Regional Operational Plan SF.1J.2018.09

Escapements of Chinook Salmon in Southeast Alaska and Transboundary Rivers in 2018

by

Philip Richards

Nathan Frost

and

Randy Peterson

July 2018

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.1J.2018.09

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by
Philip Richards, Nathan Frost, and Randy Peterson
Alaska Department of Fish and Game, Division of Sport Fish, Douglas

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Division of Sport Fish

July 2018

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Philip Richards, Nathan Frost, and Randy Peterson
Alaska Department of Fish and Game, Division of Sport Fish,
P.O. Box 110024
Juneau, AK 99811-0024

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SIGNATURE/TITLE PAGE

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Project leader(s):	Philip Richards, Fisheries Biologist III
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Approval

Title	Name
Project Leader	Philip Richards
Area Management Biologist	Kelly Reppert
Area Management Biologist	Dan Teske
Biometrician	Randy Peterson
Research Coordinator	Ed Jones
Research Coordinator	Jeff Nichols
Regional Supervisor	Judy Lum

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ABSTRACT

Estimates of Chinook salmon *Oncorhynchus tshawytscha* spawning escapement will be summarized for 2018 in 11 Southeast Alaska river systems. Chinook salmon systems include: 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 and 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.

PURPOSE

The 2018 project goals are: 1) collect peak Chinook salmon aerial and foot survey counts for 7 river systems, which include the Taku River, Blossom River, Keta River, Unuk River, Chickamin River, King Salmon River, and Andrew Creek; and 2) summarize and report the total spawning escapement estimates for 11 river systems, which include the Situk River, Alsek River, Chilkat River, Taku River, King Salmon River, Stikine River, Unuk River, Chickamin River, Blossom River, Keta River, and Andrew Creek. The Alaska Department of Fish and Game (ADF&G) and Fisheries and Oceans Canada (FOC) use these spawning escapement data to make terminal and regional management decisions, and the Pacific Salmon Commission (PSC) uses the data for coastwide management and stock assessment.

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 (PST) 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 principal method of assessing Chinook salmon stock status is via the estimation of spawning escapement as judged against escapement goals. Since 1975, the SEAK Chinook Salmon Escapement Project has annually estimated escapements to select river systems in a standardized program (Kissner 1982). Estimates of escapement are produced through various methods including weirs, mark-recapture, foot surveys, and aerial surveys. This operational plan identifies the methods used for foot and aerial surveys as well as analytical procedures for estimating Chinook salmon escapement from these types of surveys. Identification of methods and analyses used in weir and mark-recapture studies are referenced in separate Regional Operational Plans that are specific to individual river systems (e.g., Stikine River, Taku River, Chilkat River, Situk River, Unuk River). Regardless of the approach used to estimate Chinook salmon escapement, the final escapement estimates will be presented in a single document that will promote 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 experiments employing different gear types (fish wheels, drift- and set-gillnet, rod and reel) are used on Taku, Stikine, and the Chilkat rivers. Specific methods and analytical approaches used in these systems are presented in Williams et al. (2016), Jaecks et al. (2016a, 2016b) Elliott and Power (2017), 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 of the aerial surveys from 1975 through 2017 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 out of Juneau. The same will occur in 2018. 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 (Pahlke 2007; McPherson et al. 2003). The development of expansion factors has significantly improved the accuracy of escapements estimates for most systems where in past years peak counts were the only measure of spawning abundance. 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 experiments (as conducted in the Taku and Stikine rivers) or weirs (Situk River) which are used in these 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 expansion factors requires at least 3 years of paired estimates/counts and a CV <20% (US CTC 1997). The resulting escapement estimates are provided to the Joint CTC of the Pacific Salmon Commission (PSC). In accordance with the Pacific Salmon Treaty (PST), 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 (PSC 1993). Appropriate fishery regulations are promulgated by ADF&G and the PSC to maintain escapements and to harvest any surplus production.

