Fishery Data Series No. 10-31

Production of Coho Salmon from the 2007 Smolt Emigration from Chuck Creek in Southeast Alaska

by

Steven J. McCurdy

May 2010

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

Alaska 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 2007 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 fresh water (of jack salmon). Emigrating coho smolt were captured at a weir during the spring of 2007, 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 marked with CWTs in 2008. Escapements were counted through a weir at Chuck Creek in 2007 and 2008, and coho salmon were examined for missing adipose fins and CWTs.

A total of 13,656 coho salmon smolt were tagged and released alive between April 17 and June 14, 2007. In 2008, 121 random recoveries of coho salmon bearing CWTs of Chuck Creek origin were recovered in sampled marine fisheries, yielding an estimated marine harvest of 565 fish (SE = 53). A total of 368 jacks and 309 adults returned to Chuck Creek from the 2007 smolt emigration. An estimated 17,327 (SE = 399) coho salmon smolt emigrated from Chuck Creek in 2007. Marine survival to adult of the 2007 smolt emigration was estimated at 5.0% (SE = 0.3%), and the exploitation rate in marine fisheries was estimated at 64.6% (SE = 2.1%).

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 (Halupka et al. 2000; Shaul et al. 2003; 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 salmon 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, 2006b, 2008, 2009). 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 summer prior to their spring smolt emigration) 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 Division of Commercial Fisheries, Mark, Tag and Age Laboratory, *Tag Lab* data base), both on nearby Prince of Wales Island.

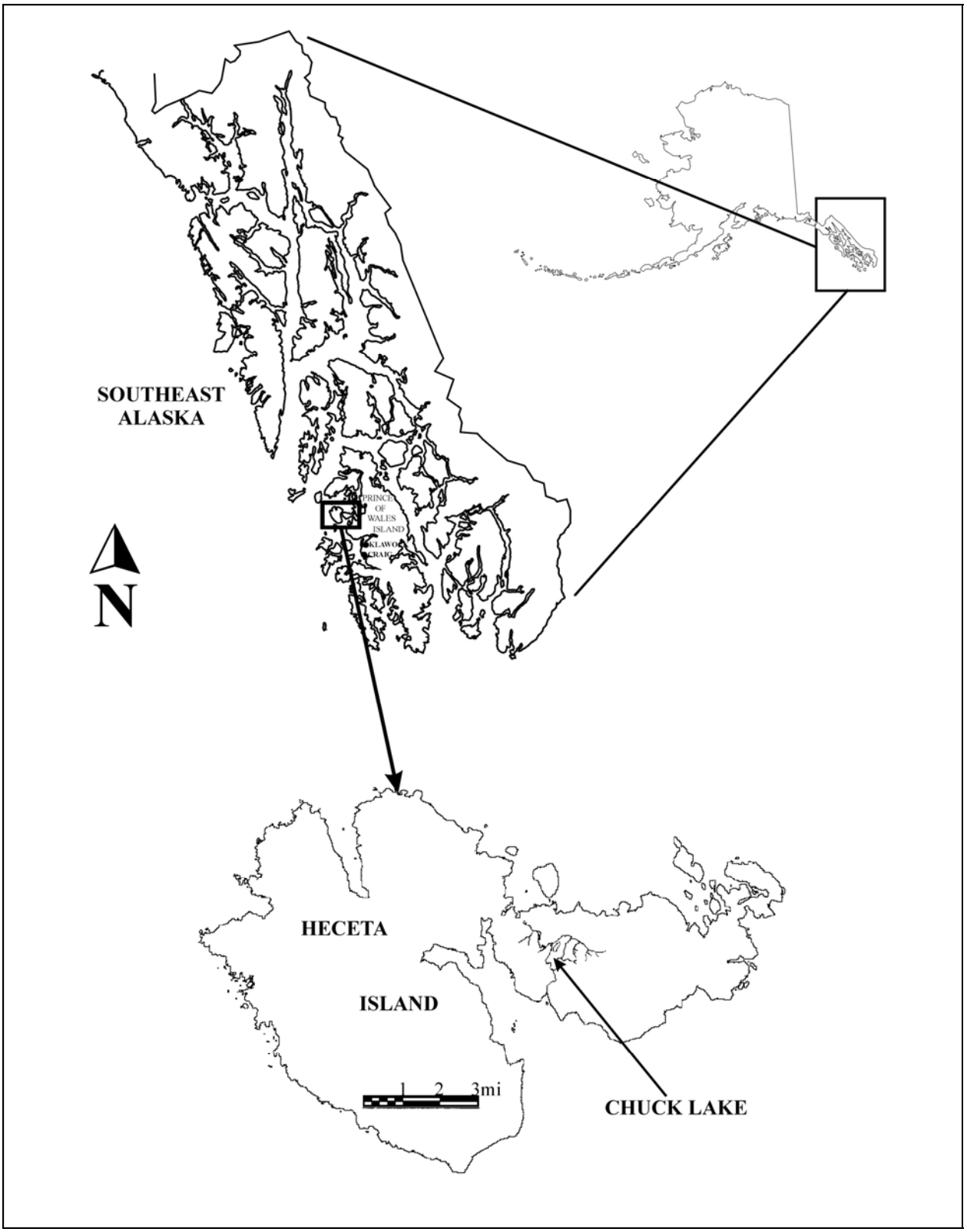

Figure 1.–Location of Heceta Island and the Chuck Creek watershed.

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 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 is water (9.8%) and non-forested land (0.5%; predominantly muskeg; (ADF&G Division of Habitat Southeast *Resource Mapping and Inventory Internet Mapping Service* [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*).

The study was designed to meet the following objectives:

1. Estimate the number of coho salmon smolt emigrating from Chuck Creek in 2007;
2. Determine if scale interpretation is accurately estimating ages of coho salmon smolt emigrating from Chuck Creek in 2007 via comparison to known-age fish;
3. Estimate the age composition, and mean length and weight of coho salmon smolt captured emigrating from Chuck Creek in 2007;
4. Count the escapement of coho salmon returning to Chuck Creek from the 2007 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 2007 smolt emigration;
6. Estimate the marine harvest of coho salmon from Chuck Creek in 2008 via recovery of CWTs;
7. Investigate the relationship between coho salmon smolt size and emigration date, and survival to maturity; and
8. Investigate the relationship between date of smolt emigration from the watershed and immigration date back to the watershed of age x.0 jacks.

In addition, although not objectives of this study, the study contributed to the following:

1. Estimates of fry abundance and survival (to the smolt stage) were made possible by the marking of newly-emergent coho salmon fry as part of a age validation study (objective 2 above), for the 2005 and 2006 fry cohorts;
2. Comparisons of growth, survival, and age-at-smoltification of marked fry between years and between separate marking locations within the watershed (for the 2006 fry cohort only); and
3. Counts of all other adult and juvenile salmonids of other species (other than young-of-the-year fry) through the adult weir and smolt weir, respectively.

An added benefit of this study is the monitoring of coho salmon production over time with the possibility of identifying factors that affect 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. Chuck Creek coho salmon were marked and recaptured with the use of weirs as they migrated from (emigrated) and returned to (immigrated) the watershed. Coho salmon smolt were captured as they were emigrating from Chuck Creek in the spring of 2007. Captured smolt were injected with a CWT and had their adipose fin removed (referred to as "adipose finclipped"). Adult coho salmon were sampled in the harvest of commercial and sport fisheries in 2008 for the presence of CWTs. The escapement of mature coho salmon was monitored through a weir on Chuck Creek in 2007 and 2008, 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 1 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 0-ocean 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 were captured in the spring of 2007 as they were emigrating from the Chuck Creek watershed using a weir and "trough" trap similar to that described by Elliott (1992). The weir and trough trap were 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 reestablish the dam (and the resulting pond) and to raise the water level upstream of the dam approximately 1 m. 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 1 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 at a minimum 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, were recorded. All non-coho salmon 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. Juvenile coho salmon that were <70 mm FL that did not have the bright coloration associated with smoltification were released untagged, as it was assumed they would not smolt until the following year (Magnus et al. 2006; note: it has been extremely rare to capture any age-1 or older coho juveniles <70 mm FL at Chuck Creek since smolt tagging began in 2002). Coho salmon smolt were counted and sorted into 2 size categories (*small* smolt ≤100 mm FL and *large* smolt >100 mm FL). All captured coho salmon smolt that appeared healthy were anesthetized with a solution of tricain-methane-sulfonate (MS-222), had a 1.1 mm sequentially numbered CWT injected into their snout, and had their adipose fin removed. Coho salmon smolt were tagged daily, regardless of the number captured. Before tagging the first fish and after tagging the last fish in each size category, on each day, 1 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 tagging machines[1] 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, 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 the Tag Lab in Juneau at the end of field operations. The tags used in 2007 contained the codes 04-11-57 and 04-14-79 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 m-r experiment for a closed population was used to estimate the abundance of coho salmon smolt emigrating from the Chuck Creek watershed in 2007. Event 1 consisted of marking captured coho salmon smolt by removing their adipose fin in 2007. Event 2 consisted of sampling returning mature coho salmon in 2007 (jacks) and 2008 (adults) to determine the marked fraction.

The abundance of coho salmon smolt emigrating from Chuck Creek in 2007 was estimated using Chapman's modification of the Petersen estimator for a closed population (Seber 1982):

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

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

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

where n_1 was the number of smolt marked in 2007 by removing their adipose fin, n_2 was the number of returning coho salmon inspected for marks in 2007 (jacks only) and 2008 (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 (requiring that marked and unmarked fish survive at the same rate), *or* marked fish mixed completely with unmarked fish in the population between events (also requiring equal survival rates between marked and unmarked fish); (2) there was no recruitment to the population 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.

Physiological and life history traits of coho salmon, along with design of this experiment allowed for discounting concerns over several of these conditions. Because almost all coho salmon return to their natal stream to spawn (Quinn 2005; Sandercock 1991), the possibility of any fish recruiting into the population (strays from hatcheries or other watersheds) was thought to be at such a low level as to not significantly affect the population estimate (condition 2); all immigrating fish in the escapement were obligated to pass through the salmon weir when returning to spawn so catchability in event 2 was unaffected by marking (condition 3); adipose fins do not regenerate when completely removed (condition 4), and missing adipose fins were easy to note when examining the captured fish (condition 5).

Because smolt capture and marking in this study did not occur for the entire duration of the emigration, all smolt did not have an equal probability of being marked in event 1 (condition 1). Removal of adipose fins has been shown to have no significant effect on mortality (condition 1; Vincent-Lang 1993), but smolt emigration date has been shown to affect survival to maturity of coho salmon smolt in other studies (Bilton et al. 1982; Lum 2003) and in past years in this study (McCurdy 2006a, 2006b, 2008, 2009). Thus, it is likely that marked and unmarked fish did not survive at the same rate, and almost assures that condition 1 was violated in this study. However, the impact of this violation on the abundance estimate is low, as shown in the Discussion section below.

ESTIMATION OF SMOLT AGE, WEIGHT AND LENGTH (AWL)

A sample of the emigrating coho salmon smolt was obtained by systematically sampling every 40th fish as they were coded wire tagged. Each sampled fish was measured to the nearest mm FL, weighed to the nearest gram, and had a scale sample taken for age determination. 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 freshwater after hatching and the number of years in salt water are separated by a period (Groot and Margolis 1991). Ages

were determined 1 time by 1 reader. Standard sample summary statistics were used to calculate estimates of mean length and weight and its variance (Thompson 2002).

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 with CWTs in the spring of 2005 and 2006 to identify their year of emergence. A portion of the surviving fish were then recaptured as emigrating smolt in 2007, sampled for AWL and then sacrificed for retrieval of the CWT that would verify their age. Scale samples from approximately half of the known-age fish sampled were then examined (before examining the random AWL samples) by the scale reader to attempt to distinguish circuli patterns that could be used to improve the accuracy in estimating the age of the random sample. After examining the known-age samples, the scale reader combined the known-age samples with the random samples, and then aged all the samples 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.

In 2005 and 2006, fry were injected with half-length CWTs (0.5 mm in length) and had their adipose fin removed. Fry were captured in the outlet of Chuck Lake ("Outlet Stream") and in "Roadside Creek" from April 22 to April 26, 2005 and from April 18 to April 30, 2006. Roadside Creek is the project name for one of the small tributary streams to the lake. The 2 tagging locations basically covered the extremes of spawning locations in the watershed in relationship to migration distance from salt water. Fry were captured with hand-held dip nets, tagged with CWTs, had their adipose fin removed, 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 ADF&G Tag Lab in Juneau at the end of field operations. The tag code used in 2005 for all fry was 04-01-06-01-03. In 2006, tag code 04-01-06-01-04 was used for fry from Outlet Stream, and tag code 04-01-06-01-05 was used on fry from Roadside Creek. A random sample of approximately every 35th tagged fry was measured to the nearest mm FL in 2005, and every 21st tagged fry in 2006. In 2007, 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 3 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 in commercial and recreational fisheries using standard methods (Bernard and Clark 1996). Because several fisheries exploited coho salmon bound for Chuck Creek over several months in 2008, 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[2] 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 2008 harvest of Chuck Creek coho salmon r_{ij} from the entire 2007 smolt emigration j to one fishery stratum i were calculated:

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

where H_i is the estimated harvest in stratum i, θ_j is the marked fraction of Chuck Creek coho salmon j possessing CWTs (the portion of the 2008 *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 the Chuck Creek 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 heads that reached the Tag Lab, 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.

ESTIMATES OF 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 2007 (McCurdy 2008), and from August 18 until October 20 in 2008. Pickets were 18 mm in diameter and were spaced a maximum of 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, 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 appeared that capture at the weir was an excellent indicator of return date to the stream.

[2] Alaska Department of Fish and Game, Division of Commercial Fisheries unpublished document, 2006. Coded wire tag sampling program, detailed sampling instructions, Division of Commercial Fisheries sampling. Available through ADF&G, Douglas.

All migrating mature salmon were captured, 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 450 mm MEF or larger were considered adults, and those less than 380 mm were considered jacks; any fish between 380 mm and 450 mm in length had a scale sample taken to verify the ocean age. In the previous 7 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 ocean age, and there has been no overlap in fork length detected between jacks and adults; the largest jack was 395 mm MEF, and the smallest adult was 400 mm MEF (McCurdy 2009).

Captured coho salmon were systematically sampled throughout the entire migration for age, sex, and length (ASL). In both 2007 and 2008 every 4th adult coho and every 3rd jack coho salmon encountered at the weir was sampled. In both years fish length was 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, Inc.). If a sampled jack was missing its adipose fin it was sacrificed for retrieval of its CWT. Total escapement was the number of coho salmon counted through the weir, which was categorized by 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 is (note that age refers to freshwater age, as ocean age is assumed to be correctly determined on the entire escapement as mentioned above):

$$\hat{p}_a = \frac{n_a}{n} \tag{4}$$

$$var[\,\hat{p}_a\,] = \left(1 - \frac{n}{N}\right)\frac{\hat{p}_a(1 - \hat{p}_a)}{n - 1} \tag{5}$$

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 ($\hat{N}_a$) is estimated:

$$\hat{N}_a = \hat{p}_a N \tag{6}$$

$$var(\hat{N}_a) = N^2\, var(\hat{p}_a) \tag{7}$$

Standard sample summary statistics were used to calculate estimates of mean length at age and its variance (Thompson 2002). 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 plus escapement) of the coho salmon bound for Chuck Creek in 2008 and its variance was calculated by summing estimates of total harvest (*T*) and the adult escapement (N_e):

$$\hat{N}_R = \hat{T} + N_e \tag{8}$$

$$\text{var}[\hat{N}_R] = \text{var}[\hat{T}] \tag{9}$$

where $\text{var}[N_e]$ is not added into equation (9) because it is 0. The estimate of the adult exploitation rate was calculated:

$$\hat{E} = \frac{\hat{T}}{\hat{N}_R} \tag{10}$$

$$\text{var}[\hat{E}] \approx \frac{\text{var}[\hat{T}]N_e^2}{\hat{N}_R^4} \tag{11}$$

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:

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \tag{12}$$

$$\text{var}[\hat{S}] \approx \hat{S}^2\left[\frac{\text{var}[\hat{N}_R]}{\hat{N}_R^2} + \frac{\text{var}[\hat{N}_s]}{\hat{N}_s^2}\right] \tag{13}$$

where N_s is the smolt abundance estimate from equation (1) and the variance was approximated with the delta method.

ESTIMATES OF FRY ABUNDANCE AND SURVIVAL

A two-event mark-recapture experiment for a closed population was used to estimate the abundance of newly-emerged coho salmon fry from the Chuck Creek watershed in 2005 and 2006. Event 1 consisted of marking captured coho salmon fry by removing their adipose fin and injecting with a half length CWT in years 2005 and 2006. Event 2 consisted of sampling the emigration of coho salmon smolt in the 2 years following tagging to determine the marked fraction. Abundance was estimated using equation (1), where n_1 was the number of fry marked in a given year by removing their adipose fin, n_2 was the number of emigrating coho salmon smolt inspected for marks in the year following marking (age-1 smolt only) and 2 years following marking (age-2 smolt only), and m_2 was the subset of n_2 missing adipose fins. The fraction and abundance of each year's smolt emigration by age group (age-1 or age-2) was estimated using equations 4 and 6, respectively. The estimated number of tagged fry in each year's smolt emigration is the number of tagged fry captured each year as smolt divided by the marked fraction (θ) of coho salmon in the escapement from that year's smolt emigration. Fry-to-smolt survival was estimated using equation (12), where N_s is the fry abundance estimate from equation (1).

