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Escapement and Harvest of Chilkoot River Sockeye Salmon, 2004–2006

by

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November 2013

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 Alaska Department of Fish and Game, Division of Commercial Fisheries, conducted a stock assessment program to estimate escapements and harvests of adult Chilkoot Lake sockeye salmon (*Oncorhynchus nerka*) in 2004–2006. This program began in 1976. Adult sockeye salmon were counted through a weir near the outlet of Chilkoot Lake, and age, length, and sex data were collected and analyzed each year. Visual scale pattern analysis was conducted to determine the proportion of Chilkoot sockeye salmon harvested annually in the District 15 commercial drift gillnet fishery. In addition, zooplankton and hydroacoustic surveys were conducted in Chilkoot Lake and analyzed each year. Sockeye salmon escapement counts at the weir were 75,591 in 2004, 51,178 in 2005, and 96,203 in 2006, all of which met established escapement goals. The commercial drift gillnet harvest of Chilkoot Lake sockeye salmon was estimated to be 66,498 in 2004, 29,276 in 2005, and 119,201 in 2006. Estimated exploitation rates were 48% in 2004, 38% in 2005, and 56% in 2006. A mark-recapture study was conducted in 2004 to estimate the sockeye salmon spawning population in the Chilkoot drainage. The mark-recapture estimate of 150,000 fish (SE 26,000, 95% CI of 119,000–181,000) was double the weir count. Over the nine-year series of mark-recapture estimates since 1996, mark-recapture estimates averaged 1.85 times greater than weir counts and were highly variable compared to weir counts. Rearing sockeye salmon fry population estimates of approximately 247,000 (2005) and 357,000 (2006) were well below average.

Key words: abundance estimate, Chilkoot Lake, Chilkoot River, commercial harvest, hydroacoustic survey, *Oncorhynchus nerka*, mark-recapture, scale pattern analysis, sockeye salmon, weir, zooplankton

INTRODUCTION

The Chilkoot and Chilkat river watersheds, located in northern Southeast Alaska, near the town of Haines, support two of the largest sockeye salmon (*Oncorhynchus nerka*) runs in Southeast Alaska. Between 1900 and 1920, the annual commercial harvest of sockeye salmon in northern Southeast Alaska averaged 1.5 million fish, the majority of which were believed to originate from Chilkat and Chilkoot (Rich and Ball 1933). Over the past two decades, the average sockeye salmon harvest in northern Southeast Alaska was 0.5 million fish, of which an average 65,000 fish originated from Chilkoot Lake and 96,000 fish originated from Chilkat Lake (Eggers et al. 2010). Historically, Chilkoot Lake sockeye salmon were harvested in the large fish trap and purse seine fisheries in Icy and northern Chatham straits as well as in terminal drift gillnet areas of Lynn Canal. Fish traps were eliminated with Alaska statehood in 1959 and Lynn Canal developed into a designated drift gillnet fishing area (Alaska Department of Fish and Game [ADF&G] District 15; Figure 1) where most of the commercial harvest of Chilkoot sockeye salmon takes place. A smaller portion of the Chilkoot run is intercepted in commercial purse seine fisheries that target pink salmon (*O. gorbuscha*) in Icy and northern Chatham straits. Annual contributions to those fisheries are not known and likely vary annually depending on fishing effort and the strength of pink salmon runs. Chilkoot sockeye salmon are also harvested annually in subsistence and sport fisheries, which average about 2,500 fish per year (Eggers et al. 2010).

The Alaska Department of Fish and Game (ADF&G) initiated a scale pattern analysis program in 1980 to estimate contributions of sockeye salmon stocks to the District 15 commercial drift gillnet fishery. Bergander (1974) first developed a dichotomous key to classify sockeye salmon scale samples from the Lynn Canal fishery as Chilkoot or Chilkat fish, based on distinct differences in their freshwater scale patterns (Stockley 1950). Marshall et al. (1982) improved the sample design and estimated stock contributions using linear discriminant function analysis. McPherson and Marshall (1986) showed that all age classes of the two stocks could be identified accurately using a visual classification technique and blind testing procedure. That technique was expanded to include a third stock group, a combination of Chilkat River mainstem and Berners

Bay stocks that contribute to early-season catches in Lynn Canal (McPherson 1987b). Blind tests to verify accuracy and correct for misclassification have not been conducted since the early 1990s; however, historical stock-specific harvest estimates based solely on visual classification were highly accurate and the difference between initial and corrected estimates varied by only 2% or less (McPherson and Marshall 1986; McPherson 1987a-b; McPherson and Jones 1987; McPherson 1989; McPherson et al. 1992; McPherson and Olsen 1992). The consistent differences in freshwater scale patterns makes visual scale pattern analysis highly accurate, and it is more cost effective and requires less time than other stock-identification methods (McPherson 1990; McPherson and Olsen 1992).

Chilkoot sockeye salmon escapements have been counted annually through an adult counting weir on the Chilkoot River since 1976 (Bachman and Sogge 2006; Appendix B). The run has two components, an early and a late run, which were managed as separate units through 2005 (Geiger et al. 2005). Total annual weir counts averaged 80,000 sockeye salmon through 1993, but declined to an average of only 30,000 fish from 1994 to 2000. An extremely low escapement in 1995 (7,177) prompted ADF&G to conduct mark-recapture studies to verify weir counts, and mark-recapture studies have been conducted annually since 1996 (Kelley and Bachman 1999; Bachman and Sogge 2006; Appendix C). In addition to salmon counts, biological data have been collected annually at the weir to estimate age, size, and sex composition of the escapement and for use in scale pattern analysis. Basic information about lake productivity and rearing sockeye salmon fry populations has been collected through limnological and hydroacoustic sampling conduced most years from 1987 to 2003 (Barto 1996; Riffe 2006). Those studies have been used to assess potential sockeye salmon production from the lake (Barto 1996).

The Chilkoot Lake run was managed for informal escapement goals of 80,000–100,000 sockeye salmon starting in 1976, then 60,000–80,000 sockeye salmon starting in 1981 (Bergander et al. 1988; McPherson 1990; Appendix A). Those goals were based on limnological and limited stock-recruit analyses. In 1990, a *biological* escapement goal of 50,500–91,500 sockeye salmon was established based on an extensive stock-recruit analysis by McPherson (1990). The goal was divided into separate goals for early (16,500–31,500) and late runs (34,000–60,000). In 2006, the escapement goal was rounded to 50,000–90,000 sockeye salmon and classified as a *sustainable* escapement goal, rather than a *biological* escapement goal, due to uncertainty in escapement levels based on weir counts (Geiger et al. 2005). Early- and late-run goals were eliminated and replaced with weekly cumulative escapement targets based on historical run timing.

The primary purpose of sockeye salmon stock assessment studies in 2004–2006 was to estimate the escapement and commercial harvest of Chilkoot Lake sockeye salmon. This information was used to determine if escapement goals were met, provide information for inseason management of the fisheries, and to reconstruct brood-year returns for use in future escapement goal evaluation. We conducted hydroacoustic and limnological surveys of the lake in 2005–2006 to estimate populations of rearing sockeye salmon fry and collect information on zooplankton abundance, light penetration, and water temperature profiles. In addition, we conducted a mark-recapture study in 2004 to estimate the sockeye salmon population in the Chilkoot drainage for comparison to the weir count.

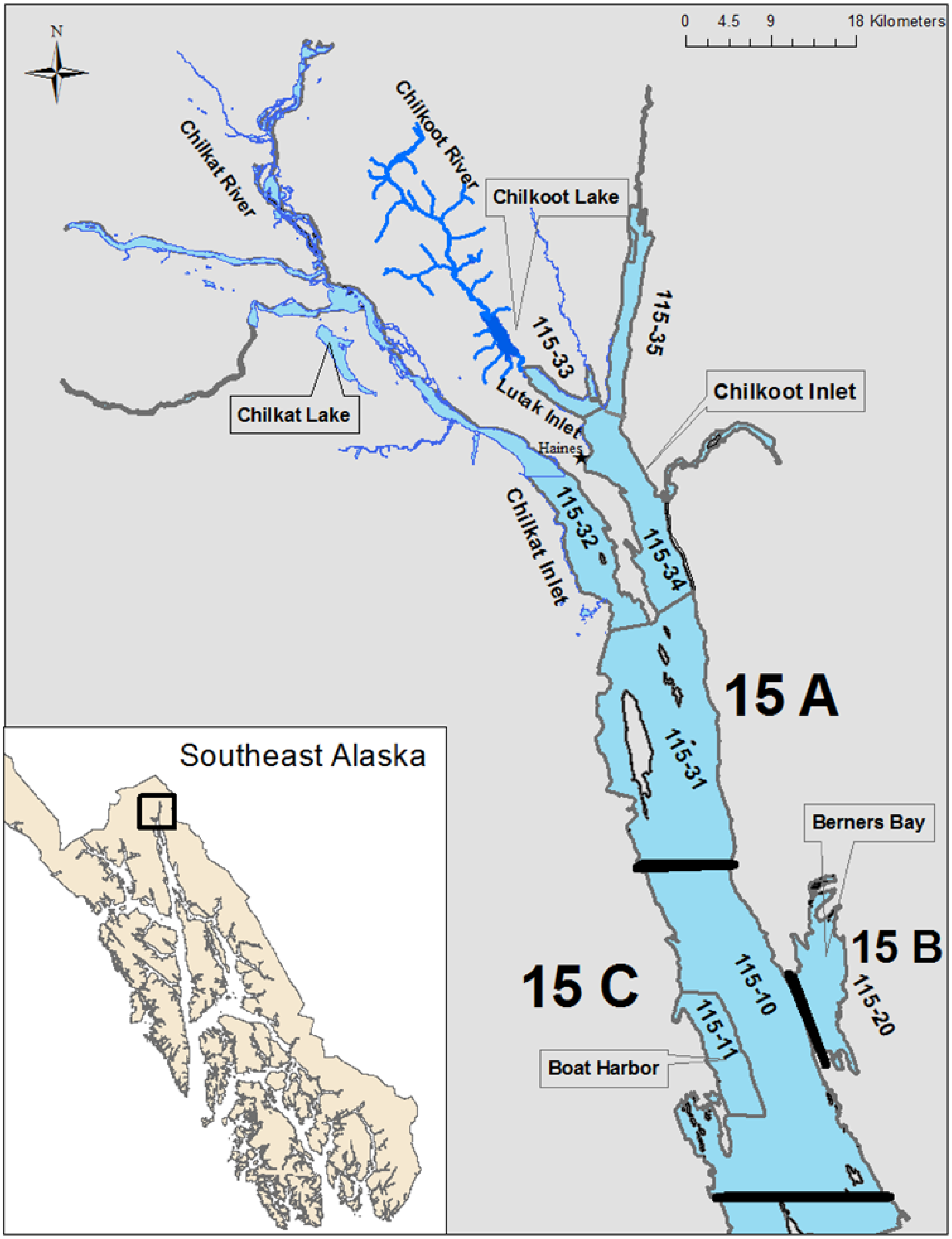

Figure 1.–Map of Lynn Canal and the Haines area showing District 115 commercial fishing subdistricts and management areas.

STUDY AREA DESCRIPTION

Chilkoot Lake (ADF&G Anadromous Waters Catalogue No. 115-33-10200-0010; 59°21′16” N, 135°35′42” W) is located at the head of Lutak Inlet, approximately 16 km northeast of the city of Haines, Alaska (Figures 1 and 2). It is glacially turbid, has a surface area of 7.2 km^2 (1,734 acres), a mean depth of 55 m, a maximum depth of 89 m, and a total volume of 382.4×10^6 m^3. The Chilkoot River begins at glacier terminuses east of the Takshunak Mountains and west of the Ferebee Glacier. The glacial river flows approximately 26 km southeast into Chilkoot Lake, then flows approximately 2 km into Lutak Inlet. Early-run sockeye salmon spawn in small lake and river tributaries and late-run fish spawn in the main channel of the Chilkoot River and along lake beaches where upwelling water occurs (McPherson 1990). Other species of salmon in Chilkoot Lake include pink, coho (*O. kisutch*), chum (*O. keta*), and Chinook (*O. tshawytscha*). Chilkoot Lake is located within the northern temperate rainforest that dominates the Pacific Northwest coast of North America. The climate is characterized by cold winters and cool, wet summers. Average precipitation for the study area is approximately 165 cm/yr (Bugliosi 1988). Sitka spruce, western hemlock, and Sitka alder dominate the forested watershed. The lake is set in a transitional zone, with warmer and drier summers and cooler winters than the rest of Southeast Alaska.

OBJECTIVES

1. Enumerate Pacific salmon by species as they migrate upstream through the Chilkoot River weir; 2004–2006.
2. Estimate age, sex, and length composition of the Chilkoot Lake sockeye salmon escapement; 2004–2006.
3. Estimate the Chilkoot Lake sockeye salmon escapement using mark-recapture techniques such that the coefficient of variation is no greater than 15% of the point estimate; 2004.
4. Estimate the annual commercial harvest of Chilkoot Lake sockeye salmon in the Lynn Canal drift gillnet fishery; 2004–2006.
5. Estimate abundance and density of sockeye salmon fry and other pelagic fish species in Chilkoot Lake such that the coefficient of variation is no greater than 15% of the point estimate; 2005–2006.
6. Measure water column temperature, record light profiles, and estimate zooplankton species composition, size, density, and biomass in Chilkoot Lake on a monthly basis, April–October; 2005–2006.

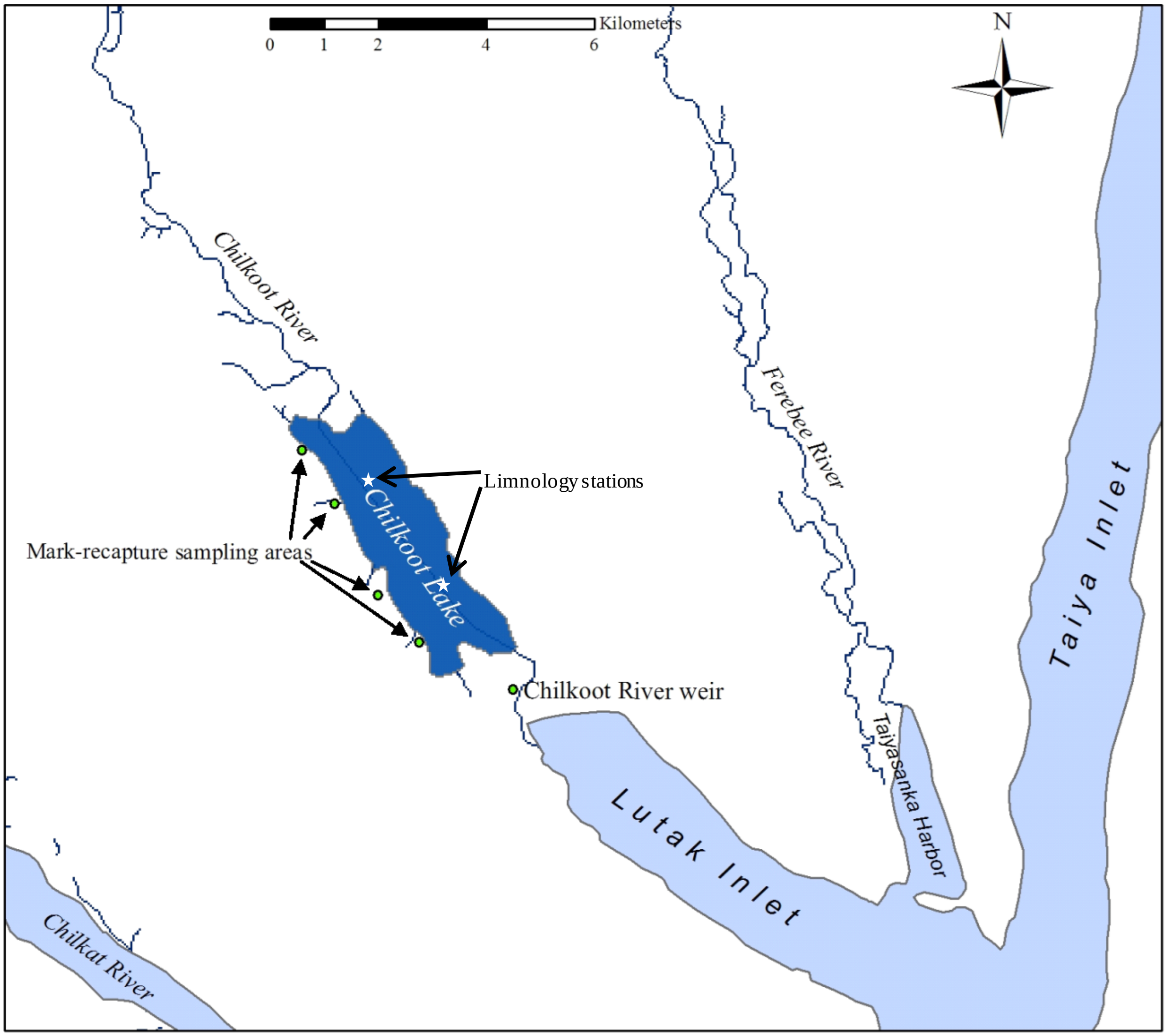

Figure 2.–Map showing Lutak Inlet, Chilkoot lake and river, and locations of limnology stations, the salmon counting weir, and mark-recapture areas.

METHODS

ESCAPEMENT

The Chilkoot River adult salmon counting weir is located 1 km downstream from Chilkoot Lake. The weir is supported by a 110-m long permanent steel structure, anchored with 20-cm steel pilings driven approximately 7 m into the bottom of the Chilkoot River channel. Pickets were installed into the support structure to form a fence across the river channel. Pickets were black iron pipe, 2- to 3-m long, 2.5 cm outside diameter, spaced 3.8 cm apart. The weir was regularly inspected, and gaps or small openings were blocked with sandbags or plastic coated wire mesh to prevent fish from passing undetected. Fish traps, recovery pens, and sampling stations were installed near mid-channel of the weir structure.

In order to minimize handling, most fish were passed by temporarily removing two to three pickets at a counting station near the center of the weir. Fish were counted by species as they passed through the opening. A panel of plywood, painted white, was placed in front of and below the opening to facilitate enumeration and identification of fish. Jack sockeye salmon (fish ≤360 mm mideye to tail fork) were not counted separately (most jacks were able to swim through the weir pickets undetected). Fish were trapped as well as caught with a dip net from the face of the weir for age, sex, and length sampling and marking. Fish that were sampled or marked were released into a 2×2 m plywood recovery box on the upstream side of the weir to recover from handling. Fish exited through a large hole in the side of the box once recuperated.

Stream height and water temperature were recorded at approximately 0630 hrs each day. Stream height (cm) was measured on a stadia rod, and water temperature (°C) was measured with a permanently installed thermometer near the east end of the weir.

MARK–RECAPTURE ESTIMATE

In 2004, the total sockeye salmon population was estimated with a stratified, two-event mark-recapture study (Seber 1982). The mark-recapture study allowed us to determine if sockeye salmon passed through the weir undetected, and served as a back-up estimate in case the weir was breached or damaged. In Event 1, adult sockeye salmon (fish ≥360 mm mideye to tail fork) were marked with a fin clip at a rate of 10% of the fish enumerated at the Chilkoot River weir. Marking was stratified through time by applying a primary mark (adipose fin clip) and a secondary fin clip in different combinations over eight two-week periods (Table 1). Fish that did not appear healthy were released unmarked.

