H	HF		H	H	H	H			H	H	H	
Indian - Slough21	F	B	B	B		H		B	H	HF		H	H	H	H			H	H		
Slough21 - Portage	F	B	B	B		H		B	H	HF		H	H	H	H				H		
Portage - Impediment1	F			B		H				HF		H	H	H			H	H		H	
Impediment1 - Cheechako						H				HF		H	H	H			H	H		H	
Cheechako - Impediment2						H				HF		H	H	H			H	H		H	
Impediment2 - Chinook						H				HF		H	H	H			H	H		H	
Chinook - Impediment3						H				HF		H	H	H			H	H		H	
Impediment3 - Devil Stn						H				HF		H	H	H			H	H		H	
Devil - Wantana										HF		H	H	H			H	H		H	
Wantana - Kosina										H		H	H	H			H	H		H	
Above Kosina														H							

Notes:
B - boat; F - fixed wing; H - helicopter

Table B-3. Continued.

	Survey Date																				
Susitna Mainstem	**8/3**	**8/5**	**8/6**	**8/7**	**8/8**	**8/9**	**8/10**	**8/11**	**8/13**	**8/14**	**8/15**	**8/16**	**8/17**	**8/18**	**8/21**	**8/22**	**8/24**	**8/25**	**8/27**	**8/28**	**8/29**
Outside Susitna																					
Confluence - Yetna				F										H			F	F			
Yetna - Deshka	F		F	F										H			F			H	
Deshka - Kashwitna			F		H	F								H		F	H			H	F
Kashwitna - Montana			F		H	F	F				H			H		F	H			H	F
Montana - Sunshine			F		H	F	F				H			H		F	H			H	F
Sunshine - Talkeetna			HF			F	F				H					HF				H	F
Talkeetna - Lane			HF			F	F		H			H				HF			H		F
Lane - Gateway			HF				F		H			H				HF			H		F
Gateway - Slough11		H	HF				F		H			H				HF			H		F
Slough11 - Indian		H	HF	H			F		H			H				HF			H		F
Indian - Slough21		H	H				F		H			H				HF			H		F
Slough21 - Portage		H	H	H		H	F		H			H			H	HF			H		F
Portage - Impediment1		H	F	H		HF	F	H	H	H			H		H	HF			H		F
Impediment1 - Cheechako		H	F	H		H	F	H		H			H		H	F			H		F
Cheechako - Impediment2		H	F	H		H	F	H		H			H		H	F			H		F
Impediment2 - Chinook		H		H		H	F	H		H			H		H	F			H		F
Chinook - Impediment3		H		H		H	F	H		H			H		H	F			H		F
Impediment3 - Devil Stn		H		H		H	F	H		H			H		H	F			H		F
Devil - Wantana		H		H		H		H		H			H		H						
Wantana - Kosina		H		H		H		H		H			H		H						
Above Kosina																					

Notes:

B - boat; F - fixed wing; H - helicopter

Table B-3. Continued.

	Survey Date																		
Susitna Mainstem	**8/30**	**9/3**	**9/7**	**9/9**	**9/10**	**9/11**	**9/13**	**9/17**	**9/24**	**9/26**	**9/27**	**10/1**	**10/2**	**10/3**	**10/9**	**10/10**	**10/16**	**10/29**	**11/12**
Outside Susitna																			
Confluence - Yetna	H		F								F								
Yetna - Deshka			F																
Deshka - Kashwitna			F		H					F									
Kashwitna - Montana					H					F									
Montana - Sunshine		H			H		F			F			H						
Sunshine - Talkeetna		H			H		F		H	F			H			H	H		
Talkeetna - Lane		H		H				H	H	F			H			H	H	H	
Lane - Gateway		H		H				H	H	F		H			H	H	H	H	H
Gateway - Slough11		H		H				H	H	F		H			H		H	H	H
Slough11 - Indian		H		H				H	H	F		H			H		H	H	H
Indian - Slough21		H		H				H	H	F		H			H		H	H	H
Slough21 - Portage		H		H				H	H	F		H			H		H	H	H
Portage - Impediment1		H		H				H	H	F		H			H		H	H	H
Impediment1 - Cheechako		H		H				H	H	F		H			H		H	H	H
Cheechako - Impediment2		H								F								H	
Impediment2 - Chinook		H								F								H	
Chinook - Impediment3										F								H	
Impediment3 - Devil Stn										F								H	
Devil - Wantana																		H	
Wantana - Kosina																			
Above Kosina																			

Notes:

B - boat; F - fixed wing; H - helicopter

Table B-3. Continued.

Tributaries and Other Watersheds	Survey Date																				
	6/29	6/30	7/3	7/5	7/8	7/9	7/10	7/13	7/16	7/17	7/18	7/19	7/20	7/23	7/24	7/25	7/26	7/28	7/30	7/31	8/1
Little Susitna							F														
Alexander Creek																					
Yentna River																				F	
Deshka River	F										F									F	
Willow and Little Willow cr	F						F				F										
Kashwitna River	F										F										
Caswell area tribs	F										F										
Sunshine Creek																					
Rabideux Creek																					
Talkeetna River										F											
Chulitna River										F	F										
Whiskers Creek																					
Trib off Zone 95																					
Lane Creek																					
5th of July Creek																					
Slough 8A																					
Slough 9																					
Sherman Creek																					
4th of July Creek												H	H	H	H		H		H		
Slough 11												H		H							
Gold Creek																					
Indian trib	F								H	F		H		H	H			H		H	
Slough 21												H									
Jack Long Creek																					
Portage trib	F								H	HF		H			H			H	H		
Cheechako Creek													H				H	H		H	
Chinook Creek												H	H				H	H		H	
Devils Creek												H	H	H			H	H		H	
Fog Creek												H		H			H				
Tsusena Creek												H					H				
Deadman & Watana cr.												H		H			H				
Kosina Creek										H			H	H			H			H	
Oshetna Creek																					

B - boat; F - fixed wing; H - helicopter

Table B-3. Continued.

Tributaries and Other Watersheds	Survey Date																				
	8/3	8/5	8/6	8/7	8/8	8/9	8/10	8/11	8/13	8/14	8/15	8/16	8/17	8/18	8/21	8/22	8/24	8/25	8/27	8/28	8/29
Little Susitna																					
Alexander Creek																					
Yentna River				F	F													F		F	F
Deshka River				F	F	F										F					F
Willow and Little Willow cr			F				F										F			F	
Kashwitna River	F						F										F				F
Caswell area tribs	F						F										F				F
Sunshine Creek																					
Rabideux Creek																					
Talkeetna River			F			F	F				H					F					F
Chulitna River			F			F	F					H					F				F
Whiskers Creek																					
Trib off Zone 95																					
Lane Creek																					
5th of July Creek																					
Slough 8A			H						H			H				H			H		
Slough 9									H			H				H			H		
Sherman Creek																					
4th of July Creek		H	H						H			H				H			H		
Slough 11		H	H	H					H			H							H		
Gold Creek		H		H					H			H									
Indian trib			HF		H	F			H				H			F					F
Slough 21		H	H						H			H							H		
Jack Long Creek									H			H				H			H		
Portage trib			HF			F		H					H			F					F
Cheechako Creek		H		H		H		H		H			H		H						
Chinook Creek		H		H		H		H		H			H								
Devils Creek		H		H		H		H		H			H								
Fog Creek		H		H		H		H		H			H								
Tsusena Creek		H		H		H		H		H			H								
Deadman & Watana cr.		H		H		H		H		H			H								
Kosina Creek		H		H		H		H		H			H								
Oshetna Creek																					

B - boat; F - fixed wing; H - helicopter

Table B-3. Continued.

	Survey Date																		
Tributaries and Other Watersheds	**8/30**	**9/3**	**9/7**	**9/9**	**9/10**	**9/11**	**9/13**	**9/17**	**9/24**	**9/26**	**9/27**	**10/1**	**10/2**	**10/3**	**10/9**	**10/10**	**10/16**	**10/29**	**11/12**
Little Susitna																			
Alexander Creek			F																
Yentna River						F	F				F			F					
Deshka River							F							F					
Willow and Little Willow cr			F									F							
Kashwitna River			F									F							
Caswell area tribs			F									F							
Sunshine Creek																			
Rabideux Creek																			
Talkeetna River												F					H	H	
Chulitna River							F			F				F				H	
Whiskers Creek								H					H			H		H	
Trib off Zone 95																H		H	
Lane Creek												H				H		H	
5th of July Creek												H			H			H	
Slough 8A		H		H				H	H			H							
Slough 9		H		H				H	H			H							
Sherman Creek												H			H			H	
4th of July Creek		H										H			H		H	H	
Slough 11		H		H				H	H			H			H		H	H	H
Gold Creek									H			H						H	
Indian trib									H	F		H			H		H	H	H
Slough 21								H	H			H					H		
Jack Long Creek												H			H		H	H	
Portage trib										F		H			H			H	
Cheechako Creek												H							
Chinook Creek																			
Devils Creek																		H	
Fog Creek																			
Tsusena Creek																			
Deadman & Watana cr.																			
Kosina Creek																			
Oshetna Creek																			

B - boat; F - fixed wing; H - helicopter

APPENDIX C: FISHWHEEL EFFORT, CATCH, AND TAGS APPLIED

Table C-1. Fishwheel effort and speed at the Curry fishwheels, 2012.

	Site 1[1]		Site 2			Site 1		Site 2	
Date	Effort (h)	RPM	Effort (h)	RPM	Date	Effort (h)	RPM	Effort (h)	RPM
17-Jun	9.0	2.8			28-Jul	9.0	3.2	9.0	3.1
18-Jun	12.3	2.5	7.6	2.8	29-Jul	8.6	3.4	11.4	3.3
19-Jun	15.4	2.7	15.6	3.2	30-Jul	9.1	3.6	8.5	3.6
20-Jun	16.9		16.2	3.2	31-Jul	9.1	3.6	9.1	3.5
21-Jun	15.9	3.6	14.0	3.5	01-Aug	8.7	3.2	8.7	2.9
22-Jun	16.1	3.2	15.6	3.4	02-Aug	8.9	3.3	8.7	2.7
23-Jun	17.7	3.2	16.8	3.3	03-Aug	9.2	3.0	9.0	3.0
24-Jun	17.1	3.3	16.7	3.6	04-Aug	9.0	3.7	9.1	3.6
25-Jun	10.6	3.2	9.7	3.5	05-Aug	9.2	3.4	9.0	3.0
26-Jun	12.0	2.7	9.6	3.5	06-Aug	9.1	3.1	9.0	2.8
27-Jun	9.9	2.7	10.2	3.3	07-Aug	9.1	2.6	9.2	2.4
28-Jun	9.8	2.7	9.8	3.0	08-Aug	10.0	2.6	9.1	2.5
29-Jun	11.9	2.8	9.8	2.7	09-Aug	9.0	2.7	9.1	3.4
30-Jun	14.8	2.5	7.6	2.2	10-Aug	9.0	2.5	9.0	3.2
01-Jul	12.5	2.8	11.8	3.4	11-Aug	9.0	2.9	9.1	3.5
02-Jul	14.0	2.5	14.0	2.7	12-Aug	9.1	2.7	9.0	3.2
03-Jul	11.6	3.0	13.5	3.2	13-Aug	9.0	2.6	9.0	3.4
04-Jul	14.0	2.9	13.4	3.2	14-Aug	9.0	2.6	9.0	3.2
05-Jul	13.9	2.8	13.9	2.7	15-Aug	9.1	2.6	9.0	3.3
06-Jul	13.8	2.0	13.6	2.4	16-Aug	9.0	2.5	9.0	3.3
07-Jul	12.2	1.7	9.7	3.1	17-Aug	9.1	2.5	9.0	2.9
08-Jul	9.0	3.7	11.9	4.3	18-Aug	9.0	2.4	9.0	3.0
09-Jul	8.0	4.0	5.3	3.1	19-Aug	8.8	2.4	8.4	3.0
10-Jul	11.8	3.4	8.4	2.9	20-Aug	9.0	2.5	8.1	3.0
11-Jul	14.9	2.6	11.2	3.3	21-Aug	9.0	3.0	8.9	3.5
12-Jul	14.0	2.6	11.8	2.8	22-Aug	11.1	3.0	3.6	3.9
13-Jul	13.9	2.8	8.8	2.6	23-Aug	11.9	2.4		
14-Jul	12.3	2.6	4.7	2.4	24-Aug	11.9	2.2		
15-Jul	8.4	2.8	0.0	0.0	25-Aug	11.8	2.3		
16-Jul	7.2	2.9	3.9	2.6	26-Aug	11.9	2.2		
17-Jul	9.2	3.4	9.8	2.7	27-Aug	4.2	3.5		
18-Jul	9.3	3.2	8.4	2.4	28-Aug	0.0	0.0		
19-Jul	8.5	2.9	8.3	2.2	29-Aug	8.8	3.5		
20-Jul	9.0	2.9	7.3	2.1	30-Aug	10.0	2.8		
21-Jul	11.2	3.3	11.8	2.6	31-Aug	6.7	2.5		
22-Jul	11.6	4.0	11.5	3.4	01-Sep	9.1	2.8		
23-Jul	8.6	4.7	11.7	4.5					
24-Jul	10.0	4.3	9.0	4.1					
25-Jul	8.4	4.1	8.6	3.6					
26-Jul	9.0	3.6	7.9	3.1					
27-Jul	8.7	3.5	8.0	3.1					

Notes:

[1] Fishwheel 1 operated at Site 1 from 17-Jun to 15-Jul; Fishwheel 3 operated at Site 1 from 16-Jul to 1-Sep.