RESULTS

FRY TAGGING AND RECAPTURE AS EMIGRANT SMOLT

In April of 2005 and 2006, newly-emerged coho salmon fry were captured and coded wire tagged at 2 locations in the Chuck Creek watershed (Appendix A2). After holding the tagged fry overnight and examining them for mortality and tag retention, a total of 2,304 fry were released with adipose finclips and 2,284 fry with valid CWTs in 2005, and a total of 948 fry were released with adipose finclips and valid CWTs in 2006 (Table 1).

Table 1.–Number of newly-emerged coho salmon fry coded wire tagged, sampled for length, and mean length of sampled fry by tagging location and year at Chuck Creek in 2005 and 2006, and the number of subsequent recoveries and length data as smolt.

2005 Emergent fry cohort	Year sampled	Outlet Stream	Roadside Creek	Combined
Number of fry tagged	2005	474	1,810	2,284
Number of fry sampled for length	2005	17	47	64
Mean length of fry (mm)	2005	39	37	37
SE mean length of fry	2005	0.6	0.2	0.3
Number recovered as age -1 smolt[b]	2006			158
Estimated # tagged age-1 smolt in emigration	2006			191
Mean length age-1 smolt (mm)	2006			100
SD mean length age-1 smolt	2006			11
Range of lengths age-1smolt	2006			81 to 131
Number recovered as age -2 smolt[c]	2007			6
Estimated # tagged age-2 smolt in emigration	2007			8
Mean length age-2 smolt (mm)	2007			131
SD mean length age-2 smolt	2007			14
Range of lengths age-2smolt	2007			109 to 145

2006 Emergent fry cohort	Year sampled	Outlet Stream	Roadside Creek	Combined
Number of fry tagged	2006	267	681	948
Number of fry sampled for length	2006	10	36	46
Mean length of fry (mm)	2006	39	38	38
SE mean length of fry	2006	0.6	0.2	0.2
Number recovered as age -1 smolt[c]	2007	33	59	92
Estimated # tagged age-1 smolt in emigration	2007			117
Mean length age-1 smolt (mm)	2007	118	104	109
SD mean length age-1 smolt	2007	10	10	12
Range of lengths age-1smolt	2007	94 to 142	90 to 138	90 to 142
Number recovered as age -2 smolt[d]	2008	2	10	12
Estimated # tagged age-2 smolt in emigration	2008			14
Mean length age-2 smolt (mm)	2008	153	116	122
SD mean length age-2 smolt	2008	9	18	22
Range of lengths age-2 smolt	2008	147 to 159	96 to 146	96 to 159

Note: Recoveries are fish that retained their CWT and had the tag successfully decoded.

[b] An estimated 82.9% of the entire 2006 smolt emigration was captured and examined for known-age fish.

[c] An estimated 78.6% of the entire 2007 smolt emigration was captured and examined for known-age fish.

[d] An estimated 87.1% of the entire 2008 smolt emigration was captured and examined for known-age fish.

The tagged coho salmon fry averaged 37 mm (SE = 0.3) in length in 2005, and 38 mm (SE = 0.2) in 2006 (Table 1); fry tagged in the Outlet Stream were significantly larger than fry tagged in Roadside Creek in both years ($t = 3.9$, assuming unequal variance, $P < 0.001$ in 2005; and $t = 2.7$, assuming unequal variance, $P = 0.02$ in 2006). The average size of fry tagged in 2006 were slightly larger than those in 2005 (Table 1), but the dates of tagging varied by a few days between years (Appendix A2), and this could account for some of the difference in size.

Tagged fry were recaptured as smolt in years 2006 through 2008. Of the tagged fry that survived to become smolt (and retained their CWT), the vast majority were recovered as age-1 smolt from both fry cohorts (Table 1). An estimated 96% and 89% of the tagged fry emigrated as smolt at age-1 from the 2005 and 2006 fry cohorts, respectfully (Table 1).

The average length of age-2 smolt was larger than age-1 for fish from both fry cohorts (Table 1), but was only significant for the 2005 fry cohort ($t = 5.5$, assuming unequal variance, $P = 0.003$), and not for the 2006 cohort ($t = 1.9$, assuming unequal variance, $P = 0.08$). Smolt from the 2006 fry cohort tagged in the Outlet Stream were significantly larger than those tagged from Roadside Creek when recaptured as age-1 smolt ($t = 6.6$, assuming unequal variance, $P < 0.0001$), and also significantly larger when recaptured as age-2 smolt ($t = 4.5$, assuming unequal variance, $P = 0.02$).

Smolt Age Validation

During the 2006 smolt emigration, a sample of 158 known age-1 smolt were collected with CWTs from the 2005 fry tagging. Age was estimated on these samples without the scale reader having knowledge of the true age (i.e. they were mixed in with the random sample of all smolt sampled from the 2006 smolt emigration, McCurdy 2009). Age was incorrectly estimated as age-2 on 10% of the known-age samples. There were no age-2 known-age samples from the 2006 smolt emigration for testing. McCurdy (2009) provides further details on age estimation of the 2006 Chuck Creek coho salmon smolt emigration.

During the 2007 smolt emigration, a sample of 92 known age-1 smolt and 6 known age-2 smolt were collected. Before estimating ages of the random samples of coho salmon smolt from the 2007 smolt emigration, the scale reader was provided with the true ages of half the known age-1 samples and all 6 of the known age-2 samples to potentially identify criteria (i.e. circuli patterns) that could be used to improve the accuracy of the age estimation. After examining the known-age samples, they were mixed in with all the random samples and age was estimated on the entire batch without knowledge of which samples were from the known-age fish. All of the known-age-1 samples had their age correctly estimated, but 2 of the 6 known age-2 fish had their age incorrectly estimated as age-1.

During the 2008 smolt emigration, a sample of 12 known age-2 smolt were collected. The scale reader was provided with the true ages of all 12 of these fish to potentially identify criteria that could be used in improving the accuracy of the age estimation. After examining the known-age samples, these samples were mixed in with all the random samples and age was estimated on the entire batch without knowledge of which samples were from the known-age fish. One of the known-age samples could not have its age estimated due to a regenerated scale sample. Of the 11 remaining samples, age was correctly estimated for 4 and incorrectly estimated as age-1 for the remaining 7. The errors occurred with the 7 smallest smolt (FL range 96-117 mm), and the 4 largest fish had their age correctly estimated (FL range 137-159 mm).

Fry Abundance and Survival

Estimation of fry abundance is somewhat complicated in this study because: 1) not all the fry coded wire tagged in this study retained their tag; 2) the secondary mark (adipose finclip) was not unique between years; and 3) some of the surviving fish from the 2 separate fry cohorts emigrated as smolt in the same year (2007). Adipose-finclipped smolt in 2007 that had not retained their CWT (n = 27) could have been age-1 (2006 fry cohort) or age-2 (2005 fry cohort). But because tag loss from the 2005 fry cohort was known to be low (2.4% or 4 of 166 adipose-finclipped smolt sampled as age-1 smolt in 2006), it seems reasonable to assumed that adipose-finclipped smolt from the 2007 smolt emigration that had not retained their tag were from the 2006 fry cohort. Tag loss was confirmed to be high from the 2006 fry cohort as 7 of 19 adipose-finclipped smolt examined in the 2008 smolt emigration had not retained their CWTs (when only fish from the 2006 fry cohort would be present).

2005 fry cohort

In the 2006 smolt emigration, 166 fish of 11,009 age-1 smolt examined were missing adipose fins (166 = 158 smolt with CWTs, 4 adipose-finclipped smolt with no CWT, and 4 adipose-finclipped smolt with CWTs but the heads were lost prior to shipping to the Tag Lab). In the 2007 smolt emigration 6 of an estimated 383 age-2 smolt were tagged with CWTs from the 2005 fry cohort. Pooling both smolt emigration samples (172 marks in 11,393 inspected) yields an estimate of θ = 1.5% for the fraction of the 2005 fry cohort marked. An estimated 151,809 (SE = 10,984) coho salmon fry emerged from the gravel in 2005 at Chuck Creek (n1 = 2,304, n2 = 11,392, m2 = 172). Survival from emergent fry to emigrant smolt was estimated at 8.9% (SE = 0.6%).

Note that because smolt AWL sampling was biased for size in 2006 (*larger* smolt were sampled for AWL at a rate higher than their true proportion in the captured population, McCurdy 2009), it could have also been biased for age if the AWL sample also contained a higher proportion of older fish than the true proportion. This would underestimate the true number of age-1 fish in the sampled population, but cannot be tested for in this study.

2006 fry cohort

From the 2007 smolt emigration, 124 fish of 13,406 age-1 smolt were missing adipose fins (124 = 92 smolt with CWTs, 27 adipose-finclipped smolt with no CWT, and 5 adipose-finclipped smolt with CWT's but the heads were lost prior to shipping to the Tag Lab). In the 2008 smolt emigration. 19 of 508 age-2 smolt were missing adipose fins (19 = 12 smolt with CWTs, and 7 adipose-finclipped smolt with no CWT). Pooling both smolt emigration samples (143 marks in 13,913 inspected) yields an estimate of θ = 1.0% for the fraction of the 2006 fry cohort marked. An estimated 91,696 (SE = 6,977) coho salmon fry emerged from the gravel in 2006 at Chuck Creek (n_1 = 948, n_2 = 13,931, m_2 = 143). Survival from emergent fry to emigrant smolt was estimated at 19.1% (SE = 1.5%).

SMOLT EMIGRATION IN 2007

A total of 13,791 coho salmon smolt were captured emigrating from Chuck Creek between April 17 and June 14, 2007. Of these fish, 103 were sacrificed because they already contained a CWT that needed to be retrieved as part of the age validation study mentioned above. The remaining 13,688 coho salmon smolt were coded wire tagged and had their adipose fin removed (Appendix A3). Thirty two fish died after tagging, leaving a total of 13,656 smolt (3,530 fish

≤100 mm and 10,126 fish >100 mm FL) that were released with adipose finclips and valid CWTs in 2007. Emigrating coho salmon smolt were first captured in the trough trap on the night of April 16-17 (Appendix A4), and peak catches occurred in mid May (Figure 2) when almost 17% of all the coho salmon smolt captured emigrating in less than one 24-hour period from late on May 11 to the early morning of May 12 (fish tagged on May 12).

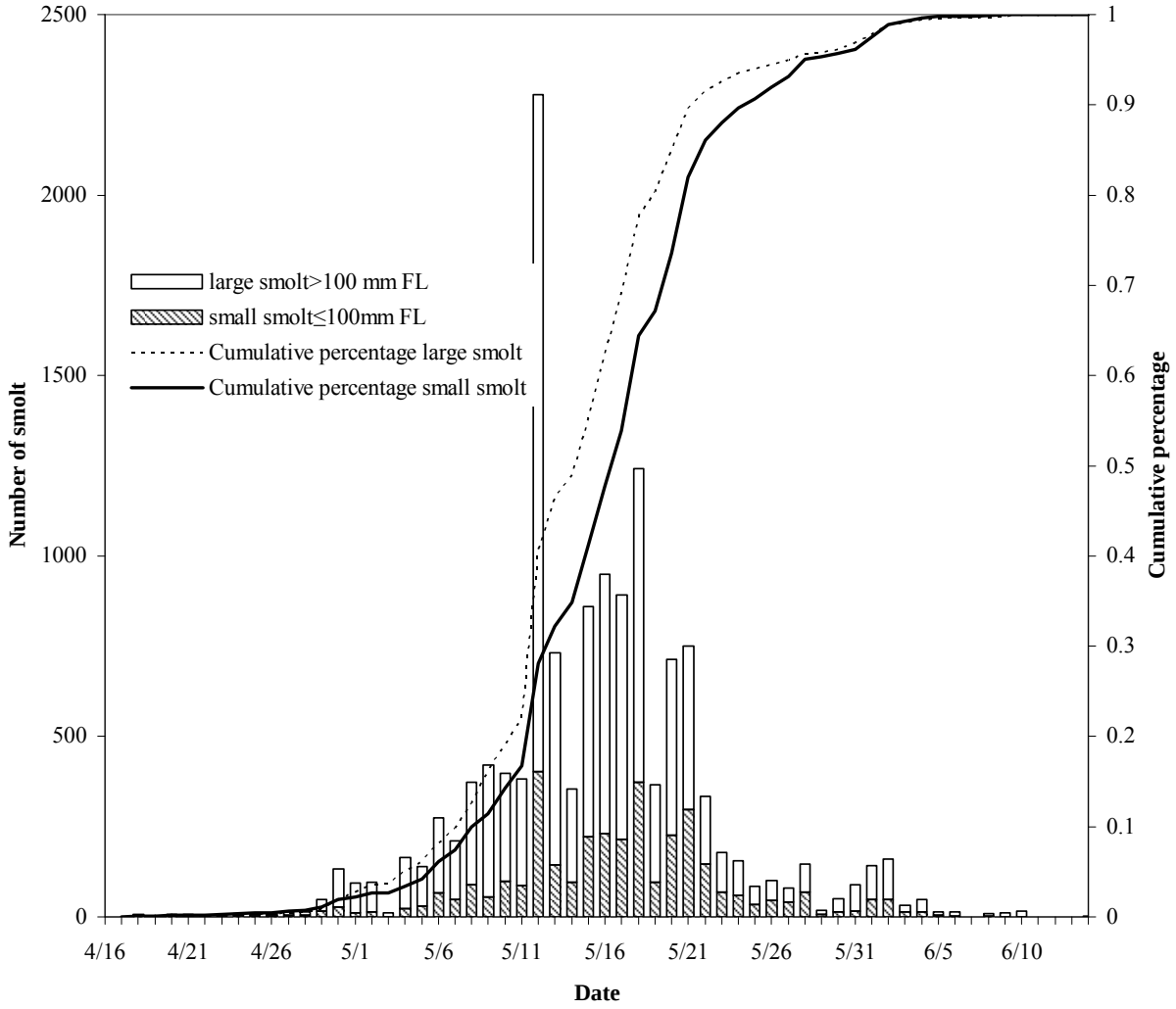

Figure 2.–Daily catch and cumulative percentage of the coho salmon smolt emigration, by size category, counted past the Chuck Creek weir in 2007.

A total of 332 captured coho salmon smolt ≥70 mm FL were sampled for age, length and weight (Table 2, Figure 3). Age could not be estimated on 5 fish due to regenerated scale samples. Age-1 coho constituted 97.2% (SE = 0.9%) of the sampled and averaged 109 mm FL (SE = 0.6) and 12.8 g (SE = 0.2). Age-2 coho smolt constituted 2.8% (SE = 0.9%) of the sample and averaged 137 mm FL (SE= 2.6) and 24.1 g (SE = 1.2).

Table 2.–Estimated freshwater age composition, and mean length and weight at age of emigrating coho salmon smolt captured at Chuck Creek in 2007.

	Age 1	Age 2	Combined
Sample size	318	9	327
Estimated composition	97.2%	2.8%	100%
SE composition	0.9%	0.9%	
Mean length (mm)	109	137	110
SE mean length	0.6	2.6	0.7
Mean weight (g)	12.8	24.1	13.1
SE mean weight	0.2	1.2	0.2

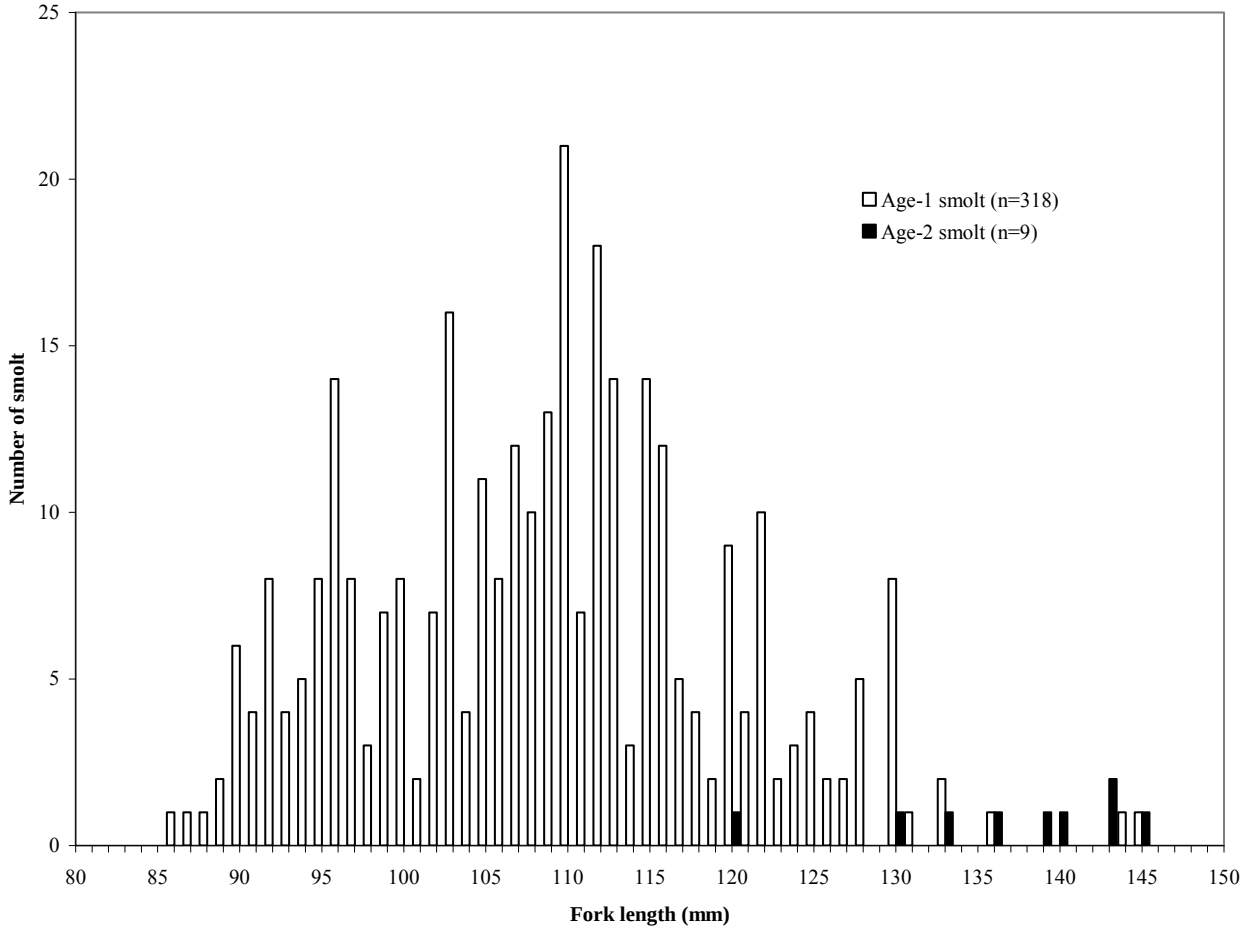

Figure 3.–Length frequency of the coho salmon smolt emigration systematically sampled at Chuck Creek in 2007, by freshwater age.

