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Abundance and Distribution of the Chinook Salmon Escapement on the Alsek River, 1998

by

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and

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December 1999

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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by

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ABSTRACT

The distribution and abundance of chinook salmon *Oncorhynchus tshawytscha* returning to spawn in the Alsek River in 1998 was estimated by means of radiotelemetry and 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, 1998 were used to capture 315 immigrant chinook salmon, of which, 307 were marked with individually numbered spaghetti tags and batch marked with opercle punches and axillary appendage clips. In addition, 180 of these fish had radio transmitters inserted into their stomachs. During July and August, chinook salmon were captured at spawning sites and inspected for tags. Marked fish were also recovered from Canadian recreational fisheries. We used a modified Petersen model (M = 239, C = 206 , R = 9) to estimate that 4,967 (SE =1,430) large (≥660 mm MEF) and 735 (SE = 233) medium (<660 mm MEF) chinook salmon immigrated to the Alsek River above Dry Bay. Canadian fisheries on the Tatshenshini River harvested 346 chinook salmon (mainly ≥660 mm MEF), leaving an escapement of 4,621 large fish. An estimated 1,184 of the 1,364 chinook salmon counted at the Klukshu River weir were large fish, about 24% of the estimated spawning escapement of large fish. The radiotelemetry study estimated that 16% of the spawning chinook salmon went to the Klukshu River, 19% to the upper Tatshenshini River, 9% to Takhanne River, 9% to Blanchard River, 3% to Goat Creek, 13% to Middle Tatshenshini, 23% to Lower Tatshenshini, and 10% to Low Fog Creek.

An estimated 16% of the Dry Bay gillnet catch was age -1.2 fish, 45% age -1.3, 37% age -1.4, and 1% age -2.4, with 156 males and 134 females sampled. An estimated 15% of the Alsek River escapement was age -1.2, 51% age -1.3, 30% age -1.4, and 2% age -2.4, with 97 males and 75 females sampled.

Key words: chinook salmon, *Oncorhynchus tshawytscha*, Alsek River, Klukshu River, Tatshenshini River, mark-recapture, escapement, radiotelemetry, 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). Alsek River chinook salmon *Oncorhynchus tshawytscha* are caught primarily in commercial and subsistence set gillnet fisheries in the lower Alsek River and in recreational and aboriginal fisheries 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 these populations 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). The status of chinook salmon has been evaluated, in part, by monitoring trends in indices of escapement for important stocks. Eleven rivers in Southeast Alaska and Canada are surveyed annually: the Situk, Alsek, Chilkat, Taku, King Salmon, Stikine, Unuk, Chickamin, Blossom, and Keta rivers, and Andrew Creek. Total escapements of chinook salmon have been estimated at ten of these eleven index systems: Stikine, Situk, Chilkat, Taku, Unuk, Chickamin, Blossom, Keta and King Salmon rivers, and Andrew Creek.

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. The proportion of the total chinook salmon escapement to the Alsek River drainage counted at the Klukshu River weir is unknown. A Klukshu weir expansion of 1.56 (64%) was used for many years (Pahlke 1997) and a recent analysis of the biological escapement goal for Klukshu River chinook salmon used a range of 30% to 100%

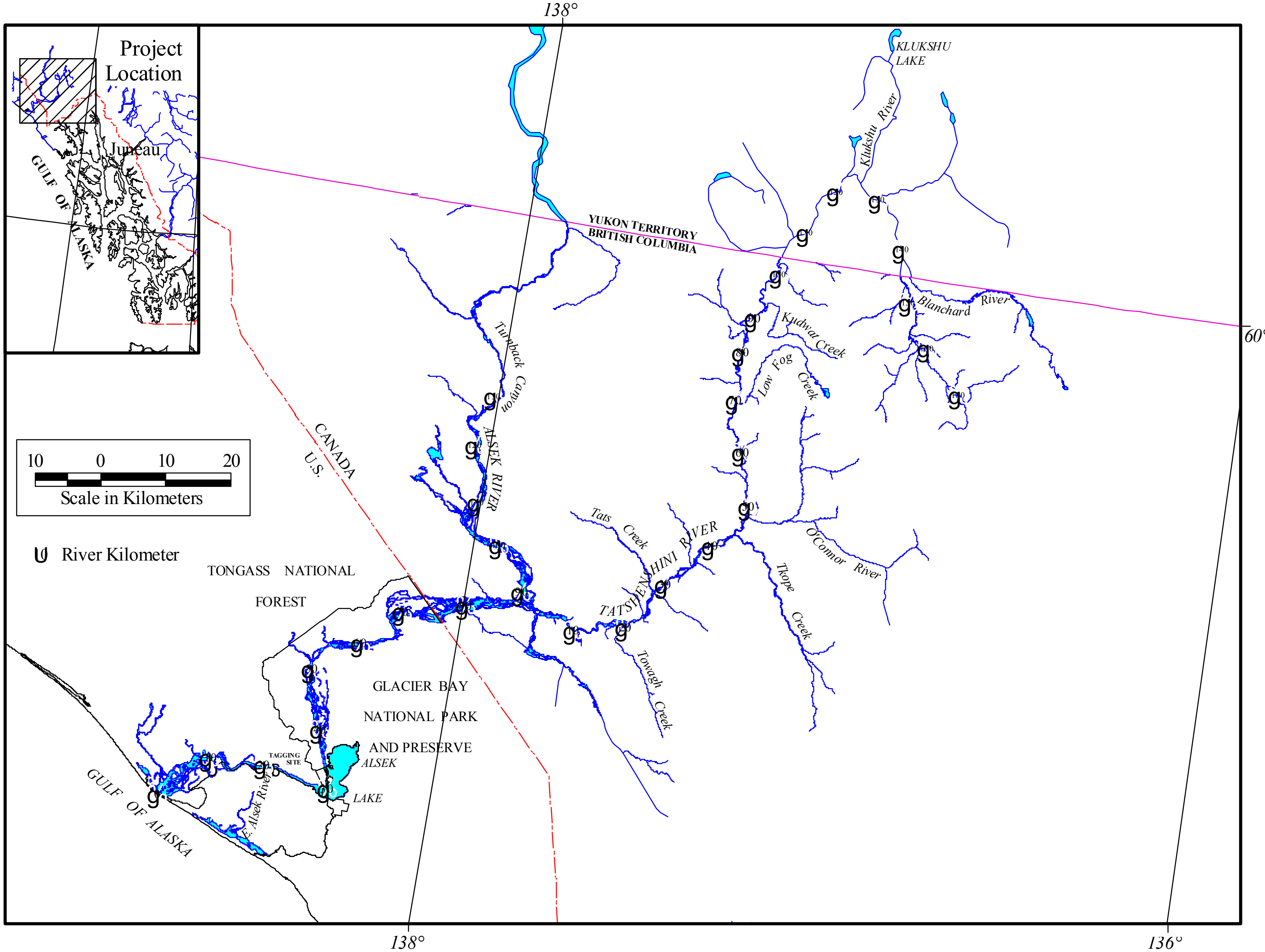

Figure 1.–Alsek River drainage, showing principal tributaries and river kilometers.

Table 1.–Harvests of chinook salmon in the Canadian Alsek River aboriginal and sport fisheries, 1976–1998.

	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

(McPherson et al. 1998). Annual spawning escapements of chinook salmon in the Klukshu River system have been estimated annually by subtracting from the weir count: (1) Canadian aboriginal fishery harvests taken upstream of the weir site; (2) Canadian sport fishery harvests taken above the weir site (1976–1978 only); and (3) brood stock removed at the weir site.

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 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 short, compact bodies and lighter color. They are, however, difficult to distinguish from other smaller species such as pink *O. gorbuscha* and 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.

Table 2.–Annual harvests of chinook salmon in the U.S. Alsek River commercial gillnet fishery, 1941– 1998.

Year(s)	Harvest	Year(s)	Harvest
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
1957	1,800	1987	347
1958	888	1988	223
1959	969	1989	228
1960	525	1990	78
1956–1960 Average	1,487	1986–1990 Average	271
1961	2,120	1991	103
1962	2,278	1992	301
1963	131	1993	300
1964	591	1994	805
1965	719	1995	670
1961–1965 Average	1,168	1991–1995 Average	436
1966	934	1996	771
1967	225	1997	568
1968	215	1998	550
1969	685		
1970	1,128		
1966–1970 Average	637		

The 1998 study had three objectives: (1) to estimate the abundance of large (≥660 mm MEF) spawning chinook in the Alsek River; (2) to estimate the age, sex, and length compositions of chinook salmon spawning in the Alsek River; and (3) to detect all spawning areas in the Alsek River drainage which receive ≥5% of the large-sized immigrant salmon.

Results from the study provide a survey expansion factor; i.e., an estimate of the fraction of total escapement 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, 1962–1998.

Year[a]	Klukshu River							Blanchard River		Takhanne River		Goat Creek	
	Aerial count		Weir count	Above-weir harvest AF	Sport	Brood	Escape-ment[b]						
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)	–	
1988–1997 average	964		2,956	161	0	16	2,779	237		219		41	
1998	–		1,364	17	0	0	1,347	71	P(H)	136	N(H)	39	N(H)

— = no survey; (A) = aerial survey from fixed wing aircraft; (H) = helicopter 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 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)(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 on 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 in 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 28. One net was fished daily, unless high water prevented fishing. The primary fishing site was at approximately river kilometer 19, just above the Dry Bay commercial fisheries 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. 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 due to entanglements, snags, cleaning the net, etc., the lost time (processing time) was added on to the end of the day to bring fishing time to 9 hours per day.

Captured chinook salmon were placed in a box 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 $\geq$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 was recorded, 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). A portion of the large fish caught were also fitted with esophageal radio transmitters. 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. 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.

Post-spawning fish were speared at Blanchard River and Goat Creek, and samples were collected

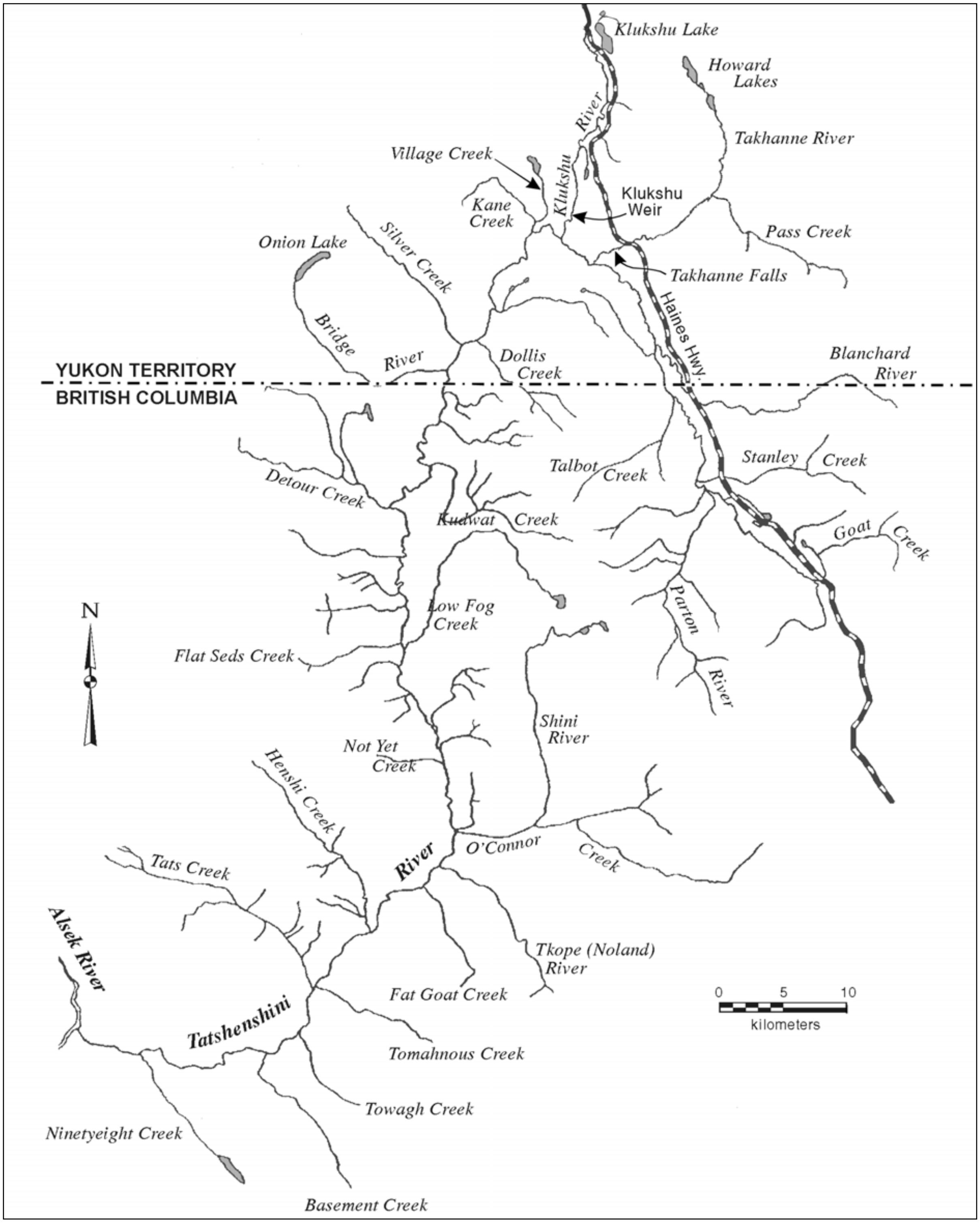

Figure 2.–Tatshenshini River drainage and associated tributaries, Yukon Territory and northern British Columbia.

