Regional Operational Plan CF.1J.2019.09

Operational Plan: Hugh Smith Lake Sockeye Salmon Stock Assessment, 2019–2021

by

Malika T. Brunette

July 2019

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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by
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Division of Commercial Fisheries

July 2019

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SIGNATURE PAGE

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Project leader(s):	*Malika T. Brunette*
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Field Dates:	*15 April–10 November*
Plan Type:	*Category II*

Approval

Title	Name	Signature	Date
Project leader	Malika Brunette		
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PURPOSE

Hugh Smith Lake salmon runs have been monitored since 1980 and information provided by stock assessment studies constitutes the longest series of sockeye and coho salmon population data in southern Southeast Alaska. The Alaska Department of Fish and Game will continue long-term stock assessment by operating an adult weir through the summer and fall to enumerate the escapement and determine if the optimal escapement goal of 8,000–18,000 adult sockeye salmon is met. Juvenile sockeye salmon abundance will be estimated through a smolt weir in the spring, operated by a separate project that monitors coho salmon abundance. We will estimate the size and age composition of emigrating smolt, as well as the length, sex, and age composition of the adult escapement, thereby providing valuable information for run-reconstruction and stock-recruit analysis. Continued evaluation of the Hugh Smith Lake sockeye salmon stock is essential to improving the optimal escapement goal and evaluating fishery management actions to achieve that goal, and will benefit the commercial, sport, and subsistence fisheries that depend upon the health of this resource.

Key words: Hugh Smith Lake, sockeye salmon, *Oncorhynchus nerka,* escapement, optimal escapement goal, mark–recapture, otolith, thermal mark, coho salmon, *Oncorhynchus kisutch*

OBJECTIVES

1. Enumerate the adult salmon escapement through the Hugh Smith Lake weir by species.
2. Provide a mark-recapture estimate of the total spawning population of adult sockeye salmon (>400 mm mid eye to tail fork length) in Hugh Smith Lake with an estimated coefficient of variation no greater than 15% of the estimate.
3. Estimate the age, length, and sex composition of adult sockeye salmon in Hugh Smith Lake such that the estimated proportions are within 5% of the true value with at least 95% probability.
4. Estimate the age composition and size-at-age of sockeye salmon smolt leaving Hugh Smith Lake.
5. Project the current year's total sockeye salmon run size each week based on historical run timing at the weir.

ADDITIONAL TASKS

Stream height, water and air temperature, and daily precipitation will be recorded daily at the weir. Gauging stations and instruments have been standardized to enable comparisons between years.

BACKGROUND

Hugh Smith Lake, located southeast of Ketchikan, Alaska, in Boca de Quadra Inlet, has been an important sockeye salmon (*Oncorhynchus nerka*) contributor to southern Southeast Alaska commercial fisheries for over a century. Intense fisheries in the late 1800s and early 1900s supplied a saltery adjacent to the Hugh Smith Lake estuary and two canneries in Boca de Quadra Inlet (Rich and Ball 1933; Roppel 1982). A private hatchery was operated at the head of the lake from 1901 to 1903 and from 1908 to 1935, but numbers of adult sockeye salmon returning to the lake were not recorded (Roppel 1982). Egg take records suggest 3,000–6,000 females were collected annually for broodstock from Buschmann Creek, the primary sockeye salmon spawning tributary (Roppel 1982). Moser (1898) concluded that despite overfishing, Hugh Smith Lake should produce annual runs of 50,000 sockeye salmon under average conditions.

The Alaska Department of Fish and Game (ADF&G) has monitored adult salmon escapements through a weir at the outlet of Hugh Smith Lake from 1967 to 1971 and annually since 1980. Beginning in the early 1980s, the lake was the subject of ADF&G sockeye salmon enhancement and rehabilitation efforts which included nutrient enrichment from 1981 to 1984 and fry plants from 1986 to 1997 (Geiger et al. 2003). The vast majority of juveniles from these early stocking programs were not marked, so detailed information on the contribution of stocked fish to subsequent escapements is unavailable. Despite rehabilitation efforts, total sockeye salmon escapements declined from an average of 17,500 fish in the 1980s, to 12,000 fish in the 1990s, and 3,500 fish from 1998 to 2002.

In 2003, the Alaska Board of Fisheries classified Hugh Smith Lake sockeye salmon a stock of management concern (5 AAC 39.222) due to the long-term decline in escapement (Geiger et al. 2003). Based on escapement goal analyses outlined in Geiger et al. (2003) the board set an optimal escapement goal of 8,000–18,000 sockeye salmon (5 AAC 33.390) to include spawning salmon of wild and hatchery origin. They also adopted an action plan that directed ADF&G to review stock assessment and rehabilitation efforts at the lake, and it contained measures to reduce commercial harvests of Hugh Smith Lake sockeye salmon when the projected escapement was below the lower bound of the escapement goal range. Fishery restrictions, in the form of time and area closures, affected the commercial net fisheries closest to the entrance of Boca de Quadra (Figure 1). The rehabilitation effort included Southern Southeast Regional Aquaculture Association's (SSRAA) existing stocking program for which eggs, collected from Buschmann Creek, were reared and thermal marked at Burnett Inlet Hatchery. Each spring, from 1999 through 2003, thermal marked fry were returned to Hugh Smith Lake, fed in net pens to presmolt size, and released in summer.

ADF&G conducted a project to estimate the contribution, distribution, and run timing of stocked Hugh Smith Lake sockeye salmon in the District 101 commercial net fisheries from recoveries of thermal marked fish from 2003 to 2007. Results from this project showed that management restrictions outlined in the action plan were appropriately timed and located to reduce harvests on this stock (Heinl et al. 2007). Additionally, ADF&G conducted studies to identify factors that might limit juvenile sockeye salmon survival at various stages of their early life history; however, these studies did not identify any factors in the freshwater environment that would increase mortality of juvenile sockeye salmon (Piston et al. 2006 and 2007; Piston 2008). Adult escapements steadily improved from a low of 1,138 fish in 1998, and fish from the SSRAA stocking program made up a significant portion (57%–65%) of escapements from 2003 to 2007 (Heinl et al. 2007, Piston 2008). The stock of concern status was removed in 2006 due to improved escapements (Geiger et al. 2005), and escapements surpassed the lower bound of the escapement goal in thirteen of sixteen years, 2003–2018.

