Fishery Data Series No. 09-57

Production of Coho Salmon from the 2006 Smolt Emigration from Chuck Creek in Southeast Alaska

by

Steven J. McCurdy

November 2009

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

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

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

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The primary purpose of this study was to estimate smolt production, marine survival, exploitation rates, and escapements of coho salmon (*Oncorhynchus kisutch*) from the 2006 smolt emigration from the Chuck Creek watershed in Southeast Alaska. Additional objectives were to determine if smolt size and the date of smolt emigration influenced survival to maturity, and/or the date of return to freshwater (of jacks). Emigrating coho smolt were captured at a weir during the spring of 2006, tagged with a sequentially numbered coded wire tag (CWT), and marked by removing their adipose fin. Commercial and sport fisheries were sampled for coho salmon tagged with CWTs in 2007. Escapements were counted through a weir at Chuck Creek in 2006 and 2007 and coho salmon were examined for missing adipose fins and CWTs.

A total of 12,945 coho salmon smolt were tagged and released alive between April 16 and June 2, 2006. In 2007, 154 random recoveries of coho salmon bearing CWTs of Chuck Creek origin were recovered in sampled marine fisheries in Alaska and British Columbia, yielding an estimated marine harvest of 782 fish (SE = 61). A total of 572 jacks and 425 adults returned to Chuck Creek from the 2006 smolt emigration. An estimated 15,604 (SE = 218) coho salmon smolt emigrated from Chuck Creek in 2006. Marine survival to adult of the 2006 smolt emigration was estimated at 7.7% (SE = 0.4%) and the exploitation rate in marine fisheries was estimated at 64.8% (SE = 1.8%).

Key words: coho salmon, *Oncorhynchus kisutch*, Chuck Creek, Warm Chuck, Heceta Island, Southeast Alaska, mark-recapture, coded wire tag, recreational fishery, troll fishery, seine fishery, smolt production, marine survival, exploitation rate, escapement, weir, jack, age validation.

INTRODUCTION

Harvest of wild coho salmon (*Oncorhynchus kisutch*) in Southeast Alaska is important to numerous commercial, sport and subsistence users (Shaul et al. 2003; Halupka et al. 2000; Thedinga and Koski 1984). Wild coho salmon stocks are widely distributed in Southeast Alaska and are believed to be present in over 2,500 streams (Shaul et al. 2003). The Alaska Department of Fish and Game (ADF&G) maintains a stock assessment program in Southeast Alaska to better understand and manage coho salmon stocks in the region. ADF&G's stock assessment program includes monitoring a number of key coho salmon stocks in Southeast Alaska where juvenile coho are tagged with coded wire tags (CWTs). Systematically sampling escapements and harvest in fisheries for coho salmon with CWTs allows for estimates of total smolt production as well as marine survival, exploitation (harvest) rates and contributions to various fisheries from the monitored stocks. Data collected from the stock assessment program helps managers assess the effectiveness of regulations to ensure sustained yield of these and neighboring stocks of coho salmon.

Chuck Creek was selected to be part of the coho salmon stock assessment program in 2001 to fill the geographical gap in coverage in Southeast Alaska for the southern outside coast. The Chuck Creek watershed is located on Heceta Island (Figure 1), about 35 km northwest of the town of Craig, and it is believed to produce between 850 and 3,000 adult coho salmon annually (Shaul et al. 1991; McCurdy 2005, 2006a-b, and 2008). Prior to this study, an adult salmon weir was operated successfully on Chuck Creek in 1950 (Edgington et al. 1981) as well as 1982, 1983 and 1985 (Shaul et al. 1991). Also, presmolt juvenile coho salmon from Chuck Creek were marked with CWTs in the early 1980s to enable estimates of survival, fishery contributions and exploitation rates (Shaul et al. 1991). Recoveries of coho salmon with CWTs in commercial fisheries in the 1980s indicated that the Chuck Creek stock has an ocean distribution and exploitation pattern similar to that of coho salmon from the Klakas River (Shaul et al. 1991), and the Klawock River (ADF&G's Mark, Tag and Age Laboratory database), both on nearby Prince of Wales Island.

The Chuck Creek watershed drains an area of approximately 750 hectares (1,853 acres), and contains Chuck Lake that has a surface area of approximately 63 hectares (155 acres). Chuck Lake drains to the south into Warm Chuck Inlet by way of the 1.5-km long outlet stream, Chuck Creek. Four separate tributary streams to the lake

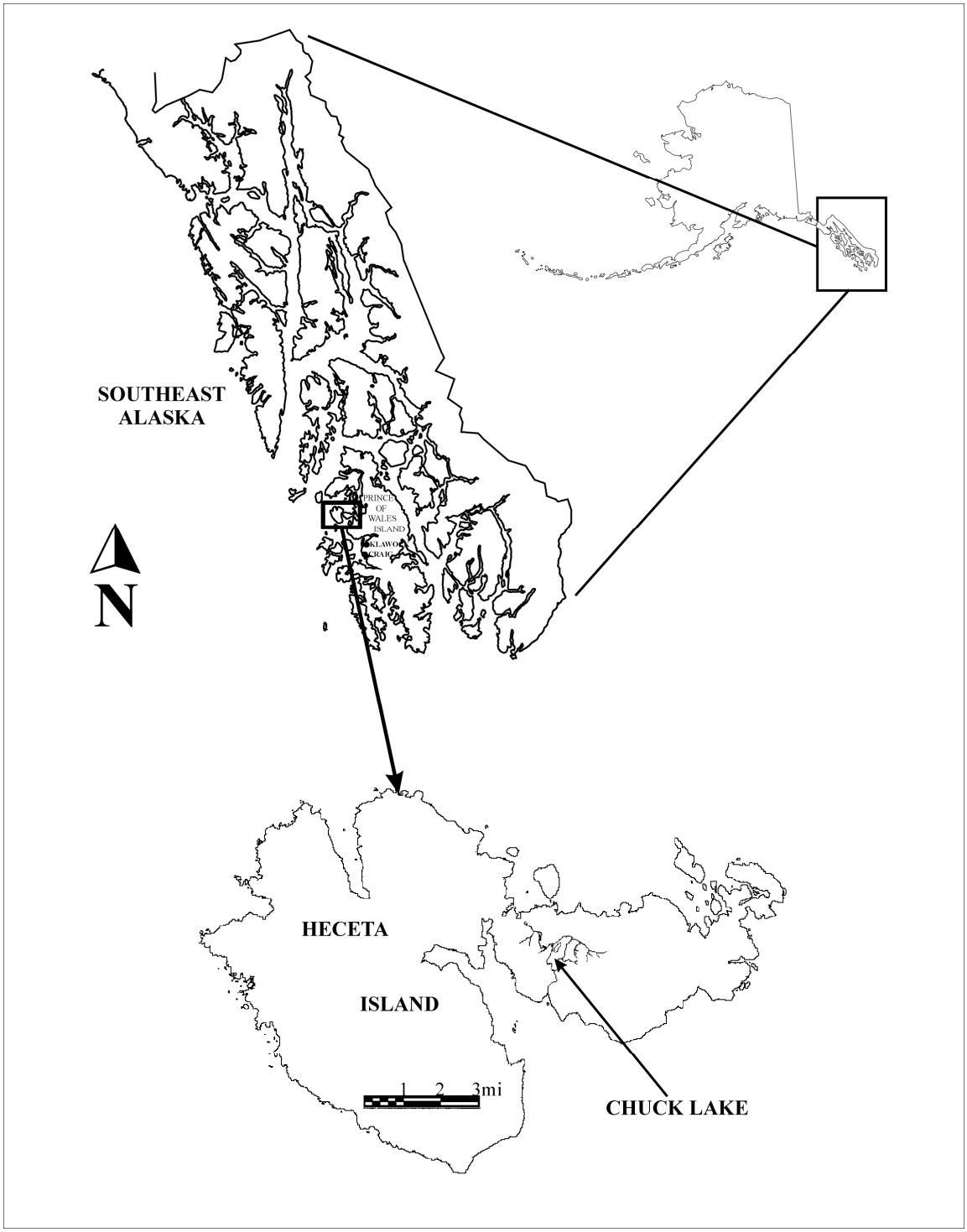

Figure 1.–Location of Heceta Island and the Chuck Creek watershed.

contain spawning and rearing habitat for anadromous fish. The watershed is generally low gradient with the highest point of elevation in the drainage being 169 meters (553 feet) above sea level. The topography of the watershed is predominately karst (formed on carbonated bedrock, mostly limestone) and there are numerous springs and ground water sources present, indicating a well-developed subsurface drainage pattern typically associated with Karst geology (Baichtal and Swanston 1996). The watershed land cover is 89.4% forested, and the

remainder being water (9.8%) and non forested land (0.5%; predominantly muskeg; ADF&G Southeast Habitat Information IMS Website). Approximately 81% of the forested land in the watershed was logged in the 1970s and 1980s, at which time extensive timber harvest occurred in riparian areas and along the lakeshore. A vast network of logging roads (approximately 12.8 km) is present throughout the watershed. The watershed contains numerous beaver dams and ponds, and vegetation in the riparian area is significantly influenced by beaver (*Castor canadensis*) activity. In addition to coho salmon, Chuck Creek contains sockeye salmon (*O. nerka*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), Dolly Varden (*Salvelinus malma*), steelhead (*O. mykiss*) and cutthroat trout (*O. clarkii*), as well as three-spine stickleback (*Gasterosteus aculeatus*) and coastrange sculpin (*Cottus aleuticus*).

OBJECTIVES

Objectives of this study were to:

1. Estimate the number of coho salmon smolt emigrating from Chuck Creek in 2006;
2. Determine if scale interpretation is accurately determining ages of coho salmon smolt emigrating from Chuck Creek in 2006 via comparison to known-age fish;
3. Estimate the age composition, and mean length and weight at age of coho salmon smolt captured emigrating from Chuck Creek in 2006;
4. Count the escapement of coho salmon returning to Chuck Creek from the 2006 smolt emigration;
5. Estimate the age and sex composition, and mean length at age of the escapement of coho salmon to Chuck Creek from the 2006 smolt emigration;
6. Estimate the marine harvest of coho salmon from Chuck Creek in 2007 via recovery of CWTs;
7. Investigate the relationship between coho salmon smolt size and emigration date, and survival to maturity;
8. Investigate the relationship between date of smolt emigration from the watershed and immigration date back to the watershed of age x.0 jacks; and
9. Document diurnal migration patterns of emigrating coho salmon smolt and other emigrating fish in Chuck Creek in the spring of 2006.

In addition, all other adult and juvenile salmonids of other species (other than young-of-the-year fry) were counted through the adult and smolt weirs.

An added benefit of this study is the monitoring of coho salmon production over time with the possibility of identifying factors that effect coho salmon production. Factors that could influence smolt production include escapement magnitudes, abiotic factors, and anthropomorphic changes to the watershed (such as large scale timber harvesting and road building).

METHODS

A mark–recapture (m-r) experiment was used to estimate smolt abundance. Coho salmon were marked and recaptured with the use of weirs as they migrated from (emigrated) and returned to (immigrated) the Chuck Creek watershed. Coho salmon smolt were captured as they were emigrating from Chuck Creek in the spring of 2006, marked by removing their adipose fin, and injected with a CWT. Adult coho salmon were sampled in the harvest of commercial and sport fisheries in 2007 for the presence of CWTs. The escapement of mature coho salmon was monitored through a weir on Chuck Creek in 2006 and 2007 and fish were inspected for missing adipose fins and CWTs, to determine the fraction missing adipose fins (θ), and the fraction containing CWTs (θ_{cwt}). Unless otherwise defined in this report, the term "marked" is used to describe a fish with its adipose fin removed, and the term "tagged" is used to describe a fish containing a CWT. The marked fraction (θ) and tagged fraction (θ_{cwt}) could differ as smolt marked with an adipose finclip may not retain their CWT. The marked fraction of mature fish was used in estimating smolt abundance, and the tagged fraction of adult fish was used for estimating harvest in marine fisheries. Harvest of coho

salmon in marine waters of Southeast Alaska is limited to adult fish that have spent one winter in the marine environment. The term "adult" is used to describe coho salmon that mature and return to spawn the year following their emigration from fresh water (noted as age x.1 or 1-ocean fish), and the term "jack" is used to describe male coho salmon that mature and return to spawn in the same year as their emigration from fresh water (noted as age-x.0 or saltwater-age-0 fish). The term "mature" refers to all coho salmon (both jack and adult) that are sexually mature and returning to spawn.

SMOLT CAPTURE AND CODED WIRE TAGGING

Coho salmon smolt emigrating from the Chuck Creek watershed were captured using a weir and "trough" trap similar to that described by Elliott (1992). The weir and trap was constructed on Chuck Creek at the site of a blown-out beaver dam located approximately 500 m upstream from salt water. The opening in the beaver dam was repaired using rough-cut lumber planks to raise the water level upstream of the dam approximately 1 meter. A "V" shaped, perforated, plastic fence (the weir) upstream of the dam extended from both banks and funneled emigrating smolt to the entrance of the trough located on the top of the rebuilt dam. The fence was constructed using two 15-m rolls of 1.5-m wide, 5-mm mesh rigid plastic fence, held in place with iron pipe pounded into the substrate. The bottom 30 cm of the fence was folded facing upstream on the bottom of the stream and weighted down with rocks and sand bags to seal any openings large enough for fish passage. The top of the fence extended above the water surface. The trough was prefabricated out of aluminum and was approximately 2.4-m long and 30-cm wide. Flexible sewer hose (10-cm diameter) was attached to the downstream end of the trough to funnel fish into a live box located just downstream of the beaver dam. The live box was prefabricated aluminum and had perforated aluminum on one side to allow for water flow. The trap was fished continuously from April 16 until June 2.

Captured fish were removed from the live box several times a day and sorted by species. The trap was checked daily at dawn, midday, dusk and after dark, and more frequently when fish were migrating. The time the trap was checked, as well as the number of fish captured since the previous check, was recorded. All species, other than young-of-the-year salmonid fry, which could freely pass through the trap fence and perforated live box wall, were counted and released at the trap site. Coho salmon smolt were sorted into two size categories (*small* smolt ≤100 mm fork length (FL) and *large* smolt >100 mm FL), counted, and tagged daily with sequentially numbered CWTs. All captured coho salmon ≥70 mm FL that appeared healthy were anesthetized with a solution of tricain-methane-sulfonate (MS-222), had a 1.1 mm CWT injected into their snout, had their adipose fin removed, and were counted. Before tagging the first fish and after tagging the last fish in each size category, on each day, one tag would be ejected from the machine and the unique sequential number on the tag would be read and recorded. Subsequently recovered tagged fish could then be identified as to their size category and date of emigration from the unique sequential number on their respective CWT. Northwest Marine Technology Mark IV[1] tagging machines were used for tagging. Tag placement was checked at the beginning of tagging operations, and periodically throughout the operation using methods suggested in Koerner (1977). Short-term (16 hr) CWT loss and mortality due to the handling and tagging procedure was evaluated by holding all fish overnight (remixed together in a single holding box), at which time they were inspected for mortalities and the presence of a CWT using a metal (tag) detector, then released downstream of the trap. Tag retention procedures required that a random sample of at least 100 fish have a retention rate of 98% or greater. If the sample had less than 98% retention of their CWTs, then the entire batch of fish being held overnight was checked for the presence of CWTs and retagged if found missing a tag. The number of fish tagged, the number of overnight mortalities following tagging, and the number of fish that had shed their tags was recorded and the information submitted (along with a sample of the coded wire used) to ADF&G Tag Lab in Juneau at the end of field operations. The

[1] This and subsequent product names are included for a complete description of the process and do not constitute product endorsement.

tags used in 2006 contained the codes 04-13-03 and 04-13-04 plus a unique sequential number. Water temperatures were recorded hourly with the use of an Onset Computer Corporation WTA08 Optic Stow Away data logger placed in the stream at the weir site.

ESTIMATION OF SMOLT ABUNDANCE

A two-event mark–recapture (m-r) experiment for a closed population was used to estimate the abundance of coho salmon smolt emigrating from the Chuck Creek watershed in 2006. Event 1 consisted of marking captured coho salmon smolt ≥70 mm FL by removing their adipose fin in 2006. Event 2 consisted of sampling returning mature coho salmon in 2006 (jacks) and 2007 (adults) to estimate the marked fraction.

The abundance of coho salmon smolt emigrating from Chuck Creek in 2006 was estimated using Chapman's modification of the Petersen estimator for a closed population (Seber 1982):

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

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

where n_1 was the number of smolt marked in 2006 by removing their adipose fin, n_2 was the number of returning coho salmon inspected for marks in 2006 (jacks only) and 2007 (adults only), and m_2 was the subset of n_2 missing their adipose fins.

The conditions for an accurate estimate of smolt abundance using this methodology were: (1) all fish had an equal probability of being marked in event 1, *or* all fish had an equal probability of being inspected for marks in event 2, *or* marked fish mixed completely with unmarked fish in the population between events; (2) both recruitment and death (emigration from the population) did not occur between events; (3*)* marking did not affect catchability of fish; (4) fish did not lose their marks between events; and (5) all marks were reported on recovery in Event 2 (Seber 1982, p. 59).

Physiological and life history traits of coho salmon, along with design of this experiment allow for discounting concerns over several of these conditions. Because coho salmon return to their natal stream to spawn, the population is closed to recruitment (condition 2); all immigrating fish in the escapement are obligated to pass through the salmon weir when returning to spawn so catchability in event 2 (which is 100%) is unaffected by marking (conditions 1 and 3); adipose fins do not regenerate when completely removed (condition 4), and missing adipose fins are easy to note when examining the captured fish (condition 5).

Removal of adipose fins has been shown to have no significant affect on mortality (Vincent-Lang 1993; condition 1). However, because smolt capture and marking (Event 1) in this study did not span the entire duration of the emigration, and smolt emigration date has been shown to affect survival to maturity (Event 2; Bilton et al. 1982; Lum 2003; McCurdy 2006a-b) it is almost assured that condition 1 was violated in this study. However, the impact of this violation on the abundance estimate was likely low, as discussed below.

ESTIMATION OF SMOLT AGE, WEIGHT AND LENGTH (AWL)

A sample of the emigrating coho salmon smolt was obtained from the fish held overnight in net pens following tagging. The sample was obtained by gently mixing all the fish in the holding pen with a dip net, then scooping up fish with the net, and sampling all the netted fish. Each sampled fish was measured to the nearest mm for FL, weighed to the nearest gram, and had a scale sample taken for age determination. The goal was to sample a 40th of the smolt emigration each day. Scale samples were taken from the preferred area as described by Scarnecchia (1979), and mounted between two 25-mm x 75-mm microscope slides. Slides and scale samples were labeled to match corresponding recorded length and weight data. Scale samples were viewed at magnification and ages recorded in European notation (where the number of winters in fresh water after hatching and the number of years in salt water are separated by a period, Groot and Margolis 1991). Ages were determined one time by one reader.

