Regional Operational Plan SF.3F.2013.08

Gulkana River Chinook Salmon Distribution

by

Corey J. Schwanke

June 2013

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.3F.2013.08

GULKANA RIVER CHINOOK SALMON DISTRIBUTION

by

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Alaska Department of Fish and Game, Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish

June 2013

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SIGNATURE PAGE

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Project leader(s):	Corey Schwanke, *Fishery Biologist II*
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Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	Corey Schwanke		5/22/13
Biometrician	Jiaqi Huang		5/24/13
Research Coordinator	Matthew Evenson		5/28/13
Regional Supervisor	Don Roach		6/3/13

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

PURPOSE

This study will estimate the spawning distribution and run timing patterns of Chinook salmon in the Gulkana River. Chinook salmon will be captured and implanted with radio transmitters over the course of the run in the lower end of the Gulkana River (Figure 1). Migrations of radiotagged fish will be monitored with a combination of tracking stations and aerial tracking surveys. There is an established counting tower that estimates the majority of Chinook salmon escapement on the Gulkana River; however, studies have shown that under certain river conditions (i.e., low water, high temperatures) a substantial proportion (>40%) of the escapement may not be assessed (Savereide 2005). This study will estimate proportions of Chinook salmon spawning above and below the counting tower. A series of proportion estimates over differing environmental conditions coupled with estimates of escapement from the counting tower will allow researchers to estimate total escapement and derive an escapement goal for the Gulkana River. Run timing patterns will be estimated from final spawning locations and the date and time of initial capture. The study will also collect age, sex, and length (ASL) information from Chinook salmon to characterize the composition of the Chinook salmon escapement and use that information in an age-structured model to evaluate the escapement goal and forecast returns.

OBJECTIVES

The objectives of this study during 2012–2014 are to:

1) estimate the proportions of spawning Chinook salmon above and below the counting tower on the Gulkana River such that all estimates are within 6% of the true values 95% of the time;
2) describe inriver timing patterns of Chinook salmon spawning in the Gulkana River; and,
3) estimate ASL composition of the escapement of Chinook salmon in the Gulkana River such that estimated proportions are within 0.10 of the true proportions 95% of the time.

BACKGROUND

INTRODUCTION

The Gulkana River Chinook salmon stock is subject to a substantial commercial fishery at the mouth of the Copper River, significant subsistence and personal-use (PU) fisheries in the mainstem Copper River, and the largest Chinook salmon sport fishery in the drainage. There are no stock specific estimates of harvest available for the subsistence or personal use fisheries, but there is for the sport fishery. Annual sport fishing catch and harvest has been substantial in the past, peaking in 1997, but has steadily declined over the last 15 years (Figure 2; Somerville 2011). Recently, catch and harvest rates have decreased due to poor returns and associated sport fishing restrictions. Similar trends in overall harvest in the PU fishery exist;

