Regional Operational Plan No. ROP.CF.1J.22.05

Tagging Response, Distribution, and Inriver Abundance of Taku River Sockeye Salmon, 2022 and 2023

by

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June 2022

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

REGIONAL OPERATIONAL PLAN NO. ROP.CF.1J.22.05

MIGRATION, TAGGING RESPONSE, DISTRIBUTION, AND INRIVER ABUNDANCE OF TAKU RIVER SOCKEYE SALMON, 2022 AND 2023

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SIGNATURE/TITLE PAGE

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Approval

Title	Name	Signature	Date
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PURPOSE

Estimates of the inriver abundance of Taku River sockeye salmon, *Oncorhynchus nerka*, are needed to assess the achievement of the spawning escapement goal and international harvest sharing arrangements for stocks specified by the U.S./Canada Pacific Salmon Treaty (Treaty). The Taku River capture-recapture project has been conducted annually since 1984 as a joint U.S./Canada program involving the Alaska Department of Fish and Game (ADF&G), Fisheries and Oceans Canada (DFO), and the Taku River Tlingit First Nation (TRTFN). The objectives of the studies are to provide estimates of the inriver abundance of Taku River sockeye salmon and to document biological characteristics (migratory timing, migratory rates, final fates, and age, sex, and size composition) of stocks. Sockeye salmon are captured via fish wheels at Canyon Island on the U.S. side of the border and the recapture consists of sampling (inspecting) sockeye salmon for tags above border in the Canadian commercial and assessment fisheries. Tagged-to-untagged ratios of salmon harvested in the Canadian inriver gillnet fisheries are used to develop the estimates of the inriver abundance of sockeye salmon.

Additionally, ADF&G, in cooperation with DFO and TRTFN, will continue a sockeye salmon radiotelemetry study on the Taku River to clarify recent insights into key assumptions of annual Taku River sockeye salmon capture–recapture studies that have potential to influence abundance estimates. An array of fixed towers throughout the drainage and fixed-wing aerial surveys will be used to track radiotagged sockeye salmon to determine final fates in the drainage, to determine annual fish dropout rates (defined as any fish tagged during event one at the Canyon Island fish wheels that did not cross the border and therefore was not available for recapture in event two of the capture–recapture project), and to estimate the proportion of mainstem and lake spawners.

OBJECTIVES

PRIMARY OBJECTIVES

Capture–Recapture Project

1. Estimate the postseason annual abundance of sockeye salmon (*Oncorhynchus nerka*; fish ≥ 350 mm measured from mid eye to tail fork (METF)) migrating upstream past the U.S./Canada border on the Taku River such that the estimate is within 20% of the true value 95% of the time.
2. On a weekly basis inseason, estimate current inriver abundance of sockeye salmon in the Canadian portion of the Taku River based on capture–recapture data.
3. On a weekly basis inseason, project annual abundance of sockeye salmon passage into the Canadian portion of the Taku River based on the current inriver estimate and historical migration timing data.
4. Estimate the annual age, length (METF), and sex composition of sockeye salmon caught in the Canyon Island fish wheels such that estimates are within 5% of the true proportion 95% of the time.

Radiotelemetry Project

1. Estimate the proportion of radiotagged fish that dropout of the capture–recapture study and determine, to the extent possible, the fate of these fish.
2. Estimate the annual stock composition of the fish wheel catch using genetic analysis of the radiotagged fish such that estimates are within 5% of the true population size 90% of the time.
3. Determine final fates of radiotagged fish that cross the border to determine likely spawning locations for Canadian-origin sockeye salmon using radiotelemetry.

SECONDARY OBJECTIVES

Capture–Recapture Project

1. Postseason estimate the age and cleithral arch to fork length (CAF) of sockeye salmon caught in the Canadian commercial fishery by statistical week.
2. Estimate the sex composition of pink salmon (*O. gorbuscha*) caught in the Canyon Island fish wheels.
3. Estimate the age and sex composition of chum salmon (*O. keta*) caught in the Canyon Island fish wheels.

Radiotelemetry Project

1. Use genetic stock composition to examine the radiotagged fish captured in the Canadian fishery.
2. Perform individual genetic assignment on all sockeye salmon captured and radiotagged at the fish wheels to determine genetic affinity with telemetry fates.
3. Examine the proportion of lake-type and river-type sockeye salmon in the Taku River using radiotelemetry data and genetic analysis of radiotagged fish.
4. Estimate the migratory timing profiles of sockeye salmon stocks in the Taku River from the point of radiotagging, at the Canyon Island fish wheels, to their final spawning destination.

BACKGROUND

Taku River sockeye salmon returning to spawn in British Columbia, Canada are harvested in marine waters of Southeast Alaska in the U.S. District 111 traditional commercial drift gillnet fishery in Stephens Passage and Taku Inlet. In the Taku River, the fish are also harvested by the U.S. personal use fishery and the Canadian commercial and First Nations fisheries (Figure 1). During the period 1985–2021, the annual average harvest of Taku River sockeye salmon was 102,300 fish, of which 77,400 fish were harvested in the U.S. District 111 fishery, 1,100 fish were harvested in the U.S. personal use fishery, 23,600 fish were harvested in the Canadian commercial fishery, and 200 fish were harvested in the Canadian First Nations fishery (TTC 2022).

The Taku River sockeye salmon stocks are managed as an aggregate under provisions of Chapter 1, Annex IV of the Pacific Salmon Treaty (PST) and are jointly managed by the Alaska Department of Fish and Game (ADF&G), Fisheries and Oceans Canada (DFO), and the Taku River Tlingit First Nation (TRTFN). The Pacific Salmon Commission, via the PST, commits Canada and the

U.S. to conservation and allocation obligations for salmon originating in the waters of the Canadian portion of the Taku River. The historical spawning escapement objective of 71,000 to 80,000 fish, with a point goal of 75,000 fish, was established in 1985 and was considered an "interim" objective since it was based on harvest and escapement data that were very limited at the time. For the 2019 fishing season, a revised "interim" escapement objective of 55,000 to 62,000 fish, with a management target of 59,000 fish, was established by the Transboundary Panel of the Pacific Salmon Commission (TTC 2019). The "interim" objective incorporated a 22% reduction to account for historical tag dropout rates observed through radiotelemetry studies completed in 1984, 2015, 2017 and 2018. These studies indicated that dropouts biased capture–recapture abundance estimates high (Bernard et al. 1999; Pestal et. al. 2020). In 2020, the escapement goal was replaced with a revised biological escapement goal of 40,000 to 75,000 fish (Miller and Pestal 2020) that was based on revised historical abundance estimates that were adjusted for size-selectivity of sampling gear and dropout of tagged fish (Pestal et. al 2020).

Annually since 1984, a joint U.S./Canada Taku River sockeye salmon stock assessment program, involving ADF&G, DFO, and TRTFN, has conducted a capture–recapture study to provide weekly abundance estimates of Canadian-origin Taku River sockeye salmon (Clark et al. 1986; McGregor and Clark 1987, 1988, 1989; McGregor et al. 1991; Boyce and Andel 2014; Pestal et. al 2020). Migrating adult salmon are captured with fish wheels, located on opposite riverbanks in the vicinity of Canyon Island on the downstream (U.S.) side of the U.S./Canada border (Figure 1), tagged, secondarily marked, and released. Tag recovery and secondary mark data are obtained from Canadian commercial and assessment gillnet fisheries. These gillnet fisheries involve both set and drift gillnets and occur on the upstream (Canada) side of the border with almost all harvest within 5 km of the border. Additional information on the distribution and abundance of discrete spawning stocks is collected at weirs at Little Trapper and Tatsamenie lakes (operated by DFO), and Kuthai and King Salmon lakes (operated by TRTFN).

A more comprehensive multi-year radiotelemetry study to assess tagged fish dropout rate, lake and mainstem spawning distribution, and migration rates was added to the Taku River stock assessment project beginning in 2019 and will continue at least through the 2022 season. Fish dropout was defined as any fish tagged during event one at the Canyon Island fish wheels that did not cross the U.S./Canada border and therefore was not available for recapture in event two of the capture–recapture project. Potential reasons for dropouts include tagged fish spawning below the border, tag loss through shedding of tags (regurgitation), and mortality of tagged fish due to predation or stress from capture and handling during the tagging event. A key assumption of capture–recapture is that the marked (tagged) fish behave similarly to unmarked fish and that tagged and untagged fish will experience the same mortality. Assessment of dropout rates is important, as unaccounted dropouts cause the capture–recapture abundance estimates to be biased high. For this study, fish tagged with spaghetti tags in capture–recapture studies are assumed to experience similar dropout rate to radiotagged fish. Previous radiotelemetry studies on Taku River sockeye salmon conducted in 1984 (Eiler et al. 1992), 2015, 2017, and 2018 have been used to assess dropout rates in the historical inriver run estimates (1984–2018) (Pestal et. al 2020). A radiotelemetry study was also conducted in 1986 (Eiler et al. 1992); however, since the study area included the upper Taku Inlet near the Taku Lodge, approximately 20 km from the border, it was not comparable to the capture–recapture study area.

Radiotelemetry studies conducted in 1984 and 1986 were the only studies conducted prior to 2019 that intentionally characterized the distribution of spawning sockeye salmon in the Taku River

(Eiler et al. 1992). All other drainagewide spawning distribution information has been acquired through related projects like weirs at the lakes and incidental tag recoveries from the capture–recapture study. Additional years of radiotelemetry studies were needed to properly define the spawning distribution and locations of sockeye salmon in the Taku River drainage. Therefore, studies conducted since 2019 have continued to assess the distribution of spawning sockeye salmon in the Taku River.

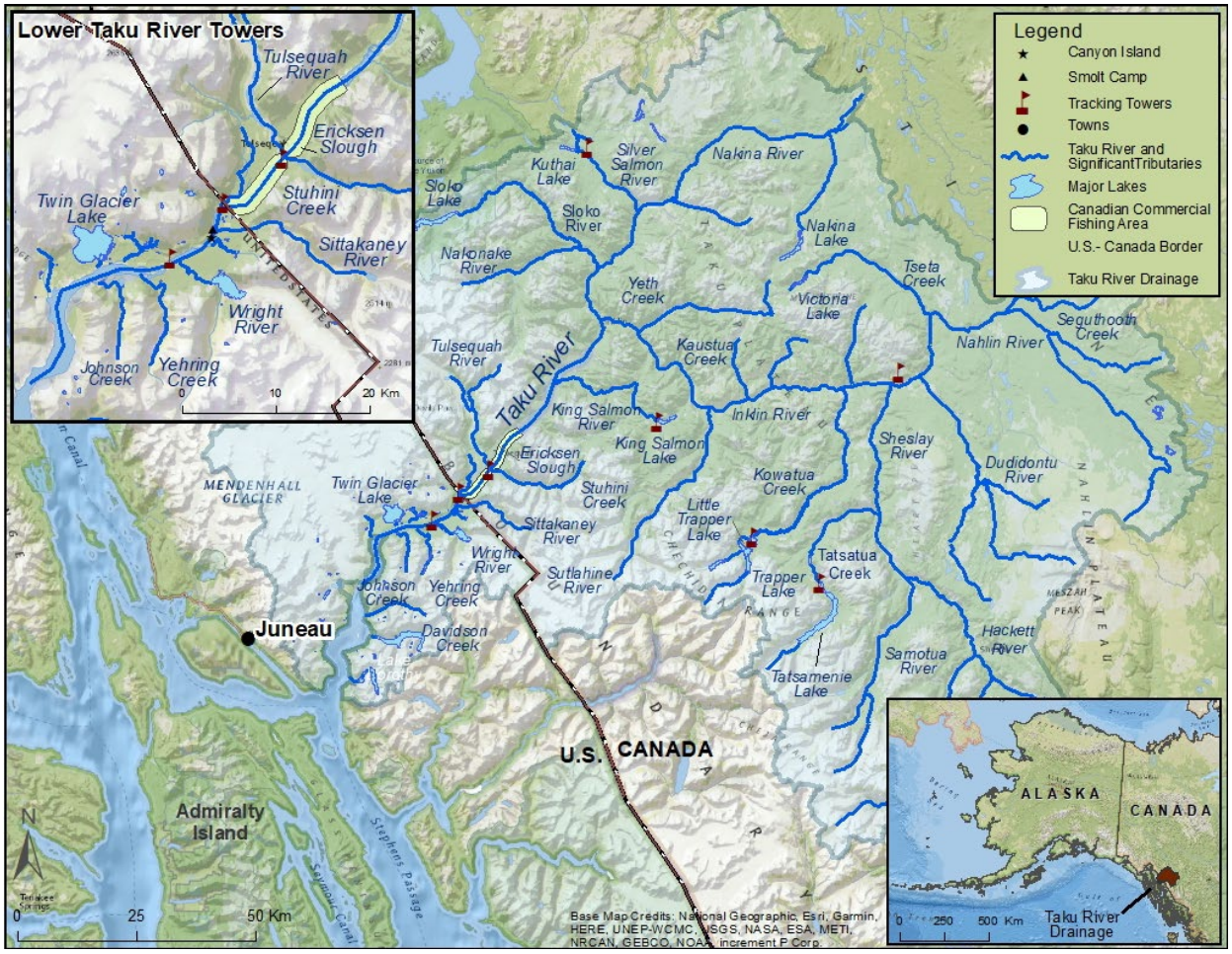

Figure 1.–Taku River drainage in Southeast Alaska and British Columbia identifying key landmarks, including the marking (Canyon Island) and recovery (Canadian fishery) locations of the capture–recapture experiment and radiotelemetry tracking towers.

STUDY SITE

The Taku River is a transboundary river system originating in the Stikine Plateau of northwestern British Columbia. The merging of two principal tributaries, the Inklin and Nakina rivers, approximately 50 km upstream from the border, forms the mainstem of the Taku River. The river flows southwest from this point through the Coast Mountain Range, eventually draining into Taku Inlet in Southeast Alaska, about 30 km northeast of Juneau (ADF&G Subdistrict 111-32) (Figure 1). A majority of the 17,000 km^2 Taku River watershed lies within Canada. The river produces one of the largest runs of sockeye salmon in northern British Columbia and Southeast Alaska, and sockeye salmon spawn throughout the drainage in both river and lake habitats.

The Taku River is glacially turbid with a large amount of seasonal variation in discharge. Water discharge in the winter (November–March) ranges from approximately 49 to 196 m^3/s at the U.S. Geological Survey water gauging station located on the lower Taku River near Canyon Island (USGS 2019a; 1988–2018). Discharge increases in April and May and reaches a maximum average flow of 890 to 1,000 m^3/s during June. Flow usually remains high in July, but drops to approximately 500 m^3/s in late August. Sudden increases in discharge in the lower river result from a Jökulhlaup; release of the glacially impounded waters along the Tulsequah Glacier (Kerr 1948; Marcus 1960). These floods usually occur once or twice a year between June and September. During the floods, water levels fluctuate dramatically, and the river carries a tremendous load of debris. From 1987 to 2018, the instantaneous peak flow was as high as 3,200 m^3/s (22 July 2007). From 1987 to 2003, a majority of the annual peak floods occurred in August (53%); from 2004 to 2018 only 2 annual peak floods occurred in August and a majority of the peaks occurred in July (53%) (USGS 2019b).

METHODS

FISH WHEELS

Sockeye salmon will be captured using two fish wheels in the lower Taku River. Fish wheels will be positioned in the vicinity of Canyon Island on opposite riverbanks, approximately 200 m apart. The Taku River channel at this location is ideal for fish wheel operation since the river is fully channelized through a relatively narrow canyon that has very steep walls. The fish wheels will be secured in position by anchoring to large trees with 0.95 cm steel cable and held out from, and parallel to, the shoreline by log booms. Each fish wheel consists of two aluminum pontoons, measuring approximately 12.2 m (length) × 0.8 m (width), filled with closed cell Styrofoam for flotation. The pontoons support a 5.2 m wide structure consisting of an adjustable height axle, two or three catch baskets, metal slides, and one live box that holds captured fish. The live boxes are 2.4 m (length) × 0.9 m (width) × 1.5 m (depth). The aluminum catch baskets are 3.0 m (width) × 3.7 m (depth), covered with nylon webbing (5.1 × 5.1 cm openings), and bolted to a metal axle that spins in a pillow-block bearing assembly. The fish-catching baskets are rotated about the axle by the force of the water current against the baskets and/or paddles. The fish wheel on river right (facing downstream) is labeled as fish wheel 1 and the fish wheel on river left is labeled as fish wheel 2. The fish wheels are constructed to be used as 2- or 3- basket wheels.

At the start of the season during high water discharge, the fish wheels will be operated in the 2-basket configuration to keep revolutions per minute (rpm) within the optimal range of 2.0 to 3.0 rpm. To adjust rpm as needed, when operated in the 2-basket configuration, heavy canvas or boards can be attached to or removed from the fish wheel uprights. The fish wheels will be switched to a 3-basket configuration when water discharge drops below that necessary to maintain fish wheel rpms. During extremely high discharge events, chain hoists are attached to the axles from the top of the stanchion and the baskets are hoisted out of the water to prevent damage due to excessive rpms or debris in the river.

