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Klag Lake Subsistence Sockeye Salmon Project: 2005 Annual Report

by

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and

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

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	$\geq$
harvest per unit effort	HPUE
less than	$<$
less than or equal to	$\leq$
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. 08-30

KLAG LAKE SUBSISTENCE SOCKEYE SALMON PROJECT: 2005 ANNUAL REPORT

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The Division of Sport Fish Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or group of closely related projects. Since 2004, the Division of Commercial Fisheries has also used the Fishery Data Series. Fishery Data Series reports are intended for fishery and other technical professionals. Fishery Data Series reports 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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TABLE OF CONTENTS

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The number of adult sockeye salmon returning to Klag Bay in 2005 was estimated by means of a subsistence and sport harvest survey in Klag Bay and an escapement count using a weir, verified with a mark-recapture study. Age, sex, and length composition of the escapement was estimated using standard measurements, scale sampling, and analysis. A strong run of sockeye salmon was observed, with an estimated total harvest of 2,500 fish, and an escapement of about 14,000 fish. The harvest in 2005 comprised just 15% of the total number of adult sockeye salmon returning to the marine terminal area within Klag Bay. The mark-recapture estimate validated the weir count and did not indicate that sockeye salmon passed through the weir undetected. Age-1.3 fish, from the 2000 brood year, represented an estimated 63% of the sockeye escapement in 2005. This was consistent with the large percentage of age-1.2 fish from the same brood year that appeared in the 2004 escapement.

Key words: Sockeye salmon, *Oncorhynchus nerka*, subsistence, Chichagof Island, Klag Lake, Sitka, escapement, mark-recapture, weir, harvest survey, age composition

INTRODUCTION

Currently, Klag Lake (ADF&G Stream No. 113-72-002) is one of the larger producers of sockeye salmon (*Oncorhynchus nerka*) in Southeast Alaska. For subsistence users in Sitka, it is second or third in importance, after Necker Bay and, depending on the year, Redoubt Lake. The abundance of Redoubt Lake sockeye salmon has fluctuated a great deal in recent times (Geiger 2003). In years when sockeye runs to Redoubt Lake are small and conservation measures are in place, subsistence users rely more heavily on sockeye salmon from Klag Bay. Fisheries managers became concerned about increasing effort and large sockeye harvests in Klag Bay during some seasons. Having no adequate estimates of abundance for Klag Lake sockeye salmon, managers at Alaska Department of Fish and Game (ADF&G) were compelled to implement conservative management practices when fishing effort appeared to be high. For example, they closed the subsistence fishery early in 1997, after observing few fish in the system during aerial surveys (Dave Gordon ADF&G Division of Commercial Fisheries, personal communication 2005). In 2000 the Sitka Tribe of Alaska, the U.S. Forest Service, and the Alaska Department of Fish and Game responded to concerns about possible over-harvesting of Klag Lake sockeye stocks by initiating a three-year sockeye monitoring project at Klag Lake, in 2001, with a second three-year study approved for 2004 through 2006.

ADF&G has compiled subsistence fishery data since 1985 from subsistence permit holders who returned their harvest information at the end of the season or upon requesting a permit for the following season. For the four-year period, 2002–2005, the average annual harvest of sockeye salmon from Klag Bay increased to about three times what it was in the preceding seventeen years, 1985–2001, and the number of permits issued annually for Klag Bay doubled during the same recent period (Appendix A). Furthermore, the average harvest per permit increased from 25 to 40 sockeye salmon. However, these reported annual harvest totals do not necessarily represent the actual sockeye harvest, because ADF&G does not independently verify the user-reported harvest numbers. Evidence from the few subsistence sockeye systems in which on-site harvest surveys have been conducted shows that harvest is typically, but not always, under-reported; the degree of under-reporting appears to be highly variable (Table 1; Conitz and Cartwright 2003, 2005; Lewis and Cartwright 2004; Lorrigan et al. 2004; Conitz et al. 2005). Klag Bay subsistence fishers have exhibited the unusual practice of reporting higher harvest numbers on their permits than during on-site interviews. Possibly, they obtain more accurate fish counts when they process their harvests after returning to Sitka. An important project objective was to obtain accurate annual estimates of fishing effort and sockeye harvest in Klag Bay, using direct observation and interviews in the sport and subsistence fisheries.

Prior to the start of the Klag Lake subsistence sockeye salmon project, the only escapement data available for Klag Lake were unreliable aerial survey counts for some years. The Klag Lake subsistence sockeye salmon project was initiated to provide accurate annual sockeye salmon escapement estimates, using a weir and mark-recapture study. From 2001 through 2004 the weir counts, verified with mark-recapture estimates, ranged from about 12,000 to about 23,000 fish (Conitz et al. 2005; Stahl et al. 2007). Estimates of sockeye fry and zooplankton populations in Klag Lake in 2001–2003 did not reveal any obvious food resource limitations, although high proportions of sticklebacks and the possibility of competition with sockeye fry were noted (Conitz et al. 2005). Overall, the Klag Lake sockeye population appeared to be stable and adequate to support subsistence and sport harvests at existing levels. The purpose of the 2004 to 2006 continuation of the project, therefore, was to monitor this stock through annual estimates of escapement, harvest, and run timing. The primary objective for the Klag Lake project in 2005 was to obtain an accurate weir count of sockeye salmon entering the lake to spawn, verified by a mark-recapture estimate, for a fifth consecutive year.

