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

by

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October 2000

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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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 1999 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 during May, June, and July, 1999 to capture 318 immigrant chinook salmon, from which 254 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. We used a modified Petersen model to estimate an immigration of 23,716 (SE = 3,240) large chinook salmon to the Stikine River above Kakwan Point. Canadian fisheries on the Stikine River harvested 3,769 large chinook salmon, which left an escapement of 19,947 large fish. The total count of large fish at the Little Tahltan River weir was 4,738, representing about 20% of the estimated abundance of large fish above Kakwan Point. An aerial survey was used to estimate an escapement of 1,210 large fish in Andrew Creek. An estimated 20% of the chinook salmon passing by Kakwan Point were age -1.2, 22% age -1.3, 54% age -1.4, and 4% age -1.5; 136 males and 128 females were sampled. An estimated 13% of samples from the Little Tahltan River weir were age -1.2, 35% age -1.3, 47% age -1.4, and 2% age -1.5; 370 males and 311 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 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. Ten rivers in Southeast Alaska and Canada are surveyed annually: the Situk, Alsek, 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 (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 stocks in the river appear to be responding well to the rebuilding program (Pahlke 1996). As originally developed, The program 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 salmon 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 fisheries; aboriginal food fisheries target chinook salmon (Table 1). 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).

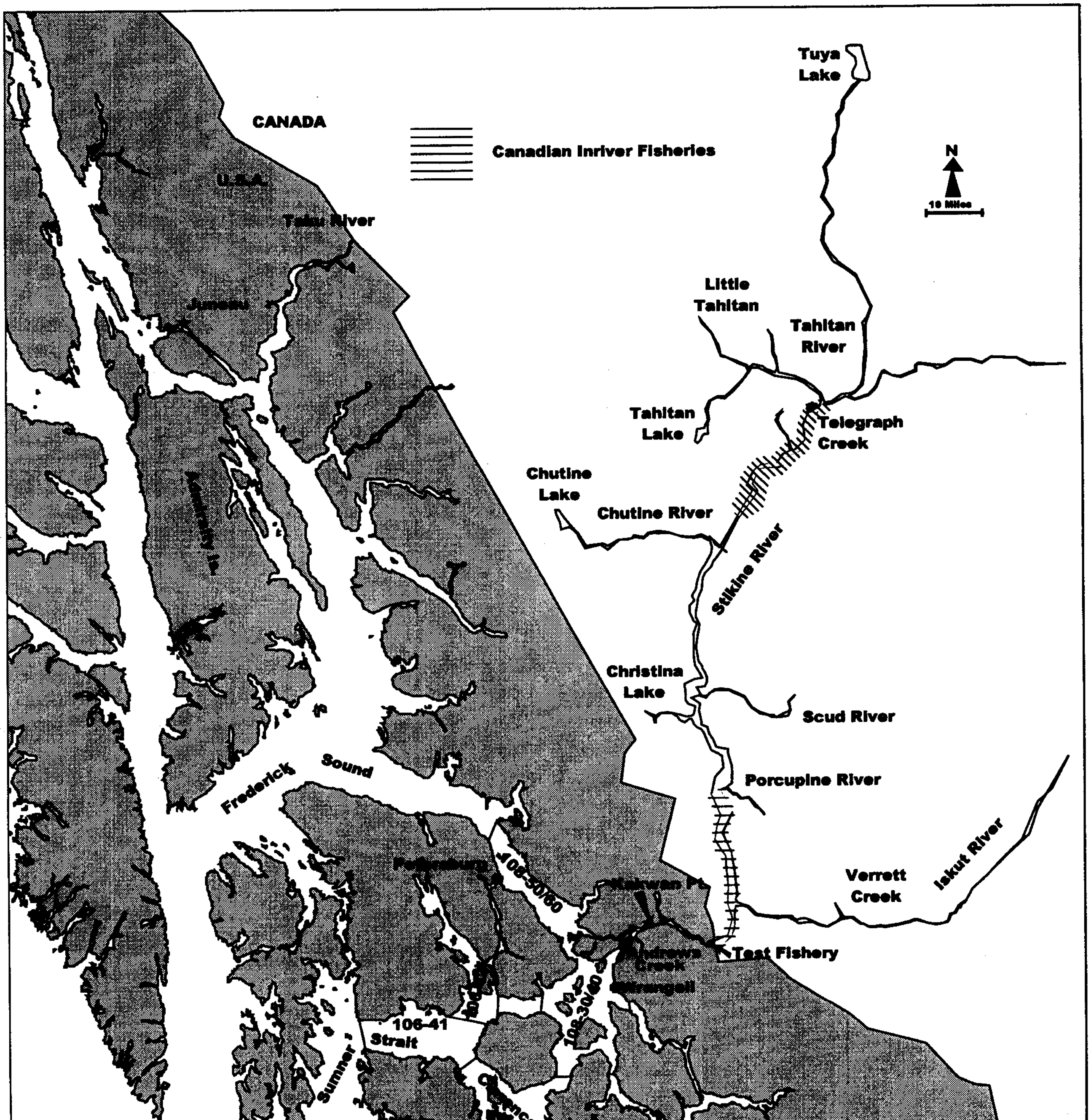


Figure 1.–Stikine River drainage, showing location of principal U.S. and Canadian fishing areas.

Table 1.–Harvests of chinook salmon in Canadian fisheries in the Stikine River and U.S. fisheries near the mouth of the river, 1975–1999.

Year	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			
			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
1999	1,078	1,824	789	2,127	12	24	463	765	97	853	1,361	3,769

[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 conducting aerial surveys to count spawners in 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. 2000).

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, 1975–1999. Abbreviations: H = helicopter survey, F = foot survey, W = weir count, A = airplane survey; E = excellent visibility, N = normal visibility, P = poor visibility.

	Little Tahltan River			Mainstem		Beatty		Andrew		North Arm		Clear	
Year	Peak count		Weir count[a]	Tahltan River		Creek		Creek		Creek		Creek	
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)	–		–	
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			4,738	–		–		605	E(A)	22	N(A)	–	

[a] Above weir harvest and broodstock collections are removed from weir counts; zero (0) fish removed in 1999.

