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Chilkat River Chinook Salmon Escapement Studies in 2022

by

Brian W. Elliott

March 2023

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

Symbols and Abbreviations

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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 NO. ROP.CF.1J.2023.06

CHILKAT RIVER CHINOOK SALMON ESCAPEMENT STUDIES IN 2022

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SIGNATURE/TITLE PAGE

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ABSTRACT

Chilkat River large (age-1.3 and older) Chinook salmon *Oncorhynchus tshawytscha* inriver abundance and age and sex composition will be estimated using a 2-event mark–recapture experiment in 2022. Event 1 marking is conducted in the lower Chilkat River, and event 2 recapture is conducted in principal spawning areas within the Chilkat River drainage. Data produced from this project includes estimated spawning abundance and age, sex and length compositions of the large Chinook salmon run, and when possible, estimated spawning abundance and sex and length composition of the age-1.2 Chinook salmon run in the Chilkat River drainage. The Chilkat River stock of Chinook salmon is a Pacific Salmon Commission Chinook Technical Committee exploitation rate and escapement indicator stock, and contributes toward the coastwide Chinook model used by the Pacific Salmon Commission to monitor coastwide abundance. Mark–recapture experiments of adult Chinook salmon inriver abundance have been conducted in the Chilkat River drainage since 1991 and resulting escapement estimates have had an average coefficient of variation of 16%, which contributes toward precise stock assessment production estimates for the Chilkat River Chinook stock. As part of ongoing Chilkat River Chinook salmon coded wire tag studies, all Chinook salmon encountered in the mark–recapture experiment of adult Chinook salmon inriver abundance will be examined for missing adipose fins, an indication that fish may be tagged with a coded wire tag, information that leads to estimates of juvenile production and marine harvest. These data when used in conjunction with inriver abundance allows full production estimates for the Chilkat stock.

Key words: Chilkat River, Chinook salmon, *Oncorhynchus tshawytscha,* inriver abundance, age and sex composition, mark–recapture, escapement indicator stock, Pacific Salmon Commission, coded wire tag, full production

BACKGROUND

The purpose of this study is to estimate Chilkat River Chinook salmon *Oncorhynchus tshawytscha* inriver abundance, escapement, and age and sex compositions in 2022. The Chilkat River (Figure 1) is the third or fourth largest producer of Chinook salmon in Southeast Alaska (McPherson et al. 2003). In 2003, the Alaska Department of Fish and Game (ADF&G) adopted a Chilkat River biological escapement goal (BEG) range of 1,750–3,500 large (age-1.3 and older) Chinook salmon (Ericksen and McPherson 2004). The Lynn Canal and Chilkat River King Salmon Fishery Management Plan (5 AAC 33.384) directs the ADF&G to manage fisheries to achieve an inriver run goal of 1,850 to 3,600 large (age-1.3 fish and older) Chinook salmon upstream of the event 1 capture (marking) site at milepost 9 (MP 9) of the Haines Highway. The Chilkat River stock of Chinook salmon is a Pacific Salmon Commission (PSC) Chinook Technical Committee (CTC) exploitation rate and escapement indicator stock that contributes to management of the Southeast Alaska sport fishery in accordance with the Pacific Salmon Treaty (PST) and Southeast Alaska King Salmon Management Plan (5 AAC 47.055), in addition to Southeast Alaska commercial troll and gillnet fishery management. Harvest of Chilkat Chinook salmon is part of the all-gear harvest limit in Aggregate Abundance Based Management (AABM) fisheries in Southeast Alaska as determined by the PST.

Annual abundance and age and sex composition estimates are important stock assessment components. Accurate estimates improve run forecasts and supports the sustainable harvest of the Chilkat River Chinook salmon Southeast Alaska fisheries.

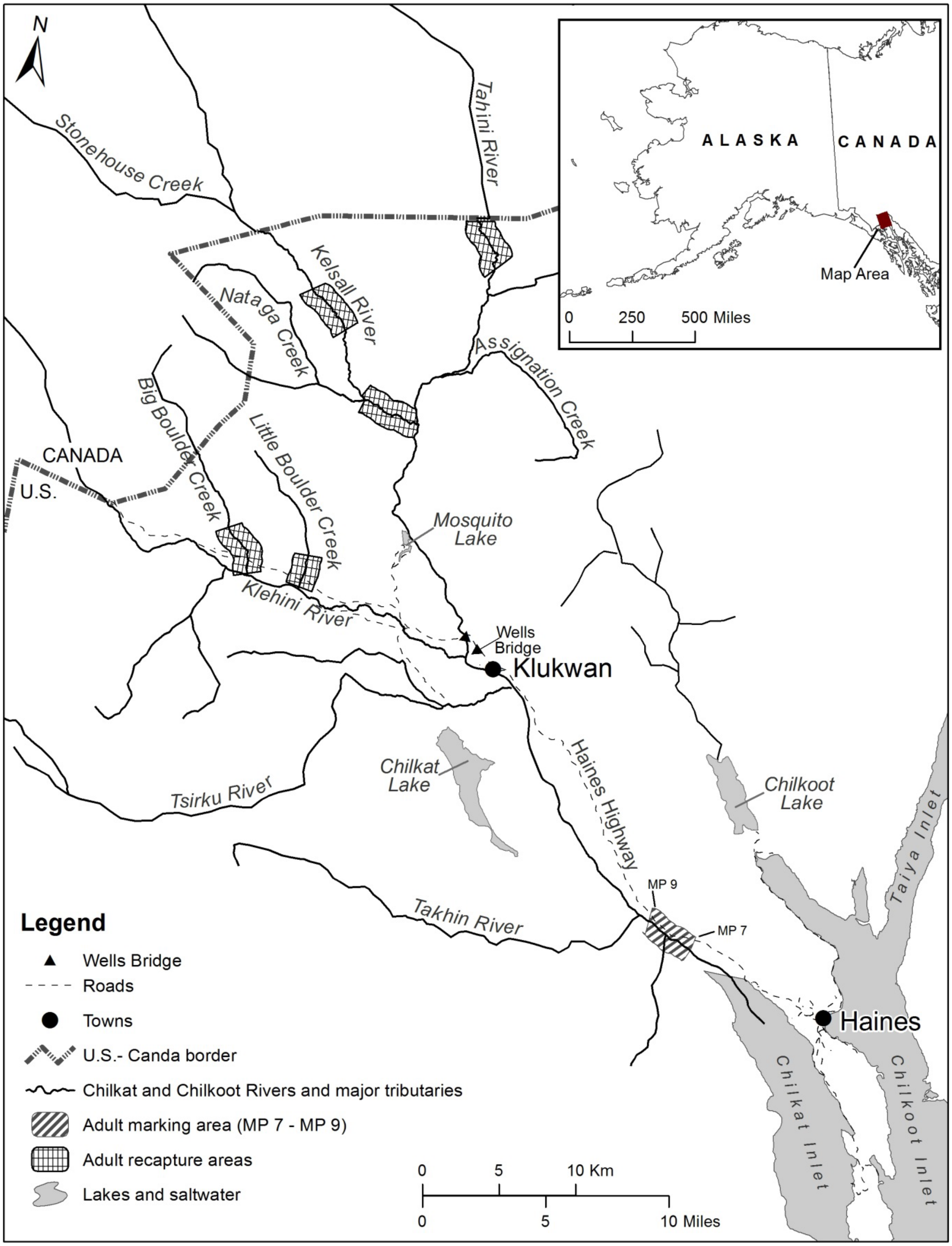

Figure 1.–The Chilkat River drainage in Southeast Alaska, showing the location of sampling sites.

The Chilkat River is one of the principal producers of Chinook salmon in Southeast Alaska (SEAK; McPherson et al. 2003) and this stock is included in the updated PSC Chinook model, which is used to forecast the Abundance Index (AI) of coastwide Chinook salmon stocks, subject to management under the PST. The AI determines the annual AABM all-gear harvest limit for Southeast Alaska, which is allocated as specified in 5 AAC 29.060 (allocation of Chinook salmon in the Southeastern-Yakutat Alaska area). Several fisheries harvest the Chilkat River stock in Southeast Alaska including commercial (marine troll, drift gillnet, and purse seine), sport (terminal marine near Haines and northern Southeast mixed stock), and subsistence (terminal marine in Chilkat Inlet and freshwater in the Chilkat River) fisheries (Table 1).

From anticipated return years 2004–2021, drift gillnet and spring troll commercial fisheries account for the highest average harvest of Chilkat Chinook salmon (30% and 17% respectively), followed by the Haines area spring sport (14%) fishery, and the northern Southeast Alaska mixed-stock sport fishery (12%, Table 1). Anticipated return year starts August 1 and continues through July 31 of the following year and is used to account for rearing fish harvested after a calendar year's spawning run has concluded (i.e., a Chilkat fish harvested in September 2000 is from anticipated return year 2001). Most of the drift gillnet commercial harvest occurs in District 115, and the spring troll commercial harvest is concentrated in a few principle areas, mostly in District 114 including Cross Sound and Icy Strait (Appendix A).

From 1975 through 1990, the Chilkat River Chinook salmon escapement was estimated through peak survey counts on clearwater tributaries to the Chilkat River (Big Boulder Creek, Stonehouse Creek) as an index of abundance (Pahlke 1992). A mark–recapture experiment, concurrent with a radiotelemetry project, was initiated in 1991 and continued in 1992, whereby returning Chinook salmon were captured in the lower river and given an external mark in addition to a radio tag, to determine spawning abundance and distribution within the Chilkat River drainage (Johnson et al. 1993). Survey counts on Big Boulder Creek and Stonehouse Creek were continued in 1991–1992 to assess viability of each estimation method. Comparisons of 1991 and 1992 mark–recapture 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).

Because the 1991–1992 mark–recapture projects were successful, inriver mark–recapture estimation has continued to present day, and includes event 1 marking in the lower Chilkat River and event 2 sampling on the spawning grounds including the Tahini, Kelsall, and Klehini river tributaries of the Chilkat River (Figure 1). From 1991 through 2021, escapement estimates ranged from 873 (SE = 546) to 8,089 (SE = 1,003) large Chinook salmon, and averaged 3,313 (SE = 472) large fish. Since 2007, returns have declined sharply and escapements have averaged 2,086 (SE = 335) large fish (Table 2).

In 2003, the ADF&G adopted an escapement goal range of 1,750–3,500 (point estimate = 2,200) large Chinook salmon for the Chilkat River drainage, and an inriver run goal range of 1,850–3,600 large Chinook salmon upstream of the adult marking area (5 AAC 33.384; Ericksen and McPherson 2004). The lower bound of the escapement goal range has been reached in 24 of the past 31 years that abundance has been estimated by mark–recapture methods.

Table 1.–Estimated harvest and standard error in parenthees as determined through coded-wire tag recovery data analysis of ≥ age-1.2 Chilkat Chinook salmon in Southeast Alaska by fishery, 2004–2021.

Anticipated Return Year[1]	Winter Troll	Spring Troll	Summer Troll	Drift Gillnet	Purse Seine	SEAK Sport	Haines Sport	Haines Subsistence
2004	0 (0)	257 (131)	36 (35)	309 (74)	0 (0)	0 (0)	269 (21)	117
2005	0 (31)	107 (43)	141 (100)	210 (77)	14 (38)	134 (58)	130 (18)	77
2006	0 (0)	138 (73)	155 (155)	63 (39)	322 (94)	171 (98)	81 (7)	96
2007	0 (0)	229 (66)	15 (15)	131 (79)	0 (0)	83 (71)	153 (22)	64
2008	16 (15)	257 (194)	229 (146)	285 (120)	0 (0)	27 (0)	5 (1)	50
2009	0 (0)	244 (74)	0 (0)	37 (27)	0 (0)	53 (12)	80 (7)	75
2010	132 (70)	128 (64)	0 (0)	394 (155)	80 (44)	172 (141)	121 (14)	85
2011	125 (92)	120 (55)	0 (0)	273 (118)	155 (117)	64 (130)	174 (13)	114
2012	117 (82)	155 (100)	0 (0)	230 (87)	43 (30)	89 (170)	153 (24)	96
2013	0 (0)	40 (30)	0 (0)	141 (59)	126 (11)	61 (67)	74 (17)	65
2014	0 (0)	0 (0)	0 (0)	535 (136)	55 (38)	112 (151)	197 (22)	79
2015	0 (0)	59 (42)	46 (45)	318 (119)	0 (0)	109 (221)	0 (0)	15
2016	36 (25)	0 (0)	0 (0)	7 (7)	12 (0)	103 (242)	0 (0)	12
2017	30 (40)	45 (33)	0 (0)	11 (11)	0 (0)	47 (125)	0 (0)	0
2018	0 (0)	0 (0)	0 (0)	69 (69)	0 (0)	43 (134)	0 (0)	0
2019	0 (0)	0 (0)	0 (0)	87 (65)	0 (0)	0 (0)	0 (0)	0
2020	0 (0)	0 (0)	10 (9)	59 (41)	0 (0)	10 (9)	0 (0)	0
2021	0 (0)	0 (0)	11 (11)	28 (7)	0 (0)	34 (33)	0 (0)	0
Average	25 (20)	99 (50)	36 (29)	177 (72)	45 (21)	73 (92)	80 (9)	52 (0)

[1] Anticipated return year (t) runs from August 1 in year (t-1) to July 31 in year t.

Table 2.–Mark–recapture data used to estimate the inriver abundance and escapement of large (≥ age-1.3) Chilkat River Chinook salmon, 1991–2021.

	Event 1		Event 2						
	GN	FW	Total[a]		Inriver	Inriver			
	M	M	C	R	abundance	harvest[b]	Escapement	SE	CV[c]
1991[d]	80	145	733	27	5,897	15	5,882	763	0.13
1992[e]	148	ND	905	23	5,284	7	5,277	778	0.15
1993[f]	159	ND	614	21	4,472	9	4,463	659	0.15
1994[g]	212	84	776	33	6,795	3	6,792	839	0.12
1995[h]	121	59	383	17	3,790	22	3,768	662	0.18
1996[i]	188	45	714	33	4,920	18	4,902	642	0.13
1997[j]	189	128	967	37	8,100	11	8,089	1,003	0.12
1998[k]	166	61	531	32	3,675	19	3,656	419	0.11
1999[l]	108	124	233	23	2,271	13	2,258	322	0.14
2000[m]	86	31	476	25	2,035	6	2,029	256	0.13
2001[n]	174	72	695	39	4,517	3	4,514	722	0.16
2002[o]	236	170	649	63	4,050	16	4,034	433	0.11
2003[p]	206	126	878	50	5,657	26	5,631	690	0.12
2004[q]	126	82	665	39	3,422	16	3,406	456	0.13
2005[r]	133	54	496	26	3,366	5	3,361	554	0.16
2006[s]	73	70	820	37	3,039	36	3,003	380	0.13
2007[t]	65	22	276	17	1,442	7	1,435	230	0.16
2008[u]	100	46	439	19	2,905	24	2,881	452	0.16
2009[v]	113	86	623	25	4,429	23	4,406	589	0.13
2010[w]	97	41	361	30	1,815	18	1,797	226	0.13
2011[x]	107	109	569	43	2,688	14	2,674	269	0.10
2012[y]	76	51	339	25	1,744	21	1,723	266	0.15
2013[y]	31	24	392	11	1,730	11	1,719	333	0.19
2014[y]	37	23	190	10	1,534	5	1,529	307	0.20
2015[y]	49	72	522	30	2,456	4	2,452	273	0.11
2016[y]	66	30	253	17	1,386	6	1,380	198	0.14
2017[y]	50	15	155	10	1,173	0	1,173	240	0.20
2018[y]	39	23	125	2	873	0	873	546	0.63
2019[y]	126	53	272	25	2,028	0	2,028	246	0.12
2020[z]	150	70	299	22	3,180	0	3,180	518	0.16
2021[z]	72	30	245	13	2,038	0	2,038	348	0.17
Average	116	67	503	27	3,313	12	3,302	472	0.16

--continued--

Table 2.–Page 2 of 2.

