Fishery Data Series No. 01-11

Abundance of the Chinook Salmon Escapement on the Alsek River, 1999

by

Keith A. Pahlke

and

Peter Etherton

July 2001

Alaska Department of Fish and Game

Division of Sport Fish

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
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

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

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
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
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

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	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
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.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
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
standard length	SL
total length	TL
variance	Var

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Keith A. Pahlke
Division of Sport Fish, Douglas

and

Peter Etherton
Department of Fisheries and Oceans, Whitehorse, Yukon Territory, Canada

Alaska Department of Fish and Game
Division of Sport Fish
333 Raspberry Road
Anchorage, AK 99518-1599

July 2001

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Keith A. Pahlke
Alaska Department of Fish and Game, Division of Sport Fish, Region I
P. O. Box 240020, Douglas, AK 99824-0020, USA
email: keith_pahlke@fishgame.state.ak.us

Peter Etherton
Department of Fisheries and Oceans, Stock Assessment Division
Suite 100-419 Range Road, Whitehorse, Yukon Territory, Canada Y1A3V1

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ABSTRACT

Abundance of chinook salmon *Oncorhynchus tshawytscha* returning to spawn in the Alsek River in 1999 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 Champaign/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, 1999 were used to capture 420 large immigrant chinook salmon, of which, 402 were marked with individually numbered spaghetti tags, a hole punched in their left opercle, and removal of an axillary appendage. During July and August, chinook salmon were captured at spawning sites and inspected for marks. Marked fish were also recovered from Canadian aboriginal and recreational fisheries. We used a modified Petersen model (M = 398, C = 449 , R = 14) to estimate that 11,969 (SE = 2,886) large (≥660 mm MEF) chinook salmon immigrated into the Alsek River above Dry Bay. Canadian fisheries on the Tatshenshini River harvested an estimated 372 large chinook salmon, leaving an escapement of 11,597 large fish. An estimated 1,663 of the 2,193 chinook salmon counted at the Klukshu River weir were large fish, about 14% of the total estimated spawning escapement of large fish in the Alsek River.

An estimated 12% of the Dry Bay gillnet catch were age -1.2 fish, 68% age -1.3, and 20% age -1.4, with 180 males and 269 females sampled. An estimated 22% of the Alsek River escapement were age -1.2 fish, 62% age -1.3, and 14% age -1.4, with 87 males and 85 females sampled.

Key words: chinook salmon, *Oncorhynchus tshawytscha*, Alsek River, Klukshu River, Tatshenshini River, mark-recapture, escapement, abundance

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 1,2). Small harvests of this stock are also probably taken in marine recreational and commercial set gillnet and troll 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 1962 (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 weir count is used as the index for the Alsek River. Prior to 1997, the proportion of the total chinook salmon escapement to the Alsek River drainage counted at the Klukshu River weir was unknown. The U.S. used a weir expansion of 1.56 (64%) to estimate total Alsek River chinook escapement, while Canada used an expansion of 2.5 (40%) (Pahlke 1997). A recent analysis of the biological escapement goal for Klukshu River chinook salmon used a range of 30% to 100%. A biological escapement goal (BEG) range of 1,100 to 2,300 chinook salmon spawners in the Klukshu River was recommended (McPherson et al. 1998). In 1991, the Transboundary River Technical Committee of the PSC recommended that an expansion factor not be adopted due to the lack of applicable studies (TTC 1991). Mark-recapture studies in 1997–1999 indicate that Klukshu River chinook salmon account for approximately 25% of the total run (Pahlke 2000; Pahlke and Etherton 2000). 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 and; (2) in a sport fishery (1976–1978 only); and (3) brood stock removed at the weir site.

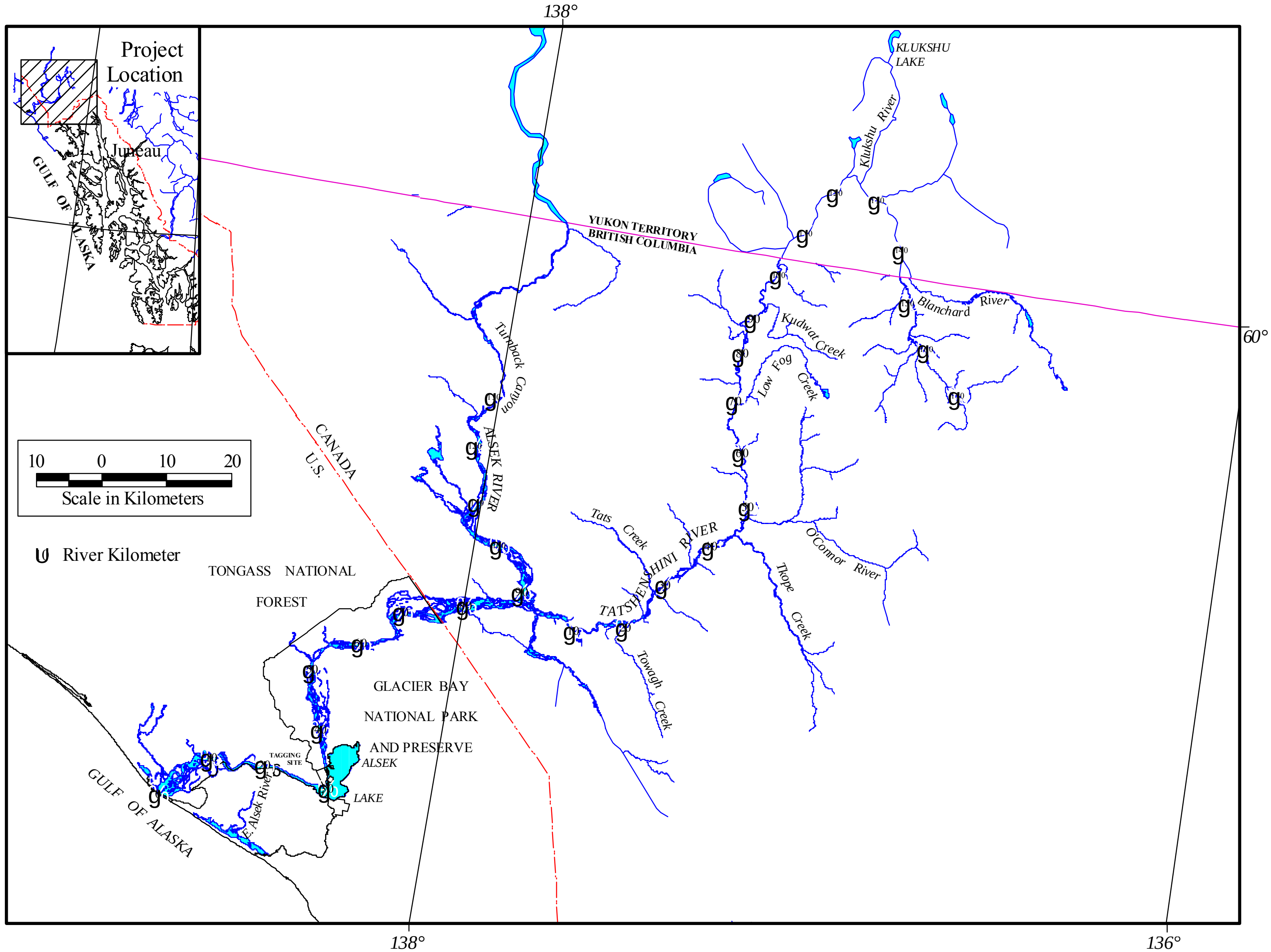

Figure 1.–Alsek River drainage, showing principal tributaries and river kilometers.

Table 1.–Estimated harvests of chinook salmon in the Canadian Alsek River aboriginal and sport fisheries, 1976–1999.

	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	122	38	14	174

[a] Includes 8 fish harvested from Village Creek.

Aerial surveys to count spawning chinook salmon have been conducted by the Alaska Department of Fish and Game (ADF&G) with a helicopter since 1981. Prior to 1981, surveys were made from fixed-wing aircraft. The 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 annually 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 index 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 and -.2) chinook salmon <660 mm MEF. These small chinook salmon, also called jacks, are primarily males that are considered to be surplus to spawning escapement needs (Mecum 1990). They are easy to separate visually from their older 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.

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. The results of the feasibility project were encouraging, and in 1998 a revised, expanded mark-recapture study was conducted along with a radiotracking study to estimate spawning distribution (Pahlke et al. 1998).

Table 2.–Annual harvests of chinook salmon in the U.S. Alsek River commercial and subsistence/personal use gillnet fisheries, 1941–1999.

