Regional Operational Plan SF.1J.2014.15

Chinook Salmon Coded Wire Tagging on the Unuk River, Southeast Alaska: 2014–2015

by

Todd Johnson

October 2014

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.2014.15

CHINOOK SALMON CODED WIRE TAGGING ON THE UNUK RIVER, SOUTHEAST ALASKA: 2014–2015

by

Todd Johnson

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

Alaska Department of Fish and Game
Division of Sport Fish

October 2014

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 Drive, Suite 205, Ketchikan, AK 99901

This document should be cited as:
Johnson, T. 2014. Chinook salmon coded wire tagging on the Unuk River, Southeast Alaska: 2014–2015. Alaska Department of Fish and Game, Regional Operational Plan No.SF.1J.2014.15, Anchorage.

SIGNATURE/TITLE PAGE

Project Title:	Chinook salmon coded wire tagging on the Unuk River, Southeast Alaska: 2014-2015
Project leader(s):	Todd Johnson, Fishery Biologist II
Division, Region and Area	Sport Fish Region I, Ketchikan
Project Nomenclature:	Governor's Chinook Initiative Fund and F-10-30 –S-1-8
Period Covered	July 1, 2014–June 30, 2015
Field Dates:	September 24–October 30, 2014; April 2–May 10, 2015
Plan Type:	Category III

Approval

Title	Name	Signature	Date
Project Leader	Todd Johnson	Todd Johnson	5/28/14
Area Management Biologist	Kelly Piazza	Kelly Piazza	5/28/14
Biometrician	David Evans	[signature]	5/30/14
Regional Research Coordinator	Jeff Nichols	[signature]	8/29/14
Regional Supervisor	Brian Frenette	[signature]	9.16.14

Chinook Salmon Research Initiative Approval

Title	Name	Signature	Date
Fish and Game Coordinator	Ed Jones	[signature]	6-9-14
Fisheries Scientist	James Hasbrouck	James Hasbrouck	6/6/2014
Fisheries Scientist	Eric Volk	[signature]	6/9/2014

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

This plan describes the coded wire tagging of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) on the Unuk River for the 2013 brood year and will cover the coded-wire tagging of parr in fall of 2014 and smolt in spring of 2015, along with the recovery of CWT's in the escapement, recreational and commercial fisheries from the 2016–2020 return years. This study provides estimates of smolt and parr abundance, harvest information, and mean lengths and weights of juvenile Chinook salmon originating in the Unuk River. A separate project conducted on the Unuk River employs a two-event mark-recapture experiment to estimate large (>660 mm mid eye to fork of tail length) adult Chinook salmon returning to river in 2014. The primary goals of this and the companion study are to estimate inriver run size, total run size, marine harvest rate and distribution, marine exploitation rates, smolt and parr abundance, marine survival (smolt to adult) and overwinter (parr to smolt) survival. The Alaska Department of Fish and Game uses these data to make local and regional management decisions, and the Pacific Salmon commission uses the data for coastwide management and stock assessment through the Chinook Technical Committee.

Key words: Chinook Salmon, *Oncorhynchus tshawytscha,* escapement, Unuk River, Behm Canal, parr, smolt, harvest, age, sex length composition, mark tag fraction, coded wire tag, adipose fin, Southeast Alaska.

PURPOSE

The primary goals of this and a companion study (Johnson 2014) are to estimate Chinook salmon inriver run size, total run size, marine harvest rate and distribution, marine exploitation rates, smolt and parr abundance, marine survival (smolt to adult) and overwinter (parr to smolt) survival. This study provides estimates of smolt and parr abundance, adult harvest, and mean lengths and weights for juvenile fish.

The information provided by the two studies will be used to refine the current biological escapement goal (BEG) for the Unuk River. The updated BEG will meet the Alaska Department of Fish and Game's (ADF&G) role as designated in the Policy for Statewide Salmon Escapement Goals (5 AAC 39.223) to "establish biological escapement goals for salmon stocks for which the department can reliably enumerate salmon escapement levels, as well as total annual returns." The BEG estimation will also partially meet the provisions of the 2009 Pacific Salmon Treaty. This treaty requires "an abundance-based framework for managing all Chinook fisheries"; the framework should involve "harvest regimes based on annual estimates of abundance" that are "designed to meet maximum sustained yield (MSY) or other agreed biologically-based escapement and/or harvest rate objectives." Finally, the results will also be used by the Chinook Technical Committee of the Pacific Salmon Commission for: (1) development of a model stock for southern Southeast Alaska (SEAK), (2) exploitation rate analysis, and (3) improved escapement assessment for Behm Canal Chinook salmon stocks.

The Unuk River is 1 of 12 stocks chosen by the ADF&G as an indicator stock for the Chinook salmon research initiative (CSRI) projects. These projects were chosen to help address issues of low production for Chinook salmon statewide. The recent downturn in Chinook salmon production initiated a look at production statewide and identification of gaps in our knowledgebase. Juvenile information was identified as missing. The Unuk River is 1 of 2 projects state wide that provides information on parr and smolt abundance and freshwater survival from parr to smolt; the other system providing this information is the Chilkat River.

BACKGROUND

The Unuk, Chickamin, Blossom, and Keta rivers traverse the Misty Fjords National Monument (Figure 1). The Unuk and Chickamin rivers produce the largest natural runs of Chinook salmon (*Oncorhynchus tshawytscha*) in southern SEAK and flow into Behm Canal, a narrow saltwater passage east of Ketchikan. These four rivers are "index streams" for the escapement estimation program in SEAK (Pahlke 1996). The escapement in these streams is indexed using standardized surveys conducted by helicopter and foot. Since 1977, the indices have been roughly dome-shaped for each of these systems, with peak values occurring between 1986 and 1990 (Pahlke 1996). Concern for Chinook salmon escapement in Behm Canal systems was raised in 1992 when escapement indices dropped in all 4 rivers. As a result, all available historical harvest and escapement data for the Unuk and Chickamin rivers was reviewed to evaluate the status of these stocks.

The evaluation resulted in the ADF&G Division of Sport Fish (DSF) initiating a research program in Behm Canal in 1993–1994. Total escapement had not been estimated in any Behm Canal Chinook salmon system prior to 1994. Mark-recapture (MR) experiments were used to estimate the escapement of large (≥660 mm mid-eye-to-fork of tail (MEF)) Chinook salmon in the Unuk River in 1994 (Pahlke et al. 1996), and from 1997 through 2013; the 2010, 2012 and 2013 estimates were considered untrustworthy, so aerial expansion estimates were used for adjustment (Jones et al. 1998; Jones and McPherson 1999, 2000, 2002; Weller and McPherson 2003a-b, 2004, 2006a-b; Weller and Evans 2009; Weller et al. 2012; Johnson and Evans *in prep*). The estimates of escapement for large Chinook salmon spawners from 1997 to 2011 (excluding that of 2010) ranged from 2,970 in 1997 to 10,541 in 2001, averaged 5,185, and demonstrated that approximately 13% to 25% of all large Chinook spawners were counted in surveys, a much lower percentage than previously thought. Spawning distribution in the Unuk River was estimated using radio telemetry studies in 1994 and 2009, and in the Chickamin River in 1996; these studies showed that the index surveys are conducted in tributaries on each river that contain over 80% of the large Chinook salmon escapement.

Early research (1983–1988) in Behm Canal systems included coded wire tagging wild juvenile (mostly smolt) Chinook salmon on the Unuk and Chickamin rivers to estimate adult harvest, harvest distribution, and rearing areas for juvenile fish (Kissner 1985; Pahlke 1995). The majority of recovered coded wire tags (CWTs) were made in troll fisheries and during escapement sampling. Harvest estimates for Unuk River Chinook salmon ranged from 726 fish (1985 brood) to 3,039 fish (1983 brood), with 95% relative precision of harvest estimates ranging from 24% (1982 brood) to 78% (1985 brood). Harvest estimates for Chickamin River Chinook salmon ranged from approximately 1,300 fish (1985 brood) to 4,100 fish (1984 brood). Further indications were that these stocks were harvested as both immature and mature fish throughout SEAK. Harvests were most abundant in southern and central SEAK inside waters from 1986 to 1992, but ranged from outer coast waters near Yakutat in the north to northern British Columbia to the south.

