Regional Operational Plan SF.3F.2014.01

Gulkana River Chinook Salmon Escapement Estimation, 2014–2016

by

Scott H. Maclean

January 2015

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

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Division of Sport Fish

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Signature Page

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Approval

Title	Name	Signature	Date
Project leader	Scott Maclean	(Supervisor)	
Biometrician	Jiaqi Huang		
Research Coordinator	Matthew Evenson		1.27.15
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TABLE OF CONTENTS

Page

LIST OF TABLES....ii
LIST OF FIGURES....ii
LIST OF APPENDICES....ii
ABSTRACT....1
PURPOSE....1
BACKGROUND....1
Introduction....1
OBJECTIVES....2
METHODS....3
Study Area....3
Study Design....3
Data Collection and Reduction....5
Sample Size....7
DATA ANALYSIS....7
Chinook Salmon Escapement....7
Sockeye Salmon Escapement....11
SCHEDULE AND DELIVERABLES....12
RESPONSIBILITIES....13
REFERENCE CITED....14
APPENDIX A....15
APPENDIX B....17

LIST OF TABLES

Table **Page**

1. Water clarity classification scheme....6

LIST OF FIGURES

Figure **Page**

1. Expanded counts of Chinook salmon from the Gulkana River counting tower, 2002–2012....2
2. Gulkana River drainage and location of the fish counting tower....4

LIST OF APPENDICES

Appendix **Page**

A1. Example of the field form for daily counts of Chinook and sockeye salmon, Gulkana River, 2014–2016....16
B1. Daily crew schedule and work assignments....18

ABSTRACT

Objectives of this study are to estimate the spawning escapement and run timing patterns of Chinook salmon *Oncorhynchus tshawytscha* in an index area of the Gulkana River using counting tower methodology. In addition, sockeye salmon *Oncorhynchus nerka* passage at the tower site will be estimated during the period of tower operation. The number of Chinook salmon and sockeye salmon passing the tower site will be estimated by visually counting fish as they pass two counting towers located approximately 2.5 km upstream of the confluence of the West Fork. Ten-minute visual counts will be conducted for each river channel every hour, 24 hours per day, seven days per week. The count schedule will start prior to the beginning of the run, approximately June 4, and continue into August until there are three consecutive days with no daily net upstream passage of Chinook salmon (approximately 15 August). The abundance estimate will be stratified by day. Because counts are planned for all hours, daily estimates of abundance will be a single-stage direct expansion from the 10-min counting periods.

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* sockeye salmon, *Oncorhynchus nerka,* Gulkana River, run timing, counting tower, abundance, escapement.

PURPOSE

The Gulkana River Chinook salmon counting tower coupled with distribution estimates of spawning (Schwanke 2013) 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.

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 have been substantial in the past, peaking in 1997, but have steadily declined the last 15 years (Somerville 2011). The most recent declines in catch and harvest rates are due to poor returns and associated sport fishing restrictions. Similar trends in overall harvest in the PU fishery exist; 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 and Somerville 2011).

Concerns over the steady increase in harvest of Copper River Chinook salmon stocks beginning in the early 1990s were addressed at the 1999 Board of Fisheries meeting. The result was the development and establishment of the *Copper River King Salmon Management Plan* (5 AAC 24.361, 2006) under which the Copper River Chinook salmon fisheries are currently managed. The plan mandates the department to manage the fisheries to achieve a drainage-wide sustainable escapement goal of 24,000 or more Chinook salmon and provides a regulatory framework for achieving this goal. There are provisions in the plan for managing the sport fisheries when additional conservation measures are needed to ensure the escapement goal is met. Total drainage escapement is estimated each year in the Lower Copper River using mark-recapture techniques. However, this assessment program does not provide inseason estimates of run size. To achieve the goals established in the management plan, an accurate and reliable means of monitoring and estimating Gulkana River Chinook salmon escapement inseason is needed to allow for effective management of the fisheries. The Gulkana River is a critical part of the Copper River system because a high proportion of the total Copper River drainage Chinook salmon run is made up of this stock (Savereide and Evenson 2002; Savereide 2005).

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. The number of Chinook salmon spawners past the tower has declined each year for a total decline > 70% from 2002–2012 (Figure 1; Maclean 2013). In 2012, the smallest escapement of Chinook salmon was recorded at 1,730 fish. Gulkana River Chinook salmon are genetically distinct 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.

