Regional Operational Plan SF.3X.2014.10

Chena River Chinook Salmon Smolt Abundance Feasibility Study

by

James W. Savereide

March 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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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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Signature/Title Page

Project Title:	Chena River Chinook Salmon Smolt Abundance Feasibility Study
Project leader(s):	James W. Savereide Fishery Biologist III
Division, Region and Area	Sport Fish, Region III, Fairbanks
Project Nomenclature:	
Period Covered	7 April–15 May 2014
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	James Savereide		
Biometrician	Jiaqi Huang		
Research Coordinator	Matt Evenson		
Regional Supervisor	Don Roach		3/5/15

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ABSTRACT

This project is designed to assess the feasibility of deriving estimates of annual Chinook salmon *Oncorhynchus tshawytscha* smolt abundance outmigrating from the Chena River. Chinook salmon stocks are declining throughout the State of Alaska and numerous projects, such as this, are addressing the established information gaps from 12 chosen indicator stocks. The escapement goal for the Chena River is based on a production model that relies on estimates of escapement and recruitment, but information about mortality could improve our understanding of the stocks population dynamics. To obtain this information Region III Sport Fish Division would like to establish a tagging study to estimate the annual outmigration of Chinook salmon smolt and their marine survival. However, a project of this magnitude is costly and determining whether or not enough fish can be captured to obtain reliable estimates is required.

Key words: Chinook salmon smolt, *Oncorhynchus tshawytscha,* Chena River, escapement, marine survival.

PURPOSE

The Yukon River is 1 of 12 indicator stocks chosen by the ADF&G in the *Chinook Salmon Stock Assessment and Research Plan* (ADFG Chinook Research Team 2013) as a stock for which additional information on stock productivity is desired, and the lack of estimates of juvenile abundance and survival for this stock has been identified as an information gap. Age-structured production models that are widely used to understand a stock's dynamics require information about processes like escapement, recruitment, and mortality. To better understand these processes, Region III Sport Fish Division would like to conduct a passive integrated transponder (PIT) tag study to estimate the annual abundance of Chinook salmon smolt emigrating from the Chena River and their subsequent marine survival. However, before a project of this magnitude is funded, it is prudent to assess the feasibility of capturing emigrating smolts from the Chena River to gain a better understanding of suitable capture sites, potential catch rates, and outmigration timing.

BACKGROUND

The Chena River, a tributary of the Tanana River, supports one of the largest spawning populations of Chinook salmon in the Yukon River drainage (Eiler et al. 2006). The Chena River stock is subject to subsistence and commercial fisheries while migrating up the Yukon and Tanana rivers, and a popular sport fishery while migrating to their spawning grounds. Since 1986, the average Chinook salmon escapement was 6,407; however, the last two years have been the lowest escapements on record with an average less than 2,000 (Savereide *In prep*.)

Migration and distribution patterns of juvenile salmon have been described only sporadically throughout the Yukon River drainage and in the Chena River, which supports both Chinook salmon and summer chum salmon *O. keta*. A majority of these studies on the Chena River have focused on the open water season beginning sometime after spring river break-up (Daigneault 1997; Peterson 1997; Lambert 1998; Perry 2012). However, a temporal knowledge gap exists regarding juvenile life histories before and during spring break-up, a time period when sampling is logistically difficult and dangerous, but is potentially a critical time for juvenile fishes, particularly salmon smolts. It is hypothesized, but unconfirmed, that salmon smolts in the Chena River begin their outmigration to the ocean either prior to or during spring break-up.

Spring break-up is a dramatic change in the aquatic environment and may serve as an important cue for fish migration, specifically salmon smolts. The Chena River offers a unique opportunity for such sampling as a power plant in downtown Fairbanks discharges warm water throughout the winter, leaving an approximately 5 km stretch of open water. We will sample for outmigrating Chinook and chum salmon smolts in this open water reach beginning in April before river break-up, using a variety of sampling gears including fyke nets, minnow traps, and small beach seines. These results will document when smolt outmigrate and if the initiation is associated with any environmental cues such as temperature or discharge. Additionally, by sampling throughout the majority of the outmigration, the magnitude of the outmigration can be deduced.

