Fishery Data Series No. 06-12

Abundance of the Chinook Salmon Escapement on the Alsek River in 2004

by

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and

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March 2006

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 Department of Fish and Game	ADF&G
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)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

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

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ABSTRACT

The abundance of Chinook salmon *Oncorhynchus tshawytscha* returning to spawn in the Alsek River in 2004 was estimated with a mark-recapture experiment conducted by the Alaska Department of Fish and Game, the Canadian Department of Fisheries and Oceans, and the Champagne/Aishihik First Nation. Age, sex, and length compositions for the immigration were also estimated. Set gillnets fished near the mouth of the Alsek River during May, June, and July, 2004 were used to capture 773 large (≥660 mm MEF) immigrant Chinook salmon, 732 of which were marked with individually numbered spaghetti tags, as well as two batch marks–a hole punched in their left opercle, and removal of an axillary appendage. In addition, 43 medium (440–659 mm) fish were marked. During July and August, Chinook salmon were captured at spawning sites and inspected for marks. We used a modified Petersen model to estimate that 7,528 (SE = 595) large Chinook salmon immigrated into the Alsek River above Dry Bay. Canadian fisheries on the Tatshenshini River harvested an estimated 185 large Chinook salmon, leaving an escapement of 7,343 large fish. We used a second modified Petersen model to estimate that 274 (SE = 59) medium (440-659mm) Chinook salmon immigrated into the Alsek River above Dry Bay. About 33% of the total estimated spawning escapement of large fish in the Alsek River were counted at the Klukshu River weir. An estimated 2.4% of the Alsek River escapement were age-1.2 fish, 71.7% age-1.3 fish, and 24.2% age-1.4 fish, with an estimated 4,614 females in the total escapement of 7,802 (SE = 595). After seven years of study, the average expansion factor for Chinook salmon ≥ 660 mm MEF passing into the Klukshu River to the abundance passing through Dry Bay is 4.17 (SD = 1.14).

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, Alsek River, Klukshu River, Tatshenshini River, mark-recapture, escapement, abundance, expansion factor, age and sex composition

INTRODUCTION

The Alsek River originates in the Yukon Territory, Canada, and flows in a southerly direction into the Gulf of Alaska, southeast of Yakutat, Alaska (Figure 1). Chinook salmon *Oncorhynchus tshawytscha* returning to this river are caught primarily in commercial and subsistence set gillnet fisheries in the lower Alsek River and in recreational and aboriginal fisheries on the upper Tatshenshini River in Canada (Tables 1 and 2). Small harvests of this stock are also probably taken in marine recreational and commercial fisheries near Yakutat. Exploitation of this population is managed jointly by the U.S. and Canada through a subcommittee of the Pacific Salmon Commission (PSC) as part of the U.S./Canada Pacific Salmon Treaty (PST) adopted in 1985 (TTC 1999).

Counts of Chinook salmon spawning in tributaries of the Alsek River have been collected since 1965 (Table 3). Since 1976, the Canadian Department of Fisheries and Oceans (DFO) has operated a weir at the mouth of the Klukshu River to count Chinook, sockeye *O. nerka*, and coho salmon *O. kisutch*. The Alaska Department of Fish and Game (ADF&G) has counted spawning Chinook salmon from helicopters since 1982 and earlier from fixed-wing aircraft. Escapement to the Klukshu River is difficult to count by aerial, boat or foot surveys because of deep pools and overhanging vegetation. However, surveys of the Klukshu River are conducted periodically to provide some continuity in the database in the event that funding for the weir is discontinued. The Blanchard and Takhanne rivers and Goat Creek, three smaller tributaries of the Tatshenshini River, are also surveyed annually, but counts from these surveys are not used to monitor trends in escapements.

Only large (typically age-.3, -.4, and -.5) Chinook salmon ≥660 mm mideye-to-fork length (MEF) are counted during aerial or foot surveys. No attempt is made to accurately count small (typically age-.1 ≤439 mm MEF) or medium (440–659 mm and age-.2) Chinook salmon. These Chinook salmon, also called jacks, are primarily males that are considered to be surplus to spawning needs (Mecum 1990). They are easy to separate visually from their older, larger counterparts under most conditions, because of their shorter, compact bodies and lighter color. They are, however, difficult to distinguish from other smaller species such as sockeye salmon.

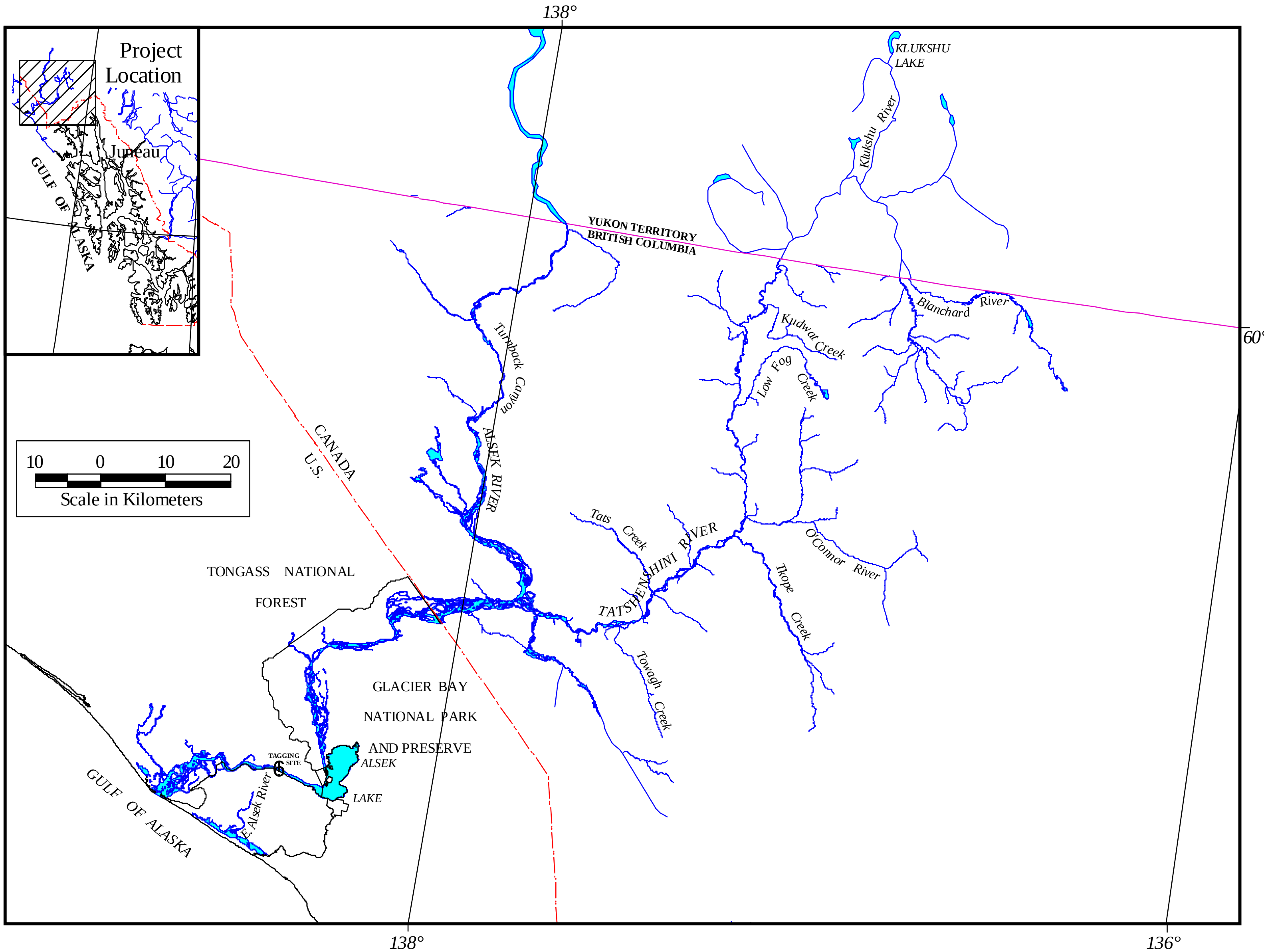


Figure 1.–Alsek River drainage, showing principal tributaries and main tagging site.

Table 1.–Estimated harvests of Chinook salmon in Canadian Alsek River fisheries, 1976–2004.

	Klukshu River aboriginal fishery			Canadian sport fishery			
Year	Below weir	Above weir	Total	Dalton Post	Blanchard River	Takhanne River	Total
1976	0	150	150	130	45	25	200
1977	0	350	350	195	67	38	300
1978	0	350	350	195	67	38	300
1979	0	1,300	1,300	422	146	82	650
1980	0	150	150	130	45	25	200
1981	0	150	150	150	200	50	400
1982	0	400	400	183	110	40	333
1983	0	300	300	202	60	50	312
1984	0	100	100	275	125	50	450
1985	0	175	175	170	20	20	210
1986	0	102	102	125	20	20	165
1987	0	125	125	326	113	63	502
1988	0	43	43	249	87	48	384
1989	0	234	234	215	75	41	331
1990	0	202	202	468	162	91	721
1991	268	241	509	384	29	17	430
1992	60	88	148	79	6	18	103
1993	88	64	152	170	25	42	237
1994	190	99	289	197	69	38	304
1995	320	260	580	601	330	113	1,044
1996	233	215	448	423	78	149	650
1997	72	160	232	195	69	34	298
1998	154	17	171	112	43	20	175
1999	211[a]	27	238	134	42	16	192
2000	21[b]	44	65	32	44	1	77
2001	33	87	120	119	31	8	157
2002	20	100	120	165	30	1	197
2003	14	76	90	122	12	4	138
2004	71	68	139	42	3	1	46

[a] Includes 8 fish harvested from Village Creek.

[b] Includes 4 fish harvested from Village Creek and 3 from Blanchard River.

In 1997, ADF&G, in cooperation with DFO, instituted a project to determine the feasibility of a mark-recapture experiment to estimate abundance of Chinook salmon spawning in the Alsek River drainage (Pahlke and Etherton 2002). The results of the feasibility project were encouraging, and in 1998 a revised, expanded mark-recapture study was conducted along with a radiotelemetry study to estimate spawning distribution (Pahlke et al. 1999). The radiotelemetry study was repeated in 2002.

Mark-recapture studies in 1997–2003 indicate that counts at the weir represent between 15 and 27% of the total run of Chinook salmon to the Alsek River (Pahlke et al. 1999; Pahlke and Etherton 2001a, 2001b; Pahlke and Etherton 2002; Pahlke and Waugh 2004). Prior to 1997, the proportion of the total Chinook salmon escapement to the Alsek River drainage counted at the Klukshu River weir was unknown but was guessed to be between 40% (Canada) and 64% (U.S.) (Pahlke 1997b). In 1991, the Trans-boundary River Technical Committee of the PSC recommended that an expansion factor not be adopted due to the lack of applicable studies (PSC 1991). A 1998 analysis of the biological escapement goal for Klukshu River Chinook salmon resulted in a biological escapement goal (BEG) range of 1,100 to 2,300 Chinook salmon spawners in the Klukshu River (McPherson et al. 1998).

The 2004 study had three objectives: (1) to estimate the abundance of large (≥660 mm MEF) spawning Chinook salmon in the Alsek River; (2) estimate the proportion of the escapement of spawning Chinook salmon in the Alsek River counted at the Klukshu River weir, and (3) to

Table 2.–Annual harvests of Chinook salmon in the U.S. Alsek River commercial and subsistence/personal use gillnet fisheries, 1941–2004.

Year(s)	Commercial harvest	Year(s)	Commercial harvest	Subsistence/ personal use
1941	3,943	1971	1,222	
1942	0	1972	1,827	
1943	0	1973	1,757	
1944	2,173	1974	1,162	
1945	6,226	1975	1,379	
1941–1945 Average	2,468	1971–1975 Average	1,469	
1946	1,161	1976	512	
1947	266	1977	1,402	
1948	853	1978	2,441	
1949	72	1979	2,525	
1950	unknown	1980	1,382	
1946–1949 Average	588	1976–1980 Average	1,652	
1951	151	1981	779	
1952	2,020	1982	532	
1953	1,383	1983	93	
1954	1,833	1984	46	
1955	2,883	1985	213	
1951–1955 Average	1,654	1981–1985 Average	333	
1956	3,253	1986	481	22
1957	1,800	1987	347	27
1958	888	1988	223	13
1959	969	1989	228	20
1960	525	1990	78	85
1956–1960 Average	1,487	1986–1990 Average	271	38
1961	2,120	1991	103	38
1962	2,278	1992	301	15
1963	131	1993	300	38
1964	591	1994	805	60
1965	719	1995	670	51
1961–1965 Average	1,168	1991–1995 Average	436	34
1966	934	1996	771	60
1967	225	1997	568	38
1968	215	1998	550	63
1969	685	1999	482	44
1970	1,128	2000	677	73
1966–1970 Average	637	1996–2000 Average	609	56
		2001	541	19
		2002	700	60
		2003	937	24
		2004	656	38

Table 3.–Escapement of Chinook salmon to the Klukshu River and counts of spawning adults in other tributaries of the Alsek River, 1965–2004. — = no survey; (A) = aerial survey from fixed wing aircraft; (H) = helicopter survey; E = excellent survey conditions; N = normal conditions; P = poor conditions.

