Fishery Data Series No. 12-43

Production and Escapement of Chilkat River Coho Salmon, 2007–2008

by

Brian W. Elliott

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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 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)

Mathematics, statistics

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

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ABSTRACT

The purpose of this study was to conduct a full stock assessment of Chilkat River coho salmon *Oncorhynchus kisutch*. Coho salmon smolt were captured in the Chilkat River during spring 2007, marked with an adipose fin clip and a coded wire tag (CWT), and sampled for age, weight, and length. In 2008, adult coho salmon were sampled for CWTs in sport and commercial fishery harvests throughout Southeast Alaska and in the Chilkat River to estimate the marked fraction. The 2008 escapement to the Chilkat River was estimated by expanding peak survey counts.

An estimated 893,032 (SE = 95,380) coho salmon smolt emigrated from the Chilkat River in 2007. Most (86.7%, SE = 1.8%) of the smolt emigrating were age 1. In 2008, the total (nonjack) return of Chilkat River coho salmon was estimated at 110,349 (SE = 11,405), of which 52,989 (SE = 3,518) were harvested in marine fisheries, 991 (SE = 261) were harvested inriver, and 56,369 (SE = 10,846) escaped into the Chilkat River. Most (53.0%) of the harvest occurred in the District 115 drift gillnet fishery (28,623, SE = 2,632). The majority of the escapement was age 1.1 (2005 brood year, 75.9%, SE = 1.3%), and male (59.6%, SE = 0.9%). The marine survival (smolt-to-adult) and exploitation rates were estimated at 12.4% (SE = 1.8%) and 48.0% (SE = 5.0%), respectively.

Key words: abundance, escapement, coded wire tag, harvest, contribution, subsistence fishery, recreational fishery, troll fishery, drift gillnet fishery, seine fishery, age composition, size composition, sex composition, length-at-age, marine survival, exploitation rate, coho salmon, *Oncorhynchus kisutch*, Chilkat River, Haines, Southeast Alaska

INTRODUCTION

The purpose of this study was to conduct a full stock assessment of Chilkat River coho salmon *Oncorhynchus kisutch*. The long-term goal of this study is to gather information needed to manage harvests in accordance with sustained yield principles.

The Chilkat River produces annual adult returns of 100,000 to 300,000 coho salmon, making it one of the largest in Southeast Alaska. Research conducted during the 1980s on coho salmon stocks in Lynn Canal (including the Chilkat River) concluded that these stocks have, at times, been subjected to very high (over 85%) exploitation rates (Elliott and Kuntz 1988; Shaul et al. 1991).

The Chilkat River is a large glacial system that originates in British Columbia, Canada, flows through rugged dissected mountainous terrain, and terminates in Chilkat Inlet near Haines, Alaska (Figure 1). The mainstem and major tributaries comprise approximately 350 km of river channel in a watershed covering about 2,600 km² (Bugliosi 1988).

The economic impact of sport fishing in Southeast Alaska is considerable and constitutes a significant component of the overall economy for both Southeast Alaska and the Haines/Skagway management area, as indicated by recent studies. Overall in 2007, anglers spent $274 million in Southeast Alaska, including $175 million by nonresident anglers. Nonresident anglers fishing in Southeast Alaska spent an average of $403.94 per day on sport fishing activities (all types combined) in 2007, while residents spent an average of $102.54 per day of fishing (Southwick Associates Inc. et al. 2008). The freshwater coho salmon fishery in Haines provides a small but important component of the local economy and sport fishery in Southeast Alaska. In 1988, anglers fishing in Haines and Skagway for coho salmon spent an estimated $181,000 (Jones & Stokes 1991). This fishery operates late in the year when other fisheries have finished and is popular with local and nonlocal anglers. In 2007, 79.5% of anglers who fished in freshwater areas of Haines were nonresidents (Jennings et al. 2010a), and while they may spend less than the average for Southeast Alaska, their economic impact in Haines is significant.

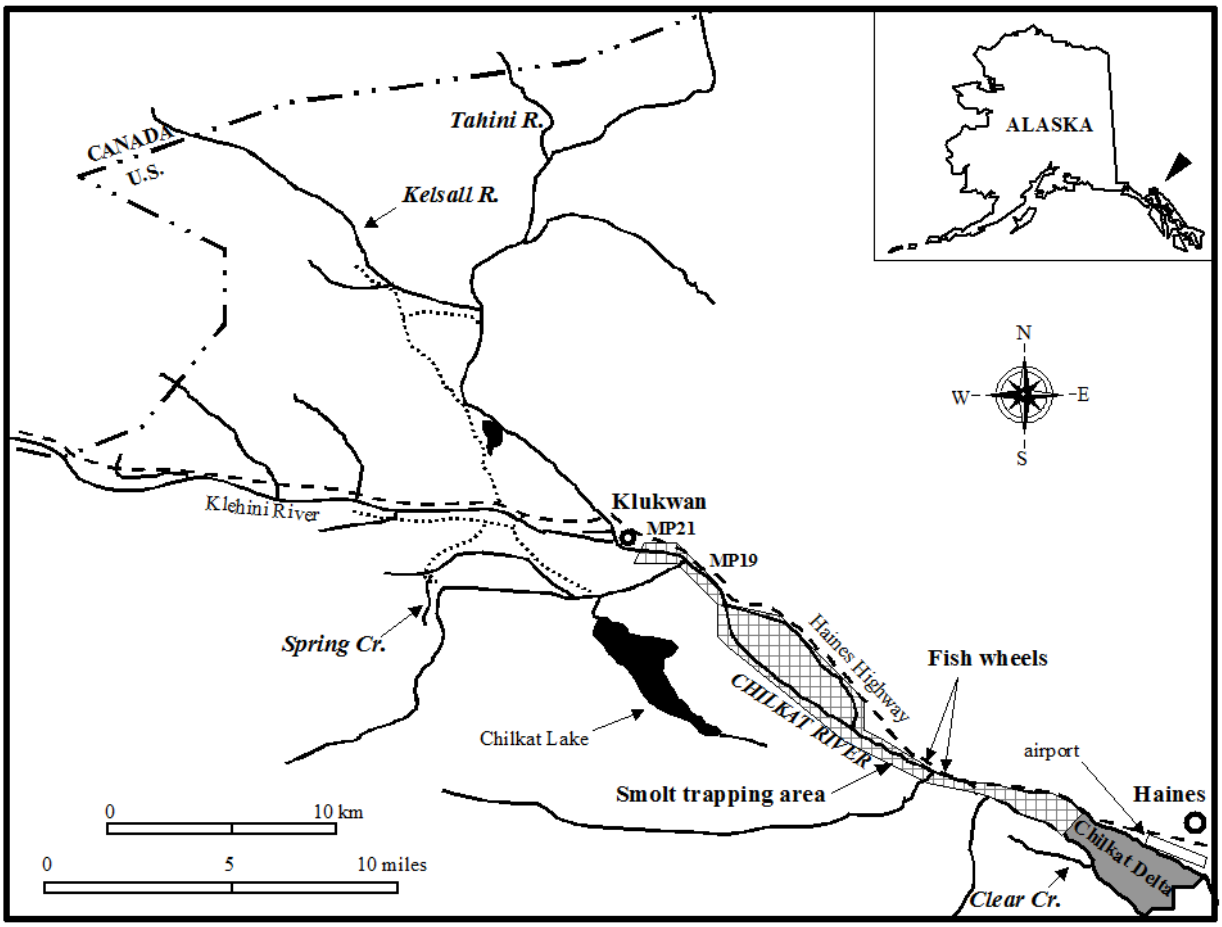

Figure 1.–The Chilkat River drainage, showing location of sampling sites.

The Chilkat River produces most of the coho salmon harvested in the Haines management area and supports one of the largest freshwater coho fisheries in Southeast Alaska; annual harvests have averaged 2,149 coho salmon from 2000 to 2007 (Howe et al. 2001; Jennings et al. 2004, 2006a-b, 2007, 2009a-b, 2010a-b, Walker et al. 2003). This stock also contributes a significant number (more than 60,000 per year) of fish to the commercial troll, gillnet, and seine fisheries in northern Southeast Alaska (Elliott and Kuntz 1988; Shaul 1991; Ericksen 2001-2003; Ericksen and Chapell 2005; Elliott 2009).

The current management program for Chilkat River coho salmon relies on monitoring of escapement on 4 index streams: Clear Creek, Spring Creek, Tahini River, and Kelsall River (Figure 1). Alaska Department of Fish and Game (ADF&G) personnel survey the index streams by foot or boat on a weekly basis in October during peak spawning, and count all observed coho salmon. The peak number counted for each stream was used as the index count for that year. Peak survey count estimation has been performed consistently since 1987.

The escapement of coho salmon to the Chilkat River drainage has also been estimated by mark-recapture experiments in 5 years (1990, 1998, 2002, 2003, and 2005), and ranged from 38,589 (SE = 4,625) in 2005 to 205,429 (SE = 31,165) in 2002 (Table 1; Ericksen 2006).

Table 1.–Peak survey counts and estimated escapement of coho salmon to the Chilkat River, 1987–2008. Escapement estimates in bold were estimated directly through mark-recapture studies (inriver abundance minus inriver harvest). All others were expanded from the combined peak surveys.

	Peak surveys					Estimated escapement		
	Spring Creek	Kelsall River	Tahini River	Clear Creek	Combined (C_t)	($\widehat{N}$)	SE ($\widehat{N}$)	Estimation method
1987	99	197	792	25	1,113	37,432	7,202	expanded survey
1988	87	160	590	40	877	29,495	5,675	expanded survey
1989	57	190	1,064	141	1,452	48,833	9,395	expanded survey
1990	88	379	2,766	150	3,383	**79,807**	**9,980**	**mark-recapture**
1991	176	417	1,785	135	2,513	84,517	16,260	expanded survey
1992	183	281	1,143	700	2,307	77,588	14,927	expanded survey
1993	101	129	1,041	460	1,731	58,217	11,200	expanded survey
1994	451	440	4,482	408	5,781	194,425	37,405	expanded survey
1995	268	197	1,033	189	1,687	56,737	10,916	expanded survey
1996	204	179	412	315	1,110	37,331	7,182	expanded survey
1997	227	133	684	250	1,294	43,519	8,373	expanded survey
1998	271	265	649	275	1,460	**50,758**	**10,698**	**mark-recapture**
1999	335	207	962	195	1,699	57,140	10,993	expanded survey
2000	305	571	1,324	435	2,635	88,620	17,050	expanded survey
2001	450	225	1,272	1,285	3,232	108,698	20,912	expanded survey
2002	1,328	440	2,582	1,310	5,660	**205,429**	**31,165**	**mark-recapture**
2003	500	356	1,419	1,675	3,950	**134,340**	**15,070**	**mark-recapture**
2004	564	170	827	445	2,006	67,465	12,980	expanded survey
2005	221	42	219	495	977	**38,589**	**4,625**	**mark-recapture**
2006	503	220	761	915	2,399	80,683	15,523	expanded survey
2007	55	51	415	237	758	25,493	4,905	expanded survey
2008	337	64	779	526	1,706	57,376	11,039	expanded survey
Mean	308	250	1,249	480	2,287	75,568	14,797	
					Expansion factor ($\bar{\pi}$)	33.6		
					SE(π_p)	6.5		

This was the eighth consecutive year in this study designed to monitor the cycle of smolt production and subsequent adult return of Chilkat River coho salmon. Between 1999 and 2005, 750,000–3,000,000 smolt emigrated from the Chilkat River and contributed 40,000–132,000 adults to commercial, sport, and subsistence fisheries (Ericksen 2001, 2003, 2006; Ericksen and Chapell 2005; Elliott 2009, 2010).

OBJECTIVES

Research objectives for this study were:

1. estimate the number of coho salmon smolt leaving the Chilkat River in 2007;
2. estimate the age composition of coho salmon smolt leaving the Chilkat River in 2007;
3. estimate the escapement of coho salmon to the Chilkat River in 2008;
4. estimate the age, sex, and length composition of adult (ocean age-1) coho salmon entering the Chilkat River in 2008; and
5. estimate the marine harvest of Chilkat River coho salmon in 2008.

METHODS

During the spring of 2007, coho salmon smolt were captured in main channels of the Chilkat River and marked with an adipose fin clip and a coded wire tag (CWT). In 2008, adult coho salmon were sampled for CWTs in sport and commercial fisheries harvests throughout Southeast Alaska and in the Chilkat River to estimate the adipose finclip mark fraction (θ_{smolt} or θ_s) used to estimate abundance of the 2007 coho smolt emigration. The fraction of adipose fin-clipped adult coho salmon sampled in the Chilkat River containing valid CWTs (θ_m) was used to estimate marine harvest of adult coho salmon in sampled fisheries in 2008.

SMOLT CAPTURE, SAMPLING, AND MARKING

Smolt were captured in the main channels of the Chilkat River from the Haines airport (Haines Highway milepost [MP] 4) upstream to approximately MP 21 during spring 2007; Figure 1). Two 2-person crews fished approximately 100 G-40 minnow traps per day between April 13 and May 31. Traps were baited with disinfected salmon roe and checked at least once per day. Crew members immediately released coho salmon obviously less than 75 mm FL and nontarget species at the capture site. Remaining fish were transported to holding pens for processing at the tagging site, located on the bank of the Chilkat River adjacent to MP 19. Water depth (cm) and temperature (°C) were recorded each morning near the tagging site. The weekly peak catch, as measured by coho smolt per minnow trap (CPUE), was determined.

Preceding tagging, coho salmon smolt were sorted into 3 size classes: small (75–84 mm FL), medium (85–99 mm FL), and large (≥100 mm FL). All healthy coho salmon smolt ≥75 mm FL were marked with an adipose fin clip and given a CWT following the methods in Koerner (1977). Fish were first tranquilized in a solution of tricain-methane sulfonate (MS 222) buffered with sodium bicarbonate.

Spring 2007 was the second year when Chilkat River juvenile coho salmon were differentially marked by size class. During April 14–May 31, small fish were marked with tag code 04-13-70. Medium and large fish were marked with tag code 04-13-71 from April 14–May 20, and tag code 04-13-72 from May 22–May 31. These two codes were combined to represent fish in the large (≥85mm) category. In an experimental analysis, statistical methods outlined in Weller et al. (2005) and discussed in Appendix B1, were used to test for size-based differences.

All marked coho salmon smolt were held overnight to check for 24-hour tag retention and handling-induced mortality. The following morning, 100 fish from the previous day's marking effort were checked for the retention of CWTs. If tag retention was 98/100 or greater, mortalities were counted and all live fish from that batch were released. If tag retention was less than 98/100, then every smolt presumed to contain a CWT was checked for tag retention and those that tested negative were re-tagged. The number of fish tagged, number of tagging-related mortalities, and number of fish that had shed their tags were compiled and submitted to the ADF&G Division of Commercial Fisheries (CF) Mark, Tag, and Age Laboratory in Juneau at the completion of the field season.

Every 60th coho salmon smolt tagged was measured to the nearest mm FL, weighed to the nearest gram, and 12 to 15 scales were collected for age analysis using methods outlined by Scarnecchia (1979). Scales were mounted individually between two 25 mm × 75 mm glass slides and viewed through a microfiche reader at 70× magnification. Age was estimated once for each fish and reported in European notation.

LOWER RIVER ADULT SAMPLING

Returning coho salmon were captured in fish wheels operating adjacent to MP 9 (Figure 1) during 2008. CF personnel installed two 3-basket aluminum fish wheels in early June to estimate escapement of coho, sockeye *O. nerka*, Chinook *O. tshawytscha*, and chum salmon *O. keta*, to the Chilkat River. One fish wheel was operated adjacent to MP 9, and the other about 300 m downstream of the first. The fish wheels were operated continuously from June 10 through October 10, except for maintenance. The wheels were located along the east bank of the river where the main flow was constrained primarily to one side of the floodplain. Water depth (cm) and temperature (°C) were recorded each morning near MP 8.

Every captured coho salmon was inspected for missing adipose fins and sampled for sex determination and length (measured to the nearest 5 mm MEF). Coho salmon ≥350mm MEF were assumed to be adults for preliminary estimates of the marked fraction (θ_s). Every third coho salmon was systematically sampled for scales. Five scales were removed from the left side of the fish, along a line 2 to 4 scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin. Ages were estimated according to methods in Mosher (1968).

Fish wheel personnel retained heads from all coho salmon with missing adipose fins, and a plastic cinch strap with a unique number was inserted through the jaw of the head. Heads and CWT recovery data were sent to the CF Mark, Tag, and Age Laboratory in Juneau where any tags present were removed and decoded; corresponding information was entered into the tag lab database.

SMOLT ABUNDANCE

A two-event mark-recapture experiment was used to estimate the abundance of coho salmon smolt ($\hat{N}_s$) emigrating from Chilkat River in 2007. The number of smolt marked during spring 2007 defined the first sampling event. Sampling returning adults for missing adipose fins during fall 2008 defined the second sampling event.

The number of emigrating coho salmon smolt was estimated using the Chapman's modified Petersen estimator for a closed population (Seber 1982):

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

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

where n_1 is the number of smolt marked in the spring of 2007, n_2 is the number of age-1.1 and -2.1 coho salmon captured in the Chilkat River fish wheels in 2008, and m_2 is the subset of n_2 that had been marked with an adipose fin clip as coho smolt in 2007. The marked fraction θ_s was calculated as m_2/n_2. The standard error of θ_s was calculated using standard methods for variance of proportions, because m_2 and n_2 were measured with certainty:

$$\mathrm{var}[\theta_s] = \frac{\theta_s(1-\theta_s)}{(n_2-1)}. \qquad (1c)$$

The validity of the Petersen mark-recapture experiment rests on several assumptions: (a) that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish; (b) that recruitment and "death" (emigration) do not occur disproportionately among marked and unmarked fish between sampling events; (c) that marking does not affect the ability to capture fish, or the probability of mortality; (d) that fish do not lose marks between sample events; (e) that all recovered marks are reported; and (f) that double sampling does not occur (Seber 1982).

