Fishery Data Series No. 09-28

Estimation of the Chickamin River Chinook Salmon Escapement in 2006–2008, 2002–2007 Smolt Abundance, and Marine Harvest Through 2008 of the 2000–2005 Broods

by

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and

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June 2009

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Measures (fisheries)

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

Mathematics, statistics

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

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ABSTRACT

As part of a continuing stock assessment program in Southeast Alaska, the Alaska Department of Fish and Game's Division of Sport Fish implanted coded wire tags in juvenile Chinook salmon *Oncorhynchus tshawytscha* on the Chickamin River from 2001–2007 (2000–2005 broods) as part of a harvest estimation study. The adipose fins of tagged fish were also excised as the first event in a two-event mark–recapture study to estimate smolt abundance. Escapements were sampled annually for adipose clips, coded wire tags, and age, sex, and length information in order to estimate the fraction of each brood marked with coded wire tags and as the second event of the mark–recapture study. Commercial and recreational fisheries in Alaska and British Columbia were sampled for coded wire tagged fish from 2003–2008. The marked fraction and catch sampling data were used to estimate harvest of Chinook salmon of Chickamin River origin from the 2000–2005 broods. An estimated 3,085 (SE 513) fish from the 2000 brood and 2,267 (SE 372) fish from the 2001 brood were harvested from 2003–2008. Smolt abundance was estimated to be 321,870 (SE 34,464) and 246,907 (SE 34,676) for the 2000 and 2001 broods, respectively. Estimates of smolt abundance and harvest of the 2002–2005 broods is incomplete pending complete adult returns in 2009–2012.

A separate project obtained standardized peak survey counts of large (≥ 600 mm MEF) spawners on 8 index tributaries of the Chickamin River in 2006–2008. A system-specific predictive expansion factor of 4.75 (SE = 0.70) was used to expand the annual peak counts to estimates of large spawner abundance. The abundance of small-sized fish (<660 mm MEF) was estimated indirectly by expanding the estimates for large fish by the estimated size composition of the spawning escapements. The size compositions of the spawning populations were estimated from the annual age, sex, and length samples collected on the spawning grounds. Spawning abundance was estimated to be 7,131 (SE = 943) in 2006, 4,984 (SE = 638) in 2007, and 6,700 (SE = 822) in 2008. Females comprised an estimated 44.5% (SE = 1.9%; 2006) to 48.1% (SE = 1.8%; 2007) of large spawners. Age-1.3 fish comprised 45.5% (SE = 2.1%), 53.6% (SE = 3.2%), and 62.0.5% (SE = 2.4%) of the total escapement in 2006-2008, respectively.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, escapement, Chickamin River, peak survey count, expansion factor, age, sex, length composition, coded wire tag, adipose fin, smolt abundance, Southeast Alaska

INTRODUCTION

The Chickamin River flows into Behm Canal in the Misty Fjords National Monument Wilderness in southern Southeast Alaska (SEAK; Figure 1). The Chickamin River produces the second largest run of Chinook salmon *Oncorhynchus tshawytscha* in southern SEAK, and is one of 4 Behm Canal index streams. In response to depressed Chinook salmon stocks in many SEAK streams in the mid-1970s, a fisheries management program was implemented to rebuild stocks. Peak counts of large (≥660 mm MEF) Chinook salmon serve as an index of abundance and have been collected annually by helicopter since 1975 using a standardized method (time and area). In SEAK, large Chinook salmon are generally fish that are age .3 or older. Chinook salmon <660 mm MEF can not be readily distinguished from other species of salmon, primarily chum salmon *Oncorhynchus keta,* during aerial surveys. These index counts are used by the Alaska Department of Fish and Game (ADF&G) and the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC) to evaluate stock status and implement abundance-based management. An expansion factor has been developed for the peak counts of Chinook salmon from the Chickamin River to provide estimates of the annual escapement of large spawners since 1975.

Peak counts of Chinook salmon in the Chickamin River have exhibited marked trends, ranging from lows of fewer than 450 Chinook salmon annually during the PSC base period (1975–1980) to highs of over 900 fish (with broad interannual fluctuations) during the 1980s, then a return to lower counts through the 1990s. Peak counts began to increase again in 1999, and from 2000 to 2008 have remained at levels similar to that of the 1980s. The current biological escapement goal range for the Chickamin River stock is a survey index count of 450 to 900 large spawners (McPherson and Carlile 1997).

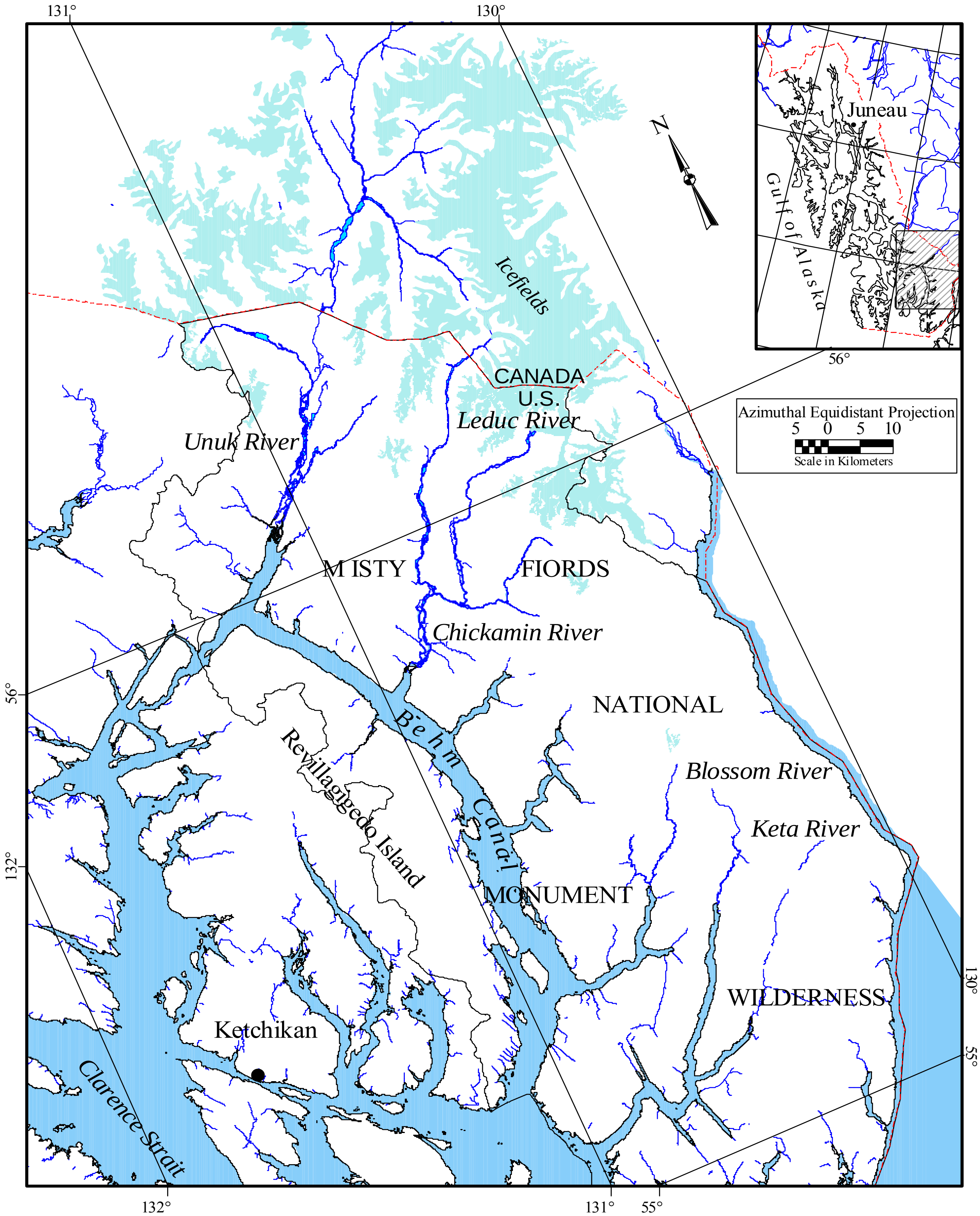

Figure 1.–Behm Canal in Southeast Alaska and the location of the Chickamin River.

From 1981 to 1994, it was assumed that the sum of index counts on 8 tributaries represented 62.5% of the total annual escapement to the Chickamin River (Pahlke 1997, Figure 2), resulting in an expansion factor of 1.6. In order to validate the index, mark–recapture studies were conducted to estimate the escapement of large Chinook salmon. In 1995 and 1996, estimated escapements of large Chinook salmon were 2,309 (SE = 723; Pahlke 1996) and 1,587 (SE = 199; Pahlke 1997), with accompanying peak aerial counts of 356 and 422, respectively. In addition, radiotelemetry studies in 1996 estimated that approximately 83% of all spawning occurred in the 8 index streams, approximately 17% of spawning occurred in small unnamed tributaries of the upper Chickamin River, and no salmon were tracked into British Columbia (Pahlke 1997). On the basis of these studies the expansion factor (EF) applied to peak aerial survey counts to estimate total escapement of large fish was revised to 4.0 (Pahlke 1998).

As part of the State of Alaska's commitment to a coastwide rebuilding program, the ADF&G Division of Sport Fish obtained funding to conduct expanded research on the Chickamin River, beginning in 2001, to estimate abundance and age, sex, and length composition of spawners. Funding for this program was approved by the CTC using monies appropriated by the U.S. Congress to implement abundance-based management of Chinook salmon from Oregon to Alaska, as detailed in "*The 1996 U.S. Letter of Agreement,*" signed by U.S. parties in the Pacific Salmon Treaty (PST) arena, and as detailed in the 1999 PST Agreement.

The U.S. section of the CTC (PSC 1997) developed data standards for stock-specific assessments of escapement, terminal runs, and forecasts of total returns. The standard for escapement is as follows:

> *"Escapement. Annual age- and sex-specific estimates of total escapement should be available. Point estimates should be accompanied by variance estimates, and both should be based on annual sampling data. Factors used to expand the escapement from index areas (or counts of components of the escapement) should be initially verified a minimum of three times. Those expansion factors that have moderate to large amounts of inter-annual variability (a coefficient of variation of more than 20%) should be monitored annually."*

The CTC concluded that the Chickamin River stock-assessment program required improvement and that ADF&G needed to:

1) estimate total escapement in additional years;
2) estimate an expansion factor converting historical survey counts into estimates of total escapement; and
3) estimate the escapement by sex and age annually.

In order to address the CTC requirements, ADF&G conducted a series of mark–recapture studies from 2001 to 2005. In 2001 the estimated escapement of large Chinook salmon was 5,177 (SE = 972), and the expansion factor for the peak aerial survey count was 5.13 (SE = 0.96 Freeman and McPherson 2003). The estimated escapements and expansion factors were 5,007 (SE = 738) and 4.94 (SE = 0.73) in 2002, 4,579 (SE = 592) and 4.75 (SE = 0.61) in 2003, 4,268 (SE = 893) and 5.35 (SE = 1.12) in 2004, and 4,257 (591) and 4.60 (SE = 0.64) in 2005 (Freeman and McPherson 2004, 2005; Freeman et al. 2007; Weller et al. 2007). The long-term or mean EF was estimated to be 4.75 (SE = 0.70) based on the data from 1996 and 2001–2005. The data from 1995 was not included in this estimate due to small sample size and poor precision relative to the other estimates (Weller et al. 2007). The coefficient of variation of the 6 annual expansion factors used to estimate the mean EF is 15.6%.

Juvenile Chinook salmon were injected with coded wire tags (CWTs) on the Chickamin River from 1983–1988 to estimate smolt abundance and adult migration routes, run timing, and contribution rates to commercial and recreational fisheries (Pahlke 1995). Overall harvest rates of Chickamin River Chinook salmon were estimated to range from 31% to 50% (note that incidental harvest mortality is not included in these estimates). Smolt abundance was estimated to range from 174,000 (SE = 23,997) to 510,000 (SE = 115,976).

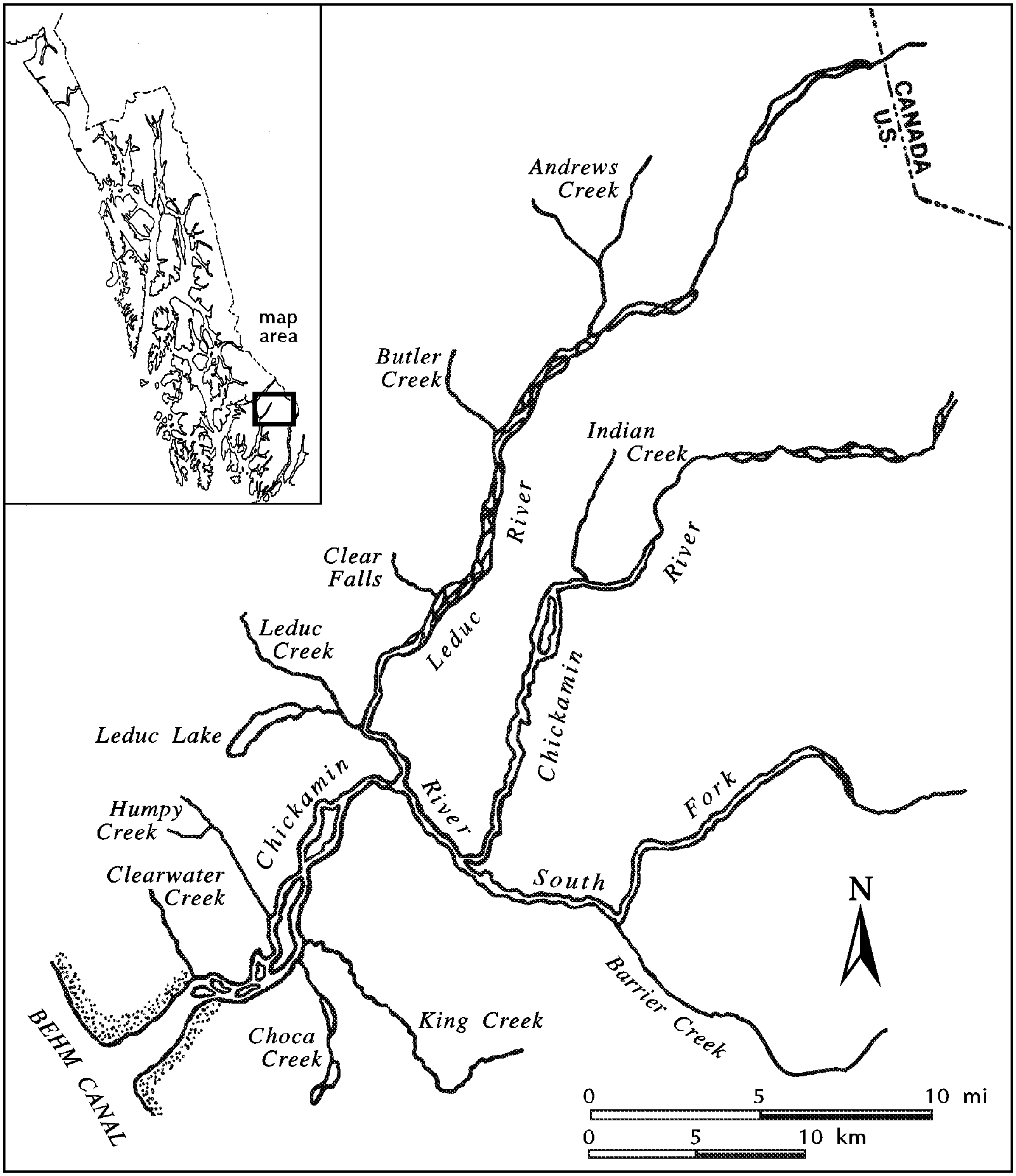

Figure 2.–The Chickamin River drainage in Southeast Alaska, showing location of major tributaries.

