Regional Operational Plan SF.1J.2015.16

Estimation of Age, Sex, and Length Composition of Chinook Salmon in the Chickamin, Blossom, Keta and King Salmon Rivers, and Andrew Creek, 2015

by

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and

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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.2015.16

ESTIMATION OF AGE, SEX, AND LENGTH COMPOSITION OF CHINOOK SALMON IN THE CHICKAMIN, BLOSSOM, KETA AND KING SALMON RIVERS, AND ANDREW CREEK, 2015

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ABSTRACT

The primary goals of this project are to estimate the age-sex-length composition of the Chinook salmon (*Oncorhynchus tshawytscha)* escapement for the Chickamin, Blossom, Keta, King Salmon and Andrew Creek systems in Southeast Alaska and to expand peak survey counts on these systems to total escapement estimates. Sampled fish will also be examined for adipose clips. A separate project "Escapement of Chinook Salmon in Southeast Alaska and Trans-boundary rivers in 2015" will conduct standardized peak survey counts of these 5 systems. The age-sex composition of small (<400 mm Mid-eye to Fork (MEF), medium (≥400 mm and <660 mm MEF), and large (≥660 mm MEF) Chinook salmon will be estimated.

Key words: Chinook Salmon, *Oncorhynchus tshawytscha,* expansion factor, age, sex length composition, Southeast Alaska, aerial surveys, Chickamin River, Keta River, Blossom River, King Salmon River, Andrew Creek.

PURPOSE

The primary goals of this project are to: 1) estimate adult age-sex-length composition for 5 Chinook salmon index systems in Southeast Alaska, 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 of the Pacific Salmon Commission.

BACKGROUND

The Chickamin, Blossom, and Keta rivers are on the mainland and traverse the Misty Fjords National Monument in southern Southeast Alaska (SEAK); these rivers support runs of Chinook salmon (*Oncorhynchus tshawytscha)* ranging from approximately 200 to 8,200 large fish (≥660 mm Mid-eye to Fork (MEF), of which the Chickamin River represents the high end. The King Salmon River is located on Admiralty Island, south 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). Large spawners are defined as fish ≥660mm MEF. Locations of the 5 rivers are shown in Figure 1.

These five stocks of Chinook salmon are all harvested in SEAK fisheries and the Behm Canal stocks (Chickamin, Keta and Blossom) are also harvested to a minor extent in northern British Columbia fisheries. The Chickamin River produces one of the largest wild runs of Chinook salmon in the Behm Canal and Ketchikan area. The five 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, Blossom, Keta, and King Salmon rivers as well as Andrew Creek using a standardized method described in Richards et al. (*in press*). 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 Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC) 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 coast wide, from SEAK through Oregon, and to judge performance of management actions designed to rebuild wild stocks, in accordance with the 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).

