Regional Operational Plan SF.1J.2016.08

Spawning Escapement of Chinook Salmon in the Stikine River, 2016-2018

by

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June 2016

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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SIGNATURE/TITLE PAGE

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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The spawning escapement of large (≥660 mm MEF) Chinook salmon *Oncorhynchus tshawytscha* above the U.S.-Canada border will be estimated yearly from 2016-2018 in the Stikine River, near Wrangell, Alaska. A modified Petersen 2-event mark-recapture project will be conducted using drift gillnets to mark Chinook salmon in the first event, and collection of samples in the Canadian commercial fishery, Little Tahltan River weir, and on the spawning grounds will serve as the second event. Age, sex and length of both the inriver run and spawning escapement of Chinook salmon will also be estimated. The Alaska Department of Fish and Game and Fisheries and Oceans Canada use these data to make terminal and regional management decisions, and the Pacific Salmon Commission uses the data for coastwide management and stock assessment through the Chinook Technical Committee.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, adult production, abundance-based management, Petersen estimator, coded wire tag ,marine survival, exploitation, mark-recapture, inriver run, escapement, total run, age composition, Stikine River.

PURPOSE

The primary goals of this study are to estimate the annual spawning escapement of large (≥660 mm mid eye to fork of tail length (MEF)) Chinook salmon above the U.S.-Canada border in the Stikine River from 2016 to 2018 using a modified Petersen 2-event mark-recapture project, and to estimate the age, sex and length composition of both the inriver run and spawning escapement. The Alaska Department of Fish and Game (ADF&G) and Department of Fisheries and Oceans Canada (DFO) use these data to make terminal and regional management decisions, and the Pacific Salmon Commission (PSC) uses the data for coastwide management and stock assessment through the Chinook Technical Committee (CTC).

The Stikine River is 1 of the 11 stocks chosen by the ADF&G as a Chinook salmon indicator stock and will serve as an existing and continuing source of data regarding Chinook trends in the state. Age-structured production models that are widely used to understand a stock's dynamics require information about processes like recruitment, mortality and abundance. To better understand these processes, the ADF&G, Region 1, Division of Sport Fish (DSF) will continue to conduct a mark recapture experiment that estimates the annual abundance of large Chinook salmon in the Stikine River.

The Stikine River is one of 50 Chinook escapement indicator stocks included in annual assessments by the CTC of the PSC to determine stock status and other requirements of the 1999 U.S./Canada Pacific Salmon Treaty. That agreement called for abundance-based management of Stikine River Chinook salmon to be developed by 2004. To that end, a coded wire tag (CWT) program was started in 2000 to improve the marine harvest and smolt estimation aspects of the stock assessment program (covered in a separate operational plan), and preseason and inseason run estimation methods were developed and continue to be refined. Additionally, the CTC is contemplating incorporating inriver abundance of Stikine River Chinook salmon into the PSC Chinook salmon model, which, among other things, produces annual forecasts of abundance used in setting annual harvest quotas for fisheries under the jurisdiction of the Pacific Salmon Treaty. Hence, data from this project are essential in providing effective management tools for this stock.

BACKGROUND

The Stikine River is one of the two largest producers of Chinook salmon *Oncorhynchus tshawytscha* in northern British Columbia and Southeast Alaska (Pahlke 1995), with the other being the Taku River. Commercial catches in the U.S. gillnet fishery in District 108 through early July (the period when mature adults return) exceeded 8,400 fish in 1959 and 7,000 fish were caught in 1974 (unpublished Chinook salmon plan for Southeast Alaska, ADF&G, Douglas, Alaska). In the mid-1970s Chinook salmon stocks were considered depleted; as a result in 1978, the U.S. spring gillnet fishery for Chinook salmon was suspended. Annual incidental harvests, taken in the District 106 and 108 gillnet sockeye salmon *Oncorhynchus nerka* fisheries, averaged 860 Chinook from 1978 to 2004. In addition, District 108 troll and spring troll fisheries harvested an average of 1,200 over the same period, while the Canadian inriver fisheries (which include the lower and upper river commercial fisheries and the test, Aboriginal, and sport fisheries) harvested an average of 2,300 large Chinook salmon (fish ≥660 mm). The majority of the Chinook salmon catches were taken in the lower Canadian commercial fishery and were incidental to the harvest of sockeye salmon as a result of Canada prohibiting directed commercial fisheries on Chinook salmon prior to 2005. Canadian inriver test, Aboriginal, and sport fisheries targeted Chinook salmon and harvests were typically <1,000 large fish. The marine recreational fishery targeting Stikine River Chinook salmon remained open in the Wrangell-Petersburg area in 1985–2015 and harvests ranged from 761 to 4,300 fish (Richards et al. 2012; Jaecks et al a-g *in prep*).

In 1981, the Chinook salmon management program was formalized into a 15-year program designed to rebuild spawning escapements by 1995 (ADF&G 1981), and restore production to a level capable of supporting sustainable fisheries in Alaska and Canada. To track rebuilding, ADF&G and DFO have counted spawning Chinook salmon in a designated set of watersheds. Counts from these index areas are considered to be indicators of relative abundance based on the assumption that counts are a relatively constant proportion of the escapement to a system. Past and present escapement index counts for Chinook salmon in the Stikine River consist of: (1) a survey count of Andrew Creek; and (2) a count at a weir across the Little Tahltan River. Prior to 1991, the Little Tahltan River weir count was expanded by a factor of 4.0 to estimate total inriver escapement. However, because this expansion was not based on any scientific study, the Transboundary River Technical Committee (TTC) of the PSC decided to omit the expansion factor from escapement analyses and to simply monitor the trends in Stikine River escapement from the Little Tahltan River weir counts. An escapement goal of 5,300 large Chinook through the weir was established by the TTC (PSC 1991). Estimates of total escapement were consequently needed to determine whether the Little Tahltan River weir count represented a consistent index of escapement.

A cooperative program between ADF&G, DFO, and the Tahltan First Nation (TFN) was started in 1995 as a small-scale pilot study to estimate escapement and inriver harvest rate of Stikine River Chinook salmon. The pilot study showed that mark-recapture experiments could be used to estimate escapement of Chinook salmon to the Stikine River and a rigorous program was started in 1996. The spawning escapement of Chinook salmon to the Stikine River in 1996 was estimated to be about 29,000 (SE = 1,978) large fish (Pahlke and Etherton 1998).

The studies revealed that Chinook salmon stocks in the Stikine River had rebounded from overfishing and low survival rates in the 1970s (Bernard et al. 2000). In February 2005, an agreement was negotiated between the United States and Canada by the Transboundary Rivers

Panel and approved by the PSC for directed harvest of wild Chinook salmon returning to the Stikine and Taku rivers in 2005–2008 (Annex IV, Paragraph 3). Directed commercial fisheries were re-established in District 108 and established in the lower and upper Stikine River in 2005. Initial harvests were large, followed by steep declines through 2008, but have been relatively stable since 2009 at around 5,000 fish (Table 2). Annexes to the 2005 Pacific Salmon Treaty expired in 2008, and Annex provisions were renegotiated and accepted in December 2008. Based on the current U.S.-Canada harvest sharing agreement, directed commercial fisheries may occur in the U.S. and Canada when the preseason terminal run forecast exceeds about 28,100 large fish. The preseason terminal run forecast for 2016 is 33,900 large fish. As a result, limited directed commercial fisheries on Chinook salmon are likely to occur in the U.S. waters but there is a sufficient allowable catch for directed fisheries in Canadian waters in 2016. Terminal run forecast estimates will similarly be compiled for both 2017 and 2018 using both inriver and marine harvests and data gathered during the mark-recapture experiment.

Table 1.–Estimated harvest of large (≥660 mm MEF) Stikine River Chinook salmon in Southeast Alaska and British Columbia, 2005–2015.

	United States[b]				Canada					
Year	Petersburg-Wrangell sport	D8 troll	D8 gillnet	Inriver subsistence	Lower river commercial[c]	Upper river commercial	Aboriginal	Lower river-Tuya test	Sport	Total harvest
2005	3,002	4,330	22,242	15	19,070	28	800	33	118	49,638
2006	3,030	1,792	22,147	37	15,098	22	616	0	40	42,782
2007	3,273	1,346	9,705	36	10,130	10	364	5	0	24,869
2008	1,352	1,063	7,015	26	7,051	40	769	26	46	17,388
2009	761	188	636	31	1,757	11	496	31	20	3,931
2010	941	423	348	61	2,605	16	512	13	50	4,969
2011[a]	1,063	471	1,111	66	2,565	2	515	37	53	5,883
2012[a]	1,110	498	2,025	53	4,527	6	513	105	64	8,901
2013[a]	635	423	456	40	2,502	8	809	48	50	4,971
2014[a]	697	677	204	14	1,319	0	1,020	19	50	4,000
2015[a]	781	245	378	34	3,134	38	1,022	0	76	4,233

[a] Preliminary

[b] US harvests are the district 108 harvests from SW 18-29 minus hatchery fish as determined by coded wire tags

[c] Includes directed Chinook test fishery harvests 2009–2015

Table 2.–Estimated spawning escapement of large (≥660 mm MEF) Stikine River Chinook salmon versus Little Tahltan River weir counts in Southeast Alaska and British Columbia, 1996–2015.

Year	Estimated spawning escapement, large Chinook	Weir count, large Chinook	Weir count as % of estimated spawning escapement	Source
1996	28,949	4,821	17	Pahlke and Etherton (1998)
1997	26,996	5,557	21	Pahlke and Etherton (1999)
1998	25,968	4,879	19	Pahlke and Etherton (2000)
1999	19,947	4,738	24	Pahlke et al. (2000)
2000	27,531	6,640	24	Der Hovanisian et al. (2001)
2001	63,523	9,728	15	Der Hovanisian et al. (2003)
2002	50,875	7,490	15	Der Hovanisian et al. (2004)
2003	46,824	6,492	14	Der Hovanisian et al. (2005)
2004	48,900	16,381	33	Der Hovanisian and Etherton. (2006)
2005	39,806	7,253	18	Richards et al. 2008)
2006	24,405	3,860	16	Richards et al. (2012)
2007	14,560	562	3	Richards et al. (2012)
2008	18,352	2,634	15	Richards et al. (2012)
2009	12,803 [a]	2,245	18 [a]	Jaecks et al. (*in prep* a)
2010	15,116 [a]	1,057	7 [a]	Jaecks et al. (*in prep* b)
2011	14,480 [a]	1,754	12 [a]	Jaecks et al. (*in prep* c)
2012	22,327 [a]	720	3 [a]	Jaecks et al. (*in prep* d)
2013	16,735 [a]	878	5 [a]	Jaecks et al. (*in prep* e)
2014	24,360 [a]	169	0.7 [a]	Jaecks et al. (*in prep f*)
2015	21,343[a]	450	2.[1a]	Jaecks et al. (*in prep g*)

[a] Preliminary

In addition to escapement counts for the entire Stikine River, smaller escapement counts and goals were made for the Little Tahltan River tributary. The 1996 count through the Little Tahltan River weir was 4,821 fish, or about 17% of the estimated Stikine River escapement. In 1997 and 2005, radiotelemetry was used to estimate the relative distribution of spawners in the Stikine River. The spawning escapement in 1997 was estimated to be about 27,000 large Chinook salmon (Pahlke and Etherton 1999), and the weir count was 5,557, or about 21% of the estimated escapement. This percentage was similar to the radiotelemetry study estimate of about 18%. The spawning escapement in 2005 was estimated to be about 40,000 large Chinook salmon (Richards et.al 2008), and the weir count was 7,253, or about 18% of the estimated escapement. This was also similar to the radiotelemetry study estimate of about 17%. Similar percentages of the escapement have been observed at the Little Tahltan River weir in ensuing years, although the percentage for 2004 was higher (33%) and those for 6 of the last 8 years have been substantially lower (2007 (3%), 2010 (7%), 2012 (3%) and 2013 (5%) (Table 1). A landslide at the mouth of the Tahltan River in spring 2014 potentially affected escapement and fish behavior (or both), since the number of fish passing the weir represented only 0.7% of the total Stikine escapement in 2014 and 2.1% in 2015.