from Canadian recreational fisheries. Foot surveys of the spawning area were conducted August 5–9, 1998. Numbers of fish observed were recorded and 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 (Pahlke and Etherton 1999, Bendock and Alexandersdottir 1992, Johnson et al. 1992, Milligan et al. 1984). This behavior puts marked fish at greater risk of capture in the commercial fishery that begins in mid-June, located immediately downstream from the tagging site. Censoring marked chinook salmon killed in this fishery avoids bias in estimates of abundance from this phenomenon.

This censoring also makes estimates germane to the number of spawning fish, not to the number passing by Dry Bay. The tagging program was well publicized and a high proportion of the U. S. catch was inspected for tags. Because of a reward (Can$2 for spaghetti tag; $10 for radio 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. 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 adjustments were made to account for some increased harvest rate of marked fish in the lower river gill-net 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, bias, and confidence intervals for the abundance estimate were estimated with modifications of bootstrap procedures in Buckland and Garthwaite (1991).

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

All fish captured at the Dry Bay tagging site and spawning ground surveys were sampled for

Table 4.–Numbers of chinook salmon marked on lower Alsek River, removed by fisheries and inspected for marks in tributaries in 1998, by length group (excluding 1 aboriginal and 6 sport fish tags returned voluntarily)**.**

		Length (MEF)			
		0–439 mm	**440–659 mm**	**≥660 mm**	**Total**
A. Released at Dry Bay with marks		1	61	245	307
B. Removed by:					
1. U.S. sport fisheries					
2. U.S. gillnet		0	6	6	12
3. Aboriginal fishery					
Subtotal of removals		0	6	6	12
C. Estimated number of marked fish remaining in mark-recapture experiment		1	55	239	295
D. Spawning ground samples					
	Inspected				1,067
Klukshu weir	Marked				21
	Marked/inspected				0.0197
E. Inspected at:					
1. Klukshu weir live	Inspected	0	91	206	297
	Marked	0	6	9	15
	Marked/inspected		0.0645	0.0437	0.0505
2. Blanchard/Goat	Inspected	0	6	31	37
	Marked	0	0	1	1
	Marked/ inspected		0.0000	0.0323	0.0270
3(a). Sport fishery	Inspected	0	13	57	70
	Marked	0	1	0	1
	Marked/inspected		0.0769	0.0000	0.0143
3(b). Yukon Safari	Inspected		7	29	36
	Marked [a]		1	0	1
	Marked/inspected		0.1428	0.0000	0.0278

[a] Only sport fish that were kept (fish released alive were not included in mark-recapture analysis).

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 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).

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

$$\hat{p}_i = \frac{n_i}{n} \quad (1)$$

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

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

n_i = the number in the sample of group i; and

n = the 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.

DISTRIBUTION OF SPAWNERS

Radiotelemetry was used to estimate the distribution of chinook salmon in the Alsek River drainage. Initially, every other large healthy chinook salmon had a 150-151 MHz Advanced Telemetry Systems (ATS) radio transmitter esophageally inserted into its stomach (Eiler 1990). However, capture rates were lower than anticipated and on June 2 the radiotagging rate was increased to every fish, which was then decreased to every other fish on June 17. Individual transmitters were identified by frequency and signal pattern (Eiler 1995). Transmitters used in this study were equipped with motion (mortality) sensors that doubled the pulse rate to 2 pulses per second following 3 to 4 h of inactivity. Subsequent movement reset the transmitter to the normal mode. Signals from radio tagged fish were recorded as either normal or mortality mode (Eiler 1990, Bendock and Alexandersdottir 1992, Johnson et al. 1993).

Radio tagged fish that moved upriver were recorded by fixed, remote tracking stations at selected sites in the drainage. The tracking stations were constructed and operated as described in Eiler (1995), but without satellite up-link capabilities. Instead, records of radio tagged fish movements were periodically downloaded from the tracking station computers to a laptop computer. Tracking stations were installed at three locations on the Alsek River drainage. The lowest site was located about five km upriver from the primary tagging site and consisted of two stations, one on each river bank, to record all radio tagged fish that moved upriver. Another tracking station was installed on the Tatshenshini River below Dalton Post (~km105) to record any transmitters going to tributaries of the upper Tatshenshini. A final station was operated at the Klukshu River weir to record all radio tagged fish that approached the weir.

Assumptions of the experiment to estimate spawning distributions include: a) fish were captured for radiotracking in proportion to abundance during the immigration, b) tagging did not change the destination (fate) of a fish; and c) fates of radiotracked fish are accurately determined. The first assumption will be true if fishing effort and catchability were constant for all "stocks" (fish spawning in the same area) in the immigration (stocks might be characterized by their age composition and immigration timing). Catchability would presumably vary with river conditions. Thus, sampling effort was held as constant as practical during the immigration. The river stage (height) was recorded for comparison to catch rates at the gillnet sites.

Beginning June 11, an attempt was made to locate each radio transmitter periodically by airplane or helicopter. The location of each tag was recorded

Table 5.–Criteria used to assign fates to radio tagged chinook salmon.

FATE CODES AND CRITERIA	
1	Probable spawning in a tributary: a chinook salmon whose radio transmitter was tracked into a tributary, and remained in or was tracked downstream from that location. When a transmitter was tracked to more than one tributary, the last tributary was assumed to be the spawning location.
2	Mortality or regurgitation: a chinook salmon whose radio transmitter either did not advance upstream after tagging, or stopped in the mainstem Alsek River and broadcast in the mortality mode (perhaps intermittently) over at least 4 weeks, and never tracked to a lower location in the river.
3	Gillnet mortality: chinook salmon captured in the Alsek River commercial fishery.
4	Upriver Fishery: chinook salmon harvested in upriver sport or aboriginal fisheries.

by river kilometer from the mouth of the river or tributary. After combining the data from the tracking stations and the tracking surveys, each radio tagged fish was assigned one of four possible fates (Table 5; Johnson et al. 1993). Each fish assigned to fate 1 (probable spawning in a tributary) was then further assigned to a final spawning area.

The proportion of large (660 mm and larger) chinook salmon spawning in each area was estimated

$$\hat{P}_a = \frac{\sum_{t=1}^{y}\left(\frac{N_t}{n_t}\right) r_{a,t}}{\sum_{a=1}^{x}\sum_{t=1}^{y}\left(\frac{N_t}{n_t}\right) r_{a,t}} \qquad (3)$$

where

$r_{a,t}$ = the number of large fish tagged with radios in period t that were tracked to and assumed to spawn in area a (=1 to 8)

N_t = the number of large fish captured in gillnets in period t, and

n_t = the number of large fish tagged in period t that were tracked to a spawning area .

Period (t) refers to distinct spans of time when the tagging fraction was constant. Transmitters assigned to fates not associated with successful spawning (Table 5) are ignored in computing $\hat{P}_a$, so that the sum of the estimated proportions equals one. The standard error of $\hat{P}_a$ was estimated using simulation with 1,100 trials. In each period, n_t new samples were drawn from all assigned fates (Table 5) using the empirical distribution of the data, and new values of $\hat{P}_a$ computed. Confidence intervals for the estimated proportions were calculated from the 1,100 trials using the percentile method (Efron and Tibshirani 1993), since the assumption of normality was clearly inappropriate for the smaller estimated proportions.

RESULTS

DRY BAY TAGGING

Between May 14 and June 26, 1998, 253 large (≥660 mm MEF) and 62 small and medium chinook salmon were captured in the lower Alsek River. Of these, 245 large fish became the marked population for our mark-recapture experiment (Table 4, Appendices A1 and A2). Set gillnet effort was maintained at 9 hours per day, although reduced sampling effort occurred on several days (Figure 3; Appendices A2). Catch rates ranged from 0 to 2.4 fish/net-hour and peaked on June 5, when 22 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 slightly towards males (143 females, 168 males). In addition, 36 sockeye salmon were captured, marked with T-bar anchor tags and released (Appendix A2).

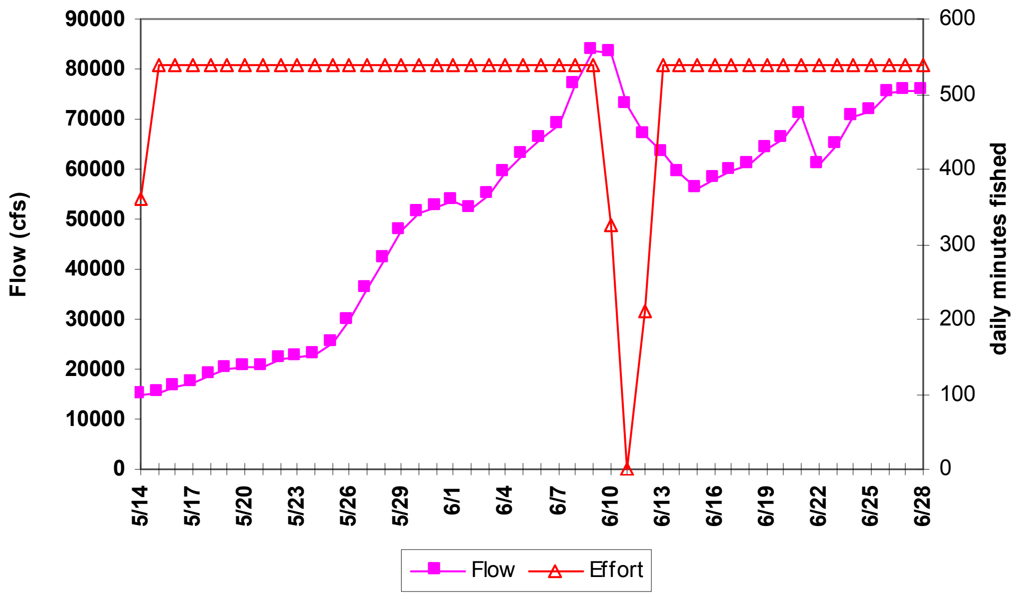

Figure 3.–Daily fishing effort (min) and river flow (cfs), Alsek River near Dry Bay, 1998.