River systems are not included in this operational plan that have been periodically surveyed in the past, including 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 aerial and foot survey counts for the King Salmon River and Andrew Creek.
3. Collect peak aerial survey counts for the 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) and Chickamin River (Butler, Leduc, Clear Falls, Humpy, King, Indian and Barrier creeks and South Fork Chickamin River).

SECONDARY OBJECTIVES:

1. Summarize and report the 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 (≥660 mm MEF, assumed to be ocean age-3, 4, or 5) Chinook salmon spawning in select survey areas will be counted shortly before, during, or immediately after the peak of spawning. Peak spawning times are well defined from previous surveys of these same river systems over the last 30 years (Table 1). Survey areas within each index area are selected based on their 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 an annual comparable index of the spawning escapement. Surveys will be conducted on foot, or from a Bell 206 or Hughes 500D helicopter during the peak of spawning. Each survey area will be surveyed at least twice per year and most river systems are 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	August-4	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	July-24	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	August-23	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	August-20	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	July-29	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	August-2	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		July-28	All	Mostly in lower 4.8 km, but on years with large escapement, spawning occurs far upstream.	Many pinks and chums present.

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Table 1.–Page 2 of 3.

River system	Tributary	Spawning peak date (historic)	Survey area	Spawner distribution	Remarks
Stikine River	Little Tahltan River	August-3	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.
Andrew Creek		August-15	Andrew Slough to barrier, include North Fork.	Evenly distributed	Pink, Chums and sockeye present
Alsek River	Klukshu River	August-1	Confluence with Tatshenshini up River to Klukshu Lake.	Evenly distributed.	Difficult to survey because of over-hanging trees. Many sockeye present
Alsek River	Takhanne River	August-1	Confluence with Tatshenshini up-river to falls.	Evenly distributed.	Survey in a.m. Windy in the p.m.
Alsek River	Blanchard River	August-1	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	August-6	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	August-27	Confluence with Genes Lake up river for about 6.5 km.	Evenly distributed.	Many sockeye in area. Survey by foot. Poor surveys by helicopter.
Unuk River	Eulachon River	August-18	1.6 km below forks up left fork 1 km to barrier, right fork to barrier about 4.8 km up-steam.	Evenly distributed.	Some Chinook will still be in holes below forks until late August.
Unuk River	Clear Creek	August-10	Confluence with lake Creek up river for 1.6 km.	Evenly distributed.	Some Chinook just above narrow cut.
Unuk River	Lake Creek	August-10	Confluence with Clear Creek up-steam to falls.	Spawning on shallow riffles and in falls	

-continued-

Table 1.–Page 3 of 3.

River system	Tributary	Spawning peak date (historic)	Survey area	Spawner distribution	Remarks
Unuk River	Kerr Creek	August-10	Falls to glacial water.	Falls pool area usually has 10–20 spawning Chinook.	
Chickamin River	South Fork	August-18	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	August-12	From junction of South Fork to Barrier 1.6 km upstream.	Evenly distributed.	Chums in survey area.
Chickamin River	Butler Creek	August-10	All.	Evenly distributed.	Chums in survey area.
Chickamin River	Leduc Creek	August-10	Mouth to barrier.	Evenly distributed.	Chums and pinks in survey area.
Chickamin River	Indian Creek	August-10	All.	Evenly distributed.	Chums and pinks in survey area.
Chickamin River	King Creek	1 Sept.	All.	Evenly distributed.	Chums and pinks in survey area.
Chickamin River	Clear Falls Creek	August-10	All.	Evenly distributed.	Chums and pinks in survey area. Note 2008 disturbance in upper water-shed above falls few Chinook seen spawning since.
Blossom River		August-28	All.	Fairly evenly distributed. A bit higher percent spawners in head waters.	Many pinks and chums.
Keta River		August-21	All.	Fairly evenly distributed.	Many pinks and chums
Marten River[a]	Mainstem	August-28	All.	Fairly evenly distributed.	Many pinks and chums
Marten River[a]	Dicks Creek	August-28	All.	Very even distribution	Moderate pinks and chums
Marten River[a]		August-28	All.	Very even distribution	Large numbers of pinks and chums

[a] Aerial surveys for the Marten River are conducted opportunistically.

