Fishery Data Series No. 06-60

Production of Coho Salmon from the Unuk River, 2003–2004

by

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and

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November 2006

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

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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

The Unuk River stock of coho salmon *Oncorhynchus kisutch* was assessed in 2003–2004. Baited minnow traps were fished daily on the Unuk River from 6 April through 10 May 2003. Smolt were marked with coded wire tags and the excision of the adipose fin. Different codes were used for small (70–84 mm FL) and large (≥85 mm FL) smolt. Sampled smolt averaged 80.7 mm FL and 5.4 g. Estimated smolt abundance in 2003 was 674,590 (SE = 210,831). In 2004, port and creel sampling projects recovered 29 of these coded wire tags, representing an estimated harvest of 10,218 (SE = 5,397) in U.S. marine waters. Of this harvest the purse seine fishery took an estimated 51%, troll fisheries 40%, recreational fisheries 7%, and drift gillnet fisheries 2%. The harvest of Unuk River coho salmon was determined to be intermediate in timing relative to local hatchery stocks. Set gillnets were used in the lower Unuk River to determine the proportion of coho salmon having coded wire tags and an excised adipose fin. The relationship between the estimated escapement of coho salmon in the Unuk River and the average CPUE at the set gillnets from 1999–2003 was modeled using a weighted regression function. This model was then used to estimate escapement in 2004 at 13,436 (SE = 4,647), based on calculation of the average CPUE in 2004.

Key words: coho salmon, *Oncorhynchus kisutch*, Unuk River, coded wire tags, smolt abundance, harvest, troll fishery, seine fishery, drift gillnet fishery, recreational fishery, hatchery stocks, regression, CPUE, escapement

INTRODUCTION

The Unuk River (Figure 1) originates in a heavily glaciated area of northern British Columbia and flows for 129 km where it empties into Burroughs Bay 85 km northeast of Ketchikan, Alaska. The lower 39 km of the river are in Alaska (Figure 2).

From 1998 to 2003, estimated coho salmon *Oncorhynchus kisutch* returns (harvest and escapement) to the Unuk River averaged 55,495 fish, ranging from 31,740 in 2000 to 71,242 in 2002 (Table 1). Many (22–79%) of these fish are harvested throughout Southeast Alaska (SEAK) in marine and recreational fisheries (Jones III et al. 1999, 2001a,b; Weller et al. 2002, 2003, 2005). Coho salmon returning to the Unuk River must pass through a series of commercial (i.e., troll, purse seine, and drift gillnet) and recreational fisheries as they travel in a southward migration along the northern outside coast of SEAK before entering the inside waters of southern SEAK (Figure 3). Some members of this stock are also harvested in the marine fisheries of northern British Columbia, Canada. Perceived changes in run strength for stocks near Ketchikan prompted concerns over the status of coho salmon in SEAK. Being a large producer of coho salmon having early to mid run timing (important for inseason management), the Unuk River stock of coho salmon has been used as an indicator for estimating trends in exploitation rates of wild stocks in the inside waters of southern SEAK.

Harvests from this stock have been estimated through programs based on coded wire tags (CWTs). Juvenile coho salmon were marked with CWTs from 1983 through 1986, and from 1996 through 2003. The recapture of adult coho salmon possessing these tags from 1998 to 2003 indicated that on average the majority of marine harvest occurs in the Southeast (49%) and Northwest (33%) Quadrants of SEAK (Figure 3) primarily by troll (53%) gear and to a lesser extent by purse seine (21%), drift gillnet (17%), and recreational (9%) gear (Jones III et al. 1999, 2001a,b; Weller et al. 2002; 2003; 2005).

Mark-recapture studies were used to estimate the escapement of adult coho salmon into the Unuk River from 1998 to 2003. During this period, the estimated escapement of coho salmon in the Unuk River averaged 28,746 (SE = 7,948) with a range of 12, 422 (SE = 3,298) in 1998 to 55,409 (SE = 12,084) in 2002 (Table 1; Jones III et al. 1999, 2001a,b; Weller et al. 2002, 2003, 2005).

In this final year of the study, objectives were limited to the estimation of: (1) abundance, mean length, and mean weight of Unuk River coho salmon smolt in 2003; (2) marine recreational and commercial harvest of adult coho salmon bound for the Unuk River in 2004 and (3) and the age,

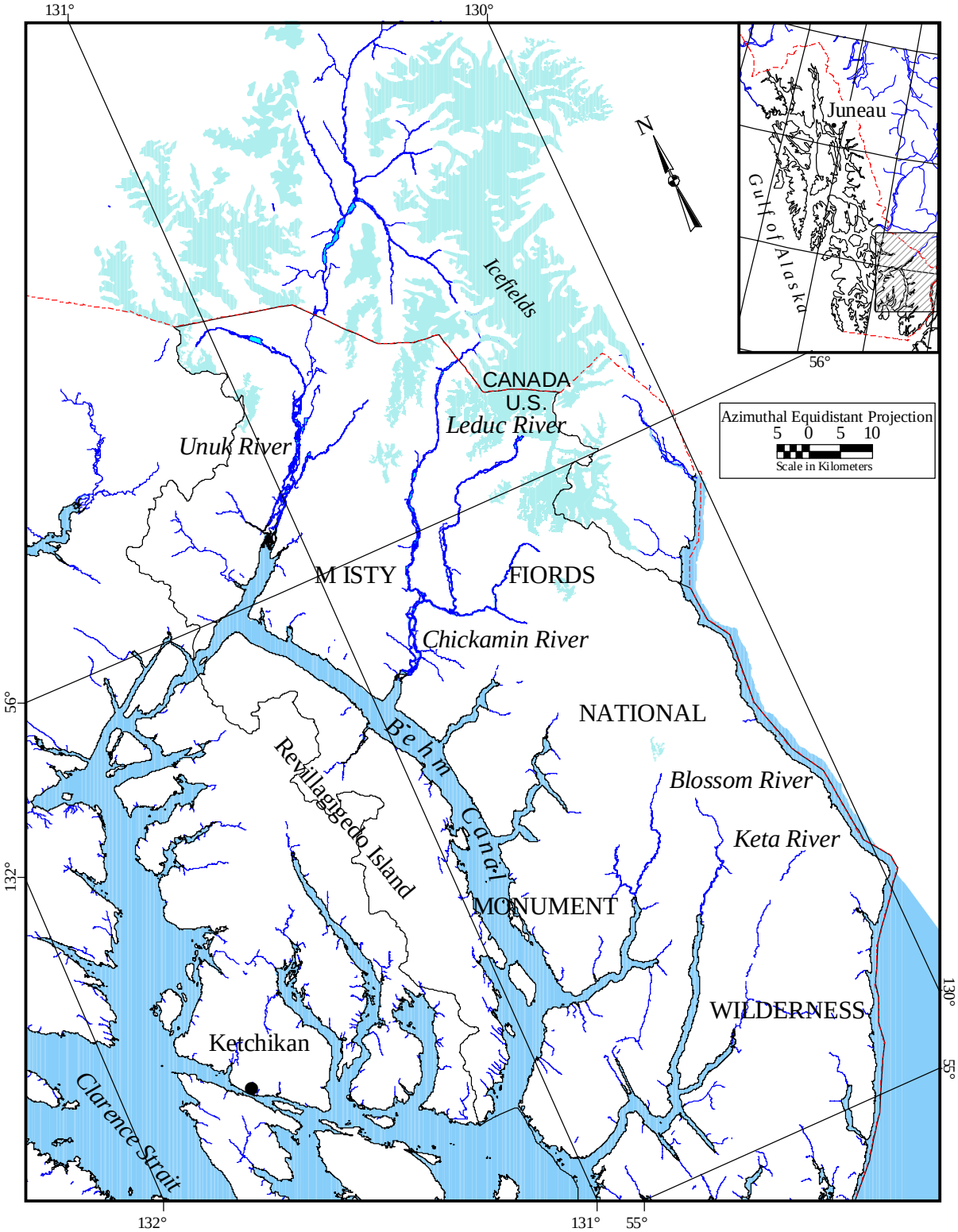

Figure 1.–Behm Canal and surrounding area in Southeast Alaska showing streams supporting major coho salmon stocks noted.