Results from this rigorous escapement program were used to develop an expansion factor for the Little Tahltan River counts prior to 1996, and for estimating spawning escapements from 1981 to 1995 (Bernard et al. 2000). The escapement goal established by the TTC is 14,000 to 28,000 large Chinook to the entire Stikine River (corresponding values for counts through the Little Tahltan River weir are 2,700 to 5,300) (Bernard et al. 2000). Estimated spawning escapements have met or exceeded the escapement goal range of 14,000 to 28,000 adult spawners since 1985, with the exception of 2009 (Table 1), whereas the Little Tahltan escapement objective has not been met since 2006. The weir count and its comparison to the estimated spawning escapement will continue to be monitored.

OBJECTIVES

The research objectives for 2016-2018 are to:

1. Estimate annually the spawning escapement of large (≥660 mm MEF) Chinook salmon above the U.S.-Canada border such that the relative precision of the 95% confidence interval is within 25%. This also satisfies the PSC's requirement of a CV of 15% or less.
2. Estimate annually the age, sex, and length compositions of Chinook salmon harvested in the inriver commercial fishery such that the absolute precision of the 95% confidence interval is within 5 percentage points; and
3. Estimate annually the age, sex, and length compositions of all Chinook salmon spawning above the U.S.-Canada border such that the absolute precision of the 95% confidence intervals are all within 8 percentage points..

SECONDARY OBJECTIVES

1. Estimate annually the spawning escapement of Chinook salmon <660 mm MEF either directly from mark-recapture techniques **or** from the proportion estimated on the spawning grounds.
2. Estimate annually the inriver run at Kakwan Point of large Chinook salmon and Chinook salmon <660 mm MEF.
3. Estimate annually the age, sex and length composition of all Chinook salmon in the inriver run at Kakwan Point.
4. Collect heads and a scale sample from all returning Chinook salmon missing adipose fins that are sampled each year at Kakwan Point, the spawning grounds, and the inriver fisheries to document the marked fraction of returning fish by age (from Stikine River CWT tagging) and straying of other tagged stocks.
5. Calculate annually an expansion factor that describes the relationship between the Stikine River spawning escapement estimate for large Chinook salmon and the Little Tahltan River weir count of large Chinook salmon.
6. Collect axillary appendages from all fish tagged each year at Kakwan Point for genetic stock identification.

METHODS

STUDY DESIGN

Spawning Abundance

A mark-recapture experiment will be used to estimate the inriver abundance of large Chinook salmon at the U.S.-Canada border in the Stikine River, annually 2016-2018. Spawning abundance of large Chinook salmon will be estimated by subtracting the large fish harvested upriver of the border. Spawning escapement of Chinook salmon <660 mm will also be estimated using mark-recapture techniques and subtraction of relevant upriver harvest if mark-recapture sample sizes for fish <660 mm are sufficient; otherwise spawning escapement of fish <660 mm will be estimated by multiplying the proportion of medium and small fish to large fish on the spawning grounds with the estimate of large fish escapement. Immigrating Chinook salmon caught in drift gillnets in the vicinity of Kakwan Point will be tagged and marked as the first of 2 sampling events. During the second sampling event, Chinook salmon will be inspected for marks upriver in test, commercial, and Aboriginal fisheries, at the Little Tahltan weir, and Verrett River (Figures 1 and 2). Johnny Tashoots Creek (the outlet to Tahltan Lake) may be sampled if the resources are available.

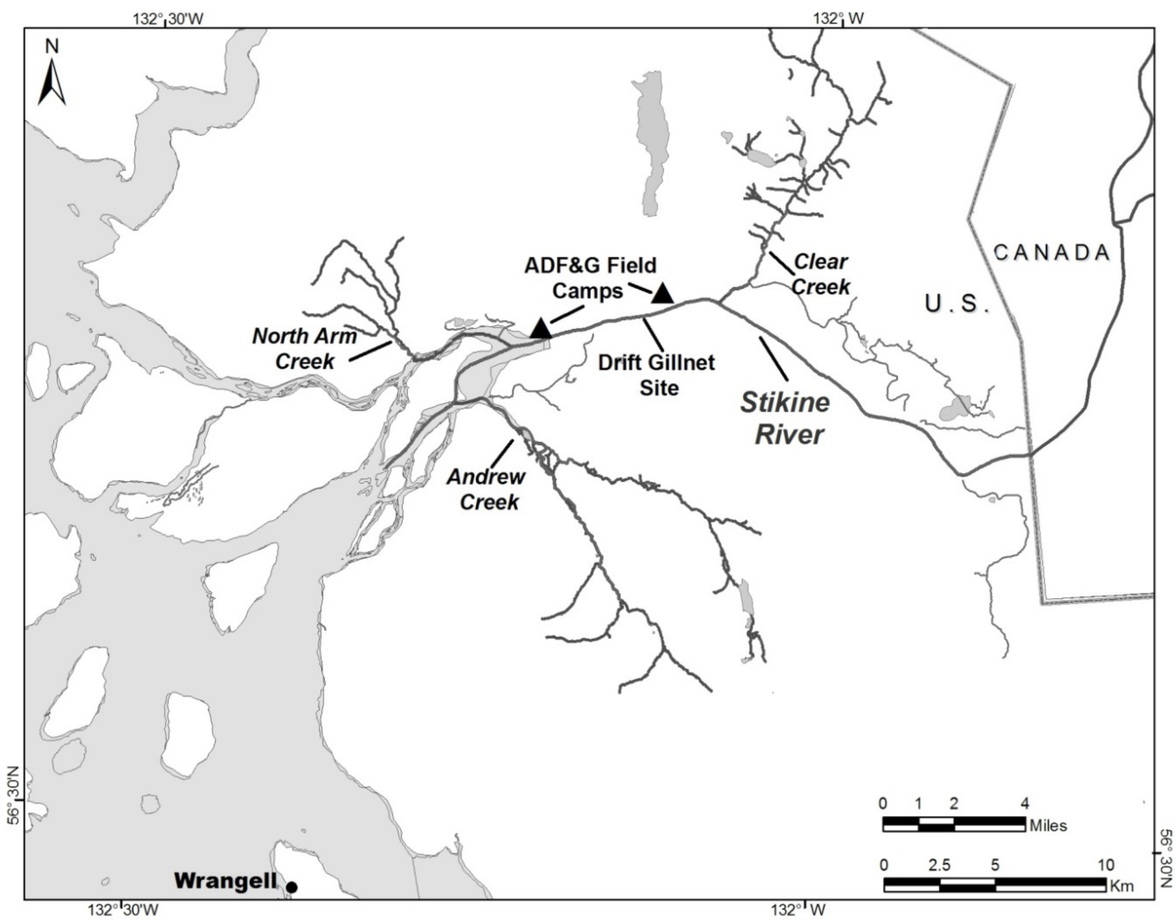

Figure 1.–Drift and set gillnet sites on lower Stikine River, Southeast Alaska.

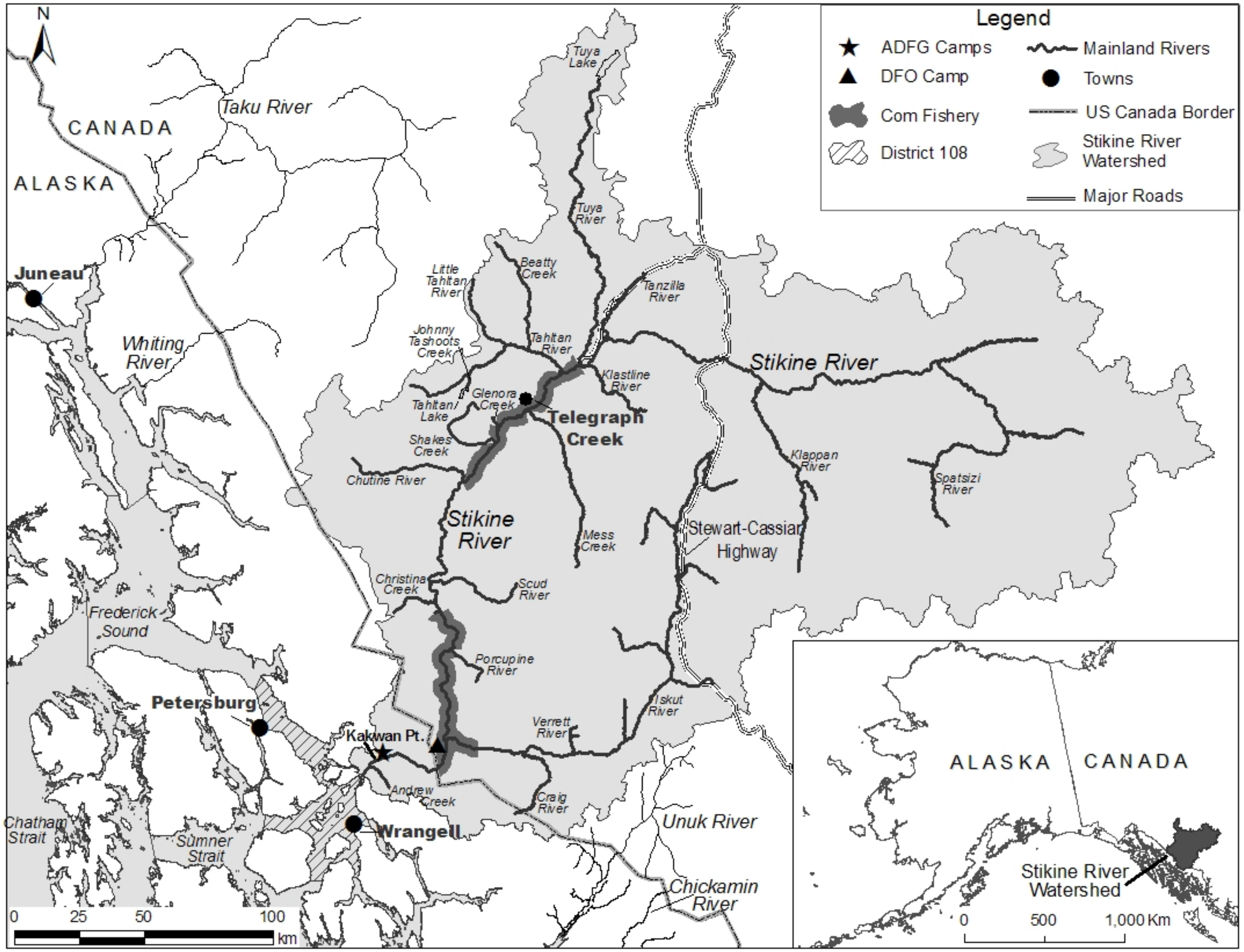

Figure 2.–Stikine River drainage in Southeast Alaska and British Columbia, showing location of principal U.S. and Canadian fishing areas.

Capture and Tagging at Kakwan Point

Personnel will capture Chinook salmon in drift gillnets near Kakwan Point. Drift net capture techniques and suitable sites were developed and identified in 1995 and are refined annually due to changing river conditions. Mesh in drift gillnets will be 18.4 cm (stretch), a size that primarily catches large (fish ≥ 660 mm MEF) and some medium Chinook (fish <660 mm MEF). Nets will be 36.6 m long and approximately 5.5 m deep.

Two skiffs will be used during the drift gillnet tagging operation and a minimum of 2 people will operate each skiff. Two crews will fish, each crew aiming to fish 7 days per week. For safety, crews will fish at the same time due to high water and frequent debris during the timeframe of this study. It will be a priority to keep fishing effort as constant as possible. The ADF&G and DFO crew leaders will coordinate fishing schedules and insure that fishing is conducted as safely as possible. Crews will carefully record fishing and processing time on the **Gillnet Effort Recording Form** (Appendix A1). The time expended fishing during each drift will be tallied and used to ensure a minimum of **4 hours of fishing effort per day per crew is completed**. Drifts at the sites identified on the lower river are short (approximately 15 min), which results in relatively high amount of processing time and boat travel to complete each drift. Fishing operations will begin in early May and end in mid-July. The first Chinook salmon has generally been captured around May 7–9, while the final capture generally occurs around July 8–9.