Size selectivity in the sampling procedure described above was evaluated by comparing the proportions of small and large smolt (≤100 mm FL and >100 mm FL) in the AWL sample to the proportions in the population of smolt tagged using a chi-square test (Ho: $p_{\leq 100} = p_{>100}$, Conover 1980). If the AWL sample was representative of all the smolt tagged (with respect to smolt size), the proportion of smolt sampled for AWL from both size classes of tagged smolt would be equal. If size selectivity was significant, the AWL sample could be post-stratified into groups ≤100 mm FL and >100 mm FL to reduce bias in AWL estimates. Stratified estimates of age composition ($\hat{p}_a$) were calculated (Cochran 1977):

$$\hat{p}_{a,h} = \frac{n_{a,h}}{n_h} \tag{3}$$

$$\text{var}(\hat{p}_{a,h}) = \left[1 - \frac{n_h}{N_h}\right] \frac{\hat{p}_{a,h}\left(1 - \hat{p}_{a,h}\right)}{n_h - 1} \tag{4}$$

$$\hat{p}_a = \frac{1}{N}\sum_h N_h \ \hat{p}_{a,h} \tag{5}$$

$$\text{var}(\hat{p}_a) = \sum_h W_h^2 \text{var}(\hat{p}_{a,h}) \tag{6}$$

where $\hat{p}_{a,h}$ is the estimated proportion of the population in age group *a* and length strata *h*, n_h is the number of fish successfully aged in strata *h*, $n_{a,h}$ is the subset of n_h belonging to group *a*, and N_h is the total count at the weir in length stratum *h*. Sampling weights $W_h = N_h / N$, and $N = \sum N_h$.

Similarly, stratified estimates of mean length ($\hat{\bar{\ell}}$) or mean weight were calculated:

$$\hat{\bar{l}}_h = \frac{1}{n_h}\sum_i l_{h,i} \tag{7}$$

$$\text{var}\left(\hat{\bar{l}}_h\right) = \left[1 - \frac{n_h}{N_h}\right] \sum_i \frac{\left(l_{h,i} - \hat{\bar{l}}_h\right)}{n_h\left(n_h - 1\right)} \tag{8}$$

$$\hat{\bar{l}} = \frac{1}{N}\sum_h N_h \ \hat{\bar{l}}_h \tag{9}$$

$$\text{var}(\hat{\bar{l}}) = \sum_h W_h^2 \ \text{var}\left(\hat{\bar{l}}_h\right) \tag{10}$$

where ℓ_{hi} is the length of individual fish i in length stratum h, n_h is the sample size in length stratum h, N_h is the number of smolt in length stratum h, $N = \sum N_h$, and W_h is a strata weight (= N_h / N). Because size selectively would likely also occur within each size-class, the procedures above would reduce, but not eliminate, bias in the estimate.

Interpretation of circuli patterns on fish scales is often used for estimating ages of Pacific salmon (Bilton and Jenkinson. 1977), yet this technique of aging is often not validated in most fishery studies (Beamish and McFarlane 1983). In order to determine if bias in age determination through scale interpretation of Chuck Creek coho salmon smolt is occurring in this study (and to potentially improve accuracy in age determination in the future), estimated ages were compared to actual ages in a sample of known-age fish. Newly emerged coho salmon fry were captured and tagged in 2005 with half-length (0.5 mm) CWTs to identify their year of emergence. Each tagged fry was also marked by removing its adipose fin. Surviving fish were then recaptured as emigrating smolt in 2006, sampled for AWL and then sacrificed for retrieval of the coded wire tag that would verify their age. Scale samples from these known-age fish were then examined (along with the random AWL samples) by the scale reader without knowledge of which samples were the known-aged fish. Ages estimated through scale interpretation were then compared to the true ages to determine how many were accurately estimated in the sample of known-age fish.

Fry for this aging study were captured in Chuck Creek (the outlet stream of Chuck Lake) and in one of the tributaries to the lake between April 22 and April 26, 2005 using hand held dip nets, and were held overnight in perforated 5-gallon buckets placed in the stream at their capture location. Short-term (16 hr) CWT loss and mortality due to the handling and tagging procedure was evaluated by holding all fish overnight, at which time they were inspected for mortalities and the presence of a CWT using a metal (tag) detector, then released at their capture location. The number of fish tagged, the number of overnight mortalities following tagging, and the number of fish that had shed their tags was recorded and the information submitted (along with a sample of the coded wire used) to the ADF&G Tag Lab in Juneau at the end of field operations. The tag code used in 2005 for the fry was 04-01-06-01-03. A random sample of approximately every 35th tagged fry was measured for fork length to the nearest mm. In 2006 captured coho salmon smolt were examined for a missing adipose fin and a healed scar at the location of the missing fin. Fish were then tested for the presence of a CWT and if all three criteria tested positive, the smolt was sampled for AWL and the fish was sacrificed for retrieval of its CWT.

ESTIMATION OF MARINE HARVEST

Estimates of the harvest of coho salmon originating from Chuck Creek and its variance were derived from fish sampled from harvest in commercial and recreational sport fisheries using standard methods (Bernard and Clark 1996). Because several fisheries exploited coho salmon bound for Chuck Creek over several months in 2007, harvest was estimated over several strata, each a combination of time, area, and type of fishery. Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant (Appendix A1). Statistics from the purse seine fishery were stratified by week and fishing district. Statistics from the sport fishery were stratified by fortnight. Hubartt et al. (1999) present details of sampling sport fisheries. An ADF&G Division of Commercial Fisheries manuscript (ADF&G *Unpublished*) describes sampling of commercial fisheries in Southeast Alaska in which samplers stationed at fish processors throughout the region attempt to sample 20% of the commercial coho salmon harvest for missing adipose fins. Databases from the Pacific States Marine Fisheries Commission (PSMFC) were also queried for any reported recoveries of coho salmon containing CWTs from Chuck Creek in Canadian fisheries.

Estimates of the 2007 harvest r_{ij} of Chuck Creek coho salmon from the 2006 smolt emigration j to one fishery stratum i were calculated:

$$\hat{r}_{ij} = \hat{H}_i \left(\frac{m_{ij}}{\lambda_i n_i} \right) \hat{\theta}_j^{-1} \qquad (11)$$

where H_i is the estimated harvest in stratum i, θ_j is the marked fraction of stock j possessing CWTs (the portion of the *adult* escapement sampled *found to have CWTs*), n_i is the subset of H_i examined for missing adipose fins, m_{ij} is the number of decoded CWTs recovered from stock j in stratum i, and $\lambda_i = (a_i' \; t_i') \; / \; (\; a_i \; t_i \;)$ is the decoding rate for CWTs from recovered salmon (a_i is the number of adipose finclipped fish in the sample from stratum i, a_i' is the subset of a_i for which heads reach the laboratory, t_i is the subset of a_i' with CWTs detected, and t_i' is the subset of t_i with CWTs decoded). Estimates of harvest were summed across strata and fisheries to obtain an estimate of the total harvest $T = \sum \hat{r}_{ij}$. Because sampling was independent across strata and across fisheries, the variance of the total harvest was estimated by summing the variances across strata. See Bernard and Clark (1996) for further details.

ESCAPEMENTS

An aluminum bipod and picket weir was installed across the lower end of Chuck Creek (approximately 500 m from salt water) and operated from August 15 until October 15 in 2006 (McCurdy 2008), and from August 15 until October 15 in 2007. Pickets were 18 mm in diameter and were spaced 31 mm apart. The bottom and sides of the weir were sealed with sandbags and the weir was monitored continuously. A 2.4-m square trap was built into the weir to capture and hold all migrating salmon. All migrating salmon had to enter the trap to pass upstream. Personal observations of the author and field crews since the project began in 2001 have shown that the vast majority of coho salmon, upon entering the stream, arrive at the weir within a few

hours and enter the cage in under an hour upon arriving at the weir (usually within minutes). Using these methods, it appears that capture at the weir is an excellent indicator of return date to the stream.

All migrating mature salmon were identified and counted by species and date as they passed the weir. All coho salmon were counted by life-history type (adult or jack) and examined for missing adipose fins. Life-history type was assumed to be accurately determined for each fish enumerated at the weir. Fish that were 400 mm in length (mideye-to-fork, MEF) or larger were considered adults and those less than 400 mm in length were considered jacks; any fish between 380 mm and 450 mm in length had a scale sample taken to verify the assumed saltwater age. In the previous 6 years of monitoring the escapement of coho salmon at Chuck Creek, all fish between 380 mm and 450 mm in length had a scale sample taken to verify the assumed saltwater age, and there has been no overlap in fork length detected between jacks and adults, as the largest jack has been 395 mm in length and the smallest adult has been 400 mm in length (McCurdy 2008).

Coho salmon were systematically sampled throughout the entire migration for age, sex, and length (ASL). In 2006 every 3rd adult coho and every 3rd jack coho salmon encountered at the weir was sampled. In addition every 4th adipose fin-clipped jack coho salmon encountered at the weir was sacrificed for retrieval of its coded wire tag in 2006, and these fish were also sampled for ASL. In 2007 every 4th adult coho salmon and every 3rd jack coho salmon was sampled for ASL and additionally, every 3rd adipose fin-clipped jack encountered at the weir was sacrificed for retrieval of its coded wire tag. In both years fish were measured to the nearest 5 mm MEF, and sex was estimated by external characteristics. All sampled coho salmon missing an adipose fin were also examined for CWTs using a magnetometer (hand-held CWT detector from Northwest Marine Technology). Total escapement was the number of coho salmon counted through the weir. These numbers were divided into the number of jacks and the number of adults.

The fraction of the adult and jack migrations that belong to each age or sex group was estimated:

$$\hat{p}_a = \frac{n_a}{n} \tag{12}$$

$$var[\hat{p}_a] = \left(1 - \frac{n}{N}\right) \frac{\hat{p}_a(1 - \hat{p}_a)}{n - 1} \tag{13}$$

where n is the number of fish successfully aged (or sexed), n_a is the number from this sample that belong to age (or sex) group a, and N is the total migration (weir count). Abundance of age or sex group ($\hat{N}_a$) was estimated:

$$\hat{N}_a = \hat{p}_a N \tag{15}$$

$$\text{var}(\hat{N}_a) = N^2 \text{var}(\hat{p}_a) \tag{16}$$

Standard sample summary statistics were used to calculate estimates of mean length-at-age and its variance (Cochran 1977). The relationship between jack emigration and immigration date was analyzed using a simple linear regression model.

ESTIMATES OF TOTAL RETURN, EXPLOITATION RATE, AND MARINE SURVIVAL

The total adult return (i.e., harvest and escapement) of the coho salmon bound for Chuck Creek in 2007 and its variance was calculated by summing estimates of total harvest (T) and the adult escapement (N_e):

$$\hat{N}_R = \hat{T} + N_e \tag{17}$$

$$\text{var}[\hat{N}_R] = \text{var}[\hat{T}] \tag{18}$$

where $\text{var}[N_e]$ is not included in equation (18) because it is 0. The estimate of the adult exploitation rate was calculated:

$$\hat{E} = \frac{\hat{T}}{\hat{N}_R} \tag{19}$$

$$\text{var}[\hat{E}] \approx \frac{\text{var}[\hat{T}] N_e^2}{\hat{N}_R^4} \tag{20}$$

where the variance was approximated with the delta method (Seber 1982), recalling that $\text{var}[N_e] = 0$. Smolt-to-adult survival rate was estimated as:

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \tag{21}$$

$$\text{var}[\hat{S}] \approx \hat{S}^2 \left[\frac{\text{var}[\hat{N}_R]}{\hat{N}_R^2} + \frac{\text{var}[\hat{N}_s]}{\hat{N}_s^2} \right] \tag{22}$$

where N_s is the smolt abundance estimate from equation (1), and $\text{var}[\hat{S}]$ is an approximation using the delta method.

RESULTS

SMOLT AGE VALIDATION

Between April 22 and April 26, 2005 a total of 2,309 newly emerged coho salmon fry were captured at two locations in the Chuck Creek watershed (Table 1). Five fry died after tagging and an estimated 20 others shed their tags before release, leaving a total of 2,284 fry released with a valid CWT. A total of 158 of the tagged fry were recaptured in 2006 as age-1 smolt as they emigrated from Chuck Creek and were sampled for length, weight, and had a scale sample taken for age estimation. Scale age was not estimated on two samples because of regenerated scales. Age was correctly estimated on 140 (90%) of the scale samples and incorrectly estimated as age 2 on 16 samples (or 10%, Table 2; recall that true age of the smolt was not known by the scale reader). Aging error was associated with smolt size; no error occurred in aging smolt <110 mm FL (Table 2).

A random sample of 64 fry tagged in 2005 were measured for fork length. The mean length of the fry sampled was 37 mm FL (SD = 2), and length ranged from 33 mm to 44 mm FL. The smolt recaptured in 2006 were also sampled for length and weight and had a mean length of 100 mm FL (SD = 11, *n* = 158, range 81 mm to 131 mm), and mean weight of 8.9 g (SD = 3.0; *n* = 135).

SMOLT EMIGRATION IN 2006

A total of 13,009 coho salmon smolt ≥70 mm FL were captured and tagged between April 16 and June 2, 2006 (Appendix A2). Sixty-four fish died after tagging, leaving a total of 12,945 smolt (8,468 fish ≤100 mm and 4,477 fish >100 mm FL) that were released with adipose finclips and valid CWTs in 2006.

Emigrating coho salmon smolt were first captured in the trough trap on April 16 (Appendix A2). The timing of the coho salmon smolt emigration was pulsed throughout the migration period and peak catches occurred in the third week of May (Figure 2). Smolt were still emigrating when the weir and trap were dismantled on June 2.

Because the frequency and time of day that the smolt trap was checked varied throughout the smolt emigration in 2006, only coarse observations concerning the diurnal pattern of smolt migration are possible in this study. The majority (73%, Table 3) of coho smolt moved into the trap box during evening hours. Of the fish that moved during daylight hours, the majority moved into the trap box in the early afternoon, and little migration occurred during morning hours. The rate of migration would usually slow down in the late afternoon until it picked up again at dusk. This pattern of the majority of fish moving from dusk to dawn, little fish migration in the morning, then a pulse of fish moving in the early afternoon is consistent with observation of the field crews and author in past years at Chuck Creek. When fish movement was low to moderate it was not necessary for field crews to check the trap throughout the night, so the lack of frequent, time consistent trap checks throughout the season during evening hours precludes quantifying smolt movement into smaller time segments during this period of the day. However, for nights when substantial smolt movement required the crew to check the trap frequently, the majority of the fish moved in the first few hours after darkness, and then migration slowed considerably after midnight. Early in the smolt emigration almost all the smolt moved during evening hours and it wasn't until May 11 when substantial numbers of smolt began moving during daylight hours. This observation of the early portion of the emigration occurring almost

Table 1.–Summary of emergent coho salmon fry tagged with coded wire tags, held overnight and released following sampling for tag retention at Chuck Creek in 2005.

Date	Location in watershed	Total tagged	Overnight mortality	Number released with: Valid tags	Shed tags
4/22	Outlet Stream[a]	20	0	20	0
4/23	Outlet Stream	196	1	195	0
4/24	Outlet Stream	169	0	169	0
4/24	Roadside Creek[b]	405	1	404	0
4/25	Roadside Creek	743	3	737	3
4/26	Outlet Stream	94	0	90	4
4/26	Roadside Creek	682	0	669	13
Totals		2,309	5	2,284	20

[a] The "Outlet Stream" is Chuck Creek, the outlet stream of Chuck Lake.

[b] "Roadside Creek" is the project name for a small tributary stream to Chuck Lake.

Table 2.–Summary of age estimation accuracy in a blind test of known age-1 coho salmon smolt from the Chuck Creek smolt emigration in 2006.

Smolt Size class	Number of fish	# Correctly aged	% Correctly aged
≤ 109 mm FL	123	123	100%
110 to 119 mm FL	18	14	78%
≥ 120 mm FL	15	3	20%
Totals:	156	140	90%

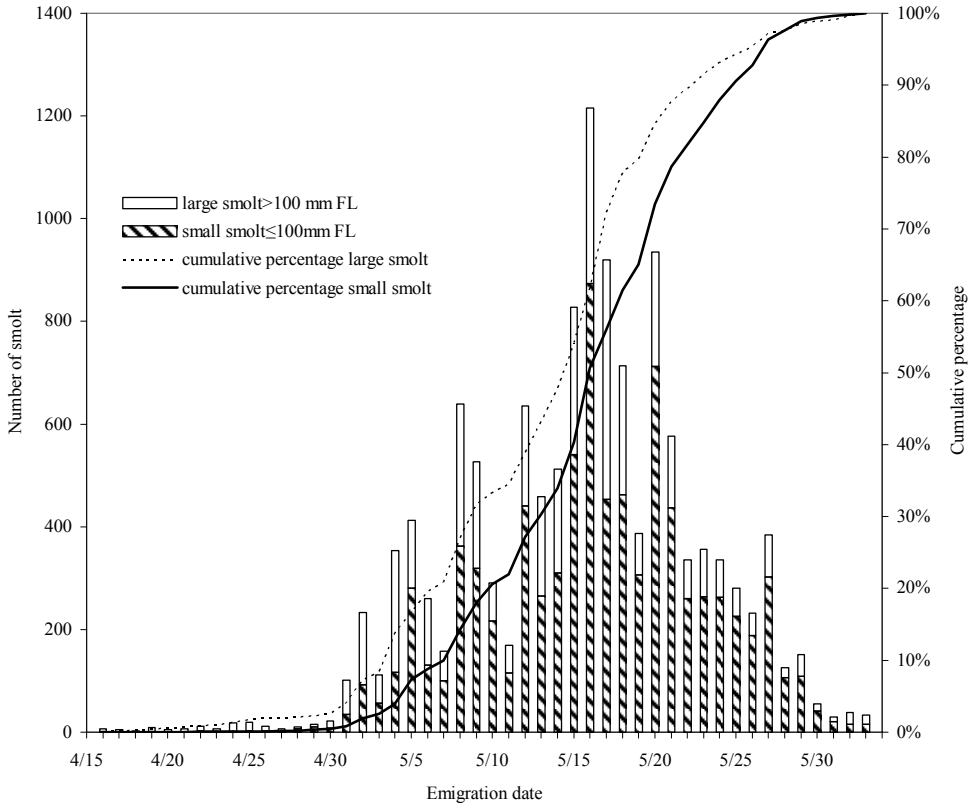

Figure 2.–Daily catch and cumulative percentage of coho salmon smolt emigration, by smolt size category, counted past the Chuck Creek weir in 2006.

Table 3.–Summary of the number of emigrating coho and sockeye salmon smolt, Dolly Varden and Sculpin captured in the trough trap, by diel period at Chuck Creek between April 16 and June 2, 2006.