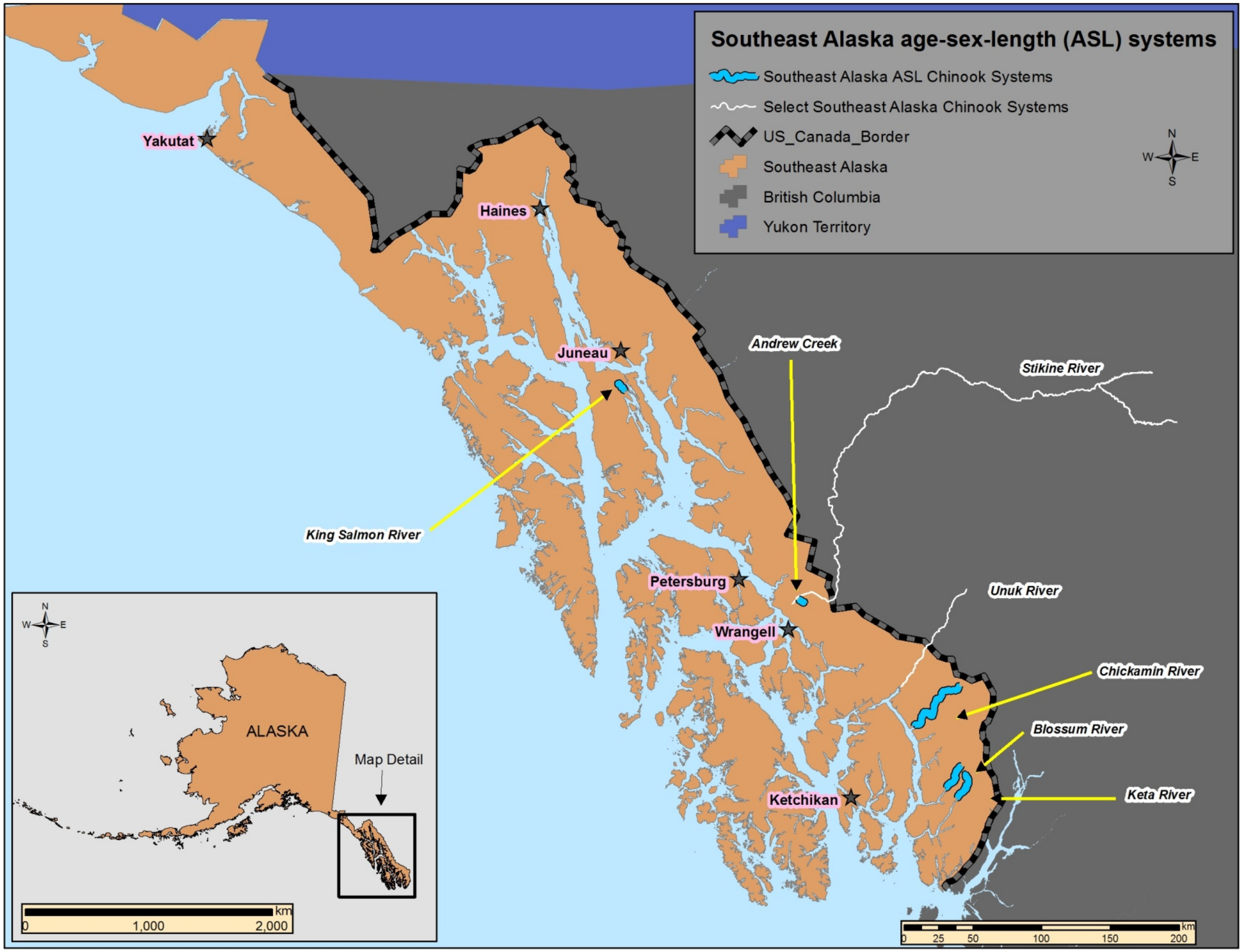

Figure 1.–Location of Chinook salmon systems in Southeast Alaska where age-sex-length information is collected.

The standard for escapement, developed by the USCTC, 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 escapement of large fish from 1998 to 2000 (Fleischman et al. 2011). 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 escapement counts of large Chinook salmon from 1975 to 2014 for the Keta River are summarized in Table 1.

The expansion factor for Blossom River was addressed in 4 annual mark-recapture estimates of escapement of large fish in 1998 and 2004–2006 (Fleischman et al. 2011). 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 large Chinook salmon escapement counts from 1975 to 2014 for the Blossom River are summarized in Table 2.

Peak annual escapement counts and mark recapture estimates of large Chinook salmon for Andrew Creek are summarized in Table 3, and those for King Salmon River are summarized in Table 4.

Table 1.–Escapement survey counts, escapement estimates of large (≥660 mm MEF) spawners, and expansion factors for Keta River Chinook salmon from 1975 to 2014, in Southeast Alaska.

Year	Survey Count	Spawning escapement	Expansion Factor
1975	203	611 [a]	–
1976	84	253 [a]	–
1977	230	692 [a]	–
1978	392	1,180 [a]	–
1979	426	1,282 [a]	–
1980	192	578 [a]	–
1981	329	990 [a]	–
1982	754	2,270 [a]	–
1983	822	2,474 [a]	–
1984	610	1,836 [a]	–
1985	624	1,878 [a]	–
1986	690	2,077 [a]	–
1987	768	2,312 [a]	–
1988	575	1,731 [a]	–
1989	1,155	3,477 [a]	–
1990	606	1,824 [a]	–
1991	272	819 [a]	–
1992	217	653 [a]	–
1993	362	1,090 [a]	–
1994	306	921 [a]	–
1995	175	527 [a]	–
1996	297	894 [a]	–
1997	246	740 [a]	–
1998	180	446 [b]	2.5
1999	276	968 [b]	3.5
2000	300	914 [b]	3.0
2001	343	1,032 [a]	–
2002	411	1,237 [a]	–
2003	322	969 [a]	–
2004	376	1,132 [a]	–
2005	497	1,496 [a]	–
2006	747	2,248 [a]	–
2007	311	936 [a]	–
2008	363	1,093 [a]	–
2009	172	518 [a]	–
2010	475	1,430 [a]	–
2011	223	671 [a]	–
2012	241	725 [a]	–
2013	493	1,484 [a]	–
2014	439	1321 [a]	
Averages:			
1975-2010	420	1,265	–
2006-2014	385	1,159	–