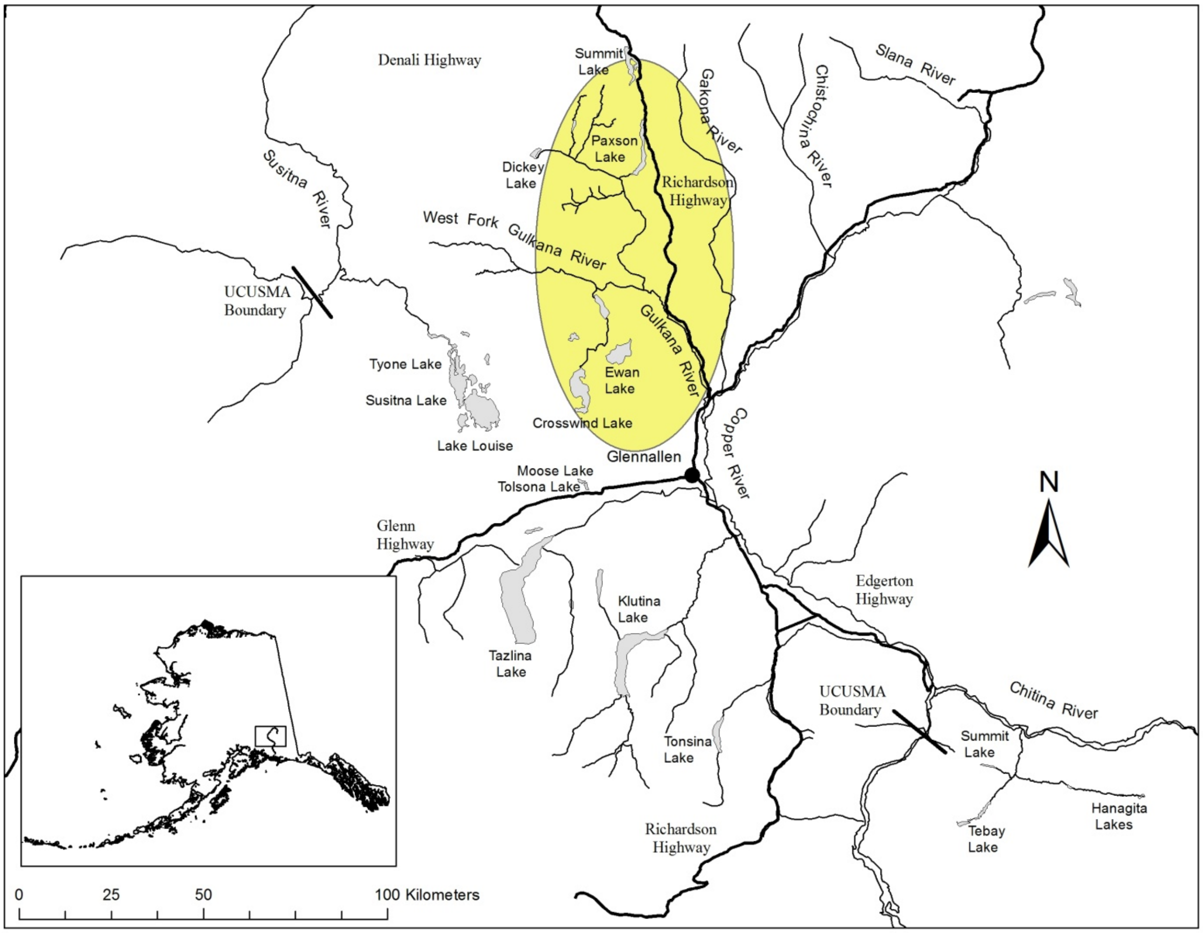

Figure 1.–Map of the Gulkana River drainage within the Upper Copper Upper Susitna Management Area.

