Regional Operational Plan SF.1J.2016.11

Production and Escapement of Chinook Salmon in the Taku River, 2016–2018

by

Jeffrey T. Williams

Sarah J. H. Power

and

Edgar L. Jones III

June 2016

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.1J.2016.10

PROCUCTION AND ESCAPEMENT OF CHINOOK SALMON IN THE TAKU RIVER, 2016-2018

by

Jeffrey T. Williams, Sarah J. H. Power and Edgar L. Jones III

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

Alaska Department of Fish and Game
Division of Sport Fish
P.O. Box 110024, Juneau, AK 99811-0024
June 2016

Jeffrey T. William, Sarah J. H. Power and Edgar L. Jones III,
Alaska Department of Fish and Game, Division of Sport Fish,
P.O. Box 110024, Juneau, AK 99811-0024

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SIGNATURE/TITLE PAGE

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Approval

Title	Name	Signature	Date
Project Leader	Jeffrey Williams		3-31-16
Project Leader	Edgar Jones III		3.31.16
Area Management Biologist	Dan Teske		3.31.16
Biometrician	Sarah Power		3.15.16
Research Coordinator	Jeff Nichols		4-7-16
Regional Supervisor	Brian Frenette		4.7.16

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Chinook salmon *Oncorhynchus tshawytscha* smolt abundance and adult escapement will be estimated from the Taku River, above Canyon Island, near Juneau, Alaska using coded wire tags implanted in smolt, adult harvest sampling, and an inriver adult mark-recapture experiment. A modified Petersen estimator will be used to estimate smolt abundance for the 2014-2016 brood years, which represent smolt leaving the system during 2016-2018. Chinook salmon smolt will be systematically sampled to estimate mean length and weight. Escapement of large (≥660 mm; mid eye to fork of tail) and medium (401–659 mm; similarly mid eye to fork of tail) Taku River adult Chinook salmon will be estimated using mark-recapture methodology in 2016-2018. Adult Chinook salmon will be captured and marked near Canyon Island in the lower Taku River using fish wheels, set and drift gillnets from late April through early August each year. Each fish will be tagged with uniquely-numbered, solid-core spaghetti tags, and two secondary marks. Sampling in the lower river lethal test fishery, Canadian commercial sockeye fishery, and on the spawning grounds will be used to estimate the fraction of the population that had been marked. In addition, the age, sex, and length composition of the spawning escapement of large and medium Chinook salmon will be estimated.

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* Taku River, adult production, smolt production, spawning abundance, mark-recapture, escapement, inriver run, fish wheels, set gillnets, drift gillnets, spaghetti tags, secondary marks.

PURPOSE

This operational plan details procedures necessary for the estimation of Chinook smolt abundance, and adult Chinook salmon harvest for the 2014-2016 brood years using information gathered from the coded wire tag (CWT) sampling programs. This plan also details methods used for the estimation of Chinook escapement in 2016-2018 using information gathered from the adult sampling program. Improved stock identification is a critical element in the strategy to improve stock assessment and management of Chinook salmon, as outlined in Attachment F to the 1996 U.S. Letter of Agreement (L.O.A), the 1999 Pacific Salmon Treaty (PST) agreement, and U.S. coastwide Chinook salmon stock assessment standards (USCTC 1997). Stock identification programs provide stock specific harvests, from which total adult production, exploitation rates, harvest distribution and survival parameters are estimated. These data are necessary for implementation and improvement in: 1) Alaska Department of Fish and Game (ADF&G) management, 2) terminal run management by the ADF&G and Department of Fisheries and Oceans Canada (DFO) and 3) coastwide management in the Pacific Salmon Commission (PSC) process. This project will aid both countries in following the management directive. Stock assessment parameters such as harvest, escapement, exploitation rate, smolt abundance, and brood year production will be directly estimated through implementation of the smolt tagging and adult escapement projects.

BACKGROUND

The Taku River (Figure 1) produces the largest run of Chinook salmon *Oncorhynchus tshawytscha* in British Columbia north of the Skeena River, and in Southeast Alaska (Hubartt and Kissner 1987; Pahlke 1997; Pahlke and Bernard 1996; McPherson et al. 1996–1998). The escapement of large Chinook salmon (≥ 660 mm mid eye to fork of tail (MEF)) originating from the Taku River has been estimated in all but 4 years since 1989 (Table 1). Small (≤400 mm MEF) and medium (401–659 mm MEF) Chinook salmon are not included in these estimates; over the past 10 years the terminal run consisted of an estimated 3% small and 23% medium Chinook salmon on average.

Figure 1.–The Taku River drainage of northwestern British Columbia and Southeast Alaska.

Table 1.—Estimated escapement and standard error (SE) of large (> 660 mm) Chinook salmon originating from the Taku River in Southeast Alaska, 1989-2015.

Year	Estimated escapement of large Chinook salmon	SE	References
1989	40,329	5,646	McPherson et al. (2000)
1990	52,143	9,326	McPherson et al. (2000)
1995	33,805	5,060	Pahlke and Bernard (1996)
1996	79,019	9,048	McPherson et al. (1996)
1997	114,938	17,888	McPherson et al. (1997)
1998	31,039	10,604	McPherson et al. (1998)
1999	16,786	3,171	McPherson et al. (1999)
2000	34,997	5,403	Jones III et al. (2010)
2001	46,544	6,766	Jones III et al. (2010)
2002	55,044	11,087	Jones III et al. (2010)
2003	36,435	6,705	Boyce et al. (2006); Jones et al. (2010)
2004	75,032	10,280	Jones III et al. (2010)
2005	38,725	4,908	Jones III et al. (2010)
2006	42,296	5,535	Jones III et al. (2010)
2007	14,854	3,277	Jones III et al. (2010)
2008	27,383	2,454	Jones III et al. (*in prep*)
2009	20,762	2,694	Jones III et al.(*in prep*)
2010	29,307	2,553	Jones III et al.(*in prep*)
2011	27,523	4,139	Jones III et al. (*in prep*)
2012	19,538	2,268	Jones III et al. (*in prep*)
2013	18,002	6,889	Jones III et al. (*in prep*)
2014	23,532	9,472	Williams et al. (*in prep*)
2015	28,827	4,080	Williams et al. (*in prep*)

Detailed stock assessment projects designed to directly estimate parameters such as harvest, escapement, exploitation rate, smolt abundance, survival rates, and brood year production have been in place since 1995 for Chinook salmon. This is a cooperative program between the ADF&G, DFO, and the Taku River Tlingit First Nation (TRTFN). Coded wire tags were placed in Chinook salmon smolt captured in the mainstem Taku River beginning in 1993 (McPherson et al. 2000) and estimates of escapement, age, sex, and length (ASL) composition parameters have been estimated annually since 1995 (McPherson et al. 1996).

In 2009, a Ricker spawner-recruit analysis was performed using the most recent 18 years of brood year production (McPherson et al. 2010). This investigation suggested the spawning abundance that would produce maximum sustained yield (N_{MSY}) was 25,075 large Chinook salmon with a 90% confidence interval of 18,470 to 36,530 (McPherson et al. 2010). As a result, a biological escapement goal range of 19,000 to 36,000 fish with a point goal of 25,500 large spawning Chinook salmon was adopted prior to the 2009 season for management purposes. This goal was formally adopted by ADF&G, the Chinook Technical Committee (CTC) of the PSC, and the Center for Science Advice - Pacific in 2010.

Management of this Chinook salmon stock is negotiated by the Transboundary Technical Committee (TTC) and CTC, both being subcommittees of the PSC and each consisting of members from the U.S. and Canada representing cooperating agencies. An international agreement, reached in June of 1999, called for development of an abundance-based management approach by 2005. Through a 2-year negotiation process, the U.S. and Canada came to bilateral agreement at a meeting in Portland, Oregon in February 2005 to implement directed commercial fisheries for 4 years (2005–2008). Annexes to the PST expired in 2008; thus, Annex provisions were renegotiated and accepted in January 2009 and will be in place until renegotiations in 2018.

Chinook salmon are marked using fish wheels at Canyon Island and two drift gillnet boats. One boat will tag fish immediately upstream of the Wright River and the other just downstream of the US/Canada international border (Figure 2). Chinook salmon are recaptured in Canada in the inriver test fishery (primarily lethal, although some fish are sampled and released) and the commercial and Aboriginal fisheries, as well as on the spawning grounds. The Canadian commercial fishery consists of both Chinook salmon catches that occur incidentally during the annual sockeye salmon fishery (approximately 1,500 large Chinook salmon) and those that occur during years of directed Chinook salmon fishing.

For abundance-based management, inseason estimates of escapement for 1999–2004, 2007, 2008, 2014–2015 were generated using a lethal test fishery. Inseason estimates for 2005, 2006, 2009 and 2011 were generated using the directed commercial fishery. Inseason estimates for 2010 and 2012 were generated using a combination of lethal test and directed commercial fisheries. No inseason estimates were generated in 2013 using a non-lethal test fishery because of insufficient recaptures. All recaptures took place in Canada just upriver of the international border

Postseason estimates of escapement for large Chinook salmon (1989, 1990, 1996, 1997, 1999–2010, 2014, and 2015) have been generated using mark-recapture methodology. Postseason estimates in 1995, 2011, and 2012 were generated by expanding the estimated medium-sized Chinook salmon escapement to a large-sized escapement based on the ratio of medium- to large-sized Chinook salmon observed across all spawning ground samples. This method was used because the numbers of large-sized fish recaptured on the spawning grounds were small (1995 = 8, 2011 = 9, 2012 = 6), yielding inadequate sample sizes for mark-recapture estimation. The 2013 estimate of large Chinook salmon was generated by expanding the peak aerial survey because insufficient recaptures of both medium (15) and large (13) fish were recovered on the spawning grounds.

In general, results from the past lethal test fisheries have produced coarse, but reliable, run strength estimates by statistical week 21 (approximately mid-May). Per negotiations, the allowable catch is germane to large Chinook salmon and is calculated by subtracting the midpoint of the escapement goal range (27,500 fish), the traditional base fisheries (i.e., U.S. = 3,500 fish, Canada = 1,500 fish), and harvest in the lethal test fishery (1,400 fish) from the preseason forecast. Any remaining fish are considered allowable catch to be allocated between the U.S. and Canada according to a detailed harvest sharing agreement (PSC 2014, p. 29, Chapter 1, Paragraph 3(b)(3)(xiii)). Once available, inseason mark-recapture information generated by this project supersedes the preseason forecast and the calculation is then based on the escapement point goal of 25,500 fish.

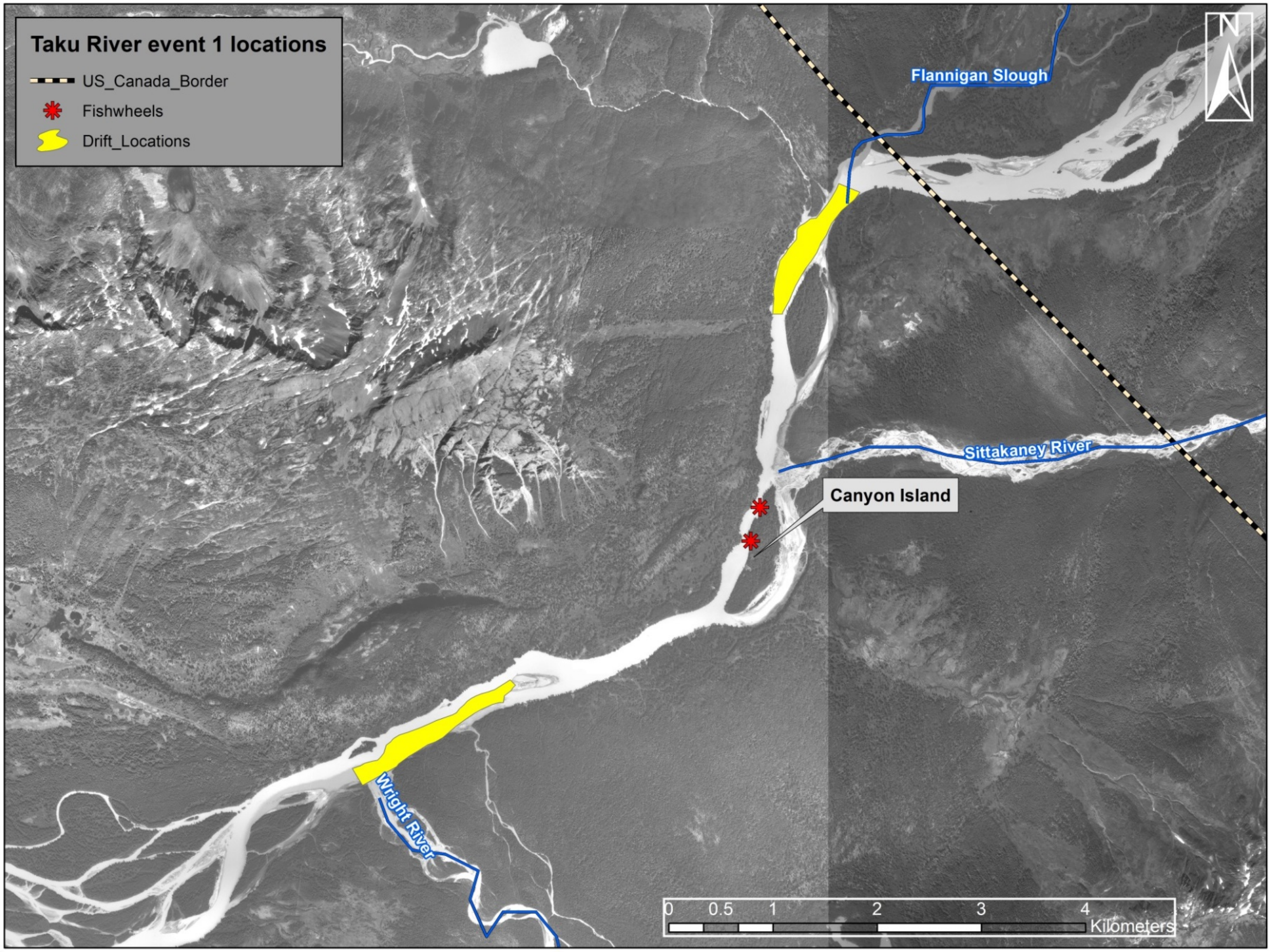

Figure 2.–Adult event 1 capture locations on the lower Taku River, Southeast Alaska.