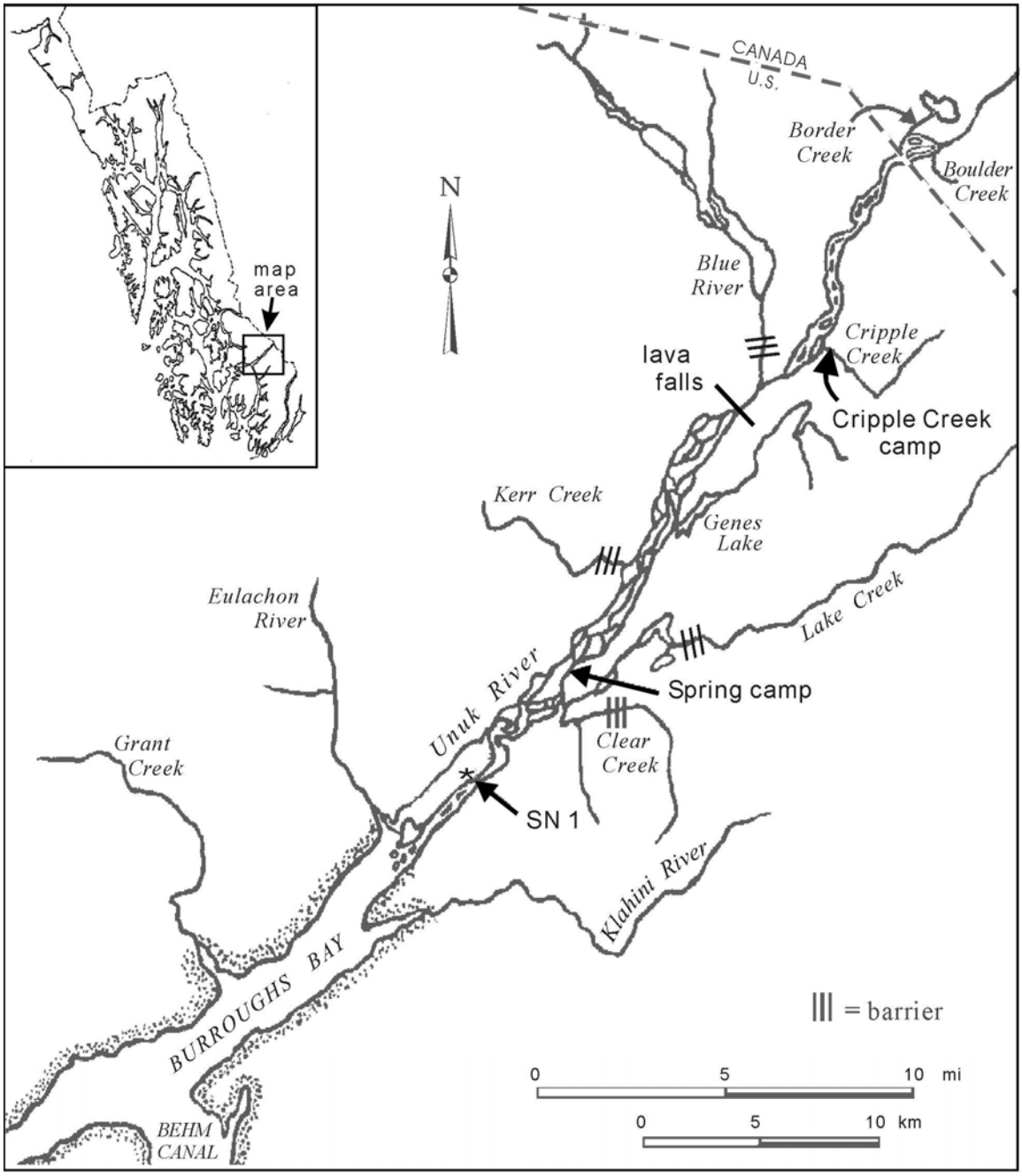

Figure 2.–Unuk River and surrounding area showing major tributaries, barriers to salmon migration, and locations of Alaska Department of Fish and Game research sites.

sex, and length (ASL) composition of the inriver escapement in 2004. These objectives were accomplished by placing CWTs in smolt during the spring of 2003, sampling adults in marine recreational and commercial fisheries, and by inriver sampling of the escapement in 2004.

Investigations into the relationship between CPUE at the set net site (SN1) and subsequent estimates of spawning abundance, as determined from mark-recapture studies from 1999 to 2003, led to the post-study inclusion of a fourth objective: estimation of escapement in 2004.

Table 1.–Estimates of run size, harvest, escapement, marine survival rate, exploitation rate, handling-induced mortality of adults, smolt abundance, and smolt size for the Unuk River stock of coho salmon, 1998–2003.

Parameters	1997	1998	1999	2000	2001	2002	2003	Average
Run size		57,811	55,147	31,740	68,080	71,242	48,953	55,495
SE		8,158	13,201	6,764	9,522	12,253	7,111	9,502
Harvest		45,388	29,300	14,826	32,633	15,584	21,735	22,781
SE		7,461	2,950	3,510	6,276	2,033	2,896	3,590
Escapement[a]		12,422	25,846	16,845	35,022	55,409	26,934	28,746
SE		3,298	12,867	5,782	7,161	12,084	6,495	7,948
Relative precision (α=0.05)		52	65[b]	54[b]	40	43	47	
Marine survival rate (%)		7.1	9.8	3.9	11.8	9.4	6.5	8.1
SE (%)		2.0	2.9	1.5	2.2	2.4	2.3	2.2
Exploitation rate (%)		79	53	47	48	22	44	49
SE (%)		5	12	10	7	4	7	8
M-R mortality		181	258	69	425	249	0	197
% M-R mortality		24.4	28.2	15.2	26.5	14.3	23.5	22.0
Smolt abundance	809,677	562,796	819,475	577,343	757,080	755,905		713,713
SE	189,345	101,122	257,309	70,720	142,167	239,117		166,630
Smolt mean length (mm FL)	84.04	88.87	86.47	83.88	84.24	84.50		85.33
SE	0.51	0.62	0.56	0.42	0.80	0.57		0.58
Smolt mean weight (gm)	5.76	6.92	6.51	6.12	6.43	6.70		6.40
SE	0.28	0.15	0.13	0.10	0.18	0.13		0.16

[a] Mark-recapture experiments were used to estimate escapement from 1998–2003.

[b] =0.10.

METHODS

SMOLT CAPTURE, TAGGING, AND SAMPLING

Between 58 and 153 G-40 minnow traps, baited with salmon roe, were fished daily for 24 h/d from 6 April to 10 May 2003. Traps were located between river km 10 and 26 along mainstem banks and in some backwater areas of the Unuk River. Minnow traps were checked at the beginning of each day when water levels were stable and more frequently throughout the day when water levels were irregular. Two teams consisting of two personnel each were used to set and fish traps on a regular basis. Generally, one crew was responsible for traps set upstream of Spring Camp (km 14) and one crew was responsible for downstream traps. Early in the season, water levels were low and ice and snow restricted fishing to the mainstem of the river. These conditions changed as the season progressed enabling trapping in backwater and side channel areas.

Juvenile fish were removed from minnow traps during each visit, transported to holding pens at camp, and tagged and marked each day. Coho and Chinook salmon *O. tshawytscha* smolt were separated from other species of salmon and fish like Dolly Varden *Salvelinus malma*) by using a combination of external morphological characteristics (Meehan and Vania 1961; McConnell and Snyder 1972; Pollard et al. 1997).

Live smolt were tranquilized in a water solution of tricain methane-sulfonate (MS 222) buffered with sodium bicarbonate. To minimize stress on smolt, the anesthetic solution was kept near ambient river temperature by frequent water changes, and numbers of smolt tranquilized at any one time were kept small (~50-75) to limit their exposure. All smolt ≥70 mm FL not missing adipose fins were tagged following procedures described in Koerner (1977) and their adipose fins were excised. Different codes were used on CWTs implanted in small smolt (70–84 mm FL) and large smolt (≥85 mm FL) to permit subsequent detection of possible size-specific differences in

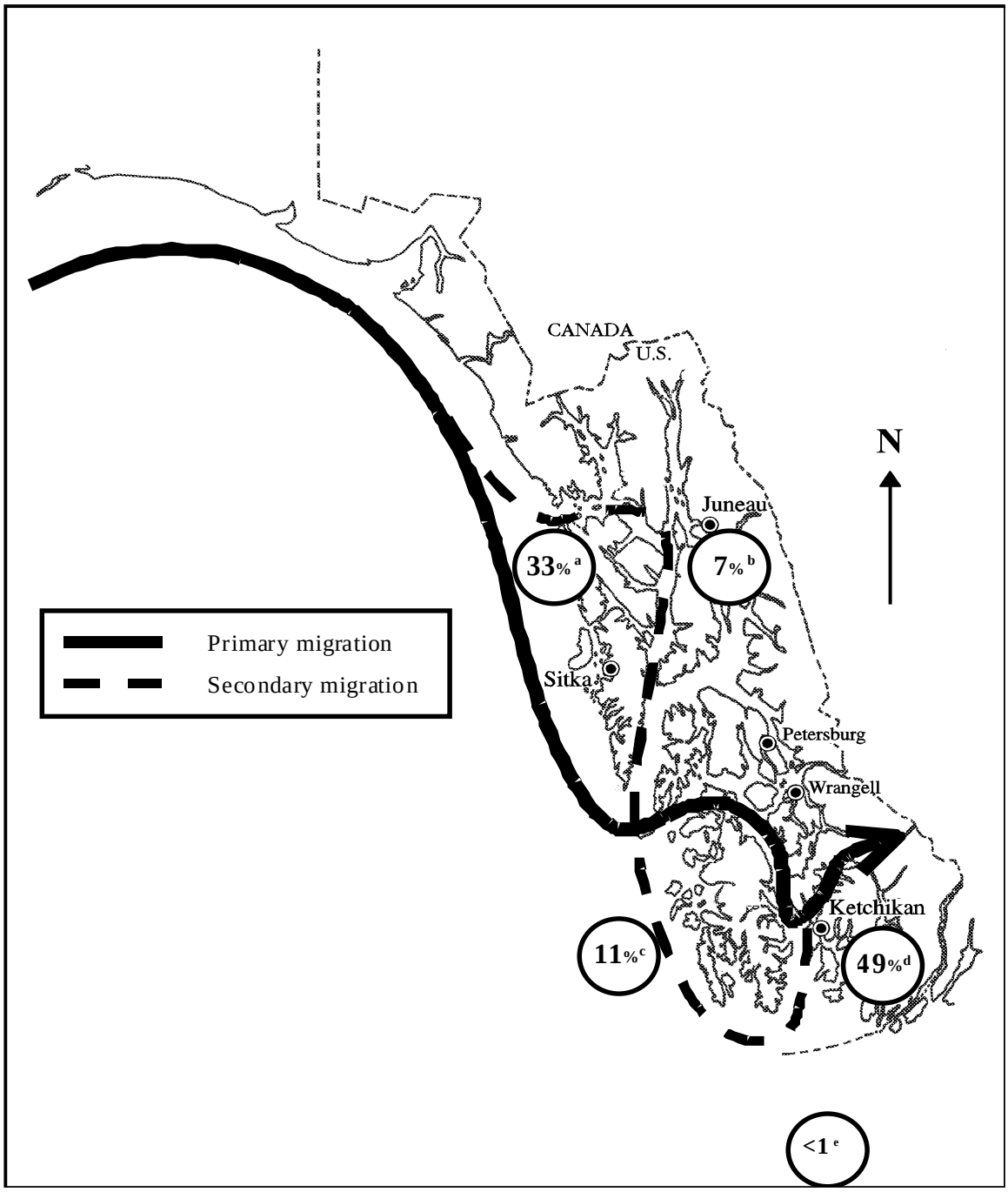

Figure 3.–Migration routes through SEAK and average percentage of marine harvest (1998–2003) by quadrant for the Unuk River stock of coho salmon. Superscripts denote quadrants: [a]Northwest, [b]Northeast, [c]Southwest, [d]Southeast, and [e]Canadian**.**

marine survival rates. Chinook salmon smolt ≥50 mm FL were tagged with different codes. All captured smolt with an excised adipose fin were subsequently passed through a magnetic tag detector to test for the presence of a CWT. All tagged fish were held overnight and then released the following morning after being checked for tag retention and mortality. The number of fish tagged, the number that died in the holding pen, and the number that shed their tags were compiled

and recorded on *ADF&G CWT Tagging Summary and Release Information Forms.* These forms were submitted to the Commercial Fishery Division's Mark, Tag, and Age Laboratory (a.k.a. Tag Lab) in Juneau after the field season. Mean length and weight of coho salmon smolt was estimated by systematically sampling every 30th fish captured. Each sampled smolt was measured to the nearest mm FL and weighed to the nearest 0.1 g.