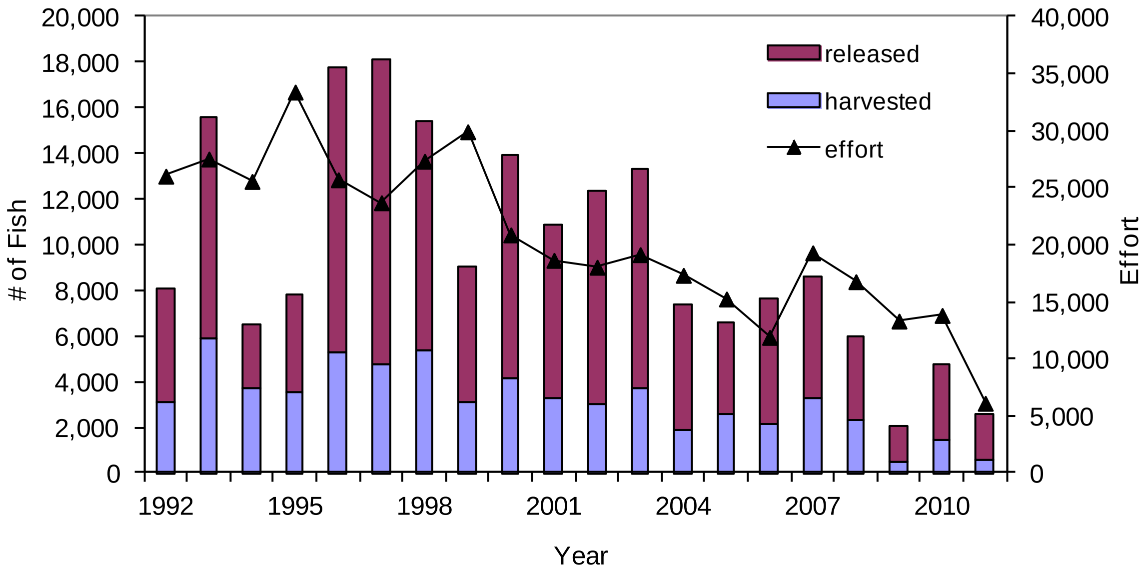

Figure 2.–Number of Chinook salmon harvested and released (the sum is catch), and fishing effort for all species, Gulkana River, 1992–2011.

however, harvest has remained relatively stable in the subsistence fisheries (i.e., state and federal) as no restrictions have taken place on these fisheries (Botz et al. 2011 and Somerville 2011).

Since 2002, a salmon counting tower has been cooperatively operated on the Gulkana River by ADF&G and the Bureau of Land Management (BLM). The counting tower is located in the mainstem about 2.5 km above the confluence of the West Fork Gulkana River. Since 2002, the number of Chinook salmon spawners past the tower has declined each year for a total decline > 50% from 2002–2012 (Figure 3; Maclean 2013). In 2012, the smallest escapement of Chinook salmon was recorded at 1,730 fish. This study will estimate the spawning distribution above and below the counting tower and investigate the relationship between inriver habitat conditions (e.g., river height, water temperature) and spawning distribution, both of which are needed to establish an escapement goal for Gulkana River Chinook salmon.

Past drainage-wide telemetry studies have shown that not all Chinook salmon spawn above the tower with factors such as water temperature, water height, and likely just general run timing affecting not only swim speeds, but the proportions of the overall escapement above the tower (Savereide 2005; Maclean 2013). Telemetry studies have demonstrated that 14–50% of the run may spawn below the tower site annually. In 2004, nearly 50% of all radiotagged Gulkana River Chinook salmon appeared to have spawned below the counting tower. That year the Gulkana River was low and clear, and abnormally high water temperatures were recorded at the counting tower site (Maclean 2013). Larger sample sizes of radiotagged fish within the Gulkana

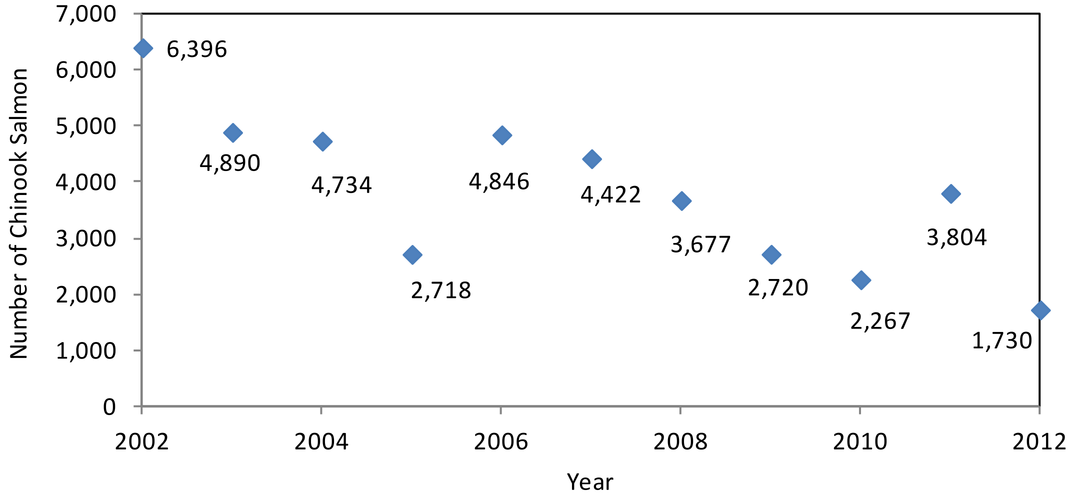

Figure 3.–Historic expanded counts of Chinook salmon from the counting tower, Gulkana River, 2002–2012.