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. 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. A 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) 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) chinook salmon <660 mm MEF (Mecum 1990). These smaller 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 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 radiotelemetry study to estimate distribution of spawners was also conducted.

The objectives of the 1999 study were:

(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) index abundance of 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 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 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. 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. Drift gillnets 120 feet (36.5 m) long, 18 feet (5.5 m) deep, and made of 7.25-inch (18.5-cm) stretch mesh, were fished on the lower Stikine River 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.

Captured chinook salmon were placed in a box filled with water, quickly untangled or cut from the net, marked, measured for length, sexed, and sample for scales (as per Johnson et al. 1993). Fish were classified as "large" if their MEF measurement was ≥660 mm, "medium" if their MEF was 440–659 mm or "small" if their MEF was <440 mm (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. Each uninjured fish was marked with a uniquely numbered, blue spaghetti tag consisting of a 2" (~5 cm) section of Floy tubing shrunk onto a 15" (~38 cm) piece of 80-lb (~36.3 kg) monofilament fishing line. The monofilament line was sewn through the musculature of

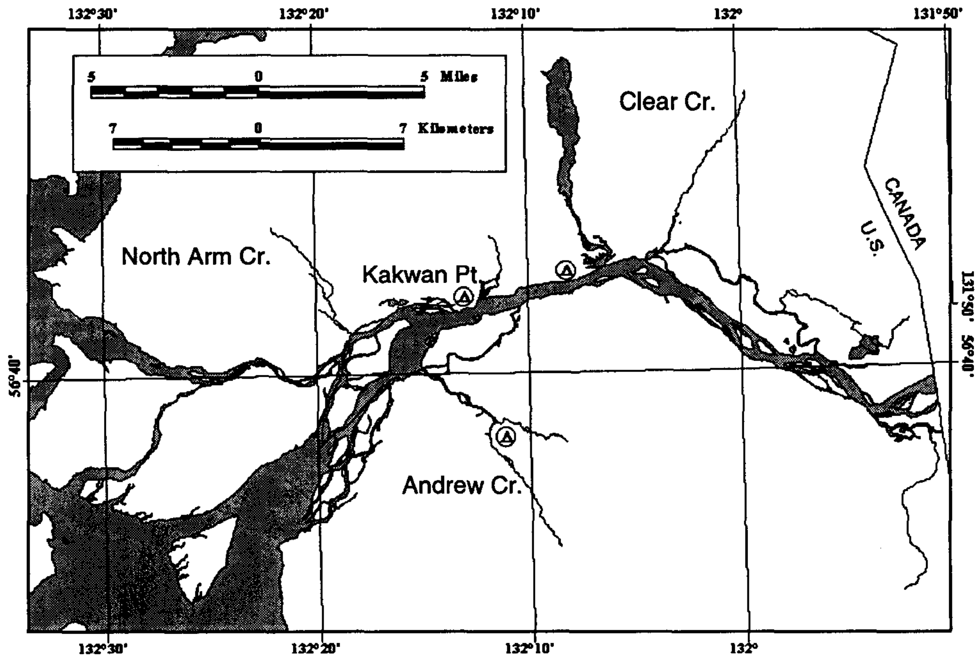


Figure 2.–Location of drift gillnet site on the lower Stikine River, 1999.

the fish approximately 20 mm posterior and ventral to the dorsal fin and secured by crimping both ends. 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.

Upstream Sampling

Sampling on the spawning grounds and in the inriver commercial and test 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 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 dipnets, 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.

Daily foot surveys of the spawning area in Verrett Creek (Figure 1) were conducted from August 2–11, 1999. 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 and sex, length, and marked composition data were collected on Andrew Creek (Figure 2) by foot surveys in August and additional surveys were conducted from 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 get information on age, sex, length, and marked compositions.

ABUNDANCE

The number of marked large fish moving upstream from Kakwan Point was calculated 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 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 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) are expanded by the fraction of the catch sampled. All marked fish in the U.S. recreational harvest are assumed to be reported.

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 by expanding the peak count by a factor of two (Pahlke 1999). The number of marked fish recaptured in Andrew Creek are 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: (a) that 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) that 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 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. We assumed marked and unmarked fish experienced the same mortality rates from natural causes (assumption c). To avoid 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, 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 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.

Table 3.–Numbers of chinook salmon marked on lower Stikine River, removed by fisheries, and inspected for marks in tributaries in 1999, by length group. Bold numbers used in mark-recapture estimate.

		Length (MEF) in mm			
		0–439	440–659	≥660	Total
A. Released at Kakwan Point		0	58	254	312
B. Removed by:					
1. U.S. recreational fisheries		0	0	2	2
2. U.S gillnet		0	0	0	0
3. Andrew Creek		0	0	0	0
Subtotal of removals		0	0	2	2
C. Estimated number of marked fish remaining in mark-recapture experiment		0	58	**252**	310
D. Canadian recreational fisheries				1	
Observed at:					
Little Tahltan weir	Observed [a]	44	158	3,782	3,984
	Marked [b]	0	0	26	26
	Marked/observed	0.0000	0.0000	0.0069	0.0065
E. Inspected at:					
1. L. Tahltan weir	Inspected	51	168	**956**	1,175
	Marked [c]	0	0	**16**	16
	Marked/inspected	0.0000	0.0000	0.0167	0.0136
2. Above weir	Inspected	42	37	105	184
carcasses	Marked	0	2	0	2
	Marked/inspected	0.0000	0.0541	0.0000	0.0109
3. Verrett River	Inspected	1	32	**94**	127
fresh	Marked	0	1	**1**	2
	Marked/inspected	0.0000	0.0313	0.0106	0.0157
	Inspected [d]				2
old carcasses	Marked				0
	Marked/inspected				0.0000
Inriver commercial/test gillnet	Harvested	0	886	**2,980**	3,866
Lower	Marked [e,f,g]	0	14	**35**	49
	Marked/harvested	0.0000	0.0158	0.0117	0.0127
Upriver gillnet	Harvested	0	475	789	1,264
Commercial and aboriginal	Marked	0	2	7	9
	Marked/harvested	0.0000	0.0042	0.0089	0.0071
Andrew Creek	Inspected	8	45	101	154
	Marked	0	0	0	0
	Marked/inspected	0.0000	0.0000	0.0000	0.0000

[a] Sizes of fish <660 mm estimated by proportions in E.1; 202 jacks passed through weir.