Table 1.–Annual subsistence sockeye harvests at Klag Bay, reported by permit-holders upon returning ADF&G subsistence permits (ADF&G Division of Commercial Fisheries database, 2005), and from on-site surveys, 2001–2004 (Conitz et al. 2005; Stahl et al. 2007).

	Total sockeye harvest	
Year	**Reported on permits**	**On-site survey**
2001	1,325	1,706
2002	4,065	3,048
2003	2,475	1,988
2004	3,196	2,842

OBJECTIVES

1. Count the escapement of sockeye salmon into Klag Lake through a weir on the outlet stream, and verify the count with a mark-recapture estimate with estimated coefficient of variation of less than 10%.
2. Estimate the subsistence harvest of sockeye salmon from the terminal marine area around the mouth of the Klag Lake outlet stream, using direct observation and on-site interviews, 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 Klag Lake escapement.

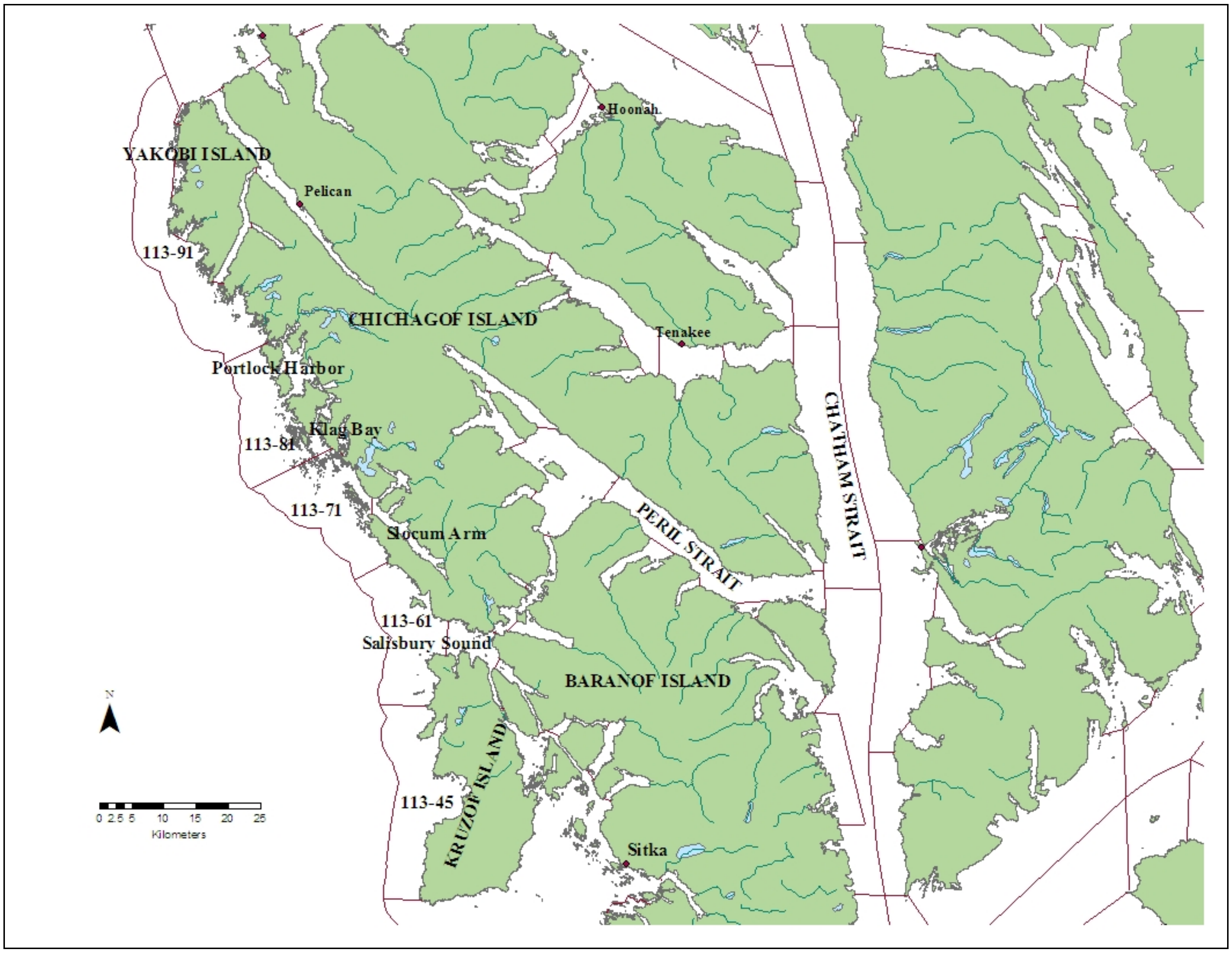

Figure 1.–Location of Klag Bay on Chichagof Island. The town of Sitka and commercial fishing districts along the outside coast of Chichagof Island are also shown.