Larger smolt tended to emigrate earlier than smaller smolt. Smolt length was negatively correlated to emigration date ($R^2 = 0.04$, $P < 0.001$, Figure 4). In a systematic sample of the coho salmon smolt emigration, each additional day during the emigration period was worth about -0.34 mm FL, this despite the fact that the coho salmon smolt were certainly growing in freshwater during the sampling time period of almost 2 months. Additionally, smolt in the *larger* size category tended to emigrate earlier than *small* smolt (Figure 2, Appendix A3). Dividing the time period when smolt were captured (April 16-June 14) into 2 equal time periods, 55% of all the *large* smolt captured emigrated during the *early* period (April 16-May 15), whereas only 41% of all the *small* smolt captured did.

Surviving fish from the 2007 smolt emigration returned to Chuck Creek in both 2007 (as jacks) and in 2008 (as adults), and returning fish were examined for a missing adipose fin to determine the marked fraction (θ). In the 2007 escapement, 294 of 365 jacks examined were missing adipose fins ($\theta = 0.805$). In the 2008 escapement, 237 of 309 adults examined were missing their adipose fin ($\theta = 0.767$). These 2 marked fractions were not significantly different ($\chi^2 = 1.5$, df = 1, $P = 0.22$). Pooling both escapement samples (531 marks in 674 inspected) yields an estimate of $\theta = 0.788$ for the fraction of the 2007 smolt emigration marked. An estimated 17,327 (SE = 339) coho salmon smolt emigrated from Chuck Creek in 2007 ($n_1 = 13{,}656$, $n_2 = 674$, $m_2 = 531$).

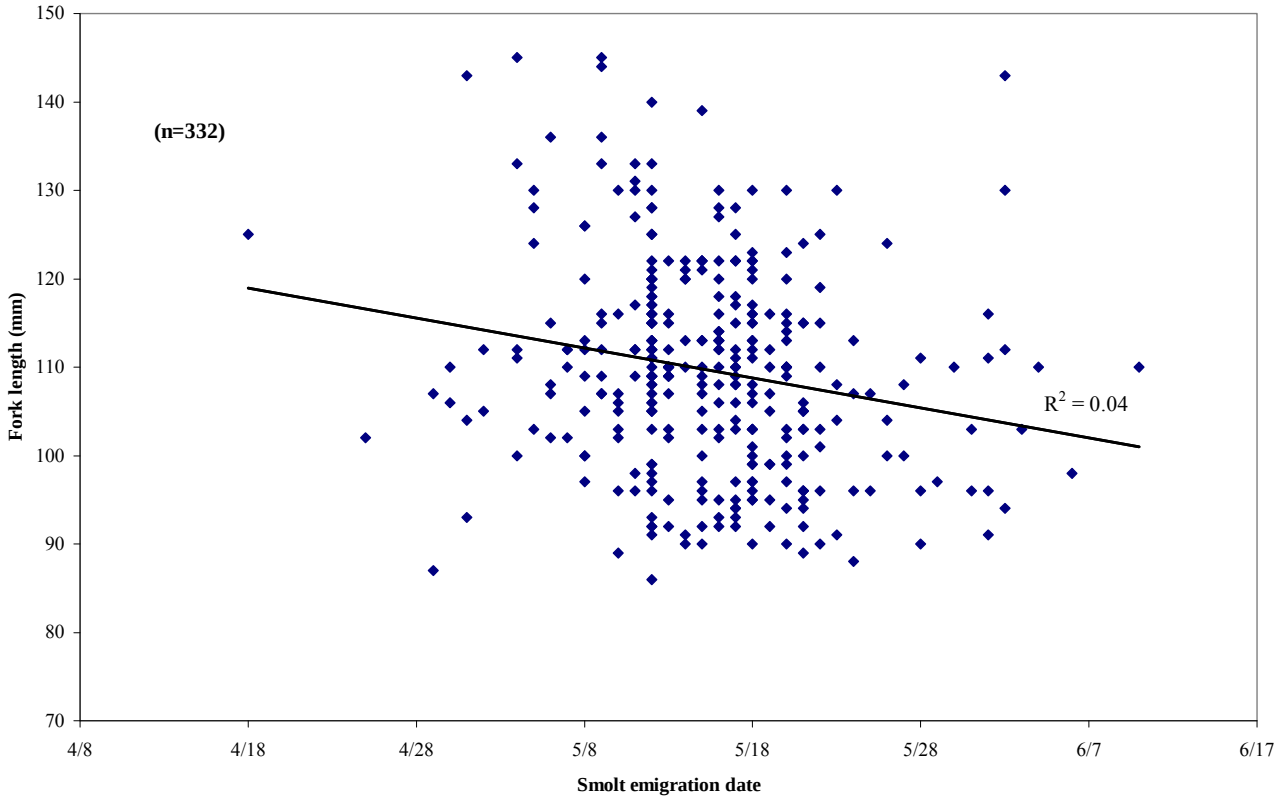

Figure 4.–Date of smolt emigration plotted vs. smolt fork length of systematically sampled coho salmon smolt from the 2007 Chuck Creek smolt emigration.

ESCAPEMENT ENUMERATION AND SAMPLING

2007 Jack Escapement

A total of 368 jack coho salmon were counted through the weir between August 15 and October 15, 2007 (McCurdy 2009). Of the total jack escapement, 3 fish were passed upstream before they could be examined for the presence or absence of an adipose fin; of the remaining 365 fish, 294 were missing their adipose fin ($\theta = 0.805$).

Every 3rd adipose-clipped jack encountered was sacrificed to yield a sample of 101 fish with sequential CWTs that were successfully decoded (Appendix A5). Of the 101 sampled jacks, *large* smolt were recovered as jacks at a rate of 0.92% (= 93/10,126) and *small* smolt were recovered at a rate of 0.23% (= 8/3,530; Table 3). This was a significantly different recovery rate ($\chi^2 = 17.1$, df = 1, $P < 0.001$; Table 4; see discussion). There was also a statistically significant difference in the average length of the 101 recovered tagged jacks between those that were tagged as *small* or *large* smolt (t = 3.3, assuming unequal variance, df = 10, P = 0.008); jacks from *small* smolt averaged 313 mm MEF (SD = 16), and jacks from *large* smolt averaged 333 mm MEF (SD = 24).

Table 3.–The number of coho salmon smolt coded wire tagged by size class and emigration time period from the 2007 Chuck Creek smolt emigration, and their subsequent recovery rate as mature fish in marine fisheries and escapement sampling programs.

				Recovery rate of tagged smolt as:								
	Number smolt tagged			Jack[b]			Adult[b]			All mature		
	Small[a]	*Large*[a]	Total	*Small*	*Large*	Total	*Small*	*Large*	Total	*Small*	*Large*	Total
Early (April 16-May 15)	1,455	5,597	7,052	0.48%	1.23%	1.08%	0.69%	0.66%	0.67%	1.17%	1.89%	1.74%
Late (May 16-June 14)	2,075	4,529	6,604	0.05%	0.53%	0.38%	1.30%	1.17%	1.21%	1.35%	1.70%	1.59%
Total	3,530	10,126	13,656	0.23%	0.92%	0.74%	1.05%	0.89%	0.93%	1.27%	1.81%	1.67%

[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 4.–Summary of significance tests of the recovery rate of coded wire tagged coho salmon smolt from the 2007 Chuck Creek smolt emigration by smolt category (*small* or *large*: *early* or *late*). P-values ≤ 0.05 are bold.

		Recoveries of tagged smolt as:					
Smolt categories tested		Jacks		Adults		All mature fish	
		χ^2	P-value	χ^2	P-value	χ^2	P-value
	small vs. large[a]	17.1	< **0.001**	0.7	0.40	4.5	**0.03**
	early vs. late[b]	22.7	< **0.001**	11.0	**0.001**	0.5	0.48
Small only	*early vs. late*	7.1	**0.008**	3.1	0.08	0.2	0.64
Large only	*early vs. late*	13.6	< **0.001**	7.4	**0.007**	0.5	0.47
Early only	*small vs. large*	6.1	**0.01**	0.0	0.91	3.5	0.06
Late only	*small vs. large*	8.8	**0.003**	0.2	0.65	1.1	0.29

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

[b] Early period is April 16-May 15; late period is May 16-June 14.

The average number of days between tagging and recapture of the 101 jacks was 126 days (SD = 11.2); 99 days was the minimum time spent in the marine environment and 158 days the maximum. For the *small* smolt only, the average number of days between capture events was 129 days (SD = 10.7), and for the *large* smolt the average number of days was 126 (SD= 11.3). This was not a significant difference (t = 0.7, df = 8, assuming unequal variance, P = 0.5). The length of the 101 jacks was positively correlated with number of days at sea (days between capture events; $R^2 = 0.06$, P = 0.01, Figure 5); each additional day at sea was worth about 0.5 mm in additional length.

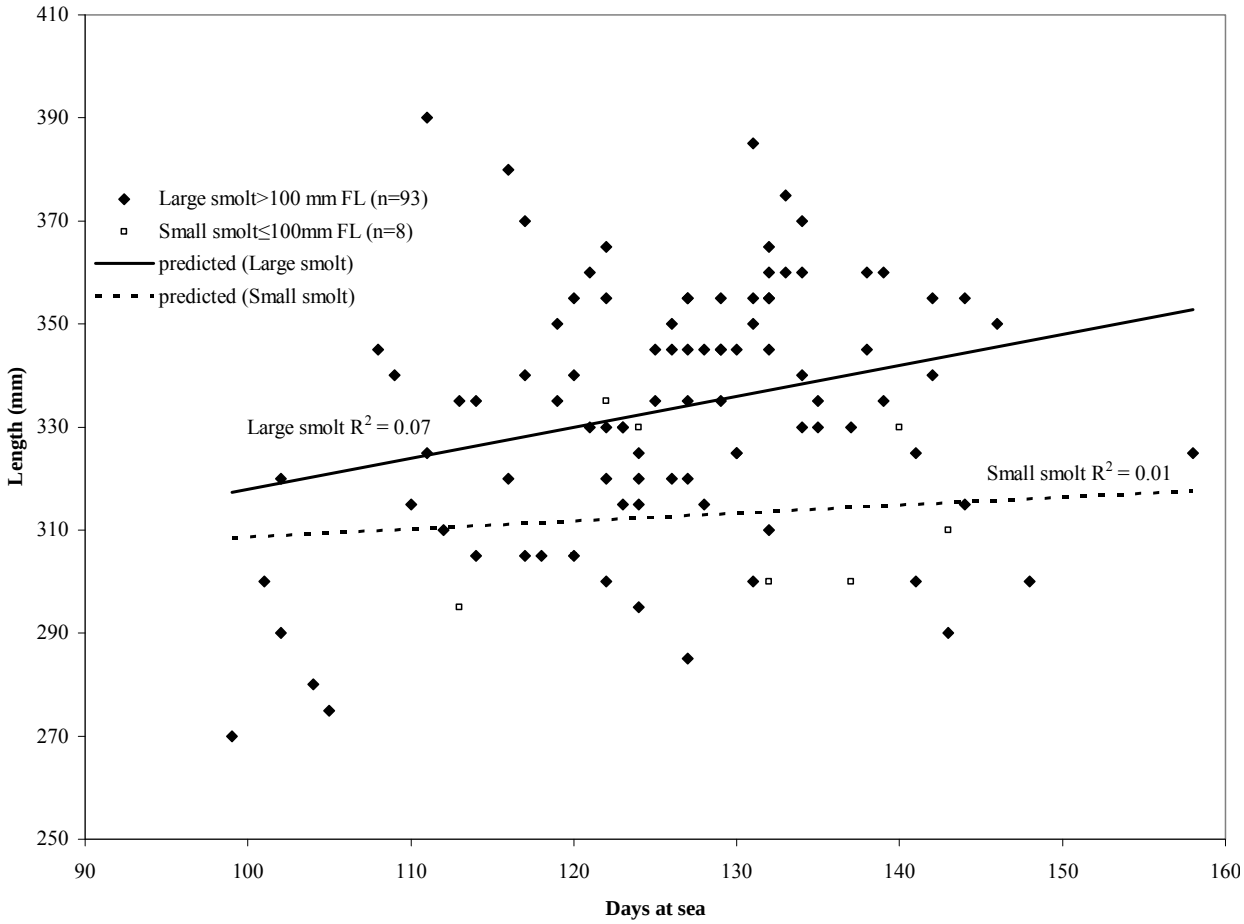

Figure 5.–Lengths (MEF) of jack coho salmon sampled at the Chuck Creek weir in 2007 plotted vs. days at sea (days between capture as smolt and mature fish).

A simple linear regression model analyzing the relationship of jack immigration date (date of capture at the adult weir) as a function of smolt emigration date (date of capture at the smolt weir) of the 101 jacks yields an R^2 value of 0.034 (P = 0.065, Figure 6).

McCurdy (2009) provides further details on the 2007 escapement of coho salmon to Chuck Creek.

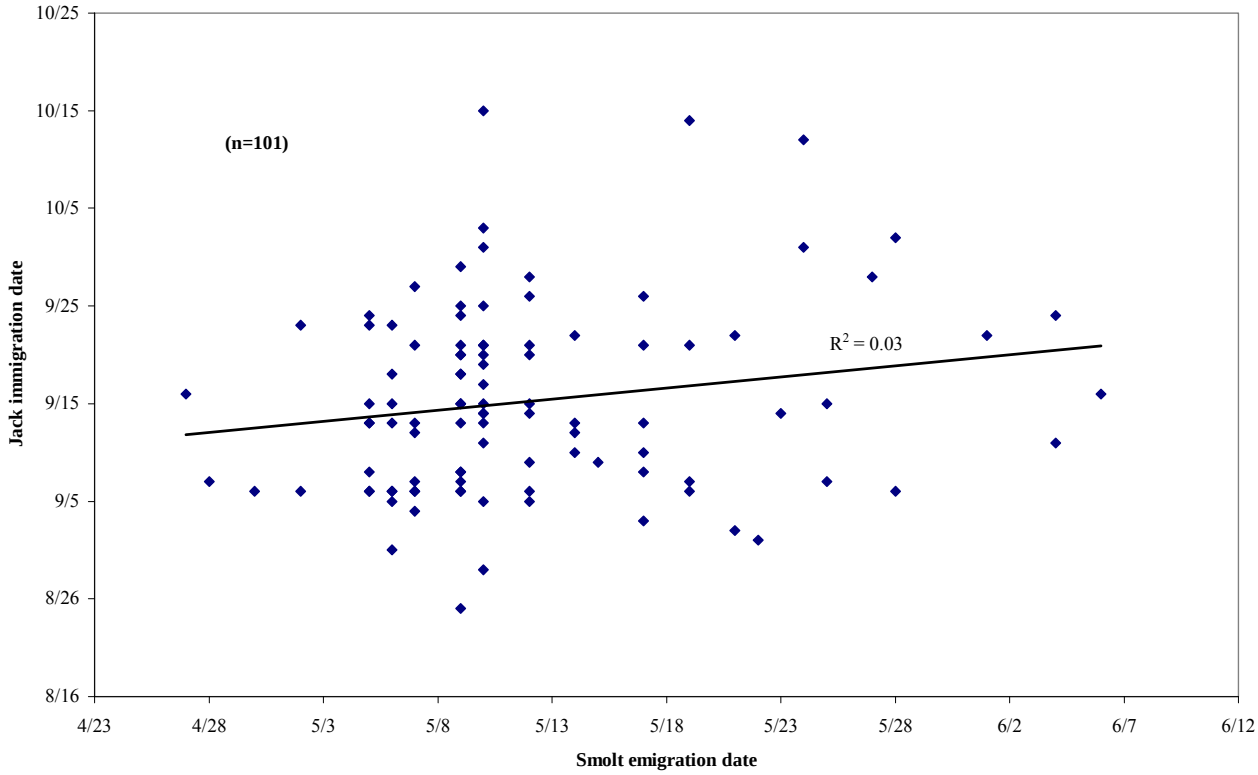

Figure 6.–Date of smolt emigration (capture at weir) plotted by immigration date (capture at weir) of jack coho salmon from the 2007 Chuck Creek smolt emigration.