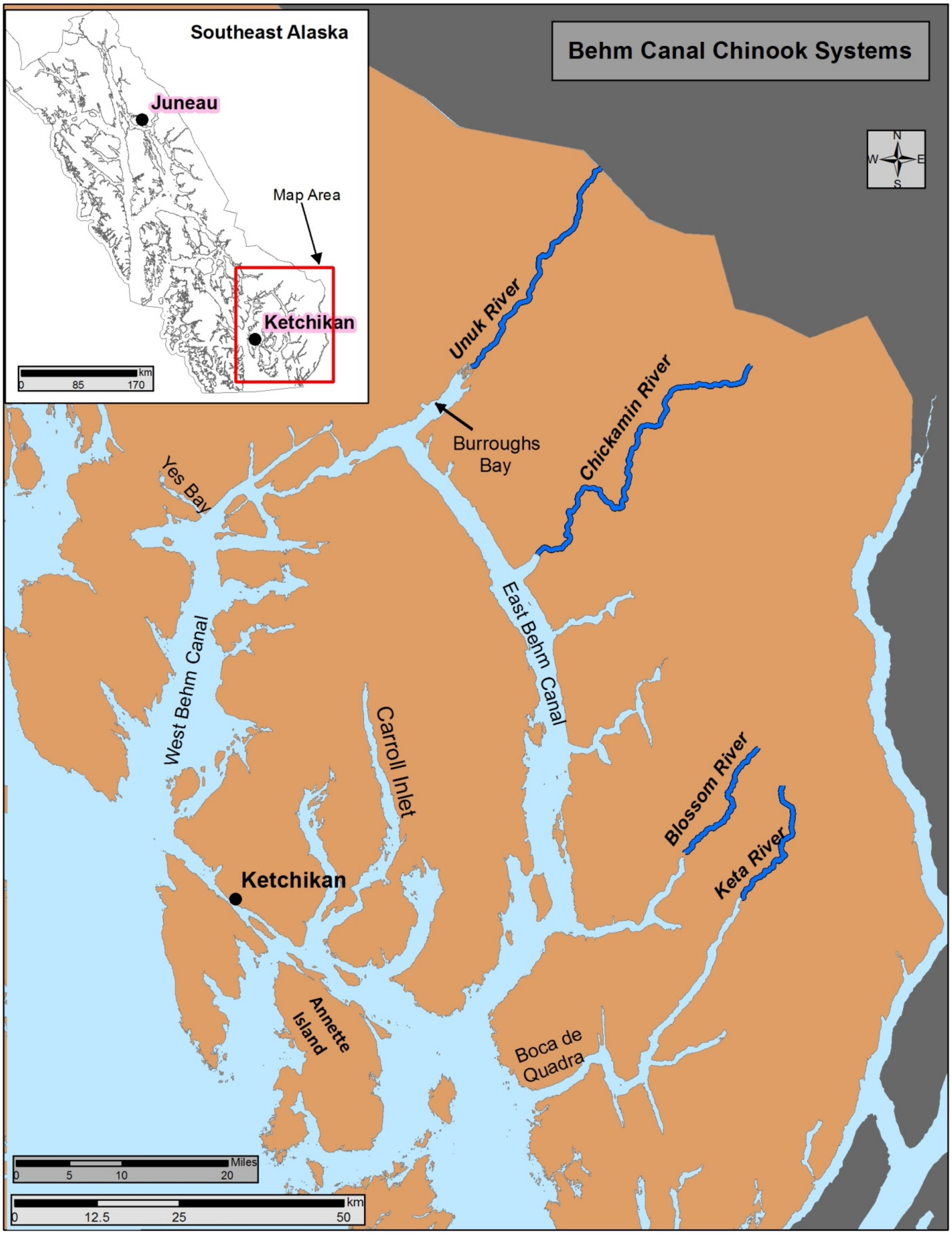

Figure 1.–Behm Canal area in Southern Southeast Alaska (inset), showing major Chinook salmon systems.

Beginning in the fall of 1993, Chinook salmon parr rearing in the Unuk River were tagged with CWTs, and in the spring of 1994, smolt from the same brood year were tagged. Beginning in 1999, all principal age classes of adult Chinook salmon returning to the Unuk River were tagged with CWTs in prior years as juveniles. As many as 79,000 Chinook salmon parr and smolt, since the 1996 brood year, have been tagged per (emigration) year (Table 1) and have resulted in CWT marked fractions as high as 10.7% (Table 2). Recent tagging efforts however, have not been as successful, ranging from about 26,000 for the 2009 brood year to 17,600 for the 2010 brood year. About 24,800 parr and smolt were tagged for the 2012 brood year. The marked fraction for the most recent brood year for which the 1.1 through 1.4 age classes have returned (2007) is only 3%.

In 2014, three studies will be conducted on the Unuk River: tagging juvenile Chinook salmon in freshwater with CWTs (this study), estimating the abundance of adult Chinook salmon in the spawning population using a MR experiment (Johnson 2014), and conducting an aerial survey of large Chinook salmon (Richards et al. 2014) in the Unuk River and other select systems. The latter study will be used in conjunction with the adult escapement study to update the expansion factor (EF) needed to derive escapement estimates for years with no mark recapture estimate; details of the EF estimation are provided in Johnson (2014).

The data from these three Unuk river studies should enable us to estimate adult escapement, total harvest, harvest distribution, smolt abundance, and marine survival and exploitation rates for this stock. These estimates will ultimately be used to update the BEG for this stock, last developed by Hendrich (2008) using spawner-recruit data through 2004.

OBJECTIVES

The research objectives for July 2014 to June 2015 are to:

1. Estimate the total harvest of Unuk River Chinook salmon, brood year 2013, in sampled sport and commercial salmon fisheries from 2016 to 2020 via recovery of CWTs applied in the fall of 2014 and spring of 2015 such that the estimated half-width of the calculated 90% confidence interval is $\leq$25% of the estimate[1].
2. Estimate the mean lengths of Chinook salmon parr (fall 2014) and smolts (spring 2015) such that the estimates are within 1 mm of the true values 95% of the time.

SECONDARY OBJECTIVES

1. Estimate smolt abundance for the 2015 outmigration.
2. Estimate fall parr abundance in 2014.

[1] In prior years objective 1 criteria were set such that the half-width of the 95% confidence interval is ≤ 20% of the estimate; the reduction was made because budget shortfalls have limited sampling and tagging of fall parr and emigrating smolt.

Table 1.–Numbers of Unuk River Chinook salmon fall fry and spring smolt captured and tagged with coded wire tags, 1992 brood year to present.

Brood year	Year tagged	Fall/ spring	Tag code	Dates tagged	Number of Chinook salmon released with adipose clips	Estimated number of Chinook salmon released with valid CWTs and adipose clips
1992	1993	Fall	04-38-03	10/13–10/22/93	10,304	10,263
1992	1993	Fall	04-38-04	10/25/1993	439	433
1992	1993	Fall	04-38-05	10/16–10/21/93	3,192	3,093
1992	1994	Spring	04-42-06	5/05–5/23/94	2,642	2,642
1992 brood year total					16,577	16,431
1993	1994	Fall	04-33-49	10/07–10/24/94	1,706	1,700
1993	1994	Fall	04-33-50	10/07–10/22/94	11,152	11,139
1993	1994	Fall	04-35-57	10/22–11/01/94	7,688	7,687
1993	1995	Spring	04-42-13	4/10–5/05/95	3,227	3,227
1993 brood year total					23,773	23,753
1994	1995	Fall	04-35-56	10/07–10/10/95	11,537	11,476
1994	1995	Fall	04-35-58	10/11–10/16/65	11,645	11,645
1994	1995	Fall	04-35-59	10/17–10/24/95	11,100	10,825
1994	1995	Fall	04-42-31	10/25–10/26/95	6,324	6,260
1994	1996	Spring	04-42-07	4/13–4/23/96	6,099	6,099
1994	1996	Spring	04-42-08	4/23–4/27/96	1,357	1,357
1994 brood year total					48,062	47,662
1995	1996	Fall	04-47-12	9/30–9/15/96	24,224	24,224
1995	1996	Fall	04-42-36	10/16–10/19/96	11,200	11,200
1995	1996	Fall	04-42-18	10/20–10/21/96	3,753	3,753
1995	1997	Spring	04-38-29	3/31–4/18/97	12,517	12,517
1995 brood year total					51,694	51,694
1996	1997	Fall	04-47-13	10/04–10/11/97	24,303	24,176
1996	1997	Fall	04-47-14	10/06-10/11/97	22,975	22,583
1996	1997	Fall	04-47-15	10/11–10/20/97	15,396	15,146
1996	1998	Spring	04-46-46	3/29–4/05/98	11,188	11,134
1996	1998	Spring	04-43-39	4/08–4/13/98	5,987	5,987
1996 brood year total					79,849	79,026
1997	1998	Fall	04-01-39	10/04–10/13/98	22,374	22,366
1997	1998	Fall	04-01-40	10/13–10/23/98	11,640	11,522
1997	1999	Spring	04-01-44	4/08–5/01/99	7,948	7,948
1997 brood year total					41,962	41,836
1998	1999	Fall	04-01-42	10/04–10/17/99	16,661	16,661
1998	2000	Spring	04-02-56	4/01–4/27/00	11,124	11,124
1998	2000	Spring	04-02-57	4/29–5/4/00	2,209	2,209
1998 brood year total					29,994	29,994
1999	2000	Fall	04-03-74	10/06–10/20/00	21,853	21,853
1999	2000	Fall	04-02-88	10/20–10/29/00	10,072	10,072
1999	2001	Spring	04-01-45	4/2–4/23/01	16,561	16,561
1999 brood year total					48,486	48,486

-continued-

Table 1.–Page 2 of 3.

