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Abundance of the Chinook Salmon Escapement on the Stikine River, 2004

by

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and

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

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
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
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
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)	
fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL
Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
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	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
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.
minute (angular)	'
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
variance	
population	Var
sample	var

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ABSTRACT

Abundance of large (≥660mm MEF) and small-medium (<660 mm MEF) Chinook salmon *Oncorhynchus tshawytscha* that returned to spawn in the Stikine River above the U.S./Canada border in 2004 was estimated using mark-recapture data. Age, sex, and length compositions for the immigration were also estimated. Drift and set gillnets fished near the mouth of the Stikine River were used to capture 2,085 immigrant Chinook salmon during May, June, July, and August of which 2,039 Chinook salmon were initially marked. During July and August, Chinook salmon were captured at spawning sites and inspected for marks. Marked fish were also recovered from Canadian commercial, test and aboriginal fisheries. Using a modified Petersen model, an estimated 52,538 (SE = 3,896) large and 14,189 (SE = 1,664) small-medium fish immigrated to the Stikine River above Kakwan Point and Rock Island. Canadian fisheries on the Stikine River harvested 3,638 large and 3,074 small-medium Chinook salmon, leaving a spawning escapement of 48,900 (SE = 3,896) large and 11,115 (SE = 1,664) small-medium fish. The count of large fish at the Little Tahltan River weir was 16,381, representing about 33% of the estimated spawning escapement of large fish. A helicopter survey and expansion factor were used to estimate an escapement of 3,068 large fish in Andrew Creek. The estimated spawning escapement of 60,015 (SE = 4,236) Chinook salmon was composed of 20.4% (SE = 2.3%) age-1.2 fish, 49.6% (SE = 2.2%) age-1.3 fish, and 28.3% (SE = 1.9%) age-1.4 fish. The estimated spawning escapement included 28,401 (SE = 2,472) females. Sibling and CPUE data were used to generate pre- and in-season abundance estimates for the inriver run of large Chinook salmon.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, Stikine River, Little Tahltan River, Verrett River, Andrew Creek, mark-recapture, spawning escapement, inriver run abundance, age and sex composition, pre-season, in-season, CPUE, sibling data

INTRODUCTION

Many Southeast Alaska and transboundary river Chinook salmon *Oncorhynchus tshawytscha* stocks 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 and transboundary Chinook salmon stocks over a 15-year period (roughly three life cycles; ADF&G 1981). In 1979, the Canadian Department of Fisheries and Oceans (DFO) initiated commercial fisheries on the transboundary Taku and Stikine rivers. The fisheries primarily target sockeye salmon *O. nerka* and have been structured to limit the harvest of Chinook salmon to incidental catches. In 1985, the Alaskan and Canadian programs were incorporated into a comprehensive 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 escapement for important stocks. Escapements in 11 rivers in Southeast Alaska and Canada are directly estimated or surveyed annually: the Situk, Alsek, Chilkat, Taku, King Salmon, Stikine, Unuk, Chickamin, Blossom, and Keta rivers, and Andrew Creek. Annual escapements of Chinook salmon have been estimated at least once in all 11 key index systems, providing expansion factors for index counts to estimate actual escapement of large Chinook salmon. Escapements in the Stikine River have rebounded since initiation of the rebuilding program (Pahlke et al. 2000).

The Stikine River is a transboundary river, originating in British Columbia (B.C.) and flowing to the sea near Wrangell, Alaska (Figure 1). Chinook salmon in this river comprise one of over 50 indicator stocks included in annual assessments by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC) to determine stock status, effects of management regimes, and other requirements of the PST. The river is one of the largest producers of Chinook salmon in Northern B.C. and Southeast Alaska.

The CTC is contemplating incorporating the inriver abundance of Stikine River Chinook salmon into the Pacific Salmon Commission (PSC) Chinook Model, which, among other things, produces pre-season forecasts of

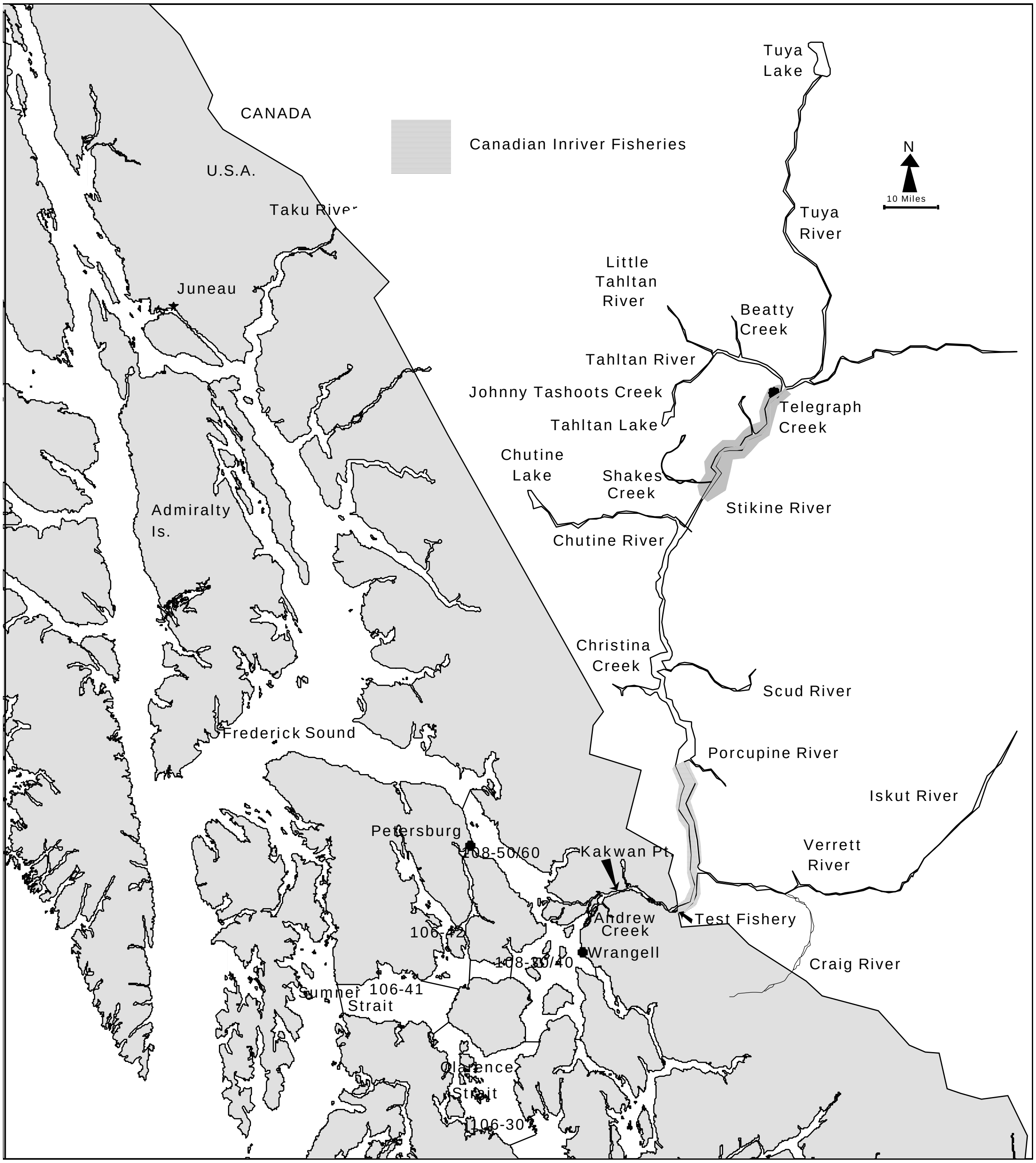

Figure 1.–Stikine River drainage, showing location of principal U.S. and Canadian fishing areas.

abundance for setting annual quotas for fisheries under the jurisdiction of the PST. Hence, data from annual assessments are not only essential for development of management tools for this stock, but may serve in the management of other coastwide stocks as well.

A major enhancement program for sockeye salmon in the Stikine River has been ongoing since 1989 (Pacific Salmon Commission [PSC] 2000). The run timing of sockeye salmon overlaps the latter component of the Chinook salmon migration, hence Chinook salmon returning to the

Stikine River are caught incidentally to sockeye salmon in U.S. marine gillnet fisheries in Districts 106 and 108 offshore of the river mouth, and in riverine Canadian commercial and test fisheries; aboriginal food fisheries target Chinook and sockeye salmon (Table 1; Figure 1). Stikine River Chinook salmon are also caught in marine recreational fisheries near Wrangell and Petersburg, in the commercial troll fishery in Southeast Alaska, and in recreational fisheries in Canada. The exploitation of terminal runs is managed jointly by the U.S. and Canada through the PSC.

Helicopter surveys of the Little Tahltan River have been conducted annually since 1975, and a fish counting weir has been operated at the mouth of the Little Tahltan River since 1985 (Table 2). Because virtually all fish spawning in the Little Tahltan River spawn above the weir, counts from the weir represent the spawning escapement to that tributary. Sufficient data have since been collected to establish a relationship between the two sources of information, and spawning escapement estimates from surveys conducted prior to 1985 were revised based on that relationship. Discontinuation of aerial surveys has been recommended (Bernard et al. 2000).

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

Chinook salmon spawning in Andrew Creek, a lower river tributary in the U.S., have historically been treated as a separate stock from salmon spawning upriver in Canada. Escapements into Andrew Creek have been assessed annually since 1975 by foot, airplane, or helicopter surveys. In addition, a weir was operated to collect hatchery brood stock from 1976 to 1984 and also provided escapement counts. Another weir was operated in 1997 and 1998 to count escapement, sample Chinook salmon to estimate age, sex and length composition of escapements, and to inspect fish for marks. North Arm and Clear creeks, two small streams in the U.S., have as well been periodically surveyed by foot, helicopter, and fixed-wing aircraft.

Only large (typically age-.3, -.4, and -.5 fish) Chinook salmon, approximately ≥660 mm mideye-to-fork length (MEF), are counted during aerial or foot surveys. No attempt is made to accurately count smaller (typically age-.1 and -.2 fish) Chinook salmon <660 mm MEF, which are primarily males. These smaller Chinook salmon 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 above the U.S./Canada border. Since 1996 a revised, expanded mark-recapture study has been used to estimate annual spawning escapement abundance (Pahlke and Etherton 1997, 1999; 2000; Pahlke et al. 2000; Der Hovanisian et al. 2001; 2003–2005). In 1997, a radio-telemetry study to estimate distribution of spawners was also conducted in concert with the mark-recapture experiment (Pahlke and Etherton 1999).

Table 1.–Harvests of small-medium (sm-med) and large Chinook salmon in Canadian fisheries in the Stikine River and U.S. fisheries near the mouth of the Stikine River, 1975–2004.

United States[a, b]					**Canada**											
			U.S. inriver subsistence.		Commercial harvest, lower Stikine[c]		Commercial harvest, upper Stikine[d]		Inriver sport harvest[e], Tahltan River		Aboriginal fishery, Telegraph Creek		Lower river test fishery		Total inriver commercial, sport, aboriginal, test, subsistence	
Year	Dist. 108 gillnet	Psg/Wrn sport	Sm-med	Large	Sm-med	Large	Sm-med	Large	Sm-med	Large	Sm-med	Large	Sm-med	Large	Sm-med	Large
1975	1,529							178				1,024			-	1,202
1976	1,101	-						236				924			-	1,160
1977	1,378	-						62				100			-	162
1978	-	2,282						100				400			-	500
1979	48	1,759			63	712			10	74	80	323			153	1,109
1980	407	2,498				1,488		156	18	136	171	686			189	2,466
1981	258	2,022				664		154	28	213	118	473			146	1,504
1982	1,032	2,929				1,693		76	24	181	124	499			148	2,449
1983	46	2,634			430	492		75	5	38	215	851			650	1,456
1984	14	2,171				Fishery closed			11	83	59	643			70	726
1985	20	2,953			91	256		62	12	92	94	793			288	1,203
1986	76	2,475			365	806	41	104	12	93	569	1,026	12	27	1,417	2,056
1987	94	1,834			242	909	19	109	18	138	183	1,183	30	189	492	2,528
1988	137	2,440			201	1,007	46	175	27	204	197	1,178	29	269	500	2,833
1989	227	2,776			157	1,537	17	54	18	132	115	1,078	24	217	331	3,018
1990	308	4,283			680	1,569	20	48	17	129	259	633	18	231	994	2,610
1991	876	3,657			318	641	32	117	17	129	310	753	16	167	693	2,565
1992	528	3,322			89	873	19	56	24	181	131	911	182	614	445	2,635
1993	866	4,227			164	830	2	44	52	386	142	929	87	568	447	2,757
1994	1,402	2,140			158	1,016	1	76	29	218	191	698	78	295	457	2,303
1995	945	1,218			599	1,067	17	9	14	107	244	570	184	248	1,058	2,001
1996	878	2,464			221	1,708	44	41	22	162	156	722	76	298	519	2,931
1997	1,934	3,475			186	3,283	6	45	25	188	94	1,155	7	30	318	4,701
1998	157	1,438			359	1,585	0	12	22	165	95	538	11	25	487	2,325
1999	688	3,668			789	2,127	12	24	22	166	463	765	97	853	1,383	3,935
2000	737	2,581			936	1,274	2	7	30	226	386	1,100	334	389	1,688	2,996
2001	7	2,263			59	826	0	0	12	190	44	665	59	1,442	174	3,123
2002	26	3,077			209	433	3	2	46	420	366	927	323	1,278	947	3,060
2003	103	3,252			459	908	12	19	46	167	373	682	792	1,281	1,682	3,057
2004	5,515	2,939 [f]	9	12	1,773	2,735	1	0	18	91	1,184	738	79	62	3,074	3,638

a District 108 gillnet catch of Chinook salmon through SW29 excluding Alaska hatchery fish.

b The estimated sport harvest is the number of legal size (>28") Stikine River Chinook salmon landed in the Petersburg/Wrangell (Psg/Wrn) ports from biweek 9-12 (i.e., approximately early April to early June).

c Harvests were apportioned into size categories based on length samples beginning in 1998 and may not reflect catches reported by fishers.

d Small-medium Chinook salmon were not segregated before 1983.

e Sport harvests in 2001–2004 are based on creel census. Harvests in 1979–2000 are based on the harvest at the Tahltan River mouth area fishery vs. the Little Tahltan River weir counts (3.9%). All harvests are apportioned by the combined 2001–2003 age-sex-length samples from the creel. An additional estimated 25 fish are harvested at other Canadian sites (Verrett, Craig, and Little Tahltan rivers).

f Preliminary.