	Coho smolt		Sockeye smolt		Dolly Varden adults[a]		Dolly Varden juveniles[b]		Sculpin	
Time period	No. fish	% of total	No. fish	% of total	No. fish	% of total	No. fish	% of total	No. fish	% of total
Dawn to noon	605	4.6%	808	1.6%	9	1.6%	40	5.8%	17	0.5%
Noon to 16:00	1,815	13.9%	376	0.7%	4	0.7%	52	7.5%	3	0.1%
16:00 to dusk	1,201	9.2%	2,207	4.4%	15	2.7%	91	13.1%	6	0.2%
Dusk to dawn	9,547	72.9%	46,934	93.3%	529	95.0%	510	73.6%	3,512	99.3%

[a] Fish > 175 mm FL.

[b] Fish ≤ 175 mm FL.

exclusively at night is also consistent with previous year's observation at Chuck Creek. The vast majority of the other fish species captured (Appendix A3) also migrated during evening hours (Table 3); 93% of sockeye salmon smolt moved from dusk to dawn.

A total of 225 captured coho salmon smolt ≥70 mm FL were sampled for age and length. Because of an equipment problem in the field, weight was only measured on 146 of the 225 sampled fish. Size selectivity occurred in sampling ($\chi^2 = 47.7$, df = 1, $P < 0.001$); 2.8% (128 of 4,477 smolt) of the large (>100 mm FL) smolt were sampled, and only 1.2% (100 of 8,468 smolt) of the small smolt were sampled. Using the stratified methods detailed in the Methods section, the mean length of the captured smolt was an estimated 100.1 mm FL (SE = 0.5) and the mean weight was an estimated 10.0 g (SE = 0.2). Because the age validation portion of this study determined that there was bias in the age estimation of age-1 coho salmon smolt in the 2006 emigration, and the extent of any bias in estimating age of age-2 smolt cannot be estimated at this time (as there were no known age-2 smolt in the emigration), length- and weigh-at-age were not calculated.

Analysis of any relationship between smolt size and emigration date is also hindered by the size-selective sampling that occurred in obtaining the AWL sample. However the number of smolt captured daily greater than or less than 100 mm FL is an accurate count, as all smolt that were close to 100 mm FL were measured prior to tagging to confirm their length. Smolt in the *larger* size category tended to emigrate earlier than *small* smolt (Figure 2, Appendix A2). Dividing the time period when smolt were captured (April 16–June 2) into two equal time periods, 31.7% of all the *large* smolt captured emigrated during the *early* period (April 16–May 9), whereas only 18.1% of all the *small* smolt captured did.

Surviving fish from the 2006 smolt emigration returned to Chuck Creek in both 2006 (as jacks) and in 2007 (as adults), and returning fish were examined for a missing adipose fin to determine the marked fraction (θ). In the 2006 escapement, 487 of 561 jacks examined ($\theta = 0.868$) were missing adipose fins. In the 2007 escapement, 330 of 424 adults examined ($\theta = 0.778$) were missing their adipose fin. These two marked fractions were significantly different ($\chi^2 = 13.8$, df = 1, $P < 0.001$). Pooling both escapement samples (817 marks in 985 inspected) yields an estimate of $\theta = 0.829$ for the fraction of the 2006 smolt emigration marked. An estimated 15,604 (SE = 218) coho salmon smolt emigrated from Chuck Creek in 2006 ($n_1 = 12{,}945$, $n_2 = 985$, $m_2 = 817$).

ESCAPEMENT ENUMERATION AND SAMPLING

2006 Jack Coho Salmon Escapement

A total of 572 jack coho salmon were counted through the weir between August 15 and October 15, 2006 (McCurdy 2008). Of the total jack escapement, 11 fish were passed upstream before they could be examined for the presence or absence of an adipose fin.

Systematically sacrificing every 4th adipose-finclipped jack encountered at the weir in 2006 yielded a sample of 119 fish with sequential coded wire tags that were successfully decoded, and an additional 5 fish that had readable CWTs, but unreadable unique sequential numbers (Appendix A4). Four additional jacks containing CWTs were sampled in the escapement as non-random samples (1 carcass recovered downstream of the weir and 3 upstream of the weir; Appendix A4). Of the 119 sampled jacks, *large* smolt were recovered as jacks at a rate of 1.47% (66/4,477) and *small* smolt were recovered at a rate of 0.63% (53/8,468; Table 4); this was a significantly different recovery rate ($\chi^2 = 23.1$, df = 1, $P < 0.001$; Table 5). There was also a statistically significant difference in the average length of the 119 recovered tagged jacks between those that were tagged as *small* or *large* smolt ($t = 6.8$, assuming unequal variance, df = 113, $P < 0.001$), with the jacks from the *small* smolt averaging 302 mm MEF (SD = 24) and jacks from the *larger* smolt averaging 332 mm MEF (SD = 25).

The average number of days between tagging and recapture of the 119 jacks was 120 (SD = 10, range = 100-151). For the *small* smolt only, the average number of days between capture events was 119 (SD = 8), and for the *large* smolt the average number of days was 121 (SD = 10); this was not a significant difference ($t = 1.3$, df = 117,

Table 4.–Numbers of coho salmon smolt coded wire tagged by size class and emigration time period from the 2006 Chuck Creek smolt emigration, and their subsequent recovery rates as mature fish in marine fishery and escapement sampling programs.

	No. smolt tagged			Recovery rate of tagged smolt as:								
				Jack[b]			Adult[b]			All mature		
	Small[a]	*Large*[a]	Total	*Small*	*Large*	Total	*Small*	*Large*	Total	*Small*	*Large*	Total
Early (April 16–May 9)	1,529	1,417	2,946	1.18%	1.69%	1.43%	1.11%	0.85%	0.98%	2.29%	2.54%	2.41%
Late (May 10–June 2)	6,939	3,060	9,999	0.50%	1.37%	0.77%	1.25%	1.60%	1.36%	1.76%	2.97%	2.13%
Total	8,468	4,477	12,945	0.63%	1.47%	0.92%	1.23%	1.36%	1.27%	1.85%	2.84%	2.19%

[a] Small smolt ≤100 mm FL, large smolt > 100 mm FL.

[b] Jacks and adults were sampled at different rates so recovery rates between the two life history types are not directly comparable.

Table 5.–Summary of significance tests of the recovery rate of coded wire tagged coho salmon smolt from the 2006 Chuck Creek smolt emigration by smolt category (small or large; early or late). P-values ≤ 0.05 are bold.

		Recovery of tagged smolt as:					
		Jacks		Adults		All mature fish	
Smolt Categories Tested		χ^2	P-value	χ^2	P-value	χ^2	P-value
	small vs. large[a]	23.1	**< 0.001**	0.4	0.52	13.2	**< 0.001**
	early vs. late[b]	10.7	**0.001**	2.6	0.11	0.8	0.36
Small only	*early vs. late*	9.1	**0.003**	0.2	0.65	1.9	0.16
Large only	*early vs. late*	0.7	0.41	4.1	**0.04**	0.7	0.42
Early only	*small vs. large*	1.4	0.24	0.5	0.47	0.2	0.66
Late only	*small vs. large*	20.9	**< 0.001**	1.9	0.17	15.1	**< 0.001**

[a] *Small* smolt ≤100 mm FL, *large* smolt >100 mm FL.

[b] *Early* period is April 16–May 9; *late* period is May 10–June 2.

assuming unequal variance, P = 0.2). The length of the 119 jacks was positively correlated with number of days at sea (days between capture events; $R^2 = 0.196$, $P < 0.001$, Figure 3), and each additional day at sea produced about 1.3 mm in additional length.

A simple linear regression of jack immigration date (date of capture at the adult weir) against smolt emigration date (date of capture at the smolt weir) does not reveal a significant relationship ($n = 119$, $P = 0.24$, $R^2 = 0.012$). When one outlier is removed from the analysis (a small smolt tagged on April 22 and recovered on September 20) the relationship remains non-significant ($P = 0.1$, $R^2 = 0.023$). When large and small smolt are analyzed separately (Figure 4), $R^2 = 0.0006$ for large smolt ($n = 66$, $P = 0.85$), and $R^2 = 0.067$ for small smolt ($n = 53$, $P = 0.06$). When the outlier noted above is removed from the small-smolt analysis, the relationship is significant ($R^2 = 0.16$, $n = 52$, $P = 0.003$).

McCurdy (2008) provides further details on the 2006 escapement of coho salmon to Chuck Creek.

2007 Escapement

In 2007, a total of 425 adult and 368 jack coho salmon were counted past the weir on Chuck Creek between August 15 and October 15 (Appendix A5). Life-history type (adult, jack) was assumed to be accurately determined on all mature fish in the 2007 escapement, as no overlap in length between jacks and adults was detected by aging a random sample of 224 fish (Figure 5). In addition, all fish that measured between 380 mm and 450 mm MEF were sampled for age verification ($n = 9$, 4 random samples and 5 non-random samples); the largest jack measured 390 mm and the smallest adult measured 405 mm MEF. The temporal pattern of immigration of the escapement was similar to previous years. Timing of the coho salmon escapement was also similar to that reported during weir operations in 1982,

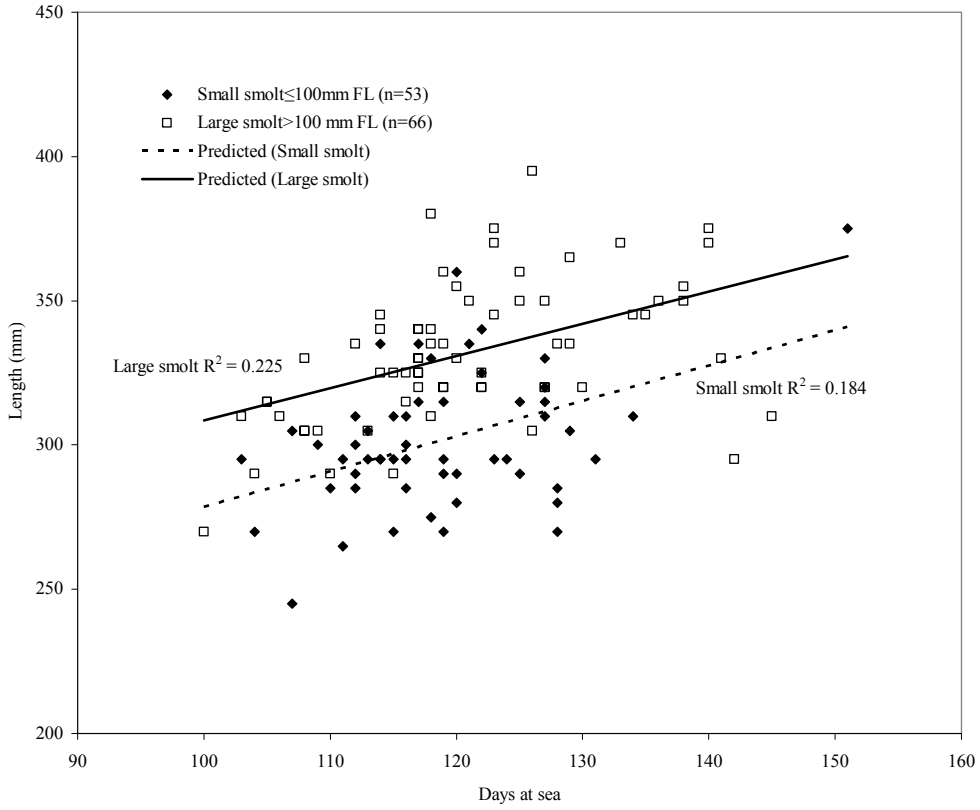

Figure 3.–Lengths (MEF) of jack coho salmon sampled at the Chuck Creek weir in 2006 plotted vs. days at sea (days between capture as smolt and mature fish); $R^2 = 0.196$ for all jacks combined.

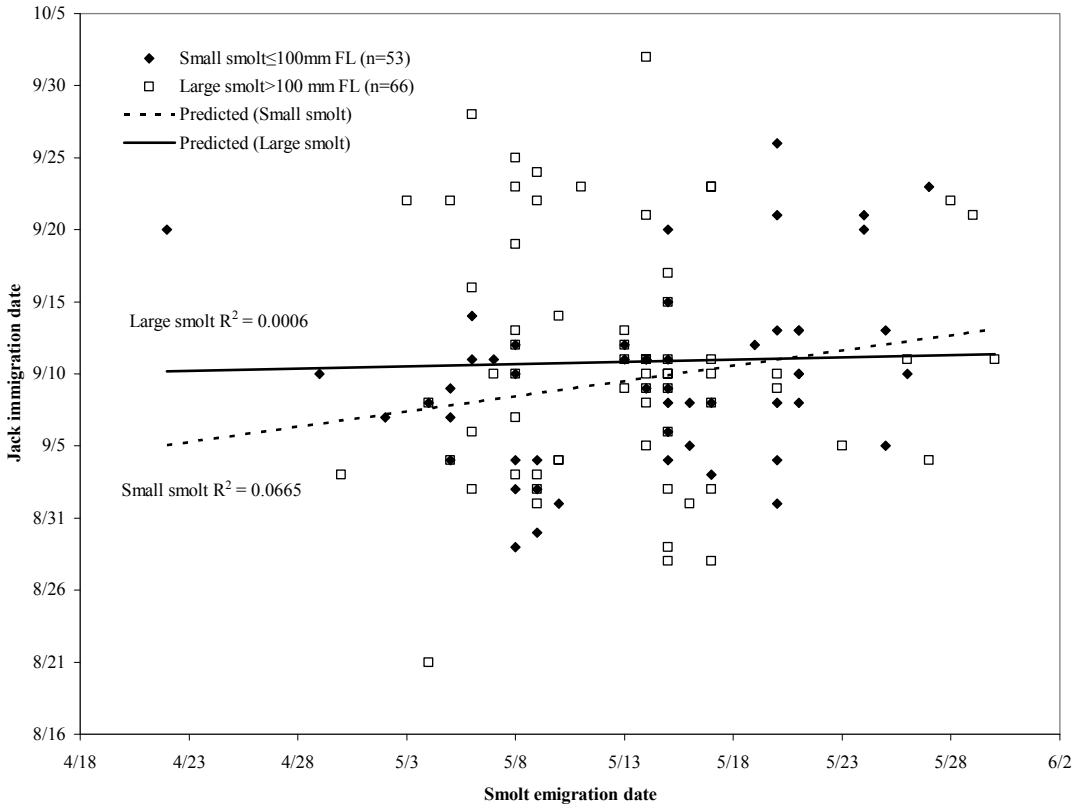

Figure 4.–Date of smolt emigration (capture at weir) plotted by immigration date (capture at weir) of jack coho salmon from the 2006 Chuck Creek smolt emigration; R^2 = 0.012 for all jacks combined.

1983, and 1985 (Integrated Fisheries Database, Commercial Fisheries Division, Douglas), and in 1950 (Edgington et al. 1981). A small number of mature coho salmon likely entered Chuck Creek after the weir was dismantled on October 15, however this number is likely a very small percentage of the total return as past weir operations have shown few fish return after this date (McCurdy 2005).

Twenty two percent of the adult escapement and 27% of the jack escapement that was passed through the weir had a scale sample taken that allowed for age estimation (Table 6). The sample size was larger for length and sex determination than age determination (Table 6), as length and sex was measured and estimated on all fish sampled, but not all scale samples were readable because some had regenerated scales. An estimated 34.0% (SE = 4.1%) of the 425 adult coho salmon counted in the escapement were male. The vast majority of both jack and adult coho salmon in the 2007 escapement had emigrated as age-1 smolt (Table 6).

A total of 249 adult sockeye salmon, 20 jack sockeye salmon (males < 400 mm MEF), 38 chum salmon, and 4,489 pink salmon, 9 Dolly Varden, and 3 steelhead trout were also counted through the weir between August 15 and October 15, 2007 (Appendix A6). Escapements were larger than weir counts for all salmon species as an unknown number of sockeye and pink salmon passed upstream of the weir site before weir installation on August 15, and a number of pink and chum salmon spawned downstream of the weir site (personal observations). When the weir was installed on August 15, the water was extremely low making fish migration difficult. No sockeye and only one pink salmon were observed upstream of the weir site when a foot survey was conducted to the lake on August 16. It is likely that few fish (sockeye or pink salmon) entered the stream before installation of the weir due to the

Table 6.–Estimated freshwater age composition, and mean length-at-age (MEF) and sex of the 2007 Chuck Creek coho salmon escapement.

	Age 1.0	Age 2.0	All jacks[a]	Age 1.1	Age 2.1	All adults[a]
Females						
Sample size	0	0	0	62	1	68
Percent				98.4%	1.6%	100.0%
SE percent				1.4%	1.4%	
Mean length (mm)				591	630	592
SE mean length (mm)				5	na	5
Males						
Sample size	93	5	122	29	0	35
Percent	94.9%	5.1%	100.0%	100.0%	0.0%	100.0%
SE percent	1.9%	1.9%		0.0%	0.0%	
Mean length (mm)	325	353	327	602		602
SE mean length (mm)	2	5	2	8		7
All fish						
Sample size	93	5	122	91	1	103
Percent	94.9%	5.1%	100.0%	98.9%	1.1%	100 .0%
SE percent	1.9%	1.9%		1.0%	1.0%	
Mean length (mm)	325	353	327	595	630	596
SE mean length (mm)	2	5	2	4	na	4

[a] Includes fish that were sampled for sex and length, but not successfully aged. A total of 425 adults and 368 jacks were counted through the weir in 2007.

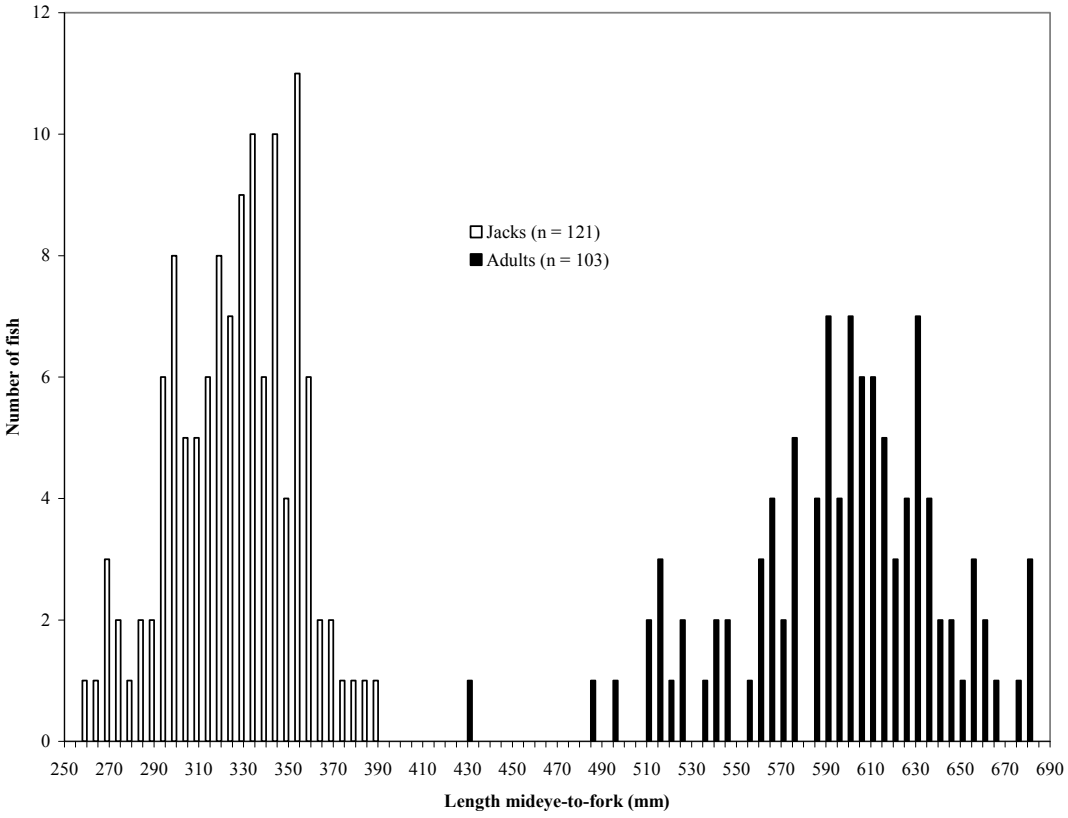

Figure 5.–Length frequency of the coho salmon escapement sampled at the Chuck Creek weir in 2007, by saltwater age. Note that the sampling rate differed between jacks (every 3rd jack encountered) and adults (every 4th adult).

low flows and high water temperatures. The crew observed Dolly Varden passing between the pickets on the weir and it is likely that the weir captured only a small percentage of immigrating Dolly Varden. The 3 steelhead captured were all less than 400 mm FL, appeared to have recently entered the stream from the marine environment (bright silver coloration, and in one case sea lice were present), and showed no external characteristics that allowed for sex determination (i.e., appeared to be immature).