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. Chinook salmon captured (any size) in good condition will be measured (both MEF and POH; i.e., postorbit of eye-to-hypural), inspected to determine their sex, sampled to collect scales, triple-marked, and released. The primary mark will be a numerically-coded spaghetti tag featuring a laminated protective sheath and a solid monofilament core that is threaded through the back of the fish at a point located approximately 2 cm below the posterior half of the dorsal fin, so as to be embedded in fin rays; the ends of the monofilament core will then be crimped together. The secondary mark (a batch mark) will be a hole punched in the upper one-third of the left operculum (ULOP) with a paper punch. Hole punches must be clearly severed to prevent them from healing shut. A tertiary mark (a second batch mark) will be a left axillary appendage clip (LAA). The left axillary appendage is located at the left pelvic fin. This combination of marks will help identify marked fish on the spawning grounds up to 2–4 months later. Use of batch marks provides redundancy for cases where the primary tag is lost or unobserved. The condition (maturity) of each fish will be assessed and noted. Fish with deep wounds, damaged gills, or in a lethargic condition will be sampled for length, sex and scales and released without being tagged. There have been few such fish in the past.

In 2016-18, the axillary appendage from each tagged fish will be collected for genetic stock identification (GSI). All axillary appendages will be stored together in full strength ethanol labeled with date, location, species, number of samples, fixative, collector, agency and phone number.

Spawning Ground Recoveries

Canadian personnel will take the lead role in sampling fish for recovery of tags at or near spawning grounds above the international border, and may be assisted by ADF&G personnel. Under ideal conditions, from June through August, DFO and TFN personnel will sample a total of about 700 large Chinook salmon to measure length, determine sex, collect scales, and note presence or absence of primary, secondary and/or tertiary marks. The sample will be taken from live fish at the Little Tahltan River weir and from carcasses on spawning grounds. Every effort will be made to sample on the grounds shortly after spawning, so that samples will be of fresh (newly expired) carcasses or moribund salmon. Experience has shown that delayed sampling on the spawning grounds increases the chances of not recognizing marks on partially decomposed carcasses. The Little Tahltan River Weir has displayed anomalous abundance, size and sex ratios compared to previous years, which has prompted modification of the method, means or location of escapement sampling starting in 2016 and decreased sampling rates are possible while the methodology is under review. However, personnel from DFO and TFN will operate the Little Tahltan River weir from late June through late August. In early August, a second DFO and TFN crew will capture and sample Chinook salmon in the Verrett River. If time and resources permit, Chinook salmon will be captured and sampled in Johnny Tashoots Creek, the outlet of Tahltan Lake. Other spawning sites on the Stikine River, such as the mainstem Tahltan River, where 40–50% of the population spawns, are nearly impossible to sample due to swift and deep glacial water.

Additionally, foot surveys will be conducted in August by ADF&G in Andrew Creek as part of the PST regionwide escapement sampling. ADF&G personnel will count spawning salmon to estimate escapement as well as collect age, sex and length samples. The mouth of Andrew Creek is approximately 8 km downstream of the tagging site and occasionally tags are recovered during escapement sampling. In the event tagged Chinook salmon are encountered, the number of tags recovered in Andrew Creek will be expanded to the total estimated escapement for Andrew Creek and subtracted from the number of tags (marks) applied at the tagging site. For example, if we sample (inspect) 200 large Chinook salmon in Andrew Creek for age, sex and length, recover 1 tag, and the Andrew Creek escapement is estimated to be 2000, 10 tags will be censored from the mark-recapture experiment (2000/200 x 1). Foot surveys will also be conducted on North Arm Creek by ADF&G Division of Commercial Fisheries (DCF) staff and tags observed there will be censored from the experiment on a per tag basis; escapement to this creek is relatively small (<100) and no historic aerial survey-weir relationship is available.

Additionally, in a very general sense, the strategy covers the geographical distribution of the Chinook salmon population passing Kakwan Point, with the Verrett River stock representing the Iskut River or mid Stikine River subpopulation, and the Little Tahltan River stock representing the subpopulation of salmon spawning in the upper Stikine River. Although not part of the recapture event, sampling in Andrew and North Arm creeks provides a representation of the escapement of the lower river stocks.

Inriver Fishery Recoveries

Canadian personnel will take the lead role in sampling the inriver test fishery (Chinook and sockeye salmon) and the inriver commercial and Aboriginal gillnet fisheries for tags. Directed inriver Chinook fisheries will take place in 2016 (based on the adjusted preseason terminal run forecast of 34,000 large fish which takes into account the percent difference between original model outputs and actual terminal runs for the previous five years). Canadian fishermen will submit captured tags to Fisheries and Oceans Canada personnel who will also sample commercial and, resources permitting, Aboriginal fisheries to estimate age, sex, and length (ASL) composition. Each fish will be carefully examined for spaghetti tags, for secondary marks indicating a fish that had been tagged (tags are usually removed by the fisher), and for missing adipose fins. Comparison of tag (mark) rates from the DFO sampling with those from the inriver fisheries will test the hypothesis that all tags recovered in the inriver fisheries are being reported.

Sample Size

Sample sizes for tagging and recovery are set under the consideration that we will be estimating escapement of large fish only. Large Chinook salmon are fish $\geq$660 mm MEF that are generally age-.3 and older (3-ocean-age and older). Chinook salmon <660 mm MEF will be tagged however, and recoveries will be stratified by size to estimate the escapement of smaller fish, if possible. If mark-recapture data are insufficient to estimate the abundance of fish <660 mm MEF, abundance will be estimated based on the proportion of fish <660 mm MEF sampled on the spawning grounds (Secondary Objective 1).

The approximate number of large salmon to mark in order to obtain desired precision can be determined by approximating two parameters, 1) the inriver run, and 2) the number of fish that are sampled for marks in the second event. These can be approximated using the terminal run forecasts and allowable catches as outlined by the Pacific Salmon Treaty (2014). Terminal run forecasts dictate allowable catch (AC) above a certain base level catch (BLC) for US and Canadian fisheries. The approximate inriver run would be the terminal run forecast reduced by US catches. In recent years only about ½ of the U.S. base level catch (BLC) has been utilized so in order to calculate the inriver run we take the forecast and subtract 1,700 (half of the U.S. BLC) and subtract all of the U.S. allowable catch (AC.) The second event in the escapement estimate includes many of the Canadian fisheries. We expect about 64% of the total Canadian catch as outlined in treaty language to become a part of our second event. The 64% rate assumes a recent trend of 85% utilization of base level, allowable and/or test fishery catches and that a 75% inspection rate of those fish will continue to hold true. These two rates are from median values of the last 5 years, 20011- 2015. Additionally we intend to inspect about 500 fish on the spawning grounds. With this information, sample sizes to mark can be calculated to ensure that the half width of a 95% CI is within 25% of the estimate as outlined in Robson and Regier (1964).

For example (see Figure 3 and Table 4), in 2016 the adjusted terminal run forecast is 34,000. We expect the U.S. marine fisheries (troll, sport and gillnet) to harvest 1,700 of its 3,400 base level catch and 100% of its allowable catch of 1100 which would leave 31,200 for an estimated inriver run size. Of the maximum Canadian catch of about 7, 000 fish, we expect 64%, or about 4480 to be inspected for tags along with 500 fish from the spawning grounds, for a total of 4980 large fish in our second event. Per the procedure in Robson and Regier (1964), our tagging target for the coming year is 363 large Chinook salmon at Kakwan Point This sampling level will result in a 95% relative precision (RP) of 25% for an estimate of passage by Kakwan Point and also satisfy the PSC's requirement of escapement estimates have a CV of 15% or less. (PSC Joint Chinook Technical Committee 2013, pg 244) Note: in the execution of meeting the tagging goal for large Chinook salmon, all Chinook salmon, regardless of size, will be tagged.

These calculations are germane to years that are most similar to the past 5 years, which may serve this 3 year plan well. If forecasts appear to be outside the range of the graph, reevaluation of the sample sizes will be required. Each year, we will start sampling immediately in established fishing sites with proven techniques, while also modifying the net depth and location in response to seasonal changes in the river channel and in adjustment to water depth. We will also continue, albeit in modified fashion, sampling efforts at the Little Tahltan River Weir and attempt to bolster sampling rates at other escapement areas to compensate if weir sampling is reduced.

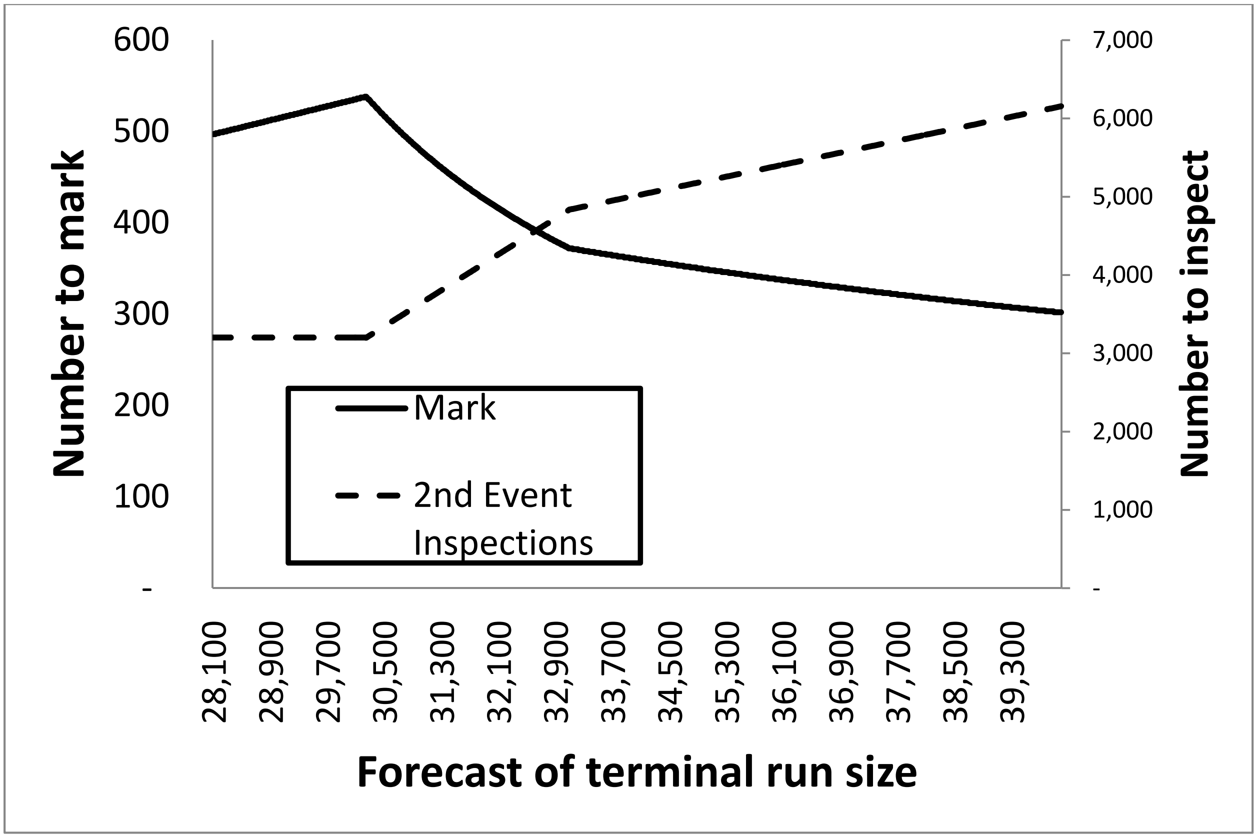

Figure 3.–Number of large (660 mm mef) Chinook salmon to mark to achieve 25% precision for a 95% confidence interval given the run size forecast for the Stikine, and all Canadian commercial and test fishery fish are inspected for marks.

Table 3.–Number of Chinook salmon ≥660 mm MEF marked and inspected for marks and estimates of inriver run size, Stikine River 1996–2015.