Table C-2. Catch, catch-per-unit-effort, and tags applied to Chinook salmon at the Curry fishwheels, 2012.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
17-Jun	0	0.00	0				0	0.00	0
18-Jun	0	0.00	0	1	0.13	1	1	0.13	1
19-Jun	2	0.13	2	3	0.19	3	5	0.32	5
20-Jun	3	0.18	3	5	0.31	5	8	0.49	8
21-Jun	2	0.13	2	4	0.29	4	6	0.41	6
22-Jun	3	0.19	3	4	0.26	4	7	0.44	7
23-Jun	13	0.74	10	5	0.30	4	18	1.03	14
24-Jun	5	0.29	4	4	0.24	4	9	0.53	8
25-Jun	5	0.47	5	0	0.00	0	5	0.47	5
26-Jun	7	0.58	5	4	0.42	4	11	1.00	9
27-Jun	11	1.11	10	4	0.39	3	15	1.50	13
28-Jun	8	0.82	7	4	0.41	4	12	1.23	11
29-Jun	13	1.09	13	8	0.81	8	21	1.91	21
30-Jun	26	1.75	23	8	1.05	7	34	2.80	30
01-Jul	13	1.04	11	16	1.36	14	29	2.39	25
02-Jul	24	1.72	20	21	1.50	17	45	3.22	37
03-Jul	10	0.87	8	20	1.48	18	30	2.35	26
04-Jul	16	1.15	14	8	0.60	3	24	1.74	17
05-Jul	15	1.08	12	7	0.50	6	22	1.58	18
06-Jul	19	1.38	16	8	0.59	5	27	1.97	21
07-Jul	19	1.56	14	8	0.83	6	27	2.39	20
08-Jul	9	1.00	7	2	0.17	2	11	1.17	9
09-Jul	0	0.00	0	1	0.19	1	1	0.19	1
10-Jul	3	0.25	3	4	0.48	3	7	0.73	6
11-Jul	8	0.54	6	3	0.27	2	11	0.80	8
12-Jul	5	0.36	4	2	0.17	2	7	0.53	6
13-Jul	5	0.36	4	2	0.23	2	7	0.59	6
14-Jul	4	0.33	3	1	0.21	0	5	0.54	3
15-Jul	0	0.00	0	0	0.00	0	0	0.00	0
16-Jul	1	0.14	1	2	0.51	2	3	0.65	3
17-Jul	0	0.00	0	0	0.00	0	0	0.00	0
18-Jul	1	0.11	0	1	0.12	1	2	0.23	1
19-Jul	1	0.12	1	0	0.00	0	1	0.12	1
20-Jul	0	0.00	0	1	0.14	1	1	0.14	1
21-Jul	1	0.09	1	2	0.17	1	3	0.26	2
22-Jul	0	0.00	0	1	0.09	1	1	0.09	1
23-Jul	0	0.00	0	0	0.00	0	0	0.00	0
24-Jul	0	0.00	0	0	0.00	0	0	0.00	0
25-Jul	0	0.00	0	0	0.00	0	0	0.00	0
26-Jul	0	0.00	0	0	0.00	0	0	0.00	0
27-Jul	0	0.00	0	0	0.00	0	0	0.00	0
28-Jul	0	0.00	0	0	0.00	0	0	0.00	0
29-Jul	0	0.00	0	0	0.00	0	0	0.00	0
30-Jul	0	0.00	0	0	0.00	0	0	0.00	0
31-Jul	0	0.00	0	0	0.00	0	0	0.00	0
01-Aug	1	0.11	1	0	0.00	0	1	0.11	1

Table C-2. Continued.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
02-Aug	1	0.11	1	0	0.00	0	1	0.11	1
03-Aug	0	0.00	0	0	0.00	0	0	0.00	0
04-Aug	0	0.00	0	0	0.00	0	0	0.00	0
05-Aug	1	0.11	0	0	0.00	0	1	0.11	0
06-Aug	0	0.00	0	1	0.11	0	1	0.11	0
07-Aug	0	0.00	0	0	0.00	0	0	0.00	0
08-Aug	0	0.00	0	0	0.00	0	0	0.00	0
09-Aug	1	0.11	0	1	0.11	0	2	0.22	0
10-Aug	0	0.00	0	0	0.00	0	0	0.00	0
11-Aug	0	0.00	0	0	0.00	0	0	0.00	0
12-Aug	0	0.00	0	0	0.00	0	0	0.00	0
13-Aug	0	0.00	0	0	0.00	0	0	0.00	0
14-Aug	0	0.00	0	0	0.00	0	0	0.00	0
15-Aug	0	0.00	0	0	0.00	0	0	0.00	0
16-Aug	0	0.00	0	0	0.00	0	0	0.00	0
17-Aug	0	0.00	0	0	0.00	0	0	0.00	0
18-Aug	0	0.00	0	0	0.00	0	0	0.00	0
19-Aug	0	0.00	0	0	0.00	0	0	0.00	0
20-Aug	0	0.00	0	0	0.00	0	0	0.00	0
21-Aug	0	0.00	0	0	0.00	0	0	0.00	0
22-Aug	0	0.00	0	0	0.00	0	0	0.00	0
23-Aug	0	0.00	0				0	0.00	0
24-Aug	0	0.00	0				0	0.00	0
25-Aug	0	0.00	0				0	0.00	0
26-Aug	0	0.00	0				0	0.00	0
27-Aug	0	0.00	0				0	0.00	0
28-Aug	0	0.00	0				0	0.00	0
29-Aug	0	0.00	0				0	0.00	0
30-Aug	0	0.00	0				0	0.00	0
31-Aug	0	0.00	0				0	0.00	0
01-Sep	0	0.00	0				0	0.00	0
Total	256		214	166		138	422		352

Table C-3. Catch, catch-per-unit-effort, and tags applied to sockeye salmon at the Curry fishwheels, 2012.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
17-Jun	0	0.00	0				0	0.00	0
18-Jun	0	0.00	0	0	0.00	0	0	0.00	0
19-Jun	0	0.00	0	0	0.00	0	0	0.00	0
20-Jun	0	0.00	0	0	0.00	0	0	0.00	0
21-Jun	0	0.00	0	0	0.00	0	0	0.00	0
22-Jun	0	0.00	0	0	0.00	0	0	0.00	0
23-Jun	0	0.00	0	0	0.00	0	0	0.00	0
24-Jun	0	0.00	0	0	0.00	0	0	0.00	0
25-Jun	0	0.00	0	0	0.00	0	0	0.00	0
26-Jun	0	0.00	0	0	0.00	0	0	0.00	0
27-Jun	0	0.00	0	0	0.00	0	0	0.00	0
28-Jun	0	0.00	0	0	0.00	0	0	0.00	0
29-Jun	0	0.00	0	0	0.00	0	0	0.00	0
30-Jun	0	0.00	0	0	0.00	0	0	0.00	0
01-Jul	0	0.00	0	0	0.00	0	0	0.00	0
02-Jul	1	0.07	1	0	0.00	0	1	0.07	1
03-Jul	0	0.00	0	0	0.00	0	0	0.00	0
04-Jul	0	0.00	0	0	0.00	0	0	0.00	0
05-Jul	0	0.00	0	0	0.00	0	0	0.00	0
06-Jul	2	0.15	1	0	0.00	0	2	0.15	1
07-Jul	0	0.00	0	1	0.10	0	1	0.10	0
08-Jul	0	0.00	0	1	0.08	1	1	0.08	1
09-Jul	0	0.00	0	1	0.19	1	1	0.19	1
10-Jul	1	0.08	1	0	0.00	1	1	0.08	2
11-Jul	1	0.07	1	0	0.00	0	1	0.07	1
12-Jul	2	0.14	2	1	0.08	0	3	0.23	2
13-Jul	0	0.00	0	0	0.00	1	0	0.00	1
14-Jul	2	0.16	2	0	0.00	0	2	0.16	2
15-Jul	2	0.24	1	0	0.00	0	2	0.24	1
16-Jul	0	0.00	0	2	0.51	0	2	0.51	0
17-Jul	0	0.00	0	2	0.20	1	2	0.20	1
18-Jul	0	0.00	0	3	0.36	1	3	0.36	1
19-Jul	0	0.00	0	0	0.00	2	0	0.00	2
20-Jul	1	0.11	1	0	0.00	0	1	0.11	1
21-Jul	2	0.18	1	4	0.34	0	6	0.52	1
22-Jul	0	0.00	0	1	0.09	2	1	0.09	2
23-Jul	0	0.00	0	0	0.00	1	0	0.00	1
24-Jul	0	0.00	0	1	0.11	0	1	0.11	0
25-Jul	0	0.00	0	1	0.12	1	1	0.12	1
26-Jul	0	0.00	0	0	0.00	1	0	0.00	1
27-Jul	0	0.00	0	3	0.38	0	3	0.38	0
28-Jul	2	0.22	1	4	0.45	3	6	0.67	4
29-Jul	0	0.00	0	3	0.26	3	3	0.26	3
30-Jul	0	0.00	0	2	0.24	2	2	0.24	2
31-Jul	1	0.11	1	1	0.11	1	2	0.22	2
01-Aug	0	0.00	0	1	0.11	0	1	0.11	0

Table C-3. Continued.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
02-Aug	0	0.00	0	1	0.11	1	1	0.11	1
03-Aug	1	0.11	1	3	0.33	1	4	0.44	2
04-Aug	0	0.00	0	1	0.11	3	1	0.11	3
05-Aug	0	0.00	0	4	0.44	0	4	0.44	0
06-Aug	1	0.11	0	6	0.67	4	7	0.78	4
07-Aug	2	0.22	2	1	0.11	4	3	0.33	6
08-Aug	3	0.30	3	4	0.44	1	7	0.74	4
09-Aug	1	0.11	1	1	0.11	2	2	0.22	3
10-Aug	1	0.11	1	0	0.00	1	1	0.11	2
11-Aug	2	0.22	1	0	0.00	0	2	0.22	1
12-Aug	2	0.22	2	2	0.22	0	4	0.44	2
13-Aug	1	0.11	1	0	0.00	2	1	0.11	3
14-Aug	1	0.11	1	0	0.00	0	1	0.11	1
15-Aug	1	0.11	1	0	0.00	0	1	0.11	1
16-Aug	0	0.00	0	0	0.00	0	0	0.00	0
17-Aug	0	0.00	0	0	0.00	0	0	0.00	0
18-Aug	0	0.00	0	1	0.11	0	1	0.11	0
19-Aug	0	0.00	0	0	0.00	1	0	0.00	1
20-Aug	0	0.00	0	1	0.12	0	1	0.12	0
21-Aug	1	0.11	0	0	0.00	1	1	0.11	1
22-Aug	1	0.09	0	0	0.00	0	1	0.09	0
23-Aug	0	0.00	0				0	0.00	0
24-Aug	0	0.00	0				0	0.00	0
25-Aug	0	0.00	0				0	0.00	0
26-Aug	0	0.00	0				0	0.00	0
27-Aug	0	0.00	0				0	0.00	0
28-Aug	0	0.00	0				0	0.00	0
29-Aug	0	0.00	0				0	0.00	0
30-Aug	0	0.00	0				0	0.00	0
31-Aug	0	0.00	0				0	0.00	0
01-Sep	0	0.00	0				0	0.00	0
Total	35		27	57		43	92		70

Table C-4. Catch, catch-per-unit-effort, and tags applied to pink salmon at the Curry fishwheels, 2012.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
17-Jun	0	0.00	0				0	0.00	0
18-Jun	0	0.00	0	0	0.00	0	0	0.00	0
19-Jun	0	0.00	0	0	0.00	0	0	0.00	0
20-Jun	0	0.00	0	0	0.00	0	0	0.00	0
21-Jun	0	0.00	0	0	0.00	0	0	0.00	0
22-Jun	0	0.00	0	0	0.00	0	0	0.00	0
23-Jun	0	0.00	0	0	0.00	0	0	0.00	0
24-Jun	0	0.00	0	0	0.00	0	0	0.00	0
25-Jun	0	0.00	0	0	0.00	0	0	0.00	0
26-Jun	0	0.00	0	0	0.00	0	0	0.00	0
27-Jun	0	0.00	0	0	0.00	0	0	0.00	0
28-Jun	0	0.00	0	0	0.00	0	0	0.00	0
29-Jun	0	0.00	0	0	0.00	0	0	0.00	0
30-Jun	0	0.00	0	0	0.00	0	0	0.00	0
01-Jul	0	0.00	0	0	0.00	0	0	0.00	0
02-Jul	0	0.00	0	0	0.00	0	0	0.00	0
03-Jul	0	0.00	0	0	0.00	0	0	0.00	0
04-Jul	0	0.00	0	0	0.00	0	0	0.00	0
05-Jul	0	0.00	0	0	0.00	0	0	0.00	0
06-Jul	0	0.00	0	0	0.00	0	0	0.00	0
07-Jul	0	0.00	0	0	0.00	0	0	0.00	0
08-Jul	0	0.00	0	0	0.00	0	0	0.00	0
09-Jul	0	0.00	0	0	0.00	0	0	0.00	0
10-Jul	0	0.00	0	0	0.00	0	0	0.00	0
11-Jul	0	0.00	0	0	0.00	0	0	0.00	0
12-Jul	0	0.00	0	0	0.00	0	0	0.00	0
13-Jul	0	0.00	0	0	0.00	0	0	0.00	0
14-Jul	0	0.00	0	0	0.00	0	0	0.00	0
15-Jul	0	0.00	0	0	0.00	0	0	0.00	0
16-Jul	1	0.14	1	0	0.00	0	1	0.14	1
17-Jul	0	0.00	0	0	0.00	0	0	0.00	0
18-Jul	0	0.00	0	0	0.00	0	0	0.00	0
19-Jul	0	0.00	0	0	0.00	0	0	0.00	0
20-Jul	0	0.00	0	0	0.00	0	0	0.00	0
21-Jul	0	0.00	0	2	0.17	0	2	0.17	0
22-Jul	0	0.00	0	0	0.00	1	0	0.00	1
23-Jul	0	0.00	0	0	0.00	0	0	0.00	0
24-Jul	0	0.00	0	0	0.00	0	0	0.00	0
25-Jul	0	0.00	0	1	0.12	0	1	0.12	0
26-Jul	4	0.44	4	0	0.00	1	4	0.44	5
27-Jul	4	0.46	1	3	0.38	0	7	0.84	1
28-Jul	8	0.89	1	2	0.22	1	10	1.11	2
29-Jul	12	1.40	1	9	0.79	1	21	2.18	2
30-Jul	42	4.61	1	6	0.71	1	48	5.31	2
31-Jul	86	9.45	4	13	1.42	1	99	10.87	5
01-Aug	177	20.31	10	40	4.58	4	217	24.89	14

