Fishery Data Series No. 10-10

Klawock Lake Subsistence Sockeye Salmon Project 2008 Annual Report

by

Jan M. Conitz

March 2010

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

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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.

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ABSTRACT

Klawock Lake produces one of the largest island-based sockeye salmon runs in Southeast Alaska, which supported an important Tlingit settlement and an early commercial fishery. Subsistence sockeye salmon harvest continues in an unbroken tradition dating back thousands of years, but has also evolved significantly with development of commercial fisheries and other changes. In recent years, Klawock residents have expressed concern that the sockeye run is diminished and may no longer be capable of supporting sustainable subsistence fishing opportunities. In response, a stock assessment project was launched in 2001; this report covers the eighth year of harvest and escapement data collection. Subsistence harvest assessment was continued using direct observations of fishing and interviews on the fishing grounds. Escapement in the three main sockeye spawning streams in Klawock Lake was estimated with mark-recapture methods consistently employed each year since 2004. Sockeye salmon counts at Klawock River weir were also provided by the Prince of Wales Hatchery Association (POWHA), the Klawock Watershed Council, and ADF&G Division of Sport Fish. Sockeye salmon adult age, sex, and length composition was estimated from samples collected at the weir. Otoliths were examined for hatchery marks in samples collected in the fishery and spawning grounds. The subsistence harvest was approximately 6,700 sockeye salmon (95% confidence interval 6,500–6,900; CV=1.3%). The sockeye escapement count at the weir was 21,165 fish. The combined mark-recapture estimate of 15,600 fish (CV=13%) substantially underestimated the weir count. Using the weir count, the combined escapement and subsistence harvest of about 27,865 sockeye salmon exceeded the total run size for any year since 2001. Fish with one freshwater year dominated the escapement age composition at an overall average of 79%, nearly identical with the historical proportion. Hatchery-reared fish comprised an estimated 14 to 15% of the 2008 harvest and escapement, up substantially from previous years.

Key words: Sockeye salmon, *Oncorhynchus nerka*, subsistence, Klawock, Klawock Lake, escapement, mark-recapture, age composition, hatchery, otolith, Southeast Alaska

INTRODUCTION

The Klawock Lake watershed is an important sockeye salmon (*Oncorhynchus nerka*) system that historically supported one of the few permanent Tlingit settlements on Prince of Wales Island. Tlingit oral history describes how the original settlers, fleeing a conflict in their home village near the mainland, crossed Prince of Wales Island from Kasaan Bay and discovered Klawock Lake with its exceptional sockeye runs (Langdon 1977). Archeological findings show evidence of human habitation in the Klawock River area dating to 6,000 years ago, and link the ancient inhabitants with present day Tlingit residents (Ratner et al. 2005). Klawock was also the site of one of the earliest commercial fisheries in Alaska, where a salmon saltery was established by George Hamilton in 1868 and then sold to the North Pacific Packing and Trading Company which built a cannery in 1878 (Bower 1929; Langdon 1977; Ellanna and Sherrod 1987). From the beginning of the commercial fishing period, commercial and subsistence fishing and other harvesting have been completely intertwined in the household economies of Klawock residents. The people of Klawock actively participated in developing commercial fisheries, first working for the canneries as both harvesters and fish processors, and later as owner-operators of not only fishing boats but also canneries. Although the outside commercial fishing industry disrupted traditional systems of resource ownership and harvesting, it also provided new opportunities for people to access resources for traditional uses. In particular, larger commercial vessels enabled extended families to continue to access resources more distant from Klawock as they had in the past from a network of seasonal villages and camps. Thus, during the earlier commercial fishing period, the involvement of Klawock residents enhanced both the cash and subsistence sectors (Ellanna and Sherrod 1987). Starting in the 1950s, however, a long decline in the local commercial fishing economy, combined with introduction of the salmon limited entry program, contributed to loss of both commercial fishing capital and access to more distant resources among Klawock residents. The loss of seasonal mobility and access to diverse resources, combined with an influx of new residents from other places due in part to logging and transportation infrastructure development, has put more pressure on nearby subsistence resources, including sockeye salmon from Klawock Lake (Ellanna and Sherrod 1987). Most present-day Klawock residents rely primarily on the Klawock Lake stock for their subsistence sockeye salmon, although a few alternative locations including the Sarkar River are also used, particularly during years of low sockeye abundance at Klawock (Ratner et al. 2005).

Commercial harvest records from the end of the 19th Century indicate annual harvests of sockeye salmon in the Klawock River estuary averaging around 40,000 fish, with peak numbers up to about 70,000 fish (Moser 1899; Rich and Ball 1933). Depletion of the stock became apparent early in the commercial period, and managers responded with attempts at hatchery supplementation and implementation of fishery regulations, measures which were largely ineffective (Rich and Ball 1933; Roppel 1982). The first recorded measures of sockeye salmon escapement into Klawock Lake were a series of weir counts from the 1930s, which ranged from 7,000 to 65,000 fish (Orrell et at. 1963). Later, the Klawock River hatchery staff counted sockeye salmon at a weir operated for collection of hatchery broodstock, but the counts were notoriously unreliable (Lewis and Zadina 2001). Detailed reviews of available historical information on Klawock sockeye salmon, including some assessment of juvenile populations and lake habitat variables, 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; Conitz 2009). 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).

The recent subsistence sockeye salmon monitoring project was started in 2001; its main goal has been to achieve reliable estimates of sockeye escapement and subsistence harvest in the Klawock Lake system to facilitate better management of the subsistence resource. The primary tool for escapement estimation was the counting of sockeye salmon migrating through the Klawock River, validated with mark-recapture studies conducted in the primary spawning areas. In two out of the first three years, the mark-recapture estimates were significantly higher than the weir counts, and consequently, improvements were made to the weir in 2004. Mark-recapture sampling methods were also improved, including the use of individually-numbered tags so that sockeye spawners could be tracked to both location and time of spawning (Conitz et al. 2006). Sockeye spawning populations were also estimated independently at the three main spawning streams in Klawock Lake. After comparing these independent estimates with the weir counts for three years, the spawning population estimates, while not as precise, were deemed sufficiently accurate that the weir enumeration could be omitted as a cost savings. In 2007, no count of sockeye salmon was obtained at the weir, and the spawning population estimate provided the only measure of sockeye escapement. In 2008, Prince of Wales Hatchery Association (POWHA) personnel counted sockeye salmon, although without the associated mark-recapture validation study, but again, the independent spawning population mark-recapture estimate was obtained. The use of redundant escapement estimation methods has permitted some degree of continuity in the estimates, even when the primary estimation method has changed. The subsistence harvest of Klawock sockeye salmon has also been independently estimated since 2001 with a harvest survey conducted on the fishing grounds. Without the harvest survey, the only indicator of the size of the subsistence harvest would be the total catch reported on returned permits, which is not available until at least one year following the season, and tends to underestimate actual harvest (Cartwright and Conitz 2006; Conitz 2008). Other assessment activities in 2008 were to sample the sockeye escapement for its age, sex, and length distribution and the escapement and harvest for proportions of hatchery marked otoliths. These objectives were carried out in the same or similar manner to previous years.