Note: GN = drift gillnet captures, FW = fishwheel captures, M = number marked, C = number caught and examined, and R = number of marked fish recaptured. The 2018 estimate and standard error is derived from the event 2 CPUE model (Appendix C 1).

[a] Includes Kelsall River, Tahini River, and Klehini River tributaries.

[b] Collected from returned subsistence permits

[c] Coefficient of variation (CV) = SE / Estimate.

[d] Taken from Johnson et al. (1992).

[e] Taken from Johnson et al. (1993).

[f] Taken from Ericksen (1994).

[g] Taken from Ericksen (1995).

[h] Taken from Ericksen (1996).

[i] Taken from Ericksen (1997).

[j] Taken from Ericksen (1998).

[k] Taken from Ericksen (1999).

[l] Taken from Ericksen (2000).

[m] Taken from Ericksen (2001).

[n] Taken from Ericksen (2002).

[o] Taken from Ericksen (2003).

[p] Taken from Ericksen (2004).

[q] Taken from Ericksen (2005).

[r] Taken from Ericksen and Chapell (2006)

[s] Taken from Chapell (2009).

[t] Taken from Chapell (2010).

[u] Taken from Chapell (2012).

[v] Taken from Chapell (2013a).

[w] Taken from Chapell *(*2013b).

[x] Taken from Chapell (2014).

[y] Taken from Elliott *(In prep* a).

[z] Taken from Elliott (*In prep* b).

Harvest of Chilkat Chinook salmon in SEAK mixed stock fisheries is estimated through expansion of coded-wire tags following the methods of Bernard and Clark (1996). A coded wire tag (CWT) program was initiated for Chilkat River Chinook salmon in spring of 2000 starting with brood year (BY) 1998, and has been conducted annually since. The ADF&G has an annual goal to sample 20% of harvests in SEAK commercial troll and net fisheries, and in mixed stock sport fisheries in various ports. This sampling rate, combined with adequate marking rates of Chilkat Chinook, produces precise estimates of harvest and contributes toward estimates of total return for the Chilkat stock. Sport fishery harvests from the Haines marine boat fishery are estimated through a creel survey which has been conducted since 1984, however there has been no Chilkat Inlet sport fishery from 2015–2021. Harvest from the Chilkat Inlet and Chilkat River subsistence fishery is gathered from returned subsistence permits (Table 1).

Harvests of Chilkat Chinook salmon in the Haines spring marine boat fishery have fluctuated over the past 30 years. From 1984–1988, an average of 1,196 Chinook salmon were harvested in the Haines area marine spring sport fishery. In 1989–2014, excluding the Chilkat Inlet closure years 1991, 1992, 2008, and 2015–2020, the Haines area spring sport fishery harvested an average of 255 Chinook salmon. The high harvests in 1984–1988 were a result of high effort (average 23,708 hours) and high catch per unit effort (CPUE, average 0.061) resulting from above average terminal run sizes of Chilkat Chinook salmon (Table 3). Since 1987, at least the northern portion of Chilkat

Inlet has been closed for some period of time to protect immigrating Chinook salmon milling at the mouth of the Chilkat River, as detailed in Ericksen and McPherson (2004).

The Chilkat River stock is one of six PSC Chinook salmon escapement indicator stocks in Southeast Alaska (Treaty, 2019) and is included in annual assessments by the PSC CTC. The CTC determines stock status, which is used by the PSC to determine compliance with the PST. The PST is renewed every 10 years and the 2019 agreement calls for continuation of abundance-based management of Chinook salmon coastwide, and for improved stock assessment, escapement goals, and modeling. The 2019 agreement also incorporates the completed Phase 2 Chinook Model, which includes the Chilkat Chinook salmon stock. To that end, the estimation methods for escapement, harvest, and run forecasting for Chilkat Chinook salmon are continually being improved to be in compliance with Treaty obligations. A CWT program produces smolt abundance estimates, and also produces marine harvest estimates from marine mixed stock fisheries, which are important components of production. Preseason forecasts primarily using sibling-based models have also been developed. Data from the Chilkat River escapement estimation project is important for management of this stock and all other stocks in Southeast Alaska.

OBJECTIVES

PRIMARY OBJECTIVES

1. Estimate the inriver abundance of large (age-1.3 fish and older) Chinook salmon in the Chilkat River upstream of the ADF&G's tagging site at Haines Highway MP 9 such that the estimate is within 40% of the true value 90% of the time. This will result in an estimate with a CV of 24%.
2. Estimate the age and sex composition of the inriver run of large (age-1.3 fish and older) Chinook salmon in the Chilkat River such that the estimates are within 20% of the true value 90% of the time. This will result in estimates with a CV of 6%.

SECONDARY OBJECTIVES

1. Sample all adult Chinook salmon captured during this experiment for adipose fin clips as part of the CWT program wire tag sampling protocal.
2. Estimate the inriver abundance of age-1.2 Chinook salmon in the Chilkat River.
3. Estimate the length composition of the inriver run of Chinook Salmon in the Chilkat River.

Table 3.–Estimated angler effort, catch, harvest, and CPUE of large Chinook salmon in the Haines marine boat sport fishery for comparable sample periods, 1984–2021.

		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
2013[ac]	5/06-6/23	7,097	599	7,041	596	129	28	123	28	0.018
2014[ac]	5/05-6/22	6,798	363	6,737	360	230	31	228	30	0.034
2015[ac]	5/11-6/28	671	127	612	123	2	2	2	2	0.003
2016–2021[ad]	no survey									
1984–1988 average		25,710		23,708		1,207		1,196		0.061
1989–1990, 1993–2007, 2009–2015 average		8,288	730	8,267	714	255	37	243	34	0.031

--continued—

Table 3.–Page 2 of 2.

Note: The sport fishery was closed in Chilkat Inlet in 1991, 1992, 2008, and 2015–2021.

Note: Large Chinook salmon in sport fisheries is defined as the legal limit of 28” or greater in length.

Note: There were no surveys in 2016–2020.

[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. (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 (2001).

[r] From Ericksen (2002).

[s] From Ericksen (2003).

[t] From Ericksen (2004).

[u] From Ericksen (2005).

[v] From Ericksen and Chapell (2006).

[w] From Chapell (2009).

[x] From Chapell (2010).

[y] From Chapell (2012).

[z] From Chapell (2013a).

[aa] From Chapell (2013b).

[ab] From Chapell (2014).

[ac] From Elliott (*In prep* a).

[ad] From Elliott (*In prep* b).

METHODS

STUDY DESIGN

The abundance of large (age-1.3 and older) and age-1.2 Chinook salmon entering the Chilkat River will be estimated using two-event mark–recapture experiments for a closed population (Seber 1982). Adult Chinook salmon will be captured and marked in event 1 in the lower Chilkat River between June 10 and July 25 in 2022. Adult Chinook salmon will be captured and inspected for marks in event 2 from August 1 through approximately September 4 in the three principal spawning areas in the Chilkat drainage: Kelsall River, Tahini River, and Klehini River tributaries (Big Boulder Creek, Little Boulder Creek, and 37-Mile Creek, Primary Objective 1). Age and sex compositions (Primary Objective 2) and length composition (Secondary Objective 3) will be estimated from the event 1 and event 2 samples.

Inriver Abundance and Age and Sex Composition (Primary Objectives 1, 2)

Event 1, Lower Chilkat River

A drift gillnet 70 ft. (21.3 m) long and 10 ft. (3.0 m) deep will be used to capture adult Chinook salmon immigrating to the Chilkat River from June 10 to July 25 in 2022. Ninety-eight percent of Chinook salmon captures in 1991–2021 occured from June 12 to July 21 (Figure 2). The net will consist of 7 $^1/_2$ in (191 mm) mesh. The crew will perform minor net repairs as required. In the event of a major tear, another net of the same dimensions will be deployed, and the damaged net will be taken to a professional net mender for repair at the end of the day. There will be a minimum of 3 nets on hand for fishing. ADF&G will also operate two 3-basket fish wheels in the lower river during this same time period. The two types of event 1 capture gear will be fished in a consistent manner throughout the migration in an attempt to tag salmon in proportion to their abundance as they enter the lower Chilkat River.

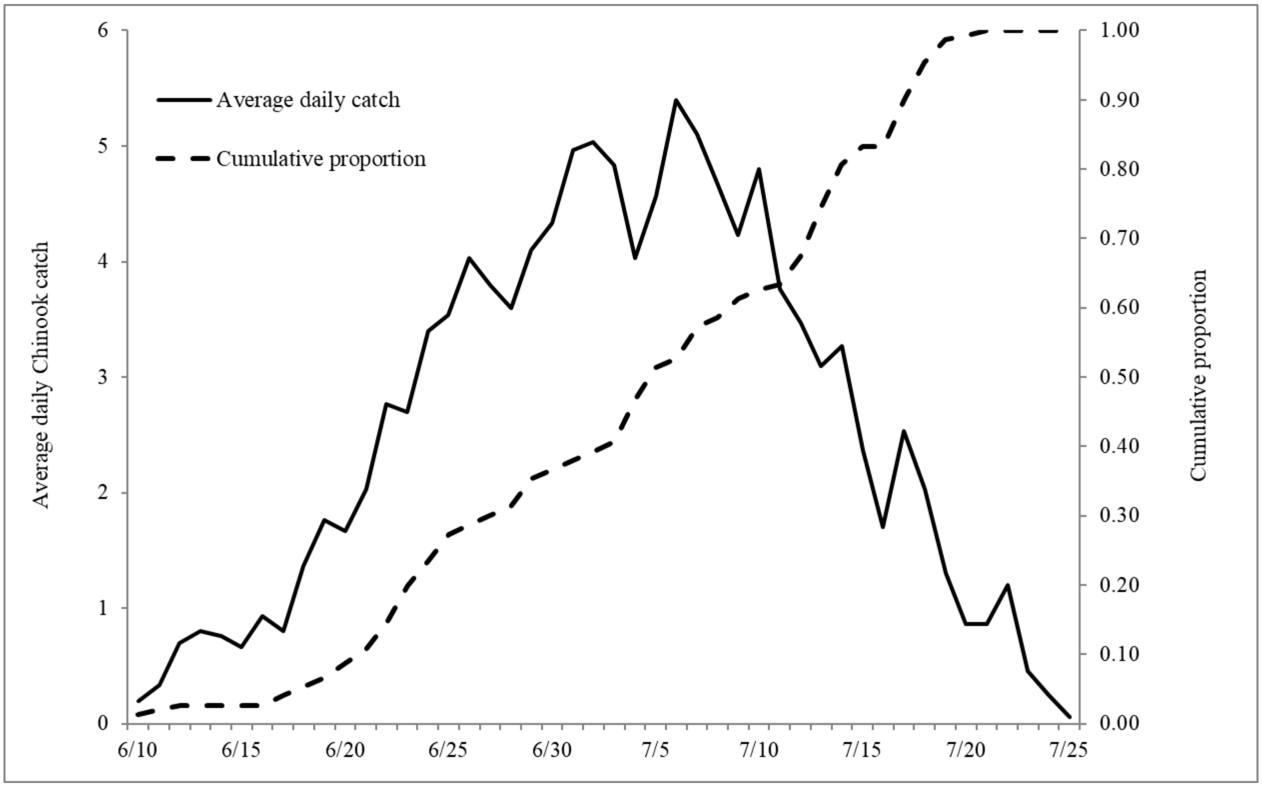

Figure 2.–Average daily catches and cumulative proportions of large Chinook salmon captured in the drift gillnet project operated on the Chilkat River between MP 7 and MP 9 on the Haines Highway, 1991–2021.

A crew of at least two people will operate a skiff during drift gillnet capture and tagging. Six 0.25 mi (400 m) long areas of the Chilkat River between Haines Highway MP 7 and MP 9 will be fished and each section will be defined as a "drift area" (Figure 3). The CPUE of Chinook salmon in the drift gillnet is generally higher earlier in the day (Figure 4), so the equivalent of 43 drift areas, or 6 hours of fishing time, whichever is greater, will be fished earlier each day starting at approximately 6:30 am. When a drift is interrupted to bring captured fish aboard, the drift will resume from the area of capture after the sampling procedure is complete. If the daily goal is not achieved, the remainder of time or area will be completed the following day. If 43 drift areas are completed in less than 6 hours, additional drift areas will be fished to achieve 6 hours with the net deployed. The tagging crew will be responsible for keeping the number of drifts completed in each of the six areas as even as possible each day.

Care will be taken not to injure Chinook salmon during capture and sampling. Fish will be retrieved immediately after capture in the net by lifting the webbing, while supporting the weight of the fish, into an onboard tagging tank that contains fresh river water. The fish will then be immediately and carefully untangled or cut from the net.

The Chilkat River fish wheels are checked twice daily, usually around 9 am and 3 pm; during these periods the fish wheel holding pens are emptied, and captured Chinook salmon are sampled identically as in the drift gillnet protocol.

Every Chinook salmon captured by the Chilkat River fish wheels or drift gillnet will be measured to the nearest 5 mm mid-eye to fork (METF) length, examined externally to determine sex, sampled for scales as described in the Data Collection section, and inspected for adipose fin status (present or absent). All Chinook salmon in good health and not sacrificed for CWT head collection (see criteria below) will receive a uniquely numbered external tag and a one quarter inch (7 mm) diameter hole punched along the upper (dorsal) edge of the left operculum (ULOP). External tags will be a solid-core spaghetti tag for fish ≥ 440 mm METF, and a t-bar anchor tag for fish < 440 mm METF. All external tags will be gray to reduce visibility in occluded glacial water. Lower visibility will reduce the potential for spawning ground samplers to target tagged fish. Chinook salmon tagged by the drift gillnet crew will be given a tertiary mark by clipping off a portion of the left axillary process (LAP), which is located at the base of the left pelvic fin. This tertiary mark will allow us to detect differences in tag loss between gillnets and fish wheels. Fish with deep scars or lesions, damaged gill filaments, or in lethargic condition (presumably a result of capture and/or handling) will be sampled for length, sex, scales, and adipose fin status, given a lower left operculum punch (LLOP) to prevent double sampling, then released without a tag.