Funding from the Alaska Sustainable Salmon Fund was used to re-implement a coded wire tagging program on juvenile Chinook salmon on the Chickamin River beginning in the fall of 2001. Tagging was continued each spring and fall through the spring of 2006. Funding from the Northern Fund of the PSC extended the CWT project by 1 year, through spring of 2007. Recoveries of the Chinook salmon tags will be used to revise estimates of harvest and production of Chinook salmon in the Chickamin River.

The Chinook salmon CWT study from 2001 to 2012 and the estimation of adult Chinook salmon spawning abundance and age, sex and length composition study from 2006–2008 on the Chickamin River has/had the following objectives:

1. Estimate the age and sex composition of large Chinook salmon spawning in the Chickamin River in 2006, 2007, and 2008 such that all estimated fractions are within 5 percentage points of the true values 95% of the time; and
2. Estimate the abundance of emigrating smolt from brood years 2000–2005 such that estimates are within 30% of the true value 90% of the time; and
3. Estimate adult escapement in 2006, 2007, and 2008 by expanding the peak survey counts such that the coefficient of variation of the expanded survey counts are <15%; and
4. Estimate the marine harvest of Chickamin River Chinook salmon from the 2000–2005 brood year (via recovery of coded wire tagged smolt emigrating in 2002–2007) such that the anticipated half-width of the calculated 95% confidence interval is 30% of the estimate. The estimates will be derived from tag recoveries in marine salmon fisheries and in the Chickamin River from 2003 through 2012.

STUDY AREA

The Chickamin River is a transboundary river that originates in a heavily glaciated area of northern British Columbia and flows into Behm Canal in the Misty Fjords National Monument Wilderness approximately 65 km northeast of Ketchikan, Alaska (Figure 1). Although the Chickamin River is a transboundary river, no Chinook salmon spawning areas have been documented in Canada. Many of its anadromous spawning tributaries flow clear; however, the mainstem flows mostly turbid during summer from glacial influence. The lower river flows through a broad valley bordered by steep-sided mountains. The lower river channel has a relatively flat bottom, with fine riverbed sediments, exposed bars, low gradient with braided channels, and large, bedrock-controlled pools. Moving upstream, the river is narrower, with progressively coarser substrates, more bedrock, steeper gradient, and more logjams.

METHODS

AGE, SEX, AND LENGTH COMPOSITION

The Chickamin River was sampled by a 4–5 person crew that traveled by float plane from Ketchikan to a base camp on the lower mainstem of the river. The crew then traveled daily from the base camp by boat(s) to the various tributaries and sampled the systems on foot, weather and river conditions permitting. Each tributary required multiple sampling trips to achieve desired sampling goals.

Chinook salmon were captured primarily using dip nets and rod and reel gear, although carcasses were also sampled if available. Five scales were taken from each captured fish (Welander 1940). Scales were mounted onto gum cards; each gum card had the capacity to hold scales from up to 10 fish. The age of each fish was determined later from annual growth patterns of circuli (Olsen 1992) on images of scales impressed onto acetate magnified 70× (Clutter and Whitesel 1956). Each fish was measured to the nearest 5 mm MEF, and sex was determined by external morphological characteristics. Data was recorded on standard ADF&G biological-sampling forms. All sampled Chinook salmon carcasses were slashed along their left side and all live fish sampled were marked with a hole punched in their left operculum to ensure double sampling did not occur. All fish were examined for the absence of the adipose fin, indicating the possible presence of a coded wire tag. Heads from fish without adipose fins that were dead, post-spawn, or ≤700 mm MEF (jacks) were collected and forwarded to the ADF&G Mark, Tag, and Age Laboratory (Tag Lab) in Juneau for decoding, along with all pertinent data and forms.

Scales of known marine but unknown (regenerated) freshwater (FW) age were assumed to have a FW age of 1, as historically less than 1% of fish have been found to have a FW age other than 1. Fish of unknown marine water (MW) age were assumed to have a MW age of 1 if fish length was <500 mm MEF. No fish <500 mm MEF has been found to have a MW age other than

1 in the Chickamin River since 2001. Fish of unknown MW age that were greater than 495 mm MEF were not included in the age composition estimates. It is noted that fish scales of fish of age 1.1 have a significantly greater tendency to show regeneration than scales of fish of marine ages 2 and above. Historically less than 2% of scale samples have regenerated or otherwise unknown marine water age.

The proportion of the spawning population composed of a given age within a size class was estimated as a binomial variable:

$$\hat{p}_{kc} = \frac{n_{kc}}{n_k}, \tag{1}$$

$$\text{var}(\hat{p}_{kc}) = \frac{\hat{p}_{kc}(1-\hat{p}_{kc})}{n_k - 1} \tag{2}$$

where $\hat{p}_{kc}$ is the estimated proportion of the population of age c in size group k, n_{kc} is the number of Chinook salmon of age c of size group k, and n_k is the number of Chinook salmon in the sample n of size group k. Numbers of spawning fish by age were estimated as the sum of the products of estimated age composition and estimated abundance within a size category:

$$\hat{N}_c = \sum_k (\hat{p}_{kc}\hat{N}_k) \tag{3}$$

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

$$\text{var}(\hat{N}_c) = \sum_k \begin{pmatrix} \text{var}(\hat{p}_{kc})\hat{N}_k^2 + \text{var}(\hat{N}_k) \\ \hat{p}_{kc}^2 - \text{var}(\hat{p}_{kc})\,\text{var}(\hat{N}_k) \end{pmatrix} \tag{4}$$

The proportion of the spawning population composed of a given age was estimated as the summed totals across size categories:

$$\hat{p}_c = \frac{\hat{N}_c}{\hat{N}} \tag{5}$$

and:

$$\text{var}(\hat{p}_c) = \frac{\sum_k \begin{pmatrix} \text{var}(\hat{p}_{kc})\hat{N}_k^2 + \text{var} \\ (\hat{N}_k)(\hat{p}_{kc} - \hat{p}_c)^2 \end{pmatrix}}{\hat{N}^2} \tag{6}$$

where $\hat{N}$ is the sum of fish of all sizes, and variance is approximated according to procedures in Seber (1982, p. 8–9).

Sex composition and age-sex composition for the entire spawning population and its associated variances were also estimated using the above equations by first redefining the binomial variables in samples to produce estimated proportions by sex $\hat{p}_s$, where g denotes gender (male or female), such that $\sum_g \hat{p}_g = 1$, and by age-sex $\hat{p}_{cg}$, such that $\sum_{cg} \hat{p}_{cg} = 1$.

Standard sample summary statistics were used to calculate estimates of mean length at age and its variance (Cochran 1977).

ESTIMATION OF SPAWNING ABUNDANCE

Standardized, low altitude helicopter and/or foot surveys have been used to count large Chinook salmon in index tributaries of the Chickamin River since 1975 (Pahlke 1998). The 8 index tributaries of the Chickamin River are South Fork, Barrier, Butler, Leduc, Indian, Humpy, Clear Falls, and King Creeks (Figure 2). In most cases, multiple surveys were conducted on each tributary annually, and the largest or "peak" survey count was used as an index of the spawning abundance of large Chinook salmon. Peak survey counts were multiplied by the long-term EF (4.75) to provide estimates of the spawning abundance of large Chinook salmon in 2006–2008.

The abundance of small-sized fish (<660 mm MEF) was estimated indirectly by expanding the estimate for large fish by the estimated size composition of the spawning escapement:

$$\hat{N}_U = \hat{N}_L\left(\frac{1}{\hat{\phi}} - 1\right), \tag{7}$$

$$\text{var}(\hat{N}_U) = \text{var}(\hat{N}_L)\left[\frac{1}{\phi} - 1\right]^2 + \hat{N}_L{}^2 \left[\frac{1}{\phi^4}\frac{\phi(1-\phi)}{n-1}\right] - \text{var}(\hat{N}_L)\left[\frac{1}{\phi^4}\frac{\phi(1-\phi}{n-1}\right] \quad (8)$$

where $\hat{N}_U$ is the estimated spawning escapement of small-sized fish, $\hat{N}_L$ is the estimated spawning escapement of large fish, and $\hat{\phi}$ is the estimated fraction of large-sized fish in the Chinook salmon spawning population, as determined from age, sex, and length (ASL) samples collected on the spawning grounds (McPherson et al. 1996). Testing of the spawning grounds samples collected on these systems has consistently found no evidence of size or gender selectivity.

JUVENILE CHINOOK SALMON CAPTURE, TAGGING, AND SAMPLING

A mark–recapture experiment was used to estimate the abundance of Chinook salmon smolt emigrating from the Chickamin River in spring 2002–2007. Chinook salmon fingerlings were captured in the Chickamin River drainage each fall in 2001–2006 and smolt were captured each spring in 2002–2007. Fish captured (over minimum size limits) were marked by removing the adipose fin and inserting a CWT as the first of 2 sampling events. A systematic sample of each group was measured for length to estimate size composition. Chinook salmon from the Chickamin River are almost all (>99% based on previous age studies) from a single freshwater age, overwintering 1 year as fingerlings and emigrating as age-1 (yearling) smolt. Nearly all Chinook salmon fingerlings tagged in the fall of year $t + 1$, and smolt tagged in the spring of year $t + 2$, are thus from brood year t. Adult Chinook salmon return to the river over 5 years, beginning with age-1.1 "jacks" and ending with age 1.5. Adult salmon were/will be sampled in the Chickamin River as they return in 2003–2012 for the second sampling event.

To obtain precision criteria in Objectives 2 and 4, CWT sampling goals were based on procedures described in Bernard et al. (1998) and the following assumptions:

1. annual returns of 5,000 age-1.2 to age-1.5 fish, and smolt population averaging 225,000 fish (from Pahlke 1995);
2. 17,000 fingerlings are tagged each fall;
3. 75% of fingerlings survive to smolt (overwinter survival), i.e. 12,750 tagged fingerlings survive to smolt;
4. 10,000 smolt are tagged each spring, resulting in an anticipated marked fraction of approximately 0.1 (12,750+ 10,000/225,000) for each brood;
5. 40% exploitation rate, yielding adult harvests of 2,000 fish (5,000 x 0.4) and harvest sampling rates of 40% (Objective 4 only); and
6. sampling at least 410 adults per brood for CWTs on the spawning grounds.

Historic patterns of tag recovery and total harvest among fishery strata were used to anticipate stratum specific tag recoveries, harvest (and its variance) of Chickamin River Chinook salmon.

Fall

Each October in 2001–2006, 60 to 180 minnow traps baited with salmon eggs (treated for 15 minutes in a 1% Betadine solution) were fished daily in the mainstem of the Chickamin River and the lower Leduc River. Traps were divided between 2 trap lines, each of which was operated and checked by a 2-person crew. Each trap line was checked at least once per day. All fish caught in traps were transported to a central tagging station, sorted by species, finclipped, marked with CWT, held overnight to check for tag retention, then released in the general area where captured. All healthy Chinook salmon ≥55 mm FL captured each day were given a CWT, formed by cutting a 1.1 mm section of coded wire from a spool which was stamped with a unique code. Minimum tagging lengths were those used in the neighboring Unuk River, to insure we did not tag fish that would not emigrate in spring 2007.

Spring

From early April to mid-May in 2002–2007, 60 to 180 baited minnow traps were fished daily in the mainstem of the Chickamin River from above the confluence of the Leduc River downstream

(Figure 2). Two crews of 2 people each were employed to fish 2 trap lines. Methodology for capture and tagging of fish is as described above. Unique codes were used for spring and fall tagging. Codes were ordered in spools of approximately 5,000 or 10,000 tags and were only changed when exhausted.

ESTIMATION OF FRACTION OF ADULTS BEARING CWTS

The fraction of adults from brood year *i* that possess a CWT was estimated as:

$$\hat{\theta}_i = \frac{\sum_{j=i+3}^{i+7} a_j \rho_j}{\sum_{j=i+3}^{i+7} n_j} \tag{9}$$

where

n_j = number of adults examined in year *j* from brood year *i* for adipose finclips;

a_j = number of adipose finclips observed in n_j;

$\rho_j = \frac{t_j}{a'_j}$, the proportion of sacrificed adults out of a_j that also possessed a CWT;

and

a'_j = number of heads examined for CWTs from the a_j fish with adipose finclips;

t_j = number of CWTs found in a'_j.

The variance of $\hat{\theta}_i$ was estimated using a parametric bootstrap simulation (e.g., Geiger 1990), where binomial sampling variability pertaining to recovery of adipose clips from fish examined, and the variability associated with recovery of CWTs from a subsample of adipose-clipped fish selected for CWT detection (sacrificed fish) were incorporated.

Adipose finclips were simulated (a^*_j) for each of the calendar years $j = i + 3$ through $i + 7$ from a binomial distribution: bin ($size = n_j, prob = a_j / n_j$). Notation for parameters follows that of the R language (R Development Core Team 2005).

Adipose-finclipped fish bearing CWTs were simulated (t^*_j) as hypergeometric ($m = t_j / a'_j a^*_j, n = a^*_j - t_j / a'_j a^*_j, k = a'_j / a_j a^*_j$). The proportion ρ^*_j was then calculated as $t^*_j / (a^*_j a'_j / a_j)$. Simulated values of the marked fraction $\hat{\theta}^*_i$ were then calculated as described in Equation 9, and its variance calculated over the simulations.

Returning Chinook salmon were/will be inspected for marks (missing adipose fins) annually through 2012 at or near spawning locations (Butler, Leduc, Clear Falls, Indian, South Fork, Humpy and King creeks; Figure 2). Each Chinook salmon was/will be examined for presence of the adipose fin, and a fish missing its adipose fin will be noted. Furthermore, heads will be removed from all adipose-finclipped Chinook salmon that are dead, post spawn, or <700 mm MEF (jacks), with the resulting heads collected and shipped to the Tag Lab for CWT processing. Scales (age) and length data were/will be collected from all adult Chinook salmon sampled to determine the marked rate by brood year.

CONTRIBUTIONS TO FISHERIES

Harvest and CWT sampling data from fisheries managed by the State of Alaska were obtained from the Tag Lab's database http://www.cf.adfg.state.ak.us. The Regional Mark Processing Center (RMPC, http://www.rmpc.org), which maintains the coastwide CWT central database (Regional Mark Information System or RMIS) provided harvest and CWT sampling data from fisheries not included in the Tag Lab database.