Escapements estimated between 2001 and 2007 have been remarkably uniform, ranging from 13,000 to 21,000 fish. Similarly, subsistence sockeye harvest estimates have remained at a fairly stable size between about 2,500 to 6,500 fish, with the exception of an extreme low harvest, 175 fish, in 2005. Excluding any commercial harvest, the total run size has thus ranged from about 15,000 to about 27,000 sockeye salmon in 2001 through 2007, showing stability although apparently at a lower level than in the past. Fulfillment of the 2008 objectives adds another year's information to these escapement and harvest series, along with auxiliary information about age composition and hatchery contribution.

OBJECTIVES

1. Estimate the subsistence harvest of sockeye and other salmon in the subsistence fishery in Klawock Inlet and the Klawock River estuary.
2. Estimate the sockeye salmon spawning populations in Threemile, Halfmile and Inlet Creeks using mark-recapture methods, so that the estimated coefficient of variation is less than 15%.
3. Estimate the age, length, and sex composition of the sockeye salmon in the escapement at Klawock Lake, so that the estimated coefficient of variation is less than or equal to 5% for the largest two age classes.
4. Estimate the proportion of hatchery-produced sockeye salmon in the escapement and subsistence fishery.

STUDY SITE

The Klawock River system (ADF&G 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^{o} 32.97'N, long 133^{o} 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 to 988 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 clarkii*), Dolly Varden char (*Salvelinus malma*), threespine stickleback (*Gasterosteus aculeatus*), and cottids (*Cottus* sp.). Mysid shrimp (*Neomysis mercedis*) are also present in the lake.

METHODS

SUBSISTENCE HARVEST ESTIMATE

By regulation, the subsistence fishery was open on weekdays from 08:00 on Mondays to 17:00 on Fridays, between 7 July and 31 July 2008. Prior to the season, three days out of each five-day week were selected at random for observations and interviews with subsistence users. However, due to the availability of extra personnel in 2008, a daily sampling schedule was possible and was implemented starting in the middle of the first week (Table 1). Sampling days ran from 06:00 to 22:00, 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 so they could see all boat-parties fishing in Klawock Inlet. In addition to direct verbal interviews, direct observation and hand signals were used to communicate the size of the catch. 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."

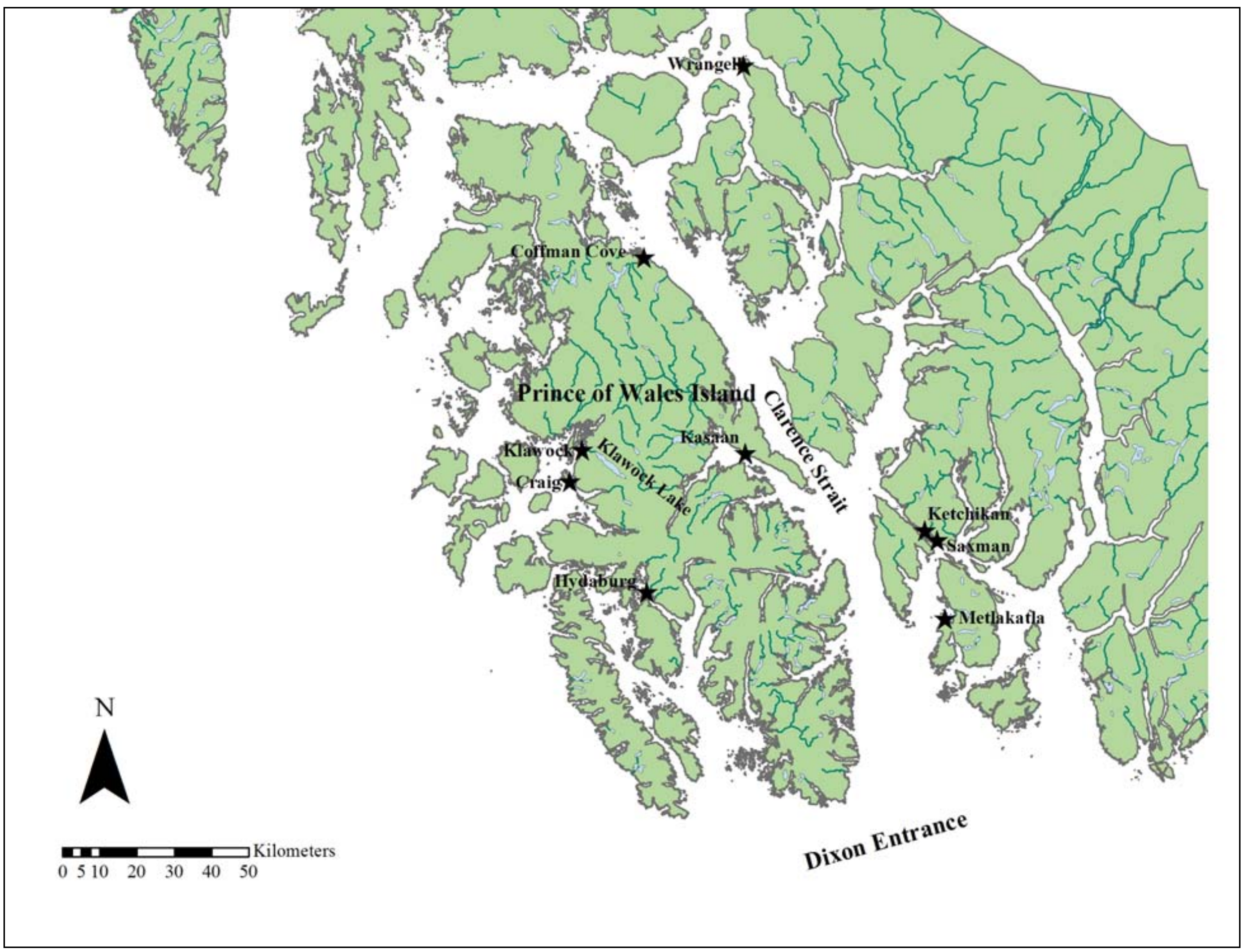

Figure 1.–Geographic location of Klawock Lake, in Southeast Alaska on Prince of Wales Island. The communities of Klawock and Craig, and other towns on and near Prince of Wales Island are shown.