[b] Number of large tagged fish (24) expanded to 24/(1-1/16) = 26, based on tag loss (1) among 16 large fish sampled at the weir.

[c] Includes one large fish that lost its tag.

[d] Two deteriorated carcasses inspected but not measured.

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

[f] Number of jacks observed with tags (12) expanded to 12 + 1/0.690 = 14, based on tag loss (1) among jacks sampled in inriver commercial and test fisheries and the proportion of the harvest of jacks sampled (576 sampled/886 = 0.650).

[g] Number of large fish observed with tags (26) expanded to 26 + 2/0.287 = 35, based on tag loss (2) among large fish sampled in inriver commercial and test fisheries and the proportion of the harvest of large fish sampled (662 sampled/2,980 = 0.222).

Proportions by age or by sex in gillnet and spawning grounds samples were estimated by:

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

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

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

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

n = the sample size.

Estimated age composition of chinook 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

Two hundred sixty (260) large (≥660 mm MEF) and 58 medium (440–659 mm MEF) chinook salmon were captured in the lower Stikine River between May 7 and July 9, 1999, of which 254 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 2.30 fish/net/hour, and the highest catch occurred on July 2 when 12 large chinook were captured (Figure 4). The date of 50% cumulative catch was June 3, the earliest date recorded by this project.

However, catches were low from June 10 to 22 because of high water conditions (Figures 3–4; Appendix A1). 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 essentially 1:1 (158 females, 160 males). In addition, 17 sockeye were captured and released (Appendix A1).

UPSTREAM SAMPLING

The lower inriver Canadian commercial and test gillnet fisheries began fishing June 13 and 21, respectively, and harvested 2,980 large and 886 jack chinook salmon. Twenty-eight (28) large marked fish were recovered. Two of the recovered fish had lost their tags. The number of large marked fish recovered was expanded to 35, based on the number of tags lost and the proportion of the harvest of large fish sampled (Table 3). Aboriginal and commercial fisheries near Telegraph Creek harvested 789 large and 475 jack chinook salmon; tags were recovered from 9 marked fish. One large marked fish was reported from the Canadian sport fishery on the Tahltan River, which is not sampled but believed to harvest about 200 fish annually. Two large marked fish were reported from a creel survey of the U.S. recreational fishery near Petersburg and Wrangell. All marked fish in the recreational harvest were assumed reported. No marked fish were reported in the U.S. district 106/108 gillnet fishery.

Technicians examined 1,175 chinook salmon for marks at the Little Tahltan River weir, 956 of which were large fish. Sixteen (16) large marked fish were recovered (Table 3). One of the recovered fish had lost its numbered tag. The remaining fish passing through the weir were not physically examined for marks; however, each fish was observed from a distance and its size category and sex estimated. The presence of an additional 24 large marked fish was noted and this number was expanded to 26, based on one lost numbered tag among large fish inspected at the weir (Table 3). An additional 184 (105 large) previously unsampled carcasses were examined above the weir, and two marked jacks were recovered.

At Verrett Creek, 129 live and dead chinook salmon were examined (94 large, 32 medium, 1 small, and 2 unknown). One large and one medium marked fish were recovered. One carcass in the sample had deteriorated beyond

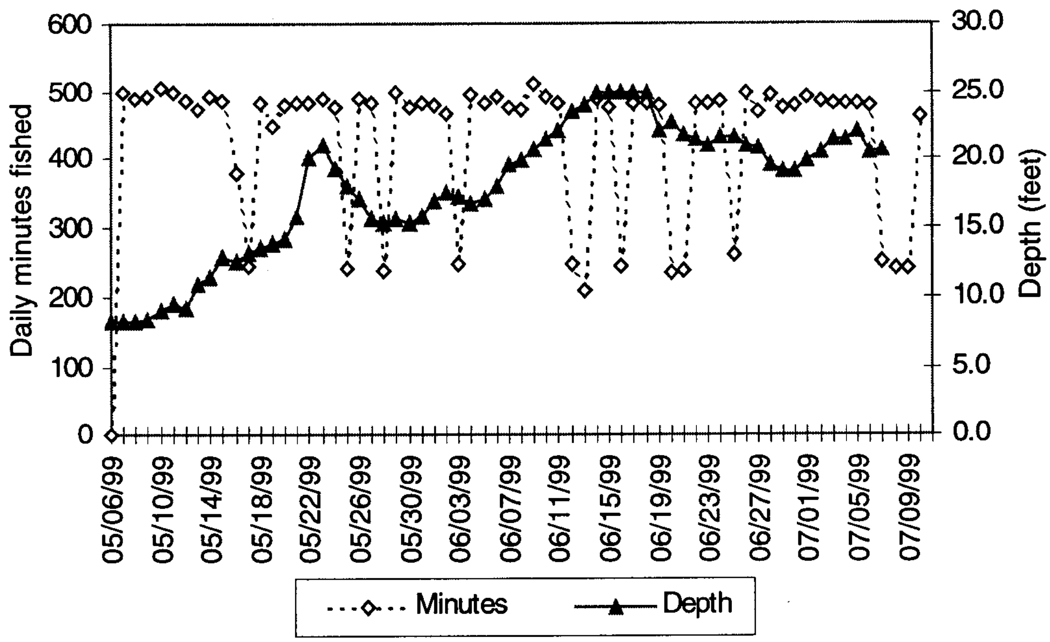


Figure 3.–Daily drift gillnet fishing effort (minutes) and river depth (ft), near Kakwan Point, lower Stikine River, 1999.