METHODS

STUDY SITE

Klag Lake (ADF&G stream no. 113-72-007; lat. 57^{o} 39'N, long. 136^{o} 4'W) is located on the southwest side of Chichagof Island. This lake has a surface area of 83 ha, an elevation of about 12 m, and a maximum depth of 43 m (Figure 2). The Klag Lake drainage consists of approximately 7 km^2 of sparsely wooded low hills, large areas of muskeg, and numerous small shallow lakes and ponds. The lake drains to the south via an outlet that flows through a series of three large ponds before emptying into the east side of Klag Bay. In Klag Lake, sockeye salmon have been observed spawning in the first 500 m of the main inlet stream. A 1.3 m high barrier falls blocks further upstream migration in low to moderate water flow; however, sockeye salmon may be able to pass the falls during high water, as observed for coho salmon (*O. kisutch*; Terry Suminski, U.S. Forest Service, personal communication). In addition, small groups of sockeye salmon have been observed spawning on beaches in the northeast end of the lake (Conitz and Cartwright 2002). The spawning habitat is not typical and comprises mainly large angular cobble and bedrock. In addition, to sockeye and coho salmon, this drainage supports small populations of pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), steelhead (*O. mykiss*), cutthroat trout (*O. clarki*), Dolly Varden char (*Salvelinus malma*), and threespine stickleback (*Gasterosteus aculeatus*).

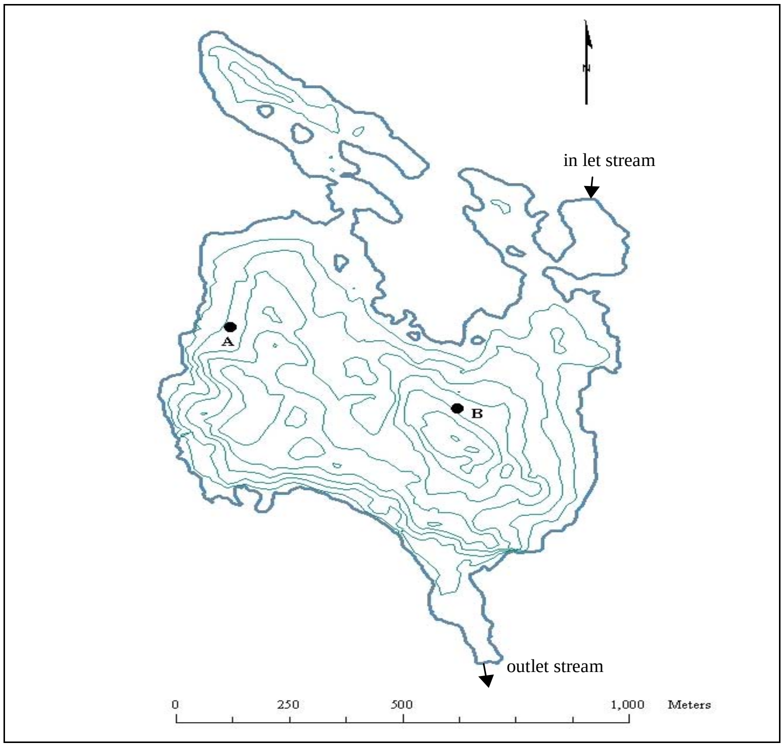

Figure 2.–Bathymetric map of Klag Lake, showing 5 m depth contours.

WEIR AND MARK-RECAPTURE ESTIMATE

A rigid weir was installed in the outlet stream of Klag Lake, approximately 100 meters upstream from the estuary, in the same location and with the same construction used in 2001–2004 (Conitz et al. 2005). The weir went into operation 7 July and all salmon entering the lake were counted, by species, from that date until 7 September. A portion of the sockeye salmon counted through the weir was marked with fin-clips for a mark-recapture escapement study. A stratified two-sample design was used. Marks given sockeye salmon at the weir were stratified by time, to allow separate parameter estimates for different parts of the run, in the event of large biological or sampling differences over time (Arnason et al. 1996). The overall cumulative marking fraction was 18% by the end of the run. Marks were stratified into just two periods, identified by fin clips: 7 July–1 August (left ventral) and 2 August–7 September (right ventral). The field crew conducted two recapture events on the spawning grounds, on 27 August and 6 September. The recapture study area began at the inlet stream mouth, above Klag Lake, and extended to the first falls. Both live and dead fish were examined for marks and all sampled fish received a secondary mark to prevent duplicate sampling.