Population studies at Hugh Smith Lake provide the longest time series (1982–2018) of escapement and age, sex, and length (ASL) information for both sockeye and coho (*O. kisutch*) salmon (Shaul et al. 2009) in southern Southeast Alaska. Thus, these important indicator stocks provide information useful for managing southern Southeast Alaska commercial fisheries. These population studies will continue through 2019–2021 at Hugh Smith Lake. We will enumerate the adult escapement by species and conduct a mark–recapture study on sockeye salmon as a substitute escapement estimate if the weir fails. Biweekly foot surveys will be conducted on the two inlet streams to count spawning salmon. The ASL information will be collected from a subset of the adult sockeye salmon escapement. In addition to sockeye salmon research, we will also collect biological data and enumerate the coho salmon escapement each summer following detailed protocols outlined in the operational plan for Southeast Alaska coho salmon stock assessment

(Shaul and Crabtree 2017). Coho salmon research personnel will be responsible for operating the smolt weir in the spring and the adult weir after 15 September (Shaul and Crabtree 2017).

STUDY SITE

Hugh Smith Lake (55° 06' N, 134° 40' W; Orth 1967) is located on mainland Southeast Alaska, 67 km southeast of Ketchikan in Misty Fjords National Monument (Figure 1) and covers a surface area of 320 ha. The lake is organically stained and is meromictic—a layer of saltwater lies at the bottom of the lake below 60 m and does not interact with the freshwater layer above it. It has a mean depth of 70 m, a maximum depth of 121 m, and a volume of 222.7×10^6 m^3 (Figure 2). Hugh Smith Lake empties into nearby Boca de Quadra inlet via 50-m-long Sockeye Creek (*ADF&G Anadromous Waters Catalog* number 101-30-10750). Sockeye salmon spawn in two inlet streams: Buschmann Creek flows northwest 4 km to the head of the lake (*ADF&G Anadromous Waters Catalog* number 101-30-10750-2006, Beaver Pond Channel 101-30-10750-3003, Figure 3); and Cobb Creek flows north 8 km to the southeast head of the lake (*ADF&G Anadromous Waters Catalog* number 101-30-10750-2004; Figure 3). Cobb Creek has a barrier to anadromous migration approximately 0.8 km upstream.

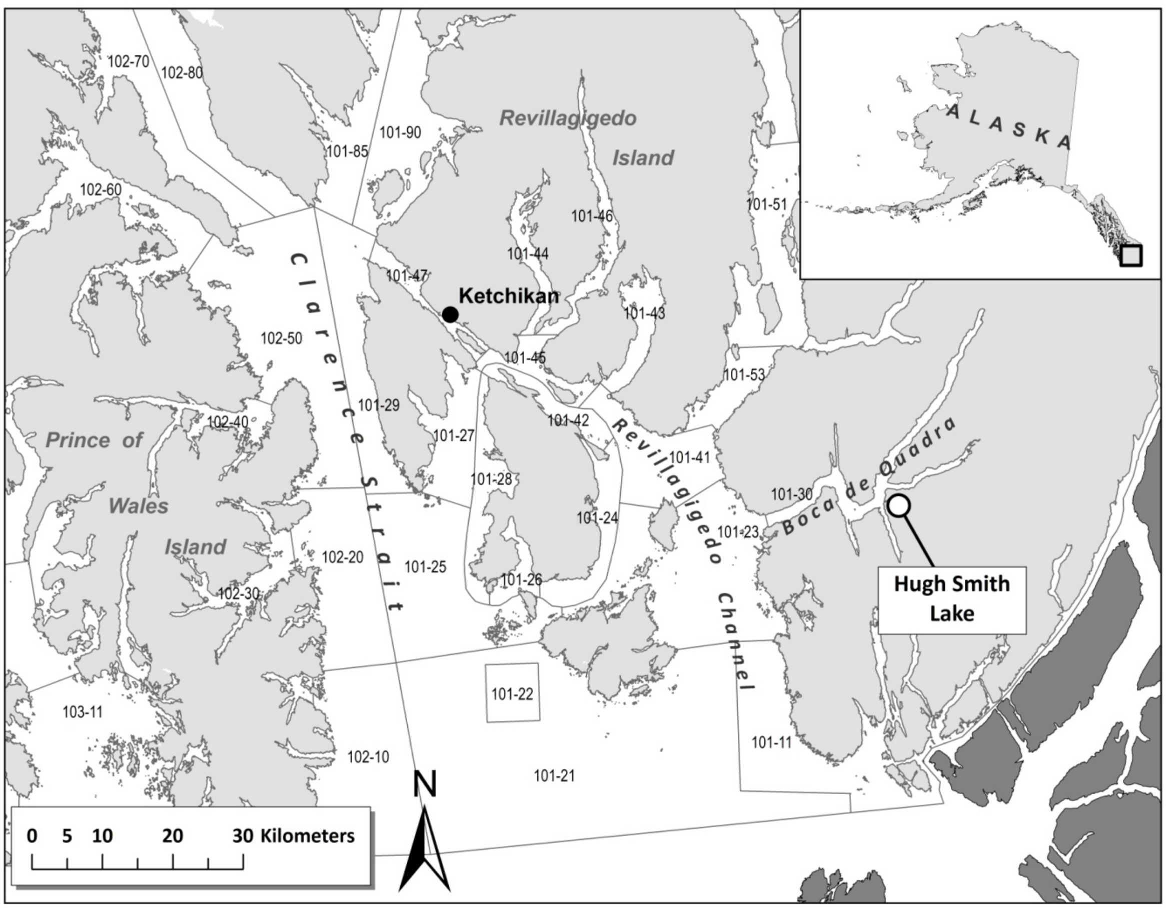

Figure 1.–Location of Hugh Smith Lake in southern Southeast Alaska.