All CWT samples are classified as either random, select, or voluntary. Random samples are those collected by either creel (recreational fisheries) or port (commercial fisheries) sampling projects according to protocols established by ADF&G, the Canadian Department of Fisheries and Oceans (CDFO), and other entities. Random recoveries of Chickamin River CWTs from sampled fisheries with known (or estimated) harvest were used to estimate harvest contributions. The estimated contribution $\hat{Z}_{ij}$ of a release group or brood of interest (i) to 1 fishery stratum (j) is:

$$\hat{Z}_{ij} = \hat{N}_j \left[\frac{m_{ij}}{\lambda_j n_j} \right] \hat{\theta}_i^{-1}; \qquad \lambda_j = \frac{a'_j t'_j}{a_j t_j} \quad (10)$$

where $\hat{N}_j$ = total harvest in the fishery, n_j = number of fish inspected (the sample), a_j = number of fish that are missing an adipose fin, a'_j = number of heads that arrive at the Tag Lab, t_j = number of heads with CWTs detected, t'_j = number of CWTs that are dissected from heads and decoded, m_{ij} = number of CWTs with code(s) of interest, and $\hat{\theta}_i$ = the fraction of the cohort tagged with code(s) of interest. When $\hat{N}_j$ and $\hat{\theta}_i$ are known without error, an unbiased estimate of the variance of $\hat{Z}_{ij}$ can be calculated as shown by Clark and Bernard (1987). However, $\hat{N}_j$ is estimated with error in our sport fisheries, and $\hat{\theta}_i$ is estimated with error on the Chickamin River because it is not possible to tag every fish. For these reasons, approximate estimates of the variance of $\hat{Z}_{ij}$ were obtained using equations in Table 2 of Bernard and Clark (1996), which show the formulations for large samples. The total harvest for a cohort is the sum of the $\hat{Z}_{ij}$'s over j.

Select samples are non-random samples collected by port or creel samplers. Generally these are fish that are brought to the attention of a sampler by a fisher or processor employee, fish that would not otherwise have been sampled during routine sampling operations, however any sampled fish that violated random sampling protocols would be considered select. Select recoveries of Chickamin River CWTs were not used in harvest contribution estimation.

Voluntary samples are CWT fish that are brought to project samplers by fishers, and would not otherwise have been sampled by established creel or port sampling projects. One important difference between select and voluntary samples is that voluntary samples are from otherwise unsampled fisheries, or from fisheries not sampled during the time strata in question. Voluntary recoveries of Chickamin River CWTs were used to estimate harvest contributions. In these cases an awareness approximation was used to expand the recoveries. The awareness approximation is based on extrapolations of data from previous years according to protocols established by the CTC of the PSC (Brian Riddell, CDFO, Nanaimo, personal communication). In such cases, the estimated contribution $\hat{Z}_{ij}$ of brood year i to fishery stratum j is:

$$\hat{Z}_{ij} = 4 m_{ij} \theta_i^{-1}; \ \text{var}\left(\hat{r}_{ij}\right) = \left(\hat{r}_{ij}\right)^2 \quad (11)$$

where 4 equals the awareness approximation, m_{ij} = number of CWTs with code(s) of interest from brood i recovered in fishery stratum j, and $\hat{\theta}_i$ = the fraction of the cohort tagged with code(s) of interest.

Fishery strata are defined as a combination of gear and harvest type with specific spatial and temporal characteristics. Commercial fishery harvest types in SEAK of relevance to this study were traditional fisheries, experimental area (troll) fisheries, and private non-profit (PNP) hatchery harvests in the Neets Bay terminal area. The traditional and experimental area fisheries are managed by ADF&G to achieve harvest targets (quotas) pursuant to the PST and as determined by the CTC of the PSC. Experimental area fisheries target Alaska hatchery returns of Chinook salmon in SEAK each spring (approximately May through June), although fish other than Alaskan hatchery fish (treaty fish) are also harvested. The proportion of treaty fish harvested in each experimental fishery determines the total catch limit for each fishery (See Lynch and Skannes 2008a for further details on these fisheries). Experimental area fisheries are spatially small (sub district specific; Figure 3) and harvest by fishery is tallied by statistical week.

The Neets Bay terminal area fishery is a cost recovery fishery managed jointly by ADF&G and the Southern Southeast Aquaculture Association (SSRAA) to harvest returns to the Neets Bay

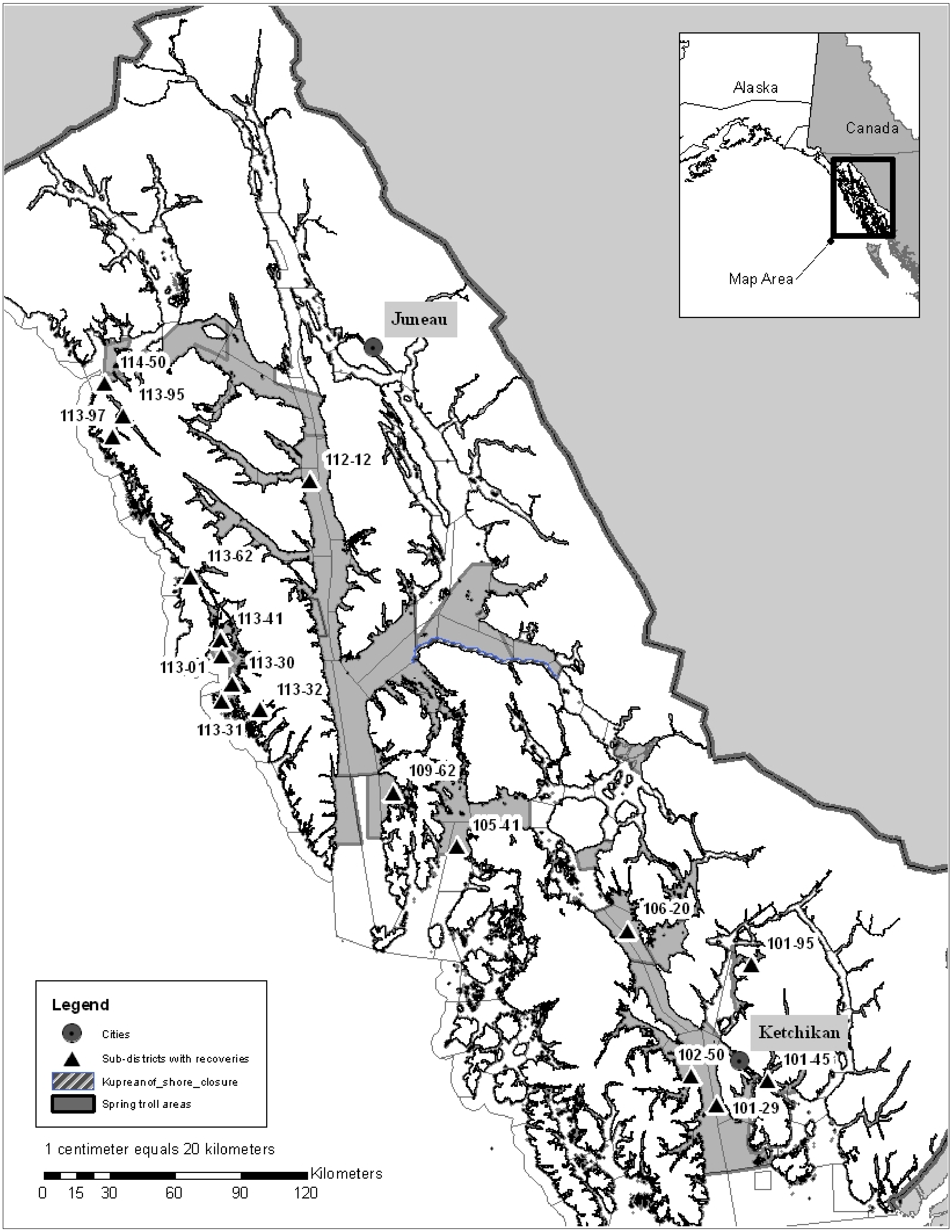

Figure 3.–Southeast Alaska experimental troll fishing areas (district-sub district) from which Chinook salmon with Chickamin River CWTs were recovered from 2003–2008.

hatchery (Lynch and Skannes 2008b). The fishery is confined to District 101-95 (Figure 3), harvest is tallied by statistical week, and gear is undefined.

Traditional fisheries are mixed stock interception fisheries; terminal area, aboriginal, experimental area, and test fisheries are not considered traditional fisheries. Harvest from SEAK traditional purse seine and drift gillnet fisheries are tallied by statistical week and district fished (Davidson et al. 2008a-b; Figure 4). In SEAK the traditional troll fishery is comprised of winter, spring (experimental area), and summer components. The winter fishery begins 11 October and ends when 45,000 Chinook salmon have been harvested, or on 30 April, whichever occurs first (Lych and Skannes 2007). The summer troll fishery begins 1 July and ends 20 September, unless the fishery is extended (Lynch and Skannes 2008b).

Traditional (ocean troll per RMIS protocols) Canadian troll harvests are tallied by statistical week and management Area (Figure 5). Traditional troll harvests in SEAK are tallied by quadrant and period. A quadrant is a group of combined contiguous districts that divides SEAK into 4 large troll reporting areas (NE, NW, SE, and SW; Figure 6). Period is a group of consecutive statistical weeks. Period 1 starts on 1 January (statistical week 1) and ends when the winter troll fishery closes. Period 2 encompasses the spring, or experimental area, fishery. Period 3 begins when the summer troll fishery opens, generally 1 July, and ends when an inseason assessment of Chinook salmon harvest sampling data determines the summer quota of Chinook salmon has been reached and the fishery is closed to Chinook salmon retention (note that the summer troll fishery may remain open to retention of other salmon species). Period 4 may encompass the remainder of the summer troll fishery (i.e., through 20 September), or management actions may necessitate use of additional periods during the summer troll fishery. For example, if Chinook salmon harvest during Period 1 was found to be substantially less than the quota, the fishery may reopen to Chinook salmon retention, necessitating use of an additional period(s). The final period of each calendar year is from 1 October to 31 December. Note that as Chickamin River Chinook salmon have generally completed spawning by 1 October, harvest contributions of Chickamin River Chinook during this period are accredited to returns the following calendar year.

Creel surveys and/or catch sampling of recreational fisheries were randomly conducted in SEAK at marine boat landing sites in Haines, Petersburg, Wrangell, Sitka, Juneau, Craig, Ketchikan, Elfin Cove, and Gustavus during times of peak sport fishing activity, e.g., April through September (Figure 4). Information collected from individual fishers included harvest type, harvest date, harvest location, number of Chinook salmon inspected for missing adipose fins, and the number of Chinook salmon observed with missing adipose fins. Harvest types relevant to this study were marine boat (MB) and derby fishing in which the sampled fish was entered in the derby (DE). Each sample was classified as either random, select, or voluntary. Creel surveys were used to estimate recreational harvest by fortnight, harvest type, and port of landing (e.g., Wendt and Jaenicke *In prep*). Recoveries from Canadian recreational fisheries in Northern B.C. are strictly voluntary. The awareness factor was used to expand these recoveries by month and region (British Columbia).

SMOLT ABUNDANCE

Experience has shown that estimates of the proportion of adults from a given brood year with adipose finclips does not change appreciably over return years, and thus recovery data from brood year *i* was pooled over the years during which fish from brood year *i* returned. Smolt abundance for brood year *i* was estimated using a version of the Chapman-modified Petersen formula:

$$\hat{N}_{s,i} = \frac{(\hat{M}_i + 1)(n_{\bullet i} + 1)}{(a_{\bullet i} + 1)} - 1 \qquad (12)$$

where

$n_{\bullet i} = \sum_{j=i+3}^{i+7} n_j$, where n_j is the number of adults examined in year *j* from brood year *i* for adipose finclips;

$a_{\bullet i} = \sum_{j=i+3}^{i+7} a_j$, where a_j is the number of adipose finclips observed in n_j; and

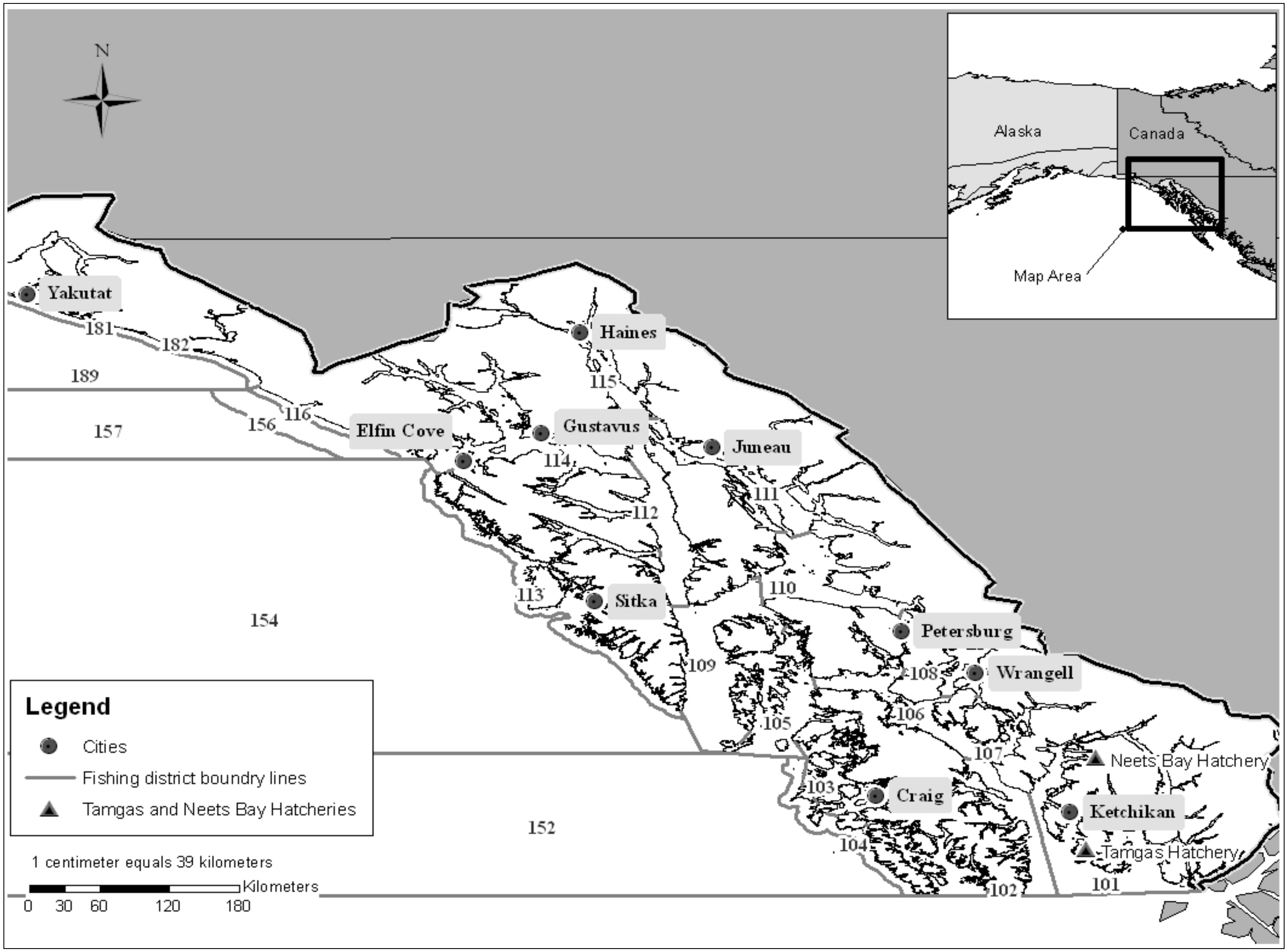

Figure 4.–Southeast Alaska with commercial fishing districts, creel census ports, and the Tamgas and Neets Bay Hatcheries.

