Regional Operational Plan No. SF.1J.2013.07

Chilkat River Chinook Salmon Escapement Studies in 2013

by

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and

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June 2013

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 SF.1J.2013.07

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Richard S. Chapell and Brian W. Elliott

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

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Division of Sport Fish

June 2013

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SIGNATURE/TITLE PAGE

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PURPOSE

The purpose of this study is to estimate Chilkat River Chinook salmon (*Oncorhynchus tshawytscha*) inriver abundance, escapement, and age-sex-length compositions in 2013. The Chilkat River (Figure 1) is considered the third or fourth largest producer of Chinook salmon in Southeast Alaska (McPherson et al. 2003). In 2003, the department 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 department to manage fisheries to achieve an inriver run goal of 1,850 to 3,600 large (age 1.3 and older) Chinook salmon upstream of the department fish wheels located at milepost 9 (MP 9) of the Haines Highway. Chilkat River Chinook salmon is a Pacific Salmon Commission (PSC) 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). A key component of stock assessment is estimating annual abundance and age and sex composition. Accurate stock assessment data will improve run forecasting accuracy and will support sustainable exploitation of the Chilkat River Chinook salmon stock in sport and commercial fisheries in Southeast Alaska.

From 1981 to 1992, Chilkat River Chinook salmon abundance was monitored by aerial survey counts on 2 clearwater spawning tributaries to the Chilkat River: Big Boulder Creek and Stonehouse Creek. Starting in 1991, inriver mark-recapture estimation was initiated to more precisely estimate drainagewide abundance and to sample the three principal spawning areas, Kelsall River, Tahini River, and Klehini River, all tributaries with glacially occluded waters. From 1991 through 2012, Inriver abundance estimates ranged from 1,442 (SE = 227) to 8,100 (SE = 1,193) large Chinook salmon, and averaged 3,928 (SE = 604) large Chinook salmon. The lower bound of the inriver goal has been achieved in 19 of the 22 years that abundance has been estimated by mark-recapture methods.

BACKGROUND

The Chilkat River is one of the principal producers of Chinook salmon in Southeast Alaska (McPherson et al. 2003), and it is an indicator stock that is included in PSC forecasts of the aggregate abundance of Chinook salmon stocks subject to management under the PST. The Chinook Technical Committee (CTC) of the PSC determines the annual all-gear quota for Southeast Alaska, which is allocated as specified in 5 AAC 29.060 (Allocation of king salmon in the Southeastern-Yakutat Alaska Area). There are several sources of harvest of the Chilkat stock, including commercial troll fisheries, commercial drift gillnet fisheries, commercial purse seine fisheries, and various sport fisheries in Southeast Alaska, including the spring marine boat fishery in Chilkat Inlet near Haines (Table 1).

Restrictive management of the sport fishery began in 1987 when high harvests of Chinook salmon coincided with low index counts. 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). In 1989, the Haines King Salmon Derby was suspended because of conservation concerns. Restrictions increased in the following years until the fishery was closed in 1991 and 1992. The fishery was reopened in 1993 and the Haines King Salmon Derby was reinstated in 1995.

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

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

Note: The sport fishery was closed in Chilkat Inlet in 1991, 1992, and Chinook salmon harvest was prohibited in Chilkat Inlet in 2008.

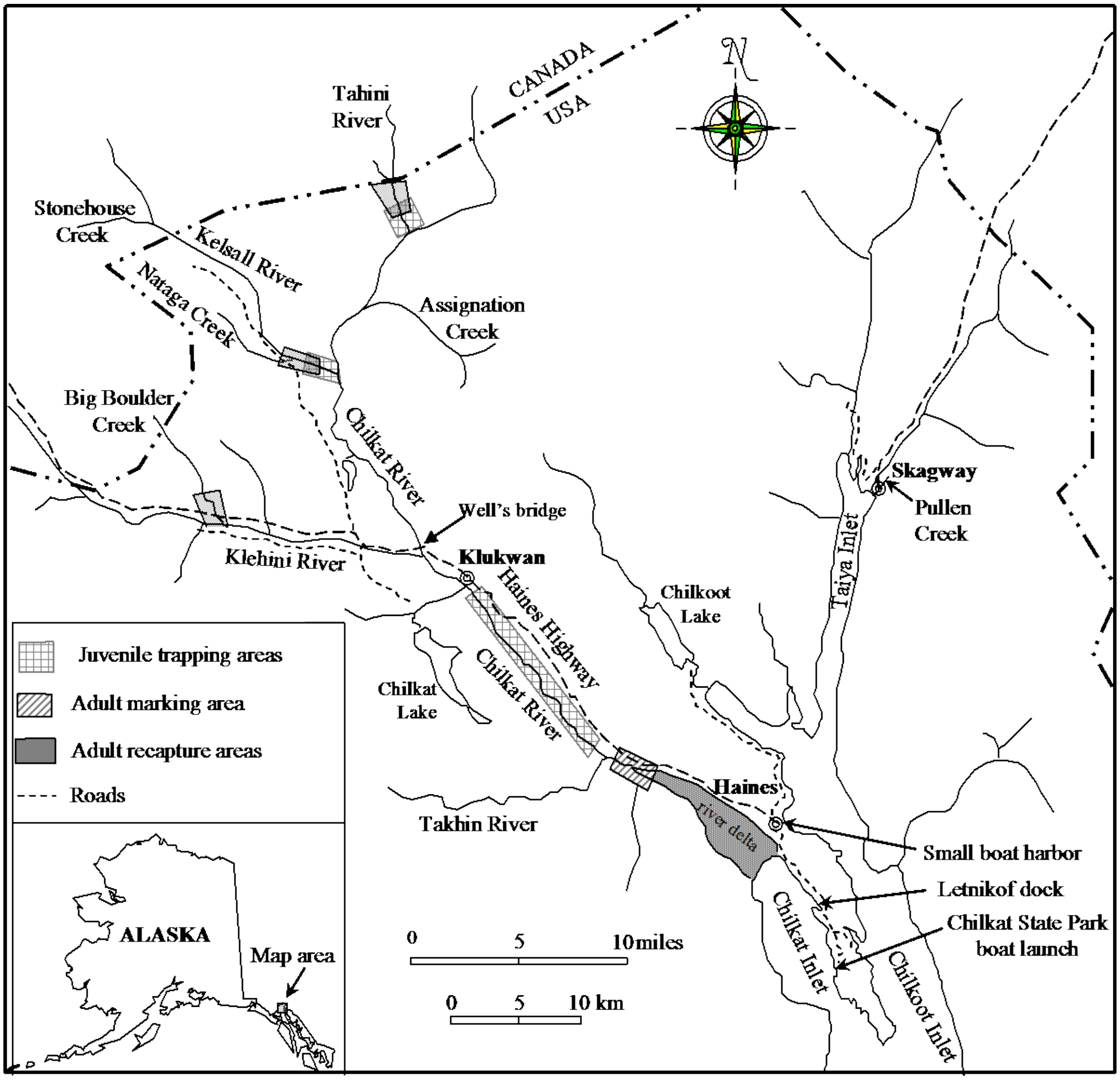


Figure 1.–The Chilkat River drainage showing the location of sampling sites.

From 1981 through 1992, the Chilkat River Chinook salmon escapement was monitored through peak survey counts on clearwater tributaries to the Chilkat River (Big Boulder Creek, Stonehouse Creek) as an index of abundance (Pahlke 1992). Mark-recapture experiments have been used to estimate the abundance of large Chinook salmon entering the Chilkat River since 1991. 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). Mark-recapture estimates of the inriver abundance of large Chinook salmon have ranged from 1,442 to 8,100 fish (Table 2). In 2003, the department adopted an escapement goal range of 1,750–3,500 (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, based on mark-recapture

Table 2.–Parameters used to estimate the inriver abundance of large (≥age-1.3) Chilkat River Chinook salmon, 1991–2012.

	Event 1		Event 2												
	Gill-net M	Fish wheel M	Kelsall/ Nataga C	R	Tahini gillnet C	R	Tahini other[a] C	R	Klehini tribs[b] C	R	Total C	R	Inriver abundance	SE	RP[c]
1991[d]	80	145	507	15	155	9	39	2	30	0	733	27	5,897	1,005	0.28
1992[e]	148	ND	571	18	158	4	156	1	20	0	905	23	5,284	949	0.30
1993[f]	159	ND	445	15	90	4	43	1	36	1	614	21	4,472	851	0.31
1994[g]	212	84	482	24	ND	ND	250	5	44	4	776	33	6,795	1,057	0.26
1995[h]	121	59	240	11	ND	ND	84	4	59	2	383	17	3,790	805	0.35
1996[i]	188	45	328	13	ND	ND	257	14	129	6	714	33	4,920	751	0.25
1997[j]	189	128	487	21	ND	ND	400	13	80	3	967	37	8,100	1,193	0.24
1998[k]	166	61	385	21	ND	ND	112	8	34	3	531	32	3,675	565	0.25
1999[l]	108	124	121	14	ND	ND	53	7	59	2	233	23	2,271	408	0.30
2000[m]	86	31	216	14	ND	ND	112	6	148	5	476	25	2,035	334	0.27
2001[n]	174	72	366	23	ND	ND	211	11	119	5	695	39	4,517	722	0.26
2002[o]	236	170	325	31	ND	ND	203	19	121	13	649	63	4,050	433	0.18
2003[p]	206	126	264	14	ND	ND	518	33	96	3	878	50	5,657	690	0.20
2004[q]	126	82	307	20	ND	ND	262	14	96	5	665	39	3,422	456	0.22
2005[r]	133	54	210	12	ND	ND	198	9	73	4	496	26	3,358	550	0.27
2006[s]	73	70	333	15	ND	ND	321	14	163	8	820	37	3,027	437	0.24
2007[t]	65	22	119	10	ND	ND	108	6	46	1	276	17	1,442	227	0.26
2008[u]	100	46	150	8	ND	ND	207	7	82	4	439	19	2,905	544	0.31
2009[v]	113	86	103	5	ND	ND	444	16	76	4	623	25	4,429	586	0.22
2010[w]	97	41	43	5	ND	ND	279	23	39	2	361	30	1,815	226	0.20
2011[x]	107	109	198	20	ND	ND	319	19	52	4	569	43	2,810	359	0.21
2012[y]	76	51	146	15	ND	ND	125	8	68	2	339	25	1,744	129	0.12
1991–2012 average	136	77	254	16			235	12	83	4	573	32	3,724	551	0.24

Note: M = number marked, C = number caught and examined, and R = number of marked fish recaptured.

