Regional Operational Plan No. ROP.CF.1J.2022.06

Escapements of Chinook Salmon in Southeast Alaska and Transboundary Rivers in 2022

by

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and

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July 2022

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

REGIONAL OPERATIONAL PLAN NO.ROP.CF.1J.2022.06

ESCAPEMENTS OF CHINOOK SALMON IN SOUTHEAST ALASKA AND TRANSBOUNDARY RIVERS IN 2022

by

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Signature/Title Page

Project Title:	*Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 2022*
Project leader(s):	*Philip Richards, Fishery Biologist III* *Nathan Frost, Fishery Biologist II*
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Approval

Title	Name	Signature	Date
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PURPOSE

Estimates of Chinook salmon *Oncorhynchus tshawytscha* spawning escapement in 2022 will be summarized for 11 Southeast Alaska river systems: Situk River, Alsek River, Chilkat River, Taku River, King Salmon River, Stikine River, Unuk River, Chickamin River, Blossom River, Keta River, and Andrew Creek. Spawning escapements will be estimated using aerial surveys, foot surveys, mark–recapture studies, and weirs. The Alaska Department of Fish and Game and Fisheries and Oceans Canada use these data, along with age composition data to make terminal and regional management decisions, and the Pacific Salmon Commission uses these data for coastwide management and stock assessment.

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* aerial surveys, foot surveys, mark–recapture, weir, inriver run, escapement, total run, age composition, Situk River, Alsek River, Chilkat River, Taku River, King Salmon River, Stikine River, Unuk River, Chickamin River, Blossom River, Keta River, Andrew Creek, Southeast Alaska

BACKGROUND

Populations of Chinook salmon *Oncorhynchus tshawytscha* are known to occur in 34 river systems throughout Southeast Alaska (SEAK), northwestern British Columbia, and the Yukon Territory. In the mid-1970s, it became apparent that some of the Chinook salmon populations in the region were depressed relative to historical levels of production (Kissner 1974). As a result, a fisheries management program (ADF&G 1981) was implemented to rebuild depressed stocks of Chinook salmon in SEAK that included transboundary rivers (rivers that originate in Canada and flow into SEAK coastal waters) and non-transboundary systems existing only within U.S. lands. Initially, this management program included regulatory closures of commercial and recreational fisheries in terminal and near-terminal areas. This program was formalized and expanded in 1981 to a 15-year (roughly 3 life cycles) rebuilding program for the transboundary Taku, Stikine, Alsek, Unuk, Chickamin, and Chilkat rivers, and the non-transboundary Blossom, Keta, Situk, and King Salmon rivers (ADF&G 1981; Figure 1).

The objective of this program, which included regionwide, all-gear catch ceilings for Chinook salmon, was to rebuild spawning escapements to interim escapement goals by 1995 (ADF&G 1981). In 1985, the SEAK rebuilding program was incorporated into a broader coastwide rebuilding program for natural-wild stocks of Chinook salmon when the U.S./Canada Pacific Salmon Treaty was first implemented.

Figure 1.–Location of select Chinook salmon river systems annually surveyed to produce estimates of spawning escapement in Southeast Alaska, British Columbia, and the Yukon Territories.

One method of assessing Chinook salmon stock status is via the estimation of spawning escapement and the development and application of escapement goals. Since 1975, the SEAK Chinook Salmon Escapement Project has been conducted to estimate annual escapements to select river systems in a standardized program (Kissner 1982). Estimates of escapement are produced using various methods including weirs, mark–recapture, foot surveys, and aerial surveys. This operational plan describes the foot and aerial survey methods used as well as the analytical procedures for estimating Chinook salmon escapement from these types of surveys. The methods and analyses used in weir and mark–recapture studies are documented in separate Regional Operational Plans that are specific to individual river systems (e.g., Stikine River, Taku River, Chilkat River, Situk River, Unuk River). The final escapement estimates will be reported in a single document, which promotes standardization of results and efficiencies in reporting and publication.

A weir is used to estimate total Chinook salmon spawning escapement on the Situk River; mark–recapture, foot, and aerial surveys are not used in this system. Mark–recapture studies employing different gear types (fish wheels, drift and set gillnet, rod and reel) are used on the Taku, Stikine, Alsek, and Chilkat Rivers. Specific methods and analytical approaches used in these systems are presented in Williams et al. (*In prep.*), Courtney et al. (2022), Richards et al. (*In prep.*), and Elliott (2022), respectively.

Counts made during aerial or foot surveys are timed to occur during periods of peak spawning of Chinook salmon by index area, recognizing past observations of migration and spawning chronology as well as environmental factors that dictate timing. Nearly all aerial surveys from 1975 through 2021 were conducted by seven individuals: the first from 1975 through 1987, the second from 1988 through 1989, and the third from 1990 to 2010. From 2006 to 2010, two surveyors were trained to conduct the aerial surveys, one out of Juneau and one out of Ketchikan. These 2 surveyors conducted the aerial surveys from 2010 to 2015, while at the same time training two additional surveyors out of Juneau. In 2016 and 2017, two surveyors from Juneau conducted the aerial surveys and two additional surveyors were trained, one out of Juneau and one out of Ketchikan. From 2018 to 2020, two surveyors conducted the surveys in Juneau and Ketchikan, respectively, and one was trained out of Juneau. In 2021, two surveyors conducted the surveys in Juneau and two surveyors conducted the surveys in Ketchikan. The same will occur in 2022. Consistency in survey timing and observers, with respect to peak spawning activity and personnel, reduces the effects of temporal and observer bias associated with index surveys conducted by air or foot.