Table 1.–Temporal marking strata for sockeye salmon at the Chilkoot River weir, 2004.

Date	Statistical week	Primary mark	Secondary mark
4–12 June	23–24	Adipose fin	None
13–26 June	25–26	Adipose fin	Right ventral fin
27 June–10 July	27–28	Adipose fin	Left ventral fin
11–24 July	29–30	Adipose fin	Right axillary process
25 July–7 August	31–32	Adipose fin	Left axillary process
8–21 August	33–34	Adipose fin	Dorsal fin (last 4 rays)
22 August–4 September	35–36	Adipose fin	Right pectoral fin
5–12 September	37–38	Adipose fin	Left pectoral fin

In Event 2, recapture surveys were conducted weekly, beginning in mid–July, on inlet tributaries and spawning areas along the Chilkoot Lake shoreline. Lake spawners were typically concentrated on beaches along the western shoreline. Sockeye salmon were recaptured with a 20×3 m beach seine, and each examined fish was recorded as unmarked (no fin-clip) or marked (by the appropriate fin clip). All sampled fish were marked with a left operculum punch to prevent repeated sampling of the same fish. Scheduling of recapture surveys varied depending on fish abundance and the percentage of fish that had already been examined in a given area. Sockeye salmon carcasses found on stream surveys or floating in the lake were also examined for marks.

We used Stratified Population Analysis System (SPAS) software (Arnason et al. 1996; http://www.cs.umanitoba.ca/~popan/) to analyze mark-recapture data. SPAS was designed for analysis of two-sample mark-recapture data where Event 1 (marking) and Event 2 (recapture) samples are collected over a number of strata. This software was used to calculate the maximum likelihood Darroch and pooled-Petersen (Chapman's modified) estimates and their standard errors. The general assumptions that must hold for a two-event mark-recapture estimate to be consistent were listed by Seber (1982) and Schwarz and Taylor (1998): "(1) either or both of the samples are a simple random sample, i.e., all fish in the population have the same probability of being tagged or all fish have the same probability of being captured in the second sample; or tagged fish mix uniformly with untagged fish, (2) the population is closed, (3) there is no tag loss, (4) the tagging status of each fish is determined without error, and (5) tagging has no effect on the subsequent behavior of the fish."

Assumption (1) could be violated if size- or gender-selective sampling occurred during the study. To test the hypothesis that fish of different sizes were captured with equal probability during Event 1 and Event 2, we compared the length distributions of fish for groups of marked (M), captured (C), and recaptured (R) sockeye salmon using the Kolmogorov-Smirnov (K-S) two-sample test (Conover 1999; Appendix D). The test hypothesis for each comparison was that there were no differences in mideye to tail fork lengths between the data sets being tested ($P > 0.05$). Similarly, we conducted two chi-square consistency tests to check for gender-selective sampling, with the test hypothesis that there were no differences in the ratio of males to females between the data sets being tested ($P > 0.05$). Gear selectivity in Event 1 was examined by comparing the number of fish of each gender marked in Event 1, and the number of fish of each gender sampled for marks in Event 2. Sampling bias in Event 2 was examined by comparing the number of fish of each gender marked in Event 1 and recaptured during Event 2, to the number of each gender that were marked but not recaptured.

In addition, we conducted two chi-square consistency tests for temporal violations of assumption (1): a test for complete mixing, or the probability that the time of recapture of a marked fish in Event 2 was independent of when it was marked in Event 1; and a test of equal proportions of marked fish recaptured in Event 2. A test statistic with $P < 0.05$ was considered "significant," but serious bias was indicated in the pooled-Petersen estimate only if both test statistics were significant. If neither test statistic or only one of them was significant, we accepted the pooled-Petersen estimate (Schwarz and Taylor 1998); if both tests were significant, a temporally-stratified estimate was generated using the SPAS software. We evaluated the stratified Darroch estimate and attempted to find a reasonable partial pooling scheme in order to reduce the number of parameters that needed to be estimated. We used two additional goodness-of-fit tests for the Darroch estimate provided in the SPAS software, along with the guidelines and suggestions in Arnason et al. (1996) and Schwarz and Taylor (1998), to evaluate the estimate and partial pooling schemes.

We assumed the population at Chilkoot Lake was closed to emigration and recruitment, assumption (2), because sampling activities were conducted over the entire migration and spawning periods. We addressed loss of marks, assumption (3), through the use of fin clips, rather than tags. Careful inspection of all fish sampled on the spawning grounds helped ensure that mark status, assumption (4), was determined without error during Event 2. Finally, substantial stress from capture and handling in Event 1 could lead to a reduction of marked fish in the recapture sample, assumption (5), and a positive bias in the mark-recapture estimate, either through direct mortality or through change in behavior of marked fish. Marked fish found dead at the weir were counted and subtracted from the number of marked fish released, but we assumed that handling effects were minimal.

ESCAPEMENT AGE, SEX, AND LENGTH COMPOSITION

Scales were collected at the weir from a daily sample of 40 healthy sockeye salmon for use in scale pattern and age composition analyses. Samples included jacks (fish ≤360 mm in length); however, very few jacks (<10) have been sampled in the past (1982–2006), because most of them are small enough to swim through the weir. Approximately 20 fish were sampled during the morning shift and 20 more in the afternoon or evening shift. The length of each fish was measured from mideye to tail fork to the nearest 5 mm. Sex was determined by examining external dimorphic sexual maturation characteristics, such as kype development, belly shape, and trunk depth. One scale per fish was taken from the preferred area above the lateral line on the left side of the fish on a diagonal downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (INPFC 1963) and placed on a gum card. Date of sample, sex, length, and data regarding the condition of each fish were recorded on standard optical scan forms.

Scale samples were analyzed at the ADF&G salmon-aging laboratory in Douglas, Alaska. Scale impressions were made in cellulose acetate and prepared for analysis as described by Clutter and Whitesel (1956). Scales were examined under moderate (70×) magnification to determine age. Age classes were designated by the European aging system where freshwater and saltwater years are separated by a period (e.g., 1.3 denotes a fish with one freshwater and three ocean years; Koo 1962). The weekly age distribution, the seasonal age distribution weighted by week, and standard error of mean length by age and sex by week were calculated using equations from Cochran (1977; Appendix E).

COMMERCIAL HARVEST ESTIMATE

Visual scale pattern analysis was used to determine stock composition of sockeye salmon harvested in the Lynn Canal (District 15) commercial drift gillnet fishery. The general methods have remained unchanged since the mid-1980s: escapement scale samples from three stocks of known origin, Chilkoot, Chilkat, and "other" (Chilkat mainstem and Berners Bay stocks), were aged and compared to scale samples from the commercial fisheries.

Commercial Harvest Information

Commercial harvest data for the District 15 drift gillnet fishery were obtained from the ADF&G Southeast Alaska Integrated Fisheries Database. Commercial harvest was summarized by statistical weeks, which began on Sunday at 12:01 a.m. and ended the following Saturday at midnight. Statistical weeks were numbered sequentially starting from the beginning of the calendar year (Appendix F).

Scale samples from District 15 commercial drift gillnet landings of sockeye salmon were collected weekly through the season by ADF&G personnel at the fish processing facility at Excursion Inlet. A sampling goal of 520 fish per week was sufficient to describe the estimated sockeye salmon age composition with a precision of ± 5% and a probability of 0.10 (Thompson 1987). Sampling protocols ensured that samples were as representative of catches as possible: deliveries with catches mixed from more than one gear type or fishing district were not sampled, no more than 40 samples were taken from a single delivery, and, whenever possible, samples were systematically taken from the entire hold as it was offloaded to ensure they were representative of the entire delivery. Sampled fish were identified to sex and one scale per fish was taken from the preferred area (INPFC 1963). Length was measured from mideye to tail fork for 20% of fish sampled in the commercial fishery. Samples were processed and aged at the ADF&G salmon-aging laboratory following procedures described above for Chilkoot Lake escapement samples.

Scale Pattern Analysis

Known-origin scale samples were collected weekly at the Chilkoot River weir (this study), at Chilkat Lake, and from a fishwheel project conducted on the Chilkat River, which included both Chilkat Lake and Chilkat River mainstem spawners (Bachman 2010). Samples were also collected annually from spawning populations in Berners Bay (Berners and Lace rivers) and along the mainstem of the Chilkat River where sockeye salmon were concentrated in clear tributaries. These samples were temporally and spatially limited and may not be representative of the entire Berners and Chilkat mainstem populations. Samples were processed and aged at the ADF&G salmon-aging laboratory following procedures described above for Chilkoot Lake escapement samples.

Known-origin scale samples were processed inseason on a weekly basis, after which commercial fishery samples were analyzed and assigned to one of three stocks: Chilkoot, Chilkat, and "other" based on scale characteristics. The size of the freshwater annulus and the number of circuli in the freshwater growth zones were the principle scale characteristics used to distinguish between runs; however, the total size of the freshwater growth zone, size of the freshwater-plus growth zone, and completeness of circuli and spacing between circuli in the freshwater growth zone were also considered. Differences in age composition between stocks and migratory timing by age were also accounted for inseason. The weekly proportions of classified scale samples were applied to the District 15 commercial harvest to provide weekly estimates of stock contribution for inseason management and postseason estimates of total harvest by stock, weighted by statistical week.

FRY POPULATION ESTIMATE

Hydroacoustic and mid-water trawl sampling methods were used to estimate abundance and age-size distributions of sockeye salmon fry and other small pelagic fish in Chilkoot Lake. To control year-to-year variation in our estimates, acoustic surveys were conducted annually along the same 12 transects (two from each of six sampling sections of the lake) that were randomly chosen in 2002 as permanent transects (Riffe 2006). Hydroacoustic surveys were conducted annually in November. This report includes sampling results from 2005 and 2006; results of sampling in 2004 were reported by Riffe (2006).

Hydroacoustic sampling of each transect was conducted during post-sunset darkness in one night. A Biosonics DT-X™[1] scientific echosounder (430 kHz, 7.3° split-beam transducer) with Biosonics Visual Acquisition © version 5.0 software was used to collect data. Ping rate was set at five pings/sec, pulse width at 0.3 ms, and a constant boat speed of about 2.0 m/sec was maintained during each transect. Target strength of -40 dB to -70 dB was used to represent fish within the size range of juvenile sockeye salmon and other small pelagic fish.

Fish-target density (targets/m^2) was estimated using Biosonics software (User Guide, Visual Analyser™ 4.1, BioSonics, Inc.), using echo integration methods (MacLennan and Simmonds 1992). Mean target density for each sampling area was calculated as the average of the two replicate transects. A total-target estimate for each of the sampling areas was calculated as the

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[1] Product names in the document are included for completeness but do not constitute product endorsement.

product of the mean target density and the surface area of each of the sampling areas. The sum of the area estimates provided an estimate of total targets for the entire lake. The variance of the total-target estimate within an area was calculated based on 1-degree-of-freedom estimates for each group of transects. Because the estimate of total targets in each section was essentially independent (neglecting any movement of fry from one section to the other during surveys), an estimate of the sample variance of the estimate of the total targets in the entire lake was formed by summing the 1-degree-of-freedom sample variances across the six sections. Sampling error for the estimate of total targets for the entire lake was measured and reported with the coefficient of variation (Sokal and Rohlf 1981).

In conjunction with the hydroacoustic surveys, we collected pelagic fish samples using a 2×2 m trawl net. A Bayesian hierarchical model was used to apportion the population estimates by species based on our trawl samples (Piston et al. 2006; Appendix G). We conducted about six nighttime trawls at various depths during each survey.

LIMNOLOGICAL ASSESSMENT

Basic limnological data, including zooplankton, light, and temperature sampling, were collected monthly between April and October. Sampling was conducted at four stations marked by anchored buoys in the lake (Riffe 2006). Stations 1 and 2 were located at opposite ends of the lake, and stations 1A and 2B were located between stations 1 and 2 (Figure 2). This report includes sampling results from 2005 and 2006; results of sampling in 2004 were reported by Riffe (2006).

Light and Temperature Profiles

Light and temperature profiles were collected at stations 1 and 2. Underwater light intensity was recorded at 0.5-m intervals, from just below the surface to the depth at which ambient light level equaled one percent of the light level just below the surface, using an electronic light meter (Li-Cor). Measurements of underwater light intensity were used to determine vertical light extinction coefficients and algal compensation depths. The natural log (ln) of the ratio of light intensity just below the surface (I_0) to light intensity at depth z (I_z,), I_0/I_z, was calculated for each depth. The vertical light extinction coefficient (K_d) was estimated as the slope of $\ln(I_0/I_z)$ versus depth. The euphotic zone depth (EZD) was defined as the depth at which light (photosynthetically available radiation at 400–700 nm) was attenuated to 1% of the intensity just below the lake surface (Schindler 1971) and calculated with the equation $EZD = 4.6502/K_d$ (Kirk 1994). Temperature (ºC) was measured with a Yellow Springs Instruments (YSI) Model 57 meter. Measurements were made at 1-m intervals from the surface to a depth of 20 m and continued in 5-m intervals to a depth of 50 m.

Secondary production

Zooplankton samples were collected at all four sampling stations using a 0.5-m diameter, 153-μm mesh conical net. Vertical zooplankton tows were pulled from a depth of 50 m to the surface at a constant speed of 0.5 m/sec^{-1}. The net was rinsed prior to removing the organisms, and all specimens were preserved in buffered 10% formalin. Samples were analyzed at the ADF&G Kodiak Limnology Lab, using methods detailed in the ADF&G Limnology Field and Laboratory Manual (Koenings et al. 1987). Results were averaged between stations by month and season.

RESULTS

ESCAPEMENT

2004

In 2004, 75,596 sockeye, 89 coho, 107,994 pink, 617 chum, and 17 Chinook salmon were enumerated through the Chilkoot River weir between 4 June and 12 September (Appendix H). The total sockeye salmon count fell within the total *biological* escapement goal range of 50,500–91,500 sockeye salmon (Table 2; Figure 3). The pink salmon count was the highest on record for the Chilkoot River weir and over four times the recent historical average (Appendix B). The cumulative weir count for the early sockeye salmon run (through 10 July; statistical week 28) was 6,375 fish, which fell below the early-run escapement goal range of 16,500–31,500 fish (Table 2). The cumulative weir count for the late sockeye salmon run (11 July–12 September; statistical weeks 29–40) was 69,216 fish, which exceeded the late-run escapement goal range of 34,000–60,000 fish (Table 2; Figure 4). There was a strong surge of fish in statistical weeks 30 through 36.

Two high water events required the removal of every other picket to prevent damage to the weir and scouring of the riverbed. The first event occurred on 9 June (statistical week 24); pickets were removed at 1400 hrs and the weir was not fish tight until 1700 hrs on 10 June. The second high water event occurred on 19 June; pickets were pulled at 2130 hrs and the weir was not fish tight until 1100 hrs on 26 June. Thus, the weir was not in operation for all of statistical week 26 due to flooding.

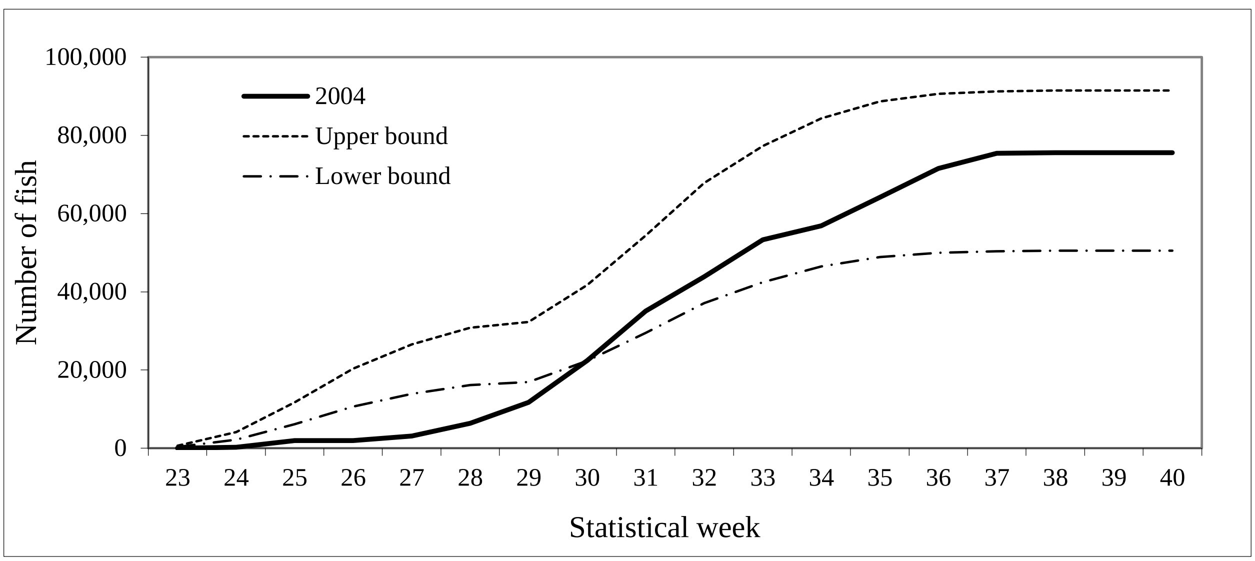

Figure 3.–Cumulative weekly escapement of sockeye salmon through the Chilkoot River weir compared to lower and upper *biological* escapement goal ranges, 2004.

Table 2.–Weekly escapement counts of sockeye salmon at the Chilkoot River weir compared to early- and late-run escapement goals and total *biological* escapement goal, 2004.

Run	Statistical week	Weir count		Escapement goal	
		Weekly	Cumulative	Lower	Upper
Early	23	41	41	337	644
Early	24	233	274	2,151	4,107
Early	25	1,635	1,909	6,142	11,725
Early	26	0	1,909	10,657	20,346
Early	27	1,178	3,087	13,890	26,517
Early	28	3,288	6,375	16,500	31,500
Late	29	5,343	5,343	452	798
Late	30	10,724	16,067	5,814	10,260
Late	31	12,655	28,722	12,990	22,923
Late	32	8,750	37,472	20,585	36,327
Late	33	9,457	46,929	25,942	45,780
Late	34	3,583	50,512	29,954	52,860
Late	35	7,307	57,819	32,402	57,180
Late	36	7,333	65,152	33,490	59,100
Late	37	3,908	69,060	33,864	59,760
Late	38	156	69,216	34,000	60,000
Late	39	0	69,216	34,000	60,000
Late	40	0	69,216	34,000	60,000
Total		75,596		50,500	91,500

2005

In 2005, 51,178 sockeye, 23 coho, 90,486 pink, 262 chum, and 9 Chinook salmon were enumerated through the Chilkoot River weir between 6 June and 12 September (Table 3; Appendix I). The cumulative sockeye salmon escapement was below goal until early September (statistical week 37), and the total escapement of 51,178 fish was just within the total *biological* escapement goal range of 50,500–91,500 fish (Table 3; Figure 5). The pink salmon count greatly exceeded the 1976–2003 average and was the second largest count on record for the Chilkoot River weir (Appendix B).