[a] Sampling at this site was not consistent before 1994.

[b] Includes Big Boulder, Little Boulder, and 37-Mi. creeks.

[c] Relative precision (90%) = 1.645 x SE / estimate.

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

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

[f] Taken from Johnson (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 *(in prep a*).

[y] Taken from Chapell *(in prep b*).

estimates (5 AAC 33.384, Ericksen and McPherson 2004). The escapement goal range will be refined with spawner-recruit data derived from the escapement estimate combined with smolt emigrations, marine survival, and marine harvest estimates provided by an ongoing juvenile coded wire tagging (CWT) study described in a separate operational plan.

The 2007 Chilkat River Chinook salmon inriver run was estimated at 1,442 (SE = 227) large fish, which was below the goal range. In 2008, the preseason forecast for Chilkat River Chinook salmon inriver abundance was below the minimum goal, so in May and June 2008 the Chilkat Inlet was closed to commercial drift gillnet fishing and retention of Chinook salmon by sport anglers, and cancelation of the Haines King Salmon Derby. The 2008 inriver abundance was within the goal range (Table 2). The 2013 preseason forecast is an inriver run of 2,000 large fish, which is within the goal range, so harvest restrictions in Chilkat Inlet will not be required.

In 1984–1988, an average of 1,196 Chinook salmon was harvested in the Haines area spring sport fishery (Table 1). In 1989–2012, excluding the Chilkat Inlet closure years 1991, 1992, and 2008, the Haines sport fishery harvested an average of 250 Chinook salmon. High harvests in 1984–1988 could have been the result of higher returns of Chinook salmon to the Chilkat River, higher effort, angling opportunity in a productive fishing area at the Chilkat River mouth, or a combination of factors. The Lynn Canal and Chilkat River King Salmon Fishery Management Plan (5 AAC 33.384) is intended to allow annual escapements in the goal range that will optimize Chinook salmon production.

The Chilkat River stock and 10 other Chinook salmon stocks in this region are used in coastwide abundance-based management by the Pacific Salmon Commission (PSC 1994). The Chilkat River stock is one of over 50 Chinook salmon escapement indicator stocks included in annual assessments by the CTC of the PSC. The CTC determines stock status through formulation of an abundance index (AI), which sets harvest levels to comply with the PST. The PST is renewed every 10 years, and was recently renegotiated in 2008. The agreement calls for continuation of abundance-based management of Chinook salmon coastwide, and for improved stock assessment, escapement goals, and modeling. To that end, the estimation methods for escapement, harvest, and run forecasting for this stock are being improved. A CWT program was started in 2000 to improve marine harvest and smolt emigration estimates, important components of production estimation. Preseason forecasts using sibling regression have also been developed. Additionally, the CTC is in the process of improving the PSC Chinook Model to include inriver abundance and age data for Chilkat River Chinook salmon. Chilkat River production estimates will directly contribute to the AI, which in turn will determine harvest levels in Southeast Alaska under the PST. Data from the Chilkat River escapement estimation project is important for management of this stock and Southeast Alaska stocks.

OBJECTIVES

The primary research objectives for 2013 are to:

1) estimate the inriver abundance of large (age 1.3 and older) Chinook salmon in the Chilkat River upstream of the department’s tagging site at Haines Highway MP 9, so that precision is within 30% of the estimate when constructing a 90% confidence interval;

2) estimate the age and sex compositions of the inriver run of large Chinook salmon in the Chilkat River, so that precision is within 10% of the estimate when constructing a 90% confidence interval.

SECONDARY OBJECTIVES

The secondary research objectives for 2013 are to:

1) sample all adult Chinook salmon captured during this experiment for adipose fin clips and CWTs placed on juvenile Chinook salmon from brood years 2006–2010;

2) estimate abundance of age-1.2 Chinook salmon immigrating to the Chilkat River. The precision of this estimate will depend on the number of age-1.2 fish sampled and present in the drainage;

3) collect length information from sampled Chinook salmon.

METHODS

The abundance of large (age 1.3 and older) as well as age-1.2 Chinook salmon entering the Chilkat River in 2013 will be estimated using a 2-sample mark-recapture experiment 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 24. Adult Chinook salmon will be captured and inspected for marks in event 2 from August 1 through 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 length compositions (Primary Objective 2) will be estimated from the event 1 and event 2 samples.

ABUNDANCE ESTIMATE

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 24, 2013. Ninety-eight percent of the Chinook salmon captured in 1991–2012 were caught from June 12 to July 21 (Figure 2). The net will consist of 2 panels of equal length: one with 6¾ in (171 mm) mesh, and the other with 8 in (203 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 that day's fishing. There will be a minimum of 3 nets on hand for fishing. In addition, we will assist Division Commercial Fisheries personnel in operating 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.

A crew of at least 2 people will operate a skiff during drift gillnet capture and tagging. Six 400 m (0.25 mi) long areas of the Chilkat River between Haines Highway MP 7 and MP 9 will be fished in 2013 (Figure 3). The CPUE of Chinook salmon in the drift gillnet is higher earlier in the day (Figure 4), so the equivalent of 43 drift areas will be fished between 0630 and 1400 each day. When a drift is interrupted to bring captured fish aboard, the proportion of each incomplete drift will be recorded, and additional drifts will be made to complete the equivalent of 43 drift areas each day. If 43 drift areas cannot be completed in a day, the remainder will be added to the goal for the next day. The tagging crew will be responsible for keeping the number of drifts completed in each of the 6 areas as even as possible each day.

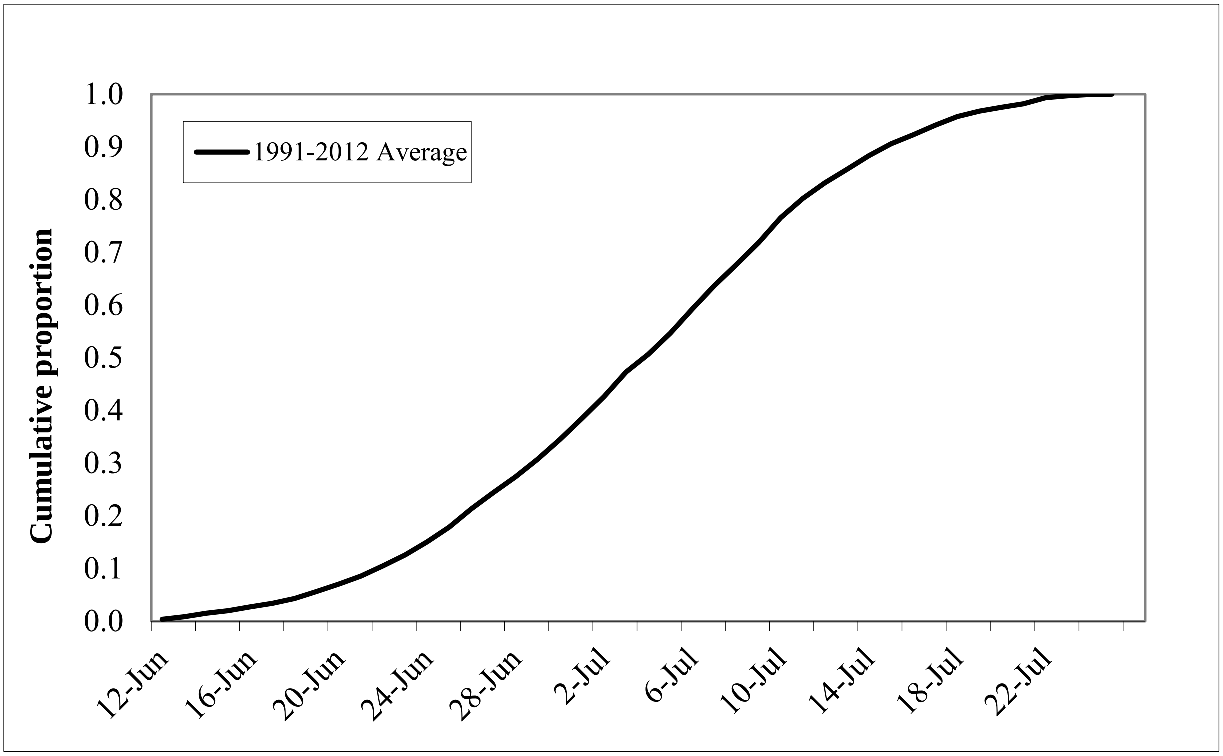


Figure 2.–Mean catches (top) and cumulative proportions (bottom) of large Chinook salmon captured in the drift gillnet by day, Chilkat River near Haines Highway milepost 8, 1991–2012.

Care will be taken not to injure Chinook salmon during capture. Fish will be retrieved immediately after entanglement in the net by lifting the webbing, while supporting the weight of the fish, into a tagging tank, including a leather sling submerged in fresh river water, on board the skiff. The fish will then be immediately and carefully untangled or cut from the net. The fish wheel holding pens will be emptied of Chinook salmon at least twice each day.

Every Chinook salmon captured by fish wheel or gillnet will be measured to the nearest 5 mm MEF length, examined externally to estimate the 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 ¼ in (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 MEF, and a t-bar anchor tag for fish <440 mm MEF. 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 appendage (LAA), which is located at the base of the left pelvic fin. This tertiary mark will allow us to detect differences in tag loss between fish captured by gillnet and by fish wheel. Fish with deep scars or lesions, damaged gill filaments, or in lethargic condition 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 other marks.

A portable wand CWT detector will be used at the tagging sites to check all adipose-finclipped Chinook salmon for a CWT in the head and a CWT in the body around the base of the dorsal fin.