River will be attained with this study. It is also hoped that a variety of water conditions will be experienced during this study to further investigate those effects on the proportions of fish spawning above and below the counting tower.

The Gulkana River Chinook salmon distribution study, in conjunction with the counting tower, will provide a method to estimate the total escapement of Chinook salmon on a highly utilized stock. Gulkana River Chinook salmon are genetically distinct from other Copper River stocks and exhibit an early run-timing pattern. They comprise an average of 21% of the Copper River drainage Chinook salmon spawning population (Savereide 2005) and over 29% of the Chinook salmon available to upper Copper River (Glennallen Subdistrict) subsistence fisheries. On average, over 70% of the average (2002–2011) annual subsistence harvest of 2,710 Chinook salmon is harvested before 4 July. The Gulkana River Chinook salmon counting tower coupled with distribution estimates of spawning will provide the only method to assess the inseason progression of escapement for any individual Chinook salmon stock in the Copper River drainage. This inseason monitoring combined with anecdotal harvest data from the various Upper Copper River fisheries is vital to managers when making decisions about the Copper River's important subsistence, personal-use, commercial, and sport fisheries. The estimates of total escapement will be used to establish a SEG for Gulkana River Chinook salmon.

METHODS

STUDY AREA

The Gulkana River is one of six major spawning tributaries for Chinook salmon in the Copper River drainage (Savereide 2005). The mainstem Gulkana River is fed by the East Fork, Middle

Fork, and West Fork Gulkana rivers. The study area will include most of the Gulkana River drainage, from its confluence with the Copper River upriver to spawning locations of radiotagged Chinook salmon (Figure 4). Radiotagging will take place in the lower river from the Richardson Highway downstream to the confluence with the Copper River, a distance of approximately 7 rkm. The majority of the sampling will take place at the confluence with the Copper River.

STUDY DESIGN

Overview

This study will estimate the spawning distribution and run timing of Chinook salmon in the Gulkana River. Migrations of radiotagged fish will be monitored with 5 tracking stations positioned at strategic points throughout the Gulkana River drainage, as well as a series of aerial tracking surveys from a fixed-wing aircraft. Spawning distribution will be estimated as the ratio of numbers of radiotagged fish migrating above and below the counting tower to the total number of radiotagged fish surviving and migrating to all spawning areas. Run timing will be identified from final locations and the date and time of initial capture.

Fish capture

Some technical information (Savereide 2005) is available as to when Chinook salmon reach the mouth of the Gulkana River, but we feel run timing has changed substantially the last few years, and that the handling effects (i.e., fish wheel capture and tagging) might have influenced the arrival times during these studies. For this study, the initial tagging schedule will be based partially on previous telemetry work, run timing curves from the counting tower, personal experiences of the principal investigator and anecdotal information on angling at the mouth of the Gulkana River. First, the date of 3 June was chosen as when fish are expected to arrive in catchable numbers at the mouth of the Gulkana River. Second, a run curve was constructed from 11 years of data from the counting tower. This was calculated by averaging the mean daily proportion of fish passing the counting tower each day. Finally, this run curve was shifted to a start date of June 3 to project an expected passage rate at the tagging area (the mouth of the Gulkana River). The proportion of expected passage at the mouth was then summed by week and multiplied by the total number of tags to be deployed (150) to determine weekly tagging goals (Table 1). The tagging schedule will be evaluated at specified times during the run and increased or decreased based on the perceived run strength and timing. Sampling will only take place during the workweek (Mon-Fri) and possibly at night to avoid potential conflicts with sport fisherman using the area.

Chinook salmon will be captured with rod-and-reel, dip nets, and possibly beach seine. Tackle used to capture Chinook salmon will be flies, wiggle warts, and spinning glow/salmon roe combinations. A total of 150 Chinook salmon will be radiotagged from 3 June through 28 July in the lower portion of the Gulkana River to ensure radio transmitters are distributed across the entire run. Every healthy fish will receive a radio tag. When the quota for a tagging period (i.e., a work-week) has been reached, sampling will cease. A sampling day or two may take place prior to 3 June to ensure that no fish are missed.