Tagging smolt groups according to size allows for testing of assumption (a), which is violated by either different marking probabilities during event 1 or different capture probabilities in event 2. If significant differences in event 1 or 2 capture probability by size class are detected, an unbiased size-stratified smolt abundance estimator, based on Chapman's modification of the Peterson estimator (Appendix B1; Seber 1982; Weller et al. 2005) could be used.

ADULT HARVEST

In 2008, harvest of coho salmon originating from the Chilkat River was estimated by sampling for CWTs in commercial and recreational marine fisheries, and in the Chilkat River recreational fishery. To account for tag loss, the marked fraction relevant to the marine environment was calculated as θ_m = number of CWTs successfully decoded/n_2.The parameter θ_m is a subset of the ratio of adipose fin-clipped fish observed (θ_s), and variance was calculated similarly to equation (1c).

The CF port sampling program sampled landings from commercial drift gillnet, set gillnet, purse seine, and troll fisheries throughout Southeast Alaska and Yakutat. During summer and early fall, samplers were stationed at processors in Ketchikan, Craig, Wrangell, Petersburg, Sitka, Pelican, Port Alexander, Elfin Cove, Excursion Inlet, and Juneau. The sample goal was to inspect at least 20% of the total catch of Chinook and coho salmon for missing adipose fins. Heads from fish missing their adipose fin were sent to the CF Mark, Tag, and Age Laboratory in Juneau on a weekly basis where CWTs were removed and decoded, and the resulting information was compiled. The annual CF port sampling manual (*Coded Wire Tag Sampling Program Detailed Sampling Instructions, commercial fisheries sampling*, located at Alaska Department of Fish and Game, Division of Commercial Fisheries, 802 3rd Street, Douglas, Alaska) provides a detailed explanation of commercial catch sampling procedures and logistics.

Methods used by ADF&G Division of Sport Fish (SF) creel surveys to sample recreational fisheries in Southeast Alaska are described in Hubartt et al. (1997). Chilkat River coho salmon CWTs recovered from sport fisheries in 2008 depend on creel survey sampling data for harvest estimation.

Because there was no consistent sampling in the Haines area, the estimated harvests of Chilkat River coho salmon in the Haines marine and Chilkat River sport fisheries came from the Statewide Harvest Survey (SWHS) produced by SF. SWHS estimates in all streams and tributaries within the Chilkat River drainage were summed to estimate the total inriver coho salmon harvest. Haines area marine sport fishery estimates were restricted to SWHS locations near the terminus of the Chilkat River, and all coho salmon harvested within these locations were assumed to be of Chilkat River origin.

Because several fisheries exploit coho salmon over several months, the 2008 harvest was estimated over several strata, each a combination of time, area, and type of fishery. Sampling

data from the commercial troll fishery were stratified by fishing period and quadrant. Statistics from drift gillnet fisheries were stratified by week and district.

Data from the port sampling program were used to estimate the commercial harvest of coho salmon bound for the Chilkat River $\hat{r}_i$ and its variance (by stratum) using the procedures in Bernard and Clark (1996). Estimates of harvest were summed across strata and across fisheries to obtain an estimate of the total $\hat{T}$:

$$\hat{T} = \sum_i \hat{r}_i \qquad (2a)$$

$$\mathrm{v}[\hat{T}] = \sum_i \mathrm{v}[\hat{r}_i] \qquad (2b)$$

Variance was estimated as the sum of variances across strata because sampling was independent across strata and fisheries.

The mean date of harvest for a commercial fishery was estimated as (Mundy 1982):

$$\hat{\bar{d}} = \sum_{d=1}^{n} d\hat{P}_d \qquad (3)$$

where $\hat{P}_d$ is the estimated proportion of harvest on day *d*, and its variance was estimated:

$$\hat{P}_d = \frac{\hat{H}_d}{\sum_d \hat{H}_d} \qquad (4)$$

$$v\left(\hat{P}_d\right) = \frac{\hat{P}_d(1-\hat{P}_d)}{n-1}$$

where $\hat{H}_d$ is the estimated number of Chilkat River coho salmon harvested on day *d*, and *n* is number of days sampled.

ADULT ESCAPEMENT

The 2008 coho salmon escapement to the Chilkat River was estimated by expanding the combined peak survey counts on 4 index spawning tributaries. The surveys were repeated weekly during the peak spawning period of October 1 to October 31. Five mark-recapture studies were compared to corresponding index counts to calculate a mean expansion factor (33.6 SE=6.5), and validated that the peak survey counts are a good relative measure of coho escapement to the Chilkat River with the former surveyor (Ericksen 2006). While the current surveyor has not had a mark-recapture experiment to validate the accuracy of spawning grounds peak counts, methods are identical to the previous surveyor and it is assumed that counts are similar.

Expansion for Peak Survey Counts

The ratio ($\hat{\pi}_i$) of abundance to peak survey counts for spawning Chilkat coho salmon in year *i* was:

$$\hat{\pi}_i = \hat{N}_i / C_i \qquad (5a)$$

$$\mathrm{v}(\hat{\pi}_i) = \mathrm{v}(\hat{N}_i) / C_i^2 \qquad (5b)$$

where $\hat{N}_i$ was the mark-recapture escapement estimate of coho salmon (inriver abundance minus inriver harvest) and C_i was the total of peak survey counts for that year.

The mean ratio $(\overline{\pi})$ from the 5 years with mark-recapture estimates was used to expand peak survey counts in years *t* without such estimates:

$$\hat{N}_t = \overline{\pi}\ C_t \qquad (6a)$$

$$\mathrm{v}(\hat{N}_t) = C_t^2\ \mathrm{v}(\pi_p) \qquad (6b)$$

where

$$\overline{\pi} = \frac{\sum_{y=1}^{k} \hat{\pi}_y}{k} \qquad (7a)$$

Note that the variance of year *t*, $v(\pi_p)$, instead of average mark-recapture variance, $v(\overline{\pi})$, was used in equation 6b to capture the expected year-to-year variability in the expansion factor, while simultaneously accounting for measurement error from the mark-recapture experiments.

Estimating variance of the expansion of index counts also needs to reflect these 2 sources of variability for the prediction of π, represented by (π_p).The variance expression has 2 components, which reflect an estimate of process error and measurement error:

$$\hat{var}(\pi_p) = \hat{var}(\pi) + \hat{var}(\overline{\pi}) \qquad (7b)$$

The term $\hat{\mathrm{var}}(\pi)$ represents process error, i.e., error that is present through environmental variability or the population dynamics process. The term $\hat{\mathrm{var}}(\overline{\pi})$ represents the inter-annual uncertainty in predicting $\hat{\pi}$, or measurement error, which declines with every subsequent mark-recapture estimate of $\hat{\pi}$.

Expanding these two terms into variance terms that can be estimated yields the expressions:

$$\hat{var}(\hat{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \overline{\pi})^2}{k-1} \qquad (7c)$$

and,

$$\hat{var}(\overline{\pi}) = \frac{\sum_{y=1}^{k} (\hat{\pi}_y - \overline{\pi})^2}{k(k-1)} \qquad (7d)$$

Estimates of $var(\hat{\pi})$ and $var(\overline{\pi})$ were performed through a parametric bootstrap technique with 1,000,000 iterations as described in Efron and Tibshirani (1993). A bootstrap sample of size *k* is drawn from the *k* values of the individual estimates of $\hat{\pi}_y$ to produce a set of values represented by $\hat{\pi}_{y(b)}$. The bootstrap mean, $\overline{\pi}_{(b)}$, of these values is used to estimate $var(\hat{\pi})$ using these relationships:

$$\hat{var}_B(\hat{\pi}) = \frac{\sum_{b=1}^{B} (\hat{\pi}_{(b)} - \overline{\hat{\pi}_{(b)}})^2}{B-1} \qquad (7e)$$

where

$$\overline{\hat{\pi}_{(b)}} = \frac{\sum_{b=1}^{B} \hat{\pi}_{(b)}}{B} \qquad (7f)$$

Calculating $var_B(\overline{\pi})$ uses equations 7e and 7f by substituting appropriate terms. The overall variance of expansion factor prediction combined the bootstrap estimates, with the average of estimated variance of the individual expansion terms $\hat{\pi}_y$, to yield the result:

$$\hat{var}(\pi_p) = \hat{var}_B(\hat{\pi}) - \frac{\sum_{y=1}^{k} \hat{\text{var}}(\hat{\pi}_y)}{k} + \hat{var}_B(\overline{\pi}) \qquad (7g)$$

AGE, SEX, AND SIZE COMPOSITIONS

Age composition of coho salmon smolt in 2007 and age and sex compositions of adults in 2008 were estimated from systematically drawn samples as described above. Standard sample summary statistics were used to calculate estimates of mean length and mean weight-at-age and their variances (Cochran 1977). Proportions in the age (or sex) compositions and their variances were estimated as:

$$\hat{p}_a = \frac{n_a}{n} \qquad (8a)$$

$$\text{v}[\hat{p}_a] = \frac{\hat{p}_a\ (1 - \hat{p}_a)}{n - 1} \qquad (8b)$$

where n is the number of successfully aged (or sexed) fish and n_a is the subset of n determined to be age (or sex) a.

The abundance of sex x coho salmon in the escapement was estimated as:

$$\hat{N}_x = \hat{N}_e\ \hat{p}_x \qquad (9a)$$

$$\text{v}[\hat{N}_x] = \text{v}[\hat{p}_x]\hat{N}_e^{\,2} + \text{v}[\hat{N}_e]\hat{p}_x^{\,2} - \text{v}[\hat{p}_x]\text{v}[\hat{N}_e] \qquad (9b)$$

where $\hat{N}_e$ is the estimated escapement of coho salmon in 2008. The abundance of age a coho salmon by sex in the escapement $\hat{N}_{x,a}$ was estimated by substituting $\hat{N}_x$ and $\hat{p}_{x,a}$ for $\hat{N}_e$ and $\hat{p}_x$ in equations 9a and 9b.

RETURN, EXPLOITATION RATE, AND MARINE SURVIVAL

In 2008, the Chilkat River coho salmon return (harvest plus escapement) was estimated as:

$$\hat{N}_R = \hat{T} + \hat{N}_e \qquad (10a)$$

$$\text{v}\left[\hat{N}_R\right] = \text{v}\left[\hat{T}\right] + \text{v}\left[\hat{N}_e\right] \qquad (10b)$$

The fraction of the return harvested (the exploitation rate) was calculated as:

$$\hat{E} = \frac{\hat{T}}{\hat{N}_R} \qquad (11a)$$

$$\mathrm{v}[\hat{E}] \approx \frac{\mathrm{v}[\hat{T}]\hat{N}_e^2}{\hat{N}_R^4} + \frac{\mathrm{v}[\hat{N}_e]\hat{T}^2}{\hat{N}_R^4} \qquad (11b)$$

where the variance is an approximation from the delta method (Seber 1982).

The estimated marine survival rate (smolt-to-adult) and the delta method approximation of its variance were calculated as:

$$\hat{S} = \frac{\hat{N}_R}{\hat{N}_s} \qquad (12a)$$

$$\mathrm{v}[\hat{S}] \approx \hat{S}^2 \left[\frac{\mathrm{v}[\hat{N}_R]}{\hat{N}_R^2} + \frac{\mathrm{v}[\hat{N}_s]}{\hat{N}_s^2} \right] \qquad (12b)$$

RESULTS

2007 SMOLT TAGGING, AGE AND SIZE

In spring 2007, 24,214 coho salmon smolt ≥75 mm FL were marked with an adipose fin clip and a CWT (Table 2). Ninety-nine (99) of these died and 11 lost their tags within 24 hours of tagging, leaving a total marked population of 24,104. In a concurrent study, 2,238 Chinook salmon were released with adipose fin clips and CWTs (Table 3).

Spring 2007 was relatively clear and cold and the Chilkat River rose slowly, resulting in productive trapping and an above-average CPUE (5.5, Table 3). Catch rates varied during April depending on available habitats; the daily catch of coho salmon peaked on May 12 (Figure 2). The average weekly CPUE peaked May 4-10, when coho salmon smolt per minnow trap was 6.0 fish (Table 3).

During spring 2007, 409 coho salmon smolt ≥75 mm were sampled from the Chilkat River for age, weight, and length (Table 4). Of the 406 scale samples successfully aged, age-1. fish dominated the Chilkat River smolt emigration (86.7%, SE = 1.7%). Overall, coho salmon smolt weighed 7.1 g (SE = 2.8 g) and averaged 88.1 mm FL (SE = 10.8 mm; Table 4).

Table 2.–Summary of coded wire tagging data in the Chilkat River drainage during spring 2007. CWT = coded wire tag.

Tag code	Species	Last date	Tagged	24h mortalities	Marked	Shed tags	Valid CWTs
04-13-70	coho	5/31/2007	10,768	43	10,725	11	10,714
04-13-71	coho	5/20/2007	10,237	14	10,223	0	10,223
04-13-72	coho	5/31/2007	3,209	42	3,167	0	3,167
Total			24,214	99	24,115	11	24,104

Table 3.–Number of traps checked and smolt caught, tagged, and released in the Chilkat River by time period, April 13 through May 31, 2007.

Dates	Traps checked	Chilkat River number tagged		CPUE[a]	
		Coho	Chinook	Coho	Chinook
4/13 - 4/19	452	2,676	262	5.9	0.6
4/20 - 4/26	595	3,405	328	5.7	0.6
4/27 - 5/3	610	3,086	199	5.1	0.3
5/4 - 5/10	603	3,636	486	6.0	0.8
5/11 - 5/17	719	4,119	603	5.7	0.8
5/18 - 5/24	715	3,896	256	5.4	0.4
5/25 - 5/31	706	3,286	104	4.7	0.1
Total	4,400	24,104	2,238	5.5	0.5

[a] Catch of smolt per trap day.

Table 4.–Estimated age and size composition of coho salmon smolt ≥75 mm FL marked in the Chilkat River, 2007.

		Age-1	Age-2	Total aged	Total sampled
Chilkat River	sample size	352	54	406	409
	percent (SE)	86.7 (1.7)	13.3 (1.7)		
	mean length (SE)	85.4 (8.5)	105.3 (8.1)		88.1 (10.8)
	mean weight (SE)	6.4 (2.1)	11.5 (2.9)		7.1 (2.8)

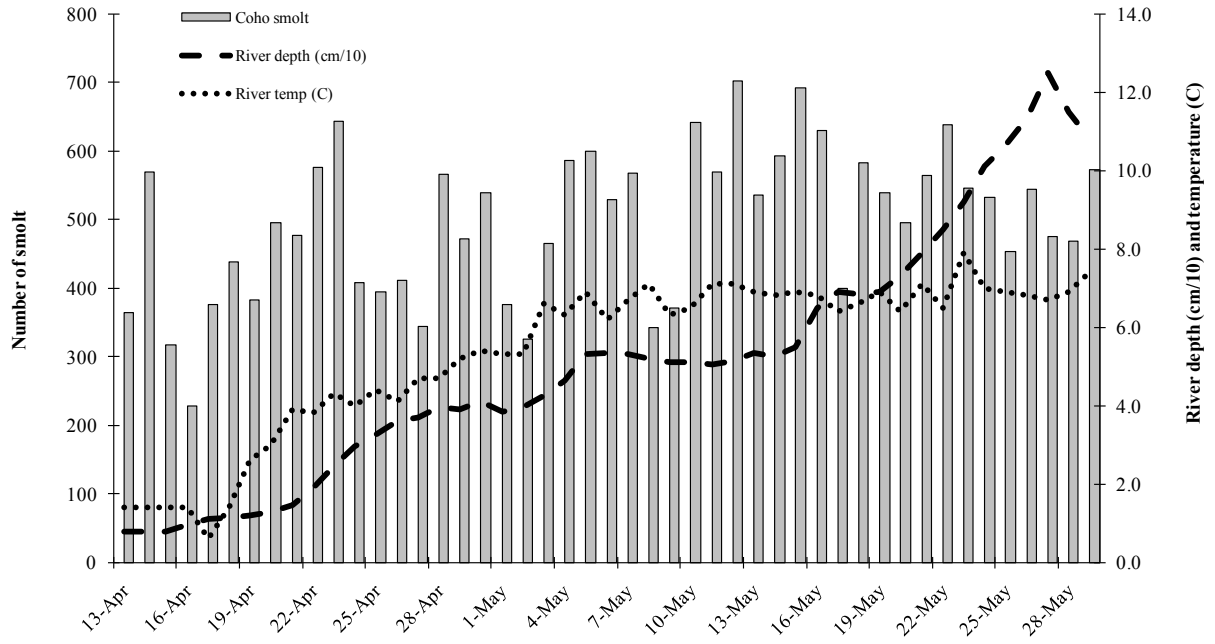

Figure 2.–Catches of coho salmon smolt ≥75 mm, daily water temperature (°C), and depth (cm/10), in the Chilkat River, April 13 through May 31, 2007.

2008 LOWER RIVER ADULT SAMPLING

From July 31 through October 10 2008, a total of 3,202 adult coho salmon were captured in the fish wheels (Figure 3), of which 3,167 were examined for missing adipose fins; 3,099 were 350 mm FL or greater, and were assumed to be ocean-age-1 fish. Eighty-five (85) fish were missing an adipose fin, and their heads were examined for CWTs (Table 5). Seventy-nine (79) heads contained decodable tags that were released in the Chilkat River in 2007. Four fish missing adipose fins did not contain tags; 1 tag was released in the Chilkat River in 2006, and 1 tag was a Berners River code released in 2007.