Year	Marked	Inspected	Estimated inriver run size	Inriver CV	95% Relative Precision
1996	736	1,415	31,718	6.20%	12.15%
1997	674	1,793	31,509	9.40%	18.42%
1998	418	1,960	28,133	14.00%	27.44%
1999	254	1,155	23,716	13.70%	26.85%
2000	614	3,657	30,301	10.50%	20.58%
2001	1,454	5,596	66,646	8.80%	17.25%
2002	935	4,375	53,893	11.00%	21.56%
2003	1,089	4,696	49,881	12.20%	23.91%
2004	1,509	5,914	52,538	7.40%	14.50%
2005	1,228	21,381	59,885	4.20%	8.23%
2006	519	16,356	40,181	16.79%	32.91%
2007	343	10,691	25,069	8.80%	17.25%
2008	420	7,051	26,284	11.43%	22.40%
2009	138	2,123	15,118	21.73%	42.59%
2010	402	3,371	18,312	10.31%	20.21%
2011	507	3,335	17,652	9.01%	17.66%
2012	380	5,204	27,542	10.46%	20.50%
2013	253	3,173	20,154	14.25%	27.93%
2014	277	3,387	27,701	15.76%	30.89%
2015	301	3,729	25,600	13.70%	26.85%
Average 1996–2015	623	5,518	33,592	11.48%	22.50%

Age, Sex, Length Composition of Chinook Salmon Harvest

Age compositions for Chinook salmon harvested upriver of the border will be estimated from scales sampled from the harvest. If scale readability is 80%, then 636 scales need to be taken from the harvest (Thompson 1987: 509/0.80). More than this number of scales is expected to be collected from the harvest of the inriver fisheries. Only in years of low abundance in which Canada has a harvest of only the BLC and test fishery (3,700 fish total) will an increased sampling rate be required to meet this objective. In 2016, we expect to examine at least 50% of the lower river harvest (approximately 7,000 x 0.5 large fish) for adipose fin clips-CWTs (see separate operational plan), or about 3,500 fish. Sampling every second large fish inspected for adipose fin clip-CWTs for scales, sex and length. Given that fish <660 mm will also be sampled, the sample size required for Objective 2 criteria should be easily met. Ages will be determined from patterns of circuli according to objective criteria developed by the DCF scale-aging group (Olsen 1992). Sex and length measurements from fish sampled for scales should yield estimates with precision, satisfying Objective 2.

Age, Sex, Length Composition of Chinook Salmon Escapement

Although Stikine River Chinook are managed based on large >660mm fish, an age composition for all fish is needed to help with sibling forecasts for later years and if possible an escapement estimate of all ages. Age compositions for Chinook salmon captured at Kakwan Point and in each escapement spawning location (tributary) will be separately estimated. Data from separate sampling locations (including the inriver fisheries sample) may be pooled to yield the composition estimates for the escapement when compositions by age class are not meaningfully different. Samples collected at the Little Tahltan and Verrett rivers should be more representative of overall spawning escapement age composition because these systems are upstream of the inriver fisheries which may be size and age selective, and if age compositions among sources vary, then the Little Tahltan and Verrett river data will be used.

Scales from a systematically drawn sample of 249 adult Chinook salmon must be collected from the escapement to meet objective criteria. In 2015, scales from 780 fish were collected from Little Tahltan River weir, representing about 83% of the 940 fish counted at the weir, a dramatic increase in percentage from former years. Also in 2015, 157 large fish were sampled at the Verrett River. If conditions are the same we can expect about 830 fish to be sampled for ages. Despite increased sampling rates in 2015, the 2014 and 2015 returns to the Little Tahltan River weir have shown abnormally high proportions of fish < 660 mm despite historically normal proportions in the harvest and Verrett River samples casting doubt on the validity of this data set in recent years. The reason for this elevated presence of smaller fish is unknown but may be a combination of weir effects and the landslide that occurred in 2014 that significantly increased the velocity near the mouth of the Tahltan River. Weir operations/location/method will likely be modified beginning in 2016 and former sampling rates cannot be guaranteed. If this continues to be the case, efforts to bolster escapement age samples will be made at the Verrett River or other escapement sites identified in telemetry studies to reach the required sample size.

To meet Objective 3 criteria in 2016 we will: 1) maintain effort; 2) maintain an electric fence at the Little Tahltan River weir to deter bears; 3) maintain an upstream weir trap (first used in 2010); and 4) ages will be determined from patterns of circuli according to objective criteria developed by the DCF scale-aging group (Olsen 1992). These sample sizes will also provide estimates of length and sex composition that meet the Objective 3 criteria.

DATA COLLECTION

Capture and Tagging

Effort and catch during drift gillnetting operations will be recorded on forms drafted by ADF&G and DFO. Weekly scheduling and effort will be determined by onsite staff in consultation with the project leaders (Jaecks and Boyce). Effort and catch will be recorded on the **Gillnet Effort Recording Form** (Appendix A1). River height to nearest 0.1 ft (from the USGS gauging station), temperature to nearest 1^{o}C (both at 0900 hours each day), shutdown times, and other comments will be recorded on these forms.

Data collected from each previously uncaptured Chinook salmon will be recorded on the **EVENT 1: Catch, Tag, and ASL Form** (Appendix A2) and includes the date and time caught, fish number, sex, length in mm MEF and POH, spaghetti tag and cinch tag numbers, condition (1:

silver bright, 2: slight coloration, etc.), secondary-tertiary mark query, and any pertinent comments (wounds, sea lice, etc.). Under cumulative fish number, newly captured Chinook salmon will be sequentially numbered so that each fish has a unique fish number. Fish number is arbitrarily assigned to keep track of the total number of Chinook salmon inspected and released and is not to be confused with the spaghetti tag number. Each previously uncaptured Chinook salmon should have a row of data associated with it on the ASL form, *even if it is not tagged.* WE WILL NOT RECORD RECAPTURES ON THE EVENT 1: CATCH, TAG, AND ASL FORM. A list of recaptured fish should be kept at the end of the data book and should note date and time of recapture, spaghetti tag number, and condition of fish. The daily numbers of Chinook salmon caught during the Kakwan Point drift net operation and associated effort will be recorded on the **Catch-Effort** and **Chinook Release Data** forms (Appendices A3 and A4) and reported to Douglas, Alaska and Whitehorse Yukon Territory staffs on a daily basis for the purpose of estimating inseason abundance.

Samplers will collect ASL data from each previously uncaptured Chinook salmon (all sizes) caught in the gillnets. Five scales will be collected per fish. Scales will be taken from the left side of the fish from the preferred area (3 taken 2–3 rows up from the lateral line and 1 inch apart, and 2 taken from 4–5 rows up 1 cm apart horizontally from the lower three scales) per the methods in Welander (1940). Scales will be affixed anterior side up on completely labeled gum cards (species, card number, locality = Stikine-Kakwan Point, Stat. code = 108-41-012, date, gear = drift gillnet, collectors = last names, remarks = weather, missing scales, etc.). Scale samples from 10 fish will be mounted on each gum card, and the scale card and scale numbers will be recorded on the **EVENT 1: Catch, Tag, and ASL Form**. It will be very important to completely label gum cards and forms so that the scales and data can be matched up in the aging lab. It will also be very important to keep the gum cards dry and free of dirt. Excessive moisture will dissolve the card's glue, which can lead to scales falling off the card or washing out of alignment. Running glue and dirt can also cover scales and cause unreadable imprints. *On wet weather days, scales will be placed in appropriately labeled slide holders, and transferred to gum cards later.* If for some reason scales are not collected from a fish, that column on the scale card will be crossed off in pencil and "no scales no. *X*" noted in the comments box. Recaptured fish will be released without taking scales.

In the event that a Chinook salmon with an adipose fin clip is netted, the fish will be sacrificed, sampled for ASL data, and tagged around the jaw with a cinch strap from the DCF's Mark, Age and Tag Laboratory (Tag Lab) as detailed in the next section.

Sampling Chinook Salmon with Missing Adipose Fins

Data for documenting the fraction of the escapement missing adipose fins will be recorded each day adult sampling occurs. Sampling data collected at Kakwan Point, and Andrew Creek will be recorded by ADF&G on **HATCHERY RACK AND ESCAPEMENT SURVEY** forms; data collected from spawning grounds in Canada and the inriver fisheries will be recorded by DFO on forms provided by their tag lab (Secondary Objective 4). In addition to potential CWT-tagged Chinook salmon strays, we anticipate the return of age-1.1 to age-1.5 Stikine River Chinook salmon from the 2009–2013 brood years that were CWT tagged in 2011–2015. Heads will be taken from all adult Chinook salmon that are missing adipose fins, and a uniquely-numbered cinch strap will be attached to each head. Capture site, date, sex, length (MEF), sample and head number (off the cinch strap) will be recorded by field staff on a Rite-n-Rain®[1] label, which will be included with each head shipped. Each head will be shipped to ADF&G in Douglas or DFO in Whitehorse (depending on whether the sampling site is in the U.S. or Canada). If shipment is delayed and refrigeration is unavailable, heads will be preserved with salt or borax. Each agency will ship the heads they collect and associated data forms, which will include the daily number inspected, to their tag lab. A scale sample will also be taken from every adult Chinook salmon that is missing the adipose fin to verify brood year. Presence of spaghetti tag or secondary marks will also be recorded for each fish examined.

Sampling Chinook Salmon For Axillary Appendages

Axillary appendages will be sampled from each Chinook salmon tagged at Kakwan Point. Sampling protocols are given in Appendix A5. Duplicate axillary samples will be taken, one for ADF&G and one for DFO.

Spawning Ground Recoveries

All fish sampled on the spawning grounds (regardless of size), will be inspected for the three tagging marks, marks indicating the fish had been previously inspected at the recovery site, and adipose fin clips. Note that the first time a Chinook salmon is examined, it will be given a hole punch on the lower (ventral) left operculum (LLOP), after it has been sampled. <u>It is extremely important that during recovery sampling that we obtain an accurate count of the total number of fish inspected by size and a precise estimate of the age category, and of those, accurately detect any fish that were marked at Kakwan Point, or CWT-tagged</u>. Sampling will be scheduled on the spawning grounds for times when most fish are still alive and the carcasses of dead fish are relatively fresh.

These steps will be followed for sampling each fish. First, each fish will be inspected for a <u>lower</u> left opercle punch (LLOP), which means the fish has already been inspected on the spawning grounds and <u>should not be sampled again</u>. On fish that do not have a LLOP, we will look for: 1) an <u>upper</u> <u>left</u> opercle punch (ULOP); 2) a spaghetti tag (or scar where a spaghetti tag may have once been affixed); and/or 3) a missing <u>left</u> axillary appendage (LAA) - any of these indicate the fish was tagged at Kakwan Point. After a fish is inspected for these marks, the lower left operculum will be punched and, if the fish is dead, the left side will be slashed with a knife as well to prevent double sampling. <u>Note that in the event the spaghetti tag has fallen off, it will be vital that the other marks (tag scar, ULOP and/or LAA) are found</u>. These marks may heal partially or fully, but because they are standardized, it should be fairly easy to detect them with careful inspection.

All recovery sampling information will be recorded on the **EVENT 2: Inspection, Recapture, and ASL Form** (Appendix A6). A data line of information will be recorded for each <u>newly inspected</u> fish. Date, fish number, sex, length (MEF and POH), and spaghetti tag number (if

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

present) will be recorded. Age and AEC (age error code) columns will be left blank. Most importantly, we will record whether the upper opercle punch and axillary appendage clips are present (even for fish with a spaghetti tag) in the comments column. If a fish has a tag scar and no tag, "scar" will be recorded in place of the spaghetti tag number and the presence of the secondary or tertiary marks will be documented as well. All fish on the spawning grounds (outside of the Little Tahltan weir) will be sampled for scales (5, anterior side up), sex, and both lengths (MEF and POH). As before, scales will be mounted on gum cards, 10 fish per card, and the scale card and scale numbers will be recorded. If a carcass is so deteriorated that a length measurement is not possible, it will be assigned to a size category (<660 or ≥660 mm MEF), sex will be determined if possible, and a scale sample, even if it is taken from outside the preferred area, will be collected. The opercle punch should be visible in carcasses that are little more than a head, and if the head can be examined and size and sex determined, it is a valid and valuable sample.

