Regional Operational Plan SF.1J.2013.10

Estimation of Age, Sex, and Length Composition of Chinook Salmon in the Chickamin, Blossom, Keta and King Salmon Rivers, and Andrew Creek, 2013

by

Todd Johnson

June 2013

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

REGIONAL OPERATIONAL PLAN SF.1J.2013.10

ESTIMATION OF AGE, SEX, AND LENGTH COMPOSITION OF CHINOOK SALMON IN THE CHICKAMIN, BLOSSOM, KETA AND KING SALMON RIVERS, AND ANDREW CREEK, 2013

by

Todd Johnson

Alaska Department of Fish and Game, Division of Sport Fish, Ketchikan

Alaska Department of Fish and Game
Division of Sport Fish

June 2013

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: http://www.adfg.alaska.gov/sf/publications/

Todd Johnson,
Alaska Department of Fish and Game, Division of Sport Fish,
2030 Sea Level Dr. Suite 205
Ketchikan, AK 99901

This document should be cited as:
Johnson, T. A. 2013. Estimation of age, sex, and length composition of Chinook salmon in the Chickamin, Blossom, Keta and King Salmon rivers, and Andrew Creek, 2013. Alaska Department of Fish and Game, Regional Operational Plan No. SF.1J.2013.10, Anchorage.

SIGNATURE/TITLE PAGE

Project Title:	Estimation of age, sex, and length composition of Chinook Salmon in the Chickamin, Blossom, Keta and King Salmon rivers, and Andrew Creek, 2013
Project leader(s):	Todd Johnson, Fishery Biologist II
Division, Region and Area	Sport Fish, Region I, Ketchikan
Project Nomenclature:	LOA
Period Covered	August–September, 2013
Field Dates:	August 1–September 25, 2013
Plan Type:	Category III

Approval

Title	Name	Signature	Date
Project leader	Todd Johnson	Todd Johnson	5/1/13
Area Management Biologist	Kelly Piazza	Kelly Piazza	5/1/13
Biometrician	David Evans	David Evans	4/26/13
Salmon Research Coordinator	Ed Jones	Ed Jones	5.31.13
Regional Research Coordinator	John DerHovanisian	John DerH	5/31/13
Regional Supervisor	Brian Frenette	Brian Frenette	5.31.13

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

PURPOSE

The primary goals of this project are to: 1) collect adult age-sex-length (ASL) information for 5 Chinook salmon index systems in Southeast Alaska (SEAK), and 2) expand index counts to provide estimates of total escapement in the five systems. This information partially fulfills the escapement data requirements of the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC).

BACKGROUND

The Unuk, Chickamin, Blossom, and Keta rivers are on the mainland and traverse the Misty Fjords National Monument in southern SEAK (Figure 1); these rivers support substantial runs of Chinook salmon *Oncorhynchus tshawytscha* ranging approximately from 200 to 7,900 fish.

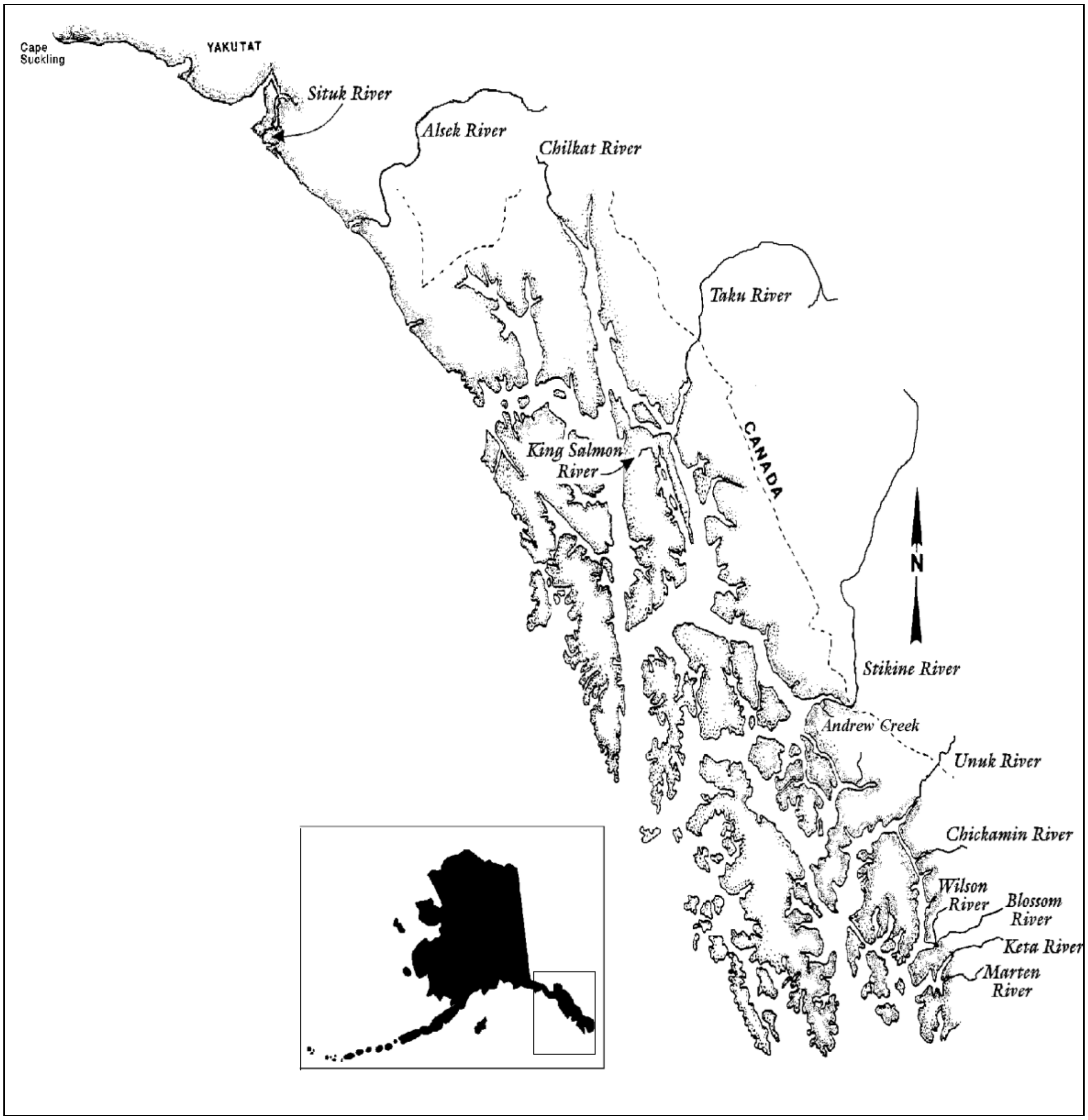

Figure 1.–Location of selected Chinook salmon age-sex-length systems in Southeast Alaska and transboundary rivers.

The King Salmon River is located on Admiralty Island, southeast of Juneau, and supports a small run of Chinook salmon. Andrew Creek is a tributary of the lower Stikine River and supports a moderate run of Chinook salmon, averaging about 1,100 large spawners (Pahlke 2010). These six stocks of Chinook salmon are all harvested in SEAK fisheries and the Behm Canal stocks (Unuk, Chickamin, Keta and Blossum) are also harvested to a minor extent in northern British Columbia fisheries. The Unuk and Chickamin rivers produce the largest wild runs of Chinook salmon in the Behm Canal and Ketchikan area. The six rivers are "index streams" for the Chinook salmon escapement estimation program in SEAK (Pahlke 1993). Indices of escapement (peak counts of large Chinook salmon) have been collected annually on the Chickamin, Unuk, Blossom, Keta, and King Salmon rivers and Andrew Creek using a standardized method (time and area, see the operational plan *Escapement of Chinook Salmon in Southeast Alaska and Transboundary Rivers in 2013*). The peak counts and resulting estimates of total escapement for these stocks are used by the Alaska Department of Fish and Game (ADF&G) and the CTC to evaluate stock status, and to implement abundance-based management.

