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Abundance of the Chinook Salmon Escapement on the Stikine River, 2000

by

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November 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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TABLE OF CONTENTS

	Page
LIST OF TABLES	ii
LIST OF FIGURES	ii
LIST OF APPENDICES	ii
ABSTRACT	1
INTRODUCTION	1
STUDY AREA	6
METHODS	6
Kakwan Point and Rock Island tagging	6
Upstream sampling	7
Abundance	7
Age, sex, and length composition	9
RESULTS	10
Kakwan Point and Rock Island tagging	10
Upstream sampling	11
Abundance of large chinook salmon	11
Abundance of small-medium chinook salmon	14
Age, sex, and length composition	15
DISCUSSION	18
CONCLUSION AND RECOMMENDATIONS	22
ACKNOWLEDGMENTS	22
LITERATURE CITED	22
APPENDIX A	25

LIST OF TABLES

Table **Page**

1. Harvests of chinook salmon in Canadian fisheries on the Stikine River and in U.S. fisheries near the mouth of the Stikine River, 1975–2000 3
2. Index and survey counts of large spawning chinook salmon in Stikine River tributaries, 1975–2000 5
3. Numbers of chinook salmon marked on the lower Stikine River, removed by fisheries, and inspected for marks in tributaries in 2000, by size category 8
4. Estimated abundance, age and sex composition by size category of the escapement of chinook salmon in the Stikine River, 2000 19

LIST OF FIGURES

Figure **Page**

1. Map of Stikine River drainage, showing location of principal U.S. and Canadian fishing areas 2
2. Map showing locations of drift and set gillnet sites on the lower Stikine River, 2000 7
3. Daily drift gillnet fishing effort and river depth near Kakwan Point, lower Stikine River, 2000 12
4. Daily catch of chinook and sockeye salmon near Kakwan Point, lower Stikine River, 2000 12
5. Daily set gillnet fishing effort (min) and river depth (ft) at Rock Island, lower Stikine River, 2000 13
6. Daily catch of chinook and sockeye salmon at Rock Island, lower Stikine River, 2000 13
7. Cumulative relative frequency of large chinook salmon (≥660 mm MEF) captured at Kakwan Point and Rock Island, and inspected at the weir on the Little Tahltan River, at Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000 16
8. Cumulative relative frequency of large chinook salmon (≥660 mm MEF) captured at Kakwan Point and Rock Island, and recaptured at the weir on the Little Tahltan River, at Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000 16
9. Cumulative relative frequency of small-medium chinook salmon (<660 mm MEF) captured at Kakwan Point and Rock Island, and inspected at the Little Tahltan River, Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000 17
10. Cumulative relative frequency of small-medium chinook salmon (<660 mm MEF) captured at Kakwan Point and Rock Island, and recaptured in the Little Tahltan River, Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000 17

LIST OF APPENDICES

Appendix **Page**

A1. Drift gillnet daily effort, catches, and catch per hour near Kakwan Point, Stikine River, 2000 27
A2. Set gillnet daily effort, catches, and catch per hour at Rock Island, Stikine River, 2000 29
A3. Detection of size-selectivity in sampling and its effects on estimation of size composition 30
A4. Estimated age and sex composition and mean length by age of chinook salmon passing by Kakwan Point, 2000 32
A5. Estimated age and sex composition and mean length by age of chinook salmon passing by Rock Island, 2000 33
A6. Estimated age and sex composition and mean length by age of chinook salmon harvested in the Canadian commercial and test gillnet fisheries on the Lower Stikine River, 2000 34
A7. Estimated age and sex composition and mean length by age of chinook salmon at Little Tahltan River weir, 2000 35
A8. Estimated age and sex composition and mean length by age of moribund and recently expired chinook salmon in Verrett River, 2000 36
A9. Estimated age and sex composition and mean length by age of chinook salmon in Andrew Creek, 2000 37
A10. Origin of coded-wire tags recovered from chinook salmon collected at Kakwan Point and Rock Island, 2000 38
A11. Files used to estimate the spawning abundance of chinook salmon in the Stikine River in 2000 38

ABSTRACT

The abundance of large (≥660mm MEF) and small-medium (<660 mm MEF) chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Stikine River above the U.S./Canada border in 2000 was estimated using a mark-recapture experiment. Age, sex, and length compositions for the immigration were also estimated. Drift and set gillnets fished near the mouth of the Stikine River were used to capture 866 immigrant chinook salmon during May, June, July, and August of which 614 large and 237 small-medium chinook salmon were marked. During July and August, chinook salmon were captured at spawning sites and inspected for tags. Marked fish were also recovered from Canadian commercial, test and aboriginal fisheries. Using a modified Petersen model, we estimated that 30,301 (SE = 3,168) large and 13,995 (SE = 2,423) small-medium chinook salmon immigrated to the Stikine River above Kakwan Point and Rock Island. Canadian fisheries on the Stikine River harvested 2,770 large and 1,658 small-medium chinook salmon, leaving an escapement of 27,531 (SE = 3,168) large and 12,337 (SE = 2,423) small-medium fish. The total count of large fish at the Little Tahltan River weir was 6,640, representing about 22% of the estimated abundance of large fish above Kakwan Point and Rock Island. An aerial survey and expansion factor were used to estimate an escapement of 1,380 large fish in Andrew Creek. Estimated age compositions of chinook salmon captured at Kakwan Point and Rock Island, respectively, were 24% (SE = 1.9%) and 53% (SE = 4.7%) age-1.2 fish, 52% (SE = 2.3%) and 37% (SE = 4.5%) age-1.3 fish, and 23% (SE = 1.9%) and 10% (SE = 2.8%) age-1.4 fish; 234 and 83 males and 260 and 32 females were sampled. The estimated spawning escapement of 39,868 (SE = 3,988) chinook salmon was composed of 31% (SE = 4.2%) age-1.2 fish, 38% (SE = 2.3%) age-1.3 fish, and 30% (SE = 2.3%) age-1.4 fish. The estimated spawning escapement included 16,967 (SE = 1,871) females.

Key words: chinook salmon, *Oncorhynchus tshawytscha*, Stikine River, Little Tahltan River, Verrett River, Andrew Creek, mark-recapture, escapement, abundance

INTRODUCTION

Many chinook salmon *Oncorhynchus tshawytscha* stocks in the Southeast Alaska region were depressed in the mid- to late 1970s, relative to historical levels of production (Kissner 1982). The Alaska Department of Fish and Game (ADF&G) developed a structured program in 1981 to rebuild Southeast chinook salmon stocks over a 15-year period (roughly three life cycles; ADF&G 1981). In 1979, the Canadian Department of Fisheries and Oceans (DFO) initiated commercial fisheries on the transboundary Taku and Stikine rivers. The fisheries primarily target sockeye salmon and have been structured to limit the harvest of chinook salmon to incidental catches. In 1985, the Alaskan and Canadian programs were incorporated into a comprehensive coast-wide rebuilding program under the auspices of the U.S./Canada Pacific Salmon Treaty (PST). The rebuilding program 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 least once in all eleven key index systems.

The Stikine River is a transboundary river, originating in British Columbia (B.C.) and flowing to the sea near Wrangell, Alaska (Figure 1). The river is one of the largest producers of chinook salmon in Northern B.C. and Southeast Alaska. Chinook salmon escapements in the river have rebounded to healthy levels since initiation of the rebuilding program (Pahlke et al. 2000). The program, as originally developed, was to be completed in 1995; if assessment of the stocks indicated a surplus at that time, increased harvest would be warranted.

A major sockeye salmon *O. nerka* enhancement program in the Stikine River has been ongoing since 1989 [Pacific Salmon Commission (PSC) 2000]. The run timing of sockeye salmon overlaps the latter component of the chinook

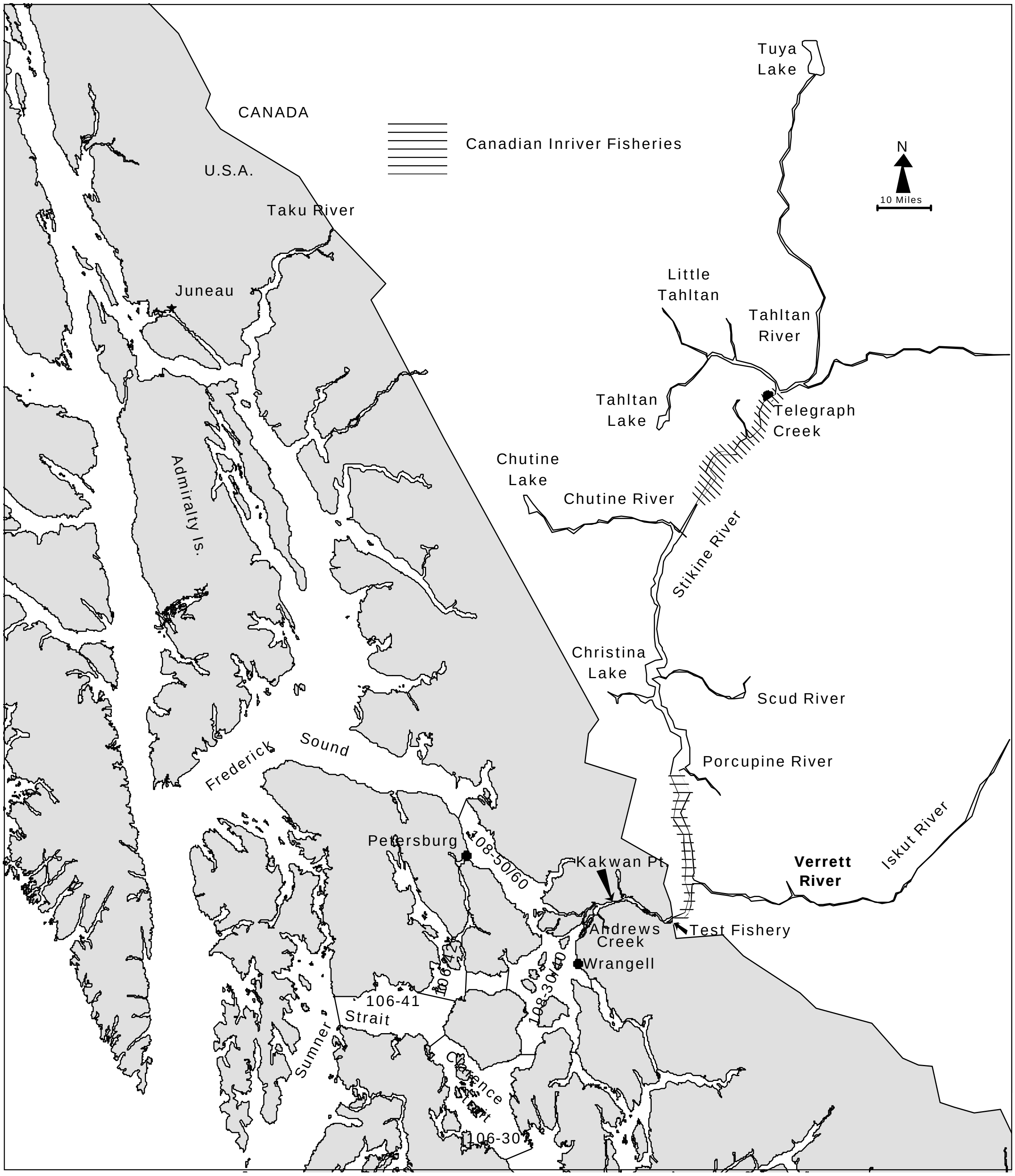


Figure 1.–Stikine River drainage, showing location of principal U.S. and Canadian fishing areas.

salmon migration, and mature chinook salmon returning to the Stikine River are caught incidentally to sockeye salmon in U.S. marine gillnet fisheries in Districts 106 and 108 offshore of the river mouth, and in riverine Canadian commercial fisheries; aboriginal food fisheries target chinook salmon (Table 1, Figure 1). Stikine River chinook salmon are also caught in marine recreational fisheries near Wrangell and Petersburg, in the commercial troll fishery in

Table 1.–Harvests of chinook salmon in Canadian fisheries in the Stikine River and U.S. fisheries near the mouth of the Stikine River, 1975–-2000.

	United States		Canada									
			Commercial harvest lower Stikine		Commercial harvest upper Stikine		Aboriginal fishery Telegraph Creek		Lower River test fishery		**Total inriver**[e] commercial, aboriginal, test	
Year	District 108 gillnet[a]	Wrangell sport through mid-June[b]	Jacks[c]	Large	Jacks[d]	Large	Jacks	Large	Jacks	Large	Jacks	Large
1975	1,534					178		1,024			–	1,202
1976	1,123					236		924			–	1,160
1977	1,443	1,463				62		100			–	162
1978	531	819				100		400			–	500
1979	91	813	63	712				850			63	1,562
1980	631	1,325		1,488		156		587			–	2,231
1981	283	1,068		664		154		586			–	1,404
1982	1,033	1,426		1,693		76		618			–	2,387
1983	47	1,346	430	492		75	215	851			645	1,418
1984	14	1,202	-----------*fishery closed*---------				59	643			59	643
1985	20	1,683	91	256		62	94	793	–	–	185	1,111
1986	102	2,014	365	806	41	104	569	1,026	12	27	987	1,963
1987	149	1,023	242	909	19	109	183	1,183	30	189	474	2,390
1988	207	1,381	201	1,007	46	175	197	1,178	29	269	473	2,629
1989	310	2,153	157	1,537	17	54	115	1,078	24	217	313	2,886
1990	557	3,203	680	1,569	20	48	259	633	18	231	977	2,481
1991	1,366	3,503	318	641	32	117	310	753	16	167	676	1,678
1992	967	2,815	89	873	19	56	131	911	182	614	421	2,454
1993	1,628	3,229	164	830	2	44	142	929	87	568	395	2,371
1994	1,996	1,924	158	1,016	1	76	191	698	78	295	428	2,085
1995	1,702	1,327	599	1,067	17	9	244	570	184	248	1,044	1,894
1996	1,717	2,210	221	1,708	44	41	156	722	76	298	497	2,769
1997	2,566	2,625	186	3,283	6	45	94	1,155	7	30	293	4,513
1998	460	878	359	1,585	0	12	95	538	11	25	465	2,160
1999	1,078	2,837	789	2,127	12	24	463	765	97	853	1,361	3,769
2000	1,692	1,217	936 [f]	1,274	2	7	386	1,100	334[g,h]	389	1,658	2,770

[a] Jacks not reported in U.S. gillnet catch, not legal in U.S. sport catch.