Expansion factors have been estimated to convert peak counts from aerial or foot surveys to escapement of large fish for all river systems except the Chilkat River (McPherson et al. 2003; Pahlke 2007). The development of expansion factors has significantly improved the assessment of SEAK Chinook salmon stocks where in past years only measures of relative spawning abundance were available. Expansion factors and escapement estimates are evaluated and revised periodically as new information becomes available. In general, expansion factors are estimated through the concurrent use of aerial or foot surveys and mark–recapture studies or weirs, which are used in river systems where inseason data are needed to conduct fisheries, or where they are called for in management plans. The Chinook Technical Committee (CTC) data standard for escapement estimates is a CV ≤ 15% (John Carlile, ADF&G, personal communication) and the U.S. CTC data standard for expansion factors requires at least 3 years of paired estimates/counts and suggests that expansion factors with a CV >20% should be monitored annually (US CTC 1997). The resulting escapement estimates are provided to the Joint CTC of the Pacific Salmon Commission. In accordance with the Pacific Salmon Treaty, these estimates are used to ascertain progress towards meeting escapement goals for the Chinook salmon stocks of SEAK and transboundary rivers shared by the U.S. and Canada (CTC 1993). Appropriate fishery regulations are promulgated by ADF&G and the Pacific Salmon Commission to maintain escapements and to harvest any surplus production.

River systems not included in this operational plan though periodically surveyed in the past include the Bradfield River, Harding River, Wilson River, Marten River, and Aaron Creek.

OBJECTIVES

1. Collect peak aerial survey counts for tributaries of the Taku River. Aerial counts will be made in the Nakina, Nahlin, Tatsamenie, Kowatua, Tseta, and Dudidontu Rivers.
2. Collect peak foot survey counts for the King Salmon River and Andrew Creek.
3. Collect peak aerial survey counts for the Chickamin, Blossom, and Keta Rivers.
4. Collect peak aerial and foot survey counts for tributaries of the Unuk River (Eulachon River, Cripple, Kerr, Gene’s Lake, Clear, and Lake creeks).

SECONDARY OBJECTIVES

1. Summarize and report spawning escapement estimates for 11 Chinook salmon river systems in Southeast Alaska: Situk River, Alsek River, Chilkat River, Taku River, King Salmon River, Stikine River, Unuk River, Chickamin River, Blossom River, Keta River, and Andrew Creek.
2. Train additional surveyors to perform aerial and foot survey counts for Chinook salmon in Southeast Alaska.

METHODS

STUDY DESIGN

Estimating Escapement Using Peak Aerial and Foot Survey Counts

Large Chinook salmon spawning in select survey areas will be counted shortly before, during, or immediately after the peak of spawning activity. Large Chinook salmon are defined as fish ≥660 mm mid eye to tail fork in length and are assumed to be ocean-age-3, -4, or -5. Peak spawning times are well defined from previous surveys of these same river systems over the last 30 years (Table 1); however, recent observations suggest that peak spawning times are approximately 1–3 weeks later than average in Behm Canal systems (ADF&G unpublished data). Survey areas within each index area are selected based on historical importance, size of the population, geographic distribution, historical database, and ease of data collection (i.e., water clarity, logistical access, canopy cover, and general survey conditions). Survey areas were originally described by landmarks and have since been defined by GPS coordinates (Kissner 1982; Pahlke 2010; Appendix A1). Peak counts made for the river systems will serve as annual comparable indices of spawning escapement. Surveys will be conducted on foot or from a helicopter during the peak of spawning. Each survey area will be surveyed at least twice per year and most river systems will be surveyed 3 times per year.

Table 1.–Survey areas, peak spawning dates, and spawner distribution of select Chinook salmon river systems in Southeast Alaska, British Columbia, and Yukon Territories.

River system	Tributary	Spawning peak date (historic)	Survey area	Spawner distribution	Remarks
Taku River	Nakina River	4 Aug	Grizzly Bar to canyon 3.2 km above confluence with Silver Salmon River.	Prime spawning habitat just above Grizzly Bar (Kissner 1982).	Large numbers of spawning pinks and schooled sockeye will be observed in this area.
Taku River	Nahlin River	24 Jul	Telegraph Trail Crossing to forks about 48 km up-stream. Up each fork 1.6 km.	Most fish are found in index area III (Kissner 1982).	Many sockeye in survey area.
Taku River	Tatsamenie River	23 Aug	Tatsatua Junction to big Tatsaminie Lake.	Fish distributed throughout the index area (Kissner 1982).	Sometimes semi-glacial. Survey should start by 10 a.m. Some sockeye in survey area.
Taku River	Kowatua River	20 Aug	Little Trapper Lake outlet to junction of small glacial stream that flows into Kowatua from south about 8 km below Little Trapper Lake.	Evenly distributed (Kissner 1982).	Glacial survey, should start by 8 a.m. some sockeye in survey area.
Taku River	Tseta River	29 Jul	Upper barrier (falls) down-river to start of canyon.	Densest spawning in upper 3.2 km (Kissner 1982).	Only Chinook observer in this tributary.
Taku River	Dudidontu River	2 Aug	End of canyon up-stream to 3.2 km past junction of Matsatu Creek. Survey lower 1.6 km of Matsatu Creek.	Evenly distributed (Kissner 1982).	Some sockeye sometimes present.
King Salmon River		28 July-	All.	Mostly in lower 4.8 km, but on years with large escapement, spawning occurs far upstream.	Many pinks and chums present.
Stikine River	Little Tahltan River	3 Aug	Confluence with mainstem Tahltan up-river for 16km to area where 762 m contour crosses the river.	Densest Spawning between Saloon Lake outlet and Tahltan junction. (Kissner 1982).	Usually only Chinook in this System. Can be semi-glacial. Survey before noon.

-continued-

Table 1.–Page 2 of 3.