Escapement indicator stocks are used by the CTC to judge stock status of naturally spawning Chinook salmon stocks coastwide, from SEAK through Oregon, and to judge performance of management actions designed to rebuild wild stocks, in accordance with Pacific Salmon Treaty, Annex IV, Chapter 3 of the 2008 Agreement. The United States Section of the CTC (USCTC) developed data standards for stock specific assessments of escapement, terminal runs, and forecasts of abundance, against which existing stock assessment programs could be evaluated (USCTC 1997). The standard for escapement is as follows:

> "***Escapement.*** *Annual age and sex-specific estimates of total escapement should be available. Point estimates should be accompanied by variance estimates, and both should be based on annual sampling data. Factors used to expand the escapement from index areas (or counts of components of the escapement) should be initially verified a minimum of three times. Those expansion factors that have moderate to large amounts of interannual variability (a coefficient of variation of more than 20%) should be monitored annually."*

The USCTC (1997) report made specific findings for all U. S. escapement indicator stocks relative to these data standards. The original King Salmon River and Andrew Creek Chinook salmon stock assessment programs failed to meet minimum data standards because, while expansion factors existed, age and sex composition of the annual escapements were not annually sampled. The Keta, Blossom, and Chickamin Chinook salmon stock assessment programs also failed to meet minimum data standards developed by the USCTC because age and sex composition was not sampled on an annual basis, and index expansion factors specific to these rivers had not been estimated. The USCTC (1997) recommendations for SEAK included development of permanent annual age and sex composition sampling of escapements for several river systems that were not sampled and development of expansion factors for these systems.

The expansion factor program deficiency for the Keta River was addressed in 3 annual mark-recapture estimates of total escapement from 1998 to 2000. The expansion factor for the Keta River is 3.01 (SE = 0.56, CV = 18.6%), and meets the USCTC standard for precision. Peak annual Chinook salmon escapement counts from 1975 to 2011 for the Keta River are summarized in Table 1.

Table 1.–Escapement survey counts, spawning escapement estimates of large (≥660 mm MEF) spawners, and expansion factors for Keta River Chinook salmon from 1975 to 2012. Escapement estimates in bold are from mark–recapture studies, and estimates in italics are from expanded survey counts

Year	Survey count	Spawning escapement	Expansion factor
1975	203	*611*	
1976	84	*253*	
1977	230	*692*	
1978	392	*1,180*	
1979	426	*1,282*	
1980	192	*578*	
1981	329	*990*	
1982	754	*2,270*	
1983	822	*2,474*	
1984	610	*1,836*	
1985	624	*1,878*	
1986	690	*2,077*	
1987	768	*2,312*	
1988	575	*1,731*	
1989	1,155	*3,477*	
1990	606	*1,824*	
1991	272	*819*	
1992	217	*653*	
1993	362	*1,090*	
1994	306	*921*	
1995	175	*527*	
1996	297	*894*	
1997	246	*740*	
1998	180	**446**	2.5
1999	276	**968**	3.5
2000	300	**914**	3.0
2001	343	*1,032*	
2002	411	*1,237*	
2003	322	*969*	
2004	376	*1,132*	
2005	497	*1,496*	
2006	747	*2,248*	
2007	311	*936*	
2008	363	*1,093*	
2009	172	*518*	
2010	475	*1,430*	
2011	223	*671*	
2012	241	*725*	
Averages:			
75–10	420	1,265	
06–12	362	1,089	

The expansion factor for Blossom River was addressed in 4 annual mark-recapture estimates of total escapement in 1998 and 2004–2006. The expansion factors in 1998 and 2006 were 4.0 and 3.75, respectively, and they were estimated under normal survey conditions; the expansion factors of 2.20 in 2004 and 2.08 in 2005 were estimated under excellent conditions and during the lowest water levels seen by the surveyor (Keith Pahlke, ADF&G, Division of Sport Fish, Douglas, retired, personal communication). The mean expansion factor for the two years with normal survey conditions is 3.87 (SE = 0.62, CV = 16.1%), and the overall mean for all 4 years is 3.01 (SE = 1.03, CV = 34.3%). Survey conditions have been recorded since 1991 and from 1991 to 2007, normal conditions were noted in 12 of 17 years. Although based on only 2 years of data, an expansion factor of 3.87 is therefore believed to be germane to most years, and meets the USCTC standard for precision. Peak annual Chinook salmon escapement counts from 1975 to 2011 for the Blossom River are summarized in Table 2.

The expansion factor for the Chickamin River (Table 3) was addressed in 6 mark-recapture estimates of total escapement in 1996 and 2001–2005. The expansion factor for the Chickamin River is 4.75 (SE = 0.70, CV = 14.7%), and meets the USCTC standard. Peak annual Chinook salmon escapement counts from 1975 to 2011 for the Chickamin River are summarized in Tables 4 and 5.

Maintaining the stock assessment program for SEAK Chinook salmon at minimum USCTC standards is important to abundance-based management of PSC Chinook fisheries for 2 reasons. First, the CTC uses escapement data from 6 SEAK stocks, aggregated into a single stock group, in the Chinook salmon model for producing the annual preseason and postseason abundance indices, and other parameters. These six stocks include the five targeted in this operational plan. A second reason is that this work is important for stock specific, rather than coastwide, implementation of abundance-based management regimes. In the Pacific Salmon Treaty 2008 Revised Annexes, it states "SEAK fisheries will be managed to achieve escapement objectives for Southeast Alaska and Transboundary River Chinook stocks." (Chapter 3, footnote 16 to Attachment I). Data from this and other projects are essential for evaluation of escapement goals.

Table 2.–Escapement index counts, spawning escapement estimates of large (≥660 mm MEF) spawners, and expansion factors for Blossom River Chinook salmon population from 1975 to 2012. Escapement estimates in bold are from mark–recapture studies, and estimates in italics are from expanded survey counts.

Year	Survey counts	Spawning escapement	Expansion factor
1975	146	*565*	
1976	68	*263*	
1977	112	*433*	
1978	143	*553*	
1979	54	*209*	
1980	89	*344*	
1981	159	*615*	
1982	345	*1,335*	
1983	589	*2,279*	
1984	508	*1,966*	
1985	709	*2,744*	
1986	1,278	*4,946*	

-continued-

Table 2.–Page 2 of 2.

Year	Survey counts	Spawning escapement	Expansion factor
1987	1,349	*5,221*	
1988	384	*1,486*	
1989	344	*1,331*	
1990	257	*995*	
1991	239	*925*	
1992	150	*581*	
1993	303	*1,173*	
1994	161	*623*	
1995	217	*840*	
1996	220	*851*	
1997	132	*511*	
1998	91	**364**	4.0
1999	212	*820*	
2000	231	*894*	
2001	204	*789*	
2002	224	*867*	
2003	203	*786*	
2004	333	**734**	2.2
2005	445	**926**	2.0
2006	339	**1,270**	3.8
2007	135	*522*	
2008	257	*995*	
2009	123	*476*	
2010	180	*697*	
2011	147	*569*	
2012	205	*793*	
Averages:			
1975–2012	297	1,113	
2008–2012	182	706	

Table 3.–Estimated abundance ($\hat{N}$) from mark-recapture studies, relative precision (RP) of estimated abundance, numbers of large Chinook counted in the peak aerial survey (C), and associated expansion factors (E) for the Chickamin River.

Year	$\hat{N}$ *(SE)*	95% RP ($\hat{N}$)	*C* (condition)	$E = \hat{N} / C$
1995	2,309 (723)	0.61	356 (n/e)	6.49
1996	1,587 (199)	0.25	422 (n/e)	3.76
2001	5,177 (972)	0.37	1,010 (n/e)	5.12
2002	5,007 (708)	0.28	1,013 (n/e)	4.94
2003	4,579 (592)	0.25	964 (n/e)	4.75
2004	4,268 (893)	0.41	798 (n/e)	5.35
2005	4,257 (591)	0.27	926 (n/e)	4.60
Average[a]	4,146	0.31	856	4.75

[a] 1995 not included due to the relatively low precision in $\hat{N}$.