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).

To test for consistency of capture probabilities in the marking and recapture strata, two chi-square tests are commonly used. A test for equal capture probability in the first sample compares observed and expected numbers of marked and unmarked fish in each recapture stratum. A test for equal capture probability in the second sample, or equivalently, complete mixing, compares observed and expected numbers of those fish marked in the initial (marking) strata which were recaptured or not recaptured. These tests are provided in the Stratified Population Analysis System (SPAS) software and are labeled "equal proportions" and "complete mixing," respectively (Arnason et al. 1996; for details, refer to http://www.cs.umanitoba.ca/~popan/). We considered a test statistic with p-value ≤ 0.05 to be "significant." If neither test statistic, or only one test statistic, was significant, we 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, we 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, we followed the guidelines and suggestions in Arnason et al. (1996) to search for a partial pooling scheme that would lead to a valid estimate. We 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 quality. If a valid estimator could not be found, the weir count was accepted as the best estimate, of at least minimum escapement.

ESCAPEMENT AGE AND SIZE COMPOSITION

A sample of 613 adult sockeye salmon passing through the Klag Lake weir were measured and identified by sex, and had scales taken for age determination, primarily in order to estimate the age structure of the population. Fish were selected systematically to prevent selection bias, and roughly in proportion to weekly escapement, throughout the entire run. 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 standard error of the proportion in each age class was estimated using standard statistical techniques and assuming a binominal distribution (e.g. Thompson 1992). We expected that this binomial assumption would adequately approximate the standard error, even though we used a systematic sample rather than a random sample.

SUBSISTENCE AND SPORT HARVEST ESTIMATE

Subsistence and sport fisheries were monitored seven days a week, from 7 July to 7 September during daylight hours. The crew contacted all fishery participants as they entered the area, noting gear type (subsistence seine, subsistence gillnet, subsistence dip net, or sport rod) and asking fishers to complete an interview before leaving the area. Data collected during each interview included effort (rod or net hours) and total harvest by species. Experience has shown that samplers could interview nearly all participants during this time period, with the exception of those participants who chose to leave the area without completing an interview. These instances were recorded as missed interviews.

Equations for estimating harvest, catch, and effort in each harvest survey were those for a one-stage direct expansion (access point, completed-trip interview) survey (Cochran 1977). This design was appropriate because the crew could accurately count all boats in the fishery and interview participants in most boats after they completed fishing. The primary sampling units were boat-parties within days. For each gear group and species, let h_j denote harvest on boat j, m denote number of boat-parties interviewed, and M denote number of boat-parties counted. The harvest, for a given species, was estimated as,

$$\hat{H} = \frac{M}{m} \sum_{j=1}^{m} h_j .$$

Letting $\bar{h}$ denote the mean harvest per boat, the variance of the harvest by stratum (gear group) was estimated as,

$$\mathrm{var}(\hat{H}) = (1 - \frac{m}{M}) M^2 \frac{\sum_{j=1}^{m} (h_j - \bar{h})^2}{m(m-1)} .$$

If all boat-parties in a gear group were interviewed, the one-stage design collapsed into a complete census, and we estimated harvest of each species by simply summing the harvests reported by all the boat-parties. The total harvest estimate of each species for the season was the sum of harvests for all gear groups, and estimated variance of the total harvest estimate was the sum of variances for all gear groups.

RESULTS

WEIR AND MARK-RECAPTURE ESTIMATE

A total of 13,975 sockeye salmon were counted through the Klag Bay weir from 7 July to 7 September 2005 (Appendix B). In addition, 2,809 coho, 53,900 pink and 29 chum salmon were counted through the weir. Peak sockeye counts on 18 July, 27 July, 30 July, and 5 August coincided with increasing water flow in the Klag Lake outlet stream (Figure 3).