River system	Tributary	Spawning peak date (historic)	Survey area	Spawner distribution	Remarks
Andrew Creek		15 Aug	Andrew Slough to barrier, include North Fork.	Evenly distributed.	Pink, Chum and sockeye present.
Alsek River	Klukshu River	1 Aug	Confluence with Tatshenshini upriver to Klukshu Lake.	Evenly distributed.	Difficult to survey because of over-hanging trees. Many sockeye present.
Alsek River	Takhanne River	1 Aug	Confluence with Tatshenshini up-river to falls.	Evenly distributed.	Survey in a.m. Windy in the p.m.
Alsek River	Blanchard River	1 Aug	Confluence with Tatshenshini up-river to bridge.	Many Chinook spawn up-river of bridge, but very difficult to observe. Survey to lake if clear.	Very glacial. Survey by 9 a.m.
Unuk River	Cripple Creek	6 Aug	Confluence with Unuk up-river for 3.2 km.	Evenly distributed.	Semi-glacial. Survey in early a.m. by foot. Poor surveys by helicopter.
Unuk River	Genes lake Creek	27 Aug	Confluence with Genes Lake upriver for about 6.5 km.	Evenly distributed.	Many sockeye in area. Survey by foot. Poor surveys by helicopter.
Unuk River	Eulachon River	18 Aug	1.6 km below forks up left fork 1 km to barrier, right fork to barrier about 4.8 km up-steam.	Mostly around the forks during peak spawning.	Some Chinook will still be in holes below forks until late August.
Unuk River	Clear Creek	10 Aug	Confluence with lake Creek upriver for 1.6 km.	Evenly distributed.	Some Chinook just above narrow cut. Survey by foot. Poor surveys by helicopter.
Unuk River	Lake Creek	10 Aug	Confluence with Clear Creek up-steam to falls.	Spawning on shallow riffles (“the mounds”) and at the falls .	
Unuk River	Kerr Creek	10 Aug	Falls to glacial water.	Falls pool area usually has the majority of thespawning Chinook.	

-continued-

Table 1.–Page 3 of 3.

River system	Tributary	Spawning peak date (historic)	Survey area	Spawner distribution	Remarks
Chickamin River	South Fork	18 Aug	From junction of Chickamin Branch up-river to junction of Barrier Creek.	Evenly distributed.	Many chums and pinks. Semi-glacial. Survey by 10 a.m.
Chickamin River	Barrier Creek	12 Aug	From junction of South Fork to Barrier 1.6 km upstream.	Evenly distributed.	Chums in survey area.
Chickamin River	Butler Creek	10 Aug	All.	Evenly distributed.	Chums in survey area.
Chickamin River	Leduc Creek	10 Aug	Mouth to barrier.	Evenly distributed.	Chums and pinks in survey area.
Chickamin River	Indian Creek	10 Aug	All.	Evenly distributed.	Chums and pinks in survey area. Note 2016 change in mainstem flow into the creek. Few Chinook spawning since.
Chickamin River	King Creek	1 Sept.	All.	Evenly distributed.	Chums and pinks in survey area.
Chickamin River	Clear Falls Creek	10 Aug	All.	Evenly distributed.	Chums and pinks in survey area. Note 2008 disturbance in upper watershed above falls few Chinook seen spawning since.
Blossom River		28 Aug	All.	Fairly evenly distributed. A bit higher percent spawners in head waters.	Many pinks and chums.
Keta River		21 Aug	All.	Fairly evenly distributed.	Many pinks and chums.
Marten River[a]	Mainstem	28 Aug	All.	Fairly evenly distributed.	Many pinks and chums.
Marten River[a]	Dicks Creek	28 Aug	All.	Very even distribution.	Moderate pinks and chums.
Wilson River[a]		28 Aug	All.	Very even distribution.	Large numbers of pinks and chums.

[a] Aerial surveys for the Marten and Wilson Rivers are conducted opportunistically.

Peak count escapement estimates will be compared with mark–recapture estimates to evaluate accuracy on the Taku River. Mark–recapture escapement estimates from the Stikine and Alsek

Rivers will be compared with weir counts from the Little Tahltan River (tributary of the Stikine) and Klukshu River (tributary of the Alsek).

As mentioned earlier, expansion factors exist for all river systems that use aerial or foot surveys, each of which require at least three independent estimates of escapement, estimated by either mark–recapture study or weir count data with sufficiently low error (CV<20% for expansion factor). See Appendix B1 for details on calculation of expansion factors and variance estimation.

Comparison of Survey Methods

Several survey areas are routinely surveyed by more than one method: Andrew Creek is surveyed by airplane, helicopter, or by foot, and the King Salmon River is surveyed by helicopter or by foot. When possible, we attempt to conduct multiple survey methods on the same day to enable comparison of results. In general, foot surveys are believed to be the most precise, followed by helicopter aerial counts, with fixed-wing aerial surveys being the least precise. The project leaders will make the final decision on which count will be considered the peak survey count based on several factors including the system, survey conditions, and surveyor experience.

DATA COLLECTION

Only large Chinook salmon will be counted during aerial or foot surveys. Depending on observed water conditions, weather, and run timing, survey conditions will be rated as poor, normal, or excellent and recorded for each survey. For each survey area (see Appendix A1) the observer will evaluate and record the following attributes: stream level, water visibility, weather conditions (clear or overcast, wind, precipitation), and light conditions. Additional surveys will be conducted if the survey conditions are not rated normal or excellent. Raw data from all surveys will be reported in a Fishery Data Series report.

When the survey is conducted from a helicopter and when conditions permit, the craft will be flown approximately 6 to 15 m above the river at approximately 6 to 16 km per hour. The observer's door will be removed, and the helicopter will hover sideways so that observations can be made from the open space. The best views are gained by leaning outside the helicopter as it travels upriver at a slight angle, so the left side of the helicopter is at 10 to 30 degrees pointed upriver. This angle will differ throughout the flight and will be controlled by the helicopter pilot with the objective of giving the observer the best view of the river yet maintaining a safe flight path. Whenever possible, the sun will be kept behind the helicopter and the observer will wear polarized sunglasses to eliminate reflection. The observer will wear an inflatable life jacket, broad billed hat, and radio headset while surveying. While in the helicopter, a shoulder harness and lap belt will be used, and survival gear and a firearm will always be carried in the helicopter. Reserve fuel for the helicopter will be placed at strategic locations in the Taku River watershed (Windy, Long, and Trapper Lakes), Stikine Watershed (Tahltan Lake), along the Unuk and Chickamin Rivers, and near Wilson Arm.