The preseason forecast of the terminal run size of large Chinook salmon is based on a sibling model that predicts age class run size using brood year performance from prior years. In other words, the run of the age-1.2 fish representing brood year *X* is used to estimate the run of age-1.3 fish the following year, also representing brood year *X*. Accurate forecasts are necessary in order to plan and implement the directed Chinook salmon fisheries prior to having inseason estimates of run strength. The performance of both the preseason forecasts and inseason estimates from 2005 are shown in Table 2. These stock assessment tools are necessary to effectively implement and manage salmon fisheries targeting the stock of Chinook salmon from the Taku River.

Table 2.–Preseason forecasts, inseason, and final estimates of large Chinook salmon escapement for the Taku River and relative bias (RB) of forecast and inseason estimates compared to final estimate, 2005–2015.

Statistical		Final	Preseason forecast[b]		Inseason		
week	Date	estimate[a]	Point	RB[c]	Estimate	Projection	RB[c]
			YEAR 2005				
21	15 May - 21 May	65,334	99,610	52%	18,565	65,837	1%
22	22 May - 28 May	65,334	99,610	52%	30,175	68,935	6%
23	29 May - 4 June	65,334	99,610	52%	41,313	68,984	6%
24	5 June - 11 June	65,334	99,610	52%	48,414	64,196	2%
25	12 June - 18 June	65,334	99,610	52%	52,463	61,019	7%
			YEAR 2006				
21	21 May - 27 May	61,859	64,150	4%	25,071	67,759	10%
22	28 May - 3 June	61,859	64,150	4%	34,921	68,745	11%
23	4 June - 10 June	61,859	64,150	4%	41,711	69,474	12%
24	11 June - 17 June	61,859	64,150	4%	44,876	54,808	11%
25	18 June - 24 June	61,859	64,150	4%	44,694	55,604	10%
			YEAR 2007				
20	13 May - 19 May	18,650	38,720	108%	5,034	16,404	12%
21	20 May - 26 May	18,650	38,720	108%	7,638	16,428	12%
22	27 May - 2 June	18,650	38,720	108%	10,061	18,889	1%
23	3 June - 9 June	18,650	38,720	108%	12,367	18,400	1%
24	10 June - 16 June	18,650	38,720	108%	15,625	20,108	8%
			YEAR 2008				
20	11 May – 17 May	30,186	30,186	0%	4,047	22,613	25%
21	18 May - 24 May	30,186	30,186	0%	6,827	23,943	21%
22	25 May - 31 May	30,186	30,186	0%	13,255	23,760	21%
23	1 June - 7 June	30,186	30,186	0%	15,445	21,990	27%
24	8 June - 14 June	30,186	30,186	0%	21,467	26,585	12%

-continued-

Table 2.–Page 2 of 2.

Statistical week	Date	Final estimate[a]	Preseason forecast[b] Point	Preseason forecast[b] RB[c]	Inseason Estimate	Inseason Projection	Inseason RB[c]
			YEAR 2009				
20	10 May – 16 May	35,106	50,164	43%	7,840		100%
21	17 May - 23 May	35,106	50,164	43%	14,520	47,519	35%
22	24 May - 30 May	35,106	50,164	43%	23,876	50,043	43%
23	31 May - 6 June	35,106	50,164	43%	25,625	39,994	14%
24	7 June - 13 June	35,106	50,164	43%	27,760	37,361	6%
			YEAR 2010				
20	9 May – 15 May	35,784	41,328	15%	18,565	65,837	84%
21	16 May - 22 May	35,784	41,328	15%	30,175	68,935	93%
22	23 May - 29 May	35,784	41,328	15%	41,313	68,984	93%
23	30 May - 5 June	35,784	41,328	15%	48,414	64,196	79%
24	6 June - 12 June	35,784	41,328	15%	52,463	61,019	71%
			YEAR 2011				
20	8 May – 14 May	31,939	40,986	28%	25,071	67,759	112%
21	15 May - 21 May	31,939	40,986	28%	34,921	68,745	115%
22	22 May - 28 May	31,939	40,986	28%	41,711	69,474	118%
23	29 May - 4 June	31,939	40,986	28%	44,876	54,808	72%
24	5 June - 11 June	31,939	40,986	28%	44,694	55,604	74%
			YEAR 2012				
20	13 May - 19 May	23,872	48,036	101%	4,930	16,316	32%
21	20 May - 26 May	23,872	48,036	101%	5,919	13,273	44%
22	27 May - 2 June	23,872	48,036	101%	6,999	13,090	45%
23	3 June - 9 June	23,872	48,036	101%	8,231	12,655	47%
24	10 June - 16 June	23,872	48,036	101%	9,644	12,513	48%
			YEAR 2013				
20	12 May - 18 May	19,366	26,088	35%	–[d]	–[d]	–[d]
21	19 May - 25 May	19,366	26,088	35%	–[d]	–[d]	–[d]
22	26 May - 1 June	19,366	26,088	35%	–[d]	–[d]	–[d]
23	2 June - 8 June	19,366	26,088	35%	–[d]	–[d]	–[d]
24	9 June - 15 June	19,366	26,088	35%	–[d]	–[d]	–[d]
			YEAR 2014				
20	11 May - 17 May	27,227	26,781	2%	11,480	34,292	26%
21	18 May - 24 May	27,227	26,781	2%	30,339	25,034	8%
22	25 May - 31 May	27,227	26,781	2%	33,936	31,802	17%
23	1 June - 7 June	27,227	26,781	2%	12,182	19,600	28%
24	8 June - 14 June	27,227	26,781	2%	46,643	66,094	143%
			YEAR 2015				
24	7 June - 13 June	32,059	26,137	18%	15,900	22,712	29%
25	14 June - 20 June	32,059	26,137	18%	24,167	30,420	5%
26	21 June - 27 June	32,059	26,137	18%	23,624	27,053	16%
27	June 28 - July 4	32,059	26,137	18%	25,319	27,550	14%

[a] Final estimates are germane to terminal run size (i.e., escapement plus harvest in the terminal area).

[b] The preseason forecast of large Chinook salmon bound for the Taku River in 2016 is 29,233 (terminal run), which results in no directed Chinook salmon fishery in the U.S. and Canada.

[c] RB is the relative bias and is calculated by subtracting the estimate from the actual and then dividing it by the actual expressed as an absolute value.

[d] No inseason estimates were generated in 2013 because inadequate recaptures were seen in event 2.

The 2016 preseason forecast for the terminal run of large Chinook salmon bound for the Taku River is 32,635 fish. The recent 5-year average percentage error in the forecast versus actual terminal run is 12%. After accounting for this, the revised 2016 terminal run forecast of large Taku River Chinook salmon is 29,233 [(32,635-29,233)/29,233] = 12%). Terminal run forecasts for large Chinook salmon will be generated similarly for 2017 and 2018 returns as for 2016.

Adult marking efforts at Canyon Island using fish wheels and one drift gillnet boat below Canyon Island will be used as event 1 of the inseason mark-recapture study. The inriver fisheries (lethal test, Canadian commercial sockeye salmon and Aboriginal) along with the upstream drift gillnet boat will serve as event 2 of the inseason mark-recapture study. On years preseason forecast does not project a terminal run large enough to generate an allowable catch, the lethal test fishery will be implemented. In summary, if there is no directed commercial fishery, it is assumed that 1,400 large Chinook salmon will be sampled in the lethal test fishery and another 1,500 will be caught incidentally in the traditional sockeye fishery, totaling 2,900 fish.

Adult marking efforts at Canyon Island and on drift gillnet boats will be used as event 1 of the postseason mark-recapture study. Fish sampled in the lethal test fishery, Canadian commercial, Aboriginal fisheries, and on the spawning grounds will serve as event 2 of the postseason mark-recapture study. If the marked fractions differ among the event 2 locations, then the spawning grounds samples will be considered the best sample. Ideally, the samples gathered in the lower river will not be significantly different than those gathered on the spawning grounds and the samples will be combined. The spawning ground samples produce the least biased estimates of the marked fraction primarily because a multitude of gear types (rod and reel, carcass weir, live weir, spears, creel surveys, and dip nets) are used and the marked fish are thoroughly mixed with the unmarked population. Sampling on the spawning grounds will take place from late July through mid-September.

PRIMARY OBJECTIVES

1. Estimate the number of Chinook salmon smolt (≥50 mm FL) leaving the Taku River annually such that the relative precision of the calculated 95% CI is ≤ 25%.
2. Estimate the spawning escapement of large-sized Chinook salmon (≥660 mm MEF) in the Taku River annually such that the relative precision of the calculated 95% CI is ≤ 20.[1]
3. Estimate the spawning escapement of medium-sized Chinook salmon (401–659 mm MEF) in the Taku River annually such that the relative precision of the calculated 95% CI is ≤ 20%.
4. Estimate the age, sex, and length composition of the spawning escapement of medium and large Chinook salmon in the Taku River annually such that the absolute precision of the calculated 95% CI is ≤ 5 percentage points.

[1] This more than satisfies the PSC requirement of a 15% CV for spawning escapement of large Chinook salmon (≥660mm MEF)

SECONDARY OBJECTIVES

1. Estimate the weekly passage of large Chinook salmon by Canyon Island as an aid to inseason management of commercial fisheries in U.S. and Canadian waters using a 2 event mark-recapture study.
2. Estimate the marine harvest in sampled fisheries of adult Chinook salmon for the 2014-2016 brood years via recovery of CWTs applied each spring, such that the relative precision of the calculated 95% CI is ≤ 60%.
3. Estimate the mean length of Chinook salmon smolt (≥50 mm FL) captured near Canyon Island annually such that the precision of the 95% CI is within 2 mm of estimated mean.
4. Estimate the mean weight of Chinook salmon smolt to the nearest 0.1g annually such that the precision of the 95% CI is within 0.1g of the estimated mean.
5. Estimate the spawning escapement of small (≤400 mm MEF) Chinook salmon in the Taku River annually if mark-recapture data are adequate.

METHODS

STUDY DESIGN

SMOLT ABUNDANCE

All methods described below will be similar for each year of the study (2016-2018).

Separate mark-recapture experiments will be used to estimate the abundance of Chinook salmon smolt emigrating from Taku River above Canyon Island (Figure 1) and adult salmon escapement. Smolt will be tagged with CWTs and marked with adipose fin clips as part of Event I of a two-event closed population mark-recapture experiment. As part of Event II to estimate smolt, returning adult Chinook salmon will be inspected for a missing adipose fins as part of the adult escapement project described later in this document.

Smolt trapping operations will be based out of a camp located just upstream of Canyon Island to implement the marking event (Figure 3). Approximately 150–300 minnow traps baited with salmon roe will be fished daily in the mainstem of the Taku River near Canyon Island beginning as soon as the river is open to boat and plane traffic, with a tentative startup date of mid-April each season. Three trap lines will be set between approximately 10 km above and below the upper camp. Each trap line will be maintained by 2 personnel and will consist of 50–100 traps per trap line. Smolt from all trap lines will be transported back to camp for processing each day. Seine nets will also be used along gravel bars on the Taku River mainstem by 3-person crews to capture Chinook salmon smolt to supplement minnow trap catches. When outmigration of smolt commences in early May, seining effort will increase accordingly. All healthy **Chinook smolt ≥50 mm FL** captured each day will be tranquilized with a buffered tricaine methanesulfonate (MS-222) solution, injected with a CWT, and have their adipose fin excised. Each CWT is formed by cutting a 1.1 mm section of wire from a spool stamped with a numeric code unique to that spool. Each spool contains enough wire for approximately 5,000, 10,000 or 20,000 tags.

Figure 3.–Location of central portion of study area on Taku River, near Canyon Island, Southeast Alaska.

Adult Chinook salmon will be sampled each year (2016-2018) as they return to the Taku River. Each season adult Chinook salmon caught at Canyon Island in fish wheels, set gillnets, or drift gillnets as well as in inriver test and commercial gillnet fisheries, will be inspected for missing adipose fins (April to early August). Personnel from the ADF&G Division of Sport Fish (SF) and Division of Commercial Fisheries (CF), DFO, and TRTFN Fisheries will sample these adults and record the associated data. The marked fraction (fish missing adipose fins) of Chinook salmon captured in the fish wheels and gillnets will be used to estimate smolt abundance for each brood year. Given the life history of Chinook salmon, adults carrying CWTs from smolt marked in one season will return to the Taku River 1 (age-1.1 fish) to 5 (age-1.5 fish) year later, hence, will require sampling over a 5-year duration to obtain data from an entire brood year.