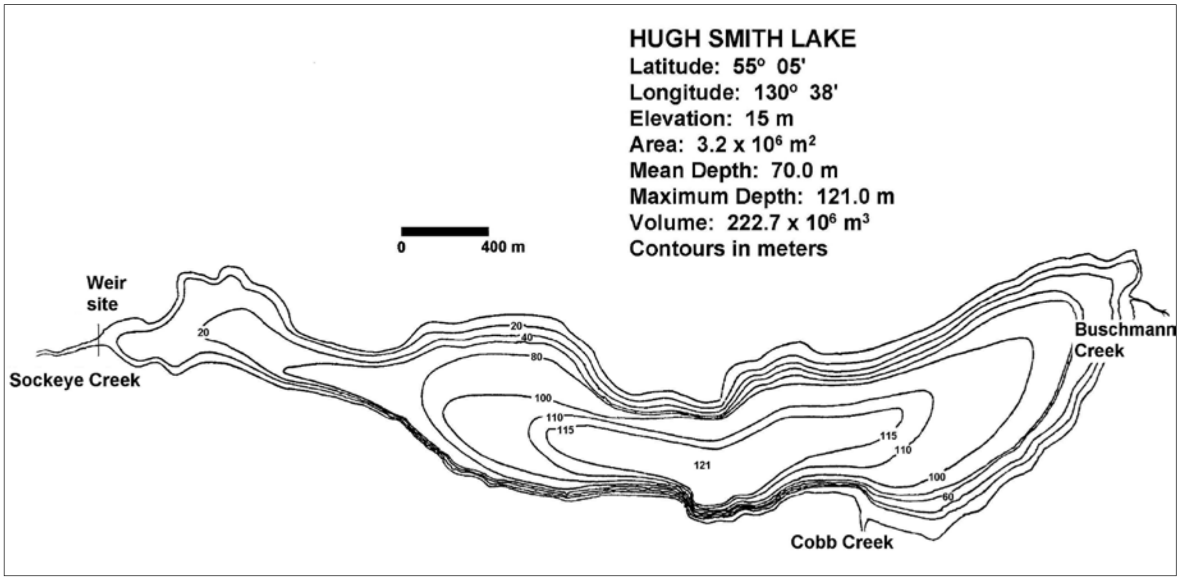

Figure 2.–Bathymetric map of Hugh Smith Lake showing the location of the weir site, the two inlet streams, and other features of the lake system.

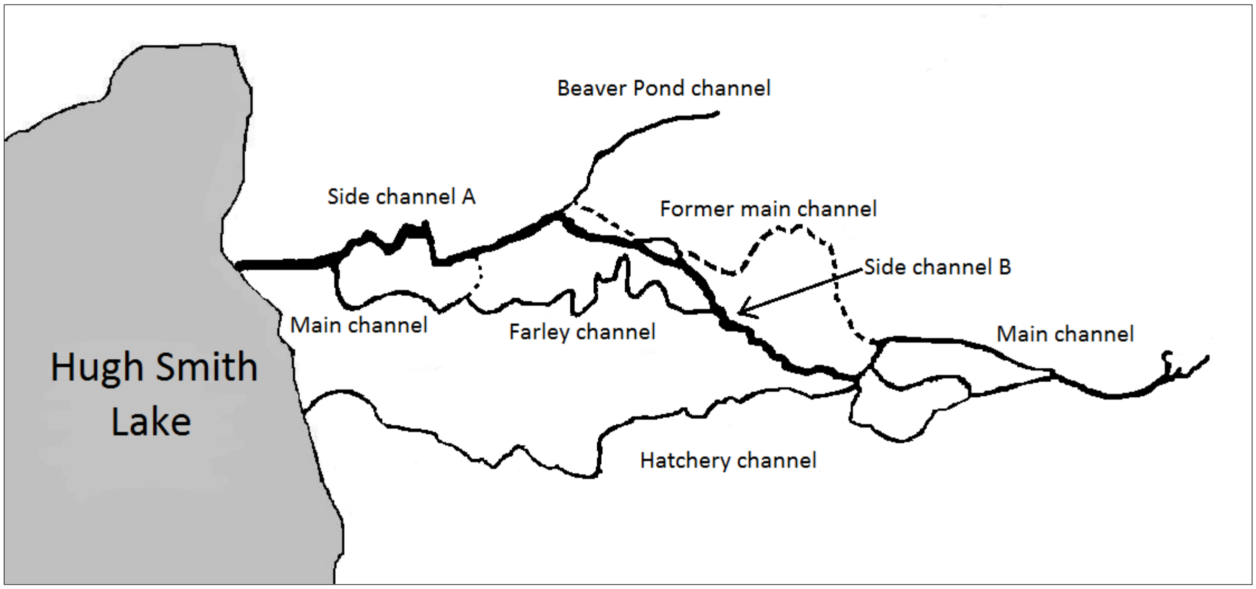

Figure 3.–Schematic diagram of the main channels of lower Buschmann Creek, as of September 2018. Dashed lines indicate tributaries that were accessible in the past but are now either blocked by beaver dams or did not have adequate water flow to accommodate spawning salmon.

METHODS

ADULT SALMON ENUMERATION

ADF&G operated an adult salmon counting weir at the outlet of the lake, approximately 50 m from saltwater, from 1967 to 1971 and annually since 1980 (Appendix A). The adult weir will be operated from approximately 16 June to early November; approximately 99% of the sockeye salmon escapement has been counted through the weir between 16 June and 15 September. A concurrent mark–recapture study and regular underwater inspections will also be conducted to verify the integrity of the weir.

The weir is an aluminum bipod channel-and-picket design with an upstream trap for enumerating and sampling salmon. Guillotine-style drop-closing doors on the upstream face of the trap allow us to pass fish freely into the lake or immediately close the trap when a fish of interest is identified. Hugh Smith Lake coho salmon are an important wild indicator stock in Southeast Alaska so it is imperative that all are examined for coded-wire tags before entering the lake (Shaul et al. 2009). The drop-closing doors ensure the sampling goals of the ongoing coho salmon study are met while efficiently counting and passing >90% of all salmon into the lake. The fish not passed through the doors will be dipnetted out of the trap, anesthetized, marked, sampled, and released upstream of the weir.

