Regional Operational Plan SF.1J.2015.03

Estimation of Chinook Salmon Escapement in the Taku River, 2015

by

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and

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April 2015

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.1J.2015.03

ESTIMATION OF CHINOOK SALMON ESCAPEMENT IN THE TAKU RIVER, 2015

by

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SIGNATURE/TITLE PAGE

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Approval

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Project Leader	Ed Jones		3.13.15
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Chinook Salmon Research Initiative Approval

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ABSTRACT

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 Chinook salmon *Oncorhynchus tshawytscha* will be estimated using mark-recapture methodology. Chinook salmon will be captured and marked near Canyon Island in the lower Taku River using fish wheels, set gillnets, and drift gillnets from late April through early August, 2015. 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, spawning abundance, mark-recapture, escapement, fish wheels, set gillnets, drift gillnets, spaghetti tags, secondary marks.

PURPOSE

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). A stock assessment program that will directly estimate essential production parameters for the stock of Chinook salmon originating from the Taku River is required. Information from this project and a concurrent project, reestablished in 1993 and covered in a separate operational plan: *Production of Coho and Chinook salmon in the Taku River*(Williams et al. 2015) that includes injecting a coded wire tag (CWT) into each healthy Chinook salmon smolt captured in the Taku River will provide production parameter estimates such as smolt abundance, escapement, total harvest, exploitation rate, migratory timing, and migratory distribution. These tools are being used to improve management of this stock. Estimates of escapement form the basis of primary management objectives of the Alaska Department of Fish and Game (ADF&G) and the Department of Fisheries and Oceans Canada (DFO) as dictated by the PST through the Pacific Salmon Commission (PSC) and associated technical committees.

The ADF&G has chosen the Taku River as 1 of the 12 statewide Chinook salmon indicator stocks.

BACKGROUND

The Taku River 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 22 of the past 26 years as presented in 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 3% small and 23% medium Chinook salmon on average.

Table 1.—Estimated escapement and standard error (SE) of large (> 660 mm) Chinook salmon originating from the Taku River in Southeast Alaska, 1989-2014.

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	19,539	2,268	Jones III et al. (*in prep*)
2013	18,002	6,889	Jones III et al. (*in prep*)
2014	23,532	9,472	Jones III et al. (*in prep*)

A cooperative program between the ADF&G, DFO, and the Taku River Tlingit First Nation (TRTFN) was initiated in 1995 (McPherson et al. 1996) to estimate escapement, and age, sex, and length (ASL) composition parameters annually. This is an ongoing stock assessment project. This operational plan covers work during the 2015 season.

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 December 2008.

Fish are marked at Canyon Island and in the drift gillnet effort immediately upstream of the Wright River (Figure 1) in the lower Taku River and 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, 2013, and 2014 were generated using a lethal test fishery. Inseason estimates for 2005, 2006 and 2009 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, and 2014) 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), yeilding 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). In 2005, the directed Canadian commercial fishery provided a large number of samples for inseason escapement estimates. In 2007 and 2008, the preseason forecasts of 38,720 and 37,719, respectively, were not large enough to yield an allowable catch; moreover, information generated inseason supported the preseason forecast and no directed fishing took place in either year. 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. 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.