2008 Escapement

In 2008, a total of 309 adult and 617 jack coho salmon were counted past the weir on Chuck Creek between August 18 and October 20 (Appendix A6). Life-history type (adult, jack) was assumed to be accurately determined on all mature fish in the 2008 escapement, as no overlap in length between jacks and adults was detected by aging a random sample of 282 fish (Figure 7). In addition, all fish that measured between 380 and 450 mm MEF were sampled for age verification (n = 3). In the 2008 escapement the largest jack measured 385 mm and the smallest adult measured 465 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, 1983, and 1985 (Integrated Fisheries Database, Division of Commercial Fisheries, 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 20; 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 percent of the adult escapement and 28% of the jack escapement that was passed through the weir had a scale sample taken that allowed for age estimation. The sample size was larger for length and sex determination than age determination (Table 5), as length and sex were measured and estimated, respectively, on all fish sampled, but not all scale samples were readable due to some regenerated scale samples. An estimated 41.3% (SE = 5.0%) of the 309 adult coho salmon counted in the escapement were male. The vast majority of both jack and adult coho salmon in the 2008 escapement had emigrated as 1-year old smolt (Table 5).

Table 5.–Estimated freshwater age composition, and mean length at age and sex of the 2008 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				32	7	44
Percent				82.1%	17.9%	100.0%
SE percent				5.5%	5.5%	
Mean length (mm)				635	616	632
SE mean length				7	24	6
Males						
Sample size	155	19	206	20	2	31
Percent	89.1%	10.9%	100.0%	90.9%	9.1%	100.0%
SE percent	2.0%	2.0%		5.7%	5.7%	
Mean length (mm)	296	333	300	623	555	626
SE mean length	2	5	1	13	64	10
All fish						
Sample size				52	9	75
Percent				85.2%	14.8%	100.0%
SE percent				4.1%	4.1%	
Mean length (mm)				630	603	626
SE mean length				7	23	5

[a] Includes fish that were sampled for sex and length, but the freshwater age could not be estimated.

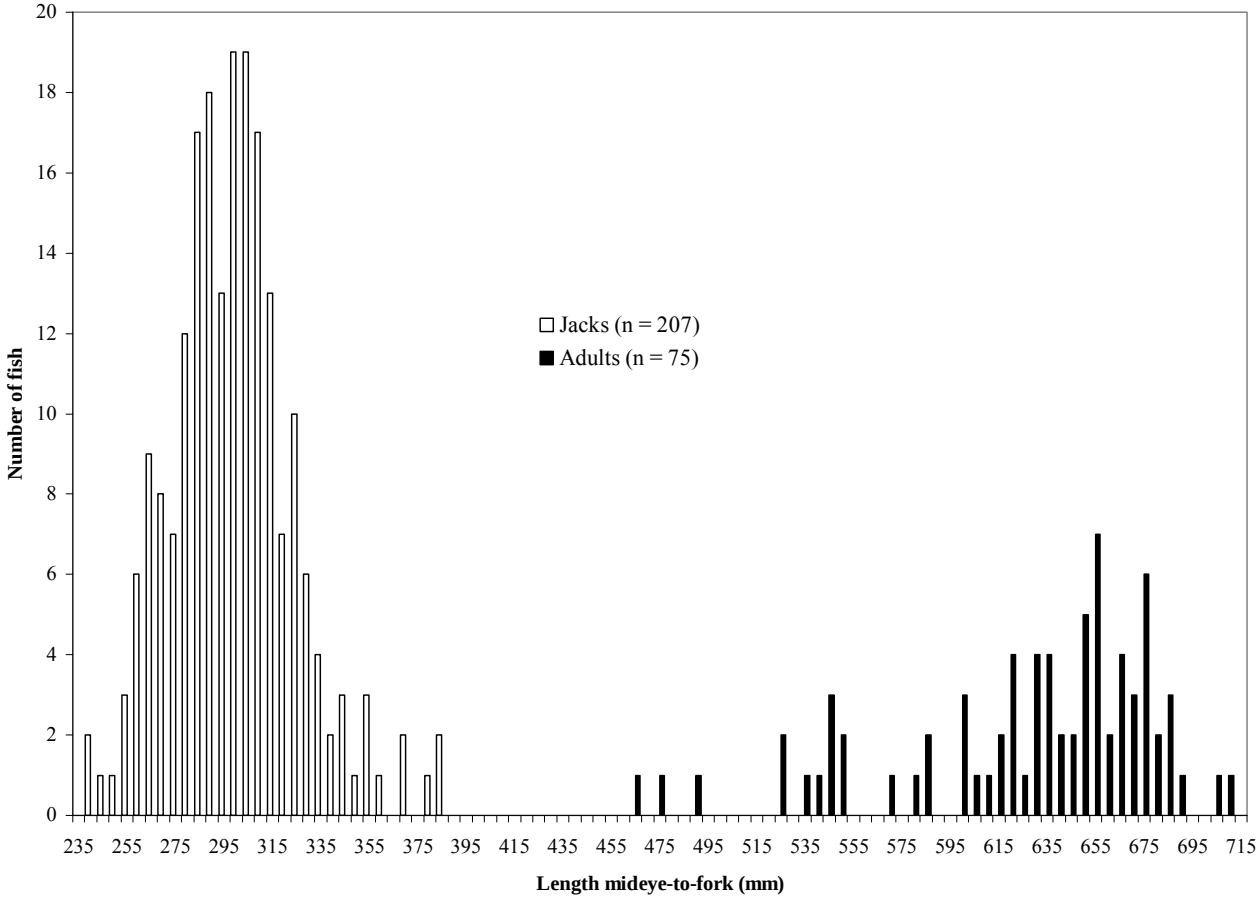

Figure 7.–Length frequency (by 5 mm size classes) of the coho salmon escapement sampled at the Chuck Creek weir in 2008, by ocean age (every 3rd jack and every 4th adult systematically sampled).

A total of 967 adult sockeye salmon, 29 jack sockeye salmon (males < 400 mm MEF), 87 chum salmon, 12,522 pink salmon, 8 Dolly Varden, 1 steelhead trout, and 1 cutthroat trout were also counted through the weir between August 18 and October 20, 2008 (Appendix A7). 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 20, and a number of pink and chum salmon spawned downstream of the weir site (personal observations). The crew observed Dolly Varden fitting between the pickets on the weir and it is likely that the weir captured only a small percentage of immigrating Dolly Varden. The 1 steelhead captured was less than 400 mm FL, and appeared to have recently entered the stream from the marine environment (bright silver coloration), 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 2008 escapement, all adults found to be missing an adipose fin (n = 61) 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 fraction of the adult escapement missing adipose fins ($\theta = 0.767$), as all adults missing an adipose fin were assumed to have retained their CWT.

A total of 126 adult coho salmon tagged as smolt emigrating from Chuck Creek in 2007 were recovered in creel and port sampling programs that sampled marine fisheries in Alaska in 2008 (Appendix A8), and one other fish was recovered in a sampled Canadian fishery. Of these 127 recoveries, *large* smolt were recovered as adults at a rate of 0.9% (= 90/10,126) and *small* smolt were recovered at a rate of 1.0% (= 37/3,530; Table 3). This was not a significantly different recovery rate ($\chi^2 = 0.7$, df = 1, P = 0.4; Table 4; see discussion). There was a significant difference in the average length of the adults recovered in marine fisheries (n = 125, as length was not measured on 2 samples; Appendix A8) between those tagged as *small* smolt or *large* smolt (t = 3.1, assuming unequal variance, df = 52, P = 0.003). Adults originating from *small* smolt averaged 589 mm FL (SD = 44), and adults from *large* smolt averaged 614 mm FL (SD = 31).

Of the 126 marine recoveries of coded wire tagged coho salmon from Chuck Creek in Alaskan waters, 120 were random samples that were useful for estimating marine harvest in various fisheries (Appendix A9). The greatest number (92) of the random CWT recoveries were in the troll fishery and the remainder were in the seine fishery (19), sport fishery (6), and gillnet fishery (3). There were also 5 random recoveries in marine fisheries where the fishing area was not designated and 1 non-random recovery (Appendix A8). Of the random troll recoveries, 60 were recovered in the SW quadrant, 21 in the NW quadrant, 8 in the SE quadrant, and 3 in the NE quadrant. Purse seine recoveries were in fishing Districts 102, 103 and 104 (Appendix A1). Drift gillnet recoveries were in fishing District 101 (in the "Tree Point" area). Sport recoveries were from the port of Craig/Klawock. The 1 Canadian recovery was a random sample from the Northern British Columbia troll fishery that was useful for estimating marine harvest in this fishery.

An estimated 565 (SE = 53) coho salmon originating from Chuck Creek were harvested in marine commercial and sport fisheries in 2008 (Tables 6 and 7, Appendix A9). The commercial troll fishery in Alaska harvested an estimated 389 fish or 68.8% of the total harvest. The Alaskan purse seine fishery harvested an estimated 146 fish (25.8% of the total harvest), the Alaskan gillnet fishery harvested an estimated 17 fish (or 3.0% of the total harvest), and the Alaskan sport fishery harvested an estimated 8 fish (or 1.4% of the total harvest). The commercial troll fishery in northern British Columbia harvested an estimated 5 fish (or 0.9% of the total harvest). Harvested fish were sampled from early July through mid-September (Figure 8, Appendix A8).

The total return of Chuck Creek adult coho salmon was estimated at 874 fish (SE = 53) in 2008 (Table 6). Marine survival to adult of the 2007 smolt emigration was estimated at 5.0% (SE = 0.3%) and the exploitation rate in marine fisheries was estimated at 64.6% (SE = 2.1%). An additional 368 fish, or 2.1% (SE = 0.04%) of the estimated 17,327 smolt that emigrated in 2007 survived to return as jacks in the same year as their emigration.

Table 6.–Estimated harvest, exploitation rate, and total return of Chuck Creek coho salmon in 2008.

Fishery	Area	Estimated harvest	SE (harvest)	Percent of harvest	Exploitation rate	SE (exploitation rate)
Alaska Troll	NE Quadrant	13	7	2.3%	1.5%	0.3%
	NW Quadrant	99	19	17.5%	11.3%	0.8%
	SE Quadrant	43	14	7.6%	4.9%	0.6%
	SW Quadrant	234	26	41.4%	26.8%	1.1%
	Subtotal	389	36	68.8%	44.5%	1.5%
Alaska Gillnet	District 101	17	11	3.0%	1.9%	0.4%
	Subtotal	17	11	3.0%	1.9%	0.4%
Alaska Seine	District 102	9	5	1.6%	1.0%	0.2%
	District 103	114	35	20.2%	13.0%	1.4%
	District 104	23	9	4.1%	2.6%	0.4%
	Subtotal	146	37	25.8%	16.7%	1.5%
Alaska Sport	Craig/Klawock	8	2	1.4%	0.9%	0.1%
	Subtotal	8	2	1.4%	0.9%	0.1%
Canadian Troll	Northern B.C.	5	4	0.9%	0.6%	0.2%
	Subtotal	5	4	0.9%	0.6%	0.2%
Total harvest		565	53	100.0%	64.6%	2.1%
Escapement		309			35.4%	
Total return		874			100.0%	

Table 7.–Annual estimates of harvest, escapement, total return, and exploitation rate of adult coho salmon form Chuck Creek in years with returning coded wire tagged fish.

	Harvest								
Return year	**Alaska troll**	**Alaska seine**	**Alaska gillnet**	**Alaska sport**	**Canadian harvest[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[g]	577	116		29	60	782	425	1,207	64.8%
2008	389	146	17	8	5	565	309	874	64.6%

[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.
[g] Estimates from McCurdy 2009.

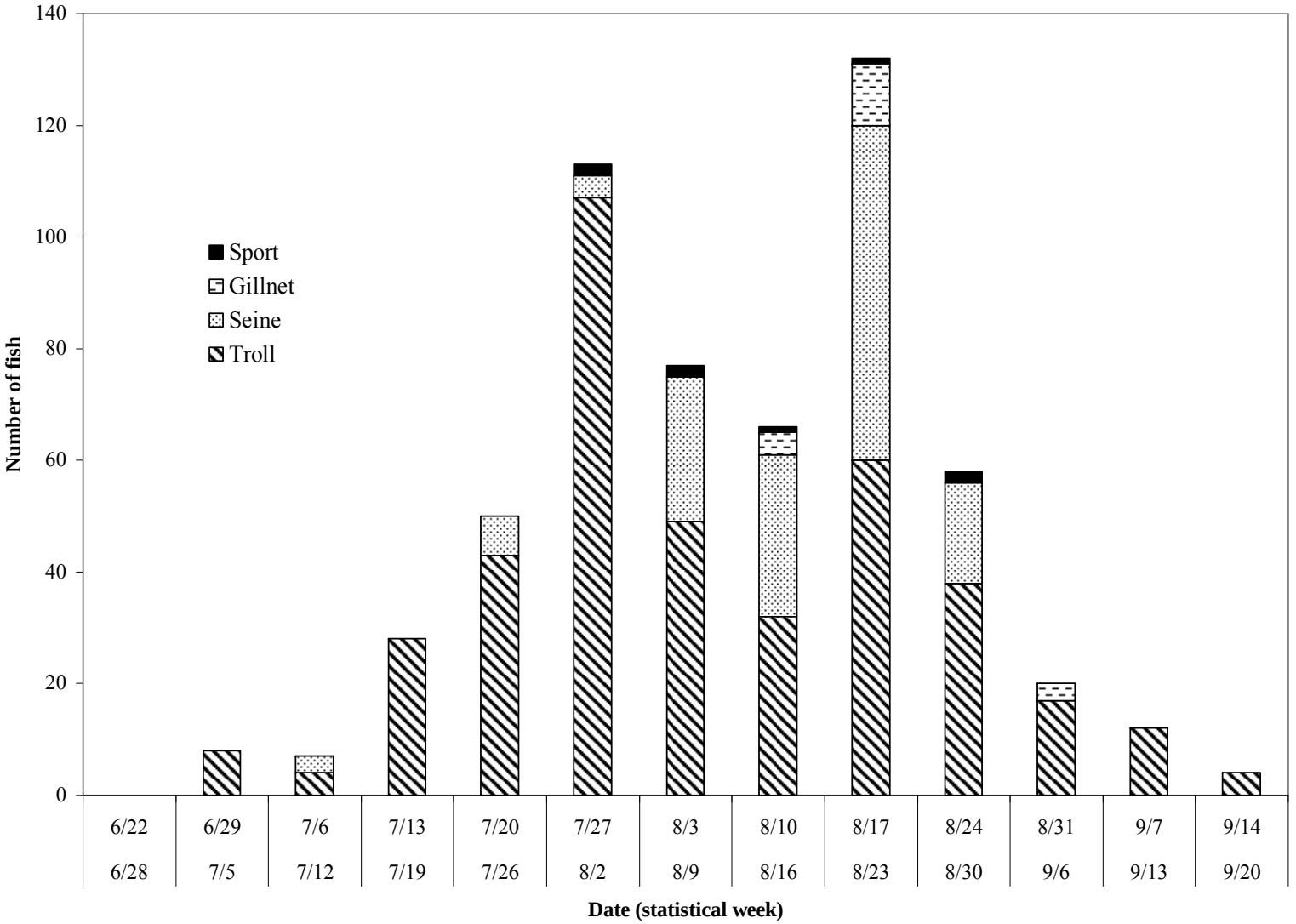

Figure 8.–Estimated marine harvest in Alaskan waters of coho salmon bound for Chuck Creek by statistical week and fishery in 2008.

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; Mathews and Ishida 1989; Hagar and Noble 1976; 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. 2004) 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. 2004), 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 2 equal emigration time periods (*early* and *late)* and 2 size groups (*small* and *large,* Table 4). All smolt captured in 2007 were tagged with a unique, sequentially numbered CWT that identified their date of emigration (date of capture) and their inclusion into 1 of 2 size categories (*small* smolt ≤100 mm FL and *large* smolt >100 mm FL, Appendix A3). Subsequently, 228 of these uniquely-tagged fish were recovered (Appendices A3, A5 and A8) as either adults in marine fisheries in 2008 (127 fish), or jacks in the 2007 escapement (101 fish). It is assumed that all recoveries represent an unbiased sample of surviving fish.