[b] Hatchery contribution included in U.S. catches.

[c] Jacks are small and medium fish <660 mm MEF.

[d] Jacks not segregated in Canadian fisheries before 1983.

[e] Inriver sport harvest is unknown but believed to be approximately 200 large fish annually. Estimated sport catch not included in total harvest. Total harvest of large fish including sport fish catch in 2000 is 2,770 + 200 = 2,970.

[f] Chinook salmon length samples were used to apportion the harvest of 2,210 fish into jacks and large size categories: (58/137) 2,210 = 936 jacks, (79/137) 2,210 = 1,274 large.

[g] Chinook test fishery: 760 caught, 756 sampled (490 large, 266 jacks), 226 released. Length samples from released fish used to apportion the release group into jacks and large fish: (2/182)226 = 2 jacks, (180/182)226 = 224 large. Harvest = sampled – released: 266 – 2 = 264 jacks, 490 – 224 = 266 large + 4 not sampled and assumed large = 270 large.

[h] Sockeye test fishery: chinook salmon length samples used to apportion harvest of 189 fish into jack and large size categories: (28/76) 189 = 70 jacks, (48/76) 189 = 119 large.

Southeast Alaska, and in recreational fisheries in Canada. The terminal run exploitation of these populations is managed jointly by the U.S. and Canada through the PSC.

Chinook salmon escapement to the Stikine River has been monitored since 1975 by conducting aerial surveys to count spawners in the Little Tahltan River, the mainstem Tahltan River, and Beatty and Andrew creeks (Table 2). Prior to 2000, the escapement goal for the Stikine River was based on the peak count in the Little Tahltan River before 1981. Historically, total escapement to the Stikine River was estimated by multiplying the aerial survey count in the Little Tahltan River by an expansion factor (4.0) thought to represent the proportion of the escapement represented by that tributary (Pahlke 1996). The original expansion factor was based on judgment rather than empirical data, and in 1991 the Transboundary Technical Committee (TTC) of the PSC decided to use only the actual counts of escapement to the Little Tahltan River to assess rebuilding (PSC 1991). Helicopter surveys of the Little Tahltan River have been conducted annually since 1975, and a fish counting weir has been operated at the mouth of the Little Tahltan River since 1985. Because virtually all fish spawning in the Little Tahltan River spawn above the weir, counts from the weir represent the escapement to that tributary. Sufficient data have been collected to establish a relationship between the two sources of information, and aerial indices from surveys conducted prior to 1985 have been adjusted; discontinuation of aerial surveys has been recommended (Bernard et al. 2000).

Maximum sustained yield (MSY) for this stock has been estimated at 17,368 based on analysis of spawner-recruit data from the 1977 to 1991 brood years (Bernard et al. 2000). This estimate may be biased low, but a more complex model that incorporates survival estimates and better estimates of harvest in marine fisheries should improve accuracy. This information will be acquired through a coded wire tagging program that was initiated in 2000. Based on the estimate of MSY, an escapement goal range of 14,000 to 28,000 adult spawners (age-.3, -.4, and -.5 fish), which corresponds to Little Tahltan River weir counts of 2,700 and 5,300, was recommended and accepted by the Chinook Technical Committee and an internal review committee of ADF&G in spring 1999. The Pacific Scientific Advice Review Committee of DFO declined to pass judgment on this range in deference to a decision by the TTC; the TTC accepted the range in March 2000.

The chinook salmon population in Andrew Creek has historically been treated as separate from those spawning upriver in Canada. Escapements into Andrew Creek have been assessed annually since 1975 by foot, airplane, or helicopter surveys. In addition, a weir was operated to collect hatchery brood stock from 1976 to 1984 and also provided escapement counts. Another weir was operated in 1997 and 1998 to count escapement, sample chinook salmon for age, sex and length data, and to recover tags. North Arm and Clear creeks, two small streams in the U.S., have been periodically surveyed.

Only large (typically age-.3, -.4, and -.5 fish) chinook salmon, approximately ≥660 mm mideye-to-fork length (MEF), are counted during aerial or foot surveys. No attempt is made to accurately count smaller (typically age-.1 and -.2 fish) chinook salmon <660 mm MEF. These smaller chinook salmon, also called jacks, are primarily males that are considered "surplus" to the reproduction of the next generation (Mecum 1990). These young males are easy to separate visually from older fish 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 1995, the DFO, in cooperation with the Tahltan First Nation (TFN), ADF&G, and the U.S. National Marine Fisheries Service (NMFS) instituted a project to determine the feasibility of a mark-recapture experiment to estimate abundance of chinook salmon spawning in the Stikine River. Since 1996 a revised, expanded mark-recapture study has been used to estimate annual abundance (Pahlke and Etherton 1998, 1999, 2000; Pahlke et al. 2000). In 1997, a radiotelemetry study to estimate distribution of spawners was also conducted in concert with the mark-recapture experiment (Pahlke and Etherton 1999).

Table 2.–Index and survey counts of large spawning chinook salmon in tributaries of the Stikine River, 1975–2000. Abbreviations: H = helicopter survey, F = foot survey, W = weir count, A = airplane survey; E = excellent visibility, N = normal visibility, P = poor visibility.

Year	Little Tahltan River			Mainstem Tahltan River		Beatty Creek		Andrew Creek		North Arm Creek		Clear Creek	
	Peak count		Weir count[a]										
1975	700	E(H)	-	2,908	E(H)	-		260	(F)	-		-	
1976	400	N(H)	-	120	(H)	-		468	(W)	-		-	
1977	800	P(H)	-	25	(A)	-		534	(W)	-		-	
1978	632	E(H)	-	756	P(H)	-		400	(W)	24	E(F)	-	
1979	1,166	E(H)	-	2,118	N(H)	-		382	(W)	16	E(F)	-	
1980	2,137	N(H)	-	960	P(H)	122	E(H)	363	(W)	68	N(F)	-	
1981	3,334	E(H)	-	1,852	P(H)	558	E(H)	654	(W)	84	E(F)	4	P(F)
1982	2,830	N(H)	-	1,690	N(F)	567	E(H)	947	(W)	138	N(F)	188	N(F))
1983	594	E(H)	-	453	N(H)	83	E(H)	444	(W)	15	N(F)	-	
1984	1,294	(H)	-	-		126	(H)	389	(W)	31	N(F)	-	
1985	1,598	E(H)	3,114	1,490	N(H)	147	N(H)	319	E(F)	44	E(F)	-	
1986	1,201	E(H)	2,891	1,400	P(H)	183	N(H)	707	N(F)	73	N(F)	45	E(A)
1987	2,706	E(H)	4,783	1,390	P(H)	312	E(H)	788	E(H)	71	E(F)	122	N(F))
1988	3,796	E(H)	7,292	4,384	N(H)	593	E(H)	564	E(F)	125	N(F)	167	N(F)
1989	2,527	E(H)	4,715	-		362	E(H)	530	E(F)	150	N(A)	49	N(H)
1990	1,755	E(H)	4,392	2,134	N(H)	271	E(H)	664	E(F)	83	N(F)	33	P(H)
1991	1,768	E(H)	4,506	2,445	N(H)	193	N(H)	400	N(A)	38	N(A)	46	N(A)
1992	3,607	E(H)	6,627	1,891	N(H)	362	N(H)	778	E(H)	40	E(F)	31	N(A)
1993	4,010	P(H)	11,437	2,249	P(H)	757	E(H)	1,060	E(F)	53	E(F)		
1994	2,422	N(H)	6,373	-		184	N(H)	572	E(H)	58	E(F)	10	N(A)
1995	1,117	N(H)	3,072	696	E(H)	152	N(H)	343	N(H)	28	P(A)	1	E(A)
1996	1,920	N(H)	4,821	772	N(H)	218	N(H)	335	N(H)	35	N(F)	21	N(A)
1997	1,907	N(H)	5,547	260	P(H)	218	E(H)	293	N(F)	-		-	
1998	1,385	N(H)	4,873	587	P(H)	125	E(H)	487	E(F)	35	N(A)	28	N(A)
1989–1998 avg.	2,242		5,636	1,379		284		546		58		27	
1999	1,379	N(H)	4,738	-		-		605	E(A)	22	N(A)	-	
2000	2,720	N(H)	6,631	-		-		690	N(A)	35	N(A)	-	

[a] Above-weir harvest and broodstock collections are removed from weir counts; in 2000 nine (9) large fish were removed.

Objectives of the 2000 study were:

(1) estimate abundance of large (≥660 mm MEF) chinook salmon spawning in the Stikine River above the U.S./Canada border;

(2) estimate the age, sex, and length compositions of chinook salmon spawning in the Stikine River above the U.S./Canada border;

(3) index the abundance of chinook salmon spawning in Andrew Creek; and

(4) estimate age, sex and length composition of chinook salmon spawning in Andrew Creek.

The abundance of small-medium (<660 mm MEF) chinook salmon was also estimated.

Results from the study provide an abundance expansion factor for index counts; i.e., the estimated total escapement from the mark-recapture experiment divided by the count at the Little Tahltan River weir. Results also provide information on run timing through the lower Stikine River of chinook salmon bound for their various spawning areas, and other stock assessment and management information needs.

STUDY AREA

The Stikine River drainage covers about 52,000 km^2 (Bigelow et al. 1995), much of which is inaccessible to anadromous fish because of natural barriers. Principal tributaries include the Tahltan, Chutine, Scud, Iskut, and Tuya rivers (Figure 1). The lower river and most tributaries are glacially occluded (e.g., Chutine, Scud, and Iskut rivers). Only 2% of the drainage is in Alaska (Beak Consultants Limited 1981), and most of the chinook salmon spawning areas in the watershed are located in B.C., Canada, in the Tahltan, Little Tahltan, and Iskut rivers (Pahlke and Etherton 1999). Andrew Creek, in the U.S. portion of the Stikine River, supports a small run of chinook salmon averaging about 5% of the above-border escapement. The upper drainage of the Stikine is accessible via the Telegraph Creek Road.

METHODS

KAKWAN POINT AND ROCK ISLAND TAGGING

Abundance of chinook salmon by size category (small-medium or large) was estimated with Chapman's modification of Petersen's estimator for a two-event mark-recapture experiment on a closed population (Seber 1982, p. 59–61). Variance was estimated with modifications of bootstrap procedures described in Buckland and Garthwaite (1991), and the 95% C.I. was found by solution of the cubic equation described in Seber (1982, p. 63).

Fish captured by gillnet and marked in the lower river near Kakwan Point and at Rock Island were included in event 1. Kakwan Point and Rock Island are below all known spawning areas, except for Andrew and North Arm creeks, and are upstream of any tidal influence (Figure 2).

Drift gillnets 120 ft (36.5m) long, 18 ft (5.5m) deep, of 7¼" (18.5-cm) stretch mesh, were fished near Kakwan Point between May 7 and July 9. Two nets were fished daily, unless high water or staff shortages occurred. Nets were watched continuously, and fish were removed from the net immediately upon capture. 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 4 hours per net.

Catches near Kakwan Point were augmented by chinook salmon captured and tagged during a sockeye salmon tagging project operated by DFO, ADF&G Commercial Fisheries Division (CFD), and TFN at Rock Island. Chinook salmon were caught in a 5⅜" (13.7-cm) stretch mesh set gillnet 120 ft (36.5 m) long and 18 ft (5.5 m) deep between June 20 and August 10. The net was watched continuously, and fish were removed from the net immediately upon capture. If more fish were caught than could be effectively sampled, the net was shortened. Sampling effort was held reasonably constant at about 7 hours per day.

Captured chinook salmon were placed in a plastic fish tote filled with water, quickly untangled or cut from the net, marked, measured for length (MEF, and post orbital hypural length POH), sexed, and sampled for scales. Fish were classified as 'large' if their MEF measurement was $\geq$660 mm, 'medium' if their MEF was 440–659 mm, or 'small' if their MEF was <440 mm (Pahlke and Bernard 1996). Fish maturation was judged on a scale from 1 to 4—where 1 is a silver bright fish, 2 is a fish with slight coloration, 3 is a fish with obvious coloration and the onset of sexual dimporhism, and 4 is a fish with the characteristics listed in category 3 that released gametes upon capture. The presence or absence of sea lice (*Lepeophtheirus* sp.) was also noted. 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, using a modified design developed by Johnson et al. 1993. The monofilament was sewn through the musculature of the fish approximately 20mm posterior and ventral to the dorsal fin and secured by crimping both ends. Each fish was also marked with a ¼" (7-mm) diameter hole in the upper (dorsal) portion of its operculum applied with a paper punch, and by amputation of

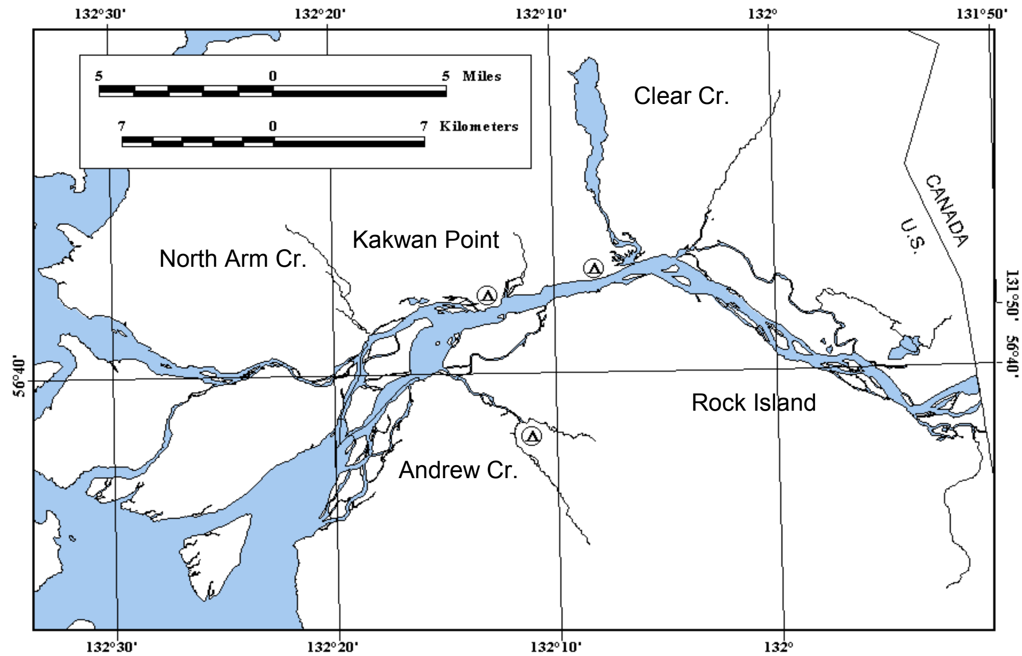


Figure 2.–Locations of drift and set gillnet sites on the lower Stikine River, 2000.

its left axillary appendage (as per McPherson et al. 1996). Fish that were seriously injured were sampled but not marked.