RECOVERY OF CWTS AND ESTIMATES OF HARVEST, RETURN, AND MARINE SURVIVAL

In a random sample of adult coho salmon captured at the weir in the 2007 escapement, all adults found to be missing an adipose fin (n = 78) also tested positive for the presence of a CWT in their snout. Thus, the tagged fraction (θ_{cwt}) used to estimate marine harvest was the same fraction of the adult escapement missing adipose fins (θ = 0.778), as all adults missing an adipose fin were assumed to have retained their CWT.

A total of 153 adult coho salmon tagged as smolt emigrating from Chuck Creek in 2006 were recovered in creel and port sampling programs that sampled marine fisheries in Alaska in 2007 (Appendix A7), and another 11 fish were recovered in sampled Canadian fisheries. Of the 153 marine recoveries of coded wire tagged coho salmon from Chuck Creek in Alaskan waters, 132 were random samples that were useful for estimating marine harvest in various fisheries (Appendix A8). The greatest number (104) of the random CWT recoveries of Chuck Creek coho salmon were in the troll fishery, and the remainder were in the seine (14) and the sport fisheries (14). There were also 18 random recoveries in marine fisheries where the fishing area was not designated and 3 non-random recoveries (Appendix A7). Of the random troll recoveries, 75 were recovered in the SW quadrant, 21 in the NW quadrant, and 8 in the SE quadrant. Seine recoveries were in fishing Districts 102, 103 and 104 (Appendix A1). Sport fish recoveries were from the ports of Sitka, Craig/Klawock, and Ketchikan. Of the 11 recoveries in Canadian waters, 4 were random samples useful for estimating marine harvest in commercial fisheries; one was a voluntary recovery in the sport fishery that was also useful in estimating marine harvest; and the other 6 were non-random recoveries. Harvest of CWT marked salmon in Canadian sport fisheries is estimated using an "awareness factor" that is based on the voluntary recovery of heads from adipose fin-clipped salmon and on extrapolations of data from previous years according to protocols established by the Chinook Technical Committee of the Pacific Salmon Commission. All of the 11 Canadian recoveries were sampled in Northern British Columbia, 8 were recovered in the troll fishery, and one each in the seine, gillnet and sport fisheries. More details on the Canadian recoveries is available from the Pacific States Marine Fisheries Commission's (PSMFC) Regional Mark Information System (RMIS) database.

An estimated 782 (SE = 61) coho salmon originating from Chuck Creek were harvested in marine commercial and sport fisheries in 2007 (Appendix A8). The commercial troll fishery in Alaska harvested an estimated 577 fish or 74% of the total harvest. The Alaskan purse seine fishery harvested an estimated 116 fish, or 15%, of the total harvest (Table 7), and the Alaskan sport fishery harvested an estimated 29 fish, or 4%, of the total. Marine fisheries in Northern British Columbia harvested an estimated 60 fish or 8% of the total harvest. Harvested fish were sampled from early July through mid-September (Figure 6, Appendix A5).

The total return of Chuck Creek adult coho salmon was estimated at 1,207 fish (SE = 61) in 2007. Marine survival to adult of the 2006 smolt emigration was estimated at 7.7% (SE = 0.4%) and the exploitation rate in marine fisheries was estimated at 64.8% (SE = 1.8%). An additional 572 fish, or 3.7% (SE = 0.05%) of the estimated 15,604 smolt that emigrated in 2006 survived to return as jacks in the same year as their emigration (McCurdy 2008).

L*arge* tagged smolt were recovered as adults at a rate of 1.4% (61/4,477) and *small* smolt were recovered at a rate of 1.2% (= 104/8,468; Table 4). These were not a significantly different recovery rates (χ^2 = 0.4, df = 1, P = 0.5; Table 5).

There was a significant difference in the average length of the adults recovered in marine fisheries

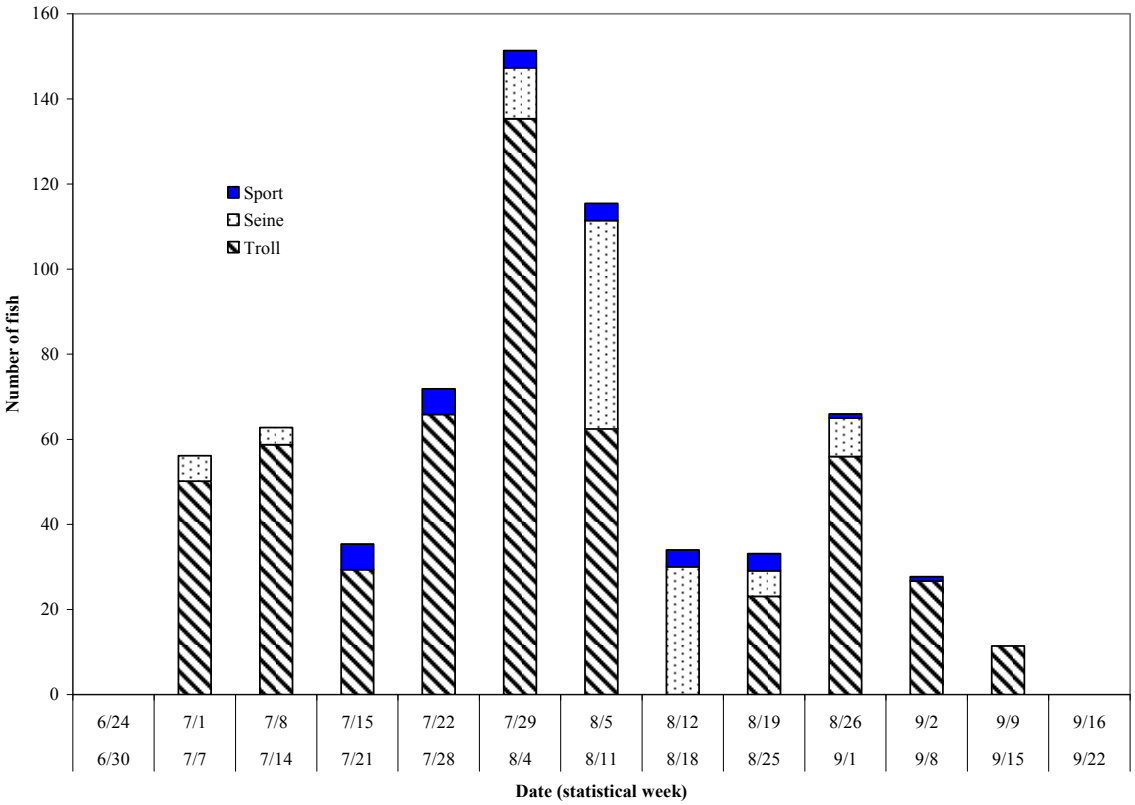

Figure 6.–Estimated marine harvest in Alaskan waters of coho salmon bound for Chuck Creek by statistical week and fishery in 2007.

between those tagged as *small* smolt or *large* smolt (t = 2.2, assuming unequal variance, df = 109, P = 0.02, Appendix A7); adults originating from *small* smolt averaged 552.3 mm FL (SD = 41.6), and adults from *large* smolt averaged 568.5 mm FL (SD = 43.6).

DISCUSSION

MARINE SURVIVAL

Survival to maturity of coho salmon smolt has been shown to be a function of smolt size and/or emigration date (Bilton et al. 1982; Hagar and Noble 1976; Mathews and Ishida 1989; Holtby et al. 1990; Lum 2003). Smolt size and/or emigration date has also been shown to affect age-at-maturity of male coho salmon in studies of hatchery coho salmon (Hagar and Noble 1976; Bilton et al. 1982; Vøllestad et al. 2003) and wild coho salmon (Lum 2003). Larger smolt that are released or emigrate earlier have been shown to produce more jacks than smaller smolt that are released or emigrate later (Bilton et al. 1982; Lum 2003). In addition, studies point to freshwater processes, rather than marine processes, being the dominant forces affecting the frequency of jacks in coho populations (Koseki and Fleming 2006, 2007; Vøllestad et al. 2003), indicating that at the time smolt emigrate, the life history type (jack or adult) of the emigrants has been largely determined.

Differences in survival and propensity to mature as jacks were examined for tagged fish in this study by dividing the data for tagged smolt into two equal emigration time periods (*early* and *late)* and two size groups (*small* and *large,* Table 4). All smolt captured in 2006 were tagged with a unique, sequentially numbered CWT that identified their date of emigration (date of capture) and their inclusion into one of two size categories (*small* smolt ≤ 100 mm FL and *large* smolt > 100 mm FL, Appendix A2).

Table 7.–Estimated harvest, exploitation rate, and total return of Chuck Creek coho salmon in 2007.

Fishery	Area	Estimated harvest	SE (harvest)	Percent of harvest	Exploitation rate	SE (exploitation rate)
Alaska troll	NW Quadrant	103	20	13.2%	8.6%	0.6%
	SW Quadrant	418	44	53.4%	34.6%	1.3%
	SE Quadrant	56	19	7.1%	4.6%	0.6%
	subtotal	577	52	73.8%	47.8%	1.6%
Alaska seine	District 102	19	11	2.5%	1.6%	0.3%
	District 103	30	17	3.9%	2.5%	0.5%
	District 104	66	23	8.5%	5.5%	0.7%
	subtotal	116	30	14.8%	9.6%	0.9%
Alaska sport	Ketchikan	3	2	0.4%	0.2%	0.1%
	Sitka	15	7	1.9%	1.3%	0.2%
	Craig/Klawock	11	2	1.4%	0.9%	0.1%
	subtotal	29	7	3.7%	2.4%	0.2%
Canada troll	North B.C.	10	6	1.3%	0.8%	0.2%
Seine	North B.C.	2	1	0.2%	0.2%	0.0%
Gillnet	North B.C.	3	3	0.4%	0.3%	0.1%
Sport	North B.C.	45	NA	5.8%	3.7%	NA
	subtotal	60		7.7%	5.0%	
Total harvest		782	61	100.0%	64.8%	1.8%
Escapement		425			35.2%	
Total return		1,207	61		100.0%	

Subsequently, 284 of these uniquely tagged fish were recovered (Appendices A2, A4 and A7) as either adults in 2007 (164 in marine fisheries and 1 in the escapement), or jacks in the 2006 escapement (119 fish). It's assumed that all recoveries represent an unbiased sample of surviving fish.

The *early* smolt emigration period ran from April 16 through May 9 (smolt tagged = 2,946; subsequent recoveries = 70; Appendix A2), and the *late* period ran from May 10 through June 2 (smolt tagged = 9,999; recoveries = 203). No trend in survival to maturity (adults and jacks combined) as a function of emigration date is apparent based on these recoveries (Figure 7). However, the recovery rate for fish that returned as jacks decreased significantly from the *early* to the *late* emigration period (χ^2 = 10.7, P = 0.001, Tables 4 and 5), while a significant difference was not found for returning adults (χ^2 = 2.6, P = 0.11, Table 5).

Smolt size was related to the recovery rate of marked fish in this study as *large* smolt were recovered at maturity (jacks and adults combined) at a rate of 2.84% (Table 4), while *small* smolt were recovered at a rate of 1.85%. These are significantly different recovery rates (χ^2 = 13.2, P < 0.001, Table 5), and the difference is mostly due to *large* smolt being recovered at a higher rate as jacks than were *small* smolt.

In this study, a larger portion of the *large* smolt emigrated during the *early* period than did *small*

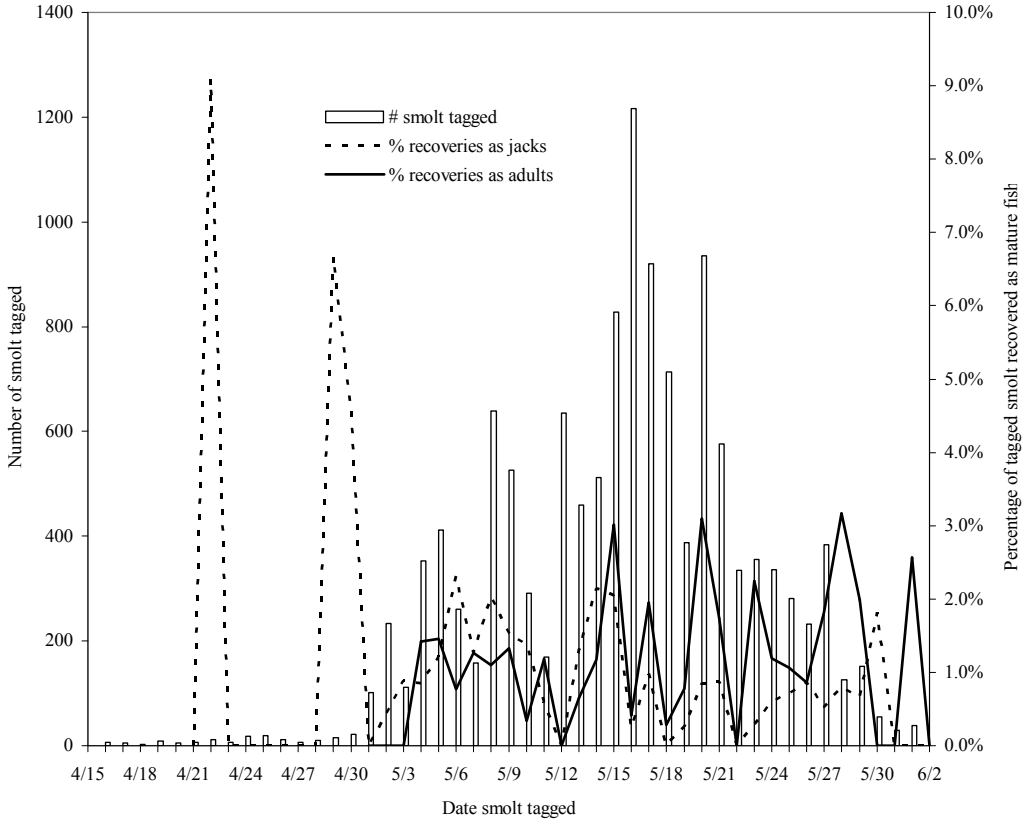

Figure 7.–Number of smolt tagged by date, and their subsequent recovery rate as mature fish sampled in marine fisheries and escapement sampling from the 2006 Chuck Creek coho salmon smolt emigration. Note that sampling rates differed between jacks and adults. Tagged jacks were sampled at a rate of approximately 23.9%, and tagged adults at approximately 17.2%. Note: There is a strong correlation between the recovery rates for tagged jacks and tagged adults by tagging date (R^2 = 0.69, P < 0.0001, tagging May 1 thru May 29, when >100 smolt were tagged and recoveries of 1 or more fish were expected).

smolt (Figure 2). This is consistent with other studies where larger coho salmon smolt tended to emigrate earlier in the wild than smaller fish (Thedinga and Koski 1984; Irvine and Ward 1988; but see Holtby et al. 1989; Quinn and Peterson 1996; Lum 2003). Smolt size does not explain all of the significant difference in the recovery rate of jacks between the early and late time periods in this study, as early-emigrating, small smolt came back as jacks at a significantly higher rate than late-emigrating, small smolt (1.18% versus 0.50%, $\chi^2 = 9.1$, P = 0.003, Tables 4 and 5).

Summarizing recovery rates as jacks, *large* smolt returned as jacks at a higher rate than *small* smolt and *early* smolt returned as jacks at a higher rate than *late* smolt. Because the proportion of large and small smolt differed between emigration period, differences in recovery rates between the two emigration periods was likely influenced by smolt size, and conversely, emigration period likely influence recovery rates between size groups. The observed differences in recovery rates can be due to different survival rates and/or differences in the proportions of emigrants likely, or "predetermined," to return as jacks. It seems reasonable to assume smolt from the earlier emigration period contained a higher portion of "predetermined" jacks than later migrating smolt, and that a higher portion of large smolt were more likely "predetermined" to be jacks than small smolt. Under this model, fish predetermined to mature as jacks are unavailable to be recovered as adults, and in fact, the lowest recovery rate for adults is the 0.85% seen for early-emigrating, large-sized smolt (Table 4). Conversely, the early-emigrating, large-size smolt had the highest recovery rate as jacks.

In this study, the marine mortality rate is an estimated 88.6% ($1-[1{,}207_{adults}+572_{jacks}]/15{,}604_{smolt}$), nearly identical to the average of 87.8% for Chuck Creek coho salmon over the previous 4 years (McCurdy 2008) and within the range reported in the literature (Groot and Margolis 1991). Other studies have suggested that a significant portion of marine mortality occurs shortly after the fish have entered the marine environment (e.g., Fisher and Pearcy 1988; Briscoe et al. 2005). Data collected in this study is consistent with this hypothesis. First, there has been a nearly constant proportion of surviving jacks (to all surviving jacks and adults) from all the tagged smolt cohorts (range 23.3% to 32.3%, for emigration years 2002–2006). This ratio would likely have greater variability if the majority of the mortality occurred after the time the jacks had returned (given that the population has some intrinsic rate of producing jacks, Quinn 2005). Also, there is a strong correlation between the recovery rates of tagged jacks and tagged adults across their emigration dates in this study (r = 0.69, for emigration days May 1 through May 29; Figure 7). Note that it seems reasonable to examine the days when sufficient smolt were tagged to make recovering a surviving fish likely. By limiting analysis of the data to days when at least 100 smolt were tagged, i.e., May 1 through May 29, the probability of not sampling a surviving fish was ≤0.1 (Appendix A9). This correlation places the mortality forces shared by each return group (jack and adult) from each emigration day at times when the two groups are in close proximity, and prior to complete mixing of the daily tag groups in space and time. It is hard to imagine a natural mortality schedule that leads to such similar tag recovery rates and nearly constant annual (23% to 32%) proportions of surviving jacks, that does not require most mortality to occur in the very early marine experience.

