Fishery Data Series No. 03-07

Smolt Production and Adult Harvest of Coho Salmon from the Naha River, 1998–2000

by

Glenn M. Freeman

May 2003

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	v
watts	w

General

all commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
all commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	var

FISHERY DATA SERIES NO. 03-07

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ABSTRACT

A three-year study was conducted in 1998–2000 on the Naha River to estimate the number of coho salmon *Oncorhynchus kisutch* smolt produced in 1998 and 1999, and to estimate the harvest of adults in the marine sport and commercial fisheries in 1999 and 2000. Smolt abundance was estimated using a two-event mark-recapture method. Smolt were captured in the lower river each spring with a rotary screw trap and baited minnow traps, and tagged with coded wire tags and adipose finclips as the first of two sampling events. The second event entailed sampling the adult escapement inriver each fall using hook and line and beach seine nets. The smolt abundance was estimated at 116,736 (SE = 20,104) fish in 1998 and 102,486 (SE = 19,353) fish in 1999. Seventy-two percent (72%) of the smolt aged in 1998 were age-1 and 28% were age-2; in 1999, 70% were age-1 and 30% were age-2. Estimates of theta, the fraction of sampled adults bearing adipose finclips, were 0.1049 (SE = 0.0188) in 1998 and 0.0615 (SE = 0.0127) in 1999. Estimated harvests of Naha River coho salmon in the marine fisheries were 9,822 (SE = 1,306) fish in 1999 and 5,501 (SE = 727) fish in 2000. Composition of the marine harvest in 1999 was estimated at 60% troll, 26% drift gillnet, 8% purse seine and 6% sport fishery. In 2000, marine harvest estimates were 77% troll, 15% drift gillnet, 6% sport fishery and 2% purse seine. Four brood years were represented in the adult escapement each year, with age-1.1 the dominant age class for both males and females.

Key words: coho salmon, *Oncorhynchus kisutch*, smolt abundance, Naha River, mark-recapture, Petersen model, marine harvest, escapement, age, sex, length composition, Behm Canal, Southeast Alaska

INTRODUCTION

The Naha River, located 40 km northeast of Ketchikan (Figure 1), is one of the most popular streams in the Ketchikan area for sport fishing for coho salmon *Oncorhynchus kisutch* and other salmonid species. The river flows for 30 km and drains seven lakes on western Revillagigedo Island before entering Naha Bay in west Behm Canal. The anadromous reach extends approximately 11.5 km upstream from Roosevelt Lagoon, 2.5 km upstream from Heckman Lake, the second lowest lake in the drainage (Figure 2). The U.S. Forest Service maintains three small cabins and a maintained streamside trail which facilitate sport fishing and other recreational access.

Through the 1990s, staff of the Alaska Department of Fish and Game (ADF&G) and the general public perceived a decline in coho salmon returns to the Naha drainage, despite generally increasing coho returns to Ketchikan area streams. A shared concern was that exploitation on coho salmon returning to this "inside" Southeast Alaska location was high.

Between 1977 and 1998, the Naha River provided about 18% of the coho salmon freshwater harvest and 14% of the angler effort expended in fresh water in the Ketchikan area (see Howe et al. 2001). Since 1990, only about 9% of the area's freshwater coho harvest has come from the Naha River. Freshwater harvests from 1977 to 1998 ranged from 0 to 363 fish while angler effort (for all fish species) ranged from 356 to 2,137 angler-days. With the exception of an estimated peak harvest of 363 fish in 1993, annual coho harvests from the Naha River in the 1990s declined from those in the 1980s (Figure 3).

A study was conducted by the ADF&G from 1998 to 2000 on the Naha River, to investigate coho salmon smolt production and adult harvest. The objectives were to estimate: (1) the abundance, mean length, and age composition of coho salmon smolt leaving the Naha River in 1998 and 1999; (2) the harvest of adult coho salmon bound for the Naha River in the common property fisheries (CPF) in 1999 and 2000; and (3) the age composition of returning adult coho salmon in 1999 and 2000.

METHODS

Coho salmon smolt were captured in the Naha River during the spring of 1998 and 1999 and marked with an adipose finclip and a coded-wire tag (CWT). Adult fish were sampled for CWTs in the marine commercial and sport fishery harvests throughout Southeast Alaska in 1999 and 2000. The inriver escapement was also sampled in 1999 and 2000 to determine the marked fraction used to

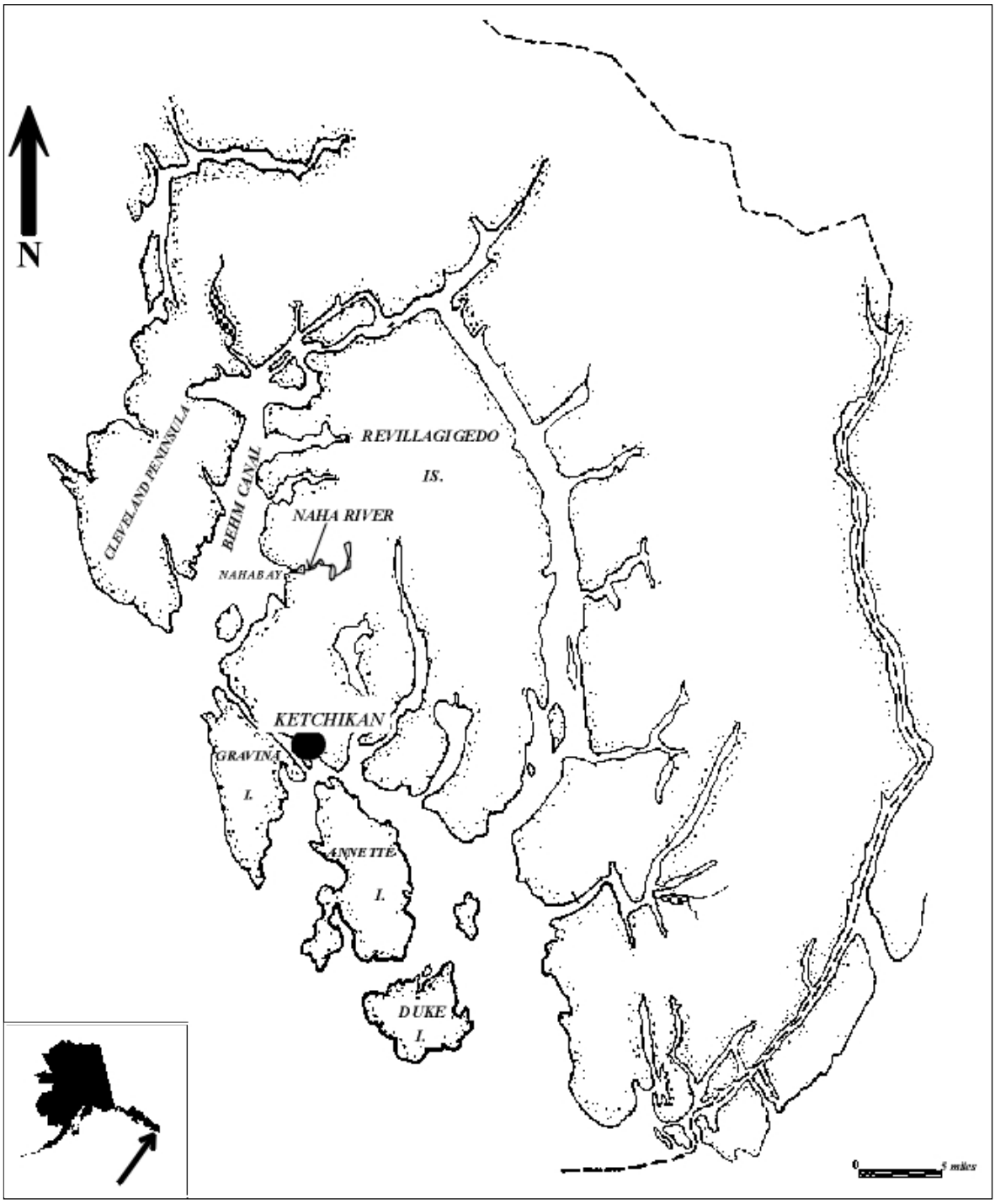

Figure 1.–Ketchikan and adjacent islands in southern Southeast Alaska, and the Naha River system.

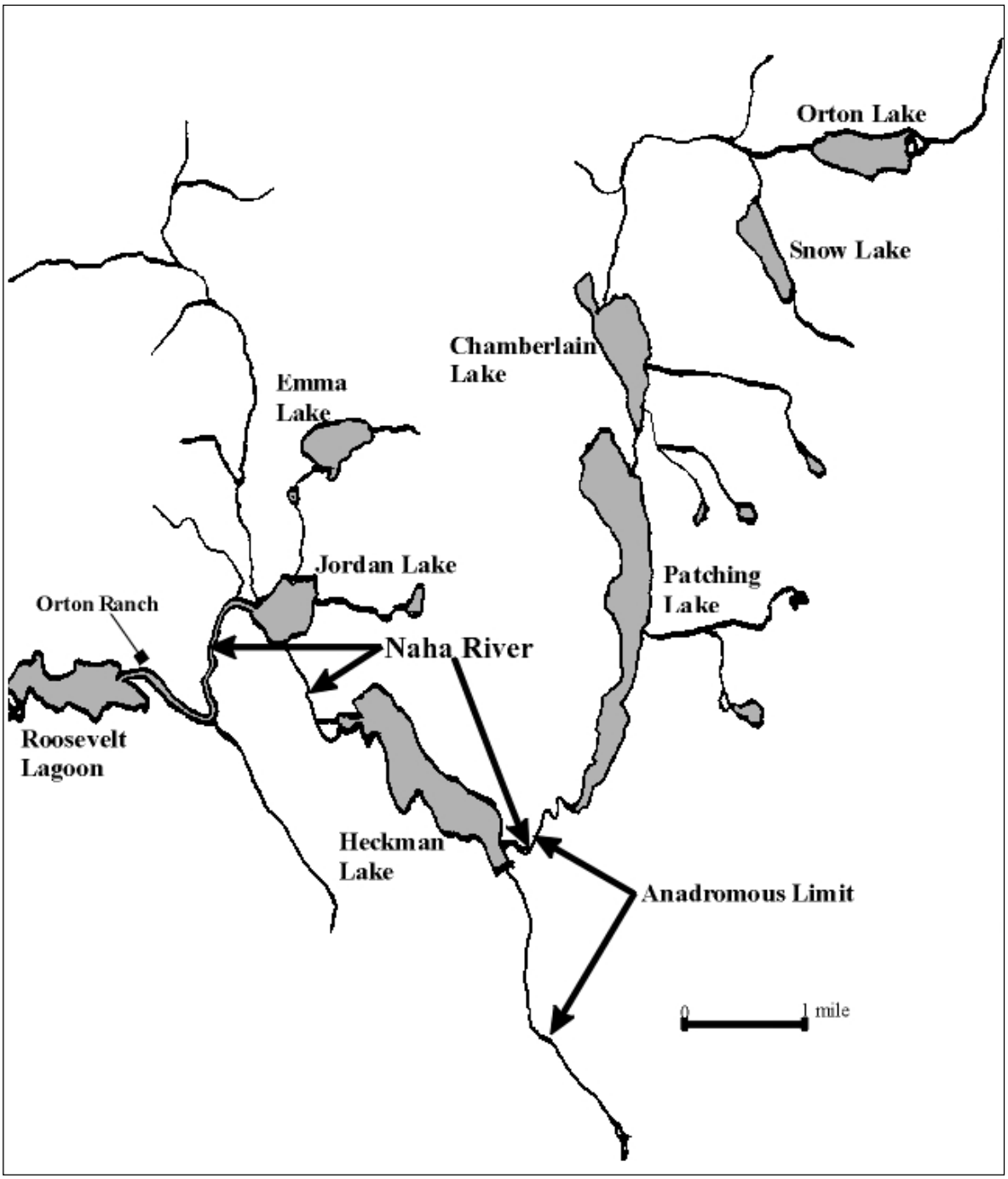

Figure 2.–Naha River system in Southeast Alaska, showing primary tributaries and upstream limits to anadromous fish migration.