UPSTREAM SAMPLING

Sampling on the spawning grounds and in the inriver test and commercial fisheries constituted the second event in the mark-recapture experiment. Pre- and post-spawning fish were sampled at the Little Tahltan River weir and post-spawning fish were speared at Verrett River. Little Tahltan River flows southeast and empties into the Tahltan River approximately 30 km northwest of Telegraph Creek, British Columbia. As fish accumulated below the weir across the Little Tahltan River, a portion were captured with dip nets, inspected for tags and marks, and sampled for length, sex, and scales. Each sampled fish was marked with a hole punched in its lower left opercle to prevent resampling and released. In addition, some post-spawning fish and carcasses were sampled upstream of the weir.

Age, sex, length and marked composition data were collected at Verrett River (Figure 1) from August 3 to 10, 2000. Numbers of fish observed were recorded and carcasses and moribund chinook salmon were sampled to obtain scales and information on length, sex, and marks. Escapement counts, age, sex, length, and marked composition data were collected on Andrew Creek (Figure 2) by foot surveys in early August and additional surveys were conducted by airplane and helicopter.

Catches in the lower and upper Canadian commercial gillnet, aboriginal, and test fisheries and in the U.S. gillnet and marine recreational fisheries were sampled to recover tags and obtain data to estimate age, sex, and length compositions.

ABUNDANCE

The number of marked fish moving upstream from Kakwan Point and Rock Island was calculated by subtracting (censoring) the number of marked fish estimated to have moved downstream to be caught in U.S. waters or spawn in Andrew Creek (Table 3). Handling and tagging have caused a downstream movement and/or a delay in continuing upstream migration of marked chinook salmon (Bernard et al. 1999). This "sulking" behavior puts marked fish at greater risk of capture from commercial fisheries for sockeye

Table 3.–Numbers of chinook salmon marked on lower Stikine River, removed by fisheries and inspected for marks in tributaries in 2000, by size category. Numbers in bold were used in mark-recapture estimates.

			Length (MEF) in mm			
			0–439 (small)	440–659 (medium)	≥660 (large)	**Total**
A.	Released at Kakwan Point		0	143	515	658
B.	Released at Rock Island		6	88	99	193
C.	Removed by:					
	1. U.S. recreational fisheries		0	0	1	1
	2. U.S gillnet				1	1
	3. Andrew Creek		0	0	0	0
Subtotal of removals			0	0	2	2
D.	Estimated number of marked fish remaining in mark-recapture experiment		**6**	**231** [a]	**612**	847
E.	Canadian recreational fisheries				2	
F.	Inspected at:					
	1. L. Tahltan weir	Inspected	**3**	**175**	**1,190**	1,368
		Marked	**0**	**4**	**27**	31
		Marked/inspected	0.0000	0.0229	0.0227	0.0227
	2. Above weir, carcasses	Inspected	**16**	**184**	351	551
		Marked	**0**	**2**	7	9
		Marked/inspected	0.0000	0.0109	0.0199	0.0163
	3. Verrett River	Inspected	**1**	**90**	**580**	671
		Marked	**0**	**4**	**10**	14
		Marked/inspected	0.0000	0.0444	0.0172	0.0208
Inriver commercial/test [b] **gillnet**		Harvested [c, d]	**0**	**1,272**	**1,887**	3,159
Lower		Marked	**0**	**18**	**36**	54
		Marked/harvested	0.0000	0.0142	0.0191	0.0171
Upriver gillnet		Harvested [d]	0	388	1,107	1,495
Commercial and aboriginal		Marked	0	6	10	16
		Marked/harvested	0.0000	0.0155	0.0090	0.0107
Andrew Creek		Inspected	0	20	131	151
		Marked	0	0	0	0
		Marked/inspected	0.0000	0.0000	0.0000	0.0000

[a] Five (5) fish designated as jacks but not measured during event 1 were omitted from small-medium chinook salmon abundance estimate calculations to permit comparisons between stratified (by length) and unstratified estimates.

[b] Chinook and sockeye salmon test fisheries.

[c] Includes two jacks and 224 large fish that were inspected and released during the chinook test fishery.

[d] Inriver commercial and test gillnet harvest of jacks not segregated into small and medium fish.

salmon that begin in mid-June (Pahlke and Etherton 1999).

Censoring marked chinook salmon killed in downstream fisheries avoids bias in estimates of abundance from this phenomenon. The number of tagged salmon recovered from the Alaska gillnet fishery at the mouth of the Stikine River (District 108) is expanded by the fraction of the catch sampled. All marked fish caught in the U.S. recreational harvest, an infrequent occurrence, are assumed to be reported.

A separate escapement estimate was calculated for Andrew Creek by expanding the peak count by a factor of 2.0 (Pahlke 1999). The number of marked fish recaptured in Andrew Creek is expanded by the fraction of the estimated escapement sampled and is then censored from the mark-recapture experiment in the Stikine River.

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 between events; (b) *both* recruitment and "death" (emigration) do not occur between events; (c) marking does not affect catchability (or mortality) of the fish; (d) fish do not lose their marks between events; (e) all recaptured fish are reported; and (f) double sampling does not occur (Seber 1982). Assumption (a) implies that fish are marked 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, samples of fish taken in upper watershed (Little Tahltan River), in the Iskut River (Verrett River) and in the inriver test and commercial fisheries in the lower watershed would have similar rates of marked fish. Contingency table analysis was used to test the null hypothesis that such estimated rates are the same. Samples were stratified by size to detect and eliminate potential effects of size-selective sampling. Assumption (b) was met because the life history of chinook salmon isolates those fish returning to the Stikine River as a "closed" population. Mortality rates from natural causes for marked and unmarked fish were assumed to be the same (assumption c). To avoid effects of tag loss (assumption d), all marked fish carried secondary (a dorsal opercle punch), and tertiary marks (the left axillary appendage was clipped). Similarly, all fish captured on the spawning grounds were inspected for marks, and a reward (Can$2) was given for each tag returned from the inriver commercial, aboriginal, and recreational fisheries (assumption e). Double sampling was prevented by an additional mark (ventral opercle punch, assumption f).

AGE, SEX, AND LENGTH COMPOSITION

Scale samples were taken, processed, and age determined according to procedures in Olsen (1995). 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×. Samples from Kakwan Point, Andrew Creek, and Verrett River were processed at the ADF&G Scale Aging Lab in Douglas; all other samples were processed at the DFO lab in Nanaimo, B.C. All scales were read by one person except when scales appeared atypical or the first reading was of questionable accuracy.

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

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{1}$$

$$v[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{n_i - 1} \tag{2}$$

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

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

$$\hat{N}_j = \sum_i (p_{ij} \hat{N}_i) \qquad (3)$$

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

$$v(\hat{N}_j) = \sum_i \begin{pmatrix} v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)\hat{p}_{ij} \\ - v(\hat{p}_{ij})v(\hat{N}_i) \end{pmatrix} \qquad (4)$$

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

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}} \qquad (5)$$

where $\hat{N} = \sum \hat{N}_i$. Variance of $\hat{p}_j$ was approximated according to the procedures in Seber (1982, p. 8-9):

$$v(\hat{p}_j) = \frac{\sum_i \left(v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2 \right)}{\hat{N}^2} \qquad (6)$$

Sex and age-sex composition for the spawning population and associated variances were also estimated with the equations above by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_k$, where k denotes sex, such that $\sum_k \hat{p}_k = 1$, and by age-sex, such that $\sum_j \sum_k \hat{p}_{jk} = 1$. Sex composition was estimated from samples collected on the spawning grounds since spawning and post-spawning fish provide more reliable sex composition estimates.

Age, sex, and age-sex composition and associated variances for the Kakwan Point, Rock Island, and inriver fisheries samples were also estimated as described above.

Estimated age compositions of the samples from Kakwan Point and Rock Island were compared to determine if the samples could be combined. The same was done with samples collected from the inriver fisheries and spawning grounds. For these tests, age-0. and -2. chinook salmon were pooled with age-1. fish of the same brood year, and only age classes common to each sample were compared.

Estimates of mean length-at-age and their estimated variances were calculated with standard normal procedures.

RESULTS

KAKWAN POINT AND ROCK ISLAND TAGGING

Six hundred fourteen (614) large (≥660 mm MEF), 231 medium (440-659 mm MEF), and 6 small (<440 mm MEF) chinook salmon were captured, marked, and released at Kakwan Point and Rock Island between May 7 and August 10 (Table 3).

Drift gillnet effort near Kakwan Point was maintained at 4 hours per net per day (two nets fishing), although reduced sampling effort occurred on several days (Figure 3; Appendix A1). We captured a total of 520 large and 146 small-medium chinook salmon. Catch rates ranged from 0 to 5.44 large chinook/hour, and the highest catch occurred on June 3, when 43 large fish were captured (Figure 4). The date of 50% cumulative catch of large fish was June 3, the same date seen in 1999. Catch rates for small-medium fish ranged from 0 to 1.52 fish/hour, and the highest catch also occurred on June 3, when 12 small-medium fish were captured (Figure 4). Date of 50% cumulative catch of small-medium fish was June 4. Catches were low from June 8 to 15 because of high water conditions (Figures 3 and 4, Appendix A1). Harbor seals killed or injured several fish before they could be removed from the nets, especially early in the season. In addition, 103 sockeye salmon were captured and released (Appendix A1).

Set gillnet effort at Rock Island was maintained at about 7 hours per day with one net fishing, although reductions and increases in sampling effort occurred on several days (Figure 5; Appendix A2). We captured a total of 101 large and 99 small-medium chinook salmon. Catch rates ranged from 0 to 1.36 large chinook/hour, and the highest catch occurred on June 22, when 10 large fish were captured (Figure 6). Catch rates for small-medium fish ranged from 0 to 1.76 fish/hour, and the highest catch occurred on June 26, when 13 small-medium fish were captured (Figure 6). In addition, 1,131 sockeye salmon were captured (Appendix A12).

UPSTREAM SAMPLING

The lower inriver test and commercial gillnet fisheries began May 8 and June 25, respectively, and harvested 1,663 large and 1,270 jack (small and medium) chinook salmon. An additional 224 large fish and two jacks were inspected and released. Thirty-six (36) large and 18 jack chinook salmon with tags were recovered. The aboriginal and commercial fisheries near Telegraph Creek harvested 1,107 large and 388 jack chinook salmon, and 16 tags were recovered. Two large marked fish were reported from the Canadian sport fishery on the Tahltan River, which is not sampled but believed to harvest approximately 200 fish annually. One large marked fish was reported from the U.S. recreational fishery near Petersburg and Wrangell, and all marked fish in the recreational harvest were presumably reported. One tag from a large marked fish caught in the U.S. District 108 gillnet fishery was voluntarily returned (Tables 1 and 3).

Technicians examined 1,368 chinook salmon for marks at the Little Tahltan River weir, of which 1,190 were large fish. Twenty-seven (27) large and 4 medium marked fish were recovered, and none of these fish had lost its numbered tag. An additional 551 (16 small, 184 medium, and 351 large) previously unsampled carcasses were examined above the weir, 9 of which were marked (Table 3). One of these had lost its tag, but it was identified by secondary and tertiary marks.

At Verrett River, 671 live and dead chinook salmon were examined (1 small, 90 medium, and 580 large); 14 marked fish were recovered (Table 3). Four of these had lost their tags, but all were identified by secondary and tertiary marks.

At Andrew Creek, 151 (20 medium and 131 large) fish were examined in 2000, but no spaghetti tags or adipose finclipped fish were recovered.

ABUNDANCE OF LARGE CHINOOK SALMON

The estimated abundance of large chinook salmon passing by Kakwan Pt and Rock Island, based on live fish inspected at Little Tahltan weir, samples at Verrett River and samples from the lower inriver commercial and test gillnet fisheries is 30,301 salmon (SE = 3,168; 95% CI: 24,879, 38,049; M = 612, C = 3,657, R = 73). For this estimate, all large marked fish intercepted by U.S. gillnet (one fish) and recreational fisheries (one fish, assuming all marked fish in the recreational harvest were reported) were censored from the experiment.

Evidence from upstream sampling supports the supposition that every large chinook salmon passing by Kakwan Point and Rock Island had a near equal chance of being marked regardless of when they passed these sites. Fish bound for the Little Tahltan River pass by these sites in May and June, and fish bound for Verrett River pass by in June and early July. The test and commercial fisheries began just upstream of Kakwan Pt and Rock Island on May 8 and June 25, respectively, and would exploit fish passing these sites from early May through August. Marked fractions (see Table 3 for data) estimated for large fish at the Little Tahltan weir (0.0227), Verrett River (0.0172), and the lower inriver commercial and test gillnet fisheries (0.0191) were not significantly different ($\chi^2 = 0.72$, df = 2, P = 0.70).