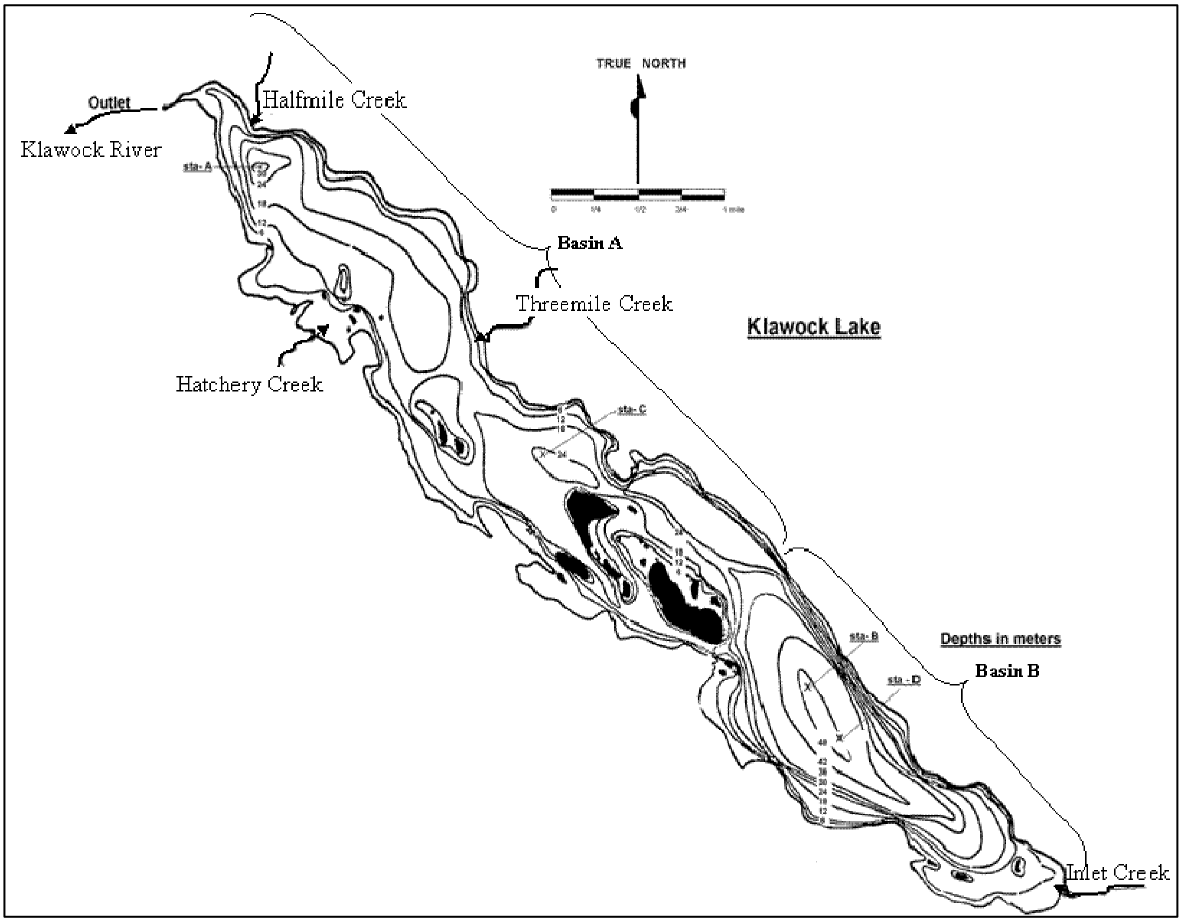

Figure 2.–Bathymetric map of Klawock Lake, showing the two main lake basins, four main inlet streams (Halfmile, Threemile, Inlet, Hatchery), and the outlet to Klawock River.

Table 1.–Dates selected for sampling in the Klawock Inlet subsistence fishery in 2008.

Week	Fishery Open Dates	Actual Sampling Days
1	7–11 July	M, W, Th, F (4 days)
2	14–18 July	M–F (5 days)
3	21–25 July	M–F (5 days)
4	28–31 July	M–Th (4 days)
Totals	19 days	18 days

The statistical population was designated to be the collection of "net sets." Sets were organized into a day within a week. In week one, 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 weeks 2 to 4, all days within a week were sampled so the first stage was essentially eliminated. 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. When all days in a week were sampled, no expansion was necessary.

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. 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 $\bar{h}_{jk}$ denote the mean harvest per set, on day j in week k, and $\bar{h}_k$ denote the mean harvest for the week. We then estimated the variance for the estimated harvest in week k as,

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

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

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

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

SOCKEYE SALMON ESCAPEMENT ESTIMATE

Sockeye salmon spawning populations in the three main spawning tributaries of Klawock Lake (Threemile, Inlet, and Halfmile Creeks; Figure 2) were estimated with mark-recapture studies. Marking of fish began when sockeye spawners started accumulating at the mouth of each stream, continuing at weekly intervals until the end of the spawning period.

During the first marking event at each stream, live sockeye salmon were captured at the mouth of the stream and marked with an opercular punch and a t-bar tag. During subsequent sampling events, all sockeye salmon were checked for opercular punches and tags. Any unmarked fish were tagged and marked with the specific opercular punch for that sampling event. When visual surveys revealed that sockeye spawners were migrating upstream to spawn, sampling was extended to the entire length of the spawning area in each stream. A tag number was recorded for each fish caught in a given sample, whether initial capture or recapture. The opercular punch served as a primary mark which would identify the fish to the sampling event in which it was captured and marked, even in the event of tag loss.

The tag number data were used to construct an individual capture history for each fish, by location and sampling event. Fish were sampled without replacement during a given sampling event, 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). In the event of tag loss, capture histories were reconstructed by means of the opercular punch mark(s) present.

The Jolly-Seber model for open populations (Pollock et al. 1990) extends the Schnabel method (Seber 1982, p. 130) to open populations. Schwarz et al. (1993) developed an adjustment for spawning salmon 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 the following 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:

$$\hat{M}_i = m_i + \frac{(R_i+1)z_i}{r_i+1};$$

$$\hat{N}_i = \frac{(n_i+1)\hat{M}_i}{m_i+1};$$

$$\hat{\phi}_i = \frac{\hat{M}_{i+1}}{\hat{M}_i - m_i + R_i}; \qquad (5)$$

$$\hat{B}_i = \hat{N}_{i+1} - \hat{\phi}_i(\hat{N}_i - n_i + R_i).$$

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,

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

$\hat{B}_0$, $\hat{B}_1$, 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,

$$\hat{N}_2 = \hat{B}_0\phi_1 + \hat{B}_1. \qquad (7)$$

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,

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

The super-population, or total escapement, is then the sum,

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

We 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 Division 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*.

The three main spawning streams are well-separated from each other, and capture history data from previous years (Conitz 2008; Conitz and Cartwright 2007; Cartwright and Conitz 2006) has shown very little evidence of spawner movement between streams. Therefore the three independent population estimates (one for each stream) were 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). Because the estimates for the three stream spawning groups were assumed to be independent, the standard error for the total spawning population estimate was simply the square root of the summed variance estimates for each stream spawning group. We reported the coefficient of variation as the standard error divided by the total population estimate.

The Klawock River weir was operated by the Prince of Wales Hatchery Association, and an early-season video counting effort at the weir was conducted by the Klawock Watershed Council. Details about the methods used can be obtained from these two organizations (J. Bruns, manager, Prince of Wales Hatchery Association; D. Williams, president, Klawock Watershed Council).

ESCAPEMENT AGE, SEX, AND LENGTH COMPOSITION

Although sockeye salmon escapement counting was not conducted at the Klawock River weir, about 600 adult sockeye were sampled for length, sex, and scales (for age determination) at the 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. 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 proportion. Mean lengths by age and sex and their standard errors were estimated as for simple random samples.

HATCHERY CONTRIBUTION

The present-day Klawock hatchery began incubating sockeye eggs taken from wild broodstock in the 1980s, and released 250,000 and 900,000 emergent, mostly unfed sockeye fry annually between 1996 and 2005 (Appendix C in Prince of Wales Hatchery Association (POWHA) 2005 annual management plan). The hatchery thermally marked incubating sockeye salmon in their facility from brood year 1999 through brood year 2004, after which the hatchery discontinued sockeye production. A thermal mark pattern template was assigned to each year of Klawock hatchery sockeye production by the ADF&G Mark, Tag, and Age Laboratory in Juneau. The laboratory checked a subsample of otoliths and the associated temperature log to verify the thermal mark pattern (John Bruns, Prince of Wales Hatchery Association manager, personal communication 2005). Juvenile and returning adult sockeye salmon have been sampled since 2001 to determine the number and proportions of marked fish. In 2008, adult sockeye salmon were sampled for otoliths in the Klawock Inlet subsistence fishery and on the spawning grounds in Klawock Lake. Adult sockeye salmon returning to the Klawock Lake system in 2008 could have been offspring from brood years 2001 through 2005, of which all but 2005 included some hatchery sockeye production. Fish returning in 2008 from the 2005 brood year would comprise only age-1.1 jacks.