Fish passage will also be recorded using a GoPro HERO3 Silver Edition[1] HD camera mounted approximately 1 m upstream of the trap doors. Daily review of the video files will verify weir counts. If a coho salmon passes through the trap doors before it can be physically examined for a coded-wire tag, the crew will review the video files to determine size class, sex, and presence of the adipose fin. Additionally, 4–6 mil plastic sheeting will be spread across the upstream face of the weir during periods of low water to concentrate the stream flow through the trap. The resultant increase in current through the trap prompts fish to move upstream, thereby reducing their holding time below the weir (Piston and Brunette 2010).

In addition to species enumeration, lengths from mid eye to tail fork (METF) will be recorded for all sockeye and coho salmon to classify each as a jack or adult. Sockeye (ocean-age-1) and coho salmon (ocean-age-0) less than 400 mm METF length will be classified as jacks.

ADULT WEIR DATA ENTRY

Inseason Hugh Smith Lake sockeye salmon weir counts are provided to the public on the ADF&G Division of Commercial Fisheries website. Weir counts will be entered daily (or as timely as possible) into the ADF&G database at the Ketchikan ADF&G office using the Zander data entry application on the ADF&G OceanAK website. Data to be entered include the water temperature (°C), stream height (mm), brief comments, and fish numbers by count type, maturity, and species.

It is important that a count of 0 be entered into the database for any species/maturity type that might reasonably be expected to be present if none are counted on a given day. Adult and jack sockeye salmon, for example, should be expected on any given day that the weir is operated; thus, a count of 0 should be entered for all days when none are counted. Conversely, there is no need to enter a count of 0 coho salmon until at least 1 coho salmon has been counted at the weir (usually

[1] Product names used in this publication are included for completeness but do not constitute product endorsement.

in early August), after which counts of 0 coho salmon should be entered for all days when none are counted.

To ensure accuracy, entered data should be checked against the raw data files each time they are entered into the database. Once the project is completed, daily weir counts for the entire season should be downloaded from OceanAK and double-checked again to ensure they are accurate and complete.

SOCKEYE SALMON RUN PROJECTION

Though not currently a stock of management concern, ADF&G fisheries managers may still use conservation measures from the Hugh Smith Lake Sockeye Salmon action plan to reduce harvest in the District 101 drift gillnet and purse seine fisheries. If inseason escapement projections of Hugh Smith Lake sockeye salmon are below the lower bound of the optimal escapement goal in statistical weeks 29–33 (Appendix B), commercial fishing areas near the mouth of Boca de Quadra may be reduced. From 2019 through 2021, current weir counts and projections of total escapement will be provided to the Ketchikan management biologists regularly throughout the season to facilitate management decisions. The projected weekly cumulative weir count needed to achieve the lower end of the optimal escapement goal will be calculated by multiplying the lower bound of the escapement goal range (8,000 fish) by the average daily cumulative percentage of the run through the weir over the past 37 years, 1982–2018 (Table 1).

Table 1.–Average cumulative proportion of Hugh Smith Lake sockeye salmon counted through the adult salmon weir by statistical week, 1982–2018, and the projected weekly number of adults desired to meet the lower end of the escapement goal of 8,000–18,000 adult sockeye salmon.

2019 Statistical week			1982–2018 Average cumulative proportion on stat. week end date	Weekly projected escapement needed to reach lower end of escapement goal range of 8,000 adults
Number	Start date	End date		
25	16-Jun	22-Jun	0.01	82
26	23-Jun	29-Jun	0.03	279
27	30-Jun	6-Jul	0.08	638
28	7-Jul	13-Jul	0.15	1,188
29	14-Jul	20-Jul	0.24	1,925
30	21-Jul	27-Jul	0.38	3,046
31	28-Jul	3-Aug	0.50	4,025
32	4-Aug	10-Aug	0.62	4,986
33	11-Aug	17-Aug	0.73	5,806
34	18-Aug	24-Aug	0.82	6,534
35	25-Aug	31-Aug	0.90	7,190
36	1-Sep	7-Sep	0.94	7,548
37	8-Sep	14-Sep	0.97	7,765
38	15-Sep	21-Sep	0.98	7,872
39	22-Sep	28-Sep	0.99	7,958
40	29-Sep	5-Oct	1.00	7,978
41	6-Oct	12-Oct	1.00	7,993
42	13-Oct	19-Oct	1.00	7,997
43	20-Oct	26-Oct	1.00	7,998
44	27-Oct	2-Nov	1.00	7,999
45	3-Nov	9-Nov	1.00	8,000

Adult Age and Size-at-Age Composition

The adult sockeye salmon age composition at Hugh Smith Lake will be determined from a minimum of 600 scale samples collected from live fish at the weir. This sample size was based on work by Thompson (1992) to estimate proportions of four or more major age classes simultaneously. A sample of 510 fish is needed to ensure the estimated proportion of each adult age class will be within 5% of the true value with at least 95% probability. We increased our scale sample goal to 600 samples to guarantee the sampling goal would be achieved, even if 15% of our samples are unreadable. We will begin collecting scale samples from 1 out of every 10 fish (10%) and may adjust the sampling rate if necessary, based on inseason escapement projections. Each fish sampled for age-sex-length will be anesthetized in a clove oil solution (Woolsey et al. 2004), placed in a padded measuring trough, and METF length will be recorded to the nearest five millimeters. Jacks (METF <400 mm) will not be sampled. Three scales will be collected from the preferred area (INPFC 1963) from each fish, placed on a gum card, and prepared for analysis as described by Clutter and Whitesel (1956). Scales will be aged at the ADF&G salmon-aging laboratory in Douglas, Alaska. Scale samples from coho salmon (four scales per fish) will also be collected at the weir following protocols outlined in Shaul and Crabtree (2017).