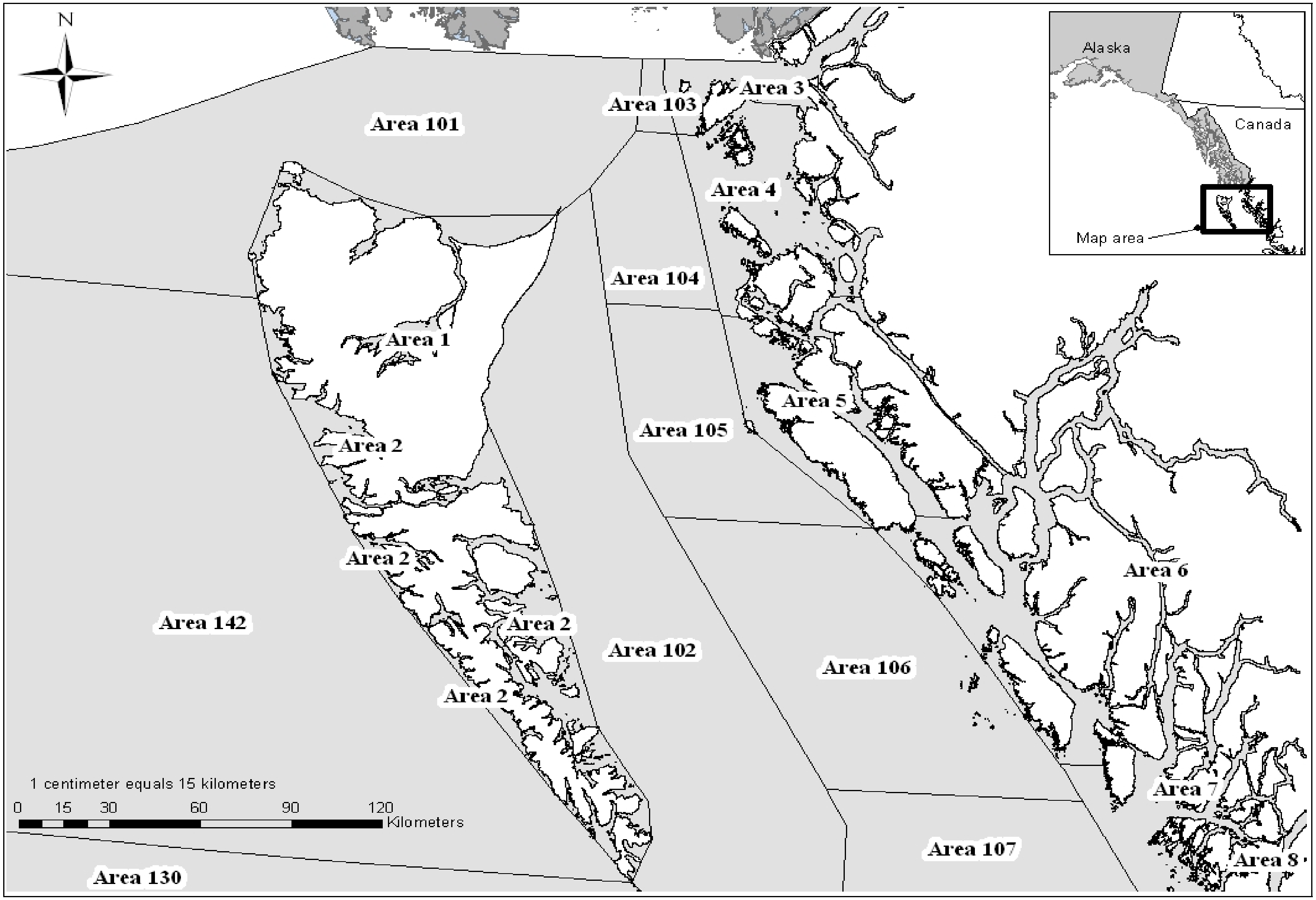

Figure 5.–Canadian management areas.

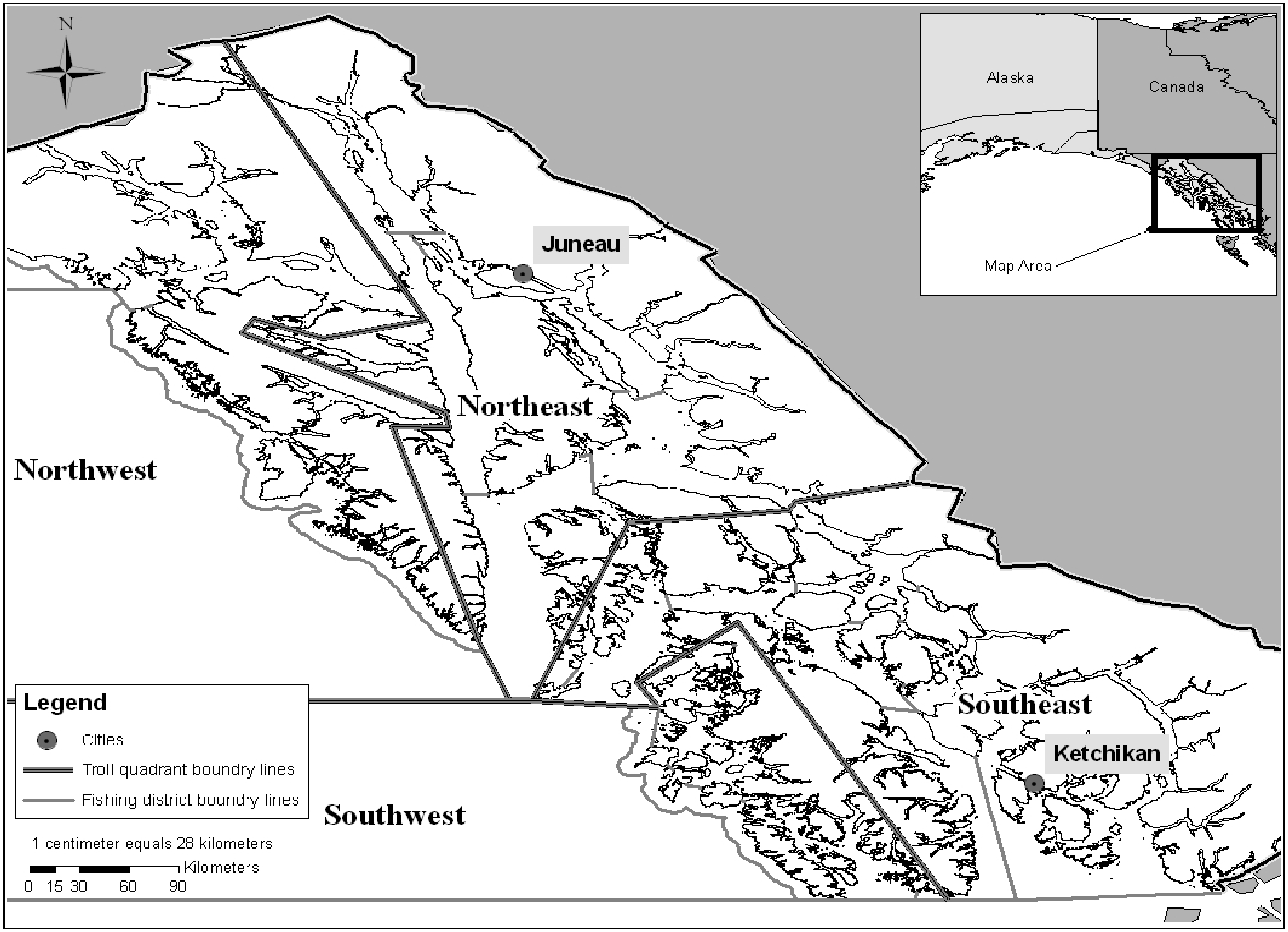

Figure 6.–Southeast Alaska troll quadrants.

$\hat{M}_i$ = estimated number of outmigrating smolt originating from brood year *i* that bore an adipose finclip; these fish may be from either the fall (year *i* + 1) or spring (year *i* + 2) tagging programs.

$\hat{M}_i$ was estimated by summing the estimate of the fall-tagged fingerlings (note that fingerling abundance was estimated according to the procedures in Weller and McPherson 2003, Appendix A8) surviving to the spring ($\hat{M}_{f->s,i}$) and the spring-tagged smolt ($M_{s,i}$):

$$\hat{M}_i = \hat{M}_{f->s,i} + M_{s,i} \tag{13}$$

where (see Weller and McPherson 2003, Appendix A7):

$$\hat{M}_{f->s,i} = M_{f,i}\hat{S}_w \tag{14}$$

and

$M_{f,i}$ = number of adipose finclips given to fingerlings in the fall of year *i* + 1; and

$\hat{S}_w$ = estimated survival of fall fingerlings to the spring.

The variance of the smolt estimate was estimated:

$$\text{var}(\hat{N}_{s,\,i}) = (n_\bullet + 1)^2 \text{ var} \left[(\hat{M}_{f->s,i} + M_{s,i} + 1)\frac{1}{(a_\bullet + 1)} \right] \tag{15}$$

Where, by Goodman (1960) for independent variables:

$$\begin{aligned} &\text{var}\left[(\hat{M}_{f->s,i} + M_{s,i} + 1)\frac{1}{(a_{\bullet i} + 1)} \right] \\ &= (M_{s,i} + \hat{M}_{f->s,i} + 1)^2 \\ &\text{var}\left[\frac{1}{a_{\bullet,i} + 1} \right] + \left(\frac{1}{a_{\bullet,i} + 1} \right)^2 \text{var}(\hat{M}_{f->s,i}) \\ &- \text{var}\left[\frac{1}{a_{\bullet,i} + 1} \right] \text{var}(\hat{M}_{f->s,i}) \end{aligned} \tag{16}$$

And $\hat{\text{var}}(\hat{M}_{f->s})$ is obtained as described in Weller and McPherson (2003). According to the delta method:

$$\text{var}\left[\frac{1}{a_\bullet + 1} \right] = \left[\frac{1}{a_{\bullet,i} + 1} \right]^4 n_{\bullet,i}\hat{p}_a(1 - \hat{p}_a) \tag{17}$$

where $\hat{p}_{a,i} = a_{\bullet,i} / n_{\bullet,i}$ is the estimated proportion of inspected adults from brood year *i* with an adipose finclip.

The 2 components in Equation 16 are not independent, but a simulation using data from studies on 7 brood years of Unuk River Chinook salmon to establish realistic population parameters showed the correlation to be negligible. The simulation also showed the simulated variance of smolt abundance to be almost identical to that provided by the average of the Goodman (1960) method estimates (above) over the simulation.

RESULTS

AGE, SEX, AND LENGTH COMPOSITION

2006

A total of 772 fish were captured on the spawning grounds and sampled for ASL between 6 August and 30 September, 2006. Scales from 26 of the samples were not used in the age composition analysis due to MW regeneration, and 1 fish was not measured for length. ASL data from 660 large fish were used to estimate the age and sex composition of large spawners, exceeding the minimum of 472 samples necessary to meet Objective 1 precision criteria for 2006.

Age-1.1 fish, all male, comprised 15.1% (SE = 3.9%) of small-sized fish and 1.7% (SE = 0.6%) of the total escapement (Table 1). Age-1.2 fish comprised an estimated 81.4% (SE = 4.2%) of small-sized fish, 19.5% (SE = 1.5%) of large fish, and 26.6% (SE = 2.1%) of the total escapement. Age-1.3 fish comprised an estimated 2.3% (SE = 1.6%) of small-sized fish, 51.1% (SE = 1.9%) of large fish, and 45.5% (SE = 2.1%) of the total escapement. Age-1.4 fish comprised 25.9% (SE = 1.7%) of the escapement. Females, all large, accounted for 39.4% (SE = 2.0%) of the escapement (Table 1).

Table 1.–Age and sex composition of small (<660 mm MEF) and large (≥660 mm MEF) Chinook salmon in the Chickamin River determined using data gathered on the spawning grounds in 2006.

		Brood year and age class					
		2003	2002	2001	2001	2000	
		1.1	1.2	1.3	2.2	1.4	Total
PANEL A: AGE COMPOSITION OF SMALL CHINOOK SALMON							
Males	Sample size	13	70	2	1		86
	p_{kcg} x100	15.1	81.4	2.3	1.2		100.0
	SE(p_{kcg})x100	3.9	4.2	1.6	1.2		
	N_{kcg}	123	662	19	9		813
	SE(N_{kcg})	38	127	14	9		150
Females	Sample size						
	p_{kcg} x100						
	SE(p_{kcg})x100						
	N_{kcg}						
	SE(N_{kcg})						
Sexes combined	Sample size	13	70	2	1		86
	p_{kc}x100	15.1	81.4	2.3	1.2		100.0
	SE(p_{kc})x100	3.9	4.2	1.6	1.2		
	N_{kc}	123	662	19	9		813
	SE(N_{kc})	38	127	14	9		150
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON							
Males	Sample size		120	181	1	64	366
	p_{kcg} x100		18.2	27.4	0.2	9.7	55.5
	SE(p_{kcg})x100		1.5	1.7	0.2	1.2	1.9
	N_{kcg}		1,149	1,733	10	613	3,504
	SE(N_{kcg})		194	277	10	115	530
Females	Sample size		9	156		129	294
	p_{kcg} x100		1.4	23.6		19.5	44.5
	SE(p_{kcg})x100		0.5	1.7		1.5	1.9
	N_{kcg}		86	1,493		1,235	2,814
	SE(N_{kcg})		31	243		206	432
Sexes combined	Sample size		129	337	1	193	660
	p_{kc}x100		19.5	51.1	0.2	29.2	100.0
	SE(p_{kc})x100		1.5	1.9	0.2	1.8	
	N_{kc}		1,235	3,226	10	1,848	6,318
	SE(N_{kc})		206	491	10	294	931
PANEL C: AGE COMPOSITION OF SMALL AND LARGE CHINOOK SALMON							
Males	Sample size	13	190	183	2	64	452
	p_{cg} x100	1.7	25.5	24.5	0.3	8.6	60.6
	SE(p_{cg})x100	0.6	2.1	1.7	0.2	1.0	2.0
	N_{kg}	123	1,810	1,752	19	613	4,317
	SE(N_{kg})	38	231	278	13	115	551
Females	Sample size		9	156		129	294
	p_{cg} x100		1.2	20.9		17.3	39.4
	SE(p_{cg})x100		0.4	1.6		1.4	2.0
	N_{kg}		86	1,493		1,235	2,814
	SE(N_{kg})		31	243		206	432
Sexes combined	Sample size	13	199	339	2	193	746
	p_k x100	1.7	26.6	45.5	0.3	25.9	100.0
	SE(p_k)x100	0.6	2.1	2.1	0.2	1.7	
	N_k	123	1,897	3,245	19	1,848	7,131
	SE(N_k)	38	242	491	13	294	943

The average length of age-1.2 and age-1.3 males was 670 mm MEF (SD = 55) and 801 mm MEF (SD = 69), respectively (Table 2). On average, age-1.3 males were smaller than their female counterparts at 801 mm MEF (SD = 69) compared to 830 mm MEF (SD = 44), and age-1.4 males were larger than were age-1.4 females at 905 mm MEF (SE = 68) and 890 mm MEF (SE = 45), respectively.

2007

A total of 910 fish were captured on the spawning grounds and sampled for ASL between 6 August and 23 September, 2007. Scales from 37 of the samples were not used in the age composition analysis due to regeneration, and 7 fish were not measured for length. ASL data from 747 large fish were used to estimate the age and sex composition of large spawners, exceeding the minimum of 455 samples necessary to meet Objective 1 precision criteria for 2007.