Size-selective sampling did not appear to occur during events 1 or 2 (Appendix A3). The size distributions of fish marked at Kakwan Pt and Rock Island versus combined samples of fish inspected at the weir on the Little Tahltan River, in the lower inriver commercial and test gillnet fisheries, and at Verrett River (Figure 7) were not significantly different (Kolmogorov-Smirnov: $d_{max} = 0.05$; n = 598, 2,368; P = 0.17). Similarly, the size distributions of fish marked at Kakwan Point and Rock Island were not

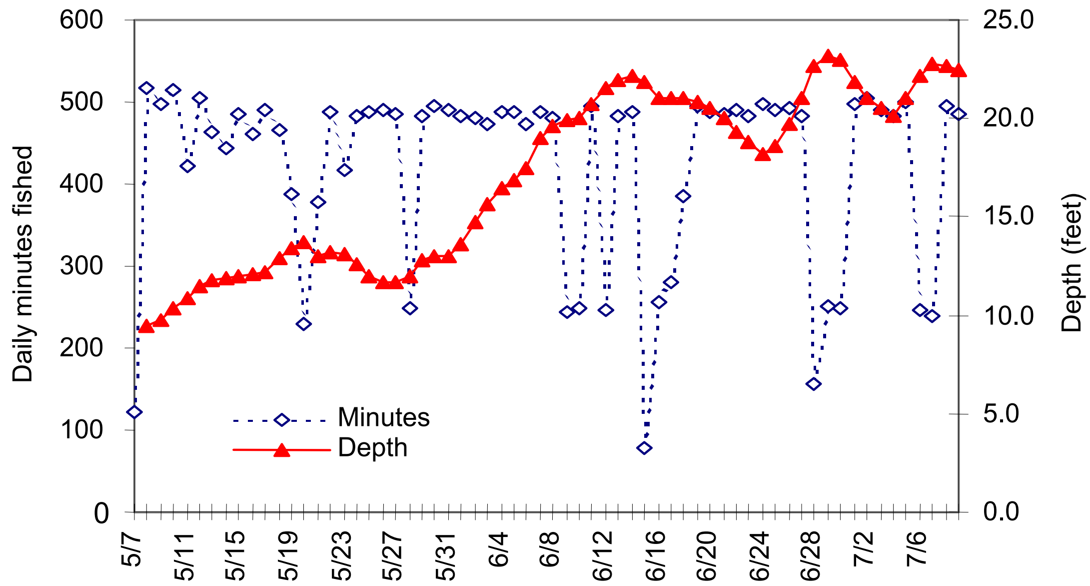


Figure 3.–Daily drift gillnet fishing effort (min) and river depth (ft) near Kakwan Point, lower Stikine River, 2000.

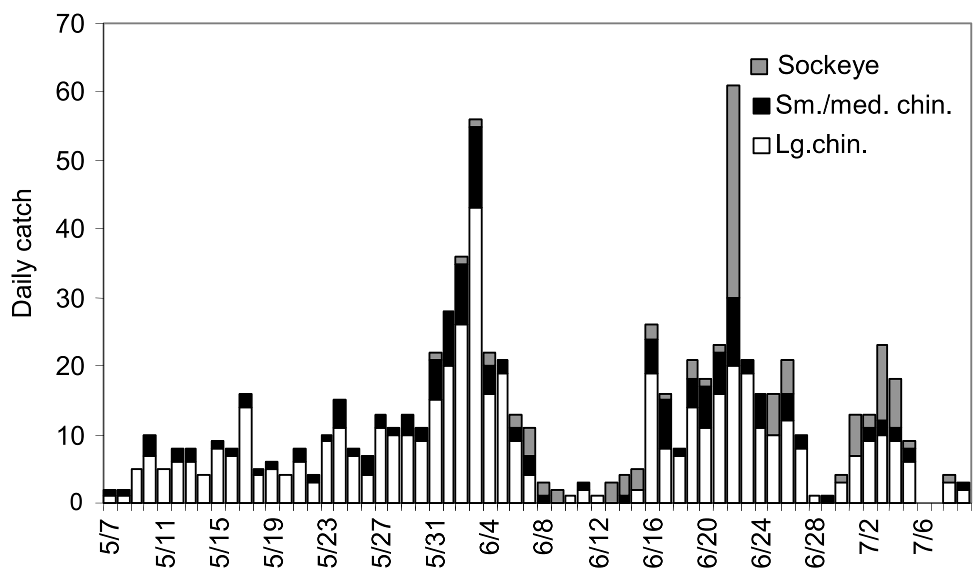


Figure 4.–Daily catch of chinook and sockeye salmon near Kakwan Point, lower Stikine River, 2000.

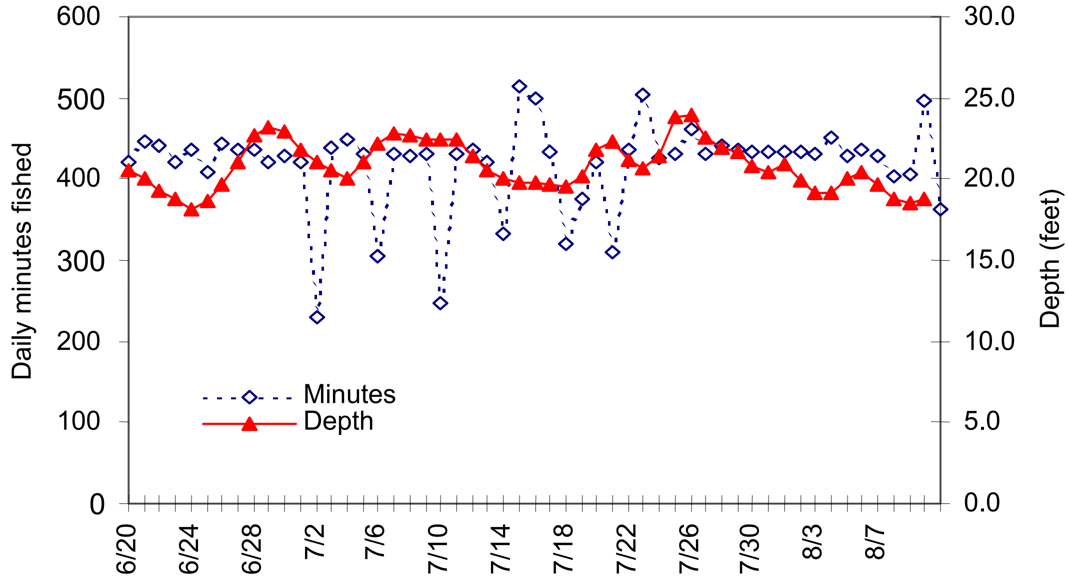


Figure 5.–Daily set gillnet fishing effort (min) and river depth (ft) at Rock Island, lower Stikine River, 2000.

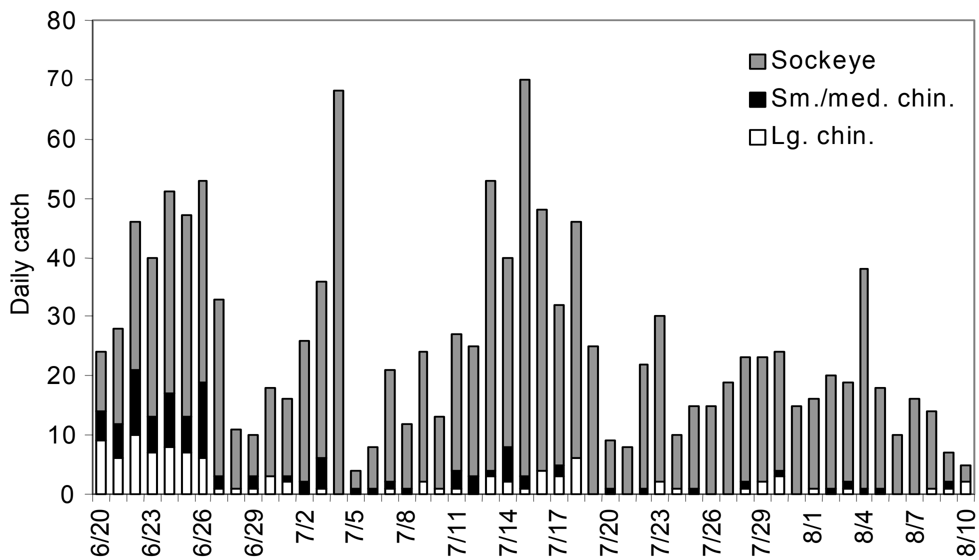


Figure 6.–Daily catch of chinook and sockeye salmon at Rock Island, lower Stikine River, 2000.

significantly different (Kolmogorov-Smirnov: d_{max} = 0.55; n = 598, 73; P = 0.90) from fish recaptured at the weir, in the inriver fisheries, or Verrett River (Figure 8).

Additional evidence from upstream sampling also supports the supposition that every large chinook salmon passing by Kakwan Point and Rock Island had a near equal chance of being *marked* regardless of their size. Pooled length samples of large fish from the weir, Verrett River, and the lower inriver commercial and test gillnet fisheries were arbitrarily split into two groups at the median length of large fish (790 mm MEF) to permit comparison of marked fractions:

	660–790 mm	>790 mm
Marked	41	32
Unmarked	1,146	1,149
Marked fraction	0.036	0.028

These marked fractions were not significantly different (χ^2 = 1.10, df = 1, P = 0.29).

Finally, evidence from upstream sampling also supports the supposition that every large chinook salmon had a near equal chance of being *captured* upstream regardless of their size. Pooled length samples of large fish from the weir, Verrett River, and the lower inriver commercial and test gillnet fisheries were again split into two size groups, as were samples of large fish marked at Kakwan Point and Rock Island. After censoring marked fish removed by U.S. recreational and gillnet fisheries (two fish >790 mm MEF) and fish not measured during event 1 (14 fish), the fractions (rates) of recaptured fish were compared as surrogates for probabilities of capture upstream:

	660–790 mm	>790 mm
Released	314	284
Recaptured	41	32
Fraction	0.131	0.113

These fractions recaptured were not significantly different (χ^2 = 0.35, df = 1, P = 0.55).

An aerial survey was conducted at Andrew Creek on August 9, where 690 large chinook salmon were counted. The total escapement of large chinook salmon to Andrew Creek was estimated by expanding the survey count by a factor of 2.0 (Pahlke 1999), resulting in an estimate of 1,380 large fish.

ABUNDANCE OF SMALL-MEDIUM CHINOOK SALMON

A sufficient number of small-medium chinook salmon were marked and recaptured in 2000 to estimate abundance. The estimated abundance of small-medium fish passing by Kakwan Point and Rock Island, based on samples from the lower inriver commercial and test fisheries, Verrett River, Little Tahltan River weir, and above weir carcass surveys is 13,995 salmon (SE = 2,423; 95% C.I.: 10,345, 20,482; M = 232 C = 1,741, R = 28). Fish that were designated as jacks but were not measured during event 1 (5 fish) were omitted so comparisons between this estimate and one stratified by length could be made.

Marked fractions in the spawning ground and lower inriver fisheries samples were compared to test whether every small-medium fish had an equal chance of being marked regardless of when they passed Kakwan Point and Rock Island. However, the number of recaptures in samples from the Little Tahltan River (henceforth meaning weir plus carcass samples) and Verrett River were too small to yield reliable chi-square statistics in comparisons with the lower inriver fisheries sample. Marked fractions in samples from the Little Tahltan River and Verrett River were subsequently compared with a Fisher exact test (Zar 1984) to determine if these samples could be pooled:

Area	Inspected	Marked
L. Tahltan weir/carcass	378	6
Verrett River	91	4

These fractions were not significantly different (P = 0.12). Marked fractions in the pooled Little

Tahltan River-Verrett River (0.0213) and lower inriver fisheries (0.0142) samples were then compared and were not significantly different (χ^2 = 1.07, df = 1, P = 0.30), which suggested that small-medium fish had an equal chance of being marked during event 1.

Small-medium fish chinook salmon appeared to have a near equal chance of being *marked* regardless of their size. Pooled length samples from the Little Tahltan River, Verrett River, and lower inriver fisheries were arbitrarily split into two groups at the median length of small-medium fish (595 mm MEF) to permit comparison of marked fractions:

	≤595 mm	596–659 mm
Marked	16	12
Unmarked	405	388
Marked fraction	0.040	0.031

These marked fractions were not significantly different (χ^2 = 0.40, df = 1, P = 0.53).

Every small-medium chinook salmon also appeared to have a near equal chance of being *captured* upstream regardless of their size. Pooled length samples of small-medium fish from the Little Tahltan River, Verrett River, and lower inriver fisheries were again split into two size groups as were samples of small-medium fish marked at Kakwan Pt and Rock Island. After censoring fish that were not measured during event 1 (5 fish), the fractions (rates) of recaptured fish were compared as surrogates for probabilities of capture upstream:

	≤595 mm	596–659
Released	91	141
Recaptured	16	12
Fraction recaptured	0.176	0.085

The fractions recaptured were marginally, but not significantly different (χ^2 = 3.31, df = 1, P = 0.07).

Although there was little evidence supporting size-selective sampling of small-medium chinook salmon, size distributions of fish marked at Kakwan Point and Rock Island versus samples of fish inspected at the Little Tahltan River, Verrett River, and in the lower inriver fisheries were significantly different (Kolmogorov-Smirnov: d_{max} = 0.22; n = 232, 552; P < 0.001) (Figure 9). The length distributions of fish marked at Kakwan Point and Rock Island and recaptured at the Little Tahltan River, Verrett River, and in the lower inriver fisheries were similar (Kolmogorov-Smirnov: d_{max} = 0.20; n = 232, 28; P = 0.22), but the recapture sample may have been too small to detect a difference (Figure 10; Appendix A3).