Peak count escapement estimates will be compared with mark-recapture estimates of escapement to evaluate accuracy on the Taku and Stikine rivers and to weir counts on the Little Tahltan (tributary to the Stikine River).

As mentioned earlier, expansion factors exist for all river systems that use aerial or foot surveys, each of which requiring at least three independent estimates of escapement, enumerated by either mark-recapture experiment or weir-survey 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 from airplanes (ADF&G, Division of Commercial Fisheries; DCF, hereafter), helicopters and by foot, while the King Salmon River is surveyed from helicopter and foot survey. We will attempt to conduct these various surveys on the same day to enable comparison of the different methods. 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 (≥660 mm MEF) 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 from a helicopter and when conditions permit, the craft will fly 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 with observations made out of 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 is controlled by the helicopter pilot with the objective of giving the observers 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 (Richards and Frost 2017). Foot surveys are used where aerial surveys are ineffective, and also 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 2018. 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 do 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 calibrations flights should be made in each survey area.

DATA REDUCTION

The surveyor will record start/stop times, visibility and 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 Chinook salmon < 660 mm MEF, 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 where there is both the trainer and trainee recording counts, both numbers will be entered in the database for calibration purposes.

DATA STORAGE

The Department of Commercial Fisheries (DCF), Integrated Fisheries Database (IFDB) 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, and then the data will be entered into the IFDB via the Alexander interface. The database entry system prevents many common data entry errors such as nonsensical stream codes or 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. For this project, all escapement data will be archived permanently on IFDB. Prior to final archiving, data files will be stored on the H drive under pjrichards (H:\REPORTS\Escapement\ESC2018).

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 (TTC) of the PSC. Estimates of escapement will either be provided from mark-recapture experiments, weir survey 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 experiment or weir survey 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 by river system. An estimate of the calibration constant 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 equation for the estimated calibration constant r will be as follows:

$$\hat{r} = \frac{\sum_{i=1}^{g} \frac{n_i}{t_i}}{g} \quad (1)$$

where n_i is the ith 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 specific new observer-trainer pair. The variance of *r* will be calculated:

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

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:

$$\hat{C} = c\,\hat{r} \quad (3)$$

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

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

BUDGET

This investigation is financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-34, Job No. S-1-6 and a PSC Grant.

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 IFDB, maintained by DCF Region I staff.

REPORTS

A Fishery Data Series report containing the estimates of escapements will be completed by October 31, 2020 This report will fulfill the reporting obligation as an annual report of progress for Federal Aid Project F-10-34, Job No. S-1-6. In addition, information from the project will be summarized in reports to the Alaska Board of Fisheries, CTC, and TTC.

RESPONSIBILITIES

Philip Richards, Fisheries Biologist III (project leader)

Duties: This position is responsible for supervision of all project activities including administrative, field, personnel and other activities. He 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. He will also train an additional Juneau-based surveyor.

Nathan Frost, Fisheries Biologist I (project leader)

Duties: Will assist in all aspects of this project. Will fly all surveys based out of Ketchikan area (Unuk, Chickamin, Blossom, and Keta rivers), conduct several foot surveys, and assist with data analysis and preparation of the final report. Will also train an additional Ketchikan-based surveyor.

Ed Jones, Salmon Research Coordinator

Duties: Responsible for overseeing all aspects of the project, including review of budgets, operational plan and reports.

Jeff Nichols, Regional Research Coordinator

Duties: Responsible for overseeing all aspects of the project, including reviewing budgets, operational plans and reports.

Randy Peterson, Biometrician II

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 train to conduct aerial surveys (Juneau-based surveyor).

REFERENCES CITED

ADF&G. 1981. Proposed management plan for Southeast Alaska Chinook salmon runs in 1981. Regional Information Report 1J81-3.

Bernard, D. R., and E. L. Jones III. 2010. Optimum escapement goals for Chinook salmon in the transboundary Alsek River. Alaska Department of Fish and Game, Fishery Manuscript Series No. 10-02, Anchorage.