ESTIMATING SMOLT ABUNDANCE

Abundance of smolt in 2003 was estimated with a two-event mark-recapture study using Chapman's modification of the Petersen estimate (Chapman 1951):

$$\hat{N}_s = \frac{(n_c+1)\,(n_e+1)}{(m_a+1)} - 1 \qquad (1)$$

$$\mathrm{var}\left[\hat{N}_s\right] = \frac{(n_c+1)(n_e+1)(n_c-m_a)(n_e-m_a)}{(m_a+1)^2(m_a+2)} \qquad (2)$$

where N_s is number of smolt emigrating in 2003, n_c is the number of smolt released alive with a missing adipose fin in 2003, n_e is the number of adults sampled inriver in 2004, and m_a is the number of adults sampled inriver in 2004 missing their adipose fin. To be consistent, this estimator must meet the following conditions:

a) every smolt had an equal probability of being tagged and marked, or every smolt had an equal probability of being captured as an adult (proportional sampling); or marked fish mixed completely with unmarked fish in the population between events; and

b) there was no recruitment to the population between sampling events; and

c) there was no tag-induced mortality; and

d) fish did not lose their marks in the time between the two events; and

e) all marked fish were recognized.

We believe these conditions were met: a) we found no significant difference in marine survival between the two size groups (χ^2 = 0.63, df = 1, P = 0.43) and inriver adult recovery rates by smolt size were also not significantly different (χ^2 = 0.17, df = 1, P = 0.68) and these findings are a necessary condition for mixing or proportional sampling of adults in the river; b) the fidelity of coho salmon to their natal watershed precludes recruitment; c) short-term, tag-induced mortality was not indicated in our study; d) coastwide experience is that excised adipose fins do not grow back; and e) diligent examination of captured adults ensures all marks were recovered.

INRIVER ESCAPEMENT SAMPLING

Fish were captured in the lower river at SN1 between 26 July and 4 October using set gillnets. Located on the south channel of the lower Unuk River, SN1 was approximately 3 km downstream of all known coho salmon spawning tributaries with the exception of the Eulachon River (Figure 4). Two gillnets 37 m (120 ft) long by 4 m (14 ft) deep, with one having 14-cm (5⅜") stretch mesh and the other having 11.5-cm (4½") stretch mesh, were fished from 2 August to 4 October. Prior to 2 August, two gillnets 37m long and 3.7m deep with 18 cm (7¼") stretch mesh were used to capture Chinook salmon as part of a mark-recapture study. Conditions permitting, set gillnets were fished 8 h/d by two people. One net (a cross net) was attached to the shore and ran directly across a small slough to a fixed buoy placed just downstream of a small island such that the net was perpendicular to the main flow of the Unuk River. Another net (a lead net) was attached to the same buoy and fished downstream along the eddy line created between the mainstem flow and the side slough (Figure 5). The 11.5- and 14-cm stretch mesh gillnets were alternated daily between cross and lead net positions.

All coho salmon captured, regardless of condition and not including recaptures, were sampled to determine their ASL. Length was measured to the nearest 5 mm MEF, and gender was determined from external characteristics. Five scales approximately 2 cm apart were taken from the preferred area on the left side of the fish. The preferred area is two to three rows above the lateral line and between the posterior terminus of the dorsal fin and the anterior margin of the anal fin (Scarnecchia 1979). Scales were mounted on gum cards capable of holding scales from 10 fish.

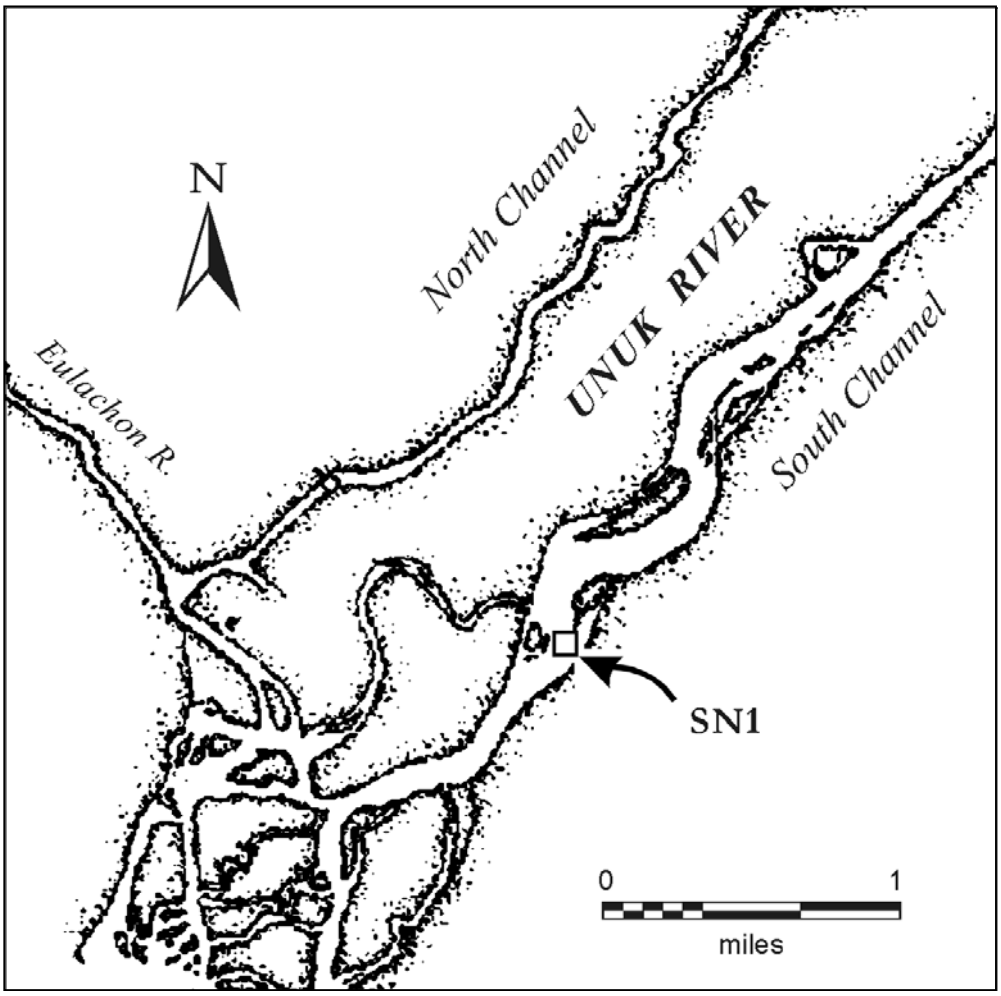

Figure 4.–Location of the set net site (SN1) on the lower Unuk River, 2004.

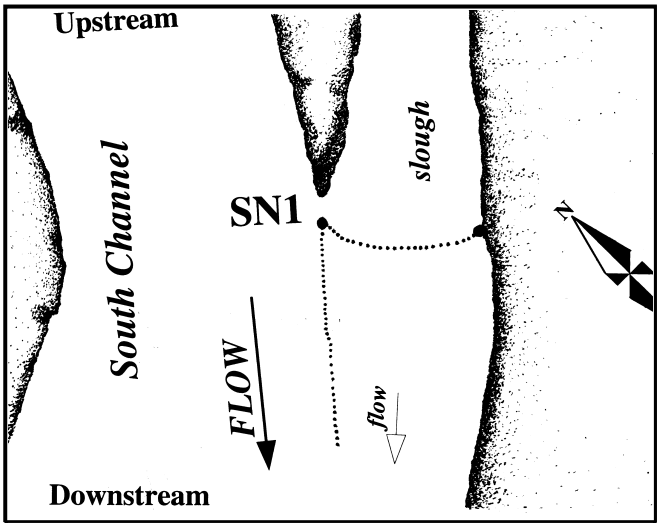

Figure 5.–Detailed drawing of net placement used at the set net site (SN1) on the lower Unuk River, 2004.

The age of each fish was later determined from the pattern of circuli as seen on images of scales impressed into acetate cards (Clutter and Whitesel 1956; Mosher 1968) under 70× magnification. Fish missing adipose fins were noted as such and then sacrificed by having their heads removed and sent to the Tag Lab in Juneau for detection and decoding of CWTs. To prevent double sampling, each previously uncaptured fish was marked with a clip of the left axillary appendage and a left upper operculum punch ¼" in diameter.

AGE, SEX, AND LENGTH - ADULTS

The proportion of the escapement composed of a given age or sex was estimated as a binomial variable:

$$\hat{p}_j = \frac{n_j}{n} \tag{3}$$

$$\mathrm{var}(\hat{p}_j) = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1} \tag{4}$$

where $\hat{p}_j$ is the estimated proportion of the sample of age or sex *j*, n_j is the number of coho salmon of age or sex *j*, and *n* is the number of adult coho salmon sampled.