Brood year	Year tagged	Fall/ spring	Tag code	Dates tagged	Number of Chinook salmon released with adipose clips	Estimated number of Chinook salmon released with valid CWTs and adipose clips
2000	2001	Fall	04-02-92	9/29–10/05/01	10,950	10,950
2000	2001	Fall	04-04-57	10/05–10/09/01	11,231	11,231
2000	2001	Fall	04-04-58	10/09–10/14/01	11,223	11,200
2000	2001	Fall	04-04-60	10/14–10/23/01	10,990	10,990
2000	2002	Spring	04-05-38	4/4–4/24/02	10,904	10,904
2000	2002	Spring	04-05-39	4/25–4/26/02	1,067	1,067
2000 brood year total					56,365	56,342
2001	2002	Fall	04-05-23	9/28–10/05/02	11,402	11,402
2001	2002	Fall	04-05-24	10/05–10/13/02	11,538	11,538
2001	2002	Fall	04-05-25	10/13–10/17/02	11,778	11,778
2001	2002	Fall	04-05-26	10/17–10/20/02	11,425	11,425
2001	2002	Fall	04-46-52	10/20–10/25/02	8,403	8,403
2001	2003	Spring	04-08-07	4/8–5/10/03	11,354	11,354
2001	2003	Spring	04-08-03	5/10/2003	483	483
2001 brood year total					66,383	66,383
2002	2003	Fall	04-08-42	9/29–10/10/03	23,255	23,255
2002	2003	Fall	04-08-10	10/10–10/14/03	11,464	11,464
2002	2003	Fall	04-04-61	10/14–10/18/03	9,779	9,779
2002	2004	Spring	04-09-75	03/29–04/10/04	11,666	11,666
2002	2004	Spring	04-09-76	04/10–04/17/04	2,730	2,730
2002 brood year total					58,894	58,894
2003	2004	Fall	04-09-77	9/19–10/03/04	11,789	11,789
2003	2004	Fall	04-09-78	10/03–10/19/04	11,417	11,417
2003	2004	Fall	04-09-81	10/19–10/21/04	3,923	3,923
2003	2005	Spring	04-09-80	4/10–4/28/05	8,618	8,585
2003 brood year total					35,747	35,714
2004	2005	Fall	04-11-55	9/24–10/18/05	23,330	23,330
2004	2005	Fall	04-11-56	10/18/05	941	941
2004	2006	Spring	04-11-52	4/2–4/23/06	16,371	16,269
2004 brood year total					40,642	40,540
2005	2006	Fall	04-13-05	10/3–10/12/06	23,406	23,406
2005	2006	Fall	04-11-51	10/12–10/19/06	9,393	9,393
2005	2007	Spring	04-12-81	4/9–4/27/07	4,731	4,721
2005 brood year total					37,530	37,520
2006	2007	Fall	04-12-82	9/30–10/03/07	11,777	11,777
2006	2007	Fall	04-12-83	10/03–10/07/07	11,716	11,716
2006	2007	Fall	04-12-84	10/07–10/13/07	11,756	11,756
2006	2007	Fall	04-12-85	10/13–10/21/07	9,840	9,840
2006	2008	Spring	04-14-62	4/19–4/27/08	10,489	10,489
2006 brood year total					55,578	55,578
2007	2008	Fall	04-14-65	10/03–10/21/08	16,595	16,595
2007	2009	Spring	04-14-63	4/17–5/02/09	5,578	5,573
2007 brood year total					22,173	22,168

-continued-

Table 1.–Page 3 of 3.

Brood year	Year tagged	Fall/ spring	Tag code	Dates tagged	Number of Chinook salmon released with adipose clips	Estimated number of Chinook salmon released with valid CWTs and adipose clips
2008	2009	Fall	04-13-87	9/28–10/01/09	10,963	10,933
2008	2009	Fall	04-13-88	10/02–10/05/09	11,289	11,289
2008	2009	Fall	04-13-89	10/05–10/09/09	11,556	11,556
2008	2009	Fall	04-13-85	10/09–10/14/09	11,149	11,149
2008	2010	Spring	04-13-86	4/9–4/24/10	8,190	8,190
2008 brood year total					53,147	53,117
2009	2010	Fall	04-13-90	9/26–10/17/10	11,619	11,619
2009	2010	Fall	04-09-95	10/17–10/22/10	4,115	4,115
2009	2011	Spring	04-09-99	4/11–4/27/11	10,216	10,216
2009 brood year					25,950	25,950
2010	2011	Fall	04-09-93	10/13–10/16/12	11,466	11,466
2010	2011	Fall	04-09-94	10/17–10/18/12	2,211	2,211
2010	2012	spring	04-14-66	4/16–4/28/12	3,942	3,942
2010 brood year					17,619	17,619
2011	2012	fall	04-09-91	10/3–10/8/12	10,364	10,364
2011	2012	fall	04-14-67	10/10/2012	3,292	3,292
2011	2013	Spring	04-09-90	4/13–4/25/13	6,176	6,140
2011 brood year					19,832	19,796
2012	2013	fall	04-15-35	9/30-103/13	12,070	12,070
2012	2013	fall	04-09-92	10/3/2013	464	464
2012	2014	Spring				
2012 brood year					12,534	12,534

Table 2.–Numbers of adult Unuk River Chinook salmon examined for adipose fin clips, number sacrificed for coded wire tag (CWT) sampling purposes, and the number of valid coded-wire tags decoded, 1992 brood year to present.

						Number of valid tags					Marked fraction (θ)	
Brood year	Age class	Year	Number examined	Adipose fin clips	Number sacrificed	Fall	Spring	Total	Percent adipose clips with CWT	Percent adipose fin clips	Percent CWT in examined	Event
1992	1.2	1996	33	0	0	0	0	0	–	0.0	0.0	1&2
1992	1.3	1997	436	11	11	10	1	11	100.0	2.5	2.5	1&2
1992	2.2	1997	1	0	0	0	0	0	–	0.0	0.0	1&2
1992	1.4	1998	324	15	11	4	4	8	72.7	4.6	3.4	1&2
1992	1.5	1999	1	0	0	0	0	0	–	0.0	0.0	1&2
1992 brood year total			795	26	22	14	5	19	86.4	3.3	2.8	1&2
1993	1.1	1996	4	1	1	1	0	1	100.0	25.0	25.0	1&2
1993	1.2	1997	300	35	35	28	3	31	88.6	11.7	10.3	1&2
1993	1.3	1998	736	63	48	36	8	44	91.7	8.6	7.8	1&2
1993	2.2	1998	1	0	0	0	0	0	–	0.0	0.0	1&2
1993	1.4	1999	325	34	19	14	4	18	94.7	10.5	9.9	1&2
1993	1.5	2000	9	0	0	0	0	0	–	0.0	0.0	1&2
1993 brood year total			1,375	133	103	79	15	94	91.3	9.7	8.8	1&2
1994	1.1	1997	56	4	4	2	2	4	100.0	7.1	7.1	1&2
1994	1.2	1998	311	31	28	14	11	25	89.3	10.0	8.9	1&2
1994	2.1	1998	1	0	0	0	0	0	–	0.0	0.0	1&2
1994	1.3	1999	421	45	14	6	5	11	78.6	10.7	8.4	1&2
1994	1.4	2000	247	12	7	3	3	6	85.7	4.9	4.2	1&2
1994	1.5	2001	4	0	0	0	0	0	–	0.0	0.0	1&2
1994 brood year total			1,040	92	53	25	21	46	86.8	8.8	7.7	1&2
1995	1.1	1998	81	15	14	8	5	13	92.9	18.5	17.2	1&2
1995	0.2	1998	1	0	0	0	0	0	–	0.0	0.0	1&2
1995	1.2	1999	462	54	45	29	16	45	100.0	11.7	11.7	1&2
1995	1.3	2000	742	77	20	10	7	17	85.0	10.4	8.8	1&2
1995	1.4	2001	512	53	19	12	7	19	100.0	10.4	10.4	1&2
1995	1.5	2002	6	1	1	1	0	1	100.0	16.7	16.7	1&2
1995	2.4	2002	1	0	0	0	0	0	–	0.0	0.0	1&2
1995 brood year total			1,805	200	99	60	35	95	96.0	11.1	10.6	1&2
1996	0.1	1998	2	0	0	0	0	0	–	0.0	0.0	1&2
1996	1.1	1999	65	6	6	4	1	5	83.3	9.2	7.7	1&2
1996	1.2	2000	541	69	49	33	14	47	95.9	12.8	12.2	1&2
1996	1.3	2001	1,177	137	43	27	11	38	88.4	11.6	10.3	1&2
1996	1.4	2002	551	58	15	11	4	15	100.0	10.5	10.5	1&2
1996	1.5	2003	7	1	0	0	0	0	–	14.3	0.0	1&2
1996 brood year total			2,343	271	113	75	30	105	92.9	11.6	10.7	1&2

-continued-

Table 2.–Page 2 of 4.