Clark, J. H., S. A. McPherson and D. M. Gaudet. 1998. Biological escapement goal for Andrew Creek Chinook salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 5J98-08 Juneau.

Cochran, W.G. 1977. Sampling Techniques, 3rd Edition. ISBN: 978-0-471-16240-7. 448 pages. Wiley and Sons. New York.

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman Hall, New York.

Elliott, B. W., and S. J. H. Power. 2017. Chilkat River Chinook salmon escapement studies in 2017. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan ROP.SF.1J.2017.04, Anchorage.

Elliott, B. W., and S. J. H. Power. 2016. Production and harvest of Chilkat River Chinook and coho salmon, 2016–2017. Alaska Department of Fish and Game, Regional Operational Plan No SF.1J.2016.16, Anchorage.

Fleischman, S. J., J. A. Der Hovanisian, and S. A. McPherson. 2011. Escapement goals for Chinook salmon in the Blossom and Keta rivers. Alaska Department of Fish and Game, Fishery Manuscript No. 11-05, Anchorage.

Hendrich, C. F., J. L. Weller, S. A. McPherson, D. R. Bernard. 2008. Optimal production of Chinook salmon from the Unuk River. Alaska Department of Fish and Game, Fishery Manuscript No. 08-03, Anchorage.

Jaecks, T., S. H. J. Power, P. Richards, and I. Boyce. 2016a. Spawning escapement of Chinook salmon in the Stikine River, 2016-2018. Alaska Department of Fish and Game, Regional Operational Plan, SF.1J.2016.08, Anchorage.

Jaecks, T., S. J. H. Power, P. Richards, and I. Boyce. 2016b. Estimation of smolt production and harvest of Stikine River Chinook Salmon, 2016-2018. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan No. SF.1J.2016.09, Anchorage.

REFERENCES CITED (Continued)

Kissner, P. D., Jr. 1974. A study of Chinook salmon in southeast Alaska. Alaska Dept. of Fish and Game. Annual report 1973–1974, Project F-9-7, (AFS-41-2).

Kissner, P.D., Jr. 1982. A study of Chinook salmon in southeast Alaska. Alaska Department of Fish and Game. Annual report 1981–1982, Project F-9-14, 23(AFS-41-10).

Neter, J., W. Wasserman, and M.H. Kutner. 1990. Applied linear statistical models, third edition. Irwin Publishing Company. Homewood, IL.

McPherson, S. A. and J. Carlile. 1997. Spawner-recruit analysis of Behn Canal Chinook salmon stocks. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J97-06, Juneau.

McPherson, S., and J. H. Clark. 2001. Biologcial escapement goal for King Salmon River Chinook salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J01-40, Juneau.

McPherson, S., D. R. Bernard, J. Clark, K. Pahlke, E. Jones, J. Der Hovanisian, J. Weller, and R. Ericksen. 2003. Stock status and escapement goals for Chinook salmon stocks in Southeast Alaska. Alaska Dept. of Fish and Game, Special Publication No. 03-01.

McPherson, S. A., E. L. Jones III, S. J. Fleischman and I. M. Boyce. 2010. Optimal Production of Chinook Salmon from the Taku River Through the 2001 Year Class. Alaska Department of Fish and Game, Fishery Manuscript Series No. 10-03, Anchorage.

PSC (Pacific Salmon Commission). 1993. Joint Chinook Technical Committee, 1992 Annual Report. Report TCCHINOOK (93)-2. Vancouver, B.C.

Pahlke, K. A. 2007. Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 2005. Alaska Department of Fish and Game, Fishery Data Series No. 07-62, Anchorage.

Pahlke, K. A. 2010. Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-71, Anchorage.

Richards, P., and N. Frost. 2017. Chinook salmon coded wire tagging on the Unuk River 2017-2018 and estimation of the adult tag fraction and harvest. Alaska Department of Fish and Game, Regional Operational Plan No. SF.1J.2017.05, Anchorage.

(US CTC) United States Chinook Technical Committee. 1997. A review of stock assessment data and procedures for U.S. Chinook Salmon Stocks. USTCCHINOOK (97)-1. January 1997.