Heads from subsistence caught sockeye salmon were collected from fishers on a voluntary basis; fishers were asked to drop off samples in marked collection totes at either of the two public docks in Klawock village. The sample size goal was 200 fish from the subsistence harvest, distributed among weeks of the subsistence fishery roughly in proportion to weekly harvest. If the number of contributed samples exceeded the weekly sampling goal, heads were sampled randomly from those available. In the escapement, sockeye salmon carcasses were sampled from each inlet stream during escapement surveys and mark-recapture sampling. Because most carcasses are removed by bears or washed back downstream, nearly all available carcasses were sampled. Sampling goals in 2008 were 125 heads each from Threemile and Inlet Creeks, and 50 heads from Halfmile Creek, for a total of 300 otolith pairs. The crew was directed to collect at least one-third up to one-half of the sampling goal during the first time sampling was conducted within each creek and the remainder during the next two sampling events.

Otolith pairs were dissected from the sampled fish, cleaned, and sent to the ADF&G Mark, Tag, and Age Laboratory. Laboratory staff examined the otoliths under a microscope to determine the presence and identification (hatchery, brood year) of thermal marks.

Results were reported in the Thermal Mark Laboratory Mark Summary Report database: (http://tagotoweb.adfg.state.ak.us/OTO/reports/MarkSummary.aspx). Estimates of hatchery proportions in the subsistence harvest, escapement, and combined harvest plus escapement were calculated from the proportion of marked otoliths in the respective samples. We assumed that the proportion of hatchery fish in a sample followed a binomial distribution, and estimated the binomial standard error for the proportion.

RESULTS

SUBSISTENCE HARVEST ESTIMATE

The estimated total subsistence harvest for Klawock Inlet in 2008 was approximately 6,700 sockeye salmon (95% confidence interval 6,500–6,900; CV=1.3%). Subsistence fishing for sockeye salmon was open for 19 days, and the crew conducted observations and interviews during all days except 8 July, during the first week, and reported missed interviews on only the first day, 7 July (Table 2). Therefore, all of the observed sampling error was from the first week; harvest estimates for weeks 2 to 4 were actually censuses with no sampling error. The maximum daily and weekly harvest of sockeye salmon was taken during the third week of the fishery. Other salmon harvest reported in the interviews included 170 coho salmon, 111 pink salmon, 35 chum salmon, and four Chinook salmon. Because the season for species other than sockeye salmon did not close on 31 July, these reported harvests should not be considered season totals.

Table 2.–Summary of subsistence harvest survey results from Klawock Inlet in 2008, including the number of net sets for which harvest interviews were conducted, and daily and weekly totals for sockeye salmon. Harvest of other salmon species was considered incidental and is not shown. The fishery was open weekdays from 7 to 31 July.

Date	Number Sets Interviewed	Estimated Daily Harvest	Estimated Weekly Harvest	Std. Error of Weekly Harvest	Comments
7-Jul	12	222	628	87	Two missed interviews on 7-7; no observations or interviews on 7-8
9-Jul	18	172			
10-Jul	9	32			
11-Jul	6	77			
14-Jul	24	296	1,807	0	Census, all days and sets included
15-Jul	30	192			
16-Jul	30	369			
17-Jul	29	467			
18-Jul	21	483			
21-Jul	26	260	2,589	0	Census, all days and sets included
22-Jul	40	670			
23-Jul	33	526			
24-Jul	41	549			
25-Jul	18	584			
28-Jul	22	256	1,657	0	Census, all days and sets included
29-Jul	24	227			
30-Jul	24	562			
31-Jul	23	612			

SOCKEYE SALMON ESCAPEMENT ESTIMATE

At Threemile Creek, 1,210 sockeye spawners were sampled (Table 3) during six approximately weekly sampling events in 2008 (26 August; 4, 10, 18, 23 September; 6 October). Despite the intensive sampling effort, only 7.2% of all fish sampled and tagged were recaptured. About half of the recaptured fish were caught in the next event after initial tagging, and the remainder were caught in a later event. Almost three-quarters of the recaptures were fish first caught and tagged in the first or second sampling event, indicating that stream survival rates dropped considerably as the spawning period progressed.

The Jolly-Seber estimate of the total number of sockeye salmon that spawned in Threemile Creek in 2008 was about 7,500 fish (95% confidence interval 6,200–10,500; CV=14.9%). The coefficient of variation met the objective (coefficient of variation less than 15%).

Table 3.–Summary of capture-recapture histories of sockeye salmon sampled on the spawning grounds at Threemile Creek in Klawock Lake, 2008.

Capture-recapture Category	**Capture History[a]**	**Number of Fish[b]**
Captured only once; tagged and released	100000	177
	010000	237
	001000	248
	000100	189
	000010	196
	000001	76
Subtotal		1,123
Captured and released, then recaptured and released at next event	110000	10
	011000	8
	001100	17
	000110	10
	000011	3
Subtotal		48
Captured and released, not captured in next event, but recaptured and released in a later event	101000	5
	100100	1
	100010	4
	010100	10
	010010	3
	001010	11
	001001	1
	000110	10
	000101	1
Subtotal		46
Recaptured and released more than once	100011	1
	011100	1
	001110	1
Subtotal		3
Total sampled and released		1,210

[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.
[b]The number of fish with each observed capture history is shown.

At Inlet Creek, a total of 1,061 sockeye spawners was sampled (Table 4) during five sampling events in 2008 (25 August; 2, 8, 15, 22 September). Recapture numbers were low, and recaptures comprised only about 5% of all fish sampled.

The Jolly-Seber estimate of the total number of sockeye salmon that spawned in Inlet Creek in 2008 was about 7,400 fish (95% confidence interval 5,700–12,100; CV=23%). The coefficient of variation exceeded the objective (coefficient of variation less than 15%).

Table 4.–Summary of capture-recapture histories of sockeye salmon sampled on the spawning grounds at Inlet Creek in Klawock Lake, 2008.

Capture-recapture Category	**Capture History**[a]	**Number of Fish**[b]
Captured only once; tagged and released	10000	156
	01000	191
	00100	336
	00010	209
	00001	111
Subtotal		1,003
Captured and released, then recaptured and released at next event	11000	4
	01100	14
	00110	10
	00011	10
Subtotal		38
Captured and released, not captured in next event, but recaptured and released in a later event	10100	4
	10010	2
	01010	6
	01001	1
	00101	5
Subtotal		18
Recaptured and released more than once	01110	2
Subtotal		2
Total sampled and released		1,061

[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.
[b]The number of fish with each observed capture history is shown.

At Halfmile Creek, as in previous years, fewer sockeye spawners were present than in Threemile and Inlet Creeks. and only 166 fish (Table 5) were sampled in a total of five approximately weekly sampling events in 2008 (27 August; 5, 11, 19, 25 September). Only about 5% of the total number of fish sampled at Halfmile Creek was recaptures.