Brood year	Age class	Year	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent adipose clips with CWT	Percent adipose fin clips	Marked fraction (θ): Percent CWT in examined	Event
1997	1.1	2000	12	1	1	0	1	1	100.0	8.3	8.3	1&2
1997	1.2	2001	189	26	23	12	5	17	73.9	13.8	10.2	1&2
1997	0.4	2002	1	0	0	0	0	0	–	0.0	0.0	1&2
1997	1.3	2002	598	56	7	4	3	7	100.0	9.4	9.4	1&2
1997	2.2	2002	1	0	0	0	0	0	–	0.0	0.0	1&2
1997	1.4	2003	379	31	6	4	0	4	66.7	8.2	5.5	1&2
1997	1.5	2004	6	2	0	0	0	0	–	33.3	0.0	1&2
1997 brood year total			1,186	116	37	20	9	29	78.4	9.8	7.7	1&2
1998	1.1	2001	31	3	3	0	3	3	100.0	9.7	9.7	1&2
1998	1.2	2002	419	26	21	12	9	21	100.0	6.2	6.2	1&2
1998	0.4	2003	1	0	0	0	0	0	–	0.0	0.0	1&2
1998	1.3	2003	1,112	117	28	11	17	28	100.0	10.5	10.5	1&2
1998	2.2	2003	1	0	0	0	0	0	–	0.0	0.0	1&2
1998	1.4	2004	542	51	1	1	0	1	100.0	9.4	9.4	1&2
1998	1.5	2005	6	1	0	0	0	0	–	16.7	0.0	1&2
1998 brood year total			2,112	198	53	24	29	53	100.0	9.4	9.4	1&2
1999	0.2	2002	1	0	0	0	0	0	–	0.0	0.0	1&2
1999	1.1	2002	3	0	0	0	0	0	–	0.0	0.0	1&2
1999	1.2	2003	147	15	13	7	5	12	92.3	10.2	9.4	1&2
1999	1.3	2004	396	49	3	2	1	3	100.0	12.4	12.4	1&2
1999	2.3	2005	4	0	0	0	0	0	–	0.0	0.0	1&2
1999	1.4	2005	200	15	6	1	3	4	66.7	7.5	5.0	1&2
1999	1.5	2006	1	0	0	0	0	0	–	0.0	0.0	1&2
1999 brood year total			752	79	22	10	9	19	86.4	10.5	9.1	1&2
2000	1.1	2003	72	4	4	2	2	4	100.0	5.6	5.6	1&2
2000	1.2	2004	804	62	52	29	22	51	98.1	7.7	7.6	1&2
2000	2.2	2005	1	1	1	1	0	1	100.0	100.0	100.0	1&2
2000	1.3	2005	1,158	107	15	10	3	13	86.7	9.2	8.0	1&2
2000	1.4	2006	529	46	2	2	0	2	100.0	8.7	8.7	1&2
2000	2.3	2006	1	0	0	0	0	0	–	0.0	0.0	1&2
2000	1.5	2007	8	0	0	0	0	0	–	0.0	0.0	1&2
2000 brood year total			2,573	220	74	44	27	71	95.9	8.6	8.2	1&2
2001	1.1	2004	36	7	7	5	2	7	100.0	19.4	19.4	1&2
2001	1.2	2005	186	20	17	11	5	16	94.1	10.8	10.1	1&2
2001	1.3	2006	618	57	7	5	1	6	85.7	9.2	7.9	1&2
2001	2.2	2006	1	0	0	0	0	0	–	0.0	0.0	1&2
2001	1.4	2007	272	29	4	2	2	4	100.0	10.7	10.7	1&2
2001	2.3	2007	2	0	0	0	0	0	–	0.0	0.0	1&2
2001	1.5	2008	4	1	1	0	0	0	0.0	25.0	0.0	1&2
2001 brood year total			1,119	114	36	23	10	33	91.7	10.2	9.3	1&2

-continued-

Table 2.–Page 3 of 4.

Brood year	Age class	Year	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent adipose clips with CWT	Percent adipose fin clips (%)	Marked fraction (θ): % CWT in examined	Event
2002	1.1	2005	70	5	5	1	1	2	40.0	7.1	2.9	1&2
2002	1.2	2006	794	58	46	21	14	35	76.1	7.3	5.6	1&2
2002	1.3	2007	1,266	120	19	10	4	14	73.7	9.5	7.0	1&2
2002	1.4	2008	423	48	4	3	0	3	75.0	11.3	8.5	1&2
2002	1.5	2009	4	1	0	0	0	0	–	25.0	0.0	1&2
2002 brood year total			2,557	232	74	35	19	54	73.0	9.1	6.6	1&2
2003	1.1	2006	28	2	2	1	1	2	100.0	7.1	7.1	1&2
2003	1.2	2007	218	22	21	8	10	18	85.7	10.1	8.7	1&2
2003	2.1	2007	1	0	0	0	0	0	–	0.0	0.0	1&2
2003	1.3	2008	324	30	2	1	1	2	100.0	9.3	9.3	1&2
2003	1.4	2009	151	14	3	1	2	3	100.0	9.3	9.3	1&2
2003	2.3	2009	1	0	0	0	0	0	–	0.0	0.0	1&2
2003	1.5	2010	3	0	0	0	0	0	–	0.0	0.0	1&2
2003 brood year total			726	68	28	11	14	25	89.3	9.4	8.4	1&2
2004	0.2	2007	1	0	0	0	0	0	–	0.0	0.0	1&2
2004	1.1	2007	38	5	5	2	3	5	100.0	13.2	13.2	1&2
2004	0.3	2008	1	0	0	0	0	0	–	0.0	0.0	1&2
2004	1.2	2008	216	18	14	4	4	8	57.1	8.3	4.8	1&2
2004	1.3	2009	581	57	15	4	5	9	60.0	9.8	5.9	1&2
2004	2.3	2010	1	0	0	0	0	0	–	0.0	0.0	1&2
2004	1.4	2010	161	7	2	1	1	2	100.0	4.3	4.3	1&2
2004	1.5	2011	1	0	0	0	0	0	–	0.0	0.0	1&2
2004 brood year total			1,000	87	36	11	13	24	66.7	8.7	5.8	1&2
2005	0.1	2007	1	0	0	0	0	0	–	0.0	0.0	1&2
2005	1.1	2008	25	2	2	2	0	2	100.0	8.0	8.0	1&2
2005	1.2	2009	582	44	43	20	16	36	83.7	7.6	6.3	1&2
2005	2.2	2010	1	0	0	0	0	0	–	0.0	0.0	1&2
2005	1.3	2010	663	51	7	5	1	6	85.7	7.7	6.6	1&2
2005	1.4	2011	143	16	2	2	0	2	100.0	11.2	11.2	1&2
2005 brood year total			1,415	113	54	29	17	46	85.2	8.0	6.8	1&2
2006	1.1	2009	20	2	2	1	0	1	50.0	10.0	5.0	1&2
2006	0.3	2010	1	0	0	0	0	0	–	0.0	0.0	1&2
2006	1.2	2010	222	13	12	7	3	10	83.3	5.9	4.9	1&2
2006	1.3	2011	354	17	5	5	0	5	100.0	4.8	4.8	1&2
2006	1.4	2012	44	4	3	2	1	3	100.0	9.1	9.1	1&2
2006 brood year total			641	36	22	15	4	19	86.4	5.6	4.9	1&2

-continued-

Table 2.–Page 4 of 4.

Brood year	Age class	Year	Number examined	Adipose fin clips	Number sacrificed	Number of valid tags: Fall	Spring	Total	Percent adipose clips with CWT	Percent adipose fin clips	Marked fraction (θ): Percent CWT in examined	Event
2007	1.1	2010	23	1	1	1	0	1	100.0	4.3	4.3	1&2
2007	1.2	2011	172	5	5	3	1	4	80.0	2.9	2.3	1&2
2007	1.3	2012	199	8	2	1	1	2	100.0	4.0	4.0	1&2
2007	1.4	2013	44	3	1	0	0	0	0.0	6.8	0.0	1&2
2007 brood year total			438	17	9	5	2	7	77.8	3.9	3.0	1&2
2008	1.1	2011	11	0	0	0	0	0	–	0.0	0.0	1&2
2008	1.2	2012	117	16	16	5	10	15	93.8	13.7	12.8	1&2
2008	1.3	2013	152	16	4	3	1	4	100.0	10.5	10.5	1&2
2008 brood year total			280	32	20	8	11	19	95.0	11.4	10.9	1&2
2009	1.1	2012	23	1	1	0	1	1	100.0	4.3	4.3	1&2
2009	1.2	2013	88	3	2	0	1	1	50.0	3.4	1.7	1&2
2009 brood year total			111	4	3	0	2	2	66.7	3.6	2.4	1&2
2010	1.1	2013	10	0	0	0	0	0	–	0.0	0.0	1&2
2010 brood year total			10	0	0	0	0	0	0.0	0.0	0.0	1&2

METHODS

STUDY DESIGN

Harvest of Chinook Salmon from the 2013 Brood Year

Harvest of Unuk River Chinook salmon from the 2013 brood year will be estimated from the recovery of CWT fish in sampled marine commercial and recreational fisheries in 2016 through 2020. Chinook salmon parr from the 2013 brood year will be tagged with CWTs in the fall of 2014, and smolt will be tagged in the spring of 2015.

Chinook salmon parr will be captured from late September through the end of October in the fall of 2014, and smolt will be captured from early April through early May in the spring of 2015. Minnow traps will be set in the mainstem of the Unuk River between approximately river km 3 and 19 (Figure 2). Approximately 120 to 150 traps baited with salmon eggs will be fished daily. These traps will be divided between 2 trap lines, each of which will be operated and checked by a 2-person crew. Tag codes used for parr and smolt will be unique and NOT mixed.

Chinook salmon from the Unuk River are almost all from a single freshwater age and near uniform size, overwintering 1 year as parr and emigrating as age-1 (yearling) smolt. All tagged smolt are therefore basically from a single brood year. Chinook salmon mature and return over 5 years beginning with age-1.1 “jacks” and ending with age-1.5 fish.