SAMPLE SIZES

Since 1993, on average, 2 million Chinook salmon smolt leave the Taku River each year and marine survival averages 3.5%. Thus, about 70,000 adults will return in subsequent years from an average smolt outmigration of 2 million. If we mark 26,000 smolt annually, based on marking 1.3% of an average annual smolt outmigration of 2 million fish, then about 900 (3.5%) marked smolt will survive to return as adults in subsequent years. To meet primary objective 1 precision criteria for each brood year, (precision within 25% of the true value 95% of the time) about 5,300 known-age adults will need to be sampled at the various inriver sampling locations to provide an expected 68 recaptures (Robson and Regier 1964). Because Chinook salmon return at various ages, returning Chinook salmon will be inspected for marks and scales will be collected for aging over a 5 year duration (age-1.1 to -1.5; European age notation) near Canyon Island, in the test and Canadian commercial fisheries, and on the spawning grounds of tributaries to the Taku River (Nahlin, Nakina, Kowatua, Tatsamenie, Tseta and Dudidontu rivers; Figure 1) for each brood year. In 2015, about 6,400 adult Chinook salmon were inspected: approximately 2,000 at Canyon Island in fish wheels and in gillnets, 2,700 in the inriver test and commercial fisheries, and about 1,700 on the spawning grounds. If about 6,000 returning Chinook salmon are inspected each year and about 95% of them are aged, then objective statements regarding Chinook salmon smolt estimates will be met or exceeded.

MODEL ASSUMPTIONS FOR ESTIMATION OF SMOLT ABUNDANCE

These two-event closed population mark-recapture experiments are designed so that a Petersen-type estimator may be used to estimate abundance. For the estimates of abundance to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures, are:

Assumption I: There Is No Recruitment to the Population Between Years and Removals are Random.

Considering the life histories of Chinook salmon, there should be no recruitment between sampling events. Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment or removal to the population while they are at sea (i.e., low incidence of straying). Incidents of natural mortality or harvest will occur in a random fashion. In other words, marked and unmarked individuals will have the same rates of mortality.

In regards to Chinook salmon, negligible numbers of fish have been observed spawning in U.S. sections of the drainage and it is believed that tagging near Canyon Island measures the vast majority of production from the Taku drainage.

Assumption II: There Is No Trap-Induced Behavior

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that clipping adipose fins and implanting CWTs does not affect the mortality of tagged salmon smolts.

Assumption III: Tagged Fish Will Not Lose Their Marks Between Sampling Events and All Marks Are Recognizable

The use of properly applied adipose fin clips will ensure that marks are not lost and that all marked fish are recognizable during second event sampling. Adipose fins will not regenerate like other fins if excised at the base. Naturally missing adipose fins on wild stocks of Chinook salmon are very rare (Magnus et al. 2006). All adipose fin clipped fish will be used for estimating smolt abundance regardless of the presence of valid CWT wire.

Assumption IV: One of the Following Three Sets of Conditions on Mortality and Sampling Will Be Met:

S1) All fish have an equal probability of being captured and marked during the first event; or

S2) Complete mixing of marked and unmarked fish occurs prior to the second event, hence all fish have the same probability of surviving between events across all tagging groups; or

S3) All fish have an equal probability of being captured and inspected for marks during the second event, hence all fish have the same probability of surviving between events across all tagging groups

Regarding S1 for the smolt to adult mark recapture:

Both minnow traps and beach seines are used to capture smolt. Minnow traps can be size-selective, however the majority of Chinook sampled are caught in beach seines which are not size-selective. Fish are tagged throughout the emigration.

Regarding S2 for the smolt to adult mark recapture:

Due to the extended time period between the marking and recovery events and behavior of salmon between these events, it is believed that complete mixing of marked and unmarked fish occurs prior to the adult recovery events in the lower river.

Regarding S3 for the smolt to adult mark recapture:

Adult Chinook salmon immigrations will be sampled almost continuously with fish wheels and gillnets and for Chinook salmon with surveys of spawning locations. These methods promote equal probabilities of capture through migrations and, at a minimum, ensure that no segments of the adult immigrations have zero probability of capture during the second event. However, all Chinook salmon will not have an equal probability of being inspected for marks during Event II sampling, as not every spawning location will be sampled.

In summary, for Chinook, we rely on the situation that all Chinook smolt have an equal probability of capture during event 1 (condition S1), or that complete mixing holds true (condition S2).

MEAN LENGTH OF CHINOOK SALMON SMOLT

A systematically drawn sample of 200 Chinook salmon smolt $\geq$50 mm FL will be collected each year of the study. This exceeds the required 78 ($([(1.96)(9)/(2)])^2 = 77.8$) needed to meet the criteria in secondary objective 3 (Thompson 2002, p. 36). This assumes a standard deviation of 9 mm as seen in past studies. Only Chinook salmon smolt $\geq$50 mm FL are considered for sampling as smaller fish are more difficult to handle and have a higher probability of being fingerling fish that will remain in the river for another year. Based on an expected catch of 26,000 Chinook smolt, every 130th Chinook salmon smolt should be measured for length and weight. However, to ensure meeting our sampling target in the event less than 26,000 fish are captured, and for ease of tracking, <u>we will measure every 100th Chinook salmon smolt captured</u>.

HARVEST OF CHINOOK SALMON

Chinook salmon from the Taku River are mostly (i.e., 95% to 100%) age-1. fish, spending 1 year as fry in fresh water and emigrating as smolt in the following spring (McPherson et al. 2000; Olsen 1992). Thus, tagged smolt are essentially from the same brood year (e.g., Chinook salmon smolt tagged in 2016 are from the 2014 brood year). Unlike coho salmon that return to spawn after 1 year at sea, Chinook salmon return as adults after 1 to 5 years at sea.

Recovery of CWT-tagged Chinook salmon in the various SEAK fisheries will be used to estimate the total marine harvest (exploitation) of Chinook salmon from the Taku River for each brood year. To meet the criteria in secondary objective 2 (95% RP = ±60%), 26,000 or more Chinook salmon smolt need to be CWT-tagged each year, according to procedures in Bernard et al. (1998). This judgment is based on historical inspection of 40% of marine commercial and sport harvests from April through June, an estimated 2 million smolt leaving Taku River each year, an ocean survival rate of 3.5% with a marine exploitation of about 15% for adults aged 2 to 4 ocean age. Note the marine harvests will be added to inriver harvests from Canada fisheries to estimate total harvest in a calendar year, and both will be apportioned by age to estimate total adult harvest and exploitation by brood year.

A simulated data set to anticipate U.S. marine harvest from future broods is shown in Appendix A1 and is based on the above-mentioned numeric and sampling assumptions and past recoveries of Taku River CWTs from the 2006-2008 broods. Simulations suggest that 14 random CWTs will be recovered in the various marine commercial and sport fisheries of SEAK for each brood year.

Based on methodology in Bernard et al. (1998), the probabilities of recovering at least 1 tag in each individual stratum varied from 0% to 81%. The product of the probabilities for all 18 strata listed in Appendix A1 indicates a 100% probability of not recovering a tag in every one of the strata. The probability of getting at least 1 CWT in each of the troll strata was 0%. The probability of finding at least 1 CWT in each of the sport, gillnet, and seine strata was 5%, 1%, and 47% respectively. Overall, for the strata producing 60% of the anticipated harvest, there is a 0.08 probability of recovering at least 1 CWT in all of these strata.

CHINOOK SALMON ESCAPEMENT AND AGE COMPOSITION

Simultaneous mark-recapture experiments will be used to estimate the spawning escapements of large- and medium-sized Chinook salmon in the Taku River annually, 2016-2018. Immigrating salmon caught using fish wheels and drift gillnets at or near Canyon Island will be tagged and marked as the first of two sampling events. Event 2 will use samples from the inriver lethal test fishery, the annual Canadian sockeye commercial, and Aboriginal fisheries (all located in the lower river above the U.S. Canada border), and from sampling on the spawning grounds at the Nakina, Nahlin, Tatsamenie, Kowatua, and Dudidontu rivers, and at Tseta Creek. Additionally, one drift gillnet boat will fish upstream of Canyon Island just below the U.S.-Canada border and operate as both a non-lethal test fishery for event 2 for in season abundance estimation (secondary objective 1), while continuing to tag all healthy untagged fish as a part of event 1 for the postseason abundance estimation (primary objectives 2 and 3).

Event 1 – Canyon Island Fish Wheels and Drift Gillnet

Personnel from ADF&G and TRTFN will capture Chinook salmon in two fish wheels operated at Canyon Island. At Canyon Island, a fish wheel will be set up on each riverbank and the set gillnet will be fished below the lower fish wheel. All event 1 capture locations with reference to Canyon Island and the international boundary are depicted in Figure 2. Fish wheels will operate continuously (22–24 hours each day) throughout the season, beginning approximately May 7 or as soon as water levels are high enough to turn the wheels. A few Chinook salmon may enter the river prior to project startup but the number is assumed to be negligible.

Water levels often fluctuate by more than 3 m during the season at Canyon Island. Generally, 95% of the upriver migration of returning Chinook salmon occurs by the first week of July on the Taku River. Fish wheels will be operated throughout the summer and into fall (autumn operations concentrate on capturing sockeye *O. nerka* and coho salmon *O. kisutch*, but Chinook salmon will be sampled whenever captured).

Each fish wheel consists of aluminum pontoons for floatation, a solid steel axle with connecting struts for up to 4 baskets, two aluminum basket frames covered with seine webbing, and aluminum live boxes. Design of the aluminum basket enables fish wheels to spin over a wide range of water levels or current velocities.

Personnel will capture Chinook salmon in two drift gillnet boats below the U.S.-Canada border. One boat will drift in the area just upstream of the Wright River. The other boat will drift just downstream of the U.S.-Canada border. If recaptured fish in this area are in poor condition as a result of multiple recaptures they may be censored from the overall abundance estimate. The drift net mesh will be 18.4 cm, a mesh size used for marking Chinook salmon in the Stikine, Unuk, and Chilkat rivers mark-recapture studies. This mesh size tends to catch primarily large Chinook ($\geq$ 660 mm MEF) and some small and medium sized Chinook (<660 mm MEF). The drift gillnet will be 36.6 m (approximately120 ft) long and 5.5 m (approximately 18 ft) deep.

The drift gillnet crews will fish 4 hours per day (time for each drift will be tallied to obtain 4 wet net hours). Two skiffs will be used during the drift gillnet tagging operation and a minimum of 2 people will operate each skiff. The crews will fish 7 days per week. For safety purposes each crew will have a VHF radio tuned to Channel 88, a frequency monitored by Canyon Island staff and local river residents. Crews will carefully record fishing and processing time. Fishing operations will commence in late April or early May each spring and terminate in late June or early July.

All gillnets will be monitored continuously. When capture of a Chinook salmon is indicated (tug of the net, bobbing cork line), fish will be carefully removed from the net, cutting the net if needed, and placed into a sling in a tote partially filled with water.

Every Chinook salmon captured (any size) in either fish wheels or gillnets will be first checked for a missing adipose fin, sampled for ASL and primary and secondary marks. Sex will be determined by visual inspection, and a scale sample will be taken. If the adipose fin is missing, the fish will be sacrificed, and its head sent to the ADF&G Mark, Age and Tag Laboratory (Tag Lab). Otherwise the captured fish will be released. Released fish in good condition will be marked with the primary spaghetti tag and the two secondary marks as detailed below. Since 1997, the primary mark has been a solid-core spaghetti tag (Johnson et al. 1992), which consists of a 6.4 cm (2 1/2 in) piece of standard blue tubing shrunk onto 38 cm (15 in) piece of 80 lb monofilament, all laminated with clear plastic. Lettering on the tag will read “U.S.-CANADA-PH 907-465-4270 COLLECT” and “SALMON TAG #K?????,” where ????? is a unique number between 10000 to 20000. These tags will be sewn just posterior to the dorsal fin.

The primary mark will be placed on all healthy Chinook salmon along with 2 secondary marks as follows:

> Canyon Island (fish wheels) - A left upper operculum punch (LUOP) and a clip of the left axillary appendage (LAA), located at the base of the left pelvic fin.
>
> Drift gillnet - A double left upper operculum punch (DLUOP), and a clip of the left axillary appendage (LAA), located at the base of the left pelvic fin

These two marks will ensure that tagged fish are recognized as such when encountered during the second sampling event (i.e., test fishery, commercial fishery, Aboriginal fishery, or spawning ground sampling).

Event 2 – Inriver Lethal and Non-lethal Test and Canadian Commercial Fishery

Catches in the inriver lethal and non-lethal test, Canadian commercial sockeye salmon, and Aboriginal fisheries upriver of Canyon Island will be used as a part of the inseason event 2. Fish that are recaptured in the non-lethal test fishery will have their tag number and condition noted. Unhealthy fish, tagged or untagged, will be censored from abundance estimates. Fish caught in the non-lethal test fishery will be included in event 2 for the inseason abundance estimate. They will be counted in event 1 for the postseason estimate. For lethal fisheries, large-, medium-, and small-sized Chinook salmon will be tallied separately on fish tickets (sales receipts). A reward of $5 Canadian will be given for each returned tag from the Canadian commercial fishery. Staff from DFO will sample the commercial catch weekly to independently estimate marked fractions and proportions by size. The inriver lethal test and Canadian commercial fisheries operate primarily within the first 10 km of river above the U.S.-Canada border. The commercial fishery will open to sockeye salmon on third Sunday of June and any incidental catches of Chinook salmon thereafter will be sampled accordingly. DFO staff stationed at Ericksen Slough will collect tags recovered in the fishery. Any tags recovered downriver of the border may be reported to the ADF&G staff stationed at Canyon Island or to the ADF&G, Division of Sport Fish phone number printed on the tag (Ed Jones, 465-4417 or Jeff Williams, 465-8251). A $2 U.S. reward will be given to anyone returning a tag recovered in the U.S.