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	1996–1999 Average	593	51
1966–1970 Average	637			

The project was continued in 1999 without the radiotelemetry study. The 1999 study had two objectives: (1) to estimate the abundance of large (≥660 mm MEF) spawning chinook in the Alsek River; and (2) to estimate the age, sex, and length compositions of chinook salmon spawning in the Alsek River.

Results from the study provide a survey expansion factor; i.e., an estimate of the fraction of escapement to the Alsek River counted at the Klukshu River weir. Results also provide information on the run timing through the lower Alsek River of chinook salmon bound for the various spawning areas.

Table 3.–Escapement of chinook salmon to the Klukshu River and counts of spawning adults in other tributaries of the Alsek River, 1962–1999.

Year[a]	Klukshu River: Aerial count		Weir count	Above-weir harvest: AF	Sport	Brood	Escape-ment [b]	Blanchard River		Takhanne River		Goat Creek	
1962	86	(A)	–	–	–		86	–		–		–	
1963	–		–	–	–		–	–		–		–	
1964	20	(A)	–	–	–		20	–		–		–	
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)
1989–1998 average	964		2,889	158	0	15	2,716	192		216		39	
1999	500	P(H)	2,193	27	0	0	2,166	371	E(H)	194	N(H)	51	N(H)

— = no survey; (A) = aerial survey from fixed wing aircraft; (H) = helicopter survey; (F) = foot survey; E = excellent survey conditions; N = normal conditions; P = poor conditions.

[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 fishery (AF) and broodstock.

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, rkm 130) (Figure 1). Significant chinook salmon spawning has been documented to occur annually 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 chinook salmon spawning areas probably exist downstream of the confluence of the Klukshu and Tatshenshini rivers such as in mainstream areas of the Tatshenshini and Alsek rivers. Small numbers of chinook have been documented spawning in Village, Kane, Silver, Bridge, Detour, O'Connor, Low Fog and Stanley creeks, and 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 from a two-event mark-recapture experiment for a closed population (Seber 1982:59–61). Fish captured by set gillnet 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.

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 15 and July 1. One net was fished daily, unless high water prevented fishing. The primary fishing site was at approximately river kilometer (rkm) 19, just above the Dry Bay commercial fishery boundary. The tagging site is below all known spawning areas, and is upstream of any tidal influence. Other nearby sites were fished when water levels were too high to safely fish the primary site. In 1999, extremely heavy snowpack and low water in the river prevented access to the primary site until June 1. Prior to that, nets were fished at a lower site about rkm 10. Nets were watched continuously, and a captured fish was removed from the net as soon as it was observed. Sampling effort was held reasonably constant across the temporal span of the migration. If fishing time was lost from entanglements, snags, cleaning the net, etc., the lost time (processing time) was added on at the end of the day to bring fishing time to 9 hours per day.

Captured chinook salmon were placed in a plastic fish tote filled with water, quickly untangled or cut from the net, tagged, scale sampled, and their length and sex recorded during a visual examination (as per Johnson et al. 1993). Fish were classified as "large" if their mideye to fork length (MEF) was ≥660 mm, "medium" if between 440 and 659 mm or "small" if <440 mm (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 tubing shrunk onto a 15" (~38-cm) piece of 80-lb (~36.3-kg) monofilament fishing line. The monofilament was sewn through the musculature of the fish approximately 20 mm posterior and ventral to the dorsal fin and secured by crimping both ends in a line crimp. Each fish was also marked with a ¼-inch-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 for length, scales and sex but 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 for length, sex, scales, and inspected for marks and released. Fish were sampled in proportion to the historical run timing at the weir, with a sample goal of 800 fish. The remaining fish were passed through the weir without being individually handled, while an observer counted them and recorded the presence of spaghetti tags. In addition, some post-spawning fish and carcasses were sampled upstream of the weir.

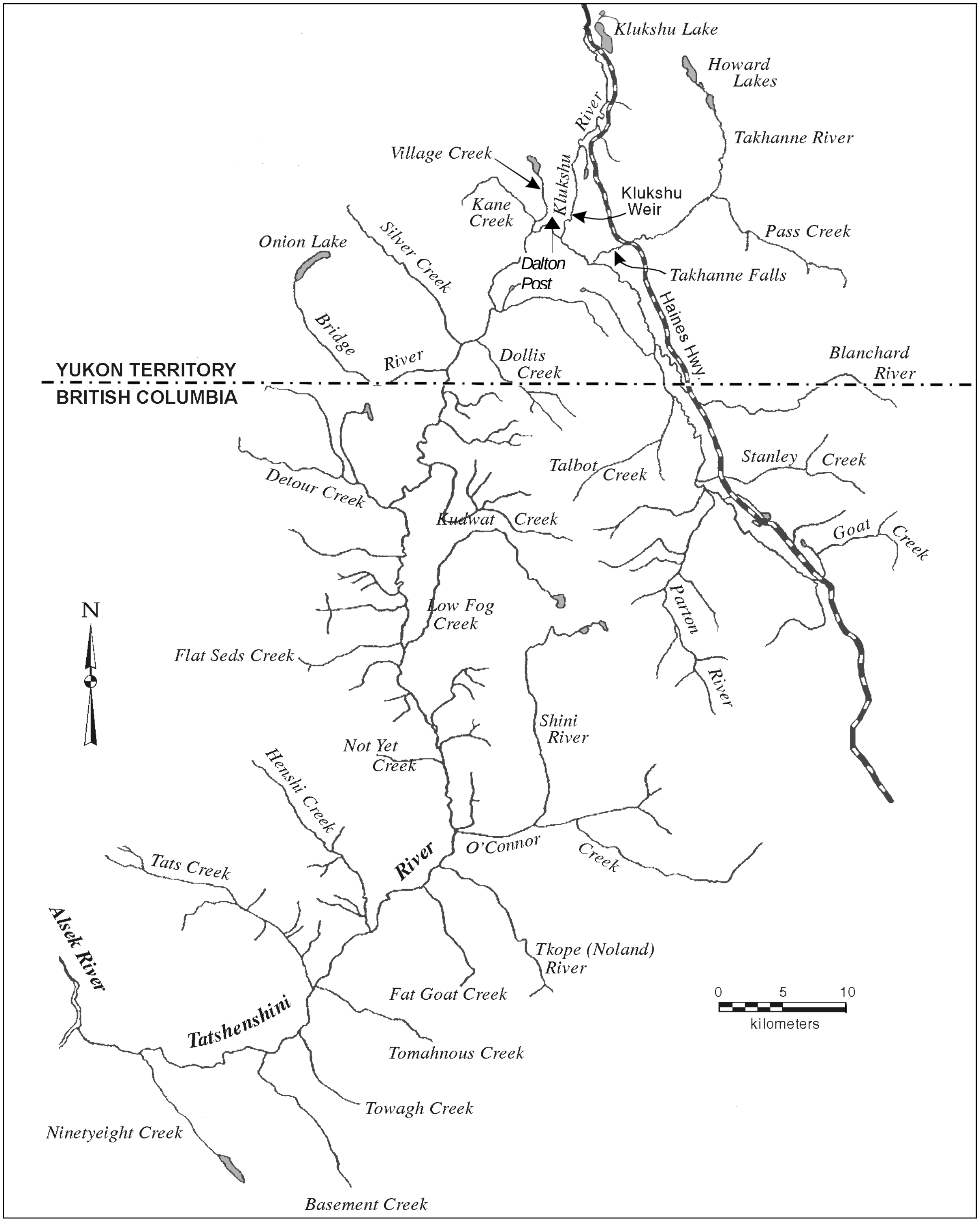

Figure 2.–Tatshenshini River drainage and associated tributaries, Yukon Territory and northern British Columbia.

Foot surveys of the spawning areas on the Blanchard and Takhanne rivers and Goat and Low Fog creeks, were conducted August 2–12, 1999. Carcasses and moribund chinook salmon were sampled for length, sex, scales and marks.

FISHERY SAMPLING

Catches in the upper Tatshenshini Canadian aboriginal, and recreational fisheries and the U.S. gillnet fisheries located in the lower Alsek River below the tagging site, were sampled for age, sex, and length data and inspected for tags.

ABUNDANCE

The number of marked fish on the spawning grounds was estimated by subtracting the estimated number of marked fish removed by fishing in U.S. fisheries (censored from the experiment) from the number of fish tagged in event 1 (Table 4). Handling and tagging has caused a downstream movement and/or a delay in continuing upstream migration of marked chinook salmon in other studies (Pahlke and Etherton 1999, Bernard et al. 1999, Bendock and Alexandersdottir 1992, Johnson et al. 1992, Milligan et al. 1984). This behavior puts fish marked in June at risk of capture in the downstream commercial fishery in U.S. waters that begins in mid-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, and almost the entire catch goes through one processor where a high proportion of the U. S. catch was inspected for tags. This censoring makes estimates germane to the number of spawning fish, not to the number passing by Dry Bay.