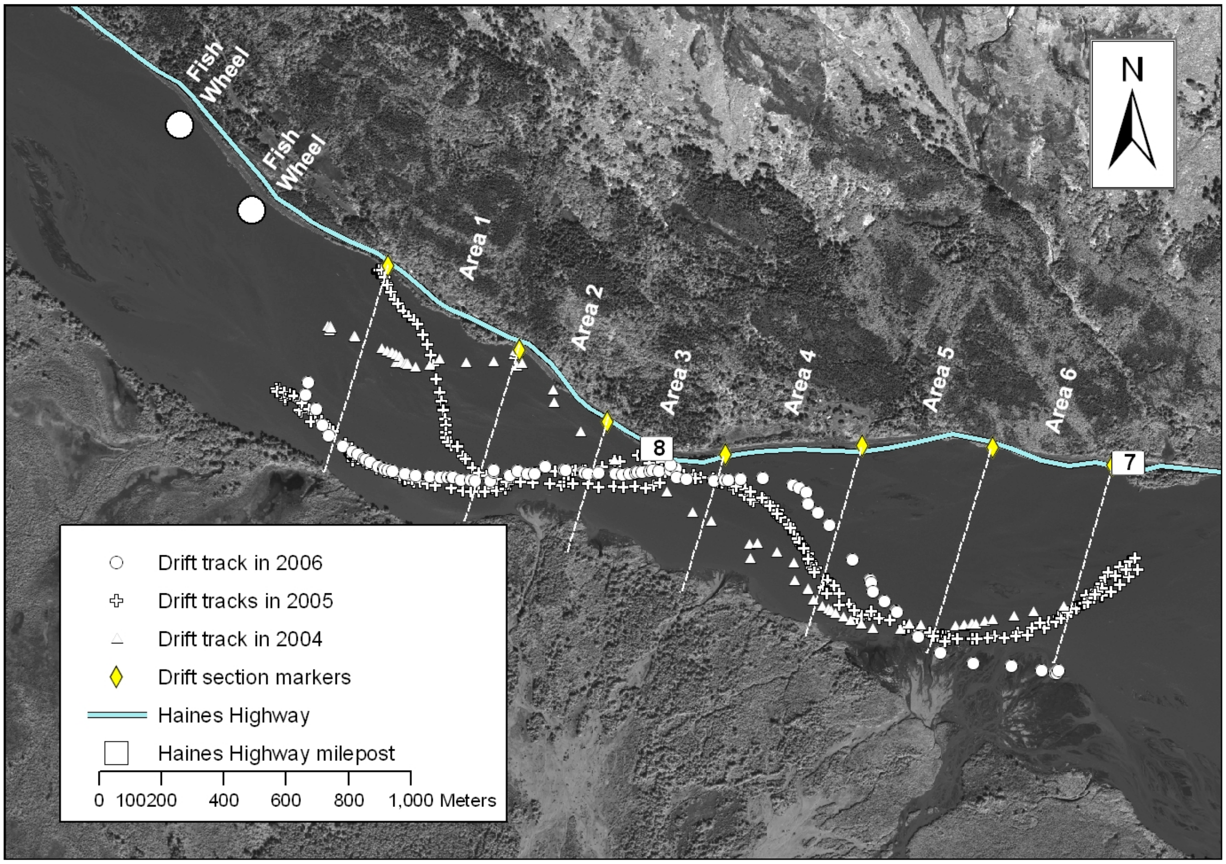


Figure 3.–Drift gillnet areas and fish wheel locations in the lower Chilkat River, 2004–2006.

Drift gillnet and fish wheel staff will be instructed in portable wand CWT detector operation using instruction materials provided by the manufacturer. Important scanning techniques are: 1) insert the wand inside the oral cavity of large fish to improve detection of deeply embedded CWTs; and 2) identify magnetized items in the sampling area that could cause false positive CWT detection.

All adipose-finclipped Chinook salmon <660 mm MEF will be sacrificed for CWT recovery. Adipose-finclipped fish ≥660 mm MEF that test positive for CWT presence in the head will be tagged and released. Adipose-finclipped fish ≥660 mm MEF that test negative for a head 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, Age and Tag Laboratory in Juneau for CWT recovery and decoding.

Event 2, Spawning Grounds

The spawning ground sampling effort will:

- examine as many Chinook salmon as possible for the primary and secondary marks applied at the lower Chilkat River tagging sites (Primary Objective 1);
- sample as many Chinook salmon as possible for age, sex, and length (Primary Objective 2, Secondary Objective 3); and
- examine as many Chinook salmon as possible for missing adipose fins, scan all adipose-finclipped fish for head and dorsal CWTs, and collect heads from adipose-finclipped fish (Secondary Objective 1).

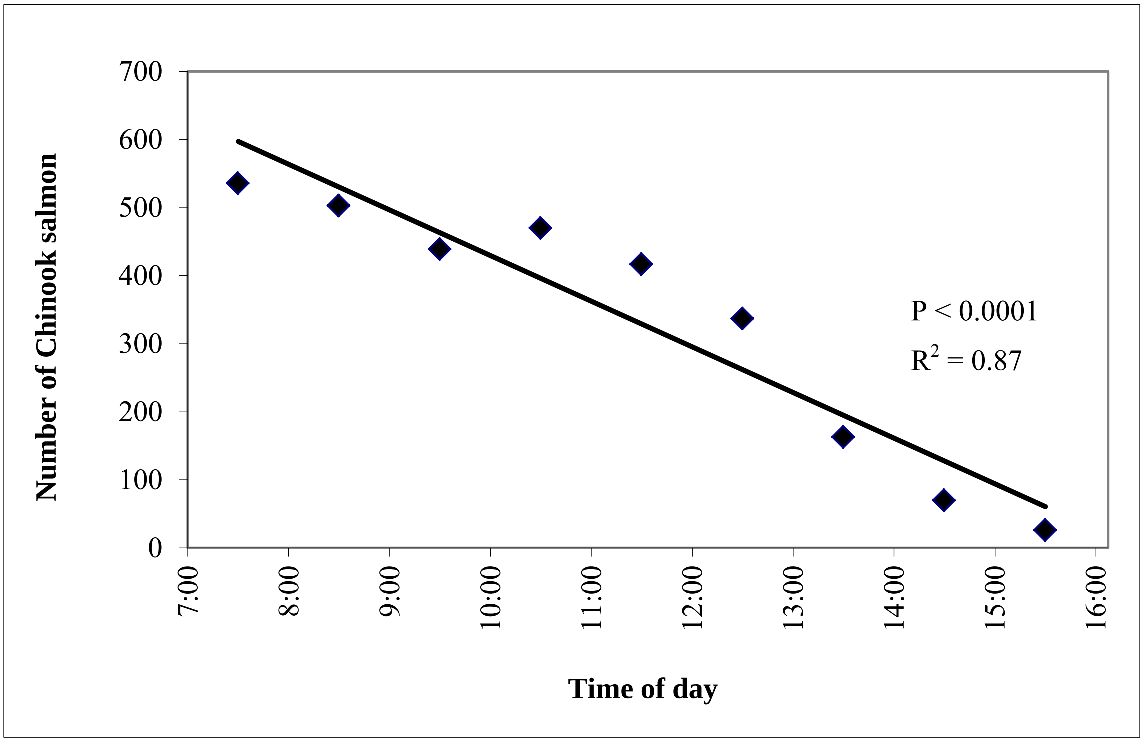


Figure 4.–Total catch of Chinook salmon in the lower Chilkat River drift gillnets by hour of day, 1992–2012.

Snagging gear, dip nets, short gillnets, and beach seines will be used to collect live adults, and a spear or hands will be used to collect dead and moribund Chinook salmon. It is important that samplers not select fish to sample based on fish size, sex, or tag status. Spaghetti tags are not to be removed from live fish. However, spaghetti tags will be removed from sampled carcasses. The sides of carcasses will be slashed after sampling so sampled carcasses will be identifiable at a distance.

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 r sample sizes and to minimize bias that would result from any small annual differences in the marked fractions by recovery area.

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 radiotelemetry study years 1991, 1992, and 2005). On average during 1994–2012, 97% of Chinook salmon samples were collected between July 30 and August 31 (Figure 5). Areas of Chinook salmon abundance will be accessed primarily on foot and by boat. Sampling on the Tahini River spawning grounds may be discontinued earlier if the number of fish sampled indicates that die-off is complete (i.e., 1 to 2 fish sampled per day for several days). If problems occur such as injury or equipment failure, sampling effort will not be reduced on the Kelsall River in favor of the Tahini River.