[a] Escapement estimates calculated from expanded survey counts.

[b] Escapement estimates calculated from mark-recapture studies.

Table 2.–Escapement index counts, escapement estimates of large (≥660 mm MEF) spawners, and expansion factors for Blossom River Chinook salmon population from 1975 to 2014, in Southeast Alaska.

Year	Survey Counts	Spawning Escapement	Expansion factor
1975	146	565 [a]	–
1976	68	263 [a]	–
1977	112	433 [a]	–
1978	143	553 [a]	–
1979	54	209 [a]	–
1980	89	344 [a]	–
1981	159	615 [a]	–
1982	345	1,335 [a]	–
1983	589	2,279 [a]	–
1984	508	1,966 [a]	–
1985	709	2,744 [a]	–
1986	1,278	4,946 [a]	–
1987	1,349	5,221 [a]	–
1988	384	1,486 [a]	–
1989	344	1,331 [a]	–
1990	257	995 [a]	–
1991	239	925 [a]	–
1992	150	581 [a]	–
1993	303	1,173 [a]	–
1994	161	623 [a]	–
1995	217	840 [a]	–
1996	220	851 [a]	–
1997	132	511 [a]	–
1998	91	364 [b]	4.0
1999	212	820 [a]	–
2000	231	894 [a]	–
2001	204	789 [a]	–
2002	224	867 [a]	–
2003	203	786 [a]	–
2004	333	734 [b]	2.2
2005	445	926 [b]	2.0
2006	339	1,270 [b]	3.8
2007	135	522 [a]	–
2008	257	995 [a]	–
2009	123	476 [a]	–
2010	180	697 [a]	–
2011	147	569 [a]	–
2012	205	793 [a]	–
2013	255	987 [a]	–
2014	217	840 [a]	–
Averages:			
1975–2014	304	1,137	–
2006–2014	206	794	–

[a] Escapement estimates calculated from expanded survey counts.

[b] Escapement estimates calculated from mark-recapture studies.

Table 3– Escapement index counts, escapement estimates of large (≥660 mm MEF) spawners, and expansion factors for Andrew Creek Chinook salmon population from 1975 to 2014, in Southeast Alaska.

	Survey count	Spawning escapement[a]	Weir count	Expansion factor
1975	260	507	–	–
1976	ND	– [b]	404	–
1977	ND	– [b]	456	–
1978	ND	– [b]	388	–
1979	221	431	327	1.48
1980	ND	– [b]	282	–
1981	300	585	536	1.79
1982	332	647	672	2.02
1983	ND	– [b]	366	–
1984	154	300	389	2.53
1985	320	624 [a]	–	–
1986	708	1,381 [a]	–	–
1987	788	1,537 [a]	–	–
1988	564	1,100 [a]	–	–
1989	530	1,034 [a]	–	–
1990	664	1,295 [a]	–	–
1991	400	780 [a]	–	–
1992	778	1,517 [a]	–	–
1993	1,060	2,067 [a]	–	–
1994	572	1,115 [a]	–	–
1995	343	669 [a]	–	–
1996	335	653 [a]	–	–
1997	293	571 [a]	–	–
1998	487	950 [a]	–	–
1999	605	1,180 [a]	–	–
2000	690	1,346 [a]	–	–
2001	1,054	2,055[a]	–	–
2002	876	1,708 [a]	–	–
2003	595	1,160 [a]	–	–
2004	153	298 [a]	–	–
2005	1,015	1,979 [a]	–	–
2006	1,089	2,124 [a]	–	–
2007	890	1,736 [a]	–	–
2008	503	981 [a]	–	–
2009	322	628 [a]	–	–
2010	618	1,205 [a]	–	–
2011	480	936 [a]	–	–
2012	301	587 [a]	–	–
2013	472	920 [a]	–	–
2014	674	1261 [a]		
Averages:				
1975-2010	610	1075	–	–
2006-2014	591	1,153	–	–

[a] Escapement estimates calculated from expanded survey counts.