OBJECTIVES

The objectives for 2014 are to:

1. capture emigrating Chinook salmon smolt from early April to mid-May using minnow traps, fyke nets, and beach seines in the open water section on the Chena River; and,
2. evaluate catch per unit effort, total catches, and run timing of Chinook salmon smolt and determine what level of accuracy and precision could potentially be achieved for future abundance estimates and what level, timing, and location of sampling would be required.

METHODS

Study Area and Sampling Design

Chinook salmon smolt will be captured as they migrate out of the Chena River from early April through mid-May. Fish will be captured with baited minnow traps, fyke nets, and beach seines. The capture gears will be deployed in the open water area of the Chena River during the spring smolt outmigration (Figure 1). Between 1 and 4 fyke nets (depending on availability of suitable sites) will be placed near-shore in an area with a gently sloping gradient and moderate velocity, and be checked a minimum of two times a day. Minnow traps (50) will be placed in and around woody debris and will be checked and re-baited once per day. All Chinook salmon captured will be identified and measured to the nearest mm. The number of salmon captured by species and day will provide the information needed to estimate the timing of their emigrations. The expectation for capturing chum salmon is low because they are typically not vulnerable to baited minnow traps and depending on river flow their susceptibility to fyke nets and beach seines may also be low. Additionally, for each fyke net set, water velocity will be measured. This will allow capture data to be converted to catch-per-unit-effort (CPUE) by volume of water. Time series data for each gear type will be analyzed separately as each will have different capture efficiencies. The duration of time fished may be reduced as small pieces of submerged ice may clog the gear as break-up approaches. Attempts will be made to fish the fyke nets and minnow traps during break-up, which is typically around late April; however, conditions may not allow the traps to be in the water. If fishing is not feasible during break-up, all capture gear will be removed and immediately re-set when river conditions allow.