Abundance estimates were subsequently generated for two length groups (≤595 mm and 596–659 mm MEF), after censoring fish that were not measured during event 1. Estimated abundance of fish ≤595 mm was 5,427 (SE = 1,260, M = 91, C = 1,002, R = 16); for fish 596–659 mm, abundance was estimated at 8,079 (SE = 2,367, M = 141, C = 739, R = 12). Combining the strata estimates yielded an overall estimate of 13,505 small-medium fish. Because the stratified estimate was similar to the unstratified estimate (bias = 3.5%), the unstratified estimate of 13,995 small-medium chinook salmon was accepted.

AGE, SEX, AND LENGTH COMPOSITION

Age-1.3 chinook salmon dominated all samples except those from the Little Tahltan River weir, constituting an estimated 52% of fish captured at Kakwan Point, 37% at Rock Island, 46% in the lower inriver test and commercial fisheries, 63% at Verrett River, and 57% at Andrew Creek.

Age-1.4 chinook dominated the Little Tahltan River weir sample at 47%, although age-1.3 fish were the second largest group at 35%. As in 1999, there was a high incidence of age-1.1 and -1.2 fish (Appendices A4–A9).

Age composition estimates within small-medium and large size categories for chinook salmon sampled at Kakwan Point and Rock Island were not significantly different (small-medium: χ^2 = 0.18, df = 1, P = 0.67; large: χ^2 = 3.66, df = 2, P = 0.16). However, age composition estimates across size categories were significantly different

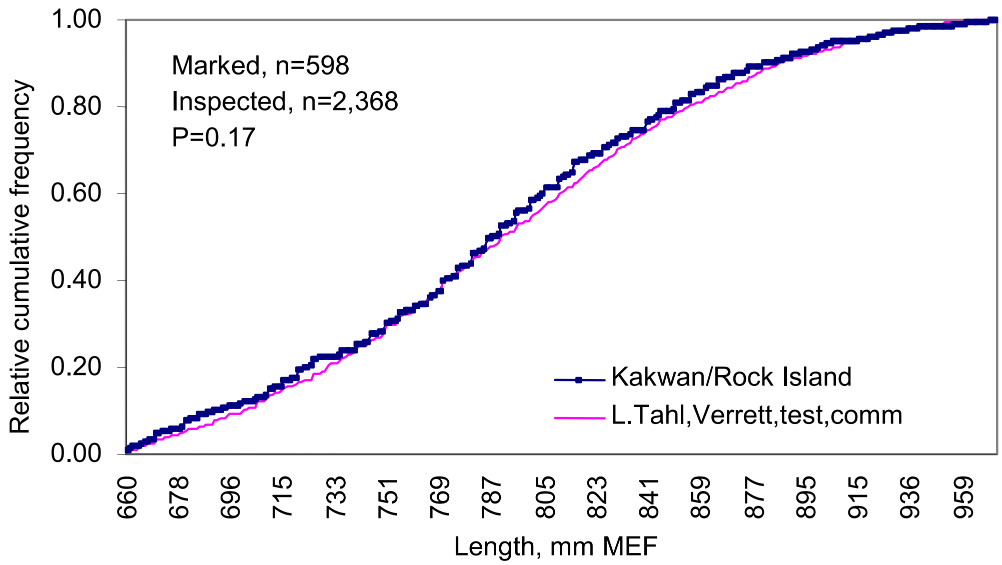


Figure 7.–Cumulative relative frequency of large chinook salmon (≥660 mm MEF) captured at Kakwan Point and Rock Island, and inspected at the weir on the Little Tahltan River, at Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000.

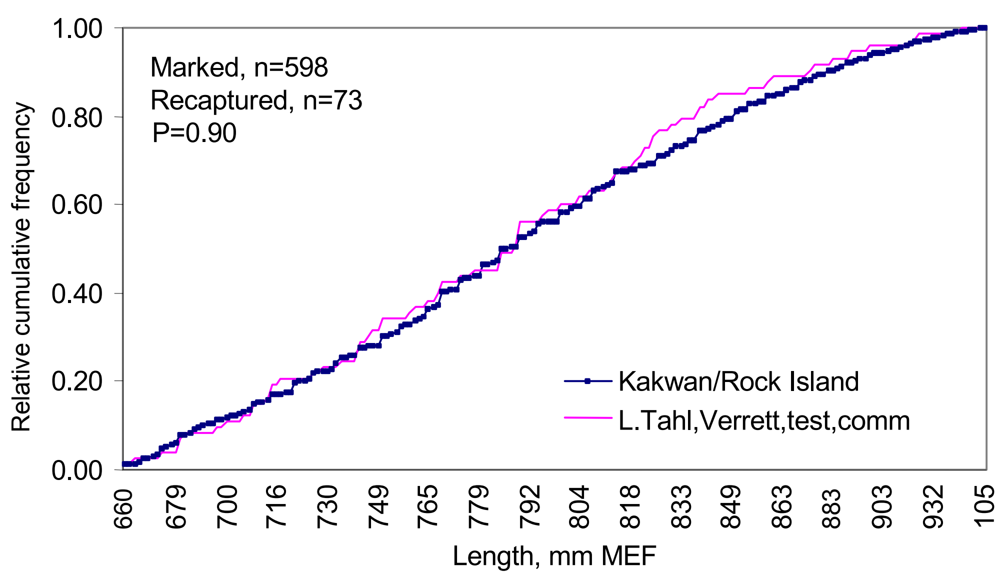


Figure 8.–Cumulative relative frequency of large chinook salmon (≥660 mm MEF) captured at Kakwan Point and Rock Island, and recaptured at the weir on the Little Tahltan River, at Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000.

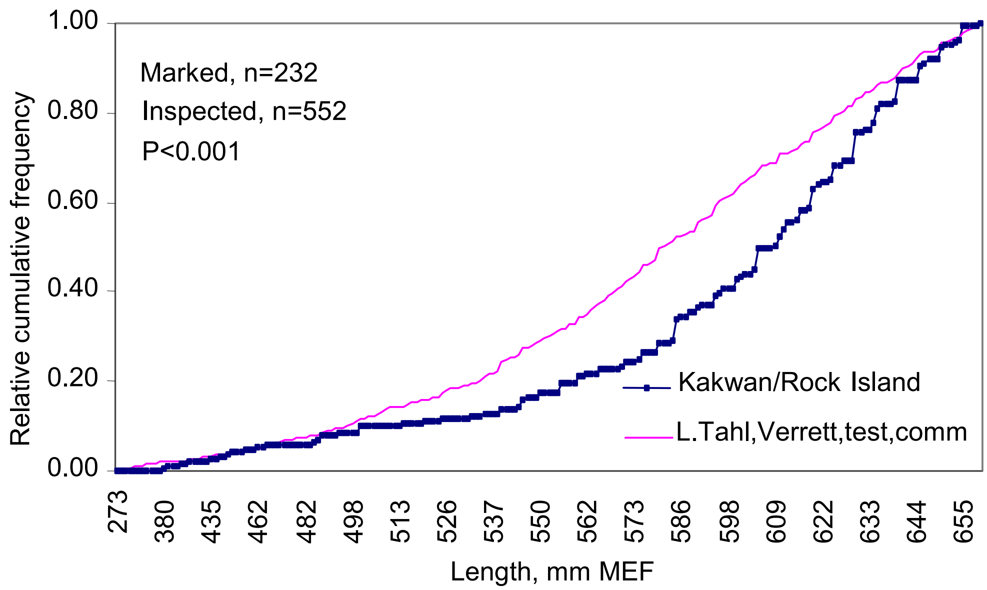


Figure 9.–Cumulative relative frequency of small-medium chinook salmon (<660 mm MEF) captured at Kakwan Point and Rock Island, and inspected at the Little Tahltan River, Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000.

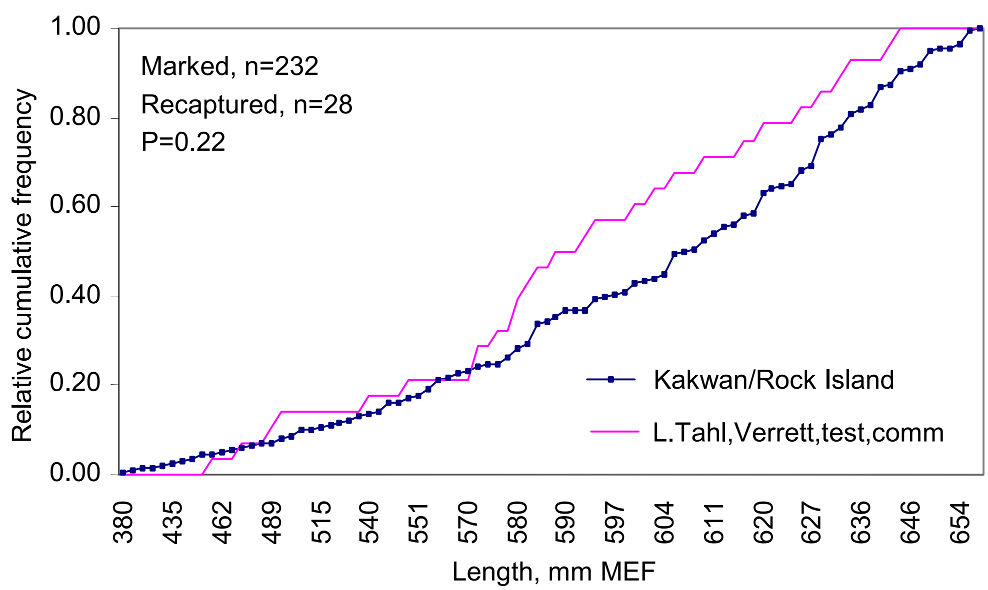


Figure 10.–Cumulative relative frequency of small-medium chinook salmon (<660 mm MEF) captured at Kakwan Point and Rock Island, and recaptured in the Little Tahltan River, Verrett River, and in the commercial and test fisheries in the lower Stikine River, 2000.

(χ^2 = 38.2, df = 2, P < 0.001) because of the overall high incidence of age-1.3 and older fish in the Kakwan Point sample and age-1.2 fish in the Rock Island sample (Appendices A4 and A5). This is attributed to the different mesh sizes used at each site (7¼" at Kakwan Point versus 5⅜" at Rock Island).

Age composition estimates for small-medium fish sampled at the Little Tahltan River weir, the lower inriver gillnet test and commercial fisheries, and Verrett River were not significantly different (χ^2 = 4.08, df = 2, P = 0.13), but were significantly different among large fish (χ^2 = 162, df = 6, P <0.001). The difference among large fish is attributed to dominance of age-1.4 fish in the Little Tahltan River sample versus predominance of age-1.3 fish in the lower inriver gillnet fisheries and Verrett River samples (Appendices A6–A8). Differences in age class dominance may be biologically linked to a flood in fall 1994, which could have impacted age-1.4 fish in lower Stikine River stocks such as those exploited in the lower inriver gillnet fisheries and fish from Verrett River (see next section for discussion).

Age composition estimates for small-medium fish sampled at the Kakwan Point and Rock Island tagging sites and the lower inriver test and commercial gillnet fisheries were not significantly different (χ^2 = 0.33, df = 2, P = 0.85), nor were estimates for fish sampled at the tagging sites and the Little Tahltan River weir (χ^2 = 2.06, df = 2, P = 0.55) and the Verrett River (χ^2 = 1.20, df = 2, P = 0.36). Among large fish, comparisons between the samples collected at the tagging sites and the lower inriver gillnet fisheries and Verrett River were not significantly different (inriver fisheries: χ^2 = 5.52, df = 4, P = 0.24; Verrett: χ^2 = 9.06, df = 4, P = 0.06). However, comparisons between samples of large fish collected at the tagging sites and the Little Tahltan River weir were significantly different (χ^2 = 79.4, df = 4, P < 0.001), because of the high incidence of age-1.4 fish in the weir sample and age-1.3 fish in the tagging site samples (Appendices A4, A5, and A7). Differences in age class dominance may again be biologically linked to the 1994 flood.

Escapement by age and sex (Table 4) was estimated on the basis of combined samples collected at the Little Tahltan River weir and Verrett River. Although comparisons between these samples among small-medium and large chinook salmon were statistically different (small-medium: χ^2 = 4.17, df = 1, P = 0.04; large: χ^2 = 113.87, df = 3, P <0.001), these differences are believed to be biological as noted above. The estimated spawning escapement of 39,868 chinook salmon was composed of 31% age-1.2 fish, 38% age-1.3 fish, and 30% age-1.4 fish. The estimated spawning escapement included 16,967 females.

DISCUSSION

In past years of this study, there have been inconsistencies between the results from tests for size-selective sampling and the length distribution of samples of large fish taken at Kakwan Point and the spawning grounds. Capture probabilities suggested that selective sampling had not occurred, whereas length distributions implied that it had. These discrepancies were attributed to differences in migratory timing among stocks, differences in the size of fish across stocks, and differences in time of sampling. Chinook salmon spawning in the Little Tahltan River tend to pass Kakwan Point earlier than do fish bound for Verrett River and are larger, while Verrett River fish enter later and are usually smaller than chinook salmon spawning in other tributaries. The commercial and test fisheries have also begun after about half the run has passed Kakwan Point and have consequently intercepted smaller fish. In 2000, we augmented catches of chinook salmon at Kakwan Point with fish captured at Rock Island. Because the tagging operation at Rock Island extended into August and a smaller mesh net was used, smaller fish late in the run were tagged more intensively than they have been in the past. The test fishery also began at the same time tagging at Kakwan Point was initiated, thereby increasing the opportunity to recover fish early in the run. The net effect was that length distributions of large fish sampled during events 1 and 2 were similar (Figures 7 and 8). The marked sample also had

Table 4.–Estimated abundance, age and sex composition by size category of the escapement of chinook salmon in the Stikine River, 2000.