Migrating salmon will be captured in the rotating baskets as they swim under the structure. Foam-padded metal slides are bolted to the rib midsection of each basket to direct fish through chutes into an aluminum live box, which is bolted to the outer side of a pontoon. The live boxes are perforated to allow constant flow of fresh river water. Sampling occurs directly from a boat, which is tied to the live boxes to allow immediate access to the fish. The sampling area on the boat includes a data station and a water-filled holding trough for fish.

The fish wheels will be deployed inriver on approximately 01 May, statistical week 19. The fish wheels will then be fished as continuously as possible for approximately 16 hours each day over two shifts (from 04:00 to 12:00 and 14:00 to 22:00), with each shift consisting of a crew of two or three people. The fish wheels will be shut down between shifts and started again when the next crew's shift begins (i.e., shut down from 22:00 to 04:00 and from 12:00 to 14:00). Shift work will start approximately within the first two weeks of June, statistical weeks 23 or 24, based on daily catches as indicated under Data Collection. Shift hours may be adjusted by the crew inseason to account for reductions in daylight after late June.

DATA COLLECTION

At the start of the season fish wheels will be checked frequently throughout the day. Once daily counts of total salmon reach about 50 per day, generally around the middle of June, fish wheel checks will transition to hourly checks to prevent overcrowding of fish in the live boxes. When fish are numerous, the crew will remain with the fish wheels during the entire shift to ensure holding times do not exceed one hour. The crew members will intermittently switch shifts (from AM to PM or PM to AM) throughout the season to minimize potential operational differences between crews. Sampling will be conducted consistently throughout the season (i.e., the crew should not change behavior during peak or low times).

Fish will be removed from the live boxes with a dip net and all salmon will be enumerated by species and recorded on the Taku Fish Wheel field sheet. Biological sampling will be conducted on Chinook, sockeye, chum, pink, and coho salmon caught in the fish wheels as outlined in the ASL Composition and individual species sections. Fish selected for sampling will be placed in a trough partially filled with fresh river water, processed, and carefully released back into the river. The spaghetti tagging and biological sampling procedures should take from 40 to 60 seconds per fish to complete. The fish will then be immediately and carefully released back into the river. Other information recorded daily at the fish wheels will include water temperature (°C), fish wheel rpm, and fish wheel start and stop times. River water level (decimal feet) will be measured daily at a gauging staff located on river right. Catch-per-unit-effort (CPUE) will be defined as the combined number of fish caught in the two fish wheels divided by the number of hours the two fish wheels are operated per day.

Age, Sex, and Length Composition

Scale samples from Chinook, coho, sockeye, and chum salmon will be collected from fish captured in the fish wheels (Appendix A). The length of each sampled fish will be measured to the nearest 5 mm METF. Sex will be determined from examination of external dimorphic sexual maturation characteristics, such as kype development, belly shape, and trunk depth. Sex and length data will be recorded either on tablets with the ADF&G Salmon Escapement ASL Mobile app or on standardized Age, Sex, Length (ASL) optical scan data forms. Both forms of entry will be matched with scale cards (Appendix B). Separate ASL forms will be used for sockeye, pink, and coho salmon that are sampled only for length and sex data, and which do not have associated scale samples; these forms will have a separate numbering sequence (Appendix B). The ASL data forms for all salmon species will be scanned and archived in the ADF&G Region 1 Commercial Fisheries Database.

Scale samples will be taken from the "preferred area," two scale rows above the lateral line on the left side of the fish on a diagonal downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963). All regenerated scales will be discarded. It is

critical that all scale cards are clean and dry, and all scales are properly oriented on the card. Scales need to be carefully cleaned of dirt, slime, and skin, then moistened and mounted on the gum card with the ridged side with grooves (rough outer side of the scale) facing out, and the anterior end (the end of the scale pointing toward the salmon's head when plucked) pointed toward the top of the scale card (Appendix C). Scales will then be pressed down so that they stick to the scale card. Scales will be collected from each fish and placed on gum cards at the rate of one fish per column. Depending on the required number of scales per, per salmon species (Appendix C), scales from the first fish will potentially cover row spaces 1, 11, 21, and 31 on the gum card. Room will be left at the top middle portion of the card to accommodate the label. It is important to keep the scale cards as dry as possible to prevent the gum (glue) from running and obscuring the scale ridges. The gum card will be filled out completely including the names of the samplers, species, card number, locality, and statistical area/stream code.

Scale samples will be analyzed at the Region I Scale Aging Laboratory in Douglas, Alaska. Scale impressions will be made in cellulose acetate and prepared for analysis as described by Clutter and Whitesel (1956). Scales will be examined under moderate (70×) magnification to determine age. Age classes will be designated by the European aging system where freshwater and saltwater years are separated by a period (e.g., an age-1.3 fish spent one year in the freshwater, three years in the ocean, and represents a 5-year-old fish; Koo 1962). The year spent in the gravel during egg incubation and hatching is not included in the European aging system.

Sockeye Salmon

All healthy sockeye salmon captured in fish wheels will be enumerated and sampled for sex and length and recorded on the ASL forms. Fish with deep wounds, damaged gills, or which are lethargic or in otherwise unhealthy condition will be enumerated then released without being sampled or tagged. Captured fish < 350 mm METF (defined as jacks) will be measured, but not tagged. All captured healthy sockeye salmon (≥ 350 mm METF) will be spaghetti tagged as part of the annual capture–recapture project. The fish will be tagged with spaghetti tags (Floy Tag and Manufacturing Inc., Seattle, WA) made of hollow fluorescent orange PVC tubing (approximately 2.0 mm in diameter and 30 cm in length) that are consecutively numbered and labeled with project description information. The fish wheel associated with the capture of fish will be documented in the code type section on the ASL form as either 1 or 2 followed by the 5-digit spaghetti tag number.

To apply the spaghetti tags to sockeye salmon, one person will hold the fish in the tagging trough while a second person inserts a 15 cm applicator needle with attached spaghetti tag through the dorsal musculature at the base of the dorsal fin. The ends of the spaghetti tag will be knotted together with a single overhand hitch and cinched tight to the fish's back. To reduce tag-induced mortality, fish will be handled carefully, and every effort will be made to limit handling time.

To assess tag loss (along with tag hole/scar) and genetic stock composition at the fish wheels, the left axillary appendage will be removed from all spaghetti tagged fish and placed in a daily bulk bottle with EtOH (one bottle per day). Samples will later be transferred to Whatman filter paper cards for dry preservation (Appendix D). All left axillary appendages from radiotagged fish will be placed in individual vials to acquire a matched (i.e., ASL/genetic) sample for the radiotagged fish. Genetic tissue samples will be shipped to the ADF&G Gene Conservation Laboratory in Anchorage for analysis and will be shared with Canada as requested.

In addition, every 5th healthy sockeye salmon ≥ 350 mm METF irrespective of sex or size will be sampled for matched scales and METF length, CAF length (Appendix E), the left axillary

appendage (removed and stored in individual vials) and will be radiotagged. To maintain matched sampling and radiotagging in proportion to the run, the rate of sampling will be assessed throughout the season and adjustments made if it seems too few or too many matched samples are being taken.

Chum Salmon

All chum salmon will be sampled for sex, scales, and length, and data will be recorded on the ASL form.

Pink Salmon

The daily sampling goal for pink salmon is 25 fish; these fish will be sampled for sex and length, and data will be recorded on the ASL form.

Chinook Salmon

A capture–recapture study to estimate the number of Chinook salmon that migrate past the Canyon Island fish wheels will be conducted as described by Williams et al. (*In prep* a). All healthy Chinook salmon captured in the fish wheels will be tagged as part of the capture–recapture project, sampled for ASL, and examined for the presence/absence of an adipose clip. All male Chinook salmon missing an adipose fin will be sacrificed; the heads will be recovered, labelled with a uniquely numbered head cinch strap, and sent to the ADF&G Mark, Tag, and Age Laboratory for coded wire tag removal and decoding. All female Chinook salmon missing an adipose fin will be tested with a wand-type metal detector for the presence/absence of a coded wire tag and recorded accordingly.

Coho Salmon

A capture–recapture study to estimate the number of coho salmon returning past the Canyon Island fish wheels will be conducted as described by Williams et al. (*In prep* b). All coho salmon (≥ 350 mm METF) captured in the fish wheels will be spaghetti tagged as part of the adult capture–recapture project and sampled for sex, length, and the presence/absence of an adipose fin. For coho salmon ≥ 350 mm METF, every 4th fish will be sampled for scales and every 10th fish that is healthy will be radiotagged. The radio tagging rate will be assessed throughout the season and adjustments made if it seems too few or too many radio tags are being deployed. A total of 200 coho salmon ≥ 350 mm METF will be radiotagged in proportion to the run. All fish missing an adipose fin will be sacrificed; the heads will be recovered, labelled with a uniquely numbered head cinch strap, and sent to the ADF&G Mark, Tag, and Age Laboratory for coded wire tag removal and decoding.

RADIOTELEMETRY PROJECT

In conjunction with the spaghetti tags, a portion of the sockeye salmon captured during this study will also be tagged with radio transmitters. Radiotelemetry of salmon is the preferred method to determine spawning distribution of river stocks (Eiler 1995; Koehn 2000; Reine 2005). This project's methods are similar to radiotelemetry studies that have been implemented by ADF&G on the Susitna River drainage for sockeye salmon (Yanusz et al. 2007 and 2011) and on the Taku and Stikine rivers for Chinook salmon (Richards et al. 2016a and 2016b). Internal pulse-coded radio tags manufactured by Advanced Telemetry Systems (ATS^{TM}) will be placed in a subset of sockeye salmon that are handled and marked in conjunction with the spaghetti tagged sockeye salmon capture–recapture project. The radio tags will be 52 mm long, 19 mm in diameter, 22 g in mass, have a 30 cm external whip antenna, a terminal battery life of 115 d, and operate on several

frequencies within the 150.000–152.999 MHz range. Seven frequencies will have up to 100 pulse codes each, resulting in a potential deployment of 700 uniquely identifiable radio tags. Each radio tag will be equipped with a mortality indicator mode that activates when the radio tag is motionless for approximately 24 h. Radio tags will be inserted through the esophagus and into the upper stomach of the fish using a 1.0 cm (outside diameter), 30 cm long plastic tube. The antenna of the radio tag will be threaded through the tube and pinched by hand at the end of the tube, such that the radio transmitter is held tightly against the opposite end of the tube. The plastic tube will be marked with reference points to assist in proper tag insertion depths based on the size of the fish. Resistance felt during tag insertion will be the most useful indicator, and the esophagus will be visually inspected to ensure none of the radio tag body is visible.

The rate of deployment of the radio tags will be determined by the total number of radio tags allotted for the season, the 2019–2021 weekly proportional CPUE at the fish wheels, the 2021 postseason abundance estimate, and the preseason forecast for the upcoming season (Table 1, 2022 preseason forecast of 128,000). This plan assumes 640 radio tags will be allocated for the season. The ultimate goal is to apply the radio tags proportionally throughout the run while using all 640 tags. The radio tagging rate will be assessed throughout the season and adjustments made if it seems too few or too many tags are being deployed daily. Movements of radiotagged fish will be monitored from time of release by a combination of twice weekly aerial surveys and eight stationary radiotelemetry tracking towers (towers) located throughout the drainage (Figure 1).

Table 1.–The sampling goal for radio tags is 640 sockeye salmon and the seasonal goal for matched biological sampling of scales, tissues, and paired METF/CAF lengths is 640 sockeye salmon. The proposed weekly tagging rate of sockeye salmon for the radio tagging project during the 2022 season (1 in 5 fish sampled) will be based on the proportion of 2019–2021 weekly CPUE (fish/hour) at the fish wheels in statistical weeks 21 through 40 and a projected fish wheel catch of 3,562 fish.

		Weekly				Cumulative			
		Expected		Goal		Expected		Goal	
Statistical week	Start date	CPUE	Catch	Radio	Scale/length sampling	CPUE	Catch	Radio	Scale/length sampling
21	15-May	0.00	0	0	0	0.00	0	0	0
22	22-May	0.00	0	0	0	0.00	0	0	0
23	29-May	0.00	0	0	0	0.00	0	0	0
24	5-Jun	0.00	7	1	1	0.00	7	1	1
25	12-Jun	0.01	29	5	5	0.01	36	6	6
26	19-Jun	0.02	78	14	14	0.03	114	20	20
27	26-Jun	0.08	269	48	48	0.11	383	68	68
28	3-Jul	0.08	279	50	50	0.19	662	118	118
29	10-Jul	0.13	453	81	81	0.31	1,115	199	199
30	17-Jul	0.17	592	106	106	0.48	1,707	305	305
31	24-Jul	0.19	665	120	120	0.67	2,372	425	425
32	31-Jul	0.13	470	85	85	0.80	2,842	510	510
33	7-Aug	0.06	220	40	40	0.86	3,062	550	550
34	14-Aug	0.08	268	48	48	0.93	3,330	598	598
35	21-Aug	0.03	115	21	21	0.97	3,445	619	619
36	28-Aug	0.02	85	15	15	0.99	3,530	634	634
37	4-Sep	0.01	28	5	5	1.00	3,558	639	639
38	11-Sep	0.00	4	1	1	1.00	3,562	640	640
39	18-Sep	0.00	0	0	0	1.00	3,562	640	640
40	25-Sep	0.00	0	0	0	1.00	3,562	640	640
Totals:		1.00	3,562	640	640				

TAG RECOVERY AND FINAL FATES

Aerial Telemetry Surveys

Fixed-wing aerial surveys will be flown to track radiotagged sockeye salmon to determine their final fate locations, where they presumably spawn, and to calculate the dropout rate of fish radiotagged at the fish wheels. Weekly, two aerial surveys in fixed wing aircraft will be conducted starting around 1 July through the end of September: one survey on the east side (Inklin River drainage) and one survey on the west side (Nakina River drainage). Surveys will be conducted on the mainstem Taku River and the major spawning tributaries as well as those previously identified by Eiler et al. (1988, 1992). An antenna will be mounted to the side of the aircraft and an ATS R4520 receiver with internal GPS receiver will be used during the surveys to record the location of each fish. The date and time of decoding, and the frequency, pulse code, latitude and longitude, signal strength, and activity status of each decoded transmitter will be automatically recorded by the receiver. A handheld GPS will also be used to track the aerial survey flight route. An aerial

survey sheet will be completed for each survey and will include date, time of flight (start and end time), surveyor, weather, general flight path (based on handheld GPS), name of file downloaded, and a brief description of the survey. After each survey is completed, a preliminary map of survey points will be created for detection of possible errors.

Fixed Telemetry Towers

The fixed telemetry towers (hereafter referred to as towers) will mainly be used to confirm detection of radiotagged fish that are not detected in aerial surveys and to provide information on migratory timing to the lake sites. Eight towers will be used on the Taku River to record movements (upstream or downstream passage) of radiotagged fish (Figure 1). One tower will be placed below the marking site, one between the marking site and the Canadian assessment/commercial fishery (at the border), one above the main Canadian assessment/commercial fishery (Tulsequah) and one near the Nahlin River sonar site. Towers will also be placed at the outlets of the four lake systems with weirs (Tatsamenie, King Salmon, Little Trapper, Kuthai lakes). The tower downstream of the tagging site will be used to estimate the emigration rate of radiotagged sockeye salmon from the study area. The upstream towers will be used to estimate immigration rates into Canada.

The towers will be constructed and operated as described by Eiler (1995), except that they will not have satellite up-link capabilities (also see Richards et al. 2016a). Each tower will consist of an ATS R4500C integrated receiver and data logger, two directional Yagi antennae (one aimed upstream and one aimed downstream), a solar panel, and battery power system. The towers will be strategically placed to afford the antennae unobstructed downstream and upstream views. Radiotagged fish within reception range of the towers will be uniquely identified by radio frequency and recorded on the data logger. The detection range of each tower will be verified by placing test radio tags in the water column through likely migration routes and observing preliminary data results. The towers will record date and time that each radio tag is detected, the antenna that detected the tag (upstream, downstream, or both combined), the signal strength, and the activity pattern (active or inactive) of the radio tag. The towers will be programmed to record data every 60 minutes. The location of each radio tag relative to the tower (upriver or downriver from the site) will be deduced by comparing the upstream and downstream antenna signal strengths. A reference radio tag placed near each tower will verify that the tower components are functioning properly and to identify if/when the tower stops working. Depending on the tower's location and accessibility, the tower will be checked from weekly to approximately every three weeks and data will be downloaded from the receivers via a laptop computer and copied onto a separate external hard drive. A logbook will be maintained at each tower noting date, staff, settings, and battery voltage for each visit. A checklist with radio receiver settings and the download steps will also be stored at each site. Inseason, downloaded data will be checked for preliminary fates and possible data errors.

The final fates of all radiotagged sockeye salmon will be determined and categorized following the completion and processing of all aerial survey data (Table 2). Fates will be determined based on the highest signal strength (signal strength of 120 dBm or above) recorded along the fish's route and maximum upstream location based on aerial surveys. Lake tower data will be used to verify the radiotagged fish that were detected at the lakes. River towers will be used to provide data on radiotagged fish not detected in aerial surveys. Final fate location will be then be used to assign each fish to one of the general spawning locations corresponding to genetic stock reporting groups as described in Table 3 (Appendix F).

