Fishery Manuscript Series No. 17-06

A Comprehensive Review of Chilkat Lake and River Sockeye Salmon Stock Assessment Studies

by

Julie A. Bednarski

Mark Sogge

Sara E. Miller

and

Steve Heinl

December 2017

Alaska Department of Fish and Game

Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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

FISHERY MANUSCRIPT SERIES NO. 17-06

A COMPREHENSIVE REVIEW OF CHILKAT LAKE AND RIVER SOCKEYE SALMON STOCK ASSESSMENT STUDIES

by
Julie A. Bednarski
Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas

Mark M. Sogge
Alaska Department of Fish and Game, Division of Commercial Fisheries, Haines

Sara E. Miller
Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau

and

Steven C. Heinl
Alaska Department of Fish and Game, Division of Commercial Fisheries, Ketchikan

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

December 2017

The Fishery Manuscript Series was established in 1987 by the Division of Sport Fish for the publication of technically-oriented results of several years' work undertaken on a project to address common objectives, provide an overview of work undertaken through multiple projects to address specific research or management goal(s), or new and/or highly technical methods, and became a joint divisional series in 2004 with the Division of Commercial Fisheries. Fishery Manuscripts are intended for fishery and other technical professionals. Fishery Manuscripts are available through the Alaska State Library and on the Internet: http://www.adfg.alaska.gov/sf/publications/ This publication has undergone editorial and peer review.

Julie A. Bednarski,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
802 Third Street, Douglas, Alaska 99824, USA

Mark M. Sogge,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
P.O. Box 330, Haines, Alaska 99827, USA

Sara E. Miller,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
1255 W. 8th Street, Juneau, AK 99801

and

Steven C. Heinl
Alaska Department of Fish and Game, Division of Commercial Fisheries,
2030 Sea Level Drive, Suite 205, Ketchikan Alaska 99901, USA

This document should be cited as follows:
Bednarski, J. A., M. M. Sogge, S. E. Miller, and S. C. Heinl. 2017. A comprehensive review of Chilkat Lake and River sockeye salmon stock assessment studies. Alaska Department of Fish and Game, Fishery Manuscript Series No. 17-06, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Since 1967 the Alaska Department of Fish and Game, Division of Commercial Fisheries, has operated a stock assessment program to estimate escapements and harvests of Chilkat sockeye salmon (*Oncorhynchus nerka*). Sockeye salmon were counted through a weir near the outlet of Chilkat Lake, and age, length, and sex data were collected and analyzed each year. Since 1994, mark–recapture studies were conducted to estimate Chilkat sockeye salmon escapements. Since the start of the 2008 season, DIDSON sonar has been used at the weir site to directly enumerate adult sockeye salmon escapement into Chilkat Lake. Visual scale pattern analysis was conducted to determine the proportion of Chilkat sockeye salmon harvested annually in the District 15 commercial drift gillnet fishery. In addition, limnological sampling was conducted in Chilkat Lake and analyzed each year. The intent of this report was to review Chilkat sockeye salmon stock assessment data from 1971 to 2016. The visual and DIDSON weir counts provide an index of escapement; however, concerns regarding mark–recapture as a reliable index of abundance lead us to recommend eliminating mark–recapture studies in 2017 and, instead, maintain the DIDSON to estimate escapement into Chilkat Lake. We also recommend reviewing the current Chilkat Lake biological escapement goal to ensure that the goal and escapement estimates are in the same units, which is currently based on mark–recapture units. An average of 77,800 Chilkat Lake sockeye salmon were harvested annually in the District 15 commercial drift gillnet fishery (1976–2016). A comparison of historical fish wheel counts to Chilkat Lake escapement estimates demonstrates that the fish wheel project provides a rough indication of Chilkat Lake run strength. Zooplankton samples from Chilkat Lake were composed primarily of one species of copepod (*Cyclops columbianus*) and three species of cladocerans (*Bosmina longerostris*, *Daphnia longiremus*, and *Daphnia rosea*).

Key words: Chilkat Lake, Chilkat River, Chilkat River mainstem, commercial harvest, DIDSON, District 15 commercial drift gillnet fishery, fish wheel, escapement, expanded counts, zooplankton, mark–recapture, Oncorhynchus nerka, scale pattern analysis, sockeye salmon, limnology

INTRODUCTION

The Chilkoot and Chilkat sockeye salmon (*Oncorhynchus nerka*) runs in northern Southeast Alaska, near the town of Haines, are two of the largest in Southeast Alaska (Figure 1). 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 be Chilkat and Chilkoot sockeye salmon (Rich and Ball 1933). Historically, Chilkat 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 was developed into a designated drift gillnet fishing area (District 15) where most of the commercial harvest of Chilkat sockeye salmon takes place (Figure 1). The annual harvest of sockeye salmon in the District 15 commercial drift gillnet fishery averaged 191,500 fish (1984–2015), of which an average 78,000 fish originated from Chilkat Lake, 92,000 fish originated from Chilkoot Lake, and the remainder were of mixed stock origin (Bednarski et al. 2016). A smaller portion of the Chilkat run is harvested in the commercial purse seine fisheries that target pink salmon (*O. gorbuscha*) in Icy and northern Chatham straits (Ingledue 1989; Gilk-Baumer et al. 2015). Annual contributions to those fisheries are not known and probably vary annually depending on fishing effort and the strength of pink salmon runs. Chilkat sockeye salmon are also harvested annually in subsistence fisheries in Chilkat Inlet and in the Chilkat River and reported harvest for the period 1985–2015 averaged approximately 4,300 fish per year (Appendix A).

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 fishery as Chilkoot Lake or Chilkat drainage 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 group of "other" stocks—a combination of Chilkat River mainstem and Berners Bay stocks that contribute to early season harvests in Lynn Canal (McPherson 1987b). The term "mainstem" includes all sockeye salmon populations spawning in the Chilkat River and its tributaries; i.e., all non-Chilkat Lake fish. 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, 1987b; McPherson and Jones 1987; McPherson 1989; McPherson et al. 1992; McPherson and Olsen 1992). The consistent differences in freshwater scale patterns made visual scale pattern analysis highly accurate, and it was more cost effective and required less time than other stock-identification methods (McPherson 1990; McPherson and Olsen 1992).

Chilkat Lake sockeye salmon escapements have been estimated through weir counts (1967–1993), weir counts with mark–recapture estimates (1994 and 1995, 1999–2007), mark–recapture estimates only (1996–1998), and Dual-frequency Identification Sonar (DIDSON) counts with mark–recapture (2008–2016) (Eggers et al. 2010; Sogge and Bachman 2014). Two-event mark–recapture studies in conjunction with operation of fish wheels in the lower Chilkat River were initiated in 1994 because weir counts at Chilkat Lake were thought to underestimate escapement. Periodic flooding of silty Tsirku River into Chilkat Lake required removing pickets from the weir, sometimes for extended periods, and increased boat traffic in and out of the lake required frequent lowering of a boat gate in the center of the weir through which fish could pass uncounted (Kelley and Bachman 2000). Sockeye salmon were marked at the fish wheels and sampled for marks at the Chilkat Lake weir and various Chilkat River mainstem and tributary spawning locations; drainagewide mark–recapture estimates were then generated and divided into Chilkat Lake and Chilkat River mainstem estimates (Kelley and Bachman 2000; Bachman and McGregor 2001; Bachman 2005, 2010). Mark–recapture estimates of Chilkat Lake fish in 1994 and 1995 (and most other years) were substantially larger than weir counts. As a result, the weir was not operated from 1996 to 1998; however, it was reinstated in 1999 to improve mark–recapture sampling at the lake (Kelley and Bachman 2000). In 2008, a DIDSON was installed at the Chilkat Lake weir to improve counts (Eggers et al. 2010), and the purpose of the mark–recapture studies was changed to primarily provide estimates of Chilkat River mainstem spawning populations (Sogge and Bachman 2014). Biological data have been collected annually at Chilkat Lake and at Chilkat River mainstem spawning locations to estimate age, size, and sex composition of escapements, and for use in scale pattern analysis.

The Chilkat Lake sockeye salmon run has been managed for at least five different escapement goals since 1976. Informal goals of 60,000–70,000 fish (1976–1980) and 70,000–90,000 fish (1981–1989) (Bergander et al. 1988) were replaced in 1990 with a biological escapement goal of 52,000–106,000 sockeye salmon based on extensive stock-recruit analysis by McPherson (1990). Efforts to update the escapement goal were hindered by lake stocking in the 1990s and concerns regarding accuracy of weir counts (Geiger et al. 2005). Geiger et al. (2005) converted the weir based goal to mark–recapture units and the goal was revised to a sustainable escapement goal of 80,000–200,000 sockeye salmon from 2006 to 2008. In 2009, the Chilkat Lake escapement goal was revised again to the present biological escapement goal of 70,000–150,000 sockeye salmon, based on weir counts converted to mark–recapture units (Eggers et al. 2008, 2010). Eggers et al. (2010) further recommended the escapement be assessed using DIDSON counts at the Chilkat Lake weir site. Escapement goals have not been established for mainstem populations, since scale pattern analysis cannot be used to differentiate between Chilkat River mainstem sockeye salmon, Berners Bay, and other sockeye salmon runs harvested in the District 15 commercial drift gillnet fishery.

The primary purpose of this report is to provide a comprehensive review of Chilkat Lake and River sockeye salmon stock assessment studies. This report is not intended to provide an overview of stock status; stock status and escapement goals will be reviewed in a future escapement goal report. Here we provide estimates of the escapement and commercial harvest of Chilkat Lake sockeye salmon from 2005 to 2016; the last published stock assessment report included information only through 2004 (Bachman 2010). We also reviewed and edited all historic data associated with the project, including weir counts, DIDSON counts, fish wheel counts, and age composition data, and we updated mark–recapture and commercial harvest estimates. Much of this information, in conjunction with information from stock assessment projects on the adjacent Chilkoot River (Sogge 2016), was used inseason to manage the District 15 commercial drift gillnet fishery to ensure escapement goals were met while maximizing and sustaining the harvest of sockeye salmon from the two watersheds. Escapement and stock-specific harvest data, along with biological data on age at return, were essential for reconstruction of brood year returns of Chilkat Lake sockeye salmon for use in future escapement goal evaluation. Limnological surveys of Chilkat Lake were also conducted to continue collection of baseline information on zooplankton abundance, light penetration, and water temperature profiles.

STUDY SITE

Chilkat Lake (ADF&G Anadromous Waters Catalogue No. 115-32-10250-2067-3001-0010; 59.32577° N, 135.89436° W) is located approximately 27 river miles upstream from the city of Haines, Alaska (Figure 1 and 2). It is a relatively large clear lake with a surface area of 9.8 × 106 m^2 (2,432 acres), mean depth of 32.5 m, a maximum depth of 57 m, and a volume of 319 × 106 m^3. The lake drains through Clear Creek, a 0.5 km long channel, which is also the location of the weir, and into the Chilkat River by way of the Tsirku River. Resident fish include sockeye salmon, coho salmon (*O. kisutch*), Dolly Varden (*Salvelinus malma*), cutthroat trout (*Salmo clarki*), threespine stickleback (*Gasterosteus aculeatus*), sculpin (*Cottus sp.*) and whitefish (*Prosopium cylindraceum*) (Johnson and Daigneault 2013). Very small numbers of adult pink and chum salmon (*O. keta*) have been observed moving through the Chilkat Lake weir, but the spawning location of these fish is not known. Chilkat Lake is a remote lake with moderate to heavy boat traffic. There are numerous private cabins on the lake (50 to 100 cabins) with access limited to jet boats and floatplanes only.

The Chilkat River (ADF&G Anadromous Waters Catalogue No. 115-32-10250) drains a large watershed stretching from British Columbia, Canada to the northern end of Lynn Canal, near Haines, Alaska (Figure 2). It is characterized by rugged, highly dissected mountains with steep-gradient streams, and braided rivers through glaciated valleys. The watershed encompasses approximately 1,600 km^2, and the main river and tributaries comprise approximately 350 km of river channels. Principle tributaries include the Tahkin, Tsirku, Klehini, Kelsall, and Tahini rivers. The Chilkat River discharge rates range from 80 to 20,400 ft^3/s (Bugliosi 1988). The river supports large runs of sockeye, coho, chum, Chinook (*O. tshawytscha*), and pink salmon. The Chilkat River receives input from several glaciers, and heavy silt loads in the main river impairs visual salmon stock assessment methods.

OBJECTIVES

1. Edit, correct, and reanalyze 1999–2016 sockeye salmon mark–recapture data, and estimate the drainagewide, Chilkat Lake, and Chilkat River mainstem sockeye salmon populations such that the estimated coefficient of variation is no greater than 15% of the point estimate.
2. Edit and correct Chilkat Lake weir (1971–2007) and DIDSON (2008–2016) count data, and expand annual counts to a set of standardized dates where needed to account for late installation or early removal of the weir.
3. Enumerate the annual escapement of adult sockeye salmon into Chilkat Lake using a standard picket weir (2005–2007) and DIDSON (2008–2016).
4. Estimate the age, sex, and length composition of the sockeye salmon escapement in Chilkat Lake and Chilkat River mainstem, 2005–2016.
5. Estimate the annual commercial harvest of Chilkat Lake sockeye salmon in the District 15 commercial drift gillnet fishery, 2005–2016.
6. Measure water column temperatures, record light penetration profiles, and estimate zooplankton species composition, size, density, and biomass in Chilkat Lake on a monthly basis, April–October, 2005–2016.

METHODS

ESCAPEMENT ESTIMATION

Chilkat River Fish Wheels

Fish wheels have been operated in the lower Chilkat River for stock assessment and management purposes as early as 1977 and annually since 1994. Sockeye salmon abundance and stock composition data collected at the fish wheels are used to inform inseason management of the District 15 commercial drift gillnet fishery (Kelley 1998; Kelley and Bachman 2000). The type, number, and period of operation of fish wheels have varied over the years. Types and numbers deployed included one wooden, four-basket fish wheel (1977–1978, 1982–1983); two wooden, four-basket fish wheels (1990–1991, 1994–1996); and two aluminum, three-basket fish wheels (1997 to present). Dates of operation have varied depending on the focus of the project, but since 1997 the fish wheels have typically been operated from statistical week 24 (about mid-June) to statistical week 42 (about mid-October) (Table 1). Statistical weeks are numbered sequentially starting from the beginning of the calendar year, and begin on Sunday at 12:01 a.m. and end the following Saturday at midnight.

Fish wheels were deployed on the eastern bank of the Chilkat River, between mile 7.5 and 10 on the Haines Highway, where the main flow was constrained primarily to the eastern side of the floodplain (Figure 2). The wooden fish wheels used before 1997 were deployed between mile 9 and 9.5 on the Haines Highway. The aluminum fish wheels used since 1997, however, provide more operating flexibility and the deployment area has been expanded to encompass the east bank of the river between mile 7.5 and 10 on the Haines Highway. The best operating location was determined at the beginning of each season based on assessment of river conditions. The fish wheels were launched from the Haines Highway and, depending on location, lowered into the river with a crane or pushed into the river with a tractor, then drifted downstream or pushed upstream with jet boats to the pre-determined site. The fish wheels were anchored to the highway guardrail with 0.95 cm steel cable and a 1-inch diameter polyethylene rope bridle, and held out from, and parallel to, the shoreline with an adjustable boom log system (Kelley and Bachman 2000). An average river depth of at least 1.5 m was required for the aluminum fish wheels to maintain revolution speeds adequate to capture migrating salmon (approximately 1.5–4 rpm; Bachman and McGregor 2001). Seasonal changes in water flow (particularly from late August through early October, when water levels subsided) required minor changes in fishing location in order to maintain adequate rotation speed; e.g., fish wheels were moved farther from shore into faster current or to a nearby (<1 mile) alternate location.

The fish wheel design used since 1997 consisted of two aluminum pontoons, measuring approximately 12 m (length) × 6 m (width) and filled with closed cell Styrofoam for flotation. The pontoons supported a 6 m wide structure consisting of an adjustable height axle, three catch baskets, wooden slides, and enclosed fabric chutes, along with two live boxes per wheel designed to hold fish prior to sampling. A plywood deck spanning the full width between the pontoons provided a fish sampling area. The aluminum baskets were 3.1 m (width) × 3.7 m (depth), covered with nylon seine mesh (5.1 × 5.1 cm openings), and bolted to a metal axle that spins in a pillow-block bearing assembly. The three catch baskets were rotated about the axle by the force of the water current, and were adjusted vertically in the water column by moving the axle up or down within tower support channels. Migrating salmon were captured in the rotating baskets as they swam under the structure. V-shaped, foam-padded wooden slides were bolted to the rib midsection of each basket to direct fish through fabric chutes into the lidded aluminum live boxes, which were bolted to the outer sides of each pontoon.

Live boxes were inspected first thing each morning, and all fish were removed with a dip net and counted by species. Fish selected for sampling and marking were placed in padded troughs partially filled with fresh river water then processed and quickly released back into the river; all other fish were counted and released into the river. Every afternoon the fish wheels and live boxes were reexamined and the fish were processed. The fish wheels were checked more often during periods of peak fish movement. Scale samples were collected daily from the first 40 sockeye salmon counted out of the live boxes. This sampling goal was established to ensure sufficient samples of each age class for use in scale pattern analysis of the fish wheel catch (Sogge and Bachman 2014). The length of each sampled fish was measured from mid eye to fork of tail (MEF) to the nearest 5 mm. Sex was determined from examination of 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. Data recorded on standard optical scan forms included the date, sex, length, and condition of each fish.

Sockeye salmon mark–recapture studies were conducted annually from 1994 to 2016. Fish were marked at the fish wheels with a primary mark (adipose clip) to identify it as a marked fish. Marking was then stratified through time by applying secondary fin clips in different combinations. From 1994 to 2001, fish were marked in four strata that corresponded approximately to the historic quartiles of migration timing at the fish wheels. From 2002 to 2016, marks were applied in ten strata, each consisting of two statistical weeks (Table 2). Typically all healthy sockeye salmon >360 mm MEF captured at the wheels were marked (Kelley and Bachman 2000; Bachman 2005, 2010). Sockeye salmon ≤360 mm MEF (precocious males or "jacks") were not marked or were censored from the study, because fish in that size category did not have the same probability of capture in recovery events as larger fish. In 2014, the size for "jacks" was increased to ≤400 mm MEF after a review of historical length and age data (Sogge and Bachman 2014).

Other information recorded daily at the fish wheels included water temperature (°C), fish wheel rotation speed (rpm), and fish wheel start and stop times. River water level (mm) was measured at an established staff gauge located near milepost 8.5 on the Haines Highway.

Chilkat Lake Weir

The Chilkat Lake weir (Figure 3) was installed on the outlet stream, Clear Creek, approximately 0.4 km downstream of Chilkat Lake, and was operated between mid-June and mid-October. The weir was a semi-removable steel bipod structure approximately 33 m wide. The weir framework consisted of 11 5-cm steel pipe bipods spaced between 2.4 and 2.7 m driven into the bed of the river and connected together with steel stringers of varying lengths. Iron pipe pickets with 2.5 cm outside diameter were inserted through regularly-spaced holes in the stringers and extended to the stream bed, forming a fence across the lake outlet. The stringer holes were spaced 3.8 cm apart, and the maximum possible space between each picket was 4.1 cm. A 3.6 m wide boat gate was installed in the center of the weir to allow boat traffic to access the lake. The boat gate was operated remotely via an electric hoist/winch. Sandbags and fencing were placed along the upstream side of the weir to ensure the weir was fish tight, and to keep fish from passing uncounted. The bottom substrate was mud and maximum depth at the weir site averaged approximately 3 m. The integrity of the weir was verified throughout the season by regular underwater inspections.

Before 2008, fish were counted visually during daylight hours. A few pickets were pulled and fish were counted as they passed through the small opening. If the water was murky from wind, fish were held behind the weir until the water was considered clear enough to continue counting (this condition could sometimes last for days). Operation of the boat gate complicated counting fish at the weir. The gate was only opened to allow boat traffic to move quickly by, and the period of time the gate was down was minimized as much as possible. It was assumed that boat activity would scatter the fish and few, if any, would pass through the opening during the short period of time the gate was open. If it was clear that fish were backed up behind the weir then a seine plunger was often used to scare the fish downstream before opening the gate. Periodic flow reversals, caused when glacial water from the flooding Tsirku River backed into Clear Creek and into Chilkat Lake (Bergander et al. 1988) (Figure 4), also required the boat gate to be opened to prevent damage to the gate until the reversal subsided. Flow reversals could last from a few hours to several days, during which time fish could not be counted because it was not possible to see into the turbid water. It was assumed that fish did not move into the lake during flow reversals (Bergander et al. 1988). If the boat gate had to be opened because it was broken, an estimate of fish passage was made based on how long the gate was down and the abundance of fish before and after the problem occurred.

A total of 40 sockeye salmon were sampled at the weir each day for length, sex, and scale data following the procedures outlined for sampling at the fish wheels (above). This sampling goal ensured sufficient samples of each age class would be collected for use as known-origin standards in scale pattern analysis of fish wheel and commercial fishery samples (McPherson and Olsen 1992) and was more than sufficient to estimate the age composition of the escapement. Fish were captured for sampling with a beach seine on the downstream side of weir structure. If fish were present, sampling usually began at 0600, early enough to be completed prior to the start of the daily boat traffic. In addition, all captured sockeye salmon were examined for the presence of primary (adipose clips) and secondary marks that had been applied at the fish wheels. Sampled fish were then marked with a left operculum punch to prevent resampling. All captured coho salmon were counted, and those counts were used for species apportionment of the DIDSON counts (see below). After sampling, fish were released on the upstream side of the weir.