Foot surveys will be conducted on Andrew Creek, King Salmon River, and most of the index tributaries of the Unuk River (Frost et al. *In prep*). Foot surveys are used where aerial surveys are ineffective, and in areas that are surveyed aerially to calibrate the foot surveys.

Training and calibrating additional Juneau-based surveyors started in 2012 and will continue in 2022. The objective of the training flights is to allow the trainee to become familiar with the start and stop points of each survey area and the unique geography and topography of each system. Training flights also allow the observer to become familiar with distinguishing large Chinook salmon from the helicopter and how to count when presented with various densities or mixed species congregations; the trainer will point out these instances. Ideally the trainee would count in a fashion similar to the trainer.

The trainer will be in the front seat of the helicopter and the trainee will be in the back seat. The doors will be removed to optimize the field of view. During training, the trainer will point out different species and be in communication with the trainee as much as possible. At least two training flights will be made for each survey area in each system. After the training flights are completed, calibration flights will be flown the same way except there will be no communication between the trainer and the trainee. Flying with both the trainer and the trainee will be the most cost-effective means to conduct calibration flights. It will also eliminate most of the temporal and spatial potential for bias, ensuring that both the trainer and the trainee are counting the same area given the same speed, time, and environmental conditions. Calibration flights should be conducted whenever possible and across the spatial and temporal spectrum of the project. A minimum of 2 calibration flights should be made in each survey area.

DATA REDUCTION

The surveyor will record start/stop times, visibility, survey conditions, and counts of live and dead large Chinook salmon for each survey area. In addition, for each day, the surveyor will record the pilot's name, aircraft, and other comments concerning numbers of large Chinook salmon, other salmonid species, predators, and run timing. Data will be recorded in waterproof field notebooks (Appendix A3) and transferred to escapement survey forms (Appendix A2) at the regional office at least once each week. For flights when both a trainer and trainee record counts, both numbers will be entered in the database for calibration purposes.

DATA STORAGE

The Division of Commercial Fisheries Region I database will be the repository for all information collected for the aerial and foot salmon escapement surveys. Files will be checked for data entry errors such as incorrect dates or counts, then the data will be entered into the Zander data entry application on the ADF&G OceanAK website. The database entry system prevents many common data entry errors such as nonsensical stream codes or omitting survey conditions.

A final, edited copy of the data will be sent to ADF&G Research and Technical Services (RTS) in Anchorage electronically for archiving. Prior to archiving, data files will be stored on the H drive under pjrichards (H:\REPORTS\Escapement\ESC2022).

DATA ANALYSIS

Counts from foot and helicopter surveys will be tabulated for analysis by ADF&G, and either estimates of total escapement or peak counts will be provided to the CTC and Transboundary River Technical Committee of the Pacific Salmon Commission. Estimates of escapement will either be provided from mark–recapture studies or weir count data or be based on expansions of peak counts; the expansion factors used will be based on previously paired peak count data with mark–recapture estimates or weir count data. The method of calculating the expansion factor $\hat{\pi}$ and associated variance for each system is shown in Appendix B1 along with an example for the Keta River (Appendix B2).

Calibration for new observers with respect to current or past observers will be conducted by river system. An estimate of the calibration factor r for a given river system will be the average ratio of the trainer count to the new observer count for a particular survey area or entire river system. The calibration factor *r* will be estimated as follows:

$$\hat{r} = \frac{\sum_{i=1}^{g} \frac{n_i}{t_i}}{g}, \tag{1}$$

where n_i is the i^{th} count from the new observer, t_i is the corresponding count from the trainer, and g is the number of times a calibration is done on that particular system with the new observer-trainer pair. The variance of *r* will be calculated as

$$var(\hat{r}) = \frac{\frac{\sum_{i=1}^{g}\left(\frac{n_i}{t_i} - r\right)^2}{g-1}}{\text{g}}. \tag{2}$$

The calibration factor will be used to adjust the number of fish reported for a new observer only if $\hat{r}$ is significant (i.e., <0.75 or >1.25). The adjustment, if necessary, will be made as follows:

$$\hat{C} = c\,\hat{r}, \tag{3}$$

where *c* is the count the new observer obtained, with variance

$$var(\widehat{C}) = c^2 var(\widehat{r}). \tag{4}$$

SCHEDULE AND DELIVERABLES

Field activities will be initiated annually around 20 July and will conclude around 15 September. Data editing and analysis will be initiated before the end of the field season. Escapement survey data will be entered into microcomputer files on a biweekly basis, and at the end of the season all data will be entered into the Region I database, maintained by Division of Commercial Fisheries Region I staff.

REPORTS

A Fishery Data Series report containing estimates of escapements will be completed by 31 October 2022. In addition, information from the project will be summarized in reports to the Alaska Board of Fisheries, CTC, Transboundary River Technical Committee, and multiple grant progress reports.

RESPONSIBILITIES

Philip Richards, Fishery Biologist III (project leader). Duties: This position is responsible for supervision of all project activities including administrative, field, personnel, and other activities. Will fly the index surveys on the Taku River drainage, King Salmon River, and Andrew Creek, analyze the data, prepare the end-of-season memo, and write the final report. Will also train an additional Juneau-based surveyor.

Nathan Frost, Fishery Biologist II (assistant project leader, Ketchikan-based surveyor). Duties: Will assist in all aspects of this project. Will fly all Behm Canal surveys based out of Ketchikan area (Unuk, Chickamin, Blossom, and Keta rivers), conduct several foot surveys on the Unuk River, and assist with data analysis and preparation of the final report. Will also continue to train an additional Ketchikan-based surveyor.

Ed Jones, Fish and Game Coordinator. Duties: Responsible for overseeing all aspects of the project, including review of budgets, operational plan, and reports.

