Fishery Data Series No. 08-48

Klawock Lake Subsistence Sockeye Salmon Project 2006 Annual Report and 2004–2006 Summary

by

Jan M. Conitz

October 2008

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)

Measures (fisheries)

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

Mathematics, statistics

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

FISHERY DATA SERIES NO. 08-48

KLAWOCK LAKE SUBSISTENCE SOCKEYE SALMON PROJECT 2006 ANNUAL REPORT AND 2004–2006 SUMMARY

by
Jan M. Conitz
Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas

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

October 2008

The Federal Subsistence Board approved the Klawock Lake Sockeye Salmon Stock Assessment Project (Study Number FIS 05-603). The project was funded by the USDA Forest Service, managed by U.S. Fish and Wildlife Service Office of Subsistence Management, and is a cooperative project between the USDA Forest Service (USFS), the Alaska Department of Fish and Game (ADF&G), and the Klawock Cooperative Association (KCA). This annual report partially fulfills contract obligations for Sikes Act Contracts AG-0109-C-06-0015 and AG-0109-C-06-007. Additional funds for this project were provided by the Southeast Sustainable Salmon Fund.

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

Jan M. Conitz
Alaska Department of Fish and Game, Division of Commercial Fisheries,
802 3rd St., Douglas, Alaska, 99824-0020

This document should be cited as:
Conitz, J. M. 2008. Klawock Lake subsistence sockeye salmon project 2006 annual report and 2004–2006 summary. Alaska Department of Fish and Game, Fishery Data Series No. 08-48, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Sockeye salmon (*Oncorhynchus nerka*) returning to Klawock Lake support one of the largest subsistence sockeye fisheries in Southeast Alaska. The location and history of Klawock village at the mouth of the lake outlet stream, and the long history of commercial fishing and processing at this site attest to the prolific salmon runs returning to this system. According to historical records and local ecological knowledge of Klawock residents, sockeye runs are diminished from former levels. The primary purpose of the assessment project, started in 2001, has been to accurately determine Klawock sockeye salmon run sizes, as an aid to managing a sustainable subsistence fishery. Other objectives were directed towards understanding factors that control and limit sockeye salmon production in this system. In 2006, the sixth consecutive annual estimates of subsistence sockeye salmon harvest in Klawock Inlet and sockeye escapement into Klawock Lake were completed, through observations and interviews on the fishing grounds, and a weir and mark-recapture experiments in the lake. The estimated subsistence harvest of 3,100 sockeye salmon (95% confidence interval 2,600–3,600) in 2006 was below the six year average of about 4,400 sockeye salmon, but a marked improvement over the extreme low harvest of just 175 fish in 2005. The weir count of 14,757 sockeye salmon was nearly identical to the average escapement estimate for 2001–2006 of about 14,800 sockeye salmon. The combined total run in 2006, including sockeye salmon harvested in the subsistence fishery and those escaping to spawn, was approximately 18,000 fish, slightly lower than the average for the previous five years. The sum of separate mark-recapture estimates for Threemile, Inlet, and Halfmile Creeks was about 11,000 sockeye salmon, with a wide range of uncertainty (coefficient of variation = 30%).

Key words: Sockeye salmon, *Oncorhynchus nerka*, subsistence, local ecological knowledge, Klawock Lake, Klawock, weir, escapement, mark-recapture, age composition

INTRODUCTION

Sockeye salmon (*Oncorhynchus nerka*) returning to Klawock Lake (Figure 1) have supported a permanent human settlement since pre-historic times (Langdon 1977), as well as one of the first commercial fishing and processing operations in Alaska (Moser 1899; Roppel 1982). Present-day residents of Klawock continue to depend on sockeye salmon, harvesting about 7,500 fish annually from nearby waters, including some 4,000–6,000 annually from the Klawock River estuary (Alaska Department of Fish and Game (ADF&G) Division of Subsistence Community Profile Database 2001; Conitz et al. 2006). Klawock sockeye salmon undoubtedly also contribute to commercial catches, mostly through incidental harvest in nearby seine fisheries, although proportions of individual stocks in these harvests are not yet being quantified. Because of the size and importance of the Klawock subsistence fishery, and ongoing concern in the community over a real or perceived decline in sockeye run sizes, researchers at ADF&G initiated the subsistence sockeye salmon stock assessment program in 2001 (Lewis and Cartwright 2002).

Previous assessments of the Klawock sockeye salmon run date back to at least the 1930s, when a weir was operated on the Klawock River (Orrell et at. 1963). Prior to that, commercial harvest reports provided a rough indication of annual run size (Moser 1899; Rich and Ball 1933). Attempts at hatchery supplementation and implementation of fishery regulations during the early commercial period acknowledged depletion of the stock due to over-exploitation (Rich and Ball 1933; Roppel 1982). Yet, with the exception of the series of weir counts from the 1930s, previous assessment efforts did not provide a reliable record of stock size, annual escapements, or numbers of sockeye salmon harvested from this run (Lewis and Zadina 2001). In particular, Klawock hatchery personnel operated the weir primarily for broodstock collection during the 1970s and 1980s, and their weir counts were notoriously unreliable (H. Geiger, ADF&G retired fisheries biologist, personal communication 2004; Lewis and Zadina 2001). Detailed reviews of available historical information on Klawock sockeye salmon can be found in the annual report series for the stock assessment program beginning in 2001 (Lewis and Zadina 2001; Lewis and Cartwright 2002; Cartwright and Lewis 2004; Cartwright and Conitz 2006; Conitz et al. 2006;

Conitz and Cartwright 2007). The overall impression, both from available historical information and local ecological knowledge, is that abundance of Klawock Lake sockeye salmon was much greater in the past than in recent years (Ratner et al. 2005). Nevertheless, recent run sizes appear to be remarkably stable. In the five years since the recent stock assessment project started, annual escapements have remained consistently close to a five-year average of about 14,000 sockeye salmon. Subsistence harvests from 2001 to 2004 also remained consistently close to a four-year average of about 5,700 sockeye salmon (Conitz et al. 2006). The extremely low harvest in 2005 was puzzling, and was attributed in part to the timing and size of concurrent pink salmon runs. The overall run size (subsistence harvest plus escapement) for 2005 was also below the five-year average of about 19,000 fish and was the lowest overall run size for this five year period (Conitz and Cartwright 2007).

Hatchery production of sockeye fry was started in the 1980s as a means to supplement and increase the Klawock Lake stock (Lewis and Zadina 2001). Between about 250,000 and 900,000 sockeye fry were released annually between 1996 and 2005, as emergent unfed fry (Appendix C in Prince of Wales Hatchery Association (POWHA) 2005 annual management plan). However, the results of this program were not evaluated until after POWHA began thermally marking sockeye otoliths in 1999 (Lewis and Zadina 2001). In 2001, ADF&G researchers began sampling otoliths from sockeye fry and smolt for thermal marks, and beginning in 2003, they also began sampling otoliths from adult sockeye salmon returning to the Klawock subsistence fishery and the Klawock Lake spawning population. Preliminary results indicate that hatchery origin sockeye salmon have comprised less than one percent of total escapements and about four percent of subsistence harvests between 2003 and 2006. Total contribution of hatchery-produced sockeye salmon to the subsistence fishery and the Klawock Lake escapement has been a net loss after subtracting numbers harvested for broodstock (ADF&G Thermal Mark Laboratory Mark Summary Report database, http://tagotoweb.adfg.state.ak.us/OTO/reports/MarkSummary.aspx; J. Conitz, ADF&G Division of Commercial Fisheries, unpublished memo to Scott Kelley, Regional Supervisor, 2007).

Extensive human land-use activities have reduced or degraded the quality of available sockeye spawning habitat in the Klawock Lake watershed. For example, over 90% of the Klawock watershed has been logged in the last 60 years. The logging and associated road building have increased sediment loads, reduced large woody debris in the spawning streams, and rendered culverts dysfunctional for movement of salmon (Klawock Watershed Assessment, USDA Forest Service Craig Ranger District 2002 unpublished agency report). Floods and streambed scouring have become more frequent; these events can disturb spawning beds, increasing mortality in developing sockeye salmon eggs (Scrivener and Brownlee 1989). A recent housing subdivision in the floodplain of Threemile Creek, one of the major sockeye spawning tributaries, impacts streambanks and hydrology, and adds a potential source of pollution. In addition, the City of Klawock diverts water from Halfmile Creek, another major sockeye salmon spawning stream, for its domestic water needs, and has also recently proposed to withdraw water from Threemile Creek (State of Alaska online public notice concerning Threemile Creek (Klawock Reservoir) 3/22/2004, http://notes5.state.ak.us/pn/pubnotic.nsf).

In 2006, an independent review of all available data pertinent to Klawock Lake sockeye salmon production was completed, including water chemistry, primary and secondary production, lake sediment core analyses, and escapement, harvest, and hatchery production information (A. Mazumder, University of Victoria, unpublished report 2006). Unfortunately, past data collection efforts were inconsistent and sporadic, and the existing data were insufficient to permit reliable inferences and modeling. Data from the lake sediment cores were difficult to interpret due to the paucity and poor quality of salmon abundance estimates over the past 150 years, and high water turnover or flushing rates in the lake. The reviewer recommended several years of more focused data collection, to fill some of the gaps in existing information and permit evaluation of the lake ecosystem and its past and current potential for sockeye production.