Chilkat Lake DIDSON

Starting in 2008, a DIDSON system was used to enumerate fish as they passed through the boat gate opening in the weir. The DIDSON was deployed just upstream of the weir approximately 3–5 m from the left bank of the river. Sandbags and wire mesh fencing were anchored between the weir and the transducer to block fish from passing uncounted between the left bank and transducer. The DIDSON transducer was attached to an aluminum pod and oriented perpendicular to the current. The wide axis of the beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. The DIDSON, manufactured by Sound Metrics Corporation, was operated at 1.8 MHz (high frequency 96 beams) with a viewing angle of 29° × 14°. A 30 m cable connected the DIDSON to the “topside box” in the camp cabin next to the weir. This cable transmitted power and data between the “topside box” and the DIDSON unit in the water. An Ethernet cable was used to route data to a laptop computer. Sampling was controlled by the laptop computer running the latest version of DIDSON software. A small gasoline powered generator provided power for all equipment. Daily visual inspections were conducted to confirm proper placement and orientation of the transducer to accommodate varying water levels.

The DIDSON was operated continuously from 0600 to 2200 each day. Each morning at 0600 the DIDSON was turned on, but the boat gate was kept closed until daily seining and sampling was completed. Once sampling was completed, the boat gate was opened and fish were recorded immediately after they passed through the opening at a range of approximately 5 m to 10 m from the face of the transducer, well within the 30-m effective range for a DIDSON set at the high frequency. The sample rate was set at 6 frames per second. Data were recorded continuously in 60-minute increments and saved on a two terabyte portable external hard drive, which had sufficient capacity to allow for the storage of an entire season’s data. At 2200, the boat gate was closed (preventing fish passage) and the DIDSON was turned off. The boat gate was infrequently opened between 2200 and 0600 to allow boats to pass, but the DIDSON was not turned on (and thus no fish were counted). The boat gate was also opened for the duration of flow reversals, to prevent damage to the gate. The DIDSON was operated normally from 0600 to 2200 during flow reversals, but it was still turned off between 2200 and 0600.

Sockeye salmon were enumerated by counting DIDSON images with a hand counter during play back of recorded files. Fish that displayed feeding or milling behavior known to be associated with cutthroat trout or whitefish were not counted. Fish that exhibited behavior associated with sockeye salmon, such as direct upstream migration with no milling, were assumed to be sockeye salmon. All images identified as salmon were counted as sockeye salmon until coho salmon arrived (typically in late August or early September), after which the ratio of coho and sockeye salmon caught in beach seine sampling sets was used to apportion daily DIDSON counts by species (see Chilkat Lake Weir section for details). Pink and chum salmon were counted if present in the seine catches; however, their numbers were expected to be insignificant since very few were historically counted through the weir (the 1981–2007 average annual count was 10 chum salmon and 1 pink salmon).

Chilkat River Mainstem Sampling

Mark–recapture surveys were conducted weekly from mid-July through mid-September at Chilkat River mainstem spawning areas. The term “mainstem” includes all sockeye salmon populations spawning in the Chilkat River and its tributaries; i.e., all non-Chilkat Lake fish. Sampling locations included Mule Meadows, Bear Flats, Mosquito Lake, and the Tahini, Little Salmon, and Kelsall rivers (Figure 2). Sockeye salmon were captured with a beach seine (dimensions 3 m × 25 m) and examined for the presence of primary (adipose clips) and secondary marks that had been applied at the fish wheels (Sogge and Bachman 2014). Carcasses of spawned-out sockeye salmon were also examined for marks, and all sampled fish were marked with a left operculum punch to prevent resampling. Recovery sampling trips in a given area were limited to once every 3–5 days to allow for replacement of spawning fish and to minimize repeated handling of fish on the spawning grounds. A minimum of 100 fish per week were also sampled for length, sex, and scale data following the procedures outlined for sampling at the fish wheels (above). Scale samples collected from sockeye salmon at Chilkat River mainstem spawning areas were used as known-origin standards for scale pattern analysis of fish wheel and commercial fishery samples.

ESCAPEMENT DATA ANALYSIS

Mark–recapture Estimates

Two-event mark–recapture studies for a closed population (Seber 1982) were used to estimate the sockeye salmon escapement at Chilkat Lake and Chilkat River mainstem spawning areas. Adult sockeye salmon were marked at the fish wheels with a primary (adipose clip) and secondary fin clip in the first sampling event (marking) (Table 2) and sampled at mainstem river spawning grounds and at the Chilkat Lake weir in the second sampling event (recapture).

From 1994 to 2007, mark–recapture data were organized into a single matrix of release and recovery data, where release data were stratified according to the marking schedule at the fish wheels, and recovery data from Chilkat Lake and Chilkat River mainstem spawning areas were combined and stratified by statistical week. This information was used to generate a mark–recapture estimate of sockeye salmon abundance for the entire drainage. Chilkat Lake and Chilkat River mainstem populations were then estimated by multiplying the drainagewide estimate by the annual ratio of the two stocks at the fish wheels (weighted by week), which was determined from scale pattern analysis of sockeye salmon scale samples collected at the fish wheels (drainagewide approach; Method A; Appendix B) (Kelley and Bachman 2000; Bachman and McGregor 2001; Bachman 2005, 2010). The assumption that scale pattern analysis provided accurate stock identification was not verified; however, radio telemetry studies conducted in

2003 and 2004 showed that sockeye salmon radio-tagged and sampled for scales at the fish wheels were identified as "lake" or "river" spawners with 96% accuracy based on scale pattern analysis (Brian Elliot, ADFG Fishery Biologist, personal communication, unpublished data).

After the DIDSON system was installed at Chilkat Lake in 2008, the mark–recapture study objectives were modified to provide only an estimate of the abundance of Chilkat River mainstem sockeye salmon populations (Sogge and Bachman 2014). Mark–recapture data were organized into a single matrix of release and recovery data, where release data were stratified according to the marking schedule at the fish wheels, and recovery data from Chilkat River mainstem spawning areas were stratified by statistical week. The number of Chilkat River mainstem sockeye salmon marked and released at the fish wheels each week was estimated by multiplying the number of fish marked by the ratio of Chilkat River mainstem spawners at the fish wheels, which again was determined from scale pattern analysis of weekly sockeye salmon scale samples collected at the fish wheels. This information was then used to generate direct estimates of the Chilkat River mainstem sockeye salmon population (direct approach; Method B; Appendix B).

The general assumptions that must be met for a mark–recapture estimate to be consistent were provided by Seber (1982:59):

1. all adults have an equal probability of being marked;
2. all adults have an equal probability of being sampled for marks;
3. there is no recruitment, death, or emigration to the population between the fish wheels and the sampling sites upstream (i.e., the population is closed);
4. there is no trap induced behavior; and
5. there is no tag loss due to shedding, misidentification, or nonreporting.

An additional assumption based on a stratified estimate is that

6. all adults released in an initial stratum have the same probability distribution of movement to the final recapture strata.

The first five assumptions can be easily generalized to a stratified estimate. The closed population assumption is true for the Chilkat sockeye salmon populations; each sampling day is a snapshot of the sockeye salmon population as the fish move past the fish wheels. The population's location in time functions as if it were a location in space; a salmon population passing the fish wheels in a time stratum could be considered a closed population (Schwarz and Taylor 1998). There should be no trap induced behavior in this study because different sampling gears are used in different sampling events. Fish were identified as marked fish by their clipped adipose fin and secondary fin clips (Table 2); therefore, there was insignificant tag loss and tag nonreporting. To reduce tag-induced mortality, fish were handled as carefully and as little as possible and any fish exhibiting any sign of reduced vitality were not tagged.

Mark–recapture data were analyzed using the software program Stratified Population Analysis System (SPAS) (Arnason et al. 1996). The program SPAS was used to evaluate the adequacy of using the Chapman modified pooled-Petersen estimator (PPE) versus the stratified maximum likelihood (ML) Darroch estimator (Darroch 1961, Seber 1982). One of two conditions must be satisfied in order for the PPE to be unbiased and the preferred model. The first condition, "complete mixing," states that the recovery probabilities were constant across strata. The second condition, "equal proportions," states that the expected ratio of marked to unmarked individuals was constant across all recovery strata due to similar migration patterns. Chi-square tests were used to evaluate these conditions. If either of these conditions were satisfied (P > 0.05), based on the output of the chi-square tests, the PPE (N^*) was considered to be the appropriate model and was used as the abundance estimate (Arnason et al. 1996). Let M denote the number of fish marked in the lower Chilkat River fish wheels. Let C denote the number of fish examined for marks at a different time period, and let R denote the number of fish in the second sample that were marked (Seber 1982),

$$N^* = \frac{(M+1)(C+1)}{(R+1)} - 1, \quad (1)$$

with variance,

$$v^* = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)}. \quad (2)$$

The approximate 95% confidence intervals for N^* based on normal theory is

$$N^* \pm 1.96\sqrt{v^*}, \quad (3)$$

and the coefficient of variation (CV) is

$$\mathrm{CV}(N^*) = \frac{\sqrt{v^*}}{N^*}(100\%). \quad (4)$$

If neither of the conditions of the chi-square tests were met, the stratified ML Darroch estimator was used to estimate abundance. Strata that contained zero recoveries or releases were dropped from the analysis and partial pooling of the recovery and marking strata was done. Partial pooling was guided by pooling of adjacent strata with similar initial capture or recapture probabilities, pooling of adjacent strata with few initial capture or recapture numbers, minimization of the number of cells with $\{M_{ij}\}$<5 (the total number of fish tagged in stratum i and recovered in recovery stratum j) to avoid problems of sampling zeros, goodness of fit (GOF) tests, additional chi-square tests, minimization of the standard error of the abundance estimate, and formulation of admissible ML Darroch estimates of abundance (Arnason et al. 1996; Schwarz and Taylor 1998). If a recovery stratum had few counts it may be an indication that little movement occurred to this particular stratum (e.g., fish in this stratum died before reaching the recovery spawning grounds), the recovery effort was small, or the stratification interval (time period) was too small. In this case, two or more recovery strata were temporally pooled. The GOF tests were used to assess the adequacy of the stratified model for lack of fit. Nonadmissible estimates of abundance included failure of the ML algorithm to converge, or convergence to unrealistic estimators such as negative capture probabilities or negative stratum abundances. Other than GOF statistics, there are no formal tests to determine if one should pool or drop strata (Arnason et al. 1996; Schwarz and Taylor 1998).

As part of our objectives to review all historic project data, we edited, corrected, and reanalyzed all available mark–recapture data for the history of the project from 1999 to 2016 (data from 1994 to 1998 were not available). In addition, we generated both drainagewide and Chilkat River mainstem-only mark–recapture estimates for all years in order to a) compare estimates of Chilkat River mainstem spawning populations using both methods, and b) compare mark–recapture population estimates of Chilkat Lake sockeye salmon (based on the drainagewide estimates) to weir and DIDSON counts (Table 3 and 4). Additional mark–recapture estimates were generated for informational purposes only and are described and presented in Appendix B.

Weir and DIDSON Review and Count Expansions

As part of our objectives to review all historic project data, we reviewed and edited Chilkat Lake weir (1971–2007) and DIDSON (2008 to 2016) count data. A common occurrence in nearly all years when only the weir was operated (1971–2007) were instances when either "0" fish were counted or no data were entered for a day or for a string of days. We reviewed daily comments provided with weir data in the ADF&G Southeast Integrated Fisheries Database, (and in some cases original paper records) to verify counts of "0" fish on those days. In most cases, the boat gate had been closed (and no fish were allowed to pass) or the boat gate had been opened during a flow reversal (and no fish were counted) as described earlier in the weir and DIDSON sections. In a few cases counts had mistakenly not been entered into the ADF&G database. In one case (30 September 1992) the boat gate had been left open while fish were moving; we imputed a value for that day using the method described in Sogge (2016). We did not change any historical values that had already been estimated and entered into the database.

We expanded weir and DIDSON counts in years with shortened seasons to allow for comparison across all years, because weir and DIDSON operations did not always encompass the entire run. In some years weir operations were started later and/or ended earlier than average due to budget constraints, flooding, or other problems (Table 3). Based on choosing the standardized range of weir operations as 16 June–15 October, the weir was installed late (between 18 June and 13 July) in years 1982, 1983, 1985, 1987, 1988, 1999, and 2001–2007, and the weir was removed early (between 28 September and 14 October) in years 1972, 1974, 1977, 1980, 1982, 1984, 1994, 1995, 2001, and 2003–2006. In years 1982, 2001, and 2003–2006 the weir was installed late and removed early.

Weir counts were expanded using simple linear regression in two steps. Weir counts missing early escapement data were expanded first, by regressing cumulative escapement by date (18 June–13 July) against total escapement for the late installation base years (1971–1981, 1984, 1986, 1989–1995, 2000). The expanded escapements were then added to the early removal base years, except the years in which the weir was installed late *and* removed early. Weir counts in years when the weir was removed early were then expanded by regressing cumulative escapement by date (27 September–13 October) against total escapement in the early removal base years (1971, 1973, 1975, 1976, 1978, 1979, 1981, 1983, 1985–1993, 1999, 2000, 2002, 2007). For example, in 2007 the weir was installed very late on 13 July and the total weir count was 21,236 (X) sockeye salmon for that year. To determine the late installation expansion, cumulative escapement from 13 July on (X) was regressed against total escapement in the late installation base years (Y). Using the results of this regression,

$$\hat{Y}_i = a + bX_i, \tag{5}$$

the expanded weir count in 2007 ($\hat{Y}$) was then calculated as 27,915, where a=5,770 and b=1.04. Therefore, based on this expansion, it was assumed that 6,679 fish were missed because the weir was installed late. The year 2007 was then added to the early removal base years. In 2005, the weir was terminated early on 12 October and the total weir count was 31,628 (X) sockeye salmon for that year (after first expanding for late installation). To determine the early removal expansion, cumulative escapement to 12 October (X) was regressed against total escapement in the early removal base years (Y). Using the results of this regression, the expanded weir count in 2005 ($\hat{Y}$) was then calculated as 32,098, where a = -706 and b = 1.04. Therefore, based on this expansion, it was assumed that 470 fish were missed because the weir was removed early.

DIDSON counts were also expanded to account for late installation or early removal (Table 3). Based on choosing the standardized range of DIDSON operations as 20 June–10 October, the DIDSON was installed late in years 2008, 2015, and 2016 (27 June in 2008, 26 June in 2015, 24 June 2016) and removed early (between 30 September and 7 October) in years 2012, 2013, and 2015. Years with complete DIDSON counts were used to expand truncated (late installation or early removal) DIDSON counts using simple linear regression. DIDSON counts from late installation, which were missing early escapement data, were expanded first, by regressing cumulative escapement by date (24 June–27 June) against total escapement in the late installation base years 2009–2014. The expanded 2008 and 2016 escapements were then added to the early removal base years. DIDSON counts in years when the DIDSON was removed early were then expanded by regressing cumulative escapement by date (29 September–6 October) against total escapement in the early removal base years (2008–2011, 2014, 2016). In the year 2015, the weir was installed late and removed early so expansions were done to account for both late installation and early removal.

Age, Sex, Length

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 were separated by a period (e.g., 1.3 denoted a fish with one freshwater and three ocean years; Koo 1962). The weekly age distribution, the seasonal age distribution weighted by week, SE of mean length by age, and SE of sex composition by week were calculated using equations from Cochran (1977) (Appendix C).

COMMERCIAL HARVEST ESTIMATE

Visual scale pattern analysis was used to determine stock composition of sockeye salmon harvested in the District 15 commercial drift gillnet fishery (Bachman et al. 2014). The general methods have remained unchanged since the mid-1980s: escapement scale samples from three stocks of known origin, Chilkoot Lake, Chilkat Lake, and "other" (Chilkat River 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 commercial drift gillnet fishery were obtained from the ADF&G Southeast Alaska Integrated Fisheries Database and summarized by statistical week. Scale samples from District 15 commercial drift gillnet fishery landings of sockeye salmon were collected weekly throughout the season by ADF&G personnel at fish processing facilities at Excursion Inlet and Juneau. A sampling goal of 510 fish was sufficient to estimate the weekly sockeye salmon age composition within 0.05 of the true proportion with probability 0.95 (Thompson 1987). Sampling protocols help ensure that samples were as representative of harvests as possible: deliveries with harvests mixed from more than one gear type or fishing district were not sampled, no more than 40 samples were collected from a single delivery, and, whenever possible, samples were systematically collected from the entire hold as it was offloaded to ensure they were representative of the entire delivery. Sampled fish were identified by sex and one scale per fish was taken from the preferred area (INPFC 1963). Samples were processed and aged at the ADF&G salmon-aging laboratory.

Scale Pattern Analysis

Known-origin scale samples were collected weekly at the Chilkoot River weir (Sogge 2016) and at Chilkat Lake, and annually from spawning populations in Berners Bay (Berners, Antler, and Lace rivers) and along the mainstem of the Chilkat River where sockeye salmon are concentrated in spawning tributaries. These latter samples were collected opportunistically and may not be representative of the entire Berners Bay and Chilkat River mainstem populations. Samples were processed and aged at the ADF&G salmon-aging laboratory in Douglas.

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 Lake, Chilkat Lake, 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 drift gillnet harvest to provide weekly estimates of stock contribution for inseason management and postseason estimates of total harvest by stock, weighted by statistical week. Because total District 15 commercial drift gillnet harvest was not apportioned to Chilkoot Lake, Chilkat Lake, and "other" in the ADF&G database in years 1976 through 1983, the apportionment percentages from McPherson (1990) were reapplied to updated harvests from those years (Table 5).

CHILKAT LAKE LIMNOLOGICAL ASSESSMENT

Basic limnological data, including zooplankton, light, and temperature sampling, were collected monthly between May and October. All light and temperature data were collected at two primary stations marked by anchored buoys in the lake (station 1A at 59.3420° N, 135.9131° W; station 2A at 59.3263° N, 135.8961° W). Zooplankton samples were collected at stations 1A and 2A from 1987 to 1991 and from 2008 to 2016. From 1994 to 2007 zooplankton samples were collected at four stations (stations 1A, 1B, 2A, 2B).

Light and Temperature Profiles

Light and temperature profiles were collected at stations 1A and 2A. Underwater light intensity was recorded at 0.5-m intervals, from just below the surface to the depth at which ambient light level equals 1% of the light level just below the surface, using a Protomatic electronic light meter. 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 (I) just below the surface to light intensity at depth 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 was 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 then continued in 5-m increments to a depth of 50 m.

Secondary Production

Zooplankton samples were collected at each sampling station 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. Once the top of the net cleared the surface, the rest of the net was pulled slowly out of the water and rinsed from the outside with lake water to wash organisms into the screened sampling container at the cod end of the net. All specimens in the sampling container were carefully rinsed into a sampling bottle and 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 AND DISCUSSION

ESCAPEMENT ESTIMATES

Expanded weir counts from 1971 to 2007 provided an index of sockeye salmon escapement; however, the counts clearly underrepresented total escapements (Table 3). All weirs require vigilant maintenance to ensure they are fish tight, but additional problems unique to the Chilkat weir likely allowed increased fish to pass uncounted. The boat gate in the center of the weir was lowered and raised an average 15 times per day (range: 0–64 gate drops per day) and more than 2,000 times per season. It was assumed that fish did not move through the weir in the short time the gate was down. Attempts were made to scare fish away from the weir before dropping the gate, particularly when fish abundance was high; however, the water depth at the boat gate made it difficult or impossible to determine with certainty that fish did not pass uncounted. It was also assumed that fish did not move through the weir during flow reversals (Bergander et al. 1988), when it was necessary to leave the boat gate open to prevent damage to the weir. However, operation of the DIDSON in subsequent years showed that while fish movement slows down during flow reversals, sockeye salmon continue to enter the lake at a reduced rate. Finally, weir operations were also interrupted when the water was too murky to see fish due to windy conditions on the lake. As a result, fish were held behind the weir for long periods, sometimes days at a time, which interrupted the natural movement of fish into the lake and increased the chance that fish would exploit weaknesses in the weir.

In order to improve the sockeye salmon counts at the Chilkat Lake weir, visual weir counts were replaced with DIDSON counts in 2008 (Table 3). Although no direct comparisons were made between visual weir counts and DIDSON counts at Chilkat Lake, DIDSON counts have proven more accurate than visual counts in other studies, particularly in turbid water (Cronkite et al. 2006; Holmes et al. 2006; Burwen et al. 2007; Maxwell and Gove 2007). Both upstream and downstream fish movement can be detected with the DIDSON (Cronkite et al. 2006; Crossman et al. 2011). Although downstream fish movement was not detected in some studies, because of river debris or due to the swimming behavior of the fish (Coyle and Reed 2012; Pipal et al. 2012, Petreman et. al 2014), this was not an issue at Chilkat Lake. The boat gate opening is no longer a potential source of uncounted fish, but is instead used to funnel fish past the DIDSON lens. Fish continue to be counted during flow reversals and no longer have to be held behind the weir when the water is murky. As long as the DIDSON is operated, fish can be detected and counted during adverse conditions that prevented visual counts in the past.

The use of the DIDSON to count fish does have limitations that must be addressed, including species apportionment, shadowing effects, and observer counting rates. The DIDSON cannot be used to identify salmon to species when individuals of two species are of similar size and shape (Martignac et al. 2015). At Chilkat Lake, species identification is not a problem until coho salmon arrive in late August or early September, after which beach seine sampling is used to apportion DIDSON counts by species. This appears to have been an effective method, as the proportion of coho salmon counted in September and October was very similar (roughly 10%) in both the visual weir counts (2000–2007) and the DIDSON counts (2008–2016). Also, acoustic shadowing can be a problem when fish are present in high densities—fish nearer to the DIDSON mask or "shadow" fish passing farther away—which leads to undercounting. In studies conducted elsewhere, problems associated with shadowing occurred when fish densities were above 1,000 fish an hour (Holmes et al. 2006; Maxwell and Gove 2007; Westerman and Willette 2012). Because hourly fish counts at Chilkat Lake were usually well below 1,000 fish with only occasional large pulses, acoustic shadowing was a minor and rare problem that was addressed by slowing down the counting. Accurate DIDSON counts also rely on an observer's expertise to detect individual fish (Martignac et al. 2015). Observer fatigue or interruptions in viewing can also bias observations between operators (Cronkite et al. 2006). Observer comparisons of Chilkat Lake DIDSON counts have been conducted occasionally since 2008; few discrepancies have been found, but observer comparisons should be conducted more routinely in the future to maintain quality control and ensure accuracy.