The inriver lethal test fishery catch will have a sampling target of 100% for length, primary tags, secondary marks, missing adipose fins, and age. If the inseason abundance estimate permits a directed Chinook commercial fishery, at least 40% of the harvest will be sampled for length, primary tags, secondary marks, missing adipose fins, and age. Age samples will comprise 5 scales per fish; presence or absence of secondary marks will be noted; length measurements will be cleithral arch to fork (CAF) because the bulk of the harvest from the commercial fishery will be beheaded. When possible, MEF and post orbit-to-hypural plate (POH) measurements will also be taken in order to permit conversion of CAF to MEF and POH.

Event 2 – Spawning Grounds Sampling

Sampling will occur at several locations on the spawning grounds as part of the second sampling event (Figure 1). Sampling will concentrate on moribund fish as opposed to carcasses because marks have proven to be more easily recognized on living fish. Chinook salmon in the Nahlin and Dudidontu rivers, and Tseta Creek will be sampled by ADF&G; DFO will be responsible for sampling fish on the Kowatua River, Big Tatsamenie Lake, and Little Tatsamenie Creek; and TRTFN will operate a carcass weir on the Nakina River. The Nakina River has the majority of spawning fish, and in some years it can contain over half the total spawning abundance (Appendix B1). Experience has shown that using a combination of gear types during spawning ground sampling produces the least biased estimates (non-size selective) of abundance, age, sex, and size composition (McPherson et al. 1997). Additional sampling may be conducted depending on: 1) numbers of Chinook salmon marked, 2) number of Chinook salmon seen during helicopter surveys of escapement, and 3) changes in migratory timing from past years. This sampling strategy should cover the most abundant subpopulations within the drainage as well as early, middle, and late run components passing Canyon Island (see Alaska Department of Fisheries 1951 and Pahlke and Bernard 1996; John Eiler, fisheries biologist, Alaska Fisheries Science Center, personal communication).

As in catch sampling downriver, all fish sampled on the spawning grounds will be inspected for marks. Presence or absence of primary and secondary marks will be noted. All fish will be sampled for ASL data and for adipose fin clips to determine the marked rate of CWTs by brood year. All live sampled fish will be marked with a left lower operculum punch (LLOP) before release to identify them as having been previously sampled. All sampled carcasses will be marked by multiple slashes on the left side of the carcass.

Model Assumptions for Estimation of Abundance

For the estimate of abundance from this mark-recapture experiment to be unbiased, certain assumptions must be met (Seber 1982). These assumptions, expressed in the circumstances of this study, along with their respective design considerations and test procedures include:

Assumption I: The Population is Closed to Recruitment, Immigration and Emigration

Considering the life history of Chinook salmon, there should be no significant recruitment between sampling events. First event sampling (marking) will begin prior to any significant passage of fish past the tagging sites and will continue through the run until passage has dropped to near zero. The population of Chinook salmon passing by Canyon Island is closed to significant immigration or emigration because of the fidelity of salmon to their natal stream. Natural mortality may occur as long as deaths consititute a simple random sample of the marked and unmarked population.

Assumption II: Marking and Handling Will Not Affect the Catchability of Chinook Salmon in the Second Event

There is no explicit test for this assumption because the behavior of unhandled fish cannot be observed. There may be some handling-induced behavior that, with no adjustment, may bias estimated abundance. In response to being handled, marked Chinook salmon have a tendency to delay their upriver migration upon release, even temporarily heading downriver into marine waters before resuming their upriver migration (Bernard et al. 1999). In the past, a few fish released at Canyon Island have been caught in late June by the marine commercial sockeye salmon fishery (Pahlke and Bernard 1996; McPherson et al. 1997). Although these few instances have been mostly an annoyance, this phenomenon may be pronounced with implementation of directed Chinook salmon fishing in May and early June. The adjustment for this phenomenon is to censor any marked fish caught in marine fisheries. To that end, the Divisions of Commercial Fisheries and Sport Fish (DCF and DSF) will sample harvest in the commercial gillnet fishery in Taku Inlet and the sport fishery near Juneau to recover fish marked at Canyon Island. The primary purpose of these independent sampling programs is to recover CWTs. An expected 40% of the commercial catch will be inspected along with 20% of the sport catch. In 2005 the same protocol was in place; moreover, the sampling rates for each fishery were higher than planned. While looking for CWTs, any primary or secondary marks from the mark-recapture experiment will be noted. The number of fish recaptured in marine fisheries will be expanded according to the fraction of harvests inspected for marks and the result subtracted from the number marked (see Data Analysis section). There should be no trap-induced behavior because different sampling gears are used in different sampling events. However, we will attempt to meet this assumption by minimizing holding and handling time of all captured fish. Any obviously stressed or injured fish will not be tagged.

Assumption III: Tagged Fish Will Not Lose Their Marks Between Sampling Events and All Marks Are Recognizable and Detected

The use of multiple marks will ensure that marks are not lost and that all marked fish are recognizable during second event sampling. Fish may shed tags during transit but will be identified as marked fish by an opercular punch (LUOP) and a clipped axillary appendage (LAA). Past experience has shown a low rate of primary tag loss (spaghetti) and some fading of the opercular punch can occur. However, there has been no recorded instance on any recoveries of an LAA being unrecognizable as a mark. Marking fish with an operculum punch (LLOP) and slashing carcasses will prevent double sampling in the second event. There may be some failure to recognize marked fish caught in the Canadian commercial fishery. Rate of voluntary return of tags may not be 100%, and some fishermen might not recognize secondary marks if the primary mark (tag) is lost as the fish struggles in the net. Marked fractions from this fishery will be compared with those from spawning grounds and the lethal test fishery, as described below, and data from inriver fisheries may be included or censored depending upon test results.

Assumption IV: One of the Following Three Conditions Will Be Met

1. all Chinook salmon will have the same probability of being caught in the first event;
2. all Chinook salmon will have the same probability of being captured in the second event; or
3. marked fish will mix completely with unmarked fish between samples.

In this experiment, it is unlikely that marked and unmarked fish will mix completely for fish caught in the Canadian Fisheries since the tagging event and recapture event are so close together. Also, all Chinook salmon will not have an equal probability of being inspected for marks during event 2 sampling as not every spawning location will be sampled. Under these circumstances it is necessary that event 1 sampling be conducted to ensure that condition (1) will be satisfied. Fish wheels and set gillnets at Canyon Island will be operated continuously during the migration. This relatively constant production of sampling effort will tend to equalize the probabilities of capture for all fish passing by Canyon Island regardless of when they pass as has been the case in past years (Pahlke and Bernard 1996; McPherson et al. 1996, 1997). Experience has shown that the marked fraction does not differ significantly among tributaries under the sampling protocol used at Canyon Island even though populations using those tributaries had different migratory timing. Although probability of capture during event 1 may vary from day to day due to short-term changes in water conditions, attempting to maintain similar effort over the entire run will be necessary to ensure that the final spawning destination of different stocks of Chinook salmon within the Taku River system is independent of the probability of capture during event 1.

Equal probability of capture will be evaluated by time, area, size, and sex. The procedures to analyze sex and length data for statistical bias due to gear selectivity are described in Appendix B1. If different probabilities are indicated, abundance estimates will be stratified by category.

To further evaluate the three conditions of this assumption, contingency table (Chi squared) analyses recommended by Seber (1982) and described in Appendix E2 will be used to detect significant temporal or geographic violations of assumptions of equal probability of capture. Results from 2005 and 2006 showed that with implementation of the directed Chinook fisheries, a higher incidence of fishery removals of marked fish occurred that introduced bias to both the Canadian commercial data and the spawning grounds data. Further, the tendency for some Chinook salmon to delay upriver migration immediately after release may result in a higher probability of capture for marked versus unmarked fish in the inriver assessment and Canadian commercial fisheries that occur a short distance upriver from the tagging site at Canyon Island. Initial tests for violations of equal probability of capture throughout the first and second event will be based on second event data collected on the spawning grounds. After the initial tests are performed, secondary tests will include data from the inriver assessment and commercial fisheries (Appendix B2). If initial and secondary tests indicate no evidence of capture heterogeneity during the first sampling event, all second event data will be used to estimate abundance. If initial tests detect no evidence of capture heterogeneity during the first event, but the secondary tests detect significant differences in marked to unmarked ratios between the spawning grounds and one or both inriver fisheries, we may conclude sampling bias occurred during the inriver fisheries due to lack of detection of marks in the commercial fishery and/or differential probability of capture between marked and unmarked fish in one or both fisheries. Remedial measures for these sources of bias may include complete censoring of data from a biased source and, where applicable, reducing the effective number of marked fish in the experiment by subtracting marks removed during biased sampling, similar to what is described for marine sport and commercial fisheries.

SAMPLE SIZE

Annual sampling goals during 2016-2018 for large Chinook salmon are to mark **1,100** (= n_1 fish wheels + drift gillnets) and inspect **2,634** (= n_2 total) upriver. Terminal run estimates for large Chinook salmon have ranged from 19,000 to 32,000 from 2011 to 2015. To ensure adequate sample sizes, a terminal run of 35,000 large Chinook will be assumed for calculating sample sizes. Using a terminal run forecast of 35,000 fish and assuming the U.S. marine commercial and sport fisheries harvest their traditional catch of large Chinook salmon in the existing base fisheries (i.e., 3,500 in the combined Juneau sport and District 111-32 traditional commercial sockeye fishery), we can expect about 31,500 large Chinook salmon of the forecasted run of large Chinook salmon to pass Canyon Island. The average capture rate during event 1 tagging since drift gillnetting has commenced is 3.5% of large fish. Assuming this 1,100 large fish should be marked and released. Fourteen hundred (1,400) large Chinook will be sampled in the inriver lethal test fishery for primary tags and secondary marks using a 100% sampling rate. Assuming the Canadian commercial fishery harvest of 1,500 during the sockeye fishery, then 1200 large Chinook salmon will be sampled using a 80% sampling rate. Another 34 large Chinook salmon will need to be sampled on the spawning grounds such that the total event 2 sample size is 2,634. We sampled over 1000 in 2015, so we expect to sample more than the minimum needed for an estimate that is within 20% of the true value 95% of the time according to methods in Robson and Regier (1964).

Similarly, the goals for medium-sized Chinook salmon are to mark **540** (= n_1 Canyon Island + drift gillnet) and inspect **2,106** (= n_2 total) fish upriver. Terminal run estimates for medium Chinook salmon have ranged from 5,500 to 14,000 from 2011 to 2015. To ensure adequate sample sizes, a terminal run of 15,000 medium Chinook will be assumed for calculating sample sizes. Assuming a forecasted terminal run of medium Chinook salmon is 15,000 and based on past experience, about 10% or 1,500 medium Chinook salmon should be harvested in the marine fisheries. As a result, 13,500 medium Chinook should pass by Canyon Island annually. Also, we can expect that 4.0% of the medium fish will be caught as they pass Canyon Island; therefore, 540 medium fish should be caught and released from Canyon Island and the drift gillnet effort with tags. About 500 medium Chinook salmon will be sampled in the lethal test and traditional Canadian commercial sockeye fisheries. Another 1,606 medium Chinook will need to be sampled on the spawning grounds for a total of 2,106 to achieve the precision criteria according to methods in Robson and Regier (1964).

These projections of expected precision for estimates of spawning escapement of both large and medium Chinook salmon are based on the assumption that a simple Petersen-type model will be appropriate for estimating abundance. If some portions of the second event data, such as from the lethal test or Canadian commercial fishery must be censored to eliminate potential bias, the precision criteria stated in objectives 2 and 3 will not be met. Also, if the methods of Darroch (1961) must be used to estimate abundance due to temporal and/or geographic capture heterogeneity during both first and second sampling events, it is unlikely that the precision criteria will be met.

Samples taken for the mark-recapture experiment should be sufficient to meet primary objective 4 criteria for estimating relative age composition. Information on age composition obtained at Canyon Island and on the spawning grounds will be tabulated separately. History has shown that the pooled tributary sample (within medium and large size groups) produces unbiased estimates of age and length composition for the spawning population (McPherson et al. 1997). Based on procedures in Thompson (1987) for a 5-age-class population, 403 samples are needed to meet primary objective 4 criteria if all scales are readable. Because 20% of adult scale samples from Chinook salmon have in the past proven unreadable, **504** (403/0.80) fish need to be sampled to meet criteria for each age group of fish. More than this number of scales will be collected at each venue. These sample sizes will also meet sex composition requirements, as only 271 samples (assuming no data loss) are necessary to achieve the precision criteria for estimating sex composition (Thompson 2002).

DATA COLLECTION

Smolt Abundance

All healthy Chinook salmon smolt ≥50 mm FL captured near Canyon Island without marks will be tranquilized with a buffered MS-222 solution, tagged with a CWT (Table 1) following procedures described in Koerner (1977), given an adipose fin clip, and then released. Note that all tagged fish of both species will be held overnight to test for post-tagging mortality and a portion will be tested for tag retention. Any smolt captured possessing an adipose fin clip prior to tagging will be tested for the presence or absence of a CWT (i.e., passed through a magnetic tag detector) and recorded as positive or negative.