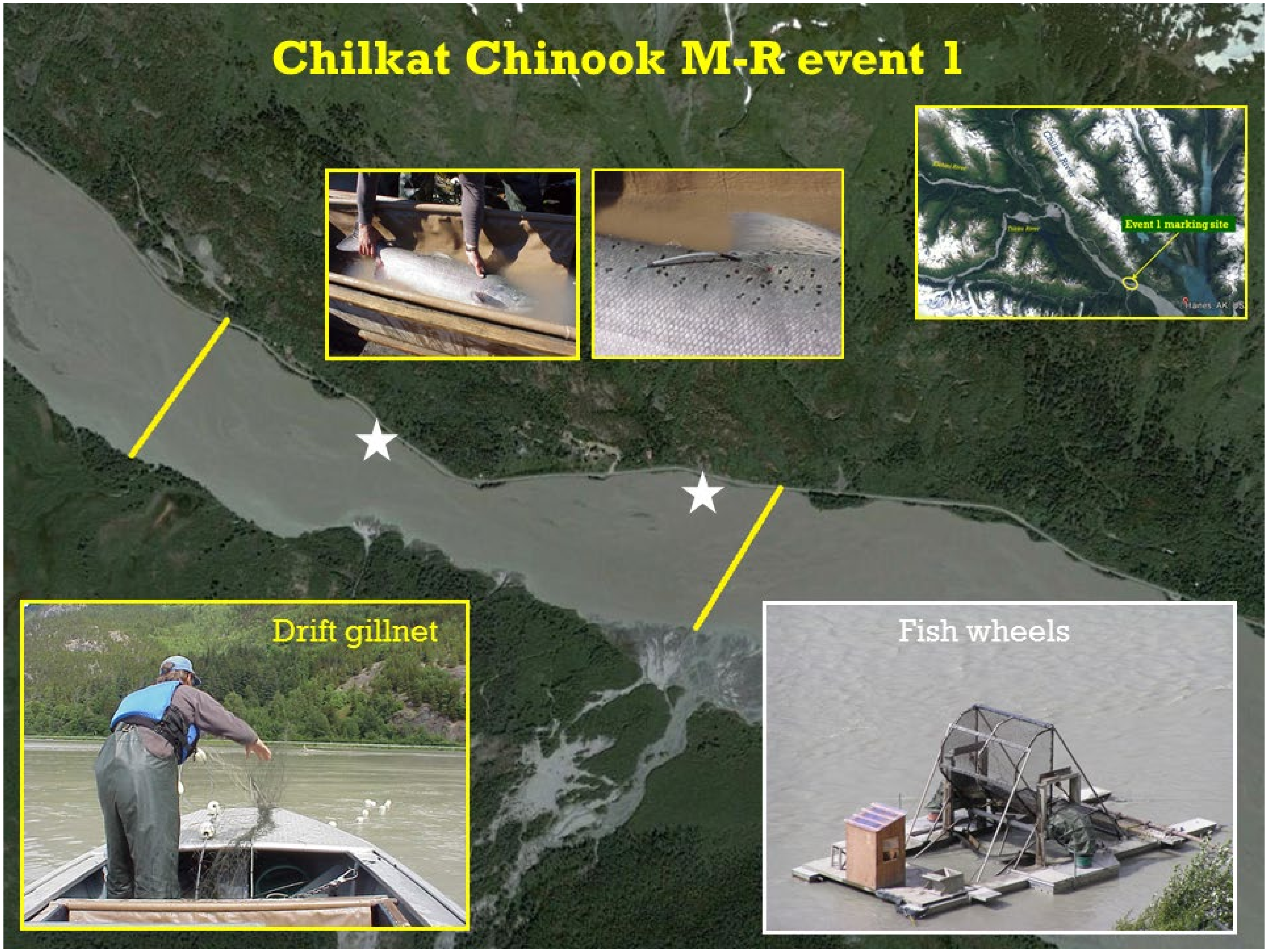

Figure 3.–Drift gillnet areas and fish wheel locations in the lower Chilkat River, Southeast Alaska.

Note: Approximate fish wheel locations are denoted by the star icon.

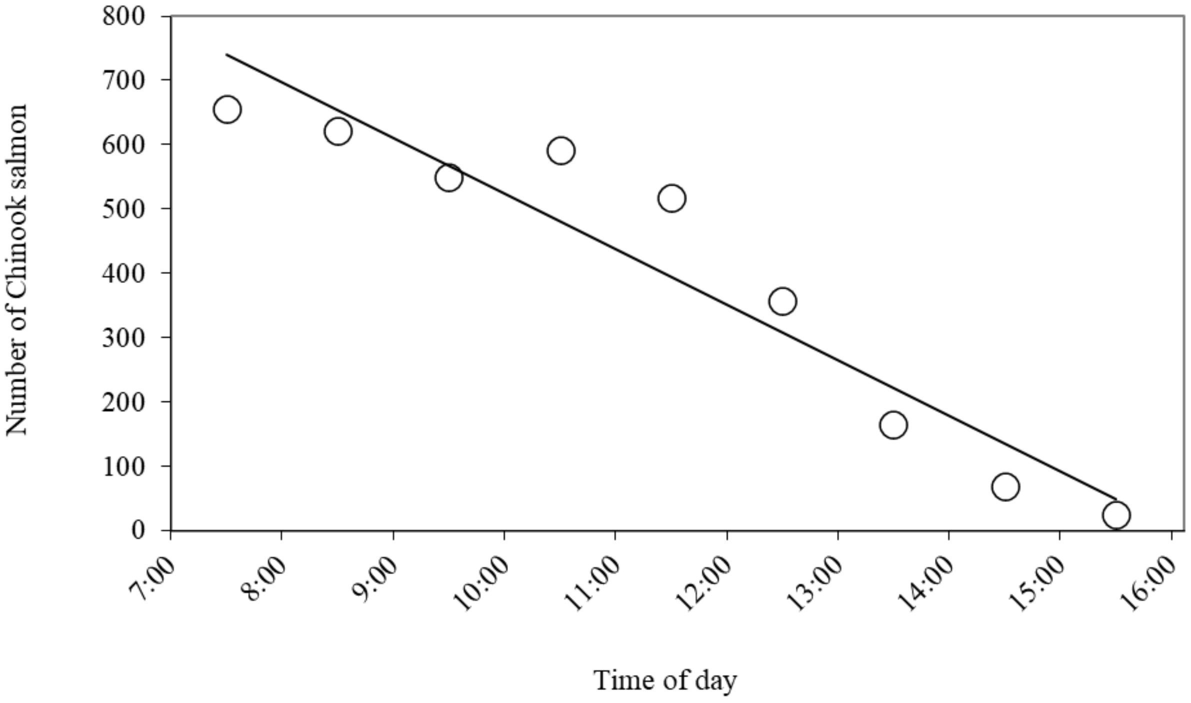

Figure 4.–Total number of Chinook salmon tagged in the lower Chilkat River drift gillnets by hour of day, 1992–2021, denoted by military (24-hour) time.

The estimated fraction of the run, by age, that possess CWTs are an essential component in the expansion of CWTs recovered from mixed stock commercial fisheries. A portable CWT detector will be used at the tagging sites to check all adipose fin-clipped Chinook salmon for presence of a CWT. All adipose fin-clipped Chinook salmon < 440 mm METF will be sacrificed for CWT recovery. The length threshold of 440 mm METF is used because historical length at age data indicates this length typically defines the break between 1-ocean and 2-ocean and older fish. Female Chinook salmon are typically ocean-age-3 fish and older; however, in recent years more females have been seen in the 2-ocean component. Chilkat River Chinook that are ≥ age-1.2 are not sacrificed until they are in post-spawning condition during event 2 sampling. Adipose fin-clipped fish ≥ 440 mm METF that test positive for a CWT will be tagged and released. Adipose fin-clipped fish ≥ 440 mm METF that test negative for a CWT will be sacrificed to verify tag loss. A numbered cinch strap will be attached around the jaw of the head of all sacrificed fish. Heads will be stored in a designated freezer and shipped to the Mark, Tag and Age Laboratory in Juneau for CWT recovery and decoding.

Event 2, Spawning Grounds

The event 2 spawning grounds sampling strives to accomplish several objectives simultaneously. This includes examining captured Chinook salmon for primary, secondary and tertiary marks applied during event 1 from the lower Chilkat River (Primary Objective 1); sampling Chinook salmon as possible for age and sex (Primary Objective 2); sampling Chinook salmon as possible for length (Secondary Objective 3); and examining Chinook salmon for missing adipose fins and collecting heads from fish with missing adipose fins with the same criteria as used during event 1 (Secondary Objective 1). Field teams will strive to capture and examine as many Chinook salmon as possible while leaving fish unharmed.

Snagging gear, dip nets, short tangle nets, and beach seines will be used to collect live adults, and carcass retrieval will be by hand or a spear. Attempts will be made to capture all fish encountered equally; samplers do not select fish based on size, sex, or tag status. Spaghetti tags will not be removed from live fish to avoid ambiguity upon potential recapture; however, spaghetti tags will be removed from carcasses, and the side of the carcass will be slashed multiple times on the preferred side after sampling so sampled carcasses can be identifiable at a distance.

A crew of 2 people will sample fish for marks on the Tahini River spawning grounds, where 33%, 20%, and 33% of Chinook salmon spawning occurred in radio-telemetry study years 1991, 1992, and 2005, respectively (Johnson et al. 1992, 1993; Ericksen and Chapell 2006). On average during 1994–2021, 97% of Chinook salmon samples were collected between August 1 and August 31 (Figure 5). Areas of Chinook salmon abundance will be accessed primarily on foot or by boat. Sampling on the Tahini River spawning grounds may be discontinued earlier if the number of available samples dwindles (i.e., 1 to 2 fish sampled per day for several days) and the spawning event is complete.

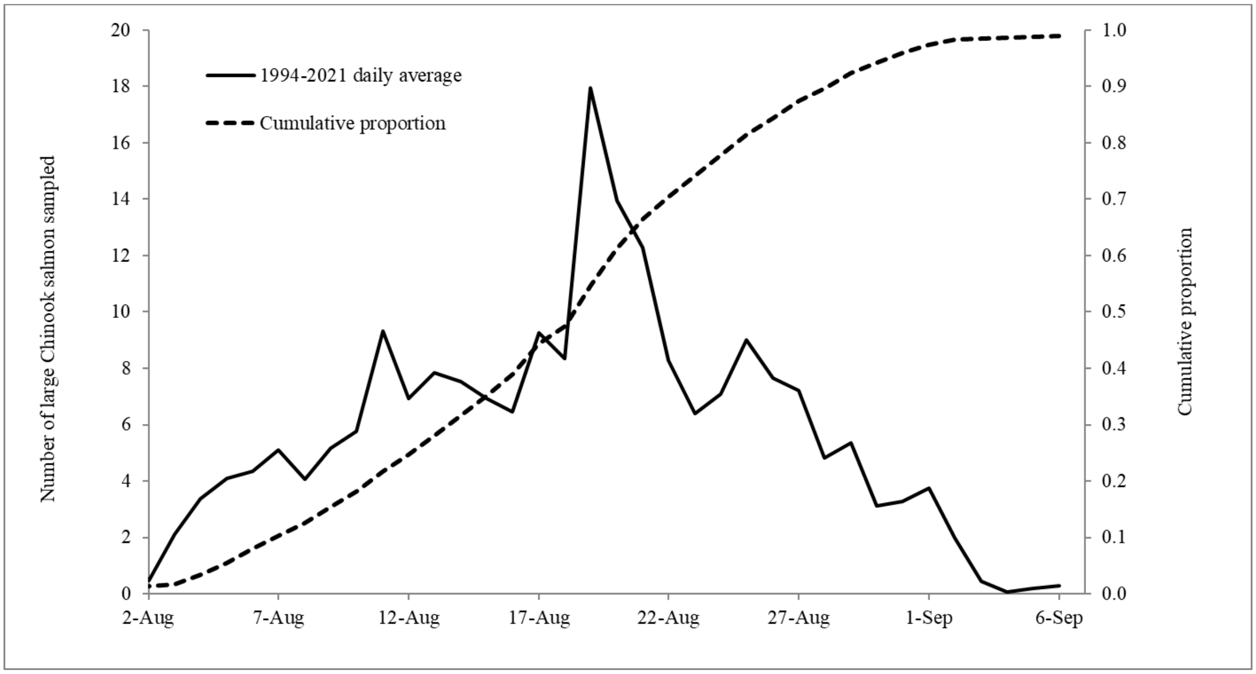

Figure 5.–Mean number sampled and cumulative proportion of large Chinook salmon captured per day in the Tahini River drainage, 1994–2021.

A crew of two people will sample fish for marks in the Kelsall River drainage, where 54%, 73%, and 53% of Chinook salmon spawning occurred in 1991, 1992, and 2005, respectively (Johnson et al. 1992, 1993; Ericksen and Chapell 2006). On average between August 1 and September 2, 97%

of Chinook salmon were sampled in 1994–2021 (Figure 6). The 2005 radio-tagging study found that the 62 radio-tagged fish that spawned in the Kelsall drainage were distributed as follows: 23% below the Kelsall River bridge, 29% upstream of the bridge but downstream of the upper canyon, 38% in the upper canyon, and 10% in Stonehouse Creek. Many radio-tagged fish returned downstream after spawning, some as carcasses, so by August 22 the majority (61%) of all Kelsall spawners were downstream of the bridge and in sampling areas A, B and C (Appendix B1). Most (71%) of the upper canyon spawners did not wash down below the Kelsall River bridge (Ericksen and Chapell 2006). The upper Kelsall River canyon area, designated as area D, will be sampled frequently to access the large spawning component and the post-spawners that do not wash down to the lower Kelsall River areas. Areas of Chinook salmon abundance will be accessed on foot.

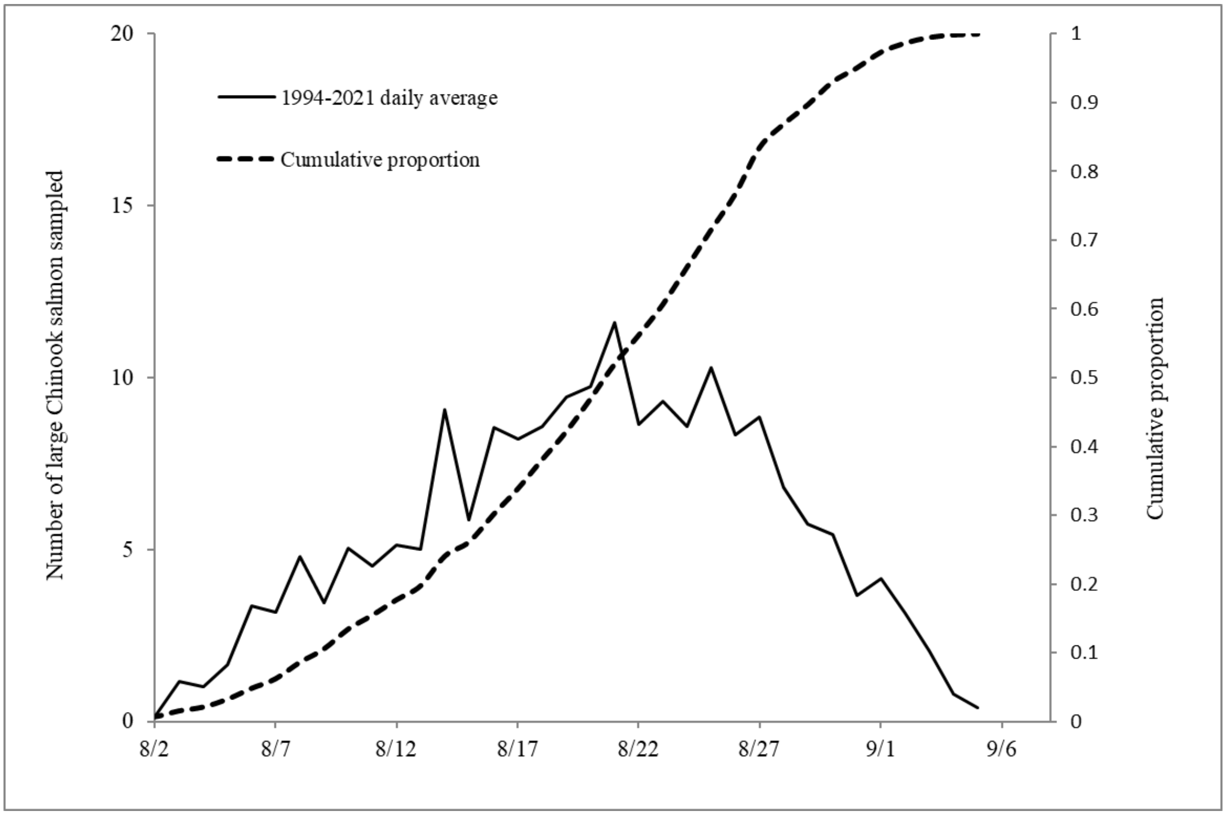

Figure 6.–Mean number sampled and cumulative proportion of large Chinook salmon captured per day in the Kelsall River drainage, Southeast Alaska, 1994–2021.