In general, the limitations of the DIDSON have been addressed in this project and there is much greater confidence in the DIDSON escapement counts of Chilkat Lake sockeye salmon than in the visual weir counts or mark–recapture estimates; however, DIDSON counts should still be considered minimum estimates of escapement due to operational rather than technological limitations. The operational plan required that the DIDSON be turned off between 2200 and 0600, when the boat gate was closed for the night, which would have allowed fish to pass uncounted if the weir was not fish tight. In a 2003 and 2004 Chilkat River sockeye salmon radio telemetry study, some of the radiotagged fish tracked to Chilkat Lake passed the weir undetected when the boat gate was closed (Brian Elliot, ADF&G Fishery Biologist, personal communication, unpublished data). This illustrates the difficulty of keeping this weir fish tight. The DIDSON was also turned off every night even when the boat gate was left open during flow reversals, and fish that moved into or out of the lake between 2200 and 0600 would not have been counted. Finally, the DIDSON project was usually not operated throughout the entire length of the sockeye salmon run. In some Alaska sockeye salmon escapement counting projects a "cessation criterion" is applied; e.g., projects are operated until the daily count is ≤1% of the cumulative count for three consecutive days (Westerman and Willette 2007). This criterion is feasible when a salmon run is condensed into a few summer months, but the Chilkat Lake sockeye salmon run lasts for at least five months and budget constraints prevent operating the project for that length of time. Instead, the DIDSON project could be operated with standardized start and end dates that encompass the majority of the run. On average <1% of escapement has been counted before 20 June and about 3% of escapement has been counted after 10 October (Sogge and Bachman 2014). Thus, on average, 96% of the run would be counted if the DIDSON project was operated from 20 June to 10 October.

Mark–recapture

In the mid-1990s, the mark–recapture program on the Chilkat River was chosen as the primary method of estimating Chilkat Lake sockeye salmon escapements after it was determined that visual weir counts were unreliable (Kelley and Bachman 2000; Eggers et al. 2010). The 1994–2007 mark–recapture estimates of Chilkat Lake sockeye salmon escapement averaged 2.2 times expanded weir counts (Table 4). In their revision of the Chilkat Lake sockeye salmon escapement goal, Eggers et al. (2010) expanded weir counts into mark–recapture units and recommended escapements be assessed with DIDSON in lieu of mark–recapture. Most of the problems with visual weir counts were thought to have been overcome after the DIDSON project was established, yet mark–recapture estimates of Chilkat Lake sockeye salmon have still averaged 1.6 times the expanded DIDSON counts (Table 4).

The accuracy of mark–recapture studies depends on the degree to which the underlying assumptions are met, and serious, hard-to-detect bias may result when those conditions do not hold true (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 biased mark–recapture estimates (Seber 1982; Schwarz and Taylor 1998; see also Underwood et al. 2004, Bromaghin et al. 2007, and Willette et al. 2012 regarding potential bias in fish wheel-based mark–recapture studies). Bias tends to result in inflated estimates, the magnitude of which may not be consistent among river systems or among years within a river system (Simpson 1984). Although the assumptions particular to the Chilkat mark–recapture studies have been thoroughly discussed in previous reports and are assumed to have been met, the degree to which they have been met is uncertain.

In addition to the usual challenges facing mark–recapture studies, Chilkat mark–recapture estimates have all relied in some way on stock composition estimates at the fish wheels (i.e., the ratio of Chilkat Lake to Chilkat River mainstem spawners). Implicit in this assumption is that the fish wheel catch provides an accurate assessment of the relative abundance of the two stocks. That ratio is probably influenced by the seasonal dates the fish wheels are operated, seasonal differences in abundance and run timing of the various spawning populations within the drainage, and by seasonal changes in water flow, which in turn affects the behavior and catchability of various spawning populations. As a result, recapture probabilities likely vary by recovery area and time. In addition, some Chilkat River mainstem spawning areas were not sampled annually or not sampled at all due to logistical challenges.

Finally, the two methods used to analyze mark–recapture data from 1994 to 2016 provided very different estimates of Chilkat Lake and Chilkat River mainstem spawning populations (Appendix B). Mark–recapture estimates of Chilkat River mainstem fish generated with the drainagewide method (Method A) averaged 52% larger (range: -25 to 133%) than estimates generated from the direct method (Method B) (Table 4; Appendix B). Conversely, mark–recapture estimates of Chilkat Lake fish generated with the drainagewide method (Method A) averaged 18% smaller (range: -4 to -44%) than estimates generated from the direct method (Method B) (Appendix B). These estimates were all relatively precise (mean CV = 0.12; range: 0.05–0.23), and only two drainagewide estimates, four Chilkat River mainstem estimates, and four Chilkat Lake estimates had CVs >0.15 (Appendix B). It is not possible, however, to determine with confidence which method may have generated more accurate estimates.

Concerns regarding mark–recapture as a reliable measure of abundance lead us to recommend suspending mark–recapture studies in 2017 and, instead, maintain the DIDSON to estimate escapement into Chilkat Lake. In the near term, this means that no effort will be made to estimate the population of Chilkat River mainstem sockeye salmon. Future mark–recapture studies will require careful consideration to address potential pitfalls and would certainly benefit from concurrently conducted radio-telemetry studies to estimate inriver mortality and loss of marked fish (Bernard et al. 1999; Willette et al. 2012; Richards et al. 2016). This recommendation does not mean that Chilkat River mainstem populations are not considered valuable; however, Chilkat Lake and Chilkoot Lake sockeye salmon contribute substantially more fish to the District 15 commercial drift gillnet fishery than all other sockeye salmon stocks combined (Table 5; McPherson 1990), and the fishery is managed to ensure escapement goals for those two stocks are met. The management priority on Chilkat and Chilkoot lake sockeye salmon does not appear to have been detrimental to Chilkat River mainstem populations, which are more prevalent in the fishery earlier in the season (McPherson 1987b; McPherson and Jones 1987; McPherson 1989; McPherson et al. 1992; McPherson and Olson 1992), when fishery management has tended to be more conservative.

COMMERCIAL HARVEST ESTIMATE

An average of 77,771 Chilkat Lake sockeye salmon were harvested annually in the District 15 commercial drift gillnet fishery (1976–2016) (Figure 5; Table 5; Appendix D). The maximum estimated harvest was 168,006 fish in 1986 and the minimum estimated harvest was 14,208 fish in 2007. The lower quartile was 48,079 fish and the upper quartile was 112,630 fish. The 1999 harvest of 149,410 Chilkat Lake sockeye salmon was the most recent year in which the annual harvest was greater than 100,000 fish. The most evident aspect of the commercial harvest time series was a steady decline from an average annual harvest of 107,000 fish during the 1980s–1990s to an average harvest of only 19,000 fish during 2005–2008—a decline of 82% (Figure 5). Annual commercial harvests have since improved but are still well below the average of the 1980s–1990s.

Since 1976, scale pattern analysis has been used to determine the contribution of Chilkat Lake, Chilkoot Lake, and other stocks to the District 15 commercial drift gillnet fishery harvest (McPherson et al. 1992). Scale pattern analysis required intensive field sampling and inseason analysis of a very large number of scale samples, and it required highly skilled personnel trained in very specific pattern recognition, which could take years to master. From 2013 to 2016, scale pattern analysis and genetic stock identification were conducted concurrently to compare estimates using the two methods and to provide a transition period to assess the viability of switching exclusively to genetic stock identification. This information will be summarized in future reports (Serena Rogers Olive, ADF&G Fisheries Geneticist, personal communication). The benefits of genetic stock identification over scale pattern analysis are that the genetic methods are standardized and repeatable and do not require subjective judgement, they provide stock composition estimates with an estimate of precision, and are used widely throughout the state (Shedd et al. 2016). Genetic stock identification also allows for finer identification of individual stocks, such as Chilkat River mainstem sockeye salmon, which were not identifiable using scale pattern analysis. Scale pattern analysis will be discontinued in 2017, and stock separation estimates will be determined by genetic stock identification.

FISH WHEEL COUNTS

The Chilkat River fish wheel project was initially implemented to provide fishery managers with information about inriver sockeye salmon abundance on a timelier basis than could be obtained from Chilkat Lake weir counts alone (Kelley and Bachman 2000). It is thought to take about a month for fish to travel between the commercial fishery and the Chilkat Lake weir (McPherson 1990), whereas the fish wheel project provides information about the magnitude of the run roughly two weeks ahead of the weir—in a 2003 and 2004 study, it took an average of 16 days for radiotagged Chilkat Lake sockeye salmon to travel between the fish wheels and the weir (Brian Elliot, ADF&G Fishery Biologist, personal communication, unpublished data). Fish wheel catch was not considered "a definitive index of abundance" (Kelley 1998), but was compared to historical escapement information and used as an indicator of relative abundance, which managers then used, along with other information, to manage the District 15 commercial drift gillnet fishery (Kelley and Bachman 2000). Annual dates of fish wheel operation and counts of sockeye salmon are presented in Table 1 and weekly fish wheel counts of sockeye salmon are presented in Appendices E–G.

A comparison of historical fish wheel counts to Chilkat Lake escapement estimates demonstrates that the fish wheel project does provide a rough indication of Chilkat Lake run strength (Figure 7). When total fish wheel catches were below 4,000 fish, escapements were below average (<65,000 fish) (in this analysis, 1999–2016 fish wheel counts were compared to estimated escapements in which visual weir counts were converted into the DIDSON counts; Appendix H). When total fish wheel catches were above 7,000 fish, escapements were above average (>150,000 fish). Fish wheel catches in the range of 4,000–7,000 fish have been less informative, as associated escapements have been highly variable (range: 63,000–122,000 fish). Interestingly, knowing the stock composition of the fish wheel catch (based on scale pattern analysis) does not appear to improve information about Chilkat Lake sockeye salmon abundance. The relationship of the Chilkat Lake escapement to the estimated fish wheel catch of Chilkat Lake sockeye salmon is actually weaker ($R^2 = 0.60$; P-value < 0.001) than its relationship to the total catch of sockeye salmon ($R^2 = 0.66$; P-value < 0.001; Figure 6). As mentioned in the mark–recapture section, the reasons for this are probably related to variation in the range of dates the fish wheels have been operated each season, seasonal differences in abundance and run timing of the various spawning populations within the drainage, and seasonal changes in water flow, which affects the behavior and catch rate of the various spawning populations.

CHILKAT LAKE ESCAPEMENT AGE COMPOSITION

On average, the Chilkat Lake sockeye salmon escapement is composed primarily of age-2.3 (40%), age-1.3 (29%), and age-2.2 (25%) fish (Appendices I and J). The remainder of the escapement is composed of age-1.2 (4%) fish and all other ages combined (2%). Age composition has varied widely from year to year as a result of changes in the magnitude of returns from individual brood years; e.g., age-2.3 fish composed 80% of the escapement in 2000, but only 15% in 2001. As discussed by McPherson (1990), the Chilkat Lake sockeye salmon run exhibits differential migration timing by freshwater age. Age-1. fish run earlier and are a smaller component of the overall escapement (average = 33%) compared to age-2. fish, which run later and account for the majority of the escapement (average = 66%), though there is clearly much overlap (Figure 8). The spawning distribution of early and late run fish is similar (both runs spawn in the lake and at inlet spawning areas), so it is thought that run timing is determined by the time of parental spawning. Eggs that are deposited earlier hatch earlier and the fry tend to grow large enough to smolt after rearing in the lake for one year; fry that emerge later spend an additional year in the lake (McPherson 1990).

LIMNOLOGICAL ASSESSMENT

Light and Temperature

From 1987 to 2016, the seasonal mean (May–August) EZD in Chilkat Lake averaged 18.7 m (range: 14.8–26.0 m); it was deepest in August (average = 19.7 m) and shallowest in May (average = 17.2 m) (Table 6). From 1987 to 2016, the seasonal mean (May–September) water temperature at a depth of 1 m averaged 13.2 ºC (range: 11.5–15.8 ºC); it was coldest in May (average = 8.3 ºC) and warmest in August (average = 15.7 ºC) (Table 6). The years 2013, 2015, and 2016 were the warmest over the time series, but otherwise there was no trend in the temperature data. A thermocline was present in the lake from June through August each year and averaged approximately 15 m deep (ADF&G unpublished data).

Zooplankton Composition

Zooplankton samples from Chilkat Lake were composed primarily of one species of copepod (*Cyclops columbianus*) and three species of cladocerans (*Bosmina longerostris*, *Daphnia longiremus*, and *Daphnia rosea*) (Figure 9; Appendices K and L). Total zooplankton density, all species combined, declined substantially in the mid-1990s before trending upward again over the last 10 years (Figure 9; Appendix M). The decline was particularly dramatic in the copepod population, which exhibited a 98% reduction in average density from 515,000 per m^2 prior to 1996 to only 12,000 per m^2 over the next decade (Figure 9; Appendices L and M). Eggers et al. (2010) attributed this decline to increased predation resulting from a sockeye salmon fry stocking project that occurred at Chilkat Lake from 1994 to 1997 and in 2001, when an average 3.0 million fry were back-planted annually into Chilkat Lake. Additional enhancement from incubation boxes introduced an average 0.3 million sockeye salmon fry annually from 1989 to 1998 and in 2003. Once restructured by excessive predation, zooplankton communities can be slow to recover even after grazing pressure is reduced (Koenings and Kyle 1997). This is particularly true of copepods, which have a more protracted reproductive strategy compared to cladocerans (Pennak 1978), and are not as quick to respond to variation in lake productivity and abundance of predators (Kyle et al. 1990; Edmundson et al. 1992; Edmundson and Edmundson 2002). Zooplankton populations at Chilkat Lake have clearly improved over the past decade (Figure 9). The mean density of copepods averaged 227,000 per m^2 over the past four years (which is still about 48% of the density observed prior to the mid-1990s), and the seasonal mean density of cladocerans (particularly *Daphnia* sp.), the preferred prey of juvenile sockeye salmon (Koenings 1983; Kyle et al. 1988; Koenings et al. 1989), has been more or less similar to what was observed before the lake stocking project began in the mid-1990s (Figure 9; Appendix M).

RECOMMENDATIONS

DIDSON RECOMMENDATIONS

- Continue to use the DIDSON to estimate the sockeye salmon escapement at Chilkat Lake.
- Standardize the dates of DIDSON operation; e.g., from 20 June to 10 October. Otherwise expand DIDSON counts to account for late installation or early removal.
- Restrict fish passage by reducing the size of the weir opening when large schools of fish (estimated at >1000 fish) are present immediately below the weir. This should help reduce the occurrence of acoustic shadowing.
- Operate the DIDSON 24 hours a day once or twice a week to check the weir for fish tightness. If fish are found to be moving though the weir uncounted, consider operating the DIDSON 24 hours a day for the entire season.
- Operate the DIDSON 24 hours a day when the boat gate is open for a flow reversal.
- Maintain frequent (scheduled) beach seine sampling in September–October to ensure accurate species apportionment between coho and sockeye salmon.
- Perform periodic, systematic observer comparison of DIDSON counts to increase precision of the DIDSON count. Disagreement between observers of more than 5% should be flagged for a detailed review.

OTHER RECOMMENDATIONS

- Standardize limnology sampling to occur on or near the 15th of each month.
- Review the current Chilkat Lake biological escapement goal of 70,000–150,000 sockeye salmon to ensure that the goal which was developed using mark–recapture estimates (Eggers et al. 2010), is in the same units as escapement counts, which will continue to be measured with the DIDSON.
- Suspend the mark–recapture program to estimate the Chilkat River mainstem and Chilkat Lake escapements since estimates are likely biased and inflated. Any future mark–recapture project should be paired with a radio-telemetry study to help test assumptions and account for biases.
- Salmon should continue to be counted at the fish wheels to provide inseason abundance information for management purposes, but discontinue use of the fish wheels as a marking platform (because no mark–recapture studies will be conducted).

ACKNOWLEDGEMENTS

We thank Randy Bachman. We would also like to thank Mark Eisenman, the previous assistant area management biologist; fish wheel crew leaders Lane Taylor, Reed Barber, Dave Folletti, and Will Prisciandaro; Chilkat weir crew leaders Robert Pettet and Tim Brush; and Haines program technician Faith Lorentz. Iris Frank read more than 500,000 scales for this project to determine age and stock identification. Andy Piston and Leon Shaul provided suggestions and advice that greatly improved the quality of the report.

REFERENCES CITED

Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2106.

Bachman, R. L. 2005. Stock assessment studies of Chilkat River adult sockeye and chum salmon stocks in 2002. Alaska Department of Fish and Game, Fishery Data Series No. 05-36, Anchorage.

Bachman, R. L. 2010. Stock assessment studies of Chilkat River adult sockeye and chum salmon stocks in 2003 and 2004. Alaska Department of Fish and Game, Fishery Data Series No. 10-23, Anchorage.

Bachman, R. L., and A J. McGregor. 2001. Stock assessment studies of Chilkat River adult salmon stocks in 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J01-36, Juneau.

Bachman, R. L., J. A. Bednarski, and S. C. Heinl. 2014. Escapement and harvest of Chilkoot River sockeye salmon, 2007–2012. Alaska Department of Fish and Game, Fishery Data Series No. 14-07, Anchorage.

Bednarski, J. A., M. Sogge, and S. C. Heinl. 2016. Stock assessment study of Chilkoot Lake sockeye salmon, 2013–2015. Alaska Department of Fish and Game, Fishery Data Series No. 16-29, Anchorage.

Bergander, F. 1974. Southeastern Alaska sockeye salmon optimum escapement studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anadromous Fish Conservation Act, Completion Report for period July 1, 1971 to June 30, 1974, AFC-40, Juneau.

Bergander, F. E., S. A. McPherson, and J. P. Koenings. 1988. Southeast Alaska sockeye salmon studies, 1987–1988. Technical Report for the period July 1, 1987, to June 30, 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J88-44, Juneau.

Bernard, D. R., J. J. Hasbrouck, and S. J. Fleischman. 1999. Handling-induced delay and downstream movement of adult Chinook salmon in rivers. Fisheries Research 44:37–46.

Bromaghin, J. F., T. J. Underwood, and R. F. Hander. 2007. Residual effects from fish wheel capture and handling of Yukon River fall chum salmon. North American Journal of Fisheries Management 27:860–872.

Bugliosi, E. F. 1988. Hydrologic reconnaissance of the Chilkat River basin. U.S. Geological Survey, Water-Resources Investigations Report 88-4023, Anchorage.

Burwen, D. L., S. J. Fleischman, and J. D. Miller. 2007. Evaluation of a dual-frequency imaging sonar for estimating fish size in the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 07-44, Anchorage.

Clutter, R., and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bull. Int. Pac. Salmon Fish. Comm., No. 9.

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

Coyle, C. L., and D. J. Reed. 2012. Assessment of the performance of a DIDSON (Dual Frequency IDentification SONar) to count steelhead in Peterson Creek, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 12-42, Anchorage.

Cronkite, G. M. W., H. Enzenhofer, T. Ridley, J. Holmes, J. Lilja, and K. Benner. 2006. Use of high-frequency imaging sonar to estimate adult sockeye salmon escapement in the Horsefly River, British Columbia. Canadian Technical Report of Fisheries and Aquatic Sciences 2647.

Crossman, J. A., G. Martel, P. N. Johnson, and K. Bray. 2011. The use of Dual-frequency IDentification SONar (DIDSON) to document white sturgeon activity in the Columbia River, Canada. Journal of Applied Ichthyology 27(supplement 2): 53–57.

Darroch, J. N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48:241–260.

REFERENCES CITED (Continued)

Edmundson, J. M., and J. A. Edmundson. 2002. Sockeye salmon production relative to changes in rearing capacity of Crescent Lake, Upper Cook Inlet. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A02-08, Anchorage.

Edmundson, J. A., G. B. Kyle, and M. Willette. 1992. Limnological and fisheries assessment of Coghill Lake relative to sockeye salmon (*Oncorhynchus nerka*) production and lake fertilization. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Report No. 118, Juneau.

Eggers, D. M., J. H. Clark, R. L. Bachman, and S. C. Heinl. 2008. Sockeye salmon stock status and escapement goals in Southeast Alaska. Alaska Department of Fish and Game, Special Publication No. 08-17, Anchorage.

Eggers, D. M., R. L. Bachman, and J. Stahl. 2010. Stock status and escapement goals for Chilkat Lake sockeye salmon in Southeast Alaska. Alaska Department of Fish and Game, Fishery Manuscript No. 10-05, Anchorage.

Geiger, H. J., R. L. Bachman, S. C. Heinl, K. Jensen, T. A. Johnson, A. Piston, and R. Riffe. 2005. Sockeye salmon stock status and escapement goals in Southeast Alaska [*In*] Der Hovanisian, J. A. and H. J. Geiger, editors. Stock status and escapement goals for salmon in Southeast Alaska 2005. Alaska Department of Fish and Game, Special Publication No. 05-22, Anchorage.

Gilk-Baumer, S. E., S. D. Rogers Olive, D. K. Harris, S. C. Heinl, E. K. C. Fox, and W. D. Templin. 2015. Genetic mixed stock analysis of sockeye salmon harvests in selected northern Chatham Strait commercial fisheries, Southeast Alaska, 2012–2014. Alaska Department of Fish and Game, Fishery Data Series No. 15-03, Anchorage.

Holmes, J. A., G. M. W. Cronkite, H. J. Enzenhofer, and T. J. Mulligan. 2006. Accuracy and precision of fish-count data from a "dual-frequency identification sonar" (DIDSON) imaging system. ICES Journal of Marine Science 63:543–555.

Ingledue, D. 1989. Hawk Inlet shoreline purse seine fishery, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J89-31, Juneau.

INPFC (International North Pacific Fisheries Commission). 1963. Annual report 1961. Vancouver, British Columbia.

Johnson, J., and M. Daigneault. 2013. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southeastern Region, Effective July 1, 2013. Alaska Department of Fish and Game, Special Publication No. 13-09, Anchorage.