Because of a reward (Can$2 for spaghetti tag;) for each tag returned from the inriver Canadian recreational and aboriginal fisheries, 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 sample events; (e) all recovered marks are reported; and (f) double sampling does not occur (Seber 1982). Assumption (a) implies that tagging 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 Goat creeks) and Klukshu River spawning sites and 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 (α = 0.05). 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 tagged and untagged 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 (1991).

Table 4.–Numbers of chinook salmon marked on lower Alsek River, removed by fisheries and inspected for marks in tributaries in 1999, by length group. Numbers in bold used in mark-recapture estimate.

		Length (MEF)			
		0–439 mm	**440–659 mm**	**≥660 mm**	**Total**
A. Released at Dry Bay with marks		0	39	402	441
B. Removed by:					
1. U.S. sport fisheries					
2. U.S. gillnet		0	1	4	5
Subtotal of removals		0	1	4	5
C. Estimated number of marked fish remaining in mark-recapture experiment		0	38	**398**	436
D. Spawning ground samples					
Klukshu weir	Observed				1,887
	Marked				22
	Marked/observed				0.0116
E. Inspected at:					
1a. Klukshu weir Live	Inspected	4	70	**232**	306
	Marked	0	2	**7**	9
	Marked/inspected		0.0286	0.0302	0.0294
1b. Carcass	Inspected	0	6	**19**	25
	Marked	0	0	**1**	1
	Marked/inspected			0.0526	0.0400
2. Blanchard/Goat	Inspected	0	15	74	89
	Marked	0	0	0	0
	Marked/ inspected		0.0000	0.0000	0.0000
3(a). Sport fishery	Inspected	0	5	46	51
	Marked	0	0	0	0
	Marked/inspected		0.0000	0.0000	0.0000
3(b). Yukon Safari	Inspected				75
	Marked [a]				2
	Marked/inspected				0.0267
4. Aboriginal Fishery	Inspected		40	**198**	238
	Marked		0	**6**	6
	Marked/inspected		0.0	0.0303	0.0250

[a] Includes fish released alive.

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

All fish captured at the Dry Bay tagging site and spawning ground surveys were sampled for scales to enable age determination (Olsen 1995). In addition, a portion of the Canadian recreational harvest was sampled to get length, sex and age data. Five scales were collected from the preferred area of each fish (Welander 1940), mounted on gum cards, and impressions 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). Dry Bay scale samples 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 one staff member of the scale aging lab, unusual or questionable scales were read again by one or more staff. Proportions by age or by sex in gillnet and spawning grounds samples were estimated by

$$\hat{p}_i = \frac{n_i}{n} \tag{1}$$

$$v[\hat{p}_i] = \frac{\hat{p}_i(1-\hat{p}_i)}{n-1} \tag{2}$$

where p_i = proportion in the age, sex, or length group i,

n_i = number in the sample of group i, and

n = sample size.

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 the gillnet samples 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. The proportion of the estimated spawning population composed of a given age within medium- and small-sized (combined) or large fish was estimated using procedures described in McPherson et al. 1998b.

RESULTS

DRY BAY TAGGING

Between May 15 and July 1, 1999, 420 large (≥660 mm MEF) and 41 small and medium chinook salmon were captured in the lower Alsek River. Of these, 402 large fish were sampled, marked and released (Table 4, Appendix A1). Set gillnet effort was maintained at 9 hours per day, although reduced sampling effort occurred on several days (Figure 3; Appendix A1). Catch rates ranged from 0 to 4.9 fish/net-hour and peaked on June 21, when 44 large chinook were captured (Figure 4). The date of 50% cumulative catch was June 5. The sex ratio of chinook salmon caught in the gillnets was skewed towards females (279 females, 182 males). In addition, 110 sockeye salmon were captured, marked with T-bar anchor tags and released (Appendix A1).

FISHERY SAMPLING

The inriver U.S. commercial gillnet fishery harvested 482 chinook salmon—including 5 tagged fish and U.S. subsistence and personal use fisheries harvested 44 more (Tables 2, 4).

SPAWNING GROUND SAMPLING

Three hundred six (232 large) chinook salmon were examined for marks at the Klukshu River weir, and 9 (7 large) marked fish were recovered (Table 4). The sex ratio of fish sampled at the weir was nearly even (162 females, 144 males). No tag loss was noted in the sample of fish examined. The remaining 1,887 fish passing through the weir were not physically examined for marks; however, each fish was observed from a distance and the presence of 22 additional spaghetti tags was noted. Size category and sex of each fish was not estimated.

At Blanchard River, 55 chinook carcasses were examined for marks, and 0 marked fish were recovered (Table 4). At Goat Creek on the upper Tatshenshini River, 23 chinook salmon were sampled and on the Takhanne River 11 fish were sampled and 0 tagged fish were recaptured.

The aboriginal fishery near Dalton Post harvested 238 chinook salmon with five tags

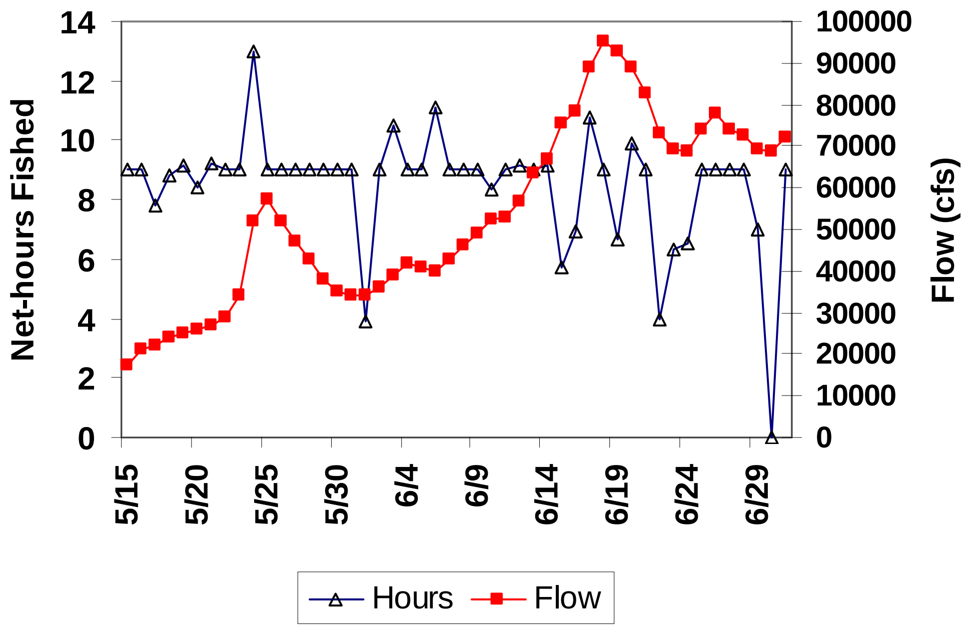

Figure 3.–Daily fishing effort (hours) and river flow (cfs), Alsek River near Dry Bay, 1999. Flow information from USGS water information system.

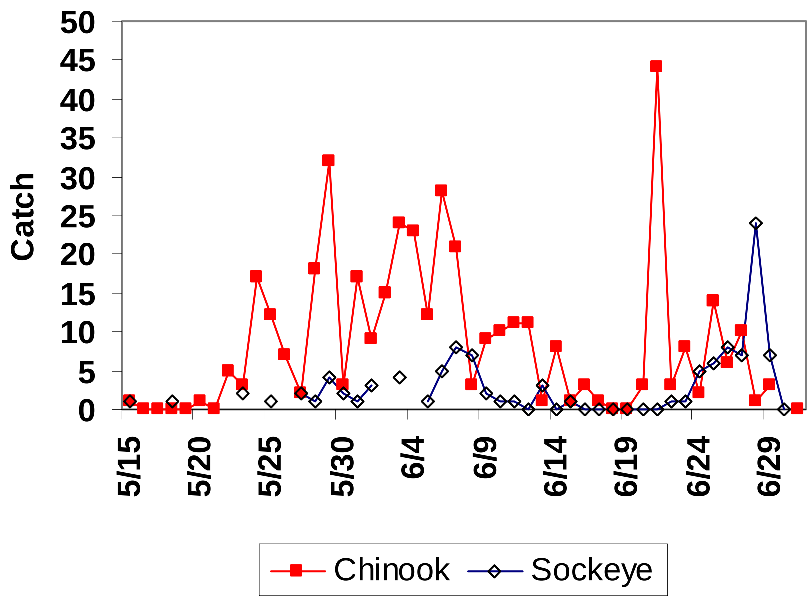

Figure 4.–Daily catch of chinook and sockeye salmon, lower Alsek River, 1999.

reported and one marked fish missing the numbered spaghetti tag. The entire catch was not sampled, but all tagged fish harvested are assumed to have been reported due to the close proximity of the DFO camp and signs posted describing the tagging study and reward program. The sport fishery near Dalton Post harvested approximately 121 chinook with additional fish released. Fifty-one (51) fish were examined by DFO technicians and an additional 75 were examined by Yukon Safari guides, with two tagged fish reported, both of which were released. An additional 1 tag was voluntarily turned in by sport fishers.