Williams, J. T., S. J. H. Power, and E. L. Jones III. 2016. Production and escapement of Chinook salmon in the Taku River, 2016-2018. Alaska Department of Fish and Game, Regional Operational Plan No. SF.1J.2016.10, Anchorage.

APPENDIX A

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

River system[a]	Survey area way point	Survey area description	Latitude	Longitude	Altitude
KS	1	Top of King Salmon River SA	N58 04.662	W134 24.073	82 m
TAK	2	Windy Lake fuel cache, near Nakina	N59 05.262	W132 55.529	893 m
TAK	3	Grizzly Bar, bottom of SA1 Nakina	N59 03.494	W133 01.789	355 m
TAK	4	Top of SA1, Nakina River, Taku	N59 04.581	W133 01.264	303 m
TAK	5	Top of SA2, Nakina River	N59 05.866	W133 00.646	309 m
TAK	6	Top of SA3, Nakina River	N59 07.560	W132 55.143	349 m
TAK	7	Top of SA4, Nakina Canyon, telegraph trail	N59 11.048	W132 50.210	408 m
TAK	8	Top of Tseta Creek, Taku River	N59 02.011	W132 13.255	816 m
TAK	9	Long Lake fuel cache, near Nahlin River	N58 44.557	W131 30.607	1085 m
TAK	10	Top of SA3, Nahlin River	N58 39.557	W131 10.259	1062 m
TAK	11	Top of SA1, Nahlin River	N58 48.541	W131 28.027	934 m
TAK	12	Bottom of SA1, Nahlin River	N58 53.126	W131 45.054	704 m
TAK	13	Bottom of Dudidontu SA	N58 38.816	W131 48.707	1005 m
TAK	14	Fork with Matsatu Creek, Dudidontu	N58 35.358	W131 47.002	965 m
TAK	15	Top of Dudidontu SA, maybe need to be revised	N58 31.005	W131 50.585	962 m
STK	18	Top end of Little Tahltan River SA, Stikine	N58 11.896	W131 28.876	764 m
STK	19	Saloon Lake fuel cache, near Tahltan	N58 07.473	W131 22.752	706 m
STK	20	Little Tahltan River weir	N58 07.328	W131 19.239	592 m
ALK	21	Bottom Takhanne River SA, Alsek	N60 05.687	W136 59.386	713 m
ALK	22	Top Takhanne River SA, Alsek	N60 06.493	W136 56.838	698 m
UNK	23	Bottom of [Eulachon River SA, Unuk	N56 06.597	W131 07.293	98 m
UNK	24	Top of Eulachon River SA, 2nd avalanche chute	N56 09.216	W131 07.884	55 m
CHK	25	Chickamin River camp	N55 49.493	W130 52.826	16 m
CHK	26	Bottom King Creek SA, Chickamin River	N55 50.507	W130 51.162	95 m
CHK	27, 28	Top of King Creek SA, Chickamin	N55 49.149	W130 48.006	54 m
BLM	29–31	Blossom river fish locations			
TAK	32	Bottom of Kowatua River SA, Taku	N58 30.324	W132 32.512	815 m
TAK	33	Bottom of Tatsamenie SA, Taku	N58 28.647	W132 23.273	938 m
BLM	34–36	Blossom river fish locations			

-continued-

Appendix A1.–Page 2 of 3.

