Regional Operational Plan SF.1J.2013.16

Production and Harvest of Chilkat River Chinook and Coho Salmon, 2013–2014

by

Richard S. Chapell

and

Brian W. Elliott

November 2013

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

Symbols and Abbreviations

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

Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

REGIONAL OPERATIONAL PLAN SF.1J.2013.16

PRODUCTION AND HARVEST OF CHILKAT RIVER CHINOOK AND COHO SALMON, 2013–2014

by

Richard S. Chapell and Brian W. Elliott

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

Alaska Department of Fish and Game
Division of Sport Fish

November 2013

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

Richard S. Chapell and Brian W. Elliott,
Alaska Department of Fish and Game, Division of Sport Fish,
PO Box 330, Haines, AK 99827

This document should be cited as:
Chapell, R. S., and B. W. Elliott. 2013. Production and harvest of Chilkat River Chinook and coho salmon, 2013–2014. Alaska Department of Fish and Game, Regional Operational Plan No. SF.1J.2013.16, Anchorage

SIGNATURE/TITLE PAGE

Project Title:	Production and harvest of Chilkat River Chinook and coho salmon, 2013–2014
Project leader(s):	Richard S. Chapell, Fishery Biologist III; Brian W. Elliott, Fishery Biologist II
Division, Region and Area:	Sport Fish, Region 1, Haines/Skagway Management Area
Project Nomenclature:	CWTIT, Chinook Salmon Research Initiative
Period Covered:	August 1, 2013–June 30, 2014
Field Dates:	September 16, 2013–May 15, 2014
Plan Type:	Category III

Approval

Title	Name	Signature	Date
Project leader	Richard Chapell		7/29/2013
Project leader	Brian W. Elliott		7.29.2013
Biometrician	Sarah Power		7.29.2013
Research Coordinator	John DerHovanisian		8/2/13
Regional Supervisor	Brian Frenette		8.5.13

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

LIST OF APPENDICES (continued)

Appendix **Page**

PURPOSE

The Chilkat River is considered the third or fourth largest producer of Chinook salmon *Oncorhynchus tshawytscha* in Southeast Alaska (McPherson et al. 2003). Chilkat River Chinook salmon is a Pacific Salmon Commission (PSC) indicator stock and contributes towards management of the Southeast Alaska sport fishery allocation in accordance with the Pacific Salmon Treaty (PST). The Chilkat River is also the second largest producer of coho salmon *O. kisutch* (Shaul et al. 2008), and provides the majority of the coho salmon freshwater fishery in the Haines area, which is one of the largest freshwater fisheries in Southeast Alaska (Jennings et al. 2009).

Chilkat River Chinook and coho salmon are full indicator stocks; the Chilkat River coded wire tag (CWT) project is an important component towards estimating smolt abundance, marine harvest in mixed-stock fisheries, and marine survival from smolt to adult. Coded wire tag studies have been conducted on the Chilkat River consistently since 1999. Smolt abundance along with harvest contributions have been estimated for Chilkat River Chinook salmon brood years 1998–2005, with brood years 2006–2010 in progress. Smolt abundance, marine harvest, and marine survival have been estimated for coho salmon outmigration years 1999–2009, with 2010–2012 in progress.

Chilkat River Chinook salmon smolt abundance averaged 165,867 (SE = 37,290) for brood years (BY) 1999–2004, average total return averaged 4,867 (SE = 638), marine harvest averaged 887 (SE = 277), and marine survival averaged 3.2% (SE = 0.8%). For emigration years 1999–2010, Chilkat River coho salmon smolt abundance averaged 1,333,080 (SE = 258,417), total return averaged 142,889 (SE = 21,085), marine harvest averaged 58,804 (SE = 10,444), and marine survival averaged 10.9% (SE = 2.0%).

This operational plan includes the study design for fall CWT- tagging of Chinook salmon parr on the Tahini River, Kelsall River, and Chilkat River during September and October 2013, in addition to spring tagging of Chinook and coho salmon smolt during April and May 2014.

BACKGROUND

The Chilkat River is a large glacial system that originates in British Columbia, Canada, flows through rugged dissected mountainous terrain, and terminates in Chilkat Inlet near the northern terminus of Lynn Canal (Figure 1). The main channels and major tributaries comprise approximately 350 km of river channel in a watershed covering about 1,600 km² (Bugliosi 1988). The Chilkat River is the third or fourth largest producer of Chinook (McPherson et al. 2003) and the second largest producer of coho salmon (Shaul et al. 2008) in Southeast Alaska.

The spring marine boat fishery near Haines has harvested up to 1,700 Chinook salmon annually, many of which are Chilkat River spawners (Table 1). From 1981 through 1992, the Chilkat River Chinook salmon escapement was monitored through peak survey counts on clearwater tributaries to the Chilkat River (Big Boulder Creek, Stonehouse Creek) as an index of abundance. Mark-recapture (M-R) experiments have been used to estimate the abundance of large Chinook salmon entering the Chilkat River since 1991. Comparisons of 1991 and 1992 M-R estimates to expanded Stonehouse Creek and Big Boulder Creek index counts showed that the expanded index counts grossly underestimated total Chilkat River abundance (Johnson et al. 1993). Mark-recapture estimates of the inriver abundance of large Chinook salmon have ranged from 1,442 to 8,100 fish (Table 2). In 2003, the department adopted an escapement goal range of 1,750–3,500

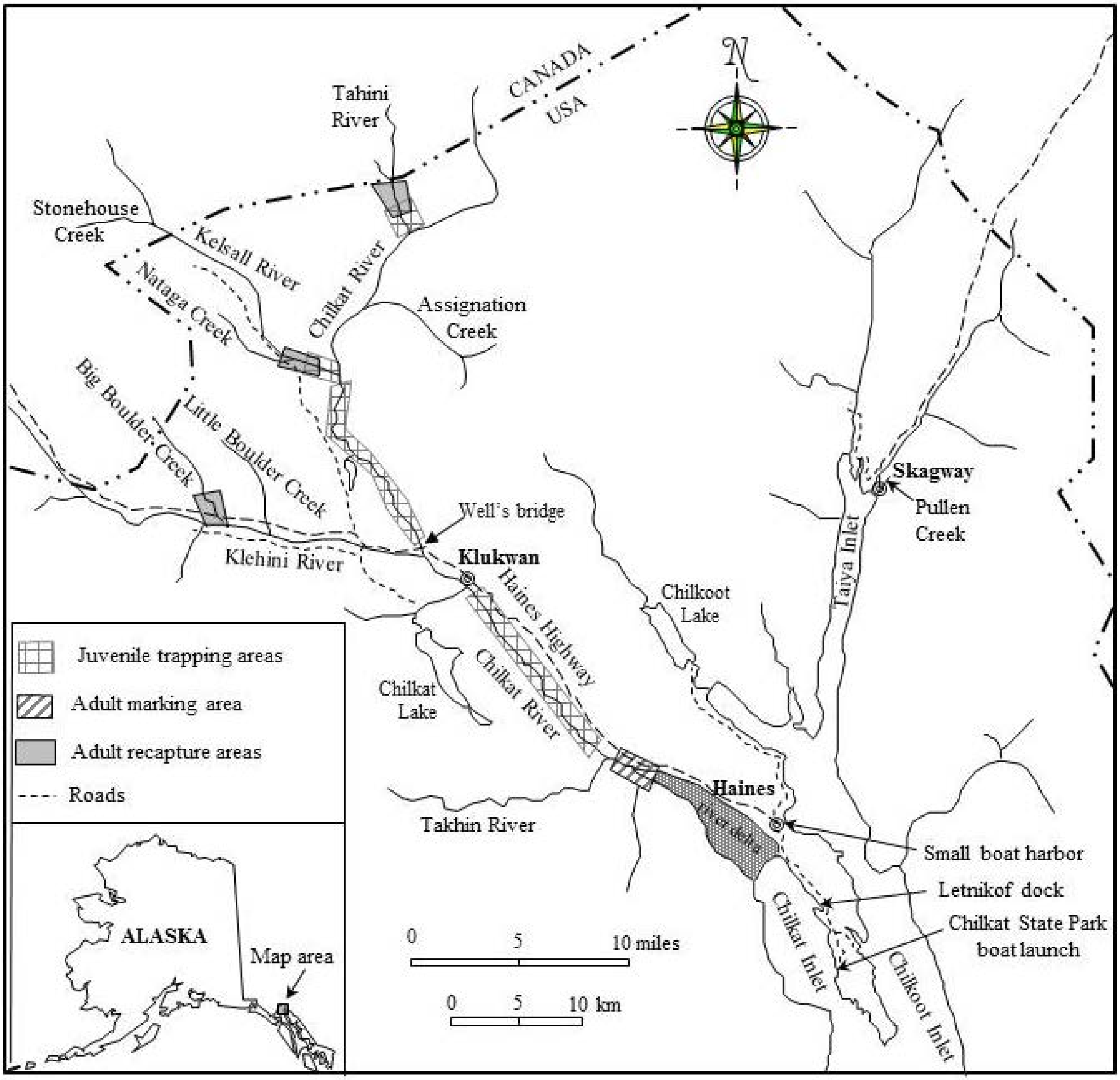

Figure 1.–Chinook salmon sampling sites in the Chilkat River drainage.

Table 1.–Estimated angler effort, and large Chinook salmon catch and harvest in the Haines marine boat sport fishery for comparable sample periods, 1984–2012.

		Effort				Large (28") Chinook salmon				
Year	Survey dates	Angler-hr	SE	Salmon-hr	SE	Catch	SE	Harvest	SE	CPUE[a]
1984[b]	5/06–6/30	10,253	[c]	9,855	[c]	1,072	[c]	1,072	[c]	0.109
1985[d]	4/15–7/15	21,598	[c]	20,582	[c]	1,705	[c]	1,696	[c]	0.083
1986[e]	4/14–7/13	33,857	[c]	32,533	[c]	1,659	[c]	1,638	[c]	0.051
1987[f]	4/20–7/12	26,621	2,557	22,848	2,191	1,094	189	1,094	189	0.048
1988[g]	4/11–7/10	36,222	3,553	32,723	3,476	505	103	481	101	0.015
1989[h]	4/24–6/25	10,526	999	9,363	922	237	42	235	42	0.025
1990[i]	4/23–6/21	[i]	[i]	11,972	1,169	248	60	241	57	0.021
1993[j]	4/26–7/18	11,919	1,559	9,069	1,479	349	63	314	55	0.038
1994[k]	5/09–7/03	9,726	723	7,682	597	269	41	220	32	0.035
1995[l]	5/08–7/02	9,457	501	8,606	483	255	42	228	41	0.030
1996[m]	5/06–6/30	10,082	880	9,596	866	367	43	354	41	0.038
1997[n]	5/12–6/29	9,432	861	8,758	697	381	46	381	46	0.044
1998[o]	5/11–6/28	8,200	811	7,546	747	222	60	215	56	0.029
1999[p]	5/10–6/27	6,206	736	6,097	734	184	24	184	24	0.030
2000[q]	5/08–6/25	4,428	607	4,043	532	103	34	49	12	0.025
2001[r]	5/07–6/24	5,299	815	5,107	804	199	26	185	26	0.039
2002[s]	5/06–6/30	7,770	636	7,566	634	343	40	337	40	0.045
2003[t]	5/05–6/29	10,651	596	10,055	578	405	40	404	40	0.040
2004[u]	5/10–6/27	12,761	763	12,518	744	413	46	403	44	0.033
2005[v]	5/09–6/26	12,641	1,239	12,287	1,216	260	31	252	31	0.021
2006[w]	5/08–6/25	8,172	610	7,869	558	176	15	165	13	0.022
2007[x]	5/07–6/24	7,411	725	7,223	690	285	43	285	43	0.039
2008[y]	5/05–6/22	1,211	177	1,132	167	27	11	27	11	0.024
2009[z]	5/04–6/21	7,405	534	7,267	520	145	12	143	12	0.020
2010[aa]	5/10–6/27	7,823	534	7,737	520	219	25	216	25	0.028
2011[ab]	5/09–6/26	8,734	478	8,592	471	217	16	217	16	0.025
2012[ac]	5/07–6/24	7,423	498	7,403	496	229	33	217	33	0.031
1984–1988 average		25,710		23,708		1,207		1,196		0.061
1989–1990, 1993–2007, 2009–2011 average		8,876		8,448		264		250		0.031

-continued-

Table 1.–Page 2 of 2.

[a] Catch of large Chinook salmon per salmon-hour of effort.
[b] From Neimark (1985).
[c] Estimates of variance were not provided until 1987.
[d] From Mecum and Suchanek (1986).
[e] From Mecum and Suchanek (1987).
[f] From Bingham et al. et al. (1988).
[g] From Suchanek and Bingham (1989).
[h] From Suchanek and Bingham (1990).
[i] From Suchanek and Bingham (1991); no estimate of total angler effort and harvest was provided
[j] From Ericksen (1994).
[k] From Ericksen (1995).
[l] From Ericksen (1996).
[m] From Ericksen (1997).
[n] From Ericksen (1998).
[o] From Ericksen (1999).
[p] From Ericksen (2000).
[q] From Ericksen (2001a).
[r] From Ericksen (2002a).
[s] From Ericksen (2003a).
[t] From Ericksen (2004).
[u] From Ericksen (2005).
[v] From Ericksen and Chapell (2006b).
[w] From Chapell (2009).
[x] From Chapell (2010).
[y] From Chapell (2012).
[z] From Chapell (2013a)
[aa] From Chapell (2013b)
[ab] From Chapell (*in prep* a)
[ac] From Chapell (*in prep* b)

large Chinook salmon for the Chilkat River drainage, and the Chilkat River and Lynn Canal King Salmon Fishery Management Plan (5 AAC 33.384) specifies an inriver run goal range of 1,850–3,600 large Chinook salmon upstream of the adult marking area, based on M-R estimates (Ericksen and McPherson 2004). Since Chilkat River Chinook salmon inriver M-R studies were begun in 1991, inriver run estimates were below the lower bound of the goal range in 3 years: 2007, 2010, and 2012 (Chapell 2010, 2013b, *in prep b*).

Coded wire tag studies of Chilkat River Chinook salmon have been conducted since 1985, and consistently since 1999 (Table 3). Chinook harvest contributions have been estimated for the Tahini River BY 1984 and 1985 (Johnson et al. 1993) and the Chilkat River BYs 1988, 1989, 1991, 1998, and 1999–2004 (Ericksen 1996, 1999; Ericksen and Chapell 2006b; Chapell 2009, 2010, 2012, 2013a-b, *in prep* a). These studies indicate that Chilkat River Chinook salmon rear primarily in the inside marine waters of northern Southeast Alaska, and that exploitation rates on this stock have ranged from 8% to 25% (Table 4). However, a 1991 study that compared logbook-recorded catch rates to fish ticket-reported catches showed that the Chinook salmon harvest in the Lynn Canal commercial drift gill net fishery was grossly underreported, so marine exploitation rates may be substantially higher (Ericksen and Marshall 1997). The inriver abundance and escapement goal ranges will be refined with spawner-recruit data from escapement studies combined with smolt emigration, marine survival, and marine harvest estimates provided by CWT studies.

Table 2.–Estimated sport harvest of wild mature Chinook salmon in the Haines marine boat fishery and inriver run of large Chinook salmon in the Chilkat River, 1991–2012.

	Sport harvest		Chilkat River abundance	
Year	Wild mature Chinook	SE	Large (≥age 1.3) Chinook	SE
1991	Sport fishery closed		5,897[a]	1,005
1992	Sport fishery closed		5,284[b]	949
1993	252[c]	46	4,472[d]	851
1994[e]	190	29	6,795	1,057
1995[f]	193	35	3,790	805
1996[g]	257	29	4,920	751
1997[h]	311	41	8,100	1,193
1998[i]	153	51	3,675	565
1999[j]	82	11	2,271	408
2000[k]	27	8	2,035	334
2001[l]	126	20	4,517	722
2002[m]	272	37	4,051	429
2003[n]	285	27	5,657	690
2004[o]	269	29	3,422	456
2005[p]	165	26	3,366	555
2006[q]	86	9	3,027	437
2007[r]	177	33	1,442	278
2008[s,t]	5	2	2,905	544
2009[u]	80	10	4,429	747
2010[v]	121	19	1,815	226
2011[w]	174	13	2,688	318
2012[x]	153	30	1,744	129

[a] From Johnson et al. (1992).
[b] From Johnson et al. (1993).
[c] From Ericksen (1994).
[d] From Johnson (1994).
[e] From Ericksen (1995).
[f] From Ericksen (1996).
[g] From Ericksen (1997).
[h] From Ericksen (1998).
[i] From Ericksen (1999).
[j] From Ericksen (2000).
[k] From Ericksen (2001a).
[l] From Ericksen (2002a).
[m] From Ericksen (2003a).
[n] From Ericksen (2004).
[o] From Ericksen (2005).
[p] From Ericksen and Chapell (2006b).
[q] From Chapell (2009).
[r] From Chapell (2010).
[s] From Chapell (2012).
[t] Chilkat Inlet was closed to Chinook salmon retention.
[u] From Chapell (2013a).
[v] From Chapell (2013b).
[w] From Chapell (*in prep* a).
[x] From Chapell (*in prep* b).

Table 3.–Number of live coded wire tagged Chinook salmon released into the Chilkat River by brood year (BY) and year of release, through spring 2013.

Brood year	Capture/release site	Release year	Stage	Total marked	Shed tags	Valid tags
BY 1984 total	Tahini River	1985	Fed fry	42,961	601	42,360
BY 1985 total	Tahini River	1986	Fed fry	46,478	1,457	44,120
BY 1987 total	Kelsall River	1988	Parr	4,553	0	4,553
1988	Chilkat River	1989	Parr	9,897	119	9,778
1988	Chilkat River	1990	Smolt	2,220	29	2,191
1988	Kelsall River	1989	Parr	20,199	120	20,079
1988	Tahini River	1989	Parr	5,293	0	5,293
BY 1988 total				37,609	268	37,341
1989	Chilkat River	1990	Parr	2,230	0	2,230
1989	Kelsall River	1990	Parr	10,242	82	10,160
1989	Tahini River	1990	Fed fry	30,146	180	29,966
1989	Tahini River	1990	Parr	1,403	0	1,403
BY 1989 total				44,021	262	43,759
BY 1990 total	Tahini River	1991	Fed fry	36,316	796	35,520
1991	Big Boulder Creek	1992	Fed fry	44,820	1,470	43,018
1991	Tahini River	1992	Fed fry	62,579	2,024	60,555
BY 1991 total				107,399	3,494	103,573
BY 1992 total	Big Boulder Creek	1993	Fed fry	23,389	1,614	21,775
1993	Big Boulder Creek	1994	Emergent fry	24,324	243	24,081
1993	Big Boulder Creek	1994	Fed fry	28,062	1,516	26,546
BY 1993 total				52,386	1,759	50,627
BY 1994 total	Big Boulder Creek	1995	Emergent fry	45,060	2,569	42,491
BY 1995 total	Big Boulder Creek	1996	Emergent fry	62,014	3,082	58,556
BY 1997 total	Chilkat River	1999	Smolt	771	0	771
1998	Lower Chilkat	2000	Smolt	446	0	446
1998	Upper Chilkat	2000	Smolt	1,550	0	1,550
BY 1998 total				1,996	0	1,996
1999	Chilkat River	2000	Parr	6,974	0	6,974
1999	Kelsall River	2000	Parr	17,647	0	17,647
1999	Klehini River	2000	Parr	173	0	173
1999	Tahini	2000	Parr	5,310	0	5,310
1999	Lower Chilkat	2001	Smolt	4,506	0	4,506
BY 1999 total				34,610	0	34,610
2000	Tahini River	2001	Parr	2,740	0	2,740
2000	Kelsall River	2001	Parr	10,913	0	10,913
2000	Lower Chilkat	2001	Parr	9,470	0	9,470
2000	Lower Chilkat	2002	Smolt	4,714	5	4,709
BY 2000 total				27,837	5	27,832

-continued-

Table 3.–Page 2 of 3.

Brood year	Capture/release site	Release year	Stage	Total marked	Shed tags	Valid tags
2001	Tahini River	2002	Parr	6,519	0	6,519
2001	Kelsall River	2002	Parr	18,251	0	18,251
2001	Lower Chilkat	2002	Parr	6,620	0	6,620
2001	Lower Chilkat	2003	Smolt	2,797	0	2,797
BY 2001 total				34,187	0	34,187
2002	Tahini River	2003	Parr	4,939	0	4,939
2002	Kelsall River	2003	Parr	17,039	0	17,039
2002	Lower Chilkat	2003	Parr	14,662	0	14,662
2002	Lower Chilkat	2004	Smolt	5,707	0	5,707
BY 2002 total				42,347	0	42,347
2003	Tahini River	2004	Parr	5,671	0	5,671
2003	Kelsall River	2004	Parr	19,395	0	19,395
2003	Lower Chilkat	2004	Parr	12,179	0	12,179
2003	Lower Chilkat	2005	Smolt	5,825	16	5,809
BY 2003 total				43,160	16	43,054
2004	Tahini River	2005	Parr	6,473	0	6,473
2004	Kelsall River	2005	Parr	17,867	0	17,867
2004	Lower Chilkat	2005	Parr	10,356	0	10,356
2004	Lower Chilkat	2006	Smolt	5,080	5	5,075
BY 2004 total				39,776	5	39,771
2005	Tahini River	2006	Parr	2,832	0	2,832
2005	Kelsall River	2006	Parr	15,205	0	15,205
2005	Chilkat River	2006	Parr	281	0	281
2005	Chilkat River	2007	Smolt	2,239	1	2,238
BY 2005 total				20,557	1	20,556
2006	Tahini River	2007	Parr	5,273	0	5,273
2006	Kelsall River	2007	Parr	12,196	0	12,196
2006	Chilkat River	2007	Parr	11,180	0	11,180
2006	Chilkat River	2008	Smolt	2,499	0	2,499
BY 2006 total				31,148	0	31,148
2007	Tahini River	2008	Parr	3,947	0	3,947
2007	Kelsall River	2008	Parr	9,866	0	9,866
2007	Chilkat River	2008	Parr	6,361	0	6,361
2007	Chilkat River	2009	Smolt	3,911	0	3,911
BY 2007 total				24,085	0	24,085
2008	Tahini River	2009	Parr	3,041	0	3,041
2008	Kelsall River	2009	Parr	4,784	0	4,784
2008	Chilkat River	2009	Parr	8,162	0	8,162
2008	Chilkat River	2010	Smolt	995	0	995
BY 2008 total				16,982	0	16,982

-continued-

Table 3.–Page 3 of 3.