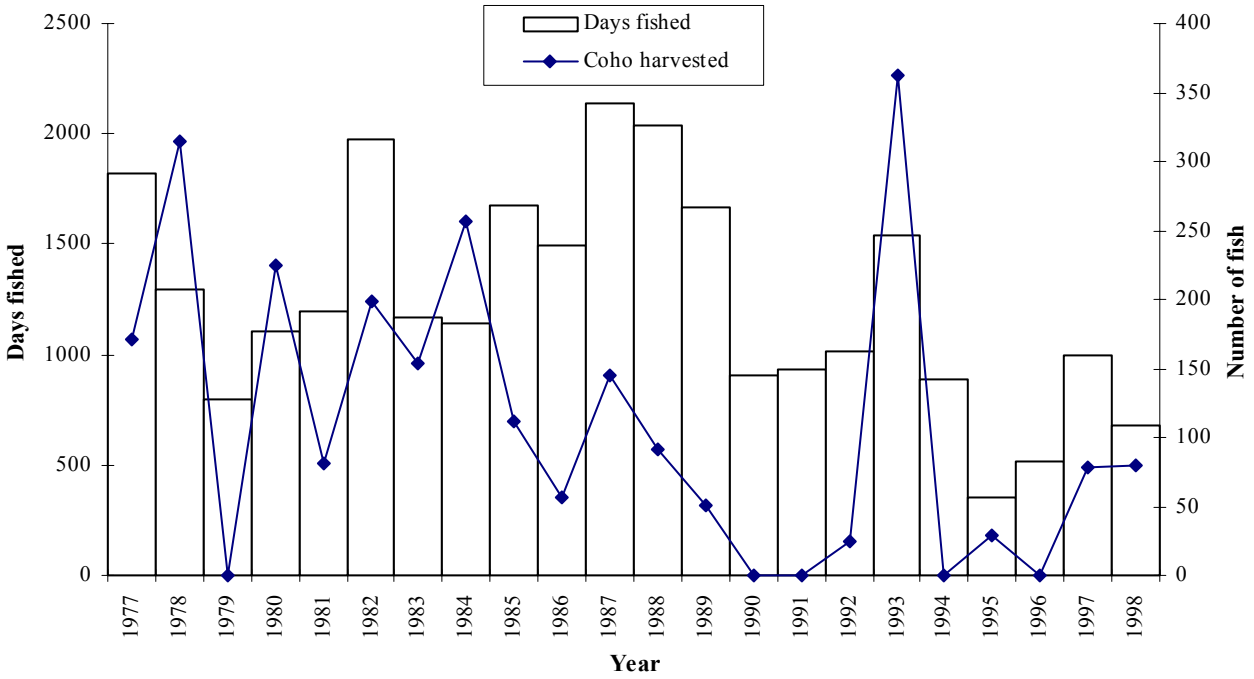

Figure 3.–Sport fishing effort and coho salmon harvest in Naha River, 1977–1998.

estimate the 1998 and 1999 smolt emigration and the harvest of adult coho salmon in the sampled fisheries in 1999 and 2000.

SMOLT CAPTURE, CODED-WIRE-TAGGING, AND LENGTH-WEIGHT SAMPLING

Two methods were used to capture coho salmon smolt in the lower Naha River in the springs of 1998 and 1999. One rotary screw trap 2.4 m (8 ft) in diameter, manufactured by E.G. Solutions, Inc., was fished 0.5 km upstream of Roosevelt Lagoon from 3 April to 28 May 1998 and from 15 April to 6 June 1999. Two "wings" made of 5-mm mesh Vexar™ secured by wooden frames (about 1 m deep by 2.5 m and 4 m in length) were angled in a "V" immediately upstream of and toward the trap to direct emigrating smolt into the trap. Fish were diverted through a trapping cone and into a live box at the downstream end of the structure. The screw trap was fished continuously, except during periods of extremely high tides or stream flows, days off work, and briefly during cleaning. The screw trap was cabled to two upstream anchors and secured to the adjacent northwest stream bank at a deep, narrow run immediately downstream of a large pool. During low to moderate flows most of the river flowed through this run, which contained approximately 25 percent of the channel width. However, during high water the river flowed across the expanse of the channel, thereby reducing screw trap efficiency and catches.

Up to 40 G-40 minnow traps baited with salmon eggs (roe) were also fished daily, mostly in the lower mainstem reach, to supplement catches throughout the study period. A two-person crew fished the screw trap and minnow traps.

Fish captured in the screw trap and minnow traps were removed and transported in buckets partially filled with water to separate covered holding pens located in the pool adjacent to both the screw trap and the campsite. Coho salmon smolt were separated from other species of salmon, trout, and char by inspection, using a combination of external morphological characteristics. All live coho salmon ≥70 mm FL were tranquilized in a water solution of tricaine

methanesulfonate (MS-222) buffered with sodium bicarbonate. The solution and holding water were changed often, and numbers of tranquilized fish were kept low to minimize stress on the fish. All healthy fish were tagged with a CWT and externally marked by removal of the adipose fin each day as described in Koerner (1977).

After tagging, smolt were returned to holding pens and held overnight and then checked for tag retention and mortality. The numbers of fish tagged, holding pen mortalities and fish with shed tags were compiled, recorded on appropriate forms and submitted to the Commercial Fisheries Division (CFD) Tag Lab in Juneau after each field season.

Length and weight of coho salmon smolt were estimated by systematically sampling every 12th smolt captured. Each sampled smolt was measured to the nearest mm FL, weighed to the nearest g and scale sampled for age. Twelve (12) to 15 scales were taken from the preferred area (Scarnecchia 1979) on the left side of each fish sampled. Additionally, each smolt recaptured (i.e., with missing adipose fin) in the screw trap was counted and measured to the nearest mm FL.

ESTIMATES OF SMOLT ABUNDANCE

The abundance of coho salmon smolt emigrating from the Naha River in 1998 was estimated with a two-event mark-recapture study using Chapman's modified Petersen estimator for a closed population (Seber 1982):

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \qquad (1)$$

$$\mathrm{var}[\hat{N}] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)} \qquad (2)$$

where n_1 is the number of smolt marked in 1998, n_2 is the number of returning coho salmon inspected for marks in 1999, and m_2 is the number of adults inspected in 1999 that are missing their adipose fins and contain a CWT from the 1998 tagging on the Naha River. Similarly, estimates of abundance and variance were calculated for smolt marked in 1999 and adults inspected in 2000 using the same formulas.

Conditions which must be met for use of Chapman's modification of the Petersen estimator (Seber 1982) include:

(a) every fish has an equal probability of being marked in the first sample, or that every fish has an equal probability of being captured in the second sample, or that marked fish mix completely with unmarked fish; and

(b) recruitment and mortality do not occur between samples; and

(c) marking does not affect the catchability of an animal; and

(d) animals do not lose their marks in the time between the two samples; and

(e) all marks are reported on recovery in the second sample; and

(f) double sampling does not occur.

Assumptions of the experiments were addressed by comparing the fractions of fish marked with CWTs, using simple contingency tables and chi-square tests from the range of sampled spawning areas (upriver vs. downriver) and time segments (early and late). Size selectivity of the sampling gear was investigated by comparing the size distributions of fish captured with minnow traps and the rotary trap using a Kolmogorov-Smirnov (K-S) two-sample test (Appendix A10).

It was assumed that all marked fish would smolt that year. Any evidence of fish ≥70 mm marked on the Naha River and *not* emigrating to sea during the year of tagging was summarized for analysis. Examples of this include: 1) all fish marked with CWTs in 1998 and detected in sport and commercial fisheries in 2000, or sampled as jacks during escapement sampling in 1999; and 2) all fish marked with CWTs in 1999 and sampled as jacks during escapement sampling in 2000.

ESCAPEMENT SAMPLING

Adult coho salmon were captured in the Naha River and examined for adipose finclips from 21 September to 5 November 1999 and from 19 September to 3 November 2000. Angling with artificial lures was the primary method used to

capture adult fish. Other methods of capture included use of 45-m beach seine nets, dip nets, snagging and carcass retrieval. Two or three personnel normally fished five days a week to capture fish throughout the anadromous reach.

All coho salmon captured were visually examined to estimate sex, sampled for age, length and marked with a 0.6-cm punch in the left operculum (LOP) to prevent re-sampling prior to release. Fish were measured to the nearest 5 mm mideye-to-fork length (MEF) and sex was determined from secondary maturation characteristics. Four or five scales were taken from the preferred area two to three rows above the lateral line and between the posterior terminus on the dorsal fin and the anterior margin of the anal fin, on the left side of each fish (Scarnecchia 1979). Scales were mounted onto gum cards which each held scales from up to 10 fish. The age of each fish was determined later from annual growth patterns of circuli (Olsen 1992) on images of scales impressed onto acetate cards under 70× magnification (Clutter and Whitesel 1956). For this study, "large" fish were distinguished from jacks based on scale aging; large fish spent about 16 months at sea while jacks spent about 4 months at sea.

Personnel retained heads from all coho salmon captured with a missing adipose fin, and inserted a uniquely numbered plastic cinch strap through the jaw of each head. Heads and recovery data were shipped to the ADF&G CWT Tag Processing Laboratory in Juneau, where tags were removed, decoded and corresponding information entered into the tag lab database.

HARVEST

Harvest in 1999 and 2000 of coho salmon originating from the Naha River was estimated from fish sampled from catches in the Southeast Alaska marine commercial and recreational fisheries and in the Naha River escapement. Because coho salmon were harvested in most Southeast Alaska fisheries, harvest was estimated over a number of strata, each a combination of time, area and type of fishery. Statistics from the commercial troll fishery were stratified by fishing period and by quadrant. Statistics from drift gillnet and purse seine fisheries were stratified by week and by fishing district. Statistics from the recreational fishery were stratified by bi-week.

