Fishery Data Series No. 00-24

Abundance of the Chinook Salmon Escapement on the Stikine River, 1998

by

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and

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October 2000

Alaska Department of Fish and Gaı

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

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The abundance of large (≥660mm MEF) chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Stikine River above the U.S./Canada border in 1998 was estimated using a mark-recapture experiment. Age, sex, and length compositions for the immigration were also estimated. Drift gillnets fished near the mouth of the Stikine River were used to capture 450 immigrant chinook salmon during May, June, and July, 1998, of which 418 large fish (≥660 mm MEF) 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 28,133 (SE = 3,931) large chinook salmon immigrated to the Stikine River above Kakwan Point. Canadian fisheries on the Stikine River harvested 2,165 large chinook salmon, which left an escapement of 25,968 large fish. The total count of large fish at the Little Tahltan River weir was 4,879, representing about 19% of the estimated spawning escapement of large fish above Kakwan Point. Weir counts and a foot survey were used to estimate an escapement of 974 large fish in Andrew Creek. An estimated 5% of the chinook salmon passing by Kakwan Point were age -1.2, 30% age -1.3, 63% age -1.4, and 1% age -1.5; 146 males and 223 females were captured. An estimated 3% of samples from the Little Tahltan River were age -1.2, 21% age -1.3, 73% age -1.4, and 3% age -1.5; 298 males and 300 females were sampled.

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

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 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 coastwide 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 index systems.

The Stikine River is a transboundary river, originating in British Columbia 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 stocks in the river appear to be responding well to the rebuilding program (Pahlke 1996). 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; the run timing of sockeye salmon overlaps the chinook migration, and migrating chinook salmon from the Stikine River are caught incidentally to sockeye salmon in U.S. marine gillnet fisheries in Districts 106 and 108, and in riverine Canadian commercial and aboriginal food fisheries (Table 1). An increase in the harvest rate on enhanced sockeye salmon will likely result in increased harvest of the chinook salmon as well. Stikine River chinook salmon are also caught in marine recreational fisheries near Wrangell and Petersburg, in the commercial troll fishery in Southeast Alaska, and in recreational fisheries in Canada. Exploitation of these populations is managed jointly by the U.S. and Canada through the Pacific Salmon Commission (PSC).

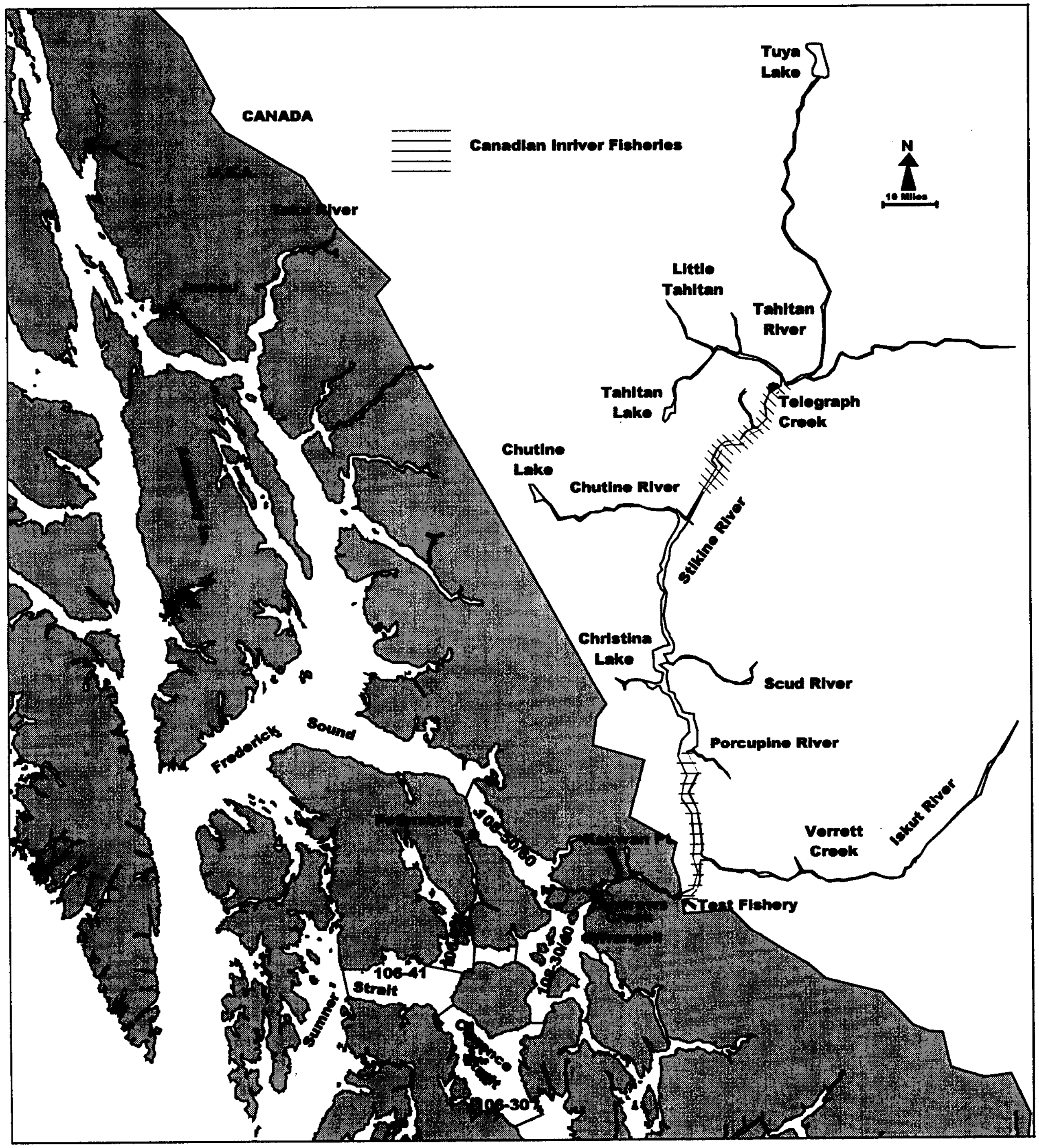

Figure 1.–Stikine River drainage, showing location of principal U.S. and Canadian fishing areas.

Table 1.–Harvests of chinook salmon in Canadian fisheries in the Stikine River and U.S. fisheries near the mouth of the river, 1975–1998.

	United States		Canada								Total inriver[c] (commercial, aboriginal, test)	
	District 108 gillnet[a]	Wrangell sport through mid-June	Commercial harvest lower Stikine		Commercial harvest upper Stikine		Aboriginal fishery Telegraph Creek		Test fishery			
Year			Jacks	Large	Jacks[b]	Large	Jacks	Large	Jacks	Large	Jacks	Large
1975	1,534					178		1,024			–	1,202
1976	1,123	d				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	1,133	---	fishery	closed	---	59	643			59	643
1985	20	1,683	91	256		62	94	793	–	–	185	1,111
1986	102	1,825	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	1,361	201	1,007	46	175	197	1,178	29	269	473	2,629
1989	310	1,966	157	1,537	17	54	115	1,078	24	217	313	2,886
1990	557	2,630	680	1,569	20	48	259	633	18	231	977	2,481
1991	1,366	2,876	318	641	32	117	310	753	16	167	676	1,678
1992	967	2,674	89	873	19	56	131	911	182	614	421	2,454
1993	1,628	2,925	164	830	2	44	142	929	87	568	395	2,371
1994	1,996	1,625	158	1,016	1	76	191	698	78	295	428	2,085
1995	1,702	1,169	599	1,067	17	9	244	570	184	248	1,044	1,894
1996	1,717	1,578	221	1,708	44	41	156	722	76	298	497	2,769
1997	2,566	2,329	186	3,283	6	45	94	1,155	7	30	293	4,513
1998	460	972	359	1,585	0	12	95	538	11	25	465	2,160

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

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

[c] Inriver sport harvest is unknown but believed to be approximately 200 fish annually.