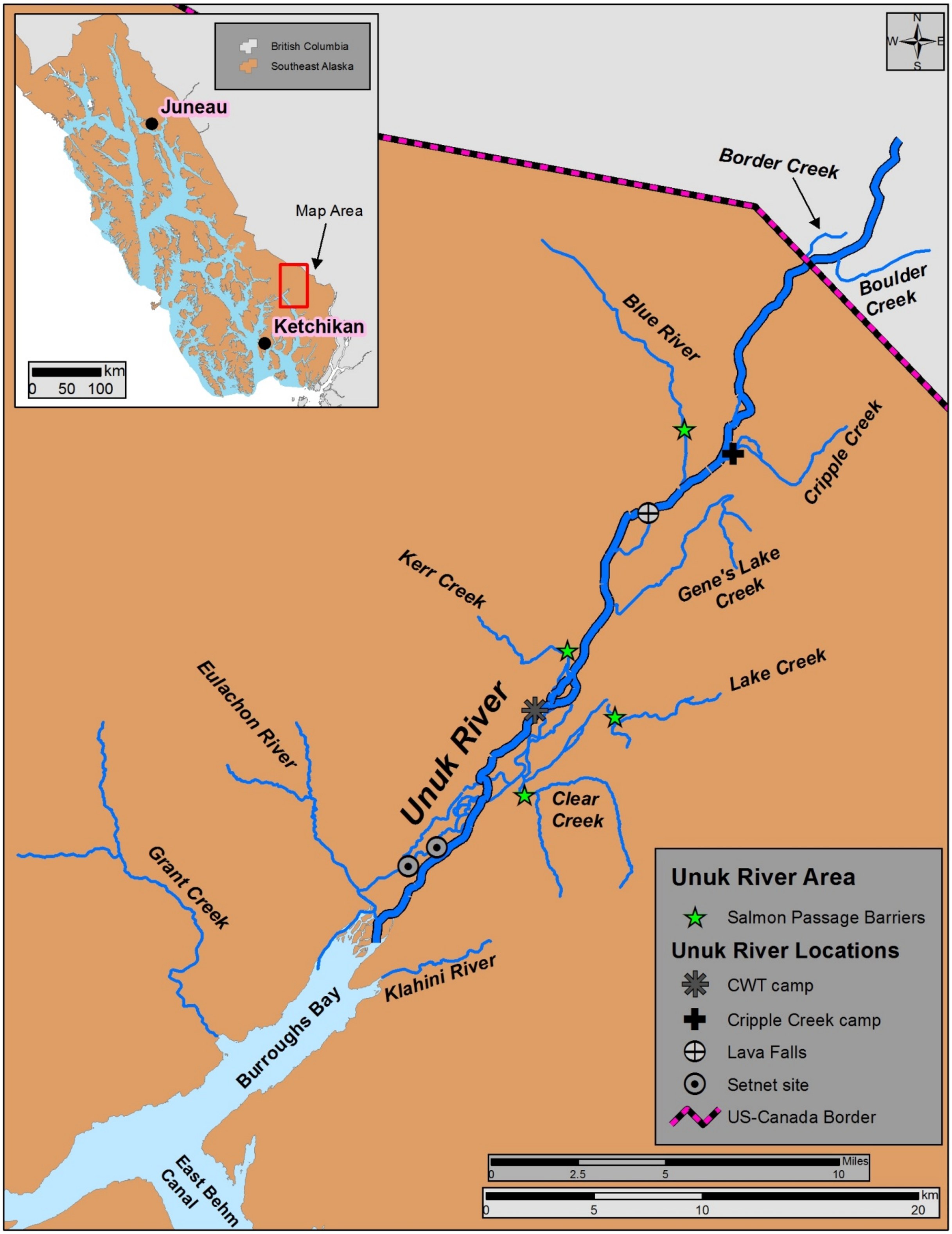

Figure 2.–Unuk River area in Southeast Alaska, showing major tributaries, barriers to fish migration and location of research sites.

An average of 30,925 parr were tagged annually from 1993 through 2013, yielding a range between 12,534 valid tags in 2013 to 61,905 in 1997. Similarly, an average of 9,669 smolt have been tagged annually since 1993, ranging from 2,642 Chinook tagged in 1994 to 17,119 valid tags in 1998 (Table 1). The cost of tagging a single fall parr in 1995 was $0.90, which equates to $1.20 per smolt assuming a 75% overwinter survival. The cost of tagging a Chinook salmon smolt in the spring of 1996 was $3.00 each, indicating it is more cost effective to tag fall parr (providing relative costs and survival are consistent over time). As it is, most juvenile Chinook salmon are tagged in the fall, but we do tag smolt to further boost sample sizes and the spring sampling allows us to estimate overwinter survival. The numbers of Chinook salmon fall parr and smolt tagged each year are shown in Table 1. In the MR studies undertaken from 1998 to 2013, the numbers of adult Chinook salmon sampled for CWTs has averaged 1,341 unique fish annually (Table 2).

A simulated data set (Appendix A1) and the methods of Bernard et al. (1998) were used to anticipate precision of the contribution estimates (Objective 1) for the 2013 brood year. The simulated dataset was based on the following assumptions:

1. Chinook salmon smolt abundance in 2015 is 350,000 (approximate average of brood years 2000–2009; with the 2009 abundance based on recoveries from age 1.1 (2012) through 1.2 (2013) adults.
2. Number of tagged smolt emigrating in 2015 is 30,000 (includes smolt surviving from fall tagging and spring-tagged smolt). It is noted that the average number of tagged smolt emigrating between calendar years 2008 and 2014 is estimated at 20,579. We will have the resources for the fall of 2014 through spring of 2015, to expend enough trapping effort such that 30,000 tagged smolt emigrate in 2015 for brood year 2013. (An anticipated partition between fall and spring is approximately 35,800 parr and 10,300 smolt tagged, assuming a 55% survival from parr to smolt). The anticipated marked fraction is therefore 0.086 (30,000/350,000).
3. Port and creel sampling rates similar to 2006–2010 average rates (listed in Appendix A1);
4. Number of adults sampled for CWTs is similar to the 2009–2013 average (800).
5. Probabilities (π_i) that fish from the Unuk River 2013 brood year are in fishery harvest samples (from a particular strata *i*, e.g. Traditional Troll, period 1) are calculated as averages of probabilities for brood years 2000–2004 (listed in Appendix A1).

Specific fishery strata listed in Appendix A1 are those responsible for the majority of CWT recoveries from tagged brood year 2000–2004 fish. We anticipate that of the estimated harvest from the 2013 brood, 16% will be harvested at age 1.2, 57% at age 1.3, and 27% at age 1.4. Based on past experience, we expect about 65% of the harvest will be taken in the troll fishery, 14% in the sport fishery, and 10% in the gillnet fishery; the remainder will be taken in other, rarer strata, classified as "Other" in Appendix A1. Based on our assumptions, we anticipate about 50 random fishery CWT recoveries. Under these conditions, the expected 90% relative precision (RP) for the harvest is about 25%, meeting Objective 1 criteria. An additional 69 (0.086*800) adipose-clipped fish bearing CWTs should be encountered inriver annually in sampling associated with the annual escapement study.

Based on methodology in Bernard et al. (1998), the probabilities of recovering at least 1 tag in each individual stratum varied from 14% to near 100%. The product of the probabilities of recovering at least 1 tag in all strata listed in Appendix A1 indicates that we have almost no chance of recovering a CWT in every one of the strata in Appendix A1. For strata representing 52% of the harvest of Unuk River Chinook salmon, there is a 72% chance of recovering at least one tag from them.

The above statistics are not encouraging, but would be improved by increasing the number of tagged emigrating smolt. Figure 3 shows that increasing the number of tagged smolt (top plot) or the proportion of the harvest inspected (bottom plot) is more effective at reducing the relative precision of the total harvest estimate than increasing the number sampled for estimation of the tagged fraction ("theta"; middle plot). Such increases would also reduce the risk of not recovering any tags.

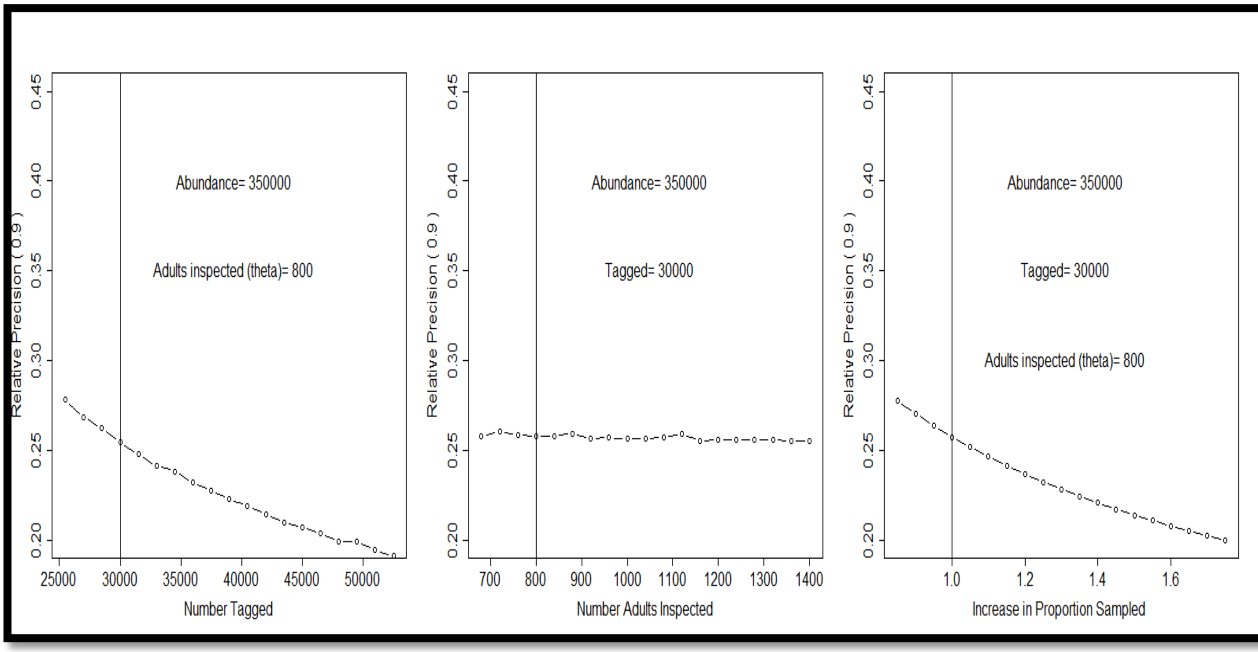

Figure 3.–Effect of increasing number tagged, number of adults inspected, and proportion of harvest sampled on relative precision of estimate of total harvest of Unuk River Chinook salmon, brood year 2013. Vertical bars denote anticipated level for brood year 2013.