	Klukshu River												
			Weir	Above-weir harvest				**Blanchard**		**Takhanne**			
Year[a]	Aerial count		count	AF	Sport	Brood	Escapement [b]	**River**		**River**		**Goat Creek**	
1965	100		–	–	–		100	100		250		–	
1966	1,000		–	–	–		1,000	100		200		–	
1967	1,500		–	–	–		1,500	200		275		–	
1968	1,700		–	–	–		1,700	425		225		–	
1969	700		–	–	–		700	250		250		–	
1970	500		–	–	–		500	100	(F)	100		–	
1971	300	(A)	–	–	–		300	–		205	(F)	–	
1972	1,100		–	–	–		1,100	12	(A)	250		38	(F)
1973	–		–	–	–		–	–		49	(A)	–	
1974	62		–	–	–		62	52	(A)	132	(F)	–	
1975	58		–	–	–		58	81	(A)	177	(A)	–	
1976	–		1,278	150	64		1,064	–		38	(F)	16	(F)
1977	–		3,144	350	96		2,698	–		38	(F)	–	
1978	–		2,976	350	96		2,530	–		50	(F)	–	
1979	–		4,404	1,300	0		3,104	–		–		–	
1980	–		2,673	150	0		2,487	–		–		–	
1981	–		2,113	150	0		1,963	35	(H)	11	(H)	–	
1982	633	N(H)	2,369	400	0		1,969	59	(H)	241	(H)	13	(H)
1983	917	N(H)	2,537	300	0		2,237	108	(H)	185	(H)	–	
1984	–		1,672	100	0		1,572	304	(H)	158	(H)	28	(H)
1985	–		1,458	175	0		1,283	232	(H)	184	(H)	–	
1986	738	P(H)	2,709	102	0		2,607	556	(H)	358	(H)	142	(H)
1987	933	E(H)	2,616	125	0		2,491	624	(H)	395	(H)	85	(H)
1988	–		2,037	43	0		1,994	437	E(H)	169	E(H)	54	E(H)
1989	893	E(H)	2,456	234	0	20	2,202	–		158	E(H)	34	E(H)
1990	1,381	E(H)	1,915	202	0	15	1,698	–		325	E(H)	32	E(H)
1991	–		2,489	241	0	25	2,223	121	N(H)	86	E(H)	63	E(H)
1992	261	P(H)	1,367	88	0	36	1,243	86	P(H)	77	N(H)	16	N(H)
1993	1,058	N(H)	3,303	64	0	18	3,221	326	N(H)	351	E(H)	50	N(H)
1994	1,558	N(H)	3,727	99	0	8	3,620	349	N(H)	342	E(H)	67	N(H)
1995	1,053	E(H)	5,678	260	0	21	5,397	338	P(H)	260	P(H)	–	
1996	788	N(H)	3,599	215	0	2	3,382	132	N(H)	230	N(H)	12	N(H)
1997	718	P(H)	2,989	160	0	0	2,829	109	P(H)	190	P(H)	–	
1998	–		1,364	17	0	0	1,347	71	P(H)	136	N(H)	39	N(H)
1999	500	P(H)	2,193	27	0	0	2,166	371	E(H)	194	N(H)	51	N(H)
2000	–		1,365	44	0	0	1,321	168	N(H)	152	N(H)	33	N(H)
2001	–		1,825	87	0	0	1,738	543	N(H)	287	N(H)	21	N(H)
2002	–		2,240	100	0	0	2,140	351	N(H)	220	N(H)	86	E(H)
2003			1,737	76	0	0	1,661	127	N(H)	105	N(H)	10	N(H)
1994–2003 average	923		2,672	109	0	3	2,560	256		212		40	
2004	--		2,525	68	0	0	2,457	84	P(H)	46	P(H)	--	

a Escapement counts prior to 1975 may not be comparable because of differences in survey dates and counting methods.

b Klukshu River escapement = weir count minus above weir aboriginal and sport fishery harvest, and broodstock.

estimate the age, sex, and length compositions of Chinook salmon spawning in the Alsek River.

Annual spawning escapements of Chinook salmon in the Klukshu River system have been estimated annually by subtracting from the weir count: (1) harvests taken upstream of the weir site in an aboriginal fishery; (2) sport fishery harvests upstream of the weir (1976–1978 only); and (3) brood stock removed at the weir site. Results from the study provide an expansion factor for index weir counts; i.e., the mark-recapture estimate of escapement divided by the escapement counted at the Klukshu River weir. Results also provide information on run timing through the lower Alsek River of Chinook salmon bound for the various spawning areas.

STUDY AREA

The Alsek River drainage covers about 28,000 km^2 (Bigelow et al. 1995). The drainage supports spawning populations of anadromous Pacific salmon, including Chinook salmon; however, most anadromous production in the Alsek drainage is limited to the Tatshenshini River because of a velocity barrier on the lower Alsek near Lowell Glacier (Turnback Canyon; Figure 1). Significant numbers of Chinook salmon spawn in various tributary streams of the Tatshenshini River, including the Klukshu River, the Blanchard River, the Takhanne River, and Goat Creek (Figure 2). Other significant spawning areas exist downstream of the confluence of the Klukshu and Tatshenshini rivers in mainstream areas of the Tatshenshini and Alsek rivers. Small numbers of Chinook salmon have been documented spawning in Village, Kane, Silver, Bridge, Detour, O'Connor, Low Fog and Stanley creeks, and in the Bridge River. The Klukshu and upper Tatshenshini rivers are accessible by road from the Haines Highway.

METHODS

The number of large Chinook salmon in the Alsek River escapement was estimated with a two-event mark-recapture experiment for a closed population (Seber 1982:59–61). Fish captured by set gillnets in the lower river near Dry Bay and marked were included in event 1. Chinook salmon captured upstream on or near their spawning grounds constituted event 2 of the mark-recapture experiment.

DRY BAY TAGGING

Set gillnets 120 feet (36.5 m) long, 18 feet (5.5 m) deep, and made of 7.25-inch (18.5-cm) stretch mesh, were fished on the lower Alsek River between May 14 and June 30; from May 18 through August 18, a similar net with 5¼" (13.5-cm) mesh was fished at another site. Nets were fished daily unless prevented by high water. The primary fishing site for the larger-meshed gear was at approximately river kilometer (rkm) 19, just above the boundary of the Dry Bay commercial fishery. The tagging site is below all known spawning areas, and is upstream of any tidal influence. Other nearby locations were fished when water levels were too high to safely fish the primary site. The primary site for the smaller-meshed gear was upriver a few km near the outlet of Alsek Lake. Nets were watched continuously, and captured fish were removed from the net as soon as observed. Sampling effort was held reasonably constant across the temporal span of the migration. If fishing time was lost from entanglements, snags, net cleaning, etc., the lost time (processing time) was added on to the end of the day to bring fishing time for the larger-mesh gear to 8 hours/day and 7 hours/day for the smaller-mesh gear.

Captured Chinook salmon were placed in a plastic fish tote filled with water, quickly untangled or cut from the net, tagged, scale sampled, measured and visually examined to determine sex (as per Johnson et al. 1993). Fish ≥660 mm MEF were classified as 'large', 'medium' if between 440 and 659 mm, or 'small' if <440 mm MEF (Pahlke and Bernard 1996). General health and appearance of the fish were noted, including injuries due to handling or predators. Each uninjured fish was marked with a uniquely numbered, blue spaghetti tag, consisting of a 2" (~5-cm) section of Floy[1] tubing shrunk onto a 15" (~38-cm) piece of 80-lb (~36.3-kg) monofilament fishing line. The

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

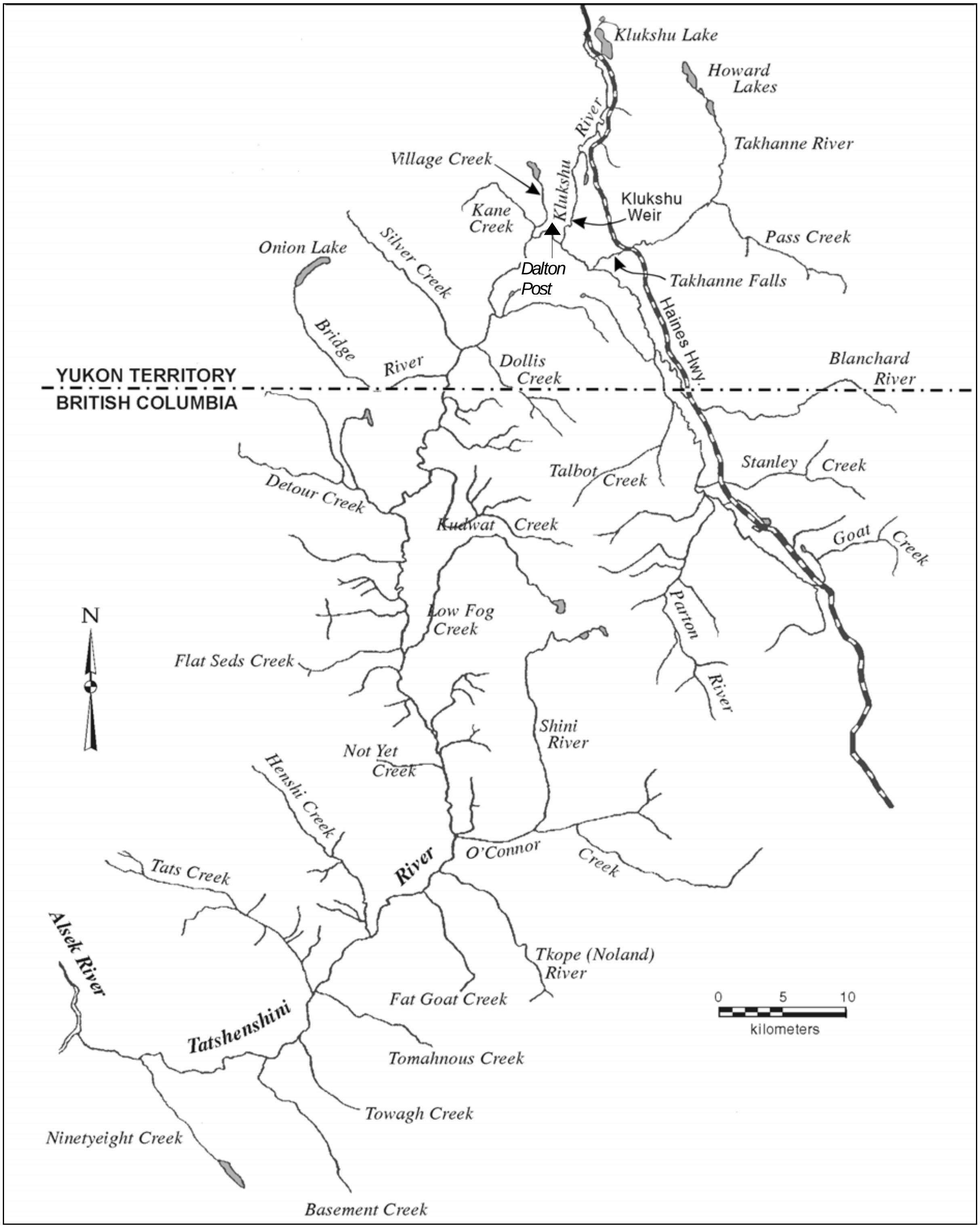


Figure 2.–Tatshenshini River drainage and associated tributaries, Yukon Territory and northern British Columbia, Canada.

monofilament was sewn through the musculature of the fish approximately 20 mm posterior and ventral to the dorsal fin and secured by securing both ends in a line crimp. Each fish was also batch marked with a ¼"-diameter (6-mm) hole in the upper (dorsal) portion of the left operculum applied with a paper punch, and by amputation of the left axillary appendage (as per McPherson et al. 1996). Fish that were seriously injured were sampled to determine their length, age, and sex, but were not tagged.

SPAWNING GROUND SAMPLING

During event 2, pre- and post-spawning fish were sampled at the Klukshu River weir. As fish entered a trap in the weir, a portion were captured; sampled to determine their length, sex, and age; inspected for marks; marked with a hole punched in the lower left operculum to prevent resampling; and released. In addition, some post-spawning fish and carcasses were sampled upstream of the weir and some pre-spawning fish were sampled below the weir. Foot surveys of the spawning areas on the Blanchard and Takhanne rivers were conducted August 2–3, 2004. We used snagging gear to sample both pre- and post-spawning Chinook salmon to determine their length, sex, age and the presence of marks.

FISHERY SAMPLING

Catches in Canadian fisheries in the upper Tatshenshini River and the U.S. gillnet fisheries below the tagging site were inspected for tags and sampled to estimate age, sex, and length composition.

ABUNDANCE

The number of marked fish on the spawning grounds was estimated by subtracting the estimated number of marked fish removed by U.S. fisheries from the number of fish tagged in event 1. Handling and tagging has caused a downstream movement and/or a delay in upstream migration of marked Chinook salmon in other studies (Bernard et al. 1999; Bendock and Alexandersdottir 1992; Johnson et al. 1992; Milligan et al. 1984; Pahlke and Etherton 1999). This behavior puts fish marked in June and July at risk of capture in the downstream commercial fishery in U.S. waters that begins in early June; fish marked earlier would have no such risk. Censoring marked Chinook salmon killed in this fishery avoided bias in estimates of abundance from this phenomenon. The tagging program was well publicized with a reward for each tag recovered, and almost the entire U.S. catch goes through one processor where a high proportion of the U. S. catch was inspected for marks.