Age-1.1 fish, all male, comprised 17.5% (SE = 3.4%) of small-sized fish and 2.6% (SE = 0.7%) of the total escapement (Table 3). Age-1.2 fish comprised an estimated 78.6% (SE = 3.7%) of small-sized fish, 8.3% (SE = 1.0%) of large fish, and 18.8% (SE = 2.3%) of the total escapement. Age-1.3 fish comprised an estimated 4.0% (SE = 1.7%) of small-sized fish, 72.2% (SE = 1.6%) of large fish, and 62.0% (SE = 2.4%) of the total escapement. Age-1.4 fish comprised 15.8% (SE = 1.3%) of the escapement. Females accounted for 41.2% (SE = 2.1%) of the escapement (Table 3).

The average length of age-1.2 and age-1.3 males was 639 mm MEF (SD = 54) and 806 mm MEF (SD = 71), respectively (Table 4). On average, age-1.3 males were smaller than their female counterparts at 806 mm MEF (SD = 71) compared to 822 mm MEF (SD = 44).

2008

A total of 459 fish were captured on the spawning grounds and sampled for ASL between 3 August and 13 September, 2008. Scales from 5 of the samples were not used in the age composition analysis due to regeneration, and 1 fish was not measured for length. ASL data from 358 large fish were used to estimate the age and sex composition of large spawners, below the minimum of 465 samples necessary to meet Objective 1 precision criteria for 2008. We are, however, 94% confident that the age classes were estimated to be within ± 5 percentage points of their true values.

Age-1.1 fish, all male, comprised 28.1% (SE = 4.6%) of small-sized fish and 6% (SE = 1.5%) of the total escapement (Table 5). Age-1.2 fish comprised an estimated 65.6% (SE = 4.8%) of small-sized fish, 9.5% (SE = 1.5%) of large fish, and 21.5% (SE = 2.7%) of the total escapement. Age-1.3 fish comprised an estimated 5.2% (SE = 2.3%) of small-sized fish, 66.8% (SE = 2.5%) of large fish, and 53.6% (SE = 3.2%) of the total escapement. Age-1.4 fish comprised 18.5% (SE = 2.0%) of the escapement. Females accounted for 36.0% (SE = 2.7%) of the escapement (Table 5).

The average length of age-1.2 and age-1.3 males was 635 mm MEF (SD = 57) and 788 mm MEF (SD = 70), respectively (Table 6). On average, age-1.3 males were smaller than their female counterparts at 788 mm MEF (SD = 70) compared to 807 mm MEF (SD = 55). Age-1.4 males, on average, were larger than their female counterparts at 899 mm MEF (SE = 62) compared to 870 mm MEF (SE = 38).

SPAWNING ABUNDANCE

2006

Standardized low altitude helicopter and/or foot surveys of the 8 index tributaries resulted in a peak index count of 1,330 large Chinook salmon. Using the long-term EF of 4.75, the index count was expanded to a spawning population estimate of 6,318 (SE = 931) large Chinook salmon ($\hat{N}_L$; Table 7). Expansion of $\hat{N}_L$ by the estimated size composition of the spawning population, as determined from ASL samples, resulted in an estimated escapement of 813 (SE = 150) small Chinook salmon (Table 8). The total estimated spawning population was estimated to be 7,131 (SE = 943) Chinook salmon. The Objective 3 precision criterion was exceeded in 2006.

2007

Standardized low altitude helicopter and/or foot surveys of the 8 index tributaries resulted in a peak index count of 893 large Chinook salmon. Using the long-term EF of 4.75, the index count was expanded to a spawning population estimate

Table 2.–Estimated average length (mm MEF) by age and sex of Chinook salmon sampled in the Chickamin River, 2006.

		Brood year and age class					
		2003	2002	2001	2001	2000	
		1.1	1.2	1.3	2.2	1.4	Total
Males[a]	Sample size	13	190	183	2	64	466
	Average length	416	670	801	643	905	749
	SD	37	55	69	32	68	119
	SE	10	4	5	23	8	6
Females[b]	Sample size		9	157		128	305
	Average length		739	830		890	853
	SD		30	44		45	57
	SE		10	4		4	3
Sexes combined[c]	Sample size	13	199	340	2	192	771
	Average length	416	673	814	643	895	790
	SD	37	56	61	32	54	112
	SE	10	4	3	23	4	4

[a] Sample size of total includes 14 fish of unknown age.

[b] Sample size of total includes 11 fish of unknown age.

[c] Sample size of total includes 25 fish of unknown age.

of 4,242 (SE = 625) large Chinook salmon ($\hat{N}_L$; Table 7). Expansion of $\hat{N}_L$ by the estimated size composition of the spawning population, as determined from ASL samples, resulted in an estimated escapement of 742 (SE = 129) small Chinook salmon (Table 8). The total estimated spawning population was estimated to be 4,984 (SE = 638) Chinook salmon. The Objective 3 precision criterion was exceeded in 2007.

2008

Standardized, low altitude helicopter and/or foot surveys of the 8 index tributaries resulted in a peak index count of 1,111 large Chinook salmon. Using the long-term EF of 4.75, the index count was expanded to a spawning population estimate of 5,277 (SE = 778) large Chinook salmon ($\hat{N}_L$; Table 7). Expansion of $\hat{N}_L$ by the estimated size composition of the spawning population, as determined from ASL samples, resulted in an estimated escapement of 1,433 (SE = 266) small Chinook salmon (Table 8). The total estimated spawning population was estimated to be 6,710 (SE = 822) Chinook salmon. The Objective 3 precision criterion was exceeded in 2008.

The Chickamin River Chinook stock exceeded the lower end of the biological escapement goal (BEG) range of 450 to 900 large Chinook salmon as counted in peak surveys for the tenth consecutive year in 2008 (Appendix A1; Figure 7).

Brood year escapement

Spawning abundance for the 2000 and 2001 broods was estimated to be 7,434 (SE = 586) and 8,538 (SE = 549), respectively (Table 9). Estimates of spawning abundance through 2008 from the 2002–2006 broods are listed in Table 9; however total estimates for these broods are pending complete cohort returns in 2009–2013.

JUVENILE CHINOOK SALMON TAGGING, OVERWINTER SURVIVAL, AND SMOLT ABUNDANCE

A total of 18,057 fingerlings and 7,425 smolt from the 2000 brood year (BY 2000) were released with valid CWTs (Tables 10 and 11). The proportion of tagged BY 2000 fingerlings that survived to smolt, overwinter survival or $\hat{S}_W$, was estimated to be 0.495 (SE = 0.101), resulting in an estimated total of 16,369 CWT smolt emigrating from the Chickamin River in 2002 (Table 11). The estimated abundance of BY 2000 fingerlings and smolt was 650,278 (SE = 149,527) and 322,087 (SE = 34,487), respectively (Table 11). We are 90% confident that smolt abundance was estimated to be within 18 percentage points of the

Table 3.–Age and sex composition of small (<660 mm MEF) and large (≥ 660 mm MEF) Chinook salmon in the Chickamin River determined using data gathered on the spawning grounds in 2007.

		Brood year and age class						
		2004	2003	2003	2002	2001	2000	
		1.1	1.2	0.3	1.3	1.4	1.5	Total
PANEL A: AGE COMPOSITION OF SMALL CHINOOK SALMON								
Males	Sample size	22	98		5			125
	p_{kcg} x100	17.5	77.8		4.0			99.2
	SE(p_{kcg})x100	3.4	3.7		1.7			0.8
	N_{kcg}	130	577		29			736
	SE(N_{kcg})	34	104		14			128
Females	Sample size		1					1
	p_{kcg} x100		0.8					0.8
	SE(p_{kcg})x100		0.8					0.8
	N_{kcg}		6					6
	SE(N_{kcg})		6					6
Sexes combined	Sample size	22	99		5			126
	p_{kc}x100	17.5	78.6		4.0			100.0
	SE(p_{kc})x100	3.4	3.7		1.7			
	N_{kc}	130	583		29			742
	SE(N_{kc})	34	105		14			129
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON								
Males	Sample size		59	1	280	48		388
	p_{kcg} x100		7.9	0.1	37.5	6.4		51.9
	SE(p_{kcg})x100		1.0	0.1	1.8	0.9		1.8
	N_{kcg}		335	6	1,590	273		2,203
	SE(N_{kcg})		64	6	246	55		334
Females	Sample size		3		259	91	6	359
	p_{kcg} x100		0.4		34.7	12.2	0.8	48.1
	SE(p_{kcg})x100		0.2		1.7	1.2	0.3	1.8
	N_{kcg}		17		1,471	517	34	2,039
	SE(N_{kcg})		10		229	91	15	310
Sexes combined	Sample size		62	1	539	139	6	747
	p_{kc}x100		8.3	0.1	72.2	18.6	0.8	100.0
	SE(p_{kc})x100		1.0	0.1	1.6	1.4	0.3	
	N_{kc}		352	6	3,061	789	34	4,242
	SE(N_{kc})		67	6	456	131	15	625
PANEL C: AGE COMPOSITION OF SMALL AND LARGE CHINOOK SALMON								
Males	Sample size	22	157	1	285	48		513
	p_{cg} x100	2.5	18.0	0.1	32.6	5.5		58.8
	SE(p_{cg})x100	0.7	2.2	0.1	1.8	0.8		2.1
	N_{kg}	130	912	6	1,619	273		2,940
	SE(N_{kg})	34	122	6	246	55		357
Females	Sample size		4		259	91	6	360
	p_{cg} x100		0.5		29.7	10.4	0.7	41.2
	SE(p_{cg})x100		0.2		1.8	1.1	0.3	2.1
	N_{kg}		23		1,471	517	34	2,045
	SE(N_{kg})		12		229	91	15	310
Sexes combined	Sample size	22	161	1	544	139	6	873
	p_k x100	2.6	18.8	0.1	62.0	15.8	0.7	100.0
	SE(p_k)x100	0.7	2.3	0.1	2.4	1.3	0.3	
	N_k	130	935	6	3,090	789	34	4,984
	SE(N_k)	34	125	6	456	131	15	638

Table 4.–Estimated average length (mm MEF) by age and sex of Chinook salmon sampled in the Chickamin River, 2007.

		Brood year and age class						
		2004	2003	2003	2002	2001	2000	
		1.1	0.3	1.2[a]	1.3[b]	1.4[c]	1.5	Total
Males[d]	Sample size	22	1	157	285	48		517
	Average length	426	780	639	806	896		747
	SD	28		54	71	69		127
	SE	6		4	4	10		6
Females[e]	Sample size			4	259	91	6	366
	Average length			688	822	880	895	837
	SD			72	44	49	54	55
	SE			36	3	5	22	3
Sexes combined[f]	Sample size	22	1	168	556	140	6	903
	Average length	426	780	640	814	886	895	784
	SD	28		54	817	57	54	112
	SE	6		4	35	5	22	4

[a] Sample size of sexes combined includes 7 fish of unknown gender.

[b] Sample size of sexes combined includes 12 fish of unknown gender.

[c] Sample size of sexes combined includes 1 fish of unknown gender.

[d] Sample size of total includes 4 fish of unknown age.

[e] Sample size of total includes 6 fish of unknown age.

[f] Sample size of total includes 20 fish of unknown age.

true value, exceeding Objective 2 precision criteria.

A total of 28,979 fingerlings and 7,748 smolt from BY 2001 were released with valid CWTs (Tables 10 and 11). Overwinter survival of BY 2001 fingerlings was estimated to be 0.388 (SE = 0.090), resulting in an estimated total of 18,995 CWT smolt emigrating from the Chickamin River in 2003 (Table 11). The estimated abundance of BY 2001 fingerlings and smolt was 682,554 (SE = 182,455) and 264,907 (SE = 34,676), respectively (Table 11). We are 90% confident that smolt abundance was estimated to be within 22 percentage points of the true value, exceeding Objective 2 precision criteria.

A total of 21,296 fingerlings and 11,039 smolt from BY 2002 were released with valid CWTs (Tables 10 and 11). Overwinter survival of BY 2002 fingerlings was estimated to be 0.364 (SE = 0.093), resulting in an estimated total of 18,796 CWT smolt emigrating from the Chickamin River in 2004 (Table 11). The estimated abundance of BY 2002 fingerlings and smolt was 1,157,726 (SE = 350,828) and 421,705 (SE = 68,614), respectively (Table 11). We are 90% confident that smolt abundance was estimated to be within 27 percentage points of the true value, exceeding Objective 2 precision criteria. BY 2002 estimates are preliminary pending returns of age-1.5 fish in 2009.

A total of 23,733 fingerlings and 10,368 smolt from BY 2003 were released with valid CWTs (Tables 10 and 11). Overwinter survival of BY 2003 fingerlings was estimated to be 0.349 (SE = 0.117), resulting in an estimated total of 18,662 CWT smolt emigrating from the Chickamin River in 2005 (Table 11). The estimated abundance of BY 2003 fingerlings and smolt was 844,542 (SE = 322,452) and 295,157 (SE = 53,948), respectively (Table 11). We are 90% confident that smolt abundance was estimated to be within 30 percentage points of the true value, exceeding Objective 2 precision criteria. BY 2003 estimates are preliminary pending returns of age-1.4 and age-1.5 fish in 2009 and 2010.

A total of 18,781 fingerlings and 7,979 smolt from BY 2004, and 20,230 fingerlings and 6,956 smolt from BY 2005 were released with valid CWTs (Tables 10 and 11). Preliminary estimates of overwinter survival and juvenile abundance, based on age-1.1 returns (BY 2005) and age-1.1 and age-1.2 returns (BY 2004) are presented in Table 11.

Table 5.–Age and sex composition of small (<660 mm MEF) and large (≥660 mm MEF) Chinook salmon in the Chickamin River determined using data gathered on the spawning grounds in 2008.