ABUNDANCE

An estimated 11,969 (SE = 2,886) large chinook salmon passed upstream of Dry Bay in 1999. An estimated 398 marked fish moved upstream of which 14 were found in the 449 large fish inspected upstream at the weir or in the aboriginal fishery (Table 4). Samples taken at the weir, from carcasses above the weir and from the aboriginal fishery were pooled because their marked fractions are not significantly different (0.0302 vs. 0.0526 vs. 0.0303, χ^2 = 0.302, df = 2, P = 0.859). Because no tags were recovered in samples collected on the Blanchard and Takhanne rivers and Goat Creek, these samples could not be included in the analysis (Table 4). If the marked fraction is as estimated to be 0.03118 (the combined weir and aboriginal fishery samples), there is a 9.6% random chance of not observing a marked fish in a sample of 74 from the Blanchard River/Goat Creek or a 23.3% random chance from a sample of 46 large fish (the sport fishery). The samples from the Yukon Safari guides were also excluded because no sex or size data was collected and many of the fish were released alive and could have been sampled again. A 95% confidence interval around estimated abundance past Dry Bay estimated from bootstrapping is 8,243–22,035; estimated statistical bias is 6.5%. The estimated number of large spawners in the entire Alsek River is 11,597 (= 11,969–198–174).

Abundance was estimated only for large chinook salmon because of evidence for size-selective sampling at Dry Bay. Length distribution of fish recaptured at the Klukshu weir was not significantly different than the length distribution of fish released at Dry Bay (KS test, P = 0.491; Figure 5), evidence that sampling at the weir was not size-selective. However, fish caught at Dry Bay in gillnets were larger than fish sampled from the trap at the weir (KS test, P < 0.001; Figure 5), evidence that sampling at Dry Bay was "different" and therefore selective for larger fish. Sampling of carcasses in the Blanchard River/Goat Creek was also likely selective towards larger fish in that length distribution of fish collected in these tributaries was not significantly different than the distribution of marked fish released at Dry Bay (KS test, P = 0.389). Not enough small and medium-sized fish were marked or sampled for marks to estimate abundance of medium or small fish by mark-recapture methods.

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

Age 1.3 chinook salmon were again the most common in all samples, constituting an estimated 68% of fish sampled in Dry Bay, 62% at the weir across the Klukshu River, 60% at Blanchard River/ Goat Creek, 70% in the Aboriginal fishery and 83% in the Canadian sport fishery (Appendix A3–A8). Age 1.4 fish were the second most common and age 1.2 fish were also common, especially at the Klukshu weir. Sampled populations were an estimated 43–64% males. Estimated age compositions were significantly different for fish at Dry Bay and at the Klukshu weir (χ^2 = 11.46, df = 3, P = 0.0097). However, when age compositions of only large fish were compared, the difference was no longer significantly different (χ^2 = 1.08, df = 2, P = 0.584). Estimated age composition of fish at the Klukshu weir did not differ from estimates for fish at the three other spawning ground locations (χ^2 = 10.32, df = 6, P = 0.1112) so the samples were pooled. The pooled estimate of age composition was used to estimate the abundance by age of the estimated total escapement to the Alsek River. Abundance of small and medium salmon was estimated as described in Appendix A9.

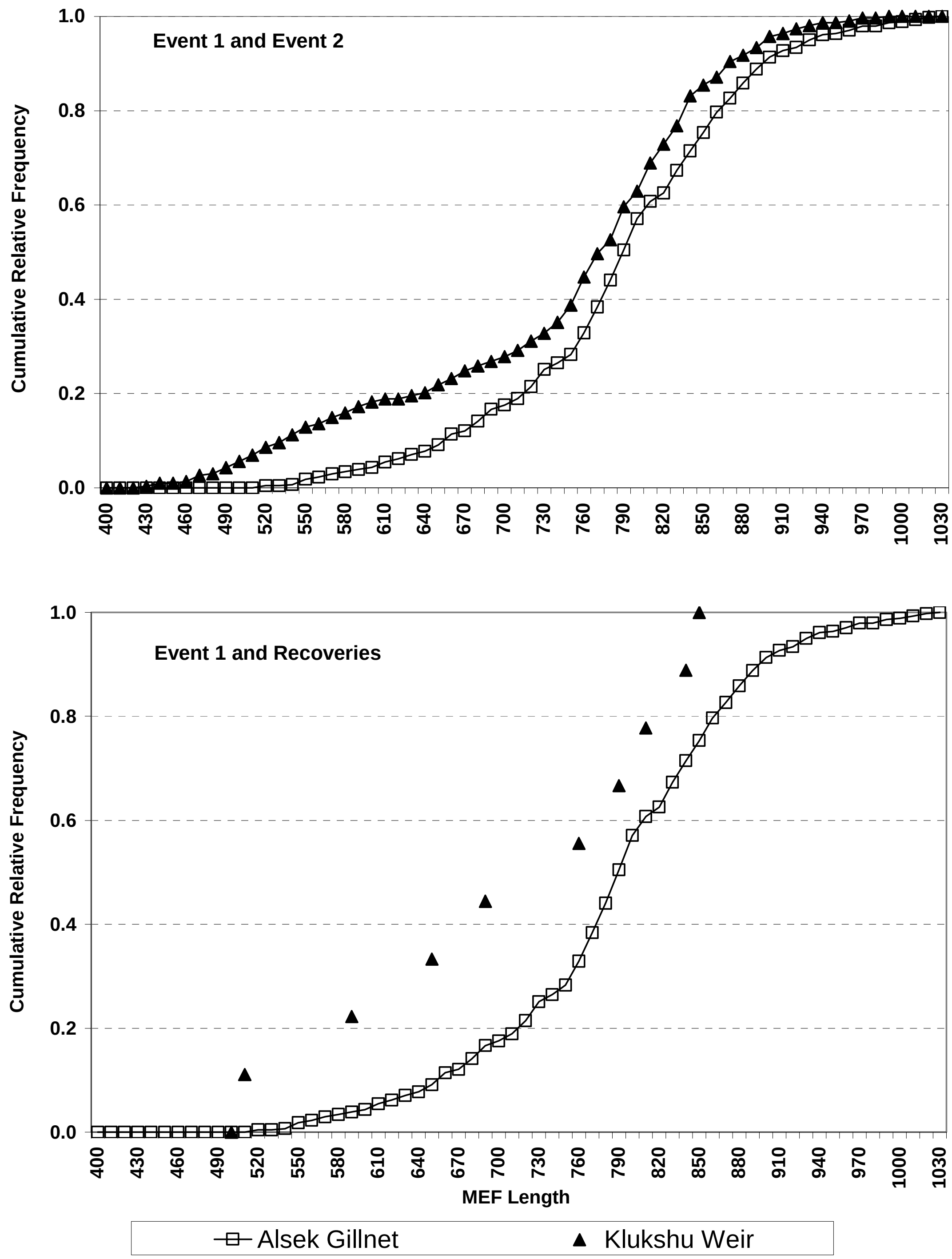

Figure 5.–Cumulative relative frequency of large chinook salmon captured in event 1 (Dry Bay gillnet) **and marked chinook salmon recaptured in event 2** (spawning ground sampling, Klukshu weir), **Alsek River, 1999**.

Table 5.–Estimated abundance and composition by age and sex of the escapement of chinook salmon in the Alsek River in 1999.