The cumulative weir count for the early sockeye salmon run (through 9 July; statistical week 28) was 9,634 fish, which fell below the early-run escapement goal range of 16,500–31,500 fish (Table 3). The early run peaked in the third week of June (statistical week 26), about a week later than the long-term average (1976–2003; Figure 4). The cumulative weir count for the late sockeye salmon run (10 July–12 September; statistical weeks 29–40) was 41,544 fish, which met the late-run escapement goal range of 34,000–60,000 fish. There were two distinct peaks for late-run fish: the first peak occurred in the third week in July (statistical week 30) and a stronger peak occurred at the end of August (statistical weeks 35 and 36; Table 3; Figure 5). No high water events occurred and the weir was considered fish tight throughout the season.

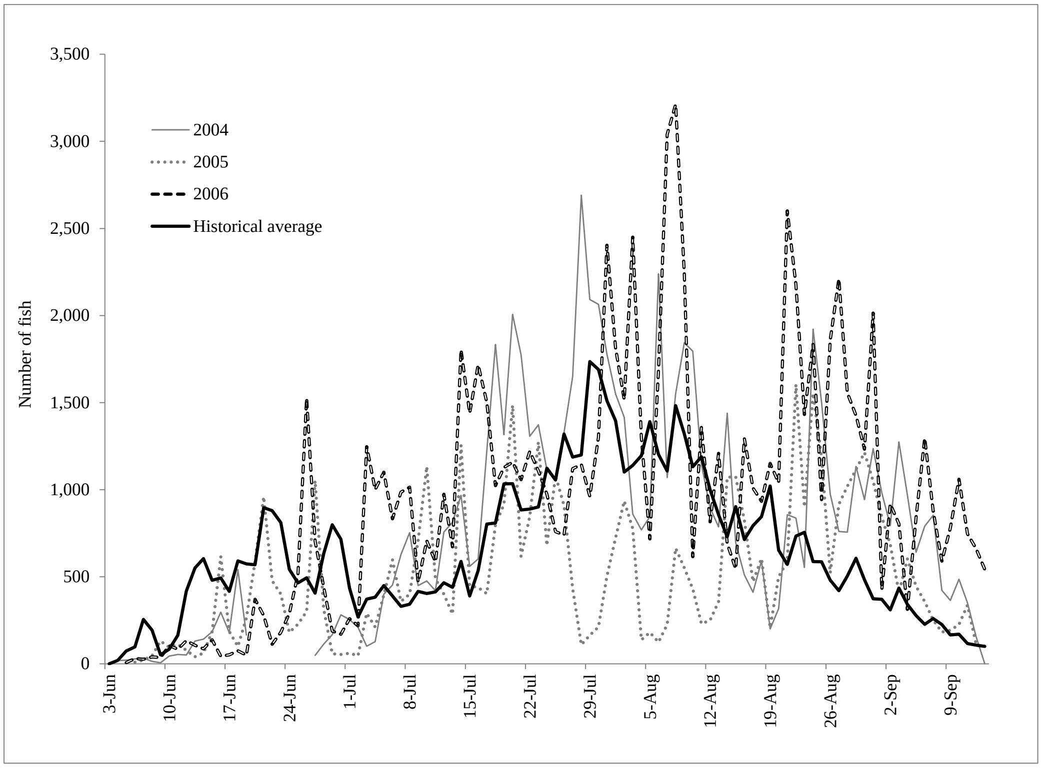

Figure 4.–Daily sockeye salmon counts at the Chilkoot River weir 2004, 2005, 2006, compared to the long-term average (1976–2003).

Table 3.–Weekly escapement counts of sockeye salmon at the Chilkoot River weir compared to early- and late-run escapement goals and total *biological* escapement goal, 2005.

	Statistical	Weir count		Escapement goal	
Run	week	Weekly	Cumulative	Lower	Upper
Early	23	0	0	337	644
Early	24	417	417	2,151	4,107
Early	25	1,270	1,687	6,142	11,725
Early	26	3,098	4,785	10,657	20,346
Early	27	1,886	6,671	13,890	26,517
Early	28	2,963	9,634	16,500	31,500
Late	29	4,452	4452	452	798
Late	30	6,339	10,791	5,814	10,260
Late	31	3,588	14,379	12,990	22,923
Late	32	3,382	17,761	20,585	36,327
Late	33	2,710	20,471	25,942	45,780
Late	34	4,755	25,226	29,954	52,860
Late	35	7,272	32,498	32,402	57,180
Late	36	6,336	38,834	33,490	59,100
Late	37	2,259	41,093	33,864	59,760
Late	38	451	41,544	34,000	60,000
Late	39	0	41,544	34,000	60,000
Late	40	0	41,544	34,000	60,000
Total		51,178	51,178	50,500	91,500

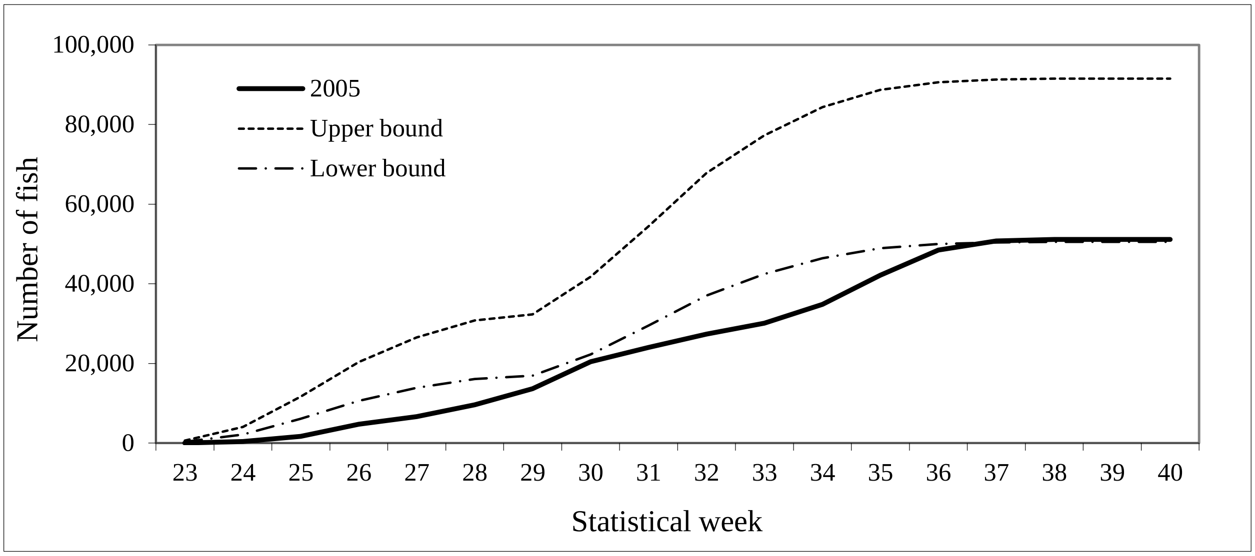

Figure 5.–Cumulative weekly escapement of sockeye salmon through the Chilkoot River weir compared to lower and upper *biological* escapement goal ranges, 2005.

2006

In 2006, 96,203 sockeye, 158 coho, 33,888 pink, 257 chum, and 1 Chinook salmon were enumerated through the Chilkoot River weir between 5 June and 13 September (Figure 4; Appendix J). The total 2006 sockeye salmon count exceeded the *sustainable* escapement goal range of 50,000–90,000 fish[2] (Table 4; Figure 6). The pink salmon count was only about one-third of the record high counts in 2004 and 2005, but still almost twice the 1976–2003 historical average (Appendix B).

The weekly cumulative sockeye salmon escapement was below target through statistical week 27, within target ranges from statistical week 28 to 34, and exceeded target ranges after week 35 (Table 4). The lower bound of the escapement goal range (50,000) was met by early August (statistical week 32), and the upper escapement goal range (90,000) was exceeded in late August (statistical week 35; Table 4; Figure 6). No high water events occurred and the weir was considered fish tight throughout the season.

[2] Prior to the 2006 season, the total sockeye salmon escapement goal was changed from a *biological* goal to a *sustainable* goal and adjusted slightly (rounded to 50,000–90,000); separate early- and late-run escapement goals were replaced with weekly cumulative escapement targets (Geiger et al. 2005).

Table 4.–Weekly escapement counts of sockeye salmon at the Chilkoot River weir compared to weekly management targets and *sustainable* escapement goal, 2006.

Statistical week	Weir count		Escapement goal	
	Weekly	Cumulative	Lower bound	Upper bound
23	247	247	461	830
24	644	891	2,525	4,545
25	1,358	2,249	5,926	10,666
26	3,801	6,050	8,888	15,998
27	6,400	12,450	11,094	19,969
28	6,650	19,100	13,620	24,516
29	8,805	27,905	18,284	32,912
30	6,810	34,715	24,775	44,594
31	11,503	46,218	31,731	57,116
32	12,972	59,190	37,540	67,572
33	6,832	66,022	41,619	74,914
34	11,886	77,908	45,152	81,274
35	9,783	87,691	47,733	85,920
36	5,501	93,192	49,404	88,927
37	3,011	96,203	49,863	89,753
38	0	96,203	49,948	89,907
39	0	96,203	49,983	89,969
40	0	96,203	50,000	90,000
Total	96,203	96,203	50,000	90,000

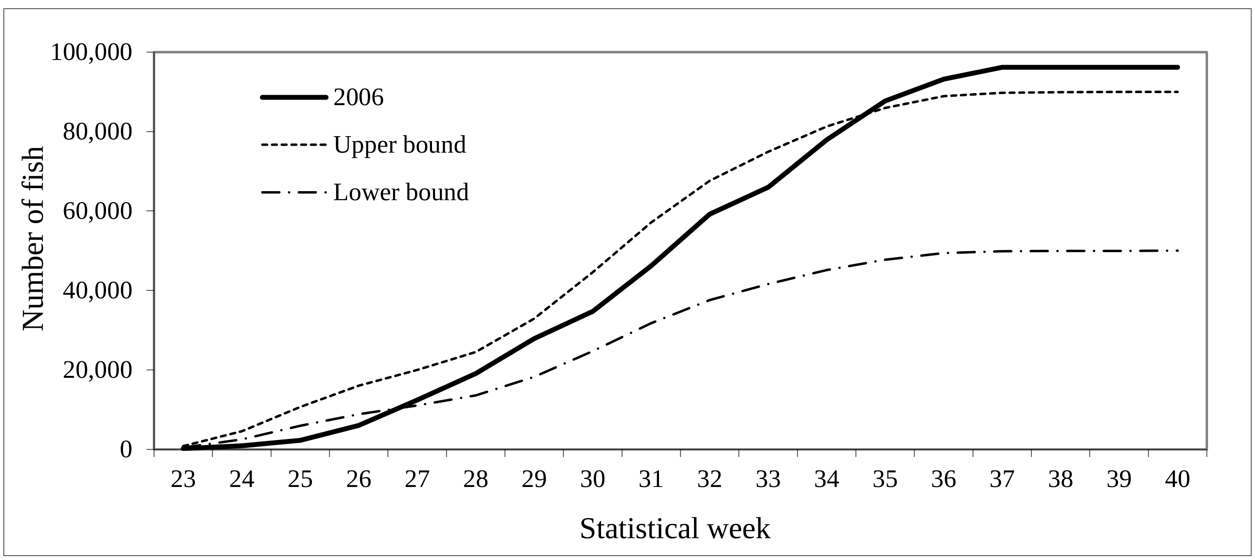

Figure 6.–Cumulative weekly escapement of sockeye salmon through the Chilkoot River weir compared to lower and upper sustainable escapement goal ranges, 2006. (A slightly revised, *sustainable* escapement goal was adopted in 2006; Geiger et al. 2005.)

2004 Mark-Recapture Escapement Estimate

In 2004, 6,682 sockeye salmon were marked and released at the Chilkoot River weir (Table 5). A total of 28 marked fish were found dead at the weir, a mortality rate of less than 1%. We subtracted observed mortalities and reduced the number of marked sockeye salmon to 6,654 (9% of the total escapement). Recapture surveys were conducted in Chilkoot Lake and its inlet tributaries on 18 dates between 16 July and 25 October 2004 (Table 6). Recovery events in early and late October (statistical weeks 40 and 43) were cancelled due to stormy weather and flooding in the upper watershed. A total of 1,869 sockeye salmon were examined for marks, of which only 82 marked fish were recaptured, or about 4% of the total sample. We combined recapture surveys into 14 one-week periods that resulted in an 8×14 matrix of mark-recapture data (Appendix K). Analysis of the full mark-recapture data set in SPAS yielded a significant chi-square test statistic for complete mixing of marked fish between the marking (Event 1) and recapture (Event 2) events (χ^2 = 77.9, P = 0.01, df = 7); however, the result of the test for equal proportions of marked fish on the spawning grounds was not significant (χ^2 = 77.9, P = 0.10, df = 13). A non-significant result for one of these diagnostic tests indicated the pooled estimator was appropriate for estimating abundance.

In addition, no size- or gender-selective sampling was detected. There was no significant difference in size of all fish sampled in Event 2 and fish marked in Event 1 and recaptured in Event 2 (D = 0.09, P = 0.59). There was also no significant difference in size of fish marked in Event 1 and marked fish recaptured in Event 2 (D = 0.14, P = 0.10). No difference was detected in the proportions of males and females marked in Event 1 and sampled in Event 2 (χ^2 = 0.88, P = 0.35, df = 1) or in the frequency of marked males and females recaptured compared to those not recaptured in Event 2 (χ^2 = 13, P = 0.72, df = 1). These results further suggested abundance could be estimated using a pooled-Petersen model without stratification (*Case I* situation; Appendix D).

We pooled the mark-recapture data and calculated a Petersen estimate of 150,000 fish (SE = 16,000; 95% CI = 119,000–181,000). The CV (11%) of the estimate met our objective for a CV less than 15%. We also explored stratified estimates using the same 8×14 matrix of mark-recapture data. The initial analysis failed to produce a valid Darroch estimate, however, due to negative capture probability estimates for two release strata (left axillary and left pectoral fin clips) and one recapture stratum (statistical week 36). We then manipulated strata to yield non-negative estimates and minimize lack of fit. The Darroch estimates with the best fit (e.g., χ^2 = 0.77; P = 0.68, df = 1) resulted from pooling data into four or five release and six to eight recapture strata, all of which yielded estimates of about 152,000 (SE = 25,000) sockeye salmon, very similar to the pooled-Petersen estimate. The weir count (75,596) was approximately half the point estimates and well below the confidence interval ranges of both the pooled-Peterson and stratified Darroch estimates.

Table 5.–Number of sockeye salmon counted and marked at the Chilkoot River weir by marking stratum, 2004.

Statistical week	Date	Weir count	Secondary clip	Total marked	Observed mortality	Marks adjusted	Percent marked
23–24	30 May–12 Jun[a]	274	None	29	0	29	11%
25–26	13 Jun–26 Jun	1,640	Right ventral	163	1	162	10%
27–28	27 Jun–10 Jul	4,466	Left ventral	428	4	424	9%
29–30	11 Jul–24 Jul	16,067	Right axillary	1,606	9	1,597	10%
31–32	25 Jul–7 Aug	21,405	Left axillary	1,574	9	1,565	7%
33–34	8 Aug–21 Aug	13,040	Dorsal	1,115	2	1,113	9%
35–36	22 Aug–4 Sep	14,640	Right pectoral	1,297	3	1,294	9%
37–38	5 Sep–18 Sep[b]	4,064	Left pectoral	470	0	470	12%
Total		75,596		6,682	28	6,654	9%

[a] First day of marking was 4 June.

[b] Last day of marking was 12 September.

Table 6.–Number of fish sampled and number of marked fish recaptured by sampling date at Chilkoot Lake, 2004.

	Recaptures by marking stratum									
Recapture date	Adipose Only	Right ventral	Left ventral	Right axillary	Left axillary	Dorsal	Right pectoral	Left pectoral	Total recaps.	Total sampled
16-Jul	0	3	0	0	0	0	0	0	3	86
20-Jul	0	1	0	0	0	0	0	0	1	59
23-Jul	0	3	1	1	0	0	0	0	5	66
26-Jul	0	1	1	0	0	0	0	0	2	97
28-Jul	0	0	0	0	0	0	0	0	0	23
2-Aug	0	0	1	0	0	0	0	0	1	100
6-Aug	2	1	1	1	0	0	0	0	5	76
13-Aug	0	0	2	1	0	0	0	0	3	86
20-Aug	0	0	2	2	0	0	0	0	4	88
27-Aug	0	0	2	2	1	0	0	0	5	95
3-Sep	1	1	1	5	4	1	1	0	14	142
10-Sep	0	0	1	2	0	1	3	1	8	146
18-Sep	0	1	0	1	1	1	4	0	8	152
24-Sep	0	0	0	0	2	3	2	0	7	94
4-Oct	0	0	0	2	0	2	0	0	4	181
8-Oct	0	0	0	2	3	2	1	0	8	162
15-Oct[a]	0	0	0	0	1	0	1	0	2	100
25-Oct[a]	0	0	0	1	1	0	0	0	2	116
Total	3	11	12	20	13	10	12	1	82	1,869

[a] All Event 2 samples were collected in Chilkoot Lake with the exception of 15-Oct and 25-Oct samples, which were collected the inlet stream (Chilkoot River).

COMMERCIAL HARVEST ESTIMATE

2004

In 2004, a total of 151,245 sockeye salmon were caught in the District 15 commercial drift gillnet fishery, of which approximately 66,498 (44%) were estimated to be Chilkoot stock (Table 7; Appendix L). The total sample size used to determine the stock proportions was 6,370 scales; about 4% of the total commercial sockeye salmon harvest. The 2004 exploitation rate, based on the weir count, was estimated to be 48% (including small, estimated subsistence and sport harvests; Appendix A).

Table 7.–Estimated commercial harvest of Chilkoot, Chilkat, and other sockeye salmon stocks in the District 15 drift gillnet fishery based on scale pattern analysis, 2004.

Statistical week	Commercial harvest	Sample size	Estimated stock composition			Estimated harvest		
			Chilkoot	Chilkat	Other	Chilkoot	Chilkat	Other
26	4,231	426	23%	28%	49%	993	1,182	2,056
27	10,680	727	20%	29%	51%	2,101	3,100	5,480
28	22,686	570	25%	35%	40%	5,612	7,920	9,154
29	22,286	472	36%	36%	28%	8,027	7,980	6,280
30	18,144	496	47%	37%	16%	8,560	6,658	2,926
31	14,908	513	52%	33%	14%	7,817	4,969	2,121
32	20,640	463	73%	19%	8%	15,157	3,878	1,605
33	20,189	491	60%	28%	12%	12,048	5,674	2,467
34	7,171	500	40%	48%	12%	2,883	3,428	861
35	6,504	486	37%	57%	6%	2,409	3,680	415
36	2,425	523	30%	60%	10%	733	1,461	232
37	731	359	13%	86%	2%	92	627	12
38–40	650	344	10%	85%	4%	68	554	28
Total	151,245	6,370	44%	34%	22%	66,498	51,110	33,637

2005

In 2005, a total of 65,469 sockeye salmon were caught in the District 15 commercial drift gillnet fishery, of which approximately 29,276 (45%) were estimated to be Chilkoot stock (Table 8; Appendix L). The total sample size used to determine the stock proportions was 5,676 scales; about 9% of the total commercial sockeye salmon harvest. The 2005 exploitation rate was estimated to be 36% (including small, estimated subsistence and sport harvests; Appendix A).