Average lengths by age and sex were calculated using standard procedures.

ESTIMATING HARVEST

The 2004 harvest of coho salmon originating from the Unuk River was estimated from catch samples in U.S. marine fisheries. In 2004 several fisheries harvested coho salmon bound for the Unuk River, consequently harvest was estimated over several strata, each a combination of time, area, and fishery type. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics for drift gillnet and seine fisheries were stratified by statistical week and by fishing district. Statistics from the recreational fishery were stratified by fortnight and location. Estimates of harvest $\hat{r}_i$ were calculated for each stratum and summed across strata to obtain an estimate of the total $\hat{T}$:

$$\hat{T} = \sum_i \hat{r}_i \tag{5}$$

$$\mathrm{var}\left[\hat{T}\right] = \sum_i \mathrm{var}\left[\hat{r}_i\right] \tag{6}$$

Oliver (1990) and Hubartt et al. (1999) present details of sampling commercial and recreational fisheries, respectively. Information from catch and field sampling programs was expanded to estimate harvest and the associated variance of coho salmon bound for the Unuk River for each stratum, using methods and equations from Bernard and Clark (1996).

The mean date and associated SE of marine harvest in SEAK was estimated using methods in Mundy (1979). For comparative purposes, the mean date of marine harvest was also estimated for hatchery returns of CWT coho salmon from eight separate release sites in the vicinity of Ketchikan. In all cases, harvest was estimated using only valid, random recoveries of CWT fish from non-terminal fisheries in SEAK.

ESTIMATING ESCAPEMENT

The relationship between the estimated escapement of coho salmon in the Unuk River and the average CPUE at SN1 was modeled using mark-recapture data collected from 1999 to 2003. Small sample size and heteroscedasticity dictated the use of a weighted regression. This model was then used to estimate escapement in 2004.

RESULTS

SMOLT CAPTURE, TAGGING, AND SAMPLING

Smolt trapping commenced on 6 April, tagging began on 9 April, and both activities ceased on 10 May. Dramatic changes in water level result in poor trapping conditions that decrease efficiency. In 2003, the river was initially low and, as snow melt commenced, rose at a relatively slow steady rate through 24 April. Precipitation and warm weather resulted in a rapid two-foot rise in water level on 25 April. This state was sustained through approximately 2 May, after which time water levels fluctuated (Figure 6). Overall, trapping conditions were considered relatively typical.

A total of 10,462 small (70-84 mm FL) and 4,861 large (≥ 85 mm FL) coho salmon smolt were tagged with codes 04-08-08 and 04-08-09, respectively. Of this total, 4 small and 2 large tagged fish died overnight, and an additional 25

small fish were estimated to have shed their tags. This resulted in a final release of 15,292 (10,433 small and 4,859 large) coho salmon smolt with valid CWTs in 2003. Coho salmon smolt averaged 80.7 mm FL and 5.4 g (Table 2); the length distribution of smolt ≥ 70 mm is shown in Figure 7.

SMOLT ABUNDANCE

The estimated abundance $\hat{N}_s^*$ of coho salmon smolt outmigrating from the Unuk River in 2003 was 674,590 (SE = 210,831). Of the 10,433 small smolt released with CWTs in 2003, 17 were recovered in 2004 from adults harvested in various marine commercial and recreational fisheries and six were recovered during inriver sampling (Appendix A1). One of the fishery recoveries was a select (non-random) sample, which was not used in harvest estimation. Of the 4,859 large smolts released, 12 were recovered in marine fisheries and two were recovered inriver in 2004. Overall recovery rates by smolt size were not significantly different ($\chi 2$ = 0.63, df = 1, P = 0.43), implying no difference in survival rates between the two size groups. Inriver recovery rates by smolt size were also similar ($\chi 2$ = 0.17, df = 1, P = 0.68). These results are consistent with mixing of smolt after tagging and/or proportional sampling of adults, either of which allows unbiased estimation of smolt abundance with the Petersen estimator.

ESCAPEMENT

From 2 August to 4 October, the set gillnets were fished for 297 hours and captured 395 adult coho salmon. One coho salmon was captured at SN1 on 29 July during the Chinook salmon study. Eight fish were sacrificed for CWTs, each of which carried a CWT implanted in 2003. The fraction of fish sampled at SN1 with valid 2003 CWTs was estimated to be 0.0202 (SE = 0.0071). Fishing effort was maintained at a relatively consistent level through 7 September, after which time effort declined due to recurrent flooding, large amounts of debris, and logistical problems (Figure 8).

From 2 August to 4 October, the number of coho salmon captured per hour, or CPUE, averaged 1.3, with a maximum value of 4.3 on 30 August. By statistical week, CPUE ranged from approximately 0.4 in week 34 (15–21 August) to 2.6 in week 38 (12–18 September; Figure 8).

The estimated escapement of coho salmon in the Unuk River was 13,436 (SE = 4,647) in 2004, based on a weighted regression of estimated abundance on CPUE at SN1 (1999–2003). The 90% confidence interval for the estimate is 2,499 to 24,373 (Figure 9). It should be noted that CPUE in 2004 was lower than any of the CPUE values used to model the relationship between escapement and CPUE; this fact should be born in mind when interpreting the estimated escapement for 2004.

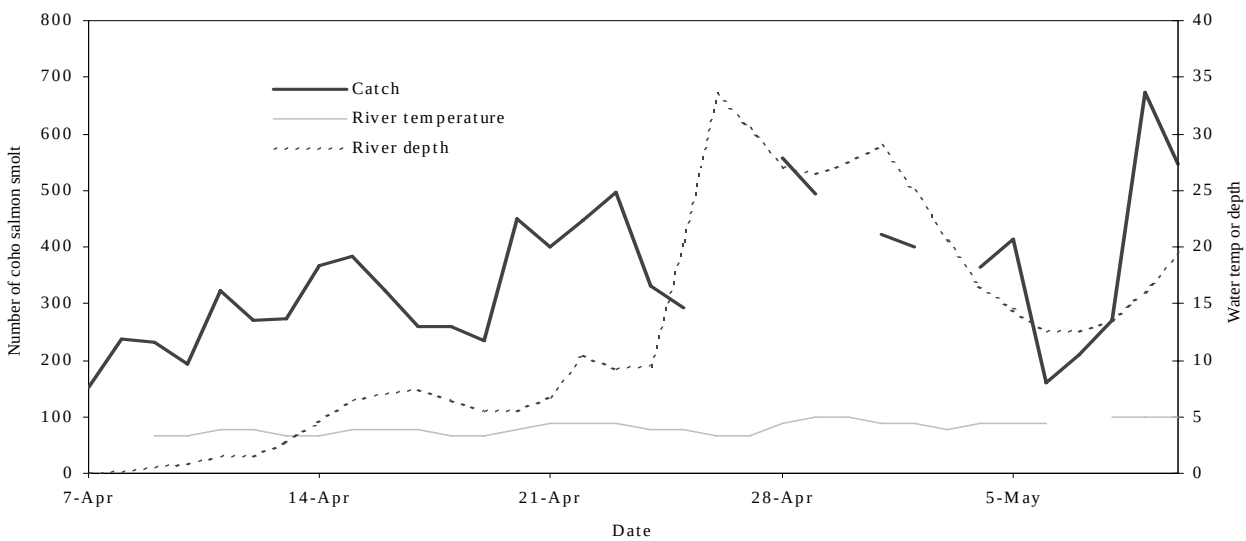

Figure 6.–Catches of coho salmon smolt ≥70 mm FL, daily river temperature (°C), and river depth (cm) in the Unuk River, 2003.

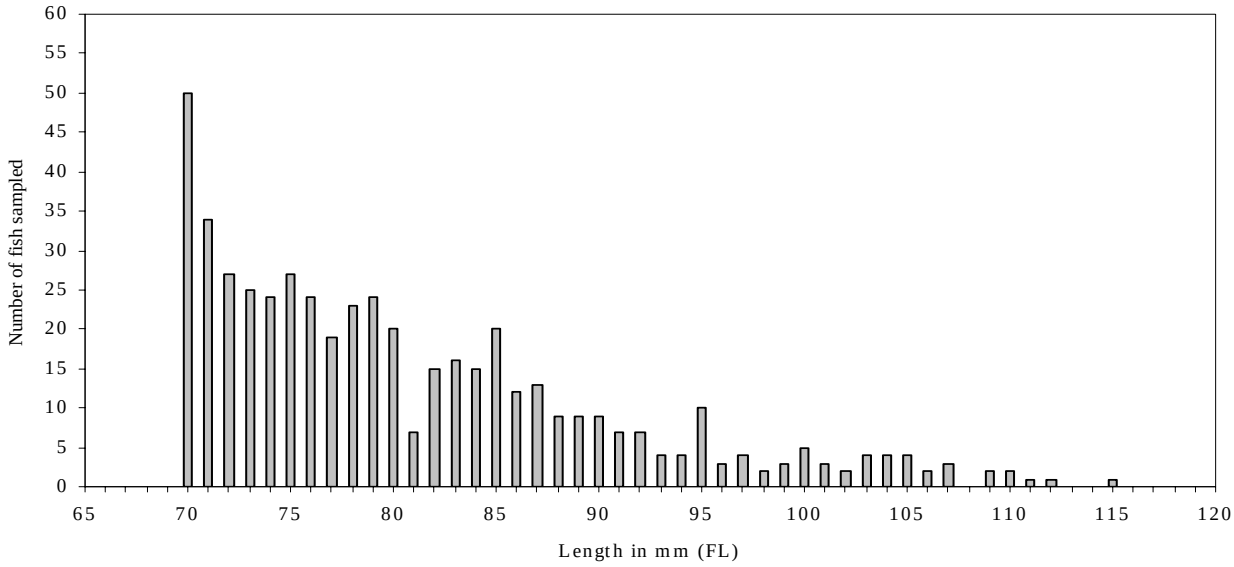

Figure 7.–Length frequency of coho salmon smolt ≥70 mm FL captured and measured in the Unuk River, 2003.