Brood year	Capture/release site	Release year	Stage	Total marked	Shed tags	Valid tags
2009	Tahini River	2010	Parr	7,254	0	7,254
2009	Kelsall River	2010	Parr	15,883	0	15,883
2009	Chilkat River	2010	Parr	15,703	25	15,678
2009	Chilkat River	2011	Smolt	5,514	0	5,514
BY 2009 total				44,354	25	44,329
2010	Tahini River	2011	Parr	1,840	0	1,840
2010	Kelsall River	2011	Parr	8,534	0	8,534
2010	Chilkat River	2011	Parr	15,986	0	15,986
2010	Chilkat River	2012	Smolt	3,175	0	3,175
BY 2010 total				29,535	0	29,535
2011	Tahini River	2012	Parr	4,973	0	4,973
2011	Kelsall River	2012	Parr	10,173	0	10,173
2011	Chilkat River	2012	Parr	11,726	0	11,726
2011	Chilkat River	2013	Smolt	5,917	6	5,911
BY 2011 total				32,789	6	32,783

The Chilkat River produces most of the coho salmon harvested in Haines area recreational fisheries and supports one of the largest freshwater coho fisheries in the Southeast Alaska region, with an average annual harvest of 2,060 coho salmon from 2000 to 2009 (Jennings et al. 2004, 2006a-b, 2007, 2009; Walker et al. 2003; http://docushare.sf.adfg.state.ak.us/dsweb/View/Collection-222, accessed July 2011). The contribution of Chilkat River coho salmon to the commercial troll, gillnet, and seine fisheries in northern Southeast Alaska averaged 58,804 from 2000 to 2011 (Table 5). Escapement and harvest research conducted during the 1980s on coho salmon stocks in Lynn Canal suggest that these stocks were subjected to very high (over 85%) exploitation rates (Elliott and Kuntz 1988; Shaul et al. 1991).

Chilkat River coho salmon smolts were CWT-tagged intermittently from 1976 to 1984, and annually from 1999 to 2013 (Table 6). In 2013, marine fisheries and the Chilkat River escapement will be sampled for CWT-tagged fish released during the project. A proportion of the 18,307 coho salmon smolts tagged in 2012 (Table 6) will start entering the lower Chilkat River as adults in August 2013. The Chilkat River coho salmon CWT project allows for estimates of smolt emigration abundance, marine harvest by fishery, total marine and fresh water exploitation, and smolt-to-adult survival (Table 5). Total marine harvest (commercial, sport, and subsistence fisheries) has ranged from 12,142 fish in return year 2007 to 128,466 fish in 2004. Most of the marine harvest occurs in the commercial troll fishery (54–68%) and the Lynn Canal drift gillnet fishery (26–54%). Marine exploitation has varied from 29% to 65% in 2000–2011 (Table 5). Commercial fishery management, weather conditions, and the price of coho salmon are the primary reasons for the fluctuation in marine exploitation.

The Chilkat River coho salmon total escapement, including ocean age-.0 fish, has been estimated each year since 1987 by expanding peak counts from index area foot surveys in 4 widely distributed streams: Spring Creek in the Tsirku River drainage, Kelsall River, Tahini River, and

Table 4.–Summary of Chilkat Chinook salmon stock assessment parameters from coded wire tag studies, brood years 1988–1989, 1991, and 1999–2004.

PARAMETER ESTIMATES

					Harvest (≥age 1.1)			≥Age 1.2				
Brood year (BY)	Fall parr	Overwinter survival %	Smolt	Marked fraction, inriver	Commercial	Sport	Subsistence	Total harvest	Inriver return	Total return	Exploitation, %	Smolt to ≥age-1.2 survival %
1988[a]	ND	ND	ND	0.037	910	719	9	1,638	7,111	8,749	18.7	ND
1989[a]	ND	ND	ND	0.110	283	373	27	683	6,233	6,916	9.9	ND
1991[b]	ND	ND	ND	0.048	681	374	58	1,006	11,900	12,906	7.8	ND
1998[c]	ND	ND	123,680	0.015	191	849	ND	1,040	3,596	4,636	22.4	3.7
1999[d]	386,400	36.4	139,500	0.113	589	972	252	1,572	4,764	6,336	24.8	4.5
2000[e]	510,700	21.1	105,300	0.102	414	353	236	990	4,173	5,163	19.2	4.9
2001[f]	596,410	24.9	148,800	0.076	407	304	192	821	4,561	5,382	15.3	3.6
2002[g]	509,700	38.8	194,000	0.106	254	124	2	380	1,577	1,957	19.4	1.0
2003[h]	668,000	43.0	284,800	0.078	719	355	81	1,125	5,519	6,644	16.9	2.3
2004	529,700	23.4	122,800	0.110	270	163	1	434	3,283	3,717	11.7	3.0
1999–2004	533,485	31.3	165,867	0.098	442	379	127	887	3,980	4,867	17.9	3.2

STANDARD ERRORS

					Harvest (≥age 1.1)			≥Age 1.2				
Brood year (BY)	Fall parr	Overwinter survival, %	Smolt	Marked fraction, inriver	Commercial	Sport	Subsistence	Total harvest	Inriver return	Total return	Exploitation, %	Smolt to ≥age-1.2 survival, %
1988[a]	ND	ND	ND	0.009	235	327	1	403	789	885	NE	ND
1989[a]	ND	ND	ND	0.019	74	132	2	152	781	796	NE	ND
1991[b]	ND	ND	ND	0.008	176	124	2	210	1,167	1,186	NE	ND
1998[c]	ND	ND	30,554	NE	190	706	ND	731	488	879	12.5	1.2
1999[d]	38,020	6.5	21,920	0.009	108	550	78	541	562	780	6.7	0.9
2000[e]	74,290	4.8	17,170	0.010	107	161	86	211	681	713	4.2	1.0
2001[f]	87,540	10.1	49,770	0.002	130	126	139	222	727	760	4.1	1.3
2002[g]	81,390	10.6	47,020	0.015	77	52	0	93	234	252	4.5	0.2
2003	75,490	8.3	49,870	0.008	118	116	60	226	657	695	3.3	0.5
2004	70,150	4.6	19,820	0.012	91	67	0	112	435	449	3.0	0.6

Note: ND = no data, NE = not estimated.

[a] Data from Ericksen (1996).
[b] Data from Ericksen (1999).
[c] Data from Ericksen and Chapell (2006b).
[d] Data from Chapell (2009).
[e] Data from Chapell (2010).
[f] Data from Chapell (2012).
[g] Data from Chapell (2013a).
[h] Data from Chapell (2013b).
[i] Data from Chapell (*in prep* a).

Table 5.–Production parameter estimates for 1-ocean-age Chilkat River coho salmon, 2000–2011. Complete estimates for 2012 inriver harvest, marine harvest, and related variances are not yet available.

Return year, t	Number CWT smolt (t-1)	Smolt theta (θ_s)	Smolt estimate	SE	Marine theta (θ_m)	Marine harvest	SE	Inriver harvest	SE	Age x.1 esc	SE	Total return	SE	Marine exploit.	SE	Marine survival	SE
2000[a]	25,915	0.019	1,237,056	219,715	0.019	39,546	3,745	853	221	84,843	16,330	125,242	16,755	0.32	0.05	0.10	0.02
2001[b]	25,016	0.021	1,185,804	164,121	0.020	45,658	7,194	2,176	451	107,697	20,720	155,531	21,938	0.29	0.05	0.13	0.03
2002[c]	36,114	0.012	2,970,458	377,695	0.012	110,105	10,355	3,888	742	204,787	31,071	318,780	32,759	0.35	0.04	0.11	0.02
2003[d]	25,296	0.015	1,696,212	190,330	0.015	83,302	6,956	2,932	497	133,109	14,926	219,291	16,474	0.38	0.03	0.13	0.02
2004[e]	24,563	0.012	1,938,322	401,419	0.010	128,466	19,882	3,169	661	67,053	12,901	198,688	23,710	0.65	0.05	0.10	0.03
2005[f]	17,276	0.021	776,934	147,738	0.020	29,518	3,483	1,453	293	34,575	4,561	65,546	5,746	0.45	0.04	0.08	0.02
2006[g]	26,342	0.014	1,807,837	217,352	0.013	70,813	7,632	2,082	293	79,050	15,210	151,945	17,020	0.47	0.05	0.08	0.01
2007[h]	22,149	0.025	875,478	134,864	0.023	12,142	1,585	635	149	24,770	4,769	37,547	5,027	0.32	0.05	0.04	0.01
2008[i]	24,104	0.027	893,032	95,380	0.025	52,989	3,518	991	261	56,369	10,846	110,349	11,405	0.48	0.05	0.12	0.02
2009[j]	23,059	0.032	716,689	88,013	0.031	30,558	2,585	2,424	421	47,911	9,219	80,893	9,584	0.38	0.05	0.11	0.02
2010[k]	24,937	0.028	872,829	151,981	0.026	68,385	5,165	706	138	85,066	16,375	154,157	17,171	0.44	0.05	0.18	0.04
2011[l]	26,877	0.026	1,026,314	162,061	0.022	34,161	2,585	1,437	289	61,099	15,747	96,698	15,961	0.35	0.06	0.09	0.02
2012[m]	31,092	0.024	1,229,468	242,671	0.021					36,961	7441						
Avg. 2000–2011	25,595	0.021	1,333,080	258,417	0.020	58,804	10,444	1,896	500	82,194	19,515	142,889	21,085	0.41	0.05	0.11	0.02

[a] From Ericksen (2001b).
[b] From Ericksen (2002b).
[c] From Ericksen (2003b).
[d] From Ericksen and Chapell (2005).
[e] From Ericksen and Chapell (2006a).
[f] From Ericksen (2006).
[g] From Elliott (2009).
[h] From Elliott (2010).
[i] From Elliott (2012a).
[j] From Elliott (2012b).
[k] From Elliott (2013).
[l] From Elliott (*in prep a*).
[m] From Elliott (*in prep b*).

Table 6.–Number of live coded wire tagged coho salmon released into the Chilkat River by year of release, through 2013.

Release year	Capture site	Stage	Total marked	Shed tags	Valid tags
1976 total	Chilkat River[a]	Parr	9,074	0	9,074
1977	Chilkat Lake	Parr	6,344	0	6,344
1977	Chilkat ponds[b]	Parr	2,729	0	2,729
1977 total			9,073	0	9,073
1981 total	Chilkat Lake	Parr	2,603	0	2,603
1982 total	Chilkat ponds	Parr	8,608	93	8,515
1984 total	Chilkat ponds	Parr	14,644	102	14,542
1999	Chilkat River	Smolt	12,037	10	12,027
1999	Chilkat Lake	Smolt	4,078	0	4,078
1999	Chilkat tributaries	Smolt	9,800	29	9,771
1999 total			25,915	39	25,876
2000	Chilkat tributaries	Smolt	9,980	20	9,960
2000	Lower Chilkat River	Smolt	11,953	4	11,949
2000	Upper Chilkat River	Smolt	3,083	0	3,083
2000 Total			25,016	24	24,992
2001 Total	Lower Chilkat River	Smolt	36,114	117	35,997
2002 Total	Lower Chilkat River	Smolt	25,296	7	25,289
2003 Total	Lower Chilkat River	Smolt	24,563	4	24,559
2004 Total	Lower Chilkat River	Smolt	17,279	0	17,279
2005 Total	Lower Chilkat River	Smolt	26,342	16	26,326
2006 Total	Lower Chilkat River	Smolt	22,168	24	22,149
2007 Total	Lower Chilkat River	Smolt	24,104	0	24,104
2008 Total	Lower Chilkat River	Smolt	23,059	0	23,059
2009 Total	Lower Chilkat River	Smolt	24,937	0	24,937
2010 Total	Lower Chilkat River	Smolt	26,932	55	26,877
2011 Total	Lower Chilkat River	Smolt	31,101	9	31,092
2012 Total	Lower Chilkat River	Smolt	18,353	46	18,307
2013 Total	Lower Chilkat River	Smolt	10,878	44	10,834

[a] This includes several locations throughout the drainage including the airport tributaries in 1976.
[b] Chilkat ponds refers to several ponds throughout the drainage where fish access was improved.

Clear Creek on the west side of Chilkat Inlet (Table 7, Figure 2). The total of index counts is expanded to estimate escapement, based on 5 M-R experiments used to calibrate the index count. Mark-recapture projects were conducted in 1990 (estimate: 79,807 fish, SE = 9,980), 1998 (estimate: 50,758, SE = 10,698), 2002 (estimate: 205,429, SE = 31,165), 2003 (estimate: 134,340, SE = 15,070), and 2005 (estimate: 38,589, SE = 4,625) (Elliott 2009). Averaging the ratios of M-R estimates to the sum of concurrent peak index counts has produced an expansion

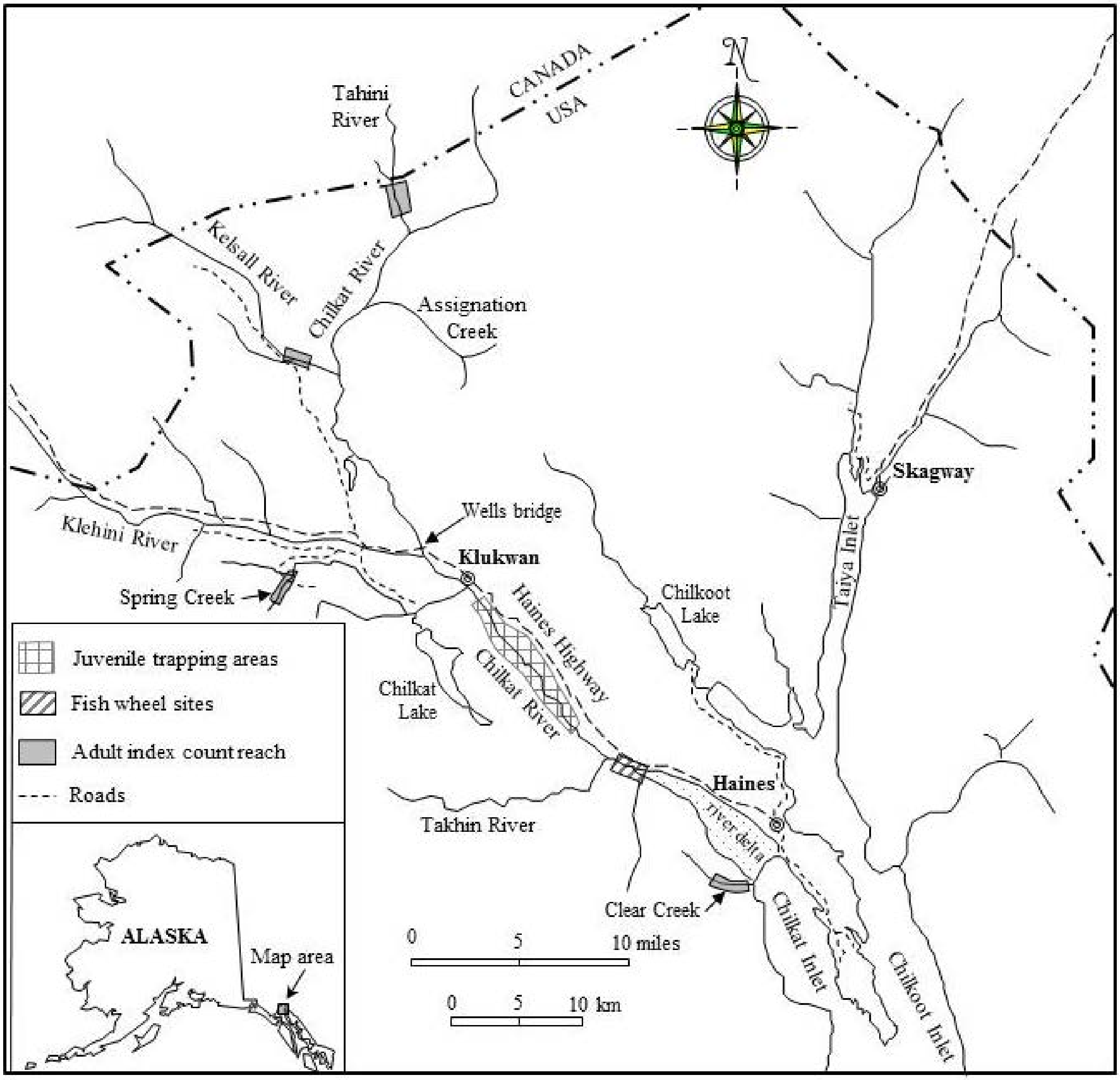

Figure 2.–Coho salmon sampling sites in the Chilkat River drainage.

Table 7.–Peak number of coho salmon counted on spawning index tributaries of the Chilkat River, 1987–2012, compared to mark-recapture estimates for the entire drainage in 1990, 1998, 2002, 2003, and 2005.

	Peak surveys					Estimated		
	Spring Ck.	Kelsall R.	Tahini R.	Clear Ck.	Combined (C_t)	escapement ($\hat{N}$)	SE ($\hat{N}$)	Estimation method
1987	99	197	792	25	1,113	37,432	7,202	expanded survey
1988	87	160	590	40	877	29,495	5,675	expanded survey
1989	57	190	1,064	141	1,452	48,833	9,395	expanded survey
1990	88	379	2,766	150	3,383	79,807	9,980	mark-recapture
1991	176	417	1,785	135	2,513	84,517	16,260	expanded survey
1992	183	281	1,143	700	2,307	77,588	14,927	expanded survey
1993	101	129	1,041	460	1,731	58,217	11,200	expanded survey
1994	451	440	4,482	408	5,781	194,425	37,405	expanded survey
1995	268	197	1,033	189	1,687	56,737	10,916	expanded survey
1996	204	179	412	315	1,110	37,331	7,182	expanded survey
1997	227	133	684	250	1,294	43,519	8,373	expanded survey
1998	271	265	649	275	1,460	50,758	10,698	mark-recapture
1999	335	207	962	195	1,699	57,140	10,993	expanded survey
2000	305	571	1,324	435	2,635	88,620	17,050	expanded survey
2001	450	225	1,272	1,285	3,232	108,698	20,912	expanded survey
2002	1,328	440	2,582	1,310	5,660	205,429	31,165	mark-recapture
2003	500	356	1,419	1,675	3,950	134,340	15,070	mark-recapture
2004	564	170	827	445	2,006	67,465	12,980	expanded survey
2005	221	42	219	495	977	38,589	4,625	mark-recapture
2006	503	220	761	915	2,399	80,683	15,523	expanded survey
2007	55	51	415	237	758	25,493	4,905	expanded survey
2008	337	64	779	526	1,706	57,376	11,039	expanded survey
2009	183	159	429	682	1,453	48,867	9,402	expanded survey
2010	439	58	1,122	1,031	2,650	89,124	17,147	expanded survey
2011	221	66	882	810	1,979	66,557	12,805	expanded survey
2012	164	50	589	347	1,150	38,677	7,441	expanded survey
Mean	301	217	1,155	518	2,191	73,297	14,176	
					Expansion factor (π)	33.6		
					SE(π)	6.5		

factor of 33.6 (SE = 6.5). Mark-recapture studies must be repeated periodically to calibrate the expansion factor.

This operational plan covers sampling and estimation of smolt abundance and subsequent adult harvest via the application of CWTs to Chinook salmon fingerling in fall 2013, and to Chinook and coho salmon smolts in spring 2014.

OBJECTIVES

1. Estimate the number of Chinook salmon smolts leaving the Chilkat River in spring 2014 such that the anticipated half-width of the calculated 90% confidence interval is less than 25% of the estimate.
2. Estimate the marine harvest of Chilkat River Chinook salmon from the 2012 brood year (via recovery of adults with coded wire tags that emigrate as smolts in 2014) such that the anticipated half-width of the calculated 90% confidence interval is less than 35% of the estimate.[1]
3. Estimate the number of coho salmon smolts leaving the Chilkat River in 2014, such that the anticipated half-width of the calculated 90% confidence interval is less than 40% of the estimate.
4. Estimate the marine harvest of Chilkat River coho salmon in 2015 (via recovery of adults with coded wire tags that emigrate as smolts in 2014) such that the anticipated half-width of the calculated 90% confidence interval is less than 25% of the estimate.[2]
5. Estimate the proportion of adult coho salmon returning to the Chilkat River in 2015 that were marked with coded wire tags in 2014, such that the anticipated half-width of the calculated 90% confidence interval is less than 0.05 of the estimated proportion.
6. Estimate the age composition of coho salmon smolts emigrating from the Chilkat River in 2014 such that the anticipated half-width of the calculated 90% confidence interval is less than 0.05 of the estimated proportions.
7. Estimate the age composition of adult coho salmon in the Chilkat River in 2015 such that the anticipated half-width of the calculated 90% confidence interval is less than 0.05 of the estimated proportions.