PANEL A: AGE COMPOSITION OF SMALL AND MEDIUM CHINOOK SALMON

		Brood year and age class									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Males	n	1	0	44	1	13	1	0	0	0	**60**
	%	1.5		66.7	1.5	19.7	1.5				**90.9**
	SE of %	1.5		5.8	1.5	4.9	1.5				**3.6**
	Escapement	47		2,057	47	608	47				**2,805**
	SE of esc.	47		767	47	263	47				**1,026**
Females	n	0	0	4	0	2	0	0	0	0	**6**
	%			6.1		3.0					**9.1**
	SE of %			3.0		2.1					**3.6**
	Escapement			187		94					**281**
	SE of esc.			109		70					**145**
Sexes combined	n	1	0	48	1	15	1	0	0	0	**66**
	%	1.5		72.7	1.5	22.7	1.5				**100.0**
	SE of %	1.5		5.5	1.5	5.2	1.5				**0.0**
	Escapement	47		2,244	47	701	47				**3,086**
	SE of esc.	47		832	47	296	47				**1,123**

PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON

		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Males	n	0	0	7	0	82	1	19	0	0	**109**
	%			2.7		32.0	0.4	7.4			**42.6**
	SE of %			1.0		2.9	0.4	1.6			**3.1**
	Escapement			327		3,834	47	888			**5,096**
	SE of esc.			142		985	47	287			**1,281**
Females	n	0	0	1	0	112	1	33	0	0	**147**
	%			0.4		43.8	0.4	12.9			**57.4**
	SE of %			0.4		3.1	0.4	2.1			**3.1**
	Escapement			47		5,236	47	1,543			**6,873**
	SE of esc.			47		1,313	47	445			**1,696**
Sexes combined	n	0	0	8	0	194	2	52	0	0	**256**
	%			3.1		75.8	0.8	20.3			**100.0**
	SE of %			1.1		2.7	0.6	2.5			**0.0**
	Escapement			374		9,070	94	2,431			**11,969**
	SE of esc.			155		2,209	68	655			**2,886**

PANEL C: AGE COMPOSITION OF SMALL, MEDIUM AND LARGE CHINOOK SALMON

		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Males	n	1	0	51	1	95	2	19	0	0	**169**
	%	0.3		15.8	0.3	29.5	0.6	5.9			**52.5**
	SE of %	0.3		4.8	0.3	2.7	0.4	1.4			**4.3**
	Escapement	47		2,384	47	4,442	94	888			**7,901**
	SE of esc.	47		780	47	1,019	66	287			**1,641**
Females	n	0	0	5	0	114	1	33	0	0	**153**
	%			1.6		35.4	0.3	10.2			**47.5**
	SE of %			0.8		3.8	0.3	1.9			**4.3**
	Escapement			234		5,330	47	1,543			**7,153**
	SE of esc.			119		1,315	47	445			**1,702**
Sexes combined	n	1	0	56	1	209	3	52	0	0	**322**
	%	0.3		17.4	0.3	64.9	0.9	16.1			**100.0**
	SE of %	0.3		5.2	0.3	4.5	0.5	2.5			**0.0**
	Escapement	47		2,618	47	9,772	140	2,431			**15,055**
	SE of esc.	47		846	47	2,229	82	655			**3,097**

DISCUSSION

Length and age composition data in this study indicate that size selective sampling may have occurred during gillnet fishing and during spawning ground sampling (Seber 1982). The lengths of fish captured in event 1 and fish captured in event 2 at the Klukshu River weir were significantly different. The lengths of tagged fish recovered at the Klukshu River weir indicate possible size selection during both event 1 and 2. Recoveries at the other locations—the Blanchard River/Goat Creek and Canadian aboriginal and sport fisheries—were insufficient to test.

Results from statistical tests on mean age compositions also indicate gear selectivity. Although tagging rates were not significantly different between the three recovery strata, sample sizes were so small as to render this test meaningless. It is not surprising that the large mesh (7¼-in.) gillnets used in the tagging operation would be selective towards larger fish, and that requires the mark-recapture analysis be stratified by size. There were insufficient small and medium fish marked to generate an mark-recapture estimate, however, total escapement of all sizes (15,055) was estimated by using the estimates of large escapement and the size composition of the escapement (Appendix 9).

Daily catch is dependent not only on effort but on river conditions which can change dramatically from day to day. Sampling effort in 1999 was consistent, however changing river conditions often made fishing difficult or ineffective. For several weeks in May the tagging set gillnet was operated at a site lower in the river than the preferred site. The lower site is believe to be a less efficient capture site, however the upper site was inaccessible until June 1.

Traditional indicators of chinook salmon escapement to the Alsek River indicate a below average escapement in 1999. The count at the Klukshu weir, although above the poor count in 1998 and within the escapement goal range, was still below the recent ten year average of 2,889. Index counts in the Blanchard and Takhanne rivers were about average.

The number of large chinook salmon tagged at the set nets in Dry Bay increased from 245 in 1998 to 402 in 1999, due to a higher abundance of fish and the experience gained in operation of the nets the previous two years. However, the number of fish sampled at the Klukshu River weir did not increase and sample sizes at the other recovery sites were also low. Low sample sizes in the mark-recapture experiment make it difficult to test the assumptions of the experiment and result in poor precision in the estimates.

Results from abundance estimates in 1998 and 1999 indicate that the Klukshu River weir count represents a smaller proportion of the total escapement than previously believed. The weir count of 2,193 fish is about 18% of the mark-recapture estimated escapement of large fish (11,969), and only 14.6% of the estimated escapement of all sizes (15,055), similar to the 16% estimated from the 1998 telemetry study, but much less than the 40–65% previously assumed.

Observation of fish passing by the Klukshu weir boosted sample sizes, but did not provide age, size, sex, or tag loss data. The blue tag used in the study was designed to prevent predators from targeting on marked fish. Unfortunately, this same quality would hamper recognition at a distance by technicians as well, which may explain why the tagged rate of inspected/handled fish at the weir was higher than the rate for fish merely observed while in transit through the weir. A more likely explanation for the difference in tagging rates between the two recovery methods may be a natural propensity for the crew to target on tagged fish while sampling.

The apparent size selectivity toward smaller fish in the sample from the weir is hard to explain. Weirs are generally regarded as the most accurate technique available for escapement enumeration and sampling (Cousens et al. 1982). The most common problems with weirs are smaller fish slipping through holes in the fence or fish passing the weir during high water events. Neither of these scenarios would explain the increased propensity to sample smaller, younger fish. There are both sport and aboriginal fisheries below the weir and if the fishermen targeted larger fish it is possible they could affect the size composition of the escapement, especially in years of low escapement like 1998. There may have been a propensity within the field crew to sample smaller fish due to the ease of handling compared to large chinook salmon.

CONCLUSIONS AND RECOMMENDATIONS

This was the second attempt at estimating the total escapement of chinook salmon to the Alsek River. It appears feasible to conduct a mark-recapture experiment with acceptable results using methods developed in 1997 and 1998. 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. Sample sizes in both events 1 and 2 must be increased to achieve an acceptably precise estimate of abundance, and the samples at the Klukshu River must be collected in a representative and random manner.

The results of the study indicate that the Klukshu River weir is a valid index of chinook salmon escapement to the Alsek River.

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APPENDIX A

Appendix A1.–Gillnet daily effort (minutes fished), catches, and catch per net hour, and river flow (cfs) near Dry Bay, lower Alsek River, 1999.