Although significant variation in the recovery rates of mature fish from the daily smolt tagging groups is to be expected, the data suggest the variation in this study is due to more than random chance. Besides the significant correlation between jack and adult recoveries from individual smolt days, contingency table analysis of the tagged fish (date tagged vs. numbers recovered and numbers not recovered) shows that the recovery probabilities vary significantly by tagging date ($\chi^2 = 116$, df = 28, P < 0.0001; Appendix A9). Also, from each smolt emigration day, fish either survive and are recovered or not, and this suggests a binomial model. Using this model, probabilities of recovering the observed number of recoveries (for the number of fish tagged from each smolt emigration day) can be calculated. The probability of success (recoveries) in each trial was the average recovery probability for the entire data set (2.19% or 284/12,945). This test found that on 6 of the 28 tagging days (21%

of days) from May 1 to May 29, the probability was well below 0.0001 of recovering *as few as or as many as* the observed number of recoveries (see Appendix A9). This result (under the binomial model) suggests a simple binomial process is not leading to the observed recovery data (e.g., at most 3 deviant days using a 90% experiment-wise error rate might be expected). Logic suggest that a mortality component acting on near a "daily" basis is the source of this *variation* in the daily recovery rate, and that this is occurring very near the time of marine entry (before smolt from different emigration days mix in time and space).

Four factors have been identified as major sources of marine mortality for coho salmon smolt: predation, starvation, disease, and/or ability to adapt to salt water (Mathews and Ishida 1989). Predation would seem to be the most likely cause of the *variation* in mortality affecting the 2006 Chuck Creek coho salmon smolt emigration, as starvation, disease, and/or ability to adapt to salt water as major causes of mortality would not be expected to show such daily variation. This is not to say whether the cause(s) of mortality that led to the observed *variation* is responsible for much of the overall observed mortality, or not, because other mortality forces of significantly greater magnitude could act similarly after smolt from different emigration days have mixed in time and space.

Although the smolt capture and tagging process cannot be ruled out as the cause of some of the variation in the survival observed, it seems unlikely, as smolt were captured, held, tagged and released at the same time using the same procedures every day. The short-term (overnight) mortality rate of tagged fish in this study is only 0.14% (= 95/68,163 for years 2002–2006), and majority of this mortality occurred during the tagging procedure (i.e. dropped fish, fish left too long in the solution of MS-222), with almost no mortality occurring overnight. Also, coho salmon smolt are believed to robustly survive typical coded wire tagging procedures (Vincent-Lang 1993; Magnus et al. 2006). Finally, it is also worth noting that daily recovery rates were not correlated to the number of smolt emigrating (r^2 = 0.03, P = 0.36, for days May 1 through May 29) or to the daily mean length of the smolt (r^2 =0.005, P = 0.73, for days May 1 through May 29).

SMOLT ABUNDANCE

The smolt weir appeared to be operational and virtually 100% effective at capturing coho salmon smolt prior to significant emigration in 2006 (Appendix A2, Figure 2). However, an estimated 17.1% of the escapement from the 2006 smolt emigration was unmarked. It seems reasonable to assume that the majority of these unmarked fish emigrated after the smolt weir was removed on June 4, 2006. Therefore, it appears that all coho salmon smolt did not have an equal probability of being marked in this study.

The unequal probability of marking noted above would bias the smolt abundance estimate if the marked and unmarked fish survived at different rates. Differences in survival rates between marked and unmarked smolt in this study cannot be tested for, but comparisons of survival rates between different tagged groups of fish is discussed above. Also, a simple simulation (used in past Chuck Creek studies) to estimate potential bias in the smolt abundance estimate as related to different survival rates between marked and unmarked smolt can be conducted.

Although the portion of the smolt emigration that was unmarked in this study likely contained lower proportions of *large* smolt and of "predetermined" jacks than the portion of the emigration that was marked (based on their likely emigration date and analysis of CWT recovery trends in the tagged population), there is no data suggesting that their overall survival rate varied greatly one way or the other from marked smolt. However, it is unlikely that unmarked and marked fish survived at the same rate in this study (knowing that emigration date and smolt size do affect survival to maturity in coho salmon). In past years at Chuck Creek the survival rate of marked fish has been a function of emigration date (McCurdy 2006a-b). However, a model used to estimate potential bias in smolt abundance estimates in those years demonstrated it would take a very large difference in the survival rate between marked and unmarked fish to greatly bias the smolt abundance estimates (McCurdy 2006a-b).

By applying the same model (Appendix A10) to the 2006 smolt emigration, potential bias in the abundance estimate can be estimated by conducting simulations where *unmarked* fish survive to maturity (to either jack or adult) at a rate different than the 11.1% survival rate of *marked* fish estimated in this study. If *unmarked* fish survive at 13.9% (a rate 25% higher than the rate of 11.1% for marked fish) then the smolt abundance estimate in this report (15,604) would be biased by -1.2% (and the actual abundance would be 15,419). Similarly, if the actual survival rate for unmarked fish was 8.3% (25% lower than for marked fish) the smolt abundance estimate would be biased by 8.6% (and actual abundance would be 17,068). These simulations suggest it would require a large difference in survival rates between marked and unmarked fish to greatly bias the smolt abundance estimate.

The apparent propensity for earlier emigrating marked smolt to return as jacks at a higher rate than subsequent marked emigrants in this study (Figure 7) helps explain the significant difference in the marked fraction between jacks (θ = 0.868) and adults (θ = 0.778) noted above; as it is likely that most untagged fish emigrated after the smolt weir was removed, it seems reasonable to assume that the group of marked smolt contained a higher percentage of fish "predetermined" to return as jacks than the group of unmarked smolt.

SMOLT AWL SAMPLING

The age on a number of large age-1 fish was incorrectly estimated as age 2 in the known-age sample. Thus, it is likely that a portion of age-1 fish in the random sample (up to 10%) were also incorrectly estimated to be age-2 fish. Since this study will continue in 2007, known age-2 fish from the 2005 fry tagging will be collected to help evaluate aging on both age classes. Smolt AWL samples were also compromised by size-selective sampling. This problem will be eliminated in the future by systemically sampling fish as they are tagged.

RELATIONSHIP BETWEEN SMOLT EMIGRATION DATE AND JACK RETURN DATE

There was no significant relationship between the date of smolt emigration and jack immigration date for the 119 jacks sampled in the 2006 escapement. Nor was there a significant relationship between emigration and immigration dates when *small* and *large* smolt were analyzed separately. When one outlier (a smolt tagged on April 22 and recovered on September 20) is removed from analysis of *small* smolt, the relationship is significant (R^2 = 0.16, n = 52, P = 0.003).

Entry into natal streams by anadromous salmonids can be influenced by environmental factors such as water temperature and stream discharge (Holtby et al. 1984; Sandercock (in Groot and Margolis 1991). Holtby et al. (1984) noted that the immigration of mature coho salmon at Carnation Creek on the west coast of Vancouver Island, Canada, was pulsed in years with few freshets and that fish would enter the stream during these events. Sandercock (in Groot and Margolis 1991) noted that coho salmon will hold off stream mouths for several weeks or more before entering if stream conditions are unsuitable. In past years at Chuck Creek, the author and/or crew would commonly observe adult and jack coho salmon that were holding off the stream mouth, and that would often enter the tidally-influenced portion of the stream at high tide, but would back out of the stream with the ebb of the tide if the stream level was low. In addition, the Chuck Creek jack immigration (and all other salmonids) would be pulsed and peak catches occurred during high water events caused by freshets (McCurdy 2008). In 2006, the jack immigration was also pulsed (Figure 8) and peak catches were associated with rising or high water. It seems reasonable to assume that at Chuck Creek some fish enter the stream soon after arriving in the proximate vicinity of the stream and others delay until stream conditions are suitable. Hence, sampling for return date in this experiment (if "return" is defined as to the proximate vicinity of the stream mouth) is likely biased, as fish cannot be captured any earlier than the date they return, but they can be captured days after their return (i.e., if they hold off the stream mouth). If "return date" had been defined as return to the vicinity of the stream mouth then environmental factors in the stream that influence entry could be controlled in this experiment. However there is no practical way to capture fish when they arrive at the stream mouth.

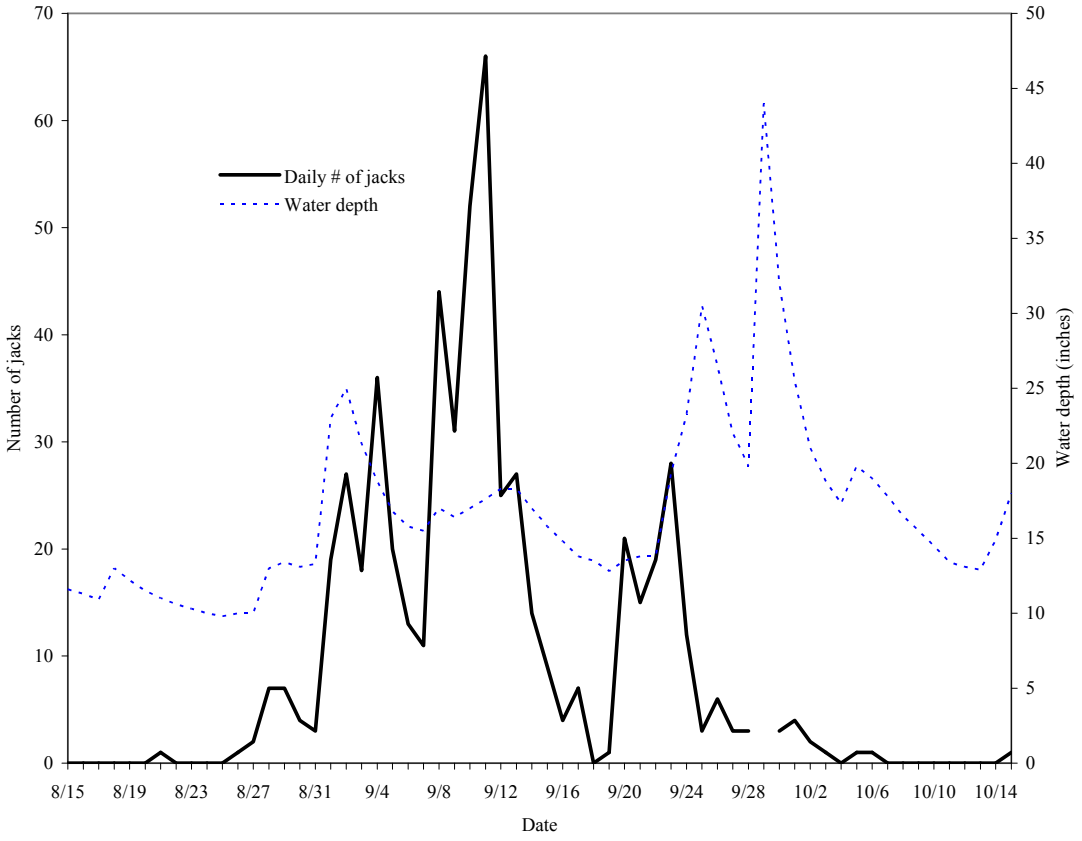

Figure 8.–Daily weir counts of jack coho salmon and stream water depth at Chuck Creek in 2006. Note: weir cage was closed on September 29 due to extreme high water.

Any environmental influences in the marine environment that may influence migration and return date can also not be controlled for this experiment.

Even if the environmental factors just mentioned could be controlled, it seems reasonable to expect that any relationship between emigration and immigration dates would be minimal. Timing of both migration events are controlled by seasonal day length, with other factors acting more as proximate stimuli that trigger a migration event. The vast majority of the smolt that emigrate do so in a small time frame of a few weeks in May (in 2006, 85% of all smolt captured emigrated in a 20-day period; Appendix A2) and the vast majority of the mature fish return in a short time frame of a few weeks in September (in 2006, 91% of all jacks captured immigrated during a 24-day period; Appendix A5). These time periods have obviously been selected by evolutionary processes as being the best migration time (on average) to increase both survival and reproductive success. However, there is temporal variation in both migrations among individuals (as one would expect of an organism that has evolved in such a dynamic ecosystem, particularly during their freshwater life history stage). Given the constraints listed above (both the life history characteristic of coho salmon and the experimental design) it could be difficult to detect a relationship (if one exists), as sampling design may be inadequate to detect a relationship that is likely mild at best. A similar experiment was conducted at Chuck Creek in 2005 (McCurdy 2008), where a simple linear regression analyzing emigration and immigration date of 76 jack coho salmon yield a significant relationship (R^2 = 0.071, P = 0.02) when smolt were not divided into size categories. The results from 2005 and the mixed results from 2006 are not definitive one way or the other.

Table 8.–Estimated harvest, escapement, total return, and exploitation rate of adult coho salmon from Chuck creek in years with returning coded wire tagged fish.

	Harvest							
Return year	Alaska troll	Alaska seine	Alaska sport	Canadian fisheries[a]	Total harvest	Escapement	Total adult return	Exploitation rate
1982[b]	1,320	418			1,738	1,017	2,755	63.1%
1983[b]	551	618			1,169	1,238	2,407	48.6%
1985[b]	1,906	975			2,881	956	3,837	75.1%
2003[c]	539	252	83		874	614	1,488	58.7%
2004[d]	725	179	76		980	606	1,586	61.8%
2005[e]	652	232	120		1,004	646	1,650	60.8%
2006[f]	401	32	8	7	448	409	857	52.3%
2007	577	116	29	60	782	425	1,207	64.8%

[a] Includes all marine fisheries (commercial troll, seine, gillnet and sport).

[b] Estimates from Shaul et al. 1991.

[c] Estimates from McCurdy 2005.

[d] Estimates from McCurdy 2006a.

[e] Estimates from McCurdy 2006b.

[f] Estimates from McCurdy 2008.

MARINE HARVEST

Harvest distribution patterns in Alaskan waters in 2007 were similar to past years (Shaul et al. 1991; McCurdy 2005; 2006a-b; 2008); almost all harvest occurred in districts along the outside coast (Appendices A1 and A7). The estimated harvest of 60 Chuck Creek coho salmon in Canadian waters in 2007 was unusually high compared to previous years (this was only the second year in the last five that coded wire tagged Chuck Creek coho salmon were recovered in sampled Canadian fisheries), and it seems reasonable to speculate that more Chuck Creek coho salmon than usual migrated through Canadian waters in 2007 (as opposed to any changes in Canadian fisheries or sampling programs). The estimated marine harvest of 782 Chuck Creek coho salmon and the estimated total run of 1,147 fish were the second smallest to date (for years when this stock has been monitored), with only 2005 producing fewer adult fish (Table 8). The small total run was due to an average smolt emigration coupled with below average marine survival. The marine exploitation rate of 64.8 % in 2007 was higher than the previous 4 years (Table 8).

The escapement of sockeye and pink salmon to Chuck Creek in 2007 were by far the lowest to date since the start of this project in 2001; the number of sockeye and pink salmon counted through the weir were 14% and 18% of the previous 6-year average for each species, respectively. Regionwide sustainable escapement goals (SEGs) for pink salmon were met or exceeded for 40 of 44 stock groups, and regional harvest was near the 10-year average; Districts 103 and 104 produced about half of this harvest (Nelson et al. 2008). This high effort and harvest by the seine fleet that occurred in commercial fishing Districts 103 and 104 likely influenced the low escapement of Chuck Creek pink salmon. Run timing of Chuck Creek sockeye salmon is very similar to local pink salmon stocks and it is likely that the seine fishery in Districts 103 and 104 also harvested a large portion of the 2007 sockeye salmon run.

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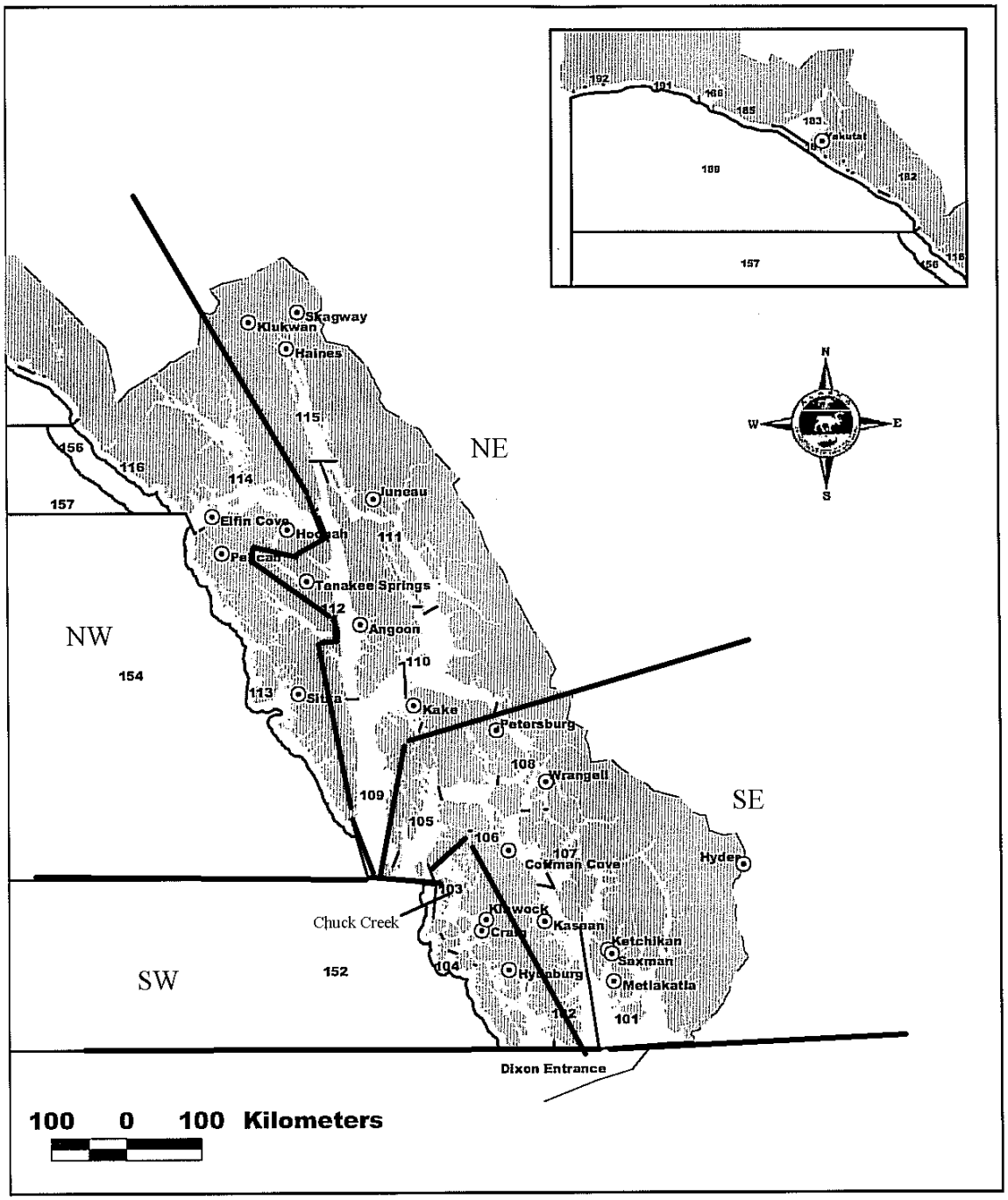
APPENDIX A



Appendix A1.–Map of Southeast Alaska commercial fishing districts and troll quadrants.