AGE, SEX, AND LENGTH

Age-1.1 fish accounted for an estimated 86.0% (SE = 1.9%) and age-2.1 fish for 14.0% (SE = 1.9%) of the inriver return. An estimated 54.2% (SE = 2.8%) of the inriver return were males (Appendix A2).

The average length of coho salmon captured at SN1 was 575 mm MEF (SE = 3; Appendix A2).

Coho salmon captured from 2- 21 August (Figure 10) averaged 509 mm MEF (SE = 7), with subsequent average length steadily increasing to a maximum of 678 mm MEF (SE = 38) on 4 October. It is typical to find the early-run component composed primarily of small-sized fish (Weller et al. 2002, 2003, 2005). Of the small (<541 mm MEF) fish captured at SN1, 26% were captured prior to 12 August, 54% by 25 August,

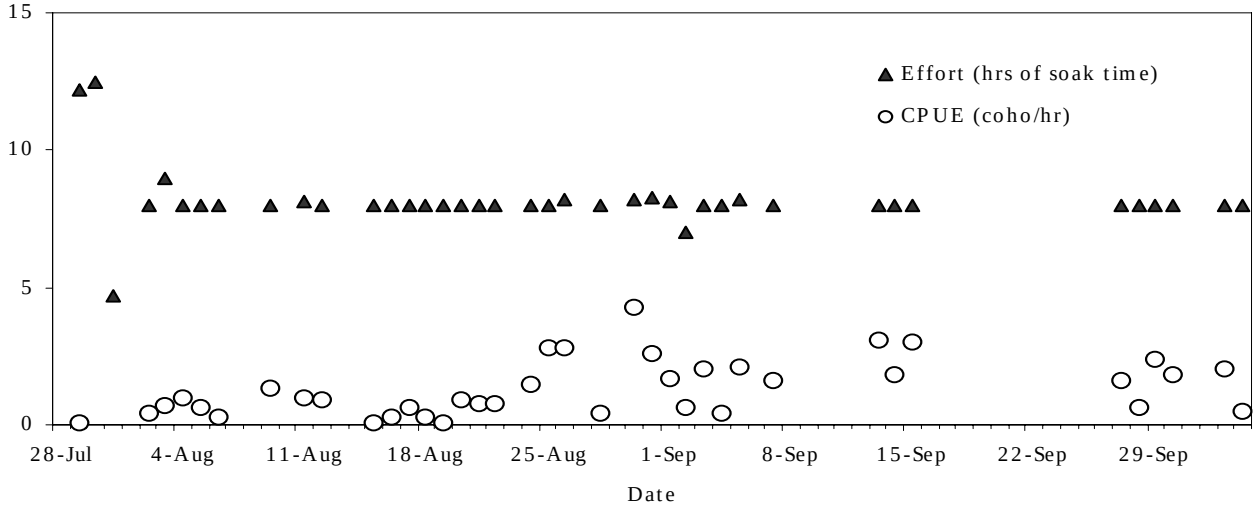

Figure 8.–Effort and CPUE of adult coho salmon at the set net site on the Unuk River, 2004.

Table 2.–Number of coho salmon caught and subsequently released with valid coded wire tags in the Unuk River, 2003.

		Smolt 70-84 mm (FL)					Smolt > 84 mm (FL)					All Smolt						
Date	Traps checked[a]	Captured[b]	Tagged	Percent retention	Overnight mortalities	Valid tagged[c]	Captured	Tagged	Percent retention	Overnight mortalities	Valid tagged	CPUE[d]	Valid tagged	Recaps	Average length (mm FL)	Average weight (g)	Water temp	Water depth
7-Apr	59	151					88					4.1						0.0
8-Apr	92	236					137					4.1						0.2
9-Apr	90	231	618	100.0		618	134	359	100.0		359	4.1	977				3.3	0.5
10-Apr	96	195	195	100.0	1	194	131	131	100.0	1	130	3.4	324	2	81.1	5.5	3.3	0.8
11-Apr	102	323	323	100.0		323	200	200	100.0		200	5.1	523	3	81.5	5.5	3.9	1.5
12-Apr	114	269	269	100.0		269	159	159	100.0		159	3.8	428	6	80.6	5.4	3.9	1.5
13-Apr	125	273	273	100.0		273	155	155	100.0		155	3.4	428	11			3.3	2.8
14-Apr	114	367					167					4.7					3.3	4.5
15-Apr	119	384	751	100.0	2	749	175	342	100.0		342	4.7	1,091	23	80.5	5.2	3.9	6.5
16-Apr	115	322	322	100.0		322	135	135	100.0		135	4.0	457	14			3.9	7.0
17-Apr	119	261					141					3.4					3.9	7.5
18-Apr	119	261	521	100.0		521	142	283	100.0		283	3.4	804	26	82.0	5.7	3.3	6.5
19-Apr	123	235	235	100.0		235	115	115	100.0		115	2.8	350	23	81.5	5.7	3.3	5.5
20-Apr	138	449	449	100.0		449	134	134	100.0		134	4.2	583	18	75.7	4.5	3.9	5.5
21-Apr	130	400					214					4.7					4.4	6.8
22-Apr	145	446	846	100.0		846	238	452	100.0		452	4.7	1,298	43	82.8	5.9	4.4	10.5
23-Apr	153	496	496	100.0		496	237	237	100.0		237	4.8	733	23			4.4	9.3
24-Apr	147	332					170					3.4					3.9	9.5
25-Apr	130	294	626	100.0		626	151	321	100.0		321	3.4	947	32	79.2	5.6	3.9	20.5
26-Apr																	3.3	33.5
27-Apr																	3.3	30.5
28-Apr	58	565	565	98.4		556	189	189	100.0		189	13.0	745	25	83.5	6.3	4.4	27.0
29-Apr	122	494					147					5.3					5.0	26.5
30-Apr			494	100.0		494		147	100.0		147		641	44			5.0	27.5
1-May	137	423					160					4.3					4.4	29.0
2-May	130	401	824	100.0		824	152	312	100.0		312	4.3	1,136	72	79.6	5.2	4.4	25.0
3-May																	3.9	20.5
4-May	104	370					134					4.9					4.4	16.5
5-May	119	424	794	98.0		778	154	288	100.0		288	4.9	1,066	84	79.5	5.0	4.4	14.5

-continued-

Table 2.–Page 2 of 2.

		Smolt 70-84 mm (FL)					Smolt > 84 mm (FL)					All Smolt						
Date	Traps checked[a]	Captured[b]	Tagged	Percent retention	Overnight mortalities	Valid tagged[c]	Captured	Tagged	Percent retention	Overnight mortalities	Valid tagged	CPUE[d]	Valid tagged	Recaps	Average length (mm FL)	Average weight (g)	Water temp (°C)	Water depth (cm)
6-May	89	160					64					2.5					4.4	12.5
7-May	116	209					84					2.5			81.7	5.7		12.5
8-May	151	272	641	100.0	1	640	109	257	100.0	1	256	2.5	896	80			5.0	13.5
9-May	140	672					356					7.3					5.0	16.0
10-May	114	548	1,220	100.0		1,220	289	645	100.0		645	7.3	1,865	194	81.2	5.4	5.0	19.5
Total	3,510	10,462	10,462		4	10,433	4,861	4,861		2	4,859		15,292	723				
Max.	153	672	1,220	100.0	2	1,220	356	645	100.0	1	1,865	13.0	1,865	194	83.5	6.3	5.0	33.5
Min.		151	195	98.0	0	194	64	115	100.0	0	324	2.5	324	0	75.7	4.5	3.3	0.0
Average	103	349	551	99.8	0	549	162	256	100.0	0	256	4.4	805	38	80.7	5.4	5.5	18.8
Total weighed and/or measured															506	506		
SD															9.80	2.07		
SE															0.44	0.09		

[a] Equals the total number of trap checks that day, i.e., individual traps checked twice daily would count as two traps checked.

[b] Equals the number of previously uncaptured coho smolt captured.

[c] Total valid tagged equals total tagged minus overnight mortalities times percent tag retention.

[d] Equals the average number of previously uncaptured coho smolt per trap check

[e] Depth standardized such that 0.0 cm represents minimal depth recorded.

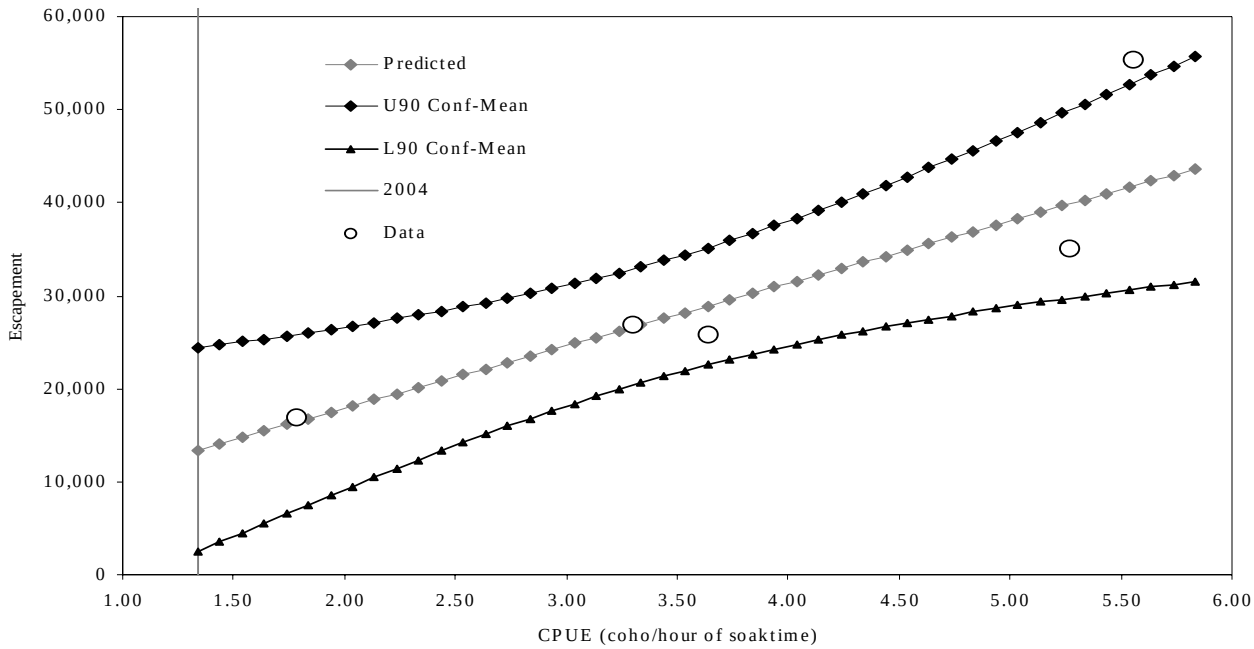

Figure 9.–Results of weighted regression of estimated spawning abundance of coho salmon on CPUE at the set net site (SN1) from 1999 to 2003, upper (U90) and lower (L90) 90% confidence means (conf. mean), and resulting 2004 CPUE estimate of spawning abundance in the Unuk River**.**