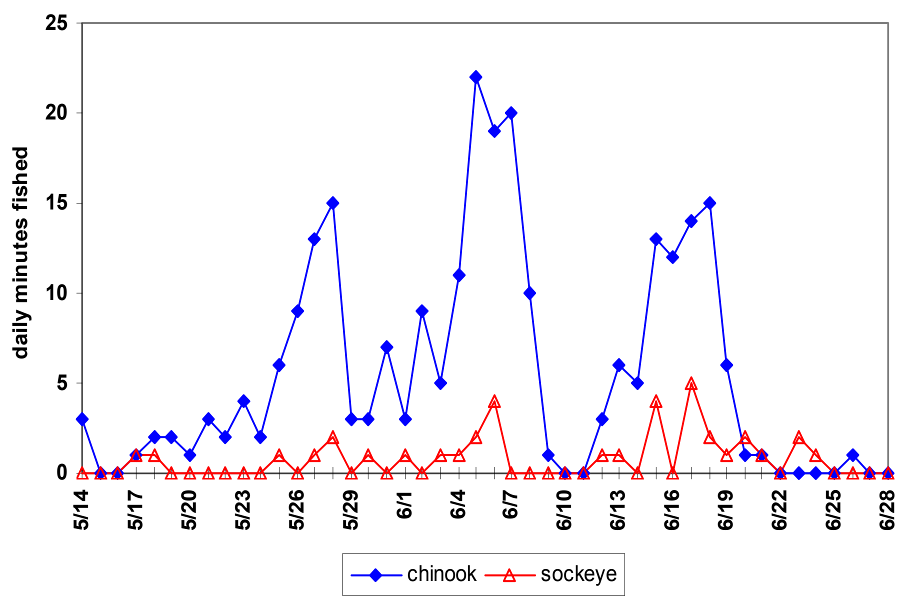

Figure 4.–Daily catch of chinook and sockeye salmon, lower Alsek River, 1998.

FISHERY SAMPLING

The inriver U.S. commercial gillnet fishery harvested 550 chinook salmon—including 12 tagged fish and U.S. subsistence and personal use fisheries harvested 42 more (Tables 2, 4).

SPAWNING GROUND SAMPLING

Two hundred ninety-seven (297) chinook salmon were examined for marks at the Klukshu River weir, and 15 marked fish were recovered (Table 4). No tag loss was noted in the sample of fish examined. The remaining 1,067 fish passing through the weir were not physically examined for marks; however, each fish was observed from a distance and the presence of 21 additional spaghetti tags was noted. Size category and sex of each fish was not estimated.

At Blanchard River, twelve chinook carcasses were examined for marks, with 0 marked fish recovered (Table 4). At Goat Creek on the upper Tatshenshini River, 25 chinook salmon were sampled and 1 tagged fish was recaptured.

The aboriginal fishery near Dalton Post harvested 171 chinook salmon with one tag reported from Village Creek. The sport fishery near Dalton Post harvested approximately 112 chinook with additional fish released. Seventy (70) fish were examined by DFO technicians and additional 155 were examined by Yukon Safari guides, with four tagged fish reported, of which three were released. An additional 6 tags were voluntarily turned in by sport fishers.

ABUNDANCE

Length distributions of fish marked in event 1 and all fish sampled at Klukshu weir were not significantly different (KS test, P = 0.065; Figure 6); those for event 1 and Blanchard/Goat and Tatshenshini sport harvest were also not significantly different (KS test, P = 0.0362; P = 0.0778, respectively). However, there appears to have been size-selective sampling at both event 1, tagging in Dry Bay, and event 2, the sampling at Klukshu River weir. Length distributions of all fish marked in event 1 and recovered at Klukshu River differed significantly (KS tests, P < 0.044; Figure 5). When stratified by size, the weir samples were still significantly different, but the sample size was so low that power of the tests is weak. Sample sizes at the Blanchard River and Goat Creek and the sport fishery were too small for this comparison to be made.

The probability of recovering a marked fish at any of the three recovery strata: Klukshu weir, Blanchard River/Goat Creek or the Tatshenshini sport fishery, was equal (χ^2 = 0.20, df =2, P = 0.906) (Table 4).

Fish observed at the Klukshu River weir constituted the largest recovery sample. However, because tests indicate size selective sampling at the weir, the abundance estimate must be stratified by size and this was not possible with the fish that were observed but not inspected. Therefore, only the sample of fish inspected at the weir was used in the abundance estimate. The abundance estimate based on large fish inspected at the weir is 4,967 fish (SE = 1,430; M = 239, C = 206, R = 9, 95% relative precision = 57.6%, bias 9.8%, 95% CI 3,027–9,765). The estimated abundance of medium fish is 735 fish (SE = 233; 95% relative precision = 63.7%, M = 55, C = 91, R = 6, bias 11.4%, 95% CI 434–1,643).

AGE, SEX, AND LENGTH COMPOSITION OF ESCAPEMENT

Age 1.3 chinook salmon were the most common in all samples, constituting an estimated 45% of fish passing by Dry Bay, 43% at the weir across the Klukshu River, 69% at Blanchard River/ Goat Creek, and 74% in the Canadian sport fishery (Appendix A4–A7). Age 1.4 fish were the second most common and age 1.2 fish were also common, especially at the Klukshu weir where it appears that sampling was biased toward smaller fish. Estimated age composition was significantly different between Dry Bay and either Klukshu (χ^2 = 14.86, df = 2, P = 0.0006) or Canadian sport samples (χ^2 = 12.41, df = 2, P = 0.0020); and the two spawning ground locations differed significantly from each other (χ^2 = 14.0, df = 2, P = .0009). However, when age compositions of only large fish were compared, the Dry Bay and weir samples were not significantly different (χ^2 = 2.29, df =1, P = 0.130). Sampled populations were 53–56%

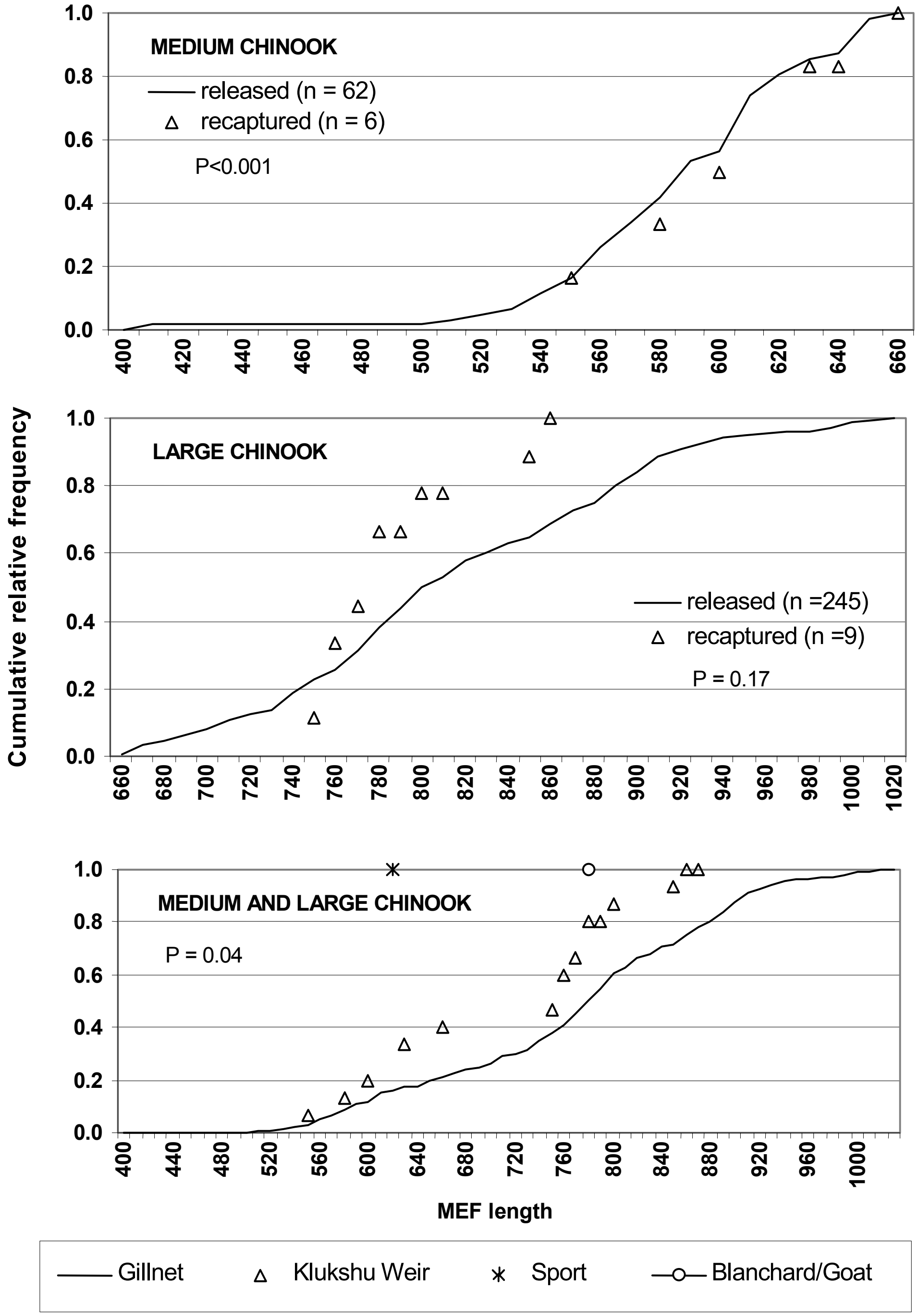

Figure 5.–Cumulative relative frequency of medium, large and medium and large combined chinook salmon captured in event 1 (Dry Bay gillnet) **and marked chinook salmon recaptured in event 2** (spawning ground sampling, Klukshu weir, Blanchard/Goat, Tatshenshini sport)**, Alsek River, 1998**.

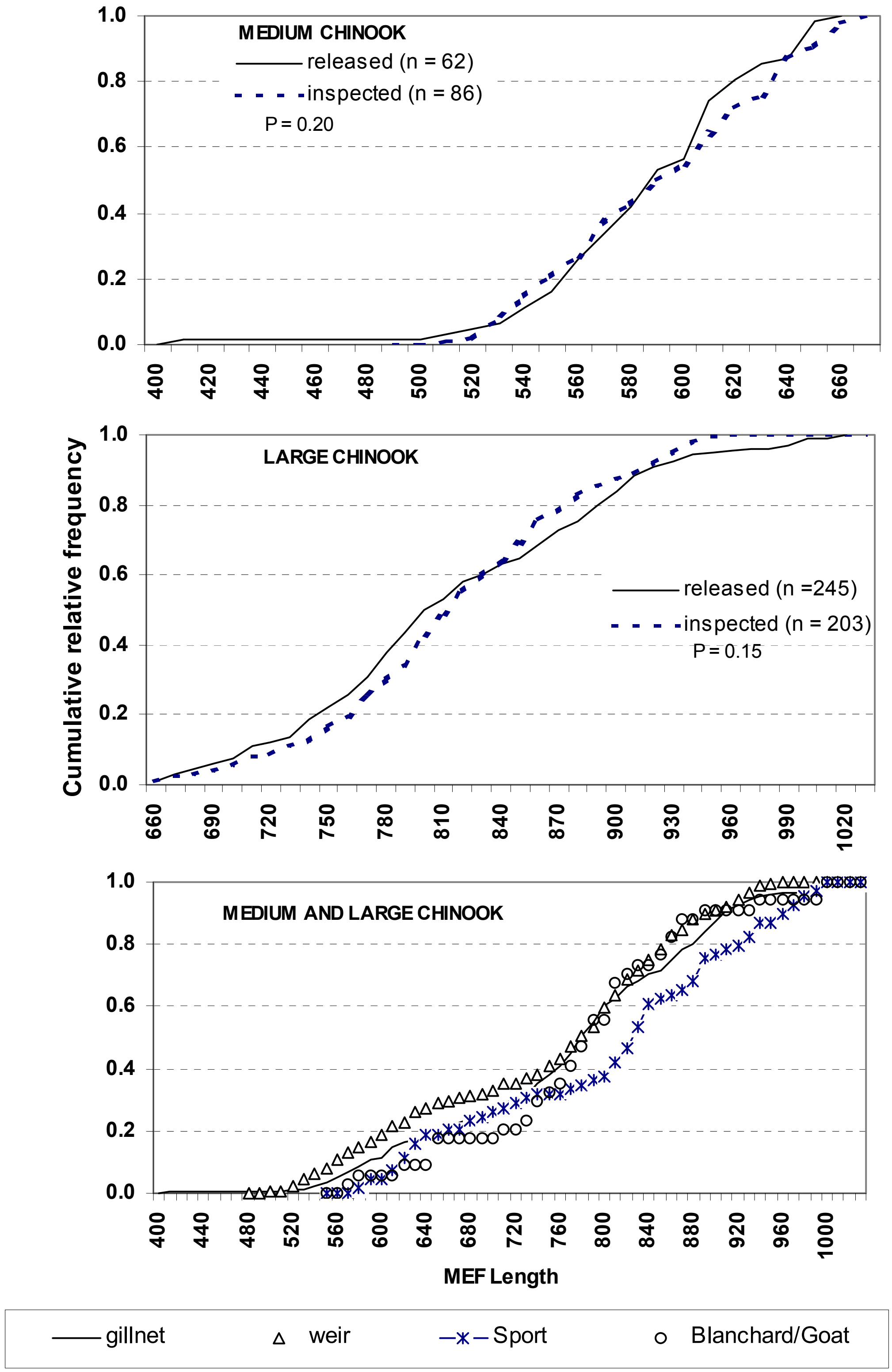

Figure 6.–Cumulative relative frequency of medium, large, and medium and large combined chinook salmon captured in event 1 (Dry Bay gillnet) **and inspected in event 2** (spawning ground sampling, Klukshu weir, Blanchard/Goat, Tatshenshini sport).

males. The Klukshu weir samples were used to estimate the abundance by age of the estimated total escapement to the Alsek River (Table 6).