The contribution of the tagged emigration to the sport and commercial fisheries was estimated:

$$\hat{r}_{ij} = \hat{H}_i \left(\frac{m_{ij}}{\lambda_i n_i} \right) \hat{\theta}_j^{-1} \qquad (3)$$

where $\hat{H}_i$ is the estimated harvest in stratum i, $\hat{\theta}_j$ is the fraction of emigration marked with CWTs, n_i is the subset of $\hat{H}_i$ examined for missing adipose fins, m_{ij} is the number of decoded CWTs recovered from stock j, and $\lambda_i = (a_i' t_i')/(a_i t_i)$ is the decoding rate for CWTs from recovered salmon (Bernard and Clark 1996). Variance of $\hat{r}_{ij}$ was estimated using the appropriate large-sample formulations in Bernard and Clark (1996, their Table 2) for a wild stock tagging program.

Estimates of harvest were summed across strata and across fisheries to obtain estimates of the total harvest each year. Variance of the sum of estimates was estimated as the sum of variances across strata and across fisheries.

RESULTS

SMOLT TAGGING, AGE AND SIZE

1998

From 3 April to 28 May 1998, 12,705 coho salmon smolt ≥70 mm FL were captured, adipose finclipped and tagged with a CWT (Table 1). Seventy-eight percent (78%) of the fish tagged were captured in the screw trap and 22% were captured in minnow traps. Numbers of fish caught, along with the average length and weight are presented in Figure 4 and Appendix A1. Of the total tagged 55 died after tagging and 19 were estimated to have shed their tags, leaving a total valid release of 12,631 tagged smolt. Two tag codes were used, 04-45-04 (9,622 fish) and 04-46-45 (3,009 fish) (Table 1).

Length frequencies of smolt captured in minnow traps were significantly different than smolt captured in the screw trap (K-S test, P <0.0001; Figure 5). Age-1. coho smolt constituted 72% of

Table 1.–Summary of coded-wire-tagging data for coho salmon smolt in the Naha River, spring 1998 and 1999.

Tag code	Year	Start date	End date	Tagged	24 h morts	Marked	Shed tags	Valid CWTs
04-45-04	1998	4/4/98	5/11/98	9,649	8	9,641	19	9,622
04-46-45	1998	5/11/98	5/28/98	3,056	47	3,009	0	3,009
subtotal				12,705	55	12,650	19	12,631
04-47-28	1999	4/17/99	5/18/99	5,179	5	5,174	36	5,138
04-47-29	1999	5/19/99	6/3/99	1,973	11	1,962	0	1,962
subtotal				7,152	16	7,136	36	7,100
Total				19,857	71	19,786	55	19,731

sampled smolt and averaged 101 mm FL (SD = 11) and 10 g (SE = 3) in weight. Age-2. fish were 28% of the total and averaged 120 mm FL (SD = 10) and 16 g (SE = 5). The combined catch averaged 106 mm FL (SD = 14 mm) and 11 g (SE = 5) (Table 2).

Daily catches of coho smolt and water conditions are displayed in Figure 6, and summarized along with the estimated numbers of steelhead *O. mykiss* and sockeye *O. nerka*, pink *O. gorbuscha* and chum *O. keta* salmon smolt captured in the screw trap in 1998 in Appendix A2.

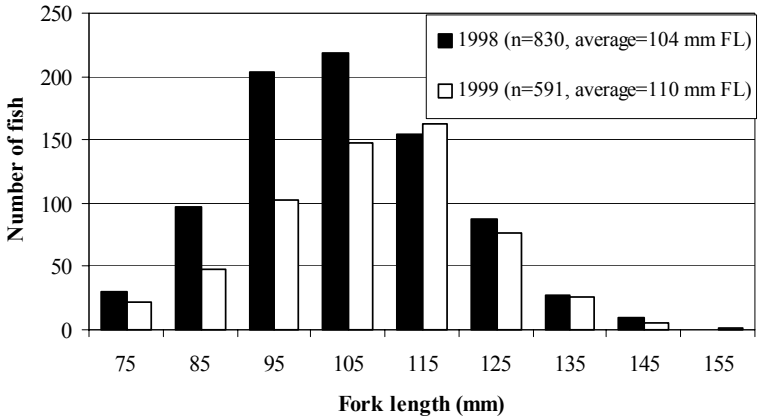

Figure 4.–Length-frequency data collected from coho salmon smolt captured in a screw trap and minnow traps (combined) in the Naha River, spring 1998 and 1999.

1999

From 15 April to 6 June 1999, 7,152 coho salmon smolt ≥70 mm FL were captured, adipose finclipped and tagged with a CWT (Table 1). Seventy-four percent (74%) of the fish tagged were captured in the screw trap and 26% were captured in minnow traps. Numbers of fish caught, along with the average length and weight of each are presented in Appendix A3. Of the total tagged 16 died after tagging and 36 were estimated to have shed their tags, leaving a total valid release of 7,100 tagged smolt. Two tag codes were used, 04-47-28 (5,138 fish) and 04-47-29 (1,962 fish) (Table 1).

Length frequencies of smolt captured in minnow traps were again significantly different than smolt captured in the screw trap (K-S test, P <0.0001; Figure 7). Age-1. coho smolt constituted 70% of sampled smolt and averaged 106 mm FL (SD = 12) and 11 g (SD = 4) in weight. Age-2. fish were 30% of the total and averaged 120 mm FL (SD = 10) and 16 g (SD = 5). The combined catch averaged 110 mm FL (SD = 13) and 13 g (SD = 5).

Daily catches of coho smolt and water conditions are displayed in Figure 8, and summarized along with the estimated numbers of steelhead and sockeye, pink and chum salmon smolt captured in the screw trap in 1999 in Appendix A4. The

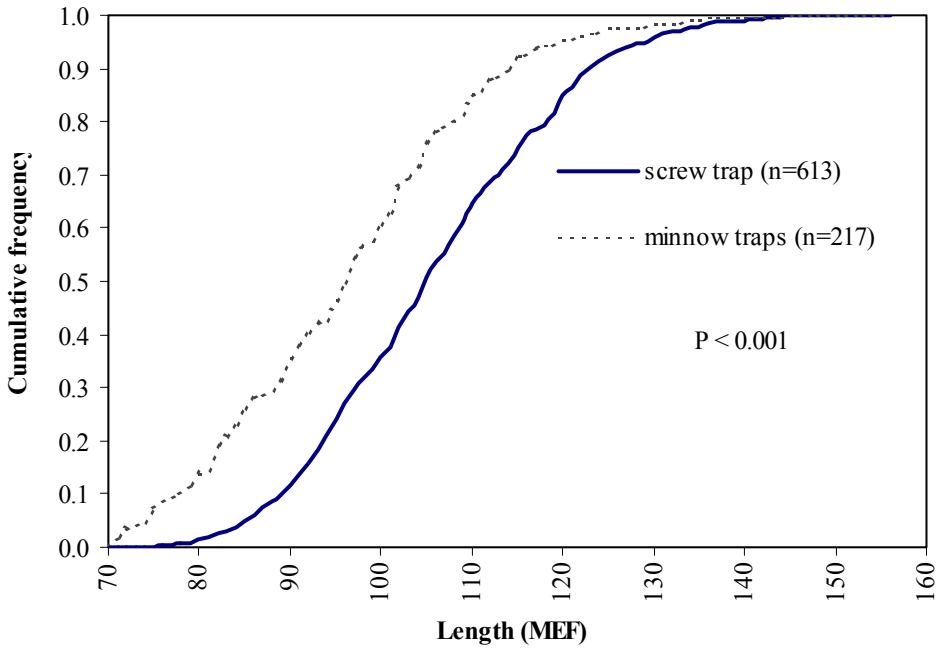

Figure 5.–Cumulative fractions of lengths of coho salmon smolt captured in a screw trap versus fish captured in minnow traps in the Naha River, spring 1998.

Table 2.–Freshwater age, weight (g) and length (mm FL) data from coho salmon smolt sampled in the lower Naha River, spring 1998 and 1999.

		Freshwater age		
		1	**2**	**Total**
1998	Sample size	436	167	603
	Percent at age	72	28	
	SE [% at age]	2	2	
	Avg. length	101	120	106
	SD [length]	11	10	14
	Avg. weight (g)	10	16	11
	SD [weight]	3	5	5
1999	Sample size	310	133	443
	Percent at age	70	30	
	SE [% at age]	2	2	
	Avg. length	106	120	110
	SD [length]	12	10	13
	Avg. weight (g)	11	16	13
	SD [weight]	4	5	5

timing of coho smolt emigration was earlier in 1998, with a peak on about 9 May as opposed to a smaller, bimodal peak in 1999 near 16 May.

ESTIMATE OF SMOLT ABUNDANCE

1998

From 21 September to 5 November 1999, 267 adult coho salmon were sampled in the Naha River. Of the total, 28 fish inspected were missing their adipose fin, and all were sacrificed to determine the tag codes present; 26 heads bore valid Naha River tags and two heads had no tags (Appendix A5). I assumed these two heads originally bore valid Naha River tags, as 100% of the valid tags were of Naha River origin.

A chi-square test of the hypothesis that marked and unmarked fractions of large fish were constant across spatial recovery strata yielded a nonsignificant result ($\chi^2 = 0.08$, P = 0.78, df = 1). Another chi-square test of the hypothesis that marked and unmarked fractions of large fish were constant across time strata yielded a non-significant result ($\chi^2 = 0.98$, P = 0.32, df = 1).

Passing at least one of the tests (above) was sufficient in our analysis to allow use of the Petersen estimator (Arnason et al. 1996). The fraction of fish with adipose finclips that returned to the Naha

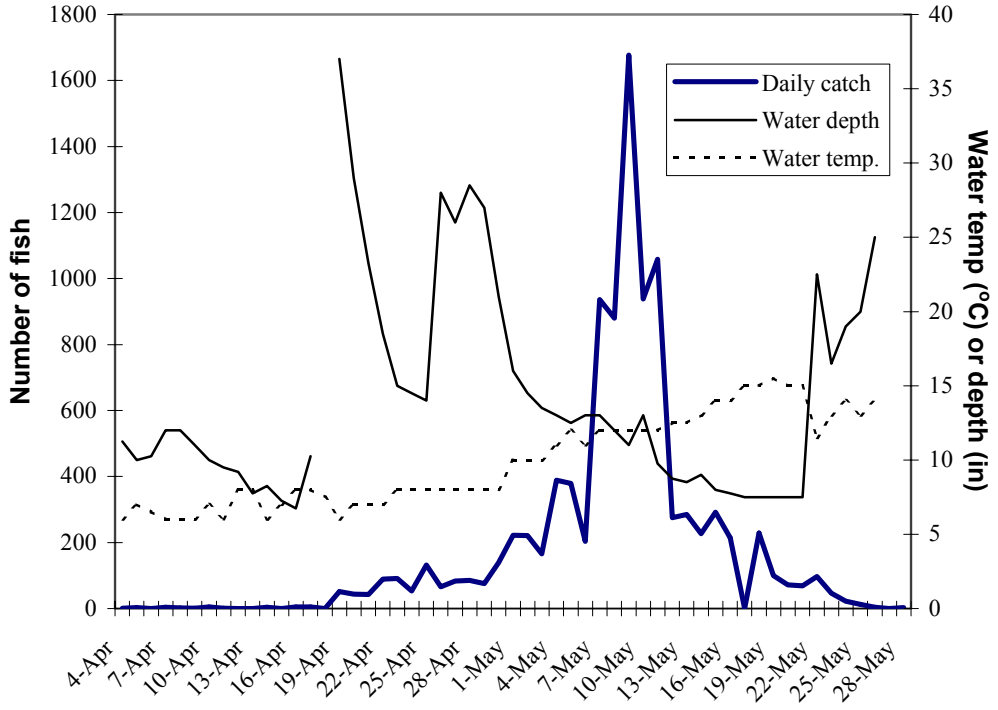

Figure 6.–Daily catch of coho salmon smolt in a screw trap, water temperature and depth in the lower Naha River, spring 1998.