[b] Estimates of spawning escapement were not possible during years in which a survey count was not generated.

Table 4.–Escapement index counts, escapement estimates of large (≥660 mm MEF) spawners, and expansion factors for King Salmon River Chinook salmon population from 1975 to 2014, in Southeast Alaska.

Year	Survey counts	Spawning escapement	Expansion factor
1975	42	64 [a]	–
1976	65	99 [a]	–
1977	134	204 [a]	–
1978	57	87 [a]	–
1979	88	134 [a]	–
1980	70	106 [a]	–
1981	101	154 [a]	–
1982	259	394 [a]	–
1983	183	245 [b]	1.17
1984	184	265 [b]	1.37
1985	105	175 [b]	1.57
1986	190	255 [b]	1.25
1987	128	196 [b]	1.38
1988	94	208 [b]	2.02
1989	133	240 [b]	1.59
1990	98	179 [b]	1.74
1991	91	134 [b]	1.38
1992	58	99 [b]	1.71
1993	175	266 [a]	–
1994	140	213 [a]	–
1995	97	147 [a]	–
1996	192	292 [a]	–
1997	238	362 [a]	–
1998	88	134 [a]	–
1999	200	304 [a]	–
2000	91	138 [a]	–
2001	98	149 [a]	–
2002	102	155 [a]	–
2003	78	119 [a]	–
2004	89	135 [a]	–
2005	94	143 [a]	–
2006	99	150 [a]	–
2007	119	181 [a]	–
2008	79	120 [a]	–
2009	72	109 [a]	–
2010	104	158 [a]	–
2011	126	192 [a]	–
2012	102	155 [a]	–
2013	62	94 [a]	–
2014	45	68 [a]	
Averages:			
1975–2014	116	178	–
2006–2014	90	136	–

[a] Escapement estimates calculated from expanded survey counts.

[b] Escapement estimates calculated from mark-recapture studies

The expansion factor for the Chickamin River (Table 5) was addressed in 6 mark-recapture estimates of escapement of large fish in 1996 and 2001–2005. The mark-recapture conducted in 1995 was not used in the expansion factor calculations because of the coefficient of variation of 31% on the estimate. The expansion factor for the Chickamin River is 4.75 (SE = 0.70, CV = 14.7%), and meets the USCTC standard. Peak annual escapement counts of large Chinook salmon from 1975 to 2014 are summarized in Table 6 (Chickamin River) and Table 7 (index tributaries to the Chickamin River).

The age-sex composition estimation requirements for the Chickamin, Blossom, Keta and King Salmon Rivers and Andrew Creek are met by the project described in this operational plan.

Maintaining the stock assessment program for SEAK Chinook salmon at minimum USCTC standards is important to abundance-based management of PSC Chinook fisheries for two reasons. First, the CTC uses escapement data from six 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 (The sixth stock is the Unuk River stock and is covered by a separate 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 5.–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, in Southeast Alaska.

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 $\hat{N}$.

Table 6.–Estimated abundance ($\hat{N}$) of the spawning population of large (≥ 660 mm MEF) Chinook salmon in the Chickamin River, Southeast Alaska, using the mean expansion factor (4.75, SE = 0.70), 1975–2014.