Table 2.–Index and survey counts of large spawning Chinook salmon in tributaries of the Stikine River, 1975–2004. 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												
Year	Peak count		Weir count[a]	Mainstem Tahltan River		Beatty Creek		Andrew Creek		North Arm Creek		Clear Creek[b]	
1975	700	E(H)	-	2,908	E(H)	-		260	(F)	-		-	
1976	400	N(H)	-	120	(H)	-		468	(W)	-		-	
1977	800	P(H)	-	25	(A)	-		534	(W)	-		-	
1978	632	E(H)	-	756	P(H)	-		400	(W)	24	E(F)	-	
1979	1,166	E(H)	-	2,118	N(H)	-		382	(W)	16	E(F)	-	
1980	2,137	N(H)	-	960	P(H)	122	E(H)	363	(W)	68	N(F)	-	
1981	3,334	E(H)	-	1,852	P(H)	558	E(H)	654	(W)	84	E(F)	4	P(F)
1982	2,830	N(H)	-	1,690	N(F)	567	E(H)	947	(W)	138	N(F)	188	N(F)
1983	594	E(H)	-	453	N(H)	83	E(H)	444	(W)	15	N(F)	-	
1984	1,294	(H)	-	-		126	(H)	389	(W)	31	N(F)	-	
1985	1,598	E(H)	3,114	1,490	N(H)	147	N(H)	319	E(F)	44	E(F)	-	
1986	1,201	E(H)	2,891	1,400	P(H)	183	N(H)	707	N(F)	73	N(F)	45	E(A)
1987	2,706	E(H)	4,783	1,390	P(H)	312	E(H)	788	E(H)	71	E(F)	122	N(F)
1988	3,796	E(H)	7,292	4,384	N(H)	593	E(H)	564	E(F)	125	N(F)	167	N(F)
1989	2,527	E(H)	4,715	-		362	E(H)	530	E(F)	150	N(A)	49	N(H)
1990	1,755	E(H)	4,392	2,134	N(H)	271	E(H)	664	E(F)	83	N(F)	33	P(H)
1991	1,768	E(H)	4,506	2,445	N(H)	193	N(H)	400	N(A)	38	N(A)	46	N(A)
1992	3,607	E(H)	6,627	1,891	N(H)	362	N(H)	778	E(H)	40	E(F)	31	N(A)
1993	4,010	P(H)	11,437	2,249	P(H)	757	E(H)	1,060	E(F)	53	E(F)		
1994	2,422	N(H)	6,373	-		184	N(H)	572	E(H)	58	E(F)	10	N(A)
1995	1,117	N(H)	3,072	696	E(H)	152	N(H)	343	N(H)	28	P(A)	1	E(A)
1996	1,920	N(H)	4,821	772	N(H)	218	N(H)	335	N(H)	35	N(F)	21	N(A)
1997	1,907	N(H)	5,547	260	P(H)	218	E(H)	293	N(F)	-		-	
1998	1,385	N(H)	4,873	587	P(H)	125	E(H)	487	E(F)	35	N(A)	28	N(A)
1999	1,379	N(H)	4,738	-		-		605	E(A)	22	N(A)	1	N(A)
2000	2,720	N(H)	6,631	-		-		690	N(A)	35	N(A)	-	
2001	4,158	N(H)	9,730	-		-		1,054	N(F)	54	N(F)	-	
2002	1,131 [c]	N(H)	7,476	-		-		876	N(F)	34	N(F)	8	N(A)
2003	1,903	N(H)	6,492	-		-		595	N(H)	39[d]	N(F)	19	N(A)
2004	6,014	N(H)	16,381	-		-		1,534	N(H)	60	N(A)	65	P(F)
1995–2004 avg.	2,363		6,976	579		178		681		38			

a Above weir harvest and broodstock collections are removed from weir counts; there was no broodstock collection in 2004.

b "Clear Creek" is a local name. The ADFG survey name is "West of Hot Springs", stream number 108-40-13A.

c The Little Tahltan River survey was conducted on 14 August and was considered post-peak.

d Partial survey.

The objectives of the 2004 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, and

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

An additional task included estimation of the factor used to expand counts of large Chinook salmon at the weir on the Little Tahltan River to spawning abundance in the Stikine River. Mark-recapture data were also used to estimate the spawning abundance of small-medium (<660 mm MEF) Chinook salmon.

Results from the study also provide information on the run timing through the lower Stikine of Chinook salmon bound for the various spawning areas, and other stock assessment and management information needs such as construction of spawner-recruit tables and inseason inriver run abundance estimates.

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, Porcupine, Tanzilla, Iskut, and Tuya rivers (Figure 1). The lower river and most tributaries are glacially occluded (e.g., Chutine, Scud, Porcupine, and Iskut rivers). Only 2% of the drainage is in Alaska (Beak Consultants Limited 1981), and most of the spawning areas used by Chinook salmon 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 watershed, supports a small run of Chinook salmon averaging about 5% of the above-border escapement. The upper drainage of the watershed is accessible via the Telegraph Creek Road and the Stewart-Cassiar Highway.

METHODS

KAKWAN POINT AND ROCK ISLAND TAGGING

Drift gillnets 120 feet (36.5m) long, 18 feet (5.5m) deep, of 7¼ inch (18.5cm) stretch mesh, were fished near Kakwan Point (Figure 2) between May 10 and July 7. Two nets were fished concurrently daily, unless high water or staff shortages occurred. Nets were watched continuously, and fish were removed from the net immediately upon capture. Daily sampling effort was held reasonably constant across the temporal span of the migration at 4 hours per net. Time lost because of entanglements, snags, cleaning the net, etc. (processing time) did not count towards fishing time.

Catches near Kakwan Point were augmented by Chinook salmon captured in a project at Rock Island directed at sockeye salmon and run jointly by DFO, ADF&G Commercial Fisheries Division (CFD), and TFN (Figure 2). Salmon were caught in a 5 to 5½ inch (12.7 to 13.8 cm) stretch mesh set gillnet 120 feet (36.5m) long and 18 feet (5.5 m) deep between May 7 and September 3, but Chinook salmon caught after July 31 were omitted from the experiment to preclude inclusion of post-spawn fish. The net was watched continuously, and fish were removed from the net immediately upon capture. If more fish were caught than could be effectively sampled, or if high water rendered the net difficult to fish, the net was shortened. Sampling effort was held reasonably constant at about 7 hours per day.

Regardless of where caught, captured Chinook salmon were placed in a plastic fish tote filled with water, quickly untangled or cut from the net, marked, measured for length (MEF) and post orbital hypural length (POH), classified by sex and maturity, and sampled for scales. Fish were classified as "large" if their MEF measurement was $\geq$660mm, as "medium" if their MEF was 440-659mm or "small" if their MEF was <440mm (Pahlke and Bernard 1996). Fish maturation was judged on a scale from 1 to 4, where 1 is a silver bright fish, 2 is a fish with slight coloration, 3 is a fish with obvious coloration and the onset of sexual dimporhism, and 4 is a fish with the characteristics listed in category 3 that released gametes upon capture. The presence or absence of sea lice (*Lepeophtheirus* sp.) was also noted. General health and appearance of the fish was recorded, including injuries caused by handling or predators. Each uninjured fish was marked with a uniquely numbered, blue spaghetti tag consisting of a 2"(~5cm) section of Floy tubing shrunk and laminated onto a 15" (~38cm) piece of 80-lb (~36.3kg) monofilament fishing line using a modified design developed by Johnson et al. 1993. The monofilament was sewn through the musculature of the fish approximately ½ inch (20 mm) posterior and ventral to the dorsal fin and secured by crimping both ends in a metal sleeve. Each fish was also marked with a ¼ inch (7 mm) diameter hole in the upper (dorsal) portion of its left operculum applied with a paper punch, and by amputation of its left axillary appendage (McPherson et al. 1996). Fish that were seriously injured were sampled but not marked.

UPSTREAM SAMPLING

Pre- and post-spawning fish and carcasses were collected with spears, dipnets, and snagging gear at Andrew Creek, Verrett River, the Little Tahltan River weir, and other spawning ground sites (Figures 1 and 2). All fish were inspected for

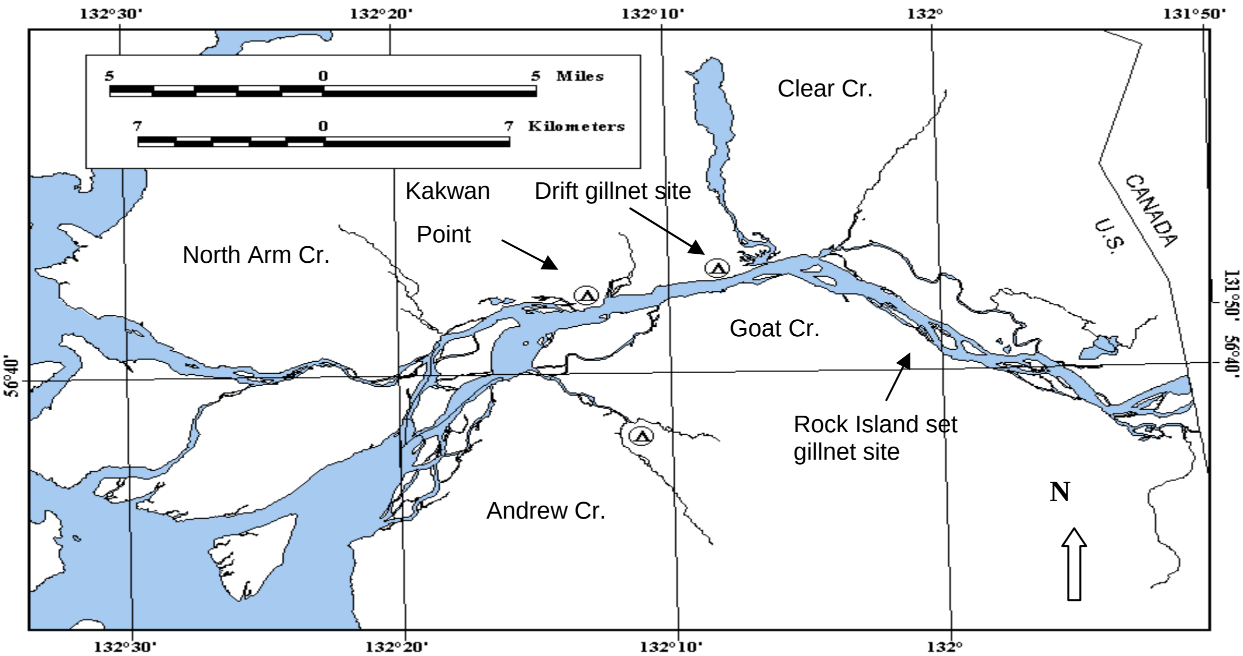

Figure 2.–Locations of drift and set gillnet sites on the lower Stikine River, 2004.

tags and marks, sampled for length, sex, and scales, and marked with a hole punched in the lower left opercle to prevent resampling. Carcasses were also slashed along the left side.

Tags were recovered from the Canadian commercial and test gillnet, aboriginal, and recreational fisheries, and from the U.S. marine commercial and recreational fisheries. Catches were sampled in some of these fisheries to estimate age, sex, and length composition.

ABUNDANCE

The abundance of Chinook salmon that passed by Kakwan Point and Rock Island was estimated with Chapman's modification of Petersen's estimator for a two-event mark-recapture experiment on a closed population (Seber 1982) if assumptions of the model were met (i.e., stratification by time of marking and/or recapture area were not required). A Darroch model was used otherwise (Seber 1982). Fish captured by gillnet and marked in the lower river near Kakwan Point and at Rock Island were included in event 1, and sampling on the spawning grounds and inriver fisheries constituted the event 2.

Handling and tagging have caused a downstream movement and/or a delay in upstream migration of marked Chinook salmon (Bernard et al. 1999). This "sulking" behavior may increase the probability of capture by U.S. commercial and recreational fisheries near the mouth of the Stikine River (Pahlke and Etherton 1999). Further, fish marked at Kakwan Point and Rock Island may spawn in Andrew Creek. Because censoring marked Chinook salmon killed in downstream fisheries or spawning in Andrew Creek reduces bias in the inriver run abundance estimate, the numbers of marked fish recovered in Andrew Creek and the commercial fisheries, expanded by sampling fractions, were censored from the experiment. All marked fish caught in the U.S. recreational harvest were assumed to have been reported and were also censored on a per tag basis from the experiment.

The estimated number of marked fish available for recapture on the spawning grounds and inriver fisheries was $\hat{M} = T - \hat{H}$, where T is the initial number of marked fish released near Kakwan Point and at Rock Island, and $\hat{H}$ is the estimated number of fish that moved downstream to be caught in U.S. fisheries or spawn in Andrew Creek.

Variance, bias, and confidence intervals for modified Petersen abundance estimates were estimated with bootstrap procedures described in Buckland and Garthwaite (1991). McPherson et al. (1996) provide modifications that account for

$\hat{M}$. A bootstrap sample was built by drawing with replacement a sample of size $\hat{N}^{+}$ from the empirical distribution defined by the capture histories (the effective population $\hat{N}^{+}$ is greater than the estimate of abundance by the number of marked fish censored from the experiment $\hat{H}$). A new set of statistics from each bootstrap sample $\{\hat{M}^{*}, C^{*}, R^{*}, \hat{H}^{*}, T^{*}\}$ was generated, along with the new estimate $\hat{N}^{*}$, and 1,000 such bootstrap samples were drawn creating the empirical distribution $\hat{F}(\hat{N}^{*})$, which is an estimate of $\mathrm{F}(\hat{N})$. The difference between the average $\overline{\hat{N}}^{*}$ of the bootstrap estimates and $\hat{N}$ is an estimate of statistical bias in the later statistic (Efron and Tibshirani 1993, Section 10.2). Confidence intervals were estimated from $\hat{F}(\hat{N}^{*})$ with the percentile method (Efron and Tibshirani 1993, Section 13.3). Variance was estimated as:

$$v(\hat{N}^{*}) = (B-1)^{-1}\sum_{b=1}^{B}\left(\hat{N}_{b}^{*} - \overline{\hat{N}}^{*}\right)^{2} \qquad (1)$$

where B is the number of bootstrap samples.

If a Darroch model was needed, the computer program Stratified Population Analysis System program (SPAS; Arnason et al. 1996) was used to estimate abundance, standard errors, and confidence intervals. Similar temporal and/or spatial strata were pooled to find admissible (non-negative) estimates, reduce the number of parameters, increase precision, and assess goodness-of-fit. However, standard errors calculated by SPAS are biased low when *M* is estimated because the error in *M* cannot be incorporated into the program.

The spawning escapements of large $\hat{N}_{L,esc}$ and small-medium $\hat{N}_{SM,esc}$ Chinook salmon were estimated by subtracting the respective inriver harvest of large and small-medium fish from $\hat{N}_{L}$ and $\hat{N}_{SM}$. Variance was estimated as described above or by SPAS. The estimated spawning escapement of large and small-medium fish $\hat{N}_{esc}$ was the sum of $\hat{N}_{L,esc}$ and $\hat{N}_{SM,esc}$, and its variance $v(\hat{N}_{esc})$ was the sum of $v(\hat{N}_{L,esc})$ and $v(\hat{N}_{SM,esc})$. Its confidence interval was estimated as described above or by normal approximation.

The validity of the mark-recapture experiment rests on several assumptions, including: (a) every fish passing through the lower river has an equal probability of being marked, *or* that every fish has an equal probability of being inspected for marks upriver, *or* that marked fish mix completely with unmarked fish between sampling events; *and* (b) both recruitment and "death" (emigration) do not occur between events; *and* (c) marking does not affect catchability (or mortality) of the fish; *and* (d) fish do not lose their marks between events; *and* (e) all recaptured fish are reported; *and* (f) double sampling does not occur (Seber 1982).

Because temporal mixing cannot occur in the experiment, and because not all spawning grounds were sampled, assumption (a) would be met only if fish are marked in proportion to abundance during immigration, or if there is no difference in migratory timing among stocks bound for different spawning locations upstream. Assumption (a) also implies that sampling is not size or gender selective. If capture on the spawning grounds was not size-selective, fish of different sizes would be captured with equal probability. If assumption (a) was met, samples of fish taken in upper watershed (Little Tahltan River, aboriginal fishery), in the Iskut River (Verrett River) and in the inriver test and commercial fisheries in the lower watershed would have similar proportions of marked fish. Temporal and size-gender conditions associated with assumption (a) were investigated with a battery of statistical tests. Assumption (b) was met because the life history of Chinook salmon isolates those fish returning to the Stikine River as a "closed" population. Mortality rates from natural causes for marked and unmarked fish were assumed to be the same (assumption c). Past telemetry studies in the Stikine River indicate that a high percentage of Chinook salmon captured in this study, but fitted with esophageal radio transmitters, survived to spawn (Pahlke and Etherton 1999). To avoid effects of tag loss (assumption d), all marked fish carried secondary (a dorsal opercle punch), and tertiary marks (the left axillary appendage was clipped). Similarly, all fish captured on the spawning grounds were inspected for marks, and a reward (Can $5) 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 collected, processed, and aged 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, Rock Island, Andrew Creek, and Verrett River were processed at the ADF&G Scale Aging Lab in Douglas; all others were processed at the DFO lab in Nanaimo, B.C.

Estimated age compositions for the Little Tahltan and Verrett rivers were compared with chi-square tests to determine if the samples could be pooled and used to estimate spawning population proportions. For these tests, age-2. Chinook salmon were pooled with age-1. fish of the same brood year, and only age classes common to each sample were compared.

