Regional Operational Plan No. ROP.CF.1J.2023.03

Juvenile Abundance and Harvest of Chilkat River Chinook and Coho Salmon, 2022–2023

by

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and

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March 2023

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	′
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	″
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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Approval

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ABSTRACT

An ongoing coded wire tag project, used as part of a stock assessment program for Chilkat River Chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch*, will be conducted during fall 2022 and spring 2023 to provide estimates of smolt abundance and marine harvest for Chinook and coho salmon. This project uses modified Peterson 2-event mark–recapture methods to estimate smolt abundance, and port sampling of coded wire tags in mixed stock commercial and sport fisheries to estimate marine harvest for both species. Juvenile salmon will be measured for length and weight, marked with adipose fin clips, and tagged with coded wire tags in fall 2022 (juvenile Chinook salmon) and spring 2023 (Chinook and coho salmon smolt) as event 1 of the mark–recapture study. During event 2, adult Chinook salmon will be sampled for missing adipose fins, coded wire tags, age, sex, and length in Chilkat River fishwheels and drift gillnets, which are operated in the lower Chilkat River as part of a separate adult mark–recapture project. Adult Chinook salmon will be also sampled for missing adipose fins, coded wire tags, and age, sex, and length during Chilkat River drainage spawning grounds surveys to complete event 2 sampling. Coho salmon will also be sampled as adults during event 2 in the lower Chilkat River fishwheels. Age composition of Chinook salmon adults will be estimated by scale ageing techniques; age composition of coho salmon smolt and adults will also be estimated. The Alaska Department of Fish and Game uses these data to make local and regional management decisions. Chilkat River Chinook salmon is a Pacific Salmon Commission exploitation rate and escapement indicator stock and has recently been added to the base model of abundance indicator stocks for the Chinook Technical Committee, which influences coastwide management.

Keywords: Chinook salmon, *Oncorhynchus tshawytscha,* coho salmon, *Oncorhynchus kisutch,* coded wire tag, mark–recapture, escapement, Chilkat River, Haines, Lynn Canal, marine harvest, marine survival

PURPOSE

The Chilkat River is generally the third or fourth largest producer of Chinook salmon *Oncorhynchus tshawytscha* (McPherson et al. 2003) in Southeast Alaska (SEAK) and is also the second largest producer of coho salmon *O. kisutch* in the region (Shaul et al. 2008) and provides one of the largest coho salmon freshwater fisheries in SEAK (Jennings et al. 2015). The Chinook salmon stock is also a Pacific Salmon Commission (PSC) exploitation rate and escapement indicator stock and contributes towards management of the mixed stock fisheries in accordance with the Pacific Salmon Treaty (PST).

Stock assessment of Chilkat River Chinook and coho salmon includes full production estimates; the Chilkat River coded wire tag project is an important component towards estimating smolt abundance, marine harvest in mixed-stock fisheries, and marine survival from smolt to adult. Coded wire tag studies have been conducted on the Chilkat River consistently since 2000. Smolt abundance along with harvest contributions have been estimated consistently for Chilkat River Chinook salmon brood years (BY) 1999–2014, with brood years 2015–2019 in progress. Smolt abundance, marine harvest, and marine survival have been estimated for coho salmon outmigration years 1999–2019, with 2021 and 2022 in progress.

Chilkat River Chinook salmon smolt abundance averaged 162,407 fish (avg. CV = 32%) for BY 1999–2014, total return averaged 3,910 fish (avg. CV = 12%), marine harvest averaged 884 fish (avg. CV = 27%), and marine survival averaged 2.6% (avg. CV = 34%). For emigration years 1999–2019, Chilkat River coho salmon smolt abundance averaged 1,090,159 fish (avg. CV = 20%) and marine harvest averaged 45,519 fish (avg. CV = 15%). For return years 2000–2020, total return averaged 115,730 fish (avg. CV = 13%), and marine survival averaged 11% (avg. CV = 24%).

This operational plan includes the study design for fall coded-wire-tagging of juvenile Chinook salmon in the Chilkat River drainage, including the Tahini and Kelsall Rivers and Chilkat River main channels during September and October 2022, as well as spring tagging of Chinook and coho salmon smolt during April and May 2023 in main channels of the Chilkat River.

BACKGROUND

The Chilkat River is a large glacial system that originates in British Columbia, Canada and traverses rugged mountainous terrain and terminates in Chilkat Inlet in northern Lynn Canal (Figure 1). The main channels and major tributaries comprise approximately 350 km of fluvial habitat in a watershed covering about 1,600 km² (Bugliosi 1988).

Chilkat River Chinook salmon are harvested primarily in commercial drift gillnet (2004–2021 average 176 fish ≥ age-1.2), commercial troll (163 fish), and Haines area sport (96 fish) fisheries, with smaller harvests occurring in SEAK sport fisheries (73 fish) and purse seine fisheries (45 fish). Haines area subsistence fisheries also averaged 52 fish ≥ age-1.2 (Table 1). From 1981 through 1992, the Chilkat River Chinook salmon escapement was monitored through peak survey counts on clearwater tributaries to the Chilkat River (Big Boulder Creek and Stonehouse Creek) as an index of abundance. Mark–recapture experiments have been used to estimate the abundance of large Chinook salmon entering the Chilkat River since 1991. Comparisons of 1991 and 1992 mark–recapture estimates to expanded Stonehouse Creek and Big Boulder Creek index counts showed that the expanded index counts grossly underestimated total Chilkat River abundance (Johnson et al. 1993).

Between 1991 and 2020, mark–recapture estimates of inriver abundance of large Chinook salmon have ranged from 873 to 8,100 fish. After removing reported inriver subsistence harvest, escapement estimates have ranged from 873 to 8,089 fish during the same period (Table 2). In 2003, the Alaska Department of Fish and Game (ADF&G) adopted an escapement goal range of 1,750–3,500 large Chinook salmon for the Chilkat River drainage, concurrent with the Board of Fisheries approving the Chilkat River and Lynn Canal King Salmon Fishery Management Plan (5 AAC 33.384). The plan uses an inriver abundance goal range of 1,850–3,600 large Chinook salmon upstream of the adult marking area, based on stock-recruit analysis and the size of the Chilkat River drainage (Ericksen and McPherson 2004). Since Chilkat River Chinook salmon inriver mark–recapture studies were initiated in 1991, escapement estimates were below the lower bound of the goal range in six years: 2007, 2012, 2013, 2014, 2016, 2017, and 2018 (Chapell 2010, 2013b, Elliott and Peterson *in prep*).

Coded wire tag studies of Chilkat River Chinook salmon have been conducted periodically since 1985, and consistently from 2000 through 2021 (Table 3). Chinook salmon harvest contributions have been estimated for the Tahini River BYs 1984 and 1985 (Johnson et al. 1993) and the Chilkat River BYs 1988, 1989, 1991, 1998, and 1999–2012 (Ericksen 1996, 1999; Ericksen and Chapell 2006b; Chapell 2009, 2010, 2012, 2013a-b, 2014, Elliott and Peterson *in prep*). These studies indicate that Chilkat River Chinook salmon rear primarily in the inside marine waters of northern SEAK, and that exploitation rates on this stock have ranged from 4% to 42% for BYs 1999–2014 (Table 4). However, a 1991 study that compared logbook-recorded catch rates to fish ticket-reported catches showed that the Chinook salmon harvest in the Lynn Canal commercial drift gillnet fishery was grossly underreported, so estimated marine exploitation rates are most likely biased low (Ericksen and Marshall 1997). Stock assessment data will also be continuously updated by including estimates of fall juvenile abundance, smolt abundance, overwinter survival, marine survival, and annual harvest rates and brood year exploitation rates provided by coded wire tag studies.

The Chilkat River produces coho salmon harvested in Haines area recreational fisheries including one of the largest freshwater coho salmon fisheries in the SEAK region, with an average annual harvest of 1,228 coho salmon from 2000 to 2020 (Elliott 2013, Elliott *in prep a-j*). The contribution of Chilkat River coho salmon to mixed stock commercial and sport marine fisheries in SEAK averaged 45,519 fish from 2000 to 2020 (Table 5). Escapement and harvest research conducted during the 1980s on coho salmon stocks in Lynn Canal suggest that these stocks were subjected to very high (> 85%) exploitation rates (Elliott and Kuntz 1988; Shaul et al. 1991); since coded wire tag studies began in 1999 exploitation rate estimates have ranged from 14% to 65% (Table 5).

Chilkat River coho salmon smolt were coded-wire-tagged intermittently from 1976 to 1984, and annually from 1999–2019 and 2021–2022 (Table 6). Because of Covid-19 concerns, no Chilkat River coho salmon smolt were coded-wire-tagged in the spring of 2020. Of the 7,895 coho salmon smolt tagged in 2022 (Table 6), about 3% are expected to return as ocean-age-0 jacks in 2023. The majority of those tagged in 2021 (97%) will start entering the lower Chilkat River as ocean-age-1 adults in August 2022, where a proportion will be captured and sampled for coded wire tags, which is used to produce the smolt abundance estimate for the 2021 emigrating class. Overall, the Chilkat River coho salmon coded wire tag project creates estimates of smolt emigration abundance, marine harvest by fishery, and smolt-to-adult survival (Table 5). Total marine harvest (commercial, sport, and subsistence fisheries) has ranged from 4,534 fish in 2020 to 128,466 fish in 2004. Most of the marine harvest occurs in the commercial troll fishery (range 18–68%) and the Lynn Canal drift gillnet fishery (27–80%). Overall marine exploitation has averaged 38% from 2000–2020 (Table 5). Commercial fishery management, weather conditions, and the price of coho salmon are the primary reasons for the fluctuation in marine exploitation.

The Chilkat River coho salmon total escapement, including ocean-age-0 fish, has been estimated each year since 1987 by expanding peak counts from index area foot surveys in four widely distributed streams: Spring Creek in the Tsirku River drainage, Kelsall River, Tahini River, and Clear Creek on the west side of Chilkat Inlet (Figure 2, Table 7). The total of all four index counts is expanded to estimate escapement, based on five previous mark–recapture experiments used to calibrate the index count. Mark–recapture projects were conducted in 1990 (estimate = 79,807 fish, SE = 9,980), 1998 (estimate = 50,758, SE = 10,698), 2002 (estimate = 205,429, SE = 31,165), 2003 (estimate = 134,340, SE = 15,070), and 2005 (estimate = 38,589, SE = 4,625) (Elliott 2009). Averaging the ratios of mark–recapture estimates to the sum of concurrent peak index counts has produced an expansion factor of 33.6 (SE = 6.5). Mark–recapture studies must be repeated periodically to calibrate the expansion factor.

This operational plan covers sampling and estimation of smolt abundance and subsequent adult harvest by marking juvenile Chinook salmon with adipose fin clips and coded-wire-tagging of Chinook salmon juveniles in the fall of 2022 and marking and tagging Chinook and coho salmon smolts in the spring of 2023.

OBJECTIVES

1. Estimate the number of Chinook salmon smolt leaving the Chilkat River in the spring of 2023 such that the estimate is within 25% of the true value 90% of the time.
2. Estimate the number of coho salmon smolt leaving the Chilkat River in the spring of 2023 such that the estimate is within 40% of the true value 90% of the time.

3. Estimate the proportion of adult coho salmon returning to the Chilkat River in 2024 that were marked with coded wire tags in 2023, such that the estimate is within 5% of the true value 90% of the time.
4. Estimate the mean length and weight of Chilkat River juvenile Chinook salmon in the fall of 2022 and the mean length and weight of Chinook and coho smolt emigrating in the spring of 2023 such that the estimates are within 5 mm or 1 gram of the true value 95% of the time.

SECONDARY OBJECTIVES

1. Estimate the marine harvest of Chilkat River Chinook salmon from the 2021 BY (via recovery of adults with coded wire tags that emigrated as smolt in 2023).
2. Estimate the marine harvest of Chilkat River coho salmon in 2024 (via recovery of adults with coded wire tags that emigrated as smolt in 2023).
3. Estimate the abundance of juvenile Chinook salmon rearing in the Chilkat River in the fall of 2022.
4. Estimate the age composition of coho salmon smolt emigrating from the Chilkat River in 2023.
5. Estimate the mean length-at-age of coho salmon smolt emigrating from the Chilkat River in 2023.

METHODS

Two-event mark–recapture experiments will be used to estimate the abundance of juvenile Chilkat River Chinook salmon rearing in the Chilkat drainage in the fall of 2022, Chinook salmon smolt emigrating in the spring of 2023, and coho salmon smolt emigrating in the spring of 2023. Fish in mark–recapture event 1 will be marked by removing the adipose fin and inserting a coded wire tag in the nose cartilage. All marked fish will be sampled to estimate mean length and weight and only coho salmon smolt will be sampled to estimate freshwater age composition. For mark–recapture event 2 sampling, adult Chinook and coho salmon will be sampled for missing adipose fins and the presence of a coded wire tag as they return to the Chilkat River in 2024 (coho salmon) and 2024–2028 (Chinook salmon). The harvest of Chinook and coho salmon will be estimated through the recovery of coded wire tags in randomly sampled fisheries.

Chilkat River Chinook salmon are almost all (> 99%) yearling smolt, overwintering 1 year and emigrating as freshwater-age-1 smolt (Olsen 1992). Therefore, Chinook juvenile salmon tagged in the fall of year t+1, and smolt tagged in the spring of year t+2, are from BY t. Adult Chinook salmon return to the river over a span of five years, beginning with age-1.1 “jacks” in year t+3 and ending with age-1.5 fish in year t+7. For example, Chinook salmon implanted with coded wire tags in the fall of 2022 (juvenile) and spring of 2023 (smolt), both from BY 2021, will return in 2024 (age-1.1 “jacks”) though 2028 (age-1.5 fish).

Coho salmon returning to the Chilkat River belong primarily to 2 age classes: age-1.1 (1998–2010 average = 76%), and age-2.1 (1998–2010 average = 22%). The remaining age classes are age-1.0 and age-2.0 “jacks” that have composed 3% of the escapement over the same time. Because the majority of coho salmon return as ocean-age-1 fish, coho smolt implanted with coded wire tags in 2023, from BYs 2020 and 2021, will return primarily in 2024.

SMOLT AND JUVENILE TAGGING

Fall 2022 - Juvenile Chinook Salmon Tagging

To estimate juvenile Chinook salmon abundance, a range of 80–100 baited minnow traps will be set and retrieved per day in the Tahini River, Kelsall River, and Chilkat River main channels from the Kelsall River confluence downstream to Haines Highway milepost (MP) 10. Captured fish will be sorted, and only juvenile Chinook salmon will be retained for tagging. All trapping locations will be recorded with global positioning system (GPS) coordinates and juvenile Chinook salmon catches will be recorded by location. All juvenile Chinook salmon caught in traps will be transported to a central tagging location. Once at the tagging site, all healthy juvenile Chinook salmon ≥ 50 mm fork length (FL) will have their adipose fin removed and will be tagged with a 1.1 mm coded wire tag (see Data Collection for details of processing). All Chinook salmon tagged will be checked the day after tagging for tag retention and released in the same stream as captured. One code of 10,000 tags will be used until exhausted; additional codes will be used for every subsequent 10,000 fish tagged during the fall project.

The Tahini and Kelsall Rivers trapping areas align closely with results of 1991, 1992, and 2005 radio telemetry studies (Johnson et al. 1992–1993; Ericksen and Chapell 2006b), which indicated that 85–92% of the Chinook salmon entering the Chilkat River spawn in these two drainages.

Tagging operations will begin September 16 on the Tahini River, where a crew of four technicians will trap and tag juvenile Chinook salmon for up to 10 days, depending on river conditions and catch rates. If catch rates are lower than expected in traditional trapping areas, traps will be set over a wider area in an exploratory fashion to locate concentrations of rearing fish. In efforts to maximize catch rates, traps will be moved consistently when catch rates drop.

The Kelsall River has been the biggest producer of juvenile Chinook salmon in most years (Table 3) and will continue to be the major focus of effort in fall 2023. Trapping efforts on the Kelsall River will commence October 1 and will continue for up to 14 days, or until all trapping areas are exhausted.

After leaving the Kelsall River, trapping efforts will move to Chilkat River main channels. Traps will be set primarily between MP 13 and MP 19, and in the section between MP 24 and the Kelsall River confluence. The Chilkat River portion of the project does not require a field camp, as the crew is based out of the Haines office.

Spring 2023 - Chinook and Coho Salmon Smolt Tagging

From April 1 through May 15, 2023, a minimum of 80 and up to 100 baited minnow traps will be set and retrieved daily in main channels of the lower Chilkat River, MP 10–21, and in the upper Chilkat River area as conditions permit, to maximize Chinook salmon smolt catches. All coho salmon smolt ≥ 75 mm FL captured in the process will also be tagged. Gear will be set in Chinook salmon habitat sites that provide the best chance of capturing a representative sample of smolt from several tributaries of the Chilkat River. Global positioning system coordinates and Chinook and coho salmon smolt catches will be recorded at each tagging site. Two trap lines will be checked at least once per day by two teams of 2 technicians each. If time permits, traps that produced the greatest catches during the first check will be checked twice.

Beginning in early April, and running until mid-May, a minimum of 41 trapping days will be used. The expected number of valid coded wire tags released is based on an average daily trap total (90 traps, Appendix A). The estimated number of Chinook salmon smolt based on 2013–2022 CPUE is 4,249 fish, and estimated coho salmon smolt released with valid coded wire tags is 8,977 fish. Only the most recent CPUE is used because of the shift in project focus and duration compared to 2000–2012. Average Chinook salmon smolt CPUE in 2013–2022 was 1.2 fish per trap, and average coho salmon smolt CPUE was 2.4 fish per trap.

All target species caught in traps will be transported to a central tagging location. Every second day, depending on the number of smolts caught, collected fish will be sorted by species and size. All healthy Chinook ≥ 50 mm and coho ≥ 75 mm FL salmon that are captured will be adipose fin-clipped and will have a 1.1 mm coded wire tag implanted in their snout (see Data Collection for details of processing). Tagging every second day will increase efficiency of set up and take down of tagging equipment and will also increase capture rates by allowing for more time to seek out productive trapping areas. A Northwest Marine Technology Mark IV[1] tag injector will be dedicated to tagging Chinook salmon with a unique code. Spools of coded wire will be changed only when exhausted.

Coho salmon smolt will be sorted into 3 size categories: small (75 mm–84 mm), medium (85 mm–99 mm), and large (100 mm and larger). A tag injector will be dedicated to tagging coho salmon. A different size head mold (small, medium, large) will be used with each size group to achieve optimal coded wire tag placement and retention. Two unique tag codes will be assigned by size: small fish will receive one code, and medium and large fish (all coho salmon ≥ 85 mm) will receive the other code. Tagging each size group (small vs. medium/large) of coho salmon smolt with unique tag codes will allow for detection of differential recovery rates in samples of adults. An alternate smolt population estimator discussed in Data Analysis can eliminate bias created in disproportionate tagging of coho salmon smolt.