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

Chinook salmon escapement to the Stikine River has been monitored since 1975 by counting spawners from the air over the Little Tahltan River, the mainstem Tahltan River, and over Beatty and Andrew creeks (Table 2). The escapement goal for the Stikine River was based on the peak count prior to 1981, in the Little Tahltan River. Historically, total escapement to the Stikine River was estimated by multiplying the count in the Little Tahltan River by an expansion factor (4×) thought to represent the proportion of the escapement represented by that tributary (Pahlke 1996). The original expansion factors were based on judgment rather than empirical data, and in 1991 the Transboundary Technical Committee of the PSC decided to use only the actual counts of escapement to the Little Tahltan River to assess rebuilding (PSC 1991). Expansion factors and escapement goals are under revision (Bernard et al. *In prep*).

Helicopter surveys of the Little Tahltan River have been conducted annually since 1975, and a fish counting weir has been operated at the

Table 2.–Counts of large spawning chinook salmon in tributaries of the Stikine River, 1975–1998. 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 F(E)	–
1979	1,166 E(H)	–	2,118 N(H)	–	382 (W)	16 F(E)	–
1980	2,137 N(H)	–	960 P(H)	122 E(H)	363 (W)	68 F(N)	–
1981	3,334 E(H)	–	1,852 P(H)	558 E(H)	654 (W)	84 F(E)	4 F(P)
1982	2,830 N(H)	–	1,690 N(F)	567 E(H)	947 (W)	138 F(N)	188 F(N)
1983	594 E(H)	–	453 N(H)	83 E(H)	444 (W)	15 F(N)	–
1984	1,294 (H)	–	–	126 (H)	389 (W)	31 F(N)	–
1985	1,598 E(H)	3,114	1,490 N(H)	147 N(H)	319 E(F)	44 F(E)	–
1986	1,201 E(H)	2,891	1,400 P(H)	183 N(H)	707 N(F)	73 F(N)	45 A(E)
1987	2,706 E(H)	4,783	1,390 P(H)	312 E(H)	788 E(H)	71 F(E)	122 F(N)
1988	3,796 E(H)	7,292	4,384 N(H)	593 E(H)	564 E(F)	125 F(N)	167 F(N)
1989	2,527 E(H)	4,715	–	362 E(H)	530 E(F)	150 A(N)	49 H(N)
1990	1,755 E(H)	4,392	2,134 N(H)	271 E(H)	664 E(F)	83 F(N)	33 H(P)
1991	1,768 E(H)	4,506	2,445 N(H)	193 N(H)	400 N(A)	38 A(N)	46 A(N)
1992	3,607 E(H)	6,627	1,891 N(H)	362 N(H)	778 E(H)	40 F(E)	31 A(N)
1993	4,010 P(H)	11,437	2,249 P(H)	757 E(H)	1,060 E(F)	53 F(E)	
1994	2,422 N(H)	6,373	–	184 N(H)	572 E(H)	58 F(E)	10 A(N)
1995	1,117 N(H)	3,072	696 E(H)	152 N(H)	343 N(H)	28 A(P)	1 A(E)
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)	–	–
1988–1997 avg.	2,483	5,902	1,854	331	548	68	45
1998	1,385 N(H)	4,873	587 P(H)	125 E(H)	487 E(F)	35 N(A)	28 N(A)

[a] Above weir harvest and broodstock collections are removed from weir counts; in 1998 six fish removed.

mouth of the Little Tahltan River since 1985. Since virtually all fish spawning in the Little Tahltan River spawn above the weir, counts from the weir represent the escapement to that tributary. Escapement into Andrew Creek has been surveyed annually since 1975 by foot, aerial or helicopter surveys. In addition, a weir operated on Andrew Creek to collect hatchery brood stock from 1976 to 1984 and also provided escapement counts. A weir was operated in 1997 and 1998 to count escapement, and to sample fish to get data on age, sex and lengths of chinook salmon, 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) chinook salmon approximately ≥660 mm mideye-to-fork length (MEF), are counted during aerial or foot surveys. No attempt is made to accurately count small (typically age-.1 and -.2) chinook salmon <660 mm (MEF) (Mecum 1990). These small chinook salmon, also called jacks, are primarily males that are considered "surplus" to the reproduction of the next generation. 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 Canadian Department of Fisheries and Oceans (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). In 1997, a radio-tracking study to estimate distribution of spawners was also conducted.

The objectives of the 1998 study were to:

(1) estimate the 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 above the U.S./Canada border in the Stikine River.

(3) census chinook salmon spawning in Andrew Creek, and

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

Results from the study provide a survey-to-abundance expansion factor, *i.e.*, an estimate of the fraction of total escapement seen in the peak survey count, and at the Little Tahltan River weir. Results also provide information on the run timing through the lower Stikine River of chinook salmon bound for the various spawning areas.

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 British Columbia, 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. The upper drainage of the Stikine is accessible via the Telegraph Creek Road.

METHODS

KAKWAN POINT TAGGING

Abundance was estimated with Chapman's modification of Petersen's estimator for a two-event mark-recapture experiment on a closed population (Seber 1982:59-61). Fish captured by gillnet in the lower river near Kakwan Point and marked were included in event 1. Kakwan Point is below all known spawning areas, with the exception of Andrew and North Arm Creeks (Figure 2), and is upstream of any tidal influence. Chinook salmon captured upstream on or near their spawning grounds and in the Canadian gillnet fishery on the lower Stikine, constituted event 2 in the mark-recapture experiment. Drift gillnets 120 feet (36.5m) long, 18 feet (5.5m) deep, and made of 7.25-inch (18.5cm) stretch mesh, were fished on the lower Stikine River, between May 4 and July 9. Two nets were fished daily, unless high water or staff shortages occurred. Nets were watched continuously, and a captured fish was removed from the net as soon as it was observed. Sampling effort was held reasonably constant across the temporal span of the migration. If fishing time was lost due to entanglements, snags, cleaning the net, etc., the lost time (processing time) was added on to the end of the day to bring fishing time to 4 hours per net.

Captured chinook salmon were placed in a box filled with water, quickly untangled or cut from the net, marked, their length measured, their sex recorded, and a sample of scales taken (as per Johnson et al. 1993). Fish were classified as "large" if their mid-eye to fork length (MEF) was ≥660mm, "medium" if their MEF was 440-659mm or "small" if their MEF was <440mm (Pahlke and Bernard 1996). Fish were judged on the basis of external appearance to be "bright" or "dark," and the presence or absence of sea lice (*Lepeophtheirus* sp.) was noted. General health and appearance of the fish was recorded, including injuries from handling or predators.

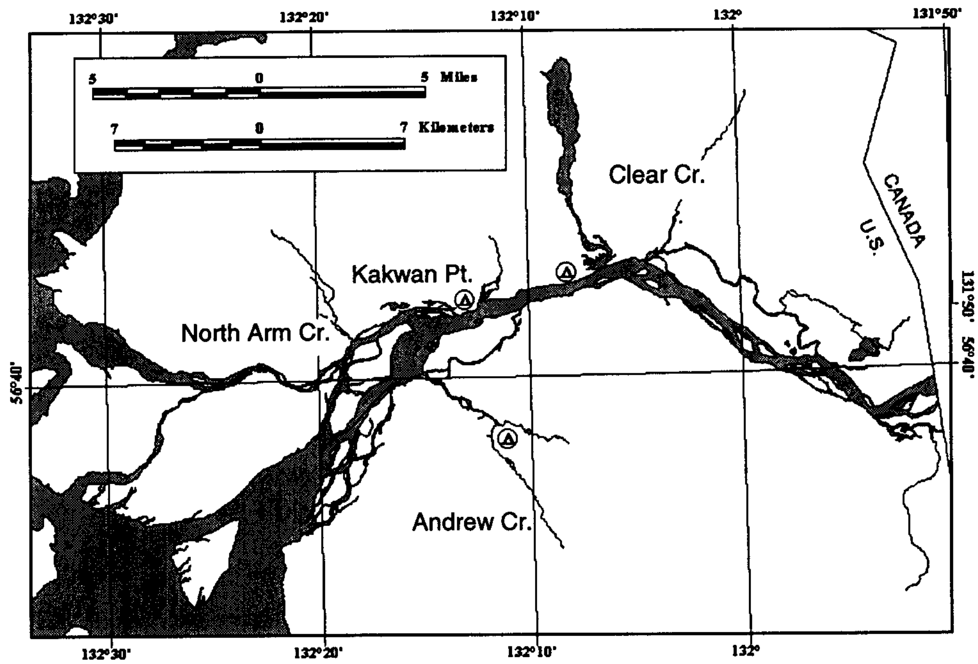

Figure 2.–Location of drift gillnet site on the lower Stikine River, 1998.