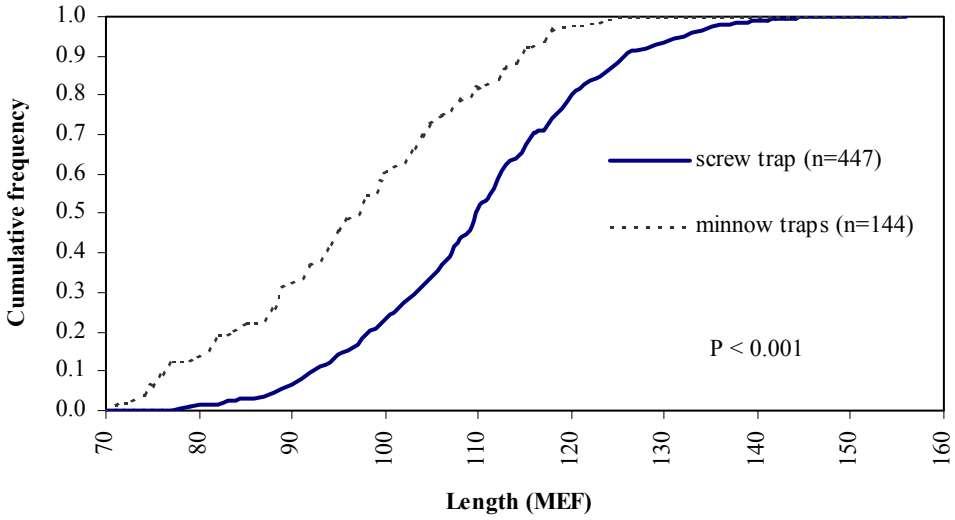

Figure 7.–Cumulative fractions of lengths of coho salmon smolt captured in a screw trap versus fish captured in minnow traps in the Naha River, spring 1999.

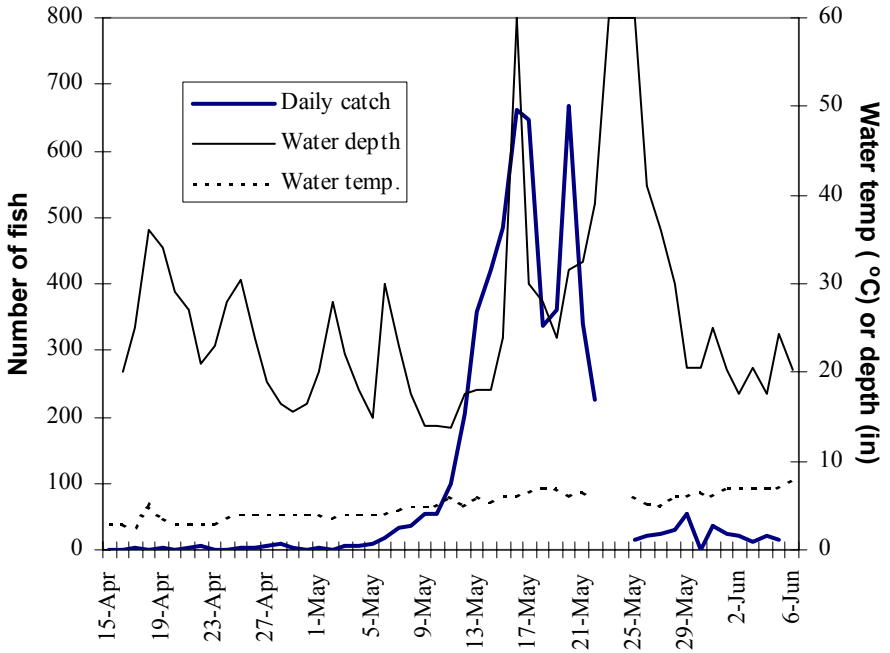

Figure 8.–Daily catch of coho salmon smolt, water temperature and depth in the Naha River, spring 1999.

River (θ) was estimated at 0.1049 (SE = 0.0188). The estimate of smolt abundance $\hat{N}$ for 1998 was 116,736 (SE = 20,104).

1999

From 19 September to 3 November 2000, 373 adult coho salmon were sampled in the Naha River. Of the total, 24 fish inspected were missing their adipose fin, and all were sacrificed to determine the tag codes present; 22 heads bore valid Naha River tags and two heads had no tags (Appendix A6). As in 1998, I assumed these two heads originally bore valid Naha River tags.

A chi-square test of the hypothesis that marked and unmarked fractions of large fish were constant across spatial recovery strata yielded a nonsignificant result ($\chi^2 = 0.01$, P = 0.94, df = 1). Another chi-square test of the hypothesis that marked and unmarked fractions of large fish were constant across time strata yielded a nonsignificant result ($\chi^2 = 0.09$, P = 0.76, df = 1).

The fraction of fish with adipose finclips that returned to the Naha River (θ) was estimated at 0.0615 (SE = 0.0127). The estimate of smolt abundance $\hat{N}$ for 1999 was 102,486 (SE = 19,353).

ESTIMATES OF AGE, SEX AND LENGTH IN THE ADULT ESCAPEMENT

1999

Adult coho salmon (279) were captured by hook and line (72%), beach seine (20%) and dip net (8%). Of the 226 fish for which age was determined, 65% (SE = 3%) were age-1.1, 30% (SE = 3%) were age-2.1, 2% (SE = 1%) were age-1.0, and 3% (SE = 1%) were age-2.0 (Table 3). All fish ≤370 mm FL MEF aged were males age-1.0 (5) or 2.0 (6). Large fish sampled ranged from 400 to 760 mm MEF in length, and averaged 606 mm (SE = 5); 62% were males and 38% were females.

2000

All fish sampled during escapement sampling in 2000 were captured by hook and line, as beach seining proved ineffective. Of the 314 fish for which age was determined, 59% (SE = 3%) were age-1.1, 37% (SE = 3%) were age-2.1, 2% (SE = 1%) were age-1.0, and 3% (SE = 1%) were age-2.0 (Table 4). All fish ≤380 mm FL MEF aged were males age-1.0 (5) or 2.0 (9). Large fish sampled ranged from 385 to 755 mm MEF, and averaged 597 mm (SE = 5); 68% of large fish sampled were males and 31% were females.

Table 3.–Average length by sex and age of coho salmon returning to the Naha River, 1999.

		Brood year and age class				
		1997	1996	1996	1995	
		1.0	1.1	2.0	2.1	Total
Males	Sample size	5	93	6	41	145
	Percent	2.2	41.2	2.7	18.1	64.2
	SE of percent	1.0	3.3	1.1	2.6	3.2
	Average length	308	584	316	621	568
	SD	43	83	41	77	107
	SE	19	9	17	12	9
Females	Sample size		53		28	81
	Percent		23.5		12.4	35.8
	SE of percent		2.8		2.2	3.2
	Average length		626		619	622
	SD		41		43	42
	SE		6		8	5
Total	Sample size	5	146	6	69	226
	Percent	2.2	64.6	2.7	30.5	100
	SE of percent	1.0	3.2	1.1	3.1	
	Average length	308	600	316	620	586
	SD	43	74	41	65	94
	SE	19	6	17	8	6

Table 4.–Average length by sex and age of coho salmon returning to the Naha River, 2000.

		Brood year and age class				
		1998	1997	1997	1996	
		1.0	1.1	2.0	2.1	Total
Males	Sample size	5	122	9	78	214
	Percent	1.6	38.9	2.9	24.8	68.2
	SE of percent	0.7	2.8	0.9	2.4	2.6
	Average length	339	583	351	592	571
	SD	9	82	30	82	98
	SE	4	7	10	9	7
Females	Sample size		62		38	100
	Percent		19.7		12.1	31.8
	SE of percent		2.3		1.8	2.6
	Average length		641		643	644
	SD		40		40	41
	SE		5		7	4
Total	Sample size	5	184	9	116	314
	Percent	1.6	58.6	2.9	36.9	100.0
	SE of percent	0.7	2.8	0.9	2.7	
	Average length	339	601	351	610	594
	SD	9	77	30	76	91
	SE	4	6	10	7	5

ESTIMATE OF HARVEST

1999

In 1999, CWTs from 324 coho salmon tagged in the Naha River in 1998 were recovered in Southeast Alaska's sampled fisheries; 314 were random recoveries (Table 5). Three fish bearing Naha River tags were commercially caught in Alaska but sampled in B. C., Canada, on 21 August 1999 (R. Josephson, ADF&G, personal communication). In all, 2.5% of the valid tags released in 1998 were randomly recovered in the sampled fisheries. The

Table 5.–Estimated marine harvest statistics of coho salmon bound for the Naha River, 1999.