All Chinook salmon that are missing adipose fins will be sacrificed. The head will be saved, a cinch strap tag will be affixed around the jaw, and the cinch number will be recorded. Scales, sex, and lengths from every fish without an adipose fin will also be taken. Heads will be clearly labeled with information on capture site (Little Tahltan River weir or carcass, Verrett River, Andrew Creek, etc.) date, species, sex, and length (mm MEF). *For each day fish are sampled* on the various spawning sites, project biologists will complete a Tag Lab **HATCHERY RACK AND ESCAPEMENT SURVEY** form, or a DFO tag lab form, depending on whether the sampling site is in the U.S. or Canada. Each head will be shipped to ADF&G in Douglas or DFO in Whitehorse, again depending on the sampling site.

Inriver Fishery Recoveries

Chinook salmon caught in the inriver fisheries will be sampled for scales, sex, length, and inspected for the three tagging marks as described in the previous section. In addition, Canadian commercial/assessment fishery license conditions stipulate that all tags must be returned which should ensure that all tags captured in the inriver fisheries are recovered. In addition to the Chinook salmon sampled for ASL data and tag recovery, 100% of the test fishery and a minimum of 50% of the lower river inriver harvest will also be examined for missing adipose fins. Heads from all Chinook salmon without an adipose fin will be saved, a cinch strap tag affixed around the jaw, and the cinch number recorded. Scales, sex, and lengths from every fish without an adipose fin will also be taken. Each head will be clearly labeled with information on capture site (Stikine River - lower commercial fishery, etc.) date, species, sex, and length (MEF). Heads will be sent to DFO in Whitehorse.

Inseason Estimates of Passage

In order to honor Annex IV, Chapter1, Paragraph 3(a)(3)(x and xi) of the Pacific Salmon Treaty, which obliges the Parties to apportion their overall total allowable catch by historical weekly run timing, weekly fishery openings are announced based on weekly guideline harvests (PSC 2007). The preseason Chinook salmon forecast is used during statistical weeks 18 through week 20. After week 20, inseason forecasts of total run size and allowable catch are used to assist in determining weekly fishing plans.

The Stikine Chinook Management Model and inseason mark-recapture estimates will be used to produce weekly inseason run projections starting around statistical week 21. The Stikine Chinook Management Model is based on the linear regression between weekly cumulative CPUE of large Chinook salmon observed at the Kakwan Point tagging site and total run size based on mark-recapture studies conducted in 1996–2015. There is a significant positive relationship between weekly cumulative CPUE and run size for most weeks (DerHovanisian and Etherton 2006). Inseason model estimates are typically available by statistical week 21 (around May 18). Mark-recapture estimates based on the cumulative ratio of tagged-to-untagged fish observed in the inriver commercial fishery are typically available by statistical week 22. The Canadian guideline harvests are derived from historical run timing data from the 2005–2014 inriver commercial fisheries and the 2000–2003 inriver test fisheries. The U.S. guidelines are derived from historical run timing in District 108 (1969–1973 and 2005–2010) and historical CPUE from the Kakwan Point tagging site, delayed 1 week (1996–2004) and the 2001–2003 average CPUE from the Canadian Chinook test fishery, delayed 2 weeks.

Accurate forecasts are necessary in order to plan and prosecute directed Chinook salmon fisheries prior to having inseason estimates of run strength. 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. 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 from brood year *X*. This process is performed for the two major age classes representing large Chinook salmon (i.e., age-1.2 predicts age-1.3; and age-1.3 predicts age-1.4) and is based on a simple linear regression using brood year information gathered since 1995. The performance of both the preseason forecasts of terminal run and inseason estimates from 2005 through 2015 are shown in Table 4.

DATA REDUCTION

Field crew leaders will record and error check all data on field data forms, which will be kept up to date at all times (primary data capture). Kakwan Point catch-effort data will be relayed to the Douglas ADF&G office, daily, for inseason abundance estimation purposes. Scale cards will be checked to ensure that scales are clean and mounted correctly, and that the cards are correctly labeled and matched up with the corresponding data forms. Scales that were placed in slide holders will be mounted on clean, dry cards every evening. The Kakwan Point scales will be pressed and aged in the scale-aging lab in Douglas. Fisheries and Oceans Canada project leader (Etherton) will do likewise for age data collected at the Little Tahltan River, Verrett River, and other spawning grounds, and from the inriver fisheries. Data collected by ADF&G and DFO will be entered into Excel™ spreadsheet files at the end of the season (secondary data capture). When input is complete, the data will be checked for nonsensical values (e.g., transposed lengths and invalid tag numbers) and against the original field data for transcription errors. When error checking is complete, ADF&G and DFO will exchange spreadsheet files. Copies of the data and a data map will be sent to the DSF Research and Technical Services (RTS) in Anchorage for archiving with the final report. Inspection data collected by ADF&G will be recorded on **HATCHERY RACK AND ESCAPEMENT SURVEY** forms, and completed forms will be sent to the Tag Lab, the local clearinghouse for all information on CWTs.

Table 4.–Preseason and inseason forecasts of terminal run, and final estimates of large Chinook salmon terminal run to the Stikine River, and associated prediction errors , 2005–2015.

Year	Statistical week	Date	Final estimate[a]	Preseason forecast[b]		Inseason	
				Point	Prediction error	Estimate	Prediction error
2015	21	17 May–23 May	27,308	40,600	33%	preseason	NA
	22	24 May–30 May	27,308	40,600	33%	preseason	NA
	23	31 may–6 June	27,308	40,600	33%	preseason	NA
	24	7 June–13 June	27,308	40,600	33%	preseason	NA
	25	14 June–20 June	27,308	40,600	33%	preseason	NA
	26	21 June–27 June	27,308	40,600	33%	28,131	3%
	27	28 June – 4 July	27,308	40,600	33%	29,508	8%
	28	5 July–11 July	27,308	40,600	33%	29,441	8%
	29	12 July–18 July	27,308	40,600	33%	29,441	8%
2014	21	18 May–24 May	29,225	37,700	29%	preseason	NA
	22	25 May- 31 May	29,225	37,700	29%	preseason	NA
	23	1 June- 7 June	29,225	37,700	29%	preseason	NA
	24	8 June-14 June	29,225	37,700	29%	25,031	-14%
	25	15 June- 21 June	29,225	37,700	29%	26,000	-11%
	26	22 June-28 June	29,225	37,700	29%	26,000	-11%
	27	29 June-5 July	29,225	37,700	29%	26,150	-11%
	28	6 July-12 July	29,225	37,700	29%	26,150	-11%
	29	13 July- 19 July	29,225	37,700	29%	26,150	-11%
2013	21	19 May–25 May	21,708	32,032	48%	preseason	NA
	22	26 May–1 June	21,708	32,032	48%	23,800	10%
	23	2 June–8 June	21,708	32,032	48%	20,343	6%
	24	19 June–15 June	21,708	32,032	48%	24,635	13%
	25	16 June–22 June	21,708	32,032	48%	22,944	6%
	26	23 June–29 June	21,708	32,032	48%	24,861	15%
	27	30 June–6 July	21,708	32,032	48%	22,921	6%
	28	7 July–13 July	21,708	32,032	48%	21,930	1%
	29	14 July–20 July	21,708	32,032	48%	21,930	1%
2012	21	20 May–26 May	31,228	40,800	31%	preseason	NA
	22	27 May–22 June	31,228	40,800	31%	29,275	-6%
	23	3 June–10 June	31,228	40,800	31%	20,950	-33%
	24	11 June–16 June	31,228	40,800	31%	31,102	0%
	25	17 June–23 June	31,228	40,800	31%	29,249	-6%

Table 4.–Page 2 of 3.

	Statistical week	Date	Final estimate[a]	Preseason forecast[b] Point	Prediction error	Inseason Estimate	Prediction error
	26	24 June–30 June	31,228	40,800	31%	33,629	8%
	27	1 July–6 July	31,228	40,800	31%	25,331	-19%
	28	7 July–13 July	31,228	40,800	31%	26,244	-16%
	29	14 July–20 July	31,228	40,800	31%	27,300	-13%
2011	21	15 May–21 May	20,557	30,000	46%	preseason	NA
	22	22 May–28 May	20,557	30,000	46%	preseason	NA
	23	29 May–4 June	20,557	30,000	46%	18,327	-11%
	24	5 June–11 June	20,557	30,000	46%	18,896	-8%
	25	12 June–18 June	20,557	30,000	46%	18,963	-8%
	26	19 June–25 June	20,557	30,000	46%	18,503	-10%
	27	26 June–2 July	20,557	30,000	46%	21,206	3%
	28	3 July–9 July	20,557	30,000	46%	22,716	11%
	29	10 July–16 July	20,557	30,000	46%	22,716	11%
2010	21	16 May–22 May	23,356	22,900	-2%	preseason	NA
	22	23 May–29 May	23,356	22,900	-2%	preseason	NA
	23	30 may–5 June	23,356	22,900	-2%	22,300	-3%
	24	6 June–12 June	23,356	22,900	-2%	19,715	-15%
	25	13 June–19 June	23,356	22,900	-2%	20,968	-10%
	26	20 June–26 June	23,356	22,900	-2%	20,646	-10%
	27	27 June–3 July	23,356	22,900	-2%	21,924	-6%
	28	4 July–10 July	23,356	22,900	-2%	21,924	-6%
	29	11 July–17 July	23,356	22,900	-2%	21,924	-6%
2009	21	17 May–23 May	15,006	32,000	213%	preseason	NA
	22	24 May–30 May	15,006	32,000	213%	preseason	NA
	23	31 may–6 June	15,006	32,000	213%	25,500	68%
	24	7 June–13 June	15,006	32,000	213%	25,200	65%
	25	14 June–20 June	15,006	32,000	213%	24,700	65%
	26	21 June–27 June	15,006	32,000	213%	24,700	57%
	27	28 June – 4 July	15,006	32,000	213%	23,600	33%
	28	5 July–11 July	15,006	32,000	213%	19,900	33%
	29	12 July–18 July	15,006	32,000	213%	19,900	33%
2008	21	18 May–24 May	36,414	46,118	27%	preseason	NA
	22	25 May–31 May	36,414	46,118	27%	48,000	32%
	23	1 May–7 June	36,414	46,118	27%	44,000	21%
	24	8 June–14 June	36,414	46,118	27%	44,000	21%
	25	15 June–21 June	36,414	46,118	27%	50,000	37%
	26	22 June–28 June	36,414	46,118	27%	38,000	4%
	27	29 June–05 July	36,414	46,118	27%	38,000	4%
	28	06 July–12 July	36,414	46,118	27%	38,000	4%
	29	13 July–19 July	36,414	46,118	27%	38,750	6%

Table 4.–Page 3 of 3.

	Statistical week	Date	Final estimate[a]	Preseason forecast[b] Point	Preseason forecast[b] Prediction error	Inseason Estimate	Inseason Prediction error
2007	21	15 May–22 May	40,546	37,355	-8%	preseason	NA
	22	22 May–29 May	40,546	37,355	-8%	48,000	18%
	23	19 May–5 June	40,546	37,355	-8%	44,000	9%
	24	5 June–12 June	40,546	37,355	-8%	44,000	9%
	25	12 June–19 June	40,546	37,355	-8%	50,000	23%
	26	20 June–26 June	40,546	37,355	-8%	50,000	23%
	27	27 June–03 July	40,546	37,355	-8%	45,000	11%
	28	04 June–10 July	40,546	37,355	-8%	42,000	4%
	29	11 July–17 July	40,546	37,355	-8%	44,000	9%
2006	21	16 May–22 May	66,952	60,600	-9%	69,300	4%
	22	23 May–29 May	66,952	60,600	-9%	74,000	11%
	23	30 May–5 June	66,952	60,600	-9%	65,800	-2%
	24	6 June–12 June	66,952	60,600	-9%	64,000	-4%
	25	13 June–19 June	66,952	60,600	-9%	70,000	5%
	26	20 June–16 June	66,952	60,600	-9%	61,000	-9%
	27	17 June–23 June	66,952	60,600	-9%	73,100	9%
	28	24 June–30 June	66,952	60,600	-9%	67,300	1%
	29	01 July–07 July	66,952	60,600	-9%	75,050	12%
2005	21	18 May–24 May	89,626	94,392	5%	preseason	NA
	22	25 May–31 May	89,626	94,392	5%	71,711	-20%
	23	1 June–7 June	89,626	94,392	5%	72,388	-19%
	24	8 June–14 June	89,626	94,392	5%	72,966	-19%
	25	15 June–21 June	89,626	94,392	5%	75,161	-16%
	26	22 June–28 June	89,626	94,392	5%	75,309	-16%
	27	29 June–05 July	89,626	94,392	5%	78,063	-13%
	28	06 July–12 July	89,626	94,392	5%	NA	NA
	29	13 July–19 July	89,626	94,392	5%	NA	NA

[a] Final estimates from 2005 to 2014 are germane to terminal run size (i.e., inriver run estimate at Kakwan Point plus harvest in the D108 terminal area).