Note: observed survey condition are p = poor, n = normal, e = excellent.

Table 4.–Estimated abundance ($\hat{N}$) of the spawning population of large ($\geq$ 660 mm MEF) Chinook salmon in the Chickamin River using the mean expansion factor (4.75, SE = 0.70), 1975–2012. The expansion factor is calculated from mark-recapture experiments and survey results in 1996 and 2001–2005.

Year	Peak index count	$\hat{N}$	SE ($\hat{N}$)	M-R	SE (M-R)	Preferred	SE
1975	370	1,758	259			1,758	259
1976	157	746	110			746	110
1977	363	1,724	254			1,724	254
1978	308	1,463	216			1,463	216
1979	239	1,135	167			1,135	167
1980	445	2,114	312			2,114	312
1981	384	1,824	269			1,824	269
1982	571	2,712	400			2,712	400
1983	599	2,845	419			2,845	419
1984	1,102	5,235	771			5,235	771
1985	956	4,541	669			4,541	669
1986	1,745	8,289	1,222			8,289	1,222
1987	975	4,631	683			4,631	683
1988	786	3,734	550			3,734	550
1989	934	4,437	654			4,437	654
1990	564	2,679	395			2,679	395
1991	487	2,313	341			2,313	341
1992	346	1,644	242			1,644	242
1993	389	1,848	272			1,848	272
1994	388	1,843	272			1,843	272
1995	356	1,691	249	2,309	723	2,309	723
1996	422	2,005	295	1,587	199	1,587	199
1997	272	1,292	190			1,292	190
1998	391	1,857	274			1,857	274
1999	501	2,380	351			2,380	351
2000	801	3,805	561			3,805	561
2001	1,010	4,798	707	5,177	972	5,177	972
2002	1,013	4,812	709	5,007	738	5,007	738
2003	964	4,579	675	4,579	592	4,579	592
2004	798	3,791	559	4,268	893	4,268	893
2005	926	4,399	648	4,257	591	4,257	591
2006	1,330	6,318	931			6,318	931
2007	893	4,242	625			4,242	625
2008	1,111	5,277	778			5,277	778
2009	611	2,902	428			2,902	428
2010	1,156	5,491	809			5,491	809
2011	852	4,047	596			4,047	596
2012	444	2,109	311			2,109	311
Averages:							
1975–2012	683	3,245	478			3,274	501
2008–2012	835	3,965	584			3,965	584

Table 5.–Peak counts of Chinook salmon in index tributaries of the Chickamin River, 1975–2012.

Year	South Fork Creek		Barrier Cr		Butler Cr		Leduc Cr		Indian Cr		Humpy Cr		King Creek		Clear Falls Creek	
1975	141	(H)	9	(H)	66	(H)	6	(H)	90	(H)	7	(H)	30	(H)	–	–
1976	46	(H)	10	(H)	15	(H)	12	(H)	9	(H)	–	–	–	–	–	–
1977	52	(H)	66	(H)	30	(H)	26	(H)	53	(H)	0	(H)	–	–	–	–
1978	21	(H)	94	(H)	4	(H)	42	(H)	20	(H)	–	–	–	–	–	–
1979	63	(H)	17	(H)	29	(H)	0	(H)	31	(H)	–	–	–	–	–	–
1980	56	(H)	62	(H)	104	(H)	17	(H)	22	(H)	–	–	–	–	–	–
1981	51	(H)	105	(H)	51	(H)	25	(H)	12	(H)	4	(F)	105	(F)	31	(H)
1982	84	(H)	149	(H)	37	(H)	36	(H)	30	(F)	37	(F)	165	(F)	33	(H)
1983	28	(H)	138	(H)	91	(H)	30	(H)	47	(H)	–		212	(F)	30	(H)
1984	185	(H)	171	(H)	124	(H)	15	(H)	103	(H)	88	(F)	388	(F)	28	(H)
1985	163	(H)	129	(H)	92	(H)	8	(H)	125	(H)	50	(H)	377	(H)	12	(H)
1986	562	(H)	168	(H)	203	(H)	20	(H)	120	(H)	–		564	(H)	40	(H)
1987	261	(H)	76	(H)	120	(H)	19	(H)	115	(H)	26	(H)	310	(H)	48	(H)
1988	280	(H/F)	82	(H/F)	159	(H)	25	(H/F)	32	(H)	19	(H/F)	164	(H)	25	(H/F)
1989	226	(H/F)	90	(H)	137	(H)	57	(H)	84	(H)	22	(H/F)	224	(H)	94	(H)
1990	135	(F)	107	(H)	27	(H)	20	(H)	24	(H)	35	(H)	163	(H)	53	(H)
1991	125	(H)	18	(H)	49	(H)	14	(H)	38	(H)	13	(H)	185	(H)	45	(H)
1992	87	(H)	4	(H)	68	(H)	4	(H)	20	(H)	8	(H)	131	(H)	24	(H)
1993	67	N(H)	46	E(H)	68	N(H)	11	N(H)	29	N(H)	13	N(H)	80	N(H)	75	N(H)
1994	31	N(H)	29	E(H)	64	E(H)	18	E(H)	16	N(H)	44	N(H)	129	E(H)	57	E(H)
1995	87	E(H)	12	E(F)	59	E(F)	60	E(H)	36	N(F)	13	N(F)	62	N(H)	27	E(H)
1996	72	N(H)	13	N(F)	74	E(H)	23	E(H)	48	N(F)	30	N(F)	106	F(E)	56	E(H)
1997	28	P(H)	10	N(H)	43	N(H)	7	N(H)	24	N(H)	15	N(H)	95	N(H)	50	N(H)
1998	46	N(H)	0	N(H)	124	E(H)	16	P(H)	46	N(H)	28	N(H)	123	N(H)	8	P(H)
1999	54	N(H)	18	N(H)	106	N(H)	33	N(H)	52	N(F)	16	N(F)	200	N(H)	22	N(H)
2000	109	N(H)	27	N(H)	230	E(H)	61	N(H)	63	N(H)	20	N(H)	251	N(H)	40	P(H)
2001	264	E(H)	27	N(H)	270	E(H)	59	N(H)	61	N(H)	78	N(F)	221	N(H)	30	N(H)
2002	329	N(H)	20	N(H)	102	N(H)	23	N(H)	146	E(H)	9	P(H)	361	E(H)	23	N(H)
2003	183	E(H)	13	N(H)	172	N(H)	37	E(H)	21	N(H)	119	E(H)	363	N(H)	56	N(H)
2004	109	N(H)	17	N(H)	143	N(H)	35	E(F)	56	E(F)	162	E(F)	272	N(H)	4	P(H)
2005	104	P(H)	46	E(H)	115	N(H)	69	N(H)	49	N(H)	38	N(H)	450	E(H)	53	N(H)
2006	179	E(H)	10	N(H)	325	N(H)	52	N(H)	55	N(H)	37	E(H)	620	N(H)	52	N(H)
2007	197	N(H)	19	N(H)	133	N(H)	15	N(F)	66	N(F)	96	F(N)	315	N(H)	52	N(H)
2008	87	N(H)	3	N(H)	68	N(H)	5	P(H)	76	N(F)	190	E(H)	622	E(H)	60	N(H)
2009	74	N(H)	7	N(H)	251	N(H)	17	N(H)	55	N(F)	30	E(H)	172	N(H)	5	N(H)
2010	243	E(H)	43	N(H)	240	N(H0	57	E(H)	123	N(F)	80	N(H)	368	N(H)	2	(H)
2011	158	N(H)	3	N(H)	166	N(H)	10	N(H)	79	N(H)	17	N(H)	418	N(H)	1	N(H)
2012	90	N(H)	26	N(H)	134	N(H)	27	N(H)	20	N(H)	26	N(H)	121	N(H)	0	N(H)
Averages:																
1975–2012	134		50		113		27		55		43		253		36	
2008–2012	130		16		172		23		70		68		340		14	

Note: H = helicopter, F = foot, P = poor, N = normal, E = excellent.