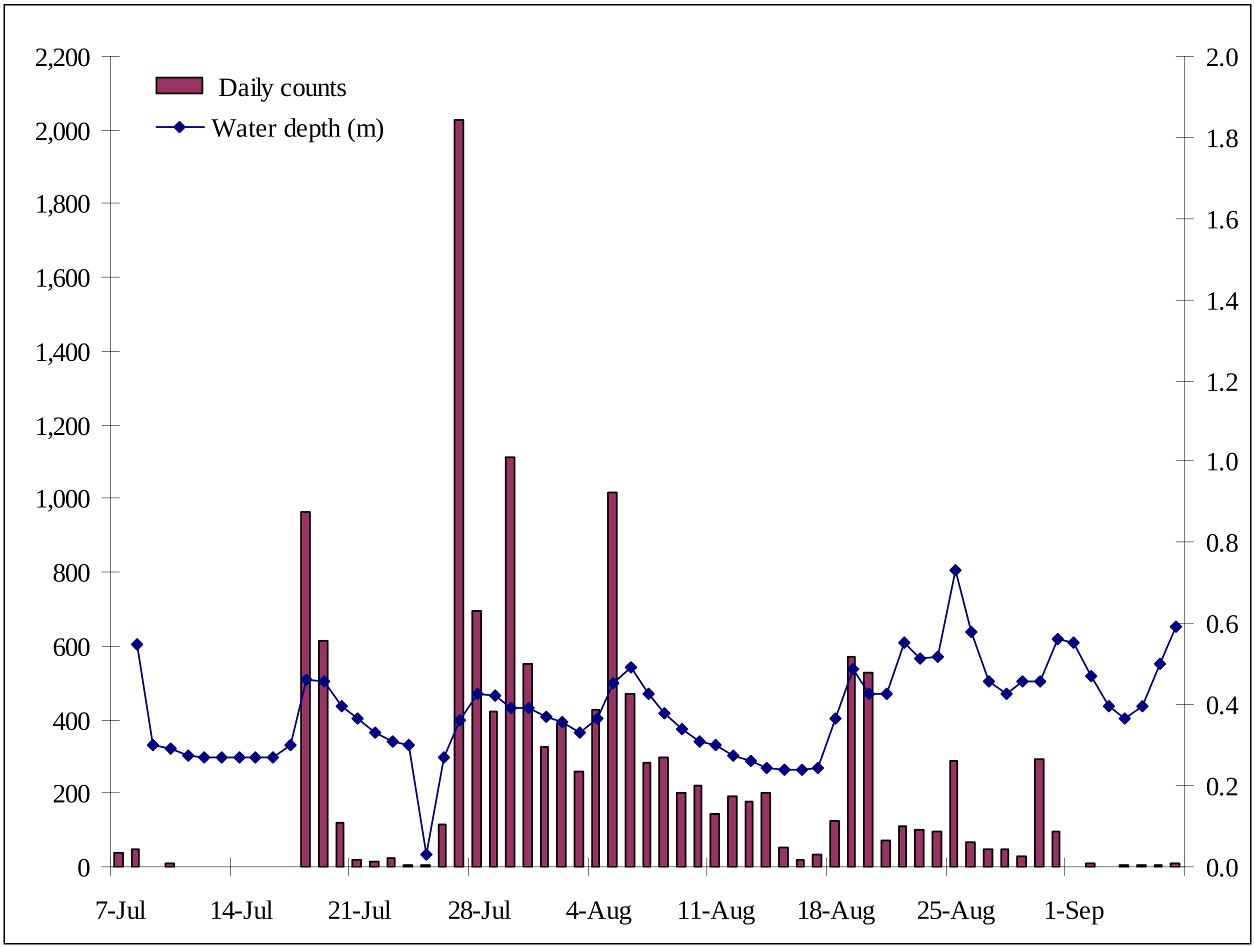

Figure 3.–Daily counts of sockeye salmon passed through the weir and water depth in the Klag Lake outlet stream, 2005.

The mark-recapture study began by realizing a 19.8% marking rate through 1 August for the first stratum. The second marking stratum began 2 August and concluded 7 September, with a 17.1% marking rate. The crew performed the first recapture event on 27 August, finding 18.6% of the fish sampled on the spawning ground to be marked. The second recapture event occurred 6 September, and 15.0% of the fish sampled had marks (Table 2).

The pooled Petersen estimate was 16,000 (CV=12%); the 95% confidence interval for the true population was 13,000–22,000 fish. Chi-square tests presented no evidence of a violation of the assumption of equal probability of capture in the first sample ($X^2 = 0.69$, $p = 0.4$) but did indicate a problem with the assumption of complete mixing ($X^2 = 25.96$, $p < 0.01$). Because at least one chi-square test result was non-significant, we concluded the pooled Petersen estimate was valid. The weir count of 13,975 sockeye salmon fell within the 95% confidence interval for the population, and so the estimate confirmed the weir count with no detectable difference. In the absence of any evidence of inaccuracy in the count, we used it as the more conservative measure, rounded to 14,000 fish, to represent the sockeye escapement estimate for Klag Lake in 2005.

Table 2.–Numbers of sockeye salmon counted and marked at the weir in each marking stratum, and numbers of recaptures of marked fish by recapture event and marking stratum, in Klag Lake in 2005.

Marking at weir					Recaptures on spawning grounds			
Stratum	**Dates**	**Number counted**	**Number marked**	**Marking rate**	**27 Aug**	**6 Sep**	**Sum, both events**	**Percentage of marks recaptured**
1	7 Jul–1 Aug	7,099	1,410	19.9%	17	33	50	3.6%
2	2 Aug–7 Sep	6,876	1,178	17.1%	0	7	7	0.6%
Totals		13,975	2,588	18.5%	17	40	57	2.2%
Total sampled on spawning grounds					91	267	358	
Percentage of marks in recapture samples					18.7%	15.0%	15.9%	

ESCAPEMENT AGE AND SIZE COMPOSITION

The largest age class in the 2005 sockeye escapement was age-1.3, from the 2000 brood year, representing an estimated 63.3% of the total (Table 3). The second largest age class was age-1.2, representing about 12.6% of escapement, followed by age-2.3, representing about 12.1% of escapement. By brood year, we estimated a spawning population composed of about 13% 4-year olds from brood year 2001, 74% 5-year olds from brood year 2000, and 13% 6-year olds from brood year 1999. About 77% of sockeye salmon in the 2005 escapement had one freshwater year.