TROLL FISHERY

Stat. week	Date	Period	Quadrant	N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
30-33	7/18–8/14	3	SE	121,202	-	65,626	1,172	1,164	878	877	12	229	106	91%	11,314
35-40	8/22–10/1	4	SE	91,203	-	35,346	811	800	589	589	25	672	285	83%	81,392
27-33	6/27–8/14	3	SW	216,938	-	85,717	1,033	1,019	778	777	10	264	126	94%	15,983
34-37	8/15–9/11	4	SW	43,009	-	17,534	249	242	175	175	7	181	93	101%	8,713
28-32	7/4–8/7	3	NE	205,643	-	72,468	925	910	723	723	25	741	315	83%	99,038
35-38	8/22–9/18	4	NE	135,765	-	52,283	1,735	1,720	1,501	1,497	7	189	97	101%	9,442
27-33	6/27–8/14	3	NW	128,318	-	45,686	1,147	1,138	945	944	73	2,124	847	78%	717,288
34-39	8/15–9/25	4	NW	516,263	-	146,026	3,164	3,127	2,576	2,573	41	1,508	618	80%	381,721
		Subtotal troll fishery		1,458,341	-	520,686	10,236	10,120	8,165	8,155	200	5,908	1,151	38%	1,324,891

SEINE FISHERY

Stat. week	Date	District	N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
34	8/15–8/21	101	3,984	0	147	4	4	3	3	1	278	278	196%	77,223
35	8/22–8/28	102	6,542	0	482	11	11	10	10	2	279	211	148%	44,353
31,34	7/25–8/21	109	12,370	0	2,081	29	29	22	22	4	244	146	117%	21,299
		Subtotal seine fishery	12,370	0	2,710	44	44	35	35	7	801	378	92%	142,875

SPORT FISHERY

Biweek	Date	Sample area	N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
13-14	6/21–7/18	Craig	56,074	-	12,237	90	90	77	77	2	94	71	147%	5,002
17-19	8/16–9/26	Ketchikan	20,719	5,453,062	9,120	291	283	247	247	11	264	127	94%	16,141
15-16	7/19–8/15	Sitka	73,757	55,367,611	19,977	514	498	455	454	6	235	127	106%	16,244
		Subtotal sport fishery	150,550	60,820,673	41,334	895	871	779	778	19	593	325	107%	37,387

GILLNET FISHERY

Stat. week	Date	District	N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
35	8/22–8/28	101	5,080	-	2,181	46	45	38	38	1	24	24	193%	577
38	9/12–9/18	101	11,056	-	5,205	216	212	172	172	2	44	33	146%	1,096
39	9/19–9/25	101	16,038	-	6,185	218	216	183	182	3	81	53	127%	2,769
40	9/26–10/2	101	7,714	-	4,209	148	148	113	113	2	38	28	146%	781
41	10/3–10/9	101	4,370	-	2,624	99	99	83	83	1	17	17	191%	278
29	7/11–7/17	106	5,616	-	2,594	111	110	101	101	1	22	22	192%	484
31	7/25–7/31	106	12,674	-	4,758	105	105	96	96	1	27	27	193%	725
32	8/1–8/7	106	7,659	-	3,913	78	78	63	63	1	20	20	192%	387
33	8/8–8/14	106	11,511	-	4,493	47	46	38	38	3	81	52	127%	2,739
34	8/15–8/21	106	13,531	-	7,651	98	98	79	79	11	200	94	92%	8,815
35	8/22–8/28	106	10,749	-	3,839	49	48	42	42	4	117	70	117%	4,873
36	8/29–9/4	106	19,200	-	9,256	177	177	156	156	12	256	119	91%	14,071
37	9/5–9/11	106	24,104	-	4,405	120	120	103	103	7	393	203	101%	41,350
38	9/12–9/18	106	34,655	-	10,982	408	403	343	343	22	722	311	84%	96,489
39	9/19–9/25	106	18,529	-	5,273	190	189	162	161	7	256	132	101%	17,371
40	9/26–10/2	106	9,596	-	4,019	172	172	144	143	5	123	69	109%	4,743
41	10/3–10/9	106	9,852	-	5,459	193	193	165	165	3	56	36	126%	1,287
42	10/10–10/16	106	3,925	-	1,909	69	69	59	59	2	42	31	146%	987
		Subtotal gillnet fishery	225,859	-	88,955	2,544	2,528	2,140	2,137	88	2,520	1,340	104%	199,823
TOTAL			1,847,120	60,820,673	653,685	13,719	13,563	11,119	11,105	314	9,822	1,306	26%	1,704,977

commercial troll fishery accounted for 60% of the recoveries, followed by the drift gillnet (26%), purse seine (8%) and sport (6%) fisheries (Table 6). Southeast Alaska is divided into four primary quadrants (Figure 3 in Jones et al. 1999). Of the 200 CWTs recovered in the commercial troll fishery, 57%, 19%, 16% and 9% were from the Northwest, Southeast, Northeast and Southwest quadrants, respectively. In the commercial drift gillnet fishery all 88 CWTs recovered were taken in the Southeast quadrant, in District 106 (79) and District 101 (9). Of 19 CWTs recovered in the marine sport fishery near three Southeast communities, 11 were from the Ketchikan area, 6 from the Sitka area and 2 from the Craig area. Of seven CWTs recovered in the commercial purse seine fishery, four were from the Northeast and three from the Southeast quadrants.

Table 6.–Estimated marine harvest of Naha River coho salmon, 1999.

Fishery	Area	Estimated harvest	SE	Percent of marine harvest
Troll	SE Quadrant	901	392	9.2
	SW Quadrant	445	220	4.5
	NE Quadrant	929	412	9.5
	NW Quadrant	3,632	1,465	37.0
	Subtotal	5,908	1,151	60.1
Seine	District 101	278	278	2.8
	District 102	279	211	2.8
	District 109	244	146	2.5
	Subtotal	801	378	8.2
Sport	Craig	94	71	1.0
	Ketchikan	264	127	2.7
	Sitka	235	127	2.4
	Subtotal	593	193	6.0
Gillnet	District 101	205	74	2.1
	District 106	2,315	441	23.6
	Subtotal	2,520	447	25.7
Total marine harvest		9,822	1,306	100.0

Harvest of coho salmon originating from the Naha River in the marine commercial and sport fisheries of Southeast Alaska in 1999 was estimated at 9,822 (SE = 1,306) fish (Table 5; Appendix A7). Harvests occurred throughout Southeast Alaska; the largest estimated harvests were in the Southeast (43%) and Northwest (39%) quadrants, followed by the Northeast (12%) and Southwest (6%) quadrants (Table 6). Recoveries of Naha River origin fish in marine fisheries occurred from late June through mid-October, with the highest number of recoveries in August and September (Appendix A7).

2000

In 2000, CWTs from 136 coho salmon tagged in the Naha River in 1999 were recovered in Southeast Alaska fisheries; 130 were random recoveries (Table 7; Appendix A8). No Naha River tags were reported in the British Columbia fisheries. In all, 1.8% of the valid tags released in 1998 were randomly recovered in the sampled fisheries. The commercial troll fishery accounted for 77% of the estimated harvest, followed by the drift gillnet (15%), sport (6%) and purse seine (2%) fisheries (Table 8). Of 105 CWTs recovered in the commercial troll fishery, 55%, 23%, 22% and 5% were from the Northwest, Southeast, Southwest and Northeast quadrants, respectively. In the commercial drift gillnet fishery all 17 CWTs recovered were taken in the Southeast quadrant, in District 106 (16) and District 101 (1). Of 7 CWTs recovered in the marine sport fishery, 4 were from the Ketchikan area, 2 from the Sitka area and 1 from the Craig area. The single CWT recovered in the commercial purse seine fishery was from the Southwest quadrant, in District 104.

The harvest of coho salmon originating from the Naha River in the marine commercial and sport fisheries of Southeast Alaska in 2000 was estimated at 5,501 (SE = 727) fish (Table 7; Appendix A8). The estimated harvest, in descending order by quadrant, occurred in the Northwest (54%), Southeast (29%), Southwest (12%) and Northeast (5%) quadrants (Table 8). Recoveries of known Naha River bound fish in the marine fisheries occurred from early July through late September, with the highest number of recoveries in July and August (Appendix A8).

Table 7.–Estimated marine harvest statistics of coho salmon bound for the Naha River, 2000.

TROLL FISHERY															
Stat. week	Date	Period	Quadrant	N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
36-38	8/27-9/16	5,6	SE	21,742	-	13,020	394	388	353	352	13	360	129	70%	16,641
30-33	7/16-8/12	3,4	SE	61,397	-	42,635	753	740	595	595	10	238	92	76%	8,471
27-34	6/25-8/19	3,4	SW	129,204	-	98,355	1,818	1,798	1,450	1,449	22	476	150	62%	22,554
33	8/6-8/12	4	NE	18,021	-	6,329	101	98	78	78	1	48	47	194%	2,235
29-32	7/9-8/5	3	NE	64,721	-	21,282	310	302	242	242	4	203	109	105%	11,951
35-36	8/20-9/2	5	NW	135,765	-	52,283	1,735	1,720	1,501	1,497	12	513	189	72%	35,614
33	8/6-8/12	4	NW	128,318	-	45,686	1,147	1,138	945	944	10	461	179	76%	32,087
28-32	7/2-8/5	3	NW	516,263	-	146,026	3,164	3,127	2,576	2,573	33	1,923	567	58%	321,183
		Subtotal troll fishery		1,075,431	-	425,616	9,422	9,311	7,740	7,730	105	4,222	671	31%	450,736
SEINE FISHERY															
Stat. week	Date	District		N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
33	8/6-8/12	104		12,370	0	2,081	29	29	22	22	1	97	96	195%	9,266
		Subtotal seine fishery		12,370	0	2,081	29	29	22	22	1	97	96	195%	9,266
SPORT FISHERY															
Biweek	Date	Sample area		N	v(N)	n	a	a'	t	t'	mc	r	SE(r)	RP(r)	var(r)
14	6/25-7/8	Craig		34,782	-	6,773	135	130	118	118	1	87	86	195%	7,449
17-18	8/14-9/10	Ketchikan		14,778	5,361,466	5,986	201	197	180	180	4	164	91	108%	8,221
16,18	7/31-9/10	Sitka		38,247	16,502,779	12,001	311	308	279	279	2	105	76	142%	5,768
		Subtotal sport fishery		87,807	21,864,245	24,760	647	635	577	577	7	355	253	139%	21,438
GILLNET FISHERY															
Stat. week	Date	District		N	v(N)	n	a	a'	t	t'	mc	r^	SE(r)	RP(r)	var(r)
30	7/16-7/22	106		10,308	-	4,129	137	134	112	111	1	42	41	194%	1,717
31	7/23-7/29	106		7,453	-	3,460	56	55	43	43	1	36	35	193%	1,240
34	8/13-8/19	106		4,276	-	2,085	19	19	15	15	1	33	33	193%	1,082
35	8/20-8/26	106		8,206	-	2,420	47	47	41	41	3	166	100	119%	10,053
36	8/27-9/2	106		6,327	-	2,609	63	63	61	61	4	158	85	105%	7,179
37	9/3-9/9	106		8,401	-	2,383	62	61	60	60	1	58	58	194%	3,345
38	9/10-9/16	106		9,740	-	2,471	74	74	67	67	4	257	138	106%	19,119
39	9/17-9/23	106		5,727	-	1,859	77	77	72	72	1	50	50	194%	2,466
32	7/30-8/5	101		190	-	112	2	2	2	2	1	28	27	193%	736
		Subtotal gillnet fishery		60,628	-	21,528	537	532	473	472	17	827	567	134%	46,937
TOTAL				1,236,236	21,864,245	473,985	10,635	10,507	8,812	8,801	130	5,501	727	26%	528,377

Table 8.–Estimated marine harvest of Naha River coho salmon, 2000.

Fishery	Area	Estimated harvest	SE	Percent of marine harvest
Troll	SE Quadrant	598	221	10.9
	SW Quadrant	476	150	8.6
	NE Quadrant	251	157	4.6
	NW Quadrant	2,897	935	52.7
	Subtotal	4,222	671	76.7
Seine	District 104	97	96	1.8
	Subtotal	97	96	1.8
Sport	Craig	87	86	1.6
	Ketchikan	164	91	3.0
	Sitka	105	76	1.9
	Subtotal	355	146	6.5
Gillnet	District 101	28	27	0.5
	District 106	799	215	14.5
	Subtotal	827	217	15.0
Total marine harvest		5,501	727	100.0

DATA FILES

Data collected during this study have been archived in data files (Appendix A11) kept in ADF&G offices in Ketchikan, Douglas and Anchorage.