Randy Peterson, Biometrician III. Duties: Project biometrician and provides input to and approves sampling design. Reviews and preforms biometrics for the operational plan, data analysis, and final report.

Jeff Williams, Fishery Biologist II. Duties: Will conduct aerial surveys on the Taku River drainage (Juneau-based surveyor).

Kristin Courtney, Fishery Biologist II. Duties: Will continue to train to conduct aerial surveys (Juneau-based surveyor).

Joe Simonowicz, Fishery Biologist I. Duties: Will conduct aerial surveys on the Behm Canal rivers (Ketchikan-based surveyor).

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APPENDIX A

Appendix A1.–Latitude and longitude of Chinook salmon survey areas (SA) and other survey landmarks.

River system[a]	Survey area waypoint	Survey area description	Latitude	Longitude
KS	1	Top of King Salmon River SA	N58 04.662	W134 24.073
KS	2	King Salmon River mouth	N58 02.384	W134 19.841
TAK	3	Windy Lake fuel cache, near Nakina	N59 05.262	W132 55.529
TAK	4	Grizzly Bar, bottom of SA1 Nakina	N59 03.494	W133 01.789
TAK	5	Top of SA1, Nakina River	N59 04.581	W133 01.264
TAK	6	Top of SA2, Nakina River	N59 05.866	W133 00.646
TAK	7	Top of SA3, Nakina River	N59 07.560	W132 55.143
TAK	8	Top of SA4, Nakina Canyon, telegraph trail	N59 11.048	W132 50.210
TAK	9	Top of Tseta Creek SA, Taku River	N59 02.073	W132.14.176
TAK	10	Tseta Creek Camp	N59 02.011	W132 13.255
TAK	11	Long Lake fuel cache, near Nahlin River	N58 44.556	W 131 30.592
TAK	12	Top of SA3, Nahlin River	N58 39.585	W131 10.136
TAK	13	Top of SA2, Nahlin River	N58 39.589	W131 10.138
TAK	14	Top of SA1, Nahlin River	N58 43.424	W131 17.651
TAK	15	Bottom of SA1, Nahlin River	N58 53.126	W131 45.054
TAK	16	Nahlin Camp	N58 40.441	W131 11.656
TAK	17	Bottom of Dudidontu SA	N58 38.814	W131 48.870
TAK	18	Fork with Matsatu Creek, Dudidontu	N58 35.304	W131 46.957
TAK	19	Trapper Lake Fuel Cache	N58 28.071	W132 38.074
TAK	20	Top of Dudidontu SA, may need to be revised	N58 31.016	W131 50.561
TAK	21	Bottom of Kowatua River SA, Taku	N58 30.324	W132 32.512
TAK	22	Bottom of Tatsamenie SA, Taku	N58 28.647	W132 23.273
STK	23	Top end of Little Tahltan River SA, Stikine	N58 11.896	W131 28.876
STK	24	Saloon Lake fuel cache, near Tahltan	N58 07.473	W131 22.752
STK	25	Little Tahltan River weir	N58 07.328	W131 19.239
ALK	26	Bottom Takhanne River SA, Alsek	N60 05.687	W136 59.386
ALK	27	Top Takhanne River SA, Alsek	N60 06.493	W136 56.838
CHK	28	Chickamin River camp/fuel cache	N55 49.699	W130 54.613
CHK	29	Bottom King Creek SA, Chickamin River	N55 50.507	W130 51.162
CHK	30	Top of King Creek SA, Chickamin	N55 49.149	W130 48.006
CHK	31	Top of King Creek king distribution, Chickamin	N55 48.523	W130 46.940
CHK	32	Top of King Creek foot survey	N55 49.262	W130 48.449

Appendix A1.–Page 2 of 3.

River system[a]	Survey area waypoint	Survey area description	Latitude	Longitude
CHK	33	Leduc Creek, Bottom	N55 55.857	W130 48.415
CHK	34	Leduc Creek, Top (Barrier)	N55 55.797	W130 48.794
CHK	35	Bottom Humpy Creek SA, Chickamin	N55 50.812	W130 52.416
CHK	36	Top Humpy Creek SA, Chickamin	N55 52.076	W130 53.638
CHK	37	Indian Creek, Chickamin, mouth	N55 57.355	W130 41.532
CHK	38	Indian Creek, Chickamin, top	N55 59.534	W130 40.017
CHK	39	Lucky Jake Creek, Chickamin	N55 59.148	W130 37.889
CHK	40	Ranger Paige Creek, Chickamin	N55 59.701	W130 36.985
CHK	41	Butler Creek mouth	N56 02.450	W130 43.484
CHK	42	Butler Creek, top	N56 02.870	W130 43.359
CHK	43	Clear Falls, Chickamin	N55 58.984	W130 45.564
CHK	44	South Fork Bottom SA, Chickamin	N55 52.435	W130 44.351
CHK	45	South Fork Top SA, Chickamin	N55 51.146	W130 37.624
CHK	46	Barrier Creek Mouth, Chickamin	N55 51.146	W130 37.624
BLM	47	Apparent barrier on Blossom River	N55 30.285	W130 28.708
BLM	48	top SA of good habitat above Barrier, Blossom R.	N55 32.398	W130 25.251
BLM	49	Blossom/Wilson Arm Fuel Cache	N55 21.999	W130 37.506
KET	50	Bottom of Keta River	N55 19.880	W130 29.099
KET	51	First big rapids on Keta, not barrier	N55 21.357	W130 26.923
KET	52	Chute on Keta, not barrier	N55 25.087	W130 20.881
KET	53	Second rapids, not barrier	N55 26.004	W130 20.919
KET	54	Top of SA Keta River	N55 27.430	W130 20.946
KET	55	Keta Platform	N 55 23.347	W130 22.378
KET	56	Keta King spots, August 2004	N55 20.562	W130 28.239
KET	57	Keta King spots, August 2004	N55 22.515	W130 24.182
KET	58	Keta King spots, August 2004	N55 24.990	W130 21.301
KET	59	Keta King spots, August 2004	N55 26.282	W130 20.809
NA	56	Wheeler Creek, barrier	N57 59.437	W134 41.555
AC	57	Andrew Creek, top SA	N56 36.008	W132 09.408
AC	58	Andrew Creek, Bottom SA	N56 38.896	W132 12.742
AC	59	Andrew Creek, Mouth	N56 40.082	W132 15.352
NA	60	Arron Creek chinook spawning area	N56 27.760	W131 57.469

-continued-

Appendix A1.–Page 3 of 3.