All captured fish will be measured to the nearest 5-mm mid-eye to fork length (MEF) and sex will be determined from external characteristics. After capture, Chinook salmon will be placed in a tagging cradle filled with water. Two types of radio tags will be used the first year of the

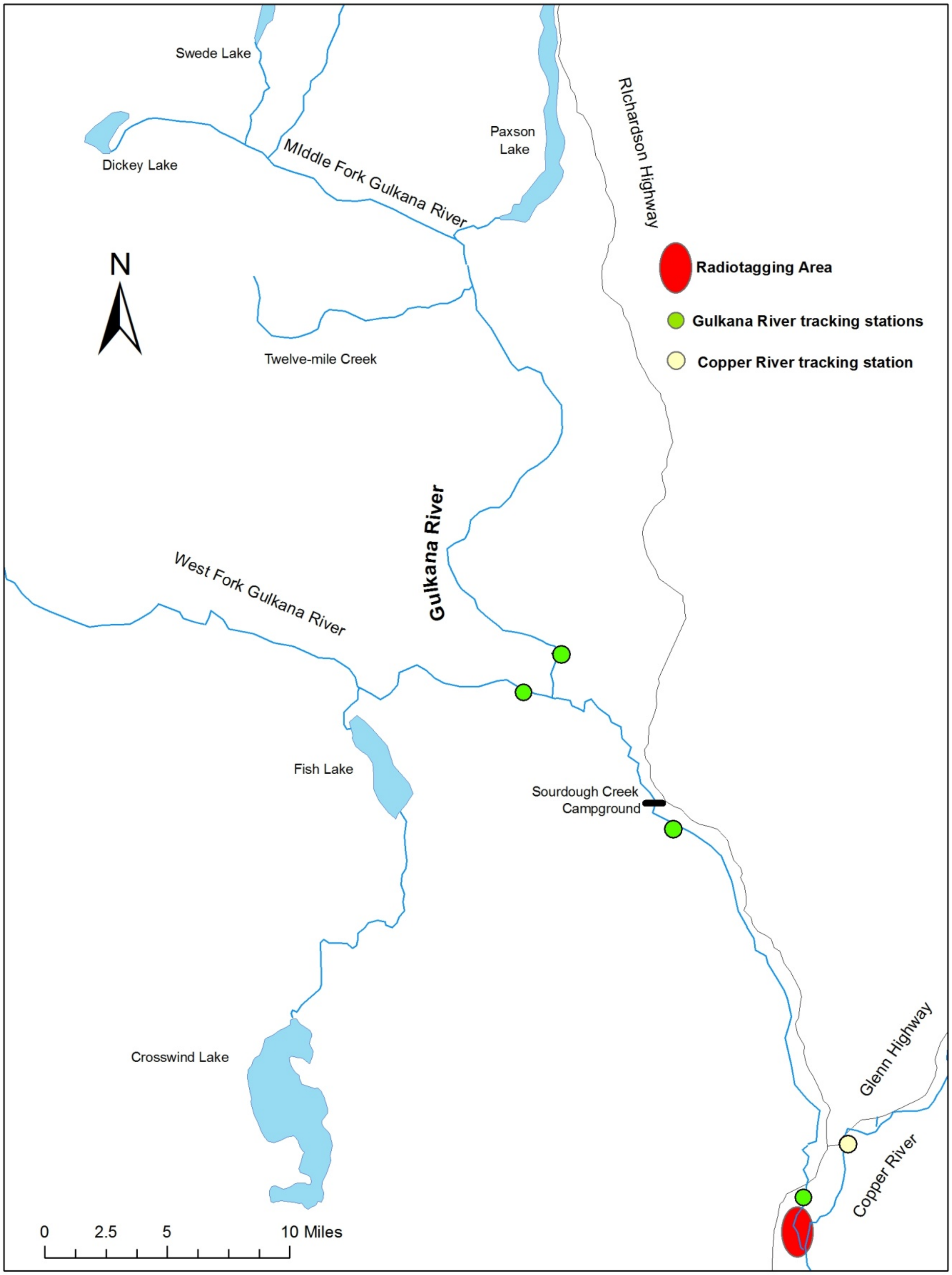

Figure 4.–Map of the Gulkana River with radiotagging and tracking station locations.