Sampling Adult Chinook and Coho Salmon to Estimate Smolt and Fall Juvenile (Chinook) Abundance

Escapement sampling of adult Chinook salmon in the Chilkat River is detailed in a separate operational plan covering the use of fish wheels and drift gillnets in the lower river (event 1) and various gear types on the spawning grounds (event 2) to capture and sample adults (Elliott 2019). The details relevant to the objectives of this plan are as follows: all adult Chinook salmon captured in the lower river and on the spawning grounds will be inspected for missing adipose fins and sampled for age, sex, and length. Heads will be collected (for coded wire tags) from Chinook salmon less than 440 mm METF (primarily age-1.1 males). Heads will also be taken from fish that do not test positive for the presence of a coded wire tag using a handheld wand detector (metal detector) to confirm the valid tag rate (i.e., fish that are missing their adipose fins and possess a valid coded wire tag). Heads will also be taken from spawned-out fish and carcasses of all sizes on the spawning grounds (62% of the large fish sampled in 1991–2021). These criteria for sacrificing fish will minimize the impact of sampling on Chinook salmon spawning production.

Division of Commercial Fisheries (CF) personnel will capture adult coho salmon in two fish wheels along the Chilkat River, adjacent to the Haines Highway between MP 7 and 9, operated annually from approximately June 10 to October 15. Data collected in previous years indicates that 97% of the immigrating coho salmon will be caught during this time. Fish wheels will operate continuously except when stopped for maintenance.

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[1] Northwest Marine Technology, 976 Ben Nevis Loop, Shaw Island, WA, 98286

Proportional sampling of coho salmon in the lower Chilkat River fish wheels (Figure 2) will allow estimation of the marked fraction used to calculate smolt abundance and adult harvest. In 2022, for example, we will sample the coho salmon adult return for adipose fin clips and coded-wire tags. Calculation of the mark fraction includes inspecting all ocean-age-1 coho salmon that emigrated in spring 2021, when 3,788 fish were marked with adipose fin clips and coded-wire tagged. Coho salmon will be carefully removed from the fish wheel holding pen and placed into a trough filled with water. All newly captured coho salmon will be sampled for length from mid eye to tail fork (METF), sex, and inspected for missing adipose fins. Data will be recorded on the ADF&G adult salmon age-length (ASAL) form version 3.0 (Figures 3 and 4). Fish that are missing their adipose fins will be sacrificed for recovery of the coded wire tag. Heads will be removed and marked with a numbered plastic cinch strap; the strap number will be recorded on the ASAL form and a coded wire tag recovery form. To prevent double sampling, all coho salmon captured in the lower river will be given a lower left operculum punch that will be recognized upon recapture.

To systematically subsample the coho salmon migration for age composition, scales will be collected at a rate of approximately 1 out of 4 fish, and in addition, from all fish with missing adipose fins. The first 10 of 40 fish, regardless of adipose fin clip status, will be recorded on an ASAL labeled *044* (Figure 3). The associated scale cards will be numbered sequentially, with the first 10 scales on card *044*, and the remaining 3 scale samples, plus any additional scales from adipose fin-clipped fish, on card *044(A)*. The fish numbered 11 or higher (coded wire tag fish only) will not be used for calculating age composition, but for determination of recovery rates and freshwater ages of the 2 different coho salmon smolt tagging groups. The remaining 30 out of 40 fish will be sampled for sex and length only, and their data will be recorded on ASAL form labeled *044(N)* (Figure 4). For subsequent batches of up to 40 fish, the first 13 fish will again be sampled for sex, length and scales, their scales placed on cards *045,* and *045(A)*, and their ASAL form labeled accordingly. The data (sex and length only) for the remaining 30 of 40 fish will be recorded on ASAL form *045(N)*. Each new sampling day will start with a new set of ASAL forms scale cards, with numbering continued sequentially. This numbering system will assist CF staff in entering the sex, length, and age data into the CF database.

The scale sampling procedure includes removing 5 scales from the left side of each sampled fish (right side if left-side scales are regenerated) along a line 2 to 4 scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin (Scarnecchia 1979). Scales will be carefully cleaned and placed on gum cards at the rate of one fish per column (i.e., scales from fish #1 will be placed over 1, 11, 21, and 31 on the gum card, and the fifth scale will be placed in the blank space just below 31). Scales need to be upright (posterior down) with the rough (convex) side out. Obvious regenerated scales will be discarded, and new scales selected. When placing scales, room will be left at the top middle portion of the card, so a label can be affixed later. Scale cards will be kept as dry as possible to prevent gum from running and obscuring the scale ridges and will be completely labeled including the last names of each sampler. A triacetate impression of the scales (30 seconds at 3,500 lb/in^2, at a temperature of 97°C) will be used for age determination. Scales will be read for age using protocols in Mosher (1969) and the CF scale-aging group.

Sample Sizes

Smolt Abundance

Chinook Salmon

Returning Chinook salmon in the Chilkat River will be inspected for marks (missing adipose fins), 2024–2028 (age-1.1 to age-1.5) during annual adult mark–recapture studies, as detailed in Elliott (2019). Lower Chilkat River capture gear used for event 1 marking and sampling includes drift gillnets and fish wheels operated by CF. Spawning Chinook salmon will also be inspected during event 2 in several spawning locations using various capture gear types. Inriver abundance of ocean-age-2 and older Chinook salmon in recent brood years (1999–2014) has averaged 3,026 fish (SE = 405; Table 4). The brood year exploitation rate of Chilkat River Chinook salmon has averaged 22.2% (SE = 5.1%) under SEAK fishing regulations, which averages 884 (SE = 224) fish per year in all marine fisheries, including commercial, sport, and subsistence (Table 4). Assuming average fall juvenile abundance, we anticipate that 454,270 Chinook salmon will be rearing in the Chilkat River drainage during fall 2022. Assuming average overwinter survival (36.6%, SE = 12.3%, Table 4), it is anticipated that 166,316 Chinook juvenile salmon will emigrate from the Chilkat River in 2023. If the tagging goal of 25,000 Chinook juvenile salmon is reached in fall 2022, 5.5% of the juvenile population will be marked. Approximately 7,322 marked juvenile Chinook salmon (36.6% x 20,000) should survive to emigrate as smolt. Using anticipated spring CPUE from 2013–2022, measured by valid coded-wire-tagged fish per trap deployed (Appendix A), an additional 4,249 Chinook salmon smolt will be marked with adipose fin clips and tagged with coded wire in spring 2023, so it is reasonable to expect 11,571 fish from an expected smolt population of 162,407 to be marked with adipose fin clips and tagged with coded wire (marked fraction 7.1%, Appendix A).

From 1994 to 2021, an average of 886 immigrating Chinook salmon (308 in the lower river and 578 on spawning grounds) have been inspected annually for missing adipose fins. In efforts to conserve spawning productivity, not all fish with missing adipose fins will be sacrificed to recover coded wire tags (Objective 1). Heads will be taken only from fish $<$ 440 mm METF during event 1 and from post spawners and carcasses during event 2. The expected sample size of age-1.1 fish during event 1 is 67 Chinook salmon (based on return years 1994–2021). The expected sample sizes for ≥ age-1.2 event 2 Chinook salmon that are in post-spawning condition or carcasses is 323 fish, made up of 293 ≥ age-1.3 fish and 30 age-1.2 fish. Because 595 adult fish need to be inspected for missing adipose fins to meet the criteria for Objective 1 (Robson and Regier (1964), smolt emigration of 162,407 fish with 11,571 marked fish and no lost tags and alpha = 0.10 and d = 0.25), it is reasonable to expect that Objective 1 criteria will be met.

Coho Salmon

Using 2013–2019 and 2021 average CPUE and projected traps deployed for 41 days of trapping (April 4–May 14, Appendix A), it is expected that 8,977 coho salmon smolt will be marked with adipose fin clips, injected with a coded wire tag, and released in 2023. Under the current study design, therefore, it is unlikely that the number of coho salmon smolt tagged and released will meet or exceed the 2001–2012 average of 24,998 Chilkat River coho salmon (Table 6).

Returning adult coho salmon will be inspected for missing adipose fins in 2024 in Chilkat River fish wheels operated by CF. The fraction used to estimate smolt abundance is the proportion of ocean-age-1 coho salmon missing adipose fins (θ_{smolt}). It is anticipated that we will capture and sample about 2,167 returning ocean-age-1 coho salmon in the fish wheels (average number inspected 2000–

2020). Using the methods of Robson and Regier (1964) with an assumed population size of 1,090,159 (Table 5) and 9,807 marks released, 2,446 adults need to be inspected for missing adipose fins to meet precision criteria (Objective 2, assuming alpha = 0.10, d = 0.40). It is expected that 19 of those fish will have adipose fin clips. This field sampling design has resulted in the 90% confidence interval being within 40% of the Chilkat River coho salmon smolt estimate in 16 of 21 outmigration years 1999–2019 (Table 5); the goal remains to mark and inspect as many fish as possible.

Mean Length and Weight of Smolt and Juvenile Chinook and Coho Salmon

Smolt and juvenile Chinook salmon will be systematically sampled to estimate mean length and weight of the populations within 1 mm or 1 gram of the true value 95% of the time. According to procedures in Cochran (1977, p. 77–78), the sample size *n* needed to estimate juvenile or smolt length or weight within d units for 100 * (1-α) % relative precision under simple random sampling, with a standard deviation of length or weight s, is given by:

$$n = (Z_{(1-\alpha/2)}\ s\ /\ d)^2 \qquad (1)$$

For juvenile Chinook salmon, the required sample size to estimate length is 178 fish ($Z_{(1-\alpha/2)}$ = 1.96, s = 6.8 mm, d = 1 mm) and the required sample size to estimate weight is 6 fish ($Z_{(1-\alpha/2)}$ = 1.96, s = 1.3 grams, d = 1 gram). Using the greater of the two sample sizes and based on a catch of 20,000 juvenile Chinook salmon, every 112st juvenile captured will need to be measured. Similarly for Chinook salmon smolt, the required sample size to estimate length is 178 fish ($Z_{(1-\alpha/2)}$ = 1.96, s = 6.8 mm, d = 1 mm) and the required sample size to estimate weight is 6 fish ($Z_{(1-\alpha/2)}$ = 1.96, s = 1.2 grams, d = 1 gram). Using the greater of the two sample sizes based on a catch of 4,249 Chinook salmon smolt, every 27th smolt captured will need to be measured. For coho salmon smolt, the required sample size to estimate length is 377 fish ($Z_{(1-\alpha/2)}$ = 1.96, s = 9.9 mm, d = 1 mm) and the required sample size to estimate weight is 26 fish ($Z_{(1-\alpha/2)}$ = 1.96, s = 2.6 grams, d = 1 gram). Using the greater of the two sample sizes based on a catch of 8,977 smolt, every 24th coho smolt will need to be measured.

Adult Age Composition, Mean Length, and Marked Fraction

Chinook Salmon

Age composition, mean length-at-age, and marked fraction of immigrating Chinook salmon in 2023–2027 will be estimated as detailed in a separate operational plan for the annual Commercial Fisheries adult stock assessment project (Elliott 2019).

Coho Salmon

Age composition and mean length-at-age of immigrating coho salmon will be estimated from a systematically drawn sample of the fish caught in the fish wheels. Based on procedures in Thompson (2002) for a 4-age-class population and an average estimated escapement of 68,646 fish, with alpha = 0.10 and d = 0.05, 403 fish need to be sampled. In an exercise to numerically demonstrate how sample sizes are derived, the proportions representing age-1.0 fish and age-2.0 fish were constrained at historical proportions of 0.03 and 0.01, respectively, and the highest variability scenario when proportions between age-1.1 fish and age-2.1 fish are almost equal, was investigated (Figure 5). This model, based on Thompson (2002), produces a sample size maximum of 426 fish, when data loss is accounted for, was not commensurate with the required sample size

(403 fish) as specified in Thompson (2002) for a multinomial proportion with the given precision criteria.

Because on average 90% of adult scale samples are readable, the highest possible required sample size is 448 (d = 0.05, alpha = 0.10, data loss = 10%). The average fish wheel catch of ocean-age-1 coho salmon from 2000 to 2020 is 2,167 fish. To ensure that this sample goal is met, <u>every fourth fish caught (2,167/4 = 542) will be sampled for scales</u>. Fish wheel catches have shown considerable variability from year to year; even though the projected number sampled greatly exceeds the requirement, in low catch years sampling every third fish should come close to meeting the goal. Since coho salmon sampling was started in the Chilkat River, the lowest proportion of age-1.1 fish has been approximately 0.70, requiring fewer than 448 samples to meet secondary objective 5. As a result, 542 fish sampled should be ample to meet secondary objective 5. Objective 3 criteria should also be achieved, based on procedures in Thompson (2002), because 301 fish are required to estimate a binomial proportion to within 0.05 of the true value 90% of the time (d = 0.05, alpha = 0.10, p = 0.030 (the highest theta for this project since 2000), data loss = 10%). The estimates should be unbiased because, even if the sampling gear is size selective, the differences in age composition for coho salmon in SEAK are exclusively related to differences in freshwater age (except for a small number of "jacks"), and there is no relationship between freshwater age and the size of adult coho salmon.

Coho Smolt Age Composition

Age composition of coho salmon smolt will be estimated from a systematically drawn sample of fish caught in the minnow traps. Based on the procedures in Thompson (2002), 285 samples are necessary to estimate binomial proportions (d = 0.05, alpha = 0.10, p = 0.5, data loss = 5%); this sample will also be sufficient to estimate mean length-at-age and weight in our secondary objectives, for which we have no precision criteria.

Harvest of Chinook Salmon from the 2021 Brood Year

Recovery of coded-wire-tagged Chinook salmon in SEAK mixed-stock fisheries in 2023–2027, through a marine harvest sampling program, will be used to estimate the total marine harvest of BY 2021 Chilkat River Chinook salmon. To meet secondary objective 1, approximately 10,500 Chinook salmon smolt from BY 2021 emigrating in 2023 need to be marked with coded wire tags according to procedures in Bernard et al. 1998. It is expected that 11,571 Chinook salmon smolt to be marked based on average smolt populations and mark fractions. The sample size calculation is based on historical sampling rates in the following fisheries where Chilkat River coded wire tags are encountered: 37% in winter troll, 55% in spring troll, 31% in summer troll, 43% in drift gillnet, 26% in purse seine, and 41% in SEAK sport. These sampling rates are based on sampling data from 2004–2021, in fishery strata where a Chilkat recovery occurred. Overall, the sampling rate is 44% for all SEAK mixed stock fisheries combined. Brood year 2021 should produce an expected 162,407 smolt leaving the Chilkat River in 2023, which should survive (smolt-to-adult) at 2.6% during marine rearing. While rearing, coded wire tag recoveries and harvest expansions (Bernard and Clark 1996) from BY 2021 should result in exploitation rate estimates of 10.7% in mixed stock fisheries (Appendix B).

Protocols for the collection of data from adult Chinook salmon at the ADF&G fish wheels, lower river drift gillnets, and in marine commercial fisheries can be found in operational plans developed by CF for these projects. Other CF operational plans can be obtained from the CF Area Management Biologist in Haines.

Coho Salmon in 2023

Almost all coho salmon smolt tagged in 2023 that avoid mortality will emigrate to sea, mature, and return to the Chilkat River drainage to spawn in 2024. Some returning adults will be harvested in marine sport and commercial fisheries, which are sampled for missing adipose fins and presence of a coded wire tag by the CF port sampling program and SF creel sampling program. Recoveries of coded wire tags from Chilkat River coho salmon tagged in 2023 will be used to estimate that cohort's contribution to the sampled fisheries in 2024 (secondary objective 2; Bernard and Clark 1996).

Historical data from port sampling efforts from 2000 through 2021, along with the projected smolt coded wire tag total in spring 2023, was used to calculate expected coded wire tag recoveries from SEAK marine fisheries in 2023. Assuming average smolt abundance of 1,090,159 Chilkat River coho salmon smolt, the number of valid tagged coho salmon smolt of 8,977, an average harvest of approximately 1.56 million fish in SEAK mixed stock fisheries where Chilkat River coho salmon are present, and an overall sampling rate of 27% in these fisheries, 115 Chilkat River coho salmon coded wire tags should be recovered. The expected smolt tagging total results in an anticipated fraction of valid tags (θ_{marine}) of 0.8% and using methodology in Bernard et al. (1998) results in a coded wire tag expanded harvest estimate of 46,324 Chilkat River coho salmon, comprised of 24,594 from commercial troll, 20,187 from commercial drift gillnet, 389 from commercial purse seine, and 1,154 from SEAK sport fisheries (Appendix C).

DATA COLLECTION

SMOLT ABUNDANCE

All captured coho salmon smolt ≥ 75 mm FL (spring 2023) and all Chinook salmon ≥ 50 mm FL (fall 2022 and spring 2023) without adipose fin clips will be tranquilized with a buffered MS 222 solution, tagged with a coded wire tag following procedures described in Koerner (1977), marked with an adipose fin clip, and released. All tagged fish will be held overnight to test for mortality and 100 fish of each species will be tested for retention of their tags. Any smolts captured that have missing adipose fins prior to tagging will be passed through a magnetic tag detector and the presence or absence of a coded wire tag will be recorded. In addition, the tag location of all Chinook salmon will be verified with a wand detector.

A short section of each spool of coded wire will be taped to the COMMERCIAL FISH DIVISION SALMON SMOLT CWT DAILY LOG form (Appendix D) the first day of tagging with a new tag code. In addition, a short section of the beginning and ending wire for each location (i.e., Tahini River, Kelsall River, and Chilkat River) will be taped to the CWT Daily Log. A new form will be started for each tagging day. All tag and recapture data will be recorded daily on the CWT Daily Log form. The crews will record detailed trapping information in field notebooks following the protocols in Appendix E. Catch, tagging, release, and recapture data for each day's operation will be summarized on the MINNOW TRAP SUMMARY FORM, an example of which is found in Appendix F. Daily procedures follow.

Fall 2022 Chinook Juvenile Tagging

1. Record location, date, and species on the SALMON SMOLT CWT DAILY LOG.
2. Record water and air temperature (Min-Max) to nearest 1ºC, and water depth to the nearest cm on the MINNOW TRAP SUMMARY FORM. Data should be collected at 0900 each day.

3. At 0830–0900 hrs mix the fish in the holding net pen for each tag code and check 100 that are representative for tag retention and record on the SALMON SMOLT CWT DAILY LOG. If tag retention is 98/100 or greater, empty the net pen and count and record mortalities, transport to release site, and release all fish. If tag retention is 97/100 or less, reprocess the entire batch and retag all fish that test negative.
4. Check minnow traps and transport to tagging site. Sort Chinook salmon ≥ 50 mm FL from other species (coho salmon are not tagged). Inspect each live fish and count the number with adipose clips and record the number under "Recaptures" on the SALMON SMOLT CWT DAILY LOG. Check all recaptures for tag retention, record results, and release all recaptures with coded wire tags. Retag all recaptures without coded wire tags.
5. Give all live untagged fish a coded wire tag and pass each through the tag detector. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the SALMON SMOLT CWT DAILY LOG and record retags, erroneous tags (misses, tagged fingers, etc), and practice tags. Show your calculations for the number of tags used.
6. Systematically select every 100th Chinook salmon from combined catches and measure for FL to nearest mm and record all data, including gear type and location on the CHILKAT RIVER FALL CHINOOK SAMPLING FORM (Appendix G).