OBJECTIVES

The research objectives[1] for 2013 are to:

1. Estimate the age and sex composition of large (≥660 mm MEF) Chinook salmon spawning in:
    a. the Chickamin River such that all estimated fractions are within 10[2] percentage points of the true values 95% of the time;

[1] Age, sex, and length data and estimation of escapement for the Unuk River (1 of 6 index systems for SEAK) is described in a separate operational plan: A Mark-Recapture Experiment to Estimate the Escapement of Chinook Salmon in the Unuk River, 2013

[2] In prior years prescribed precision for the Chickamin River was 5 percentage points; reduced budgets have forced us to reduce anticipated precision. The cited level of precision (within 10 percentage points 95% of the time) is still acceptable with respect to PSC guidelines

b. the Keta River such that all estimated fractions are within 10 percentage points of the true values 95% of the time;

c. the Blossom River such that all estimated fractions are within 10 percentage points of the true values 90% of the time;

d. the King Salmon River such that all estimated fractions are within 15 percentage points of the true values 90% of the time; and

e. Andrew Creek such that all estimated fractions are within 8 percentage points of the true values 95% of the time.

2. Estimate adult escapements of Chinook salmon in the systems outlined in Objective 1 by expanding the peak survey counts such that the coefficient of variation of the expanded survey counts is ≤20% for the Chickamin, Keta, Blossum and King Salmon systems and ≤25% for Andrew Creek[3].

SECONDARY OBJECTIVES

1. Estimate mean length-at-age of Chinook salmon by system.
2. Count all large fish observed during age-sex-length sampling trips.

3 Estimate the escapement and age-sex composition of small (<400 mm MEF) and medium (≥400 mm and <660 mm MEF) Chinook salmon.

4 Examine all sampled fish for a missing adipose fin; these fish will be strays in 2013.

METHODS

STUDY DESIGN

Age, sex, and length data will be collected from all Chinook salmon sampled at upriver spawning locations, and all observed Chinook salmon will be counted (Objective 1 a-e, Secondary Objectives 1–3). All sampled Chinook salmon will also be inspected for adipose fins and dead, postspawn fish, or fish <700 mm MEF without adipose fins, will be sacrificed for coded wire tag (CWT) information (Secondary Objective 4). Peak survey counts of large fish in the five rivers will be expanded to total escapements of large fish using established expansion factors; collection of peak survey data is described in the operational plan: *Escapement of Chinook Salmon in Southeast Alaska and Transboundary Rivers in 2013.*

Effort Distribution

Effort will be distributed across known spawning areas and time of spawning for each system with the goal that every spawning fish has a similar probability of being sampled.

Effort will be distributed among tributaries on the Chickamin River (Figure 2) based on a spawning distribution calculated from peak counts over an 12-year period 2001–2012. It is assumed that peak survey counts are a constant proportion of the spawning abundance in each area of the Chickamin River. The distribution of effort and estimates of spawning dates around which sampling should be concentrated are shown below:

[3] The coefficient of variation for Andrew Creek does not meet USCTC standards; improvement of this precision requires studies outside the scope of this plan (more precise estimation of the escapement for Andrew Creek along with accompanying peak survey data).

Tributary	Range of prime sampling dates	Estimated date of peak spawning	% Effort (based on 12-year average of survey counts)
Chickamin River			
1. King Creek	8/15–9/06	9/01	39
2. South Fork Creek	8/12–8/30	8/18	18
3. Butler Creek	8/01–8/20	8/10	19
4. Humpy Creek	8/24–9/06	9/01	8
5. Indian Creek	8/01–8/20	8/10	7
6. Clear Falls Creek	8/01–8/20	8/10	3
7. Leduc Creek	8/01–8/20	8/10	4
8. Barrier Creek	8/07–8/20	8/12	2

Actual sample dates may be adjusted to coincide with observed abundances and/or water conditions. Roughly 55% of sampling effort should be spent on South Fork and King creeks, roughly 30% on Butler and Humpy creeks, and about 20% on Indian, Clear Falls, Barrier, and Leduc creeks.

Samplers will sample each tributary on at least 2 different days across the range of sampling dates, with the exception of Butler Creek, which will only be sampled on 1 day in compliance with U.S. Forest Service permit stipulations regarding helicopter landings. Tributaries with fewer fish (Barrier, Leduc, and Clear Falls) may be thoroughly sampled in a day, while those with many fish (King, South Fork, and Butler creeks) may take a day or two per trip to sample thoroughly. However, Indian Creek, (and the “Indian Creek tributaries”) may take an entire day because it requires a long boat ride and a long walk. An initial trip into Indian Creek should occur on or about 3 August, based on historically low catches at Indian Creek after 9 August. Sampling data will be collected as described below (Escapement Sampling).

The Blossom and Keta rivers are too big and the spawning areas too widely dispersed to conduct foot surveys without helicopter assistance. Crews from Ketchikan and/or the Chickamin and Unuk base camps must fly in by helicopter and have the aircraft standby all day to move the crew from one spawning area to the next. Two to four trips to each system are required and each trip may take as much as 6 hours of flight time and up to 14 hours on the spawning grounds to maximize efficiency of helicopter and fishing time. It is noted that unlike the Chickamin River, the Blossom and Keta rivers do not have substantial spawning tributaries.

To sample the King Salmon River, a crew from Juneau will be dropped off by helicopter at the upper end of the spawning area, work their way downstream to the mouth and be picked up again by helicopter. Flight time per trip is variable and 3 or 4 trips may be necessary to collect enough samples because of the small run size and dispersed spawning.

To sample Andrew Creek a crew must fly to Wrangell and travel by boat to a camp, and boat from there to the stream proper.