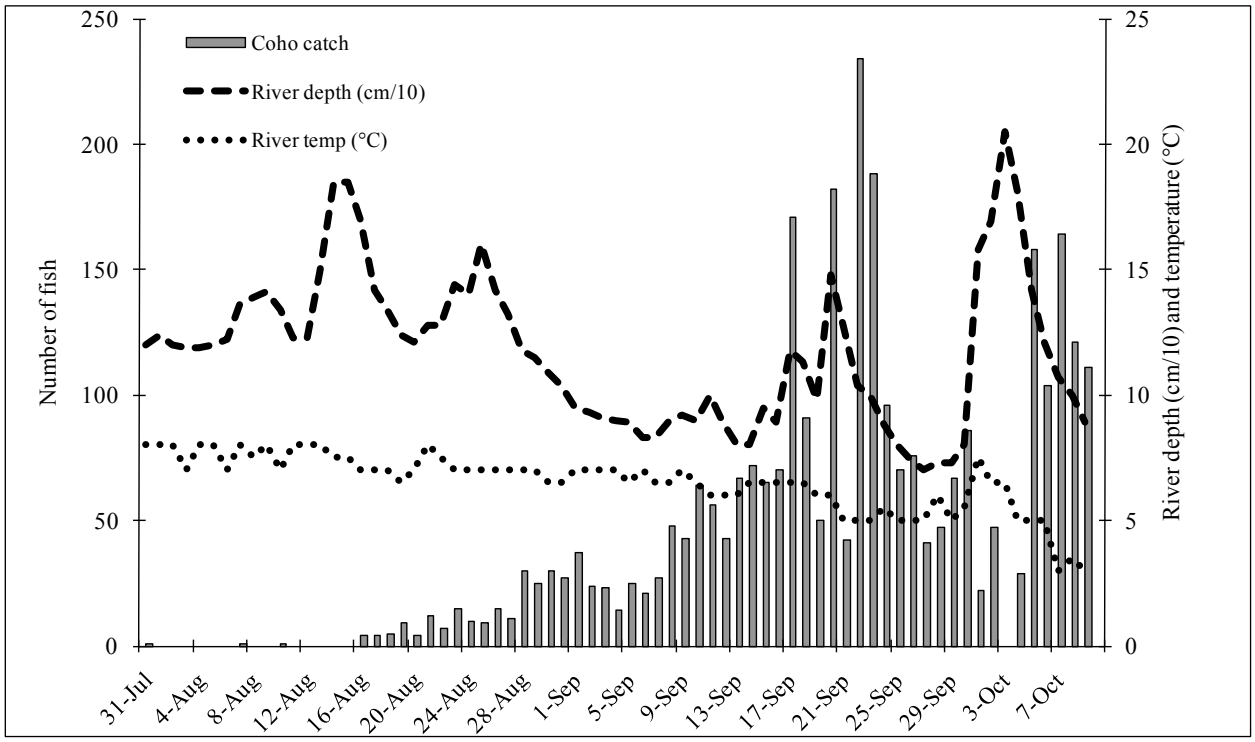

Figure 3.–Fish wheel catch of adult coho salmon, daily water depth (cm/10), and temperature (°C) in the lower Chilkat River, July 31 through October 10, 2008.

Table 5.–Number of age-.1 adult coho salmon sampled in the lower Chilkat River for missing adipose fins and coded wire tags, 2008.

		Tag code						
Statistical week	Number sampled	04-13-70	04-13-71	04-13-72	No tag	other	Adipose fin clips	Proportion marked
31	1						0	0.000
32	1						0	0.000
33	5						0	0.000
34	55			1			1	0.018
35	128	1					1	0.008
36	168	1					1	0.006
37	342	5	1	2			8	0.023
38	689	4	7	2			13	0.019
39	734	12	11	2	3	1[a]	28	0.038
40	293	5	3	2			10	0.034
41	697	9	10	1	1	1[b]	23	0.033
Total	3,111	37	32	10	4	2	85	0.027

[a] Tag code 04-10-49 released in the Berners River in 2007.
[b] Tag code 04-08-30 released in the Chilkat River in 2006.

Scale samples were collected from 1,302 coho salmon and 1,139 were successfully aged. Of these, 98.2% were age-1.1 or -2.1 (ocean age-1; Table 6). Applying the ocean age-1 proportion to all sampled fish, an estimated 3,111 adults sampled for missing adipose fins in 2008 emigrated as smolt during 2007.

SMOLT ABUNDANCE

Using Chapman's modified Petersen estimator for a closed population (Seber 1982), the 2007 Chilkat River coho salmon smolt abundance estimate was 893,032 (SE = 95,380). This estimate is based on n_1 = 24,104 smolt released in spring 2007, n_2 = 3,111 ocean-age-1 adults sampled from the fish wheels in 2008, and a total of m_2 = 83 valid-marked fish recovered inriver (79 with 2007 Chilkat River tag codes and 4 missing or invalid tags). The estimated marked fraction θ_s relevant to calculating smolt abundance was 0.027 (SE = 0.0029).

Table 6.–Combined first and second half stratified estimates for the sampled age/sex composition and length of coho salmon captured in the fish wheels, and estimated escapement in the Chilkat River, 2008.

	Brood year and age class					
	2006 1.0	2005 2.0	2005 1.1	2004 2.1	Total aged	Total sampled[a]
Females						
Sample size			341	106	447	1,286
Percent			29.9	9.3		40.1
SE			1.4	0.9		0.9
Number			17,287	5,418		22,706
SE			2,337	860		3,180
Mean length			640	654		
SD			47	45		
Males						
Sample size	1	19	524	148	692	1,913
Percent	0.1	1.7	46.1	13.0		59.6
SE		0.4	1.5	1.0		0.9
Number	46	988	26,207	7,430		34,670
SE		260	3,407	1,094		4,723
Mean length	285	328	604	628		
SD		31	104	91		
All fish[b]						
Sample size	1	19	865	254	1,139	3,210
Percent	0.1	1.7	75.9	22.3		
SE		0.4	1.3	1.2		
Number	46	988	43,494	12,848		57,376
SE		260	4,131	1,391		10,227
Mean length	285	328	618	639		
SD		31	88	76		

[a] Includes fish not assigned an age.
[b] Includes fish with no sex information.

Using chi-square testing, a significant difference was detected in recovery rates between 2 distinct tagging groups (Table 7). Group 1 was smolt 75–84 mm FL, given tag code 04-13-70, while group 2 was smolt ≥85 mm FL, and given codes 04-13-71 and 04-13-72. Overall 10,714 coho salmon smolt were released in group 1; 136 CWTs were recovered in fisheries, and 37 CWTs were recovered in lower Chilkat River sampling, for a total of 173. In group 2, 13,390 coho salmon smolt were released; 234 were recovered in fisheries, and 42 were recovered in lower river sampling for a total of 276. A 2x2 contingency table revealed a significant difference in recovery rates for these 2 tagging groups ($\chi^2 = 6.26$, df = 1, P = 0.01).

The recovery rate (B) for larger coho salmon smolt was 1.28 times the rate for smaller smolt. The alternate smolt abundance estimator (Appendix B1) used to eliminate bias introduced by significantly different recovery rates could not be used because insufficient age information was collected from adipose fin-clipped fish captured in the Chilkat River fish wheels. Because fish were systematically sampled, ages from only 31 of the 83 adipose fin-clipped fish were obtained. All of these 31 samples were freshwater-age-1 coho salmon. Therefore, comparisons of age proportions between the adult and smolt populations were not possible.

Table 7.–Comparison of coded wire recoveries for 2 classes of coho smolt sizes tagged in the Chilkat River in 2007. Tag code 04-13-70 was used for smolt 75–84 mm and tag codes 04-13-71 and 04-13-72 were used for smolt ≥85 mm; Chi-square tests show significant difference at alpha = 0.10 between the two size groups.

Tag code		Chi-square tests of independence	
Tag code 04-13-70 (75–84mm)		2 X 2 contingency table	
number tagged (*N1*)	10,714	*N1*	*N2*
recovered in fisheries	136	10,714	13,390
recovered in fish wheels	67	173	276
total recoveries	173		
survival rate 1 (S_1) =	0.0161	$X^2 = 6.26$, df = 1, P = 0.0124	
Tag code 04-13-71 and 04-13-72 (≥85 mm)			
number tagged (*N2*)	13,390		
recovered in fisheries	234		
recovered in fish wheels	42		
total recoveries	276		
survival rate 2 (S_2) =	0.0206		
survival rate ratio (B) =	1.277		

CODED WIRE TAG RECOVERY

In 2008, 370 CWTs with Chilkat River codes were recovered from coho salmon during the random sampling of commercial marine harvests (Table 8, Appendix A1). Most tags (216) were recovered in the drift gillnet fisheries, followed by 151 recoveries in the commercial troll fisheries (Table 8). There were 3 recoveries in marine sport fisheries, and no recoveries in the inside purse seine fishery. There were also no select recoveries of coho salmon bearing 2007 Chilkat River codes in 2008. Coho salmon bearing Chilkat River tag codes were recovered with comparable relative frequencies in the District 115 (Lynn Canal) drift gillnet fishery from August 13 to October 2, and in the Northwest Quadrant troll fishery from July 5 through September 20 ($\chi^2 = 2.19$, df = 2, P = 0.33, Table 8).

Table 8.–Random marine recoveries of coded wire tags from Chilkat River coho salmon by tag code, fishery, and gillnet statistical week or troll period, 2008.

Statistical week	Dates	Tag code 04-13-70	04-13-71	04-13-72	Total
District 111 gillnet fishery					
35	8/24–8/30		1		1
District 115 gillnet fishery					
33	8/17–8/23	1	1		2
35	8/24–8/30	4	3	2	9
36	8/31–9/6	6	10	1	17
37	9/7–9/13	16	29	7	52
38	9/14–9/20	3	4	2	9
39	9/21–9/27	49	47	19	115
40	9/28–10/4	6	4	1	11
Gillnet subtotal		85	99	32	216
Northwest Quadrant troll fishery					
27	6/29–7/5	1			1
29	7/13–7/19	1	1	1	3
30	7/20–7/26	1	1		2
31	7/27–8/2	3	5	2	10
32	8/3–8/9	4	4		8
33	8/10–8/16	5	6		11
34	8/17–8/23	1	6	3	10
35	8/24–8/30	1	10		11
36	8/31–9/6	12	14	10	36
37	9/7–9/13	8	12	9	29
38	9/14–9/20	12	11	4	27
Northeast Quadrant troll fishery					
35	8/24–8/30		1		1
37	9/7–9/13		2		2
Troll subtotal		49	73	29	151
Elfin Cove marine sport fishery					
33	8/10–8/16	1			1
Gustavus sport fishery					
34	8/17–8/23			1	1
Juneau sport fishery					
36	8/31–9/6	1			1
Marine sport subtotal		2		1	3
Total recoveries		136	172	62	370
Valid tags released		10,714	10,223	3167	24,104
Percent gillnet		63	58	52	58
Percent troll		36	42	47	41

HARVEST

The tagged fraction θ_m, used for estimating marine harvest contributions, was 0.025 (SE = 0.003). This estimate is based on 79 Chilkat River CWTs decoded out of the heads collected from 83 adipose fin-clipped fish among the 3,111 one-ocean adult coho salmon inspected for marks in the Chilkat River in 2008.

An estimated 52,822 (SE = 3,518) Chilkat River coho salmon were harvested in sampled marine commercial fisheries in 2008 (Table 9). An additional 390 coho salmon were harvested in the Chilkat Inlet and Chilkat River subsistence fisheries, an estimated 738 (SE = 261) in Chilkat River recreational fisheries, and 30 (SE = 30) in Haines marine recreational fisheries, for a total harvest of 53,980 (SE = 3,528, Table 10). Most of the Chilkat harvest (53.2%; 28,727, SE = 2,634) occurred in commercial drift gillnet fisheries, followed by commercial troll fisheries (44.2%; 23,875, SE = 2,327). The remainder of the harvest occurred in the recreational (1.8%) and subsistence (0.7%) fisheries. Harvests in the troll fisheries occurred earlier in the year due to the migration route from Gulf of Alaska feeding grounds to the Chilkat River (Figures 4 and 5), and covered a period of 12 weeks during the migration (Table 8). In contrast, harvest in the drift gillnet fisheries occurred from mid-August through the first week of October. The estimated mean date of harvest in the Northwest Quadrant troll fishery was August 28 compared to September 17 for the Lynn Canal drift gillnet fishery.

ESCAPEMENT

A total of 1,706 coho salmon were counted during peak surveys in the Chilkat River drainage in 2008 (Table 1). Expansion factors for peak survey counts from past years, when mark-recapture was used to estimate adult abundance, ranged from 23.6 (SE = 2.9) in 1990 to 39.5 (SE = 4.7) in 2005. The mean expansion factor 33.6 (SE = 6.5) was used to estimate that 57,376 (SE = 11,039) coho salmon reached spawning areas in the Chilkat River in 2008 (Table 1).

AGE AND SEX COMPOSITION OF THE ESCAPEMENT

There was no difference in age composition between the first half of the immigration (prior to September 22; the median date of the fish wheel catch) and second half ($\chi^2 = 0.9$, df = 1, P = 0.33), however sex compositions varied significantly over time for age-1.1 ($\chi^2 = 5.1$, df = 1, P = 0.024) and age–2.1 fish ($\chi^2 = 2.7$, df = 1, P = 0.098). Thus, the samples were temporally stratified to estimate the age and sex composition of the escapement (Appendices A2 and A3). Age-1.1 males comprised 49.8% (SE = 2.1%) of the sample in the first half of the escapement, and 42.2% (SE = 2.1%) in the second half. Comparing proportions of brood year 2004 fish, age-2.1 females comprised 7.7% (SE = 1.1%) in the first half of the sample, and 10.9% (SE = 1.3%) in the second half of the sample. Overall, males comprised 59.6% (SE = 0.9%), and age-1.1 fish comprised 75.9% (SE = 1.3%) of the escapement (Table 6).

MARINE EXPLOITATION AND SURVIVAL

The total ocean age-.1 component of the estimated escapement was 56,369 fish (SE = 10,846, Table 11). Assuming all 52,989 fish harvested in marine fisheries and 991 fish harvested in inriver fisheries in 2008 (Tables 9 and 10) were age-.1, the total 2008 return of age-.1 Chilkat River coho salmon was 110,349 fish (SE = 11,405). The estimated marine survival rate for 2007 emigrants was 12.4% (SE = 1.8%). The marine exploitation of this stock was estimated at 48.0% (SE = 5.0%).

Table 9.–Estimated marine harvest by coded wire tag recoveries in 2008 of adult coho salmon bound for the Chilkat River, by fishery and temporal stratum (troll period or gillnet statistical week).

Fishery	District	Stat. week	Catch harvest	Var[*N*]	*n*	*a*	*a′*	*t*	*t′*	*m*	*r*	SE[*r*]
NW troll period 3		27-33	499,985		149,957	2,016	1,979	1,539	1,531	35	4,583	823
NW troll period 4		34-37	322,084		78,038	1,485	1,461	1,259	1,254	86	16,083	2,074
NE troll period 4		34-37	34,632		11,307	109	109	85	85	3	362	211
	Troll subtotal		889,331		251,952	3,938	3,865	3,153	3,140	151	23,875	2,327
District 114 sport	114	17	512	47,695	506	12	12	12	12	2	80	61
Juneau sport	112	18	601	109,201	168	2	2	2	2	1	141	141
	Sport subtotal		1,113	156,896	674	14	14	14	14	3	221	153
District 111 gillnet	111	35	4,999		1,887	15	15	11	11	1	104	104
Lynn Canal gillnet	115	34	802		338	6	6	4	4	2	187	132
Lynn Canal gillnet	115	35	4,398		1,220	28	28	26	26	9	1,278	445
Lynn Canal gillnet	115	36	4,530		1,223	32	32	29	29	17	2,480	656
Lynn Canal gillnet	115	37	11,480		3,077	117	117	109	109	52	7,640	1,347
Lynn Canal gillnet	115	38	5,690		920	41	41	40	40	9	2,192	764
Lynn Canal gillnet	115	39	13,751		4,774	205	203	192	192	115	13,173	1,897
Lynn Canal gillnet	115	40	2,724		705	24	24	22	22	11	1,674	533
	Gillnet subtotal		48,374		14,144	468	466	433	433	216	28,727	2,634
		Total	938,818	156,896	266,770	4,420	4,345	3,600	3,587	370	52,822	3,518

Table 10.–Total (marine and freshwater) harvest and estimated Chilkat River harvest of coho salmon in Alaska fisheries, by fishery and area, 2008.

		Coho salmon harvest			Percent of harvest	
Fishery	Area	Total	Chilkat	SE	Fishery	Chilkat
Drift gillnet	District 111	4,999	104	104	2.1	0.2
	District 115	43,375	28,623	2,632	66.0	53.0
	Subtotal	48,374	28,727	2,634	59.4	53.2
U.S. troll fishery	NW Quadrant	854,699	23,513	2,318	2.8	43.6
	NE Quadrant	34,632	362	211	1.0	0.7
	Subtotal	889,331	23,875	2,327	2.7	44.2
Recreational	District 114 sport	512	80	61	15.6	0.1
	Juneau sport	601	141	141	23.4	0.3
	Haines marine[a]	104	30	30	28.8	0.1
	Chilkat River[a]	738	738	261	100.0	1.4
	Subtotal	1,955	989	304	50.6	1.8
Subsistence	Chilkat Inlet[b]	137	137	0	100.0	0.3
	Chilkat River[b]	253	253	0	100.0	0.5
	Subtotal	390	390	0	100.0	0.7
Total		940,050	53,980	3,528	5.7	100.0

[a] Estimates derived from the Statewide Harvest Survey.
[b] Subsistence harvests as reported on returned permits.

Table 11.–Estimated stock assessment parameters for coho salmon that emigrated from the Chilkat River in 2007.

Parameter	Estimate	SE
2007 smolt emigration	893,032	95,380
2008 marine harvest	52,989	3,518
2008 inriver harvest[a]	991	261
2008 1-ocean age escapement[b]	56,369	10,846
Total 2008 return	110,349	11,405
Marine exploitation rate, %	48.0	5.0
Marine survival, %	12.4	1.8

[a] Includes harvest from Haines marine recreational from the Statewide Harvest Survey and Chilkat Inlet subsistence.
[b] Total escapement excluding age-1.0 and -2.0 coho salmon.