We have aimed in the past to have 30,000 tagged smolt emigrating for each brood year, but have failed to reach this level in recent years, considering that we tagged only about 19,000 for brood year 2009, and anticipating (using an average fall to spring survival rate of 0.55) only 11,500 for brood year 2010, about 14,000 for brood year 2011, and 19,000 for brood year 2012. It is noted that we succeeded in tagging about 33,500 for brood year 2008. Budget constraints for the 2010 and 2011 brood year curtailed our tagging program; it was reported that parr and smolt were present and that had resources been available, substantially more fish could have been tagged. Resources for the 2013 brood year will be available to conduct a full tagging project and we are optimistic that we can reach the target of 30,000 tagged outmigrating smolt, and will tag more as the weather permits. A reassessment of the utility of the estimates generated from this study may be warranted if for some reason our tagging rates remain low.

Mean Length of Chinook Salmon Juveniles

Systematically drawn samples of captured juvenile Chinook salmon will be measured for length to estimate the mean length of the populations within 1 mm for 95% relative precision (Objective 2). According to procedures in Cochran (1977, p. 77–78), the sample size *n* needed to estimate the mean length of parr within d mm for 100*(1-α)% relative precision under simple random sampling, with a standard deviation of lengths, s is given by:

$$n = (Z_{(1-\alpha/2)}\ s / d)^2$$

For standard normal variate $Z_{(1-\alpha/2)}$ =1.96, s=6.5 mm and d=1 mm, the required sample size n=162.. Based on a catch of 35,800 Chinook salmon parr (see Assumption 2 above), every 221st parr captured should be measured. However, in case we capture less than 35,800 parr**,** we will measure to the nearest 1 mm every 100th Chinook salmon parr captured. Similarly, assuming 10,300 smolt with a standard deviation of 7 mm are captured, every 55th smolt should be sampled for a total of 188. However, to be conservative, every 33rd (3 in every 100) Chinook salmon spring smolt will be measured to the nearest 1 mm. Juvenile Chinook salmon that are measured for length will also be weighed to the nearest 1/10 g. There is no reason to collect scales on Unuk River Chinook salmon smolt for aging purposes as nearly all (i.e., 100%) are age-1.0 smolt (Hendrich et al. 2008).

DATA COLLECTION

Juvenile Tagging

All captured Chinook salmon parr and smolt not missing adipose fins will be tranquilized with a buffered MS 222 solution and tagged with a CWT following procedures described in Koerner (1977). These fish will then have their adipose fin removed and will be subsequently released. All CWT fish will be held overnight to test for mortality and tag retention. We assume that there is no impact on mortality from simply holding fish overnight, and that any mortality observed the following day is due to tagging. All smolt captured that are missing an adipose fin will be passed through a magnetic tag detector, and the presence or absence of a CWT will be recorded.

All tagging, recapture, and retention data will be recorded daily on a *CWT Daily Log Form* (Appendix B1). A separate *CWT Daily Log Form* will be filled out for each day of operation and a summary page will be updated periodically. A new form is also required upon initial use of each tag code, with a 1 mm length of wire taped to the form on the first day a new code is used. Daily procedures will be as follows:

1. Record tagging site, date, and species.
2. On the Physical Data Form (Appendix B2) record date, water temperature to the nearest 0.5^{o}C, and water depth at the staff gauge to the nearest 0.5 inch. Data should be collected at approximately 0800 each day.
3. At 0800–0900 hrs check 100 fish for tag retention in the sample of fish from the previous day's tagging and record the results. If retention is less than 98 out of 100 fish, the entire batch will be rechecked and every fish that tests negative will be retagged. After all tag retention fish have been checked, count any mortalities and then release all of the live fish from the net pens into suitable habitat. Retag all fish that test negative if retention is less than 98 out of 100.
4. Run the trap lines. Remove fish from the traps and transport them to the tagging station. Inspect each live fish and count the number missing adipose fins. Record this number under "Recaptures" on the CWT Daily Log Form. Check all recaptures for tags with the detector and record the number without CWTs. Release all recaptures after testing and retag any that test negative.

5. Give all live fish not previously tagged a CWT and pass each through the tag detector. If a fish tests negative for the presence of a CWT, retag the fish. Keep a count of all retagged fish on a hand counter. Write the beginning and ending machine numbers from the specific Northwest Marine Technology Mark IV[2] tagging machine used on the *CWT Daily Log Form* and record the total number of retagged fish and erroneous tags (i.e., goofs, misses, tagged fingers, practice tags, etc.). Write out all hand calculations on the form so that these calculations can be checked and verified at a later date.
6. Systematically select and measure to the nearest 1 mm FL every 100th unmarked Chinook salmon parr (fall 2012) and every 33rd unmarked Chinook salmon smolt (spring 2013). All of these fish will also be weighed to the nearest 1/10 g. All or a subset of parr (smolts) recaptured in a single day (missing an adipose fin) will be measured (FL) as well, but no more than the number of unmarked fish measured on the same day. The first recaptured fish encountered will be the subset measured. No recaptured fish will be weighed.

DATA REDUCTION

It is the responsibility of the field crew leaders to insure that all data are recorded daily. Data forms will be kept up to date at all times. Data will be transferred from field forms to EXCEL™ database spreadsheets in the office at a later date. Field forms will be inspected for accuracy and compliance with sampling procedures, compared with the electronic database files, and error checked. Inspections for data entry errors will include looking for incorrect dates, transposed nonsensical lengths, incorrect length measurement method (i.e., FL), etc. Data forms will be kept up to date at all times.

The ADF&G Division of Commercial Fisheries (DCF) is the clearinghouse for all information on CWTs. Completed *CWT TAGGING SUMMARY AND RELEASE INFORMATION Form*s will be compiled using CWT Assist (Version 3.2.0) and sent to the DCF Mark, Tag, and Age Laboratory (Tag Lab). Note that the Tag Lab is the permanent repository for all CWT data for the State of Alaska. The Alaskan CWT data is annually transferred to the Pacific States Marine Fisheries Commission, which stores coastwide CWT data in a permanent and standardized database. An edited copy of the data, along with a data map, will be sent to Research and Technical Services (RTS) in Anchorage with the final report for archiving. All electronic files submitted with the final report will be archived in a report-specific folder on the Docushare system.

DATA ANALYSIS

Estimates of Mean Length

Estimates of mean length and its variance will be calculated with standard sample summary statistics (Cochran 1977). Because size distributions of Chinook salmon parr and smolts are believed to be relatively narrow, any size-selective sampling with minnow traps should be negligible. Even so, measured lengths of recaptured smolts and parr will be compared against lengths of unmarked fish captured on the same dates using analysis of variance. The null hypothesis will be that average lengths of marked and unmarked fish captured on the same date (day or week) are the same. If significant, the difference will be estimated and a determination made regarding its practical significance.

[2] This and subsequent product names are included for a complete description of the process and do not constitute product endorsement.

Contributions to Fisheries

The contribution r_{ij} of a release group or brood of interest j to one fishery stratum i is

$$\hat{r}_{ij} = H_i \left[\frac{m_{ij}}{\lambda_i n_i} \right] \theta_j^{-1}; \qquad \lambda_i = \frac{a_i' t_i'}{a_i t_i} \tag{1}$$

where H_i = total harvest in the stratum, n_i = number of fish inspected (the sample) from the stratum, a_i = number of fish in n_i that are missing an adipose fin, a_i' = number of heads from a_i that arrive at the Tag Lab, t_i = number of heads out of a_i' with CWTs detected, t_i' = number of CWTs out of t_i that are dissected and decoded, m_{ij} = number of CWTs with code of interest j (i.e. Unuk River, brood year 2012), and θ_j = fraction of the cohort tagged with code of interest. H_i is estimated with error in sport fisheries, and θ_j is estimated from sampling returning adults inriver. For these reasons, unbiased estimates of the variance of $\hat{r}_{ij}$ will be obtained using equations in Table 2 of Bernard and Clark (1996), which show the formulations for large samples. The marked fraction θ will be based on the fraction of adults without adipose fins, adjusted for tag loss (see Johnson 2013). While an estimate of θ will be available at the end of 2016 (from 1.1 returns), the final estimate for the 2013 brood year of Chinook salmon will not be “complete” until the end of 2020. Numbers of recovered tags by age and numbers sampled by age will be summed across samples (years) to obtain the final estimate of θ (see Johnson 2014 for details). The total harvest for the 2013 brood year will be calculated as the sum of harvests over sampled fishery strata.

Commercial catch data for the analysis will be summarized by ADF&G statistical week and district for experimental troll, gillnet and seine fisheries, or by period and quadrant for traditional troll fisheries (Clark et al. 1985). Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2011) will be apportioned using information from sampled marine sport fisheries to obtain estimates of total harvest by biweek and fishery. Sport fish CWT recovery data will be obtained from DCF Tag Lab reports and summarized by biweek and fishery (e.g., biweek 16 during the Sitka Marine Creel Survey) to estimate contribution. In most cases, CWTs of interest may be recovered in only a few of the sport fish sampling strata that defined the fishery biweek. Assuming that the harvests of fish with CWTs of interest are independent of sampling strata within fishery biweeks, harvests and sampling information will be totaled over the fishery biweek to estimate contributions.”