Kelley, M. S. 1998. Fishery management plan for the Lynn Canal (District 15) drift gillnet fishery, 1998. Alaska Department of Fish and Game, Regional Information Report 1J88-22, Juneau.

Kelley, M. S., and R. L. Bachman. 2000. Stock assessment studies of the Chilkat River adult salmon stocks in 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J00-29, Juneau.

Kirk, J. T. O. 1994. Light and Photosynthesis in Aquatic Ecosystems. Cambridge University Press, England.

Koenings, J. P. 1983. Southeast lake fertilization project progress report: limnology investigations at Bakewell Lake (1981–1982) and at Badger Lake (1982). Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Report No. 5, Juneau.

Koenings, J. P., and G. B. Kyle. 1997. Consequences to juvenile sockeye salmon and the zooplankton community resulting from intence predation. Alaska Fishery Research Bulletin 4:120−135.

Koenings, J. P., G. B. Kyle, J. A. Edmundson, and J. E. Edmundson. 1987. Limnology field and laboratory manual: methods for assessing aquatic production. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Report No. 71, Juneau.

Koenings, J. P., R. D. Burkett, M. Haddix, G. B. Kyle, and D. L. Barto. 1989. Experimental manipulation of lakes for sockeye salmon (*Oncorhynchus nerka*) rehabilitation and enhancement. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Report No. 96, Juneau.

REFERENCES CITED (Continued)

Koo, T. S. Y. 1962. Age designation in salmon [*In*] Studies of Alaska red salmon. University of Washington Press, Seattle.

Kyle, G. B., J. P. Koenings, and B. M. Barrett. 1988. Density-dependent, trophis level responses to an introduced run of sockeye salmon (*Oncorhynchus nerka*) at Frazer Lake, Kodiak Island, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 45:856–867.

Kyle, G. B., L. E. White, and J. P. Koenings. 1990. Limnological and fisheries assessment of the potential production of sockeye salmon (*Oncorhynchus nerka*) in Spiridon Lake. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development, Report No. 108, Juneau.

Marshall, S. L., S. A. McPherson, and S. Sharr. 1982. Origins of sockeye salmon (*Oncorhynchus nerka*) in the Lynn Canal drift gillnet fishery of 1981 based on scale pattern analysis. Alaska Department of Fish and Game, Technical Data Report No. 75, Juneau.

Martignac, F., A. Daroux, J. L. Bagliniere, D. Ombredane, and J. Guillard. 2015. The use of acoustic cameras in shallow waters: new hydroacoustic tools for monitoring migratory fish population. A review of DIDSON technology. Fish and Fisheries 16:486–510.

Maxwell, S. L., and N. E. Gove. 2007. Assessing a dual-frequency identification sonars' fish-counting accuracy, precision, and turbid river range capability. Journal of the Acoustical Society of America 122:3364–3377.

McPherson, S. A. 1987a. Contribution, exploitation, and migratory timing of Chilkat and Chilkoot river runs of sockeye salmon (*Oncorhynchus nerka*) in the Lynn Canal drift gillnet fishery of 1984. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 198, Juneau.

McPherson, S. A. 1987b. Contribution, exploitation, and migratory timing of returns of sockeye salmon (*Oncorhynchus nerka*) stocks to Lynn Canal in 1985 based on analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 217, Juneau.

McPherson, S. A. 1989. Contribution, exploitation, and migratory timing of Lynn Canal sockeye salmon runs in 1987 based on analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J89-18, Juneau.

McPherson, S. A. 1990. An in-season management system for sockeye salmon returns to Lynn Canal, southeast Alaska. M. S. Thesis, University of Alaska, Fairbanks.

McPherson, S. A., and E. L. Jones. 1987. Contribution, exploitation, and migratory timing of sockeye salmon stocks to Lynn Canal in 1986 based on analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 220, Juneau.

McPherson, S. A., and S. L. Marshall. 1986. Contribution, exploitation, and migratory timing of Chilkat and Chilkoot river runs of sockeye salmon (*Oncorhynchus nerka*) in the Lynn Canal drift gillnet fishery of 1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 165, Juneau.

McPherson, S. A., and M. A. Olsen. 1992. Contribution, exploitation, and migratory timing of Lynn Canal sockeye salmon runs in 1989 based on analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report No. 92-22, Juneau.

McPherson, S. A., F. E. Bergander, M. A. Olsen, and R. R. Riffe. 1992. Contribution, exploitation, and migratory timing of Lynn Canal sockeye salmon runs in 1988 based on analysis of scale patterns. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report No. 92-21, Juneau.

Pennak, R. W. 1978. Fresh-Water Invertebrates of the United States. Second edition. John Wiley & Sons, Inc., New York.

Petreman, I. C, and N. E. Jones, S. W. Milne. 2014. Observer bias and subsampling efficiencies for estimating the number of migrating fish in rivers using Dual-frequency Identification SONar (DIDSON). Fisheries Research 155:160–167.

REFERENCES CITED (Continued)

Pipal, K. A., J. J. Notch, S. A. Hayes, and P. B. Adams. 2012 Estimating escapement for a low-abundance steelhead population using dual-frequency identification sonar (DIDSON). North American Journal of Fisheries Management 32:880–893.

Rich, W. H., and E. M. Ball. 1933. Statistical review of the Alaska salmon fisheries. Part IV: Southeastern Alaska. Bulletin of the Bureau of Fisheries, Vol. XLVII (47), No. 13: 437–673.

Richards, P., J. Williams, S. J. H. Power, I. Boyce, and B. Huebschwerlen. 2016. Migration, tagging response, and distribution of Chinook salmon returning to the Taku River, 2016. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan ROP.SF.1J.2016.04, Anchorage.

Schindler, D. W. 1971. Light, temperature, and oxygen regimes of selected lakes in the experimental lakes area, northwestern Ontario. Journal of the Fisheries Research Board of Canada 28:157–169.

Schwarz, C. J., and C. G. Taylor. 1998. Use of the stratified-Petersen estimator in fisheries management: estimating the number of pink salmon (*Oncorhynchus gorbuscha*) spawners in the Fraser River. Canadian Journal Fisheries and Aquatic Sciences 55: 281–296.

Seber, G. A. F. 1982. The Estimation of Animal Abundance, 2nd ed. Griffen, London.

Simpson, K. 1984. The accuracy of mark–recapture estimates of escapements. Pages 209-225 [*In*] P. E. K. Symons and M. Waldichuk, editors. Proceedings of the workshop on stream indexing for salmon escapement estimation, West Vancouver, B.C., 2-3 February 1984. Canadian Technical Report of Fisheries and Aquatic Sciences No. 1326.

Shedd, K. R., T. H. Dann, M. B. Foster, and C. Habicht. 2016. Addendum to FMS 16-03: Redefinition of reporting groups by combining Ayakulik and Frazer into one group for the genetic baseline of North American sockeye salmon for mixed stock analyses of Kodiak Management Area commercial fisheries, 2014–2016. Alaska Department of Fish and Game, Fishery Manuscript Series No. 16-05, Anchorage.

Sogge, M. M. 2016. Operational Plan: stock assessment studies of Chilkoot Lake adult salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Operational Plan ROP CF.1J.16.01, Douglas.

Sogge, M. M., and R. L. Bachman. 2014. Operational Plan: Stock assessment studies of Chilkat River adult salmon. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF.1J.14-03, Douglas.

Stockley, C. 1950. The sockeye salmon of Chilkat and Chilkoot inlets. Fisheries Research Institute Paper No 286, University of Washington, Seattle.

Thompson, S. K. 1987. Sample size for estimating multinomial proportions. The American Statistician 41:62–46.

Underwood, T. J., J. F. Bromaghin, and S. P. Klosiewski. 2004. Evidence of handling mortality of adult chum salmon caused by fish wheel capture in the Yukon River, Alaska. North American Journal of Fisheries Management 24:237–243.

Willette, T. M., T. McKinley, R. D. DeCino, and X. Zhang. 2012. Inriver abundance and spawner distribution of Kenai River sockeye salmon, Oncorhynchus nerka, 2006–2008: a comparison of sonar and mark–recapture estimates. Alaska Department of Fish and Game, Fishery Data Series No. 12-57, Anchorage.

Westerman, D. L., and T. M. Willette. 2007. Upper Cook Inlet salmon studies, 2006. Alaska Department of Fish and Game, Fishery Data Series No.07-82, Anchorage.

Westerman, D. L., and T. M. Willette. 2012. Upper Cook Inlet salmon escapement studies, 2011. Alaska Department of Fish and Game, Fishery Data Series No. 12-83, Anchorage.

TABLES AND FIGURES

Table 1.–Fish wheel dates of operation, total counts of sockeye salmon, and counts of Chilkat Lake and Chilkat River mainstem sockeye salmon based on scale pattern analysis, 1999−2016.

				Sockeye Salmon		
Year	Statistical Weeks	Start date	End date	Total Count	Chilkat Lake	Mainstem
1999	24–41	7-Jun	8-Oct	7,735	7,012	723
2000	24–41	9-Jun	7-Oct	3,699	2,630	1,069
2001	23–41	6-Jun	7-Oct	4,417	3,318	1,099
2002	23–42	7-Jun	19-Oct	4,217	3,231	986
2003	23–43	6-Jun	21-Oct	4,551	3,502	1,049
2004	24–43	7-Jun	19-Oct	4,366	3,154	1,212
2005	24–42	6-Jun	11-Oct	3,692	2,341	1,351
2006	23–41	7-Jun	14-Oct	3,169	2,414	755
2007	24–41	11-Jun	9-Oct	2,751	2,177	574
2008	24–41	9-Jun	10-Oct	6,412	4,601	1,811
2009	24–41	11-Jun	9-Oct	9,052	7,950	1,102
2010	24–42	7-Jun	11-Oct	3,504	2,175	1,329
2011	24–41	7-Jun	7-Oct	4,940	3,504	1,436
2012	24–41	11-Jun	7-Oct	4,096	2,722	1,374
2013	23–40	5-Jun	3-Oct	5,961	5,178	783
2014	23–41	5-Jun	8-Oct	6,165	4,956	1,209
2015	24-41	8-Jun	6-Oct	9,971	5,776	4,195
2016	24–41	7-Jun	8-Oct	4,651	2,403	2,248

Table 2.–Marking schedule for sockeye salmon captured at the Chilkat River fish wheels, 2002−2016.

Dates (varies annually)	Statistical Weeks	Primary Mark	Secondary Mark
Start–15 June	Start–24	Adipose fin clip	None
16 June–29 June	25–26	Adipose fin clip	Right axillary appendage clip
30 June–13 July	27–28	Adipose fin clip	Left axillary appendage clip
14 July14–27 July	29–30	Adipose fin clip	Right ventral fin clip
28 July–10 August	31–32	Adipose fin clip	Left ventral fin clip
11 August–24 August	33–34	Adipose fin clip	Right pectoral fin clip
25 August–7 September	35–36	Adipose fin clip	Left pectoral fin clip
8 September–21 September	37–38	Adipose fin clip	Clip last 4 rays of dorsal fin
22 September–5 October[a]	39–40	Adipose fin clip	Right operculum punch
6 October–End[b]	41–End	Adipose fin clip	Left operculum punch

[a] From 2015 to 2016 the mark applied in statistical weeks 39−40 was a right axillary appendage clip.

[b] From 2015 to 2016 the mark applied in statistical weeks 41+ was a left axillary appendage clip.

Table 3.–Chilkat Lake weir and DIDSON dates of operation, sockeye salmon counts, and counts expanded to account for late installation and early removal of the project, 1971–2016. (The weir was not operated from 1996 through 1998.)

			Weir Sockeye Salmon		DIDSON Sockeye Salmon	
Year	Start Date	End Date	Count	Expanded Count	Count	Expanded Count
1971	31-May	28-Oct	49,342	49,342	---	---
1972	3-Jun	12-Oct	51,860	53,082	---	---
1973	11-Jun	15-Oct	50,527	50,527	---	---
1974	31-May	30-Sep	84,456	94,900	---	---
1975	4-Jun	6-Nov	41,520	41,520	---	---
1976	3-Jun	20-Oct	69,729	69,729	---	---
1977	3-Jun	27-Sep	41,044	50,363	---	---
1978	5-Jun	5-Nov	67,528	67,528	---	---
1979	9-Jun	11-Nov	80,588	80,588	---	---
1980	15-Jun	8-Oct	95,347	101,135	---	---
1981	11-Jun	22-Oct	84,097	84,097	---	---
1982	24-Jun	7-Oct	80,221	86,213	---	---
1983	22-Jun	12-Nov	134,022	134,601	---	---
1984	9-Jun	7-Oct	115,269	123,190	---	---
1985	23-Jun	23-Oct	57,649	58,335	---	---
1986	16-Jun	14-Nov	23,947	23,947	---	---
1987	19-Jun	20-Nov	48,861	48,972	---	---
1988	18-Jun	14-Nov	27,662	27,722	---	---
1989	5-Jun	28-Oct	141,475	141,475	---	---
1990	6-Jun	13-Nov	60,230	60,230	---	---
1991	9-Jun	25-Oct	51,138	51,138	---	---
1992	8-Jun	15-Oct	95,880	95,880	---	---
1993	13-Jun	15-Oct	212,757	212,757	---	---
1994	31-May	6-Oct	80,859	86,385	---	---
1995	6-Jun	9-Oct	59,698	61,783	---	---
1996–1998	---	---	---	---	---	---
1999	30-Jun	27-Oct	129,533	134,048	---	---
2000	16-Jun	16-Oct	47,077	47,077	---	---
2001	19-Jun	13-Oct	51,979	53,239	---	---
2002	22-Jun	17-Oct	65,085	65,611	---	---
2003	27-Jun	10-Oct	52,417	55,516	---	---
2004	6-Jul	13-Oct	75,632	83,534	---	---
2005	28-Jun	12-Oct	30,145	32,098	---	---
2006	27-Jun	10-Oct	37,108	38,850	---	---
2007	13-Jul	17-Oct	21,236	27,915	---	---
2008	27-Jun	19-Oct	---	---	71,735	74,919
2009	15-Jun	12-Oct	---	---	153,033	153,033
2010	18-Jun	20-Oct	---	---	61,906	61,906
2011	8-Jun	16-Oct	---	---	63,628	63,628
2012	18-Jun	1-Oct	---	---	107,723	121,810
2013	19-Jun	6-Oct	---	---	110,979	116,300
2014	17-Jun	16-Oct	---	---	70,470	70,470
2015	26-Jun	29-Sep	---	---	135,110	175,874
2016	24-Jun	11-Oct	---	---	85,935	88,513
Average	15-Jun	18-Oct	71,056	73,333	95,613	102,939

Note: There is much greater confidence in the DIDSON escapement counts of Chilkat Lake sockeye salmon than in the visual weir counts or mark–recapture estimates; however, DIDSON counts should still be considered minimum estimates of escapement due to operational rather than technological limitations (see the escapement estimates section of the Results and Discussions).

Table 4.–Expanded Chilkat Lake weir (1994–2007) and DIDSON (2008–2016) sockeye salmon counts compared to mark–recapture estimates of Chilkat Lake sockeye salmon, and comparison of different mark–recapture estimates of Chilkat River mainstem sockeye salmon. Mark–recapture values for 1994–1998 are from Bachman (2010). Mark–recapture data for 1999–2016 were edited and recalculated in 2016; values reported here are different from values reported in Eggers et al. (2010).

	Chilkat Lake Sockeye Salmon			Chilkat River Mainstem Sockeye Salmon		
Year	Expanded Weir or DIDSON counts	Mark–Recapture Estimate (Method A)	Ratio[a]	Mark–Recapture Estimate (Method A)	Mark–Recapture Estimate (Method B)	Percent Difference
1994	86,385	153,540	1.8	26,186	---	---
1995	61,783	184,541	3.0	26,080	---	---
1996	---	262,852	---	53,369	---	---
1997	---	238,803	---	14,638	---	---
1998	---	211,114	---	24,959	---	---
1999	134,048	240,002	1.8	25,186	13,557	86%
2000	47,077	132,687	2.8	54,633	29,142	87%
2001	53,239	105,064	2.0	35,740	21,925	63%
2002	65,611	148,465	2.3	45,094	19,388	133%
2003	55,516	116,891	2.1	37,216	20,204	84%
2004	83,534	118,795	1.4	45,556	36,158	26%
2005	32,098	89,072	2.8	51,639	36,473	42%
2006	38,850	91,439	2.4	30,457	22,779	34%
2007	27,915	59,884	2.1	16,079	21,491	-25%
2008	74,919	119,808	1.6	48,444	41,269	17%
2009	153,033	285,218	1.9	39,645	26,935	47%
2010	61,906	72,318	1.2	44,482	34,876	28%
2011	63,628	109,335	1.7	45,696	36,170	26%
2012	121,810	171,924	1.4	89,039	48,457	84%
2013	116,300	224,516	1.9	34,642	18,974	83%
2014	70,470	212,201	3.0	51,899	41,381	25%
2015	175,874	124,892	0.7	95,947	57,382	67%
2016	88,513	96,148	1.1	90,519	60,937	49%

[a] The ratio is the Chilkat Lake mark–recapture estimate divided by the expanded weir or DIDSON count.

Table 5.–Estimated commercial harvest of Chilkoot Lake, Chilkat Lake, and other sockeye salmon stocks in the District 15 commercial drift gillnet fishery based on scale pattern analysis, 1984–2016. Chilkat River mainstem fish are included in other stocks.

	Harvest [a]			Percentile Rank			Percent of Harvest		
Year	Chilkoot Lake	Chilkat Lake	Other	Chilkoot Lake	Chilkat Lake	Other	Chilkoot Lake	Chilkat Lake	Other
1976	61,861	58,765	4,796	0.50	0.38	0.13	49%	47%	4%
1977	113,555	41,477	5,389	0.65	0.20	0.15	71%	26%	3%
1978	14,264	89,558	4,658	0.10	0.65	0.10	13%	83%	4%
1979	69,864	115,995	7,117	0.58	0.80	0.18	36%	60%	4%
1980	21,244	31,267	1,588	0.20	0.13	0.03	39%	58%	3%
1981	43,756	48,420	1,070	0.43	0.28	0.00	47%	52%	1%
1982	144,748	127,174	1,911	0.80	0.88	0.05	53%	46%	1%
1983	242,034	124,180	3,965	0.93	0.83	0.08	65%	34%	1%
1984	225,634	99,592	9,502	0.88	0.68	0.20	67%	30%	3%
1985	153,533	131,091	18,704	0.83	0.90	0.53	51%	43%	6%
1986	110,114	168,006	12,174	0.60	1.00	0.33	38%	58%	4%
1987	327,323	69,900	18,658	1.00	0.48	0.50	79%	17%	4%
1988	248,640	76,883	26,353	0.95	0.55	0.80	71%	22%	7%
1989	292,830	156,160	25,908	0.98	0.98	0.78	62%	33%	5%
1990	181,260	149,377	31,499	0.85	0.93	0.85	50%	41%	9%
1991	228,607	60,721	24,353	0.90	0.43	0.73	73%	19%	8%
1992	142,471	113,146	33,729	0.78	0.78	0.93	49%	39%	12%
1993	52,080	103,531	19,605	0.45	0.73	0.60	30%	59%	11%
1994	25,367	126,852	19,578	0.28	0.85	0.58	15%	74%	11%
1995	9,637	68,737	10,302	0.08	0.45	0.25	11%	78%	12%
1996	19,882	99,677	30,019	0.18	0.70	0.83	13%	67%	20%
1997	31,822	73,761	13,245	0.35	0.50	0.38	27%	62%	11%
1998	2,838	112,630	19,469	0.00	0.75	0.55	2%	83%	14%
1999	4,604	149,410	9,547	0.03	0.95	0.23	3%	91%	6%
2000	14,622	78,265	16,673	0.13	0.58	0.43	13%	71%	15%
2001	66,355	60,183	21,273	0.53	0.40	0.65	45%	41%	14%
2002	24,200	47,332	10,482	0.25	0.23	0.30	30%	58%	13%
2003	32,446	49,955	12,729	0.40	0.30	0.35	34%	53%	13%
2004	66,498	51,110	33,637	0.55	0.33	0.90	44%	34%	22%
2005	29,276	22,852	13,341	0.33	0.10	0.40	45%	35%	20%
2006	119,201	15,979	10,400	0.68	0.05	0.28	82%	11%	7%
2007	125,199	14,208	17,529	0.75	0.00	0.48	80%	9%	11%
2008	7,491	22,156	17,008	0.05	0.08	0.45	16%	47%	36%
2009	16,622	85,551	24,422	0.15	0.63	0.75	13%	68%	19%
2010	32,064	48,079	20,830	0.38	0.25	0.63	32%	48%	21%
2011	26,766	15,599	21,428	0.30	0.03	0.68	42%	24%	34%
2012	124,366	54,884	45,393	0.73	0.35	1.00	55%	24%	20%

-continued-

Table 5.–Page 2 of 2.

Year	Harvest			Percentile Rank			Percent of Harvest		
	Chilkoot Lake	Chilkat Lake	Other	Chilkoot Lake	Chilkat Lake	Other	Chilkoot Lake	Chilkat Lake	Other
2013	23,111	75,588	23,404	0.23	0.53	0.70	19%	62%	19%
2014	110,487	81,502	42,693	0.63	0.60	0.98	47%	35%	18%
2015	58,568	33,085	39,924	0.48	0.15	0.95	45%	25%	30%
2016	119,843	35,991	33,010	0.70	0.18	0.88	63%	19%	17%
Average (1984–2016)	91,831	77,771	18,471	0.50	0.50	0.50	42%	46%	12%
Median (1984–2016)	61,861	73,761	18,658	0.50	0.50	0.50	45%	46%	11%
Lower Quartile (1984–2016)	24,200	48,079	10,302	0.25	0.25	0.25	27%	30%	4%
Upper Quartile (1984–2016)	125,199	112,630	24,422	0.75	0.75	0.75	55%	60%	18%

[a.] 1976–1983 harvest estimates are based on stock compositions from McPherson (1990) applied to updated harvest data.

Note: Percentile rank returns the rank of a value in a data set as a percentage of the data set, which can be used to evaluate the relative standing of a value within a data set.