and 74% before 30 August (Figure 11). Of the larger fish, 4%, 13%, and 27% fish were captured at SN1 by the same dates. These observations are similar to those of prior years. The mean date of capture at SN1 for large coho salmon (>540 mm MEF) was 7 September.

HARVEST

The harvest estimates produced by this study should be interpreted with caution. The marked fraction determined from inriver sampling was very low (about 2%) and was based on a relatively small adult sample size of 395. The consequence of these facts is that our estimate of the reciprocal of the marked fraction (θ^{-1}, as defined in Bernard and Clark (1996) is subject to significant bias. Simulations show the bias is of the order of about 20 %. Such bias translates directly to estimates of harvest.

Harvest of Unuk stocks in the fisheries

An estimated 10,218 (SE = 5,397) coho salmon originating from the Unuk River were harvested in marine commercial and recreational fisheries in 2004 throughout SEAK (Table 3). In 2004, 28 coho salmon with CWTs released in the Unuk River in 2003, and 1 coho salmon released with a CWT in 2002, were recovered from various U.S. marine fisheries by the port and creel census sampling programs. The first marine recovery of a CWT occurred on 15 July in the Northwest Quadrant of the troll fishery while the last marine recovery in 2004 was from the Prince of Wales (District 106) drift gillnet fishery in the Southeast Quadrant on 22 September.

Marine harvest was primarily by purse seine (51%), troll (40%), and recreational fisheries (7%). The expansion of one marine recovery, from the District 101 purse seine fishery in statistical week 33, accounted for nearly 51% of the total estimated marine harvest of Unuk River coho salmon in 2004 (Table 3). In this harvest stratum, of 5,466 coho salmon harvested, 5,203 were estimated to be of Unuk River origin. However, this result is based on a very small sample size (52). From 1998 to 2003, seine harvest accounted for an average of 21% of the total estimated harvest of coho salmon originating from the Unuk River, ranging from 10% in 1998 to 37% in 2001. During that period, an estimated 53% of marine harvest was by troll, 17% by gillnet, and 8% by recreational fisheries. Coho salmon bound for the Unuk River accounted

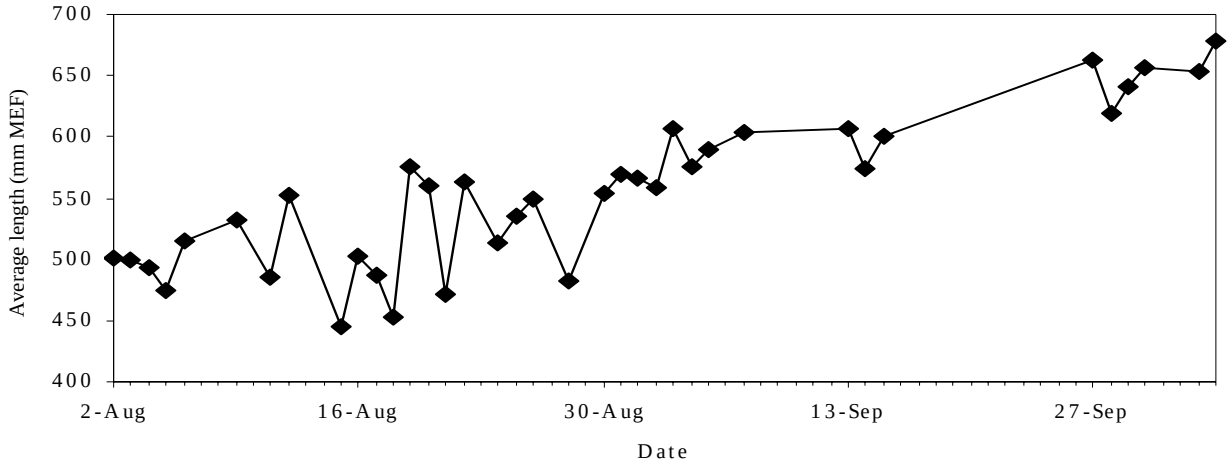

Figure 10.–Average length of coho salmon captured at the set net site (SN1) on the Unuk River, 2004.

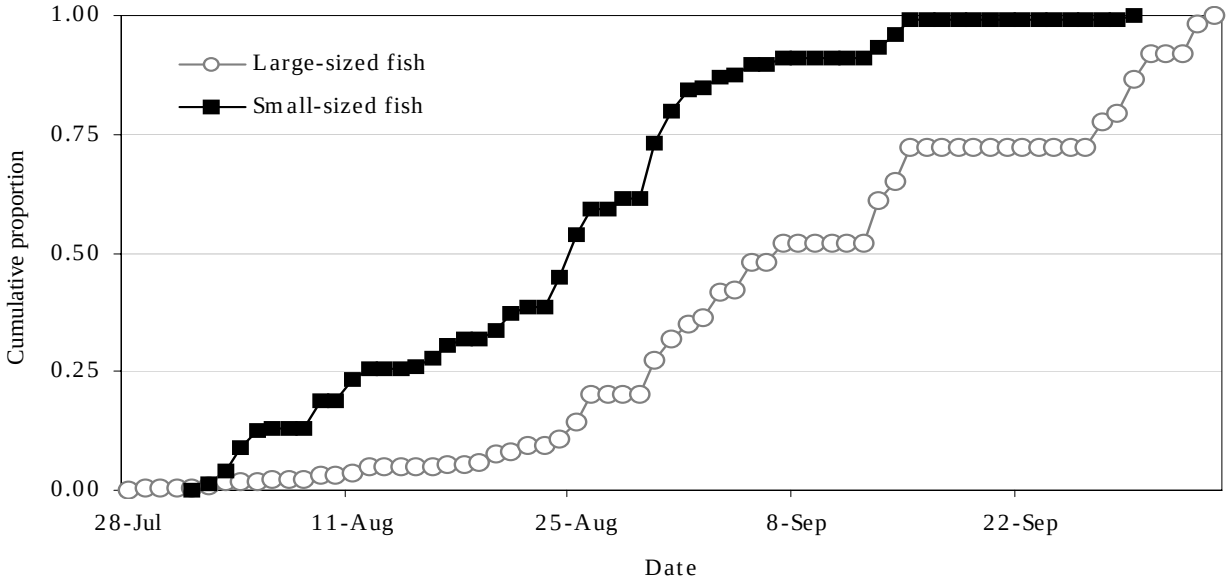

Figure 11.–Cumulative proportion of small (<541 mm MEF) and large (>540 mm MEF) coho salmon captured at SN1 on the Unuk River, 2004.

for approximately 2.9% of the recreational harvest in the Ketchikan area in 2004, compared to an average of 5.1% from 1998 to 2003 (Jones III et al. 1999, 2001a,b; Weller et al. 2002, 2003, 2005).

Harvest of Unuk stocks versus hatchery stocks

Hatchery produced coho salmon with CWTs have been released annually from eight locations in the Ketchikan area since 1997. The Southern and Southeast Regional Aquaculture Association (SSRAA) released fish at Neets Bay, Nakat Inlet, Herring Cove (Figure 12). The parental stock of these fish was from Indian Creek, a tributary of the Chickamin River. The Ketchikan Indian Community's Deer Mountain Tribal Hatchery released fish at Ketchikan Creek and Ward Lake, and SSRAA released fish at Neck Lake (Figure 12). The parental stock of these fish was from Reflection Lake. The Metlakatla Indian

Table 3.–Estimated marine harvest of adult coho salmon bound for the Unuk River in 2004.