Spring 2023 Chinook and Coho Salmon Smolt Tagging

1. Record location, date, and species on the SALMON SMOLT CWT DAILY LOG.
2. Record water and air temperature (Min-Max) to nearest 1ºC, and water depth to the nearest cm on the MINNOW TRAP SUMMARY FORM. Data should be collected at 0900 each day.
3. At 0830–0900 hrs mix the fish in the holding net pen for each tag code and check a representative sample of 100 coho salmon smolt for tag retention and record on the SALMON SMOLT CWT DAILY LOG. If tag retention is 98/100 or greater, empty the net pen and count and record mortalities, transport to release site, and release all fish. If tag retention is 97/100 or less, reprocess the entire batch and retag all fish that test negative. The same procedures apply to Chinook salmon smolt. The snout of each fish will be scanned by swiping the marked side of the coded wire tag detector wand (Vander Haegen et al. 2002) in contact with the snout at a rate of 2–3 m per second.
4. Check minnow traps and transport catch to tagging site. Sort coho salmon ≥ 75 mm FL and Chinook salmon ≥ 50 mm FL from smaller fish and other species. Inspect each live fish and count the number with adipose clips and record the number under "Recaptures" on the SALMON SMOLT CWT DAILY LOG. Check all recaptures for tag retention and tag location (for Chinook salmon smolt), record results, and release all recaptures with coded wire tags. Retag recaptures without coded wire tags.
5. Give all live untagged fish a coded wire tag and pass each through the tag detector. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the SALMON SMOLT CWT DAILY LOG and record retags, erroneous tags (misses, tagged fingers, etc.), and practice tags. Show your calculations for the number of tags used.
6. Systematically select every 25th coho salmon and measure for FL to nearest mm, weigh to nearest 0.1 g, sample for scales, and record all data, including gear type and location on the CHILKAT RIVER COHO SALMON AWL FORM (Appendix H).

7. Systematically select every 20th Chinook salmon from combined catches and measure for FL to nearest mm and record all data, including gear type and location (Appendix G).

At the end of the fall 2022 and spring 2023 tagging projects, daily tagging information will be entered into CWT Online Release Entry software program (http://www.taglab.org), which will estimate the number of smolt that had retained coded wire tags and will submit the tag release information to the Tag Lab. A 2 cm length of wire from each spool will be attached to a TAG CODE VERIFICATION FORM and mailed to the Tag Lab for code verification.

For coho salmon smolt sampled for length, weight, and scales, remove 12 to 15 scales from the preferred area (Scarnecchia 1979) on the left side of the coho salmon smolt. Sandwich scales from up to 4 fish between two 25 x 75 mm microscope slides and tape the slides together with transparent tape. Write the length of each fish on the frosted portion of the bottom slide in accordance with the position of the scales on the slide (Figure 6). Instructions to improve our ability to read scales (as determined by Sue Millard, ADF&G-SF, retired, through experience) are:

1. Do not tape over any scales.
2. Make sure scales are placed and remain in the designated area for each fish.
3. Always number each slide at the top.
4. Always put your initials under the slide number.
5. Spread scales out so they do not contact one another and align them as shown in Figure 6.
6. Remember to clean the scalpel of scales between samples.

Once Chilkat River Chinook salmon from BY 2021 have been captured, implanted with coded wire tags, marked with adipose fin clips, and released during the two tagging projects (fall 2022 and spring 2023), monitoring and recovery of these tags begins and continues over a 5-year period. Between 2024 and 2028, ADF&G will sample landings from commercial, sport and subsistence fisheries throughout SEAK and Yakutat for adipose fin clips and coded wire tags. The sample goal will be to inspect at least 20% of the total catch of Chinook salmon for missing adipose fins. Heads from fish missing their adipose fin will be sent to the ADF&G Tag Lab where coded wire tags will be removed and decoded. The annual ADF&G port sampling manual (*Coded wire tag sampling program detailed sampling instructions, commercial fisheries sampling*; located at ADF&G, Division of Commercial Fisheries, 802 3rd Street, Douglas, Alaska) provides a detailed explanation of commercial catch sampling procedures and logistics.

The number of BY 2021 Chilkat River Chinook salmon coded wire tags recovered 2024–2028 in all marine fisheries (commercial, sport, and subsistence) will be compiled by release group, i.e., fall 2022 or spring 2023, which is determined by the specific tag code from successfully read coded wire tags.

In addition to marine fisheries sampling, heads will also be collected from Chinook salmon with missing adipose fins during Chilkat River escapement sampling from 2024 through 2028. Escapement sampling is conducted annually in the Chilkat River drainage to estimate inriver abundance. Heads will not be collected from large (≥ 660 mm FL) fish in pre-spawning condition. The brood year of adipose-finclipped fish whose heads are not taken will be determined from scale age analysis. All adipose finclipped fish will be examined with a handheld wand detector (Vander Haegen et al. 2002) to determine presence/absence of a coded wire tag. Heads from fish with missing adipose fins that do not indicate presence of a coded wire tag will be collected to detect for tag loss.

INJURED, ENTANGLED, OR DEAD MARINE MAMMALS

- Document with photos/video (if possible, remain at least 100 yards from the animal) and record the date, time, and location (latitude/longitude, description of bay, point, island, etc.).
- If possible, record the species of marine mammal, age class, sex (for sea lions), type of gear, a description of the gear (i.e., line, gillnet, etc.) and how the animal is entangled, its relative degree of impairment, and direction of travel.
- As soon as possible, report to **ALASKA MARINE MAMMAL STRANDING NETWORK** (24-hr hotline 877-925-7773; 877-9-AKR-PRD) and include information gathered above. Ideally for dead animals, if communications allow, contact the hotline while near the carcass to determine if additional information/samples can be collected.
- Specifically for an observed live and entangled whale, immediately call the **U.S. COAST GUARD** (VHF Channel 16).

DATA REDUCTION

It is the responsibility of the field crew leader to ensure accurate records are maintained for all data collected daily (e.g., sampling rates for age and length, correct secondary marks are applied, etc.). The field crew leader will also ensure data collections (such as samplers initials, environmental data, fish length and condition, tag codes applied, etc.) are complete and methods (such as FL measurements, scale collection procedures, head mold sizes, etc.) are correctly implemented. The field crews will record tagging site GPS coordinates in field notebooks following the instructions found in Appendix I.

Data will be inspected daily for errors such as incorrect dates, transposed nonsensical lengths (210 mm when the fish was 120 mm), transposed or nonsensical tag numbers, incorrect tagging totals, lengths less than prescribed guidelines, etc. Data forms will be always kept up to date. Scale slides will be checked to ensure that scales are clean and mounted correctly; the slides are correctly labeled, and samples are matched up with the corresponding data form. Data will be sent to the project biologist weekly, where they will be re-inspected for accuracy and compliance with sampling procedures. The project biologist will error-check and enter field data into Microsoft Excel™ spreadsheets while it is collected inseason and will produce weekly reports to other management biologists in SEAK. Ages from scale samples will be estimated in the scale aging lab in Douglas. Scale ages will be entered into the spreadsheet files. When all input is complete, data lists will be obtained and checked against the original field data.

When the final reports are complete, electronic copies of the data, along with a data map, will be sent to Research and Technical Services (RTS) for archiving. The data map will include a description of the electronic files contained in the data archive, and where copies of any associated data are to be archived, if not in RTS. After the daily coded-wire-tagging, retention, and overnight mortality data have been entered using the CWT Online Release Entry program, the ADF&G Tag Lab will maintain a permanent database of juvenile and smolt releases and will share this data with the Pacific States Marine Fisheries Commission.

DATA ANALYSIS

SMOLT AND FALL JUVENILE ABUNDANCE

Chinook Salmon Smolt Abundance

Experience has shown that estimates of the proportion of adults from a given brood year with adipose-finclips does not change appreciably over return years, and thus recovery data are pooled over the i years (5 maximum) in which fish from brood year j return. Smolt abundance ($\hat{N}_{smolt,j}$) from brood year j will be estimated using a version of the Chapman-modified Petersen formula:

$$\hat{N}_{smolt,j} = \frac{(\hat{M}_j + 1)(n_{\bullet j} + 1)}{(a_{\bullet j} + 1)} - 1 \qquad (1)$$

where

$n_{\bullet j}$ = $\sum_{i=1}^{L} n_i$, where n_i is the number of adults examined in year i from brood year j for missing adipose fins;

L = number of years over which fish from a given brood return (maximum = 5).

$a_{\bullet j}$ = $\sum_{i=1}^{L} a_i$, where a_i is the number of adipose-finclips observed in n_i; and

$\hat{M}_j$ = estimated number of outmigrating smolt originating from brood year j that bore an adipose-finclip; these fish may be from either the fall (f; year $j+1$) or spring (s; year $j+2$) tagging programs. $\hat{M}_j$ is the sum of the estimated number of parr with adipose-finclips from brood year j surviving to the spring ($\hat{M}_{f \to s,j}$) and the number of smolt with adipose-finclips from brood year j ($M_{s,j}$), where:

$$\hat{M}_{f \to s,j} = M_{f,j}\hat{S}_j \qquad (2)$$

and

$M_{f,j}$ = number of parr released with adipose-finclips in the fall of year $j+1$; and

$\hat{S}_j$ = estimated relative odds of $M_{f,j}$ that survived to the spring of $j+2$ against the survival of $M_{s,j}$ (overwinter survival) (see Weller and McPherson 2003), where:

$$\hat{S}_j = \frac{\hat{M}_{s,valid,j} v_{\bullet,f,j}}{\hat{M}_{f,valid,j} v_{\bullet,s,j}} \qquad (3)$$

and

$\hat{M}_{s,valid,j}$ = estimated number of adipose-finclipped smolt released with valid coded wire tags in the spring of year $j+2$;

$\hat{M}_{f,valid,j}$ = estimated number of adipose-finclipped parr released with valid coded wire tags in the fall of year $j+1$;

$v_{\bullet,f,j}$ = $\sum_{i=1}^{L} v_{i,f,j}$, where $v_{i,f,j}$ is the total number of fish from brood year j implanted with valid coded wire tags in the fall of year $j+1$ that were subsequently recovered, regardless of recovery circumstances (for instance recovery location; marine fishery, escapement, etc., or sample type; random, select, or voluntary; see Harvest section below); and

$v_{\bullet,s,j}$ = $\sum_{i=1}^{L} v_{i,s,j}$, where $v_{i,s,j}$ is the total number of fish from brood year j implanted with valid coded wire tags in the spring of year $j+2$ that were subsequently recovered, regardless of recovery location or sample type.

The variance of the smolt estimate will be estimated as:

$$\text{var}\left(\hat{N}_{smolt,j}\right) = \left(n_{\bullet j} + 1\right)^2 \text{var}\left[\left(\hat{M}_{f \to s,j} + M_{s,j} + 1\right)\frac{1}{\left(a_{\bullet j} + 1\right)}\right] \tag{4}$$

where, by Goodman (1960) for independent variables:

$$\begin{aligned} \text{var}\left[\left(\hat{M}_{f \to s,j} + M_{s,j} + 1\right)\frac{1}{\left(a_{\bullet,j} + 1\right)}\right] &= \left(M_{s,j} + \hat{M}_{f \to s,j} + 1\right)^2 \text{var}\left[\frac{1}{a_{\bullet,j} + 1}\right] + \left[\frac{1}{a_{\bullet,j} + 1}\right]^2 \text{var}\left(\hat{M}_{f \to s,j}\right) \\ &- \text{var}\left[\frac{1}{a_{\bullet,j} + 1}\right] \text{var}\left(\hat{M}_{f \to s,j}\right) \end{aligned} \tag{5}$$

and $\text{var}\left(\hat{M}_{f \to s,j}\right)$ is obtained as described in Weller and McPherson (2003).

According to the delta method:

$$\text{var}\left[\frac{1}{a_{\bullet} + 1}\right] = \left[\frac{1}{a_{\bullet,j} + 1}\right]^4 n_{\bullet,j} \hat{p}_a \left(1 - \hat{p}_a\right) \tag{6}$$

where $\hat{p}_{a,j} = \dfrac{a_{\bullet,j}}{n_{\bullet,j}}$ is the estimated proportion of inspected adults from brood year j with an adipose-finclip.

The two components in equation 5 are not independent, but a simulation study from a similar project showed the correlation to be negligible (Richards and Frost, 2017). Results from the simulation showed the simulated variance of smolt abundance to be almost identical to that provided by the average of the Goodman-derived estimates (equation 5) over the simulation.

Chinook Salmon Juvenile Abundance

Parr abundance $\hat{N}_f$ for brood year j will be estimated as:

$$\hat{N}_{f,j} = \hat{N}_{smolt,j} \frac{1}{\hat{S}_j} \tag{7}$$

$$\text{var}(\hat{N}_{f,j}) \approx \hat{N}^2_{f,j} \left| cv^2\left(\hat{N}_{smolt,j}\right) + cv^2\left(\hat{S}_j\right) \right| \tag{8}$$

Equation 8 was derived using the delta method as described in Seber (1982, see p. 8).

Coho Salmon Smolt Abundance

The abundance $\hat{N}_s$ of coho salmon smolt (by emigration year) will be estimated using Chapman's modification of the Petersen Method (Seber 1982, see p. 60):

$$\hat{N}_s = \frac{(n_c+1)(n_e+1)}{(m_e+1)} - 1 \tag{9}$$

$$var[\hat{N}_s] = \frac{(n_c+1)(n_e+1)(n_c - m_e)(n_e - m_e)}{(m_e+1)^2(m_e+2)} \tag{10}$$

where n_c is the number of valid coded wire tags (on fish that survive the tagging event) placed in smolt during the spring, n_e is the number of ocean-age-1 salmon examined in the escapement that are successfully aged and found to have been smolt that emigrated from the Chilkat River during the previous spring, and m_e is the subset of n_e with successfully decoded coded wire tags placed at that time. The marked fractions of jacks and ocean-age-1 fish are Apnot statistically different, so in the interest of parsimony, only ocean-age-1 fish are used for n_e. Because n_e represents ocean-age-1 coho salmon in the escapement, and this is estimated from a proportion of aged fish, there is a small amount of additional process error involved with the term n_e. However, because the proportion of ocean-age-1 fish in the population has averaged 0.97, the increase in error is small, and the increase in estimated variance is also small.

Fish sometimes lose their coded wire tags, coded wire tags can be lost from recovered heads, and coded wire tags can be unreadable. If any of these conditions occur, the estimators (equations 9 and 10) must be modified to compensate for the lost marks/coded wire tags (i.e., loss of m_e). This will be accomplished by adding a term $\lambda = a / t'$ (an overall rate for recovering and decoding coded wire tags, where a = # adipose-finclipped fish sampled and t' = # coded wire tags decoded) to the denominator of the Lincoln-Petersen / maximum-likelihood estimator, i.e., $\hat{N}^*_S = n_c\ n_e / m_e\ \lambda$. Variance of $\hat{N}^*_S$ will be estimated using a Monte-Carlo simulation if a suitable closed form estimator is not identified. Although the Lincoln-Petersen estimator is not unbiased, the bias should be negligible in this experiment because the numbers of fish marked, inspected, and recaptured are not small (Seber 1982).

The conditions for accurate use of the mark–recapture method for both species/experiments are:

1. One of the following three items, a through c must hold true:
    a. all smolts/juveniles have an equal probability of being marked; *or*

b. adults escaping to the Chilkat River have an equal chance of being inspected for marks; *or*
c. marked fish mixed completely with unmarked fish in the population between sampling events.
2. There is no recruitment to the population between sampling events.
3. There is no trap or tagging induced behavior.
4. Fish do not lose their marks and all marks are recognizable.

Minnow traps will be operated continuously during smolt emigrations and returning adults will be sampled almost continuously either in fish wheel catches or spawning grounds sampling. A possible late start in tagging projects, periodic sessions of high water, or varying outmigration timing in the spring could possibly cause temporal changes in probabilities of capture. However, these vagaries are troublesome only if migratory timing of smolt from sub-populations within the Chilkat River parallel that of returning adults <u>and</u> these vagaries are coincident in the migratory pattern for both adults and smolt. If migratory patterns of smolt are different than that of adults, marked and unmarked smolt are completely mixed in the population prior to their return as adults. We will test for temporal changes in the fraction of adults missing adipose fins: if at least one of the conditions has been met, this fraction will not change with time. Temporal changes in these fractions will be tested against a χ^2 distribution. Although fish wheels and gillnets can be size selective, their size selectivity should not be a problem because there is no relation between the size of a smolt (when marked) and the size of the returning adult (when recaptured). Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment added to the population while they are at sea. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that excising adipose fins and implanting coded wire tags will not increase the mortality of marked salmon.

As outlined in the Study Design section, coded-wire-tagging coho salmon smolt in different size groups allows for testing of mark–recapture assumption [1 a-c], i.e., that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish. If fish are faithful to their natal grounds and if certain tributaries have different run timings, it is possible that (marked) fish do not mix completely. Therefore, if χ^2 tests indicate unequal probabilities of tagging in event 1 and capture in event 2, an alternate Petersen mark–recapture model will be used for a 2-group population. See Appendix J for details.

A coho salmon smolt population divided into 2 groups labeled (1) and (2), Petersen's mark–recapture model can be expanded into (adapted from Weller et al. 2005):

$$N_1 + N_2 = \left(N_1\alpha_1 + N_2\alpha_2\right)\frac{N_1\alpha_1 S_1\beta_1 + N_2\alpha_2 S_2\beta_2 + N_1\left(1-\alpha_1\right)S_1\beta_1 + N_2\left(1-\alpha_2\right)S_2\beta_2}{N_1\alpha_1 S_1\beta_1 + N_2\alpha_2 S_2\beta_2} \quad (11)$$

In the above equation, N is abundance, α_I is the capture probability in event 1 for each group, S_i the survival rate for each group, and β_i the capture probability for each group.

If one or both capture probability parameters, α_i or β_i, are equal, then the above equation reduces to a more simplified version. Consider the case when $\beta_1 = \beta_2$, the abundance estimator reduces to:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1 + N_2\alpha_2 S_2 + N_1(1-\alpha_1)S_1 + N_2(1-\alpha_2)S_2}{N_1\alpha_1 S_1 + N_2\alpha_2 S_2} \qquad (12)$$

If the relationship between α_i parameters is expressed as $A = \alpha_2 / \alpha_1$ and the relationship between S_i parameters is expressed as $B = S_2 / S_1$, equation (12) reduces further to:

$$N_1 + N_2 = \frac{(N_1 + AN_2)(N_1 + BN_2)}{N_1 + ABN_2} \qquad (13)$$

It is important to note that equation (13) is only true if $A = 1$ (i.e., $\alpha_2 = \alpha_1$) OR if $B = 1$ ($S_2 = S_1$). If both A and B are not equal to 1, the above relationship does not hold, and an unbiased estimator of abundance cannot be produced. If it is determined that there are both unequal marking probabilities (event 1) and unequal capture or survival probabilities (event 2), Petersen's model can be adjusted to produce an unbiased estimate of smolt abundance. Consider Chapman's modification of the standard Petersen model with 2 tagging groups, labeled group 1 and group 2:

$$\hat{N} = \frac{(N1_1 + N1_2 + 1)(N2 + 1)}{(M2_1 + M2_2 + 1)} \qquad (14)$$

where $N1_1$ and $N1_2$ are the number marked in groups 1 and 2, $N2$ is the number inspected for marks in the second event, and $M2_1$ and $M2_2$ are the amounts of marks recovered from groups 1 and 2. Consider the case where $A > 1$ and $S > 1$, that is, group 2 had both a higher marking probability and capture probability. This would create negative bias in the estimator and $N > \hat{N}$. Adjusting Chapman's modification for this tagging bias results in a new, unbiased estimator:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}M2_1 + M2_2 + 1} - 1 \qquad (15)$$

Using the scalar $\hat{A}$, i.e., the ratio of marking rates of the 2 groups, essentially forces the two groups to have the same marking probability, and therefore the expected value of equation (15) equals N as a result.