Table C-4. Continued.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
02-Aug	423	47.80	12	125	14.37	10	548	62.16	22
03-Aug	451	49.20	9	65	7.21	12	516	56.41	21
04-Aug	160	17.71	11	31	3.43	9	191	21.14	20
05-Aug	292	31.91	12	42	4.65	11	334	36.56	23
06-Aug	449	49.52	9	57	6.35	12	506	55.87	21
07-Aug	385	42.46	12	80	8.74	9	465	51.21	21
08-Aug	327	32.59	12	20	2.21	12	347	34.80	24
09-Aug	402	44.50	5	14	1.55	12	416	46.05	17
10-Aug	250	27.83	3	5	0.56	5	255	28.38	8
11-Aug	163	18.11	2	7	0.77	3	170	18.88	5
12-Aug	137	15.11	2	4	0.44	2	141	15.55	4
13-Aug	107	11.89	1	4	0.44	0	111	12.33	1
14-Aug	91	10.09	1	3	0.33	0	94	10.43	1
15-Aug	43	4.74	1	2	0.22	0	45	4.96	1
16-Aug	39	4.32	1	2	0.22	1	41	4.54	2
17-Aug	34	3.74	1	2	0.22	0	36	3.97	1
18-Aug	13	1.44	1	0	0.00	0	13	1.44	1
19-Aug	16	1.83	1	0	0.00	0	16	1.83	1
20-Aug	17	1.90	1	0	0.00	0	17	1.90	1
21-Aug	8	0.89	1	2	0.23	0	10	1.11	1
22-Aug	2	0.18	1	0	0.00	0	2	0.18	1
23-Aug	9	0.76	0				9	0.76	0
24-Aug	6	0.51	0				6	0.51	0
25-Aug	2	0.17	0				2	0.17	0
26-Aug	2	0.17	0				2	0.17	0
27-Aug	1	0.24	0				1	0.24	0
28-Aug	0	0.00	0				0	0.00	0
29-Aug	0	0.00	0				0	0.00	0
30-Aug	0	0.00	0				0	0.00	0
31-Aug	1	0.15	0				1	0.15	0
01-Sep	0	0.00	0				0	0.00	0
Total	4,164		122	541		108	4,705		230

Table C-5. Catch, catch-per-unit-effort, and tags applied to chum salmon at the Curry fishwheels, 2012.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
17-Jun	0	0.00	0				0	0.00	0
18-Jun	0	0.00	0	0	0.00	0	0	0.00	0
19-Jun	0	0.00	0	0	0.00	0	0	0.00	0
20-Jun	0	0.00	0	0	0.00	0	0	0.00	0
21-Jun	0	0.00	0	0	0.00	0	0	0.00	0
22-Jun	0	0.00	0	0	0.00	0	0	0.00	0
23-Jun	0	0.00	0	0	0.00	0	0	0.00	0
24-Jun	0	0.00	0	0	0.00	0	0	0.00	0
25-Jun	0	0.00	0	0	0.00	0	0	0.00	0
26-Jun	0	0.00	0	0	0.00	0	0	0.00	0
27-Jun	0	0.00	0	0	0.00	0	0	0.00	0
28-Jun	0	0.00	0	0	0.00	0	0	0.00	0
29-Jun	0	0.00	0	0	0.00	0	0	0.00	0
30-Jun	0	0.00	0	0	0.00	0	0	0.00	0
01-Jul	0	0.00	0	0	0.00	0	0	0.00	0
02-Jul	0	0.00	0	0	0.00	0	0	0.00	0
03-Jul	0	0.00	0	0	0.00	0	0	0.00	0
04-Jul	0	0.00	0	0	0.00	0	0	0.00	0
05-Jul	0	0.00	0	0	0.00	0	0	0.00	0
06-Jul	0	0.00	0	0	0.00	0	0	0.00	0
07-Jul	0	0.00	0	0	0.00	0	0	0.00	0
08-Jul	0	0.00	0	0	0.00	0	0	0.00	0
09-Jul	0	0.00	0	0	0.00	0	0	0.00	0
10-Jul	1	0.08	1	0	0.00	0	1	0.08	1
11-Jul	0	0.00	0	0	0.00	0	0	0.00	0
12-Jul	0	0.00	0	0	0.00	0	0	0.00	0
13-Jul	0	0.00	0	0	0.00	0	0	0.00	0
14-Jul	0	0.00	0	0	0.00	0	0	0.00	0
15-Jul	1	0.12	1	0	0.00	0	1	0.12	1
16-Jul	0	0.00	0	0	0.00	0	0	0.00	0
17-Jul	0	0.00	0	1	0.10	0	1	0.10	0
18-Jul	0	0.00	0	0	0.00	1	0	0.00	1
19-Jul	0	0.00	0	0	0.00	0	0	0.00	0
20-Jul	1	0.11	1	1	0.14	0	2	0.25	1
21-Jul	5	0.45	4	9	0.77	1	14	1.21	5
22-Jul	7	0.61	2	10	0.87	8	17	1.47	10
23-Jul	0	0.00	0	3	0.26	2	3	0.26	2
24-Jul	1	0.10	1	1	0.11	1	2	0.21	2
25-Jul	0	0.00	0	2	0.23	1	2	0.23	1
26-Jul	2	0.22	1	2	0.25	1	4	0.47	2
27-Jul	8	0.92	2	6	0.75	1	14	1.68	3
28-Jul	14	1.55	1	22	2.45	2	36	4.00	3
29-Jul	25	2.91	3	31	2.72	1	56	5.62	4
30-Jul	30	3.29	3	22	2.59	3	52	5.88	6
31-Jul	14	1.54	3	11	1.20	2	25	2.74	5
01-Aug	46	5.28	13	47	5.38	2	93	10.66	15

Table C-5. Continued.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
02-Aug	66	7.46	15	115	13.22	13	181	20.68	28
03-Aug	49	5.35	10	33	3.66	15	82	9.01	25
04-Aug	27	2.99	9	22	2.43	10	49	5.42	19
05-Aug	32	3.50	9	37	4.10	9	69	7.59	18
06-Aug	42	4.63	9	81	9.02	9	123	13.65	18
07-Aug	41	4.52	12	75	8.20	9	116	12.72	21
08-Aug	31	3.09	10	60	6.63	12	91	9.72	22
09-Aug	20	2.21	5	38	4.20	10	58	6.41	15
10-Aug	44	4.90	3	39	4.33	5	83	9.23	8
11-Aug	41	4.56	3	26	2.87	3	67	7.42	6
12-Aug	35	3.86	2	18	2.00	3	53	5.86	5
13-Aug	40	4.44	2	38	4.22	1	78	8.67	3
14-Aug	35	3.88	1	14	1.55	2	49	5.43	3
15-Aug	40	4.41	2	24	2.66	2	64	7.07	4
16-Aug	21	2.32	0	9	1.00	1	30	3.32	1
17-Aug	27	2.97	0	13	1.44	2	40	4.42	2
18-Aug	25	2.77	0	14	1.55	2	39	4.32	2
19-Aug	20	2.28	0	15	1.78	2	35	4.06	2
20-Aug	16	1.78	1	10	1.24	2	26	3.03	3
21-Aug	16	1.77	2	7	0.79	1	23	2.56	3
22-Aug	7	0.63	2	1	0.28	0	8	0.91	2
23-Aug	14	1.17	2				14	1.17	2
24-Aug	7	0.59	2				7	0.59	2
25-Aug	7	0.60	2				7	0.60	2
26-Aug	9	0.76	1				9	0.76	1
27-Aug	0	0.00	0				0	0.00	0
28-Aug	0	0.00	0				0	0.00	0
29-Aug	3	0.34	0				3	0.34	0
30-Aug	2	0.20	0				2	0.20	0
31-Aug	3	0.45	0				3	0.45	0
01-Sep	2	0.00	0				2	0.00	0
Total	877		140	857		139	1,734		279

Table C-6. Catch, catch-per-unit-effort, and tags applied to coho salmon at the Curry fishwheels, 2012.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
17-Jun	0	0.00	0				0	0.00	0
18-Jun	0	0.00	0	0	0.00	0	0	0.00	0
19-Jun	0	0.00	0	0	0.00	0	0	0.00	0
20-Jun	0	0.00	0	0	0.00	0	0	0.00	0
21-Jun	0	0.00	0	0	0.00	0	0	0.00	0
22-Jun	0	0.00	0	0	0.00	0	0	0.00	0
23-Jun	0	0.00	0	0	0.00	0	0	0.00	0
24-Jun	0	0.00	0	0	0.00	0	0	0.00	0
25-Jun	0	0.00	0	0	0.00	0	0	0.00	0
26-Jun	0	0.00	0	0	0.00	0	0	0.00	0
27-Jun	0	0.00	0	0	0.00	0	0	0.00	0
28-Jun	0	0.00	0	0	0.00	0	0	0.00	0
29-Jun	0	0.00	0	0	0.00	0	0	0.00	0
30-Jun	0	0.00	0	0	0.00	0	0	0.00	0
01-Jul	0	0.00	0	0	0.00	0	0	0.00	0
02-Jul	0	0.00	0	0	0.00	0	0	0.00	0
03-Jul	0	0.00	0	0	0.00	0	0	0.00	0
04-Jul	0	0.00	0	0	0.00	0	0	0.00	0
05-Jul	0	0.00	0	0	0.00	0	0	0.00	0
06-Jul	0	0.00	0	0	0.00	0	0	0.00	0
07-Jul	0	0.00	0	0	0.00	0	0	0.00	0
08-Jul	0	0.00	0	0	0.00	0	0	0.00	0
09-Jul	0	0.00	0	0	0.00	0	0	0.00	0
10-Jul	0	0.00	0	0	0.00	0	0	0.00	0
11-Jul	0	0.00	0	0	0.00	0	0	0.00	0
12-Jul	0	0.00	0	0	0.00	0	0	0.00	0
13-Jul	0	0.00	0	0	0.00	0	0	0.00	0
14-Jul	0	0.00	0	0	0.00	0	0	0.00	0
15-Jul	0	0.00	0	0	0.00	0	0	0.00	0
16-Jul	0	0.00	0	0	0.00	0	0	0.00	0
17-Jul	0	0.00	0	0	0.00	0	0	0.00	0
18-Jul	0	0.00	0	0	0.00	0	0	0.00	0
19-Jul	0	0.00	0	0	0.00	0	0	0.00	0
20-Jul	0	0.00	0	0	0.00	0	0	0.00	0
21-Jul	0	0.00	0	0	0.00	0	0	0.00	0
22-Jul	0	0.00	0	0	0.00	0	0	0.00	0
23-Jul	0	0.00	0	0	0.00	0	0	0.00	0
24-Jul	0	0.00	0	0	0.00	0	0	0.00	0
25-Jul	0	0.00	0	0	0.00	0	0	0.00	0
26-Jul	0	0.00	0	0	0.00	0	0	0.00	0
27-Jul	0	0.00	0	0	0.00	0	0	0.00	0
28-Jul	1	0.11	0	0	0.00	0	1	0.11	0
29-Jul	1	0.12	0	0	0.00	0	1	0.12	0
30-Jul	0	0.00	0	0	0.00	0	0	0.00	0
31-Jul	0	0.00	0	1	0.11	0	1	0.11	0
01-Aug	1	0.11	1	0	0.00	1	1	0.11	2

Table C-6. Continued.