Each uninjured fish was marked with a uniquely numbered, blue spaghetti tag, consisting of a 2" (~5cm) section of Floy tubing shrunk onto a 15" (~38cm) piece of 80-lb (~36.3kg) monofilament fishing line. The monofilament was sewn through the musculature of the fish about 20mm posterior and ventral to the dorsal fin and secured by crimping both ends in a line crimp. Each fish was also marked in the upper (dorsal) portion of its operculum by a ¼"-diameter hole applied with a paper punch, and by amputation of its left axillary appendage (as per McPherson et al. 1996). Fish that were seriously injured were sampled but not marked.

Spawning Ground Sampling

During event 2, pre- and post spawning fish were sampled at the Little Tahltan River weir and post spawning fish were speared at Verrett Creek. Little Tahltan River flows southeast and empties into the Tahltan River about 30 km northwest of Telegraph Creek, B.C. As fish accumulated below the weir across the Little Tahltan River, a portion were captured with dip nets, sampled for length, sex, scales and inspected for marks and released. Each sampled fish was marked with a hole punched in its lower opercle flap to prevent resampling. The majority of fish were passed through the weir without being individually handled. A few pickets were pulled and fish were allowed to swim upstream while an observer counted them and recorded size (large or jack), sex, and the presence of spaghetti tags. In addition, some post-spawning fish and carcasses were sampled upstream of the weir.

Verrett Creek flows south into the Iskut River approximately 60 km upstream of the confluence of the Iskut and Stikine rivers. The lower 1 km of the Creek is used by spawning chinook, sockeye, chum (*O. keta*), and coho (*O. kisutch*) salmon. Daily foot surveys of the spawning area were conducted from August 5–13, 1998. Numbers of fish observed were recorded and carcasses and moribund chinook salmon were sampled to obtain scales and information on length, sex, and marks.

Shakes Creek flows into the Stikine River approximately 15 km below the town of Telegraph Creek. The lower 3 km of the creek is used by spawning chinook, sockeye, and coho salmon. A foot survey of the spawning area was conducted in August.

Andrew Creek flows northwest into the Stikine River approximately 4 km below Kakwan Pt. A weir was installed in 1998 to count the chinook salmon escapement and to sample the escapement to get information on age, sex, length, and marked compositions. Escapement counts were also collected by helicopter, airplane and foot surveys.

FISHERY SAMPLING

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 for to get information on age, sex, length, and marked compositions.

ABUNDANCE

The number of marked large fish moving upstream from Kakwan Pt. was estimated by subtracting the estimated number of marked fish estimated to have moved downstream into U.S. waters to be caught in fisheries or spawn in Andrew Creek (Table 3). Handling and tagging has 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 from commercial fisheries for sockeye 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) was expanded by the fraction of the catch sampled.

Andrew Creek is slightly downstream from Kakwan Point and chinook salmon spawning there have historically been treated as a separate population from those spawning upriver in Canada. A separate escapement estimate was calculated for Andrew Creek. The number of marked fish recaptured in Andrew Creek was expanded by the fraction of the estimated escapement sampled and 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 Creek) and in the commercial fishery in the lower watershed would have similar rates of marked fish. Contingency table analysis was used to test 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. We assumed marked and unmarked fish experienced the same mortality rates from natural causes (assumption c). To minimize effects of tag loss, all marked fish carried secondary (a dorsal opercle punch, and tertiary marks (the left axillary appendage was clipped). Similarly, we inspected all fish captured on the spawning grounds for marks (assumption e), and a reward (Can$2) was given for each tag returned from the inriver commercial and aboriginal fisheries (assumption e). Double sampling was prevented by an additional mark (ventral opercle punch) (assumption f).

The estimated number of small chinook salmon $\hat{N}_{sm}$ in the population was calculated as a product of the number of large salmon $\hat{N}_{la}$ estimated

Table 3.–Numbers of chinook salmon marked on lower Stikine River, removed by fisheries and inspected for marks in tributaries in 1998, by length group. Bold numbers included in mark-recapture estimate.

		Length (MEF) in mm			
		0-439	440-659	≥660	Total
A. Released at Kakwan Point		0	24	418	442
B. Removed by:					
1. U.S. gillnet		0	0	0	0
2. Andrew Creek		0	0	13 [a]	2
Subtotal of removals		0	1	9	10
C. Estimated number of marked fish remaining in mark-recapture experiment		0	23	**405**	432
D. Spawning ground samples					
Observed at:	Inspected [b]	10	147	4,759 [c]	4,916
Little Tahltan weir	Marked	0	8	44	52
	Marked/Inspected		0.0542	0.0092	0.0106
Inspected at:					
1a. L. Tahltan weir	Inspected	9	56	**1,210**	1,275
	Marked	0	2	**13**	15
	Marked/Inspected	0.0000	0.0357	0.0107	0.0118
1b. Above weir	Inspected	61	57	285	403
Carcasses	Marked	0	1	4	5
	Marked/Inspected	0.0000	0.0175	0.0140	0.0124
2a. Verrett River	Inspected	6	21	**223**	250
Fresh	Marked	0	0	**2**	2
	Marked/Inspected		0.0000	0.0090	0.0080
2b. Verrett River	Inspected	0	0	242	242
Old carcasses	Marked	0	0	2	2
	Marked/Inspected			0.0083	0.0083
3. Andrew Creek	Inspected	44	59	153	256
	Marked	0	0	2	2
	Marked/Inspected	0.0000	0.0000	0.0132	0.0078
Canadian gillnet	Inspected	73	292	**1,615**	1,978
Lower river & test	Marked		3	**29**	32
	Marked/Inspected		0.0103	0.0180	0.0162
Sport fisheries, U.S. and Canada		0	0	2	2
Aboriginal fishery, upper river		0	1	5	6

[a] Andrew Creek tag recoveries (2) expanded by fraction of escapement sampled.

[b] Includes fish inspected in (1a).

[c] Sizes estimated from proportions from fish sampled in (1a), observed count at weir was 4,879 large fish and 37 jacks.

through the mark-recapture experiment and an expansion factor $\hat{\theta}$ estimated through sampling to estimate relative size composition of the population:

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

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

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

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

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

When substituted into the equation above, the following relationships:

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

simplify the calculation to:

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

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

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

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

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

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 and Verrett Creek 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. Proportions by age or by sex in gillnet and spawning grounds samples were estimated by

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

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

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

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

n = the sample size.

Estimated age composition of chinook captured in the different spawning areas was compared using a chi-square test to determine if the samples could be combined. Estimated age composition of the gillnet samples was compared with estimated age composition from data pooled across spawning grounds using another chi-square test. Estimates of mean length at age and their estimated variances were calculated with standard normal procedures.

RESULTS

KAKWAN POINT TAGGING

Four hundred twenty-six (426) large (≥660 mm MEF) and 24 small chinook salmon were captured in the lower Stikine River between May 4 and July 9, 1998, of which 418 large fish became the initial marked population for the mark-recapture experiment (Table 3, Appendix A1). Drift gillnet effort was maintained at 4 hours per net per day, with two nets fishing, although reduced sampling effort occurred on several days (Figure 3; Appendix A1). Catch rates ranged from 0 to 2.85 fish/net/hour, peaking on June 17, when 23 large chinook were captured (Figure 4). The date of 50% cumulative catch was June 17. Harbor seals killed or injured many fish before they could be removed from the nets, especially early in the season. The sex ratio of chinook salmon caught in the gillnets was skewed towards females (273 females, 169 males). In addition, 37 sockeye were captured and released (Appendix A1).