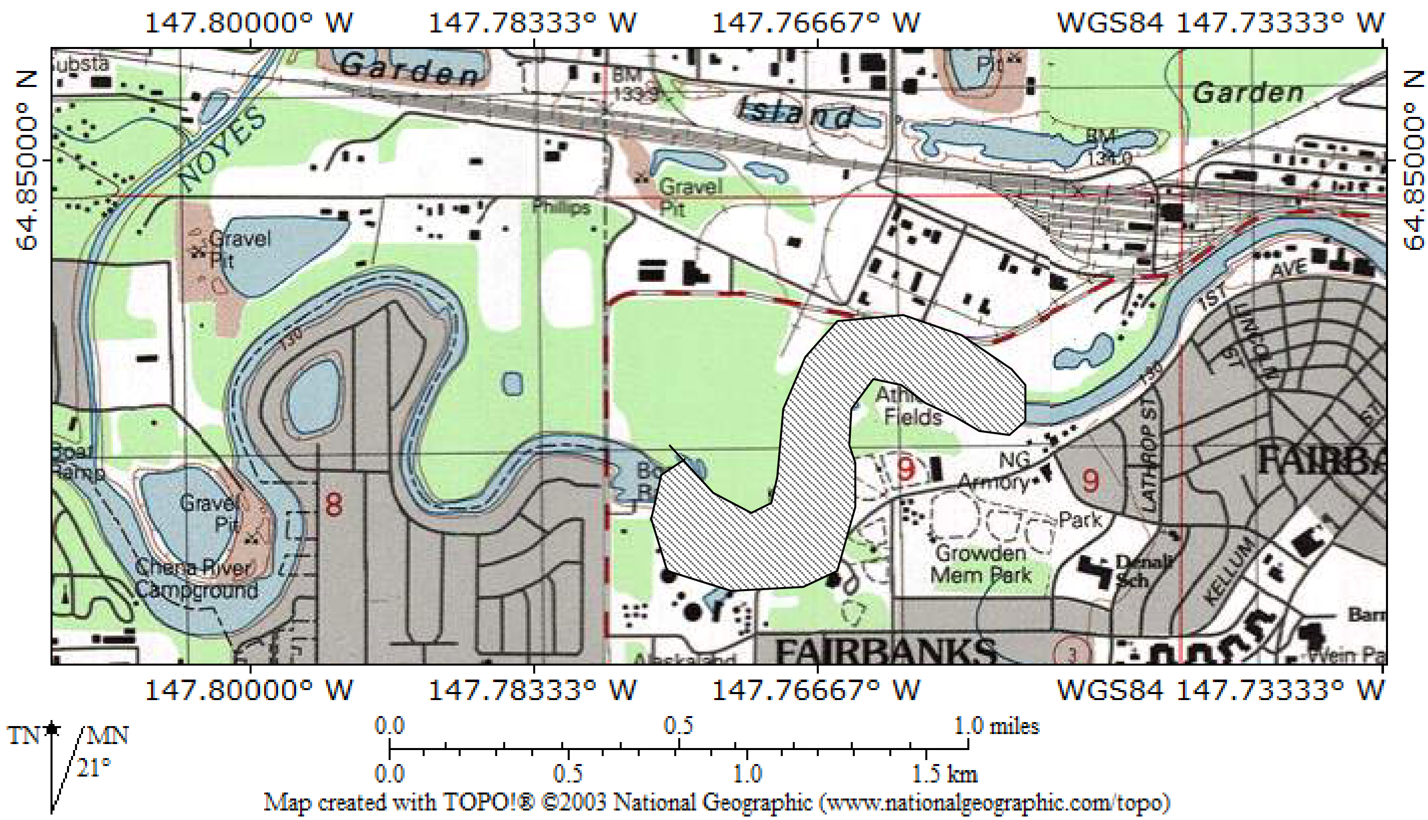

Figure 1.–Map of the Chena River in Fairbanks, AK. The eccentric shaded area is the proposed sample space.

Data Collection

The following data will be collected and recorded for each minnow trap, fyke net, and each beach seine set:

1. Trap or fyke net number (or seine set number);
2. Set date and time (and pull date and time for minnow traps);
3. GPS coordinates of each trap, site, or set;
4. Total catch of Chinook salmon; and,

Total catch of other species (listed individually). All captured Chinook salmon smolt will be measured (FL) to the nearest mm. If catch rates are so high that measuring all smolt becomes impractical then a subset of Chinook salmon smolt will be sampled for length composition. In addition, water temperature and level will be recorded each day.

Data Reduction

During the fieldwork, all data will be recorded into all-weather field notebooks or on data forms printed on all-weather paper. Following the fieldwork, data will be transcribed into an Excel workbook spreadsheet from which all data analysis will be referenced and performed. The electronic files will be submitted upon completion of the final report and placed into the Division's Intranet Docushare website – the file name and directory location will be presented in the final report. The spreadsheet will also be archived with the ADF&G Research and Technical Service (333 Raspberry Road, Anchorage, AK 99518) when completed.

Data Analysis

CPUE summary statistics will be calculated for each gear type for the following categories:

1. by entire sampling period;
2. by day to examine for temporal patterns; and,
3. by bank/channel (north/south) to examine spatial patterns.

CPUE will be estimated as a ratio (Cochran 1977) by the desired time period (e.g., hour, day, week, or entire period), gear type, and bank/channel as:

$$CPUE_{i,g,t,l} = \sum_{d=1}^{n_{g,t,l}} c_{i,g,t,l,d} \Bigg/ \sum_{d=1}^{n_{g,t,l}} s_{g,t,l,d} \tag{1}$$

with variance:

$$\hat{V}(CPUE_{i,g,t,l}) = \frac{n_{g,t,l} \sum_{d=1}^{n_{g,t,l}} \left(c_{i,g,t,l,d}^2 - 2CPUE_{i,g,t,l} c_{i,g,t,l,d} s_{g,t,l,d} + CPUE_{i,g,t,l}^2 s_{g,t,l,d}^2 \right)}{(n_{g,t,l} - 1) \left(\sum_{d=1}^{n_{g,t,l}} s_{g,t,l,d} \right)^2} \tag{2}$$

where:

$c_{i,g,t,l,d}$ = catch *i* using gear *g* during time period *t* at location *l* for observation *d* (d=1 to $n_{g,t,l}$);

$s_{g,t,l,d}$ = fishing time using gear *g* during time period *t* at location *l* for observation *d*; and,

$n_{g,t,l}$ = number of observations for gear g during time period t at location l .