The proportion of the spawning population composed of a given age within small-medium or large size categories *i* was estimated as a binomial variable from fish sampled in the Little Tahltan and/or Verrett rivers:

$$\hat{p}_{ij} = \frac{m_{ij}}{m_i} \qquad (2)$$

$$v[\hat{p}_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{m_i - 1} \qquad (3)$$

where $\hat{p}_{ij}$ is the estimated proportion of the population of age *j* in size category *i*, and m_{ij} is the number of Chinook salmon of age *j* in size category *i* in the sample *m* taken in the Little Tahltan and/or Verrett rivers.

Numbers of spawning fish by age were estimated as the summation of products of estimated age composition and estimated spawning escapement within size category *i*:

$$\hat{N}_j = \sum_i \left(\hat{p}_{ij}\hat{N}_{i,esc}\right) \qquad (4)$$

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

$$v(\hat{N}_j) = \sum_i \begin{pmatrix} v(\hat{p}_{ij})\hat{N}^2_{i,esc} + v(\hat{N}_{i,esc})\hat{p}^2_{ij} \\ - v(\hat{p}_{ij})v(\hat{N}_{i,esc}) \end{pmatrix} \qquad (5)$$

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

$$\hat{p}_j = \frac{\hat{N}_j}{\hat{N}_{esc}} \qquad (6)$$

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

$$v(\hat{p}_j) = \frac{\sum_i \left(v(\hat{p}_{ij})\hat{N}_i + v(\hat{N}_i)(\hat{p}_{ij} - \hat{p}_j)^2\right)}{\hat{N}^2_{esc}} \qquad (7)$$

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

Age, sex, and age-sex composition and associated variances for fish caught at Kakwan Point, at Rock Island, in Little Tahltan and Verrett rivers, and in inriver fisheries were estimated with equations 2 and 3 by substituting

n_{ij} for m_{ij} and n_i for m_i, where n_{ij} is the number of Chinook salmon of age j in size category i in the sample n.

Estimates of mean length at age and their estimated variances were calculated with standard sample summary statistics (Cochran 1977).

RESULTS

KAKWAN POINT AND ROCK ISLAND TAGGING

Between May 7 and September 31, 2,085 Chinook salmon were captured near Kakwan Point and at Rock Island, of which 2,039 (8 small, 468 medium, and 1,563 large) were initially marked, and released (Appendix Tables A1 and A2; Table 3). Fish caught and tagged after July 31 were omitted to preclude inclusion of post-spawn fish.

Drift gillnet effort near Kakwan Point was maintained at 4 hours per net per day (two nets fishing), although reduced sampling effort occurred on several days (Figure 3). From May 10 through July 7, 1,395 large and 316 small-medium Chinook salmon were captured; one fish with a missing adipose fin was recovered (Appendices A1 and A11). Catch rates ranged from 0 to 10.98 large fish/hour, and the highest catch occurred on May 31 when 85 large fish were captured (Figure 4). The date of 50% cumulative catch of large fish was June 3. Catch rates for small- medium fish ranged from 0 to 4.05 fish/hour, and the date of 50% cumulative catch of small-medium fish was June 4. Catches were low during the first and third weeks in June because of high water conditions (Figures 3 and 4, Appendix A1). Harbor seals killed or injured several fish before they could be removed from the nets, especially early in the season. In addition, 15 sockeye salmon were captured and released (Appendix A1).

Set gillnet effort at Rock Island was maintained at about 7.0 hours per day with one net fishing, although there was a two-week hiatus in early June between crew changes (Figure 5). From May 7 through September 3, 188 large and 186 small-medium Chinook salmon were captured (Appendix A2), but as previously noted, fish captured after July 31 were omitted from the experiment to preclude inclusion of post-spawn fish. Catch rates ranged from 0 to 3.15 large fish/hour, and the highest catch occurred on May 31 when 24 large fish were captured (Figure 6). Catch rates for small-medium fish ranged from 0 to 4.18 fish/hour, and the highest catches occurred on June 17 when 24 small-medium fish were captured (Figure 6). In addition, 2,292 sockeye salmon were captured at Rock Island (Appendix A2).

UPSTREAM SAMPLING

The lower river commercial and test gillnet fisheries began June 20 and June 24, respectively, and harvested 2,797 large and 1,852 small-medium Chinook salmon. Ninety-two large and 60 small-medium Chinook salmon with tags were recovered. The aboriginal fishery near Telegraph Creek harvested 738 large and 1,184 small-medium Chinook salmon and 27 tags were recovered. The upper river commercial fishery harvested one small-medium fish, and no tags were recovered. The Canadian recreational fishery on the Tahltan River, which was sampled in 2004, reported one marked fish; an estimated 91 large and 18 small-medium Chinook were harvested. There were seven voluntarily returned tags from the recreational fishery near Petersburg and Wrangell, and all marked fish in the recreational harvest were presumably reported. Six marked fish (expanded to 46) were recovered in U.S. marine commercial fisheries (Tables 1 and 3).

Technicians examined 1,396 Chinook salmon for marks at the Little Tahltan River weir, of which 1,177 were large fish. There were 29 large and five small-medium marked fish recovered, none of which had lost its tag. An additional 400 previously unsampled carcasses were examined above the weir; five of these were marked and all had retained their tags (Table 3).

At Verrett River, 1,336 live and dead Chinook salmon were examined; 37 marked fish were recovered, four of which had lost their tags (Table 3). At Andrew Creek, 230 fish were examined and two marked fish (expanded to 32) were recovered. One tag was recovered in Goat Creek (Figure 2) and voluntarily returned–it was included with those recovered in the U.S. recreational fishery.

Table 3.–Numbers of Chinook salmon marked on lower Stikine River, removed by fisheries and inspected for marks in 2004, by size category. Numbers in bold were used in mark-recapture estimates.

		Length (MEF) in mm			
		0-439 (small)	**440-659 (medium)**	**≥660 (large)**	**Total**
A. Released at Kakwan Point		0	316	1,392	1,708
B. Released at Rock Island through July 31		8	152	171	331
C. Removed by:					
1. U.S. recreational fisheries [a]		0	1	6	7
2. Goat Creek[a]		0	0	1	1
3. U.S marine gillnet fisheries[b]		0	15	31	46
4. Andrew Creek[c]		0	16	16	32
Subtotal of removals			32	54	86
D. Estimated number of marked fish remaining in mark-recapture experiment		**8**	**436**	**1,509**	1,953
E. Canadian recreational fisheries	Harvested[d]	0	18	91	109
Tahltan River	Marked	0	0	1	1
	Marked/harvested	0.0000	0.0000	0.0110	0.0092
F. Inspected at:					
1. L. Tahltan weir, live fish	Inspected	**2**	**217**	**1,177**	1,396
	Marked	**0**	**5**	**29**	34
	Marked/inspected	0.0000	0.0230	0.0246	0.0244
2. L. Tahltan weir, post-spawn fish and carcasses	Inspected	19	160	221	400
	Marked	0	2	3	5
	Marked/inspected	0.0000	0.0125	0.0136	0.0125
3. Verrett River	Inspected	**2**	**132**	**1,202**	1,336
	Marked	**1**	**3**	**33**	37
	Marked/inspected	0.5000	0.0221	0.0275	0.0277
4. Johnny Tashoots Creek	Inspected	**1**	**57**	147	205
	Marked	**0**	**1**	0	1
	Marked/inspected	0.0000	0.0175	0.0000	0.0049
Subtotal: L. Tahltan weir/Verrett/Johnny Tashoots	Inspected	24	566	2,747	3,337
	Marked	1	11	65	77
	Marked/inspected	0.0417	0.0194	0.0237	0.0231
G. Lower river commercial/test[e] gillnet	Harvested[f,g]	**36**	**1,816**	**2,797**	4,649
	Marked	**1**	**59**	**92**	152
	Marked/harvested	0.0278	0.0325	0.0329	0.0327
I. Upper river gillnet	Harvested[h]	56	1,128	**738**	1,922
Aboriginal	Marked	0	12	**15**	27
	Marked/harvested	0.0000	0.0106	0.0203	0.0193
Subtotal: lower river/upper river gillnet	Harvested	92	2,944	3,535	6,571
	Marked	1	71	107	179
	Marked/harvested	0.0109	0.0237	0.0303	0.0272
Total: L. Tahltan weir, Verrett, Tashoots, lower river/upper river gillnet	Inspected, harvested	116	3,510	6,282	9,908
	Marked	2	82	172	256
	Marked/insp. and harv.	0.0172	0.0234	0.0274	0.0258
Andrew Creek	Inspected	1	39	190	230
	Marked	0	1	1	2
	Marked/inspected	0.0000	0.0256	0.0111	0.0087

[a] Voluntary return.

[b] The number of marked Chinook salmon recovered in U.S. marine gillnet fisheries was expanded by the fraction sampled. Because there were no sublegal sampling data available, recoveries of fish <660 mm MEF were expanded by the sampling fraction for large fish: (2 medium fish recovered in D6 and 8 x 10,136 harvested/1,337 sampled) = 15. Four large fish recovered in D8 was expanded to 31 (4 recoveries x 7,406 harvested/959 sampled).

[c] The number of marked Chinook salmon was expanded by the fraction sampled. One medium fish recovered was expanded to 16 (1 recovery x 615 medium escapment/39 sampled), and one large recovery was expanded to 16 (1 recovery x 2,988 large escapement/190 sampled).

-continued-

Table 3.–page 2 of 2

[d] The recreational harvest of 109 fish in the Tahltan River was apportioned into size categories based on the creel length sample data: (7/42)109 = 18 medium, (35/42)109 = 91 large.

[e] Sockeye salmon test fishery.

[f] The sockeye test fishery harvest was entirely sampled (1 small, 78 medium, and 62 large fish).

[g] The lower river commercial fishery harvest of 4,508 fish was apportioned into size categories using length sample data collected during the commercial fishery: (9/1,152)4,508 = 35 small, (444/1,152)4,508 = 1,738 medium, (699/1,152)4,508 = 2,735 large.

[h] The aboriginal harvest of 1,922 fish was apportioned into size categories using length sample data collected during the aboriginal fishery: (4/138)1,922 = 56 small, (81/138)1,922 = 1,128 medium, (52/138)1,922 = 738 large.

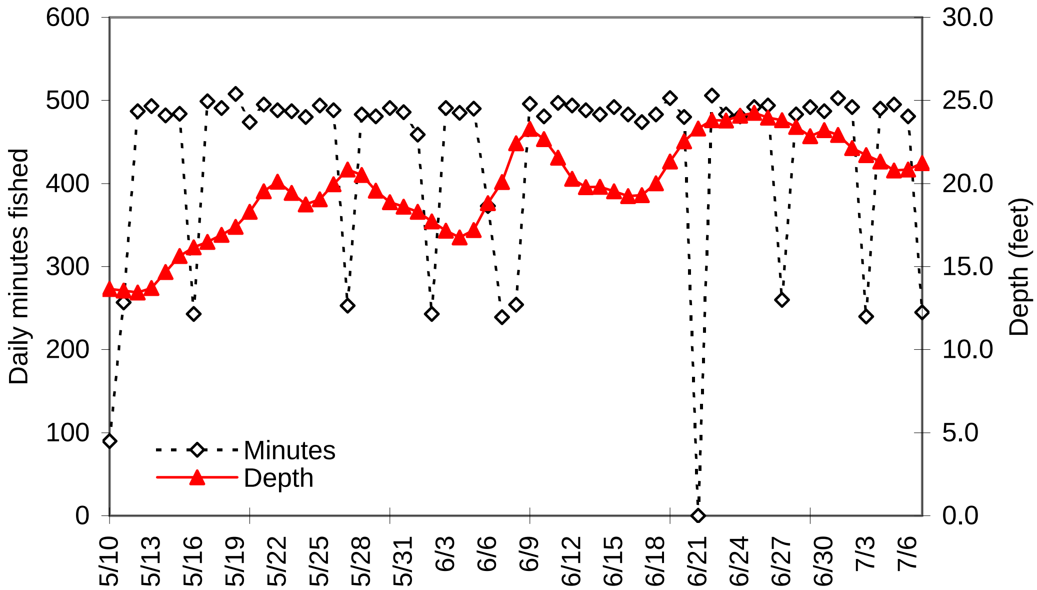

Figure 3.–Daily drift gillnet fishing effort (minutes) and river depth (feet) near Kakwan Point, lower Stikine River, 2004.

ABUNDANCE OF LARGE CHINOOK SALMON

A modified Petersen model was used to estimate the inriver run abundance of large Chinook salmon that passed by Kakwan Point and Rock Island. Based on fish inspected at the Little Tahltan River weir and samples from Verrett River, the lower river commercial and test gillnet fishery, and the aboriginal fishery, the estimate is 52,538 large fish (SE = 3,896; bias = 0.47%; 95% CI: 45,817 to 61,217; $\hat{M}_L$ = 1,509, C_L = 5,914, R_L = 169). Variance, bias, and confidence intervals were estimated as described above given seven capture histories:

Capture history	Large	Source of statistics
Marked, but censored in recreational fishery and Goat Creek	7	Voluntary return
Marked, but censored in Andrew Creek	16	Observed/0.0634
Marked, but censored in marine gillnet fishery	31	Observed/0.1295
Marked and never seen again	1,340	$\hat{M}_L - R_L$
Marked and recaptured in event 2	169	R_L
Un-marked and captured in event 2	5,745	$C_L - R_L$
Un-marked and never seen	45,284	$\hat{N}_L - \hat{M}_L - C_L + R_L$
Effective population for simulations	52,592	$\hat{N}_L^+$

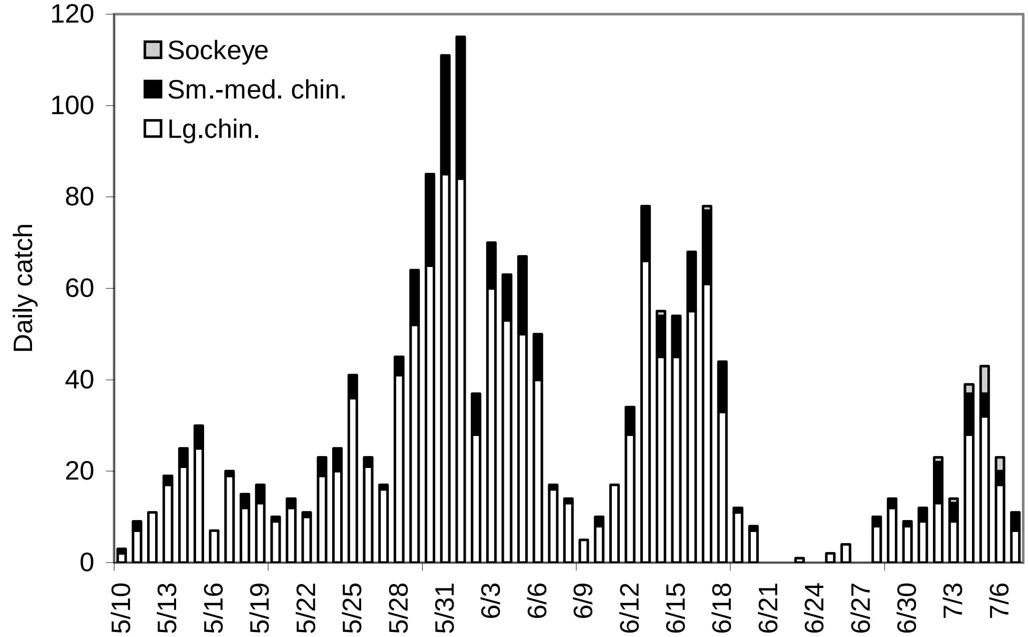

Figure 4.–Daily catch of Chinook and sockeye salmon near Kakwan Point, lower Stikine River, 2004.