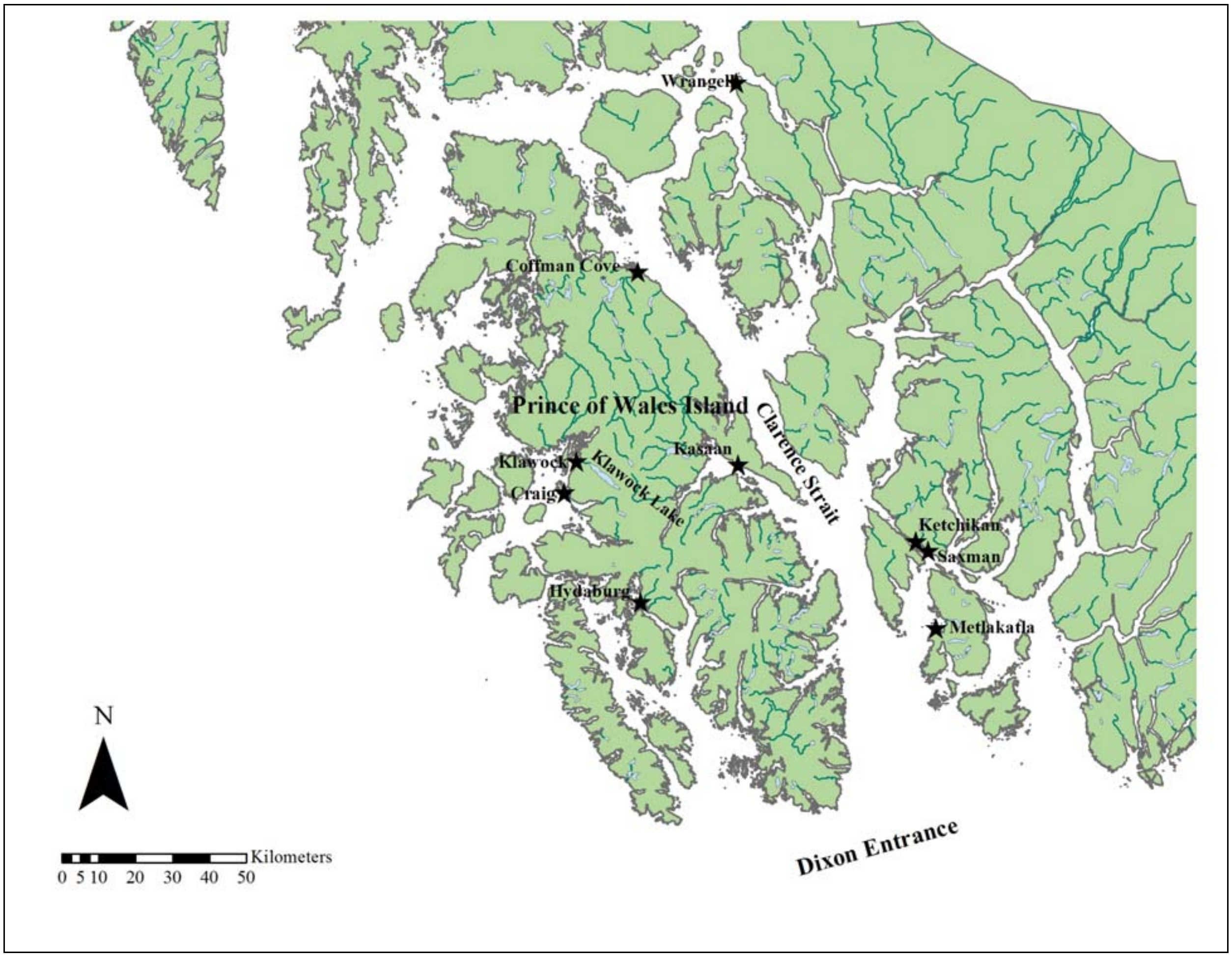

Figure 1.–Geographic location of Klawock Lake, in Southeast Alaska on Prince of Wales Island. The communities of Klawock and Craig, and other towns on and near Prince of Wales Island are shown.

The primary focus of the subsistence sockeye salmon project is to produce reliable annual estimates of the numbers of adult sockeye salmon returning to Klawock Lake. In 2006, sockeye salmon harvest from the subsistence fishery, and sockeye escapement into Klawock Lake, were estimated for a sixth consecutive year. As in the five preceding years, the escapement estimate was based on a weir count validated by a mark-recapture estimate. In addition, the project included, for a third consecutive year, independent estimates of sockeye spawning populations in each of the main lake tributaries: Threemile, Halfmile, and Inlet Creeks. These independent estimates of the primary spawning populations may provide a less intrusive and less expensive option for estimating escapement, compared with the weir-based study. The estimate of subsistence sockeye harvest in Klawock Inlet, was based, as in previous years, on observations and interviews in the fishery, using a “roving-access” survey design. We also continued to sample sockeye salmon spawners for age, sex, and length information, and looked for trends or changes in the age structure of the population.

OBJECTIVES

1. Estimate the subsistence harvest of Klawock Lake sockeye salmon, so the estimated coefficient of variation was less than 15%.
2. Count the number of salmon through the weir, by species and date, from 1 July to 15 October.
3. Estimate the sockeye salmon escapement into Klawock Lake with mark-recapture methods, marking salmon at the weir and conducting recapture sampling in the major spawning streams, so the estimated coefficient of variation was less than 10%.
4. Estimate the sockeye salmon spawning populations in Threemile, Halfmile and Inlet Creeks using mark-recapture methods so that the estimated coefficient of variation for each population was less than 15%.
5. Estimate the age, sex, and length composition of the sockeye salmon in the escapement at Klawock Lake, so the estimated coefficient of variation was less than or equal to 5% for the largest two age classes.

STUDY SITE

The Klawock River system (ADF&G Division of Commercial Fisheries stream number 103-60-047; is located on the west side of Prince of Wales Island (Figure 1), and drains into Klawock Inlet at the site of the village of Klawock (lat 55° 32.97'N, long 133° 02.60'W). Klawock Lake has two main basins and numerous tributaries, with four major tributaries providing most of the sockeye salmon spawning habitat in this system (Figure 2). At the head of the lake, Inlet Creek flows into basin B (maximum depth 49 m), draining a total area of 37.6 km^2. Hatchery Creek, Halfmile Creek, and Threemile Creek flow into basin A, the larger and shallower of the two basins (maximum depth 30 m), and drain a total watershed area of 76.1 km^2. The surface elevation of Klawock Lake is 9.1 m, and the lake has a total surface area of 11.9 km^2, mean depth of 17.7 m, maximum depth of 49.0 m, and volume of 209 x 10^6 m^3 (Figure 2). The lake is dimictic and organically stained, and its mean euphotic zone depth (EZD) is 4.2 m, based on limnological data collected in 1986–1988 and 2001 (Lewis and Cartwright 2002). Klawock Lake drains into the Klawock River, which is 2.85 km from the lake outlet to the estuary at the head of Klawock Inlet. The Prince of Wales hatchery and the weir are located on the Klawock River approximately 300 m below the lake. In addition to sockeye salmon, native fish species in Klawock Lake include coho (*O. kisutch*), pink (*O. gorbuscha*), and chum (*O. keta*) salmon, steelhead (*O. mykiss*) and cutthroat trout (*Oncorhynchus clarki*), Dolly Varden char (*Salvelinus malma*), threespine stickleback (*Gasterosteus aculeatus*), and cottids (*Cottus* sp.). Mysid shrimp (*Neomysis mercedis*) are also present in the lake.

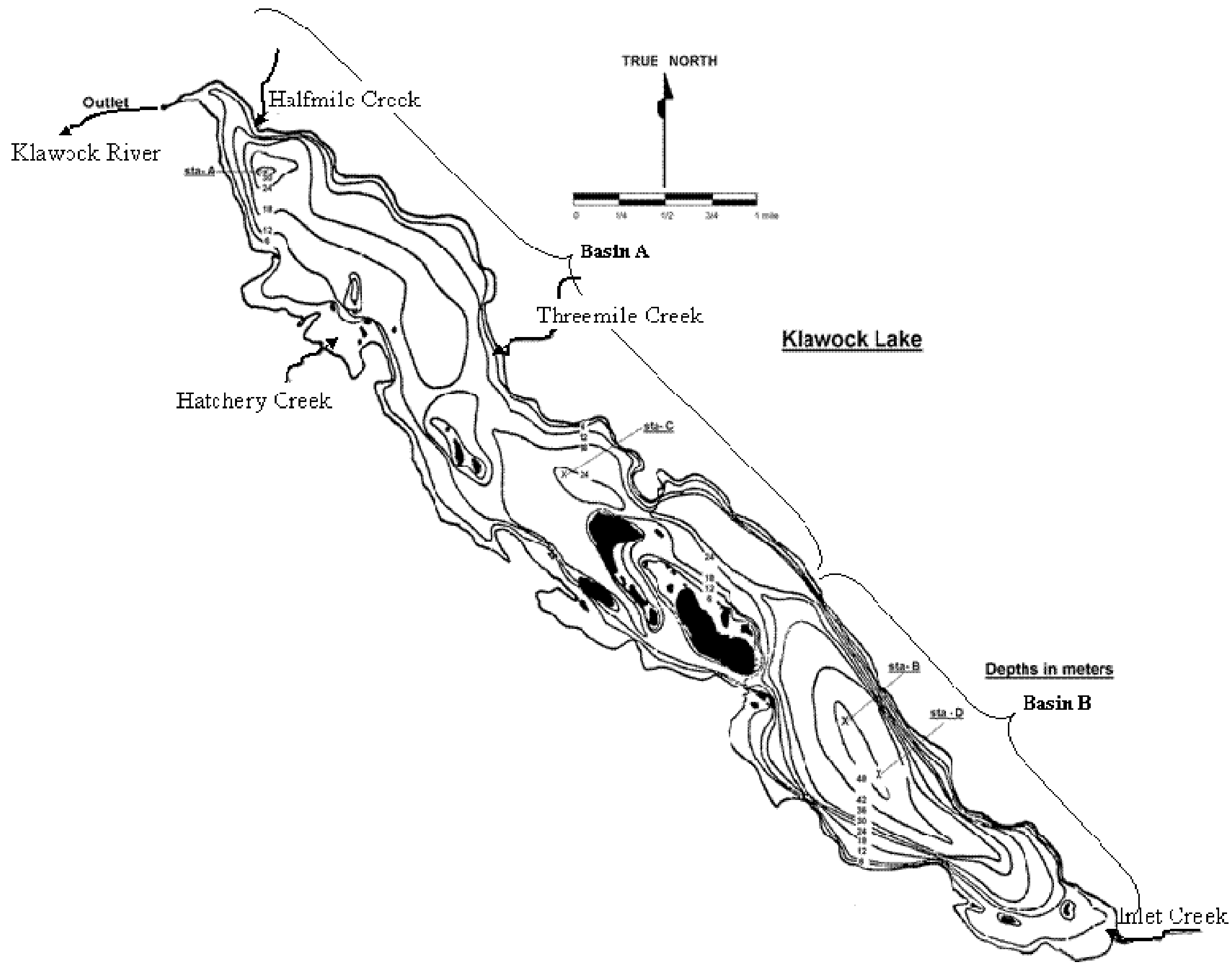

Figure 2.–Bathymetric map of Klawock Lake, showing the two main lake basins, four main inlet streams (Halfmile, Threemile, Inlet, Hatchery), and the outlet to Klawock River.