[b] The official preseason inriver forecast of large Chinook salmon bound for the Stikine River in 2005 was 80,300. The official inriver forecast did not account for fish caught in the U.S. marine terminal fishery. The terminal run forecast should have been 94,392.

DATA ANALYSIS

Spawning Escapement, Harvest, and Inriver Run of Chinook Salmon ≥660 mm

Assuming the experiment does not need to be stratified by time-area, Chapman's modification of Petersen's method (Seber 1982:60) will be used to estimate spawning escapement of large Chinook salmon $\hat{N}_{LE}$ as:

$$\hat{N}_{LE} = \hat{N}_{LR} - \hat{N}_{LH} \tag{1}$$

where:

$\hat{N}_{LR}$ = Estimated abundance of large Chinook salmon passing by Kakwan Point, i.e., inriver run size:

$$\hat{N}_{LR} = \frac{(\hat{M} + 1)(C + 1)}{(R + 1)} - 1$$

$\hat{M}$ = Estimated number of large (Kakwan Point) marked Chinook present for possible recovery in the inriver fisheries or on the spawning grounds, which will be the number of marked fish minus the estimated fish that moved downstream; $\hat{M} = M - \hat{M}_d$

C = Number of large adults inspected for (Kakwan Point) marks in the inriver fisheries and on the spawning grounds;

R = Number of large adults with (Kakwan Point) marks in samples taken in the inriver fisheries and on the spawning grounds; and

$\hat{N}_{LH}$ = Estimate of inriver harvest of large adults above Kakwan Point, where $\hat{N}_{LH} = N_H \hat{p}_{LH}$, N_H is the (known) fish-ticket derived harvest, and $\hat{p}_{LH}$ is the estimated proportion of large fish in N_H (see section on ASL of harvest below).

The conditions for accurate use of this methodology are:

1a. all Chinook salmon have an equal probability of being marked at Kakwan Point; <u>or</u>

1b. all Chinook salmon have an equal probability of being inspected for marks; <u>or</u>

1c. marked fish mixed completely with unmarked fish in the population between events; <u>and</u>

2. there is no recruitment to the population between events; <u>and</u>

3. there is no tag-induced mortality or behavior; <u>and</u>

4. fish do not lose their marks and all marks are recognizable.

Conditions 1b and 1c will not be met for Chinook salmon in different stocks within the Stikine River. The reasons are as follows. Stocks within the Stikine River have different inriver migratory patterns (Pahlke and Etherton 1999), so complete mixing of marked and unmarked fish is not possible (1c). Inspection efforts will be restricted to the inriver Chinook test and sockeye gillnet fisheries, Little Tahltan River, Verrett River, and perhaps other large spawning concentrations. Fish at the targeted spawning grounds will have a higher probability of being captured, and while the fishery targets may capture a mix of stocks, fishing effort will not necessarily be constant, and probability of capture for stocks with different timing and migratory patterns may differ. Therefore every spawner in the Stikine watershed above Kakwan Point will not have the same chance of being caught in the second sampling event (1b). , Because these two conditions will not be satisfied, our chance for an unbiased estimate of spawning abundance of large fish depends solely on meeting the first condition (1a). For this reason, gillnets will be fished with consistent effort throughout the immigration past Kakwan Point. This relatively constant sampling effort will tend to equalize the probabilities of capture for all fish passing by Kakwan Point *regardless of when they pass* this site. We will use the contingency table tests outlined in Appendix B2 to determine whether a simple Chapman modified Lincoln-Petersen estimator (described above) or a partially stratified estimator (e.g. Darroch 1961, Schwarz and Taylor 1998) should be used. Such tests have shown that in most years all large salmon passing by Kakwan Point had an equal or near equal chance of being captured and marked with the proposed sampling protocols.

Multiple hypothesis tests will be used to determine if size-selective sampling occurred in the tributaries, inriver fisheries, or Kakwan Point (see Appendix B1). If size selective-sampling is indicated for Chinook salmon ≥660 mm, data will be stratified into size groups, and abundance, age, sex and length will be estimated as the sum of stratum estimates. Such stratification will also be considered for the estimate of Chinook salmon <660 mm. Significant size-selective sampling has not been detected for large fish in most years. We may also use the models developed by Huggins (1989, 1991) to test for, and if necessary, incorporate size-selective sampling into the abundance estimates. Program MARK (White and Burnham 1999) will be used to fit and test these models.

The life history of Chinook salmon isolates those fish returning to the Stikine River as a ‘closed’ population (condition 2). Marked fish may have a greater mortality rate than do unmarked fish (condition 3) or may otherwise “emigrate” due to handling, moving back downstream (Bernard et al. 1999). To help account for downstream movement the estimated number of marked fish that reach the inriver fisheries and upriver spawning grounds ($\hat{M}$) will be the number of marked fish minus estimated marked fish that have moved downstream. Marked fish have been caught downstream in marine commercial and U.S. recreational fisheries and have been observed in Andrew Creek, downriver from Kakwan Point. Independent programs run by DCF and DSF sample harvest in the U.S. commercial gillnet fishery and the recreational fishery near Petersburg. Marked fish recovered by these sampling programs, expanded for fractions of harvest sampled, will be censored from the experiment. Marked fish observed in Andrew and North Arm creeks will also be censored from the experiment. For Andrew Creek, the number of marked fish observed will be expanded by the estimated sampling fraction (estimated escapement/total fish examined for marks). The estimated escapement for Andrew Creek will be derived from a historical relationship between peak aerial survey count and escapement through a weir operated from 1976–1984 and 1997. The escapement to North Arm Creek is small (peak count average = 36 large fish 1993–2003, Pahlke 2005) and to date, no tags have been observed in North Arm Creek during the annual DCF foot survey. Any tags encountered in North Arm Creek will be individually censored from the experiment. The estimated number of marked fish that reach the inriver fisheries and upriver spawning grounds ($\hat{M}$) will be the number of uncensored marked fish remaining in the experiment. The number of fish censored in 2013 as a result of recoveries in the U.S. gillnet and sport fisheries and in Andrew and North Arm creeks was 22 (1 from the District 108 commercial gillnet fishery and 3, expanded to 21, from Andrew Creek), however similar sampling in 2014 encountered no tagged fish. We believe we successfully censor the large majority of tags applied to fish that do not sustain an upstream migration, i.e., those not susceptible to capture in the recapture events upstream. In 2005, about 3% of radio-tagged fish were tracked as known 'down-streamers' (i.e., located in either the U.S. gillnet District 108 harvest, the U.S. sport harvest, or Andrew Creek; 11 were tracked to these locations out of 369 radio tags deployed). The number of censored marks in the 2013 mark-recapture study was about 8.7% (22 out of 253 applied). Each marked fish will receive a numbered spaghetti tag, a secondary mark, and a tertiary mark, meaning marks will be recognizable during the second event sampling and any spaghetti tag loss will be accounted for in the analysis (condition 4).

An estimate of the variance for $\hat{N}_{LR}$ will be obtained through bootstrapping (Efron and Tibshirani 1993) according to methods in Buckland and Garthwaite (1991). The estimated $\hat{N}_{LR}$ in the experiment will be divided into capture histories (Table 5) to form an empirical probability distribution (epd). A bootstrap sample of size $\hat{N}_{LR}$ will be drawn from the epd with replacement.

Table 5.–Capture histories for Chinook salmon in the Stikine River mark-recapture experiment, 2016-18.

1. Marked but censored in U.S. marine recreational fishery.
2. Marked but censored in U.S. marine commercial fisheries.
3. Marked but censored in Andrew and North Arm creeks.
4. Marked and not sampled on spawning grounds or inriver fisheries.
5. Marked and recaptured on spawning grounds or inriver fisheries.
6. Not marked but captured on spawning grounds and inriver fisheries.
7. Not marked and not sampled on spawning grounds and inriver fisheries.

From the resulting collection of resampled capture histories, R^*, C^*, $\hat{M}^*$, and $\hat{N}^*_{LR}$ will be calculated. A large number (B) of bootstrap samples will be so drawn. The approximate variance will be calculated as:

$$var(\hat{N}_{LR}) = \frac{\sum_{b=1}^{B}(\hat{N}^*_{LRb} - \bar{\hat{N}}^*_{LR})^2}{B-1} \tag{2}$$

where $\bar{\hat{N}}^*_{LR}$ is the average of the $\hat{N}^*_{LRb}$. Confidence intervals will be obtained using the percentile method.

With respect to the variance of $\hat{N}_{LE}$, sample sizes used to estimate the proportion of large fish harvested ($\hat{p}_{LH}$) are typically large (over 1,000 in 2010–2014) and $\hat{p}_{LH}$ has been far from the worse-case scenario of 0.5 A typical relative 95% precision for the estimate of $\hat{N}_{LH} = \hat{p}_{LH} N_H$ is less than 2%. The parameter $\hat{N}_{LH}$ is therefore treated as a constant and:

$$var(\hat{N}_{LE}) = var(\hat{N}_{LR}) \tag{3}$$

Spawning Escapement, Harvest, and Inriver Run of Chinook Salmon <660 mm

The spawning escapement of Chinook salmon <660 mm MEF will be estimated separately from that of large fish. The preferred estimate for spawning escapement of fish <660 mm will be calculated as in Equations 1 through 3 above, substituting large fish with fish <660 mm.

If we mark, inspect, and recapture too few fish <660 mm, such that the estimate of fish <660 mm past Kakwan Point has insufficient precision (estimated relative precision >50% for a 95% CI), then we will base the spawning escapement estimate for fish <660 mm on the spawning escapement estimate of large fish and the proportion of large fish in the spawning ground samples:

$$\hat{N}_{<660E} = \hat{N}_{LE}\left(\frac{1}{\hat{p}_{LE}} - 1\right) \tag{4}$$

where $\hat{p}_{LE}$ is the estimated fraction of large fish in the spawning population, obtained from spawning ground ASL sampling; this proportion is typically based on a greater sample size than that on which spawning ground age-sex composition is based; many fish are measured for length but do not contribute to the age-sex composition.

The variance of the estimate of the escapement of fish <600 mm will be estimated (Goodman 1960):

$$\mathrm{var}(\hat{N}_{<660E}) = \mathrm{var}(\hat{N}_{LE})\left[\frac{1}{\hat{p}_{LE}} - 1\right]^2 + \hat{N}_{LE}^{\,2}\,\mathrm{var}\left(\frac{1}{\hat{p}_{LE}}\right) - \mathrm{var}\left(\frac{1}{\hat{p}_{LE}}\right)\mathrm{var}(\hat{N}_{LE}) \tag{5}$$

where, by the delta method,

$$\mathrm{var}\left(\frac{1}{\hat{p}_{LE}}\right) \approx \left(\frac{1}{\hat{p}_{LE}}\right)^4 \frac{\hat{p}_{LE}(1 - \hat{p}_{LE})}{n_E - 1} \tag{6}$$

and n_E is the number of fish of all sizes in the spawning ground sample. Confidence intervals will be derived via simulation, where for each bootstrap realization of the abundance of large fish a binomial random variable will be drawn (~binomial (trials = number of fish inspected on the spawning grounds, probability = $\hat{p}_{LE}$)) and a simulated $\hat{p}_{LE}$ produced. A simulated $\hat{N}_{<660E}$ will be calculated and confidence intervals derived using the percentile method.