Overall retention rates for coded-wire-tagged fish are rarely 100%; adipose fin clipped fish sometime do not contain valid coded wire tags as tags are shed during freshwater or marine rearing. Also, occasionally heads are lost from adipose fin clipped fish before they can become decoded. Because of this, a new parameter $\hat{\pi}$ can be used to adjust for adipose fin clipped fish with no tag information ($M2_U$), which is the observed ratio of tags recovered from group 1 divided by group 2. Basically, the observed recovery rate is extrapolated for fish marked in the first event (as indicated by an adipose fin clip) that contain no tag information:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}(M2_1 + (\hat{\pi})M2_U) + M2_2 + (1 - \hat{\pi})M2_U + 1} - 1 \qquad (16)$$

If all observed adipose-finclipped fish contain valid coded wire tags, the term $M2_U$ is zero and equation (16) is identical to equation (15).

Variance and relative bias in the modified estimator can be estimated through bootstrapping techniques outlined in Efron and Tibshirani (1993).

AGE COMPOSITION

Proportions and variance or proportions by age for coho salmon smolt and adults will be estimated:

$$\hat{\rho}_j = \frac{n_j}{n} \tag{17}$$

$$\hat{\text{var}}[\hat{\rho}_j] = \frac{\hat{\rho}_j(1-\hat{\rho}_j)}{n-1} \tag{18}$$

where $\hat{\rho}_j$ is the estimated proportion in the population in group j, n is the number successfully aged, and n_j is the subset of n that belong to group j. Systematic selection of samples will promote proportional sampling and reduce bias from any inseason changes in age composition.

Collecting scale samples in fall 2024 from all returning adult coho salmon with clipped adipose fins will be done to provide the scale ager with known-age reference samples. Collecting age information from adipose-finclipped coho salmon will also allow for calculation of an unbiased smolt estimator discussed above.

ESTIMATES OF MEAN LENGTH

Standard sample summary statistics will be used to calculate estimates of mean length of Chinook salmon smolt or mean length-at-age of coho salmon smolt and adults, and their variances (Thompson 2002).

ESTIMATION OF THE CODED WIRE TAG MARKED FRACTION

Experience has shown that estimates of the proportion of adults from a given brood year with coded wire tags does not change appreciably over return years, and thus the fraction of adults from brood year j that are marked with a coded wire tag will be estimated from pooled data. The coded wire tag marked fractions of BY 2021 Chinook salmon and for emigration year 2023 coho salmon will be estimated as:

$$\hat{\theta}_j = \frac{\sum_{i=1}^{L} a_{ij}\hat{\rho}_{ij}}{\sum_{i=1}^{L} n_{ij}} \tag{19}$$

where

n_{ij} = number of adults examined in year i from brood year j for adipose-finclips;

a_{ij} = number of adipose-finclips observed in n_{ij};

ρ_{ij} $= \frac{t_{ij}}{a'_{ij}}$, the proportion of sacrificed adults from brood year j in year i that also possess a valid Chilkat coded wire tag; where

$a_{ij}^{'}$ = number of heads examined for coded wire tags from the a_{ij} fish with adipose-finclips;

t_{ij} = number of coded wire tags found in $a_{ij}^{'}$; and

L = number of years over which fish from a given brood return (maximum = 5, representing ages 1.1 through 1.5).

The variance of $\hat{\theta}_j$ will be estimated using a parametric bootstrap simulation (e.g., Geiger 1990).

For each year of recovery i, adipose-finclips will be generated as $a_{ij}^{*} \sim \text{binomial}\left(n_{ij}, \frac{a_{ij}}{n_{ij}}\right)$, and then coded wire tags will be generated as, $t_{ij}^{*} \sim$ hypergeometric ($m = t_{ij} / a_{ij}^{'} a_{ij}^{*}$, $n = a_{ij}^{*} - t_{ij} / a_{ij}^{'} a_{ij}^{*}$, $k = a_{ij}^{'} / a_{ij} a_{ij}^{*}$). Notation for hypergeometric parameters follows that of the R language (R Development Core Team 2005). ρ_{ij}^{*} will then be calculated as $t_{ij}^{*} / (a_{ij}^{*} a_{ij}^{'} / a_{ij})$, and $\hat{\theta}_j^{*}$ as:

$$\hat{\theta}_j^{*} = \frac{\sum_{i=1}^{L} a_{ij}^{*} \rho_{ij}^{*}}{\sum_{i=1}^{L} n_{ij}} \tag{20}$$

Many values of $\hat{\theta}_j^{*}$ will be simulated and the variance of $\hat{\theta}_j$ and $\frac{1}{\hat{\theta}_j}$ estimated as the sample variance of the simulated values.

To estimate coded wire tag contributions in the mixed stock marine fisheries, it is necessary to account for tag loss, which prevents recognition of the stock of origin. For each coded wire tag population (BY 2021 Chinook salmon, emigration year 2023 coho salmon) the equation for the coded wire tag marked fraction $\hat{\theta}_j$ corrects for tag loss by using the proportion of heads with successfully decoded coded wire tags out of the heads sent to the ADF&G Tag Lab.

For emigration year 2023 coho salmon, the coded wire tag marked fraction will be estimated using adult sampling data collected at the lower river fish wheel sampling site in 2024.

The potential for the Chinook salmon $\hat{\theta}_j$ to vary significantly by recovery area (e.g., lower river, Tahini River, Kelsall River, etc.) will be investigated using a series of χ^2 tests. If differences in the marked fractions are significant ($\alpha = 0.10$) and large enough to lead to serious bias in estimates of smolt abundance or fisheries contributions, only samples collected in the lower river will be used to estimate $\hat{\theta}_j$. Deterministic modeling was done to estimate the effect on $\hat{\theta}_j$ of tagging smolt non-proportionally on the 2 main spawning areas (Table 8). The model assumes sampling on the spawning grounds would proceed as it has in the past. As the fraction marked in the Tahini River area diverges from the fraction marked in the Kelsall River area, the estimate of θ for the river, based on spawning ground samples, varies little. This occurs because samples are distributed from the bulk of the spawning population. Also, the model suggests that the usual χ^2 test will indicate that problems exist well before they are severe enough to lead to serious bias in estimates of smolt abundance or fisheries contributions (bias in those estimates is approximately proportional to bias in θ for the river). For example, as tagging fractions for the upriver and downriver rearing areas diverge by 100% (θ_{Tahini} = 0.089 and $\theta_{Kelsall}$ = 0.179), the resulting estimate of $\theta_{ChilkatRiver}$ = 0.148 varies by only 3.8% from its true value.

HARVEST

Harvest of Chilkat River coho salmon will be estimated by calendar year, and Chinook salmon will be estimated both by calendar year and brood year through a stratified catch sampling program of commercial and recreational fisheries. Methods in Bernard and Clark (1996) will be used to expand harvest estimates from recovered coded wire tags. Commercial catch data for the analysis will be summarized by ADF&G statistical week and district. Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2015) will be apportioned using information from sampled marine sport fisheries to obtain estimates of total harvest by bi-week and fishery. Sport fish coded wire tag recovery data will be obtained from ADF&G Tag Lab reports and summarized by bi-week and fishery (e.g., bi-week 16 during the Sitka Marine Creel Survey) to estimate contribution. In most cases, coded wire tags of interest may be recovered in only a few of the sport fish sampling strata that defined the fishery bi-week. If the harvests of fish with coded wire tags of interest are independent of sampling strata within fishery bi-weeks, harvests and sampling information will be totaled over the fishery bi-week to estimate contributions.

The estimates will be based on information from SF and CF sampling of:

1. Number of salmon harvested by species.
2. Fraction of the harvest inspected for missing adipose fins.
3. Number of salmon in the sample with missing adipose fins.
4. Number of fish heads that reached the Tag Lab.
5. Number of these heads that contained coded wire tags.
6. Number of these coded wire tags that were decodable.
7. Number of decodable tags of the appropriate code(s).

As noted earlier, estimating tagging fractions $\hat{\theta}_j$ for Chinook salmon takes place over 5 years as fish return to spawn. Data from all sample years will be pooled to estimate $\hat{\theta}_j$ for the harvest study.

SCHEDULE AND DELIVERABLES

Field activities for juvenile Chinook salmon tagging will begin inriver approximately September 15, 2022 and extend through October 31, 2022. A memorandum summarizing fall field activities, successes, and suggestions for improvement will be submitted to the project biologist by November 1. Field activities for Chinook and coho salmon smolt tagging will begin inriver approximately April 1, 2023, and run through May 15, 2023, or as river conditions permit. Adult coho salmon will be sampled in the fish wheels beginning around August 1 and extending through October 15, 2024. Data editing and analysis will be initiated before the end of each season. A memorandum summarizing smolt field activities, successes, and suggestions for improvement will be submitted to the regional Chinook salmon research coordinator by June 15, 2023.

Juvenile Chinook salmon trapping and tagging data collected in this study will be reported in a Division of Commercial Fisheries Fishery Data Series report and submitted by December 31, 2028. Coho salmon smolt data collected in 2023 will be reported in a Fisheries Data Series report and submitted by December 1, 2024. This report will cover all 2023 smolt data and subsequent adult coho salmon recoveries, harvest contributions, etc. in 2024. Chinook salmon fall juvenile and spring smolt tagging data including any adult harvests will be reported by December 2028.

RESPONSIBILITIES

Brian W. Elliott, FB 3, Lead Biologist. The Lead Biologist sets up all major aspects of the project, including planning, budget, sample design, permits, equipment, personnel, and training. This position will oversee all field operations for juvenile tagging and adult abundance estimation. This position will also assist in the field during the spring coded wire tag project, including tagging, data collection, and general field duties. This position also supervises the overall project; edits, analyzes, and reports Chinook salmon data; assists with fieldwork; arranges logistics with the field crew, area management biologist, and expeditor. Coauthors operational plan and assures that it is followed or modified appropriately.

Randy Peterson, BM 3. The Biometrician provides input to and approves sampling design. Coauthors operational plan and provides biometric details. Reviews and conducts data analysis and final report.

Ed Jones, Fish and Game Coordinator. This position reviews the operational plan and the annual technical report and assists in obtaining funding for Chilkat River Chinook salmon projects.

Richard Chapell, FB 3, SF Area Management Biologist (AMB). The AMB performs index counts for the adult coho escapement estimation project and provides drainage-wide escapement estimates annually.

Dave Folletti, Reed Barber, and Liam Cassidy, FWT 3. These positions act as crew leaders for coded wire tag operations and make sure the operational plan is followed. Crew leaders will oversee running minnow trap lines, and adjusting traps to maximize catches, and are responsible for recording all daily records on daily forms. These positions are responsible for assisting in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection, and general field camp duties including keeping camp and field equipment neat and orderly. They will be the lead smolt taggers and are responsible, along with Elliott, for making sure that species identification is done correctly, and that tag retention is at or near 100%. Will take the lead roles in any construction activities and will oversee equipment maintenance (outboards, coded wire tag machines, detectors, power tools, generators, etc.). Will do inventory at end of year in cooperation with Elliott.

Mark Brouwer, Bryan Harmon, and Siyel George, FWT 2. These positions are responsible for assisting in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection and general field camp duties including keeping camp and field equipment neat and orderly. These positions are typically clippers in tagging shed, but may be trained as taggers, and will assist crew leaders with data collection and entry as needed.

Shelby Flemming, FB 2. As leader of the Chilkat River fish wheels project, this position will capture and sample adult Chinook and coho salmon for age, sex, length, and adipose fin clip status. This position will also collect heads from ad-clipped fish that meet the coded wire tag recovery criteria. This position will also submit sample data in a timely manner to Elliott.

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TABLES AND FIGURES

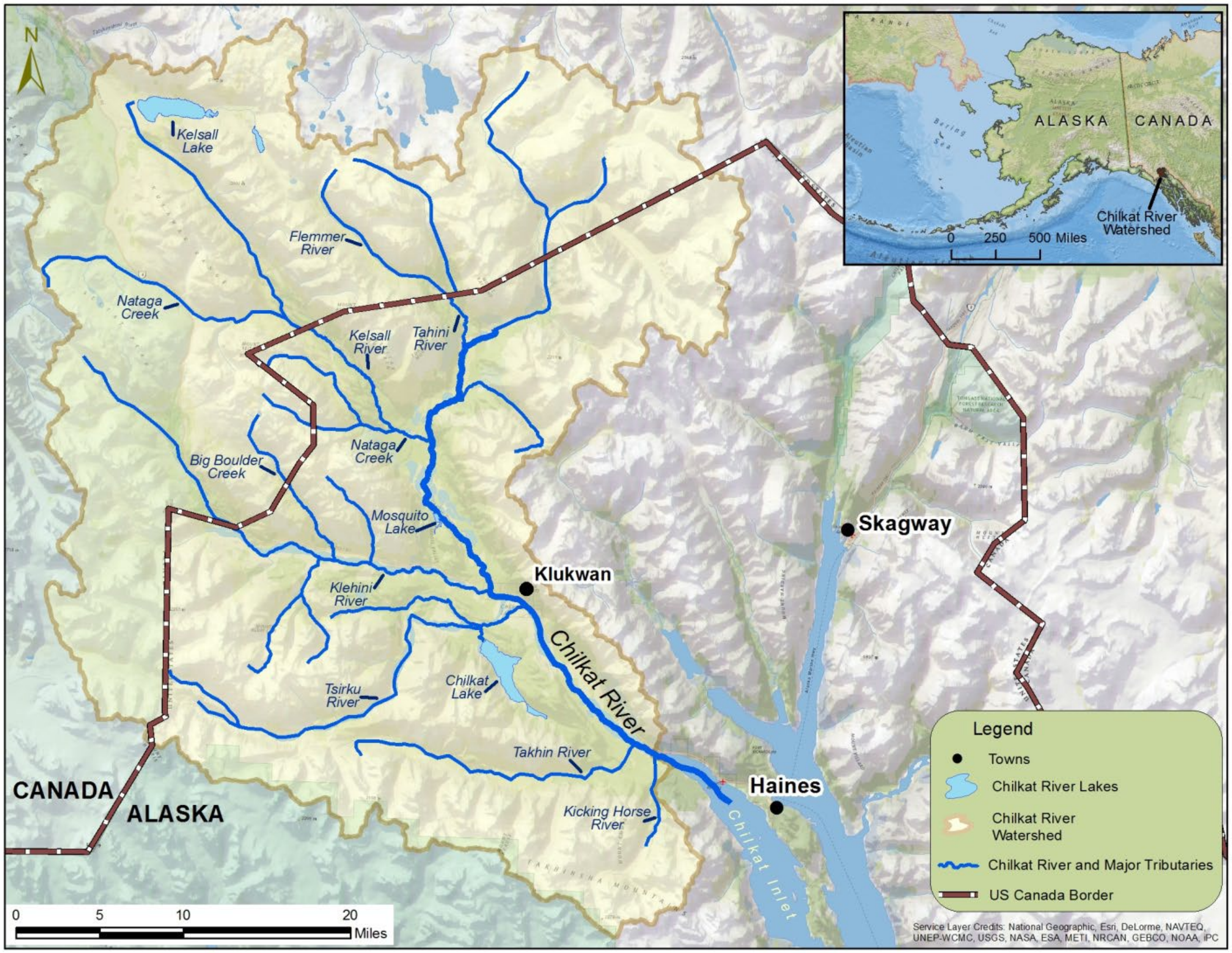

Figure 1.–The Chilkat River drainage in Southeast Alaska.

Table 1.–Chilkat River Chinook salmon age (≥ 1.2) calendar year harvest estimates and standard errors in parenthesis through expansion of coded wire tag recoveries by fishery, accounting years 2004–2021, Southeast Alaska.

Accounting Year[1]	Winter Troll	Spring Troll	Summer Troll	Drift Gillnet	Purse Seine	SEAK Sport	Haines Sport	Haines Subsistence
2004	0 (0)	257 (224)	36 (35)	295 (151)	0 (0)	0 (0)	285 (27)	117
2005	32 (31)	107 (94)	141 (140)	210 (157)	14 (38)	134 (124)	269 (29)	77
2006	0 (0)	138 (136)	155 (155)	63 (62)	322 (255)	171 (169)	130 (22)	96
2007	0 (0)	229 (103)	15 (15)	131 (129)	0 (0)	83 (82)	81 (9)	64
2008	16 (15)	257 (273)	229 (169)	285 (250)	0 (0)	27 (19)	153 (31)	50
2009	0 (0)	244 (215)	0 (0)	37 (36)	0 (0)	53 (52)	5 (2)	75
2010	132 (118)	128 (126)	0 (0)	394 (390)	80 (79)	172 (171)	80 (10)	85
2011	125 (103)	120 (118)	0 (0)	273 (348)	155 (90)	64 (63)	121 (19)	114
2012	117 (116)	155 (154)	0 (0)	230 (190)	43 (42)	89 (74)	174 (13)	96
2013	0 (0)	40 (39)	0 (0)	141 (112)	126 (92)	61 (61)	153 (30)	65
2014	0 (0)	0 (0)	0 (0)	535 (414)	55 (54)	112 (85)	74 (26)	79
2015	0 (0)	59 (58)	46 (45)	318 (234)	0 (0)	109 (108)	197 (30)	15
2016	36 (35)	0 (0)	0 (0)	7 (7)	11 (10)	103 (102)	0 (0)	12
2017	58 (40)	45 (44)	0 (0)	11 (11)	0 (0)	47 (46)	0 (0)	0
2018	0 (0)	0 (0)	0 (0)	69 (69)	0 (0)	48 (48)	0 (0)	0
2019	0 (0)	0 (0)	0 (0)	90 (69)	0 (0)	0 (0)	0 (0)	0
2020	0 (0)	0 (0)	10 (9)	57 (40)	0 (0)	10 (9)	0 (0)	0
2021	0 (0)	0 (0)	11 (11)	28 (6)	0 (0)	34 (33)	0 (0)	0
Avg.	29	99	36	176	45	73	96	52
SE	26	88	32	148	37	69	14	

[1] Accounting Year (*t*) runs from August 1 in year (*t*-1) to July 31 in year *t*.

Table 2.–Estimated inriver abundance, inriver harvest, and escapement of large Chinook salmon in the Chilkat River, 1991–2020.