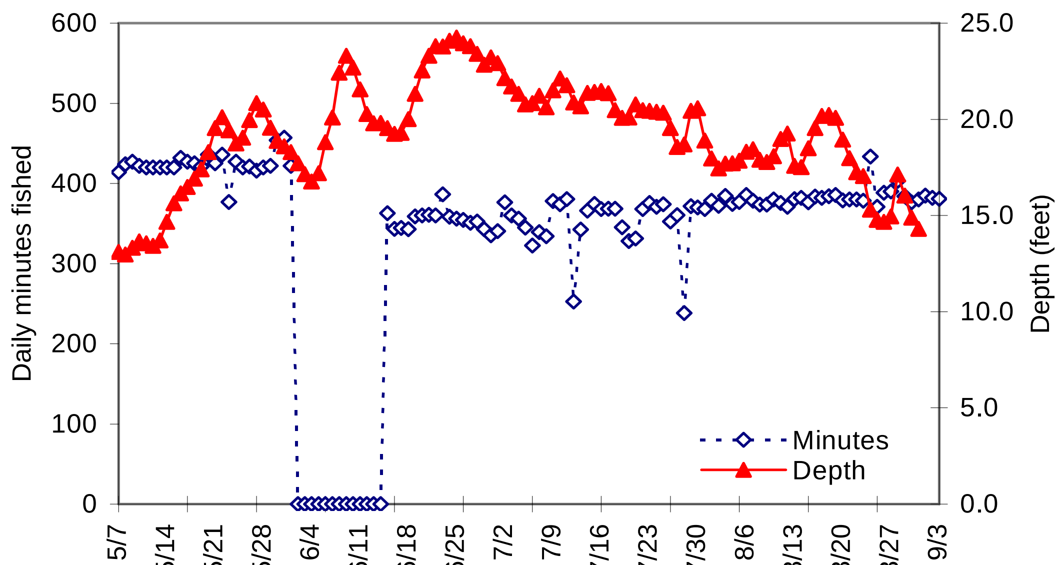

Figure 5.–Daily set gillnet fishing effort (minutes) and river depth (feet) at Rock Island, lower Stikine River, 2004.

For this estimate, all large marked fish intercepted by U.S. fisheries (six fish in the recreational fishery, assuming all marked fish in the harvest were reported, and four in the marine gillnet fishery, expanded to 31) were censored from the experiment. The number of large marked Chinook salmon recovered in Andrew Creek (one fish, expanded to 16) and one tag recovered in Goat Creek that was voluntarily returned, were also censored (Table 3).

Evidence from sampling upstream supports the supposition that every large Chinook salmon passing by Kakwan Point and Rock Island had a near equal chance of being marked regardless of when they passed these sites. Estimated marked fractions (Table 3) for large fish at the Little Tahltan weir (0.0246), Verrett River (0.0275), the lower river commercial and test gillnet fisheries (0.0329), and the aboriginal fishery (0.0203) were not significantly different (χ^2 = 4.16, df = 3, P = 0.24). The majority of fish bound for the Little Tahltan River passed by Kakwan Point and Rock Island in May and June and most fish bound for Verrett River passed in June and early July; sampling at the Little Tahltan weir, Verrett River, and the inriver fisheries occurs from late June though August such that fish that passed the tagging sites from May through July are intercepted (Figure 7).

Neither was there evidence that size-selective sampling violated assumption (a). Size distributions of fish marked downstream and recaptured upstream were not significantly different (Kolmogorov-Smirnov: d_{max} = 0.052; n = 1,562, 168; P = 0.78; Figure 8). Size distributions of fish marked at Kakwan Point and Rock Island versus combined samples of fish captured at the weir on the Little Tahltan River, Verrett River, in the lower river commercial and test gillnet fisheries, and in the aboriginal fishery were marginally different (Kolmogorov-Smirnov: d_{max} = 0.041; n = 1,562, 3,297; P = 0.06; Figure 9), which suggests capture probabilities for salmon of different sizes were not equal during the first event. However, sample sizes were large and the Kolmogorov-Smirnov test was probably sensitive to small differences. Further, the empirical cumulative distribution function (ecdf) plots were similar (Figure 9) for fish captured upstream and downstream. The combined results from these tests indicate there was no size-selectivity during the second event but perhaps there was during the first. These results suggest that an unstratified estimate was appropriate (Appendix A3, Case II).

Further evidence from upstream sampling supported the supposition that every large Chinook salmon passing by Kakwan Point and Rock Island had a near equal chance of being marked regardless of their size (i.e., capture probabilities *were equal during the first event*). Pooled length samples of large fish from the Little Tahltan River weir, Verrett River, the lower river commercial and test gillnet fisheries, and the aboriginal fishery were arbitrarily split into two groups at the median length of large fish (794 mm MEF) to permit comparison of marked fractions:

	660 – 794 mm	>794 mm
Marked	84	85
Unmarked	3,239	2,506
Marked fraction	0.025	0.033

The marked fractions were not significantly different (χ^2 = 2.97, df = 1, P = 0.08).

Finally, evidence from upstream sampling also supported the supposition that every large Chinook salmon had a near equal chance of being captured upstream regardless of their size (i.e., capture probabilities were equal during the second event). Pooled length samples of large fish from the Little Tahltan weir, Verrett River, the lower river commercial and test gillnet fisheries, and the upriver gillnet fisheries were again split into two size groups as were samples of large fish marked at Kakwan Point and Rock Island.

The fractions (rates) of recaptured fish were compared as surrogates for probabilities of capture upstream:

	660 – 794 mm	>794 mm
Released with marks	716	793
Recaptured	84	85
Fraction recaptured	0.117	0.107

The fractions recaptured were not significantly different (χ^2 = 0.310, df = 1, P = 0.58).

The peak count on Andrew Creek was 1,534 large fish (helicopter survey, August 7). The total escapement of large Chinook salmon to Andrew

Creek was estimated by expanding the survey count by a factor of 2.0 (Pahlke 1999), for an estimate of 3,068 large fish.

ABUNDANCE OF SMALL-MEDIUM CHINOOK SALMON

A modified Petersen model was used to estimate the inriver run abundance of small- medium fish that passed by Kakwan Point and Rock Island. Based on fish inspected at the Little Tahltan River weir, Verrett River, JohnnyTashoots Creek, and the lower river commercial and test gillnet fisheries, the estimate is 14,189 small-medium fish (SE = 1,664; bias = 0.98%; 95% C.I.: 11,409, 17,930; M_{SM} = 444, C_{SM} = 2,263, R_{SM} = 70). Variance, bias, and confidence intervals were estimated as described above given seven capture histories:

Capture history	Sm-med	Source of statistics
Marked, but censored in recreational fishery	1	Voluntary return
Marked, but censored in Andrew Creek	16	Observed/0.0634
Marked, but censored in marine gillnet fishery	15	Observed/0.1319
Marked and never seen again	374	$\hat{M}_{SM} - R_{SM}$
Marked and recaptured in event 2	70	R_{SM}
Unmarked and captured in event 2	2,193	$C_{SM} - R_{SM}$
Unmarked and never seen	11,552	$\hat{N}_{SM} - \hat{M}_{SM} - C_{SM} + R_{SM}$
Effective population for simulations	14,221	$\hat{N}^{+}_{SM}$

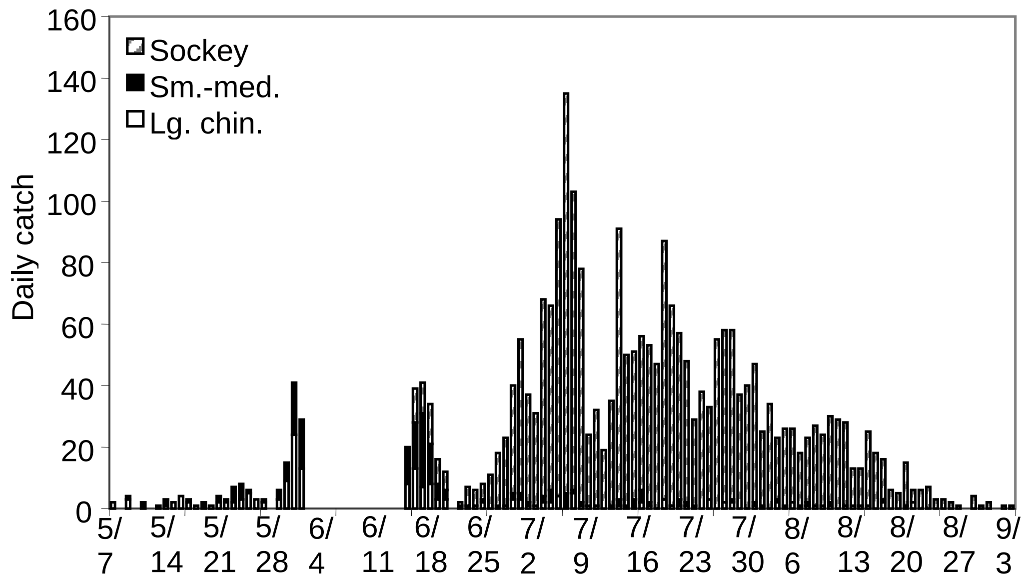

Figure 6.–Daily catch of Chinook and sockeye salmon at Rock Island, lower Stikine River, 2004.

For this estimate, all small-medium marked fish intercepted by U.S. fisheries (one fish in the recreational fishery, assuming all marked fish in the harvest were reported, and two in the marine gillnet fishery, expanded to 15) were censored from the experiment. The number of small-medium marked Chinook salmon recovered in Andrew Creek (one fish, expanded to 16) was also censored (Table 3).

Although a modified Petersen model was finally deemed appropriate, comparison of marked fractions from all upstream sampling areas did not support the supposition that every small-medium

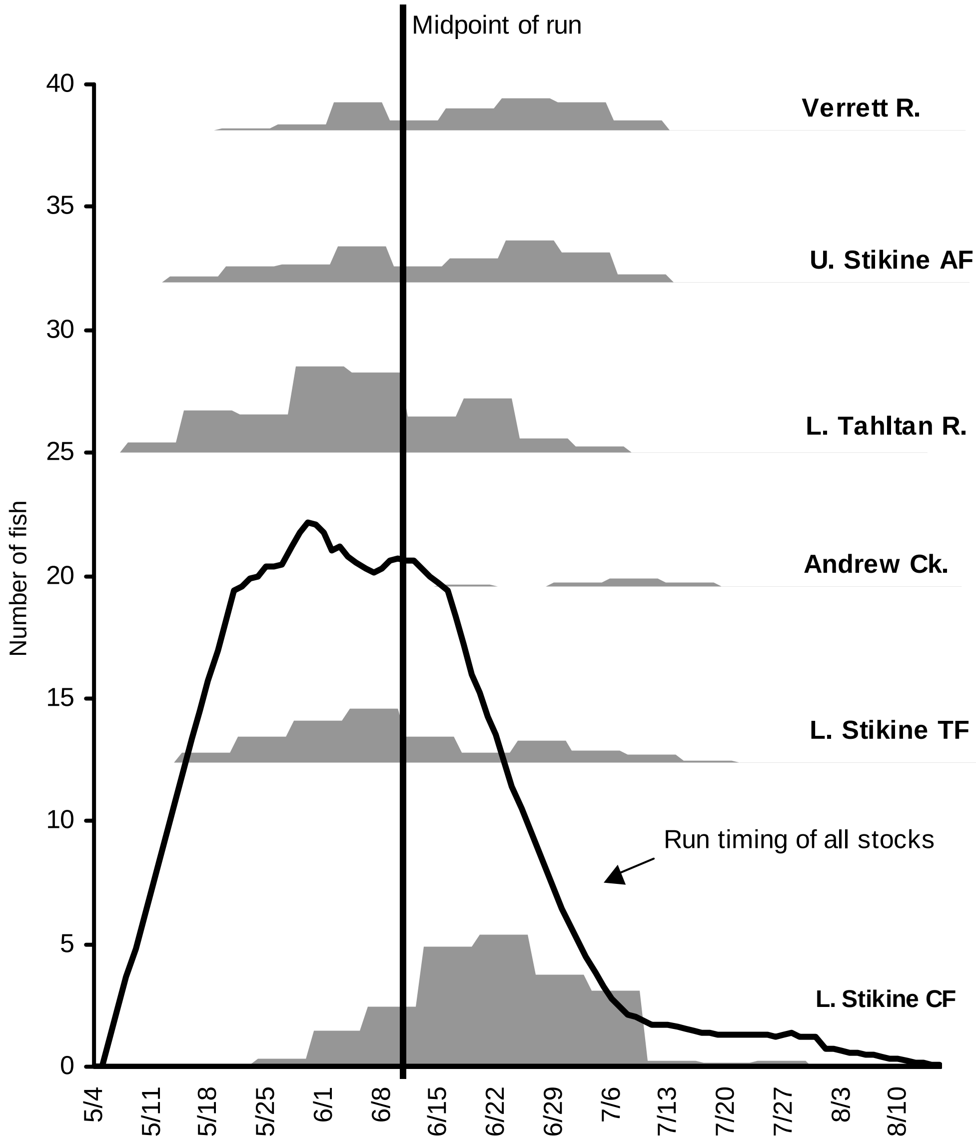

Figure 7.–Weekly numbers of recaptured Chinook salmon sampled at six locations (bar graphs) and associated time of marking, set against the average daily drift and set gillnet catches in the lower Stikine River (line graph), 1996–2004. X-axis pertains to time of marking.

Chinook salmon passing by Kakwan Point and Rock Island had an equal chance of being marked. Estimated marked fractions at the Little Tahltan weir (0.0228), Verrett River (0.0299), Johnny Tashoots Creek (0.0172), the lower river commercial and test gillnet fisheries (0.0324), and the aboriginal fishery (0.0101) were significantly different ($\chi^2 = 15.7$, df = 4, $P < 0.01$).

Given the difference in marked fractions, the data were initially divided into five temporal (release) and five spatial (recovery) strata (Appendix A4). These strata were subsequently pooled (based on stream stage levels, geographic proximity of recovery areas, run timing, and χ^2 contingency test results) and subjected to a battery of SPAS analyses. Out of 120 runs involving different

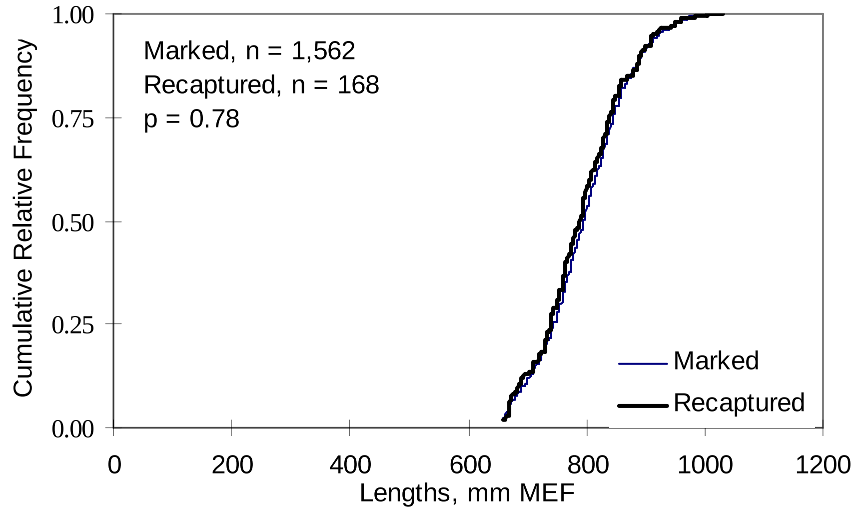

Figure 8.–Cumulative relative frequency of large Chinook salmon (≥660 mm MEF) marked at Kakwan Point and Rock Island, and recaptured at the weir on the Little Tahltan River, in the Verrett River, in the lower river commercial and test fisheries, and in the aboriginal fishery, lower Stikine River, 2004.