Table 8.–Estimated commercial harvest of Chilkoot, Chilkat, and other sockeye salmon stocks in the District 15 drift gillnet fishery based on scale pattern analysis, 2005.

Statistical week	Commercial harvest	Sample size	Estimated stock composition			Estimated harvest		
			Chilkoot	Chilkat	Other	Chilkoot	Chilkat	Other
26	1,252	124	39%	40%	22%	485	495	273
27	3,518	493	31%	43%	26%	1,085	1,506	928
28	5,058	495	33%	36%	31%	1,645	1,839	1,574
29	3,821	461	27%	38%	35%	1,036	1,459	1,326
30	4,711	474	38%	26%	36%	1,799	1,222	1,690
31	4,897	443	43%	24%	33%	2,111	1,183	1,603
32	9,046	493	48%	21%	30%	4,367	1,927	2,752
33	6,988	456	65%	21%	13%	4,551	1,502	935
34	11,235	518	63%	22%	15%	7,114	2,473	1,648
35	5,388	510	51%	43%	6%	2,747	2,314	328
36	3,553	526	39%	58%	4%	1,371	2,047	135
37	3,560	528	16%	80%	4%	587	2,839	135
38–40	2,442	155	15%	84%	1%	378	2,048	16
Total	65,469	5,676	45%	35%	20%	29,276	22,852	13,341

2006

In 2006, a total of 145,579 sockeye salmon were caught in the District 15 commercial drift gillnet fishery, of which approximately 119,201 (82%) were estimated to be Chilkoot stock (Table 9; Appendix L). The total sample size used to determine the stock proportions was 4,624 scales; about 3% of the total commercial sockeye salmon harvest. The 2006 exploitation rate was estimated to be 55% (including small, estimated subsistence and sport harvests; Appendix A).

Table 9.–Estimated commercial harvest of Chilkoot, Chilkat, and other sockeye salmon stocks in the District 15 drift gillnet fishery based on scale pattern analysis, 2006.

Statistical week	Commercial harvest	Sample size	Estimated stock composition			Estimated harvest		
			Chilkoot	Chilkat	Other	Chilkoot	Chilkat	Other
25	1,917	294	52%	27%	21%	998	509	411
26	2,748	390	33%	35%	31%	916	972	860
27	6,536	416	37%	30%	34%	2,388	1,948	2,200
28	3,957	403	55%	21%	24%	2,180	815	962
29	6,123	420	56%	24%	20%	3,426	1,458	1,239
30	14,833	415	67%	16%	16%	10,008	2,430	2,395
31	21,131	324	88%	8%	4%	18,587	1,696	848
32	20,676	410	96%	2%	2%	19,869	454	353
33	17,562	384	93%	5%	2%	16,419	823	320
34	21,776	387	97%	2%	0%	21,213	506	56
35	16,806	401	88%	10%	2%	14,836	1,676	293
36-40	11,514	398	73%	23%	4%	8,361	2,690	463
total	145,579	4,642	82%	11%	7%	119,201	15,979	10,400

ESCAPEMENT AGE, SEX, AND LENGTH COMPOSITION

2004

In 2004, the sockeye salmon escapement was composed primarily of age-1.3 (70%) and age-1.2 (15%) fish (Table 10; Appendix M). The remainder of the escapement (15%) was composed of age-2.2 and age-2.3 fish. Age-1.2 fish had a mean length of 501 mm for males and 512 mm for females, and age-1.3 fish had a mean length of 580 mm for males and 568 mm for females (Table 11; Appendix N).

Table 10.–Age composition of the Chilkoot Lake sockeye salmon escapement, weighted by statistical week, 2004.

Brood year	2000	1999	1998	1999	1998	
Age class	1.2	1.3	1.4	2.2	2.3	Total
Sample size	399	1,929	2	161	220	2,711
Escapement	11,478	52,806	27	5,736	5,544	75,596
Escapement SE	606	764	21	460	410	
Percent	15%	70%	0%	8%	7%	
Percent SE	0.8%	1.0%	0.0%	0.6%	0.5%	

Table 11.–Average length (mideye to tail fork) of Chilkoot Lake sockeye salmon by age class and sex, 2004.

Brood year	2000	1999	1998	1999	1998	
Age class	1.2	1.3	1.4	2.2	2.3	Total
Male						
Sample size	253	801	1	96	96	1,247
Mean length (mm)	501	580	535	500	576	555
SE	2.3	0.9		4	2.3	1.3
Female						
Sample size	146	1,128	1	65	124	1,464
Mean length (mm)	512	568	559	499	569	558
SE	1.9	0.6		3.2	1.6	0.8
All Fish						
Sample size	399	1,929	2	161	220	2,711
Mean length (mm)	505	573	552	500	571	557
SE	1.7	0.5	12	2.7	1.4	0.7

2005

In 2005, the sockeye salmon escapement was composed primarily of age-1.3 (64%) and age-1.2 (22%) fish (Table 12; Appendix M). The remainder of the escapement (14%) was composed of age-2.2 and age-2.3 fish. Age-1.2 fish had a mean length of 484 mm for males and 500 mm for females, and age-1.3 fish had a mean length of 574 mm for males and 561 mm for females (Table 13; Appendix N).

Table 12.–Age composition of the Chilkoot Lake sockeye salmon escapement, weighted by statistical week, 2005.

Brood year	2001	2000	1999	2000	1999	
Age class	1.2	1.3	1.4	2.2	2.3	Total
Sample size	542	1,843	4	106	235	2,730
Escapement	11,048	32,908	71	2,242	4,909	51,178
Escapement SE	433	508	38	228	326	
Percent	22%	64%	<1%	4%	10%	
Percent SE	0.8%	1.0%	0.1%	0.4%	0.6%	

Table 13.–Average length (mideye to tail fork) of Chilkoot Lake sockeye salmon by age class and sex, 2005.

Brood year	2001	2000	1999	2000	1999	
Age class	1.2	1.3	1.4	2.2	2.3	Total
Male						
Sample size	407	862	3	80	92	1,444
Mean length (mm)	484	574	617	487	569	543
SE	1.7	0.8	16.4	4	2.5	1.3
Female						
Sample size	134	980	1	26	143	1,284
Mean length (mm)	500	561	575	499	555	552
SE	1.9	0.7		4.8	1.8	0.8
All Fish						
Sample size	541	1,842	4	106	236	2,728
Mean length (mm)	488	567	606	490	561	548
SE	1.4	0.5	15.6	3.3	1.5	0.8

2006

In 2006, the sockeye salmon escapement was composed primarily of age-1.3 (79%) fish, followed by age-2.3 (11%) and age-1.2 (9%) fish (Table 14; Appendix M). Age 2.2 fish composed only 1% of the escapement. Single age-0.3 and age-2.4 fish were sampled in 2006, whereas none were sampled in 2004 or 2005. Age-1.2 fish had a mean length of 480 mm for males and 511 mm for females, and age-1.3 fish had a mean length of 569 mm for males and 554 mm for females (Table 15; Appendix N).

Table 14.–Age composition of the Chilkoot Lake sockeye salmon escapement, weighted by statistical week, 2006.

Brood year	2002	2002	2001	2000	2001	2000	1999	
Age class	0.3	1.2	1.3	1.4	2.2	2.3	2.4	Total
Sample size	1	211	2076	1	22	269	1	2,581
Escapement	22	8,492	76,211	48	817	10,578	34	96,202
Escapement SE	21	582	839	48	187	653	34	
Percent	0%	9%	79%	0%	1%	11%	0%	
Percent SE	0.0%	0.6%	0.9%	0.0%	0.2%	0.7%	0.0%	

Table 15.–Average length (mideye to tail fork) of Chilkoot Lake sockeye salmon by age class and sex, 2006.

Brood year	2002	2002	2001	2000	2001	2000	1999	
Age class	0.3	1.2	1.3	1.4	2.2	2.3	2.4	Total
Male								
Sample size	1	160	991	0	14	124	1	1,291
Mean length (mm)	595	480	569		493	567	550	557
SE		3.1	0.8		13.1	1.9		1.1
Female								
Sample size	0	50	1,084	1	8	143	0	1,286
Mean length (mm)		511	554	560	511	555		552
SE		4.3	0.6		13.5	1.6		0.6
All Fish								
Sample size	1	210	2,075	1	22	267	1	2,577
Mean length (mm)	595	487	561	560	499	560	550	555
SE		2.7	0.5		9.7	1.3		0.6

FRY POPULATION ESTIMATE

Hydroacoustic and trawl surveys were conducted at Chilkoot Lake on 10 November 2005 and 9 November 2006. Riffe (2006) reported hydroacoustic and trawl results for 2004. In 2005, the total pelagic fish population was estimated to be 247,283 fish (SE = 54,715; CV = 22.1%). In 2006, the total pelagic fish population was estimated to be 356,957 fish (SE = 61,286; CV = 17.2%). Sockeye salmon fry were the only species of fish caught in trawl surveys in both years: 25 fish in seven trawls in 2005 and 80 fish in six trawls in 2006. We assumed that sockeye salmon fry accounted for 100% of the pelagic fish population; however, threespine stickleback (*Gasterosteus aculeatus*), sculpin (*Cottus* sp.), and other species were caught in trawl surveys in past years and were likely also present in 2005 and 2006 (Table 16). The overall precision of the pelagic fish estimates did not meet the objectives for a CV ≤ 15%, likely due to the very small populations of sockeye salmon fry present in the lake. Estimated populations in both years were below the 25th percentile of 1987–2004 estimates (Table 16).

Table 16.–Number and percentage of fish collected in trawl samples by species, and estimated total number of fish (hydroacoustic targets) and sockeye salmon fry in autumn surveys of Chilkoot Lake, 1987–1991 and 1995–2006.

	Tow net samples				Percent	Percent	Percent	Estimated	
Year	Total fish	Sockeye	Stickleback	Other	sockeye	stickleback	other	Targets	Sockeye
1987	194	141	41	12	73%	21%	6%	1,344,951	977,516
1988	85	83	0	2	98%	0%	2%	3,066,118	2,993,974
1989	209	208	1	0	100%	1%	0%	874,794	870,608
1990	240	238	0	2	99%	0%	1%	607,892	602,826
1991	47	38	9	0	81%	19%	0%	475,404	384,369
1995	775	708	52	15	91%	7%	2%	260,797	238,250
1996	174	173	0	1	99%	0%	1%	418,152	415,749
1997	117	116	0	1	99%	0%	1%	755,060	748,606
1998	526	523	0	3	99%	0%	1%	1,446,736	1,438,485
1999	263	248	11	4	94%	4%	2%	351,096	330,478
2000	14	13	0	1	93%	0%	7%	1,190,717	1,105,666
2001	61	29	23	9	48%	38%	15%	696,000	330,885
2002	289	288	0	1	100%	0%	0%	1,196,701	1,192,560
2003	139	138	1	0	99%	0%	0%	1,384,754	1,384,754
2004	199	187	4	8	94%	2%	4%	1,059,963	996,046
2005	20	20	0	0	100%	0%	0%	247,283	247,283
2006	348	348	0	0	100%	0%	0%	356,957	356,957

LIMNOLOGICAL ASSESSMENT

Light and Temperature Profiles

In both 2005 and 2006, the euphotic zone depth in Chilkoot Lake was deepest at the beginning of the season, and gradually became shallower as the season progressed. In 2005, the average euphotic zone depth ranged from 12.4 m in May to 2.2 m in September and averaged about 6 m for the entire season (Table 17). In 2006, the euphotic zone depth ranged from 13.5 m in May to 5.3 m in late August and averaged about 8 m for the entire season (Table 17).

In both 2005 and 2006, weak thermoclines (the depths at which temperature change was >1ºC per m) developed between May and September but were not detected every month (Figure 7). The thermocline depth ranged from 1 m to 3 m, below which temperature declined steadily to a depth of about 20 m. The maximum lake surface temperature recorded in 2005 was 13.0 ºC on 26 May, and the maximum lake surface temperature recorded in 2006 was 16.0 ºC on 14 June.

Table 17.–Euphotic zone depths (m) in Chilkoot Lake in 2005 and 2006.

Year	Date	Station 1	Station 2	Mean
2005	22 Apr	12.30	12.40	12.35
	26 May	9.90	7.60	8.75
	1 Jul	3.80	4.90	4.35
	25 Jul	3.50	2.60	3.05
	14 Sep	1.80	2.50	2.15
	Seasonal mean			6.13
2006	3 May	13.00	NA	13.00
	22 May	12.00	15.00	13.50
	14 Jun	6.60	10.80	8.70
	14 Jul	6.10	5.60	5.85
	28 Aug	5.00	5.50	5.25
	21 Sep	7.10	7.30	7.20
	Seasonal mean			8.10

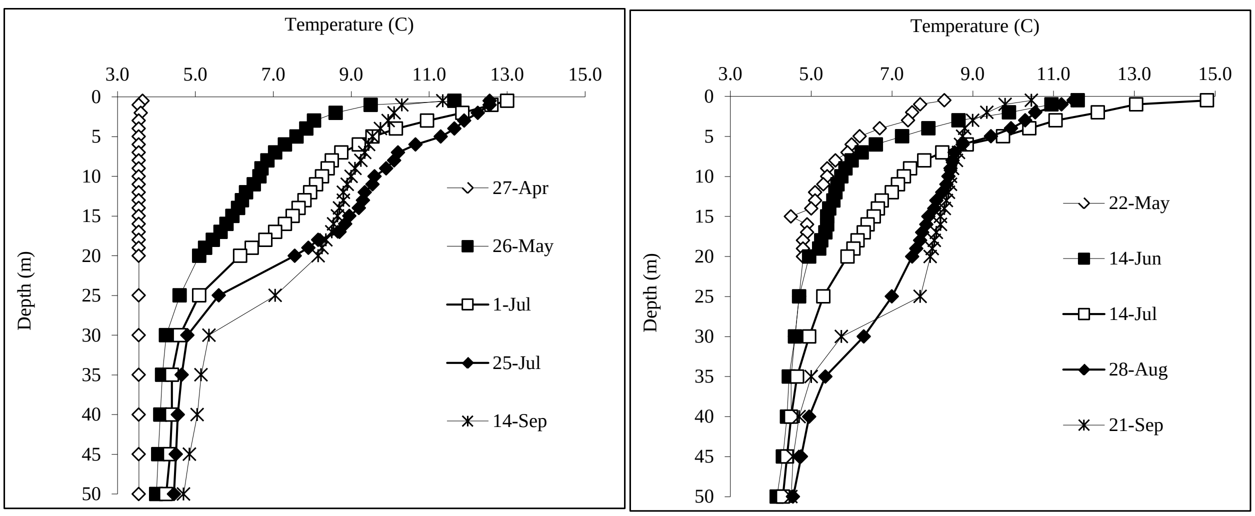

Figure 7.–Water temperature profiles at Chilkoot Lake in 2005 (left) and 2006 (right); average of stations 1 and 2 by date).

Zooplankton Composition

Zooplankton samples from Chilkoot Lake were composed entirely of copepods (*Cyclops* sp.) in both 2005 and 2006 (Tables 18–21). The zooplankton population was remarkably lower in 2005 than in 2006—seasonal mean density was 3,222 per m^2 in 2005 and 78,358 per m^2 in 2006, and seasonal mean biomass was 7.65 per m^3 in 2005 and 211.40 per m^3 in 2006. In 2005, zooplankton density peaked in the middle of the summer but was very low all season. In 2006, zooplankton density was variable through the summer, but was highest in May and July. Mean lengths of non-ovigerous *Cyclops* sp. increased throughout the season in both years but were larger later in the season in 2006 than in 2005.

Table 18.–Mean density of zooplankton per m^2 of lake surface area, by sampling date and taxon, in Chilkoot Lake, 2005. Estimates were averaged by date across all four sampling stations.

	Zooplankton density (number/m^2) by sampling date							Seasonal mean	
Taxon	22-Apr	26-May	1-Jul	25-Jul	10-Aug	14-Sep	19-Oct	Density	% Density
Cyclops sp.	221	1,732	2,991	6,160	3,859	2,904	1,312	2,865	89%
Ovig. *Cyclops*	0	13	0	43	19	403	153	92	23%
Cyclops nauplii	348	688	221	189	157	55	210	266	8%
Total	569	2,433	3,212	6,392	4,035	3,362	1,675	3,222	

Table 19.–Mean length and biomass of zooplankton by sampling date and taxon, in Chilkoot Lake, 2005. Estimates were averaged by date across all four sampling stations.

	Macrozooplankton length (mm) by sampling date							Seasonal means (weighted)		
Taxon	22-Apr	26-May	1-Jul	25-Jul	10-Aug	14-Sep	19-Oct	Length (mm)	Biomass (mg/m^2)	% biomass
Cyclops sp.	0.67	0.51	0.74	0.85	0.91	0.98	0.95	0.84	7.06	92%
Ovig. *Cyclops*	0.00	1.29	0.00	1.18	1.25	1.31	1.30	1.31	0.59	8%
Cyclops nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0%
Total									7.65	

Table 20.–Mean density of zooplankton per m^2 of lake surface area, by sampling date and taxon, in Chilkoot Lake, 2006. Estimates were averaged by date across all four sampling stations.

	Macrozooplankton density (number/m^2) by sampling date						Seasonal mean	
Taxon	3-May	22-May	14-Jun	14-Jul	28-Aug	21-Sep	Density	% Density
Cyclops sp.	101,397	92,015	51,919	90,083	27,000	30,396	66,822	85%
Ovig. *Cyclops*	0	0	85	6,962	11,759	16,528	5,510	7%
Cyclops nauplii	11,250	6,941	3,375	1,698	3,863	9,736	6,026	8%
Total	112,646	98,956	55,379	98,743	42,622	56,659	78,358	

Table 21.–Mean length and biomass of zooplankton by sampling date and taxon, in Chilkoot Lake, 2006. Estimates were averaged by date across all four sampling stations.

	Macrozooplankton length (mm) by sampling date						Seasonal means (weighted)		
Taxon	3-May	22-May	14-Jun	14-Jul	28-Aug	21-Sep	Length (mm)	Biomass (mg/m^2)	% biomass
Cyclops sp.	0.65	0.76	0.85	1.06	1.10	1.04	0.87	176.56	84%
Ovig. *Cyclops*	0.00	0.00	1.57	1.33	1.31	1.26	1.29	34.84	16%
Cyclops nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0%
Total								211.40	

DISCUSSION

Chilkoot Lake sockeye salmon runs have steadily improved since declining to low levels in the 1990s (Appendix A). Although the 2005 run was below the long-term average in size, escapements and commercial harvests were above the recent 10-year average in all three years of this study, including 2005, and the 2006 run was the largest in 14 years. Chilkoot weir counts were higher than the long-term average in 2004 and 2006 and below the long-term average in

2005, but established escapement goals were met or exceeded for all years, 2004–2006. Daily weir passages for all years fluctuated dramatically throughout the migration (Figure 4). On average, peak migratory timing occurs on approximately 30 July. Peak weir counts in 2005 and 2006 occurred later than average, while peak weir counts during 2004 were close to the historical average.