Codes used will be recorded on the **CODED WIRE VERIFICATION FORM** (C1) obtained from the CF Mark, Tag, and Age Laboratory (CF Tag Lab); a short section of each spool of coded wire will be taped to the form the first day of tagging with a new tag code. All tag and recapture data will be recorded daily on the form entitled **CWT DAILY TAGGING FORM** (Appendix C2). Environemental conditions will be recorded daily on the form entitled **DAILY ENVIRONMENTAL CONDITIONS FORM** (Appendix C3). A new **CWT DAILY TAGGING FORM** will be filled out for each day of operation. Daily procedures will be as follows:

1. Record location, date, and species.
2. Record water and air temperature (Min-Max) to nearest 1°C, water depth. Data should be collected at 0800 hours each day.
3. At 0800–0830 hours mix the fish in the holding net pen, then net and check 100 fish from each holding pen for tag retention and record this information on the **CWT DAILY TAGGING FORM**. If tag retention is 98/100 or greater, empty the net pen of all smolt making sure to count and record all mortalities. Next, transport the smolt to the release site and release all fish. If tag retention is less than 98/100, reprocess the entire batch of smolt in the net pen and retag any that test negative for CWTs. Examine any mortalities for proper tag placement and adjust the head mold if necessary. Check the position of the bevel on the needle and the sharpness of the needle. Reposition, sharpen, or replace the needle if necessary.
4. Check the minnow trap lines and transport all fish to camp for processing. Inspect each live fish and count the number possessing adipose fin clips; record the number of fish with adipose fin clips under "Recaptures" on the **CWT DAILY TAGGING FORM**. Test all recaptures for tag retention. Record results of tag retention on the **CWT DAILY TAGGING FORM**.
5. For all unmarked fish, apply a CWT and test for a positive reading using a tag detector. If rejected by the detector, retag. Keep an accurate tally of all retags on a hand counter. Write the beginning and ending machine numbers on the form and record retags, mistags, and practice tags. Show your calculations for the number of tags used for each tag code daily.
6. Measure and record FL to nearest whole millimeter and weight to nearest 0.1 g for every 100th Chinook salmon smolt captured.

ADF&G CWT ONLINE RELEASE maintained by the CF Tag Lab will be filled out after at the end of the tagging season. Information in this database will be used to estimate the number of smolt retaining CWTs. A 5 cm length of coded-wire will be attached to the **CODED WIRE VERIFICATION FORM** to verify the tag codes. If one roll of coded wire is depleted during a tagging session, a new **CWT DAILY TAGGING FORM** will be filled out, and a piece of wire from the new spool will be attached to the **CODED WIRE VERIFICATION FORM**.

Chinook salmon escapement and age composition

Canyon Island

Effort and catch during fish wheel operations will be recorded at Canyon Island on standard forms used by ADF&G. River height to nearest inch and temperature to nearest 1°C (both collected at about 0900 hrs each day), any shutdown time, and other comments will be recorded on the forms. Water level will be measured at a staff gauge permanently affixed to a rock face adjacent to Canyon Island.

Data collected from each Chinook salmon captured at Canyon will be recorded on the **CANYON ISLAND ASL FORM** (Appendix D1) and includes the date and time caught, fish number, sex, length in mm MEF, size class, solid-core spaghetti tag number, secondary marks applied (LUOP, DLUOP and LAA), and any pertinent comments (state of maturation [bright, dark red, etc.], condition, wounds, previously marked [spaghetti tag number and secondary marks], etc.). The first Chinook salmon capture in the fish wheels and tagged will be given a ”5001” for fish number and numbering will continue sequentially throughout the remainder of the season. This means each Chinook salmon caught and tagged will have a unique fish number. Every <u>healthy Chinook salmon of any size will be tagged and marked (UOP, LAA) prior to release.</u> Fish number is arbitrarily assigned to keep track of total numbers tagged and released and is not to be confused with the solid-core spaghetti tag number. Note: one series of forms will be kept for all set gillnet-caught Chinook salmon and a separate series for all fish wheel-caught Chinook salmon. Fishing effort data will be recorded daily for gillnet activities on a **GILLNET RECORDING FORM** (Appendix D2). Items to be recorded include: date, location, the initials of the crew members working, number of sets, hours and number of Chinook salmon caught; other comments such as catch of sockeye salmon, any problems encountered, etc. will also be recorded. At the fish wheels and gillnet sites, the presence or absence of the adipose fin will be determined first, after which the sex will be identified and a length measurement (MEF for all sizes of fish) will be collected for each fish carefully. **Scales will be taken from every fish**; **<u>5</u>** scales will be collected per fish. Scales will be taken from the left side of the fish from the preferred area (2–3 rows up from the lateral line and taken 25 mm (1 in) apart, one from 4–5 rows up 12 mm (1/2 in) from one of the lower three). Scales will be affixed anterior side up on gum cards and labeled completely. Scales will remain in camp until mid-July; the total scale sample will then be sent to Juneau in an envelope or box clearly labeled “Attn: Jeff Williams, ADF&G-Sport Fish, 465-8251” and the ADF&G office will be notified accordingly. Age-sex-length forms will be sent in <u>weekly</u> to Juneau in a separate envelope and also clearly labeled. A copy of all ASL forms will be made at camp using the Canyon Island copier before sending them in as a backup.

<u>Any fish caught at Canyon Island missing an adipose fin will be sacrificed</u>, sampled for ASL data, and decapitated. Pre-labeled totes and coolers will be provided for this activity. Scales from sacrificed fish will be put on a separate series of gum cards and returned to Jeff Williams at the end of the season. A cinch strap will be affixed to each removed head. The number on the cinch strap along with data on length and sex will be recorded on the **CANYON ISLAND ASL FORM**, or **DRIFT GILLNET ASL FORM** (Appendix D1, and D3). A **CODED WIRE TAG SAMPLING FORM** (Appendix D4) will be filled out each day that at least one Chinook or coho salmon is captured regardless of whether or not any captured fish is missing its adipose fin. All accumulated **CODED WIRE TAG SAMPLING FORMS** and all accumulated heads will be sent to Juneau <u>weekly</u>. Each shipment should be clearly labeled “Attn: Jeff Williams, ADF&G-Sport Fish, 465-8251”.

Drift Gillnet

Immigrating Chinook salmon caught in the drift gillnets will be inspected for secondary marks and the presence of the adipose fin. All healthy untagged fish will be tagged with a uniquely numbered spaghetti tag and given 2 secondary marks, a clip of the left axillary appendage (LAA) and a double left upper operculum punch (DLUOP). The first Chinook salmon captured in the first drift boat (named “D1”) and tagged will be given a “10001” for fish number and numbering will continue sequentially throughout the remainder of the season; for Chinook salmon caught in the second drift boat (named “D2”), the beginning number will start with ”15001”. This means each Chinook salmon caught and tagged will have a unique fish number. Every <u>healthy Chinook salmon of any size will be tagged and marked (UOP, LAA) prior to release</u>. These fish will then be included as part of the event 1 release group in the 2-event mark-recapture study. Those fish possessing spaghetti tags or secondary marks will have the spaghetti tag number recorded and will be released immediately. Fish possessing only secondary marks and missing the primary tag will be noted as such and retagged with a new spaghetti tag and released immediately. Any fish missing their adipose fin will be sacrificed for coded wire tag sampling purposes. All fish having not been previously tagged with a spaghetti tag or marked will also be sampled for age, sex, and length (MEF) information and recoded on the **DRIFT GILLNET ASL FORM** (Appendix D4).

Canadian Fisheries

The inriver test fishery will commence a short distance upriver from the U.S.-Canada border in early May each season, 2016-2018. On the third Sunday in June, the traditional Canadian commercial sockeye salmon fishery will begin; this will be sampled for incidental catches of Chinook salmon. A small (< 200 fish) Aboriginal fishery in the same location may also be sampled opportunistically. All Chinook salmon caught will be processed according to protocols established by DFO. Each fish will be measured, sexed by inspection of external characteristics (if not beheaded), and the presence or absence of a primary mark, secondary marks, and adipose fin will be noted. As well, 5 scales will be taken for age determination. Data from the commercial and lethal test fishery will be recorded on **COMMERCIAL FISHERY SAMPLE FORM** (Appendix D5). Data from the Aboriginal fisheries will be recorded on the **CANADIAN ABORIGINAL FISHERY SAMPLE FORM** (Appendix D6). The procedures regarding fish with missing adipose fins in fishery samples will match those followed at Canyon Island.

Spawning Grounds

All Chinook salmon (regardless of size) encountered on the spawning grounds will be sampled. Sampling will concentrate on moribund fish as opposed to carcasses because marks have proven to be more easily recognized on living fish. Note that the first time a Chinook salmon is examined on the spawning grounds a 6 mm (1/4 in) hole will be punched on the *lower* left operculum (LLOP). Each fish will be inspected to detect missing adipose fins, the primary mark (individually numbered tag), the three secondary marks, and a mark indicating that the fish had been previously inspected (i.e., LUOP, DLUOP or LLOP). <u>It is crucial that during the spawning grounds sampling, we obtain an accurate count of the total number of fish inspected by size and age category and of those, accurately detect any fish that were marked during event 1 without double sampling</u>.

The following steps will be used for sampling each fish encountered. If a marked fish has an LLOP or slashes, the next fish will be sampled; if a fish does not have an LLOP, then observers should look for any of the following: 1) LUOP; 2) solid-core spaghetti tag; 3) LAA; or 4) DLUOP. The presence of any of these four marks or tags indicates a valid recovery, via capture and marking at Canyon Island or in the drift gillnet. If a spaghetti tag is present, the number should be recorded; the presence/absence of either secondary mark will also be recorded. After these steps have been completed, the fish should be inspected again for the presence or absence of an adipose fin clip. All fish will be sampled for ASL information and each fish in turn will be given an LLOP and slashes before moving on to the next fish. If a fish is missing its adipose fin, it will be sampled for ASL information, decapitated, and the head will be retained and have a numbered cinch strap affixed to it; the cinch strap number will be recorded, the body will be slashed, and the fish will once more be checked for the presence or absence of primary and secondary marks from the lower river. If questions arise concerning whether or not an adipose fin is missing, the fish will be treated as if it was ad clipped (missing adipose fin), but a “2” will be recorded in the clip field. If a fish has no marks at all, it will be sampled for ASL information and given a LLOP mark. All data will be recorded on the **SPAWNING GROUNDS SAMPLE FORM** (Appendix D7). Note that it is imperative to look for the presence or absence of the LUOP, DLUOP, or LAA in the event that the spaghetti tag has fallen off.

On the **SPAWNING GROUNDS SAMPLE FORM** (Appendix D7), the date, fish number (1–10), sex, length (MEF), and number from a solid-core spaghetti tag number (if present) and the presence or absence of an adipose fin will be recorded for each fish that has not been previously sampled. Note that for length, 200 matched MEF and POH lengths will be collected at the Nakina River, elsewhere MEF will be the standard length for all fish; each fish should be measured carefully. The book number or gum card number will be recorded in the appropriate column. Most importantly, the presence or absence of the LUOP, DLUOP, and LAA needs to be documented. If confirming the presence or absence of these marks is not possible, record a question mark. If a fish has a scar behind the dorsal fin but no solid-core spaghetti tag, record “scar” in the comments column.

With one exception, all heads with cinch straps will be dissected off-site at either U.S. or Canadian facilities. Heads collected from the Dudidontu and Nahlin rivers, and Tseta Creek will be sent to Jeff Williams in Juneau, Alaska. Heads from all other sampling areas will be sent to Ian Boyce in Whitehorse, Yukon. All heads will be sealed in air-tight plastic bags and be accompanied with the appropriate forms. The exception occurs at Nakina River, where heads are dissected and code wire tags extracted onsite. The extracted tags, along with the appropriate forms, will be sent to Ian Boyce in Whitehorse.

Data Processing at Canyon Island

Alaska Department of Fish and Game field staff will relay Canyon Island and the drift gillnet catch (by size group), effort, tagging, and hydrological data to Jeff Williams and Jim Andel, ADF&G, Juneau, on a daily basis. Department of Fisheries and Oceans field staff will relay fishery catch (by size group), effort and tag recovery data to Ian Boyce and Bill Waugh, DFO, Whitehorse. Alaska Department of Fish and Game staff will record and error-check all tagging data from Canyon Island and the drift gillnet tagging site. Data forms will be kept up-to-date at all times and all data will be entered in the field. Data will be sent to ADF&G (Juneau office) at regular intervals and inspected for accuracy and compliance with sampling procedures. Data will be transferred from field books or forms to Excel™[2] spreadsheet files in the field using the computer system provided, and forwarded to ADF&G Juneau electronically. When input is complete, data lists will be obtained and checked against the original field data.

Department of Fisheries and Oceans staff will maintain up-to-date forms for inriver fishery data. All data will be entered into Excel™ and error-checked in the field. Except for fishery CWT material, all biological samples and associated paper data will be sent to Ian Boyce at regular intervals.

On or about the third week in May (approximately statistical week 21), when sufficient inseason mark-recapture data have been acquired, weekly estimates of the inriver run will be generated by ADF&G and DFO. These estimates will then be projected to determine total terminal run, and, after consensus by each country (on a weekly basis), recalculation of each country’s allowable catch will be made and managers will be updated accordingly.

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[2]This and subsequent product names are included for a complete description of the process and do not constitute product endorsement.