Date	Effort (min.)	Net/ hours	Large chinook	Catch/ net hour	Cum. total	Cum %	Small chinook	Sockeye	Flow (cfs)
5/15/99	540	9.0	1	0.1	1	0.002		1	17300
5/16/99	540	9.0	0	0.0	1	0.002			21000
5/17/99	470	7.8	0	0.0	1	0.002			22000
5/18/99	530	8.8	0	0.0	1	0.002		1	23800
5/19/99	550	9.2	0	0.0	1	0.002			25000
5/20/99	505	8.4	1	0.1	2	0.005			26000
5/21/99	555	9.3	0	0.0	2	0.005			27000
5/22/99	540	9.0	5	0.6	7	0.017	1		29000
5/23/99	540	9.0	3	0.3	10	0.025		2	34000
5/24/99	540	9.0	15	1.7	25	0.062			52000
5/24/99	284	4.7	2	0.4	27	0.067		1	57000
5/25/99	540	9.0	12	1.3	39	0.097			52000
5/26/99	540	9.0	7	0.8	46	0.114	1	2	47000
5/27/99	540	9.0	2	0.2	48	0.119		1	43000
5/28/99	540	9.0	18	2.0	66	0.164	2	4	38000
5/29/99	540	9.0	32	3.6	98	0.244	4	2	35000
5/30/99	541	9.0	3	0.3	101	0.251	0	1	34000
5/31/99	540	9.0	17	1.9	118	0.294	0	3	34000
6/1/99	235	3.9	9	2.3	127	0.316	1		36000
6/2/99	540	9.0	15	1.7	142	0.353	4	4	39000
6/3/99	630	10.5	24	2.3	166	0.413	4		42000
6/4/99	540	9.0	23	2.6	189	0.470	3	1	41000
6/5/99	540	9.0	12	1.3	201	0.500	4	5	40000
6/6/99	666	11.1	28	2.5	229	0.570	5	8	43000
6/7/99	541	9.0	21	2.3	250	0.622	2	7	46000
6/8/99	540	9.0	3	0.3	253	0.629	1	2	49000
6/9/99	540	9.0	9	1.0	262	0.652	1	1	52500
6/10/99	500	8.3	10	1.2	272	0.677	2	1	52700
6/11/99	540	9.0	11	1.2	283	0.704	1	0	56600
6/12/99	550	9.2	11	1.2	294	0.731	0	3	63600
6/13/99	540	9.0	1	0.1	295	0.734	1	0	66900
6/14/99	550	9.2	8	0.9	303	0.754	0	1	75700
6/15/99	345	5.8	1	0.2	304	0.756	0	0	78300
6/16/99	415	6.9	3	0.4	307	0.764	0	0	88800
6/17/99	645	10.8	1	0.1	308	0.766	0	0	95000
6/18/99	540	9.0	0	0.0	308	0.766	0	0	93000
6/19/99	400	6.7	0	0.0	308	0.766	0	0	89000
6/20/99	595	9.9	3	0.3	311	0.774	0	0	82700
6/21/99	540	9.0	44	4.9	355	0.883	0	1	72900
6/22/99	236	3.9	3	0.8	358	0.891	1	1	69400
6/23/99	380	6.3	8	1.3	366	0.910	0	5	68900
6/24/99	390	6.5	2	0.3	368	0.915	0	6	73800
6/25/99	540	9.0	14	1.6	382	0.950	0	8	77700
6/26/99	540	9.0	6	0.7	388	0.965	1	7	74000
6/27/99	540	9.0	10	1.1	398	0.990	0	24	72600
6/28/99	540	9.0	1	0.1	399	0.993	0	7	69000
6/29/99	420	7.0	3	0.4	402	1.000	0	0	68700
6/30/99							0		72000
7/1/99	540	9.0	0	0.0					
TOTALS		407.2	402				39	110	

Appendix A2.–Daily and cumulative counts of Klukshu River sockeye, chinook, and coho salmon while in transit through the Klukshu River weir, 1999.

	Sockeye				Chinook				Coho			
Date	Daily	Daily prop.	Cum.	Cum. prop.	Daily	Daily prop.	Cum.	Cum. prop.	Daily	Daily prop.	Cum.	Cum. prop.
6-Jun	0	0.00	0	0.00	1	0.00	1	0.00	0	0.00	0	0.00
7-Jun	0	0.00	0	0.00	0	0.00	1	0.00	0	0.00	0	0.00
8-Jun	0	0.00	0	0.00	1	0.00	2	0.00	0	0.00	0	0.00
9-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
10-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
11-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
12-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
13-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
14-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
15-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
16-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
17-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
18-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
19-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
20-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
21-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
22-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
23-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
24-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
25-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
26-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
27-Jun	0	0.00	0	0.00	0	0.00	2	0.00	0	0.00	0	0.00
28-Jun	0	0.00	0	0.00	2	0.00	4	0.00	0	0.00	0	0.00
29-Jun	0	0.00	0	0.00	1	0.00	5	0.00	0	0.00	0	0.00
30-Jun	0	0.00	0	0.00	0	0.00	5	0.00	0	0.00	0	0.00
1-Jul	0	0.00	0	0.00	5	0.00	10	0.00	0	0.00	0	0.00
2-Jul	0	0.00	0	0.00	0	0.00	10	0.00	0	0.00	0	0.00
3-Jul	0	0.00	0	0.00	1	0.00	11	0.01	0	0.00	0	0.00
4-Jul	0	0.00	0	0.00	0	0.00	11	0.01	0	0.00	0	0.00
5-Jul	0	0.00	0	0.00	3	0.00	14	0.01	0	0.00	0	0.00
6-Jul	1	0.00	1	0.00	4	0.00	18	0.01	0	0.00	0	0.00
7-Jul	0	0.00	1	0.00	11	0.01	29	0.01	0	0.00	0	0.00
8-Jul	5	0.00	6	0.00	8	0.00	37	0.02	0	0.00	0	0.00
9-Jul	0	0.00	6	0.00	3	0.00	40	0.02	0	0.00	0	0.00
10-Jul	5	0.00	11	0.00	2	0.00	42	0.02	0	0.00	0	0.00
11-Jul	0	0.00	11	0.00	3	0.00	45	0.02	0	0.00	0	0.00
12-Jul	0	0.00	11	0.00	4	0.00	49	0.02	0	0.00	0	0.00
13-Jul	0	0.00	11	0.00	2	0.00	51	0.02	0	0.00	0	0.00
14-Jul	5	0.00	16	0.00	15	0.01	66	0.03	0	0.00	0	0.00
15-Jul	118	0.02	134	0.03	430	0.20	496	0.23	0	0.00	0	0.00
16-Jul	8	0.00	142	0.03	376	0.17	872	0.40	0	0.00	0	0.00
17-Jul	2	0.00	144	0.03	130	0.06	1,002	0.46	0	0.00	0	0.00
18-Jul	2	0.00	146	0.03	27	0.01	1,029	0.47	0	0.00	0	0.00
19-Jul	2	0.00	148	0.03	53	0.02	1,082	0.49	0	0.00	0	0.00
20-Jul	9	0.00	157	0.03	165	0.08	1,247	0.57	0	0.00	0	0.00
21-Jul	8	0.00	165	0.03	23	0.01	1,270	0.58	0	0.00	0	0.00
22-Jul	0	0.00	165	0.03	39	0.02	1,309	0.60	0	0.00	0	0.00
23-Jul	0	0.00	165	0.03	16	0.01	1,325	0.60	0	0.00	0	0.00
24-Jul	0	0.00	165	0.03	11	0.01	1,336	0.61	0	0.00	0	0.00