METHODS

SUBSISTENCE HARVEST ESTIMATE

By regulation, the subsistence fishery was open from 7 July through 31 July, on Monday at 0800 through Friday at 1700 each week. Three days out of each five-day week were randomly selected for sampling (observation and interviews) of the fishery. In 2006, weeks one and five had only one legal fishing day each and both of these dates were included for sampling (Table 1). Sampling days ran from 0600 to 2200 hours, with reduced hours on Monday and Friday. All subsistence fishing was conducted with small, hand-pulled seine nets, usually using two boats to deploy a single net. A set was defined as a single net deployment and retrieval. A *boat-party* referred to all the people on one or two boats fishing the same net. The technicians used binoculars and a motorized skiff to monitor the fishery, positioning themselves on the shore or in the skiff where they could see all boat-parties fishing in Klawock Inlet. As a net was being pulled up, the technician approached the participants to verbally interview them. In addition to direct verbal interviews, direct observation and hand signals were used to communicate the size of the catch. Hand signals or direct visual observation were often used if the set was a "water haul" with zero fish caught. Verbal interviews were usually used when larger numbers of fish were caught in a set. At the conclusion of the interview, the technician recorded the date, type of interview (hand, verbal, or visual), number of salmon caught by species, time of day, gear, town of residence, and any comments. The technician assigned a number to each interview. To maintain the confidentiality of individual catch information, names of fishers were not recorded. Technicians attempted to interview all boat-parties after each set. However, in cases where technicians were unable to interview a boat-party after a set, the set was recorded as a "missed interview."

Table 1.–Dates selected for sampling in the Klawock Inlet subsistence fishery in 2006.

Week	Calendar dates	Sample dates
1	7–8 July	7 July
2	9–15 July	10, 11, 12 July
3	16–22 July	17, 19, 20 July
4	23–29 July	24, 27, 28 July
5	30–31 July	31 July

The statistical population was designated to be the collection of "net sets." Sets were organized into a day within a week. Sampling followed a two-stage design: a day within a week was selected at random (first stage), and then a set within a day (second stage) was selected if needed (Bernard et al. 1998; Thompson 1992). In the second stage estimation, the average harvest for the day was assigned to any set with a "missed interview." In the first stage estimation, the average harvest per day, within a week, was expanded to estimate the harvest for the days not sampled each week. If the fishery was open for three or fewer days in a week, all days were sampled and no expansion was necessary for days not sampled.

We let h_{ijk} denote the harvest for set *i* on day *j* in week *k*, and m_{jk} denote the number of completed interviews on day *j*, in week *k* (i.e. the total number of sets for which interviews were obtained). Also, M_{jk} denoted the total number of net sets counted on day *j* in week *k* (i.e. the total number of sets observed, including any missed interviews), and d_k denoted the total number of days sampled out of D_k fishing days in week *k*. In 2006, the first and fifth week had only one legal fishing day and both were sampled, and the remaining weeks had five fishing days, with three days sampled in each (Table 1). For a given species, the harvest for week *k* was estimated as,

$$\hat{H}_k = \frac{D_k}{d_k} \sum_{j=1}^{d_k} \frac{M_{jk}}{m_{jk}} \sum_{i=1}^{m_{jk}} h_{ijk} \ , \tag{1}$$

and the total harvest for the season was estimated as the sum of weekly harvests,

$$\hat{H} = \sum_{k=1}^{5} \hat{H}_k \ . \tag{2}$$

To estimate the variance of $\hat{H}$, we let $\overline{h}_{jk}$ denote the mean harvest per set, on day *j* in week *k*, and $\overline{h}_k$ denote the mean harvest for the week. We then estimated the variance for the estimated harvest in week *k* as,

$$\mathrm{var}(\hat{H}_k) = \frac{D_k}{d_k} \sum_{j=1}^{d_k} M_{jk}^{\ 2} \left(1 - \frac{m_{jk}}{M_{jk}}\right) \frac{\sum_{i=1}^{m_{jk}} (h_{ijk} - \overline{h}_{jk})^2}{m_{jk}(m_{jk} - 1)} + D_k^{\ 2} (1 - \frac{d_k}{D_k}) \frac{\sum_{j=1}^{d_k} (\overline{h}_{jk} - \overline{h}_k)^2}{d_k (d_k - 1)} \tag{3}$$

(Thompson 1992, p. 129). The overall variance for the season was estimated by summing the five weekly variance estimates,

$$\operatorname{var}(\hat{H}) = \sum_{k=1}^{5} \operatorname{var}(\hat{H}_k), \tag{4}$$

and the standard error was estimated by taking the square root of the seasonal variance estimate.

SOCKEYE ESCAPEMENT ESTIMATES

Weir Counts and Mark-Recapture Estimate

The Klawock River weir was operated from 15 June to 23 October 2006 by project crew and Prince of Wales Hatchery staff. The permanent weir structure, rebuilt and substantially improved in 2004, was located adjacent to the hatchery, spanning the 50 m stream width, about 100 m below the lake (Conitz et al. 2006). Fish migrating upstream were diverted at the weir into the hatchery's raceway and sampling platform, where they were identified by species, counted, and passed upstream.

To test the accuracy of the weir count, I also estimated escapement using a stratified, closed-population mark-recapture study (Arnason et al. 1996). Technicians marked sockeye salmon as they passed them through the weir with an adipose fin clip and a uniquely-numbered t-bar tag, at an attempted rate of about twenty percent of the weekly number counted. The primary mark was the adipose clip, indicating presence of a tag; this dual marking system allowed the crew to monitor for tag loss. Following the season, I used tag numbers to assign all tagged fish into marking strata of one week each.

Recapture sampling was conducted on the spawning grounds at intervals approximately one week apart, throughout the spawning season. At least six sampling events were attempted in Threemile Creek, Inlet Creek, and Halfmile Creek (Figure 2). Fish were sampled with small beach seines as they schooled at the mouth of the stream, and with dip nets in the channel of each stream. All unmarked fish in these samples were tagged and given an opercular punch to identify the sampling event in which the fish were caught. Tag numbers were recorded for all fish caught in the sample, whether newly tagged or tagged in a previous event or at the weir. Because the sampling design specified sampling without replacement, I eliminated any repeat captures within a given sampling event during data processing. The recapture sample data were naturally stratified by location (stream), but as a check, I also stratified the data by sampling event date, pooling data from all locations for each date.

The two-sample Petersen model provides a simple method for estimating population size, based on the number of animals marked in the first sample, the number of animals subsequently sampled for marks in the second sample, and the number of marks recovered in the second sample (Seber 1982, p. 59; Pollock et al. 1990). Stratified mark-recapture models extend the two-sample Petersen method over two or more sampling events in both the marking (first) and mark-recovery (second) samples. Stratified models are widely used for estimating escapement of salmonids as they migrate into their spawning streams (Arnason et al. 1996). Spawning migrations may last for a month or more, during which time there can be substantial variation in biological parameters such as mortality rates. A fundamental assumption of the Petersen and related mark-recapture models is that capture probabilities for individual animals are equal (Pollock et al. 1990). Briefly stated, the three assumptions of equal capture probability required by the Petersen model are: 1) all fish have an equal probability of capture in the first sample (marking), 2) all fish have an equal probability of capture in the second sample (mark-recovery), and 3) fish mix completely between the first and second sample. In stratified sampling, if one or more of these assumptions is met, the marking and recovery strata can generally be pooled, thereby providing the most precise estimate. However, if none of the assumptions are met, the pooled estimate can be badly biased (Arnason et al. 1996).

I used two chi-square tests to test for consistency of capture probabilities in the marking and recapture strata. The test for equal capture probability in the first sample compared observed and expected numbers of marked and unmarked fish in each recapture stratum. The test for equal capture probability in the second sample, or equivalently, complete mixing, compared observed and expected numbers of those fish marked in the initial (marking) strata which were recaptured or not recaptured. These tests were comparable to those provided in the Stratified Population Analysis System (SPAS) software labeled "equal proportions" and "complete mixing," respectively (Arnason et al. 1996; for details, refer to http://www.cs.umanitoba.ca/~popan/). A test statistic with p-value ≤ 0.05 was considered "significant." If neither test statistic, or only one test statistic, was significant, I concluded all marking and all recapture strata could be pooled without significant risk of bias and the simple Petersen ("pooled Petersen") estimator could be used. If both test statistics were significant, I concluded the pooled estimator had a significant risk of bias, and used the stratified Darroch estimator if it could be found. If the SPAS program was unable to converge to a solution for the Darroch estimator, I followed the guidelines and suggestions in Arnason et al. (1996) to search for a partial pooling scheme that would lead to a valid estimate. I also examined the data for any obvious deficiencies or discrepancies in sample sizes and recapture numbers, and considered events during the season, such as flooding or missed sampling dates, that may have affected data collection.

I used a parametric bootstrap procedure to estimate the standard error and construct the 95% confidence interval for pooled Petersen escapement estimate. I assumed that the number of marked fish recaptured in the second sample, m_2, followed a hypergeometric probability distribution. Then I used the number of fish marked in the first sample, n_1, the number of fish caught in the second sample, n_2, and the Petersen estimate of escapement, $\hat{N}$, to generate 5,000 simulated recapture numbers based on the hypergeometric probability density function, $f(m_2 | n_1, n_2, \hat{N})$. From the bootstrap values of m_2, I derived 5,000 Petersen escapement estimates, then calculated the standard error of these estimates and used the 0.025 and 0.975 quantiles to form the 95% confidence interval.

The 95% confidence interval bounds were used to judge the accuracy of the weir count. If 95% confidence interval included the weir count, the weir count was considered accurate. If the weir count fell below the lower 95% confidence interval bound, and the estimate met the criteria discussed above, the estimate was accepted as the more accurate measure of escapement. If the weir count fell above the upper 95% confidence interval bound, the mark-recapture estimate was most likely inaccurate, because the weir count, if free of gross counting errors, would always represent a minimum number of fish in the lake.

Spawning Grounds Mark-Recapture Study

The Jolly-Seber model for open populations (Pollock et al. 1990), with an adjustment for spawning salmon populations (Schwarz et al. 1993), was used to estimate the number of sockeye salmon in each of the three main spawning tributaries of Klawock Lake (Threemile, Inlet, and Halfmile Creeks; Figure 2). Data collected for this study were the same as for the weir mark-recapture study described above. I assumed minimal or no mortality between the first and second sampling events, and I also assumed minimal immigration of new spawners into the study area between the next-to-last and last sampling events. A tag number was recorded for each fish caught in a given sample, whether initial capture or recapture. Fish caught with tags applied at the weir were treated as initial captures the first time they were encountered in the spawning grounds sampling. (Fish tagged at the weir but never recaptured on the spawning grounds were not included in the data for this study.) I used the tag number data to construct an individual capture history for each fish, by location and sampling event. For a given sampling event, sampling was without replacement, but a fish could be recaptured in multiple sampling events. A "1" denoted a sampling event in which a fish with a given tag number was captured, and a "0" denoted a sampling event in which the fish with that tag number was not captured (Pollock et al. 1990).

Data Analysis

The Jolly-Seber model extends the Schnabel method (Seber 1982, p. 130) to open populations. Population size is estimated at the time of each sample, and the number of new animals entering the population is estimated between sampling events, for s sampling events. This model requires four assumptions:

1. Every fish present in the population at time of the i^{th} sampling event (i=1, 2, …, s) has the same probability of capture (p_i);
2. Every fish (marked and unmarked) present in the population immediately after the i^{th} sampling event has the same probability of survival (ϕ_i) until the $(i+1)^{th}$ sampling event (i = 1, 2,…, s-1);
3. Marks are not lost or overlooked;
4. Sampling time is negligible.