	Site 1			Site 2			Total		
Date	Catch	CPUE	Tags	Catch	CPUE	Tags	Catch	CPUE	Tags
02-Aug	0	0.00	0	0	0.00	0	0	0.00	0
03-Aug	3	0.33	2	3	0.33	0	6	0.66	2
04-Aug	0	0.00	0	2	0.22	1	2	0.22	1
05-Aug	0	0.00	0	2	0.22	2	2	0.22	2
06-Aug	2	0.22	2	1	0.11	2	3	0.33	4
07-Aug	2	0.22	2	7	0.77	1	9	0.99	3
08-Aug	7	0.70	7	5	0.55	7	12	1.25	14
09-Aug	5	0.55	4	1	0.11	5	6	0.66	9
10-Aug	14	1.56	12	2	0.22	1	16	1.78	13
11-Aug	21	2.33	19	0	0.00	2	21	2.33	21
12-Aug	14	1.54	14	3	0.33	0	17	1.88	14
13-Aug	13	1.44	13	2	0.22	2	15	1.67	15
14-Aug	13	1.44	8	1	0.11	2	14	1.55	10
15-Aug	18	1.99	7	3	0.33	0	21	2.32	7
16-Aug	15	1.66	6	1	0.11	1	16	1.77	7
17-Aug	19	2.09	5	1	0.11	0	20	2.20	5
18-Aug	12	1.33	4	0	0.00	1	12	1.33	5
19-Aug	8	0.91	6	0	0.00	0	8	0.91	6
20-Aug	8	0.89	6	0	0.00	0	8	0.89	6
21-Aug	5	0.55	5	0	0.00	0	5	0.55	5
22-Aug	11	0.99	6	0	0.00	0	11	0.99	6
23-Aug	8	0.67	7				8	0.67	7
24-Aug	7	0.59	5				7	0.59	5
25-Aug	9	0.77	9				9	0.77	9
26-Aug	6	0.51	2				6	0.51	2
27-Aug	0	0.00	0				0	0.00	0
28-Aug	0	0.00	0				0	0.00	0
29-Aug	2	0.23	1				2	0.23	1
30-Aug	3	0.30	2				3	0.30	2
31-Aug	1	0.15	1				1	0.15	1
01-Sep	0	0.00	0				0	0.00	0
Total	229		156	35		28	264		184

APPENDIX D: RADIO TELEMETRY RESULTS

Table D-1. Summary of radio tag recovery information for fish released at the Curry fishwheels, 2012. No recovery coordinates were available for the tag that was sent to ADF&G by an angler.

	Tag	Date	Recovery Location			Recovery
	Number	Recovered	Description	Latitude	Longitude	Method
Chinook	2	30-Jul	Portage	62.87766	-149.31946	LGL crew
	307	31-Jul	4th of July	62.71873	-149.80825	LGL crew
	319	2-Aug	Indian	62.78955	-149.66135	LGL crew
	419	3-Aug	4th of July	62.71897	-149.80937	LGL crew
	6	5-Aug	Indian	62.87664	-149.58420	LGL crew
	24	5-Aug	Indian	62.87664	-149.58420	LGL crew
	51	5-Aug	Indian	62.87531	-149.58328	LGL crew
	89	5-Aug	Indian	62.86866	-149.59660	LGL crew
	142	5-Aug	Indian	62.85728	-149.61330	LGL crew
	183	5-Aug	Indian	62.87002	-149.59393	LGL crew
	186	5-Aug	Indian	62.85728	-149.61330	LGL crew
	308	5-Aug	Indian	62.87945	-149.58168	LGL crew
	18	8-Aug	Indian	62.80849	-149.66151	LGL crew
	22	8-Aug	Indian	62.79346	-149.66273	LGL crew
	28	8-Aug	Indian	62.81335	-149.66116	LGL crew
	50	8-Aug	Indian	62.81142	-149.65912	LGL crew
	111	8-Aug	Indian	62.81639	-149.65948	LGL crew
	126	8-Aug	Indian	62.79686	-149.66078	LGL crew
	130	8-Aug	Indian	62.80689	-149.66249	LGL crew
	154	8-Aug	Indian	62.82144	-149.65526	LGL crew
	210	8-Aug	Indian	62.82255	-149.65404	LGL crew
	231	8-Aug	Indian	62.81335	-149.66116	LGL crew
	255	8-Aug	Indian	62.82144	-149.65526	LGL crew
	288	8-Aug	Indian	62.81639	-149.65948	LGL crew
	333	8-Aug	Indian	62.81908	-149.65714	LGL crew
	149	18-Aug	Indian	62.87887	-149.58185	Angler
	409	18-Aug	Mouth of Indian	62.78561	-149.65559	Angler
	394	19-Aug	Portage	62.83023	-149.37965	LGL crew
Chum	828	6-Aug	Slough 8 c/d	62.62378	-149.98213	LGL crew
	1008	6-Aug	Slough 8 c/d	62.62378	-149.98213	LGL crew
	868	7-Aug	Slough 8 c/d	62.63065	-149.97787	LGL crew
	583	8-Aug	Chulitna - Byer's	62.73127	-150.19466	Angler
	848	26-Aug	Mouth of Indian	62.7849	-149.6592	LGL crew
	1374	26-Aug	Slough 9a	62.7275	-149.7496	LGL crew
Coho	929	15-Aug	Chulitna - Byer's	62.7312722	-150.194658	Angler
	1643	26-Aug	Mouth of Portage	62.8300433	-149.381723	Angler
	2237	13-Sep	Chulitna - Byer's	62.7312722	-150.194658	Angler

Table D-1. Continued.

	Tag Number	Date Recovered	Recovery Location Description	Latitude	Longitude	Recovery Method
Pink	1033	7-Aug	Gateway	62.67699	-149.89204	LGL crew
	1607	16-Aug	Talkeetna - Clear Cr	62.3677	-150.0171	Angler
	1025	26-Aug	Mouth of Indian	62.7848	-149.6585	LGL crew
	1401	3-Oct	Talkeetna - Clear Cr	n/a	n/a	Angler/ADFG

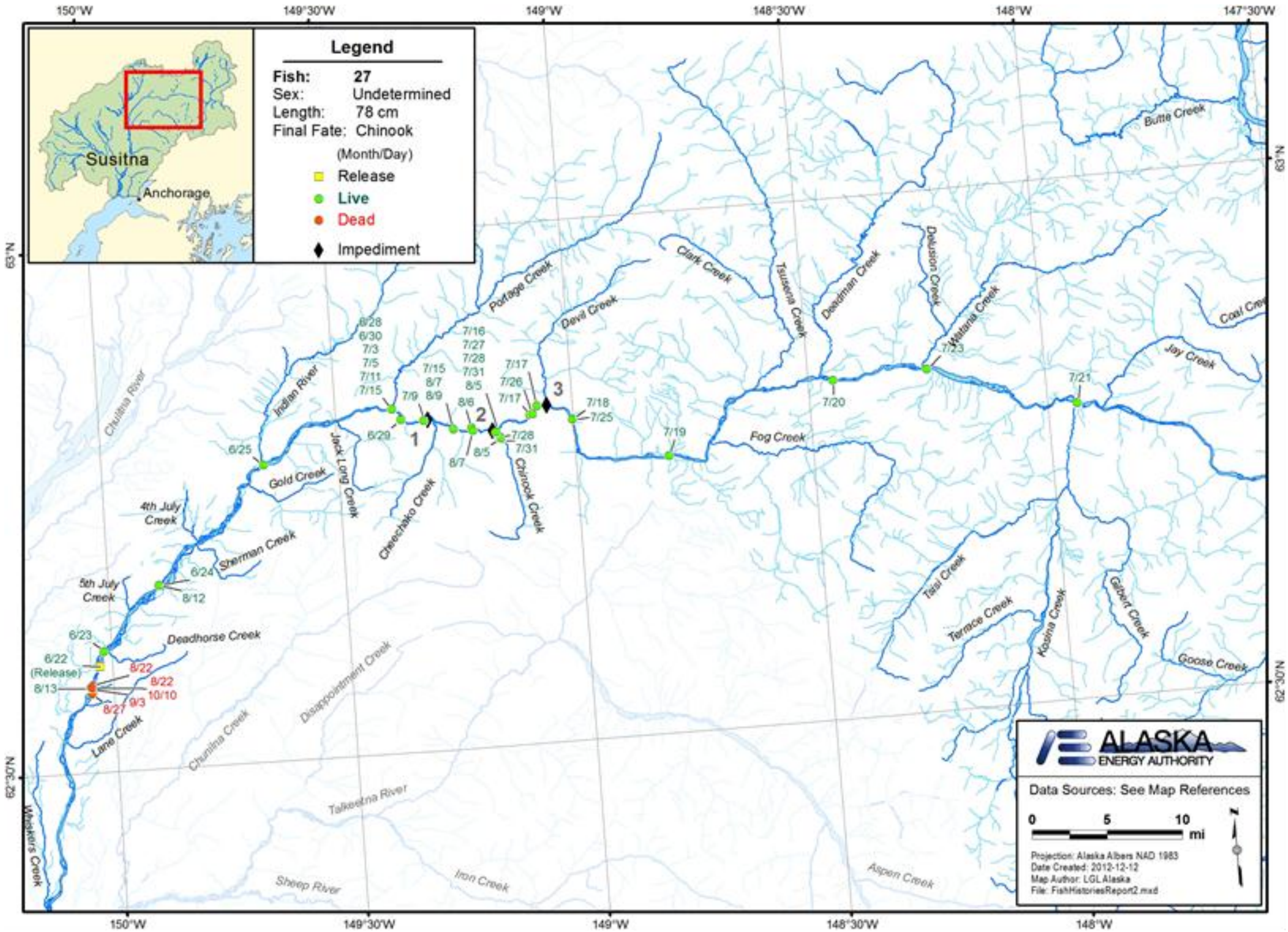
Table D-2. Summary of radio tag recovery information for fish released at the Lower River fishwheels. The recovery method was unknown for most tags, but it was assumed to be largely tags sent to ADF&G by anglers.

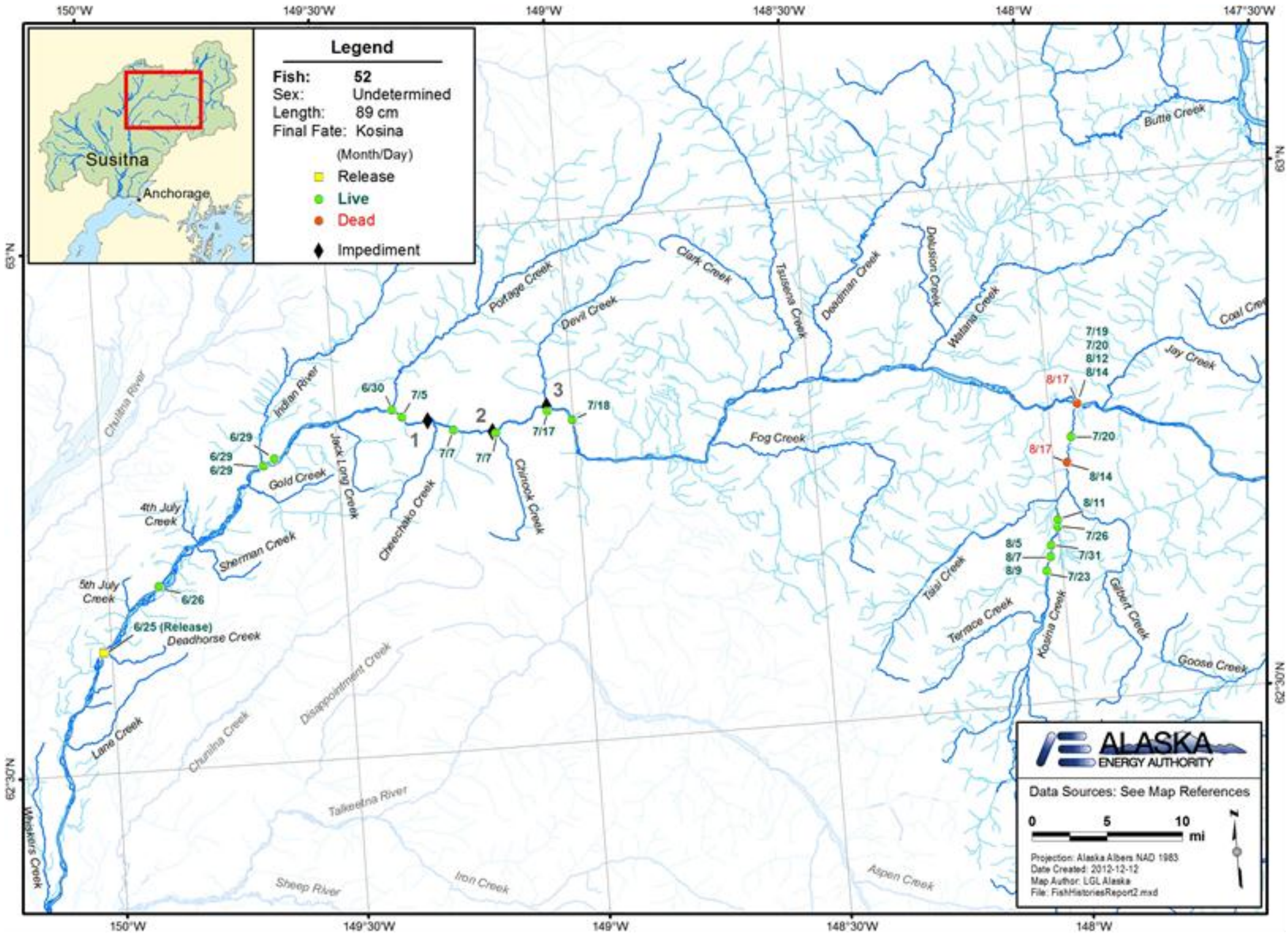
	Tag Number	Date Recovered	Recovery Location
Chinook	5081	4-Jun	Deshka River
	5148	8-Jun	Deshka River mouth
	5018	12-Jun	Deshka River
	5165	15-Jun	Deshka River
	5263	15-Jun	Deshka River mouth
	5166	16-Jun	Deshka River
	5330	19-Jun	Deshka River mouth
	5387	10-Jul	Talkeetna watershed
	5426	10-Jul	Talkeetna watershed
	5436	18-Jul	Deshka River
	5415	20-Jul	Sunshine Creek mouth
	5109	30-Jul	Willow Creek
	5053	10-Aug	Chulitna
	5209	19-Aug	Sheep Creek
	5217	1-Sep	Montana Creek
Chum	3822	10-Aug	Yentna watershed
	3241	16-Aug	Willow Creek
	3414	18-Aug	Willow Creek
	3115	30-Aug	Montana Creek
	3147	5-Oct	Montana Creek
Coho	3465	22-Jul	Deshka River
	3179	27-Jul	Deshka River mouth
	3172	3-Aug	Alexander Creek mouth
	3369	5-Aug	Deshka weir
	4291	5-Aug	Talkeetna watershed
	3397	8-Aug	Deshka River
	3763	9-Aug	Yentna watershed
	3391	11-Aug	Rabideaux Creek
	3483	13-Aug	Willow Creek Mouth
	3266	14-Aug	Goose Creek
	3461	14-Aug	Yentna watershed
	3361	15-Aug	Yentna watershed
	3081	16-Aug	Sunshine Creek
	3357	18-Aug	Yentna watershed
	3880	20-Aug	Yentna watershed
	4299	25-Aug	Deshka River

Table D-2. Continued.