Table 6.–Monthly and seasonal mean (May–August) euphotic zone depth (EZD) and monthly and seasonal mean (May–September) water temperature of Chilkat Lake. (Average of data from stations 1A and 2A.)

	EZD (m)[a]					Water Temperature (ºC) at 1.0 m Depth					
Year	May	June	July	Aug	Mean	May	June	July	Aug	Sept	Mean
1987	18.3	15.3	14.9	20.2	17.2	7.3	9.6	14.5	15.7	11.6	11.7
1988	17.3	11.7	16.6	16.8	15.6	9.1	13.3	14.3	14.2	12.5	12.7
1989	17.4	16.7	12.9	18.9	16.4	6.7	11.8	17.0	17.3	13.9	13.3
1990	18.7	13.6	16.5	19.1	16.9	7.8	13.0	14.9	15.5	14.8	13.2
1991	17.7	13.0	14.4	16.0	15.3	5.0	10.6	14.3	15.3	12.2	11.5
---	---	---	---	---	---	---	---	---	---	---	---
1995	16.5	11.5	16.8	14.3	14.8	8.5	13.3	16.0	16.0	13.7	13.5
1996	16.2	ND	ND	ND	---	6.5	ND	ND	ND	ND	6.5
---	---	---	---	---	---	---	---	---	---	---	---
1999	17.0	10.0	17.8	21.1	16.5	8.3	14.3	14.7	16.2	12.7	13.2
2000	17.4	15.7	19.9	23.2	19.1	9.4	12.1	14.3	14.8	12.0	12.5
2001	12.3	28.4	23.5	16.5	20.2	7.2	14.0	14.5	17.2	12.7	13.1
2002	20.7	ND	18.5	18.0	19.1	5.5	13.4	13.6	15.5	12.3	12.1
2003	16.5	19.5	20.5	23.7	20.1	9.6	12.8	17.3	16.4	13.4	13.9
2004	19.1	21.9	ND	19.7	20.2	ND	ND	ND	ND	17.0	17.0
2005	14.4	23.0	ND	23.6	20.3	11.3	14.3	16.2	17.3	ND	14.8
2006	14.9	ND	ND	18.3	---	9.5	ND	ND	ND	ND	9.5
2007	13.2	28.3	16.2	25.0	20.7	7.0	12.7	16.2	15.6	13.1	12.9
2008	14.5	ND	21.5	18.1	18.0	7.5	ND	13.0	14.8	11.6	11.7
2009	15.7	20.8	9.1	ND	15.2	7.5	ND	ND	ND	ND	7.5
2010	14.6	13.4	22.4	14.8	16.3	10.8	12.4	15.0	15.2	14.6	13.6
2011	21.3	18.0	35.8	28.8	26.0	8.5	13.1	14.8	13.9	11.6	12.4
2012	17.1	ND	28.1	25.5	23.6	5.8	ND	11.6	16.2	12.6	11.6
2013	21.1	13.9	28.9	17.3	20.3	7.9	16.8	19.9	15.8	ND	15.1
2014	ND	19.9	17.0	21.6	19.5	ND	8.2	14.0	15.3	ND	12.5
2015	23.0	28.0	19.8	16.0	21.7	16.2	16.1	16.1	15.1	ND	15.9
2016	ND	15.6	17.5	16.5	16.5	ND	12.2	15.8	16.5	15.8	15.1
Average	17.2	17.9	19.5	19.7	18.7	8.3	12.8	15.1	15.7	13.2	12.7

[a]. Data from 1987 to 1991 are from Barto (1996).

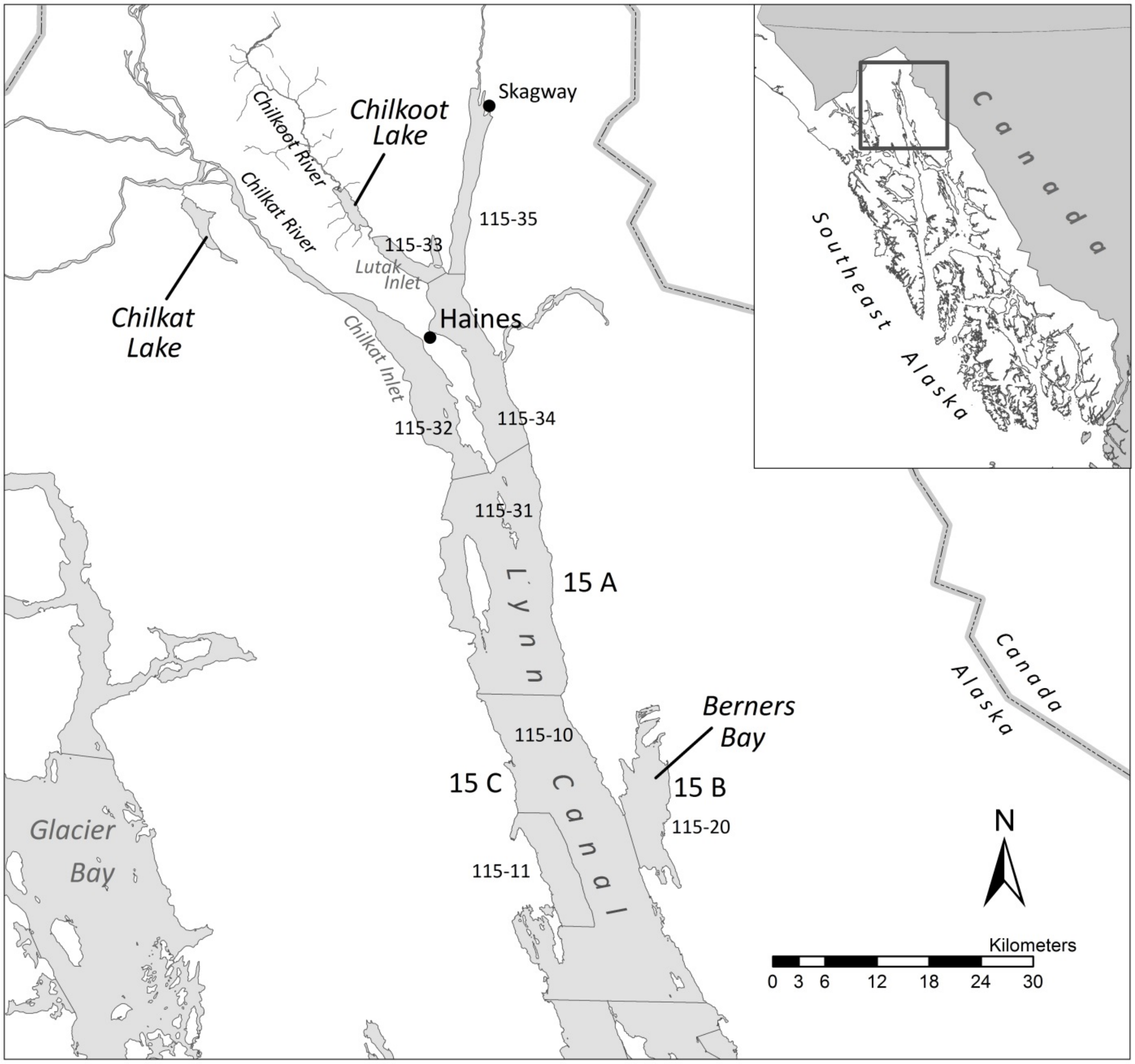

Figure 1.–Commercial fishing subdistrict and management boundary lines within District 15 in the Haines area, Southeast Alaska.

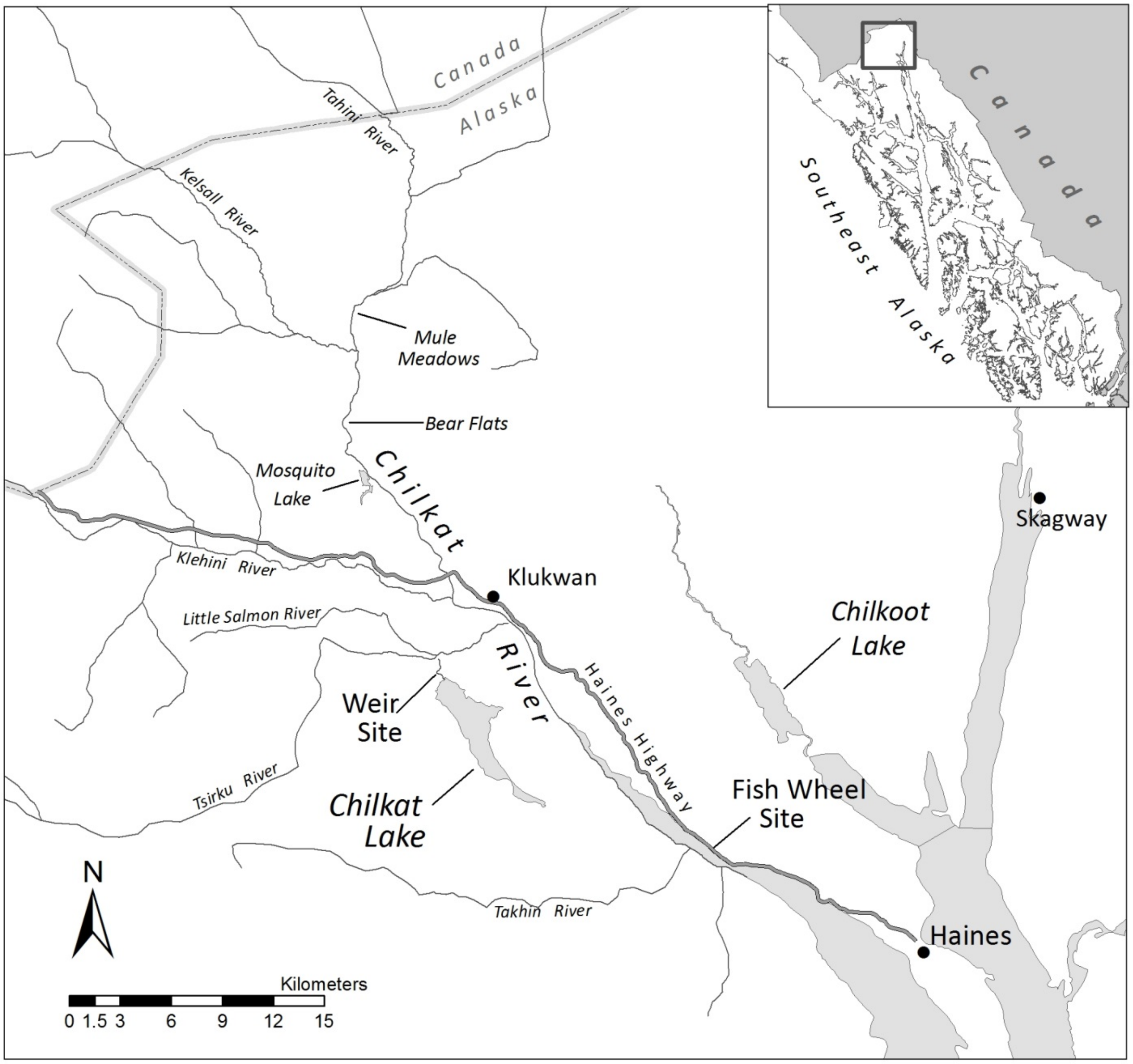

Figure 2.–Chilkat drainage with fish wheel locations, Chilkat River mainstem sockeye salmon recovery sites, and Chilkat Lake weir location.

Figure 3.–Chilkat Lake weir. The boat gate is closed in the center of the weir, and the DIDSON transducer is attached to the aluminum pod visible in the lower center of the photo (©2013 ADF&G/Photo by Steven C. Heinl).

Figure 4.–Chilkat Lake weir during flow reversal, August 2014. Silty Tsirku River water is flowing from left to right into Chilkat Lake. The boat gate in the center of the weir is open to prevent damage (©2014 ADF&G/Photo by Timothy Brush).

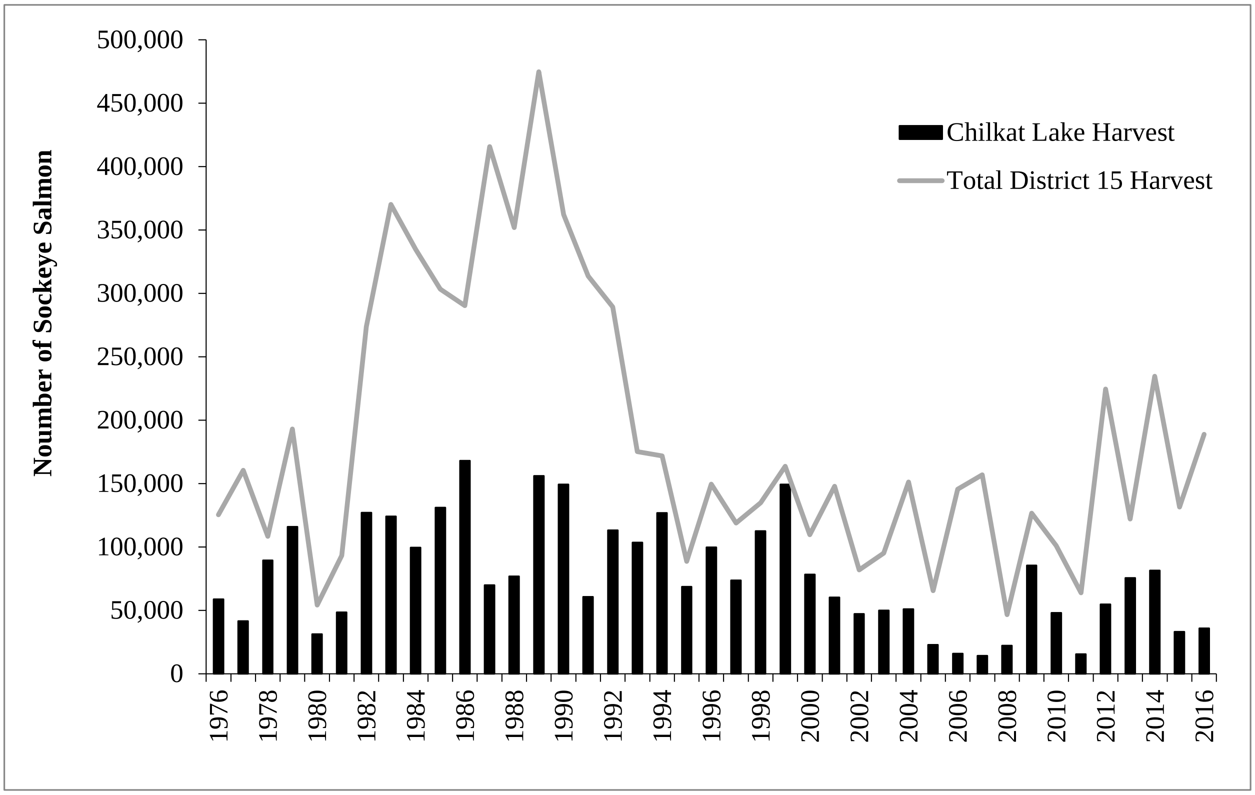

Figure 5.–Total sockeye salmon harvest and estimated number of Chilkat Lake sockeye salmon harvested in the District 15 commercial drift gillnet fishery, 1976–2016.

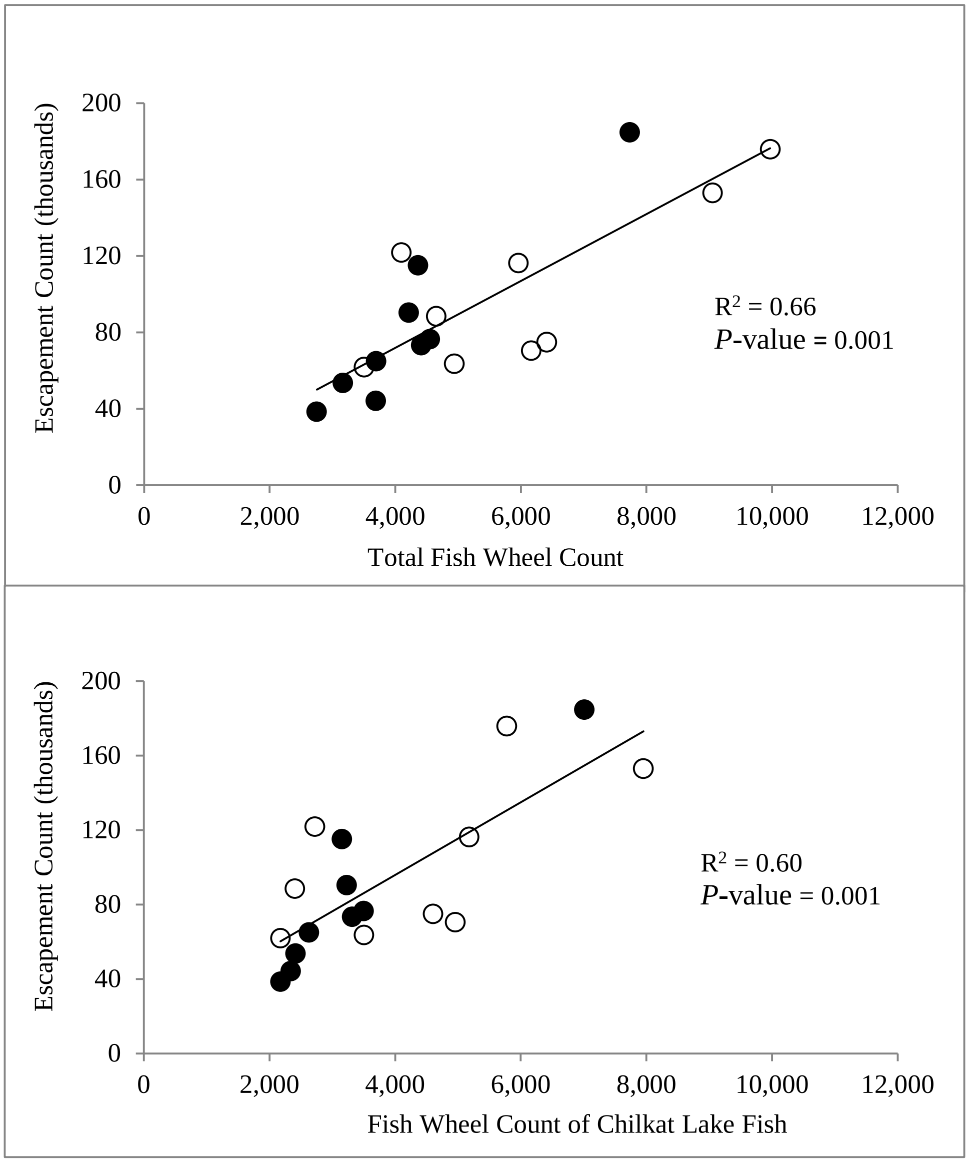

Figure 6.–Total fish wheel count of sockeye salmon (top) and fish wheel count of Chilkat Lake sockeye salmon (bottom) compared to estimated Chilkat Lake sockeye salmon escapement (1999–2016). Weir counts were scaled to DIDSON counts. Open circles are years when the DIDSON was operated and black circles are years when visual counts were conducted.

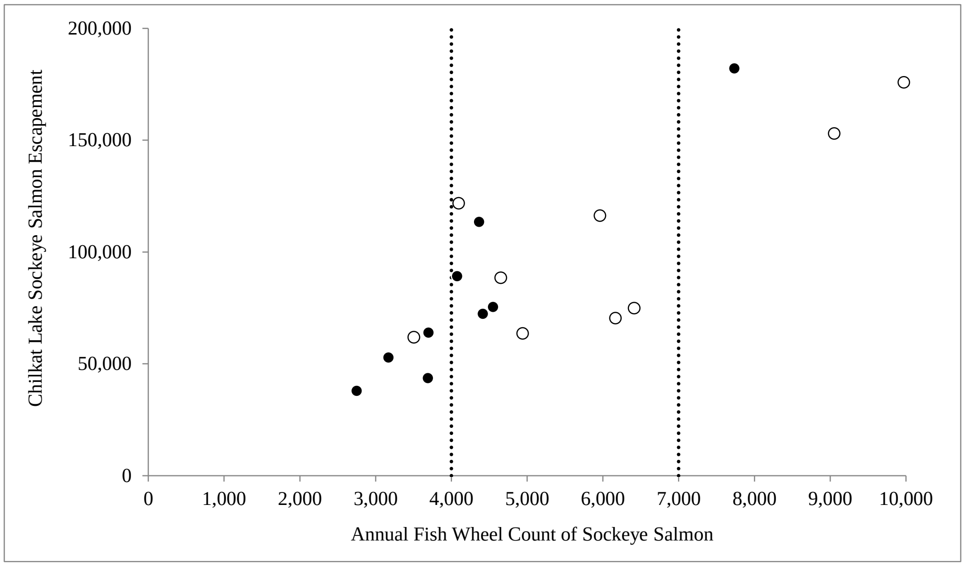

Figure 7.–Total fish wheel count of sockeye salmon compared to estimated Chilkat Lake sockeye salmon escapement (1999–2016). Weir counts were scaled to DIDSON counts. Open circles are years when the DIDSON was operated and black circles are years when visual counts were conducted.