River system[a]	Survey area waypoint	Survey area description	Latitude	Longitude
UNK	61	Boundary Creek	N56 20.340	W130 45.207
UNK	62	Genes Lake Creek, bottom SA	N56 12.573	W130 52.021
UNK	63	Genes Lake Creek, Top SA	N56 14.979	W130 49.097
UNK	64	Cripple Creek, bottom SA	N56 15.637	W130 48.732
UNK	65	Cripple Creek, Top SA	N56 14.865	W130 45.587
UNK	66	Cripple Creek Platform	N56 15.756	W130 48.282
UNK	67	Clear Creek mouth	N56 08.104	W130 58.347
UNK	68	Clear Creek Barrier	N56 07.550	W130 57.478
UNK	69	Lake Creek, bottom SA	N56 08.104	W130 58.347
UNK	70	Lake Creek Barrier	N56 09.355	W130 53.877
UNK	71	Kerr Creek Mouth	N56 10.599	W130 55.852
UNK	72	Kerr Creek bottom SA	N56 10.640	W130 55.960
UNK	73	Kerr Creek Barrier	N56 11.000	W130 55.846
UNK	74	Bottom of Eulachon River SA, Unuk	N56 06.597	W131 07.293
UNK	75	Top of Eulachon River SA, 2nd avalanche chute	N56 09.216	W131 07.884
UNK	76	Unuk Field Camp	N56 09.641	W130 57.458
UNK	77	Unuk Fuel Cache	N56 05.132	W131 05.334

[a] KS, King Salmon River; TAK, Taku River; STK, Stikine River; ALK, Alsek River; UNK, Unuk River; CHK, Chickamin River; BLM, Blossom River; KET, Keta River; AC, Andrew Creek.

Appendix A2.–ADF&G salmon escapement survey form.