SECONDARY OBJECTIVES

1. Estimate the abundance of Chinook salmon parr rearing in the Chilkat River in fall 2013.
2. Estimate the mean length of Chilkat River Chinook salmon parr (in fall 2013) and the mean length of smolts emigrating in spring 2014.
3. Estimate the mean length-at-age of coho salmon smolts emigrating from the Chilkat River in 2014.

METHODS

Two-event M-R experiments will be used to estimate the drainagewide abundance of Chinook salmon parr rearing in in fall 2013, Chinook salmon smolts emigrating in spring 2014, and coho salmon smolts emigrating in spring 2014. Fish in M-R event 1 will be marked by removing the adipose fin and inserting a CWT in the nose cartilage. Marked fish will be sampled to estimate mean length. Chinook salmon and coho salmon smolts will also be sampled to estimate mean weight. Coho salmon smolts will be sampled to estimate freshwater age composition. For M-R event 2 sampling, adult Chinook and coho salmon will be sampled for missing adipose fins and CWT presence as they return to the Chilkat River in 2015 (coho salmon) and 2015–2019

[1] Estimate will be derived from tag recoveries in marine fisheries and the Chilkat River from 2015 through 2019.

[2] Estimate will be derived from tag recoveries in marine fisheries and the Chilkat River in 2015.

(Chinook salmon). The harvest of Chinook and coho salmon will be estimated through the recovery of CWTs in randomly sampled fisheries.

Chilkat River Chinook salmon are almost all (>99%) from a single freshwater age, overwintering 1 year as parr and emigrating as age-1. smolts (Olsen 1992). Therefore, Chinook salmon parr tagged in the fall of year t+1, and smolts tagged in the spring of year t+2, are from BY t. Adult Chinook salmon return to the river over 5 years, beginning with age-1.1 "jacks" in year t+3 and ending with age-1.5 fish in year t+7. For example, Chinook salmon tagged with CWTs in the fall of 2013 (parr) and spring 2014 (smolts), both from BY 2012, will return in 2015 (age-1.1 "jacks") though 2019 (age-1.5 fish).

Coho salmon returning to the Chilkat River belong primarily to 2 age classes: age 1.1 (1998–2010 average 76%), and age 2.1 (1998–2010 average 22%). The remaining age classes are age-1.0 and age-2.0 "jacks" that have composed 3% of the escapement over the same time period. Because the majority of coho salmon are 1-ocean year rearing fish, coho smolts tagged with CWTs in 2014, from BYs 2012 and 2013, will return primarily in 2015 (age x.1).

SMOLT AND PARR TAGGING

Fall 2013 - Chinook Salmon Parr Tagging

To estimate juvenile (parr) Chinook abundance, we will fish 80–100 baited minnow traps per day in the Tahini River, Kelsall River, and Chilkat River main channels from the Kelsall River confluence downstream to Haines Highway milepost (MP) 10. Trapped fish will be sorted, and only juvenile Chinook salmon will be retained for tagging. All trapping locations will be recorded with global positioning system (GPS) coordinates and juvenile Chinook salmon catches will be recorded by location. All Chinook salmon parr caught in traps will be transported to a central tagging station. Once at the tagging site, all healthy Chinook salmon parr ≥50 mm FL will have their adipose fin removed and will be tagged with a 1.1 mm CWT (see Data Collection for details of processing). All Chinook salmon tagged will be checked the day after tagging for tag retention and released in the same stream as captured. One code of 10,000 tags will be used until exhausted; additional codes will be used for every subsequent 10,000 fish tagged during the fall project.

The Tahini and Kelsall river trapping areas align closely with results of 1991, 1992, and 2005 radio telemetry studies (Johnson et al. 1992, 1993; Ericksen and Chapell 2006b), which indicated that 85–92% of the Chinook salmon entering the Chilkat River spawn in these two drainages.

Tagging operations will begin September 16 on the Tahini River, where a crew of 4 technicians will trap and tag juvenile Chinook salmon for up to 10 days, depending on river conditions and catch rates. If catch rates are lower than expected in traditional trapping areas, we will set traps over a wider area in an exploratory fashion to locate concentrations of rearing fish. We will then concentrate effort to maximize catch rates, and move traps to other areas as catches drop. The Chilkat River near the Tahini River confluence had poor catches in 2000, where only 81 fish were caught in 16 traps set for 3 days. Although rapidly rising water and poor visibility may have been responsible, we will not expend effort that can better be used to capture fish in the more productive Kelsall River.

The Kelsall River has been the biggest producer of juvenile Chinook salmon in most years (Table 3) and will continue to be the major focus of effort in fall 2013. Trapping efforts on the

Kelsall River will commence October 1 and will continue for up to 14 days, or until all trapping areas are exhausted.

After leaving the Kelsall River, trapping efforts will move to Chilkat River main channels. Traps will be set primarily between MP 13 and MP 19, and in the section between MP 24 and the Kelsall River confluence. Additional trapping areas will probably not include the Klehini River because it had poor catches in 2000 (173 fish in 2 days). The Chilkat River portion of the project does not require a field camp, as the crew is based from the Haines office.

Spring 2014 - Chinook and Coho Smolt Tagging

From April 3 through May 13, 2014, a total of 80 baited minnow traps will be fished daily in main channels of the lower Chilkat River, MP 10–21, in an effort to maximize Chinook salmon smolt catches. All coho salmon smolts captured in the process will also be tagged. Gear will be set in Chinook salmon habitat sites that provide the best chance of capturing a representative sample of smolts from several tributaries of the Chilkat River. Global positioning system coordinates and Chinook and coho salmon smolt catches will be recorded at each tagging site. Two trap lines will be checked at least once per day by 2 teams of 2 technicians each. If time permits, traps that produced the greatest catches during the first check will be checked twice.

Compared to spring CWT efforts in years 2001–2012, the spring 2014 effort will be shorter, only 41 trapping days, and will start and end earlier. This schedule will be similar to spring 2013 CWT operations. The expected number of valid CWTs released will be similar to the 2013 effort (Appendix A1). Then number CWT-tagged and released should be between 4,545 and 6,135 Chinook salmon smolts and between 11,185 and 15,936 coho salmon smolts. These ranges come from using average minnow trap CPUEs in years 2001–2013 versus CPUEs in 2013 alone, when methods targeting Chinook salmon were used. Overall Chinook salmon CPUE in 2013 was 1.9 fish per trap, the highest since spring CWT efforts began in 2001. Overall coho salmon CPUE in 2013 was 3.5 fish per trap, the lowest since 2001.

All target species caught in traps will be transported to a central tagging station. Every second day, depending on the number of smolts caught, collected fish will be sorted by species and size. All healthy Chinook ≥50 mm and coho ≥75 mm FL captured will be adipose finclipped and tagged in the snout with a 1.1 mm CWT (see Data Collection for details of processing). In addition, all previously untagged Chinook salmon captured during the spring will be given a secondary CWT (CWT2) inserted in the muscle tissue at the base of the dorsal fin. The CWT2 enables use of a handheld wand CWT detector to distinguish spring-tagged fish from fall-tagged fish during the adult return without sacrificing the fish. Tagging every second day will increase capture rates by allowing for more time to seek out productive trapping areas. A Northwest Marine Technology MKIV[3] tag injector will be dedicated to tagging Chinook salmon with a unique code. Spools of coded wire will be changed only when exhausted.

Coho salmon smolts will be sorted into 3 size categories: small (≥75 mm and <85 mm), medium (≥85 and <100 mm), and large (≥100 mm). A tag injector will be dedicated to tagging coho salmon. A different size head mold (small, medium, large) will be used with each size group to

---

[3] The juvenile abundance data would be difficult to analyze correctly using standard statistical methods.

achieve optimal CWT placement. Two unique tag codes will be assigned by size: small fish will receive one code, and medium and large fish (all coho salmon ≥85 mm) will receive the other code. Tagging each size group (small vs. medium/large) of coho salmon smolts with unique tag codes will allow for detection of differential recovery rates as adults. An alternate smolt population estimator discussed in Data Analysis can eliminate bias created in disproportionate tagging of coho salmon smolts.

SAMPLING ADULT COHO AND CHINOOK SALMON TO ESTIMATE SMOLT AND PARR ABUNDANCE

Division of Commercial Fisheries (CF) personnel will capture adult coho salmon in 2 fish wheels along the Chilkat River, adjacent to the Haines Highway between MP 7 and 9, from approximately June 10 to October 15, 2013. Data collected in previous years indicates that 97% of the immigrating coho salmon will be caught during this time period. Fish wheels will operate continuously except when stopped for maintenance.

Assumed proportional sampling of coho salmon in the lower Chilkat River fish wheels will produce the marked fraction estimate used to calculate smolt abundance and adult harvest (Figure 2). In 2013, we expect the return of coho salmon that emigrated in spring 2012, when 18,307 fish were CWT-tagged and released. It is very important that all coho salmon be inspected for missing adipose fins. Coho salmon will be carefully removed from the fish wheel holding pen, and placed into a trough filled with water. All newly captured coho salmon will be sampled for length from mid eye to fork of tail (MEF), sex, and missing adipose fins. All data will be recorded on the Alaska Department of Fish and Game (ADF&G) Adult Salmon Age-Length form version 3.0 (ASAL, Figures 3 and 4). Fish that are missing their adipose fins will be sacrificed, so the tag can be read. Heads will be removed and marked with a numbered plastic cinch strap; the strap number will be recorded on the ASAL form and a CWT recovery form. To prevent double sampling, all coho salmon captured in the lower river will be given an operculum punch that will be recognized upon recapture.

To systematically subsample the coho salmon immigration for age composition, scales will be collected at a rate of approximately 1 out of 3 fish, and in addition, from all fish with missing adipose fins. The first 13 of 40 fish will be recorded on an ASAL labeled *001* (Figure 3). The associated scale cards will be numbered sequentially, with the first 10 scales on card *001*, and the remaining 3 scale samples, plus any scales from adipose-finclipped fish, on card *002*. The fish numbered 14 or higher (CWT fish) will not be used for calculating age composition, but rather as known-age references for age determination quality control. The remaining 27 out of 40 fish will be sampled for sex and length only, and their data will be recorded on ASAL form labeled *002A* (Figure 4). For subsequent batches of up to 40 fish, the first 13 fish will again be sampled for sex, length and scales, their scales placed on cards *003* and *004*, and their ASAL form labeled *004*. The data (sex and length only) for the remaining 27 of 40 fish will be recorded on ASAL form *004A*. Each new sampling day will start with a new set of ASAL forms scale cards, with numbering continued sequentially. This numbering system will assist CF staff in entering the sex, length, and age data into the CF database.

The scale sampling procedure is: 5 scales will be removed from the *left* side of each sampled fish (right side if left-side scales are regenerated) along a line 2 to 4 scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin (Scarnecchia 1979). Scales will be carefully cleaned and placed on gum cards at the rate of one

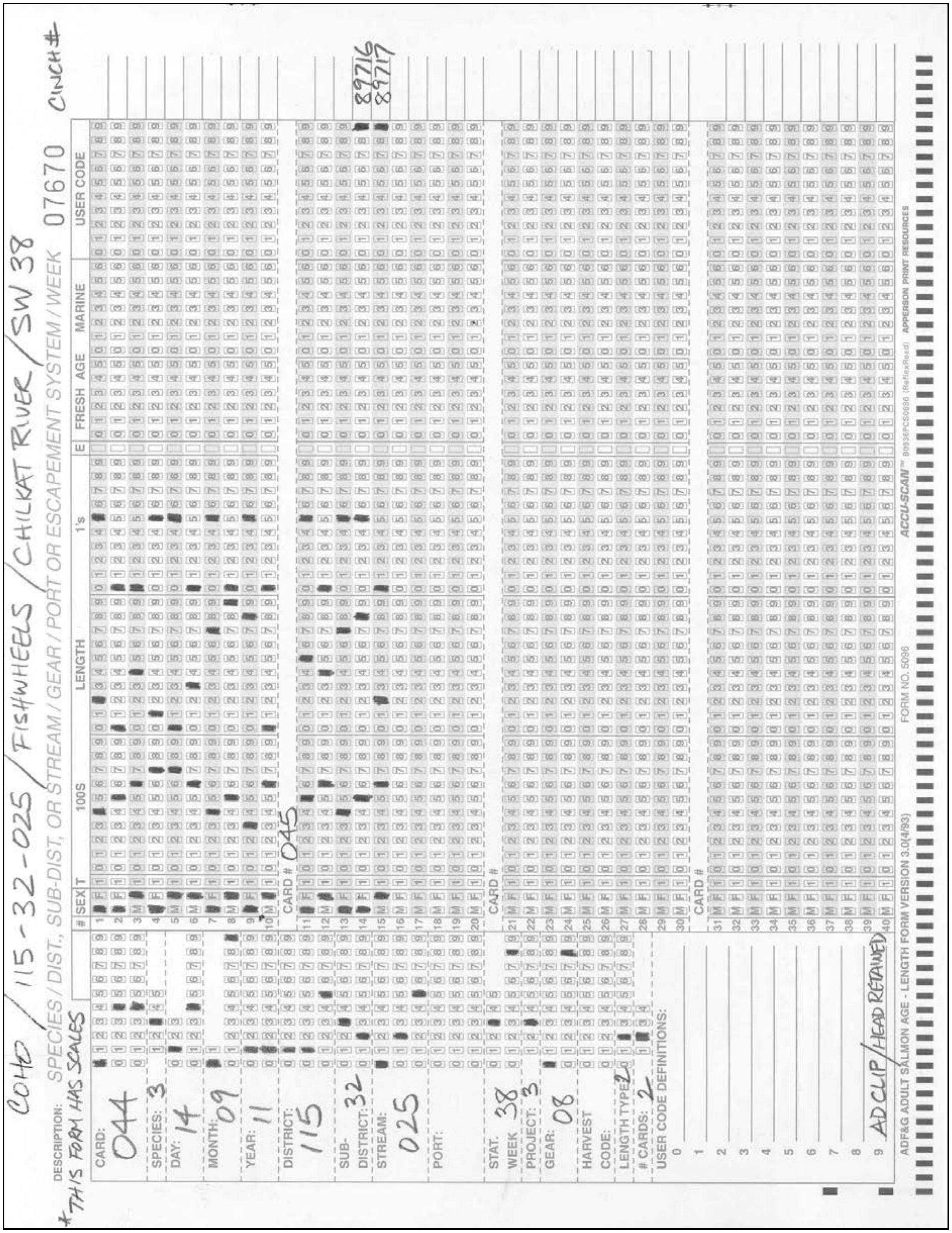

Figure 3.–Example of ADF&G adult salmon age-length form to record sex, length, and scale sample data from the first 13 of 40 coho salmon caught in fish wheels, and from any coho salmon with a clipped adipose fin.

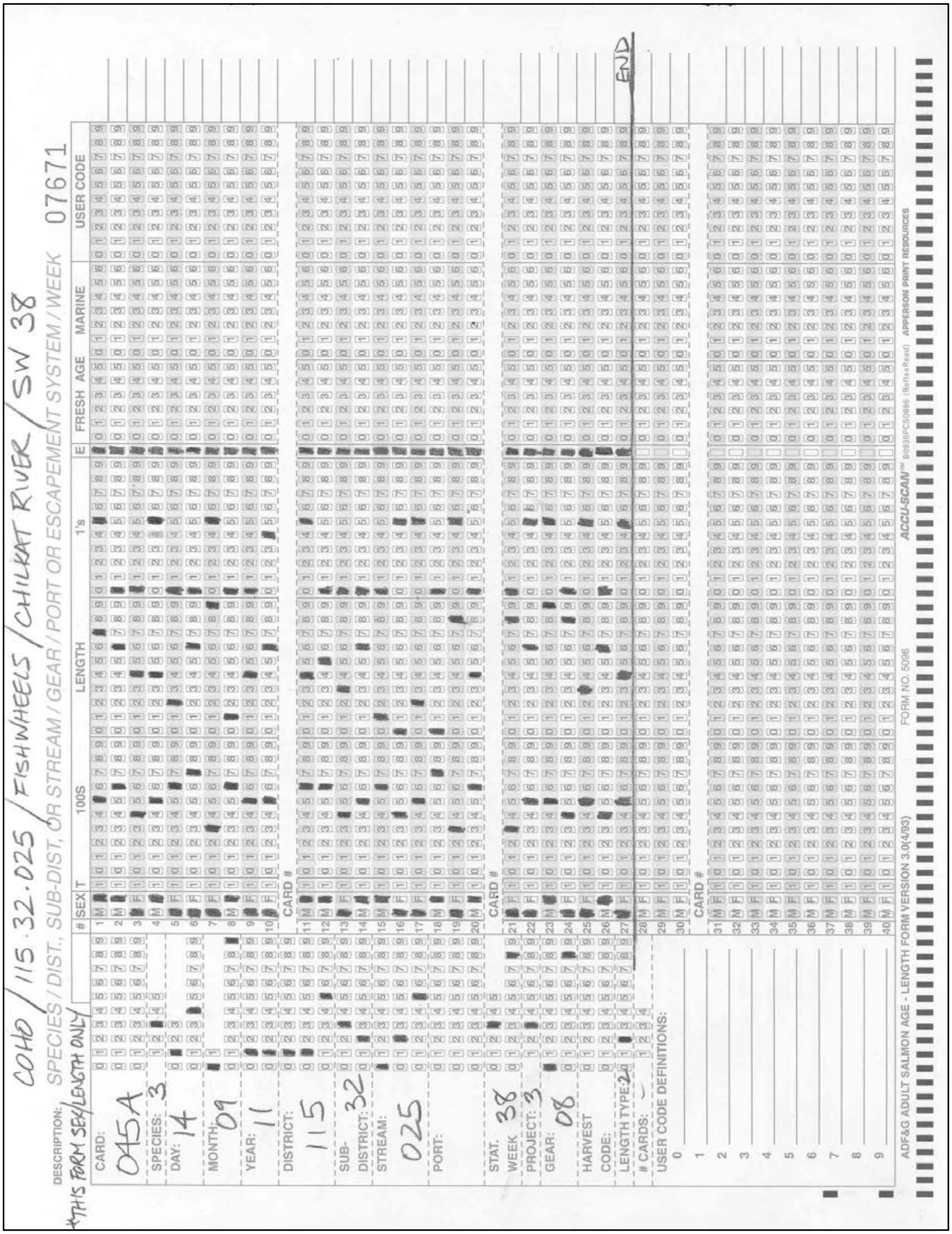

Figure 4.–Example of ADF&G adult salmon age-length form to record sex, length, and scale sample data from the last 27 of 40 coho salmon caught in fish wheels.

fish per column (i.e., scales from fish #1 will be placed over 1, 11, 21, and 31 on the gum card, and the fifth scale will be placed in the blank space just below 31). Scales need to be upright (posterior down) with the rough (convex) side out. Obvious regenerated scales will be discarded and new scales selected. When placing scales, room will be left at the top middle portion of the card so a label can be affixed later. Scale cards will be kept as dry as possible to prevent gum from running and obscuring the scale ridges, and will be completely labeled including the last names of each sampler. A triacetate impression of the scales (30 seconds at 3,500 lb/in^2, at a temperature of 97°C) will be used for age determination. Scales will be read for age using protocols in Mosher (1969) and the CF scale-aging group.

Escapement sampling of adult Chinook salmon is detailed in a separate operational plan covering the use of fish wheels and drift gillnets in the lower river and various gear types on the spawning grounds to capture adults (Chapell and Elliott 2013). The details relevant to the objectives of this plan are as follows: all adult Chinook salmon captured in the lower river and on the spawning grounds will be inspected for missing adipose fins and sampled for age, sex, and length. All adult Chinook salmon missing their adipose fins will also be scanned with a handheld wand CWT detector to assess presence/absence of a head CWT and a CWT2 in the body near the base of the dorsal fin. Fish that were tagged in the spring will have CWT2, while fish tagged in the fall will not. Heads will be collected (for CWTs) from Chinook salmon less than 660 mm MEF (primarily age-1.1 and-1.2 males). Heads will also be taken from fish that show a negative wand detector result for a head CWT to confirm the head CWT loss rate. Heads will also be taken from spawned-out fish and carcasses of all sizes on the spawning grounds (61% of the large fish sampled in 1991–2012). These criteria for sacrificing fish will minimize the impact of sampling on Chinook salmon spawning production.

SAMPLE SIZES

Smolt and Parr Abundance

Chinook Salmon

Returning Chinook salmon in the Chilkat River will be inspected for marks (missing adipose fins) in 2015 through 2019 (ages 1.1 to 1.5) during annual adult M-R studies, as detailed in Chapell and Elliott (2013). Lower Chilkat River capture gear will be drift gillnets operated by Division of Sport Fish (SF) and the fish wheels operated by CF. Spawning Chinook salmon will also be inspected in several spawning locations using various capture gear types. Inriver abundance of 2-ocean-age and older Chinook salmon in recent brood years (1999–2004) has averaged 3,980 fish (SE = 612; Table 4). The harvest rate of Chilkat River Chinook salmon has averaged 17.9% (SE = 4.3%) under recent fishing regulations (BY 1999–2004), which totaled 844 fish per year in all marine fisheries, including commercial, sport, and subsistence (Appendix A2). Assuming average smolt abundance, we anticipate 165,867 Chinook smolts will leave the Chilkat River in 2014. Assuming average overwinter survival (31.3%, Table 4), we anticipate that 533,485 Chinook salmon parr will be rearing in the Chilkat River drainage during the fall of 2013. If the tagging goal of 25,000 Chinook salmon parr is reached in fall 2013, 4.7% of the parr population will be marked. This 25,000 parr goal has been met in 9 of the last 13 years (2000–2012, Table 3), so the goal is likely to be attained. Approximately 7,825 (31.3% x 25,000) of these marked parr should survive to emigrate as smolts. Using the spring trapping schedule based on 2013 CPUE, we expect to mark 6,135 additional Chinook salmon smolts (Appendix A1). Therefore, we can reasonably expect 13,960 of the 165,867 smolts emigrating from the Chilkat River in 2014 to be marked with CWTs (marked fraction = 8.4%, Appendix A2).