Fishery Sampling

The lower inriver Canadian commercial and test gillnet fisheries began fishing June 14 and harvested 1,615 large and 365 jack chinook salmon—including 32 marked fish (Table 3). The aboriginal and commercial fisheries near Telegraph Creek harvested 550 large and 95 jack chinook salmon with tags recovered from 6 marked fish. Two 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. No marked fish were reported from a creel survey of the U.S. recreational fishery near Petersburg and Wrangell or in the U.S. District 106/108 gillnet fishery.

Spawning Ground Sampling

At the Little Tahltan River weir, 1,275 chinook salmon were examined for marks, 1,210 of which were large fish. Thirteen (13) large and 2 small marked fish were recovered (Table 3). None of the recovered fish had lost their numbered tag. The remaining fish passing through the weir were not physically examined for marks; however, each fish was observed from a distance and the size category and sex of each was estimated and the presence of an additional 37 spaghetti tags noted. An additional 403 (285 large) previously unsampled carcasses were examined above the weir, and four marked large fish were recovered.

At Verrett Creek, 492 live and dead chinook salmon were examined and four marked fish were recovered (Table 3). Two hundred fifty (250; 223 large) live or freshly killed fish were sampled, two of which were tagged. The remaining 242 in the sample were old carcasses that had deteriorated beyond the point where length could be measured or scales could be taken. Only two old carcasses were recognized as being marked, and then only by holes punched in their opercula.

At the Andrew Creek weir 256 (153 large) fish were examined and 2 spaghetti tags were recovered in 1998. A foot survey of Shakes Creek was conducted in August and no chinook salmon were observed.

Abundance

The estimated abundance of large chinook salmon passing by Kakwan Point, based on only live fish inspected at Little Tahltan weir, fresh samples at Verrett Creek and samples from the lower river Canadian gillnet fishery is 28,133 salmon (SE = 3,931; M = 405, C = 3,048, R = 43). For this estimate, all large marked fish that migrated downstream to spawn in Andrew Creek (2 expanded to 13 marked fish) were censored from the experiment. Also, all large salmon marked prior to June 12 and caught in the inriver commercial and test gillnet fisheries (only one fish) was culled from the recaptures. The shortest delay for a marked fish between release at Kakwan Point and recapture in the commercial fishery was two days, with a maximum delay of 51 days and average of 15 days.

Evidence from sampling upstream supports the supposition that every large chinook salmon passing by Kakwan Point had a near equal chance of being marked regardless of when they passed the point. Marked fractions estimated for large fish at the Little Tahltan weir (0.0107), Verrett Creek (0.0090) or the commercial gillnet fishery (0.0180); were not significantly different ($\chi^2 = 2.95$, df = 2, P = 0.229) (see Table 3 for data). Fish bound for the Little Tahltan River pass by Kakwan Point in May and June; fish bound for Verrett Creek pass by Kakwan Point in June and early July. The commercial fishery began on 14 June just upstream of Kakwan Point and would exploit fish passing Kakwan Point in late June and July.

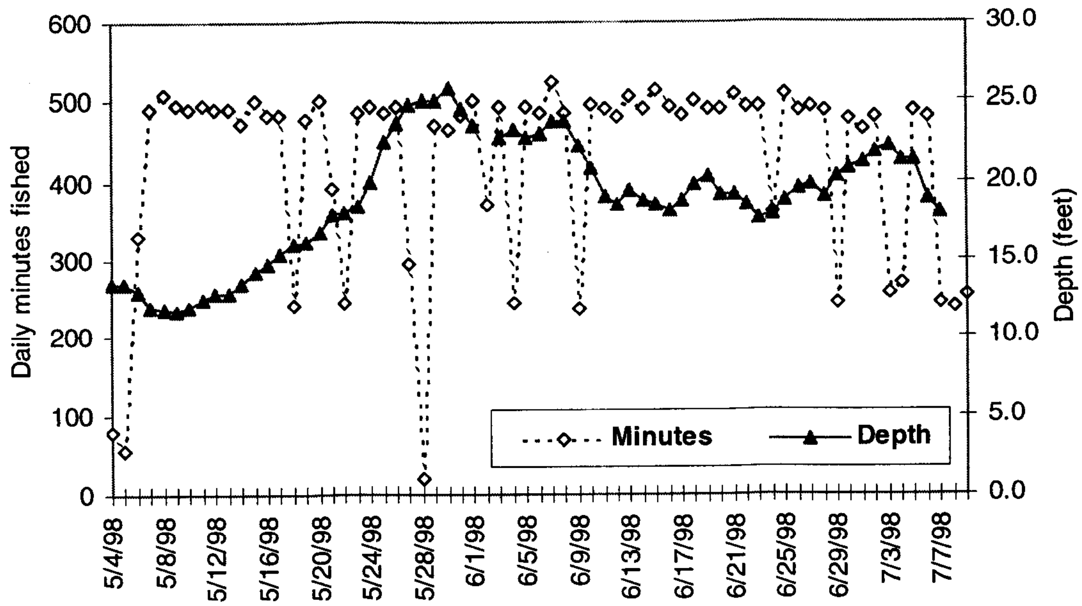

Figure 3.–Daily fishing effort (min) and river depth (ft), Stikine River near Kakwan Point, 1998.

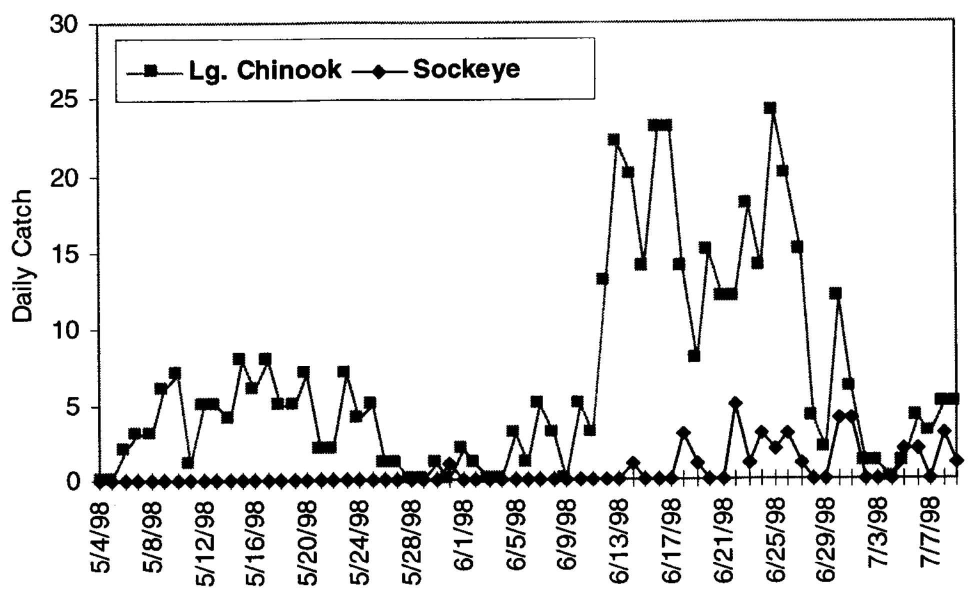

Figure 4.–Daily catch of chinook and sockeye salmon near Kakwan Point, 1998.