The *early* smolt emigration period ran from April 16 through May 15 (smolt tagged = 7,052; subsequent recoveries = 123; Appendix A3), and the *late* period ran from May 16 through June 14 (smolt tagged = 6,604; recoveries = 105). No trend in survival to maturity (adults and jacks combined) as a function of emigration date is apparent based on these recoveries ($\chi^2 = 0.5$, P = 0.48, Tables 3 and 4, Figure 9). However, the recovery rate for fish that returned as jacks decreased significantly from the *early* to the *late* emigration period ($\chi^2 = 22.7$, $P < 0.001$, Tables 3 and 4), while the recovery rate as adults increased significantly from the same emigration period ($\chi^2 = 11.0$, P = 0.001).

Smolt size was related to the recovery rate of marked fish at maturity (jacks and adults combined) in this study. L*arge* smolt were recovered at maturity at a rate of 1.80% (Table 3), while *small* smolt were recovered at a rate of 1.27%. These are significantly different recovery rates ($\chi^2 = 4.5$, P = 0.03, Table 4), and the difference is due to *large* smolt being recovered at a higher rate as jacks than were *small* smolt.

In this study, a higher portion of the *large* smolt emigrated during the *early* period than did *small* smolt (Figure 2). This is consistent with past coho salmon smolt emigrations at Chuck Creek (McCurdy 2009) and other studies where larger coho salmon smolt tended to emigrate earlier in the wild than smaller fish (Irvine and Ward 1989; Lum 2003; but see Holtby et al. 1989; Quinn and Peterson 1996; Thedinga and Koski 1984). 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 (0.48% versus 0.05%, $\chi^2 = 7.1$, P = 0.008, Tables 3 and 4).

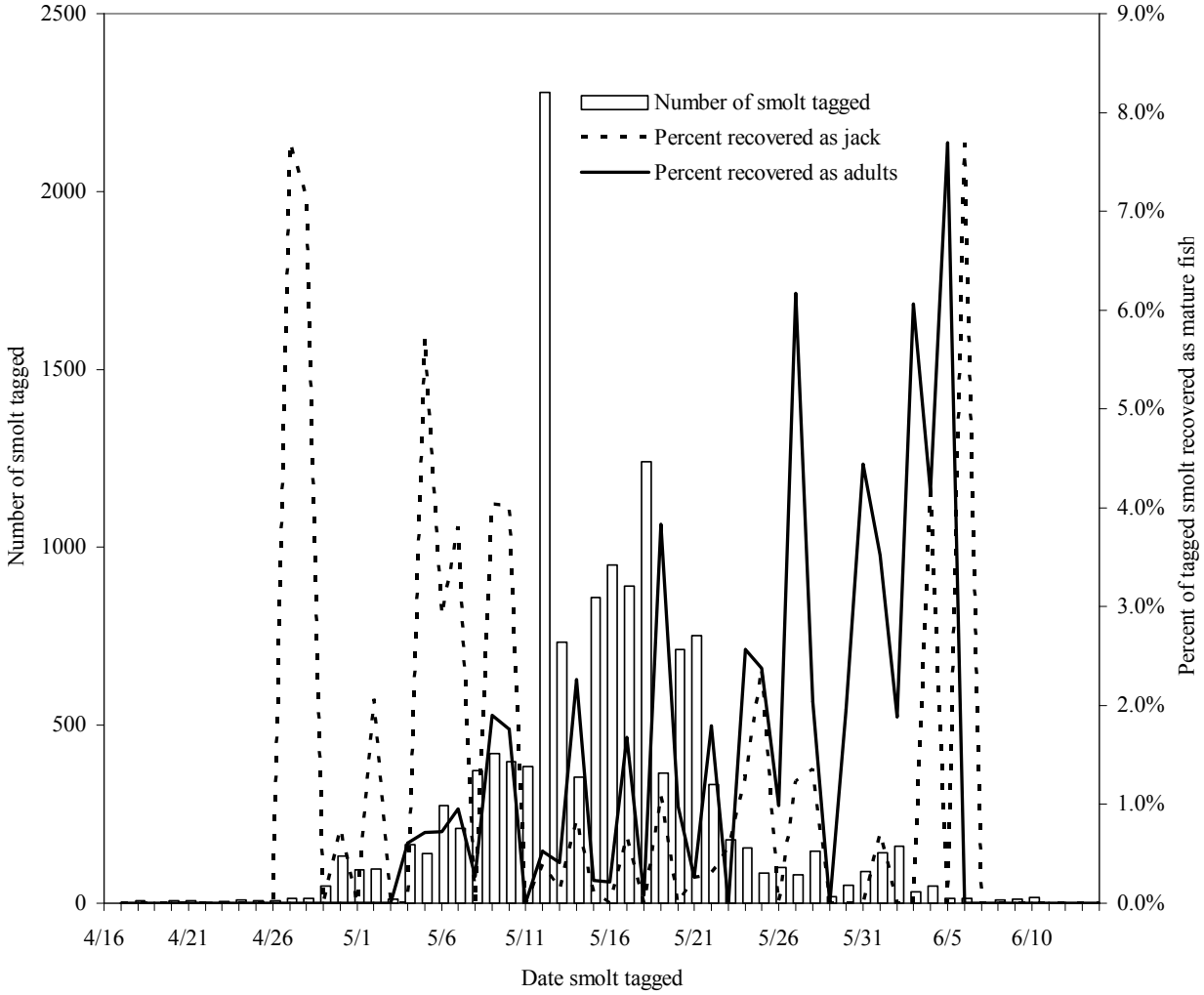

Figure 9.–Number of smolt tagged by date, and their subsequent recovery rate as mature fish sampled in marine fisheries and the return escapement from the 2007 Chuck Creek coho salmon smolt emigration. Note that tagged jacks and adults were sampled at different rates.

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 periods, differences in recovery rates between the 2 emigration periods was likely influenced by smolt size, and conversely, emigration period likely influenced 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 0.66% seen for early-emigrating, large-sized smolt (Table 3), whereas the early-emigrating, large-size smolt had the highest recovery rate as jacks.

In this study, the marine mortality rate (from smolt to maturity) is an estimated 92.8% (= 1 - [874_{adults} +368_{jacks}]/$17{,}327_{smolt}$), within the range (83.0% to 93.9%) for Chuck Creek coho salmon over the previous 5 years (McCurdy 2009) and within the range reported in the literature (Sandercock 1991). Other studies have suggested that a significant portion of marine mortality occurs shortly after the fish have entered the marine environment (Briscoe et al. 2005; Fisher and Pearcy 1988). Data collected in this study are consistent with this hypothesis. First, there has been a nearly constant proportion of surviving jacks (to all surviving mature fish) from all the tagged smolt cohorts (range 23.3% to 32.3%, for emigration years 2002-2007). 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; Koseki and Fleming 2006). Also, there is a significant correlation between the recovery rates of tagged jacks and tagged adults in both the *early* (April 16-May 15) and *late* (May 16-June 14) periods ($r = 0.60$ for the early period and $r = 0.81$ for the late period, for emigration days with at least 100 smolt tagged; Figure 9). 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, the probability of not sampling a surviving fish was ≤ 0.18; Appendix A10). 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 ($\chi^2 = 261$, $df = 25$, $P < 0.0001$, for days with at least 100 smolt tagged; Appendix A10). 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 (= 1.67% or 228/13,656). This test found that on 8 of the 26 tagging days (31% of days) with at least 100 smolt tagged, the probability was well below $P = 0.001$ of recovering *as few as or as many as* the observed number of recoveries (see Appendix A10). 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 suggests 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 2007 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 0.16% (= 127/81,851 for years 2002-2007), and the majority of this mortality occurred during the tagging process (i.e. dropped fish, fish left too long in the solution of MS-222); almost no mortality occurred overnight. Also, coho salmon smolt are believed to robustly survive typical coded wire tagging procedures (Magnus et al. 2006; Vincent-Lang et al. 1993). Finally, it is also worth noting that daily recovery rates (jacks and adults combined) were not correlated to the number of smolt emigrating ($r^2 = 0.14$, P = 0.06, for days with at least 100 smolt tagged) or to the daily mean length of the smolt ($r^2 = 0.002$, P = 0.83, for days with at least 100 smolt tagged).

SMOLT ABUNDANCE

The smolt weir appeared to be operational and virtually 100% effective at capturing coho salmon smolt prior to significant emigration in 2007 (Appendix A4, Figure 2). However, an estimated 21.4% of the escapement from the 2007 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 14, 2007. 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 are 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 2006 a,b, 2008). Still, 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 2006 a,b, 2008, 2009).

By applying the same model (Appendix A11) to the 2007 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 7.1% survival rate of *marked* fish estimated in this study. If *unmarked* fish survive at 8.8% (a rate 25% higher than the rate of 7.1% for marked fish), then the smolt abundance estimate in this report (17,327) would be biased by 3.3% (and the actual abundance would be 16,766). Similarly, if the actual survival rate for

unmarked fish was 5.3% (25% lower than for marked fish) the smolt abundance estimate would be biased by -8.0% (and actual abundance would be 18,840). 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 9) helps explain the difference in the marked fraction between jacks (θ=0.805) and adults (θ=0.767) 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.

AGE VALIDATION

It appears that the age estimation error that occurred on a small percentage of the larger smolt was due to the inability to distinguish "false" annuli (a circuli pattern similar to annuli formation) from actual annuli by the scale reader. A small percentage of age-1 smolt from the 2006 emigration were incorrectly aged as age-2 fish because of the presence of false annuli. After the scale reader learned that false annuli were occurring (and that an age-1 smolt could be as large as 142 mm FL), no age estimation error occurred with age-1 smolt in subsequent emigration years. However, some age-2 smolt in the 2007 and 2008 emigrations were incorrectly aged as age-1 fish, and again the problem appeared to be the inability to distinguish between false and actual annuli on some smolt. Thus, the estimation of the age composition of the 2007 smolt emigration is likely biased (as well as for the other smolt emigration years). However the effect of the bias on the estimated age composition of the smolt emigration is likely low. Data in this study points to almost all the smolt from Chuck Creek being age-1. The vast majority of the tagged fry emigrated at age-1 (97% from the 2005 fry cohort, and 87% from the 2006 fry cohort). Fish size (and not age) appears to be the determining factor in whether or not a juvenile coho salmon emigrates in any given spring (Quinn 2005). The productivity of the Chuck Creek watershed is such that coho salmon smolt can easily exceed a minimum threshold size for smoltification after 1 year of growth. ADF&G smolt tagging procedures set a minimum size of from 70 mm FL to 85 mm FL for juvenile coho salmon tagging in the spring in Southeast Alaska (to insure that the fish will smolt that spring; Magnus et al. 2006). Tagged fry in this study recaptured as age-1 smolt in 2007 averaged 109 mm FL (Table 1), and rarely are juvenile coho captured less than 80 mm FL in any spring at Chuck Creek. The large size of the age-1 smolt (Tables 1 and 2) emigrating from Chuck Creek suggest that few juvenile coho salmon remain in the watershed for a second year. In addition, the scale reader correctly aged 91% of all the tagged fry recaptured as smolt. Because almost all the smolt at Chuck Creek are age-1 (and it appears that after the 2006 smolt emigration all age-1 fish are correctly being aged) it would require incorrectly estimating age on a large portion of the age-2 smolt to greatly bias the age composition estimates in this study.

Further analysis of the known-age scale samples collected in this study is warranted as it may reveal criteria (for example: minimum distance or numbers of circuli between annuli), that can be used to improve age estimation accuracy in this and other studies of coho salmon.

FRY ABUNDANCE ESTIMATES

The validity of the abundance estimates assumes that the marked fry survived at the same rate as unmarked fry, which cannot be tested for in this experiment, but comparisons of survival between fry from the 2 tagging locations in 2006 are possible. Fry from Outlet Stream were recovered at a slightly higher rate (13.1%) as smolt than those from Roadside Creek were (10.1%), but this difference was not significant ($\chi^2 = 1.7$, df = 1, P = 0.19). It seems reasonable to assume that if fry from the 2 tagging locations (that are situated near the spatial extremes of anadromous habitat in the watershed) had similar survival, then untagged fry from these same locations and areas in between also experienced similar survival. Additionally, marked and unmarked fish experienced similar growth in this experiment, as there was no significant difference in length of smolt at age between sampled marked smolt and the random sample (unmarked) of each year's smolt emigration of the same age. In 2006, marked age-1 smolt (n = 158) averaged 100 mm FL, and the random sample of age-1 smolt (n = 188) averaged 100 mm FL (t = 0.1, df = 299, assuming unequal variance, P = 0.9). Marked age-1 smolt in the 2007 smolt emigration (n = 92) averaged 109 mm FL and the random sample (n = 318) averaged 109 mm FL (t = 0.3, df = 136, assuming unequal variance, P = 0.8). Marked age-2 smolt in the 2007 (n = 6) averaged 131 mm FL and the random sample (n = 9) averaged 137 mm FL (t = 1.0, df = 7, assuming unequal variance, P = 0.4). This suggests that marked fry were a representative sample of the population, and any difference in survival rates between marked and unmarked fish was likely minimal.

Because the estimated age composition of each year's smolt emigration was used in calculating the fry abundance estimates, and the age composition estimates were likely biased, this bias would also affect the fry abundance estimates. This bias is likely low for the reasons mentioned above describing the age composition bias.

SMOLT EMIGRATION DATE AND JACK RETURN DATE

There was no significant relationship between the date of smolt emigration and jack immigration date for the 101 jacks sampled in the 2007 escapement. Nor was there a significant relationship between emigration and immigration dates when *small* and *large* smolt were analyzed separately. See McCurdy (2009) for further discussion into limitations in the design of this experiment.

MARINE HARVEST

Harvest distribution patterns in Alaskan waters in 2008 were mostly similar to past years (Shaul et al. 1991; McCurdy 2005, 2006 a,b, 2008, 2009); almost all harvest occurred in districts along the outside coast (Appendices A1 and A8), and a few tagged fish were recovered from the District 1 gillnet fishery for the first time. The estimated marine harvest of 565 Chuck Creek coho salmon and the estimated total run of 874 fish were the second smallest to date (for years when this stock has been monitored); only the 2005 smolt emigration produced fewer adult fish (Table 7). The small total run was attributed to an average smolt emigration coupled with the lowest marine survival to date since this project began in 2001. The marine exploitation rate of 64.6 % in 2008 was the second highest to date on this stock for years with returning coded wire tagged fish (Table 7).

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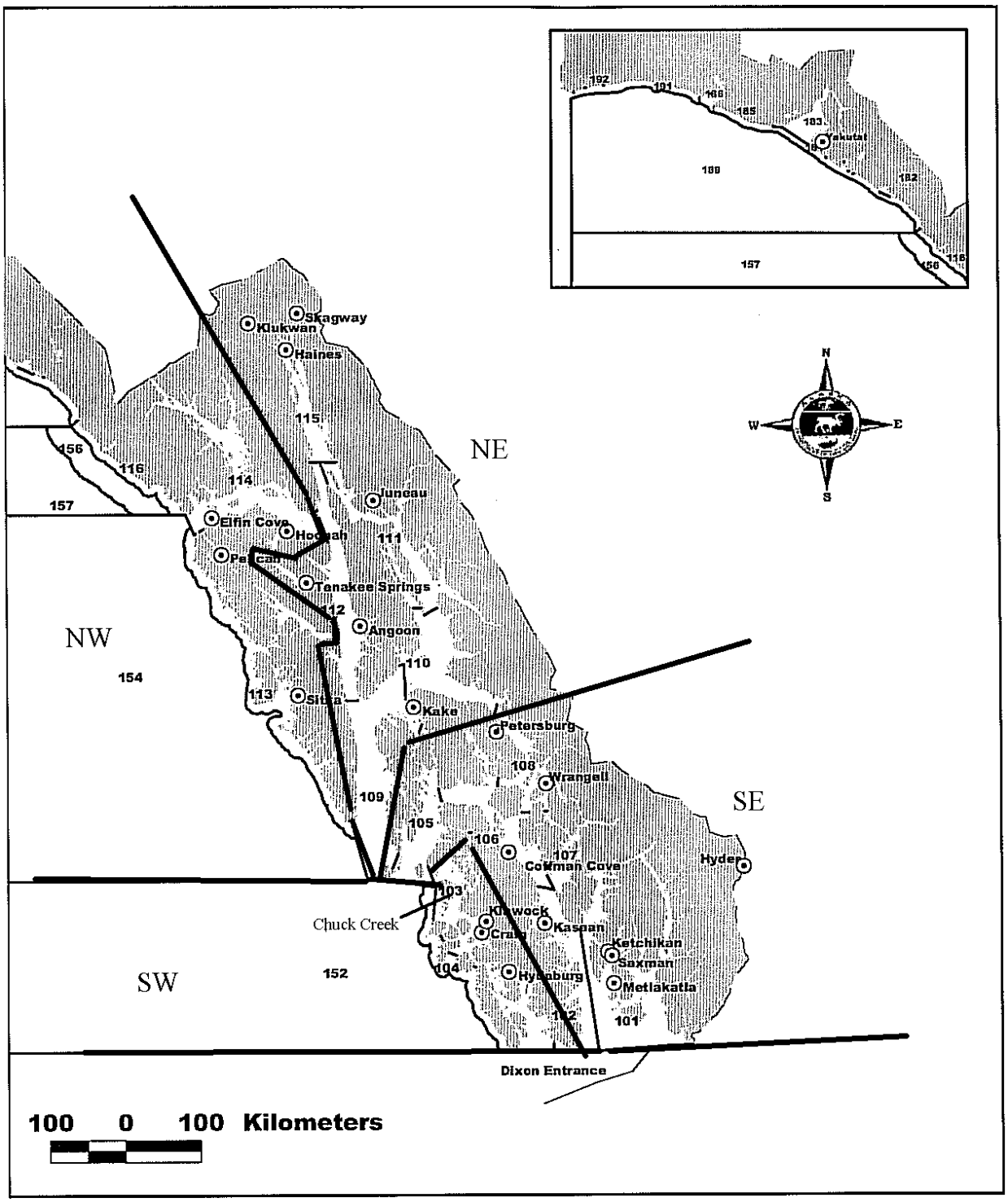
APPENDIX A



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

Appendix A2.–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 and 2006.