		Brood year and age class									
		1997	1996	1996	1995	1995	1994	1994	1993	1993	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
PANEL A. SMALL AND MEDIUM CHINOOK SALMON											
Males	n	1		125		15					141
	%	0.6		77.2		9.3					87.0
	SE of %	0.6		3.3		2.3					2.6
	Escapement	76		9,516		1,142					10,738
	SE of esc.	76		1,912		356					2,133
Females	n			19		2					21
	%			11.7		1.2					13.0
	SE of %			2.5		0.9					2.6
	Escapement			1,447		152					1,599
	SE of esc.			418		109					449
Combined	n	1		144		17					162
	%	0.6		88.9		10.5					100.0
	SE of %	0.6		2.5		2.4					0.0
	Escapement	76		10,966		1,295					12,337
	SE of esc.	76		2,174		387					2,423
PANEL B. LARGE CHINOOK SALMON											
Males	n			47	2	235		174	1	8	467
	%			4.4	0.2	22.2		16.5	0.1	0.8	44.2
	SE of %			0.6	0.1	1.3		1.1	0.1	0.3	1.5
	Escapement			1,224	52	6,121		4,532	26	208	12,164
	SE of esc.			223	37	786		608	26	77	1,461
Females	n			7		294	1	280	2	6	590
	%			0.7		27.8	0.1	26.5	0.2	0.6	55.8
	SE of %			0.2		1.4	0.1	1.4	0.1	0.2	1.5
	Escapement			182		7,658	26	7,293	52	156	15,367
	SE of esc.			71		958	26	918	37	66	1,817
Combined	n			54	2	529	1	454	3	14	1,057
	%			5.1	0.2	50.0	0.1	43.0	0.3	1.3	100.0
	SE of %			0.7	0.1	1.5	0.1	1.5	0.2	0.4	0.0
	Escapement			1,407	52	13,779	26	11,825	78	365	27,531
	SE of esc.			246	37	1,640	26	1,423	46	105	3,168
PANEL C. SMALL, MEDIUM AND LARGE CHINOOK SALMON											
Males	n	1		172	2	250		174	1	8	608
	%	0.2		26.9	0.1	18.2		11.4	0.1	0.5	57.4
	SE of %	0.2		3.7	0.1	1.3		1.1	0.1	0.2	2.5
	Escapement	76		10,743	52	7,263		4,532	26	208	22,901
	SE of esc.	76		1,925	37	863		608	26	77	2,585
Females	n			26		296	1	280	2	6	611
	%			4.1		19.6	0.1	18.3	0.1	0.4	42.6
	SE of %			1.0		1.6	0.1	1.6	0.1	0.2	2.5
	Escapement			1,629		7,810	26	7,293	52	156	16,967
	SE of esc.			424		965	26	918	37	66	1,871
Combined	n	1		198	2	546	1	454	3	14	1,219
	%	0.2		31.0	0.1	37.8	0.1	29.7	0.2	0.9	100.0
	SE of %	0.2		4.2	0.1	2.3	0.1	2.3	0.1	0.3	0.0
	Escapement	76		12,373	52	15,073	26	11,825	78	365	39,868
	SE of esc.	76		2,188	37	1,685	26	1,423	46	105	3,988

the highest number of small and medium fish to date (237 versus 58, 24, 28, and 43 in 1999, 1998, 1997, and 1996, respectively).

In the 1996 study, discrepancies among estimates of abundance and observed tagging rates in samples arose because of sampling problems in the Little Tahltan River and at Kakwan Point. Daily catch is dependent not only on effort, but also on river conditions, which can change dramatically from day to day. Sampling effort in 1996 was erratic at Kakwan Point. In an attempt to correct these problems we added another technician to the tagging crew in 1997. We were able to increase the total fishing effort at Kakwan Point from 362 net-hours in 1996 to about 460 net-hours in subsequent years, thus maintaining a higher level of effort. With addition of the Rock Island project in 2000, fishing effort was nearly doubled. We also increased the sample size of fish physically inspected at the Little Tahltan weir and Verrett River. The fractions marked in samples taken at the Little Tahltan River, Verrett River, and the lower river commercial and test fisheries were not statistically different in 2000, indicating every fish had an equal chance of being marked in event 1. This was in spite of large fluctuations in river depth that affected the catch per net hour at Kakwan Point in mid-June when the peak of the Little Tahltan run would have been passing (Figures 3 and 4). The setnet operation at Rock Island and high water conditions, which may delay migrant fish, could have offset the reduction in fishing efficiency at Kakwan Point.

To make the abundance estimate of large chinook salmon past Kakwan Point and Rock Island comparable to other estimates of spawning abundance, harvests in the commercial, test, and aboriginal fisheries should be subtracted. The final estimate of large spawning abundance in 2000 is 27,531 (= 30,301– 2,770).

The total weir count in 2000 of 6,640 large fish in the Little Tahltan River is 22% of the estimated abundance past Kakwan Point and Rock Island, for an expansion factor of 4.56 for weir counts to abundance. This statistic is the smallest expansion factor estimated thus far:

Year	Estimated expansion	SE	Source
1996	5.67	0.59	M-R experiment[a]
1997	5.08	0.53	M-R experiment[b]
1997	5.48	0.95	Telemetry study
1998	5.77	0.80	M-R experiment
1999	5.00	0.68	M-R experiment
2000	4.56	0.48	M-R experiment
Avg	5.26	0.67	

[a] Modified from data in Pahlke and Etherton (1998).

[b] Modified form data in Pahlke and Etherton (1999).

Still, the average expansion factor of 5.26 is greater than the factor of 4.0 that was traditionally used to expand aerial survey counts in the Little Tahltan River.

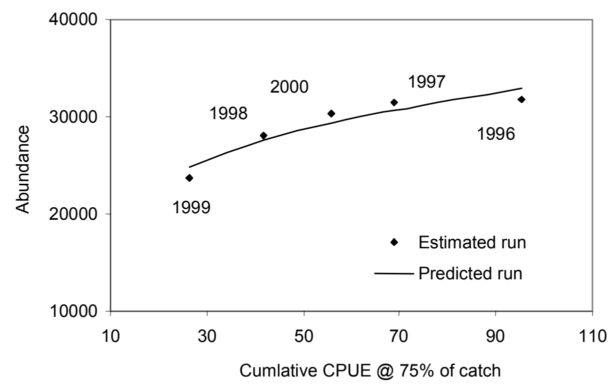
Verrett River chinook and other lower Stikine River stocks that spawn and rear near the mainstem of the river may have been adversely affected by record stream flows in late September 1994 (350,000 cubic feet per second [cfs] versus the 1977 to 1998 average of 220,000 cfs; USGS 1977 to 1998). Gametes from the 1994 brood year may have been dislodged, smothered, or crushed by the effects of high water, and juvenile fish from the 1993 brood year may have been flushed from their rearing areas and perhaps stranded after the flood waters receded. Evidence of impacts caused by the 1994 flood include relatively poor returns of stocks originating from sites other than the Little Tahltan River in 1999, and the disparity in age class dominance observed in 2000 between samples collected at the Little Tahltan River and elsewhere. Both observations suggest poor survival of lower river stocks from the 1993 and 1994 brood years.

Estimated age compositions for the population in the Stikine River tend to differ from those in the nearby Taku River. Age-1.1 and -1.2 fish (jacks) are common in the Taku chinook salmon run, often making up over 20% or more of the return. Jacks usually constitute a much smaller percentage of the Stikine River run. Jacks were uncommon in 1996 through 1998, and more common in 1999 and 2000 (about 23 and 31% of the spawning escapement, respectively), rivaling returns to the Taku River. Jacks (<660 mm MEF) constituted 34% of the carcass sample collected above the Little Tahltan River weir, while jacks constituted only 13% of the weir sample. This suggests that the smaller fish may be able to squeeze through the weir unobserved.

Chinook salmon of hatchery origin were not found in samples collected in Andrew Creek in 2000. However, three fish with adipose finclips were recovered during tagging operations at Kakwan Point and Rock Island, and from the inriver fisheries. One had been tagged at Crystal Lake hatchery and released at Neets Bay, one had been tagged and released at Little Port Walter, and the third head was lost (Appendix A10). These fish were not spawning when captured and may have only temporarily entered the Stikine River.

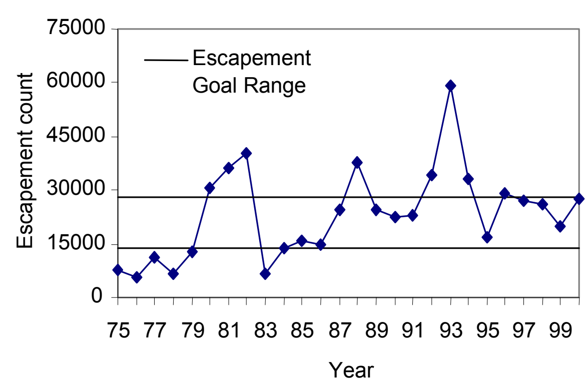
The U.S. and Canada signed a new PST agreement in June 1999, which included a specific directive in Annex IV to develop abundance-based management of Stikine River chinook salmon. In 2000, the feasibility of an inseason mark-recapture experiment to estimate abundance of large chinook salmon was investigated. Tagging data from Kakwan Point and recovery data from the Canadian chinook salmon test fishery collected concurrently from early May to the beginning of the Canadian commercial gillnet fishery on June 25 were used. Kakwan Point data collected after June 19 were omitted to allow for travel time to the test fishery (a minimum of 5 days as estimated by tag recoveries). The inseason estimated abundance of large chinook salmon passing Kakwan Point as of June 19 was 15,890 (SE = 6,018; M = 355, C = 490, R = 10). About 70% of large chinook salmon have historically passed Kakwan Point by June 19, so this estimate should have been closer to 21,200, based on the post-season estimate of 30,301. To estimate this level of abundance at 95% relative precision of 30%, either 5× as many fish needed to be inspected during the recovery event, given a tagging rate of 1 to 2%, or the tagging rate needed to be increased to 8%. However, at 90% relative precision of 30%, inspection of 2× as many fish, or an increase in the tagging rate to about 3%, would have sufficed. Size-selective sampling and unequal capture probability over time also seemed to be problematic.

Preliminary analysis indicates there may be a nonlinear relationship (R^2 = 0.89, P = 0.02) between cumulative CPUE at Kakwan Point and abundance of large chinook salmon. The additive error model $\hat{N} = a\,(CPUE)^b$ was fit to cumulative CPUE data at 75% of the catch at Kakwan Point and abundance estimates from 1996 to 2000:



The historic average date at which 75% of the catch at Kakwan Point has occurred is June 21, just prior to the start of inriver commercial fisheries. If this relationship persists as data accumulate, this or a similar model may be a helpful addition to the tools used towards satisfying the Annex IV directive.

The 1999 PST agreement states that we will manage SEAK chinook stocks for MSY escapement goals (Chapter 3, Attachment 1, footnote 5). Estimated escapements have met or exceeded the escapement goal range (established in 2000) of 14,000 to 28,000 adult spawners since 1985. The ADF&G and DFO assessment is that chinook salmon in the Stikine River have recovered from the recruitment overfishing of the 1970s (Bernard et al. 2000).



CONCLUSIONS AND RECOMMENDATIONS

This was the fifth year of estimating the total escapement of chinook salmon to the Stikine River. We continue to improve our methods and mark-recapture estimates. Drift gillnets are an effective method of capturing enough large chinook salmon migrating up the Stikine River for a post-season estimate, but may be inadequate for inseason management. The use of a set gillnet at Rock Island in 2000 proved effective and will hopefully in the future provide a larger marked release group of chinook salmon <600 mm. The results of five years' studies also confirm that counts of salmon through the Little Tahltan River weir are a useful index (i.e., the counts represent a relatively constant percentage of the run) of chinook salmon escapement to the Stikine River. However, the weir counts do not serve as a timely indicator of run strength for inseason abundance-based management per the 1999 PST. In 2000, we started the test fishing operation in early May to cover the entire chinook salmon migration. Preliminary analysis indicates that tagging or recovery rates need to be increased to obtain meaningful inseason abundance estimates. Since tagging effort at Kakwan Point has been maximized, we recommend initiating the tagging operation at Rock Island in early May, and/or adding one more net to the test fishing program. Size-selective sampling should also be mitigated by using a mixture of net mesh sizes (7¼" and 5⅜"). Models that describe the relationship between CPUE and abundance data are encouraging, but CPUE varies with changing river conditions and may not be a good indicator of run strength in some years. Other indicators, such as a pre-season forecast utilizing brood year strength, may be useful early in the season. Sampling rates at the weir should be maintained or increased and efforts continued to insure that smaller fish are not passing unobserved.

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APPENDIX A

Appendix A1.–Drift gillnet daily effort (minutes fished), catches, and catch per hour near Kakwan Point, Stikine River, 2000.