A crew of 2 people will sample fish for marks in Klehini River tributaries every 4–5 days in August, where 4%, 5%, and 15% of Chinook salmon spawning occurred in 1991, 1992, and 2005, respectively (Johnson et al. 1992, 1993; Ericksen and Chapell 2006). Big Boulder Creek has historically been the primary Klehini River spawning tributary, but in recent years Little Boulder Creek has contained as many or more spawners. Sampling at the confluence of 37-Mile Creek and the Klehini River will also occur during the peak of spawning. Areas of Chinook salmon abundance will be accessed on foot.

Chinook salmon captured on the spawning grounds will immediately be removed from the sampling gear. If a fish has not been previously sampled on the spawning grounds, as indicated by the presence of a LLOP, it will be examined for spaghetti or T-bar anchor tags, presence/absence of an adipose fin, and an ULOP. In addition, it will be sampled for sex, length (METF), and scales as described in the Data Collection section whenever possible. After sampling, all fish, including carcasses, will be given a ¼ in (7 mm) diameter LLOP. If a fish is marked with a ULOP but no spaghetti tag is present, the fish will be examined for a LAP clip to identify where tag loss is occurring in the lower river gear. When sampling in the Kelsall River drainage, the sampling area as listed in Appendix B1 will be recorded.

Spawning ground sampling crews will use a portable wand CWT detector to scan all adipose-finclipped fish for the presence of a CWT. Heads will be collected from all adipose-finclipped fish < 440 mm METF and all spawned-out and dead adipose-finclipped fish regardless of length. Heads are not collected from large fish in pre-spawning condition. Collected heads will be marked with a numbered cinch strap around the jaw. Heads collected will be preserved in field camp and frozen when delivered to the ADF&G office in Haines. The heads will then be shipped to the Mark, Tag, and Age Laboratory in Juneau for CWT extraction and reading.

Results of annual experiments to estimate abundance on the Chilkat River (1994–2000) and a meta-analysis using those data (Ericksen 2001) were unable to detect significant ($\alpha = 0.1$) differences in the fractions of fish captured in the Tahini and Kelsall rivers that were marked in the lower Chilkat River. However, we continue to sample Chinook salmon at 3 locations (Kelsall River, Tahini River and Klehini River tributaries) to increase sample sizes, minimize bias that would result from any small annual differences in the marked fractions by recovery area, and to allow testing of the assumption of equal marked:unmarked ratios among recovery strata.

Sample Size-Inriver Abundance

The total run forecast for 2022 is based on 2020 and 2021 returns of fish from the same brood year: previous returns from a given brood year has proven to be a good indicator of overall strength of an age class and early life-stage survival (Bernard and Jones 2014). For return year 2022, the estimated abundance of age-1.2 fish from brood year 2017 (BY2017) is used to forecast the number of age-1.3 fish; the estimated abundance of age-1.2 fish that returned in 2020 and age-1.3 fish that returned in 2021 (BY2016) are used to forecast the number of age-1.4 fish. There have been no observed age-1.5 fish since 2011; that age is commensurately excluded from run projections. Using this method, the 2022 total run forecast is 1,550 large Chilkat Chinook salmon, comprised of 1,200 age-1.3 fish from BY2017 and 350 age-1.4 fish from BY2016. Applying recent harvest rates by age in non-terminal areas, the inriver abundance forecast is 1,506 large Chinook salmon, comprised of 1,156 age-1.3 fish from BY2017 and 350 age-1.4 fish from BY2016.

Table 4.–Forecasted 2021 inriver run and event 1 catch of large Chinook salmon in the lower Chilkat River sampling gear by age and gear type in Southeast Alaska.

Brood year	2017	2016	
Age	1.3	1.4	Total
Inriver run[a]	1,156	350	1,506
Drift gillnet			
q_{age}[b]	0.036	0.038	
Catch	42	13	55
Fish wheels			
q_{age}[c]	0.026	0.022	
Catch	30	8	37

[a] Predicted total return and inriver run of Chilkat River Chinook is based upon a regression of sibling returns (e.g., the return of age-1.4 fish in year *t* is forecasted from the return of age-1.3 fish in year *t*-1 and the return of age-1.2 fish in year *t*-2; the return of age-1.3 fish is forecasted from the return of age-1.2 fish in year *t*-1).

[b] Average catchability-at-age in the lower river drift gillnet from 1991 to 2021 data.

[c] Average catchability-at-age in the fish wheels from 1991 to 2021 data.

Expected numbers of fish captured in event 1 utilize historical data including catchability-at-age and by gear (Table 4). Assuming average catchability-at-age (q_{age}), we expect to capture 55 large Chinook salmon in the lower river gillnet and 37 fish in the fish wheels, for a total of 92 marked fish. Expected numbers of fish captured in event 2 also utilize historical data including catchability-at-age and by area (Table 5). Based on historical sampling data, we expect to sample 99 large Chinook salmon for marks in the Kelsall River drainage, 125 fish on the Tahini River, and 38 fish in Klehini River tributaries including Big Boulder Creek, for a total of 263 large Chinook salmon (Table 5). Applying the 2000–2020 average drainage wide marked fraction of 0.059, we expect (R) 16 marks will be recovered (Table 6). The expected mark–recapture parameters would produce an abundance estimate of 1,441 (SE = 297) large Chinook salmon with a CV of 21%. According to the procedures of Robson and Regier (1964), for a population of 1,506 fish, of which 92 fish are marked during event 1, the number of animals that need to be inspected to meet the precision criteria in Objective 1 during event 2 is 259 fish. Provided that we anticipe inspecting 263 large Chinook salmon during event 2 in 2022, we expect to meet the precision criteria in objective 1.

The sampling design during event 1 and event 2 has been consistent for most of the 31-year span (1991–2021) of this project. Variations in event 1 effort include the Chilkat River fish wheels not operating in 1992 and 1993 (Table 2). Variations in event 2 effort include gillnets used at the Tahini River mouth in 1991–1993, and Kelsall River sampling effort was reduced from 7d/week in 1991–2008 to 5 d/week in 2009–2021. The Kelsall River effort was scaled back to reduce the stress of multiple live captures of the few Chinook salmon present in low abundance years. Kelsall River sampling effort will remain at 5 d/week until the number of unique fish encountered returns to historic levels, e.g., ≥ 300 fish per season.

Table 5.–Forecasted 2022 captures of large Chinook salmon by age and spawning area in three Chilkat River tributaries, Southeast Alaska.

Brood year	2017	2016	
Age	1.3	1.4	Total
Inriver run	1,156	350	1,506
Kelsall River			
q_{large}[a]			0.066
Catch	76	23	99
Tahini River			
q_{large}[a]			0.083
Catch	96	29	125
Klehini River			
q_{large}[a]			0.025
Catch	29	9	38

[a] Average proportion of large Chinook salmon escapement sampled by spawning area, from 2000–2021 data.

Table 6.–Forecasted 2022 mark–recapture parameters and abundance estimate of large Chinook salmon escaping to the Chilkat River drainage, Southeast Alaska.

Note: The estimate of R is based on average marked fraction on the spawning grounds.

≥ Age-1.3 Peterson estimator	
M[a] =	92
C[b] =	263
R[c] =	16
	Pooled
N^ =	1,441
Var(N) =	88,376
SE(N) =	297
CV =	0.21

[a] Estimate of number of tags (M) from average catchability-at-age of lower river drift gillnet and fish wheels, 2000–2021.

[b] Estimate of spawning ground captures (C) from average sampling rate of large Chinook salmon, 2000–2020. Spawning ground sampling was not consistent prior to 2000.

[c] Estimate of number of recoveries (R) based on 2000–2021 average marked fraction $\theta = 0.059$.

The target precision criterion of a CV of 24% in Objective 1 has been met in most previous experiments and has ranged from 10% to 21% (Table 2). The only exception to meeting the Objective 1 criterion was in 2018 when mark–recapture results were spurious due to low tag recoveries (4 tags recovered during event 2) and the alternate event 2 CPUE model was used to estimate abundance (Appendix C1). Failing to meet the precision goal is a function of low abundance (reducing the number of recovered marks) and poor sampling conditions (reducing the ability to capture fish). In 2008, the number of marks recovered was very low. In 2013, the marked fraction (0.028) was the lowest since 1992. Despite sampling a high proportion (24%) of the estimated escapement in event 2, the low marked fraction resulted in the second-lowest number (11) of marks recovered during event 2 for this project. During event 1 and event 2 in 2014, the Haines area experienced abnormally large precipitation and flood conditions persisted in July and August, severely reducing capture and sampling efforts. Despite record low abundance in 2016–2017, the CV precision goal was met as sampling conditions were favorable and an above average marked fraction (0.066) and percentage of the escapement sampled (21.0%) was adequate to meet the precision goal.Similar to prior years, we will make every effort to meet or exceed the required number of large Chinook salmon inspections in event 2 needed in ordered to meet Primary Objective 1.

Sample Size-Age and Sex Composition

Assuming no sex or size selectivity (see Data Analysis), 119 large fish (95/0.80) need to be collected to meet the objective criteria for estimating age composition according to the methods of Thompson (1987), based on an inriver run of 1,506 large Chinook salmon and being unable to read 20% of scales. Again assuming no sex or size selectivity, 65 large fish must be collected to meet objective criteria for estimating sex composition according to the methods of Thompson (2002), based on an inriver run of 1,506 large Chinook salmon. Because we expect to sample 92 large fish in the lower river and 263 large fish on the spawning grounds, we antipciate meeting the objective criteria for Primary Objective 2.

Coded Wire Tag Study (Secondary Objective 1)

All adult Chinook salmon encountered in events 1 and 2 will be examined for missing adipose fins and scales will be collected for age determination. Age determination will allow for assignment of each sampled fish to the correct brood year. All adipose fin-clipped fish will be scanned for presence of a CWT. Heads will be collected from adipose fin-clipped fish that are < 440 mm METF length and from fish ≥ 440 mm METF that are in post-spawning condition. For each brood year, the number of fish examined, the number with missing adipose fins, the CWT wand scan results, the number of heads taken, and the number of CWTs recovered will be compiled.

Adipose fin clip data during event 1 is collected for each brood year as fish return to the Chilkat River, starting with age-1.1 fish from brood year 2019. Sampling data from each successive age class (e.g., age-1.2, age-1.3, and age-1.4) from the same brood year is added to the previous data for a complete adipose fin clip percentage estimate. In addition, we will sample fish on the spawning grounds during event 2 for adipose fin clips and presence of CWTs. For each brood year, if coded wire tagged fractions are not significantly different between events 1 and 2, we will pool the samples to increase sample sizes. Adipose fin clip sampling during event 2 is conducted similar to event 1; each captured fish is inspected for adipose fin clips and age information is also collected to assign each sampled fish to the appropriate brood year. Sampling also is conducted over the typical 4-year time span of the return at age for each brood year, including age-1.1 fish through age-1.4 fish. See the Regional Operational Plan *Production and harvest of Chilkat River Chinook and Coho Salmon, 2019-2020* (Elliott and Peterson 2018) for further details and sample size objectives.

Abundance of Age-1.2 Fish (Secondary Objective 2)

The study design for age-1.2 fish will be the same as described previously for the age-1.3 and older fish.

Length Composition (Secondary Objective 3)

The study design for length composition is described in the Study Design/Inriver Abundance section and will take place during event 1 and 2 of the mark–recapture experiment.

DATA COLLECTION

INRIVER ABUNDANCE (PRIMARY OBJECTIVE 1)

Event 1, Lower Chilkat River

Data for each unique Chinook salmon captured in the lower river will be recorded on either a Fish Wheel Capture Form or Drift Gillnet Capture Form (Appendices D2 and D3). Data to be recorded for each sampled fish are the date, time of day, adipose fin clip status (N = not clipped, Y = clipped), if clipped, the result of the CWT wand scan (Y = CWT present, N = CWT absent), sex (based on external characteristics), length to the nearest 5 mm METF, scale sample card and column number, presence of sea lice, and comments about fish condition and/or sampling irregularities. For all fish that are tagged, the type of tag and tag number will also be recorded on the data form. For all fish that are sacrificed for CWT sampling, the head cinch strap number will be recorded in the comments column.

For gillnet sampling, the date, crew member initials, first drift start time, and last drift end time will be recorded daily on a Gillnet Drift Effort Form (Appendix D1). Water temperature (nearest 1°C), and river depth (nearest 1 cm) will be measured and recorded twice daily, at approximately 0630 and 1300 hours, at a staff gage and thermometer on a piling near MP 8. For each drift, the number of Chinook salmon captured, and relevant comments will be recorded on a single row.

Data unique to drift gillnet capture will be recorded on the Drift Gillnet Capture Form (Appendix D2) are fish number (consecutively numbered through the season beginning with 1), channel fished when 2 main channels are used (R = right, L = left, as seen looking downstream), and percent of the area fished when a drift was interrupted. Previously sampled fish that are recaptured may be noted on this form, but will not be assigned a fish number.

Data that are unique to fish wheel capture that will be recorded on the Fish Wheel Capture Form (Appendix D3) are fish number (consecutively numbered through the season beginning with 1) and fish wheel site (1 = upstream, 2 = downstream). In the past there have been cases at the fish wheels when fish have escaped before sampling was completed. To avoid ambiguity about the marked status of each fish, the upper left operculum punch status of each fish will be recorded (Y = ULOP punched, N = not punched), and "NE" will be recorded in each data column if the fish was not examined.

Event 2, Spawning Grounds

For each Chinook salmon sampled, the following data will be recorded on the Spawning Ground Sampling Form (Appendix D4): date, sampling gear used, fish number (consecutively numbered at each spawning tributary through the season beginning with 1, sex (based on external characteristics), adipose fin clip status (Y = clipped, N = not clipped), results of handheld wand CWT scan (Y =

CWT present, N = CWT not present), and length to the nearest 5 mm METF. If the carcass is not intact, estimated METF length category (≥ 660 mm, < 660 mm and ≥ 440 mm, or < 440 mm) based on head size will be recorded in the length column. Other data recorded include scale card and column number, condition of the fish (bright/turning, spawning, spawned-out, carcass), presence of an ULOP, tag number if present, and LAP status if there is an ULOP and no spaghetti tag. Comments about the fish include other marks, injuries, and cinch strap number if the head was taken. In addition, if an adipose fin-clipped carcass is scanned for a CWT, the flesh condition (e.g. "firm" or "soft") will be recorded to assess potential recent CWT loss due to decomposition.

Field crews will also maintain a set of field notes that describes the areas sampled by river mile, the river conditions including visibility and water level, comments on the ability to sample fish each day, and any other relevant information.

AGE AND SEX COMPOSITION (PRIMARY OBJECTIVE 2)

Scales will be collected from Chinook salmon according to a standard procedure, which is to remove 5 scales from the left side of each sampled fish (right side if scales on the left side look compromised), 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 (ADF&G 1990). The first scale removed is from the center of this area (preferred scale), the second scale is 1 in to the left of the preferred scale, and the third is 1 in to the right. The fourth and fifth scales are selected 2 rows above the preferred scale row, ½ in to the left and ½ in to the right of the preferred scale. Scales are carefully cleaned and placed on the gum cards with all the scales from one Chinook salmon in 1 column (i.e., scales from fish #1 will be placed over 1, 11, 21, 31, and below 31 on the gum card). All scales are moistened and mounted upright (posterior side down) with the rough (outer side of the scale) side out. Scales are then pressed down with a finger or pencil so that they stick to the scale card. Room is left at the top middle portion of the card to accommodate a label. Scale cards are kept as dry as possible to prevent gum from running and obscuring the scale ridges. The gum card label is filled out completely, 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) is used for age determination. Scales will be read for age using procedures in Olsen (1992).