Table 2.–List of possible fate for radiotagged sockeye salmon on the Taku River.

Fate description
Never located, unknown fate
Never passed the border, regurgitated tag/died
Never passed the border, was recovered in a U.S. fishery
Passed the border, unknown fate
Passed the border, captured in the Canadian inriver fishery
Passed the border, tracked to a probable spawning location

Table 3.– Sockeye salmon reporting groups for genetic stock composition of river and lake stocks for the Taku River.

Taku Lakes	Taku/Stikine Mainstem River	Non-Taku/Stikine stocks
Tatsamenie Lake	Nahlin River	Others
Little Trapper Lake	Tatsatua Lake	
Kuthai Lake	Mainstem	
King Salmon Lake		

Dropout

A dropout is defined as a radiotagged fish that did not migrate above the U.S./Canada border. Based on the final fates of the radiotagged fish, the proportion of fish that dropout of the study will be determined by dividing the total number of fish that did not cross the U.S./Canada border by the total number of fish, excluding any fish with a fate description of 'Never located, unknown fate.'

Canadian Fisheries

Tag recovery and secondary mark data will be obtained daily from the Canadian commercial fishery and any DFO assessment fisheries. A directed sockeye salmon fishery is anticipated to occur from about 28 June to 15 August, after which time directed fishing effort will shift to coho salmon. Weekly commercial fishing periods may range from one to seven days. It is anticipated that commercial fishing effort will be minimal by mid-September, and it may be necessary to conduct an assessment fishery to continue to estimate the abundance of coho salmon (Williams et al. in prep. b). A small number of sockeye salmon may still be present at this time.

Commercial license conditions stipulate that both spaghetti and radio tags recovered from harvested sockeye salmon must be submitted to DFO personnel daily. Harvest statistics, secondary mark data, and tag information will be collected daily by DFO personnel based at Ericksen Slough and reported to the Whitehorse office. This information will be forwarded by the Whitehorse DFO office to the ADF&G office in Douglas via email. Approximately 200 fish per week will be randomly sampled at the Canadian landing stations for matched age (five scales per fish), genetics and CAF lengths (fish are landed headless and gutted rendering METF lengths and sex unavailable), as well as inspected for tagging scars and secondary marks. Spaghetti tags are removed by fishermen prior to landing but spaghetti tagged fish are identifiable by the presence of entrance and exit holes below the dorsal fin along with an excised left axillary appendage. Inspection of fish for these marks by the DFO crew will identify if there is loss or nonreporting of

spaghetti tags. Weekly sampling effort will be spread out over commercial fishery openings to the extent practical and will be conducted at various landing stations. ADF&G staff will also recover small numbers of spaghetti tags from the U.S. inriver personal use fishery and the District 111 commercial drift gillnet fishery downriver from the fish wheels. These tags are not removed from the analysis because they comprise part of the dropout reduction that is applied to marks deployed during the estimate.

The DFO staff will also collect 192 otolith samples per week to inform wild and enhanced sockeye salmon ratios. Although the fish biologically sampled (age, length, genetics, mark inspection) are landed headless and gutted, fishermen save removed heads in buckets for later otolith extraction. Unfortunately, it is not possible to match these heads (otolith samples) with the other biological samples. The heads are collected across fishery openings in proportion to the run as much as possible. Genetic samples will be analyzed at the Molecular Genetics Lab in Nanaimo, BC, and otolith samples will be delivered to Canyon Island weekly for analysis at the ADF&G Mark, Tag, and Age Laboratory by the following statistical week.

Observations and recoveries of spaghetti tagged fish will also be made at weirs located at the outlets of Little Trapper, Tatsamenie, Kuthai, and King Salmon Lakes. Fish sampled for ASL will also be inspected for tag loss (e.g., tagging scars or secondary marks). Additional recoveries may be made during escapement sampling activities directed at Chinook or sockeye salmon at the Nakina, Nahlin, and Tatsatua rivers, and in the mainstem Taku River. Tag recoveries at the weirs and during escapement sampling activities will be used for migratory timing estimates. To date, these data have not been used in formal capture–recapture population estimates, but they do provide insight into the fishery-based capture–recapture project with respect to proportionality of marking across stocks.

Sample Sizes and Statistical Methods

CAPTURE–RECAPTURE PROJECTS

Two-event capture–recapture studies for a closed population (Seber 1982) will be used to estimate the abundance of Taku River sockeye salmon. Sockeye salmon will be marked at the fish wheels with a spaghetti tag in the first sampling event (capture) and then sampled from the inriver commercial fishery and any assessment fisheries in the second sampling event (recapture).

The general assumptions that must be met for a capture–recapture estimate to be suitable are (Seber 1982, pg. 59):

1. all adults have an equal probability of being marked (tagged) or all adults have an equal probability of being sampled for marks;

2. there is no recruitment or emigration to the population between the fish wheels and the sampling sites upstream (i.e., the population is closed) and the rate of death of tagged and untagged fish is the same;

3. there is no tag loss due to shedding, misidentification, or nonreporting; and

4. there are no tagging effects (i.e., tagging does not affect the fate, behavior, or mortality of a fish).

These four assumptions were extensively tested for Taku River sockeye salmon using a variety of diagnostic tools and capture–recapture data from 1984 through 2018 (Pestal et al. 2020) and

potential issues were addressed. Assumption one should be met if tagging at the fish wheels occurs in proportion to abundance during immigration; all healthy sockeye salmon ≥ 350 mm METF will be spaghetti tagged. Recruitment of untagged fish into the population after tagging at the fish wheels is highly unlikely (assumption two) as tagging will continue until few or no sockeye salmon are captured at the fish wheels. Although tag loss (assumption three) has been shown to be negligible because of the close proximity of the fishery to the fish wheels (Pestal et al. 2020), 200 fish/week will continue to be inspected for secondary marks (i.e., spaghetti-tagging needle marks and missing left axillary appendages) at Canadian fisheries landing stations. The proportion of secondary marks observed in the commercial and assessment fisheries samples will then be compared to spaghetti-tag recovery rates to determine if tag shedding or nonreporting has occurred. It is assumed that tagged and untagged fish will experience the same mortality, and tagging will not affect the fate or behavior of the fish (assumption four).

Based on the results of radiotelemetry studies, dropout rates (assumption two) are likely a source of major bias and the capture–recapture abundance estimates need to be adjusted to account for it (Pestal et al. 2020; Vinzant et al. *In prep a* and Vinzant et al. *In prep b*). For unknown reasons, there were high radio tag dropout rates observed in 1984 (20.4%; 19/93; Eiler et al. 1992), 2015 (17.2%; 17/99; Pestal et al. 2020), and 2017 (32.1%; 89/277; Pestal et al. 2020), but extended fish holding time might be an explanation as fish were often held in live boxes for up to 12 hours before being sampled. Other studies have documented adverse effects on fish captured and handled in fish wheels with extended holding times (Bromaghin and Underwood 2003; Cleary 2003; Underwood et al. 2004; Bromaghin et al. 2007; Liller et al. 2011). Therefore, fish holding time at the fish wheels was modified beginning with the 2018 season. The intent of the revised method was to reduce fish holding time in the fish wheel live boxes to less than one hour. Also, from 2018 to 2021, a study was conducted to compare the dropout rates of radiotagged fish that experienced reduced holding times with radiotagged fish held in live boxes for a longer period (i.e., similar to holding times used historically; Bednarski et al. 2020). After four years (2018–2021), this comparison study will not be continued moving forward, and the revised method of fish holding time, (i.e., fish holding time not to exceed one hour in the fish wheel live boxes) will be used. The revised method should reduce dropout rate (but not eliminate it); therefore, the inriver capture–-recapture abundance estimate will continue to be adjusted by a bilaterally agreed-upon dropout rate to account for this bias.

If a population of 97,500 fish (based on the 20-year, 2002–2021 average wild and enhanced escapement) is marked in event one at a rate of 2% (or 1,950 marks; the average number of fish tagged at the fish wheels from 2012 to 2021 was 4,300 fish), 16,047 fish would need to be inspected for marks in event two to provide a postseason capture–recapture estimate with a 0.95 probability that the estimate will not differ from the true population size by more than 10% (Robson and Regier 1964). The 20-year (2002–2021) average Canadian commercial harvest is 22,600 fish. Therefore, if a Canadian fishery is prosecuted similarly to an average year, the number of fish inspected should easily exceed the statistical requirement of 16,047 fish for event two.

Inseason Abundance Estimates

After event two begins (usually around statistical week 27), sockeye salmon inriver abundance estimates will be generated inseason on a weekly basis by Thursday at noon. Inriver abundance estimates will be calculated by ADF&G personnel in Douglas and/or by DFO personnel in Whitehorse. Spaghetti-tag release and recovery data will be organized by statistical week and date for analysis. Statistical weeks begin at 00:01 AM Sunday and end the following Saturday at

midnight, and weeks are numbered sequentially beginning with the week encompassing the first Saturday in January. Weekly abundance estimates will be the Bayesian time-stratified Petersen abundance estimate. If the Bayesian estimate does not converge, most likely due to limited data at the start of the fishing season, and if at least one of the conditions ("equal proportions" or "complete mixing") is satisfied (failure to reject the null hypothesis; $P > 0.05$; Appendix H) for data up through the forecasted statistical week, the pooled Petersen estimate may be used as a secondary estimate. These conditions state that the expected ratio of marked to unmarked individuals is constant across all recovery strata due to similar migration patterns (equal proportions) and the expected ratio of marked to unmarked individuals is constant across all marking strata because of tagging in proportion to the run (complete mixing). Chi-square tests will be used to evaluate the "equal proportions" and "complete mixing" conditions inseason (Appendix H). Within the analysis, the weekly abundance estimate N will then be adjusted by a preseason, bilaterally-agreed upon dropout rate d by,

$$N_{adj} = N(1 - d). \quad (1)$$

Prior to the season each year, a bilaterally-agreed upon dropout rate will be implemented for the inseason abundance estimates. The protocol for the 2019 to 2021 season was to model the year-to-year variation in dropout (including sampling uncertainty) as binomial (i.e., $d = x/n$); n = number of fish and x = number of fish that dropped out; Pestal et al. 2020). The protocol for the 2019 season was to use a 22% dropout rate determined from historical dropout rates observed through radiotelemetry studies conducted in 1984, 2015, 2017, and 2018 (TTC 2019). Therefore, the inputs for the 2019 season were $n = 50$ and $x = 11$, resulting in a mean dropout rate of 22%. The protocol for the 2020 season was to use the 2019 radio telemetry dropout rate combined with the average difference between the size selectivity estimates from 2003 to 2018 and the pooled Petersen estimates from 2003 to 2018 (size-stratified estimate was about 6.4% smaller on average; Pestal et al. 2020). Therefore, the inputs for the 2020 season were $n = 50$ and $x = 11$, resulting in a mean dropout/size selectivity rate of 22%. The protocol for the 2021 season was to use the 2020 radio telemetry dropout rate combined with the average difference between the size selectivity estimates from 2016 to 2020 and the pooled Petersen estimates from 2016 to 2020 (size-stratified estimates were about 3% smaller on average). Therefore, the inputs for the 2021 season were $n = 52$ and $x = 11$, resulting in a mean dropout/size selectivity rate of 21%. The weekly inriver abundance estimate, N, is adjusted by the dropout rate within the analysis (equation 1). These weekly inriver abundance estimates will be projected to terminal inseason run sizes using historical U.S. District 111 harvest and CPUE data along with run timing at the Canyon Island fish wheels (TTC 2019).

Postseason Abundance Estimates

Size differences between fish caught and tagged at the fish wheels (event one) and fish harvested in the Canadian commercial fishery (event two) can vary drastically between years, and can produce a substantial size bias in the unadjusted estimate for some years (Pestal et al. 2020). Fish wheels are assumed to be unbiased and to capture sockeye salmon of all sizes, adequately representing the true size distribution of the population. The size of sockeye salmon harvested in the Canadian commercial fishery (and the subsequent tagged recoveries in the fishery) is dependent on gear selectivity and there is a tendency of commercial gillnets to capture larger-sized fish compared to the fish wheels. These differences in fish size (between releases and recoveries) are more pronounced in years with smaller-sized fish (e.g., 2014, 2018, 2020 and 2021). Therefore, based on the Taku sockeye salmon stock assessment program review, it was recommended that a

size-stratified estimate of inriver abundance be considered postseason (Pestal et al. 2020; Appendix I).

Size-stratified pooled Petersen abundance estimate

To calculate a size-stratified pooled Petersen estimate, the capture and recapture data sets will be split at the length where the KS test statistic of length distribution of captured fish (at the fish wheels in event one) versus the length distribution of recaptured fish (tagged fish recovered in the Canadian commercial harvest in event two) is maximized (Appendix G). This maximizes the difference in capture probability of the two length strata. For example, if the KS statistic (i.e., absolute difference in cumulative proportions of captured/released fish at the fish wheels and of recaptured fish) is largest at 510 mm METF length, then the capture data (at the fish wheels) and recapture data (from the Canadian commercial harvest) would be split at 509 mm METF length and smaller for the small fish, and split at 510 mm METF length and greater for the large fish.

Unlike the fish wheels where every fish tagged is measured for METF length, fish sampled from the harvest in the Canadian commercial fishery are measured CAF length because fish are landed with their heads removed. The CAF lengths must first be converted to METF lengths (see Cleithral Arch to Fork Length Measurement Conversion section) to standardize length. These length samples from the Canadian commercial fishery will be used to represent the length distribution of the entire Canadian commercial fishery harvest, since not every fish harvested is sampled. For example, if 24% of the sample data (converted METF lengths) from the Canadian commercial fishery harvest are small fish (based on splitting the data into large and small using the KS statistic) and the total harvest is 20,000 fish, then an estimated 4,800 fish would be small fish and 15,200 fish would be large fish. The inputs for the size-stratified pooled Petersen estimate for the small fish data set (for example) are:

n_{1S} = number of small fish tagged and released at the Canyon Island fish wheels (first sample; event one);

m_{2S} = number of small fish from n_{1S} that are recaptured in the Canadian commercial harvest (i.e., tagged recoveries in event two); and

u_{2S} = number of unmarked (nontagged) small fish in the Canadian commercial harvest where

$$u_{2S} = n_{2S} - m_{2S} \tag{2}$$

and n_{2S} is number of small fish in the Canadian commercial harvest; $n_{2S} = n_2 p$ (4,800 fish from the example above). The variable p is the proportion of the observed size distribution in the samples from the Canadian commercial harvest that are 'small' fish (24% from the example above), and n_2 (event two) is the total commercial harvest. The inputs for the large data set are similar n_{1L}, m_{2L}, and u_{2L}, but the data set is large fish rather than small fish and $n_{2L} = n_2(1-p)$ and $u_{2L} = n_{2L} - m_{2L}$. Separate pooled Petersen estimates will be calculated for each data set (i.e., large fish (N_L) and small fish (N_S)), the estimates will be adjusted separately by the dropout rate using equation 1, and then the two estimates will be added together for an estimate of the total abundance (i.e., $N_{LS_{\text{adj}}} = N_{L_{\text{adj}}} + N_{S_{\text{adj}}}$; the size-stratified pooled Petersen abundance estimate). The applied dropout rate (equation 1) will be based on the most current radiotelemetry study results or a bilaterally-agreed upon dropout rate based on prior radiotelemetry studies. Variances of the adjusted abundance estimates will also be summed,

$$SD_{LS_{\text{adj}}} = \sqrt{SD^2_{L_{\text{adj}}} + SD^2_{S_{\text{adj}}}}, \quad (3)$$

and the lower and upper 95% confidence interval for the size-stratified pooled Petersen estimate will be calculated as

$$N_{LS_{\text{adj}}} \pm (1.96 \times SD_{LS_{\text{adj}}}). \quad (4)$$

Bayesian size- and time-stratified Petersen abundance estimate

The Bayesian size- and time-stratified Petersen abundance estimate will be calculated with a similar approach as the size-stratified pooled Petersen estimate (i.e., a Bayesian time-stratified estimate is run for 'large' fish and a Bayesian time-stratified estimate is run for 'small' fish based on splitting the fish using the KS test, these two estimates are adjusted separately by a bilaterally-agreed upon dropout rate, and then the two mean (adjusted) estimates are summed). Variances from the two adjusted estimates will also be summed,

$$SD_{LS_{\text{Bayesian(adj)}}} = \sqrt{SD^2_{L_{\text{Bayesian(adj)}}} + SD^2_{S_{\text{Bayesian(adj)}}}}, \quad (5)$$

and the lower and upper 95% credible interval for the Bayesian size- and time- stratified abundance estimate will be calculated as

$$N_{LS_{\text{Bayesian(adj)}}} \pm (1.96 \times SD_{LS_{\text{Bayesian(adj)}}}). \quad (6)$$

Analysis of Inriver Abundance Estimates

To generate inseason and postseason sockeye salmon inriver abundance estimates and projections (TTC 2019), capture–recapture data will be analyzed within the R environment[1] using the Bayesian Time Stratified Population Analysis System (BTSPAS) package with custom extensions (Schwarz 2006; Schwarz et al. 2009; Bonner and Schwarz 2020). The Bayesian version of the time-stratified Petersen estimate extrapolates a run timing curve from the tag data and computes abundance based on that. Details are available in Schwarz et al. (2009, Sec. 3.4), Schwarz (2006), and Pestal et al. (2020). To calculate any pooled Petersen estimates, the *SimplePetersenMod* function is used, which is a wrapper for the *SimplePetersen* function from the BTSPAS package with custom extensions (Schwarz 2006; Schwarz et al. 2009; Bonner and Schwarz 2020). The "complete mixing" test is automatically implemented in the BTSPAS package, but the "equal proportions" test must be implemented separately in a program such as the Stratified Population Analysis System (SPAS; Arnason et al. 1996) using the matrix output from the BTSPAS package. All associated files, data, and code are located at https://gitlab.com/transboundary-committee/Taku-Sockeye-Private.