Date	Minutes	Large chinook	Sm-med chinook	Sockeye	Temp	Depth	Large chinook/ hour	Cumul. percent	Sm-med chinook/hr	Cumul. percent
05/07/00	122	1	1	0			0.49	0.00	0.49	0.01
05/08/00	517	1	1	0	8.0	9.5	0.12	0.00	0.12	0.01
05/09/00	497	5	0	0	8.0	9.8	0.60	0.01	0.00	0.01
05/10/00	514	7	3	0	7.0	10.4	0.82	0.03	0.35	0.03
05/11/00	423	5	0	0	7.5	10.9	0.71	0.04	0.00	0.03
05/12/00	506	6	2	0	7.0	11.5	0.71	0.05	0.24	0.05
05/13/00	464	6	2	0	8.0	11.8	0.78	0.06	0.26	0.06
05/14/00	444	4	0	0	7.0	11.9	0.54	0.07	0.00	0.06
05/15/00	485	8	1	0	7.0	12.0	0.99	0.08	0.12	0.07
05/16/00	461	7	1	0	7.0	12.1	0.91	0.10	0.13	0.08
05/17/00	491	14	2	0	6.5	12.2	1.71	0.12	0.24	0.09
05/18/00	466	4	1	0	6.0	12.9	0.52	0.13	0.13	0.10
05/19/00	387	5	1	0	7.0	13.4	0.78	0.14	0.16	0.10
05/20/00	230	4	0	0	6.0	13.7	1.04	0.15	0.00	0.10
05/21/00	377	6	2	0	7.0	13.0	0.95	0.16	0.32	0.12
05/22/00	488	3	1	0	6.0	13.2	0.37	0.17	0.12	0.12
05/23/00	418	9	1	0	7.0	13.1	1.29	0.18	0.14	0.13
05/24/00	483	11	4	0	6.5	12.6	1.37	0.20	0.50	0.16
05/25/00	487	7	1	0	7.0	12.0	0.86	0.22	0.12	0.16
05/26/00	490	4	3	0	8.0	11.7	0.49	0.23	0.37	0.18
05/27/00	485	11	2	0	8.5	11.7	1.36	0.25	0.25	0.20
05/28/00	248	10	1	0	8.5	12.0	2.42	0.27	0.24	0.21
05/29/00	482	10	3	0	6.5	12.8	1.24	0.28	0.37	0.23
05/30/00	495	9	2	0	8.0	13.0	1.09	0.30	0.24	0.24
05/31/00	490	15	6	1	9.0	13.0	1.84	0.33	0.73	0.28
06/01/00	483	20	8	0	9.0	13.6	2.48	0.37	0.99	0.34
06/02/00	481	26	9	1	9.0	14.7	3.24	0.42	1.12	0.40
06/03/00	474	43	12	1	9.5	15.6	5.44	0.50	1.52	0.48
06/04/00	488	16	4	2	9.0	16.5	1.97	0.53	0.49	0.51
06/05/00	487	19	2	0	9.0	16.9	2.34	0.57	0.25	0.52
06/06/00	474	9	2	2	8.5	17.5	1.14	0.59	0.25	0.53
06/07/00	487	4	3	4	8.0	19.0	0.49	0.59	0.37	0.55
06/08/00	480	0	1	2	7.0	19.6	0.00	0.59	0.13	0.56
06/09/00	243	0	0	2	8.0	19.9	0.00	0.59	0.00	0.56
06/10/00	248	1	0	0	8.0	20.0	0.24	0.60	0.00	0.56
06/11/00	496	2	1	0	9.0	20.7	0.24	0.60	0.12	0.57
06/12/00	247	1	0	0	9.0	21.5	0.24	0.60	0.00	0.57
06/13/00	484	0	0	3	9.0	22.0	0.00	0.60	0.00	0.57
06/14/00	487	0	1	3	9.0	22.2	0.00	0.60	0.12	0.58
06/15/00	77	2	0	3	9.0	21.8	1.56	0.61	0.00	0.58
06/16/00	256	19	5	2	8.0	21.0	4.45	0.64	1.17	0.61
06/17/00	280	8	7	1	8.0	21.0	1.71	0.66	1.50	0.66
06/18/00	385	7	1	0	8.0	21.0	1.09	0.67	0.16	0.66
06/19/00	495	14	4	3	9.0	20.8	1.70	0.70	0.48	0.69
06/20/00	488	11	6	1	8.5	20.5	1.35	0.72	0.74	0.73
06/21/00	485	16	6	1	8.0	20.0	1.98	0.75	0.74	0.77
06/22/00	491	20	10	31	8.0	19.3	2.44	0.79	1.22	0.84
06/23/00	483	19	2	0	8.5	18.8	2.36	0.83	0.25	0.86
06/24/00	498	11	5	0	9.0	18.2	1.33	0.85	0.60	0.89
06/25/00	491	10	0	6	9.0	18.6	1.22	0.87	0.00	0.89

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Appendix A1.–Page 2 of 2.

Date	Minutes	Large chinook	Sm-med chinook	Sockeye	Temp	Depth	Large chinook/ hour	Cumul. percent	Sm-med chinook/hr	Cumul. percent
06/26/00	492	12	4	5	9.0	19.7	1.46	0.89	0.49	0.92
06/27/00	482	8	2	0	9.0	21.0	1.00	0.90	0.25	0.93
06/28/00	157	1	0	0	0.0	22.7	0.38	0.91	0.00	0.93
06/29/00	252	0	1	0	9.0	23.2	0.00	0.91	0.24	0.94
06/30/00	250	3	0	1	8.5	23.0	0.72	0.91	0.00	0.94
07/01/00	497	7	0	6	9.0	21.8	0.85	0.93	0.00	0.94
07/02/00	505	9	2	2	9.0	21.0	1.07	0.94	0.24	0.95
07/03/00	490	10	2	11	9.5	20.5	1.22	0.96	0.24	0.97
07/04/00	484	9	2	7	10.0	20.1	1.12	0.98	0.25	0.98
07/05/00	499	6	2	1	10.0	21.0	0.72	0.99	0.24	0.99
07/06/00	246	0	0	0	9.5	22.2	0.00	0.99	0.00	0.99
07/07/00	240	0	0	0	9.0	22.8	0.00	0.99	0.00	0.99
07/08/00	496	3	0	1	9.5	22.7	0.36	1.00	0.00	0.99
07/09/00	485	2	1	0	9.0	22.5	0.25	1.00	0.12	1.00
Total	450 hours	520	146	103						

Appendix A2.–Set gillnet daily effort (minutes fished), catches, and catch per hour, at Rock Island, Stikine River, 2000.

Date	Minutes	Large chinook	Sm-med chinook	Sockeye	Temp	Depth	Large chinook/ hour	Cumul. percent	Sm-med chinook/hr	Cumul. percent
06/20/00	421	9	5	10	8.5	20.5	1.28	0.09	0.71	0.05
06/21/00	445	6	6	16	8.0	20.0	0.81	0.15	0.81	0.11
06/22/00	442	10	11	25	8.0	19.3	1.36	0.25	1.49	0.22
06/23/00	420	7	6	27	8.5	18.8	1.00	0.32	0.86	0.28
06/24/00	436	8	9	34	9.0	18.2	1.10	0.40	1.24	0.37
06/25/00	409	7	6	34	9.0	18.6	1.03	0.47	0.88	0.43
06/26/00	444	6	13	34	9.0	19.7	0.81	0.52	1.76	0.57
06/27/00	437	1	2	30	9.0	21.0	0.14	0.53	0.27	0.59
06/28/00	435	1	0	10	0.0	22.7	0.14	0.54	0.00	0.59
06/29/00	420	1	2	7	9.0	23.2	0.14	0.55	0.29	0.61
06/30/00	429	3	0	15	8.5	23.0	0.42	0.58	0.00	0.61
07/01/00	421	2	1	13	9.0	21.8	0.29	0.60	0.14	0.62
07/02/00	230	0	2	24	9.0	21.0	0.00	0.60	0.52	0.64
07/03/00	438	1	5	30	9.5	20.5	0.14	0.61	0.68	0.69
07/04/00	450	0	0	68	10.0	20.1	0.00	0.61	0.00	0.69
07/05/00	430	0	1	3	10.0	21.0	0.00	0.61	0.14	0.70
07/06/00	304	0	1	7	9.5	22.2	0.00	0.61	0.20	0.71
07/07/00	432	1	1	19	9.0	22.8	0.14	0.62	0.14	0.72
07/08/00	429	0	1	11	9.5	22.7	0.00	0.62	0.14	0.73
07/09/00	432	2	0	22	9.0	22.5	0.28	0.64	0.00	0.73
07/10/00	247	1	0	12		22.5	0.24	0.65	0.00	0.73
07/11/00	431	1	3	23		22.5	0.14	0.66	0.42	0.76
07/12/00	435	0	3	22		21.4	0.00	0.66	0.41	0.79
07/13/00	420	3	1	49		20.6	0.43	0.69	0.14	0.80
07/14/00	333	2	6	32		20.0	0.36	0.71	1.08	0.86
07/15/00	515	1	2	67		19.8	0.12	0.72	0.23	0.88
07/16/00	500	4	0	44		19.8	0.48	0.76	0.00	0.88
07/17/00	433	3	2	27		19.6	0.42	0.79	0.28	0.90
07/18/00	320	6	0	40		19.6	1.13	0.85	0.00	0.90
07/19/00	375	0	0	25		20.1	0.00	0.85	0.00	0.90
07/20/00	421	0	1	8		21.8	0.00	0.85	0.14	0.91
07/21/00	310	0	0	8		22.3	0.00	0.85	0.00	0.91
07/22/00	435	0	1	21		21.2	0.00	0.85	0.14	0.92
07/23/00	504	2	0	28		20.6	0.24	0.87	0.00	0.92
07/24/00	427	1	0	9		21.5	0.14	0.88	0.00	0.92
07/25/00	430	0	1	14		23.8	0.00	0.88	0.14	0.93
07/26/00	462	0	0	15		23.9	0.00	0.88	0.00	0.93
07/27/00	430	0	0	19		22.6	0.00	0.88	0.00	0.93
07/28/00	441	1	1	21		21.9	0.14	0.89	0.14	0.94
07/29/00	436	2	0	21		21.7	0.28	0.91	0.00	0.94
07/30/00	434	3	1	20		20.8	0.41	0.94	0.14	0.95
07/31/00	434	0	0	15		20.5	0.00	0.94	0.00	0.95
08/01/00	434	1	0	15		20.9	0.14	0.95	0.00	0.95
08/02/00	434	0	1	19		20.0	0.00	0.95	0.14	0.96
08/03/00	430	1	1	17		19.2	0.14	0.96	0.14	0.97
08/04/00	452	0	1	37		19.1	0.00	0.96	0.13	0.98
08/05/00	429	0	1	17		20.0	0.00	0.96	0.14	0.99
08/06/00	436	0	0	10		20.4	0.00	0.96	0.00	0.99
08/07/00	429	0	0	16		19.7	0.00	0.96	0.00	0.99
08/08/00	403	1	0	13		18.8	0.15	0.97	0.00	0.99
08/09/00	405	1	1	5		18.6	0.15	0.98	0.15	1.00
08/10/00	496	2	0	3		18.8	0.24	1.00	0.00	1.00
Total	364 hrs	101	99	1,131						

Appendix A3.–Detection of size-selectivity in sampling and its effects on estimation of size composition.

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

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

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

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

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

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

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

n_i	Number of unique fish sampled during **SECOND** event **ONLY** within stratum *i*
n_{ij}	Number of unique fish of age *j* sampled during the **SECOND** event **ONLY** within stratum *i*
$\hat{p}_{ij} = \frac{n_{ij}}{n_i}$	Estimated fraction of fish of age *j* in stratum *i*. Note that $\sum_j \hat{p}_{ij} = 1$
$v(\hat{p}_{ij}) = \frac{\hat{p}_{ij}(1-\hat{p}_{ij})}{n_i - 1}$	An unbiased of variance [1]
$\hat{N}_i$	Estimated abundance in stratum *i* from the mark-recapture experiment
$\hat{N}_j = \sum_i (\hat{p}_{ij}\hat{N}_i)$	Estimated abundance of fish in age group *j* in the population
$v(\hat{N}_j) = \sum_i (v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)\hat{p}^2{}_{ij} - v(\hat{p}_{ij})v(\hat{N}_i))$	An unbiased estimate of variance [2]
$\hat{p}_j = \frac{\hat{N}_j}{\sum_i \hat{N}_i} = \frac{\hat{N}_j}{\hat{N}}$	Estimated fraction of fish in age group *j* in the population
$v(\hat{p}_j) = \frac{\sum_i (v(\hat{p}_{ij})\hat{N}_i^2 + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2)}{\hat{N}^2}$	An approximate estimate of variance [3]

[1] page 52 in Cochran, W.G. 1977. Sampling techniques, 3rd ed. John Wiley and Sons, Inc. New York.

[2] from methods in Goodman, L.G. 1960. On the exact variance of a product. Journal of the American Statistical Association.

[3] from the delta method, page 8 in Seber, G.A.F. 1982. The estimation of animal abundance and related parameters, 2nd ed. Charles Griffin and Company, Limited. London.

Appendix A4.–Estimated age and sex composition and mean length by age of chinook salmon passing by Kakwan Point , 2000.

		SMALL AND MEDIUM CHINOOK SALMON									
		Age class									
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Females	n		4								4
	% age comp.		3.7								3.7
	SE of %		1.8								1.8
	Avg. length		635								635
	SE		11								11
Males	n		94		10						104
	% age comp.		87.0		9.3						96.3
	SE of %		3.2		2.8						1.8
	Avg. length.		615		621						615
	SE		3		10						3
Sexes combined	n		98		10						108
	% age comp.		90.7		9.3						100.0
	SE of %		2.8		2.8						0.0
	Avg. length.		616		621						616
	SE		3		10						2
		LARGE CHINOOK SALMON									
Females	n		8		174		72		2		256
	% age comp.		2.1		45.1		18.7		0.5		66.3
	SE of %		0.7		2.5		2.0		0.4		2.4
	Avg. length		673		770		843		899		788
	SE		4		3		4		2		4
Males	n		14		72		42		2		130
	% age comp.		3.6		18.7		10.9		0.5		33.7
	SE of %		1.0		2.0		1.6		0.4		2.4
	Avg. length.		681		786		890		933		811
	SE		8		7		10		13		8
Sexes combined	n		22		246		114		4		386
	% age comp.		5.7		63.7		29.5		1.0		100.0
	SE of %		1.2		2.5		2.3		0.5		0.0
	Avg. length.		678		775		860		916		796
	SE		5		3		5		11		4
		SMALL, MEDIUM, AND LARGE CHINOOK SALMON									
Females	n		12		174		72		2		260
	% age comp.		2.4		35.2		14.6		0.4		52.6
	SE of %		0.7		2.2		1.6		0.3		2.2
	Avg. length		660		770		843		899		786
	SE		7		3		4		2		4
Males	n		108		82		42		2		234
	% age comp.		21.9		16.6		8.5		0.4		47.4
	SE of %		1.9		1.7		1.3		0.3		2.2
	Avg. length.		623		766		890		933		724
	SE		3		9		10		13		8
Sexes combined	n		120		256		114		4		494
	% age comp.		24.3		51.8		23.1		0.8		100.0
	SE of %		1.9		2.3		1.9		0.4		0.0
	Avg. length.		627		769		860		916		757
	SE		3		4		5		11		4

Appendix A5.–Estimated age and sex composition and mean length by age of chinook salmon passing by Rock Island , 2000.