Sex data will be collected as described in the Data Collection/Abundance Estimate section.

CODED WIRE TAG STUDY (SECONDARY OBJECTIVE 1)

A Coded Wire Tag Sampling Form (Appendix D5) will be completed for each day that Chinook salmon are sampled in events 1 and 2 of the adult abundance estimation mark–recapture study. Daily totals of Chinook salmon examined and adipose fin-clipped fish found will be summarized by event and by fish length category; either "CHIN" (≥618 mm METF, species code 410) or "JACK" (< 618 mm METF, species code 411). The 618 mm threshold corresponds with 28" sport length (measured from tip of nose to edge of tail) used by the Mark, Age, and Tag Lab. Data that will be recorded on the daily CWT sampling form for each adipose fin-clipped fish will be head cinch strap number, species code, length to the nearest 5 mm METF, clip status, and sex. For adipose fin-clipped fish whose heads are not taken for CWT recovery (fish ≥440mm pre-spawn and testing positive for CWT), a dummy head number 902XXX will be assigned. Heads taken from adipose fin-clipped fish will be frozen as soon as possible and will be shipped weekly to the Mark, Age, and Tag Lab in Juneau for dissection and CWT recovery.

ABUNDANCE OF AGE-1.2 FISH (SECONDARY OBJECTIVE 2)

Data collection for age-1.2 fish will be the same as described for age-1.3 and older fish.

LENGTH COMPOSITION (SECONDARY OBJECTIVE 3)

Length composition data will be collected as described in the Data Collection/Abundance section above.

INJURED, ENTANGLED, OR DEAD MARINE MAMMALS

- Document with photos/video (if possible, remain at least 100 yards from the animal) and record the date, time, and location (latitude/longitude, description of bay, point, island, etc.).
- If possible, record the species of marine mammal, age class, sex (for sea lions), type of gear, a description of the gear (i.e., line, gillnet, etc.) and how the animal is entangled, its relative degree of impairment, and direction of travel.
- As soon as possible, report to **ALASKA MARINE MAMMAL STRANDING NETWORK** (24-hr hotline 877-925-7773; 877-9-AKR-PRD) and include information gathered above. Ideally for dead animals, if communications allow, contact the hotline while near the carcass to determine if additional information/samples can be collected.
- Specifically for an observed live and entangled whale, immediately call the **U.S. COAST GUARD** (VHF Channel 16).

DATA ANALYSIS

INRIVER ABUNDANCE (PRIMARY OBJECTIVE 1)

Data collected during event 1 and event 2 sampling will be tabulated serparately in order to estimate abundance and evaluate mark–recapture assumptions. In event 1, the number of fish tagged by age, sex, size category, time period, and gear type will be tabulated. In event 2, the number of fish captured and the number recaptured will be tabulated by age, sex, size category and tributary. If age cannot be determined, fish will be assigned an age by its size: small = age-1.1 (length < 440 mm METF), medium = age-1.2 (length ≥ 440 mm METF and < 660 mm METF), and large = age-1.3 or older (length ≥ 660 mm METF) fish. Tabulated data will be used to estimate abundance and determine if the mark–recapture experiment needs to be stratified by age, sex, size category, time period, or gear type per the methods described in Appendix E1.

Assuming the experiment does not need to be stratified, Chapman's modification of Petersen's method (Seber 1982) will be used to estimate the abundance of large Chinook salmon, $\widehat{N}_i$:

$$\widehat{N}_i = \frac{(M+1)(C+1)}{(R+1)} - 1, \qquad (1)$$

$$\mathrm{var}\left(\widehat{N}_i\right) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}, \qquad (2)$$

where *M* = number of large marked Chinook salmon, *C* = number of large adults inspected for marks on spawning grounds, and *R* = number of marked large adults recaptured on spawning grounds. The same estimator will be used to estimate the abundance of age-1.2 (medium-sized) fish as well. If time or area stratification is necessary, a Darroch estimator (Seber 1982, Chapter 11) will be used. Assumptions of the Petersen model are:

a) all Chinook salmon have an equal probability of being marked in the lower Chilkat River or all Chinook salmon have an equal probability of being inspected for marks, or marked fish mix completely with unmarked fish in the population between events;

b) recruitment of untagged fish does not occur between the tagging and sampling events;

c) tagging does not affect the fate (behavior or mortality) of a fish;

d) tagged fish do not lose their tags and tags are recognizable and detected; and

e) double sampling does not occur.

Tagging will occur in proportion to abundance during immigration (assumption a) if fishing effort and catchability are constant for each size category, sex, and stock (fish spawning in the same area) immigrates to the river. Each stock can be characterized by its age-size composition and immigration timing. Fishing effort will be constant over time, and catchability (*q*) is a function of age-size composition and run timing of the stocks, along with environmental variability.

Size-selectivity sampling will be evaluated ($\alpha = 0.1$) using Kolmogorov-Smirnov (K-S) tests on the lengths of fish marked, captured, and recaptured (Appendix E1). Similarly, sex composition in each sampling event will be compared to investigate the possibility of sex-selective sampling and the need for stratification of the data by sex (Appendix E1). Additionally, the sex estimation of recaptured fish will be compared between events 1 and 2 to assess the accuracy of the event 1 estimation. We generally assume that the event 2 sex data is more accurate because secondary sex characteristics are more developed on the spawning grounds than in the lower river and thus more accurate.

Chi-squared tests will be used to test for differences in proportion tagged between the Kelsall and Tahini rivers as outlined in Appendix E2. Klehini River tributary sampling data are not included in this test due to low expected number of recoveries (Ericksen 2001). If the proportions of tagged fish at two spawning areas are found to be unequal (assumption a), contributing causes will be investigated. As such we will use the chi-squared tests outlined in Appendix E2 to determine whether a simple Petersen estimator (described above) or a partially stratified estimator (e.g. Darroch 1961, Schwarz and Taylor 1998) should be used.

Contingency table analysis (or a K-S test) can also be used to see if the age (age 1.3 compared to age 1.4) or size composition of large fish captured in Kelsall and Tahini rivers are statistically different for fish captured during event 1. Results of the test will dictate the estimator used for calculating abundance (Appendix E1). Field personnel will not target tagged fish because all encountered fish are pursued and sampled (assumption a).

Recruitment of untagged fish into the population after tagging is highly unlikely (assumption b) because lower river tagging continues until few or no fish are captured, and also because a late run of Chinook salmon has not documented in the Chilkat River.

We assume tagged and untagged fish experience the same mortality (assumption c) due to natural causes and subsistence fishing. In the 2005 telemetry study, 88% of radio-tagged fish reached probable spawning areas, 6% were taken in fisheries, and 6% failed to reach spawning areas for unknown reasons; possibilities were tag regurgitation, handling effects, natural mortality, or unreported harvest (Ericksen and Chapell 2006). Included in the 6% with unknown fates were 2 fish (weighted 1% of the sample) that failed to resume upriver movement after being tagged.

Despite sport, subsistence, and commercial fisheries operating in Chilkat Inlet off the mouth of the Chilkat River, only 2 tagged Chinook salmon have ever been recovered downstream of the tagging site. The first was a radio-tagged fish recovered in the commercial drift gillnet fishery in 1992 (Johnson et al. 1993), and the second was a spaghetti tag recovered in a subsistence net in Chilkat Inlet in 2003. Thus, backing out of tagged fish does not appear to be a significant problem, which is consistent with assumption c.

To account for tag loss, each fish will receive a numbered tag and an ULOP. To examine where tag loss may be occurring during event 1, gillnet-captured fish will also be marked with an LAP. Recovery crews will check each captured fish for an ULOP to assess primary tag loss (assumption d). If tags are lost, the observation will be recorded on the sampling form comment section, and a fish with an ULOP but without a primary tag will be counted as a recovery. If primary tags are lost, samplers will also look for the tertiary LAP mark. Double sampling (assumption e) will be controlled by using numbered tags and adding a punch mark to the lower (ventral) edge of the left operculum (LLOP).

AGE AND SEX COMPOSITION (PRIMARY OBJECTIVE 2)

As described in the abundance estimate data analysis section, size-selective sampling will be investigated within each of large and medium fish, using K-S tests (see Appendix E1 for details). If selectivity is detected, the methods described in Appendix E1 will be used to reduce bias.

Assuming no size or sex selectivity, the fraction of fish, $\hat{p}_{a,i}$, in age or sex group *a* and length stratum *i* (medium or large fish) will be estimated as:

$$\hat{p}_{a,i} = \frac{n_{a,i}}{n_i}, \tag{3}$$

$$\mathrm{var}\left(\hat{p}_{a,i}\right) = \frac{\hat{p}_{a,i}\left(1-\hat{p}_{a,i}\right)}{n_i-1}, \tag{4}$$

where n_i is the number of fish in length stratum *i*, and $n_{a,i}$ is the number from this sample that belong to age or sex group *a*.

The estimated abundance of age or sex group *a* in the population ($\widehat{N}_a$) is:

$$\widehat{N}_a = \textstyle\sum_i \hat{p}_{a,i}\widehat{N}, \tag{5}$$

$$\mathrm{var}\left(\widehat{N}_a\right) = \textstyle\sum_i \left[\mathrm{var}\left(\hat{p}_{a,i}\right)\widehat{N}_i^{\,2} + \mathrm{var}\left(\widehat{N}_i\right)\hat{p}_{a,i}^2 - \mathrm{var}\left(\hat{p}_{a,i}\right)\mathrm{var}\left(\widehat{N}_i\right)\right], \tag{6}$$

where $\widehat{N}_i$ is the estimated abundance in length stratum *i* of the mark–recapture experiment and variance is estimated using the relationship in Goodman (1960).

The estimated fraction of the population that belongs to age or sex group *a* ($\hat{p}_a$) is:

$$\hat{p}_a = \frac{\widehat{N}_a}{\sum_i \widehat{N}_i}, \tag{7}$$

$$\mathrm{var}(\hat{p}_a) \approx \frac{1}{\widehat{N}^2}\textstyle\sum_i\left[\mathrm{var}\left(\hat{p}_{a,i}\right)\widehat{N}_i^2\right] + \frac{1}{\widehat{N}^2}\sum_i \left[\mathrm{var}\left(\widehat{N}_i\right)\left(\hat{p}_{a,i} - \hat{p}_a\right)^2\right], \tag{8}$$

where the variance is an approximation based on the delta method (Seber 1982) and $\hat{N} = \sum_i \hat{N}_i$

Estimates of mean length at age and its variance will be calculated with standard sample summary statistics (Thompson 2002, Section 2.2).

CODED WIRE TAG STUDY (SECONDARY OBJECTIVE 1)

The project operational plan *Production and Harvest of Chilkat River Chinook and Coho Salmon, 2021-2022* (Elliott and Peterson 2021) describes how adipose fin clip and CWT detection data collected during this study will be analyzed to generate estimates of juvenile abundance, overwinter survival, marine survival, marine harvest, and total return for a given brood year.

ABUNDANCE OF AGE-1.2 FISH (SECONDARY OBJECTIVE 2)

Data analysis for abundance of age-1.2 fish will follow the same methods described for age-1.3 and older fish.

LENGTH COMPOSITION (SECONDARY OBJECTIVE 3)

Length composition will be collected and analyzed following the same methods described for age 1-3 and older fish.

SCHEDULE AND DELIVERABLES

It is the responsibility of the field crew leaders to ensure accurate data are collected on a daily basis. The field crew leader will also ensure data collections (such as samplers' initials, environmental data, fish sex and condition, etc.) are complete, and sampling methods (such as length measurements, sex and scale collection procedures, etc.) are correctly implemented. Daily inspections for recording errors will include identification of incorrect dates or transposed numbers, such as fish lengths or tag numbers. Data forms will be kept up to date at all times. Scale cards will be visually inspected to ensure that scales are clean, mounted correctly, and correctly labeled. Data will be sent to the project biologist weekly, where it will be re-inspected for accuracy and compliance with sampling procedures. At later dates, data will be transferred from field forms to Excel™[1] spreadsheet files. Scales will be pressed and ages estimated in the scale-aging lab in Juneau. 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. All entry and editing will be completed by January 31, 2023. Data files will be archived in 2 locations: on the Haines area office network hard drive at

"Haines DSF S:\Data archive\Chilkat Chinook escapement\2021"

and on the Douglas regional network hard drive at

"Region1Shared-DCF R:\Divisions\CF\Offices\Haines\Data archive\Chilkat Chinook escapement\2022".

The ADF&G-CF maintains the clearinghouse for all CWT information. Completed CWT tagging summary and release information will be sent to the Mark, Tag and Age Laboratory in Juneau, after first being given to the project leader and error checked using computer software. All CWT data (sampled fish, adipose-finclipped fish, decoded tags, location, data type, samplers, etc.) are

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

archived and accessible on an ADF&G statewide database (https://mtalab.adfg.alaska.gov/CWT/reports/default.aspx) and once per year are provided to the permanent coastwide database at the Pacific States Marine Fisheries Commission.

A final, edited copy of the data, and its metadata will be sent to Division of Sport Fish, Research and Technical Services (RTS) in Anchorage electronically for archiving when the Fishery Data Series report is submitted for publication. The metadata file will include a description of all electronic files contained in the data archive, all data fields and details of where hard copies of any associated data are to be archived, if not in RTS. For this project, all tagging and recovery data are recorded by hand on specialized fields forms, transcribed into Excel™ workbooks and analyzed in Excel™ and other commercial and custom software. All age, sex, and length and associated CWT and mark data for individual fish will be reformatted and archived in the Integrated Fisheries Database in the Douglas Region 1 office with the ADF&G-CF. All electronic data sent to RTS and not archived elsewhere, will include the Excel™ workbooks (presently in Office 2016). The original hard copies of all tagging and recovery forms, scale gum cards and acetates, will be logged and stored in the Region I age, sex, and length data archives, located in file cabinets in the Douglas regional office.

The research coordinators and project leaders, in consultation with RTS staff, will develop an archive tree to keep track of all data archived with RTS and on Docushare in Region I, to facilitate accuracy of data archiving and retrieval, and then deposit data archives in the appropriate location.

Field sampling activities during 2022 are scheduled as follows:

1. Lower Chilkat River drift gillnet	June 10–July 24
2. Tahini River spawning grounds surveys	July 30–September 5
3. Kelsall River spawning grounds surveys	July 30–September 5

Data editing and analysis will be initiated before the end of the season. A memorandum summarizing observations including successes/difficulties for sampling each area, with recommendations for future project modification, will be prepared by field crews and presented to the project leader prior to leaving the project. The project leader will complete a draft Fisheries Data Series report by June 30, 2023.

Information from the project will also be summarized in reports to the Alaska Board of Fisheries and PSC Chinook Technical Committee.

RESPONSIBILITIES

Brian W. Elliott, Fishery Biologist 3, Lead Biologist. Writes operational plan, supervises overall project; edits, analyzes, and reports data. Supervises field operations to ensure the study design is implemented properly. He is also responsible for writing personnel evaluations for crew members.

Randy Peterson, Biometrician 3. Reviews operational plan, provides input to and approves study design. Reviews final report, writes programming code and completes data analysis.