DISCUSSION

The assumptions needed to satisfy the mark-recapture experiment were mostly met in this study. Two gear types were used to capture smolt, a screw trap and minnow traps. The average length of fish caught in minnow traps was smaller than fish caught in the screw trap each year. Despite size differences among trap types in event one, sampling effort for adults in the second event was relatively constant over time, presumably equalizing probability of capture during the second event. Trapping occurred largely in the lower 2 km of the mainstem, away from direct influence from tributaries. Migratory timing during April and May, and silvery coloration of most juvenile coho ≥70 mm, especially in the screw trap, support the contention that they were essentially all smolt. This is further substantiated through examination of all tag recoveries in the marine commercial and sport fisheries and inriver escapement sampling in 1999 and 2000. Collectively, only one of 492 total tags recovered in 1999 and 2000 was from a fish that did not emigrate in the year tagged. That fish was originally tagged in 1998 and sampled in the troll fishery in July 2000. No Naha River tags were recovered in sampling of fisheries in 2001. Thus, the established 70 mm minimum length for tagging on the Naha River was validated by this study.

The marked fractions of fish captured inriver in the first half (20 September to 12 October) and second half (13 October to 4 November) of escapement sampling each year were not significantly different. This suggests that marked and unmarked fish mixed completely between sampling events, and that assumption (a) was met. It is unlikely that a substantial number of adult coho salmon sampled were not of Naha River origin because fidelity of adult coho to natal streams is high (assumption (b); Labelle 1992). It is unlikely that marking affected the catchability of fish (assumption c) because different gears were used to capture fish in the two events. Previous studies have shown that marked coho smolt do not have significantly higher mortality than unmarked fish (Elliott and Sterritt 1990; Vincent-Lang 1993). Care was taken in the first event to double-check adipose finclips. Because secondary marks on fish were not lost, assumption (d) was satisfied. Personnel were diligent in carefully examining each fish for marks to ensure satisfaction of assumption (e). All fish captured in each event were carefully marked and checked for marks such that double sampling did not transpire (assumption f). Tag loss between sampling events was not a problem in the mark-recapture study, because fish did not lose their adipose finclips.

Though not measured directly, exploitation of Naha River coho salmon seemed high in 1999. That year, 2.5% of the Naha River fish released with valid tags were recovered during random sampling of the marine fisheries. By comparison, 1.4% of the valid Unuk River coho tags were recovered in 1999, when the exploitation rate was estimated at 53% (SE = 10.0%)

(Jones et al. 2001). The Unuk River is a larger, glacial stream located 64 km northeast of the Naha River. Estimation of the marine exploitation and survival rates was beyond the scope of this study because escapement to the Naha River is unknown and would be costly to determine.

A sharp decline occurred in random tag recoveries in the marine fisheries, from 314 in 1999 to 130 (1.7% of valid tag releases) in 2000. Declines were noted in all the common property fisheries, but were most pronounced in the commercial net fisheries (Table 5, 7). The marine sport fishing effort was somewhat higher in 1999 in the Ketchikan and Sitka fisheries, and coho harvests were substantially higher in 1999 than in 2000 (Hubartt et al. 2001). Fishing time and coho salmon harvests were reduced in the District 106 gillnet fishery in 2000. Reductions in fishing time and harvests occurred in the southern Southeast purse seine fishery in 2000 because of low pink salmon returns following a year of high returns in 1999 (T. Zadina, ADF&G, personal communication).

Smolt emigration timing occurred about a week later in 1999 than in 1998. Much heavier snow pack in 1999 resulted in consistently higher stream flows and water temperatures several degrees cooler than in 1998 (Appendix A1, A3). The screw trap fished more efficiently in 1999 than in 2000 because stream flows were lower and contained inside an adjacent gravel bar, thereby directing more emigrating fish into the structure.

CONCLUSIONS AND RECOMMENDATIONS

The Naha River is a proven, relatively cost-effective location to conduct fish population studies. The importance of this river to the Ketchikan area sport fishery is well documented. A developed boat dock and trail system facilitates access to and along the river. Its smaller size and proximity to Ketchikan and the southern Southeast inside waters supports its consideration as a stream to track. Two personnel are generally enough to staff field operations, and specifics learned during this study should be incorporated to maximize efficiency. The rotary screw trap proved effective at capturing smolt during low to normal stream flows. A drawback of this stream is the typically tannin-stained water that limits visibility when conducting stream surveys. Typically abundant pink salmon returns to the river also limit our ability to use net gear to target coho salmon in the lower river during immigration. For these reasons, I recommend that ADF&G returns to monitor the coho salmon smolt production every four to six years, in two-year study intervals (i.e., spring smolt then fall escapement work the following year).

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APPENDIX A

Appendix A1.–Number and size, by gear type, of coho salmon smolt caught and coded-wire tagged on the Naha River, 1998.

	Screw trap			Minnow traps			Water conditions		
Date	Number caught	Average length (mm)	Average weight (g)	Number caught	Fish per trap	Average length	Temp. (°C)	Depth (cm)	Screw trap RPM
3-Apr	1			18	1.4				
4-Apr	1			8	1.0		6.0	29	2.75
5-Apr	3			10	0.4	73	7.0	25	2.25
6-Apr	0			7	0.2		6.5	26	2.75
7-Apr	4			4	0.1		6.0	30	3.50
8-Apr	2			4	0.1	79	6.0	30	3.00
9-Apr	1	107	15	3	0.1		6.0	28	3.00
10-Apr	5			6	0.2		7.0	25	3.00
11-Apr	1			87	2.2	94	6.0	24	2.50
12-Apr	0						8.0	23	2.10
13-Apr	0			12	1.2	88	8.0	20	1.75
14-Apr	4			83	2.1		6.0	21	1.75
15-Apr	0			35	0.9	86	7.0	18	1.75
16-Apr	5	119	18	67	1.7		8.0	17	1.75
17-Apr	5			49	1.2		8.0	26	3.25
18-Apr	0			30	0.8	86	7.5		4.50
19-Apr	51	110	14				6.0	94	5.00
20-Apr	44	115	17				7.0	74	5.00
21-Apr	43	107	13	55	1.4		7.0	59	5.00
22-Apr	89	100	10	76	1.9		7.0	47	4.00
23-Apr	91	119	15	51	1.3	85	8.0	38	4.25
24-Apr	53	111	13	39	1.0	86	8.0	37	3.50
25-Apr	132	103	12	70	1.8	110	8.0	36	3.25
26-Apr	66						8.0	71	4.00
27-Apr	83	104	13				8.0	66	
28-Apr	85	109	13	225	5.8		8.0	72	
29-Apr	76	114	16	134	3.4	89	8.0	69	3.25
30-Apr	140	96	10	138	3.5	98	8.0	53	3.25
1-May	222	114	14	30	7.5		10.0	41	4.00
2-May	221	111	13	30	6.0		10.0	37	4.25
3-May	166	117	15				10.0	34	4.00
4-May	389	119	15				11.0	33	4.00
5-May	379	112	13	320	10.0		12.0	32	3.75
6-May	204	109	12	394	8.0	107	11.0	33	4.00
7-May	936	111	13	290	11.2		12.0	33	4.00
8-May	880	109		239	9.2	106	12.0	30	4.00
9-May	1677	109		125	10.4	102	12.0	28	3.75
10-May	938	109					12.0	33	3.00
11-May	1058	101	10				12.0	25	2.75
12-May	275	103	10	44	2.2	99	12.5	22	2.25
13-May	285	101	10	49	1.6		12.5	22	2.25
14-May	227			7	0.4		13.0	23	2.25
15-May	292	101	10	8	0.4		14.0	20	2.00
16-May	214	101	10	7	0.4		14.0	20	2.00
17-May	0						15.0	19	2.00
19-May	100	96	8	3	0.2		15.5	19	2.00
20-May	72	94	8	2	0.1		15.0	19	2.00
21-May	69	90	7	1	0.1		15.0	19	2.00
22-May	97						11.5	57	5.00
23-May	47	100	10				13.0	42	4.50
24-May	22						14.0	48	4.25

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Date	Screw trap			Minnow traps			Water conditions		
	Number caught	Average length (mm)	Average weight (g)	Number caught	Fish per trap	Average length	Temp. (^{o}C)	Depth (cm)	Screw trap RPM
18-May	229	91	7				15.0	19	2.00
25-May	13						13.0	51	3.75
26-May	4						14.0	25	2.00
27-May	0								
28-May	3						15.0	21	
Totals	10,004			2,760					
Max.	1,677	119	18	394	11.2	110	15.5	94	5.00
Min.	0	90	7	0	0	73	6.0	17	1.75
Average	179	106	11	66		96	10.0	35	3.17
SD		13	5			14			

Appendix A2.–Daily smolt catches and water data at a screw trap operated on the lower Naha River, spring 1998.

	Coho		Steelhead		Sockeye		Cutthroat		Pink (est.)		Chum (est.)		
Date	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Comments
3-Apr	1	1							7,000	7,000			screw trap put in water
4-Apr	1	2	1	1					8,000	15,000			water slightly above normal
5-Apr	3	5	1	2					18,000	33,000			1 hooligan and 1 steelhead
6-Apr		5	1	3					12,000	45,000			day off - water just below lawn
7-Apr	4	9		3					15,000	60,000			water level with bank
8-Apr	2	11	1	4					18,000	78,000			stream gage installed; high water
9-Apr	1	12		4					25,000	103,000			1 fall male adult SH in screw trap
10-Apr	5	17		4					30,000	133,000	100	100	
11-Apr	1	18		4					25,000	158,000	100	200	
12-Apr		18		4					20,000	178,000		200	
13-Apr		18		4	1	1			2,000	180,000		200	
14-Apr	4	22		4	0	1			20,000	200,000	50	250	3 lampreys
15-Apr		22	1	5	0	1			27,000	227,000	30	280	
16-Apr	5	27		5	3	4			30,000	257,000	50	330	
17-Apr	5	32		5	11	15			25,000	282,000	40	370	
18-Apr		32		5	1	16				282,000		370	
19-Apr	51	83	1	6	47	63			20	282,020	4	374	
20-Apr	44	127	4	10	48	111			15	282,035	15	389	
21-Apr	43	170	2	12	46	157			10	282,045	5	394	
22-Apr	89	259	1	13	147	304				282,045		394	
23-Apr	91	350	2	15	198	502				282,045	12	406	
24-Apr	53	403	1	16	153	655			5	282,050	5	411	
25-Apr	132	535	2	18	786	1441				282,050		411	
26-Apr	66	601		18	235	1676			30	282,080	5	416	
27-Apr	83	684		18	376	2052			5	282,080	10	426	
28-Apr	85	769		18	511	2563				282,080	5	431	2 DV
29-Apr	76	845	1	19	421	2984				282,080		431	3 DV
30-Apr	140	985		19	735	3719				282,080		431	1 DV
1-May	222	1207	3	22	1139	4858				282,080	2	433	2 DV
2-May	221	1428	3	25	1035	5893	1	1	1	282,081	1	434	High tides affect water level
3-May	166	1594		25	1130	7023		1		282,081		434	High tides affect water level
4-May	389	1983	2	27	1245	8268		1		282,081		434	High tides; 5 DV and 2 RB
5-May	379	2362	1	28	1660	9928		1		282,081		434	High tides; 1 adult SH
6-May	204	2566		28	500	10428		1		282,081		434	tidal influence
7-May	936	3502		28	850	11278	1	2		282,081		434	tidal influence
8-May	880	4382	2	30	1010	12288		2		282,081		434	Rain, water hi; 2 adult SH
9-May	1677	6059	3	33	1420	13708		2		282,081		434	water covering bar
10-May	938	6997		33	670	14378		2		282,081		434	very high water (on grass)
11-May	1058	8055	2	35	680	15058		2		282,081	2	436	39 recaps
12-May	275	8330		35	260	15318		2		282,081		436	5 recaps
13-May	285	8615	3	38	170	15488		2		282,081		436	15 recaps
14-May	227	8842	2	40	70	15558		2		282,081		436	10 recaps
15-May	292	9134	10	50	150	15708		2		282,081		436	10 recaps + 1 flounder