A reward (Can$5 for spaghetti tag) was given for each tag returned from the inriver Canadian recreational and aboriginal fisheries, so tags from all marked fish caught in these fisheries were considered recovered.

The validity of the mark-recapture experiment rests on several assumptions, including: (a) every fish has an equal probability of being marked in event 1, *or* that every fish has an equal probability of being captured in event 2, *or* that marked fish mix completely with unmarked fish; (b) *both* recruitment and ‘death’ (emigration) do not occur between sampling events; (c) marking does not affect catchability (or mortality) of the fish; (d) fish do not lose their marks between sampling events; (e) all recovered marks are reported; and (f) double sampling does not occur (Seber 1982). Assumption (a) implies that marking must occur in proportion to abundance during immigration, or if it does not, that there is no difference in migratory timing among stocks bound for different spawning locations, since temporal mixing can not occur in the experiment. We attempted to meet assumption (a) by fishing the same gear in a standardized method throughout the Chinook salmon migration. Assumption (a) also implies that sampling is not size or sex-selective. If capture on the spawning grounds was not size-selective, fish of different sizes would be captured with equal probability. The same is true for sex-selective sampling on the spawning grounds. If assumption (a) was met, fish sampled in upper Tatshenshini (Blanchard and Takhanne rivers) and Klukshu River spawning sites and in the recreational fishery would be marked at similar rates.

Contingency table analysis was used to test the assumption of proportional tagging. The hypothesis that fish of different sizes were captured with equal probability was also tested using two Kolmogorov-Smirnov (K-S) 2-sample tests ($\alpha = 0.05$). These hypotheses tests and adjustments for bias are described in Appendix B1. Assumption (b) was met because the life history of Chinook salmon isolates those fish returning to the Alsek River as a 'closed' population. We assumed marked and unmarked fish experience the same mortality (assumption c) due to natural causes, and censoring was used to adjust the potentially higher harvest rate of marked fish in the U.S. commercial fishery.

To minimize effects of tag loss, all marked fish received secondary (a dorsal left opercle punch) and tertiary marks (the left axillary appendage was clipped). Similarly, we inspected all fish captured on the spawning grounds for marks (assumption e), and double sampling was prevented by an additional mark (ventral opercle punch) (assumption f). Variance, statistical bias, and confidence intervals for the abundance estimate were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (Buckland and Garthwaite 1991).

An expansion factor π for the estimated counts of large salmon through the weir on the Klukshu River was estimated as:

$$\hat{\pi} = \hat{N}_L \big/ \hat{C}_L \qquad (1)$$

where N_L is the abundance of large salmon past Dry Bay *including the inriver harvest in Canada*, and C_L is the number of large fish through the weir *including the harvest immediately below the* weir. The approximate variance is:

$$v(\hat{\pi}) \cong \hat{\pi}^2[cv^2(\hat{N}_L) + cv^2(\hat{C}_L)] \qquad (2)$$

Fish of all sizes were counted as they passed through the weir and the number of large fish was estimated by capturing and measuring the lengths of a subset (*n*) of the passage (*C*). Statistics describing the number of large fish at the weir were calculated as:

$$\hat{\theta} = n_L \big/ n \qquad (3)$$

$$v(\hat{\theta}) = \frac{C-n}{C-1}\frac{\hat{\theta}(1-\hat{\theta})}{n-1} \qquad (4)$$

$$\hat{C}_L = C\hat{\theta} \qquad (5)$$

$$v(\hat{C}_L) = C^2 v(\hat{\theta}) \qquad (6)$$

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

Scales were sampled from all fish captured in Dry Bay during event 1 and during spawning ground surveys and from portions of the Canadian aboriginal and recreational harvests to determine their age. Five scales were collected from the preferred area of each fish (Welander 1940) and mounted on gum cards, and impressions were made in cellulose acetate (Clutter and Whitesel 1956). Age of each fish was determined later from the pattern of circuli on images of scales magnified 70× (Olsen 1995). Samples from Dry Bay were processed at the ADF&G Scale Aging Lab in Douglas, AK; all other samples were processed at the DFO lab in Nanaimo, B.C. All scales were read by at least one staff member, with unusual or questionable scales read again by one or more staff.

The proportion of the spawning population composed of a given age within small-medium or large categories of salmon was estimated as a binomial variable from fish sampled on the spawning grounds:

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \qquad (7)$$

$$v[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{n_i - 1} \qquad (8)$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age *j* in size category *i*, n_{ij} is the number of Chinook salmon of age *j* sampled in size category *i*, and n_i is the number of Chinook salmon in the sample *n* of size category *i* taken on the spawning grounds.

Numbers of spawning fish by age *j* were estimated as the summation of products of estimated age composition and estimated abundance, minus harvest, within a size category *i*:

$$\hat{N}_j = \sum_i (p_{ij} \hat{N}_i) \qquad (9)$$

with a sample variance calculated according to procedures in Goodman (1960):

$$v(\hat{N}_j) = \sum_i \begin{pmatrix} v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)\hat{p}_{ij} \\ -v(\hat{p}_{ij})v(\hat{N}_i) \end{pmatrix} \qquad (10)$$

The proportion of the spawning population composed of a given age was estimated by:

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}} \qquad (11)$$

where $\hat{N} = \sum \hat{N}_i$. Variance of $\hat{p}_j$ was approximated according to the procedures in Seber (1982):

$$v(\hat{p}_j) = \frac{\sum_i \left(v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2 \right)}{\hat{N}^2} \qquad (12)$$

Sex and age-sex composition for the spawning population and associated variances were also estimated with the equations above by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes sex, such that $\sum_k \hat{p}_k = 1$, and by age-sex, such that $\sum_{jk} \hat{p}_{jk} = 1$.

Age, sex, and age-sex composition and associated variances for fish passing through Dry Bay or caught in Alaskan commercial fisheries were also estimated as described above.

Estimated age composition of Chinook salmon captured in the different spawning areas was compared using a chi-square test prior to combining these samples. Estimated age composition of samples from gillnets was compared with estimated age composition from data pooled across spawning grounds using another chi-square test. Estimates of mean length at age and their estimated variances were calculated with standard normal procedures.

RESULTS

DRY BAY TAGGING

Between May 15 and August 8, 2004, 773 large (611 in larger-mesh gear, 162 in the smaller mesh) and 49 small and medium (23 in larger-mesh gear, 26 in the smaller mesh) Chinook salmon were captured in the lower Alsek River. Of these, 732 large and 43 medium fish were sampled, marked and released (Table 4, Appendix A1 and A2). Fishing effort was maintained at 8 hours per day for the larger-mesh net and 7 hours per day for the smaller-mesh net (Figure 3; Appendix A1 and A2). Catch rates in the larger-mesh gear ranged from 0 to 5.76 fish/net-hour and peaked on May 29, when 46 large Chinook salmon were captured (Figure 4). Catches in the smaller-mesh gear peaked on May 27 when 17 large fish were caught (Figure 5). The date of 50% cumulative catch was May 31. The sex ratio of Chinook salmon caught in the gillnets was skewed towards females (475 females, 337 males). In addition, each healthy sockeye salmon captured was marked with a spaghetti tag and released (reported in a separate study). A subset of these marked sockeye salmon were fitted with radio tags and released as part of separate mark-recapture experiment conducted by Commercial Fisheries Division and DFO.

FISHERY SAMPLING

The inriver U.S. commercial gillnet fishery harvested 656 Chinook salmon–including 2 tagged fish, and U.S. subsistence and personal use fisheries harvested 38 more (Tables 2 and 4).

SPAWNING GROUND SAMPLING

A total of 2,525 Chinook salmon were passed through the Klukshu River weir and 1,187 were physically handled and sampled, of which 1,118 were large fish and 116 were marked (Table 4). Of fish sampled at the weir, 669 were females and 518 were males. In addition, 14 carcasses (10 large) were sampled at or above the weir and one large marked fish was recovered.

The remaining 1,324 Chinook salmon that passed through the weir were not physically handled (inspected) for marks; however, each fish was

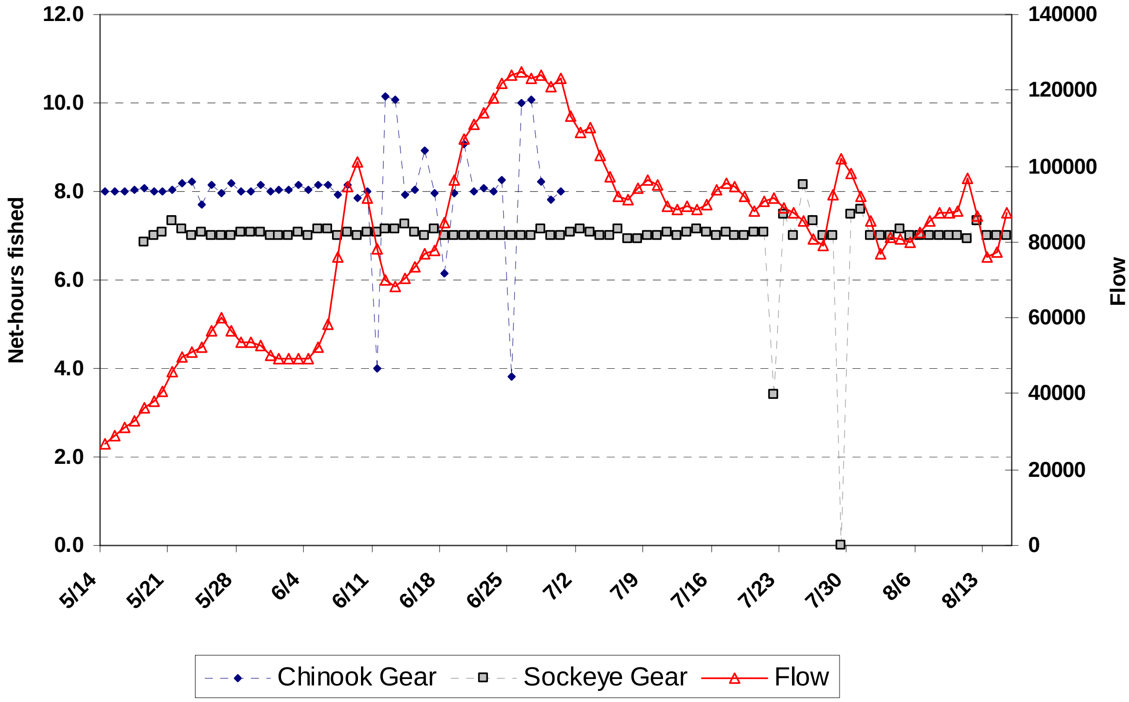


Figure 3.–Daily fishing effort (hours) for Chinook (7¼") and sockeye (5¼") gillnets and river flow (ft^3/s), Alsek River near Dry Bay, 2004. (Flow information from USGS water information system.)

carefully observed from a short distance as they passed over a white observation board. Even so, comparison of marked fractions of fish inspected (handled) at the weir vs. those observed (not handled) indicated that observation alone was insufficient to reliably detect tags. Pooling data on medium and large fish from statistics in Table 4 produced:

	Observed	Inspected
Marked	74	128
Unmarked	1,250	1073
Marked fraction	0.056	0.107

This almost two-fold difference is highly significant (χ^2 = 18.69, df = 1, P < 0.0001) Determining the size and sex of fish not physically handled was not attempted.

At Blanchard River, 52 large live Chinook salmon and carcasses were examined for marks, and one marked fish was recovered (Table 4). At the Takhanne River, 56 (55 large) fish were sampled and one tag was recovered.

The aboriginal fishery near Dalton Post harvested an estimated 139 Chinook salmon and four tags were returned. About half of the harvest was taken above the weir and not all the catch was sampled. The sport fishery near Dalton Post harvested about 42 Chinook, with additional fish released. Twelve (12) fish from the sport harvest were examined by DFO technicians, and 2 tagged fish were recovered.

ABUNDANCE

Sampling on the spawning grounds proved to be non selective (by size) at Klukshu River weir and selective towards larger fish in samples taken from the Takhanne and Blanchard Rivers. We stratified the abundance estimate into separate estimates of medium and large Chinook salmon to accommodate as many samples as possible and to improve precision of estimates. Samples taken at Blanchard and Takhanne Rivers were pooled because their marked fractions were not significantly different (0.019 vs 0.018, χ^2 = 0.002, df = 1, P = 0.969). However, the marked fraction of this pooled sample was significantly different than the marked fraction of fish inspected at the Klukshu River weir (0.107 vs. 0.019, χ^2 = 7.586, df = 1, P = 0.006).

Most of the estimated harvest in the aboriginal fisheries was not sampled and the inspected sample size in the sport fishery was too small to be included in the mark-recapture analysis.

Comparison of length distributions of fish of all sizes marked in event 1, fish captured for the first time in event 2, and marked fish recaptured in event 2, indicated no size-selective sampling at the weir and a shift to encountering large fish on the spawning grounds in the Blanchard and Takhanne rivers (Figure 6 and Table 4). The cumulative relative frequencies of fish marked (all sizes) in Dry Bay vs. fish recaptured at Klukshu weir were not similar (Figure 6, lower graph, K-S test P = 0.009). Fish marked in Dry Bay were statistically larger than fish inspected at Klukshu weir (Figure 6, upper graph, K-S test P < 0.001), although this test is sensitive to very small differences with sample sizes as large as these. Additionally, fish inspected at Blanchard and Takhanne Rivers were significantly larger than fish marked in Dry Bay (Figure 6 upper panel, K-S test P <0.001) and the weir sample.