Coded Wire Tag Sampling

Coho salmon smolt have been coded-wire tagged at Hugh Smith Lake annually since 1982 (Shaul 1994). All adult and jack coho salmon will be examined at the weir for an adipose fin and presence of coded wire tags.

- Coho salmon that have their adipose fin intact will be recorded as “unmarked” and released upstream alive.
- All coho salmon that have had their adipose fin removed (or “adipose-clipped”) will be examined with a handheld metal detector across the nose and along the right and left sides of the dorsal fin to verify presence of a coded-wire tag.
    - Adipose-clipped coho salmon that signal positive for a nose imbedded coded-wire tag will be recorded as “marked” and released upstream alive.
    - Adipose-clipped coho salmon that do not indicate the presence of a coded-wire tag in the snout will be recorded as “adipose-clipped; no tag” and sacrificed.
    - Adipose-clipped coho salmon that signal positive for a dorsal coded-wire tag (or “back tag”) will be sacrificed. Data from these select fish are incredibly valuable to the ongoing known-age study on juvenile coho salmon and should be treated with extreme care. Sex and METF length will be recorded on a separate ASL form, and ten scales from each fish will be collected and mounted on a separate scale card with a separate numbering sequence.
    - The heads from “back tagged” and “adipose-clipped; no tag” coho salmon will be retained, frozen, and sent to the ADF&G Mark, Tag and Age Laboratory in Juneau with a completed Coded Wire Tag Sample form.

Stray Chinook salmon (*O. tshawytscha)* are occasionally recovered at the Hugh Smith Lake weir; however, since this system does not support a natural Chinook salmon spawning population, no Chinook salmon will be passed into the lake. Chinook salmon that have an adipose fin will be released downstream below the weir where they will usually leave the system within 1–2 days. Adipose-clipped Chinook salmon will be sacrificed at the weir and the frozen heads will be sent to the ADF&G Mark, Tag and Age Laboratory in Juneau with a completed CWT Sample form.

MARK–RECAPTURE POPULATION ESTIMATE

A two-sample mark–recapture population study will be conducted to estimate the total spawning population of sockeye and coho salmon at Hugh Smith Lake. This study will help determine if fish passed through the weir uncounted or if sockeye salmon entered the lake before the weir was fish tight in mid-June. Adult sockeye salmon will be marked at a rate of 1 in 10 (10%) with a readily identifiable fin clip at the weir. Those fish will be anesthetized in a clove oil solution (Woolsey et al. 2004), fin-clipped, sampled, and released upstream next to the trap to recover. Fish that do not appear healthy will not be marked. Marking will be stratified through time on the following schedule:

- 16 June–22 July: right pelvic fin clip,
- 23–31 July: left pelvic fin clip, and
- 1 August–November: partial dorsal fin clip.

We will not mark jack sockeye salmon (<400 mm METF length) because most jacks can pass freely through the weir pickets and are not generally encountered in the spawning streams.

All coho salmon (100%) will be marked on the following schedule:

- prior to 15 September: partial dorsal fin clip,
- 16 September–6 October: left pelvic fin clip, and
- 7 October–November: right pelvic fin clip.

Weekly stream surveys will be conducted on the spawning grounds to sample spawners for marks. Live fish will be captured and examined for marks using a beach seine off the creek mouths or dip nets in the spawning streams. All carcasses encountered will also be examined for fin clips. Each fish examined will be recorded as either unmarked (no fin-clip) or marked, and if marked, then by the appropriate fin clip (right pelvic, left pelvic, or dorsal fin clip). A secondary mark will be applied to all sampled fish (a left operculum hole punch for live fish, or removal of the entire tail for carcasses) to prevent double sampling on subsequent sampling events. Our goal is to examine at least 600 sockeye salmon throughout the entire spawning season. A sample of 600 fish in the second sampling event should yield a population estimate with a coefficient of variation less than 15% when 10% of individuals in a population of 10,000 fish (recent 20-year average wild sockeye salmon escapement) have been marked (Robson and Regier 1964).

STREAM SURVEYS

The number of live and dead salmon in the creek will be estimated, by species, during each survey of Buschmann and Cobb creeks. Cobb Creek will be surveyed from the mouth to the barrier falls (0.42 miles; 55° 05.35’ N, 130° 38.673’ W). Buschmann Creek will be surveyed to just above the confluence with Hatchery Channel (Figure 3). Surveys of all the major Buschmann Creek channels will be attempted twice per week near the peak of the run. Data will be entered into the ADF&G database at the end of the field season.

SMOLT ENUMERATION AND SAMPLING

Since 1982, ADF&G coho salmon research personnel have operated a weir to enumerate and sample coho and sockeye salmon smolt as they emigrate from Hugh Smith Lake in the spring (Appendix C). Peltz and Haddix (1989) and Shaul et al. (2009) provided a physical description of weir. Coho salmon research personnel will enumerate all species through the smolt weir and collect scale samples and length-weight data. Fish will be systematically sampled from the first sort through the trap each day following the schedule in Table 2.

The snout-to-fork length (in mm) and weight (to the nearest 0.1 g) will be recorded for each fish sampled. A preferred-area scale smear (Clutter and Whitesel 1956) will be collected from each fish and mounted on a 2.5 cm × 7.5 cm glass slide, four fish per slide.

Table 2.–Daily length, weight, and scale sample sizes for sockeye salmon smolt.