		Brood year and age class						
		2006	2005	2004	2003	2002	2001	
		1.0	1.1	1.2	1.3	1.4	1.5	Total
PANEL A: AGE COMPOSITION OF SMALL CHINOOK SALMON								
Males	Sample size	1	27	63	3			94
	p_{kcg} x100	1.0	28.1	65.6	3.1			97.9
	$SE(p_{kcg})$x100	1.0	4.6	4.8	1.8			1.5
	N_{kcg}	15	403	940	45			1,403
	$SE(N_{kcg})$	15	99	187	26			261
Females	Sample size				2			2
	p_{kcg} x100				2.1			2.1
	$SE(p_{kcg})$x100				1.5			1.5
	N_{kcg}				30			30
	$SE(N_{kcg})$				21			21
Sexes combined	Sample size	1	27	63	5			96
	p_{kc}x100	1.0	28.1	65.6	5.2			100.0
	$SE(p_{kc})$x100	1.0	4.6	4.8	2.3			
	N_{kc}	15	403	940	75			1,433
	$SE(N_{kc})$	15	99	187	35			266
PANEL B: AGE COMPOSITION OF LARGE CHINOOK SALMON								
Males	Sample size			32	130	31	1	194
	p_{kcg} x100			8.9	36.3	8.7	0.3	54.2
	$SE(p_{kcg})$x100			1.5	2.5	1.5	0.3	2.6
	N_{kcg}			472	1,916	457	15	2,860
	$SE(N_{kcg})$			105	312	103	15	443
Females	Sample size			2	109	53		164
	p_{kcg} x100			0.6	30.4	14.8		45.8
	$SE(p_{kcg})$x100			0.4	2.4	1.9		2.6
	N_{kcg}			29	1,607	781		2,418
	$SE(N_{kcg})$			21	269	151		382
Sexes combined	Sample size			34	239	84	1	358
	p_{kc}x100			9.5	66.8	23.5	0.3	100.0
	$SE(p_{kc})$x100			1.5	2.5	2.2	0.3	
	N_{kc}			501	3,523	1,238	15	5,277
	$SE(N_{kc})$			110	535	217	15	778
PANEL C: AGE COMPOSITION OF SMALL AND LARGE CHINOOK SALMON COMBINED								
Males	Sample size	1	27	95	133	31	1	288
	p_{cg} x100	0.2	6.0	21.0	29.2	6.8	0.2	63.5
	$SE(p_{cg})$x100	0.2	1.5	2.8	2.4	1.2	0.2	2.7
	N_{kg}	15	403	1,412	1,961	457	15	4,262
	$SE(N_{kg})$	15	99	215	313	103	15	514
Females	Sample size			2	111	53		166
	p_{cg} x100			0.4	24.0	11.6		36.0
	$SE(p_{cg})$x100			0.3	2.3	1.6		2.7
	N_{kg}			29	1,607	781		2,418
	$SE(N_{kg})$			21	270	151		382
Sexes combined	Sample size	1	27	97	244	84	1	454
	p_k x100	0.2	6.0	21.5	53.6	18.5	0.2	100.0
	$SE(p_k)$x100	0.2	1.5	2.7	3.2	2.0	0.2	
	N_k	15	403	1,441	3,598	1,238	15	6,710
	$SE(N_k)$	15	99	217	536	217	15	822

Table 6.–Estimated average length (mm MEF) by age and sex of Chinook salmon sampled in the Chickamin River, 2008.

		Brood year and age class						
		2006	2005	2004	2003	2002	2001	
		1.0	1.1	1.2	1.3	1.4	1.5	Total
Males[a]	Sample size	1	27	96	133	31	1	291
	Average length	275	445	635	788	899	1,000	715
	SD		40	57	70	62		142
	SE		8	6	6	11		8
Females[b]	Sample size			2	111	53		167
	Average length			678	807	870		824
	SD			11	55	38		61
	SE			8	5	5		5
Sexes combined[c]	Sample size	1	27	97	244	84	1	458
	Average length	275	445	635	797	880	1,000	755
	SD		40	55	64	50		130
	SE		8	6	4	5		6

[a] Total includes 4 fish with unknown age.

[b] Total includes 1 fish with unknown age.

[c] Total includes 5 fish with unknown age.

Table 7.–Peak survey counts from index survey streams from return years 2006–2008 with expanded population estimates for large Chinook salmon on the Chickamin River.

	Peak survey counts		
Year	2006	2007	2008
South Fork Creek	179	197	87
Barrier Creek	10	19	3
Butler Creek	325	133	68
Leduc Creek	52	15	5
Indian Creek	55	66	76
Humpy Creek	37	96	190
King Creek	620	315	622
Clear Falls Creek	52	52	60
Total peak count	1,330	893	1,111
$\hat{N}_L$ [a]	6,318	4,242	5,277
SE ($\hat{N}_L$)	931	625	778

[a] expansion factor of 4.75 (SE = 0.70) is used to calculate N_L (Weller et al. 2007).

Table 8.–Estimated total escapement of small (<660 mm MEF) and large (≥660 mm MEF) Chinook salmon based on proportion of spawning ground samples taken from 2006–2008.

	2006		2007		2008	
	Small	Large	Small	Large	Small	Large
Sample size	88	684	134	766	98	361
Proportion of large fish in the sample		0.89		0.85		0.79
Abundance estimate	813	6,318	742	4,242	1,433	5,277
SE	150	931	129	625	266	778
CV (%)	18.5	14.7	17.4	14.7	18.5	14.7
$\hat{N}$	7,131		4,984		6,710	
SE ($\hat{N}$)	943		638		822	

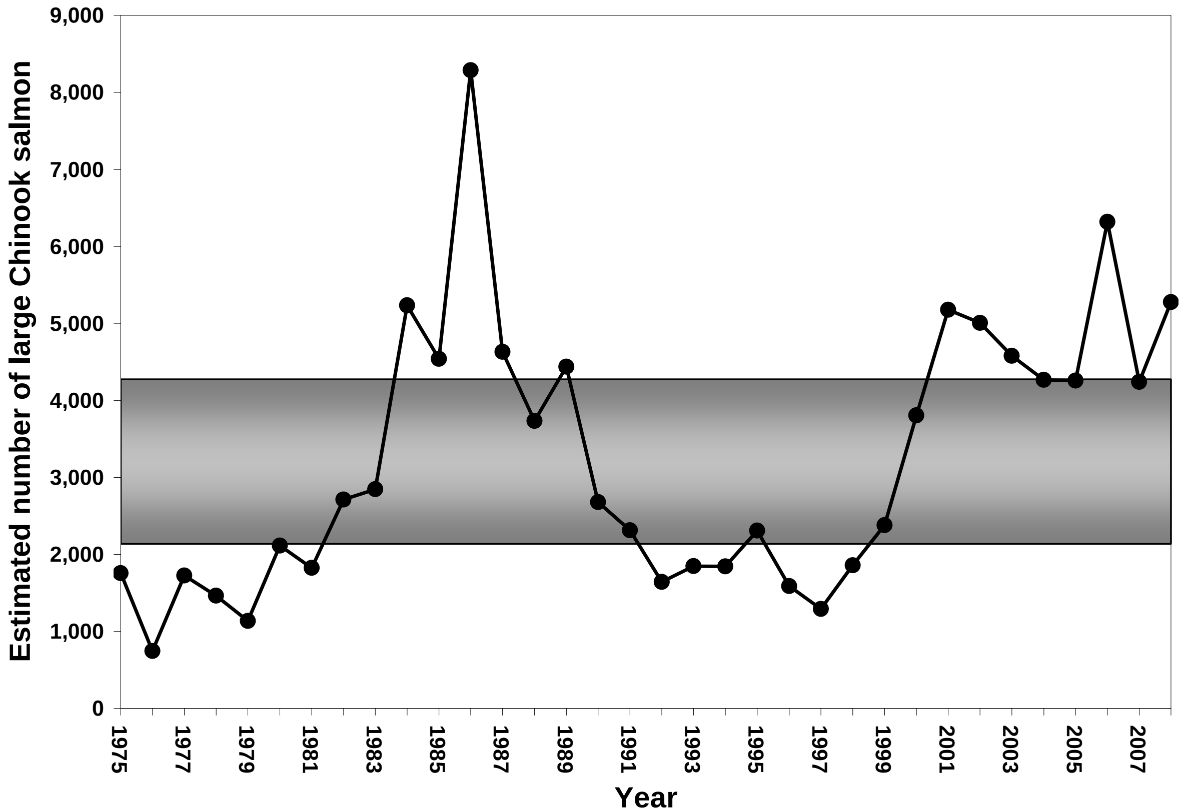

Figure 7.–Estimated escapement of large (≥ 660 mm MEF) Chinook salmon in the Chickamin River from 1975 to 2008. The biological escapement goal range was multiplied by the mean expansion factor to estimate the lower (2,138 large spawners) and upper (4,275 large spawners) bounds of the escapement goal in large fish (shaded area).

Table 9.–Estimated total spawning abundance of the 2000–2006 broods by return year, 2003–2008 (associated SE in gray font directly beneath each estimate).

	Return year						
Brood year	2003[a]	2004[b]	2005[c]	2006	2007	2008	Total
2000	222	2,077	3,253	1,848	34		7,434
	64	220	452	294	15		586
2001		186	1,020	3,264	789	15	8,538
		43	204	491	131	15	549
2002				1,897	3,090	1,238	6,225
				242	456	217	560
2003				123	941	3,598	5,603
				38	125	536	552
2004					130	1,441	1,571
					34	217	220
2005						403	403
						99	99
2006						15	15
						15	15

[a] Escapement data taken from Freeman and McPherson 2005.

[b] Escapement data taken from Pahlke 2005.

[c] Escapement data taken from Pahlke 2006.

Table 10.–Number of Chinook salmon fingerlings and smolt captured and tagged with coded wire tags in the Chickamin River, by tag code number, 2000–2005 brood years.

Year	Season	Brood year	Tag code	Life stage	Number tagged	Valid tagged
2001	Fall	2000	40450	Fingerling	11,109	11,085
2001	Fall	2000	40451	Fingerling	6,982	6,972
2002	Spring	2000	40521	Smolt	7,455	7,425
2002	Fall	2001	40545	Fingerling	11,301	11,138
2002	Fall	2001	40546	Fingerling	11,422	11,410
2002	Fall	2001	44618	Fingerling	6,431	6,431
2003	Spring	2001	40837	Smolt	7,793	7,748
2003	Fall	2002	40840	Fingerling	21,979	21,296
2004	Spring	2002	40965	Smolt	11,048	11,039
2004	Fall	2003	41021	Fingerling	21,308	21,288
2004	Fall	2003	40979	Fingerling	2,445	2,445
2005	Spring	2003	41137	Smolt	10,456	10,368
2005	Fall	2004	41140	Fingerling	11,529	11,521
2005	Fall	2004	41141	Fingerling	7,272	7,260
2006	Spring	2004	40983	Smolt	8,012	7,979
2006	Fall	2005	41294	Fingerling	10,685	10,479
2006	Fall	2005	41295	Fingerling	10,017	9,751
2007	Spring	2005	41289	Smolt	7,195	6,956

CWT MARKED FRACTIONS

The estimated fraction of BY 2000 and BY 2001 Chinook salmon bearing a valid CWT ($\hat{\theta}$) was 0.041 (SE = 0.0046) and 0.062 (SE = 0.0083; Table 12), respectively. Three BY 2000 CWTs were recovered from strays; 1 fish originated from the nearby Unuk River and 2 fish were released from the Neets Bay hatchery (Figures 1 and 4). One BY 2001 stray from Tamgas hatchery was recovered (Figure 4).

Pending the return of age-1.5 fish in 2009, the preliminary estimate of $\hat{\theta}$ for the 2002 brood is 0.039 (SE = 0.0064; Table 12). Preliminary estimates of $\hat{\theta}$ for the 2003–2005 broods, pending complete returns, are 0.053 (SE = 0.0109, BY 2003), 0.057 (SE = 0.0211, BY 2004), and 0.103 (SE = 0.0576, BY 2005; Table 12).

HARVEST

An estimated 3,085 (SE = 513) fish were harvested from BY 2000 returns (Table 13; Appendix A2). The half-width of the calculated 95% confidence interval is 33% of the harvest estimate, which is slightly outside the desired precision criteria for Objective 4. Harvest occurred primarily in the Northwest (42%) and Southeast (42%) quadrants of SEAK (Table 14; Figure 6). An estimated 5% of harvest occurred in Canadian waters. Troll gear accounted for 71% of the harvest and recreational, purse seine, and drift gillnet gear accounted for 20%, 6%, and 3% of the harvest, respectively (Table 15). Age-1.3 fish comprised approximately 56% of the harvest. Age-1.4 and age-1.2 fish accounted for 25% and 14% of the estimated harvest, respectively.

An estimated 2,267 (SE = 372) fish were harvested from BY 2001 returns (Table 13; Appendix A2). The half-width of the calculated 95% confidence interval is 32% of the harvest estimate, which is slightly outside the desired precision criteria for Objective 4. Harvest occurred primarily in the Southeast (47%) and Northwest (35%) quadrants of SEAK (Table 14; Figure 6). An estimated 5% of harvest occurred in Canadian waters. Troll gear accounted for 69% of the harvest and recreational, purse seine, and drift gillnet gear accounted for 25%, 5%, and 1% of the harvest, respectively (Table 15). Age-1.3 fish comprised approximately 48% of the harvest. Age-1.2 and age-1.4 fish accounted for 28% and 23% of the estimated harvest, respectively.

Brood year 2002 returns are incomplete, pending the return of age-1.5 fish in 2009. However, through 2008 an estimated 2,398 (SE = 414) fish have been harvested from BY 2002 returns (Table 13; Appendix A2). The half-width of the

Table 11.–Number of fingerlings and smolt tagged, number of tags recovered, estimated overwinter survival of tagged fingerlings $\hat{S}_W$, the estimated number of tagged fingerlings that survived to smolt $\hat{M}_{f \rightarrow s}$, the total estimated number of tagged smolt $\hat{M}_s$, and the estimated abundance and associated standard error of fall fingerlings $\hat{N}_f$ and spring smolt $\hat{N}_s$ 2000–2005 brood years. Note that estimates for the 2002–2005 brood years are preliminary, pending complete brood year returns.

Brood year	Year tagged	Season	Number tagged	Tags recovered	Recovery years	Recovery ages	$\hat{S}_W$	SE ($\hat{S}_W$)	$\hat{M}_{f \rightarrow s}$	SE ($\hat{M}_{f \rightarrow s}$)	$\hat{M}_s$	$\hat{N}_f$ / $\hat{N}_s$	SE ($\hat{N}_f$)/ SE($\hat{N}_s$)
2000	2001	Fall	18,057	53	2003–2007	1.1-1.5	0.495	0.101	8,944	1,820		650,278	149,527
2000	2002	Spring	7,425	44	2003–2007	1.1-1.5					16,369	322,087	34,487
2001	2002	Fall	28,979	45	2004–2008	1.1-1.5	0.388	0.090	11,247	2,621		682,554	182,455
2001	2003	Spring	7,748	31	2004–2008	1.1-1.5					18,995	264,907	34,676
2002	2003	Fall	21,296	26	2005–2008	1.1-1.4	0.364	0.093	7,757	1,983		1,157,726	350,828
2002	2004	Spring	11,039	37	2005–2008	1.1-1.4					18,796	421,705	68,614
2003	2004	Fall	23,733	16	2006–2008	1.1-1.3	0.349	0.117	8,294	2,780		844,542	322,452
2003	2005	Spring	10,368	20	2006–2008	1.1-1.3					18,662	295,157	53,948
2004	2005	Fall	18,781	8	2007–2008	1.1-1.2	0.486	0.251	9,119	4,718		541,451	330,036
2004	2006	Spring	7,979	7	2007–2008	1.1-1.2					17,098	262,894	84,714
2005	2006	Fall	20,230	4	2008	1.1	0.688	0.596	13,912	12,047		227,597	218,682
2005	2007	Spring	6,956	2	2008	1.1					20,868	156,517	65,157

Table 12.–Numbers of adult Chinook salmon examined for adipose finclips on the Chickamin River, sacrificed for CWT sampling purposes, valid CWTs decoded, percent of fish examined with adipose clips, and the estimated fraction of the fish sampled with germane CWTs, $\hat{\theta}$, 2000 brood year to present.