These results are consistent with use of gill nets at Dry Bay, snagging fish as a capture method on the spawning grounds, and using a weir to capture live fish on the Klukshu River. The cumulative relative frequencies of large fish marked in Dry Bay vs. large fish recaptured in the combined spawning grounds samples are similar (Figure 7). Looking at the recapture rates of medium vs. large fish at the weir supports the equal probability of capture for these fish at the weir:

	440-659 mm	> 660 mm
Marked Dry Bay	43	732
Inspected Klukshu	11	117
Marked fraction	0.26	0.16

These marked fractions were not significantly different (χ^2 = 1.890, df = 1, P = 0.169).

Catches of large Chinook in Dry Bay showed a bimodal pattern not observed in other years (Figure 4), so tags recovered at the weir were split by tagging date into early (though May 31) and late (after May 31) strata to compare recovery rates:

	Early	Late
Marked Dry Bay	383	349
Recovered Klukshu	56	58
Marked fraction	0.14	0.17

These recovery rates were not significantly different (χ^2 = 0.421, df = 1, P = 0.516). This supports the assumption that each large Chinook had a nearly equal chance of being captured during the tagging operation and that the bimodal pattern was probably the result of high water during the mid-point of the run.

Additional evidence from spawning ground sampling also supports the supposition that the tagging operation was not size selective within the category of larger fish. Length samples of live large fish sampled at the weir were arbitrarily split into two groups at the median length of large fish (800 mm MEF) to permit comparison of marked fractions:

	660–800 mm	> 800 mm
Marked	57	59
Unmarked	501	501
Marked fraction	0.114	0.118

This non-significant comparison (χ^2 = 0.031, df = 1, P = 0.860) is sufficient to meet condition (*a*) for having a consistent estimate from Petersen's model when estimating the abundance of large fish regardless of their size.

Evidence from spawning ground sampling supports the supposition that every large Chinook salmon had a nearly equal chance of being captured upriver regardless of its size. Pooled length samples of large fish from the spawning grounds were again split into two size groups as were samples of larger fish marked in Dry Bay. After censoring large fish removed by the U.S. gillnet fishery, rates of recaptured fish were compared as surrogates for probabilities of capture upstream at the Klukshu River weir:

	660–800 mm	> 800 mm
Released	306	424
Recaptured	57	59
Fraction	0.189	0.139

Table 4.–Numbers of Chinook salmon marked on lower Alsek River, removed by fisheries and inspected for marks in tributaries in 2004, by length group. **Note: Numbers in bold were used in the mark-recapture estimate.**

		Length (MEF)			
		Small 0–439 mm	**Medium 440–659 mm**	**Large ≥660 mm**	**Total**
A. Released at Dry Bay with marks		3	43	732	778
B. Removed by:					
1. U.S. sport/subsistence		0	0	0	0
2. U.S. gillnet		0	0	2	2
	Subtotal of removals	0	0	2	2
C. Estimated number of marked fish remaining in mark-recapture experiment		3	**43**	**730**	776
D. Spawning ground samples					
Observed at Klukshu weir	Observed [a]		149	2,376[b]	2,525
	Marked		17	185[c]	202
	Marked/observed		0.118	0.078	0.072
Inspected at:					
1. Klukshu weir live and carcass	Inspected	0	**73**	**1,128**	1,201
	Marked	0	**11**	**117[d]**	128
	Marked/inspected		0.151	0.104	0.107
2. Blanchard/ Takhanne	Inspected	0	**1**	**107**	108
	Marked	0	**0**	**2**	2
	Marked/ inspected		0.0	0.019	0.019
3. Sport fishery	Harvest	*Estimated catch, voluntary tag returns*			46
	Marked		1	1	2
	Marked/inspected				0.044
4. Aboriginal fishery	Harvest	*Below weir catch sample*			23
	Marked				3
	Marked/inspected				0.130

[a] Observed sample includes those fish inspected sample.

[b] size category estimated from sample proportions.

[c] Tags estimated from proportion of large tags in sample.

[d] Includes two tags where number was not recorded.

These fractions recaptured were not significantly different (χ^2 = 2.130, df = 1, P = 0.144).

Thus, there is some evidence of size-selectivity during the first sampling event in Dry Bay and on the Blanchard and Takhanne River samples (Appendix B1). Information from sampling on the Takhanne and Blanchard rivers was included in the analysis. Length, sex and age data from the Klukshu River weir were used to estimate proportions in compositions and both sampling events were stratified by size, and abundance estimated for each strata (Appendix B1).

Sex composition of large fish captured in Dry Bay was estimated to be 38% male, with 42% at the Klukshu River weir, and 56% in the Blanchard and Takhanne river samples. This outcome shows that fish had essentially the same probability of being captured regardless of their sex. The gender recorded for 24 out of 115 (21%) of the fish recaptured on the spawning grounds was different from what was recorded when the fish were tagged in Dry Bay. There was no obvious bias in sex determination, with nine fish recorded as females in Dry Bay called males at recovery, and fifteen males called females.

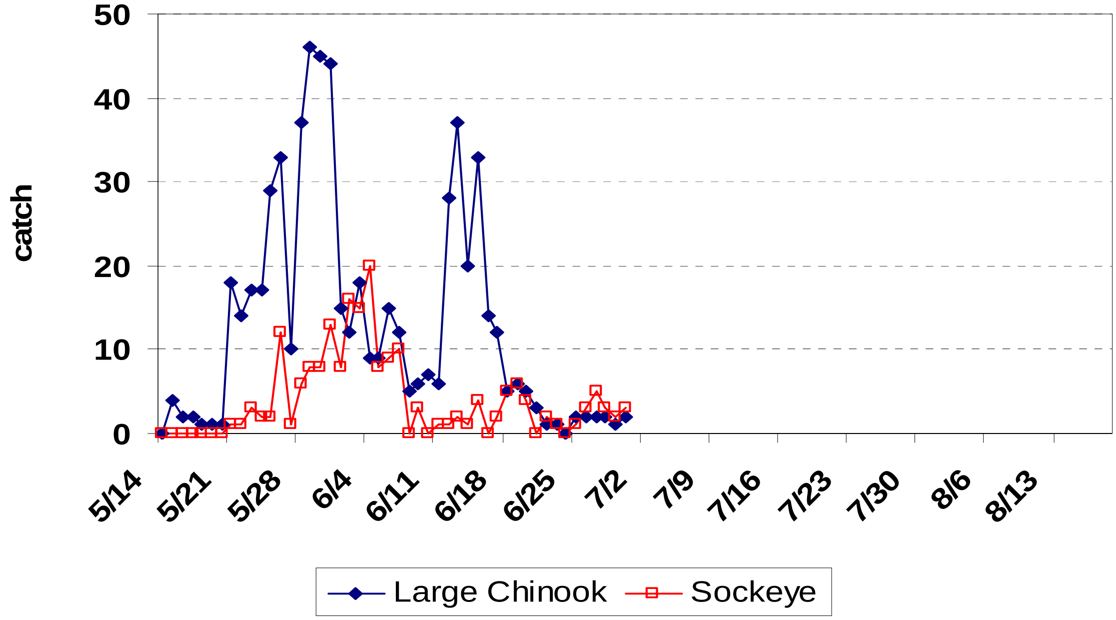


Figure 4.–Daily catch of Chinook and sockeye salmon in larger-mesh gillnet, lower Alsek River, 2004.

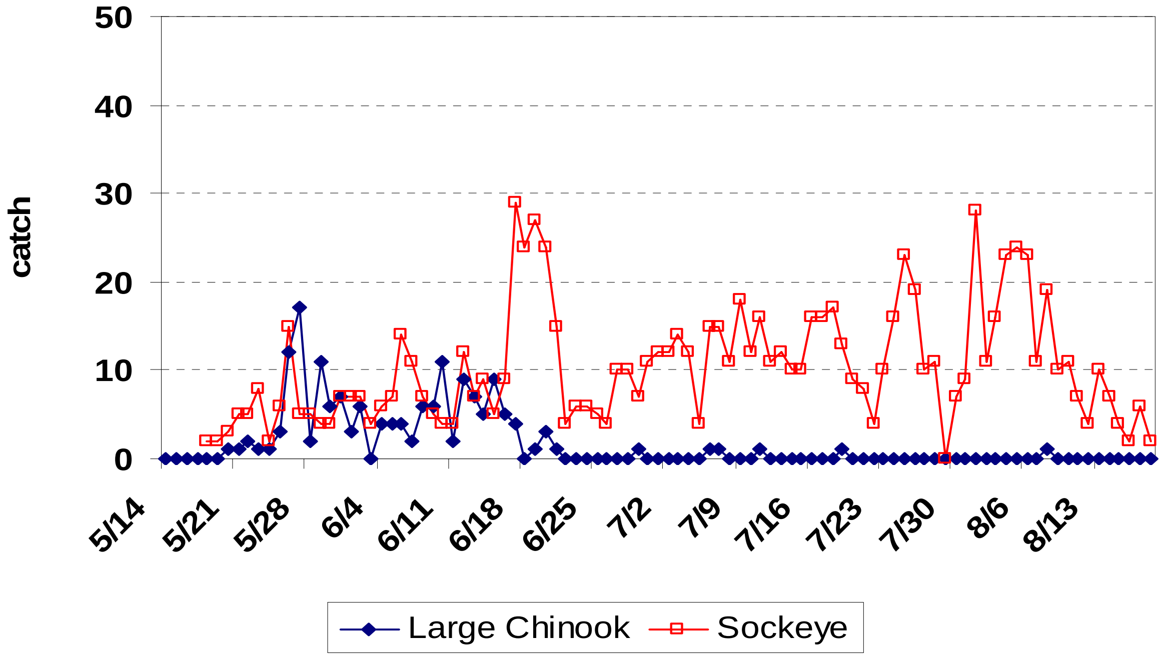


Figure 5.–Daily catch of Chinook and sockeye salmon in smaller-mesh gillnet, lower Alsek River, 2004.

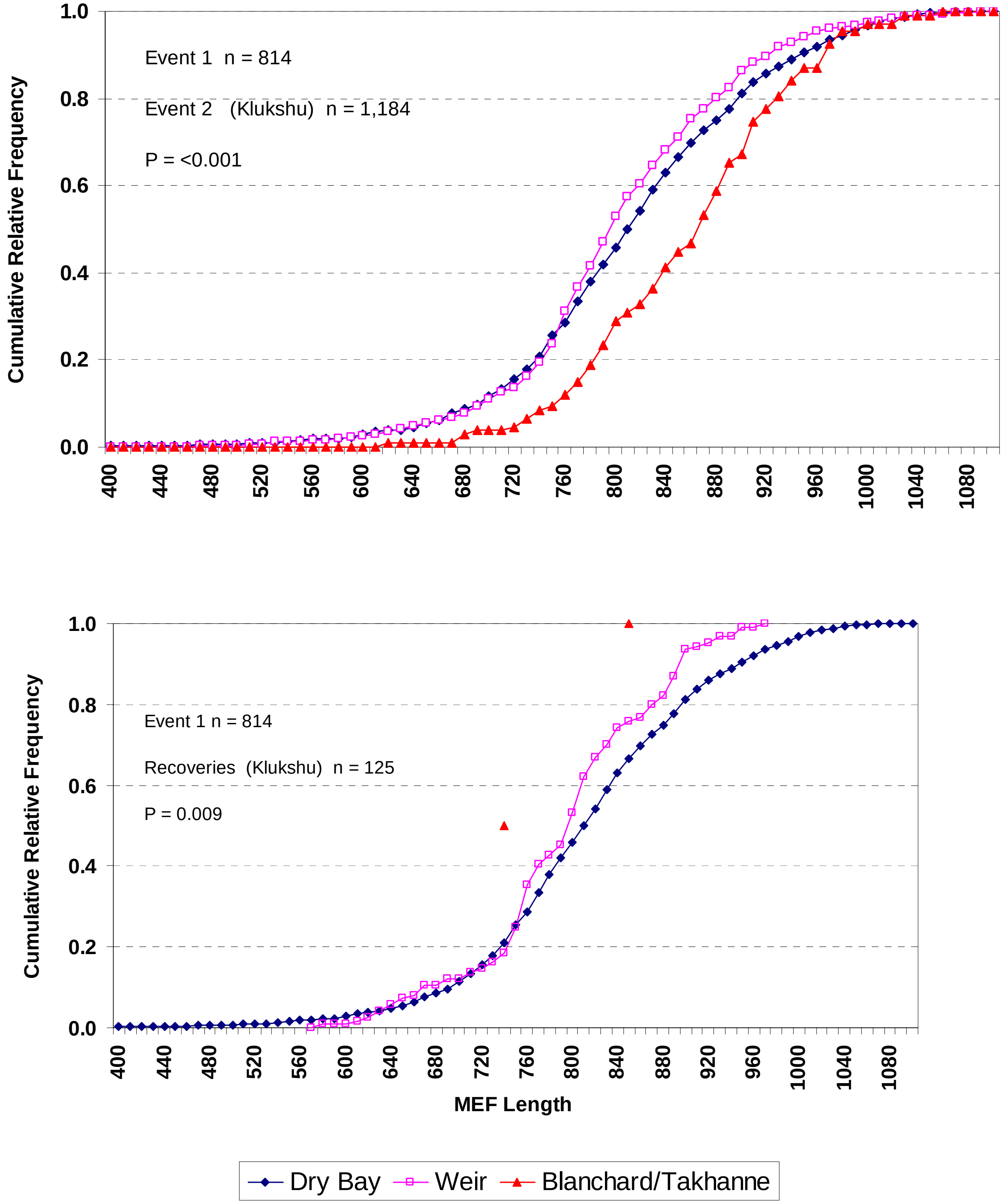


Figure 6.–Cumulative relative frequency of Chinook salmon captured in event 1 (gillnets in Dry Bay) compared with those inspected (upper graph) and marked fish recaptured (lower graph) in event 2 (combined sampling on the Takhanne and Blanchard Rivers and at the weir on the Klukshu River), Alsek River, 2004.