Age, Sex, and Length Composition

The sockeye salmon age composition in the Taku River will be determined from a minimum of 510 readable scale samples collected from healthy, live fish (≥ 350 mm METF) irrespective of sex at the two fish wheels. This sample size was selected based on work by Thompson (2002) for calculating a sample size to estimate several proportions simultaneously. A sample size of 510 fish

[1] R Core Team. 2021. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

is needed to ensure the estimated proportion of each adult age class will be within 5% of the true value 95% of the time. The sampling goal was increased to 640 fish to guarantee the sample size target would be achieved, even if 20% of the scale samples are unreadable, and to make sample size consistent with spaghetti and radiotagging goals. This sample size will also meet length and sex composition requirements, as 510 fish samples are needed for length composition and only 385 fish samples (assuming no data loss) are necessary to achieve the precision criteria for estimating sex composition (Thompson 2002).

Cleithral Arch to Fork Length Measurement Conversion

Only CAF measurements (Appendix E) will be available from inriver commercial fishery harvest samples, because fish are landed with their heads removed as Canadian fish buyers prefer a headless, gutted product. Paired METF and CAF measurements collected from the fish wheels will be used to verify current linear regressions used for converting CAF lengths to METF lengths. Based on a medium effect size, a significance level of 0.05, and a power of 0.95, a minimum sample of 130 paired METF and CAF length measurements collected throughout the season will be adequate for a linear regression relationship (Cohen 1988). A medium effect size is defined as one that accounts for about 9% of the Y variance (R^2=0.10/(1+0.10)=0.09). Sockeye salmon from different inriver stocks present different morphologies based on dates of adult entry into freshwater, migration distances, spawning dates, and incubation habitats (Blair et al. 1993; Quinn et al. 2001). Due to the size variability across stocks, paired METF and CAF length measurements will be collected from 640 sockeye salmon throughout the season during radio tag deployment at the fish wheels (Table 1). The current CAF/METF regression (METF =1.90 + 1.15CAF), based on data from 1998 to 2002 (Andel and Boyce 2004), will be updated in the future when a longer, more current time series is available. With a longer time series, it will be determined if a separate regression is needed every year, or if samples across years can be pooled in the regression.

RADIOTELEMETRY PROJECT

Assumptions of the radiotagging study included: 1) sockeye salmon will be radiotagged in proportion to the run, 2) radiotagging will not change the survival, movement (i.e., destination or fate), or catchability of a fish (i.e., no tagging effects), 3) fates of radiotagged fish will be accurately determined (Bednarski et al. 2019), and 4) the radiotagged fish will be a representative sample of the spaghetti tagged fish.

The first assumption (i.e., sockeye salmon will be radiotagged in proportion to the run) will be true if fishing effort and catchability is constant for all "stocks" (i.e., fish that spawn in the same area) that enter the river. Throughout the study, sampling effort will be held as consistent as possible (i.e., every x^{th} sockeye salmon captured in the fish wheels was tagged with a radio transmitter) so that the cumulative distribution of tagged fish would be like the cumulative distribution of sockeye salmon returning the Taku River to spawn, over the same time. If nonproportional tagging occurs, the proportions will be stratified by time and CPUE. If fishing effort at the fish wheels (event one marking) and/or in the Canadian fishery (potentially recaptured in the fishery) were not consistent across the run, the ratios of radiotagged fish observed in the various spawning areas would be biased.

Assumption two (i.e., tagging effects) cannot be directly tested as an individual fish that was not handled or tagged cannot be tracked along its route or to its final destination. An indirect test of this assumption, though, is the time between tag application and recovery. Based on capture–recapture data from spaghetti tagged fish on the Taku River in years 1984 through 2018, the

behavior of tagged fish, such as sulking, was not very long for most fish that eventually migrated upstream and, thus, was not a major source of bias (Pestal et al. 2020).

The third assumption (i.e., fates of radiotracked fish will be accurately determined) will be true if 1) radiotags remain operational throughout the project, 2) all radiotagged fish are detected during aerial surveys during their migration upstream, and 3) radiotagged fish are detected at their final destination during aerial surveys. It is likely that radiotelemetry towers and radio tags will remain operational throughout the project and concerted effort will be made to ensure proper installation, testing, and monitoring of all remote tracking towers. Aerial surveys may not detect the final destination of radiotagged fish if the first survey occurs after fish have reached their final destination and their carcasses have washed downstream, or if the last survey is conducted before radiotagged fish have reached their final destination. We will assume, however, that all radiotagged fish that successfully spawn should be at or near their spawning location during at least one of the aerial tracking surveys (Richards et al. 2014).

To ensure the fourth assumption (i.e., the radiotagged fish will be a representative sample of the spaghetti tagged fish) will be met, every 1 in *x* fish captured and spaghetti tagged in the fish wheels will be radiotagged. We assume that the radiotagged fish will provide a representative sample of the spaghetti tagged fish (i.e., share similar survival, movement, and catchability) and the results derived from radiotagged fish (i.e., fates, dropout rates, genetic stock composition) could be extended to the inriver population (i.e., spaghetti tagged fish). To test this assumption, the cumulative time to recovery in the Canadian harvest (i.e., sulk time) will be compared between the radiotagged and the spaghetti tagged fish. In addition, KS tests (Conover 1980) will be used to compare the length distribution of radiotagged fish to spaghetti tagged fish to determine if radiotagged sockeye salmon are representative of the size distribution of the inriver population. Three KS tests will be performed using the statistical program R[1] to compare the lengths of radiotagged fish to the lengths of nonradiotagged fish (i.e., spaghetti tagged fish) for 1) all fish, both sexes combined; 2) males only; and 3) females only. All associated files, data, and code will be archived at https://gitlab.com/transboundary-committee/Taku-Sockeye-Private.

In 2018, the holding time methodology at the fish wheels was changed. Therefore, the proposed weekly radio tagging rate for the 2022 season (1 in 5 fish sampled) will be based on the proportion of the 2019–2021 weekly fish wheel CPUE in statistical weeks 21 through 40, and a 2022 projected fish wheel catch of 3,562 fish. The 2022 projected fish wheel catch of 3,562 fish is based on the total 2021 total fishwheel catch (5,068 fish), the 2021 (preliminary) postseason abundance estimate (182,115 fish), and the 2022 preseason forecasted run size (128,000 fish). This accounts for the lower forecasted run size in 2022 (128,000 fish) as compared to the 2021 postseason abundance estimate; (5,068x128,000)/182,115=3,562 fish). Depending on whether the run is below or above projections, the sampling rate may be adjusted if too few or too many samples are being collected.

An effective sample size of at least 385 radio tags is required to estimate of the proportion of mainstem versus lake spawning stocks with an absolute precision within 5% of the true proportion with at least 95% probability and no finite population correction factor (Equation 7). For simplicity, this estimate assumes proportional radio tag application across stocks, as well as a similar exploitation rate across stocks. Applying a 14.1% dropout rate (based on the averaged dropout rates from the 2018 to 2021 radiotelemetry studies), and the 5-year (2017–2021) average harvest rate (19.2%) in the Canadian fisheries (e.g., [640x0.859]x[1-0.192]) to the total of 640 systematically deployed radio tags, will provide an effective sample size of 444 radio tags (Table 4). If we also assume a conservative scenario where the population proportion is equally distributed

between the mainstem and lake spawning populations, the 444 radio tags will exceed the objective criteria,

$$n = \frac{z^2 p(1-p)}{d^2} = \frac{(1.96)^2 \cdot 0.50 \cdot 0.50}{0.05 \cdot 0.05} \approx \text{ 385 fish samples.} \quad (7)$$

Table 4.–Effective sample size needed for estimating binomial proportions at a desired precision of ± 0.05 and a given probability (0.95) with no finite population correction factor (Thompson 2002, pg. 42) and the actual effective sample size based on the initial sample size, a 14.1% dropout rate, and a 19.2% harvest rate.

Initial sample size	Sample size after 14.1% dropout rate	Effective sample size after inriver fishery (19.2% harvest rate)	Effective sample size needed
640	550	444	385

Genetic Analyses

To meet the objectives of this study, two different genetic analyses will be performed, including the stock composition of sockeye salmon analysis and individual assignment analysis where each radiotagged fish will be individually assigned to the most probable reporting group. Each analysis will be conducted using 8 reporting groups: 1) mainstem Taku/Stikine River (mainstem Taku River), 2) Nahlin River, 3) King Salmon Lake, 4) Kuthai Lake, 5) Little Trapper Lake, 6) Tatsatua Lake, 7) Tatsamenie Lake, and 8) Other. Among these genetic reporting groups, four (King Salmon Lake, Kuthai Lake, Little Trapper Lake, and Tatsemenie Lake) are considered to be lake-type stocks and the remaining (mainstem Taku River, Nahlin River, Tatsatua Lake, and Other) are grouped as river-type stocks (Miller and Pestal 2020).

Stock composition analysis will be conducted on all fish radiotagged at the fish wheels (e.g., then expanded to the population captured in event one of the capture–recapture study) and also conducted separately on only radiotagged fish harvested in the Canadian commercial fishery. Sample sizes obtained in the study should be adequate for estimating the stock composition within 5% of true value, 90% of the time. The individual assignment data will be used to calculate the number of fish in each reporting group and to compare with known telemetry fates. In addition, the genetic results will be used to examine genetic mark–recapture, but this will be exploratory analysis and will not be used to propose a formal inriver abundance estimate (Appendix J).

Laboratory Analysis

To determine the genetic stock composition of the samples from radiotagged fish captured in the fish wheels, genomic DNA will be extracted from tissue samples using a NucleoSpin® 96 Tissue Kit by Macherey-Nagel (Düren, Germany). DNA will be amplified by polymerase chain reaction (PCR) and screened for 96 single nucleotide polymorphism markers (SNPs) using Fluidigm® 96.96 Dynamic Arrays (http://www.fluidigm.com). The Dynamic Arrays will be read on a Fluidigm® EP1™ System after amplification and scored using Fluidigm® SNP Genotyping Analysis software. If necessary, SNPs may be rescreened on a QuantStudio™ 12K Flex Real-Time PCR System (Life Technologies) as a backup method for assaying genotypes. Approximately 8% of individuals analyzed for this project will be reextracted and genotyped as a quality control measure to identify laboratory errors and to measure rates of inconsistencies during repeated analyses. The quality control analyses will be performed by staff not involved in the original

genotyping, and the methods are described in detail in Dann et al. (2012). Genotypes will be imported and archived in the Gene Conservation Laboratory Oracle database, LOKI.

Genotypes in the LOKI database will be imported into the statistical program R for analysis[1]. Prior to statistical analysis, three statistical quality control analyses will be performed to ensure high-quality data: 1) individuals missing >20% of their genotype data (markers) will be identified and removed from analyses, as this is indicative of low quality DNA (80% rule; Dann et al. 2012); 2) duplicate individuals will be identified and removed; and 3) non-sockeye salmon will be identified and removed.

Stock Composition

The current genetic baseline consists of 241 populations, which are representative of the major producing stocks in the study area. The baseline consists of minor changes to Rogers Olive et al. (2018), with additional years pooled with existing Tatsatua and Nahlin River populations and additional collections in the Yakutat area (Appendix F). The baseline was evaluated to ensure that the reporting groups meet reporting criteria as outlined in Barclay et al. (2019). Stock composition for the entire season, by strata, and for the subset of fish harvested in the Canadian commercial fishery will be estimated using the R package rubias (Moran and Anderson 2019). Strata generally corresponded to statistical week but will be determined postseason as some weeks will need to be pooled to maintain greater than 30 fish per stratum. A single Markov Chain Monte Carlo chain with starting values equal among all populations formed the posterior distribution that described the stock composition of each stratum. Summary statistics will be tabulated from these distributions to describe stock compositions.

Spawning Distributions

If we assume that the population migrating past the fish wheels was proportionally radiotagged, the proportion of sockeye salmon destined for probable spawning location $\hat{p}_i$ will be estimated as (Cochran 1977, pg. 52),

$$\hat{p}_i = \frac{r_i}{r}, \tag{8}$$

where:

r_i = number of radiotagged fish out of r assumed to have spawned in location i, and

r = number of radiotagged fish released from the marking site that retained upstream migration and were assigned to a probable spawning location.

The variance of $\hat{p}_i$ will then be estimated by (Cochran 1977, pg. 52),

$$\text{var}(\hat{p}_i) = \frac{\hat{p}_i(1-\hat{p}_i)}{r-1}. \tag{9}$$

If the assumption of proportional radiotagging was not met, the number of fish with radio tags r, distributed by time stratum j and spawning location i, will be adjusted to compensate for unequal effort and unequal tagging fractions over time (Ericksen and Chapell 2006),

$$r'_{ij} = \frac{r_{i,j}}{\hat{\phi}_j}, \tag{10}$$

where $\hat{\phi}_j$ = the proportion of sampled fish that were radiotagged, adjusted for unequal fish wheel effort over time,

$$\hat{\phi}_j = \frac{x_{1,j}+x_{2,j}}{X_{1,j}\frac{H_{1,j}}{h_{1,j}}+X_{2,j}\frac{H_{2,j}}{h_{2,j}}}, \quad (11)$$

where:

X = number of sockeye salmon captured in the fish wheels (fish wheel designation by subscript 1, 2);

x = number of sockeye salmon radiotagged in the fish wheels (fish wheel designation by subscript 1, 2);

H = total possible number of hours of fish wheel operation (fishing effort); and

h = actual number of hours of fish wheel operation (fishing effort).

All quantities are specific to time stratum j. Then, the proportion of fish that spawn in location i will be estimated as,

$$\hat{q}_i = \frac{\sum_j^{\text{weeks}} r'_{i,j}}{\sum_i^{\text{fates}} \sum_j^{\text{weeks}} r'_{i,j}}, \quad (12)$$

with approximate variance,

$$\text{var}(\hat{q}_i) \cong \frac{\hat{q}_i(1-\hat{q}_i)}{\sum_j^{\text{weeks}}(x_{1,j}+x_{2,j})-1}. \quad (13)$$

Equations 12 and 13 are restricted to those radiotagged fish that were assigned a spawning fate.

Based on the final fates of the radiotagged fish (Table 2), the proportion of radiotagged fish that dropout of the study (i.e., do not cross the border) will be determined by dividing the total number of radiotagged fish that dropped out of the study by the total number of radiotagged fish, excluding any fish with a fate description of 'Never located, unknown fate.'

Individual Assignment

Once final fates are assigned and probable spawning locations are mapped out, the data will be paired with the individual genetic assignment results, which will be used to examine evidence of straying by reporting group. Specifically, are there any indications that lake-type stocks do not make it to their natal lakes where they can be enumerated as escapement.

Individual assignment data is generated concurrently with the stock composition output using the R package rubias (Moran and Anderson 2019). Briefly, for each radiotagged fish, the posterior means of reporting group membership will be calculated based on the probability of the individual's genotype arising from a population within that reporting group. Together, these data will be used to determine the most probable reporting group. We will implement a cut-off requirement of 95% probability to determine a 'true' group membership (Simmons et al. 2013). Samples that fall below the cut-off will be considered inconclusive and not assigned to a reporting group. It is worth noting that while stock composition estimates could be calculated from 'hard' individual assignment data, it is not recommended because calculations would be limited to the subset of fish that met the assignment threshold, as opposed to the holistic method of summarizing fractional reporting group probabilities across individuals to estimate stock composition. Further, depending on the study objectives, individual assignment thresholds could be modified, resulting in changes to stock composition derived from 'hard' individual assignments.

Migratory Timing and Travel Rates

For the secondary objectives, migratory timing and travel rate statistics will be calculated for the following sockeye salmon stocks: Kuthai, Little Trapper, Tatsamenie, and King Salmon Lakes. These statistics are useful for characterizing the annual timing of fish migrations and for comparing the timing of migrations between years. Although spaghetti tags can provide some migratory timing information, radio tags can provide timing statistics at a finer spatial and temporal resolution.

Migratory timing profiles can be described as time density. Two simple features of the time density are mean date and variance or dispersion of the migration through time. Fish wheel CPUE will be used as an index of the abundance of fish migrating past the Canyon Island fish wheels, and migratory timing statistics will be calculated following the procedures of Mundy (1979, 1982, 1984). Mean date of passage in a migration of m days will be estimated by,

$$\bar{t} = \sum_{t=1}^{m} tP_t \tag{14}$$

where:

$\bar{t}$ = the estimated mean day of the migration (t =1 is the first day of the migration and m is the last day), and

P_t = the proportion of the total cumulative fish wheel CPUE that occurred on day t (the CPUE on time interval t divided by the total CPUE).