DISTRIBUTION OF SPAWNERS

Of the 180 fish marked with radio transmitters 165 (92%) were successfully tracked to spawning areas or were captured in fisheries. The remaining 15 transmitters were either regurgitated, lost because a fish died before spawning, never found, or tracked in a way that defied assignment of a fate (Appendix A1). Three radio tagged fish moved downriver and were captured in the U.S. gillnet fishery. Spawning radio tagged fish were assigned to one of these eight areas: (1) *Lower Tatshenshini*, km 10–55, (2) *Middle Tatshenshini* [includes all fish recorded between km 70 and 100], (3) *Upper Tatshenshini River* [fish tracked above km 105 or recorded at Tatshenshini tower but not tracked to Klukshu, Takhanne, or Blanchard rivers or Goat Creek], (4) *Low Fog Creek* [fish tracked to Low Fog Creek or km 60–65], (5) *Klukshu River* [includes fish tracked to Klukshu River above and below the weir], (6) *Takhanne River*, (7) *Blanchard River*, and (8) *Goat Creek.* On the basis of radiotelemetry results, the proportions of large chinook spawning in each area of the Alsek/Tatshenshini River were estimated to be: Lower 23.0%, Middle 12.7%, Upper 18.6%, Low Fog 9.6% Klukshu 15.8%, Takhanne 8.8%, Blanchard 9.0%, and Goat 2.6%. Bootstrap confidence intervals for the proportions spawning in each area were asymmetric for the areas with small contributions (Table 7).

The median time for radio tagged fish to travel the 5km from the tagging site to the lower tracking station was 2 days, ranging from less than 1 to 17 days. The median travel time for fish recorded at the Tatshenshini River tower (km 105) was 39 days, ranging from 18 to 62 days (Appendix A1). Studies on the Stikine and Unuk 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 Etherton 1999; Pahlke et al. 1996). That trend was not apparent in this study (Table 7).

The remote tracking stations did not record every radio tagged fish that passed them. Similar problems with tracking stations were observed in a tagging study conducted on the Stikine River (Pahlke and Etherton 1999). The tracking stations were useful in supplementing the data from aerial surveys.

The telemetry data also provide an estimate of abundance. Of the 297 fish handled at the Klukshu River weir, 69% (206) were large fish, giving an estimate of 946 large fish passed through the weir (SE = 25). If 15.8% of radio tags passed through the weir (all on large fish), an estimate of abundance passing by Dry Bay would be 5,987 (946/0.158). This number is probably biased low because of the predilection to sample smaller fish at the weir. Of 55 medium fish marked, 6 were recovered at the weir; 9 of 239 marked large fish were recovered. This disparity shows the odds of capturing a medium-sized fish to be 2.897:1. Using these odds, one can solve the following equations:

$$N_{med}\,p_{med} = n_{med} = 91$$

$$N_{lar}\,p_{lar} = n_{lar} = 206$$

where

N_{lar} = the total number of large fish passing through the weir;

N_{med} = the number of medium fish passing through the weir;

p_{med} = the probability of sampling a medium fish at the weir; and

p_{lar} = the probability of sampling a large fish.

Substituting $p_{med} = (2.897)\,p_{lar}$ and solving gives an estimate of the true relationship corrected for size selectivity: $N_{med} = N_{lar}(0.15248)$.

Substituting this relationship into

$$N_{med} + N_{lar} = 1{,}364$$

gives

$$N_{lar} + N_{lar}(0.15248) = 1{,}364$$

Table 6.–Estimated abundance and composition by age and sex of the escapement of chinook salmon in the Alsek River in 1998, determined from samples collected at the Klukshu River weir.

PANEL A: AGE COMPOSITION OF SMALL AND MEDIUM CHINOOK SALMON

		Brood year and age class									
		1995	1994	1994	1993	1993	1992	1992	1991	1991	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Males	n	2	0	39	0	6	0	0	0	0	**47**
	%	3.8		73.6		11.3					**88.7**
	SE of %	2.6		6.1		4.4					**4.4**
	Escapement	28		541		83					**652**
	SE of esc.	20		177		40					**209**
Females	n	0	0	6	0	0	0	0	0	0	**6**
	%			11.3							**11.3**
	SE of %			4.4							**4.4**
	Escapement			83							**83**
	SE of esc.			40							**40**
Sexes combined	n	2	0	45	0	6	0	0	0	0	**53**
	%	3.8		84.9		11.3					**100.0**
	SE of %	2.6		5.0		4.4					**0.0**
	Escapement	28		624		83					**735**
	SE of esc.	20		201		40					**233**

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	3	0	30	0	14	3	0	**50**
	%			2.5		25.2		11.8	2.5		**42.0**
	SE of %			1.4		4.0		3.0	1.4		**4.5**
	Escapement			125		1,252		584	125		**2,087**
	SE of esc.			78		408		220	78		**639**
Females	n	0	0	3	0	38	1	27	0	0	**69**
	%			2.5		31.9	0.8	22.7			**58.0**
	SE of %			1.4		4.3	0.8	3.9			**4.5**
	Escapement			125		1,586	42	1,127			**2,880**
	SE of esc.			78		500	42	373			**857**
Sexes combined	n	0	0	6	0	68	1	41	3	0	**119**
	%			5.0		57.1	0.8	34.5	2.5		**100.0**
	SE of %			2.0		4.6	0.8	4.4	1.4		**0.0**
	Escapement			250		2,838	42	1,711	125		**4,967**
	SE of esc.			120		845	42	535	78		**1,430**

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	2	0	42	0	36	0	14	3	0	**97**
	%	0.5		11.7		23.4		10.2	2.2		**48.0**
	SE of %	0.4		3.7		3.6		2.6	1.3		**4.6**
	Escapement	28		666		1,335		584	125		**2,739**
	SE of esc.	20		193		410		220	78		**672**
Females	n	0	0	9	0	38	1	27	0	0	**75**
	%			3.7		27.8	0.7	19.8			**52.0**
	SE of %			1.4		4.0	0.7	3.5			**4.6**
	Escapement			208		1,586	42	1,127			**2,963**
	SE of esc.			87		500	42	373			**858**
Sexes combined	n	2	0	51	0	74	1	41	3	0	**172**
	%	0.5		15.3		51.2	0.7	30.0	2.2		**100.0**
	SE of %	0.4		4.3		4.6	0.7	4.2	1.3		**0.0**
	Escapement	28		874		2,921	42	1,711	125		**5,702**
	SE of esc.	20		234		846	42	535	78		**1,449**

Table 7.–Summary of fates assigned to radio transmitters on Alsek River, 1998. Tags assigned to fates by tagging period, estimated proportions spawning in each tributary, with SE and upper and lower 95% confidence intervals for estimates.

	Period			Estimated proportion in tributary	Bootstrap (%)		
Assigned fate	**1**	**2**	**3**		**SE**	**LCI**	**UCI**
Tributary:							
Lower Tatshenshini	11	18	5	23.0	3.62	16.0	30.5
Middle Tatshenshini	1	18	3	12.7	2.57	8.1	18.2
Low Fog Creek	8	6	0	9.6	2.29	5.3	14.2
Upper Tatshenshini	4	23	4	18.6	3.06	12.7	24.7
Klukshu River	6	20	1	15.8	2.91	10.4	21.7
Takhanne River	4	7	2	8.8	2.42	4.1	13.8
Blanchard River	2	15	0	9.0	2.15	4.8	13.5
Goat Creek	2	2	0	2.6	1.34	0.5	5.6
Subtotal	38	109	15	100			
Unknown[a]	0	3	2				
Mort/regurgitation	1	9	0				
Lower River gillnet	0	1	2				
Total	39	122	19				

[a] Unknown: fish tracked upriver from the tagging site at least once but never found again.

which solved gives an estimate of 1,184 large chinook salmon passing through the weir or 7,494 (=1,184/0.158) spawning in the watershed (SE=1,633, relative precision 43%, Appendix B).

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 all three strata of event 2 were not 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 two locations—the Blanchard River/Goat Creek and Canadian sport fishery—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.

Daily catch is dependent not only on effort but on river conditions which can change dramatically from day to day. Sampling effort in 1998 was consistent, however changing river conditions often made fishing difficult or ineffective.

Traditional indicators of chinook salmon escapement to the Alsek River indicate a low escapement in 1998. The count at the Klukshu weir was one of the three lowest since the installation of the weir in 1976. Index counts in the Blanchard and Takhanne rivers were also far below average. The low abundance of fish in the river and the learning curve associated with a new project made it difficult to catch many fish both at the tagging site and on the spawning grounds. Low sample sizes in both events 1 and 2 of the mark-recapture experiment make it difficult to test the assumptions of the experiment and result in poor precision in the estimates.

It is likely that the actual escapement is somewhere between the mark-recapture estimate of about 5,000 and the telemetry estimate of about 7,500 large fish. Both estimates indicate that the Klukshu River weir count represents a smaller proportion of the total escapement than previously believed. The weir count of 1,364 fish is about 24% of the mark-recapture estimated escapement of large and medium fish combined (5,702), similar to the 16% estimated from the telemetry study, but much less than the 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 fish at the weir was higher than the rate for visually observed fish. 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.

Twenty-seven (27) radio tagged fish were tracked to the Klukshu River; 6 were tagged in period 1, 20 in period 2, and 1 period 3. Based on the radiotagging rates (period 1 = 1 out of every 2 large fish tagged, period 2 = 1 of 1.1, period 3 = 1 out of 2), we would expect to see about 35 large spaghetti tagged fish at the weir. Actual numbers were less: 7 large inspected plus 21 more observed, indicating either higher than estimated tag loss or that not all spaghetti tags were seen in the observation of live fish passing through the weir. It is also possible that some radio tags that were recorded as tracked to the Klukshu River were actually in other waters nearby such as Village Creek, portions of the Tatshenshini or the Klukshu River below the weir. The land in that area is fairly flat and radio signals could be received from longer distances than in steep terrain. Every radio tag that was tracked to the Klukshu River was also recorded at the Klukshu weir receiver; however, that receiver also recorded many tags that ended up in other areas of the upper Tatshenshini River (Appendix A1).

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.

The telemetry study confirmed the importance of the Klukshu River and other upper tributaries of the Tatshenshini. Almost 55% of the chinook salmon escapement was tracked to the upper Tatshenshini River including the Klukshu, Takhanne, and Blanchard rivers and Goat Creek. There were two other significant findings resulting from the telemetry study. The first was that no fish were tracked up the Alsek River past the velocity barrier at Turnback Canyon. This was not unexpected, but had not been verified. The second finding was the existence of chinook salmon spawning in the lower Tatshenshini River, apparently in the glacial mainstem. Chinook salmon spawning in glacial mainstem waters have rarely been documented in Southeast Alaska and northern British Columbia, however we are confident in this finding as many fish were repeatedly tracked to this area and many mortality signals were recorded. No fish were actually observed and this spawning area would not have been documented without the use of radiotelemetry. The number of fish tracked to Low Fog Creek is also noteworthy. Low Fog is a small creek which is impossible to survey from the air because of thick overhanging canopy. A foot survey found very few fish and without the telemetry data the importance of this tributary would have remained undetected.

Many radio tags were not tracked to specific spawning locations. The long distances between refueling sites made surveying the Alsek/ Tatshenshini drainage difficult and expensive. Many small tributaries were surveyed only once or not at all.