River system[a]	Survey area way point	Survey area description	Latitude	Longitude	Altitude
CHK	37	Top of King Creek king distribution, Chickamin	N55 48.523	W130 46.940	45 m
CHK	38	Mouth of King Creek	N55 50.441	W130 50.848	254 m
CHK	39	Bottom Humpy Creek SA, Chickamin	N55 50.812	W130 52.309	127 m
CHK	40	Top Humpy Creek SA, Chickamin	N55 52.076	W130 53.638	32 m
BLM	41	Apparent barrier on Blossom River	N55 30.285	W130 28.708	77 m
BLM	42	top end of good habitat above Barrier, Blossom R.	N55 32.398	W130 25.251	179 m
KET	43	Bottom of Keta River	N55 19.880	W130 29.099	337 m
KET	44	First big rapids on Keta, not barrier	N55 21.357	W130 26.923	70 m
KET	45	Chute on Keta, not barrier	N55 25.087	W130 20.881	78 m
NA	46	Second rapids, not barrier	N55 26.004	W130 20.919	78 m
KET	47	Top of SA Keta River	N55 27.430	W130 20.946	78 m
NA	49	Wheeler Creek, barrier	N57 59.437	W134 41.555	ND
AC	50	Andrew Creek, top SA	N56 36.008	W132 09.408	ND
AC	51	Andrew Creek, mouth	N56 38.398	W132 12.002	ND
NA	52	Arron Creek chinook spawning area	N56 27.760	W131 57.469	ND
CHK	53	Indian Creek, Chickamin, mouth	N55 57.355	W130 41.532	ND
CHK	54	Indian Creek, Chickamin, top	N55 59.534	W130 40.017	ND
CHK	55	Lucky Jake Creek, Chickamin	N55 59.207	W130 38.001	ND
CHK	56	Ranger Paige Creek, Chickamin	N55 59.701	W130 36.985	ND
CHK	57	Butler Creek mouth	N56 02.357	W130 43.354	ND
CHK	58	Butler Creek, top	N56 02.870	W130 43.359	ND
CHK	59	Clear Falls, Chickamin	N55 58.812	W130 45.560	ND
CHK	60	Top of King Creek foot survey	N55 49.262	W130 48.449	ND
KET	61	Keta King spots, August 2004	N55 20.562	W130 28.239	ND
KET	62	Keta King spots, August 2004	N55 22.515	W130 24.182	ND
KET	63	Keta King spots, August 2004	N55 24.990	W130 21.301	ND
KET	64	Keta King spots, August 2004	N55 26.282	W130 20.809	ND

-continued-

Appendix A1.–Page 3 of 3.

River system[a]	Survey area way point	Survey area description	Latitude	Longitude	Altitude
UNK	NA	Kerr Creek Mouth	N56 10.599	W130 55.852	ND
UNK	NA	Genes lake start	N56 12.573	W130 52.021	ND
UNK	NA	Genes Lake Creek end point	N56 14.979	W130 49.097	ND
UNK	NA	Cripple Creek Start Point	N56 15.637	W130 48.732	ND
UNK	NA	Cripple Creek End Point	N56 14.865	W130 45.587	ND
UNK	NA	Clear Creek mouth	N56 08.104	W130 58.347	ND
UNK	NA	Clear Falls Barrier	N56 07.550	W 130 57.478	ND
UNK	NA	Lake Creek start	N56 08.104	W130 58.347	ND
UNK	NA	Lake Creek Barrier	N56 09.355	W130 53.877	ND
UNK	NA	Kerr Creek start	N56 10.640	W130 55.960	ND
UNK	NA	Kerr Creek Barrier	N56 11.000	W130 55.846	ND