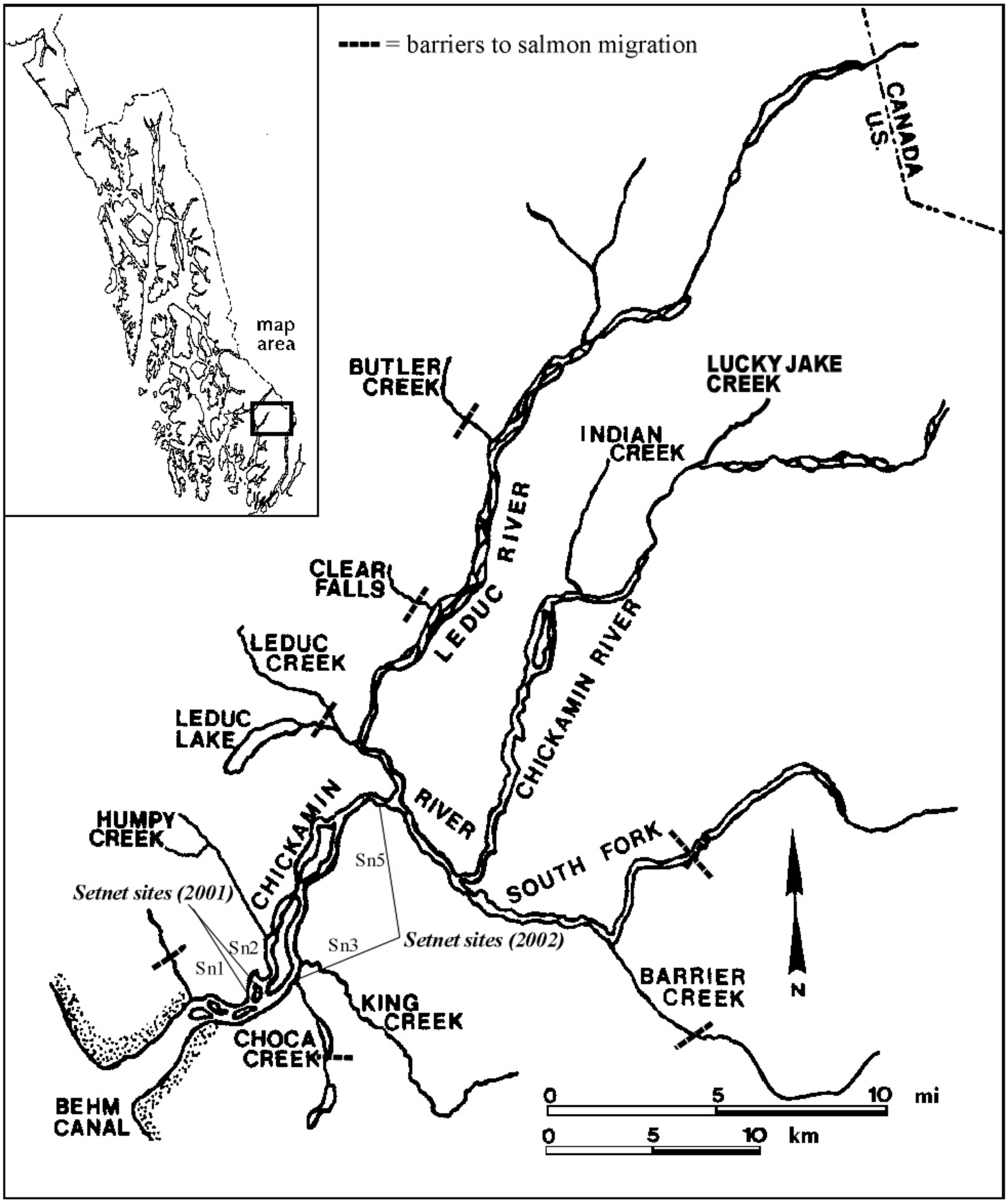

Figure 2.–Chickamin River drainage, with major tributaries, Alaska Department of Fish and Game research sites, and barriers to salmon migration depicted.

The project leader will adjust the actual sampling schedule in concert with the crew leader as needed; the goal is to sample as many fish as possible while attempting to sample a constant fraction of the escapement from every major spawning area.

Age-Sex-Length and Coded Wire Tag Sampling

Spawning ground sampling will begin approximately 1 August and continue as long as sampling is effective (approximately 15 September). The goal of sampling is 2-fold: 1) to estimate ASL compositions, and 2) to report the numbers of large fish seen.

In order to prevent double sampling of fish on the spawning grounds, every live and dead fish sampled will be given an operculum punch on the lower one-third (ventral side) of the left operculum (LLOP). Additionally, every dead fish sampled will be slashed several times through the preferred area on the left side using a knife. All previously unsampled Chinook salmon found or captured on the spawning grounds, regardless of size, will be counted and sampled for ASL and adipose clips. Note that any fish not suitable for sampling (head or tail missing, mangled beyond accurate length measurement, etc.) will be ignored and not sampled. A variety of gear including dip nets, rod and reel snagging gear, short sections of netting, and spears (for dead fish) will be used to collect fish for sampling. Previous studies have shown this approach is effective for collecting age and sex composition samples and has little significant potential for bias. During studies on the Unuk River (Jones et al. 1998; Jones and McPherson 1999, 2000, and 2002), the Taku River (McPherson et al. 1997), and the Chickamin River (Freeman and McPherson 2003–2005), no significant size bias was detected for large Chinook salmon when these field procedures were carefully and diligently applied. Fish observed on the spawning grounds will be selected for sampling without conscious regard to their sex or size. During each survey all fish will be counted and previously unsampled fish will be inspected to identify marks and determine sex, and measured to determine length (mm MEF). All fish <700 mm MEF (predominantly males) found during sampling that are missing the adipose fin will be sacrificed for recovery of the CWT (See CWT sampling section), whether dead or alive. All fish ≥700 mm MEF missing the adipose fin and determined to be in a postspawn state will also be sacrificed for recovery of the CWT.

SAMPLE SIZES

Age Composition Estimation

Assuming no size or sex selectivity, 240 large fish for Andrew Creek, 153 large fish each for Chickamin and Keta rivers, 122 large fish for Blossom River (no FPC and a scale regeneration rate of 17%), and 50 large fish for the King Salmon River (assuming an FPC, a population size of about 150 fish, and a scale regeneration rate of 30%) must be collected to meet objective criteria, according to the methods of Thompson (1987). From 2006 to 2012, an average of 454 large fish were sampled annually for scales in the Chickamin River, and from 2001 through 2009 an average of 121 and 192 large fish were sampled in the Blossom and Keta rivers, respectively; the Blossom and Keta rivers were not sampled in 2010 due to budget shortfalls and were not sampled in 2011 because of persistent flooding and inclement weather. In 2012, 20 samples were collected on the Bossom River and 91 were collected on the Keta River. Poor weather and higher than normal water resulted in few trips and smaller sample sizes. Effort on the Chickamin River will likely be reduced in 2013 due to budget constraints, but we are confident that more than 153 aged scales can be sampled. Effort on the Keta and Blossom rivers will be commensurate with the levels associated with sampling in 2001–2009, and the precision criteria in Objective 1 should be met. Effort on Andrew Creek will be commensurate with levels in the past when typically 200 to 250 samples are collected, and we are confident that sampling goals can be met. King Salmon River sampling effort will be similar to levels in the past when 60 to 80 samples were typically collected, and we are confident that we will meet sampling goals. If we exceed the scale sampling goal for a river, all scales will be aged because it is not difficult or expensive.

Expanded Survey Count

Chickamin

The bootstrap variance estimated using Eq. 15 in Appendix B1 ($\mathrm{var}(\pi_p)$) for the mark-recapture and survey count data for 1995–1996 and 2001–2005 is 0.7^2 (Weller et al. 2007b). The mean expansion factor for these years is 4.75. From Eq 16 and 17 in Appendix B1, the expected coefficient of variation of the expanded peak survey count is then,

$$\sqrt{C_{2013}^2 0.7^2} \Big/ \bar{\pi} C_{2013} = 0.7/4.75 \approx 0.15$$

so the objective criterion in Objective 2 should be achieved in the Chickamin River.

Blossom

The mean expansion factor for the two years with normal survey conditions is 3.87 (SE = 0.62, CV = 16.1%) and meets the USCTC standard for precision (Objective 2, Weller et al. 2007a)

Keta

The expansion factor for the Keta River is 3.01 (SE = 0.56, CV = 18.6%), and meets the USCTC standard for precision (Objective 2; Der Hovanisian et. al 2011)

King Salmon

The expansion factor for the King Salmon River is 1.52 (SE = 0.27, CV = 17.8%), and meets the USCTC standard for precision (Objective 2; Der Hovanisian et. al 2011)

Andrew Creek

The expansion factor for the Andrew Creek is 1.95 (SE = 0.45, CV = 23.1%), and meets the USCTC standard for precision. (Objective 2; Der Hovanisian et. al 2011)

DATA COLLECTION

Age-Sex-Length and Coded Wire Tag Sampling

All Chinook salmon caught on the spawning grounds will be sampled for ASL. Data from fish sampled on the spawning grounds will be recorded on the Spawning Grounds Age-Sex-Length Form (Appendix A1). For age composition sampling, it is imperative that good scale samples be taken. Five scales will be removed from the preferred area on the left side accordingly: 3 scales from 2 to 3 rows above the lateral line taken 1 inch apart, and 2 scales 4 to 5 rows up and 0.5 inch from one of the lower 3 scales (Welander 1940). In some cases the preferred area on the left side of the fish may be devoid of scales. In such instances, the preferred area on the right side of the fish should be sampled for scales and if this is devoid of adequate samples, then samples should be taken from the areas near the dorsal or anal fins on the left side of the fish. All scales will be carefully cleaned, mounted on scale gum cards, five per column, using methods described in ADF&G (*unpublished*)[4]. The gum cards will be labeled completely at the time of sampling, or shortly thereafter. Scale cards are sequentially numbered by sampling location, beginning with 001 at each sampling location. The correct ASL stream code (Table 6) should also be recorded on each card. Gender will be determined from secondary maturation characteristics and length will be measured to the nearest 5 mm MEF. Secondary maturation characteristics can include predominant snouts and compressiform bodies for males, and abraded caudal fins (i.e., white tails) and prominent bellies for females. Scales will be cleaned and mounted neatly, without excess water, sand, or mucus. If it is not possible to mount the scales in this manner on site, then the scales will be stored in numbered plastic slide pockets and then mounted later with care taken to clean them properly and to label the gum cards completely, including last names of all samplers for that location for that day. If scales are not collected from a fish for any reason, note that in the comment column on the ASL form and make sure to skip that column on the gum card.