Appendix A2.–Summary of coho salmon smolt tagged with coded wire tags, held overnight, and released following sampling for tag retention at Chuck Creek in 2006; and subsequent recoveries of mature fish in marine fisheries (as adults in 2007) and escapement sampling (as jacks in 2006).

				Number released with CWTs[a]			Range of sequential CWT numbers			Recovered as adult		Recovered as jack	
Date	Tag code	Total tagged	Overnight mortality	Total	Small smolt	Large smolt	Start small	End small[b]	End large	Small smolt	Large smolt	Small smolt	Large smolt
4/16	41303	6	0	6	1	5	131	134	145	0	0	0	0
4/17	41303	5	0	5	0	5	na	150	165	0	0	0	0
4/18	41303	2	0	2	0	2	na	168	186	0	0	0	0
4/19	41303	9	0	9	1	8	190	200	214	0	0	0	0
4/20	41303	5	0	5	0	5	na	225	238	0	0	0	0
4/21	41303	6	0	6	0	6	na	247	262	0	0	0	0
4/22	41303	11	0	11	2	9	266	277	292	0	0	1	0
4/23	41303	7	0	7	1	6	338	344	356	0	0	0	0
4/24	41303	18	0	18	1	17	362	369	400	0	0	0	0
4/25	41303	19	0	19	3	16	412	418	447	0	0	0	0
4/26	41303	11	0	11	2	9	454	463	484	0	0	0	0
4/27	41303	6	0	6	2	4	496	506	515	0	0	0	0
4/28	41303	10	0	10	6	4	522	537	545	0	0	0	0
4/29	41303	15	0	15	10	5	554	575	584	0	0	1	0
4/30	41303	22	0	22	8	14	592	609	635	0	0	0	1
5/1	41303	101	0	101	35	66	666	751	830	0	0	0	0
5/2	41303	233	0	233	92	141	866	1,014	1,240	0	0	1	0
5/3	41303	112	0	112	56	56	1,288	1,378	1,472	0	0	0	1
5/4	41303	354	1	353	116	237	1,513	1,702	2,084	2	3	1	2
5/5	41303	412	0	412	280	132	2,122	2,579	2,795	4	2	3	2
5/6	41303	260	0	260	131	129	2,834	3,049	3,260	1	1	2	4
5/7	41303	158	0	158	100	58	3,299	3,464	3,599	2	0	1	1
5/8	41303	639	0	639	363	276	3,601	4,194	4,642	3	4	5	8
5/9	41303	526	0	526	319	207	4,677	5,195	5,531	5	2	3	5
5/10	41303	291	0	291	216	75	5,593	5,945	6,068	1	0	1	3
5/11	41303	169	0	169	115	54	6,105	6,293	6,382	0	2	0	1
5/12	41303	635	0	635	440	195	6,421	7,134	7,452	0	0	0	0
5/13	41303	459	0	459	265	194	7,497	7,927	8,241	2	1	2	4
5/14	41303	512	0	512	310	202	8,278	8,781	9,110	3	3	3	8
5/15	41303	828	0	828	541	287	9,148	10,021	10,491	20	5	7	10
5/16	41303	1,225	9	1,216	873	343	10,532	11,955	12,520	5	0	2	1
5/17	41303	922	2	921	453	467	12,560	13,299	14,059	5	13	2	7

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Date	Tag code	Total tagged	Overnight mortality	Number released with CWTs[a] Total	Small smolt	Large smolt	Range of sequential CWT numbers Start small	End small[b]	End large	Recovered as adult Small smolt	Large smolt	Recovered as jack Small smolt	Large smolt
5/18	41303	714	0	714	462	252	14,089	14,840	15,249	2	0	0	0
5/19	41303	388	1	387	306	81	15,279	15,779	15,912	3	0	1	0
5/20	41303	942	7	935	712	223	15,940	17,100	17,468	21[c]	8	6	2
5/21	41303	576	0	576	437	139	17,502	18,211	18,448	5	5	5	0
5/22	41303	335	0	335	260	75	18,486	18,909	19,033	0	0	0	0
5/23	41304	358	2	356	264	92	160	582	731	5	3	0	1
5/24	41304	349	13	336	262	74	767	1,196	1,329	2	2	2	0
5/25	41304	281	0	281	226	55	1,357	1,721	1,809	2	1	2	0
5/26	41304	244	12	232	188	44	1,851	2,163	2,245	2	0	1	1
5/27	41304	396	12	384	302	82	2,279	2,773	2,919	4	3	1	1
5/28	41304	126	0	126	106	20	2,951	3,124	3,157	4	0	0	1
5/29	41304	153	2	151	109	42	3,191	3,368	3,440	1	2	0	1
5/30	41304	58	3	55	41	14	3,473	3,542	3,570	0	0	0	1
5/31	41304	29	0	29	21	8	3,604	3,638	3,652	0	0	0	0
6/1	41304	39	0	39	15	24	3,654	3,690	3,732	0	1	0	0
6/2	41304	33	0	33	15	18	3,736	3,767	3,798	0	0	0	0
Totals		13,009	64	12,945	8,468	4,477				104	61	53	66

[a] No smolt were detected that had shed their CWT after being tested for overnight tag retention.

[b] Small smolt were tagged prior to large smolt daily, so the ending sequential tag number for small smolt is the beginning number for large smolt.

[c] One of the 21 fish was sampled in the escapement.

Appendix A3.–Daily counts of downstream migrating sockeye salmon smolt, Dolly Varden, steelhead trout, cutthroat trout, and sculpin captured at the Chuck Creek weir, 2006.

Date	Sockeye smolt	Dolly Varden adults[a]	Dolly Varden juveniles[b]	Steelhead juveniles[c]	Cutthroat adults[a]	Cutthroat juveniles[b]	Sculpin
4/16	4	1	0	0	0	0	118
4/17	5	2	0	0	0	0	122
4/18	0	3	0	0	0	0	218
4/19	5	1	0	0	0	0	71
4/20	5	2	0	0	0	0	107
4/21	9	25	0	0	0	0	129
4/22	18	9	0	0	0	0	128
4/23	15	13	0	0	0	0	114
4/24	32	12	0	0	1	0	152
4/25	70	34	0	0	0	0	125
4/26	30	13	0	0	0	0	150
4/27	24	19	0	0	0	0	84
4/28	21	20	0	0	0	0	86
4/29	46	58	1	0	0	0	97
4/30	176	58	0	1	0	0	159
5/1	139	21	2	0	0	0	119
5/2	718	16	4	0	0	0	85
5/3	641	45	2	0	0	0	75
5/4	813	11	12	0	0	0	54
5/5	1,656	5	7	0	0	0	57
5/6	614	16	16	0	0	1	45
5/7	5,809	7	9	0	0	0	34
5/8	5,311	9	20	0	0	0	37
5/9	1,908	11	15	0	0	0	23
5/10	2,109	3	5	0	0	0	34
5/11	7,395	17	15	0	0	0	3
5/12	2,576	35	56	0	0	0	9
5/13	1,729	10	31	0	0	0	24
5/14	3,111	9	41	0	0	0	25
5/15	4,255	35	58	0	0	0	32
5/16	2,787	11	44	0	0	0	63
5/17	2,339	2	72	0	0	0	98
5/18	1,039	2	20	0	0	0	36

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Date	Sockeye smolt	Dolly Varden adults[a]	Dolly Varden juveniles[b]	Steelhead juveniles[c]	Cutthroat adults[a]	Cutthroat juveniles[b]	Sculpin
5/19	1,101	0	10	0	0	0	32
5/20	1,492	8	106	0	0	0	26
5/21	748	1	9	0	0	0	71
5/22	497	0	6	0	0	0	48
5/23	171	1	23	0	0	0	76
5/24	712	2	32	0	0	0	50
5/25	159	0	6	0	0	0	44
5/26	323	7	15	0	0	0	58
5/27	116	0	0	0	0	0	40
5/28	23	1	31	0	0	1	42
5/29	52	0	1	0	0	1	153
5/30	77	0	0	0	0	0	33
5/31	28	0	4	0	0	0	40
6/1	48	1	6	0	0	0	16
6/2	45	0	13	0	0	0	44
Totals	51,001	556	692	1	1	3	3,486

[a] Fish 175 ≥mm FL.

[b] Fish 175< mm FL.

[c] All fish sexually immature. Includes both fish that appear to be smolt and non-smolt.

Appendix A4.–Recoveries of coho salmon that were coded wire tagged in the 2006 Chuck Creek smolt emigration and subsequently recovered during escapement sampling.

Head no.	CWT code	Sequential CWT no.	Date tagged	Smolt size	Recovery date[a]	Sex	Age[b]	Length[c] (mm)
RANDOM ESCAPEMENT RECOVERIES								
320808	41303	272	4/22/06	small	9/20/2006	m	R	375
276866	41303	560	4/29/06	small	9/10/2006	m	1.0	310
276818	41303	625	4/30/06	large	9/3/2006	m	2.0	395
276835	41303	1,000	5/2/06	small	9/7/2006	m	1.0	285
320814	41303	1,419	5/3/06	large	9/22/2006	m	R	295
276840	41303	1,962	5/4/06	large	9/8/2006	m	1.0	320
276841	41303	1,633	5/4/06	small	9/8/2006	m	1.0	315
294098	41303	2,013	5/4/06	large	8/21/2006	m	2.0	305
276820	41303	2,553	5/5/06	small	9/4/2006	m	1.0	325
276822	41303	2,777	5/5/06	large	9/4/2006	m	R	320
276837	41303	2,206	5/5/06	small	9/7/2006	m	1.0	290
276852	41303	2,416	5/5/06	small	9/9/2006	m	1.0	310
320815	41303	2,634	5/5/06	large	9/22/2006	m	2.0	370
276809	41303	3,201	5/6/06	large	9/2/2006	m	1.0	335
276833	41303	3,230	5/6/06	large	9/6/2006	m	2.0	345
276885	41303	2,895	5/6/06	small	9/11/2006	m	1.0	280
276898	41303	2,990	5/6/06	small	9/14/2006	m	1.0	295
320801	41303	3,148	5/6/06	large	9/16/2006	m	1.0	370
320828	41303	3,240	5/6/06	large	9/28/2006	m	1.0	310
276864	41303	3,486	5/7/06	large	9/10/2006	m	1.0	305
276870	41303	3,441	5/7/06	small	9/11/2006	m	1.0	330
276802	41303	3,746	5/8/06	small	8/29/2006	m	1.0	295
276810	41303	3,744	5/8/06	small	9/2/2006	m	R	315
276816	41303	4,439	5/8/06	large	9/3/2006	m	1.0	310
276824	41303	3,610	5/8/06	small	9/4/2006	m	1.0	315
276836	41303	4,495	5/8/06	large	9/7/2006	m	1.0	325
276856	41303	4,317	5/8/06	large	9/10/2006	m	1.0	360
276858	41303	4,027	5/8/06	small	9/10/2006	m	1.0	315
276887	41303	4,455	5/8/06	large	9/12/2006	m	1.0	320
276889	41303	3,781	5/8/06	small	9/12/2006	m	1.0	320
276896	41303	4,639	5/8/06	large	9/13/2006	m	R	335
320805	41303	4,460	5/8/06	large	9/19/2006	m	R	345
320822	41303	4,634	5/8/06	large	9/23/2006	m	1.0	350
320826	41303	4,474	5/8/06	large	9/25/2006	m	1.0	375

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Head no.	CWT code	Sequential CWT no.	Date tagged	Smolt size	Recovery date[a]	Sex	Age[b]	Length[c] (mm)
276803	41303	5,043	5/9/06	small	8/30/2006	m	1.0	305
276805	41303	5,368	5/9/06	large	9/1/2006	m	R	325
276812	41303	5,264	5/9/06	large	9/2/2006	m	1.0	315
276813	41303	5,009	5/9/06	small	9/2/2006	m	R	310
276815	41303	5,317	5/9/06	large	9/3/2006	m	1.0	320
276821	41303	4,933	5/9/06	small	9/4/2006	m	1.0	275
320816	41303	5,384	5/9/06	large	9/22/2006	m	R	350
320824	41303	5,485	5/9/06	large	9/24/2006	m	2.0	355
276806	41303	5,656	5/10/06	small	9/1/2006	m	1.0	295
276823	41303	6,007	5/10/06	large	9/4/2006	m	1.0	330
276827	41303	6,006	5/10/06	large	9/4/2006	m	1.0	340
276897	41303	6,019	5/10/06	large	9/14/2006	m	1.0	350
320821	41303	6,329	5/11/06	large	9/23/2006	m	2.0	345
276851	41303	8,035	5/13/06	large	9/9/2006	m	1.0	360
276877	41303	8,201	5/13/06	large	9/11/2006	m	R	350
276882	41303	7,870	5/13/06	small	9/11/2006	m	1.0	335
276888	41303	8,214	5/13/06	large	9/12/2006	m	R	320
276890	41303	7,755	5/13/06	small	9/12/2006	m	1.0	340
276895	41303	8,188	5/13/06	large	9/13/2006	m	2.0	375
276829	41303	8,925	5/14/06	large	9/5/2006	m	2.0	340
276842	41303	8,799	5/14/06	large	9/8/2006	m	1.0	325
276853	41303	9,082	5/14/06	large	9/9/2006	m	R	380
276854	41303	8,293	5/14/06	small	9/9/2006	m	1.0	330
276867	41303	8,875	5/14/06	large	9/10/2006	m	1.0	320
276878	41303	8,907	5/14/06	large	9/11/2006	m	R	330
276879	41303	8,372	5/14/06	small	9/11/2006	m	2.0	360
276881	41303	8,915	5/14/06	large	9/11/2006	m	1.0	355
276883	41303	8,771	5/14/06	small	9/11/2006	m	1.0	290
320811	41303	8,884	5/14/06	large	9/21/2006	m	2.0	320
320829	41303	9,058	5/14/06	large	10/2/2006	m	2.0	330
276801	41303	10,266	5/15/06	large	8/29/2006	m	2.0	310
276811	41303	10,314	5/15/06	large	9/2/2006	m	1.0	290
276826	41303	9,543	5/15/06	small	9/4/2006	m	R	290
276832	41303	10,156	5/15/06	large	9/6/2006	m	R	345
276834	41303	9,400	5/15/06	small	9/6/2006	m	1.0	335

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Head no.	CWT code	Sequential CWT no.	Date tagged	Smolt size	Recovery date[a]	Sex	Age[b]	Length[c] (mm)
276845	41303	9,894	5/15/06	small	9/8/2006	m	1.0	300
276849	41303	10,128	5/15/06	large	9/9/2006	m	1.0	340
276855	41303	9,955	5/15/06	small	9/9/2006	m	1.0	335
276862	41303	10,383	5/15/06	large	9/10/2006	m	1.0	340
276863	41303	10,277	5/15/06	large	9/10/2006	m	1.0	335
276872	41303	10,149	5/15/06	large	9/11/2006	m	1.0	320
276876	41303	9,714	5/15/06	small	9/11/2006	m	R	295
276899	41303	9,506	5/15/06	small	9/15/2006	m	1.0	295
276900	41303	10,380	5/15/06	large	9/15/2006	m	1.0	370
294099	41303	10,272	5/15/06	large	8/28/2006	m	1.0	315
320802	41303	10,434	5/15/06	large	9/17/2006	m	1.0	350
320806	41303	9,574	5/15/06	small	9/20/2006	m	1.0	270
276804	41303	12,115	5/16/06	large	9/1/2006	m	1.0	305
276828	41303	10,808	5/16/06	small	9/5/2006	m	R	310
276838	41303	10,536	5/16/06	small	9/8/2006	m	1.0	295
276814	41303	14,054	5/17/06	large	9/2/2006	m	1.0	305
276817	41303	13,245	5/17/06	small	9/3/2006	m	R	300
276839	41303	13,594	5/17/06	large	9/8/2006	m	1.0	325
276846	41303	13,274	5/17/06	small	9/8/2006	m	1.0	295
276860	41303	13,947	5/17/06	large	9/10/2006	m	R	325
276869	41303	13,669	5/17/06	large	9/11/2006	m	1.0	325
294100	41303	13,581	5/17/06	large	8/28/2006	m	1.0	310
320818	41303	14,033	5/17/06	large	9/23/2006	m	2.0	335
320823	41303	13,861	5/17/06	large	9/23/2006	m	2.0	365
276886	41303	15,686	5/19/06	small	9/12/2006	m	1.0	285
276808	41303	16,802	5/20/06	small	9/1/2006	m	1.0	270
276819	41303	16,862	5/20/06	small	9/4/2006	m	1.0	305
276848	41303	16,879	5/20/06	small	9/8/2006	m	R	295
276850	41303	17,437	5/20/06	large	9/9/2006	m	1.0	335
276857	41303	17,286	5/20/06	large	9/10/2006	m	1.0	305
276894	41303	16,784	5/20/06	small	9/13/2006	m	1.0	295
320809	41303	16,881	5/20/06	small	9/21/2006	m	1.0	295
320827	41303	16,527	5/20/06	small	9/26/2006	m	1.0	305
276847	41303	17,954	5/21/06	small	9/8/2006	m	1.0	285
276861	41303	17,803	5/21/06	small	9/10/2006	m	1.0	285
276868	41303	17,779	5/21/06	small	9/10/2006	m	1.0	300

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Head no.	CWT code	Sequential CWT no.	Date tagged	Smolt size	Recovery date[a]	Sex	Age[b]	Length[c] (mm)
276891	41303	17,993	5/21/06	small	9/13/2006	m	1.0	270
276893	41303	17,926	5/21/06	small	9/13/2006	m	1.0	310
276830	41304	675	5/23/06	large	9/5/2006	m	1.0	315
320807	41304	1,034	5/24/06	small	9/20/2006	m	1.0	290
320813	41304	848	5/24/06	small	9/21/2006	m	1.0	280
276831	41304	1,438	5/25/06	small	9/5/2006	m	1.0	295
276892	41304	1,384	5/25/06	small	9/13/2006	m	1.0	265
276865	41304	1,966	5/26/06	small	9/10/2006	m	1.0	245
276880	41304	2,230	5/26/06	large	9/11/2006	m	R	330
276825	41304	2,779	5/27/06	large	9/4/2006	m	R	270
320820	41304	2,418	5/27/06	small	9/23/2006	m	1.0	270
320817	41304	3,127	5/28/06	large	9/22/2006	m	1.0	330
320812	41304	3,371	5/29/06	large	9/21/2006	m	1.0	290
276884	41304	3,558	5/30/06	large	9/11/2006	m	1.0	290
276807	41303	unreadable			9/1/2006	m	1.0	305
276844	41304	unreadable			9/8/2006	m	1.0	290
276871	41303	unreadable			9/11/2006	m	1.0	270
276874	41303	unreadable			9/11/2006	m	1.0	370
276875	41303	unreadable			9/11/2006	m	1.0	310
NON RANDOM ESCAPEMENT RECOVERIES								
276843	41304	2,913	5/27/06	large	9/8/2006	m	1.0	275
276859	41303	15,019	5/18/06	large	9/10/2006	m	1.0	275
276873	41303	7,042	5/12/06	small	9/11/2006	m	1.0	280
320810	41303	8,098	5/13/06	large	9/21/2006	m	1.0	355
55232	41303	16,091	5/20/2006	small	9/8/2007	m	x.1	420

[a] Date of recovery for random samples was the date of capture at the weir (every 4th jack captured, missing an adipose fin was sampled). All non-random samples were from carcasses found in the watershed and the date of recovery was the date the carcass was found.