		Age class									
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
SMALL AND MEDIUM CHINOOK SALMON											
Females	n		9		1						10
	% age comp.		14.5		1.6						16.1
	SE of %		4.5		1.6						4.7
	Avg. length		628		590						624
	SE		9								9
Males	n		46		6						52
	% age comp.		74.2		9.7						83.9
	SE of %		5.6		3.8						4.7
	Avg. length.		547		615						555
	SE		9		15						9
Sexes combined	n		55		7						62
	% age comp.		88.7		11.3						100.0
	SE of %		4.1		4.1						0.0
	Avg. length.		560		612						566
	SE		9		13						8
LARGE CHINOOK SALMON											
Females	n		1		14		7				22
	% age comp.		1.9		26.4		13.2				41.5
	SE of %		1.9		6.1		4.7				6.8
	Avg. length		680		740		765				745
	SE				9		20				9
Males	n		5[a]		22		4				31
	% age comp.		9.4		41.5		7.5				58.5
	SE of %		4.1		6.8		3.7				6.8
	Avg. length.		751		737		827				751
	SE		50		12		25				13
Sexes combined	n		6		36		11				53
	% age comp.		11.3		67.9		20.8				100.0
	SE of %		4.4		6.5		5.6				0.0
	Avg. length.		740		738		788				749
	SE		43		8		18				8
SMALL, MEDIUM, AND LARGE CHINOOK SALMON											
Females	n		10		15		7				32
	% age comp.		8.7		13.0		6.1				27.8
	SE of %		2.6		3.2		2.2				4.2
	Avg. length		633		730		765				707
	SE		9		13		20				12
Males	n		51[a]		28		4				83
	% age comp.		44.3		24.3		3.5				72.2
	SE of %		4.7		4.0		1.7				4.2
	Avg. length.		567		711		827				628
	SE		13		14		25				13
Sexes combined	n		61		43		11				115
	% age comp.		53.0		37.4		9.6				100.0
	SE of %		4.7		4.5		2.8				0.0
	Avg. length.		578		718		788				650
	SE		11		10		18				10

[a] Includes one age-0.3 male.

Appendix A6.–Estimated age and sex composition and mean length by age of chinook salmon harvested in the Canadian commercial and test gillnet fisheries on the Lower Stikine River, 2000.

		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
SMALL AND MEDIUM CHINOOK SALMON											
		Age class									
Females	n	1[a]	94		11						106
	% age comp.	0.4	40.5		4.7						45.7
	SE of %	0.4	3.2		1.4						3.3
	Avg. length	545	582		634						587
	SE		4		8						4
Males	n		111		11	4					126
	% age comp.		47.8		4.7	1.7					54.3
	SE of %		3.3		1.4	0.9					3.3
	Avg. length.		581		604	569					583
	SE		5		12	39					5
Sexes combined	n	1	205		22	4					232
	% age comp.	0.4	88.4		9.5	1.7					100.0
	SE of %	0.4	2.1		1.9	0.9					0.0
	Avg. length.	545	581		619	569					585
	SE		3		8	39					3
LARGE CHINOOK SALMON											
Females	n		11		150	1	54		2		218
	% age comp.		2.7		36.7	0.2	13.2		0.5		53.3
	SE of %		0.8		2.4	0.2	1.7		0.3		2.5
	Avg. length		682		757	673	814		823		768
	SE		7		4		7		12		4
Males	n		16		123	2	44	1	5		191
	% age comp.		3.9		30.1	0.5	10.8	0.2	1.2		46.7
	SE of %		1.0		2.3	0.3	1.5	0.2	0.5		2.5
	Avg. length.		696		759	673	853	777	851		777
	SE		8		5	8	10		49		5
Sexes combined	n		27		273	3	98	1	7		409
	% age comp.		6.6		66.7	0.7	24.0	0.2	1.7		100.0
	SE of %		1.2		2.3	0.4	2.1	0.2	0.6		0.0
	Avg. length.		691		758	673	831	777	843		772
	SE		6		3	4	6		34		3
SMALL, MEDIUM, AND LARGE CHINOOK SALMON											
Females	n	1[a]	105		161	1	54		2		324
	% age comp.	0.2	16.4		25.1	0.2	8.4		0.3		50.5
	SE of %	0.2	1.5		1.7	0.2	1.1		0.2		2.0
	Avg. length	545	592		749	673	814		823		708
	SE		5		5		7		12		6
Males	n		127		134	6	44	1	5		317
	% age comp.		19.8		20.9	0.9	6.9	0.2	0.8		49.5
	SE of %		1.6		1.6	0.4	1.0	0.2	0.3		2.0
	Avg. length.		595		746	604	853	777	851		700
	SE		6		6	33	10		49		7
Sexes combined	n	1	232		295	7	98	1	7		641
	% age comp.	0.2	36.2		46.0	1.1	15.3	0.2	1.1		100.0
	SE of %	0.2	1.9		2.0	0.4	1.4	0.2	0.4		0.0
	Avg. length.	545	594		748	614	831	777	843		704
	SE		4		4	30	6		34		4

[a] Age-0.2 female.

Appendix A7.–Estimated age and sex composition and mean length by age of chinook salmon at Little Tahltan River weir, 2000.

		Age class									
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
SMALL AND MEDIUM CHINOOK SALMON											
Females	n		17		1						18
	% age comp.		17.9		1.1						18.9
	SE of %		4.0		1.1						4.0
	Avg. length		602		623						603
	SE		8								7
Males	n	1	71		5						77
	% age comp.	1.1	74.7		5.3						81.1
	SE of %	1.1	4.5		2.3						4.0
	Avg. length.	500	597		601						596
	SE		6		12						5
Sexes combined	n	1	88		6						95
	% age comp.	1.1	92.6		6.3						100.0
	SE of %	1.1	2.7		2.5						0.0
	Avg. length.	500	598		605						598
	SE		5		10						5
LARGE CHINOOK SALMON											
Females	n		6		154		230	1	5	2	398
	% age comp.		0.9		22.3		33.2	0.1	0.7	0.3	57.5
	SE of %		0.4		1.6		1.8	0.1	0.3	0.2	1.9
	Avg. length		728		785		839	814	870	824	817
	SE		25		3		3		18	17	2
Males	n		29		112	2	142		8	1	294
	% age comp.		4.2		16.2	0.3	20.5		1.2	0.1	42.5
	SE of %		0.8		1.4	0.2	1.5		0.4	0.1	1.9
	Avg. length.		704		786	712	889		912	928	831
	SE		6		7	45	4		15		5
Sexes combined	n		35		266	2	372	1	13	3	692
	% age comp.		5.1		38.4	0.3	53.8	0.1	1.9	0.4	100.0
	SE of %		0.8		1.9	0.2	1.9	0.1	0.5	0.2	0.0
	Avg. length.		708		785	712	858	814	896	858	823
	SE		6		3	45	2		13	36	3
SMALL, MEDIUM, AND LARGE CHINOOK SALMON36											
Females	n		23		155		230	1	5	2	416
	% age comp.		2.9		19.7		29.2	0.1	0.6	0.3	52.9
	SE of %		0.6		1.4		1.6	0.1	0.3	0.2	1.8
	Avg. length		635		784		839	814	870	824	808
	SE		14		4		3		18	17	3
Males	n	1	100		117	2	142		8	1	371
	% age comp.	0.1	12.7		14.9	0.3	18.0		1.0	0.1	47.1
	SE of %	0.1	1.2		1.3	0.2	1.4		0.4	0.1	1.8
	Avg. length.	500	628		778	712	889		912	928	782
	SE		6		7	45	4		15		6
Sexes combined	n	1	123		272	2	372	1	13	3	787
	% age comp.	0.1	15.6		34.6	0.3	47.3	0.1	1.7	0.4	100.0
	SE of %	0.1	1.3		1.7	0.2	1.8	0.1	0.5	0.2	0.0
	Avg. length.	500	629		781	712	858	814	896	858	796
	SE		6		4	45	2		13	36	4

Appendix A8.–Estimated age and sex composition and mean length by age of moribund and recently expired chinook salmon in Verrett River, 2000.

		Age class									
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
SMALL AND MEDIUM CHINOOK SALMON											
Females	n		2		1						3
	% age comp.		3.0		1.5						4.5
	SE of %		2.1		1.5						2.5
	Avg. length		643		655						647
	SE		13								8
Males	n		54		10						64
	% age comp.		80.6		14.9						95.5
	SE of %		4.9		4.4						2.5
	Avg. length.		596		627						601
	SE		6		7						5
Sexes combined	n		56		11						67
	% age comp.		83.6		16.4						100.0
	SE of %		4.6		4.6						0.0
	Avg. length.		598		629						603
	SE		6		7						5
LARGE CHINOOK SALMON											
Females	n		1		140		50		1		192
	% age comp.		0.3		38.4		13.7		0.3		52.6
	SE of %		0.3		2.5		1.8		0.3		2.6
	Avg. length		670		762		823		830		777
	SE				3		6				3
Males	n		18		123		32				173
	% age comp.		4.9		33.7		8.8				47.4
	SE of %		1.1		2.5		1.5				2.6
	Avg. length.		678		755		839				763
	SE		4		4		10				5
Sexes combined	n		19		263		82		1		365
	% age comp.		5.2		72.1		22.5		0.3		100.0
	SE of %		1.2		2.4		2.2		0.3		0.0
	Avg. length.		677		759		829		830		770
	SE		4		3		5				3
SMALL, MEDIUM, AND LARGE CHINOOK SALMON											
Females	n		3		141		50		1		195
	% age comp.		0.7		32.6		11.6		0.2		45.1
	SE of %		0.4		2.3		1.5		0.2		2.4
	Avg. length		652		761		823		830		775
	SE		12		3		6				3
Males	n		72		133		32				237
	% age comp.		16.7		30.8		7.4				54.9
	SE of %		1.8		2.2		1.3				2.4
	Avg. length.		617		746		839				719
	SE		6		5		10				6
Sexes combined	n		75		274		82		1		432
	% age comp.		17.4		63.4		19.0		0.2		100.0
	SE of %		1.8		2.3		1.9		0.2		0.0
	Avg. length.		618		754		829		830		744
	SE		6		3		5				4

Appendix A9.–Estimated age and sex composition and mean length by age of chinook salmon in Andrew Creek, 2000.

		Age class									
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
SMALL AND MEDIUM CHINOOK SALMON											
Females	n										
	% age comp.										
	SE of %										
	Avg. length										
	SE										
Males	n		12		5						17
	% age comp.		70.6		29.4						100.0
	SE of %		11.4		11.4						0.0
	Avg. length.		579		613						589
	SE		21		14						15
Sexes combined	n		12		5						17
	% age comp.		70.6		29.4						100.0
	SE of %		11.4		11.4						0.0
	Avg. length.		579		613						589
	SE		21		14						15
LARGE CHINOOK SALMON											
Females	n		2		38		28		1		69
	% age comp.		1.8		33.9		25.0		0.9		61.6
	SE of %		1.3		4.5		4.1		0.9		4.6
	Avg. length		713		779		829		935		800
	SE		18		7		7				6
Males	n		2[a]		31		10				43
	% age comp.		1.8		27.7		8.9				38.4
	SE of %		1.3		4.2		2.7				4.6
	Avg. length.		698		760		846				777
	SE		23		10		13				10
Sexes combined	n		4		69		38		1		112
	% age comp.		3.6		61.6		33.9		0.9		100.0
	SE of %		1.8		4.6		4.5		0.9		0.0
	Avg. length.		705		771		833		935		791
	SE		12		6		6				5
SMALL, MEDIUM, AND LARGE CHINOOK SALMON											
Females	n		2		38		28		1		69
	% age comp.		1.6		29.5		21.7		0.8		53.5
	SE of %		1.1		4.0		3.6		0.8		4.4
	Avg. length		713		779		839		935		800
	SE		18		7		7				6
Males	n		14[a]		36		10				60
	% age comp.		10.9		27.9		7.8				46.5
	SE of %		2.7		4.0		2.4				4.4
	Avg. length.		596		739		846				724
	SE		21		12		13				14
Sexes combined	n		16		74		38		1		129
	% age comp.		12.4		57.4		29.5		0.8		100.0
	SE of %		2.9		4.4		4.0		0.8		0.0
	Avg. length.		611		760		833		935		764
	SE		21		7		6				8

[a] Includes one age-0.3 male.

Appendix A10.–Origin of coded-wire tags recovered from chinook salmon collected at Kakwan Point and Rock Island, 2000.

Year	Head	Tag code	Brood year	Agency	Rearing	Location	Date released	Release site	Tag ratio
2000	216092	032301	1996	NMFS	H	LITTLE PORT WALTER	5/15/98	LITTLE PORT WALTER 109-10	1.086
2000	216094	045003	1996	ADFG	H	CRYSTAL LAKE/NEETS BAY	5/26/98	NEETS BAY 101-90	11.704
2000	216093	Head lost							

Appendix A11.–Computer files used to estimate the spawning abundance of chinook salmon in the Stikine River in 2000.

FILE NAME	DESCRIPTION
CAPTPROB00.xls	EXCEL spreadsheet with chi-square capture probability tests.
INSEASON00.xls	EXCEL spreadsheet with 2000 inseason abundance estimates including CPUE models.
POSTSEASON00.xls	EXCEL spreadsheet with 2000 post-season abundance estimates including bootstrap output for variance and bias estimation
STIKMR-CPUE00.xls	EXCEL spreadsheet with Kakwan Point and Rock Island catch-effort, hydrology, and temperature data including charts.
SIZESELPOST00.xls	EXCEL spreadsheet with Kolmogorov-Smirnov size-selectivity tests including charts.
STIKMR-TAG&ASL00.xls	EXCEL spreadsheet with Kakwan Point, Rock Island, and spawning ground tag, recovery, and age-sex-size data.