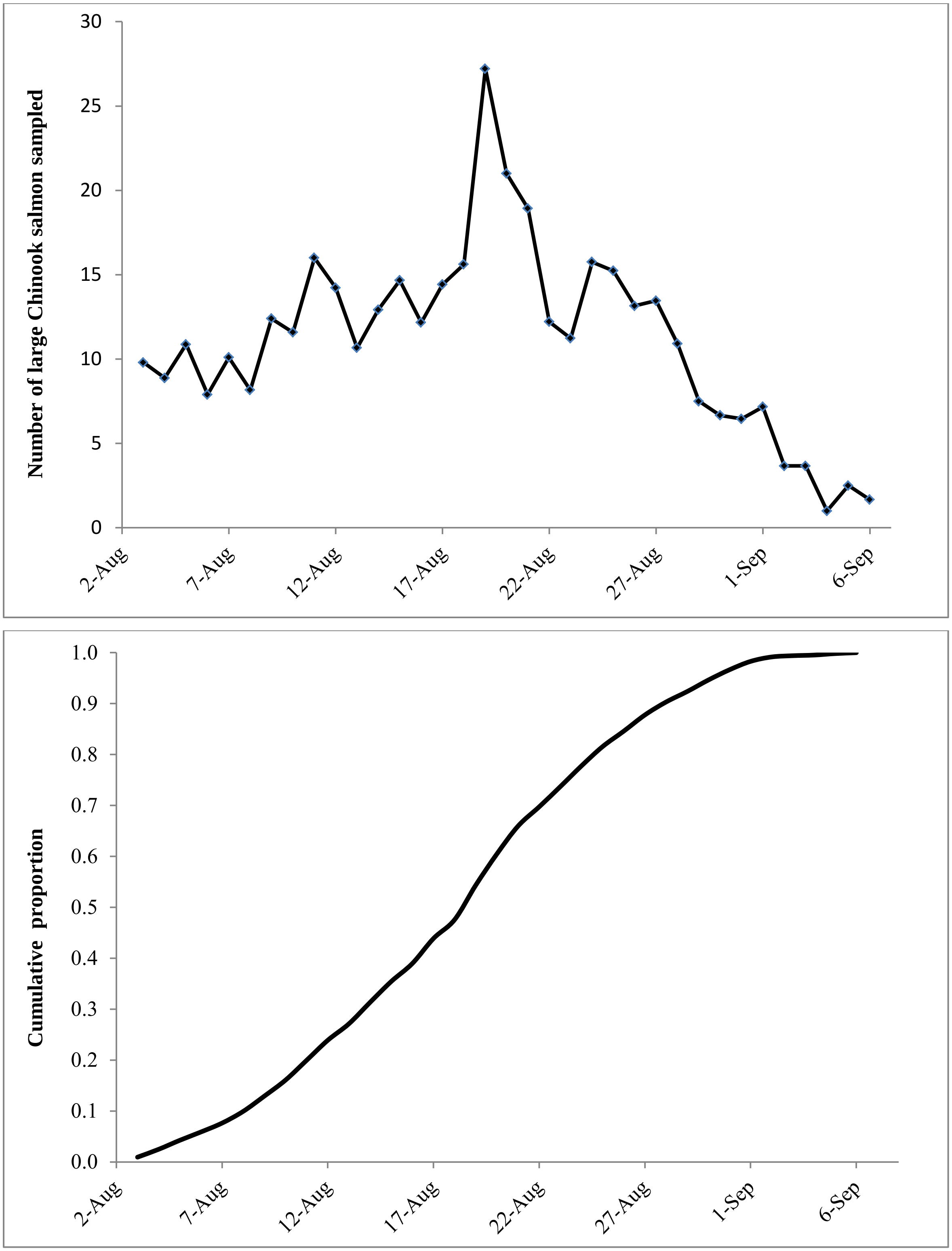


Figure 5.–Mean numbers (top) and cumulative proportions (bottom) of large Chinook salmon captured per day in the Tahini River drainage, 1994–2012.

A crew of 2 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) between August 2 and September 2, when 97% of Chinook salmon were sampled in 1994–2012 (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 Nataga Creek bridge, 29% upstream of the bridge but downstream of the upper canyon, 39% 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 A1). Most (71%) of the upper canyon spawners did not wash down below the Nataga bridge. The upper Kelsall canyon area, designated as area D, will be sampled periodically to access the large spawning component and the postspawners that do not wash down to the lower Kelsall areas. Areas of Chinook salmon abundance will be accessed on foot.

A crew of 2 people will sample fish for marks in Klehini River tributaries (where 4%, 5%, and 15% of Chinook salmon spawning occurred in 1991, 1992, and 2005) every 4–5 days in August. 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.

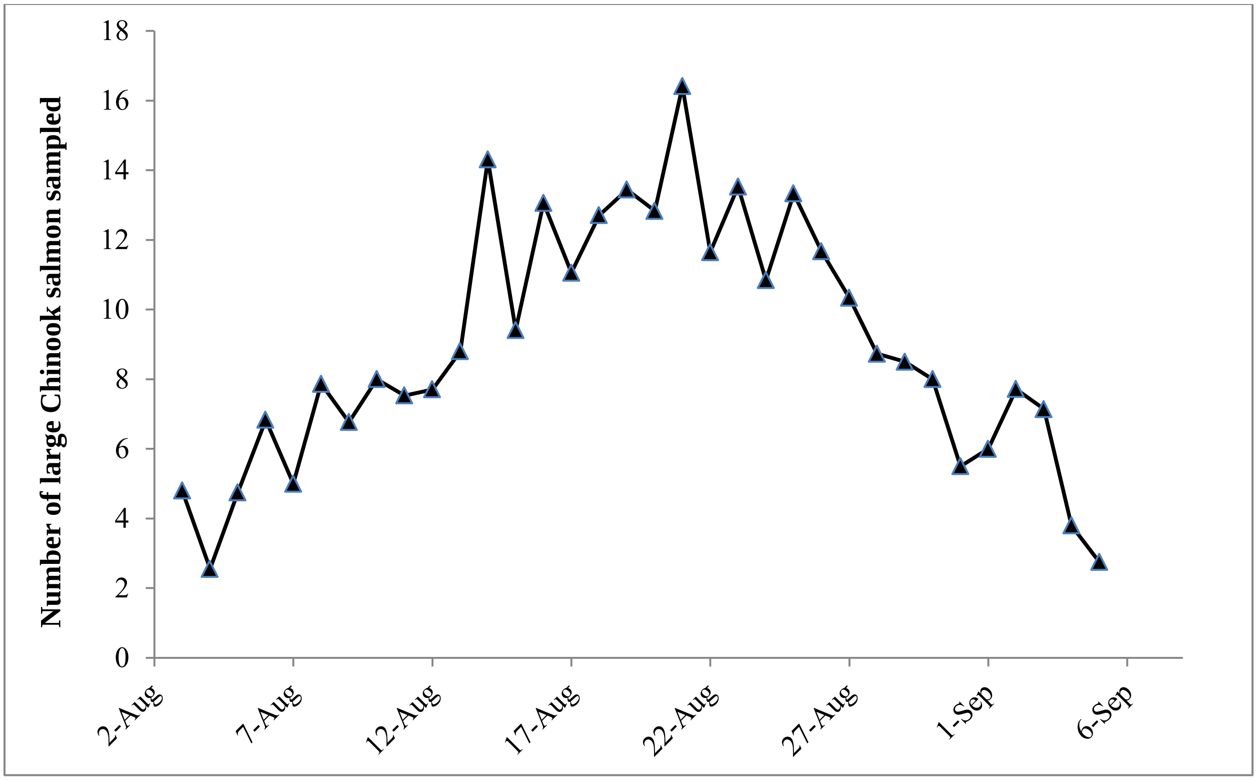
Chinook salmon captured on the spawning grounds will immediately be removed from the sampling gear. If a fish has not been previously sampled on the spawning grounds, as indicated by the presence of a LLOP, it will be examined for a spaghetti tag, adipose fin, and a ULOP. In addition, it will be sampled for sex, length (MEF), 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 LAA clip. When sampling in the Kelsall River drainage, the sampling area as listed in Appendix A will be recorded.

Spawning ground sampling crews will use a portable wand CWT detector to scan all adipose-finclipped fish for the presence of CWTs at 2 locations: in the head and in the body (both sides) at the base of the dorsal fin. Heads will be collected from all adipose-finclipped fish <660 mm MEF and all spawned-out and dead adipose-finclipped fish regardless of length. 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, Age and Tag Laboratory in Juneau for tag reading.

Abundance Estimate - Sample Size (Primary Objective 1)

Primary Objective 1 is to estimate the inriver abundance of large Chinook salmon in the Chilkat River upstream of the department's tagging site at Haines Highway MP 9, so that precision is within 30% of the estimate when constructing a 90% confidence interval.

Based on previous year's returns of younger fish from the same brood year (i.e., number of age 1.3 in 2012 is used to forecast the number of age 1.4 fish in 2013), the total return forecast is 2,482 large Chilkat River Chinook salmon in 2013 (Table 3). Assuming average exploitation rates in Lynn Canal commercial gillnet, sport, and subsistence fisheries, we expect an inriver run ($\hat{N}$) of 2,037 large Chinook salmon.



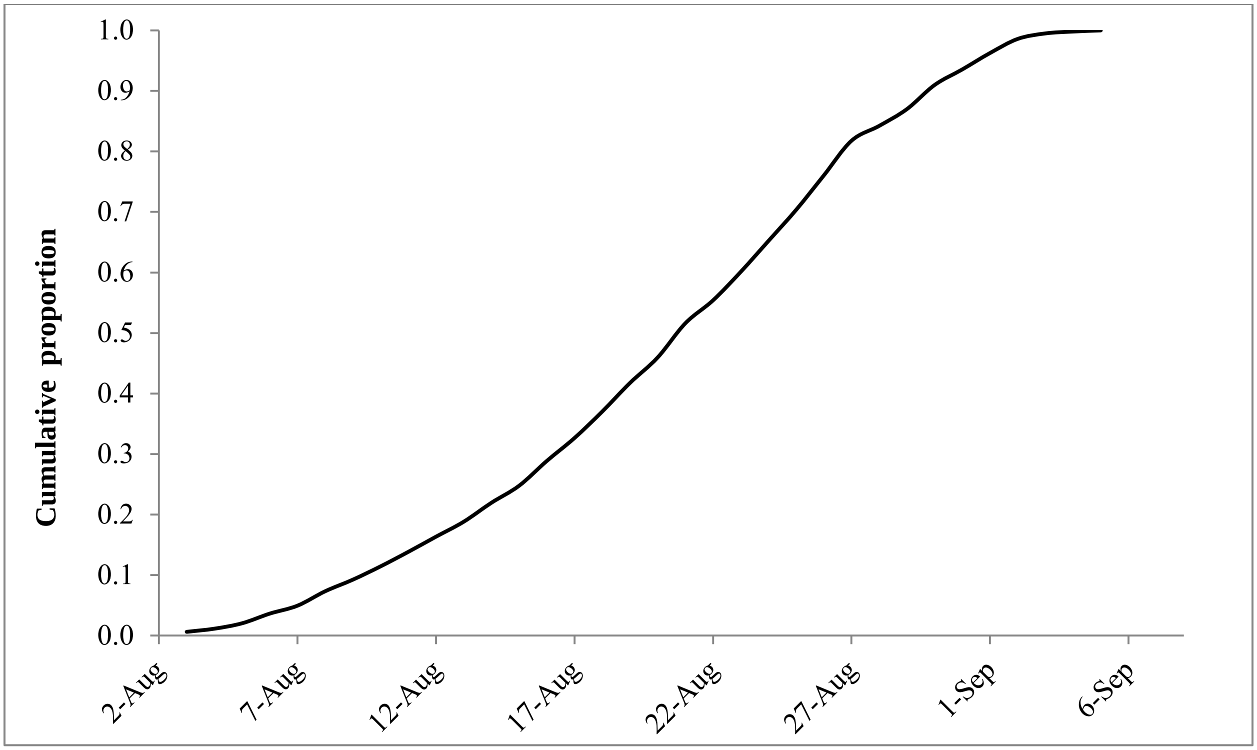


Figure 6.–Mean numbers (top) and cumulative proportions (bottom) of large Chinook salmon captured per day in the Kelsall River drainage, 1994–2012.