Year	Peak index count	$\hat{N}$	SE ($\hat{N}$)	M-R	SE (M-R)	Preferred Estimate	SE
1975	370	1,758	259	ND	ND	1,758	259
1976	157	746	110	ND	ND	746	110
1977	363	1,724	254	ND	ND	1,724	254
1978	308	1,463	216	ND	ND	1,463	216
1979	239	1,135	167	ND	ND	1,135	167
1980	445	2,114	312	ND	ND	2,114	312
1981	384	1,824	269	ND	ND	1,824	269
1982	571	2,712	400	ND	ND	2,712	400
1983	599	2,845	419	ND	ND	2,845	419
1984	1,102	5,235	771	ND	ND	5,235	771
1985	956	4,541	669	ND	ND	4,541	669
1986	1,745	8,289	1,222	ND	ND	8,289	1,222
1987	975	4,631	683	ND	ND	4,631	683
1988	786	3,734	550	ND	ND	3,734	550
1989	934	4,437	654	ND	ND	4,437	654
1990	564	2,679	395	ND	ND	2,679	395
1991	487	2,313	341	ND	ND	2,313	341
1992	346	1,644	242	ND	ND	1,644	242
1993	389	1,848	272	ND	ND	1,848	272
1994	388	1,843	272	ND	ND	1,843	272
1995	356	1,691	249	2,309	723	1,691	249
1996	422	2,005	295	1,587	199	1,587	199
1997	272	1,292	190	ND	ND	1,292	190
1998	391	1,857	274	ND	ND	1,857	274
1999	501	2,380	351	ND	ND	2,380	351
2000	801	3,805	561	ND	ND	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	ND	ND	6,318	931
2007	893	4,242	625	ND	ND	4,242	625
2008	1,111	5,277	778	ND	ND	5,277	778
2009	611	2,902	428	ND	ND	2,902	428
2010	1,156	5,491	809	ND	ND	5,491	809
2011	852	4,052	596	ND	ND	4,052	596
2012	444	2,109	311	ND	ND	2,109	311
2013	468	2,223	328	ND	ND	2,223	328
2014	652	3,097	456	ND	ND	3,097	456
Averages:							
1975–2014	677	3,216	474	–	–	3,244	496
2008–2014	756	3,593	530	–	–	3,593	530

Note: The expansion factor is calculated from mark-recapture experiments and survey results in 1996 and 2001–2005.

Table 7.–Peak counts of Chinook salmon in index tributaries of the Chickamin River, Southeast Alaska, 1975–2014.

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)
2013	59	N(H)	24	N(H)	127	N(H)	36	N(H)	33	N(H)	16	N(H)	137	N(H)	36	N(H)
2014	166	N(H)	25	N(H)	120	N(H)	56	N(H)	31	N(H)	41	N(H)	195	N(H)	18	N(H)
Averages:																
1975–2014	133		48		114		28		54		36		217		30	
2008–2014	125		19		158		30		60		57		290		17	

Note: peak count conducted by: helicopter (H) or foot (F); conditions rated as poor (P), normal (N), or excellent (E).

OBJECTIVES

The research objectives[1] for 2015 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 percentage points of the true values 95% of the time[2],[3];
   b. the Keta River such that all estimated fractions are within 10 percentage points[3] of the true values 95% of the time;
   c. the Blossom River such that all estimated fractions are within 10 percentage points[3] of the true values 90% of the time;
   d. the King Salmon River such that all estimated fractions are within 15 percentage points[3] of the true values 90% of the time; and
   e. Andrew Creek such that all estimated fractions are within 10 percentage points[3] of the true values 95% of the time.
2. Estimate adult escapements of large Chinook salmon in the systems outlined in Objective 1 (a-e) by expanding the peak survey counts such that the coefficient of variation of the expanded survey counts is ≤20% for the Chickamin, Keta, Blossom and King Salmon systems and ≤25% for Andrew Creek.

SECONDARY OBJECTIVES

1. Estimate mean length-at-age of Chinook salmon by system.
2. Count all large fish (live and dead) 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 are considered to be strays in 2015, since no coded-wire-tagging (CWT) or clipping occurred in any of these systems.

METHODS

STUDY DESIGN

Age, sex, and length data will be collected from all Chinook salmon sampled at upriver spawning locations, and all observed large 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). In systems with no active CWT program, all Chinook salmon missing adipose fins will be sacrificed. Data collected from these CWT recoveries will be used to determine the proportion of the escapement consisting of strays and the origins of the stray fish. Peak survey counts of large fish in the five rivers will be

[1] Age, sex, and length data and estimation of escapement for the Unuk River (1 of 6 index systems for SEAK) is described in separate operational plans: Chinook Salmon Coded Wire Tagging on the Unuk River 2015-2016 and Adult Tag Fraction and Harvest and Escapements of Chinook Salmon in Southeast Alaska and Transboundary Rivers in 2015

[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

[3] Within d percentage points of the true value A% of the time' implies: $P(p_i - d/100 \le \hat{p}_i \le p_i + d/100) = A/100$ for all i, where p_i denotes population age proportion for age class i

expanded to total escapements of large fish using established expansion factors (Objective 2); collection of peak survey data is described in a 2015 Regional Operational Plan (Richards et al. 2015).