From 1994 to 2012, an average of 811 adult Chinook salmon (215 in the lower river and 596 on spawning grounds) have been inspected annually for missing adipose fins. In efforts to conserve the small stock, not all fish missing adipose fins will be sacrificed to recover CWTs (Objectives 1 and 2). Sampling all Chinook salmon encountered in the escapement for adipose fin clip status, age by scale samples, and CWT2 presence/absence is an adequate surrogate for CWT recovery (Chapell 2012, 2013a-b). Heads will be taken only from fish <660 mm MEF and from postspawners, and carcasses, so samples sizes for a BY are expected to be 124 "jacks" (average number of fish <660mm MEF sampled for adipose fin clips, 1994–2012) and 378 adults (average number of postspawners or carcasses ≥660mm MEF sampled for adipose fin clips, 1994–2012), or 502 valid samples. An escapement sample of 492 fish is needed to meet the criteria for Objective 1 (Robson and Regier (1964), smolt emigration of 165,867, 13,960 marked, no lost CWTs; alpha = 0.10; d = 0.25), so the Objective 1 criteria are reasonable.

Coho salmon

Using 2013 CPUE and average number of traps deployed for 41 days of trapping (April 3–May 13, Appendix A1), 11,185 coho salmon smolts will be CWT-tagged and released in 2014. Under the current study design, therefore, it is unlikely that the number of coho salmon smolt tagged and released will meet or exceed the 2001–2013 average of 23,908 fish (Table 6).

Returning adult coho salmon will be inspected for marks (missing adipose fins) in 2015 in CF fish wheels. The fraction used to estimate smolt abundance is the proportion of 1-ocean coho salmon missing adipose fins (θ_{smolt}). We anticipate capturing and sampling about 2,426 returning 1-ocean coho salmon in the fish wheels (average number inspected 2000–2012). Assuming the fraction of tagged smolts (θ_{smolt}) is 0.021 (average from return years 2000–2012), then 46 of the 2,426 sampled fish should be missing adipose fins. Using the model of Robson and Regier (1964) with an assumed population size of 1,333,080 (Table 5) and 11,185 marks released, a sample of 2,403 adults is needed to meet criteria (±40% for a 90% confidence interval, Objective 3, assuming alpha = 0.10, d = 0.40). Thus, our anticipated escapement sample is greater than that required to reach the desired goal. Our field sampling design has resulted in meeting the ±40% level of precision in all 13 outmigration years 1999–2011 (Table 5); the goal remains to mark and inspect as many fish as possible.

AGE COMPOSITION, MEAN LENGTH, AND MARKED FRACTION

The age composition, mean length-at-age, and marked fraction of immigrating Chinook salmon in 2015–2019 will be estimated as detailed in a separate operational plan for the annual SF adult M-R project (Chapell and Elliott 2013).

Age composition and mean length-at-age of immigrating coho salmon will be estimated from a systematically drawn sample of the fish caught in the fish wheels. Based on procedures in Thompson (2002) for a 4-age-class population and an average estimated escapement of 84,962, with alpha = 0.10 and d = 0.05, 504 samples are needed. In an exercise to numerically demonstrate how sample sizes are derived, the proportions representing 1.0- and 2.0-age fish were constrained at historical proportions of 0.03 and 0.01, respectively, and the highest variability scenario when proportions between age 1.1 and 2.1 coho salmon are almost equal, was investigated (Figure 5). This model, based on Thompson (2002), produces a sample size maximum that, when data loss is accounted for, is commensurate with the required sample size (504) for a multinomial estimation with the given precision criteria.

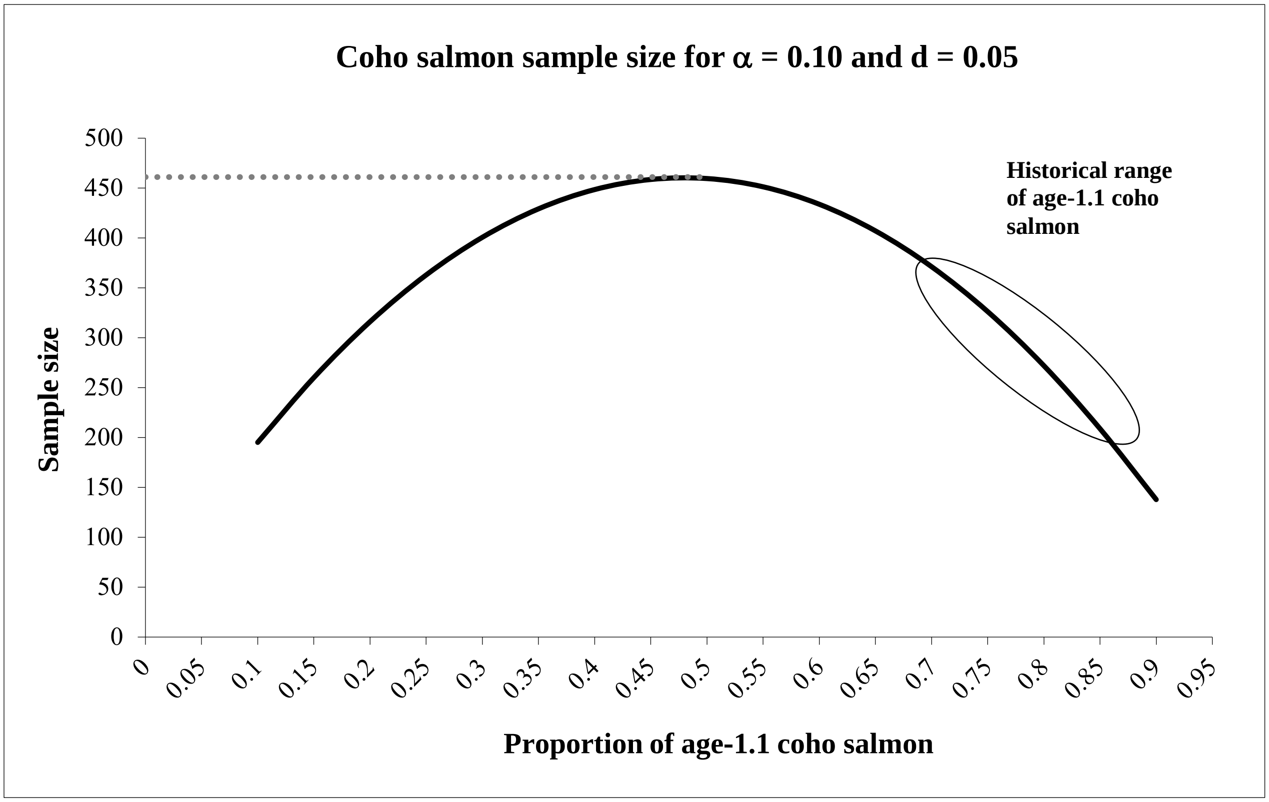

Figure 5.–Maximum number of Chilkat coho salmon smolt scale samples required, from Thompson (2002), based on an alpha value of 0.10 and precision value of 0.05.

Because 90% of adult scale samples were readable in 2010, the maximum required sample size is 448 (d = 0.05, alpha = 0.10, *n* = 84,962, data loss = 10%). The average fish wheel catch of all-aged coho salmon from 2000 to 2012 is 2,426 fish. To ensure that this sample goal is met, every third fish caught (2,426/3 = 809) will be sampled for scales. Fish wheel catches have shown considerable variability from year to year; even though the projected number sampled greatly exceeds the requirement, in low catch years sampling every third fish should come close to meeting the goal. Since coho salmon sampling was started in the Chilkat River, the lowest proportion of age-1.1 fish has been around 0.70, requiring fewer than 448 samples to meet Objective 7. As a result, 809 fish sampled should be ample to meet Objective 7 criteria. Objective 5 criteria will also be achieved, based on procedures in Thompson (2002), because only 39 fish are required to estimate a binomial proportion to within 0.05 of the true value 90% of the time (d = 0.05, alpha = 0.10, p = 0.030 (the highest theta for this project since 2000), *n* = 84,692, data loss = 20%, no FPC). The estimates should be unbiased because, even if the sampling gear is size selective, the differences in age composition for coho salmon in Southeast Alaska are differences in freshwater age (except for a small number of “jacks”), and there is no practical relationship between freshwater age and the size of adult coho salmon.

Age composition of coho salmon smolts will be estimated from a systematically drawn sample of fish caught in the minnow traps. Based on the procedures in Thompson (2002), 285 samples are necessary to estimate binomial proportions (d = 0.05, alpha = 0.10, p = 0.5, N = 1,333,080, data loss = 5%) and satisfy Objective 6 criteria; this sample will also be sufficient to estimate mean length-at-age (2013 mean = 88.7 mm, SE = 10.3). If we tag 11,185 smolts as anticipated and systematically sample every 30th coho salmon smolt ≥75 mm FL, the resulting sample of 373 is larger than required to meet objective criteria.

We will systematically sample every 100th Chinook salmon parr ≥50 mm FL during the fall 2013, and every 20th Chinook salmon smolt for length during the spring 2014 to estimate mean length (2013 mean = 70.3 mm SE = 7.2).

HARVEST OF CHINOOK SALMON FROM THE 2012 BROOD YEAR

Recovery of CWT-tagged Chinook salmon in the various fisheries in 2015–2019 (to sample age-1.1 to age-1.5 fish) will be used to estimate the total marine harvest of Chinook salmon from the Chilkat River for BY 2012. To meet the criterion in Objective 2 (90% relative precision = ±35%), approximately 10,500 Chinook salmon smolts from BY 12 emigrating in 2014 need to be marked with CWTs according to procedures in Bernard et al. 1998 (see example in the next paragraph and Appendix A3). As we expect 13,960 emigrant smolts to be marked, the objective criteria should be met. The sample size calculation is based on historical inspection of 55% of commercial harvests, 50% of the recreational harvests, and 31% of the subsistence harvest, for an overall marine fishery sampling rate of 46%, an estimated 165,867 smolts leaving the Chilkat River in 2014, an ocean survival rate of 3.2% for smolts, and an overall marine exploitation rate of 17.3% for adults (Appendix A2).

A simulated data set to anticipate harvest from the 2012 Chilkat Chinook brood, based on the above assumptions and past recoveries of Chilkat River CWTs from BYs 1999–2004, suggests that Objective 2 will likely be met (Appendix A3). We anticipate that under average fishing regimes 36.5% of the total harvest of Chilkat Chinook salmon will be taken in the sport fishery, 16.5% in the commercial troll fishery, 26.5% in the commercial gillnet and purse seine fisheries, and 20.4% in the subsistence gillnet fishery (Appendix A2). Using a 46% overall sampling rate in marine fisheries, we expect that 71 CWT-tagged fish will be recovered, of which 28 are anticipated to be random recoveries of CWT-tagged Chilkat River Chinook salmon. Probabilities for recovery of a Chilkat River CWT at varying ages from different sport, troll, drift gillnet, purse seine, and subsistence fisheries were based on historical recoveries of Chilkat River CWTs. In efforts to represent all principal fisheries (area+gear+time) for Chilkat CWT recoveries, there are instances when the calculated value for m_i is less than one, creating a low probability that a Chilkat River Chinook salmon will be represented in a particular fishery. Methodology in Bernard et al. (1998) was used to estimate the chance of missing harvest in fisheries. Reported harvests in each stratum are not large (generally less than 100 fish), and our expectation is for the recovery of only 1 CWT in some commercial fishery strata. The average anticipated probability of recovering a CWT from each time-area-fishery stratum is 36%, and the probability of getting CWTs in all strata (the product of the individual stratum probabilities) is less than 1%. Despite this low probability, harvests in most individual strata are small, and the loss of some harvest estimates will not be critical. Given the significant current fishery sampling effort and 8.6% average marked fraction (Table 4), there is little that can be done to improve the situation at this time.

Protocols for the collection of data from adult Chinook salmon at the ADF&G fish wheels and drift gillnets and in the marine commercial fishery can be found in operational plans developed by SF and CF for these projects. The CF operational plans can be obtained from CF Area Management Biologist Randy Bachman in Haines.

HARVEST OF COHO SALMON IN 2015

Almost all coho salmon smolts tagged in 2014 will emigrate to sea, mature, and return to the Chilkat River watershed to spawn in 2015. Some returning adults will be harvested in marine sport and commercial fisheries, which are sampled by for missing adipose fins and head recovery by the CF port sampling program. Recoveries of CWTs from Chilkat River coho salmon tagged in 2014 will be used to estimate that cohort's contribution to the sampled fisheries in 2015 (Objective 4; Bernard and Clark 1996).

Historical data from port sampling efforts from 2000 through 2012, along with smolt tagging data for these cohorts, was used to calculate average recovery probabilities (π_i) of tagged adults bound for the Chilkat River by sport and commercial fishery recovery strata (Bernard et al. 1998). A simulation based on these recovery probabilities was then used to anticipate precision of the contribution estimate to the marine commercial and recreational fisheries for 2015. The simulation (Appendix A4) assumes an average smolt abundance of 1,333,080 tagging 11,185 smolts, an average (2000–2012) harvest of 1.4 million fish of mixed stock, typical port sampling efforts by strata, and an average adult escapement sample of 2,426 1-ocean adults in 2015. These assumptions result in an anticipated fraction of valid tags (θ_{marine}) of 0.84% and an estimated recovery of 115 CWT-tagged coho salmon bound for the Chilkat River in 2015 (Appendix A4). The estimate of relative precision for the 2015 harvest estimate is ±16.5% for a 90% confidence interval. This is within the desired objective criteria of ±25%.

Methodology in Bernard et al. (1998) was used to estimate the chance of missing harvest in fisheries. Anticipated recoveries of fish bound for the Chilkat River in most sport and seine fisheries strata are small (less than 1 tag), which leads to relatively small probabilities of recovering tags in these strata (Appendix A4). However, the total contribution from *all* sport and seine strata is 3% of the total (2% from sport, 1% from seine strata). Thus, missing harvest from a significant fraction of these strata does not lead to a significant bias in the total contribution estimate. Excluding strata where <1 tag recovery is expected suggests the probability of recovering CWTs in *all* other strata (the product of all individual stratum probabilities) is about 33%. Furthermore, the probability of recovering CWTs in all of the major strata (expected tag recovery >2, including troll and District 115 gillnet) is 96%.

DATA COLLECTION

SMOLT ABUNDANCE

All captured coho smolts ≥75 mm FL (spring 2014) and all Chinook ≥50 mm FL (fall 2013 and spring 2014) without CWTs will be tranquilized with a buffered MS 222 solution, tagged with a CWT following procedures described in Koerner (1977), marked with an adipose fin clip, and released. In addition, all Chinook salmon smolts tagged in the spring will also be given a CWT2. All tagged fish will be held overnight to test for mortality and 100 of each species will be tested for retention of their tags. Any smolts captured that have missing adipose fins prior to tagging will be passed through a magnetic tag detector and the presence or absence of a CWT will be recorded. In addition, the tag location of all Chinook salmon will be verified with a wand detector.

A short section of each spool of coded wire will be taped to the SPORT FISH DIVISION SALMON SMOLT CWT DAILY LOG form (Appendix B1) the first day of tagging with a new tag code. In addition, a short section of the beginning and ending wire for each location (i.e., Tahini River, Kelsall River, and Chilkat River) will be taped to the CWT Daily Log. A new form will be started for each tagging day. All tag and recapture data will be recorded daily on the CWT Daily Log form. The field crews will record tagging site GPS coordinates in field notebooks following the instructions found in Appendix D1. The crews will record detailed trapping information in field notebooks following the protocols in Appendix B2. Catch, tagging, release, and recapture data for each day's operation will be summarized on the MINNOW TRAP SUMMARY FORM, an example of which is found in Appendix B3. Daily procedures follow.

Fall 2013 Chinook Parr Tagging

1. Record location, date, and species on the SALMON SMOLT CWT DAILY LOG.
2. Record water and air temperature (Min-Max) to nearest 1^{o}C, and water depth to the nearest cm on the MINNOW TRAP SUMMARY FORM. Data should be collected at 0900 each day.
3. At 0830–0900 hrs mix the fish in the holding net pen for each tag code and check 100 that are representative for tag retention and record on the SALMON SMOLT CWT DAILY LOG. If tag retention is 98/100 or greater, empty the net pen and count and record mortalities, transport to release site, and release all fish. If tag retention is 97/100 or less, reprocess the entire batch and retag all fish that test negative.
4. Check minnow traps and transport to tagging site. Sort Chinook salmon ≥50 mm FL from other species (coho salmon are not tagged). Inspect each live fish and count the number with adipose clips and record the number under "Recaptures" on the SALMON SMOLT CWT DAILY LOG. Check all recaptures for tag retention, record results, and release all recaptures with CWTs. Retag all recaptures without CWTs.
5. Give all live untagged fish a CWT and pass each through the tag detector. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the SALMON SMOLT CWT DAILY LOG and record retags, erroneous tags (misses, tagged fingers, etc), and practice tags. Show your calculations for the number of tags used.
6. Systematically select every 100th Chinook salmon from combined catches and measure for FL to nearest mm and record all data, including gear type and location on the CHILKAT RIVER FALL CHINOOK SAMPLING FORM (Appendix B4).

Spring 2014 Chinook and Coho Smolt Tagging

1. Record location, date, and species on the SALMON SMOLT CWT DAILY LOG.
2. Record water and air temperature (Min-Max) to nearest 1^{o}C, and water depth to the nearest cm on the MINNOW TRAP SUMMARY FORM. Data should be collected at 0900 each day.
3. At 0830–0900 hrs mix the fish in the holding net pen for each tag code and check a representative sample of 100 coho smolts for tag retention and record on the SALMON SMOLT CWT DAILY LOG. If tag retention is 98/100 or greater, empty the net pen and count

and record mortalities, transport to release site, and release all fish. If tag retention is 97/100 or less, reprocess the entire batch and retag all fish that test negative. The same procedures apply to Chinook salmon smolts except that a wand detector will be used to determine tag retention in both locations. The snout of each fish will be will be scanned by swiping the marked side of the wand in contact with the snout at a rate of 2–3 m per second. If a tag is detected, the fish will be turned around and the base of the dorsal fin will be swiped with the wand in a similar fashion. Because of the importance of this second tag in identifying spring vs. fall tagged fish, if CWT2 tag retention is less than 100/100, the entire batch of Chinook smolts will be reprocessed and those that test negative will be retagged.

4. Check minnow traps and transport catch to tagging site. Sort coho salmon ≥75 mm FL and Chinook salmon ≥50 mm FL from smaller fish and other species. Inspect each live fish and count the number with adipose clips and record the number under "Recaptures" on the SALMON SMOLT CWT DAILY LOG. Check all recaptures for tag retention and tag location (for Chinook smolts), record results, and release all recaptures with CWTs. Retag recaptures without (snout) CWTs. If a recaptured Chinook is missing the dorsal tag (CWT2) but has a snout CWT, do not insert a CWT2 unless it is obvious the fish was tagged this spring (adipose scar has not healed).
5. Give all live untagged fish a CWT and pass each through the tag detector. Insert a second CWT at the base of the dorsal fin in all newly-tagged Chinook salmon smolts. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the SALMON SMOLT CWT DAILY LOG and record retags, erroneous tags (misses, tagged fingers, etc), and practice tags. Show your calculations for the number of tags used.
6. Systematically select every 30th coho salmon and measure for FL to nearest mm, weigh to nearest 0.1 g, sample for scales, and record all data, including gear type and location on the CHILKAT RIVER COHO SALMON AWL FORM (Appendix B5).
7. Systematically select every 20th Chinook salmon from combined catches and measure for FL to nearest mm and record all data, including gear type and location (Appendix B4).

At the end of the fall 2013 and spring 2014 tagging seasons, daily tagging information will be entered into CWT Online Release Entry software program (http://www.taglab.org), which will estimate the number of smolts that had retained CWTs and will submit the tag release information to the Tag Lab (Appendix B6). A 5 cm length of each code wire used will be attached to a TAG CODE VERIFICATION FORM and mailed to the Tag Lab for code verification.

For coho salmon smolts sampled for length, weight and scales, remove 12 to 15 scales from the preferred area (Scarnecchia 1979) on the left side of the coho salmon smolts. Sandwich scales from up to 4 fish between two 25 x 75 mm microscope slides, and tape the slides together with transparent tape. Write the length of each fish on the frosted portion of the bottom slide in accordance with the position of the scales on the slide (Figure 6). Instructions to improve our ability to read scales (as determined by Sue Millard, ADF&G-SF, retired, through experience) are:

1. Don't tape over any scales,
2. Make sure scales are placed and remain in the designated area for each fish,

3. Always number each slide at the top,
4. Always put your initials under the slide number,
5. Spread scales out so they don't contact one another and align them as shown in Figure 6,
6. Remember to clean the scalpel of scales between samples.