Reed Barber, Fishery Technician 3. This position is responsible for supervising 2 technicians during event 1 drift gillnet Chinook capture and tagging on the lower Chilkat River, and for the Kelsall River spawning grounds sampling portion of the project. He is to ensure that the technicians are trained in the proper operation of all aspects of the program including boat safety, fish handling, conduct in the public's view, and adherence to ADF&G policies. In addition, he is to inform the field supervisor of any maintenance or repairs that the crew is not capable of performing in a timely manner. He will be responsible for assisting preparation of, and adhering to the schedules, ensuring equipment is operated properly, and submitting data in a timely and accurate manner. With the field supervisor, he will attempt to resolve as many personnel and administrative problems as possible. This position will be responsible for a brief postseason report describing the conduct of the lower Chilkat River drift gillnet portion of the project, including any recommendations for improvement.

Bryan Harmon, Fishery Technician 2. During lower river event 1, this position is responsible for deploying and retrieving the net, measuring fish, collecting the biological samples and tagging the fish. Further duties require assisting in the maintenance and repair of equipment. This position will operate the gillnetting boat. This position is also responsible for conducting spawning ground sampling on the Kelsall and Tahini rivers. He will assist the crew leader in capturing fish on the spawning grounds, and will collect age, sex, and length information while inspecting fish for missing adipose fins.

Liam Cassidy, Fishery Technician 3. This position is responsible for the Tahini River spawning grounds sampling portion of the project. He ensures that crewmembers are trained in the proper operation of all aspects of the program including boat safety, fish handling, conduct in the public's view, and adherence to ADF&G policies. In addition, he is to inform the field supervisor of any maintenance or repairs that the crews are not capable of performing in a timely manner. Position will be responsible for assisting preparation of, and adhering to the schedules, insuring equipment is operated properly, and submitting data in an accurate and timely manner. With the field supervisor, he will attempt to resolve as many personnel and administrative problems as possible. This position will be responsible for a brief postseason report describing the details of the spawning grounds sampling, including any recommendations for improvement.

Dave Folletti, Fishery Technician 3. During lower river event 1, this position is responsible for deploying and retrieving the net, measuring fish, collecting the biological samples and tagging the fish. Further duties require assisting in the maintenance and repair of equipment. This position will operate the gillnetting boat. This position is also responsible for conducting spawning ground (carcass) surveys on the Kelsall River and Tahini River. This position will assist the crew leader in capturing fish on the spawning grounds, and will collect age, sex, and length information while inspecting fish for missing adipose fins.

Nicole Zeiser, Fishery Biologist 3. This position is responsible for supervising the Division of Commercial Fisheries fish wheel tagging operations on the lower Chilkat River. This position ensures that crewmembers are trained in the proper operation of all aspects of the program including boat safety, fish handling, fish sampling, conduct in the public's view, and adherence to ADF&G policies. In addition, this position is to inform the supervisor of any maintenance or repairs that the crews are not capable of performing in a timely manner. Position will be responsible for assisting preparation of and adhering to the schedules, insuring equipment is operated properly, and submitting data in an accurate and timely manner.

Shelby Flemming, Fishery Biologist 1. This position will assist in the installation, operation, and maintenance of the fish wheels. In addition, this position and the crew will sample and mark Chinook salmon captured in the fish wheels while collecting biological data. This position will be responsible for proofreading all Chinook salmon data collected at the fish wheels, including any recommendations for improvement.

Richard Chapell, Fishery Biologist 3, Area Management Biologist. This position provides estimates of Haines marine sport harvest from the Haines marine creel program, collaborates with the Lead Biologist on data collection and analysis.

Ed Jones, Fish and Game Coordinator. This position reviews the operational plan and the annual technical report and assists in obtaining funding for Chilkat River Chinook salmon projects.

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APPENDIX A: DRIFT GILLNET AND SPRING TROLL HARVEST OF CHILKAT CHINOOK SALMON

Appendix A1.–Estimated drift gillnet harvest and standard errors by ADF&G district, 2004–2021.

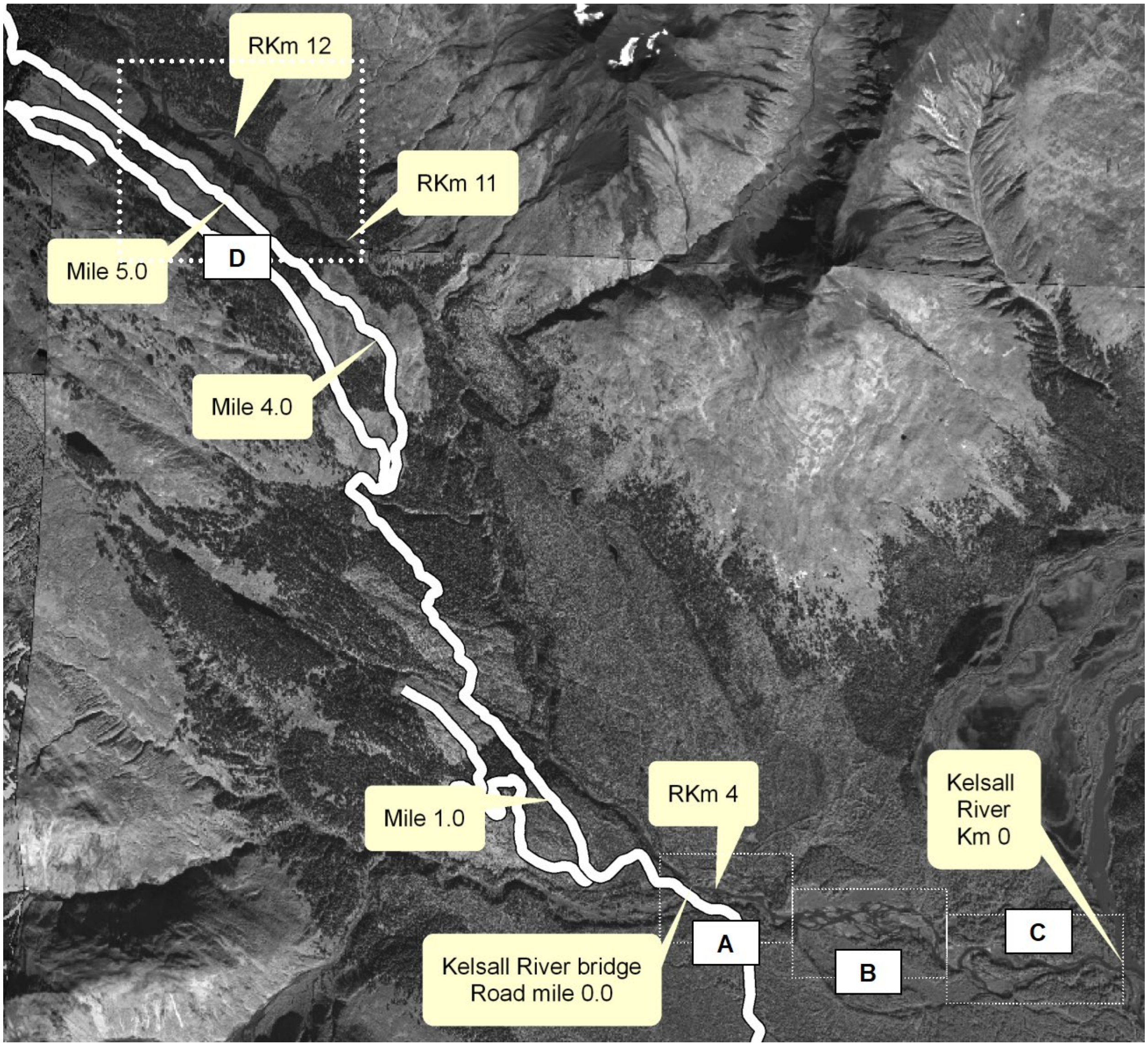
Anticipated Return	Harvest estimates by district			Standard errors by district		
Year	108	111	115	108	111	115
2004	0	0	295	0	0	73
2005	0	30	180	0	29	71
2006	0	22	41	0	21	33
2007	0	0	131	0	0	79
2008	25	0	261	24	0	118
2009	24	0	12	24	0	12
2010	0	0	394	0	0	155
2011	80	79	114	80	57	67
2012	0	0	230	0	0	87
2013	20	0	121	20	0	55
2014	0	48	487	0	48	128
2015	0	0	318	0	0	120
2016	0	0	7	0	0	7
2017	0	0	11	0	0	11
2018	0	0	80	80	0	79
2019	0	0	87	0	0	65
2020	0	0	59	0	0	41
2021	0	0	28	0	0	7
Average	8	10	159	13	9	67

Appendix A2.–Estimated spring troll harvest and standard errors by ADF&G district in Southeast Alaska, 2004–2021.

Anticipated Return	Harvest estimates by district						Standard errors by district					
Year	105	109	112	113	114	183	105	109	112	113	114	183
2004	0	0	0	134	123	0	0	0	0	134	41	0
2005	0	0	0	0	107	0	0	0	0	0	43	0
2006	0	0	0	58	80	0	0	0	0	58	45	0
2007	0	172	0	0	57	0	0	57	0	0	33	0
2008	30	13	0	0	214	0	30	13	0	0	192	0
2009	0	0	0	94	151	0	0	0	0	46	57	0
2010	0	25	0	43	60	0	0	17	0	43	45	0
2011	13	0	43	29	35	0	12	0	30	29	35	0
2012	0	0	34	31	90	0	0	0	34	31	89	0
2013	0	0	0	27	0	13	0	0	0	27	0	12
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	22	0	37	0	0	0	22	0	36	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	14	0	30	0	0	0	14	0	30	0
2018	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0
Average	2	12	6	23	55	1	2	5	6	20	36	1

APPENDIX B: KELSALL RIVER DRAINAGE SAMPLING AREAS

Appendix B1.–Satellite photo of the Kelsall River showing the delta (area B), upper canyon (area D) and other sampling areas in the Chilkat River drainage, Southeast Alaska.



APPENDIX C: ALTERNATE MODEL TO ESTIMATE INRIVER ABUNDANCE

Appendix C1.–Alternate model to estimate inriver abundance using spawning ground catch per unit effort data.

If seven or less marked fish are recovered during event 2 of the mark–recapture experiment the mark–recapture based estimate of inriver abundance is likely biased (Seber 1982) and an alternative model will be used. Catch per unit effort (CPUE) data, as measured by the number of large Chinook salmon inspected from the two principal spawning ground locations (Kelsall River and Tahini River) divided the number of survey days, and past mark–recapture studies with valid estimates, will be combined and used to predict inriver abundance. The Kelsall and Tahini River CPUE indices as well as the mark–recapture estimates of inriver abundance are reported in Appendix C2. The time series begins in 2000 when sampling methods were standadized. Inriver abundance, $\widehat{N}$, is estimated using a linear regression model:

$$\widehat{N} = 316.3x \tag{1}$$

where x is the Kelsall and Tahini rivers combined CPUE. The intercept parameter was dropped because it was not significant at the $\alpha = 0.05$ level and the overall model is significant at the $\alpha = 0.05$ level. A plot of predicted vs. observed values of inriver abundance shows that model fit to data is good (see Appendix C3) and residual diagnostics suggest that a linear model is appropriate. The standard error of a new observation will be calculated using the methods described in Kutner et al. (2005):

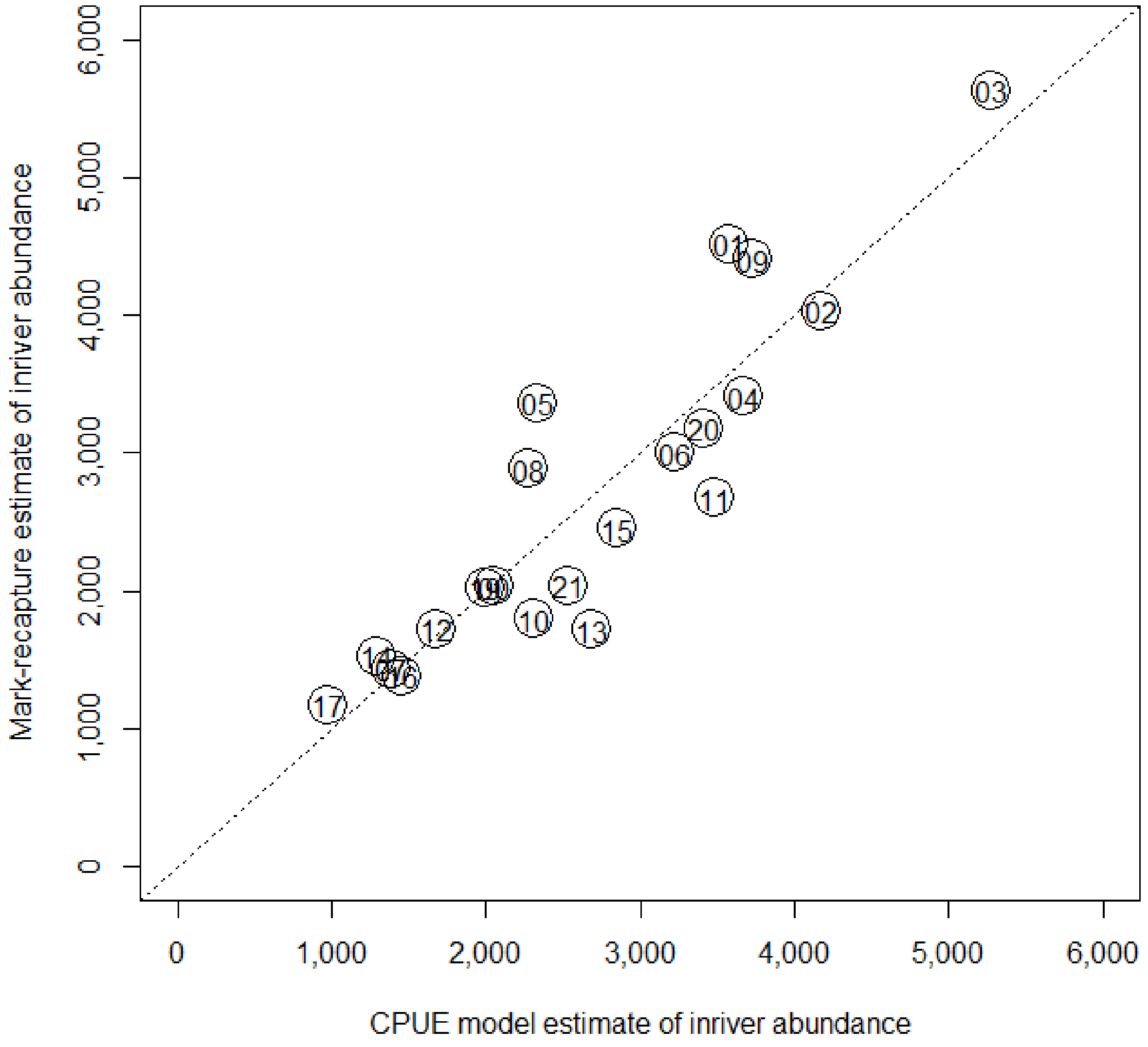
$$SE\left(\widehat{N}\right) = 520\sqrt{1 + 0.00057x} \tag{2}$$

The average CV of new observation predicted using equations 1 and 2 is 23%, as determined through a retrospective evaluation. Appendix C4 shows the relationship between the Kelsall and Tahini rivers combined CPUE along with the associoated 90% prediction intervals.

Appendix C2.–CPUE from event 2 sampling on the Kelsall and Tahini rivers and mark–recapture estimates of inriver abundance, 2000–2021.