Chilkoot mark-recapture estimates have typically been much larger than weir counts (Kelley and Bachman 1999; Bachman and Sogge 2006), and our 2004 mark-recapture population estimate of 152,000 sockeye salmon was approximately double the weir count. Over the nine-year series of mark-recapture estimates since 1996, mark-recapture estimates averaged 1.85 times greater than weir counts and weir counts fell within the 95% CI of the estimates in only two years (Appendix C). The reasons for the large differences between mark-recapture estimates and weir counts could be the result of bias in the mark-recapture estimates, systematic undercounting of fish at the weir, or potentially both.

Mark-recapture studies are subject to many assumptions, and serious, hard-to-detect bias may result when those conditions are not met (Arnason et al. 1996). In particular, loss of marked fish due to mortality, change in behavior, or non-recognition of marks, and variation in initial capture and final recapture probabilities could result in a mark-recapture estimate that is biased (Seber 1982; Schwarz and Taylor 1998). The initial mortality rate on fish marked at the Chilkoot weir in 2004 was very low (<1%); however, once fish reach the lake it is impossible to know if marked fish died at a higher rate or behaved differently than unmarked fish. In 2004, our objective to mark fish at a constant rate of 10% of the daily weir passage was not maintained throughout the season (Table 5), resulting in diluted marked fraction on the spawning grounds and lower or variable mark ratios. Finally, it is often difficult to consistently sample the portion of the run that spawns above the lake in the Chilkat River. Fast river currents, high summer water levels, and glacial turbidity hampers recovery trips to upriver locations. Sampling opportunity improves later in the fall as the river level drops and visibility improves, but in some years a significant portion of the run that spawns upriver of Chilkoot Lake may have received little or no sampling for marks.

Weir counts, too, can be biased low due to the difficulty of maintaining the physical integrity of the weir. Flooding can allow fish to pass above or around the sides of the weir, streambed erosion can create holes large enough for fish to pass undetected under the weir, and glacial turbidity in the Chilkoot River makes it difficult to detect small gaps and openings. Pickets are removed from the weir during extreme high water levels to prevent damage to the weir. Recognition of these problems led to improvements in weir construction and maintenance. The Chilkoot weir was inspected daily for holes, loose pickets, and gaps through which fish could pass undetected and sand bags and wire mesh are used liberally to plug or close small holes. Although flooding required the weir to be opened for a full week in June 2004, it is highly unlikely that 50% of the run escaped in that one week. No major holes or other problems were identified in the weir in 2005 or 2006. Estimates of escapement, total return, and exploitation rate would all change substantially if mark-recapture estimates were used instead of weir counts. Differences between the two estimates, however, have not been consistent enough to calibrate past weir counts, and escapement goal analyses to date have been based on weir counts, recognizing that they are likely conservative (Geiger et al. 2005; Eggers et al. 2009).

Exploitation rates on Chilkoot sockeye salmon (including commercial, subsistence, and sport harvest) fluctuated around the long term average of 38% during 2004–2006. The exploitation rate was lower in 2005 (38%) than in 2004 (48%) and 2006 (56%) as a result of the below-average run size and more conservative fishery management in 2005. The District 15 drift gillnet fishery is managed to achieve Chilkoot escapement objectives through time, area, and gear restrictions that are guided by inseason run projections based on daily weir counts. Openings early in the season are designed to harvest large hatchery runs of summer chum salmon in section 15-C (lower Lynn Canal; Figure 1) while minimizing the harvest of north bound sockeye salmon and other wild stocks until run strength can be determined. Once escapement objectives for Chilkoot Lake sockeye salmon are projected to be met (e.g., in 2004 and 2006), area along the eastern shoreline of section 15-A (upper Lynn Canal; Figure 1) is opened to target this stock. During years of high Chilkoot sockeye salmon abundance, additional time and area are granted north of the latitude of Mud Bay point, and during very strong years, like in 2006, Lutak Inlet (Figure 1) has been open for extended time each week to harvest Chilkoot sockeye salmon in excess of escapement needs. In 2006, Lutak Inlet was open to the terminus of the Chilkoot River in statistical weeks 36–38 for 3–4 days each week (Davidson et al. 2008).

Fishing effort in the District 15 Lynn Canal drift gillnet fishery has been lower over the past two decades compared to the peak years in the 1980s (Figure 8). Participation in the drift gillnet fishery decreased from an average of 290 boats to 110 boats in recent years, due to restrictions to improve Chilkoot sockeye salmon escapements and to a downturn in salmon exvessel values.

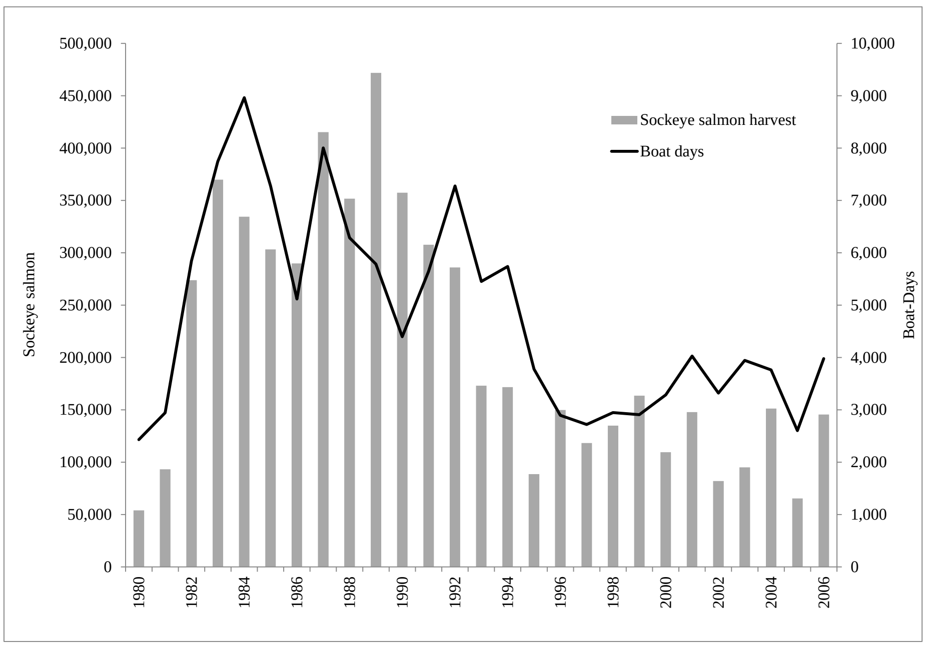

Figure 8.–Annual fishing effort in boat-days and total sockeye salmon harvest in the District 15 commercial drift gillnet fishery, 1980–2006.

The changing productivity of Chilkoot Lake presents challenges for management of this stock. Riffe (2006) and Eggers et al. (2009) hypothesized that the dramatic downturn in Chilkoot Lake sockeye salmon production observed in the 1990s (Appendix A) was due to changes in freshwater conditions brought about by local warming. Chilkoot Lake is in transition between being a clear lake and a glacial lake. In the spring and winter, the lake has characteristics consistent with clear lakes and during the summer, especially warm dry summers, Chilkoot Lake becomes cold and silty as glacial melt flows into the lake. During hot dry summers similar to those observed in the 1990s and in 2004–2005, glacial melt increases, more silt is deposited into the lake, and the euphotic volume is reduced. Reduced euphotic volume affects all trophic levels, from phytoplankton to zooplankton to sockeye salmon fry (Koenings and Burkett 1987). Like most glacially-influenced Alaska lakes (Koenings et al. 1989, 1990), the macrozooplankton community in Chilkoot Lake is represented solely by copepods (*Cyclops columbianus*; Barto 1996), which are not as responsive as cladocerans to variation in lake productivity and abundance of predators (Edmundson et al. 1992; Kyle et al. 1990).

Results of our 2005–2006 surveys of Chilkoot Lake productivity suggest the potential for reduced runs of sockeye salmon in the future. Our estimates of rearing sockeye salmon fry populations, in particular, were well below average in 2005 and 2006 (Table 16). As in most years, euphotic zone depths in Chilkoot Lake are highest in the spring and steadily drop through the season as turbidity increases due to warm summer snow and ice melt into the lake. Euphotic zone depths in 2005 were generally lower than in 2006. The seasonal mean was almost two meters deeper in 2006—2005 was a very hot and dry summer while 2006 was much cooler and wetter than average.

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APPENDICES

Appendix A.–Annual Chilkoot Lake sockeye salmon escapements (weir counts), and estimated harvests (commercial, sport, and subsistence), total runs, and exploitation rates, 1976–2006.

Year	Weir count	Escapement goal range		Harvest				Total run	Exploitation Rate (%)
		Lower	Upper	Commercial	Sport[a]	Subsistence[b]	Total		
1976	71,296	80,000	100,000	62,452	ND	ND	62,452	133,748	47%
1977	97,368	80,000	100,000	113,313	400	ND	113,713	211,081	54%
1978	35,454	80,000	100,000	14,264	500	ND	14,764	50,218	29%
1979	95,948	80,000	100,000	69,864	300	ND	70,164	166,112	42%
1980	96,513	80,000	100,000	20,846	700	ND	21,546	118,059	18%
1981	84,047	60,000	80,000	43,792	1,200	ND	44,992	129,039	35%
1982	103,038	60,000	80,000	144,592	800	ND	145,392	248,430	59%
1983	80,141	60,000	80,000	241,469	600	ND	242,069	322,210	75%
1984	100,781	60,000	80,000	231,792	1,000	ND	232,792	333,573	70%
1985	69,141	60,000	80,000	152,325	1,100	1,001	154,426	223,567	69%
1986	88,024	60,000	80,000	110,430	3,000	1,640	115,070	203,094	57%
1987	94,208	60,000	80,000	334,995	1,700	1,237	337,932	432,140	78%
1988	81,274	60,000	80,000	253,968	300	828	255,096	336,370	76%
1989	54,900	60,000	80,000	291,863	900	1,831	294,594	349,494	84%
1990	76,119	50,500	91,500	178,864	2,600	2,207	183,671	259,790	71%
1991	90,754	50,500	91,500	224,041	600	4,348	228,989	319,743	72%
1992	67,071	50,500	91,500	140,719	500	4,104	145,323	212,394	68%
1993	52,080	50,500	91,500	51,424	100	2,896	54,420	106,500	51%
1994	37,007	50,500	91,500	25,414	400	1,589	27,403	64,410	43%
1995	7,177	50,500	91,500	7,946	200	384	8,530	15,707	54%
1996	50,741	50,500	91,500	18,861	400	2,311	21,572	72,313	30%
1997	44,254	50,500	91,500	28,913	500	1,781	31,194	75,448	41%
1998	12,335	50,500	91,500	2,206	closed	160	2,366	14,701	16%
1999	19,284	50,500	91,500	4,258	closed	115	4,373	23,657	18%
2000	43,555	50,500	91,500	14,133	400	251	14,784	58,339	25%
2001	76,283	50,500	91,500	67,502	2,300	1,499	71,301	147,584	48%
2002	58,361	50,500	91,500	24,275	1,500	1,258	27,033	85,394	32%
2003	74,459	50,500	91,500	32,324	1,500	2,091	35,915	110,374	33%
2004	75,596	50,500	91,500	66,498	889	1,766	69,153	144,749	48%
2005	51,178	50,500	91,500	29,276	566	1,427	31,269	82,447	38%
2006	96,203	50,000	90,000	119,201	520	2,279	122,000	218,203	56%
Average	65,590			100,704	842	1,752	102,719	169,964	50%

a. Sport fish salmon record keeping began in 1977.

b. Subsistence salmon record keeping began in 1985.

Appendix B.–Chilkoot River weir dates of operation and annual counts by salmon species, 1976–2006.

Year	Dates	Chinook salmon	Sockeye salmon	Coho salmon	Pink salmon	Chum salmon
1976	5/29–11/4	NA	71,296	991	1,250	241
1977	5/28–9/18	NA	97,368	5	5,270	195
1978	6/6–11/8	NA	35,454	1,092	112	382
1979	6/9–11/4	NA	95,948	899	NA	253
1980	6/15–10/4	NA	96,513	628	4,683	719
1981	6/10–10/12	NA	84,047	1,585	34,821	405
1982	6/3–9/14	6	103,038	5	6,665	507
1983	6/4–11/12	0	80,141	1,844	11,237	501
1984	6/3–9/14	0	100,781	321	5,034	372
1985	6/5–10/28	5	69,141	2,202	33,608	1,031
1986	6/4–10/28	6	88,024	1,966	1,249	508
1987	6/4–11/2	3	94,208	576	6,689	431
1988	6/9–11/12	1	81,274	1,476	5,274	450
1989	6/3–10/30	0	54,900	3,998	2,118	223
1990	6/3–10/30	0	76,119	988	10,398	216
1991	6/7–10/8	0	90,754	4,000	2,588	357
1992	6/2–9/26	1	67,071	1,518	7,836	193
1993	6/3–9/30	203	52,080	322	357	240
1994	6/4–9/24	118	37,007	463	22,472	214
1995	6/5–9/10	7	7,177	95	1,243	99
1996	6/6–9/11	19	50,741	86	2,867	305
1997	6/04–9/09	6	44,254	17	26,197	268
1998	6/04–9/13	11	12,335	131	44,001	368
1999	6/02–9/13	29	19,284	11	56,692	713
2000	6/03–9/12	10	43,555	47	23,636	1050
2001	6/07–9/12	24	76,283	103	32,294	810
2002	6/08–9/11	36	58,361	304	79,639	352
2003	6/06–9/09	12	74,459	15	55,424	498
2004	6/3–9/12	17	75,596	89	107,994	617
2005	6/6–9/12	9	51,178	23	90,486	262
2006	6/5–9/13	1	96,203	158	33,888	257
Average		21	67,245	837	23,867	421

Appendix C.–Chilkoot Lake sockeye salmon mark-recapture data and estimates compared to weir counts, 1996–2004.

Year	Number marked	Number captured	Number recaptured	Mark-recapture estimate	SE	95% CI Lower	95% CI Upper	Weir count	Expansion factor [a]
1996[b]	NA	NA	NA	65,000	9,000	46,000	83,000	50,741	1.28
1997[b]	3,489	NA	NA	80,000	5,393	68,040	89,180	44,254	1.80
1998	1,248	700	29	28,000	5,000	18,000	38,000	12,335	2.27
1999	3,952	1,410	89	62,000	6,000	50,000	70,000	19,284	3.22
2000	4,386	1,781	128	60,000	5,000	50,000	70,000	43,555	1.38
2001	6,368	1,480	92	100,000	10,000	81,000	119,000	76,283	1.31
2002	5,419	1,887	166	61,000	4,000	52,000	70,000	58,361	1.05
2003	6,363	1,529	60	177,000	39,000	99,000	524,000	74,459	2.38
2004	6,682	1,869	82	150,000	16,000	123,000	186,000	75,596	1.98

a. The expansion factor equals the mark-recapture estimated divided by the weir count.

b Mark-recapture data not available for studies conducted in 1996 and 1997.

Appendix D.–Detection of size and/or sex selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1999) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (*M*) with that of marked fish recaptured during the second event (*R*) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (*C*) with that of *R*. A third test that compares *M* and *C* is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for *R* and <100 for *M* or *C*.

Sex selective sampling: Contingency table analysis (χ^2 test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between *M* and *R*, *C* and *R*, and *M* and *C* using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually *C*), rather observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g., Student's t-test).

M* vs. *R	***C* vs. *R***	***M* vs. *C***
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:

Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:

Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:

Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:

Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for *M* vs. *R* and *C* vs. *R* tests are not small and sample sizes for *M* vs. *C* test are very large, the *M* vs. *C* test will likely detect small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for *M* vs. *R* are small, b) the *M* vs. *R* *P*-value is not large (~0.20 or less), and c) the *C* vs. *R* sample sizes are not small and/or the *C* vs. *R* *P*-value is fairly large (~0.30 or more), the rejection of the null in the *M* vs. *C* test was likely the result of size/sex selectivity during the second event which the *M* vs. *R* test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

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C. If a) sample sizes for *C* vs. *R* are small, b) the *C* vs. *R P*-value is not large (~0.20 or less), and c) the *M* vs. *R* sample sizes are not small and/or the *M* vs. *R P*-value is fairly large (~0.30 or more), the rejection of the null in the *M* vs. *C* test was likely the result of size/sex selectivity during the first event which the *C* vs. *R* test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for *C* vs. *R* and *M* vs. *R* are both small, and b) both the *C* vs. *R* and *M* vs. *R P*-values are not large (~0.20 or less), the rejection of the null in the *M* vs. *C* test may be the result of size/sex selectivity during both events which the *C* vs. *R* and *M* vs. *R* tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the *M* vs. *R* test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the *C* vs. *R* test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{ ; and,} \quad (1)$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \left(\sum_{i=1}^{j} \hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}[\hat{N}_i] \right). \quad (2)$$

where:

where:	j	=	the number of sex/size strata;
	$\hat{p}_{ik}$	=	the estimated proportion of fish that were age or size k among fish in stratum i;
	$\hat{N}_i$	=	the estimated abundance in stratum i; and,
	$\hat{N}_\Sigma$	=	sum of the $\hat{N}_i$ across strata.

The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week, were calculated using equations from Cochran (1977).

Let

h	=	index of the stratum (week),
j	=	index of the age class,
p_{hj}	=	proportion of the sample taken during stratum h that is age j,
n_h	=	number of fish sampled in week h, and
n_{hj}	=	number observed in class j, week h.

Then the age distribution was estimated for each week of the escapement in the usual manner:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \tag{1}$$

If N_h equals the number of fish in the escapement in week h, standard errors of the weekly age class proportions are calculated in the usual manner (Cochran 1977, page 52, equation 3.12):

$$SE(\hat{p}_{hj}) = \sqrt{\left[\frac{(\hat{p}_{hj})(1-\hat{p}_{hj})}{n_h - 1}\right][1 - n_h / N_h]} \ . \tag{2}$$

The age distributions for the total escapement were estimated as a weighted sum (by stratum size) of the weekly proportions. That is,

$$\hat{p}_j = \sum_h p_{hj} (N_h / N), \tag{3}$$

such that N equals the total escapement. The standard error of a seasonal proportion is the square root of the weighted sum of the weekly variances (Cochran 1977, pages 107–108):

$$SE(\hat{p}_j) = \sqrt{\sum_j^h [SE(\hat{p}_{hj})]^2 (N_h / N)^2} \ . \tag{4}$$

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, were calculated using the following equations from Cochran (1977, pages 142–144) for estimating means over subpopulations. That is, let i equal the index of the individual fish in the age-sex class j, and y_{hij} equal the length of the ith fish in class j, week h, so that,

$$\hat{\bar{Y}}_j = \frac{\sum_h (N_h / n_h) \sum_i y_{hij}}{\sum_h (N_h / n_h) n_{hj}} \text{, and} \tag{5}$$

$$\hat{V}\left(\hat{\bar{Y}}_j\right) = \frac{1}{\hat{N}_j^2} \sum_h \frac{N_h^2 (1 - n_h / N_h)}{n_h (n_h - 1)} \left[\sum_i (y_{hij} - \bar{y}_{hj})^2 + n_{hj}\left(1 - \frac{n_{hj}}{n_h}\right)\left(\bar{y}_{hj} - \hat{\bar{Y}}_j\right)^2\right].$$

Appendix F.–ADF&G statistical weeks, 2004–2006.