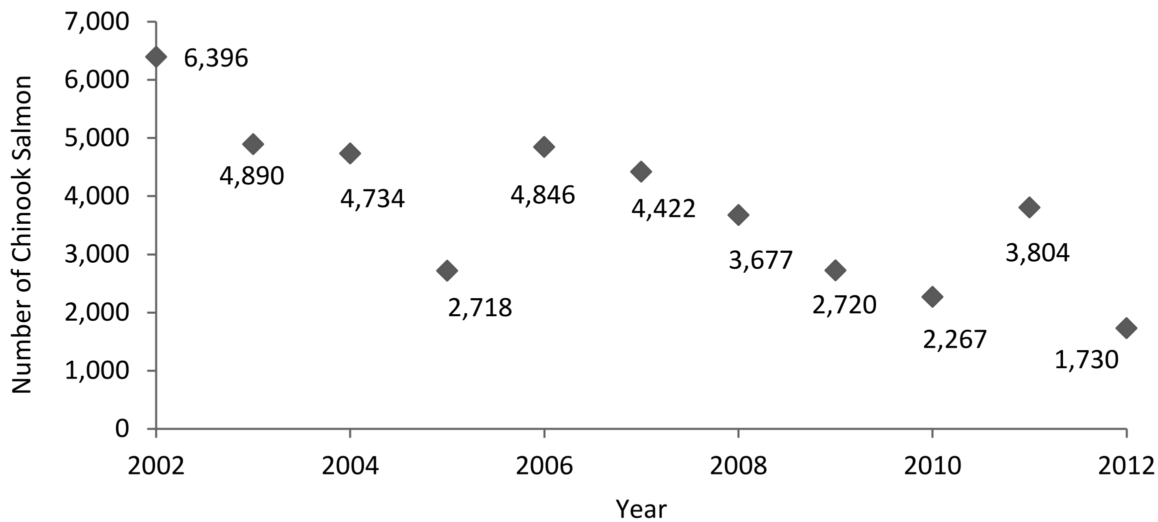

Figure 1.–Expanded counts of Chinook salmon from the Gulkana River counting tower, 2002–2012.

OBJECTIVES

The objectives of this study during 2014–2016 are to:

1) estimate the escapement of Chinook salmon upstream of an established counting tower site on the mainstem Gulkana River, using counting tower techniques, such that the estimate is within 15% of the actual value 95% of the time;
2) describe inriver run timing for Chinook and sockeye salmon in the Gulkana River; and,

3) enumerate sockeye salmon passage at the tower site during the period of tower operation.

METHODS

STUDY AREA

The Gulkana River originates in the Alaska Range and its watershed drains approximately 5,543 square kilometers in southcentral Alaska. From its headwaters upstream of Summit Lake, the Gulkana River flows for approximately 161 km south to its confluence with the Copper River. In the stretch of river from Paxson Lake to its confluence with the Copper River, the Gulkana River falls 4.1 kilometers. Three main branches feed into the mainstem river: the East, Middle, and West forks (Figure 2). The Gulkana River supports recreational fisheries for sockeye and Chinook salmon, rainbow trout *O. mykiss*, and Arctic grayling *Thymallus arcticus*, with access primarily by boat. Primarily a clear water system, the clarity and water level of the Gulkana River can fluctuate considerably and quickly in response to weather. The West Fork is known for its often turbid input.

The Gulkana River is one of six major spawning tributaries for Chinook salmon in the Copper River drainage (Savereide 2005). The study area is located between Paxson Lake and Sourdough Landing. The section of the Gulkana River upstream of Sourdough Landing has been recognized for its exceptional scenic, recreational, and fish and wildlife habitat values, and has been designated by the U.S. Congress as a "wild river," part of the National Wild and Scenic Rivers System. The Federal Bureau of Land Management administers this corridor. The tower site is located on the mainstem approximately 2.5 km upstream of the confluence with the West Fork (Figure 1). A small island splits the mainstem into two channels at the tower site. This split, with counting towers located on each side of the island, allows for a comprehensive view of the total width of the river (approximately 30 meters per channel). Maximum depth in both channels ranges from 1 to 1.5 m during normal summer flow, and the flow is fairly even from bank to bank. The bottom composition is cobble, gravel, and sand/silt, with relatively few boulders. Normal powerboat access to this upper part of the river, including the tower site, is from the public boat launch at Sourdough Landing, which is 19.3 km downstream of the West Fork.