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	Sockeye				Chinook				Coho			
Date	Daily	Daily prop.	Cum.	Cum. prop.	Daily	Daily prop.	Cum.	Cum. prop.	Daily	Daily prop.	Cum.	Cum. prop.
25-Jul	0	0.00	165	0.03	12	0.01	1,348	0.61	0	0.00	0	0.00
26-Jul	0	0.00	165	0.03	17	0.01	1,365	0.62	0	0.00	0	0.00
27-Jul	0	0.00	165	0.03	45	0.02	1,410	0.64	0	0.00	0	0.00
28-Jul	0	0.00	165	0.03	84	0.04	1,494	0.68	0	0.00	0	0.00
29-Jul	21	0.00	186	0.04	122	0.06	1,616	0.74	0	0.00	0	0.00
30-Jul	1	0.00	187	0.04	61	0.03	1,677	0.76	0	0.00	0	0.00
31-Jul	0	0.00	187	0.04	23	0.01	1,700	0.78	0	0.00	0	0.00
1-Aug	7	0.00	194	0.04	20	0.01	1,720	0.78	0	0.00	0	0.00
2-Aug	2	0.00	196	0.04	95	0.04	1,815	0.83	0	0.00	0	0.00
3-Aug	37	0.01	233	0.05	58	0.03	1,873	0.85	0	0.00	0	0.00
4-Aug	13	0.00	246	0.05	21	0.01	1,894	0.86	0	0.00	0	0.00
5-Aug	5	0.00	251	0.05	26	0.01	1,920	0.88	0	0.00	0	0.00
6-Aug	3	0.00	254	0.05	29	0.01	1,949	0.89	0	0.00	0	0.00
7-Aug	3	0.00	257	0.05	18	0.01	1,967	0.90	0	0.00	0	0.00
8-Aug	92	0.02	349	0.07	29	0.01	1,996	0.91	0	0.00	0	0.00
9-Aug	5	0.00	354	0.07	13	0.01	2,009	0.92	0	0.00	0	0.00
10-Aug	4	0.00	358	0.07	11	0.01	2,020	0.92	0	0.00	0	0.00
11-Aug	1	0.00	359	0.07	18	0.01	2,038	0.93	0	0.00	0	0.00
12-Aug	0	0.00	359	0.07	5	0.00	2,043	0.93	0	0.00	0	0.00
13-Aug	1	0.00	360	0.07	2	0.00	2,045	0.93	0	0.00	0	0.00
14-Aug	1	0.00	361	0.07	8	0.00	2,053	0.94	0	0.00	0	0.00
15-Aug	10	0.00	371	0.07	12	0.01	2,065	0.94	0	0.00	0	0.00
16-Aug	15	0.00	386	0.08	6	0.00	2,071	0.94	0	0.00	0	0.00
17-Aug	3	0.00	389	0.08	8	0.00	2,079	0.95	0	0.00	0	0.00
18-Aug	0	0.00	389	0.08	8	0.00	2,087	0.95	0	0.00	0	0.00
19-Aug	3	0.00	392	0.08	7	0.00	2,094	0.95	0	0.00	0	0.00
20-Aug	0	0.00	392	0.08	16	0.01	2,110	0.96	0	0.00	0	0.00
21-Aug	0	0.00	392	0.08	10	0.00	2,120	0.97	0	0.00	0	0.00
22-Aug	0	0.00	392	0.08	5	0.00	2,125	0.97	0	0.00	0	0.00
23-Aug	0	0.00	392	0.08	7	0.00	2,132	0.97	0	0.00	0	0.00
24-Aug	4	0.00	396	0.08	6	0.00	2,138	0.97	0	0.00	0	0.00
25-Aug	4	0.00	400	0.08	6	0.00	2,144	0.98	0	0.00	0	0.00
26-Aug	3	0.00	403	0.08	12	0.01	2,156	0.98	0	0.00	0	0.00
27-Aug	2	0.00	405	0.08	3	0.00	2,159	0.98	0	0.00	0	0.00
28-Aug	2	0.00	407	0.08	3	0.00	2,162	0.99	0	0.00	0	0.00
29-Aug	15	0.00	422	0.08	10	0.00	2,172	0.99	0	0.00	0	0.00
30-Aug	10	0.00	432	0.08	8	0.00	2,180	0.99	0	0.00	0	0.00
31-Aug	1	0.00	433	0.08	1	0.00	2,181	0.99	0	0.00	0	0.00
1-Sep	2	0.00	435	0.08	2	0.00	2,183	1.00	0	0.00	0	0.00
2-Sep	1	0.00	436	0.08	1	0.00	2,184	1.00	0	0.00	0	0.00
3-Sep	808	0.16	1,244	0.24	0	0.00	2,184	1.00	0	0.00	0	0.00
4-Sep	1,420	0.28	2,664	0.52	3	0.00	2,187	1.00	0	0.00	0	0.00
5-Sep	89	0.02	2,753	0.54	2	0.00	2,189	1.00	0	0.00	0	0.00
6-Sep	0	0.00	2,753	0.54	0	0.00	2,189	1.00	0	0.00	0	0.00
7-Sep	136	0.03	2,889	0.56	0	0.00	2,189	1.00	0	0.00	0	0.00
8-Sep	2	0.00	2,891	0.56	0	0.00	2,189	1.00	0	0.00	0	0.00
9-Sep	381	0.07	3,272	0.64	0	0.00	2,189	1.00	0	0.00	0	0.00
10-Sep	0	0.00	3,272	0.64	0	0.00	2,189	1.00	0	0.00	0	0.00
11-Sep	0	0.00	3,272	0.64	0	0.00	2,189	1.00	0	0.00	0	0.00

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	Sockeye				Chinook				Coho			
Date	Daily	Daily prop.	Cum.	Cum. prop.	Daily	Daily prop.	Cum.	Cum. prop.	Daily	Daily prop.	Cum.	Cum. prop.
12-Sep	45	0.01	3,317	0.65	0	0.00	2,189	1.00	0	0.00	0	0.00
13-Sep	0	0.00	3,317	0.65	0	0.00	2,189	1.00	0	0.00	0	0.00
14-Sep	2	0.00	3,319	0.65	0	0.00	2,189	1.00	0	0.00	0	0.00
15-Sep	3	0.00	3,322	0.65	0	0.00	2,189	1.00	0	0.00	0	0.00
16-Sep	57	0.01	3,379	0.66	0	0.00	2,189	1.00	0	0.00	0	0.00
17-Sep	0	0.00	3,379	0.66	0	0.00	2,189	1.00	0	0.00	0	0.00
18-Sep	93	0.02	3,472	0.68	0	0.00	2,189	1.00	0	0.00	0	0.00
19-Sep	1,134	0.22	4,606	0.90	0	0.00	2,189	1.00	135	0.05	135	0.05
20-Sep	0	0.00	4,606	0.90	0	0.00	2,189	1.00	0	0.00	135	0.05
21-Sep	1	0.00	4,607	0.90	1	0.00	2,190	1.00	0	0.00	135	0.05
22-Sep	0	0.00	4,607	0.90	0	0.00	2,190	1.00	0	0.00	135	0.05
23-Sep	0	0.00	4,607	0.90	3	0.00	2,193	1.00	2	0.00	137	0.06
24-Sep	0	0.00	4,607	0.90	0	0.00	2,193	1.00	0	0.00	137	0.06
25-Sep	7	0.00	4,614	0.90	0	0.00	2,193	1.00	14	0.01	151	0.06
26-Sep	0	0.00	4,614	0.90	0	0.00	2,193	1.00	4	0.00	155	0.06
27-Sep	0	0.00	4,614	0.90	0	0.00	2,193	1.00	31	0.01	186	0.07
28-Sep	1	0.00	4,615	0.90	0	0.00	2,193	1.00	21	0.01	207	0.08
29-Sep	0	0.00	4,615	0.90	0	0.00	2,193	1.00	16	0.01	223	0.09
30-Sep	25	0.00	4,640	0.90	0	0.00	2,193	1.00	49	0.02	272	0.11
1-Oct	156	0.03	4,796	0.93	0	0.00	2,193	1.00	201	0.08	473	0.19
2-Oct	158	0.03	4,954	0.97	0	0.00	2,193	1.00	108	0.04	581	0.23
3-Oct	12	0.00	4,966	0.97	0	0.00	2,193	1.00	16	0.01	597	0.24
4-Oct	1	0.00	4,967	0.97	0	0.00	2,193	1.00	10	0.00	607	0.24
5-Oct	77	0.02	5,044	0.98	0	0.00	2,193	1.00	154	0.06	761	0.31
6-Oct	36	0.01	5,080	0.99	0	0.00	2,193	1.00	267	0.11	1,028	0.41
7-Oct	10	0.00	5,090	0.99	0	0.00	2,193	1.00	365	0.15	1,393	0.56
8-Oct	9	0.00	5,099	0.99	0	0.00	2,193	1.00	215	0.09	1,608	0.65
9-Oct	7	0.00	5,106	1.00	0	0.00	2,193	1.00	190	0.08	1,798	0.72
10-Oct	0	0.00	5,106	1.00	0	0.00	2,193	1.00	122	0.05	1,920	0.77
11-Oct	11	0.00	5,117	1.00	0	0.00	2,193	1.00	211	0.09	2,131	0.86
12-Oct	10	0.00	5,127	1.00	0	0.00	2,193	1.00	246	0.10	2,377	0.96
13-Oct	4	0.00	5,131	1.00	0	0.00	2,193	1.00	90	0.04	2,467	0.99
14-Oct	0	0.00	5,131	1.00	0	0.00	2,193	1.00	14	0.01	2,481	1.00
		1.00				1.00				1.00		
Adjustments [a]			250								50	
Total			5,381				2,193				2,531	
Catch above weir			280				27				0	
Total escapement			5,101				2,166				2,531	

[a] Estimated number of fish counted below the weir at date of weir removal.

Appendix A3.–Estimated age composition of chinook salmon in the Dry Bay set gillnet catch, by sex and age class, 1999.

		Brood year and age class						Total
		1997	1996	1995	1995	1994	1994	
		1.1	1.2	1.3	2.2	1.4	2.3	
Females	n		10	199		58	2	269
	% age comp.		3.7	74.0		21.6	0.7	59.9
	SE		1.2	2.7		2.5	0.5	2.3
Males	n		42	105		33		180
	% age comp.		23.3	58.3		18.3		40.1
	SE		3.2	3.7		2.9		2.3
Total	n		52	304		91	2	449
	% age comp.		11.6	67.7		20.3	0.4	100.0
	SE		1.5	2.2		1.9	0.3	

Appendix A4.–Estimated length composition of chinook salmon in the Dry Bay set gillnet catch, by sex and age class, 1999.