DATA ANALYSIS

Smolt Abundance

Chinook salmon smolt abundance will be estimated from brood years 2014-2016, almost all of which will emigrate from 2016 – 2018. For each brood year, event 2 will take place over a period of 5 years. Samples of Chinook salmon will build annually that describe marked fractions by brood year over the five age classes of return (e.g., in 2016, only age-1.1 fish, as determined from scale analysis, will be used to estimate smolt abundance in the previous year; in 2017, estimated smolt abundance will be further strengthened with the addition of age-1.2 fish, and so on). The ratio estimator described by Seber (1982, sec 3.4.1) will be used to estimate abundance of Chinook salmon smolt:

$$\hat{S}_{Ch} = \frac{M}{R_{\Sigma}/C_{\Sigma}} \tag{1}$$

where $\hat{S}_{Ch}$ is estimated abundance of Chinook salmon smolts in 2015 and M is the number of marked smolt released alive into the population in 2015. Also

$$R_{\Sigma} = \sum_{i=1}^{y} R_i \text{ and } C_{\Sigma} = \sum_{i=1}^{y} C_i \tag{2}$$

where C_i is the number of known-age adult Chinook salmon inspected for marks in return year i from the age class that smolted in 2015, R_i is the number of fish in C_i with missing adipose fins, and y indicates the number of return years accumulated to date (e.g., 1 indicates 2016, 2 indicates 2017, etc.).

An estimate of the variance for $\hat{S}_{Ch}$ will be obtained through bootstrapping (Efron and Tibshirani 1993) similar to methods in Buckland and Garthwaite (1991) but adjusted for the ratio estimator. The fate of the estimated $\hat{S}_{Ch}$ in the experiment will be divided into capture histories (Table 2) to form an empirical probability distribution (*epd*). A bootstrap sample of $\hat{S}_{Ch}$ will be drawn from the *epd* with replacement. From the resulting collection of resampled capture histories, M^*, R_i^*, and C_i^* will be calculated. Then, from the year y (for y >1) paired values R_i^*, and C_i^* a bootstrap sample of size y will be drawn, resulting in R_i^{**} and C_i^{**}. The values M^*, R_i^{**}, and C_i^{**} will be used to calculate a bootstrap value for $\hat{S}^*_{Ch,b}$. A large number (B) of bootstrap samples will be so drawn. The approximate variance will be calculated as:

$$\hat{\text{var}}(\hat{S}_{Ch}) = \frac{\sum_{b=1}^{B}(\hat{S}^*_{Ch,b} - \hat{\bar{S}}^*_{Ch})^2}{B-1} \tag{3}$$

where $\hat{\bar{S}}^*_{Ch}$ is the average of the $\hat{S}^*_{Ch,b}$.

Table 3.–Fates of $\hat{S}_{Ch}$ Chinook salmon in the mark-recapture experiment.

$M - R_{\Sigma}$	Marked	and never seen again (up to year *y*)
R_i	Marked	and recaptured during Event II in year *i (i=1 to y)*
$C_i - R_i$	Unmarked	and inspected during Event II in year *i (i=1 to y)*
$\hat{S}_{Ch} - M - C_{\Sigma} + R_{\Sigma}$	Unmarked	and never seen

Harvest

Methods described in Bernard and Clark (1996, their Table 2) will be used to estimate the marine harvest of Chinook salmon from the Taku River annually using a stratified catch sampling program of marine commercial and sport fisheries. Commercial catch data for the analysis will be summarized by ADF&G statistical week and district (for gillnet and seine fisheries), or by period and quadrant for troll fisheries (similar to Clark et al. 1985).

Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2011) will be apportioned using information from sampled marine sport fisheries to obtain estimates of total harvest by biweek and fishery. Sport fish CWT recovery data will be obtained from CF Tag Lab reports and summarized by biweek and fishery (e.g., biweek 16 during the Sitka Marine Creel Survey) to estimate contribution. In most cases, CWTs of interest may be recovered in only a few of the sport fish sampling strata that defined the fishery biweek. Assuming that the harvests of fish with CWTs of interest are independent of sampling strata within fishery biweeks, harvests and sampling information will be totaled over the fishery biweek to estimate contributions.

The estimates will be based on the:

1) The fraction of the cohort marked;
2) number of Chinook salmon harvested;
3) fraction of the harvest inspected for the presence of adipose fin clips;
4) number of Chinook salmon in the sample possessing adipose fin clips;
5) number of sacrificed fish whose heads reached the CF Tag Lab;
6) number of these heads that contained coded wire;
7) number of these valid, legible coded wire that were decodable; and
8) number of decodable tags of the appropriate code (i.e., originally released in the Taku River).

Adult Abundance

A two-sample mark-recapture model will be used to estimate the number of Chinook salmon passing by Canyon Island, annually 2016-2018. The appropriate abundance estimator will depend on the results of the aforementioned tests. If stratification by size is not needed and assuming no need for stratification by time-area, a modified form of Chapman's version of Petersen’s abundance estimator for closed populations (see Seber 1982) will be used:

$$\hat{N} = \frac{(\hat{n}_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \qquad (1)$$

where $\hat{N}$ = estimated number of large Chinook salmon, $\hat{n}_1$ = estimated number of large marked Chinook salmon moving upriver of Canyon Island, n_2 = number of large adults inspected for marks on spawning grounds or caught in the Canadian fisheries (commercial and Aboriginal) or lethal test fishery, and m_2 = number of marked large adults recaptured on spawning grounds or in the Canadian fisheries (commercial and Aboriginal) or lethal test fishery. Note that the same estimator will be used for medium-sized fish as well. Further description of analyses will implicitly represent calculations and tests for both large and medium-sized fish.

The number of marked, large-sized Chinook salmon moving upriver of Canyon Island will be estimated:

$$\hat{n}_1 = k - \frac{r_c}{\phi_c} - \frac{r_s}{\phi_s} \qquad (2)$$

where k = number marked at Canyon Island, r_c = number of marked fish recovered through catch sampling in the marine commercial fishery, ϕ_c = fraction in that fishery sampled, r_s number of marked fish recovered through catch sampling the marine sport (sport) fishery, and ϕ_s = fraction in that fishery sampled. If fish are voluntarily turned in from the public which are not a part of the commercial or sport fishery sampling program they will be removed one for one.

All diagnostic tests for equal probability of capture (Appendices E1 and E2) will be performed on the mark-recapture data:

a. The inseason event 1 sample will consist of all fish marked and released at Canyon Island and in the drift gillnet effort. The inseason event 2 samples will consist of fish inspected for marks in the upper drift boat, lethal and non-lethal test fisheries, and in the Canadian commercial and Aboriginal fisheries.

b. The postseason event 1 sample will consist of all fish marked and released at Canyon Island and in the drift gillnet effort. The postseason event 2 samples will consist of fish inspected for marks in the lethal test fishery, in the Canadian commercial and Aboriginal fisheries, or on the spawning grounds.

If temporal-geographic stratification is not required but stratification by size or sex is (see Appendix E1), estimates for each stratum will be generated using equations (1) and (2) and these estimates summed to estimate total abundance and variance.

An estimate of the variance for $\hat{N}$ for inseason purposes will be obtained through variance equation for a modified form of Chapman's version of Petersen’s abundance estimator for closed populations (see Seber 1982):

$$\widehat{var}(\hat{N}) = \frac{(\hat{n}_1+1)(n_2+1)(\hat{n}_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \quad (3)$$

An estimate of the variance for $\hat{N}$ for postseason purposes will be obtained through bootstrapping (Efron and Tibshirani 1993) according to methods in Buckland and Garthwaite (1991). The fate of the estimated $\hat{N}$ in the experiment will be divided into capture histories (Table 4) to form an empirical probability distribution (*epd*). A bootstrap sample of $\hat{N}$ will be drawn from the *epd* with replacement. From the resulting collection of resampled capture histories, k^*, r_c^*, r_s^*, $\hat{n}_1^*$, n_2^*, m_2^*, and $\hat{N}^*$ will be calculated. A large number (B) of bootstrap samples will be so drawn.

Table 4.–Fates of $\hat{N}$ Chinook salmon in the mark-recapture experiment for the Taku River, Southeast Alaska.

1	Marked	and never seen again
2	Marked	and recaptured on the spawning grounds
3	Marked	and voluntarily returned from an inriver commercial fishery
4	Marked	and recaptured in the inriver lethal test fishery
5	Marked	and recovered from the Aboriginal fishery
6	Marked	and recovered from sampling the marine commercial fishery
7	Marked	and recovered from sampling the marine sport fishery
8	Unmarked	and never seen
9	Unmarked	and caught in the inriver commercial fishery
10	Unmarked	and caught in the inriver lethal test fishery
11	Unmarked	and inspected on the spawning grounds
12	Unmarked	and caught in the aboriginal fishery

The approximate variance will be calculated as:

$$\text{var}(\hat{N}) = \frac{\sum_{b=1}^{B} (\hat{N}_b^* - \bar{\hat{N}}^*)^2}{B-1} \quad (4)$$

where $\bar{\hat{N}}^*$ is the average of the $\hat{N}_b^*$.

If geographic or temporal stratification is required, estimation of abundance will follow procedures described by Darroch (1961) using the computer program SPAS (Arnason et al. 1996). The contingency tables described in Appendix D2 will be further analyzed to identify: 1) event 1 strata (individual or contiguous groupings of temporal-geographic categories) where probability of recapture during event 2 is homogeneous within strata and different between strata; and 2) event 2 strata where marked: unmarked ratios are homogeneous within strata and different between strata. It will be necessary to vary from Darroch's suggested model by substituting estimates of (rather than known) numbers of marked fish released in each event 1 strata using methods similar to those described for equation (2) above. Temporal categories generally will consist of groupings of sample data collected by week and geographic categories and of groupings of sample data by location where data were collected. Stratification will also be guided by environmental conditions encountered during data collection (river stage, height and rainfall) and by previous experience gained when conducting mark-recapture experiments in this system. If the initial stratification does not result in an admissible maximum-likelihood (ML) estimate of abundance, further stratification may be necessary before an admissible estimate can be calculated. Non admissible estimates include failure of convergence of the ML algorithm in SPAS, or convergence to estimators with estimated negative capture probabilities, or estimated negative abundance within stratum. Goals in this case are always that observations within the pooled stratum should be as homogeneous as possible with respect to capture, migration, and recapture (Arnason et al. 1996).

A goodness of fit (GOF) test (provided in SPAS) that compares the observed and predicted statistics will indicate the adequacy of a stratified model. Once a stratification is identified that results in an admissible estimate of abundance, GOF will be evaluated. Further stratification, according to the guidelines described above, may be necessary to produce a model and abundance estimate with a satisfactory GOF. In general, the model selected will be that which provides an admissible estimate of abundance where no stratification guidelines are violated, no significant evidence of lack of fit is detected, and the smallest number of strata parameters are estimated for the model. This model will usually yield the smallest ML estimate of variance for the abundance estimate. If the Darroch (1961) procedure is used to estimate abundance and the number of event 1 and event 2 strata are not equal, the ML estimate of variance provided by the SPAS software will be used. This ML estimate of variance will be biased low because estimated, rather than known, numbers of marked fish will be used in each event 1 strata. If the number of event 1 and event 2 strata are equal for the selected model it may be possible to use bootstrap methodology to estimate variance and confidence intervals, in which case the variability in estimates of event 1 marks can be modeled and the variance estimate will be unbiased.

The estimated escapement is the difference between the estimated passage by Canyon Island and the inriver harvest above Canyon Island (tallies from the lethal test and Canadian commercial and Aboriginal fisheries in Canada). If it is assumed the inriver harvest is known without error, the estimated variance for spawning escapement will be the same as the variance estimated for the passage by Canyon Island (equation 4).

Inseason Estimates of Passage

Historic run timing information and data from Chinook salmon sampled at Canyon Island, in the drift gillnet effort, in the test fishery, and Canadian fisheries (commercial and Aboriginal) will be used to estimate the number of Chinook salmon on a weekly basis passing Canyon Island. Diagnostic tests, as described under "Adult Abundance", for equal probability of capture and model selection will be performed where appropriate and as data becomes available. Inseason estimates of abundance are expected to have more potential for bias than the final estimate because:

a. smaller sample sizes will result in less powerful diagnostic tests, potentially resulting in incorrect model selection;

b. lack of spawning ground samples will preclude evaluation of bias in the lethal test and commercial fisheries samples for event 2; and

c. adjustments of $\hat{n}_1$ (see equation 2) may be unavailable or only approximate, due to the lack of timely data from downriver fisheries sampling.

Abundance will be estimated separately by size category. Additional temporal stratification may be needed if the marked fraction varies significantly over time within a size category. This will require multiple Petersen or Darroch estimators such as those employed to estimate the inriver abundance of coho salmon in the Taku River annually (see Jones et al. 2006 for an example).

Age-Sex Composition

The fraction p_{ij} of spawning fish in age (or sex or length) group *j* in stratum *i* (large or medium, or small fish) will be estimated as:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{5}$$

where n_i = the number of large (or medium-sized or small) fish sampled on the spawning ground, and n_{ij} = the number from this sample that belong to age (or sex or length) group *j*; note that $\sum_j p_{ij} = 1$. Estimated variance for $\hat{p}_{ij}$ is:

$$\hat{\text{var}}(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1} \tag{6}$$

The estimated abundance of group *j* in the population ($\hat{N}_j$) is:

$$\hat{N}_j = \sum_i \hat{p}_{ij}\hat{N}_i \tag{7}$$

where $\hat{N}_i$ = the estimated abundance in stratum *i* of the mark-recapture experiment. From Goodman (1960), $\text{var}(\hat{N}_j)$ is:

$$\text{var}(\hat{N}_j) = \sum_i [\text{var}(\hat{p}_{ij})\hat{N}_i^2 + \text{var}(\hat{N}_i)\hat{p}_{ij}^2 - \text{var}(\hat{N}_i)\,\text{var}(\hat{p}_{ij})] \tag{8}$$

The estimated fraction of the population that belongs to group j ($\hat{p}_j$) is:

$$\hat{p}_j = \frac{\hat{N}_j}{\sum_i \hat{N}_i} \tag{9}$$

The variance of the estimated fraction can be approximated with the delta method (see Seber 1982):

$$\text{var}(\hat{p}_j) \cong \hat{N}^{-2} \sum_i [\hat{N}_i^2 \text{ var}(\hat{p}_{ij})] + \hat{N}^{-2} \sum_i [\text{var}(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2] \tag{10}$$

where $\hat{N} = \sum_i \hat{N}_i$. The diagnostic tests described in Appendix B1 will be used to identify any size and/or sex selectivity within large and medium Chinook stratum. If further stratification is required to eliminate bias due to size or sex selective sampling, equations 5–10 will be applied to calculate unbiased estimates.