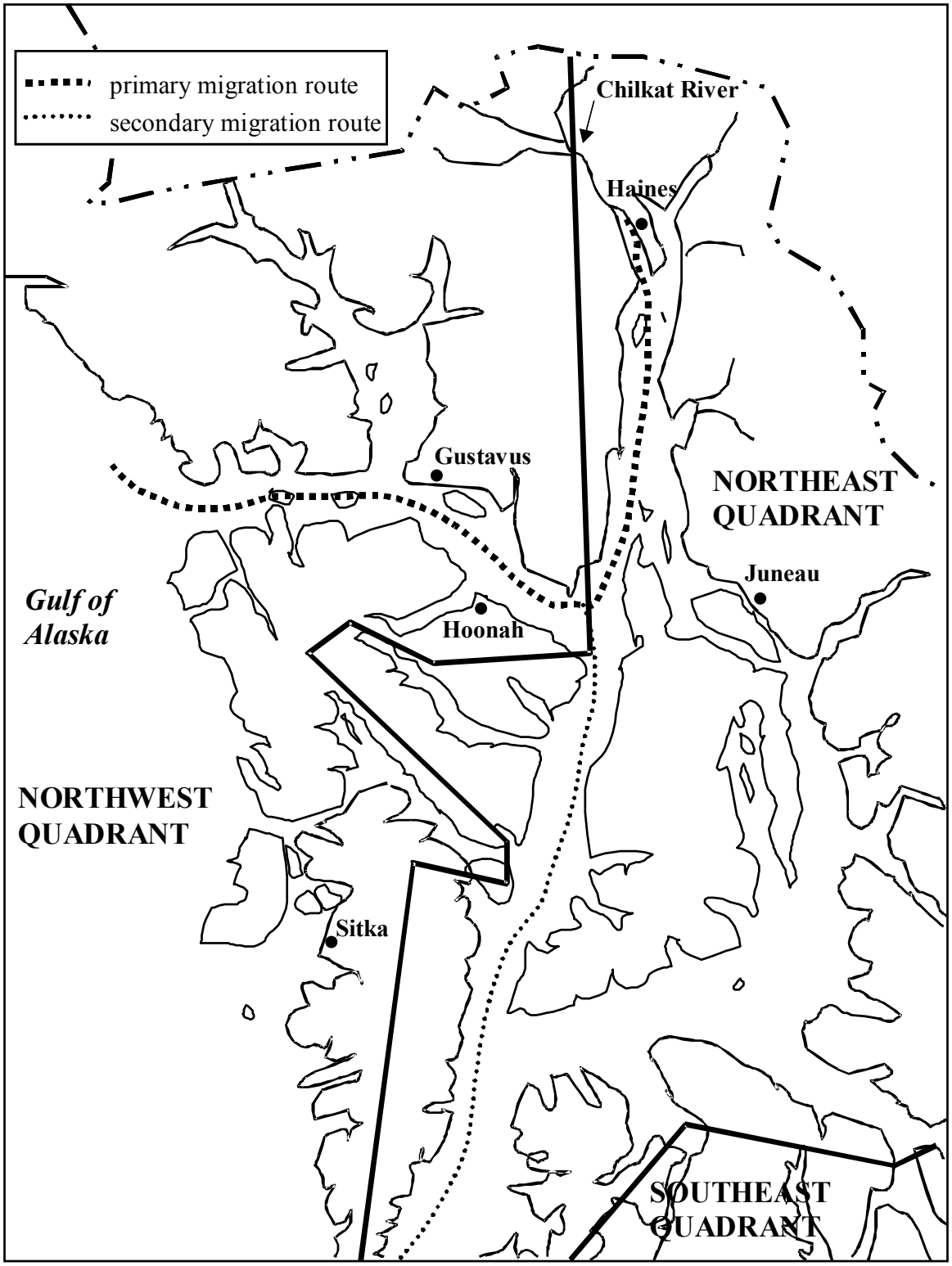

Figure 4.–Commercial troll quadrants and migration routes of Chilkat River coho salmon through northern Southeast Alaska.

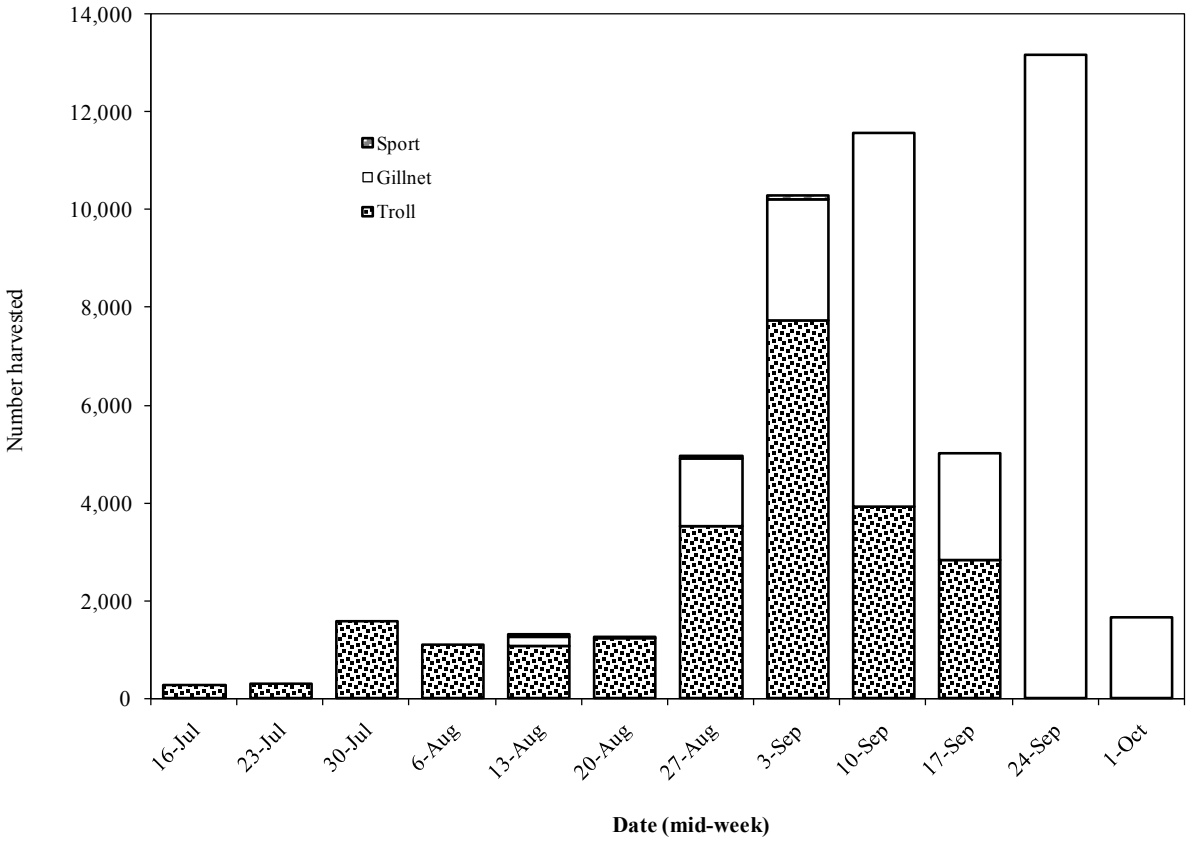

Figure 5.–Estimated marine harvests of coho salmon bound for the Chilkat River, by fishery and statistical week, 2008. Weekly estimates of harvest in the troll (period) and marine sport fisheries (bi-week) are approximated.

DATA FILES

Data collected during this study (Appendix C1) have been archived in ADF&G offices in Haines, Douglas, and Anchorage.

DISCUSSION

The estimate of smolt abundance satisfies the several mark-recapture assumptions discussed above. Attempts were made to ensure every smolt had an equal chance of being marked. Although smolt were still being captured when trapping ceased on May 30, catch rates were declining from the peak in mid-May (Table 3). Therefore, the majority of the emigration was probably sampled. In addition, sampling effort for adults in the fish wheels (to estimate the marked fraction) was relatively constant over time, tending to equalize probability of capture during the second sampling event. Comparing CWT recovery rates for different smolt size categories (Table 7) revealed a significant difference between groups (assumption a), and an alternate smolt estimator can be used to eliminate bias resulting from unequal sampling probabilities (Appendix B1). Smaller smolt were marked at a higher rate than larger smolt (Tables 4 and 6), and larger smolt have a higher survival rate, so the estimated marking fraction was biased low. The 2008 smolt estimate, therefore, was biased high which underestimates marine survival. Because insufficient age data existed from adult coho salmon tagged in 2007, Chapman's modified Peterson estimator was used.

Although the population in this experiment was not closed to losses from mortality, it was essentially closed to recruitment (assumption b) because salmon return to their natal stream to spawn. There have been only rare instances when coho salmon with Berners River tags have been recovered in the Chilkat River, or when juvenile coho salmon containing Chilkat River tags have been captured in other drainages. Because different capture gear was used during the first and second sampling events, it is unlikely that marking affected the ability to capture adults (assumption c). Other studies have shown that marked coho smolt do not suffer significantly higher mortality than unmarked fish (Elliott and Sterritt 1990; Vincent-Lang 1993). Because all fish had secondary marks (adipose fin clips) that were not lost, assumption (d) was satisfied. Overall, 98.9% of fish captured in the Chilkat River fish wheels were examined (3,167 examined out of 3,202 captured) for missing adipose fins; fish that were not examined either escaped or were overlooked. Once examined, fish were marked to prevent re-sampling, satisfying assumption (e).

Although freshwater age-2. fish composed approximately 13% of the smolt emigration, they represented over 24% of the adult escapement. One possible explanation for this difference is that age-2. smolt had better marine survival than age-1. fish. A second explanation is that the minnow traps were biased toward smaller fish because the limited diameter of the G-40 minnow trap entrance tunnel excluded the largest coho salmon smolt. This phenomenon was investigated on the Unuk River in response to differential marking and survival rates between large and small smolt (Weller et al. 2005). That study concluded that minnow trap design could result in smolt estimates that were biased low by as much as 20%. A third explanation is that coho salmon smolt emigrating from Chilkat Lake were under-represented in event 1. Results from smolt sampling by CF personnel at Chilkat Lake in 2006 indicated that age-2. fish represented 27% of the population, which is much closer to the proportion in the adult escapement (Tables 4 and 6). In future years of the Chilkat River coho salmon smolt study, small (<85mm) and medium/large (≥85mm) fish will continue to be marked with distinct tag codes, to investigate marking or survival rate differences by size class.

Regarding the closed population mark-recapture assumption (b), there is evidence that smolt occasionally migrate through salt water then enter another freshwater drainage to rear for a period of time. One juvenile coho salmon with a Chilkat River tag code was captured moving upstream into Auke Creek near Juneau (Ericksen and Chapell 2005). This was the first time that a juvenile Chilkat River fish was captured migrating upstream into another drainage in the fall. However, smolt with Chilkat River tag codes have been recovered in other drainages. One coho salmon smolt with a 2001 Chilkat River tag code was sampled as it emigrated from Jordan Creek near Juneau in 2002 (Ericksen 2003). Two smolt were recaptured in the Berners River in 2000 with 1999 codes (Ericksen 2001).

Adult coho salmon have also been recovered in the Chilkat River fish wheels with tags from other drainages (Ericksen 1999; Ericksen and Chapell 2005; Elliott 2010). These fish may have originated from the Chilkat River and reared in other drainages. An example of this occurred again in 2008, when a returning adipose fin-clipped adult coho salmon captured in the Chilkat River fish wheels had a Berners River coded wire tag released in 2007. This fish could either have strayed as an adult or more likely was of Chilkat River origin, and reared for some period of time in the Berners River where it was captured and tagged.

Because it is sometimes difficult to identify the sex of ocean-phase fish by visual observation, the sex ratio of samples at the fish wheels may be inaccurate. Ericksen (2006) examined 62 coho salmon that were sampled at the fish wheels then recaptured and sexed on the spawning grounds.

Assuming that sex determination is more reliable on the spawning grounds than in the lower river, 8 of 62 fish were incorrectly identified as females, and 6 out of 62 were incorrectly identified as males at the fish wheels. In mark-recapture years, sex compositions determined in the second sampling event can be used to accurately estimate proportions at age of males and females.

The 2008 1-ocean escapement estimate of coho salmon (excluding jacks) to the Chilkat River (56,369, SE = 10,846) rebounded from a low 2007 estimate, however it was still below average and most likely was the result of a low smolt emigration (893,032, SE = 95,380). Abundance of the 2008 return benefitted from an above average marine survival estimate (12.4%, SE = 1.8%), while escapement remained within goals despite an above average marine exploitation estimate (48.0%, SE = 5.0%). The high marine survival rate compensated for low smolt emigration abundance and high exploitation in commercial fisheries (Table 12).

Despite high catch variability, the median date of coho salmon immigration at the Chilkat River fish wheels in 2008 (September 21) was consistent with the 1997–2007 average (September 19, Figure 6). Fifty-four percent of the 2008 fish wheel catch occurred in two 7-day periods towards the end of the lower Chilkat River sampling project, and indicates the variability in catch totals. During the period from September 17 to 23, 964 coho salmon were captured, and from October 4 through October 10, there were 757 captures (Figure 3).

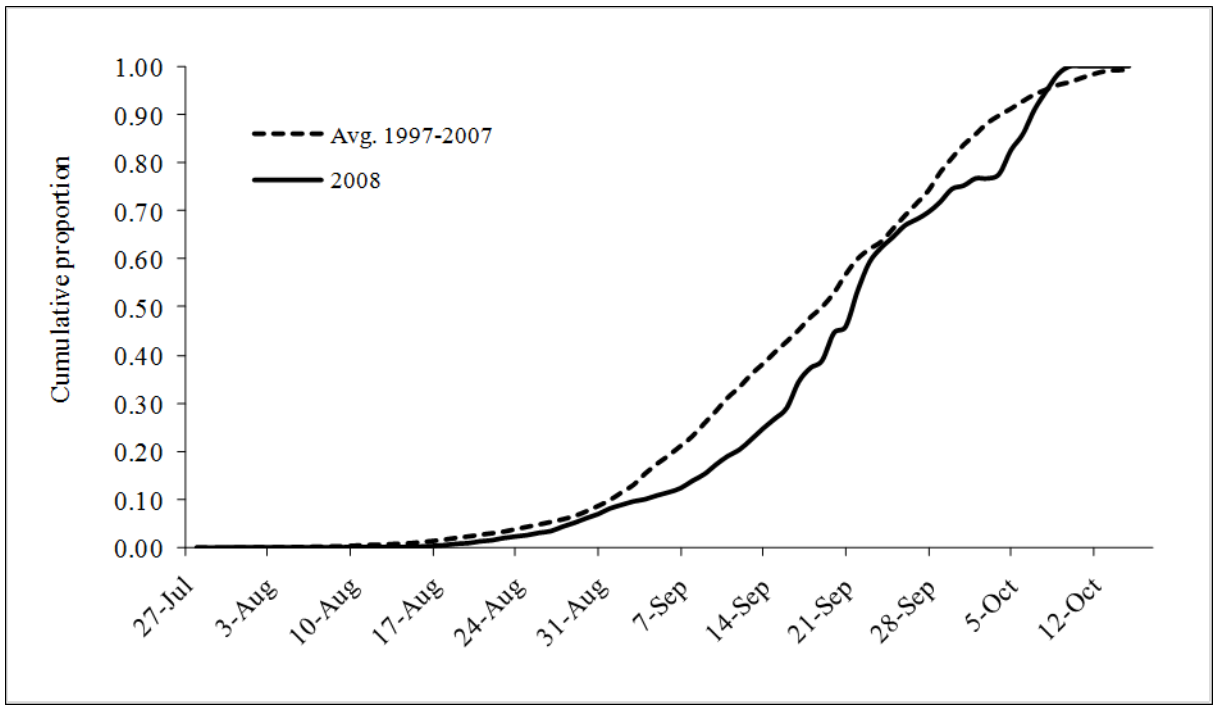

Figure 6.–Cumulative proportion of adult coho salmon captured in Chilkat River fish wheels during 2008 compared to the mean cumulative proportion of 1997–2007.

Table 12.–Estimates of Chilkat River coho salmon smolt and adult production, 2000–2008. Esc = escapement, expl = exploitation.

Return year, t	Number CWT smolt (t-1)	Smolt theta (θ_s)	Smolt estimate	SE	Marine theta (θ_m)	Marine harvest	SE	Inriver harvest	SE	Age-x.1 esc	SE	Total return	SE	Marine expl	SE	Marine survival	SE
2000[a]	25,915	0.019	1,237,056	219,715	0.019	39,546	3,745	853	221	84,843	16,330	125,242	16,755	0.316	0.046	0.101	0.023
2001[b]	25,016	0.021	1,185,804	164,121	0.020	45,658	7,194	2,176	451	107,697	20,720	155,531	21,938	0.294	0.051	0.131	0.026
2002[c]	36,114	0.012	2,970,458	377,695	0.012	110,105	10,355	3,888	742	204,787	31,071	318,780	32,759	0.345	0.040	0.107	0.018
2003[d]	25,296	0.015	1,696,212	190,330	0.015	83,302	6,956	2,932	497	133,109	14,926	219,291	16,474	0.380	0.032	0.129	0.017
2004[e]	24,563	0.012	1,938,322	401,419	0.010	128,466	19,882	3,169	661	67,053	12,901	198,688	23,710	0.647	0.054	0.103	0.025
2005[f]	17,276	0.021	776,934	147,738	0.020	29,518	3,483	1,453	293	34,575	4,561	65,546	5,746	0.450	0.042	0.084	0.018
2006[g]	26,342	0.014	1,807,837	217,352	0.013	70,813	7,632	2,082	293	79,050	15,210	151,945	17,020	0.466	0.053	0.084	0.014
2007[h]	22,149	0.025	875,478	134,864	0.023	12,142	1,585	635	149	24,770	4,769	37,547	5,027	0.323	0.050	0.043	0.009
2008	24,104	0.027	893,032	95,380	0.025	52,989	3,518	991	261	56,369	10,846	110,349	11,405	0.480	0.050	0.124	0.018
Average 00–07	24,334	0.017	1,561,013	250,620	0.017	64,944	9,284	2,149	458	91,986	17,050	159,071	19,419	0.403	0.047	0.098	0.020

[a] From Ericksen (2001).
[b] From Ericksen (2002).
[c] From Ericksen (2003).
[d] From Ericksen and Chapell (2005).
[e] From Ericksen and Chapell (2006).
[f] From Ericksen (2006).
[g] From Elliott (2009).
[h] From Elliott (2010).