Brood year	Age class	Year examined	Number examined	Adipose finclips	Number sacrificed	Number of valid tags	Percent valid tags	Percent adipose clipped	Valid marked fraction $(\hat{\theta})$	Event[c]
2000	1.1	2003	18	0						1
2000	1.1	2003	30	1	1	1	100.0	3.3	.033	2
2000	1.2	2004	210	10	10[a]	9	90.0	4.8	.043	1
2000	1.2	2004	523	29	29[b]	24	82.8	5.5	.046	2
2000	1.3	2005	231	10				4.3		1
2000	1.3	2005	709	29	10	9	90.0	4.1	.037	2
2000	1.4	2006	193	11	6	6	100.0	5.7	.057	2
2000	1.5	2007	6	1	0	0		16.7		2
2000 Brood year total			1,920	91	56	49	87.5	4.7	.041	1&2
2001	1.1	2004	8	1	1	1	100.0	12.5	.125	1
2001	1.1	2004	55	2	2	2	100.0	3.6	.036	2
2001	1.2	2005	81	4	4	4	100.0	4.9	.049	1
2001	1.2	2005	213	11	10[a]	9	90.0	5.2	.046	2
2001	2.1	2005	2	0						2
2001	2.2	2006	2	0						2
2001	1.3	2006	339	27	4	3	75.0	8.0	.060	2
2001	2.2	2006	2	0		0				2
2001	1.4	2007	140	12	4	4	100.0	8.6	.086	2
2001	1.5	2008	1	0		0				2
2001 Brood year total			843	57	25	23	92.0	6.8	.062	1&2
2002	1.1	2005	16	1	1	1	100.0	6.3	.063	1
2002	1.1	2005	61	4	4[a]	3	75.0	6.6	.049	2
2002	1.2	2006	199	6	5	5	100.0	3.0	.030	2
2002	1.3	2007	561	22	10	10	100.0	3.9	.039	2
2002	1.4	2008	83	5	0	0		6.0		2
2002 Brood year total			920	38	20	19	95.0	4.1	.039	1&2
2003	1.1	2006	14	0						2
2003	1.2	2007	168	15	13	11	84.6	8.9	.076	2
2003	0.3	2007	1	0						2
2003	1.3	2008	243	11	2	2	100.0	4.5	.045	2
2003 Brood year total			426	26	15	13	86.7	6.1	.053	2

-continued-

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Brood year	Age class	Year examined	Number examined	Adipose finclips	Number sacrificed	Number of valid tags	Percent valid tags	Percent adipose clipped	Valid marked fraction $(\hat{\theta})$	Event[c]
2004	1.1	2007	24	2	2	2	100.0	8.3	.083	2
2004	1.2	2008	98	5	3	3	100.0	5.1	.051	2
2004 Brood year total			122	7	5	5	100.0	5.7	.057	2
2005	1.1	2008	29	3	3	3	100.0	10.3	.103	2
2005 Brood year total			29	3	3	3	100.0	10.3	.103	2
2006	0.1	2008	1	0						2
2006 Brood year total			1	0						2

[a] One sacrificed fish contained a valid CWT from a hatchery or other system and was not included with valid tags.

[b] Two sacrificed fish contained a valid CWT from a hatchery or other system and were not include with valid tags.

[c] Event 1 refers to the inriver marking portion of mark–recapture studies conducted through 2005. Event 2 refers to escapement grounds sampling.

calculated 95% confidence interval is 34% of the harvest estimate, which is slightly outside the desired precision criteria for Objective 4. Harvest occurred primarily in the Southeast (54%), Northwest (29%), and Northeast (15%) quadrants of SEAK (Table 14; Figure 6). An estimated 2% of harvest occurred in Canadian waters. Troll gear accounted for 67% of the harvest and recreational, purse seine, and drift gillnet gear accounted for 20%, 9%, and 4% of the harvest, respectively (Table 15). Age-1.3 fish comprised approximately 48% of the harvest. Age-1.2 and age-1.4 fish accounted for 39% and 11% of the estimated harvest, respectively.

Brood year 2003 returns are incomplete, pending the return of age-1.4 fish in 2009 and age-1.5 fish in 2010. However, through 2008 an estimated 1,121 (SE = 300) fish have been harvested from age-1.1 through age-1.3 BY 2003 returns (Table 13; Appendix A2). Harvest only occurred in the Southeast (67%), Northwest (26%), and Northeast (6%) quadrants of SEAK (Table 14; Figure 6) Troll gear accounted for 61% of the harvest, and recreational and drift gillnet gear accounted for 16% and 5% of the harvest, respectively (Table 15). PNP hatchery harvest in the Neets Bay terminal area, in which gear is not specified, accounted for the remaining 18% of estimated the harvest. Age-1.3 and age-1.2 fish comprised an estimated 71% and 29% of the estimated harvest, respectively.

An estimated 173 (SE = 92) age-1.2 fish and 31 (SE = 31) age-1.1 fish have been harvested from BY 2004 returns through 2008 (Table 13; Appendix A2). The majority of these fish were harvested in the Southeast Quadrant (62%; Table 14). Troll gear accounted for 72% of the harvests, followed by purse seine (15%) and drift gillnet gear (13%; Table 15).

An estimated 10 (SE = 9) age-1.1 fish from the 2005 brood year were harvested in the Southeast Quadrant by purse seine gear in 2008 (Tables 13–15; Appendix A2).

DISCUSSION

In 2006–2008 we were able to conduct aerial or foot surveys on all 8 index streams in the Chickamin River. Peak counts are reported in Appendix A2. The survey flights are also important for ASL sampling as they give us information on known concentrations of fish for sampling. This has saved time and money by allowing the Chickamin river crew to sample more effectively, limiting the amount of time and fuel used to scout for fish. Sampling of the 2006 and 2007 escapements for ASL and CWT information exceeded expectations. Sampling of the 2008 escapement was less than desired, primarily due to unusually persistent flooding that severely limited sampling opportunities and effectiveness throughout much of the peak period of spawning in August.

Overwinter survival of fingerlings has averaged approximately 0.4 for the 2000–2003 brood years, broods with substantive returns through 2008. Based on previous studies on the Chickamin and Unuk rivers, an average overwinter survival rate of 0.75 was used in operational planning and in determination of sampling goals. The lower than anticipated rate of overwinter survival is the primary reason for failing to attain our goal of a 0.1 juvenile marking fraction, as fingerling tagging goals were exceeded each fall. Additional factors included failure to attain the spring tagging goal in 4 of 6 years and slightly higher than anticipated smolt populations. Spring tagging was often hampered by low water and river ice that precluded access to some prime juvenile Chinook salmon habitat.

Estimates from previous studies of the harvest rate on Chickamin Chinook salmon returns, defined as marine harvest/ (spawning abundance + marine harvest) by brood year (not return year), ranged from 31% (BY 1982) to 50% (BY 1984; Pahlke 1995). However spawning abundance in these studies was estimated using an expansion factor of 4.0 rather than the more recently and rigorously derived EF of 4.75. Use of the revised EF lowers the harvest rate range to approximately 23% to 46%. For BYs 2000–2002, broods with complete (BY 2000 and BY 2001) or substantively complete returns (BY 2002), the rate of harvest was estimated to be 29% for BY 2000, 21% for BY 2001, and 28% for BY 2002.

Caution should be used in the interpretation of marine harvest estimates of jack Chinook salmon (<590 mm TL) from purse seine fisheries (Appendix A2). Jacks are often, probably most often, inadvertently sold as pink salmon.

Table 13.–Estimated harvest of Chinook salmon from the 2000–2005 Chickamin River brood year returns, with associated standard errors in gray font below estimates, 2003–2008.

Brood year	Return year 2003	2004	2005	2006	2007	2008	Total
2000	24	435	1,789	782	54		3,085
	24	177	397	267	54		513
2001		32	634	1,090	512		2,267
		32	227	234	176		372
2002			51	931	1,165	251	2,398
			35	258	287	146	414
2003					330	791	1,121
					156	256	300
2004					31	173	204
					31	92	97
2005						10	10
						9	9

Table 14.–Harvest by location (PANEL A) and proportion of harvest by location (PANEL B) of Chinook salmon from the 2000–2005 Chickamin River broods , through return year 2008.

PANEL A: HARVEST OF BROOD YEAR 2000–2005 RETURNS BY LOCATION

Brood year	Harvest location: British Columbia	Northeast Quadrant	Northwest Quadrant	Southeast Quadrant	Southwest Quadrant	Total
2000	155	165	1,287	1,285	192	3,085
2001	104	252	798	1,056	57	2,267
2002[a]	60	355	693	1,289		2,398
2003[b]		71	294	756		1,121
2004[c]			49	126	29	204
2005[d]				10		10
Total	319	844	3,122	4,522	278	9,085

PANEL B: PROPORTION OF BROOD YEAR 2000–2005 HARVEST BY LOCATION

Brood year	Harvest location: British Columbia	Northeast Quadrant	Northwest Quadrant	Southeast Quadrant	Southwest Quadrant	Total
2000	0.05	0.05	0.42	0.42	0.06	1.00
2001	0.05	0.11	0.35	0.47	0.03	1.00
2002[a]	0.02	0.15	0.29	0.54		1.00
2003[b]		0.06	0.26	0.67		1.00
2004[c]			0.24	0.62	0.14	1.00
2005[d]				1.00		1.00
Total	0.04	0.09	0.34	0.50	0.03	1.00

[a] Harvest includes age-1.1 through age-1.4 returns only; pending age-1.5 returns in 2009.

[b] Harvest includes age-1.1 through age-1.3 returns only; pending age-1.4 and -1.5 returns in 2009 and 2010.

[c] Harvest includes age-1.1 through age-1.2 returns only; pending age-1.3, -1.4, and -1.5 returns in 2009 through 2011.

[d] Harvest includes age-1.1 returns only; pending age-1.2, -1.3, -1.4, and -1.5 returns in 2009 through 2012.

Sampling pink salmon deliveries for jack CWTs is prohibitively expensive and logistically difficult. Individual fishers generally deliver their catch to tenders, who typically purchase fish harvested in diverse areas prior to delivery to a processor. Accurately sampling the catch from individual fishers prior to delivery to a tender is almost logistically impossible, and sampling of tender deliveries of fish harvested in diverse areas is of little use in harvest contribution estimation. Consequently, few samples from discreet harvest locations are attained, catch is likely underestimated, and contribution estimates are probably conservative.

Table 15.–Harvest by gear type (PANEL A) and proportion of harvest by gear type (PANEL B) of Chinook salmon from the 2000–2005 Chickamin River broods , through return year 2008.

PANEL A: HARVEST OF BROOD YEAR 2000–2005 RETURNS BY GEAR TYPE

	Gear type					
Brood year	Drift gillnet	Unknown	Recreational	Purse seine	Troll	Total
2000	89		605	196	2,195	3,085
2001	19		571	118	1,560	2,267
2002[a]	104		470	220	1,604	2,398
2003[b]	54	205[c]	181		681	1,121
2004[c]	27			31	146	204
2005[d]				10		10
Total	292	205	1,827	574	6,187	9,085

PANEL B: PROPORTION OF BROOD YEAR 2000–2005 HARVEST BY GEAR TYPE

	Gear type					
Brood year	Drift gillnet	Unknown	Recreational	Purse seine	Troll	Total
2000	0.03		0.20	0.06	0.71	1.00
2001	0.01		0.25	0.05	0.69	1.00
2002[a]	0.04		0.20	0.09	0.67	1.00
2003[b]	0.05	0.18[c]	0.16		0.61	1.00
2004[d]	0.13			0.15	0.72	1.00
2005[e]				1.00		1.00
Total	0.03	0.02	0.20	0.06	0.68	1.00

[a] Harvest includes age-1.1 through age-1.4 returns only; pending age-1.5 returns in 2009.

[b] Harvest includes age-1.1 through age-1.3 returns only; pending age-1.4 and -1.5 returns in 2009 and 2010.

[c] Harvest in Neets Bay hatchery cost recovery fishery from unspecified gear.

[d] Harvest includes age-1.1 through age-1.2 returns only; pending age-1.3, -1.4, and -1.5 returns in 2009 through 2011.

[e] Harvest includes age-1.1 returns only; pending age-1.2, -1.3, -1.4, and -1.5 returns in 2009 through 2012.

CONCLUSIONS AND RECOMMENDATIONS

Fewer than anticipated fish were sampled for CWTs on the spawning grounds in 2008. To ensure that the goal of sampling 410 fish per brood for the presence or absence of CWTs is attained, we recommend that the sampling goal be increased by 15–20% in 2009 and 2010.

This is the first in a series of annual FDS publications that will report results of the Chickamin River Chinook salmon CWT project and the spawning abundance and age, sex, and length composition project through 2012. We recommend that future publications include estimates of incidental harvest mortality (IM), using procedures established by the PSC. We further recommend that marine harvest and spawning abundance be reported in age equivalents. This will enable estimates of marine survival and exploitation rates to be reported according to standards adopted by the PSC.

PSC guidelines recommend sampling at least 20% of harvested Chinook salmon for CWTs, by fishery strata, from Chinook salmon fisheries coastwide (PSC CWT Workgroup 2008). Of fisheries that harvest Chinook salmon of Chickamin River origin, the Ketchikan recreational marine boat fishery has had the most difficulty in consistently attaining the 20% sampling threshold. The primary problem is the relatively large number of possible landing points in relation to the number of available catch samplers. We recommend increased funding and/or sampling design review for the Ketchikan creel census program in order to improve the project's ability to sample at the desired 20% rate.

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APPENDIX A

Appendix A1.–Estimated abundance of the spawning population of large (≥660 mm MEF) Chinook salmon in the Chickamin River, 1975–2008. Mean expansion factor is 4.75 (SE = 0.70).

		Abundance estimated from expanded count		Abundance estimated from m-r experiment		Preferred abundance estimate	
Year	Peak index count	$\hat{N}$	$SE(\hat{N})$	$\hat{N}$	$SE(\hat{N})$	$\hat{N}$	$SE(\hat{N})$
1975	370	1,758	259			1,758	259
1976	157	746	110			746	110
1977	363	1,724	254			1,724	254
1978	308	1,463	216			1,463	216
1979	239	1,135	167			1,135	167
1980	445	2,114	312			2,114	312
1981	384	1,824	269			1,824	269
1982	571	2,712	400			2,712	400
1983	599	2,845	419			2,845	419
1984	1,102	5,235	771			5,235	771
1985	956	4,541	669			4,541	669
1986	1,745	8,289	1,222			8,289	1,222
1987	975	4,631	683			4,631	683
1988	786	3,734	550			3,734	550
1989	934	4,437	654			4,437	654
1990	564	2,679	395			2,679	395
1991	487	2,313	341			2,313	341
1992	346	1,644	242			1,644	242
1993	389	1,848	272			1,848	272
1994	388	1,843	272			1,843	272
1995	356	1,691	249	2,309	723	2,309	723
1996	422	2,005	295	1,587	199	1,587	199
1997	272	1,292	190			1,292	190
1998	391	1,857	274			1,857	274
1999	501	2,380	351			2,380	351
2000	801	3,805	561			3,805	561
2001	1,010	4,798	707	5,177	972	5,177	972
2002	1,013	4,812	709	5,007	738	5,007	738
2003	964	4,579	675	4,579	592	4,579	592
2004	798	3,791	559	4,268	893	4,268	893
2005	926	4,399	648	4,257	591	4,257	591
2006	1,330	6,318	931			6,318	931
2007	893	4,242	625			4,242	625
2008	1,111	5,277	778			5,277	778

Appendix A2.–Estimated marine harvest by fishery strata of Chinook salmon, 2000–2005 brood years (Panels A–F), returning to the Chickamin River, 2003–2008. Notation explained in harvest contribution section of Methods.