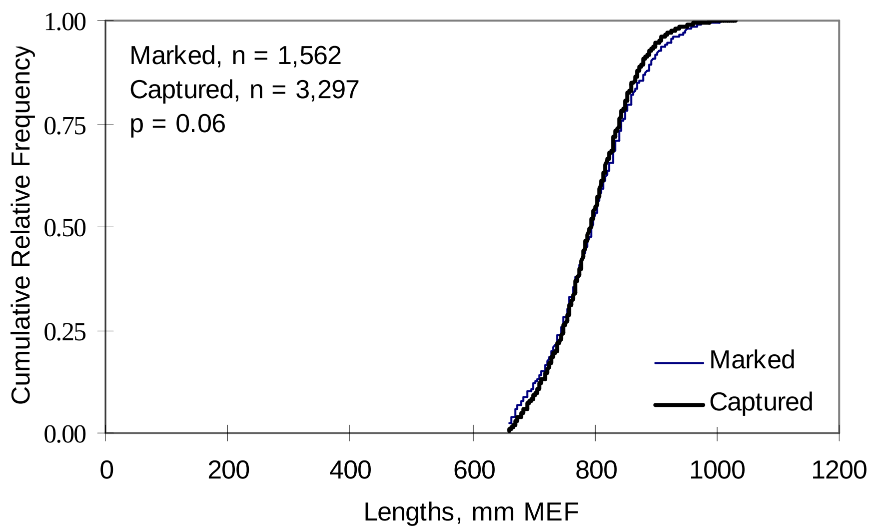

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Figure 9.–Cumulative relative frequency of large Chinook salmon (≥660 mm MEF) marked at Kakwan Point and Rock Island, and captured at the weir on the Little Tahltan River, in the Verrett River, in the lower river commercial and test fisheries, and in the aboriginal fishery, Stikine River, 2004.

groupings, 112 either failed to converge, returned negative results, or yielded results that fit the data poorly. The remainder provided Darroch estimates that ranged from 42,000 to 47,000 small-medium fish. These were rejected as overestimates for the following reasons: 1) the associated pooled Petersen estimate was 18,485; 2) run size estimates based on the relative size composition (Appendix A5) of fish in the Little Tahltan River weir and Kakwan Point/Rock Island samples were 9,776 and 16,661, respectively; and 3) the run of Chinook salmon <660 mm MEF to the Taku River, which tends to have larger runs of jacks than the Stikine River, was about 21,300 (Ed Jones, Sport Fish Biologist, ADF&G, Douglas, personal communication).

Additional runs through SPAS analyses were performed by systematically omitting recovery areas until problems with non-convergence, negative results, etc. were eliminated. This approach resulted in removal of the aboriginal fishery sample from the analysis. Ensuing analyses involving different pooling options (again based on stream stage levels, geographic proximity of recovery areas, run timing, and χ^2 contingency test results) and omission of additional recovery sites provided relatively stable estimates that ranged from 18,000 to 19,000. However, these analyses also yielded insignificant equal proportions tests that indicated the associated pooled Petersen estimates, which were all around 14,000, were acceptable. Among these estimates, the pooled Petersen estimate with the lowest %CV (SE from SPAS) was chosen.

The size distributions of fish marked at Kakwan Point and Rock Island versus combined samples of fish captured at the weir on the Little Tahltan River, Verrett River, Johnny Tashoots Creek, and in the lower river commercial and test gillnet fisheries, were significantly different (Kolmogorov-Smirnov: $d_{max} = 0.153$; n = 476, 1,001; $P < 0.001$; Figure 10), which indicates capture probabilities were not equal during the first event. However, the size distributions of fish marked and recaptured were not significantly different (Kolmogorov-Smirnov: $d_{max} = 0.047$; n = 476, 69; $P > 0.99$; Figure 11), which indicates that capture probabilities were similar regardless of size during the second event. These tests indicate there was no size-selectivity during the second event but there was during the first (Appendix A3: Case II, stratification by length is not required).

Further tests supported the conclusion that sampling at Kakwan Point and Rock Island had been selective for larger members of the small-medium size group. Pooled length samples of small-medium fish from the Little Tahltan River weir, Verrett River, Johnny Tashoots Creek, and the lower river commercial and test gillnet fisheries were arbitrarily split into two groups at the median length of small-medium fish (594 mm MEF) to permit comparison of marked fractions:

	≤ mm 594	594-659 mm
Marked	27	43
Unmarked	1,203	990
Marked fraction	0.022	0.042

The marked fractions were significantly different ($\chi^2 = 7.25$, df = 1, $P < 0.01$).

Finally, evidence from upstream sampling supported the supposition that every small-medium Chinook salmon had a near equal chance of being captured upstream regardless of their size (i.e., capture probabilities were equal during the second event). Pooled length samples of large fish from the Little Tahltan weir, Verrett River, Johnny Tashoots Creek, and the lower river commercial and test gillnet fisheries were again split into two size groups as were samples of large fish marked at Kakwan Point and Rock Island. The fractions (rates) of recaptured fish were compared as surrogates for probabilities of capture upstream:

	≤ mm 594	594-659 mm
Released with marks	153	291
Recaptured	27	43
Fraction recaptured	0.176	0.148

The fractions recaptured were not significantly different ($\chi^2 = 0.45$, df = 1, $P = 0.50$).

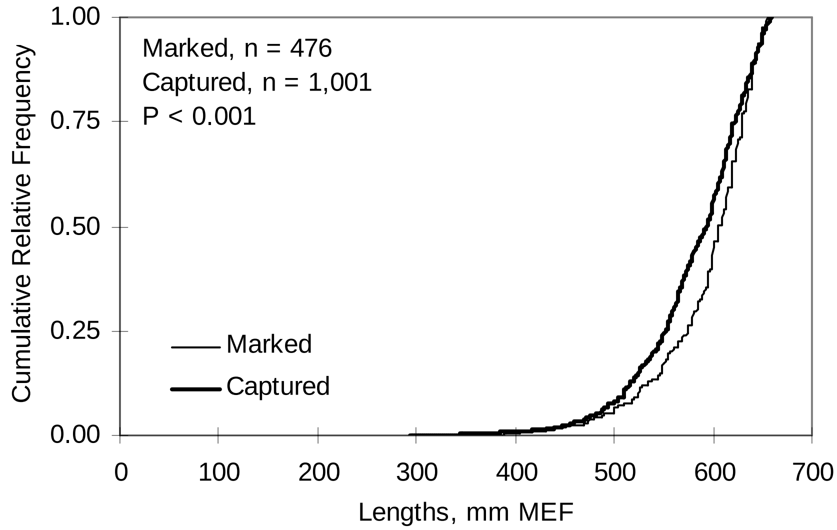


Figure 10.–Cumulative relative frequency of small-medium Chinook salmon (<660 mm MEF) marked at Kakwan Point and Rock Island, and captured at the weir on the Little Tahltan River, in the Verrett River, in Johnny Tashoots Creek, and in the lower river commercial and test fisheries, Stikine River, 2004.

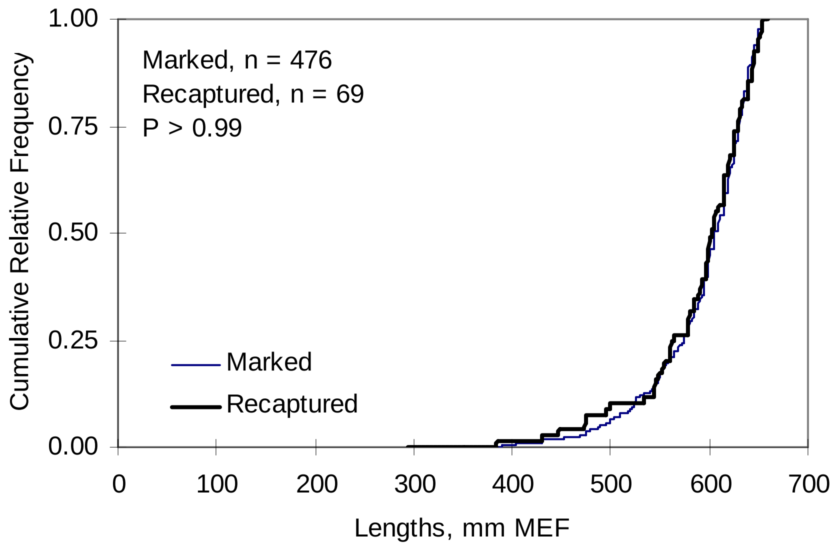


Figure 11.–Cumulative relative frequency of small-medium Chinook salmon (<660 mm MEF) marked at Kakwan Point and Rock Island, and recaptured at the weir on the Little Tahltan River, in the Verrett River, in Johnny Tashoots Creek, and in the lower river commercial and test fisheries, Stikine River, 2004.

AGE, SEX, AND LENGTH COMPOSITION

Age-1.3 Chinook salmon dominated all samples except those from Rock Island and Verrett River, constituting an estimated 43% of fish captured at Kakwan Point, 31% at Rock Island, 41% in the lower river test and commercial fisheries, 34% at Verrett River, 51% at the Little Tahltan River weir, and 42% at Andrew Creek (Appendices A6-A11). Age-1.2 fish dominated the Rock Island sample (47%), and age-1.4 fish the Verrett River sample (53%).

Estimated age compositions from the Little Tahltan River weir and Verrett River samples were compared to determine if they could be pooled and used to estimate spawning population proportions. No comparison was possible within the small-medium size category, but comparisons with the large category were significantly different (χ^2 = 9.63, df = 2, P < 0.01), as was the across-category comparison (χ^2 = 12.3, df = 2, P <0.01). Consequently, the Little Tahltan River weir and Verrett River samples were not pooled and because the age composition of Little Tahltan River Chinook salmon is considered relevant to all spawners in the Stikine River (Bernard et al. 2000), this sample was used to estimate spawning population proportions.

The estimated spawning escapement of 60,115 (SE = 4,236; 95% CI: 51,712 to 68,318) was composed of 20% age-1.2 fish, 50% age-1.3 fish, and 28% age-1.4 fish, and included 28,401 (SE = 2,472) females (Table 4).

DISCUSSION

To estimate the spawning escapement of large Chinook salmon that passed by Kakwan Point and Rock Island, inriver harvests in the commercial, test, aboriginal, U.S. subsistence, and Tahltan River sport fisheries were subtracted from the inriver run abundance estimate. The final estimate of the spawning escapement for large Chinook salmon above the U.S./Canada border in 2004 is 48,900 (= 52,538- 3,638).

Historically, spawning escapement to the Stikine River was estimated by multiplying the Little Tahltan River weir count by an expansion factor (4.0) thought to represent the proportion of the spawning escapement represented by that tributary (Pahlke 1996). The original expansion factor was based on professional judgment rather than empirical data, and in 1991 the TTC of the PSC decided to use only the actual counts of escapement to the Little Tahltan River to assess rebuilding (PSC 1991). The relationship between weir counts and the spawning escapement for the watershed is being refined through weir operations and this mark-recapture experiment.

The total weir count in 2004 of 16,381 large fish in the Little Tahltan River was 33% of the estimated spawning escapement, for an expansion factor of 2.99 (48,900/16,381) for weir counts to escapement (Table 5). The average expansion factor of 5.35 (SE = 1.33, 19% of the spawning population) is greater than the factor of 4.0 (25% of the spawning escapement) that was formerly used to expand weir counts in the Little Tahltan River.

The Little Tahltan River contribution of 33% was nearly double the 1996 to 2003 average of 19%. Further, the Little Tahltan River escapement was 160% above the 1996 to 2003 average (6,294), while the escapement of other Stikine Chinook stocks was 12% above average. The cumulative catch per hour through June 18, the latest date that a fish recaptured at the Little Tahltan River weir was tagged, was also a record, which indicated a strong return of this run component. The escapement to Verrett River was characterized as a record by field staff and the sample size collected there bears witness to this. The peak survey count at Andrew Creek was also a record. Approximately 100 Chinook salmon were counted at Tahltan Lake, whereas none were counted in 2002 and 2003. Additionally, approximately 300 Chinook salmon were caught in the Tuya River sockeye fishery, which indicated that the run there was also well above average. Residents at the mouth of Shakes Creek, in concert with stream walks, were of the impression that the 2004 run was very large. Considering the above ancillary information, the 2004 escapement estimate for large Chinook salmon may be negatively biased.

In 2004, 22 Chinook salmon with missing adipose fins were recovered in the Stikine River (Appendix A12). Fourteen were of Stikine River origin, eight of which were released by the ADF&G Sport Fish Division and six by DFO

Table 4.–Estimated age and sex composition by size category of the spawning escapement of Chinook salmon in the Stikine River, 2004.

		Brood year and age class									
		2001	2000	2000	1999	1999	1998	1998	1997	1997	
		1.1	2.1	1.2	2.2	1.3	2.3	1.4	2.4	1.5	Total
Panel A. Small and medium Chinook salmon (<660 mm MEF)											
Females	n			3							3
	%			2.9							2.9
	SE of %			1.6							1.6
	Escapement			318							318
	SE of esc.			186							186
Males	n	5		89		8					102
	%	4.8		84.8		7.6					97.1
	SE of %	2.1		3.5		2.6					1.6
	Escapement	529		9,421		847					10,797
	SE of esc.	243		1,463		313					1,626
Combined	n	5		92		8					105
	%	4.8		87.6		7.6					100.0
	SE of %	2.1		3.2		2.6					0.0
	Escapement	529		9,739		847					11,115
	SE of esc.	243		1,501		313					1,664
Panel B. Large Chinook salmon (≥660 MEF)											
Females	n			5		176	2	129		1	313
	%			0.9		32.3	0.4	23.7		0.2	57.4
	SE of %			0.4		2.0	0.3	1.8		0.2	2.1
	Escapement			449		15,792	179	11,574		90	28,084
	SE of esc.			202		1,593	127	1,280		90	2,465
Males	n			23	1	146	2	60			232
	%			4.2	0.2	26.8	0.4	11.0			42.6
	SE of %			0.9	0.2	1.9	0.3	1.3			2.1
	Escapement			2,064	90	13,100	179	5,383			20,816
	SE of esc.			451	90	1,395	127	782			1,954
Combined	n			28	1	322	4	189		1	545
	%			5.1	0.2	59.1	0.7	34.7		0.2	100.0
	SE of %			0.9	0.2	2.1	0.4	2.0		0.2	0.0
	Escapement			2,512	90	28,891	359	16,958		90	48,900
	SE of esc.			503	90	2,521	181	1,678		90	3,896
Panel C. Small, medium and large Chinook salmon											
Females	n			8		176	2	129		1	316
	%			1.3		26.3	0.3	19.3		0.1	47.3
	SE of %			0.5		1.8	0.2	1.6		0.1	2.2
	Escapement			766		15,792	179	11,574		90	28,401
	SE of esc.			275		1,593	127	1,280		90	2,472
Males	n	5		112	1	154	2	60			334
	%	0.9		19.1	0.1	23.2	0.3	9.0			52.7
	SE of %	0.4		2.3	0.1	1.7	0.2	1.1			2.2
	Escapement	529		11,485	90	13,947	179	5,383			31,614
	SE of esc.	243		1,531	90	1,430	127	782			2,542
Combined	n	5		120	1	330	4	189		1	650
	%	0.9		20.4	0.1	49.6	0.6	28.3		0.1	100.0
	SE of %	0.4		2.3	0.1	2.2	0.3	1.9		0.1	0.0
	Escapement	529		12,251	90	29,738	359	16,958		90	60,015
	SE of esc.	243		1,583	90	2,540	181	1,678		90	4,236

Table 5.–Counts at the weir on the Little Tahltan River, mark-recapture estimates of inriver run abundance and spawning escapement, expansion factors, and other statistics for large Chinook salmon in the Stikine River, 1996–2004.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	Average
Weir count	4,821	5,557	4,879	4,738	6,640	9,738	7,490	6,492	16,381	7,415
M[a]	359	653	405	252	612	1,416	935	1,089	1,509	803
C	2,006	4,528	3,048	4,030	3,657	5,596	4,375	4,696	5,914	4,206
R	47	93	43	42	73	118	75	118	169	86
Inriver run abundance	31,718[b]	31,509	28,133	23,716	30,301	66,646	53,893	49,881	52,538	40,926
SE	1,978[c]	2,960	3,931	3,240	3,168	5,853	5,912	6,078[d]	3,896	4,113
CV	6.2%	9.4%	14.0%	13.7%	10.5%	8.8%	11.0%	12.2%	7.4%	10.0%
95% lower C.I.	NA	NA	NA	NA	24,879	56,521	43,798	37,968	45,817	
95% upper C.I.	NA	NA	NA	NA	38,049	78,982	67,023	61,795	61,217	
Bias	NA	NA	NA	NA	1.0%	0.76%	0.31%	NA	0.47%	
Spawning escapement	28,949	26,996	25,968	19,947	27,531	63,523	50,875	46,824	48,900	37,724
SE	1,978[c]	2,960	3,931	3,240	3,168	5,853	5,912	6,078[d]	3,896	4,113
CV	6.8%	11.0%	15.1%	16.2%	11.5%	9.2%	11.6%	13.0%	8.0%	10.9%
95% lower C.I.	NA	NA	NA	NA	22,220	53,741	40,675	34,911	42,179	
95% upper C.I.	NA	NA	NA	NA	34,565	75,718	63,900	58,738	57,579	
Bias	NA	NA	NA	NA	1.14%	0.79%	0.33%	NA	0.50%	
Expansion factor	6.00[e]	4.86[f]	5.32	4.21	4.15	6.52	6.79	7.21	2.99	5.35
SE	0.41	0.53	0.81	0.68	0.48	0.60	0.79	0.94	0.24	1.33[g]

a Estimated in 1998 and 2001–04.

b An estimated 15,052 large Chinook immigrated to the Stikine River after June 12. This estimate, prorated for differences in sampling effort, was expanded to 31,718 for the entire season (Pahlke and Etherton 1997).

c This is a minimum estimate because variance of the prorated expansion was not estimable.

d A Darroch model was used to estimate run abundance and escapement using the program SPAS. Because M was estimated and the error in M could not be incorporated into the program, the standard error was biased low.