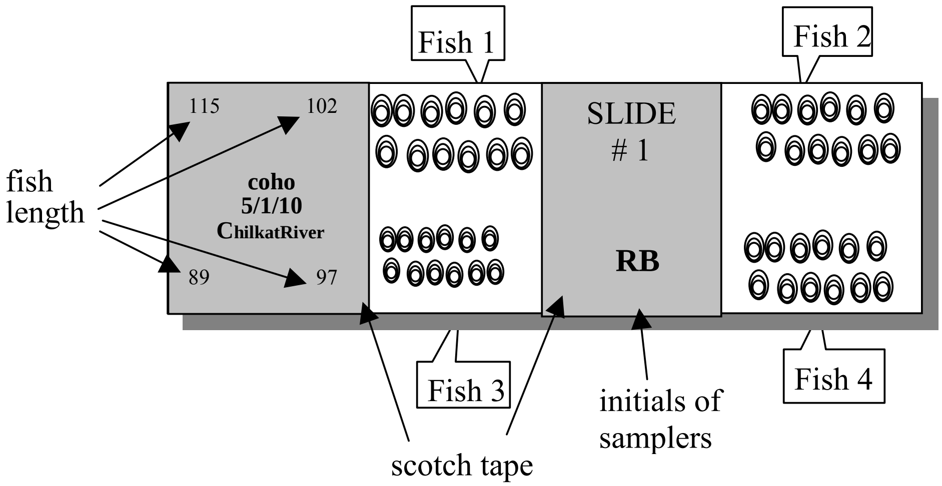

Figure 6.–Preferred microscope slide layout for coho salmon smolt scale samples.

DATA REDUCTION

It is the responsibility of the field crew leader to ensure accurate records are maintained for all data collected on a daily basis (e.g., sampling rates for age and length, correct secondary marks are applied, etc). The field crew leader will also ensure data collections (such as samplers initials, environmental data, fish length and condition, tag codes applied, etc.) are complete and methods (such as FL length measurements, scale collection procedures, head mold sizes, etc.) are correctly implemented.

Data will be inspected daily for errors such as incorrect dates, transposed nonsensical lengths (210 mm when the fish was actually 120 mm), transposed or nonsensical tag numbers, incorrect tagging totals, CWT tagging lengths less than prescribed guidelines, etc. Data forms will be kept up to date at all times. Scale slides will be checked to insure that scales are clean and mounted correctly; the slides are correctly labeled, and samples are matched up with the corresponding data form. Data will be sent to the project biologist weekly, where they will be re-inspected for accuracy and compliance with sampling procedures. The project biologist will keep field data updated in Microsoft Excel™ while it is collected, in season, and produce weekly reports to other management biologists in Southeast Alaska. Ages from scale samples will be estimated in the scale aging lab in Douglas. Scale ages will be entered into the spreadsheet files. When all input is complete, data lists will be obtained and checked against the original field data.

When the final reports are complete, electronic copies of the data, along with a data map, will be sent to Research and Technical Services (RTS) for archiving. The data map will include a description of the electronic files contained in the data archive, and where copies of any associated data are to be archived, if not in RTS. After the daily CWT tagging, retention, and overnight mortality data have been entered using the CWT Online Release Entry program, the Tag Lab will maintain a permanent database of parr and smolt releases and will share this data with the Pacific States Marine Fisheries Commission.

DATA ANALYSIS

SMOLT AND PARR ABUNDANCE

Chinook Salmon

During Chilkat River Chinook salmon escapement sampling, when BY 2012 heads are taken and CWTs are recovered by the CF Mark, Age, and Tag Laboratory (Tag Lab), the handheld wand scan result for CWT2 presence/absence will be compared with the season tagged determined by CWT code. A correct determination of season tagged by the wand method will be defined as either detected presence of the CWT2 in spring-tagged fish, or the detected absence of the CWT2 in fall-tagged fish.

To assess the accuracy of the wand scan method, all available years of handheld wand scan results will be tallied by correct, false positive, or false negative CWT2 detections. The rate of false positive (ω_{f+}) and false negative (ω_{f-}) identifications will be used to adjust the error associated with estimates of spring-tagged and fall-tagged fish in the BY 2012 return. To assess sampling bias by body size, numbers of correct and incorrect CWT2 detections for large (≥660 mm MEF) and medium/small (<660 mm MEF) will be compared using χ^2 tests.

A statistical model will be fit to the BY 2012 data to estimate the number of parr rearing in fall 2013 (N_{PARR}), the overwinter survival to spring 2014 (ϕ_1), the number of smolts emigrating in 2014 (N_{SMOLT}), and the false negative (ω_{f-}) and the false positive (ω_{f+}) error rates. The number of fish assigned to fall and spring marking events among all BY 2012 Chinook salmon sampled in the Chilkat River in 2015–2019 will be modeled as having a multinomial distribution with parameters π_1, π_2, π_3, π_4, and C, where

$\pi_1 = ((1 + \omega_{f+})*q_{FALL} - \omega_{f-}*q_{SPRING})*\rho$,
$\pi_2 = ((1 + \omega_{f-})*q_{SPRING} - \omega_{f+}*q_{FALL})*\rho$,
$\pi_3 = (q_{FALL} + q_{SPRING})\ (1 - \rho)$,
$\pi_4 = 1 - \pi_1 - \pi_2 - \pi_3$,
$q_{FALL} = M_{PARR} / N_{PARR}$,
$q_{SPRING} = M_{SMOLT} / N_{SMOLT}$, and
$C = R_1 + R_2 + R_3 + R_4$ = the total number of adult BY 2012 Chinook salmon examined for adipose fin clips in the Chilkat River in 2015–2019, where

R_1 = the number of adipose-finclipped adult fish with wand scan result second CWT absent, implying a fall-tagged fish

R_2 = the number of adipose-finclipped adult fish with wand scan result second CWT present, implying a spring-tagged fish

R_3 = the number of adipose-finclipped adult fish with no wand scan result

R_4 = the number of adult fish without adipose fin clips,

ρ = the proportion of adipose-finclipped adult fish that were wand scanned and assigned a fall or spring tagging event,

M_{PARR} = number of CWT-tagged parr released during fall 2013,

M_{SMOLT} = number of CWT-tagged smolts released during spring 2014, and

falseposDorsal = the number of adult fish known to have been CWT-tagged in the fall that had a positive second CWT scan result in 2015–2019,

correct.ID.NoDorsal = the number of adult fish known to have been CWT-tagged in the fall that had a negative second CWT scan result in 2015–2019,

falsenegDorsal = the number of adult fish known to have been CWT-tagged in the spring that had a negative second CWT scan result in 2015–2019,

correct.ID.Dorsal = the number of adult fish known to have been CWT-tagged in the spring that had a positive second CWT scan result in 2015–2019.

The relative proportion of fall and spring CWTs recovered elsewhere (fisheries outside of the Chilkat River) also contains information about the survival probability ϕ_I. Therefore the number of valid CWTs from the fall 2013 marking event recovered from Chinook salmon sampled elsewhere in 2015–2019 was modeled as having a binomial distribution with parameters:

$\pi_{FALL} = q_{FALL} \,/\, (q_{FALL} + q_{SPRING})$,

and m = number of BY 2012 Chilkat River Chinook salmon fall and spring CWTs recovered in fisheries outside of the Chilkat River from 2015 to 2019.

Bayesian statistical methods, which are well-suited for analyzing unconventional data[4], will be used to estimate the error associated with maximum likelihood estimates. Bayesian methods use probability distributions to express uncertainty about model parameters. The user supplies the "prior" probability distribution, which expresses knowledge about the parameters outside the frame of the experiment itself. The output of a Bayesian analysis is the "posterior" distribution, which describes the new, updated knowledge about the parameters after consideration of the experimental data. Percentiles of the posterior distribution can be used to construct one-sided probability statements or two-sided intervals about the parameters. Point estimates are de-emphasized in Bayesian statistics; however the mean, median, or mode of the posterior can be used to describe the central tendency of a parameter. The standard deviation of the posterior distribution can be used as an analogue of the standard error of a point estimate in classical statistics.

Bayesian analyses require that prior probability distributions be specified for all unknowns in the model. A normal prior distribution with very large variance will be specified for N_{PARR}, essentially equivalent to a uniform distribution. A beta (0.3, 0.3) prior will be used for ϕ_I and a beta (0.1, 0.1) prior will be used for ρ. These priors are noninformative, chosen to have a

[4] The juvenile abundance data would be difficult to analyze correctly using standard statistical methods.

negligible effect on the posterior. Informative priors for ω_{f-} and ω_{f+} will be based on the known wand results from 2005 through the most recent year of available data. Using 2005–2012 sampling results for ω_{f-}, a beta (7, 63) prior will be used where the 7 is equal to the number of false negative wand results for the dorsal CWT, and the 63 is the number of correctly identified dorsal CWTs. For ω_{f+}, a beta (11, 182) prior will be used where the 11 is equal to the number of false positive wand results for the dorsal CWT, and 82 is the number of correctly identified fish without a dorsal CWT.

Markov-Chain Monte Carlo simulation, implemented with the Bayesian software WinBUGS (Gilks et al. 1994), will be used to draw samples from the joint posterior probability distribution of all unknowns in the model. Three Markov chains will be initiated, a 4,000-sample burn-in period discarded, and 100,000+ updates generated to estimate the marginal posterior means, standard deviations, and percentiles. The diagnostic tools of WinBUGS will be used to assess mixing and convergence. Interval estimates will be obtained from percentiles of the posterior distribution. WinBUGS model code, data, initial values, and results from the BY 2001 Chilkat Chinook salmon data analysis are in Appendix C1.

Coho Salmon

The abundance $\hat{N}_s$ of coho salmon smolts (by emigration year) will be estimated using Chapman's modification of the Petersen Method (Seber 1982:60):

$$\hat{N}_s = \frac{(n_c+1)(n_e+1)}{(m_e+1)} - 1 \tag{10}$$

$$var[\hat{N}_s] = \frac{(n_c+1)(n_e+1)(n_c - m_e)(n_e - m_e)}{(m_e+1)^2(m_e+2)} \tag{11}$$

where n_c is the number of valid CWTs (on fish that survive 24 hrs) placed in smolts during the spring, n_e is the number of age 1-ocean salmon examined in the escapement that are successfully aged and found to have been smolts that emigrated from the Chilkat River during the spring of interest, and m_e is the subset of n_e with successfully decoded CWTs placed at that time. The marked fractions of jacks and age 1-ocean fish are not statistically different, so in the interest of parsimony, only age 1-ocean fish are used for n_e. Because n_e represents 1-ocean coho salmon in the escapement, and this is estimated from a proportion of aged fish, there is a small amount of additional process error involved with the term n_e. However, because the proportion of 1-ocean fish in the population has averaged 0.97, the increase in error is small, and the increase in estimated variance is also small.

Fish sometimes lose their CWTs, CWTs can be lost from recovered heads, and CWTs can be unreadable. If any of these conditions occur, the estimators (equations 10 and 11) must be modified to compensate for the lost marks/CWTs (i.e., loss of m_e). This will be accomplished by adding a term $\lambda = a / t'$ (an overall rate for recovering and decoding CWTs, where a = # adipose-finclipped fish sampled and t' = # CWTs decoded) to the denominator of the Lincoln-Petersen / maximum-likelihood estimator, i.e., $\hat{N}_s^* = n_c\, n_e / m_e\, \lambda$. Variance of $\hat{N}_s^*$ will be estimated using a Monte-Carlo simulation if a suitable closed form estimator is not identified. Although the Lincoln-Petersen estimator is not unbiased, the bias should be negligible in this experiment because the numbers of fish marked, inspected, and recaptured are not small (Seber 1982).

The conditions for accurate use of the M-R method for both species/experiments are:

1. all smolts/parr have an equal probability of being marked; *or*
2. all adults escaping to the Chilkat River have an equal chance of being inspected for marks; *or*
3. marked fish mixed completely with unmarked fish in the population between years; *and*
4. there is no recruitment to the population between years; *and*
5. there is no trap-induced behavior; *and*
6. fish do not lose their marks and all marks are recognizable.

Minnow traps will be operated continuously during smolt emigrations, and returning adults will be sampled almost continuously in fish wheel catches. A possible late start in tagging projects, periodic sessions of high water, or varying outmigration timing in the spring could possibly cause temporal changes in probabilities of capture. However, these vagaries are troublesome only if migratory timing of smolt from different stocks within the Chilkat River does mimic that of returning adults and these vagaries are coincident in the migratory pattern for both adults and smolt. If migratory patterns of smolt are different than that of adults, marked and unmarked smolt are completely mixed in the population prior to their return as adults. We will test for temporal changes in the fraction of adults missing adipose fins: if at least one of the conditions has been met, this fraction will not change with time. Temporal changes in these fractions will be tested against a χ^2 distribution. Although fish wheels and gillnets can be size selective, their size selectivity should not be a problem because there is no relation between the size of a smolt (when marked) and the size of the returning adult (when recaptured). Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment added to the population while they are at sea. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that excising adipose fins and implanting CWTs will not increase the mortality of marked salmon.

As outlined in the Study Design section, CWT-tagging coho salmon smolts in different size groups allows for testing of M-R assumption [1], i.e., that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish. In the event that χ^2 tests indicate unequal probabilities of tagging in event 1 or capture in event 2, an alternate Petersen M-R model will be used for a 2-group population.

A population divided into 2 groups labeled (1) and (2), Petersen's M-R model can be expanded into (adapted from Weller et al. 2005):

$$N_1 + N_2 = \left(N_1\alpha_1 + N_2\alpha_2\right)\frac{N_1\alpha_1 S_1 B_1 + N_2\alpha_2 S_2 B_2 + N_1\left(1-\alpha_1\right)S_1 B_1 + N_2\left(1-\alpha_2\right)S_2 B_2}{N_1\alpha_1 S_1 B_1 + N_2\alpha_2 S_2 B_2} \quad (12)$$

In the above equation, N is abundance, α_i is the capture probability in event 1 for each group, S_i the survival rate for each group, and β_i the capture probability for each group.

If one or both capture probability parameters, α_i or β_i, are equal, then the above equation reduces to a more simplified version. Consider the case when $\beta_1 = \beta_2$, the abundance estimator reduces to:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1 + N_2\alpha_2 S_2 + N_1(1-\alpha_1)S_1 + N_2(1-\alpha_2)S_2}{N_1\alpha_1 S_1 + N_2\alpha_2 S_2} \quad (13)$$

If the relationship between α_i parameters is expressed as A= α_2 / α_1 and the relationship between S_i parameters is expressed as B = S_2 / S_1, equation (13) reduces further to:

$$N_1 + N_2 = \frac{(N_1 + AN_2)(N_1 + BN_2)}{N_1 + ABN_2} \quad (14)$$

It is important to note that equation (14) is only true if $A = 1$ (i.e. $\alpha_2 = \alpha_1$) OR if $B = 1$ ($S_2 = S_1$). If both A and B are not equal to 1, the above relationship does not hold and an unbiased estimator of abundance cannot be produced. If it is determined that there are both unequal marking probabilities (event 1) and unequal capture or survival probabilities (event 2), Petersen's model can be adjusted to produce an unbiased estimate of smolt abundance. Consider Chapman's modification of the standard Petersen model with 2 tagging groups, labeled group 1 and group 2:

$$\hat{N} = \frac{(N1_1 + N1_2 + 1)(N2 + 1)}{(M2_1 + M2_2 + 1)} \quad (15)$$

where $N1_1$ and $N1_2$ are the number marked in groups 1 and 2, $N2$ is the number inspected for marks in the second event, and $M2_1$ and $M2_2$ are the amount of marks recovered from groups 1 and 2. Consider the case where $A > 1$ and $S > 1$, that is, group 2 had both a higher marking probability and capture probability. This would create negative bias in the estimator and $N > \hat{N}$. Adjusting Chapman's modification for this tagging bias results in a new, unbiased estimator:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}M2_1 + M2_2 + 1} - 1 \quad (16)$$

Using the scalar $\hat{A}$, i.e., the ratio of marking rates of the 2 groups, essentially forces the two groups to have the same marking probability, and therefore the expected value of equation (16) equals N as a result.

Retention rates for CWT-tagged fish are rarely 100%; adipose-finclipped fish sometime do not contain valid CWTs as tags are shed during freshwater or marine rearing. Also occasionally heads are lost from adipose-finclipped fish before they can become decoded. Because of this, a new parameter $\hat{\pi}$ can be used to adjust for adipose-finclipped fish with no tag information ($M2_U$), which is the observed ratio of tags recovered from group 1 divided by group 2. Basically the observed recovery rate is extrapolated for fish marked in the first event (as indicated by an adipose fin clip) that contain no tag information:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}(M2_1 + (\hat{\pi})M2_U) + M2_2 + (1-\hat{\pi})M2_U + 1} - 1 \quad (17)$$

In the event that all observed adipose-finclipped fish contain valid CWTs, the term $M2_U$ is zero and equation (17) is identical to equation (16).

Variance and relative bias in the modified estimator can be estimated through bootstrapping techniques outlined in) Efron and Tibshirani (1993).

AGE COMPOSITION

Proportions and variance or proportions by age for coho salmon smolts and adults will be estimated:

$$\hat{p}_j = \frac{n_j}{n} \tag{18}$$

$$\hat{\text{var}}[\hat{p}_j] = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1} \tag{19}$$

where $\hat{p}_j$ is the estimated proportion in the population in group j, n is the number successfully aged, and n_j is the subset of n that belong to group j. Systematic selection of samples will promote proportional sampling and reduce bias from any inseason changes in age composition.

Collecting scale samples in fall 2015 from all returning adult coho salmon with clipped adipose fins will be done to provide the scale ager with known-age reference samples. Collecting age information from adipose-finclipped coho salmon will also allow for calculation of an unbiased smolt estimator discussed above.

ESTIMATES OF MEAN LENGTH

Standard sample summary statistics will be used to calculate estimates of mean length of Chinook parr or mean length-at-age of coho smolts and adults, and their variances (Thompson 2002).

ESTIMATION OF THE CODED WIRE TAG MARKED FRACTION

The marked fractions for populations of BY 2012 Chinook salmon and for emigration year 2014 coho salmon will each be estimated separately:

$$\hat{\theta}_p = \frac{y_p}{t_p} \tag{20}$$

where

$\hat{\theta}_p$ = the proportion of juveniles from brood year p or emigration year p marked with a CWT,

y_p = number of fish in the sample missing their adipose fin that are determined to be from brood year p or emigration year p, and

t_p = number of fish in the sample determined to be from brood year p or emigration year p.

For BY 2012 Chinook salmon, the CWT marked fraction will be estimated form adult inriver mark-recapture project event 1 and 2 data in years 2015–2019 using methods detailed in the Chilkat River Chinook salmon escapement operational plan (Chapell and Elliott 2013). The potential for θ for Chinook salmon to vary significantly by recovery area (e.g., lower river, Tahini River, Kelsall River, etc.) will be investigated using a series of χ^2 tests similar to those described above. If differences in the marked fractions are significant ($\alpha = 0.10$) and large enough to lead to serious bias in estimates of smolt abundance or fisheries contributions, only samples collected in the lower river will be used to estimate θ. Deterministic modeling was done to estimate the effect on θ of tagging smolts nonproportionally on the 2 main spawning areas (Table 8). The model assumes sampling on the spawning grounds would proceed as it has in the past. As the fraction marked in the Tahini River area diverges from the fraction marked in the Kelsall River area, the estimate of θ for the river, based on spawning ground samples, varies very little. This occurs because samples are distributed from the bulk of the spawning population. Also, the model suggests that the usual χ^2 test will indicate that problems exist well before they are severe enough to lead to serious bias in estimates of parr abundance or fisheries contributions (bias in those estimates is approximately proportional to bias in θ for the river). For example, as tagging fractions for the upriver and downriver rearing areas diverge by 100% (θ_{Tahini} = 0.089 and $\theta_{Kelsall}$ = 0.179), the resulting estimate of $\theta_{WholeRiver}$ = 0.148 varies by only 3.8% from its true value.

Table 8.–Model results used to determine the effect of nonproportional tagging of parr on the estimate of the overall marked fraction (θ).

θ(area) and estimated θ (whole river) vs tagging bias				% Difference in θs			
Model	θ =Tahini	θ =Kelsall	θ estimate =combined	Absolute difference in areas	% Difference relative to Tahini	% Error in combined	χ^2 Detects difference (p = 0.1)
Unbiased	0.154	0.154	0.154	0.000	0	0.0	NA.
20%	0.134	0.161	0.152	0.027	20	-1.1	No
40%	0.119	0.167	0.151	0.048	40	-2.0	No
60%	0.107	0.172	0.150	0.064	60	-2.7	No
80%	0.098	0.176	0.149	0.078	80	-3.3	Yes
100%	0.089	0.179	0.148	0.089	100	-3.8	Yes
120%	0.082	0.181	0.147	0.099	120	-4.2	Yes
250%	0.055	0.192	0.145	0.137	250	-5.8	Yes
1000%	0.019	0.206	0.142	0.187	1000	-7.9	Yes

For emigration year 2014 coho salmon, the CWT marked fraction will be estimated using adult sampling data collected at the lower river fish wheel sampling site in 2015.

To estimate contributions to mixed stock marine fisheries, it is necessary to account for CWT tag loss, which prevents recognition of the stock of origin. For each CWT-tagged population (BY 2012 Chinook salmon, emigration year 2014 coho salmon) the marked fraction $\hat{\theta}_{marine}$ used in harvest estimates will be the product of $\hat{\theta}_p$ and the proportion of heads with decoded CWTs out of the heads sent to the Tag Lab.