Table 3.–Predicted 2013 return, inriver run, and catch of large Chinook salmon in the lower Chilkat River sampling gear by age and gear type.

Brood year	2008	2007	2006	
Age	1.3	1.4	1.5	Total
Return[a]	569	1,905	7	2,482
Inriver run[b]	450	1,582	5	2,037
Gillnet				
q_{age}[c]	0.036	0.037	0.074	
Catch	16	59	0	76
Fish wheels				
q_{age}[d]	0.026	0.021	0.021	
Catch	12	34	0	45

[a] Predicted return of Chilkat River Chinook to Lynn Canal is based upon a regression of sibling returns (e.g., the return of age-1.4 fish in year *t* is forecast from the return of age-1.3 fish in year *t*-1).

[b] Difference between return and inriver run is marine harvest at historic average rates in Lynn Canal commercial drift gillnet fishery, Chilkat Inlet subsistence fishery, and Haines sport fishery.

[c] Average catchability-at-age in the lower river drift gillnet from 1991 to 2012 data.

[d] Average catchability-at-age in the fish wheels from 1991 to 2012 data.

Assuming average catchability-at-age (q_{age}), we expect to capture 76 large Chinook salmon in the lower river gillnet and 45 in the fish wheels, for a total (n_1) of 121 fish marked. Based on historical sampling data, we expect to sample 143 large Chinook salmon for marks in the Kelsall River drainage, 137 on the Tahini River, and 53 in Klehini River tributaries including Big Boulder Creek, for a total (n_2) of 333 large Chinook salmon inspected (Table 4). Applying the 1994–2012 average drainagewide marked fraction $\theta = 0.059$, we expect (m_2) 20 marks will be recovered (Table 5). The expected mark-recapture parameters would produce an abundance estimate of 1,960 large Chinook salmon with a standard error of 370, and a 90% relative precision (RP) of ±0.31, which fails to meet the statistical target of 0.30 (Primary Objective 1).

Table 4.–Predicted 2013 captures of large Chinook salmon by age and spawning area.

Brood year	2007	2006	2005	
Age	1.3	1.4	1.5	Total
Inriver run	450	1,582	5	2,037
Kelsall				
q_{large}[a]				0.070
Catch	31	111	0	143
Tahini				
q_{large}[a]				0.067
Catch	30	107	0	137
Klehini				
q_{large}[a]				0.026
Catch	12	41	0	53

[a] Average proportion of large Chinook salmon escapement sampled by spawning area, from 1991–2012 data.

Table 5.–Predicted 2013 mark-recapture parameters and Petersen abundance estimate of large Chinook salmon escaping to the Chilkat River drainage. The estimate of m_2 is based on average marked fraction on the spawning grounds.

Peterson estimator	
n1[a]	121
n2[b]	333
m2[c]	20
$\widehat{N}$	1,960
$V(\widehat{N})$	137,161
$SE(\widehat{N})$	370
CV, %	19
RP[d]	0.311

[a] Estimate of number of tags (n_1) from average catchability-at-age of lower river drift gillnet and fish wheels, 1991–2012.

[b] Estimate of spawning ground captures (n_2) from average sampling rate of large Chinook salmon, 1994–2012. Spawning ground sampling was not consistent prior to 1994.

[c] Estimate of number of recoveries (m_2) based on 1994–2012 average marked fraction $\theta = 0.059$.

[d] Relative precision (90%) = 1.645 x SE /estimate.

Alternatively, we can look at the 2012 study results as a model for precision in below-average inriver abundance years, such as is forecast for 2013. In 2012, event 1 marked 127 large Chinook salmon, event 2 captured 339 fish, of which 25 were recaptures (Table 2). Inriver abundance was estimated at 1,744 large fish, with SE = 129 and 90% RP = 0.12, well within the precision criteria. In the other 3 years (2000, 2007, and 2010) with estimated inriver abundance at or less than 2,000 large fish, relative precision has also been within 30% of the estimate when constructing a 90% confidence interval.

The event 1 and event 2 effort and sampling design has been consistent for most of the 22-year span (1991–2012) of this project. Variations in event 1 effort were that the fish wheels were not used in 1992 and 1993 (Table 2). Variations in event 2 effort were that gillnets were used in at the Tahini River mouth in 1991–1993, and Kelsall River sampling effort was reduced from 7d/week in 1991–2008 to 5d/week in 2009–2012. 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 5d/week until the number of unique fish encountered returns to historic levels, e.g., ≥200 fish per season.

The precision criterion of ±0.30 has been met in 19 of 22 (86%) previous experiments and precision has ranged from 0.12 to 0.35 (Table 2). Primary Objective 1 was not met only once in the last 17 years (2008), when the number of marks recovered was very low. The sampling design yields better than average precision in years with high abundance and/or good environmental conditions (when sampling efficiency improves), and lower than average precision when abundance is low and/or sampling conditions are poor. Similar to prior years, we will make every effort to meet or exceed the projected 333 large Chinook salmon inspections in event 2.

Age and Sex Compositions of the Inriver Run - Sample Size (Primary Objective 2)

Primary Objective 2 is to estimate the age and sex compositions of the inriver run of large Chinook salmon in the Chilkat River, so that precision is within 10% of the estimate when constructing a 90% confidence interval.

All Chinook salmon caught in the lower river and all live and dead fish encountered on the spawning grounds will be sampled for age, length, and sex. Age compositions in the lower river gillnet and fish wheel sampling and in each escapement sampling location (tributary) will be tabulated separately. Assuming no sex or size selectivity (see Data Analysis), 126 large fish must be collected to meet objective criteria according to the theory of Thompson (1987), based on an inriver run of 2,037 large fish and being unable to read 20% of scales. Because we expect to collect scales from 121 large fish in the lower river and 333 large fish on the spawning grounds, the sampled size required to meet statistical criteria in Primary Objective 2 will be met. If size-selective sampling is detected, stratification of the abundance estimate will be required per protocols in Appendix C1. Scale ages will also be used to apportion the number of fish sampled by brood year to estimate the marked fraction by brood year (see next section).

SECONDARY OBJECTIVES

Coded Wire Tag Study (Secondary Objective 1)

As described in methods for the inriver abundance estimate mark-recapture study, all adult Chinook salmon encountered in events 1 and 2 will be examined for missing adipose fins, and all adipose-finclipped fish will be scanned for head and dorsal CWTs. Heads will be collected from adipose-finclipped fish that are <660 mm MEF length and from fish ≥660 mm MEF that are in postspawning condition. For each brood year, the number of fish examined, the number with missing adipose fins, the head and dorsal CWT wand scan results, the number of heads taken, and the number of CWTs recovered will be compiled.

During the combined 2009–2012 seasons, 285 brood year 2006 (10 missing adipose fins), and 265 brood year 2007 (22 missing adipose fins) Chinook salmon were sampled from the lower river, so the lower river tagging fractions to date are $\theta_{2006} = 0.035$ and $\theta_{2007} = 0.083$ (Table 6). In 2011 and 2012, 39 brood year 2008 Chinook salmon (3 missing adipose fins) were sampled in the lower river, so the current lower river tagging fraction is $\theta_{2008} = 0.077$. In 2013, we expect 8 (= 0.083 x 93) age-1.4 and 2 (= 0.077 x 28) age-1.3 fish with CWTs to be sampled in the lower river. In addition, we will sample fish from brood years 2006–2009 on the spawning grounds for CWTs. For each brood year, if CWT-tagged fractions are not significantly different between events 1 and 2, we will pool the samples to increase sample sizes. See the operational plan titled "Production and harvest of Chilkat River Chinook and Coho Salmon" for further details.

Abundance of Age-1.2 Fish (Secondary Objective 2)

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

Lengths (Secondary Objective 3)

Lengths will be collected as described in event 1 and 2 of the methods associated with the abundance estimate.

Table 6.–Number of brood year 2006–2008 Chinook salmon sampled for adipose fin clips[a] and the number of clips sampled in the lower Chilkat River in 2009–2012, with 2006–2008 brood year projections for 2013.

		2006 BY		2007 BY		2008 BY	
Year	Gear	Examined	Clips	Examined	Clips	Examined	Clips
2009[b]	Gillnet	0	0				
2009[b]	Fish wheels	82	4				
2010[c]	Gillnet	10	0	1	1		
2010[c]	Fish wheels	27	1	60	4		
2011[d]	Gillnet	67	4	19	1	0	0
2011[d]	Fish wheels	78	1	82	9	30	2
2012[e]	Gillnet	12	0	62	3	3	0
2012[e]	Fish wheels	9	0	41	4	6	1
Total to date		285	10	265	22	39	3
2013 projections[f]							
	Gillnet	0	0	59	5	16	1
	Fish wheels	0	0	34	3	12	1
Total (2013 projected)		0	0	93	8	28	2
Grand total through 2013		285	10	358	30	67	5

Note: BY = brood year.

[a] Number of Chinook examined by brood year was estimated by expanding unsuccessfully-aged fish by successfully-aged fish in each year class.

[b] Data taken from Chapell (2013a).

[c] Data taken from Chapell (2013b).

[d] Data taken from Chapell (*in prep a*).

[e] Data taken from Chapell (*in prep b*).