	Tag Number	Date Recovered	Recovery Location
	3897	26-Aug	Deshka weir
	4274	11-Sep	Kashwitna
	3390	2-Oct	Talkeetna watershed
	4290	2-Oct	Talkeetna watershed
Pink	4153	10-Aug	Indian river
	4101	27-Aug	Willow Creek
	3909	15-Sep	Montana Creek
Sockeye	3688	9-Aug	Yentna watershed

APPENDIX E: TRACKING HISTORIES OF CHINOOK SALMON ABOVE IMPEDIMENT 3


Legend
Fish: 27
Sex: Undetermined
Length: 78 cm
Final Fate: Chinook
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd
Indian River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Fog Creek
Jay Creek
Butte Creek
Coal Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
Aspen Creek
Iron Creek
Sheep River
Talkeetna River
Chunilna Creek
Disappointment Creek
Lane Creek
Deadhorse Creek
5th July Creek
4th July Creek
Sherman Creek
Chulitna River
Whiskers Creek
6/22 (Release)
8/13
6/23
6/24
8/12
6/25
6/29
8/22
8/22
10/10
8/27
9/3
6/28
6/30
7/3
7/5
7/11
7/15
7/9
7/15
8/7
8/9
8/6
8/7
7/16
7/27
7/28
7/31
8/5
8/5
7/17
7/26
7/17
7/28
7/31
7/18
7/25
7/19
7/20
7/23
7/21
1
2
3
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N


Legend
Fish: 52
Sex: Undetermined
Length: 89 cm
Final Fate: Kosina
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Fog Creek
Indian River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
Sherman Creek
5th July Creek
Deadhorse Creek
Lane Creek
Chulitna River
Disappointment Creek
Chunilna Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
6/25 (Release)
6/26
6/29
6/29
6/29
6/30
7/5
7/7
7/7
7/17
7/18
7/19
7/20
8/12
8/14
8/17
7/20
8/17
8/14
8/11
7/26
8/5
8/7
8/9
7/31
7/23
1
2
3
ALASKA ENERGY AUTHORITY
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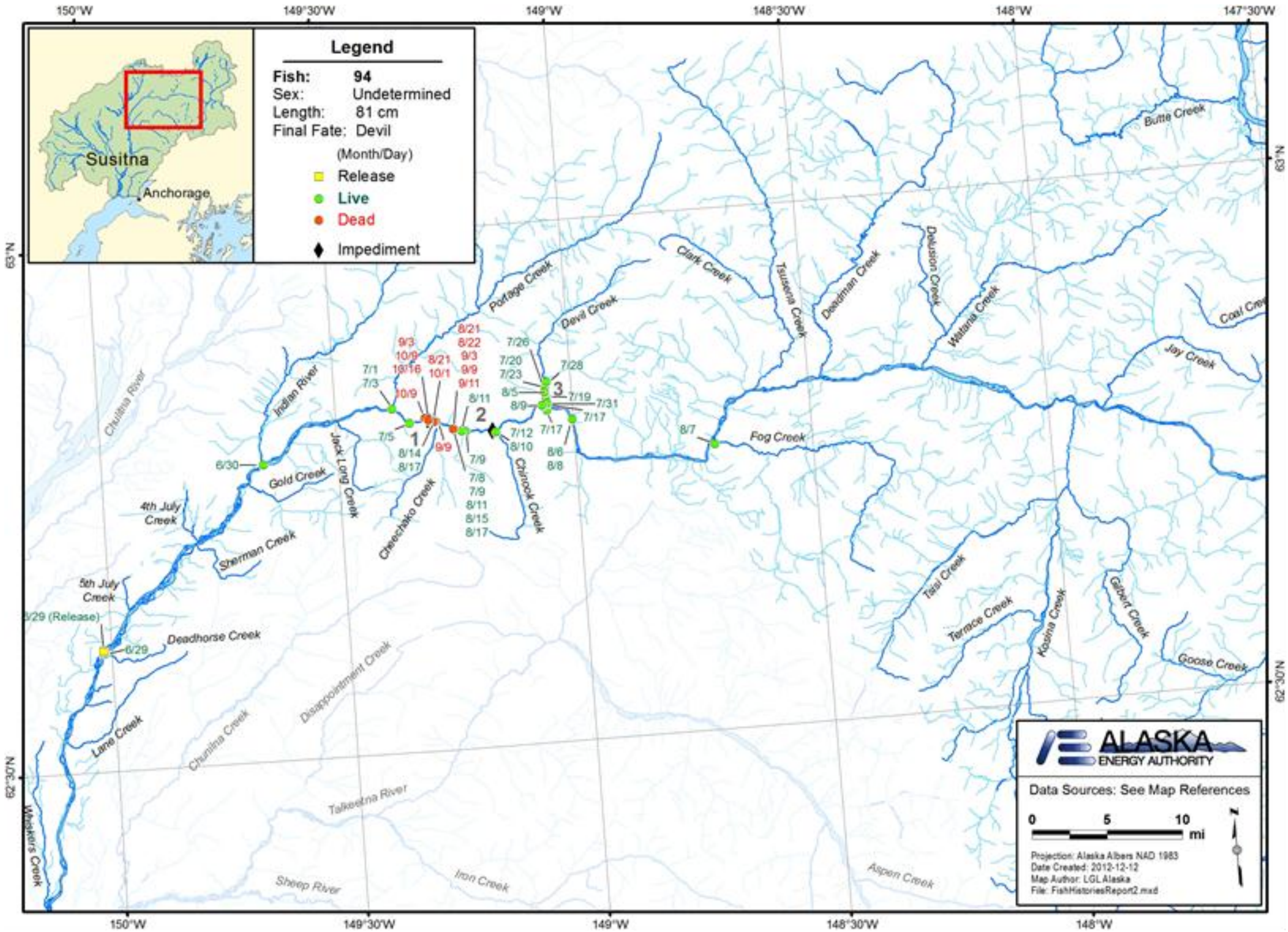
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd


Legend
Fish: 94
Sex: Undetermined
Length: 81 cm
Final Fate: Devil
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Fog Creek
Indian River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
Sherman Creek
5th July Creek
6/29 (Release)
6/29
6/30
Deadhorse Creek
Disappointment Creek
Lane Creek
Chulitna Creek
Chulitna River
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
8/7
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
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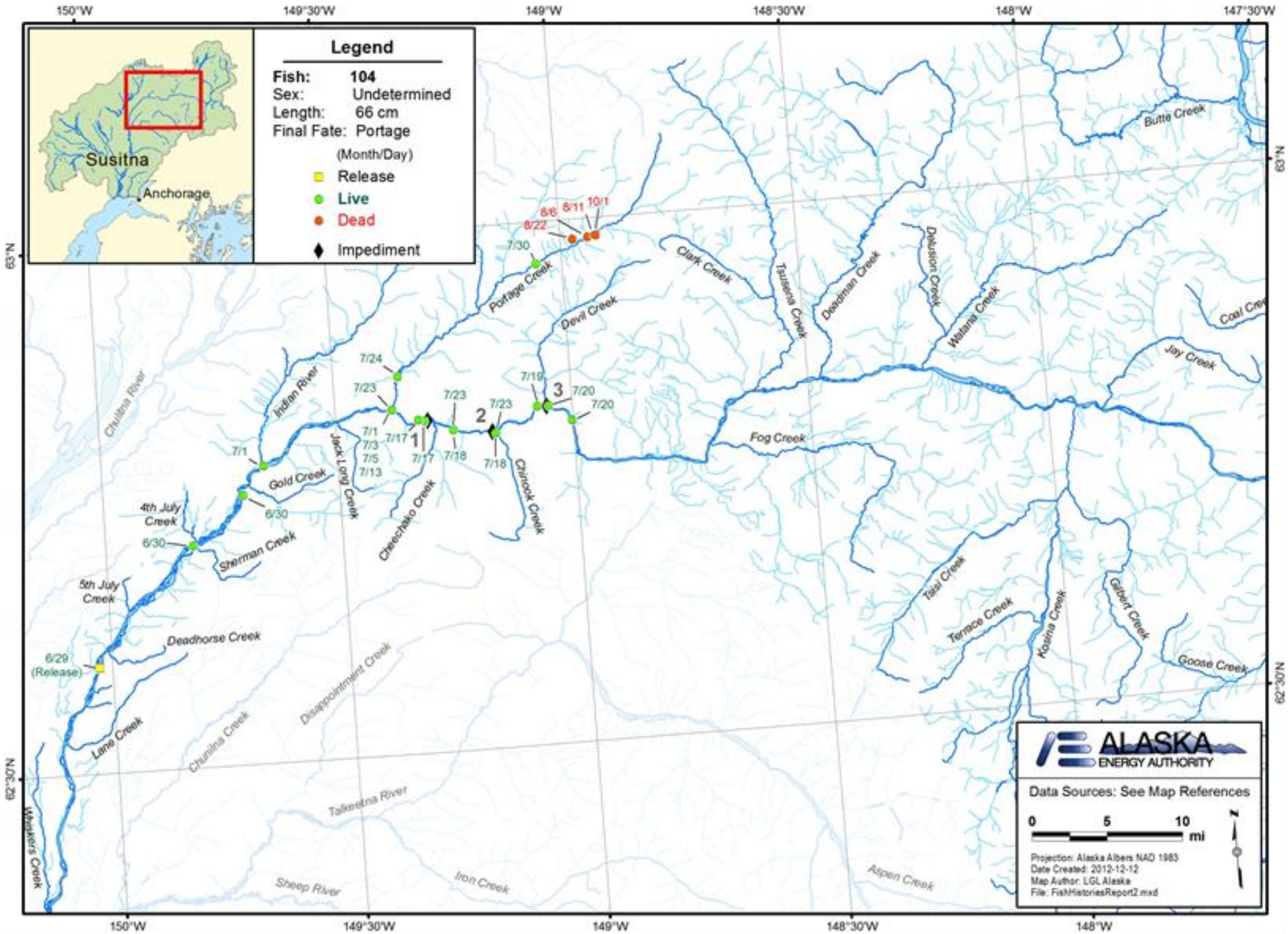
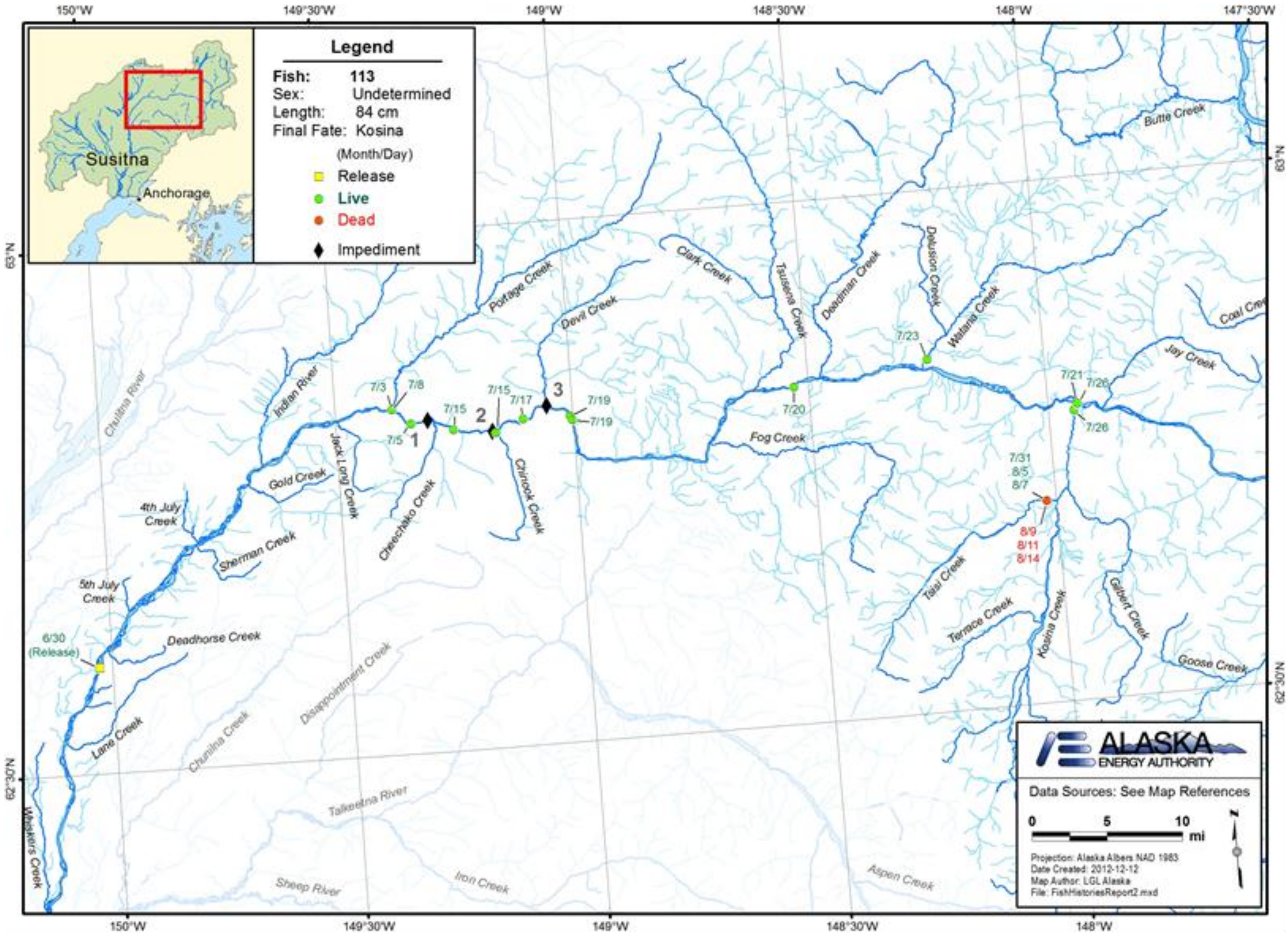
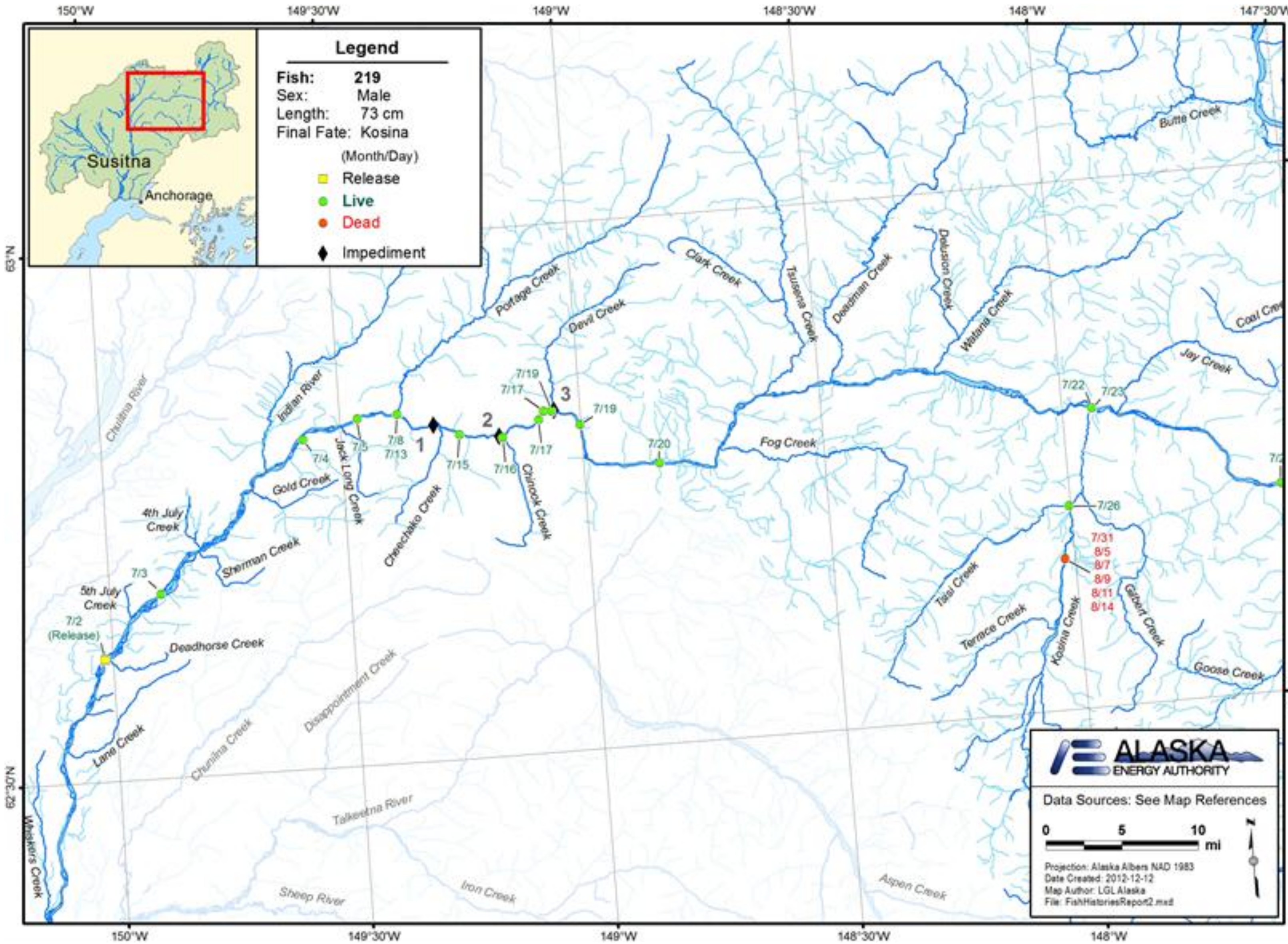
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N