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	Coho		Steelhead		Sockeye		Cutthroat		Pink (est.)		Chum (est.)		
Date	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Comments
16-May	214	9348	5	55	140	15848		2		282,081		436	9 recaps
17-May		9348	4	59	20	15868		2		282,081		436	1 flounder
18-May	229	9577	24	83	180	16048	1	3		282,081		436	20 rec. + 6 DV + 4 small coho
19-May	100	9677	14	97	90	16138		3		282,081		436	4 rec. + 2 DV + 1 small coho
20-May	72	9749	11	108	60	16198		3		282,081		436	1 recap + 2 DV
21-May	69	9818	12	120	50	16248		3		282,081		436	3 recaps
22-May	97	9915	41	161	40	16288		3		282,081		436	3 rec. + 2 DV + 1 flounder
23-May	47	9962	11	172	50	16338		3		282,081		436	
24-May	22	9984	7	179	10	16348		3		282,081		436	1 flounder
25-May	13	9997	7	186	13	13361	1	4		282,081		436	tide slowed screw trap @ night
26-May	4	10001	3	189	2	16363		4		282,081		436	tide slowed screw trap @ night
27-May		10001	6	195	10	16373		4		282,081		436	tide slowed screw trap @ night
28-May	3	10004	2	197	4	16377		4		282,081		436	

Appendix A3.–Number and size, by gear type, of coho salmon smolt caught and coded-wire tagged on the Naha River, 1999.

	Screw trap			Minnow traps			Water conditions		
Date	Number caught	Average length (mm)	Average weight (g)	Number caught	Fish per trap	Average length	Temp. (°C)	Depth (cm)	Screw trap RPM
15-Apr	0						3.0		
16-Apr	0			0	0.0		3.0	51	3.00
17-Apr	3			4	0.2		2.5	64	3.00
18-Apr	0						5.0	91	3.50
19-Apr	3			1	0.1		3.5	86	2.75
20-Apr	1			3	0.3		3.0	74	3.00
21-Apr	4			48	3.0	83	3.0	69	4.50
22-Apr	6			29	1.5	87	3.0	53	4.25
23-Apr	0			29	1.5	80	3.0	58	6.00
24-Apr	1			23	1.2	99	3.5	71	6.00
25-Apr	2						4.0	77	4.00
26-Apr	3	95	8				4.0	61	4.50
27-Apr	7			19	1.0		4.0	48	5.00
28-Apr	9			26	1.4		4.0	42	4.00
29-Apr	3			23	1.2	81	4.0	39	4.00
30-Apr	1			9	0.5		4.0	42	4.50
1-May	2			19	1.0		4.0	51	4.00
2-May	0						3.5	71	4.50
3-May	5						4.0	56	4.00
4-May	5			11	0.6	80	4.0	46	4.00
5-May	9			9	0.5	75	4.0	38	4.00
6-May	17	93	7	10	0.5	82	4.0	76	5.25
7-May	32			11	0.5		4.5	58	5.00
8-May	36	108	12	25	1.0		5.0	44	5.00
9-May	54						5.0	36	4.00
10-May	55	102	11	29	1.3	83	5.0	36	4.00
11-May	98	107	12	38	1.3		6.0	35	4.00
12-May	206	108	12	86	1.8	86	5.0	44	4.00
13-May	357	110	12	87	2.6		6.0	46	4.00
14-May	422	117	15	122	3.1	100	5.5	46	3.00
15-May	484	108	12	353	3.6	102	6.0	61	varied 0-4.5
16-May	661			274	4.0		6.0	152	varied 0-4
17-May	647	110	12	310	4.6		6.5	76	varied 0-4
18-May	338	114	14	129	1.8	100	7.0	71	varied 0-4
19-May	360	110	12	75	2.0	102	7.0	61	varied
20-May	669	112	14	51	1.4		6.0	80	6.00
21-May	341	116	14	14	0.6		6.5	83	5.00
22-May	225	110		5	0.3		6.0	99	4.25
23-May								152	
24-May								152	
25-May	16						6.0	152	3.00
26-May	20			0	0.0		5.3	104	4.00
27-May	23			0	0.0		5.0	91	4.00
28-May	31	104	11	1	0.1		6.0	76	5.00
29-May	53			0	0.0		6.0	52	5.00
30-May	0						6.5	52	5.00
31-May	35			1	0.1		6.0	64	5.00

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Appendix A3.–Page 2 of 2.

Date	Screw trap			Minnow traps			Water conditions		
	Number caught	Average length (mm)	Average weight (g)	Number caught	Fish per trap	Average length	Temp. (^{o}C)	Depth (cm)	Screw trap RPM
1-Jun	23	116	16	0	0.0		7.0	51	5.00
2-Jun	21			0	0.0		7.0	44	5.00
3-Jun	13	101	10	0	0.0		7.0	52	5.75
4-Jun	21	95	8	0	0.0		7.0	44	5.50
5-Jun	15			0	0.0		7.0	62	5.25
6-Jun				0	0.0		8.0	51	5.00
Totals	5,337			1,874					
Max.	669	117	16	353	4.6	102	8.0	152	6.00
Min.	0	93	7	0	0.0	75	2.5	35	2.75
Average	107			45	1.1		5.0	67	4.41
SD		13	5			14			

Appendix A4.–Daily smolt capture data in a screw trap operated on the lower Naha River, spring 1999.

	Coho		Steelhead		Sockeye		Cutthroat		Pink (est.)		Chum (est.)		
Date	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Comments
4/15/99									15,000	15,000	200	200	screw trap put in water
4/16/99									10,000	25,000	2,000	2,200	water slightly above normal
4/17/99	3	3							500	25,500	100	2,300	1 hooligan and 1 steelhead
4/18/99		3							300	25,800	75	2,375	day off - water just bellow lawn
4/19/99	3	6							400	26,200	400	2,775	water level with bank
4/20/99	1	7							300	26,500	100	2,875	stream gage installed; "high" water
4/21/99	4	11							10,000	36,500	1,000	3,875	1 fall m adult SH in screw trap
4/22/99	6	17			1	1			5,000	41,500	2,000	5,875	
4/23/99		17			1	2			1,000	42,500	500	6,375	
4/24/99	1	18				2			5,000	47,500	2,000	8,375	
4/25/99	2	20							5,000	52,500	700	9,075	
4/26/99	3	23			3	5			1,000	53,500	500	9,575	3 lampreys
4/27/99	7	30			4	9			4,000	57,500	1,000	10,575	
4/28/99	9	39	1	1		9			12,000	69,500	4,000	14,575	
4/29/99	3	42		1	3	12	2	2	6,000	75,500	3,000	17,575	
4/30/99	1	43		1	1	13		2	10,000	85,500	5,000	22,575	
5/1/99	2	45		1	1	14		2	5,000	90,500	4,000	26,575	
5/2/99		45		1	5	19		2	1,000	91,500	500	27,075	
5/3/99	5	50		1	30	49	2	4	2,000	93,500	500	27,575	
5/4/99	5	55		1	30	79		4	1,000	94,500	250	27,825	
5/5/99	9	64		1	51	130	1	5	500	95,000	100	27,925	
5/6/99	17	81		1	40	170		5	300	95,300	100	28,025	
5/7/99	32	113		1	65	235		5	150	95,450	75	28,100	
5/8/99	36	149		1	55	290		5	200	95,650	60	28,160	
5/9/99	54	203		1	50	340		5	100	95,750	50	28,210	
5/10/99	55	258		1	90	430		5	50	95,800	5	28,215	2 DV
5/11/99	98	356		1	290	720		5	250	96,050	56	28,271	3 DV
5/12/99	206	562	1	2	175	895		5	150	96,200	30	28,301	1 DV
5/13/99	357	919	1	3	860	1755	1	6	75	96,275	20	28,321	2 DV
5/14/99	422	1341		3	750	2505		6		96,275		28,321	High tides affected water level
5/15/99	484	1825		3	650	3155		6		96,275		28,321	High tides affected water level
5/16/99	661	2486		3	860	4015		6	10	96,285	3	28,324	High tides; 5 DV + 2 RB
5/17/99	647	3133	1	4	500	4515		6		96,285		28,324	High tides; 1 adult steelhead
5/18/99	338	3471	1	5	420	4935		6		96,285		28,324	tidal influence
5/19/99	360	3831	1	6	520	5455		6		96,285		28,324	tidal influence
5/20/99	669	4500	8	14	310	5765		6		96,285		28,324	Rain, water high; 2 adult SH
5/21/99	341	4841	2	16	210	5975		6		96,285		28,324	water covering bar
5/22/99	225	5066	2	18	220	6195		6		96,285		28,324	very high water (on grass)

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Appendix A4.–Page 2 of 2.