Smolt Abundance

Experience has shown that estimates of the proportion of adults from a given brood year with adipose fin clips does not change appreciably over return years, and thus recovery data are pooled over the i years (5 maximum) in which fish from brood year j return. Smolt abundance ($\hat{N}_{smolt,j}$) from brood year j will be estimated using a version of the Chapman-modified Petersen formula:

$$\hat{N}_{smolt,j} = \frac{(\hat{M}_j + 1)(n_{\bullet j} + 1)}{(a_{\bullet j} + 1)} - 1 \tag{2}$$

where

$n_{\bullet j}$ = $\sum_{i=1}^{L} n_i$, where n_i is the number of adults examined in year i from brood year j for missing adipose fins;

L = number of years over which fish from a given brood return (maximum = 5).

$a_{\bullet j}$ = $\sum_{i=1}^{L} a_i$, where a_i is the number of adipose fin clips observed in n_i; and

$\hat{M}_j$ = estimated number of outmigrating smolt originating from brood year j that bore an adipose fin clip; these fish may be from either the fall (f; year $j+1$) or spring (s; year $j+2$) tagging programs. $\hat{M}_j$ is the sum of the estimated number of parr with adipose fin clips from brood year j surviving to the spring ($\hat{M}_{f \to s,j}$) and the number of smolt with adipose fin clips from brood year j ($M_{s,j}$), where:

$$\hat{M}_{f \to s,j} = M_{f,j}\hat{S}_j \tag{3}$$

and

$M_{f,j}$ = number of parr released with adipose fin clips in the fall of year j+1; and

$\hat{S}_j$ = estimated proportion of $M_{f,j}$ that survived to the spring of $j+2$ (overwinter survival) (see Weller and McPherson 2003a, Appendix A7), where:

$$\hat{S}_j = \frac{\hat{M}_{s,valid,j}\, v_{\bullet,f,j}}{\hat{M}_{f,valid,j}\, v_{\bullet,s,j}} \tag{4}$$

and

$\hat{M}_{s,valid,j}$ = estimated number of adipose-finclipped smolt released with valid CWTs in the spring of year j+2;

$\hat{M}_{f,valid,j}$ = estimated number of adipose-finclipped parr released with valid CWTs in the fall of year j+1;

$v_{\bullet,f,j}$ = $\sum_{i=1}^{L} v_{i,f,j}$, where $v_{i,f,j}$ is the total number of fish from brood year j implanted with valid CWTs in the fall of year j+1 that were subsequently recovered, regardless of recovery circumstances (for instance recovery location; marine fishery, escapement, etc, or sample type; random, select, or voluntary; see Harvest section below); and

$v_{\bullet,s,j} \quad = \quad \sum_{i=1}^{L} v_{i,s,j}$, where $v_{i,s,j}$ is the total number of fish from brood year j implanted with valid CWTs in the spring of year $j+2$ that were subsequently recovered, regardless of recovery location or sample type.

The variance of the smolt estimate will be estimated as:

$$\mathrm{var}\left(\hat{N}_{smolt,j}\right) = \left(n_{\bullet j}+1\right)^2 \mathrm{var}\left[\left(\hat{M}_{f\to s,j} + M_{s,j} + 1\right)\frac{1}{\left(a_{\bullet j}+1\right)}\right] \tag{5}$$

where, by Goodman (1960) for independent variables:

$$\mathrm{var}\left[\left(\hat{M}_{f\to s,j} + M_{s,j} + 1\right)\frac{1}{\left(a_{\bullet,j}+1\right)}\right] = \left(M_{s,j} + \hat{M}_{f\to s,j} + 1\right)^2 \mathrm{var}\left[\frac{1}{a_{\bullet,j}+1}\right] + \left[\frac{1}{a_{\bullet,j}+1}\right]^2 \mathrm{var}\left(\hat{M}_{f\to s,j}\right) - \mathrm{var}\left[\frac{1}{a_{\bullet,j}+1}\right]\mathrm{var}\left(\hat{M}_{f\to s,j}\right) \tag{6}$$

and $\mathrm{var}\left(\hat{M}_{f\to s,j}\right)$ is obtained as described in Weller and McPherson (2003a), Appendix A7.

According to the delta method:

$$\mathrm{var}\left[\frac{1}{a_{\bullet}+1}\right] = \left[\frac{1}{a_{\bullet,j}+1}\right]^4 n_{\bullet,j}\hat{p}_a\left(1-\hat{p}_a\right) \tag{7}$$

where $\hat{p}_{a,j} = \dfrac{a_{\bullet,j}}{n_{\bullet,j}}$ is the estimated proportion of inspected adults from brood year j with an adipose fin clip.

The two components in equation 6 are not independent, but a simulation using data from studies on 7 brood years of Unuk River Chinook salmon to establish realistic population parameters showed the correlation to be negligible. The simulation showed the simulated variance of smolt abundance to be almost identical to that provided by the average of the Goodman-derived estimates (equation 6) over the simulation.

Parr abundance $\hat{N}_f$ for brood year j will be estimated as:

$$\hat{N}_{f,j} = \hat{N}_{smolt,j}\frac{1}{\hat{S}_j} \tag{8}$$

$$\mathrm{var}(\hat{N}_{f,j}) \approx \hat{N}_{f,j}^2\left|cv^2\left(\hat{N}_{smolt,j}\right) + cv^2\left(\hat{S}_j\right)\right| \tag{9}$$

SCHEDULE AND DELIVERABLES

Parr tagging will begin approximately 24 September, 2014 and span the month of October, after which inventory will be taken and gear will be stored for the winter. Smolt operations will begin approximately 1 April, 2015. Following a preseason logistical startup meeting the crew will then depart Ketchikan for the Unuk River, camp will be setup, and soon thereafter traps will be set and smolt tagging will commence. Spring tagging will run through approximately 30 April, 2015. All dates are subject to change and are weather dependent. All field data will be entered in computer spreadsheets and checked for errors by 30 November, 2014 (parr data), and 1 June, 2015 (spring smolt data).

An ADF&G Fishery Data Series report will be prepared by 1 June, 2022 summarizing brood year 2013 Chinook salmon harvest contributions, associated data for estimating harvest by gear and time, marked fraction of returning adults, exploitation and survival rates, and all juvenile tagging data.

RESPONSIBILITIES

Todd Johnson, Fisheries Biologist II

Duties: This position is responsible for setting up all aspects of the project, including planning, budget, sample design, permits, equipment, personnel, and training, as well as supervises Sanguinetti, Dryer, and Frost. Adjusts field sampling priorities as necessary. Responsible for tracking the budget, meeting reporting requirements, analysis, and publication of smolt and harvest contribution data, may assist with work in the field and will arrange logistics with Sanguinetti and field crew. Conducts preseason startup meetings with field crew and Sanguinetti, and follows departmental and state policy in all matters.

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, Fisheries Biologist III

Duties: Supervises Johnson.

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 the assistant project leader and is responsible for expediting project activities from Ketchikan, from June 1 through the end of the project. Responsible for daily radio call, arranging logistics with field crew and project leader, purchasing supplies, loading and unloading supply planes, proper conduct in the public's eye, and following department guidelines supplied by the project leader. Responsible for supervising field crew in absence of Johnson, assists with field operations as necessary, makes recommendations on logistics to the project leader, adjusts personnel hours and schedules as appropriate. Enters field data into spreadsheets and edits and summarizes data.

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

Duties: This position is responsible for directing all field aspects of the project under directions from the project leader. Will ensure that all crew members are trained in the proper operation of all aspects of the project including boating safety, fish handling, data collection and recording, conduct in the public's eye, and adherence to department policies. Position will be responsible for equipment maintenance and proper operation, fieldwork schedules, scheduling of flights with Sanguinetti, and submitting data accurately and timely. With the project leader and Sanguinetti, will attempt to resolve as many personnel and administrative items as is possible and is responsible for submitting inventories at the end of the season to Sanguinetti. This position is also responsible for reports to be submitted to the project leader weekly, and daily satellite phone calls or emails to Sanguinetti and Johnson. Position functions as lead technician on the morning set net crew. Follows departmental and state policy in all matters.

Nathan Frost, Fish and Wildlife Technician III.

Duties: This position is responsible for assisting in all aspects of escapement spawning grounds sampling including safe operation of riverboats and all other equipment and various data collection and conduct in the public's eye. Follows departmental and state policy in all matters.

Mike Enders, Fish and Wildlife Technician III.

Duties: This position is responsible for assisting in all aspects of escapement spawning grounds sampling including safe operation of riverboats and all other equipment and various data collection and conduct in the public's eye. Follows departmental and state policy in all matters.

Alanna Gottshall, Fish and Wildlife Technician II.

Duties: This position is responsible for assisting in all aspects of adult tagging and escapement spawning grounds sampling including safe operation of riverboats and all other equipment and various data collection, and conduct in the public's eye. Follows departmental and state policy in all matters.

REFERENCES CITED

Bernard, D. R. and J. E. Clark. 1996. Estimating salmon harvest with coded-wire tags. Canadian Journal of Fisheries and Aquatic Sciences 53:2323–2332.

Bernard, D. R., R. P. Marshall, and J. E. Clark. 1998. Planning programs to estimate salmon harvest with coded-wire tags. Canadian Journal of Fisheries and Aquatic Sciences, 55: 1983–1995.

Clark, J. E., B. W. Van Alen, and R. P. Marshall. 1985. Estimated contribution of coded wire tagged releases of Chinook salmon (Oncorhynchus tshawytscha) to the commercial fisheries of Southeastern Alaska in 1982. Alaska Department of Fish and Game, Technical Data Report No. 161, Juneau.

Cochran, W. G. 1977. Sampling Techniques, third edition, Wiley and Sons, New York.