[f] Gillnet and fish wheel projections based on predicted inriver abundance of 450 age-1.3 and 1,582 age-1.4, and 5 age-1.5 fish (Table 4). Catchabilities-at-age by gear from Table 4. Marked fractions are θ_{2006}=0.035, θ_{2007}=0.083, and θ_{2008}=0.077, calculated from samples collected through 2012.

DATA COLLECTION

ABUNDANCE ESTIMATE

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 B2 and B3). Data to be recorded for each sampled fish are the date, time of day, adipose fin clip status (N = not clipped, Y

= clipped), results of CWT wand detector head and back scans (Y = CWT present, N = CWT absent), sex (based on external characteristics), length to the nearest 5 mm MEF, scale card and column number, presence of sea lice, and comments about the fish's condition or sampling irregularities. For all fish that are tagged and released, the type of tag applied and the tag number will be recorded on the data form. For all fish that are sacrificed for a CWT, 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 each day on a **Gillnet Drift Effort Form** (Appendix B4). 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 1 row.

Data unique to drift gillnet capture that are to be recorded on the **Drift Gillnet Capture Form** (Appendix B3) are fish number (consecutively numbered through the season beginning with 1), gillnet mesh panel (L = 8 in, S = 6¾ in), drift area (1 through 6), 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.

For fish wheel sampling, data that are unique to fish wheel capture that will be recorded on the **Fish Wheel Capture Form** (Appendix B2) 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, whether or not each fish was given an upper left operculum punch will be recorded (Y = yes, N = no), and an "NE" will be recorded in each data column to indicate when a 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 B5): 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 of the head and back (Y = CWT present, N = CWT not present), and length to the nearest 5 mm MEF. If the carcass is not intact, estimated MEF 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 LAA 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-finclipped carcass is scanned for CWTs, 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 COMPOSITIONS OF THE INRIVER RUN

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 left-side scales are regenerated), along a line 2 to 4 scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin (ADF&G 1990). The first scale removed is the from the center of this area (preferred scale), the second scale is 1 in to the left of the preferred scale, 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. Obviously regenerated scales are discarded and new scales are selected. 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 fish) side out. Scales are then pressed down with a finger or pencil so that it sticks 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 above.

SECONDARY OBJECTIVES

Coded Wire Tag Study (Secondary Objective 1)

A **Coded Wire Tag Sampling Form** (Appendix B1) 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-finclipped fish found will be summarized by event and by fish length category, either “CHIN” (≥660 mm MEF, species code 410) or “JACK” (<660 mm MEF, species code 411). Data that will be recorded on the daily CWT sampling form for each adipose-finclipped fish will be head cinch strap number, species code, length to the nearest 5 mm MEF, clip status, and sex. For adipose-finclipped fish whose heads are not taken for CWT recovery, a dummy head number 902XXX will be assigned. Heads taken from adipose-finclipped 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 estimating abundance of age-1.2 fish will follow the same methods as described for age-1.3 and older fish.

Lengths (Secondary Objective 3)

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

DATA ANALYSIS

ABUNDANCE ESTIMATE

In event 1, the number of fish tagged by age, sex, size category, and time period will be tabulated by gear type. Size categories are: small = age 1.1 or length <440 mm MEF if not ageable, medium = age 1.2 or length ≥440 mm MEF and <660 mm MEF if not ageable, and large = age 1.3 or older or length ≥660 mm MEF if not ageable). In event 2, the number of fish captured and the number recaptured will be tabulated by age, sex, and size category by tributary.

Petersen estimators (Seber 1982) will be used to estimate abundance:

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \tag{1}$$

$$V\left[\hat{N}\right] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)} \tag{2}$$

where $\hat{N}$ = estimated number of large Chinook salmon, n_1 = number of large marked Chinook salmon, n_2 = number of large adults inspected for marks on spawning, and m_2 = number of marked large adults recaptured on spawning grounds. Note that the same estimator will be used for medium-sized fish as well. Further description of analyses will implicitly represent calculations and tests for both large and for medium-sized fish. If time or area stratification is necessary; a Darroch estimator (Seber 1982, Chapter 11) will be used to estimate abundance.

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;

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

d) tagging does not affect the fate (mortality) of a fish;

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

f) double sampling does not occur.

Tagging will occur in proportion to abundance during immigration (assumption a) if fishing effort and catchability are constant as each size of fish 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. Because fishing effort will be constant over time, 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 C1). 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. The sex estimation of recaptured fish will be compared in events 1 and 2 to assess the accuracy of the event 1 estimation. We assume that the event 2 sex estimation for each fish will be more accurate because secondary sex characteristics are more developed on the spawning grounds than in the lower river.

A 2x2 contingency table will be used to test for differences in proportion tagged between the Kelsall-Nataga and Tahini rivers. A meta-analysis of the data from 1994 to 2000 (Ericksen 2001) and a similar analysis updated to 2009 was conducted to search for a difference in the marked proportion over years. These analyses could not detect a difference, confirming the appropriate use of the Petersen estimator (Ericksen 2001). However, if the proportions of tagged fish at the two spawning areas in 2013 are found to be unequal (assumption ‘a’), contributing causes will be investigated.

A 2x2 contingency table (or a K-S test) can also be used to see if the age (or size) composition of fish captured in Kelsall-Nataga and Tahini rivers are statistically different for fish captured with similar gears, or for different gears after effects of partial recruitment are removed (fish aged 1.2 years and younger are removed from the samples). Field personnel will not target tagged fish because all encountered fish are pursued and sampled (assumption b).

Recruitment of untagged fish into the population after tagging seems highly unlikely (assumption d), because lower river tagging continues until few or no fish are captured, and also because a "late" run of fish is not documented in the Chilkat River. We assume tagged and untagged fish experience the same (perhaps significant) mortality (assumption e) due to natural causes and subsistence fishing. In the 2005 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 recovered in a subsistence net in Chilkat Inlet in 2003. Thus, "backing out" of tagged fish does not appear to be a significant problem in this study.

To account for tag loss, each fish will receive a numbered tag and an ULOP. In past years, tag loss has more often been associated with fish tagged at the fish wheels (Ericksen 1999). To examine this further, gillnet-captured fish will be marked with a left axillary appendage clip (LAA). Recovery crews will check each captured fish for an ULOP to assess primary tag loss (assumption f). If tags are lost, the observation will be recorded on the sampling form comment section, and fish with an ULOP but without primary tags will be counted as recoveries. Double sampling (assumption g) 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 COMPOSITIONS OF THE INRIVER RUN

As described in the abundance estimate data analysis section, size-selective sampling will be investigated using 2 K-S tests (see Appendix C1 for details). If selectivity is detected, the methods described in Appendix C1 will be used to reduce the bias.

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

$$\hat{p}_{a,i} = \frac{n_{a,i}}{n_i} \qquad (3)$$

$$\text{var}\left[\hat{p}_{a,i}\right] = \frac{\hat{p}_{a,i}(1 - \hat{p}_{a,i})}{n_i - 1} \qquad (4)$$

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 ($\hat{N}_a$) is:

$$\hat{N}_a = \sum_i \hat{p}_{a,i} \hat{N}_i \qquad (5)$$

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

where $\hat{N}_i$ 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:

$$\hat{p}_a = \frac{\hat{N}_a}{\sum_i \hat{N}_i} \qquad (7)$$

$$\text{var}(\hat{p}_a) \cong \hat{N}^{-2} \sum_i \hat{N}^2{}_i \, \text{var}\left(\hat{p}_{a,i}\right) + \hat{N}^{-2} \sum_i \text{var}\left(\hat{N}_i\right)\left(\hat{p}_{a,i} - \hat{p}_a\right)^2 \qquad (8)$$

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).

SECONDARY OBJECTIVES

Coded Wire Tag Study (Secondary Objective 1)

The project operational plan titled "Production and harvest of Chilkat River Chinook and Coho Salmon describes in detail how adipose fin clip and CWT detection data from the escapement study will be analyzed to generate estimates of juvenile abundance, overwinter survival, marine survival, harvest by fishery, and total return for a given brood year of Chilkat River Chinook salmon.

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 fish and older.

Lengths (Secondary Objective 3)

Lengths will be collected and canonical mean and variance reported.

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 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, 2014. Data files will be archived in 2 locations: on the Haines area office network hard drive at "Haines DSF S:\Data archive\Chilkat king escapement\2013" and on the Douglas regional network hard drive at "Region1Shared-DSF R:\Divisions\SF\Offices\Haines\Data archive\Chilkat king escapement\2013".

The Division of Commercial Fisheries is the clearinghouse for all information on CWTs. 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

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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.

software. All CWT data (sampled fish, adipose-finclipped fish, decoded tags, location, data type, samplers, etc.) are archived and accessible on a permanent Alaska Department of Fish and Game (ADF&G) statewide database (http://tagotoweb.adfg.state.ak.us/CWT/reports/) and once per year are provided to the permanent coastwide database at the Pacific States Marine Fisheries Commission.

A final, edited copy of the data, along with a data map, will be sent to 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 data map will include a description of all electronic files contained in the data archive, all data fields and details of where hard copies of any associated data are to be archived, if not in RTS. For this project, all 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-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 Division of Commercial Fisheries. All electronic data sent to RTS and not archived elsewhere, will include the Excel™ workbooks (presently in Office 2007). 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-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 are scheduled as follows:

1. Lower Chilkat River drift gillnet	June 10–July 24
2. Tahini River spawning grounds surveys	August 1–September 4
3. Kelsall River spawning grounds surveys	August 1–September 4

Data editing and analysis will be initiated before the end of the season. A memorandum summarizing general difficulties and abilities to sample each area sampled, with recommendations for future sampling, 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, 2014. This report will fulfill the reporting obligation as an annual report of progress for this Federal Aid Project.

Information from the project will also be summarized in reports to the Alaska Board of Fisheries and to the Joint Chinook Technical and Transboundary River Technical Committees of the Pacific Salmon Commission.

RESPONSIBILITIES

Richard Chapell, Fishery Biologist III, Lead Biologist. Writes operational plan, supervises overall project; edits, analyzes, and reports data.