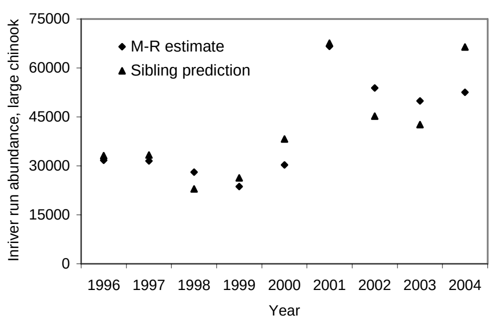
e Modified from data in Pahlke and Etherton (1997).

f Modified from data in Pahlke and Etherton (1999). The expansion factor based on radio telemetry, which was included in the average, was 5.48 (SE = 0.95).

g $SD = \sqrt{\text{var}(6.00,4.86...2.99)}$).

(Glenora Dojatin Creek Project). Two were released at Port Alexander and were recovered at Rock Island and the lower river commercial fishery. Two were released in the Taku River; one of these was recovered in the lower river commercial fishery and may have temporarily entered the river, but the other was recovered in the Tuya River (Figure 1). One pre-spawn female was recovered in Andrew Creek but was not sacrificed and the remaining three fish did not have tags.

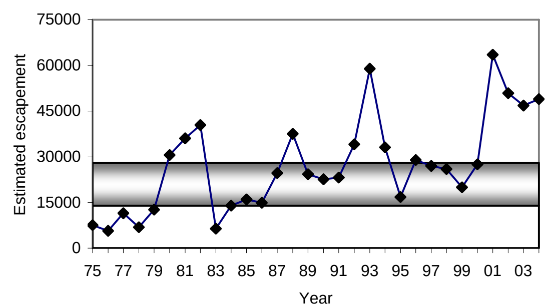
The U.S. and Canada signed a new PST Agreement in June 1999, which included a specific directive in Annex IV of the treaty to develop abundance-based management of Stikine River Chinook salmon by 2004. Towards that end, we have analyzed sibling relationships in which previous-year inriver run abundance estimates of age-1.2, age-1.3, and age-1.4 fish were used to predict current-year abundance of age-1.3 (R^2 = 0.88, P < 0.01), age-1.4 (R^2 = 0.85, P < 0.01), and age-1.5 fish (R^2 = 0.53, P = 0.04). The sum of these predictions, graphically compared to corresponding post-season inriver run abundance estimates from 1996-2004 below, has an average absolute forecast error of 14%:



The 2004 preseason inriver run forecast was 66,441 large Chinook salmon (forecast error = 26%).

In 2004 we used models that describe linear relationships between the inriver run abundance of large Chinook salmon and cumulative CPUE at Kakwan Point on May 15 (R^2 = 0.88, P < 0.01) and 31 (R^2 = 0.93, P < 0.001). These models provided inseason estimates of 55,869 on the 15th and 59,629 on the 31st, which compared reasonably well with the pre- and post-season estimates. These and similar models may provide timely in-season estimates and a method by which to judge preseason forecasts.

The 1999 PST Agreement states that we will manage Southeast Alaska fisheries to achieve escapement objectives for Southeast Alaska and transboundary river Chinook stocks (Chapter 3, Attachment 1, footnote 5). Estimated escapements have met or exceeded the escapement goal range (established in 2000) of 14,000 to 28,000 adult spawners since 1985. The ADF&G and DFO assessment is that Chinook salmon in the Stikine River have recovered from the recruitment overfishing and poor survival of the 1970s (Bernard et al. 2000).



CONCLUSIONS AND RECOMMENDATIONS

This was the ninth year of estimating the spawning escapement of Chinook salmon to the Stikine River and drift gillnets have proven to be an effective method of capturing enough large Chinook salmon for a post-season estimate. The use of a set gillnet at Rock Island has also provided a larger marked release group of Chinook salmon <660 mm MEF that has, in some years, been sufficient for a mark-recapture estimate. Although this year was unusual, the results of nine years of study confirm that counts of salmon through the Little Tahltan River weir are a useful index (i.e., the counts represent a relatively constant percentage of the escapement) of Chinook salmon escapement to the Stikine River. However, the weir counts do not serve as a timely indicator for in-season abundance-based management per the 1999 PST. However, models that predict inriver abundance from CPUE data are encouraging, and although CPUE varies with changing river conditions, it is a promising in-season indicator of run strength. Pre-season forecast models using sibling information also show potential. As coded wire tag data accumulate on marine harvests of Stikine River Chinook salmon, the escapement goal should be formally reviewed.

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REFERENCES CITED

ADF&G (Alaska Department of Fish and Game). 1981. Proposed management plan for Southeast Alaska Chinook salmon runs in 1981. Southeast Region, Alaska Department of Fish and Game Commercial Fisheries Division. Regional report 1J81-3, Juneau.

Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Canadian Technical Report of Fisheries and Aquatic Sciences 2106:36.

Beak Consultants Limited. 1981. Preliminary analysis of the potential impact of hydroelectric development of the Stikine River system on biological resources of the Stikine River estuary. Report for the British Columbia Hydro and Power Authority. Richmond, B. C.

Bernard, D. R., J. J. Hasbrouck, and S. J. Fleischman. 1999. Handling-induced delay and downstream movement of adult Chinook salmon in rivers. Fisheries 44:37-46.

Bernard, D. R., S. A. McPherson, K. A. Pahlke, and P. Etherton. 2000. Optimal production of Chinook salmon from the Stikine River. Alaska Department of Fish and Game, Fishery Manuscript No. 00-1, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-01.pdf

Bigelow, B. B., B. J. Bailey, M. M. Hiner, M. F. Schellekens, and K. R. Linn. 1995. Water resources data Alaska water year 1994. U. S. Geological Survey Water Data Report AK-94-1, Anchorage.

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

Clutter, R., and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. International Pacific Salmon Commission, Bulletin 9. Westminster, British Columbia, Canada.

Cochran, W. G. 1977. Sampling techniques. Third Edition. John Wiley & Sons, New York.

Darroch, J. N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48:241-260.

Der Hovanisian, J. A., P. Etherton, and K. A. Pahlke. 2005. Abundance of the Chinook salmon escapement on the Stikine River, 2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-25, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/Fds05-25.pdf

Der Hovanisian, J. A., K. A. Pahlke, and P. Etherton. 2001. Abundance of the Chinook salmon escapement on the Stikine River, 2000. Alaska Department of Fish and Game, Fishery Data Series No. 01-18, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds01-18.pdf

REFERENCES CITED (Continued)

Der Hovanisian, J. A., K. A. Pahlke, and P. Etherton. 2003. Abundance of the Chinook salmon escapement on the Stikine River, 2001. Alaska Department of Fish and Game, Fishery Data Series No. 03-09, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds03-09.pdf

Der Hovanisian, J. A., K. A. Pahlke, and P. Etherton. 2004. Abundance of the Chinook salmon escapement on the Stikine River, 2002. Alaska Department of Fish and Game, Fishery Data Series No. 04-08, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds04-08.pdf

Efron, B., and R. J. Tibshirani. 1993. First Edition. An introduction to the bootstrap. Chapman and Hall, New York, NY

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 55:708-713.

Johnson, R. E., R. P. Marshall, and S. T. Elliott. 1993. Chilkat River Chinook salmon studies, 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-50, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds93-50.pdf

Kissner, P. D. 1982. Status of important native Chinook salmon stocks in Southeastern Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1981-1982, Project F-9-14, 23 (AFS 41-10), Juneau.

McPherson, S. A., D. R. Bernard, M. S. Kelley, P. A. Milligan, and P. Timpany. 1996. Spawning Abundance of Chinook salmon in the Taku River in 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-36, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds96-36.pdf

Olsen, M. A. 1995. Abundance, age, sex, and size of Chinook salmon catches and escapements in Southeast Alaska in 1988. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Technical Fisheries Report 95-02, Juneau.

Pahlke, K. A. 1996. Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 1995. Alaska Department of Fish and Game, Fishery Data Series No. 96-35, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds96-35.pdf

Pahlke, K. A. 1999. Escapements of Chinook salmon in Southeast Alaska and transboundary rivers in 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-17, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds99-17.pdf

Pahlke, K. A., and D. R. Bernard. 1996. Abundance of the Chinook salmon escapement in the Taku River, 1989 to 1990. Alaska Fishery Research Bulletin 3(1):8-19, Juneau

Pahlke, K. A., and P. Etherton. 1997. Chinook salmon research on the Stikine River, 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-37, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds97-37.pdf

Pahlke, K. A., and P. Etherton. 1999. Abundance and distribution of the Chinook salmon escapement on the Stikine River, 1997. Alaska Department of Fish and Game, Fishery Data Series No. 99-6 , Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds99-06.pdf

Pahlke, K. A., and P. Etherton. 2000. Abundance of the Chinook salmon escapement on the Stikine River, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 00-24, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-24.pdf

Pahlke, K. A., P. Etherton, and J. A. Der Hovanisian. 2000. Abundance of the Chinook salmon escapement on the Stikine River, 1999. Alaska Department of Fish and Game, Fishery Data Series No. 00-25, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds00-25.pdf

PSC (Pacific Salmon Commission). 1991. Escapement goals for Chinook salmon in the Alsek, Taku, and Stikine Rivers. Transboundary River Technical Report, TCTR (91)-4. Vancouver, B. C.

REFERENCES CITED (Continued)

PSC (Pacific Salmon Commission). 2000. Estimates of transboundary river salmon production, harvest and escapement and a review of joint enhancement activities in 1998. Transboundary River Technical Report TCTR (2000)-1., Vancouver, B. C.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters. Second edition. Griffin and Company, Ltd. London.

Welander, A. D. 1940. A study of the development of the scale of Chinook salmon *Oncorhynchus tshawytscha*. Masters Thesis. University of Washington, Seattle.

APPENDIX A

Appendix A1.–Drift gillnet daily effort (minutes fished), catches, and catch per hour near Kakwan Point, Stikine River, 2004.

Date	Minutes	Lg. Chin.	Sm-med. Chin.	Sockeye	Temp	Depth	Large Chinook Fish/hour	Large Chinook Cum. percent	Small-medium Chinook Fish/hour	Small-medium Chinook Cum. percent
5/10/04	90	2	1	0	6.0	13.66	1.33	0.00	0.67	0.00
5/11/04	257	7	2	0	7.0	13.55	1.63	0.01	0.47	0.01
5/12/04	487	11	0	0	7.0	13.43	1.36	0.01	0.00	0.01
5/13/04	493	17	2	0	7.0	13.70	2.07	0.03	0.24	0.02
5/14/04	482	21	4	0	7.0	14.67	2.61	0.04	0.50	0.03
5/15/04	484	25	5	0	7.0	15.63	3.10	0.06	0.62	0.04
5/16/04	243	7	0	0	7.0	16.15	1.73	0.06	0.00	0.04
5/17/04	499	19	1	0	7.0	16.48	2.28	0.08	0.12	0.05
5/18/04	491	12	3	0	7.5	16.91	1.47	0.09	0.37	0.06
5/19/04	508	13	4	0	8.5	17.40	1.54	0.10	0.47	0.07
5/20/04	474	9	1	0	7.5	18.30	1.14	0.10	0.13	0.07
5/21/04	495	12	2	0	8.0	19.54	1.45	0.11	0.24	0.08
5/22/04	488	10	1	0	7.5	20.11	1.23	0.12	0.12	0.08
5/23/04	487	19	4	0	8.0	19.43	2.34	0.13	0.49	0.09
5/24/04	480	20	5	0	8.0	18.75	2.50	0.15	0.63	0.11
5/25/04	494	36	5	0	9.0	19.04	4.37	0.17	0.61	0.13
5/26/04	488	21	2	0	8.0	19.96	2.58	0.19	0.25	0.13
5/27/04	253	16	1	0	8.0	20.84	3.79	0.20	0.24	0.14
5/28/04	483	41	4	0	8.0	20.51	5.09	0.23	0.50	0.15
5/29/04	481	52	12	0	8.0	19.56	6.49	0.27	1.50	0.19
5/30/04	491	65	20	0	8.0	18.88	7.94	0.31	2.44	0.25
5/31/04	486	85	26	0	8.5	18.60	10.49	0.37	3.21	0.33
6/1/04	459	84	31	0	8.0	18.30	10.98	0.43	4.05	0.43
6/2/04	243	28	9	0	9.0	17.72	6.91	0.45	2.22	0.46
6/3/04	491	60	10	0	8.0	17.15	7.33	$\boxed{0.50}$	1.22	0.49
6/4/04	485	53	10	0	9.0	16.76	6.56	0.53	1.24	$\boxed{0.52}$
6/5/04	490	50	17	0	8.0	17.20	6.12	0.57	2.08	0.58
6/6/04	373	40	10	0	9.0	18.81	6.43	0.60	1.61	0.61
6/7/04	239	16	1	0	8.5	20.09	4.02	0.61	0.25	0.61
6/8/04	254	13	1	0		22.43	3.07	0.62	0.24	0.61
6/9/04	496	5	0	0	8.0	23.30	0.60	0.62	0.00	0.61
6/10/04	481	8	2	0	8.0	22.68	1.00	0.63	0.25	0.62
6/11/04	497	17	0	0	8.0	21.55	2.05	0.64	0.00	0.62
6/12/04	494	28	6	0	8.5	20.28	3.40	0.66	0.73	0.64
6/13/04	488	66	12	0	8.0	19.79	8.11	0.71	1.48	0.68
6/14/04	483	45	9	1	9.0	19.81	5.59	0.74	1.12	0.71
6/15/04	492	45	9	0	8.0	19.54	5.49	0.77	1.10	0.73
6/16/04	483	55	13	0	9.5	19.25	6.83	0.81	1.61	0.78
6/17/04	474	61	16	1	8.0	19.30	7.72	0.86	2.03	0.83
6/18/04	483	33	11	0	10.0	20.01	4.10	0.88	1.37	0.86
6/19/04	503	11	1	0	8.0	21.33	1.31	0.89	0.12	0.86
6/20/04	480	7	1	0	11.0	22.54	0.88	0.89	0.13	0.87
6/21/04	0	0	0	0		23.31	0.00	0.89	0.00	0.87
6/22/04	506	0	0	0	8.5	23.81	0.00	0.89	0.00	0.87
6/23/04	483	1	0	0	9.5	23.79	0.12	0.89	0.00	0.87
6/24/04	481	0	0	0	8.0	24.08	0.00	0.89	0.00	0.87
6/25/04	492	2	0	0	11.0	24.25	0.24	0.89	0.00	0.87
6/26/04	494	4	0	0	8.5	23.96	0.49	0.90	0.00	0.87
6/27/04	260	0	0	0	11.0	23.81	0.00	0.90	0.00	0.87
6/28/04	483	8	2	0	9.5	23.41	0.99	0.90	0.25	0.87

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Appendix A1.–Page 2 of 2.