Statistical week	2004		2005		2006	
	Beginning	Ending	Beginning	Ending	Beginning	Ending
24	6/6	6/12	6/5	6/11	6/11	6/17
25	6/13	6/19	6/12	6/18	6/18	6/24
26	6/20	6/26	6/19	6/25	6/25	7/1
27	6/27	7/3	6/26	7/2	7/2	7/8
28	7/4	7/10	7/3	7/9	7/9	7/15
29	7/11	7/17	7/10	7/16	7/16	7/22
30	7/18	7/24	7/17	7/23	7/23	7/29
31	7/25	7/31	7/24	7/30	7/30	8/5
32	8/1	8/7	7/31	8/6	8/6	8/12
33	8/8	8/14	8/7	8/13	8/13	8/19
34	8/15	8/21	8/14	8/20	8/20	8/26
35	8/22	8/28	8/21	8/27	8/27	9/2
36	8/29	9/4	8/28	9/3	9/3	9/9
37	9/5	9/11	9/4	9/10	9/10	9/16
38	9/12	9/18	9/11	9/17	9/17	9/23
39	9/19	9/25	9/18	9/24	9/24	9/30
40	9/26	10/2	9/25	10/1	10/1	10/7
41	10/3	10/9	10/2	10/8	10/8	10/14
42	10/10	10/16	10/9	10/15	10/15	10/21

To apportion out the estimates by species, we developed a Bayesian hierarchical model based on an idea of repeated binomial sampling. In short, we assumed that each trawl sample was a binomial sample with parameter p_i that is specific to that one, particular trawl sample. We then assumed that each p_i was drawn from a beta distribution with parameters α and β. In order to develop probability statements about the number of sockeye salmon targets, we assumed the Bayesian posterior distribution of the number of total targets was approximated by a *t*-distribution with a small number of degrees of freedom (like 5, for example). Then the Bayesian posterior distribution for the number of sockeye salmon fry in the lake was found by simulation: by repeatedly drawing an observation from the posterior distribution of the proportion of sockeye salmon fry and by repeatedly sampling the posterior distribution of the total targets in the lake.

Suppose there were a total of *I* total trawl samples from different parts of the lake, and that *i* indexes one possible trawl sample. First, the specimens from the i^{th} trawl sample were divided into y_i sockeye salmon fry, and n_i-y_i non-sockeye salmon targets, for a total sample size of n_i. Let p_i denote the underlying (parameter) mean proportion of sockeye salmon targets associated with the *i*th trawl sample in the lake. Conditioned on this parameter (p_i) and on the total number of fish caught in the *i*th trawl sample the number of sockeye salmon fry in the sample could be modeled with a binominal sampling law. The unknown parameter p_i, denoted the underlying proportion of sockeye salmon that the *i*th trawl sample was sampling. Each trawl sample had its own underlying proportion of sockeye salmon, depending on schooling or clustering of either sockeye salmon or else schooling or clustering of other kinds of sonar targets within the lake. Next, we supposed that p_i was itself drawn from a beta probability distribution with hyperparameters α and β, such that the hyperparameters α and β are the same for each transect in the lake at the occasion of the trawl sampling. These hyperparameters can be re-expressed as an overall mean, given by *p*, which represents the overall proportion of sockeye salmon juveniles within the whole lake:

$$p = \frac{\alpha}{\alpha + \beta}.$$

We chose a uniform distribution between 0 and 10 for both the α and β parameters. These distributions limited the influence of the prior distributions on the posterior distributions, once a large sample size was achieved, and this ensured that once a large sample was collected the data had adequate influence. We noted that as posterior probability built up on larger and larger values of α and β, the posterior means of each p_i became more alike, and the posterior variance of the overall *p* declined. Limiting the maximum values of both α and β to 10 seemed to provide a compromise between allowing the posterior means of the individual p_i's to be either alike or unalike, while still allowing the data (likelihood) to dominate the posterior distribution.

Then the properties of *p* were studied through its Bayesian posterior distribution (Appendix A1). Note that the total sample size was 97, and that in four trawl samples a total of 43 sockeye salmon were caught, for a sample proportion of 0.443 sockeye salmon. This number differs only slightly from the Bayesian posterior mean of 0.432. The usual binominal sample standard error for this

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estimate was 0.050. In this particular case, by inspection, the individual samples look like they could have come from binominal distributions with a common proportion parameter. Even so, our Bayesian standard error was 76% larger than the usual sampling-based binominal standard error.

Summary of the Markov Chain Monte Carlo simulations of the posterior distributions of the proportion of sockeye salmon fry sampled in the four trawl passes and the posterior distribution for the proportion of sockeye salmon fry in the whole lake. Each trawl pass was assumed to have a specific rate of sockeye salmon acquisition, denoted p_i, and the overall rate for the whole lake is denoted p. Each individual p_i was assumed to follow a beta distribution with the same hyperparameters α and β, such that the mean for the whole lake is given by $p = \alpha/(\alpha+\beta)$. In turn, α and β were assumed to follow uniform distribution on the interval 0 to 10.

Parameter	Posterior mean	Posterior SE	2.50 Percentile	Median	97.50 Percentile	Sample size	Sockeye sample
p_1	0.468	0.055	0.361	0.467	0.578	74	34
p_2	0.467	0.109	0.256	0.467	0.682	12	6
p_3	0.431	0.123	0.201	0.427	0.679	7	3
p_4	0.320	0.136	0.063	0.319	0.593	4	0
p	0.432	0.089	0.248	0.437	0.596	97	43

Now let S denote the number of sockeye salmon fry that were within the lake. Recalling that T denoted the total targets within the lake and p denoted the proportion of the targets that are sockeye salmon fry, obviously $S = pT$. The estimate of total targets developed above is in the sampling-based frame of reference, and we need to discuss both the estimates of p and T in the same frames of reference, either Bayesian or sampling based. To do that, we assumed that the Bayesian posterior distribution of T was adequately approximated by a *t*-distribution with a very few degrees of freedom (such as 5).

We used a Markov Chain Monte Carlo method to numerically approximate all posterior distributions. The analysis was performed with the Winbugs software. At each simulation step, a value of p and a value of T were drawn from their posterior distributions, and a value of S was generated by multiplication. At least 5,000 observations of each posterior distribution were generated for the estimation of the posterior mean and standard deviation. The interval from the 2.5^{th} percentile to the 97.5^{th} percentile of the posterior distribution of the overall S was reported as the 95% *credible interval*, which is similar to a 95% confidence interval, but with a more direct probability statement (i.e., the probability is 95% that the parameter is within the credible interval). Naturally, the trawl-sampling tool may be biased, so that there may be a substantial difference between the true proportion of sockeye salmon that could be caught with a trawl in the lake in question and the true proportion of sonar targets that are made up of sockeye salmon.

Appendix H.–Daily and cumulative Chilkoot River weir counts of salmon, by species, number of sockeye salmon marked, and water temperature and gauge heights, 2004.

	Sockeye salmon					Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
Date	Daily	Cum.	Marked	Cum.	Mark[a]	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	level (mm)	temp (°C)
4–Jun	19	19	2	2	AD	0	0	0	0	0	0	0	0	139	7.8
5–Jun	22	41	6	8	AD	0	0	0	0	0	0	0	0	146	7.5
6–Jun	29	70	0	8	AD	0	0	0	0	0	0	0	0	151	8.8
7–Jun	33	103	3	11	AD	0	0	0	0	0	0	0	0	169	8.2
8–Jun	15	118	0	11	AD	0	0	0	0	0	0	0	0	177	6.0
9–Jun	6	124	0	11	AD	0	0	0	0	0	0	0	0	166	6.6
10–Jun	45	169	6	17	AD	0	0	0	0	0	0	0	0	160	5.6
11–Jun	54	223	5	22	AD	0	0	0	0	0	0	0	0	152	6.3
12–Jun	51	274	7	29	AD	0	0	0	0	0	0	0	0	146	6.7
13–Jun	131	405	12	41	RV	0	0	0	0	0	0	1	1	147	7.0
14–Jun	142	547	16	57	RV	0	0	0	0	0	0	0	1	150	7.2
15–Jun	185	732	17	74	RV	0	0	0	0	0	0	0	1	151	7.4
16–Jun	297	1,029	28	102	RV	0	0	0	0	0	0	0	1	147	8.1
17–Jun	179	1,208	26	128	RV	0	0	0	0	0	0	1	2	149	7.7
18–Jun	541	1,749	48	176	RV	0	0	0	0	0	0	0	2	156	8.1
19–Jun	165	1,914	16	192	RV	0	0	0	0	0	0	0	2	173	8.5
20–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	177	9.0
21–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	177	9.4
22–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	178	10.0
23–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	177	10.1
24–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	172	8.8
25–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	174	10.1
26–Jun	0	1,914	0	192	RV	0	0	0	0	0	0	0	2	174	10.6
27–Jun	49	1,963	11	203	LV	0	0	0	0	0	0	0	2	169	10.1
28–Jun	114	2,077	0	203	LV	1	1	0	0	0	0	0	2	173	9.8
29–Jun	167	2,244	11	214	LV	1	2	0	0	0	0	0	2	170	9.4
30–Jun	282	2,526	25	239	LV	2	4	0	0	0	0	0	2	170	8.8
1–Jul	254	2,780	28	267	LV	0	4	0	0	0	0	0	2	165	9.1
2–Jul	210	2,990	20	287	LV	2	6	2	2	0	0	0	2	162	9.1
3–Jul	102	3,092	14	301	LV	1	7	3	5	0	0	0	2	164	8.4
4–Jul	128	3,220	10	311	LV	3	10	0	5	0	0	1	3	159	9.1
5–Jul	400	3,620	33	344	LV	9	19	2	7	0	0	0	3	155	8.0
6–Jul	453	4,073	46	390	LV	5	24	4	11	0	0	0	3	153	8.7
7–Jul	628	4,701	58	448	LV	7	31	5	16	0	0	0	3	153	8.5

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Appendix H.–continued (page 2 of 3)

Date	Sockeye salmon					Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
	Daily	Cum.	Marked	Cum.	Mark[a]	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	level (mm)	temp (°C)
8–Jul	753	5,454	72	520	LV	7	38	4	20	0	0	1	4	151	9.6
9–Jul	450	5,904	50	570	LV	20	58	4	24	0	0	1	5	152	9.1
10–Jul	476	6,380	50	620	LV	35	93	5	29	0	0	1	6	152	9.1
11–Jul	420	6,800	40	660	RA	15	108	2	31	0	0	1	7	151	9.8
12–Jul	757	7,557	79	739	RA	70	178	10	41	0	0	0	7	149	8.7
13–Jul	813	8,370	81	820	RA	70	248	9	50	0	0	2	9	149	10.3
14–Jul	968	9,338	97	917	RA	124	372	4	54	0	0	0	9	150	10.3
15–Jul	560	9,898	56	973	RA	88	460	11	65	0	0	1	10	151	10.1
16–Jul	602	10,500	60	1,033	RA	78	538	16	81	0	0	1	11	153	10.0
17–Jul	1,223	11,723	115	1,148	RA	235	773	23	104	0	0	1	12	152	10.7
18–Jul	1,834	13,557	172	1,320	RA	382	1,155	19	123	0	0	1	13	149	10.2
19–Jul	1,316	14,873	142	1,462	RA	536	1,691	8	131	0	0	0	13	145	10.7
20–Jul	2,007	16,880	140	1,602	RA	703	2,394	14	145	0	0	1	14	145	11.1
21–Jul	1,774	18,654	170	1,772	RA	594	2,988	27	172	0	0	1	15	145	11.0
22–Jul	1,307	19,961	196	1,968	RA	1,118	4,106	10	182	0	0	1	16	146	10.5
23–Jul	1,372	21,333	152	2,120	RA	814	4,920	3	185	0	0	0	16	142	11.5
24–Jul	1,114	22,447	106	2,226	RA	1,061	5,981	15	200	0	0	0	16	153	12.0
25–Jul	1,052	23,499	115	2,341	LA	588	6,569	8	208	0	0	0	16	142	11.0
26–Jul	1,327	24,826	120	2,461	LA	364	6,933	6	214	0	0	0	16	139	10.3
27–Jul	1,650	26,476	175	2,636	LA	312	7,245	10	224	0	0	0	16	136	10.5
28–Jul	2,691	29,167	200	2,836	LA	623	7,868	9	233	0	0	0	16	142	10.2
29–Jul	2,092	31,259	115	2,951	LA	331	8,199	6	239	0	0	0	16	151	9.7
30–Jul	2,065	33,324	114	3,065	LA	736	8,935	8	247	0	0	0	16	147	10.0
31–Jul	1,778	35,102	90	3,155	LA	1,286	10,221	11	258	0	0	0	16	143	10.3
1–Aug	1,550	36,652	90	3,245	LA	3,183	13,404	4	262	0	0	0	16	141	10.3
2–Aug	1,416	38,068	80	3,325	LA	11,521	24,925	8	270	0	0	1	17	136	10.1
3–Aug	860	38,928	86	3,411	LA	8,038	32,963	9	279	0	0	0	17	133	11.0
4–Aug	769	39,697	79	3,490	LA	4,611	37,574	1	280	0	0	0	17	136	11.0
5–Aug	845	40,542	90	3,580	LA	3,516	41,090	2	282	0	0	0	17	136	10.8
6–Aug	2,240	42,782	113	3,693	LA	3,438	44,528	0	282	0	0	0	17	139	9.8
7–Aug	1,070	43,852	107	3,800	LA	1,888	46,416	0	282	0	0	0	17	142	10.4
8–Aug	1,552	45,404	102	3,902	DC	1,838	48,254	1	283	0	0	0	17	142	10.7
9–Aug	1,844	47,248	105	4,007	DC	2,393	50,647	1	284	0	0	0	17	141	11.4
10–Aug	1,795	49,043	101	4,108	DC	3,436	54,083	1	285	0	0	0	17	142	11.9
11–Aug	1,144	50,187	100	4,208	DC	666	54,749	2	287	0	0	0	17	148	10.6

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Appendix H.–continued (page 3 of 3)

	Sockeye salmon					Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
Date	Daily	Cum.	Marked	Cum.	Mark[a]	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	level (mm)	temp (°C)
12–Aug	896	51,083	80	4,288	DC	1,107	55,856	6	293	0	0	0	17	146	10.5
13–Aug	787	51,870	86	4,374	DC	1,245	57,101	2	295	0	0	0	17	142	11.0
14–Aug	1,439	53,309	80	4,454	DC	2,454	59,555	2	297	0	0	0	17	140	11.6
15–Aug	696	54,005	120	4,574	DC	1,980	61,535	2	299	0	0	0	17	145	12.3
16–Aug	511	54,516	80	4,654	DC	3,530	65,065	3	302	0	0	0	17	148	12.2
17–Aug	411	54,927	59	4,713	DC	2,437	67,502	2	304	0	0	0	17	150	11.8
18–Aug	591	55,518	62	4,775	DC	1,694	69,196	0	304	0	0	0	17	150	9.9
19–Aug	201	55,719	40	4,815	DC	1,514	70,710	2	306	0	0	0	17	146	10.1
20–Aug	317	56,036	35	4,850	DC	2,533	73,243	0	306	0	0	0	17	144	10.3
21–Aug	856	56,892	65	4,915	DC	2,659	75,902	9	315	0	0	0	17	142	10.6
22–Aug	837	57,729	62	4,977	RP	1,664	77,566	1	316	0	0	0	17	144	11.3
23–Aug	554	58,283	80	5,057	RP	1,856	79,422	2	318	1	1	0	17	139	12.7
24–Aug	1,922	60,205	100	5,157	RP	2,688	82,110	2	320	0	1	0	17	132	9.7
25–Aug	1,502	61,707	106	5,263	RP	2,518	84,628	4	324	0	1	0	17	130	11.0
26–Aug	976	62,683	80	5,343	RP	2,426	87,054	8	332	0	1	0	17	129	10.7
27–Aug	760	63,443	80	5,423	RP	2,255	89,309	6	338	0	1	0	17	133	10.6
28–Aug	756	64,199	74	5,497	RP	1,784	91,093	3	341	0	1	0	17	136	9.7
29–Aug	1,134	65,333	113	5,610	RP	2,535	93,628	12	353	0	1	0	17	133	9.5
30–Aug	943	66,276	105	5,715	RP	1,292	94,920	10	363	1	2	0	17	130	10.0
31–Aug	1,236	67,512	110	5,825	RP	1,543	96,463	24	387	6	8	0	17	129	10.3
1–Sep	983	68,495	100	5,925	RP	1,066	97,529	25	412	6	14	0	17	126	10.5
2–Sep	794	69,289	100	6,025	RP	1,371	98,900	21	433	1	15	0	17	128	9.7
3–Sep	1,274	70,563	80	6,105	RP	803	99,703	30	463	7	22	0	17	135	8.7
4–Sep	969	71,532	107	6,212	RP	519	100,222	19	482	5	27	0	17	137	9.0
5–Sep	641	72,173	80	6,292	LP	393	100,615	10	492	2	29	0	17	136	9.5
6–Sep	791	72,964	80	6,372	LP	1,254	101,869	13	505	2	31	0	17	132	9.8
7–Sep	853	73,817	80	6,452	LP	871	102,740	15	520	5	36	0	17	120	9.6
8–Sep	422	74,239	50	6,502	LP	1,022	103,762	13	533	7	43	0	17	110	9.4
9–Sep	365	74,604	50	6,552	LP	878	104,640	19	552	15	58	0	17	110	9.4
10–Sep	486	75,090	50	6,602	LP	1,052	105,692	24	576	10	68	0	17	110	9.3
11–Sep	350	75,440	40	6,642	LP	1,399	107,091	25	601	11	79	0	17	108	9.4
12–Sep	156	75,596	40	6,682	LP	903	107,994	16	617	10	89	0	17	112	9.4

[a] Fin clip mark types: AD = Adipose only; RV = Right Ventral; LV = Left Ventral; RA = Right Axillary; LA = Left Axillary; DC = Dorsal; RP = Right Pectoral; LP = Left Pectoral.

Appendix I.–Daily and cumulative weir counts of salmon, by species, and water temperature and gauge heights for Chilkoot Lake, 2005.