Table 6.–Alaska Department of Fish and Game stream codes for Chickamin River drainage Chinook salmon index tributaries, and Blossom and Keta rivers.

Location	Stream number	Coded wire tag sample number	Age-sex-length number
Chickamin River	101-71-10040	46000*X*	101-71-004
Humpy Creek	101-71-10040-2005	46300X	101-71-04H
Choca Creek	101-71-10040-2004	46100X	101-71-04E
King Creek	101-71-10040-2006	46200X	101-71-04K
LeDuc Creek	101-71-10040-2015-3003	46400X	101-71-04L
Clear Falls Creek	101-71-10010-2015-3009	46600X	101-71-04C
South Fork	101-71-10040-2018	46900X	101-71-04S
Barrier Creek	101-71-10040-2018-3010	46700X	101-71-04A
Indian Creek	101-71-10040-2025	46800X	101-71-04I
Butler Creek	101-71-10040-2015-3013	46750X	101-71-04B
Clear Creek		46350X	
Pond Slough	101-71-10060	46450X	
Blossom River	101-55-10400	DQ000x	101-55-040
Keta River	101-30-10300	DQ000x	101-55-020
Andrew Creek			108-40-020
King Salmon River			111-17-010

A Coded Wire Tag Sampling Form (Appendix A3) will also be filled out for each day's spawning grounds sampling at each location. Any fish sampled on the spawning grounds, live or dead, missing an adipose fin will be noted. Furthermore, heads will be removed from all adipose-finclipped Chinook salmon that are dead, post spawn, or <700 mm MEF in length, and a scale sample will be taken. A uniquely numbered cinch tag from the escapement sampling packet provided by the ADF&G Mark, Tag, and Age Laboratory (Tag Lab) will be attached to each head. These heads will then be sent to the Tag Lab along with the CWT form.

[4] ADF&G (Alaska Department of Fish and Game). *Unpublished*. Length, sex, and scale sampling procedure for sampling using the ADF&G adult salmon age-length mark-sense form version 3.0. Division of Commercial Fisheries, Douglas.

Most importantly:

- sample every Chinook salmon encountered on the spawning grounds, regardless of size, and record all data for each fish on the appropriate form;
- check every fish for the presence or absence of an adipose fin and LLOP;
- collect clean, readable scales from the preferred area (or other areas if necessary); and
- collect heads and scales from all adipose-clipped fish that are dead, post spawn, or <700 mm MEF.

Survey Counts

A count will be made of the total number of large fish seen by observers traversing a tributary on a single day; this count will be recorded on the Spawning Grounds Survey Form (Appendix A2) each day a survey count is made (see Study Design above for more details). The location, date, stream code (Table 6), survey number, surveyors, all water and weather conditions, total number of large fish, and predators will be recorded on this form. The percentage of fish the observer(s) believed were counted, and why they thought so, will also be recorded.

DATA REDUCTION

It is the responsibility of the field crew leader to record and error-check all data. Data forms are to be filled out daily and kept up to date at all times. Data forms should be error free, legible, and complete. Scales on gum cards should be clean and cards must be labeled completely and stored flat and dry. Data will be transferred from field books or forms to Excel® [5]spreadsheet files. When input is complete, data lists will be obtained and checked against the original field data.

The Tag Lab in Juneau is the clearinghouse for all information on CWTs. Completed CWT summary and release information will be sent to the Tag Lab, after first being given to the project leader and error checked using computer software. All CWT data (sampled fish, decoded tags, location, data type, samplers, etc.) are archived and accessible on a permanent ADF&G statewide database, and once per year are provided to the permanent coastwide database at the Pacific States Marine Fisheries Commission.

A final, edited copy of the data, along with a data map, will be sent to DSF, Research and Technical Services (RTS) in Anchorage electronically for archiving. The data map will include a description of all electronic files contained in the data archive, all data fields and details of where hard copies of any associated data are to be archived, if not in RTS. For this project, all recovery data is recorded by hand on specialized field forms, transcribed into Excel® workbooks and analyzed in Excel® and other commercial and custom software. All data sent to RTS electronically, and not archived elsewhere, will include the Excel® workbooks (presently in Office 2007) of the original raw data. The original hard copies of all tagging and recovery forms, scale gum cards and acetates will be logged and stored in the Region 1 ASL data archives, located in file cabinets in the Douglas regional office.

[5] This product name is included for a complete description of the process and does not constitute product endorsement.

DATA ANALYSIS

Age and Sex Composition of Escapement

The proportion of the spawning population composed of a given age c within a size class k (large, medium, and small) will be estimated as a binomial variable:

$$\hat{p}_{kc} = \frac{n_{kc}}{n_k}, \tag{1}$$

$$\mathrm{var}(\hat{p}_{kc}) = \frac{\hat{p}_{kc}(1-\hat{p}_{kc})}{n_k - 1} \tag{2}$$

where n_{kc} is the number of Chinook salmon of age c in size group k, and n_k is the number of Chinook salmon in the sample of size group k. Numbers of spawning fish by age will be estimated as the sum of the products of estimated age composition and estimated abundance within a size category:

$$\hat{N}_c = \sum_k (\hat{p}_{kc}\hat{N}_k) \tag{3}$$

Because the $\hat{N}_k$ in Eq. 3 are correlated ($\hat{N}_S$ and $\hat{N}_M$ are estimated from $\hat{N}_L$ by Eqs. 5 and 6), the $\mathrm{var}(\hat{N}_c)$ will be estimated by simulation. The stochastic components in the simulation will be: $\hat{N}^*_L \sim N(\hat{N}_L, \hat{\sigma}_{\hat{N}_L})$, $\underline{\hat{\phi}^*} \sim multinomial(n_{sp}, \underline{\hat{\phi}})/n_{sp}$, and the vector of age-sex proportions for the k^{th} size group as $\underline{\hat{p}}^*_k \sim multinomial(n_k, \underline{\hat{p}}_k)/n_k$. The above equations will be applied to each set of simulated values to produce a set of simulated numbers of spawning fish by age, $\hat{N}^*_c$. The simulated variance of $\hat{N}_c$ will be taken as the sample variance of the $\hat{N}^*_c$'s.

The proportion of the spawning population composed of a given age will be estimated as the summed totals across size categories:

$$\hat{p}_c = \frac{\hat{N}_c}{\hat{N}} \tag{4}$$

The $\mathrm{var}(\hat{p}_c)$ will be estimated as the sample variance of the $\hat{p}_c$ generated in the simulation described above.

Sex composition and age-sex composition for the entire spawning population and its associated variances will be estimated using the above equations by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_g$, where g denotes gender (male or female), such that $\sum_g \hat{p}_g = 1$, and by age-sex $\hat{p}_{cg}$, such that $\sum_{cg} \hat{p}_{cg} = 1$.

Estimation of Adult Abundance

The estimated abundance of large Chinook salmon, $\hat{N}_L$, will be calculated as described in Appendix B1, under the section "Systems where escapement is estimated".