Contributing to this catch variability was large precipitation events in the Chilkat River during September and October, which often times necessitates fish wheel maintenance while reducing catch effectiveness. Immediately after these high water events, fish wheel catches soared, as migrating coho salmon seem to cover great distances when river levels significantly increase. Overall, the total fish wheel catch of coho salmon in 2008 (3,202) was 26% higher than the 1997–2007 average of 2,532 coho salmon. Before 1997, operation of the Chilkat River fish wheels ended around September 15, which makes comparisons difficult.

Because the number of stocks present decreases with proximity to natal streams, the percentage of Chilkat River coho salmon in the fishery harvest increased with proximity to the Chilkat River. The estimated harvest of Chilkat River fish was substantial in the Northwest Quadrant troll fishery (23,513, SE = 2,318), but those fish represented only 2.8% of the total harvest in that fishery (Table 10). The largest harvest occurred in the Lynn Canal drift gillnet fishery (28,623, SE = 2,632) where Chilkat River fish represented 66.0% of the total harvest.

The fact that there was no difference in recovery rates between the District 115 gillnet fishery or the Northwest Quadrant troll fishery indicates that tagged fish mixed well in the ocean environment. The combined gillnet (58%), troll (41%) and sport (1%) fisheries comprised 100% of all Chilkat River coho salmon CWT recoveries.

The harvest estimate of Chilkat River coho salmon in 2008 represents the minimum total harvest because not all fisheries were sampled, and some were not sampled at rates sufficient to detect small harvests. Some marine sport fishery sites (including Pelican, Prince William Sound, and Cook Inlet) were not sampled for CWTs, so stock contribution to these fisheries cannot be estimated. Furthermore, harvest contributions of Chilkat River coho salmon cannot be determined from tags recovered in mixed district fisheries. Expansions of harvest for Chilkat coho salmon are based on harvests for a particular district (Table 9). Uncertainties of total harvest quantities for individual districts preclude estimation of Chilkat River coho salmon harvest, and underestimate total harvest.

The marine exploitation rate of Chilkat River coho salmon in 2008 (48.0%, SE = 5.0%) was the second highest since 2000, however total return increased sharply compared to 2007. Return years 2007 and 2008 are an example of the weak relationship between exploitation and total return. In fact, both data appear variable and unrelated (Table 12). In 2004, for example, the total return estimate was an above-average 198,688, and the exploitation rate was 65%, approximately 61% higher than the 8-year average.

The estimate of coho salmon smolt that emigrated in 2007 was only 57% of the 1999–2006 average and was comparable to a low smolt estimate in 2006, but the estimated marine survival (12.4%, SE = 1.8%) rebounded sharply from 2007 and is largely responsible for the escapement goal (Ericksen and Fleischman 2006) being met in 2008. Declining freshwater production in the Chilkat River drainage can be best demonstrated by examining the decaying relationship between spring CWT trapping productivity as expressed by CPUE (valid tagged coho salmon per trap deployed) and resulting smolt population estimates.

For outmigration years 1999–2005, CPUE was a very useful predictor of smolt emigration size, as evidenced by an R^2 value of 0.98 when performing linear regression between the two data sets. Outmigration years 2006 and 2007 have sharply increased the error of this model,

contributing 55% of the residual sum of squares error when fitting a regression line for all outmigration years (Figure 7). In both years, spring CPUE did not predict smolt emigration sizes. Methods and environmental conditions during the spring CWT project have remained consistent; causes for this decline in freshwater production should be investigated if this trend continues.

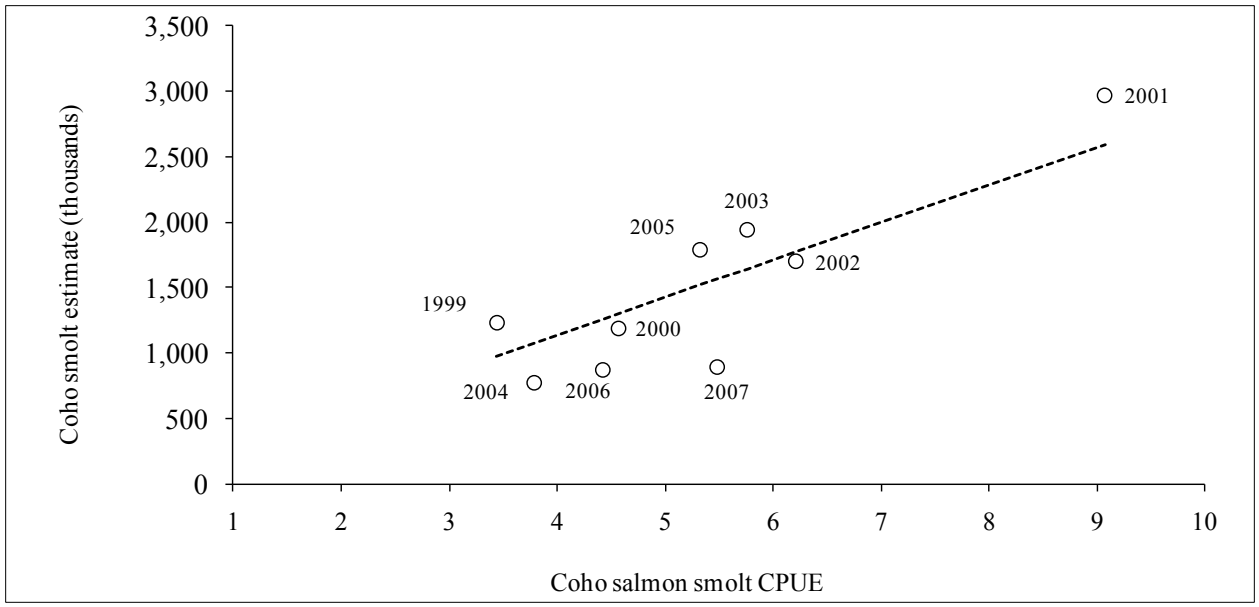

Figure 7.–Chilkat River coho salmon smolt spring coded wire tag minnow trapping CPUE and smolt emigration estimate for years 1999–2007.

The reduced ability of spring minnow trapping CPUE to predict smolt emigration size also hinders ability to predict the subsequent year's return; total return of Chilkat River coho salmon is largely dependent on the abundance of the previous year's smolt emigration. In 2002, for example, when marine survival was average (10.7%), the estimated return of 318,798 coho salmon was 107% higher than the 2000–2008 average (Table 12) due to the large smolt emigration (2,970,458 fish) in 2001. In contrast, marine survival was estimated at an above-average 13.1% for return year 2001, but the smolt outmigration in 2000 was below average at 1,185,804, resulting in a below average total return estimate of 155,531 (Figure 8, Table 12). Linear regression of smolt emigration on total return yields an R^2 value of 0.97 (Figure 9). The abundance of the previous year's smolt emigration estimate, therefore, is an important predictor of the return of Chilkat River coho salmon.

Production of Chilkat River coho salmon smolt is limited by the amount of rearing habitat (Ericksen and Fleischman 2006), which would indicate some degree of density dependence; however there is a weak relationship between smolt estimates and average fish size (Table 13, 44% negatively correlated). Average fish size is also not related to marine survival. Thomas Fulton, among others in the early 20th century, developed a method to measure the robustness of fish populations, called the K factor ($K = (\text{weight}/\text{length}^3) \times 10^5$), as an indicator of fish condition (Fulton 1902; Ricker 1975). The smolt estimate data, average K factor, and resulting marine survival were examined for Chilkat coho salmon (Table 13, Figure 10). The insignificant slope ($P = 0.53$) and poor fit ($R^2 = 0.06$) of the regression line show that overall smolt size has little effect on marine survival.

Similarly, the relationship between smolt emigration abundance and marine survival does not appear to be strong for Chilkat River coho salmon (Figure 11). Regression of survival on smolt abundance produces a line with an insignificant slope (P = 0.55) and the data is only 23% correlated. When examining the marine survival to smolt abundance relationship among all Southeast Alaska coho salmon indicator stocks, including Auke Creek, Berners River, Chilkat River, Taku River, Ford Arm Lake, Hugh Smith Lake, Chuck Creek, and Nakwasina River, the data is 14% correlated (Shaul et al. 2008). This weak relationship for the Chilkat River stock and other Southeast Alaska stocks could indicate that marine survival is driven more by ocean rearing conditions than freshwater abundance of rearing juvenile fish.

Table 13.–Smolt estimate, average smolt sizes, K factor (measuring robustness), and marine survival for Chilkat River coho salmon, 1999–2007.

		Age 1.			Age 2.				
Smolt year	Smolt estimate	*n*	Length	Weight	*n*	Length	Weight	All ages K factor	Marine survival
1999	1,237,056	236	80.0	5.4	46	101.0	10.3	1.046	10.1%
2000	1,185,804	184	86.3	6.5	22	102.0	10.4	1.008	12.9%
2001	2,970,458	379	85.0	6.4	58	101.0	7.1	0.995	10.7%
2002	1,696,212	266	83.0	6.0	61	96.0	8.8	1.039	12.9%
2003	1,938,322	315	85.0	6.2	22	104.0	10.9	1.007	10.3%
2004	776,934	203	83.5	6.1	15	102.1	10.9	1.046	8.5%
2005	1,807,837	398	83.0	5.9	38	105.0	11.2	1.026	8.4%
2006	875,478	345	84.0	5.9	26	106.6	11.1	0.999	4.3%
2007	893,032	352	85.4	6.4	54	105.3	11.5	1.038	12.4%

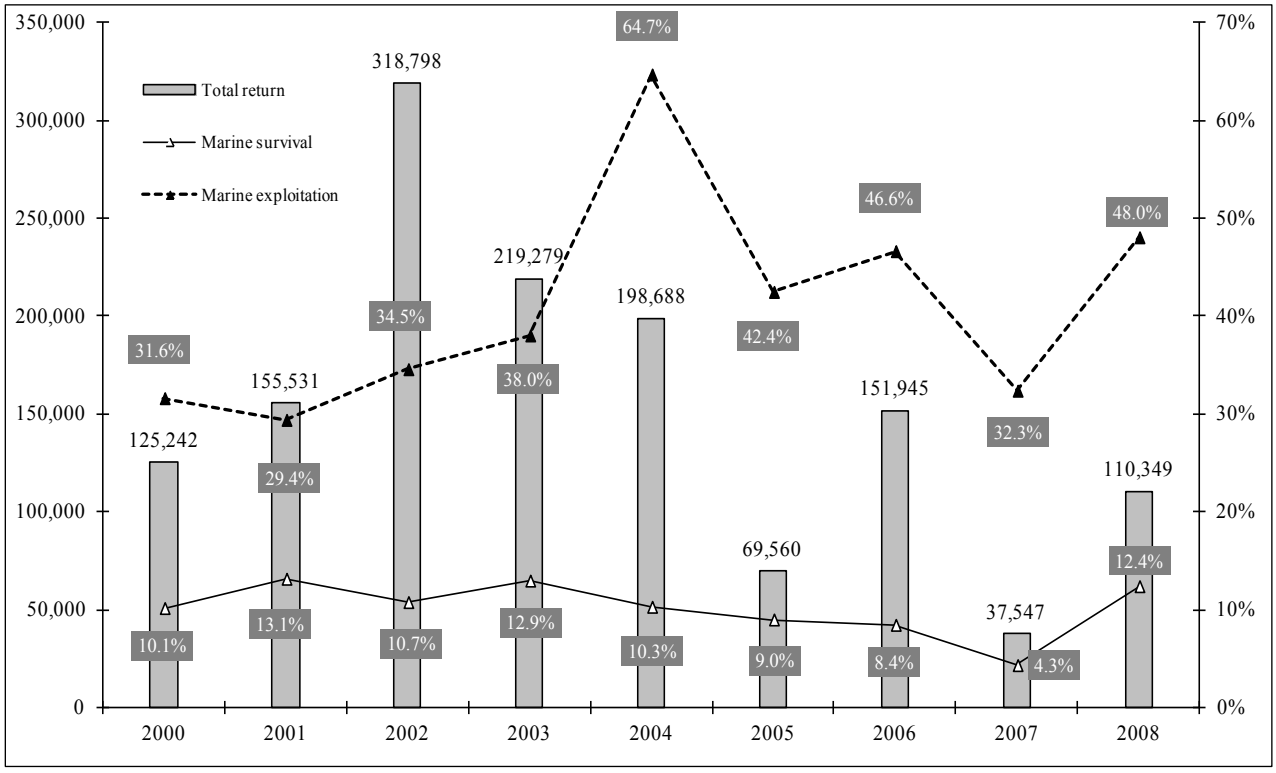

Figure 8.–Estimated total return, marine survival, and marine exploitation rate of Chilkat River coho salmon, 2000–2008.

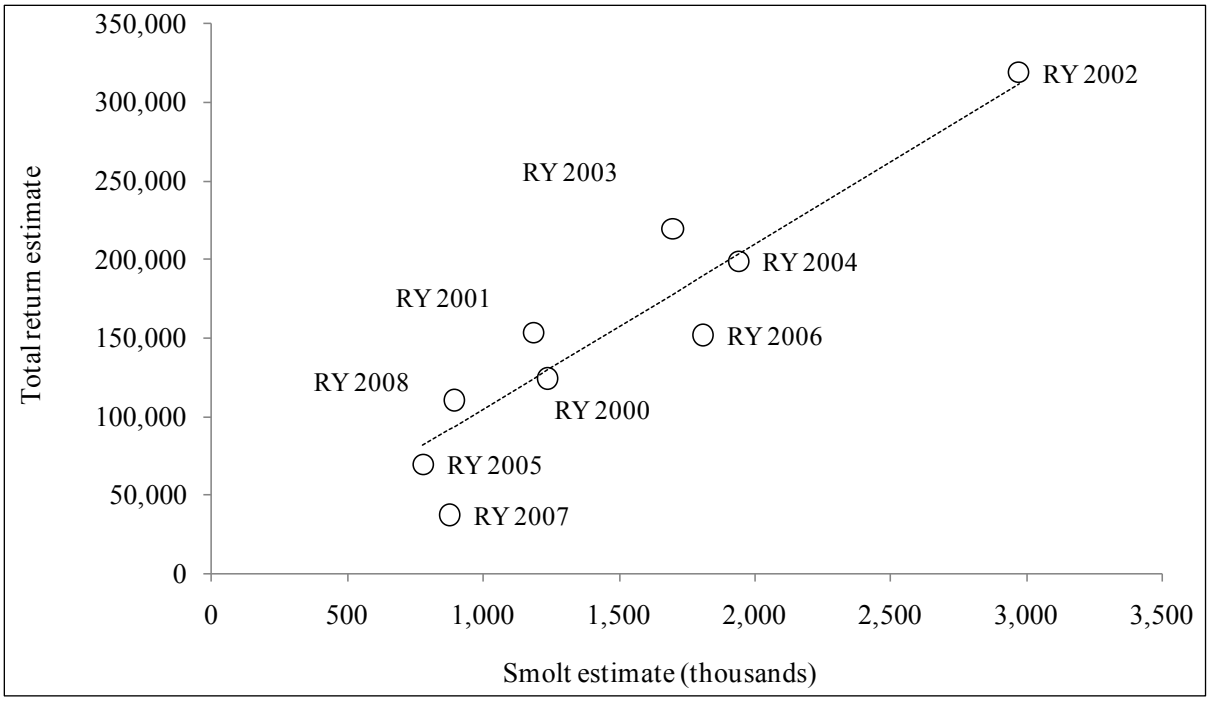

Figure 9.–Estimated smolt emigration and resulting total return of Chilkat River coho salmon, 2000–2008. Linear regression results in an R^2 value of 0.97 and a significant slope with a P value of <0.0001.

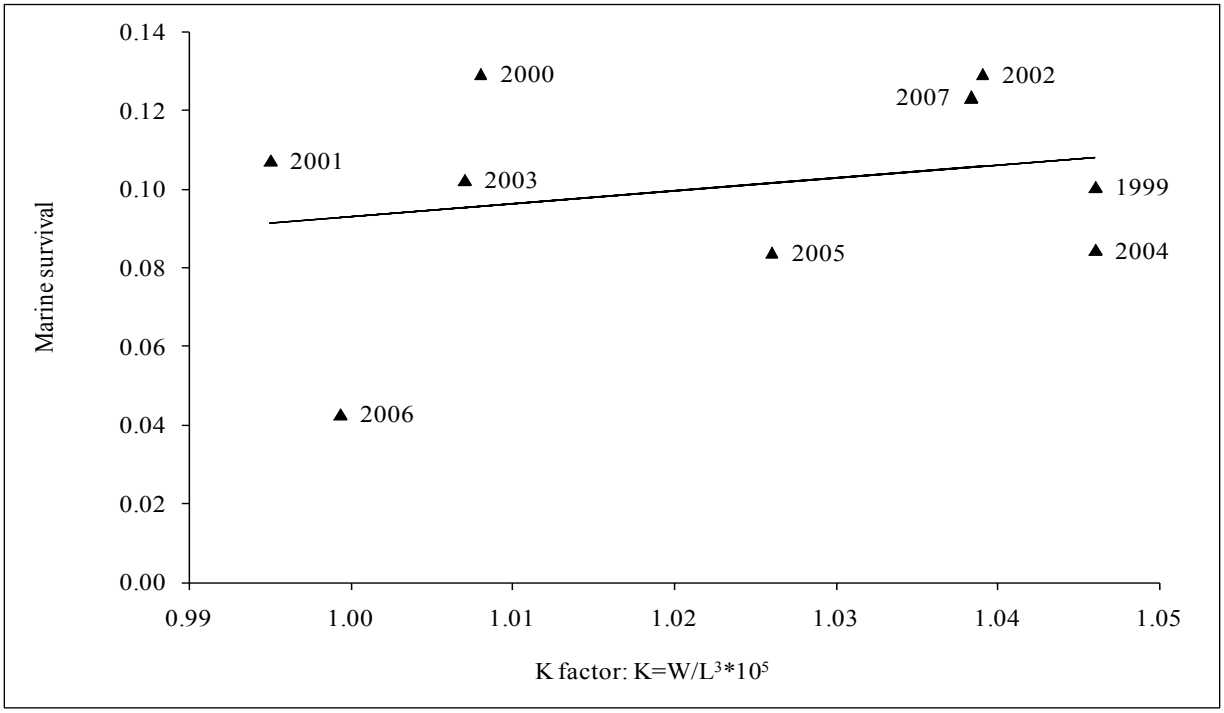

Figure 10.–Estimated smolt sizes as expressed by the K factor and resulting marine survival for Chilkat River coho salmon, smolt years 1999–2007. The data are 24% correlated and regression results in a poor fit with an R^2 value of 0.06.