Table 3.–Age composition of sockeye salmon in Klag Lake escapement by sex, brood year, and age class, sampled 8 July–29 August, 2005.

Brood Year	**2002**	**2001**	**2000**	**2000**	**1999**	**Total**
Age	**1.1**	**1.2**	**1.3**	**2.2**	**2.3**	
Male						
Sample size	7	42	207	31	38	321
Percent	1.1%	6.9%	33.8%	5.1%	6.2%	52.4%
Std. error	0.4%	1.0%	1.9%	0.9%	1.0%	2.0%
Female						
Sample size	-	35	181	36	36	292
Percent		5.7%	29.5%	5.9%	5.9%	47.6%
Std. error		0.9%	1.8%	1.0%	1.0%	2.0%
All Fish						
Sample size	7	77	388	67	74	613
Percent	1.1%	12.6%	63.3%	10.9%	12.1%	
Std. error	0.4%	1.3%	2.0%	1.3%	1.3%	

The average fork length was 554 mm for age-1.3 fish and 500 mm for age-1.2 fish (Table 4). Sockeye salmon returning with three ocean years were about 50 mm longer, on average, than their counterparts with only two ocean years, across both freshwater age classes.

Table 4.–Mean fork length (mm) of sockeye salmon in Klag Lake escapement by brood year, sex, and age class, sampled 8 July–29 August, 2005.

Brood Year	**2002**	**2001**	**2000**	**2000**	**1999**
Age	**1.1**	**1.2**	**1.3**	**2.2**	**2.3**
Male					
Avg. length	380	504	560	515	557
Std. error	1.5	7.2	1.9	6.0	3.2
Sample size	3	42	207	31	38
Female					
Avg. length	-	494	549	496	548
Std. error		5.6	1.5	6.2	3.6
Sample size		35	181	36	36
All Fish					
Avg. length	377	500	554	505	553
Std. error	14.7	4.7	1.3	4.5	2.4
Sample size	7	77	388	67	74

SUBSISTENCE AND SPORT HARVEST ESTIMATE

A total of 32 participants were counted in the Klag Bay harvest survey, of which 11 were sport fishing and 19 were subsistence fishing, and two were undetermined as to fishery type (Table 5). Interviews were completed with 27 of the participants. Because the fishery and gear type was not known for some of the missed interviews, only the combined harvest for both fishery and all gear types could be estimated. Because the estimate relied on an estimate of average harvest per participant, and the harvest per participant was much lower for sport than subsistence fishers, combining the two fishery types may have slightly overestimated harvest. The total sockeye harvest estimate was 2,500 fish (CV = 13%).

As expected, subsistence fishing accounted for most of the Klag Bay sockeye harvest in 2005. Beach seines were the most commonly used and efficient subsistence fishing gear, netting approximately 95% of the total subsistence harvest. Sport participation and effort were comparable with levels for subsistence fishing, but actual harvest of sockeye salmon in the sport fishery was minimal (Table 5).

Table 5.–Summary of subsistence and sport fisheries at Klag Bay in 2005, determined from on-site surveys.

Gear type	Participants		Gear-hours fished	Total harvest by species and gear type				
	Counted	Interviewed		Sockeye	Coho	Chum	Pink	Chinook
Beach seine	14	14	69	2,011	24	8	13	1
Gillnet	4	4	31	111	0	5	17	0
Dipnet	1	1	9	15	0	0	20	0
Subsistence subtotal	19	19	109	2,137	24	13	50	1
Sport rod	11	8	45	14	0	0	30	0
Unknown[a]	2	0	-	-	-	-	-	-

[a] Missed interviews, with gear type not determined.

Technicians observed subsistence and sport fishing in Klag Bay from 8 July to 3 August. The largest effort, in terms of numbers of participants and total hours fished per unit of gear, took place during the week of 17–23 July, but the largest harvest was taken the previous week, 10–16 July (Table 6).

Table 6.–Weekly numbers of subsistence fishers interviewed, and sockeye harvest and effort as reported to technicians conducting the interviews at Klag Bay in 2005.

Week	Participants interviewed[a]	Sockeye harvested[a]	Total gear-hours[a]
3–9 July	6	174	15
10–16 July	5	844	31
17–23 July	11	620	61.5
24 July–6 Aug[b]	5	513	46.5

[a] Includes information from only those participants that were interviewed.