HARVEST

Harvest of Chilkat River coho and Chinook salmon will be estimated by year class through a stratified catch sampling program of commercial and recreational fisheries. Methods in Bernard and Clark (1996) will be used to expand harvest estimates from recovered CWTs. Commercial catch data for the analysis will be summarized by ADF&G statistical week and district (for gillnet and seine fisheries), or by period and quadrant for troll fisheries. Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2007) 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 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."

The estimates will be based on information from SF and CF sampling of:

1) number of salmon harvested by species;

2) fraction of the harvest inspected for missing adipose fins;

3) number of salmon in the sample with missing adipose fins;

4) number of fish heads that reached the Tag Lab;

5) number of these heads that contained CWTs;

6) number of these CWTs that were decodable; and

7) number of decodable tags of the appropriate code(s).

As noted above, estimating tagging fractions θ for Chinook salmon is complicated by adults returning over 5 years. Data from all sample years will be pooled to estimate $\hat{\theta}_{marine}$ for the harvest study.

SCHEDULE AND DELIVERABLES

Adult coho salmon will be sampled in the fish wheels beginning about August 1 and extending through October 15, 2015. Field activities for Chinook salmon parr will begin inriver approximately September 16, 2013 and extend through October 31, 2013. Data editing and analysis will be initiated before the end of each season. A memorandum summarizing fall field activities, successes, and suggestions for improvement will be submitted to the project biologist by November 30. Field activities for smolts will begin inriver approximately April 3, 2014, and extend until May 15, 2014, or as river conditions permit. Data editing and analysis will be initiated before the end of each season. A memorandum summarizing smolt field activities, successes, and suggestions for improvement will be submitted to the project biologist by June 15, 2014.

Juvenile Chinook trapping and tagging data collected in this study will be reported in a Division of Sport Fish Fishery Data Series report and submitted by December 31, 2014. Coho salmon smolt data collected in 2014 will be reported in a Division of Sport Fish Fisheries Data Series report and submitted by December 1, 2016. This report will cover all 2014 smolt data and subsequent recoveries, harvest contributions, etc. of adult coho salmon in 2015. Chinook parr and smolt data including adult harvests will be reported by December 2020.

RESPONSIBILITIES

Richard Chapell, FB III, Lead Biologist. Sets up all major aspects of project, including planning, budget, sample design, permits, equipment, personnel, and training. Assists in aspects of adult coho escapement project. Supervises overall project; edits, analyzes, and reports Chinook salmon data; assists with fieldwork; arranges logistics with field crew, office biologist, and expeditor. Writes operational plan, assures that it is followed or modified appropriately with consultation with Elliott.

Sarah Power, Biometrician II. Provides input to and approves sampling design. Reviews operational plan and provides biometric details. Reviews and assists with data analysis and final report.

John Der Hovanisian, Regional Research Supervisor. Provides input to and approves sampling design. Reviews operational plan and provides operational details. Reviews and assists with data analysis and final report.

Brian Elliott, FB II, Project Biologist. This position is responsible for overseeing all field operations for smolt CWT and adult recovery, and directs activities from the Haines ADF&G Office in the absence of Chapell. Will participate in field operations during peak smolt catches, including safe operation of riverboats and all other equipment. Will also perform tagging, data collection, and general field camp duties, including keeping camp and field equipment neat and orderly. Will also assist in all other aspects of project including planning and coho salmon data reporting.

Larry Derby, Dana Van Burgh, and Reed Barber, FWT III. These positions act as crew leaders for CWT operations and make sure the operational plan is followed. Will be in charge of running minnow trap lines, and adjusting traps to maximize catches. Are responsible for recording all daily records on daily forms. These positions are responsible for assisting in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection, and general field camp duties including keeping camp and field equipment neat and orderly. They will be the lead smolt taggers and are responsible, along with Elliott, for making sure that species identification is done correctly and that tag retention is at or near 100%. Will take the lead roles in any construction activities and will be in charge of equipment maintenance (outboards, taggers, detectors, power tools, generators, etc). Will do inventory at end of year in cooperation with Elliott.

Andrea Nelson, Lyndsey Hura, Aaron Thomas, and Liam Cassidy, FWT II. These positions are responsible for assisting in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection and general field camp duties including keeping camp and field equipment neat and orderly. Will be clippers in tagging shed, and may be trained as taggers. Will be responsible for completing daily supply lists and weekly grocery orders in cooperation with rest of crew. Will assist crew leaders with data entry as needed.

REFERENCES CITED

Bernard, D.R., and J.E. Clark. 1996. Estimating salmon harvest based on return of 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.

Bingham, A.E., P.M. Suchanek, S. Sonnichsen, and R.D. Mecum. 1988. Harvest estimates for selected sport fisheries in southeast Alaska in 1987. Alaska Department of Fish and Game, Fishery Data Series No. 72, Juneau.

Bugliosi, E.F. 1988. Hydrologic reconnaissance of the Chilkat River Basin, Southeast Alaska. U.S. Geological Survey Water Resources Investigation Report 88-4021, Anchorage, Alaska.

Chapell, R.S. 2009. Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2006. Alaska Department of Fish and Game, Fishery Data Series No. 09-78, Anchorage.

REFERENCES CITED (continued)

Chapell, R.S. 2010. Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2007. Alaska Department of Fish and Game, Fishery Data Series No. 10-86, Anchorage.Chapell, R.S. 2012. Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2008. Alaska Department of Fish and Game, Fishery Data Series No. 12-68, Anchorage.

Chapell, R.S. 2013a. Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2009. Alaska Department of Fish and Game, Fishery Data Series No. 13-12, Anchorage.

Chapell, R.S. 2013b. Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2010. Alaska Department of Fish and Game, Fishery Data Series No. 13-25, Anchorage.

Chapell, R.S. *In prep a.* Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2011. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Chapell, R.S. *In prep b.* Production, escapement, and juvenile tagging of Chilkat River Chinook salmon in 2012. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Chapell, R.S. and B. W. Elliott. 2013. Chilkat River Chinook salmon escapement studies in 2013. Alaska Department of Fish and Game, Regional Operational Plan No. SF.1J.2013.07. Anchorage.

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

Elliott, B.W. 2009. Production and escapement of coho salmon from the Chilkat River, 2005–2006. Alaska Department of Fish and Game, Fishery Data Series No. 09-65, Anchorage.

Elliott, B.W. 2010. Production and escapement of coho salmon from the Chilkat River, 2006–2007. Alaska Department of Fish and Game, Fishery Data Series No. 10-60, Anchorage.

Elliott, B.W. 2012a. Production and escapement of coho salmon from the Chilkat River, 2007–2008. Alaska Department of Fish and Game, Fishery Data Series No. 12-43, Anchorage.

Elliott, B.W. 2012b. Production and escapement of coho salmon from the Chilkat River, 2008–2009. Alaska Department of Fish and Game, Fishery Data Series No. 12-51, Anchorage.

Elliott, B.W. 2013. Production, harvest, and escapement of coho salmon from the Chilkat River, 2009–2010. Alaska Department of Fish and Game, Fishery Data Series No. 13-14, Anchorage.

Elliott, B.W. *In prep* a. Production and escapement of coho salmon from the Chilkat River, 2010–2011. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Elliott, B.W. *In prep* b. Production and escapement of coho salmon from the Chilkat River, 2011–2012. Alaska Department of Fish and Game, Fishery Data Series, Anchorage.

Elliott, S.T., and K.J. Kuntz. 1988. A study of coho salmon in southeast Alaska: Chilkat Lake, Chilkoot Lake, Yehring Creek, and Vallenar Creek. Alaska Department of Fish and Game, Fishery Data Series No. 62, Juneau.

Elliott, S.T. and D.A. Sterritt. 1990. A study of coho salmon in southeast Alaska, 1989: Chilkoot Lake, Yehring Creek, Auke Lake, and Vallenar Creek. Alaska Department of Fish and Game, Division of Sport Fisheries, Fishery Data Series Report No. 90-53, Anchorage.

Ericksen, R.P. 1994. Effort, catch, and harvest of Chinook salmon in the spring marine boat sport fishery near Haines, Alaska, 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-30, Anchorage.

Ericksen, R.P. 1995. Sport fishing effort, catch, and harvest and inriver abundance of Chilkat River Chinook salmon near Haines, in 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-42, Anchorage.

Ericksen, R.P. 1996. Sport fishing effort, catch, and harvest, fishery contributions, and inriver abundance of Chilkat River Chinook salmon, in 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-48, Anchorage.

Ericksen, R.P. 1997. Sport fishing effort, catch, and harvest, and inriver abundance of Chilkat River Chinook salmon, in 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-27, Anchorage.

REFERENCES CITED (continued)

Ericksen, R.P. 1998. Sport fishing effort, catch, and harvest, and inriver abundance of Chilkat River Chinook salmon, in 1997. Alaska Department of Fish and Game, Fishery Data Series No. 98-31, Anchorage.Ericksen, R.P. 1999. Sport fishing effort, catch, and harvest, fishery contributions, and inriver abundance of Chilkat River Chinook salmon near Haines, Alaska, in 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-19, Anchorage.

Ericksen, R.P. 2000. Sport fishing effort, catch, and harvest, and inriver abundance of Chilkat River Chinook salmon, in 1999. Alaska Department of Fish and Game, Fishery Data Series No. 00-28, Anchorage.

Ericksen, R.P. 2001a. Sport fishing effort, catch, and harvest, and inriver abundance of Chilkat River Chinook salmon, in 2000. Alaska Department of Fish and Game, Fishery Data Series No. 01-12, Anchorage.

Ericksen, R.P. 2001b. Smolt production and harvest of coho salmon from the Chilkat River, 1999–2000. Alaska Department of Fish and Game, Fishery Data Series No. 01-17, Anchorage.

Ericksen, R.P. 2002a. Escapement, terminal harvest, and fall fry tagging of Chilkat River Chinook salmon in 2001. Alaska Department of Fish and Game, Fishery Data Series No. 02-23, Anchorage.

Ericksen, R.P. 2002b. Smolt production and harvest of coho salmon from the Chilkat River, 2000-2001. Alaska Department of Fish and Game, Fishery Data Series No. 02-18, Anchorage.

Ericksen, R.P. 2003a. Escapement, terminal harvest, and fall fry tagging of Chilkat River Chinook salmon in 2002. Alaska Department of Fish and Game, Fishery Data Series No. 03-26, Anchorage.

Ericksen, R.P. 2003b. Production of coho salmon from the Chilkat River, 2001–2002. Alaska Department of Fish and Game, Fishery Data Series No. 03-28, Anchorage.

Ericksen, R.P. 2004. Escapement, terminal harvest, and fall fry tagging of Chilkat River Chinook salmon in 2003. Alaska Department of Fish and Game, Fishery Data Series No. 04-20, Anchorage.

Ericksen, R.P. 2005. Escapement, terminal harvest, and juvenile tagging of Chilkat River Chinook salmon in 2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-68, Anchorage.

Ericksen, R.P. 2006. Production and escapement of coho salmon from the Chilkat River, 2004–2005. Alaska Department of Fish and Game, Fishery Data Series No. 06-77, Anchorage.

Ericksen, R.P. and R. S. Chapell. 2005. Production and spawning distribution of coho salmon from the Chilkat River, 2002–2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-18, Anchorage.

Ericksen, R.P. and R.S. Chapell. 2006a. Production and escapement of coho salmon from the Chilkat River, 2003–2004. Alaska Department of Fish and Game, Fishery Data Series No. 06-14, Anchorage.

Ericksen, R.P. and R.S. Chapell. 2006b. Production and spawning distribution of Chilkat River Chinook salmon in 2005. Alaska Department of Fish and Game, Fishery Data Series No. 06-76, Anchorage.

Ericksen, R.P., and R.P. Marshall. 1997. Diurnal variation in the catch of salmon in drift gillnets in Lynn Canal, Alaska. Alaska Fishery Research Bulletin 4(1):1–11.

Ericksen, R. P., and S. A. McPherson. 2004. Optimal production of Chinook salmon from the Chilkat River. Alaska Department of Fish and Game, Fishery Manuscript No. 04-01, Anchorage.

Gilks, W.R., A. Thomas, and D.J. Spiegelhalter. 1994. A language and program for complex Bayesian modeling. The Statistician*,* 43, 169–78.

Jennings, G.B., K. Sundet, A.E. Bingham, and D. Sigurdsson. 2004. Participation, catch, and harvest in Alaska sport fisheries during 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-11, Anchorage.

Jennings, G.B., K. Sundet, A.E. Bingham, and D. Sigurdsson. 2006a. Participation, catch, and harvest in Alaska sport fisheries during 2002. Alaska Department of Fish and Game, Fishery Data Series No. 06-34, Anchorage.

Jennings, G.B., K. Sundet, A.E. Bingham, and D. Sigurdsson. 2006b. Participation, catch, and harvest in Alaska sport fisheries during 2003. Alaska Department of Fish and Game, Fishery Data Series No. 06-44, Anchorage. Jennings, G.B., K. Sundet, and A.E. Bingham. 2007. Participation, catch and harvest in Alaska sport fisheries during 2004. Alaska Department of Fish and Game, Fishery Data Series No. 07-40, Anchorage.

Jennings, G.B., K. Sundet, and A.E. Bingham. 2009. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2005. Alaska Department of Fish and Game, Fishery Data Series No. 09-47, Anchorage.

Johnson, R.E., R.P. Marshall, and S.T. Elliott. 1992. Chilkat River Chinook salmon studies, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-49, Anchorage.

Johnson, R.E., R.P. Marshall, and S.T. Elliott. 1993. Chilkat River Chinook salmon studies, 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-50, Anchorage.

Johnson, R.E. 1994. Chilkat River Chinook salmon studies, 1993. Alaska Dept. of Fish and Game, Fishery Data Series No. 94-46, Anchorage.

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.

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

Mecum, R.D., and P.M. Suchanek. 1986. Southeast Alaska sport harvest estimates. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report 1985–1986, Project F-10-1, 27 (S-1-1), Juneau.

Mecum, R.D., and P.M. Suchanek. 1987. Harvest estimates for selected sport fisheries in southeast Alaska in 1986. Alaska Department of Fish and Game, Fishery Data Series No. 21, Juneau.

Mosher, K.H. 1969. Identification of Pacific salmon and steelhead trout by scale characteristics. U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Circular 317.

Neimark, L.M. 1985. Harvest estimates for selected fisheries throughout southeast Alaska. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report 1984-1985, Project F-9-17, 26 (AFS-41-12B), Juneau.

Olsen, M.A. 1992. Abundance, age, sex, and size of Chinook salmon catches and escapements in Southeast Alaska in 1987. Alaska Department of Fish and Game Technical Data Report No. 92-07, Juneau.

Robson, D.S. and H.A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fishery Society 93(3):215–226.

Scarnecchia, D.L. 1979. Variation of scale characteristics of coho salmon with sampling location on the body. Progressive Fish Culturist 41(3):132–135.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters, second edition. Charles Griffin and Sons, Ltd., London.

Shaul, L.D., P.L. Gray, and J.F. Koerner. 1991. Coded wire tag estimates of abundance, harvest, and survival rates of selected coho salmon stocks in Southeast Alaska, 1981–1986. Alaska Department of Fish and Game, Fishery Research Bulletin No. 91-05.

Shaul, L., E. Jones, K. Crabtree, T. Tydingco, S. McCurdy, and B. Elliott. 2008. Coho salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 08-20, Anchorage.

Suchanek, P.M., and A.E. Bingham. 1989. Harvest estimates for selected sport fisheries in southeast Alaska in 1988. Alaska Department of Fish and Game, Fishery Data Series No. 114, Juneau.

REFERENCES CITED (continued)

Suchanek, P.M., and A.E. Bingham. 1990. Harvest estimates for selected marine boat sport fisheries in southeast Alaska in 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-51, Anchorage.Suchanek, P.M., and A.E. Bingham. 1991. Harvest estimates for selected marine boat sport fisheries in southeast Alaska during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-48, Anchorage.

Thompson, S.K. 2002. Sampling, 2nd ed. John Wiley and Sons, Inc., New York

Vincent-Lang, D. 1993. Relative survival of unmarked and fin-clipped coho salmon from Bear Lake, Alaska. Progressive Fish-Culturist 55:141–148.

Walker, R. J., C. Olnes, K. Sundet, A. L. Howe, and A. E. Bingham. 2003. Participation, catch, and harvest in Alaska sport fisheries during 2000. Alaska Department of Fish and Game, Fishery Data Series No. 03-05, Anchorage.

Weller, J. L., E. L. Jones III, and A. B. Holm. 2005. Production of coho salmon from the Unuk River, 2002–2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-21, Anchorage.

APPENDIX A

Appendix A1.–Anticipated number of fish released with coded wire tags (CWT) and adipose fin clips in 2014, using Chinook and coho salmon smolt CPUEs from 2000 to 2012, and 2013. Two CPUEs are used because the trap site selection method changed significantly in 2013 compared to previous years.

		Chinook salmon smolt				Coho salmon smolt			
Date	Traps deployed	CPUE 2001–2012	Valid CWT	CPUE 2013	Valid CWT	CPUE 2001–2012	Valid CWT	CPUE 2013	Valid CWT
4-Apr	80	1.8	141	1.8	141	1.5	118	1.5	118
5-Apr	80	3.4	269	4.3	345	4.0	320	4.0	320
6-Apr	80	3.1	248	2.7	217	2.8	226	2.8	226
7-Apr	80	2.9	232	2.4	195	3.5	278	3.5	278
8-Apr	80	2.8	221	2.2	176	3.9	311	3.9	311
9-Apr	80	2.3	182	2.1	165	5.4	432	3.3	267
10-Apr	80	1.5	123	2.1	167	5.1	409	3.3	267
11-Apr	80	1.6	126	2.1	172	4.9	390	3.0	244
12-Apr	80	1.6	126	2.0	163	4.5	358	5.4	432
13-Apr	80	1.4	110	2.1	169	5.0	403	6.1	486
14-Apr	80	1.4	116	2.2	179	5.0	403	5.4	429
15-Apr	80	1.6	127	1.5	117	5.3	428	4.0	321
16-Apr	80	1.3	102	1.3	108	4.9	388	3.3	268
17-Apr	80	1.4	112	1.8	143	5.6	448	3.4	268
18-Apr	80	1.4	109	2.1	166	5.5	441	3.7	300
19-Apr	80	1.4	111	1.7	134	4.9	391	5.9	469
20-Apr	80	1.3	104	1.0	81	5.0	401	4.8	382
21-Apr	80	1.3	104	1.3	103	4.8	387	6.4	511
22-Apr	80	1.2	97	0.9	73	5.0	404	3.5	282
23-Apr	80	1.3	103	2.6	207	5.4	434	3.7	295
24-Apr	80	1.6	125	3.5	279	5.0	399	4.2	338
25-Apr	80	1.4	110	2.7	215	4.9	395	3.3	264
26-Apr	80	1.3	107	0.8	61	4.7	379	1.2	97
27-Apr	80	1.2	100	1.5	120	4.8	384	2.7	218
28-Apr	80	1.4	109	2.0	157	4.8	383	2.3	181
29-Apr	80	1.3	103	1.6	130	5.0	400	2.0	161
30-Apr	80	1.2	94	3.2	259	5.3	422	3.0	242
1-May	80	1.1	86	2.4	195	5.1	407	2.8	227
2-May	80	1.0	80	1.9	155	4.9	392	2.5	202
3-May	80	1.0	83	2.9	230	5.5	436	2.4	195
4-May	80	0.9	72	2.3	187	5.3	426	3.1	248
5-May	80	0.9	73	2.0	162	5.9	472	3.3	268
6-May	80	0.9	74	1.3	106	5.9	473	2.5	204
7-May	80	0.8	67	0.9	73	5.8	465	3.1	247
8-May	80	0.8	67	1.1	91	5.7	455	2.3	188
9-May	80	0.7	60	1.6	130	5.7	453	5.3	424
10-May	80	0.9	71	2.3	185	5.9	468	4.6	365
11-May	80	0.9	74	1.7	140	6.1	488	3.7	297
12-May	80	0.8	60	0.3	25	5.7	457	2.7	214
13-May	80	0.8	66	0.2	15	5.2	415	1.7	135
Total	3,200	1.4	4,545	1.9	6,135	5.0	15,936	3.5	11,185

Appendix A2.–Expected values used in Chilkat Chinook salmon brood year 2012 coded wire tag (CWT) sample size and precision calculations.

	Survival or harvest rate, %	Percent of Chilkat marine harvest	Number of Chilkat fish	Marked rate	Number of Chilkat CWT fish	Sampling rate	Number of Chilkat CWTs recovered
Fall 2013 parr population			533,485				
Fall 2013 parr marked with CWT				0.047	25,000		
Spring 2014 survivors	31.3		165,867		7,825		
Spring 2014 CWT marked				0.037	6,135		
Total marked spring 2014 emigrants				0.084	13,960		
Smolt-to-adult survivors	3.2		4,867		410		
Marine harvest by fishery							
Troll		17%	140	0.084	12	0.50	6
Gillnet and purse seine		27%	224	0.084	19	0.51	8
Sport		37%	308	0.084	26	0.66	11
Subsistence		20%	173	0.084	15	0.50	4
Total marine harvest	17.3	100%	844	0.084	71	0.46	28
Total inriver abundance	82.7		4,023	0.084	339	0.14	47

Appendix A3.–Hypothetical set of marine fishery recoveries of brood year 2012 Chilkat Chinook salmon CWTs used to relate the number of juveniles marked in fall 2013 and spring 2014 to the relative precision of the adult marine harvest estimate.