The calculated mean date is reported as the corresponding calendar date. The variance of the migrations will be estimated by,

$$\hat{S}_t^2 = \sum_{t=1}^{m}(t - \bar{t})^2 P_t. \tag{15}$$

The timing of sockeye salmon stocks past Canyon Island will be derived from relocation dates of radiotagged fish on the spawning grounds, which will be weighted by fish wheel CPUE to allow the escapement of a particular stock to be allotted to week of passage past Canyon Island. The proportion of the run occurring each week for each stock is

$$P_{js} = \frac{C_j T_{j,s}}{T_j - T_{j,c} - T_{j,d}} \Big/ \sum_{j=21}^{40} \frac{C_j T_{j,s}}{T_j - T_{j,c} - T_{j,d}}, \tag{16}$$

where:

j = the statistical week of interest;

C_j = the weekly proportion of the total season's fish wheel CPUE;

$T_{j,s}$ = the number of spawning grounds derived from relocation dates of stock s that were radiotagged in statistical week j;

T_j = the number of fish radiotagged in the fish wheels in statistical week j;

$T_{j,c}$= the number of fish radiotagged at the fish wheels in statistical week j and caught in the Canadian inriver fishery; and

$T_{j,d}$ =the number of fish radiotagged at the fish wheels in statistical week j, but "dropped-out."

Migratory timing is likely influenced by many factors including water level and tagging-induced behavior. An assumption implicit in this calculation is that the removal of fish by the Canadian inriver fishery does not alter the migratory timing distribution of individual stocks. This

assumption may be violated because the harvest rate of the Canadian fishery on the inriver run varies among fishing periods. “Sulking” behavior, or the tendency for a salmon captured and tagged during upstream migration to pause or move downstream before continuing upstream, can result in slower initial migration rates for tagged individuals (Bernard et al. 1999). To account for this, the number of days it takes an individual radiotagged fish to travel from the Canyon Island fish wheels to the first fixed tracking tower (Figure 1) will be used as an adjustment to the migratory timing rates of the spaghetti tagged fish from the fish wheels to the spawning areas.

DATA REDUCTION

The ADF&G tagging crew leader (FB 1), Fish & Wildlife Technician 3, and Fish & Wildlife Technician 2 at Canyon Island will record, and error check all data from the tagging operation daily. Errors may consist of incorrect dates, transposed nonsensical lengths (e.g., 360 mm when the fish was actually 630 mm or CAF length > METF length), and transposed or nonsensical tag numbers. Data forms will be kept up to date at all times. Data will be sent to the ADF&G office in Douglas at regular intervals (preferably the same day but no later than the next morning by 8:20am) and inspected for accuracy and compliance with sampling procedures. Data will be transferred from field books or forms to Excel spreadsheet files using only state computers. Catch figures and tag release totals will be forwarded daily from Douglas to the DFO office in Whitehorse. The ADF&G project biologist (Williams) will ensure all data sent from camp are collated, entered, and given a final check for errors. Feedback will be given to camp to fix common errors discovered during the season.

The DFO field technicians will process data from the Canadian fisheries in a similar manner and send them to the DFO office in Whitehorse. Catch figures, tag recoveries, and secondary mark data will be forwarded daily from Whitehorse to the ADF&G office in Douglas.

The DFO project biologist (Foos) will ensure data from Kuthai, Little Trapper, King Salmon, and Tatsamenie lakes, and any other escapement projects, are collated and error-checked. Escapement data will be forwarded from DFO to the ADF&G office weekly.

Scale cards must have the names of all personnel at the fish wheels at the time of sampling written on each card (this will always be at least two names: the dipper/tagger and the data recorder). Scale cards will be checked at camp daily to ensure that scales are clean and mounted correctly, labeled correctly, and match up with the corresponding ASL data form. Scales will be remounted when necessary. Scale samples from the Canyon Island fish wheels will be pressed and read in Douglas at the ADF&G Commercial Fisheries scale-aging lab (Heidi Ingram); likewise, scale samples from the Canadian fisheries and spawning areas will be processed at the DFO Pacific Biological Station (PBS) Schlerochronology Lab in Nanaimo, B.C.

DATA ARCHIVING

Copies of the data used to produce final reports will be provided to Research and Technical Services (Division of Sport Fish-Anchorage) for archiving. Tagging site scale cards and acetates will be archived at the ADF&G Douglas scale-aging lab. Recovery site scale cards and acetates will be archived at the Nanaimo PBS lab. ADF&G is in the process of creating a data entry platform to capture current and historical fish wheel project data, which will then be archived in the ADF&G Integrated Fishery Database. Tissue samples will be archived in the ADF&G Gene Conservation Laboratory in Anchorage

SCHEDULE AND DELIVERABLES

Field activities for tagging and sampling salmon at the Canyon Island fish wheels under this project will begin in early May and extend to early October. Field activities for recovery of tagged sockeye salmon from Canadian fisheries will begin in mid-June when the commercial fishery starts. Sampling will continue through the coho salmon commercial fishery and conclude with the coho salmon assessment fishery if required. All telemetry tracking towers will be installed and functioning prior to any fish being radiotagged and will be checked, depending on location and accessibility, from once weekly to approximately every three weeks. Data will be downloaded via a laptop computer and will be immediately copied onto a second portable, external hard drive. All telemetry data and genetic samples will be sent weekly to Jeff Williams at the ADF&G office in Douglas.

DATA EXCHANGE (ADF&G)

The Taku Field Data spreadsheet, which contains all data collected at the Canyon Island field camp, such as fish caught, fish tagged, fish wheel performance, etc., will be sent to the Douglas Office after the last wheel check of the day. If this becomes problematic, data will be sent no later than 8:20 am the following morning. If internet interruptions occur, internet bandwidth is crimped, or spreadsheet errors occur, data will be typed in the text of an e-mail and reduced to fish caught, effective tags out, and fish wheel sampling time. If e-mail is unavailable, a Garmin inReach device will be used to transmit text.

DATA EXCHANGE (DFO/ADF&G)

Canyon Island fish wheel effort, catch, tag, and hydrological data, and Canadian commercial fishery effort, catch and tag data will be exchanged daily inseason.

Weekly, inseason, Canada will transport the otolith samples from the Canadian commercial fishery to the field staff at Canyon Island. ADF&G field staff at Canyon Island, will transport the samples in a timely fashion to the ADF&G Mark Lab in Juneau. The lab will analyze the samples and will provide results online.

Updates on telemetry flights, including locations surveyed will be sent weekly.

Detailed, preliminary Canyon Island/Canadian fishery size and tag data, as well as escapement tag data will be exchanged by 1 November each year.

Final error-checked effort, catch, tag, age, and size data from Canyon Island/Canadian fisheries and escapements will be available by 1 January each year.

Final error-checked effort, catch, tag, age, and size data from Canadian fisheries and escapements will be available by 1 December each year.

RESPONSIBILITIES

I. PARTY RESPONSIBILITIES

U.S.

ADF&G, Division of Commercial Fisheries will take lead role in project planning, implementation, and reporting for the U.S. and will do the following:

- Plan project in cooperation with DFO, ADF&G Division of Sport Fish, and TRTFN.
- Write operational plan with DFO.
- Provide up to five seasonal technicians and all required equipment to conduct Canyon Island tagging.
- Summarize all tagging data from Canyon Island operations in spreadsheets and provide to DFO as per schedule outlined in previous section. Will cover the logistics associated with U.S. tag recoveries.
- Convert all data collected into digital format, and conduct quality-control checks.
- Develop/review weekly BTSPAS estimates for Taku sockeye salmon abundance inseason as well as a final postseason abundance estimate.
- Assist with escapement sampling as required.
- Provide all ATS telemetry receivers and about one half of the remote tracking towers and associated hardware.
- Purchase all radio tags and necessary hardware.
- Install and monitor all remote tracking towers.
- Conduct radiotelemetry flights.
- Provide inseason otolith mark analysis of U.S. and Canadian fishery samples.
- Be the primary author on the final radiotelemetry report covering this work.
- Coauthor the annual capture–recapture report.

Canada

DFO will take lead role in project planning, implementation and reporting for Canada. Will plan project in cooperation with ADF&G and TRTFN. Will write operational plan with ADF&G and will do the following:

- Obtain sample/catch statistics, spaghetti and radio tags, and secondary mark data from the Canadian fisheries and contribute to Canyon Island tagging operations with two technicians as available around the Canadian fisheries schedule.
- Contract and oversee weir enumeration at Little Trapper and Tatsamenie lakes and conduct escapement sampling as required. Will collate data from recovery locations.
- Convert all data collected into digital format and conduct quality-control checks.
- Provide ADF&G with all data listed above as per schedule outlined in previous section. Will develop/review weekly BTSPAS estimates for Taku sockeye salmon abundance inseason as well as a final postseason abundance estimate.
- Provide about one half of the remote tracking towers and associated hardware.
- Be primary author on the capture–recapture report and will coauthor radiotelemetry report.

TRTFN will participate in project planning with DFO and ADF&G and will do the following:

- Provide a technician to work at Canyon Island.
- Operate enumeration weirs at Kuthai and King Salmon lakes and assist with additional escapement sampling/enumeration as required.

II. PERSONNEL RESPONSIBILITIES

Jeffrey Williams, ADF&G FB 2, Project Leader. Works with Warta on field operations, data analysis, and report writing. Supervises all aspects of Canyon Island tagging operations; edits, analyzes, and reports data; assists with field work; maintains near-daily email or telephone contact

with field camps; arranges logistics with field crew and expeditor. Assures operational plans are followed or modified appropriately with consultation with Warta, Bednarski, Miller, and Foos. Is coauthor on final report with Bednarski, Miller, and Foos.

Aaron Foos, DFO BI-03, Project Leader. In concert with Williams, will assist in all aspects of the program. Directly supervises all aspects of Canadian operations. Coalesces, edits, analyzes, and reports data; assists with fieldwork when necessary. Provides feedback when required. Develops/reviews BTSPAS estimates. Will provide catch and recovery data to ADF&G, review data, provide input on reports, write sections regarding recovery, and serve as primary or co-author as required.

Sean Stark, DFO EG-05, Field Operations Coordinator. Will provide direct support and oversight to Canadian aspects of the project, ensure operational plan and all relevant guidelines are being implemented and all sampling goals are being met, and will facilitate field camp maintenance and equipment purchases, and oversee expediting for the project. Assists with fieldwork when necessary. He will assist Foos in all aspects of the project including data coordination, verification, and storage.

Stephen Warta, ADF&G FB 1. This position will be responsible for leading all field aspects of the Canyon Island tagging portion of the project under the direction of Williams. Ensures the operational plan and other departmental guidelines are followed through the course of this study. Ensures that all crew members are given necessary on-site instruction and training to accomplish all field activities, including fish wheel construction and maintenance, fish handling and tagging, species identification, data collection and recording, conduct in the public's eye, camp organization/cleanliness, and adherence to Departmental policies. Will be responsible for basic equipment maintenance and operation and submitting data and maintenance schedules accurately and timely to ADF&G office in Douglas. Under guidance of Williams, will adjust fieldwork activities and schedules as necessary for full participation in fish wheel checks and data sending routines. With Williams, will attempt to resolve as many personnel and administrative issues as possible. Will also be responsible for inventories at beginning and end of season. Will also provide Williams with an end of season purchase list for the next spring.

Derrick Allen, FWT 3. This position will be responsible for fish wheel design, construction, set-up, breakdown, and maintenance. This position also assists in all field aspects of the Canyon Island portion of the project under the direction of Warta, Williams, and Richards. This includes following operational plan for tagging and safe operations of all field equipment. Will assist Warta in maintaining high quality data.

Elijah Bagoyo, FWT 2. This position will be responsible for assisting in all field aspects of the Canyon Island portion of the project under the direction of Allen, Warta, Williams, and Richards. This includes following operational plan for tagging and safe operations of all field equipment. Will assist in fish wheel construction and placement and maintenance of all field equipment and general camp duties as needed.

Tristan Eidsness, FWT 2. This position will be responsible for assisting in all field aspects of the Canyon Island portion of the project under the direction of Allen, Warta, Williams, and Richards. This includes following operational plan for tagging and safe operations of all field equipment. Will assist in fish wheel construction and placement and maintenance of all field equipment and general camp duties as needed.

Gina Iacono, FWT 2. This position will be responsible for assisting in all field aspects of the Canyon Island portion of the project under the direction of Allen, Warta, Williams, and Richards. This includes following operational plan for tagging and safe operations of all field equipment. Will assist in fish wheel construction and placement and maintenance of all field equipment and general camp duties as needed.

Julie Bednarski, ADF&G FB 3. This position will assist with telemetry operations and other tasks as needed.

Richard Brenner, ADF&G FB 4. This position is responsible for general oversight of this project. Reviews project planning, operational plans, and technical reports.

Sara E. Miller, ADF&G Biometrician 3. Provides input to and approves sampling design. Reviews operational plan and provides biometric details. Writes programming code for statistical analysis. Reviews and conducts analysis in concert with project leaders for the final report.

Phil Richards, ADF&G FB 3. Will 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.

REPORTS

The capture–recapture and radiotelemetry reports will be coauthored by the principal investigators from DFO and ADF&G and will be published in the Pacific Salmon Commission Technical Report series and may also be published in departmental report series as a Canadian Manuscript Report of Fisheries and Aquatic Sciences and/or an ADF&G Fishery Data Series report. Project results will also be summarized in the annual report of the Pacific Salmon Commission Transboundary Technical Committee.

PRINCIPAL INVESTIGATORS

- Jeffrey Williams, Fishery Biologist, ADF&G
- Aaron Foos, Senior Aquatic Science Biologist, DFO

ASSISTING PERSONNEL

- Julie Bednarski, Fishery Biologist, ADF&G
- Philip Richards, Fishery Biologist, ADF&G
- Stephen Warta, Fishery Biologist, ADF&G
- Sean Stark, Senior Aquatic Science Technician, DFO
- Bill Waugh, Manager, Transboundary Rivers Operations, DFO
- Danielle Hosick, Aquatic Science Technician, DFO
- Mac Oliver, Fishery Technician, ADF&G
- Derrick Allen, Fishery Technician, ADF&G
- Elijah Bagoyo, Technician, ADF&G
- Gina Iacono, Fishery Technician, ADF&G
- Tristin Eidsness, Fishery Technician, ADF&G
- Mark Connor, Fisheries Coordinator, TRTFN
- Brian Mercer, Contract Biologist, DFO
- Logan O'Shea, Fisheries Technician, TRTFN

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APPENDICES

Appendix A.–Species specific sampling details.

Sockeye

no radio tags

- All healthy sockeye (thought to be able to reach the spawning grounds)
- Measure METF length.
- Sex
- Spaghetti tag all sockeye over 349 mm.
- Secondary mark with left axillary fin clip.
- Put in bulk bottle daily.

Radiotagged fish (600 fish)

- Radio tag every 6th healthy fish over 349 METF
- Same protocol as non-radio fish except save axillary clip for individual genetics
- Additionally, measure CAF—cliethral arch to fork of tail.
- Radio tag—please tag sequentially.
- Secondary mark with left axillary fin clip.
- ASL match with individual genetic vial.
- 1 scale per fish.

Chinook

- Check for presence/absence of adipose fin on every fish.
- Record quality of clip.
- Sacrifice all females under 660 METF and all males of any size missing an adipose fin
- Wand all large females missing adipose fin for the presence of CWTs and release.
- All healthy Chinook (thought to be able to reach the spawning grounds) of any size will be sampled and tagged.
- Length (METF to the nearest 5 mm) – all fish.
- Sex – all fish.
- 5 scales/fish (5th scale should go at the bottom of the column) – all fish.
- Clip left axillary fin – all fish.
- Double left upper operculum punch—only large and medium fish that are spaghetti tagged.
- Spaghetti tag only healthy fish.
    - 0–400 mm, small fish, blue tag
    - 401–659 mm, medium fish, yellow tag
    - 660+ mm, large fish, blue tag

-continued-

Coho

no radio tags

- Check for presence/absence of adipose fin on every fish.
- Record quality of clip
- Sacrifice all ad clips and take heads.
- All healthy coho (thought to be able to reach the spawning grounds) over 349mm METF will be sampled and tagged:
    - Length (METF to the nearest 5mm)—all fish.
    - Sex – all fish.
    - 4 scales/fish—every 4th fish (scheduling TBD with tablet).
    - Spaghetti tag—only healthy fish over 349 mm METF.
    - Secondary mark with left axillary fin clip – discard

Radiotagged fish (200 fish)

- Radio tag every 10th healthy fish over 349 mm METF.
- Radio tags should be deployed sequentially.
- Same protocol as non-radio fish except save axillary fin clip
- Paired genetic samples should be taken for all radiotagged fish and matched to ASL data.

Chum

- Every fish ASL.
- 1 scale per fish.

Pink

- Daily sampling goal—25 fish.
- Sex and length.
- Enumerate/FW after the first 25

Appendix B.–Taku River fish wheel ASL (age, sex, length) bubble sheets instructions.

Data must be recorded neatly and accurately on the optical scan forms.