TROLL FISHERY															
SW[a]	Date	Period	Quadrant	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	v(r^)
27-33	6/29-8/16	3	SE	108,141		32,057	427	426	288	288	2	335	278	163%	77,033
34-40	8/17-10/4	4	SE	131,369		29,623	479	474	367	364	3	671	513	150%	263,289
27-33	6/29-8/16	3	SW	152,119		48,763	525	520	360	358	2	314	260	162%	67,571
34-40	8/17-10/4	4	SW	52,739		37,029	478	475	317	315	3	214	164	150%	26,739
34-40	8/17-10/4	4	NE	131,422		27,257	443	436	333	332	1	243	243	196%	59,010
27-33	6/29-8/16	3	NW	547,017		118,686	1,587	1,560	1,230	1,229	4	929	678	143%	460,358
34-40	8/17-10/4	4	NW	690,256		149,828	2,760	2,710	2,229	2,228	6	1,394	968	136%	936,282
Subtotal troll fishery				1,813,063		443,243	6,699	6,601	5,124	5,114	21	4,100	1,375	66%	1,890,283
PURSE SEINE FISHERY															
SW[a]	Date		District	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	v(r^)
33	8/10-8/16		101	5,466		52	1	1	1	1	1	5,203	5,203	196%	27,070,177
Subtotal purse seine fishery				5,466		52	1	1	1	1	1	5,203	5,203	196%	27,070,177
RECREATIONAL FISHERY															
Biweek	Date		Area	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	v(r^)
15	7/21-8/3		Ketchikan	1,726	348,986	795	24	24	18	18	1	107	107	195%	11,490
16	8/4-8/17		Ketchikan	2,970	2,011,288	1,105	18	18	12	12	1	133	133	196%	17,637
17	8/18-8/31		Ketchikan	2,583	417,089	872	12	12	7	7	2	293	247	165%	60,777
19	9/1-9/14		Ketchikan	8,977	10,309,113	2,635	76	74	64	64	1	173	173	196%	29,903
Subtotal recreational fishery				16,256	13,086,476	5,407	130	128	101	101	5	707	346	96%	119,808
DRIFT GILLNET FISHERY															
SW[a]	Date		District	N	v(N)	n	a	a'	t	t'	mc	r^	SE(r^)	RP(r^)	v(r^)
39	9/21-9/27		106-41	9,906		2,362	65	65	56	56	1	208	207	196%	42,968
Subtotal drift gillnet fishery				9,906		2,362	65	65	56	56	1	208	207	196%	42,968
Total				1,844,691	13,086,476	451,064	6,895	6,795	5,282	5,272	28	10,218	5,397	104%	29,123,236

Note: Where V (θ)$^{-1}$ = 927.65 and G (1/ θ) = 0.379.

Note: table terms defined in Bernard and Clark 1996.

[a] Statistical week.

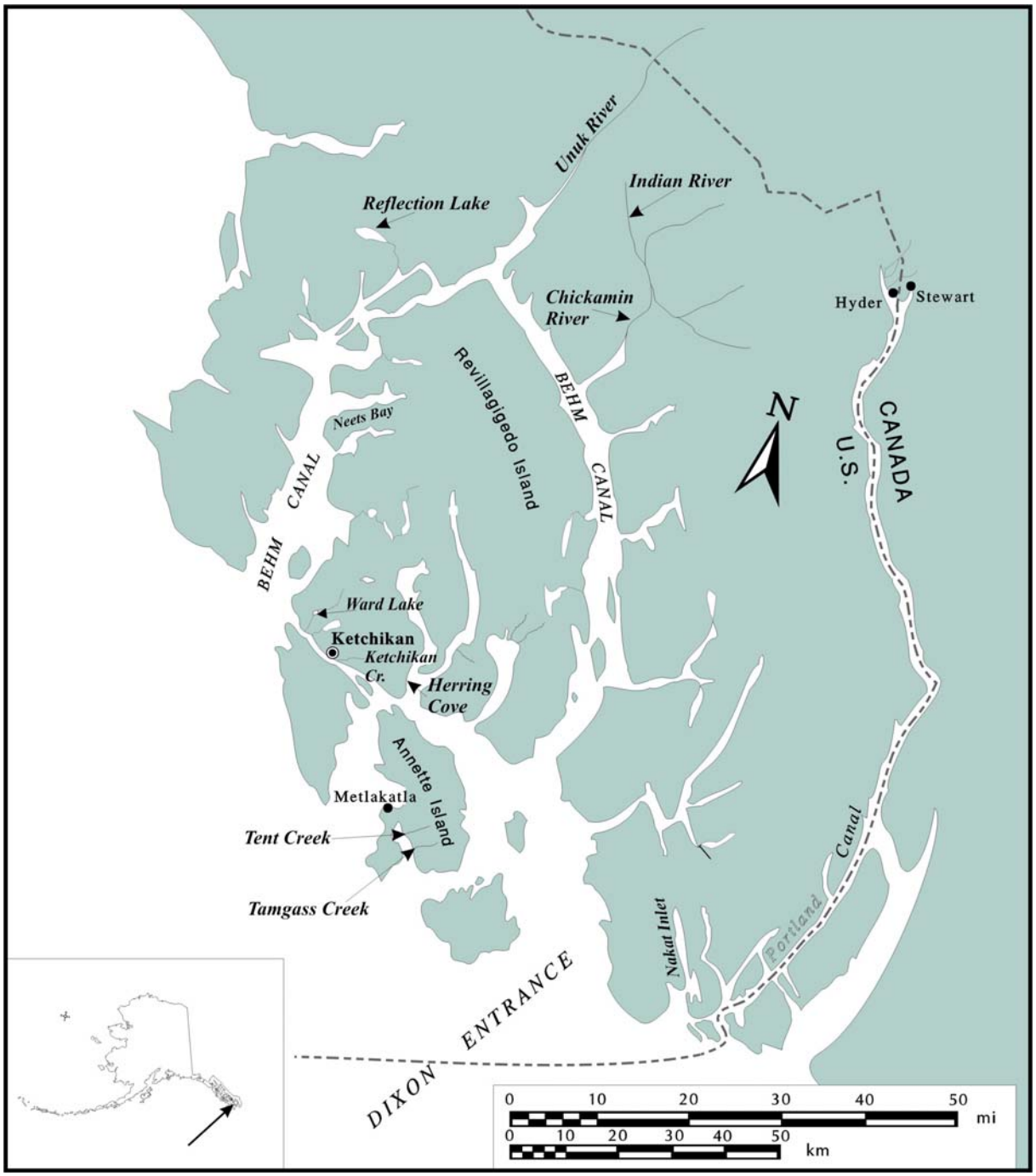

Figure 12.–Release sites and parental brood stock locations of hatchery reared coho salmon in the Ketchikan area from 1997 to 2003**.**

Community's Tamgas Hatchery released fish at Tent and Tamgas Creeks. The parental stock of these fish was from Tamgas Creek.

The harvest of Unuk River coho in SEAK was intermediate in timing relative to that of local hatchery stocks. From 1998 to 2004, the mean harvest date of coho salmon from the Unuk River averaged 16 August, with a range from 7 August to 22 August (Table 4, Figure 13). On average, the mean harvest date for hatchery stocks of

Reflection Lake lineage was about a month earlier (13 July for Ward Lake to 19 July for Ketchikan Creek) than that of the Unuk River stock. Hatchery stocks of Indian Lake lineage were most similar to the Unuk River stock, with mean date of harvest averaging 11–12 days later (27 or 28 August) than that of the Unuk River (Table 4, Figure 13). The mean date of harvest of Tent and Tamgas Creeks returns averaged about 2–3 weeks later (31 August and 6 September, respectively) than that of the Unuk stock. In general, the mean date of harvest relative to its seven-year average was similar between stocks in a given year, i.e., if the mean date of harvest of the Unuk stock was earlier or later than average then the mean date of harvest of hatchery returns were as well (Table 4, Figure 13). The most notable exception to this trend was in 2001, where the Unuk River stock had a mean date of harvest nine days earlier than average while the hatchery stocks, with the exception of Tent Creek, were average.

DISCUSSION

Using set gillnets to capture coho salmon results in size-selective sampling at SN1. From 1998 to 2003, mark-recapture studies were used to estimate the spawning abundance and age composition of coho salmon in the Unuk River. In the first three years of these studies, two 5¾" set gillnets were used to capture fish. Results from these studies suggest that these nets were likely size-selective for larger coho salmon (Jones III et al. 1999, 2001a,b). From 2001 to 2003, as in this year's study, a 4½" net was substituted for one of the larger mesh nets to minimize this size-selectivity. Cumulative length frequencies of fish tagged at SN1 versus fish examined during the second event (2001–2003) indicated that SN1 was now size-selective for mid-sized coho salmon. Consequently, estimates of length composition are likely biased to some undetermined degree in 2004.

Table 4.–Estimated mean date of harvest in Southeast Alaska of coho salmon returning to the Unuk River and eight Ketchikan area hatchery release sites (Panel A) and associated standard deviations (Panel B), 1998–2004.

PANEL A: ESTIMATED MEAN DATE OF MARINE HARVEST

	Release site								
Year	Neets Bay	Herring Cove	Nakat Inlet	Tamgas Creek	Tent Creek	Ward Lake	Ketchikan Creek	Neck Lake	Unuk River
2004[a]	27-Aug	4-Sep	29-Aug	5-Sep	5-Sep	10-Jul	18-Jul	9-Jul	18-Aug
2003	1-Sep	2-Sep	2-Sep	4-Sep	8-Sep	13-Jul	19-Jul	19-Jul	22-Aug
2002	3-Sep	31-Aug	1-Sep	20-Sep	16-Sep	11-Jul	23-Jul	18-Jul	26-Aug
2001	26-Aug	26-Aug	28-Aug	9-Sep	19-Aug	14-Jul	17-Jul	14-Jul	7-Aug
2000[a]	19-Aug	14-Aug	19-Aug	16-Aug	12-Aug	12-Jul	18-Jul	12-Jul	7-Aug
1999	24-Aug	27-Aug	26-Aug	12-Sep	27-Aug	14-Jul	17-Jul	12-Jul	16-Aug
1998	27-Aug	23-Aug	27-Aug	5-Sep	1-Sep	15-Jul	21-Jul	12-Jul	14-Aug
Average[b]	27-Aug	27-Aug	28-Aug	6-Sep	31-Aug	13-Jul	19-Jul	14-Jul	16-Aug

PANEL B: STANDARD DEVIATION (in days)

	Release site								
Year	Neets Bay	Herring Cove	Nakat Inlet	Tamgas Creek	Tent Creek	Ward Lake	Ketchikan Creek	Neck Lake	Unuk River
2004[a]	21	18	21	21	22	12	17	11	15
2003	19	19	19	22	23	15	19	17	17
2002	18	17	20	16	18	12	15	16	18
2001	27	26	28	26	26	11	11	10	23
2000[a]	22	22	23	28	26	9	13	10	19
1999	25	25	23	25	25	11	14	13	23
1998	20	24	20	18	19	14	15	11	21
Average	22	22	22	22	23	12	15	13	19

[a] Leap year.