Year	Inriver abundance	Inriver harvest	Escapement	SE (esc)	CV (esc)
1991[a]	5,897	15	5,882	763	0.13
1992[b]	5,284	7	5,277	778	0.15
1993[c]	4,472	9	4,463	659	0.15
1994[d]	6,795	3	6,792	839	0.12
1995[e]	3,790	22	3,768	662	0.18
1996[f]	4,920	18	4,902	642	0.13
1997[g]	8,100	11	8,089	1,003	0.12
1998[h]	3,675	19	3,656	419	0.11
1999[i]	2,271	13	2,258	322	0.14
2000[j]	2,035	6	2,029	256	0.13
2001[k]	4,517	3	4,514	722	0.16
2002[l]	4,050	16	4,034	433	0.11
2003[m]	5,657	26	5,631	690	0.12
2004[n]	3,422	16	3,406	456	0.13
2005[o]	3,366	5	3,361	554	0.16
2006[p]	3,039	36	3,003	380	0.13
2007[q]	1,442	7	1,435	230	0.16
2008[r]	2,905	24	2,881	452	0.16
2009[s]	4,429	23	4,406	589	0.13
2010[t]	1,815	18	1,797	226	0.13
2011[u]	2,688	14	2,674	269	0.10
2012[u]	1,744	21	1,723	266	0.15
2013[u]	1,730	11	1,719	333	0.19
2014[u]	1,534	5	1,529	307	0.20
2015[u]	2,456	4	2,452	273	0.11
2016[u]	1,386	6	1,380	198	0.14
2017[u]	1,173	0	1,173	240	0.20
2018[u]	873	0	873	546	0.63
2019[u]	2,028	0	2,028	246	0.12
2020[u]	3,180	0	3,180	518	0.16
2021[u]	2,038	0	2,038	348	0.17
1991–2021 Avg.	3,109	12	3,098	444	0.16

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Table 2.–Page 2 of 2.

[a]	Taken from Johnson et al. (1992).	[m]	Taken from Ericksen (2004).
[b]	Taken from Johnson et al. (1993).	[n]	Taken from Ericksen (2005).
[c]	Taken from Johnson (1994).	[o]	Taken from Ericksen et al. (2006)
[d]	Taken from Ericksen (1995).	[p]	Taken from Chapell (2009).
[e]	Taken from Ericksen (1996).	[q]	Taken from Chapell (2010).
[f]	Taken from Ericksen (1997).	[r]	Taken from Chapell (2012).
[g]	Taken from Ericksen (1998).	[s]	Taken from Chapell (2013a).
[h]	Taken from Ericksen (1999).	[t]	Taken from Chapell *(*2013b).
[i]	Taken from Ericksen (2000).	[u]	Taken from Elliott *(in prep a*).
[j]	Taken from Ericksen (2001a).		
[k]	Taken from Ericksen (2002a).		
[l]	Taken from Ericksen (2003a).		

Table 3.–Number of coded-wire-tagged Chinook salmon released into the Chilkat River by brood year and year of release, through spring 2020.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
1984 total	Tahini River	1985	Fed fry	42,961	601	42,360
1985 total	Tahini River	1986	Fed fry	46,478	1,457	44,120
1987 total	Kelsall River	1988	Juvenile	4,553	0	4,553
1988	Chilkat River	1989	Juvenile	9,897	119	9,778
1988	Chilkat River	1990	Smolt	2,220	29	2,191
1988	Kelsall River	1989	Juvenile	20,199	120	20,079
1988	Tahini River	1989	Juvenile	5,293	0	5,293
1988 total				37,609	268	37,341
1989	Chilkat River	1990	Juvenile	2,230	0	2,230
1989	Kelsall River	1990	Juvenile	10,242	82	10,160
1989	Tahini River	1990	Fed fry	30,146	180	29,966
1989	Tahini River	1990	Juvenile	1,403	0	1,403
1989 total				44,021	262	43,759
1990 total	Tahini River	1991	Fed fry	36,316	796	35,520
1991	Big Boulder Creek	1992	Fed fry	44,820	1,470	43,018
1991	Tahini River	1992	Fed fry	62,579	2,024	60,555
1991 total				107,399	3,494	103,573
1992 total	Big Boulder Creek	1993	Fed fry	23,389	1,614	21,775
1993	Big Boulder Creek	1994	Emergent fry	24,324	243	24,081
1993	Big Boulder Creek	1994	Fed fry	28,062	1,516	26,546
1993 total				52,386	1,759	50,627
1994 total	Big Boulder Creek	1995	Emergent fry	45,060	2,569	42,491
1995 total	Big Boulder Creek	1996	Emergent fry	62,014	3,082	58,556
1997 total	Chilkat River	1999	Smolt	771	0	771
1998	Lower Chilkat	2000	Smolt	446	0	446
1998	Upper Chilkat	2000	Smolt	1,550	0	1,550
1998 total				1,996	0	1,996
1999	Chilkat River	2000	Juvenile	6,974	0	6,974
1999	Kelsall River	2000	Juvenile	17,647	0	17,647
1999	Klehini River	2000	Juvenile	173	0	173
1999	Tahini	2000	Juvenile	5,310	0	5,310
1999	Lower Chilkat	2001	Smolt	4,506	0	4,506
1999 total				34,610	0	34,610
2000	Tahini River	2001	Juvenile	2,740	0	2,740
2000	Kelsall River	2001	Juvenile	10,913	0	10,913
2000	Lower Chilkat	2001	Juvenile	9,470	0	9,470
2000	Lower Chilkat	2002	Smolt	4,714	5	4,709
2000 total				27,837	5	27,832

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Table 3.–Page 2 of 4.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2001	Tahini River	2002	Juvenile	6,519	0	6,519
2001	Kelsall River	2002	Juvenile	18,251	0	18,251
2001	Lower Chilkat	2002	Juvenile	6,620	0	6,620
2001	Lower Chilkat	2003	Smolt	2,797	0	2,797
2001 total				34,187	0	34,187
2002	Tahini River	2003	Juvenile	4,939	0	4,939
2002	Kelsall River	2003	Juvenile	17,039	0	17,039
2002	Lower Chilkat	2003	Juvenile	14,662	0	14,662
2002	Lower Chilkat	2004	Smolt	5,707	0	5,707
2002 total				42,347	0	42,347
2003	Tahini River	2004	Juvenile	5,671	0	5,671
2003	Kelsall River	2004	Juvenile	19,395	0	19,395
2003	Lower Chilkat	2004	Juvenile	12,179	0	12,179
2003	Lower Chilkat	2005	Smolt	5,825	16	5,809
2003 total				43,160	16	43,054
2004	Tahini River	2005	Juvenile	6,473	0	6,473
2004	Kelsall River	2005	Juvenile	17,867	0	17,867
2004	Lower Chilkat	2005	Juvenile	10,356	0	10,356
2004	Lower Chilkat	2006	Smolt	5,080	5	5,075
2004 total				39,776	5	39,771
2005	Tahini River	2006	Juvenile	2,832	0	2,832
2005	Kelsall River	2006	Juvenile	15,205	0	15,205
2005	Chilkat River	2006	Juvenile	281	0	281
2005	Chilkat River	2007	Smolt	2,239	1	2,238
2005 total				20,557	1	20,556
2006	Tahini River	2007	Juvenile	5,273	0	5,273
2006	Kelsall River	2007	Juvenile	12,196	0	12,196
2006	Chilkat River	2007	Juvenile	11,180	0	11,180
2006	Chilkat River	2008	Smolt	2,499	0	2,499
2006 total				31,148	0	31,148
2007	Tahini River	2008	Juvenile	3,947	0	3,947
2007	Kelsall River	2008	Juvenile	9,866	0	9,866
2007	Chilkat River	2008	Juvenile	6,361	0	6,361
2007	Chilkat River	2009	Smolt	3,911	0	3,911
2007 total				24,085	0	24,085
2008	Tahini River	2009	Juvenile	3,041	0	3,041
2008	Kelsall River	2009	Juvenile	4,784	0	4,784
2008	Chilkat River	2009	Juvenile	8,162	0	8,162
2008	Chilkat River	2010	Smolt	995	0	995
2008 total				16,982	0	16,982

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Table 3.–Page 3 of 4.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2009	Tahini River	2010	Juvenile	7,254	0	7,254
2009	Kelsall River	2010	Juvenile	15,883	0	15,883
2009	Chilkat River	2010	Juvenile	15,703	25	15,678
2009	Chilkat River	2011	Smolt	5,514	0	5,514
2009 total				44,354	25	44,329
2010	Tahini River	2011	Juvenile	1,840	0	1,840
2010	Kelsall River	2011	Juvenile	8,534	0	8,534
2010	Chilkat River	2011	Juvenile	15,986	0	15,986
2010	Chilkat River	2012	Smolt	3,175	0	3,175
2010 total				29,535	0	29,535
2011	Tahini River	2012	Juvenile	4,973	0	4,973
2011	Kelsall River	2012	Juvenile	10,173	0	10,173
2011	Chilkat River	2012	Juvenile	11,726	0	11,726
2011	Chilkat River	2013	Smolt	5,917	6	5,911
2011 total				32,789	6	32,783
2012	Tahini River	2013	Juvenile	5,408	0	5,408
2012	Kelsall River	2013	Juvenile	6,663	0	6,663
2012	Chilkat River	2013	Juvenile	8,211	0	8,211
2012	Chilkat River	2014	Smolt	1,875	0	1,875
2012 total				22,157	0	22,157
2013	Tahini River	2014	Juvenile	3,551	0	3,551
2013	Kelsall River	2014	Juvenile	3,428	0	3,428
2013	Chilkat River	2014	Juvenile	11,282	0	11,282
2013	Chilkat River	2015	Smolt	2,829	0	2,829
2013 total				21,090	0	21,090
2014	Tahini River	2015	Juvenile	3,673	0	3,673
2014	Kelsall River	2015	Juvenile	7,057	0	7,057
2014	Chilkat River	2015	Juvenile	9,719	0	9,719
2014	Chilkat River	2016	Smolt	3,578	4	3,574
2014 total				24,027	4	24,023
2015	Tahini River	2016	Juvenile	7,526	0	7,526
2015	Kelsall River	2016	Juvenile	18,516	0	18,516
2015	Chilkat River	2016	Juvenile	14,478	0	14,478
2015	Chilkat River	2017	Smolt	3,839	0	3,839
2015 total				44,359	0	44,359
2016	Tahini River	2017	Juvenile	2,337	0	2,337
2016	Kelsall River	2017	Juvenile	3,488	0	3,488
2016	Chilkat River	2017	Juvenile	8,112	0	8,112
2016	Chilkat River	2018	Smolt	3,473	0	3,473
2016 total				17,410	0	17,410

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Table 3.–Page 4 of 4.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2017	Tahini River	2018	Juvenile	2,873	0	2,873
2017	Kelsall River	2018	Juvenile	7,387	0	7,387
2017	Chilkat River	2018	Juvenile	1,971	0	1,971
2017	Chilkat River	2019	Smolt	3,588	0	3,588
2017 total				15,819	0	15,819

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2018	Tahini River	2019	Juvenile	1,486	0	1,486
2018	Kelsall River	2019	Juvenile	4,493	0	4,493
2018	Chilkat River	2019	Juvenile	4,290	0	4,290
2018	Chilkat River	2020	Smolt	2,089[1]	0	2,089[1]
2018 total				10,269	0	10,269

[1] due to Covid-19, Chinook salmon smolt from BY18 were marked with adipose fin clips only

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2019	Tahini River	2020	Juvenile	1,746	0	1,746
2019	Kelsall River	2020	Juvenile	6,734	0	6,734
2019	Chilkat River	2020	Juvenile	3,397	0	3,397
2019	Chilkat River	2021	Smolt	2,073	0	2,073
2019 total				13,950	0	13,950

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2020	Tahini River	2021	Juvenile	4,728	0	4,728
2020	Kelsall River	2021	Juvenile	10,767	0	10,767
2020	Chilkat River	2021	Juvenile	8,021	0	8,021
2020	Chilkat River	2022	Smolt	6,452	0	6,452
2020 total				29,968	0	29,968

Table 4.–Summary of Chilkat River Chinook salmon (≥ age-1.2) juvenile abundance and harvest estimates from coded wire tag studies, brood years 1999–2014.

	Estimates							
Brood Year	Fall Juvenile	Overwinter Survival	Spring Smolt	Marine Harvest	Inriver Abundance	Total Return	Marine Survival	Marine Exploitation
1999	377,199	0.357	134,812	1,414	4,723	6,137	0.046	0.230
2000	415,192	0.237	98,541	704	4,153	4,856	0.049	0.145
2001	601,339	0.231	138,683	831	4,527	5,358	0.039	0.155
2002	475,313	0.383	182,238	873	1,572	2,445	0.013	0.357
2003	631,276	0.466	294,460	1,157	5,488	6,645	0.023	0.174
2004	490,264	0.247	121,238	651	3,283	3,934	0.032	0.166
2005	239,285	0.886	211,951	1,654	3,167	4,821	0.023	0.343
2006	577,600	0.436	251,915	1,841	2,593	4,434	0.018	0.415
2007	363,206	0.416	151,256	1,135	3,802	4,937	0.033	0.230
2008	312,444	0.265	82,645	566	1,285	1,851	0.022	0.306
2009	650,807	0.277	180,047	939	2,949	3,888	0.022	0.242
2010	532,125	0.401	213,644	1,101	3,052	4,154	0.019	0.265
2011	558,708	0.494	276,240	884	2,055	2,939	0.011	0.301
2012	310,342	0.211	65,577	239	1,261	1,500	0.023	0.159
2013	391,139	0.155	60,595	69	1,658	1,727	0.029	0.040
2014	342,085	0.394	134,674	82	2,856	2,938	0.022	0.028
1999–2014 avg.	454,270	0.366	162,407	884	3,026	3,910	0.026	0.222

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Table 4.–Page 2 of 2.

Standard errors

Brood Year	Fall Juvenile	Overwinter Survival	Spring Smolt	Marine Harvest	Inriver Abundance	Total Return	Marine Survival	Marine Exploitation
1999	55,700	0.061	19,907	262	562	620	0.008	0.039
2000	90,714	0.050	21,530	149	681	697	0.010	0.033
2001	184,835	0.066	42,628	238	727	765	0.013	0.043
2002	204,620	0.126	78,453	231	231	327	0.003	0.069
2003	144,021	0.112	67,179	238	652	694	0.005	0.034
2004	106,947	0.061	26,447	172	460	491	0.007	0.041
2005	56,195	0.334	49,775	342	353	491	0.009	0.053
2006	170,882	0.159	74,528	380	265	463	0.005	0.056
2007	82,293	0.097	34,271	269	413	493	0.007	0.046
2008	282,197	0.147	74,645	184	235	299	0.007	0.079
2009	215,319	0.080	59,569	296	422	515	0.006	0.063
2010	158,606	0.132	63,679	270	342	436	0.006	0.052
2011	142,443	0.171	70,428	291	231	372	0.003	0.073
2012	129,020	0.096	27,263	136	239	274	0.011	0.080
2013	454,128	0.110	70,336	69	208	219	0.033	0.038
2014	159,660	0.167	62,094	58	466	470	0.011	0.020
1999–2014 avg.	164,849	0.123	52,671	224	405	477	0.009	0.051

Table 5.–Juvenile abundance and harvest estimates for ocean-age-1 Chilkat River coho salmon, 2000–2021.

Return year (*t*)	Number coded wire tag smolt (*t*-1)	Smolt theta (θ_s)	Smolt estimate	SE	Marine theta (θ_m)	Marine harvest	SE	Inriver harvest	SE
2000[a]	25,915	0.019	1,237,056	219,715	0.019	39,546	3,745	853	221
2001[b]	25,016	0.021	1,185,804	164,121	0.02	45,658	7,194	2,176	451
2002[c]	36,114	0.012	2,970,458	377,695	0.012	110,105	10,355	3,888	742
2003[d]	25,296	0.015	1,696,212	190,330	0.015	83,302	6,956	2,932	497
2004[e]	24,563	0.012	1,938,322	401,419	0.01	128,466	19,882	3,169	661
2005[f]	17,276	0.021	776,934	147,738	0.02	29,518	3,483	1,453	293
2006[g]	26,342	0.014	1,807,837	217,352	0.013	70,813	7,632	2,082	293
2007[h]	22,149	0.025	875,478	134,864	0.023	12,142	1,585	635	149
2008[i]	24,104	0.027	893,032	95,380	0.025	52,989	3,518	991	261
2009[j]	23,059	0.032	716,689	88,013	0.031	30,558	2,585	2,424	421
2010[k]	24,937	0.028	872,829	151,981	0.026	68,385	5,165	706	138
2011[l]	26,877	0.026	1,026,314	162,061	0.022	34,161	2,585	1,437	289
2012[m]	31,092	0.024	1,229,468	242,671	0.021	27,913	2,375	398	165
2013[n]	18,307	0.023	788,387	135,519	0.023	68,226	7,673	1,014	281
2014[o]	10,834	0.012	875,312	114,920	0.011	26,491	3,315	958	258
2015[p]	8,661	0.013	639,750	163,928	0.013	23,697	2,719	1,067	298
2016[q]	9,318	0.010	688,274	252,179	0.010	9,120	1,496	784	142
2017[r]	7,331	0.010	541,520	209,442	0.010	16,413	4,360	1,414	343
2018[s]	6,100	0.004	1,193,507	396,558	0.004	31,235	12,731	1,455	319
2019[t]	5,994	0.012	498,938	87,442	0.010	42,631	15,447	1,161	237
2020[u]	7,554	0.014	441,211	178,516	0.014	4,534	1,249	298	91
2021[v]									
2000–2021 avg.	19,373	0.018	1,090,159	196,755	0.017	45,519	6,002	1,490	312

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Table 5.–Page 2 of 2.

Return year (*t*)	Age-*x*.1 escapement	SE	Total return	SE	Marine exploitation	SE	Marine survival	SE
2000[a]	84,843	16,330	125,242	16,755	0.32	0.05	0.1	0.02
2001[b]	107,697	20,720	155,531	21,938	0.29	0.05	0.13	0.03
2002[c]	204,787	31,071	318,780	32,759	0.35	0.04	0.11	0.02
2003[d]	133,109	14,926	219,291	16,474	0.38	0.03	0.13	0.02
2004[e]	67,053	12,901	198,688	23,710	0.65	0.05	0.1	0.03
2005[f]	34,575	4,561	65,546	5,746	0.45	0.04	0.08	0.02
2006[g]	79,050	15,210	151,945	17,020	0.47	0.05	0.08	0.01
2007[h]	24,770	4,769	37,547	5,027	0.32	0.05	0.04	0.01
2008[i]	56,369	10,846	110,349	11,405	0.48	0.05	0.12	0.02
2009[j]	47,911	9,219	80,893	9,584	0.38	0.05	0.11	0.02
2010[k]	85,066	16,375	154,157	17,171	0.44	0.05	0.18	0.04
2011[l]	61,099	15,747	96,698	15,961	0.35	0.06	0.09	0.02
2012[m]	36,961	7,441	65,272	7,813	0.43	0.05	0.05	0.01
2013[n]	51,319	9,874	120,559	12,508	0.57	0.05	0.15	0.03
2014[o]	130,200	25,050	159,272	25,274	0.17	0.03	0.18	0.04
2015[p]	47,372	9,117	72,136	9,518	0.33	0.05	0.11	0.03
2016[q]	26,280	5,060	36,185	5,279	0.25	0.05	0.05	0.02
2017[r]	33,908	6,526	51,735	7,856	0.32	0.07	0.08	0.03
2018[s]	65,749	12,650	98,439	17,950	0.32	0.10	0.08	0.03
2019[t]	34,779	6,693	78,571	16,836	0.54	0.10	0.16	0.04
2020[u]	28,660	5,520	33,492	5,660	0.14	0.04	0.08	0.03
2021[v]	53,567	10,624						
2000–2021 avg.	67,960	12,329	115,730	14,393	0.38	0.05	0.11	0.02

[a] From Ericksen (2001b).
[b] From Ericksen (2002b).
[c] From Ericksen (2003b).
[d] From Ericksen and Chapell (2005).
[e] From Ericksen and Chapell (2006a).
[f] From Ericksen (2006).
[g] From Elliott (2009).
[h] From Elliott (2010).
[i] From Elliott (2012a).
[j] From Elliott (2012b).
[k] From Elliott (2013).
[l] From Elliott (*in prep a*).
[m] From Elliott (*in prep b*).
[n] From Elliott (*in prep c*).
[o] From Elliott (*in prep d*).
[p] From Elliott (*in prep e*).
[q] From Elliott (*in prep f*).
[r] From Elliott (*in prep g*).
[s] From Elliott (*in prep h*).
[t] From Elliott (*in prep i*).
[u] From Elliott (*in prep j*).
[v] most data n/a due to no coded-wire-tagging in 2020

Table 6.–Number of coded-wire-tagged coho salmon released into the Chilkat River by year of release, through 2021. No tagged coho salmon were released in 2020.