			Catch		Harvest							
District / fishery	Stat week / biweek	Age	N_i or $\hat{N}_i$	$v(\hat{N}_i)$	m_i	λ_i	$\hat{r}_{ij}$	ϕ_i	$G(\hat{p}_i)$	$G(\hat{N}_i)$	$v(\hat{r}_{ij})$	prob ($m_{ij} > 0$)
112 Purse	30	1.1	44	0	0.3	1.000	7	44%	3.67	0	183	0.231
110 Troll	42	1.2	410	0	0.3	1.000	6	56%	3.63	0	109	0.231
111 Sport	16	1.2	393	0	0.3	0.968	5	59%	3.62	0	106	0.231
111 Sport	17	1.2	195	0	0.5	0.986	10	63%	1.80	0	182	0.409
112 Purse	26	1.2	64	0	0.3	1.000	3	101%	3.49	0	33	0.231
112 Purse	27	1.2	118	0	0.3	0.985	6	54%	3.64	0	123	0.231
114 Troll	24	1.2	379	0	0.3	0.989	5	59%	3.62	0	102	0.231
114 Troll	34	1.2	293	0	0.3	1.000	16	19%	3.75	0	979	0.231
115 Drift	25	1.2	222	0	0.3	1.000	10	30%	3.71	0	393	0.231
115 Drift	27	1.2	152	0	0.5	0.985	19	33%	1.85	0	689	0.409
115 Drift	28	1.2	91	0	0.3	0.973	9	37%	3.69	0	278	0.231
115 Drift	29	1.2	79	0	0.3	1.000	8	38%	3.69	0	241	0.231
115 Drift	30	1.2	56	0	0.4	1.000	11	44%	2.44	0	268	0.326
115 Drift	31	1.2	52	0	0.5	1.000	12	53%	1.82	0	254	0.409
115 Drift	32	1.2	34	0	0.3	1.000	4	73%	3.58	0	65	0.231
115 Drift	33	1.2	31	0	0.4	1.000	5	96%	2.33	0	55	0.326
115 Drift	34	1.2	32	0	0.3	0.880	5	67%	3.62	0	99	0.231
115 Drift	37	1.2	8	0	0.3	1.000	3	96%	3.50	0	36	0.231
115 Sport	24	1.2	71	308	0.4	1.000	13	35%	2.46	0.061	411	0.326
115 Subsistence	25	1.2	13	0	0.3	1.000	12	27%	3.72	0	505	0.231
115 Subsistence	26	1.2	15	0	0.5	1.000	12	51%	1.82	0	274	0.409
108 Drift	27	1.3	1,340	0	0.3	0.987	12	26%	3.72	0	523	0.231
109 Troll	22	1.3	637	0	0.3	0.994	5	61%	3.61	0	93	0.231
111 Sport	16	1.3	393	0	0.3	0.968	5	59%	3.62	0	106	0.231
111 Sport	17	1.3	195	0	0.3	0.986	5	63%	3.61	0	91	0.231
113 Troll	23	1.3	2,142	0	0.3	0.987	8	41%	3.68	0	213	0.231

-continued-

Appendix A3.–Page 2 of 2.

District / fishery	Stat week / biweek	Age	Catch			Harvest						
			N_i or $\hat{N}_i$	$v(\hat{N}_i)$	m_i	λ_i	$\hat{r}_{ij}$	ϕ_i	$G(\hat{p}_i)$	$G(\hat{N}_i)$	$v(\hat{r}_{ij})$	prob ($m_{ij} > 0$)
114 Troll	21	1.3	296	0	0.7	1.000	14	58%	1.45	0	263	0.481
114 Troll	22	1.3	374	0	0.4	1.000	8	57%	2.42	0	158	0.326
114 Troll	23	1.3	380	0	0.3	1.000	6	48%	3.65	0	149	0.231
114 Troll	24	1.3	379	0	1.3	0.989	27	59%	0.72	0	526	0.731
114 Troll	25	1.3	553	0	0.4	0.980	8	57%	2.42	0	170	0.326
114 Troll	26	1.3	343	0	0.3	1.000	6	50%	3.65	0	141	0.231
114 Troll	27	1.3	297	0	0.3	1.000	11	28%	3.72	0	469	0.231
115 Drift	26	1.3	163	0	0.3	0.918	11	32%	3.71	0	416	0.231
115 Drift	27	1.3	152	0	1.2	0.985	44	33%	0.82	0	1,574	0.693
115 Drift	28	1.3	91	0	0.5	0.973	17	37%	1.85	0	559	0.409
115 Drift	29	1.3	79	0	0.8	1.000	24	38%	1.23	0	734	0.545
115 Drift	33	1.3	31	0	0.3	1.000	3	96%	3.50	0	36	0.231
115 Sport	11	1.3	125	767	1.1	0.983	22	58%	0.91	0.050	434	0.650
115 Sport	12	1.3	71	308	2.5	1.000	84	35%	0.39	0.061	3,099	0.918
115 Sport	13	1.3	10	61	1.2	1.000	34	41%	0.82	0.574	1,096	0.693
115 Subsistence	25	1.3	13	0	0.4	1.000	18	27%	2.48	0	760	0.326
115 Subsistence	26	1.3	15	0	0.8	1.000	18	51%	1.22	0	413	0.545
115 Subsistence	27	1.3	18	0	1.2	1.000	52	27%	0.83	0	2,279	0.693
113 Troll	21	1.4	1,444	0	0.3	0.997	7	46%	3.66	0	166	0.231
114 Troll	22	1.4	374	0	0.3	1.000	5	57%	3.62	0	105	0.231
114 Troll	23	1.4	380	0	0.3	1.000	6	48%	3.65	0	149	0.231
115 Drift	27	1.4	152	0	0.3	0.985	10	33%	3.70	0	342	0.231
115 Sport	11	1.4	125	767	1.1	0.983	22	58%	0.91	0.050	434	0.650
115 Sport	12	1.4	71	308	2.5	1.000	84	35%	0.39	0.061	3,099	0.918
115 Sport	13	1.4	10	61	0.8	1.000	23	41%	1.23	0.574	576	0.545
115 Subsistence	24	1.4	6	0	0.3	1.000	25	13%	3.77	0	2,308	0.231
115 Subsistence	25	1.4	13	0	0.3	1.000	12	27%	3.72	0	505	0.231
115 Subsistence	27	1.4	18	0	0.5	1.000	23	27%	1.86	0	997	0.409
Total			13,442		28		844	46%			28,369	

Appendix A4.–Simulation data and statistics for anticipating precision of the estimated harvest of Chilkat River coho salmon from marine sport and commercial fisheries in 2015, from an anticipated release in 2014 of 11,185 tagged smolts from a population of 1,333,080. The term π_i is the average historical probability (from sampling in 2000–2012) of recovering a tag in a stratum, and $1-(1-\pi_i)^H$ is the anticipated probability recovering a tag in that stratum (i.e., prob(m>0)); see Bernard et al. (1998) for other details.

Stratum (type,area,wks)	N_i	$v[N_i]$	$(n_i/N_i)i$	m	λ_i	r_i	SE[r_i]	π_i	1-(1-π_i)H
Troll, NW 3	489,346	0	28%	10.1	0.98	4,382	1,405	0.000907	1.000
Troll, NE 4	62,313	0	28%	1.3	0.99	550	483	0.000116	0.727
Troll, NW 4	420,488	0	35%	54.0	0.98	18,943	2,895	0.004832	1.000
Troll, NW 5	139,380	0	28%	2.4	0.99	1,010	657	0.000212	0.907
Sport, Gustavus Ma, 12–18	29,636	7,447,441	10%	0.0	0.97	44	233	0.000003	0.034
Sport, Icy St Ma, 11–18	14,927	5,760,978	47%	0.9	1.00	238	245	0.000084	0.607
Sport, Juneau Ma, 17	7,400	1,120,364	58%	0.6	0.97	120	159	0.000051	0.432
Sport, Juneau Ma, 18–19	6,956	2,503,384	27%	0.7	0.92	339	402	0.000062	0.502
Sport, Sitka Ma, 14	9,614	11,525,161	24%	0.0	0.97	18	88	0.000003	0.034
Sport, Sitka Ma, 17	18,032	6,062,031	30%	0.1	0.97	40	127	0.000009	0.094
Sport, Yakutat Ma, 16–18	5,484	1,394,020	65%	0.2	1.00	45	89	0.000022	0.219
Gillnet, 111, 38	10,901	0	15%	0.1	0.98	53	208	0.000006	0.063
Gillnet ,115, 34	1,990	0	34%	0.9	1.00	331	339	0.000085	0.612
Gillnet, 115, 35	3,839	0	46%	3.7	0.96	1,005	525	0.000331	0.975
Gillnet,115, 36	6,786	0	29%	7.4	1.00	3,076	1,145	0.000665	0.999
Gillnet, 115, 37	10,040	0	22%	6.7	0.99	3,648	1,428	0.000599	0.999
Gillnet, 115, 38	11,900	0	21%	6.1	0.97	3,573	1,466	0.000544	0.998
Gillnet, 115, 39	8,451	0	32%	13.2	0.98	5,039	1,426	0.001182	1.000
Gillnet, 115, 40–41	3,694	0	36%	5.6	0.99	1,877	801	0.000501	0.996

-continued-

Appendix A4.–Page 2 of 2.

Stratum (type, area, wks)	N_i	$v[N_i]$	$(n_i/N_i)i$	m	λ_i	r_i	SE[r_i]	$\pi\iota$	$1\text{-}(1\text{-}\pi_i)H$
Seine, 109, 31	44,672	0	13%	0.0	0.99	32	174	0.000003	0.034
Seine, 109, 32	9,660	0	22%	0.0	0.99	27	119	0.000004	0.049
Seine, 112, 30	6,455	0	15%	0.1	0.99	95	272	0.000011	0.114
Seine, 112, 31	6,555	0	32%	0.0	0.99	18	83	0.000004	0.049
Seine, 112, 33	2,284	0	80%	0.1	0.99	15	47	0.000009	0.095
Seine, 112, 34	11,911	0	40%	0.3	0.99	87	161	0.000026	0.254
Seine, 112, 35	15,508	0	16%	0.1	0.99	73	231	0.000009	0.095
Seine, 114, 31	6,377	0	53%	0.0	0.99	8	42	0.000003	0.034
Seine, 114, 34	1,136	0	26%	0.0	1.00	22	99	0.000004	0.046
Seine, 114, 38	1,993	0	21%	0.1	1.00	57	181	0.000009	0.094
Total	1,367,726	35,813,379	30%	115		44,766	4,495	90% ρ.π. = 16.5%	0.000

APPENDIX B

Appendix B1.–Smolt coded wire tag daily log.

Tagging Site: Chilkat River

Species: Coho

Capture Site: Chilkat River

Tagger: Derby

Date: May 5, 2013

Today's Tagging: Machine Serial No.___621___________

	SMALL	MEDIUM	LARGE
Tag Code	04-18-93	04-18-94	04-18-94
End #	276,633	275,822	276,204
Start #	276,209	275,513	275,824
Subtotal	424	309	380
Double/Retags	0	2	12
Total Tagged	424	307	368

Today's Recaptures:

Total w/o CWTs	29
Total w/ CWTs	0
Total	29

Tag Retention & Mortality Calculations (hold until next day):

No. w/ CWTs	100
No. w/o CWTs	0
No. Tested	100

Summary	# valid tagged	overnight mortality	# released
75–84mm	424	1	423
85–99mm	307	0	307
>=100mm	368	2	366
TOTAL	1099	3	1096

Traps will be tied off with an overhand knot followed by a slipknot to insure traps can be pulled quickly during floodwaters. Try to tie off well above the water level in case of rising water. Always push flagging up to the knot and place extra flagging if not easily visible. Cinch the knot on the flagging tape tight so wind won't blow it into the water. Always carry extra flagging and use it if traps are in hard to find locations.

One crew leader will be in charge of a trap line, and the other will be in charge of the other trap line. Keep accurate track of all traps. **REMEMBER**: Lost traps keep fishing and kill fish. Count all traps taken out to the field at the beginning of the season and record this number in the logbook. If more traps are taken to the field later on, these need to be recorded as well. All lost or damaged traps (i.e., bear hits) will be recorded, and the damaged traps kept in a certain place until the end of the season. The goal is to be able to reconcile the number of traps we have upon pulling out from an area with the number taken out to the field, as even one trap potentially left set is a problem. Also in early–mid May, eulachon will be running in the lower river. Be sensitive to people fishing for eulachon. It may be best to stay out of the lower river during this time.

Both crews should take hand counters to help keep track of the number of traps on the longer lines. If a trap is lost during high water, it should be marked as lost in the trap-line book and the area flagged so the trap may be recovered at low water.

Name specific areas of the river where you are trapping. Naming an area after a natural feature will help you associate the area with the name. Examples are Spruce Row, Moose Bar and Big Beaver. So that everyone is using a standard method of notation in the trap-line field book, the format will be as follows:

Table 1.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in Fall, 2003.

Date: 10/20/2003

Site	Traps checked	Traps pulled	Traps added	Total traps	# Of fish by species
Spruce Row	5	2	0	3	30 coho; 10 king
Moose Bar	2	0	2	4	50 coho
Big Beaver	3	3	0	0	5 coho
Snowball	0	0	3	3	New sets
Total	10	5	5	10	85 coho; 10 king

According to the above notation, at Spruce Row we checked 5 traps; two of the traps didn't catch many fish so we pulled them. That leaves us with 3 traps in that area and we caught approximately 30 fish there. On Moose Bar we checked 2 traps and caught 50 fish so we set 2 more in that area, for a total of 4 traps in the water. At Big Beaver we checked 3 traps for a total of 5 fish, lousy fishing so we pulled all 3 traps, leaving us with 10 traps in that area. We set 3 traps in a new area called Snowball. Looking at the total we see that we caught 85 coho and 10 kings that day and have 10 traps still in the water fishing.

The rest of the crew will alternate between upriver and downriver to break up the monotony of always working with the same person.

The number of traps out is the important number. Don't waste a lot of time counting each individual fish. We will get the exact number when we tag. Be conservative in your counting. The objective is to tag a lot of fish, not to have a higher number in your book than the other crew.

Appendix B3.–Minnow trap summary form. A7

	River	River	Lower Trapline				Upper Trapline				Daily Total				Cum. Total	
	Depth	Temp	Number of traps		Est. Fish		Number of traps		Est. Fish		Est. Fish		# Tagged		# Tagged	# Tagged
Date	(in)	(C)	Checked	Set	Chinook	Coho	Checked	Set	Chinook	Coho	Chinook	Coho	Chinook	Coho	Chinook	Coho
8-Apr	6.00	2.0		50				40								
9-Apr	6.50	2.0	50	44	37	144	40	50	48	285	85	429				
10-Apr	7.00	2.0	44	40	39	201	50	36	39	432	78	633	160	1,162	160	1,162
11-Apr	7.25	3.0	40	46	26	118	36	47	39	284	65	402				
12-Apr	8.00	3.0	46	35	9	120	47	42	29	218	38	338	85	658	245	1,820
13-Apr	10.00	3.0	35	36	6	64	42	47	35	231	41	295				
14-Apr	11.50	3.0	36	50	28	85	47	47	24	221	52	306	74	553	319	2,373
15-Apr	13.50	2.5	50	46	23	91	47	50	8	180	31	271				
16-Apr	14.50	3.0	46	43	28	277	50	49	11	174	39	451	69	666	388	3,039
17-Apr	16.25	3.0	43	46	33	188	49	49	37	238	70	426				
18-Apr	16.75	2.5	46	40	21	144	49	49	84	311	105	455	138	714	526	3,753
19-Apr	17.00	3.0	40	48	33	174	49	50	66	231	99	405				
20-Apr	18.00	4.0	48	46	40	290	50	50	49	193	89	483	203	772	729	4,525
21-Apr	19.00	3.0	46	46	51	216	50	50	39	145	90	361				
22-Apr	19.00	3.0	46	46	26	201	49	49	68	171	94	372	150	389	879	4,914
23-Apr	19.25	2.5	46	48	12	143	49	48	48	270	60	413				
24-Apr	19.25	3.0	48	47	22	140	48	48	59	263	81	403	129	649	1,008	5,563
25-Apr	19.00	3.0	47	47	37	143	48	48	74	222	111	365				
26-Apr	19.00	3.0	47	46	43	147	48	48	88	174	131	321	222	653	1,230	6,216
27-Apr	19.00	3.0	46	48	65	184	48	48	114	256	179	440				
28-Apr	20.75	4.0	48	49	49	134	48	48	146	198	195	332	382	675	1,612	6,891
29-Apr	21.00	4.0	49	49	79	167	48	48	95	206	174	373				
30-Apr	22.00	4.0	49	49	50	157	48	48	142	292	192	449	357	577	1,969	7,468
1-May	22.00	4.0	49	45	58	96	48	46	147	321	205	417				
2-May	22.75	4.0	45	46	94	146	46	50	88	241	182	387	373	775	2,342	8,243
3-May	23.00	4.0	46	50	93	207	50	50	54	208	147	415				
4-May	23.00	4.0	50	50	57	173	50	49	41	265	98	438	232	748	2,574	8,991
5-May	22.75	4.0	50	50	20	139	49	48	37	309	57	448				
6-May	23.00	4.0	50	50	25	266	48	48	37	222	62	488	88	767	2,662	9,758
7-May	24.00	4.5	50	50	18	239	48	49	34	263	52	502				
8-May	26.75	4.0	50	50	14	133	49	49	40	222	54	355	104	737	2,766	10,495
9-May	26.00	3.5	50	50	7	262	49	49	64	285	71	547				
10-May	24.50	4.0	50	50	6	146	49	49	47	238	53	384	108	727	2,874	11,222
11-May	24.50	4.5	50	49	17	209	49	49	27	269	44	478				
12-May	27.00	4.0	49	49	8	176	49	49	25	220	33	396	64	740	2,938	11,962
13-May	27.75	4.0	49	49	18	192	49	49	15	244	33	436				
14-May	26.50	4.5	49	48	24	207	49	49	12	282	36	489	67	801	3,005	12,763

Appendix B4.–Chilkat River Chinook salmon sampling form.

Gear: Location:

Fish #	**Date**	**Length**	**Fish #**	**Date**	**Length**

Appendix B5.–Chilkat River coho salmon smolt age-weight-length form.

Location: ______________ **Year:** ________

Species: ______________ **Page :** ________

Samplers:

Date	Slide	Fish #	Length	Weight	Comments	Date	Slide	Fish #	Length	Weight	Comments
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			

Appendix B6.–Coded wire tag online release entry report.

CWT Online Release Entry Final Notification, Tag Code: 041546

Tag Code: 041546 | Beg. Seq.: | End. Seq.:

General Information

Project Leader:	RICHARD CHAPELL	Species:	COHO	Rearing Type:	WILD
Agency:	ADFG	Brood Year:	2007	Release Type:	
Division/Section:	SPORT FISH	Stock:	CHILKAT RIVER	Run:	SUMMER
Facility:		Ancestral Stock:		Mark Type Code:	AD
Experimental Class:				Thermal Mark:	

Experimental Narrative: 250 characters max.

WILD COHO SALMON (SIZE RANGE >=85MM FROM BY2006 AND BY2007) CAUGHT, TAGGED, AND RELEASED IN THE CHILKAT RIVER 5/16/2009 - 5/30/2009. TAG RETENTION PERFORMED ON MIXED SAMPLE OF FISH; SAMPLE SIZE PROPORTIONED ACCORDINGLY.

Statistical Replicates:

Tagging Information

Tagging Supervisor: LARRY DERBY | Size of Tagged Fish: grams | Naturally Missing Ad Fins:

Date	Mach. Number	Number Injected	Overnight Mortality	Adj. Tagged	Tag Retention Sample Ratio	% Tag Retention	Valid Tagged
5/16/2009	621	691	2	689	50 / 50	100.0%	689
5/18/2009	621	727	1	726	50 / 50	100.0%	726
5/20/2009	621	778	6	772	50 / 50	100.0%	772
5/22/2009	621	1,121	17	1,104	50 / 50	100.0%	1,104
5/24/2009	621	913	4	909	50 / 50	100.0%	909
5/26/2009	621	944	18	926	50 / 50	100.0%	926
5/28/2009	621	517	1	516	50 / 50	100.0%	516
5/29/2009	621	271	2	269	50 / 50	100.0%	269

Total Number Injected:	5,962	Total Overnight Morts:	51	Total Adjusted Tagged:	5,911
Average Tag Retention:	100.0%	Total Retention Sample:	400	Total Valid Tagged:	5,911

Release Information

Release Supervisor:	BRIAN ELLIOTT	Release Stage:	SMOLT
Release Site:	CHILKAT RIVER	Unmarked Counting Method:	
Stream #:	115-32-10250-%	Expected Survival:	NORMAL
Time of Release (Military Format):	0900	Release Strategy:	

Release Dates Began	Release Dates Ended	Date of Final Tag Retention Test	Tag Retention Sample Ratio	% Tag Retention	Size at Release Weight	Size at Release Fork Length
5/17/2009	5/30/2009	5/30/2009	50 / 50	100.0%		

Total injected	Overnight morts	Morts after tagging	Surviving tagged fish	Tag retention best estimate
5,962	51		5,911	100.0%

Marked Fish Having Tags	Marked Fish That Shed Tags	Fish Released NOT Marked but Represented	Failed Marks	Total Unmarked Fish Released	Total Fish Released	Tag Ratio
5,911	0		0		5,911	1.000

Comments: 250 characters max.