Description: Written above description line at top of ASL bubble sheet form:

- **Species/111-32-032/Fishwheel/Taku River Esc./ Wk __**

Card:

- Card numbers for sockeye and coho salmon samples with sex, length, scales, genetics, and radio tag starts with 001.
- Card numbers for sockeye and coho salmon samples with sex and length starts with 201.
- Card numbers for chum salmon samples with sex, length, and scales starts with 001.
- Card numbers for pink salmon samples with sex and length start with 001.

Species:

- Sockeye = 2
- Coho =3
- Pink = 4
- Chum = 5
- Species code listed on back of ASL bubble sheet.

Day/Month/Year:

- List Day of sample, only one day per ASL bubble sheet.

District: 111

Sub-District: 32

Stream: 032

Stat. Week:

- A Statistical week is Sunday through Saturday.
- Statistical week chart supplied.

Project: 3

- Escapement, tower, weir, sonar site, etc. Listed on back of ASL bubble sheet.

Gear: 8

- Fishwheel – listed on back of ASL bubble sheet.

Harvest Code:

- DO NOT USE- harvest code is used when sampling commercially caught salmon.

-continued-

Length Type: 2

- Measure fish mid eye to fork on all species.

Cards: 1

- Always indicate 1 even when you are sampling for sex and length only.

User Code Definitions:

- Do not use unless instructed by project supervisor.

Sex: indicate male or female

Length: record length

E: indicate no scale taken or collected

- No Scale Taken - Fill in the E column when you are sampling for sex and length only.
- No Scale Collected - Fill in the E column when a scale/scales are not collected.

Right Hand margin of ASL bubble sheet:

- Record Fishwheel Number first followed by the spaghetti tag number:
    - 1st number is fishwheel number,
    - Then 5-digit spaghetti tag number.

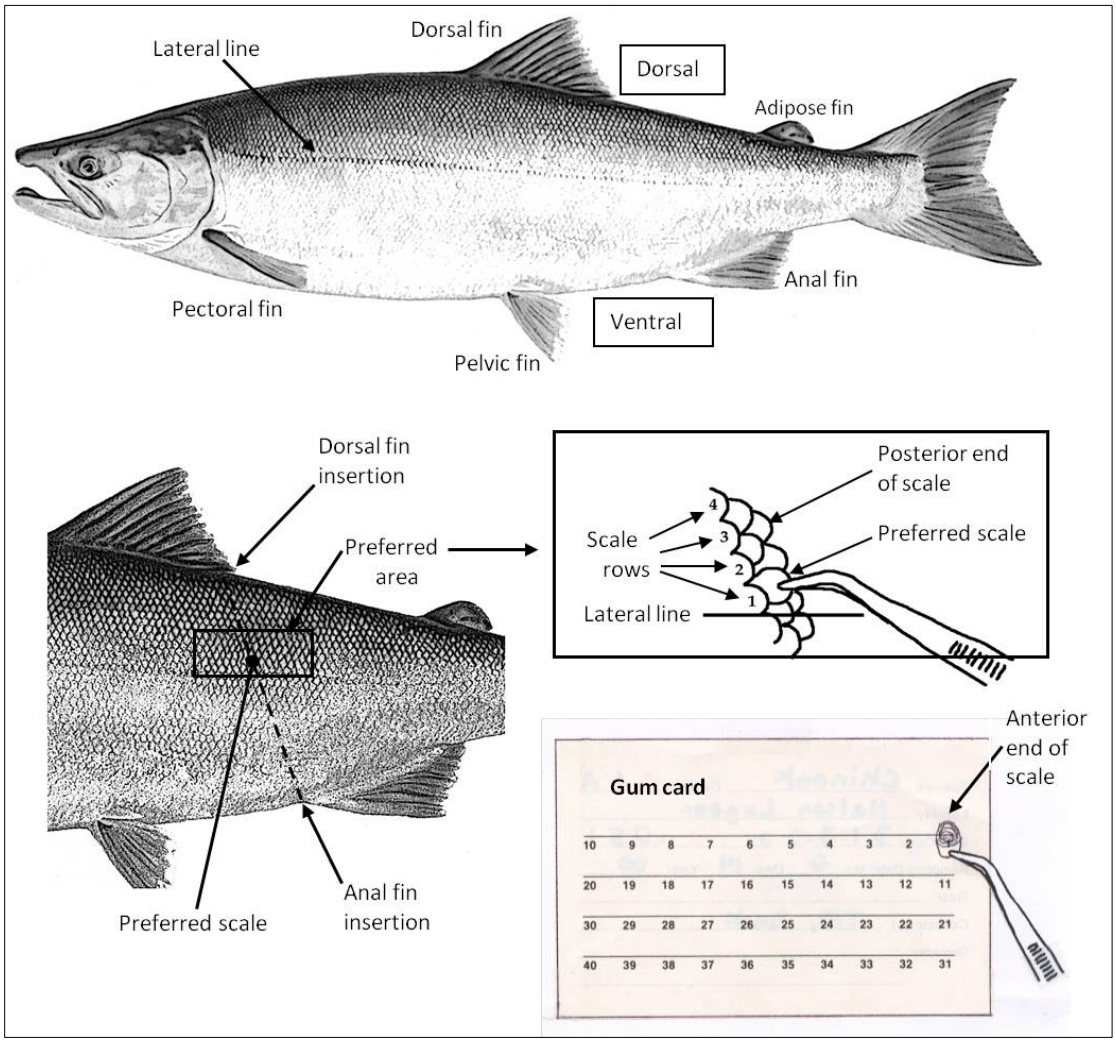
Back of ASL bubble sheet:

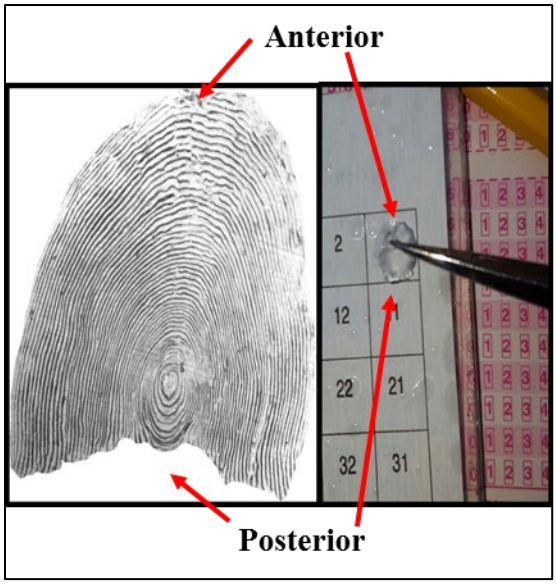
- Write in CODE TYPE = spaghetti tag.
- Record fishwheel number in the first column and the spaghetti tag number in the next five columns.

ASL Bubble sheet hints:

- Number 2 pencil is the best pencil to use to fill in bubbles.
- Always fill in the whole bubble.
- Do not fill out a new bubble sheet on top of a completed bubble sheet. Stray marks can be transferred from the completed bubble sheet to the back of the new bubble sheet.
- **DO NOT MAKE MARKS NEAR OR ON THE BOTTOM MARGIN OF THE ASL BUBBLE SHEET.**
- **DO NOT FOLD THE ASL BUBBLE SHEET.**

Appendix C.–Preferred scale sampling area on an adult salmon.





Clean, moisten and mount scale on the scale card directly over the appropriate scale number. The side of the scale facing up on the scale card is the same as the side facing up when it is attached to the fish. This outward facing side is referred to as the "sculptured" side of the scale. The ridges on this sculptured side can be felt with fingernail or forceps. When placing the scale on the scale card, place in one uniform direction. **ANTERIOR SIDE POINTING UP, SCULPTURED SIDE FACING OUT.**

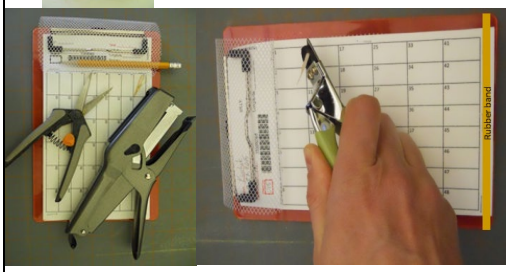
Appendix D.–Adult finfish tissue sampling for DNA analysis.

I. General Information

We use fin tissues as a source of DNA to genotype fish. Genotyped fish are used to determine the genetic characteristics of fish stocks or to determine stock compositions of fishery mixtures. 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.

Preservative used: Silica desiccant bead packet dries and preserves tissues for later DNA extraction. Quality DNA preservation requires **Fast drying** (under 5 hours at 65ºF); **Dry storage (**with 2 desiccant packs) in weathertight file box.

II. Sampling Method



III. Sampling Instructions

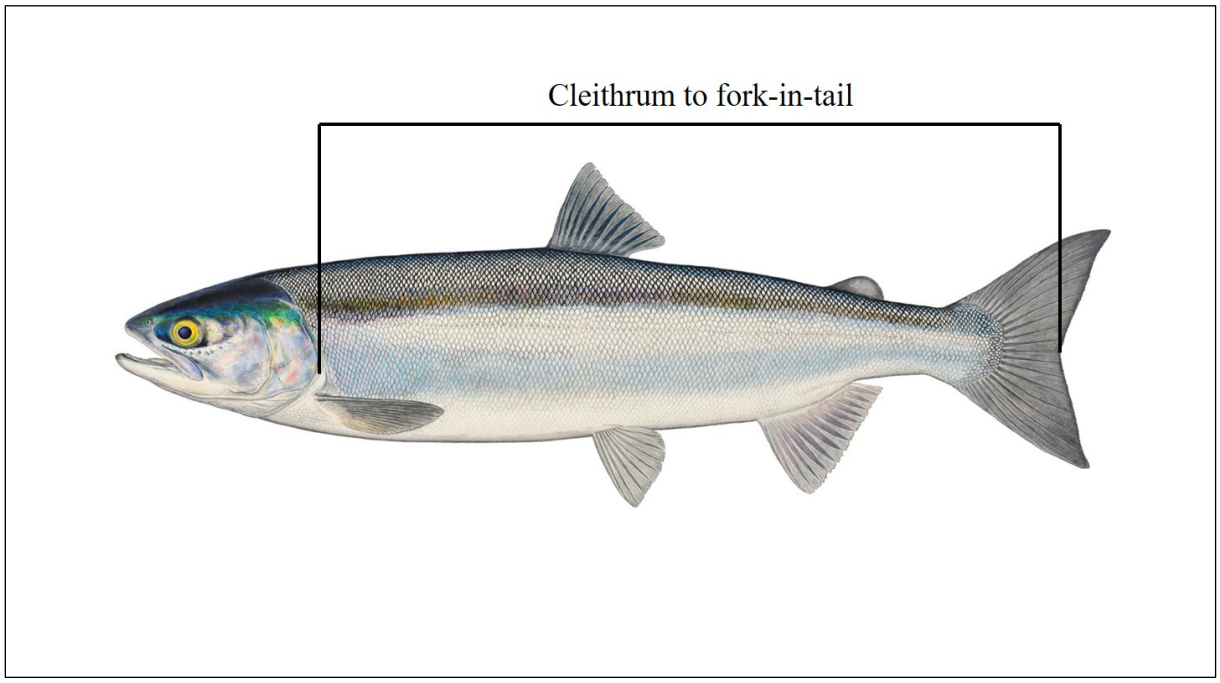
- **Prior to sampling**: Set up workspace, fill out required collection information (upper left hand corner only) and place Whatman genetics card (WGC) on clipboard, secure with rubber band; ready to sample.
- **Sampling:**
  - Wipe fin prior to sampling.
  - Briefly wipe or rinse scissors with water between samples to reduce cross contaminating.
  - Using scissors; cut one axillary fin per fish.
  - Place in daily bulk bottle with ethanol alcohol.
- **Transferring to Whatman Card:**
  - Strain bottle (keep separate per day)
  - Ideally samples would be placed randomly (i.e., not all the big axillaries first; do not sort by size or anything else).
  - Only Whatman cards valid per day (**might need multiple cards per day if over 40; do not use same card for multiple days).**
  - Place one clipped fin tissue onto appropriate grid space. Follow sampling order printed on card - do not deviate. If large tissue sample, center tissue diagonally on grid space.
  - you may have to trim down larger samples so they don't overlap into other grids.
  - **Only one fin clip per fish into each numbered grid space**.
  - Sampling complete.
  - Staple each sample to WGC (see photo to the left).
- **Loading the Pelican Case:**
  - First card: Remove blotter papers and desiccant packs from Pelican Case. Place first card in Pelican Case with tissues facing up. Next, place blotter paper directly over card and place 2 desiccant packs on top. Close and secure lid so drying begins.
  - Up to 4 cards can be added per case. Add cards so the tissue samples always face the desiccant pack through blotter paper: 2nd card facing down between desiccant packs; 3rd card facing up between desiccant packs; and 4th card facing down on top of second desiccant pack. Close and secure Pelican case after inserting each card.
  - All Whatman cards **remain in Pelican overnight**.
  - **desiccant packs should be exchanged with dry packs when samples transferred to Weather tight file box.**
- **Storage Transfer:** Remove cards from Pelican case and place in photo sleeves. Store dried tissues in Weather tight file box at room temperature or below. Two desiccant packs will dry/press cards and promote the tissue preservation process**. The packs should be dried out every 2 weeks.**
- **Storage and shipping:** Keep all Whatman cards inside in Weather tight file box **at all times** with closed /secure lid at CYI.
- **End of season will ship them to Anchorage via Douglas Regional Office.**

IV. Supplies included in sampling kit:

1. Clippers - for cutting a portion of selected fin.
2. Whatman genetics card – holds 40 fish/sheet.
3. Pelican Case - 1st stage of drying and holding card samples.
4. Silica packs – desiccant removes moisture from samples.
5. Pre-cut blotter paper – covers full sample card for drying.
6. Shipping box – put filled Pelican case inside box for shipment.
7. Clipboard – holds Whatman genetics card while sampling.
8. Stapler – extra protection, secure sample to numbered grid.
9. Staples – only use staples provided, specific for stapler.
10. Rubber bands – secure paper to clipboard (optional).
11. Laminated "return address" labels.
12. Sampling instructions.
13. Pencil

Desiccant pack—keep dry by using a dehydrator. The packets are placed into the dehydrator which is run at ~140F-160F, overnight. Dehydrators can be run longer, if necessary. Make sure to store dry desiccant packs intended for later use inside a pelican case or weather tight file box without samples.

Appendix E.–Taku River sockeye salmon cleithral arch to fork (CAF) length measurement.



Appendix F.–Reporting group, Location, ADF&G collection code, and the number (*n*) of sockeye salmon used in the genetic baseline for mixed stock analysis of Taku River fish wheel catches.

Reporting group	Location	ADF&G collection code	*n*
King Salmon Lake	Taku—King Salmon Lake	SKSLK10.SKSLK11	214
Kuthai Lake	Taku—Kuthai Lake	SKUTH06	171
Tatsatua	Taku—Tatsatua Lake (Tatsatua)	SLTAT11.SLTAT12	153
Little Trapper Lake	Taku—Little Trapper	SLTRA90.SLTRA06	237
Mainstem Taku River	Stikine—Andy Smith Slough	SFOWL07.SFOWL08.SFOWL09.SANDY07.SANDY09	54
Mainstem Taku River	Stikine—Bronson Slough	SBRON08.SBRON09	78
Mainstem Taku River	Stikine—Christina Lake	SCHRI11.SCHRI12	70
Mainstem Taku River	Stikine—Chutine Lake	SCHUTL09.SCHUT11	224
Mainstem Taku River	Stikine—Chutine River	SCHUT08	94
Mainstem Taku River	Stikine—Craig River	SCRAIG06.SCRAIG07.SCRAIG08	38
Mainstem Taku River	Stikine—Devil's Elbow	SDEVIL07.SDEVIL08	148
Mainstem Taku River	Stikine—Devil's Elbow	SDEVIL09	53
Mainstem Taku River	Stikine—Iskut River	SISKU85.SISKU86.SISKU02.SISKU06.SISKU08.SISKU09	153
Mainstem Taku River	Stikine—Iskut River (Craigson Slough)	SISKU07	42
Mainstem Taku River	Stikine—Porcupine River	SPORCU07.SPORCU11	74
Mainstem Taku River	Stikine—Scud River	SSCUD07.SSCUD08.SSCUD09	191
Mainstem Taku River	Stikine—Shakes Slough Creek	SSHAKS06.SSHAKES07.SSHAKS09	67
Mainstem Taku River	Taku—Fish Creek	SFISHCR09.SFISHCR10	159
Mainstem Taku River	Taku—Hackett River	SHACK08	52
Mainstem Taku River	Taku—Sustahine Slough	SSUSTA08.SSHUST09	185
Mainstem Taku River	Taku—Tulsequah River	STULS07.STULS08.STULS09	156
Mainstem Taku River	Taku—Tuskwa Creek	STUCH08.SCHUNK09.STUSK08.SBEARSL09.STUSKS08.STUSKS09	356
Mainstem Taku River	Taku—Yehring Creek	SYEHR07.SYEHR09	171
Mainstem Taku River	Taku—Yellow Bluff	SYELLB08.SYELLB10.SYELLB11	81
Mainstem Taku River	Taku Mainstem—Taku River	STAKU07	95
Mainstem Taku River	Taku Mainstem—Takwahoni/Sinwa	STAKWA09	67
Nahlin River	Taku—Nahlin River	SNAHL03.SNAHL04.SNAHL05.SNAHL06.SNAHL07.SNAHL12	341
Tatsamenie	Taku—Tatsamenie Lake	STATS05.STATS06	288