The failure of the remote tracking stations to record each fish was a big disappointment. One of the lower sites and the Klukshu River site had equipment failures that were easily diagnosed, but the remaining units appeared to function properly throughout the study. The sites were carefully selected, but apparently some radio tagged fish were able to pass without detection by the receivers. Similar problems occurred on the Stikine River in 1997 (Pahlke and Etherton 1999). Other investigators use multiple units to provide backup and insure that each and every transmitter is recorded. We had 2 units at the lower site and still were unsuccessful in recording every passing radio tag. The remote tracking units and aerial surveys are both expensive, requiring careful planning to meet project objectives and stay within allocated budget.

CONCLUSIONS AND RECOMMENDATIONS

This was the first 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 fluctuating river conditions 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; however, the present expansion of 1.56 times the weir count underestimates the escapement. Similar findings have been reported in previous studies on the Taku (McPherson et al. 1993), Chilkat (Johnson et al. 1993), Unuk (Pahlke et al. 1996) and Chickamin rivers (Pahlke 1997b).

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APPENDIX A

Appendix A1.–Locations of radio transmitters implanted in large chinook salmon on the Alsek River in 1998, by radio frequency, code, date tagged, Julian date located, by tracking tower, survey date and final destination.

		Date	Julian		lower		Tats		Kluk						Aerial Surveys																	
Frequency	Code	Tagged	Date	Per	tower	days	tower	days	tower	days	6/11	M	6/23	M	6/27	M	6/29	M	7/10	M	7/13	M	7-27	M	8/1	M	8/4	M	8/10	M	9/17	Destination
150.712	10	5/14	134	1	135	1					80	M	85	M			80	M					85	M			85	M				Middle
150.814	10	5/14	134	1	135	1					T 10		T65				T60		LF2	M	LF1		LF2	M	LF2	M	T60	M	LF2	M	T60M	LowFog
150.870	10	5/18	138	1	139	1					T 25		T20	M			T15	M					T5	M			T20	M	T25	M	T10M	Lower
150.953	10	5/19	139	1	144	5			193	54																			T42	M		Lower
150.993	10	5/21	141	1			191	50	207	66	80		T5				T55		T100								KS				T90M	Upper
151.013	10	5/21	141	1	141	0	185	44			T 50		T70		T75				TK2					M								Takhanne
151.093	10	5/22	142	1	144	2					T 10		T45				T75								Goat	M	T95					Goat
151.153	10	5/23	143	1	146	3	205	62			80				A125		T30		T30						BL 1							Blanchard
151.174	10	5/23	143	1							80														BL 20							Blanchard
151.193	10	5/24	144	1							T 25	M	T10	M			T10	M	T10	M			T10	M			T10		T25	M	T5M	Lower
151.213	10	5/25	145	1	146	1			197	52	85		T55		T65		T65								KS 1	M	KS		KS	M	T95M	Klukshu
151.234	10	5/25	145	1	146	1	191	46	193	48			T30				T60						T100		KS 1		KS		KS			Upper
151.253	10	5/26	146	1	151	5	185	39	195	49	85		T50				T25		T105								T95		KS I	M		Klukshu
151.273	10	5/26	146	1	149	3	181	35	193	47	T 5		T40		T65										Goat	M						Goat
151.293	10	5/26	146	1	148	2	192	46			85				T55		T65		T90						KS 1				KS 1	M	T95M	Upper
151.314	10	5/26	146	1	147	1			195	49			T40				T60		A185								T65	M	LF2	M	T60M	LowFog
151.334	10	5/27	147	1																									1			Lost
151.354	10	5/27	147	1	150	3	191	44							T35		T40		T90						TK 1						T95M	Takhanne
151.373	10	5/27	147	1	150	3									T20		T25		T30				T30	M					T43	M		Lower
151.392	10	5/27	147	1	153	6	192	45			70		T25				T40		T95						TK 1							Takhanne
151.412	10	5/27	147	1	152	5					70						T10						T30	M					T35	M	T30M	Lower
151.434	10	5/27	147	1	149	2			193	46	80		T20										LF1	M	LF2	M			LF	M		LowFog
151.453	10	5/27	147	1	149	2	197	50	201	54			T25				T25						T50	M								Klukshu
151.472	10	5/27	147	1	154	7			193	46	75		T25				T30		T20				T20	M			T25	M	T27	M	T15M	Lower
150.712	12	5/28	148	1	149	1			193	45	80								KS0								KS10	M	KS 2	M		Klukshu
150.814	12	5/28	148	1	152	4							T25				T25		T25		T20	M	T25	M					T27		T25M	Lower
150.870	12	5/28	148	1	156	8			193	45	55		85				T15	M	T30				T55									Lower
150.993	12	5/28	148	1	149	1			192	44	T 10		T60		T80								T100		KS1		KS					Upper
151.013	12	5/28	148	1	151	3					T 15		T30	M	T40		T40	M														Lower
151.093	12	5/28	148	1	151	3							T40				T60								LF1	M			LF			LowFog
151.133	12	5/29	149	1	150	1					80		T40						LF1				LF2		LF2	M			LF	M		LowFog
151.153	12	5/30	150	1	151	1	188	38	205	55	80	M	T25		T40		T45		TK2	M												Takhanne
151.174	12	5/30	150	1	155	5	201	51	194	44	55				T40		T40		T65												KS5M	Klukshu
151.193	12	5/31	151	1	154	3			193	42	70				A125		A125						T3O	M			T10				T5M	Lower
151.213	12	5/31	151	1	158	7	187	36			50						T50		T60												T55M	LowFog
151.234	12	5/31	151	1	151	0			193	42	85						T60		T60	M					LF2		T60		LF	M		LowFog

-continued-

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		Date	Julian		lower		Tats		Kluk		Aerial Surveys																				
Frequency	Code	Tagged	Date	Per	tower	days	tower	days	tower	days	6/11	M	6/23	M	6/27	M	6/29	M	7/10	M	7/13	M	7-27	M	8/1	M	8/4	M	8/10	M	9/17	Destination
151.253	12	5/31	151	1	152	1							T40						T60	M			LF3	M	LF2	M			LF1			LowFog
151.273	12	5/31	151	1	156	5					40						T20														T30M	Lower
151.293	12	5/31	151	1	155	4	191	40	200	49	60		T25				T35		T90								KS VILL		KS20	M		Klukshu
151.314	12	6/2	153	2	155	2			194	41	70		T15				T10						T5								80M	Middle
151.334	12	6/2	153	2	165	12	194	41					T25												BL 20							Blanchard
151.354	12	6/2	153	2	154	1	186	33	192	39	85		T30				T60		T105						KS1							Upper
151.373	12	6/2	153	2	155	2									T20								T75	M			T80		T80	M		Middle
151.392	12	6/2	153	2			191	38	195	42	75	M											T100						KS6	M		Klukshu
151.412	12	6/2	153	2	157	4	195	42			40								T50						T125	M						Upper
151.434	12	6/2	153	2	156	3	193	40									T60								TK				KS1	M		Upper
151.453	12	6/2	153	2	154	1			193	40	70								T35				T45	M			T40	M	T46	M		Lower
151.472	12	6/2	153	2	154	1	191	38	193	40	75						T30	M	T95				T45	M			T80	M	T80	M	T75M	Upper
150.712	16	6/3	154	2	159	5			210	56	55						T30		T65						KS1							Klukshu
150.814	16	6/3	154	2																									1			Lost
150.870	16	6/4	155	2	156	1	190	35			60						T30		T100				T100		T110		KS5	M	KS2			Upper
150.993	16	6/4	155	2	158	3							80						T15				T5									Lower
151.013	16	6/4	155	2	159	4					50		T20				T15	M	T10	M			T15	M			T25	M	T25	M	T10M	Lower
151.093	16	6/4	155	2	160	5	198	43	204	49			85																KS8			Klukshu
151.133	16	6/4	155	2			201	46			75						T50		T80						BL 15	M						Blanchard
151.153	16	6/4	155	2													10	M														Mort
151.193	16	6/4	155	2	156	1					35						35	M														Mort
151.213	16	6/4	155	2	156	1	183	28			55				T55																	Upper
150.814	19	6/5	156	2	157	1	197	41	203	47	40		T15								LF1						KS5		KS8	M	KS5M	Klukshu
150.870	19	6/5	156	2	159	3					45				A115				A120												85M	Middle
150.953	19	6/5	156	2	160	4							T5						A120													Unknown
150.993	19	6/5	156	2	157	1	192	36	195	39	60		T20		T30		T30		T90								85	M	KS2	M		Klukshu
151.093	19	6/5	156	2	157	1					55		T5				70		65	M			60	M			75	M				Middle
151.174	16	6/5	156	2			199	43	203	47	55		T30				T45		T70								KS10	M	KS8	M	KS5M	Klukshu
151.234	16	6/5	156	2	157	1					40		T20										T75				T80	M	T84	M		Middle
151.253	16	6/5	156	2	158	2					45	M			T25	M	T25	M	T30	M			T20				T30	M	T35	M		Lower
151.273	16	6/5	156	2			201	45					T5												BL 5							Blanchard
151.293	16	6/5	156	2	158	2	191	35			55		T25				T35	M							Goat	M						Goat
151.314	16	6/5	156	2	158	2	192	36			70								T110				LF2		BL 20							Blanchard
151.334	16	6/5	156	2	159	3	189	33							T40		T45		T80						T 135							Upper
151.354	16	6/5	156	2	158	2					55	M	50				55	M	40	M			50	M	Pirate Cr						45	Mort
151.373	16	6/5	156	2	157	1							T25				T45		T90						T 91	M			T84			Middle
151.392	16	6/5	156	2	173	17															85		85	M			T5				85M	Middle
151.412	16	6/5	156	2	157	1	194	38	207	51			T25						T80	M									KS1		KS1M	Klukshu
151.434	16	6/5	156	2	159	3							T30												LF2				LF			LowFog
151.453	16	6/5	156	2	162	6	205	49									T25				T35				T 134							Upper
151.472	16	6/5	156	2													3	M														Mort
151.133	19	6/6	157	2	158	1							70										LF2	M			T70		T65	M		LowFog
151.153	19	6/6	157	2	157	0					70		T30	M	T40		T30	M	T30	M			T30	M			T30	M	T35		T35M	Lower