Goodman, L. A. 1960. On the exact variation of products. Journal of the American Statistical Association 55: 708–713.

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

Jennings, G.B., K. Sundet, and A.E. Bingham. 2011. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2010. Alaska Department of Fish and Game, Fishery Data Series No. 11-60, Anchorage.

Johnson, T. A. 2013. A mark-recapture experiment to estimate the escapement of Chinook salmon in the Unuk River, 2013. Alaska Department of Fish and Game, Regional Operational Plan No. SF.1J.2013.09, Anchorage.

Johnson, T.A., and D. E Evans, and. *In prep*. Production of Unuk River Chinook salmon through 2010 from the 1992–2007 broods. Alaska Department of Fish and Game, Fisheries Data Series, Anchorage.

Jones III, E. L., S. A. McPherson and D. L. Magnus. 1998. A MR experiment to estimate the escapement of Chinook salmon in the Unuk River, 1997. Alaska Department of Fish and Game, Fisheries Data Series No. 98-23, Anchorage.

Jones III, E. L. and S. A. McPherson. 1999. A MR experiment to estimate the escapement of Chinook salmon in the Unuk River, 1998. Alaska Department of Fish and Game, Fisheries Data Series No. 99-14, Anchorage.

Jones III, E. L. and S. A. McPherson. 2000. A MR experiment to estimate the escapement of Chinook salmon in the Unuk River, 1999. Alaska Department of Fish and Game, Fisheries Data Series No. 00-22, Anchorage.

Jones III, E. L. and S. A. McPherson. 2002. A MR experiment to estimate the escapement of Chinook salmon in the Unuk River, 2000. Alaska Department of Fish and Game, Fisheries Data Series No. 02-17, Anchorage.

Kissner, P. D. Jr. 1985. A study of Chinook salmon in southeast Alaska. AlaskaDepartment of Fish and Game, Sport Fish Division. Annual report 1984–85, Project F-9-17, 26 (AFS-41).

Koerner, J. F. 1977. The use of the coded-wire tag injector under remote field conditions. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 172, Juneau.

Pahlke, K. A. 1995. Coded wire tagging studies of Chinook salmon of the Unuk and Chickamin Rivers, Alaska. Alaska Department of Fish and Game, Division of Commercial Fisheries, Alaska Fishery Research Bulletin 2(2): 93–113.

Pahlke, K. A. 1996. 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.

Pahlke, K. A. S. A. McPherson and R. P. Marshall. 1996. Chinook salmon research on the Unuk River, 1994. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 96-14, Anchorage.

Richards, P., T Johnson. *In prep*. Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 2013. Alaska Department of Fish and Game, Regional Operational Plan, Anchorage.

Weller, J.L and S. A. McPherson. 2003a. Estimation of the escapement of Chinook salmon in the Unuk River, 2001. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No. 03-13, Anchorage.

REFERENCES CITED (continued)

Weller, J.L and S. A. McPherson. 2003b. Estimation of the escapement of Chinook salmon in the Unuk River, 2002. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No.03-15, Anchorage.

Weller, J.L and S. A. McPherson. 2004. Estimation of the escapement of Chinook salmon in the Unuk River, 2003. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No.04-10, Anchorage.

Weller, J.L and S. A. McPherson. 2006a. Estimation of the escapement of Chinook salmon in the Unuk River, 2004. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No.06-07, Anchorage.

Weller, J.L and S. A. McPherson. 2006b. Estimation of the escapement of Chinook salmon in the Unuk River, 2005. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No.06-59, Anchorage.

Weller, J.L and D. G. Evans. 2009. Estimation of the escapement of Chinook salmon in the Unuk River, 2006. Alaska Department of Fish and Game, Division of Sport Fish, Fishery Data Series No.09-02, Anchorage.

Weller, J. L., D. G. Evans, and M. T. Brunette. 2012. Production of Unuk River Chinook salmon through 2008 from the 1992–2005 broods. Alaska Department of Fish and Game, Division of Sport Fish, Fisheries Data Series No. 12-04, Anchorage.

Weller, J.L., and D. E Evans, and. 2012. Production of Unuk River Chinook salmon through 2009 from the 1992–2006 broods. Alaska Department of Fish and Game, Division of Sport Fish, Fisheries Data Series No. 12-85, Anchorage.

APPENDIX A

Appendix A1.–Statistics used to estimate the harvest of Chinook salmon adults returning to the Unuk River from the 2013 brood.

θ = 0.086 (x 350,000 smolt corresponds to 30,000 smolt tagged; G (θ^{-1}) = 0.013)[a,b,c,d]

Age	Stratum	π_i	φ_i	λ_i	r_i	m_i	$G(p_i)$	$G(N_i)$	$SE(r_i)$	$P(m_i>0)$
1.2										
	Trad Troll 3	1.54E-05	0.34	0.98	16	0.5	2.1	0	24	0.37
	Trad Troll 4	1.46E-05	0.34	0.98	15	0.4	2.2	0	23	0.36
	Trad Troll 5–7	3.60E-05	0.33	0.98	39	1.1	0.9	0	37	0.66
	Exp Troll	3.49E-05	0.51	0.99	24	1.1	0.9	0	23	0.65
	Drift Gillnet	7.19E-05	0.57	0.99	45	2.2	0.4	0	30	0.88
	Sport Ketch DE	7.49E-06	0.79	0.98	3	0.2	4.2	0	7	
	Sport Ketch MB	2.02E-05	0.20	0.98	36	0.6	1.6	0.08	45	0.46
	Sport Sitka DE	1.75E-05	1.00	0.98	6	0.5	1.8	0.03	8	0.41
	Troll CDFO	4.87E-06	0.49	0.98	4	0.1	6.6	0	9	0.14
	PNP	6.93E-06	0.18	0.98	14	0.2	4.7	0	30	0.19
	Other	2.73E-05	0.69	0.98	14	0.8	1.2	0	15	0.56
1.3										
	Trad Troll 1	4.06E-05	0.40	0.98	36	1.2	0.8	0	32	0.70
	Trad Troll 3	1.97E-04	0.34	0.98	208	6.0	0.2	0	87	1.00
	Trad Troll 4	1.83E-05	0.34	0.98	19	0.6	1.8	0	25	0.42
	Trad Troll 5–7	1.13E-05	0.33	0.98	12	0.3	2.9	0	21	0.29
	Exp Troll	4.43E-04	0.51	0.99	307	13.4	0.1	0	89	1.00
	Drift Gillnet	6.26E-05	0.57	0.99	39	1.9	0.5	0	28	0.85
	Sport Ketch DE	4.32E-05	0.79	0.98	20	1.3	0.7	0	17	0.73
	Sport Ketch MB	3.00E-05	0.20	0.98	53	0.9	1.1	0.08	55	
	Sport Sitka DE	1.80E-05	1.00	0.98	6	0.6	1.7	0.03	8	0.42
	Sport Sitka MB	2.49E-05	0.38	0.98	24	0.8	1.3	0.03	27	0.53
	Sport Craig MB	1.61E-05	0.92	0.98	6	0.5	1.9	0.08	8	0.38
	Troll CDFO	1.24E-05	0.49	0.98	9	0.4	2.6	0	14	0.31
	Other	3.11E-05	0.69	0.98	16	1.0	1.0	0	16	0.61
1.4										
	Trad Troll 1	8.68E-05	0.40	0.98	77	2.7	0.4	0	47	0.93
	Trad Troll 3	2.47E-05	0.34	0.98	26	0.8	1.3	0	30	0.52
	Exp Troll	1.39E-04	0.51	0.99	96	4.2	0.2	0	47	0.98
	Drift Gillnet	5.89E-05	0.57	0.99	37	1.8	0.5	0	27	0.83
	Sport Ketch DE	4.83E-05	0.79	0.98	22	1.5	0.6	0	18	0.77
	Sport Ketch MB	4.37E-05	0.20	0.98	77	1.3	0.8	0.08	68	0.73
	Sport Sitka MB	1.69E-05	0.38	0.98	16	0.5	1.9	0.03	22	0.40
	Troll CDFO	5.63E-06	0.49	0.98	4	0.2	5.7	0	10	0.16
Total					1,326	50				

[a] See text for assumptions regarding data inputs.

[b] 90% relative precision of the estimate of harvest of brood year 2013 Unuk River Chinook salmon is anticipated to be 25.4%.

[c] Column headings are as defined in Bernard and Clark (1996).

[d] Numbers after stratum entries depict fishing periods; MB= marine boat; DE=Derby;CDFO=Canadian Dept. Fisheries and Oceans.

APPENDIX B

Appendix B1.–Division of Sport Fish coded wire tag daily log form.

Sport Fish Division CWT Daily Log Form **Date** ______________

Tagging Site: ________________________________
Species: ________________________________
Machine Serial #: ________________________________
Today's Tag Code: ________________________________

a	Machine ending number	________________
b	Machine beginning number	________________
c	# of Injections (a-b)	________________
d	Retags/Morts/Etc.	________________
e	# tagged fish for this day (c-d)	________________
f	Overnight mortality	________________
g	Total tagged fish (e-f)	________________

Recaptures from Minnow Traps:

h	# with CWTs	________________
i	# without CWTs	________________
j	Total # recaptures (h+i)	________________

24-Hour Retention:

k	# with CWTs	________________
l	# without CWTs	________________
m	Total # tested (k+l)	________________
n	Short term retention % (k/m)	________________
o	Valid tagged and released (n x g)	________________

Cumulative Tagged and Released (code specific) ______________

Appendix B2.–Physical data form.

Date	Water temp ^{o}C	Water depth (inches)