The abundance of small-sized fish $\hat{N}_S$ and medium-sized fish $\hat{N}_M$ will be estimated indirectly by expanding the estimate for large fish by the estimated size composition of the spawning escapement (McPherson et al. 1997):

$$\hat{N}_S = \hat{N}_L \frac{\hat{\phi}_S}{\hat{\phi}_L} \tag{5}$$

$$\hat{N}_M = \hat{N}_L \frac{\hat{\phi}_M}{\hat{\phi}_L} \tag{6}$$

such that $\hat{\phi}_k$ is the estimated fraction of *k*-sized (small, medium, or large) fish in the Chinook salmon spawning population:

$$\hat{\phi}_k = \frac{n_k}{n_{sp}} \tag{7}$$

where,

n_{sp} = Number of fish sampled on the spawning grounds

n_k = Number of *k*-sized fish found in n_{sp},

with variance estimated as :

$$\text{var}(\hat{\phi}_k) = \frac{\hat{\phi}_k(1-\hat{\phi}_k)}{n_{sp}-1} \tag{8}$$

Repeated testing has found no size or gender selectivity in spawning grounds samples.

The variance of the abundance of small fish will be estimated:

$$\text{var}(\hat{N}_S) = \hat{N}_L^{\ 2}\,\text{var}\left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right) + \left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right)^2 \text{var}(\hat{N}_L) - \text{var}\left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right)\text{var}(\hat{N}_L) \tag{9}$$

where by the delta method (note that $Cov(\hat{\phi}_S, \hat{\phi}_L) = -\frac{\hat{\phi}_S \hat{\phi}_L}{n_{sp}})$,

$$\text{var}\left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right) \approx \left(\frac{\hat{\phi}_S}{\hat{\phi}_L}\right)^2 \left(\frac{\text{var}(\hat{\phi}_S)}{\hat{\phi}_S^2} + \frac{\text{var}(\hat{\phi}_L)}{\hat{\phi}_L^2} + \frac{2}{n_{sp}}\right) \tag{10}$$

Similarly,

$$\text{var}(\hat{N}_M) = \hat{N}_L^{\ 2}\,\text{var}\left(\frac{\hat{\phi}_M}{\hat{\phi}_L}\right) + \left(\frac{\hat{\phi}_M}{\hat{\phi}_L}\right)^2 \text{var}(\hat{N}_L) - \text{var}\left(\frac{\hat{\phi}_M}{\hat{\phi}_L}\right)\text{var}(\hat{N}_L) \tag{11}$$

The abundance of all fish will be estimated as:

$$\hat{N}_{ALL} = \frac{\hat{N}_L}{\hat{\phi}_L} \tag{12}$$

with variance estimated as:

$$\text{var}(\hat{N}_{ALL}) = \text{var}(\hat{N}_L)\left[\frac{1}{\hat{\phi}_L}\right]^2 + \hat{N}_L^{\,2}\,\text{var}\left[\frac{1}{\hat{\phi}}\right] - \text{var}(\hat{N}_L)\,\text{var}\left[\frac{1}{\hat{\phi}}\right] \tag{13}$$

where,

$$\text{var}\left(\frac{1}{\hat{\phi}_L}\right) \approx \left[\frac{1}{\hat{\phi}_L}\right]^4 \text{var}(\hat{\phi}_L) \tag{14}$$

SCHEDULE AND DELIVERABLES

The crew will begin work on 1 August 2013. Spawning ground sampling will begin approximately 1 August and continue as long as sampling is effective (approximately 15 September). Raw field data will be entered and error checked by 30 November. An ADF&G Fishery Data Series report will be prepared in draft by 1 July 2014 summarizing the results of this project.

RESPONSIBILITIES

Todd Johnson, Fisheries Biologist II (project leader)

Duties: This position is responsible for supervision of all project activities, including administrative, field, personnel and other activities. Maintains weekly contact with crew leader, daily contact with logistics coordinator, and tracks sampling effort, logistics, personnel, etc. Will edit, error-check, analyze, and report data for project under supervision of Richards. Will track budget and stay within allocations. Ensures project follows operational plan and actively participates in field operations. Will conduct or assist Richards with aerial Chinook salmon index surveys. Will conduct start-of-project meetings with field crew and Sanguinetti. Follows departmental and state policy.

David Evans, Biometrician III

Duties: Provides input to and approves sampling design. Reviews and provided biometric support for operational plan, data analysis, and final report.

Philip Richards, FB III

Duties: Supervises Johnson. Will oversee or assign aerial Chinook salmon index surveys and may assist with field work.

Ed Jones, Salmon Research Coordinator

Duties: This position is the DSF Salmon Research Coordinator for salmon stock assessment and provides program and budget planning oversight. Also reviews the operational plan, data analysis, and final report.

Micah Sanguinetti, Fish and Wildlife Technician IV (project expeditor)

Duties: This position serves as logistics coordinator and is responsible for expediting project activities from Ketchikan over the duration. Responsible for daily contact with field crew by radio or satellite phone, arranging logistics with field crew and project leader, purchasing supplies, loading and unloading supply planes and barge, and follows departmental and state policy. Will enter and edit data and assist with field operations as needed. Follows departmental and state policy.

David Dreyer, Fish and Wildlife Technician IV (crew leader)

Duties: This position is the primary crew leader. Responsible for assisting in all aspects of field operations, including safe operation of riverboats and motors and all other equipment, data collection and editing, maintenance of jet outboard and skiff, daily radio or satellite phone contacts with office expeditor or project leader, and general camp duties. Responsible for leading spawning grounds team and for inventorying equipment and supplies at end of project. Will work in consultation with the project leader on personnel and administrative issues, as encountered. Follows departmental and state policy in all matters.

Vacant, Fish and Wildlife Technician III.

Duties: This position is responsible for assisting in all aspects of field operations, including safe operation of riverboats and motors and all other equipment, data collection and editing, maintenance of jet outboard and skiff, daily radio or satellite phone contacts with office expeditor or project leader, and general camp duties. Responsible for daily cleaning and maintenance of equipment as assigned by the crew leader. Follows departmental and state policy in all matters.

Vacant, Fish and Wildlife Technician II

Duties: This position is responsible for assisting in all aspects of field operations including data collection and the safe operation of riverboats and all other equipment. Responsible for daily cleaning and maintenance of equipment, as assigned by the crew leader. Follows departmental and state policy in all matters.

REFERENCES CITED

Der Hovanisian, J., S. McPherson, E. Jones, P. Richards, R. Chapell, B. Elliott, T. Johnson and S. Fleischman. 2011. Chinook salmon status and escapement goals for stocks in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 11-19 Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/sp11-19.pdf

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, New York. 436 pp.

Freeman, G. M. and S.A. McPherson. 2003. Spawning abundance of Chinook salmon in the Chickamin River in 2001. Alaska Department of Fish and Game, Fishery Data Series No, 03-14, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds03-14.pdf

Freeman, G. M. and S.A. McPherson. 2004. Spawning abundance of Chinook salmon in the Chickamin River in 2002. Alaska Department of Fish and Game, Fishery Data Series No, 04-09, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds04-09.pdf

Freeman, G. M. and S.A. McPherson. 2005. Spawning abundance of Chinook salmon in the Chickamin River in 2003. Alaska Department of Fish and Game, Fishery Data Series No, 05-63, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds05-63.pdf

REFERENCES CITED (continued)

Jones III, E. L. and S. A. McPherson. 1999. A mark-recapture experiment to estimate the escapement of Chinook salmon in the Unuk River, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-14, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds99-14.pdf

Jones III, E. L. and S. A. McPherson. 2000. A mark-recapture experiment to estimate the escapement of Chinook salmon in the Unuk River, 1999. Alaska Department of Fish and Game, Fishery Data Series No. 00-22, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds00-22.pdf

Jones III, E.L. and S.A. McPherson. 2002. A mark-recapture experiment to estimate the escapement of Chinook salmon in the Unuk River, 2000. Alaska Department of Fish and Game, Fishery Data Series No, 02-17, Anchorage. . http://www.adfg.alaska.gov/FedAidpdfs/fds02-17.pdf

Jones III, Edgar L, S. A. McPherson and D. L. Magnus. 1998. A mark-recapture experiment to estimate the escapement of Chinook salmon in the Unuk River, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-23 , Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds98-23.pdf

McPherson, S. A., D. R. Bernard, M. S. Kelley, P. A. Milligan, and P. Timpany. 1997. Spawning abundance of Chinook salmon in the Taku River in 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-14, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds97-14.pdf

Mood, A.M., F.A. Graybill, and D.C. Boes. 1974. Introduction to the theory of statistics, 3rd ed. McGraw-Hill Book Co. New York. 564 pp.