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		Date	Julian		lower		Tats		Kluk						Aerial Surveys																	
Frequency	Code	Tagged	Date	Per	tower	days	tower	days	tower	days	6/11	M	6/23	M	6/27	M	6/29	M	7/10	M	7/13	M	7-27	M	8/1	M	8/4	M	8/10	M	9/17	Destination
151.174	19	6/6	157	2			208	51					65				80		T65	M			T95		BL 1							Blanchard
151.193	19	6/6	157	2	158	1							T25				T45		T90								T80	M	T85		T75M	Middle
151.213	19	6/6	157	2	159	2					45				A115		A115		A105				A125						T26	M	T15M	Lower
151.234	19	6/6	157	2	158	1															T10		T10						T27	M		Lower
151.253	19	6/6	157	2	158	1	193	36					T20		T40		T40		T80						BL 20	M						Blanchard
151.273	19	6/6	157	2	160	3	191	34	195	38	35				T15				T95								KS VIL	M	KS20	M		Klukshu
151.293	19	6/6	157	2			204	47	206	49			T20		T35		T40														T95M	Upper
151.314	19	6/6	157	2	159	2							T25										LF3	M	LF2	M	T65	M	LF	M	T60M	LowFog
151.334	19	6/6	157	2	171	14											30		T110												70M	Middle
151.354	19	6/6	157	2			190	33			35		T25				T45		KS1						T 125							Upper
151.373	19	6/6	157	2	158	1					45		T10	M	T20		T10	M	T30				T80	M	TK							Takhanne
151.392	19	6/6	157	2	158	1	198	41			35		T25												BL 1							Blanchard
151.412	19	6/6	157	2	158	1							60																			Mort
151.434	19	6/6	157	2	158	1					40	M	T20						T45				LF1				T65					LowFog
151.453	19	6/6	157	2	159	2	202	45													T35				TK							Takhanne
151.472	19	6/7	158	2													T50								Goat							Goat
151.493	10	6/7	158	2	159	1	193	35	201	43													T100	M	KS1				KS1			Upper
151.514	10	6/7	158	2	159	1	208	50	193	35			T20				80	M			T35	M										Upper
151.533	10	6/7	158	2									T15		80								T90									Unknown
151.553	10	6/7	158	2					222	64									T50				T55				T50	M	T50	M	T55M	Lower
151.573	10	6/7	158	2			196	38	193	35			T5				T20										KS10	M	KS10	M		Klukshu
151.592	10	6/7	158	2	168	10							50		60				80				T40									Unknown
151.612	10	6/7	158	2			191	33	195	37																	KS10	M	KS10	M		Klukshu
151.633	10	6/7	158	2	159	1	188	30	213	55													T45		T 110		T100		T110	M	T95M	Upper
151.653	10	6/7	158	2	167	9			222	64			85						T30		T20		T30	M			T40	M	T45	M	T50M	Lower
151.672	10	6/7	158	2	161	3			222	64							A150		A160				A160				T20		T28	M	T25M	Lower
151.693	10	6/7	158	2	159	1			213	55			T15												BL 1							Blanchard
151.712	10	6/7	158	2	160	2			193	35			30	M	40	M	30	M	35	M												Lower
151.733	10	6/7	158	2															T20		T20											Lower
151.753	10	6/7	158	2	164	6															T35		T75		T 90	M			T84	M	T80M	Middle
151.774	10	6/7	158	2	160	2			213	55			60		65						T20		T60		LF	M	T60		LF	M	T65M	LowFog
151.793	10	6/7	158	2	160	2	196	38	199	41			T15				T20										KS2	M	KS7	M		Klukshu
151.812	10	6/7	158	2	160	2	198	40	213	55					80		T40								TK	M						Takhanne
151.833	10	6/7	158	2					222	64			65		75		70		80								T35	M	T42	M		Lower
151.493	12	6/8	159	2	165	6	211	52	219	60			35		75		70		TS		T20								KS1			Klukshu
151.514	12	6/8	159	2			191	32	197	38															T 100							Upper
151.533	12	6/8	159	2					198	39									T40				T65				T70	M				Middle
151.853	10	6/8	159	2	160	1	208	49	213	54			85	M					T20	M					KS1				KS2	M	T95M	Upper
151.872	10	6/8	159	2	163	4	193	34									T35															Upper
151.892	10	6/8	159	2	161	2	196	37	213	54													T95		KS 1	M	KS	M	KS3	M	T95M	Upper

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		Date	Julian		lower		Tats		Kluk						Aerial Surveys																	
Frequency	Code	Tagged	Date	Per	tower	days	tower	days	tower	days	6/11	M	6/23	M	6/27	M	6/29	M	7/10	M	7/13	M	7-27	M	8/1	M	8/4	M	8/10	M	9/17	Destination
151.913	10	6/8	159	2			202	43					75				80	M	T20	M												Upper
151.935	10	6/8	159	2	159	0			222	63			80				60		T20	M	TC1	M							TC1	M		Lower
151.954	10	6/8	159	2	160	1											T50						T50		BL 10							Blanchard
151.972	10	6/8	159	2	161	2	196	37	203	44							T35		T60										KS10			Klukshu
151.553	12	6/9	160	2			203	43	193	33			75		50				T30						BL 10							Blanchard
151.573	12	6/12	163	2	165	2											80						85								T35M	Lower
151.592	12	6/12	163	2					193	30			75						T35				T65		Pirate						T80M	Middle
151.612	12	6/13	164	2			216	52							85				T15		T10										T100M	Middle
151.633	12	6/13	164	2	164	0	204	40	193	29											T40				BL 10							Blanchard
151.653	12	6/13	164	2			195	31	213	49			85				T20		T75						BL 14							Blanchard
151.672	12	6/13	164	2	176	12	217	53	193	29					35		45		80				T30								KS5M	Klukshu
151.693	12	6/13	164	2	166	2	198	34	203	39									T70								KS2	M	KS1	M		Klukshu
151.712	12	6/14	165	2	166	1	201	36	205	40			75														KS VIL	M	KS20			Upper
151.733	12	6/14	165	2	166	1			192	27											35		T5				T15		T25		T10M	Lower
151.753	12	6/14	165	2	167	2			213	48			75								T50				BL 5							Blanchard
151.774	12	6/14	165	2	167	2							65						A100												85M	Middle
151.812	12	6/14	165	2			202	37	206	41			65				80		T30						KS1				KS20			Klukshu
151.493	16	6/15	166	2	166	0	204	38	213	47			50		75		75				T20				T 125							Upper
151.533	16	6/15	166	2	167	1	208	42	213	47			80				T5		T15						KS1				KS10			Klukshu
151.553	16	6/15	166	2	168	2	205	39	209	43							80	M	80				T90		KS1						T100M	Klukshu
151.573	16	6/15	166	2	168	2	213	47	213	47			60												T85							Upper
151.833	12	6/15	166	2	169	3	205	39	193	27			40		65		70		T30						T 130	M						Upper
151.853	12	6/15	166	2	168	2			222	56			60										T25	M			T30		T30	M	T35M	Lower
151.872	12	6/15	166	2	166	0	205	39	213	47					65		80		T25						TK							Takhanne
151.892	12	6/15	166	2	167	1	214	48	225	59			40		50				80		T5										T95M	Upper
151.913	12	6/15	166	2	167	1			213	47			85				T30		T60				LF3	M	LF	M	T60	M	LF		LF2M	LowFog
151.935	12	6/15	166	2	167	1	203	37	222	56											T30								T85	M		Middle
151.954	12	6/15	166	2	170	4	215	49	213	47			35		55		60						T50				T20	M				Lower
151.972	12	6/15	166	2	168	2	202	36																							T95M	Middle
151.612	16	6/16	167	2	168	1	206	39	213	46			65	M			80	M	T15	M	T10				KS1				VC	M	T90M	Klukshu
151.633	16	6/16	167	2	168	1			221	54			65						T5	M	T15		T95				T100	M	KS1	M		Klukshu
151.653	16	6/16	167	2	168	1	205	38	213	46															TK						T95M	Takhanne
151.672	16	6/16	167	2			198	31	213	46			75										T15	M	TK	M					T100	Takhanne
151.693	16	6/16	167	2	168	1							55						80				85	M							85M	Middle
151.712	16	6/16	167	2	168	1	199	32	213	46			85												TK				T98	M		Takhanne
151.733	16	6/16	167	2	169	2							35	M			45	M														Mort
151.753	16	6/16	167	2					213	46											10	M										Mort
151.774	16	6/16	167	2	168	1																							1			Lost
151.793	16	6/16	167	2	169	2	206	39	213	46			55				80								BL 10							Blanchard
151.812	16	6/16	167	2	168	1	204	37	213	46			75						T30						BL2							Blanchard

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		Date	Julian		lower		Tats		Kluk						Aerial Surveys																	
Frequency	Code	Tagged	Date	Per	tower	days	tower	days	tower	days	6/11	M	6/23	M	6/27	M	6/29	M	7/10	M	7/13	M	7-27	M	8/1	M	8/4	M	8/10	M	9/17	Destination
151.833	16	6/16	167	2	170	3							45				50						85	M			85	M				Middle
151.853	16	6/17	168	3	169	1	209	41									80															Upper
151.872	16	6/17	168	3	168	0			222	54			65				80	M	T25				T40	M			T20	M	T25	M	T10M	Lower
151.892	16	6/17	168	3	170	2			222	54											T15						T85	M	T80		T80M	Middle
151.913	16	6/17	168	3	169	1	213	45	213	45											T20		T40		T82						T95M	Upper
151.935	16	6/17	168	3	172	4	186	18					35				65				T15	M	T85				T85				T85M	Middle
151.954	16	6/17	168	3	168	0			193	25			55										T20	M								Lower
151.972	16	6/17	168	3	169	1							65						80		T5		T20									Unknown
151.493	19	6/18	169	3	170	1	199	30	201	32			60	M					T40		T50						KS10		KS10			Klukshu
151.514	19	6/18	169	3					222	53			55				80				T15	M	T10	M			T15	M	T25		T15M	Lower
151.533	19	6/18	169	3	170	1							35														KS10					Unknown
151.553	19	6/18	169	3	170	1	214	45									60		80	M			T25									Upper
151.573	19	6/18	169	3	173	4	209	40	213	44			30		40		55		80						TK						T95M	Takhanne
151.592	19	6/18	169	3																												Dry Bay Gillnet
151.612	19	6/18	169	3	170	1	207	38	213	44							60				T20											Upper
151.633	19	6/18	169	3	170	1											60		80		T10						T35					Lower
150.712	19	6/19	170	3	171	1							T25						T5						TK				T84	M		Takhanne
151.653	19	6/20	171	3																												Dry Bay Gillnet
151.672	19	6/21	172	3	173	1			222	50									A160								T35	M	T42	M	T40M	Lower
151.693	19	6/26	177	3															50												T90M	Middle
151.592	16	6/15	166	2																												Dry Bay Gillnet
Valid Tags	180			180																									8			
		Travel time to towers			max	17	217	62	225	66																						
					min	0	181	18	192	25																						
					median	2.0		39		46																						
					average	2.5		40		46																						

A=Mainstem Alsek above confluence w/Tat
T=Mainstem Tatshenshini
TK=Mainstem Takhanne
TC=Tats Creek BL=Blanchard
LF=Low Fog No letter = mainstem Alsek, downstream of confluence w/Tat
KS=Klukshu

Lower = T10-T55
Middle = T70-T100
Upper = Above Klukshu (T115)

Appendix A2.–Gillnet daily effort (minutes fished), catches, and catch per net hour, near Dry Bay, lower Alsek River, 1998.

Date	Minutes	Large chin.	Jacks	Sock-eye	Temp.	Water discharge	Depth	Comments	Lg. chin. cum.	Cum. %	CPUE
5/14/98	360	3	0	0	NA	15000	0	First day, 2 radios	3	1	0.50
5/15/98	540	0	0	0	NA	15400	1"	Nice sets, no action	3	1	0.00
5/16/98	540	0	0	0	1	16400	1.5"	1 hit, lots of icebergs	3	1	0.00
5/17/98	540	1	0	1	1.5	17400	2"	Slow, more ice	4	2	0.11
5/18/98	540	2	0	1	4	18700	3"	3-4 hits, ? Temp	6	2	0.22
5/19/98	540	2	0	0	2.5	19900	7"	Rain, more ice	8	3	0.22
5/20/98	540	1	0	0	1.5	20400	11"	CWT, head taken	9	4	0.11
5/21/98	540	3	0	0	2.5	20600	13"	Net fishing well	12	5	0.33
5/22/98	540	2	0	0	1	22100	14.5"	1 hit sockeye poss.	14	6	0.22
5/23/98	540	4	0	0	1	22600	16"	Radio tag spit out	18	7	0.44
5/24/98	540	2	2	0	1	22700	17.5"	Ice & debris	20	8	0.22
5/25/98	540	6	0	1	2	25200	19"	Action in P.M.	26	10	0.67
5/26/98	540	9	1	0	1.5	29800	23"	Radio tagged 4 lg. kings	35	14	1.00
5/27/98	540	13	1	1	1.5	36200	30"	Debris & ice around net	48	19	1.44
5/28/98	540	15	0	2	1.5	42100	39"	2 bright w/ lice	63	25	1.67
5/29/98	540	3	0	0	1.5	47500	47"	Stronger current, ice	66	26	0.33
5/30/98	540	3	0	1	1	51300	54"	Current moving net	69	27	0.33
5/31/98	540	7	0	0	NA	52300	59.5"	Strong eddy, lost therm.	76	30	0.78
6/1/98	540	3	0	1	NA	53800	62.5"	Ice in back eddy	79	31	0.33
6/2/98	540	9	0	0	NA	52100	64"	Radio tag every lg. king	88	35	1.00
6/3/98	540	5	1	1	NA	54700	67"	2 lg. kings not tagged	93	37	0.56
6/4/98	540	11	2	1	NA	59400	70"	1 lg. king mort in net	104	41	1.22
6/5/98	540	22	5	2	NA	62700	75.5"	Add 2nd anchor	126	50	2.44
6/6/98	540	19	8	4	NA	66000	80.5"	7 radioed, 1 jumped out	145	57	2.11
6/7/98	540	20	10	0	NA	68700	82.5"	1/3 Jacks, lots of fish	165	65	2.22
6/8/98	540	10	1	0	NA	77000	89.5"	Reset anchors hi. water	175	69	1.11
6/9/98	540	1	0	0	NA	83800	98.5"	High swift water	176	70	0.11
6/10/98	325	0	0	0	NA	83100	103"	Net twisting & whirlpools	176	70	0.00
6/11/98	0	0	0	0	NA	72800	101.5"	No fishing, high water	176	70	
6/12/98	210	3	1	1	NA	66800	96.5"	Fished sites #1 & #2	179	71	0.86
6/13/98	540	6	4	1	NA	63400	91.5"	1 recapture, fish #3 site	185	73	0.67
6/14/98	540	5	1	0	NA	59200	84.5"	Fished site #3, 5 radios	190	75	0.56
6/15/98	540	13	3	4	NA	56200	81"	Shortened net 14 fathom	203	80	1.44
6/16/98	540	12	7	0	NA	57900	79.5"	Less net fishing well	215	85	1.33
6/17/98	540	14	3	5	NA	59500	82"	Every other lg.K radioed	229	91	1.56
6/18/98	540	15	5	2	NA	60900	84"	Steady hits throughout	244	96	1.67
6/19/98	540	6	2	1	NA	64200	86"	1/2 adults w/ seal bites	250	99	0.67
6/20/98	540	1	2	2	NA	66100	88"	Fish 20 fathom @ site 4	251	99	0.11
6/21/98	540	1	1	1	NA	71000	90"	Fish 14 fathom @ site 1	252	100	0.11
6/22/98	540	0	0	0	NA	61000	94"	Fish 15 fathom @ site 4	252	100	0.00
6/23/98	540	0	2	2	NA	65000	95"	Fish 17 fathom @ site 3	252	100	0.00
6/24/98	540	0	0	1	NA	70600	96.5"	Lot of debris + hi. water	252	100	0.00
6/25/98	540	0	0	0	NA	71700	96.5"	Fish 20 fathom mid-day	252	100	0.00
6/26/98	540	1	0	0	NA	75400	100.5"	Fished sites #3 & #4	253	100	0.11
6/27/98	540	0	0	0	NA	75800	102.5"	Fished site #3, slow day	253	100	0.00
6/28/98	540	0	0	0	NA	75600	103.5"	Last day of fishing	253	100	0.00
Totals		253	62	36							