The model incorporates the following parameters:

N = size of "super-population," or escapement;

M_i = number of marked fish in the population at time of the i^{th} sampling event (i=1, 2, …, s; $M_1 = 0$);

N_i = total number of fish in the population at time of the i^{th} sampling event (i=1, 2, …, s; $N_1=B_0$);

B_i= total number of new fish entering the population before the first event and between the i^{th} event and $(i+1)^{th}$ event, and still in the population at time of the $(i+1)^{th}$ event (i=1, …, s-1);

B_0 = the number of fish that entered the population before the first event and are still alive at the time of the first event; and

ϕ_i = survival probability for all fish between the i^{th} event and $(i+1)^{th}$ event (i=1, 2, …, s-1).

The following statistics were also used in the model:

m_i = number of marked fish captured in the i^{th} event (i=1, 2, …, s);

u_i = number of unmarked fish captured in the i^{th} event (i=1, 2, …, s);

$n_i = m_i + u_i$, total number of fish captured in the i^{th} event (i=1, 2, …, s);

R_i = number of the n_i fish that are released after the i^{th} event (i=1, 2, …, s-1; this may not be all of n_i fish due to losses on capture);

r_i = number of R_i fish released at i and captured again (i=1, 2, …, s-1); and

z_i = number of fish captured before i, not captured at i, and captured again later (i=1,2, …, s-1).

Seber (1982:page 204) recommended the following unbiased estimators:

$$\begin{aligned}
\hat{M}_i &= m_i + \frac{(R_i + 1)z_i}{r_i + 1}; \\
\hat{N}_i &= \frac{(n_i + 1)\hat{M}_i}{m_i + 1}; \\
\hat{\phi}_i &= \frac{\hat{M}_{i+1}}{\hat{M}_i - m_i + R_i}; \\
\hat{B}_i &= \hat{N}_{i+1} - \hat{\phi}_i(\hat{N}_i - n_i + R_i).
\end{aligned} \tag{5}$$

Seber also recommended that m_i and r_i should be greater than 10 for satisfactory performance of these bias-adjusted estimators.

The interval between the last (s^{th}) sampling event and the next-to-last ($(s\text{-}1)^{th}$) sampling event was assumed to be so short that the number of fish entering the population during this interval was negligible. Furthermore, sampling was assumed to extend to a time when immigration had ended, and the number of fish entering the population after the last sample was negligible. In the Jolly-Seber model, the total population is usually estimated as the sum of $\hat{B}_i$, the estimated number of fish that entered the population between sampling events. However, $\hat{B}_i$ are estimates of the number of fish that entered the population after sampling event i and were alive at sampling event i+1. These estimates exclude those fish in the escapement that entered after sampling event i but died before sampling event i+1. Consequently, the sum of the Jolly-Seber estimates of B_i would underestimate the spawning recruitment, except when all fish are known to survive from their entry to the next sampling event. To account for those fish that entered the system after sampling event i, but died before sampling event i+1, $\hat{B}_i$ was adjusted before summing (Schwarz et al. 1993). Let B_i^* denote the total number of new fish entering the population between sampling events (including those that died before the next sampling event). When recruitment and mortality are assumed to occur uniformly between sampling events, the maximum likelihood estimator for B_i^* is,

$$\hat{B}_i^* = \hat{B}_i \frac{\log(\hat{\phi}_i)}{\hat{\phi}_i - 1}. \tag{6}$$

$\hat{B}_0$, $\hat{B}_1$, and $\hat{B}_{s-1}$ are confounded parameters and cannot be estimated without further assumptions (Schwarz et al. 1993). However, we assumed recruitment had virtually ended before the last sampling event, so we set $\hat{B}_{s-1}$ to zero. The number of fish alive in the population at the second sampling event, N_2, was estimated as,

$$\hat{N}_2 = \hat{B}_0\phi_1 + \hat{B}_1. \tag{7}$$

So a reasonable estimate (Schwarz et al. 1993) of the number of fish that entered the system before the first sampling event and between the first and second sampling events, including those that entered the system and died before and between these sampling events, is,

$$\hat{N}_2 \frac{\log(\hat{\phi}_1)}{\hat{\phi}_1 - 1}. \quad (8)$$

I then estimated the super-population, or total escapement, as

$$\hat{N} = \hat{N}_2 \frac{\log(\hat{\phi}_1)}{\hat{\phi}_1 - 1} + \sum_{i=2}^{k-1} \hat{B}_i^* . \quad (9)$$

I used a non-parametric bootstrap technique to estimate variance and form a confidence interval for N. A computer program to produce these estimates, written in S-Plus (Insightful Corp. 2001), is available from X. Zhang, ADF&G Div. of Commercial Fisheries (xinxian.zhang@alaska.gov). The procedure works by resampling the observed experimental data to create a series of "pseudo-experiments," according to the following algorithm.

1. Analyze observed data using the Jolly-Seber method and Schwarz's adjustment described above to obtain the $\hat{N}$.
2. Sample with replacement from the observed n capture histories to generate a bootstrap sample of the same size n; analyze the bootstrap sample exactly as if it were the observed sample.
3. Repeat step (2) for 1,000 bootstrap samples to have 1,000 estimates of N from these bootstrap samples.
4. Calculate variance and standard error for N^* from the 1,000 bootstrap estimates of N.
5. Find the 95% confidence interval by taking the 0.025 and 0.975 quantiles of the 1,000 bootstrap estimates of N.

Because the three main spawning streams are well-separated from each other, I assumed that sockeye spawners did not migrate between them after they started entering the streams. I checked that assumption in 2004 and 2005 by examining capture histories by location, and found very few capture histories (less than one-tenth of one percent) showing movement between streams. Therefore I decided that the three independent population estimates (one for each stream) could be summed. This summed estimate was expected to be somewhat less than the total population of sockeye spawners in Klawock Lake because not all spawning areas were sampled. However, evidence from visual surveys indicate that a much smaller number of sockeye spawners use Hatchery Creek, and no other spawning areas have been observed in recent years (Lewis and Cartwright 2002; Cartwright and Lewis 2004; Cartwright and Conitz 2006).

Adult Population Age, Sex, and Length Distribution

About 600 adult sockeye salmon were sampled for length, sex, and scales (for age determination) at the Klawock weir. Fish were selected systematically to prevent selection bias, and weekly sampling goals were set throughout the run based on average weekly escapements from previous years. Length of each fish was measured from mid eye to tail fork, to the nearest millimeter (mm). Sex of the fish was decided by length and shape of the kype or jaw. Three scales were taken from the preferred area of each fish (INPFC 1963), and prepared for analysis as described by Clutter and Whitesel (1956). Scale samples were analyzed at the ADF&G salmon aging laboratory in Douglas, Alaska. Age classes were designated by the European aging system where freshwater and saltwater years are separated by a period (e.g. 1.3 denotes a five-year-old fish with one freshwater and three ocean years; Koo 1962). The proportion in each age-sex group was estimated based on the number in each group compared with the total number sampled. The average proportion in each age-sex group in each of four periods (approximate quartiles of the escapement), weighted by total escapement per period, was also estimated. Associated standard errors were estimated using standard statistical techniques for binomial proportions (e.g. Thompson 1992). The binomial standard error was expected to adequately approximate the standard error for a multinomial proportions. Mean lengths by age and sex and their standard errors were estimated as for simple random samples, weighted by the total escapement per week.

RESULTS

SUBSISTENCE HARVEST ESTIMATE

Sampling was conducted in the Klawock subsistence fishery on 11 days out of the 15 weekdays the fishery was open, between 7 and 31 July, 2006 (Table 2). The crew interviewed fishery participants following most sets, but on some days one or more sets were completed without an interview and the daily total was estimated. Effort, in terms of number of sets, and total sockeye salmon harvest, were highest during the third and early part of the fourth week (17–24 July).

Table 2.–Daily subsistence harvest and effort (number of sets) in the Klawock Inlet subsistence fishery in 2006. Daily harvest and effort are shown for only those days sampled in the two-stage harvest survey. Standard error is the standard error of the average harvest per interviewed set.

				Daily Sockeye Harvest (for sampling days only)		
Week	**Sampling Date**	**Sets Counted**	**Sets Interviewed**	**Reported in Interviews**	**Estimated Total**	**Standard Error**
1	7 July	18	17	97	103	11
2	10 July	12	12	88	88	8
	11 July	17	16	42	45	5
	12 July	21	20	200	210	23
3	17 July	47	44	204	218	11
	19 July	34	33	235	242	9
	20 July	48	46	287	299	12
4	24 July	47	44	281	300	9
	27 July	22	22	41	41	1
	28 July	9	9	257	257	54
5	31 July	4	4	168	168	43

Expanding the harvest totals reported in interviews to daily estimates accounting for missed interviews and weekly estimates accounting for days not sampled, the total harvest estimate was about 3,100 sockeye salmon (95% confidence interval 2,600–3,600; CV=8%). The third week of July, beginning on 16 July, had the largest estimated weekly harvest, 41% of the total, and an estimated 78% of the harvest was taken during and after that week (Table 3). Incidental harvest of other salmon species reported to the interviewers included 8 coho salmon, 4 chum salmon, and 28 pink salmon. These incidental harvests were considered inconsequential and no total harvest or variance estimates were calculated for them.

Table 3.–Summary of weekly estimates of subsistence sockeye effort and harvest in the Klawock Inlet fishery, 2006.

				Expanded totals by week		
Week	Week beginning	Sets counted	Sets interviewed	Estimated sockeye harvest	Std. error	Percentage of season total harvest
1	2 July	18	17	103	12	3%
2	9 July	50	48	571	123	18%
3	16 July	129	123	1,266	62	41%
4	23 July	78	75	997	196	32%
5	30 July	4	4	168	0	5%
All				3,105	240	

SOCKEYE ESCAPEMENT ESTIMATES

Weir Counts and Mark-Recapture Estimate

Between 20 June and 23 October 2006, the total count of sockeye salmon through the Klawock weir was 14,757 fish, of which 12,720 were full-size adults and 2,037 were jacks. The total count of coho salmon through the weir was 7,415 fish, of which 3,023 were full-size adults and over 4,392, or 59% of the total, were jack coho salmon (Appendix A). Coho salmon were first counted at the weir on 25 July, but the highest daily numbers were counted in September and October (Appendix A). Totals of 19,308 pink salmon and 224 chum salmon were counted through the weir between late July and the end of September. Dolly Varden char entered Klawock Lake throughout the season; a total of 750 fish were counted (Appendix A). However, some pink and chum salmon, Dolly Varden char, and trout species may spawn in the Klawock River or estuary below the weir, and smaller fish could also have passed through the weir pickets without being counted. Therefore, counts for these species are most likely incomplete.