[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. ______

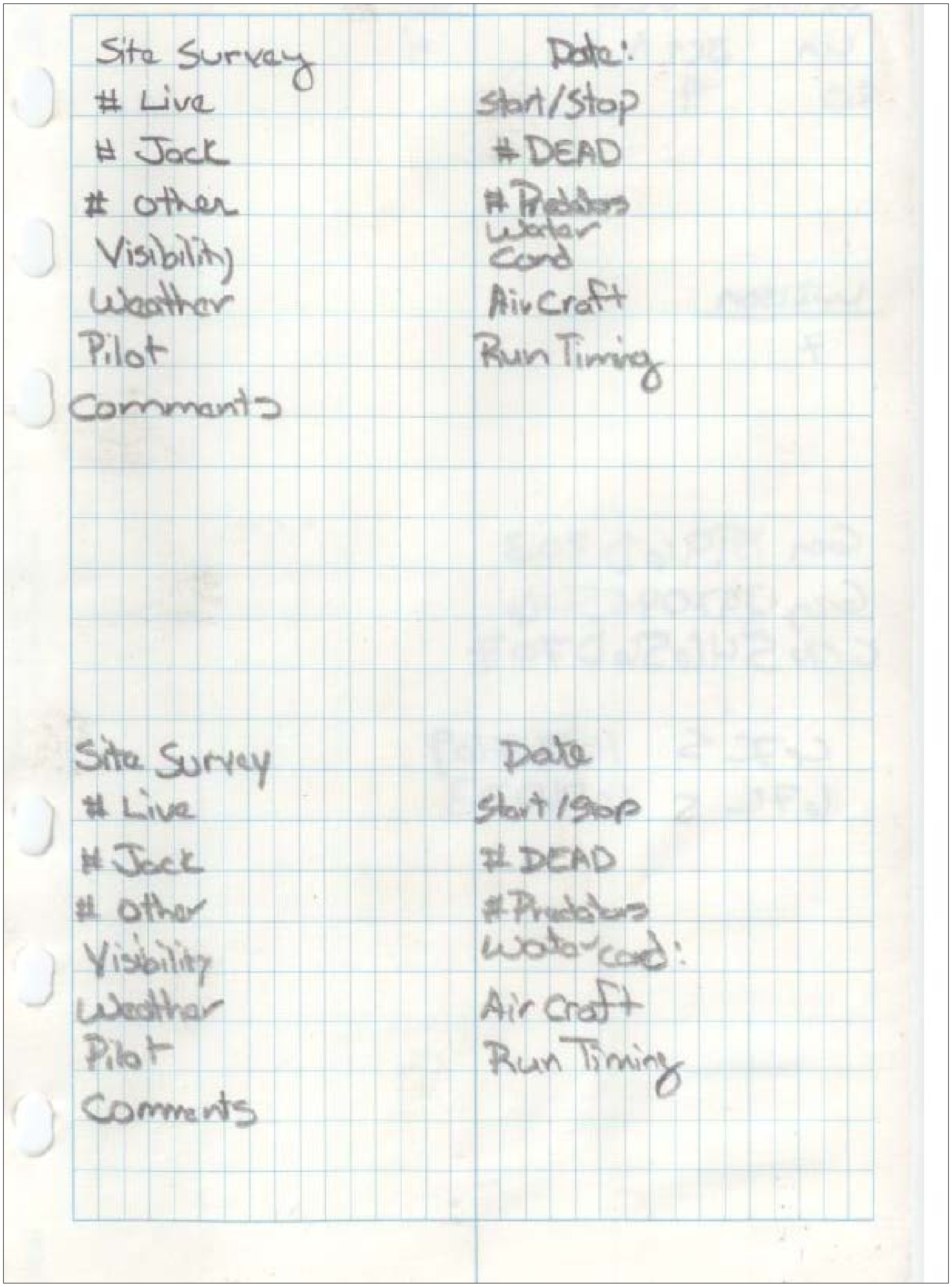
Return Time: ______

Year ______ Area ______

	Field 1			2	3	4	5	6	7	8	9	10	11	12	13
No.	Stream Number			Stream Name	Mo/Day	Length	Type	Mouth	Intertidal	Steam Live	Stream Dead	Species	Observer	Usage Code	Coded 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	Date:
# Live	Start/Stop
# Jack	# DEAD
# other	# Predators
Visibility	Water Cond
Weather	AirCraft
Pilot	Run Timing
Comments	

Site Survey	Date
# Live	Start/Stop
# Jack	# DEAD
# other	# Predators
Visibility	Water cond:
Weather	Air Craft
Pilot	Run Timing
Comments	

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

Appendix B1.–Predicting escapement from index counts using an expansion factor[a].

The expansion factor provides a means of predicting escapement in years where only an index count of the escapement is available, i.e. no weir counts or mark-recapture experiments were conducted. The expansion factor is the average over several years of the ratio of the escapement estimate (or weir count) to the index count.