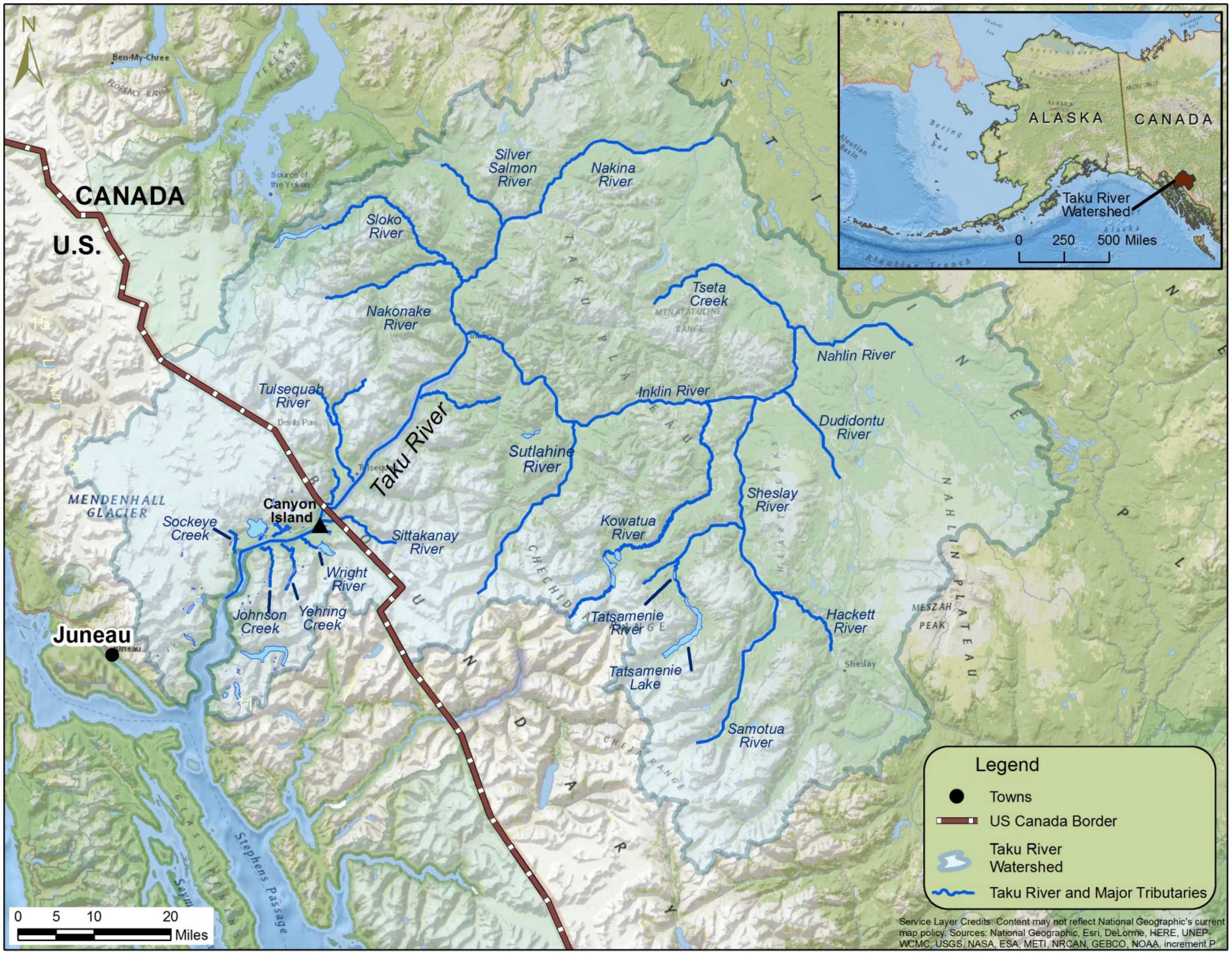

Figure 1.–The Taku River drainage of northwestern British Columbia and Southeast Alaska.

Since 2005, preseason forecasts of terminal run Chinook salmon originating in the Taku River have been inaccurate and biased high by around 40% on average. Assuming no error in the 2015 forecast of 36,936 and that the total harvest is similar to that seen in 2014 when 2,472 fish were caught, the escapement would be 34,464. However, forecasts have been erroneously high each year since 2005, and assuming an average forecast error in 2015, the terminal forecast of 36,936 would in fact be 26,156. A corrected preseason forecast of 26,156 large Chinook salmon is not enough to afford a directed commercial fishery.

Adult marking efforts at Canyon Island and the drift gillnet will be used as event 1 of the inseason mark-recapture study. The inriver fisheries (lethal test, Canadian commercial sockeye salmon and Aboriginal) will serve as event 2 of the inseason mark-recapture study. Because the adjusted 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 the run returns as per the forecast, 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 in the drift gillnet 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 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.