Sarah Power, Biometrician II. Reviews operational plan, data analysis and final report.

Brian Elliott, Fishery Biologist II, Project Biologist. This position supervises overall field operations. He drafts the operational plan and ensures that the study design is implemented properly. He is responsible for writing personnel evaluations for all crewmembers, and oversees the data collection and data entry activities.

John Der Hovanisian, Regional Research Coordinator. This position reviews the operational plan and the annual technical report and assists in obtaining funding for Chilkat River Chinook salmon projects.

Reed Barber, Fishery Technician III. This position is responsible for supervising 3 technicians during 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 department 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.

Vacant, Fishery Technician II, (2 positions). 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.

Liam Cassidy, Fishery Technician II. This position is 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-length information while inspecting fish for missing adipose fins.

Dana Van Burgh, Fishery Technician III. 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 department 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.

Vacant, Fishery Technician II. This position is 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-length information while inspecting fish for missing adipose fins.

Mark Sogge, Fishery Biologist I. This position is responsible for supervising the Division of Commercial Fisheries fish wheel tagging operations on the lower Chilkat River. He 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 department policies. In addition, he is to inform his supervisor (Bachman) 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 his supervisor, he will attempt to resolve as many personnel and administrative problems as possible. This position will be responsible for entering and proofreading all Chinook salmon data collected at the fish wheels, including any recommendations for improvement.

David Folletti, Fishery Technician III. This position will assist in the installation, operation, and maintenance of the fish wheels. In addition, he and the crew will sort, sample, and mark Chinook salmon captured in the fish wheels.

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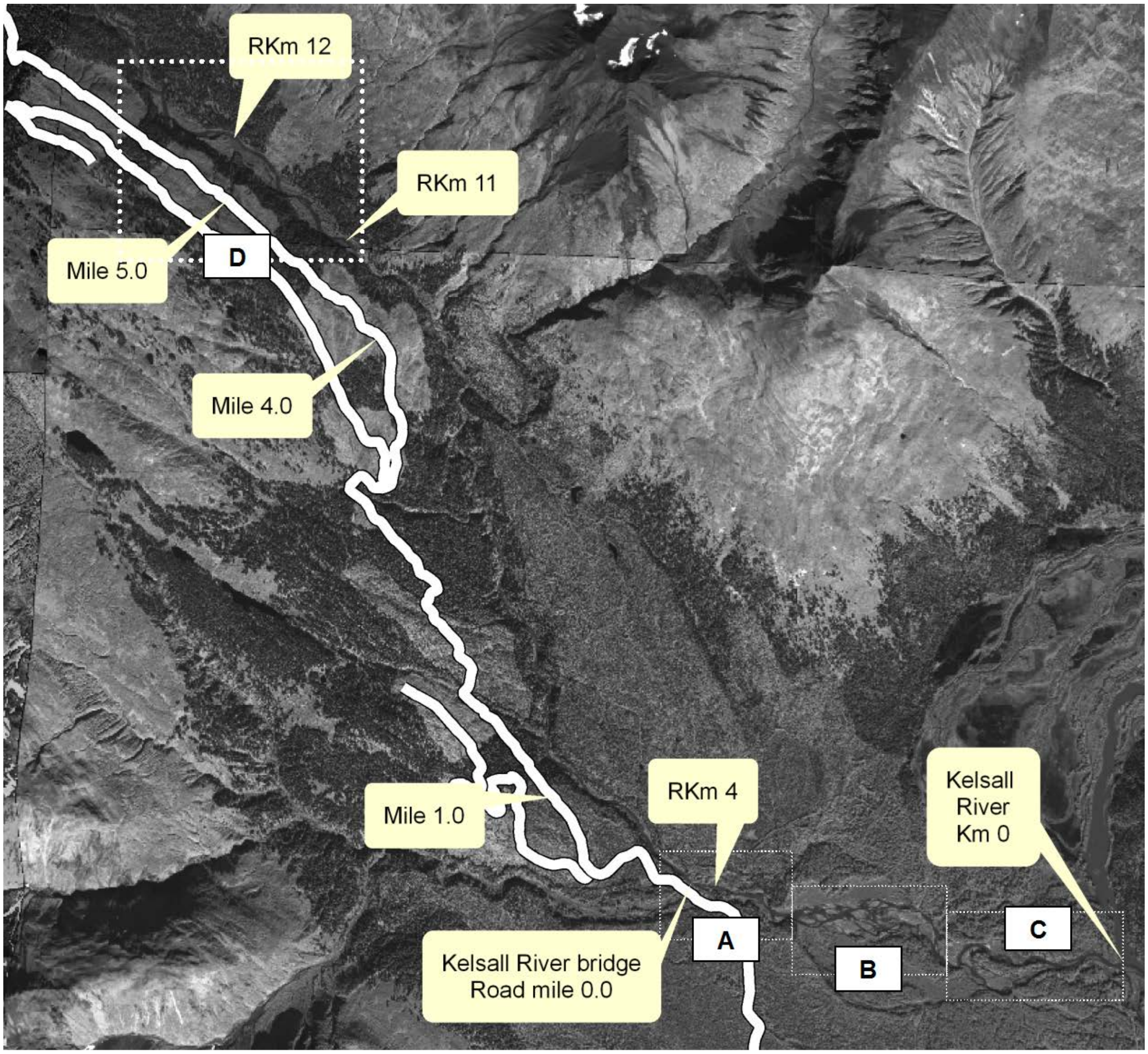
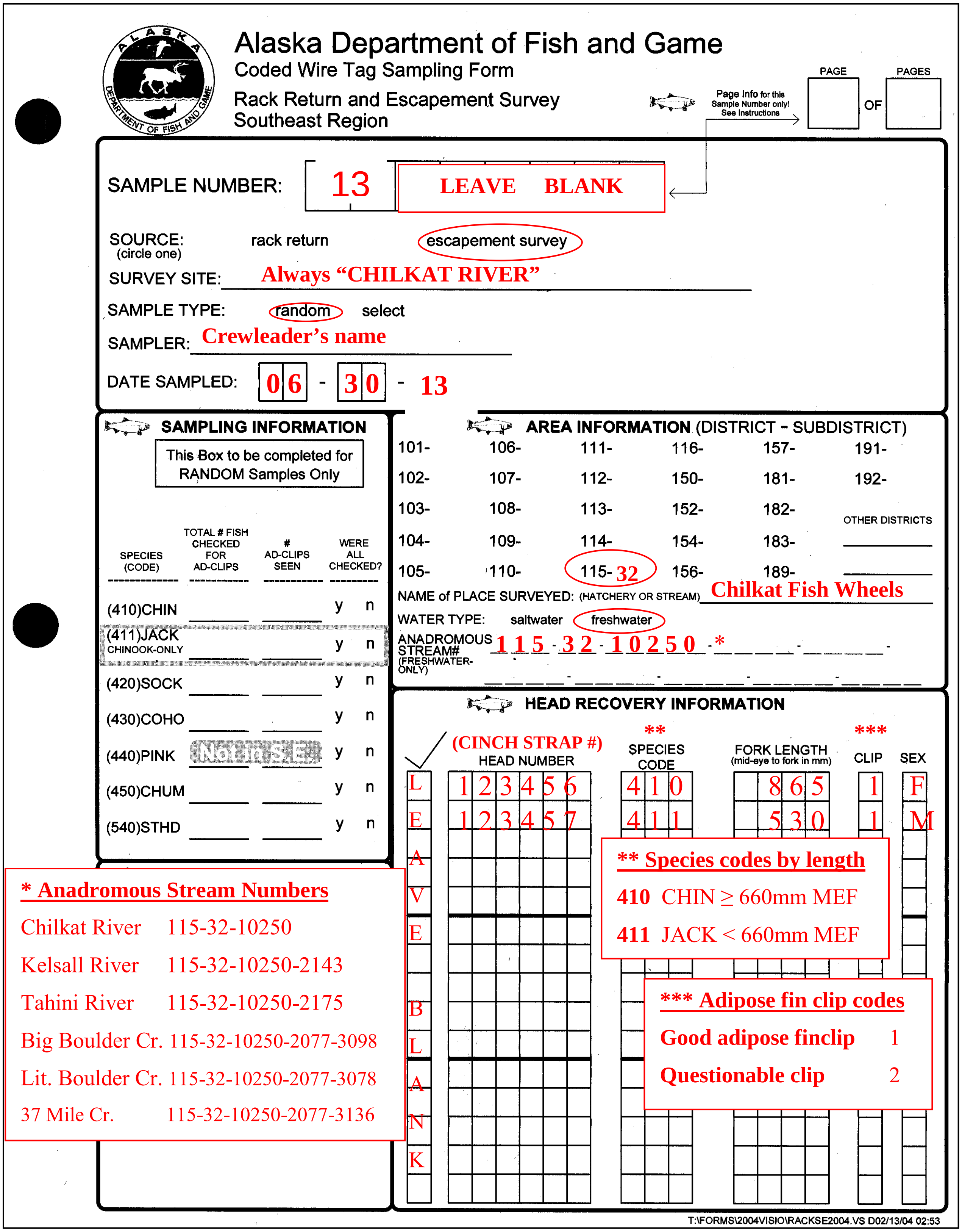
APPENDIX A: KELSALL RIVER DRAINAGE SAMPLING AREAS



Appendix A1.–Satellite photo of the Kelsall River showing the delta (area B), upper canyon (area D) and other sampling areas.

APPENDIX B: DATA COLLECTION FORMS

Appendix B1.–Coded wire tag sampling form.