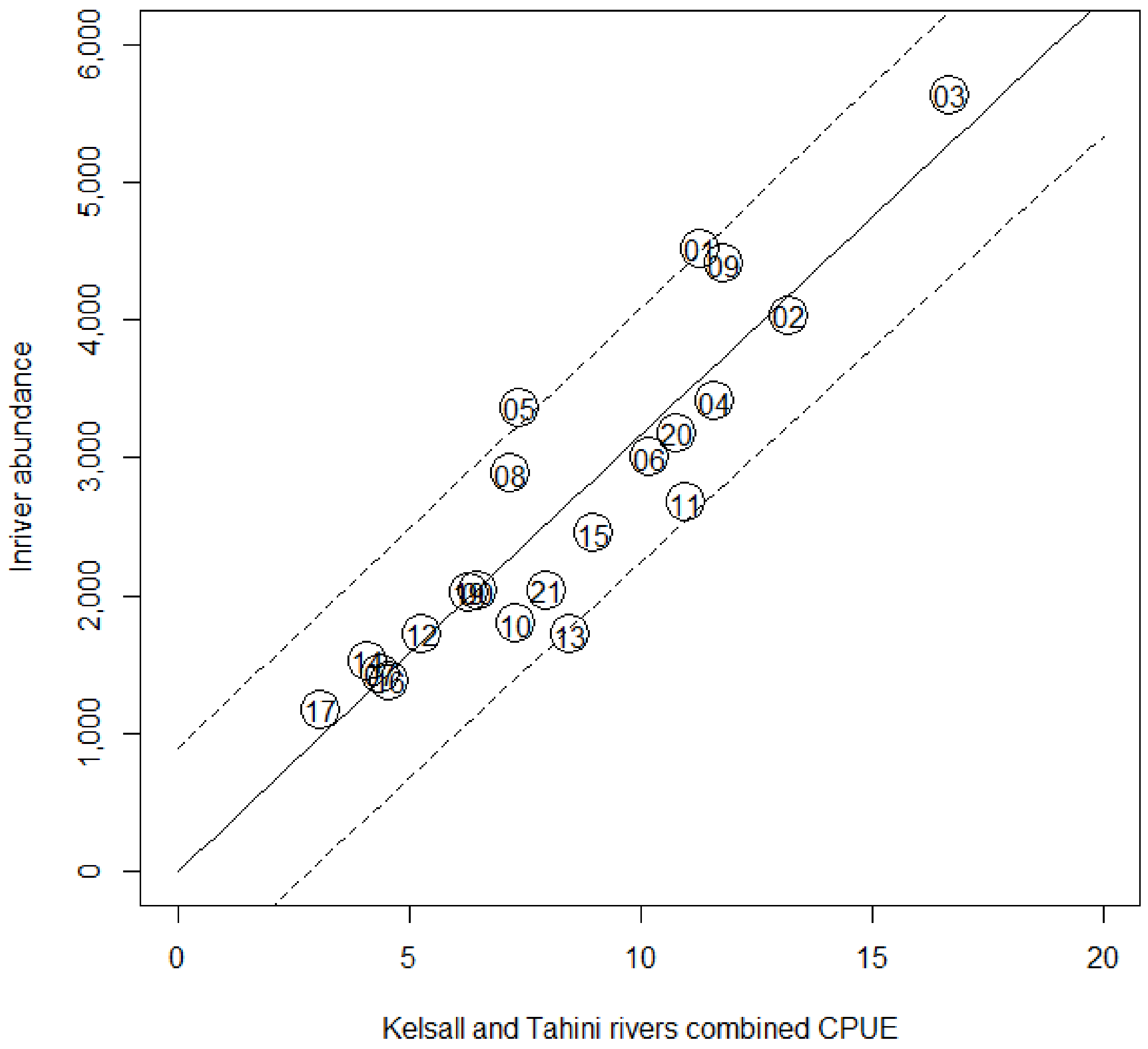
	Kelsall River			Tahini River			Combined	CPUE	Mark–recapture
Year	Days	Sampled	CPUE	Days	Sampled	CPUE	CPUE	estimate	estimate
2000	31	217	7.0	20	112	5.6	6.5	2,067	2,029
2001	30	366	12.2	21	210	10.0	11.3	3,618	4,514
2002	25	203	8.1	15	325	21.7	13.2	4,229	4,034
2003	28	265	9.5	19	519	27.3	16.7	5,344	5,631
2004	28	307	11.0	21	261	12.4	11.6	3,714	3,406
2005	31	210	6.8	24	199	8.3	7.4	2,383	3,361
2006	33	304	9.2	22	257	11.7	10.2	3,268	3,003
2007	31	120	3.9	20	105	5.3	4.4	1,413	1,435
2008	30	150	5.0	20	211	10.6	7.2	2,313	2,881
2009	22	103	4.7	23	428	18.6	11.8	3,781	4,406
2010	22	43	2.0	22	279	12.7	7.3	2,345	1,797
2011	24	198	8.3	23	319	13.9	11.0	3,524	2,674
2012	26	146	5.6	25	125	5.0	5.3	1,702	1,723
2013	21	192	9.1	22	175	8.0	8.5	2,734	1,719
2014	21	85	4.0	20	85	4.3	4.1	1,328	1,529
2015	22	149	6.8	25	272	10.9	9.0	2,870	2,452
2016	26	66	2.5	24	162	6.8	4.6	1,461	1,386
2017	24	63	2.6	21	78	3.7	3.1	1,004	1,173
2018	25	65	2.6	18	53	2.9	2.7	873	N/A
2019	25	81	3.2	19	195	10.3	6.3	2,010	2,028
2020	11	75	6.8	14	196	14.0	10.8	3,474	3,180
2021	10	26	2.6	17	190	11.2	8.0	2,564	2,038

Appendix C3.–Mark–recapture estimates of inriver abudance plotted against the CPUE model estimates of inriver abundance, 2000–2017, 2019–2021.



Note: Dotted line represents the 1:1 line.

Appendix C4.–CPUE model estimates of inriver abundance (solid black line) and mark–recapture estimates of inriver abundance and observed CPUE (circles, text indicates the year), 2000–2017 and 2019–2021.



Note: Dotted line represents a 90% prediction interval.

APPENDIX D: DATA COLLECTION FORMS

Appendix D1.–Chilkat River drift gillnet effort form.

Start Time 0647 (first drift)

Date 6-18-22 Crew LC / DF

End Time 1247 (last drift)

Water Temp. 7.1° at 0645 Hrs.

Water Depth 161 at 0645 Hrs.

Water Temp. 8.1° at 1305 Hrs.

Water Depth 160 at 1305 Hrs.

Weather Comments PtlyCldy/Wind S5k

Water Comments High, flat, muddy

Drift Num.	Done	Chinook	Area	Channel	Comments
1	X		1	R	
2	X		2	R	
3	X		3		
4	X		4		
5	X		5	R	
6	X	1	6	R	M 710 tag #4590 Caught near shore
7	X		1	L	
8	X		2	L	Large Chinook, fresh seal bite, not tagged
9	X		3		
10	X		4		
11	X		5	R	
12	X		6	R	
13	X		1	R	
14	X		2	R	
15	X	1	3		M 920 tag #4591
16	X		4		
17	X		5	R	
18	X		6	R	
19	X		1	L	
20	X		2	L	
21	X		3		
22	X		4		
23	X		5	R	
24	X		6	R	
25	X		1	R	
26	X		2	R	
27	X		3		
28	X		4		
29	X		5	R	
30	X		6	R	
Sum	XXXX	2	XXXX	XXX	Add these sums to page 2 totals.

-continued-

Appendix D1.–Page 2 of 2.

Drift Num.	Done	Chinook	Area	Channel	Comments
31	X		1	L	
32	X		2	L	
33	X		3		
34	X		4		
35	X		5	R	
36	X		6	R	
37	X		1	R	
38	X		2	R	
39	X		3		
40	X		4		
41	X		5	R	
42	X		6	R	
43	X		1	L	
44	X		2	L	
45	X		3		
46	X		4		
47	X		5	R	
48	END				
49					
50					
51					
52					
53					
54					
55					
56					
57					
58					
59					
60					
Sum	XXXX	2	XXXX	XXX	Daily total

Appendix D2.–Chilkat River drift gillnet capture form.

DATE	TIME	FISH #	ADCLIP	* CWT Head	SEX	LENGTH	CARD #	SCALE #	LICE	** TAG TYPE	TAG #	COMMENTS CWT Cinch Strap #
13-Jun	725	1	N		F	900	1	1	N	S	301	Bright
17-Jun	715	2	N		M	870	1	2	N	S	302	Bright
19-Jun	1145	3	N		M	585	1	3	N	S	303	Bright
22-Jun	1100	4	N		M	870	1	4	N	S	304	Bright, seal
23-Jun	800	5	N		F	825	1	5	N	S	305	Bright
	825	6	N		F	750	1	6	N	S	306	Bright
	1015	7	N		M	745	1	7	N	-	-	Bleeding-not
24-Jun	925	8	N		F	880	1	8	N	S	307	Bright
25-Jun	740	9	N		M	980	1	9	N	S	308	Steely grey
	840	10	N		M	535	1	10	N	S	309	Bright
26-Jun	1025	11	N		M	830	2	1	N	S	310	Bright, gash
	1105	12	Y	Y	F	915	2	2	N	S	311	Bright
27-Jun	845	13	N		F	820	2	3	N	S	312	Reddish
	855	14	N		M	920	2	4	N	S	313	Bright
	1125	15	N		M	570	2	5	N	S	314	Bright
28-Jun	700	16	Y	Y	M	435	2	6	N	-	-	CWT 264123
	715	17	N		F	810	2	7	N	S	315	Bright
	1000	18	N		F	870	2	8	N	S	316	Bright 4 scales
29-Jun	725	19	N		M	760	2	9	N	S	317	Bright
	950	20	Y	Y	M	355	2	10	N	-	-	CWT 264124
1-Jul	705	21	N		F	680	3	1	Y	S	318	Bright
	812	22	N		F	920	3	2	Y	S	319	Reddish
	905	23	N		F	825	3	3	N	S	320	Pink
	1130	24	N		F	930	3	4	N	S	321	Chromer
2-Jul	1150	25	N		M	395	3	5	N	T	1003	Bright

* For ad-clipped Chinook salmon:
Large (≥ 660 mm METF): check for a CWT in the head before tagging. If no CWT, retain the head.
Small and medium (< 660 mm METF): retain all heads.

**S = spaghetti tag (≥ 440 mm METF), T = t-bar anchor tag (< 440 mm METF)

Appendix D3.–Chilkat River fish wheel capture form.

Description: Chilkat River Fish Wheels **Be sure to give tagged fish an upper left operculum**

Species: 41 (Chinook) Stream Code: 115-32-10250 Year: 2022

Gear: 08 (fish wheel) Length Type: 02 (METF) Project: F-15-29

Date	**Time**	**FW Site**	**Fish Num**	**Ad-clip**	*** CWT Head**	**Sex**	**Length**	**Scale card #**	**Scale col. #**	**Lice**	**** Tag type**	**Tag num.**	**Upper left operc punch**	**Comments/ CWT cinch strap number**
11-Jun	850	2	1	n		F	1010	1	1	N	S	1	y	Seal bite
12-Jun	1602	2	2	n		M	860	1	2	N	S	2	y	bright
13-Jun	1630	2	3	n		M	960	1	3	N	S	3	y	
14-Jun	930	2	4	n		M	880	1	4	N	S	4	y	
15-Jun	850	2	5	y	y	M	650	1	5	N	-	-	n	CWT 265012
	850	2	6	n		M	690	1	6	N	S	5	y	
	850	2	7	n		M	880	1	7	N	S	6	Y	Turning
	950	1	8	n		M	810	1	8	N	S	7	Y	
16-Jun	845	2	9	n		F	870	1	9	N	S	8	y	
	845	2	10	n		M	780	1	10	N	S	9	y	
	945	1	11	y	y	M	830	2	1	N	S	10	y	
	1530	2	12	n		M	800	2	2	N	S	11	y	Turning
17-Jun	851	2	13	n		F	960	2	3	Y	S	12	y	
18-Jun	835	2	14	n		M	450	2	4	N	S	13	y	
19-Jun	858	2	15	n		M	640	2	5	N	S	14	y	
20-Jun	843	2	16	y	y	M	300	2	6	N	-	-	n	CWT 265013
21-Jun	1427	2	17	n		M	585	2	7	N	S	15	y	
22-Jun	900	1	18	y	y	M	340	2	8	N	-	-	n	CWT 265014
	930	2	19	n		F	900	2	9	Y	S	16	y	
	1500	2	20	n		M	780	2	10	N	S	17	y	
	1500	2	21	n		M	420	3	1	N	T	1068	y	
	1500	2	22	n		F	685	3	2	N	S	1069	y	
23-Jun	850	1	23	n		F	780	3	3	Y	S	1070	y	

* For ad-clipped Chinook salmon:

Large (≥ 660 mm METF) fish: check for a CWT in the head before tagging. If no CWT, retain the head.

Small and medium (< 660 mm METF) fish: retain all heads.

**S = spaghetti tag (≥ 440 mm METF), T = t-bar anchor tag (< 440 mm METF),

Appendix D4.–Chilkat River spawning ground sampling form.