-continued-

Reporting group	Location	ADF&G collection code	*n*
Other	Ahrnklin River	SAHRN07	90
Other	Akwe River	SAKWE09.SAKWE16	186
Other	Alsek—Blanchard River	SBLAN07	89
Other	Alsek—Blanchard River	SBLAN09	62
Other	Alsek—Border Slough	SBORD07.SBORD08	71
Other	Alsek—Border Slough	SBORD09.SBORD11	70
Other	Alsek—Datlasaka Creek	SDATLAS12	95
Other	Alsek—Goat Creek	SGOATC07.SGOATC12	56
Other	Alsek—Klukshu River	SKLUK07	94
Other	Alsek—Klukshu River Weir late	SKLUK06	95
Other	Alsek—Kudwat (Little Tatshenshini Lake)	SLTATS01.SLTATS03	65
Other	Alsek—Kudwat (Tatshenshini) - Bridge/Silver	SBRIDGE11.SBRIDGE12	105
Other	Alsek—Kudwat (Tatshenshini)—Kwatini	SKWAT11	65
Other	Alsek—Kudwat (Tatshenshini)—Stinky Creek	SSTINKY11	40
Other	Alsek—Kudwat (Upper Tatshenshini)	SUTATS03	95
Other	Alsek—Kudwat Creek (Tatshenshini)	SKUDW09.SKUDW10.SKUDW11	100
Other	Alsek—Neskataheen Lake	SNESK07	195
Other	Alsek—Tweedsmuir	STWEED07	48
Other	Alsek—Tweedsmuir	STWEED09	46
Other	Alsek—Vern Ritchie	SVERNR09.SVERNR10	114
Other	Antler-Gilkey River	SANTGILK13	53
Other	Bainbridge Lake	SBAIN10	95
Other	Banana Lake—Klutina	SBANA08	80
Other	Bar Creek—Essowah Lake	SBAR04	95
Other	Bartlett River—Creel survey	SBART13	69
Other	Bear Hole—tributary Klutina	SBEARH08	94
Other	Bering Lake	SBERI91	95
Other	Berners River	SBERN03.SBERN13	165
Other	Big Lake—Ratz Harbor Creek	SBIGLK10.SBIGLA14	161
Other	Bloomfield Lake	SBLOOM05	93
Other	Central—Kitlope Lake	SKITL06	95
Other	Central Coast—Amback Creek	SAMBA04	91
Other	Chilkat Lake	SCKAT13	189
Other	Chilkat Lake early run	SCKAT07E.SCKAT07L	190
Other	Chilkat Mainstem—Bear Flats	SBEARFL07	95
Other	Chilkat Mainstem—Mosquito Lake	SMOSQ07	95
Other	Chilkat River—Mule Meadows	SMULE03.SMULE07	190
Other	Chilkoot Lake—beaches	SCHILB07	251
Other	Chilkoot Lake—Bear Creek	SCHILBC07	233
Other	Chilkoot River	SCHIK03	159

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Reporting group	Location	ADF&G collection code	*n*
Other	Clear Creek at 40 Mile	SCLEAR07	86
Other	Coghill Lake	SCOGH91.SCOG92HL.SCOG92ES.SCOGH10	378
Other	Columbia River - Okanagan River	SOKAN02	95
Other	Crescent Lake	SCRES03	194
Other	Dangerous River	SDANG09	95
Other	East Alsek River	SEAST03B	94
Other	Eek Creek	SEEK04.SEEK07	50
Other	Eshamy Creek	SESHAR08.SESHA91	185
Other	Eyak Lake—Hatchery Creek	SEYAK10	95
Other	Eyak Lake—Middle Arm	SEYAM07	95
Other	Eyak Lake—South beaches	SEYASB07	87
Other	Falls Lake—East Baranof Island	SFALL03.SFALL10	190
Other	Fillmore Lake—Hoffman Creek	SFILLM05	52
Other	Fish Creek—off East Fork Gulkana River	SFISHC08	95
Other	Ford Arm Creek	SFORD13	199
Other	Ford Arm Lake weir	SFORD04	207
Other	Fraser—Adams River—Shuswap late	SLADA02.SADAM07	187
Other	Fraser—Birkenhead	SBIRK07	90
Other	Fraser—Chilko Lake	SCHILK01	87
Other	Fraser—Chilliwack Lake	SCHILW04	89
Other	Fraser—Cultus Lake	SCULT02	91
Other	Fraser—Fraser Lake	SFRAS96	85
Other	Fraser—Gates Creek	SGATES09	90
Other	Fraser—Harrison River	SHARR07	95
Other	Fraser—Lower Horsefly River	SLHOR01.SUHOR01.SHORSE07	274
Other	Fraser—Middle Shuswap River	SMSHU02	91
Other	Fraser—Nahatlatch—Nahatlatch River	SNAHAT02	92
Other	Fraser—North Thompson	SNTHOM05	95
Other	Fraser—Raft River	SRAFT01	84
Other	Fraser—Scotch River	SSCOT00	91
Other	Fraser—Stellako River	SSTEL07	94
Other	Fraser—Tachie River	STACH01	94
Other	Fraser—Trembleur—Kynock	SKYNO97	94
Other	Fraser—Weaver Creek	SWEAV01	88
Other	Great Central Lake	SGCENLK02	95
Other	Gulkana River—East Fork	SGULK08EF	75
Other	Hasselborg Lake	SHASSEL12.SHASSELR13	209
Other	Hatchery Creek—Sweetwater	SHATC03.SHATC07	142
Other	Heckman Lake	SHECK04.SHECK07	189
Other	Helm Lake	SHELM05	94
Other	Hetta Creek—early run	SHETT10E	95

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Reporting group	Location	ADF&G collection code	*n*
Other	Hetta Creek—late run	SHETT03.SHETT08.SHETT09L	281
Other	Hetta Creek—middle run	SHETT09M	95
Other	Hoktaheen—marine waters	SHOKTAM14	47
Other	Hoktaheen—upper lake main inlet	SHOKTAI04	47
Other	Hoktaheen—upper lake outlet	SHOKTAO04	49
Other	Hugh Smith—Cobb Creek	SCOBB07	99
Other	Hugh Smith Lake	SHSMI92.SHUGH13	155
Other	Hugh Smith Lake—Bushmann Creek	SHUGH04	150
Other	Inlet Creek—Klawock	SINCK03.SINCK08.SHALF08	212
Other	Issaquah Creek—Puget Sound Drainage	SISSA96	82
Other	Italio River	SITAL17	41
Other	Kah Sheets Lake	SKAHS03	96
Other	Kanalku Creek	SKANA07.SKANA10.SKANAL13	319
Other	Kegan Lake	SKEGA04	95
Other	Kitimat River	SKITIM10	93
Other	Kitwanga River	SKITW12	92
Other	Klag Bay Stream outlet	SKLAG09	200
Other	Klakas Lake	SKLAK04	95
Other	Klawock-Three Mile Creek	STHRE04.STHRE10	181
Other	Klutina Lake—inlet	SKLUTI08.SKLUTI09	95
Other	Klutina River—mainstem	SKLUT08	95
Other	Kook Lake	SKOOK12E.SKOOK13	148
Other	Kook Lake—late	SKOOK07.SKOOK10L.SKOOK12L	194
Other	Kunk Lake—Etolin Island system	SKUNK03	96
Other	Kushtaka Lake	SKUSH07.SKUSH08	189
Other	Kutlaku Lake	SKUTL03	95
Other	Kutlaku Lake	SKUTL12	78
Other	Kutlaku Lake	SKUTL13	50
Other	Lace River	SLACE13	63
Other	Lake Creek	SAUKE13baseline.SLAKECR14	318
Other	Lake Eva	SLEVA12	115
Other	Lake Pleasant—Soleduck River	SLAKE97	76
Other	Lake Wenatchee	SWENA98	95
Other	Long Lake weir	SLONGLK05	95
Other	Lost/Tahwah Rivers	SLOST03B.SLOST03C	139
Other	Luck Lake—P.O.W. Island	SLUCK04	94
Other	Mahlo River	SMAHL08	94
Other	Mahoney Creek	SMAHO03.SMAHO07	153
Other	Main Bay	SMAIN91	96
Other	Martin Lake	SMART07.SMART08	187
Other	Martin River Slough	SMARTR08	95

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Reporting group	Location	ADF&G collection code	*n*
Other	McDonald Lake—Hatchery Creek	SMCDO01.SMCDO03.SMCDO07.SMCDO13	368
Other	McGilvery Creek	SKART92.SMCGI03.SMCGI04.SMCGI16	472
Other	McKinley Lake	SMCKI07	95
Other	McKinley Lake	SMCKI08	95
Other	McKinley Lake	SMCKI91	95
Other	McKinley Lake—Salmon Creek	SMCKSC07	93
Other	Mendeltna Creek	SMEND08.SMEND09	188
Other	Mentasta Lake	SMENT08	95
Other	Mill Creek Weir Early—Virginia Lake	SMILLC07E	94
Other	Mill Creek Weir Late—Virginia Lake	SMILLC07L	95
Other	Miners Lake	SMINE91.SMINE09	191
Other	Mitchell River	SMITCH01	94
Other	Nass—Bonney Creek	SBONN01.SBONN12	164
Other	Nass—Bowser Lake	SBOWS01	94
Other	Nass—Damdochax Creek	SDAMD01	93
Other	Nass—Gingit Creek	SGING97	94
Other	Nass—Hanna Creek	SHANNA06	93
Other	Nass—Kwinageese	SKWIN01.SKWIN12U	76
Other	Nass—Meziadin Beach	SMERI01.SMEZIB06	186
Other	Nass—Tintina Creek	STINT06	94
Other	Necker Bay	SNECKER91.SNECKER93	95
Other	Neva Lake weir	SNEVA08	94
Other	Neva Lake weir	SNEVA09.SNEVA13	255
Other	North Berg Bay inlet	SNBERG91	53
Other	North Berg Bay inlet	SNBERG92	100
Other	Old Situk	SOSITU07	163
Other	Pavlof River	SPAVLOF12.SPAVLOFR13	174
Other	Paxson Lake—outlet	SPAXSO09	75
Other	Petersburg Lake	SPETL04	95
Other	QCI—Naden River	SNADE95	95
Other	QCI—Yakoun Lake	SYAKO93	70
Other	Red Bay Lake	SREDBL04	95
Other	Redfish Lake Beaches	SREDB93	94
Other	Redoubt Lake—outlet	SREDOUBT13	200
Other	Salmon Bay Lake	SSALM04.SSALM07	170
Other	Salmon Creek—Bremner	SSALMC08	93
Other	Salmon Lake weir	SSALML07.SSALML08	185
Other	Sarkar—Five Finger Creek	SSARK00.SSARF05	91
Other	Seclusion Lake—in lake	SSECLK14.SSECLKIN14	117
Other	Shipley Lake	SSHIP03	94
Other	Sitkoh Lake	SSITK03.SSITK11.SSITK12	351

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Reporting group	Location	ADF&G collection code	*n*
Other	Situk Lake	SSITU07	159
Other	Situk Lake	SSITU13	190
Other	Skeena—Alastair Lake	SALAS87.SALAS06	118
Other	Skeena—Four Mile Creek	SFMILE06	85
Other	Skeena—Fulton River	SFULT06	95
Other	Skeena—Grizzly Creek	SGRIZ87	76
Other	Skeena—Kispiox River	SKISP02	53
Other	Skeena—Kitsumkalum Lake	SKALUM06	56
Other	Skeena—Kitsumkalum Lake	SKALUM12	94
Other	Skeena—Lakelse Lake (Williams)	SLAKEL06	93
Other	Skeena—Lower Tahlo River	SLTAH94	78
Other	Skeena—McDonell Lake (Zymoetz River)	SMCDON02.SMCDON06	131
Other	Skeena—Morrison	SMORR07	92
Other	Skeena—Motase Lake	SMOTA87	47
Other	Skeena—Nangeese River	SNANG06	40
Other	Skeena—Nanika River	SNANI88.SNANI07	113
Other	Skeena—Pierre Creek	SPIER06	95
Other	Skeena—Pinkut Creek	SPINK94.SPINK06	187
Other	Skeena—Salix Bear	SSALIX87.SSALIX88	94
Other	Skeena—Slamgeesh River	SSLAM06	95
Other	Skeena—Stephens Creek	SSTECR01	95
Other	Skeena—Sustut River	SSUST01	79
Other	Skeena—Swan Lake	SSWANLK06	93
Other	Skeena—Tahlo Creek	STAHLO07	95
Other	Skeena—Upper Babine River	SUBAB06	95
Other	Snettisham Hatchery	SSNET06.SSPEE07	190
Other	Snettisham Hatchery—Speel Lake	SSPEE13	146
Other	Sockeye Creek	SSOCK17.SSOCK18	136
Other	Speel Lake	SSPEE03	95
Other	St. Anne Creek	SSANN05.SSTACR08	186
Other	Steamboat Lake—Bremner	SSTEAM08	95
Other	Steep Creek	SSTEE03	91
Other	Stikine—Little Tahltan	SLTAH90	95
Other	Stikine—Tahltan Lake	STAHL06	196
Other	Swede Lake	SSWEDE08	95
Other	Tanada Creek weir	STANA05	94
Other	Tanada Lake—lower outlet	STANAO09	95
Other	Tanada Lake—shore	STANAS09	93
Other	Tankeeah River	STANK03	47
Other	Tankeeah River	STANK05	47
Other	Tawah Creek	STAWA17	94

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Reporting group	Location	ADF&G collection code	*n*
Other	Thoms Lake	STHOM04.STHOM14	93
Other	Tokun Lake	STOKUN08.STOKUN09	189
Other	Tonsina Lake	STONSL09	94
Other	Unuk River—Gene's Lake	SGENE07	95
Other	Unuk River—Gene's Lake	SGENE08	69
Other	Vancouver Island—Quatse River	SQUAT03	95
Other	Vivid Lake	SVIVID93	48
Other	Windfall Lake	SWIND03.SWIND07	142

Appendix G.–Detection and mitigation of selective sampling during a two-event mark–recapture experiment (Elliott and Power 2016). Revised August 2016.

Size- and sex-selective sampling may cause bias in two-event mark–recapture estimates of abundance and size and sex composition. Kolmogorov-Smirnov (KS) two sample tests are used to detect size-selective sampling and contingency table analyses (Chi-square tests of independence) are used to detect evidence of sex-selective sampling.

Results of the KS and Chi-square tests will dictate whether the data need to be stratified to obtain an unbiased estimate of abundance. The nature of the detected selectivity will also determine whether the first, second, or both event samples are used for estimating size and sex compositions.

DEFINITIONS

M = Lengths or sex of fish marked in the first event.
C = Lengths or sex of fish inspected for marks in the second event.
R = Lengths or sex of fish marked in the first event and recaptured in the second event.

SIZE-SELECTIVE SAMPLING: KS TESTS

Three KS tests are used to test for size-selective sampling.

KS Test 1	C vs R	Used to detect size selectivity during the 1st sampling event. H_o: Length distributions of populations associated with C and R are equal.
KS Test 2	M vs R	Used to detect size selectivity during the 2nd sampling event. H_o: Length distributions of populations associated with M and R are equal.
KS Test 3	M vs C	Used to corroborate the results of the first two tests. H_o: Length distributions of populations associated with M and C are equal.

SEX-SELECTIVE SAMPLING: CHI-SQUARE TESTS

Three contingency table analyses (χ^2-tests on 2×2 tables) are used to test for sex-selective sampling.

χ^2 Test 1	C vs R	Used to detect sex selectivity during the 1st sampling event. H_o: Sex is independent of the C—R classification.
χ^2 Test 2	M vs R	Used to detect sex selectivity during the 2nd sampling event. H_o: Sex is independent of the M—R classification.
χ^2 Test 3	M vs C	Used to corroborate the results of the first two tests. H_o: Sex is independent of the M—C classification

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The following table presents possible results of selectivity testing, their interpretation, and prescribed action:

Case	KS or χ^2 Test: M vs. R (2nd event test)	KS or χ^2 Test: C vs. R (1st event test)	KS or χ^2 Test: M vs. C (1st vs 2nd event)	Interpretation and Action
I	Fail to reject H_o	Fail to reject H_o	Fail to reject H_o	**Interpretation**: No selectivity during either sampling event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use all data from both sampling events.
II	Reject H_o	Fail to reject H_o	Reject H_o	**Interpretation:** No selectivity during the 1st event but there is selectivity during the 2nd event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use data from the 1st sampling event without stratification. 2nd event data only used if stratification of the abundance estimate is performed, with weighting according to Equations 1–3 below.
III	Fail to reject H_o	Reject H_o	Reject H_o	**Interpretation:** No selectivity during the 2nd event but there is selectivity during the 1st event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use data from the 2nd sampling event without stratification. 1st event data may be incorporated into composition estimation only after stratification of the abundance estimate and appropriate weighting according to Equations 1–3 below.
IV	Reject H_o	Reject H_o	Either result	**Interpretation:** Selectivity during both 1st and 2nd events. **Action**: Abundance: Use a stratified Petersen-type model, with estimates calculated separately for each stratum. Sum stratum estimates for overall abundance. Composition: Combine stratum estimates according to Equations 1–3 below.
V	Fail to reject H_o	Fail to reject H_o	Reject H_o	**Interpretation:** The results of the 3 tests are inconsistent. **Action:** Need to determine which of Cases I–IV best fits the data. Inconsistency can arise from high power of the M vs. C test or low power of the tests involving R. Examine sample sizes (generally M or C from <100 fish and R from <30 are considered small), magnitude of the test statistics (D_{max}), and the *P*-values of the three tests to determine which of which of Cases I–IV best fits the data.