Date	Tag code	Location in watershed	# Tagged	Overnight mortality	Valid tags	Shed tags
2005						
4/22/2005	0401060103	Outlet Stream	20	0	20	0
4/23/2005	0401060103	Outlet Stream	196	1	195	0
4/24/2005	0401060103	Outlet Stream	169	0	169	0
4/26/2005	0401060103	Outlet Stream	94	0	90	4
4/24/2005	0401060103	Roadside Creek	405	1	404	0
4/25/2005	0401060103	Roadside Creek	743	3	737	3
4/26/2005	0401060103	Roadside Creek	682	0	669	13
2005 Total:			**2,309**	**5**	**2,284**	**20**
2006						
4/18/2006	0401060104	Outlet Stream	11	0	11	0
4/20/2006	0401060104	Outlet Stream	25	0	25	0
4/22/2006	0401060104	Outlet Stream	19	0	19	0
4/24/2006	0401060104	Outlet Stream	44	1	43	0
4/25/2006	0401060104	Outlet Stream	29	2	27	0
4/26/2006	0401060104	Outlet Stream	53	1	52	0
4/27/2006	0401060104	Outlet Stream	14	0	14	0
4/28/2006	0401060104	Outlet Stream	18	0	18	0
4/29/2006	0401060104	Outlet Stream	12	0	12	0
4/30/2006	0401060104	Outlet Stream	46	0	46	0
Outlet Stream total:			**271**	**4**	**267**	0
4/25/2006	0401060105	Roadside Creek	93	2	91	0
4/26/2006	0401060105	Roadside Creek	124	1	123	0
4/27/2006	0401060105	Roadside Creek	111	0	111	0
4/28/2006	0401060105	Roadside Creek	271	2	269	0
4/29/2006	0401060105	Roadside Creek	87	0	87	0
Roadside Creek total:			**686**	**5**	**681**	0
2006 total:			**957**	**9**	**948**	**0**

Appendix A3.–Summary of coho salmon smolt tagged with coded wire tags, held overnight, and released following sampling for tag retention at Chuck Creek in 2007; and subsequent recoveries of mature fish in marine fisheries (as adults in 2008) and escapement sampling (as jacks in 2007).

	Tag	Total	Overnight	Number released with CWTs:[a]			Range of sequential CWT numbers:			# Recovered as adult:		# Recovered as jack:	
Date	code	tagged	mortality	Total	Small smolt	Large smolt	Start small	End small[b]	End big	Small smolt	Large smolt	Small smolt	Large smolt
4/16		0											
4/17	41157	1	0	1	1	0	200	203		0	0	0	0
4/18	41157	6	0	6	2	4	207	217	225	0	0	0	0
4/19	41157	1	0	1	1	0	235	238		0	0	0	0
4/20	41157	7	0	7	3	4	249	259	267	0	0	0	0
4/21	41157	6	0	6	0	6		276	287	0	0	0	0
4/22	41157	3	0	3	1	2	296	299	304	0	0	0	0
4/23	41157	5	0	5	1	4	309	317	325	0	0	0	0
4/24	41157	10	0	10	4	6	333	341	354	0	0	0	0
4/25	41157	7	0	7	2	5	363	370	383	0	0	0	0
4/26	41157	7	0	7	2	5	391	399	408	0	0	0	0
4/27	41157	13	0	13	4	9	418	426	444	0	0	0	1
4/28	41157	14	0	14	4	10	449	462	482	0	0	0	1
4/29	41157	48	0	48	15	33	495	521	579	0	0	0	0
4/30	41157	132	0	132	28	104	591	637	806	0	0	0	1
5/1	41157	93	0	93	11	82	818	838	971	0	0	0	0
5/2	41157	97	0	97	14	83	982	1007	1144	0	0	0	2
5/3	41157	12	0	12	1	11	1148	1157	1177	0	0	0	0
5/4	41157	164	0	164	24	140	1186	1226	1454	0	1	0	0
5/5	41157	140	0	140	30	110	1457	1514	1693	0	1	1	7
5/6	41157	275	0	275	67	208	1699	1810	2148	1	1	1	7
5/7	41157	210	0	210	47	163	2254	2336	2602	0	2	1	7
5/8	41157	373	0	373	89	284	2605	2757	3218	1	0	0	0
5/9	41157	421	0	421	54	367	3220	3309	3903	0	8	1	16
5/10	41157	403	5	398	98	300	3911	4074	4571	0	7	0	16
5/11	41157	383	0	383	88	295	4581	4726	5206	0	0	0	0
5/12	41157	2,284	5	2,279	402	1,877	5221	5880	8935	2	10	2	7
5/13	41157	733	0	733	144	589	8940	9178	10142	2	1	1	0
5/14	41157	356	2	354	95	259	10151	10309	10735	2	6	0	3
5/15	41157	861	1	860	223	637	10742	11126	12170	2	0	0	1
5/16	41157	951	1	950	232	718	12213	12593	13768	2	0	0	0
5/17	41157	893	1	892	214	678	13783	14135	15234	4	11	0	6
5/18	41157	1,252	10	1,242	373	869	15240	15854	17297	0	1	0	0
5/19	41157	365	0	365	96	269	17304	17465	17908	1	13	0	4
5/20	41157	556	4	552	226	326	17915	18296	18830	2	5	0	0

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Date	Total code	Total tagged	Overnight mortality	Number released with CWTs:[a]			Range of sequential CWT numbers:			# Recovered as adult:		# Recovered as jack:	
				Total	Small smolt	Large smolt	Start small	End small[b]	End big	Small smolt	Large smolt	Small smolt	Large smolt
5/20[c]	41479	164	2	162	0	162		223	485	0	0	0	0
5/21	41479	752	1	751	297	454	492	967	1694	2	0	0	2
5/22	41479	334	0	334	146	188	1695	1931	2232	2	4	0	1
5/23	41479	179	0	179	68	111	2237	2349	2527	0	0	0	1
5/24	41479	156	0	156	59	97	2534	2630	2787	2	2	0	2
5/25	41479	84	0	84	35	49	2792	2850	2931	2	0	1	1
5/26	41479	101	0	101	45	56	2938	3011	3102	0	1	0	0
5/27	41479	81	0	81	42	39	3110	3178	3243	3	2	0	1
5/28	41479	147	0	147	69	78	3250	3362	3489	1	2	0	2
5/29	41479	19	0	19	8	11	3496	3511	3530	0	0	0	0
5/30	41479	51	0	51	13	38	3537	3560	3622	1	0	0	0
5/31	41479	90	0	90	16	74	3629	3656	3775	1	3	0	0
6/1	41479	142	0	142	48	94	3777	3858	4010	0	5	0	1
6/2	41479	159	0	159	49	110	4021	4102	4279	1	1	0	0
6/3	41479	33	0	33	14	19	4281	4305	4337	2	0	0	0
6/4	41479	48	0	48	13	35	4343	4365	4424	1	1	0	2
6/5	41479	13	0	13	4	9	4429	4438	4454	0	1	0	0
6/6	41479	13	0	13	3	10	4460	4467	4485	0	0	0	1
6/7	41479	0	0	0	0	0				0	0	0	0
6/8	41479	9	0	9	3	6	4488	4494	4505	0	0	0	0
6/9	41479	11	0	11	1	10	4513	4516	4534	0	0	0	0
6/10	41479	16	0	16	0	16		4540	4567	0	0	0	0
6/11	41479	1	0	1	0	1		4575	4579	0	0	0	0
6/12	41479	0	0	0	0	0				0	0	0	0
6/13	41479	0	0	0	0	0				0	0	0	0
6/14	41479	3	0	3	1	2	4580	4583	4588	0	0	0	0
Total		13,688	32	13,656	3,530	10,126				37	89	8	93

[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] Two tag codes were used on May 20.

Appendix A4.–Daily number of coho salmon smolt and other downstream migrating fish captured at the Chuck Creek weir, 2007.

Date	Coho smolt	Sockeye smolt	Dolly Varden adults[a]	Dolly Varden juveniles[b]	Steelhead juveniles[c]	Cutthroat juveniles[c]	Sculpin
4/16							
4/17	1	2	2	0	1	0	80
4/18	6	16	3	0	1	0	135
4/19	1	18	15	1	0	1	220
4/20	7	21	32	2	0	0	218
4/21	6	33	31	3	1	0	209
4/22	3	36	28	0	0	0	188
4/23	5	12	26	0	1	1	200
4/24	10	17	31	0	1	0	77
4/25	7	23	5	0	0	0	83
4/26	8	11	4	1	0	0	73
4/27	13	41	10	1	0	0	52
4/28	15	41	4	1	0	0	63
4/29	89	88	23	22	1	0	52
4/30	135	116	4	66	0	1	53
5/1	77	54	7	8	0	0	45
5/2	69	54	0	2	0	0	10
5/3	62	278	14	4	0	0	14
5/4	222	510	136	21	0	0	207
5/5	89	70	22	0	0	1	25
5/6	284	414	39	19	0	0	50
5/7	384	1,399	54	8	0	0	35
5/8	497	1,357	10	10	0	0	20
5/9	364	2,974	32	10	0	0	40
5/10	249	571	75	11	0	2	56
5/11	2,292	9,703	33	0	1	1	33
5/12	734	3,643	67	58	1	1	40
5/13	409	563	70	11	0	0	53
5/14	468	2,719	78	8	0	0	87
5/15	769	1,978	16	18	0	0	71
5/16	975	1,610	56	50	0	0	171
5/17	1,417	6,625	12	67	0	1	114
5/18	826	3,780	2	40	0	0	40
5/19	216	1,402	36	28	2	0	165
5/20	1,083	5,184	20	46	0	1	80
5/21	466	1,808	11	12	1	1	87
5/22	211	1,120	16	0	0	0	92
5/23	206	364	6	3	2	0	70
5/24	134	373	2	0	2	1	163
5/25	98	196	0	2	0	0	102
5/26	79	266	2	2	1	0	48
5/27	67	280	0	2	0	0	142
5/28	133	359	1	2	0	0	63
5/29	34	168	0	0	3	0	46
5/30	29	55	0	0	1	0	116
5/31	118	212	0	1	3	0	111
6/1	176	176	0	0	3	0	118
6/2	101	24	0	0	2	0	19
6/3	46	21	0	0	0	0	267
6/4	40	25	1	1	1	0	310

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Date	Coho smolt	Sockeye smolt	Dolly Varden adults[a]	Dolly Varden juveniles[b]	Steelhead juveniles[c]	Cutthroat juveniles[c]	Sculpin
6/5	8	17	0	0	0	0	209
6/6	13	11	0	0	0	0	163
6/7	4	5	0	0	0	0	171
6/8	5	7	0	0	0	1	65
6/9	17	10	0	0	0	0	159
6/10	11	3	0	0	0	0	85
6/11	0	8	0	0	0	0	104
6/12	0	0	0	0	0	0	117
6/13	0	1	0	0	0	0	139
6/14	3	0	0	0	0	0	9
Totals	13,791	50,872	1,036	541	29	13	6,034

[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 A5.–Recoveries of jack coho salmon that were coded wire tagged in the 2007 Chuck Creek smolt emigration and recovered during escapement sampling.

Head number[a]	CWT code	Sequential CWT number	Date tagged	Smolt size	Recovery Date[b]	Sex	Age[c]	Length[d] (mm)
320844	41157	430	4/27/2007	large	9/16/2007	m	1.0	340
55226	41157	478	4/28/2007	large	9/07/2007	m	1.0	365
55217	41157	770	4/30/2007	large	9/06/2007	m	1.0	335
55216	41157	1142	5/2/2007	large	9/06/2007	m	1.0	335
50819	41157	1008	5/2/2007	large	9/23/2007	m	1.0	355
55213	41157	1637	5/5/2007	large	9/06/2007	m	1.0	320
55221	41157	1507	5/5/2007	small	9/06/2007	m	1.0	330
55233	41157	1594	5/5/2007	large	9/08/2007	m	1.0	345
55244	41157	1584	5/5/2007	large	9/13/2007	m	1.0	355
320831	41157	1634	5/5/2007	large	9/13/2007	m	1.0	385
320838	41157	1599	5/5/2007	large	9/15/2007	m	1.0	375
50820	41157	1540	5/5/2007	large	9/23/2007	m	1.0	300
50822	41157	1578	5/5/2007	large	9/24/2007	m	2.0	355
55204	41157	2102	5/6/2007	large	8/31/2007	m	1.0	340
55225	41157	2097	5/6/2007	large	9/06/2007	m	1.0	315
55247	41157	2053	5/6/2007	large	9/13/2007	m	1.0	325
320839	41157	2133	5/6/2007	large	9/15/2007	m	1.0	345
320847	41157	1898	5/6/2007	large	9/18/2007	m	1.0	335
50818	41157	1748	5/6/2007	small	9/23/2007	m	1.0	330
55211	41157	1974	5/6/2007	large	9/05/2007	m	2.0	330
55215	41157	1917	5/6/2007	large	9/06/2007	m	R	330
55208	41157	2386	5/7/2007	large	9/04/2007	m	1.0	355
55223	41157	2535	5/7/2007	large	9/06/2007	m	1.0	300
55228	41157	2595	5/7/2007	large	9/07/2007	m	1.0	330
55242	41157	2387	5/7/2007	large	9/12/2007	m	1.0	315
55246	41157	2369	5/7/2007	large	9/13/2007	m	1.0	345
50829	41157	2291	5/7/2007	small	9/27/2007	m	1.0	310
55222	41157	2470	5/7/2007	large	9/06/2007	m	2.0	365
50814	41157	2404	5/7/2007	large	9/21/2007	m	R	330
55202	41157	3537	5/9/2007	large	8/25/2007	m	1.0	345
55214	41157	3690	5/9/2007	large	9/06/2007	m	1.0	340
55218	41157	3281	5/9/2007	small	9/06/2007	m	1.0	305
55227	41157	3498	5/9/2007	large	9/07/2007	m	1.0	360
55248	41157	3731	5/9/2007	large	9/13/2007	m	1.0	355
320836	41157	3737	5/9/2007	large	9/15/2007	m	1.0	345
320841	41157	3686	5/9/2007	large	9/15/2007	m	1.0	355
320846	41157	3718	5/9/2007	large	9/18/2007	m	1.0	355
320848	41157	3544	5/9/2007	large	9/18/2007	m	1.0	360
50805	41157	3595	5/9/2007	large	9/20/2007	m	1.0	370
50806	41157	3433	5/9/2007	large	9/20/2007	m	1.0	330
50808	41157	3487	5/9/2007	large	9/21/2007	m	1.0	330
50823	41157	3815	5/9/2007	large	9/24/2007	m	1.0	360
50832	41157	3570	5/9/2007	large	9/29/2007	m	1.0	290
55231	41157	3496	5/9/2007	large	9/08/2007	m	2.0	355
55235	41157	3794	5/9/2007	large	9/08/2007	m	R	320
50826	41157	3817	5/9/2007	large	9/25/2007	m	R	360
55210	41157	4223	5/10/2007	large	9/05/2007	m	1.0	305
55250	41157	4403	5/10/2007	large	9/13/2007	m	1.0	320
320833	41157	4326	5/10/2007	large	9/14/2007	m	1.0	355
320835	41157	4423	5/10/2007	large	9/14/2007	m	1.0	345
320840	41157	4245	5/10/2007	large	9/15/2007	m	1.0	345
320845	41157	4556	5/10/2007	large	9/17/2007	m	1.0	345
50809	41157	4180	5/10/2007	large	9/21/2007	m	1.0	340
50824	41157	4378	5/10/2007	large	9/25/2007	m	1.0	345
50833	41157	4465	5/10/2007	large	10/1/2007	m	1.0	315
50836	41157	4421	5/10/2007	large	10/3/2007	m	1.0	350