STUDY DESIGN

The number of Chinook salmon returning to an index area in the mainstem Gulkana River will be estimated by visually counting fish as they pass two counting towers located approximately 2.5 km upstream of the confluence of the West Fork. Ten-minute visual counts will be conducted for each river channel every hour, 24 hours per day, seven days per week. The count schedule will start prior to the beginning of the run, approximately June 4, and continue into August until there are three consecutive days with no daily net upstream passage of Chinook salmon (approximately 15 August). The abundance estimate will be stratified by day. Because counts are planned for all hours, daily estimates of abundance will be a single-stage direct expansion from the 10-min counting periods. The period sampling is systematic because sampling occurs hourly (i.e., systematically throughout the day).

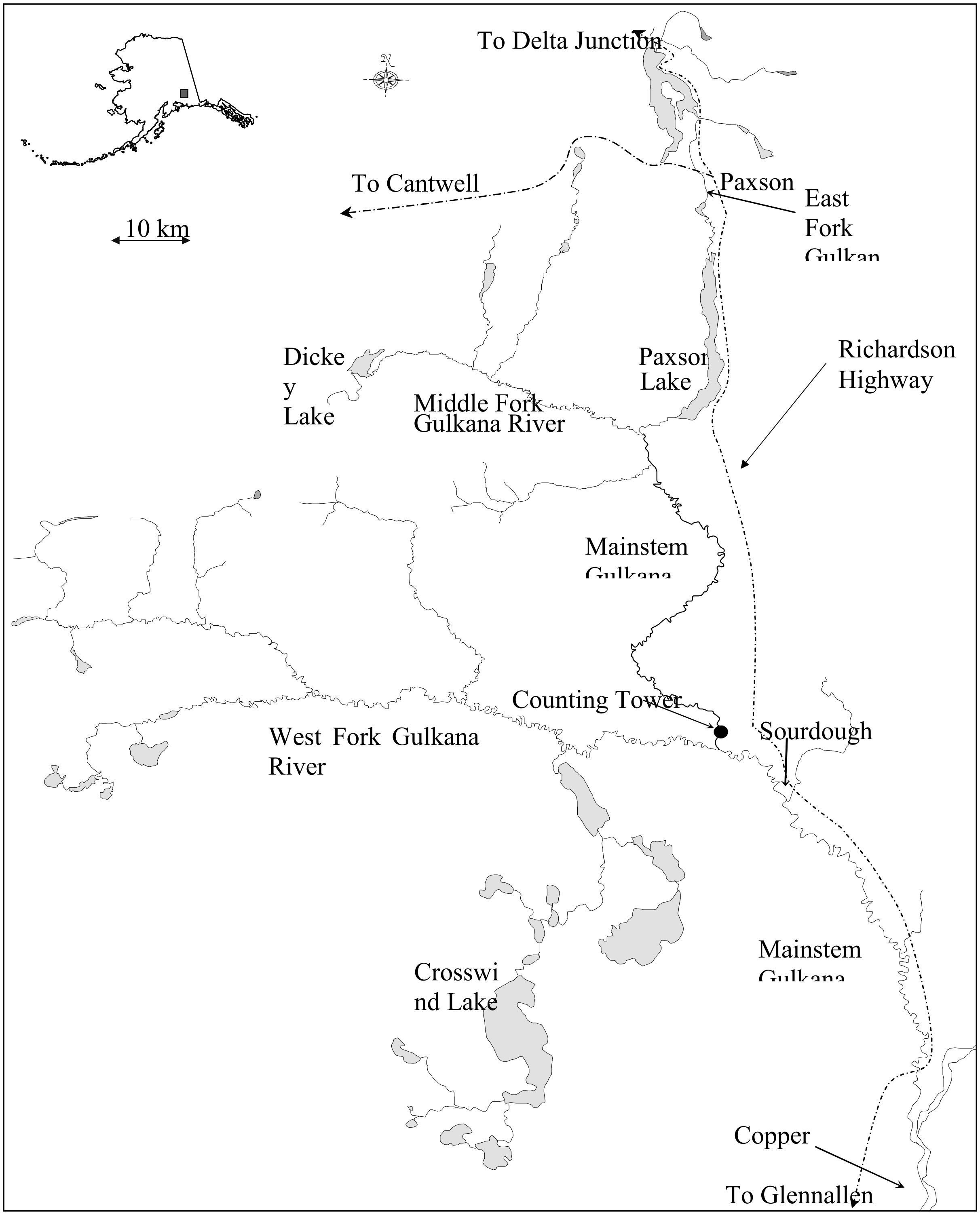

Figure 2.–Gulkana River drainage and location of the fish counting tower.