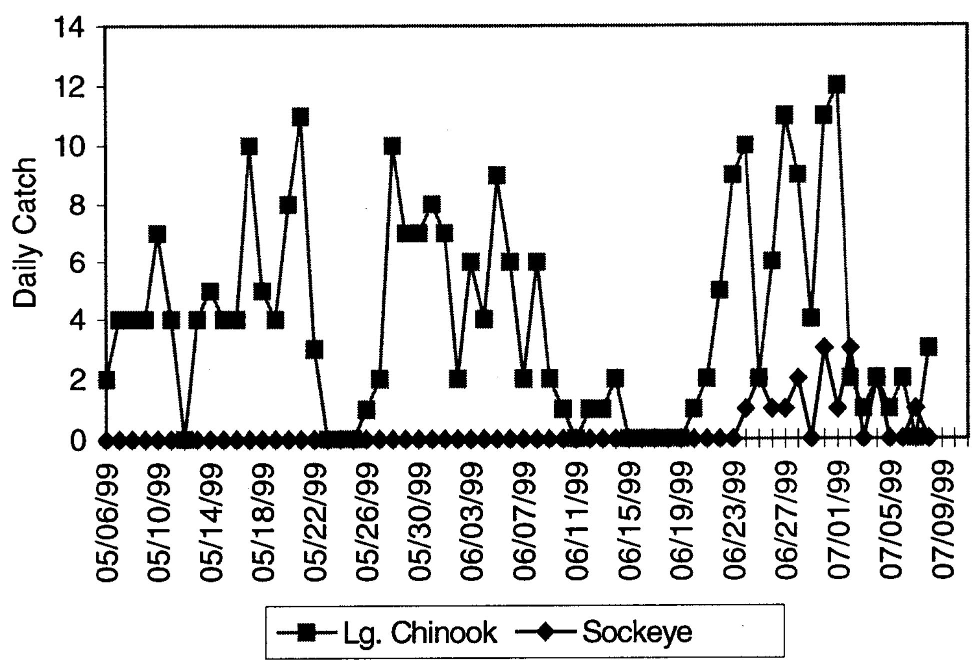


Figure 4.–Daily catch of chinook and sockeye salmon near Kakwan Point, 1999.

the point where length could be measured or scales could be taken. The remaining carcass could not be measured for length, but scales were collected.

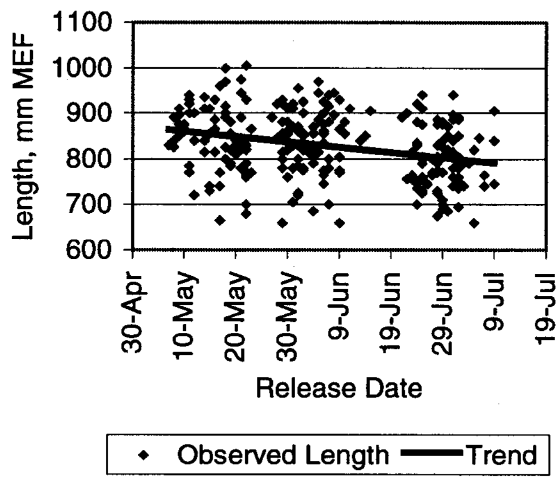
At Andrew Creek 154 (101 large) fish were examined in 1999, but no spaghetti tags were recovered. However, two fish with adipose clips were collected, one of which had been coded-wire tagged at Crystal Lake Hatchery and released at Earl West Cove; the remaining fish did not have a tag (Appendix A2).

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 commercial and test gillnet fisheries is 23,716 salmon (SE = 3,240; M = 252, C = 4,030, R = 42). For this estimate, all large marked fish intercepted by U.S. recreational fisheries (2 fish, with the assumption that all marked fish in the recreational harvest were reported) were censored from the experiment. Also, all large salmon marked prior to June 12 and caught in the inriver (lower) commercial and test gillnet fisheries (10 fish) were culled from the recaptures. The shortest delay for a marked fish between release at Kakwan Point and recapture in the gillnet fisheries was 1 day, with a maximum delay of 49 days and an average of 19 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. Fish bound for the Little Tahltan River pass by Kakwan Point in May and June, and fish bound for Verrett Creek pass by Kakwan Point in June and early July. The test and commercial fisheries began on June 13 and 21, respectively, just upstream of Kakwan Point and would exploit fish passing Kakwan Point in mid-June and July. Marked fractions (see Table 3 for data) estimated for large fish at the Little Tahltan weir (0.0167), Verrett Creek (0.0106) or the inriver (lower) commercial and test gillnet fisheries (0.0117) are not significantly different ($\chi^2 = 1.41$, df = 2, P = 0.49).

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. Inspection of the graph shows that for large chinook salmon, bigger fish tended to be caught early in the run and smaller fish later:



To determine whether these larger and smaller fish were marked with equal probability throughout the run, pooled length samples of large fish from the weir and the inriver commercial and test gillnet fisheries were arbitrarily split into two groups at the median length of large fish (830 mm MEF) to permit comparison of marked fractions:

	660–830 mm	≥831 mm
Marked	13	14
Unmarked	989	603
Marked fraction	0.013	0.023

These marked fractions are not significantly different ($\chi^2 = 2.20$, df = 1, P = 0.14).

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 length samples of large fish from the weir and the commercial and test gillnet fisheries were again split into two size groups as were samples of large fish marked at Kakwan Point. After censoring for fish that were removed by recreational fisheries (two large fish <830 mm MEF) the fractions (rates) of recaptured fish were compared as surrogates for probabilities of capture upstream:

	660–830 mm	≥831 mm
Recaptured	13	14
Not recaptured	118	107
Fraction recaptured	0.110	0.131

These fractions recaptured are not significantly different ($\chi^2 = 0.17$, df = 1, P = 0.76).

Although there is little evidence to support size-selective sampling downstream or upstream in the Stikine River in 1999, the size distributions of samples taken at Kakwan Point versus combined samples taken at the weir on the Little Tahltan River, in the inriver commercial and test gillnet fisheries, and at Verrett Creek are significantly different (Kolmogorov-Smirnov: $d_{max} = 0.1346$, n = 253, 1,709, P = 0.0003). This difference is due to the presence of smaller fish in the Verrett Creek and inriver gillnet samples (Figure 5). For reasons explained later, this inconsistency was discounted, and sampling at these three locations was assumed not to be size-selective.