[b] Date of average is for a non leap year.

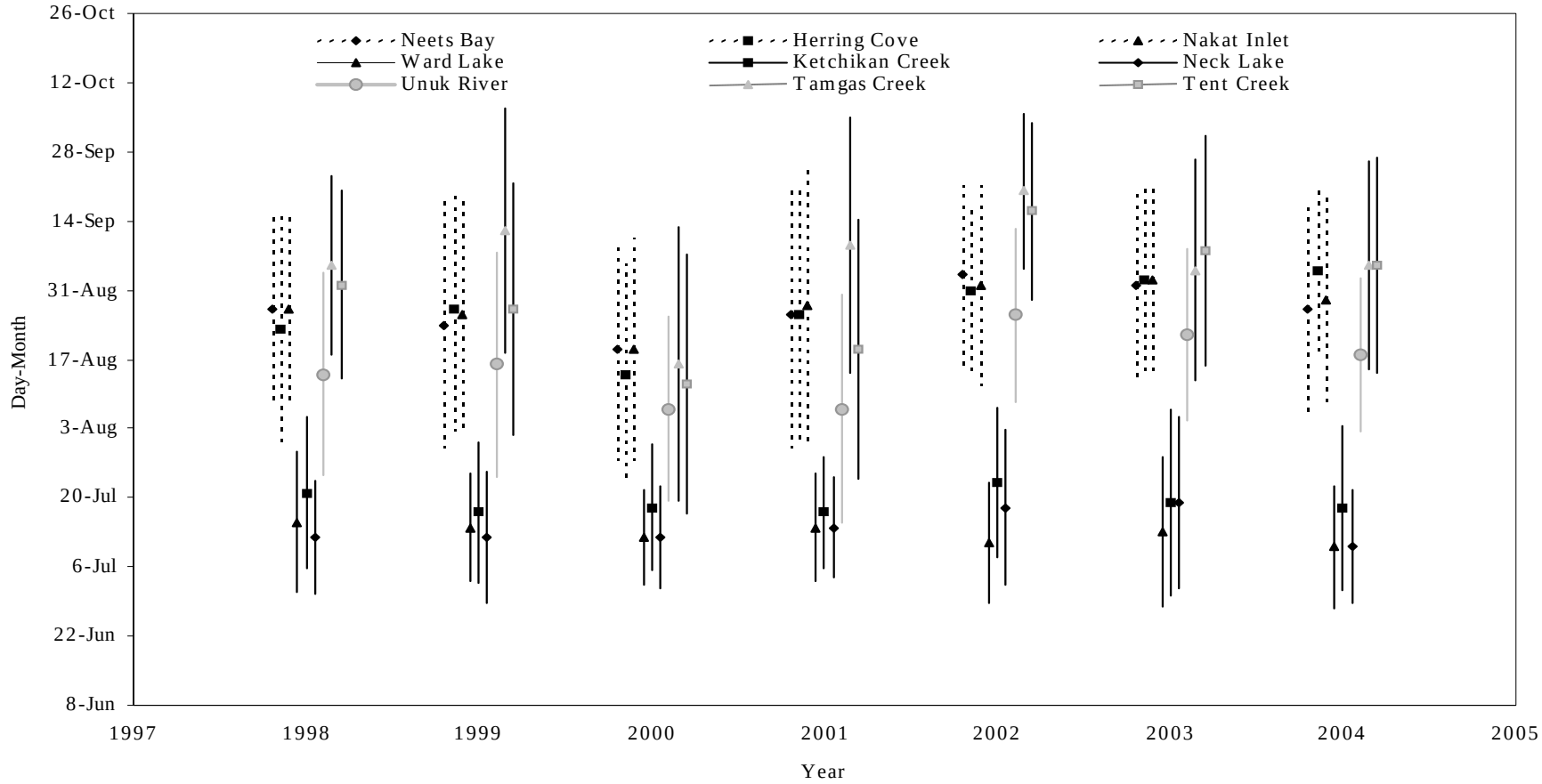

Figure 13.–Estimated mean date of harvest (and associated standard deviations) of coho salmon returning to the Unuk River and eight hatchery release sites in the Ketchikan area, 1998–2004.

CONCLUSION AND RECOMMENDATIONS

First initiated in 1997, this marks the end of a series of production studies on the stock of coho salmon originating from the Unuk River. One of the primary purposes of these studies was to determine the feasibility of using this stock as an inseason indicator of the run strength and timing of area coho returns. Toward that end, these studies worked well. Marine recoveries of CWT coho salmon returns to the Unuk River were used to track inseason the relative size and timing of the migration through SEAK. In addition, the inriver catch of coho salmon at SN1 enabled fishery managers to gauge the progress of the inriver migration or escapement. The peak of the inriver migration, as determined by CPUE at SN1, tends to occur during the first week of September on the Unuk River. Consequently, local managers were able to base late season coho fishery decisions, in part, on certain knowledge of the escapement magnitude of the Unuk River stock.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1.–Random and select recoveries of CWTs from the Unuk River stock of coho salmon, 2004.

Head number	Tag code	Gear	Recovery Date	Statistical week	Quadrant	District	Length	Survey site	Sample number
RANDOM RECOVERIES									
535553	40808	Drift	9/22/2004	39	SE	106	710	Petersburg	4050971
258336	40808	Purse	8/13/2004	33	SE	101	630	Ketchikan	4060402
535195	40809	Purse	8/20/2004	34	SE		500	Petersburg	4050785
272141	40808	Recreational	7/24/2004	30	SE	102	635	Ketchikan	4065249
272173	40808	Recreational	8/15/2004	34	SE	101	490	Ketchikan	4065278
272639	40808	Recreational	8/23/2004	35	SE	101	600	Ketchikan	4065292
272181	40808	Recreational	8/24/2004	35	SE	101	680	Ketchikan	4065297
272240	40808	Recreational	9/13/2004	38	SE	101	730	Ketchikan	4065390
284334	40808	Troll	9/3/2004	36	NE	109	680	Craig	4070367
519248	40809	Troll	7/15/2004	29	NW	113	682	Elfin Cove	4020038
263875	40808	Troll	7/26/2004	31	NW	113	590	Sitka	4031009
249708	40809	Troll	8/7/2004	32	NW	113	673	Sitka	4031084
260010	40808	Troll	8/9/2004	33	NW	113	609	Sitka	4031115
261088	40809	Troll	8/29/2004	36	NW	113	711	Sitka	4031233
274575	40808	Troll	9/4/2004	36	NW		640	Hoonah	4110345
266813	40809	Troll	9/7/2004	37	NW	113	720	Pelican	4010109
266836	40809	Troll	9/8/2004	37	NW	113	663	Pelican	4010112
262716	40808	Troll	9/11/2004	37	NW	113	632	Sitka	4031281
283679	40809	Troll	8/2/2004	32	SE	105	594	Craig	4070153
286653	40808	Troll	8/5/2004	32	SE	105	613	Craig	4070174
284207	40808	Troll	8/30/2004	36	SE	105	636	Craig	4070341
285326	40809	Troll	9/17/2004	38	SE	101	675	Ketchikan	4060513
257445	40536	Troll	9/21/2004	39	SE	101	672	Ketchikan	4060534
258444	40809	Troll	7/21/2004	30	SW		668	Ketchikan	4060282
286939	40808	Troll	7/23/2004	30	SW	104	560	Craig	4070112
286522	40809	Troll	8/9/2004	33	SW	103	630	Craig	4070204
286413	40809	Troll	8/16/2004	34	SW	152	656	Craig	4070253
286292	40808	Troll	8/27/2004	35	SW	104	601	Craig	4070328
261022	40809	Troll	8/25/2004	35			731	Sitka	4031215
223937	40808	Escapement	8/25/2004	35	SE	101	540	Unuk set gillnet	4930065
223938	40808	Escapement	8/25/2004	35	SE	101	565	Unuk set gillnet	4930065
223939	40808	Escapement	8/30/2004	36	SE	101	540	Unuk set gillnet	4930068
223940	40809	Escapement	8/31/2004	36	SE	101	630	Unuk set gillnet	4930069
223941	40808	Escapement	9/1/2004	36	SE	101	605	Unuk set gillnet	4930070
223942	40808	Escapement	9/15/2004	38	SE	101	660	Unuk set gillnet	4930078
223943	40809	Escapement	9/15/2004	38	SE	101	570	Unuk set gillnet	4930078
223906	40808	Escapement	9/27/2004	40	SE	101	700	Unuk set gillnet	4930079
SELECT RECOVERY									
900816	40808	Troll	8/2/2004	32	NW	154		Sitka	4039989

Appendix A2.–Estimated age-sex-length composition of adult coho salmon sampled at the set net site on the lower Unuk River, 2004.

		Age		
		1.1	2.1	Total
Female	Sample size	127	20	147
	%	39.6	6.2	45.8
	SE of %	2.7	1.4	2.8
	Average length	580	619	585
	SE Length	6.06	12.57	2.39
Male	Sample size	149	25	174
	%	46.4	7.8	54.2
	SE of %	2.8	1.5	2.8
	Average length	567	570	567
	SE Length	6.60	16.31	2.83
Total	Sample size	276	45	321
	%	86.0	14.0	100.0
	SE of %	1.9	1.9	
	Average length	573	592	575
	SE Length	4.54	11.16	2.65

Appendix A3.–Names of computer files containing data, statistics, and interim calculations concerning stock assessment of the Unuk River stock of coho salmon, 2003–2004.

File name	Description
04UNK43-R.XLS	Spreadsheet containing all the set net data, various pivot table results, Tables 1 and 7, Figures 8 and 11, Appendices A1 and A2, harvest estimation calculations, and abundance estimates.
HATCH43MIGRATORY98-04	Data file containing hatchery run timing analysis
03UNUKSMOLT.xls	Spreadsheet containing all smolt data files.
UNK43CPUE 97-04.WTD.XLS	Spreadsheet containing Figure 9 and the weighted CPUE regression