CPUE statistics will be examined graphically and compared by inspection to evaluate logistical similarities and differences between gear and temporal periods. CPUE statistics for combinations of catch categories or temporal periods will be calculated using equations 1 and 2 and substituting the appropriate sample size for $n_{g,t,l}$. Comparisons of CPUE statistics between gear or time periods will be performed using a t-test with appropriate variance formulas for non-independent ratio estimates (Cochran 1977).

CPUE estimates over the 4-week sampling schedule will be expanded over a number of plausible run timing and effort scenarios to determine the level of accuracy and precision of any future smolt abundance estimates. The average escapement in the Chena River since 2009 has been less than 2,700 Chinook salmon. Assuming 40 smolts per spawner (Taku River estimate of smolts per spawner; McPherson et al. 2000), approximately 110,000 smolts would be expected to emigrate from the Chena River in 2014. Tagging 3,200 juvenile Chinook salmon during their emigration to sea and then examining a total of 1,500 adults from that particular brood year would lead to abundance estimates with relative precision of ± 25% at 90% confidence. The marked to unmarked ratio of the 1,500 adults examined will be determined using the PIT tag antenna array and direct sampling of carcasses over the course of the brood year return. If insufficient carcasses are available then the age composition estimates of the escapement will be applied to the total escapement to determine an estimate of the number of unmarked salmon by brood year. Given the counting tower has observed ~2,500 Chinook salmon over the past 5 years and sufficient catch rates of juvenile Chinook salmon in similar streams have been demonstrated, this precision level could be achieved (Pahlke et al. 2010, Weller and Evans 2012).

Run-timing will be described as a time-density function for the entire population, where the relative abundance that emigrates into the capture area during time interval t is described by (Mundy 1979):

$$f(t) = \frac{S_t}{\sum_t^{days} S_t} \tag{3}$$

where:

f(t) = the empirical temporal probability distribution over the total span of the emigration; and,

S_t = the subset of Chinook salmon smolt (*S*) that would be caught during day t.

The mean date of passage ($\bar{t}$) will be estimated as:

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

with variance:

$$Var(t) = \sum_t (t - \bar{t})^2 f(t). \tag{5}$$

Length composition estimates will be calculated as described in Cochran (1977). Stratification can be done post season to evaluate any temporal/spatial differences in composition; however, all strata will be pooled if sample sizes preclude stratification and/or there are no significant differences between stratum estimates. The proportion of smolt in each length category will be estimated by:

$$\hat{p}_{l,i} = \frac{n_{l,i}}{n_i} \tag{6}$$

where:

n_i is the sample size for each time/area stratum *i*;

$n_{l,i}$ is the subset of that sample composed of smolt in length category *l*; and,

$\hat{p}_{l,i}$ is the estimated proportion of the total catch in stratum *i* composed of fish length *l*.

The variance will be estimated using Cochran (1977) formula for the variance of a proportion:

$$V\hat{a}r\left(\hat{p}_{l,i}\right) = \left(\frac{\hat{p}_{l,i}\left[1 - \hat{p}_{l,i}\right]}{n_i - 1}\right). \tag{7}$$

SCHEDULE AND DELIVERABLES

Results from this project will be summarized annually in a Fishery Data Series Report for which a draft will be submitted to the Research Supervisor by 1 March each year. The FDS report will satisfy annual report requirements from the funding source (AKSSF). Annual performance reports will also be completed by December each year. Probable dates for sampling activities are summarized below.

Sampling = (S), Mobilization = (M), Demobilization = (D), Analysis = (A), FDS Report = (R)

Date	Chena Juvenile
April 6–12	M/S
April 6–May 15	S
May 16	D
November	A
March 2015	R

RESPONSIBILITIES

Project Staff and Primary Assignments

James Savereide, *Fisheries Biologist III*. Project Leader. Responsible for supervision of all aspects of the Chena River Chinook salmon smolt project, managing the project budget, and writing the final report.

Chad Bear, *Fish & Wildlife Technician III*. Crew leader. Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Allison Martin, *Fish & Wildlife Technician II*– Mobilization, day-to-day project tasks, all aspects of field work, demobilization.

Jiaqi Huang, *Biometrician III*. Assist with project design and data analysis.

Matt Evenson, *Fishery Biologist IV.* Final report editing and project support.

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