[b] Last two weeks combined to protect confidentiality when fewer than 3 participants per week.

The on-site estimate of sockeye harvest was slightly higher than the harvest reported by users on returned subsistence permits, but not significantly so, given the uncertainty in the survey-generated estimate. A total harvest of 2,396 sockeye was reported for Klag Bay in 2005 by 62 ADF&G subsistence permit holders (ADF&G Division of Commercial Fisheries database, 2007).

DISCUSSION

The escapement of 14,000 sockeye salmon in 2005 was below the average of estimated sockeye escapements during the previous four years, about 17,000 fish (Conitz et al. 2005; Stahl et al. 2007). Again, as in 2004, we accepted the weir count, which fell within the estimated 95% confidence interval for sockeye escapement. Given the problem obtaining consistent mark-recapture samples throughout the whole system and the entire spawning period in the Klag Lake system, we cannot rule out the possibility of bias in mark-recapture estimates. Only those sockeye spawners using the main inlet stream are readily available for capture, and mark-recapture sampling has focused on this group. However, obtaining adequate, consistent samples from this group is difficult due to the extremely high concentrations of fish present during a very short spawning period. Sockeye spawners in other locations, notably the perimeter of the lake or pools along the outlet stream, and those spawning earlier or later in the season have not been represented in sampling. Failure to sample consistently from all spawning groups in the Klag Lake system almost guarantees that the assumption of equal capture probability for fish in all marking periods cannot be met, and may lead to high bias in the estimate (Arnason et al. 1996). Therefore the weir count, while more conservative, may be more realistic, especially since we have no evidence of problems with weir operation. Mark-recapture estimates, when determined to be valid, were similar to the weir counts in all four previous years of this study, and the weir count was usually accepted as the best measure of escapement (Conitz and Cartwright 2002; Lorrigan et al. 2004; Conitz et al. 2005; Stahl et al. 2007).

The estimated harvest of 2,500 sockeye salmon in the 2005 subsistence and sport fisheries in Klag Bay was slightly under the estimated average harvest of about 2,900 fish for the previous four years (Conitz et al. 2005; Stahl et al. 2007). In 2005, the harvest estimate from on-site surveys was very close to the total harvest reported by subsistence permit holders, unlike in the three previous years when reported harvests exceeded those estimated from the surveys by a substantial amount (Conitz et al. 2005; Stahl et al. 2007). We concluded that both methods gave a reasonably accurate accounting of the Klag Lake subsistence sockeye harvest. If subsistence users are able to accurately report their harvest using the permit system, the on-site survey may not be needed. Total harvest for Klag Bay was not large compared with escapement; harvest represented about 15% of the combined run in the marine terminal area (subsistence harvest plus escapement). Despite concerns that harvest has disproportionately targeted the early part of the run, over one-third of the total escapement, and twice the total number of fish that were harvested, had entered the lake by the end of subsistence fishing in 2005. We see no cause for concern about a harvest of this size, yet the extraction of the total harvest exclusively from the beginning third of the run should be noted, and escapement timing with respect to harvest should continue to be monitored.

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APPENDICES

Appendix A.–Numbers of subsistence fishing permits, total annual sockeye harvest, and average number of sockeye salmon harvested per permit, reported by Klag Bay permit holders from 1985 through 2005 (ADF&G Division of Commercial Fisheries database 2007). ADF&G compiles this harvest information from subsistence permit holders who return this information with their permit, and it is not necessarily and accurate accounting of the total subsistence sockeye harvest at Klag Bay.

Year	Number of permits	Total sockeye harvest	Average harvest per permit
1985	29	582	20
1986	46	919	20
1987	42	816	19
1988	26	629	24
1989	5	114	23
1990	5	115	23
1991	1	23	23
1992	11	276	25
1993	59	1,626	28
1994	31	809	26
1995	28	1,098	39
1996	100	3,381	34
1997	42	1,106	26
1998	33	834	25
1999	42	1,048	25
2000	48	1,082	23
2001	65	1,325	20
2002	94	4,065	43
2003	70	2,475	35
2004	75	3,196	43
2005	62	2,396	39
Average	44	1,329	28
1985–2001 average	36	928	25
2002–2005 average	75	3,033	40

Appendix B.–Daily and cumulative salmon counts by species, and daily water level and temperature, at the Klag Lake weir, 2005.