Evidence from sampling upstream also supports the supposition that every large chinook salmon passing by Kakwan Point had a near equal chance of being marked regardless of their size. The estimated average lengths in mm MEF of fish marked at Kakwan Point and the corresponding statistics for marked fish recaptured at the weir and in the commercial fishery are below:

	All marked fish	Marked before 17 June	Marked after 16 June
Kakwan Pt.	830	848	819
Recaptured in LSGN	811	834	803
Recaptured at LTW	831	843	809

Half the large chinook salmon caught at Kakwan Point were caught on or before 16 June. Inspection of the table shows that bigger fish tended to be caught before mid-June and smaller fish later. Arbitrarily splitting the pooled samples of large fish from the weir and the commercial gillnet fishery into two groups at the overall median length of large fish (855 mm MEF) permitted a comparison of the marked fraction for both size groups:

	660–855 mm	≥856 mm
Marked	31	11
Unmarked	1,990	821
Marked fraction	0.015	0.013

These marked fractions are not significantly different ($\chi^2 = 0.18$, df = 1, P = 0.67). The same comparison of marked fractions for samples from the commercial fishery taken after 14 June show no real difference (0.049 vs. 0.048). Marked fractions by size group in large fish sampled at the weir throughout the season are marginally different (0.016 vs. 0.005, $\chi^2 = 3.11$, df = 1, P = 0.08), but not enough to significantly affect the comparison on pooled data.

Evidence from sampling upstream also supports the supposition that every large chinook salmon had a near equal chance of being captured upstream regardless of their size. Pooled samples of large fish from the weir and the commercial gillnet fishery were again split into two size groups as were samples of large fish marked at Kakwan Point. After censoring for fish that had moved into Andrew Creek (both were <855 mm MEF), the fractions (rates) of recaptured fish were compared as surrogates for probabilities of capture upstream:

	660–855 mm	≥856 mm
Recaptured	31	11
Not recaptured	229	134
Fraction recaptured	0.119	0.075

These fractions recaptured are not significantly different ($\chi^2 = 1.88$, df = 1, P = 0.17). The same comparison of fractions recaptured for samples from the commercial fishery after 14 June show no real difference (0.138 vs. 0.131). Fractions by size group in large fish sampled at the weir are marginally different (0.040 vs. 0.023, $\chi^2 = 0.80$, df = 1, P = 0.67), but not enough to significantly affect the comparison on pooled data. Although there is little evidence supporting size-selective sampling downstream or upstream in the Stikine River in 1998, the size distributions of samples taken at Kakwan Point, at the weir on the Little Tahltan River, in the commercial gillnet fishery, and at Verrett Creek are significantly different (Figure 5). For reasons explained later, this inconsistency was discounted, and sampling at these three locations was assumed not to be size-selective.

Andrew Creek weir operated from 4 July until high water washed it out on 12 August. A significant number of chinook salmon in the system did not pass upstream through the weir before it failed. When the weir failed, 153 large chinook salmon had passed upstream. A foot survey was conducted on 19 August, and 487 large chinook salmon were counted. The total escapement of large chinook salmon to Andrew

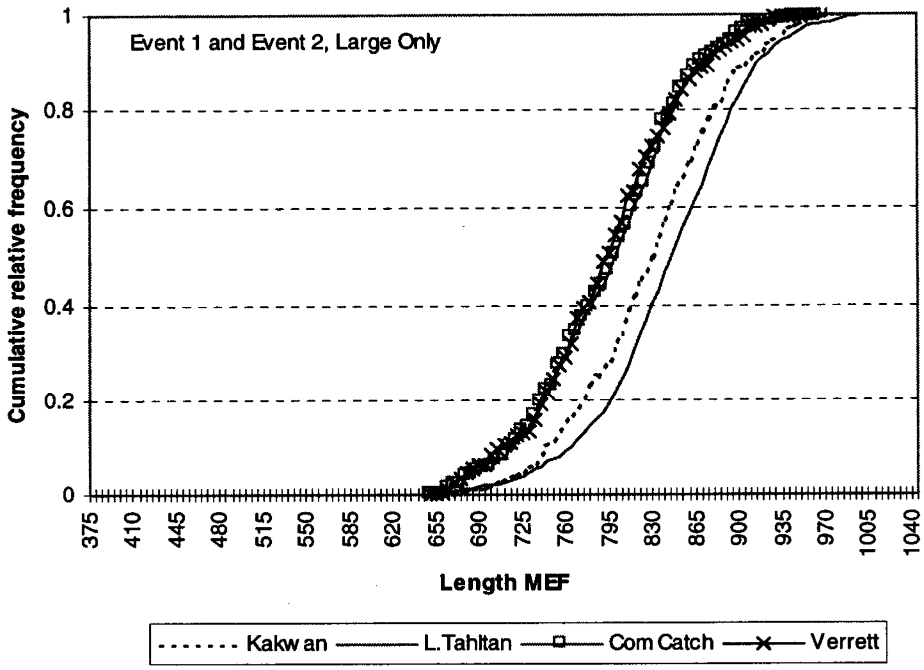

Figure 5.–Cumulative relative frequency of large chinook salmon (≥660 mm MEF) captured at Kakwan Point, at the weir on the Little Tahltan River, at Verrett Creek, and sampled from the commercial fishery in the lower Stikine River, 1998.

Creek was estimated by expanding the survey count by a factor of 2, resulting in an estimate of 974 fish (Pahlke 1999). In fish sampled at the weir, five with clipped adipose fins were sacrificed to collect coded wire tags. Three coded wire tags from Crystal Lake Hatchery and two from wild Unuk River fish were recovered (Appendix A2).

AGE, SEX, AND LENGTH COMPOSITION

Age 1.4 chinook salmon dominated all samples, constituting an estimated 62% of fish captured at Kakwan Point, 73% at the weir across the Little Tahltan River, 65% at Verrett Creek, 55% in the Canadian gillnet fishery, and 46% at the Andrew Creek weir (Tables 4–10).

Estimated age composition was not significantly different between Kakwan Point and Verrett Creek locations (χ^2 = 1.24, df = 3, P = 0.74); however, Kakwan Point was different from Little Tahltan (χ^2 = 15.48, df = 3, P = 0.0015), the two spawning ground locations differed significantly from each other (χ^2 = 10.08, df = 3, P = 0.018), and the Canadian gillnet samples differed from the Kakwan Point samples (χ^2 = 10.77, df = 3, P < 0.013). Although estimated age compositions from Verrett Creek and Little Tahltan live samples were statistically different, they both showed similar trends with high numbers of age 1.4 fish for the second year in a row. Sampled populations were 50–62% females, not unusual considering the strong age 1.4 year class, which tend to have higher proportions of females than age 1.3 fish (Olsen 1995). As seen in 1996 and 1997, mean lengths were dissimilar among sampled populations, the chinook salmon from Verrett Creek being significantly smaller than fish in other sampled populations (Tables 4–9, Figure 5) This difference is consistent with differences in cumulative distributions reported in the previous section. A sample of carcasses collected above the Little Tahltan weir contained a much higher proportion of jacks than observed in the live samples (Table 7).

Table 4.–Estimated age composition and mean length by sex of chinook salmon passing by Kakwan Point, 1998.

		Brood Year and Age Class									
		1995	1994	1993	1993	1993	1992	1992	1991	1991	
		1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	Total
Females	n				65		152	2	3		222
	% age comp.				29.3		68.5	0.9	1.4		60.2
	SE of %				0.03		0.03	0.01	0.01		0.03
	Avg. length				781		832	840	872		
	SE				5.3		4.0	25.0	3.3		
Males	n		20		46		77	1	2	1	147
	% age comp.		13.6		31.3		52.4	0.7	1.4	0.7	39.8
	SE of %		0.03		0.04		0.04	0.01	0.01	0.01	0.03
	Avg. length		591		780		871	930	888	950	
	SE		12.3		13.1		7.5	–	47.5	–	
Sexes combined	n		20		111		229	3	5	1	369
	% age comp.		5.4		30.1		62.1	0.8	1.4	0.3	100
	SE of %		0.01		0.02		0.03	0.00	0.01	0.00	0.00
	Avg. length		591		781		845	870	878	950	
	SE		12.3		6.2		3.8	33.3	15.6	–	

Table 5.–Estimated age composition and mean length by sex of chinook salmon harvested in the Canadian gillnet fishery on the Lower Stikine River, 1998.