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. 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 through 2014 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, 2005–2014.

Statistical week	Date	Final estimate[a]	Preseason forecast[b] Point	RB[c]	Inseason Estimate	Projection	RB[c]
			YEAR 2005				
21	15 May - 21 May	68,264	99,610	46%	18,565	65,837	4%
22	22 May - 28 May	68,264	99,610	46%	30,175	68,935	1%
23	29 May - 4 June	68,264	99,610	46%	41,313	68,984	1%
24	5 June - 11 June	68,264	99,610	46%	48,414	64,196	6%
25	12 June - 18 June	68,264	99,610	46%	52,463	61,019	11%
			YEAR 2006				
21	21 May - 27 May	63,457	64,150	1%	25,071	67,759	7%
22	28 May - 3 June	63,457	64,150	1%	34,921	68,745	8%
23	4 June - 10 June	63,457	64,150	1%	41,711	69,474	9%
24	11 June - 17 June	63,457	64,150	1%	44,876	54,808	14%
25	18 June - 24 June	63,457	64,150	1%	44,694	55,604	12%
			YEAR 2007				
20	13 May - 19 May	19,612	38,720	97%	5,034	16,404	16%
21	20 May - 26 May	19,612	38,720	97%	7,638	16,428	16%
22	27 May - 2 June	19,612	38,720	97%	10,061	18,889	4%
23	3 June - 9 June	19,612	38,720	97%	12,367	18,400	6%
24	10 June - 16 June	19,612	38,720	97%	15,625	20,108	3%
			YEAR 2008				
20	11 May – 17 May	31,905	39,406	24%	4,047	22,613	29%
21	18 May - 24 May	31,905	39,406	24%	6,827	23,943	25%
22	25 May - 31 May	31,905	39,406	24%	13,255	23,760	26%
23	1 June - 7 June	31,905	39,406	24%	15,445	21,990	31%
24	8 June - 14 June	31,905	39,406	24%	21,467	26,585	17%
			YEAR 2009				
20	10 May – 16 May	35,793	50,164	40%	7,840		100%
21	17 May - 23 May	35,793	50,164	40%	14,520	47,519	33%
22	24 May - 30 May	35,793	50,164	40%	23,876	50,043	40%
23	31 May - 6 June	35,793	50,164	40%	25,625	39,994	12%
24	7 June - 13 June	35,793	50,164	40%	27,760	37,361	4%
			YEAR 2010				
20	9 May – 15 May	36,791	41,328	12%	18,565	65,837	79%
21	16 May - 22 May	36,791	41,328	12%	30,175	68,935	87%
22	23 May - 29 May	36,791	41,328	12%	41,313	68,984	88%
23	30 May - 5 June	36,791	41,328	12%	48,414	64,196	74%
24	6 June - 12 June	36,791	41,328	12%	52,463	61,019	66%
			YEAR 2011				
20	8 May – 14 May	32,609	40,986	26%	25,071	67,759	108%
21	15 May - 21 May	32,609	40,986	26%	34,921	68,745	111%
22	22 May - 28 May	32,609	40,986	26%	41,711	69,474	113%
23	29 May - 4 June	32,609	40,986	26%	44,876	54,808	68%
24	5 June - 11 June	32,609	40,986	26%	44,694	55,604	71%

-continued-

Table 1.–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 2012				
20	13 May - 19 May	24,270	48,036	98%	4,930	16,316	33%
21	20 May - 26 May	24,270	48,036	98%	5,919	13,273	45%
22	27 May - 2 June	24,270	48,036	98%	6,999	13,090	46%
23	3 June - 9 June	24,270	48,036	98%	8,231	12,655	48%
24	10 June - 16 June	24,270	48,036	98%	9,644	12,513	48%
			YEAR 2013				
20	12 May - 18 May	18,002	26,088	45%			
21	19 May - 25 May	18,002	26,088	45%			
22	26 May - 1 June	18,002	26,088	45%			
23	2 June - 8 June	18,002	26,088	45%			
24	9 June - 15 June	18,002	26,088	45%			
			YEAR 2014				
20	11 May - 17 May	23,532	26,781	14%	11,480	34,292	46%
21	18 May - 24 May	23,532	26,781	14%	30,339	25,034	6%
22	25 May - 31 May	23,532	26,781	14%	33,936	31,802	35%
23	1 June - 7 June	23,532	26,781	14%	12,182	19,600	17%
24	8 June - 14 June	23,532	26,781	14%	46,643	66,094	181%

[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 2015 is 26,156 (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.