An aerial survey was conducted at Andrew Creek on August 2 and 605 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, yielding an estimate of 1,210 fish (Pahlke 1999)

AGE, SEX, AND LENGTH COMPOSITION

Age 1.4 chinook salmon dominated all samples except those from the inriver commercial and test gillnet fisheries and Andrew Creek, constituting an estimated 54% of fish captured at Kakwan Point, 47% at the weir across the Little Tahltan River, and 40% at Verrett Creek. Age 1.2 chinook salmon dominated the samples from the commercial and test gillnet fisheries and Andrew Creek at 39% and 33%, respectively, although age 1.4 was the second largest group (Tables 4–9).

Estimated age composition was not significantly different between Kakwan Point and Verrett Creek locations ($\chi^2 = 6.00$ df = 3, P = 0.11). However, Kakwan Point was different from Little Tahltan ($\chi^2 = 17.61$, df = 3, P < 0.001), the two spawning ground locations differed significantly from each other ($\chi^2 = 9.94$, df = 3, P = 0.02), and the inriver commercial and test gillnet samples differed from the Kakwan Point samples ($\chi^2 = 49.84$, df = 3, P < 0.000). 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 third year in a row. Among these populations, 40–49% were female, lower than in 1998 and likely due to the higher incidence of age 1.1 and 1.2 fish, which tend to be male. As seen in 1996, 1997 and 1998, mean lengths were dissimilar among sampled populations, with chinook salmon from Verrett Creek and the inriver commercial and test gillnet fisheries being significantly smaller than fish in other sampled populations ($t_{stat} > t_{crit}$ and P < 0.05 in all cases). These differences are consistent with differences in cumulative distributions reported in the previous section (Figure 5). 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).

Abundance of small and medium salmon was estimated as described in Appendix A3 and estimated abundance by age and sex of the entire escapement is calculated in Table 10.

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, 2000), 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 and test gillnet fisheries began after about half the run had passed Kakwan Point in 1999. Under these circumstances, chinook salmon sampled at the

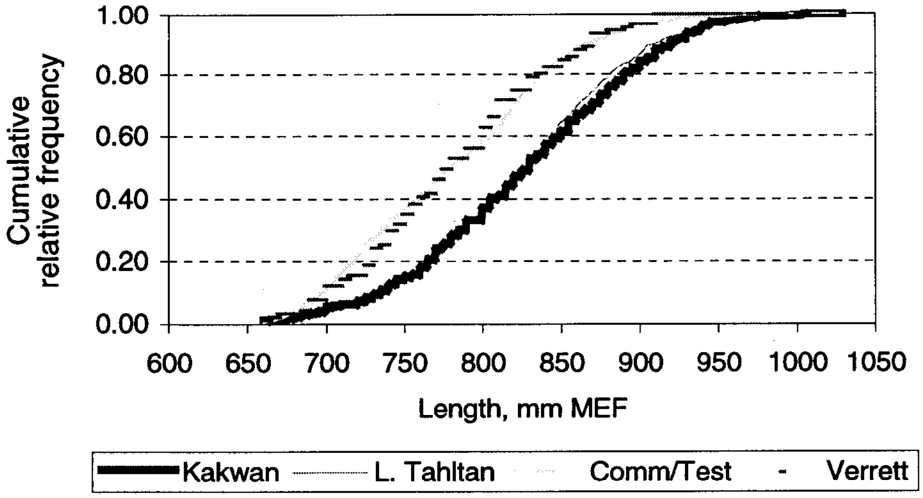


Figure 5.–Cumulative relative frequency of large chinook salmon (≥660 mm MEF) captured at Kakwan Point, at the weir on the Little Tahltan River, at Verrett Creek, and sampled from the commercial and test fisheries in the lower Stikine River, 1999.

Little Tahltan River should tend to be larger, and those sampled at Verrett Creek and in the gillnet fisheries should be smaller, even if sampling in general was not size-selective. Of the length distributions shown in Figure 5, the one for samples taken at Kakwan Point is an unbiased estimate of the length distribution of all large chinook salmon entering the Stikine River.

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 between June 7–25 had the highest average daily fishing time and 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, 473 net-hours in 1998, and 462 net-hours in 1999, thus maintaining 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 and test fisheries were not statistically different in 1999, indicating every fish had an equal chance of being marked in event 1. This was despite large fluctuations in river depth which affected the catch per net hour, especially during the last week of May and mid-June when the peak of the Little Tahltan run would have been passing (Figures 3 and 4). High water conditions may delay migrating fish and offset the reduced fishing effort.

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 on 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 a problem with carcasses, especially old carcasses.

Table 4.–Estimated age composition and mean length by sex of chinook salmon passing by Kakwan Point, 1999.

		BROOD YEAR AND AGE CLASS									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	TOTAL
Females	n		2		40		79	1	6		128
	% age comp.		1.6		31.3		61.7	0.8	4.7		48.5
	SE of %		1.1		4.1		4.3	0.8	1.9		3.1
	Avg. length		625		751		831	725	867		803
	SE		15		5		5	–	19		5
Males	n		50		18		63		4	1	136
	% age comp.		36.8		13.2		46.3		2.9	0.7	51.5
	SE of %		4.1		2.9		4.3		1.5	0.7	3.1
	Avg. length		600		742		889		891	840	763
	SE		6		16		6		43	–	12
Sexes	n		52		58		142	1	10	1	264
combined	% age comp.		19.7		22.0		53.8	0.4	3.8	0.4	100.0
	SE of %		2.5		2.6		3.1	0.4	1.2	0.4	0.0
	Avg. length		601		748		857	725	877	840	783
	SE		5		6		5	–	19	–	7

Table 5.–Estimated age composition and mean length by sex of chinook salmon harvested in the Canadian commercial and test gillnet fisheries on the Lower Stikine River, 1999.