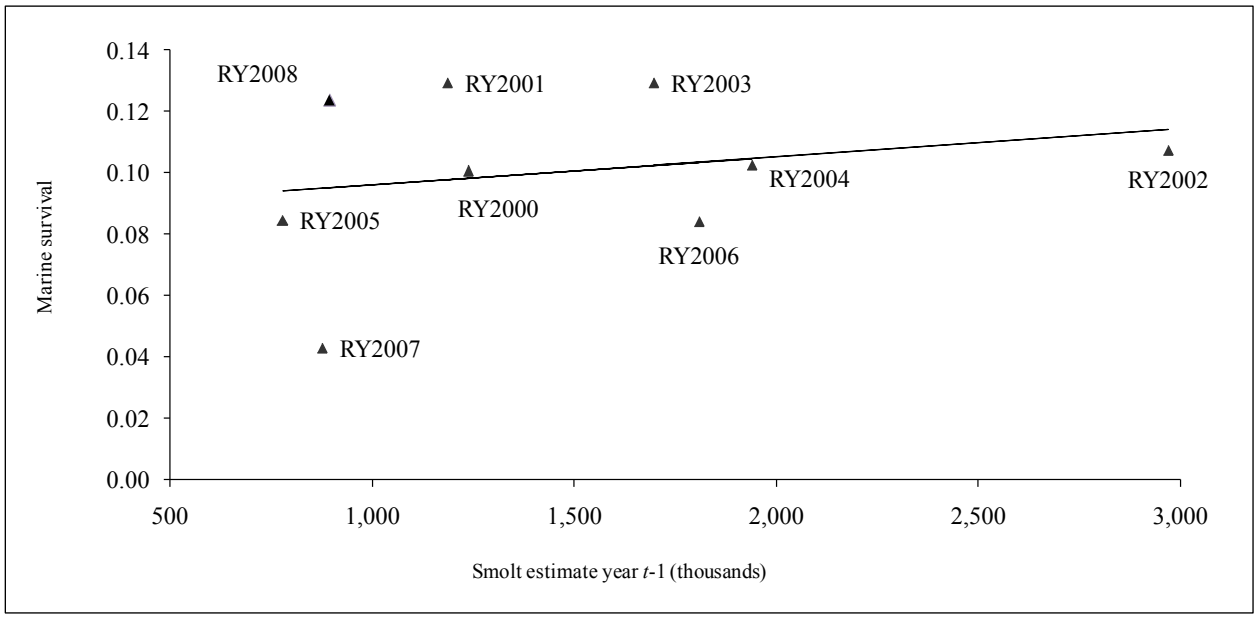

Figure 11.–Observed smolt outmigration estimates and observed and predicted marine survival for Chilkat River coho salmon, return years 2000–2008. Predicted marine survival has an insignificant slope with P value of 0.55, and the data is 23% correlated. RY = return year.

A predictor of marine survival that may be useful for making inseason fishery management decisions, such as the Chilkat River sport bag limits for coho salmon, is the CWT recovery rate from commercial troll fisheries (Table 14, Figure 12). Examining recovery rates from 2000–2008 for Chilkat River coho salmon reveals that marine recovery and marine survival are 85% positively correlated, i.e., in years with an above average marine recovery rate, marine survival is also above average. Because marine CWT interceptions largely occur before the escapement of Chilkat River coho salmon, and the recovery rate is based on known quantities (smolt released with tags and CWTs recovered), assessing this relationship can help predict marine survival and, after adding the inseason marking fraction θ_m, can be a useful predictor of return strength (Figure 13).

Table 14.–Chilkat River coho salmon marine coded wire tags released and recovered 2000–2008.

Return year	Smolt tagged (y-1)	Marine theta	Marine coded wire tags	Marine recovery rate	Adult return
2000	25,915	1.89%	265	1.02%	125,242
2001	25,016	2.03%	251	1.00%	155,531
2002	36,114	1.22%	329	0.91%	318,798
2003	25,296	1.47%	424	1.68%	219,279
2004	24,563	1.04%	254	1.03%	198,688
2005	17,276	1.97%	142	0.82%	65,546
2006	26,342	1.31%	217	0.82%	151,945
2007	22,149	2.28%	78	0.35%	37,547
2008	24,104	2.54%	370	1.54%	110,349
average	25,197	1.75%	259	1.02%	153,640

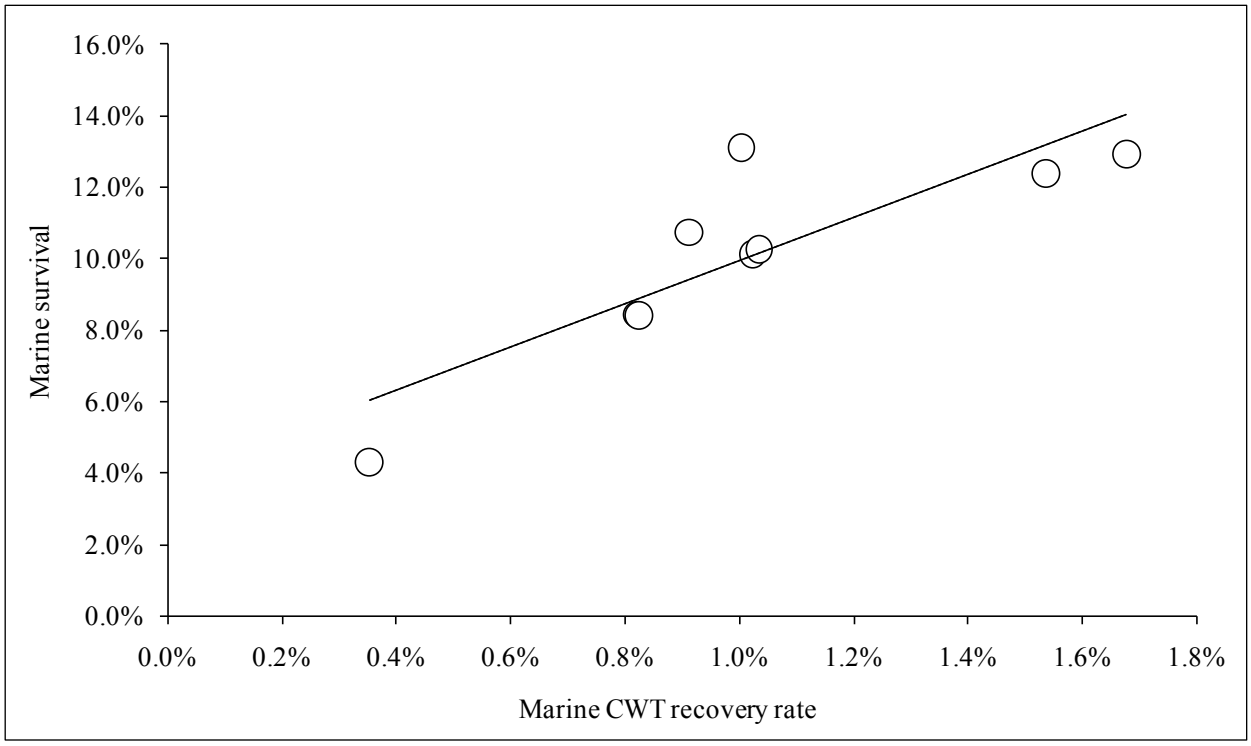

Figure 12.–Marine coded wire tag (CWT) recovery rate and marine survival for Chilkat River coho salmon, 2000–2008. The data are 85% correlated and linear regression results in an R^2 value of 0.97.

The forecasting model estimates 2 parameters; one for the CWT recovery rate from the troll fishery represented by ρ, and the other is for the marine theta, represented by ϕ. Nonlinear regression using the least squares method produces estimates for ρ and ϕ, including the residual term ε representing additive error from the model:

$$\text{Estimated return} = \rho(\text{troll CWT \%}) - \phi(\theta_m) + \varepsilon$$

Most troll fishery interceptions occur by the end of statistical week 38, which coincides with mid-September. That time frame is also the median date of the Chilkat River fish wheel catch, when marine theta can be reasonably estimated. Using the total CWTs released in year *t*-1, marine theta, and the marine CWT recovery rate produces inseason forecasted return totals with a forecasting error of less than 25% in 6 of the 9 years examined. Return year 2002 was one anomaly, as the return was the highest recorded and exceeded expectations, and accounts for 77% of the model error, expressed as a proportion of residual sum of squares (Table 12, Figure 13). Prior forecasts of coho salmon return have used CWTs released with average marine survival and average marine exploitation rates; using inseason marine CWT recovery rates allows for more accurate forecasting while utilizing contemporary data. As more data are collected in subsequent years, this forecasting tool will be developed further and should continue to be studied, to predict overall return and escapement of coho salmon to the Chilkat River.

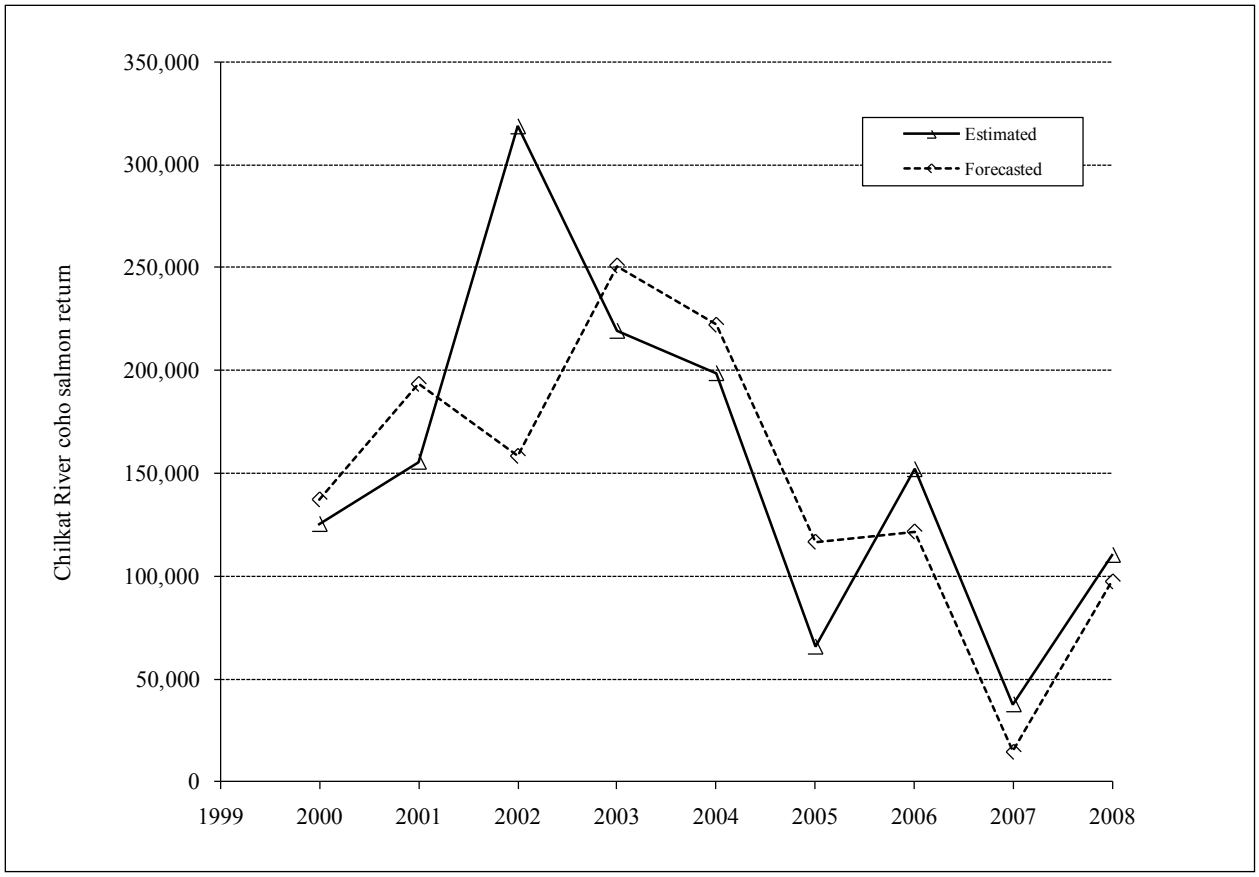

Figure 13.–Inseason forecasted returns and postseason estimated returns of Chilkat River coho salmon, 2001–2008. The number of coded wire tags released in year *t*-1, average marine theta, and the marine coded wire tag recovery rate are used to generate the forecasted total. Return year 2002 accounts for 77% of total forecast error for years 2000–2008.

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REFERENCES CITED

Bernard, D. R., and J. E. Clark. 1996. Estimating salmon harvest based on return of coded-wire tags. Canadian Journal of Fisheries and Aquatic Sciences 53:2323-2332.

Bugliosi, E. F. 1988. Hydrologic reconnaissance of the Chilkat River Basin, Southeast Alaska. U. S. Geological Survey Water Resources Investigation Report 88-4021, Anchorage.

Cochran, W. G. 1977. Sampling techniques. 3rd edition. John Wiley and Sons, New York.

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. 1st edition. Chapman and Hall, New York, NY

Elliott, B. W. 2009. Production and Escapement of Coho Salmon from the Chilkat River, 2005–2006. Alaska Department of Fish and Game, Fishery Data Series No. 09-65, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS09-65.pdf

Elliott, B. W. 2010. Production and escapement of coho salmon from the Chilkat River, 2006–2007. Alaska Department of Fish and Game, Fishery Data Series No. 10-60, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS10-60.pdf

Elliott, S. T., and K. J. Kuntz. 1988. A study of coho salmon in southeast Alaska: Chilkat Lake, Chilkoot Lake, Yehring Creek, and Vallenar Creek. Alaska Department of Fish and Game, Fishery Data Series No. 62, Juneau. http://www.adfg.alaska.gov/FedAidPDFs/fds-062.pdf

Elliott, S. T., and D. A. Sterritt. 1990. A study of coho salmon in southeast Alaska, 1989: Chilkoot Lake, Yehring Creek, Auke Lake, and Vallenar Creek. Alaska Department of Fish and Game, Fishery Data Series No. 90-53, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds90-53.pdf

Ericksen, R. P. 1999. Abundance of coho salmon in the Chilkat River in 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-29, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds99-29.pdf

Ericksen, R. P. 2001. Smolt production and harvest of coho salmon from the Chilkat River, 1999-2000. Alaska Department of Fish and Game, Fishery Data Series No. 01-17, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds01-17.pdf

Ericksen, R. P. 2002. Smolt production and harvest of coho salmon from the Chilkat River, 2000-2001. Alaska Department of Fish and Game, Fishery Data Series 02-18, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds02-18.pdf

Ericksen, R. P. 2003. Production of Coho Salmon from the Chilkat River, 2001-2002. Alaska Department of Fish and Game, Fishery Data Series No. 03-28, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds03-28.pdf

Ericksen, R. P. 2006. Production and escapement of coho salmon from the Chilkat River, 2004-2005. Alaska Department of Fish and Game, Fishery Data Series No. 06-77, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds06-77.pdf

Ericksen, R. P., and R. S. Chapell. 2005. Production and spawning distribution of coho salmon from the Chilkat River, 2002-2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-18, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds05-18.pdf

Ericksen, R. P., and R. S. Chapell. 2006. Production and spawning distribution of Chilkat River Chinook salmon in 2005. Alaska Department of Fish and Game, Fishery Data Series No. 06-76, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds06-76.pdf

Ericksen, R. P., and S. J. Fleischman. 2006. Optimal production of coho salmon from the Chilkat River. Alaska Department of Fish and Game, Fishery Manuscript No. 06-06, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fms06-06.pdf

Fulton, T. W. 1902. The rate of growth of fishes. 20th annual report of the Fishery Board of Scotland (3):326-446.

Howe, A. L., R. J. Walker, C. Olnes, K. Sundet, and A. E. Bingham. 2001. Participation, catch, and harvest in Alaska sport fisheries during 1999. Alaska Department of Fish and Game, Fishery Data Series No. 01-08, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds01-08.pdf

REFERENCES CITED (Continued)

Hubartt, D. J., A. E. Bingham, and P. M. Suchanek. 1997. Harvest estimates for selected marine sport fisheries in Southeast Alaska during 1996. Alaska Department of Fish and Game, Fishery Data Series No. 97-16, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds97-16.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2007. Participation, catch, and harvest in Alaska sport fisheries during 2004. Alaska Department of Fish and Game, Fishery Data Series No. 07-40, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds07-40.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2009a. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2005. Alaska Department of Fish and Game, Fishery Data Series No. 09-47, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS09-47.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2009b. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2006. Alaska Department of Fish and Game, Fishery Data Series No. 09-54, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/FDS09-54.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2010a. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2007. Alaska Department of Fish and Game, Fishery Data Series No. 10-02, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/Fds10-02.pdf

Jennings, G. B., K. Sundet, and A. E. Bingham. 2010b. Estimates of participation, catch, and harvest in Alaska sport fisheries during 2008. Alaska Department of Fish and Game, Fishery Data Series No. 10-22, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/FDS10-22.pdf

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2004. Participation, catch, and harvest in Alaska sport fisheries during 2001. Alaska Department of Fish and Game, Fishery Data Series No. 04-11, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds04-11.pdf

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2006a. Participation, catch, and harvest in Alaska sport fisheries during 2002. Alaska Department of Fish and Game, Fishery Data Series No. 06-34, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds06-34.pdf

Jennings, G. B., K. Sundet, A. E. Bingham, and D. Sigurdsson. 2006b. Participation, catch, and harvest in Alaska sport fisheries during 2003. Alaska Department of Fish and Game, Fishery Data Series No. 06-44, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/fds06-44.pdf

Jones & Stokes. 1991. Southeast Alaska sport fishing economic study. Final Research Report. December 1991. (JSA 88-028.) Sacramento, California. Prepared for Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, Anchorage.