Date	Coho		Steelhead		Sockeye		Cutthroat		Pink (est.)		Chum (est.)		Comments
	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	Daily	Cumul.	
5/23/99		5066		18		6195		6		96,285		28,324	very high water (to boardwalk)
5/24/99		5066		18		6195		6		96,285		28,324	flooding-screw trap not fishing
5/25/99	16	5082		19	18	3213		6		96,285		28,324	river dropping fast
5/26/99	20	5102	1	20	25	6238		6		96,285		28,324	river about even with bank
5/27/99	23	5125	4	24	55	6293		6		96,285		28,324	River rose 1", dropped
5/28/99	31	5156	4	28	45	6338		6	5	96,290	5	28,329	1 rainbow; water below bank
5/29/99	53	5209	1	29	395	6733		6		96,290		28,329	1 RB, 1 DV; water dropped
5/30/99		5209		29	75	6808		6	20	96,310		28,329	day off; rained constantly
5/31/99	35	5244	7	36	200	7008		6	10	96,320	3	28,332	catches from a 2-day period
6/1/99	23	5267	1	37	360	7368		6		96,320		28,332	1 DV
6/2/99	21	5288	2	39	210	7578		6	5	96,325		28,332	3 DV, one adult steelhead
6/3/99	13	5301	14	53	140	7718		6	5	96,330		28,332	few coho fry
6/4/99	21	5322	6	59	95	7813		6	5	96,335		28,332	Few pinks, few coho fry
6/5/99	15	5337	14	73	50	7863		6		96,335		28,332	mink in screw trap got fish
6/6/99		5337		73	45	7908		6		96,335		28,332	pulled screw trap

Appendix A5.–Numbers of coho salmon examined for adipose clips, and CWTs recovered in the Naha River, 1999.

Date	Number of fish examined	Number of clips	Valid tags	Head number	Tag code
21-Sep-99	11	1	1	21851	45004
22-Sep-99	1				
23-Sep-99	5				
24-Sep-99	2	1	1	21852	45004
27-Sep-99	7				
28-Sep-99	8				
29-Sep-99	4				
30-Sep-99	2				
1-Oct-99	6	1	1	21853	45004
4-Oct-99	3				
5-Oct-99	8				
6-Oct-99	11				
7-Oct-99	3				
8-Oct-99	2	1	1	21854	45004
13-Oct-99	16	3	1	21855	45004
			1	21856	45004
			1	21857	45004
14-Oct-99	44	2	1	21858	45004
			1	21859	45004
15-Oct-99	16	3		21860	NOT VALID
			1	21861	44645
			1	21862	45004
19-Oct-99	8	1	1	21863	45004
20-Oct-99	13	3	1	21864	45004
			1	21865	45004
			1	21866	44645
21-Oct-99	1				
27-Oct-99	29	5	1	21867	45004
				21868	NOT VALID
			1	21869	45004
			1	21870	45004
			1	21871	45004
28-Oct-99	26	3	1	21872	45004
			1	21873	45004
			1	21874	45004
29-Oct-99	8	1	1	21875	45004
4-Nov-99	26	2	1	21876	44645
			1	21877	44645
5-Nov-99	7	1	1	21878	45004
Totals	267	28	26		

Appendix A6.–Numbers of coho salmon examined for adipose clips, and CWTs recovered in the Naha River, 2000.

Date	Number of fish examined	Number of clips	Valid tags	Head number	Tag code
19-Sep-00	9				
20-Sep-00	9				
21-Sep-00	7				
25-Sep-00	2				
26-Sep-00	9	1	1	166401	44729
27-Sep-00	20	3	1	166402	44728
			1	166403	44728
			1	166404	44728
28-Sep-00	17	2	1	166405	44729
				166406	NOT VALID
29-Sep-00	8				
3-Oct-00	5				
4-Oct-00	32	3	1	166407	44729
			1	166408	44729
				166409	NOT VALID
5-Oct-00	22				
6-Oct-00	5				
7-Oct-00	8				
9-Oct-00	4	1	1	166410	44728
10-Oct-00	22				
11-Oct-00	12	1	1	166411	44728
		1	1	166412	44728
12-Oct-00	5				
16-Oct-00	7	1	1	166413	44729
17-Oct-00	13	1	1	166414	44728
18-Oct-00	21				
		1	1	166416	44728
19-Oct-00	15	1	1	166417	44728
		1	1	166418	44728
20-Oct-00	3				
21-Oct-00	1				
22-Oct-00	1				
23-Oct-00	13	1	1	166419	44728
24-Oct-00	22	1	1	166420	44729
25-Oct-00	15				
26-Oct-00	18	1	1	166421	44728
		1	1	166422	44729
27-Oct-00	5				
31-Oct-00	9				
1-Nov-00	9				
2-Nov-00	7	1	1	166423	44729
		1	1	166424	44728
		1	1	166425	44728
3-Nov-00	3				
Totals	358	24	22		

Appendix A7.–Estimated harvests of coho salmon bound for the Naha River in marine commercial and sport fisheries by statistical week, 1999.

Stat. week	Ending date (1999)	Troll tags	Harvest	Seine tags	Harvest	Sport tags	Harvest	Gillnet tags	Harvest	Total tags	Harvest	Estimated weekly prop. harvest	Estimated cumulative harvest	Estimated cum. prop. harvest
26	26-Jun					1	31			1	31	0.003	31	0.00
27	03-Jul	3	89							3	89	0.009	120	0.01
28	10-Jul	14	414							14	414	0.042	533	0.05
29	17-Jul	12	354			1	31	1	29	14	414	0.042	948	0.10
30	24-Jul	22	650			1	31			23	681	0.069	1629	0.17
31	31-Jul	25	738	1	114			1	29	27	882	0.090	2510	0.26
32	07-Aug	16	473			1	31	1	29	18	532	0.054	3043	0.31
33	14-Aug	28	827			4	125	3	86	35	1,038	0.106	4081	0.42
34	21-Aug	5	148	4	458	1	31	11	315	21	952	0.097	5033	0.51
35	28-Aug	30	886	2	229	1	31	5	143	38	1,290	0.131	6322	0.64
36	04-Sep	14	414			3	94	12	344	29	851	0.087	7173	0.73
37	11-Sep	13	384			2	62	7	200	22	647	0.066	7820	0.80
38	18-Sep	8	236			3	94	24	687	35	1,017	0.104	8837	0.90
39	25-Sep	6	177			1	31	10	286	17	495	0.050	9332	0.95
40	02-Oct	4	118					7	200	11	319	0.032	9651	0.98
41	09-Oct							4	115	4	115	0.012	9765	0.99
42	16-Oct							2	57	2	57	0.006	9822	1.00
Total		200	5,908	7	801	19	593	88	2,520	314	9,822	1.000		

Appendix A8.–Estimated harvests of coho salmon bound for the Naha River in marine commercial and sport fisheries by statistical week, 2000.

Stat. week	Ending date (2000)	Troll tags	Harvest	Seine tags	Harvest	Sport tags	Harvest	Gillnet tags	Harvest	Total tags	Harvest	Estimated weekly prop. harvest	Estimated cumulative harvest	Estimated cum. prop. harvest
27	01-Jul													
28	08-Jul	1	40							1	40	0.007	40	0.01
29	15-Jul	5	201			1	51			6	252	0.046	292	0.05
30	22-Jul	16	643					1	49	17	692	0.126	984	0.18
31	29-Jul	26	1,046					1	49	27	1,094	0.199	2,078	0.38
32	05-Aug	14	563					1	49	15	612	0.111	2,690	0.49
33	12-Aug	10	402	1	97	1	51			12	550	0.100	3,239	0.59
34	19-Aug	8	322			1	51	1	49	10	421	0.077	3,661	0.67
35	26-Aug	3	121					3	146	6	267	0.048	3,927	0.71
36	02-Sep	13	523			2	102	4	195	19	819	0.149	4,746	0.86
37	09-Sep	5	201			2	102	1	49	8	351	0.064	5,097	0.93
38	16-Sep	3	121					4	195	7	315	0.057	5,413	0.98
39	23-Sep	1	40					1	49	2	89	0.016	5,501	1.00
Total		105	4,222	1	97	7	355	17	827	130	5,501	1.000		

Appendix A9.–Lengths and weights of steelhead smolt captured in a screw trap operated on the lower Naha River, spring 1998 and 1999.

1998		1999	
Length (mm)	Weight (g)	Length (mm)	Weight (g)
184	61	163	41
154	34	160	37
170	51	163	41
211	94	235	120
249		220	96
187	63	250	146
207	87	200	75
172	46	220	118
167	46	180	53
158	32	223	110
249		220	88
143	26	223	102
186	54	175	49
198	60	193	69
180	47	188	58
218	95	148	30
131	18	157	36
185	53	187	57
150	31	206	83
163	38	159	36
167	39	180	46
190	57	203	79
226	105	155	35
157	33	180	46
143	26	183	54
180	50	183	55
202	70	170	44
143	26	169	41
200	70	198	67
191	67	216	75
188	50	180	52
173	39	200	76
210	89	153	31
180	47	195	63
199	72	225	100
153	35	192	60
168	46	152	30
160	39	173	46
164	36	199	70
135	20	238	121
149	26	157	34
171	40	168	40
175	48	201	74
179	51	177	48
279		216	91
195	64	208	82
169	38	150	29
163	34	220	99
182	54	212	77
166	39	176	49
176	45	151	31
163	35	188	66
172	44		
177	47		
188	56		

-continued-

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1998		1999	
Length (mm)	**Weight (g)**	**Length (mm)**	**Weight (g)**
167	43		
186	53		
165	35		
169	38		
167	39		
148	27		
156	29		
163	40		
170	44		
149	28		
135	20		
190	48		
130	18		
168	42		
165	41		
157	31		
143	23		
140	24		
160	32		
172	41		
185	43		
185	39		
165	33		
150	27		
170	40		
190	48		
192	52		
155	25		
168	32		
205			
145			
175			
150			
155			
165			
173			
180			
166	51		
146	27		
168	39		
198	66		
167	38		
160	37		
160	35		
155	33		
142	26		
177	48		
195	63		
189	59		
150	33		
148	29		
215	86		
172	46		
151	30		
136	21		

Appendix A10.–Detection of length-selectivity in sampling and its effects on estimation of length composition.

Results of Hypothesis Tests (K-S and χ^2) on Lengths of Fish MARKED during the First Event and RECAPTURED during the Second Event	Results of Hypothesis Tests (K-S) on Lengths of Fish CAPTURED during the First Event and CAPTURED during the Second Event
Case I:	
"Accept" H_o	"Accept" H_o
There is no length-selectivity during either sampling event.	
Case II:	
"Accept" H_o	Reject H_o
There is no length-selectivity during the second sampling event but there is during the first.	
Case III:	
Reject H_o	"Accept" H_o
There is length-selectivity during both sampling events.	
Case IV:	
Reject H_o	Reject H_o
There is length-selectivity during the second sampling event; the status of length-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, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for length bias to the pooled data (p. 17).

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, ages, and sexes from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for length bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been length-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 Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no length-selective sampling during the second event (Cases I or II).

Appendix A11.–Computer files used to estimate Naha River coho salmon smolt production in 1998-1999, and adult harvest in Southeast Alaska fisheries, 1999–2000.

File name	Description
Nahacosmolt98.xls	File containing daily smolt catch, CWT and water data, statistical tests for spring 1998 work.
Nahacosmolt99.xls	File containing daily smolt catch, CWT and water data, statistical tests for spring 1999 work.
Naha98-99.xls	File containing 1999 marine harvest data, various harvest and smolt data sets used in data calculations, Tables 3, 5 and 6, Appendices A1, A3 and A7.
Naha99-00.xls	File containing 2000 marine harvest data, various harvest and smolt data sets used in data calculations, Tables 7 and 8, Appendix A8.