Release year	Capture site	Stage	Total marked	Shed tags	Valid tags
1976 total	Chilkat River[a]	Juvenile	9,074	0	9,074
1977	Chilkat Lake	Juvenile	6,344	0	6,344
1977	Chilkat ponds[b]	Juvenile	2,729	0	2,729
1977 total			9,073	0	9,073
1981 total	Chilkat Lake	Juvenile	2,603	0	2,603
1982 total	Chilkat ponds	Juvenile	8,608	93	8,515
1984 total	Chilkat ponds	Juvenile	14,644	102	14,542
1999	Chilkat River	Smolt	12,037	10	12,027
1999	Chilkat Lake	Smolt	4,078	0	4,078
1999	Chilkat tributaries	Smolt	9,800	29	9,771
1999 total			25,915	39	25,876
2000	Chilkat tributaries	Smolt	9,980	20	9,960
2000	Lower Chilkat River	Smolt	11,953	4	11,949
2000	Upper Chilkat River	Smolt	3,083	0	3,083
2000 total			25,016	24	24,992
2001	Lower Chilkat River	Smolt	36,114	117	35,997
2002	Lower Chilkat River	Smolt	25,296	7	25,289
2003	Lower Chilkat River	Smolt	24,563	4	24,559
2004	Lower Chilkat River	Smolt	17,279	0	17,279
2005	Lower Chilkat River	Smolt	26,342	16	26,326
2006	Lower Chilkat River	Smolt	22,168	24	22,149
2007	Lower Chilkat River	Smolt	24,104	0	24,104
2008	Lower Chilkat River	Smolt	23,059	0	23,059
2009	Lower Chilkat River	Smolt	24,937	0	24,937
2010	Lower Chilkat River	Smolt	26,932	55	26,877
2011	Lower Chilkat River	Smolt	31,101	9	31,092
2012	Lower Chilkat River	Smolt	18,353	46	18,307
2013	Lower Chilkat River	Smolt	10,878	44	10,834
2014	Lower Chilkat River	Smolt	8,661	0	8,661
2015	Lower Chilkat River	Smolt	9,318	0	9,318
2016	Lower Chilkat River	Smolt	7,331	0	7,331
2017	Lower Chilkat River	Smolt	6,100	0	6,100
2018	Lower Chilkat River	Smolt	5,994	0	5,994
2019	Lower Chilkat River	Smolt	7,554	0	7,554
2020	Lower Chilkat River	Smolt	0	0	0
2021	Lower Chilkat River	Smolt	3,788	0	3,788
2022	Lower Chilkat River	Smolt	7,895	0	7,895
			2001–19, 2021–22 avg.		17,498

[a] This includes several locations throughout the drainage including the airport tributaries in 1976.

[b] Chilkat ponds refers to several ponds throughout the drainage where fish access was improved.

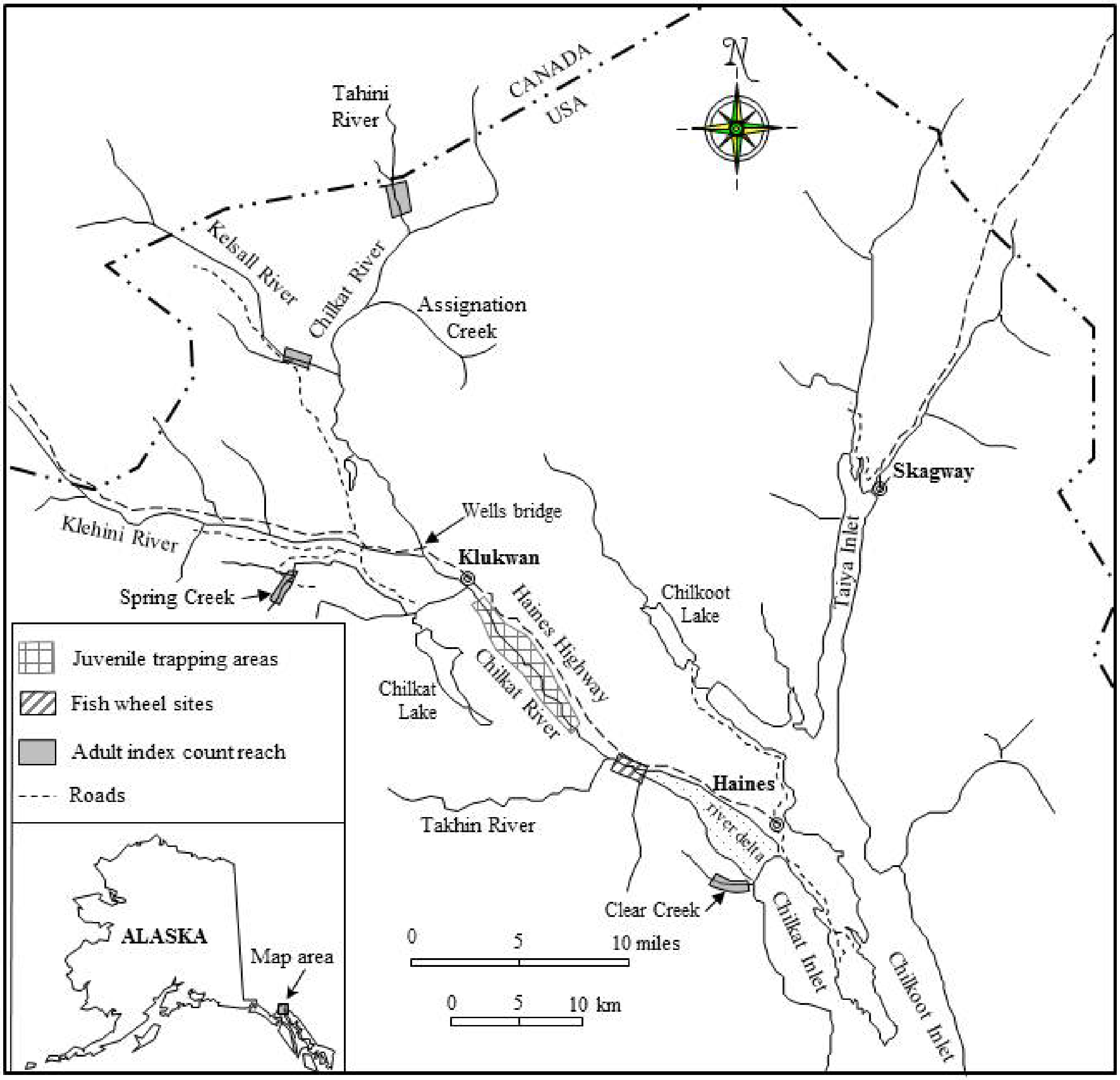

Figure 2.–Coho salmon sampling sites in the Chilkat River drainage in Southeast Alaska.

Table 7.–Peak survey counts of coho salmon in the Chilkat River drainage, 1987–2021, including mark–recapture estimates from 1990, 1998, 2002, 2003, and 2005.

Year	Peak Surveys					Estimated Escapement (N^)	SE (N^)	**Estimation Method**
	Spring Ck.	Kelsall R.	Tahini R.	Clear Ck.	Combined (C_t)			
1987[a]	99	197	792	25	1,113	37,432	7,202	expanded survey
1988[a]	87	160	590	40	877	29,495	5,675	expanded survey
1989[a]	57	190	1,064	141	1,452	48,833	9,395	expanded survey
1990[b]	88	379	2,766	150	3,383	79,807	9,980	**mark–recapture**
1991[a]	176	417	1,785	135	2,513	84,517	16,260	expanded survey
1992[a]	183	281	1,143	700	2,307	77,588	14,927	expanded survey
1993[a]	101	129	1,041	460	1,731	58,217	11,200	expanded survey
1994[a]	451	440	4,482	408	5,781	194,425	37,405	expanded survey
1995[a]	268	197	1,033	189	1,687	56,737	10,916	expanded survey
1996[a]	204	179	412	315	1,110	37,331	7,182	expanded survey
1997[a]	227	133	684	250	1,294	43,519	8,373	expanded survey
1998[b]	271	265	649	275	1,460	50,758	10,698	**mark–recapture**
1999[a]	335	207	962	195	1,699	57,140	10,993	expanded survey
2000[a]	305	571	1,324	435	2,635	88,620	17,050	expanded survey
2001[a]	450	225	1,272	1,285	3,232	108,698	20,912	expanded survey
2002[b]	1,328	440	2,582	1,310	5,660	205,429	31,165	**mark–recapture**
2003[b]	500	356	1,419	1,675	3,950	134,340	15,070	**mark–recapture**
2004[a]	564	170	827	445	2,006	67,465	12,980	expanded survey
2005[b]	221	42	219	495	977	38,589	4,625	**mark–recapture**
2006[a]	503	220	761	915	2,399	80,683	15,523	expanded survey
2007[a]	55	51	415	237	758	25,493	4,905	expanded survey
2008[a]	337	64	779	526	1,706	57,376	11,039	expanded survey
2009[a]	183	159	429	682	1,453	48,867	9,402	expanded survey
2010[a]	439	58	1,122	1,031	2,650	89,124	17,147	expanded survey
2011[a]	221	66	882	810	1,979	66,557	12,805	expanded survey
2012[a]	164	50	589	347	1,150	38,677	7,441	expanded survey
2013[a]	151	13	522	860	1,546	51,995	10,003	expanded survey
2014[a]	720	45	1,658	1,503	3,926	132,038	25,403	expanded survey
2015[a]	234	1	482	727	1,444	48,564	9,343	expanded survey
2016[a]	156	20	132	515	823	27,679	5,325	expanded survey
2017[a]	151	29	363	490	1,033	34,742	6,684	expanded survey
2018[s]	388	26	1,195	356	1,965	66,085	12,714	expanded survey
2019[t]	195	37	328	515	1,075	36,154	6,956	expanded survey
2020[u]	105	13	250	505	873	29,349	5,646	expanded survey
2021[v]	222	26	369	1,025	1,642	55,223	10,624	expanded survey
1987–2021 avg.	297	176	1,052	559	2,084	69,787	12,627	
					Expansion factor (pi)	33.6		
					SE (pi)	6.5		

[a] Estimate derived from expanded survey count
[b] Estimate derived from mark–recapture experiment

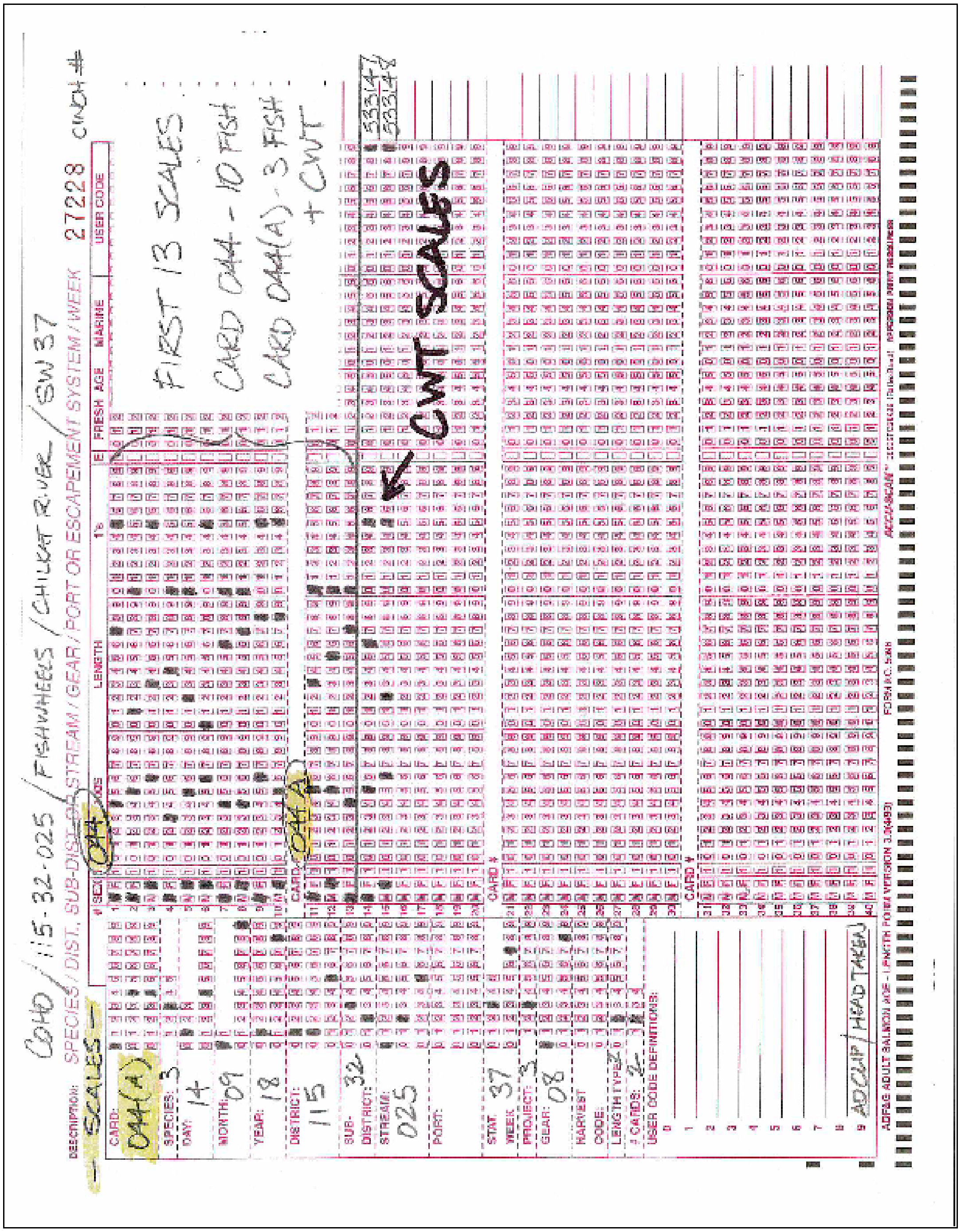

Figure 3.–Example of ADF&G adult salmon age-length form to record sex, length, and scale sample data from the first 13 of 40 coho salmon caught in fish wheels (on scale cards #44 and #44A), and from any coho salmon with a clipped adipose fin.

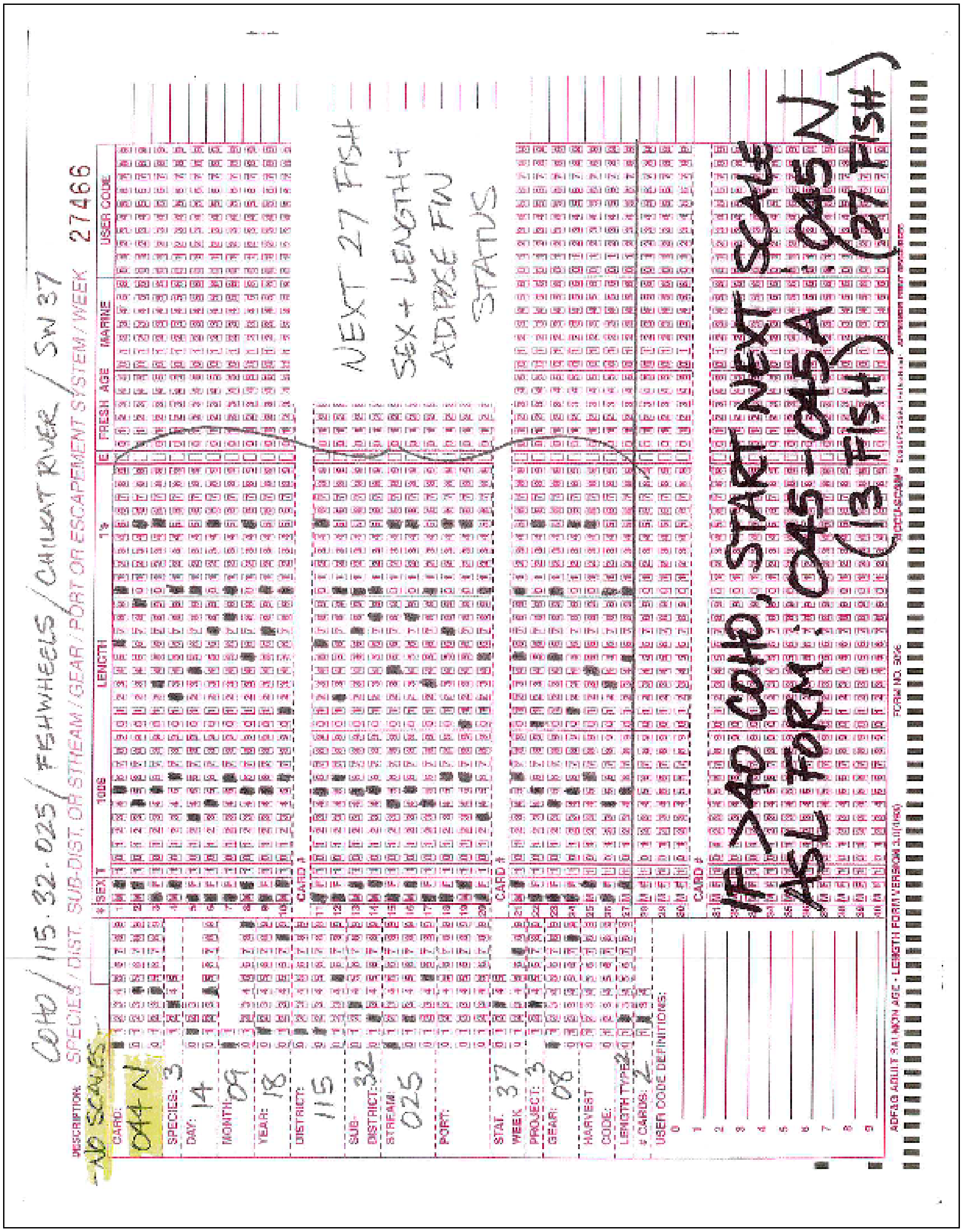

Figure 4.–Example of ADF&G adult salmon age-length form to record sex, length, and scale sample data from the last 27 of 40 coho salmon caught in fish wheels.