Legend
Fish: 104
Sex: Undetermined
Length: 66 cm
Final Fate: Portage
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
6/29 (Release)
6/30
7/1
7/3
7/5
7/13
7/17
7/18
7/19
7/20
7/23
7/24
7/30
8/6
8/11
8/22
10/1
Portage Creek
Devil Creek
Indian River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
Fog Creek
Sherman Creek
4th July Creek
5th July Creek
Deadhorse Creek
Lane Creek
Chunilna Creek
Disappointment Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
Chulitna River
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N


Legend
Fish: 113
Sex: Undetermined
Length: 84 cm
Final Fate: Kosina
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd
6/30 (Release)
7/3
7/8
7/5
7/15
7/15
7/17
7/19
7/19
7/20
7/23
7/21
7/26
7/26
7/31
8/5
8/7
8/9
8/11
8/14
Indian River
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Deception Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Fog Creek
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
Sherman Creek
5th July Creek
Deadhorse Creek
Lane Creek
Chulitna River
Chulitna Creek
Disappointment Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N


Legend
Fish: 219
Sex: Male
Length: 73 cm
Final Fate: Kosina
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
7/2 (Release)
7/3
7/4
7/5
7/8
7/13
7/15
7/16
7/17
7/19
7/20
7/22
7/23
7/26
7/31
8/5
8/7
8/9
8/11
8/14
Indian River
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Deluson Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Fog Creek
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
5th July Creek
Sherman Creek
Deadhorse Creek
Lane Creek
Chulitna River
Chulina Creek
Disappointment Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
Whiskers Creek
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd
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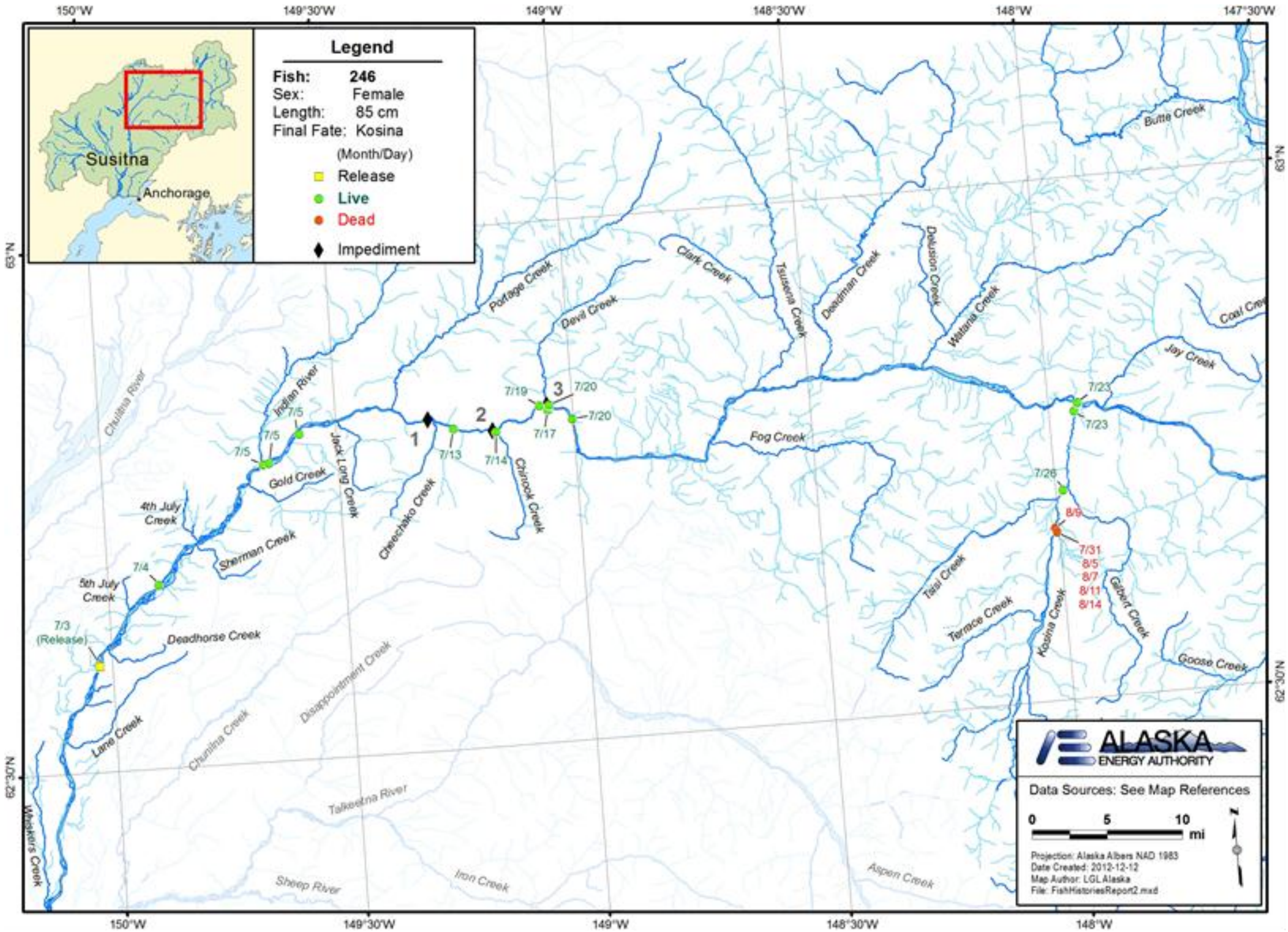
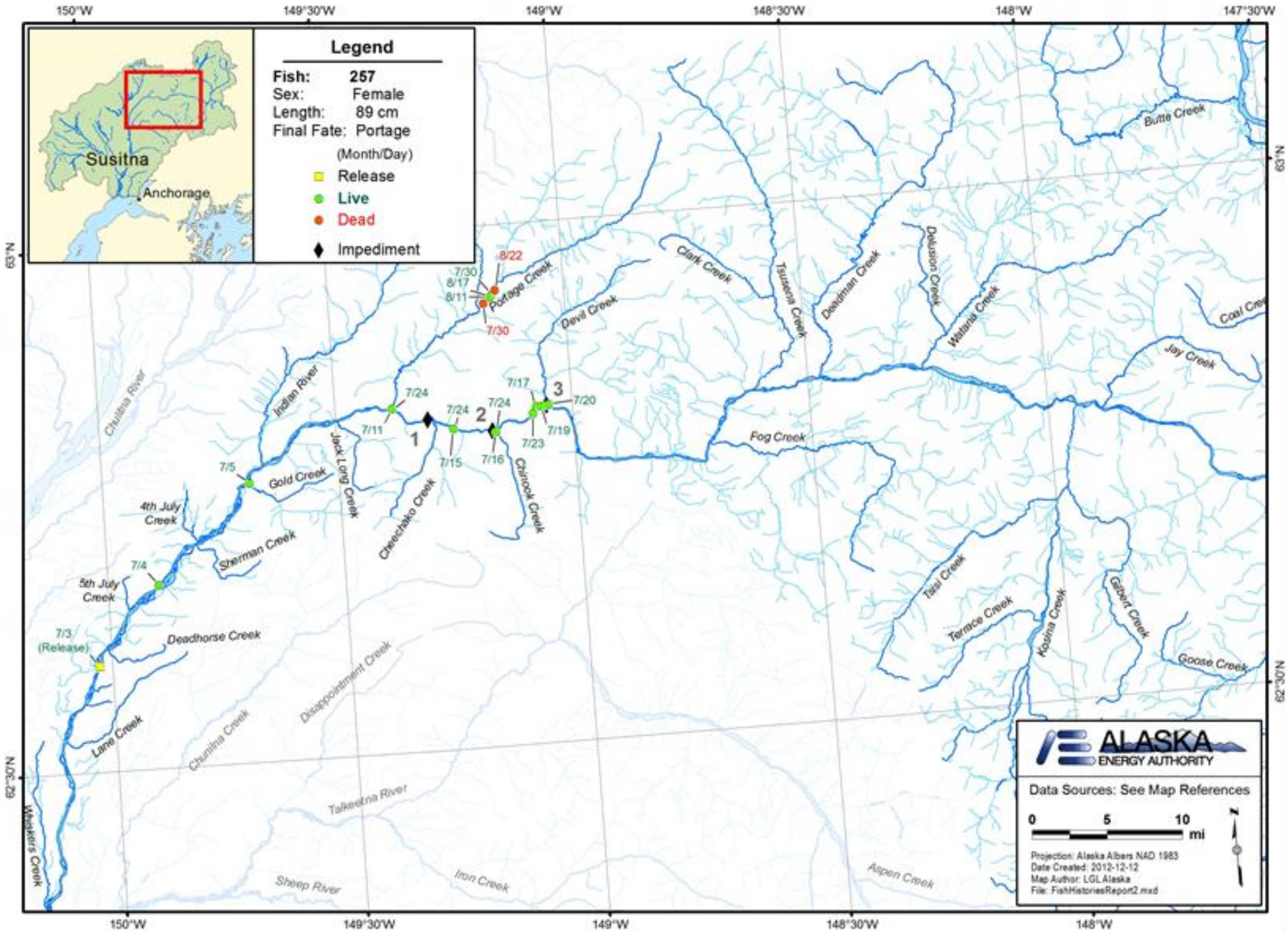
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N