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Head number[a]	CWT code	Sequential CWT number	Date tagged	Smolt size	Recovery Date[b]	Sex	Age[c]	Length[d] (mm)
50810	41157	4139	5/10/2007	large	9/21/2007	m	2.0	360
50839	41157	4413	5/10/2007	large	10/15/2007	m	R	325
55203	41157	4545	5/10/2007	large	8/29/2007	m	R	325
55241	41157	4274	5/10/2007	large	9/11/2007	m	R	325
50803	41157	4506	5/10/2007	large	9/19/2007	m	R	355
50804	41157	4316	5/10/2007	large	9/20/2007	m	R	360
55209	41157	6666	5/12/2007	large	9/05/2007	m	1.0	320
55219	41157	8650	5/12/2007	large	9/06/2007	m	1.0	370
55236	41157	6205	5/12/2007	large	9/09/2007	m	1.0	305
50811	41157	5557	5/12/2007	small	9/21/2007	m	1.0	300
50827	41157	5848	5/12/2007	small	9/26/2007	m	1.0	300
50830	41157	6015	5/12/2007	large	9/28/2007	m	1.0	335
320832	41157	6354	5/12/2007	large	9/14/2007	m	R	335
320842	41157	8843	5/12/2007	large	9/15/2007	m	R	350
50807	41157	6620	5/12/2007	large	9/20/2007	m	R	350
55239	41157	10728	5/14/2007	large	9/10/2007	m	1.0	335
50817	41157	10358	5/14/2007	large	9/22/2007	m	1.0	300
55243	41157	10722	5/14/2007	large	9/12/2007	m	R	330
55249	41157	10174	5/14/2007	small	9/13/2007	m	R	335
55237	41157	11412	5/15/2007	large	9/09/2007	m	1.0	305
55207	41157	14706	5/17/2007	large	9/03/2007	m	1.0	340
50812	41157	14201	5/17/2007	large	9/21/2007	m	1.0	320
50828	41157	14428	5/17/2007	large	9/26/2007	m	1.0	310
55234	41157	14198	5/17/2007	large	9/08/2007	m	R	305
55238	41157	14588	5/17/2007	large	9/10/2007	m	R	380
55245	41157	15095	5/17/2007	large	9/13/2007	m	R	350
50838	41157	17900	5/19/2007	large	10/14/2007	m	1.0	300
55230	41157	17640	5/19/2007	large	9/07/2007	m	1.0	390
50813	41157	17895	5/19/2007	large	9/21/2007	m	1.0	345
55224	41157	17790	5/19/2007	large	9/06/2007	m	R	315
55206	41479	1307	5/21/2007	large	9/02/2007	m	1.0	280
50815	41479	1290	5/21/2007	large	9/22/2007	m	1.0	315
55205	41479	2218	5/22/2007	large	9/01/2007	m	1.0	320
320834	41479	2475	5/23/2007	large	9/14/2007	m	1.0	335
50834	41479	2692	5/24/2007	large	10/1/2007	m	1.0	325
50837	41479	2738	5/24/2007	large	10/12/2007	m	R	325
55229	41479	2889	5/25/2007	large	9/07/2007	m	1.0	275
320837	41479	2821	5/25/2007	small	9/15/2007	m	1.0	295
50831	41479	3233	5/27/2007	large	9/28/2007	m	1.0	295
50835	41479	3463	5/28/2007	large	10/2/2007	m	1.0	285
55220	41479	3386	5/28/2007	large	9/06/2007	m	R	300
50816	41479	3997	6/1/2007	large	9/22/2007	m	1.0	335
55240	41479	4410	6/4/2007	large	9/11/2007	m	1.0	270
50821	41479	4384	6/4/2007	large	9/24/2007	m	1.0	310
320843	41479	4476	6/6/2007	large	9/16/2007	m	1.0	290

[a] The head number is a unique number assigned to each sampled fish for shipping to the Tag Lab and data entry.

[b] Date of recovery was the date of capture at the weir (every 3rd jack captured, missing an adipose fin was sampled).

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

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

Appendix A6.–Daily escapement counts of mature coho salmon passed through the weir on Chuck Creek, by life history type and marked statues in 2008.

	Adult coho (age x.1)				Jack coho (age x.0)			
Date	Marked	Unmarked	Unknown	Total	Marked	Unmarked	Unknown[a]	Total
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	1	0	0	1	0	0	0	0
8/23	5	0	0	5	0	0	0	0
8/24	7	0	0	7	2	0	0	2
8/25	5	0	0	5	6	1	0	7
8/26	9	1	0	10	6	2	0	8
8/27	1	1	0	2	3	0	0	3
8/28	4	2	0	6	2	4	0	6
8/29	3	2	0	5	13	0	1	14
8/30	4	2	0	6	11	0	0	11
8/31	0	0	0	0	3	1	0	4
9/1	3	0	0	3	1	1	0	2
9/2	0	0	0	0	1	0	0	1
9/3	4	1	0	5	8	0	0	8
9/4	0	1	0	1	5	0	0	5
9/5	3	0	0	3	13	0	0	13
9/6	5	0	0	5	21	2	0	23
9/7	2	0	0	2	13	0	0	13
9/8	1	0	0	1	5	0	0	5
9/9	3	0	0	3	14	0	0	14
9/10	21	3	0	24	76	3	0	79
9/11	15	1	0	16	34	4	0	38
9/12	18	4	0	22	35	1	0	36
9/13	7	1	0	8	32	2	0	34
9/14	9	3	0	12	36	3	0	39
9/15	7	2	0	9	24	7	0	31
9/16	11	3	0	14	27	6	0	33
9/17	14	4	0	18	32	3	0	35
9/18	13	6	0	19	16	1	0	17
9/19	16	6	0	22	14	4	0	18
9/20	12	4	0	16	8	1	0	9
9/21	3	7	0	10	9	2	0	11
9/22	0	5	0	5	8	4	0	12
9/23	1	4	0	5	1	5	0	6
9/24	1	0	0	1	4	7	0	11
9/25	0	0	0	0	3	3	0	6
9/26	0	1	0	1	5	2	0	7
9/27	0	0	0	0	1	1	0	2
9/28	2	0	0	2	2	4	0	6
9/29	16	5	0	21	10	6	0	16
9/30	5	1	0	6	4	3	0	7
10/1	3	1	0	4	3	1	0	4

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	Adult coho (age x.1)				Jack coho (age x.0)			
Date	Marked	Unmarked	Unknown	Total	Marked	Unmarked	Unknown[a]	Total
10/2	0	0	0	0	2	0	0	2
10/3	1	0	0	1	4	0	0	4
10/4	0	0	0	0	0	1	0	1
10/5	0	0	0	0	1	0	0	1
10/6	0	0	0	0	2	2	0	4
10/7	0	0	0	0	0	1	0	1
10/8	0	0	0	0	0	1	0	1
10/9	0	0	0	0	1	1	0	2
10/10	0	0	0	0	0	0	0	0
10/11	1	0	0	1	2	0	0	2
10/12	0	0	0	0	0	0	0	0
10/13	0	1	0	1	0	0	0	0
10/14	0	0	0	0	0	0	0	0
10/15	0	0	0	0	0	0	0	0
10/16	0	0	0	0	0	2	0	2
10/17	0	0	0	0	0	0	0	0
10/18	0	0	0	0	0	0	0	0
10/19	1	0	0	1	0	1	0	1
10/20	0	0	0	0	0	0	0	0
Totals	**237**	**72**	**0**	**309**	**523**	**93**	**1**	**617**

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

Appendix A7.–Daily escapement counts of sockeye, pink, and chum salmon; Dolly Varden; and cutthroat and steelhead trout passed through the weir at Chuck Creek, 2008.

Date	Sockeye adults	Sockeye jacks[a]	Pinks	Chum	Dolly Varden	Steelhead	Cutthroat
8/18	18	1	1	0	0	0	0
8/19	82	3	47	0	0	0	0
8/20	156	3	116	0	0	0	0
8/21	274	8	442	0	0	0	0
8/22	145	3	1,047	0	0	0	0
8/23	16	1	334	0	0	0	0
8/24	78	3	1,501	2	0	0	0
8/25	53	1	1,512	4	0	0	0
8/26	25	0	745	2	0	0	0
8/27	8	0	610	1	0	0	0
8/28	12	0	221	4	0	0	0
8/29	9	1	257	1	0	0	0
8/30	11	0	365	0	0	0	0
8/31	8	1	423	0	0	0	0
9/1	10	0	177	0	0	0	0
9/2	2	0	131	1	0	0	0
9/3	15	0	81	3	0	0	0
9/4	2	0	81	0	0	0	0
9/5	2	0	72	3	0	0	0
9/6	3	0	66	0	0	0	0
9/7	3	0	130	0	1	0	0
9/8	3	0	41	0	0	0	0
9/9	3	0	23	1	0	0	0
9/10	5	1	169	3	1	0	0
9/11	4	0	278	4	0	0	0
9/12	4	0	62	6	0	0	0
9/13	2	0	76	2	0	0	0
9/14	3	0	79	3	0	1	0
9/15	0	0	704	7	0	0	0
9/16	0	0	204	5	0	0	0
9/17	1	0	106	14	0	0	0
9/18	0	0	144	2	0	0	0
9/19	0	0	71	5	0	0	0
9/20	1	0	87	3	3	0	0
9/21	0	0	67	2	0	0	0
9/22	0	0	49	1	0	0	0
9/23	0	0	103	1	0	0	0
9/24	1	0	53	0	0	0	0
9/25	0	0	65	0	0	0	0
9/26	0	0	66	0	0	0	0
9/27	0	0	127	1	0	0	0
9/28	1	1	511	1	0	0	0
9/29	7	2	488	0	0	0	0
9/30	0	0	110	0	0	0	0
10/1	0	0	53	2	0	0	0
10/2	0	0	117	0	1	0	0

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Date	Sockeye adults	Sockeye jacks[a]	Pinks	Chum	Dolly Varden	Steelhead	Cutthroat
10/3	0	0	100	2	0	0	0
10/4	0	0	19	0	0	0	0
10/5	0	0	16	0	0	0	0
10/6	0	0	20	0	0	0	0
10/7	0	0	13	1	0	0	0
10/8	0	0	43	0	1	0	0
10/9	0	0	18	0	0	0	0
10/10	0	0	8	0	0	0	0
10/11	0	0	46	0	0	0	0
10/12	0	0	10	0	0	0	1
10/13	0	0	7	0	0	0	0
10/14	0	0	7	0	0	0	0
10/15	0	0	2	0	0	0	0
10/16	0	0	0	0	0	0	0
10/17	0	0	1	0	1	0	0
10/18	0	0	0	0	0	0	0
10/19	0	0	0	0	0	0	0
10/20	0	0	0	0	0	0	0
Totals	967	29	12,522	87	**8**	**1**	**1**

[a] Male fish < 400 mm MEF.

Appendix A8.–Recoveries of coho salmon that were coded weir tagged in the 2007 Chuck Creek smolt emigration and recovered in marine sport and commercial fisheries sampling programs.

Head Number[a]	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Length[b](mm)	Tag code	Sequential CWT #	Date tagged	Smolt size
RANDOM FISHERIES RECOVERIES											
356542	Ketchikan	Gillnet	9/3/2008	36	SE	101	610	41157	9,075	5/13/2007	small
356071	Ketchikan	Gillnet	8/20/2008	34	SE	101	620	41157	13,945	5/17/2007	small
335967	Ketchikan	Gillnet	8/12/2008	33	SE	101	590	41479	3,027	5/26/2007	large
352168	Ketchikan	Seine	8/1/2008	31	SW	104	630	41157	1,352	5/4/2007	large
307427	Petersburg	Seine	8/20/2008	34	SW	103	650	41157	1,564	5/5/2007	large
307432	Petersburg	Seine	8/24/2008	35	SW	103	510	41157	3,403	5/9/2007	large
71801	Wrangell	Seine	8/28/2008	35	SW	103	630	41157	4,217	5/10/2007	large
356013	Ketchikan	Seine	7/25/2008	30	SE	102	570	41157	10,186	5/14/2007	small
540765	Excursion Inlet	Seine	8/17/2008	34			535	41157	10,355	5/14/2007	large
307629	Petersburg	Seine	8/5/2008	32	SW	104	630	41157	10,487	5/14/2007	large
307425	Petersburg	Seine	8/20/2008	34	SW	103	550	41157	10,808	5/15/2007	small
307429	Petersburg	Seine	8/20/2008	34	SW	103	515	41157	13,878	5/17/2007	small
540772	Excursion Inlet	Seine	8/17/2008	34			625	41157	14,469	5/17/2007	large
307648	Petersburg	Seine	8/7/2008	32	SW	104	620	41157	15,004	5/17/2007	large
307705	Petersburg	Seine	8/17/2008	34	SW	103	625	41157	17,734	5/19/2007	large
307374	Petersburg	Seine	8/12/2008	33	SW	103	595	41157	18,617	5/20/2007	large
307642	Petersburg	Seine	8/7/2008	32	SW	103	490	41479	1,840	5/22/2007	small
540767	Excursion Inlet	Seine	8/17/2008	34			630	41479	2,168	5/22/2007	large
71802	Wrangell	Seine	8/28/2008	35	SW	103	665	41479	2,540	5/24/2007	small
324741	Ketchikan	Seine	7/25/2008	30	SE	102	495	41479	2,848	5/25/2007	small
324635	Ketchikan	Seine	7/10/2008	28	SE	102	540	41479	3,293	5/28/2007	small
307392	Petersburg	Seine	8/11/2008	33	SW	103	655	41479	3,405	5/28/2007	large
307379	Petersburg	Seine	8/12/2008	33	SW	103	660	41479	3,988	6/1/2007	large
307634	Petersburg	Seine	8/5/2008	32	SW	104	615	41479	4,282	6/3/2007	small
324771	Ketchikan	Seine	8/5/2008	32	SW	104	620	41479	4,449	6/5/2007	large
42717	Craig	Sport	7/27/2008	31	SW	104	600	41157	1,968	5/6/2007	large
42727	Craig	Sport	8/2/2008	31	SW	104	650	41157	10,654	5/14/2007	large
31991	Craig	Sport	8/22/2008	34	SW	104	625	41157	10,745	5/15/2007	small
42742	Craig	Sport	8/12/2008	33			580	41157	12,487	5/16/2007	small
31479	Craig	Sport	8/30/2008	35	SW	104	640	41157	14,368	5/17/2007	large
69828	Craig	Sport	8/3/2008	32	SW	104	565	41479	3,553	5/30/2007	small
352795	Ketchikan	Troll	8/2/2008	31	SW	103	625	41157	1,710	5/6/2007	small
324643	Ketchikan	Troll	7/25/2008	30	SW	103	640	41157	2,571	5/7/2007	large
356874	Craig	Troll	9/8/2008	37	SW	104	610	41157	2,640	5/8/2007	small
356138	Ketchikan	Troll	7/28/2008	31	SW	103	660	41157	3,360	5/9/2007	large
331736	Sitka	Troll	8/2/2008	31	NW	113	605	41157	3,362	5/9/2007	large
355402	Juneau	Troll	9/8/2008	37	NW	113	625	41157	3,385	5/9/2007	large
332359	Sitka	Troll	8/22/2008	34	NE	109	620	41157	3,555	5/9/2007	large

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Head Number[a]	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Length[b](mm)	Tag code	Sequential CWT #	Date tagged	Smolt size
352798	Ketchikan	Troll	8/2/2008	31	SW	103	605	41157	3,568	5/9/2007	large
333304	Sitka	Troll	7/18/2008	29	SW		610	41157	3,607	5/9/2007	large
355450	Juneau	Troll	9/8/2008	37	NW	113	640	41157	3,767	5/9/2007	large
70708	Yakutat	Troll	9/5/2008	36	NW	189	645	41157	4,234	5/10/2007	large
356956	Craig	Troll	8/20/2008	34	SE	105	660	41157	4,262	5/10/2007	large
310598	Craig	Troll	8/11/2008	33	SW	103	630	41157	4,310	5/10/2007	large
356139	Ketchikan	Troll	7/28/2008	31	SW	103	550	41157	4,370	5/10/2007	large
352515	Ketchikan	Troll	8/2/2008	31	SW	103	650	41157	4,488	5/10/2007	large
332386	Sitka	Troll	8/30/2008	35	NW		590	41157	4,495	5/10/2007	large
356157	Ketchikan	Troll	7/30/2008	31	SW	103	630	41157	5,825	5/12/2007	small
356934	Craig	Troll	8/11/2008	33	SW	104	620	41157	5,846	5/12/2007	small
352543	Ketchikan	Troll	8/21/2008	34	SW	103	650	41157	6,101	5/12/2007	large
357094	Sitka	Troll	8/11/2008	33	NE	109	620	41157	6,174	5/12/2007	large
310584	Craig	Troll	8/10/2008	33	SW	104	620	41157	6,226	5/12/2007	large
356939	Craig	Troll	8/11/2008	33	SE	105	590	41157	6,320	5/12/2007	large
333365	Sitka	Troll	7/20/2008	30			595	41157	6,336	5/12/2007	large
335518	Ketchikan	Troll	8/21/2008	34	SW	103	600	41157	6,393	5/12/2007	large
356947	Craig	Troll	8/20/2008	34	SE	105	500	41157	6,451	5/12/2007	large
331486	Sitka	Troll	7/24/2008	30	NW	113	625	41157	6,490	5/12/2007	large
352513	Ketchikan	Troll	8/2/2008	31	SW	103	605	41157	6,665	5/12/2007	large
352564	Ketchikan	Troll	8/21/2008	34	SW	103	620	41157	6,700	5/12/2007	large
529762	Excursion Inlet	Troll	7/15/2008	29	NW		620	41157	9,122	5/13/2007	small
354743	Hoonah	Troll	8/18/2008	34	NW	113	644	41157	9,640	5/13/2007	large
335586	Ketchikan	Troll	9/2/2008	36	SW	103	620	41157	10,291	5/14/2007	small
352511	Ketchikan	Troll	8/2/2008	31	SW	103	550	41157	10,430	5/14/2007	large
356878	Craig	Troll	9/15/2008	38	SW	104	610	41157	10,432	5/14/2007	large
356317	Ketchikan	Troll	8/26/2008	35	SW	103	635	41157	10,475	5/14/2007	large
324732	Ketchikan	Troll	7/24/2008	30	SW	103	580	41157	12,228	5/16/2007	small
331368	Sitka	Troll	8/4/2008	32	NW	113	615	41157	14,000	5/17/2007	small
310358	Craig	Troll	8/4/2008	32	SW	103	630	41157	14,115	5/17/2007	small
310557	Craig	Troll	8/7/2008	32	SW	103	660	41157	14,234	5/17/2007	large
356953	Craig	Troll	8/20/2008	34	SE	105	620	41157	14,465	5/17/2007	large
331789	Sitka	Troll	8/4/2008	32	NW	113	605	41157	14,848	5/17/2007	large
352987	Ketchikan	Troll	8/5/2008	32	SW	103	615	41157	14,861	5/17/2007	large
356112	Ketchikan	Troll	7/15/2008	29	SW	103	580	41157	14,916	5/17/2007	large
310777	Craig	Troll	8/22/2008	34	SE	105	650	41157	14,989	5/17/2007	large
354274	Hoonah	Troll	7/18/2008	29	NW	114	629	41157	15,061	5/17/2007	large
331287	Sitka	Troll	7/30/2008	31	NE	109	585	41157	15,190	5/17/2007	large
310553	Craig	Troll	8/6/2008	32	SE	105	620	41157	16,434	5/18/2007	large
335520	Ketchikan	Troll	8/21/2008	34	SW	103	515	41157	17,320	5/19/2007	small
333097	Sitka	Troll	7/6/2008	28	NW		630	41157	17,494	5/19/2007	large