DATA COLLECTION AND REDUCTION

Tower construction will begin approximately 1 June, and counting will begin 4 June, continuing through the duration of the Chinook salmon run, which ends in mid-August. During the installation of the counting tower, crews will monitor the river to ensure that the beginning of the Chinook salmon run is observed. If Chinook salmon are observed earlier than anticipated, and before the platforms are erected, then counts will begin from the riverbank. An island at the tower site divides the river into two channels, west and east. Scaffolding towers will be installed to provide a platform approximately 12 to 15 feet above water level from which to view each channel. The platform area will be covered on the top and three sides with camouflage-print tarps to prevent silhouetting the observer, and also provide the observer with protection from wind and rain. To make passing fish more visible, and provide a well-defined manner of delineating passage, a continuous band of light-colored vinyl panels, approximately 2 m wide, will be anchored to the river bottom. This band of contrast panels will be located at the base of each tower and run across the width of the adjacent river channel (west or east). There will also be a two- to three-meter section of picket weir near the base of each tower to ensure no fish are able to pass unseen due to bank characteristics on the island. For both towers the opposite mainland riverbank has a very gradual slope and the contrast panels run smoothly against the substrate and up the bank beyond water level. Debris, silt, gravel, and salmon carcasses accumulate regularly on the panels and weir sections, affecting stream flow and visibility. Clearing of such accumulations will be performed as necessary after the hourly counts. During periods of low ambient illumination, floodlights located above platform height will be used to illuminate the submerged contrast panels across the width of each channel. Once the lights are turned on, they will remain on between counts to maintain consistent conditions until no longer needed. This should reduce any associated effect that lighting changes may have on salmon passage.

Two crews of three technicians each will alternate on-site workweeks (crew change on Thursday). A 10-min count of each channel will be conducted every hour of every day. The start time for all counts for the West channel will begin between the top of the hour and 10 minutes past. The 10-min count of the East channel will begin immediately following the count on the West channel. Each technician will be assigned an eight-hour count shift; one full crew rotation will produce twenty-four 20-minute counts. Shift A begins at 0600 hours and ends at 1400 hours; shift B begins at 1400 hours and ends at 2200 hours shift; and, shift C begins at 2200 hours and ends at 0600 hours. This work-shift schedule allows the in-bound crew time each Thursday to purchase supplies prior to travel to the tower site, and the out-bound crew sufficient time to return to the Glennallen area office before 1700 hours. Crews will exchange any pertinent information regarding conditions, equipment, and other issues of concern during the turnaround. The out-bound crew brings the daily count forms (Appendix A) for their workweek and submits them to the Project Leader. Office time is used to complete administrative duties, and discuss data and project needs with the project leader. Crew schedules and work assignments are provided in Appendix B.

The observed numbers of Chinook and sockeye salmon will be tallied during each 10-minute count period, on each channel. The total counts for each period will be recorded on daily count forms (Appendix A) along with the date and the name of the observer. Separate forms will be used for each channel. Passage both upstream (+) and downstream (-) will be recorded to provide a net upstream passage for each 10-minute count for each channel. Passage is defined as movement across the full 3 m width of the contrast panels. Some fish may cross the panels multiple times in both upstream and downstream directions, in particular when spawning occurs near the tower. The observer will tally every upstream and downstream movement, regardless of whether it is suspected or known that it is the same fish. The only movement not counted (but still noted in the comment field) is that of a carcass moving downstream. Identifiable passage of steelhead and rainbow trout will also be recorded as supplemental data. At the beginning of each count hour the water level (relative level read from a staff gauge) and water clarity will be recorded on the daily form. The observer will evaluate water clarity as described in Table 1. Water temperature read at the beginning of each 8-hr count shift will also be recorded. The comment field will be used to note the circumstances under which the counts were made. Each day, the total counts from the previous day for each species, in each channel, will be relayed to the project leader in Glennallen via satellite phone.

Table 1.–Water clarity classification scheme.

Rank	Description	Salmon Viewing	Water Condition
1	Excellent	All passing salmon are observable	Virtually no turbidity or glare, “drinking water” clarity; all routes of migration observable
2	Good	All passing salmon are observable	Minimal to very low levels of turbidity or glare; all routes of migration observable
3	Fair	All passing salmon are observable	Low to moderate levels of turbidity or glare; all routes of migration observable
4	Poor	Possible, but not likely, that some passing salmon may be missed	Moderate to high levels of turbidity or glare; a few likely routes of migration are partially obscured
4.5[a]	Very poor	Likely that some passing salmon may be missed	Moderate to high levels of turbidity or glare; some, to many, likely routes of migration are obscured
5	Unobservable	Passing fish are not observable	High level of turbidity or glare; ALL routes of migration obscured

[a]4.5 was inserted in 2007 to emphasize that further delineation was necessary for defining “poor” visibility. This allows continuity with the scale used in previous years rather than change the scale to 1–6.