ALASKA DEPARTMENT OF FISH AND GAME
SALMON ESCAPEMENT SURVEYS

Depart Time: ______

Document No. ______

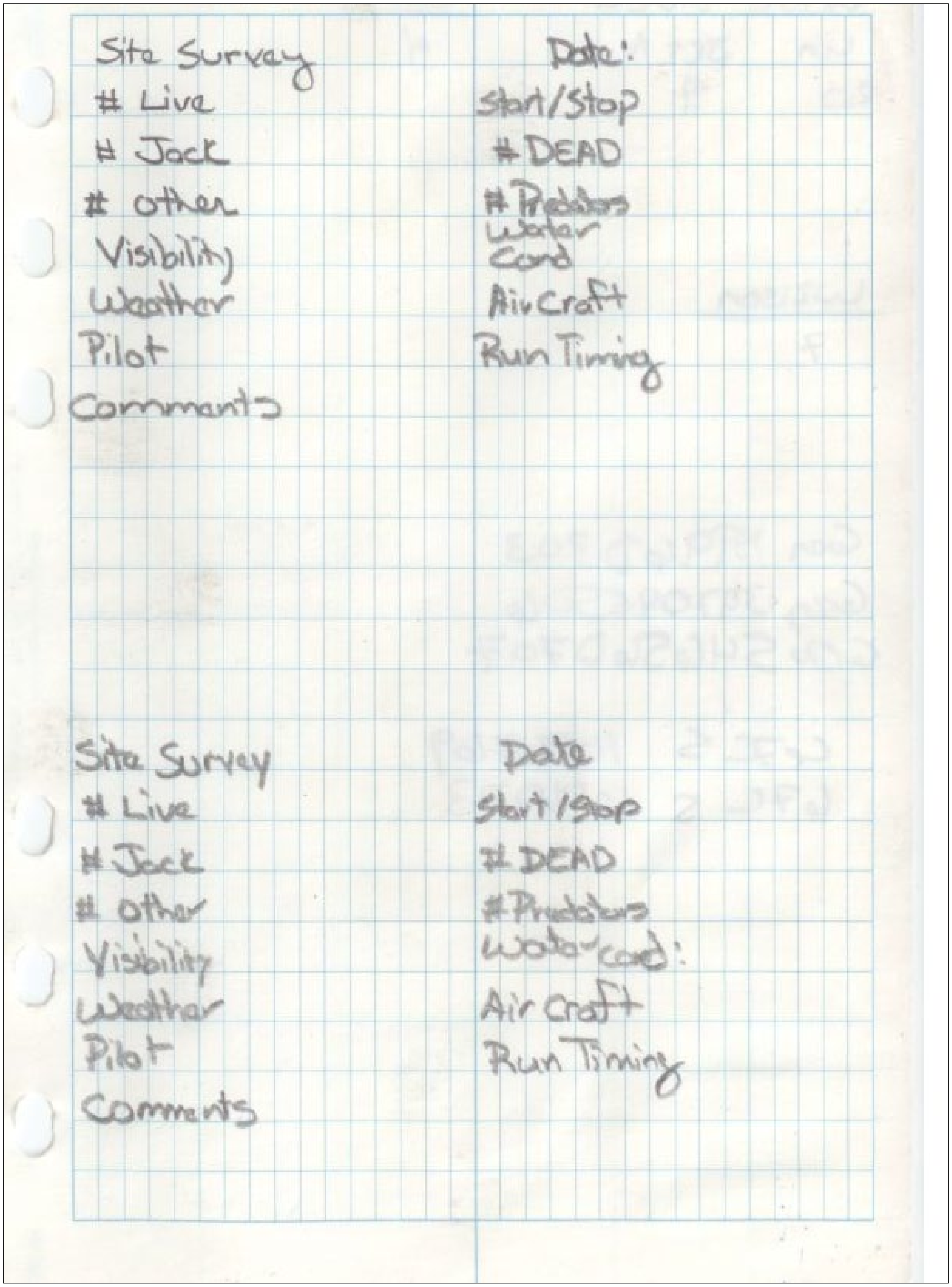
Return Time: ______

Year ______ Area ______

	Field 1			2	3	4	5	6	7	8	9	10	11	12 Usage	13 Coded
No.	Stream Number			Stream Name	Mo/Day	Length	Type	Mouth	Intertidal	Steam Live	Stream Dead	Species	Observer	Code	Remarks
01															
02															
03															
04															
05															
06															
07															
08															
09															
10															
11															
12															
13															
14															
15															

Distance: (tenths	Length:	Type:	Coded Remarks:	Usage Codes:
I=Intertidal	L=complete	A=Aerial	11=Fish present but not counted in Mouth	00=Not coded yet
M=Mouth	P=partial	F=Foot	12=Fish present but not counted in Tidal	01=Not useful for indexing or estimating escapement of this species.
B=Bay	U=unknown	B=Boat	13=Fish present but not counted in Live	02= Potentially useful for indexing or estimating escapement of this species.
L=Length		H=Helicopter	14=Fish present but not counted in Dead	03= Potentially useful as the "peak" survey count for this species.

Appendix A3.–Example of aerial sampling form.



Site Survey
Live
Jack
other
Visibility
Weather
Pilot
Comments

Date:
Start/Stop
DEAD
Predators
Water Cond
AirCraft
Run Timing

Site Survey
Live
Jack
other
Visibility
Weather
Pilot
Comments

Date
Start/Stop
DEAD
Predators
Water cond:
Air Craft
Run Timing

Appendix A4.–Expansion factors for Chinook salmon river systems in Southeast Alaska.

River system	Survey method	Expansion	SE	Reference
Alsek River	Klukshu weir	4.0	1.98	Bernard and Jones 2010
Taku River	Aerial -5 tributaries	5.2	1.78	McPherson et al. 2010
Andrew Creek	Foot	1.95	0.45	Clark et al. 1998
Unuk River	Aerial - 6 tributaries	4.83	0.60	Hendrich et al. 2008
Chickamin River	Aerial -8 tributaries	4.75	0.70	McPherson and Carlile 1997
Blossom River	Aerial	3.87	0.62	Fleischman et al. 2011
Keta River	Aerial	3.01	0.56	Fleischman et al. 2011
King Salmon River	Foot survey	1.52	0.27	McPherson and Clark 2001

APPENDIX B

Expansion factors provide a means of predicting escapement in years where only an index count of escapement is available; i.e., no weir count or mark–recapture study was conducted. An expansion factor is the average ratio of escapement (as estimated by a mark–recapture experiment or known through a weir count) to the index count over several years.

Systems where escapement is known

On systems where escapement can be completely enumerated with weirs or other complete counting methods, the expansion factor is an estimate of the expected value of the “population” of annual expansion factors (π) for that system:

$$\bar{\pi} = \frac{\sum_{y=1}^{k} \pi_y}{k} \qquad (1)$$

where $\pi_y = N_y / C_y$ is the observed expansion factor in year *y*, N_y is the known escapement in year *y*, C_y is the index count in year *y*, and *k* is the number of years for which these data are available to calculate an annual expansion factor.

The estimated variance for expansion of index counts needs to reflect two sources of uncertainty for any predicted value of π , (π_p). First is an estimate of the process error (*var*(π): the variation across years in the πs, reflecting, for example, weather or observer-induced effects on how many fish are counted in a survey for a given escapement), and second is the sampling variance of $\bar{\pi}$ (*var*($\bar{\pi}$)), which will decline as we collect more data pairs. (These two sources of variability are analogous to the variability in the ε_i and in the $\hat{Y}_i$, respectively, in the usual linear regression set-up.)

The variance for prediction will be estimated (Neter et al. 1990):

$$var(\pi_p) = var(\pi) + var(\bar{\pi}) \qquad (2)$$

where

$$var(\pi) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k-1} \qquad (3)$$

and

$$var(\bar{\pi}) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k(k-1)} \qquad (4)$$

such that

$$var(\pi_p) = \frac{\sum_{y=1}^{k}(\pi_y - \overline{\pi})^2}{k-1} + \frac{\sum_{y=1}^{k}(\pi_y - \overline{\pi})^2}{k(k-1)} \tag{5}$$

Systems where escapement is estimated

On systems where escapement is estimated, the expansion factor is an estimate of the expected value of the "population" of annual expansion factors (π s) for that system:

$$\overline{\pi} = \frac{\sum_{y=1}^{k}\hat{\pi}_y}{k} \tag{6}$$

where $\hat{\pi}_y = \hat{N}_y / C_y$ is the estimate of the expansion factor in year *y*, $\hat{N}_y$ is the estimated escapement in year *y*, and other terms are as described above.

The variance for prediction will again be estimated:

$$var(\pi_p) = var(\pi) + var(\overline{\pi}) \tag{7}$$

The estimate of *var*(π) should again reflect only process error. Variation in $\hat{\pi}$ across years, however, represents process error plus measurement error within years (e.g., the mark–recapture induced error in escapement estimation) and is described by the relationship (Cochran 1977; equation 10.2):

$$Var(\hat{\pi}) = Var[E(\hat{\pi})] + E[Var(\hat{\pi})] \tag{8}$$

This relationship can be rearranged to isolate process error, $Var[E(\hat{\pi})]$, that is:

$$Var[E(\hat{\pi})] = Var[\hat{\pi}] - E[Var(\hat{\pi})] \tag{9}$$

An estimate of *var*(π) representing only process error therefore is:

$$var(\pi) = var(\hat{\pi}) - \frac{\sum_{y=1}^{k} var(\hat{\pi}_y)}{k} \tag{10}$$

where $var(\hat{\pi}_y) = var(\hat{N}_y)/C_y^2$ and $var(\hat{N}_y)$ is obtained during the experiment when N_y is estimated.