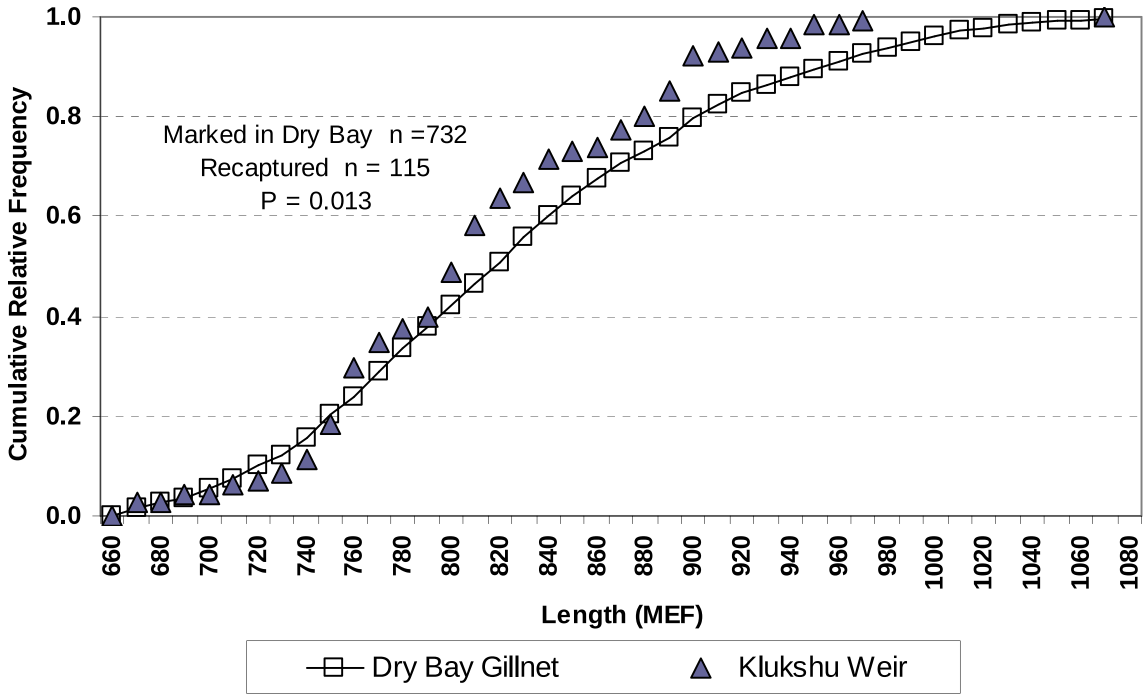


Figure 7.–Cumulative relative frequency of large Chinook salmon captured in event 1 (gillnets in Dry Bay) compared with marked fish recaptured in event 2 (combined sampling on the Takhanne and Blanchard Rivers and at the weir on the Klukshu River), Alsek River, 2004.

The mark-recapture estimate for large fish passing Dry Bay is 7,528 fish (SE = 595). An estimated 730 marked fish moved upstream, 119 of which were found in the fish inspected upstream at the weir and spawning grounds (Table 4). Marked fractions for large fish inspected at the weir and for large fish sampled on the spawning grounds were quite different (0.104 vs. 0.019), but the difference was not quite significant (χ^2 = 3.629, df = 1, P = 0.057), so the data were pooled for the estimate. A bootstrap estimate of the 95% confidence interval around the estimated abundance is 6,578–8,700 fish; estimated statistical bias is <0.01%.

After subtracting the Canadian inriver harvest of 185, which is primarily large fish, the estimated number of large spawners in the entire Alsek River is 7,343 fish (SE = 595).

Abundance of medium Chinook salmon was an estimated 274 fish (SE = 59) and the 95% confidence interval is 198–453 fish; estimated statistical bias is 5.6%. An estimated 43 marked fish moved upstream, 11 of which were found in the 74 fish inspected upstream at the weir (Table 4). No tests for size-selective sampling were conducted for medium fish because few fish were marked and fewer recaptured.

The sum of the two stratified estimates gives a total estimate of medium and large escapement of 7,802 Chinook salmon, which is similar to the unstratified estimate of escapement of 7,769 Chinook salmon of all sizes. Estimated abundance by age and sex of the entire escapement is calculated in Table 5.

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

Age-1.3 Chinook salmon accounted for an estimated 72% (SE = 1.4%) of the escapement in 2004, with age-1.4 fish (24%) accounting for most of the remainder (Table 5). Estimated age compositions were significantly different for fish sampled at Dry Bay and at the Klukshu River ($\chi2$ = 12.7, df = 3, P = 0.005) and composition of fish in the Klukshu River sample differed from

Table 5.–Estimated abundance and composition by age and sex of the escapement of Chinook salmon in the Alsek River, 2004, using samples taken at the Klukshu River weir.

		Brood year and age class									
		2001	2000	2000	1999	1999	1998	1998	1997	1997	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Medium Chinook salmon											
Males	n	0	0	9	0	8	0	0	0	0	17
	%			14.5		12.9					27.4
	SE of %			4.5		4.3					5.7
	Escapement			40		35					75
	SE of esc.			15		14					22
Females	n	0	0	25	1	18	0	1	0	0	45
	%			40.3	1.6	29.0		1.6			72.6
	SE of %			6.3	1.6	5.8		1.6			5.7
	Escapement			110	4	80		4			199
	SE of esc.			29	4	23		4			45
Sexes combined	n	0	0	34	1	26	0	1	0	0	62
	%			54.8	1.6	41.9		1.6			100.0
	SE of %			6.4	1.6	6.3		1.6			0.0
	Escapement			150	4	115		4			274
	SE of esc.			37	4	30		4			59
Large Chinook salmon											
Males	n	0	0	5	0	290	2	114	0	0	411
	%			0.5		29.2	0.2	11.5			41.3
	SE of %			0.2		1.4	0.1	1.0			1.6
	Escapement			38		2,196	15	863			3,113
	SE of esc.			17		205	11	102			273
Females	n	0	0	0	0	433	11	135	4	0	583
	%					43.6	1.1	13.6	0.4		58.7
	SE of %					1.6	0.3	1.1	0.2		1.6
	Escapement					3,279	83	1,022	30		4,415
	SE of esc.					285	26	115	15		368
Sexes combined	n	0	0	5	0	723	13	249	4	0	994
	%			0.5		72.7	1.3	25.1	0.4		100.0
	SE of %			0.2		1.4	0.4	1.4	0.2		0.0
	Escapement			38		5,476	98	1,886	30		7,528
	SE of esc.			17		446	28	181	15		595
Medium and large Chinook salmon											
Males	n	0	0	14	0	298	2	114	0	0	428
	%			1.0		28.6	0.2	11.1			40.9
	SE of %			0.3		1.4	0.1	1.0			1.5
	Escapement			78		2,232	15	863			3,188
	SE of esc.			23		205	11	102			273
Females	n	0	0	25	1	451	11	136	4	0	628
	%			1.4	0.1	43.1	1.1	13.2	0.4		59.1
	SE of %			0.4	0.1	1.5	0.3	1.1	0.2		1.5
	Escapement			110	4	3,359	83	1,027	30		4,614
	SE of esc.			29	4	286	26	115	15		371
Sexes combined	n	0	0	39	1	749	13	250	4	0	1,056
	%			2.4	0.1	71.7	1.3	24.2	0.4		100.0
	SE of %			0.5	0.1	1.4	0.3	1.3	0.2		0.0
	Escapement			188	4	5,591	98	1,890	30		7,802
	SE of esc.			40	4	447	28	181	15		598

estimates for fish at the other spawning ground locations ($\chi 2$ = 37.25, df = 3, P = <0.001; Appendix A4-A6). Because there is evidence of size-selectivity during the first sampling event in Dry Bay, samples taken at the weir were used to estimate length, sex and age composition.

DISCUSSION

In all seven years of this study, a smaller fraction of fish sampled in the tributaries carried marks than did fish inspected at the weir. Differences ranged from 24% to 87% of the marked fraction of fish at the weir. Sample sizes in the tributaries were small, making statistical tests weak, so few differences were found to be significantly different (α = 0.05). However, the probability that marked fractions would be lower in the tributaries in all seven years from random chance alone is small (< 1%).

	Klukshu Weir		Blanchard/Takhanne	
	Inspected	Marked Fraction	Inspected	Marked Fraction
1998	206	0.044	31	0.032
1999	232	0.030	74	0.000
2000	207	0.063	108	0.046
2001	546	0.084	219	0.046
2002	462	0.097	204	0.054
2003	586	0.104	141	0.071
2004	1,128	0.104	107	0.019

Relatively fewer marked fish in the tributaries does carry consequences for estimates of abundance for the entire watershed. Pooling data from the tributaries with data from the weir had little effect on the abundance estimate because of the small sample sizes from the tributaries. However, these small sample sizes are not indicative of the abundance in those streams. Telemetry studies in 1998 and 2002 show that the portion of the passage by Dry Bay headed for the Klukshu River (~15 to 30%) is about the same as the portion headed for the combined Takhanne and Blanchard rivers in the same years (Figure 7, Pahlke and Waugh 2003). A more equal weighting of samples prior to pooling would have affected abundance estimates.

Other evidence points to differences in marked fractions as being an artifact of methods used to sample fish from the tributaries. Snagging is used to capture fish from these the tributaries, and often results in size-selective sampling towards larger fish (4 of 7 years). Radiotelemetry studies conducted in 1998 and 2002 estimated the distribution and migratory timing of spawning Chinook salmon in the Alsek and Tatshenshini rivers. Studies on the Taku, Stikine, Unuk and Chickamin rivers have shown, in general, Chinook salmon migrating to lower tributaries migrated upriver later in the year than fish heading to spawning areas much farther upriver (Pahlke and Bernard 1996; Pahlke and Etherton 1999; Pahlke et al. 1996; Pahlke 1997a). That trend was not apparent in the Alsek River studies. Fish spawning in the lower and middle Tatshenshini River and those heading to the upper Tatshenshini River, including the Klukshu, Blanchard, Takhanne rivers and Goat Creek, all passed through Dry Bay in a similar pattern. With no significant differences in run timing, it would be unlikely that fish going to different tributaries would be marked at different rates.

In all seven years of this study, a larger fraction of fish inspected at the weir were marked compared with fish observed but not handled at the weir. This is most likely due to difficulties in observing tags when large numbers of sockeye salmon are passing with the Chinook salmon. Since 2001, we have increased the number of Chinook salmon inspected to respond to this condition.

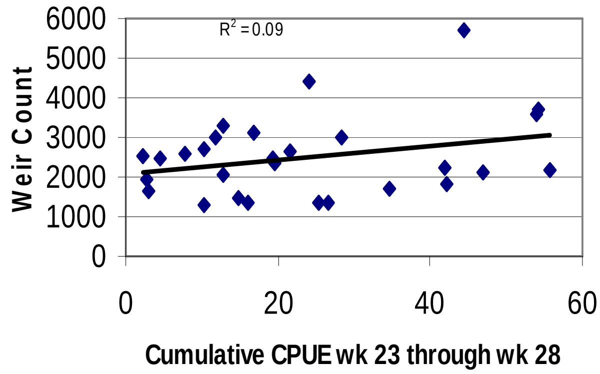
Traditional indices of Chinook salmon escapement to the Alsek River in 2004 were mixed. The count of 2,525 Chinook salmon at the Klukshu weir was above the escapement goal range of 1,100 to 2,300 fish (all sizes), and close to the recent 10-year average of 2,672. On the other hand, index counts in the Blanchard and Takhanne rivers were some of the lowest ever recorded and only 28% of the 10 year average. The number of large Chinook salmon tagged at the set nets in Dry Bay increased from 245 in 1998, 402 in 1999, 479 in 2000, 529 in 2001, to 552 in 2002 due to the experience gained in operation of the nets the previous three years and the added fishing effort with smaller mesh nets. The number decreased in 2003 to 508, and increased in 2004 to 732.

We spent two days (August 2–3) sampling on the Blanchard and Takhanne rivers. That is the historical peak spawning period for those rivers and we saw no indication of unusual run timing or abnormal tag loss. The run timing at the Klukshu weir was normal, with 50% of the fish passing by July 15 and no difference in tag recovery rate between fish tagged early and late in Dry Bay. If the mark rate for the Alsek drainage is 10% as estimated from the weir sample, the chance of 2 or fewer tags recovered in the sample from the Blanchard and Takhanne is extremely unlikely (0.07%). The bias added by including the Blanchard and Takhanne samples in the abundance estimate is small.