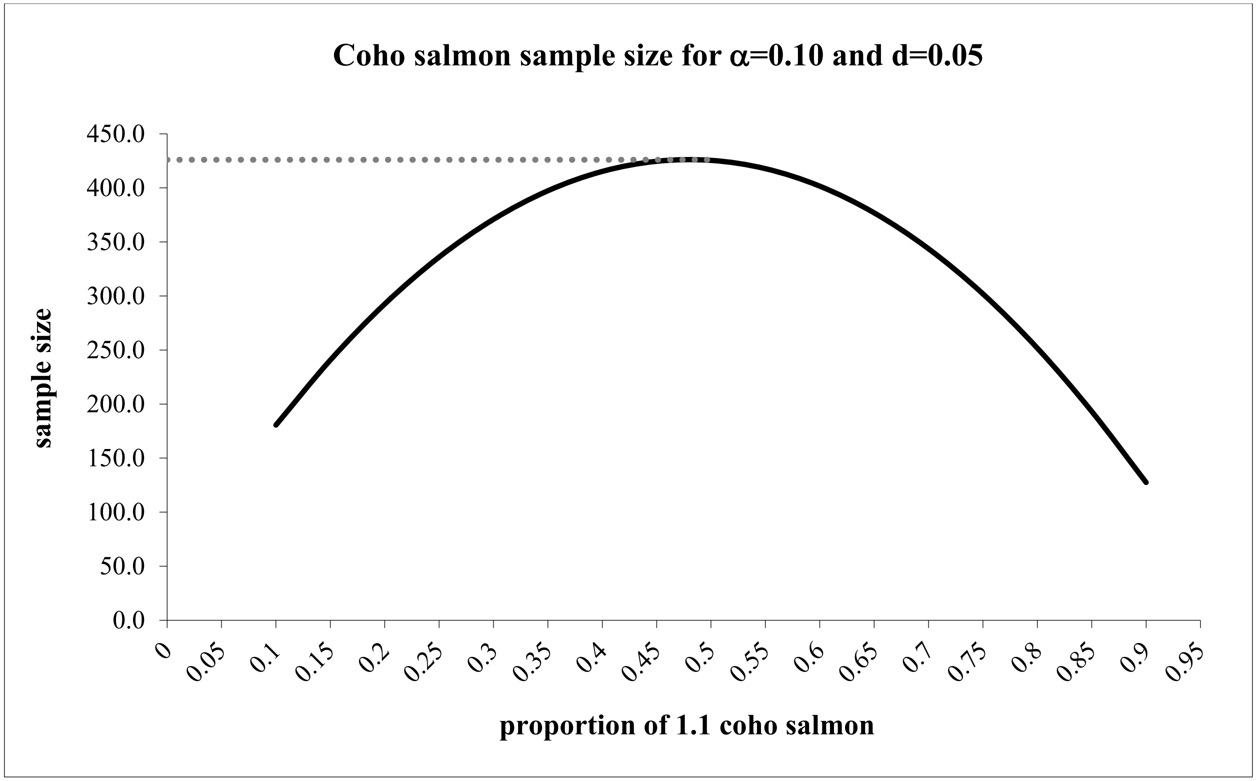

Figure 5.–Maximum number of Chilkat River coho salmon smolt scale samples required, from Thompson (2002), based on an alpha value of 0.10 and precision value of 0.05.

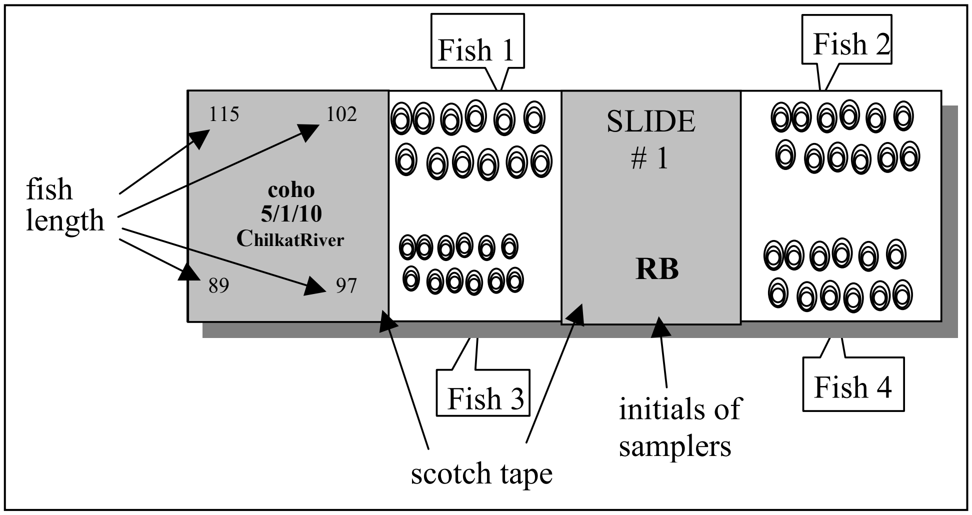

Figure 6.–Preferred microscope slide layout for coho salmon smolt scale samples.

Table 8.–Model results used to determine the effect of non-proportional tagging of smolt on the estimate of the overall marked fraction (θ) in the Chilkat River and tributary systems.

θ (area) and estimated θ (whole river) vs tagging bias				% Difference in θs			
Model	θ=Tahini	θ=Kelsall	θ estimate = combined	Absolute difference in areas	% Difference relative to Tahini	% Error in combined	χ^2 Detects difference (p = 0.1)
Unbiased	0.154	0.154	0.154	0.000	0	0.0	NA
20%	0.134	0.161	0.152	0.027	20	-1.1	No
40%	0.119	0.167	0.151	0.048	40	-2.0	No
60%	0.107	0.172	0.150	0.064	60	-2.7	No
80%	0.098	0.176	0.149	0.078	80	-3.3	Yes
100%	0.089	0.179	0.148	0.089	100	-3.8	Yes
120%	0.082	0.181	0.147	0.099	120	-4.2	Yes
250%	0.055	0.192	0.145	0.137	250	-5.8	Yes
1000%	0.019	0.206	0.142	0.187	1000	-7.9	Yes

APPENDICES

Appendix A.–Projected number of fish released with coded wire tags (CWT) and adipose fin clips in 2023, using the average traps deployed (90) and Chinook and coho salmon smolt CPUE from 2013–2022.

		Chinook salmon smolt		Coho salmon smolt	
Date	Traps deployed	CPUE 2013–2022	Valid CWT	CPUE 2013–2019, 2021–2022	Valid CWT
4-Apr	90	1.5	131	2.7	247
5-Apr	90	1.8	161	3.5	312
6-Apr	90	1.7	155	3.7	332
7-Apr	90	1.7	155	3.3	300
8-Apr	90	1.2	111	3.0	274
9-Apr	90	1.1	97	2.8	256
10-Apr	90	1.0	90	2.7	241
11-Apr	90	1.0	88	2.5	225
12-Apr	90	1.0	89	3.1	278
13-Apr	90	1.2	107	3.0	272
14-Apr	90	1.2	110	3.1	276
15-Apr	90	1.0	90	2.5	221
16-Apr	90	0.9	80	2.9	263
17-Apr	90	1.2	108	2.9	259
18-Apr	90	1.1	103	2.6	236
19-Apr	90	1.2	104	2.7	241
20-Apr	90	0.9	82	2.8	256
21-Apr	90	1.3	118	2.9	264
22-Apr	90	1.2	105	2.4	213
23-Apr	90	1.3	115	2.4	218
24-Apr	90	1.3	116	2.5	223
25-Apr	90	1.0	94	1.9	175
26-Apr	90	1.4	127	1.9	169
27-Apr	90	1.6	142	2.2	197
28-Apr	90	1.3	121	1.9	174
29-Apr	90	1.4	122	1.9	173
30-Apr	90	1.4	128	2.2	198
1-May	90	1.5	135	2.3	208
2-May	90	1.8	164	1.8	164
3-May	90	1.6	144	1.8	160
4-May	90	1.2	106	1.9	168
5-May	90	1.0	91	2.0	184
6-May	90	1.0	88	2.3	203
7-May	90	0.8	73	1.9	173
8-May	90	0.8	72	1.9	174
9-May	90	0.8	74	2.1	191
10-May	90	0.8	74	2.1	193
11-May	90	0.6	58	2.1	188
12-May	90	0.5	45	1.6	148
13-May	90	0.5	45	1.9	168
14-May	90	0.3	28	1.8	161
Total	3,600	1.2	4,249	2.4	8,977

Note: The most recent ten years' CPUE are used because the trap site selection method changed significantly in 2013.

Appendix B.–Expected values used in Chilkat River Chinook salmon brood year 2021 coded wire tag (CWT) sample size and precision calculations.

	Survival or harvest rate	Distribution of fishing mortality	Number of Chilkat fish	Marked rate	Number of Chilkat CWT fish	Sampling rate	Number of Chilkat CWTs recovered
Fall 2022 juvenile population			454,270				
Fall 2022 marked with CWTs				0.044	20,000		
Spring 2023 survivors	0.366		162,407		7,322		
Spring 2023 marked with CWTs				0.026	4,249		
Total marked spring 2023 emigrants				0.071	11,571		
Smolt to adult survivors	0.026		4,285		305		
SEAK marine harvest by fishery							
Winter troll		5%	29	0.071	2	0.37	1
Spring troll		16%	99	0.071	7	0.55	4
Summer troll		6%	36	0.071	3	0.31	1
Drift gillnet		29%	176	0.071	13	0.43	5
Purse seine		7%	45	0.071	3	0.26	1
SEAK sport		12%	73	0.071	5	0.41	2
Total SEAK marine harvest	10.7%	76%	458	0.071	33	0.44	14
Haines sport harvest	0.0%	0%	0				
Haines Chilkat Inlet subsistence	0.0%	0%	0				
Total marine harvest	10.7%	76%	458				
Total inriver abundance	89.3%		3,827	0.071	273	25%	67

Appendix C.–Expected values used in Chilkat River coho salmon 2023 smolt emigration year sample size and precision calculations.

	Survival or harvest rate	Distribution of fishing mortality	Number of Chilkat fish	Marked rate	Number of Chilkat CWT fish	Sampling rate	Number of Chilkat CWTs recovered
Spring 2023 expected smolt			1,090,159				
Spring 2023 marked with CWTs				0.008	8,977		
Total marked spring 2023 emigrants				0.008	8,977		
Smolt to adult survivors	10.6%		115,955		955		
SEAK marine harvest by fishery							
Summer troll		53%	24,594	0.008	203	0.26	54
Drift gillnet		44%	20,187	0.008	166	0.30	51
Purse seine		1%	389	0.008	3	0.26	1
SEAK sport		2%	1,154	0.008	10	0.31	3
Total SEAK marine harvest	39.9%	100%	46,324	0.008	381	0.00	109
Total inriver abundance	60.1%		69,631	0.008	573	27%	154

Appendix D.–Smolt coded wire tag daily log.

Tagging Site: Chilkat River

Species: Coho

Capture Site: Chilkat River

Tagger: Barber

Date: May 5, 2023

Today's Tagging: Machine Serial No.___621___________

	SMALL	MEDIUM	LARGE
Tag Code	04-18-93	04-18-94	04-18-94
End #	276,633	275,822	276,204
Start #	276,209	275,513	275,824
Subtotal	424	309	380
Double/Retags	0	2	12
Total Tagged	424	307	368

Today's Recaptures:

Total w/o CWTs	29
Total w/ CWTs	0
Total	29

Tag Retention & Mortality Calculations (hold until next day):

No. w/ CWTs	100
No. w/o CWTs	0
No. Tested	100

Summary	# valid tagged	overnight mortality	# released
75–84mm	424	1	423
85–99mm	307	0	307
>=100mm	368	2	366
TOTAL	1099	3	1096

Traps will be tied off with an overhand knot followed by a slipknot to ensure traps can be pulled quickly during floodwaters. Try to tie off well above the water level in case of rising water. Always push flagging up to the knot and place extra flagging if not easily visible. Cinch the knot on the flagging tape tight so wind won't blow it into the water. Always carry extra flagging and use it if traps are in hard-to-find locations.

One crew leader will oversee a trap line, and the other will oversee the other trap line. Keep accurate track of all traps. **REMEMBER**: Lost traps keep fishing and kill fish. Count all traps taken out to the field at the beginning of the season and record this number in the logbook. If more traps are taken to the field later, these need to be recorded as well. All lost or damaged traps (i.e., bear hits) will be recorded, and the damaged traps kept in a certain place until the end of the season. The goal is to be able to reconcile the number of traps we have upon pulling out from an area with the number taken out to the field, as even one trap potentially left set is a problem. Also in early–mid May, eulachon will be running in the lower river. Be sensitive to people fishing for eulachon. It may be best to stay out of the lower river during this time.

Both crews should take hand counters to help keep track of the number of traps on the longer lines. If a trap is lost during high water, it should be marked as lost in the trap-line book and the area flagged so the trap may be recovered at low water.

Name specific areas of the river where you are trapping. Naming an area after a natural feature will help you associate the area with the name. Examples are Spruce Row, Moose Bar and Big Beaver. So that everyone is using a standard method of notation in the trap-line field book, the format will be as follows:

Table E.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in Fall, 2003.

Date: 10/20/2003					
Site	Traps checked	Traps pulled	Traps added	Total traps	# Of fish by species
Spruce Row	5	2	0	3	30 coho; 10 king
Moose Bar	2	0	2	4	50 coho
Big Beaver	3	3	0	0	5 coho
Snowball	0	0	3	3	New sets
Total	10	5	5	10	85 coho; 10 king

According to the above notation, at Spruce Row we checked 5 traps; two of the traps didn't catch many fish so we pulled them. That leaves us with 3 traps in that area and we caught approximately 30 fish there. On Moose Bar we checked 2 traps and caught 50 fish, so we set 2 more in that area, for a total of 4 traps in the water. At Big Beaver we checked 3 traps for a total of 5 fish, lousy fishing so we pulled all 3 traps, leaving us with 10 traps in that area. We set 3 traps in a new area called Snowball. Looking at the total we see that we caught 85 coho and 10 kings that day and have 10 traps still in the water fishing.

The rest of the crew will alternate between upriver and downriver to break up the monotony of always working with the same person.

The number of traps out is the important number. Don't waste a lot of time counting each individual fish. We will get the exact number when we tag. Be conservative in your counting. The objective is to tag a lot of fish, not to have a higher number in your book than the other crew.

Appendix F.–Minnow trap summary form.

	River	River	Lower Trapline				Upper Trapline				Daily Total				Cum. Total	
	Depth	Temp	Number of traps		Est. Fish		Number of traps		Est. Fish		Est. Fish		# Tagged		# Tagged	# Tagged
Date	(in)	(C)	Checked	Set	Chinook	Coho	Checked	Set	Chinook	Coho	Chinook	Coho	Chinook	Coho	Chinook	Coho
8-Apr	6.00	2.0		50				40								
9-Apr	6.50	2.0	50	44	37	144	40	50	48	285	85	429				
10-Apr	7.00	2.0	44	40	39	201	50	36	39	432	78	633	160	1,162	160	1,162
11-Apr	7.25	3.0	40	46	26	118	36	47	39	284	65	402				
12-Apr	8.00	3.0	46	35	9	120	47	42	29	218	38	338	85	658	245	1,820
13-Apr	10.00	3.0	35	36	6	64	42	47	35	231	41	295				
14-Apr	11.50	3.0	36	50	28	85	47	47	24	221	52	306	74	553	319	2,373
15-Apr	13.50	2.5	50	46	23	91	47	50	8	180	31	271				
16-Apr	14.50	3.0	46	43	28	277	50	49	11	174	39	451	69	666	388	3,039
17-Apr	16.25	3.0	43	46	33	188	49	49	37	238	70	426				
18-Apr	16.75	2.5	46	40	21	144	49	49	84	311	105	455	138	714	526	3,753
19-Apr	17.00	3.0	40	48	33	174	49	50	66	231	99	405				
20-Apr	18.00	4.0	48	46	40	290	50	50	49	193	89	483	203	772	729	4,525
21-Apr	19.00	3.0	46	46	51	216	50	50	39	145	90	361				
22-Apr	19.00	3.0	46	46	26	201	49	49	68	171	94	372	150	389	879	4,914
23-Apr	19.25	2.5	46	48	12	143	49	48	48	270	60	413				
24-Apr	19.25	3.0	48	47	22	140	48	48	59	263	81	403	129	649	1,008	5,563
25-Apr	19.00	3.0	47	47	37	143	48	48	74	222	111	365				
26-Apr	19.00	3.0	47	46	43	147	48	48	88	174	131	321	222	653	1,230	6,216
27-Apr	19.00	3.0	46	48	65	184	48	48	114	256	179	440				
28-Apr	20.75	4.0	48	49	49	134	48	48	146	198	195	332	382	675	1,612	6,891
29-Apr	21.00	4.0	49	49	79	167	48	48	95	206	174	373				
30-Apr	22.00	4.0	49	49	50	157	48	48	142	292	192	449	357	577	1,969	7,468
1-May	22.00	4.0	49	45	58	96	48	46	147	321	205	417				
2-May	22.75	4.0	45	46	94	146	46	50	88	241	182	387	373	775	2,342	8,243
3-May	23.00	4.0	46	50	93	207	50	50	54	208	147	415				
4-May	23.00	4.0	50	50	57	173	50	49	41	265	98	438	232	748	2,574	8,991
5-May	22.75	4.0	50	50	20	139	49	48	37	309	57	448				
6-May	23.00	4.0	50	50	25	266	48	48	37	222	62	488	88	767	2,662	9,758
7-May	24.00	4.5	50	50	18	239	48	49	34	263	52	502				
8-May	26.75	4.0	50	50	14	133	49	49	40	222	54	355	104	737	2,766	10,495
9-May	26.00	3.5	50	50	7	262	49	49	64	285	71	547				
10-May	24.50	4.0	50	50	6	146	49	49	47	238	53	384	108	727	2,874	11,222
11-May	24.50	4.5	50	49	17	209	49	49	27	269	44	478				
12-May	27.00	4.0	49	49	8	176	49	49	25	220	33	396	64	740	2,938	11,962
13-May	27.75	4.0	49	49	18	192	49	49	15	244	33	436				
14-May	26.50	4.5	49	48	24	207	49	49	12	282	36	489	67	801	3,005	12,763

Appendix G.–Chilkat River Chinook salmon sampling form.

Project: Chilkat River Chinook Coded Wire Tag   Location:

Fish #	**Date**	**Length**	**Weight**	**Fish #**	**Date**	**Length**	**Weight**
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

Appendix H.- Chilkat River coho salmon smolt age-weight-length form.

Location: ______________ **Year:** _______

Species: ______________ **Page:** _______

Samplers:

Date	Slide	Fish #	Length	Weight	Comments	Date	Slide	Fish #	Length	Weight	Comments
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			

Overview of the Global Positioning System (GPS)

The Global Positioning System (GPS) is a world-wide radio-navigation system formed from a constellation of 24 satellites with precise atomic clocks orbiting 11,000 km above the earth's surface, and their associated ground stations. Positions on earth are determined by receiving the radio signals being emitted and measuring the very precise distances and time to the available satellite(s); the process uses mathematical 'triangulation' calculations to compute the result.