Daily Chinook and sockeye salmon count totals will be relayed the following day to the project leader via satellite phone and the data will be entered into a spreadsheet. Channel counts will be combined yielding hourly counts for the river and preliminary daily estimates of abundance for the river will be calculated by direct expansion, without interpolation. These daily counts will be made available to the public and posted to the department’s public internet site at http://www.adfg.alaska.gov/sf/FishCounts/. After each crew shift on Thursdays, the exiting crew will submit the completed count forms for the week to the project leader, who will review the count forms for completeness and accuracy. When necessary, corrections will be made to the electronic spreadsheet and the internet posting. A second spreadsheet file will include all hourly data from the daily count forms. This file will include three worksheets, one for each river channel and one for the entire river (channels combined). Each worksheet will be set up with column headings that include all the data recorded on the daily count form, and headings will be set up in a similar order as on the forms to facilitate data entry. Questionable entries (illegible, incomplete, or nonsensical entries) on field forms will be verified with technicians after each weekly crew shift. A fourth worksheet will be created that will tabulate daily counts, daily estimates of abundance (calculated by direct expansion, without interpolation), and cumulative daily estimates of abundance for the entire river (channels combined). This summary table will be distributed weekly to pertinent ADF&G staff. Similar procedures will be used to enter sockeye salmon data, although these data will be entered in a separate worksheet file.

Generally, inseason estimates of abundance will not include interpolations to adjust for periods when undercounting is suspected. However, circumstances may lead managers to request inseason abundance estimates with interpolated values (for example, for the purposes of a management action, a poor return combined with the potential for high harvest may require a more refined inseason estimate). The interpolation procedure, described in the Data Analysis section, uses the diurnal run-timing pattern in certain situations where some counts for a given day are missed. The current year's diurnal pattern may not be completely known at the time of an inseason request; therefore, the inseason estimates may differ from the final postseason estimates. Diurnal run-timing patterns from previous years will be used in the interpolations until sufficient data has been collected to establish a diurnal run-timing pattern for the current year.

Final electronic copies of the spreadsheets will be provided with the completed report when it is submitted for review. These data will be archived in the Sport Fish Division Docushare repository. During the final archival a file name and directory will be assigned, which will be included as an appendix in the final report.

SAMPLE SIZE

The proposed design, which is the same as followed in 2002–2013, calls for sampling 17% of the run. During the 2002–2013 seasons, water clarity has allowed for no less than 76% of the counts occurring under conditions of fair or better. The precision expectations of being within 15% of the true value 95% of the time were met or exceeded in all these years (Taras and Sarafin 2005; Perry-Plake et al. 2007; Perry-Plake and Antonovich 2009; Savereide 2010, 2011; Maclean 2013). Therefore, the same sampling schedule is planned for 2014, 2015, and 2016.

DATA ANALYSIS

CHINOOK SALMON ESCAPEMENT

Hourly count data will be combined across channels before calculating estimates in order to account for the covariance between channel-specific hourly counts. During each of the first 5 years of this project, the covariance between channel-specific hourly counts led to a relatively minor increase in the overall variance accounting for 2.8%, 2.3%, 0.8%, 4.6%, and 6.2% of the standard error, respectively. Because water clarity conditions vary by channel, interpolations for missing counts will be channel specific and will occur before combining data (described below). Daily passage and its variance will be estimated using one of three scenarios depending on counting conditions (Table 1):

1) when water clarity is excellent to poor (ranks 1-4) for all scheduled counts during a day, actual counts will be expanded to estimate daily passage (equations 1-3);

2) when a small portion (defined below) of a day's counts are conducted under very poor or unobservable water clarity (ranks 4.5-5), passage during the missed count(s) will be estimated using the diurnal migratory pattern, and a combination of expanded actual counts (equations 1-3) and interpolated counts (equations 1-4) will be expanded to estimate daily passage; and,

3) when most or all of a day's counts are conducted under very poor or unobservable water conditions passage for the entire day will be interpolated using a moving average estimate of daily passage estimates for successful counting day(s) prior to and after the missing day(s).