In 1999 the U.S. and Canada signed a new PSC agreement which included a specific directive in Annex IV of the treaty to develop abundance-based management of Chinook salmon returning to the Stikine, Taku and Alsek rivers by 2004. On the Taku and Stikine Rivers it appears feasible to estimate the abundance in-season with a mark-recapture experiment. On the Alsek River this is not feasible because of the smaller Chinook population, the lack of a suitable recapture site in the lower river and budget constraints.

Another possibility under investigation on the Stikine River that might have potential for abundance-based management for fisheries on the Alsek River is the relationship between cumulative CPUE in the mark-recapture experiment and the estimated abundance of large Chinook salmon (Der Hovanisian et al. 2004). Over the years June 8 is the average date of 50% cumulative catch in Dry Bay and probably the latest date that an abundance estimate would be useful inseason. When the cumulative CPUE through June 8 of the Chinook gear in the Dry Bay tagging project was regressed on abundance estimates from 1998 to 2004, there was very little relationship (R^2 = 0.02). When the cumulative CPUE through July 1 was used, the relationship was better, although still poor (R^2 = 0.51).

Cumulative CPUE in the Dry Bay commercial fishery also showed little potential for inseason management when this statistic was regressed against counts from the weir on the Klukshu River (years 1976 to 2003):



This relationship can only be examined back to 1976 when the weir was installed. Historically the commercial fishery opened in mid to late May, but since 1975, the commercial fishery has never opened before the first week in June, and effort was often low.

The use of a pre-season forecast is another option for abundance-based management. Estimated escapement of age-1.2 fish at the Klukshu River weir was regressed against estimated escapement of age-1.3 fish the following year. The regression may be meaningful (R^2 = 0.55), but when estimates of age-1.2 and 1.3 fish are regressed against following year estimates of age-1.3 and 1.4 fish, the correlation breaks down (R^2 = 0.11), indicating a weak sibling relationship or problems with the estimates of abundance by age.

Increased sampling effort in 2004 at the Klukshu River weir resulted in a higher proportion of the run being sampled than in the recent past. Below average escapement on the other tributaries resulted in lower sample sizes than 2002 or 2003 despite increased effort.

The estimated expansion factor ($\hat{\pi}$) for counts at the weir in 2004 is the lowest value on record (Appendix C1, Table C1). The weir count of 2,525 was combined with the estimated harvest of 113 fish in fisheries immediately below the weir for a total of 2,638 fish bound for the Klukshu River. In 2004, 94.1% of the fish inspected at the weir were large fish, resulting in an estimated return of 2,482 large Chinook salmon bound for the Klukshu River. This was about 33% of the mark-recapture estimated escapement of large fish past Dry Bay, or an estimated expansion factor of 3.03 (SE = 0.24). The average over these six estimates is $\overline{\pi}$ = 4.95 (SD = 1.21). If only fish inspected at the weir are included in the mark-recapture experiments from 1998 through 2004, the average expansion factor drops to 4.17 (SD = 1.14). Calculation of the average expansion factors and their variances are described in detail in Appendices C1 and C2. These two expansion factors imply that fish spawning above the weir on the Klukshu River represent 20 or 24% of the return. These two percents are within the estimates gained through radio telemetry in 1998 and 2002 (see Figure 7, Pahlke and Waugh 2003).

The 1999 PST agreement states that Southeast Alaska Chinook stocks will be managed for maximum sustained yield (MSY) escapement goals. The escapement goal for the Klukshu River was revised in 1998 to a range of 1,100 to 2,300 Chinook salmon through the weir and that goal has been met or exceeded every year since 1976. In his escapement goal analysis, McPherson et al. (1998) recommended that the goal be reexamined in 2001 after the returns from large escapements in 1993–1996 were complete. A thorough analysis of the data has not been completed, however a cursory examination of the catch and escapement numbers in the primary return years indicate that escapements of over 3,000 Chinook did not even replace themselves. These numbers support the existing escapement goal range, pending complete analysis of recent data.

CONCLUSION AND RECOMMENDATIONS

The annual total escapement of large Chinook salmon to the Alsek River has been successfully estimated during 1984–2004. The precision of the estimates improved continually over the seven years as we improved our techniques in both the Dry Bay capture event and the upriver recapture event.

Set gillnets are an effective method of capturing large Chinook salmon migrating up the Alsek River, although the tagging crew must respond to fluctuating river conditions which rapidly change the effectiveness of the gear. It appears that with the existing effort a sample size of 500 large fish tagged is possible. Sample sizes in event 2 must be increased to achieve an acceptably precise estimate of abundance, and the samples at the Klukshu River should be collected in a more systematic manner from all fish passing through the weir. This can be accomplished by increasing the effort at the weir during the period of peak migration.

Due to changes in funding priorities, the 2004 project will be the last of this series of mark-recapture studies conducted on Alsek River Chinook salmon. The results of the seven year study indicate that the Klukshu River weir is a valid index of Chinook salmon escapement to the Alsek River, but may be more variable than indicated in previous studies. The continued operation of the Klukshu River weir is essential in providing a post-season estimate of escapement (product of 4.17 and the count of large fish) and age-composition that can be used in revising the escapement goal and further work on forecasting escapement. The ADF&G and DFO will continue to work on developing a test fishery and using CPUE data in Dry Bay to provide the tools for abundance-based management as directed by the Pacific Salmon Treaty.

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APPENDIX A: GILLNET AND WEIR CATCHES AND AGE, SEX AND LENGTH SUMMARIES

Appendix A1.–Daily fishing effort (hours fished), catches, cumulative catches and catch per net hour in large-mesh (7¼ in stretch mesh) gillnets near Dry Bay, lower Alsek River, 2004.

		Large Chinook					**Jack Chinook**			
		Daily					Daily			**Sockeye**
Date	Hours	Catch	Tagged	Cum Tag	Percent	CPUE	Catch	Tagged	Cum. Tag	Daily Catch
14-May	8.0	0	0	0	0.0%	0.00	0	0	0	0
15-May	8.0	4	4	4	0.7%	0.50	0	0	0	0
16-May	8.0	2	2	6	1.0%	0.25	0	0	0	0
17-May	8.0	2	2	8	1.4%	0.25	0	0	0	0
18-May	8.1	1	1	9	1.5%	0.12	0	0	0	0
19-May	8.0	1	1	10	1.7%	0.12	0	0	0	0
20-May	8.0	1	1	11	1.9%	0.12	0	0	0	0
21-May	8.1	18	18	29	4.9%	2.24	0	0	0	1
22-May	8.2	14	13	42	7.1%	1.71	1	1	1	1
23-May	8.2	17	16	58	9.9%	2.06	0	0	1	3
24-May	7.7	17	17	75	12.8%	2.20	0	0	1	2
25-May	8.2	29	27	102	17.3%	3.55	0	0	1	2
26-May	8.0	33	32	134	22.8%	4.14	0	0	1	12
27-May	8.2	10	10	144	24.5%	1.22	0	0	1	1
28-May	8.0	37	35	179	30.4%	4.62	0	0	1	6
29-May	8.0	46	43	222	37.8%	5.75	0	0	1	8
30-May	8.2	45	44	266	45.2%	5.51	2	2	3	8
31-May	8.0	44	43	309	52.6%	5.50	0	0	3	13
1-Jun	8.1	15	13	322	54.8%	1.86	0	0	3	8
2-Jun	8.0	12	12	334	56.8%	1.49	0	0	3	16
3-Jun	8.2	18	18	352	59.9%	2.21	1	1	4	15
4-Jun	8.1	9	9	361	61.4%	1.12	1	1	5	20
5-Jun	8.2	9	9	370	62.9%	1.10	1	1	6	8
6-Jun	8.1	15	15	385	65.5%	1.84	2	2	8	9
7-Jun	7.9	12	11	396	67.3%	1.51	1	1	9	10
8-Jun	8.2	5	4	400	68.0%	0.61	0	0	9	0
9-Jun	7.9	6	6	406	69.0%	0.76	1	1	10	3
10-Jun	8.0	7	7	413	70.2%	0.88	1	1	11	0
11-Jun	4.0	6	6	419	71.3%	1.50	0	0	11	1
12-Jun	10.1	28	27	446	75.9%	2.76	1	1	12	1
13-Jun	10.1	37	37	483	82.1%	3.67	3	3	15	2
14-Jun	7.9	20	20	503	85.5%	2.52	1	1	16	1
15-Jun	8.0	33	31	534	90.8%	4.11	0	0	16	4
16-Jun	8.9	14	13	547	93.0%	1.57	1	1	17	0
17-Jun	8.0	12	11	558	94.9%	1.51	2	2	19	2
18-Jun	6.2	5	5	563	95.7%	0.81	1	1	20	5
19-Jun	8.0	6	5	568	96.6%	0.75	1	1	21	6
20-Jun	9.1	5	5	573	97.4%	0.55	1	0	21	4
21-Jun	8.0	3	3	576	98.0%	0.38	0	0	21	0
22-Jun	8.1	1	1	577	98.1%	0.12	0	0	21	2
23-Jun	8.0	1	0	577	98.1%	0.13	0	0	21	1
24-Jun	8.3	0	0	577	98.1%	0.00	1	1	22	0
25-Jun	3.8	2	2	579	98.5%	0.52	0	0	22	1
26-Jun	10.0	2	2	581	98.8%	0.20	0	0	22	3
27-Jun	10.1	2	2	583	99.1%	0.20	0	0	22	5
28-Jun	8.2	2	2	585	99.5%	0.24	0	0	22	3
29-Jun	7.8	1	1	586	99.7%	0.13	0	0	22	2
30-Jun	8.0	2	2	588	100.0%	0.25	0	0	22	3
1-Jul	0.0			588	100.0%				22	

Appendix A2.–Daily fishing effort (hours fished), catches, cumulative catches and catch per net hour in smaller-mesh (5¼ in stretch mesh) gillnets near Dry Bay, lower Alsek River, 2004.

		Large Chinook					**Jack Chinook**			
		Daily					Daily			**Sockeye**
Date	Hours	Catch	Tagged	Cum tag	Percent	CPUE	Catch	Tagged	Cum tag	Daily Catch
14-May	0.0	0	0	0	0.0%		0	0	0	
15-May	0.0	0	0	0	0.0%		0	0	0	
16-May	0.0	0	0	0	0.0%		0	0	0	
17-May	0.0	0	0	0	0.0%		0	0	0	
18-May	6.9	0	0	0	0.0%	0	0	0	0	2
19-May	7.0	0	0	0	0.0%	0	0	0	0	2
20-May	7.1	1	1	1	0.7%	0.14	0	0	0	3
21-May	7.3	1	1	2	1.3%	0.14	0	0	0	5
22-May	7.2	2	2	4	2.7%	0.28	0	0	0	5
23-May	7.0	1	1	5	3.3%	0.14	0	0	0	8
24-May	7.1	1	1	6	4.0%	0.14	0	0	0	2
25-May	7.0	3	3	9	6.0%	0.43	0	0	0	6
26-May	7.0	12	12	21	14.0%	1.71	0	0	0	15
27-May	7.0	17	16	37	24.7%	2.43	0	0	0	5
28-May	7.1	2	2	39	26.0%	0.28	0	0	0	5
29-May	7.1	11	11	50	33.3%	1.55	0	0	0	4
30-May	7.1	6	6	56	37.3%	0.85	1	1	1	4
31-May	7.0	7	7	63	42.0%	1.00	2	2	3	7
1-Jun	7.0	3	2	65	43.3%	0.43	1	1	4	7
2-Jun	7.0	6	6	71	47.3%	0.86	1	1	5	7
3-Jun	7.1	0	0	71	47.3%	0.00	1	1	6	4
4-Jun	7.0	4	3	74	49.3%	0.57	0	0	6	6
5-Jun	7.2	4	4	78	52.0%	0.56	0	0	6	7
6-Jun	7.2	4	4	82	54.7%	0.56	3	3	9	14
7-Jun	7.0	2	2	84	56.0%	0.29	2	2	11	11
8-Jun	7.1	6	6	90	60.0%	0.85	0	0	11	7
9-Jun	7.0	6	5	95	63.3%	0.86	1	1	12	5
10-Jun	7.1	11	10	105	70.0%	1.55	0	0	12	4
11-Jun	7.1	2	2	107	71.3%	0.28	1	1	13	4
12-Jun	7.2	9	7	114	76.0%	1.26	3	3	16	12
13-Jun	7.2	7	6	120	80.0%	0.98	2	2	18	7
14-Jun	7.3	5	4	124	82.7%	0.69	1	1	19	9
15-Jun	7.1	9	8	132	88.0%	1.27	2	2	21	5
16-Jun	7.0	5	5	137	91.3%	0.71	0	0	21	9
17-Jun	7.2	4	3	140	93.3%	0.56	2	2	23	29
18-Jun	7.0	0	0	140	93.3%	0.00	1	1	24	24
19-Jun	7.0	1	1	141	94.0%	0.14	0	0	24	27
20-Jun	7.0	3	2	143	95.3%	0.43	0	0	24	24
21-Jun	7.0	1	1	144	96.0%	0.14	1	1	25	15
22-Jun	7.0	0	0	144	96.0%	0.00	0	0	25	4
23-Jun	7.0	0	0	144	96.0%	0.00	0	0	25	6
24-Jun	7.0	0	0	144	96.0%	0.00	0	0	25	6
25-Jun	7.0	0	0	144	96.0%	0.00	0	0	25	5
26-Jun	7.0	0	0	144	96.0%	0.00	1	0	25	4
27-Jun	7.0	0	0	144	96.0%	0.00	0	0	25	10
28-Jun	7.2	0	0	144	96.0%	0.00	0	0	25	10
29-Jun	7.0	1	1	145	96.7%	0.14	0	0	25	7
30-Jun	7.0	0	0	145	96.7%	0.00	0	0	25	11