		BROOD YEAR AND AGE CLASS									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	TOTAL
Females	n		5		92		96	1	10	4	208
	% age comp.		2.4		44.2		46.2	0.5	4.8	1.9	39.7
	SE of %		1.1		3.5		3.5	0.5	1.5	1.0	2.1
	Avg. length		681		723		814	794	804	839	771
	SE		37		4		4	---	17	33	4
Males	n	11	197		43		56	3	6		316
	% age comp.	3.5	62.3		13.6		17.7	0.9	1.9		60.3
	SE of %	1.0	2.7		1.9		2.2	0.5	0.8		2.1
	Avg. length	396	546		687		836	785	791		618
	SE	10	4		12		8	25	83		8
Sexes	n	11	202		135		152	4	16	4	524
combined	% age comp.	2.1	38.5		25.8		29.0	0.8	3.1	0.8	100.0
	SE of %	0.6	2.1		1.9		2.0	0.4	0.8	0.4	0.0
	Avg. length	396	549		712		823	788	799	839	679
	SE	10	4		5		4	18	31	33	6

Table 6.–Estimated age composition and mean length by sex of chinook salmon at Little Tahltan River weir, 1999.

		Brood Year and Age Class									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Females	n	1	2		113		182	2	10	1	311
	% age comp.	0.3	0.6		36.3		58.5	0.6	3.2	0.3	45.7
	SE of %	0.3	0.5		2.7		2.8	0.5	1.0	0.3	1.9
	Avg. length	376	635		758		836	796	838	861	805
	SE	–	32		3		3	2	18	–	3
Males	n	18	88	1	122	1	135		5		370
	% age comp.	4.9	23.8	0.3	33.0	0.3	36.5		1.4		54.3
	SE of %	1.1	2.2	0.3	2.4	0.3	2.5		0.6		1.9
	Avg. length	355	558	392	737	621	841		811		713
	SE	5	6	–	5	–	5		45		8
Sexes combined	n	19	90	1	235	1	317	2	15	1	681
	% age comp.	2.8	13.2	0.1	34.5	0.1	46.5	0.3	2.2	0.1	100.0
	SE of %	0.6	1.3	0.1	1.8	0.1	1.9	0.2	0.6	0.1	0.0
	Avg. length	357	560	392	747	621	838	796	829	861	755
	SE	5	6	–	3	–	3	2	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, 1999.

		Brood Year and Age Class									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Females	n		1		3		7				11
	% age comp.		9.1		27.3		63.6				15.5
	SE of %		9.1		14.1		15.2				4.3
	Avg. length		553		760		820				779
	SE		---		5		11				25
Males	n	31	24				5				60
	% age comp.	51.7	40.0				8.3				84.5
	SE of %	6.5	6.4				3.6				4.3
	Avg. length	344	504				873				452
	SE	6	12				23				20
Sexes combined	n	31	25		3		12				71
	% age comp.	43.7	35.2		4.2		16.9				100.0
	SE of %	5.9	5.7		2.4		4.5				0.0
	Avg. length	344	506		760		842				503
	SE	6	12		5		14				22

Table 8.–Estimated age composition and mean length by sex of moribund and recently expired chinook salmon in Verrett Creek, 1999.

		BROOD YEAR AND AGE CLASS									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	TOTAL
Females	n		2		18		26		3		49
	% age comp.		4.1		36.7		53.1		6.1		49.0
	SE of %		2.9		7.0		7.2		3.5		5.0
	Avg. length		713		741		801		813		776
	SE		128		8		9		29		8
Males	N	1	23		11		14		2		51
	% age comp.	2.0	45.1		21.6		27.5		3.9		51.0
	SE of %	2.0	7.0		5.8		6.3		2.7		5.0
	Avg. length	390	573		751		813		813		683
	SE	---	11		23		23		4		19
Sexes	n	1	25		29		40		5		100
combined	% age comp.	1.0	25.0		29.0		40.0		5.0		100.0
	SE of %	1.0	4.4		4.6		4.9		2.2		0.0
	Avg. length	390	585		745		805		813		729
	SE	---	14		10		10		20		11

Table 9.–Estimated age composition and mean length by sex of chinook salmon in Andrew Creek, 1999.

		BROOD YEAR AND AGE CLASS									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	TOTAL
Females	n		2		10		26		5		43
	% age comp.		4.7		23.3		60.5		11.6		32.1
	SE of %		3.2		6.5		7.5		4.9		4.0
	Avg. length		698		744		841		869		815
	SE		23		17		12		28		12
Males	n	5	42		28		15		1		91
	% age comp.	5.5	46.2		30.8		16.5		1.1		67.9
	SE of %	2.4	5.3		4.9		3.9		1.1		4.0
	Avg. length	382	578		747		837		945		666
	SE	14	9		11		18		---		15
Sexes	n	5	44		38		41		6		134
combined	% age comp.	3.7	32.8		28.4		30.6		4.5		100.0
	SE of %	1.6	4.1		3.9		4.0		1.8		0.0
	Avg. length	382	583		746		840		882		714
	SE	14	10		9		10		26		12

Table 10.–Estimated abundance and composition by age and sex of the escapement of chinook salmon in the Stikine River, 1999.