Salmon escapement will be estimated using equations (1) - (5), of which equations (1) and (3) - (5) were taken directly, or modified, from those provided in Cochran (1977). Equation (2) is taken from Wolter (1985). For days when all counts were conducted under *excellent* to *poor* conditions (scenario 1 above), daily passage, $\hat{N}_d$, was calculated by expanding counts within a shift for day d :

$$\hat{N}_d = \frac{M_d}{m_d} \sum_{j=1}^{m_d} y_{dj} \tag{1}$$

The period sampling is systematic, because the sample (or primary unit) has secondary units taken within every hour in a day (i.e., systematically throughout the day). As provided in Wolter (1985), the variance associated with periods will be calculated as:

$$s_d^2 = \frac{1}{2(m_d - 1)} \sum_{j=2}^{m_d} \left(y_{dj} - y_{d(j-1)}\right)^2 \tag{2}$$

The variance for the expanded daily passage will be estimated as:

$$\hat{V}\left(\hat{N}_d\right) = \left(1 - \frac{m_d}{M_d}\right) M_d^2 \frac{s_d^2}{m_d} \tag{3}$$

Where:

d = day;

j = paired 10-min counting period (a paired 10-min counting period consists of the two 10-min counts, one per channel, during a given hour);

y = observed period count (both channels combined);

m = number of paired 10-min counting periods sampled; and,

M = total number of possible paired 10-min counting periods.

Equations 1-3 will also be used for days having a mixture of reliable and suspect counts (scenario 2 above). When water clarity leads to undercounting (water quality ratings of 4.5 and 5) the number of fish observed, y_{dj},will be estimated for periods with suspect counts using known counts for that day and the diurnal pattern. In all years of this project a distinct diurnal migratory pattern has been observed that was consistent between both river channels and throughout the span of the run. At least 80% of the passage each “day” has occurred between 2300 and 1100 hours. For each year, a “period of peak passage” was defined as the shortest, continuous period of time within a “day” that accounted for 80% of the seasonal passage of Chinook salmon. To be reliable, expansions based on the diurnal pattern must have at least some counts that were successfully completed during the period of peak passage. The following criteria have been established to ensure reliability: if counts are conducted successfully for a portion of the day that represents 25% or more of the expected passage for that day (as defined by the diurnal relationship), and if at least 25% of the periods during peak passage are successfully counted, then the channel-specific interpolated count will be calculated as the product of the sum of successful counts for the day and the ratio of the proportion of the expected daily passage not represented, to the proportion of daily passage that was represented.

$$y_{dc,\text{interp}} = y_{dc,\text{actual}} \times \frac{1-p_{edp}}{p_{edp}} \tag{4}$$

where:

$y_{dc,\text{interp}}$ = interpolated sum of counts for missing (i.e. very poor or unobservable) 10-min periods by channel;

$y_{dc,\text{actual}}$ = daily sum of successful 10-min counts by channel; and,

p_{edp} = proportion of expected daily passage successfully counted.

Analyses of hourly-daily count data collected during the first year of the project (2002) indicated that interpolating for undercounts (scenario 2) using a diurnal run-timing pattern would yield more accurate estimates of passage than using a direct expansion of the successful counts within each 8-hour shift for that day, as described in the 2002 Operational Plan (Taras and Sarafin 2005).

The interpolated count will then be allocated among missed 10-min counting periods based on the diurnal pattern for the current year. For example, if four hours of counting were missed (four 10-min counts) and the interpolated count for that period was 10 Chinook salmon, those 10 fish would be allocated to each of the four missed 10-min periods in proportions defined by the diurnal pattern. Daily abundance and variances will be calculated with equations 1-3 using a combination of actual and interpolated counts. Because treating interpolated counts as "known" leads to underestimating daily variances, variance estimates will be inflated by decreasing m_d, the number of 10-min counting periods sampled each day, by the proportion of the expected daily passage successfully counted on that day. For example, if 85% of the expected run was successfully counted on a given day, then $m_{d,adj}$ = 0.85 x m_d =0.85 x 24. For the channel-combined counts the proportion successfully counted will be the channel-specific proportions weighted by the proportion of the overall run passing each channel. Although inflating the variance calculations guards against a negative bias, this approach could still lead to unacceptably large biases if days with diurnal interpolations contribute substantially to the overall variance. Therefore, variances will be estimated using this approach only as long as interpolations using the diurnal pattern account for a small proportion of the total variance, as has been the case in all previous years. If such interpolations become much more frequent (for example, account for 10% or more of the total variance, approximately a 5% effect on the standard error) an alternate, more refined, method of analysis would be considered (e.g., multiple imputation using interpolated values). In the unlikely event that a diurnal pattern is absent, a single-stage direct expansion will be used to interpolate.