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Head Number[a]	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Length[b](mm)	Tag code	Sequential CWT #	Date tagged	Smolt size
356850	Craig	Troll	9/3/2008	36	SW	104	590	41157	17,552	5/19/2007	large
356131	Ketchikan	Troll	7/28/2008	31	SW	103	635	41157	17,572	5/19/2007	large
356309	Ketchikan	Troll	8/26/2008	35	SW	103	625	41157	17,585	5/19/2007	large
324648	Ketchikan	Troll	7/25/2008	30	SW	103	620	41157	17,662	5/19/2007	large
333406	Sitka	Troll	7/24/2008	30	NW	113	625	41157	17,714	5/19/2007	large
310576	Craig	Troll	8/9/2008	32	SW		610	41157	17,716	5/19/2007	large
356906	Craig	Troll	8/6/2008	32	SW	104	600	41157	17,745	5/19/2007	large
356901	Craig	Troll	8/6/2008	32	SW	104	610	41157	17,796	5/19/2007	large
310792	Craig	Troll	8/26/2008	35	SW	104	630	41157	17,814	5/19/2007	large
310707	Craig	Troll	8/19/2008	34	SW	103	610	41157	17,859	5/19/2007	large
356841	Craig	Troll	8/28/2008	35	SW	103	630	41157	17,905	5/19/2007	large
330627	Sitka	Troll	7/3/2008	27	NW	113	575	41157	18,077	5/20/2007	small
356021	Ketchikan	Troll	7/23/2008	30	SW	103	620	41157	18,113	5/20/2007	small
356819	Craig	Troll	8/21/2008	34	SW	103	650	41157	18,464	5/20/2007	large
310672	Craig	Troll	7/15/2008	29	SW		590	41157	18,565	5/20/2007	large
310798	Craig	Troll	8/26/2008	35	SW	103	620	41157	18,602	5/20/2007	large
310702	Craig	Troll	8/11/2008	33	SW	103	640	41157	18,684	5/20/2007	large
310508	Craig	Troll	8/3/2008	32	SW	152	610	41479	559	5/21/2007	small
310317	Craig	Troll	7/17/2008	29	SW	104	580	41479	909	5/21/2007	small
335548	Ketchikan	Troll	8/25/2008	35	SW	103	520	41479	1,850	5/22/2007	small
335562	Ketchikan	Troll	8/25/2008	35	SW	103	570	41479	1,937	5/22/2007	large
352557	Ketchikan	Troll	8/21/2008	34	SW	103	615	41479	1,953	5/22/2007	large
541336	Pelican	Troll	7/22/2008	30	NW	114	610	41479	2,100	5/22/2007	large
356135	Ketchikan	Troll	7/28/2008	31	SW	103	600	41479	2,581	5/24/2007	small
331674	Sitka	Troll	8/1/2008	31	NW	113	620	41479	2,753	5/24/2007	large
333491	Sitka	Troll	8/1/2008	31	NW	113	580	41479	2,755	5/24/2007	large
310743	Craig	Troll	8/20/2008	34	SW	104	650	41479	2,797	5/25/2007	small
331249	Sitka	Troll	7/19/2008	29	NW	113	600	41479	3,129	5/27/2007	small
310669	Craig	Troll	7/15/2008	29	SW	104	570	41479	3,154	5/27/2007	small
354471	Hoonah	Troll	7/29/2008	31	NW		630	41479	3,162	5/27/2007	small
330961	Sitka	Troll	7/15/2008	29	NW	113	605	41479	3,196	5/27/2007	large
356952	Craig	Troll	8/20/2008	34	SE	105	640	41479	3,221	5/27/2007	large
310506	Craig	Troll	7/31/2008	31	SW	104	620	41479	3,461	5/28/2007	large
335559	Ketchikan	Troll	8/25/2008	35	SW	103	580	41479	3,641	5/31/2007	small
356159	Ketchikan	Troll	7/30/2008	31	SW	103	610	41479	3,705	5/31/2007	large
324740	Ketchikan	Troll	7/24/2008	30	SW	103	570	41479	3,758	5/31/2007	large
310582	Craig	Troll	8/10/2008	33	SW	104	630	41479	3,766	5/31/2007	large
310668	Craig	Troll	7/12/2008	28	SW	103	590	41479	3,884	6/1/2007	large
307666	Petersburg	Troll	8/21/2008	34	SE	105	620	41479	3,894	6/1/2007	large
352512	Ketchikan	Troll	8/2/2008	31	SW	103	595	41479	3,954	6/1/2007	large
356129	Ketchikan	Troll	7/28/2008	31	SW	103	575	41479	3,992	6/1/2007	large

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Head Number[a]	Sampling port	Gear	Recovery date	Stat wk	Quad	District	Length[b](mm)	Tag code	Sequential CWT #	Date tagged	Smolt size
324731	Ketchikan	Troll	7/24/2008	30	SW	103	575	41479	4,070	6/2/2007	small
356909	Craig	Troll	8/6/2008	32	SW	104	650	41479	4,159	6/2/2007	large
310347	Craig	Troll	8/3/2008	32	SW	104	640	41479	4,284	6/3/2007	small
333371	Sitka	Troll	7/20/2008	30			550	41479	4,362	6/4/2007	small
331298	Sitka	Troll	7/31/2008	31	NW	113	585	41479	4,414	6/4/2007	large
NONRANDOM FISHERIES RECOVERIES											
64910	Craig	Sport	9/13/2008	37	SW	104		41157	2,337	5/7/2007	large

[a] The head number is a unique number assigned to each sampled fish for shipping to the Tag Lab and data entry.

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

Appendix A9.–Estimated marine harvest (r_i) of adult coho salmon bound for Chuck Creek in 2008. n_i = number of fish examined for missing adipose fins; a_i = number of adipose-finclipped 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]**
27-32	6/29-8/9 (3)	NE	35,031	0	9,585	75	72	48	48	1	5	4	175%
33-40	8/10-10/4 (4)	NE	60,581	0	20,192	178	178	139	139	2	8	5	120%
27-32	6/29-8/9 (3)	NW	467,970	0	137,098	1,811	1,776	1,364	1,356	16	74	16	44%
33-40	8/10-10/4 (4)	NW	386,748	0	103,574	2,019	1,988	1,706	1,702	5	25	10	79%
27-32	6/29-8/9 (3)	SE	42,564	0	9,268	67	66	51	51	1	6	6	179%
33-40	8/10-10/4 (4)	SE	67,919	0	16,979	243	240	183	183	7	37	13	67%
27-32	6/29-8/9 (3)	SW	142,568	0	50,786	373	359	238	236	35	134	20	29%
33-40	8/10-10/4 (4)	SW	67,521	0	22,101	278	277	209	209	25	100	18	34%
	Troll subtotal		1,270,902	0	369,583	5,044	4,956	3,938	3,924	92	389	36	18%
SE ALASKA DRIFT GILLNET 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 33	8/10-8/16	101	5,372	0	1,590	30	30	26	26	1	4	4	172%
wk 34	8/17-8/23	101	4,222	0	551	23	23	21	20	1	10	10	186%
wk 36	8/31-9/6	101	7,404	0	2,915	112	110	106	105	1	3	3	165%
	Drift Gillnet subtotal		16,998	0	5,056	165	163	153	151	3	17	11	119%
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	7/6-7/12	102	5,768	0	2,512	15	15	11	11	1	3	2	160%
wk 30	7/20-7/26	102	1,774	0	712	6	6	6	6	2	6	4	115%
wk 32	8/3-8/9	103	4,075	0	792	6	6	4	4	1	7	6	181%
wk 33	8/10-8/16	103	11,974	0	1,604	22	22	16	16	3	29	16	107%
wk 34	8/17-8/23	103	13,283	0	1,157	10	10	8	8	4	60	29	95%
wk 35	8/24-8/30	103	3,257	0	696	4	4	4	4	3	18	10	104%
wk 31	7/27-8/2	104	11,910	0	3,544	29	29	21	21	1	4	4	172%
wk 32	8/3-8/9	104	17,552	0	4,790	57	57	44	44	4	19	9	87%
	Purse Seine subtotal		69,593	0	15,807	149	149	114	114	19	146	37	49%
SE ALASKA SPORT FISHERY													
Biweek	**Dates**	**Area**	**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	7/21-8/3	Craig/Klawock	3,068		2,920	36	36	30	30	3	4	1	59%
bw 16	8/4-8/17	Craig/Klawock	3,647		3,439	35	35	21	21	1	1	1	103%
bw 17	8/18-8/31	Craig/Klawock	1,568		1,562	23	22	21	21	2	3	1	72%
	Sport subtotal		8,283		7,921	94	93	72	72	6	8	2	42%
NORTHERN BRITISH COLUMBIA MARINE FISHERY													
Week	**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]**
30-40	7/20-10/4	Northern troll	62,138	0	18,149	232	230	95	95	1	5	4	173%
	TOTAL ALL FISHERIES		1,427,914	0	416,516	5,684	5,591	4,372	4,356	121	565	53	18%

Appendix A10.–Daily number of: smolt tagged, actual and expected recoveries of surviving fish, probability of recovering a tagged fish (P), probably of not recovering a tagged fish $(1- P)^{13,656}$, χ^2 statistic of number of fish recovered vs. not recovered, and the binomial probability of recovery at most the actual number of fish recovered for the 2007 Chuck Creek coho smolt emigration.

	Number of	Number of recoveries					
Date	smolt tagged	Actual	Expected[a]	P	$(1 - P)^{13,656}$	χ^2	Binomial P
4/17	1	0	0.0	0.00000	0.98344	0.0	0.9833
4/18	6	0	0.1	0.00001	0.90468	0.1	0.9039
4/19	1	0	0.0	0.00000	0.98344	0.0	0.9833
4/20	7	0	0.1	0.00001	0.88970	0.1	0.8888
4/21	6	0	0.1	0.00001	0.90468	0.1	0.9039
4/22	3	0	0.1	0.00000	0.95115	0.1	0.9507
4/23	5	0	0.1	0.00001	0.91991	0.1	0.9193
4/24	10	0	0.2	0.00001	0.84623	0.2	0.8450
4/25	7	0	0.1	0.00001	0.88970	0.1	0.8888
4/26	7	0	0.1	0.00001	0.88970	0.1	0.8888
4/27	13	1	0.2	0.00002	0.80489	2.8	0.9808
4/28	14	1	0.2	0.00002	0.79156	2.5	0.9778
4/29	48	0	0.8	0.00006	0.44869	0.8	0.4457
4/30	132	1	2.2	0.00016	0.11036	0.7	0.3512
5/1	93	0	1.6	0.00011	0.21165	1.6	0.2089
5/2	97	2	1.6	0.00012	0.19798	0.1	0.7791
5/3	12	0	0.2	0.00001	0.81844	0.2	0.8171
5/4	164	1	2.7	0.00020	0.06467	1.1	0.2392
5/5	140	9	2.3	0.00017	0.09656	19.0	0.9999
5/6	275	10	4.6	0.00034	0.01013	6.4	0.9928
5/7	210	10	3.5	0.00026	0.03000	12.0	0.9991
5/8	373	1	6.2	0.00046	0.00197	4.4	0.0137
5/9	421	25	7.0	0.00051	0.00088	45.9	1.0000
5/10	398	23	6.6	0.00049	0.00130	40.3	1.0000
5/11	383	0	6.4	0.00047	0.00167	6.4	0.0016
5/12	2,279	21	38.1	0.00279	0.00000	7.6	0.0018
5/13	733	4	12.2	0.00090	0.00000	5.5	0.0061
5/14	354	11	5.9	0.00043	0.00271	4.4	0.9827
5/15	860	3	14.4	0.00105	0.00000	9.0	0.0003
5/16	950	2	15.9	0.00116	0.00000	12.1	0.0000
5/17	892	21	14.9	0.00109	0.00000	2.5	0.9515
5/18	1,242	1	20.7	0.00152	0.00000	18.8	0.0000
5/19	365	18	6.1	0.00045	0.00225	23.3	1.0000
5/20	714	7	11.9	0.00087	0.00001	2.0	0.0912
5/21	751	4	12.5	0.00092	0.00000	5.8	0.0049
5/22	334	7	5.6	0.00041	0.00378	0.4	0.8015
5/23	179	1	3.0	0.00022	0.05034	1.3	0.1983
5/24	156	6	2.6	0.00019	0.07392	4.4	0.9836
5/25	84	4	1.4	0.00010	0.24597	4.8	0.9865
5/26	101	1	1.7	0.00012	0.18519	0.3	0.4957
5/27	81	6	1.4	0.00010	0.25861	16.0	0.9996
5/28	147	5	2.5	0.00018	0.08590	2.6	0.9623

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Date	Number of smolt tagged	Number of recoveries Actual	Expected[a]	P	$(1 - P)^{13,656}$	χ^2	Binomial P
5/29	19	0	0.3	0.00002	0.72817	0.3	0.7262
5/30	51	1	0.9	0.00006	0.42677	0.0	0.7906
5/31	90	4	1.5	0.00011	0.22252	4.2	0.9823
6/1	142	6	2.4	0.00017	0.09338	5.6	0.9898
6/2	159	3	2.7	0.00019	0.07030	0.0	0.7247
6/3	33	2	0.6	0.00004	0.57639	3.8	0.9825
6/4	48	4	0.8	0.00006	0.44869	12.8	0.9988
6/5	13	1	0.2	0.00002	0.80489	2.8	0.9808
6/6	13	1	0.2	0.00002	0.80489	2.8	0.9808
6/7	0						
6/8	9	0	0.2	0.00001	0.86048	0.2	0.8594
6/9	11	0	0.2	0.00001	0.83222	0.2	0.8309
6/10	16	0	0.3	0.00002	0.76557	0.3	0.7638
6/11	1	0	0.0	0.00000	0.98344	0.0	0.9833
6/12	0						
6/13	0						
6/14	3	0	0.1	0.00000	0.951146	0.1	0.95074

[a] Expected recoveries are the number of smolt tagged multiplied by the overall recovery rate (1.67% or 228/13,656). Probability of recovering a fish is the expected number of recoveries divided by the total number of smolt tagged (13,656).

Appendix A11.–Model used to estimate potential bias in smolt abundance estimate of the 2007 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 7.1% (= $[296_{cwt\ jacks} + 237_{cwt\ adult\ esc} + 430_{cwt\ harvest}] / 13{,}656_{cwt\ smolt}$). The *CWT harvest* was estimated by expanding the number of recoveries in sampled fisheries for the fraction of the harvest not examined, and *CWT jacks* was estimated by expanding the number of recoveries in the sampled jack escapement for the fraction of the jack escapement not examined (296 = 368 * 294/365). All other variables are known from weir counts. Thus, smolt abundance at survival rates other than the assumed rate of 7.1% 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 (13,656), $m_{unmarked}$ is the number of unmarked mature fish (estimated at 280 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 ($72_{jacks\ unmarked} + 74_{adults\ unmarked}$) and the estimated number in the harvest (= 134, assuming the harvest rate for unmarked fish is the same for marked fish).

Appendix A12.–Computer files used in the analysis of data for this report.

File Name	Description
08Chuck escapement data.xls	Excel workbook containing 2008 Chuck Creek adult escapement data.
07Chuck smolt data.xls	Excel workbook containing 2007 Chuck Creek smolt and coded wire tagging data.
08Chuck Harvest.xls	Excel workbook containing 2008 marine harvest estimations and cwt recoveries.