-continued-

		Large Chinook					Jack Chinook			Sockeye
		Daily					Daily			
Date	Hours	Catch	Tagged	Cum tag	Percent	CPUE	Catch	Tagged	Cum tag	Daily Catch
1-Jul	7.1	0	0	145	96.7%	0.00	0	0	25	12
2-Jul	7.2	0	0	145	96.7%	0.00	0	0	25	12
3-Jul	7.1	0	0	145	96.7%	0.00	0	0	25	14
4-Jul	7.0	0	0	145	96.7%	0.00	0	0	25	12
5-Jul	7.0	0	0	145	96.7%	0.00	0	0	25	4
6-Jul	7.2	1	1	146	97.3%	0.14	0	0	25	15
7-Jul	6.9	1	1	147	98.0%	0.14	0	0	25	15
8-Jul	6.9	0	0	147	98.0%	0.00	0	0	25	11
9-Jul	7.0	0	0	147	98.0%	0.00	0	0	25	18
10-Jul	7.0	0	0	147	98.0%	0.00	0	0	25	12
11-Jul	7.1	1	1	148	98.7%	0.14	0	0	25	16
12-Jul	7.0	0	0	148	98.7%	0.00	0	0	25	11
13-Jul	7.1	0	0	148	98.7%	0.00	0	0	25	12
14-Jul	7.2	0	0	148	98.7%	0.00	0	0	25	10
15-Jul	7.1	0	0	148	98.7%	0.00	0	0	25	10
16-Jul	7.0	0	0	148	98.7%	0.00	0	0	25	16
17-Jul	7.1	0	0	148	98.7%	0.00	0	0	25	16
18-Jul	7.0	0	0	148	98.7%	0.00	0	0	25	17
19-Jul	7.0	1	1	149	99.3%	0.14	0	0	25	13
20-Jul	7.1	0	0	149	99.3%	0.00	0	0	25	9
21-Jul	7.1	0	0	149	99.3%	0.00	0	0	25	8
22-Jul	3.4	0	0	149	99.3%	0.00	0	0	25	4
23-Jul	7.5	0	0	149	99.3%	0.00	0	0	25	10
24-Jul	7.0	0	0	149	99.3%	0.00	0	0	25	16
25-Jul	8.2	0	0	149	99.3%	0.00	0	0	25	23
26-Jul	7.3	0	0	149	99.3%	0.00	0	0	25	19
27-Jul	7.0	0	0	149	99.3%	0.00	0	0	25	10
28-Jul	7.0	0	0	149	99.3%	0.00	0	0	25	11
29-Jul	0.0	0	0	149	99.3%		0	0	25	0
30-Jul	7.5	0	0	149	99.3%	0.00	0	0	25	7
31-Jul	7.6	0	0	149	99.3%	0.00	0	0	25	9
1-Aug	7.5	0	0	149	99.3%	0.00	0	0	25	28
2-Aug	7.0	0	0	149	99.3%	0.00	0	0	25	11
3-Aug	7.0	0	0	149	99.3%	0.00	0	0	25	16
4-Aug	7.2	0	0	149	99.3%	0.00	0	0	25	23
5-Aug	7.0	0	0	149	99.3%	0.00	0	0	25	24
6-Aug	7.0	0	0	149	99.3%	0.00	0	0	25	23
7-Aug	7.0	0	0	149	99.3%	0.00	0	0	25	11
8-Aug	7.0	1	1	150	100.0%	0.14	0	0	25	19
9-Aug	7.0	0	0	150	100.0%	0.00	0	0	25	10
10-Aug	7.0	0	0	150	100.0%	0.00	0	0	25	11
11-Aug	6.9	0	0	150	100.0%	0.00	0	0	25	7
12-Aug	7.3	0	0	150	100.0%	0.00	0	0	25	4
13-Aug	7.0	0	0	150	100.0%	0.00	0	0	25	10
14-Aug	7.0	0	0	150	100.0%	0.00	0	0	25	7
15-Aug	7.0	0	0	150	100.0%	0.00	0	0	25	4
16-Aug	6.3	0	0	150	100.0%	0.00	0	0	25	2
17-Aug	7.0	0	0	150	100.0%	0.00	0	0	25	6
18-Aug	2.7	0	0	150	100.0%	0.00	0	0	25	2

Appendix A3.–Daily and cumulative counts of sockeye and Chinook salmon through the Klukshu River weir, and Chinook salmon sampled and tags observed, 2004.

Date	Sockeye Daily	Chinook Daily	Daily Prop.	Count Cumul.	Cumul. Prop.	Sampled Daily	Sampled Cum	Tags Observ.	Tags Sampled
5-Jun	0	1	0.000	1	0.000		-		
6-Jun	0	0	0.000	1	0.000		-		
7-Jun	0	0	0.000	1	0.000		-		
8-Jun	0	0	0.000	1	0.000		-		
9-Jun	0	0	0.000	1	0.000		-		
10-Jun	0	0	0.000	1	0.000		-		
11-Jun	0	0	0.000	1	0.000		-		
12-Jun	0	1	0.000	2	0.001	1	1		
13-Jun	0	0	0.000	2	0.001		1		
14-Jun	0	0	0.000	2	0.001		1		
15-Jun	0	1	0.000	3	0.001	1	2		
16-Jun	2	2	0.001	5	0.002	2	4		
17-Jun	0	1	0.000	6	0.002	1	5		
18-Jun	0	2	0.001	8	0.003	2	7		
19-Jun	0	2	0.001	10	0.004	2	9		
20-Jun	1	1	0.000	11	0.004	1	10		
21-Jun	1	2	0.001	13	0.005	2	12		
22-Jun	0	3	0.001	16	0.006	2	14		1
23-Jun	0	3	0.001	19	0.008	3	17		
24-Jun	3	4	0.002	23	0.009	4	21		
25-Jun	2	2	0.001	25	0.010	2	23		
26-Jun	1	5	0.002	30	0.012	5	28		2
27-Jun	5	2	0.001	32	0.013	2	30		
28-Jun	3	6	0.002	38	0.015	6	36		1
29-Jun	4	6	0.002	44	0.017	6	42		
30-Jun	1	6	0.002	50	0.020	6	48		
1-Jul	2	9	0.004	59	0.023	9	57		
2-Jul	7	6	0.002	65	0.026	5	62		
3-Jul	4	15	0.006	80	0.032	15	77		
4-Jul	5	11	0.004	91	0.036	11	88		1
5-Jul	5	27	0.011	118	0.047	22	110		2
6-Jul	3	20	0.008	138	0.055	19	129		2
7-Jul	3	5	0.002	143	0.057	5	134		
8-Jul	56	60	0.024	203	0.080	22	156		
9-Jul	109	114	0.045	317	0.126	34	190	3	1
10-Jul	5	17	0.007	334	0.132	10	200		
11-Jul	0	110	0.044	444	0.176	65	265		8
12-Jul	28	108	0.043	552	0.219	77	342	2	4
13-Jul	33	112	0.044	664	0.263	58	400		6
14-Jul	112	562	0.223	1,226	0.486	38	438	44	4
15-Jul	44	41	0.016	1,267	0.502	34	472		4
16-Jul	45	57	0.023	1,324	0.524	48	520		3
17-Jul	47	92	0.036	1,416	0.561	81	601		5
18-Jul	66	155	0.061	1,571	0.622	56	657	4	6
19-Jul	26	57	0.023	1,628	0.645	48	705		5
20-Jul	45	42	0.017	1,670	0.661	20	725	1	2
21-Jul	26	40	0.016	1,710	0.677	40	765		4

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Date	Sockeye Daily	Chinook Daily	Daily Prop.	Count Cumul.	Cumul. Prop.	Sampled Daily	Sampled Cum	Tags Observ.	Tags Sampled
22-Jul	9	72	0.029	1,782	0.706	72	837		8
23-Jul	82	88	0.035	1,870	0.741	0	837	4	
24-Jul	85	40	0.016	1,910	0.756	18	855		3
25-Jul	29	77	0.030	1,987	0.787	77	932		9
26-Jul	49	35	0.014	2,022	0.801	32	964		5
27-Jul	16	52	0.021	2,074	0.821	51	1,015		8
28-Jul	144	30	0.012	2,104	0.833	18	1,033		6
29-Jul	38	67	0.027	2,171	0.860	62	1,095		6
30-Jul	70	27	0.011	2,198	0.870	20	1,115		1
31-Jul	34	51	0.020	2,249	0.891	12	1,127	4	6
1-Aug	83	44	0.017	2,293	0.908	7	1,134	2	2
2-Aug	63	18	0.007	2,311	0.915	1	1,135		
3-Aug	118	57	0.023	2,368	0.938	15	1,150	2	2
4-Aug	567	63	0.025	2,431	0.963	8	1,158	3	3
5-Aug	151	25	0.010	2,456	0.973	6	1,164		1
6-Aug	41	19	0.008	2,475	0.980	10	1,174	1	2
7-Aug	69	5	0.002	2,480	0.982	1	1,175		1
8-Aug	76	4	0.002	2,484	0.984	1	1,176		
9-Aug	95	3	0.001	2,487	0.985	0	1,176		
10-Aug	64	1	0.000	2,488	0.985	0	1,176	1	
11-Aug	102	5	0.002	2,493	0.987	1	1,177		1
12-Aug	34	6	0.002	2,499	0.990	4	1,181		
13-Aug	111	3	0.001	2,502	0.991	0	1,181		
14-Aug	544	1	0.000	2,503	0.991	0	1,181	1	
15-Aug	96	5	0.002	2,508	0.993	0	1,181	2	
16-Aug	108	4	0.002	2,512	0.995	1	1,182		
17-Aug	316	0	0.000	2,512	0.995	0	1,182		
18-Aug	158	3	0.001	2,515	0.996	2	1,184		1
19-Aug	221	2	0.001	2,517	0.997	1	1,185		
20-Aug	77	2	0.001	2,519	0.998	1	1,186		
21-Aug	187	0	0.000	2,519	0.998	0	1,186		
22-Aug	55	1	0.000	2,520	0.998	0	1,186		
23-Aug	102	0	0.000	2,520	0.998	0	1,186		
24-Aug	312	0	0.000	2,520	0.998	0	1,186		
25-Aug	146	0	0.000	2,520	0.998	0	1,186		
26-Aug	12	0	0.000	2,520	0.998	0	1,186		
27-Aug	100	0	0.000	2,520	0.998	0	1,186		
28-Aug	186	0	0.000	2,520	0.998	0	1,186		
29-Aug	122	1	0.000	2,521	0.998	0	1,186	1	
30-Aug	43	0	0.000	2,521	0.998	0	1,186		
31-Aug	13	2	0.001	2,523	0.999	0	1,186		
1-Sep	952	0	0.000	2,523	0.999	0	1,186		
2-Sep	194	1	0.000	2,524	1.000	1	1,187		1
3-Sep	1,637	0	0.000	2,524	1.000	0	1,187		
4-Sep	60	0	0.000	2,524	1.000	0	1,187		
5-Sep	438	0	0.000	2,524	1.000	0	1,187		
6-Sep	850	1	0.000	2,525	1.000	0	1,187		
7-Sep	417	0	0.000	2,525	1.000	0	1,187		

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Date	Sockeye Daily	Chinook Daily	Daily Prop.	Count Cumul.	Cumul. Prop.	Sampled Daily	Sampled Cum	Tags Observ.	Tags Sampled
8-Sep	1,077	0	0.000	2,525	1.000	0	1,187		
9-Sep	208	0	0.000	2,525	1.000	0	1,187		
10-Sep	48	0	0.000	2,525	1.000	0	1,187		
11-Sep	379	0	0.000	2,525	1.000	0	1,187		
12-Sep	22	0	0.000	2,525	1.000	0	1,187		
13-Sep	861	0	0.000	2,525	1.000	0	1,187		
14-Sep	118	0	0.000	2,525	1.000	0	1,187		
15-Sep	234	0	0.000	2,525	1.000	0	1,187		
16-Sep	7	0	0.000	2,525	1.000	0	1,187		
17-Sep	13	0	0.000	2,525	1.000	0	1,187		
18-Sep	33	0	0.000	2,525	1.000	0	1,187		
19-Sep	12	0	0.000	2,525	1.000	0	1,187		
20-Sep	80	0	0.000	2,525	1.000	0	1,187		
21-Sep	92	0	0.000	2,525	1.000	0	1,187		
22-Sep	138	0	0.000	2,525	1.000	0	1,187		
23-Sep	737	0	0.000	2,525	1.000	0	1,187		
24-Sep	41	0	0.000	2,525	1.000	0	1,187		
25-Sep	0	0	0.000	2,525	1.000	0	1,187		
26-Sep	23	0	0.000	2,525	1.000	0	1,187		
27-Sep	488	0	0.000	2,525	1.000	0	1,187		
28-Sep	60	0	0.000	2,525	1.000	0	1,187		
29-Sep	5	0	0.000	2,525	1.000	0	1,187		
30-Sep	0	0	0.000	2,525	1.000	0	1,187		
1-Oct	10	0	0.000	2,525	1.000	0	1,187		
2-Oct	10	0	0.000	2,525	1.000	0	1,187		
3-Oct	43	0	0.000	2,525	1.000	0	1,187		
4-Oct	32	0	0.000	2,525	1.000	0	1,187		
5-Oct	27	0	0.000	2,525	1.000	0	1,187		
6-Oct	6	0	0.000	2,525	1.000	0	1,187		
7-Oct	30	0	0.000	2,525	1.000	0	1,187		
8-Oct	19	0	0.000	2,525	1.000	0	1,187		
9-Oct	17	0	0.000	2,525	1.000	0	1,187		
10-Oct	78	0	0.000	2,525	1.000	0	1,187		
11-Oct	23	0	0.000	2,525	1.000	0	1,187		
12-Oct	207	0	0.000	2,525	1.000	0	1,187		
	15,348							75	127

Appendix A4.–Estimated age composition and mean length of Chinook salmon caught in Dry Bay, by sex and age class, 2004.