Table 1.–Tagging schedule for Chinook salmon, Gulkana River.

Calendar Week (Mon-Sun)	Sampling Dates (Mon-Fri)	Number of Tags Deployed	Cumulative Tags Deployed
3–9 June	3–7 June	12	12
10–16 June	10–14 June	24	36
17–23 June	17–21 June	32	68
24–30 June	24–28 June	26	94
1–7 July	1–5 July	20	114
8–14 July	8–12 July	15	129
15–21 July	15–19 July	14	143
22–28 July	22–26 July	7	150

study: esophageal and external mount models. Seventy-five of each will be used with the intent of using the model that works the best (ease of application, tag retention, fish response, etc.) in future years. Esophageal tags will be inserted through the esophagus and into the upper stomach as described in Savereide (2005). External model tags will be attached using standard procedures outlined in Schwanke and Reed (2011). All fish captured will also receive a uniquely numbered, brightly colored Floy™ tag with an encased distinctly identifiable pit tag[1]. All tagging will be performed without the use of anesthesia.

Telemetric Procedures

Radio tags will be Model Five pulse encoded transmitters made by Advanced Telemetry Systems (ATS). Each transmitter will be distinguishable by its frequency and encoded pulse pattern. Five frequencies chosen for this project are 149.420, 149.440, 149.480, 149.510 and 149.550 kHz. Each frequency will have 30 radio tags each with distinguishable encoded pulse patterns. The pulse rate for these tags will be about once every 1.3 seconds. Radiotagged Chinook salmon will be tracked along the course of the Gulkana River using a network of 4 ground-based tracking stations (Figure 4). Each station includes 2 deep-cycle batteries, a solar array, an antenna switch box, a steel housing box, 2 Yagi antennas, and an ATS Model R4500. The receiver will be programmed to scan through the frequencies at 2 s intervals, and receive from both antennas simultaneously. When a signal of sufficient strength is encountered, the receiver will pause for 12 seconds on each antenna, and then transmitter frequency, transmitter code,

[1] Pit tags are being applied to all captured Chinoook salmon to aid a study which will evaluate the efficacy of a pit tag detection array placed near the counting tower. This is a separate project being conducted by the Native Village of Eyak.

signal strength, date, time, and antenna number will be recorded on the data logger. The relatively short cycle period will minimize the chance that a radiotagged fish will swim past the receiver site without being detected. Cycling through all frequencies will require 2–3 minutes depending on the number of active tags in the reception range and level of background noise. Recorded data will be downloaded to a laptop computer every 10–12 days.

The first tracking station will be placed downstream of the Richardson Hwy Bridge (Figure 4), approximately 6 km above the capture site. This station will be used to determine the number of radiotagged fish that survived handling and tagging and continued to migrate up the Gulkana River. The next station will be placed on the mainstem Gulkana River downstream from Sourdough Landing, near the perceived lower spawning boundary. The next station will be on the West Fork Gulkana approximately 1 km upstream from the confluence with the mainstem river. This station will enumerate radiotagged Chinook salmon spawning in the tributaries and mainstem of the West Fork. The final station in the Gulkana River will be placed at the counting tower and will enumerate all radiotagged Chinook salmon spawning upstream of the counting tower. A fifth station will be placed on the mainstem Copper River approximately 2 km downstream from the mouth of the Gakona River (Figure 4). This station will be used to enumerate all radiotagged fish that were bound for Upper Copper River drainage tributaries, but were captured during their upstream migration near the mouth of the Gulkana River.