WILD COHO SALMON SMOLT TAGGED IN "MEDIUM" AND "LARGE" CATEGORY (SIZE >=85MM FROM BY2006 AND BY2007), SEPARATE FROM SMALL (>=75MM - <85MM) COHO SALMON SMOLT

APPENDIX C

Appendix C1.–WinBugs code and results of Bayesian statistical analysis of brood year 2001 juvenile Chilkat River Chinook salmon abundance.

---

data from other recoveries included, non valid tags considered

prior distributions for root nodes underlined

fixed constants in bold

deterministic relationships in black (these link the priors and the likelihoods, or calculate auxiliary quantities)

likelihood (sampling distribution of data) in italics

BY 2001 constants

adclips <- 70 # ad clips found in Chilkat escapement sampling

heads <- 38 # heads collected in Chilkat (this is actually not relevant here)

valid.tags <- 36 # tags decoded by CF Mark, Tag and Age Lab from Chilkat heads

MODEL {

N.fry ~ dnorm(0,1.0E-12) # abundance of fry in fall

phi.1 ~ dbeta(0.15,0.15) # proportion of fry surviving until spring

rho ~ dbeta(0.1,0.1) # proportion of ad clipped fish for which head collected and tag decoded

M.fry <- 31390 # fry marked

M.smolt <- 2797 # smolts marked

C <- 980 # fish inspected inriver for ad clips

m<-21 # number of Chilkat CWT recoveries elsewhere, fall and spring

N.smolt <- N.fry * phi.1 # abundance of smolt the following spring

q.fall <- M.fry / N.fry # fraction marked in fall

q.spring <- M.smolt / N.smolt # fraction marked in spring

pi[1] <- q.fall * rho # fraction of returning fish from which could expect a valid fall tag

pi[2] <- q.spring * rho # fraction of returning fish from which could expect a valid spring tag

pi[3] <- (q.fall + q.spring) * (1 - rho) # fraction of returning fish with adclip, but no valid tag

pi[4] <- 1 - pi[1] - pi[2] - pi[3] # fraction with no adclip

R.tags[1:4] ~ dmulti(pi[],C) # vector of returns by type is multinomially distributed

pi.fall <- q.fall / (q.fall + q.spring) # fraction of fall tags among all Chilkat tags

m.fall ~ dbin(pi.fall,m) # number of fall tags among Chilkat tags is binomially distributed

}

DATA

list(R.tags=c(27,9,34,910),m.fall=15) # terms in DATA list are: 27 fall tags in Chilkat escapement,

9 spring tags in Chilkat escapement; 34 heads not taken or # tags not decoded; 910 fish with

intact adipose fins; 15 fall tags recovered in marine random samples.

INITS

list(N.fry =600000, phi.1=0.3, rho=0.5)

RESULTS

Node	Mean	SD	MC error	2.5%	10.0%	Median	90.0%	97.5%	Start	Sample
N.fry	609,600	86,720	798	464,000	506,800	601,100	723,500	804,800	4,001	96,000
N.smolt	164,800	47,380	231	98,260	114,300	156,700	224,700	279,900	4,001	96,000
phi.1	0.27730	0.09484	6.494E-4	0.14480	0.17680	0.26050	0.39640	0.50880	4,001	96,000
pi[1]	0.02700	0.00488	3.598E-5	0.01830	0.02095	0.02670	0.03339	0.03738	4,001	96,000
pi[2]	0.00937	0.00267	1.055E-5	0.00489	0.00616	0.00911	0.01291	0.01527	4,001	96,000
pi[3]	0.03436	0.00574	3.155E-5	0.02402	0.02722	0.03404	0.04191	0.04644	4,001	96,000
pi[4]	0.92930	0.00809	5.88E-5	0.91260	0.91880	0.92960	0.93950	0.94440	4,001	96,000
rho	0.51420	0.05891	1.865E-4	0.39910	0.43840	0.51430	0.59020	0.62940	4,001	96,000

APPENDIX D

Appendix D1.–Global positioning system data collection protocol.

Overview of the Global Positioning System (GPS)

The Global Positioning System (GPS) is a world-wide radio-navigation system formed from a constellation of 24 satellites with precise atomic clocks orbiting 11,000 km above the earth's surface, and their associated ground stations. Positions on earth are determined by receiving the radio signals being emitted, and measuring the very precise distances and time to the available satellite(s); the process uses mathematical 'triangulation' calculations to compute the result.

Essentially, four visible satellites are necessary to accurately determine position, but three available satellites can do the same—albeit sometimes less reliably, depending on their constellation/configuration at that specific point in time. The steep terrain associated with certain parts of Alaska will at times present problems with obstructed views of the sky and therefore will play a role in how well the radio signals from the satellites are being received. However, use of external antennas, leaving units turned on over the course of the day while surveying, and waiting until certain times of day to collect data can all enhance ones ability to collect reasonably precise positions.

GPS Instrument Setup

There are a myriad of makes and models of consumer-grade GPS units available for purchase, but in the end, they all process and produce positional data the same. Before GPS units can be used for navigation or waypoint storage purposes, they need to be initialized. Each GPS receiver should only need to be initialized the first time the unit is used, or if it has been stored for several months or moved a substantial distance while turned off. The initialization procedure is automatic for most GPS receivers and begins on power-up. To initialize a unit for the first time, take the GPS receiver outside with a clear, 360 degree field of view and turn it on. Navigate through the 'pages' of the GPS using the LCD display until the unit shows that it is acquiring satellites. The unit will begin acquiring fixes on available satellites, and storing the orbital data for each in an almanac in memory on the unit. This setup should complete the initialization of the unit.

There are two key items to remember when using consumer-grade GPS units relative to coordinate data being saved/recorded: 1) coordinate information stored directly on the unit (as waypoints or routes) is always stored in a world geographic coordinate system (WGS84) datum and cannot be overridden until they are downloaded; and 2) you can override the datum and projection being displayed on the screen using the setup menu as necessary, but it is important to document what you set the datum/projection to (i.e. NAD83 Stateplane Alaska Zone 1) if recording those coordinates onto a data form/book rather than saving as waypoints on the unit—this is imperative to ensure correct display in GIS for rendering final output.

Observers should always attempt to get the best possible "fix" from satellites when taking a GPS reading. Often, fixes with accuracy (or error, as it is labeled with some GPS units) under 15 m are possible in less than 30 seconds, especially on the larger river systems where canopy cover is minimal, and the view of the horizon is not obscured (e.g., high ridge immediately above river bank). There will be days when the constellation of the satellites is insufficient to allow for good fixes (i.e., >15 m accuracy); in these instances, it is preferred that GPS locations be acquired on a return visit. If no return visit is anticipated, then observers should spend an extra 1–2min, if possible, to let the GPS instrument acquire the best fix under the circumstances.

Importance of Spatial Data to Fisheries Management and Research

Like many resource management agencies across the country, the Alaska Department of Fish and Game's mission is to protect, maintain and improve the fish, game and aquatic plant resources of the state. And almost everything that is done in our day-to-day activities, or conveyed to the public, is explicit to somewhere on the landscape. For example, research project plans typically describe specific locations where data need to be collected; news releases typically describe where users may or may NOT harvest resources, etc. Yet there is no standardized way to document where exactly these places are across the landscape and worse yet, no data management system to accommodate that type of information. Our intent is to layout some guidelines that can be used by others to assist in their spatial data collection efforts.

Spatial data when added to fish observation data is a very useful tool, and can help facilitate a number of information needs for enhancing our ability to carry out the mission of the Department. Examples include: increasing our knowledge of fish distribution for purposes of protection and conservation; documenting where boundary markers are established for fishery openings; documenting where fish are trapped/observed during sampling events for return trips; use of site-specific fish locations to develop landscape-based models that estimate fish production; identifying areas on the landscape that are most important to users for purposes of conservation and protection.

GPS Data Collection Procedures for use in Salmon Stock Assessment Projects

Smolt Tagging (Fall, Spring)

This section will describe the development and implementation of procedures and techniques for the collection of spatial data using GPS units at specific locations on the ground associated with smolt trapping sites on several Transboundary River Systems. These projects include coded wire tagging of Chinook and coho salmon presmolts and smolts which is a component of full stock assessment projects.

First and foremost, SF crews are NOT being asked to change their mode of operations, as it pertains to smolt trapping methods. Rather, the collection of spatial data using GPS units (waypoints) should be considered a task that occurs coincidentally with their delegated smolt trapping work. Generally, you will be looking to collect waypoints at smolt-trapping sites to generally describe the extent of the smolt-trapping area. For example, if we knew that trapping sites were all the same size and configuration, we could simply grab one waypoint for a group of traps known collectively to encompass site 'X'. However, the reality is that these trapping sites differ in size and configuration and migrate upstream/downstream as water levels rise and fall across the trapping season. The general practice is that vernacular names are assigned to these trapping areas in a given season, and rather than re-naming those areas where traps are moved only short distances, typically retain the same name. In other instances, SF crews move into new areas as snow/ice dissipate, at which time the area is assigned a new generic name.

Capturing waypoints in a manner that represents the whole extent or area of individual trapping sites can accommodate each of these scenarios. This may be as simple as taking single waypoints at small sites (which may represent 4–5 traps placed at a small logjam) or as involved as taking multiple waypoints to accurately determine the boundaries of a relatively larger trapping site. It may also entail taking additional waypoints as a single trapping site is fished out and traps are 'shifted' or moved down/up stream; field crews may decide to keep their generic site name, since its in close proximity. One additional waypoint may be sufficient such that we would be able to map out the entire extent of the trapping area.

The bottom line is that multiple waypoints are collected at each site to generally describe the extent of the area being trapped. If two waypoints are collected for a single trapping area, generally identifying the upper and lower portions of the site and a few traps are below or above these waypoints by 20–30 meters, this is fine. We are looking for a precision of under 50 meters in most cases although 100 meters may be the best we can do in large braided areas of the Unuk floodplain, without unduly creating chaos for field crews where the primary responsibilities are trapping large numbers of fish. Figures 1–3 illustrate the use of waypoints in delineating or 'outlining' the extent of trap sites (areas) with an acceptable level of precision. In these figures, the polygons representing the trap sites (areas) may appear to be arbitrarily drawn, considering that although the points fall inside, they do not provide all the corners. We should note that stream banks and islands present obvious boundaries for the delineation of smolt trapping areas in absence of other information, and will be evaluated using aerial photography during delineation in the office to map the site extent.

The collection of waypoints associated with individual trap sites (areas) should accompany trap data in field notebooks used by research staff. This would include recording the GPS Model/Make (Magellan 320, Garmin 12XL, Garmin 450, etc), assigned Unit letter (e.g., L, M, N, etc), the waypoint number, the GPS positional error (or accuracy), and a very brief description of what the individual waypoint represents (e.g., upper most river right or lowest point on river left, etc). If only one GPS unit model (Garmin 12XL, Magellan 320, etc) is used by a crew throughout the smolt trapping season, then it will be unnecessary to record this information daily; just make sure the relevant unit information is on the first page of each field notebook used. One additional piece of information to be recorded includes species and fish numbers. If this data is generally collected concurrent with checking trap lines, then it should be recorded in field notebooks. This information will accompany trap related records associated with the trap site (area), which field crews collect each day, such as number of traps placed, number of traps checked, number of fish, number of traps pulled, etc. **An example of the data collected during smolt trapping which captures all the relevant GPS data is provided in Table 1**. Note that if sites shift, field crews should take another waypoint on the day they are shifted or moved, which depicts the extension of the trapping area (site), and code this information in their field notebooks.

If traps are placed in areas where no site name is given (especially locations where only 1 or 2 traps are placed), specific comments should include a concise description of the general location (e.g., on small tributary to main channel approximately 250 m from the main channel or in beaver pond complex on west side of main channel approximately 400 m from the main river channel).

In general, observers should *always describe features as to right or left as if they were looking downstream (e.g., confluence right bank)*—in other words, "**going with the flow**".

Table 1.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in Fall, 2003.

Date: 10/20/2003 GPS Unit Model: Magellan 320, (unit L)

Site	Traps checked	Traps pulled	Traps added	Total traps	# of fish by species	Way-point #	Waypoint Accuracy (m)	Waypoint description
Spruce Row	5	2	0	3	30 coho; 10 king	5,6	10; 10	5 – upper; 6 – lower
Moose Bar	2	0	2	4	50 coho	7,8	8, 12	7– upper; 8 – lower
Big Beaver	3	3	0	0	5 coho	9	13	Center of trap area
Snowball	0	0	3	3	New sets	10, 11	6, 9	10 – upper; 11 – lower
Total	10	5	5	10	80 coho; 10 king			

In summary, coordinate data should be recorded at all CWT trapping sites where minnow traps are deployed. As an alternative to recording GPS coordinates at each and every minnow trap being deployed, observers can define the bounds of the area being trapped (e.g., Spaghetti Flats, 6-pack slough). If a site is fairly confined or constrained (e.g. has a defined upper and lower end such as a slough) then 1–2 waypoints should be taken at the upper and lower extents of the upper portion and additional waypoints as necessary taken at the extents of the lower reach. Trapping observations recorded in 'smolt trapping data books' should include the saved waypoint number(s), and include vernacular name assigned to that particular site.

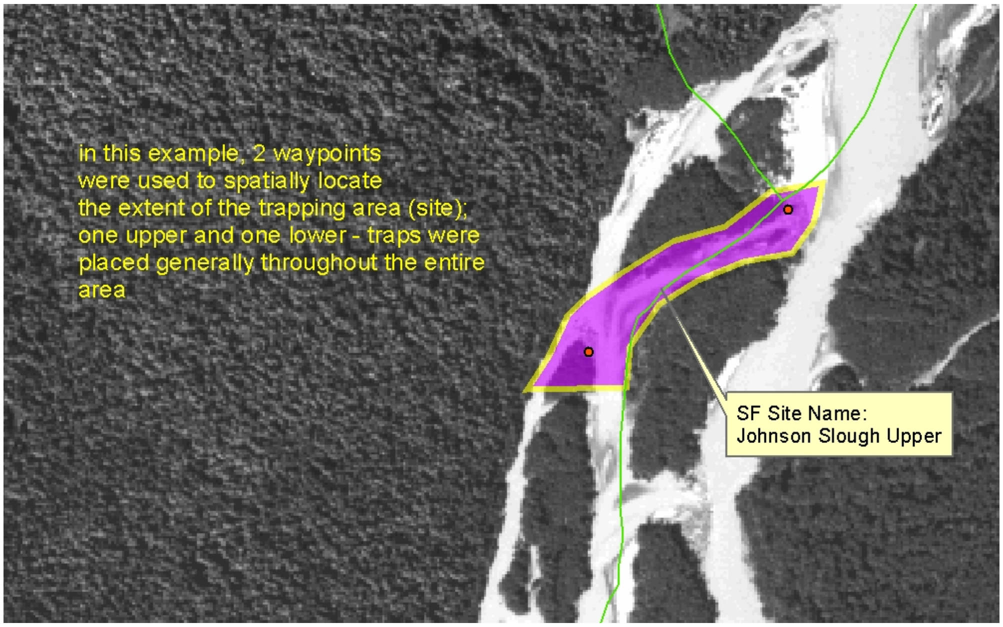

Figure 1.–Smolt trapping site on the Unuk River. The outlined polygon represents a single trapping site or area known as Johnson Slough Upper. Individual trapping sites may contain an infinite number of traps. The orange dots represent 2 waypoints collected to delineate the 'approximate' extent of trapping effort associated with this site.

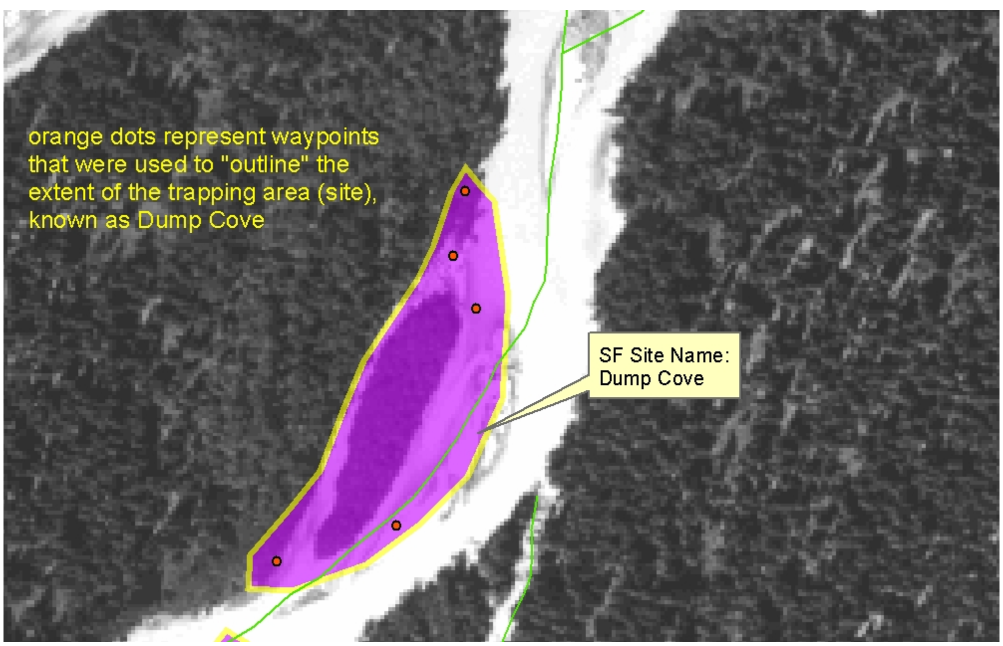

Figure 2.–Using more than two waypoints to delineate the extent of the trap site '*Dump Cove*' on the Unuk River. The upper and lower most waypoints are critical, although the 3 other points allow us to more accurately represent traps that were placed on the river left side of the island.

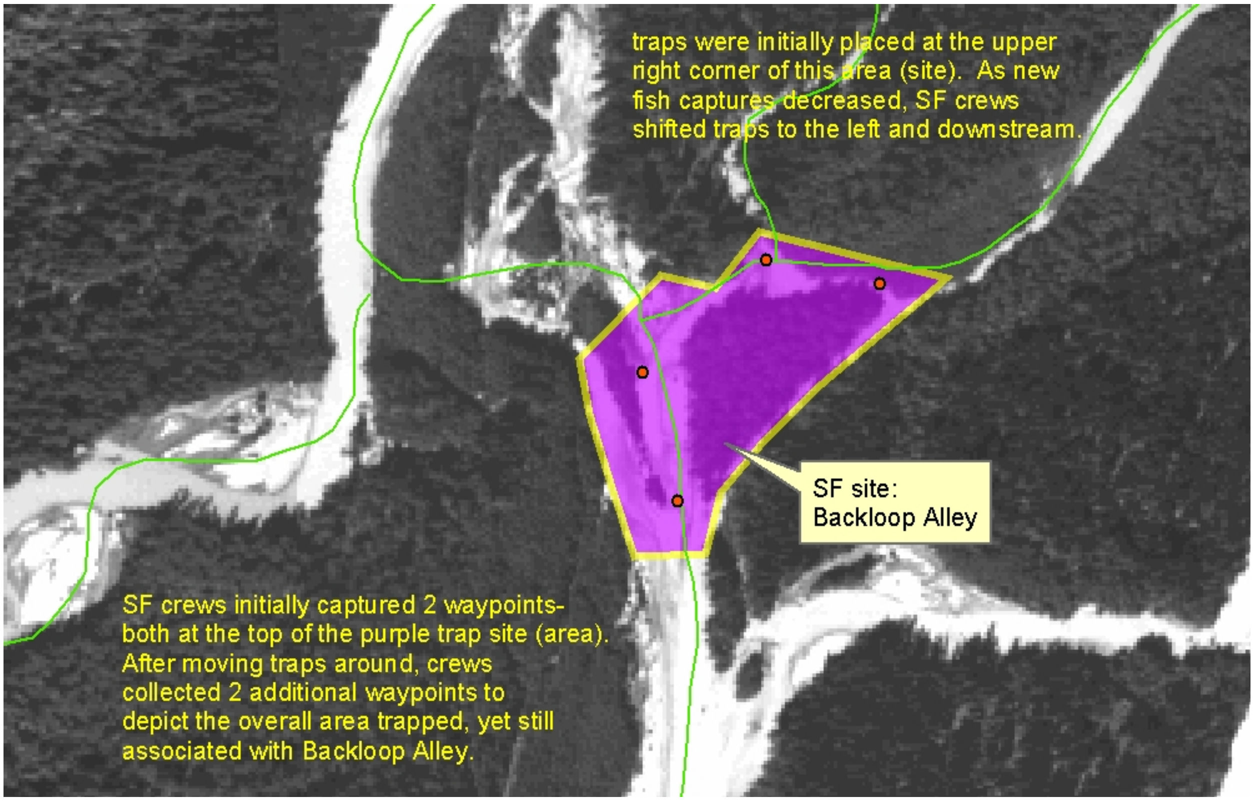

Figure 3.–Example of expanded trap site, and GPS locations used to document that site as local conditions changed due to changing trap catches, and rising and falling water conditions on the Unuk River, Alaska. Again, SF crews shifted traps in response to decreasing numbers associated with initial trap locations (upper portion of polygon). Rather than re-name the SF site, they elected to capture 2 more waypoints associated with new trap locations thereby providing 4 “corners”, where we could delineate the Backloop Alley trap site (area).