		Brood year and age class									
		2001	**2000**	**2000**	**1999**	**1999**	**1998**	**1998**	**1997**	**1997**	
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Males	n	2	26	0	145	0	96	2	0	2	273
	%	0.7	9.5		53.1		35.2	0.7		0.7	41.8
	SE of %	0.5	1.8		3.0		2.9	0.5		0.5	1.9
	Avg. length	355	586		777		944	807		990	
	SD length	28	66		83		74	117		106	
	SE length	20	13		7		8	82		75	
Females	n	0	2	0	267	0	107	3	1	0	380
	%		0.5		70.3		28.2	0.8	0.3		58.2
	SE of %		0.4		2.3		2.3	0.5	0.3		1.9
	Avg. length		660		786		884	853			
	SD length		7		47		52	46			
	SE of esc.		5		3		5	27			
Sexes	n	2	28	0	412	0	203	5	1	2	653
Combined	%	0.3	4.3		63.1		31.1	0.8	0.2	0.3	100.0
	SE of %	0.2	0.8		1.9		1.8	0.3	0.2	0.2	0.0
	Avg. length	355	591		782		912	835	920	990	
	SD length	28.28	67		62		70	72		106	
	SE length	20	13		3		5	32		75	

Appendix A5.–Estimated age composition and mean length of Chinook salmon passing through the Klukshu River weir, by sex and age class, 2004.

		Brood year and age class									
		2001	**2000**	**2000**	**1999**	**1999**	**1998**	**1998**	**1997**	**1997**	
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Males	n	0	30	0	308	1	115	2	0	0	456
	%		6.6		67.5	0.2	25.2	0.4			43.2
	SE of %		1.2		2.2	0.2	2.0	0.3			1.5
	Avg. length		573		795	590	944	777			
	SD length		74		82		94	154			
	SE length		14		5		9	109			
Females	n	0	9	0	441	0	135	11	0	4	600
	%		1.5		73.5		22.5	1.8		0.7	56.8
	SE of %		0.5		1.8		1.7	0.5		0.3	1.5
	Avg. length		572		771		870	774		850	
	SD length		47		44		50	42		62	
	SE of esc.		16		2		4	13		31	
Sexes	n	0	39		749	1	250	13		4	1,056
Combined	%		3.7		70.9	0.1	23.7	1.2		0.4	100.0
	SE of %		0.6		1.4	0.1	1.3	0.3		0.2	0.0
	Avg. length		573		781	590	904	774		850	
	SD length		68		63		82	59		62	
	SE length		11		2		5	16		31	

Appendix A6.–Estimated age composition and mean length of Chinook salmon spawning in the Blanchard and Takhanne rivers, by sex and age class, 2003.

		Brood year and age class									
		2001	**2000**	**2000**	**1999**	**1999**	**1998**	**1998**	**1997**	**1997**	
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Males	n	0	2	0	22	0	27	1	0	3	55
	%		3.6		40.0		49.1	1.8		5.5	56.1
	SE of %		2.5		6.7		6.8	1.8		3.1	5.0
	Avg. length		723		806		937	890		923	
	SD length		145		74		58			42	
	SE length		103		16		11			24	
Females	n		0	0	19	0	22	1	0	1	43
	%				44.2		51.2	2.3		2.3	43.9
	SE of %				7.7		7.7	2.3		2.3	5.0
	Avg. length				794		884	800		885	
	SD length				56		30				
	SE of esc.				13		6				
Sexes	n		2	0	41	0	49	2	0	4	98
Combined	%		2.0		41.8		50.0	2.0		4.1	100.0
	SE of %		1.4		5.0		5.1	1.4		2.0	0.0
	Avg. length		723		801		913	845		914	
	SD length		145		66		54	64		39	
	SE length		103		10		8	45		20	

APPENDIX B: DETECTION OF SIZE SELECTIVITY

Appendix B1.–Detection of size-selectivity in sampling and its effects on estimation of size composition.

Results of hypothesis tests (K-S and χ^2) on lengths of fish MARKED during the first event and RECAPTURED during the second event	Results of hypothesis tests (K-S) on lengths of fish MARKED during the first event and INSPECTED during the second event
Case I	
"Accept H_o"	"Accept H_o"
There is no size-selectivity during either event	
Case II	
"Accept H_o"	"Reject H_o"
There is no size-selectivity during the second sampling event but there is during the first	
Case III	
"Reject H_o"	"Accept H_o"
There is size-selectivity during both sampling events	
Case IV	
"Reject H_o"	"Reject H_o"
There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown	

Case I: Calculate one unstratified abundance estimate and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, sexes, and ages from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second sampling event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Case III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and the analysis can proceed as if there were no size-selective sampling during the second event (Case I or II).

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Case III or IV: Size-selective sampling in both sampling events

n_i	Number of unique fish sampled during **SECOND** event **ONLY** within stratum *i*
n_{ij}	Number of unique fish of age *j* sampled during the **SECOND** event **ONLY** within stratum *i*
$\hat{p}_{ij} = \dfrac{n_{ij}}{n_i}$	Estimated fraction of fish of age *j* in stratum *i*. Note that $\sum_j \hat{p}_{ij} = 1$
$v(\hat{p}_{ij}) = \dfrac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1}$	An unbiased of variance[a]
$\hat{N}_i$	Estimated abundance in stratum *i* from the mark-recapture experiment
$\hat{N}_j = \sum_i (\hat{p}_{ij}\hat{N}_i)$	Estimated abundance of fish in age group *j* in the population
$v(\hat{N}_j) = \sum_i (v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)\hat{p}^2{}_{ij} - v(\hat{p}_{ij})v(\hat{N}_i))$	An unbiased estimate of variance[b]
$\hat{p}_j = \dfrac{\hat{N}_j}{\sum_i \hat{N}_i} = \dfrac{\hat{N}_j}{\hat{N}}$	Estimated fraction of fish in age group *j* in the population
$v(\hat{p}_j) = \dfrac{\sum_i (v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2)}{\hat{N}^2}$	An approximate estimate of variance[c]

[a] Page 52 *in* Cochran 1977. Sampling techniques, third edition. John Wiley and Sons, Inc. New York.

[b] From methods in Goodman 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

[c] From the delta method, page 8 *in* Seber 1982. The estimation of animal abundance and related parameters, second edition. Charles Griffin and Company, Ltd. London.

APPENDIX C: CALCULATION OF AN AVERAGE EXPANSION FACTOR AND VARIANCE

Appendix C1.–Calculation of an average expansion factor and variance.

The expansion factor for use in future years with no mark-recapture experiments was calculated as the average of the expansion factors over past years:

$$\bar{\pi} = \frac{\sum_y \hat{\pi}_y}{k} \qquad \text{(C.1)}$$

where *k* is the number of years (7). Estimated variance for the expansion should reflect only process error in the factor (variation across years in the π's). Variation in $\hat{\pi}$ across years, however, represents process and measurement error as seen in the relationship $V(\hat{\pi}) = V[E(\hat{\pi})] + E[V(\hat{\pi})]$. This relationship can be rearranged to isolate process error, that is, $V[E(\hat{\pi})] = V[\hat{\pi}] - E[V(\hat{\pi})]$. An estimate of the variance representing process error only is

$$v(\pi) = \frac{\sum_y (\hat{\pi}_y - \bar{\pi})^2}{k-1} - \frac{\sum v(\hat{\pi}_y)}{k} \qquad \text{(C.2)}$$

In the future the product of the mean expansion factor from past years and the estimated number of large fish at the weir will be an estimate of the abundance of large fish past Dry Bay:

$$\hat{N}_L = \bar{\pi}\,\hat{C}_L \qquad \text{(C.3)}$$

$$v(\hat{N}_L) = v(\pi)\hat{C}_L^2 + v(\hat{C}_L)\bar{\pi}^2 - v(\pi)v(\hat{C}_L) \qquad \text{(C.4)}$$

Table C.1 contains statistics based on mark-recapture experiments that include Chinook salmon inspected at the weir on the Klukshu River and on the Blanchard, Goat, and Takhanne rivers as pooled samples for second sampling event. Table C.2 contains statistics based on these same mark-recapture experiments with the exception that only Chinook salmon inspected at the weir were used. Statistics and descriptions for the mark-recapture experiments can be found in Pahlke et al. 1999; Pahlke and Etherton 2001b; Pahlke and Etherton 2002; Pahlke and Waugh 2003; 2004.

Appendix Table C.1. Expansion factor $\overline{\pi}$ and its estimated variance $v(\pi)$ for expanding estimated numbers of large Chinook salmon passing through the weir on the Klukshu River to estimate the number passing by Dry Bay on the Alsek River. Statistics were based on a series of mark-recapture experiments at Dry Bay and on several tributaries and sampling at the weir from 1998 through 2004. Remaining notation defined in text.

	$\hat{N}_{L,y}$	$SE(\hat{N}_{L,y})$	C_y	n_y	$\hat{\theta}_y$	$\hat{C}_{L,y}$	$\hat{\pi}_y$	$v(\hat{\pi}_y)$
1998	4,967	1,430	1,630	297	0.694	1,131	4.393	1.622
1999	11,969	2,886	2,538	306	0.758	1,924	6.220	2.284
2000	8,432	1,597	1,416	232	0.892	1,263	6.674	1.616
2001	11,246	1,336	1,977	643	0.849	1,679	6.699	0.641
2002	8,807	623	2,380	501	0.922	2,195	4.013	0.083
2003	5,105	525	1,873	775	0.756	1,416	3.605	0.140
2004	7,528	595	2,638	1,187	0.941	2,482	3.033	0.058
						$\overline{\pi} \rightarrow$	4.948	
						$\dfrac{\sum_y (\hat{\pi}_y - \overline{\pi})^2}{k-1} \rightarrow$	2.386	
						$\dfrac{\sum v(\hat{\pi}_y)}{k} \rightarrow$		0.921
						$v(\pi) \rightarrow$	1.466	
						$SD(\pi) \rightarrow$	1.211	

Appendix Table C.2. Expansion factor $\bar{\pi}$ and its estimated variance $v(\pi)$ for expanding estimated numbers of large Chinook salmon passing through the weir on the Klukshu River to estimate the number passing by Dry Bay on the Alsek River. Statistics were based on a series of mark-recapture experiments at Dry Bay and sampling at the weir from 1998 through 2004. Remaining notation defined in text.

	$\hat{N}_{L,y}$	$SE(\hat{N}_{L,y})$	C_y	n_y	$\hat{\theta}_y$	$\hat{C}_{L,y}$	$\hat{\pi}_y$	$v(\hat{\pi}_y)$
1998	4,969	1,431	1,630	297	0.694	1,131	4.395	1.624
1999	13,617	4,427	2,538	306	0.758	1,924	7.077	5.337
2000	6,835	1,678	1,416	232	0.892	1,263	5.410	1.777
2001	6,111	805	1,977	643	0.849	1,679	3.640	0.232
2002	5,396	714	2,380	501	0.922	2,195	2.459	0.107
2003	4,782	534	1,873	775	0.756	1,416	3.377	0.145
2004	6,995	556	2,638	1,187	0.941	2,482	2.818	0.050
						$\bar{\pi} \rightarrow$	4.168	
						$\dfrac{\sum_y (\hat{\pi}_y - \bar{\pi})^2}{k-1} \rightarrow$	2.617	
						$\dfrac{\sum v(\hat{\pi}_y)}{k} \rightarrow$		1.325
						$v(\pi) \rightarrow$	1.293	
						$SD(\pi) \rightarrow$	1.137	

APPENDIX D: COMPUTER FILES USED IN THIS REPORT

Appendix D1.–Computer files used to estimate the spawning abundance and distribution of Chinook salmon in the Alsek River, 2004.

File name	Description
Alsek04 Chinlog.xls	EXCEL spreadsheet with gillnet tagging data--daily effort, catch by species, and water depth by site; gillnet charts.
Alsek04ChinAWL jpk .XLS	Age, sex, length (ASL) data from tagging site.
Pahlke_Alsek.xls	Pi expansion factor calculation table
2004 klukshu weir ASL data.xls	Klukshu Weir ASL data
Kscharts04.XLS	cumulative relative frequency charts and data
Blanchard Takhanne.XLS	Blanchard, Takhanne, ASL data