Appendix A3.–Daily counts of salmon through the Klukshu River weir, 1998.

Date	Daily	Chinook cumulative daily	Prop.	Daily	Sockeye cumulative daily	Prop.	Daily	Coho cumulative daily	Prop.
24-Jun	1	1	0.00	0	0	0.00	0	0	0.00
25-Jun	1	2	0.00	0	0	0.00	0	0	0.00
26-Jun	0	2	0.00	0	0	0.00	0	0	0.00
27-Jun	1	3	0.00	0	0	0.00	0	0	0.00
28-Jun	0	3	0.00	0	0	0.00	0	0	0.00
29-Jun	0	3	0.00	0	0	0.00	0	0	0.00
30-Jun	5	8	0.01	0	0	0.00	0	0	0.00
1-Jul	0	8	0.01	0	0	0.00	0	0	0.00
2-Jul	5	13	0.01	0	0	0.00	0	0	0.00
3-Jul	3	16	0.01	0	0	0.00	0	0	0.00
4-Jul	3	19	0.01	0	0	0.00	0	0	0.00
5-Jul	3	22	0.02	3	3	0.00	0	0	0.00
6-Jul	4	26	0.02	9	12	0.00	0	0	0.00
7-Jul	0	26	0.02	1	13	0.00	0	0	0.00
8-Jul	21	47	0.03	17	30	0.00	0	0	0.00
9-Jul	8	55	0.04	0	30	0.00	0	0	0.00
10-Jul	3	58	0.04	1	31	0.00	0	0	0.00
11-Jul	3	61	0.04	0	31	0.00	0	0	0.00
12-Jul	2	63	0.05	0	31	0.00	0	0	0.00
13-Jul	13	76	0.06	1	32	0.00	0	0	0.00
14-Jul	148	224	0.16	3	35	0.00	0	0	0.00
15-Jul	116	340	0.25	4	39	0.00	0	0	0.00
16-Jul	49	389	0.29	29	68	0.01	0	0	0.00
17-Jul	14	403	0.30	0	68	0.01	0	0	0.00
18-Jul	12	415	0.30	0	68	0.01	0	0	0.00
19-Jul	21	436	0.32	2	70	0.01	0	0	0.00
20-Jul	59	495	0.36	5	75	0.01	0	0	0.00
21-Jul	20	515	0.38	23	98	0.01	0	0	0.00
22-Jul	44	559	0.41	0	98	0.01	0	0	0.00
23-Jul	53	612	0.45	14	112	0.01	0	0	0.00
24-Jul	30	642	0.47	2	114	0.01	0	0	0.00
25-Jul	39	681	0.50	5	119	0.01	0	0	0.00
26-Jul	68	749	0.55	9	128	0.01	0	0	0.00
27-Jul	68	817	0.60	2	130	0.01	0	0	0.00
28-Jul	48	865	0.63	4	134	0.01	0	0	0.00
29-Jul	45	910	0.67	4	138	0.01	0	0	0.00
30-Jul	55	965	0.71	2	140	0.01	0	0	0.00
31-Jul	48	1013	0.74	5	145	0.01	0	0	0.00
1-Aug	40	1053	0.77	3	148	0.01	0	0	0.00
2-Aug	29	1082	0.79	7	155	0.01	0	0	0.00
3-Aug	14	1096	0.80	2	157	0.01	0	0	0.00
4-Aug	7	1103	0.81	2	159	0.01	0	0	0.00
5-Aug	25	1128	0.83	3	162	0.01	0	0	0.00
6-Aug	20	1148	0.84	0	162	0.01	0	0	0.00
7-Aug	11	1159	0.85	2	164	0.01	0	0	0.00

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Date	Daily	Chinook cumulative daily	Prop.	Daily	Sockeye cumulative daily	Prop.	Daily	Coho cumulative daily	Prop.
8-Aug	20	1179	0.86	3	167	0.01	0	0	0.00
9-Aug	15	1194	0.88	1	168	0.01	0	0	0.00
10-Aug	9	1203	0.88	1	169	0.01	0	0	0.00
11-Aug	10	1213	0.89	4	173	0.01	0	0	0.00
12-Aug	13	1226	0.90	249	422	0.03	0	0	0.00
13-Aug	33	1259	0.92	66	488	0.04	0	0	0.00
14-Aug	3	1262	0.93	19	507	0.04	0	0	0.00
15-Aug	17	1279	0.94	90	597	0.04	0	0	0.00
16-Aug	3	1282	0.94	5	602	0.04	0	0	0.00
17-Aug	3	1285	0.94	0	602	0.04	0	0	0.00
18-Aug	3	1288	0.94	1	603	0.05	0	0	0.00
19-Aug	5	1293	0.95	4	607	0.05	0	0	0.00
20-Aug	6	1299	0.95	239	846	0.06	0	0	0.00
21-Aug	0	1299	0.95	2	848	0.06	0	0	0.00
22-Aug	0	1299	0.95	10	858	0.06	0	0	0.00
23-Aug	14	1313	0.96	73	931	0.07	0	0	0.00
24-Aug	3	1316	0.96	6	937	0.07	0	0	0.00
25-Aug	4	1320	0.97	186	1123	0.08	0	0	0.00
26-Aug	6	1326	0.97	6	1129	0.08	0	0	0.00
27-Aug	29	1355	0.99	64	1193	0.09	0	0	0.00
28-Aug	1	1356	0.99	1	1194	0.09	0	0	0.00
29-Aug	0	1356	0.99	0	1194	0.09	0	0	0.00
30-Aug	1	1357	0.99	3	1197	0.09	0	0	0.00
31-Aug	0	1357	0.99	0	1197	0.09	0	0	0.00
1-Sep	2	1359	1.00	980	2177	0.16	0	0	0.00
2-Sep	4	1363	1.00	492	2669	0.20	0	0	0.00
3-Sep	0	1363	1.00	3	2672	0.20	0	0	0.00
4-Sep	0	1363	1.00	112	2784	0.21	0	0	0.00
5-Sep	0	1363	1.00	25	2809	0.21	0	0	0.00
6-Sep	0	1363	1.00	16	2825	0.21	0	0	0.00
7-Sep	0	1363	1.00	755	3580	0.27	0	0	0.00
8-Sep	0	1363	1.00	47	3627	0.27	0	0	0.00
9-Sep	0	1363	1.00	60	3687	0.28	0	0	0.00
10-Sep	0	1363	1.00	94	3781	0.28	0	0	0.00
11-Sep	0	1363	1.00	231	4012	0.30	0	0	0.00
12-Sep	1	1364	1.00	1829	5841	0.44	0	0	0.00
13-Sep	0	1364	1.00	468	6309	0.47	0	0	0.00
14-Sep	0	1364	1.00	273	6582	0.49	0	0	0.00
15-Sep	0	1364	1.00	6	6588	0.49	1	1	0.00
16-Sep	0	1364	1.00	0	6588	0.49	0	1	0.00
17-Sep	0	1364	1.00	1243	7831	0.58	9	10	0.01
18-Sep	0	1364	1.00	53	7884	0.59	1	11	0.01
19-Sep	0	1364	1.00	19	7903	0.59	0	11	0.01
20-Sep	0	1364	1.00	2	7905	0.59	0	11	0.01
21-Sep	0	1364	1.00	0	7905	0.59	0	11	0.01

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Date	Daily	Chinook cumulative daily	Prop.	Daily	Sockeye cumulative daily	Prop.	Daily	Coho cumulative daily	Prop.
22-Sep	0	1364	1.00	2	7907	0.59	0	11	0.01
23-Sep	0	1364	1.00	1	7908	0.59	1	12	0.01
24-Sep	0	1364	1.00	5	7913	0.59	0	12	0.01
25-Sep	0	1364	1.00	2	7915	0.59	0	12	0.01
26-Sep	0	1364	1.00	7	7922	0.59	0	12	0.01
27-Sep	0	1364	1.00	0	7922	0.59	0	12	0.01
28-Sep	0	1364	1.00	0	7922	0.59	0	12	0.01
29-Sep	0	1364	1.00	0	7922	0.59	0	12	0.01
30-Sep	0	1364	1.00	3	7925	0.59	0	12	0.01
1-Oct	0	1364	1.00	860	8785	0.66	7	19	0.01
2-Oct	0	1364	1.00	382	9167	0.68	11	30	0.02
3-Oct	0	1364	1.00	8	9175	0.69	1	31	0.02
4-Oct	0	1364	1.00	14	9189	0.69	1	32	0.02
5-Oct	0	1364	1.00	47	9236	0.69	1	33	0.02
6-Oct	0	1364	1.00	1424	10660	0.80	499	532	0.28
7-Oct	0	1364	1.00	833	11493	0.86	596	1128	0.59
8-Oct	0	1364	1.00	139	11632	0.87	155	1283	0.67
9-Oct	0	1364	1.00	78	11710	0.87	23	1306	0.68
10-Oct	0	1364	1.00	162	11872	0.89	19	1325	0.69
11-Oct	0	1364	1.00	222	12094	0.90	27	1352	0.70
12-Oct	0	1364	1.00	13	12107	0.90	2	1354	0.70
13-Oct	0	1364	1.00	15	12122	0.91	1	1355	0.71
14-Oct	0	1364	1.00	5	12127	0.91	0	1355	0.71
15-Oct	0	1364	1.00	106	12233	0.91	13	1368	0.71
16-Oct	0	1364	1.00	723	12956	0.97	250	1618	0.84
17-Oct	0	1364	1.00	221	13177	0.98	251	1869	0.97
18-Oct	0	1364	1.00	106	13283	0.99	28	1897	0.99
19-Oct	0	1364	1.00	108	13391	1.00	24	1921	1.00
Totals		1364			13391			1921	
Adjustments				200	200	b	40	40	b
Catch above weir		17			11			0	
Total escapement		1347			13580			1961	

[a] Jack chinook included in the counts.

[b] Estimated fish holding below weir during removal.

Appendix A4.–Estimated age composition of chinook salmon in the Dry Bay set gillnet catch, by sex and age class, 1998.