							Large Chinook		Small-medium Chinook	
Date	**Minutes**	**Lg. Chin.**	**Sm-med Chin.**	**Sockeye**	**Temp**	**Depth**	**Fish/hour**	**Cum. Percent**	**Fish/hour**	**Cum. Percent**
6/29/0	492	12	2	0	9.5	22.84	1.46	0.91	0.24	0.88
6/30/0	487	8	1	0	9.0	23.22	0.99	0.92	0.12	0.88
7/1/04	503	9	3	0	9.0	22.92	1.07	0.92	0.36	0.89
7/2/04	492	13	9	1	9.5	22.14	1.59	0.93	1.10	0.92
7/3/04	240	9	4	1	10.0	21.71	2.25	0.94	1.00	0.93
7/4/04	490	28	9	2	9.0	21.33	3.43	0.96	1.10	0.96
7/5/04	495	32	5	6	9.0	20.78	3.88	0.98	0.61	0.98
7/6/04	481	17	3	3	9.0	20.84	2.12	0.99	0.37	0.99
7/7/04	245	7	4	0	9.5	21.22	1.71	1.00	0.98	1.00
Total	427 hrs.	1,395	316	15						

Appendix A2.–Set gillnet daily effort (minutes fished), catches, and catch per hour, at Rock Island, Stikine River, 2004.

							Large Chinook		Small-medium Chinook	
Date	Minutes	Lg. Chin.	Sm-med Chin.	Sockeye	Temp	Depth	Fish/hour	Cum. percent	Fish/hour	Cum. percent
05/07/04	414	2	0			13.11	0.29	0.01	0.00	0.00
05/08/04	424	0	0			12.97	0.00	0.01	0.00	0.00
05/09/04	427	3	1			13.32	0.42	0.03	0.14	0.01
05/10/04	422	0	0			13.66	0.00	0.03	0.00	0.01
05/11/04	420	0	2			13.55	0.00	0.03	0.29	0.02
05/12/04	420	0	0			13.43	0.00	0.03	0.00	0.02
05/13/04	420	0	1			13.70	0.00	0.03	0.14	0.02
05/14/04	420	1	2			14.67	0.14	0.03	0.29	0.03
05/15/04	420	2	0			15.63	0.29	0.04	0.00	0.03
05/16/04	432	4	0			16.15	0.56	0.06	0.00	0.03
05/17/04	427	2	1			16.48	0.28	0.07	0.14	0.04
05/18/04	425	1	0			16.91	0.14	0.08	0.00	0.04
05/19/04	421	0	2			17.40	0.00	0.08	0.29	0.05
05/20/04	436	1	0			18.30	0.14	0.09	0.00	0.05
05/21/04	425	2	2			19.54	0.28	0.10	0.28	0.06
05/22/04	436	2	1			20.11	0.28	0.11	0.14	0.06
05/23/04	377	2	5			19.43	0.32	0.12	0.80	0.09
05/24/04	427	3	5			18.75	0.42	0.13	0.70	0.12
05/25/04	420	5	1			19.04	0.71	0.16	0.14	0.12
05/26/04	421	3	0			19.96	0.43	0.18	0.00	0.12
05/27/04	416	2	1			20.84	0.29	0.19	0.14	0.13
05/28/04	420	0	0			20.51	0.00	0.19	0.00	0.13
05/29/04	422	3	3			19.56	0.43	0.20	0.43	0.15
05/30/04	454	9	6			18.88	1.19	0.25	0.79	0.18
05/31/04	457	24	17			18.60	3.15	0.38	2.23	0.27
06/01/04	422	13	16			18.30	1.85	0.45	2.27	0.35
06/02/04	no fishing					17.72		0.45		0.35
06/03/04	no fishing					17.15		0.45		0.35
06/04/04	no fishing					16.76		0.45		0.35
06/05/04	no fishing					17.20		0.45		0.35
06/06/04	no fishing					18.81		0.45		0.35
06/07/04	no fishing					20.09		0.45		0.35
06/08/04	no fishing					22.43		0.45		0.35
06/09/04	no fishing					23.30		0.45		0.35
06/10/04	no fishing					22.68		0.45		0.35
06/11/04	no fishing					21.55		0.45		0.35
06/12/04	no fishing					20.28		0.45		0.35
06/13/04	no fishing					19.79		0.45		0.35
06/14/04	no fishing					19.81		0.45		0.35
06/15/04	363	8	12	0		19.54	1.32	0.49	1.98	0.42
06/16/04	344	13	15	11		19.25	2.27	0.56	2.62	0.50
06/17/04	345	7	24	10		19.30	1.22	0.60	4.18	0.63
06/18/04	343	8	13	13		20.01	1.40	0.64	2.27	0.70
06/19/04	359	3	5	8		21.33	0.50	0.65	0.84	0.73
06/20/04	360	3	3	6		22.54	0.50	0.67	0.50	0.74
06/21/04	361	0	0	0		23.31	0.00	0.67	0.00	0.74
06/22/04	360	0	1	1		23.81	0.00	0.67	0.17	0.75
06/23/04	387	0	1	6		23.79	0.00	0.67	0.16	0.75
06/24/04	359	1	0	5		24.08	0.17	0.68	0.00	0.75
06/25/04	356	2	1	5		24.25	0.34	0.69	0.17	0.76

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							Large Chinook		Small-medium Chinook	
Date	Minutes	Lg. Chin.	Sm-med Chin.	Sockeye	Temp	Depth	Fish/hour	Cum. percent	Fish/hour	Cum. percent
06/26/04	355	0	0	11		23.96	0.00	0.69	0.00	0.76
06/27/04	351	0	1	17		23.81	0.00	0.69	0.17	0.76
06/28/04	353	1	0	22		23.41	0.17	0.69	0.00	0.76
06/29/04	343	3	2	35		22.84	0.52	0.71	0.35	0.77
06/30/04	336	3	2	50		23.22	0.54	0.72	0.36	0.78
07/01/04	341	1	1	35		22.92	0.18	0.73	0.18	0.79
07/02/04	377	1	0	30		22.14	0.16	0.73	0.00	0.79
07/03/04	360	2	2	64		21.71	0.33	0.74	0.33	0.80
07/04/04	356	2	4	60		21.33	0.34	0.76	0.67	0.82
07/05/04	345	4	0	90		20.78	0.70	0.78	0.00	0.82
07/06/04	323	0	5	130		20.84	0.00	0.78	0.93	0.85
07/07/04	340	5	1	97		21.22	0.88	0.80	0.18	0.85
07/08/04	334	1	1	76		20.63	0.18	0.81	0.18	0.86
07/09/04	378	1	0	23		21.50	0.16	0.81	0.00	0.86
07/10/04	374	1	0	31		22.12	0.16	0.82	0.00	0.86
07/11/04	381	0	0	19		21.77	0.00	0.82	0.00	0.86
07/12/04	253	0	1	34		20.88	0.00	0.82	0.24	0.87
07/13/04	343	1	2	88		20.68	0.18	0.82	0.35	0.88
07/14/04	366	0	1	49		21.37	0.00	0.82	0.16	0.88
07/15/04	375	0	3	48		21.43	0.00	0.82	0.48	0.90
07/16/04	368	2	4	50		21.48	0.33	0.84	0.65	0.92
07/17/04	369	1	1	51		21.35	0.16	0.84	0.16	0.92
07/18/04	369	0	0	47		20.47	0.00	0.84	0.00	0.92
07/19/04	346	3	0	84		20.08	0.52	0.86	0.00	0.92
07/20/04	328	1	0	65		20.09	0.18	0.86	0.00	0.92
07/21/04	332	1	2	54		20.78	0.18	0.87	0.36	0.94
07/22/04	368	1	1	46		20.48	0.16	0.87	0.16	0.94
07/23/04	376	0	1	28		20.44	0.00	0.87	0.16	0.95
07/24/04	371	0	0	38		20.40	0.00	0.87	0.00	0.95
07/25/04	374	3	0	30		20.34	0.48	0.89	0.00	0.95
07/26/04	353	0	0	55		19.55	0.00	0.89	0.00	0.95
07/27/04	361	2	0	56		18.57	0.33	0.90	0.00	0.95
07/28/04	239	2	1	55		18.69	0.50	0.91	0.25	0.95
07/29/04	372	0	0	37		20.44	0.00	0.91	0.00	0.95
07/30/04	370	0	0	40		20.57	0.00	0.91	0.00	0.95
07/31/04	368	1	1	45		18.90	0.16	0.91	0.16	0.96
08/01/04	379	0	1	24		17.97	0.00	0.91	0.16	0.96
08/02/04	372	0	0	34		17.45	0.00	0.91	0.00	0.96
08/03/04	385	2	1	20		17.70	0.31	0.93	0.16	0.97
08/04/04	375	0	1	25		17.71	0.00	0.93	0.16	0.97
08/05/04	377	2	0	24		17.84	0.32	0.94	0.00	0.97
08/06/04	386	0	1	17		18.32	0.00	0.94	0.16	0.98
08/07/04	379	1	1	21		18.44	0.16	0.94	0.16	0.98
08/08/04	374	1	0	26		17.90	0.16	0.95	0.00	0.98
08/09/04	374	1	0	23		17.78	0.16	0.95	0.00	0.98
08/10/04	380	1	1	28		18.08	0.16	0.96	0.16	0.99
08/11/04	376	0	0	29		18.98	0.00	0.96	0.00	0.99
08/12/04	371	1	0	27		19.26	0.16	0.96	0.00	0.99
08/13/04	381	1	0	12		17.58	0.16	0.97	0.00	0.99
08/14/04	382	1	0	12		17.52	0.16	0.97	0.00	0.99
08/15/04	377	1	0	24		18.49	0.16	0.98	0.00	0.99

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Appendix A2.–Page 3 of 3.

							Large Chinook		Small-medium Chinook	
Date	Minutes	Lg. Chin.	Sm-med Chin.	Sockeye	Temp	Depth	Fish/hour	Cum. percent	Fish/hour	Cum. percent
08/16/04	384	0	0	18		19.54	0.00	0.98	0.00	0.99
08/17/04	382	2	1	13		20.17	0.31	0.99	0.16	0.99
08/18/04	384	0	0	6		20.23	0.00	0.99	0.00	0.99
08/19/04	386	0	0	5		20.07	0.00	0.99	0.00	0.99
08/20/04	379	0	1	14		18.94	0.00	0.99	0.16	1.00
08/21/04	380	2	0	4		17.98	0.32	1.00	0.00	1.00
08/22/04	380	0	0	6		17.25	0.00	1.00	0.00	1.00
08/23/04	379	0	0	7		17.05	0.00	1.00	0.00	1.00
08/24/04	434	0	0	3		15.30	0.00	1.00	0.00	1.00
08/25/04	371	0	0	3		14.77	0.00	1.00	0.00	1.00
08/26/04	389	0	0	2		14.67	0.00	1.00	0.00	1.00
08/27/04	390	0	0	1		14.96	0.00	1.00	0.00	1.00
08/28/04	403	0	0	0		17.13	0.00	1.00	0.00	1.00
08/29/04	384	0	0	4		16.04	0.00	1.00	0.00	1.00
08/30/04	377	0	0	1		14.88	0.00	1.00	0.00	1.00
08/31/04	380	0	0	2		14.31	0.00	1.00	0.00	1.00
09/01/04	385	0	0	0		-	0.00	1.00	0.00	1.00
09/02/04	382	0	0	1		-	0.00	1.00	0.00	1.00
09/03/04	381	0	0	1		-	0.00	1.00	0.00	1.00
Total	676	188	186	2,292						

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

Results of hypothesis tests (K-S and χ^2)[a] on lengths of fish MARKED during the first event and RECAPTURED during the second event.	Results of hypothesis tests (K-S) on lengths of fish MARKED during the first event and CAPTURED during the second event.

Case I

"Accept H_o"	"Accept H_o"

There is no size-selectivity during either event

Case II

"Accept H_o"	"Reject H_o"

There is no size-selectivity during the second sampling event but there is during the first

Case III

"Reject H_o"	"Accept H_o"

There is size-selectivity during both sampling events

Case IV

"Reject H_o"	"Reject H_o"

There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown

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

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

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

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

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

-continued-

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

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

[a] The K-S test is significant at $P \le 0.05$ and borderline at $0.05 < P < 0.15$; the χ^2 test at $P \le 0.05$

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

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

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

Appendix A4.–Release and recovery strata for small-medium Chinoook salmon, Stikine River, 2004.

	Releases	Recoveries				
Release time strata	**Kakwan and Rock Island**	**Test and lower river commercial, fisheries**	**Verrett**	**Aboriginal fishery**	**Johnny Tashoots**	**Little Tahltan River weir**
5/9-5/22	37	1	0	1	0	0
5/23-6/5	204	8	1	3	1	3
6/6-6/19	140	34	2	5	0	2
6/20-7/3	33	6	1	1	0	0
7/4-7/31	30	11	0	2	0	0
Total	444	60	4	12	1	5
Total examined		1,852	134	1,184	58	219

Appendix A5.–Procedures used to estimate the inriver run abundance of small and medium Chinook salmon in the Stikine River.

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 A6.–Estimated age and sex composition and mean length by age of Chinook salmon passing by Kakwan Point , 2004.

		Age class										
		1.1	**0.3**	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Small and medium Chinook salmon												
Females	n			28		3						31
	% age comp.			10.5		1.1						11.6
	SE of %			1.9		0.6						2.0
	Avg. length			619		587						616
	SE			5		15						5
Males	n			216		17	1	2				236
	% age comp.			80.9		6.4	0.4	0.7				88.4
	SE of %			2.4		1.5	0.4	0.5				2.0
	Avg. length.			614		626	625	645				615
	SE			2		5		0				2
Sexes combined	n			244		20	1	2				267
	% age comp.			91.4		7.5	0.4	0.7				100.0
	SE of %			1.7		1.6	0.4	0.5				0.0
	Avg. length.			615		620		645				616
	SE			2		6		0				2
Large Chinook salmon												
Females	n			19		387		297	2	4		709
	% age comp.			1.7		34.0		26.1	0.2	0.4		62.2
	SE of %			0.4		1.4		1.3	0.1	0.2		1.4
	Avg. length			673		774		846	815	831		802
	SE			3		2		3	40	19		2
Males	n		1	68		199		158		4		430
	% age comp.		0.1	6.0		17.5		13.9		0.4		37.8
	SE of %		0.1	0.7		1.1		1.0		0.2		1.4
	Avg. length.		690	677		773		886		983		801
	SE			2		5		5		13		5
Sexes combined	n		1	87		586		455	2	8		1,139
	% age comp.		0.1	7.6		51.4		39.9	0.2	0.7		100.0
	SE of %		0.1	0.8		1.5		1.5	0.1	0.2		0.0
	Avg. length.		690	676		774		860	815	907		802
	SE			2		2		3	40	30		2
Small, medium, and large Chinook salmon												
Females	n			47		390		297	2	4		740
	% age comp.			3.3		27.7		21.1	0.1	0.3		52.6
	SE of %			0.5		1.2		1.1	0.1	0.1		1.3
	Avg. length			641		773		846	815	831		794
	SE			5		2		3	40	19		2
Males	n		1	284		216	1	160		4		666
	% age comp.		0.1	20.2		15.4	0.1	11.4		0.3		47.4
	SE of %		0.1	1.1		1.0	0.1	0.8		0.1		1.3
	Avg. length.		690	629		761	625	883		983		735
	SE			2		5		5		13		5
Sexes combined	n		1	331		606	1	457	2	8		1,406
	% age comp.		0.1	23.5		43.1	0.1	32.5	0.1	0.6		100.0
	SE of %		0.1	1.1		1.3	0.1	1.2	0.1	0.2		0.0
	Avg. length.		690	631		769	625	859	815	907		766
	SE			2		2		3	40	30		3

Appendix A7.–Estimated age and sex composition and mean length by age of Chinook salmon passing by Rock Island , 2004.