	Daily sample size (*n*)		
Date range	Length and weight	Scales	Systematic sample guideline
24 April–6 May	4	4	<12 sockeye in the trap, sample every fish until the quota is reached.
			12–50 sockeye in the trap, sample every other fish until the quota is reached.
			51–500 sockeye in the trap, sample every 4th fish until the quota is reached.
7–27 May	24	24	<60 sockeye in the trap, sample every fish until the quota is reached.
			60–100 sockeye in the trap, sample every other fish until the sampling quota is achieved.
			101–500 sockeye in the trap, sample every 3rd fish until the sampling quota is reached.
			>500 sockeye in the trap, sample every 10th fish until the sampling quota is reached.
28 May–end of season	4	4	<12 sockeye in the trap, sample every fish until the quota is reached.
			12–50 sockeye in the trap, sample every other fish until the quota is reached.
			51–500 sockeye in the trap, sample every 4th fish until the quota is reached.
Total	600	600	

DATA ANALYSIS

Mark–recapture Population Estimate

We will use Stratified Population Analysis System (SPAS) software (Arnason et al. 1996) to generate mark–recapture estimates of the total spawning population of sockeye salmon. The program SPAS was designed for analysis of two-sample mark–recapture data where marks and recoveries take place over a number of strata and is based on work by Chapman and Junge (1956), Darroch (1961), Seber (1982), and Plante (1990). We will use this program to calculate: 1) maximum likelihood (ML) Darroch estimates and pooled-Petersen (Chapman's modified) estimates, and their standard errors; 2) χ^2 tests for goodness-of-fit (GOF) based on the deviation of predicted values (fitted by the ML Darroch estimate) from the observed values; and 3) two χ^2

tests of the validity of using fully pooled data—a test of complete mixing of marked fish between release and recovery strata and a test of equal proportions of marked fish in the recovery strata. We will choose full pooling of the data (i.e., the pooled-Petersen estimate) if the result of either of these tests is not significant (p>0.05). If neither of the conditions of the chi square tests are met, strata that contained zero recoveries will be dropped from the analysis and the recovery and marking strata will be partially pooled. Partial pooling will be guided by pooling of adjacent strata with similar initial capture or recapture probabilities, pooling of adjacent strata with few initial capture or recapture numbers, minimization of the number of cells with $\{m_{ij}\}<5$ (the total number of fish tagged in stratum i and recovered in recovery stratum j) to avoid problems of sampling zeros, GOF tests, additional chi-square tests, minimization of the standard error of the abundance estimate, and admissible ML Darroch estimates of abundance (Arnason et al. 1996; Schwarz and Taylor 1998). If a recovery stratum has few counts it may be an indication that little movement occurred to this particular stratum (e.g., fish in this stratum died before reaching the recovery spawning grounds), the recovery effort was small, or the stratification interval (time period) was too small. In this case, two or more recovery strata will be temporally pooled. The GOF tests will be used to assess the adequacy of the stratified model for lack of fit. Nonadmissible estimates of abundance include failure of the ML algorithm to converge, or convergence to unrealistic estimators such as negative capture probabilities or negative stratum abundances. Other than GOF statistics, there are no formal tests to determine if one should pool or drop strata. Our goal is to estimate the escapement such that the coefficient of variation is no greater than 15% of the point estimate.

The weir count will be deemed “verified” and entered as the official escapement estimate if it falls within the transform-based 95% confidence interval of the mark–recapture estimate for adult sockeye salmon. If the weir count does not fall within the transform-based 95% confidence interval of the mark–recapture estimate, we will assume the weir count is flawed due to fish passing before or after installation, or due to fish passing the weir uncounted, and the mark–recapture point estimate will be used as the official escapement estimate. This is the same criterion used in previous years (Geiger et al. 2003). The escapement goal will be judged to have been met if the weir count falls within the escapement goal range and within the transform-based 95% confidence interval of the mark–recapture estimate. If both the weir count and the mark–recapture point estimate are below the lower bound of the escapement goal range, the escapement goal will be deemed to have not been met. In the case where the weir count or the mark–recapture point estimate falls within the escapement goal range, the weir count will be used, unless the weir count is below the lower bound of the 95% confidence interval of the mark–recapture estimate. In that rare instance, we will use the mark–recapture point estimate, and not either end of the confidence interval, for the purpose of judging the escapement objective.

ADULT AND JUVENILE SIZE-AT-AGE AND AGE COMPOSITION

Adult sockeye salmon scale samples will be aged at the ADF&G, Commercial Fisheries Scale Lab in Douglas, Alaska. Sockeye salmon smolt scales will be aged using a video-linked microscope in the Ketchikan ADF&G office. Weekly and seasonal age composition, as well as mean length-at-age by sex will be calculated for smolt and adults using standard methods (Cochran 1977; Appendix D).

SCHEDULE AND DELIVERABLES

In 2019, we will install the adult weir on 16 June, and we will pass, mark, and sample fish immediately. Field crews will contact the office daily to relay weir counts and sampling progress. Daily cumulative weir counts and weekly run size projections will be forwarded to the Ketchikan Area Management Biologists. A final ADF&G Fisheries Data Series report will be completed by the Project Leader after the field season. Additional reporting will include a section of semi-annual, and 3-year, progress reports for Pacific Salmon Commission section entitled: Northern Boundary Annex: Fisheries management and stock assessment.

RESPONSIBILITIES

Malika Brunette, Fishery Biologist II, Project Leader. Oversees all aspects of field project including operational planning, permit acquisition, hiring, training, supervising, and evaluating field personnel, field work, logistical coordination, equipment inventory and supply acquisition, post-season data analysis and reporting. Reports inseason escapement estimates to ADF&G management staff and SSRAA. Ages sockeye salmon smolt scales.

Lewis Rogers, Fish and Wildlife Technician III, Field Crew Leader. Oversees all aspects of daily field operations, directs daily work activities of field crew, ensures data quality and that field work is completed in a safe and timely manner.

Julian Léon, Fish and Wildlife Technician II, Field Crew. Assists with all aspects of field operations, data collection, equipment maintenance, and field camp responsibilities.

Andrew Piston, Fishery Biologist IV. Assists with operational planning, budgeting, and technical report review.

Steve Heinl, Regional Salmon Research Supervisor. Assists with project operational planning and technical report review.

Sara Miller, Biometrician III. Assists with sample design, project operational planning, and data analysis.