The estimated inriver run of Chinook salmon <660mm at Kakwan Point will be estimated as:

$$\hat{N}_{<660R} = \hat{N}_{<660E} + \hat{N}_{<660H} \tag{7}$$

where $\hat{N}_{<660H} = N_H - \hat{N}_{LH}$, and with variance (ignoring $\text{var}(\hat{N}_{LH})$ which is negligible):

$$\text{var}(\hat{N}_{<660R}) = \text{var}(\hat{N}_{<660E}) \tag{8}$$

Spawning Escapement and Inriver Run of All Chinook Salmon

Total inriver run at Kakwan Point will be estimated:

$$\hat{N}_R = \hat{N}_{<660R} + \hat{N}_{LR} \tag{9}$$

with variance estimated as:

$$\text{var}(\hat{N}_R) = \text{var}(\hat{N}_{LR})\left[\frac{1}{\hat{p}_{LE}}\right]^2 + (\hat{N}_{LR} - \hat{N}_{LH})^2\,\text{var}\left(\frac{1}{\hat{p}_{LE}}\right) - \text{var}\left(\frac{1}{\hat{p}_{LE}}\right)\text{var}(\hat{N}_{LR}) \tag{10}$$

Total spawning escapement will be estimated as:

$$\hat{N}_E = \hat{N}_{<660E} + \hat{N}_{LE} \tag{11}$$

with estimated variance (harvest is known):

$$\text{var}(\hat{N}_E) = \text{var}(\hat{N}_R) \tag{12}$$

Weir Count to Spawning Escapement Expansion Factor

An expansion factor to relate the count at the Little Tahltan River weir of large fish (W_L) to spawning escapement of large fish will be estimated by:

$$\hat{\pi} = \frac{\hat{N}_{LE}}{W_L} \tag{13}$$

$$var(\hat{\pi}) = \frac{var(\hat{N}_{LE})}{W_L^2} \tag{14}$$

Large fish can be visually distinguished from smaller fish as they pass through the weir with negligible error, which makes W_L a constant,

Age, Sex, and Length Composition of Harvest

The proportion of the harvest of a given size category *i* composed of age/sex *j* will be estimated as a binomial variable from fish sampled from the fishery:

$$\hat{p}_{ijH} = \frac{n_{ijH}}{n_{iH}} \tag{15}$$

$$\mathrm{var}[\hat{p}_{ijH}] = \frac{\hat{p}_{ijH}(1 - \hat{p}_{ijH})}{n_{iH} - 1} \tag{16}$$

where n_{ijH} is the number of Chinook salmon of age/sex *j* in the sample of size category *i*, n_{iH} , taken from the fishery.

The number of fish taken in the fishery by age will be estimated as:

$$\hat{N}_{jH} = \sum_i \hat{p}_{ijH} \hat{N}_{iH} \tag{17}$$

with variance estimated as:

$$\mathrm{var}(\hat{N}_{jH}) = \sum_i \mathrm{var}(\hat{p}_{ijH}) \hat{N}_{iH}^{\ 2} \tag{18}$$

Recall that $\hat{N}_{iH}$ is estimated as the product of the known harvest of all fish and the estimated proportion of fish of size *i* in the harvest (i.e., $N_H \hat{p}_{iH}$). As mentioned earlier, the number of fish used to estimate $\hat{p}_{iH}$ is typically very large (larger than that used to estimate age and sex) and its variance is considered negligible, hence the treatment of $\hat{N}_{iH}$ as a constant in Equation 18.

Estimates for sex and length will be calculated similarly. Estimates of mean length-at-age and their estimated variances will be calculated with standard sample summary statistics (Thompson 2002).

Age, Sex, and Length Composition of Spawning Escapement

The proportion of the spawning escapement population composed of age/sex *j* in size category *i* (large or small) will be estimated as a binomial variable from fish sampled on the spawning grounds:

$$\hat{p}_{ijE} = \frac{n_{ijE}}{n_{iE}} \tag{19}$$

$$\mathrm{var}[\hat{p}_{ijE}] = \frac{\hat{p}_{ijE}(1 - \hat{p}_{ijE})}{n_{iE} - 1} \tag{20}$$

where n_{ijE} is the number of Chinook salmon of age/sex *j* in size category *i* in the aged sample n_{iE} taken on the spawning grounds.

Numbers of spawning fish of age/sex *j* in the spawning escapement will be estimated as the summation of products of estimated age composition and estimated spawning abundance within size category *i*:

$$\hat{N}_{jE} = \sum_i \left(\hat{p}_{ijE} \hat{N}_{iE} \right) \tag{21}$$

where $\hat{N}_{iE}$ is the spawning abundance within size category *i*.

Variance of individual components of Equation 21 will be estimated according to Goodman (1960):

$$\operatorname{var}(\hat{p}_{ijE}\hat{N}_{iE}) = \operatorname{var}(\hat{N}_{iE})\,\hat{p}_{ijE}^2 + \operatorname{var}(\hat{p}_{ijE})\hat{N}_{iE}^2 - \operatorname{var}(\hat{N}_{iE})\operatorname{var}(\hat{p}_{ijE}) \tag{22}$$

If sufficient tags are recovered from Chinook salmon <u><</u>660 mm, such that an independent estimate of $\hat{N}_{<600E}$ is obtained, the variance of $\hat{N}_{jE}$ will be estimated by $\sum_i \operatorname{var}(\hat{p}_{ijE}\hat{N}_{iE})$.

If insufficient tags are recovered from fish <600 mm such that the proportionality method is used, there will be dependence between the $\hat{p}_{ijE}\hat{N}_{iE}$ terms for *i* <660 mm and *i* = L in Equation 21, so the variance of $\hat{N}_{jE}$ will be estimated by simulation. Stochastic components of the simulation will be:

$N_{LR}^* \sim N(\hat{N}_{LR}, \operatorname{var}(\hat{N}_{LR}))$,

$N_{LE}^* = N_{LR}^* - \hat{N}_{LH}$,

$p_{LE}^* \sim Bin(n_E, \hat{p}_{LE}) / n_E$,

$N_{<660E}^* = N_{LE}^* \left(\dfrac{1}{p_{LE}^*} - 1 \right)$,

$N_{<660R}^* = N_{<660E}^* + \hat{N}_{<660H}$, and

$\underline{p}_{ijE}^* \sim multinomial(n_{iE}, \underline{\hat{p}}_{ijE})$.

Equations through 21 will be used to generate simulated values of $\hat{N}_{jE}$, and its sample variance calculated.

The proportion of the spawning population composed of a given age will be estimated by:

$$\hat{p}_{jE} = \frac{\hat{N}_{jE}}{\hat{N}_E} \tag{23}$$

Variance of $\hat{p}_{jE}$ will be approximated according to the procedures in Seber (1982, p. 8–9):

$$\text{var}(\hat{p}_{jE}) = \frac{\sum_i \left(\text{var}(\hat{p}_{ijE})\hat{N}_{iE}^2 + \text{var}(\hat{N}_{iE})(\hat{p}_{ijE} - \hat{p}_{jE})^2 \right)}{\hat{N}_E^2} \tag{24}$$

If insufficient tags are recovered from fish <600 mm such that the proportionality method is used, the variance of $\hat{p}_{jE}$ will be estimated through simulation.

Sex and age-sex composition for the spawning population and associated variances will also be estimated with the equations above by first redefining the binomial variables in the samples to produce estimated proportions by sex $\hat{p}_k$, where *k* denotes sex, such that $\sum_k \hat{p}_k = 1$, and by age-sex, such that $\sum_j \sum_k \hat{p}_{jk} = 1$. Sex composition from samples collected on the spawning grounds will be more reliable than those collected from the tagging and fishery samples because of the enhanced physiological development of the former.

Estimates of mean length at age and their estimated variances will be calculated with standard sample summary statistics (Thompson 2002).

Age and Sex Composition of Inriver Run

Inriver run by age category *j* will be estimated as

$$\hat{N}_{jR} = \hat{N}_{jE} + \hat{N}_{jH} \tag{25}$$

with variance estimated as:

$$\text{var}(\hat{N}_{jR}) = \text{var}(\hat{N}_{jE}) + \text{var}(\hat{N}_{jH}) \tag{26}$$

SCHEDULE AND DELIVERABLES

Field activities for tagging Chinook salmon at Kakwan Point will begin late April and extend through mid-July. Field activities for recovery of tagged Chinook at the Little Tahltan River weir will begin in late June. Recovery efforts on Verrett River Chinook will commence in early August and finish approximately mid-August. Andrew and North Arm creeks and other accessible spawning areas will be surveyed from early August to mid-August to recover tags, inspect fish for missing adipose fins, and to collect age, sex, and size data. Tag collection will occur throughout the duration of the Stikine River commercial and Aboriginal fisheries. At this juncture, personnel to measure fish (sex, size, and age) and observe for secondary and tertiary marks in the Aboriginal fishery may not be available. Data on tagging from Kakwan Point will be entered and edited in Juneau by ADF&G personnel and distributed to the other principal investigators by 31 August each year. Data from the recovery locations will be sent to Troy Jaecks in Juneau by 31 October each year, and then entered into Excel™ spreadsheets, edited, and distributed for any final editing by 30 January each year to DFO. A draft report will be written in Juneau by ADF&G by 30 April each year and distributed for editing and further writing to DFO. Changes to the report will be submitted by DFO to ADF&G by 1 July each year and the final report will be submitted for final peer review by 1 September each year.

RESPONSIBILITIES

I. Agency Responsibilities

A. ADF&G. Will plan project in cooperation with DFO. Will write operational plan with DFO. Will provide equipment for all aspects of tagging, room and board at Kakwan Point, and other operating supplies. Will summarize all tagging data from Kakwan Point operations in spreadsheets and provide to DFO. Will survey Andrew Creek escapement. Will coalesce recovery data from recovery locations. Will perform analysis and take responsibility for analysis of data and first draft of report. Will provide final data and draft of report for review to DFO.

B. DFO. Will assist in planning of project. Will provide core staff to tag at Kakwan Point and will recover tags from Little Tahltan and Verrett rivers. Will cover the costs and logistics associated with sampling the inriver commercial fishery. Will cover the costs and logistics associated with tag recoveries. Will provide tagging, recovery, and age data to ADF&G (Sport DSF) by 31 October each year. Will review data, provide input into report, write sections regarding recovery and serve as co-author.

II. U.S. Personnel Responsibilities

Troy Jaecks, FBII, Project Leader. In concert with Philip Richards, and Peter Etherton, sets up all aspects of project, including planning, budget, sample design, permits, equipment, personnel, and training. Assists in supervising Kakwan Point operations and assists with supervision of recovery. Coalesces, edits, analyzes, and reports data; assists with fieldwork; arranges logistics with field crew. Takes lead role in analysis and first draft of report.

Sarah Power, Biometrician II. Provides input to and approves sampling design. Reviews operational plan and provides biometric details. Writes code for and completes data analysis and reviews final report.

Philip Richards, FBIII. Will oversee and assist with all aspects of the project including planning, budget, sample design, permits, equipment, and supervising field operations. Coalesces, edits, analyzes and reports data; assists with fieldwork.

Ed Jones, Salmon Research Coordinator. This position is responsible for general oversight of this project and the Chinook stock assessment program in the region. Reviews project planning, operational plans and technical reports.

Scott McPherson, Fisheries Scientist. This position functions as senior technical advisor, may assist in project planning, operational plans and technical reports.

Stephen Todd, FBI. This position is responsible for supervising one portion of the field tagging program. Will coordinate schedules with DFO-Tahltan crew and share responsibility for all aspects of field operations, including safe operation of riverboats, and other equipment, tagging, data collection, and general field camp duties. Will assume lead role in equipment and camp maintenance.

Clay Culbert, FTII. Will be responsible for assisting in all aspects of field operations, including safe operation of riverboats, and other equipment, tagging, data collection, and general field camp duties. Will assist in equipment and camp maintenance. Will work closely with Tahltan crew to fish in the most efficient manner possible.