Mean Length

Standard sample summary statistics will be used to calculate estimates of mean length at age and its variance (Thompson 2002).

SCHEDULES AND DELIVERABLES

OPERATIONS

Field activities for tagging Chinook salmon smolt near Canyon Island will begin inriver approximately mid-April and extend into early June each year, 2016-2018. Adult Chinook salmon tagging will begin late April and continue through July, noting that few Chinook salmon are present after early July. The lethal test fishery will begin in early May and end on the third Saturday in June each season. The traditional Canadian commercial sockeye fishery will commence on the third Sunday of June each season. Field activities on the spawning grounds will begin in late July and continue through mid-September (Appendix F1). Aerial surveys will be conducted from late July through early September each season.

REPORTS

A draft report will be written by the lead author and distributed to other authors for input by May 1 following each sample year. The final report will be submitted for final peer review by July 1 of each year. This report will be coauthored by the principal investigators from ADF&G and the project biometrician. The report will be published in the ADF&G, DSF Fishery Data Series as well as the PSC Technical report series. The final report and all associated data will be provided to ADF&G DSF Research and Technical Services (RTS), Anchorage, and DFO Whitehorse for archiving purposes.

Project results will also be summarized in the annual report of the Joint Transboundary Technical Committee, a committee established by the PST to oversee the management of transboundary salmon stocks.

DATA EXCHANGE (ADF&G AND DFO) AND ARCHIVING

1. Canyon Island ASL-tagging data and inriver fishery catches by size class combined with recoveries will be exchanged daily inseason.
2. Preliminary escapement ASL data will be exchanged by November 1 each year.
3. Aerial survey results will be provided inseason as they become available.
4. Adult aging results will be exchanged by November 15 each year.
5. Final error-checked ASL data, collated with scale and CWT reading results, will be exchanged by December 1 each year.

Scale cards and original data forms associated with tag application near Canyon Island and from the drift gillnet, and during spawning grounds sampling at the Nahlin and Dudidontu rivers and at Tseta Creek will be stored in the ADF&G scale archive in the Douglas Regional office. Scales gathered from the commercial fishery and during escapement sampling on the Kowatua, Nakina, and Tatsamenie rivers will be archived at the Pacific Biological Station in Nanaimo. Original data forms will be stored at the DFO office in Whitehorse.

Completed **CODED WIRE TAG SAMPLING FORMs** (Appendix C2) will be submitted to the ADF&G Mark, Tag and Age Laboratory. All U.S. and some Canadian CWT data (sampled fish, decoded tags, location, data type, samplers, etc.) are archived and accessible on a permanent database maintained by ADF&G and are provided annually to the coastwide database at the Pacific States Marine Fisheries Commission. An electronic copy of the ASL, along with the adult mark and recovery data, will be permanently archived on the Integrated Fisheries Database maintained by DCF in the Douglas Regional office.

RESPONSIBILITIES

Jeff Williams, FB II, Project Leader (ADF&G- DSF smolt and adult escapement). Works with Ed Jones (ADF&G) on field operations, data analysis, and report writing. Supervises smolt and adult Chinook salmon projects; edits, analyzes, and reports data; assists with field work; maintains near-daily email or telephone contact with field camps; arranges logistics with field crew and expeditor. Writes smolt and adult Chinook salmon sampling section of operational plan, assures that it is followed or modified appropriately with consultation with Jones and Power. Is coauthor on final report with Jones and Power.

Ed Jones, Fish and Game Coordinator, Project Leader (ADF&G- DSF smolt and adult escapement). Works with Jeff Williams to set up all major aspects of adult Chinook salmon project, including planning, budget, sample design, permits, equipment, personnel, and training. Reviews operational plan. Is coauthor on final report with Williams and Power.

Sarah Power, Biometrician. Provides input to, edits, analyses, and approves sampling design. Coauthors operational plans and provides biometric details, including any changes or statistical techniques needed to provide precise and unbiased estimates for this project. Writes programming code, and computes data analysis as necessary, and coauthors final report.

Nathan Frost, FWT III. This position serves as crew leader of the smolt camp tagging operations for juvenile Chinook and coho salmon, and collection and recording of all associated biological and catch-effort data with consultation from Williams. Ensures that the operational plan is followed to the extent possible, and implements inseason changes as authorized. Determines work schedules and assigns tasks to smolt crew members with Williams. Performs tagging and sampling summaries, and error-checks CWT tagging data daily. Monitors crew performance and corrects or trains the crew as needed. Performs maintenance on all sampling and camp equipment. Ensures pertinent portions of State SOP, such as safety and time reporting, are followed. Maintains near-daily contact with Williams for safety, data, and logistical needs.

Lee Close, FWT III. Will be in charge of running one of the trap lines and adjusting trap placements accordingly to maximize catches. Is responsible for daily operation and cleaning of the Mark IV coded wire tagging machines associated with smolt tag and release operations. Will measure Chinook smolt and record lengths and weights in a Rite-in-the-Rain® book. Works closely with crew leader to follow protocol and quality control while maximizing smolt tagging operational efficiency. Will assist in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection, data recording, and general field camp duties including keeping camp and field equipment neat and orderly. Responsible for fish handling to prevent mortalities or injuries.

Tory Rhoads, FWT II. This position is responsible for assisting in all aspects of smolt field operations, including safe operation of riverboats and all other equipment, tagging, data collection and general field camp duties including keeping camp and field equipment neat and orderly. Will be clipper or tagger in tagging shed as needed.

Evan Fritz, FWT II. This position is responsible for assisting in all aspects of smolt field operations, including safe operation of riverboats and all other equipment, tagging, data collection and general field camp duties including keeping camp and field equipment neat and orderly. Will be clipper or tagger in tagging shed as needed.

Mike Lafollette, FBI. This position serves as crew leader on the Canyon Island fish wheel and set gillnet tagging operations for adult Chinook salmon, and collection and recording of all associated biological and catch-effort data, including CWT recovery. Ensures that the operational plan is followed to the extent possible, and implements inseason changes as authorized. Determines work schedules and assigns tasks to fish wheel crew members. Tags fish, collects samples, and records data according to operational plan. Monitors crew performance and corrects or trains the crew as needed. Ensures pertinent portions of state SOP, such as safety and time reporting, are followed. Maintains near-daily contact with Williams for safety, data, and logistical needs.

Michael Enders, FWT III. This position is responsible for being second in charge of fish wheel and drift gillnet operations for tagging and sampling adult salmon, and assists in all aspects of the project. Will be under direct supervision of the Canyon Island crew leader. Will consult with Williams regarding the efficiency of work and will provide input on changes necessary to improve operations.

Zane Chapman, FWT II. This position is responsible for working on the fish wheels and drift gillnetting for tagging and sampling adult salmon, and assists in all aspects of the project. Will be under direct supervision of the Canyon Island crew leader. Will consult with Williams regarding the efficiency of work and will provide input on changes necessary to improve operations.

Dave Dreyer, FWT IV. This position is in charge and responsible for running a drift gillnet efforts for tagging adult Chinook salmon and will assist in all aspects of this project including fish wheel work when available. Will consult with Williams regarding the efficiency of work and will provide input on changes necessary to improve operations. This position is responsible for assisting with adult Chinook salmon spawning grounds sampling.

BUDGET

This project is operated using budgets governed by ADF&G-DSF, ADF&G-DCF, and the DFO. Details regarding the DSF budget can be found in the FY16-19 synopses for project S-1-3. Information on the DFO budget can be found in PST and Aboriginal Fisheries Strategy files.

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APPENDIX A

Appendix A 1.–Statistics used to link the number of Chinook salmon smolt to tag each year with the ultimate relative precision of the estimated harvest from adults returning to the Taku River from the 2014 - 2016 brood years.

ϕ = 0.40 (average all fisheries); θ = 0.013 (x 2,000,000 smolt corresponds to 26,000 smolt tagged); $G(\theta^{-1})$= 0.090

Stratum	Age	Stat Week	Period/Bi-week	$\hat{N}_i$	$V[\hat{N}_i]$	n_i	m_i	λ_i	$\hat{r}_{ij}$	ϕ_i	$G(p_j)$	$SE(r_j)$
Troll SE	1.4		2	623		505	0.33	1.000	53	81%	2.981	88
Troll NW	1.3		1	22,400		6,841	1.67	0.993	702	31%	0.599	559
Troll NW	1.3		2	2,498		868	1.00	0.987	372	35%	0.997	372
Troll NW	1.3		4	26,734		7,973	0.33	0.981	145	30%	2.993	244
Troll NW	1.4		1	12,875		4,060	1.00	0.990	409	32%	0.998	408
Troll NE	1.2		6	737		187	0.33	1.000	168	25%	2.994	282
Troll NE	1.3		2	2,972		2,526	1.67	0.993	252	85%	0.596	201
Troll NE	1.3		3	2,973		2,186	1.00	0.994	175	74%	0.994	174
Troll NE	1.4		2	1,033		926	1.00	0.991	144	90%	0.993	143
Sport - Juneau	1.2		12	15	66	4	0.33	1.000	174	24%	2.994	263
Sport - Juneau	1.3		11	230	1521	98	1.00	1.000	299	43%	0.997	299
Sport - Juneau	1.4		10	40	66	18	0.33	1.000	94	45%	2.989	94
Seine	1.1		1	344		344	1.33	0.984	173	100%	0.744	152
Seine	1.1		2	238		238	1.00	1.000	128	100%	0.992	127
Drift GN - 115	1.2	31		111		76	0.33	1.000	62	69%	2.984	103
Drift GN - 111	1.2	26		217		97	0.67	1.000	191	44%	1.495	230
Drift GN - 111	1.3	20		40		25	0.33	1.000	69	62%	2.985	115
Drift GN - 111	1.3	27		242		104	0.33	1.000	99	43%	2.990	165
RP[$\hat{r}_j$] =57.%				74,322		27,076	14		3,708	36%		1,087

APPENDIX B

Appendix B 1.–Peak aerial counts of Chinook salmon in the Taku River, 1973 to 2015.

Year[a]	Nakina River	Nahlin River	Kowatua River	Tatsamenie Lake	Dudidontu River	Tseta Creek	Five tributary total
1973	2,000	300	100	200	200	4	2,800
1974	1,800	900	235	120	24	4	3,079
1975	1,800	274	ND	ND	15	ND	2,089
1976	3,000	725	341	620	40	ND	4,726
1977	3,850	650	580	573	18	ND	5,671
1978	1,620	624	490	550	ND	21	3,284
1979	2,110	857	430	750	9	ND	4,156
1980	4,500	1,531	450	905	158	ND	7,544
1981	5,110	2,945	560	839	74	258	9,528
1982	2,533	1,246	289	387	130	228	4,585
1983	968	391	171	236	117	179	1,883
1984	1,887	951	279	616	ND	176	3,733
1985	2,647	2,236	699	848	475	303	6,905
1986	3,868	1,612	548	886	413	193	7,327
1987	2,906	1,122	570	678	287	180	5,563
1988	4,500	1,535	1,010	1,272	243	66	8,560
1989	5,141	1,812	601	1,228	204	494	8,986
1990	7,917	1,658	614	1,068	820	172	12,077
1991	5,610	1,781	570	1,164	804	224	9,929
1992	5,750	1,821	782	1,624	768	313	10,745
1993	6,490	2,128	1,584	1,491	1,020	491	12,713
1994	4,792	2,418	410	1,106	573	614	9,299
1995[b]	3,943	2,069	550	678	731	786	7,971
1996	7,720	5,415	1,620	2,011	1,810	1,201	18,576
1997	6,095	3,655	1,360	1,148	943	648	13,201
1998	2,720	1,294	473	675	807	360	5,969
1999	1,900	532	561	431	527	221	3,951
2000	2,907	728	702	953	482	160	5,772
2001	1,552	935	1,050	1,024	479	202	5,040
2002	4,066	1,099	945	1,145	834	192	8,089
2003	2,126	861	850	1,000	644	436	5,481
2004	4,091	1,787	828	1,396	1,036	906	9,138
2005	1,213	471	833	1,146	318	215	3,981
2006	1,900	955	1,180	908	395	199	5,338
2007[c]	-	-	262	390	-	-	1,010

-continued-

Appendix B1 1.–Page 2 of 2.

Year	Nakina River	Nahlin River	Kowatua River	Tatsamenie Lake	Dudidontu River	Tseta Creek	Five tributary total
2008	1,437	1,185	632	1,083	480	497	4,817
2009	1,698	1,033	408	633	272	145	4,044
2010	1,636	1,018	716	821	561	128	4,752
2011[c]	1,380	808	377	917	301	ND	3,783
2012[c]	1,300	726	402	660	126	ND	3,214
2013	1,475	487	708	438	166	ND	3,274
2014	1,040	304	384	376	193	ND	2,297
2015	1,340	612	622	434	289	ND	3,297
Averages							
1973–1979	2,311	619	363	469	51	10	3,686
1980–1989	3,406	1,538	518	790	233	231	6,461
1990–1999	5,294	2,277	852	1,140	880	503	10,443
2000–2009	2,332	1,056	742	963	568	370	5,661
2010–2015	1,362	659	518	535	272	NA	3,888
All years							
1973–2015	3,079	1,297	638	844	434	325	6,291

[a] Large Chinook salmon spawning abundance was estimated using mark-recapture in bold years. In all other years not footnoted aerial counts were expanded using a 5.2 mean expansion factor, the average expansion seen between the mark-recapture estimate of escapement and the summed peak aerial count from five tributaries: the Nakina, Nahlin, Kowatua, and Dudidontu Rivers and Tatsamenie Lake in 1989, 1990, 1995–1997.