		Brood year and age class						Total
		1997	1996	1995	1995	1994	1994	
		1.1	1.2	1.3	2.2	1.4	2.3	
Females	n		10	199		58	2	269
	Avg. length		648	796		874	885	808
	SD		52	45		49	42	65
Males	n		42	105		33		180
	Avg. length		617	792		945		780
	SD		47	80		58		127
	SE		7	8		10		9
Total	n		52	304		91	2	449
	Avg. length		623	794		900	885	797
	SD		49	59		62	42	95

Appendix A5.–Estimated age composition of chinook salmon on the Alsek River spawning grounds, by sex and age class, 1999.

		Brood year and age class						Total
		1997	1996	1995	1995	1994	1994	
		1.1	1.2	1.3	2.2	1.4	2.3	
Klukshu weir								
Females	n		1	65		19		85
	% age comp.		1.2	76.5		22.4		49.4
	SE		1.2	4.6		4.5		3.8
Males	n	1	36	42	1	6	1	87
	% age comp.	1.1	41.4	48.3	1.1	6.9	1.1	50.6
	SE	1.1	5.3	5.4	1.1	2.7	1.1	3.8
Total	n	1	37	107	1	25	1	172
	% age comp.	0.6	21.5	62.2	0.6	14.5	0.6	100.0
	SE	0.6	3.1	3.7	0.6	2.7	0.6	
Blanchard/Goat/Takhanne								
Females	n		1	24		10	1	36
	% age comp.		2.8	66.7		27.8	2.8	43.4
	SE		2.8	8.0		7.6	2.8	5.5
Males	n		11	26		9	1	47
	% age comp.		23.4	55.3		19.1	2.1	56.6
	SE		6.2	7.3		5.8	2.1	5.5
Total	n		12	50		19	2	83
	% age comp.		14.5	60.2		22.9	2.4	100.0
	SE		3.9	5.4		4.6	1.7	
Sport fishery								
Females	n			18		2		20
	% age comp.			90.0		10.0		57.1
	SE			6.9		6.9		8.5
Males	n		3	11		1		15
	% age comp.		20.0	73.3		6.7		42.9
	SE		10.7	11.8		6.7		8.5
Total	n		3	29		3		35
	% age comp.		8.6	82.9		8.6		100.0
	SE		4.8	6.5		4.8		
Aboriginal fishery								
Females	n		3	7		2		12
	% age comp.		25.0	58.3		16.7		36.4
	SE		13.1	14.9		11.2		8.5
Males	n		1	16		4		21
	% age comp.		4.8	76.2		19.0		63.6
	SE		4.8	9.5		8.8		8.5
Total	n		4	23		6		33
	% age comp.		12.1	69.7		18.2		100.0
	SE		5.8	8.1		6.8		

Appendix A6.–Estimated length composition of chinook salmon on the Alsek River spawning grounds, by sex and age class, 1999.

			Brood year and age class						Total
			1997	1996	1995	1995	1994	1994	
			1.1	1.2	1.3	2.2	1.4	2.3	
Klukshu									
	Females	n		1	65		19		85
		Avg. length		484	776		843		787
		SD			45		58		64
	Males	n	1	36	42	1	6	1	87
		Avg. length	599	541	779	572	856	640	680
		SD		76	90		35		147
	Total	n	1	37	107	1	25	1	172
		Avg. length	599	539	777	572	846	640	733
		SD		76	66		53		126
Blanchard/Goat/Takhanne									
	Females	n		1	24		10	1	36
		Avg. length		615	782		867	755	800
		SD			43		44		65
	Males	n		11	26		9	1	47
		Avg. length		606	796		935	920	781
		SD		156	84		62		149
	Total	n		12	50		19	2	83
		Avg. length		607	789		899	838	789
		SD		149	67		63	117	120
Sport fishery									
	Females	n			18		2		20
		Avg. length			806		887		814
		SD			52		21		55
	Males	n		3	11		1		15
		Avg. length		653	763		890		750
		SD		41	114				114
	Total	n		3	29		3		35
		Avg. length		653	790		888		786
		SD		41	82		15		90
Aboriginal fishery									
	Females	n		3	7		2		12
		Avg. length		567	820		883		767
		SD		32	55		32		131
	Males	n		1	16		4		21
		Avg. length		710	788		930		811
		SD			107		70		114
	Total	n		4	23		6		33
		Avg. length		603	798		914		795
		SD		76	94		61		120

Appendix A7.–Estimated age composition of chinook salmon on the Alsek River all spawning ground samples pooled, by sex and age class, 1999.

		Brood year and age class						
		1997	1996	1995	1995	1994	1994	Total
		1.1	1.2	1.3	2.2	1.4	2.3	
Females	n		5	114		33	1	153
	% age comp.		1.6	35.4		10.2	0.3	47.5
	SE		0.7	2.7		1.7	0.3	2.8
Males	n	1	51	95	1	19	2	169
	% age comp.	0.3	15.8	29.5	0.3	5.9	0.6	52.5
	SE	0.3	2.0	2.5	0.3	1.3	0.4	2.8
Total	n	1	56	209	1	52	3	322
	% age comp.	0.3	17.4	64.9	0.3	16.1	0.9	100.0
	SE	0.3	2.1	2.7	0.3	2.1	0.5	0.0

Appendix A8.–Estimated length composition of chinook salmon on the Alsek River all spawning ground samples pooled, by sex and age class, 1999.

		Brood year and age class						
		1997	1996	1995	1995	1994	1994	Total
		1.1	1.2	1.3	2.2	1.4	2.3	
Females	n		5	114		33	1	153
	Avg. length		600	785		849	755	793
	SD		113	49		57		69
Males	n	1	51	95	1	19	2	169
	Avg. length	599	569	784	572	904	780	730
	SD		114	95		62	198	151
Total	n	1	56	209	1	52	3	322
	Avg. length	599	572	785	572	869	772	760
	SD		113	73		64	141	123

Appendix A9.–Procedures used in estimating the abundance of small and medium chinook salmon in the escapement to the Alsek River, 1999.

The estimated number of small chinook salmon $\hat{N}_{sm}$ in the population was calculated as a product of the number of large salmon $\hat{N}_{la}$ estimated through the mark-recapture experiment and an expansion factor $\hat{\theta}$ estimated through sampling to estimate relative size composition of the population:

$$\hat{N}_{sm} = \hat{N}_{la}\hat{\theta}$$

The estimated expansion was calculated as a ratio of two estimated, dependent fractions: $\hat{p}_{sm}$ represents small salmon and $\hat{p}_{la}$ large salmon:

$$\hat{\theta} = \hat{p}_{sm} / \hat{p}_{la}$$

The first step in the calculations to estimate variance involved the variance for the estimated expansion factor. From the delta method (see Seber 1982:7-9):

$$v(\hat{\theta}) \cong \hat{\theta}^2 \left[\frac{v(\hat{p}_{sm})}{\hat{p}_{sm}^2} + \frac{v(\hat{p}_{sm})}{\hat{p}_{la}^2} - \frac{2cov(\hat{p}_{sm}, (\hat{p}_{sm})}{\hat{p}_{sm}\hat{p}_{la}} \right]$$

When substituted into the equation above, the following relationships:

$$v(\hat{p}) \cong \frac{\hat{p}(1-\hat{p})}{n} \qquad cov(\hat{p}_{sm}, \hat{p}_{la}) \cong -\frac{\hat{p}_{sm}\hat{p}_{la}}{n}$$

simplify the calculation to:

$$v(\hat{\theta}) \cong \hat{\theta}^2 \left[\frac{1}{n\hat{p}_{sm}} + \frac{1}{n\hat{p}_{la}} \right]$$

where n is the size of the sample taken to estimate relative size of the population.

The final step in the calculations to estimate the variance of $\hat{N}_{sm}$ follows the method of Goodman (1960) for estimating the exact variance of a product:

$$v(\hat{N}_{sm}) = \hat{N}_{la}^2 v(\hat{\theta}) + \hat{\theta}^2 v(\hat{N}_{la}) - v(\hat{\theta}) v(\hat{N}_{la})$$

No covariance was involved in the above equation because both variates ($\hat{N}_{sm}$ and $\hat{\theta}$) were derived from independent programs.

Appendix A10.–Computer files used to estimate the spawning abundance and distribution of chinook salmon in the Alsek River in 1999.

File name	Description
Alsek99.xls	EXCEL spreadsheet with gillnet tagging data--daily effort, catch by species, and water depth by site; gillnet charts.
Scales991.xls	Age, sex, length (ASL) data from tagging site and spawning ground samples.
AlsekgillKS.xls	KS tests
kluCHNweir.xls	Klukshu weir tags and ASL data