At the weir, 3,104 sockeye salmon were tagged, representing about 20% of total number counted through the weir, during the 12 weeks between 9 July and 30 September 2006 (Table 4). Mark-recapture sampling was conducted between 17 August and 6 October, 2006; however, no sockeye spawners were found in Inlet or Halfmile Creek before 27 August (Table 5). Recapture samples were pooled by stream and grouped by week of marking (Tables 4 and 5). Chi-square tests for consistency yielded a non-significant result for capture probability in marking samples (χ^2=3, 2 df, *p*-value=0.27) and a significant result for capture probability in recapture samples (χ^2=57, 11 df, *p*-value<<0.01). Overall, since at least one test statistic was non-significant, these results indicated that marking and recapture data could be pooled without risking serious bias in the estimate. Very similar chi-square test results were obtained after stratifying the recapture data by sampling date rather than stream. I calculated a pooled Petersen estimate of about 13,600 fish (CV=4%; 95% confidence interval: 12,500–14,800). This estimate was lower than the weir count of 14,757 sockeye salmon, so the weir count should be considered the more accurate measure of escapement. Because the weir count was within the estimated confidence interval, though near the upper bound, the estimate confirmed that the weir count was most likely complete.

Of the 3,014 sockeye salmon tagged at the weir, 32 fish were recovered dead at the weir, but of these, only those ten fish that died within one week of being tagged were counted as tagging mortalities. This tagging mortality rate, of less than one-half to one percent, was considered negligible.

Table 4.–Numbers of sockeye salmon marked at the Klawock River weir, by week; number of recaptures by spawning stream and week when marked; and numbers and proportions of all recaptures by week when marked, in 2006.

Marking date (week)	Number marked	Recaptures by spawning stream and date marked			Outcomes for all fish marked at weir		
		Threemile	Inlet	Halfmile	Total recaptured	Not recaptured	Proportion recaptured
9-15 Jul	61	5	6	1	12	49	0.20
16-22 Jul	6	0	1	0	1	5	0.17
23-29 Jul	153	18	9	4	31	122	0.20
30 Jul -5 Aug	51	2	2	2	6	45	0.12
6-12 Aug	66	4	5	2	11	55	0.17
13-19 Aug	158	21	11	1	33	125	0.21
20-26Aug	780	76	16	25	117	663	0.15
27 Aug -2 Sep	546	44	11	8	63	483	0.12
3-9 Sep	682	53	13	11	77	605	0.11
10-16 Sep	208	8	4	2	14	194	0.07
17-23 Sep	252	4	4	4	12	240	0.05
24-30 Sep	51	0	0	0	0	51	0
Total marked	3,014						
All recaptures, by stream		235	82	60	377		

Table 5.–Numbers of sockeye salmon sampled in each of the three main spawning streams in Klawock Lake for mark-recovery, by sampling date (week).

Week	Number of fish sampled by week and location (stream)		
	Threemile	Inlet	Halfmile
13-19 Aug	23	0	0
20-26 Aug	33	0	0
27 Aug-2 Sep	239	27	40
3-9 Sep	197	119	83
10-16 Sep	272	108	34, 53[a]
17-23 Sep	192	113	14
24-30 Sep	51	32	-
1-7 Oct	60	5	8
All dates	1,067	403	232

[a] Two samples were taken at Halfmile Creek during this week, on 11 and 15 September.

Spawning Grounds Mark-Recapture Study

At Threemile Creek, the crew sampled 1,067 sockeye salmon at the mouth and in the channel of the stream (Table 6), during eight sampling events approximately one week apart (17, 24, 29 August; 6, 12, 19, 28 September; and 6 October). An additional sampling event on 11 October yielded only two fish so this event was dropped from the analysis. Low numbers of fish were recaptured overall, and particularly in some sampling events. Overall, about 8% of the total number of fish sampled were recaptured once: 58 fish were recaptured in the next event following their first capture, and 24 fish were recaptured in the second or third event after their first capture. Only three fish were recaptured more than once (Table 6). The Jolly-Seber estimate for the Threemile Creek spawning population was about 8,100 sockeye salmon (95% confidence interval: 6,100–17,700; CV=38%). The uncertainty, or sampling error, exceeded the objective (coefficient of variation less than 15%).

Table 6.–Summary of capture-recapture histories of sockeye salmon sampled on the spawning grounds at Threemile Creek in Klawock Lake, 2006.

Capture-recapture category	Capture history[a]	Number of fish
Captured only once; tagged and released	10000000	21
	01000000	32
	00100000	212
	00010000	176
	00001000	246
	00000100	189
	00000010	46
	00000001	60
Subtotal		**982**
Captured and released, then recaptured and released at next event	01100000	1
	00110000	15
	00011000	13
	00001100	22
	00000110	2
	00000011	5
Subtotal		**58**
Captured and released, not captured in next event, but recaptured and released in a later event	10010000	2
	00101000	7
	00100100	5
	00010100	3
	00010010	2
	00001010	1
	00001001	3
	00000101	1
Subtotal		**24**
Recaptured and released more than once	00011100	3
Subtotal		**3**
Total sampled and released		**1,067**

[a] Capture histories show one digit for each of eight sampling events in chronological order: a "1" indicates a sampling event in which the fish was caught, and a "0" indicates a sampling event in which the fish was not caught. The number of fish with each observed capture history is shown.

At Inlet Creek, the crew sampled 403 sockeye salmon at the mouth and in the channel of the stream (Table 7). The five sampling events took place on 30 August and 5, 11, 18, and 27 September. A final sampling event on 4 October yielded only five fish; tag records from these five fish were added to those from the 27 September event. Only 4% of total number of fish sampled were recaptures: 13 fish were caught in the event following their first capture, and only two in a later recapture event (Table 7). The Jolly-Seber estimate of the total spawning population in Inlet Creek was about 1,600 sockeye salmon (95% CI: 800–3,700; CV=43%). The large sampling error exceeded the objective (coefficient of variation less than 15%).

Table 7.–Summaries of capture-recapture histories of sockeye salmon sampled on the spawning grounds at Inlet Creek in Klawock Lake, 2006.

Capture-recapture category	Capture history[a]	Number of fish
Captured only once; tagged and released	10000	23
	01000	111
	00100	106
	00010	112
	00001	36
Subtotal		**388**
Captured and released, then recaptured and released at next event	11000	3
	01100	7
	00110	2
	00011	1
Subtotal		**13**
Recaptured and released in later event	10100	1
	01010	1
Subtotal		**2**
Total sampled and released		**403**

[a] Capture histories show one digit for each of five sampling events in chronological order: a "1" indicates a sampling event in which the fish was caught, and a "0" indicates a sampling event in which the fish was not caught. The number of fish with each observed capture history is shown.

At Halfmile Creek, the crew sampled only 232 sockeye spawners (Table 8), due to the lower abundance of fish in that stream. The six sampling events were on 28 August; 5, 11, 15, and 21 September, and 2 October. About 12% of the fish sampled in Halfmile Creek were recaptured, a higher recapture rate than in the other two streams. Eleven fish were recaptured in the event following their first capture; 13 fish were recaptured in a later event; and four fish were recaptured more than once (Table 8). The spawning population estimate for Halfmile Creek was about 1,000 sockeye salmon (95% CI: 600–1,900; CV=31%). Again, the sampling error exceeded the objective.

As in previous years, recapture data showed few or no instances of movement of sockeye spawners between streams, so I considered the three population estimates to be independent. The sum of the three estimates was about 11,000 fish (CV=30%). The combined spawning population estimate was lower than the weir count, but perhaps not significantly lower due to the large amount of uncertainty in the estimate. The combined sampling error was less than the individual estimates, but still exceeded the objective.

Table 8.–Summaries of capture-recapture histories of sockeye salmon sampled on the spawning grounds at Halfmile Creek in Klawock Lake, 2006.

Capture-recapture category	Capture history[a]	Number of fish
Captured only once; tagged and released	100000	37
	010000	68
	001000	28
	000100	51
	000010	12
	000001	8
Subtotal		**204**
Captured and released, then recaptured and released at next event	110000	1
	011000	4
	001100	4
	000011	2
Subtotal		**11**
Recaptured and released in later event	010100	6
	001010	2
	000101	2
	100100	2
	010010	1
Subtotal		**13**
Recaptured and released more than once	011100	3
	010110	1
Subtotal		**4**
Total sampled and released		**232**

[a] Capture histories show one digit for each of six sampling events in chronological order: a "1" indicates a sampling event in which the fish was caught, and a "0" indicates a sampling event in which the fish was not caught. The number of fish with each observed capture history is shown.

Adult Population Age, Sex, and Length Distribution

Length and sex data and scale samples were collected from 674 sockeye salmon at the Klawock River weir, and ages were determined for 605 of these fish (Table 9). Age-1.2 fish from the 2002 brood year were the largest age class, representing about 59% (weighted proportion) of the 2006 escapement. If weighted proportions were used, the second largest age class was age-2.2 fish from the 2001 brood year, representing about 23% of the escapement. However, a roughly equal number of age-1.3 fish, also from the 2001 brood year, were sampled, and the simple proportions of age-1.3 and age-2.2 fish in the total sample were each about 14%. Age-1.1 jacks were the other age class with a noticeable discrepancy between simple and weighted proportions. The simple proportion more closely reflects the proportion of jacks counted at the weir (2,037 jacks out of 14,757 sockeye salmon). Although the weighted average proportions were different than the simple proportions in some cases, these differences may not be significant due to the larger sampling error in the weighted proportions (Table 9). The simple proportions were used for long-term comparisons of age compositions, to be consistent with estimates from most previous years (Appendix B). Compared with weekly escapement numbers, which peaked in late August, disproportionate numbers of fish were sampled earlier in the run. Age-1.1 jacks and age-1.3 fish appeared in greater proportions during the first quarter of the run, and age-1.2 and -2.2 fish were dominant after the first quarter of the run (Table 10).

Table 9.–Age and sex composition of sockeye salmon in the 2006 Klawock Lake escapement, as simple percentages of total sample and percentages weighted by escapement through the weir in four periods (approximate quartiles shown in Table 10). Standard errors are shown in parentheses.