OBJECTIVES

1. Estimate the spawning escapement of large Chinook salmon (≥660 mm MEF) in the Taku River in 2015 such that the half width of the calculated 95% confidence interval is within 20% of the estimate.
2. Estimate the spawning escapement of medium-sized Chinook salmon (401–659 mm MEF) in the Taku River in 2015 such that the half width of the calculated 95% confidence interval is within 20% of the estimate.
3. Estimate the age, sex, and length composition of the spawning escapement of medium and large Chinook salmon in the Taku River in 2015 such that the estimated half width of all calculated 95% confidence intervals are within 5% of their estimates.

SECONDARY OBJECTIVES

1. Estimate the spawning escapement of small (≤400 mm MEF) Chinook salmon in the Taku River in 2015 if mark-recapture data are adequate.

2. Recover coded wire tags from adult Chinook salmon in the Taku River in 2015 to determine the marked-fraction by brood year for estimation of smolt production and marine harvests (objective criteria are covered in separate operational plans by smolt year, and methods are described in the 2015 plan *Production of coho and Chinook salmon in the Taku River* (Williams et al. 2015)).
3. 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.

METHODS

STUDY DESIGN

Simultaneous mark-recapture experiments will be used to estimate the spawning escapements of large- and medium-sized Chinook salmon in the Taku River in 2015. Immigrating salmon caught using fish wheels and drift gillnets below the U.S.-Canada border 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, on days when the lethal test and Canadian commercial fisheries are not operating, one of the event 1 gillnet crews located below the U.S.-Canada border will move up to the lethal fisheries site and operate as both a non-lethal test fishery for event 2 for in season abundance estimation (secondary objective 3), while continuing to tag all healthy untagged fish as a part of event 1 for the postseason abundance estimation (primary objectives 1 and 2).

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. These baskets are also more durable and manageable with replacement parts being easier to change when compared to the previous wooden basket configurations (Kelley et al. 1997).