		BROOD YEAR AND AGE CLASS							
		1994	**1993**	**1993**	**1992**	**1992**	**1991**	**1991**	
		1.2	1.3	2.2	1.4	2.3	2.4	1.5	**Total**
Male	Sample size	45	69	2	38	0	2	0	156
	Percent	15.5	23.8	0.7	13.1		0.7		53.8
	SE	2.1	2.5	0.5	2.0		0.5		2.9
Female	Sample size	1	61	0	69	1	2	0	134
	Percent	0.3	21.0		23.8	0.3	0.7		46.2
	SE	0.3	2.4		2.5	0.3	0.5		2.9
Total	Sample size	46	130	2	107	1	4	0	290
	Percent	15.9	44.8	0.7	36.9	0.3	1.4		100.0
	SE	2.1	2.9	0.5	2.8	0.3	0.7		

Appendix A5.–Estimated length composition of chinook salmon in the Dry Bay set gillnet catch, by sex and age class, 1998

		BROOD YEAR AND AGE CLASS						
		1994	**1993**	**1993**	**1992**	**1992**	**1991**	
		1.2	1.3	2.2	1.4	2.3	2.4	**Total**
Male	Sample size	45	69	2	38	0	2	156
	Average length	585	732	628	886		970	
	SD	45.6	69.8	3.5	159.7		42.4	
	SE	6.8	8.4	2.5	25.9		30.0	
Female	Sample size	1	61	0	69	1	2	134
	Average length	610	775		856	870	880	
	SD		43.0		49.8		21.2	
	SE		5.5		6.0		15.0	
Total	Sample size	46	130	2	107	1	4	290
	Average length	586	752	628	867	870	925	
	SD	45.4	62.7	3.5	103.4		58.8	
	SE	6.7	5.5	2.5	10.0		29.4	

Appendix A6.–Estimated age composition of chinook salmon on the Alsek River spawning grounds, 1998.

		BROOD YEAR AND AGE CLASS							
		1995	**1994**	**1993**	**1992**	**1992**	**1991**	**1991**	
		1.1	1.2	1.3	1.4	2.3	2.4	1.5	**Total**
Klukshu Weir									
Male	Sample size	2	42	36	14	0	3	0	97
	Percent	1.2	24.7	21.2	8.2		1.8		57.1
	SE	0.8	3.3	3.1	2.1		1.0		3.8
Female	Sample size	0	9	38	27	1	0	0	75
	Percent		5.3	21.8	15.3	0.6			42.9
	SE		1.7	3.2	2.8	0.6			3.8
Total	Sample size	2	51	74	41	1	3	0	172
	Percent	1.2	30.0	42.9	23.5	0.6	1.8		100.0
	SE	0.8	3.5	3.8	3.3	0.6	1.0		
Blanchard/Goat									
Male	Sample size	0	2	10	4	0	1	0	17
	Percent		6.9	34.5	13.8	0.0	3.4		58.6
	SE		4.8	9.0	6.5	0.0	3.4		9.3
Female	Sample size	0	0	10	1	1	0	0	12
	Percent			34.5	3.4	3.4			41.4
	SE			9.0	3.4	3.4			9.3
Total	Sample size	0	2	20	5	1	1	0	29
	Percent		6.9	69.0	17.2	3.4	3.4		100.0
	SE		4.8	8.7	7.1	3.4	3.4		
Dalton Post sport fishery									
Male	Sample size	0	2	16	3	0	1	0	22
	Percent		4.3	34.8	6.5		2.2		47.8
	SE		3.0	7.1	3.7		2.2		7.4
Female	Sample size	0	2	18	4	0	0	0	24
	Percent		4.3	39.1	8.7				52.2
	SE		3.0	7.3	4.2				7.4
Total	Sample size	0	4	34	7	0	1	0	46
	Percent		8.7	73.9	15.2		2.2		100.0
	SE		4.2	6.5	5.4		2.2		

Appendix A7.–Estimated length composition of chinook salmon on the Alsek River spawning grounds, by sex and age, 1998

		BROOD YEAR AND AGE CLASS						
		1994	**1993**	**1993**	**1992**	**1992**	**1991**	
		1.2	1.3	2.2	1.4	2.3	2.4	**Total**
Klukshu weir								
Male	Sample size	41	36	0	14	0	3	94
	Average length	586	767.2		908		898.61	
	SD	45.1	97.0		51.3		43.2	
Female	Sample size	7	37	0	26	1	0	71
	Average Length	635	790		838	802		
	SD	104.1	51.4		66.1			
Total	Sample size	48	73	0	40	1	3	165
	Average length	593	779		863	802	899	
	SD	53.7	73.9		60.9	0.0	43.2	
Blanchard/Goat								
Male	Sample size	2	10	0	4	0	1	17
	Average length	615	809		900		820	
	SD	49.5	102.0		56.6			
Female	Sample size	0	10	0	1	1	0	12
	Average Length		789		890	730		
	SD		30.3					
Total	Sample size	2	20	0	5	1	1	29
	Average length	615	799		898	730	820	
	SD	49.5	106.3		45.3			
Tatshenshini sport fishery								
Male	Sample size	2	16	0	3	0	1	22
	Average length	723	826		818		984	
	SD	131.5	137.1		115.0		0.0	
Female	Sample size	2	18	0	4	0	0	24
	Average Length	613	824		916			
	SD	11.3	73.2		63.8			
Total	Sample size	4	34	0	7	0	1	46
	Average length	668	825		874		984	
	SD	71.4	106.3		85.7			

Appendix A8.–Computer files used to estimate the spawning abundance and distribution of chinook salmon in the Alsek River in 1998.

File name	Description
EFFORT98.xls	EXCEL spreadsheet with gillnet tagging data--daily effort, catch by species, and water depth by site; gillnet charts.
Goat-Blanch.xls	Age, Sex, Length (ASL) data from spawning ground samples.
Alsek98chidata.xls	Chi Squared tests
Alsekgill99.xls	KS tests
Mastertrack7.xls	Complete telemetry tracking records
Agszlck8.xls	Klukshu weir tags and ASL data
98alsek41.xls	ASL and tagging records from tagging site in Dry Bay
alsek98boo.xls	bootstrap estimates of confidence intervals for telemetry distribution data
cktags98.xls	Tag recoveries in sport or weir samples

APPENDIX B

Appendix B1.–Procedures used to estimate variance around the abundance estimate based on the telemetry distributions.

Bootstrap simulations of the project following the procedures of Buckland and Garthwaite (1991) were used to estimate variance for estimates of abundance $\hat{N}$. The fates of all fish in the population returning to the Alsek River in 1998 were divided into 20, mutually exclusive fates:

Fate	Program variable	Numbers
Transmitters (Period 1-3), destination outside Klukshu River	m(1-3)	32,89,14
Transmitters (Period 1-3), recaptured at weir on Klukshu River	m(4-6)	2,5,0
Transmitters (Period 1-3), destination Klukshu River, not recaptured at weir	m(7-9)	4,15,1
Transmitters (Period 1-3), unknown destination/regurgitated/mortality	m(10-12)	1,12,2
Transmitters (Period 1-3), caught in lower river gillnet (LGR) fishery	m(13-15)	0,1,2
Tagged, caught in LGR fishery	n(1)	3
Tagged, recaptured at weir on Klukshu River	n(2)	2
Tagged, not recaptured	n(3)	60
Unmarked, captured at weir on Klukshu River	n(4)	197
Unmarked, not captured at weir on Klukshu River	n(5)	$\hat{N}^*$ - Σm - Σn

Numbers of each fish sharing a fate were summed to produce a cumulative frequency distribution (a CDF). A simulated sample of $\hat{N}^*$ was then drawn with replacement from this CDF with each simulated fish having a fate. Simulated fish were tallied by fate, the tallies were summed according to procedures to estimate abundance in a mark-recapture experiment and with information from radiotelemetry, and two estimates of abundance were calculated (one from a simulated mark-recapture experiment, the other for a simulated radiotelemetry project). One hundred simulated samples where so drawn. Variances for estimates of abundance were calculated as

$$v(\hat{N}) = \frac{\sum_{b=1}^{100}(\hat{N}'_b - \bar{\hat{N}}')^2}{b-1}$$

where $\hat{N}'_b$ is the estimate from the *b*th simulated sample with $\bar{\hat{N}}' = b^{-1}\sum_{b=1}^{100}\hat{N}'_b$. The relationship $abs[(\hat{N} - \bar{\hat{N}}')/\hat{N}]$ is a measure of the relative bias in the original estimate $\hat{N}$. Because the population size was originally estimated twice, once with a mark-recapture experiment and once with information from radiotelemetry project, both original estimates were used to define population size $\hat{N}^*$ in the simulations. Results showed that simulated statistics were relatively insensitive to values for $\hat{N}^*$. Simulations were conducted with the QuickBasic Program at the end of this appendix.

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	$\hat{N}^* = 7{,}494$		$\hat{N}^* = 4{,}967$	
	MR experiment	Radiotelemetry	MR experiment	Radiotelemetry
Estimate	5,268	7,519	5,199	7,520
SE	1,644	1,633	1,770	1,936
Maximum	10,999	11,605	12,704	14,603
Minimum	2,853	4,043	2,551	4,352

Buckland, S. T., and P. H. Garthwaite. 1991. Quantifying precision of mark-recapture estimates using the bootstrap and related methods. Biometrics 47:255-268.

ALSEK.BAS

```
100 DIM n(5), m(15), cdf(20)
102 OPEN "alsek.dat" FOR OUTPUT AS #1
110 REM ---------------------------Load data
115 NHAT = 4967
120 m(1) = 32: m(2) = 89: m(3) = 14
122 m(4) = 2: m(5) = 5: m(6) = 0
124 m(7) = 4: m(8) = 15: m(9) = 1
125 m(10) = 1: m(11) = 12: m(12) = 2
126 m(13) = 0: m(14) = 1: m(15) = 2
128 n(1) = 3
130 n(2) = 2
132 n(3) = 60
134 n(4) = 197
136 n(5) = NHAT - 442
140 REM ---------------------------Set up CDF
142 cdf(1) = m(1)
144 FOR i = 2 TO 15: cdf(i) = cdf(i - 1) + m(i): NEXT i
146 FOR i = 16 TO 20: cdf(i) = cdf(i - 1) + n(i - 15): NEXT i
148 REM ---------------------------Start simulation
150 FOR niter = 1 TO 100
160 FOR i = 1 TO 5: m(i) = 0: n(i) = 0: NEXT i
164 FOR i = 6 TO 15: m(i) = 0: NEXT i
170 FOR i = 1 TO NHAT
180 x = INT(RND * NHAT) + 1
188 REM ---------------------------Assign transmitters
190 FOR j = 1 TO 15
192 IF x > cdf(j) GOTO 200
194 m(j) = m(j) + 1
196 GOTO 240
200 NEXT j
202 REM ---------------------------Assign other fish
204 FOR j = 16 TO 19
206 IF x > cdf(j) GOTO 220
208 n(j - 15) = n(j - 15) + 1
210 GOTO 240
220 NEXT j
230 n(5) = n(5) + 1
```

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```
240 REM ----------------------------Calculations for MR-exp (fish caught in
LRG censored)
244 NEXT i
250 MARKS = n(2) + n(3)
260 FOR j = 1 TO 12: MARKS = MARKS + m(j): NEXT j
270 RECAPS = m(4) + m(5) + m(6) + n(2)
280 caps = RECAPS + n(4)
290 NMREXP = (MARKS + 1) * (caps + 1) / (RECAPS + 1) - 1
300 REM ---------------------------Calculation of small fish caught at KW
302 smallf = 0
304 FOR j = 1 TO 55
306 x = INT(RND * 55) + 1
308 IF x > 6 GOTO 312
310 smallf = smallf + 1
312 NEXT j
314 REM --------------------------Calculation of fraction transmitters to KW
316 num = (m(4) + m(7)) * 2 + m(5) + m(8) + (m(6) + m(9)) * 2
318 denom = num + m(1) * 2 + m(2) + m(3) * 2
320 PHI = num / denom
330 REM --------------------------Calculation of odds
344 odds = (smallf / 55) * (MARKS / RECAPS)
346 REM --------------------------Calculation of large fish at KW and Telem
348 NLKW = 1364 * caps * odds / (caps * odds + 297 - caps)
350 ntelem = NLKW / PHI
360 PRINT #1, niter; NMREXP; ntelem
370 NEXT niter
380 END
```