<u>Systems where escapement is known</u>

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's) for that system:

$$\bar{\pi} = \frac{\sum_{y=1}^{k} \pi_y}{k} \tag{1}$$

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 ($var(\pi)$: the variation across years in the π's, 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 analagous 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):

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

where

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

and

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

such that

a *var* is used to denote population variance

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

<u>Systems where escapement is estimated</u>

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:

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

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:

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

Component: $var(\pi)$

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):

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

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

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

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

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

where

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

and

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

Component: $var(\bar{\pi})$

As we did above:

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

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 $var(\bar{\pi})$ 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 $\bar{\pi}_{(b)}$. This procedure is repeated B = 1,000,000 times. We can 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 $var_B(\bar{\pi})$ using equations 13 and 14 with appropriate substitutions.

The variance for prediction is then estimated:

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

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 $var(\bar{\pi})$ 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:

$$\hat{N}_p = \overline{\pi}\, C_p \tag{16}$$

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

Appendix B2.–Peak aerial survey counts and estimated total spawning abundance $\hat{N}_L$ with associated SE's for large Chinook salmon spawning in the Keta River 1975–2016.

Year	Peak survey counts	Expansion factor	$\hat{N}_L$	SE ($\hat{N}_L$)	v ($\hat{N}_L$)	CV
1975	203	3.01	611	114	12,921	18.6%
1976	84	3.01	253	47	2,212	18.6%
1977	230	3.01	692	129	16,587	18.6%
1978	392	3.01	1,180	220	48,181	18.6%
1979	426	3.01	1,283	239	56,901	18.6%
1980	192	3.01	578	108	11,559	18.6%
1981	329	3.01	990	184	33,939	18.6%
1982	754	3.01	2,270	422	178,256	18.6%
1983	822	3.01	2,475	460	211,858	18.6%
1984	610	3.01	1,836	342	116,670	18.6%
1985	624	3.01	1,879	349	122,087	18.6%
1986	690	3.01	2,077	386	149,279	18.6%
1987	768	3.01	2,312	430	184,937	18.6%
1988	575	3.01	1,731	322	103,666	18.6%
1989	1,155	3.01	3,477	647	418,278	18.6%
1990	606	3.01	1,824	339	115,145	18.6%
1991	272	3.01	819	152	23,197	18.6%
1992	217	3.01	653	122	14,765	18.6%
1993	362	3.01	1,090	203	41,088	18.6%
1994	306	3.01	921	171	29,359	18.6%
1995	175	3.01	527	98	9,602	18.6%
1996	297	3.01	894	166	27,658	18.6%
1997	246	3.01	741	138	18,975	18.6%
1998	180	**2.48**	**446**	**50**	**2,500**	**11.2%**
1999	276	**3.51**	**968**	**116**	**13,456**	**12.0%**
2000	300	**3.05**	**914**	**122**	**14,884**	**13.3%**
2001	343	3.01	1,033	192	36,888	18.6%
2002	411	3.01	1,237	230	52,965	18.6%
2003	322	3.01	969	180	32,510	18.6%
2004	376	3.01	1,132	211	44,328	18.6%
2005	497	3.01	1,496	278	77,449	18.6%
2006	747	3.01	2,248	418	174,962	18.6%
2007	311	3.01	936	174	30,326	18.6%
2008	363	3.01	1,093	203	41,316	18.6%
2009	172	3.01	518	96	9,278	18.6%
2010	475	3.01	1,430	266	70,742	18.6%
2011	223	3.01	671	125	15,592	18.6%
2012	241	3.01	725	135	18,211	18.6%
2013	493	3.01	1,484	276	76,206	18.6%
2014	439	3.01	1,321	246	60,427	18.6%
2015	304	3.01	915	170	28,977	18.6%
2016	446	3.01	1,342	249	62,001	18.6%
2017	300	3.01	903	168	28,224	18.6%
Esc. Goal lower			525			
Esc. Goal upper			1,200			
$\overline{\pi}$		3.01				
SE $\overline{\pi}$		0.56				
var $\overline{\pi}$		0.31354				

Note: Statistics in bold come directly from mark–recapture experiments in 1998–2000; all other statistics are expanded from counts based on the relationship between counts and estimates during years with mark–recapture experiments.