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 a 14-year period 2001–2014. 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 depicted in Table 8

Table 8.-Summary information necessary to identify sampling schedules and sampling effort on the tributaries of the Chickamin River, Southeast Alaska.

Tributary	Range of prime sampling dates	Estimated date of peak spawning	% Effort (based on 14-year average of survey counts)
King Creek	8/15–9/06	9/01	38
South Fork Creek	8/12–8/30	8/18	19
Butler Creek	8/01–8/20	8/10	19
Humpy Creek	8/24–9/06	9/01	8
Indian Creek	8/01–8/20	8/10	7
Clear Falls Creek	8/01–8/20	8/10	3
Leduc Creek	8/01–8/20	8/10	4
Barrier Creek	8/07–8/20	8/12	2

Actual sampling dates will be adjusted to coincide with observed abundances and water conditions. Roughly 57% of sampling effort should be spent on South Fork and King creeks, roughly 27% on Butler and Humpy creeks, and about 16% on Indian, Clear Falls, Barrier, and Leduc creeks.

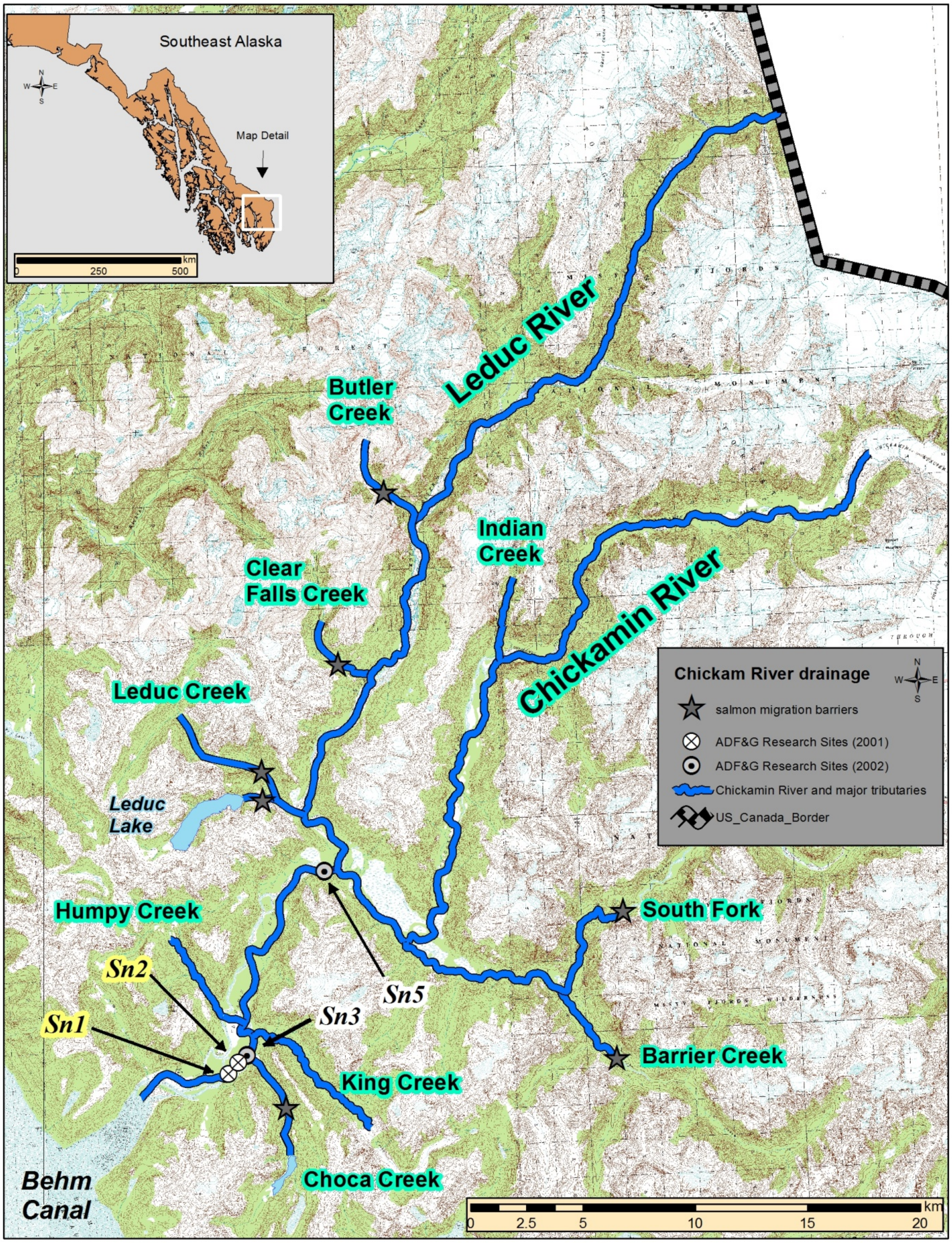

Figure 2.–Chickamin River drainage showing major tributaries, ADF&G research sampling sites, and salmon migration barriers in Southeast Alaska.

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, Indian and Clear Falls) may be thoroughly sampled in a day, while those with many fish (King Creek and South Fork,) may take more to sample thoroughly. An initial trip into Indian and Butler Creeks should occur on or about 3 August, based on historically low catches on these systems after 15 August. Sampling data will be collected as described in the Data Collection: Age-Sex-Length and Coded Wire Tag Sampling section of this plan.

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 or the Chickamin and Unuk River 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.

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 (ending approximately 15 September). The goal of sampling is 2-fold: 1) to estimate ASL compositions, and 2) to report the numbers of large fish observed.

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 to the point to preclude an 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). For Andrew

Creek, 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. ALL Chinook on the Blossom, Keta, Chickamin and King Salmon Rivers, missing adipose fins will be sacrificed. Data collected from these CWT recoveries will be used to determine straying rates and origins.

SAMPLE SIZES

Age Composition Estimation