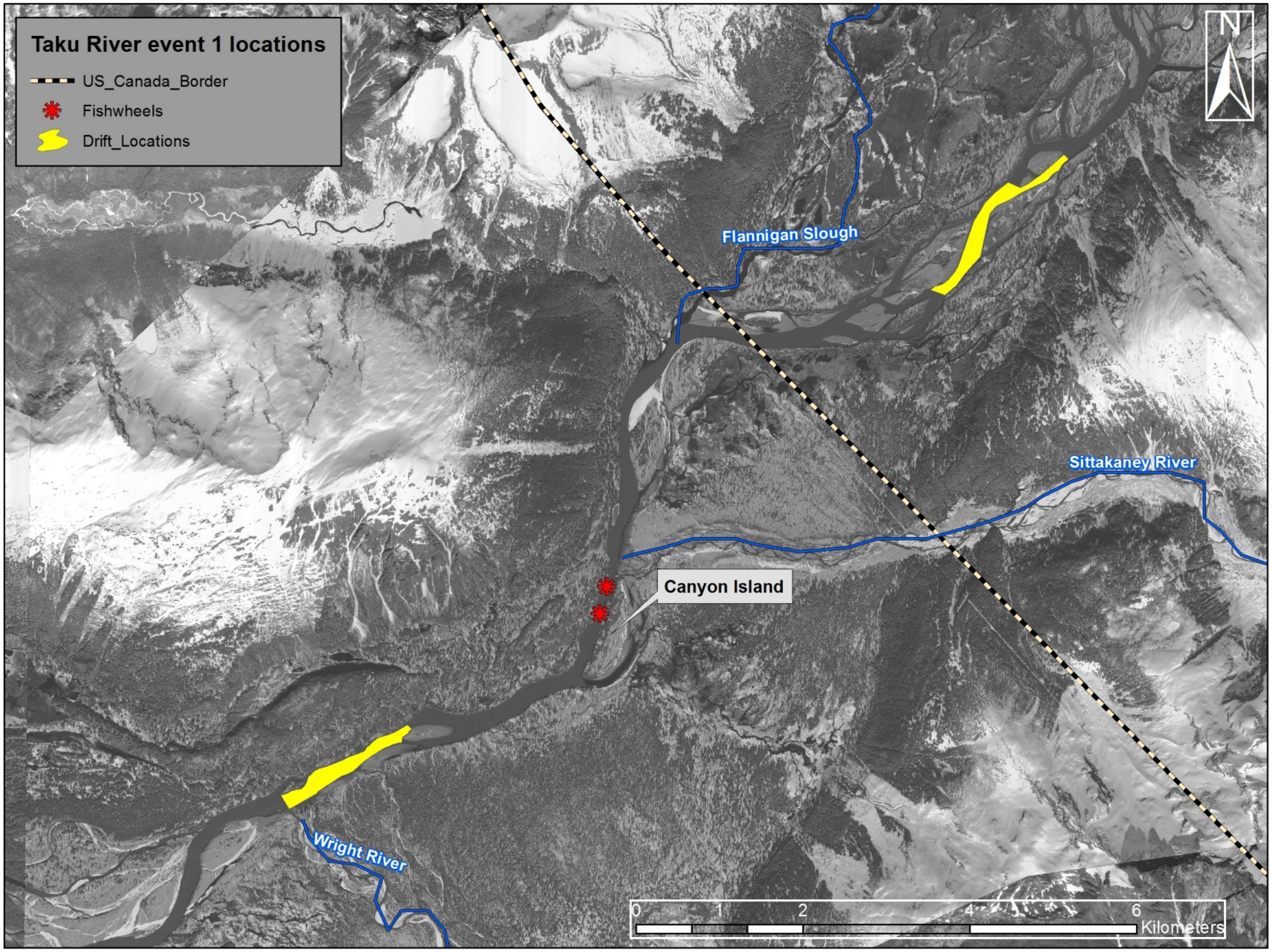

Figure 2.–Event 1 capture locations on the lower Taku River, Southeast Alaska.

Personnel will capture Chinook salmon in two drift gillnets below the U.S.-Canada border in the area just upstream of the Wright River. One boat will also drift just upstream of the U.S.-Canada border on days the lethal test and commercial fisheries are closed. 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 5 hours per day (time for each drift will be tallied to obtain 5 wet net hours). Two skiff 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 and for safety purposes and 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 on the **Drift Gillnet ASL Form**. Fishing operations will begin on Thursday, April 23 and end on Saturday, July 4.

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., lethal 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 the U.S.-Canada border 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 June 21 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 2). 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 A1). 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 Births, Deaths, Immigration and Emigration

Considering the life history of Chinook salmon, there should be no 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 recruitment because of the fidelity of salmon to their natal stream.

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 recreational 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 recreational 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. 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 analyses recommended by Seber (1982) and described in Appendix B2 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