The Jolly-Seber estimate of the total number of sockeye salmon that spawned in Halfmile Creek in 2008 was about 700 fish (95% confidence interval 160–1,900; CV=68%). The precision of the estimate was very poor, but the estimate combined with sample sizes indicates the population of spawners in Halfmile Creek was small in 2008. The combined sockeye spawning population estimate for Threemile, Inlet, and Halfmile Creeks in 2008 was 15,600 fish (CV=13%).

Table 5.–Summary of capture-recapture histories of sockeye salmon sampled on the spawning grounds at Halfmile Creek in Klawock Lake, 2008.

Capture-Recapture Category	Capture History[a]	Number of Fish[b]
Captured only once; tagged and released	10000	46
	01000	20
	00100	41
	00010	32
	00001	18
Subtotal		157
Captured and released, then recaptured and released at next event	11000	4
	00110	1
Subtotal		5
Captured and released, not captured in next event, but recaptured and released in a later event	01010	2
	00101	2
Subtotal		4
Total sampled and released		166

[a]Capture histories show one digit for each of six sampling events in chronological oreder: 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.
[b]The number of fish with each observed capture history is shown.

ESCAPEMENT AGE, SEX, AND LENGTH COMPOSITION

A total of 665 sockeye salmon were sampled from the Klawock Lake escapement in 2008, for age, sex, and length determination. Ages were determined for 556 of these fish. A full range of eight age classes and four brood years was represented in the sample. The largest classes were the age-1.2 and age-1.3, and combined with the age-1.1 jacks and a few six-year-old, age-1.4 fish, sockeye salmon with one freshwater year comprised just over 79% of the total sample (Table 6). Four-year-old fish from brood year 2004 and five-year-old fish from brood year 2003 were present in the sample in nearly equal numbers. The six-year-old fish, in all three age classes (age classes 1.4, 2.3, and 3.2) , were the largest, followed closely by five-year-old, age-1.3 fish (Table 7). The age-2.2 fish were substantially smaller.

Table 6.–Age composition and proportion of sockeye salmon sampled in 2008 at the Klawock River weir, by sex and brood year and age class.

	Brood Year, by Age Class								
	2005	2004		2003		2002			Total
Stratum	1.1	1.2	2.1	1.3	2.2	1.4	2.3	3.2	Aged
Male									
Sample size	58	147	1	63	45	1	4	1	320
Percent	10.4%	26.4%	0.2%	11.3%	8.1%	0.2%	0.7%	0.2%	57.6%
Std. error	1.3%	1.9%	0.2%	1.3%	1.2%	0.2%	0.4%	0.2%	2.1%
Female									
Sample size	2	98	—	69	62	2	2	1	236
Percent	0.4%	17.6%	—	12.4%	11.2%	0.4%	0.4%	0.2%	42.4%
Std. error	0.3%	1.6%	—	1.4%	1.3%	0.3%	0.3%	0.2%	2.1%
All Fish									
Sample size	60	245	1	132	107	3	6	2	556
Percent	10.8%	44.1%	0.2%	23.7%	19.2%	0.5%	1.1%	0.4%	—
Std. error	1.3%	2.1%	0.2%	1.8%	1.7%	0.3%	0.4%	0.3%	—

Table 7.–Length composition of sockeye salmon sampled in 2008 at the Klawock River weir, by sex, brood year, and age class.

	Brood Year, by Age Class								
	2005	2004		2003		2002			Total
Stratum	**1.1**	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**3.2**	**Aged**
Male									
Sample size	58	147	1	63	45	1	4	1	320
Length (mm)	368	514	390	579	527	620	580	560	504
SE	3	3	—	4	5	—	11	—	4
Female									
Sample size	2	98	—	69	62	2	2	1	236
Length (mm)	410	503	—	551	519	540	565	590	524
SE	10	3	—	4	4	0	5	—	2
All Fish									
Sample size	60	245	1	132	107	3	6	2	556
Length (mm)	370	509	390	564	522	567	575	575	513
SE	4	2		3	3	27	8	15	3

HATCHERY CONTRIBUTION

Totals of 406 otolith pairs from the subsistence fishery and 225 otolith pairs from the sockeye escapement were collected from the Klawock Lake sockeye run in 2008. Of these, all but one otolith pair in each category were analyzed for hatchery marks (Table 8). Overall, hatchery-marked fish comprised nearly 15% (CV=9.6%) of the total sample, with a slightly higher percentage in the subsistence fishery. Marked fish represented three brood years, 2002 to 2004; the largest number of marked fish were from the 2004 brood year, followed by brood year 2003, and only a few from brood year 2002. The age distribution of hatchery-marked fish corresponded roughly with the escapement age composition, in which age-1.2 fish from brood year 2004 were the largest age class (Table 6). In addition to the marked otoliths found in samples collected in the Klawock Lake system, seven marked otolith pairs were recovered from distant commercial fisheries (ADF&G Division of Commercial Fisheries Mark, Tag, and Age Laboratory online reports, http://tagotoweb.adfg.state.ak.us/OTO/reports/MarkSummary.aspx). These marked fish were disregarded in this analysis because they were not part of any directed fishery or sampling program for the Klawock Lake sockeye salmon stock and represented only a tiny fraction the nearly 12,000 fish sampled from Southeast Alaska commercial fisheries.

DISCUSSION

The number of sockeye salmon that returned to spawn in Klawock Lake in 2008 appeared to be very similar to returns of recent previous years. The mark-recapture estimate from the three principal spawning streams totaled about 15,600 fish, and the uncertainty or sampling error associated with this estimate was somewhat less than in previous years (Table 9). However, this mark-recapture estimate from the principal spawning streams substantially underestimated the sockeye count from the weir. Prince of Wales Hatchery Association staff counted 21,165 sockeye salmon through the weir in 2008, including 3,155 jacks and 18,010 full-size adults (Appendix A). Escapement of sockeye salmon past the weir and into the lake could be higher than the number of fish that actually arrive in the tributary streams to spawn, up to eight or more weeks later, if pre-spawning mortality is significant. Nevertheless, the spawning grounds mark-recapture estimates have typically been lower than the weir counts and weir-based mark-recapture estimates (Conitz et al. 2006; Conitz and Cartwright 2007; Conitz 2008), and the open population Jolly-Seber estimator can be susceptible to negative bias (Pollock et al. 1990). Because of this, and because a weir count would be unlikely to overestimate the escapement, the weir count should be considered the best estimate of sockeye escapement into Klawock Lake in 2008.

Table 8.–Summary of sockeye salmon otolith sample sizes and numbers of hatchery-marked otoliths from the Klawock Inlet subsistence fishery (7–28 July) and the Klawock Lake escapement (2–30 September) in 2008. Standard errors of the estimated percentages of hatchery fish in both categories and the total sockeye salmon run are shown.

Sample Date	Number Sampled	Number Analyzed	Number Not Marked	Number Marked, By Brood Year			Total Number Marked	Percent Marked (SE)
				2002	2003	2004		
7-Jul	99	99	83	3	8	5	16	16
13-Jul	101	100	89		2	9	11	11
21-Jul	147	147	124	2	6	15	23	16
28-Jul	59	59	48	1	2	8	11	19
2-Sep	3	3	3				0	0
19-Sep	100	100	98			2	2	2
24-Sep	81	81	60	1	9	11	21	26
30-Sep	41	40	31		4	5	9	23
Total	631	629	536	7	31	55	93	14.8 (1.4)
Subsistence subtotal	406	405	344	6	18	37	61	15 (1.8)
Escapement subtotal	225	224	192	1	13	18	32	14 (2.3)

Table 9.–Escapement and spawning population of sockeye salmon in Klawock Lake, and comparison of different estimation methods, 2001–2008.