	Sockeye salmon		Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
Date	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Level (mm)	Temp (°C)
6–Jun	9	9	0	0	0	0	0	0	0	0	148	10.6
7–Jun	22	31	0	0	0	0	0	0	0	0	149	9.1
8–Jun	47	78	0	0	0	0	0	0	0	0	148	6.0
9–Jun	131	209	0	0	0	0	0	0	0	0	148	6.5
10–Jun	96	305	0	0	0	0	0	0	0	0	151	6.5
11–Jun	112	417	0	0	0	0	0	0	0	1	148	6.0
12–Jun	78	495	0	0	0	0	0	0	0	1	147	6.5
13–Jun	41	536	0	0	0	0	0	0	0	1	146	7.5
14–Jun	62	598	0	0	0	0	0	0	0	1	147	7.0
15–Jun	185	783	0	0	0	0	0	0	0	1	147	6.8
16–Jun	617	1,400	0	0	0	0	0	0	0	1	146	8.0
17–Jun	186	1,586	0	0	0	0	0	0	0	1	150	8.0
18–Jun	101	1,687	0	0	0	0	0	0	0	1	156	7.5
19–Jun	263	1,950	0	0	0	0	0	0	0	1	163	7.8
20–Jun	588	2,538	0	0	0	0	0	0	0	1	160	5.5
21–Jun	960	3,498	0	0	0	0	0	0	0	1	160	7.8
22–Jun	477	3,975	0	0	0	0	0	0	0	1	153	7.8
23–Jun	401	4,376	1	1	0	0	0	0	0	1	144	7.5
24–Jun	181	4,557	0	1	0	0	0	0	0	2	140	7.5
25–Jun	228	4,785	0	1	0	0	0	0	0	2	141	6.5
26–Jun	301	5,086	4	5	0	0	0	0	0	2	146	7.0
27–Jun	1,052	6,138	13	18	0	0	0	0	1	4	149	8.8
28–Jun	313	6,451	8	26	0	0	0	0	0	4	151	8.5
29–Jun	58	6,509	5	31	0	0	0	0	0	4	155	8.8
30–Jun	54	6,563	2	33	0	0	0	0	0	4	153	8.5
1–Jul	61	6,624	3	36	0	0	0	0	0	4	152	8.0
2–Jul	47	6,671	8	44	0	0	0	0	0	4	150	8.0
3–Jul	291	6,962	9	53	0	0	0	0	0	5	152	7.0
4–Jul	212	7,174	4	57	0	0	0	0	0	5	151	8.5
5–Jul	396	7,570	1	58	1	1	0	0	0	6	147	7.9
6–Jul	597	8,167	14	72	4	5	0	0	0	6	146	8.5
7–Jul	359	8,526	17	89	3	8	0	0	0	7	150	9.0
8–Jul	400	8,926	21	110	1	9	0	0	0	7	145	8.0
9–Jul	708	9,634	41	151	2	11	0	0	0	8	144	9.0
10–Jul	1,133	10,767	302	453	0	11	0	0	1	8	147	9.4

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Date	Sockeye salmon		Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Level (mm)	Temp (^oC)
11–Jul	490	11,257	142	595	1	12	0	0	0	8	146	9.5
12–Jul	400	11,657	59	654	1	13	0	0	0	8	145	9.5
13–Jul	286	11,943	25	679	2	15	0	0	2	8	141	8.5
14–Jul	1,255	13,198	275	954	1	16	0	0	0	8	139	8.5
15–Jul	449	13,647	179	1,133	2	18	0	0	0	8	138	9.5
16–Jul	439	14,086	179	1,312	5	23	0	0	0	9	138	9.0
17–Jul	403	14,489	135	1,447	2	25	0	0	0	9	139	8.2
18–Jul	799	15,288	389	1,836	5	30	0	0	0	9	145	8.5
19–Jul	916	16,204	540	2,376	1	31	0	0	1	9	142	9.0
20–Jul	1,485	17,689	1,351	3,727	3	34	0	0	0	9	140	9.1
21–Jul	618	18,307	1,254	4,981	0	34	0	0	1	9	135	9.0
22–Jul	845	19,152	2,422	7,403	3	37	0	0	0	9	133	9.5
23–Jul	1,273	20,425	3,050	10,453	2	39	0	0	1	9	135	9.5
24–Jul	679	21,104	2,232	12,685	2	41	0	0	0	9	136	9.4
25–Jul	1,081	22,185	2,961	15,646	5	46	0	0	1	9	134	9.5
26–Jul	909	23,094	2,376	18,022	0	46	0	0	0	9	133	9.5
27–Jul	433	23,527	4,000	22,022	0	46	0	0	0	9	136	10.0
28–Jul	110	23,637	3,313	25,335	4	50	0	0	0	9	143	9.8
29–Jul	164	23,801	3,700	29,035	2	52	0	0	0	9	144	9.5
30–Jul	212	24,013	2,500	31,535	3	55	0	0	0	9	140	9.2
31–Jul	503	24,516	4,114	35,649	6	61	0	0	0	9	136	10.0
1–Aug	724	25,240	3,343	38,992	1	62	0	0	1	9	133	9.5
2–Aug	935	26,175	4,006	42,998	3	65	0	0	0	9	131	9.5
3–Aug	777	26,952	3,920	46,918	1	66	0	0	0	9	129	9.8
4–Aug	138	27,090	422	47,340	1	67	0	0	0	9	146	9.0
5–Aug	180	27,270	352	47,692	0	67	0	0	0	9	152	8.5
6–Aug	125	27,395	354	48,046	1	68	0	0	0	9	153	9.2
7–Aug	226	27,621	1,626	49,672	3	71	0	0	0	9	148	9.5
8–Aug	664	28,285	1,982	51,654	0	71	0	0	0	9	143	9.7
9–Aug	552	28,837	3,450	55,104	0	71	0	0	0	9	144	10.0
10–Aug	430	29,267	3,654	58,758	1	72	0	0	0	9	144	10.0
11–Aug	230	29,497	1,050	59,808	0	72	0	0	0	9	146	9.8
12–Aug	250	29,747	893	60,701	2	74	0	0	0	9	150	9.4
13–Aug	358	30,105	1,146	61,847	2	76	0	0	0	9	153	9.5
14–Aug	1,072	31,177	1,802	63,649	6	82	0	0	0	9	153	10.0

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Appendix I.–Page 3 of 3.

Date	Sockeye salmon		Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum.	Level (mm)	Temp (^oC)
15–Aug	1,074	32,251	1,254	64,903	1	83	0	0	0	9	150	9.5
16–Aug	824	33,075	973	65,876	1	84	0	0	0	9	146	9.5
17–Aug	472	33,547	873	66,749	0	84	0	0	0	9	141	9.8
18–Aug	605	34,152	952	67,701	4	88	0	0	0	9	139	9.5
19–Aug	208	34,360	343	68,044	0	88	0	0	0	9	145	9.2
20–Aug	500	34,860	381	68,425	2	90	0	0	0	9	141	9.4
21–Aug	588	35,448	646	69,071	1	91	0	0	0	9	137	9.4
22–Aug	1,604	37,052	1,414	70,485	2	93	0	0	0	9	134	8.5
23–Aug	901	37,953	818	71,303	3	96	0	0	0	9	139	9.5
24–Aug	1,554	39,507	850	72,153	4	100	0	0	0	9	133	9.2
25–Aug	1,188	40,695	339	72,492	5	105	0	0	0	9	142	9.0
26–Aug	521	41,216	368	72,860	4	109	0	0	0	9	151	9.0
27–Aug	916	42,132	816	73,676	3	112	0	0	0	9	141	8.8
28–Aug	1,019	43,151	1,569	75,245	6	118	0	0	0	9	136	9.2
29–Aug	1,115	44,266	1,563	76,808	2	120	0	0	0	9	132	9.8
30–Aug	1,214	45,480	955	77,763	5	125	0	0	0	9	132	9.2
31–Aug	1,050	46,530	547	78,310	10	135	0	0	0	9	137	-
1–Sep	844	47,374	1,001	79,311	4	139	0	0	0	9	136	8.2
2–Sep	686	48,060	1,363	80,674	17	156	0	0	0	9	135	9.0
3–Sep	408	48,468	1,789	82,463	11	167	0	0	0	9	131	9.0
4–Sep	602	49,070	2,211	84,674	15	182	0	0	0	9	126	9.2
5–Sep	446	49,516	1,945	86,619	14	196	1	1	0	9	126	8.8
6–Sep	358	49,874	753	87,372	7	203	1	2	0	9	132	9.0
7–Sep	251	50,125	259	87,631	5	208	0	2	0	9	141	8.8
8–Sep	183	50,308	482	88,113	2	210	0	2	0	9	144	8.7
9–Sep	193	50,501	419	88,532	3	213	2	4	0	9	136	8.2
10–Sep	226	50,727	523	89,055	19	232	11	15	0	9	130	8.8
11–Sep	337	51,064	1,169	90,224	18	250	6	21	0	9	126	9.5
12–Sep	114	51,178	262	90,486	12	262	2	23	0	9	120	9.0

Appendix J.–Daily and cumulative weir counts of salmon, by species, and water temperature and gauge heights for Chilkoot Lake, 2006.

	Sockeye salmon		Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
Date	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum	Daily	Cum.	level (mm)	temp (°C)
5-Jun	7	7	0	0	0	0	0	0	0	0	145	6.5
6-Jun	31	38	0	0	0	0	0	0	0	0	144	6.5
7-Jun	27	65	0	0	0	0	0	0	0	0	143	6.5
8-Jun	40	105	0	0	0	0	0	0	0	0	140	6.5
9-Jun	37	142	0	0	0	0	0	0	0	0	141	6.5
10-Jun	105	247	0	0	0	0	0	0	0	0	144	6.5
11-Jun	84	331	0	0	0	0	0	0	0	0	150	7.5
12-Jun	133	464	0	0	0	0	0	0	0	0	168	7.5
13-Jun	107	571	0	0	0	0	0	0	0	0	174	8.0
14-Jun	86	657	0	0	0	0	0	0	0	0	172	8.5
15-Jun	138	795	0	0	0	0	0	0	0	0	176	8.0
16-Jun	44	839	0	0	0	0	0	0	0	0	178	8.5
17-Jun	52	891	0	0	0	0	0	0	0	0	170	7.5
18-Jun	75	966	0	0	0	0	0	0	0	0	163	8.0
19-Jun	50	1,016	0	0	0	0	0	0	0	0	158	7.5
20-Jun	371	1,387	0	0	0	0	0	0	0	0	152	7.5
21-Jun	278	1,665	0	0	0	0	0	0	0	0	149	7.5
22-Jun	113	1,778	0	0	0	0	0	0	0	0	148	5.0
23-Jun	182	1,960	0	0	0	0	0	0	0	0	147	6.0
24-Jun	289	2,249	0	0	0	0	0	0	0	0	143	7.0
25-Jun	514	2,763	0	0	0	0	0	0	0	0	140	7.5
26-Jun	1,524	4,287	0	0	0	0	0	0	0	0	147	7.0
27-Jun	705	4,992	0	0	0	0	0	0	0	0	146	7.5
28-Jun	440	5,432	0	0	0	0	0	0	0	0	141	6.5
29-Jun	189	5,621	0	0	0	0	0	0	0	0	141	7.5
30-Jun	170	5,791	0	0	0	0	0	0	0	0	139	7.0
1-Jul	259	6,050	0	0	0	0	0	0	0	0	141	7.5
2-Jul	219	6,269	1	1	0	0	0	0	0	0	143	7.5
3-Jul	1,247	7,516	6	7	0	0	0	0	0	0	150	7.5
4-Jul	1,001	8,517	5	12	0	0	0	0	0	0	156	8.5
5-Jul	1,100	9,617	17	29	0	0	0	0	0	0	158	9.5
6-Jul	833	10,450	18	47	3	3	0	0	0	0	161	9.0
7-Jul	986	11,436	33	80	7	10	0	0	0	0	160	9.0
8-Jul	1,014	12,450	65	145	7	17	0	0	0	0	158	8.5
9-Jul	469	12,919	95	240	1	18	0	0	0	0	150	9.0

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Date	Sockeye salmon Daily	Sockeye salmon Cum.	Pink salmon Daily	Pink salmon Cum.	Chum salmon Daily	Chum salmon Cum.	Coho salmon Daily	Coho salmon Cum	Chinook salmon Daily	Chinook salmon Cum.	Water level (mm)	Water temp (^{o}C)
10-Jul	707	13,626	112	352	2	20	0	0	0	0	150	9.5
11-Jul	586	14,212	131	483	4	24	0	0	0	0	151	9.5
12-Jul	974	15,186	240	723	3	27	0	0	0	0	151	9.0
13-Jul	672	15,858	284	1,007	4	31	0	0	0	0	154	8.5
14-Jul	1,802	17,660	267	1,274	4	35	0	0	0	0	156	9.0
15-Jul	1,440	19,100	202	1,476	5	40	0	0	0	0	152	9.0
16-Jul	1,716	20,816	225	1,701	3	43	0	0	0	0	146	9.5
17-Jul	1,502	22,318	188	1,889	1	44	0	0	0	0	144	9.0
18-Jul	1,023	23,341	206	2,095	1	45	0	0	0	0	142	9.5
19-Jul	1,128	24,469	380	2,475	0	45	0	0	0	0	140	9.0
20-Jul	1,158	25,627	338	2,813	1	46	0	0	1	1	140	9.0
21-Jul	1,058	26,685	696	3,509	0	46	0	0	0	1	149	8.5
22-Jul	1,220	27,905	528	4,037	1	47	0	0	0	1	151	9.0
23-Jul	1,108	29,013	367	4,404	3	50	0	0	0	1	149	9.0
24-Jul	975	29,988	361	4,765	1	51	0	0	0	1	149	9.0
25-Jul	759	30,747	330	5,095	2	53	0	0	0	1	160	9.0
26-Jul	740	31,487	180	5,275	1	54	0	0	0	1	162	8.5
27-Jul	1,120	32,607	285	5,560	1	55	0	0	0	1	167	8.0
28-Jul	1,145	33,752	388	5,948	1	56	0	0	0	1	156	8.5
29-Jul	963	34,715	420	6,368	1	57	0	0	0	1	155	8.5
30-Jul	1,301	36,016	597	6,965	2	59	0	0	0	1	154	8.5
31-Jul	2,404	38,420	332	7,297	6	65	0	0	0	1	150	7.5
1-Aug	1,813	40,233	452	7,749	0	65	0	0	0	1	154	8.5
2-Aug	1,517	41,750	557	8,306	0	65	0	0	0	1	153	8.5
3-Aug	2,450	44,200	1,309	9,615	1	66	0	0	0	1	146	8.5
4-Aug	1,300	45,500	1,220	10,835	1	67	0	0	0	1	139	9.0
5-Aug	718	46,218	702	11,537	0	67	0	0	0	1	137	9.5
6-Aug	1,686	47,904	823	12,360	3	70	0	0	0	1	143	8.5
7-Aug	3,040	50,944	816	13,176	2	72	0	0	0	1	150	8.5
8-Aug	3,212	54,156	1,040	14,216	1	73	0	0	0	1	146	9.0
9-Aug	2,242	56,398	1,918	16,134	2	75	0	0	0	1	147	8.5
10-Aug	616	57,014	891	17,025	0	75	0	0	0	1	144	9.5
11-Aug	1,360	58,374	1,005	18,030	1	76	0	0	0	1	141	9.0
12-Aug	816	59,190	405	18,435	0	76	0	0	0	1	141	9.0
13-Aug	1,209	60,399	1,009	19,444	1	77	0	0	0	1	149	7.0

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Date	Sockeye salmon		Pink salmon		Chum salmon		Coho salmon		Chinook salmon		Water	Water
	Daily	Cum.	Daily	Cum.	Daily	Cum.	Daily	Cum	Daily	Cum.	level (mm)	temp (^{o}C)
14-Aug	691	61,090	368	19,812	0	77	0	0	0	1	150	8.0
15-Aug	546	61,636	337	20,149	1	78	0	0	0	1	144	8.5
16-Aug	1,293	62,929	596	20,745	0	78	0	0	0	1	140	8.0
17-Aug	1,009	63,938	1,015	21,760	3	81	1	1	0	1	140	8.5
18-Aug	933	64,871	411	22,171	1	82	0	1	0	1	148	8.5
19-Aug	1,151	66,022	458	22,629	1	83	0	1	0	1	145	8.0
20-Aug	1,041	67,063	388	23,017	3	86	0	1	0	1	144	8.0
21-Aug	2,601	69,664	914	23,931	0	86	2	3	0	1	140	8.5
22-Aug	2,176	71,840	1,546	25,477	3	89	3	6	0	1	140	8.5
23-Aug	1,432	73,272	1,513	26,990	4	93	0	6	0	1	143	8.5
24-Aug	1,835	75,107	1,444	28,434	7	100	2	8	0	1	143	9.0
25-Aug	943	76,050	451	28,885	2	102	0	8	0	1	146	8.0
26-Aug	1,858	77,908	215	29,100	1	103	0	8	0	1	158	8.0
27-Aug	2,210	80,118	340	29,440	3	106	6	14	0	1	150	8.0
28-Aug	1,556	81,674	448	29,888	4	110	0	14	0	1	148	8.0
29-Aug	1,426	83,100	545	30,433	8	118	3	17	0	1	139	8.5
30-Aug	1,233	84,333	307	30,740	7	125	2	19	0	1	134	8.5
31-Aug	2,014	86,347	309	31,049	15	140	2	21	0	1	132	8.0
1-Sep	426	86,773	47	31,096	1	141	0	21	0	1	160	8.0
2-Sep	918	87,691	89	31,185	3	144	0	21	0	1	159	8.5
3-Sep	804	88,495	241	31,426	2	146	1	22	0	1	149	8.5
4-Sep	313	88,808	243	31,669	8	154	1	23	0	1	138	9.0
5-Sep	840	89,648	226	31,895	9	163	0	23	0	1	144	8.5
6-Sep	1,296	90,944	413	32,308	7	170	8	31	0	1	140	8.0
7-Sep	877	91,821	532	32,840	15	185	2	33	0	1	142	9.0
8-Sep	590	92,411	259	33,099	14	199	5	38	0	1	148	8.0
9-Sep	781	93,192	133	33,232	6	205	7	45	0	1	145	8.0
10-Sep	1,060	94,252	188	33,420	15	220	29	74	0	1	145	7.5
11-Sep	747	94,999	129	33,549	10	230	32	106	0	1	140	8.0
12-Sep	661	95,660	94	33,643	9	239	27	133	0	1	139	8.0
13-Sep	543	96,203	245	33,888	18	257	25	158	0	1	134	8.0

Appendix K.–Initial mark-recapture matrix used to calculate pooled-Petersen and Darroch population estimates of Chilkoot Lake sockeye salmon in 2004.

Marking stratum			Recapture stratum (week)[a]														Marks recaptured	
Statistical week	Mark[b]	Marked	29	30	31	32	33	34	35	36	37	38	39	41	42	44	Total	Percent
23–24	AD	29	0	0	0	2	0	0	0	1	0	0	0	0	0	0	3	10%
25–26	RV	162	3	4	1	1	0	0	0	1	0	1	0	0	0	0	11	7%
27–28	LV	424	0	1	1	2	2	2	2	1	1	0	0	0	0	0	12	3%
29–30	RA	1,597	0	1	0	1	1	2	2	5	2	1	0	4	0	1	20	1%
31–32	LA	1,565	0	0	0	0	0	0	1	4	0	1	2	3	1	1	13	1%
33–34	D	1,113	0	0	0	0	0	0	0	1	1	1	3	4	0	0	10	1%
35–36	RP	1,294	0	0	0	0	0	0	0	1	3	4	2	1	1	0	12	1%
37–38	LP	470	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	<1%
Total sampled			86	125	120	176	86	88	95	142	146	152	94	343	100	116		
Recaptures			3	6	2	6	3	4	5	14	8	8	7	12	2	2		
Percent marked			3%	5%	2%	3%	3%	5%	5%	10%	5%	5%	7%	3%	2%	2%		

[a] No recapture sampling was conducted in weeks 40 and 43.