The sampling goals for large Chinook salmon are to mark **453** (= n_1 fish wheels + drift gillnets) and inspect **4,161** (= n_2 total) upriver in 2015. Assuming the forecast is accurate (26,156) and the U.S. marine commercial and recreational 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 22,656 large Chinook salmon of the forecasted run of large Chinook salmon to pass Canyon Island. Assuming the historical capture rate at Canyon Island of 2.0% of large fish, 453 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 600 large Chinook salmon will be sampled using a 40% sampling rate. Another 2,161 large Chinook salmon will need to be sampled on the spawning grounds such that the total event 2 sample size is 4,161 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 in 2015 are to mark **476** (= n_1 Canyon Island + drift gillnet) and inspect **2,056** (= n_2 total) fish upriver. In 2015, the forecasted run of medium-sized Chinook salmon is 13,176 and based on past experience, about 10% or 1,318 medium-sized Chinook salmon should be harvested in the marine fisheries. As a result, 11,858 medium-sized Chinook should pass by Canyon Island in 2015. Also, we can expect that 4.0% of the medium-sized fish will be caught as they pass Canyon Island; therefore, 474 medium-sized fish should be caught and released from Canyon Island and the drift gillnet effort with tags. About 500 medium-sized Chinook salmon will be sampled in the lethal test and traditional Canadian commercial sockeye fisheries. Another 1,556 medium-sized Chinook will need to be sampled on the spawning grounds for a total of 2,056 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 1 and 2 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 objective 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, 509 samples are needed to meet objective criteria if all scales are readable. Because 20% of adult scale samples from Chinook salmon have in the past proven unreadable, **636** (509/0.80) 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 384 samples (assuming no data loss) are necessary to achieve the precision criteria for estimating sex composition (Cochran 1977).

DATA COLLECTION

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 will be recorded on the **CANYON ISLAND ASL FORM** (Appendix C1) 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 healthy Chinook salmon of any size will be tagged and marked (UOP, LAA) prior to release, but a fish number will not be recorded for fish that are not tagged (i.e., badly injured or sacrificed). 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 C2). 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**; **5** scales will be collected per fish. Scales will be taken from the left side of the fish from the preferred area (three 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 weekly 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.

Any fish caught at Canyon Island missing an adipose fin will be sacrificed, 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** (Appendix C1). A **CODED WIRE TAG SAMPLING FORM** (Appendix C3) 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 weekly. 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 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 healthy Chinook salmon of any size will be tagged and marked (UOP, LAA) prior to release, but a fish number will not be recorded for fish that are not tagged (i.e., badly injured or sacrificed). 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 C4).

Canadian Fisheries

The inriver test fishery will commence a short distance upriver from the U.S.-Canada border around May 3. On June 21, 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** forms (Appendix C5). Data from the Aboriginal fisheries will be recorded on the **CANADIAN ABORIGINAL FISHERY SAMPLE** forms (Appendix C6). 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). 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.

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 above the Wright River confluence. 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 C7). 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 C7), 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. This information will then be exchanged between the two agencies by email or through the use of an FTP website.

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™[1] 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.

DATA ANALYSIS

Adult Abundance

A two-sample mark-recapture model will be used to estimate the number of Chinook salmon passing by Canyon Island. 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:

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

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

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 (recreational) fishery, and ϕ_s = fraction in that fishery sampled.

All diagnostic tests for equal probability of capture (Appendices B1 and B2) 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 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 B1), 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 3) 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 3.–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:

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

where $\hat{\bar{N}}^*$ 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 B2 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. Nonadmissible 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 (Cochran 1977).

SCHEDULES AND DELIVERABLES

OPERATIONS

Field activities for tagging adult Chinook salmon at Canyon Island will begin inriver approximately April 26 and extend into July noting that few Chinook salmon are present after early July. The drift gillnets effort to boost event 1 tags out will begin on May 3 and end on July 4. The lethal test fishery will begin around May 3 and end on June 20. The traditional Canadian commercial sockeye fishery will begin June 21. Field activities on the spawning grounds will begin in late July and continue through mid-September (Appendix D1). Aerial surveys will be conducted from July 20 through September 1.

REPORTS

A draft report will be written by the lead author and distributed to other authors for input by May 1, 2016. The final report will be submitted for final peer review by July 1, 2016. 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, 2015.
3. Aerial survey results will be provided inseason as they become available.
4. CWT sample data and reading results will be exchanged by December 1, 2015.
5. Aging results will be exchanged by November 15, 2015.
6. Final error-checked ASL data, collated with scale and CWT reading results, will be exchanged by January 15, 2016.