[b] In 1995, 2011, 2012, due to low tagging and recovery rates in the mark-recapture study, large Chinook salmon spawning abundance was derived by expanding the estimate of medium-sized Chinook salmon by size composition data gathered on the spawning grounds.

[c] Due to poor aerial survey conditions in 2007, obtaining valid counts in most sites was not possible.

APPENDIX C

Appendix C 1.–Coded Wire Verification Form.

Coded Wire Verification Form

Alaska Department of Fish and Game
Mark, Tag & Age Laboratory
10107 Bentwood Place
Juneau, AK 99811 – 5526
907-465-3483

Page ___________ of ___________

Facility or Project ____

Tag Code	Release Site	Species	# of K Purchased	Wire Samples, one per spool unless sequential wire then one from the beginning and another from the end of tagging.			
________	________	________	________				
________	________	________	________				
________	________	________	________				
________	________	________	________				
________	________	________	________				
________	________	________	________				
________	________	________	________				
________	________	________	________				
________	________	________	________				

Appendix C 2.–Data form to record daily CWT tagging results.

CWT DAILY TAGGING, ADF&G Division of Sport Fish

Location: Taku River
Species: Chinook
Year: 2016

Date: ________________

Tag code: ________________

Machine Serial Number: ________________

	a. Number of fish tagged	___
	b. Post tagging mortalities	___
	c. Total tagged fish released (a-b)	___
Recaptures:		
	d. Number with CWTs	___
	e. Total number of recaptures	___
24 hour tag retention:		
	f. Number with CWTs	___
	g. Total number tested	___
	h. Short-term retention % (f/g)	___
	i. Adjusted tagged and released (h*c)	___
	Cumulative tagged and released:	___

Comments

Appendix C 3.–Data form to record daily environmental conditions.

DAILY ENVIRONMENTAL CONDITIONS, ADF&G Division of Sport Fish

Location: Taku River
Year: 2016

	Air Temp		Water			
Date	Min	Max	Temp	Depth	Precipitation	General Weather Condition

APPENDIX D

Appendix D 1.–Age-sex-length (ASL) form, Taku River Chinook salmon.

ASL Form

Year: ________________

Stream Code:

Species: ________________

Location: ________________

Fish #	Date	Time	Gear	Sex	Card #	Scale #	Size Class	Length MEF	OFFICE USE ONLY AGE	OFFICE USE ONLY AEC	Spaghetti Tag #	Ad fin P Cinch	LAA	UOP	Condition*	Comments (lice, bleeding, bright, seal scars)
						1										
						2										
						3										
						4										
						5										
						6										
						7										
						8										
						9										
						10										
						1										
						2										
						3										
						4										
						5										
						6										
						7										
						8										
						9										
						10										
						1										
						2										
						3										
						4										
						5										
						6										
						7										
						8										
						9										
						10										

* Under Condition record PS (pre-spawn), LPS (live-post-spawn), or D (dead).

Appendix D 2.–Gillnet recording form, Taku River Chinook salmon.

Date	Location	Crew	Water Temp.	Water Depth	Weather Comments: Clear, % Clouds, Overcast (high, mid, low), Wind, Rain.
					Bright sun, upriver wind at ~ 10 knots
4/30/14	Canyon Is Eddy Line	BL, JO, HS	5 d Celsius	-2.1' CI Gauge	
	Total Time on Site (start/end)*	**Process Time**	**Fishing Effort (hrs.)**	**Number Caught**	**Fishing Comments: (tally and explanation of process times, numbers of other fish, etc.)**
	0900 to 1200 1300 to 1600	0	6	4	Low water, mostly clear, fish caught middle of net. Fished 100' of 5 3/8" web. All 4 large fish.

* = process time + fishing effort

Date	Location	Crew	Water Temp.	Water Depth	Weather Comments: Clear, % Clouds, Overcast (high, mid, low), Wind, Rain.
Tide/Time	**Total Time on Site (start/end)***	**Process Time**	**Fishing Effort (hrs.)**	**Number Caught**	**Fishing Comments: (tally and explanation of process times, numbers of other fish, etc.)**

* = process time + fishing effort

Date	Location	Crew	Water Temp.	Water Depth	Weather Comments: Clear, % Clouds, Overcast (high, mid, low), Wind, Rain.
Tide/Time	**Total Time on Site (start/end)***	**Process Time**	**Fishing Effort (hrs.)**	**Number Caught**	**Fishing Comments: (tally and explanation of process times, numbers of other fish, etc.)**

* = process time + fishing effort

Date	Location	Crew	Water Temp.	Water Depth	Weather Comments: Clear, % Clouds, Overcast (high, mid, low), Wind, Rain.
Tide/Time	**Total Time on Site (start/end)***	**Process Time**	**Fishing Effort (hrs.)**	**Number Caught**	**Fishing Comments: (tally and explanation of process times, numbers of other fish, etc.)**

* = process time + fishing effort

Appendix D 3.–Commercial fishery sample form.

2016 Taku River Drift Gillnet ASL Form

Date: 5/16/2016 Drift Location: Wright River Crew #: Drift 1

Crew: DWD, MPE Gillnet Mesh: 7 1/4" Page #: 1 of 1

Drift #	Fish #	Drift Time (min)	Adipose (P/A)	Sex	Length MEF	Scale Card #	Scale #	LAA DLUOP	Tag/Cinch #	Comments: other species, Chinook caught but not tagged
1	5236	12	P	F	715	D1 - 005	3	Y/Y	16523	
2	5237	12	P	F	825	D1 - 005	4	Y/Y	16524	
	5238		P	M	805	D1 - 005	5	Y/Y	16525	
3		17	P	F	695	D1 - 005	6	N/N		no tag - injured
4	5239	14	A	M	630	D1 - 005	7	N/N	85963	ad clip
5	5240	18	P	M	945	D1 - 005	8	Y/Y	16526	

Appendix D 4.–Coded wire tag sampling form using the Taku River, Canyon Island as an example.

Alaska Department of Fish and Game

Coded Wire Tag Sampling Form

Rack Return and Escapement Survey

Southeast Region

Page Info for this Sample Number only! See Instructions → PAGE 1 OF PAGES 1

SAMPLE NUMBER: 1 5 7 8 0 0 2 3

SOURCE: (circle one) rack return (escapement survey) hatchery other

SURVEY SITE: Taku River – Canyon Island

SAMPLE TYPE: (random) select

SAMPLER: LaFollette / Dwyer

DATE SAMPLED: 0 5 - 2 5 - 1 5

SAMPLING INFORMATION

This Box to be completed for RANDOM Samples Only

SPECIES (CODE)	TOTAL # FISH CHECKED FOR AD-CLIPS	# AD-CLIPS SEEN	WERE ALL CHECKED?
(410)CHIN	16	1	(y) n
(411)JACK CHINOOK-ONLY	5	0	(y) n
(420)SOCK			y n
(430)COHO			y n
(440)PINK			y n
(450)CHUM			y n
(540)STHD			y n

AREA INFORMATION (DISTRICT – SUBDISTRICT)

101-	106-	111-32	116-	157-	191-
102-	107-	112-	150-	181-	192-
103-	108-	113-	152-	182-	OTHER DISTRICTS
104-	109-	114-	154-	183-	
105-	110-	115-	156-	189-	

NAME of PLACE SURVEYED: (HATCHERY OR STREAM) Taku River – CYI

WATER TYPE: saltwater (freshwater)

ANADROMOUS STREAM# (FRESHWATER-ONLY) 111-32-10320-

HEAD RECOVERY INFORMATION

✓	HEAD NUMBER	SPECIES CODE	LENGTH (mid-eye to fork in mm)	CLIP	SEX
	172320	410	755	1	F

COMMENTS

T:\FORMS\2011VISIO\RACKSE2011.VS D03/07/14 01:30

Appendix D 5.–Commercial fishery sample form.

Taku River Commercial Fishery - CHINOOK 2014

Samplers' Initials: ____________________ Page ______ of ______ for Week ______

									HEAD ON						
												Operculum Punch			
Sample Date	Catch SW	Catch Day	Scale Book Serial No.	Scale No.	Length (CAF)	AA (P/A/U)	Ad. Fin (P/A/U)	Size (S/M/L)	Length (MEF)	Length (POH)	SEX	SU (P/A/U)	DU (P/A/U)	DL (P/A/U)	CWT Head Label No./ General Comments
				1											
				2											
				3											
				4											
				5											
				6											
				7											
				8											
				9											
				10											
				1											
				2											
				3											
				4											
				5											
				6											
				7											
				8											
				9											
				10											

P = Present A = Absent U = Unknown SU = Single Upper DU = Double Upper DL = Double Lower S = <34cm CAF L = > 57cm CAF

Appendix D 6.–Canadian Aboriginal fishery sample form.

Taku River Food, Social and Ceremonial Fishery - CHINOOK 2015

Samplers' Initials: ____________________

Page ______ of ______ for Week ______

									HEAD ON						
												Operculum Punch			
Sample Date	Catch SW	Catch Day	Scale Book Serial No.	Scale No.	Length (CAF)	AA (P/A/U)	Ad. Fin (P/A/U)	Size (S/M/L)	Length (MEF)	Length (POH)	SEX	SU (P/A/U)	DU (P/A/U)	DL (P/A/U)	CWT Head Label No./ General Comments
				1											
				2											
				3											
				4											
				5											
				6											
				7											
				8											
				9											
				10											
				1											
				2											
				3											
				4											
				5											
				6											
				7											
				8											
				9											
				10											

P = Present A = Absent U = Unknown SU = Single Upper DU = Double Upper DL = Double Lower S = <34cm CAF L = > 57cm CAF

Appendix D 7.–Spawning grounds sample form.

Transboundary Chinook - Escapement Location: Any River Year: 2014 Initials: JD, AB

Date	GEAR	SEX	Left UOPunch Y/N/?	Left AAClip Y/N/?	Adipose Clip Y/N/?	Scale Book Serial No.	Scale Col. No.	Length MEF	Size Class (S, M, L)	Length POH	Condition* pre/mid/post	Condition* A/M/C	Comments (eg Tag #, Tag Scar, CWT label #, etc)
1-Aug	-	F	Y*	Y	N	71551	1	-	L	-	post	C	bear kill - tag + length n/a *double
1-Aug	weir	M	N	N	N	71551	2	820	L	715	post	M	
1-Aug	rod	M	Y*	Y	N	71551	3	650	M	550	pre	A	K11092 *single + double lower
1-Aug	spear	F	N	N	Y	71551	4	790	L	695	post	M	092461
							5						
							6						
							7						
							8						
							9						
							10						

* pre-, mid- or post-spawn; A= active, M= moribund; C=carcass

APPENDIX E

Appendix E 1.–Detection of size and/or sex selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

M vs. R	C vs. R	M vs. C
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:		
Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:		
Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:		
Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the

M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{ ; and,} \tag{1}$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^{j} \left(\hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}[\hat{N}_i] \right). \tag{2}$$

where: j = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size k among fish in stratum i;

$\hat{N}_i$ = the estimated abundance in stratum i; and,

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix E 2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

Tests of consistency for Petersen estimator

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Test For Complete Mixing[a]

Area/Time	Area/Time Where Recaptured				Not Recaptured
Where Marked	**1**	**2**	**…**	**t**	(n_1-m_2)
1					
2					
…					
s					

II.-Test For Equal Probability of capture during the first event[b]

	Area/Time Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked (n_2-m_2)				

III.-Test for equal probability of capture during the second event[c]

	Area/Time Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured (n_1-m_2)				

---

[a] This tests the hypothesis that movement probabilities (θ) from time or area *i* (*i* = 1, 2, ...s) to section *j* (*j* = 1, 2, ...t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i \theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum *j* at the time of sampling, and a_i = number of marked fish released in stratum *i*.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j \theta_{ij} p_j$ = d, where p_j is the probability of capturing a fish in section *j* during the second event, and d is a constant.

APPENDIX F

Appendix F 1.–Spawning ground sampling activities by location in the Taku River.

Location	Dates	Lead agency	Methods	Anticipated sample (large Chinook)
Nakina River	August 1–31	TRTFN	Carcass weir, carcass pitch	500
Little Tatsamenie Lake	August 1–Sept 15	DFO	Carcass weir, angling	650
Big Tatsamenie Lake	Sept 1–Oct 1	DFO	Sockeye weir, carcass pitch	100
Nahlin River	July 25–Aug 7 (3-5 days)	ADF&G	Angling, carcass pitch	250
Upper Dudidontu River	Aug 1–Aug 20 (3–5 days)	ADF&G	Angling, carcass pitch	150
Lower Dudidontu River	Aug 1–Aug 20 (3–5 days)	ADF&G	Angling, carcass pitch	150
Kowatua River	Sept 1–Oct 1	DFO	Carcass weir, carcass pitch	250
Tseta Creek	Aug 1–Aug 20 (3–5 days)	ADF&G	Angling, carcass pitch	200