Koerner, J. F. 1977. The use of coded wire tag injector under remote field conditions. Alaska Department of fish and Game, Division of Commercial Fisheries, Informational Leaflet No. 172, Juneau. http://www.sf.adfg.state.ak.us/FedAidPDFs/afrbil.172.pdf

Mosher, K. H. 1968. Photographic atlas of sockeye salmon scales. U.S. Fish and Wildlife Service, Fishery Bulletin 67:243-280.

Mundy, P. R. 1982. Computation of migratory timing statistics for adult Chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. North American Journal of Fisheries Management 2:359-370.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191:382.

Scarnecchia, D. L. 1979. Variation of scale characteristics of coho salmon with sampling location on the body. Progressive Fish Culturist 41(3):132-135.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. 2nd edition. Griffin and Company, Ltd. London.

REFERENCES CITED (Continued)

Shaul, L., P. L. Gray, and J. F. Koerner. 1991. Coded wire tag estimates of abundance, harvest, and survival rates of selected coho salmon stocks in Southeast Alaska, 1981-1986. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Research Bulletin 91-05, Juneau.

Shaul, L., E. Jones, K. Crabtree, T. Tydingco, S. McCurdy, and B. Elliott. 2008. Coho salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 08-20, Anchorage. http://www.adfg.alaska.gov/sp08-20.pdf

Shaul, L. D. 1991. Fishery contributions, escapements, harvest rates, migratory patterns and survival rates of wild coho (*Oncorhynchus kisutch*) stocks in Southeast Alaska based on coded-wire tagging studies, 1986-1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J91-21, Juneau.

Southwick Associates Inc., W. J. Romberg, A. E. Bingham, G. B. Jennings, and R. A. Clark. 2008. Economic impacts and contributions of sportfishing in Alaska, 2007. Alaska Department of Fish and Game, Professional Paper No. 08-01, Anchorage. http://www.adfg.alaska.gov/FedAidpdfs/pp08-01.pdf

Vincent-Lang, D. 1993. Relative survival of unmarked and fin-clipped coho salmon from Bear Lake, Alaska. The Progressive Fish-Culturist 55(3):141-148.

Walker, R. J., C. Olnes, K. Sundet, A. L. Howe, and A. E. Bingham. 2003. Participation, catch, and harvest in Alaska sport fisheries during 2000. Alaska Department of Fish and Game, Fishery Data Series No. 03-05, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds03-05.pdf

Weller, J. L., E. L. Jones III, and A. B. Holm. 2005. Production of coho salmon from the Unuk River, 2002-2003. Alaska Department of Fish and Game, Fishery Data Series No. 05-21, Anchorage. http://www.adfg.alaska.gov/FedAidPDFs/fds05-21.pdf

APPENDIX A

Appendix A1.–Random and select recoveries of coded wire tagged Chilkat River coho salmon, 2008.

Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
RANDOM RECOVERIES									
69627	41372	Sport	Gustavus	8/23/2008	34	NW	114	25	680
98755	41370	Sport	Elfin Cove	8/14/2008	33	NW	114	21	670
265560	41370	Sport	Juneau	8/31/2008	36	NE	112	15	640
540757	41370	Drift Gillnet	Excursion Inlet	8/13/2008	33	NE	115	ND	540
540759	41371	Drift Gillnet	Excursion Inlet	8/13/2008	33	NE	115	ND	495
540966	41370	Drift Gillnet	Excursion Inlet	8/27/2008	35	NE	115	ND	595
257050	41371	Drift Gillnet	Juneau	8/27/2008	35	NE	111	32	565
540968	41372	Drift Gillnet	Excursion Inlet	8/27/2008	35	NE	115	ND	625
540979	41370	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	570
540988	41370	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	575
540985	41370	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	600
540980	41371	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	630
540984	41371	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	640
540986	41371	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	705
540983	41372	Drift Gillnet	Excursion Inlet	8/28/2008	35	NE	115	ND	665
54625	41370	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	570
54627	41370	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	610
54621	41370	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	650
54641	41370	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	585
54629	41370	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	660
54648	41370	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	665
54619	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	605
54624	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	675
54626	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	675
54620	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	700
54617	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	705
54646	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	635
54634	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	675
54645	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	680
54637	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	690
54633	41371	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	ND	725
54623	41372	Drift Gillnet	Excursion Inlet	9/3/2008	36	NE	115	31	655
355257	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	580
355240	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	610
355346	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	620
355367	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	640
355355	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	645
355255	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	650
355245	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	665
355349	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	675
355237	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	685
355259	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	695
355242	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	700
355358	41370	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	720
355340	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	585
355266	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	605
355356	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	605
355246	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	625
355359	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	630
355371	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	630
355362	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	640
355248	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	650
355365	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	660
355252	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	665
355258	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	670

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
355360	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	675
355249	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	680
355344	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	680
355368	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	680
355263	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	685
355247	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	690
355261	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	690
355262	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	695
355251	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	700
355345	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	700
355363	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	700
355267	41371	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	735
355260	41372	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	585
355339	41372	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	610
355369	41372	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	610
355264	41372	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	640
355354	41372	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	640
355254	41372	Drift Gillnet	Juneau	9/10/2008	37	NE	115	ND	655
355311	41370	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	500
355323	41370	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	600
355303	41370	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	635
355292	41370	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	700
355329	41371	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	620
355300	41371	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	675
355325	41371	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	685
355317	41371	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	690
355337	41371	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	725
355333	41371	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	745
355302	41372	Drift Gillnet	Juneau	9/11/2008	37	NE	115	ND	695
355503	41370	Drift Gillnet	Juneau	9/16/2008	38	NE	115	ND	640
355512	41370	Drift Gillnet	Juneau	9/16/2008	38	NE	115	ND	665
355393	41371	Drift Gillnet	Juneau	9/16/2008	38	NE	115	ND	605
355511	41371	Drift Gillnet	Juneau	9/16/2008	38	NE	115	ND	645
355504	41371	Drift Gillnet	Juneau	9/16/2008	38	NE	115	ND	665
355506	41372	Drift Gillnet	Juneau	9/16/2008	38	NE	115	ND	645
355550	41370	Drift Gillnet	Juneau	9/18/2008	38	NE	115	ND	640
355547	41371	Drift Gillnet	Juneau	9/18/2008	38	NE	115	ND	675
355548	41372	Drift Gillnet	Juneau	9/18/2008	38	NE	115	ND	650
334415	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	570
334451	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	605
355572	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	605
355584	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	605
334427	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	610
355574	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	610
334430	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	630
334437	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	635
355585	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	635
334433	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	650
334459	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	655
334463	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	655
334448	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	660
334440	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	680
334411	41370	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	685
355591	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	610
334401	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	625
355579	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	630

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
355586	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	630
355596	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	655
334436	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	665
334462	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	670
355575	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	670
355581	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	670
355573	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	675
334455	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	700
334418	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	720
334441	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	720
334431	41371	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	730
334458	41372	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	585
355578	41372	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	650
334450	41372	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	665
334461	41372	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	680
334456	41372	Drift Gillnet	Juneau	9/23/2008	39	NE	115	ND	690
334488	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	540
334506	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	585
334519	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	605
334491	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	610
334477	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	620
334498	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	620
334512	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	630
334517	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	630
334500	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	635
334482	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	640
334475	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	645
334476	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	645
334490	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	645
334472	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	655
334503	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	660
334547	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	665
334478	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	670
334473	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	685
334513	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	685
334514	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	690
334516	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	690
334494	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	700
334518	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	700
334510	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	710
334522	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334523	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334524	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334532	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334533	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334534	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334540	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334542	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334543	41370	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334485	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	575
334471	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	590
334481	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	605
334469	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	620
334496	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	625
334466	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	670
334470	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	670
334509	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	670

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
334548	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	670
334464	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	675
334508	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	685
334549	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	685
334468	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	690
334497	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	690
334479	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	695
334465	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	700
334483	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	710
334486	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	710
334487	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	710
334493	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	710
334489	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	720
334501	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	720
334499	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	730
334525	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334529	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334531	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334536	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334537	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334539	41371	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334484	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	570
334511	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	595
334502	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	600
334505	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	625
334474	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	640
334480	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	650
334467	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	655
334495	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	665
334507	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	690
334527	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334528	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334530	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334538	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334541	41372	Drift Gillnet	Juneau	9/25/2008	39	NE	115	ND	ND
334567	41370	Drift Gillnet	Juneau	9/26/2008	39	NE	115	10	545
334553	41371	Drift Gillnet	Juneau	9/26/2008	39	NE	115	10	595
334552	41371	Drift Gillnet	Juneau	9/26/2008	39	NE	115	10	660
334550	41371	Drift Gillnet	Juneau	9/26/2008	39	NE	115	10	685
334565	41371	Drift Gillnet	Juneau	9/26/2008	39	NE	115	10	695
334582	41370	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	610
334596	41370	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	620
334578	41370	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	660
334589	41370	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	665
334595	41370	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	670
334594	41370	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	705
334592	41371	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	660
334579	41371	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	665
334581	41371	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	705
334575	41372	Drift Gillnet	Juneau	9/30/2008	40	NE	115	ND	680
334597	41371	Drift Gillnet	Juneau	10/2/2008	40	NE	115	ND	700
529697	41370	Troll	Excursion Inlet	7/5/2008	27	NW	ND	ND	615
541330	41370	Troll	Pelican	7/19/2008	29	NW	ND	ND	545
541333	41371	Troll	Pelican	7/19/2008	29	NW	ND	ND	660
333337	41372	Troll	Sitka	7/19/2008	29	NW	ND	ND	545
331526	41371	Troll	Sitka	7/23/2008	30	NW	113	11	620
333444	41370	Troll	Sitka	7/25/2008	30	NW	113	21	535

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
354425	41371	Troll	Hoonah	7/27/2008	31	NW	114	21	587
331631	41370	Troll	Sitka	7/28/2008	31	NW	ND	ND	555
331619	41371	Troll	Sitka	7/28/2008	31	NW	ND	ND	600
517964	41370	Troll	Excursion Inlet	7/29/2008	31	NW	114	21	580
354472	41372	Troll	Hoonah	7/29/2008	31	NW	ND	ND	550
354501	41370	Troll	Hoonah	7/30/2008	31	NW	ND	ND	552
331324	41371	Troll	Sitka	7/31/2008	31	NW	ND	ND	605
331329	41371	Troll	Sitka	7/31/2008	31	NW	ND	ND	640
354555	41371	Troll	Hoonah	8/1/2008	31	NW	ND	ND	707
354558	41372	Troll	Hoonah	8/1/2008	31	NW	ND	ND	579
331941	41370	Troll	Sitka	8/3/2008	32	NW	113	21	530
331907	41371	Troll	Sitka	8/3/2008	32	NW	113	21	580
354587	41370	Troll	Hoonah	8/5/2008	32	NW	116	14	639
257018	41371	Troll	Juneau	8/5/2008	32	NW	116	11	648
540671	41371	Troll	Excursion Inlet	8/5/2008	32	NW	ND	ND	570
354643	41370	Troll	Hoonah	8/7/2008	32	NW	ND	ND	500
354642	41370	Troll	Hoonah	8/7/2008	32	NW	ND	ND	551
354641	41371	Troll	Hoonah	8/7/2008	32	NW	ND	ND	445
357054	41370	Troll	Sitka	8/10/2008	33	NW	113	21	540
540739	41370	Troll	Excursion Inlet	8/10/2008	33	NW	ND	ND	560
354680	41370	Troll	Hoonah	8/10/2008	33	NW	ND	ND	584
900090	41370	Troll	Sitka	8/10/2008	33	NW	116	13	
357057	41371	Troll	Sitka	8/10/2008	33	NW	113	21	640
354682	41371	Troll	Hoonah	8/10/2008	33	NW	ND	ND	505
354691	41371	Troll	Hoonah	8/10/2008	33	NW	ND	ND	552
354695	41371	Troll	Hoonah	8/10/2008	33	NW	ND	ND	622
540741	41371	Troll	Excursion Inlet	8/10/2008	33	NW	ND	ND	645
354656	41371	Troll	Hoonah	8/10/2008	33	NW	ND	ND	671
354644	41370	Troll	Hoonah	8/11/2008	33	NW	113	91	598
354832	41371	Troll	Hoonah	8/18/2008	34	NW	113	ND	464
540828	41371	Troll	Excursion Inlet	8/20/2008	34	NW	ND	ND	620
354902	41371	Troll	Hoonah	8/20/2008	34	NW	ND	ND	704
540827	41372	Troll	Excursion Inlet	8/20/2008	34	NW	ND	ND	695
354915	41371	Troll	Hoonah	8/21/2008	34	NW	114	ND	665
357282	41372	Troll	Sitka	8/21/2008	34	NW	113	45	635
540873	41370	Troll	Excursion Inlet	8/22/2008	34	NW	ND	ND	560
357691	41371	Troll	Sitka	8/22/2008	34	NW	113	45	675
540879	41371	Troll	Excursion Inlet	8/22/2008	34	NW	ND	ND	695
540877	41372	Troll	Excursion Inlet	8/22/2008	34	NW	ND	ND	530
540932	41371	Troll	Excursion Inlet	8/25/2008	35	NW	ND	ND	690
540950	41371	Troll	Excursion Inlet	8/25/2008	35	NW	ND	ND	695
540938	41371	Troll	Excursion Inlet	8/25/2008	35	NW	ND	ND	710
540942	41371	Troll	Excursion Inlet	8/25/2008	35	NW	ND	ND	730
355022	41371	Troll	Hoonah	8/27/2008	35	NW	114	27	664
69776	41371	Troll	Yakutat	8/27/2008	35	NW	189	30	620
69767	41371	Troll	Yakutat	8/27/2008	35	NW	189	30	670
355037	41371	Troll	Hoonah	8/27/2008	35	NW	ND	ND	672
69785	41370	Troll	Yakutat	8/28/2008	35	NW	189	30	680
332019	41371	Troll	Sitka	8/28/2008	35	NE	109	ND	650
69782	41371	Troll	Yakutat	8/28/2008	35	NW	189	30	695
541000	41371	Troll	Excursion Inlet	8/28/2008	35	NW	ND	ND	690
54562	41370	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	505
54584	41370	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	595
54590	41370	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	660
54601	41370	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	665
54583	41371	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	640
54574	41371	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	675

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
54578	41371	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	690
54585	41371	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	695
54588	41371	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	710
54569	41372	Troll	Excursion Inlet	8/31/2008	36	NW	ND	ND	670
355045	41371	Troll	Hoonah	9/1/2008	36	NW	ND	ND	570
355047	41371	Troll	Hoonah	9/1/2008	36	NW	ND	ND	729
355078	41372	Troll	Hoonah	9/2/2008	36	NW	ND	ND	628
357838	41370	Troll	Sitka	9/3/2008	36	NW	ND	ND	520
357830	41370	Troll	Sitka	9/3/2008	36	NW	ND	ND	605
332090	41370	Troll	Sitka	9/3/2008	36	NW	ND	ND	620
54650	41370	Troll	Excursion Inlet	9/3/2008	36	NW	ND	ND	655
332419	41371	Troll	Sitka	9/3/2008	36	NW	ND	ND	655
76426	41371	Troll	Excursion Inlet	9/3/2008	36	NW	ND	ND	480
76442	41371	Troll	Excursion Inlet	9/3/2008	36	NW	ND	ND	625
76424	41371	Troll	Excursion Inlet	9/3/2008	36	NW	ND	ND	680
332529	41372	Troll	Sitka	9/3/2008	36	NW	ND	ND	650
332544	41372	Troll	Sitka	9/3/2008	36	NW	ND	ND	670
332531	41372	Troll	Sitka	9/3/2008	36	NW	ND	ND	675
332523	41372	Troll	Sitka	9/3/2008	36	NW	ND	ND	690
76412	41372	Troll	Excursion Inlet	9/3/2008	36	NW	ND	ND	655
69798	41370	Troll	Yakutat	9/5/2008	36	NW	189	30	625
76481	41370	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	590
76448	41370	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	655
76464	41371	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	665
76480	41371	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	720
354945	41371	Troll	Hoonah	9/5/2008	36	NW	ND	ND	720
76458	41372	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	615
76465	41372	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	655
76462	41372	Troll	Excursion Inlet	9/5/2008	36	NW	ND	ND	680
70717	41370	Troll	Yakutat	9/6/2008	36	NW	189	30	705
71251	41370	Troll	Yakutat	9/7/2008	37	NW	181	60	605
70748	41371	Troll	Yakutat	9/7/2008	37	NW	181	60	665
332456	41372	Troll	Sitka	9/7/2008	37	NW	113	91	660
70735	41372	Troll	Yakutat	9/7/2008	37	NW	ND	ND	660
355428	41370	Troll	Juneau	9/8/2008	37	NW	113	91	650
355442	41370	Troll	Juneau	9/8/2008	37	NW	113	91	660
355458	41370	Troll	Juneau	9/8/2008	37	NW	113	91	680
355438	41370	Troll	Juneau	9/8/2008	37	NW	113	91	695
71258	41370	Troll	Yakutat	9/8/2008	37	NW	189	30	640
355457	41371	Troll	Juneau	9/8/2008	37	NW	113	91	593
355228	41371	Troll	Juneau	9/8/2008	37	NW	113	91	675
355215	41371	Troll	Juneau	9/8/2008	37	NW	113	91	715
355431	41372	Troll	Juneau	9/8/2008	37	NW	113	91	650
355233	41372	Troll	Juneau	9/8/2008	37	NW	113	91	665
337023	41371	Troll	Sitka	9/9/2008	37	NE	109	ND	600
357894	41371	Troll	Sitka	9/9/2008	37	NE	109	ND	690
332175	41371	Troll	Sitka	9/9/2008	37	NW	ND	ND	540
332174	41371	Troll	Sitka	9/9/2008	37	NW	ND	ND	570
332169	41371	Troll	Sitka	9/9/2008	37	NW	ND	ND	605
332188	41371	Troll	Sitka	9/9/2008	37	NW	ND	ND	625
332183	41371	Troll	Sitka	9/9/2008	37	NW	ND	ND	640
332928	41371	Troll	Sitka	9/9/2008	37	NW	ND	ND	710
332173	41372	Troll	Sitka	9/9/2008	37	NW	ND	ND	600
332189	41372	Troll	Sitka	9/9/2008	37	NW	ND	ND	670
332948	41372	Troll	Sitka	9/9/2008	37	NW	ND	ND	705
355115	41372	Troll	Hoonah	9/10/2008	37	NW	ND	ND	658
332676	41370	Troll	Sitka	9/12/2008	37	NW	ND	ND	630