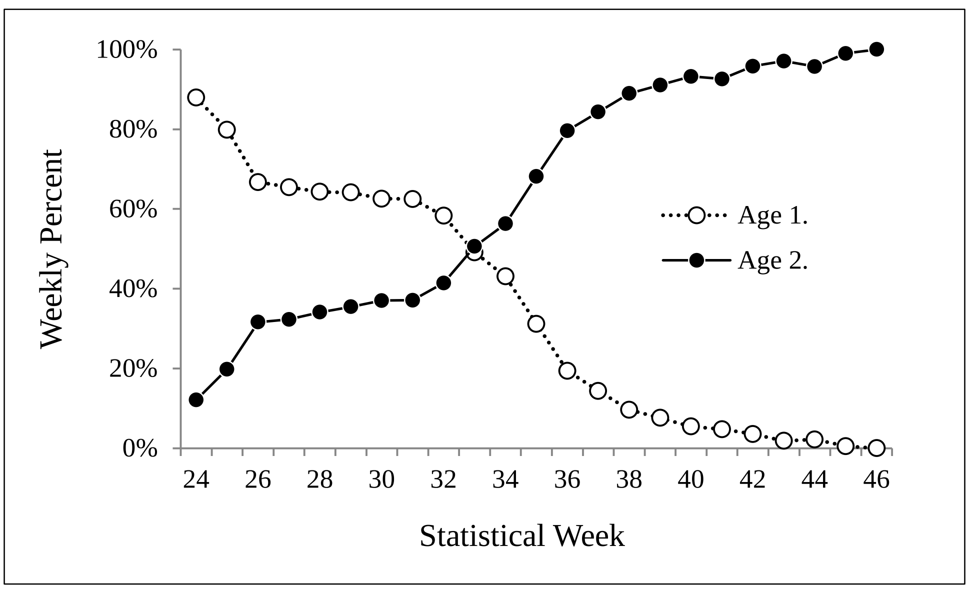

Figure 8.–Average temporal distribution (weekly percent) of age-1. and age-2. Chilkat Lake sockeye salmon in the escapement, 1983–2016.

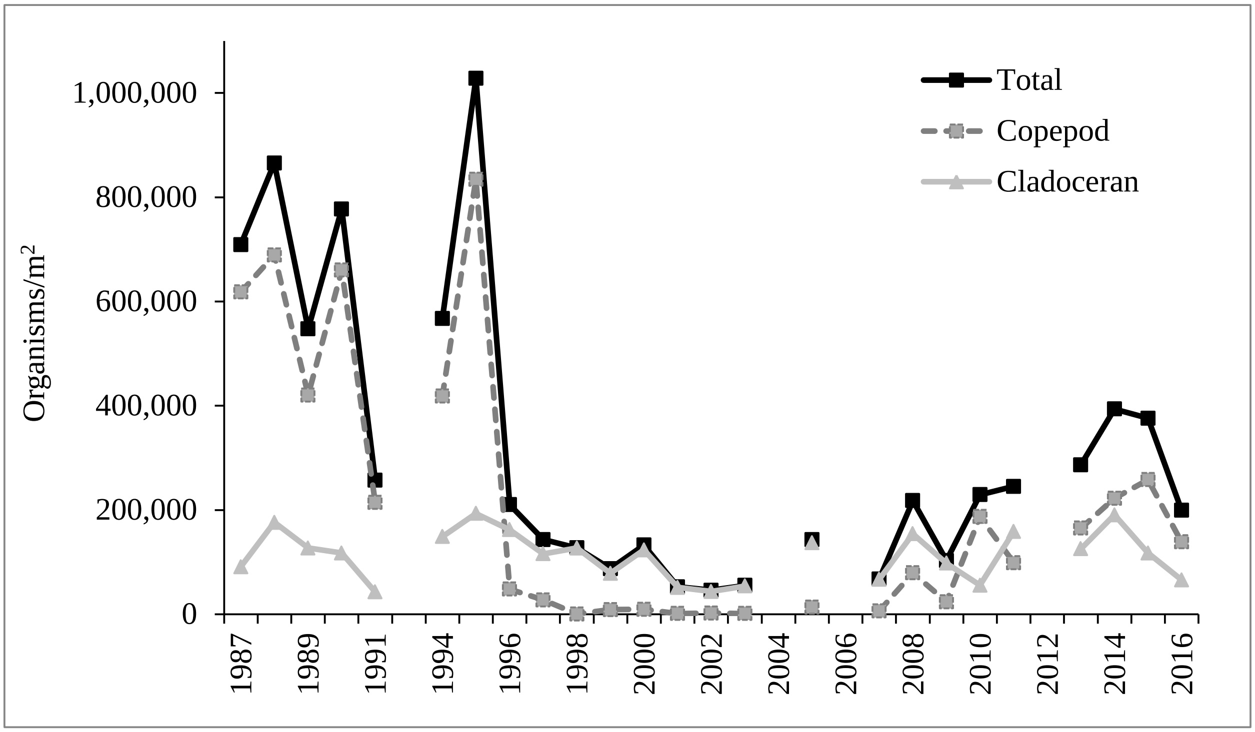

Figure 9.–Annual seasonal (May−October) mean total zooplankton abundance and abundance of copepods and cladocerans at Chilkat Lake, 1987–2016. Copepod nauplii and immature cladocerans were not included here, because they were not enumerated in lab samples until 2002 and 2004. If more than one month of sampling was missed (May−October) it was not included here (e.g., 2004, 2006, and 2012).

APPENDICES

Appendix A.–Reported subsistence harvest of Chilkat drainage sockeye salmon, 1985–2016.

Year	Chilkat Inlet	Chilkat River	Total
1985	251	1,457	1,708
1986	311	1,384	1,695
1987	942	1,239	2,181
1988	874	1,773	2,647
1989	1,328	1,837	3,165
1990	935	3,059	3,994
1991	627	3,396	4,023
1992	1,171	2,761	3,932
1993	1,385	2,517	3,902
1994	2,094	1,935	4,029
1995	2,387	2,750	5,137
1996	2,614	2,738	5,352
1997	1,490	2,578	4,068
1998	1,920	3,146	5,066
1999	2,626	2,645	5,271
2000	2,759	1,867	4,626
2001	2,796	1,636	4,432
2002	1,855	2,626	4,481
2003	1,407	3,172	4,579
2004	2,430	2,100	4,530
2005	1,576	1,807	3,383
2006	1,629	1,898	3,527
2007	1,084	1,240	2,324
2008	2,509	3,146	5,655
2009	3,064	3,585	6,649
2010	2,495	3,535	6,030
2011	2,136	3,056	5,192
2012	2,100	3,028	5,128
2013	3,321	3,003	6,324
2014	3,688	2,865	6,553
2015	1,595	1,836	3,431
2016	2,391	2,483	4,874
Average	1,868	2,441	4,309

Appendix B.–Three potential methods to estimate the Chilkat Lake, Chilkat River mainstem, and overall drainagewide sockeye salmon escapements based on mark–recapture.

For comparative purposes, three potential methods to estimate Chilkat Lake, Chilkat River mainstem, and overall drainagewide (lake and mainstem combined) sockeye salmon escapements were considered. These estimates were based on the idea that 1) fish captured, marked, and released at the fish wheels could be identified as either Chilkat Lake stock or Chilkat River mainstem stock based on scale pattern analysis; 2) marked fish could then be treated separately to produce direct estimates of Chilkat Lake or Chilkat River mainstem populations; or 3) mark and recovery data could be combined to produce a single drainagewide estimate. All estimates were generated from a Chapman modified pooled-Petersen estimate or the stratified maximum likelihood Darroch estimator (Darroch 1961; Seber 1982) using the software program Stratified Population Analysis System (SPAS) (Arnason et al. 1996) as described in detail earlier in this report. Mark–recapture data for 1999–2016 were edited and recalculated in 2016; thus, values presented here are different from values reported in Eggers et al. (2010).

The first method of generating estimates (Method A) was the direct drainagewide mark–recapture estimate (all release and recovery data combined), which was then divided into Chilkat Lake and Chilkat River mainstem estimates based on the annual ratio of the two stocks at the fish wheels (weighted by week). Therefore, in this estimate, the Chilkat Lake and Chilkat River mainstem estimates sum to the drainagewide estimate. Method A was the mark–recapture method used from 1994 to 2007 (Kelley and Bachman 2000; Bachman and MacGregor 2001; Bachman 2005, 2010).

The second method (Method B) provided separate, direct mark–recapture estimates for each of the Chilkat Lake, Chilkat River mainstem, and drainagewide sockeye salmon escapements. Fish marked and released at the fish wheels were identified as either Chilkat Lake or Chilkat River mainstem stock and separate release and recovery matrices were developed for each. Method B was the method used to generate direct estimates of Chilkat River mainstem spawners from 2008 to 2016 (Sogge and Bachman 2014). We also generated Chilkat Lake estimates using the same approach. Note that the drainagewide estimate is the same as for Method A (all data combined into one estimate), but the Chilkat Lake and Chilkat River mainstem estimates that are generated using this method do not sum to the drainagewide estimate.

The third method (Method C) was based on expanding the direct Chilkat River mainstem mark–recapture estimates from Method B to generate estimates of Chilkat Lake escapements. This method was never used, but it was explored at one time as a way to potentially cut costs by eliminating the weir/DIDSON project at the lake. Chilkat Lake escapements were generated in two steps: first, the direct Chilkat River mainstem mark–recapture estimate (from Method B) was expanded into a drainagewide estimate by dividing it by the annual proportion of mainstem fish in the Chilkat River fish wheel catch (weighted by week); the Chilkat Lake escapement was then estimated by subtracting the Chilkat River mainstem estimate from the expanded drainagewide estimate. In this method, the Chilkat Lake and Chilkat River mainstem estimates sum to the drainagewide estimate.

Appendix B.–Page 2 of 2.

	Method A				Method B						Method C			
Year	Drainage-wide	CV	Chilkat Lake	Mainstem River	Drainage-wide	CV	Chilkat Lake	CV	Mainstem River	CV	Drainage-wide	Chilkat Lake	Mainstem River	CV
1999	265,188[b]	0.05	240,002	25,186	265,188[b]	0.05	249,092[b]	0.05	13,557[a]	0.18	142,744	129,187	13,557[a]	0.18
2000	187,319[b]	0.12	132,687	54,633	187,319[b]	0.12	159,772[b]	0.12	29,142[a]	0.11	99,919	70,777	29,142[a]	0.11
2001	140,803[b]	0.07	105,064	35,740	140,803[b]	0.07	120,175[b]	0.09	21,925[a]	0.11	86,378	64,453	21,925[a]	0.11
2002	193,559[b]	0.17	148,465	45,094	193,559[b]	0.17	172,963[b]	0.15	19,388[a]	0.17	83,221	63,832	19,388[a]	0.17
2003	154,106[a]	0.07	116,891	37,216	154,106[a]	0.07	145,084[a]	0.09	20,204[a]	0.11	83,664	63,460	20,204[a]	0.11
2004	164,351[a]	0.06	118,795	45,556	164,351[a]	0.06	123,957[a]	0.06	36,158[a]	0.13	130,446	94,288	36,158[a]	0.13
2005	140,712[b]	0.10	89,072	51,639	140,712[b]	0.10	98,909[b]	0.11	36,473[a]	0.11	99,386	62,913	36,473[a]	0.11
2006	121,897[b]	0.17	91,439	30,457	121,897[b]	0.17	101,052[b]	0.17	22,779[a]	0.15	91,167	68,388	22,779[a]	0.15
2007	75,962[b]	0.10	59,884	16,079	75,962[b]	0.10	66,112[a]	0.10	21,491[a]	0.15	101,534	80,043	21,491[a]	0.15
2008	168,252[b]	0.11	119,808	48,444	168,252[b]	0.11	160,186[a]	0.11	41,269[b]	0.23	143,334	102,064	41,269[b]	0.23
2009	324,863[b]	0.13	285,218	39,645	324,863[b]	0.13	302,806[b]	0.12	26,935[a]	0.14	220,714	193,779	26,935[a]	0.14
2010	116,801[a]	0.09	72,318	44,482	116,801[a]	0.09	107,830[a]	0.16	34,876[a]	0.10	91,576	56,700	34,876[a]	0.10
2011	155,031[a]	0.08	109,335	45,696	155,031[a]	0.08	130,586[a]	0.11	36,170[a]	0.11	122,710	86,541	36,170[a]	0.11
2012	260,963[a]	0.10	171,924	89,039	260,963[a]	0.10	306,331[a]	0.17	48,457[a]	0.13	142,021	93,564	48,457[a]	0.13
2013	259,158[a]	0.10	224,516	34,642	259,158[a]	0.10	395,386[a]	0.17	18,974[a]	0.12	141,948	122,974	18,974[a]	0.12
2014	264,100[b]	0.12	212,201	51,899	264,100[b]	0.12	228,327[b]	0.21	41,381[b]	0.17	210,574	169,193	41,381[b]	0.17
2015	220,839[b]	0.10	124,892	95,947	220,839[b]	0.10	166,112[a]	0.09	57,382[a]	0.09	132,074	74,692	57,382[a]	0.09
2016	186,667[a]	0.09	96,148	90,519	186,667[a]	0.09	140,113[a]	0.15	60,937[a]	0.12	125,663	64,726	60,937[a]	0.12

[a] Mark–recapture estimates based on the Chapman modified pooled Petersen estimate (PPE).

[b] Mark–recapture estimates based on the stratified maximum likelihood (ML) Darroch estimator.

The weekly sockeye salmon 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:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \qquad (1)$$

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):

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

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

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

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):

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

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,

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

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

Appendix D.–Historical age composition estimated harvest of the Chilkat Lake sockeye salmon in the District 15 commercial drift gillnet fishery, weighted by statistical week, 1984–2016.

		Harvest by Age Class											
Year	Weighted by Statistical Week	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
1984	Total Harvest	0	4,709	5,796	0	252,637	27,791	472	42,950	49	214	93	19
	n (sample size)	0	203	172	0	8,083	1,150	19	2,173	3	14	4	1
	Percent Chilkat Lake	0.0%	0.0%	0.1%	0.0%	12.5%	8.2%	0.0%	8.8%	0.0%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	460	0	41,807	27,521	52	29,558	49	52	93	0
	SE of Number	0	0	138	0	1,075	900	52	874	32	52	59	0
1985	Total Harvest	72	2,557	9,030	16	155,490	25,600	3,161	106,354	357	199	53	441
	n (sample size)	3	153	253	2	5,645	728	125	3,603	11	9	4	27
	Percent Chilkat Lake	0.0%	0.0%	0.2%	0.0%	6.3%	8.0%	0.1%	28.4%	0.1%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.0%	0.0%	0.2%	0.3%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	27	556	10	19,065	24,288	447	86,292	347	59	0	0
	SE of Number	0	27	142	10	718	972	108	1,507	128	35	0	0
1986	Total Harvest	0	5,183	10,576	0	102,803	51,801	542	116,109	2,199	286	424	371
	n (sample size)	0	499	499	0	3,735	1,772	25	3,850	100	12	17	33
	Percent Chilkat Lake	0.0%	0.0%	0.8%	0.0%	4.1%	17.4%	0.0%	34.7%	0.8%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.2%	0.4%	0.0%	0.6%	0.1%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	2,231	0	11,941	50,489	10	100,773	2,199	80	283	0
	SE of Number	0	0	276	0	618	1,270	10	1,618	265	68	111	0
1987	Total Harvest	0	8	746	0	23,026	18,860	27	26,616	284	93	242	0
	n (sample size)	1	258	482	0	6,774	729	10	3,193	16	7	20	5
	Percent Chilkat Lake	0.0%	0.0%	0.2%	0.0%	5.5%	4.5%	0.0%	6.4%	0.1%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	8	746	0	23,026	18,860	27	26,616	284	93	242	0
	SE of Number	0	7	183	0	994	880	27	999	88	73	80	0
1988	Total Harvest	0	0	2,227	22	22,810	12,579	104	38,725	178	33	207	0
	n (sample size)	0	175	562	2	6,850	758	38	2,498	12	16	10	7
	Percent Chilkat Lake	0.0%	0.0%	0.6%	0.0%	6.5%	3.6%	0.0%	11.0%	0.1%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.3%	0.2%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	2,227	22	22,810	12,579	104	38,725	178	33	207	0
	SE of Number	0	0	314	21	888	657	67	1,084	61	22	87	0

-continued-

Appendix D.–Page 2 of 7.

Year	Weighted by Statistical Week	Harvest by Age Class											
		1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
1989	Total Harvest	195	8,604	12,367	38	239,617	60,935	655	150,120	5	203	2,006	155
	n (sample size)	3	98	149	1	3,028	1,042	12	2,368	1	2	27	3
	Percent Chilkat Lake	0.0%	0.0%	0.1%	0.0%	12.2%	10.1%	0.0%	10.4%	0.0%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.4%	0.4%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	132	0	684	38	58,017	48,006	0	49,232	5	0	45	0
	SE of Number	101	0	269	38	2,042	1,831	0	1,842	4	0	38	0
1990	Total Harvest	76	13,532	11,495	0	122,564	53,607	1,061	157,625	698	884	209	385
	n (sample size)	1	352	231	0	2,464	1,247	32	3,435	22	24	4	8
	Percent Chilkat Lake	0.0%	0.0%	0.4%	0.0%	4.7%	13.8%	0.0%	22.1%	0.2%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.3%	0.4%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	1,507	0	16,993	49,983	137	79,899	698	76	85	0
	SE of Number	0	0	275	0	976	1,480	67	1,878	174	53	84	0
1991	Total Harvest	19	9,401	14,941	0	183,006	11,761	446	92,864	76	263	316	587
	n (sample size)	1	436	397	0	3,960	314	16	2,304	1	10	11	26
	Percent Chilkat Lake	0.0%	0.0%	0.3%	0.0%	4.8%	2.7%	0.0%	11.5%	0.0%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.3%	0.2%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	821	0	15,001	8,385	9	36,192	0	137	176	0
	SE of Number	0	0	192	0	876	631	8	1,262	0	65	93	0
1992	Total Harvest	28	10,697	5,099	0	137,419	26,806	1,311	106,817	142	284	304	438
	n (sample size)	1	314	145	0	3,813	714	30	2,803	4	9	7	14
	Percent Chilkat Lake	0.0%	0.0%	0.3%	0.0%	10.1%	7.9%	0.0%	20.7%	0.0%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.4%	0.3%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	28	0	739	0	29,308	22,797	124	59,882	103	79	85	0
	SE of Number	27	0	166	0	1,042	981	71	1,413	66	46	60	0
1993	Total Harvest	0	9,934	3,158	0	46,210	20,684	310	91,747	2,649	171	221	132
	n (sample size)	0	476	150	0	2,176	924	14	3,876	103	9	10	7
	Percent Chilkat Lake	0.0%	0.0%	0.9%	0.0%	7.8%	11.4%	0.1%	37.3%	1.5%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.3%	0.4%	0.0%	0.5%	0.2%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	1,582	0	13,680	19,889	167	65,330	2,649	63	171	0
	SE of Number	0	0	179	0	504	684	67	885	282	41	68	0

-continued-

		Harvest by Age Class											
Year	Weighted by Statistical Week	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
1994	Total Harvest	208	5,478	2,424	39	88,524	14,218	213	58,402	115	115	2,011	48
	n (sample size)	9	251	111	2	4,266	721	10	2,837	7	5	101	2
	Percent Chilkat Lake	0.1%	0.0%	1.1%	0.0%	32.7%	8.2%	0.0%	30.5%	0.1%	0.1%	1.2%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.5%	0.3%	0.0%	0.5%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	92	0	1,864	15	56,193	14,043	56	52,369	115	92	2,011	0
	SE of Number	45	0	200	15	830	483	39	799	44	47	200	0
1995	Total Harvest	0	4,843	6,522	0	22,707	16,853	276	36,285	43	38	231	879
	n (sample size)	0	480	581	0	1,943	714	27	2,199	2	4	9	86
	Percent Chilkat Lake	0.0%	0.0%	2.9%	0.0%	16.8%	18.7%	0.2%	38.5%	0.0%	0.0%	0.3%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.5%	0.6%	0.0%	0.7%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	2,552	0	14,935	16,625	162	34,170	43	29	222	0
	SE of Number	0	0	191	0	436	560	41	644	34	16	83	0
1996	Total Harvest	0	8,323	4,374	34	60,151	23,897	48	52,132	133	65	71	350
	n (sample size)	0	545	275	1	3,613	823	4	1,695	4	3	2	26
	Percent Chilkat Lake	0.0%	0.0%	1.5%	0.0%	16.0%	15.7%	0.0%	33.2%	0.1%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.5%	0.5%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	2,217	34	23,870	23,553	29	49,704	133	65	71	0
	SE of Number	0	0	241	33	687	772	21	909	66	41	50	0
1997	Total Harvest	0	6,449	4,392	0	51,538	11,080	118	44,496	20	0	95	639
	n (sample size)	0	318	224	0	2,369	530	6	2,003	1	0	3	32
	Percent Chilkat Lake	0.0%	0.0%	2.3%	0.0%	15.1%	9.2%	0.0%	35.3%	0.0%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.5%	0.4%	0.0%	0.6%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	37	2,762	0	17,945	10,947	51	41,903	20	0	95	0
	SE of Number	0	26	236	0	579	466	29	675	20	0	56	0
1998	Total Harvest	0	2,723	2,723	0	71,570	19,240	172	38,080	66	25	28	308
	n (sample size)	0	87	90	0	2,370	742	6	1,511	3	1	3	11
	Percent Chilkat Lake	0.0%	0.0%	1.3%	0.0%	44.9%	11.8%	0.1%	25.2%	0.0%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.7%	0.5%	0.1%	0.6%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	60	1,739	0	60,635	15,908	143	34,025	66	25	28	0
	SE of Number	0	42	243	0	980	665	71	810	38	25	17	0