Brood year	**2003**	**2002**	**2001**	**2002**	**2001**	**2000**	
Age class	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**All ages**
Male							
Number	86	185	51	9	36	1	368
Percent (simple)	14.2 (1.4)	30.6 (1.9)	8.4 (1.1)	1.5 (0.5)	6.0 (1.0)	0.2 (0.2)	60.7 (2.0)
Percent (weighted)	4.6 (0.9)	30.0 (5.5)	6.2 (2.7)	1.5 (1.3)	7.6 (3.3)	0.4 (0.4)	50.3 (6.0)
Female							
Number		144	38	2	49	4	237
Percent (simple)		23.8 (1.7)	6.3 (1.0)	0.3 (0.2)	8.1 (1.1)	0.7 (0.3)	39.2 (2.0)
Percent (weighted)		29.3 (5.5)	2.4 (1.0)	0.5 (0.5)	15.3 (4.3)	2.3 (1.3)	49.7 (6.0)
All fish							
Number	86	**329**	**89**	11	**85**	5	605
Percent (simple)	14.2 (1.4)	**54.4 (2.0)**	**14.7 (1.4)**	1.8 (0.5)	**14.0 (1.4)**	0.8 (0.4)	
Percent (weighted)	4.6 (0.9)	**59.3 (5.8)**	**8.6 (2.9)**	1.9 (1.7)	**22.9 (5.0)**	2.7 (1.7)	100.0%
CV (weighted proportions)	20.5%	**9.8%**	**33.9%**	87.7%	**21.8%**	63.6%	

Table 10.–Age composition in the 2006 Klawock Lake escapement by week, as proportion of total sample per week in each age class. The four periods shown divide the run into four approximate quartiles based on escapement count.

		Proportion of weekly escapement, by age class						**Number**	**Weir**
Week	**Period**	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**	**sampled**	**count**
9-Jul	1	0.15	0.38	0.26	0	0.21	0	34	121
16-Jul		0.25	0.75	0	0	0	0	4	29
23-Jul		0.17	0.51	0.23	0	0.09	0	35	987
30-Jul		0.75	0	0.13	0	0.13	0	8	65
6-Aug		0.38	0.38	0.13	0.04	0.05	0.01	97	228
13-Aug		0.11	0.59	0.19	0.02	0.09	0.00	260	1,418
20-Aug	2	0.03	0.75	0.03	0.02	0.15	0.02	60	3,609
27-Aug	3	0	0.53	0.13	0.03	0.24	0.08	38	4,163
3-Sep	4	0	0.67	0.03	0.03	0.28	0	36	1,204
10-Sep		0	0.48	0	0	0.52	0	29	1,943
24-Sep		0	0.50	0	0	0.50	0	4	759

Length compositions showed additional growth for additional ocean years, but not for additional freshwater years (Table 11). The exception was age-2.1 sockeye jacks, which were substantially larger than their age-1.1 counterparts, averaging almost 430 mm. These older and larger jacks are difficult to distinguish visually from full adult fish, but constitute a much smaller proportion of the overall escapement than the age-1.1 jacks.

Table 11.–Length composition (average mid-eye to fork length) of adult sockeye salmon in the 2006 Klawock Lake escapement, by age class and sex, and weighted by weekly escapement through the weir (weeks 28–39).

Brood year	**2003**	**2002**	**2001**	**2002**	**2001**	**2000**
Age class	**1.1**	**1.2**	**1.3**	**2.1**	**2.2**	**2.3**
Male						
Sample size	85	185	51	11	36	1
Mean length in mm (SE)	386 (3)	503 (2)	572 (4)	429 (8)	507 (5)	507 (0)
Female						
Sample size	-	144	38	-	49	4
Mean length in mm (SE)	-	499 (2)	527 (6)	-	510 (3)	539 (19)
All Fish						
Sample size	85	329	89	11	85	5
Mean length in mm (SE)	386 (3)	502 (1)	567 (3)	429 (8)	508 (3)	525 (17)

DISCUSSION

The 2006 sockeye escapement into Klawock Lake continued to follow the very stable pattern of escapement sizes that have been observed since 2001. Although still lower than average, the subsistence harvest of Klawock sockeye salmon rebounded after its near failure in 2005. The combined estimate of subsistence harvest plus escapement in 2006 was below but remarkably close to the six-year average of subsistence harvest plus escapement (Table 12).

Table 12.–Summary of subsistence harvest and escapement estimates for Klawock Lake sockeye salmon in 2001–2006.

Year	**Estimated subsistence harvest**	**95% confidence interval for subsistence harvest**	**Estimated escapement**	**95% confidence interval for escapement**	**Subsistence harvest + escapement**
2001	6,400	5,300–7,400	13,000	8,000–18,000	19,400
2002	6,000	5,300–6,800	12,600	11,500–15,100	18,600
2003	6,000	5,000–7,000	21,000	18,000–27,000	27,000
2004	4,500	3,800–5,100	12,400	12,000–14,000	16,900
2005	175	110–240	14,840	na (weir count)	15,000
2006	3,100	2,600–3,600	14,760	na (weir count)	17,900
Mean	4,600		14,800		19,400

The 2006 subsistence harvest apparently fell short of need, according to at least some Klawock residents, although it was obviously much better than the previous year (P. Brown, Klawock Community Association member, personal communication 2006). The harvests in 2001–2003 of about 6,000 sockeye salmon probably more closely approached the annual community need; however, that need varies from year to year and is difficult to quantify (Ratner et al. 2005). The stability of escapement levels during the six-year period from 2001 to 2006 provides evidence that annual harvests of up to 6,000 sockeye salmon and possibly somewhat higher could be supported.

Recent discussions with community residents and fisheries managers about the subsistence sockeye season in light of 2001–2006 research findings have focused on the timing of harvest with respect to escapement timing. The harvest dates, set by regulation [Alaska Administrative

Code 5AAC 01.710(e)], occur well before the usual peak escapement dates, causing concern that early parts of the run are being disproportionately affected. These concerns are exacerbated with conditions such as the low water in 2004 and 2005, which can delay sockeye migration into the river and lake in July and early August. If large numbers of pink salmon are also present, both commercial and subsistence effort can increase while sockeye salmon, delayed in their migration, are more vulnerable to harvest. Run timing is a heritable trait in salmonids, and failing to preserve run timing could erode stock productivity (Burgner 1991). According to Klawock residents with local ecological knowledge, sockeye runs have been later in recent years than in the past (Ratner et al. 2005).

Subsistence harvests estimated on the fishing grounds in 2001–2006 were consistently larger each year than the total annual harvest reported by subsistence users returning completed permits (Table 13). Reported harvests accounted for an average of only 62% of estimated harvests, weighted by estimated harvest size, over this six-year period. The more complete harvest estimate obviously contributes to a more accurate estimate of total run size (although estimates of commercial harvest are still lacking).

Table 13.–Sockeye harvest estimates for the Klawock Inlet subsistence fishery, compared with totals reported on returned subsistence permits, for 2001–2006.

	Total sockeye harvest		
Year	**Estimated from survey data**	**Reported on permit**	**Percent of estimated harvest reported on permit**
2001	6,400	4,433	69.3%
2002	6,000	3,778	63.0%
2003	6,000	3,195	53.3%
2004	4,500	2,697	59.9%
2005	175	238	136.0%
2006	3,100	1,859	60.0%
Average	4,600	2,700	73.6%
		Weighted average percentage	61.9%

Weir count accuracy appears to have improved between 2001 and 2006. In 2001 and 2003, the weir count was much lower than the estimate, which was attributed to sockeye salmon escaping uncounted through holes in the weir or during flooding (Lewis and Cartwright 2002; Cartwright and Conitz 2006). In those years the mark-recapture estimates were accepted as a better representation of escapement, although they were associated with high levels of uncertainty. In 2002 and 2004 the weir counts fell within the range of their respective estimates and the estimates had less uncertainty (Cartwright and Lewis 2004; Conitz et al. 2006). In 2005 and 2006 the point estimates were lower than the weir counts (Conitz and Cartwright 2007), and although the counts fell within the estimated confidence intervals, clearly the counts represented at least minimum escapement. Substantial permanent improvements to the weir in 2004 (Conitz et al. 2006) improved confidence in the counts; the mark-recapture estimates in each of the three years since the changes were made, although sometimes low, generally confirmed the counts.

Attempts to estimate sockeye escapement with spawning grounds only mark-recapture experiments in 2004–2006 were at least partly successful, although the spawning grounds measures underestimated weir-based measures in all three years and their sampling errors exceeded the objective. Nevertheless, I feel the open population Jolly-Seber model, with an individual capture history for each fish, provided a more realistic and reliable approach to estimating the spawning-grounds population than previous closed population models with batch-marked strata. Furthermore, with the set of individual capture histories, I was able to re-evaluate the closed model assumptions and fit. In addition to providing a comparison between the weir based and spawning grounds based estimates, the capture histories also allowed me to track individual fish to their spawning streams. Based on previous years' visual surveys of Klawock Lake and its tributaries, I assumed that most sockeye salmon would eventually spawn in one of the three main inlet streams: Threemile, Inlet, and Halfmile Creeks (Cartwright and Conitz 2006). By deliberately ignoring other, minor spawning areas, I accepted the fact that the sum of spawning population estimates for the three major spawning areas would underestimate the total population by some, probably small, amount. Nevertheless, the partial spawning population estimate has tracked total escapement at the weir to within the limits of uncertainty over the three year period. Occasional surveys of Hatchery Creek and observations of other areas around the lake have not revealed any major, overlooked group of sockeye spawners. The capture histories also offered some insight into questions about timing, distribution, and residence time of sockeye spawners in the three main tributaries. No obvious difference was observed between the three spawning groups for entry timing, except in 2004 when proportionately more fish tagged earlier in the run were recovered in Inlet Creek than in the other two streams (Conitz et al. 2006). The spawning period appears to be approximately the same in each tributary. Very little movement of tagged fish from one inlet stream to another was observed in the three years of tagging studies, and I feel confident that each stream comprises a distinct spawning group or subpopulation. Low recapture numbers in Inlet and Threemile Creeks, even with weekly sampling, suggested that large numbers of new fish entered these streams during the spawning period, but many fish remained in the stream less than one week. Flooding and heavy scouring at times may flush most sockeye spawners out of the streams.

Ultimately, the reason for extensive study of spawning grounds based population estimates was to develop a reliable method of estimating sockeye escapement in Klawock Lake without a weir, thereby reducing cost. However the individual spawning grounds estimates based on the Jolly-Seber open population model thus far have had a much greater degree of uncertainty than the weir based mark-recapture estimate. In the 2006 study, the coefficients of variation for the Jolly-Seber estimates ranged from 30% to 43%, compared with a coefficient of variation of only 4% for the weir-based estimate.