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Composition estimation for stratified estimates

An estimate of the proportion of the population in the k^{th} size or sex category for stratified data with I strata is calculated as follows:

$$\hat{p}_k = \sum_{i=1}^{I} \frac{\hat{N}_i}{\hat{N}} \hat{p}_{ik}\,, \tag{1}$$

with variance estimated as

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

where

$\hat{p}_{ik}$ = estimated proportion of fish belonging to category k in stratum i;

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

$\hat{N}$ = estimated total abundance

$$= \sum_{i=1}^{I} \hat{N}_i\,. \tag{3}$$

Appendix H.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438). Excerpted from Elliott and Power 2016. Revised August 2016

Two contingency table analyses are used to determine if the Petersen estimate can be used (Seber 1982). If any of the null hypotheses are not rejected (i.e., $P > 0.05$), then it should be safe to use a pooled Petersen estimator (i.e., unbiased). If both of the null hypotheses are rejected, the Bayesian Time Stratified Population Analysis System (BTSPAS; Schwarz 2006; Schwarz et al. 2009; Bonner and Schwarz 2020) should be used to estimate abundance.

Seber (1982) describes four conditions that lead to an unbiased Petersen estimate, some of which can be tested directly:

1. Marked fish mix completely with unmarked fish between events,
2. Equal probability of capture in event 1 and equal movement patterns of marked and unmarked fish,
3. Equal probability of capture in event 2, and
4. The expected number of marked fish in recapture strata is proportional to the number of unmarked fish.

In the following tables, the terminology of Seber (1982) is followed, where a represents fish marked in the first event, n represents fish captured in second event, and m represents marked fish recaptured in the second event; $m_{\bullet j}$ and $m_{i\bullet}$ represent summation over the i^{th} and j^{th} indices, respectively.

I. Equal Proportions Test[ab] (SPAS[c] terminology)

Tests the hypothesis (condition 4) that the marked to unmarked ratio among recapture strata is constant: H_0: $\Sigma_i a_i\theta_{ij}/U_j = k$, where k = a constant, U_j = unmarked fish in stratum j at the time of 2nd event sampling, and a_i = number of marked fish released in stratum i. Failure to reject H_0 means the Petersen estimator should be used only if the degree of closure among tagging strata is constant, i.e., $\Sigma_j\theta_{ij} = \lambda$ (Schwarz and Taylor 1998, p 289). A special case of closure is when all recapture strata are sampled, such as in a fishwheel to fishwheel experiment, where $\Sigma_j\theta_{ij} = 1.0$; otherwise biological and experimental design information should be used to assess the degree of closure.

	Area/Time recapture strata *(j)*			
	1	2	…	t
Recaptured ($m_{\cdot j}$)	$m_{\bullet 1}$	$m_{\bullet 2}$	…	$m_{\bullet t}$
Unmarked ($n_j - m_{\cdot j}$)	$n_1 - m_{\bullet 1}$	$n_2 - m_{\bullet 2}$	…	$n_t - m_{\bullet t}$

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II. Complete Mixing Test[ad] (SPAS[c] terminology)

Tests the hypothesis that the probability of re-sighting a released animal is independent of its stratum of origin: H_0: $\Sigma_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in recapture stratum j during the second event, and d is a constant.

	Area/Time marking strata *(i)*			
	1	2	…	s
Recaptured (m_i)	m_1.	m_2.	…	m_s.
Not recaptured (a_i - m_i.)	a_1 - m_1.	a_2 - m_2.	…	a_s - m_s.

[a] There is no 1:1 correspondence between Tests I and II and conditions 2–3 above. It is pointed out that equal probability of capture in event 1 will lead to (expected) non-significant Test II results, as will mixing, and that equal probability of capture in event 2 along with equal closure ($\Sigma j \theta ij = \lambda$) will also lead to (expected) non-significant Test III results.

[b] This test can be implemented in a program such as Stratified Population Analysis System (SPAS; Arnason et al. 1996) using the matrix output from the BTSPAS package.

[c] Stratified Population Analysis System (SPAS; Arnason et al. 1996).

[d] This test is automatically implemented in the BTSPAS package and is reported in the results.txt file under the section "Test if pooled Petersen is allowable."

Appendix I.–The postseason abundance estimate procedure is as follows:

1. Perform a Kolmogorov–Smirnov test (KS) test (see Appendix G; Conover 1980) on the length distribution of captured fish (fish captured and tagged at the fish wheels in event one) versus the length distribution of recaptured fish (tagged fish recovered in the Canadian commercial harvest in event two).
    a. If the p-value of the KS test is ≤ 0.05, the null hypothesis (i.e., the length distributions of the two populations are equal) is rejected and we can conclude that the two sample data sets do not come from the same distribution and stratification is necessary. The capture and recapture data sets will then be split into a large and small data set at the length where the KS test statistic of length distribution of captured fish (at the fish wheels) versus the length distribution of recaptured fish (from the Canadian commercial harvest) is maximized. Move to step two.
    b. If the p-value of the KS test is > 0.05, we fail to reject the null hypothesis (i.e., the length distributions of the two populations are equal) and stratification is not necessary. Move to step three.
2. For the size-stratified pooled Petersen estimate to be unbiased, the conditions "equal proportions" and/or "complete mixing" must be met (see Appendix H). These conditions state that the expected ratio of marked to unmarked individuals is constant across all recovery strata due to similar migration patterns (equal proportions) and the expected ratio of marked to unmarked individuals is constant across all marking strata because of tagging in proportion to the run (complete mixing). Chi-square tests will be used to evaluate these conditions for the large fish data set and for the small fish data set (split by the KS test statistic).
    a. If at least one of the conditions is satisfied ($P > 0.05$; Arnason et al. 1996; see Appendix H) for each of the data sets, (i.e., at least one condition must be satisfied for the large fish data set and at least one condition must be satisfied for the small fish data set) the size-stratified pooled Petersen estimate, adjusted by a dropout, (see size-stratified Pooled Petersen abundance estimate section) will be considered the appropriate estimate and will be used as the postseason inriver abundance estimate.
    b. If at least one condition is not satisfied for each of the data sets (large and small), then the Bayesian size- and time-stratified Petersen abundance estimate, adjusted by a dropout, (see the Bayesian size- and time-stratified Petersen abundance estimate section) will be used as the postseason inriver abundance estimate.
3. For the pooled Petersen estimate to be unbiased, the conditions "equal proportions" and/or "complete mixing" must be met. Chi-square tests will be used to evaluate these conditions.
    a. If at least one of these conditions is satisfied ($P > 0.05$; Arnason et al. 1996; Appendix H) the pooled Petersen estimate, adjusted by a dropout, will be considered the appropriate estimate and will be used as the postseason inriver abundance estimate.
    b. If neither of these conditions is satisfied ($P \leq 0.05$), then the Bayesian time-stratified Petersen abundance estimate, adjusted by a dropout, will be used as the postseason inriver abundance estimate.

Appendix J.–Taku River sockeye salmon genetic mark–recapture inriver abundance estimate metohds.

The radiotelemetry study provides the opportunity to investigate genetic mark–recapture analysis for Taku River sockeye salmon (*Oncorhynchus nerka*) population. The genetic results will be used to examine genetic mark–recapture, but this will be an exploratory analysis and will not be used to propose a formal inriver abundance estimate.

The genetic mark–recapture analysis, as applied to Taku River sockeye salmon, consists of estimating total sockeye salmon escapement via a genetic mark–recapture experiment where the annual weir counts of lake-type sockeye salmon (Tatsamenie, King Salmon, Little Trapper, and Kuthai Lakes) are the number of marks ($M = E_m$) in the recapture event (assuming no mortality or unaccounted for catch past the fish wheels), divided by the first event stock proportion of lake-type sockeye salmon (p_m) caught in the Canyon Island fish wheels (hereafter referred to as 'fish wheels'). In terms of a Peterson mark–recapture estimator of abundance ($N = \frac{M}{p}$), M is the number of marked individuals, and p is the probability that the marked individual is encountered (Seber 1982). Lake-type sockeye salmon are considered to be "marked" (genetically), with birth being the marking event and the fish wheels being the recapture event. However, if it is determined that there is a documented severe passage issue to the weir (e.g., Kuthai Lake; Vinzant et al. *In prep a* and Vinzant et al. *In prep b*), those stocks are then considered part of the unmarked population. River-type sockeye salmon are considered unmarked. Therefore, an unbiased estimate of the above border abundance of sockeye salmon in the Taku River ($\widehat{N}$; marked and unmarked) is then

$$\widehat{N} = \frac{\widehat{N}_m}{\hat{p}_m} = \frac{\hat{E}_m}{\hat{p}_m}, \tag{1}$$

where $\widehat{N}_m = \hat{E}_m$ if there is no fishery harvest between the two sampling events or the harvest rate for all genetic stocks is equal (Hamazaki and DeCovich 2014). The annual stock composition of lake-type sockeye salmon stocks caught in the fish wheels ($p = \hat{p}_m$) is

$$\hat{p}_m = \frac{\sum_i \hat{n}_i \cdot \hat{p}_{i,m}}{\sum_i \hat{n}_i}, \tag{2}$$

where $\hat{n}_i$ is the weekly fish wheel catch of sockeye salmon and $\hat{p}_{i,m}$ is the weekly proportion of the marked stock in the fish wheel catch.

The Canadian commercial, food, First Nations, and assessment fisheries harvest occurs between the sampling events, therefore, the total Taku River sockeye salmon above border abundance is then,

$$\widehat{N} = \frac{\widehat{N}_m}{\hat{p}_m} = \frac{\hat{E}_m + \hat{C}_m}{\hat{p}_m} = \frac{\hat{E}_m + \hat{C} \cdot \hat{p}_{c,m}}{\hat{p}_m}, \tag{3}$$

where $\hat{C}$ is the total catch and $\hat{p}_{c,m}$ is the proportion of marked fish in the harvest. This method or similar methods have been applied to abundance estimates of Yentna River sockeye salmon (Willette et al. 2016), Yukon River Chinook salmon (*O. tshawytscha*) (Hamazaki and DeCovich 2014), and Alsek River Chinook and sockeye salmon stocks (Gazey 2010).

To successfully apply a genetic mark–recapture, there are four assumptions that must be met: (1) the marked stock is genetically identifiable through GSI methods, (2) accurate estimate of escapement (i.e., weir counts) of the genetically marked stock, (3) accurate estimate of the proportion of the genetically marked stock at the fish wheels (i.e., that the event one sampling is

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representative of the entire run), and (4) accurate estimates of harvest (or other removal) of the genetically marked stock between the fish wheel and escapement enumeration (weir, sonar, etc.) (Hamazaki and DeCovich 2014). In order to achieve a genetic mark–recapture estimate with high precision and accuracy, the marked stock needs to be a large enough proportion of the total, typically around 20%.

There is no evidence that the first assumption (i.e., marked stock were genetically identifiable through genetic stock identification (GSI) methods) is violated. The weekly stock composition of lake-type sockeye salmon will be estimated at the fish wheels; sockeye salmon will be proportionally sampled throughout the season for age, sex, length, GSI, and a radiotelemetry tag application. The stock composition at the fish wheels will use the current genetic baseline, which consists of 241 populations that are representative of the major producing stocks potentially present in the study area. The baseline consists of minor changes to Rogers Olive et al. (2018), with additional years pooled with existing Tatsatua Lake and Nahlin River populations and additional collections in the Yakutat area. The baseline was evaluated to ensure that the reporting groups meet reporting criteria as outlined in Barclay et al. 2019. Stock composition were estimated for the following reporting groups: 1) mainstem Taku/Stikine River (mainstem Taku River), 2) Nahlin River, 3) King Salmon Lake, 4) Kuthai Lake, 5) Little Trapper Lake, 6) Tatsatua Lake, 7) Tatsamenie Lake, and 8) Other. The weekly stock composition of lake-type sockeye salmon will also be estimated in the Canadian commercial fishery harvest. Approximately 200 fish per week will be randomly sampled at the Canadian landing stations for matched age (five scales per fish), genetics (from scale samples) and lengths, and will be inspected for tagging scars and secondary marks (Bednarski et al. 2020).

The second assumption (i.e., accurate estimate of escapement (i.e., weir counts) of the genetically marked stock) is met; four lake-type Taku River sockeye salmon escapements runs are enumerated annually. King Salmon Lake sockeye salmon has been continuously monitored through an escapement weir since 2003. The weir is operated by the TRTFN through funding provided by DFO, and is located at the outlet of King Salmon Lake. The weir was operated as a traditional counting weir through 2016, and was modified to a passive video monitoring weir in 2017. Kuthai Lake sockeye salmon was first monitored with an escapement weir in 1980 and 1981, but has been continuously monitored through an escapement weir since 1992. The weir has been operated by the TRTFN through funding provided by DFO, and is located at the outlet of Kuthai Lake. The weir was operated as a traditional counting weir through 2016, and was modified to a passive video monitoring weir in 2017. Little Trapper Lake sockeye salmon have been continuously monitored through an escapement weir since 1983. The weir is operated by Metla Environmental Inc. under contract to DFO, and is located at the outlet of Little Trapper Lake. The weir is operated as a traditional counting weir. Tatsamenie Lake sockeye salmon have been continuously monitored through an escapement weir since 1995. The weir is operated by Metla Environmental Inc. under contract to DFO, and is located at the outlet of Tatsamenie Lake. The weir is operated as a traditional counting weir.

The third assumption (i.e., accurate estimate of the proportion of the genetically marked stock at the fish wheels) is met if the catch of the fish wheels is representative of the total run and we systematically sample every 1 of *x* sockeye salmon we catch. We will use a two-sample

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Kolmogorov-Smirnov (KS) nonparametric test to verify that radiotagged sockeye salmon are representative of the size distribution of the inriver abundance (represented by the fish wheel catch). In 2019, and 2020, KS tests were performed on the length data of radiotagged fish and nonradiotagged fish (i.e., spaghetti tagged fish at the fish wheel). The radiotagged fish, adequately represented the length distribution of sockeye salmon in the Taku River, as sampled from the fish wheels (Vinzant et al. *In prep a* and Vinzant et al. *In prep b*).

The fourth assumption (i.e. complete accounting for removals of the marked stock between the fish wheels and escapement enumeration) may only be partially met. While there are catch sampling and GSI programs in place to accurately account for Canada's inriver harvest of sockeye salmon and determine the stock composition of that harvest, radiotelemetry data from 2019 and 2020 (Vinzant et al. *In prep a* and Vinzant et al. *In prep b*) indicate that a significant fraction of marked, lake-type stocks do not make it to their natal lakes where they can be enumerated as escapement and therefore are unaccounted as marked fish in the genetic mark–recapture estimate. This concern was based on examining all the radiotagged sockeye salmon that met the required ≥0.95 probability threshold for successful genetic individual assignment to reporting of group (Simmons et al. 2013). There were marked fish that passed U.S./Canada border and Canadian fisheries but did not pass into the lakes, so they were not included in the annual lake escapement estimates, and went unaccounted in the genetic mark–recapture estimate.

It is apparent that an accurate estimate of escapement of the marked stocks (i.e., Taku lake-type stocks) are not currently available; violating an underlying assumption of genetic mark–recapture. Reasons for the failure of these sockeye salmon to escape into their respective natal lakes is unknown. Intermittent and partial barriers to migration and spawning at outlet creeks (i.e. below weir sites) is likely in some cases, natural migration mortality or tagging effects (e.g., reduced fitness, increased mortality) may also influence final fate locations determined by aerial telemetry.

There are few options to account for unaccounted fish, lake-type stock can be reassigned from a "marked" to "unmarked stock" (i.e. Kuthai Lake); however, the more stocks reassigned the lower the marked population in the study. One way to attempt to account for fish genetically identified at the fish wheels as a "marked" fish, that did not pass an escapement assessment project [weir, video] and thus were not enumerated, is to expand the annual weir counts of lake-type sockeye salmon in each stock by the average proportion of marked radiotagged sockeye salmon in that stock that escaped into the respective lakes, $\hat{u}_m$,

$$\widehat{N} = \frac{(\sum_m \frac{\hat{E}_m}{\hat{u}_m}) + \hat{C} \cdot \hat{p}_{c,m}}{\hat{p}_m}, \tag{4}$$

To successfully apply this concept to historical years, when radiotelemetry data is not available, the interannual variability in the proportion of unaccounted for "marked" fish during radiotelemetry project years, would need to be low, and therefore it would be difficult to apply the escapement expansion concept to historical data and future years without radiotelemetry data as there has been substantial variability shown amongst the marked stocks.