The distribution of radiotagged Chinook salmon throughout the Gulkana River drainage will be further determined by aerial tracking from small aircraft. A series (3–5) of aerial-tracking surveys of the entire drainage will be conducted in late June, July, and August. Tracking flights will be conducted with one aircraft and one person (in addition to the pilot) utilizing one R4500 receiver. All frequencies will be loaded into the receiver prior to each flight. Dwell time on each frequency will be 2 s. Flight altitude will range from 100 to 300 m above ground. Two antennas, one on each wing strut, will be mounted such that the antennas receive signals perpendicular to the direction of travel. Once a transmitter is identified, its frequency, code, and GPS location will be recorded. The purpose of the aerial tracking will be to locate fish that tracking stations failed to record, and to validate that fish recorded at the tracking stations did migrate into that particular area.

DATA COLLECTION AND REDUCTION

For each Chinook salmon captured, data collected will include: 1) measurement of fish length to the nearest 5 mm MEF length; 2) type of capture gear used; 3) location (river kilometer and GPS coordinate); 4) number printed on the Floy™ tag; and, 5) date. For all fish receiving a radio tag, additional data collected will include the radio transmitter frequency, code, and type of tag (e.g., esophageal or external; Appendix A).

Ages will be determined from scale patterns as described by Mosher (1969). Three scales will be removed from the left side of the fish approximately 2 rows above the lateral line along a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Welander 1940).

Each tracking station will record date, time, frequency, code, signal strength, and antenna number for each time a signal of sufficient strength is encountered. Tracking stations will be periodically downloaded using a laptop computer (weekly). During each aerial tracking survey, data collected for each fish will include frequency, code, latitude, longitude, and a general description of its location (e.g., approximately 1 mile upstream of Sourdough Creek).

Coordinates of located fish will be plotted on USGS maps (represented in Alaska NAD27 Datum) using Arcview™. Final copies of the Excel and Arcview files will be provided with the completed report when it is submitted for review to be archived in the Sport Fish Division Docushare website. The file name and directory location will be presented in the final report and can be made available upon request.

DATA ANALYSIS

To facilitate data analysis, all radiotagged Chinook salmon will be assigned a "fate" (Table 2). The known fate of all radiotagged fish is required to attain unbiased estimates of parameters. Information attained from radio tag/Floy™ tag returns, tracking stations, and aerial surveys will be used to define fates. In previous studies (1999–2004) fates were assigned to all radiotagged Chinook salmon. All radiotagged fish located and designated as "spawners" will be used to estimate distribution and timing.

Table 2.–List of all possible fates of radiotagged Chinook salmon in the Gulkana River drainage.

Fate	Description
Fishery Mortality	A fish harvested in the sport or subsistence fisheries.
Spawner	A fish that migrates into a spawning area of the Gulkana River. Within this category, spawning locations will be determined, not only for tributaries, but also river segments (e.g., above and below the counting tower).
Upstream Migrant	A fish that migrates upriver of the Gulkana River.
Failure	A fish that is never recorded upstream of the Lower Gulkana River or Copper River tracking stations.

Among fish that migrate past a given tracking station, the proportion of fish that have fate j will be estimated as:

$$\hat{P}_j = \frac{\sum_{i}^{\text{days}} R_{ij}}{n} \tag{1}$$

with variance (Cochran 1977):

$$\hat{V}\left[\hat{p}_j\right] = \frac{\hat{p}_j\left(1-\hat{p}_j\right)}{n-1} \tag{2}$$

where R_{ij} is the number of fish tagged on day i having fate j and n equals the total number of radiotagged fish deemed Gulkana River spawners. Fate j can encompass a variety of fates, such as the proportion of fish that spawned above and below the counting tower.

Run timing patterns will be described as time-density functions, where the relative abundance of stock j that enters into the Gulkana River during time interval t will be described by (Mundy 1979):

$$f_j(t) = \frac{R_{tj}}{\sum_{i}^{days} R_{ij}} \tag{3}$$

where:

$f_j(t)$ = the empirical temporal probability distribution over the total span of the run for fish spawning in a tributary or mainstem (or portion thereof) j; and,

R_{tj} = the subset of radiotagged Chinook salmon bound for tributary/area j that will be caught and tagged during day t.