Scale cards and original data forms associated with tag application at 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 C3) 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 radio or telephone contact with field camp; arranges logistics with field crew and expeditor. Writes adult Chinook salmon sampling section of operational plan, assures that it is followed or modified appropriately with consultation with Power, Jones, Andel, and Lafollette. Is coauthor on final report with Jones.

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

Jim Andel, FB II, Project Leader (ADF&G-DCF Canyon Island). Sets up all major aspects of adult Chinook and coho salmon operations at Canyon Island, in cooperation with Jones and Williams, including planning, budgeting, implementation and data transfer, analysis and summarization. Reviews operational plan and agrees on sampling protocols for Canyon Island, lethal test and Canadian commercial fisheries. Implements all field operations at Canyon Island and works closely with field personnel to see that project objectives and sampling protocols are followed. Provides training, as needed, to field crew for ADF&G at Canyon Island. Provides Chinook and coho salmon CWT data, forms and heads to Jones or Williams on a weekly basis from Canyon Island and the lethal test fishery; provides ASL data from Chinook to Jones or Williams on a weekly basis.

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. Coauthors and assists with data analysis and final report.

Mike Lafollette, FBI. This position serves as crew leader on the Canyon Island fish wheel and gillnet tagging operations for adult Chinook and coho 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. Performs tagging and sampling summaries and error-checks fish wheel and gillnet 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. Oversees camp logistics, such as plane flights, fuel, groceries, and spare parts. Maintains near-daily contact with Douglas office for safety, data, and logistical needs. Does inventory at end of field season. Turns in all data to project biologist and writes preliminary performance evaluations for the crew.

Travis Orient, FWT III. This position is responsible for being second in charge of fish wheel 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 Jones or Williams regarding the efficiency of work and will provide input on changes necessary to improve operations. May assist with smolt camp operations during startup.

Zane Chapman, FWT II. This position is responsible for working on the fish wheels, 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 Jones or Williams regarding the efficiency of work and will provide input on changes necessary to improve operations. May assist with smolt camp operations during startup.

Dave Dreyer, FWT IV. This position is in charge and responsible for running a drift gillnet for tagging adult Chinook salmon upstream from the Wright River and will assist in all aspects of this project including fish wheel work when available. Will consult with Jones or 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.

Michael Enders, FWT III. This position is responsible for running a drift gillnet for tagging adult Chinook salmon upstream from the Wright River and will assist in all aspects of this project including fish wheel work when available.

Norm Miller, FWT IV. This position is responsible for being the project expeditor for the smolt and fish wheel crews in April, May, and June. Will be responsible for purchasing supplies and delivering them to the air service, as well as loading and unloading of supply planes. Will coordinate logistics with Jones, Williams, and both crew leaders.

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 FY15-FY16 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 A1.–Peak aerial counts of Chinook salmon in the Taku River, 1973 to 2014.

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-

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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
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
2008–2014	1,424	794	518	704	299	321	3,888
All years							
1973–2014	3,121	1,313	638	854	437	325	6,363

[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 B

Appendix B1.–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:

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

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

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 B2.–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 Where Marked	Area/Time Where Recaptured				Not Recaptured
	1	**2**	**…**	**t**	$(n_1\text{-}m_2)$
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 $(n_2\text{-}m_2)$				

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

	Area/Time Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured $(n_1\text{-}m_2)$				

[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 C

Appendix C1.–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	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 C2.–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 C3.–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: 05 - 25 - 15

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 C4.–Commercial fishery sample form.

2015 Taku River Drift Gillnet ASL Form

Date: 5/16/2015 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 C5.–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 C6.–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 C7.–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*		Comments (eg Tag #, Tag Scar, CWT label #, etc)
											pre/mid/post	A/M/C	
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 D

Appendix D1.–Spawning ground sampling activities by location in the Taku River in 2015.

Location	Dates	Lead agency	Methods	Anticipated sample (large Chinook)
Nakina River	August 1–31	TRTFN	Carcass weir, carcass pitch	500
Little Tatsamenie Lake	August 2–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