		Brood Year and Age Class									
		1996	1995	1995	1994	1994	1993	1993	1992	1992	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
PANEL A. AGE COMPOSITION OF SMALL AND MEDIUM CHINOOK SALMON											
Males	n	50	1	128	1	6	0	1	0	0	187
	%	26.2	0.5	67.0	0.5	3.1		0.5			97.9
	SE of %	3.2	0.5	3.4	0.5	1.3		0.5			1.0
	Escapement	1,509	30	3,863	30	181		30			5,643
	SE of Esc.	385	30	893	30	82		30			1,276
Females	n	1	0	3	0	0	0	0	0	0	4
	%	0.5		1.6							2.1
	SE of %	0.5		0.9							1.0
	Escapement	30		91							121
	SE of Esc.	30		55							64
Sexes combined	n	51	1	131	1	6	0	1	0	0	191
	%	26.7	0.5	68.6	0.5	3.1		0.5			100.0
	SE of %	3.2	0.5	3.4	0.5	1.3		0.5			0.0
	Escapement	1,539	30	3,953	30	181		30			5,764
	SE of Esc.	392	30	913	30	82		30			1,302
PANEL B. AGE COMPOSITION OF LARGE CHINOOK SALMON											
Males	n	0	0	7	0	127	0	153	0	7	294
	%			1.1		19.2		23.1		1.1	44.5
	SE of %			0.4		1.5		1.6		0.4	1.9
	Escapement			211		3,832		4,617		211	8,872
	SE of Esc.			86		692		817		86	1,491
Females	n	0	0	2	0	134	2	215	1	13	367
	%			0.3		20.3	0.3	32.5	0.2	2.0	55.5
	SE of %			0.2		1.6	0.2	1.8	0.2	0.5	1.9
	Escapement			60		4,044	60	6,488	30	392	11,075
	SE of Esc.			43		725	43	1,113	30	124	1,839
Sexes combined	n	0	0	9	0	261	2	368	1	20	661
	%			1.4		39.5	0.3	55.7	0.2	3.0	100.0
	SE of %			0.5		1.9	0.2	1.9	0.2	0.7	0.0
	Escapement			272		7,876	60	11,105	30	604	19,947
	SE of Esc.			99		1,333	43	1,844	30	164	3,240
PANEL C. AGE COMPOSITION OF ALL CHINOOK SALMON											
Males	n	50	1	135	1	133	0	154	0	7	481
	%	5.9	0.1	15.8	0.1	15.6		18.1		0.8	56.5
	SE of %	1.5	0.1	3.3	0.1	1.4		1.7		0.3	3.0
	Escapement	1,509	30	4,074	30	4,014		4,647		211	14,515
	SE of Esc.	385	30	897	30	697		817		86	1,962
Females	n	1	0	5	0	134	2	215	1	13	371
	%	0.1		0.6		15.7	0.2	25.2	0.1	1.5	43.5
	SE of %	0.1		0.3		1.6	0.2	2.1	0.1	0.4	3.0
	Escapement	30		151		4,044	60	6,488	30	392	11,196
	SE of Esc.	30		70		725	43	1,113	30	124	1,840
Sexes combined	n	51	1	140	1	267	2	369	1	20	852
	%	6.0	0.1	16.4	0.1	31.3	0.2	43.3	0.1	2.3	100.0
	SE of %	1.5	0.1	3.4	0.1	2.3	0.2	3.1	0.1	0.5	0.0
	Escapement	1,539	30	4,225	30	8,057	60	11,135	30	604	25,711
	SE of Esc.	392	30	918	30	1,336	43	1,844	30	164	3,492

To make the estimate of abundance past Kakwan Point 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 1999 is 19,947 (= 23,716-3,769; SE = 3,240).

From 1996 to 1999, the counts at the Little Tahltan River weir have been very similar, ranging from 4,738 to 5,547. The annual mark-recapture estimate of total abundance was also very similar from 1996 to 1998, but the estimate for 1999 dropped significantly:

	1996	1997	1998	1999
Peak catch	June 10 (47)	June 10 (53)	June 17 (23)	July 12 (12)
50% catch	June 12 (362)	June 10 (453)	June 17 (473)	June 3 (462)
Total effort	362	453	473	462
Total catch	742	691	432	260
Weir	4,820	5,547	4,873	4,738
Pop. Est.	31,718[a]	31,509[a]	28,133	23,716

[a] Modified from data in Pahlke and Etherton (1998, 1999).

The weir count in 1999 of 4,738 large fish in the Little Tahltan River is 20% of the estimated abundance past Kakwan Point, for an expansion factor of 5.00 for weir counts to abundance. This statistic is the smallest expansion factor estimated thus far. This may be a result of weak returns to the Iskut River and other lower river stocks, which would not be reflected in returns to Little Tahltan River:

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
Avg	5.39	0.84	

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

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

Tag loss in samples from the inriver gillnet fisheries was also inexplicably high despite efforts to improve tag durability, which added a level of uncertainty in the number of recaptures from those fisheries. These factors may have confounded the escapement estimate. Still, the average expansion factor of 5.39 is greater than the factor 4 used traditionally to expand counts at the weir.

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 appear to be rarer in Stikine River chinook salmon. Jacks were uncommon in 1996 through 1998, and more common in 1999. The 1999 samples of carcasses above the Little Tahltan weir included 42 small (<440mm MEF) jacks. Fewer 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 third 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.

The U.S. and Canada concurred on a new Pacific salmon treaty agreement in June 1999. Included in that agreement was a specific directive in Annex IV of the treaty to develop abundance-based management of Stikine River chinook salmon. Preliminary analysis indicates little relationship ($R^2 = 0.37$) between CPUE at Kakwan Point and run strength. The data are insufficient at this time to use CPUE as a predictor towards satisfying the Annex IV directive.

An in-season mark-recapture experiment with Canadian gillnet fisheries, starting in May to recover tags over the entire migration, appears to be the most feasible tool for abundance-based management.

CONCLUSIONS AND RECOMMENDATIONS

This was the fourth 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, even though we have maximized effort. The results of four years' studies also confirm that counts of salmon through the Little Tahltan River weir is a useful index of chinook salmon escapement to the Stikine River, but the weir counts do not serve as a timely indicator of run strength for in-season abundance-based management. We recommend starting the test fishing operation early enough to cover the entire chinook salmon migration. This would yield information from event 2 mark-recapture experiments that is more representative and timely for in-season abun-dance estimation. Also, 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, 1999.