The mean date of passage ($\bar{t}_j$) from the lower river tracking station for fish spawning in tributary/area j will be estimated as:

$$\bar{t}_j = \sum_t t\, f_j(t), \tag{4}$$

and the variance of the run timing distribution will be estimated as:

$$Var\ (t_j) = \sum_t \left(t - \bar{t}_j\right)^2 f_j(t). \tag{5}$$

The proportion of fish at age, sex, or length category k by sex s for samples collected solely for age, sex, and length will be calculated as:

$$\hat{p}_{sk} = \frac{y_{sk}}{n_s} \tag{6}$$

where: $\hat{p}_{sk} =$ the estimated proportion of Chinook salmon that are age or length category k and sex s; y_{sk} = the number of Chinook salmon sampled that are age or length category k; and, n_s = the total number of Chinook salmon sampled by sex.

The variance of this proportion will be estimated as:

$$\hat{V}\left[\hat{p}_{sk}\right] = \frac{\hat{p}_{sk}\left(1-\hat{p}_{sk}\right)}{n_s-1} \tag{7}$$

Escapement at age or length category *k* for each sex is then estimated by:

$$\hat{N}_{sk} = \hat{p}_{sk}\hat{N}_{s} \tag{8}$$

The variance for $\hat{N}_{sk}$ in this case is (Goodman 1960):

$$\hat{V}(\hat{N}_{sk}) = \hat{V}(\hat{p}_{sk})\hat{N}_{s}{}^{2} + \hat{V}(\hat{N}_{s})\hat{p}_{sk}^{2} - \hat{V}(\hat{p}_{sk})\hat{V}(\hat{N}_{s}). \tag{9}$$

SCHEDULE AND DELIVERABLES

Dates of sampling events, milestones, and other activities for 2013–2015 are summarized in the following table.

Date(s)	Sampling Activity/Milestone
26 April 2013	Operational Plan completed
Late May 2013–2015	Set up tracking stations
3 June-28 July 2013–2015	Deploy radio tags
Periodic Summer Dates	Download tracking stations
Late June 2013–2015	Aerial tracking survey
Early July 2013–2015	Aerial tracking survey
Late July 2013–2015	Aerial tracking survey
Early Aug 2013–2015	Aerial tracking survey
Mid-August 2013–2015	Aerial tracking survey
September 2013–2015	Disassemble tracking stations
December 2015	FDS Final Report Complete

RESPONSIBILITIES

List of Personnel and Duties:

ADF&G

Corey Schwanke:	Fishery Biologist II;	Overall supervision of project. Coordinate sampling schedules with project personnel. Analyze data and prepare reports with technical assistance.
James Savereide:	Fishery Biologist III;	Supervise project leader, assist with fixed-station set up, assist with capture, sampling, data collection and review all reports.
Jiaqi Huang:	Biometrician II;	Assist in preparation of statistical design of field investigation for operational plan, and review data analysis and final report.
Klaus Wuttig:	Fishery Biologist III;	Supervise project leader, assist with capture, sampling, data collection and review all reports.
Matt Albert:	Fishery Biologist I;	Assist with capture, sampling, and data collection.
Chad Bear:	F&W Tech III;	Assist with fixed-station set up, capture, sampling, and data collection.
Unknown:	F&W Tech III;	Assist with fixed-station set up, capture, sampling, and data collection. Serve as crew leader and provide support with operating and downloading tracking stations as well as data entry and editing.

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APPENDIX A

Appendix A1.–Example of the field form for Chinook Salmon sampling, Gulkana River, 2013.

Gulkana River Chinook Salmon Radiotelemetry

Date:________________ Samplers:_________________________ Page:_________

Time of Capture	Capture Gear	Length (MEF)	Sex	General Location (outlet, by camp, etc)	Latitude	Longitude	Radio-Tagged (Y or N)	Floy Tag #	Pit Tag #	Frequency/Code and any comments
14:00	H&L	685	M	Mouth of Gulkana	67.4552	163.1236	N	0794	0014	-----------------------
15:30	H&L	730	F	200 yds above mouth	67.4875	163.0654	Y	0795	0015	149.510/ 27