Required sample sizes associated with Objective 1 are presented in Table 9. The sample size calculations assume no size or sex selectivity, and are based on the methods of Thompson (1987). A finite population correction factor is used, based on the recent five year average escapement estimate, and a scale regeneration rate of 17% for the Chickamin, Blossom, Keta and Andrew Creek and one of 30% for the King Salmon River is used.

Table 9.–Required sample sizes and associated parameters for estimation of age composition of large fish on selected index systems in Southeast Alaska in 2015.

	Objective criteria						
System	percentage points	A%	5-yr avg. escapement	Scale regeneration rate	2015 sample size	Historic avg. sample size	2014 sample size
Chickamin	10	95	3,394	0.17	148	390 (2006–2014)	205
Blossom	10	90	777	0.17	108	110 (2001–2014)[a]	84
Keta	10	95	1,126	0.17	139	159 (2001–2014)[a]	139
Andrew	10	95	982	0.17	136	186 (2001–2014)[b]	143
King Salmon	15	90	133	0.3	49	44 (2001–2013)[c]	0

[a] Not sampled in 2010 and 2011 due to budget constraints and inclement weather, respectively ; 15 and 61 fish sampled in 2012 on Blossom and Keta Rivers, respectively (due to inclement weather).
[b] Not sampled in 2011 due to inclement weather; 62 fish sampled in 2012
[c] Not sampled in 2011 due to inclement weather; 2 fish sampled in 2012 and not sampled 2014.

Effort on the Chickamin River will be similar to 2014. We are confident that scales from more than 148 fish can be sampled for age determination. Planned effort on the Keta and Blossom rivers and Andrew Creek will be commensurate with the levels associated with historic sampling, and we believe prescribed sample sizes will be met. With the current trend in effort and population size, we are not confident in being able to meet sampling goals for King Salmon River. However, if fish are available it is not unlikely that 30 to 60 samples could be collected in a day, and we consider it worthwhile trying to sample this system again. Evaluation will take place after the first and second aerial survey in 2015, if there is enough fish present the Juneau staff will attempt to collect samples; if the count is low, sampling will not take place. The cost-benefit equation of sampling King Salmon River will be addressed after the 2015 field season. Consideration will be given to achievable sample sizes and the fact that required sample sizes also mean a substantial component of the run is handled (49/141 according to Table 8), which is not desirable.