If counts are conducted for a portion of the day that represents less than 25% of the expected passage for that day, or if less than 25% of the periods during peak passage are counted successfully (scenario 3 above), the procedure described below for missed days will be used to estimate passage for the entire day (i.e., the successful counts conducted that day will not be used for estimation). When counts for *k* consecutive days are suspected biased due to adverse viewing conditions (water clarity = 4.5 - 5), the moving average estimate for the missing day *i* will be calculated as:

$$\hat{N}_i = \frac{\sum_{j=i-k}^{i+k} I(day\, j \text{ was effectively sampled})\hat{N}_j}{\sum_{j=i-k}^{i+k} I(day\, j \text{ was effectively sampled})} \quad (5)$$

where:

$$\mathrm{I}(\cdot) = \begin{cases} 1 & \text{when the condition is true} \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

will be an indicator function. The interpolated values will be used as the point estimates for the daily counts, and the daily variation for undercounted days will be the maximum variance of the *k* days before and the *k* days after the undercounted day *i*.

Passage for the entire run past the tower site and its associated variance will be estimated incorporating all three daily passage estimation scenarios, as (Cochran 1977):

$$\hat{N}_{PT} = \sum_{d=1}^{D} \hat{N}_d \text{ ; and,} \quad (7)$$

$$\hat{V}\left(\hat{N}_{PT}\right) = \sum_{d=1}^{D} \hat{V}(\hat{N}_d) \quad (8)$$

where:

D = total number of possible days.

In 2004, the SWHS began estimating the harvest of Chinook salmon upstream of the West Fork (for the Paxson Lake to the West Fork reach), to more directly compare the harvest above the tower site with the counting tower abundance estimates. However, because it is thought that a relatively large, but unknown, portion of that harvest occurs downstream of the tower site (see Sampling Design subsection) subtracting the SWHS harvest estimate from the tower abundance estimate would lead to underestimating escapement. As a result, for 2004–2006 the harvest estimate was not used to adjust the estimate of abundance of Chinook passing the tower site but instead was used to: 1) identify years during that harvest above the tower site was insignificant relative to the uncertainty in the abundance estimate (e.g., less than the abundance estimate's estimated standard error); and, 2) identify years in which bias may have been significant and provide an upper bound for that potential bias. The further delineation of the Paxson Lake to West Fork reach into two sections will identify harvest upstream and downstream of the tower, and possibly more precisely determine the degree of bias (or lack of bias) in the abundance estimate (Jennings et al. 2008). Harvest levels and fishing patterns will continue to be monitored by the PI for background in applying harvest data to the public based on the new reporting areas for the Gulkana River. If harvest increases relative to the abundance estimate and/or the proportion of effort above the tower increases, the potential for bias will be reassessed. If there appeared to be confusion by the public as to which river section they were harvesting and/or to test the reliability of the new area reporting, follow-up mail surveys could be sent to respondents of the SWHS that harvested fish between the West Fork and Paxson Lake. A creel survey for the entire Gulkana River, or one focused on this particular issue, could be performed to refine our knowledge of harvest upstream of the tower site. However, these options would be resource intensive.

SOCKEYE SALMON ESCAPEMENT

For the duration of the Chinook salmon counting tower operation, sockeye salmon will also be counted during each hourly count period, for each channel. These numbers will be recorded on the daily count forms and tallied in the same manner as for the Chinook salmon. Data will be reduced and analyzed following the procedures outlined above for the Chinook salmon. Because the sockeye salmon run may already be in progress at the time the tower site is constructed, and continues longer in the season than the Chinook salmon run, the counts and resulting estimate will be understood to represent only a portion of the Gulkana River sockeye salmon run. Although these data are limited they will add to our understanding of the characteristics and run timing of this stock.

SCHEDULE AND DELIVERABLES

Research findings from 2014–2016 will be summarized in a State of Alaska Fishery Data Series Report. Important project dates to be completed annually, unless specified by year, are given below.

Date(s)	Activity
April 15–May 29	Complete staffing plan; organize and purchase supplies.
May 30–June 3	Haul all equipment and supplies to counting site, construct towers, and install contrast panels.
June 4–August 15	Conduct hourly counts each day.
August 31	All data edited and entered into spreadsheets and sent to biometrician.
October 15	Count data and diurnal pattern analyzed and interpolations complete and forwarded to Project Leader
November 15, 2016	First draft of report sent to project biometrician.
December 1, 2016	AKSSF Performance Report Submitted.
December 15, 2016	Edited report sent to Regional Research Supervisor.
March 30, 2017	Report sent for peer review.