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
332720	41370	Troll	Sitka	9/12/2008	37	NW	ND	ND	635
332659	41371	Troll	Sitka	9/12/2008	37	NW	ND	ND	635
332695	41371	Troll	Sitka	9/12/2008	37	NW	ND	ND	680
337302	41372	Troll	Sitka	9/12/2008	37	NW	ND	ND	690
355146	41370	Troll	Hoonah	9/15/2008	38	NW	ND	ND	646
900558	41371	Troll	Sitka	9/15/2008	38	NW	113	91	
355149	41372	Troll	Hoonah	9/15/2008	38	NW	ND	ND	687
355533	41370	Troll	Juneau	9/16/2008	38	NW	113	91	665
355182	41370	Troll	Hoonah	9/16/2008	38	NW	ND	ND	566
355524	41371	Troll	Juneau	9/16/2008	38	NW	113	91	650
355537	41371	Troll	Juneau	9/16/2008	38	NW	113	91	665
355190	41371	Troll	Hoonah	9/16/2008	38	NW			620
355482	41372	Troll	Juneau	9/16/2008	38	NW	113	91	640
337354	41370	Troll	Sitka	9/17/2008	38	NW	113	91	690
355175	41370	Troll	Hoonah	9/17/2008	38	NW	114	25	630
332848	41370	Troll	Sitka	9/17/2008	38	NW	ND	ND	630
332847	41370	Troll	Sitka	9/17/2008	38	NW	ND	ND	660
332876	41370	Troll	Sitka	9/17/2008	38	NW	ND	ND	675
332869	41371	Troll	Sitka	9/17/2008	38	NW	ND	ND	640
332865	41371	Troll	Sitka	9/17/2008	38	NW	ND	ND	680
332867	41371	Troll	Sitka	9/17/2008	38	NW	ND	ND	680
355178	41371	Troll	Hoonah	9/18/2008	38	NW	189	30	721
332731	41370	Troll	Sitka	9/19/2008	38	NW	113	45	575
337058	41370	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
337070	41370	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
337389	41370	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
337040	41371	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
337075	41371	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
337397	41372	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
337404	41372	Troll	Sitka	9/19/2008	38	NW	ND	ND	ND
355194	41371	Troll	Hoonah	9/20/2008	38	NW	114	25	731
321809	41372	Fishwheels	Chilkat River	8/20/2008	34	NW	115	32	400
321810	41370	Fishwheels	Chilkat River	8/30/2008	35	NW	115	32	570
321811	41370	Fishwheels	Chilkat River	9/6/2008	36	NW	115	32	580
321812	41371	Fishwheels	Chilkat River	9/8/2008	37	NW	115	32	600
321813	41372	Fishwheels	Chilkat River	9/8/2008	37	NW	115	32	640
321815	41370	Fishwheels	Chilkat River	9/9/2008	37	NW	115	32	620
321816	41370	Fishwheels	Chilkat River	9/9/2008	37	NW	115	32	650
321818	41370	Fishwheels	Chilkat River	9/10/2008	37	NW	115	32	330
321817	41370	Fishwheels	Chilkat River	9/10/2008	37	NW	115	32	580
321819	41370	Fishwheels	Chilkat River	9/11/2008	37	NW	115	32	590
321820	41372	Fishwheels	Chilkat River	9/13/2008	37	NW	115	32	635
321821	41370	Fishwheels	Chilkat River	9/14/2008	38	NW	115	32	390
321823	41371	Fishwheels	Chilkat River	9/16/2008	38	NW	115	32	605
321822	41371	Fishwheels	Chilkat River	9/16/2008	38	NW	115	32	640
321825	41371	Fishwheels	Chilkat River	9/16/2008	38	NW	115	32	645
321824	41372	Fishwheels	Chilkat River	9/16/2008	38	NW	115	32	715
321826	41370	Fishwheels	Chilkat River	9/18/2008	38	NW	115	32	650
321827	41371	Fishwheels	Chilkat River	9/19/2008	38	NW	115	32	485
321828	41370	Fishwheels	Chilkat River	9/20/2008	38	NW	115	32	550
321830	41370	Fishwheels	Chilkat River	9/20/2008	38	NW	115	32	660
321833	41371	Fishwheels	Chilkat River	9/20/2008	38	NW	115	32	635
321829	41371	Fishwheels	Chilkat River	9/20/2008	38	NW	115	32	640
321832	41371	Fishwheels	Chilkat River	9/20/2008	38	NW	115	32	675
321831	41372	Fishwheels	Chilkat River	9/20/2008	38	NW	115	32	630
321835	41371	Fishwheels	Chilkat River	9/21/2008	39	NW	115	32	660
321836	41371	Fishwheels	Chilkat River	9/21/2008	39	NW	115	32	685

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Head number	Tag code	Gear	Port	Recovery date	Stat. week	Quad-rant	Dist.	Sub-dist.	Length
321837	41371	Fishwheels	Chilkat River	9/21/2008	39	NW	115	32	705
321841	41370	Fishwheels	Chilkat River	9/22/2008	39	NW	115	32	495
321843	41370	Fishwheels	Chilkat River	9/22/2008	39	NW	115	32	640
321842	41370	Fishwheels	Chilkat River	9/22/2008	39	NW	115	32	695
321839	41371	Fishwheels	Chilkat River	9/22/2008	39	NW	115	32	650
321838	41371	Fishwheels	Chilkat River	9/22/2008	39	NW	115	32	675
321850	41370	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	370
321849	41370	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	655
321851	41370	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	655
321848	41370	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	690
321847	41370	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	710
321844	41371	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	620
321845	41372	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	600
321846	41372	Fishwheels	Chilkat River	9/23/2008	39	NW	115	32	640
321853	41370	Fishwheels	Chilkat River	9/24/2008	39	NW	115	32	600
321854	41371	Fishwheels	Chilkat River	9/25/2008	39	NW	115	32	680
321856	41370	Fishwheels	Chilkat River	9/26/2008	39	NW	115	32	680
321855	41371	Fishwheels	Chilkat River	9/26/2008	39	NW	115	32	545
321858	41371	Fishwheels	Chilkat River	9/26/2008	39	NW	115	32	700
321857	41371	Fishwheels	Chilkat River	9/26/2008	39	NW	115	32	720
321862	41370	Fishwheels	Chilkat River	9/27/2008	39	NW	115	32	665
321860	41370	Fishwheels	Chilkat River	9/27/2008	39	NW	115	32	670
321861	41371	Fishwheels	Chilkat River	9/27/2008	39	NW	115	32	610
321863	41371	Fishwheels	Chilkat River	9/29/2008	40	NW	115	32	600
321864	41370	Fishwheels	Chilkat River	9/30/2008	40	NW	115	32	670
321868	41370	Fishwheels	Chilkat River	9/30/2008	40	NW	115	32	670
321865	41371	Fishwheels	Chilkat River	9/30/2008	40	NW	115	32	670
321866	41372	Fishwheels	Chilkat River	9/30/2008	40	NW	115	32	610
321867	41372	Fishwheels	Chilkat River	9/30/2008	40	NW	115	32	680
321870	41370	Fishwheels	Chilkat River	10/2/2008	40	NW	115	32	630
321869	41370	Fishwheels	Chilkat River	10/2/2008	40	NW	115	32	645
321871	41370	Fishwheels	Chilkat River	10/4/2008	40	NW	115	32	695
321872	41371	Fishwheels	Chilkat River	10/4/2008	40	NW	115	32	600
321873	41370	Fishwheels	Chilkat River	10/5/2008	41	NW	115	32	690
321874	41371	Fishwheels	Chilkat River	10/5/2008	41	NW	115	32	675
321879	41370	Fishwheels	Chilkat River	10/6/2008	41	NW	115	32	585
321878	41370	Fishwheels	Chilkat River	10/6/2008	41	NW	115	32	620
321876	41370	Fishwheels	Chilkat River	10/6/2008	41	NW	115	32	625
321880	41371	Fishwheels	Chilkat River	10/6/2008	41	NW	115	32	665
321883	41370	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	595
321882	41370	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	610
321888	41371	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	570
321890	41371	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	630
321884	41371	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	660
321889	41371	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	665
321887	41371	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	705
321881	41371	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	735
321885	41372	Fishwheels	Chilkat River	10/7/2008	41	NW	115	32	630
321892	41370	Fishwheels	Chilkat River	10/8/2008	41	NW	115	32	555
321891	41371	Fishwheels	Chilkat River	10/8/2008	41	NW	115	32	620
321893	41370	Fishwheels	Chilkat River	10/9/2008	41	NW	115	32	665
321894	41370	Fishwheels	Chilkat River	10/9/2008	41	NW	115	32	700
321895	41371	Fishwheels	Chilkat River	10/9/2008	41	NW	115	32	660
254135	41372	Sport	Chilkat River	10/21/2008	43	NW	115	32	

Appendix A2.–Age, sex, and length composition of coho salmon sampled at the Chilkat River fish wheels, and estimated escapement in the first of two time strata, July 31–September 21, 2008.

	Brood year and age class					
	2006	2005	2005	2004		
	1.0	2.0	1.1	2.1	Total aged	Total sampled[a]
			Females			
Sample size			158	44	202	560
Percent			27.8	7.7		38.1
SE			1.9	1.1		1.3
Number			7,273	2,025		9,299
SE			1,384	462		2,153
Mean length			636	643		
SD			50	49		
			Males			
Sample size	1	6	284	77	368	906
Percent	0.2	1.1	49.8	13.5		61.7
SE		0.4	2.1	1.4		1.3
Number	46	276	13,074	3,545		16,940
SE		121	2,392	732		3,447
Mean length	285	319	572	602		
SD		49	115	96		
			All fish[b]			
Sample size	1	6	442	121	570	1,468
Percent	0.2	1.1	77.5	21.2		45.7
SE		0.4	1.7	1.7		0.9
Number	46	276	20,347	5,570		26,239
SE		121	2,764	866		4,677
Mean length	285	319	595	617		
SD		49	102	84		

[a] Includes fish not assigned an age.
[b] Includes fish with no sex information.

Appendix A3.–Age, sex, and length composition of coho salmon sampled at the Chilkat River fish wheels and estimated escapement in the second of 2 time strata, September 22–October 10, 2008.

	Brood year and age class					
	2006	2005	2005	2004		
	1.0	2.0	1.1	2.1	Total aged	Total sampled[a]
			Females			
Sample size			183	62	245	726
Percent			32.2	10.9		41.7
SE			2.0	1.3		1.2
Number			10,014	3,393		13,407
SE			1,883	725		2,341
Mean length			644	662		
SD			45	41		
			Males			
Sample size	13		240	71	324	1,007
Percent	2.3		42.2	12.5		57.8
SE	0.6		2.1	1.4		1.2
Number	711		13,133	3,885		17,730
SE	230		2,426	812		3,229
Mean length	332		643	655		
SD	22		71	76		
			All fish[b]			
Sample size	13		423	133	569	1,742
Percent	2.3		74.3	23.4		54.3
SE	0.6		1.8	1.8		0.9
Number	711		23,147	7,278		31,137
SE	230		3,071	1,089		5,550
Mean length	332		643	658		
SD	22		61	62		

[a] Includes fish not assigned an age.
[b] Includes fish with no sex information.

APPENDIX B

Appendix B1.–An alternate smolt abundance estimator using two tagging groups and differential recovery rates.

Coded wire tagging coho salmon smolt in different size groups allows for testing of mark-recapture assumption [a], i.e., that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish. In the event that chi-square tests indicate unequal probabilities of tagging in event 1 or capture in event 2, an alternate Peterson mark-recapture model will be used for a 2-group population.

A population divided into 2 groups labeled (1) and (2), Peterson's mark-recapture model can be expanded into:

$$N_1 + N_2 = \left(N_1\alpha_1 + N_2\alpha_2\right)\frac{N_1\alpha_1 S_1 B_1 + N_2\alpha_2 S_2 B_2 + N_1\left(1-\alpha_1\right)S_1 B_1 + N_2\left(1-\alpha_2\right)S_2 B_2}{N_1\alpha_1 S_1 B_1 + N_2\alpha_2 S_2 B_2} \qquad \text{(B.1)}$$

In the above equation, N is abundance, α_i is the capture probability in event 1 for each group, S_i the survival rate for each group, and β_i the capture probability for each group.

If one or both capture probability parameters, α_i or β_i, are equal, then the above equation reduces to a more simplified version. Consider the case when $\beta_1 = \beta_2$, the abundance estimator reduces to:

$$N_1 + N_2 = \left(N_1\alpha_1 + N_2\alpha_2\right)\frac{N_1\alpha_1 S_1 + N_2\alpha_2 S_2 + N_1\left(1-\alpha_1\right)S_1 + N_2\left(1-\alpha_2\right)S_2}{N_1\alpha_1 S_1 + N_2\alpha_2 S_2} \qquad \text{(B.2)}$$

If the relationship between α_i parameters is expressed as $A = \alpha_2 / \alpha_1$ and the relationship between S_i parameters is expressed as $B = S_2 / S_1$, equation (B.2) reduces further to:

$$N_1 + N_2 = \frac{\left(N_1 + AN_2\right)\left(N_1 + BN_2\right)}{N_1 + ABN_2} \qquad \text{(B.3)}$$

It is important to note that equation (B.3) is only true if $A = 1$ (i.e. $\alpha_2 = \alpha_1$) OR if $B = 1$ ($S_2 = S_1$). If both A and B are not equal to 1, the above relationship does not hold and an unbiased estimator of abundance cannot be produced. If it is determined that there are both unequal marking probabilities (event 1) and unequal capture or survival probabilities (event 2), Peterson's model can be adjusted to produce an unbiased estimate of smolt abundance.

-continued-

Consider Chapman's modification of the standard Peterson model with two tagging groups, labeled group 1 and group 2:

$$\hat{N} = \frac{(N1_1 + N1_2 + 1)(N2 + 1)}{(M2_1 + M2_2 + 1)} \quad \text{(B.4)}$$

where $N1_1$ and $N1_2$ are the number marked in groups 1 and 2, $N2$ is the number inspected for marks in the second event, and $M2_1$ and $M2_2$ are the amount of marks recovered from groups 1 and 2. Consider the case where $A > 1$ and $S > 1$, that is, group 2 had both a higher marking probability and capture probability. This would create a negative bias in the estimator and $N > \hat{N}$. Adjusting Chapman's modification for this tagging bias results in a new, unbiased estimator:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}M2_1 + M2_2 + 1} - 1 \quad \text{(B.5)}$$

Using the scaler $\hat{A}$, i.e. the ratio of marking rates of the 2 groups, essentially forces the 2 groups to have the same marking probability, and therefore the expected value of equation (B.5) equals N as a result.

Retention rates for coded wire tagged fish are rarely 100%; adipose fin-clipped fish sometime do not contain valid CWTs as tags are shed during freshwater or marine rearing. Also occasionally heads are lost from adipose fin-clipped fish before they can become decoded. Because of this, a new parameter $\hat{\pi}$ can be used to adjust for adipose fin-clipped fish with no tag information ($M2_U$), which is the observed ratio of tags recovered from group 1 divided by group 2. Basically the observed recovery rate is extrapolated for fish marked in the first event (as indicated by an adipose fin clip) that contain no tag information:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}(M2_1 + (\hat{\pi})M2_U) + M2_2 + (1 - \hat{\pi})M2_U + 1} - 1 \quad \text{(B.6)}$$

In the event that all observed adipose fin-clipped fish contain valid coded wire tags, the term $M2_U$ is zero and equation (B.6) is identical to equation (B.5).

Variance and relative bias in the modified estimator can be estimated through bootstrapping techniques outlined in Efron and Tibshirani (1993).

APPENDIX C

Appendix C1.–Computer files used in the analysis of data for this report.

FILE NAME	DESCRIPTION
07ChilkatCohoSmolt.xlsx	Excel workbook containing 2007 Chilkat River coho salmon smolt trapping, CWT release, smolt emigration estimator, and age-weight-length data.
08ChilkatCohoFWanalysis.xlsx	Excel workbook containing 2008 Chilkat River fish wheel coho salmon catch, marking, and age-length sample data.
08ChilkatCohoCWTrecoveries.xlsx	Excel workbook containing CWT recovery data and harvest estimates of Chilkat River coho salmon tagged as smolt during 2007.
DiscussionFiguresTables0708ChilkatCoho	Excel workbook containing figures and tables used in the discussion section of the 2007–2008 Chilkat River coho salmon FDS report