Year	Weir Count	Weir-Based Mark-Recapture Estimate	95% Confidence Interval, Weir-Based Estimate	Spawning Grounds Mark-Recapture Estimate (CV)	Best Available Estimate
2001	7,236	14,000	9,000–19,000	na	Weir-based mark-recapture
2002	13,631	13,000	11,500–15,000	na	Weir count
2003	6,276	21,300	na (CV=18%)	na (insufficient sampling)	Weir-based mark-recapture
2004	12,442	13,000	10,600–15,400	11,000 (23%)	Weir count
2005	14,840	13,700	12,400–15,200	10,500 (~30%)	Weir count
2006	14,757	13,600	12,500–14,800	11,000 (30%)	Weir count
2007	na	na	na	17,500 (22%)	Spawning grounds mark-recapture
2008	21,165	na	na	15,600 (13%)	Weir count

The subsistence harvest of sockeye salmon in Klawock Inlet rebounded in 2008 to the level observed in 2001 to 2003, after a four-year period of substantially lower harvests. Considering the total run to be the subsistence harvest plus escapement, about 24% of the run was harvested in 2008. Both the subsistence harvest and the total sockeye run were the largest for the recent eight-year period and were well above the eight-year averages (Table 10). Commercial harvest of Klawock origin sockeye salmon is not estimated, but is assumed to be a very small, incidental component of mixed stock fisheries mainly along the west coast of Prince of Wales Island.

Table 10.–Estimated subsistence sockeye salmon harvest, spawning escapement, and total run size (escapement plus subsistence harvest, but excluding any commercial harvest) for 2001 to 2008.

Year	Estimated Subsistence Harvest	Subsistence Harvest Reported on Returned Permits	Estimated Escapement	Subsistence Harvest + Escapement
2001	6,400	4,433	14,000	20,400
2002	6,000	3,778	13,600	19,600
2003	6,000	3,195	21,300	27,300
2004	4,500	2,697	12,400	16,900
2005	175	238	14,840	15,015
2006	3,100	1,849	14,757	17,857
2007	2,600	2,042	17,500	20,100
2008	6,700	na	21,165	27,865
Average, all years	4,434	2,605	16,028	20,462

Concern about the overall health of the Klawock Lake sockeye salmon stock has lessened somewhat in view of the stable levels of escapement, and subsistence harvest, since 2001 (with one year's exception). The 2008 estimates confirm this pattern, and strengthen the case for a run that is not declining or in immediate trouble. Recent years' run sizes nevertheless appear to be smaller than former run sizes, according to anecdotal information, as well as written reports from earlier years. The best historical series of escapement estimates for Klawock Lake sockeye salmon, from the 1930s (Orrell et al. 1963), shows an average escapement of over 33,000 sockeye salmon, which is 12,000 fish more than the largest recent escapement estimate (Table 11). Of course, neither commercial nor any subsistence harvest estimates are available for the 1930s and in the more recent period, commercial harvest of Klawock-origin sockeye salmon is unknown. Therefore, differences in escapement between the two periods don't necessarily reflect a similar difference in total run sizes.

Table 11.–Sockeye salmon counts at the Klawock River weir in the 1930s.

Year	Sockeye
1930	7,044
1931	34,184
1932	57,294
1934	16,374
1935	20,028
1936	65,314
1937	33,544
1938	15,368
Average, 1930–1937	33,397

The adult sockeye age composition of the 2008 escapement showed a somewhat higher proportion of fish that spent only one year in freshwater, closely matching the average age composition for all years in which it has been estimated since 1982 (Appendix B). This contrasts with the age composition of the 2007 escapement, whose lower proportion of age-1.- fish matched the recent eight-year average (Conitz 2009). Age at smolting can be an indicator of the productivity of the lake rearing environment for sockeye salmon. However, freshwater age in returning adults does not necessarily correspond to actual smolt age composition, because factors in the marine life history could differently affect the survival of fish with one year versus two years of freshwater growth. In the absence of supporting data on sockeye smolt growth and lake productivity, the adult age compositions are suggestive but not a definitive indicator of the status of sockeye production in this system.

Higher numbers of hatchery-reared sockeye salmon were recovered in both the subsistence fishery and the escapement in 2008, suggesting that the hatchery fish from brood years 2003 and especially 2004 had somewhat higher survival rates than previous brood years (Table 12). The estimated total hatchery contribution can be calculated by applying the proportion of marks by brood year from each year's sample to the total run size (harvest plus escapement) for that year and summing returns from each brood year. Any incidental commercial harvest was ignored. Returns were complete in 2008 for three brood years, 2000 to 2002, which included both thermal marking during incubation and sampling of adult returns (Table 13). Returns from brood year 2003 will be complete in 2009, and returns from brood year 2004 will be complete in 2010. The estimated numbers of hatchery-incubated sockeye salmon that returned from brood years 2000 to 2002 were less than the number of fish that were used as brood stock to produce them. On the other hand, the estimated returns from brood years 2003 and 2004, though still incomplete, have already exceeded the number of brood stock taken in those two years. Sockeye run sizes increased between 2005 and 2008 (Table 10), perhaps reflecting more favorable conditions in the lake or ocean environment, which in turn improved survival of hatchery fish. In addition, better attention to release timing of the hatchery-incubated fry may have contributed to better survival of brood year 2003 and 2004 fish. Release dates in 2004 and 2005 were later than some but not all of the previous years. All fry released in 2004 and 91% of fry released in 2005 were fed in the hatchery between hatching and release (see http://tagotoweb.adfg.state.ak.us/CWT/reports/hatcheryrelease.asp). However, hatchery records show that the conditions of sockeye fry releases in 2004 and 2005 were similar to those since the late 1990s, on average, so survival differences cannot be clearly linked to different hatchery rearing conditions. Furthermore, somewhat larger hatchery returns from the last two years of production does not equate to success of the hatchery program, as the hatchery fish could simply be replacing wild fish that would have otherwise been produced by the brood stock taken out of the wild escapement.

Table 12.–Numbers of hatchery-marked sockeye otoliths recovered from samples collected in the Klawock subsistence fishery and escapement in 2003 to 2008, identified to brood years 1999 to 2004 when the hatchery conducted thermal marking.

	Number of Marked Otoliths Recovered in All Samples, by Return Year					
Brood Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
1999	5	5	0	—	—	—
2000	0	1	2	0	—	—
2001	—	0	1	5	0	—
2002	—	—	0	6	1	7
2003	—	—	—	0	10	31
2004	—	—	—	—	3	55
Sample size[a]	606	389	300	572	506	629

[a] Sampling was conducted in the subsistence fishery and the escapement, except in 2003 when only escapement samples were collected.

Table 13.–Estimated total numbers of hatchery-incubated sockeye salmon returning to the Klawock Lake system, by brood year. The hatchery conducted thermal marking of sockeye salmon starting in 1999. Sockeye production was discontinued after 2004. Returns from brood years 2003 and 2004 will not be complete until 2009 and 2010.