[b] "R" denotes a fish where the age was undetermined due to regenerated scales.

[c] All lengths are mideye-to-fork measured to the nearest 5 mm (MEF).

Appendix A5.–Daily escapement counts of mature coho salmon passed through the weir on Chuck Creek, by life history type and marked statues in 2007.

	Adult coho (age x.1)				Jack coho (age x.0)			
Date	Marked	Unmarked	Unknown	Total	Marked	Unmarked	Unknown[a]	Total
8/15	0	0	0	0	0	0	0	0
8/16	0	0	0	0	0	0	0	0
8/17	0	0	0	0	0	0	0	0
8/18	0	0	0	0	0	0	0	0
8/19	0	0	0	0	0	0	0	0
8/20	0	0	0	0	0	0	0	0
8/21	0	0	0	0	0	0	0	0
8/22	0	0	0	0	0	0	0	0
8/23	0	0	0	0	0	0	0	0
8/24	0	0	0	0	0	0	0	0
8/25	0	0	0	0	2	0	0	2
8/26	0	0	0	0	1	0	0	1
8/27	0	0	0	0	0	0	0	0
8/28	1	0	0	1	0	0	0	0
8/29	0	0	0	0	1	0	0	1
8/30	0	0	0	0	1	0	0	1
8/31	2	1	0	3	5	0	0	5
9/1	2	0	0	2	2	0	0	2
9/2	1	0	0	1	3	0	0	3
9/3	0	1	0	1	3	0	0	3
9/4	1	0	0	1	3	0	1	4
9/5	10	1	0	11	11	1	0	12
9/6	70	7	0	77	39	0	0	39
9/7	20	1	0	21	13	0	0	13
9/8	28	4	0	32	13	0	0	13
9/9	14	5	0	19	7	0	0	7
9/10	7	2	0	9	5	0	0	5
9/11	2	3	0	5	7	1	0	8
9/12	4	2	0	6	6	0	0	6
9/13	4	0	0	4	21	0	0	21
9/14	6	1	0	7	11	2	0	13
9/15	16	2	0	18	21	0	0	21
9/16	18	4	0	22	8	2	0	10
9/17	14	2	0	16	1	0	0	1
9/18	5	2	0	7	10	1	0	11
9/19	6	1	0	7	3	1	1	5
9/20	23	5	0	28	10	4	0	14
9/21	34	5	0	39	19	6	0	25
9/22	7	5	0	12	7	1	0	8
9/23	4	1	0	5	11	2	1	14
9/24	3	1	0	4	7	3	0	10
9/25	4	1	0	5	10	6	0	16
9/26	2	3	0	5	4	3	0	7
9/27	3	5	0	8	3	3	0	6
9/28	0	1	0	1	6	6	0	12
9/29	4	4	0	8	2	0	0	2
9/30	0	2	0	2	2	2	0	4
10/1	4	2	0	6	5	5	0	10
10/2	1	3	0	4	3	3	0	6

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	Adult coho (age x.1)				Jack coho (age x.0)			
Date	Marked	Unmarked	Unknown	Total	Marked	Unmarked	Unknown[a]	Total
10/3	2	1	0	3	3	4	0	7
10/4	1	4	0	5	0	0	0	0
10/5	2	3	0	5	1	0	0	1
10/6	0	1	0	1	0	1	0	1
10/7	0	1	0	1	0	0	0	0
10/8	1	1	0	2	0	3	0	3
10/9	1	1	0	2	0	4	0	4
10/10	1	1	0	2	0	1	0	1
10/11	0	1	0	1	0	1	0	1
10/12	0	0	0	0	1	1	0	2
10/13	2	2	0	4	1	1	0	2
10/14	0	1	0	1	1	2	0	3
10/15	0	0	1[b]	1	1	1	0	2
Totals	330	94	1	425	294	71	3	368

[a] Fish passed upstream before they could be examined for the presence of an adipose fin.

[b] Fish was downstream of the weir when it was dismantled for the season and it was not examined.

Appendix A6.–Daily escapement count of sockeye, pink, and chum salmon, Dolly Varden, and steelhead trout passed through the weir at Chuck Creek, 2007.

Date	Sockeye adults	Sockeye jacks[a]	Pinks	Chum	Dolly Varden	Steelhead
8/15	0	0	0	0	0	0
8/16	0	0	0	0	0	0
8/17	2	0	0	0	0	0
8/18	7	2	1	0	0	0
8/19	3	0	1	0	0	0
8/20	9	1	0	0	1	0
8/21	0	0	0	0	0	0
8/22	21	3	21	0	1	0
8/23	7	0	14	0	0	0
8/24	11	2	20	0	1	0
8/25	6	1	53	0	1	0
8/26	4	0	20	0	1	0
8/27	3	1	5	0	1	0
8/28	14	0	34	0	0	0
8/29	19	3	49	1	0	0
8/30	9	1	47	0	0	0
8/31	26	0	61	0	0	0
9/1	30	0	252	0	0	0
9/2	6	0	171	0	0	0
9/3	9	0	81	0	0	0
9/4	9	2	251	0	0	0
9/5	8	1	470	1	0	0
9/6	19	0	285	1	0	0
9/7	6	0	160	5	0	0
9/8	5	0	151	4	0	0
9/9	2	0	94	6	0	1
9/10	0	0	50	1	1	1
9/11	1	0	76	2	0	0
9/12	0	0	34	0	0	0
9/13	1	1	11	0	0	0
9/14	0	0	3	0	0	0
9/15	3	0	56	1	0	0
9/16	0	0	78	0	0	0
9/17	0	0	50	0	0	0
9/18	0	0	75	0	0	0
9/19	0	0	154	0	0	0
9/20	0	0	52	1	0	0
9/21	0	0	204	0	0	0
9/22	0	0	106	1	0	0
9/23	0	0	13	4	0	0
9/24	0	0	20	0	0	0
9/25	1	0	104	2	0	0
9/26	1	0	115	3	0	0
9/27	0	0	68	1	0	0
9/28	0	0	41	1	0	0
9/29	0	0	65	2	0	0
9/30	1	0	48	0	0	0
10/1	0	0	69	0	0	0
10/2	3	0	145	0	0	0
10/3	0	0	113	0	0	0

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Date	Sockeye adults	Sockeye jacks[a]	Pinks	Chum	Dolly Varden	Steelhead
10/4	0	0	34	0	0	0
10/5	0	0	64	0	0	0
10/6	1	0	66	0	0	0
10/7	0	0	33	0	0	0
10/8	0	0	25	0	0	0
10/9	0	1	64	1	0	0
10/10	0	0	47	0	1	0
10/11	2	1	55	0	1	1
10/12	0	0	28	0	0	0
10/13	0	0	53	0	0	0
10/14	0	0	25	0	0	0
10/15	0	0	4	0	0	0
Totals	249	20	4,489	38	9	3

[a] Male fish <400 mm MEF.

Appendix A7.–Recoveries of coho salmon that were coded wire tagged in the 2006 Chuck Creek smolt emigration and recovered in marine sport and commercial fishery sampling programs in Alaska and British Columbia.

Head number	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Sub-district	Length[a] (mm)	Tag code	Sequential CWT number	Date tagged	Smolt size
RANDOM FISHERIES RECOVERIES												
325223	Ketchikan	Seine	7/2/2007	27	SW	104		490	41304	3388	5/29/2006	large
325248	Ketchikan	Seine	7/11/2007	28	SE	102	10	510	41304	1306	5/24/2006	large
325639	Ketchikan	Seine	7/20/2007	29	SW			620	41303	10242	5/15/2006	large
325640	Ketchikan	Seine	7/20/2007	29	SW			510	41303	16213	5/20/2006	small
325641	Ketchikan	Seine	7/20/2007	29	SW			540	41303	9405	5/15/2006	small
325642	Ketchikan	Seine	7/20/2007	29	SW			590	41304	3384	5/29/2006	large
325644	Ketchikan	Seine	7/20/2007	29	SW			565	41303	9464	5/15/2006	small
325646	Ketchikan	Seine	7/20/2007	29	SW			550	41303	2763	5/5/2006	large
20987	Petersburg	Seine	7/30/2007	31	SW	104	40	605	41303	9552	5/15/2006	small
20924	Petersburg	Seine	8/3/2007	31	SW	104	40	555	41303	9762	5/15/2006	small
21773	Petersburg	Seine	8/6/2007	32	SW	104	40	635	41303	9298	5/15/2006	small
537551	Wrangell	Seine	8/6/2007	32	SW	103	90	560	41303	16034	5/20/2006	small
352411	Ketchikan	Seine	8/7/2007	32	SW			505	41303	17231	5/20/2006	large
21786	Petersburg	Seine	8/8/2007	32	SW	103	70	610	41303	4481	5/8/2006	large
20939	Petersburg	Seine	8/9/2007	32	SW	103		640	41304	2857	5/27/2006	large
21800	Petersburg	Seine	8/10/2007	32	SW	104	40	600	41304	1737	5/25/2006	large
21994	Petersburg	Seine	8/16/2007	33	SW	104	40	550	41303	13371	5/17/2006	large
21995	Petersburg	Seine	8/16/2007	33	SW	104	40	480	41303	4992	5/9/2006	small
325467	Ketchikan	Seine	8/16/2007	33	SW	104	40	585	41303	8694	5/14/2006	small
19814	Petersburg	Seine	8/22/2007	34	SW			540	41303	4626	5/8/2006	large
325484	Ketchikan	Seine	8/22/2007	34	SE			425	41303	13317	5/17/2006	large
352422	Ketchikan	Seine	8/23/2007	34	SE	102	50	610	41303	5192	5/9/2006	small
325541	Ketchikan	Seine	8/28/2007	35	SE	102	50	565	41303	9101	5/14/2006	large
322620	Sitka	Sport	7/22/2007	30	NW	113	41	595	41303	9246	5/15/2006	small
305876	Ketchikan	Sport	7/24/2007	30	SE	101	90	560	41303	13589	5/17/2006	large
83434	Sitka	Sport	7/25/2007	30	NW	113	41	630	41303	9219	5/15/2006	small
81957	Sitka	Sport	7/27/2007	30	NW	113	61	565	41303	6319	5/11/2006	large
31937	Craig/Klawock	Sport	7/28/2007	30	SW	104	40	625	41303	13927	5/17/2006	large
324927	Sitka	Sport	7/31/2007	31	NW	113	22	570	41303	15954	5/20/2006	small
31944	Craig/Klawock	Sport	8/1/2007	31	SW	103	90	555	41303	14196	5/18/2006	small
31947	Craig/Klawock	Sport	8/7/2007	32	SW	104	40	570	41303	17134	5/20/2006	large
31469	Craig/Klawock	Sport	8/9/2007	32	SW	104	40		41303	12704	5/17/2006	small
31960	Craig/Klawock	Sport	8/18/2007	33	SW	103	50	560	41303	17285	5/20/2006	large

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Head number	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Sub-district	Length[a] (mm)	Tag code	Sequential CWT number	Date tagged	Smolt size
259363	Sitka	Sport	8/20/2007	34	NW	113	45	580	41303	10050	5/15/2006	large
31968	Craig/Klawock	Sport	8/21/2007	34	SW	104	40	575	41304	2563	5/27/2006	small
31971	Craig/Klawock	Sport	8/29/2007	35	SW	104	40	555	41304	3114	5/28/2006	small
31972	Craig/Klawock	Sport	8/29/2007	35	SW	104	40	535	41303	16651	5/20/2006	small
325924	Ketchikan	Troll	7/4/2007	27	SW			570	41303	18380	5/21/2006	large
325926	Ketchikan	Troll	7/4/2007	27	SW			510	41303	9799	5/15/2006	small
317532	Sitka	Troll	7/5/2007	27	NW	113	45	520	41303	1530	5/4/2006	small
325030	Ketchikan	Troll	7/5/2007	27	SW	103	90	545	41303	9744	5/15/2006	small
325044	Ketchikan	Troll	7/5/2007	27	SW	103	90	575	41303	4997	5/9/2006	small
325051	Ketchikan	Troll	7/5/2007	27	SW	103	90	550	41304	2781	5/27/2006	large
99123	Hoonah	Troll	7/6/2007	27	NW			555	41303	9508	5/15/2006	small
291859	Craig/Klawock	Troll	7/6/2007	27	SE	102	60	490	41303	9437	5/15/2006	small
312126	Sitka	Troll	7/6/2007	27	NW			545	41303	3364	5/7/2006	small
312310	Sitka	Troll	7/8/2007	28	NW	113	45	590	41303	9032	5/14/2006	large
312227	Sitka	Troll	7/9/2007	28	NW	113	45	585	41303	17132	5/20/2006	large
312317	Sitka	Troll	7/9/2007	28	NW	113	45	580	41303	17588	5/21/2006	small
312292	Sitka	Troll	7/10/2007	28	NW			560	41303	5385	5/9/2006	large
312299	Sitka	Troll	7/10/2007	28	NW			545	41303	13302	5/17/2006	large
522858	Pelican	Troll	7/11/2007	28	NW	116	11	540	41303	16308	5/20/2006	small
291445	Craig/Klawock	Troll	7/13/2007	28	SW	104	35	500	41303	17071	5/20/2006	small
325930	Ketchikan	Troll	7/13/2007	28	SW			490	41303	16496	5/20/2006	small
325934	Ketchikan	Troll	7/13/2007	28	SW			545	41303	16621	5/20/2006	small
325935	Ketchikan	Troll	7/13/2007	28	SW			575	41303	16342	5/20/2006	small
325938	Ketchikan	Troll	7/13/2007	28	SW			525	41303	12885	5/17/2006	small
325941	Ketchikan	Troll	7/13/2007	28	SW			510	41303	3898	5/8/2006	small
312906	Sitka	Troll	7/16/2007	29	NW	113	41	595	41303	9974	5/15/2006	small
312920	Sitka	Troll	7/16/2007	29	NW	113	21	585	41303	17333	5/20/2006	large
326795	Sitka	Troll	7/16/2007	29	NW	113		565	41303	9899	5/15/2006	small
291474	Craig/Klawock	Troll	7/17/2007	29	SW	103	70	520	41303	15969	5/20/2006	small
21718	Petersburg	Troll	7/18/2007	29				625	41303	10393	5/15/2006	large
310029	Craig/Klawock	Troll	7/18/2007	29	SW	104	30	550	41303	16336	5/20/2006	small
317930	Sitka	Troll	7/21/2007	29	NW	113	45	560	41303	17518	5/21/2006	small
325650	Ketchikan	Troll	7/24/2007	30	SW			580	41303	2529	5/5/2006	small
325652	Ketchikan	Troll	7/24/2007	30	SW			580	41303	16821	5/20/2006	small
325658	Ketchikan	Troll	7/24/2007	30	SW			670	41303	11035	5/16/2006	small

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Head number	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Sub-district	Length[a] (mm)	Tag code	Sequential CWT number	Date tagged	Smolt size
325660	Ketchikan	Troll	7/24/2007	30	SW			540	41303	13536	5/17/2006	large
325662	Ketchikan	Troll	7/24/2007	30	SW			540	41304	309	5/23/2006	small
325664	Ketchikan	Troll	7/24/2007	30	SW			550	41303	17090	5/20/2006	small
325665	Ketchikan	Troll	7/24/2007	30	SW			550	41303	13402	5/17/2006	large
309758	Craig/Klawock	Troll	7/25/2007	30	SW	103	70	580	41303	13528	5/17/2006	large
309874	Craig/Klawock	Troll	7/25/2007	30	SW	103	80	480	41303	16449	5/20/2006	small
309881	Craig/Klawock	Troll	7/25/2007	30	SW	103	90	500	41303	17380	5/20/2006	large
325075	Ketchikan	Troll	7/26/2007	30	SW	103		535	41303	4877	5/9/2006	small
325076	Ketchikan	Troll	7/26/2007	30	SW	103		615	41303	2503	5/5/2006	small
325079	Ketchikan	Troll	7/26/2007	30	SW	103		630	41303	16753	5/20/2006	small
325081	Ketchikan	Troll	7/26/2007	30	SW	103		585	41303	6300	5/11/2006	large
310085	Craig/Klawock	Troll	7/27/2007	30	SW	103	60	500	41304	2768	5/27/2006	small
309884	Craig/Klawock	Troll	7/30/2007	31	SW			580	41303	5649	5/10/2006	small
309886	Craig/Klawock	Troll	7/30/2007	31	SW	103	70	570	41303	8964	5/14/2006	large
310097	Craig/Klawock	Troll	7/30/2007	31				510	41303	9711	5/15/2006	small
310098	Craig/Klawock	Troll	7/30/2007	31				600	41303	13364	5/17/2006	large
309763	Craig/Klawock	Troll	7/31/2007	31				500	41303	1537	5/4/2006	small
309767	Craig/Klawock	Troll	7/31/2007	31	SW	103		560	41303	11166	5/16/2006	small
309894	Craig/Klawock	Troll	7/31/2007	31	SE	102	10	570	41303	2213	5/5/2006	small
309895	Craig/Klawock	Troll	7/31/2007	31	SE	102	10	620	41303	17173	5/20/2006	large
309897	Craig/Klawock	Troll	7/31/2007	31	SW	103	11	590	41303	5287	5/9/2006	large
309898	Craig/Klawock	Troll	7/31/2007	31	SW	103	60	560	41303	13787	5/17/2006	large
317950	Sitka	Troll	7/31/2007	31	NW	113	11	580	41304	408	5/23/2006	small
309771	Craig/Klawock	Troll	8/1/2007	31	SW	103	80	520	41304	2621	5/27/2006	small
309772	Craig/Klawock	Troll	8/1/2007	31	SW	103	80	610	41303	3173	5/6/2006	large
309776	Craig/Klawock	Troll	8/1/2007	31	SW	104	40	580	41303	13884	5/17/2006	large
309778	Craig/Klawock	Troll	8/1/2007	31	SW	104	40	530	41303	9624	5/15/2006	small
309899	Craig/Klawock	Troll	8/1/2007	31	SW	104	40	530	41304	3040	5/28/2006	small
327658	Sitka	Troll	8/1/2007	31	NW	113	62	630	41303	2738	5/5/2006	large
309789	Craig/Klawock	Troll	8/2/2007	31	SW	104	40	510	41303	18249	5/21/2006	large
309793	Craig/Klawock	Troll	8/2/2007	31	SW	104	40	520	41303	16230	5/20/2006	small
310201	Craig/Klawock	Troll	8/3/2007	31	SW	103	70	530	41304	1582	5/25/2006	small
325674	Ketchikan	Troll	8/5/2007	32	SW	103		610	41303	12628	5/17/2006	small
325675	Ketchikan	Troll	8/5/2007	32	SW	103		620	41303	3389	5/7/2006	small