Expanded Survey Count

Chickamin

The bootstrap variance estimated using Eq. 15 in Appendix B1 ($\text{var}(\pi_p)$) 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,

$$\sqrt{C_{2014}^{2}\,0.7^{2}}\Big/\pi C_{2014} = 0.7 / 4.75 \approx 0.15$$

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 scale gum cards will be labeled with a scale card number, date,

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[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.

initials of samplers and location at the start of sampling. Scale cards are sequentially numbered by sampling location, beginning with 001(or 00A if multiple crews are sampling the same system, on the same day). The ASL stream code (Table 10) will be recorded on each card upon returning to camp. 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, a note in the comment column on the ASL form will be placed and that column will be skipped on the gum card.

Table 10.–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	101-70-10060	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	108-40-10150-2008		108-40-020
King Salmon River	111-17-10100		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. These heads will then be sent to the ADF&G Mark, Tag, and Age Laboratory (Tag Lab) along with the CWT form. In systems with no active CWT program (every system except Andrew Creek), ALL Chinook salmon, missing adipose will be sacrificed. A uniquely numbered cinch tag from the escapement sampling packet provided by the Tag Lab will be attached to each head.

Most importantly:

- every Chinook salmon encountered must be sampled on the spawning grounds, regardless of size, and all data for each fish will be recorded on the appropriate form;

- every fish must be checked for the presence or absence of an adipose fin and LLOP;
- clean, readable scales must be collected from the preferred area (or other areas if necessary); and
- heads and scales from all adipose-clipped fish that are dead, post spawn, <700 mm MEF, or from systems with no active CWT program will be collected.

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 section for more details). The location, date, stream code (Table 10), survey number, surveyors, all water and weather conditions, total number of large fish, and predators will be recorded on this form. The percentage of large fish the observer(s) believed were counted, and why they thought so, will also be recorded.

DATA REDUCTION

<u>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</u>. 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 coast wide 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 2010) 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.

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:

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

$$\hat{p}_{kc} = \frac{n_{kc}}{n_k}, \qquad (1)$$

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

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:

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

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 $\text{var}(\hat{N}_c)$ will be estimated by simulation. The stochastic components in the simulation will be: the estimate of large fish as $\hat{N}^*_L \sim N(\hat{N}_L, \hat{\sigma}_{\hat{N}_L})$, the vector of estimated size proportions as $\underline{\hat{\phi}}^* \sim multinomial(n_{sp}, \underline{\hat{\phi}})/n_{sp}$, and the vector of estimated age-sex proportions for the k^{th} size group as $\underline{\hat{p}}^*_k \sim multinomial(n_k, \underline{\hat{p}}_k)/n_k$. Equations 1 through 7 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 :

$$\hat{p}_c = \frac{\hat{N}_c}{\hat{N}_{ALL}} \qquad (4)$$

where $\hat{N}_{ALL}$ is defined in Equation 12.

The $\text{var}(\hat{p}_c)$ 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 :

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

It is noted that the number of fish sampled for size is larger (includes all carcasses) than that sampled for age and that the $\hat{\phi}_k$ are considered relatively unbiased.

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:

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

where,

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

SCHEDULE AND DELIVERABLES

The crews will begin work on or around August 1, 2015. 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 form by 1 July 2015 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 via email 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.

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, training of lower level technicians, data collection and editing, maintenance of jet outboard and skiff, general camp maintenance and duties, and daily contacts with office expeditor or project leader. Responsible for leading spawning grounds team, and for inventorying equipment and supplies at end of the project. Dreyer will work in consultation with the project leader on personnel and administrative issues, as encountered. Responsible for daily safety checks with town via email or satellite phone. Follows departmental and state policy in all matters.

Vacant, Fish Wildlife Technician II.

Duties: This position is responsible for assisting in all aspects of field operations including data collection and editing, maintenance of jet outboard and skiff, 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 Wildlife Technician II

Duties: This position is responsible for assisting in all aspects of field operations including data collection and editing, maintenance of jet outboard and skiff, 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 editing, maintenance of jet outboard and skiff, 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.

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APPENDIX A

Appendix A1.–Spawning grounds age-sex-length form, 2015.

Location: Year: 2015
Stream code:
Species:Chinook

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, 2015.

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

COMMENTS

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

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:

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

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):

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

where

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

and

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

such that

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

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:

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

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:

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

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

We can calculate:

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

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

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

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:

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

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

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