	Estimated Numbers, by Return Year								
Brood Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**Total Hatchery Returns by Brood Year**	**Number of Broodstock**	**Net Contribution by Brood Year**
1999	225	217	0	—	—	—	incomplete[1]	480	na
2000	0	23	100	0	—	—	144	250	-116
2001	—	0	50	156	0	—	206	891	-711
2002	—	—	0	187	40	310	537	831	-375
2003	—	—	—	0	397	1,373	Incomplete[2]	1,060	na
2004	—	—	—	—	119	2,437	Incomplete[3]	1,067	na

[1]No sampling for marked otoliths was conducted in 2002.
[2]Does not include six-year-old fish (age-1.4 or -2.3) returning in 2009.
[3]Does not include five-year-old fish (age-1.3 or -2.2) returning in 2009, or six-year-old fish returning in 2010.

Overall, conditions have apparently been favorable for sockeye salmon growth and survival during the last two to three cycles, beginning with the offspring from brood year 2000, at least in the wild stocks. Limited data from 2001 to 2007 sampling of sockeye fry and smolt, lake physical conditions, and zooplankton populations have not raised any red flags in terms of extreme low numbers or out-of-balance conditions. Possible limitations in sockeye rearing potential due to the large number of combined hatchery and wild coho and sockeye fry in the lake have been suggested. The salmon habitat potential of Klawock watershed as a whole has been, and continues to be, compromised by certain human activities and alterations, especially water withdrawals, past logging and logging roads, the Klawock to Hollis highway, and subdivision development. As the sockeye stock assessment program continues in the future, these factors need to be given careful consideration, so that their effects are understood and mitigated as well as possible. If the quality of the sockeye spawning and rearing habitat in the Klawock Lake system can be maintained and, where possible, restored, the sockeye salmon population may be capable of continuing to slowly increase towards former levels.

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APPENDICES

Appendix A.–Salmon escapement counts at the Klawock River weir in 2008, provided by the Prince of Wales Hatchery Association (POWHA; John Bruns, Director), ADF&G Division of Sport Fish (Judy Lum, Fisheries Biologist), and Klawock Watershed Council (KWC; Donna Williams, Director). Counts for dates above the shaded bar (26 June–20 July) were conducted cooperatively between POWHA and the Klawock Watershed Council, using both video camera and recording equipment at the weir and the hatchery raceway. Use of the video camera equipment was discontinued after 20 July. Only coho escapement counts are included; coho cost recovery and broodstock numbers are not shown.

Date	Steelhead	Sockeye	Sockeye Jack	Coho	Coho Jack	Source	Comments
26-Jun	1	5	0	0	0	raceway+camera	
27-Jun	0	3	0	0	0	raceway+camera	
28-Jun	0	2	0	0	0	raceway+camera	
29-Jun	0	11	2	0	0	raceway+camera	
30-Jun	0	18	1	0	0	raceway+camera	
1-Jul	0	2	0	0	0	raceway+camera	
2-Jul	0	2	0	0	0	raceway+camera	
3-Jul	0	1	0	0	0	raceway+camera	
4-Jul	0	2	0	0	0	raceway+camera	
5-Jul	0	3	0	0	0	raceway+camera	
6-Jul	0	37	0	0	0	raceway+camera	
7-Jul	0	14	1	0	0	raceway+camera	
8-Jul	0	10	0	0	0	raceway+camera	
9-Jul	0	42	4	0	0	raceway+camera	
10-Jul	0	22	0	0	0	raceway+camera	
11-Jul	0	2	0	0	0	raceway+camera	
12-Jul	0	17	0	0	0	raceway+camera	
13-Jul	0	23	0	0	0	raceway+camera	
14-Jul	0	23	0	0	0	raceway+camera	
15-Jul	1	4	0	0	0	raceway+camera	
16-Jul	0	4	1	0	0	raceway+camera	
17-Jul	0	14	3	0	0	raceway+camera	
18-Jul	0	7	0	0	0	raceway+camera	
19-Jul	0	322	0	41	6	raceway+camera	
20-Jul	0	30	0	8	0	raceway+camera	weir closed
Sub-total	2	620	12	49	6		
21-Jul	0	10	0	0	1	raceway	
22-Jul	0	2	0	0	0	raceway	
23-Jul	0	13	0	8	0	raceway	
24-Jul	0	15	0	9	2	raceway	
25-Jul	0	31	0	1	0	raceway	
26-Jul	0	195	0	0	0	raceway	
27-Jul	0	123	5	0	0	raceway	
28-Jul	0	18	5	4	1	raceway	
29-Jul	0	19	6	9	3	raceway	
30-Jul	0	21	7	4	1	raceway	
31-Jul	0	15	1	9	2	raceway	
1-Aug	0	31	5	1	0	raceway	
2-Aug	0	195	22	0	0	raceway	
3-Aug	0	0	0	0	0	raceway	
4-Aug	0	45	3	4	3	raceway	
5-Aug	0	242	44	24	4	raceway	
6-Aug	0	48	22	0	0	raceway	
7-Aug	0	162	21	0	0	raceway	

–continued–

Appendix A.–Continued (page 2 of 3)

Date	Steelhead	Sockeye	Sockeye Jack	Coho	Coho Jack	Source	Comments
8-Aug	0	657	91	1	0	raceway	
9-Aug	0	103	51	0	0	raceway	
10-Aug	0	152	138	0	0	raceway	
11-Aug	0	196	76	74	13	raceway	
12-Aug	0	197	215	64	6	raceway	
13-Aug	0	4687	651	1	2	raceway	
14-Aug	0	816	158	2	3	raceway	
15-Aug	0	22	19	0	0	raceway	
16-Aug	0	9	3	0	0	raceway	
17-Aug	0	19	6	1	2	raceway	
18-Aug	0	89	37	16	7	raceway	
19-Aug	0	623	249	1	3	raceway	
20-Aug	0	241	86	1	0	raceway	
21-Aug	0	85	18	1	1	raceway	
22-Aug	0	96	49	1	1	raceway	
23-Aug	0	217	122	2	6	raceway	
24-Aug	0	3230	322	16	43	raceway	
25-Aug	0	139	17	78	6	raceway	
26-Aug	0	14	2	43	10	raceway	
27-Aug	0	18	8	2	2	raceway	
28-Aug	0	21	6	2	6	raceway	
29-Aug	0	12	1	2	1	raceway	
30-Aug	0	35	8	7	6	raceway	
31-Aug	0	27	8	8	7	raceway	
1-Sep	0	79	48	11	5	raceway	
2-Sep	0	66	20	135	7	raceway	
3-Sep	0	52	17	67	8	raceway	
4-Sep	0	124	42	5	7	raceway	
5-Sep	0	211	65	2	6	raceway	
6-Sep	0	102	16	8	7	raceway	
7-Sep	0	189	25	0	0	raceway	
8-Sep	0	167	19	9	11	raceway	
9-Sep	0	66	26	16	3	raceway	
10-Sep	0	263	56	17	2	raceway	
11-Sep	0	372	58	102	9	raceway	
12-Sep	0	321	29	97	24	raceway	
13-Sep	0	103	13	38	48	raceway	
14-Sep	0	7	0	1	6	raceway	
15-Sep	0	98	13	221	40	raceway	
16-Sep	0	115	12	23	45	raceway	
17-Sep	0	195	34	17	36	raceway	
18-Sep	0	124	42	40	121	raceway	
19-Sep	0	128	18	29	44	raceway	
20-Sep	0	215	14	31	82	raceway	
21-Sep	0	191	10	200	185	raceway	
22-Sep	0	4	1	59	15	raceway	
23-Sep	0	10	0	0	29	raceway	
24-Sep	0	35	3	2	60	raceway	
25-Sep	0	57	3	2	51	raceway	
26-Sep	0	36	0	22	56	raceway	
27-Sep	0	43	0	3	65	raceway	