Date	Minutes	Large chinook	Jacks	Sockeye	Temp	Depth	catch/net/ hour	Cum. large chinook	Cum. percent
05/07/99	498	2	0	0	5.0	8.0	0.24	2	0.008
05/08/99	490	4	0	0	5.5	8.3	0.49	6	0.023
05/09/99	492	4	0	0	6.0	8.3	0.49	10	0.038
05/10/99	504	4	1	0	6.0	8.3	0.48	14	0.054
05/11/99	499	7	0	0	6.0	8.4	0.84	21	0.081
05/12/99	486	4	2	0	6.0	9.0	0.49	25	0.096
05/13/99	473	0	0	0	6.8	9.5	0.00	25	0.096
05/14/99	492	4	0	0	6.8	9.3	0.49	29	0.112
05/15/99	486	5	0	0	6.5	10.9	0.62	34	0.131
05/16/99	378	4	1	0	6.0	11.5	0.63	38	0.146
05/17/99	243	4	0	0	6.0	12.9	0.99	42	0.162
05/18/99	482	10	2	0	7.0	12.6	1.24	52	0.200
05/19/99	448	5	0	0	6.5	13.3	0.67	57	0.219
05/20/99	480	4	0	0	6.8	13.5	0.50	61	0.235
05/21/99	484	8	0	0	6.5	13.8	0.99	69	0.265
05/22/99	484	11	1	0	6.0	14.1	1.36	80	0.308
05/23/99	489	3	0	0	6.0	15.8	0.37	83	0.319
05/24/99	476	0	0	0	3.0	20.0	0.00	83	0.319
05/25/99	240	0	0	0	4.0	21.0	0.00	83	0.319
05/26/99	489	0	0	0	4.5	19.3	0.00	83	0.319
05/27/99	483	1	0	0	4.8	18.0	0.12	84	0.323
05/28/99	237	2	3	0	6.0	17.0	0.51	86	0.331
05/29/99	497	10	2	0	6.8	15.6	1.21	96	0.369
05/30/99	477	7	2	0	6.3	15.3	0.88	103	0.396
05/31/99	483	7	2	0	7.0	15.5	0.87	110	0.423
06/01/99	480	8	1	0	7.0	15.2	1.00	118	0.454
06/02/99	468	7	4	0	8.3	15.7	0.90	125	0.481
06/03/99	248	2	1	0	8.0	16.8	0.48	127	0.488
06/04/99	494	6	0	0	6.5	17.5	0.73	133	0.512
06/05/99	484	4	1	0	5.8	17.1	0.50	137	0.527
06/06/99	491	9	2	0	7.0	16.7	1.10	146	0.562
06/07/99	475	6	1	0	7.0	17.0	0.76	152	0.585
06/08/99	472	2	0	0	9.0	18.0	0.25	154	0.592
06/09/99	511	6	1	0	7.0	19.5	0.70	160	0.615
06/10/99	492	2	0	0	9.0	19.8	0.24	162	0.623
06/11/99	483	1	0	0	9.0	20.7	0.12	163	0.627
06/12/99	247	0	0	0	9.0	21.5	0.00	163	0.627
06/13/99	209	1	0	0	9.0	22.0	0.29	164	0.631
06/14/99	488	1	0	0	8.5	23.5	0.12	165	0.635
06/15/99	475	2	0	0	8.5	24.0	0.25	167	0.642
06/16/99	245	0	0	0	7.5	25.0+	0.00	167	0.642
06/17/99	484	0	0	0	7.5	25.0+	0.00	167	0.642
06/18/99	483	0	0	0	8.0	25.0+	0.00	167	0.642
06/19/99	479	0	0	0	8.0	25.0+	0.00	167	0.642
06/20/99	234	0	0	0	9.0	25.0+	0.00	167	0.642
06/21/99	238	1	0	0	8.0	22.0	0.25	168	0.646
06/22/99	482	2	0	0	8.8	22.7	0.25	170	0.654
06/23/99	484	5	1	0	8.8	21.7	0.62	175	0.673
06/24/99	486	9	3	0	9.0	21.5	1.11	184	0.708
06/25/99	261	10	3	1	9.8	20.9	2.30	194	0.746

-continued-

Appendix A1.–Page 2 of 2.

Date	Minutes	Large chinook	Jacks	Sockeye	Temp	Depth	catch/net/ hour	Cum. large chinook	Cum. percent
06/26/99	498	2	4	2	9.5	21.7	0.24	196	0.754
06/27/99	469	6	1	1	9.0	21.6	0.77	202	0.777
06/28/99	494	11	4	1	9.0	21.0	1.34	213	0.819
06/29/99	476	9	4	2	8.0	20.9	1.13	222	0.854
06/30/99	478	4	1	0	8.0	19.5	0.50	226	0.869
07/01/99	491	11	2	3	8.5	19.0	1.34	237	0.912
07/02/99	485	12	3	1	9.8	19.0	1.48	249	0.958
07/03/99	482	2	2	3	10.0	19.8	0.25	251	0.965
07/04/99	483	1	1	0	10.5	20.5	0.12	252	0.969
07/05/99	482	2	1	2	10.0	21.5	0.25	254	0.977
07/06/99	480	1	0	0	8.8	21.4	0.13	255	0.981
07/07/99	250	2	1	0	9.0	22.0	0.48	257	0.988
07/08/99	240	0	0	1	10.0	20.5	0.00	257	0.988
07/09/99	240	3	0	0	10.0	20.7	0.75	260	1.000
Total		260	58	17					

Appendix A2.–Origin of coded-wire tags recovered from chinook salmon collected at Andrew Creek, 1999.

Year	Head	Length	Tag code	Brood year	Agency	Rearing	Location	Date released	Release site	Tag ratio
1999	61662	825	44432	1993	ADFG	H	CRYSTAL LAKE	5-21-95	EARL WEST COV 107-40	7.098

Appendix A3.–Procedures used in estimating the abundance of small and medium chinook salmon in the escapement to the Stikine River, 1999.

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

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

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

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

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

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

When substituted into the equation above, the following relationships:

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

simplify the calculation to:

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

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

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

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

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

Appendix A3.–Computer files used to estimate the spawning abundance of chinook salmon in the Stikine River in 1999.

File name	Description
CPUE96-99.XLS	EXCEL spreadsheet with 1996-99 effort data, effort vs. escapement regression, and chart.
EFFORT99.XLS	EXCEL spreadsheet with gillnet tagging data--daily effort, catch by species, and water depth by site; gillnet charts.
SIZESELECT99.XLS	EXCEL spreadsheet with Kolmogorov-Smirnov /chi-square tests, and cumulative frequency charts for Stikine chinook, 1999.
STIKMR-AWL99.XLS	EXCEL spreadsheet with Kakwan Pt. tagging data, recovery data by tributary and fishery, Kakwan Pt. and spawning tributary AWL data, AWL tables, and t-tests.
TAGRTN.XLS	EXCEL spreadsheet with summarized recovery data for chinook salmon in the lower and upper fisheries in the Stikine River in 1999. Includes release and recovery dates, travel times, and release MEF lengths.
WEIRCNTS99.XLS	EXCEL spreadsheet with weir counts for adults by sex and jacks, and tag recovery data.