Essentially, four visible satellites are necessary to accurately determine position, but three available satellites can do the same—albeit sometimes less reliably, depending on their constellation/configuration at that specific point in time. The steep terrain associated with certain parts of Alaska will at times present problems with obstructed views of the sky and therefore will play a role in how well the radio signals from the satellites are being received. However, use of external antennas, leaving units turned on over the course of the day while surveying, and waiting until certain times of day to collect data can all enhance one's ability to collect reasonably precise positions.

GPS Instrument Setup

There is a myriad of makes and models of consumer-grade GPS units available for purchase, but in the end, they all process and produce positional data the same. Before GPS units can be used for navigation or waypoint storage purposes, they need to be initialized. Each GPS receiver should only need to be initialized the first time the unit is used, or if it has been stored for several months or moved a substantial distance while turned off. The initialization procedure is automatic for most GPS receivers and begins on power-up. To initialize a unit for the first time, take the GPS receiver outside with a clear, 360-degree field of view and turn it on. Navigate through the 'pages' of the GPS using the LCD display until the unit shows that it is acquiring satellites. The unit will begin acquiring fixes on available satellites and storing the orbital data for each in an almanac in memory on the unit. This setup should complete the initialization of the unit.

There are two key items to remember when using consumer-grade GPS units relative to coordinate data being saved/recorded: 1) coordinate information stored directly on the unit (as waypoints or routes) is always stored in a world geographic coordinate system (WGS84) datum and cannot be overridden until they are downloaded; and 2) you can override the datum and projection being displayed on the screen using the setup menu as necessary, but it is important to document what you set the datum/projection to (i.e. NAD83 Stateplane Alaska Zone 1) if recording those coordinates onto a data form/book rather than saving as waypoints on the unit—this is imperative to ensure correct display in GIS for rendering final output.

Observers should always attempt to get the best possible "fix" from satellites when taking a GPS reading. Often, fixes with accuracy (or error, as it is labeled with some GPS units) under 15 m are possible in less than 30 seconds, especially on the larger river systems where canopy cover is minimal, and the view of the horizon is not obscured (e.g., high ridge immediately above river bank). There will be days when the constellation of the satellites is insufficient to allow for good fixes (i.e., >15 m accuracy); in these instances, it is preferred that GPS locations be acquired on a return visit. If no return visit is anticipated, then observers should spend an extra 1–2min, if possible, to let the GPS instrument acquire the best fix under the circumstances.

Importance of Spatial Data to Fisheries Management and Research

Like many resource management agencies across the country, the ADF&G's mission is to protect, maintain and improve the fish, game, and aquatic plant resources of the state. And almost everything that is done in our day-to-day activities, or conveyed to the public, is explicit to somewhere on the landscape. For example, research project plans typically describe specific locations where data need to be collected; news releases typically describe where users may or may NOT harvest resources, etc. Yet there is no standardized way to document where exactly these places are across the landscape and worse yet, no data management system to accommodate that type of information. Our intent is to layout some guidelines that can be used by others to assist in their spatial data collection efforts.

Spatial data when added to fish observation data is a very useful tool and can help facilitate several information needs for enhancing our ability to carry out the mission of the Department. Examples include increasing our knowledge of fish distribution for purposes of protection and conservation; documenting where boundary markers are established for fishery openings; documenting where fish are trapped/observed during sampling events for return trips; use of site-specific fish locations to develop landscape-based models that estimate fish production; identifying areas on the landscape that are most important to users for purposes of conservation and protection.

GPS Data Collection Procedures for use in Salmon Stock Assessment Projects

Smolt Tagging (Fall, Spring)

This section will describe the development and implementation of procedures and techniques for the collection of spatial data using GPS units at specific locations on the ground associated with smolt trapping sites on several Transboundary River Systems. These projects include coded wire tagging of Chinook and coho salmon presmolts and smolts which is a component of full stock assessment projects.

First and foremost, SF crews are NOT being asked to change their mode of operations, as it pertains to smolt trapping methods. Rather, the collection of spatial data using GPS units (waypoints) should be considered a task that occurs coincidentally with their delegated smolt trapping work. Generally, you will be looking to collect waypoints at smolt-trapping sites to generally describe the extent of the smolt-trapping area. For example, if we knew that trapping sites were all the same size and configuration, we could simply grab one waypoint for a group of traps known collectively to encompass site 'X'. However, the reality is that these trapping sites differ in size and configuration and migrate upstream/downstream as water levels rise and fall across the trapping season. The general practice is that vernacular names are assigned to these trapping areas in each season, and rather than re-naming those areas where traps are moved only short distances, typically retain the same name. In other instances, SF crews move into new areas as snow/ice dissipate, at which time the area is assigned a new generic name.

Capturing waypoints in a manner that represents the whole extent or area of individual trapping sites can accommodate each of these scenarios. This may be as simple as taking single waypoints at small sites (which may represent 4–5 traps placed at a small logjam) or as involved as taking multiple waypoints to accurately determine the boundaries of a relatively larger trapping site. It may also entail taking additional waypoints as a single trapping site is fished out and traps are ‘shifted’ or moved downstream/upstream; field crews may decide to keep their generic site name, since it is in proximity. One additional waypoint may be sufficient such that we would be able to map out the entire extent of the trapping area.

The bottom line is that multiple waypoints are collected at each site to generally describe the extent of the area being trapped. If two waypoints are collected for a single trapping area, generally identifying the upper and lower portions of the site and a few traps are below or above these waypoints by 20–30 meters, this is fine. We are looking for a precision of under 50 meters in most cases although 100 meters may be the best that can be done in large, braided areas of the Unuk floodplain, without unduly creating chaos for field crews where the primary responsibilities are trapping large numbers of fish. Figures 1–3 illustrate the use of waypoints in delineating or ‘outlining’ the extent of trap sites (areas) with an acceptable level of precision. In these figures, the polygons representing the trap sites (areas) may appear to be arbitrarily drawn, considering that although the points fall inside, they do not provide all the corners. We should note that stream banks and islands present obvious boundaries for the delineation of smolt trapping areas in absence of other information and will be evaluated using aerial photography during delineation in the office to map the site extent.

The collection of waypoints associated with individual trap sites (areas) should accompany trap data in field notebooks used by research staff. This would include recording the GPS Model/Make (Magellan 320, Garmin 12XL, Garmin 450, etc.), assigned Unit letter (e.g., L, M, N, etc.), the waypoint number, the GPS positional error (or accuracy), and a very brief description of what the individual waypoint represents (e.g., upper most river right or lowest point on river left, etc.). If only one GPS unit model (Garmin 12XL, Magellan 320, etc.) is used by a crew throughout the smolt trapping season, then it will be unnecessary to record this information daily; just make sure the relevant unit information is on the first page of each field notebook used. One additional piece of information to be recorded includes species and fish numbers. If this data is generally collected concurrent with checking trap lines, then it should be recorded in field notebooks. This information will accompany trap related records associated with the trap site (area), which field crews collect each day, such as number of traps placed, number of traps checked, number of fish, number of traps pulled, etc. **An example of the data collected during smolt trapping which captures all the relevant GPS data is provided in Table 1**. Note that if sites shift, field crews should take another waypoint on the day they are shifted or moved, which depicts the extension of the trapping area (site), and code this information in their field notebooks.

If traps are placed in areas where no site name is given (especially locations where only 1 or 2 traps are placed), specific comments should include a concise description of the general location (e.g., on small tributary to main channel approximately 250 m from the main channel or in beaver pond complex on west side of main channel approximately 400 m from the main river channel).

In general, observers should *always describe features as to right or left as if they were looking downstream (e.g., confluence right bank)*—in other words, "**going with the flow**".

Table C1.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in Fall, 2003.

Date: 10/20/2003 GPS Unit Model: Magellan 320, (unit L)

Site	Traps checked	Traps pulled	Traps added	Total traps	# of fish by species	Way-point #	Waypoint Accuracy (m)	Waypoint description
Spruce Row	5	2	0	3	30 coho; 10 king	5,6	10; 10	5 – upper; 6 – lower
Moose Bar	2	0	2	4	50 coho	7,8	8, 12	7– upper; 8 – lower
Big Beaver	3	3	0	0	5 coho	9	13	Center of trap area
Snowball	0	0	3	3	New sets	10, 11	6, 9	10 – upper; 11 – lower
Total	10	5	5	10	80 coho; 10 king			

In summary, coordinate data should be recorded at all coded wire tag trapping sites where minnow traps are deployed. As an alternative to recording GPS coordinates at each minnow trap being deployed, observers can define the bounds of the area being trapped (e.g., Spaghetti Flats, 6-pack slough). If a site is confined or constrained (e.g., has a defined upper and lower end such as a slough) then 1–2 waypoints should be taken at the upper and lower extents of the upper portion and additional waypoints as necessary taken at the extents of the lower reach. Trapping observations recorded in 'smolt trapping data books' should include the saved waypoint number(s), and include vernacular name assigned to that site.

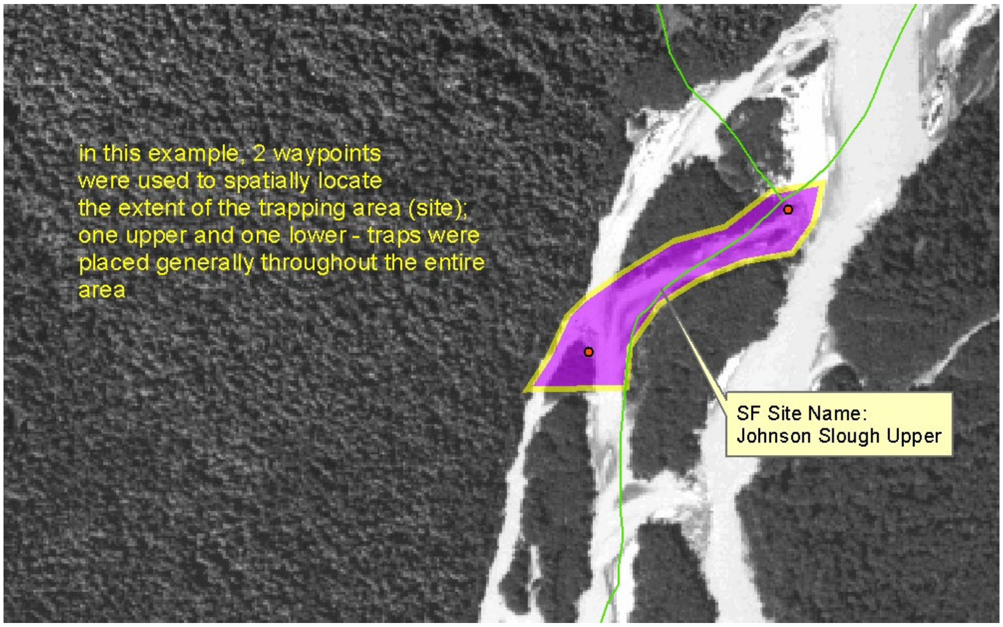

Figure 1.–Smolt trapping site on the Unuk River. The outlined polygon represents a single trapping site or area known as Johnson Slough Upper. Individual trapping sites may contain an infinite number of traps. The orange dots represent 2 waypoints collected to delineate the 'approximate' extent of trapping effort associated with this site.

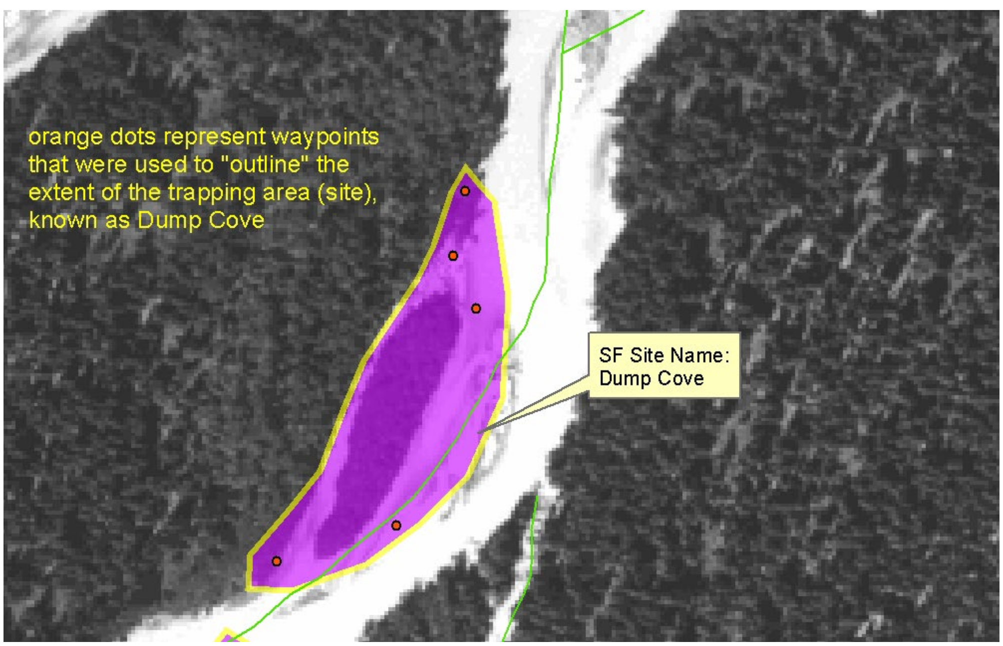

Figure 2.–Using more than two waypoints to delineate the extent of the trap site '*Dump Cove*' on the Unuk River. The upper and lower most waypoints are critical, although the 3 other points allow us to more accurately represent traps that were placed on the river left side of the island.

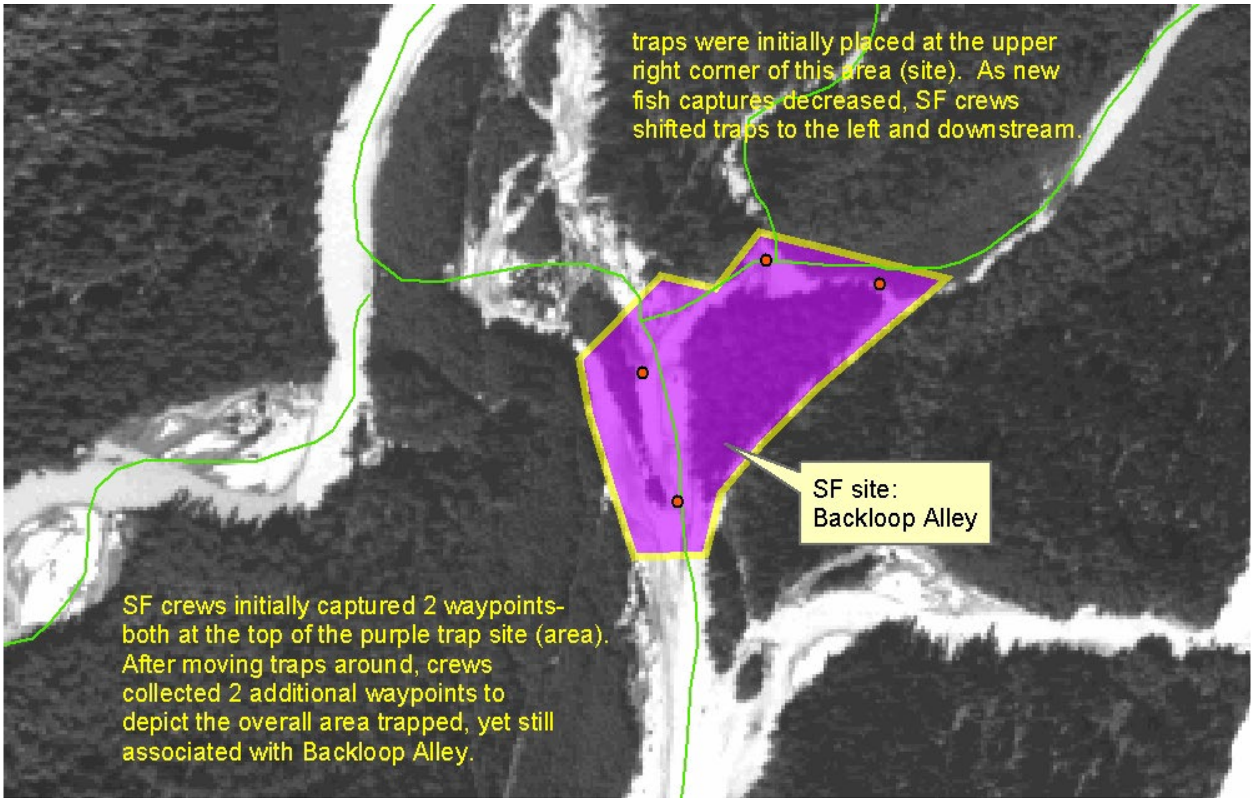

Figure 3.–Example of expanded trap site, and GPS locations used to document that site as local conditions changed due to changing trap catches, and rising and falling water conditions on the Unuk River, Alaska. Again, SF crews shifted traps in response to decreasing numbers associated with initial trap locations (upper portion of polygon). Rather than re-name the SF site, they elected to capture 2 more waypoints associated with new trap locations thereby providing 4 “corners”, where we could delineate the Backloop Alley trap site (area).

TESTS OF CONSISTENCY FOR PETERSEN ESTIMATOR

Three 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, then a Petersen estimator may be used. If all three of the null hypotheses are rejected, a temporally or spatially stratified estimator (Darroch 1961) should be used to estimate abundance.

Seber (1982) describes 4 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
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* fish captured in second event and *m* marked fish recaptured; $m_{\bullet j}$ and $m_{i\bullet}$ represent summation over the i^{th} and j^{th} indices, respectively.

I. MIXING TEST

Tests the hypothesis (condition 1) that movement probabilities (θ_{ij}), describing the probability that a fish moves from marking stratum *i* to recapture stratum *j*, are independent of marking stratum: H_0: $\theta_{ij} = \theta_j$ for all *i* and *j*.

Area/Time Marking Strata *(i)*	Area/Time Recapture Strata *(j)*				Not Recaptured
	1	2	…	t	$a_i - m_{i\bullet}$
1	m_{11}	m_{12}	...	m_{1t}	$a_1 - m_{1\bullet}$
2	m_{21}	m_{22}	...	m_{2t}	$a_2 - m_{2\bullet}$
...	...	...	...	...	…
s	m_{s1}	m_{s2}	...	m_{st}	$a_s - m_{s\bullet}$

II. EQUAL PROPORTIONS TEST[A] (SPAS[B] 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 - $m_{\cdot j}$)	$n_1 - m_{\bullet 1}$	$n_2 - m_{\bullet 2}$	…	$n_t - m_{\bullet t}$

III. COMPLETE MIXING TEST[A] (SPAS[B] 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)	$m_{1\bullet}$	$m_{2\bullet}$	…	$m_{s\bullet}$
Not Recaptured (a_i - $m_{i\bullet}$)	$a_1 - m_{1\bullet}$	$a_2 - m_{2\bullet}$	…	$a_s - m_{s\bullet}$

[a] There is no 1:1 correspondence between Tests II and III 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] Stratified Population Analysis System (Arnason, A.N., C.W. Kirby, C.J. Schwarz and J.R. Irvine. 1996. Computer Analysis of Data from Stratified Mark-Recovery Experiments for Estimation of Salmon Escapements and Other Populations, Canadian Technical Report of Fisheries and Aquatic Sciences 2106.