Date	Sockeye		Coho		Pink		Chum	Physical data		
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Water depth (mm)	Water temp (°C)	Air temp (°C)
7-Jul	36	36	0	0	0	0	0			
8-Jul	48	84	0	0	0	0	0	549	16	15.7
9-Jul	1	85	0	0	0	0	0	299	18	16
10-Jul	9	94	0	0	0	0	0	293	17	15.3
11-Jul	0	94	0	0	0	0	0	274	17	14.7
12-Jul	0	94	0	0	0	0	0	271	17	13.7
13-Jul	0	94	0	0	0	0	0	268	17	15
14-Jul	0	94	0	0	0	0	0	268	17	13
15-Jul	0	94	0	0	0	0	0	271	16	14.8
16-Jul	0	94	0	0	0	0	0	271	16	14.1
17-Jul	0	94	1	1	0	0	0	302	16	14.3
18-Jul	963	1,057	128	129	15	15	0	460	15	14.5
19-Jul	612	1,669	87	216	46	61	0	457	16	14.7
20-Jul	118	1,787	13	229	85	146	0	396	17	12.2
21-Jul	21	1,808	15	244	25	171	0	366	18	13.1
22-Jul	12	1,820	1	245	15	186	0	329	18	17.5
23-Jul	23	1,843	10	255	31	217	0	311	18	18
24-Jul	4	1,847	8	263	13	230	0	299	19	18
25-Jul	5	1,852	0	263	8	238	0	29	18	16
26-Jul	113	1,965	3	266	21	259	7	268	17	14.7
27-Jul	2,026	3,991	212	478	801	1,060	5	363	17	15.5
28-Jul	694	4,685	76	554	722	1,782	0	427	16	13.7
29-Jul	424	5,109	54	608	550	2,332	0	421	17	13.3
30-Jul	1,113	6,222	36	644	1,586	3,918	0	390	18	15
31-Jul	553	6,775	49	693	1,687	5,605	4	393	17	13
1-Aug	324	7,099	21	714	623	6,228	2	369	18	13.1
2-Aug	387	7,486	16	730	975	7,203	2	357	18	14
3-Aug	261	7,747	12	742	228	7,431	0	329	17	13.1
4-Aug	428	8,175	105	847	1,918	9,349	2	366	16	13
5-Aug	1,016	9,191	133	980	4,518	13,867	3	451	15	15.4
6-Aug	469	9,660	57	1,037	1,933	15,800	1	494	16	14.7

–continued–

Appendix B.–Page 2 of 2.

Date	Sockeye		Coho		Pink		Chum	Physical data		
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Water depth (mm)	Water temp (^oC)	Air temp (^oC)
6-Aug	469	9,660	57	1,037	1,933	15,800	1	494	16	14.7
7-Aug	282	9,942	51	1,088	928	16,728	0	427	17	13.6
8-Aug	298	10,240	35	1,123	1,193	17,921	0	381	18	16.9
9-Aug	203	10,443	26	1,149	257	18,178	0	341	19	24.7
10-Aug	219	10,662	31	1,180	417	18,595	0	311	19	15.2
11-Aug	143	10,805	11	1,191	52	18,647	0	299	19	16.5
12-Aug	194	10,999	14	1,205	142	18,789	0	274	19	15.2
13-Aug	176	11,175	8	1,213	147	18,936	0	262	19	15.1
14-Aug	199	11,374	6	1,219	203	19,139	0	244	19	14.2
15-Aug	54	11,428	2	1,221	26	19,165	0	241	19	16
16-Aug	20	11,448	0	1,221	45	19,210	0	241	19	16.2
17-Aug	32	11,480	6	1,227	67	19,277	0	244	19	16.4
18-Aug	125	11,605	151	1,378	612	19,889	0	366	18	16.2
19-Aug	572	12,177	162	1,540	2,735	22,624	0	488	18	16
20-Aug	528	12,705	153	1,693	2,673	25,297	2	427	18	15.8
21-Aug	73	12,778	36	1,729	378	25,675	0	427	19	14.1
22-Aug	108	12,886	30	1,759	2,962	28,637	0	555	19	14.2
23-Aug	101	12,987	55	1,814	1,962	30,599	0	512	19	14.2
24-Aug	94	13,081	29	1,843	2,867	33,466	0	518	18	14.8
25-Aug	286	13,367	162	2,005	4,815	38,281	0	732	16	15.8
26-Aug	65	13,432	72	2,077	2,509	40,790	0	579	16	14.1
27-Aug	50	13,482	21	2,098	2,335	43,125	0	457	15	12.6
28-Aug	49	13,531	51	2,149	297	43,422	0	427	15	13
29-Aug	28	13,559	28	2,177	126	43,548	0	457	16	15
30-Aug	291	13,850	329	2,506	4,195	47,743	0	457	15.5	n/a
31-Aug	95	13,945	113	2,619	3,088	50,831	1	561	14.5	13.2
1-Sep	2	13,947	15	2,634	122	50,953	0	555	14.5	n/a
2-Sep	8	13,955	34	2,668	105	51,058	0	469	15	n/a
3-Sep	2	13,957	42	2,710	62	51,120	0	396	n/a	n/a
4-Sep	3	13,960	1	2,711	34	51,154	0	366	14.5	13.4
5-Sep	4	13,964	12	2,723	39	51,193	0	396	15	14
6-Sep	3	13,967	8	2,731	69	51,262	0	503	15	14
7-Sep	8	13,975	78	2,809	2,638	53,900	0	594	15	14.3