Unfortunately, because the commercial harvest of Klawock sockeye salmon remains unknown, and is probably not negligible, a complete assessment of the stock is not possible. The largest commercial seine harvest of sockeye salmon in Southeast Alaska usually occurs in the District 104 fishery, off the outer coast of Prince of Wales Island (Geiger et al. 2005). Most sockeye salmon returning to Klawock Lake undoubtedly pass through this area, although their timing and migration routes and the degree of coincidence with the seine fishery are unknown (Geiger et al. 2005; Ratner et al. 2005). Apportionment of commercial catches among individual stocks using genetic markers is technically possible (C. Habicht, ADF&G Gene Conservation Lab, personal communication 2006), and the feasibility of doing so in fisheries potentially intercepting Klawock and other Prince of Wales Island sockeye stocks should be studied.

Klawock residents and other observers continue to be concerned about the small size of sockeye runs returning to the Klawock River recently, compared with the size of runs they remember, or have heard of, in the past (Ratner et al. 2005). Reasons for this apparent loss in productivity could include over-exploitation of the stock in past commercial fisheries, loss and degradation of spawning and rearing habitat in Klawock Lake and its watershed, and excessive competition from hatchery fry in the lake. Until the most important factors influencing production are better understood for this system, efforts to supplement the stock with hatchery production may not only fail, but also put the existing wild stock at risk. The realities in this system in recent years include the habitat degradation caused by clear-cut logging, evidence of food limitation in the lake, very high levels of hatchery stocking, and an unknown level of commercial harvest. Looking farther back, the Klawock system sustained a high volume, directed commercial fishery for over one hundred years. In the physical environment, sediment cores have shown evidence of changes in the lake starting in the late 1930s, associated with high sedimentation, possibly due to high rainfall and landslides (A. Mazumder, University of Victoria, unpublished data). Given all these facts, the potential for sockeye production in Klawock Lake may be less than it once was.

Despite the high numbers of fish released, the hatchery program has ultimately not increased sockeye production from Klawock Lake. Over 1,400 juvenile sockeye salmon were sampled in 2001–2003 and over 1,800 adults were sampled in 2003–2006 for marked otoliths, and thermal marks were found in only about one percent of these fish (22 juveniles and 25 adults; ADF&G Mark, Tag, and Age Laboratory database 2007, http://tagotoweb.adfg.state.ak.us/OTO/reports/MarkSummary.aspx). The survival rate of hatchery-produced sockeye fry was estimated to be only about 2%, from date of release in March through May to date of sampling in July. Of over one million sockeye fry released from the hatchery in 2001 and 2002, only about 150 fish returned to the Klawock Lake system as adults. To produce these, over 1,000 fish were taken as broodstock from the naturally spawning population in Klawock Lake in 2000 and 2001. Therefore, the end result of hatchery stocking for those two years was a net loss of about 850 adult sockeye salmon (J. Conitz, memo to Scott Kelly ADF&G Div. of Commercial Fisheries, March 2007).

An independent reviewer noticed that an increase in average freshwater age of sockeye salmon returning to Klawock Lake was associated with a lower proportion of cladocerans in the zooplankton community, and very high numbers of hatchery-stocked fish in the lake (A. Mazumder, University of Victoria, personal communication and unpublished report, 2006). Age composition of Klawock sockeye escapements during the 25-year period 1982–2006, show higher proportions of fish with two years of freshwater growth in recent years (Appendix B). This apparent shift could indicate slower sockeye fry growth, which would result in more fry remaining in the lake an additional year. A concurrent shift towards lower proportions of cladocerans in the total zooplankton population in Klawock Lake could indicate a food limitation for sockeye fry rearing in the lake (Mazumder and Edmundson 2002). During this period, over one million sockeye and coho fry were planted into Klawock Lake annually by the hatchery, in most years, with plants of nearly five million fish in 1989 and again in 2003 (ADF&G Mark, Tag, and Age Laboratory database 2007, http://tagotoweb.adfg.state.ak.us/CWT/reports/hatcheryrelease.asp).

Habitat restoration activities to repair damage to the drainages from logging and road-building, such as those implemented recently by the Klawock Watershed Council, may help improve fish production over the long term. So far, however, the restoration projects have not included an adequate monitoring component to evaluate their effectiveness in restoring both useable habitat and fish populations. Furthermore, continuing threats to sockeye spawning and rearing habitat in Klawock Lake, such as construction along and across stream channels and water removals from the primary spawning streams, must be addressed.

At present, we may have to conclude that, given current conditions in the Klawock Lake system, sockeye runs of 50,000 or more fish are unlikely. Recent escapements of between 12,000 and 20,000 sockeye salmon appear to be stable and sustainable, and capable of providing for a subsistence harvest of about 6,000 fish. However, six years is too short a period with which to determine whether this escapement level is sustainable for the long term. Because of the importance of this sockeye run to Klawock residents and other people in the region, continued careful monitoring of subsistence harvest and escapement, at minimum, is recommended. Management policies should be re-evaluated as new information becomes available, ideally every year. Activities affecting fish habitat and any proposals to re-introduce hatchery stocking should also be carefully evaluated, with the priority being to maintain the Klawock sockeye run and subsistence fishery to at least the 2001–2006 levels.

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 estimators of salmon escapements and other populations. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2106.

Bernard, D. R., A. E. Bingham, and M. Alexandersdottir. 1998. The mechanics of onsite creel surveys in Alaska. Alaska Department of Fish and Game, Special Publication No. 98-1, Anchorage, Alaska.

Burgner, R. L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*) [*in*] C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vancouver.

Cartwright, M. A., and B. A. Lewis. 2004. Klawock Lake sockeye salmon (*Oncorhynchus nerka)* stock assessment project 2002 annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries Regional Information Report 1J04-12, Juneau.

Cartwright, M. A. and J. M. Conitz. 2006. Klawock Lake sockeye salmon (*Oncorhynchus nerka*) stock assessment project: 2003 annual report and 2001-2003 final report. Alaska Department of Fish and Game, Fishery Data Series No. 06-64, Anchorage.

Clutter, R. and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin of the International Pacific Salmon Fisheries Commission 9, New Westminster, British Columbia.

Conitz, J. M. and M. A. Cartwright. 2007. Klawock Lake subsistence sockeye salmon project 2005 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 07-42, Anchorage.

Conitz, J. M., M. A. Cartwright, and H. J. Geiger. 2006. Klawock Lake subsistence sockeye salmon project 2004 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 06-72, 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. Chapter 2 [*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.

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

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

Langdon, S. J. 1977. Technology, ecology, and economy: fishing systems in southeast Alaska. Stanford University, Ph.D., Anthropology.

Lewis, B. A. and T. P. Zadina. 2001. The history of subsistence and commercial fisheries, stock assessment and enhancement activities, and watershed disturbances in the Klawock Lake drainage on Prince of Wales Island, 2000 annual report. Alaska Department of Fish and Game Regional Information Report No. 1J01-39.

REFERENCES CITED (Continued)

Lewis, B.A. and M. Cartwright. 2002. Klawock Lake sockeye salmon (*Oncorhynchus nerka*) stock assessment project 2001 annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J02-24.

Insightful Corp. 2001. S-plus for Windows: Guide to Statistics. Insightful Corporation. Seattle.

Mazumder, A. and J. A. Edmundson. 2002. Impact of fertilization and stocking on trophic interactions and growth of juvenile sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 59: 1361–1373.

Moser, J. F. 1899. The salmon and salmon fisheries of Alaska. Bulletin of the United States Fish Commission. U.S. Government Printing Office, Washington, D.C.

Orrell, R. F., C. Rosier, and L. R. Simpson. 1963. Stream catalog of Southeastern Alaska Regulatory Districts Nos. 3 and 4. U.S. Fish and Wildlife Service Special Scientific Report, Fisheries No. 465, Washington, D.C.

Pollock, K. H., J. D. Nichols, C. Brownie, and J. E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Society Monographs No. 107, 97 pp.

Ratner, N. C., P. Brown, J. A. Dizard, A. Paige, J. Rowan, M. Smith, M. F. Turek, and D. Yates. 2005. Klawock River and Sarkar River subsistence salmon harvest use patterns. U.S. Fish and Wildlife Service, Fisheries Information Service Report No. FIS01-105, Anchorage.

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.

Roppel, P. 1982. Alaska's salmon hatcheries, 1891–1959. National Marine Fisheries Service, Portland, OR. 299 pp.

Schwarz, C. J., R. E. Bailey, J. R. Irvine and F. C. Dalziel. 1993. Estimating salmon spawning escapement using capture-recapture methods. Can. J. Fish. Aquat. Sci. 50: 1181–1197.

Scrivener, J. C. and M. J. Brownlee. 1989. Effects of forest harvesting on spawning gravel and incubation survival of chum (*Oncorhynchus keta*) and coho (*Oncorhynchus kisutch*) in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46(4):681–696.

Seber, G. A. F. 1982. The estimation of animal abundance. 2nd ed. Griffin,London.

Thompson, S. K. 1992. Sampling. Wiley-Interscience, New York. 343 pp.

APPENDICES

Appendix A.–Daily and cumulative counts of fish passed through the Klawock Lake weir in 2006.