Legend
Fish: 246
Sex: Female
Length: 85 cm
Final Fate: Kosina
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N
Indian River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Fog Creek
Butte Creek
Coal Creek
Jay Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
4th July Creek
Sherman Creek
5th July Creek
Deadhorse Creek
Lane Creek
Chulitna Creek
Disappointment Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Chulitna River
7/3 (Release)
7/4
7/5
7/13
7/14
7/17
7/19
7/20
7/23
7/26
8/9
7/31
8/5
8/7
8/11
8/14
1
2
3


Legend
Fish: 257
Sex: Female
Length: 89 cm
Final Fate: Portage
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Coal Creek
Jay Creek
Butte Creek
Fog Creek
Indian River
Chulitna River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
Sherman Creek
5th July Creek
Deadhorse Creek
Disappointment Creek
Lane Creek
Chulina Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
7/3 (Release)
7/4
7/5
7/11
7/24
7/15
7/16
7/17
7/20
7/19
7/23
7/30
8/17
8/11
8/22
1
2
3
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
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Date Created: 2012-12-12
Map Author: LGL Alaska
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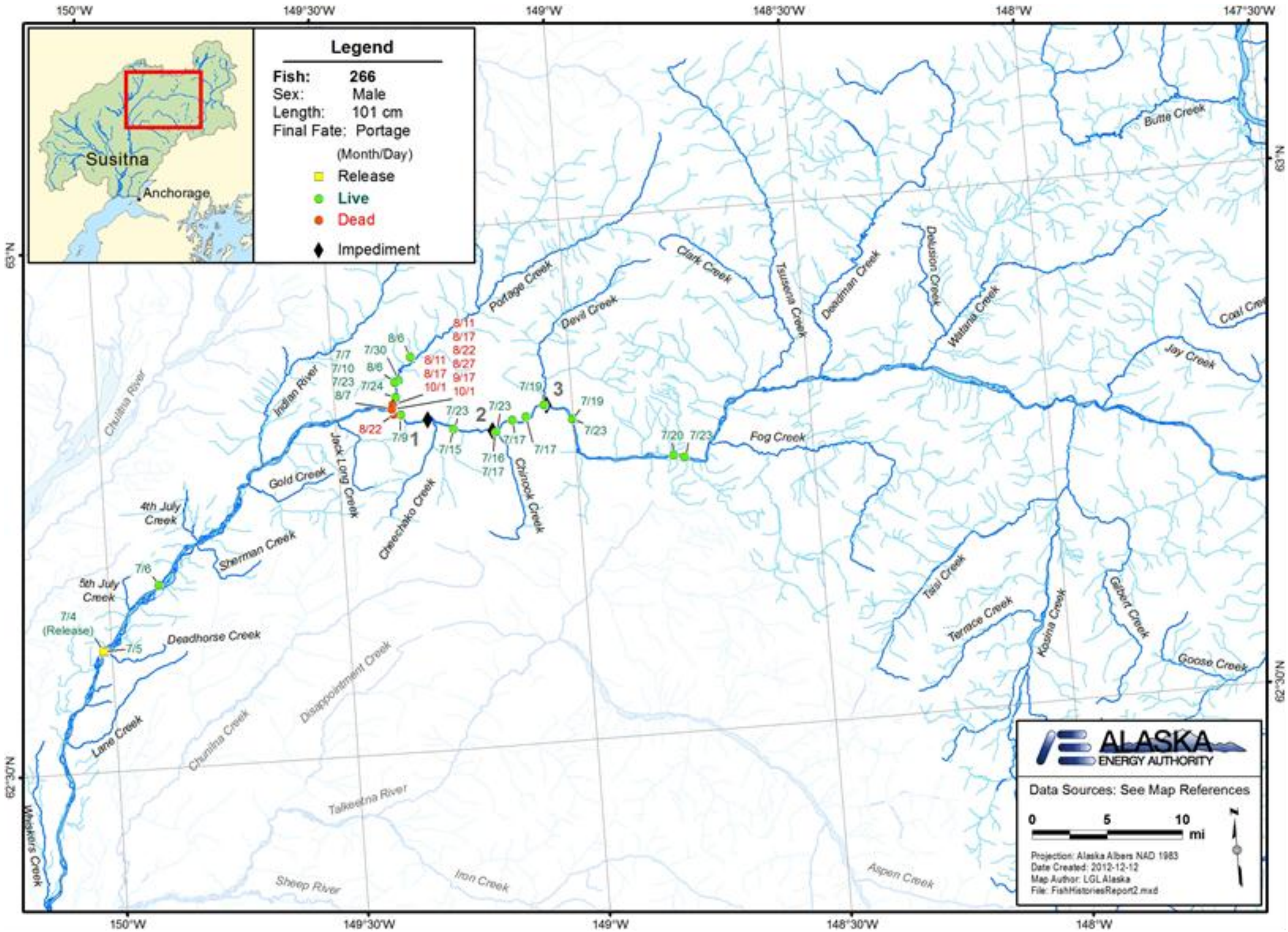
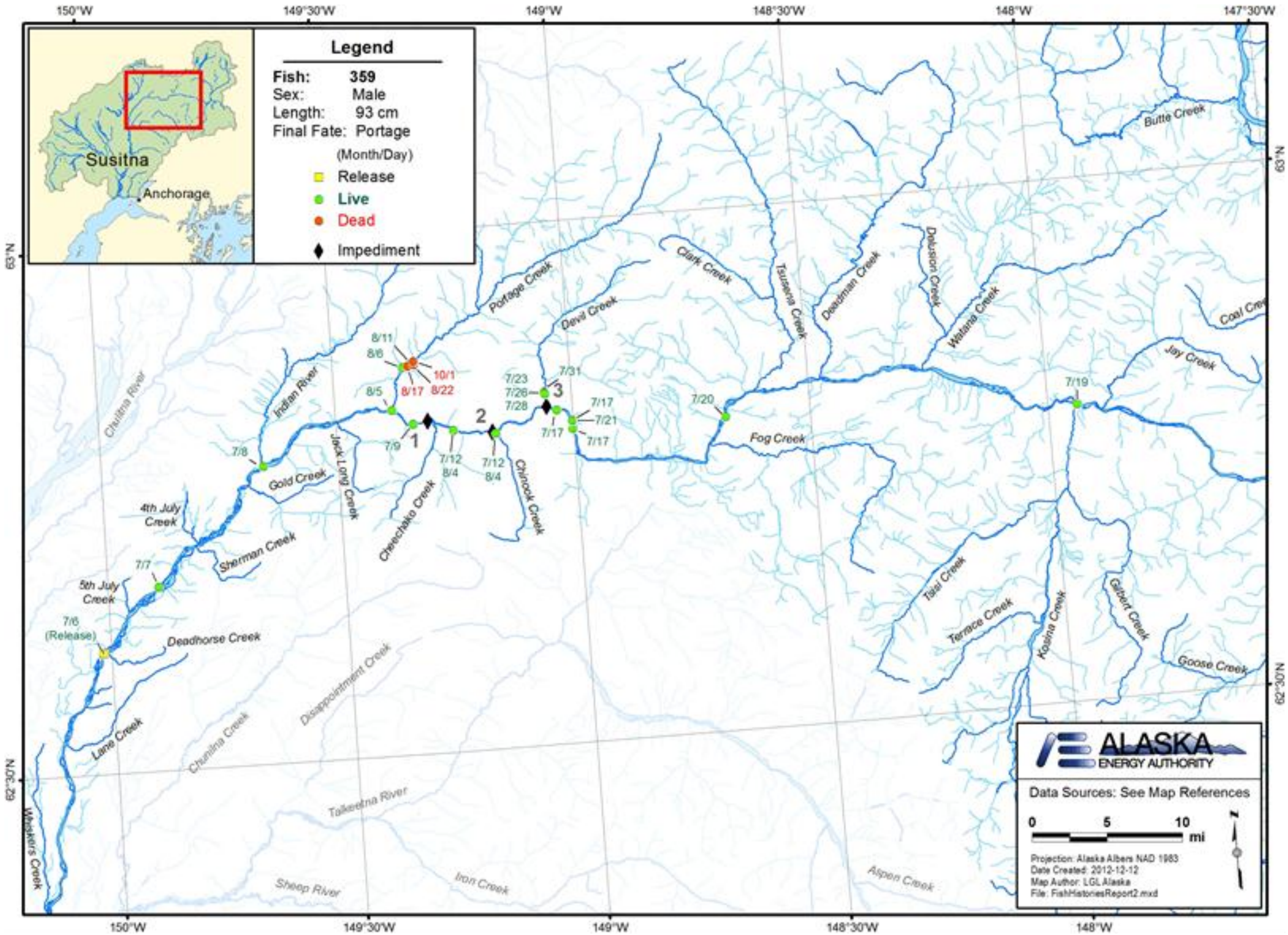
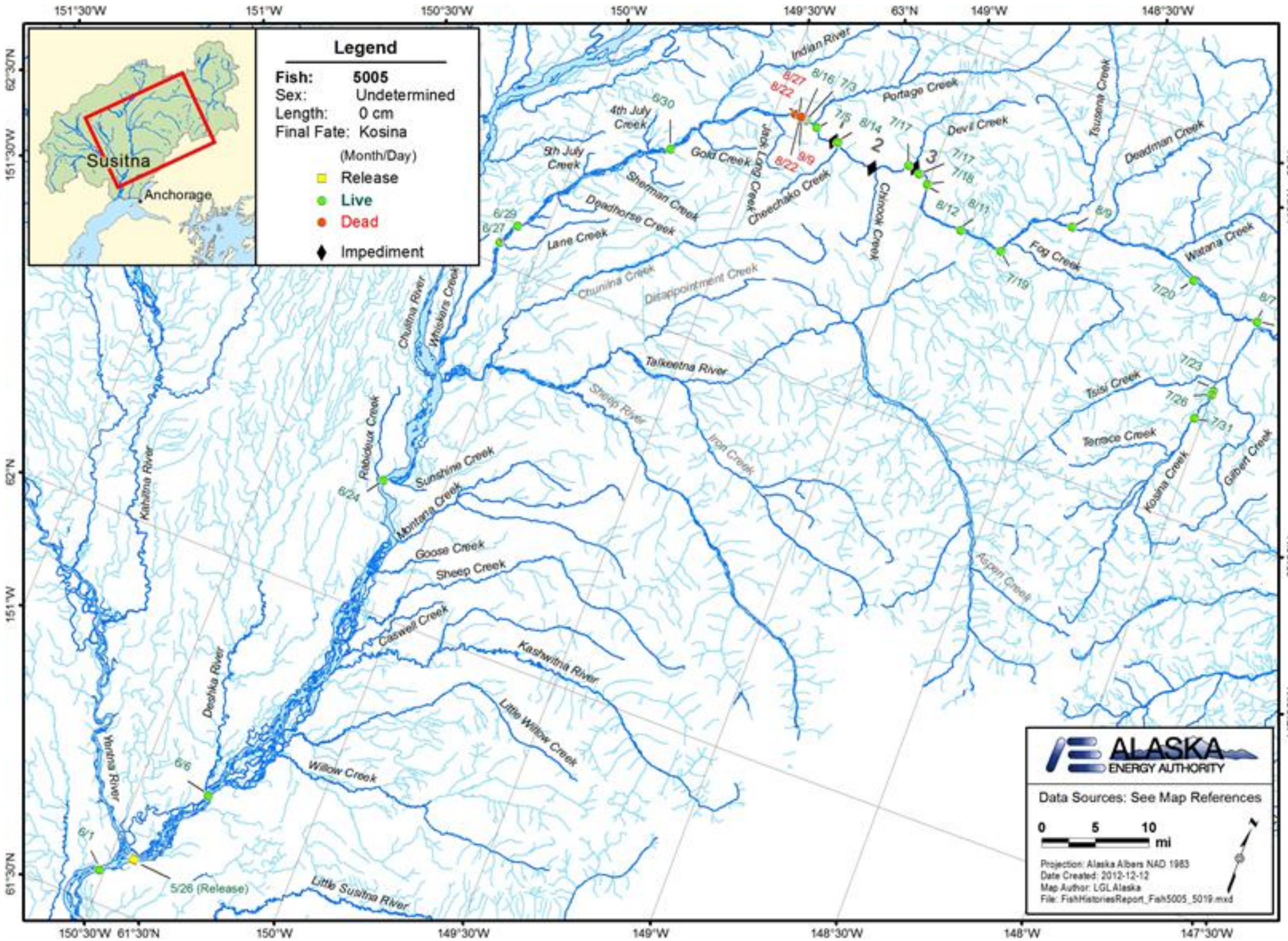
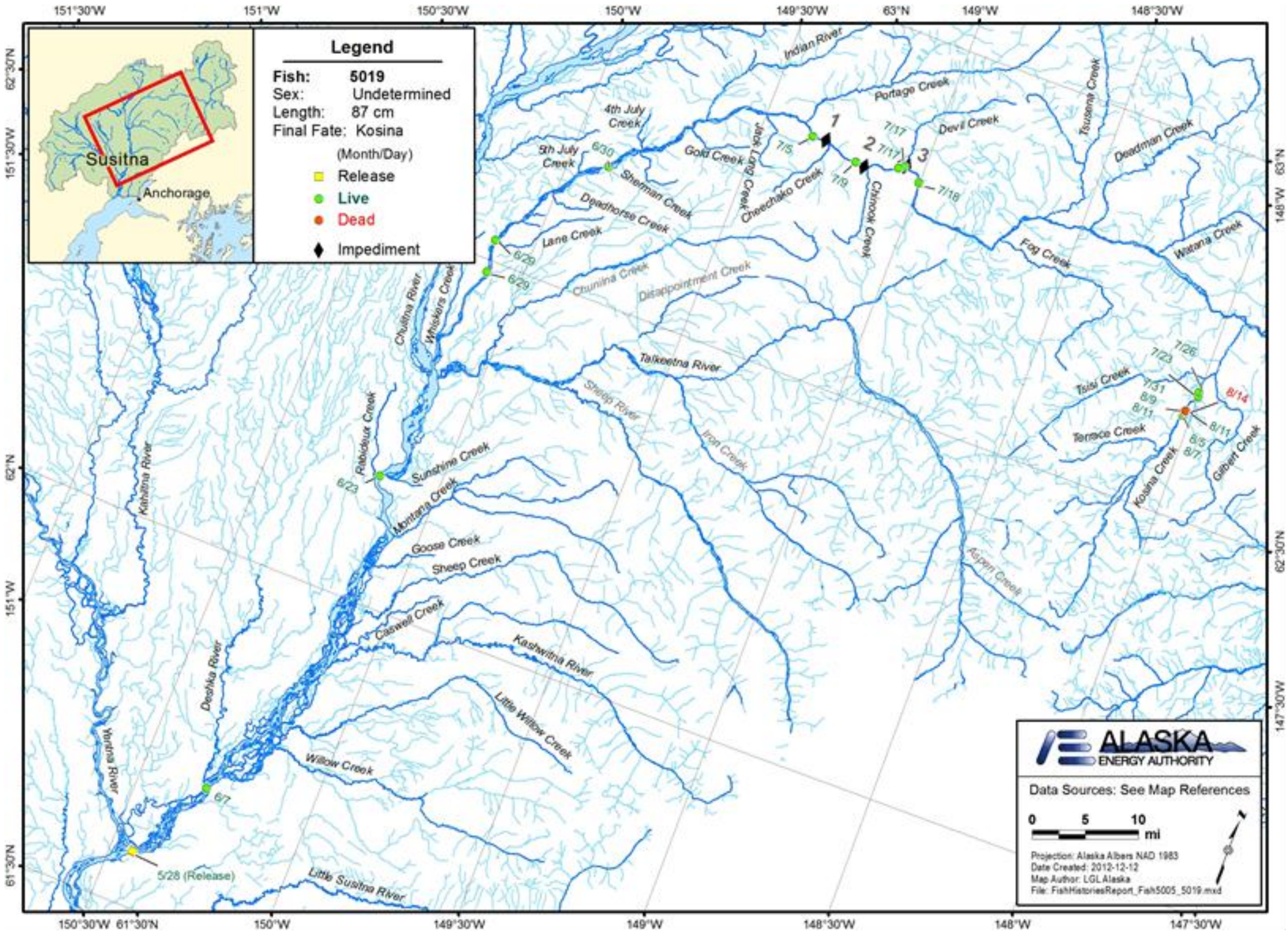