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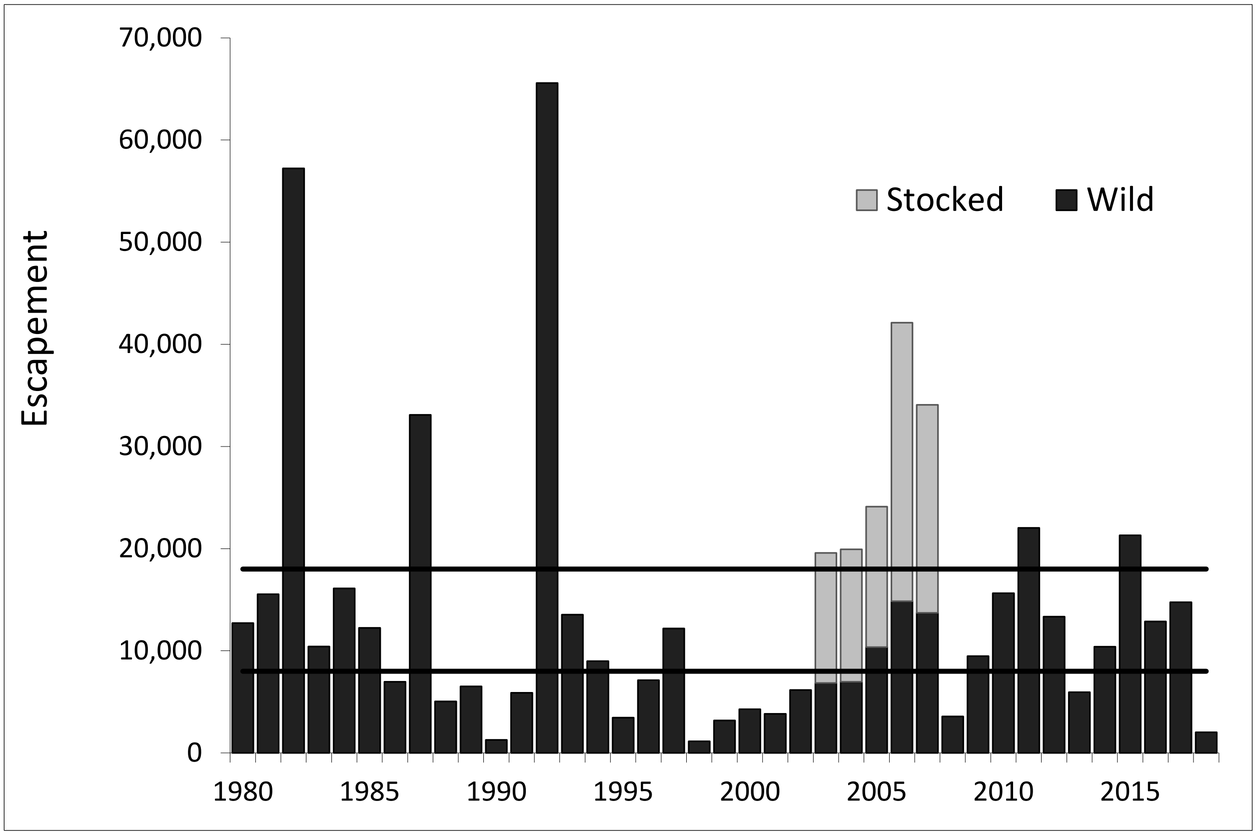
APPENDICES

Appendix A.–Annual sockeye salmon escapement at Hugh Smith Lake, 1980–2018. Black horizontal lines indicate the current optimal escapement goal range of 8,000–18,000 adult sockeye salmon, which includes both wild and hatchery stocked fish. From 2003 to 2007, the bars are divided to show our estimate of wild (black) and stocked fish (grey) in the escapement. Fry stocked from 1986 to 1997 were thought to have experienced very low survival rates with few surviving to emigrate from the lake (Geiger et al. 2003). Estimated proportions of wild and stocked fish are not available for years prior to 2003.



Appendix B.–Statistical week calendar, 2019–2021

Statistical week	2019		2020		2021	
	Start	End	Start	End	Start	End
24	9-Jun	15-Jun	7-Jun	13-Jun	6-Jun	12-Jun
25	16-Jun	22-Jun	14-Jun	20-Jun	13-Jun	19-Jun
26	23-Jun	29-Jun	21-Jun	27-Jun	20-Jun	26-Jun
27	30-Jun	6-Jul	28-Jun	4-Jul	27-Jun	3-Jul
28	7-Jul	13-Jul	5-Jul	11-Jul	4-Jul	10-Jul
29	14-Jul	20-Jul	12-Jul	18-Jul	11-Jul	17-Jul
30	21-Jul	27-Jul	19-Jul	25-Jul	18-Jul	24-Jul
31	28-Jul	3-Aug	26-Jul	1-Aug	25-Jul	31-Jul
32	4-Aug	10-Aug	2-Aug	8-Aug	1-Aug	7-Aug
33	11-Aug	17-Aug	9-Aug	15-Aug	8-Aug	14-Aug
34	18-Aug	24-Aug	16-Aug	22-Aug	15-Aug	21-Aug
35	25-Aug	31-Aug	23-Aug	29-Aug	22-Aug	28-Aug
36	1-Sep	7-Sep	30-Aug	5-Sep	29-Aug	4-Sep
37	8-Sep	14-Sep	6-Sep	12-Sep	5-Sep	11-Sep
38	15-Sep	21-Sep	13-Sep	19-Sep	12-Sep	18-Sep
39	22-Sep	28-Sep	20-Sep	26-Sep	19-Sep	25-Sep

Appendix C.–Hugh Smith Lake weir counts of sockeye salmon smolt by smolt year (1981–2018), and stocked fry and presmolt releases by release year (1980–2014). Proportions of stocked smolt were determined from otolith samples. Hatchery releases in bold were otolith-marked.