		Brood Year and Age Class									
		1995	1994	1993	1993	1993	1992	1992	1991	1991	
		1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	Total
Females	n		2		28		63	3	2	4	102
	% age comp.		2.0		27.5		61.8	2.9	2.0	3.9	58.3
	SE of %		0.01		0.04		0.05	0.02	0.01	0.02	0.04
	Avg. length		754		744		800	756	736	785	
	SE		78.8		11.9		5.9	22.3	112.4	24.0	
Males	n	3	20		15		34	1			73
	% age comp.	4.1	27.4		20.5		46.6	1.4			41.7
	SE of %	0.02	0.05		0.05		0.1	0.01			0.04
	Avg. length	413	536		707		814	591			
	SE	28.6	20.2		30.4		13.9	–			
Sexes combined	n	3	22		43		97	4	2	4	175
	% age comp.	1.7	12.6		24.6		55.4	2.3	1.1	2.3	100
	SE of %	0.01	0.03		0.03		0.04	0.01	0.01	0.01	0.0
	Avg. length	413	556		731		805	715	736	785	
	SE	28.6	23.5		13.2		6.2	44.2	112.4	24.0	

Table 6.–Estimated age composition and mean length by sex of chinook salmon at Little Tahltan River weir, 1998.

		Brood Year and Age Class									
		1995	1994	1993	1993	1993	1992	1992	1991	1991	
		1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	Total
Females	n	1	3		58		230	1	7		300
	% age comp.	0.3	1.0		19.3		76.7	0.3	2.3		50.2
	SE of %	0.00	0.01		0.02		0.02	0.00	0.01		0.02
	Avg. length	341	585		786		842	852	883		
	SE	–	38.5		6.3		2.7	–	13.3		
Males	n		15	1	66		206	2	8		298
	% age comp.		5.0	0.3	22.1		69.1	0.7	2.7		49.8
	SE of %		0.01	0.00	0.02		0.03	0.00	0.01		0.02
	Avg. length		586	769	783		883	844	918		
	SE		8.8	–	9.8		3.8	24.1	32.7		
Sexes	n	1	18	1	124		436	3	15		598
combined	% age comp.	0.2	3.0	0.2	20.7		72.9	0.5	2.5		100
	SE of %	0.00	0.01	0.00	0.02		0.02	0.00	0.01		0.00
	Avg. length	341	585	769	784		862	847	902		
	SE	–	9.1	–	6.0		2.5	14.1	18.5		

Table 7.–Estimated age composition and mean length by sex of dead chinook salmon (carcasses) above the weir on the Little Tahltan River, 1998.

		Brood Year and Age Class									
		1995	1994	1993	1993	1993	1992	1992	1991	1991	
		1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	Total
Females	n	2	1		4		32	1		2	42
	% age comp.	4.8	2.4		9.5		76.2	2.4		4.8	23.9
	SE of %	0.03	0.02		0.05		0.0[illegible]	0.02		0.03	0.03
	Avg. length	337	499		740		837	828		799	
	SE	21.5	–		18.6		8.2	–		2.0	
Males	n	47	40		16		31				134
	% age comp.	35.1	29.9		11.9		23.1				76.1
	SE of %	0.04	0.04		0.03		0.0[illegible]				0.03
	Avg. length	350	521		724		850				
	SE	6.7	10.2		24.4		13.0				
Sexes	n	49	41		20		63	1		2	176
combined	% age comp.	27.8	23.3		11.4		35.8	0.6		1.1	100
	SE of %	0.03	0.0		0.0		0.0	0.0		0.0	0.0
	Avg. length	349	520		727		844	828		799	
	SE	6.5	10.0		19.7		7.6			2.0	

Table 8.–Estimated age composition and mean length by sex of moribund and recently expired chinook salmon in Verrett Creek, 1998.

		BROOD YEAR AND AGE CLASS									
		1995	1994	1993	1993	1993	1992	1992	1991	1991	
		1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	TOTAL
Females	n				29		81		1		111
	% age comp.				26.1		73.0		0.9		57.5
	SE of %				0.04		0.04		0.01		0.04
	Avg. length				761		803		830		
	SE				9.3		4.8		–		
Males	N	3	11		24		44				82
	% age comp.	3.7	13.4		29.3		53.7				42.5
	SE of %	0.02	0.04		0.05		0.06				0.04
	Avg. length	342	574		733		824				
	SE	8.8	11.0		16.1		10.6				
Sexes	n	3	11		53		125		1		193
combined	% age comp.	1.6	5.7		27.5		64.8		0.5		100
	SE of %	0.01	0.02		0.03		0.03		0.01		0.00
	Avg. length	342	574		748		811		830		
	SE	8.8	11.0		9.0		4.9		–		

Table 9.–Estimated age composition and mean length by sex of chinook salmon at the weir on Andrew Creek, 1998.

		BROOD YEAR AND AGE CLASS									
		1995	1994	1993	1993	1993	1992	1992	1991	1991	
		1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	TOTAL
Females	n		1	1	10		64		2	1	79
	% age comp.		1.3	1.3	12.7		81.0		2.5	1.3	37.4
	SE of %		0.01	0.01	0.04		0.04		0.02	0.01	0.03
	Avg. length		656	816	773		838		869	799	
	SE		–	–	20.0		5.2		63.5	–	
Males	n	33	40	1	24	1	32		1		132
	% age comp.	25.0	30.3	0.8	18.2	0.8	24.2		0.8		62.6
	SE of %	0.04	0.04	0.01	0.03	0.01	0.04		0.01		0.03
	Avg. length	388	557	834	700	472	841		841		
	SE	16.0	10.6	–	18.6	–	9.5		–		
Sexes	n	33	41	2	34	1	96		3	1	211
combined	% age comp.	15.6	19.4	0.9	16.1	0.5	45.5		1.4	0.5	100
	SE of %	0.03	0.03	0.01	0.03	0.00	0.03		0.01	0.00	0.00
	Avg. length	388	560	825	721	472	839		859	799	
	SE	16.0	10.6	9.0	15.4	–	4.7		37.8	–	

Table 10.–Estimated abundance and composition by age and sex of the spawning population in the Stikine River for small, medium and large chinook salmon, 1998.