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Head number	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Sub-district	Length[a] (mm)	Tag code	Sequential CWT number	Date tagged	Smolt size
310107	Craig/Klawock	Troll	8/7/2007	32	SW			560	41303	10634	5/16/2006	small
327922	Sitka	Troll	8/8/2007	32	NW	113	45	480	41303	8501	5/14/2006	small
310122	Craig/Klawock	Troll	8/9/2007	32	SW	104	50	500	41303	4252	5/8/2006	large
310245	Craig/Klawock	Troll	8/9/2007	32	SW	104	40	530	41303	9968	5/15/2006	small
325289	Ketchikan	Troll	8/9/2007	32	SW	103		525	41303	9705	5/15/2006	small
310128	Craig/Klawock	Troll	8/10/2007	32	SW	104	50	550	41304	2076	5/26/2006	small
310130	Craig/Klawock	Troll	8/10/2007	32	SW	104	50	540	41304	1300	5/24/2006	large
310131	Craig/Klawock	Troll	8/10/2007	32	SW	104	50	590	41304	516	5/23/2006	small
310141	Craig/Klawock	Troll	8/10/2007	32	SW	103	70	480	41303	3954	5/8/2006	small
310252	Craig/Klawock	Troll	8/10/2007	32	SW	104	50	520	41303	15599	5/19/2006	small
310253	Craig/Klawock	Troll	8/10/2007	32	SW	104	50	520	41303	18342	5/21/2006	large
310257	Craig/Klawock	Troll	8/10/2007	32	SW	104	40	570	41303	9640	5/15/2006	small
327730	Sitka	Troll	8/10/2007	32	NW	113	45	560	41303	17800	5/21/2006	small
327953	Sitka	Troll	8/10/2007	32				570	41303	2254	5/5/2006	small
327773	Sitka	Troll	8/11/2007	32				530	41304	1891	5/26/2006	small
310277	Craig/Klawock	Troll	8/20/2007	34	SW	152		580	41304	2640	5/27/2006	small
349178	Sitka	Troll	8/21/2007	34	NW	113	31	540	41303	18085	5/21/2006	small
349380	Sitka	Troll	8/21/2007	34	NW	113	45	520	41303	11100	5/16/2006	small
349246	Sitka	Troll	8/23/2007	34	NW	113		570	41303	1705	5/4/2006	large
310421	Craig/Klawock	Troll	8/24/2007	34				440	41303	12626	5/17/2006	small
352307	Ketchikan	Troll	8/26/2007	35	SW	103		530	41303	18389	5/21/2006	large
309922	Craig/Klawock	Troll	8/28/2007	35	SE	105	50	630	41303	3929	5/8/2006	small
309923	Craig/Klawock	Troll	8/28/2007	35	SE	105	50	500	41304	634	5/23/2006	large
309926	Craig/Klawock	Troll	8/28/2007	35	SE	105	50	590	41304	3716	6/1/2006	large
310440	Craig/Klawock	Troll	8/28/2007	35	SE	105	50	520	41303	4983	5/9/2006	small
310444	Craig/Klawock	Troll	8/28/2007	35	SE	105	50	530	41304	559	5/23/2006	small
310459	Craig/Klawock	Troll	8/28/2007	35	SW	103	80	520	41303	16818	5/20/2006	small
310461	Craig/Klawock	Troll	8/28/2007	35	SW	103	80	520	41304	951	5/24/2006	small
310462	Craig/Klawock	Troll	8/28/2007	35	SW	103	80	630	41303	10343	5/15/2006	large
310463	Craig/Klawock	Troll	8/29/2007	35	SW	103	80	590	41304	2832	5/27/2006	large
349811	Sitka	Troll	8/30/2007	35	NW	113	11	580	41303	13674	5/17/2006	large
310469	Craig/Klawock	Troll	9/4/2007	36	SW	103	80	560	41303	18143	5/21/2006	small
310471	Craig/Klawock	Troll	9/4/2007	36	SW	103	80	580	41304	1160	5/24/2006	small
325153	Ketchikan	Troll	9/4/2007	36	SW	103		570	41304	3050	5/28/2006	small

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Head number	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Sub-district	Length[a] (mm)	Tag code	Sequential CWT number	Date tagged	Smolt size
325156	Ketchikan	Troll	9/4/2007	36	SW	103		550	41303	2912	5/6/2006	small
325161	Ketchikan	Troll	9/4/2007	36	SW	103		560	41303	13479	5/17/2006	large
325162	Ketchikan	Troll	9/4/2007	36	SW	103		590	41303	16214	5/20/2006	small
325166	Ketchikan	Troll	9/4/2007	36	SW	103		535	41304	310	5/23/2006	small
325167	Ketchikan	Troll	9/4/2007	36	SW	103		620	41303	1919	5/4/2006	large
325168	Ketchikan	Troll	9/4/2007	36	SW	103		610	41303	10907	5/16/2006	small
310485	Craig/Klawock	Troll	9/7/2007	36	SW	103	70	560	41304	3100	5/28/2006	small
325169	Ketchikan	Troll	9/9/2007	37	SW	103		620	41303	8528	5/14/2006	small
325170	Ketchikan	Troll	9/9/2007	37	SW	103		635	41303	8057	5/13/2006	large
325171	Ketchikan	Troll	9/9/2007	37	SW	103		590	41303	16630	5/20/2006	small
350207	Sitka	Troll	9/11/2007	37				610	41303	17176	5/20/2006	large
350221	Sitka	Troll	9/11/2007	37				520	41303	15477	5/19/2006	small
309967	Craig/Klawock	Troll	9/14/2007	37	SW	103	90	490	41304	1403	5/25/2006	small
309968	Craig/Klawock	Troll	9/14/2007	37	SW	103	90	580	41303	16656	5/20/2006	small
D710082	Northern B.C.	Troll	8/4/2007					615	41303	18406	5/21/2006	large
D712630	Northern B.C.	Troll	8/11/2007						41303	15327	5/19/2006	small
D710882	Northern B.C.	gillnet	7/14/2007					553	41303	9895	5/15/2006	small
D710608	Northern B.C.	seine	7/28/2007					512	41303	14165	5/18/2006	small
NON RANDOM FISHERIES RECOVERIES												
309953	Craig/Klawock	Troll	9/20/2007	38					41303	7514	5/13/2006	small
900840	Sitka	Troll	7/21/2007	29	NW				41303	1740	5/4/2006	large
900645	Sitka	Troll	9/12/2007	37	NW	154			41303	9753	5/15/2006	small
S712181	Northern B.C.	Troll	8/4/2007						41303	4379	5/8/2006	large
S712347	Northern B.C.	Troll	7/21/2007						41303	7863	5/13/2006	small
S710199	Northern B.C.	Troll	8/18/2007						41303	13280	5/17/2006	small
S710226	Northern B.C.	Troll	8/4/2007						41304	585	5/23/2006	large
S676216	Northern B.C.	Troll	8/4/2007						41304	591	5/23/2006	large
S675674	Northern B.C.	Troll	7/28/2007						41304	3313	5/29/2006	small
466938	Northern B.C.	Sport	7/18/2007						41303	10083	5/15/2006	large

Appendix A8.–Estimated marine harvest (r_i) of adult coho salmon bound for Chuck Creek in 2007. n_i = number of fish examined for missing adipose fins; a_i = number of adipose clipped fish seen; a_i = number of heads received at the tag lab; t_i = number of CWTs detected; t_i' number of CWTs decoded; m_i = number of CWTs with codes from Chuck Creek.

SE ALASKA TROLL FISHERY													
Stat week	Dates (period)	Quad	Harvest	Var(H)	n_i	a_i	a_i'	t_i	t_i'	m_i	r_i	SE(r_i)	RP[r_i]
26–32	7/1–8/11 (3)	NW	446,403	0	124,308	1,944	1,865	1,404	1,401	17	82	18	43%
33–40	8/12–10/6 (4)	NW	496,229	0	122,908	2,800	2,700	2,110	2,107	4	22	10	89%
26–32	7/1–8/11 (3)	SE	76,495	0	20,900	128	123	69	69	3	15	8	101%
33–40	8/12–10/6 (4)	SE	49,598	0	8,142	122	116	74	74	5	41	17	82%
26–32	7/1–8/11 (3)	SW	157,017	0	37,721	334	327	211	211	54	295	38	25%
33–40	8/12–10/6 (4)	SW	44,516	0	9,991	160	157	99	99	21	123	25	40%
	Troll subtotal		1,270,258	0	323,970	5,488	5,288	3,967	3,961	104	577	53	18%
SE ALASKA PURSE SEINE FISHERY													
Stat week	Dates	District	Harvest	Var(H)	n_i	a_i	a_i'	t_i	t_i'	m_i	r_i	SE(r_i)	RP[r_i]
wk 28	7/8–7/14	102	3,849	0	1,215	21	21	18	18	1	4	4	170%
wk 34	8/19–8/25	102	3,436	0	698	4	4	3	3	1	6	6	180%
wk 35	8/26–9/1	102	2,552	0	365	2	2	1	1	1	9	8	185%
wk 32	8/5–8/11	103	9,381	0	1,196	7	7	5	5	3	30	17	108%
wk 27	7/1–7/7	104	3,066	0	714	12	12	6	6	1	6	5	177%
wk 31	7/29–8/4	104	20,047	0	4,205	48	48	27	27	2	12	8	127%
wk 32	8/5–8/11	104	19,201	0	2,720	24	23	16	16	2	19	13	131%
wk 33	8/12–8/18	104	20,371	0	2,660	27	27	20	20	3	30	16	107%
	Purse Seine subtotal		81,903	0	13,773	145	144	96	96	14	116	30	51%
SE ALASKA SPORT FISHERY													
Biweek	Dates	Port	Harvest	Var(H)	n_i	a_i	a_i'	t_i	t_i'	m_i	r_i	SE(r_i)	RP[r_i]
bw 15	7/16–7/29	Ketchikan	3,853	656,030	1,647	6	6	4	4	1	3	2	160%
bw 15	7/16–7/29	Sitka	8,961	4695298	4,666	92	91	76	76	3	7	3	88%
bw 16	7/30–8/12	Sitka	16,670	12,201,612	7,770	119	119	90	90	1	3	2	157%
bw 17	8/13–8/26	Sitka	16,315	15,155,666	4,293	58	57	43	43	1	5	4	175%
bw 15	7/16–7/29	Craig/Klawock	2,041		1,890	17	17	12	12	1	1	1	104%
bw 16	7/30–8/12	Craig/Klawock	2,657		2,300	17	17	15	15	3	4	1	65%
bw 17	8/13–8/26	Craig/Klawock	1,497		1,416	11	11	9	9	2	3	1	72%
bw 18	8/27–9/9	Craig/Klawock	257		239	3	3	3	3	2	3	1	73%
	Sport subtotal		52,251	32,708,606	24,221	323	321	252	252	14	29	7	45%
NORTHERN BRITISH COLUMBIA MARINE FISHERIES													
	Dates	Fishery	Harvest	Var(H)	n_i	a_i	a_i'	t_i	t_i'	m_i	r_i	SE(r_i)	RP[r_i]
	7/1–8/4	Troll	160,042		40,878	382	381	219	219	2	10	6	124%
	7/8–7/14	Seine	2,697		1,778	15	15	9	9	1	2	1	137%
	7/22–7/28	Gillnet	7,136		2,794	14	14	8	8	1	3	3	163%
	7/1–7/31	Sport								1	45		
	British Columbia subtotal		169,875		45,450	411	410	236	236	5	60	7	23%
	TOTAL ALL FISHERIES		1,574,287	32,708,606	407,414	6,367	6,163	4,551	4,545	137	782	61	15%

Appendix A9.–Daily number of smolt tagged, actual and expected recoveries of surviving fish, probability of recovering a tagged fish (P), probability of not recovering a tagged fish $(1\text{-}P)^{12,945}$, χ^2 statistic of number of fish recovered vs. not recovered, and the binomial probability of recovering at most the actual number of fish recovered for the 2006 Chuck Creek coho smolt emigration.

		Number of recoveries					
Date	Number smolt tagged	Actual	Expected[a]	p	$(1 - p)^{12,945}$	χ^2	Binomial P
4/16/2006	6	0	0.1	0.00001	0.87666	0.1	0.8753782
4/17/2006	5	0	0.1	0.00001	0.89611	0.1	0.8950139
4/18/2006	2	0	0.0	0.00000	0.95707	0.0	0.9566034
4/19/2006	9	0	0.2	0.00002	0.82082	0.2	0.8190183
4/20/2006	5	0	0.1	0.00001	0.89611	0.1	0.8950139
4/21/2006	6	0	0.1	0.00001	0.87666	0.1	0.8753782
4/22/2006	11	1	0.2	0.00002	0.78558	2.4	0.9767919
4/23/2006	7	0	0.2	0.00001	0.85764	0.2	0.8561733
4/24/2006	18	0	0.4	0.00003	0.67374	0.4	0.6707909
4/25/2006	19	0	0.4	0.00003	0.65912	0.4	0.6560745
4/26/2006	11	0	0.2	0.00002	0.78558	0.2	0.7834756
4/27/2006	6	0	0.1	0.00001	0.87666	0.1	0.8753782
4/28/2006	10	0	0.2	0.00002	0.80301	0.2	0.8010498
4/29/2006	15	1	0.3	0.00003	0.71958	1.4	0.9581805
4/30/2006	22	1	0.5	0.00004	0.61714	0.6	0.9167513
5/1/2006	101	0	2.2	0.00017	0.10904	2.2	0.1064048
5/2/2006	233	1	5.1	0.00039	0.00602	3.3	0.0354411
5/3/2006	112	1	2.5	0.00019	0.08566	0.9	0.2928035
5/4/2006	353	8	7.7	0.00060	0.00043	0.0	0.6285705
5/5/2006	412	11	9.0	0.00070	0.00012	0.4	0.8013633
5/6/2006	260	8	5.7	0.00044	0.00333	0.9	0.8786025
5/7/2006	158	4	3.5	0.00027	0.03122	0.1	0.7329083
5/8/2006	639	20	14.0	0.00108	0.00000	2.6	0.9534450
5/9/2006	526	15	11.5	0.00089	0.00001	1.0	0.8782171
5/10/2006	291	5	6.4	0.00049	0.00169	0.3	0.3837969
5/11/2006	169	3	3.7	0.00029	0.02452	0.1	0.4909138
5/12/2006	635	0	13.9	0.00108	0.00000	13.9	0.0000008
5/13/2006	459	9	10.1	0.00078	0.00004	0.1	0.4477281
5/14/2006	512	17	11.2	0.00087	0.00001	3.0	0.9636287
5/15/2006	828	42	18.2	0.00140	0.00000	31.3	0.9999997
5/16/2006	1,216	8	26.7	0.00206	0.00000	13.1	0.0000199
5/17/2006	920	27	20.2	0.00156	0.00000	2.3	0.9447304
5/18/2006	714	2	15.7	0.00121	0.00000	11.9	0.0000192
5/19/2006	387	4	8.5	0.00066	0.00020	2.4	0.0725952
5/20/2006	935	37	20.5	0.00158	0.00000	13.3	0.9997050
5/21/2006	576	15	12.6	0.00098	0.00000	0.4	0.7969865
5/22/2006	335	0	7.3	0.00057	0.00064	7.3	0.0005924
5/23/2006	356	9	7.8	0.00060	0.00040	0.2	0.7414764
5/24/2006	336	6	7.4	0.00057	0.00063	0.3	0.3938107
5/25/2006	281	5	6.2	0.00048	0.00210	0.2	0.4175591
5/26/2006	232	4	5.1	0.00039	0.00615	0.2	0.4227886
5/27/2006	384	9	8.4	0.00065	0.00022	0.0	0.6635825
5/28/2006	126	5	2.8	0.00021	0.06300	1.8	0.9400604
5/29/2006	151	4	3.3	0.00026	0.03640	0.1	0.7616663
5/30/2006	55	1	1.2	0.00009	0.29918	0.0	0.6594080
5/31/2006	29	0	0.6	0.00005	0.52928	0.6	0.5255483
6/1/2006	39	1	0.9	0.00007	0.42501	0.0	0.7892781
6/2/2006	33	0	0.7	0.00006	0.48481	0.7	0.4809240
Totals	12,945	284	284				

[a] Expected recoveries are the number of smolt tagged multiplied by the overall recovery rate (2.19% or 12,945/284). Probability of recovering a fish is the expected number of recoveries divided by the total number of smolt tagged (12,945).

Appendix A10.–Model used to estimate potential bias in smolt abundance estimate of the 2006 Chuck Creek coho salmon smolt emigration if unmarked fish survived at a different rate than marked fish.

In this study, overall survival (to either jack or adult) of *marked* fish can be estimated to be 11.1% (= $[497_{cwt\ jacks} + 331_{cwt\ adult\ esc} + 609_{cwt\ harvest}] / 12{,}945_{cwt\ smolt}$), with the *CWT harvest* estimated by expanding the number of recoveries in sampled fisheries for the fraction of the harvest not examined; and *CWT jacks* estimated by expanding the number of recoveries in the sampled jack escapement for the fraction of the jack escapement not examined (497 = 572 * 487/561). All other variables are known from weir counts. Thus, smolt abundance at survival rates other than the assumed rate of 11.1% is:

$$\hat{N} = n_{marked} + \left(m_{unmarked} / S_{unmarked}\right)$$

where $\hat{N}$ is the mark-recapture estimate of smolt abundance, n_{marked} is the number of smolt that were marked (12,945), $m_{unmarked}$ is the number of unmarked mature fish (estimated at 343 in this study), and S is the fraction of unmarked smolt that survive to maturity (unknown in this study). The number of unmarked mature fish was estimated by summing the weir counts in the escapement ($75_{jacks\ unmarked} + 94_{adults\ unmarked}$) and the estimated number in the harvest (= 173, assuming the harvest rate for unmarked fish is the same for marked fish).

Appendix A11.–Computer files used in the analysis of data for this report.

File Name	Description
07Chuck adult weir.xls	Excel workbook containing 2007 Chuck Creek adult escapement data.
06Chuck smolt data.xls	Excel workbook containing 2006 Chuck Creek smolt and coded wire tagging data.
07Chuck Harvest.xls	Excel workbook containing 2007 marine harvest estimations and cwt recoveries.