–continued–

Appendix A.–Continued (page 3 of 3)

Date	Steelhead	Sockeye	Sockeye Jack	Coho	Coho Jack	Source	Comments
28-Sep	0	58	3	11	59	raceway	
29-Sep	0	573	60	344	532	raceway	
30-Sep	0	101	3	7	136	raceway	
1-Oct	0	22	1	2	68	raceway	
2-Oct	0	39	1	1	42	raceway	
3-Oct	0	45	0	6	94	raceway	
4-Oct	0	3	0	3	31	raceway	
5-Oct	0	8	0	3	24	raceway	
6-Oct	0	24	1	336	62	raceway	
7-Oct	0	13	0	1	20	raceway	
8-Oct	0	18	0	0	11	raceway	
9-Oct	0	8	0	0	24	raceway	
10-Oct	0	19	1	2	15	raceway	
11-Oct	0	57	1	3	30	raceway	
12-Oct	0	28	0	2	41	raceway	
13-Oct	0	32	1	201	35	raceway	
14-Oct	0	12	0	4	25	raceway	
15-Oct	0	13	0	3	61	raceway	
16-Oct	0	9	0	2	21	raceway	
17-Oct	0	5	0	2	20	raceway	
18-Oct	0	3	0	2	6	raceway	
19-Oct	0	28	4	12	36	raceway	
20-Oct	0	8	1	209	42	raceway	
21-Oct	0	1	0	92	9	raceway	
22-Oct	0	0	0	2465	0	raceway	Flood event
23-Oct	0	0	0	500	0	raceway	Flood event
24-Oct	0	0	0	0	0	raceway	
25-Oct	0	0	0	0	0	raceway	
26-Oct	0	0	0	0	0	raceway	
27-Oct	0	0	0	0	0	raceway	
28-Oct	0	0	0	201	0	raceway	
29-Oct	0	0	0	5	2	raceway	
30-Oct	0	0	0	0	0	raceway	
31-Oct	0	0	0	0	0	raceway	
1-Nov	0	0	0	0	0	raceway	
2-Nov	0	0	0	0	0	raceway	
3-Nov	0	0	0	0	0	raceway	
4-Nov	0	0	0	0	0	raceway	
5-Nov	0	0	0	0	0	raceway	
6-Nov	0	0	0	0	0	raceway	
7-Nov	0	0	0	0	0	raceway	
8-Nov	0	0	0	0	0	raceway	
9-Nov	0	0	0	0	0	raceway	
10-Nov	0	0	0	0	0	raceway	
11-Nov	0	0	0	0	0	raceway	
12-Nov	0	0	0	0	0	raceway	
13-Nov	0	0	0	189	0	raceway	
14-Nov	0	0	0	0	0	raceway	
15-Nov	0	0	0	0	0	raceway	Weir pulled
Total	**2**	**18,010**	**3,155**	**6,210**	**2,566**		

Appendix B.–Age composition of sockeye salmon in the Klawock Lake escapement, 1982–2008.

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	0.00	0.15	0.83	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.98	0.01	0.01
1983	—	—	—	—	—	—	—	—	—	—	—	—	—
1984	0.28	0.24	0.29	0.00	0.04	0.09	0.06	0.00	0.00	0.00	0.81	0.19	0.00
1985	—	—	—	—	—	—	—	—	—	—	—	—	—
1986	0.00	0.28	0.61	0.00	0.00	0.07	0.04	0.00	0.00	0.00	0.89	0.11	0.00
1987	0.13	0.19	0.37	0.00	0.04	0.16	0.09	0.00	0.00	0.00	0.70	0.29	0.01
1988	0.00	0.35	0.42	0.00	0.00	0.12	0.10	0.00	0.00	0.00	0.78	0.22	0.00
1989	0.03	0.07	0.67	0.00	0.01	0.10	0.12	0.00	0.00	0.00	0.77	0.23	0.00
1990	0.56	0.16	0.09	0.01	0.01	0.14	0.04	0.00	0.00	0.00	0.81	0.19	0.00
1991	0.26	0.37	0.26	0.00	0.04	0.05	0.01	0.00	0.00	0.00	0.89	0.11	0.00
1992	0.18	0.44	0.30	0.00	0.06	0.02	0.01	0.00	0.00	0.00	0.91	0.09	0.00
1993	0.07	0.20	0.50	0.00	0.04	0.08	0.09	0.00	0.00	0.01	0.77	0.22	0.01
1994	0.05	0.06	0.71	0.00	0.01	0.14	0.03	0.00	0.00	0.00	0.82	0.18	0.00
1995	0.26	0.31	0.29	0.00	0.02	0.05	0.07	0.00	0.00	0.00	0.86	0.14	0.00
1996	0.03	0.09	0.67	0.00	0.01	0.09	0.10	0.00	0.00	0.00	0.79	0.21	0.00
1997	0.09	0.27	0.43	0.00	0.01	0.10	0.11	0.00	0.00	0.00	0.79	0.21	0.00
1998–2000	—	—	—	—	—	—	—	—	—	—	—	—	—
2001	0.01	0.10	0.49	0.00	0.00	0.12	0.27	0.00	0.00	0.00	0.60	0.40	0.00
2002	0.00	0.35	0.34	0.01	0.03	0.27	0.01	0.00	0.00	0.00	0.70	0.30	0.00
2003	0.01	0.08	0.59	0.00	0.03	0.26	0.03	0.00	0.00	0.00	0.68	0.32	0.00
2004	0.02	0.33	0.34	0.00	0.02	0.27	0.01	0.00	0.00	0.00	0.70	0.30	0.00
2005	0.13	0.13	0.29	0.00	0.05	0.37	0.03	0.00	0.00	0.00	0.55	0.44	0.00
2006	0.14	0.54	0.15	0.00	0.02	0.14	0.01	0.00	0.00	0.00	0.83	0.17	0.00
2007	0.02	0.30	0.36	0.00	0.02	0.22	0.07	0.00	0.00	0.00	0.69	0.31	0.00
2008	0.11	0.44	0.24	0.01	0.00	0.19	0.01	0.00	0.00	0.00	0.79	0.21	0.00
Averages													
All Years	0.11	0.25	0.42	0.00	0.02	0.14	0.06	0.00	0.00	0.00	0.78	0.22	0.00
SE	0.08	0.08	0.09	0.01	0.03	0.06	0.05	0.00	0.01	0.01	0.07	0.07	0.01
1982–1997	0.14	0.23	0.46	0.00	0.02	0.09	0.06	0.00	0.00	0.00	0.83	0.17	0.00
SE	0.11	0.09	0.12	0.01	0.04	0.06	0.05	0.01	0.01	0.01	0.07	0.07	0.01
2001–2008	0.06	0.28	0.35	0.00	0.02	0.23	0.05	0.00	0.00	0.00	0.69	0.31	0.00
SE	0.09	0.15	0.13	0.02	0.04	0.10	0.11	0.00	0.01	0.00	0.11	0.11	0.01