		Brood Year and Age Class									
		1995	1994	1994	1993	1993	1992	1992	1991	1991	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
PANEL A. AGE COMPOSITION OF SMALL AND MEDIUM CHINOOK SALMON											
Males	n	50	0	66	0	6	0	0	0	0	**122**
	%	38.8	0.0	51.2	0.0	4.7	0.0	0.0	0.0	0.0	**94.6**
	SE of %	4.3	0.0	4.4	0.0	1.9	0.0	0.0	0.0	0.0	**2.0**
	Escapement	1,469	0	1,940	0	176	0	0	0	0	**3,585**
	SE of Esc.	273	0	335	0	75	0	0	0	0	**543**
Females	n	3	0	4	0	0	0	0	0	0	**7**
	%	2.3	0.0	3.1	0.0	0.0	0.0	0.0	0.0	0.0	**5.4**
	SE of %	1.3	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	**2.0**
	Escapement	88	0	118	0	0	0	0	0	0	**206**
	SE of Esc.	52	0	60	0	0	0	0	0	0	**81**
Sexes combined	n	53	0	70	0	6	0	0	0	0	**129**
	%	41.1	0.0	54.3	0.0	4.7	0.0	0.0	0.0	0.0	**100.0**
	SE of %	4.3	0.0	4.4	0.0	1.9	0.0	0.0	0.0	0.0	**0.0**
	Escapement	1,558	0	2,057	0	176	0	0	0	0	**3,791**
	SE of Esc.	285	0	350	0	75	0	0	0	0	**569**
PANEL B. AGE COMPOSITION OF LARGE CHINOOK SALMON											
Males	n	0	0	0	0	106	2	282	0	8	**398**
	%	0.0	0.0	0.0	0.0	12.6	0.2	33.4	0.0	0.9	**47.2**
	SE of %	0.0	0.0	0.0	0.0	1.1	0.2	1.6	0.0	0.3	**1.7**
	Escapement	0	0	0	0	3,261	62	8,677	0	246	**12,246**
	SE of Esc.	0	0	0	0	574	44	1,378	0	93	**1,906**
Females	n	0	0	0	0	91	2	343	2	8	**446**
	%	0.0	0.0	0.0	0.0	10.8	0.2	40.6	0.2	0.9	**52.8**
	SE of %	0.0	0.0	0.0	0.0	1.1	0.2	1.7	0.2	0.3	**1.7**
	Escapement	0	0	0	0	2,800	62	10,553	62	246	**13,722**
	SE of Esc.	0	0	0	0	505	44	1,656	44	93	**2,124**
Sexes combined	n	0	0	0	0	197	4	625	2	16	**844**
	%	0.0	0.0	0.0	0.0	23.3	0.5	74.1	0.2	1.9	**100.0**
	SE of %	0.0	0.0	0.0	0.0	1.5	0.2	1.5	0.2	0.5	**0.0**
	Escapement	0	0	0	0	6,061	123	19,230	62	492	**25,968**
	SE of Esc.	0	0	0	0	991	64	2,937	44	142	**3,931**
PANEL C. AGE COMPOSITION OF ALL CHINOOK SALMON											
Males	n	50	0	66	0	112	2	282	0	8	**520**
	%	4.9	0.0	6.5	0.0	11.6	0.2	29.2	0.0	0.8	**53.2**
	SE of %	1.1	0.0	1.3	0.0	1.0	0.1	1.6	0.0	0.3	**1.9**
	Escapement	1,469	0	1,940	0	3,438	62	8,677	0	246	**15,831**
	SE of Esc.	273	0	335	0	579	44	1,378	0	93	**1,981**
Females	n	3	0	4	0	91	2	343	2	8	**453**
	%	0.3	0.0	0.4	0.0	9.4	0.2	35.5	0.2	0.8	**46.8**
	SE of %	0.2	0.0	0.2	0.0	1.0	0.1	1.8	0.1	0.3	**1.9**
	Escapement	88	0	118	0	2,800	62	10,553	62	246	**13,928**
	SE of Esc.	52	0	60	0	505	44	1,656	44	93	**2,125**
Sexes combined	n	53	0	70	0	203	4	625	2	16	**973**
	%	5.2	0.0	6.9	0.0	21.0	0.4	64.6	0.2	1.7	**100.0**
	SE of %	1.1	0.0	1.4	0.0	1.4	0.2	2.2	0.1	0.4	**0.0**
	Escapement	1,558	0	2,057	0	6,238	123	19,230	62	492	**29,759**
	SE of Esc.	285	0	350	0	994	64	2,937	44	142	**3,972**

DISCUSSION

The inconsistency between the results from tests for size-selective sampling and the length distribution of samples is the consequence of differences in migratory timing among stocks, differences in the size of fish across stocks, and differences in the timing of sampling. As noted earlier and elsewhere (Pahlke and Etherton 1998; 1999), chinook salmon spawning in Verrett Creek enter later and are on the whole smaller than chinook salmon spawning in other tributaries. Chinook salmon spawning in the Little Tahltan River tend to pass Kakwan Point earlier than do fish bound for Verrett Creek and are larger. Larger fish tend to pass Kakwan Point earlier than smaller fish, and the commercial gillnet fishery began after about half the run had passed Kakwan Point in 1998.

Under these circumstances, chinook salmon sampled at the Little Tahltan River should tend to be larger, those sampled at Verrett Creek and in the fishery should be smaller, even if sampling in general was not size-selective. Because sampling at Kakwan Point occurs throughout the run, the length distribution of fish captured there should be midway between the distributions of the other two groups, which it is (Figure 5). Of the three distinct length distributions in Figure 5, the one for samples taken at Kakwan Point is an unbiased estimate of the length distribution of all chinook salmon entering the Stikine River. However, pooling all data produces essentially the same distribution.

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; the period 7–25 June had the highest average daily fishing time as well as the bulk of captured fish.

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 from 362 net-hours in 1996 to 453 net-hours in 1997 and 473 net-hours in 1998, and maintain a more consistent, higher level of effort. We also increased the sample size of fish physically inspected at the Little Tahltan weir. The fractions marked in samples taken at the Little Tahltan weir, Verrett Creek, or lower river commercial fishery were not statistically different, indicating every fish had an equal chance of being marked in event 1. This despite large fluctuations in river depth which affected the catch per net hour, especially during the last week of May and early June when the peak of the Little Tahltan run would have been passing (see Figures 3 and 4).

Observation of fish passing by the Little Tahltan weir and inspection of carcasses above the weir were not used in estimating abundance. The blue tag used in the study was designed to blend into the partially occluded waters of the upper Stikine River to prevent predators from targeting marked fish. Unfortunately, this same quality would hamper recognition at a distance by technicians as well, which may explain why the marked fraction of inspected fish at the weir was slightly higher than the fraction for observed fish. Recognition of marked fish is the problem with carcasses, especially old carcasses. This is also the reason that carcasses sampled during a late survey of Verrett Creek were not included in the estimate of abundance.

While the direction of differences in fractions marked among samples from groups excluded and included in the calculation of estimated abundance in 1998 were the same as in 1996 and 1997, the magnitude of these differences was slight. If all samples taken in 1998 except fish observed at the weir are pooled, the estimate of abundance would be 4% higher than the estimate based on only the most reliable samples.

To make the estimate of abundance past Kakwan Point comparable to other estimates of spawning abundance, harvests in the commercial and aboriginal fisheries should be subtracted. The final estimate of large spawning abundance in 1998 is 25,968 (= 28,133 – 2,165) (SE = 3,931).

The weir count of 4,879 large fish in the Little Tahltan River is 18.8% of the estimated escapement, for an expansion factor for weir counts to escapement of 5.33. This statistic compares favorably with expansion factors estimated for 1996 and 1997:

Year	Estimated expansion	SE	Source
1996	4.94	0.57	M-R experiment[a]
1997	5.03	0.53	M-R experiment[b]
1997	5.48	0.95	Telemetry Study
1998	5.33	0.80	M-R experiment
Avg	5.20	0.18	

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

[b] Modified from information in Pahlke and Etherton (1999).

The average expansion factor of 5.20 is greater than the factor 4 used traditionally to expand counts at the weir.

Migration patterns and run timing of chinook salmon returning to the Stikine River are similar to those of fish returning to the Taku River, another large transboundary river (McPherson et al. 1996), in that fish spawning higher in the watershed tend to enter the river earlier. Chinook salmon bound for the Iskut River and its tributaries are smaller and later running than upriver stocks which may result in higher harvest rates in gillnet fisheries targeting sockeye salmon.

Estimated age compositions for the population in the Stikine River 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% of the return, sometimes much more, while jacks are much rarer in Stikine River chinook salmon. The 1998 samples of carcasses above the Little Tahltan weir included 61 small (<440 mm MEF) jacks, the most ever observed there. Very few small chinook salmon are observed in the live samples at the weir indicating that the smallest fish may be able to squeeze through the weir unobserved.

This was the second year in a row that chinook salmon of hatchery origin were collected in Andrew Creek. This is not too surprising because brood stock from Andrew Creek is used in the Crystal Lake Hatchery near Petersburg and in remote releases at Earl West Cove, near Wrangell. More unexpected was the recovery in Andrew Creek in 1998, of two chinook salmon CWT tagged as wild juveniles in the Unuk River. The Unuk is a large glacial river flowing into Behm Canal northeast of Ketchikan, Alaska, with an ongoing program to mark wild juvenile chinook salmon with CWTs (Jones et al. 1998). Documented straying of CWTd wild chinook salmon is extremely rare.

CONCLUSIONS AND RECOMMENDATIONS

This was the third year of estimating the total escapement of chinook salmon to the Stikine River. We confirmed that it is feasible to conduct a mark-recapture experiment with acceptable results using methods developed in 1995 and 1996. Drift gillnets are an effective method of capturing enough large chinook salmon migrating up the Stikine River for an experiment; however, CPUE varies with changing river conditions and is not a good indicator of run strength. Results of three years' studies also confirm that counts of salmon through the Little Tahltan River weir are a useful index of chinook salmon escapement to the Stikine River, although the present expansion of 4 times the weir count probably underestimates escapement. 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 net hour, near Kakwan Point, Stikine River, 1998.