-continued-

Year	Weighted by Statistical Week	Harvest by Age Class											
		1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
1999	Total Harvest	0	3,173	2,957	0	61,780	15,398	43	79,477	0	53	98	579
	n (sample size)	0	83	81	0	1,674	495	2	2,372	0	2	3	15
	Percent Chilkat Lake	0.0%	0.0%	0.9%	0.0%	33.3%	9.1%	0.0%	47.9%	0.0%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.6%	0.4%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	1,529	0	54,458	14,926	0	78,344	0	53	98	0
	SE of Number	0	0	243	0	1,053	723	0	1,143	0	38	58	0
2000	Total Harvest	0	12,787	4,540	0	18,538	3,236	352	67,440	833	115	131	1,588
	n (sample size)	0	375	139	0	592	151	11	2,736	46	5	8	47
	Percent Chilkat Lake	0.0%	0.0%	1.6%	0.0%	6.3%	2.6%	0.3%	59.7%	0.7%	0.1%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.4%	0.2%	0.1%	0.8%	0.1%	0.1%	0.0%	0.0%
	Number of Chilkat Lake	0	0	1,766	0	6,930	2,824	326	65,364	794	115	131	14
	SE of Number	0	0	238	0	449	246	104	838	122	57	50	14
2001	Total Harvest	0	13,055	3,117	0	112,897	2,620	93	14,653	0	45	971	359
	n (sample size)	0	433	125	0	3,662	212	6	925	0	3	106	10
	Percent Chilkat Lake	0.0%	0.0%	1.1%	0.0%	29.3%	1.8%	0.0%	7.8%	0.0%	0.0%	0.7%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.7%	0.2%	0.0%	0.4%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	1,645	0	43,334	2,620	67	11,513	0	33	971	0
	SE of Number	0	0	236	0	1,029	254	34	542	0	24	150	0
2002	Total Harvest	0	2,248	4,055	0	43,737	6,580	335	24,840	0	48	33	137
	n (sample size)	0	131	199	0	2,243	530	18	1,723	0	4	1	7
	Percent Chilkat Lake	0.0%	0.0%	1.9%	0.0%	17.9%	8.0%	0.3%	29.5%	0.0%	0.1%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.6%	0.4%	0.1%	0.7%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	1,577	0	14,715	6,540	246	24,172	0	48	33	0
	SE of Number	0	0	180	0	526	312	73	574	0	24	33	0
2003	Total Harvest	0	4,786	11,259	0	31,711	8,171	88	37,912	148	11	74	969
	n (sample size)	0	405	484	0	1,799	383	3	1,673	8	1	2	85
	Percent Chilkat Lake	0.0%	0.0%	1.1%	0.0%	6.8%	8.0%	0.0%	36.4%	0.2%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.3%	0.4%	0.0%	0.7%	0.1%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	1,059	0	6,430	7,619	11	34,602	148	11	74	0
	SE of Number	0	0	121	0	332	388	11	686	51	11	52	0

-continued-

Year	Weighted by Statistical Week	Harvest by Age Class											
		1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
2004	Total Harvest	0	18,167	13,518	0	95,287	6,617	73	17,210	2	43	221	108
	n (sample size)	0	634	484	0	3,438	401	5	1,383	1	2	17	5
	Percent Chilkat Lake	0.0%	0.0%	1.8%	0.0%	21.0%	2.4%	0.0%	8.5%	0.0%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.6%	0.2%	0.0%	0.3%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	2,764	0	31,716	3,577	0	12,788	2	43	221	0
	SE of Number	0	0	295	0	905	282	0	512	1	41	77	0
2005	Total Harvest	0	6,129	5,270	0	33,410	1,966	203	18,342	7	0	0	143
	n (sample size)	0	543	412	0	2,805	184	18	1,697	1	0	0	16
	Percent Chilkat Lake	0.0%	0.0%	0.9%	0.0%	10.4%	2.0%	0.2%	21.4%	0.0%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.4%	0.2%	0.1%	0.5%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	586	0	6,833	1,288	116	14,022	7	0	0	0
	SE of Number	0	0	86	0	248	117	36	323	6	0	0	0
2006	Total Harvest	0	1,803	8,772	0	114,506	1,838	173	18,011	29	7	214	226
	n (sample size)	0	140	298	0	3,502	62	7	607	1	1	6	18
	Percent Chilkat Lake	0.0%	0.0%	0.8%	0.0%	5.1%	0.7%	0.0%	4.1%	0.0%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.3%	0.1%	0.0%	0.3%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	1,222	0	7,436	1,081	52	5,937	29	7	214	0
	SE of Number	0	0	198	0	459	190	46	406	28	7	92	0
2007	Total Harvest	0	4,593	8,833	0	120,058	2,052	402	20,096	0	119	0	784
	n (sample size)	0	259	207	0	3,456	69	14	585	0	2	0	45
	Percent Chilkat Lake	0.0%	0.0%	0.2%	0.0%	4.8%	1.0%	0.0%	3.0%	0.0%	0.1%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.0%	0.0%	0.4%	0.2%	0.0%	0.3%	0.0%	0.1%	0.0%	0.0%
	Number of Chilkat Lake	0	0	295	0	7,457	1,642	35	4,694	0	85	0	0
	SE of Number	0	0	66	0	576	269	25	452	0	85	0	0
2008	Total Harvest	0	8,977	4,627	0	18,610	10,589	276	3,508	10	40	11	8
	n (sample size)	0	835	389	0	1,731	1,129	25	382	1	4	2	1
	Percent Chilkat Lake	0.0%	0.0%	1.8%	0.0%	16.2%	22.6%	0.1%	6.7%	0.0%	0.1%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.5%	0.5%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	13	849	0	7,540	10,553	28	3,120	10	32	11	0
	SE of Number	0	12	95	0	253	217	19	164	9	18	8	0

-continued-

Year	Weighted by Statistical Week	Harvest by Age Class 1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
2009	Total Harvest	0	6,666	4,093	0	53,804	19,658	121	42,142	68	0	0	42
	n (sample size)	0	263	161	0	2,156	604	4	1,293	2	0	0	2
	Percent Chilkat Lake	0.0%	0.0%	0.7%	0.0%	18.9%	15.4%	0.0%	32.6%	0.1%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.6%	0.6%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	849	0	23,938	19,453	21	41,221	68	0	0	0
	SE of Number	0	0	153	0	710	739	20	842	51	0	0	0
2010	Total Harvest	0	7,995	3,944	19	44,692	4,754	529	38,585	116	157	24	157
	n (sample size)	0	418	169	1	2,003	153	19	1,238	4	4	2	7
	Percent Chilkat Lake	0.0%	0.0%	0.6%	0.0%	7.3%	4.2%	0.4%	34.8%	0.1%	0.2%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.4%	0.4%	0.1%	0.7%	0.1%	0.1%	0.0%	0.0%
	Number of Chilkat Lake	0	0	574	19	7,399	4,266	404	35,120	116	157	24	0
	SE of Number	0	0	127	18	417	378	110	692	61	80	17	0
2011	Total Harvest	0	3,490	7,619	0	37,289	4,371	8	10,810	39	8	45	114
	n (sample size)	0	257	528	0	2,393	407	1	747	5	1	5	7
	Percent Chilkat Lake	0.0%	0.0%	0.6%	0.0%	9.0%	6.2%	0.0%	8.6%	0.1%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.4%	0.3%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	397	0	5,710	3,950	0	5,481	39	8	14	0
	SE of Number	0	0	81	0	285	216	0	280	17	8	9	0
2012	Total Harvest	0	13,277	13,424	0	154,838	17,022	195	25,380	97	30	205	175
	n (sample size)	0	352	207	0	2,661	575	8	615	4	2	5	3
	Percent Chilkat Lake	0.0%	0.0%	1.9%	0.0%	9.6%	7.3%	0.0%	5.4%	0.0%	0.0%	0.1%	0.0%
	SE of %	0.0%	0.0%	0.3%	0.0%	0.6%	0.4%	0.0%	0.4%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	4,365	0	21,630	16,442	30	12,097	97	19	205	0
	SE of Number	0	0	605	0	1,260	1,010	30	903	57	18	118	0
2013	Total Harvest	37	3,690	7,505	0	50,359	21,683	593	37,224	427	168	228	189
	n (sample size)	1	159	256	0	1,830	579	25	1,103	12	6	5	8
	Percent Chilkat Lake	0.0%	0.0%	1.7%	0.0%	15.4%	17.2%	0.0%	27.0%	0.3%	0.1%	0.2%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.6%	0.7%	0.0%	0.8%	0.1%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	2,074	0	18,809	20,957	26	32,995	427	72	228	0
	SE of Number	0	0	242	0	724	812	26	946	135	51	103	0

-continued-

Year	Weighted by Statistical Week	Harvest by Age Class 1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
2014	Total Harvest	0	5,581	43,148	0	129,676	17,984	237	35,207	118	48	421	2,262
	n (sample size)	0	145	528	0	2,304	254	5	500	1	2	4	35
	Percent Chilkat Lake	0.0%	0.0%	1.5%	0.0%	16.4%	5.8%	0.0%	10.8%	0.1%	0.0%	0.2%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.6%	0.4%	0.0%	0.6%	0.1%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	3,611	0	38,380	13,539	7	25,385	118	40	421	0
	SE of Number	0	0	580	0	1,460	1,019	7	1,387	117	40	219	0
2015	Total Harvest	47	15,707	4,807	0	80,911	3,345	127	26,123	405	0	7	98
	n (sample size)	1	755	193	0	2,507	100	8	838	10	0	1	8
	Percent Chilkat Lake	0.0%	0.0%	0.5%	0.0%	5.9%	2.1%	0.0%	16.4%	0.3%	0.0%	0.0%	0.0%
	SE of %	0.0%	0.0%	0.1%	0.0%	0.4%	0.3%	0.0%	0.6%	0.1%	0.0%	0.0%	0.0%
	Number of Chilkat Lake	0	0	683	0	7,709	2,753	0	21,527	405	0	7	0
	SE of Number	0	0	139	0	504	331	0	839	129	0	7	0
2016	Total Harvest	0	13,235	9,381	0	131,010	5,448	106	28,957	92	44	328	242
	n (sample size)	0	447	244	0	2,665	109	2	506	2	2	7	11
	Percent Chilkat Lake	0.0%	0.0%	0.9%	0.0%	7.7%	2.7%	0.0%	7.5%	0.0%	0.0%	0.2%	0.0%
	SE of %	0.0%	0.0%	0.2%	0.0%	0.5%	0.3%	0.0%	0.5%	0.0%	0.0%	0.1%	0.0%
	Number of Chilkat Lake	0	0	1,774	0	14,489	5,134	0	14,129	92	44	328	0
	SE of Number	0	0	300	0	904	544	0	944	65	30	126	0

Appendix E.–Chilkat River fish wheel counts of sockeye salmon by statistical week and year, 1999–2016.

Statistical Week	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
23–25	43	83	24	179	77	30	46	7	4	57	545	85	157	103	117	1131	83	11	155
26	183	330	175	273	172	110	130	46	8	249	784	64	93	220	477	652	294	71	241
27	422	371	232	339	295	264	146	112	36	248	854	303	290	446	477	490	615	325	348
28	962	359	274	340	210	395	194	124	110	436	505	281	420	513	268	344	1109	658	417
29	567	441	450	303	226	396	252	99	118	620	296	399	335	278	272	308	945	491	378
30	766	317	804	337	159	305	304	152	270	454	364	233	347	291	236	357	960	441	394
31	518	306	447	433	177	352	250	385	134	343	494	285	369	250	456	251	1098	362	384
32	617	292	632	441	414	588	344	400	164	394	890	277	553	167	276	491	1067	584	477
33	680	255	348	384	527	481	258	278	235	454	806	385	461	320	415	289	856	546	443
34	654	246	280	283	491	448	258	477	163	576	552	474	367	363	539	454	713	319	425
35	602	148	238	259	498	337	216	311	247	710	610	279	289	391	318	350	679	235	373
36	295	199	253	338	490	352	350	208	395	708	604	90	430	343	630	290	404	240	368
37	302	110	91	176	368	81	260	223	313	424	696	162	164	163	420	288	415	173	268
38	413	135	75	67	175	74	423	149	190	326	435	100	344	122	534	199	494	129	244
39	308	60	67	33	130	53	158	43	225	232	465	45	198	73	340	172	89	59	153
40	317	36	27	22	80	55	81	108	118	77	129	26	104	47	186	78	89	5	88
41	86	11	ND	7	42	30	15	47	21	104	23	10	19	6	ND	21	61	2	32
42	ND	ND	ND	3	20	15	7	ND	ND	ND	ND	6	ND	ND	ND	ND	ND	ND	10
Total	7,735	3,699	4,417	4,217	4,551	4,366	3,692	3,169	2,751	6,412	9,052	3,504	4,940	4,096	5,961	6,165	9,971	4,651	5,197

Appendix F.–Chilkat River fish wheel counts of Chilkat Lake sockeye salmon from scale pattern analysis by statistical week and year, 1999–2016.

Statistical Week	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
23–25	42	76	16	133	44	19	26	2	2	45	475	52	94	39	85	997	56	7	123
26	170	287	112	152	60	65	59	17	1	89	624	29	41	80	237	461	120	36	147
27	376	258	122	165	79	149	61	39	10	84	649	69	105	159	275	269	250	61	177
28	797	193	161	185	53	215	96	47	31	101	397	77	174	88	146	191	381	120	192
29	488	185	293	172	91	205	121	50	47	118	183	154	147	80	193	163	331	115	174
30	618	165	470	234	75	198	126	81	111	201	281	79	183	141	202	210	302	148	212
31	441	144	314	310	95	212	124	244	76	225	375	143	214	195	411	186	546	170	246
32	531	191	515	388	315	415	156	319	102	267	762	144	357	143	259	419	542	309	341
33	629	204	299	352	473	371	133	198	194	416	760	305	358	301	411	262	607	382	370
34	622	231	267	257	449	386	129	383	149	528	534	406	345	356	534	430	533	264	378
35	594	145	236	248	470	287	134	278	224	671	591	279	243	389	318	333	631	211	349
36	284	198	251	326	483	330	275	193	369	700	593	90	424	340	627	281	368	218	353
37	302	110	90	176	368	78	238	216	309	417	684	162	158	162	420	285	401	167	264
38	409	135	75	67	175	72	408	149	190	326	432	100	339	122	534	199	471	129	241
39	308	60	67	33	130	53	154	43	222	232	461	45	198	73	340	172	88	59	152
40	317	36	27	22	80	55	81	108	118	77	127	25	104	47	186	78	89	5	88
41	86	11	ND	7	42	30	15	47	21	104	23	10	19	6	ND	21	61	2	32
42	ND	ND	ND	3	20	15	7	ND	ND	ND	ND	6	ND	ND	ND	ND	ND	ND	10
Total	7,012	2,630	3,318	3,231	3,502	3,154	2,341	2,414	2,177	4,601	7,950	2,175	3,504	2,722	5,178	4,956	5,776	2,403	3,847

Appendix G.–Chilkat River fish wheel counts of Chilkat River mainstem sockeye salmon from scale pattern analysis by statistical week and year, 1999–2016.

Statistical Week	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
23–25	1	7	8	46	33	11	20	5	2	12	70	33	63	64	32	134	27	4	32
26	13	43	63	121	112	45	71	29	7	160	160	35	52	140	240	191	174	35	94
27	46	113	110	174	216	115	85	73	26	164	205	234	185	287	202	221	365	264	171
28	165	166	113	155	157	180	98	77	79	335	108	204	246	425	122	153	728	538	225
29	79	256	157	131	135	191	131	50	71	502	113	245	188	198	79	145	614	376	203
30	148	152	334	103	84	107	178	71	159	253	83	154	164	150	34	147	658	293	182
31	77	162	133	123	82	140	126	141	58	118	119	143	155	55	45	65	552	192	138
32	86	101	117	53	99	173	188	81	62	127	128	133	196	24	17	72	525	275	136
33	51	51	49	32	54	110	125	80	41	38	46	80	103	19	4	27	249	164	73
34	32	15	13	26	42	62	129	94	14	48	18	68	22	7	5	24	180	55	48
35	8	3	2	11	28	50	82	33	23	39	19	0	46	2	0	17	48	24	24
36	11	1	2	12	7	22	75	15	26	8	11	0	6	3	3	9	36	22	15
37	0	0	1	0	0	3	22	7	4	7	12	0	6	1	0	3	14	6	5
38	4	0	0	0	0	2	15	0	0	0	3	0	5	0	0	0	23	0	3
39	0	0	0	0	0	0	4	0	3	0	4	0	0	0	0	0	1	0	1
40	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
41	0	0	ND	0	0	0	0	0	0	0	0	0	0	0	ND	0	0	0	0
42	ND	ND	ND	0	0	0	0	ND	ND	ND	ND	0	ND	ND	ND	ND	ND	ND	0
Total	1	7	8	46	33	11	20	5	2	12	70	33	63	64	32	134	27	4	32

Appendix H.–Expanded visual weir counts scaled to DIDSON counts.

Visual weir counts were scaled to DIDSON counts to create an uninterrupted time series of 18 years of escapement observations (1999–2016), which were then compared to the fish wheel counts. Paired estimates were only available for mark–recapture and weir counts (1994–1995, 1999–2007) and for mark–recapture and DIDSON counts (2008–2016), since visual weir counts and DIDSON counts were never compared directly. Therefore, expanded weir counts were converted to expanded DIDSON counts by using the ratio from the overlap of paired estimates. First, mark–recapture estimates were scaled to DIDSON counts by dividing the 2007–2016 mark–recapture estimates by DIDSON counts to create ratio 1. Mark–recapture estimates (1994–2007) were then converted to DIDSON counts by dividing them by the average of ratio 1 (1.6). Next, the converted mark–recapture estimates were divided by the expanded weir counts to calculate ratio 2. Finally, to convert the weir counts to DIDSON counts, the expanded weir counts were multiplied by the average of ratio 2 (1.4). The time series of escapement included 11 years of expanded weir counts converted to DIDSON counts (1994–1995; 1999–2007) and 9 years of DIDSON counts (2008–2016).

Year	Escapement Estimate Method	Expanded Escapement Count[a]	M–R Estimate[b,c] (Method A)	Ratio 1	M–R Estimate Converted to DIDSON Count	Ratio 2	Expanded Weir Count Converted to DIDSON Count	Total Escapement Estimate
1994	Weir	86,385	153,540	---	95,307	1.1	118,997	118,997
1995	Weir	61,783	184,541	---	114,551	1.9	85,107	85,107
1996	M–R	---	262,852	---	163,161	---	---	---
1997	M–R	---	238,803	---	148,233	---	---	---
1998	M–R	---	211,114	---	131,046	---	---	---
1999	Weir	134,048	240,002	---	148,977	1.1	184,654	184,654
2000	Weir	47,077	132,687	---	82,363	1.7	64,850	64,850
2001	Weir	53,239	105,064	---	65,217	1.2	73,338	73,338
2002	Weir	65,611	148,465	---	92,157	1.4	90,381	90,381
2003	Weir	55,516	116,891	---	72,558	1.3	76,474	76,474
2004	Weir	83,534	118,795	---	73,740	0.9	115,070	115,070
2005	Weir	32,098	89,072	---	55,290	1.7	44,216	44,216
2006	Weir	38,850	91,439	---	56,759	1.5	53,517	53,517
2007	Weir	27,915	59,884	---	37,172	1.3	38,453	38,453
2008	DIDSON	74,919	119,808	1.6	74,369	---	---	74,919
2009	DIDSON	153,033	285,218	1.9	177,044	---	---	153,033
2010	DIDSON	61,906	72,318	1.2	44,890	---	---	61,906
2011	DIDSON	63,628	109,335	1.7	67,868	---	---	63,628
2012	DIDSON	121,810	171,924	1.4	106,719	---	---	121,810
2013	DIDSON	116,300	224,516	1.9	139,365	---	---	116,300
2014	DIDSON	70,470	212,201	3.0	131,720	---	---	70,470
2015	DIDSON	175,874	124,892	0.7	77,525	---	---	175,874
2016	DIDSON	88,513	96,148	1.1	59,682	---	---	88,513
Average				1.6		1.4		

[a] Weir counts (1994–1995, 1999–2007) and DIDSON counts (2008–2016) were expanded to account for late installation and early removal of the weir (from Table 3).

[b] Mark–recapture values for 1994–1998 are from Bachman (2010).

[c] Mark–recapture data for 1999–2016 were edited and recalculated in 2016 (from Table 4); values here are different from values reported in Eggers et al. (2010).

Appendix I.–Historical age composition of the Chilkat Lake sockeye salmon escapement, weighted by statistical week, 1982–2016.

		Age Class											
Year[a]	Weighted by Statistical Week	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
1982	Proportion by Age Class	0.006	0.001	0.022	0.017	0.121	0.477	0.000	0.340	0.016	0.000	0.001	0
	SE of %	0.4%	0.1%	0.4%	0.2%	0.6%	1.8%	0.0%	1.8%	0.6%	0.0%	0.1%	0.1%
	n (sample size)	6	1	38	43	210	739	0	568	21	0	2	2
1983	Proportion by Age Class	0.006	0.000	0.029	0.033	0.323	0.325	0.000	0.282	0.002	0.000	0.000	0
	SE of %	0.1%	0.0%	0.3%	0.4%	0.6%	0.9%	0.0%	0.9%	0.1%	0.0%	0.0%	0.0%
	n (sample size)	21	0	92	78	1,083	795	1	772	4	1	1	0
1984	Proportion by Age Class	0.001	0.000	0.016	0.015	0.226	0.535	0.000	0.203	0.002	0.000	0.000	0
	SE of %	0.1%	0.0%	0.3%	0.3%	0.7%	0.9%	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%
	n (sample size)	2	1	41	42	621	1,463	1	550	5	1	1	0
1985	Proportion by Age Class	0.009	0.000	0.007	0.035	0.100	0.392	0.004	0.448	0.004	0.000	0.000	0
	SE of %	0.3%	0.0%	0.2%	0.5%	0.8%	1.4%	0.2%	1.4%	0.2%	0.0%	0.0%	0.1%
	n (sample size)	8	0	9	44	123	529	3	609	6	0	0	2
1986	Proportion by Age Class	0.000	0.000	0.038	0.010	0.026	0.267	0.000	0.633	0.023	0.000	0.003	0
	SE of %	0.0%	0.0%	0.8%	0.5%	0.8%	2.2%	0.0%	2.3%	0.7%	0.0%	0.3%	0.0%
	n (sample size)	0	0	16	5	15	194	0	687	18	0	5	0
1987	Proportion by Age Class	0.013	0.000	0.018	0.034	0.242	0.348	0.000	0.337	0.008	0.000	0.001	0
	SE of %	0.4%	0.0%	0.4%	0.7%	1.1%	1.5%	0.0%	1.6%	0.3%	0.0%	0.1%	0.0%
	n (sample size)	13	0	27	40	358	499	0	512	8	1	3	0
1988	Proportion by Age Class	0.000	0.001	0.006	0.000	0.250	0.128	0.001	0.612	0.001	0.000	0.002	0
	SE of %	0.0%	0.0%	0.2%	0.0%	0.8%	1.5%	0.0%	1.6%	0.1%	0.0%	0.2%	0.0%
	n (sample size)	0	2	16	0	908	151	4	833	2	1	1	0
1989	Proportion by Age Class	0.000	0.000	0.007	0.000	0.364	0.349	0.001	0.275	0.001	0.000	0.001	0
	SE of %	0.0%	0.0%	0.2%	0.0%	0.8%	0.9%	0.1%	0.9%	0.1%	0.0%	0.1%	0.0%
	n (sample size)	0	0	28	0	1,660	1,119	4	1,059	1	0	2	1
1990	Proportion by Age Class	0.000	0.001	0.020	0.000	0.146	0.270	0.004	0.553	0.006	0.000	0.000	0
	SE of %	0.0%	0.1%	0.4%	0.0%	0.8%	1.0%	0.1%	1.2%	0.2%	0.0%	0.0%	0.0%
	n (sample size)	0	2	47	0	368	653	13	1,529	20	2	1	0
1991	Proportion by Age Class	0.000	0.000	0.025	0.000	0.341	0.208	0.000	0.423	0.000	0.001	0.001	0
	SE of %	0.0%	0.0%	0.5%	0.0%	1.8%	1.1%	0.0%	1.9%	0.0%	0.1%	0.1%	0.0%
	n (sample size)	0	0	34	0	578	350	1	632	0	4	3	0

-continued-

Appendix I.–Page 2 of 4.