We calculate:

$$var(\hat{\pi}) = \frac{\sum_{y=1}^{k}(\hat{\pi}_y - \overline{\pi})^2}{k-1} \tag{11}$$

and we estimate $var(\overline{\pi})$ similarly to as we did above:

$$var(\overline{\pi}) = \frac{\sum_{y=1}^{k}(\hat{\pi}_y - \overline{\pi})^2}{k(k-1)} \tag{12}$$

For large k ($k > 30$), equations 11 and 12 provide reasonable parameter estimates, however for small k the estimates are imprecise and may result in negative estimates of variance when the results are applied as in equation 7.

Because k is typically < 10, we will obtain $var(\hat{\pi})$ and $var(\overline{\pi})$ using parametric bootstrap techniques (Efron and Tibshirani 1993). The sampling distributions for each of the $\hat{\pi}_y$ are modeled using normal distributions with means $\hat{\pi}_y$ and variances $v\hat{a}r(\hat{\pi}_y)$. At each bootstrap iteration, a bootstrap value $\hat{\pi}_{y(b)}$ is drawn from each of these normal distributions and the bootstrap value $\hat{\pi}_{(b)}$ is randomly chosen from the k values of $\hat{\pi}_{y(b)}$. Then, a bootstrap sample of size k is drawn from the k values of $\hat{\pi}_{y(b)}$ by sampling with replacement, and the mean of this bootstrap is the bootstrap value $\overline{\pi}_{(b)}$. This procedure is repeated B = 1,000,000 times. We then estimate $var(\hat{\pi})$ using:

$$var_B(\hat{\pi}) = \frac{\sum_{b=1}^{B}(\hat{\pi}_{(b)} - \overline{\hat{\pi}_{(b)}})^2}{B-1} \tag{13}$$

where

$$\overline{\hat{\pi}_{(b)}} = \frac{\sum_{b=1}^{B}\hat{\pi}_{(b)}}{B} \tag{14}$$

and we can calculate $var_B(\overline{\pi})$ using equations 13 and 14 with appropriate substitutions.

The variance for prediction is then estimated:

$$var(\pi_p) = var_B(\hat{\pi}) - \frac{\sum_{y=1}^{k}\text{var}(\hat{\pi}_y)}{k} + var_B(\overline{\pi}) \tag{15}$$

As the true sampling distributions for the $\hat{\pi}_y$ are typically skewed right, using a normal distribution to approximate these distributions in the bootstrap process will result in estimates of $var(\hat{\pi})$ and $var(\overline{\pi})$ that are biased slightly high, but simulation studies using values similar to those realized for this applications indicated that the bias in equation 15 is < 1%.

Predicting Escapement

In years when an index count, C_p, is available but escapement, N_p, is not known, it can be predicted:

$$\hat{N}_p = \bar{\pi}\, C_p \qquad (16)$$

$$var(\hat{N}_p) = C_p^2 var(\pi_p)\,. \qquad (17)$$

Appendix B2.–Peak aerial survey counts and estimated total spawning abundance ($\hat{N}_L$) with associated SE for large Chinook salmon spawning in the Keta River, 1975–2021.

Year	Peak survey counts	Expansion factor	$\hat{N}_L$	SE ($\hat{N}_L$)
1975	203	3.01	611	114
1976	84	3.01	253	47
1977	230	3.01	692	129
1978	392	3.01	1,180	220
1979	426	3.01	1,283	239
1980	192	3.01	578	108
1981	329	3.01	990	184
1982	754	3.01	2,270	422
1983	822	3.01	2,475	460
1984	610	3.01	1,836	342
1985	624	3.01	1,879	349
1986	690	3.01	2,077	386
1987	768	3.01	2,312	430
1988	575	3.01	1,731	322
1989	1,155	3.01	3,477	647
1990	606	3.01	1,824	339
1991	272	3.01	819	152
1992	217	3.01	653	122
1993	362	3.01	1,090	203
1994	306	3.01	921	171
1995	175	3.01	527	98
1996	297	3.01	894	166
1997	246	3.01	741	138
1998	180	**2.48**	**446**	**50**
1999	276	**3.51**	**968**	**116**
2000	300	**3.05**	**914**	**122**
2001	343	3.01	1,033	192
2002	411	3.01	1,237	230
2003	322	3.01	969	180
2004	376	3.01	1,132	211
2005	497	3.01	1,496	278
2006	747	3.01	2,248	418
2007	311	3.01	936	174
2008	363	3.01	1,093	203
2009	172	3.01	518	96
2010	475	3.01	1,430	266
2011	223	3.01	671	125
2012	241	3.01	725	135
2013	493	3.01	1,484	276
2014	439	3.01	1,321	246
2015	304	3.01	915	170
2016	446	3.01	1,342	249
2017	300	3.01	903	168

-continued-

Appendix B2.–Page 2 of 2.

Year	Peak survey counts	Expansion factor	$\widehat{N}_L$	SE ($\widehat{N}_L$)
2018	552	3.01	1,662	309
2019	346	3.01	1,041	194
2020	222	3.01	668	124
2021	235	3.01	707	132

Note: Statistics in bold come directly from mark–recapture studies in 1998–2000; all other statistics are expanded counts based on the relationship between peak survey counts and estimated spawning abundances. This relationship, referred to as the expansion factor, $\bar{\pi}$, for Keta River Chinook salmon is 3.01 (SE = 0.56). The escapement goal range for large Keta River Chinook salmon is 550–1,300 (Fleischman et al. 2011).