Neter, J. and W. Wasserman. 1990. Applied linear statistical models. Richard D Irwin, Inc. Homewood, Ill. 1,181 pp.

Pacific Salmon Commission United States Chinook Technical Committee (USCTC). 1997. A review of stock assessment data and procedures for U.S. Chinook salmon stocks. Pacific Salmon Commission Report USTCHINOOK (97)-1. Vancouver, British Columbia, Canada. 75 pp.

Pahlke, K.A. 1993. Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 1992. Alaska Department of Fish and Game, Fishery Data Series No 93-46. Juneau. http://www.adfg.alaska.gov/FedAidpdfs/fds93-46.pdf

Pahlke, K.A. 2010. Escapements of Chinook salmon in Southeast Alaska and trransboundary rivers in 2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-71, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds10-71.pdf

Thompson, S.K. 1987. Sample size for estimating multinomial proportions. American Statistician. 41:42–46.

Welander, A. D. 1940. A study of the development of the scale of the Chinook salmon (Oncorhynchus tshawytscha). Master's thesis, University of Washington, Seattle.

Weller, J.L.,D.L Magnus, D.J. Reed, and K.A. Pahlke. 2007a. A mark-recapture experiment to estimate the escapement of Chinook salmon in the Blossom River, 2006. Alaska Department of Fish and Game, fishery Data Series No. 07-66, anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds07-66.pdf

Weller, J. L., D. J. Reed, and G. M. Freeman. 2007b. Spawning abundance of Chinook salmon in the Chickamin River in 2005. Alaska Department of Fish and Game, Fishery Data Series No. 07-63, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds07-63.pdf

APPENDIX A

Appendix A1.–Spawning grounds age-sex-length form, 2013.

Location: Year: 2013
Stream code:
Species:

Fish #	Date	Sex	Length MEF (mm)	Card #	Scale #	Age FW	Age SW	AEC	Ad Clip/ Cinch #	Gear type	Fish condition	Comments
1	8/9		805	1	1							
2	8/9	F	800	1	2					Lure	Pre	
3	8/9	M	760	1	3					Lure	Active	
4	8/9	M	675	1	4				433110	Snag	Active	Adclip sacrificed (adsac)
5	8/9	M	350	1	5					Lure	Pre	
6	8/9	F	900	1	6					Dip net	Pre	
7	8/9	F	925	1	7					Gillnet	Post	
8	8/9	F	780	1	8					Gillnet	Active	
9	8/9	M	850	1	9					Carcass	Dead	
10	8/9	M	875	1	10					Snag	Active	
11	8/9	M	1005	2	1					Snag	Pre	
12	8/9	M	750	2	2				433111	Snag	Post	Adsac
13	8/9	M	675	2	3					Carcass	Dead	
14	8/9	F	845	2	4					Carcass	Dead	
15	8/9	F	810	2	5					Lure	Post	
16	8/9	F	940	2	6					Lure	Post	
17	8/9	F	705	2	7					Snag	Post	

Appendix A2.–Spawning grounds survey form, 2013.

SPAWNING GROUNDS SURVEY FORM

(please be as detailed as possible)

Location: ________________________ Date: _______/________/______
(River, stream name)

Survey no. ____________ Surveyors____________________________
(1st, 2nd, etc.)

Water Conditions (water level, clarity, flow, temp, etc.): __________________________

____

Weather conditions: ____

A. Total number of large-sized fish counted __________

B. Rate survey conditions on a scale of 1-10 (10 = best) __________

C. What % of the fish present do you think you counted? __________

Why? ____

____

D. % of fish counted that were *fresh*: _______________

E. % of fish counted that were *spawned out*: _______________

F. % of fish counted that were *dead*: _______________

G. Signs of predation: ____

____

____

Other notes and comments: ____

____

____

Appendix A3.–Coded wire tag sampling form.

Alaska Department of Fish and Game

Coded Wire Tag Sampling Form

Hatchery Rack and Escapement Survey
Southeast Region

SAMPLE NUMBER: 9 _ _ _ _ _ _ _ PROJECT CODE (TAG LAB USE ONLY): ___ PAGE ___ OF ___ PAGES

HARVEST TYPE: (circle one) hatchery-rack escapement-survey

SURVEY SITE: ______________________

SAMPLE TYPE: random select

SAMPLER: ______________________

DATE SAMPLED: _ _ - _ _ - 9 _

SAMPLING INFORMATION

THIS BOX IS TO BE COMPLETED ONLY FOR RANDOM SAMPLES

SPECIES (CODE)	TOTAL # FISH COUNTED	# ADIPOSE CLIPS SEEN	WERE ALL SAMPLED?
(410)CHIN			y n
(411)JACK CHIN-ONLY			y n
(420)SOCK			y n
(430)COHO			y n
(440)PINK			y n
(450)CHUM			y n
(540)STHD			y n

AREA INFORMATION (DISTRICT - SUBDISTRICT)

101-	106-	111-	116-	157-	191-
102-	107-	112-	150-	181-	192-
103-	108-	113-	152-	182-	OTHER DISTRICTS
104-	109-	114-	154-	183-	____
105-	110-	115-	156-	189-	____

NAME OF PLACE SURVEYED: (NAME OF HATCHERY OR STREAM) ______________________

WATER TYPE: saltwater freshwater

ANADROMOUS STREAM# (FRESHWATER-ONLY) ___ - ___ - ___ - ___ - ___ - ___ - ___ - ___ - ___ - ___

HEAD RECOVERY INFORMATION

✓	HEAD NUMBER	SPECIES CODE	FORK LENGTH (mid-eye to fork in mm)	CLIP	SEX

COMMENTS

T:\FORMS\RAKSE96.VSD -4/96

APPENDIX B

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

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.

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'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*(π)-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.

The variance for prediction will be estimated (Neter and Wasserman 1990):

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\bar{\pi}) \tag{2}$$

where

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

and

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

such that

$$v\hat{a}r(\pi_p) = \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k-1} + \frac{\sum_{y=1}^{k} (\pi_y - \bar{\pi})^2}{k(k-1)} \tag{5}$$

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:

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

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:

$$v\hat{a}r(\pi_p) = v\hat{a}r(\pi) + v\hat{a}r(\bar{\pi}) \tag{7}$$

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 (Mood et al. 1974):

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

This relationship can be rearranged to isolate process error, that is:

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

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

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

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

We can calculate:

$$v\hat{a}r(\hat{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \bar{\pi})^2}{k-1} \tag{11}$$

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

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

where both process and measurement errors need to be included.

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 estimate $var(\hat{\pi})$ 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 can then estimate $var(\hat{\pi})$ using:

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

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:

$$v\hat{a}r(\pi_p) = v\hat{a}r_B(\hat{\pi}) - \frac{\sum_{y=1}^{k}\text{v\^{a}r}(\hat{\pi}_y)}{k} + v\hat{a}r_B(\overline{\pi}) \tag{15}$$

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 application 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:

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

and

$$v\hat{a}r(\hat{N}_p) = C_p^2 v\hat{a}r(\pi_p) \tag{17}$$