Release year	Hatchery release numbers	Release type	Smolt year	Total smolt counted	Freshwater age percent of total Age 1	Age 2	Age 3	Wild smolt counted	Stocked smolt counted	Proportion stocked smolt
1980	0	–	1981	319,000	71%	29%	0%	319,000	–	–
1981	0	–	1982	90,000	83%	18%	0%	90,000	–	–
1982	0	–	1983	77,000	60%	40%	0%	77,000	–	–
1983	0	–	1984	330,000	92%	8%	0%	330,000	–	–
1984	0	–	1985	40,000	51%	48%	1%	40,000	–	–
1985	0	–	1986	58,000 [c]	73%	24%	3%	58,000	–	–
1986	273,000	Unfed Fry	1987	104,000	42%	57%	1%		-----ND[a]-----	
1987	250,000	Unfed Fry	1988	54,000	65%	35%	0%		-----ND-----	
1988	1,206,000	Unfed Fry	1989	427,000	83%	17%	0%		-----ND-----	
1989	532,800	Unfed Fry	1990	137,000	31%	68%	2%		-----ND-----	
1990	1,480,800	Unfed Fry	1991	75,000	64%	36%	0%		-----ND-----	
1991	0	–	1992	15,000	42%	57%	1%		-----ND-----	
1992	477,500	Fed Fry	1993	36,000	63%	36%	2%		-----ND-----	
1993	0	–	1994	43,000	75%	21%	4%		-----ND-----	
1994	645,000	Unfed Fry	1995	19,000	38%	62%	0%		-----ND-----	
1995	418,000	Unfed Fry	1996	16,000	44%	40%	16%		-----ND-----	
1996	**358,000**	**Unfed Fry/ Presmolt** [b]	1997	44,000	52%	40%	8%	26,000	18,000	40%
1997	**573,000**	**Unfed Fry**	1998	65,000[c]	81%	18%	1%	34,000	30,000	47%
1998	0	–	1999	42,000	68%	32%	0%	39,000	3,000	4%
1999	**202,000**	**Presmolt** [d]	2000	72,000	77%	22%	1%		-----ND-----	
2000	**380,000**	**Presmolt** [d]	2001	190,000	91%	8%	1%	44,000	145,000	77%
2001	**445,000**	**Presmolt** [d]	2002	297,000	88%	12%	0%	134,000	163,000	55%
2002	**465,000**	**Presmolt** [d]	2003	261,000	86%	14%	0%	76,000	185,000	71%
2003	**420,000**	**Presmolt** [d]	2004	364,000	88%	12%	0%	194,000	170,000	47%
2004	0	–	2005	77,000	54%	46%	0%	77,000	–	–
2005	0	–	2006	119,000	63%	36%	1%	119,000	–	–
2006	0	–	2007	89,000	71%	27%	2%	89,000	–	–
2007	0	–	2008	59,000	62%	37%	1%	59,000	–	–
2008	0	–	2009	116,000	40%	59%	1%	116,000	–	–
2009	0	–	2010	64,000	19%	79%	2%	64,000	–	–
2010	0	–	2011	244,000	89%	10%	1%	244,000	–	–
2011	0	–	2012	179,000	72%	28%	0%	179,000	–	–
2012	0	–	2013	186,000	74%	26%	0%	186,000	–	–
2013	0	–	2014	95,000	71%	29%	0%	95,000	–	–
2014	0	–	2015	36,000	53%	47%	0%	36,000	–	–
2015	0	–	2016	31,000	85%	14%	1%	31,000		
2016	0	–	2017	80,000	88%	12%	0%	80,000		
2017	0	–	2018	63,000	57%	42%	1%	63,000		

[a] ND indicates "no data".

[b] In 1996, Southern Southeast Regional Aquaculture Association released 251,123 unfed sockeye salmon fry into the lake in May and 106,833 presmolt in October. All fish released in 1996 and 1997 were thermal otolith marked.

[c] The 1998 total smolt count does not equal the sum of wild and stocked smolt due to rounding.

[d] From 1999 to 2003, sockeye salmon fry were pen-reared at the outlet of the lake beginning in late May and released as presmolt in late July and early August. All fish from those release groups were thermal otolith marked.

The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week, for smolt and adults, were calculated using equations from Cochran (1977; pages 52, 107–108, and 142–144).

Let

h	=	index of the stratum (week),
j	=	index of the age class,
p_{hj}	=	proportion of the sample taken during stratum h that is age j,
n_h	=	number of fish sampled in week h, and
n_{hj}	=	number observed in class j, week h.

Then the age distribution was estimated for each week of the escapement in the usual manner:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \tag{1}$$

If N_h equals the number of fish in the escapement in week h, standard errors of the weekly age class proportions are calculated in the usual manner (Cochran 1977, page 52, equation 3.12):

$$SE(\hat{p}_{hj}) = \sqrt{\left[\frac{(\hat{p}_{hj})(1-\hat{p}_{hj})}{n_h - 1}\right][1 - n_h / N_h]} \ . \tag{2}$$

The age distributions for the total escapement were estimated as a weighted sum (by stratum size) of the weekly proportions. That is,

$$\hat{p}_j = \sum_h p_{hj} (N_h / N), \tag{3}$$

such that N equals the total escapement. The standard error of a seasonal proportion is the square root of the weighted sum of the weekly variances (Cochran 1977, pages 107–108):

$$SE(\hat{p}_j) = \sqrt{\sum_j^h [SE(\hat{p}_{hj})]^2 (N_h / N)^2} \ . \tag{4}$$

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, were calculated using the following equations from Cochran (1977, pages 142–144) for estimating means over subpopulations. That is, let i equal the index of the individual fish in the age-sex class j, and y_{hij} equal the length of the ith fish in class j, week h, so that,

$$\hat{\bar{Y}}_j = \frac{\sum_h (N_h / n_h) \sum_i y_{hij}}{\sum_h (N_h / n_h) n_{hj}} \text{, and} \tag{5}$$

$$\hat{V}\left(\hat{\bar{Y}}_j\right) = \frac{1}{\hat{N}_j^2} \sum_h \frac{N_h^2 (1 - n_h / N_h)}{n_h (n_h - 1)} \left[\sum_i (y_{hij} - \bar{y}_{hj})^2 + n_{hj} \left(1 - \frac{n_{hj}}{n_h}\right) \left(\bar{y}_{hj} - \hat{\bar{Y}}_j\right)^2 \right].$$