PANEL A: BROOD YEAR 2000

Fishery strata (j)														
Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}]
Traditional purse seine (jack)[a]	2003	31	District 106	21		21	2	2	2	2	1	24	24	192%
Traditional troll	2004	3	NW Quadrant	138,726		33,927	2,002	1,965	1,502	1,496	1	101	100	195%
Traditional troll	2004	4	NW Quadrant	38,607		11,438	852	837	612	609	1	83	83	195%
Experimental area troll	2004	27	District 101-45	106		43	7	7	7	7	1	59	59	194%
Recreational DE	2004	11	Ketchikan	880		744	63	61	58	58	1	29	29	193%
Traditional drift gillnet	2004	25	District 106	195		73	4	4	4	4	1	64	64	194%
Traditional drift gillnet	2004	26	District 101	586		586	26	26	20	20	1	24	24	192%
Traditional troll	2004	3	SE Quadrant	11,727		3,924	256	252	201	201	1	73	73	195%
Traditional troll	2004[b]	5	SE Quadrant	1,413		594	38	38	35	35	1	57	57	194%
Traditional troll	2004[b]	5	NE Quadrant	1,513		956	81	81	69	69	1	38	38	193%
Recreational DE	2005	16	Juneau	274		274	59	59	57	56	1	25	24	192%
Traditional troll	2005	1	NE Quadrant	2,184		515	40	40	37	37	1	102	102	195%
Recreational MB	2005	12	Sitka	5,280	353,950	1,628	84	83	73	73	1	79	79	195%
Traditional troll	2005	1	NW Quadrant	28,349		5,803	615	608	345	345	1	119	119	195%
Traditional troll	2005	3	NW Quadrant	95,209		28,826	1,530	1,474	1,238	1,235	3	249	143	112%
Traditional troll	2005	4	NW Quadrant	49,218		13,591	874	847	655	650	1	91	90	195%
Experimental area troll	2005	22	District 105-41	213		49	2	2	2	2	1	105	104	195%
Experimental area troll	2005	23	District 101-29	750		535	29	27	25	25	1	36	36	193%
Experimental area troll	2005	24	District 101-29	952		730	47	47	41	41	1	31	31	193%
Experimental area troll	2005	25	District 102-50	388		388	32	32	25	25	1	24	24	192%
Experimental area troll	2005	26	District 102-50	894		717	58	58	50	50	3	90	51	111%
Experimental area troll	2005	27	District 101-29	801		455	31	30	27	27	1	44	43	194%

-continued-

PANEL A: BROOD YEAR 2000														
Fishery strata (j)														
Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}]
Recreational DE	2005	11	Ketchikan	1,134		898	52	51	49	48	1	32	31	193%
Recreational DE	2005	12	Ketchikan	693		619	50	44	43	43	1	31	30	193%
Recreational MB	2005	12	Ketchikan	1,471	135,408	242	18	18	17	17	1	147	146	195%
Recreational MB	2005	14	Ketchikan	1,944	188,206	343	27	27	25	25	1	137	136	195%
Traditional purse seine	2005	28	District 107	193		62	5	5	5	5	1	75	75	195%
Traditional troll	2005	1	SE Quadrant	3,933		1,167	62	60	43	42	1	86	85	195%
Recreational MB	2005	13	Craig	2,343		447	22	22	20	20	1	126	126	195%
Traditional troll	2005	3	SW Quadrant	23,066		8,841	369	354	282	282	1	66	65	194%
Traditional troll	2005	6	NW Quadrant	10,030		3,095	331	317	227	226	2	164	15	138%
Experimental area troll	2006	21	District 113-31	661		137	7	7	7	7	1	116	116	195%
Experimental area troll	2006	23	District 113-30	760		149	9	9	8	8	1	123	122	195%
Traditional troll	2006	1	NW Quadrant	24,432		7,311	600	597	364	363	2	162	114	138%
Experimental area troll	2006	25	District 101-29	1,570		622	40	40	37	37	1	61	60	194%
CDFO Sport TTWOW	2006	5									1	96	96	196%
Troll 004 CDFO	2006	27		8,316		3,467	123	122	109	108	1	59	58	194%
Experimental area troll	2007	24	District 101-29	1,165		516	20	20	13	13	1	54	54	194%
Brood year 2000 total												3,085	513	33%

-continued-

PANEL B: BROOD YEAR 2001

Fishery strata (j)														
Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}]
Traditional purse seine (jack)[a]	2004	32	District 107	2		1	1	1	1	1	1	32	32	193%
Traditional troll	2005	5	NE Quadrant	233		22	5	5	5	5	1	170	170	195%
Recreational MB	2005	12	Sitka	5,280	353,950	1,628	84	83	73	73	1	53	52	194%
Experimental area troll	2005	25	District 102-50	388		388	32	32	25	25	1	16	16	190%
Experimental area troll	2005	26	District 102-50	894		717	58	58	50	50	2	40	28	135%
Traditional drift net	2005	21	District 108	2,935		2,492	24	24	22	22	1	19	18	191%
Traditional troll	2005	3	SE Quadrant	10,208		2,707	149	141	104	104	2	128	90	138%
Traditional troll	2005	4	SE Quadrant	2,076		737	63	55	40	40	4	207	103	97%
Traditional troll	2005[b]	6	NE Quadrant	1,802		654	203	203	193	192	1	45	44	194%
Traditional troll	2005[b]	6	SE Quadrant	1,962		641	53	53	48	48	1	49	49	194%
Experimental area troll	2006	23	District 112-12	870		390	64	63	61	59	1	38	37	193%
Recreational MB	2006	12	Sitka	4,105	296,983	2,254	50	49	45	45	1	30	29	193%
Traditional troll	2006	1	NW Quadrant	24,432		7,311	600	597	364	363	2	108	76	137%
Traditional troll	2006	3	NW Quadrant	96,526		27,048	1,274	1,225	910	909	4	239	118	97%
Experimental area troll	2006	20	District 101-29	169		90	7	7	6	6	1	30	30	193%
Experimental area troll	2006	23	District 101-29	1,141		482	27	24	21	20	1	45	44	194%
Experimental area troll	2006	24	District 101-29	709		375	27	27	23	23	1	30	30	193%
Recreational DE	2006	11	Ketchikan	625		533	41	39	36	36	2	40	27	135%
Recreational MB	2006	12	Ketchikan	1,072	151,387	211	18	17	17	17	1	86	86	195%
Recreational MB	2006	14	Ketchikan	951	62,344	247	14	14	14	14	1	62	61	195%
Recreational MB	2006	12	Wrangell	119		106	9	9	9	9	1	18	18	190%
Traditional purse seine	2006	29	District 101	209		73	7	7	5	5	1	46	46	194%
Traditional troll	2006	1	SE Quadrant	4,891		2,476	142	141	117	117	1	32	31	193%
Traditional troll	2006	4	SE Quadrant	5,651		1,906	146	144	102	102	1	48	48	194%

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Fishery strata (j)														
Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}]
PANEL B: BROOD YEAR 2001														
Traditional purse seine	2006	29	District 104	901		367	6	6	4	4	1	39	39	194%
CDFO Sport 001	2006	5									1	64	64	196%
Troll 001 CDFO	2006	27		17,792		7,265	198	197	189	189	1	40	39	194%
Traditional troll	2006[b]	5	NW Quadrant	3,123		939	84	83	61	61	3	162	93	112%
Traditional troll	2006[b]	5	SE Quadrant	2,458		1,283	103	103	60	60	1	31	30	193%
Experimental area troll	2007	24	District 113-97	5		5	1	1	1	1	1	16	16	190%
Recreational DE	2007	11	Sitka	809		809	43	43	36	36	1	16	16	190%
Experimental area troll	2007	24	District 113-30	462		245	7	7	7	7	1	30	30	193%
Recreational MB	2007	13	Craig	398		366	11	11	11	11	1	17	17	190%
Recreational MB	2007	14	Ketchikan	1,077	37,853	182	5	5	5	5	1	95	95	195%
Traditional troll	2007	3	NW Quadrant	103,464		32,704	1,529	1,426	1,098	1,093	1	55	54	194%
Recreational MB	2007	11	Sitka	2,102	418,815	380	19	19	16	16	1	89	88	195%
Brood year 2001 total												2,267	372	32%
PANEL C: BROOD YEAR 2002														
Traditional purse seine (jack)[a]	2005	30	District 101	19		19	5	5	3	3	1	25	25	192%
Traditional purse seine (jack)[a]	2005	34	District 106	129		129	17	17	6	6	1	25	25	192%
Experimental area troll	2006	23	District 112-12	870		390	64	63	61	59	1	60	59	194%
Recreational DE	2006	16	Juneau	374		374	64	64	58	58	1	25	25	192%
Traditional troll	2006	4	NE Quadrant	4,273		1,402	320	319	292	292	1	78	77	195%
Recreational MB	2006	13	Sitka	4,658	226,907	1,683	72	71	62	62	1	72	71	195%
Recreational DE	2006	12	Ketchikan	337		295	18	18	18	18	2	58	409	136%
Recreational MB	2006	14	Ketchikan	951	62,344	247	14	14	14	14	1	98	98	195%
Traditional drift gillnet	2006	21	District 108	3,173		2,134	35	35	28	28	1	38	37	193%

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PANEL C: BROOD YEAR 2002														
Fishery strata (j)														
Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}]
Traditional drift gillnet	2006	26	District 108	519		328	20	20	19	19	1	40	40	194%
Traditional purse seine	2006	28	District 107	440		132	4	3	3	3	1	113	113	195%
Traditional purse seine	2006	30	District 101	234		107	15	15	9	9	1	56	55	194%
Traditional troll	2006	3	SE Quadrant	4,100		1,682	68	67	48	48	1	63	63	194%
Traditional troll	2006	4	SE Quadrant	5,651		1,906	146	144	102	102	3	230	132	112%
Traditional troll	2006[b]	5	SE Quadrant	2,458		1,283	103	103	60	60	1	49	48	194%
Experimental area troll	2007	25	District 114-50	213		83	7	7	7	7	1	65	65	194%
Recreational MB	2007	12	Gustavus	67		53	5	5	5	5	1	32	32	193%
Recreational MB	2007	11	Sitka	2,102	418,815	380	19	19	16	16	1	141	141	195%
Recreational DE	2007	12	Ketchikan	322		188	26	26	23	23	1	44	43	194%
Traditional troll	2007	1	NW Quadrant	29,540		9,788	620	615	408	407	1	78	77	195%
Experimental area troll	2007	23	District 112-12	1,099		536	103	103	98	98	1	52	52	194%
Traditional troll	2007	3	NE Quadrant	4,921		2,009	192	185	173	173	1	65	64	194%
Experimental area troll	2007	22	District 109-62	1,328		791	100	100	92	92	1	43	42	194%
Experimental area troll	2007	26	District 106-20	205		142	7	7	5	5	1	37	36	193%
Experimental area troll	2007	26	District 101-29	1,908		623	39	39	31	31	2	156	130	138%
Experimental area troll	2007	25	District 101-29	2,151		737	33	32	23	23	1	77	76	195%
Traditional troll	2007	3	SE Quadrant	7,357		3,459	185	180	127	127	1	56	55	194%
Traditional drift gillnet	2007	25	District 101	545		545	9	9	7	7	1	25	25	192%

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Appendix A2.–Page 6 of 7.

Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}]
PANEL C: BROOD YEAR 2002														
Fishery strata (j)														
Traditional troll	2007	3	NW Quadrant	103,464		32,704	1,529	1,426	1,098	1,093	1	87	86	195%
Traditional troll	2007	1	SE Quadrant	4,307		2,226	121	121	82	82	1	49	49	194%
Troll CDFO	2007	25		18,076		7,710	167	167	144	144	1	60	59	194%
Traditional troll	2007	1	SE Quadrant	4,307		2,226	121	121	82	82	1	49	49	194%
Experimental area troll	2008	21	District 113-41	632		174	10	10	7	7	2	185	130	138%
Experimental area troll	2008	22	District 113-62	485		188	14	14	11	11	1	66	65	195%
Brood year 2002 total												2,398	414	34%
PANEL D: BROOD YEAR 2003														
Traditional troll	2007	3	SE Quadrant	7,357		3,459	185	180	127	127	3	124	71	112%
Recreational MB	2007	13	Ketchikan	2,262	151,704	356	23	22	20	20	1	126	125	195%
Recreational MB	2007	15	Ketchikan	498	10,369	169	7	7	5	5	1	56	55	194%
Traditional drift gillnet	2007	26	District 101	366		279	8	8	8	8	1	25	24	192%
Traditional troll	2007[b]	5	NE Quadrant	1,380		733	133	133	123	123	1	36	35	193%
Traditional troll	2007[b]	5	SE Quadrant	1,356		661	47	46	36	36	4	159	78	97%
Traditional troll	2007[b]	5	NE Quadrant	1,380		733	133	133	123	123	1	36	35	193%
Experimental area troll	2008	26	District 113-01	387		371	30	30	25	25	1	20	19	191%
Traditional troll	2008	3	NW Quadrant	48,019		18,689	1,285	1,257	905	899	4	200	99	97%
Traditional drift gillnet	2008	27	District 106	318		209	19	19	15	15	1	29	28	193%
Experimental area troll	2008	20	District 113-95	75		74	5	4	4	4	1	24	23	192%
Traditional troll	2008	1	SE Quadrant	3,319		1,873	75	74	66	66	1	34	33	193%
Traditional troll	2008	3	NW Quadrant	48,019		18,689	1,285	1,257	905	899	1	50	49	194%
PNP cost recovery	2008	27	District 101-95	4,146		382	40	40	38	38	1	205	205	196%
Brood year 2003 total												1,121	300	52%

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Harvest type and gear	Year	Sampling period	Location	$\hat{N}_j$	var[$\hat{N}_j$]	n_j	a_j	a'_j	t_j	t'_j	m_{ij}	Z_{ij}	SE[Z_{ij}]	95%RP[Z_{ij}
PANEL E: BROOD YEAR 2004														
Fishery strata (j)														
Traditional purse seine (jack)[a]	2007	31	District 107	25		14	2	2	1	1		31	31	193%
Traditional troll	2008	3	SE Quadrant	1,160		298	25	25	20	20		68	67	195%
Traditional troll	2008	4	NW Quadrant	24,386		8,787	812	805	505	501		49	49	194%
Traditional drift gillnet	2008	26	District 101	506		326	20	20	18	18		27	27	192%
Traditional troll	2008	3	SW Quadrant	10,064		6,136	283	277	194	194		29	29	193%
Brood year 2004 total												204	97	93%
PANEL F: BROOD YEAR 2005														
Traditional purse seine (jack)[a]	2008	33	District 106	41		41	3	3	2	2		10	9	186%
Brood year 2005 total												10	9	186%

[a] Jack indicates Chinook salmon < 21 in TL. Purse seine harvest of these fish is tabulated separately; see Davidson et al. 2008b for details.

[b] Recovery occurred in latter portion of winter troll fishery (October-December). For contribution by return year purposes, contribution would be attributed to year of recovery +1.

Appendix A3.–Names of computer files containing data, statistics and interim calculations concerning stock assessment of the Chickamin River Chinook salmon stock, 2006–2008.

File name	Description
CHIX41T&F08.XLS	Tables1-15, Figure 7, Appendices A1-A3.
CHIX41ASL08.XLS	2008 ASL data, peak survey counts, and escapement estimation.
CHIX41ASL07.XLS	2007 ASL data, peak survey counts, and escapement estimation.
CHIX41ASL06.XLS	2006 ASL data, peak survey counts, and escapement estimation.
CHIX41THETA08.XLS	Theta estimation, marine harvest, overwinter survival, smolt abundance and tag codes.