			Sockeye Salmon			Daily Counts, Other Species				
Date	Water depth (m)	Water temp (°C)	Daily count	Cumulative Count	Daily Number Tagged	Coho adults	Coho jacks	Pink salmon	Chum salmon	Dolly varden
26-Jun	0.97	-	2	2	0	0	0	0	0	0
27-Jun	0.94	-	2	4	0	0	0	0	0	10
28-Jun	0.97	-	0	4	0	0	0	0	0	0
29-Jun	0.97	-	0	4	0	0	0	0	0	0
30-Jun	0.81	-	0	4	0	0	0	0	0	0
1-Jul	0.91	-	0	4	0	0	0	0	0	0
2-Jul	0.86	-	0	4	0	0	0	0	0	0
3-Jul	0.84	-	0	4	0	0	0	0	0	0
4-Jul	0.81	-	6	10	0	0	0	0	0	0
5-Jul	0.81	-	9	19	0	0	0	0	0	0
6-Jul	0.79	-	17	36	0	0	0	0	0	11
7-Jul	0.79	17.0	22	58	0	0	0	0	0	15
8-Jul	0.76	17.0	9	67	0	0	0	0	0	0
9-Jul	0.89	-	19	86	0	0	0	0	0	33
10-Jul	0.76	15.0	45	131	35	0	0	0	0	29
11-Jul	0.89	16.0	11	142	9	0	0	0	0	4
12-Jul	0.89	16.0	17	159	17	0	0	0	0	3
13-Jul	0.86	16.0	1	160	0	0	0	0	0	0
14-Jul	0.84	16.0	28	188	0	0	0	0	0	17
15-Jul	0.84	18.0	0	188	0	0	0	0	0	0
16-Jul	0.84	-	8	196	0	0	0	0	0	29
17-Jul	0.84	15.0	0	197	0	0	0	0	0	0
18-Jul	0.76	15.0	1	197	0	0	0	0	0	3
19-Jul	0.79	16.0	0	197	0	0	0	0	0	0
20-Jul	0.76	17.0	3	200	0	0	0	0	0	4
21-Jul	0.76	16.0	17	217	6	0	0	0	0	4
22-Jul	0.76	16.0	0	217	0	0	0	0	0	0
23-Jul	0.79	-	3	220	0	0	0	0	0	5
24-Jul	0.79	17.0	2	222	0	0	0	0	0	5
25-Jul	0.86	17.0	837	1,059	42	22	2	11	0	220
26-Jul	0.91	16.0	53	1,112	20	2	2	0	0	0
27-Jul	0.97	16.0	79	1,191	79	6	0	3	0	2
28-Jul	0.97	16.0	13	1,204	12	2	0	0	0	0
29-Jul	0.97	16.0	0	1,204	0	0	0	0	0	0
30-Jul	0.91	-	1	1,205	0	1	3	0	0	0
31-Jul	0.86	16.0	7	1,212	7	8	0	1	0	0
1-Aug	0.89	15.0	11	1,223	11	8	1	1	0	0
2-Aug	0.94	15.0	13	1,236	10	13	1	0	0	6
3-Aug	0.97	15.0	8	1,244	8	4	0	0	0	0
4-Aug	1.02	15.0	11	1,255	11	5	7	2	0	2
5-Aug	0.99	16.0	14	1,269	4	1	1	0	0	2
6-Aug	0.97	-	11	1,280	0	2	3	0	0	0
7-Aug	0.94	16.0	11	1,291	11	18	7	0	0	0
8-Aug	1.07	16.0	130	1,421	43	39	8	26	0	25
9-Aug	1.07	16.0	37	1,458	7	9	4	2	0	0
10-Aug	1.07	16.0	6	1,464	5	4	3	1	0	0
11-Aug	1.02	16.0	8	1,472	0	5	9	0	0	0
12-Aug	0.97	16.0	25	1,497	0	23	5	5	15	0
13-Aug	0.97	-	43	1,540	0	8	2	1	0	0
14-Aug	1.02	15.0	48	1,588	12	19	5	7	20	0

Appendix A.–continued (page 2 of 3)

			Sockeye Salmon			Daily Counts, Other Species				
Date	**Water depth (m)**	**Water temp (°C)**	**Daily count**	**Cumulative Count**	**Daily Number Tagged**	**Coho adults**	**Coho jacks**	**Pink salmon**	**Chum salmon**	**Dolly varden**
15-Aug	0.99	14.0	259	1,847	30	14	5	6	2	8
16-Aug	0.94	15.0	114	1,961	6	7	12	13	14	3
17-Aug	0.91	15.0	97	2,058	15	8	4	2	31	3
18-Aug	0.89	15.0	462	2,520	49	39	12	5	0	2
19-Aug	0.89	16.0	395	2,915	46	19	13	33	13	1
20-Aug	0.79	-	167	3,082	0	21	6	52	9	0
21-Aug	0.86	15.0	357	3,439	47	38	22	62	31	19
22-Aug	0.86	15.0	1,012	4,451	296	93	29	506	7	18
23-Aug	0.86	15.0	436	4,887	172	7	12	524	2	23
24-Aug	0.86	15.0	461	5,348	89	0	19	429	2	32
25-Aug	0.84	15.0	505	5,853	85	8	32	766	5	20
26-Aug	0.84	15.0	671	6,524	91	3	31	504	9	11
27-Aug	0.86	-	1,280	7,804	0	2	24	1,935	14	16
28-Aug	0.89	15.0	582	8,386	296	81	19	1,970	0	28
29-Aug	1.09	15.0	628	9,014	157	88	22	2,445	3	17
30-Aug	0.94	15.0	311	9,325	37	27	12	2,312	8	9
31-Aug	1.04	15.0	125	9,450	0	0	39	748	4	8
1-Sep	1.40	15.0	1,149	10,599	0	1	51	1,676	9	32
2-Sep	1.52	15.0	88	10,687	57	2	52	2,278	2	18
3-Sep	1.37	14.0	68	10,755	7	2	29	941	1	5
4-Sep	1.22	14.0	58	10,813	52	42	20	64	3	7
5-Sep	1.09	14.0	104	10,917	67	67	34	215	2	3
6-Sep	1.02	14.0	153	11,070	144	94	57	54	1	5
7-Sep	0.99	14.0	291	11,361	103	56	87	61	2	0
8-Sep	1.32	14.0	397	11,758	240	8	87	251	1	8
9-Sep	1.22	14.0	133	11,891	69	3	31	291	2	3
10-Sep	1.40	-	276	12,167	0	3	88	29	2	0
11-Sep	1.35	14.0	184	12,351	83	288	54	237	2	0
12-Sep	1.19	13.0	154	12,505	61	1	72	149	0	0
13-Sep	1.19	13.0	55	12,560	26	3	83	52	3	0
14-Sep	1.12	13.0	50	12,610	5	0	107	81	1	1
15-Sep	1.02	12.0	65	12,675	16	1	116	40	0	0
16-Sep	0.91	12.0	32	12,707	17	1	161	50	2	0
17-Sep	0.91	-	86	12,793	0	1	89	92	1	0
18-Sep	0.91	13.0	174	12,967	34	183	111	43	0	1
19-Sep	0.89	12.0	75	13,042	13	78	78	9	0	0
20-Sep	0.94	12.0	301	13,343	25	69	205	67	0	1
21-Sep	1.07	12.0	244	13,587	57	6	262	13	0	0
22-Sep	1.07	12.0	153	13,740	76	4	154	47	0	1
23-Sep	1.32	12.0	94	13,834	47	3	127	18	0	0
24-Sep	1.40	-	634	14,468	0	3	366	49	0	0
25-Sep	1.80	12.0	36	14,504	12	308	156	103	0	0
26-Sep	1.55	12.0	5	14,509	3	7	48	17	1	0
27-Sep	1.37	12.0	3	14,512	1	1	16	4	0	0
28-Sep	1.19	12.0	14	14,526	6	3	55	2	0	0
29-Sep	1.98	12.0	65	14,591	29	4	136	3	0	2
30-Sep	1.75	-	2	14,593	0	7	45	0	0	0

Appendix A.–continued (page 3 of 3)

Date	Water depth (m)	Water temp (°C)	Sockeye Salmon: Daily count	Cumulative Count	Daily Number Tagged	Daily Counts, Other Species: Coho adults	Coho jacks	Pink salmon	Chum salmon	Dolly varden
1-Oct	1.50	-	2	14,595	0	6	57	0	0	0
2-Oct	1.32	11.0	1	14,596	0	0	23	0	0	0
3-Oct	1.17	10.0	4	14,600	0	201	37	0	0	0
4-Oct	1.07	10.0	14	14,614	0	75	51	0	0	2
5-Oct	1.30	10.0	23	14,637	0	4	186	0	0	1
6-Oct	1.19	10.0	2	14,639	0	1	63	0	0	4
7-Oct	1.17	10.0	2	14,641	0	1	19	0	0	0
8-Oct	1.07	-	0	14,641	0	0	26	0	0	0
9-Oct	1.02	11.0	16	14,657	0	192	55	0	0	0
10-Oct	0.94	11.0	15	14,672	0	56	44	0	0	1
11-Oct	0.89	11.0	8	14,680	0	50	40	0	0	2
12-Oct	0.89	11.0	5	14,685	0	16	28	0	0	0
13-Oct	0.86	11.0	9	14,694	0	0	30	0	0	1
14-Oct	0.99	11.0	17	14,711	0	3	97	0	0	3
15-Oct	1.19	-	14	14,725	0	6	107	0	0	2
16-Oct	1.09	10.0	2	14,727	0	1	19	0	0	0
17-Oct	1.04	-	0	14,727	0	0	0	0	0	0
18-Oct	1.02	-	8	14,735	0	125	30	0	0	0
19-Oct	1.07	10.0	4	14,739	0	137	22	0	0	0
20-Oct	1.19	10.0	5	14,744	0	108	17	0	0	0
21-Oct	1.07	-	1	14,745	0	0	20	0	0	0
22-Oct	1.17	-	8	14,753	0	133	51	0	0	0
23-Oct	1.80	-	4	14,757	0	5	17	0	0	0
Totals			**14,757**		**3,015**	**3,023**	**4,392**	**19,308**	**224**	**750**

Appendix B.–Summary of age compositions of sockeye salmon in the Klawock Lake escapement, from 1982 to 2006.

	Estimated percentage of escapement by age class										Estimated percentage by freshwater age		
Year	**1.1**	**1.2**	**1.3**	**1.4**	**2.1**	**2.2**	**2.3**	**2.4**	**3.2**	**3.3**	**Age 1.-**	**Age 2.-**	**Age 3.-**
1982	0	15	83	0	0	0	1	0	1	0	98	1	1
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	28	24	29	0	4	9	6	0	0	0	81	19	0
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	0	28	61	0	0	7	4	0	0	0	89	11	0
1987	13	19	37	0	4	16	9	0	0	0	70	29	1
1988	0	35	42	0	0	12	10	0	0	0	78	22	0
1989	3	7	67	0	1	10	12	0	0	0	77	23	0
1990	56	16	9	1	1	14	4	0	0	0	81	19	0
1991	26	37	26	0	4	5	1	0	0	0	89	11	0
1992	18	44	30	0	6	2	1	0	0	0	91	9	0
1993	7	20	50	0	4	8	9	0	0	0	77	22	1
1994	5	6	71	0	1	14	3	0	0	0	82	18	0
1995	26	31	29	0	2	5	7	0	0	0	86	14	0
1996	3	9	67	0	1	9	10	0	0	0	79	21	0
1997	9	27	43	0	1	10	11	0	0	0	79	21	0
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	1	10	49	0	0	12	27	0	0	0	60	40	0
2002	0	35	34	1	3	27	1	0	0	0	70	30	0
2003	1	8	59	0	3	26	3	0	0	0	68	32	0
2004	2	33	34	0	2	27	1	0	0	0	70	30	0
2005	13	13	29	0	5	37	3	0	0	0	55	44	0
2006	14	54	15	0	2	14	1	0	0	0	83	17	0
Average, all years	**11**	**24**	**43**	**0**	**2**	**13**	**6**	**0**	**0**	**0**	**78**	**20**	**0**
SE	8	8	10	1	3	7	6	0	1	1	2	2	0
Average 1982–1997	**14**	**23**	**46**	**0**	**2**	**9**	**6**	**0**	**0**	**0**	**83**	**17**	**0**
SE	11	9	12	1	4	6	5	1	1	1	7	7	1
Average 2001–2006	**5**	**26**	**37**	**0**	**3**	**24**	**6**	**0**	**0**	**0**	**68**	**32**	**0**
SE	11	18	16	2	5	12	13	0	1	0	13	13	1