Small and medium Chinook salmon											
		Age class									
		0.2	**1.1**	**0.3**	**1.2**	**1.3**	**0.5**	**1.4**	**2.3**	**1.5**	**Total**
Females	n				21	2					23
	% age comp.				15 .8	1 .5					17 .3
	SE of %				3 .2	1 .1					3 .3
	Avg. length				585	636					590
	SE				13	11					8
Males	n		5		96	9					110
	% age comp.		3 .8		72 .2	6 .8					82 .7
	SE of %		1 .7		3 .9	2 .2					3 .3
	Avg. length.		38		545	616					545
	SE		17		6	10					6
Sexes combined	n		5		117	11					133
	% age comp.		3 .8		88 .0	8 .3					100 .0
	SE of %		1 .7		2 .8	2 .4					0 .0
	Avg. length.		38		552	620					553
	SE		17		5	9					5
Large Chinook salmon											
Females	n				3	56		43			102
	% age comp.				2 .1	39 .4		30 .3			71 .8
	SE of %				1 .2	4 .1		3 .9			3 .8
	Avg. length				672	738		798			762
	SE				6	4		5			5
Males	n				10	18		12			40
	% age comp.				7 .0	12 .7		8 .5			28 .2
	SE of %				2 .2	2 .8		2 .3			3 .8
	Avg. length.				675	752		803			748
	SE				6	10		15			10
Sexes combined	n				13	74		55			142
	% age comp.				9 .2	52 .1		38 .7			100 .0
	SE of %				2 .4	4 .2		4 .1			0 .0
	Avg. length.				674	742		799			758
	SE				4	4		5			4
Small, medium, and large Chinook salmon											
Females	n				24	58		43			125
	% age comp.				8 .7	21 .1		15 .6			45 .5
	SE of %				1 .7	2 .5		2 .2			3 .0
	Avg. length				596	735		798			730
	SE				10	5		5			7
Males	n		5		106	27		12			150
	% age comp.		1 .8		38 .5	9 .8		4 .4			54 .5
	SE of %		0 .8		2 .9	1 .8		1 .2			3 .0
	Avg. length.		428		557	707		803			599
	SE		17		7	14		15			9
Sexes combined	n		5		130	85		55			275
	% age comp.		1 .8		47 .3	30.9		20 .0			100 .0
	SE of %		0 .8		3 .0	2.8		2 .4			0 .0
	Avg. length.		428		564	726		799			659
	SE		17		6	6		5			7

Appendix A8.–Estimated age and sex composition and mean length by age of Chinook salmon harvested in the Canadian commercial and test gillnet fisheries on the Lower Stikine River, 2004.

		Age Class											
		1.1	**0.3**	**1.2**	**2.1**	**0.4**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Small and medium Chinook salmon													
Females	n			13			3	1	1				18
	% age comp.			10.2			2.4	0.8	0.8				14.2
	SE of %			2.7			1.4	0.8	0.8				3.1
	Avg. length			585			612	552	641				591
	SE			10			20						9
Males	n	5		95			7	2					109
	% age comp.	3.9		74.8			5.5	1.6					85.8
	SE of %	1.7		3.9			2.0	1.1					3.1
	Avg. length.	432		561			592	577					557
	SE	19		6			13	33					6
Sexes combined	n	5		108			10	3					127
	% age comp.	3.9		85.0			7.9	2.4					100.0
	SE of %	1.7		3.2			2.4	1.4					0.0
	Avg. length.	432		564			598	569					562
	SE	19		6			11	21					6
Large Chinook salmon													
Females	n			8			53		28	3			93
	% age comp.			4.0			26.5		14.0	1.5			46.5
	SE of %			1.4			3.1		2.5	0.9			3.5
	Avg. length			692			756		820	764			772
	SE			9			6		11	25			6
Males	n		1	17			63		24	2		1	107
	% age comp.		0.5	8.5			31.5		12.0	1.0		0.5	53.5
	SE of %		0.5	2.0			3.3		2.3	0.7		0.5	3.5
	Avg. length.		754	696			755		853	827		954	769
	SE			9			7		14	7			7
Sexes combined	n		1	25			116		52	5		1	200
	% age comp.		0.5	12.5			58.0		26.0	2.5		0.5	100.0
	SE of %		0.5	2.3			3.5		3.1	1.1		0.5	0.0
	Avg. length.		754	695			756		835	789		954	771
	SE			6			4		9	21		1	5
Small, medium, and large Chinook salmon													
Females	n			21			56	1	29	3		1	111
	% age comp.			6.4			17.1	0.3	8.9	0.9		0.3	33.9
	SE of %			1.4			2.1	0.3	1.6	0.5		0.3	2.6
	Avg. length			626			749	552	814	764		954	743
	SE			14			7		13	25			9
Males	n	5	1	112			70	2	24	2			216
	% age comp.	1.5	0.3	34.3			21.4	0.6	7.3	0.6			66.1
	SE of %	0.7	0.3	2.6			2.3	0.4	1.4	0.4			2.6
	Avg. length.	432	754	581			739	577	853	827			662
	SE	19		7			8	47	14	7			9
Sexes combined	n	5	1	133			126	3	53	5		1	327
	% age comp.	1.5	0.3	40.7			38.5	0.9	16.2	1.5		0.3	100.0
	SE of %	0.7	0.3	2.7			2.7	0.5	2.0	0.7		0.3	0.0
	Avg. length.	432	754	588			743	569	832	789		954	690
	SE	19		7			6	21	10	21			7

Appendix A9.–Estimated age and sex composition and mean length by age of Chinook salmon at Little Tahltan River weir, 2004.

		Age class									
		1.1	1.2	2.1	1.3	2.2	1.4	2.3	1.5	2.4	Total
Small and medium Chinook salmon											
Females	n		3								3
	% age comp.		2.9								2.9
	SE of %		1.6								1.6
	Avg. length		621								321
	SE		18								18
Males	n	5	89		8						102
	% age comp.	4.8	84.8		7.6						97.1
	SE of %	2.1	3.5		2.6						1.6
	Avg. length.	578	597		620						598
	SE	11	4		19						4
Sexes combined	n	5	92		8						105
	% age comp.	4.8	87.6		7.6						100.0
	SE of %	2.1	3.2		2.6						0.0
	Avg. length.	578	597		620						598
	SE	1.1	4		19						4
Large Chinook salmon											
Females	n		5		176		129	2	1		313
	% age comp.		0.9		32.3		23.7	0.4	0.2		57.4
	SE of %		0.4		2.0		1.8	0.3	0.2		2.1
	Avg. length		741		792		839	779	815		811
	SE		23		3		3	49			3
Males	n		23		146	1	60	2			232
	% age comp.		4.2		26.8	0.2	11.0	0.4			42.6
	SE of %		0.9		1.9	0.2	1.3	0.3			2.1
	Avg. length.		696		791	692	889	854			807
	SE		8		5		7	30			5
Sexes combined	n		28		322	1	189		1		545
	% age comp.		5.1		59.1	0.2	34.7		0.2		100.0
	SE of %		0.9		2.1	0.2	2.0		0.2		0.0
	Avg. length.		704		791	692	855				809
	SE		8		3		4				3
Small, medium, and large Chinook salmon											
Females	n		8		176		129	2	1		316
	% age comp.		1.2		27.1		19.8	0.3	0.2		48.6
	SE of %		0.4		1.7		1.6	0.2	0.2		2.0
	Avg. length		696		792		839	779	815		809
	SE		27		3		3	49			3
Males	n	5	112		154	1	60	2			334
	% age comp.	0.8	17.2		23.7	0.2	9.2	0.3			51.4
	SE of %	0.3	1.5		1.7	0.2	1.1	0.2			2.0
	Avg. length.	578	617		782	692	889	854			743
	SE	11	5		6		7	30			7
Sexes combined	n	5	120		330	1	189		1		650
	% age comp.	0.8	18.5		50.8	0.2	29.1		0.2		100.0
	SE of %	0.3	1.5		2.0	0.2	1.8		0.2		0.0
	Avg. length.	578	622		787	692	855		815		775
	SE	11	6		3		4				4

Appendix A10.–Estimated age and sex composition and mean length by age of moribund and recently expired Chinook salmon in Verrett River, 2004.

		Small and medium Chinook salmon									
		Age class									
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Females	n		1								1
	% age comp.		2.9								2.9
	SE of %		2.9								2.9
	Avg. length		620								620
	SE										
Males	n	1	33								34
	% age comp.	2.9	94.3								97.1
	SE of %	2.9	4.0								2.9
	Avg. length.	370	605								598
	SE		5								8
Sexes combined	n	1	34								35
	% age comp.	2.9	97.1								100.0
	SE of %	2.9	2.9								0.0
	Avg. length.	370	605								598
	SE		5								8
		Large Chinook salmon									
Females	n		3		82		159		2		247
	% age comp.		0.8		21.2		41.2		0.5		64.0
	SE of %		0.4		2.1		2.5		0.4		2.4
	Avg. length		735		752		807		794		788
	SE		23		4		3		14		3
Males	n		11		62		65	1	1		139
	% age comp.		2.8		16.1		16.8	0.3	0.3		36.0
	SE of %		0.8		1.9		1.9	0.3	0.3		2.4
	Avg. length.		683		770		853	790	870		803
	SE		6		7		7				6
Sexes combined	n		14		144		224	1	3		386
	% age comp.		3.6		37.3		58.0	0.3	0.8		100.0
	SE of %		1.0		2.5		2.5	0.3	0.4		0.0
	Avg. length.		694		760		820	790	819		793
	SE		9		4		3		27		3
		Small, medium, and large Chinook salmon									
Females	n		4		82		159		2		248
	% age comp.		1.0		19.5		37.8		0.5		58.9
	SE of %		0.5		1.9		2.4		0.3		2.4
	Avg. length		706		752		807		794		787
	SE		33		4		3		14		3
Males	n	1	44		62		65	1	1		173
	% age comp.	0.2	10.5		14.7		15.4	0.2	0.2		41.1
	SE of %	0.2	1.5		1.7		1.8	0.2	0.2		2.4
	Avg. length.	370	624		770		853	790	870		763
	SE		7		7		7				8
Sexes combined	n	1	48		144		224	1	3		421
	% age comp.	0.2	11.4		34.2		53.2	0.2	0.7		100.0
	SE of %	0.2	1.6		2.3		2.4	0.2	0.4		0.0
	Avg. length.	370	631		760		820	790	819		777
	SE		7		4		3		27		4

Appendix A11.–Estimated age and sex composition and mean length by age of Chinook salmon in Andrew Creek, 2004.

		Small and medium Chinook salmon									
		Age class									
		1.1	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**1.5**	**2.4**	**Total**
Females	n										
	% age comp.										
	SE of %										
	Avg. length										
	SE										
Males	n	1	31		5						37
	% age comp.	2.7	83.8		13.5						100.0
	SE of %	2.7	6.1		5.7						0.0
	Avg. length.	325	596		618						591
	SE		7		12						10
Sexes combined	n	1	31		5						37
	% age comp.	2.7	83.8		13.5						100.0
	SE of %	2.7	6.1		5.7						0.0
	Avg. length.	325	596		618						591
	SE		7		12						10
		Large Chinook salmon									
Females	n				29		53		2		84
	% age comp.				17.2		31.4		1.2		49.7
	SE of %				2.9		3.6		0.8		3.9
	Avg. length				784		840		863		821
	SE				7		6		33		6
Males	n		9		53		22		1		85
	% age comp.		5.3		31.4		13.0		0.6		50.3
	SE of %		1.7		3.6		2.6		0.6		3.9
	Avg. length.		679		752		858		980		775
	SE		6		7		14				9
Sexes combined	n		9		82		75		3		169
	% age comp.		5.3		48.5		44.4		1.8		100.0
	SE of %		1.7		3.9		3.8		1.0		0.0
	Avg. length.		679		763		845		902		798
	SE		6		6		6		43		6
		Small, medium, and large Chinook salmon									
Females	n				29		53		2		84
	% age comp.				14.1		25.7		1.0		40.8
	SE of %				2.4		3.1		0.7		3.4
	Avg. length				784		840		863		821
	SE				7		6		33		6
Males	n	1	40		58		22		1		122
	% age comp.	0.5	19.4		28.2		10.7		0.5		59.2
	SE of %	0.5	2.8		3.1		2.2		0.5		3.4
	Avg. length.	325	615		741		858		980		719
	SE		8		8		14				10
Sexes combined	n	1	40		87		75		3		206
	% age comp.	0.5	19.4		42.2		36.4		1.5		100.0
	SE of %	0.5	2.8		3.4		3.4		0.8		0.0
	Avg. length.	325	615		755		845		902		761
	SE		8		6		6		43		7

Appendix A12.–Origin of coded-wire tags recovered from Chinook salmon collected in the Stikine River, 2004.

Year	Head	Tag code	Brood year	Agency	Rearing	Recovery site	Location	Date released	Release site
2004	72741	No tag		NA	NA	Kakwan Point	Stikine	NA	NA
2004	72741	40459	1999	ADFG	W	Rock Island	Stikine	6/1/01	Stikine
2004	12383	32262	2001	NMFS	H	Rock Island	Stikine	5/19/03	L. Port Walter
2004	900871	Not sacrificed		NA	NA	Andrew Creek	Stikine	NA	NA
2004	12475	40357	1998	ADFG	W	L. river commercial	Stikine	6/13/00	Stikine
2004	12387	40357	1998	ADFG	W	L. river commercial	Stikine	6/13/00	Stikine
2004	12474	20604	2000	DFO	H	L. river commercial	Stikine	5/1/01	Stikine
2004	12298	20604	2000	DFO	H	L. river commercial	Stikine	5/1/01	Stikine
2004	12251	20604	2000	DFO	H	L. river commercial	Stikine	5/1/01	Stikine
2004	12480	20604	2000	DFO	H	L. river commercial	Stikine	5/1/01	Stikine
2004	12386	40533	2000	ADFG	W	L. river commercial	Stikine	6/1/02	Stikine
2004	12382	40459	1999	ADFG	W	L. river commercial	Stikine	6/1/01	Stikine
2004	14489	36241	1998	ADFG	H	L. river commercial	Stikine	5/18/00	L. Port Walter
2004	14488	40373	1999	ADFG	W	L. river commercial	Stikine	6/9/01	Taku
2004	12240	40459	1999	ADFG	W	L. river commercial	Stikine	6/1/01	Stikine
2004	12239	181740	2001	DFO	H	L. river commercial	Stikine	5/23/02	Stikine
2004	14494	No tag		NA	NA	Telegraph Creek	Stikine	NA	NA
2004	12301	No tag		NA	NA	Verrett River	Stikine	NA	NA
2004	2434E	40357	1998	ADFG	W	L. Tahltan R. weir	Stikine	6/13/00	Stikine
2004	2435E	40459	1999	ADFG	W	L. Tahltan R. weir	Stikine	6/1/01	Stikine
2004	648746	40354	1999	ADFG	W	Tuya River	Stikine	5/10/01	Taku
2004	648747	20604	2000	DFO	H	Tuya River	Stikine	5/1/01	Stikine

Appendix A13.–Computer files used to estimate the spawning abundance of Chinook salmon in the Stikine River in 2004.

File Name	Description
CAPTPROB04.xls	EXCEL spreadsheet with chi-square capture probability tests.
LGSTIK04.BAS	QBASIC bootstrap program for estimating abundance (Petersen model) of large Chinook salmon, variance, bias, and confidence intervals
LGSTIK04.DAT	Input file for LGSTIK03.BAS
LGSTIK04.OUT	Output file from LGSTIK03.BAS
POSTSEASON04.xls	EXCEL spreadsheet with Petersen abundance estimates including bootstrap output for variance, confidence interval and bias estimation
PRE-INSEASON04.xls	EXCEL spreadsheet with and pre-season sibling forecast and in-season CPUE models.
SIZESELPOST04.xls	EXCEL spreadsheet with Kolmogorov-Smirnov size-selectivity tests including charts.
SMSTIK04.BAS	QBASIC bootstrap program for estimating abundance (Petersen model) of small-medium Chinook salmon, variance, bias, and confidence intervals
SMSTIK04.DAT	Input file for SMSTIK03.BAS
SMSTIK04.OUT	Output file from SMSTIK04.BAS
STIKMR-CPUE04.xls	EXCEL spreadsheet with Kakwan Point and Rock Island catch-effort, hydrology, and temperature data including charts.
STIKMR-TAG&ASL04.xls	EXCEL spreadsheet with Kakwan Point, Rock Island, and inriver fishery/spawning ground tag, recovery, and age-sex-size data.