Legend
Fish: 266
Sex: Male
Length: 101 cm
Final Fate: Portage
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Fog Creek
Indian River
Chulitna River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
Sherman Creek
5th July Creek
7/4 (Release)
Deadhorse Creek
Disappointment Creek
Chunilna Creek
Lane Creek
Talkeetna River
Sheep River
Iron Creek
Aspen Creek
Whiskers Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd


Legend
Fish: 359
Sex: Male
Length: 93 cm
Final Fate: Portage
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
Portage Creek
Devil Creek
Clark Creek
Tsusena Creek
Deadman Creek
Delusion Creek
Watana Creek
Butte Creek
Coal Creek
Jay Creek
Fog Creek
Indian River
Gold Creek
Jack Long Creek
Cheechako Creek
Chinook Creek
4th July Creek
Sherman Creek
5th July Creek
Deadhorse Creek
Lane Creek
Chulitna River
Chulitna Creek
Disappointment Creek
Talkeetna River
Sheep River
Iron Creek
Alpen Creek
Whiskers Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Goose Creek
7/6 (Release)
7/7
7/8
7/9
8/5
8/6
8/11
10/1
8/17
8/22
7/12
8/4
7/23
7/26
7/28
7/31
7/17
7/21
7/20
7/19
1
2
3
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport2.mxd


Legend
Fish: 5005
Sex: Undetermined
Length: 0 cm
Final Fate: Kosina
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport_Fish5005_5019.mxd
5/26 (Release)
6/1
6/6
6/24
6/27
6/29
6/30
Indian River
Portage Creek
Devil Creek
Tsusena Creek
Deadman Creek
Watana Creek
Fog Creek
Chinook Creek
Cheechako Creek
Jack Long Creek
Gold Creek
4th July Creek
5th July Creek
Sherman Creek
Deadhorse Creek
Lane Creek
Chulitna River
Whiskers Creek
Talkeetna River
Sheep River
Iron Creek
Disappointment Creek
Chunilna Creek
Rabideux Creek
Sunshine Creek
Montana Creek
Goose Creek
Sheep Creek
Caswell Creek
Kashwitna River
Little Willow Creek
Willow Creek
Little Susitna River
Deshka River
Kahiltna River
Yentna River
Aspen Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek


Legend
Fish: 5019
Sex: Undetermined
Length: 87 cm
Final Fate: Kosina
(Month/Day)
Release
Live
Dead
Impediment
Susitna
Anchorage
ALASKA ENERGY AUTHORITY
Data Sources: See Map References
0 5 10 mi
Projection: Alaska Albers NAD 1983
Date Created: 2012-12-12
Map Author: LGL Alaska
File: FishHistoriesReport_Fish5005_5019.mxd
5/28 (Release)
6/7
6/23
6/29
6/29
6/30
7/5
7/9
7/17
7/17
7/18
7/23
7/26
7/31
8/9
8/11
8/14
8/11
8/5
8/7
1
2
3
Indian River
Portage Creek
Devil Creek
Tsusena Creek
Deadman Creek
Watana Creek
Fog Creek
Chinook Creek
Cheechako Creek
Jack Long Creek
Gold Creek
4th July Creek
5th July Creek
Sherman Creek
Deadhorse Creek
Lane Creek
Chulitna Creek
Disappointment Creek
Chulitna River
Whiskers Creek
Talkeetna River
Sheep River
Iron Creek
Tsisi Creek
Terrace Creek
Kosina Creek
Gilbert Creek
Aspen Creek
Rabideux Creek
Sunshine Creek
Montana Creek
Goose Creek
Sheep Creek
Caswell Creek
Kashwitna River
Little Willow Creek
Willow Creek
Little Susitna River
Deshka River
Kahiltna River
Yentna River
151°30'W
151°W
150°30'W
150°W
149°30'W
149°W
148°30'W
148°W
147°30'W
63°N
62°30'N
62°N
61°30'N

APPENDIX F: BASE MAP AND MAP FIGURE REFERENCES

BASE MAP REFERENCES

Category	Data Source	Date	File Name and Description
Hydrography	National Hydrography Dataset	2012	NHDArea_DoubleLineROcean_SusitnaWS: National Hydrography Dataset (NHD) Area features (double-line rivers, ocean) for the Susitna Watershed.
	National Hydrography Dataset	2012	NHDFlowlines_SusitnaWS: National Hydrography Dataset (NHD) Flowlines features for the Susitna Watershed.
	National Hydrography Dataset	2012	NHDWaterbody_Lakes_SusitnaWS: National Hydrography Dataset (NHD) Waterbody features (lakes, ponds) for the Susitna Watershed.
	Alaska Department of Natural Resources	1998	AlaskaBoundary63K: Alaska coastline.
	Alaska Department of Natural Resources	1995-10-05	SusitnaWatershedBoundary: Subset of the Hydrologic Unit Code (HUC) dataset showing entire Susitna drainage basin.
Project Location Facilities and Operations	Alaska Energy Authority	2012	PreliminaryProjectArea: Watana Dam Reservoir and Corridors
	Alaska Department of Natural Resources		PopulatedPlaces_SusitnaArea: Location of towns and villages.
	Alaska DOT & PF	2010	ProposedDamSite: Proposed Watana Dam site from Alaska DOT&PF baseline data for the evaluation of Watana Transportation Access Study.

MAP FIGURE DATA

Figure No.	Figure Name	Data Source	Date	File Name and Description
Figure 1 Figure 2	(1)Susitna River Watershed (2)Middle/Upper Susitna River	LGL Alaska Research Associates, Inc.	2012	LGLFixedStations: Locations of LGL Radio Telemetry Fixed Stations.
		LGL Alaska Research Associates, Inc.	2012	CurryFishWheels: Location of LGL Curry Fishwheels.
		Alaska Department of Fish and Game	2012	ADFGFixedStations: Locations of ADF&G Radio Telemetry Fixed Stations.
		Alaska Department of Fish and Game	2012	ADFGFishWheels Locations of ADF&G Fishwheels.:
Figure 3 Figure 5	Impediment Map Fishwheel Location Map	LGL Alaska Research Associates, Inc.	2012	FishwheelTelemetryImpedimentLocations: Locations of stationary telemetry, Fishwheel and impediment in point format.
		University of Alaska Fairbanks, Geographic Information Network of Alaska; Matanuska-Susitna Borough GIS	2011	Matanuska Susitna Borough LiDAR/Imagery Project Imagery mosaic available as a 1 ft, ortho-rectified, 4-band imagery for the entire 3680 sq/mi area, terrain corrected against the LiDAR elevation model during the 2011 collection. http://matsu.gina.alaska.edu.
Figure 24 Figure 25 Figure 26 Figure 27	Lower Susitna Mainstem Potential Spawning Locations Fish Tracking Locations	LGL Alaska Research Associates, Inc.	2012	PotentialSpawning: Locations of “likely” and “possible” mainstem spawning in the Lower Susitna River derived from radio-telemetry data in December 2012.

MAP FIGURE DATA

Figure No.	Figure Name	Data Source	Date	File Name and Description
Figure 28 Figure 29 Figure 30 Figure 31 Figure 32	Middle Susitna Mainstem Potential Spawning Locations, Fish Tracking Results Chinook, chum, coho, pink, and sockeye salmon	LGL Alaska Research Associates, Inc.	2012	PotentialSpawning_InSeason: Potential mainstem spawning locations in the Middle Susitna River derived from radio-telemetry data in early September 2012.
		LGL Alaska Research Associates, Inc.	2012	PotentialSpawning: Potential mainstem spawning locations in the Middle Susitna River derived from radio-telemetry data in December 2012.
Figure 43 Figure 44	Middle Susitna Mainstem Potential Spawning Locations and Redd Sites Fish Tracking Results	LGL Alaska Research Associates, Inc.	2012	PotentialSpawning_InSeason: Potential mainstem spawning locations in the Middle Susitna River derived from radio-telemetry data in early September 2012.
		LGL Alaska Research Associates, Inc.	2012	PotentialSpawning: Potential mainstem spawning locations in the Middle Susitna River derived from radio-telemetry data in December 2012.
		LGL Alaska Research Associates, Inc.	2012	MiddleSusitnaREDD: Confirmed locations of salmon redds in the Middle Susitna River from HSC surveys

MAP FIGURE DATA

Figure No.	Figure Name	Data Source	Date	File Name and Description
12 Figures, Appendix E	Fish 27 Fish 52 Fish 94 Fish 104 Fish 113 Fish 219 Fish 246 Fish 257 Fish 266 Fish 359 Fish 5005 Fish 5019	LGL Alaska Research Associates, Inc.	2012	DetectionHistoryforFishPassingImpediments: Locations of all detections of fish that approached or passed the middle-Susitna Impediments.