Year	Weighted by Statistical Week	Age Class											
		1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
1992	Proportion by Age Class	0.000	0.000	0.007	0.000	0.217	0.211	0.002	0.560	0.001	0.001	0.001	0
	SE of %	0.0%	0.0%	0.2%	0.0%	0.7%	1.1%	0.1%	1.2%	0.1%	0.1%	0.1%	0.0%
	n (sample size)	0	3	27	0	1,021	424	5	1,019	1	1	2	2
1993	Proportion by Age Class	0.000	0.000	0.037	0.000	0.076	0.330	0.000	0.511	0.044	0.000	0.000	0
	SE of %	0.0%	0.0%	0.4%	0.0%	0.4%	1.2%	0.0%	1.3%	0.6%	0.0%	0.0%	0.2%
	n (sample size)	0	2	151	0	356	856	0	915	85	0	0	2
1994	Proportion by Age Class	0.000	0.000	0.019	0.000	0.402	0.193	0.001	0.370	0.002	0.000	0.013	0.000
	SE of %	0.0%	0.0%	0.4%	0.0%	1.2%	1.2%	0.1%	1.4%	0.1%	0.0%	0.4%	0.0%
	n (sample size)	0	0	57	0	1,281	249	2	581	3	0	14	0
1995	Proportion by Age Class	0.000	0.000	0.044	0.000	0.250	0.214	0.007	0.482	0.002	0.001	0.000	0.000
	SE of %	0.0%	0.0%	0.5%	0.0%	1.0%	1.0%	0.2%	1.2%	0.1%	0.1%	0.0%	0.0%
	n (sample size)	0	1	148	0	730	476	23	1,308	3	1	1	0
1996	Proportion by Age Class	0.000	0.000	0.104	0.000	0.675	0.088	0.000	0.133	0.000	0.000	0.000	0.000
	SE of %	0.0%	0.0%	1.7%	0.0%	2.7%	1.6%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%
	n (sample size)	0	0	32	0	208	27	0	41	0	0	0	0
1997	Proportion by Age Class	0.004	0.000	0.388	0.013	0.199	0.140	0.000	0.256	0.000	0.000	0.000	0.000
	SE of %	0.2%	0.0%	1.8%	0.4%	1.5%	1.3%	0.0%	1.6%	0.0%	0.0%	0.0%	0.0%
	n (sample size)	3	0	291	10	149	105	0	192	0	0	0	0
1998	Proportion by Age Class	0.001	0.000	0.049	0.003	0.694	0.190	0.000	0.060	0.000	0.002	0.000	0.000
	SE of %	0.1%	0.0%	0.6%	0.2%	1.3%	1.1%	0.0%	0.7%	0.0%	0.1%	0.0%	0.0%
	n (sample size)	1	0	59	4	832	228	0	72	0	2	0	0
1999	Proportion by Age Class	0.000	0.000	0.013	0.000	0.229	0.170	0.001	0.585	0.000	0.002	0.000	0.000
	SE of %	0.0%	0.0%	0.2%	0.0%	0.7%	1.0%	0.0%	1.1%	0.0%	0.1%	0.0%	0.0%
	n (sample size)	0	0	43	0	806	365	3	1,325	1	5	0	0
2000	Proportion by Age Class	0.000	0.001	0.018	0.000	0.055	0.089	0.003	0.800	0.034	0.000	0.000	0
	SE of %	0.0%	0.1%	0.3%	0.0%	0.5%	0.7%	0.1%	1.0%	0.5%	0.0%	0.0%	0.0%
	n (sample size)	0	1	56	0	119	180	6	1,886	65	2	1	0
2001	Proportion by Age Class	0.000	0.000	0.029	0.000	0.714	0.076	0.002	0.154	0.001	0.003	0.021	0
	SE of %	0.0%	0.0%	0.4%	0.0%	0.9%	0.5%	0.1%	0.7%	0.0%	0.1%	0.3%	0.0%
	n (sample size)	0	0	71	0	1,335	289	3	631	2	4	101	5

-continued-

Appendix I.–Page 3 of 4.

Year	Weighted by Statistical Week	Age Class											
		1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
2002	Proportion by Age Class	0.000	0.000	0.025	0.002	0.203	0.250	0.004	0.514	0.000	0.000	0.001	0
	SE of %	0.0%	0.0%	0.4%	0.1%	0.8%	1.1%	0.1%	1.2%	0.0%	0.0%	0.1%	0.0%
	n (sample size)	1	0	62	3	663	503	10	1,259	0	1	1	1
2003	Proportion by Age Class	0.001	0.000	0.025	0.003	0.108	0.192	0.001	0.666	0.003	0.002	0.000	0
	SE of %	0.0%	0.0%	0.2%	0.1%	0.5%	1.3%	0.1%	1.4%	0.1%	0.1%	0.0%	0.0%
	n (sample size)	4	3	110	8	456	322	4	1,248	7	7	0	0
2004	Proportion by Age Class	0.001	0.001	0.037	0.003	0.471	0.181	0.000	0.299	0.002	0.002	0.004	0
	SE of %	0.0%	0.1%	0.4%	0.1%	0.7%	0.8%	0.0%	0.8%	0.1%	0.1%	0.1%	0.0%
	n (sample size)	4	2	106	6	1,494	517	1	853	4	5	12	0
2005	Proportion by Age Class	0.001	0.001	0.034	0.003	0.285	0.102	0.006	0.566	0.001	0.000	0.001	0
	SE of %	0.0%	0.0%	0.4%	0.2%	0.8%	0.7%	0.2%	1.0%	0.1%	0.0%	0.1%	0.0%
	n (sample size)	2	3	89	6	759	215	15	1,172	1	1	1	0
2006	Proportion by Age Class	0.001	0.001	0.046	0.006	0.554	0.065	0.000	0.323	0.000	0.000	0.003	0
	SE of %	0.1%	0.0%	0.5%	0.2%	1.1%	0.5%	0.0%	1.1%	0.0%	0.0%	0.1%	0.0%
	n (sample size)	2	4	98	13	1,069	145	1	721	1	0	9	0
2007	Proportion by Age Class	0.003	0.000	0.046	0.020	0.224	0.254	0.004	0.441	0.003	0.004	0.000	0
	SE of %	0.1%	0.0%	0.6%	0.4%	1.1%	1.4%	0.2%	1.6%	0.2%	0.1%	0.0%	0.0%
	n (sample size)	10	1	99	35	470	318	9	613	5	8	0	2
2008	Proportion by Age Class	0.002	0.012	0.038	0.004	0.242	0.579	0.001	0.120	0.000	0.000	0.000	0
	SE of %	0.1%	0.2%	0.5%	0.2%	1.2%	1.9%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%
	n (sample size)	7	45	114	4	434	405	5	148	0	1	1	1
2009	Proportion by Age Class	0.002	0.004	0.023	0.003	0.513	0.202	0.000	0.253	0.000	0.000	0.000	0
	SE of %	0.1%	0.1%	0.3%	0.1%	0.7%	0.9%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%
	n (sample size)	6	10	56	8	1,280	468	0	486	0	0	1	0
2010	Proportion by Age Class	0.006	0.000	0.020	0.013	0.248	0.122	0.008	0.581	0.001	0.001	0.000	0
	SE of %	0.2%	0.0%	0.4%	0.4%	1.0%	1.0%	0.2%	1.3%	0.1%	0.1%	0.0%	0.1%
	n (sample size)	10	0	32	13	355	142	13	597	1	1	0	1
2011	Proportion by Age Class	0.002	0.002	0.065	0.028	0.266	0.341	0.000	0.290	0.004	0.001	0.002	0
	SE of %	0.2%	0.1%	0.7%	0.5%	1.2%	1.2%	0.0%	1.4%	0.2%	0.1%	0.1%	0.0%
	n (sample size)	2	4	107	39	444	523	2	391	6	1	3	0

-continued-

Year	Weighted by Statistical Week	Age Class											
		1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Other
2012	Proportion by Age Class	0.003	0.013	0.029	0.006	0.299	0.472	0.001	0.164	0.010	0.001	0.000	0
	SE of %	0.1%	0.3%	0.5%	0.2%	1.0%	1.2%	0.1%	1.1%	0.3%	0.1%	0.0%	0.1%
	n (sample size)	7	19	49	10	587	613	3	240	15	2	1	2
2013	Proportion by Age Class	0.002	0.006	0.063	0.005	0.172	0.342	0.005	0.402	0.003	0.001	0.001	0
	SE of %	0.1%	0.2%	0.9%	0.2%	0.9%	2.1%	0.2%	2.1%	0.1%	0.1%	0.1%	0.0%
	n (sample size)	6	8	110	7	321	277	8	533	5	1	1	0
2014	Proportion by Age Class	0.002	0.000	0.006	0.014	0.416	0.300	0.000	0.246	0.004	0.001	0.008	0
	SE of %	0.1%	0.0%	0.2%	0.3%	0.9%	1.9%	0.0%	1.9%	0.2%	0.1%	0.5%	0.1%
	n (sample size)	9	0	15	24	629	320	0	279	4	3	9	4
2015	Proportion by Age Class	0.001	0.001	0.036	0.007	0.127	0.166	0.004	0.650	0.007	0.000	0.000	0
	SE of %	0.1%	0.0%	0.4%	0.2%	0.9%	1.5%	0.3%	1.7%	0.3%	0.0%	0.0%	0.0%
	n (sample size)	6	5	129	11	280	190	5	881	7	1	0	0
2016	Proportion by Age Class	0.002	0.000	0.029	0.011	0.323	0.273	0.000	0.362	0.000	0.000	0.000	0
	SE of %	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	n (sample size)	4	0	59	8	465	184	0	282	0	0	0	0

[a] Age composition from 1996–1998 is unweighted by statistical week since the weir was not operated.

Appendix J.–Average length (mid eye to tail fork) of Chilkat Lake sockeye salmon, by age class, 1982–2016.

		Mean Length (mm) by Age Class										
Year	Sample Size	1.1	0.3	1.2	2.1	1.3	2.2	1.4	2.3	3.2	2.4	3.3
1982	1,626	357	555	518	365	608	541	–	616	566	–	638
1983	2,831	330	–	504	358	596	542	615	602	563	630	601
1984	2,722	333	560	514	356	596	522	630	594	552	600	610
1985	1,333	357	–	504	372	598	518	634	596	516	–	–
1986	939	–	–	491	363	603	548	–	613	563	–	619
1987	1,459	338	–	509	346	598	534	–	600	526	565	617
1988	1,914	–	600	541	–	621	563	620	625	573	580	670
1989	3,870	–	–	537	–	599	544	570	590	480	–	575
1990	2,633	–	580	513	–	581	531	590	580	534	640	605
1991	1,602	–	–	520	–	584	528	600	584	–	565	582
1992	2,504	–	533	514	–	584	527	575	585	510	600	618
1993	2,366	–	558	509	–	574	522	–	575	526	–	–
1994	2,183	–	–	545	–	576	539	575	576	518	–	561
1995	2,689	–	510	513	–	574	521	583	573	560	605	605
1996	308	–	–	527	–	588	515	–	577	–	–	–
1997	744	400	–	480	367	575	519	–	572	–	–	–
1998	1197	385	–	478	406	543	476	–	543	–	513	–
1999	2,547	–	–	544	–	593	533	578	583	500	593	–
2000	2,296	–	620	484	–	580	509	608	580	526	593	500
2001	2,437	–	–	534	–	591	533	562	590	558	583	583
2002	2,498	370	550	514	403	607	528	616	606	–	600	610
2003	2,165	348	562	520	362	584	536	576	593	549	584	–
2004	3,004	346	563	516	348	588	511	560	589	546	592	569
2005	2,256	353	563	493	368	572	521	574	579	515	590	575
2006	2,062	325	555	528	368	583	524	560	575	620	–	581
2007	1,570	358	560	522	368	590	536	588	589	546	580	–
2008	1,165	331	584	524	394	592	545	565	593	–	630	600
2009	2,315	349	586	494	378	587	535	–	586	–	–	590
2010	1,165	339	–	513	379	581	542	588	589	505	635	–
2011	1,522	338	561	505	370	592	544	590	595	550	575	592
2012	1,547	358	592	519	366	604	546	607	611	562	623	585
2013	1,277	347	584	525	366	604	552	622	602	555	630	620
2014	1,294	374	–	544	411	609	537	–	608	588	615	623
2015	1,512	360	562	510	383	575	529	591	568	540	580	–
2016	1,001	363	–	522	–	580	522	–	582	–	–	–
Average	1,928	352	567	515	373	589	531	591	589	542	596	597

Appendix K.–Estimated seasonal mean (May−October) abundance (individuals/m^2) of dominant Chilkat Lake zooplankton taxa from 1987 to 2016. Data from all stations were averaged.

	Copepods		Cladocerans					
Year	*Cyclops*	Ovigerous *Cyclops*	*Bosmina*	Ovigerous *Bosmina*	*Daphnia l.*	Ovigerous *Daphnia l.*	*Daphnia r.*	Ovigerous *Daphnia r.*
1987	540,448	0	29,395	0	0	0	48,833	0
1988	617,126	0	95,206	0	0	0	61,504	0
1989	400,287	0	28,776	0	0	0	80,253	0
1990	580,168	0	27,677	0	0	0	73,647	0
1991	214,345	0	7,559	0	0	0	35,155	0
–								
1994	359,764	58,440	30,081	626	0	0	112,054	5,977
1995	782,425	52,061	73,335	2,632	0	0	100,708	16,704
1996	45,621	5,069	87,799	13,054	0	0	81,180	10,768
1997	24,798	3,208	8,272	8	0	0	81,572	4,022
1998	287	11	48,251	650	399	9	58,162	5,618
1999	7,477	311	38,900	754	5,699	795	28,062	3,252
2000	8,042	9	24,821	1,159	10,879	1,686	66,479	3,212
2001	1,017	19	38,347	1,762	2,709	813	4,605	510
2002	1,776	225	15,080	327	5,057	110	16,835	375
2003	1,194	0	30,216	556	14,999	1,248	6,046	1,024
2004	–	–	–	–	–	–	–	–
2005	11,982	1,377	37,639	1,314	41,340	3,101	45,929	0
2006	–	–	–	–	–	–	–	–
2007	5,873	469	15,346	2,179	17,142	1,978	24,408	0
2008	64,895	14,388	61,676	5,752	57,335	1,652	12,078	0
2009	20,403	3,243	17,847	1,842	27,577	2,819	29,182	0
2010	179,225	8,176	13,012	1,436	6,722	96	16,864	3,647
2011	57,600	41,214	11,292	5,009	8,292	234	20,625	100,944
2012	–	–	–	–	–	–	–	–
2013	99,512	65,635	52,398	410	18,361	0	47,672	2,609
2014	206,045	16,285	21,235	0	116,480	22,406	10,868	0
2015	369,743	11,420	5,745	0	98,560	2,773	0	0
2016	130,727	7,930	11,471	0	42,503	824	5,527	671

Note: Other zooplankton found in some years and in very small abundance included *Diaptomus*, *Harpacticus*, *Holopedium*, and *Chydorus*. Copepod nauplii and immature cladocerans were not included here, because they were not enumerated in lab samples until 2002 and 2004. The seasonal mean was not calculated if more than one month of sampling was missing (e.g., 2004, 2006, and 2012).

Appendix L.–Weighted seasonal mean (May−October) biomass (mg/m^2) of dominant Chilkat Lake zooplankton taxa from 1987 to 2016. Data from all stations were averaged.

	Copepods		Cladocerans					
Year	*Cyclops*	Ovigerous *Cyclops*	*Bosmina*	Ovigerous *Bosmina*	*Daphnia l.*	Ovigerous *Daphnia l.*	*Daphnia r.*	Ovigerous *Daphnia r.*
1987	989	0	40	0	0	0	115	0
1988	1,088	0	143	0	0	0	167	0
1989	764	0	33	0	0	0	172	0
1990	1,154	0	32	0	0	0	234	0
1991	554	0	10	0	0	0	94	0
–	–	–	–	–	–	–	–	–
1994	1,453	279	36	1	0	0	285	22
1995	1,875	213	90	4	0	0	290	69
1996	156	29	117	22	0	0	221	38
1997	59	18	9	0	0	0	290	24
1998	1	0	58	1	1	0	147	28
1999	30	2	47	1	12	3	91	16
2000	22	0	31	2	32	6	246	15
2001	3	0	39	2	5	2	8	1
2002	6	1	17	0	9	0	62	3
2003	1	0	32	1	24	4	11	3
2004	–	–	–	–	–	–	–	–
2005	46	10	47	2	112	11	225	0
2006	–	–	–	–	–	–	–	–
2007	17	4	19	4	39	9	117	0
2008	269	97	84	12	148	7	39	0
2009	86	22	20	3	39	11	59	0
2010	358	50	14	3	12	1	60	25
2011	138	251	10	8	17	1	49	698
2012	–	–	–	–	–	–	–	–
2013	448	339	64	0	40	0	153	15
2014	681	94	29	0	299	109	28	0
2015	700	60	7	0	293	26	0	0
2016	468	45	14	0	155	6	30	7

Note: Other zooplankton found in some years and in very small abundance included *Diaptomus*, *Harpacticus*, *Holopedium*, and *Chydorus*. The seasonal mean was not calculated if more than one month of sampling was missing (e.g., 2004, 2006, and 2012).

Appendix M.–Chilkat Lake zooplankton abundance summary, 1987 to 2016. All stations were averaged and species combined.

Lab	Year	Number of Stations	Monthly mean density (no./m^2) May	June	July	Aug	Sep	Oct	Seasonal Mean Density (no./m^2)	Seasonal Mean Biomass (mg/m^2)
Soldotna	1987	2	1,381,071	1,226,546	704,752	621,019	200,638	119,036	708,843	1,143
Soldotna	1988	2	1,612,752	1,196,298	840,555	781,582	513,138	248,674	865,500	1,398
Soldotna	1989	2	489,649	733,147	984,597	687,368	160,563	228,636	547,327	968
Soldotna	1990	2	2,158,970	946,125	640,128	481,158	298,435	138,934	777,291	1,420
Soldotna	1991	2	100,490	805,494	105,972	395,862	48,832	85,709	257,060	658

Soldotna	1994	4	ND	931103	749729	695,730	287234	170912	566,941	2,076
Soldotna	1995	4	2,460,059	1,247,877	1,156,714	840,765	422,505	39,269	1,027,865	2,542
Soldotna	1996	4	110,139	87,553	413,112	258,226	277,894	113,215	210,023	584
Soldotna	1997	4	86,041	54,618	232,617	186,489	229,034	70,011	143,135	400
Soldotna	1998	4	10,802	201,168	244,002	155,149	76,593	75,266	127,163	236
Soldotna	1999	4	10,829	17,581	65,671	146,670	123,301	159,527	87,263	202
Soldotna	2000	4	50,823	33,532	176,724	233,546	239,796	60,881	132,550	354
Soldotna	2001	4	6,261	25,133	150,292	91,879	18,137	23,567	52,545	60
Soldotna	2002	4	3,637	3,193	14,833	110,324	127,283	16,205	45,912	100
Soldotna	2003	4	6,659	7,971	32,553	98,089	97,718	88,694	55,281	75
Kodiak	2004	4	ND	ND	229,920	ND	587,536	ND	---	---
Kodiak	2005	4	12,126	98,929	364,391	204,330	ND	34,710	142,897	454
Kodiak	2006	4	71,830	ND	ND	207,844	ND	37,104	---	---
Kodiak	2007	4	7,557	29,377	79,662	130,624	120,798	37,104	67,520	210
Kodiak	2008	2	88,131	137,035	454,153	415,818	147,903	64,740	217,963	657
Kodiak	2009	2	15,496	65,546	215,232	108,677	ND	109,611	102,912	240
Kodiak	2010	2	78,685	94,116	206,126	619,716	252,802	123,620	229,177	524
Kodiak	2011	2	164,247	136,229	475,378	436,067	167,430	91,909	245,210	1,172
Kodiak	2012	2	339,701	291,561	485,651	ND	207,845	ND	---	---
Kodiak	2013	2	219,690	540,627	329,704	ND	248,090	95,294	286,681	1,061
Kodiak	2014	2	ND	529,801	801,494	327,729	229,368	79,471	393,573	1,241
Kodiak	2015	2	867,719	448,294	335,372	121,328	106,470	ND	375,836	1,086
Kodiak	2016	2	ND	291,221	362,540	173,289	99,168	72,041	199,652	726

Note: Copepod nauplii and immature cladocerans were not included here, because they were not enumerated in lab samples until 2002 and 2004. The seasonal mean was not calculated if more than one month of sampling was missing (e.g., 2004, 2006, and 2012).