RESPONSIBILITIES

List of Personnel and Duties:

<u>ADF&G</u>

Scott Maclean:	Fishery Biologist II;	Overall supervision of project. Coordinate schedules with project personnel. Supervise field operations; oversee staffing; compile, edit, and analyze data; write FDS report and AKSSF reports.
Jiaqi Huang:	Biometrician II;	Provide biometric support for study design during operational planning; assist with data analysis, and provide biometric review during report preparation.
Crew leaders:	Two FWT III;	Assist with tower installation; conduct and record hourly salmon counts as scheduled; record additional data as indicated on the daily count form; and assist with project logistics and camp maintenance. As crew leader, review daily count forms for completeness and accuracy; summarize daily salmon counts and communicate daily totals to Project Leader or Glennallen office; coordinate daily field camp tasks.
Crew members:	Two FWT II;	Assist with tower installation; conduct and record hourly salmon counts and associated data as scheduled on the daily count form; assist with project logistics and camp maintenance.
BLM crew:	Bio. Technicians;	Assist with tower installation; conduct and record hourly salmon counts and associated data as scheduled on the daily count form; assist with project logistics and camp maintenance.

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Appendix A

Appendix A1.–Example of the field form for daily counts of Chinook and sockeye salmon, Gulkana River, 2014–2016.

2014 Gulkana River Fish Counting Tower Form

Date (m/dd): ______________ Daily Totals: Chinook [ ] Sockeye [ ] Channel:__________________

(WEST - far side or EAST - cabin side)

Grave Shift C Observer:											
	Chinook			Sockeye			RbT/	Water	Water	
Time	Up +	Down -	Ttl +/-	Up +	Down -	Ttl +/-	Stld	Clarity	Level	Comments
0:00										
1:00										
2:00										
3:00										
4:00										
5:00										

Morning Shift A Observer:				Water Temp: °C					Air Temp: °F	
	Chinook			Sockeye			RbT/	Water	Water	
Time	Up +	Dwn -	Ttl +/-	Up +	Down -	Ttl +/-	Stld	Clarity	Level	Comments
6:00										
7:00										
	SubTtl (0:00 -7:00)			SubTtl (0:00 -7:00)						
8:00										
9:00										
10:00										
11:00										
12:00										
13:00										

Evening Shift B Observer:				Water Temp: °C					Air Temp: °F	
	Chinook			Sockeye			RbT/	Water	Water	
Time	Up +	Down -	Ttl +/-	Up +	Down -	Ttl +/-	Stld	Clarity	Level	Comments
14:00										
15:00										
	SubTtl (8:00-15:00)			SubTtl (8:00-15:00)						
16:00										
17:00										
18:00										
19:00										
20:00										
21:00										

Grave Shift C Observer:				Water Temp: °C					Air Temp: °F	
	Chinook			Sockeye			RbT/	Water	Water	
Time	Up +	Down -	Ttl +/-	Up +	Down -	Ttl +/-	Sthd	Clarity	Level	Comments
22:00										
23:00										
	SubTtl(16:00-23:00)			SubTtl(16:00-23:00)			CHECK YOUR MATH			
	DAILY TOTAL			DAILY TOTAL			↔ ENTER DAILY TOTALS AT THE TOP OF THE PAGE			

Water Clarity/Visibility Scale: 1=Excellent; 2=Good; 3=Fair; 4=Poor; 4.5= Very Poor; 5=Un-observable

Appendix B

Appendix B1.–Daily crew schedule and work assignments.

	WORK-SHIFT SCHEDULE							
	THUR	FRI	SAT	SUN	MON	TUES	WED	THUR
Worker A								
Count	2.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0
Maint./Public	1.5	2.0	2.0	2.0	2.0	1.0		
Gear Prep	2.0						1.0	1.0
Travel	2.5							2.5
Total	7.5	10.0	10.0	10.0	10.0	9.0	9.0	9.5
Worker B								
Count	8.0	8.0	8.0	8.0	8.0	8.0	8.0	
Maint./Public		0.5	0.5	1.0	2.0	2.0		1.5
Gear Prep	1.0						2.0	3.5
Travel	2.5							2.5
Total	11.5	8.5	8.5	9.0	10.0	10.0	10.0	7.5
Worker C								
Count	2.0	8	8	8	8	8	8	6.0
Maint./Public	1.0	2	1.0	2	2	0.5	0.5	
Gear Prep	2.0		1.0					2
Travel	2.5							2.5
Total	7.5	10	10	10	10	8.5	8.5	10.5

The pay week runs Monday–Sunday, 37.5 hours. A = Morning Shift, 0600 to 1400 hours; B = Afternoon Shift, 1400 to 2200 hours; C = Grave Shift, 2200 to 0600 hours