Location: **Kelsall River** **Crew:** RB, LC

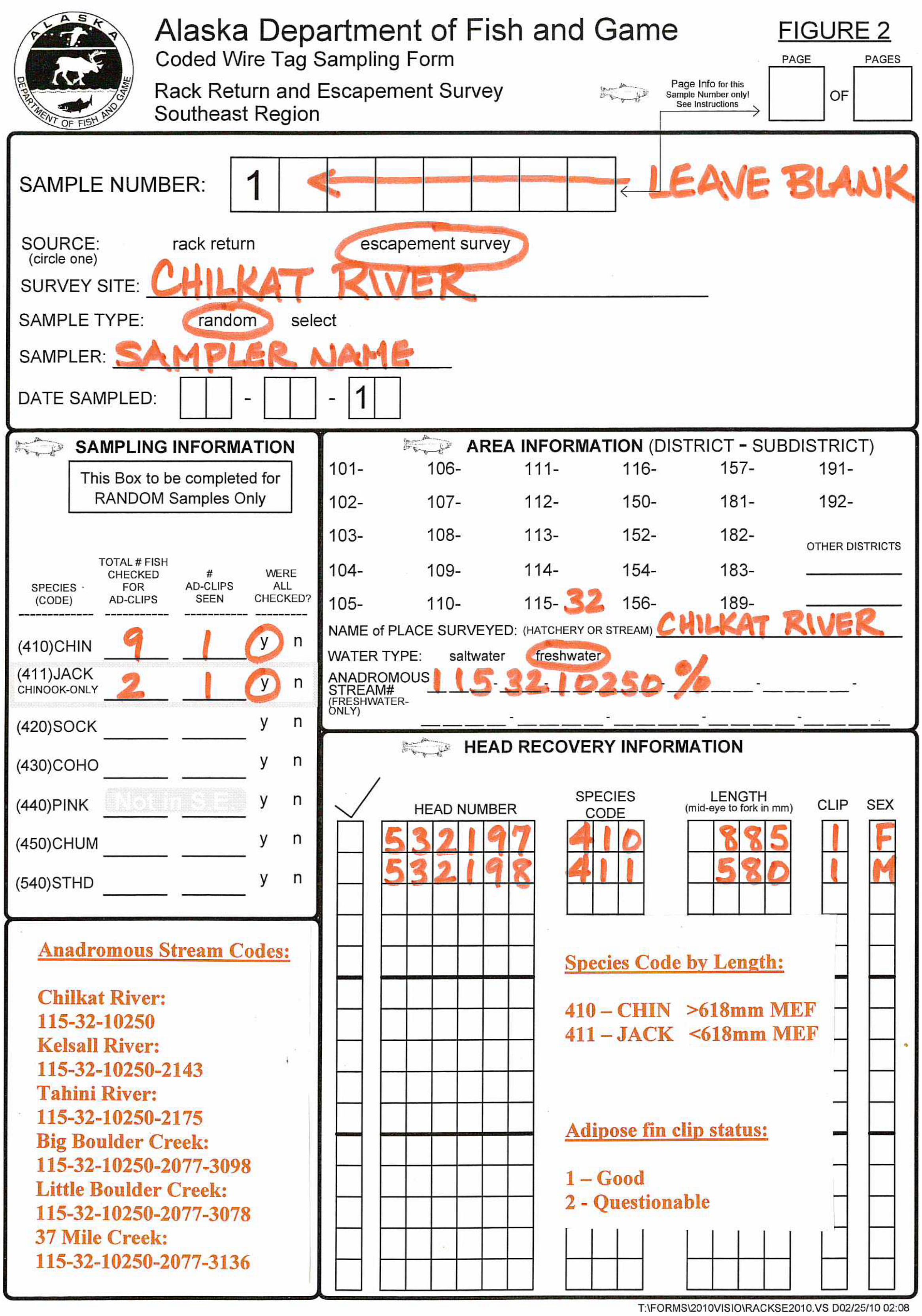
DATE	* GEAR	FISH num	SEX	Ad-CLIP	CWT		Length METF	SCALE		** COND	OP. PUNCH		*** Kels. area	TAG Num or LAP	COMMENTS/ Cinch strap number
					HEAD	BACK		CARD	COL.		Lower given	Upper present			
8/8	S	1	F	N			780	1	1	S	Y	Y	B		Tag missing, No LAP
8/11	S	2	M	N			875	1	2	S	Y	Y	A	4001	Good s-tag placement
	S	3	M	N			880	1	3	S	Y	Y	B	4257	Left spag tag in fish
8/12	S	4	M	N			1150	1	4	C	Y	N	A		
	C	5	M	N			825	1	5	C	Y	N	A		
8/13	S	6	F	N			900	1	6	S	Y	N	A		
8/15	S	7	F	N			635	1	7	S	Y	N	B		
	S	8	F	N			780	1	8	S	Y	N	B		
	C	9	F	N			785	1	9	C	Y	Y	B	4002	Good s-tag placement
8/16	S	10	F	N			795	1	10	SO	Y	N	A		
	S	11	F	N			820	2	1	SO	Y	N	A		
	S	12	F	N			825	2	2	S	Y	N	A		
	S	13	M	N			940	2	3	SO	Y	N	A		
	C	14	F	Y	Y	N	730	2	4	C	N	N	A		CWT #626456, firm
	S	15	M	Y	Y	N	535	2	5	S	N	N	A		CWT #626457
	S	16	M	N			910	2	6	SO	Y	N	A		
	C	17	M	N			> 660	2	7	C	Y	N	A		Estimated length group
	C	18	F	N			790	2	8	C	Y	N	A		
	S	19	M	N			920	2	9	S	Y	N	B		
	S	20	M	N			680	2	10	S	Y	N	B		
8/17	C	21	M	N			1010	3	1	C	Y	N	A		
	C	22	F	N			800	3	2	SO	Y	N	B		
	C	23	M	N			435	3	3	C	Y	Y	A	605	Good T-tag placement
8/18	S	24	F	N			855	3	4	S	Y	N	A		
	S	25	M	N			520	3	5	S	Y	Y	A	4210	Hole from tag wear
	S	26	F	N			750	3	6	S	Y	N	A		

* **S** = Snagging, **GN** = Gillnet, **DN** = Dipnet, **E** = Seine, **C** = Carcass pickup.

** **B** = Bright/Turning, **S** = Spawning, **SO** = Spawned out, **C** = Carcass.

*** Kelsall/Nataga areas: **A** = above delta, **B** = delta, **C** = below delta, D = upper canyon.

Appendix D5.–Coded-wire tag sampling form.



Alaska Department of Fish and Game

FIGURE 2

Coded Wire Tag Sampling Form

Rack Return and Escapement Survey
Southeast Region

Page Info for this Sample Number only! See Instructions

PAGE ____ OF PAGES ____

SAMPLE NUMBER: 1 ← LEAVE BLANK

SOURCE: (circle one) rack return [✓ escapement survey]

SURVEY SITE: CHILKAT RIVER

SAMPLE TYPE: [✓ random] select

SAMPLER: SAMPLER NAME

DATE SAMPLED: __ __ - __ __ - 1 __

SAMPLING INFORMATION

This Box to be completed for RANDOM Samples Only

SPECIES (CODE)	TOTAL # FISH CHECKED FOR AD-CLIPS	# AD-CLIPS SEEN	WERE ALL CHECKED?
(410)CHIN	9	1	[✓ y] n
(411)JACK CHINOOK-ONLY	2	1	[✓ y] n
(420)SOCK			y n
(430)COHO			y n
(440)PINK	Not in S.E.		y n
(450)CHUM			y n
(540)STHD			y n

AREA INFORMATION (DISTRICT - SUBDISTRICT)

101-	106-	111-	116-	157-	191-
102-	107-	112-	150-	181-	192-
103-	108-	113-	152-	182-	OTHER DISTRICTS
104-	109-	114-	154-	183-	
105-	110-	115- 32	156-	189-	

NAME of PLACE SURVEYED: (HATCHERY OR STREAM) CHILKAT RIVER

WATER TYPE: saltwater [✓ freshwater]

ANADROMOUS STREAM# (FRESHWATER-ONLY) 115-32-10250-%

HEAD RECOVERY INFORMATION

✓	HEAD NUMBER	SPECIES CODE	LENGTH (mid-eye to fork in mm)	CLIP	SEX
	532197	410	885	1	F
	532198	411	580	1	M

Anadromous Stream Codes:

Chilkat River:
115-32-10250
Kelsall River:
115-32-10250-2143
Tahini River:
115-32-10250-2175
Big Boulder Creek:
115-32-10250-2077-3098
Little Boulder Creek:
115-32-10250-2077-3078
37 Mile Creek:
115-32-10250-2077-3136

Species Code by Length:

410 – CHIN >618mm MEF
411 – JACK <618mm MEF

Adipose fin clip status:

1 – Good
2 - Questionable

T:\FORMS\2010VISIO\RACKSE2010.VS D02/25/10 02:08

APPENDIX E: DETECTION AND MITIGATION OF SELECTIVE SAMPLING DURING A TWO-EVENT MARK RECAPTURE EXPERIMENT

Appendix E1.–Detection and mitigation of selective sampling during a two-event mark–recapture experiment.

Size- and sex-selective sampling may cause bias in two-event mark–recapture estimates of abundance and size and sex composition. Kolmogorov-Smirnov (KS) two sample tests are used to detect size-selective sampling and contingency table analyses (Chi-square tests of independence) are used to detect evidence of sex-selective sampling.

Results of the KS and Chi-square tests will dictate whether the data needs to be stratified to obtain an unbiased estimate of abundance. The nature of the detected selectivity will also determine whether the first, second, or both event samples are used for estimating size and sex compositions.

DEFINITIONS

M = Lengths or sex of fish marked in the first event
C = Lengths or sex of fish inspected for marks in the second event
R = Lengths or sex of fish marked in the first event and recaptured in the second event

SIZE-SELECTIVE SAMPLING: KS TESTS

Three KS tests are used to test for size-selective sampling.

KS Test 1	C vs R	Used to detect size selectivity during the 1st sampling event. H_o: Length distributions of populations associated with C and R are equal
KS Test 2	M vs R	Used to detect size selectivity during the 2nd sampling event. H_o: Length distributions of populations associated with M and R are equal
KS Test 3	M vs C	Used to corroborate the results of the first two tests. H_o: Length distributions of populations associated with M and C are equal

SEX-SELECTIVE SAMPLING: CHI-SQUARE TESTS

Three contingency table analyses (χ^2-tests on 2x2 tables) are used to test for sex-selective sampling.

χ^2 Test 1	C vs R	Used to detect sex selectivity during the 1st sampling event. H_o: Sex is independent of the C - R classification
χ^2 Test 2	M vs R	Used to detect sex selectivity during the 2nd sampling event. H_o: Sex is independent of the M - R classification
χ^2 Test 3	M vs C	Used to corroborate the results of the first two tests. H_o: Sex is independent of the M - C classification

Table E1 presents possible results of selectivity testing, their interpretation, and prescribed action.

Table E1.–Possible results of selectivity testing, interpretation and action.

	KS or χ^2 Test			
Case	M vs. R (2nd event test)	C vs. R (1st event test)	M vs. C (1st vs 2nd event)	Interpretation and Action
I	Fail to reject H_o	Fail to reject H_o	Fail to reject H_o	**Interpretation**: No selectivity during either sampling event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use all data from both sampling events.
II	Reject H_o	Fail to reject H_o	Reject H_o	**Interpretation:** No selectivity during the 1st event but there is selectivity during the 2nd event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use data from the 1st sampling event without stratification. 2nd event data only used if stratification of the abundance estimate is performed, with weighting according to Equations 1-3 below.
III	Fail to reject H_o	Reject H_o	Reject H_o	**Interpretation:** No selectivity during the 2nd event but there is selectivity during the 1st event. **Action**: Abundance: Use a Petersen-type model without stratification. Composition: Use data from the 2nd sampling event without stratification. 1st event data may be incorporated into composition estimation only after stratification of the abundance estimate and appropriate weighting according to Equations 1-3 below.
IV	Reject H_o	Reject H_o	Either result	**Interpretation:** Selectivity during both 1st and 2nd events. **Action**: Abundance: Use a stratified Petersen-type model, with estimates calculated separately for each stratum. Sum stratum estimates for overall abundance. Composition: Combine stratum estimates according to Equations 1-3 below.
V	Fail to reject H_o	Fail to reject H_o	Reject H_o	**Interpretation:** The results of the 3 tests are inconsistent. **Action:** Need to determine which of Cases I-IV best fits the data. Inconsistency can arise from high power of the M vs. C test or low power of the tests involving R. Examine sample sizes (generally M or C from < 100 fish and R from < 30 are considered small), magnitude of the test statistics (D_{max}), and the *P*-values of the three tests to determine which of which of Cases I-IV best fits the data.

COMPOSITION ESTIMATION FOR STRATIFIED ESTIMATES

An estimate of the proportion of the population in the k^{th} size or sex category for stratified data with I strata is calculated as follows:

$$\hat{p}_k = \sum_{i=1}^{I} \frac{\hat{N}_i}{\hat{N}} \hat{p}_{ik} \,, \tag{1}$$

with variance estimated as

$$var\left[\hat{p}_k\right] \approx \frac{1}{\hat{N}^2} \sum_{i=1}^{I} \left(\hat{N}_i^2\, var\left[\hat{p}_{ik}\right] + \left(\hat{p}_{ik} - \hat{p}_k \right)^2 var\left[\hat{N}_i\right] \right), \tag{2}$$

where

$\hat{p}_{ik}$ = estimated proportion of fish belonging to category k in stratum i;

$\hat{N}_i$ = estimated abundance in stratum i; and

$\hat{N}$ = estimated total abundance

$$= \sum_{i=1}^{I} \hat{N}_i \,. \tag{3}$$

Appendix E2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).Tests of Consistency for Petersen Estimator.

Three contingency table analyses are used to determine if the Petersen estimate can be used (Seber 1982). If any of the null hypotheses are not rejected, then a Petersen estimator may be used. If all three of the null hypotheses are rejected, a temporally or spatially-stratified estimator (Darroch 1961) should be used to estimate abundance.

Seber (1982) describes 4 conditions that lead to an unbiased Petersen estimate, some of which can be tested directly:

1. Marked fish mix completely with unmarked fish between events.
2. Equal probability of capture in event 1 and equal movement patterns of marked and unmarked fish.
3. Equal probability of capture in event 2
4. The expected number of marked fish in recapture strata is proportional to the number of unmarked fish.

In the following tables, the terminology of Seber (1982) is followed, where *a* represents fish marked in the first event, *n* fish captured in second event and *m* marked fish recaptured; $m_{\bullet j}$ and $m_{i\bullet}$ represent summation over the i^{th} and j^{th} indices, respectively.

I. Mixing Test

Tests the hypothesis (condition 1) that movement probabilities (θ_{ij}), describing the probability that a fish moves from marking stratum *i* to recapture stratum *j*, are independent of marking stratum: H_0: $\theta_{ij} = \theta_j$ for all *i* and *j*.

Area/Time Marking Strata *(i)*	Area/Time Recapture Strata *(j)*				Not Recaptured
	1	2	…	t	$a_i - m_{i\bullet}$
1	m_{11}	m_{12}	...	m_{1t}	$a_1 - m_{1\bullet}$
2	m_{21}	m_{22}	...	m_{2t}	$a_2 - m_{2\bullet}$
...	...	...	...	...	…
s	m_{s1}	m_{s2}	...	m_{st}	$a_s - m_{s\bullet}$

II. Equal Proportions Test[a] (SPAS[b] terminology)

Tests the hypothesis (condition 4) that the marked to unmarked ratio among recapture strata is constant: H_0: $\Sigma_i a_i\theta_{ij}/U_j = k$, where k = a constant, U_j = unmarked fish in stratum *j* at the time of 2nd event sampling, and a_i = number of marked fish released in stratum *i*. Failure to reject H_0 means the Petersen estimator should be used only if the degree of closure among tagging strata is constant, i.e. $\Sigma_j\theta_{ij} = \lambda$ (Schwarz and Taylor 1998; p 289). A special case of closure is when all recapture strata are sampled, such as in a fishwheel to fishwheel experiment, where $\Sigma_j\theta_{ij} = 1.0$; otherwise biological and experimental design information should be used to assess the degree of closure.

	Area/Time Recapture Strata *(j)*			
	1	2	…	t
Recaptured ($m_{.j}$)	$m_{\bullet 1}$	$m_{\bullet 2}$	…	$m_{\bullet t}$
Unmarked (n_j - $m_{.j}$)	n_1 - $m_{\bullet 1}$	n_2 - $m_{\bullet 2}$	…	n_t - $m_{\bullet t}$

III. Complete Mixing Test[a] (SPAS[b] terminology)

Tests the hypothesis that the probability of re-sighting a released animal is independent of its stratum of origin: H_0: $\Sigma_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in recapture stratum j during the second event, and d is a constant.

	Area/Time Marking Strata *(i)*			
	1	2	…	s
Recaptured (m_i)	$m_{1\bullet}$	$m_{2\bullet}$	…	$m_{s\bullet}$
Not Recaptured (a_i - $m_{i\bullet}$)	$a_1 - m_{1\bullet}$	$a_2 - m_{2\bullet}$	…	$a_s - m_{s\bullet}$

[a] There is no 1:1 correspondence between Tests II and III and conditions 2-3 above. It is pointed out that equal probability of capture in event 1 will lead to (expected) non-significant Test II results, as will mixing, and that equal probability of capture in event 2 along with equal closure ($\Sigma j\theta ij = \lambda$) will also lead to (expected) non-significant Test III results.

[b] Stratified Population Analysis System (Arnason, A.N., C.W. Kirby,C.J. Schwarz and J.R. Irvine. 1996. Computer Analysis of Data from Stratified Mark-Recovery Experiments for Estimation of Salmon Escapements and Other Populations, Canadian Technical Report of Fisheries and Aquatic Sciences 2106.