[b] Mark types: AD = adipose clip; RV = right ventral fin clip; LV = left ventral fin clip; RA = right axillary process clip; LA = left axillary process clip; D = dorsal fin clip; RP = right pectoral fin clip; LP = left pectoral fin clip.

Appendix L.–Estimated commercial harvest of Chilkoot, Chilkat, and other sockeye salmon stocks in the District 15 drift gillnet fishery based on scale pattern analysis, 1984–2006.

	Chilkoot		Chilkat		Other	
Year	Harvest	Percent	Harvest	Percent	Harvest	Percent
1984	225,634	67%	99,592	30%	9,502	3%
1985	153,533	51%	131,091	43%	18,704	6%
1986	110,114	38%	168,006	58%	12,174	4%
1987	327,323	79%	69,900	17%	18,658	5%
1988	248,640	71%	76,883	22%	26,353	8%
1989	292,830	62%	156,160	33%	25,908	6%
1990	181,260	50%	149,377	41%	31,499	9%
1991	228,607	73%	60,721	19%	24,353	8%
1992	142,471	49%	113,146	39%	33,729	12%
1993	52,080	30%	103,531	59%	19,605	11%
1994	30,717	18%	119,245	69%	21,834	13%
1995	9,637	11%	68,737	78%	10,302	12%
1996	19,882	13%	99,677	67%	30,019	20%
1997	31,822	27%	73,761	62%	13,245	11%
1998	2,838	2%	112,630	84%	19,469	14%
1999	4,604	3%	149,410	91%	9,547	6%
2000	14,622	13%	78,265	71%	16,673	15%
2001	66,355	45%	60,183	41%	21,273	14%
2002	24,200	30%	47,332	58%	10,482	13%
2003	32,446	34%	49,955	53%	12,729	13%
2004	66,498	44%	51,110	34%	33,637	22%
2005	29,276	45%	22,852	35%	13,341	20%
2006	119,201	82%	15,979	11%	10,400	7%

Appendix M.–Historical age composition of the Chilkoot Lake sockeye salmon escapement, weighted by statistical week, 1982–2006.

		Age Class														
Year	Weighted by stat. week	0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	Total
1982	Escapement by Age Class	66	0	65	0	0	19,342	560	0	139	80,980	914	0	972	0	103,038
	SE of Number	65	0	65	0	0	938	185	0	98	989	244	0	243	0	
	Percent by Age Class	0%	0%	0%	0%	0%	19%	1%	0%	0%	79%	1%	0%	1%	0%	
	SE of %	0.10%	0.00%	0.10%	0.00%	0.00%	0.90%	0.20%	0.00%	0.10%	1.00%	0.20%	0.00%	0.20%	0.00%	
	Sample size	1	0	1	0	0	320	9	0	2	1,322	16	0	16	0	1,687
1983	Escapement by Age Class	0	84	42	0	0	9,852	1,352	0	95	48,435	20,043	0	238	0	80,141
	SE of Number	0	59	42	0	0	637	279	0	69	972	837	0	118	0	
	Percent by Age Class	0%	0%	0%	0%	0%	12%	2%	0%	0%	60%	25%	0%	0%	0%	
	SE of %	0.00%	0.10%	0.10%	0.00%	0.00%	0.80%	0.30%	0.00%	0.10%	1.20%	1.00%	0.00%	0.10%	0.00%	
	Sample size	0	2	1	0	0	214	25	0	2	1,081	461	0	4	0	1,790
1984	Escapement by Age Class	0	0	0	0	0	4,712	345	0	0	86,112	8,635	0	977	0	100,781
	SE of Number	0	0	0	0	0	525	132	0	0	921	751	0	279	0	
	Percent by Age Class	0%	0%	0%	0%	0%	5%	0%	0%	0%	85%	9%	0%	1%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.50%	0.10%	0.00%	0.00%	0.90%	0.70%	0.00%	0.30%	0.00%	
	Sample size	0	0	0	0	0	86	7	0	0	1,649	145	0	15	0	1,902
1985	Escapement by Age Class	0	46	0	0	0	8,132	1,661	45	0	45,675	11,517	0	1,857	208	69,141
	SE of Number	0	46	0	0	0	552	252	45	0	876	700	0	342	93	
	Percent by Age Class	0%	0%	0%	0%	0%	12%	2%	0%	0%	66%	17%	0%	3%	0%	
	SE of %	0.00%	0.10%	0.00%	0.00%	0.00%	0.80%	0.40%	0.10%	0.00%	1.30%	1.00%	0.00%	0.50%	0.10%	
	Sample size	0	1	0	0	0	198	43	1	0	1,078	258	0	39	5	1,623
1986	Escapement by Age Class	0	43	0	0	0	11,398	1,934	0	0	59,561	14,425	67	493	102	88,024
	SE of Number	0	42	0	0	0	627	289	0	0	906	718	67	144	59	
	Percent by Age Class	0%	0%	0%	0%	0%	13%	2%	0%	0%	68%	16%	0%	1%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	0.30%	0.00%	0.00%	1.00%	0.80%	0.10%	0.20%	0.10%	
	Sample size	0	1	0	0	0	284	47	0	0	1,438	361	1	12	3	2,147
1987	Escapement by Age Class	0	0	0	0	0	7,706	2,074	0	0	62,153	21,773	79	283	139	94,208
	SE of Number	0	0	0	0	0	537	294	0	0	915	811	79	132	80	
	Percent by Age Class	0%	0%	0%	0%	0%	8%	2%	0%	0%	66%	23%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.30%	0.00%	0.00%	1.00%	0.90%	0.10%	0.10%	0.10%	
	Sample size	0	0	0	0	0	185	49	0	0	1,527	437	1	5	3	2,207

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		Age Class														
Year	Weighted by stat. week	0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	Total
1988	Escapement by Age Class	0	0	0	0	0	3,265	2,103	0	0	63,381	11,060	52	1,115	299	81,274
	SE of Number	0	0	0	0	0	317	263	0	0	705	592	51	196	107	
	Percent by Age Class	0%	0%	0%	0%	0%	4%	3%	0%	0%	78%	14%	0%	1%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.30%	0.00%	0.00%	0.90%	0.70%	0.10%	0.20%	0.10%	
	Sample size	0	0	0	0	0	117	72	0	0	2,074	350	1	38	9	2,661
1989	Escapement by Age Class	0	0	0	0	0	1,743	2,169	0	0	30,584	19,213	304	649	238	54,900
	SE of Number	0	0	0	0	0	178	226	0	0	680	657	102	146	96	
	Percent by Age Class	0%	0%	0%	0%	0%	3%	4%	0%	0%	56%	35%	1%	1%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%	0.40%	0.00%	0.00%	1.20%	1.20%	0.20%	0.30%	0.20%	
	Sample size	0	0	0	0	0	116	130	0	0	1,419	866	14	31	10	2,586
1990	Escapement by Age Class	0	0	0	0	0	1,227	1,006	11	0	35,537	36,830	64	736	708	76,119
	SE of Number	0	0	0	0	0	185	180	10	0	806	807	46	161	150	
	Percent by Age Class	0%	0%	0%	0%	0%	2%	1%	0%	0%	47%	48%	0%	1%	1%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.20%	0.00%	0.00%	1.10%	1.10%	0.10%	0.20%	0.20%	
	Sample size	0	0	0	0	0	55	41	1	0	1,277	1,382	3	27	29	2,815
1991	Escapement by Age Class	0	0	0	0	0	12,357	4,631	0	0	49,735	23,625	90	158	159	90,754
	SE of Number	0	0	0	0	0	861	537	0	0	1,221	1,087	53	53	67	
	Percent by Age Class	0%	0%	0%	0%	0%	14%	5%	0%	0%	55%	26%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.90%	0.60%	0.00%	0.00%	1.30%	1.20%	0.10%	0.10%	0.10%	
	Sample size	0	0	0	0	0	287	112	0	0	1,283	596	3	9	7	2,297
1992	Escapement by Age Class	0	0	0	0	0	1,335	3,852	56	17	43,265	17,679	105	419	342	67,071
	SE of Number	0	0	0	0	0	263	371	31	16	674	624	64	119	115	
	Percent by Age Class	0%	0%	0%	0%	0%	2%	6%	0%	0%	65%	26%	0%	1%	1%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.60%	0.00%	0.00%	1.00%	0.90%	0.10%	0.20%	0.20%	
	Sample size	0	0	0	0	0	36	118	3	1	1,277	577	3	14	10	2,039
1993	Escapement by Age Class	0	0	0	19	0	1,560	901	0	0	18,693	30,396	91	180	239	52,080
	SE of Number	0	0	0	18	0	207	149	0	0	541	560	43	76	84	
	Percent by Age Class	0%	0%	0%	0%	0%	3%	2%	0%	0%	36%	58%	0%	0%	1%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.40%	0.30%	0.00%	0.00%	1.00%	1.10%	0.10%	0.10%	0.20%	
	Sample size	0	0	0	1	0	54	37	0	0	739	1,224	5	6	9	2,075

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Year	Weighted by stat. week	0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	Total
		Age Class														
1994	Escapement by Age Class	0	0	0	0	0	671	549	23	48	24,876	10,573	22	194	50	37,007
	SE of Number	0	0	0	0	0	112	98	23	34	392	378	21	56	24	
	Percent by Age Class	0%	0%	0%	0%	0%	2%	2%	0%	0%	67%	29%	0%	1%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%	0.30%	0.10%	0.10%	1.10%	1.00%	0.10%	0.20%	0.10%	
	Sample size	0	0	0	0	0	35	32	1	2	1,328	571	1	12	4	1,986
1995	Escapement by Age Class	0	0	0	0	0	3,360	298	0	0	2,176	1,219	0	78	46	7,177
	SE of Number	0	0	0	0	0	129	67	0	0	139	114	0	40	27	
	Percent by Age Class	0%	0%	0%	0%	0%	47%	4%	0%	0%	30%	17%	0%	1%	1%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	1.80%	0.90%	0.00%	0.00%	1.90%	1.60%	0.00%	0.60%	0.40%	
	Sample size	0	0	0	0	0	267	23	0	0	186	121	0	5	4	606
1996	Escapement by Age Class	0	0	0	0	0	3,365	517	23	11	43,232	3,559	0	35	0	50,741
	SE of Number	0	0	0	0	0	338	145	22	10	461	308	0	18	0	
	Percent by Age Class	0%	0%	0%	0%	0%	7%	1%	0%	0%	85%	7%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	0.30%	0.00%	0.00%	0.90%	0.60%	0.00%	0.00%	0.00%	
	Sample size	0	0	0	0	0	128	16	1	1	1,737	176	0	4	0	2,063
1997	Escapement by Age Class	0	0	0	0	0	1,022	183	0	23	39,858	3,114	8	45	0	44,254
	SE of Number	0	0	0	0	0	146	65	0	23	286	244	8	31	0	
	Percent by Age Class	0%	0%	0%	0%	0%	2%	0%	0%	0%	90%	7%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.30%	0.10%	0.00%	0.10%	0.60%	0.60%	0.00%	0.10%	0.00%	
	Sample size	0	0	0	0	0	47	8	0	1	1,902	150	1	2	0	2,111
1998	Escapement by Age Class	15	0	0	0	0	631	268	0	0	7,478	3,753	13	165	13	12,335
	SE of Number	15	0	0	0	0	86	57	0	0	189	177	13	44	13	
	Percent by Age Class	0%	0%	0%	0%	0%	5%	2%	0%	0%	61%	30%	0%	1%	0%	
	SE of %	0.10%	0.00%	0.00%	0.00%	0.00%	0.70%	0.50%	0.00%	0.00%	1.50%	1.40%	0.10%	0.40%	0.10%	
	Sample size	1	0	0	0	0	47	20	0	0	570	288	1	13	1	941
1999	Escapement by Age Class	0	0	0	0	0	5,934	1,597	0	0	8,550	3,136	0	34	34	19,284
	SE of Number	0	0	0	0	0	203	124	0	0	212	163	0	16	18	
	Percent by Age Class	0%	0%	0%	0%	0%	31%	8%	0%	0%	44%	16%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	1.10%	0.60%	0.00%	0.00%	1.10%	0.80%	0.00%	0.10%	0.10%	
	Sample size	0	0	0	0	0	585	164	0	0	945	331	0	4	4	2,033

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Year	Weighted by stat. week	Age Class 0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	Total
2000	Escapement by Age Class	0	0	0	0	24	6,678	1,041	0	0	25,864	9,903	0	29	15	43,555
	SE of Number	0	0	0	0	24	359	160	0	0	468	377	0	20	15	
	Percent by Age Class	0%	0%	0%	0%	0%	15%	2%	0%	0%	59%	23%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.10%	0.80%	0.40%	0.00%	0.00%	1.10%	0.90%	0.00%	0.00%	0.00%	
	Sample size	0	0	0	0	1	295	42	0	0	1,306	581	0	2	1	2,228
2001	Escapement by Age Class	0	0	0	0	0	3,565	50	0	157	68,859	3,600	0	53	0	76,283
	SE of Number	0	0	0	0	0	436	29	0	62	606	437	0	52	0	
	Percent by Age Class	0%	0%	0%	0%	0%	5%	0%	0%	0%	90%	5%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.10%	0.80%	0.60%	0.00%	0.10%	0.00%	
	Sample size	0	0	0	0	0	113	4	0	7	2,106	114	0	1	0	2,345
2002	Escapement by Age Class	0	0	0	0	0	4,989	800	0	0	50,880	1,400	0	292	0	58,361
	SE of Number	0	0	0	0	0	382	155	0	0	441	181	0	85	0	
	Percent by Age Class	0%	0%	0%	0%	0%	9%	1%	0%	0%	87%	2%	0%	1%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.70%	0.30%	0.00%	0.00%	0.80%	0.30%	0.00%	0.10%	0.00%	
	Sample size	0	0	0	0	0	182	30	0	0	2,540	71	0	13	0	2,836
2003	Escapement by Age Class	0	0	0	0	0	42,375	2,564	0	0	24,641	4,716	0	131	33	74,459
	SE of Number	0	0	0	0	0	957	324	0	0	901	456	0	60	32	
	Percent by Age Class	0%	0%	0%	0%	0%	57%	3%	0%	0%	33%	6%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	1.30%	0.40%	0.00%	0.00%	1.20%	0.60%	0.00%	0.10%	0.00%	
	Sample size	0	0	0	0	0	1,078	110	0	0	1,174	238	0	10	1	2,611
2004	Escapement by Age Class	0	0	0	0	0	11,478	5,736	0	0	52,806	5,544	0	27	0	75,591
	SE of Number	0	0	0	0	0	606	460	0	0	764	410	0	21	0	
	Percent by Age Class	0%	0%	0%	0%	0%	15%	8%	0%	0%	70%	7%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.80%	0.60%	0.00%	0.00%	1.00%	0.50%	0.00%	0.00%	0.00%	
	Sample size	0	0	0	0	0	399	161	0	0	1,929	220	0	2	0	2,711
2005	Escapement by Age Class	0	0	0	0	0	11,048	2,242	0	0	32,908	4,909	0	71	0	51,178
	SE of Number	0	0	0	0	0	433	228	0	0	508	326	0	38	0	
	Percent by Age Class	0%	0%	0%	0%	0%	22%	4%	0%	0%	64%	10%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.80%	0.40%	0.00%	0.00%	1.00%	0.60%	0.00%	0.10%	0.00%	
	Sample size	0	0	0	0	0	542	106	0	0	1,843	235	0	4	0	2,730

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Appendix M.–Page 5 of 5.

Year	Weighted by stat. week	Age Class 0.1	1.1	2.1	3.1	0.2	1.2	2.2	3.2	0.3	1.3	2.3	3.3	1.4	2.4	Total
2006	Escapement by Age Class	0	0	0	0	0	8,492	817	0	22	76,211	10,578	0	48	34	96,203
	SE of Number	0	0	0	0	0	582	187	0	21	839	653	0	48	34	
	Percent by Age Class	0%	0%	0%	0%	0%	9%	1%	0%	0%	79%	11%	0%	0%	0%	
	SE of %	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.20%	0.00%	0.00%	0.90%	0.70%	0.00%	0.00%	0.00%	
	Sample size	0	0	0	0	0	211	22	0	1	2,076	269	0	1	1	2,581

Appendix N.–Average length (mideye to tail fork) of Chilkoot Lake sockeye salmon, by age class, 1982–2006.

Year	Sample size	Mean length (mm) by age class[a]												Average
		0.3	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	
1982	1,684	620	–	466	577	621	–	489	584	–	–	–	–	560
1983	1,790	572	377	455	573	595	420	474	567	–	–	–	–	504
1984	1,901	–	–	461	571	600	–	470	570	–	–	–	–	534
1985	1,623	–	320	471	569	604	–	476	565	608	–	470	–	510
1986	2,146	–	410	472	582	611	–	485	581	618	–	–	565	541
1987	2,207	–	–	468	583	593	–	472	582	596	–	–	560	551
1988	2,658	–	–	496	578	604	–	499	575	590	–	–	565	558
1989	2,584	–	–	468	580	604	–	480	576	592	–	–	569	553
1990	2,815	–	–	467	579	607	–	497	577	596	–	490	580	549
1991	2,293	–	–	481	565	616	–	477	565	583	–	–	550	548
1992	2,038	575	–	471	570	596	–	470	571	595	–	508	565	547
1993	2,073	–	–	487	575	583	–	506	573	565	550	–	550	549
1994	1,985	540	–	471	568	596	–	489	569	582	–	450	610	542
1995	605	–	–	496	571	594	–	506	573	608	–	–	–	558
1996	2,042	635	–	509	589	611	–	514	585	–	–	490	–	562
1997	2,107	565	–	508	577	577	–	508	569	–	–	–	575	554
1998	936	–	–	492	572	574	–	514	570	605	–	–	595	560
1999	2,030	–	–	491	578	579	–	512	574	605	–	–	–	557
2000	2,211	–	–	508	582	582	–	505	583	425	–	–	–	531
2001	2,344	562	–	494	581	560	–	527	574	–	–	–	–	550
2002	2,834	–	–	479	584	615	–	482	579	–	–	–	–	548
2003	2,605	–	–	494	577	590	–	496	578	574	–	–	–	552
2004	2,711	–	–	503	573	547	–	500	570	–	–	–	–	539
2005	2,728	–	–	488	567	606	–	490	561	–	–	–	–	542
2006	2,577	595	–	487	561	560	–	499	560	550	–	–	–	545
Average	2,141	583	369	483	575	593	420	493	573	581	550	482	571	546

[a] An n-dash indicates no samples for that age class in that year.