II. Canadian Personnel Responsibilities

Ian Boyce, Stock Assessment Biologist. In concert with Troy Jaecks, Philip Richards, and Stephen Todd, will assist in all aspects of the program, including: tag application, tag recovery, and report preparation. Will be responsible for scheduling Canadian staff at both the tagging and recovery sites. Will participate in both the tagging and recovery component of the program. Will arrange and participate in meetings with Canadian, commercial, and Aboriginal fishers. Will provide recovery data to ADF&G. Will review data, provide input into report, write sections regarding recovery and serve as co-author.

Kyle Inkster, Tahltan Fisheries Technician. This position is responsible for supervising the other portion of the field tagging program. Will coordinate schedules with the ADF&G crew and share responsibility for all aspects of field operations, including safe operation of riverboats, and other equipment, tagging, data collection, and general field camp duties. Will assist in equipment and camp maintenance.

Drew Inkster, Tahltan Fisheries Technician. Will be responsible for assisting in all aspects of field operations, including safe operation of riverboats, and other equipment, tagging, data collection, and general field camp duties. Will assist in equipment and camp maintenance. Will work closely with ADF&G crew to fish in the most efficient manner possible.

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APPENDIX A

Appendix A1.–Gillnet effort recording form.

Location ___________________________ Date _______________ Page_______________

Water Temp________ at ________ Hr __ Water Depth____ _________ at ___ _____ Hr __

Water Comments ____________________ Weather Comments________________________

Gear Description ____________________Crew ___________________________________

Drift/ Set #	Start	Stop	Minutes Fished	Cumulative Minutes	Large (≥660 mm MEF) Chinook	Small-medium (<660 mm MEF) Chinook	Comments: other species, snags. Note, ad clips and Chinook caught but not tagged
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
Daily Totals							

Appendix A2.–Event 1: catch, tag, and age-sex-length form.

Location ________________________ Page______________________

Stream Code 108-41-012 Year_____________________

Species __________________________ Gear Type __________________

Cum Fish #	Date	Time Caught	Sex	Card #	Scale #	MEF	POH	Age FW	SW	AEC	Spag Tag #	Ad Clip	Cinch Tag #	Cond.	Comments: rel’d w/o LAA or ULOP? Note lice, scars, bleeding, morts
					1										
					2										
					3										
					4										
					5										
					6										
					7										
					8										
					9										
					10										

					1										
					2										
					3										
					4										
					5										
					6										
					7										
					8										
					9										
					10										

					1										
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					9										
					10										

					1										
					2										
					3										
					4										
					5										
					6										
					7										
					8										
					9										
					10										

Condition (Cond.): 1 = bright; 2 = slight coloration; 3 = obvious coloration and the onset of sexual dimorphism; 4 = same as 3 but gametes released upon capture

Appendix A3.–Catch-effort form.

RECORD AND PHONE IN DATA FROM SHADED CELLS

Date	ADFG, minutes	DFO, minutes	Total minutes	Total hours	Large Catch	Large Tagged	Cum Large Catch	Cum Large Tagged	Jack Catch	Jack Tagged	Cum Jack Catch	Cum Jack Tagged	Large CPUE

Appendix A4.–Chinook release data form.

Year: 2015 Page _____ of ______

Site: Kakwan Pt.

STAT WEEK	DATE	Large Chinook, ≥660 mm MEF			Small-Med. Chinook, <660 mm MEF		Comments (missing tags)
		Tag Count	Tags Out		Tag Count	Tags Out	
			Beginning Number	Ending Number		Tag Numbers	
18	May 1	K					
		S					
18	May 2	K					
		S					
19	May 3	K					
		S					
19	May 4	K					
		S					
19	May 5	K					
		S					
19	May 6	K					
		S					
19	May 7	K					
		S					
19	May 8	K					
		S					
19	May 9	K					
		S					
20	May 10	K					
		S					
20	May 11	K					
		S					
20	May 12	K					
		S					

Appendix A5.–Tissue sampling instructions from the Gene Conservation Laboratory.

Stikine River Chinook Salmon Genetic Collection Procedures

Non-lethal sampling of Finfish Tissue for DNA Analysis

ADF&G Gene Conservation Lab, Anchorage

I. General Information

We use axillary process samples from individual fish to determine the genetic characteristics and profile of a particular run or stock of fish. This is a non-lethal method of collecting tissue samples from adult fish for genetic analysis. The most important thing to remember in collecting samples is that **only quality tissue samples give quality results**. If sampling from carcasses: tissues need to be as "fresh" and as cold as possible and recently moribund, do not sample from fungal fins.

Sample preservative: Ethanol (ETOH) preserves tissues for later DNA extraction without having to store frozen tissues. Avoid extended contact with skin.

II. Sample procedure:

1. Tissue type: Axillary process, clip axillary process from each fish (see attached print out).
2. Data to record: Record each vial number to paired data information.
3. Prior to sampling, fill the tubes half way with ETOH from the squirt bottle. Fill only the tubes that you will use for a particular sampling period.
4. To avoid any excess water or fish slime in the vial, wipe the axillary process dry prior to sampling. Using the dog toe nail clipper or scissors, clip off axillary process (**1/2 -1" max**) to fit into the cryovial.
5. Place axillary process into ETOH. The tissue/ethanol ratio should be **slightly less than 1:3** to thoroughly soak the tissue in the buffer.
6. Top up tubes with ETOH and screw cap on securely. Invert tube twice to mix ETOH and tissue. Periodically, wipe the dog toe nail clippers or scissor blade so not to cross contaminate samples.

Discard remaining ethanol from the 500 ml bottle before returning samples. **Tissue samples must remain in 2 ml ethanol** after sampling. HAZ-MAT paperwork will be required for return shipment. Store vials containing tissues at cool or room temperature, away from heat in the white sample boxes provided. In the field: keep samples out of direct sun, rain and store capped vials in a dry, cool location. Freezing not required.

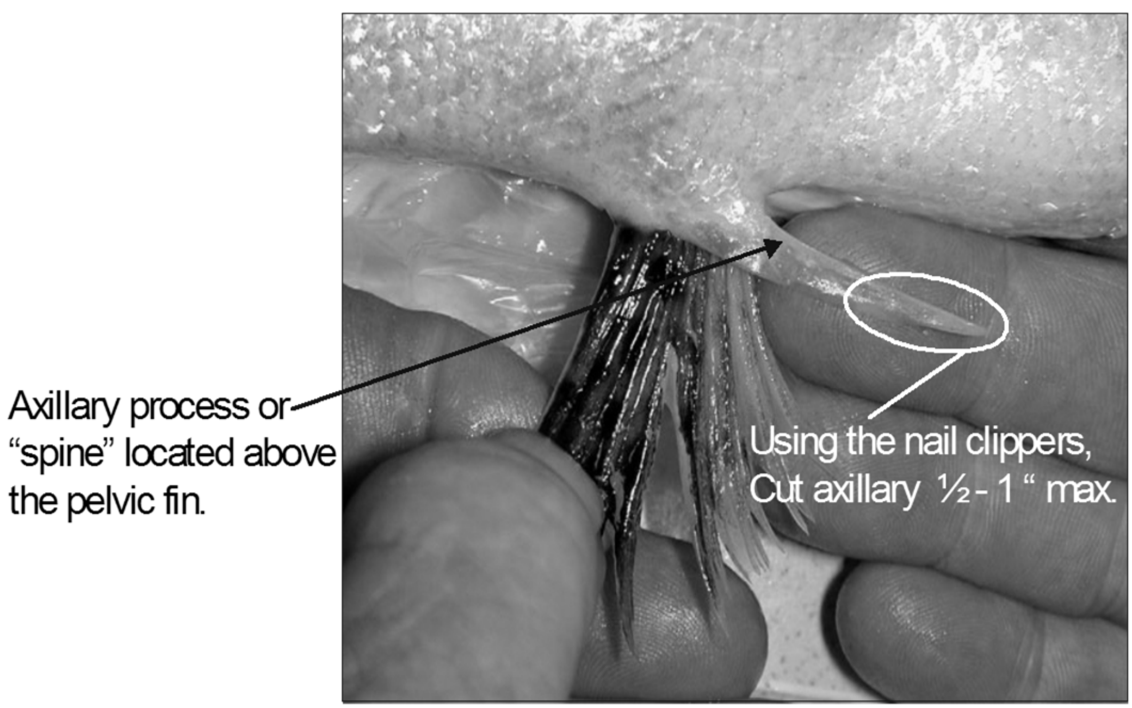
III. Supplies included with sampling kit:

1. (1) - Dog toe nail clipper - used for cutting the axillary process
2. (1) - Scissors can be used to cut a portion axillary process – if clippers don't work for your crew
3. Cryovial- a small (2 ml) plastic vial, pre-labeled.
4. Caps - with or without gasket to prevent evaporation of ETOH.
5. Cryovial rack- white plastic rack with holes for holding cryovials while sampling
6. Ethanol (ETOH) - in (2) 500 ml plus (1) - 125 ml Nalgen bottle
7. Squirt bottle - to fill or "top off" each cryovial with ETOH
8. Paper towels - use to blot any excess water or fish slime off axillary process
9. Printout of sampling instructions
10. (3) - three pair of lab gloves (size large)
11. Laminated "return address" label

IV. Shipping: HAZMAT paperwork is required for return shipment of these samples and is included in the kit.

<u>Ship samples to:</u> ADF&G - Genetics | Lab staff: 1-907-267-2247
333 Raspberry Road | Nick Decovich: 1-907-267-2239

Axillary process tissue for Genetic Stock Identification (GSI)



Appendix A6.–Event 2: inspection, recapture, and age-sex-length form.

Location ________________________ Page ________________________

Stream Cod________________________ Year ________________________

Species ________________________ Gear Type ___________________

Cum Fish #	Date	Sex	Card #	Scale #	MEF	POH	Age FW	Age SW	AEC	Spag Tag #	Ad Clip	Cinch Tag #	Cond.	Comments: LAA and/or ULOP present, **ULOP shape**?
				1										
				2										
				3										
				4										
				5										
				6										
				7										
				8										
				9										
				10										
				1										
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				9										
				10										

Condition (Cond.): PS = pre-spawn, LPS = live post-spawn, D = dead; Stream Code: Verrett River = 108-70-080, Little Tahltan R. = 108-80-120, Andrew Creek = 108-40-020,Stikine R. Fishwheels to Talbot (lower inriver TF/CF) = 108-70-0;

APPENDIX B

Appendix B1.–Detection of size or sex selective sampling during a 2-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 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), 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, comparing M and C, is 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 of second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C as described above, using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. When 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 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	Reject H_o

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

Case V		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered in Case V:

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 that have little potential to result in bias during estimation. *Proceed as for Case 1.*

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. May proceed as for *Case I* 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. May proceed as for *Case I* 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. May proceed as for *Cases I, II, or III* 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 then estimated within strata, and weighted by stratified Petersen abundances, to yield overall composition estimates (see 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 then estimated within strata, and weighted by stratified Petersen abundances, to yield overall composition estimates (see formulae below)

Case IV. 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, an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

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

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

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

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

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

$\hat{N}_\Sigma$ = $\sum_{i=1}^{j} \hat{N}_i$

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. –Mixing Test[a]

Area/time	Time/area where recaptured				Not recaptured
where marked	1	2	…	t	(n_1-m_2)
1					
2					
…					
s					

II.–Equal Proportions Test (SPAS terminology)[b]

	Area/time where examined			
	1	2	…	t
Marked (m_2)				
Unmarked (n_2-m_2)				

III.–Complete Mixing Test (SPAS terminology) [c]

	Area/time where marked			
	1	2	…	s
Recaptured (m_2)				
Not recaptured (n_1-m_2)				

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

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i\theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i. Note that failure to reject H_0 means the Pooled Petersen estimator can be considered consistent only if the degree of closure among tagging strata is constant ($\Sigma_j\theta_{ij} = \lambda$,) (Schwarz and Taylor 1998). One way this may be achieved is to sample all or the large majority of spawning areas.

[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.