Alaska Department of Fish and Game

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: 13 LEAVE BLANK

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

SURVEY SITE: Always "CHILKAT RIVER"

SAMPLE TYPE: [✓ random] select

SAMPLER: Crewleader's name

DATE SAMPLED: 06 - 30 - 13

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			y n
(411)JACK CHINOOK-ONLY			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 Fish Wheels

WATER TYPE: saltwater [✓ freshwater]

ANADROMOUS STREAM# (FRESHWATER-ONLY) 115-32-10250-*____-____-
____-____-____-____-____

HEAD RECOVERY INFORMATION

✓	(CINCH STRAP #) HEAD NUMBER	** SPECIES CODE	FORK LENGTH (mid-eye to fork in mm)	*** CLIP	SEX
L	123456	410	865	1	F
E	123457	411	530	1	M
A					
V					
E					
B					
L					
A					
N					
K					

*** Anadromous Stream Numbers**

Chilkat River	115-32-10250
Kelsall River	115-32-10250-2143
Tahini River	115-32-10250-2175
Big Boulder Cr.	115-32-10250-2077-3098
Lit. Boulder Cr.	115-32-10250-2077-3078
37 Mile Cr.	115-32-10250-2077-3136

**** Species codes by length**

410 CHIN ≥ 660mm MEF
411 JACK < 660mm MEF

***** Adipose fin clip codes**

Good adipose finclip	1
Questionable clip	2

T:\FORMS\2004VISIO\RACKSE2004.VS D02/13/04 02:53

Appendix B2.–Chilkat River fish wheel capture form.

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

Species: 41 (Chinook) Stream Code: 115-32-10250 Year: 2012

Gear: 08 (fish wheel) Length Type: 02 (MEF) Project: F-12-28, 29

Date	**Time**	**FW Site**	**Fish Num**	**Ad-clip**	*** CWT Head**	**** CWT Back**	**Sex**	**Length**	**Scale card num**	**Scale col. num**	**Lice**	***** Tag type**	**Tag num.**	**Upper left operc punch**	**Comments/ CWT cinch strap number**
6/11	850	2	1	n			F	1010	001	1	N	S	0001	y	Seal bite
6/12	1602	2	2	n			M	860	001	2	N	S	0002	y	bright
6/13	1630	2	3	n			M	960	001	3	N	S	0003	y	
6/14	930	2	4	n			M	880	001	4	N	S	0004	y	
6/15	850	2	5	y	y	n	M	650	001	5	N	-	-	n	CWT 265,012
	850	2	6	n			M	690	001	6	N	S	0005	y	
	850	2	7	n			M	880	001	7	N	S	0006	Y	Turning
	950	1	8	n			M	810	001	8	N	S	0007	Y	
6/16	845	2	9	n			F	870	001	9	N	S	0008	y	
	845	2	10	n			M	780	001	10	N	S	0009	y	
	945	1	11	y	y	n	M	830	002	1	N	S	0010	y	
	1530	2	12	n			M	800	002	2	N	S	0011	y	Turning
6/17	851	2	13	n			F	960	002	3	Y	S	0012	y	
6/18	835	2	14	n			M	450	002	4	N	S	0013	y	
6/19	858	2	15	n			M	640	002	5	N	S	0014	y	
6/20	843	2	16	y	y	y	M	300	002	6	N	-	-	n	CWT 265,013
6/21	1427	2	17	n			M	585	002	7	N	S	0015	y	
6/22	900	1	18	y	y	n	M	340	002	8	N	-	-	n	CWT 265,014
	930	2	19	n			F	900	002	9	Y	S	0016	y	
	1500	2	20	n			M	780	002	10	N	S	0017	y	
	1500	2	21	n			M	420	003	1	N	T	1068	y	
	1500	2	22	n			F	685	003	2	N	S	1069	y	
6/23	850	1	23	n			F	780	003	3	Y	S	1070	y	

* For ad-clipped Chinook salmon:

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

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

** Check all ad-clipped Chinook salmon for a CWT at the base of the dorsal fin.

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

Appendix B3.–Chilkat River drift gillnet capture form.

DATE	TIME	FISH #	PANEL	ADCLIP	* CWT Head	** CWT Back	SEX	LENGTH	CARD #	SCALE #	LICE	*** TAG TYPE	TAG #	COMMENTS CWT Cinch Strap #
6/13	0725	1	L	N			F	900	001	1	N	S	00301	Bright
6/17	0715	2	L	N			M	870	001	2	N	S	00302	Bright
6/19	1145	3	L	N			M	585	001	3	N	S	00303	Bright
6/22	1100	4	L	N			M	870	001	4	N	S	00304	Bright, seal bite
6/23	0800	5	S	N			F	825	001	5	N	S	00305	Bright
	0825	6	L	N			F	750	001	6	N	S	00306	Bright
	1015	7	L	N			M	745	001	7	N	-	-	Bleeding-not tagged
6/24	0925	8	L	N			F	880	001	8	N	S	00307	Bright
6/25	0740	9	L	N			M	980	001	9	N	S	00308	Steely grey
	0840	10	L	N			M	535	001	10	N	S	00309	Bright
6/26	1025	11	L	N			M	830	002	1	N	S	00310	Bright, gash dorsal
	1105	12	L	Y	Y	N	F	915	002	2	N	S	00311	Bright
6/27	0845	13	L	N			F	820	002	3	N	S	00312	Reddish
	0855	14	L	N			M	920	002	4	N	S	00313	Bright
	1125	15	L	N			M	570	002	5	N	S	00314	Bright
6/28	0700	16	S	Y	Y	Y	M	435	002	6	N	-	-	CWT 264,123; 2 CWT
	0715	17	S	N			F	810	002	7	N	S	00315	Bright
	1000	18	S	N			F	870	002	8	N	S	00316	Bright 4 scales
6/29	0725	19	L	N			M	760	002	9	N	S	00317	Bright
	0950	20	L	Y	Y	N	M	355	002	10	N	-	-	CWT 264,124; 1 CWT
7/1	0705	21	S	N			F	680	003	1	Y	S	00318	Bright
	0812	22	S	N			F	920	003	2	Y	S	00319	Reddish
	0905	23	S	N			F	825	003	3	N	S	00320	Pink
	1130	24	L	N			F	930	003	4	N	S	00321	Chromer
7/2	1150	25	S	N			M	395	003	5	N	T	01003	Bright

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

** Check all ad-clipped Chinook salmon for a CWT at the base of the dorsal fin.

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

Appendix B4.–Chilkat River drift gillnet effort form.

Start Time 0647 (first drift)
Date 6-18-12 Crew LD / RB
End Time 1145 (last drift)
Water Temp. 7.1^{o} at 0645 Hrs.
Water Depth 161 at 0645 Hrs.
Water Temp. 8.1^{o} at 1305 Hrs.
Water Depth 160 at 1305 Hrs.
Weather Comments PtlyCldy/Wind S5k
Water Comments High, flat, muddy

Drift Num.	Done	Num. kings	Area	Channel	% incomplete	Comments
1	X		1	R		
2	X		2	R		
3	X		3			
4	X		4			
5	X		5	R		
6	X	1	6	R	50%	M 710 tag #4590 Caught near shore
7	X		1	L		
8	X		2	L		Large king got away
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		55%	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	105%	Add these sums to page 2 totals.

Turn over to continue

Appendix B4.–Page 2 of 2.

Drift Num.	Done	# Fish	Area	Channel	% Incomplete	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		3			
Sum	XXXX	2	XXXX	XXX	**(A)** 105%	Totals including sums from page 1
44	X		4			
45						
46						
47						
48						
49						
50						
51						
52						
53						
54						
55						
56						
57						
58						
59						
60						
Sum	XXXX	2	XXXX	XXX	Should be <1	Totals from all drifts

Calculate (**A**/100) = Number of drifts (largest whole number) to achieve 43 complete drifts. Repeat this procedure until less than one drift remains to achieve the equivalent of 43 complete drifts.

Appendix B5.–Chilkat River spawning ground sampling form.

Location: **Kelsall River** **Crew:** MZ, DVB

DATE	* GEAR	FISH num	SEX	Ad-CLIP	CWT		Length MEF	SCALE		** COND	OP. PUNCH		*** Kels. area	TAG Num or LAA	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 LAA
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 #626,456, firm
	S	15	M	Y	Y	N	535	2	5	S	N	N	A		CWT #626,457
	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 C: SIZE AND SEX SELECTIVITY DETECTION PROCEDURES FOR MARK-RECAPTURE EXPERIMENTS

Appendix C1.–Detection of size or sex-selective sampling during a 2-sample mark recapture experiment and recommended procedures for estimating population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect size-selective sampling during the first or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R), using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test, comparing M and C, is conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling. Contingency table analysis (Chi^2-test) is used to detect sex-selective sampling during the first or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C as described above, using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. When the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are compared between samples using a two sample test (e.g. Student's t-test).

M versus R	**C versus R**	**M versus C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during either sampling event.		
Case II:		
Reject H_o	Fail to reject H_o	Reject H_o
There is no size/sex selectivity detected during the first event but there is during the second event sampling.		
Case III:		
Fail to reject H_o	Reject H_o	Reject H_o
There is no size/sex selectivity detected during the second event but there is during the first event sampling.		
Case IV:		
Reject H_o	Reject H_o	Reject H_o
There is size/sex selectivity detected during both the first and second sampling events.		
Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M versus R and C versus R tests are not small and sample sizes for M versus C test are very large, the M versus. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M versus. R are small, b) the M versus. R p-value is not large (~0.20 or less), and c) the C versus. R sample sizes are not small and/or the C versus. R p-value is fairly large (~0.30 or more), the rejection of the null in the M versus. C test was likely the result of size/sex selectivity during the second event which the M versus. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

-continued-

C. If a) sample sizes for C versus. R are small, b) the C versus. R p-value is not large (~0.20 or less), and c) the M versus. R sample sizes are not small and/or the M versus. R p-value is fairly large (~0.30 or more), the rejection of the null in the M versus. C test was likely the result of size/sex selectivity during the first event which the C versus. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C versus. R and M versus. R are both small, and b) both the C versus. R and M versus. R p-values are not large (~0.20 or less), the rejection of the null in the M versus. C test may be the result of size/sex selectivity during both events which the C versus. R and M versus. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M versus. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C versus. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary, overall composition is estimated by combining within-stratum composition estimates as follows:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{, and} \tag{1}$$

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

where: j = the number of sex/size strata;

$\hat{p}_{ik}$ = the estimated proportion of fish that were age or size *k* among fish in stratum *i*;

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

$\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.