Date	Minutes	Large chinook	Jacks	Sockeye	Temp. (°C)	Depth	Catch/net/ hour	Large chinook cumul.	Cumul. percent
5/4/98	78	0	0	0	7.5	12.2	0.00	0	0.000
5/5/98	55	0	0	0	7.0	13.0	0.00	0	0.000
5/6/98	331	2	0	0	6.0	13.5	0.36	2	0.005
5/7/98	490	3	0	0		13.5	0.37	5	0.012
5/8/98	508	3	0	0	6.0	13.0	0.35	8	0.019
5/9/98	495	6	2	0	6.0	12.0	0.73	14	0.032
5/10/98	490	7	0	0	6.0	11.8	0.86	21	0.049
5/11/98	495	1	0	0	7.0	11.7	0.12	22	0.051
5/12/98	490	5	0	0	7.0	11.9	0.61	27	0.063
5/13/98	491	5	1	0	7.0	12.5	0.61	32	0.074
5/14/98	474	4	0	0	7.0	12.8	0.51	36	0.083
5/15/98	501	8	0	0	8.0	12.8	0.96	44	0.102
5/16/98	482	6	0	0	9.0	13.5	0.75	50	0.116
5/17/98	483	8	0	0	9.0	14.2	0.99	58	0.134
5/18/98	241	5	0	0		14.8	1.24	63	0.146
5/19/98	479	5	1	0	9.0	15.4	0.63	68	0.157
5/20/98	500	7	1	0	9.0	16.0	0.84	75	0.174
5/21/98	392	2	0	0	9.0	16.2	0.31	77	0.178
5/22/98	245	2	0	0	8.5	16.8	0.49	79	0.183
5/23/98	486	7	1	0	9.0	17.9	0.86	86	0.199
5/24/98	494	4	1	0	9.0	18.1	0.49	90	0.208
5/25/98	486	5	0	0	8.0	18.4	0.62	95	0.220
5/26/98	492	1	0	0	10.0	20.0	0.12	96	0.222
5/27/98	296	1	0	0	9.5	22.5	0.20	97	0.225
5/28/98	20	0	0	0	9.5	23.7	0.00	97	0.225
5/29/98	470	0	0	0	10.0	24.8	0.00	97	0.225
5/30/98	465	1	0	0	10.0	25.1	0.13	98	0.227
5/31/98	484	0	0	1	10.0	25.0	0.00	98	0.227
6/1/98	501	2	0	0	10.0	25.8	0.24	100	0.231
6/2/98	370	1	0	0	10.0	24.5	0.16	101	0.234
6/3/98	494	0	0	0	10.0	23.5	0.00	101	0.234
6/4/98	244	0	0	0	10.0	22.6	0.00	101	0.234
6/5/98	492	3	0	0	10.5	22.8	0.37	104	0.241
6/6/98	486	1	0	0	11.0	23.2	0.12	105	0.243
6/7/98	523	5	0	0	11.0	22.8	0.57	110	0.255
6/8/98	485	3	1	0	11.0	23.0	0.37	113	0.262
6/9/98	237	0	0	0	11.0	23.8	0.00	113	0.262
6/10/98	497	5	0	0	10.0	23.8	0.60	118	0.273
6/11/98	491	3	0	0	10.0	22.2	0.37	121	0.280
6/12/98	481	13	1	0	9.5	20.9	1.62	134	0.310
6/13/98	505	22	0	0	9.5	19.1	2.61	156	0.361
6/14/98	490	20	1	1	9.0	18.5	2.45	176	0.407
6/15/98	513	14	0	0	8.0	19.5	1.64	190	0.440
6/16/98	494	23	2	0	10.0	18.8	2.79	213	0.493
6/17/98	484	23	2	0	10.0	18.5	2.85	236	0.546
6/18/98	501	14	0	3	11.0	18.2	1.68	250	0.579
6/19/98	490	8	0	1	11.2	18.8	0.98	258	0.597
6/20/98	491	15	0	0	11.0	19.8	1.83	273	0.632

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Appendix A1.–Page 2 of 2.

Date	Minutes	Large chinook	Jacks	Sockeye	Temp. (°C)	Depth	Catch/net/ hour	Large chinook cumul.	Cumul. percent
6/21/98	508	12	0	0	11.0	20.3	1.42	285	0.660
6/22/98	494	12	0	5	10.0	19.2	1.46	297	0.688
6/23/98	492	18	0	1	10.2	19.2	2.20	315	0.729
6/24/98	361	14	0	3	9.0	18.5	2.33	329	0.762
6/25/98	508	24	0	2	10.5	17.7	2.83	353	0.817
6/26/98	487	20	2	3	11.0	17.9	2.46	373	0.863
6/27/98	493	15	1	1	11.0	18.8	1.83	388	0.898
6/28/98	487	4	0	0	11.0	19.6	0.49	392	0.907
6/29/98	245	2	0	0	10.0	19.8	0.49	394	0.912
6/30/98	479	12	0	4	11.0	19.1	1.50	406	0.940
7/1/98	466	6	1	4	11.0	20.4	0.77	412	0.954
7/2/98	480	1	0	0	11.0	20.9	0.13	413	0.956
7/3/98	257	1	0	0	11.0	21.2	0.23	414	0.958
7/4/98	270	0	0	0	11.0	21.9	0.00	414	0.958
7/5/98	487	1	0	2	11.0	22.3	0.12	415	0.961
7/6/98	481	4	0	2	10.0	21.4	0.50	419	0.970
7/7/98	244	3	0	0	10.0	21.4	0.74	422	0.977
7/8/98	240	5	0	3	10.0	19.0	1.25	427	0.988
7/9/98	255	5	0	1	10.0	18.0	1.18	432	1.000
Total		432	18	37					

Appendix A2.–Origin of coded-wire tags recovered from chinook salmon collected at Andrew Creek weir, 1998.

Year	Head	Length	Tag code	Brood year	Agency	Rearing	Location	Date released	Release site	Tag ratio
1998	61674	780	44432	1993	ADFG	H	CRYSTAL LK/EARL WEST	21-May-95	EARL WEST COV 107-40	7.098
1998	61673	645	43559	1994	ADFG	W	(W) UNUK R 101-75	25-Oct-95	UNUK R 101-75	1.026
1998	61671	455	44236	1995	ADFG	W	(W) UNUK R 101-75	20-Oct-96	UNUK R 101-75	1
1998	61672	472	44538	1995	ADFG	H	CRYSTAL LK/EARL WEST	28-May-97	EARL WEST COV 107-40	10.822
1998	61675	511	44538	1995	ADFG	H	CRYSTAL LK/EARL WEST	28-May-97	EARL WEST COV 107-40	10.822

Appendix A3.–Computer files used to estimate the spawning abundance of chinook salmon in the Stikine River in 1998.

File Name	Description
EFFORT.xls	EXCEL spreadsheet with gillnet tagging data--daily effort, catch by species, and water depth by site; gillnet charts.
STIKINE98.XLS	EXCEL spreadsheet of Kakwan Pt. tagging data, AWL, tag numbers, dates.
CKTAG98.xls	EXCEL spreadsheet with recovery data for chinook salmon in the Stikine River in 1998. Includes recovery data by tributary (date, length (MEF), sex, age and any marks); length frequencies; length at age; age composition of gillnet and tributary samples; KS test data; charts.
CHISQUAR98.XLS	Chi-square tests for Stikine chinook, 1998.
TAHLTAGE.xls	EXCEL spreadsheet with Little Tahltan samples--site, date, sex, length (MEF), age, tag numbers and comments.
VERSAM98.XLS	Verrett Creek AWL samples.
98ANDREWCHIN	Andrew Creek AWL samples.